INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.

Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center
* frequency of the channel. When a fault occurs within the protected equipment, protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel.
*See Fig. No. 15.

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal * Y11, transistors Q12 and Q13, or IC201 (Fig. 17) and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 kHz above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the later is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20kHz, 2fc + 20kHz, fc + 20kHz and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 * hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero output frequency. This separation of 200 hertz between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 hertz in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20 kHz-100 hertz. Similarly, the Trip frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears, the discriminator output at term. 15 will turn Q101 off. C101 will change and after 120 ms. it will reach the breakdown voltage of CR104 and turn Q102 on. This will allow C102 to quickly discharge through R123 and Q102 and provide the full 150 ms. time delay to be effective on any subsequent loss of guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functi---

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 2.25 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.6 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental ininsertion of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	1000 hertz, minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42 - 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

* In case the transmitter has a 1 Watt/1 Watt output and diode D84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode D84 in the Trip output path. *

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

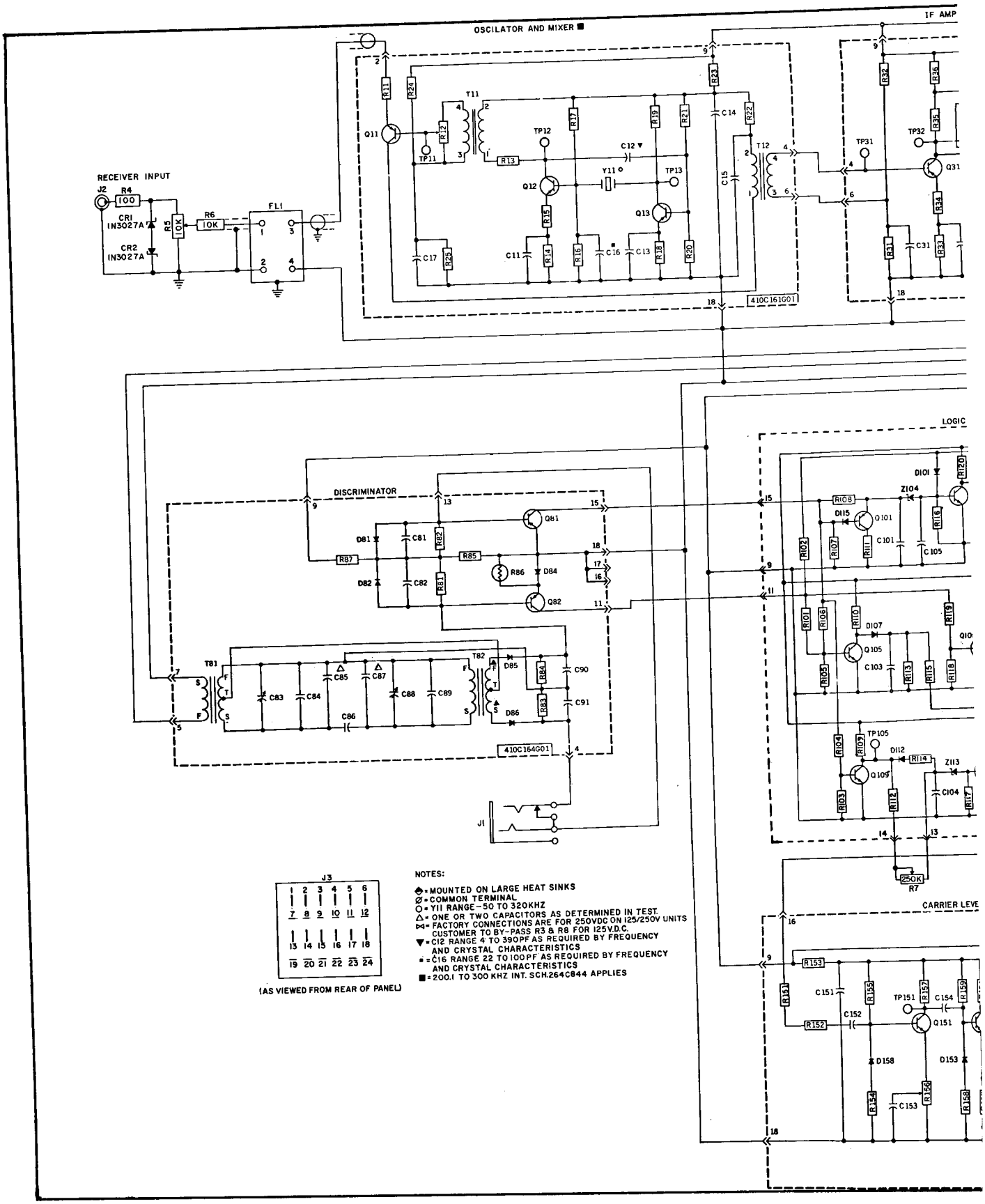
These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

ADDENDUM

With shipments of sets starting in early 1973, the germanium transistors used in the various modules were replaced with silicon transistors. In addition, due to the nature of silicon transistors, some resistor values in the circuits had to be changed In order to correctly bias these transistors. Therefore the transistors are not replaceable on a pin for pin basis throughout the receiver. Before attempting to replace a germanium transistor with a silicon transistor on older sets using germanium, please check the schematics on the following pages to see if the location where the replacement is desired has additional component changes. If that is the case, then the replacement can only be made by the same designation transistor or the additional component changes must also be made. It should be pointed out that the modules containing the silicon transistors are completely interchangeable with the modules containing germanium transistors. Therefore, there is no problem with intermixing the silicon transistor modules in the same receiver. Thus complete new modules containing silicon transistors can be ordered and used as replacements in older receivers having germanium transistor modules. The new modules have the same style numbers as the old germanium transistor modules they replace.

Type TCF Receiver (Front View).

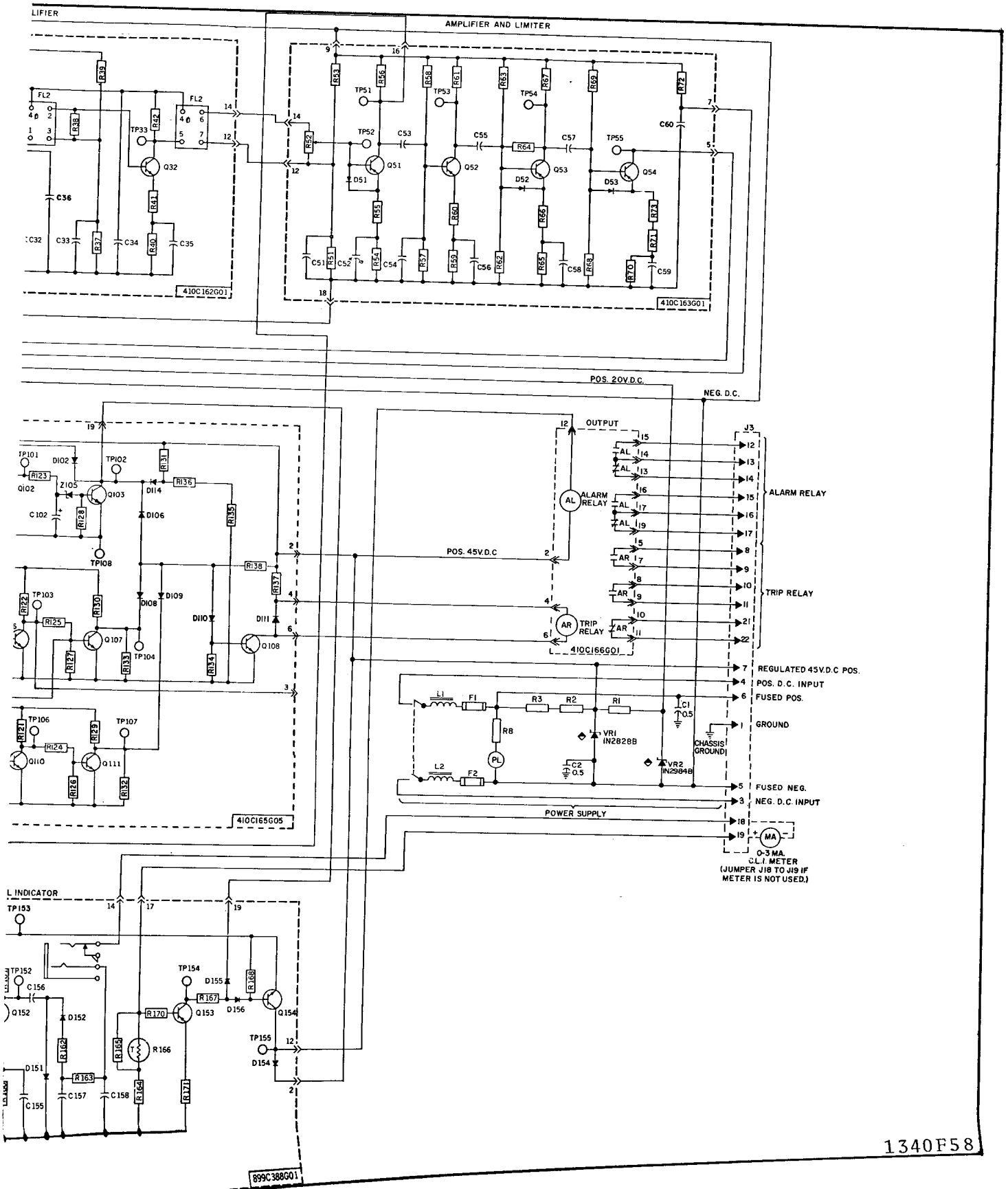


NOTES:

◆ = MOUNTED ON LARGE HEAT SINKS
⊘ = COMMON TERMINAL
○ = YII RANGE −50 TO 320KHZ
△ = ONE OR TWO CAPACITORS AS DETERMINED IN TEST.
▷◁ = FACTORY CONNECTIONS ARE FOR 250VDC ON 125/250V UNITS CUSTOMER TO BY-PASS R3 & R8 FOR 125V.D.C.
▼ = CI2 RANGE 4 TO 390PF AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS
■ = CI6 RANGE 22 TO 100PF AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS
■ = 200.1 TO 300 KHZ INT. SCH.264C844 APPLIES

J3
1 2 3 4 5 6
7 8 9 10 11 12
13 14 15 16 17 18
19 20 21 22 23 24
(AS VIEWED FROM REAR OF PANEL)

* *Fig. 2. Internal schematic of the type TCF*



receiver with the carrier level indicator – silicon version.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).

Voltage Range:	1.5 to 300 volts
Imput Impedance:	7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator

Output Voltage:	up to 8 volts
Frequency Range:	20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

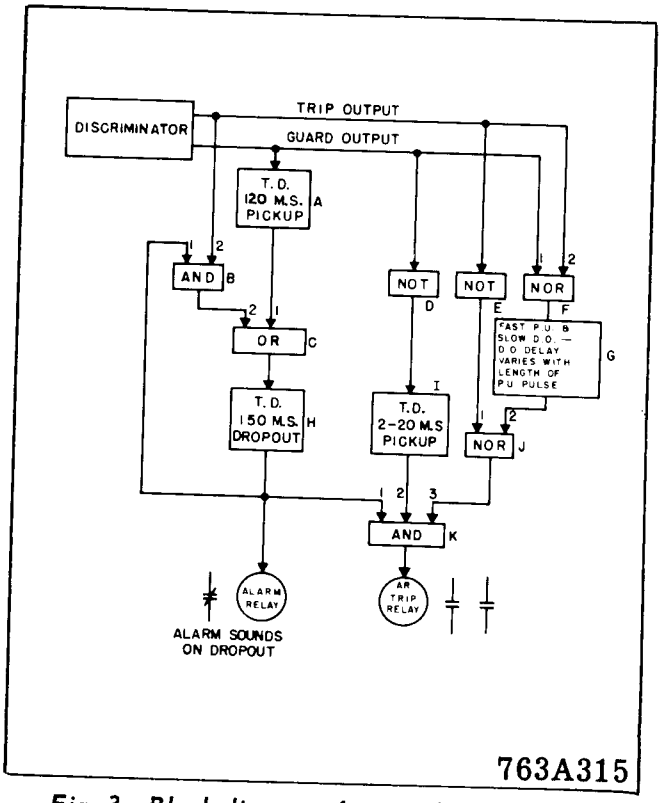


Fig. 3 Block diagram of output logic circuit

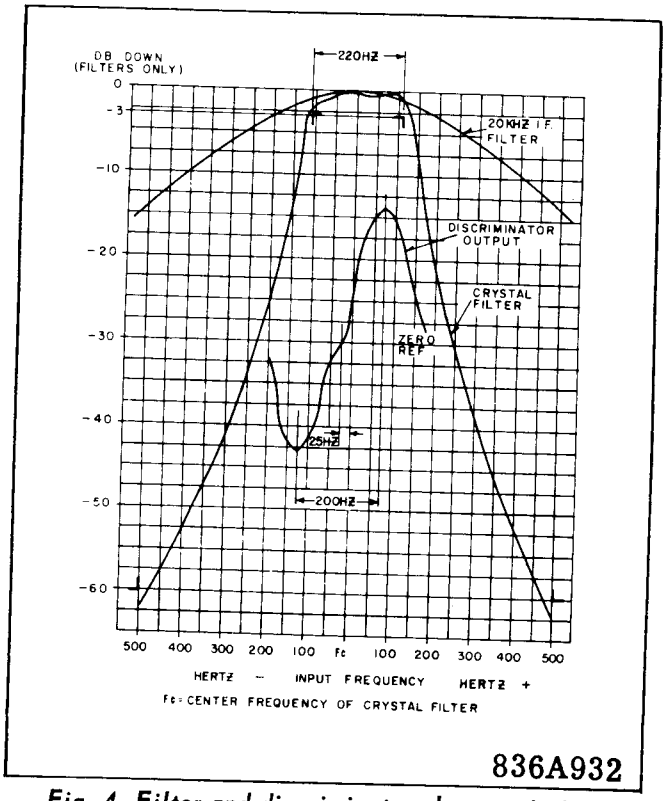


Fig. 4 Filter and discriminator characteristics of the type TCF receiver

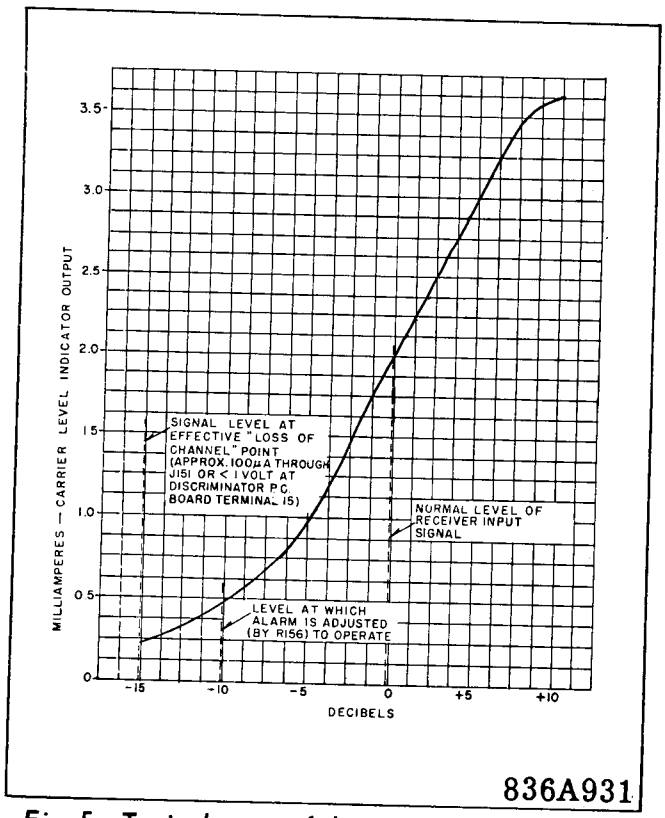


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

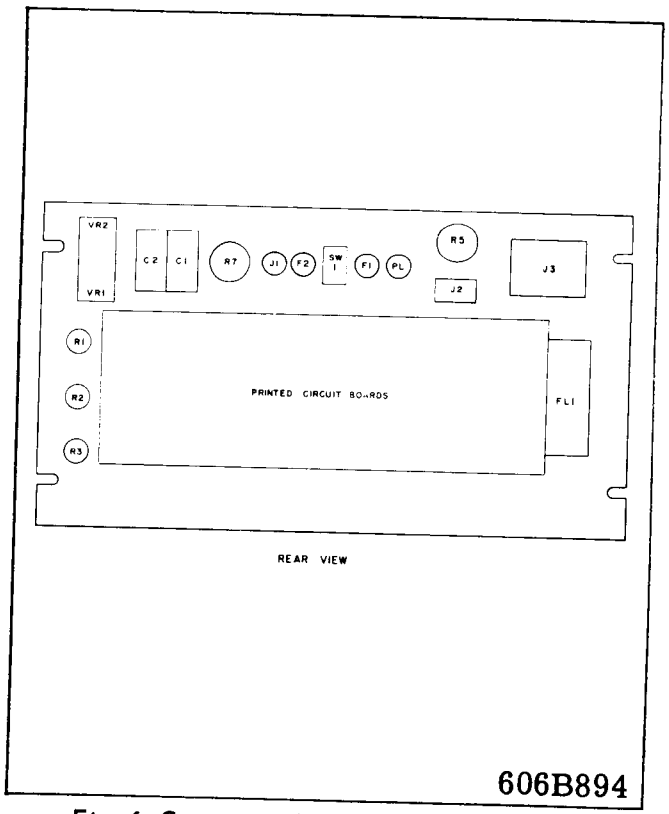
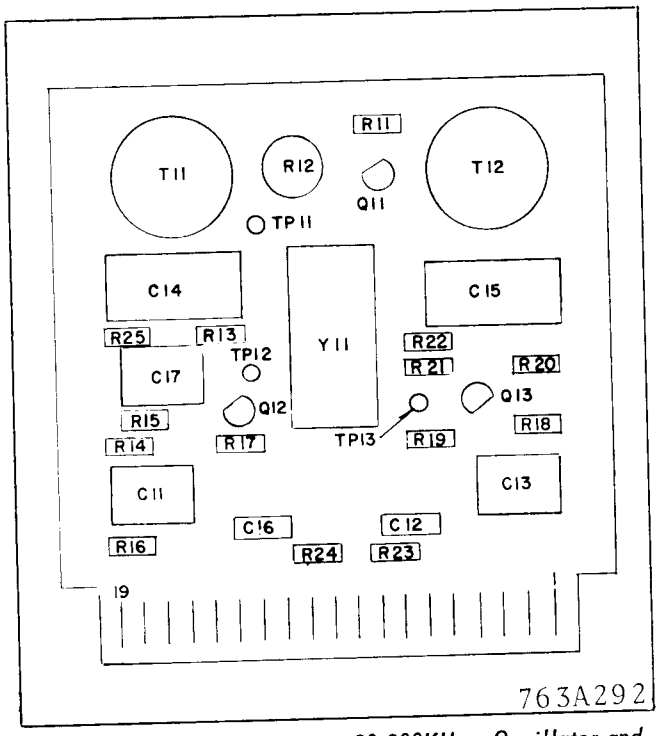
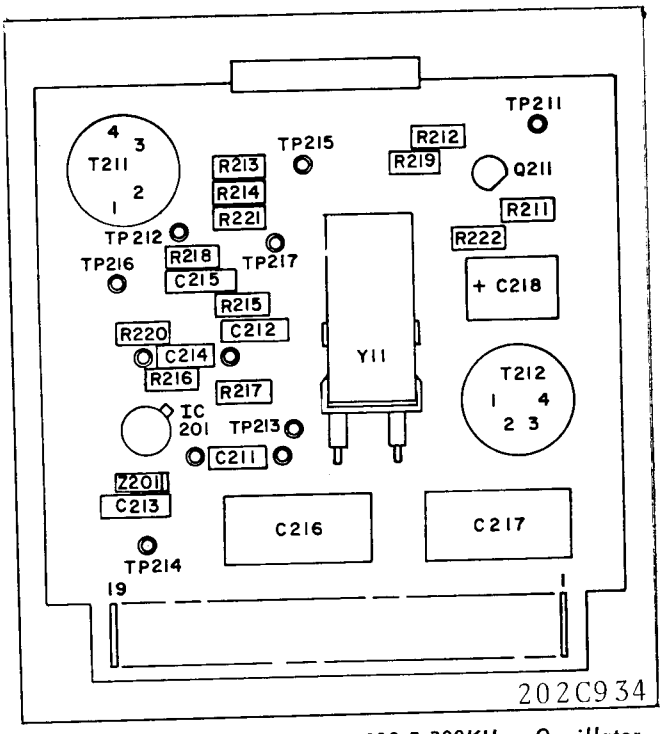


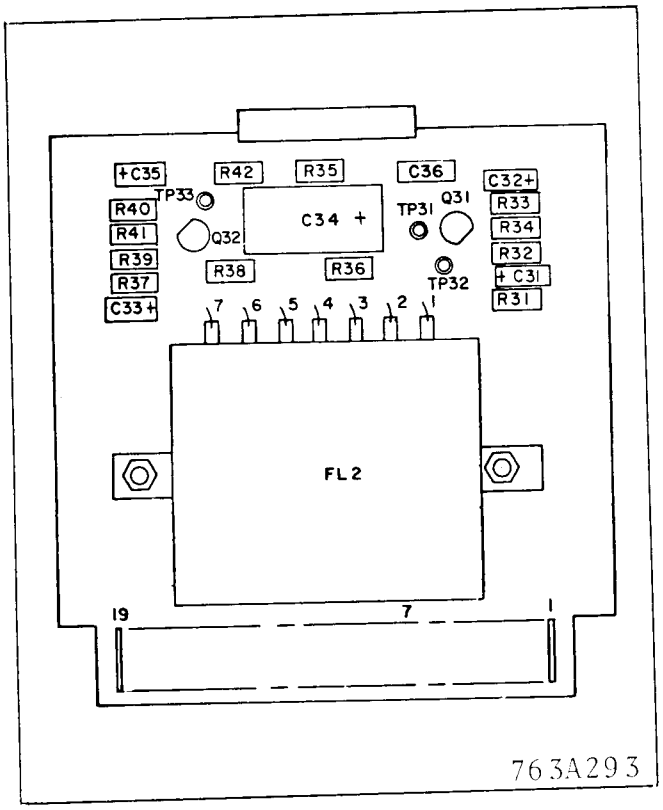
Fig. 6 Component locations on the type TCF receiver panel



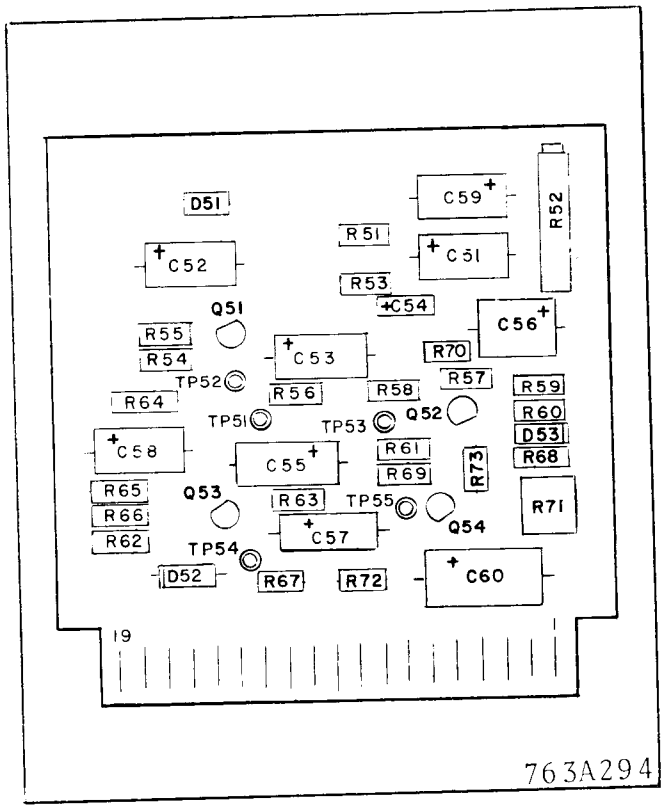
* *Fig. 7. Component Locations 30-200KHz. Oscillator and Mixer Silicon Transistor Version*



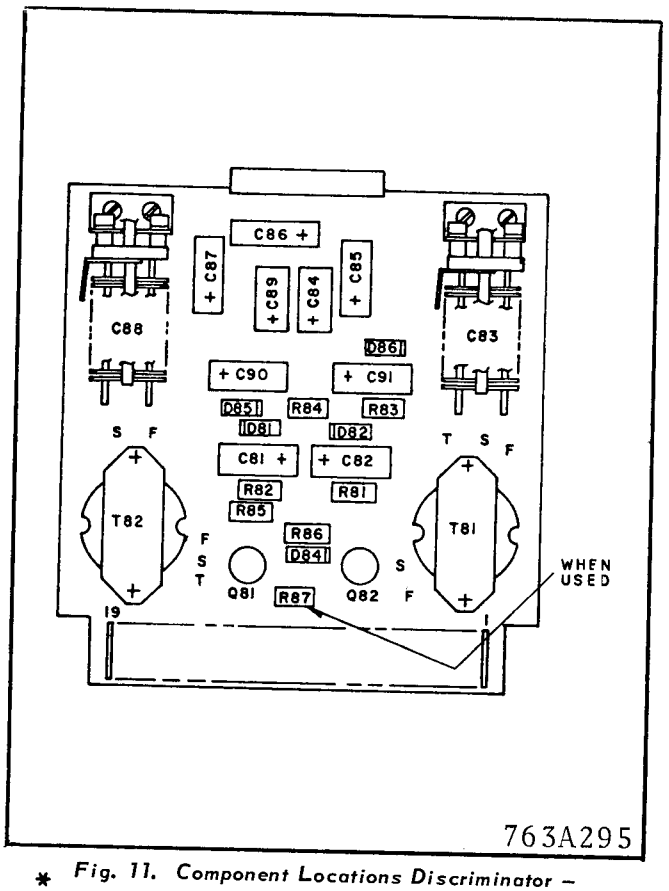
* *Fig. 8. Component Locations 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version*



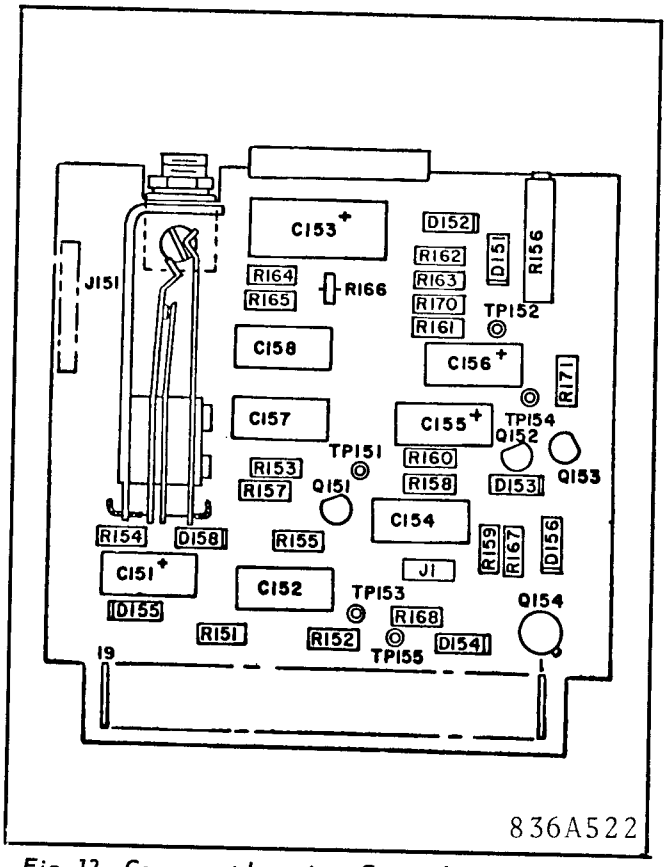
* *Fig. 9. Component Locations I.F. Amplifier – Silicon Transistor Version*



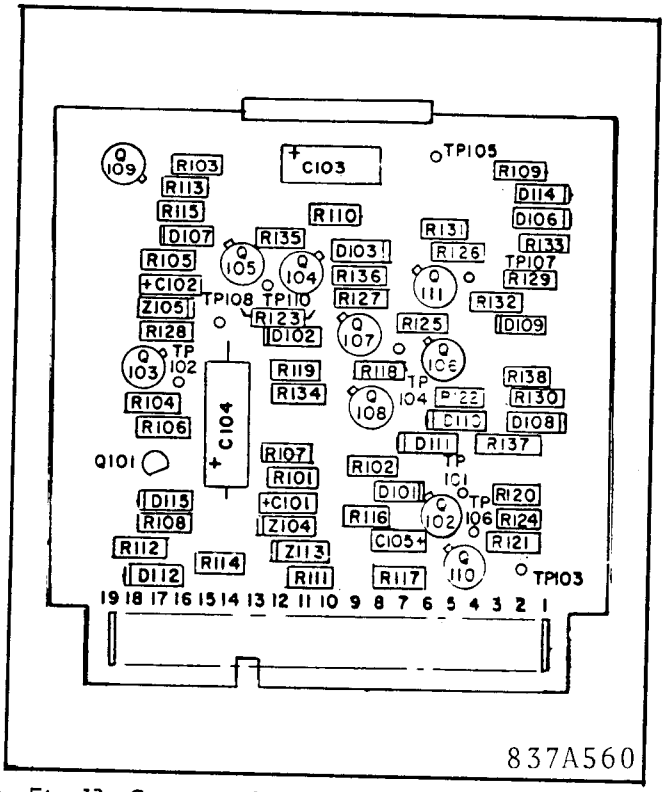
* *Fig. 10. Component Locations Amplifier and Limiter – Silicon Transistor Version*



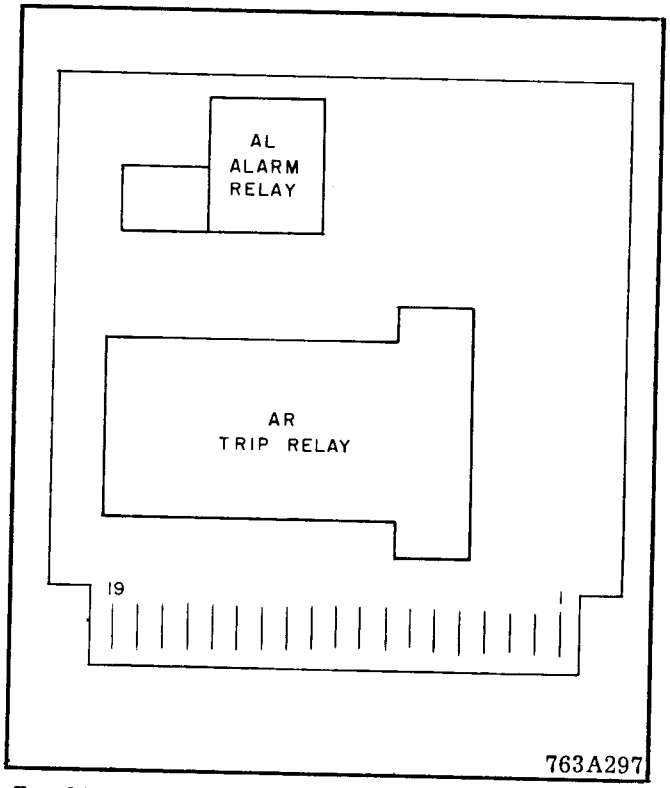
* *Fig. 11. Component Locations Discriminator – Silicon Transistor Version*



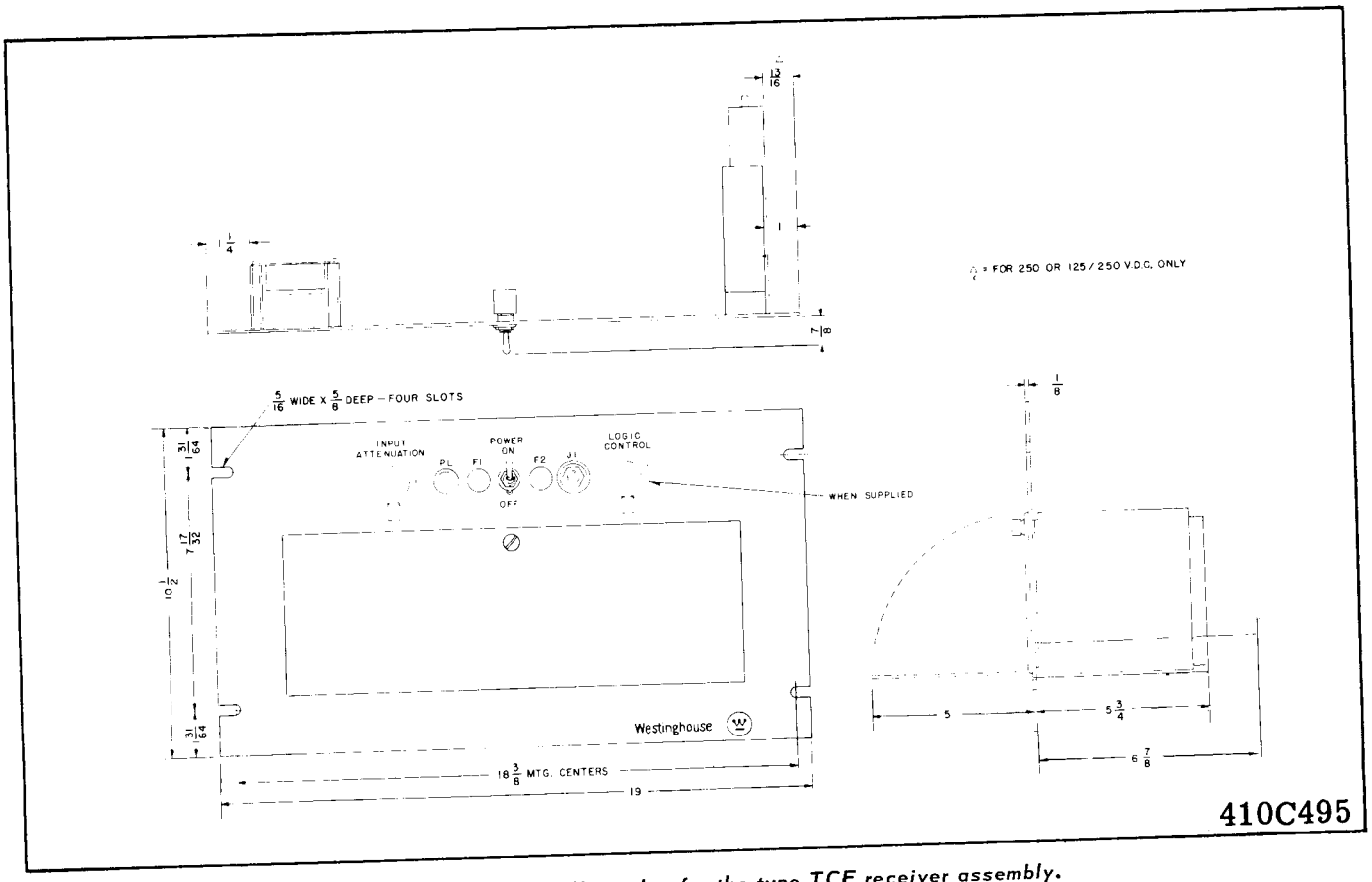
* *Fig. 12. Component Locations Carrier Level Indicator – Silicon Transistor Version*



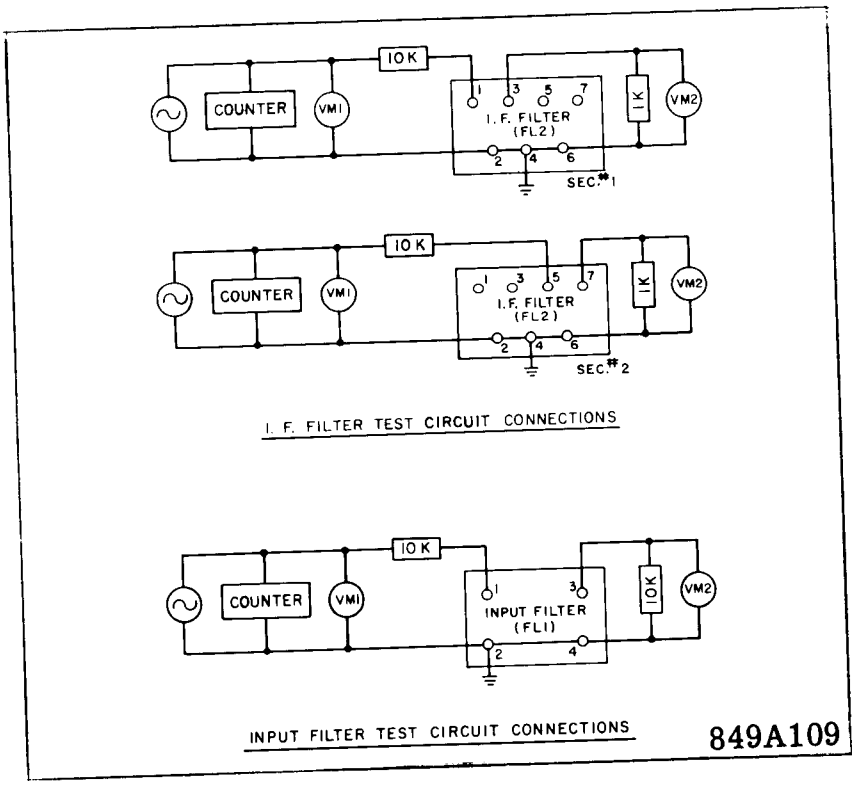
* *Fig. 13. Component Locations Logic Board – Silicon Transistor Version*



* *Fig. 14. Component locations on the output printed circuit board.*



* *Fig. 15. Outline and drilling plan for the type TCF receiver assembly.*



* *Fig. 16. Test Currents for TCF Frequency Shift Receiver Filters.*

COMPONENT	STYLE	REQ.	REF
TRANSISTOR			
Q11–Q12–Q13	849A441H03	3	2N4249
RESISTOR			
R15–R22	184A763H15	2	330Ω 1/2W ±5%
R14–R18–R19	184A763H39	3	3.3K 1/2W ±5%
R13	184A763H45	1	5.6K 1/2W ±5%
R11–R16–R20–R23	184A763H51	4	10K 1/2W ±5%
R17–R21	184A763H63	2	33K 1/2W ±5%
R24	184A763H83	1	220K 1/2W ±5%
R25	184A763H43	1	4.7K 1/2W ±5%
CAPACITOR			
C11–C13–C17	187A624H02	3	.25MFD. 200V.
C14–C15	187A624H04	2	1MFD. 200V.
C12	SEE NOTE ▼		
C16	SEE NOTE ■		
POTENTIOMETER			
R12	629A430H02	1	1000Ω
TRANSFORMER			
T11	205C043G01	1	10,000/400
T12	205C043G03	1	25,000/300
CRYSTAL			
Y11	SEE NOTE o		

▼ =C12 RANGE 4 TO 390PF. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

■ =C16 RANGE 22 TO 100PF. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

o =Y11 RANGE-50 TO 220 KHZ.

REF. COMPONENT LOCATION- 763A292

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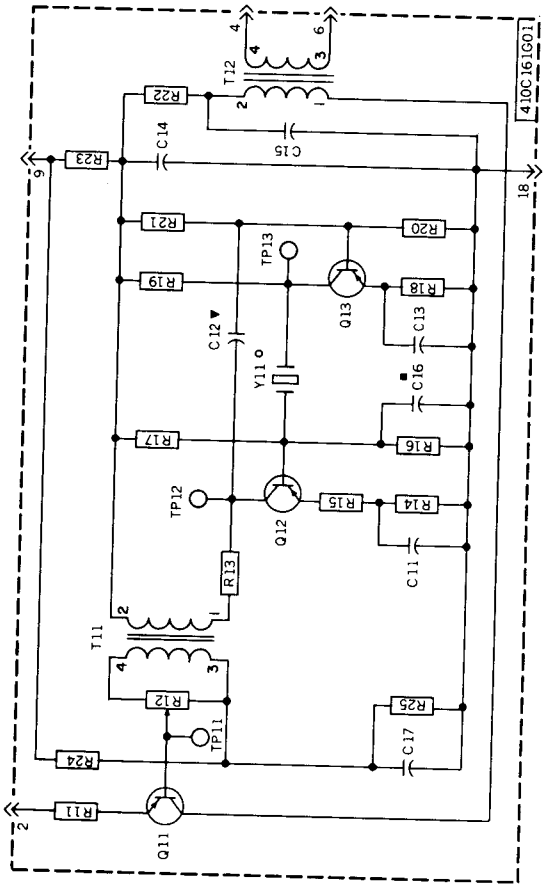

✱ *Fig. 17. Internal Schematic 30-200KHz Oscillator and Mixer Silicon Transistor Version*

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q211	849A441H03	1	2N4249
RESISTOR			
R211-R213-R215	184A763H51	3	10K 1/2W ±5%
R212	184A763H27	1	1K 1/2W ±5%
R214	184A763H37	1	2.7K 1/2W ±5%
R216	184A763H49	1	8.2K 1/2W ±5%
R217	184A763H34	1	2K 1/2W ±5%
R218	184A763H07	1	150Ω 1/2W ±5%
R219	184A763H15	1	330Ω 1/2W ±5%
R220	184A763H67	1	47K 1/2W ±5%
R221	184A763H83	1	220K 1/2W ±5%
R222	184A763H43	1	4.7K 1/2W ±5%
CAPACITOR			
C211	SEE NOTE ▲		
C212-C213-C215	184A663H04	3	.1MFD. 50V.
C214	SEE NOTE ○		
C216-C217	187A624H04	2	1 MFD. 200V.
C218	187A624H02	1	.25 MFD. 200V.
ZENER DIODE			
Z201	862A606H01	1	1N753A
INTERNAL CIRCUIT			
IC201	201C826H04	1	UA710C
TRANSFORMER			
T211	714B677G01	1	
T212	205C043G03	1	
CRYSTAL			
Y11	SEE NOTE □	1	

▲= C211 RANGES FROM 100PF. TO 1,000PF.
○= C214 STYLE NO. 187A695H17 .56PF. BUT MAY VARY UP TO 100PF.
□= Y11 FREQUENCY EQUALS RECEIVER (CHANNEL) FREQUENCY PLUS 20 KHZ.

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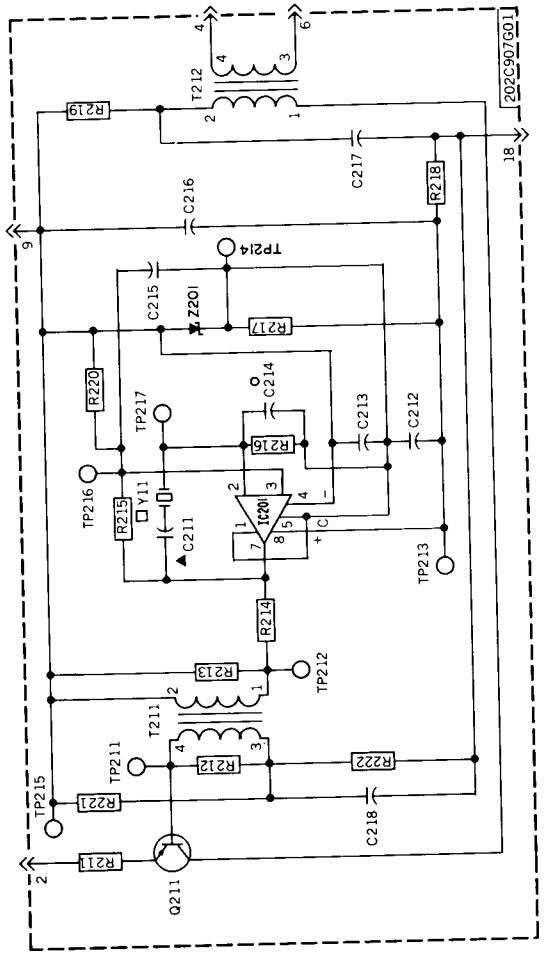

Fig. 18. Internal Schematic 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q31-Q32	849A441H03	2	2N4249
RESISTOR			
R34-R41	187A290H21	2	68Ω 1/2W ±5%
R36	184A763H15	1	330Ω 1/2W ±5%
R33-R40	184A763H23	2	680Ω 1/2W ±5%
R38	184A763H27	1	1K 1/2W ±5%
R31-R37	184A763H39	2	3.3K 1/2W ±5%
R35-R42	184A763H51	2	10K 1/2W ±5%
R32-R39	184A763H59	2	**22K** 1/2W ±5%
CAPACITOR			
C31-C32-C33-C35	187A624H02	4	.25MFD. 200V
C34	187A624H04	1	1MFD. 200V.
C36	762A757H01	1	100 Pf.
FILTER			
FL2	762A613G01	1	

ø = COMMON TERMINAL

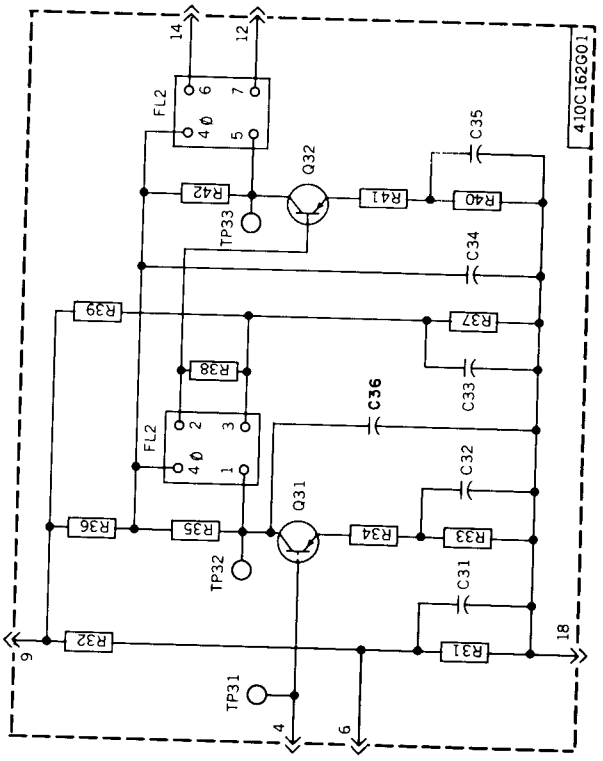

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Fig. 19. Internal Schematic I.F. Amplifier – Silicon Transistor Version

COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q51-Q52-Q53-Q54	849A441H03	4	2N4249
RESISTOR	187A290H21	1	68Ω 1/2W ±5%
R66	187A290H11	1	27Ω 1/2W ±5%
R55	184A763H11	1	220Ω 1/2W ±5%
R70	184A763H15	1	330Ω 1/2W ±5%
R72	184A763H23	1	680Ω 1/2W ±5%
R65	184A763H31	1	1.5K 1/2W ±5%
R59	184A763H35	2	2.2K 1/2W ±5%
R54-R62	184A763H37	2	2.7K 1/2W ±5%
R64-R68	184A763H43	4	4.7K 1/2W ±5%
R51-R57-R61-R67	184A763H51	1	10K 1/2W ±5%
R56	184A763H57	1	18K 1/2W ±5%
R69	184A763H61	2	27K 1/2W ±5%
R53-R58	184A763H63	1	33K 1/2W ±5%
R63	09D8326G20	1	100Ω ±2%
R71	184A763H09	1	180Ω 1/2W ±5%
R60	629A531H02	1	56Ω 1/2W ±2%
R73			
CAPACITOR	187A584H15	1	1300MMF. 500V.
C54	187A624H02	5	25MFD. 200V.
C51-C52-C56-C58-C59	187A624H01	3	0.1MFD. 200V.
C53-C55-C57	187A624H04	1	1.0MFD. 200V.
C60			
DIODE	184A855H07	3	1N457A
D51-D52-D53			
POTENTIOMETER	629A645H04	1	1K
R52			

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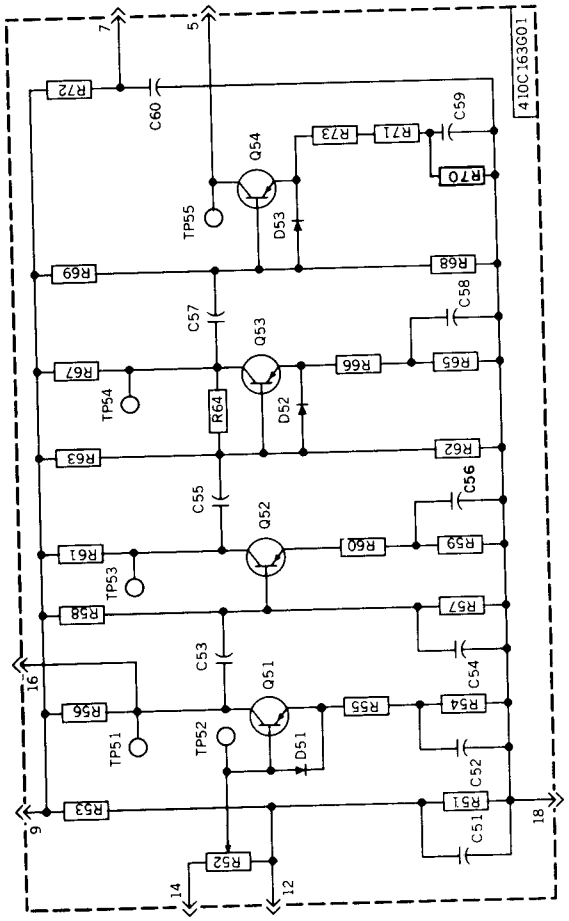


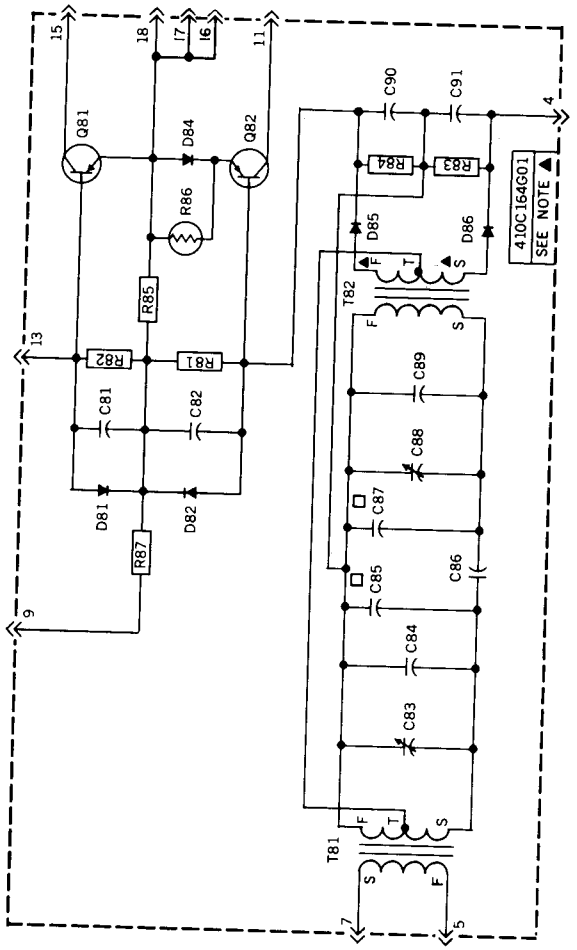
* *Fig. 20. Internal Schematic Amplifier and Limiter – Silicon Transistor Version*

COMPONENT	STYLE	REQ.	REF
TRANSISTOR			
Q81–Q82	849A441H01	2	2N3645
RESISTOR			
R81–R82	184A763H38	2	3K 1/2W ±5%
R83–R84	184A763H35	2	2.2K 1/2W ±5%
R85	184A763H11	1	220Ω 1/2W ±5%
R87	184A763H53	1	12K 1/2W ±5%
SENSISTOR			
R86	187A685H03	1	1.2K 1/4W ±10%
CAPACITOR			
C81–C82–C90–C91	762A703H01	4	.22MFD. 50V.
C83–C88	762A736H02	2	4.5 TO 100Pf.
C84–C89	187A624H16	2	.0091MFD. 200V.
C86	187A684H08	1	100Pf.
C85–C87	SEE NOTE □		
DIODE			
D81–D82–D84	184A855H07	3	1N457A
D85–D86	184A855H12	2	1N628
TRANSFORMER			
T81	606B533G01	1	
T82	606B533G02	1	

□=ONE OR TWO CAPACITORS USED; VALUES DETERMINED IN TEST.

▲=FOR STYLE 410C164G03 REVERSE START AND FINISH LEADS OF T82.

264C842



* *Fig. 21. Internal Schematic Discriminator – Silicon Transistor Version*

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q151–Q152–Q153	849A441H03	3	2N4249
Q154	184A638H19	1	2N699
RESISTOR			
R151–R168	184A763H51	**2**	10K 1/2W ±5%
R152	187A685H01	1	2.2K
R153	184A763H11	1	220Ω 1/2W ±5%
R154	184A763H39	1	3.3K 1/2W ±5%
R155–R159	184A763H55	**2**	15K 1/2W ±5%
R157–R158	184A763H43	2	4.7K 1/2W ±5%
R160	184A763H21	1	560Ω 1/2W ±5%
R161	184A763H29	1	1.2K 1/2W ±5%
R162–R163	184A763H09	2	180Ω 1/2W ±5%
R164	184A763H19	1	470Ω 1/2W ±5%
R165	184A763H27	1	1K 1/2W ±5%
R167	184A763H57	1	18K 1/2W ±5%
R171	**184A763H07**	1	1500 1/2W ±5%
R170	184A763H23	1	680Ω 1/2W ±5%
POTENTIOMETER			
R156	629A645H07	1	2.5K
THERMISTOR			
R166	185A211H08	1	1D201
CAPACITOR			
C151–C152–C154 TO C158	187A624H02	7	25MFD. 200V.
C153	187A624H04	1	1MFD. 200V.
DIODE			
D151 TO D156–D158	184A855H07	7	1N457A
TELEPHONE JACK			
J151	187A606H01	1	

264C853

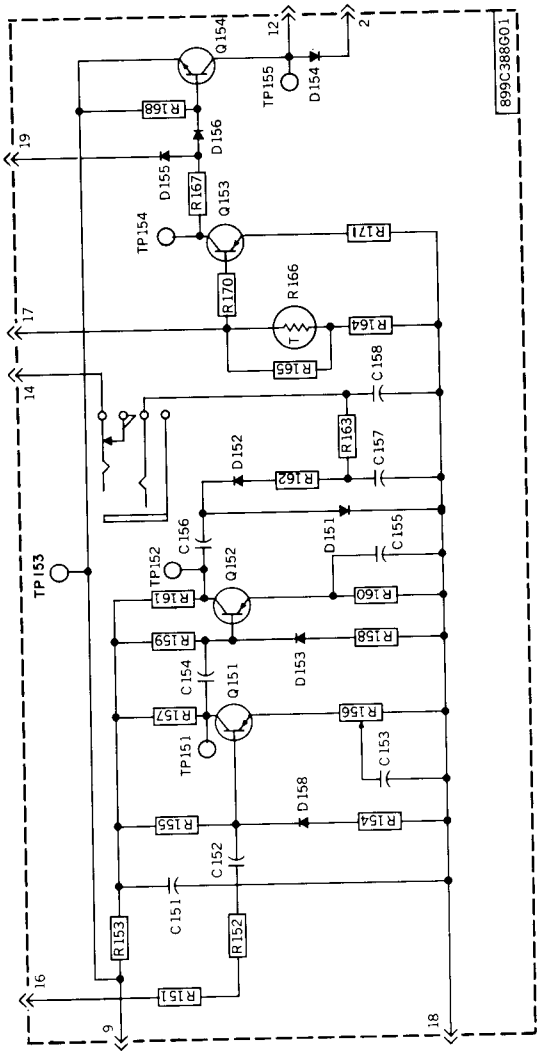
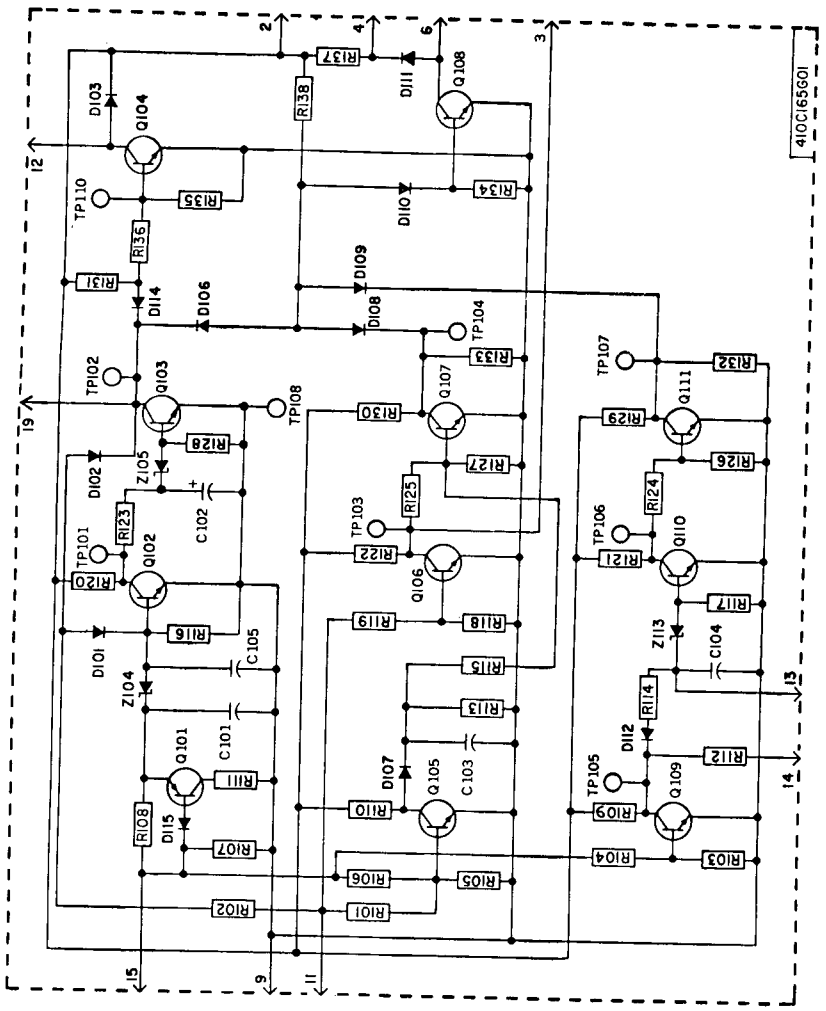


Fig. 22. Internal Schematic Carrier Level Indicator – Silicon Transistor Version ★

COMPONENT	STYLE	REQ	REF
TRANSISTORS			
Q101	849A441H03	1	(2N4249)
Q102-106-110-111	762A585H01	4	(2N696)
Q103	184A638H18	1	(2N697)
Q107	762A585H02	1	(2N698)
Q105-108-109-104	184A638H19	4	(2N699)
RESISTORS			
R110	187A643H47	1	(6.8K 1W ±5%)
R109	187A643H51	1	(10K 1W ±5%)
R137	184A859H06	1	(800 Ω 3W)
R111	184A763H19	1	(470 1/2W ±5%)
R112-R114-R123	184A763H27	3	(1K 1/2W ±5%)
R136	184A763H39	1	(3.3K 1/2W ±5%
R103-105-116 TO 118-126 TO 128-134-135-138	184A763H51	11	(10K 1/2W ± 5%)
R131	184A763H53	1	(12K 1/2W ±5%)
R107	184A763H57	1	(18K 1/2W ±5%)
R104	184A763H61	1	(27K 1/2W ±5%)
R102-124-125-132-133	184A763H63	5	(33K 1/2W ±5%)
R101-106-120	184A763H65	3	(39K 1/2W ±5%)
R108	184A763H69	1	(56K 1/2W ±5%)
R121-122-129-130	184A763H71	4	(68K 1/2W ±5%)
R115	184A763H73	1	(82K 1/2W ±5%)
R119	184A763H75	1	(100K 1/2W ±5%)
R113	184A763H91	1	(470K 1/2W ±5%)
CAPACITORS			
C101	184A661H12	1	(4.7MFD. 10%)
C105	184A663H02	1	(.05MFD. 50V)
C102	184A661H25	1	(6.8MFD.)
C103-104	187A624H11	2	(.5MFD. ±10%)
DIODES			
D114	182A881H07	1	(IN100A)
D101 TO 103-106 TO 112-115	184A855H07	11	(IN457A)
DIO-ZENER			
Z105	185A212H06	1	(IN3686B)
Z113-104	186A797H06	2	(IN957B)



* *Fig. 23. Internal Schematic Logic Board – Silicon Transistor Version*

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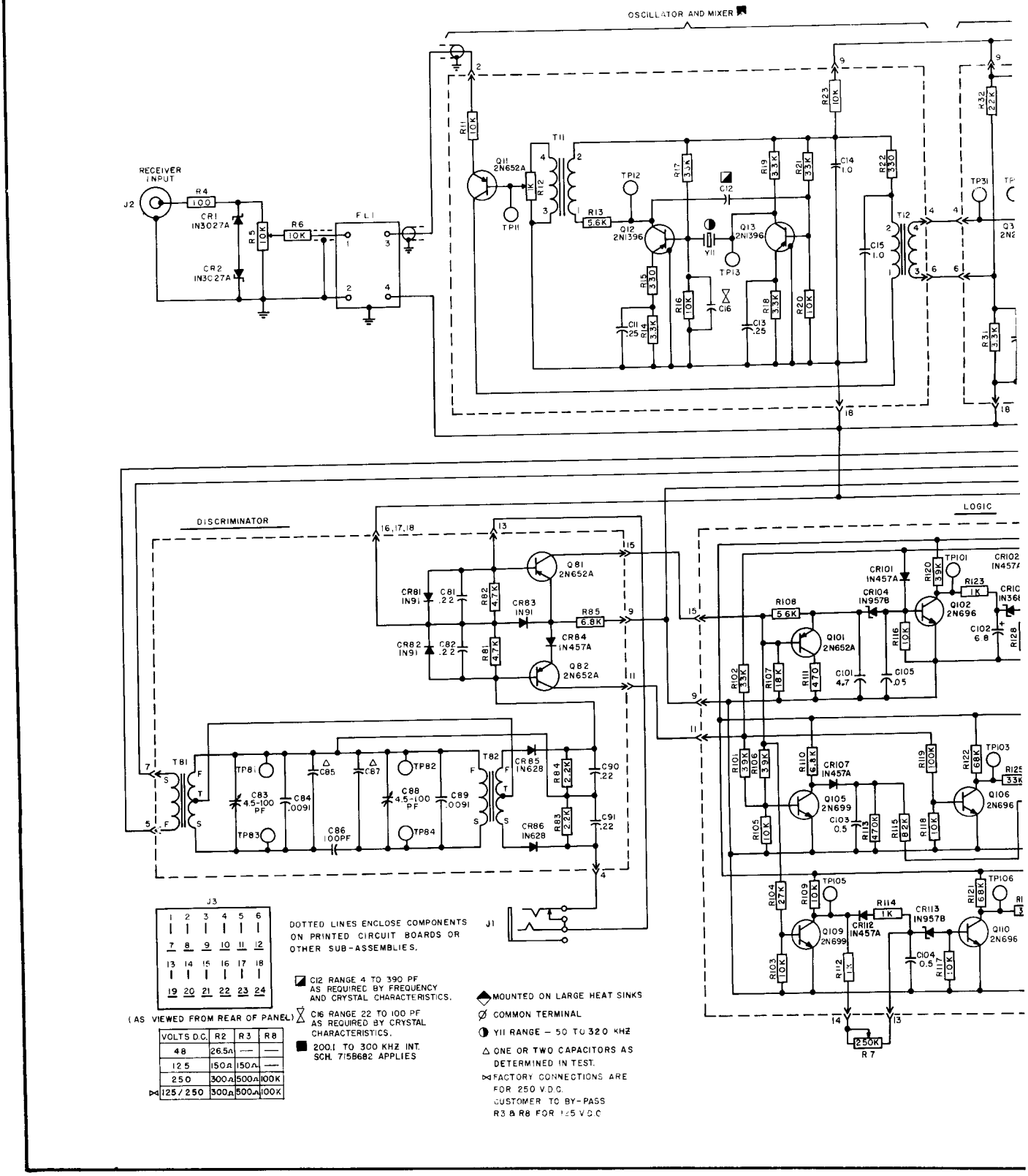
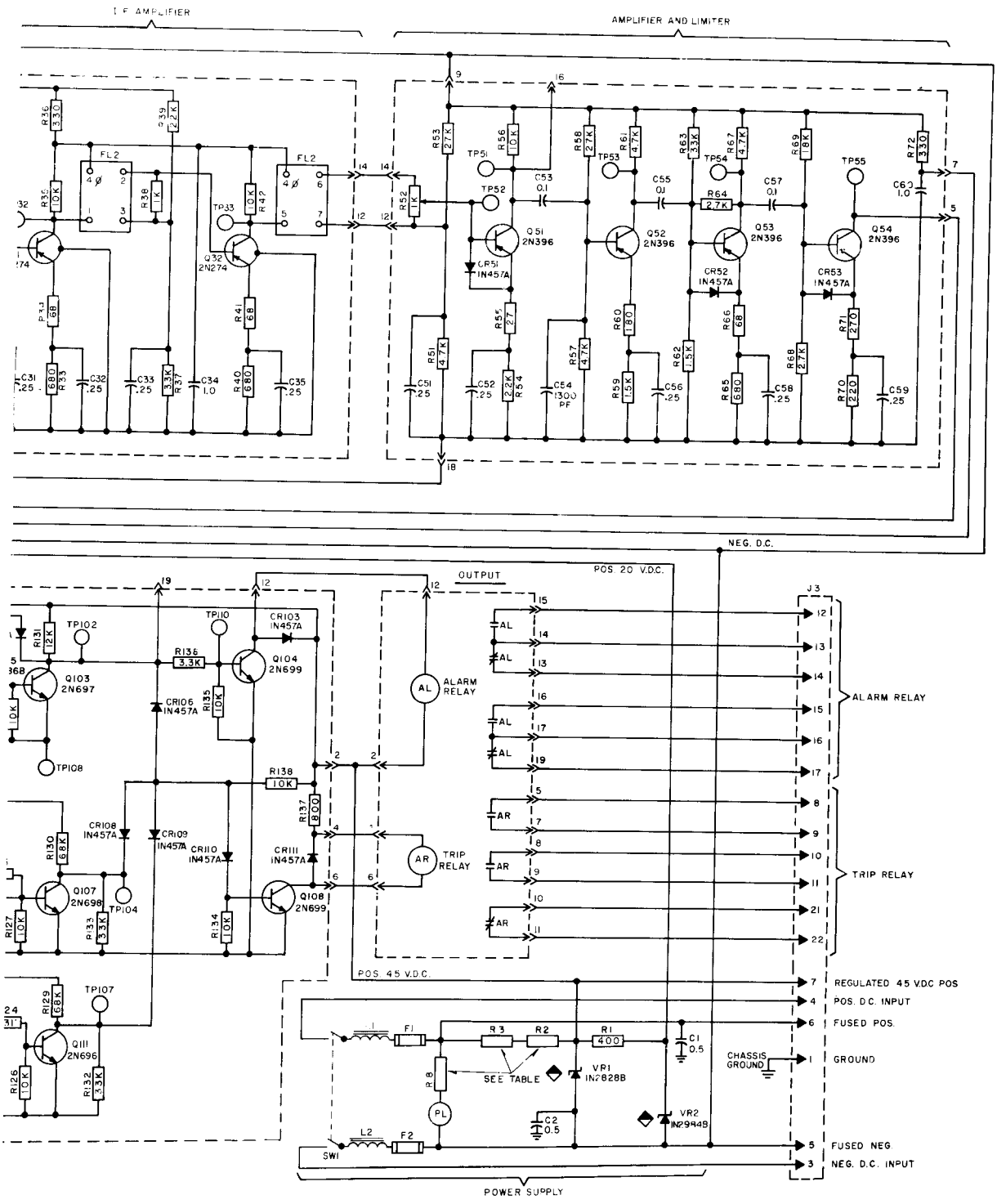


VOLTS D.C.	R2	R3	R8
48	26.5Ω	—	—
125	150Ω	150Ω	—
250	300Ω	500Ω	100K
125/250	300Ω	500Ω	100K

* *Fig. 24. Internal schematic of the type TCF receive*



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r without the carrier level indicator – germanium version.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf, 50 v.d.c.	184A663H04
C213	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. ± 5%; 400 MW.	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

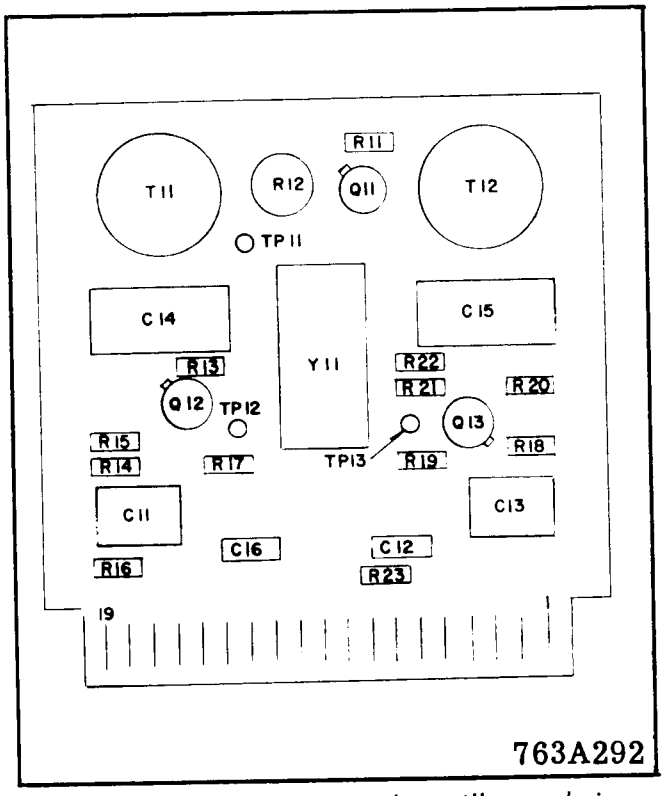
CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ± 5%; Wire Wound	09D832G19
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

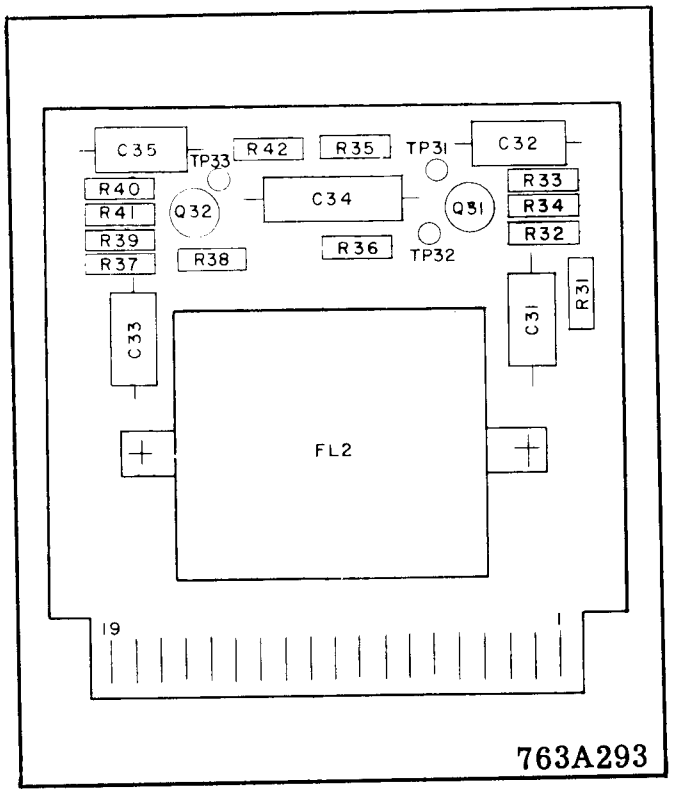
CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

ELECTRICAL PARTS LIST (Cont'd.)

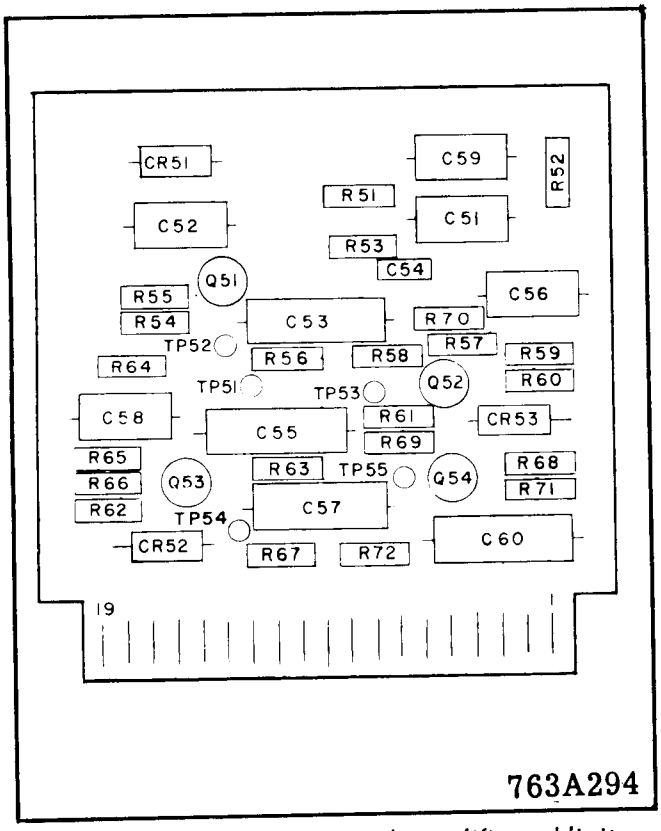
CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	205C043G03
T12	Toroidal type, 25000/300 ohms	205C043G03
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	205C043G01
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01+(Req.Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408C845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04



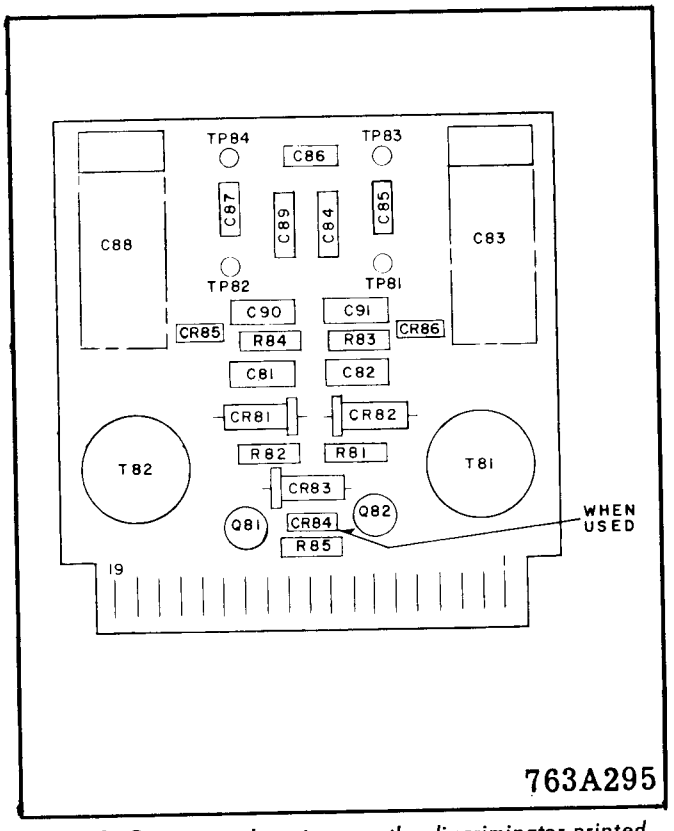
* *Fig. 26 Component locations on the oscillator and mixer printed circuit board - germanium version.*



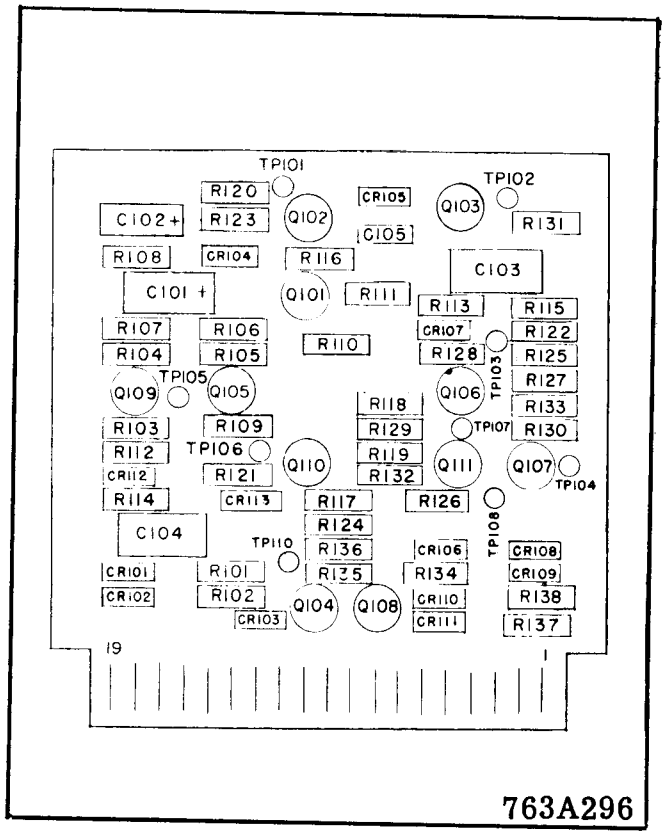
* *Fig. 27 Component locations on the I.F. amplifier printed circuit board - germanium version.*



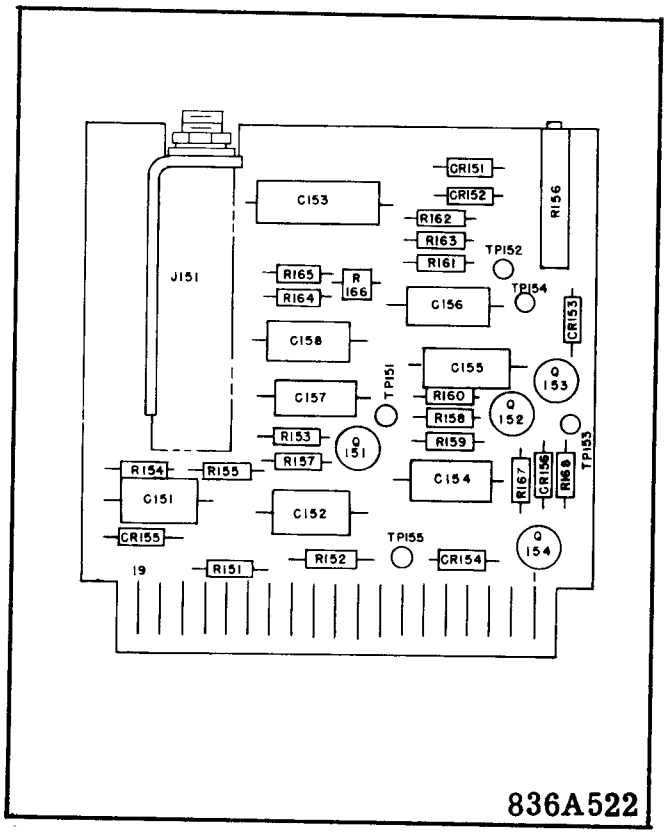
* *Fig. 28 Component locations on the amplifier and limiter printed circuit board - germanium version.*



* *Fig. 29 Component locations on the discriminator printed circuit board - germanium version.*



* *Fig. 30 Component locations on the logic printed circuit board - germanium version.*



* *Fig. 31 Component locations on the carrier level indicator printed circuit board - germanium version.*

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION
NEWARK, N. J.
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.

Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center
* frequency of the channel. When a fault occurs within the protected equipment, protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. *See Fig. No. 15.

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

SUPERSEDES I.L. 41-945.51K, dated October 1973
* Denotes change from superseded issue.

EFFECTIVE JANUARY 1976

terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal * Y11, transistors Q12 and Q13, or IC201 (Fig. 17) and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 kHz above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the later is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20kHz, 2fc + 20kHz, fc + 20kHz and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 * hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero output frequency. This separation of 200 hertz between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 hertz in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20 kHz-100 hertz. Similarly, the Trip frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears, the discriminator output at term. 15 will turn Q101 off. C101 will change and after 120 ms. it will reach the breakdown voltage of CR104 and turn Q102 on. This will allow C102 to quickly discharge through R123 and Q102 and provide the full 150 ms. time delay to be effective on any subsequent loss of guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functi~~

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 2.25 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.6 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental ininsertion of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	1000 hertz, minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42 - 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

* In case the transmitter has a 1 Watt/1 Watt output and diode D84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode * D84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.3	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

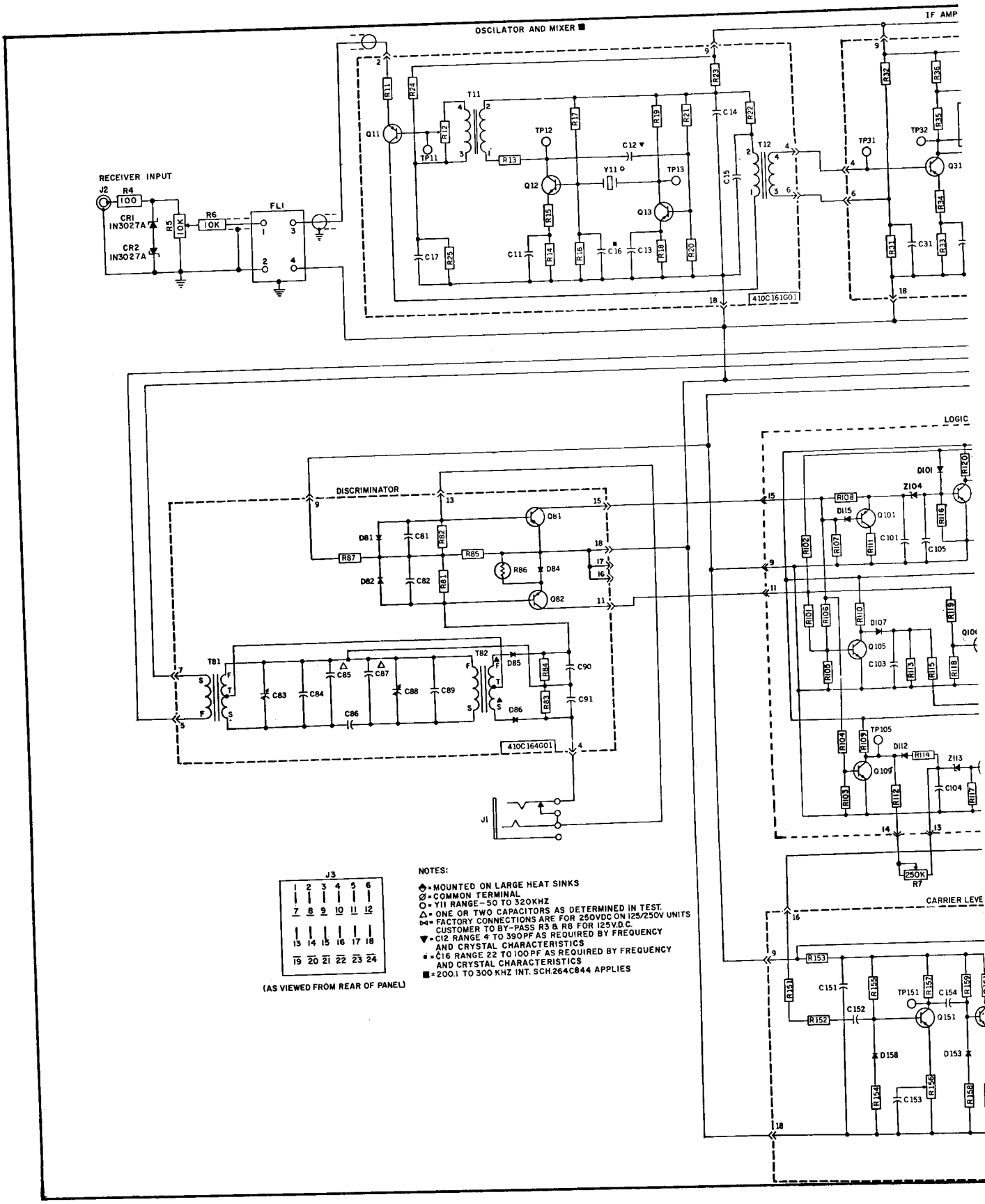
These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

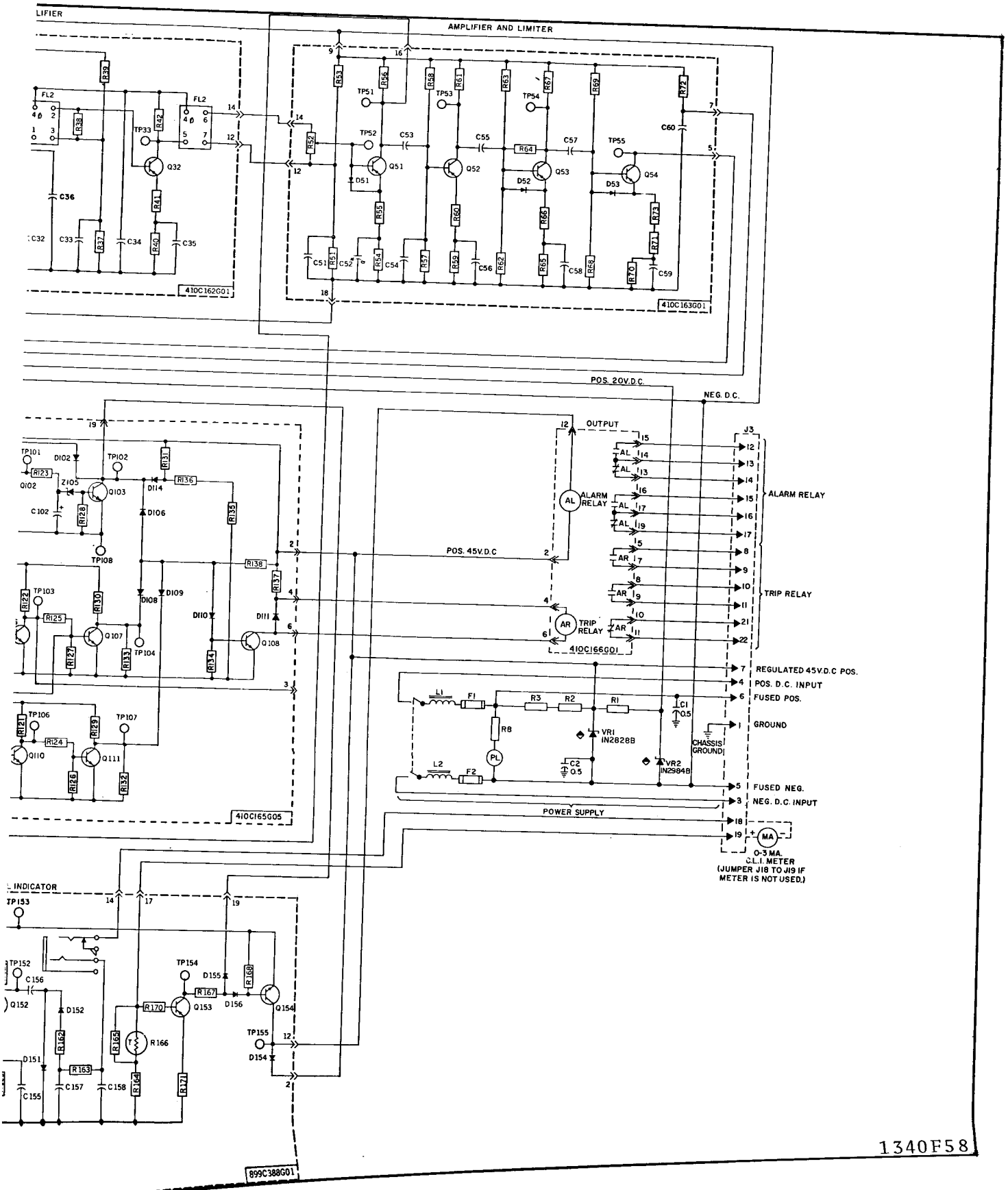
ADDENDUM

With shipments of sets starting in early 1973, the germanium transistors used in the various modules were replaced with silicon transistors. In addition, due to the nature of silicon transistors, some resistor values in the circuits had to be changed In order to correctly bias these transistors. Therefore the transistors are not replaceable on a pin for pin basis throughout the receiver. Before attempting to replace a germanium transistor with a silicon transistor on older sets using germanium, please check the schematics on the following pages to see if the location where the replacement is desired has additional component changes. If that is the case, then the replacement can only be made by the same designation transistor or the additional component changes must also be made. It should be pointed out that the modules containing the silicon transistors are completely interchangeable with the modules containing germanium transistors. Therefore, there is no problem with intermixing the silicon transistor modules in the same receiver. Thus complete new modules containing silicon transistors can be ordered and used as replacements in older receivers having germanium transistor modules. The new modules have the same style numbers as the old germanium transistor modules they replace.

Type TCF Receiver (Front View).



* *Fig. 2. Internal schematic of the type TCF*



receiver with the carrier level indicator – silicon version.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Imput Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

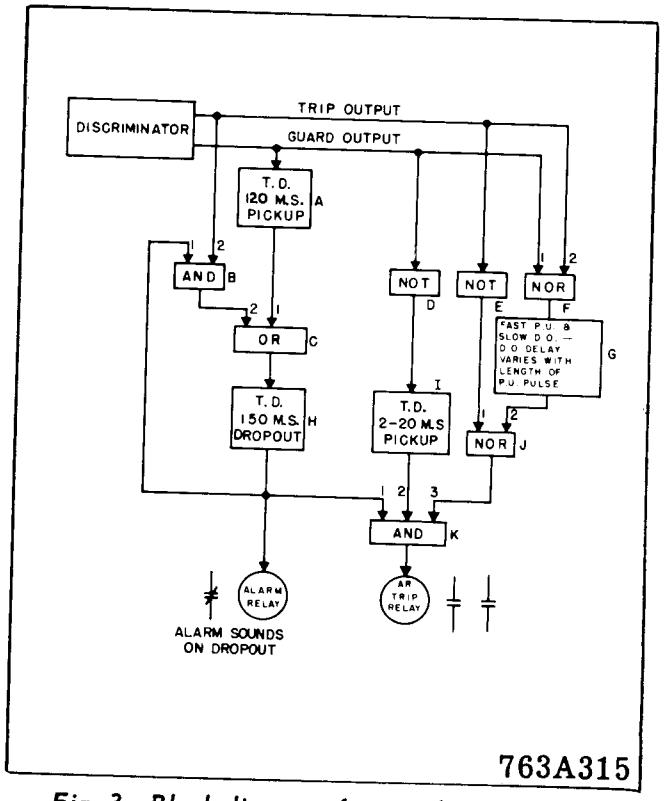


Fig. 3 Block diagram of output logic circuit

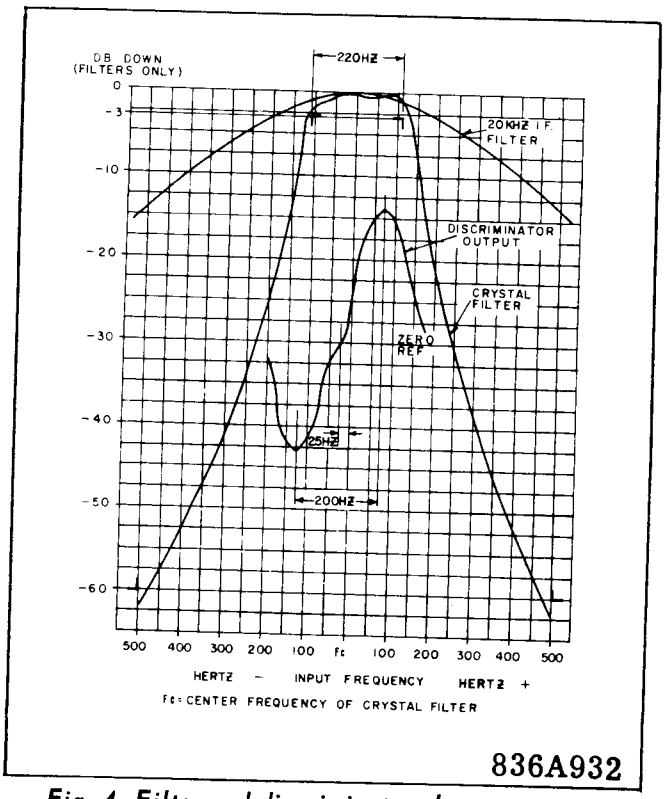


Fig. 4 Filter and discriminator characteristics of the type TCF receiver

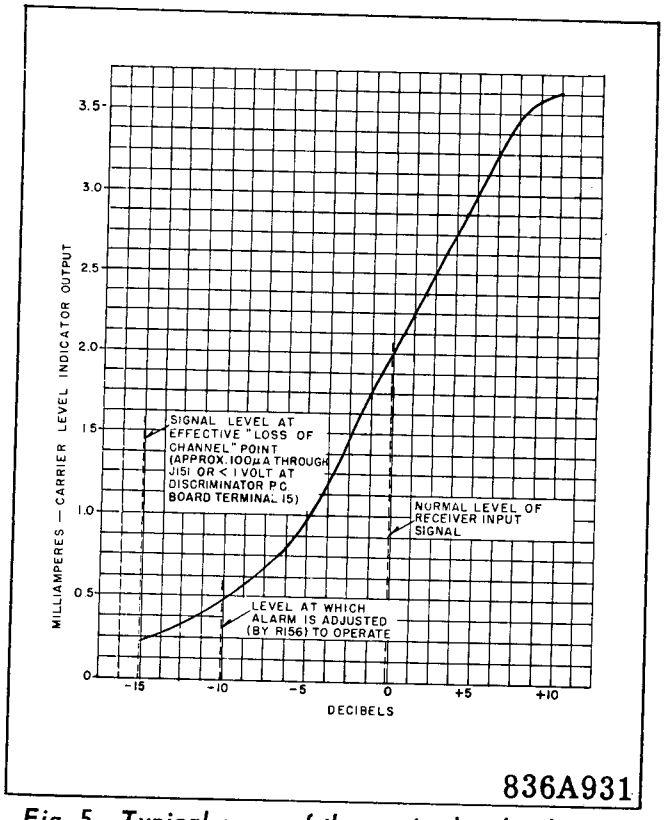


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

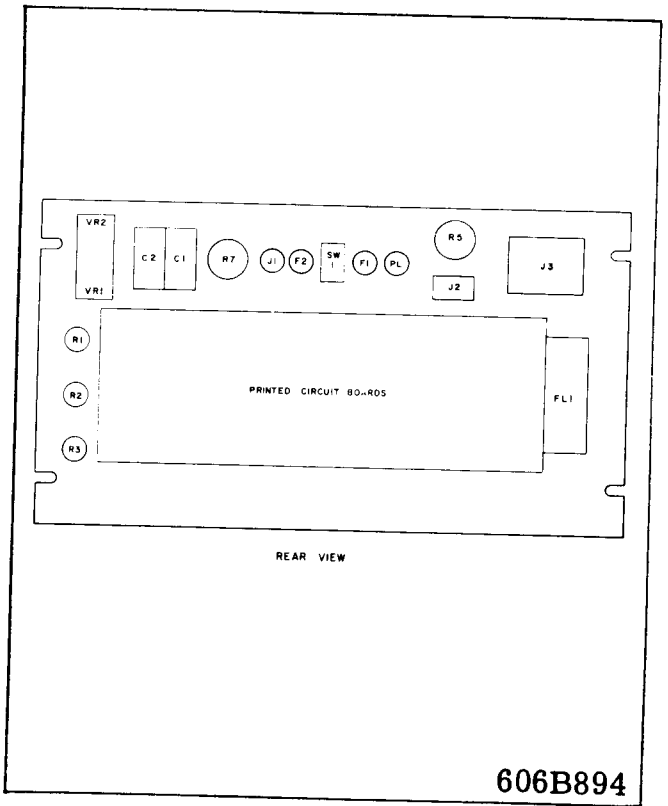
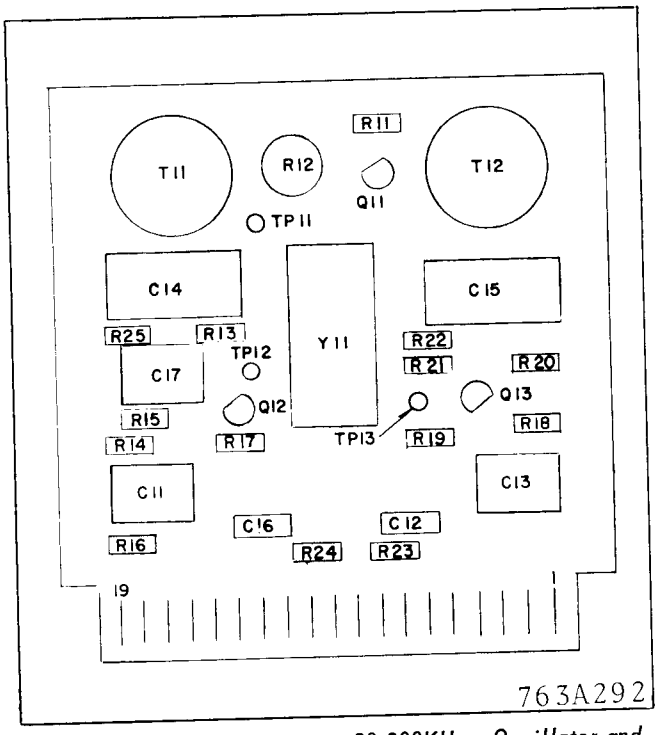
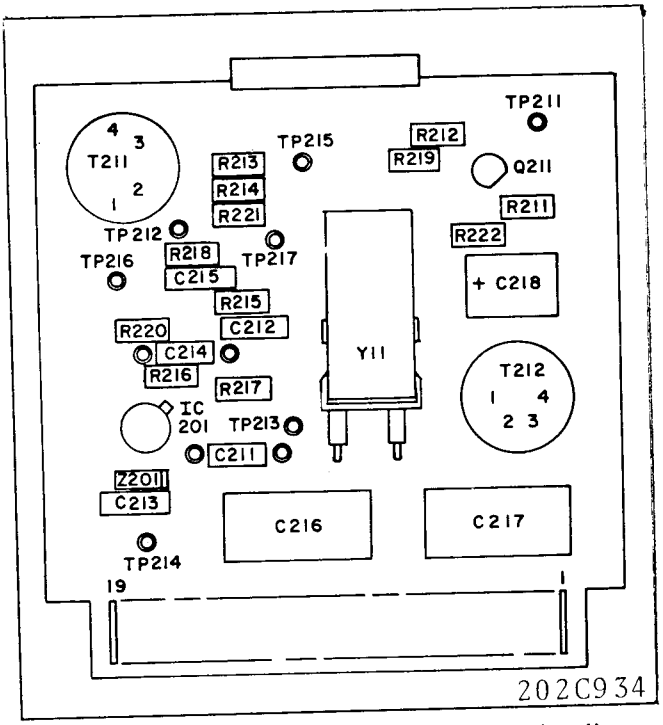


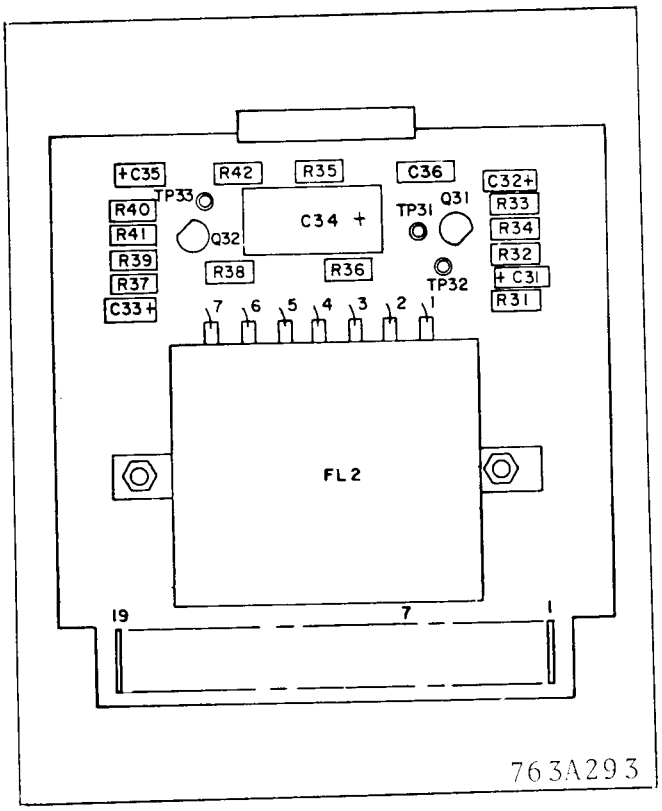
Fig. 6 Component locations on the type TCF receiver panel



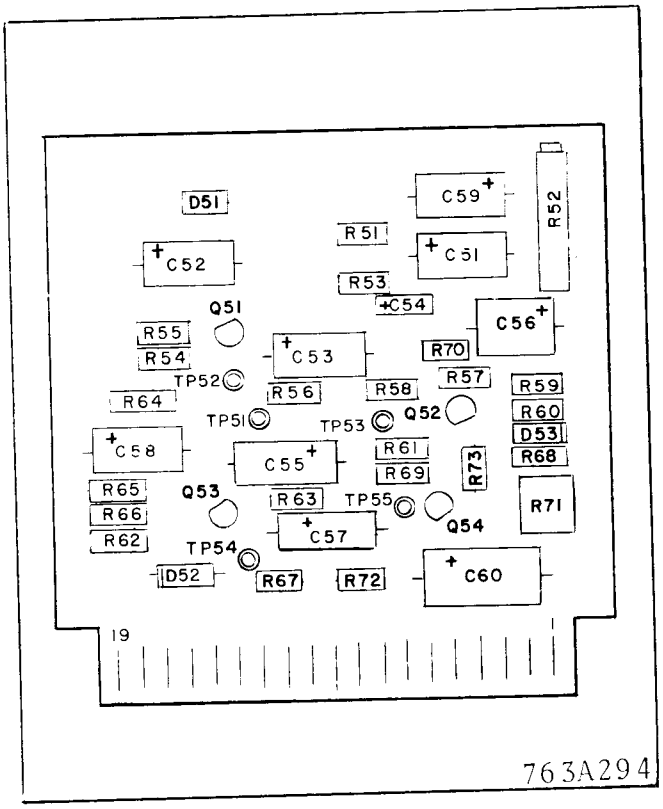
* *Fig. 7. Component Locations 30-200KHz. Oscillator and Mixer Silicon Transistor Version*



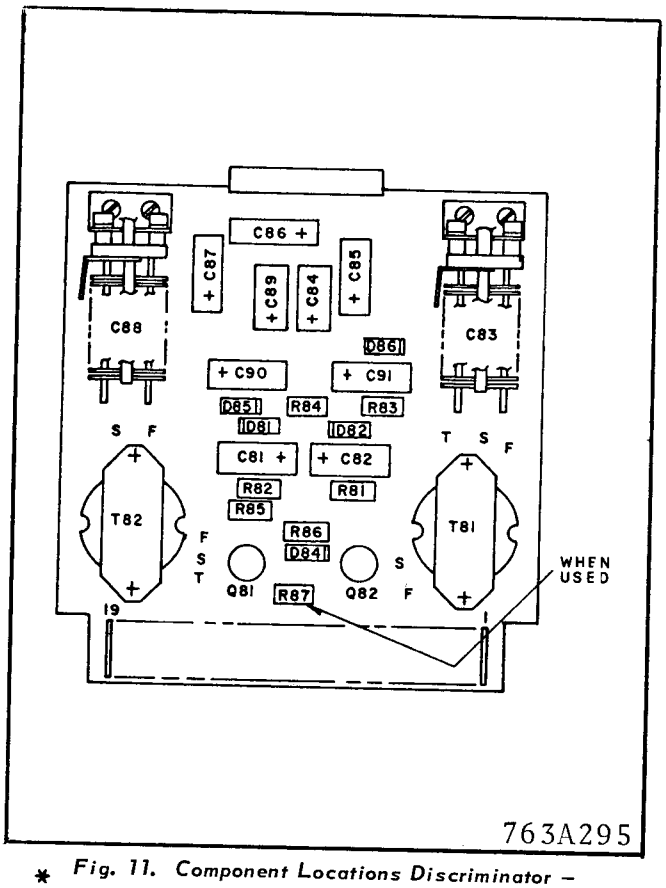
* *Fig. 8. Component Locations 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version*



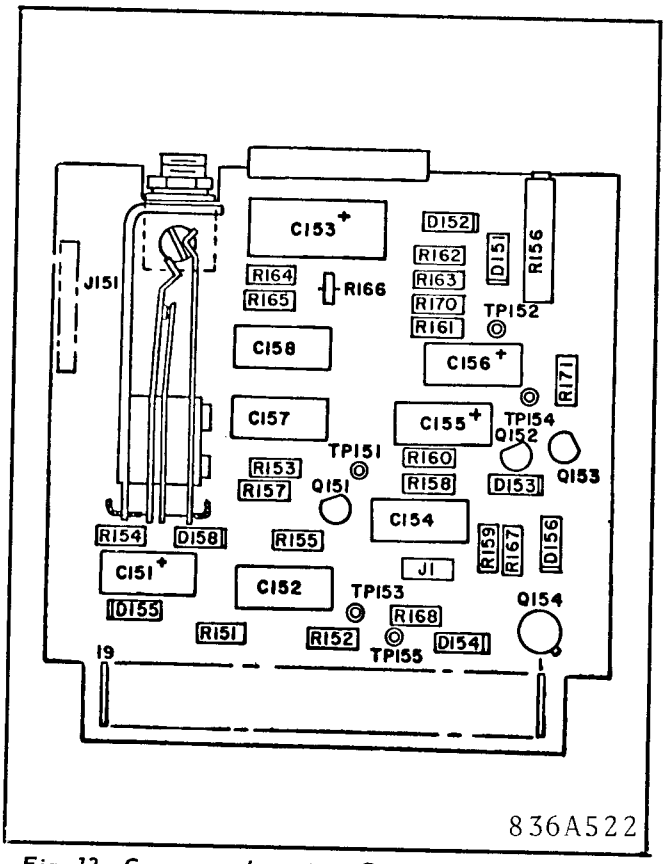
* *Fig. 9. Component Locations I.F. Amplifier – Silicon Transistor Version*



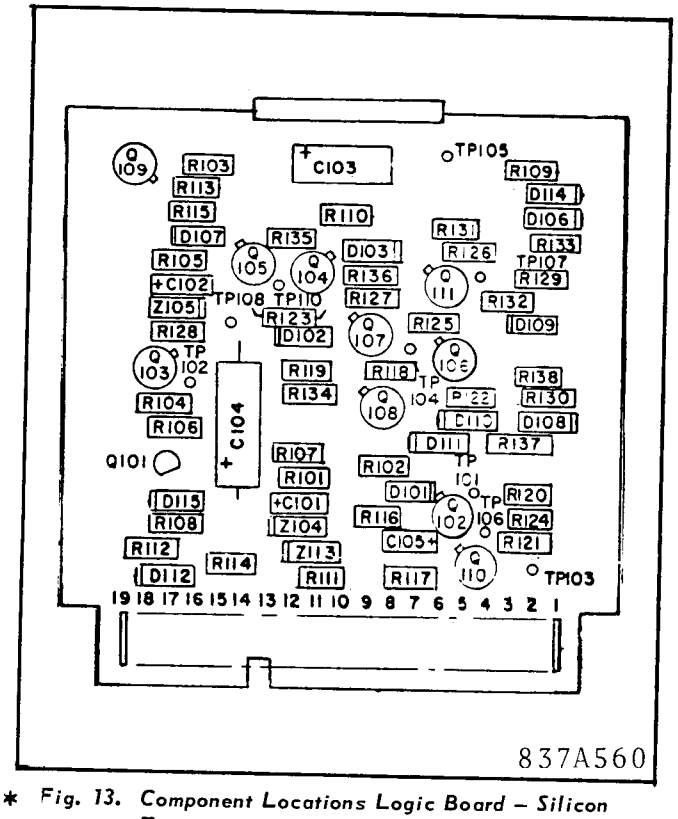
* *Fig. 10. Component Locations Amplifier and Limiter – Silicon Transistor Version*



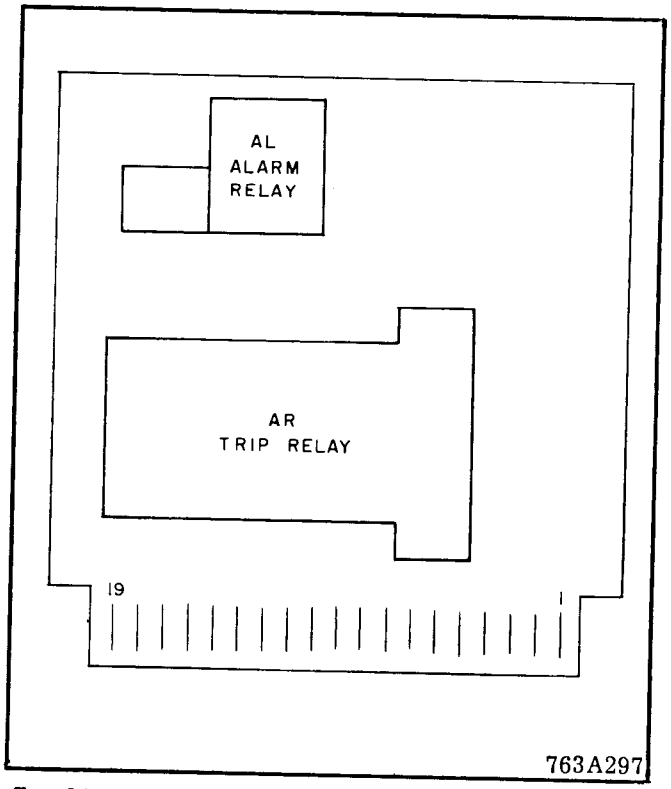
* *Fig. 11. Component Locations Discriminator – Silicon Transistor Version*



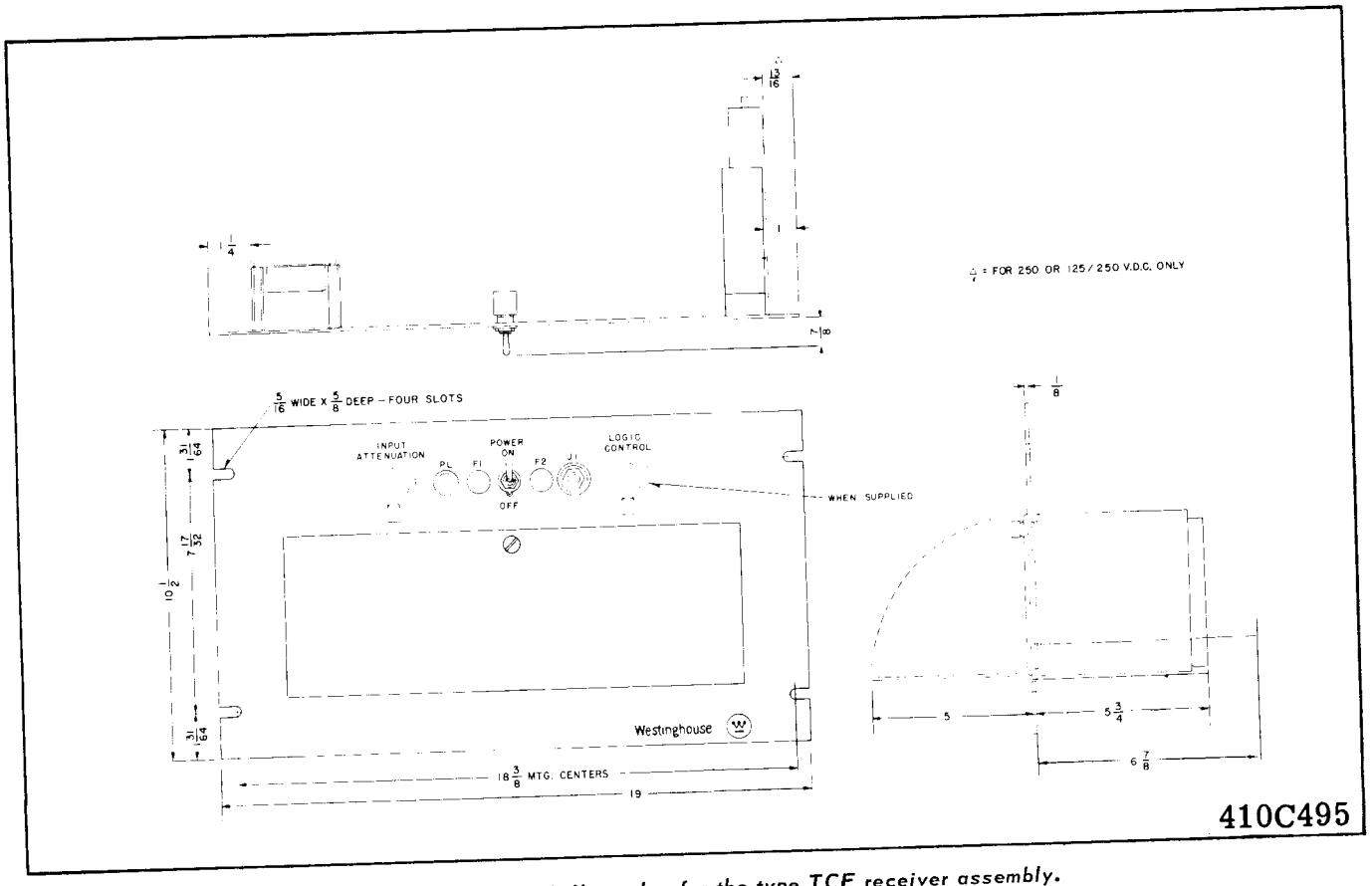
* *Fig. 12. Component Locations Carrier Level Indicator – Silicon Transistor Version*



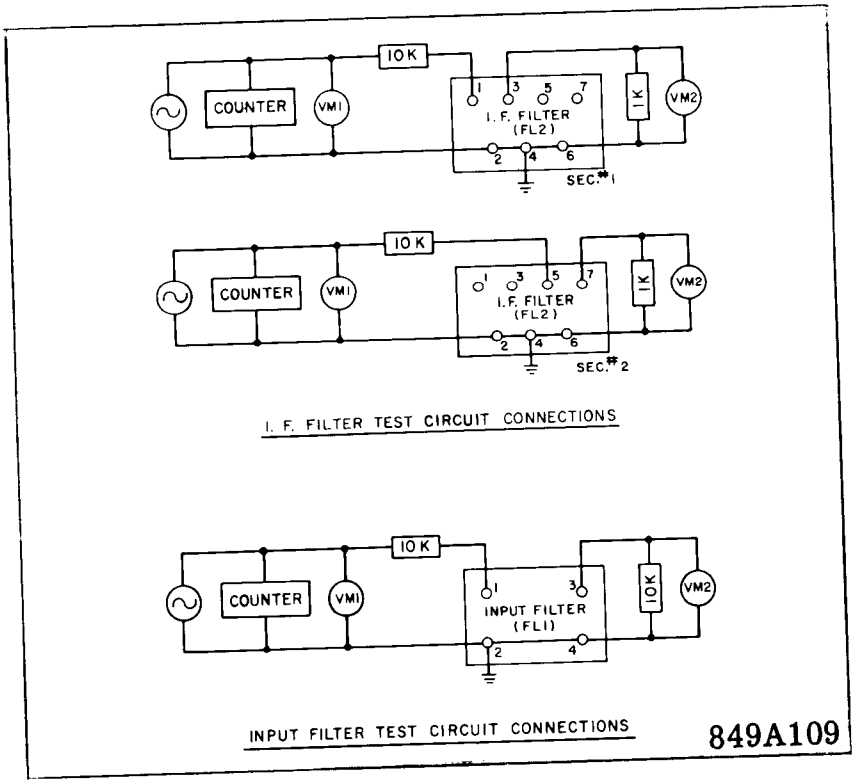
* *Fig. 13. Component Locations Logic Board – Silicon Transistor Version*



* *Fig. 14. Component locations on the output printed circuit board.*



* *Fig. 15. Outline and drilling plan for the type TCF receiver assembly.*



* *Fig. 16. Test Currents for TCF Frequency Shift Receiver Filters.*

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q11-Q12-Q13	849A441H03	3	2N4249
RESISTOR			
R15-R22	184A763H15	2	330Ω 1/2W ±5%
R14-R18-R19	184A763H39	3	3.3K 1/2W ±5%
R13	184A763H45	1	5.6K 1/2W ±5%
R11-R16-R20-R23	184A763H51	4	10K 1/2W ±5%
R17-R21	184A763H63	2	33K 1/2W ±5%
R24	184A763H83	1	220K 1/2W ±5%
R25	184A763H43	1	4.7K 1/2W ±5%
CAPACITOR			
C11-C13-C17	187A624H02	3	.25MFD. 200V.
C14-C15	187A624H04	2	1MFD. 200V.
C12	SEE NOTE ▼		
C16	SEE NOTE ■		
POTENTIOMETER			
R12	629A430H02	1	1000Ω
TRANSFORMER			
T11	205C043G01	1	10,000/400
T12	205C043G03	1	25,000/300
CRYSTAL			
Y11	SEE NOTE o		

▼=C12 RANGE 4 TO 390Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

■=C16 RANGE 22 TO 100Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

o=Y11 RANGE-50 TO 220 KHZ.

REF COMPONENT LOCATION- 7634292

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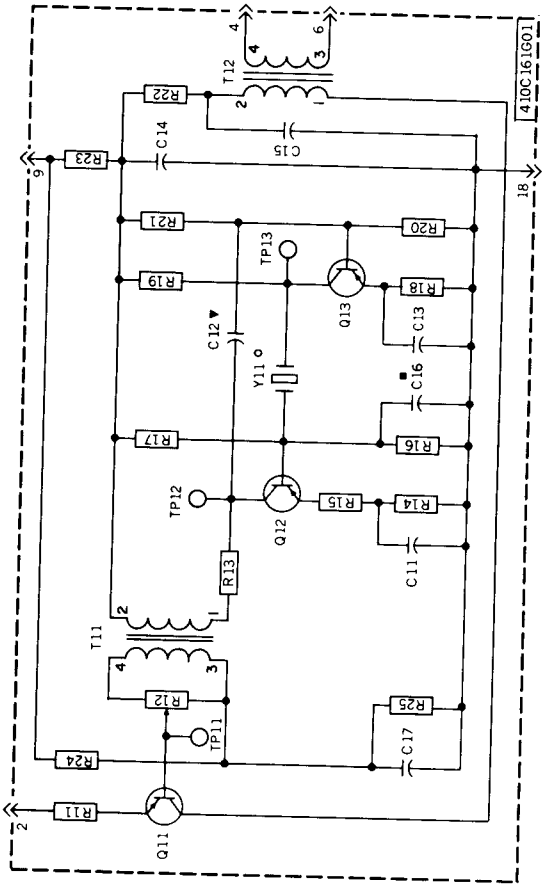

* *Fig. 17. Internal Schematic 30-200KHz Oscillator and Mixer Silicon Transistor Version*

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q211	849A441H03	1	2N4249
RESISTOR			
R211–R213–R215	184A763H51	3	10K 1/2W ±5%
R212	184A763H27	1	1K 1/2W ±5%
R214	184A763H37	1	2.7K 1/2W ±5%
R216	184A763H49	1	8.2K 1/2W ±5%
R217	184A763H34	1	2K 1/2W ±5%
R218	184A763H07	1	150Ω 1/2W ±5%
R219	184A763H15	1	330Ω 1/2W ±5%
R220	184A763H67	1	47K 1/2W ±5%
R221	184A763H83	1	220K 1/2W ±5%
R222	184A763H43	1	4.7K 1/2W ±5%
CAPACITOR			
C211	SEE NOTE ▲		
C212–C213–C215	184A663H04	3	.1MFD. 50V.
C214	SEE NOTE o		
C216–C217	187A624H04	2	1 MFD. 200V.
C218	187A624H02	1	25 MFD. 200V.
ZENER DIODE			
Z201	862A606H01	1	1N753A
INTERNAL CIRCUIT			
IC201	201C826H04	1	UA710C
TRANSFORMER			
T211	714B677G01	1	
T212	205C043G03	1	
CRYSTAL			
Y11	SEE NOTE □	1	

▲= C211 RANGES FROM 100PF. TO 1,000PF.
o = C214 STYLE NO. 187A695H17 .56PF. BUT MAY VARY UP TO 100PF.
□= Y11 FREQUENCY EQUALS RECEIVER (CHANNEL) FREQUENCY PLUS **20 KHZ.**

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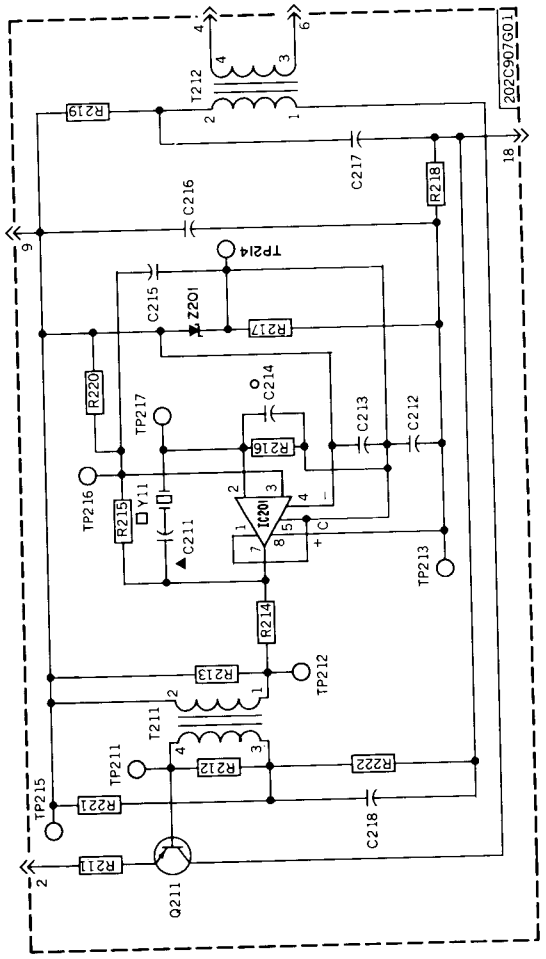

* *Fig. 18. Internal Schematic 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version*

COMPONENT	STYLE	REQ.	REF
TRANSISTOR			
Q31-Q32	849A441H03	2	2N4249
RESISTOR			
R34-R41	187A290H21	2	68Ω 1/2W ±5%
R36	184A763H15	1	330Ω 1/2W ±5%
R33-R40	184A763H23	2	680Ω 1/2W ±5%
R38	184A763H27	1	1K 1/2W ±5%
R31-R37	184A763H39	2	3.3K 1/2W ±5%
R35-R42	184A763H51	2	10K 1/2W ±5%
R32-R39	184A763H59	2	**22K** 1/2W ±5%
CAPACITOR			
C31-C32-C33-C35	187A624H02	4	.25MFD 200V
C34	187A624H04	1	1MFD 200V
C36	762A757H01	1	100 PF.
FILTER			
FL2	762A613G01	1	

Ø = COMMON TERMINAL

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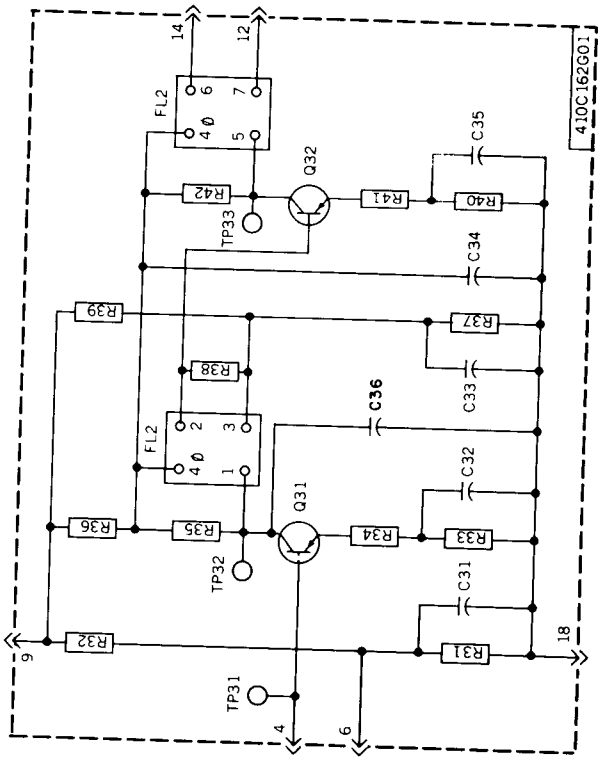

Fig. 19. Internal Schematic I.F. Amplifier – Silicon Transistor Version

COMPONENT	STYLE	REQ.	REF
TRANSISTOR			
Q51-Q52-Q53-Q54	849A441H03	4	2N4249
RESISTOR			
R66	187A290H21	1	68Ω 1/2W ±5%
R55	187A290H11	1	27Ω 1/2W ±5%
R70	184A763H11	1	220Ω 1/2W ±5%
R72	184A763H15	1	330Ω 1/2W ±5%
R65	184A763H23	1	680Ω 1/2W ±5%
R59	184A763H31	1	1.5K 1/2W ±5%
R54-R62	184A763H35	2	2.2K 1/2W ±5%
R64-R68	184A763H37	2	2.7K 1/2W ±5%
R51-R57-R61-R67	184A763H43	4	4.7K 1/2W ±5%
R56	184A763H51	1	10K 1/2W ±5%
R69	184A763H57	1	18K 1/2W ±5%
R53-R58	184A763H61	2	27K 1/2W ±5%
R63	184A763H63	1	33K 1/2W ±5%
R71	09D8326G20	1	100Ω ±2%
R60	184A763H09	1	180Ω 1/2W ±5%
R73	629A531H02	1	56Ω 1/2W ±2%
CAPACITOR			
C54	187A584H15	1	1300MMF. 500V
C51-C52-C56-C58-C59	187A624H02	5	.25MFD. 200V.
C53-C55-C57	187A624H01	3	0.1MFD. 200V.
C60	187A624H04	1	1.0MFD. 200V.
DIODE			
D51-D52-D53	184A855H07	3	1N457A
POTENTIOMETER			
R52	629A645H04	1	1K

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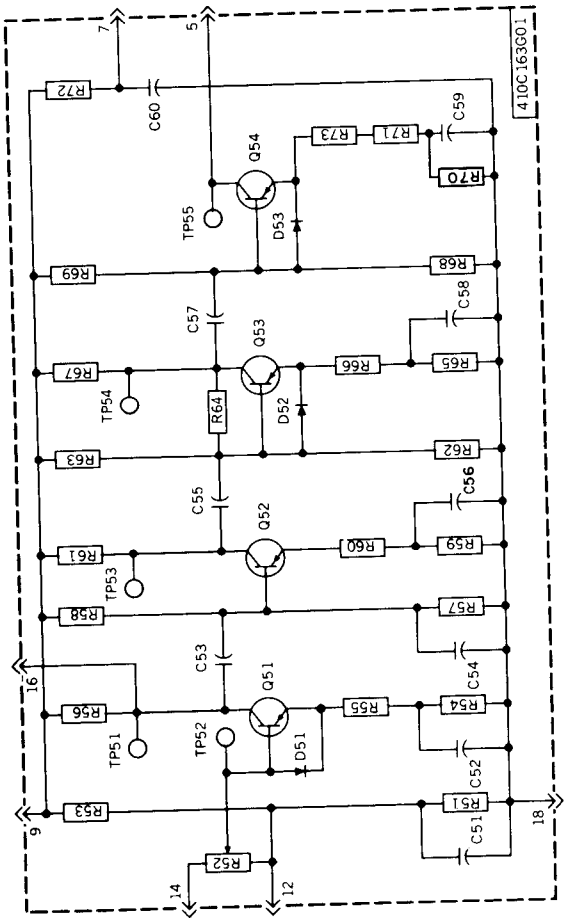

* *Fig. 20. Internal Schematic Amplifier and Limiter – Silicon Transistor Version*

COMPONENT	STYLE	REQ.	REF
TRANSISTOR			
Q81-Q82	849A441H01	2	2N3645
RESISTOR			
R81-R82	184A763H38	2	3K 1/2W ±5%
R83-R84	184A763H35	2	2.2K 1/2W ±5%
R85	184A763H11	1	220Ω 1/2W ±5%
R87	184A763H53	1	12K 1/2W ±5%
SENSISTOR			
R86	187A685H03	1	1.2K 1/4W ±10%
CAPACITOR			
C81-C82-C90-C91	762A703H01	4	22MFD 50V.
C83-C88	762A736H02	2	4.5 TO 100 PF.
C84-C89	187A624H16	2	0091MFD. 200V.
C86	187A684H08	1	100 PF.
C85-C87	SEE NOTE □		
DIODE			
D81-D82-D84	184A855H07	3	1N457A
D85-D86	184A855H12	2	1N628
TRANSFORMER			
T81	606B533G01	1	
T82	606B533G02	1	

□=ONE OR TWO CAPACITORS USED; VALUES DETERMINED IN TEST.

▲=FOR STYLE 410C164G03 REVERSE START AND FINISH LEADS OF T82.

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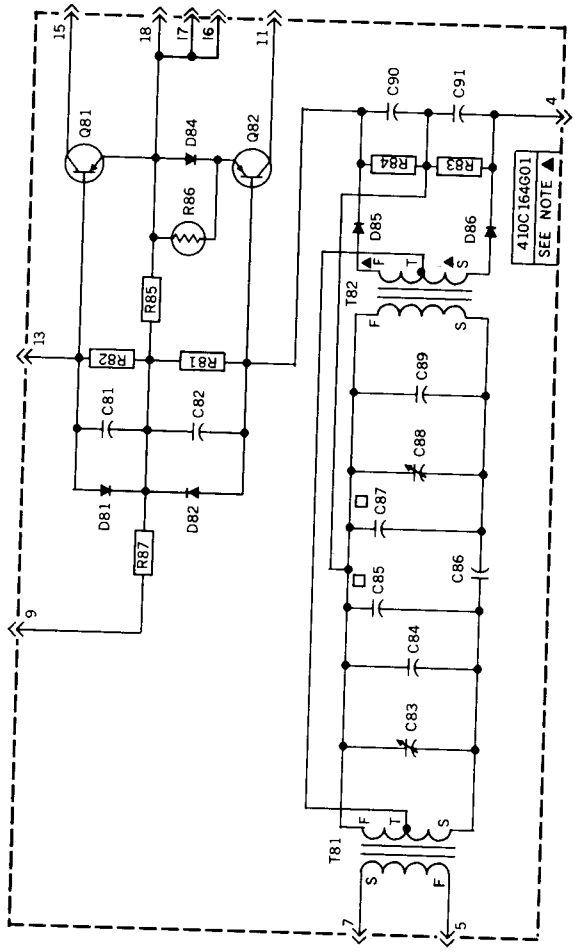

✱ *Fig. 21. Internal Schematic Discriminator – Silicon Transistor Version*

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q151-Q152-Q153	849A441H03	3	2N4249
Q154	184A638H19	1	2N699
RESISTOR			
R151-R168	184A763H51	2	10K 1/2W ±5%
R152	187A685H01	1	2.2K
R153	184A763H11	1	220Ω 1/2W ±5%
R154	184A763H39	1	3.3K 1/2W ±5%
R155-R159	184A763H55	2	15K 1/2W ±5%
R157-R158	184A763H43	2	4.7K 1/2W ±5%
R160	184A763H21	1	560Ω 1/2W ±5%
R161	184A763H29	1	1.2K 1/2W ±5%
R162-R163	184A763H09	2	180Ω 1/2W ±5%
R164	184A763H19	1	470Ω 1/2W ±5%
R165	184A763H27	1	1K 1/2W ±5%
R167	184A763H57	1	18K 1/2W ±5%
R171	**184A763H07**	1	1500 1/2W ±5%
R170	184A763H23	1	680Ω 1/2W ±5%
POTENTIOMETER			
R156	629A645H07	1	2.5K
THERMISTOR			
R166	185A211H08	1	1D201
CAPACITOR			
C151-C152-C154 TO C158	187A624H02	7	.25MFD. 200V.
C153	187A624H04	1	1MFD. 200V.
DIODE			
D151 TO D156-D158	184A855H07	7	1N457A
TELEPHONE JACK			
J151	187A606H01	1	

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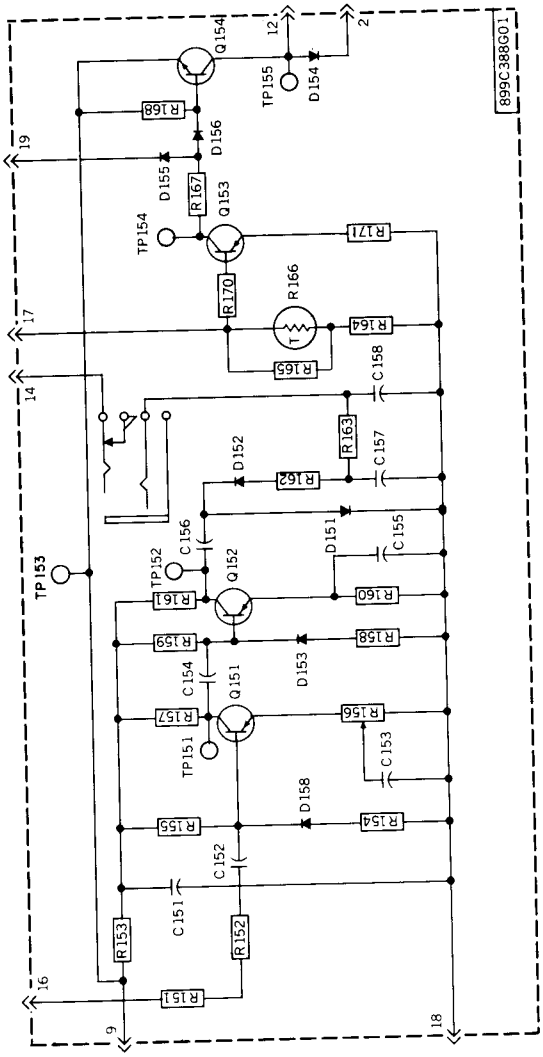
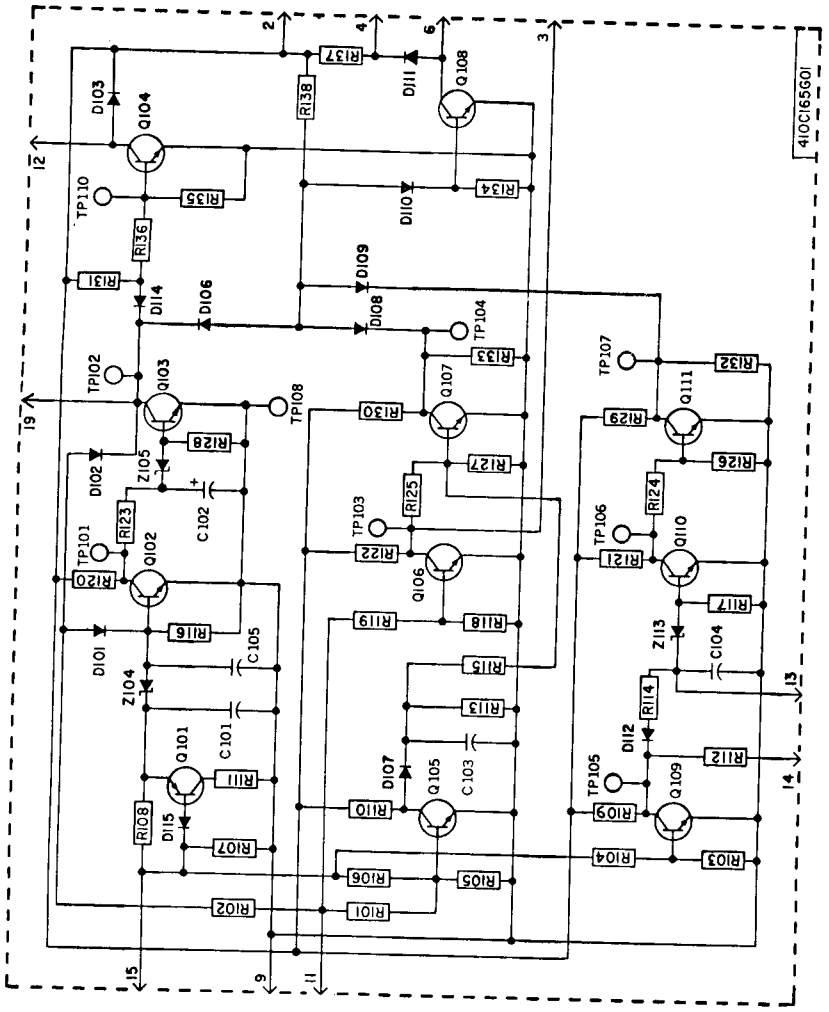


* *Fig. 22. Internal Schematic Carrier Level Indicator – Silicon Transistor Version*

COMPONENT	STYLE	REQ	REF
TRANSISTORS			
Q101	849A441H03	1	(2N4249)
Q102-106-110-111	762A585H01	4	(2N696)
Q103	184A638H18	1	(2N697)
Q107	762A585H02	1	(2N698)
Q105-108-109-104	184A638H19	4	(2N699)
RESISTORS			
R110	187A643H47	1	(6.8K 1W ±5%)
R109	187A643H51	1	(10K 1W ±5%)
R137	184A859H06	1	(800 Ω 3W)
R111	184A763H19	1	(470 1/2W ±5%)
R112-R114-R123	184A763H27	3	(1K 1/2W ±5%)
R136	184A763H39	1	(3.3K 1/2W±5%
R103-105-116 TO118-126 TO128-134-135-138	184A763H51	11	(10K 1/2W ± 5%)
R131	184A763H53	1	(12K 1/2W ±5%)
R107	184A763H57	1	(18K 1/2W ±5%)
R104	184A763H61	1	(27K 1/2W ±5%)
R102-124-125-132-133	184A763H63	5	(33K 1/2W ±5%)
R101-106-120	184A763H65	3	(39K 1/2W ±5%)
R108	184A763H69	1	(56K 1/2W ±5%)
R121-122-129-130	184A763H71	4	(68K 1/2W ±5%)
R115	184A763H73	1	(82K 1/2W ±5%)
R119	184A763H75	1	(100K 1/2W ±5%)
R113	184A763H91	1	(470K 1/2W ±5%)
CAPACITORS			
C101	184A661H12	1	(4.7MFD. 10%)
C105	184A663H02	1	(.05MFD. 50V)
C102	184A661H25	1	(6.8MFD.)
C103-104	187A624H11	2	(.5MFD. ± 10%)
DIODES			
D114	182A881H07	1	(IN100A)
D101 TO 103-106 TO112-115	184A855H07	11	(IN457A)
DIO-ZENER			
Z105	185A212H06	1	(IN3686B)
Z113-104	186A797H06	2	(IN957B)



* *Fig. 23. Internal Schematic Logic Board – Silicon Transistor Version*

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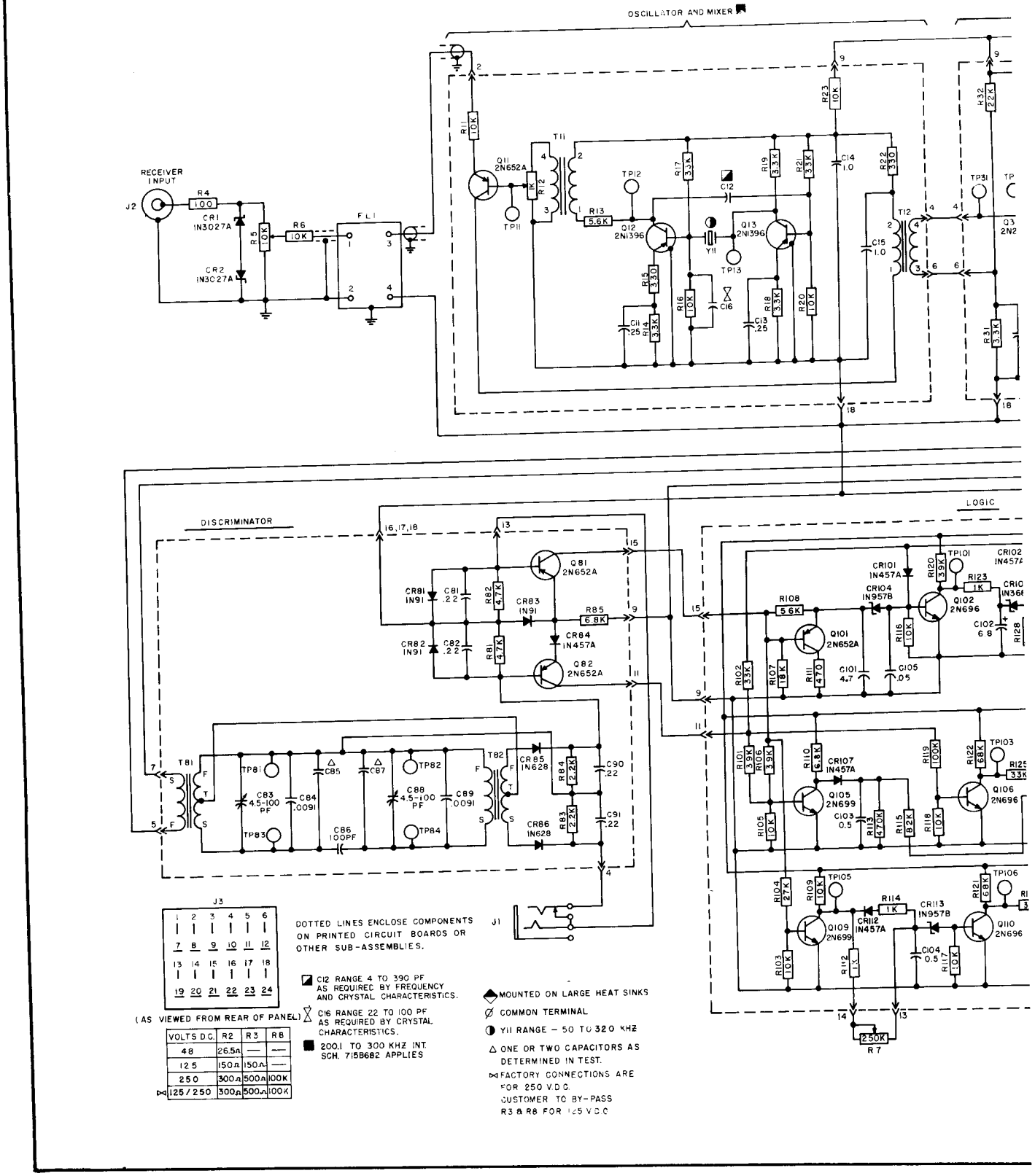
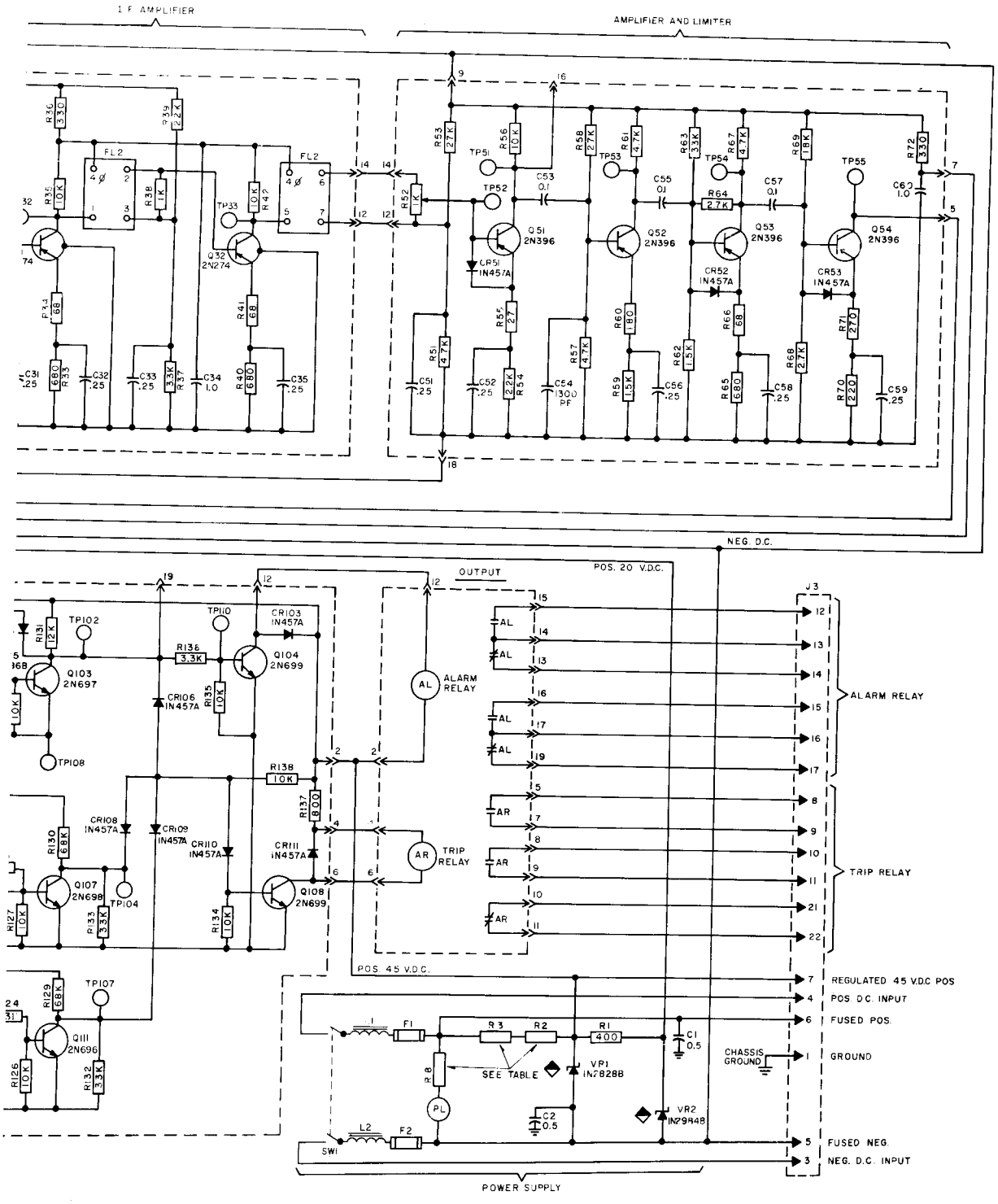


VOLTS D.C.	R2	R3	R8
48	26.5Ω	—	—
125	150Ω	150Ω	—
250	300Ω	500Ω	100K
125/250	300Ω	500Ω	100K

* *Fig. 24. Internal schematic of the type TCF receiv*



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...without the carrier level indicator – germanium version.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf, 50 v.d.c.	184A663H04
C213	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES – ZENER	
CR1	IN3027A; 20 V. ± 10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ± 10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. ± 5%; 400 MW.	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

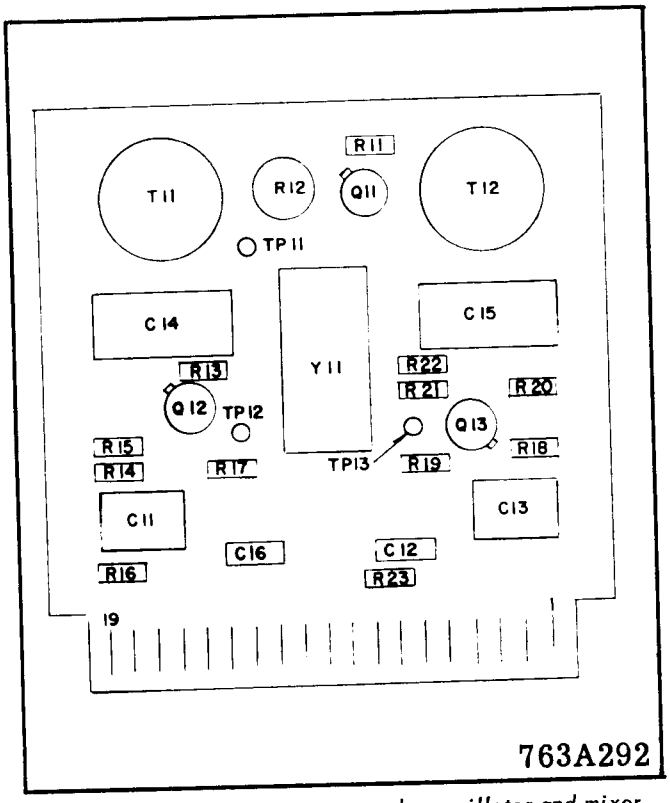
CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ± 5%; Wire Wound	09D832G19
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

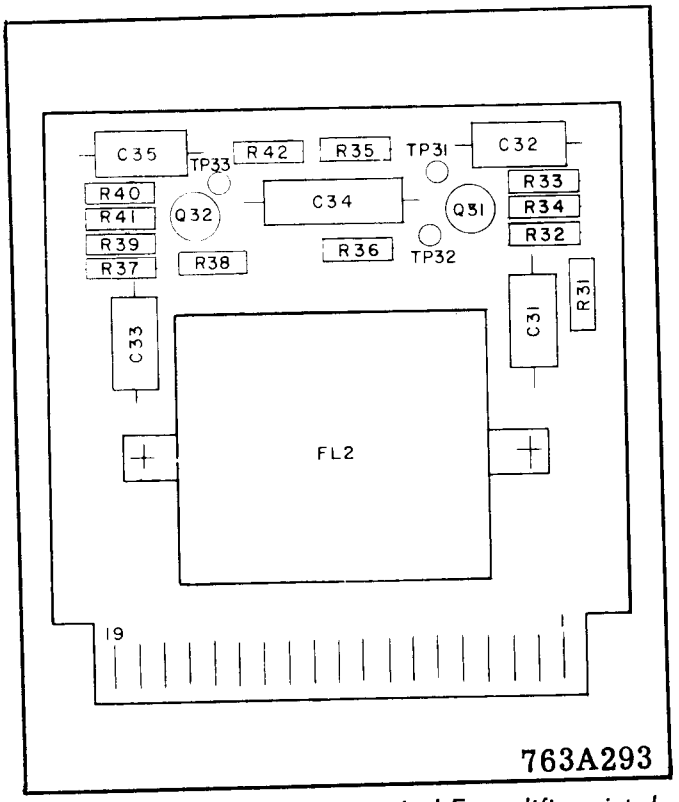
CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

ELECTRICAL PARTS LIST (Cont'd.)

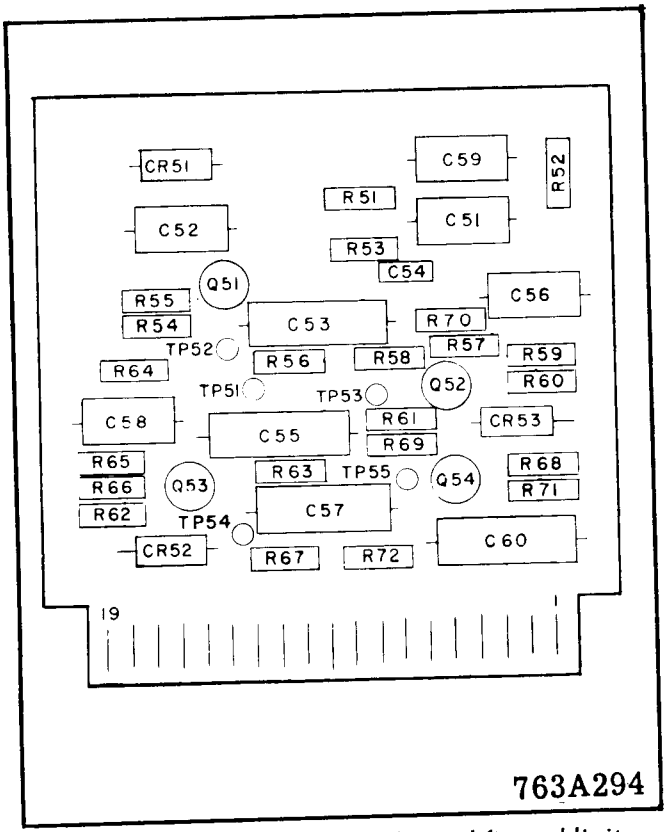
CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	205C043G03
T12	Toroidal type, 25000/300 ohms	205C043G03
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	205C043G01
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01+(Req.Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408C845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04



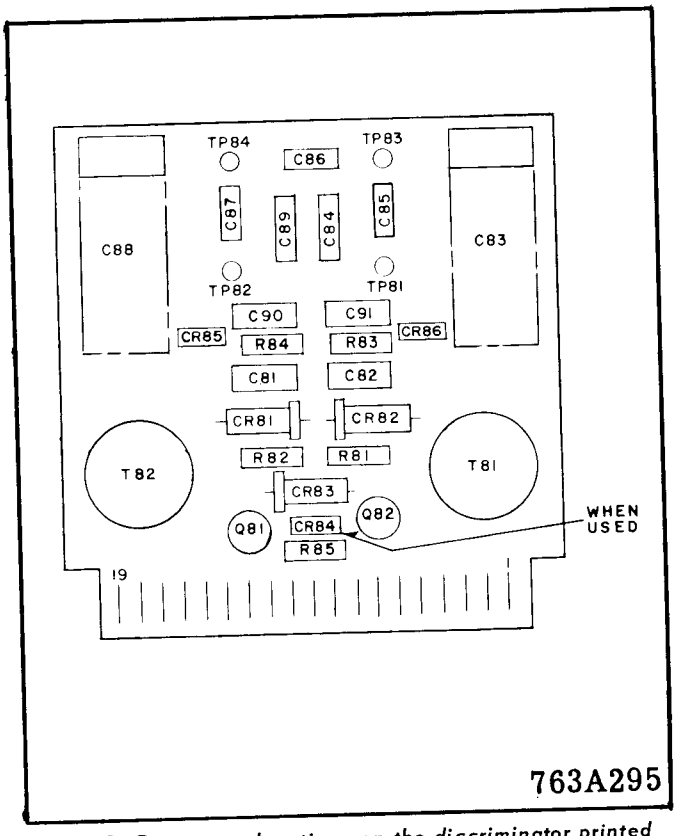
* *Fig. 26 Component locations on the oscillator and mixer printed circuit board - germanium version.*



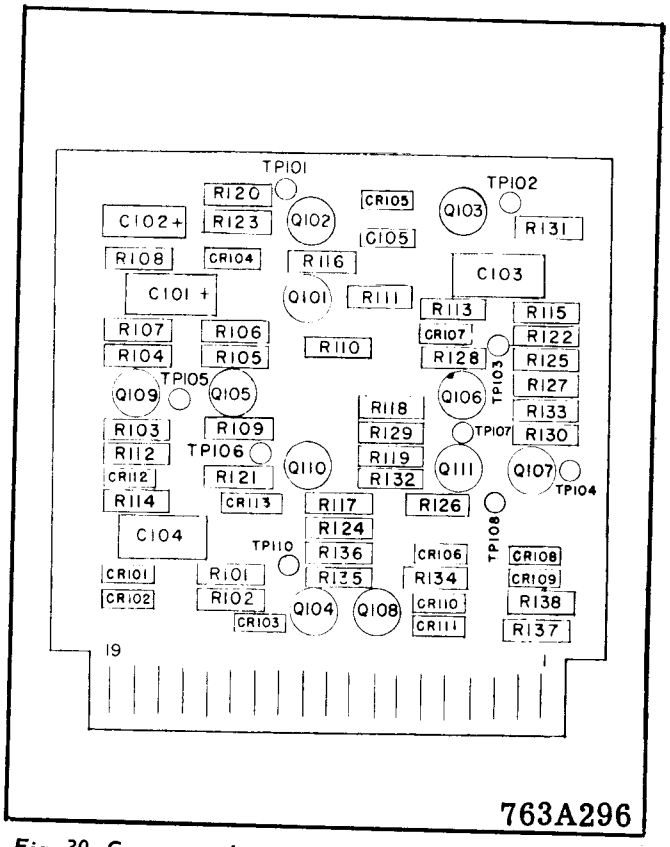
* *Fig. 27 Component locations on the I.F. amplifier printed circuit board - germanium version.*



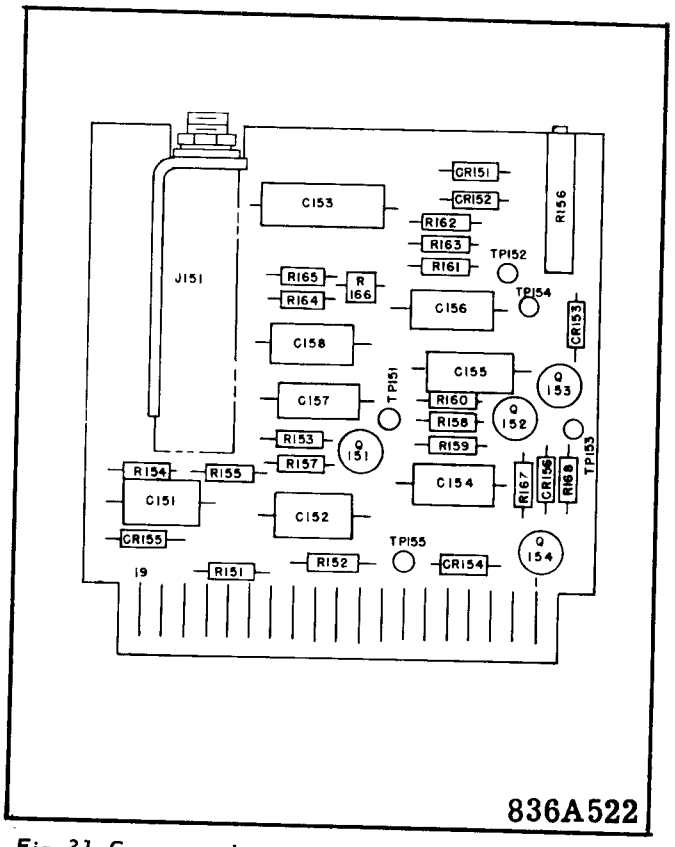
* *Fig. 28 Component locations on the amplifier and limiter printed circuit board - germanium version.*



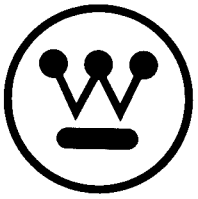
* *Fig. 29 Component locations on the discriminator printed circuit board - germanium version.*



* *Fig. 30 Component locations on the logic printed circuit board - germanium version.*



* *Fig. 31 Component locations on the carrier level indicator printed circuit board - germanium version.*



WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION
NEWARK, N. J.
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.

Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

SUPERSEDES I.L. 41-945.51J
*Denotes change from superseded issue.

EFFECTIVE OCTOBER 1973

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 2.25 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.6 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental ininsertion of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	* 1000 hertz, minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

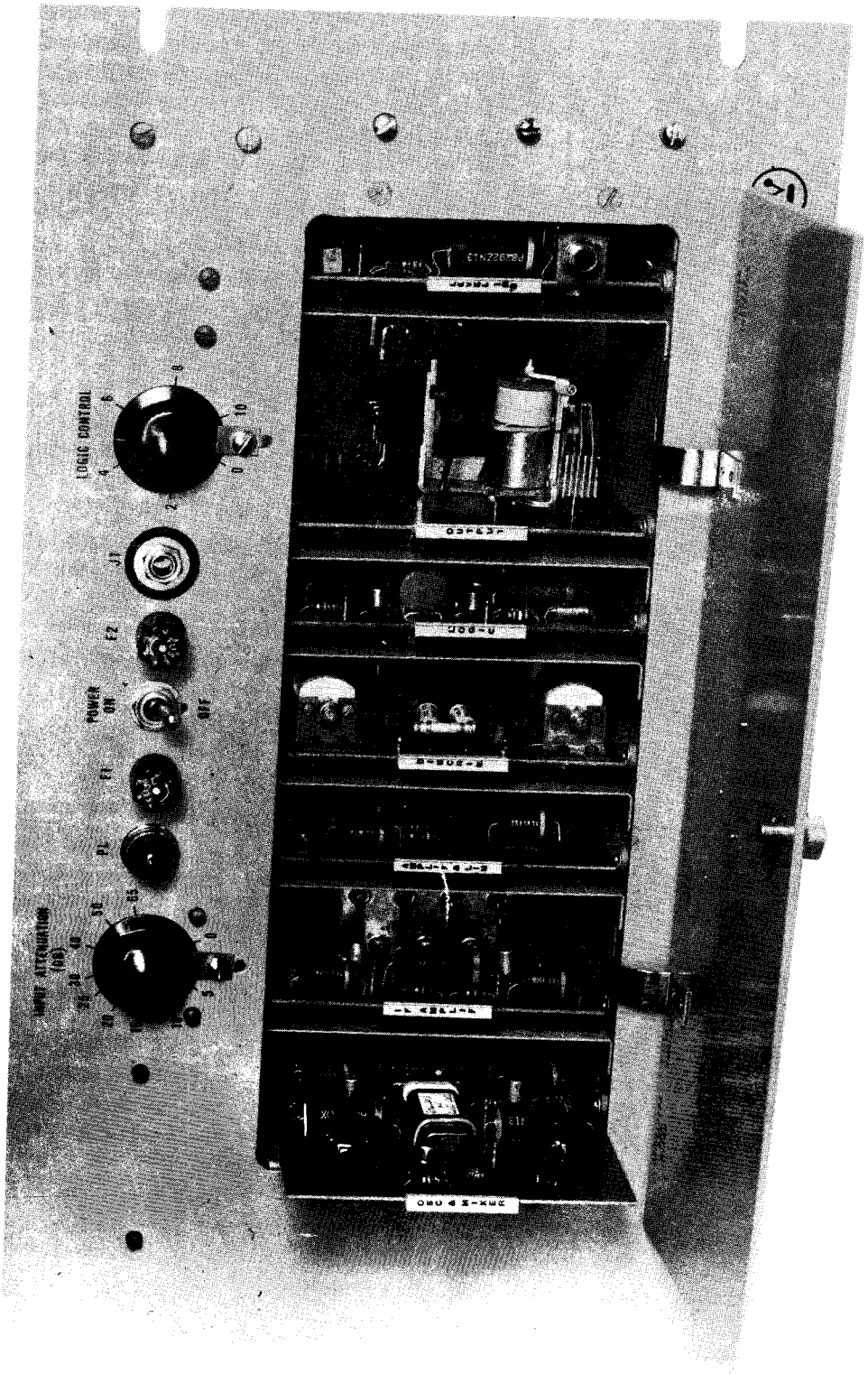
The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

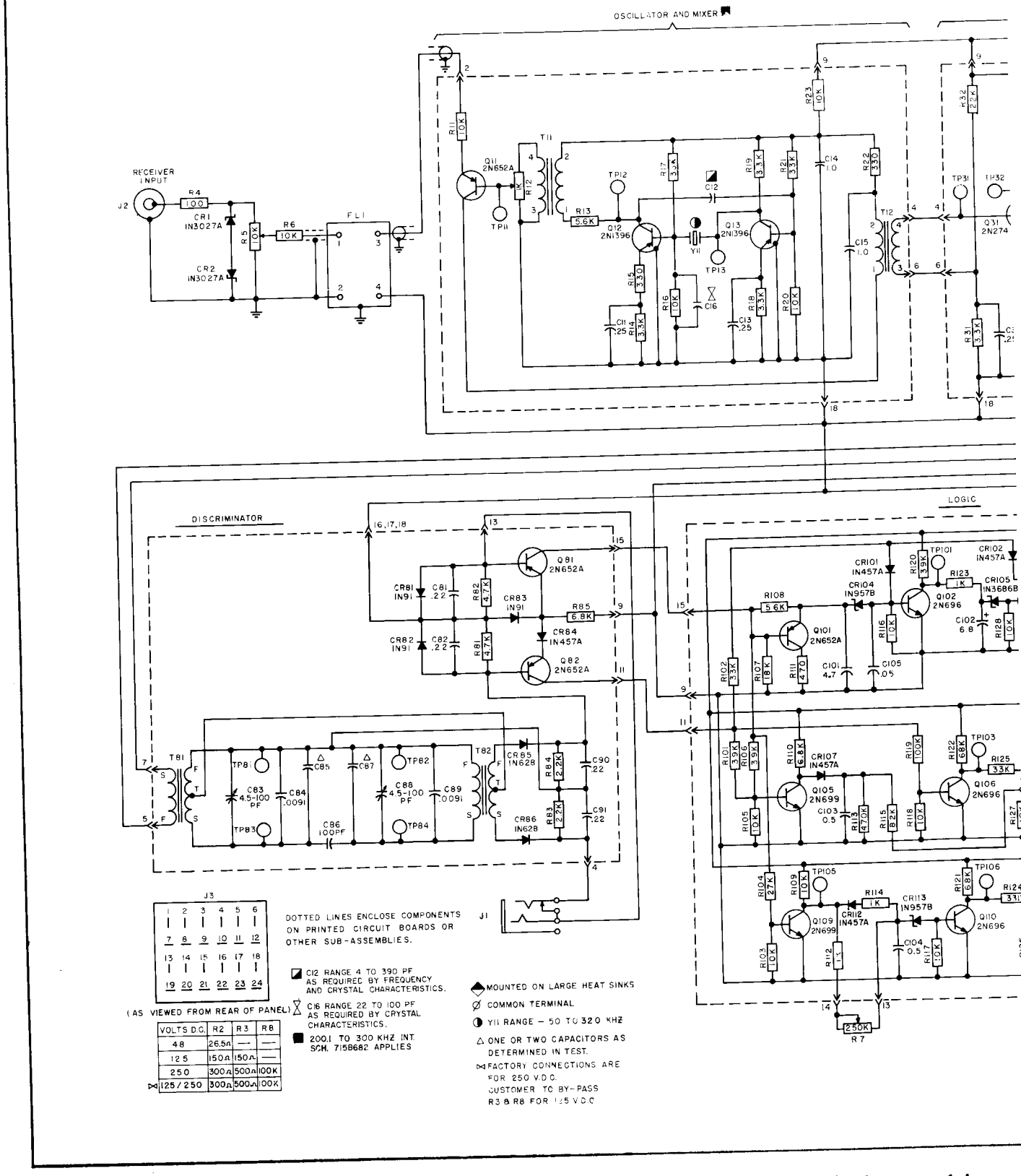
In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

ADDENDUM

With shipments of sets starting in early 1973, the germanium transistors used in the various modules were replaced with silicon transistors. In addition, due to the nature of silicon transistors, some resistor values in the circuits had to be changed In order to correctly bias these transistors. Therefore the transistors are not replaceable on a pin for pin basis throughout the receiver. Before attempting to replace a germanium transistor with a silicon transistor on older sets using germanium, please check the schematics on the following pages to see if the location where the replacement is desired has additional component changes. If that is the case, then the replacement can only be made by the same designation transistor or the additional component changes must also be made. It should be pointed out that the modules containing the silicon transistors are completely interchangeable with the modules containing germanium transistors. Therefore, there is no problem with intermixing the silicon transistor modules in the same receiver. Thus complete new modules containing silicon transistors can be ordered and used as replacements in older receivers having germanium transistor modules. The new modules have the same style numbers as the old germanium transistor modules they replace.

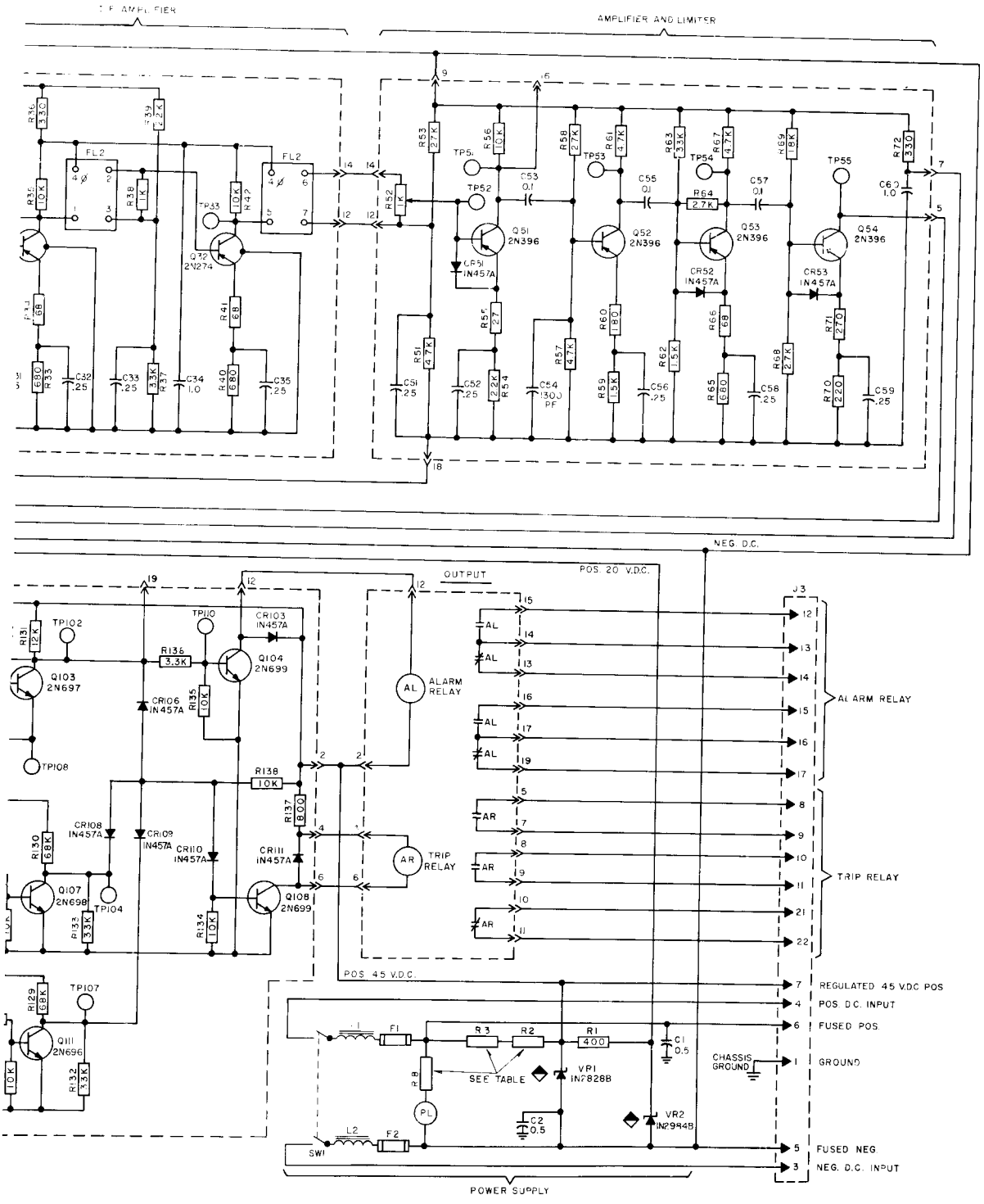


Type TCF Receiver (Front View).



VOLTS D.C.	R2	R3	R8
48	26.5Ω	—	—
125	150Ω	150Ω	—
250	300Ω	500Ω	100K
125/250	300Ω	500Ω	100K

Fig. 1. ***Internal schematic of the type***



543D637

TCF receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Imput Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf, 50 v.d.c.	184A663H04
C213	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A855H07
CR156	IN457A; 60 V.; 200 MA.	
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. v 5%; 400 MW.	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ± 5%; Wire Wound	09D832G19
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	205C043G03
T12	Toroidal type, 25000/300 ohms	205C043G03
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	205C043G01
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01+(Req.Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408C845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

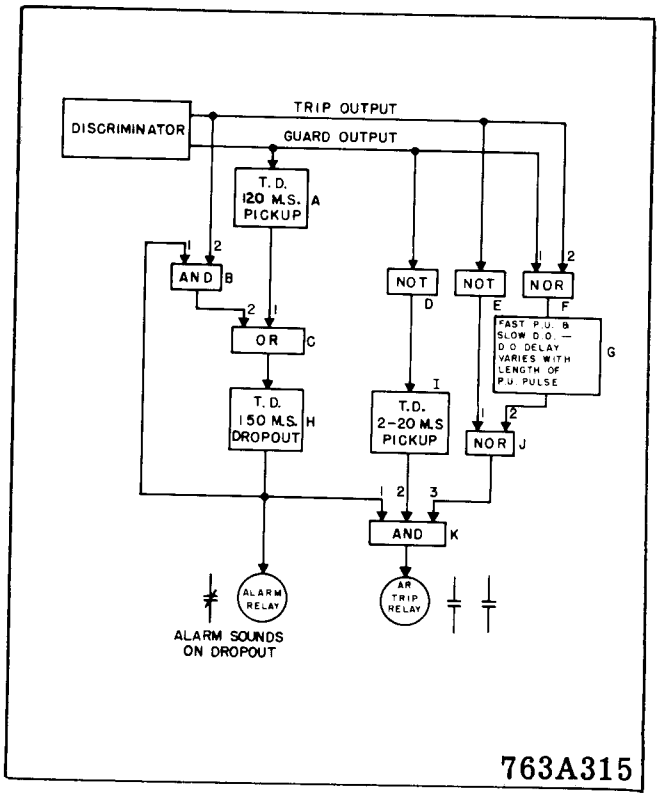


Fig. 3 Block diagram of output logic circuit

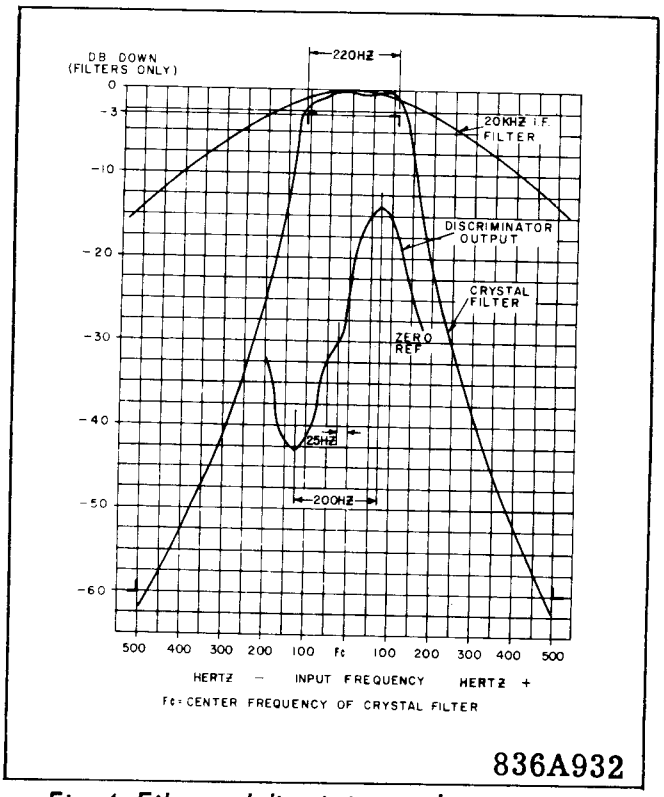


Fig. 4 Filter and discriminator characteristics of the type TCF receiver

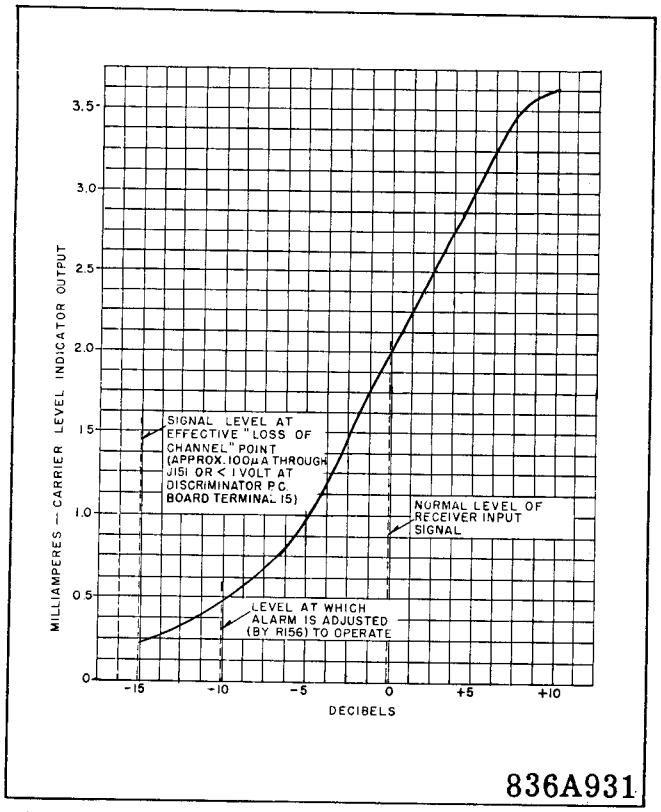


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

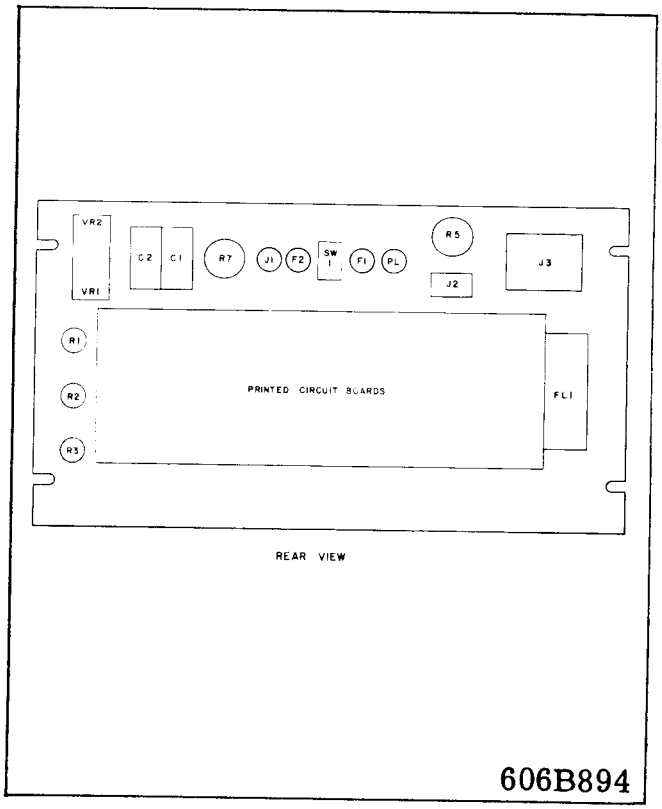


Fig. 6 Component locations on the type TCF receiver panel

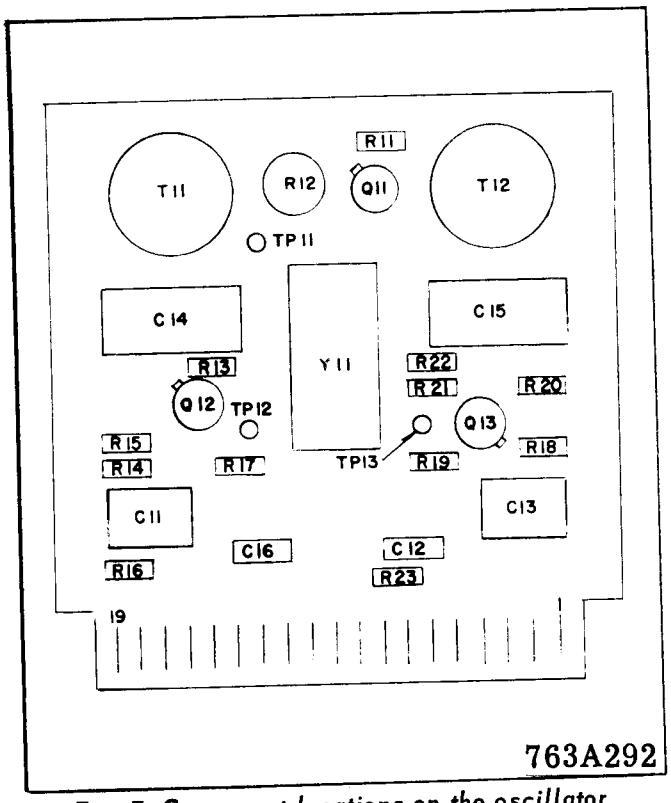


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

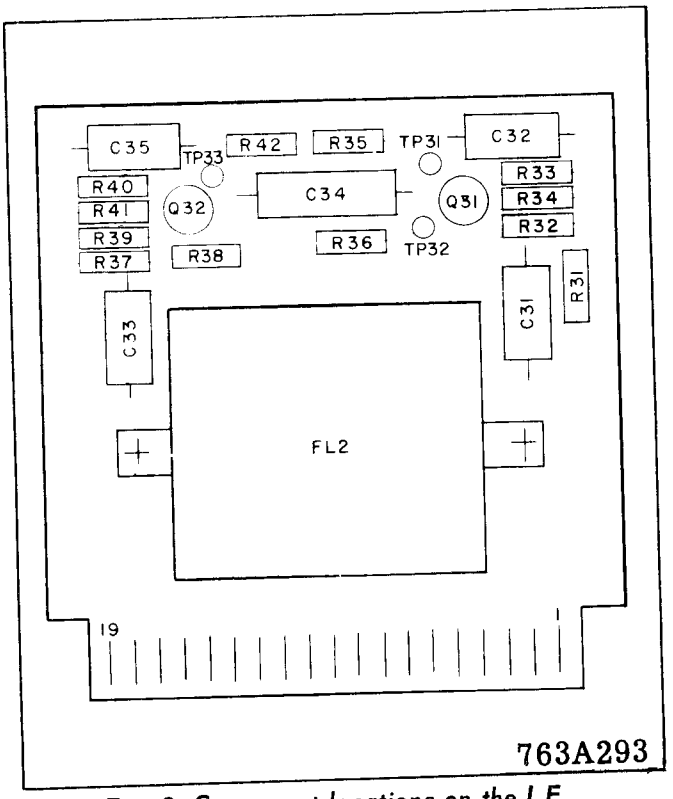


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

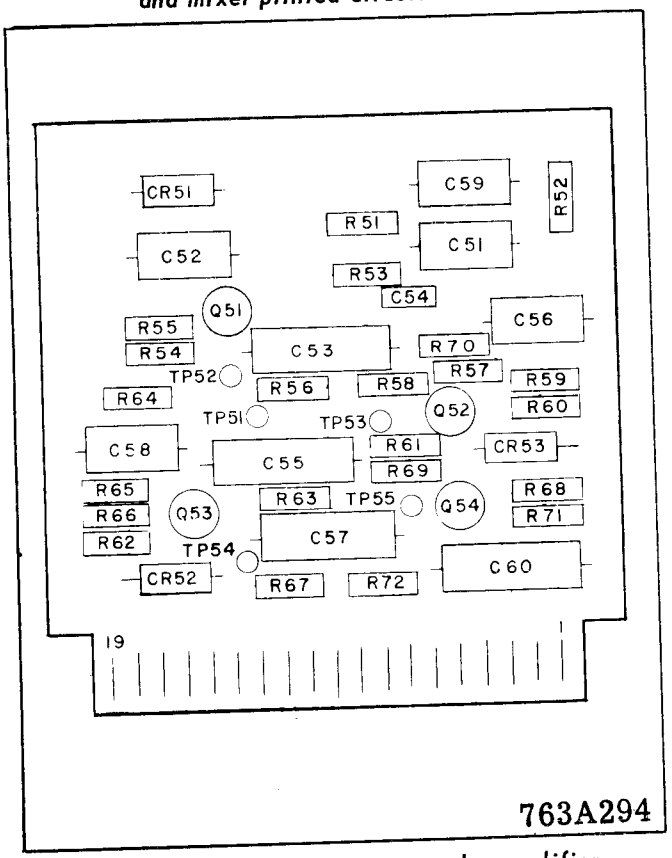


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

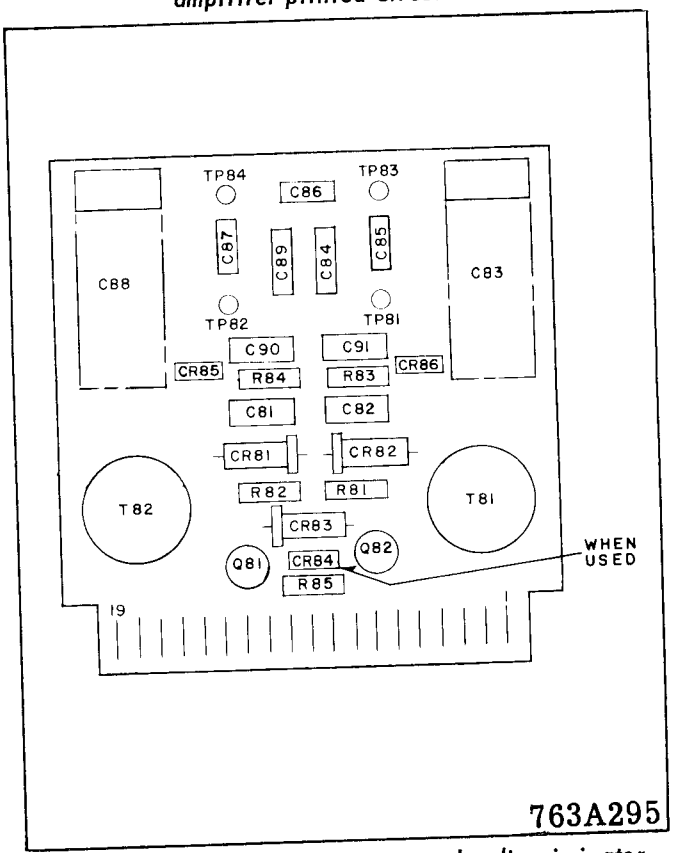


Fig. 10 Component locations on the discriminator printed circuit board.

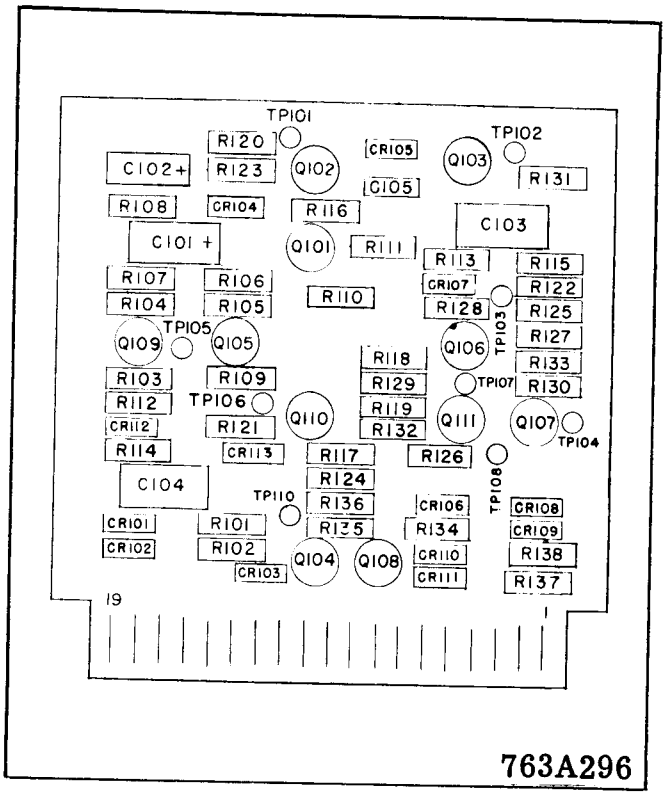


Fig. 11 Component locations on the logic printed circuit board.

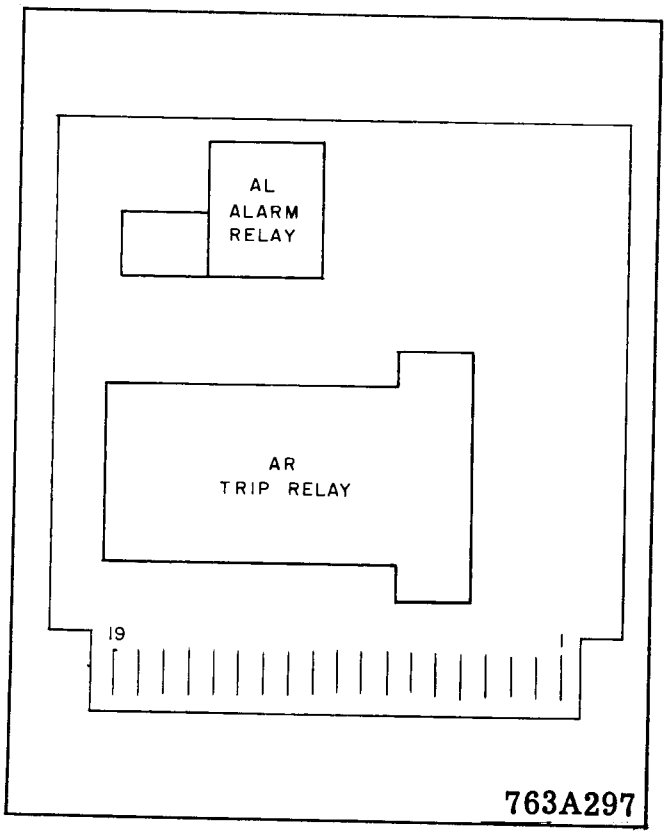


Fig. 12 Component locations on the output printed circuit board.

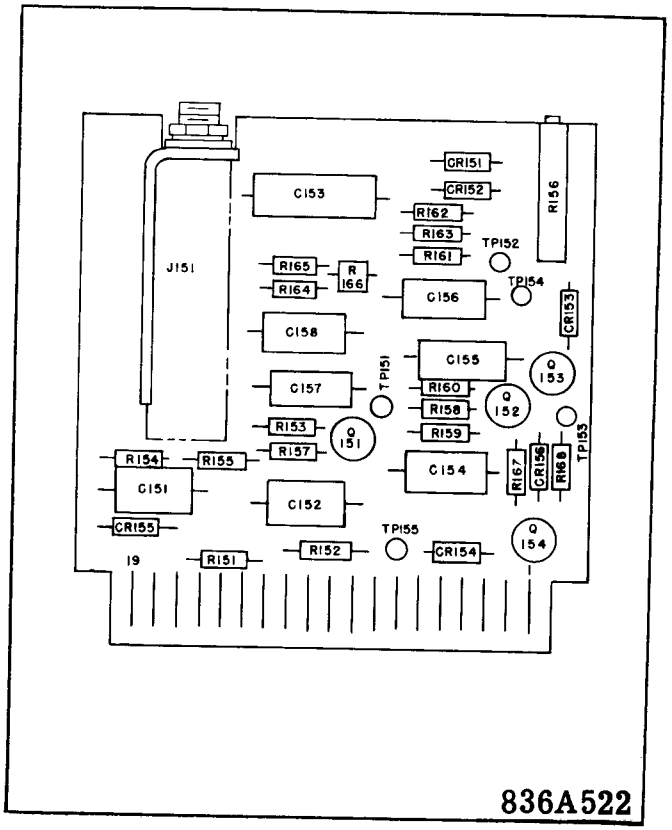


Fig. 13 Component locations on the carrier level indicator printed circuit board.

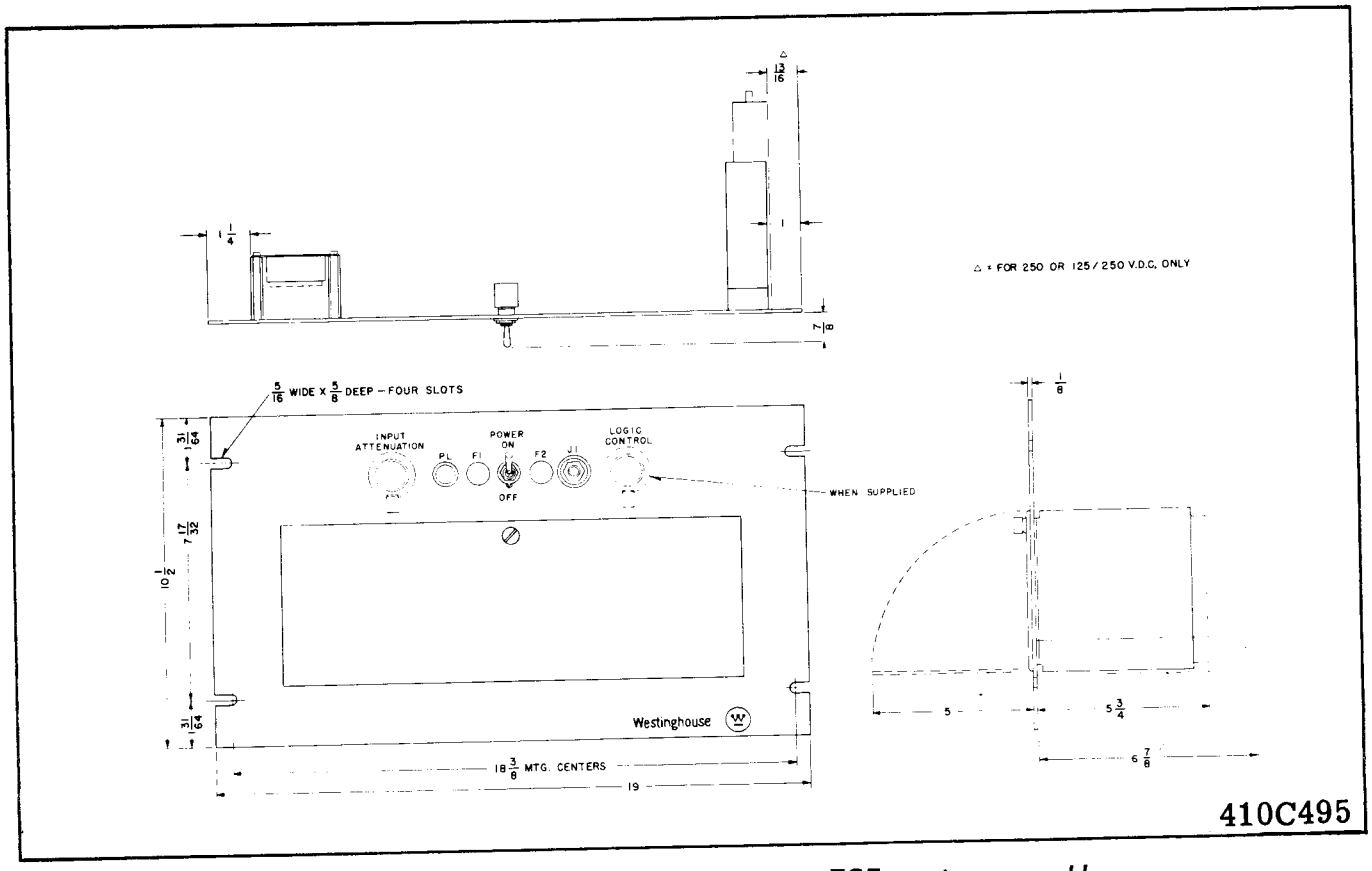


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

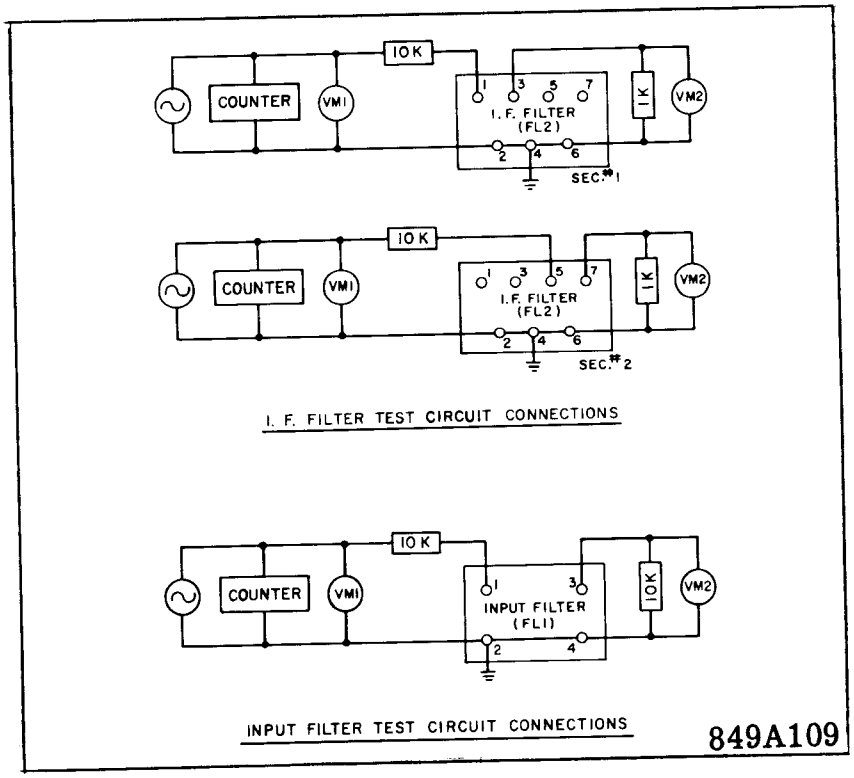


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q11–Q12–Q13	849A441H03	3	2N4249
RESISTOR			
R15–R22	184A763H15	2	330Ω 1/2W ±5%
R14–R18–R19	184A763H39	3	3.3K 1/2W ±5%
R13	184A763H45	1	5.6K 1/2W ±5%
R11–R16–R20–R23	184A763H51	4	10K 1/2W ±5%
R17–R21	184A763H63	2	33K 1/2W ±5%
R24	184A763H83	1	220K 1/2W ±5%
R25	184A763H43	1	4.7K 1/2W ±5%
CAPACITOR			
C11–C13–C17	187A624H02	3	25MFD. 200V.
C14–C15	187A624H04	2	1MFD. 200V.
C12	SEE NOTE ▼		
C16	SEE NOTE ■		
POTENTIOMETER			
R12	629A430H02	1	1000Ω
TRANSFORMER			
T11	205C043G01	1	10,000/400
T12	205C043G03	1	25,000/300
CRYSTAL			
Y11	SEE NOTE o		

▼=C12 RANGE 4 TO 390Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

■=C16 RANGE 22 TO 100Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

o=Y11 RANGE–50 TO 220 KHZ.

REF. COMPONENT LOCATION– 763A292

264C855

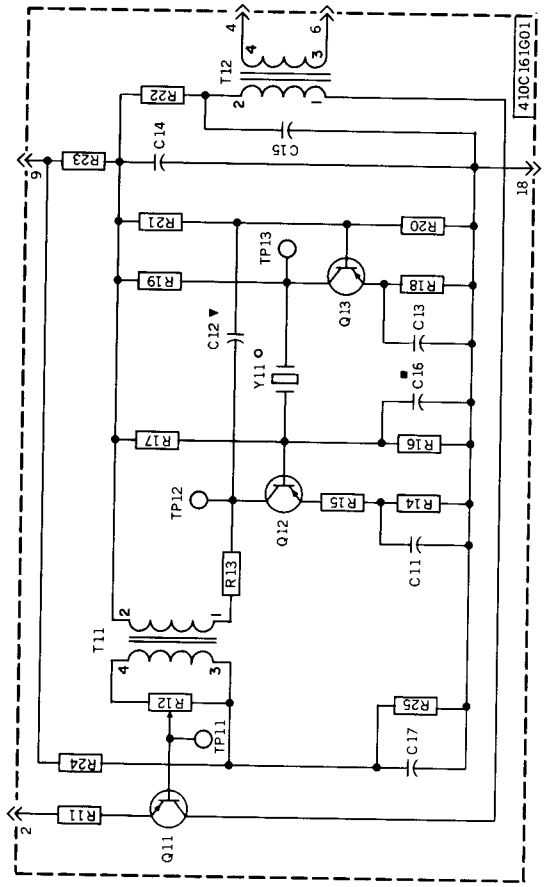


Fig. 18. Internal Schematic 30-200KHz Oscillator and Mixer Silicon Transistor Version

COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q211	849A441H03	1	2N4249
RESISTOR			
R211–R213–R215	184A763H51	3	10K 1/2W ±5%
R212	184A763H27	1	1K 1/2W ±5%
R214	184A763H37	1	2.7K 1/2W ±5%
R216	184A763H49	1	8.2K 1/2W ±5%
R217	184A763H34	1	2K 1/2W ±5%
R218	184A763H07	1	150Ω 1/2W ±5%
R219	184A763H15	1	330Ω 1/2W ±5%
R220	184A763H67	1	47K 1/2W ±5%
R221	184A763H83	1	220K 1/2W ±5%
R222	184A763H43	1	4.7K 1/2W ±5%
CAPACITOR			
C211	SEE NOTE ▲		
C212–C213–C215	184A663H04	3	.1MFD. 50V.
C214	SEE NOTE o		
C216–C217	187A624H04	2	1 MFD. 200V.
C218	187A624H02	1	.25 MFD. 200V.
ZENER DIODE			
Z201	862A606H01	1	1N753A
INTERNAL CIRCUIT			
IC201	201C826H04	1	UA710C
TRANSFORMER			
T211	714B677G01	1	
T212	205C043G03	1	
CRYSTAL			
Y11	SEE NOTE □	1	

▲ = C211 RANGES FROM 100PF. TO 1,000PF.
o = C214 STYLE NO. 187A695H17 .56PF. BUT MAY VARY UP TO 100PF.
□ = Y11 FREQUENCY EQUALS RECEIVER (CHANNEL) FREQUENCY PLUS 20 KHZ.

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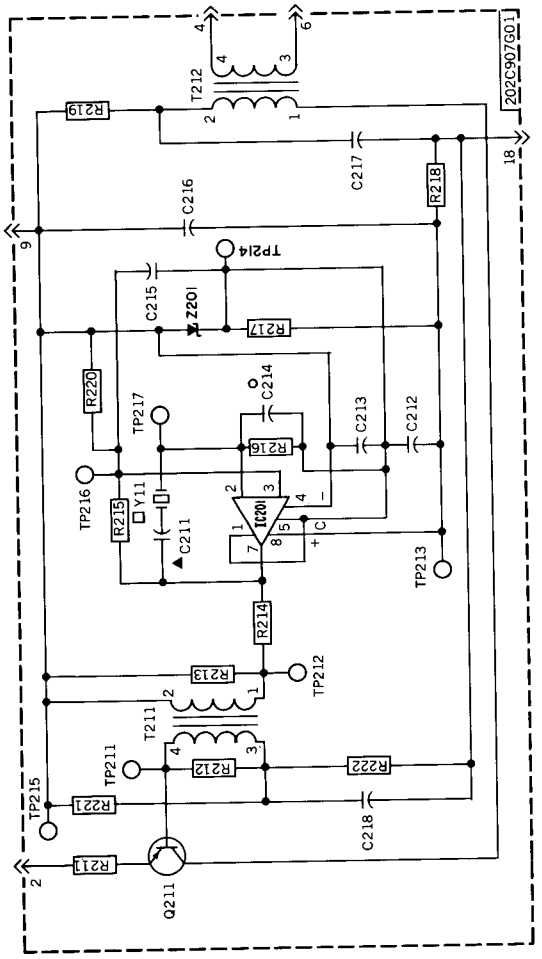

* *Fig. 19. Internal Schematic 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version*

COMPONENT	STYLE	REQ	REF.
TRANSISTOR			
Q31-Q32	849A441H03	2	2N4249
RESISTOR			
R34-R41	187A290H21	2	68Ω 1/2W ±5%
R36	184A763H15	1	330Ω 1/2W ±5%
R33-R40	184A763H23	2	680Ω 1/2W ±5%
R38	184A763H27	1	1K 1/2W ±5%
R31-R37	184A763H39	2	3.3K 1/2W ±5%
R35-R42	184A763H51	2	10K 1/2W ±5%
R32-R39	184A763H59	2	22K 1/2W ±5%
CAPACITOR			
C31-C32-C33-C35	187A624H02	4	.25MFD. 200V
C34	187A624H04	1	1MFD. 200V.
C36	762A757H01	1	100 Pf.
FILTER			
FL2	762A613G01	1	

ø = COMMON TERMINAL

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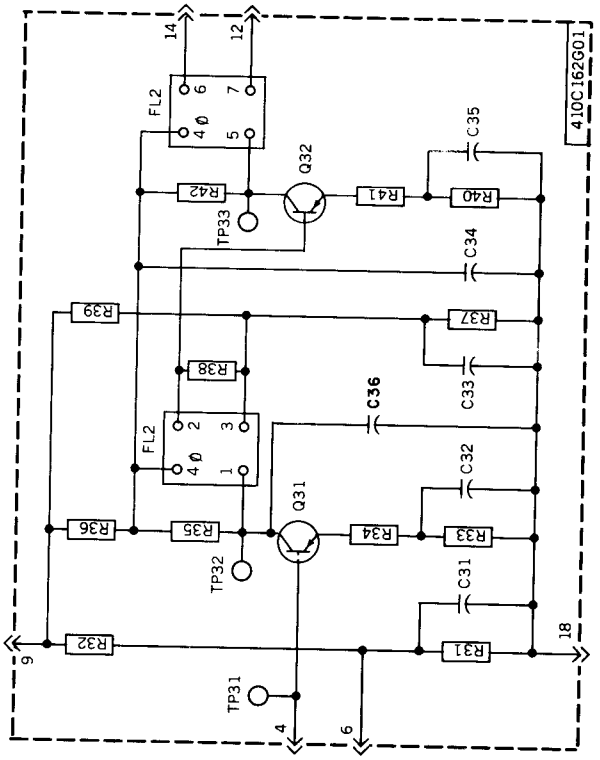
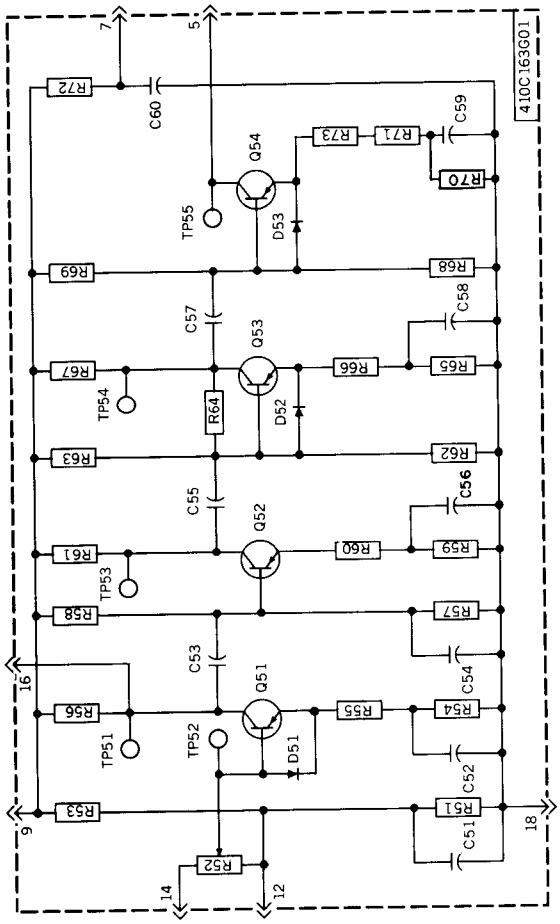


* *Fig. 20. Internal Schematic I.F. Amplifier – Silicon Transistor Version*

COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q51-Q52-Q53-Q54	849A441H03	4	2N4249
RESISTOR			
R66	187A290H21	1	68Ω 1/2W ±5%
R55	187A290H11	1	27Ω 1/2W ±5%
R70	184A763H11	1	220Ω 1/2W ±5%
R72	184A763H15	1	330Ω 1/2W ±5%
R65	184A763H23	1	680Ω 1/2W ±5%
R59	184A763H31	1	1.5K 1/2W ±5%
R54-R62	184A763H35	2	2.2K 1/2W ±5%
R64-R68	184A763H37	2	2.7K 1/2W ±5%
R51-R57-R61-R67	184A763H43	4	4.7K 1/2W ±5%
R56	184A763H51	1	10K 1/2W ±5%
R69	184A763H57	1	18K 1/2W ±5%
R53-R58	184A763H61	2	27K 1/2W ±5%
R63	184A763H63	1	33K 1/2W ±5%
R71	09D8326G20	1	100Ω ±2%
R60	184A763H09	1	180Ω 1/2W ±5%
R73	629A531H02	1	56 Ω 1/2W ±2%
CAPACITOR			
C54	187A584H15	1	1300MMF. 500V.
C51-C52-C56-C58-C59	187A624H02	5	.25MFD. 200V.
C53-C55-C57	187A624H01	3	0.1MFD. 200V.
C60	187A624H04	1	1.0MFD. 200V.
DIODE			
D51-D52-D53	184A855H07	3	1N457A
POTENTIOMETER			
R52	629A645H04	1	1K



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* *Fig. 21. Internal Schematic Amplifier and Limiter – Silicon Transistor Version*

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q81–Q82	849A441H01	2	2N3645
RESISTOR			
R81–R82	184A763H38	2	3K 1/2W ±5%
R83–R84	184A763H35	2	2.2K 1/2W ±5%
R85	184A763H11	1	220Ω 1/2W ±5%
R87	184A763H53	1	12K 1/2W ±5%
SENSISTOR			
R86	187A685H03	1	1.2K 1/4W ±10%
CAPACITOR			
C81–C82–C90–C91	762A703H01	4	.22MFD. 50V.
C83–C88	762A736H02	2	4.5 TO 100Pf.
C84–C89	187A624H16	2	.0091MFD. 200V.
C86	187A684H08	1	100Pf.
C85–C87	SEE NOTE □		
DIODE			
D81–D82–D84	184A855H07	3	1N457A
D85–D86	184A855H12	2	1N628
TRANSFORMER			
T81	606B533G01	1	
T82	606B533G02	1	

□=ONE OR TWO CAPACITORS USED; VALUES DETERMINED IN TEST.

▲=FOR STYLE 410C164G03 REVERSE START AND FINISH LEADS OF T82.

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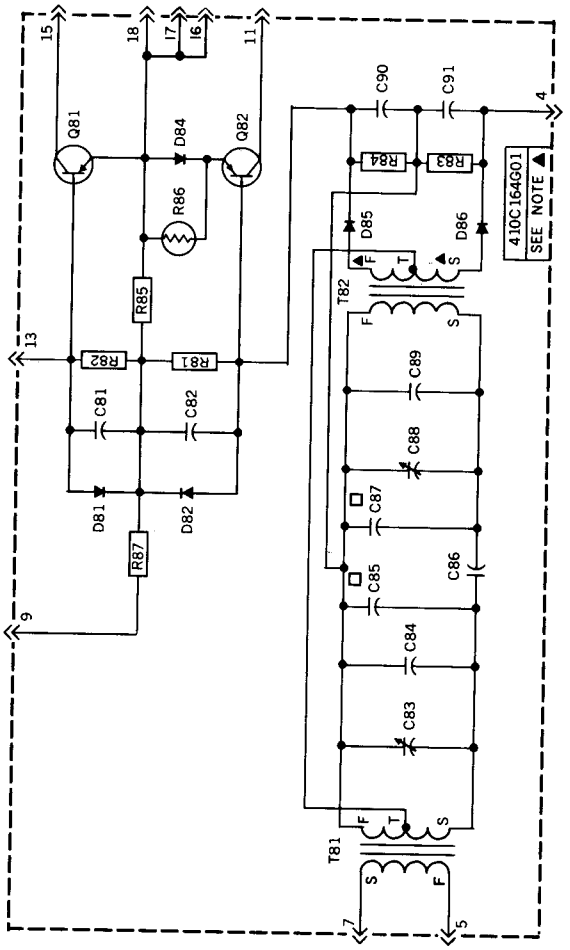

★ *Fig. 22. Internal Schematic Discriminator – Silicon Transistor Version*

COMPONENT	STYLE	REQ.	REF
TRANSISTOR			
Q151–Q152–Q153	849A441H03	3	2N4249
Q154	184A638H19	1	2N699
RESISTOR			
R151–R168	184A763H51	**2**	10K 1/2W ±5%
R152	187A685H01	1	2.2K
R153	184A763H11	1	220Ω 1/2W ±5%
R154	184A763H39	1	3.3K 1/2W ±5%
R155–R159	184A763H55	**2**	15K 1/2W ±5%
R157–R158	184A763H43	2	4.7K 1/2W ±5%
R160	184A763H21	1	560Ω 1/2W ±5%
R161	184A763H29	1	1.2K 1/2W ±5%
R162–R163	184A763H09	2	180Ω 1/2W ±5%
R164	184A763H19	1	470Ω 1/2W ±5%
R165	184A763H27	1	1K 1/2W ±5%
R167	184A763H57	1	18K 1/2W ±5%
R171	**184A763H07**	1	**150Ω 1/2W ±5%**
R170	184A763H23	1	680Ω 1/2W ±5%
POTENTIOMETER			
R156	629A645H07	1	2.5K
THERMISTOR			
R166	185A211H08	1	1D201
CAPACITOR			
C151–C152–C154 TO C158	187A624H02	7	25MFD. 200V.
C153	187A624H04	1	1MFD. 200V.
DIODE			
D151 TO D156–D158	184A855H07	7	1N457A
TELEPHONE JACK			
J151	187A606H01	1	

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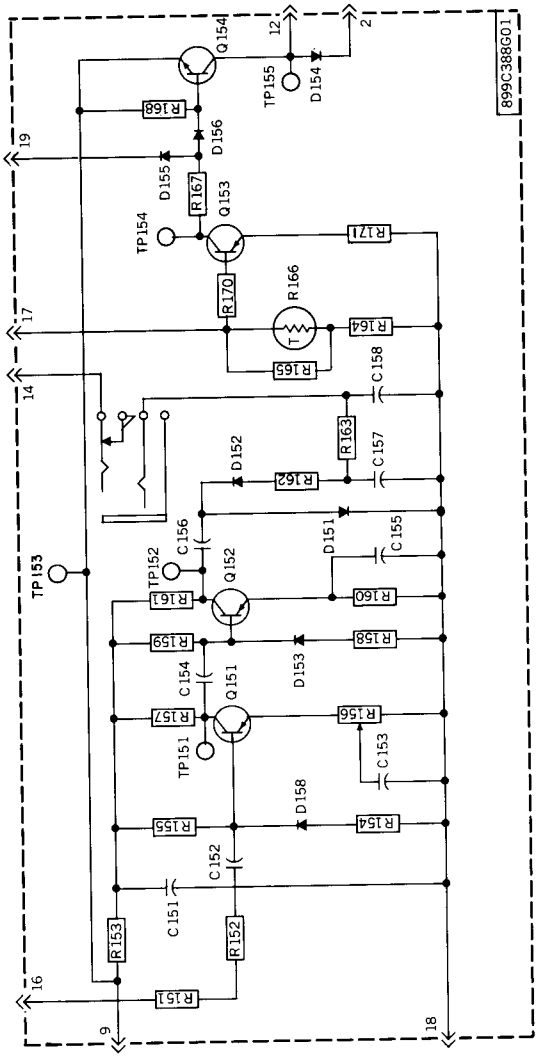
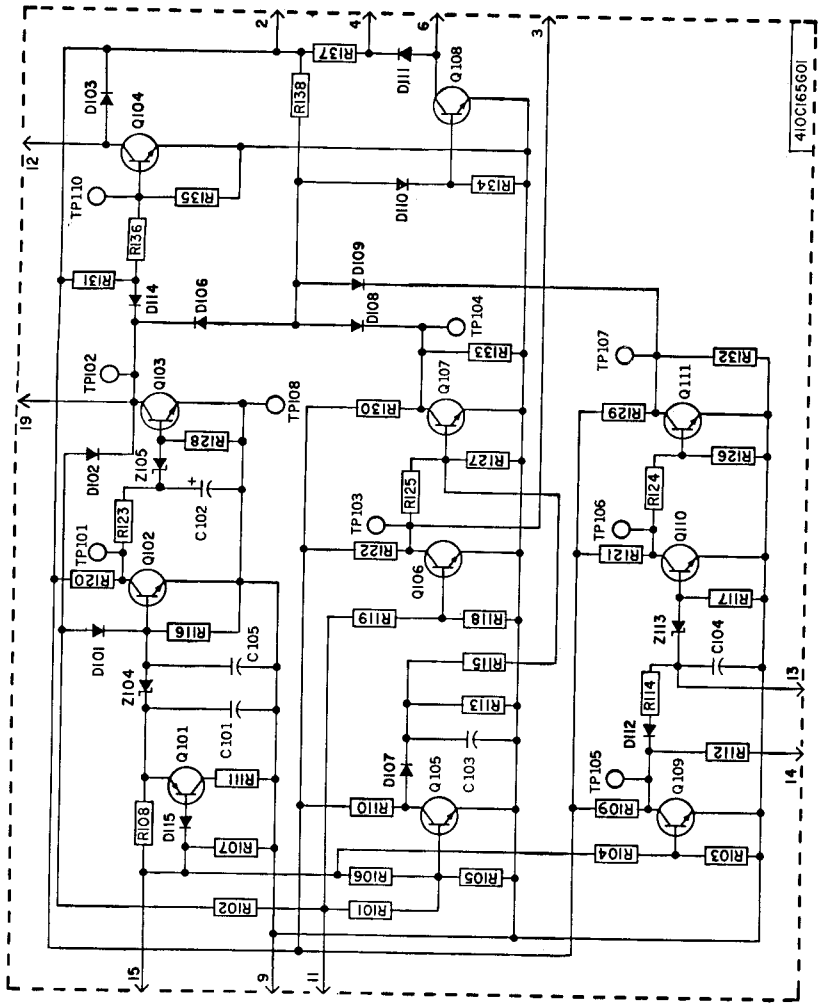


* *Fig. 23. Internal Schematic Carrier Level Indicator – Silicon Transistor Version*

COMPONENT	STYLE	REQ	REF
TRANSISTORS			
Q101	849A441H03	1	(2N4249)
Q102-106-110-111	762A585H01	4	(2N696)
Q103	184A638H18	1	(2N697)
Q107	762A585H02	1	(2N698)
Q105-108-109-104	184A638H19	4	(2N699)
RESISTORS			
R110	187A643H47	1	(6.8K 1W ±5%)
R109	187A643H51	1	(10K 1W ±5%)
R137	184A859H06	1	(800 Ω 3W)
R111	184A763H19	1	(470 1/2W ±5%)
R112-R114-R123	184A763H27	3	(1K 1/2W ±5%)
R136	184A763H39	1	(3.3K 1/2W ±5%)
R103-105-116 TO 118-126 TO 128-134-135-138	184A763H51	11	(10K 1/2W ±5%)
R131	184A763H53	1	(12K 1/2W ±5%)
R107	184A763H57	1	(18K 1/2W ±5%)
R104	184A763H61	1	(27K 1/2W ±5%)
R102-124-125-132-133	184A763H63	5	(33K 1/2W ±5%)
R101-106-120	184A763H65	3	(39K 1/2W ±5%)
R108	184A763H69	1	(56K 1/2W ±5%)
R121-122-129-130	184A763H71	4	(68K 1/2W ±5%)
R115	184A763H73	1	(82K 1/2W ±5%)
R119	184A763H75	1	(100K 1/2W ±5%)
R113	184A763H91	1	(470K 1/2W ±5%)
CAPACITORS			
C101	184A661H12	1	(4.7MFD. 10%)
C105	184A663H02	1	(.05MFD. 50V)
C102	184A661H25	1	(6.8MFD.)
C103-104	187A624H11	2	(.5MFD. ±10%)
DIODES			
D114	182A881H07	1	(IN100A)
D101 TO 103-106 TO 112-115	184A855H07	11	(IN457A)
DIO-ZENER			
Z105	185A212H06	1	(IN3686B)
Z113-104	186A797H06	2	(IN957B)



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** Fig. 24. Internal Schematic Logic Board – Silicon Transistor Version*

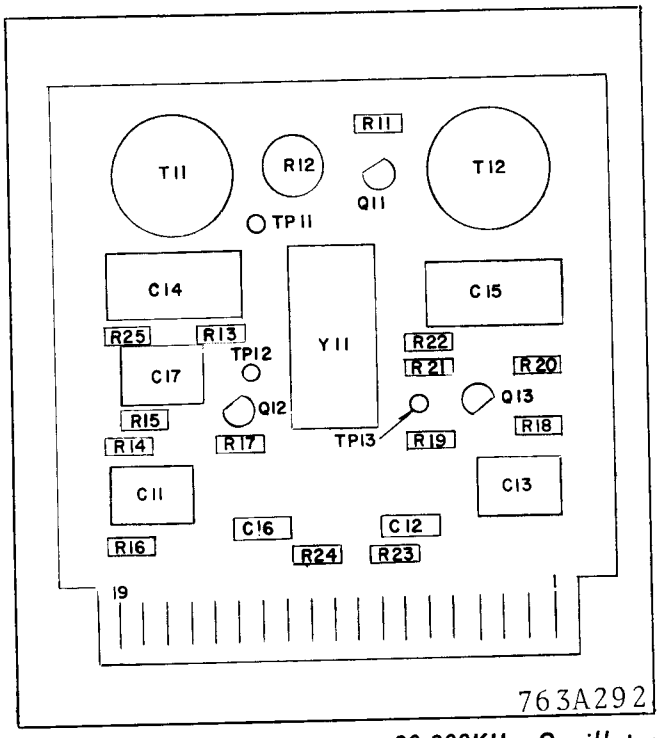

Fig. 25. Component Locations 30-200KHz. Oscillator and Mixer Silicon Transistor Version

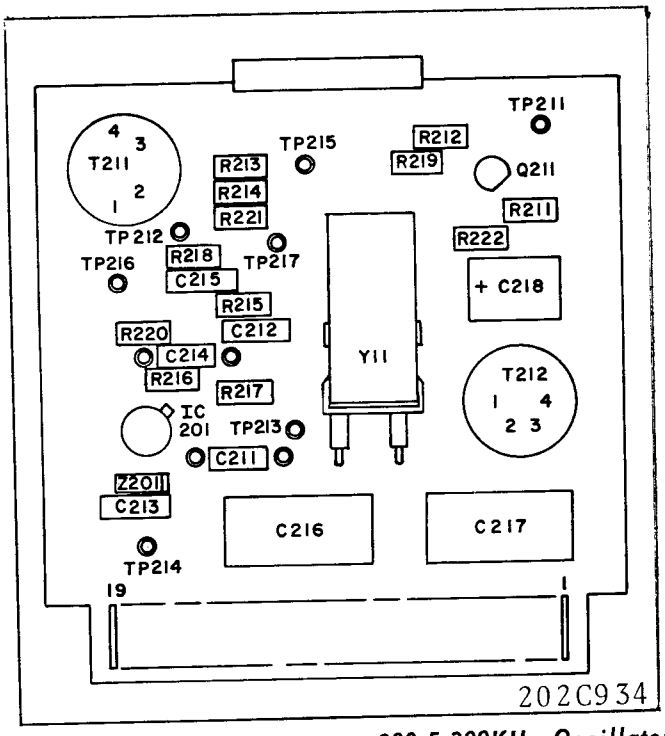

Fig. 26. Component Locations 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version

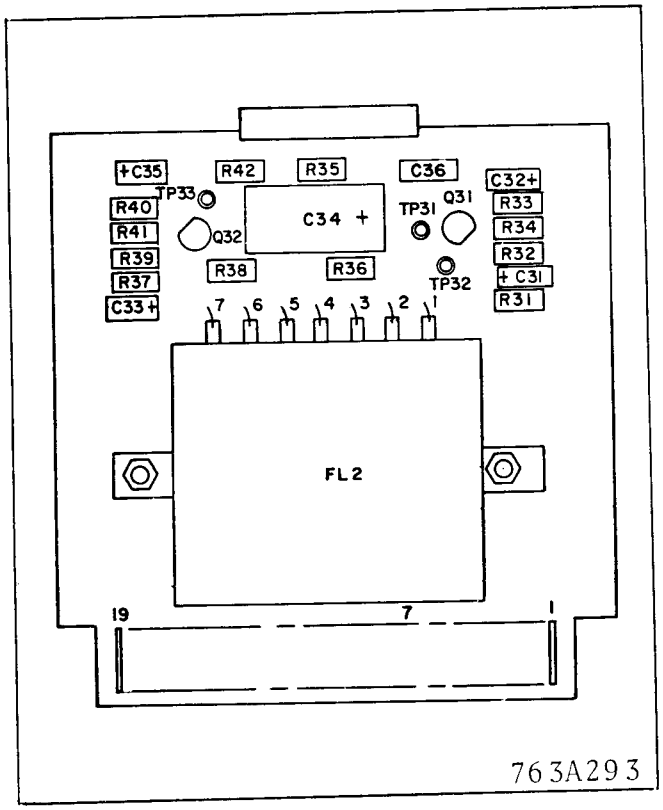

Fig. 27. Component Locations I.F. Amplifier – Silicon Transistor Version

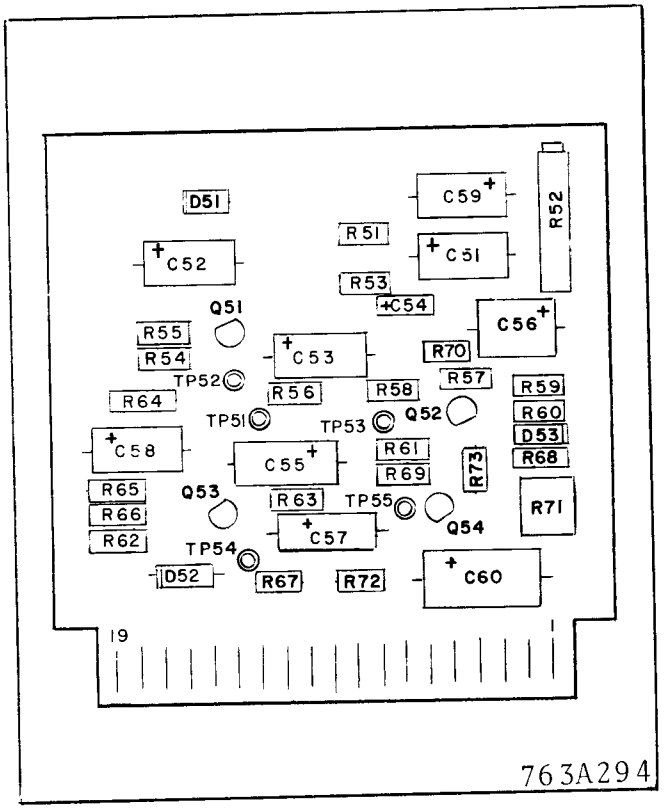

Fig. 28. Component Locations Amplifier and Limiter – Silicon Transistor Version

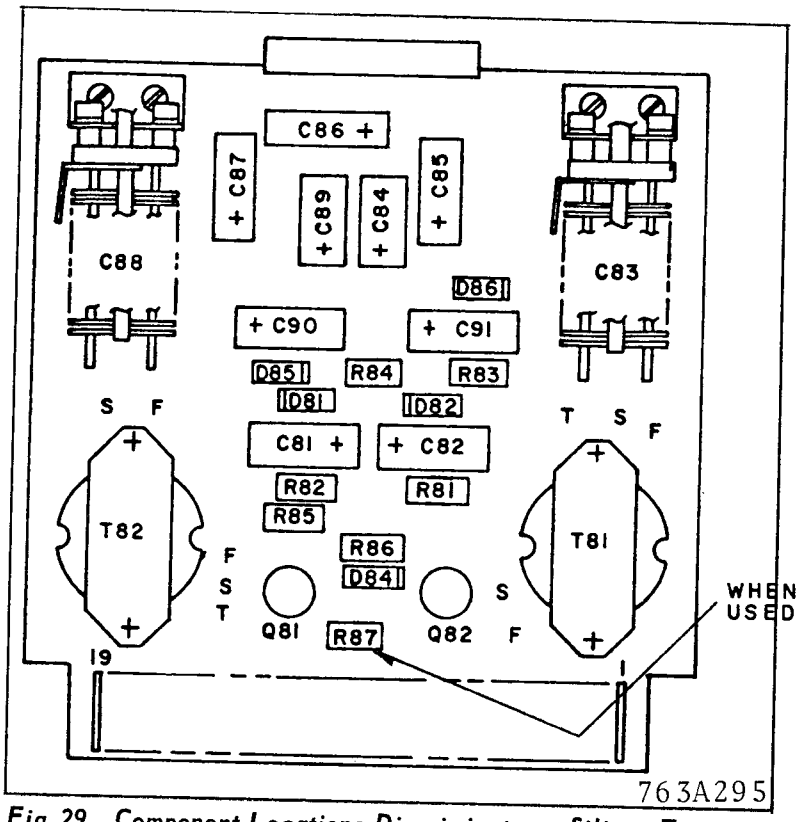

Fig. 29. Component Locations Discriminator – Silicon Transistor Version

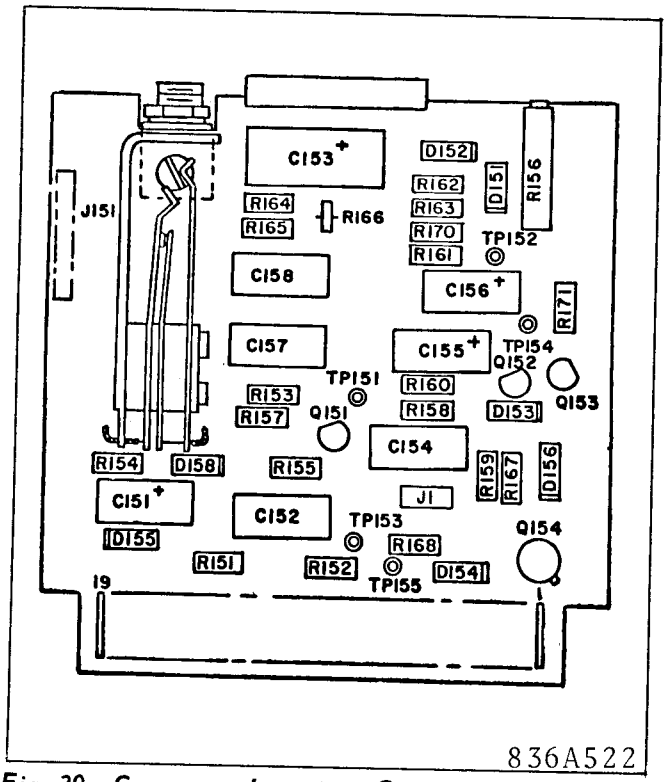

Fig. 30. Component Locations Carrier Level Indicator – Silicon Transistor Version

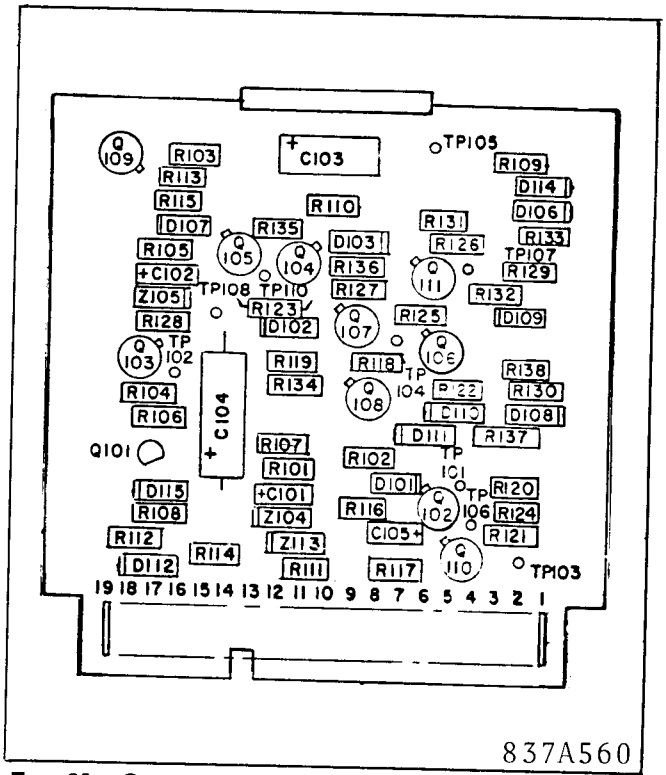

Fig. 31. Component Locations Logic Board – Silicon Transistor Version

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.
Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

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*Denotes change from superseded issue.

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terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, or IC201 (Fig. 16) and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 kHz above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the later is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20kHz, 2fc + 20kHz, fc + 20kHz and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero output frequency. This separation of 200 hertz between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 hertz in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20 kHz-100 hertz. Similarly, the Trip frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears, the discriminator output at term. 15 will turn Q101 off. C101 will change and after 120 ms. it will reach the breakdown voltage of CR104 and turn Q102 on. This will allow C102 to quickly discharge through R123 and Q102 and provide the full 150 ms. time delay to be effective on any subsequent loss of guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 2.25 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.6 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental ininsertion of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	* 1000 hertz, minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

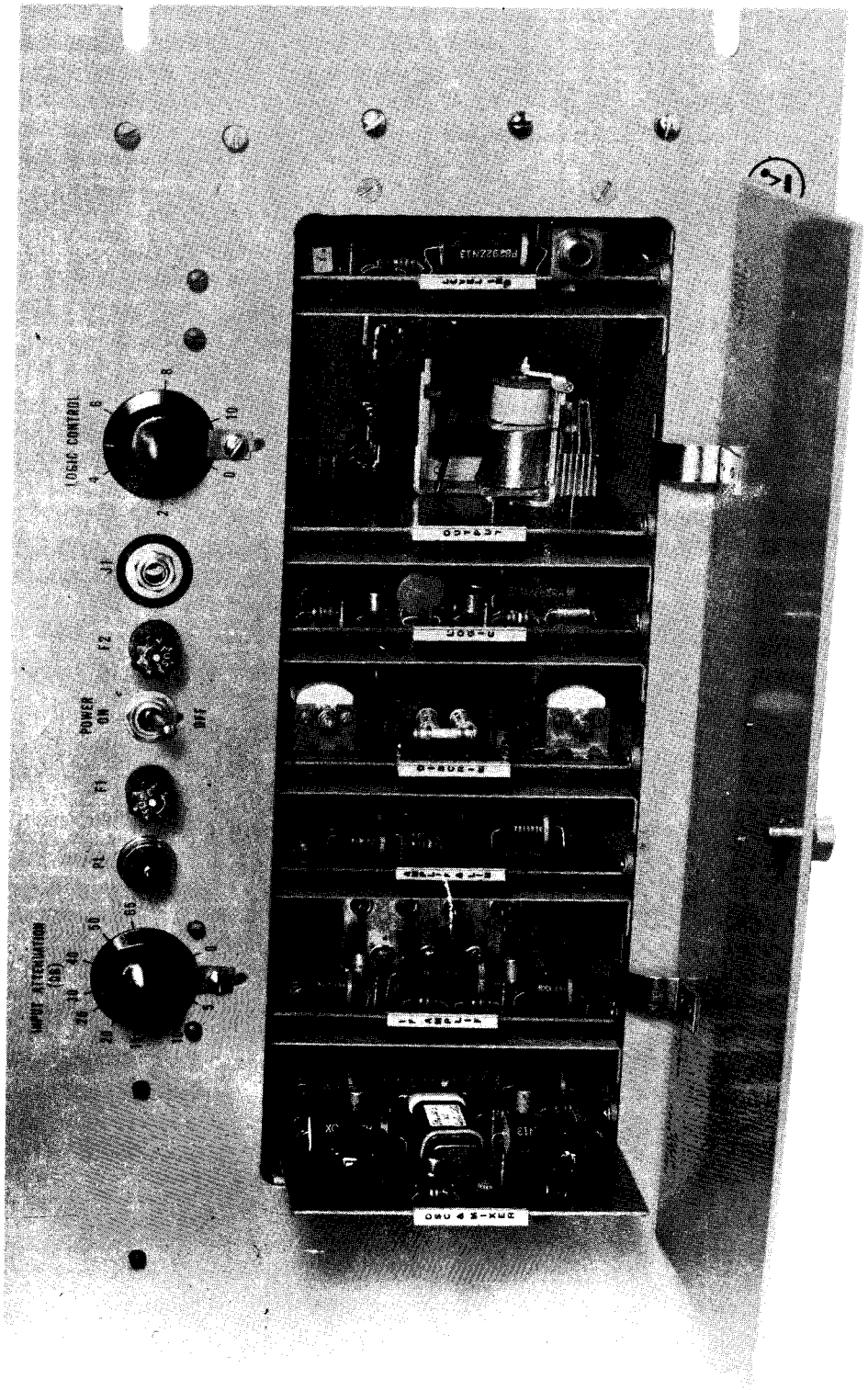
The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

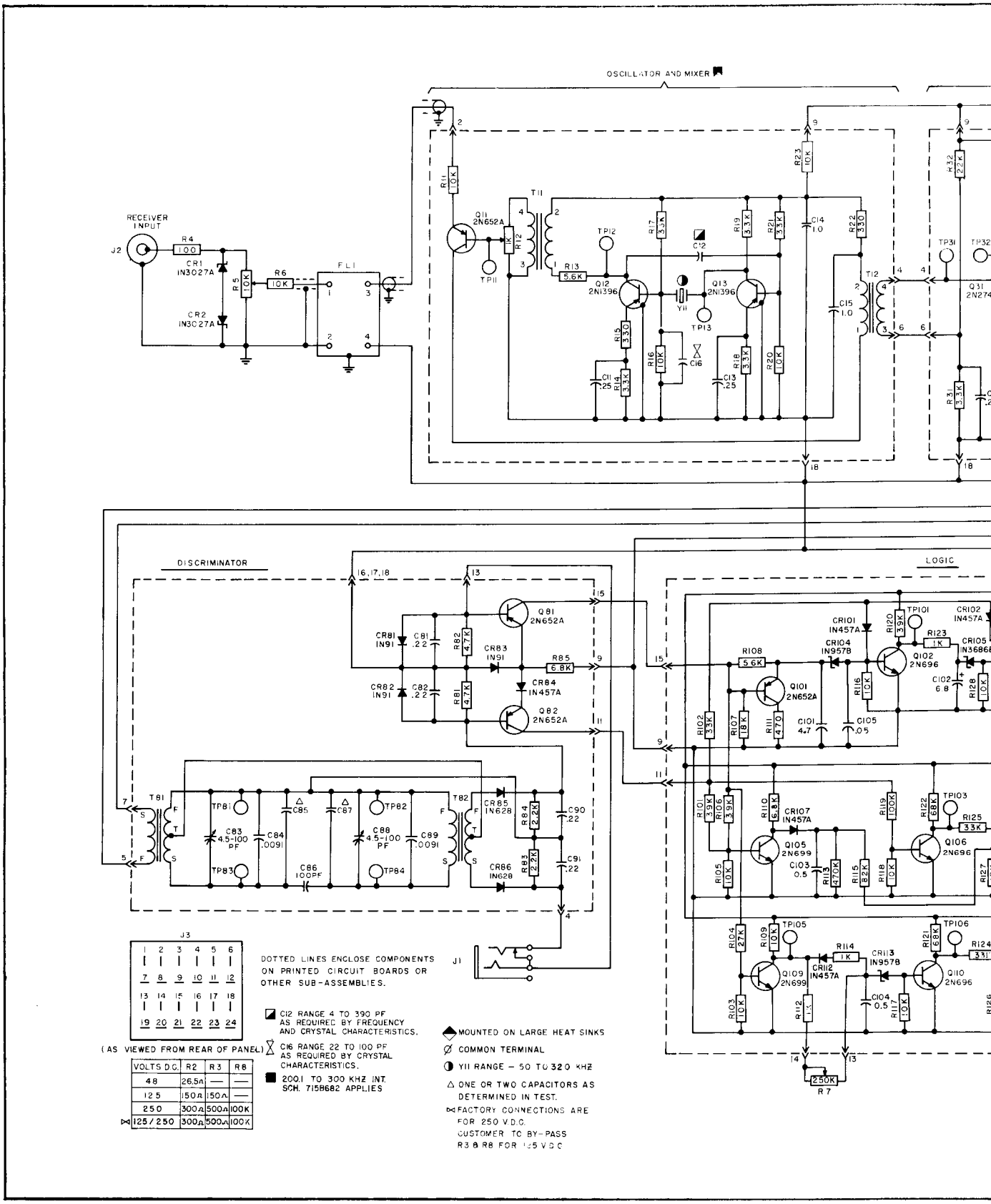
In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

ADDENDUM

With shipments of sets starting in early 1973, the germanium transistors used in the various modules were replaced with silicon transistors. In addition, due to the nature of silicon transistors, some resistor values in the circuits had to be changed In order to correctly bias these transistors. Therefore the transistors are not replaceable on a pin for pin basis throughout the receiver. Before attempting to replace a germanium transistor with a silicon transistor on older sets using germanium, please check the schematics on the following pages to see if the location where the replacement is desired has additional component changes. If that is the case, then the replacement can only be made by the same designation transistor or the additional component changes must also be made. It should be pointed out that the modules containing the silicon transistors are completely interchangeable with the modules containing germanium transistors. Therefore, there is no problem with intermixing the silicon transistor modules in the same receiver. Thus complete new modules containing silicon transistors can be ordered and used as replacements in older receivers having germanium transistor modules. The new modules have the same style numbers as the old germanium transistor modules they replace.

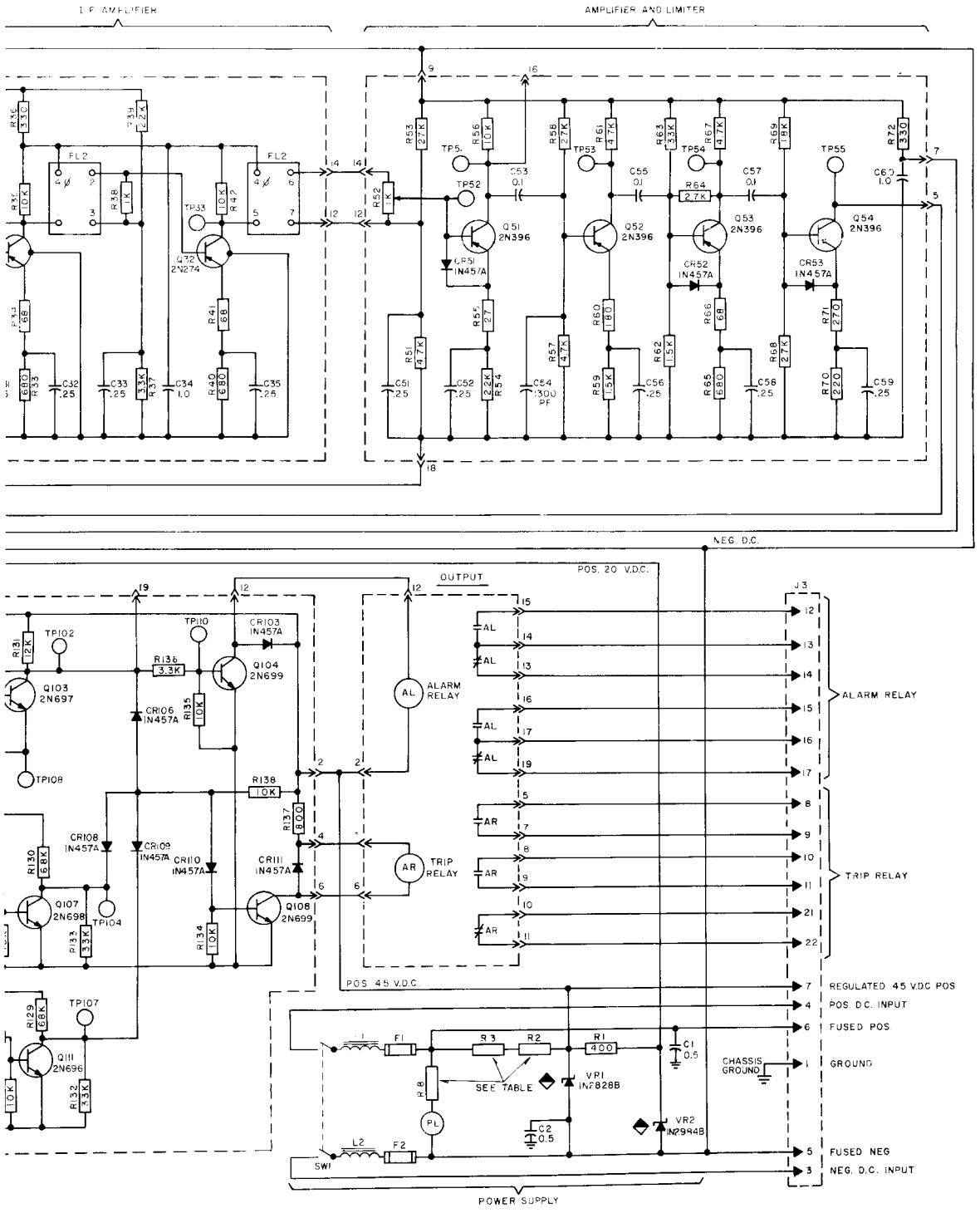


Type TCF Receiver (Front View).



VOLTS D.C.	R2	R3	R8
48	26.5Ω	—	—
125	150Ω	150Ω	—
250	300Ω	500Ω	100K
125/250	300Ω	500Ω	100K

Fig. 1. Internal schematic of the type



543D637

TCF receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Imput Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf, 50 v.d.c.	184A663H04
C213	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. v 5%; 400 MW.	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ± 5%; Wire Wound	09D832G19
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	205C043G03
T12	Toroidal type, 25000/300 ohms	205C043G03
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	205C043G01
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01+(Req.Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408C845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

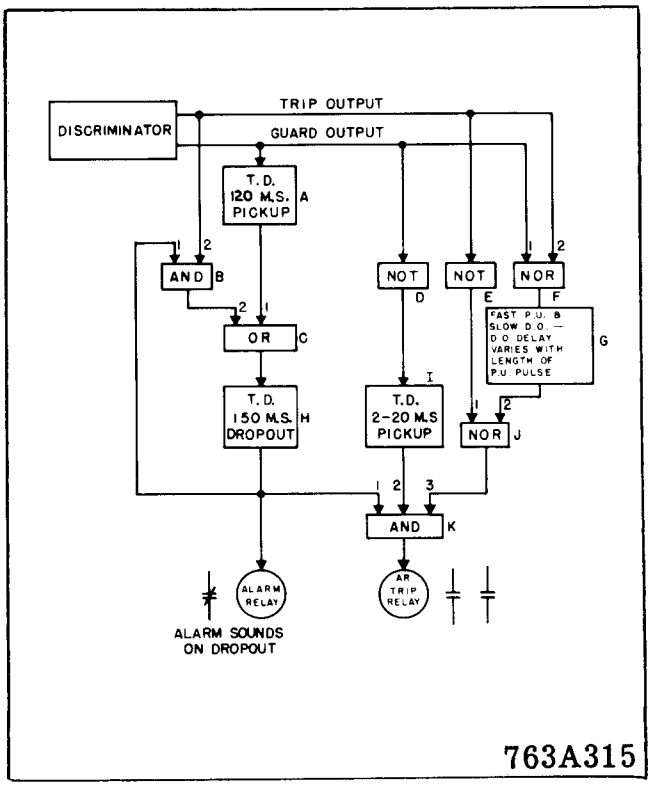


Fig. 3 Block diagram of output logic circuit

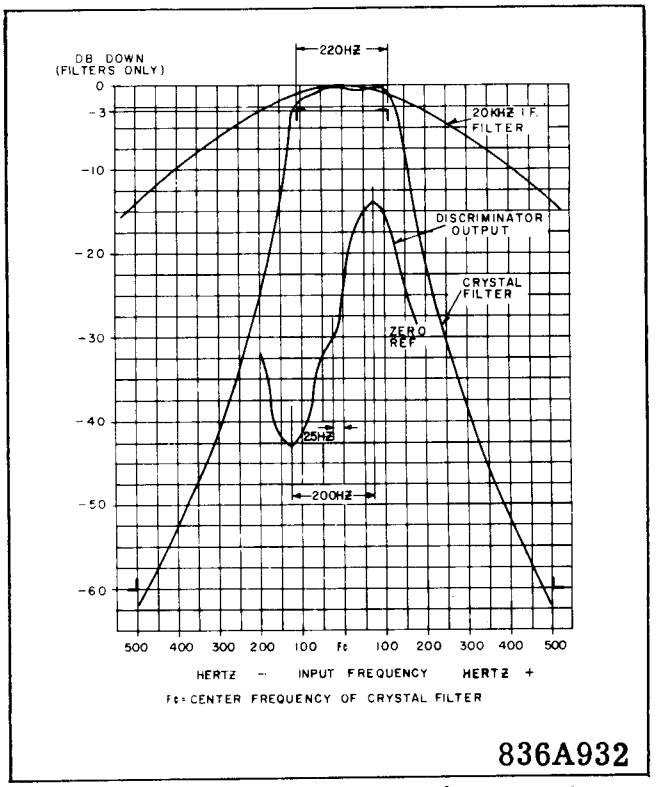


Fig. 4 Filter and discriminator characteristics of the type TCF receiver

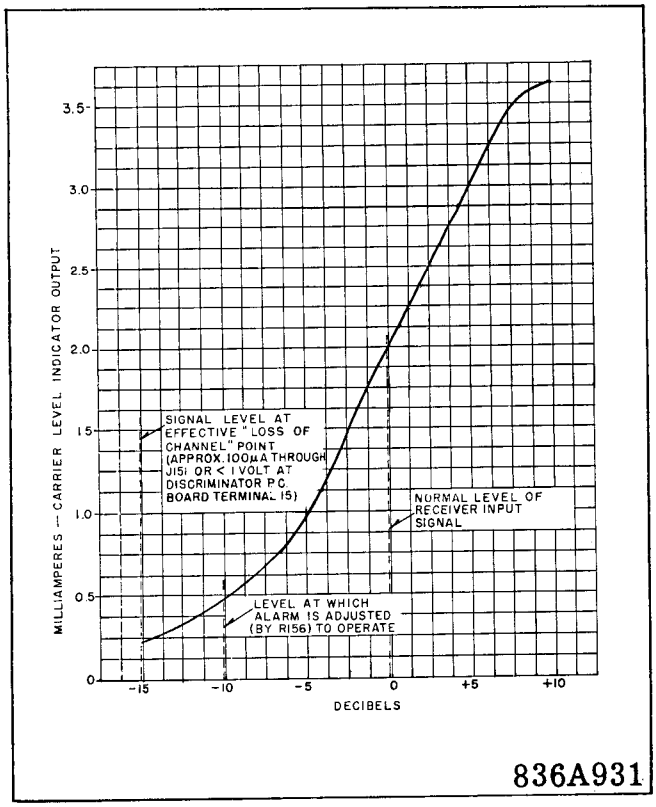


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

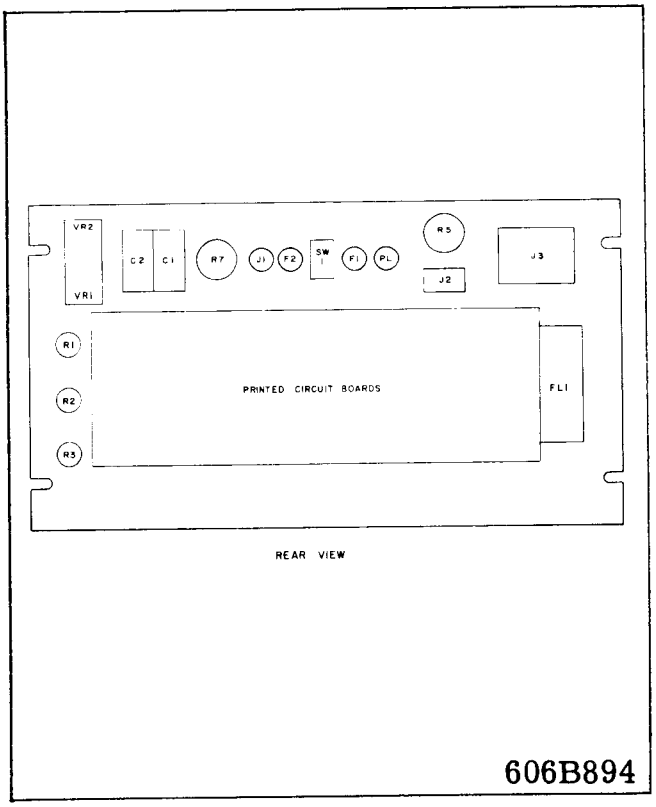


Fig. 6 Component locations on the type TCF receiver panel

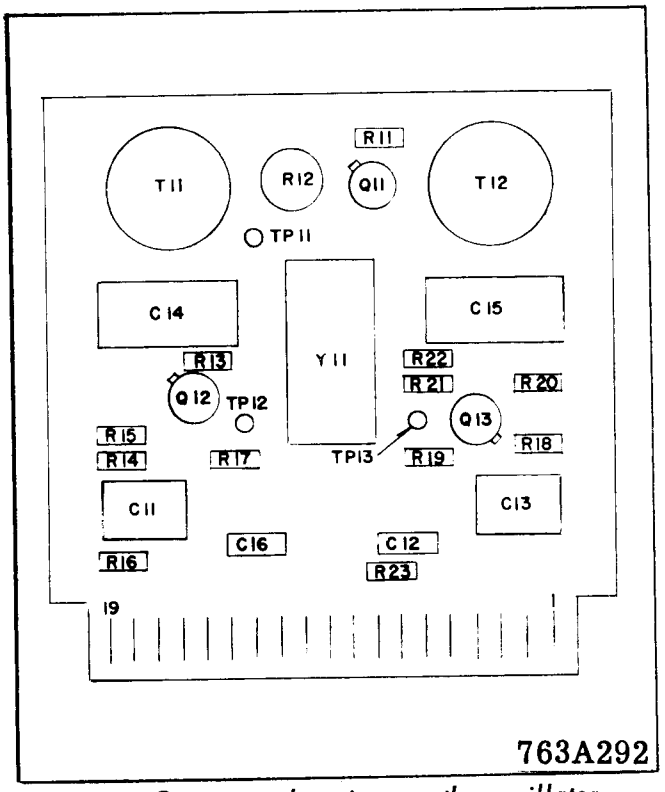


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

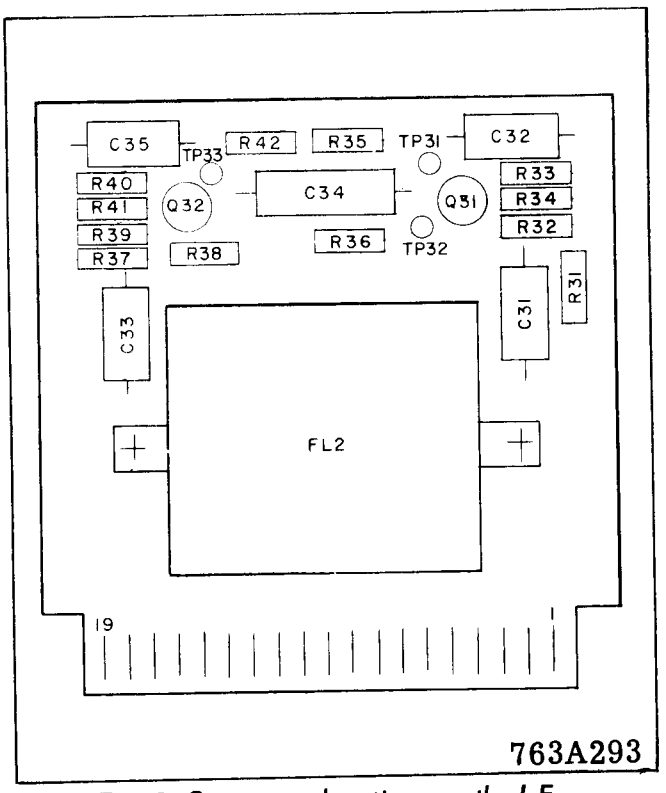


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

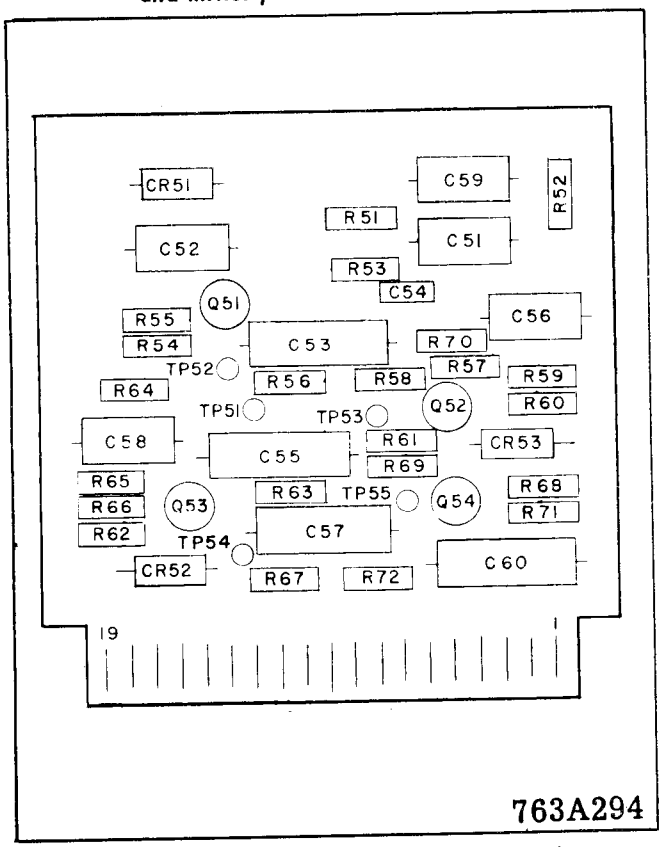


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

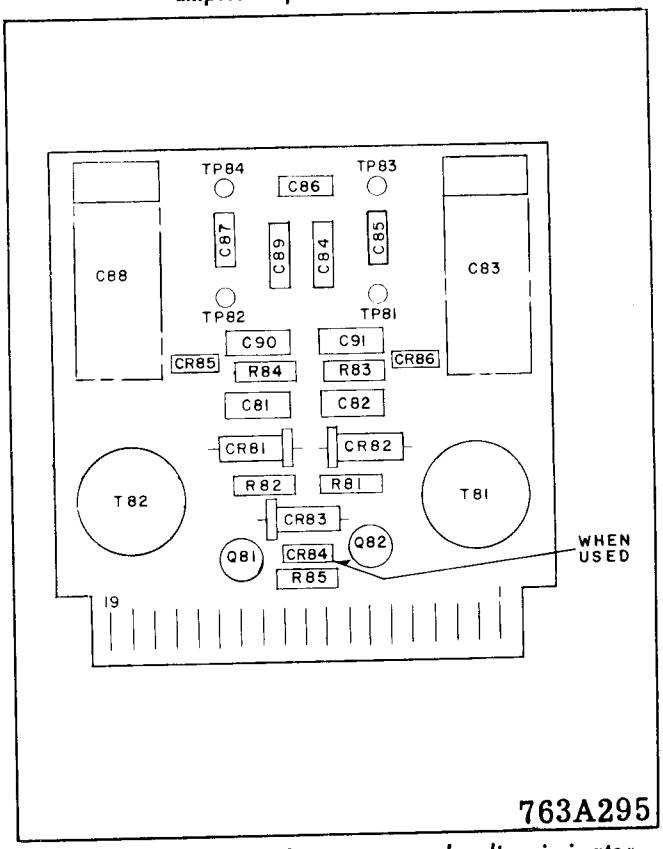


Fig. 10 Component locations on the discriminator printed circuit board.

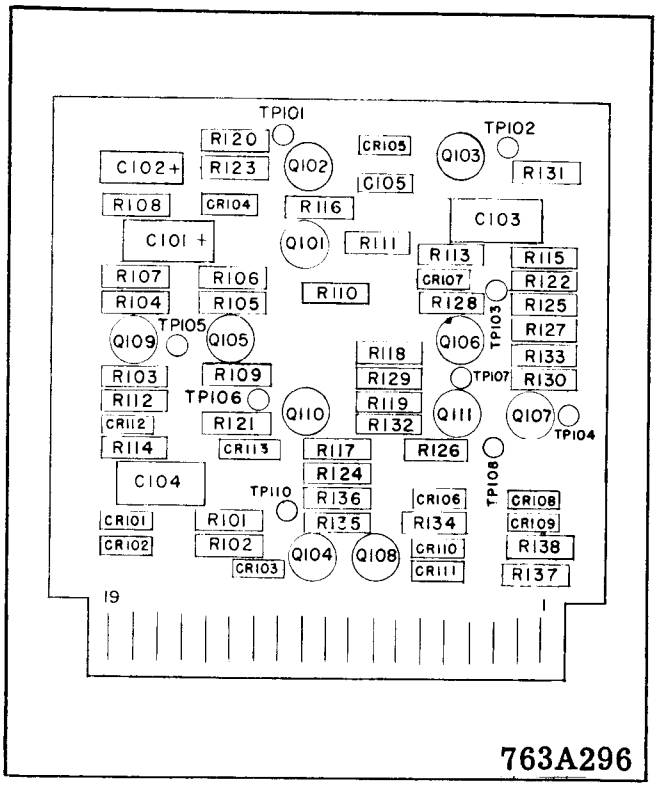


Fig. 11 Component locations on the logic printed circuit board.

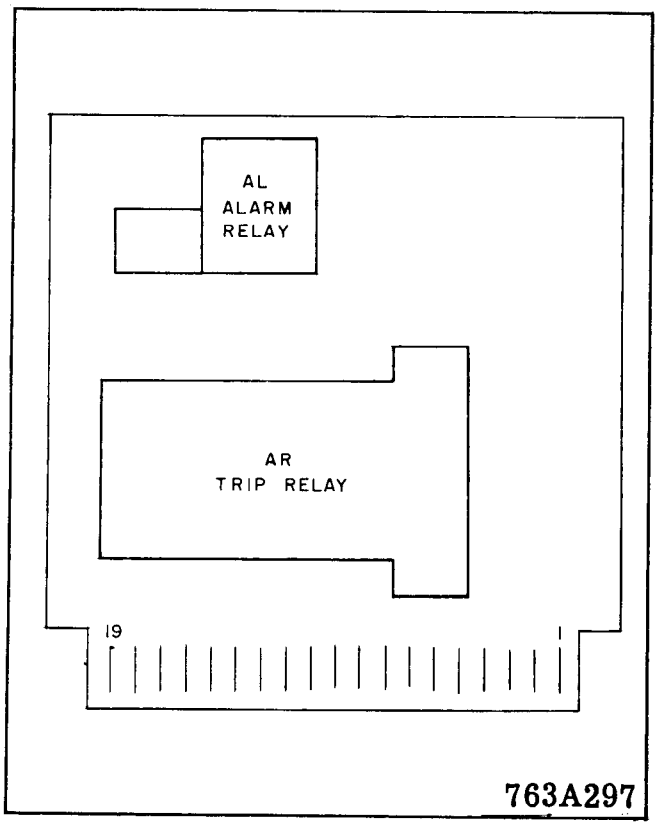


Fig. 12 Component locations on the output printed circuit board.

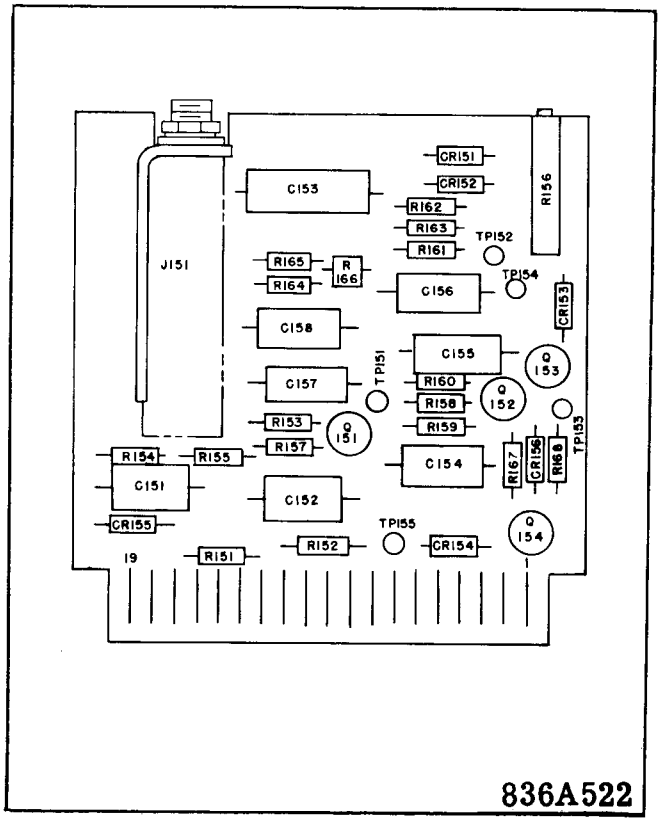


Fig. 13 Component locations on the carrier level indicator printed circuit board.

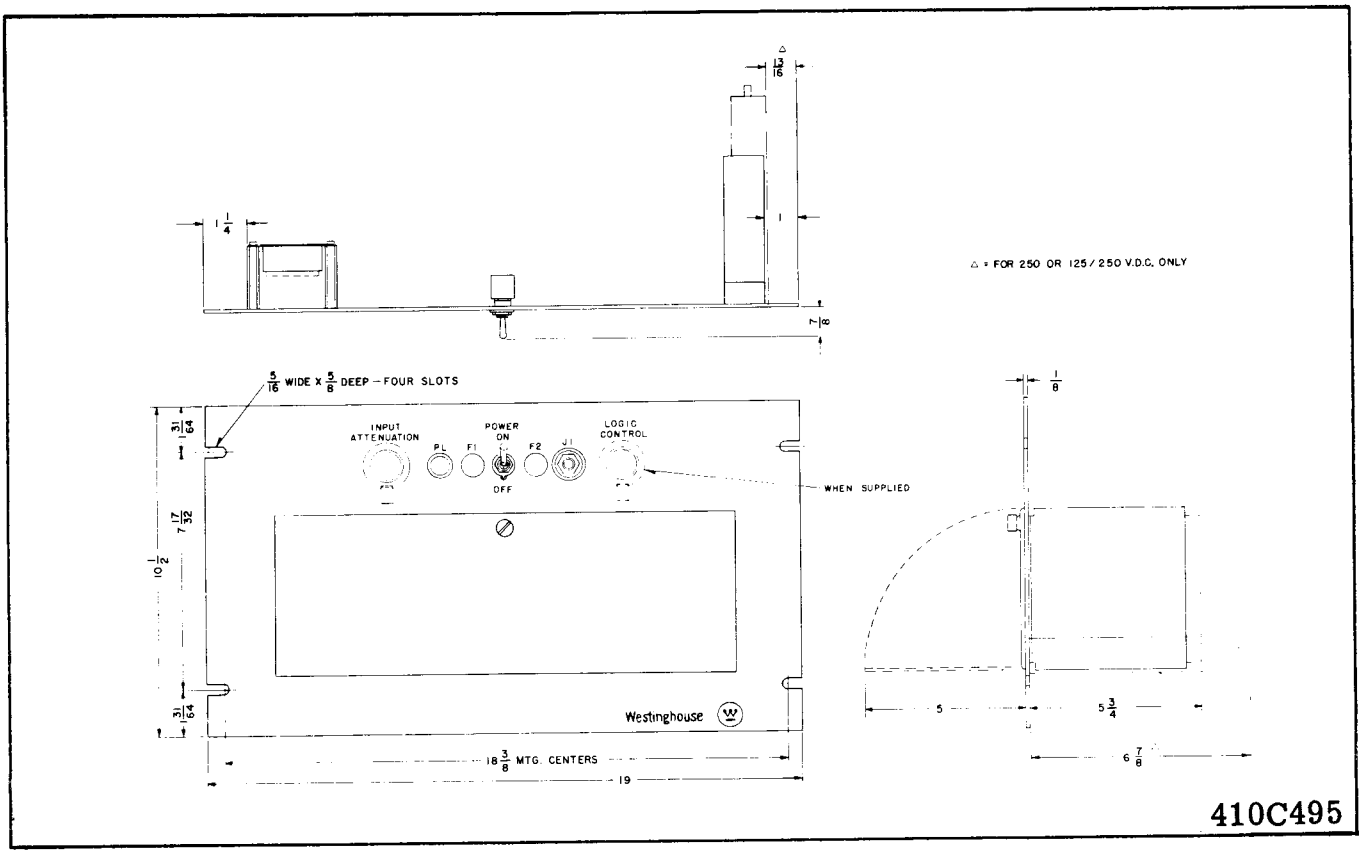


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

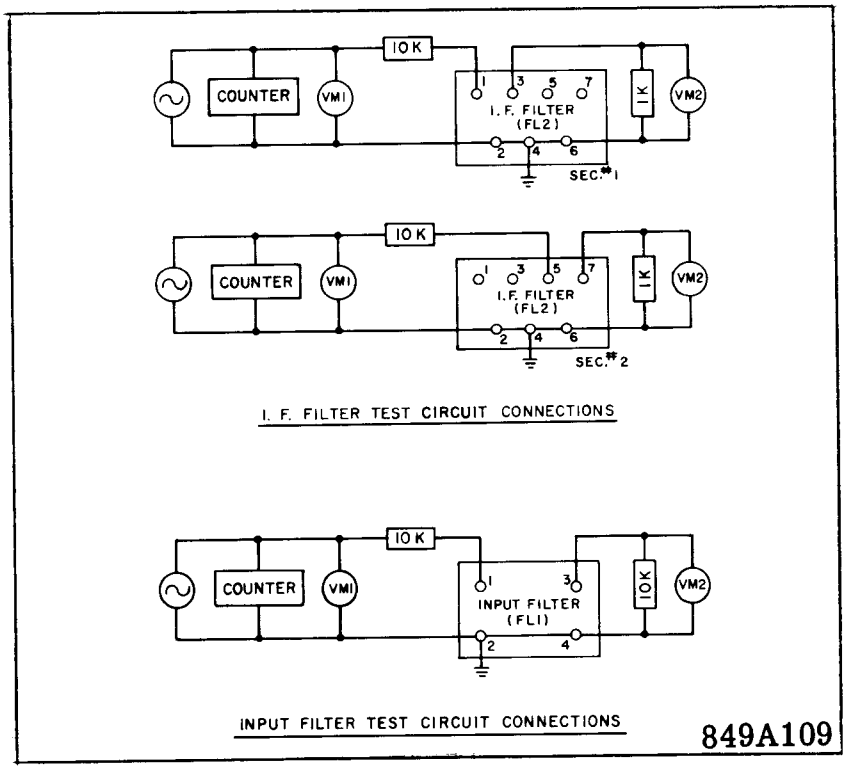


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.

COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q11–Q12–Q13	849A441H03	3	2N4249
RESISTOR			
R15–R22	184A763H15	2	330Ω 1/2W ±5%
R14–R18–R19	184A763H39	3	3.3K 1/2W ±5%
R13	184A763H45	1	5.6K 1/2W ±5%
R11–R16–R20–R23	184A763H51	4	10K 1/2W ±5%
R17–R21	184A763H63	2	33K 1/2W ±5%
R24	184A763H83	1	220K 1/2W ±5%
R25	184A763H43	1	4.7K 1/2W ±5%
CAPACITOR			
C11–C13–C17	187A624H02	3	.25MFD. 200V.
C14–C15	187A624H04	2	1MFD. 200V.
C12	SEE NOTE ▼		
C16	SEE NOTE ■		
POTENTIOMETER			
R12	629A430H02	1	1000Ω
TRANSFORMER			
T11	205C043G01	1	10,000/400
T12	205C043G03	1	25,000/300
CRYSTAL			
Y11	SEE NOTE ○		

▼=C12 RANGE 4 TO 390Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

■=C16 RANGE 22 TO 100Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

○=Y11 RANGE-50 TO 220 KHZ.

REF. COMPONENT LOCATION- 763A292

264C855

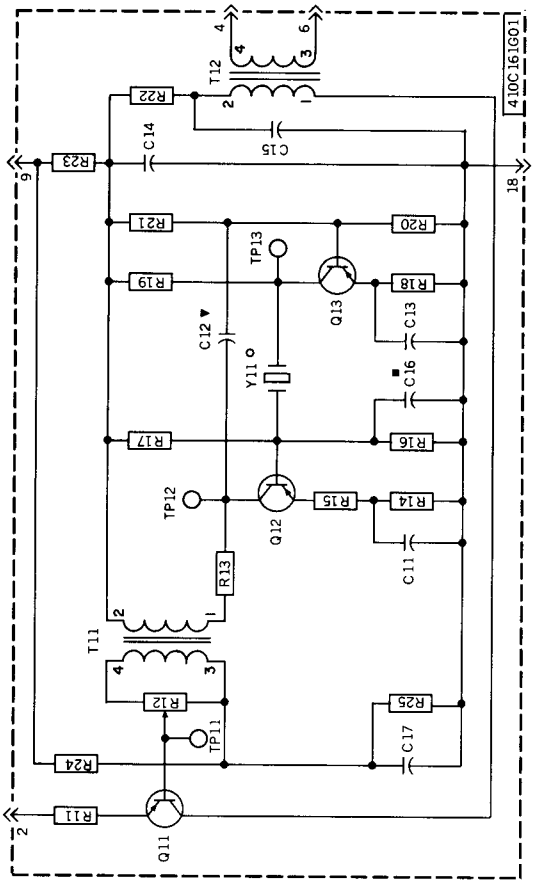


Fig. 18. Internal Schematic 30-200KHz Oscillator and Mixer Silicon Transistor Version

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q211	849A441H03	1	2N4249
RESISTOR			
R211–R213–R215	184A763H51	3	10K 1/2W ±5%
R212	184A763H27	1	1K 1/2W ±5%
R214	184A763H37	1	2.7K 1/2W ±5%
R216	184A763H49	1	8.2K 1/2W ±5%
R217	184A763H34	1	2K 1/2W ±5%
R218	184A763H07	1	150Ω 1/2W ±5%
R219	184A763H15	1	330Ω 1/2W ±5%
R220	184A763H67	1	47K 1/2W ±5%
R221	184A763H83	1	220K 1/2W ±5%
R222	184A763H43	1	4.7K 1/2W ±5%
CAPACITOR			
C211	SEE NOTE ▲		
C212–C213–C215	184A663H04	3	.1MFD. 50V.
C214	SEE NOTE ○		
C216–C217	187A624H04	2	1 MFD. 200V.
C218	187A624H02	1	.25 MFD. 200V.
ZENER DIODE			
Z201	862A606H01	1	1N753A
INTERNAL CIRCUIT			
IC201	201C826H04	1	UA710C
TRANSFORMER			
T211	714B677G01	1	
T212	205C043G03	1	
CRYSTAL			
Y11	SEE NOTE □	1	

▲= C211 RANGES FROM 100Pf. TO 1,000Pf.
○= C214 STYLE NO. 187A695H17 .56Pf. BUT MAY VARY UP TO 100Pf.
□= Y11 FREQUENCY EQUALS RECEIVER (CHANNEL) FREQUENCY PLUS 20 KHZ.

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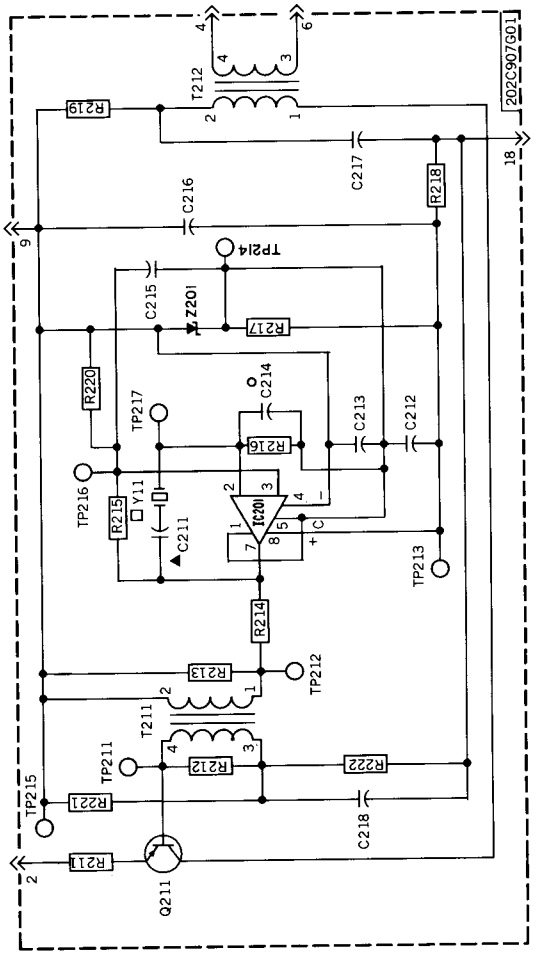

* *Fig. 19. Internal Schematic 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version*

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q31–Q32	849A441H03	2	2N4249
RESISTOR			
R34–R41	187A290H21	2	68Ω 1/2W ±5%
R36	184A763H15	1	330Ω 1/2W ±5%
R33–R40	184A763H23	2	680Ω 1/2W ±5%
R38	184A763H27	1	1K 1/2W ±5%
R31–R37	184A763H39	2	3.3K 1/2W ±5%
R35–R42	184A763H51	2	10K 1/2W ±5%
R32–R39	184A763H59	2	22K 1/2W ±5%
CAPACITOR			
C31–C32–C33–C35	187A624H02	4	.25MFD. 200V
C34	187A624H04	1	1MFD. 200V.
C36	762A757H01	1	100 Pf.
FILTER			
FL2	762A613G01	1	

Ø = COMMON TERMINAL

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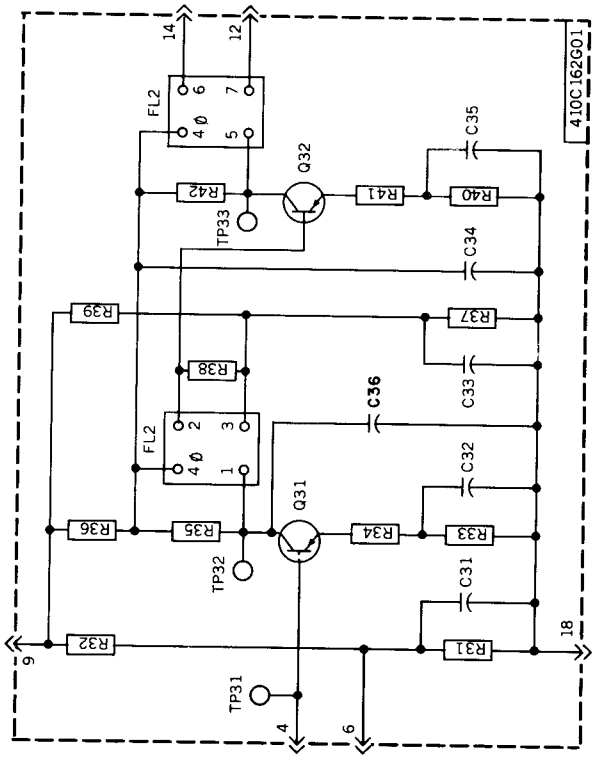

Fig. 20. Internal Schematic I.F. Amplifier – Silicon Transistor Version

COMPONENT	STYLE	REQ.	REF
TRANSISTOR			
Q51–Q52–Q53–Q54	849A441H03	4	2N4249
RESISTOR			
R66	187A290H21	1	68Ω 1/2W ±5%
R55	187A290H11	1	27Ω 1/2W ±5%
R70	184A763H11	1	220Ω 1/2W ±5%
R72	184A763H15	1	330Ω 1/2W ±5%
R65	184A763H23	1	680Ω 1/2W ±5%
R59	184A763H31	1	1.5K 1/2W ±5%
R54–R62	184A763H35	2	2.2K 1/2W ±5%
R64–R68	184A763H37	2	2.7K 1/2W ±5%
R51–R57–R61–R67	184A763H43	4	4.7K 1/2W ±5%
R56	184A763H51	1	10K 1/2W ±5%
R69	184A763H57	1	18K 1/2W ±5%
R53–R58	184A763H61	2	27K 1/2W ±5%
R63	184A763H63	1	33K 1/2W ±5%
R71	09D8326G20	1	100Ω ±2%
R60	184A763H09	1	180Ω 1/2W ±5%
R73	629A453H02	1	56Ω 1/2W ±2%
CAPACITOR			
C54	187A584H15	1	1300MMF. 500V.
C51–C52–C56–C58–C59	187A624H02	5	25MFD. 200V.
C53–C55–C57	187A624H01	3	0.1MFD. 200V.
C60	187A624H04	1	1.0MFD. 200V.
DIODE			
D51–D52–D53	184A855H07	3	1N457A
POTENTIOMETER			
R52	629A645H04	1	1K

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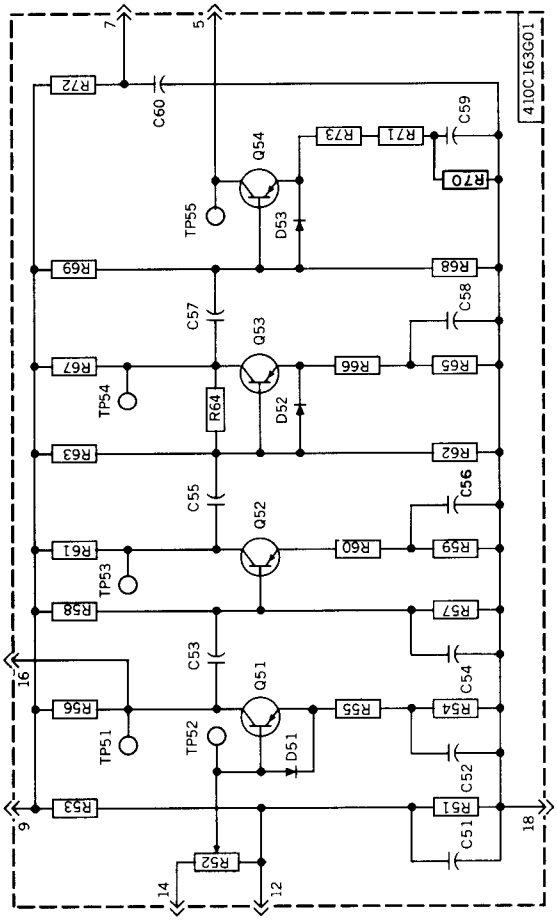

Fig. 21. Internal Schematic Amplifier and Limiter – Silicon Transistor Version

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q81–Q82	849A441H01	2	2N3645
RESISTOR			
R81–R82	184A763H38	2	3K 1/2W ±5%
R83–R84	184A763H35	2	2.2K 1/2W ±5%
R85	184A763H11	1	220Ω 1/2W ±5%
R87	184A763H53	1	12K 1/2W ±5%
SENSISTOR			
R86	187A685H03	1	1.2K 1/4W ±10%
CAPACITOR			
C81–C82–C90–C91	762A703H01	4	.22MFD. 50V.
C83–C88	762A736H02	2	4.5 TO 100PF.
C84–C89	187A624H16	2	.0091MFD. 200V.
C86	187A684H08	1	100PF.
C85–C87	SEE NOTE □		
DIODE			
D81–D82–D84	184A855H07	3	1N457A
D85–D86	184A855H12	2	1N628
TRANSFORMER			
T81	606B533G01	1	
T82	606B533G02	1	

□=ONE OR TWO CAPACITORS USED; VALUES DETERMINED IN TEST.

▲=FOR STYLE 410C164G03 REVERSE START AND FINISH LEADS OF T82.

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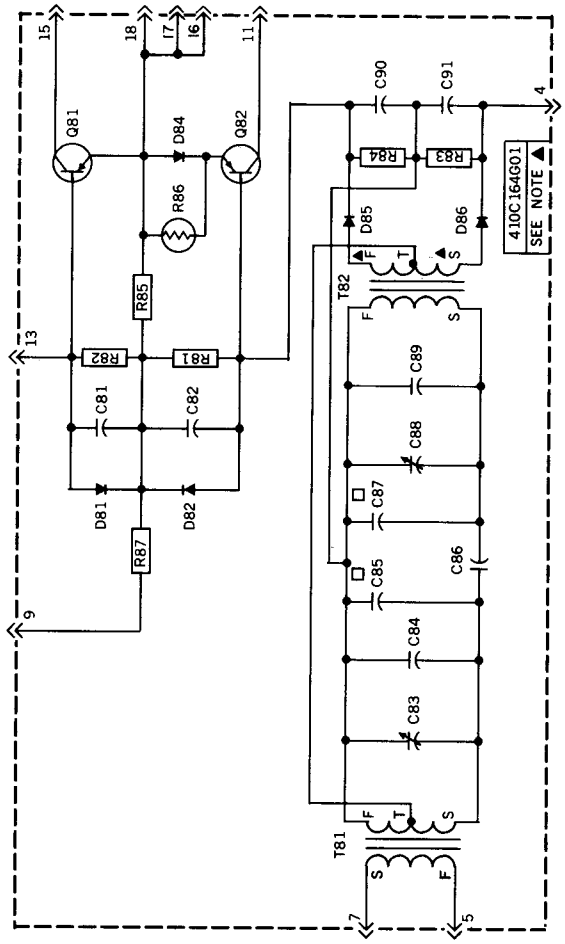

* *Fig. 22. Internal Schematic Discriminator – Silicon Transistor Version*

COMPONENT	STYLE	REQ.	REF
TRANSISTOR			
Q151–Q152–Q153	849A441H03	3	2N4249
Q154	184A638H19	1	2N699
RESISTOR			
R151–R168	184A763H51	2	10K 1/2W ±5%
R152	187A685H01	1	2.2K
R153	184A763H11	1	220Ω 1/2W ±5%
R154	184A763H39	1	3.3K 1/2W ±5%
R155–R159	184A763H55	2	15K 1/2W ±5%
R157–R158	184A763H43	2	4.7K 1/2W ±5%
R160	184A763H21	1	560Ω 1/2W ±5%
R161	184A763H29	1	1.2K 1/2W ±5%
R162–R163	184A763H09	2	180Ω 1/2W ±5%
R164	184A763H19	1	470Ω 1/2W ±5%
R165	184A763H27	1	1K 1/2W ±5%
R167	184A763H57	1	18K 1/2W ±5%
R171	**184A763H07**	1	**150Ω 1/2W ±5%**
R170	184A763H23	1	680Ω 1/2W ±5%
POTENTIOMETER			
R156	629A645H07	1	2.5K
THERMISTOR			
R166	185A211H08	1	1D201
CAPACITOR			
C151–C152–C154 TO C158	187A624H02	7	.25MFD. 200V.
C153	187A624H04	1	1MFD. 200V.
DIODE			
D151 TO D156–D158	184A855H07	7	1N457A
TELEPHONE JACK			
J151	187A606H01	1	

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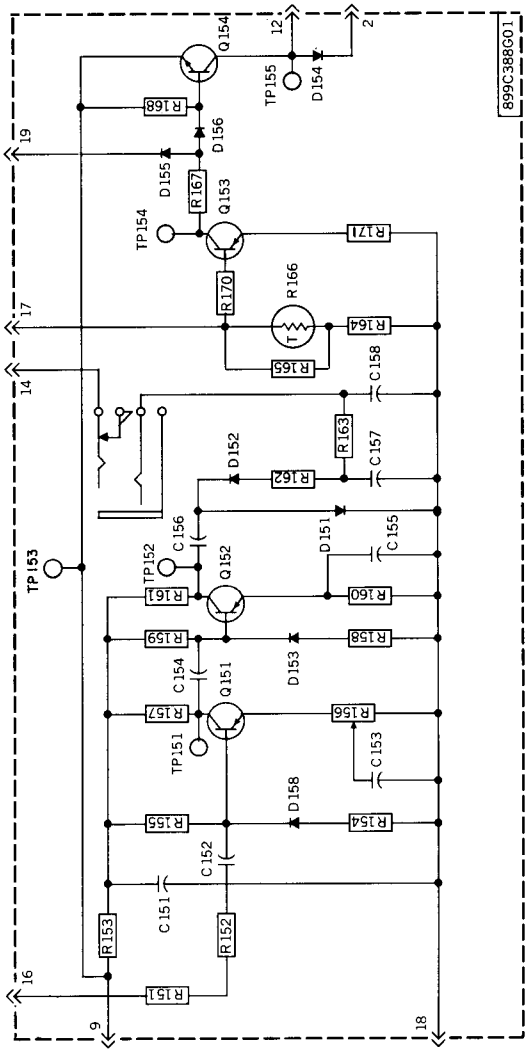
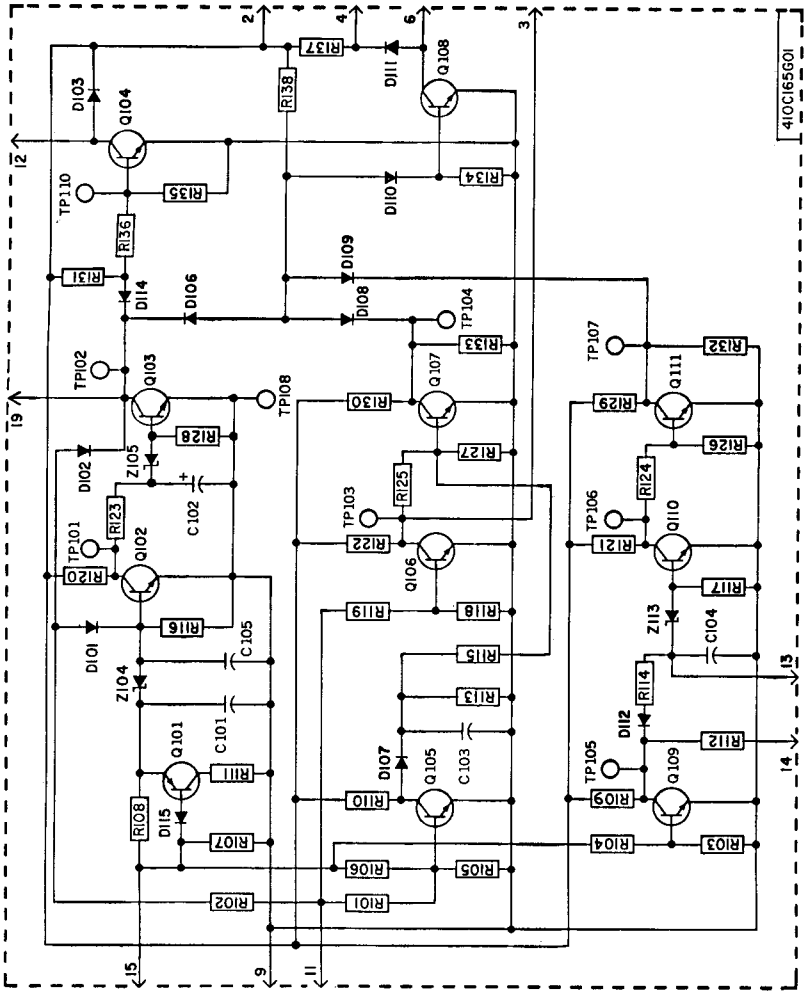


* *Fig. 23. Internal Schematic Carrier Level Indicator – Silicon Transistor Version*

COMPONENT	STYLE	REQ	REF
TRANSISTORS			
Q101	849A441H03	1	(2N4249)
Q102-106-110-111	762A585H01	4	(2N696)
Q103	184A638H18	1	(2N697)
Q107	762A585H02	1	(2N698)
Q105-108-109-104	184A638H19	4	(2N699)
RESISTORS			
R110	187A643H47	1	(6.8K 1W ±5%)
R109	187A643H51	1	(10K 1W ±5%)
R137	184A859H06	1	(800 Ω 3W)
R111	184A763H19	1	(470 1/2W ±5%)
R112-R114-R123	184A763H27	3	(1K 1/2W ±5%)
R136	184A763H39	1	(3.3K 1/2W ±5%
R103-105-116 TO 118-126 TO 128-134-135-138	184A763H51	11	(10K 1/2W ± 5%)
R131	184A763H53	1	(12K 1/2W ±5%)
R107	184A763H57	1	(18K 1/2W ±5%)
R104	184A763H61	1	(27K 1/2W ±5%)
R102-124-125-132-133	184A763H63	5	(33K 1/2W ±5%)
R101-106-120	184A763H65	3	(39K 1/2W ±5%)
R108	184A763H69	1	(56K 1/2W ±5%)
R121-122-129-130	184A763H71	4	(68K 1/2W ±5%)
R115	184A763H73	1	(82K 1/2W ±5%)
R119	184A763H75	1	(100K 1/2W ±5%)
R113	184A763H91	1	(470K 1/2W ±5%)
CAPACITORS			
C101	184A661H12	1	(4.7MFD. 10%)
C105	184A663H02	1	(.05MFD. 50V)
C102	184A661H25	1	(6.8MFD.)
C103-104	187A624H11	2	(.5MFD. ±10%)
DIODES			
D114	182A881H07	1	(IN100A)
D101 TO 103-106 TO 112-115	184A855H07	11	(IN457A)
DIO-ZENER			
Z105	185A212H06	1	(IN3686B)
Z113-104	186A797H06	2	(IN957B)



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* *Fig. 24. Internal Schematic Logic Board – Silicon Transistor Version*

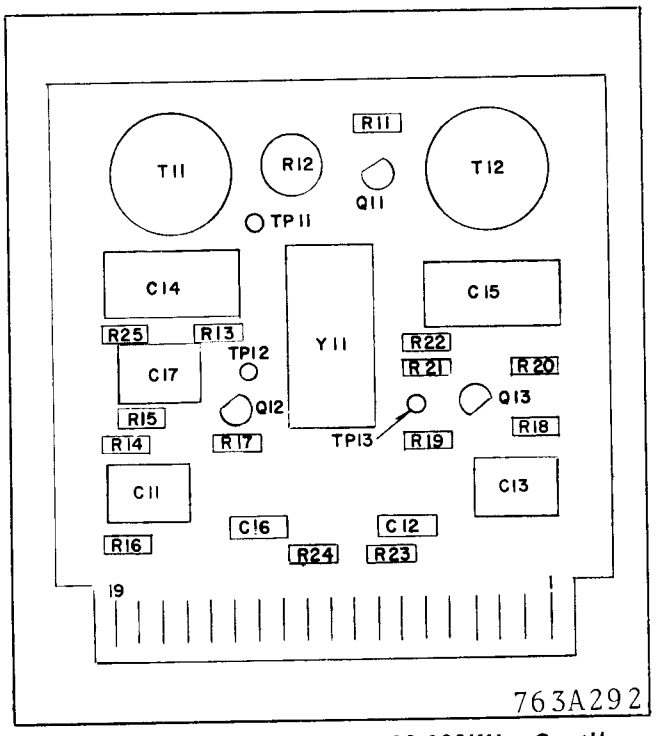

Fig. 25. Component Locations 30-200KHz. Oscillator and Mixer Silicon Transistor Version

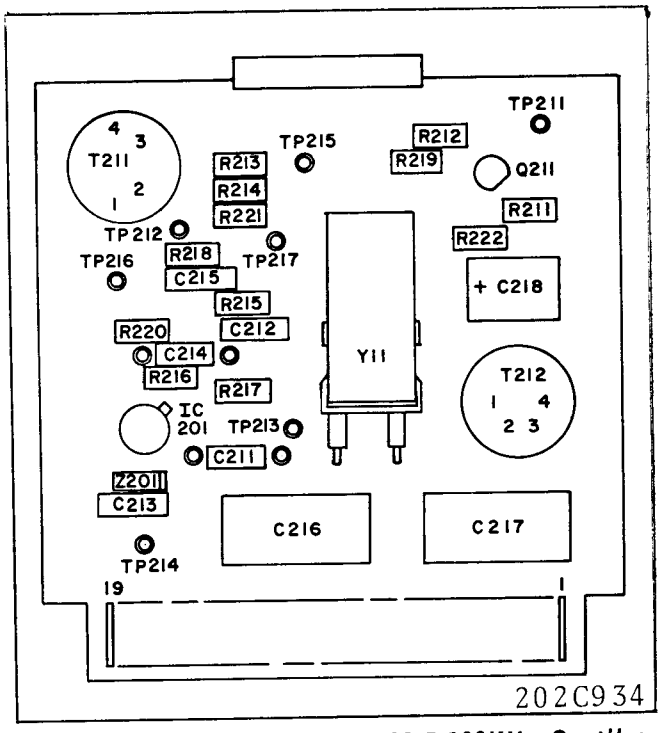

Fig. 26. Component Locations 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version

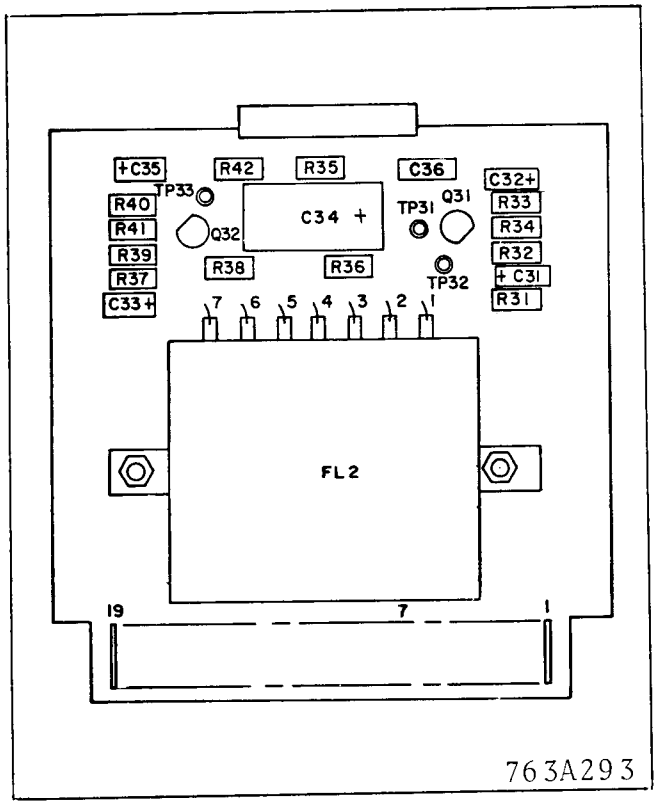

Fig. 27. Component Locations I.F. Amplifier – Silicon Transistor Version

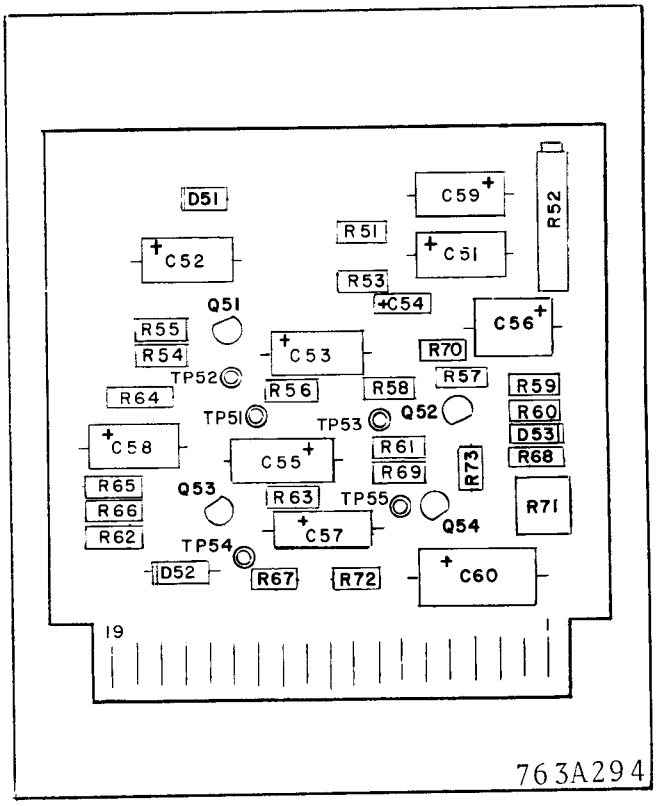

Fig. 28. Component Locations Amplifier and Limiter – Silicon Transistor Version

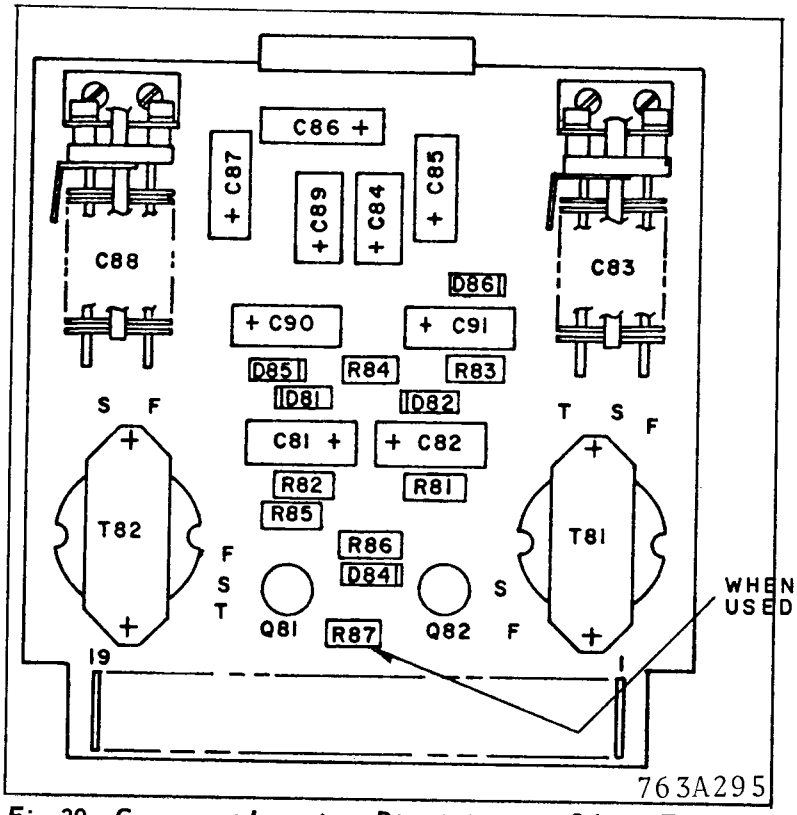

Fig. 29. Component Locations Discriminator – Silicon Transistor Version

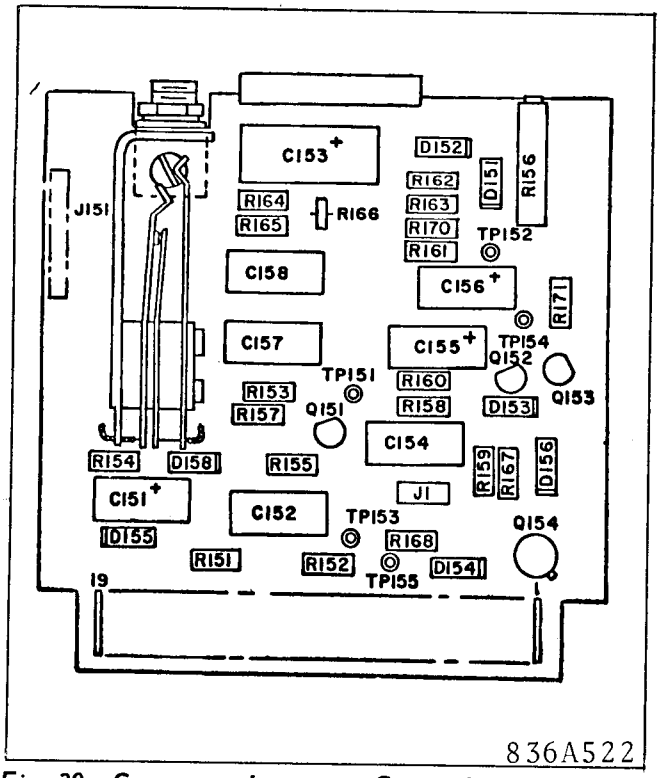

Fig. 30. Component Locations Carrier Level Indicator – Silicon Transistor Version

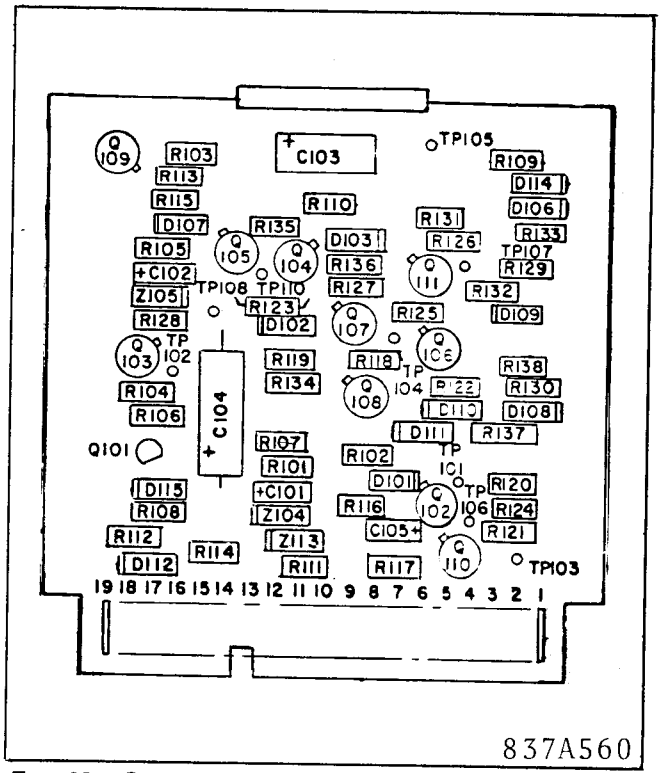

Fig. 31. Component Locations Logic Board – Silicon Transistor Version

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.

Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

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SUPERSEDES I.L. 41-945.51H
*Denotes change from superseded issue.

terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, or IC201 (Fig. 16) and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 kHz above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the later is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20kHz, 2fc + 20kHz, fc + 20kHz and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero output frequency. This separation of 200 hertz between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 hertz in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20 kHz-100 hertz. Similarly, the Trip frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears, the discriminator output at term. 15 will turn Q101 off. C101 will change and after 120 ms. it will reach the breakdown voltage of CR104 and turn Q102 on. This will allow C102 to quickly discharge through R123 and Q102 and provide the full 150 ms. time delay to be effective on any subsequent loss of guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

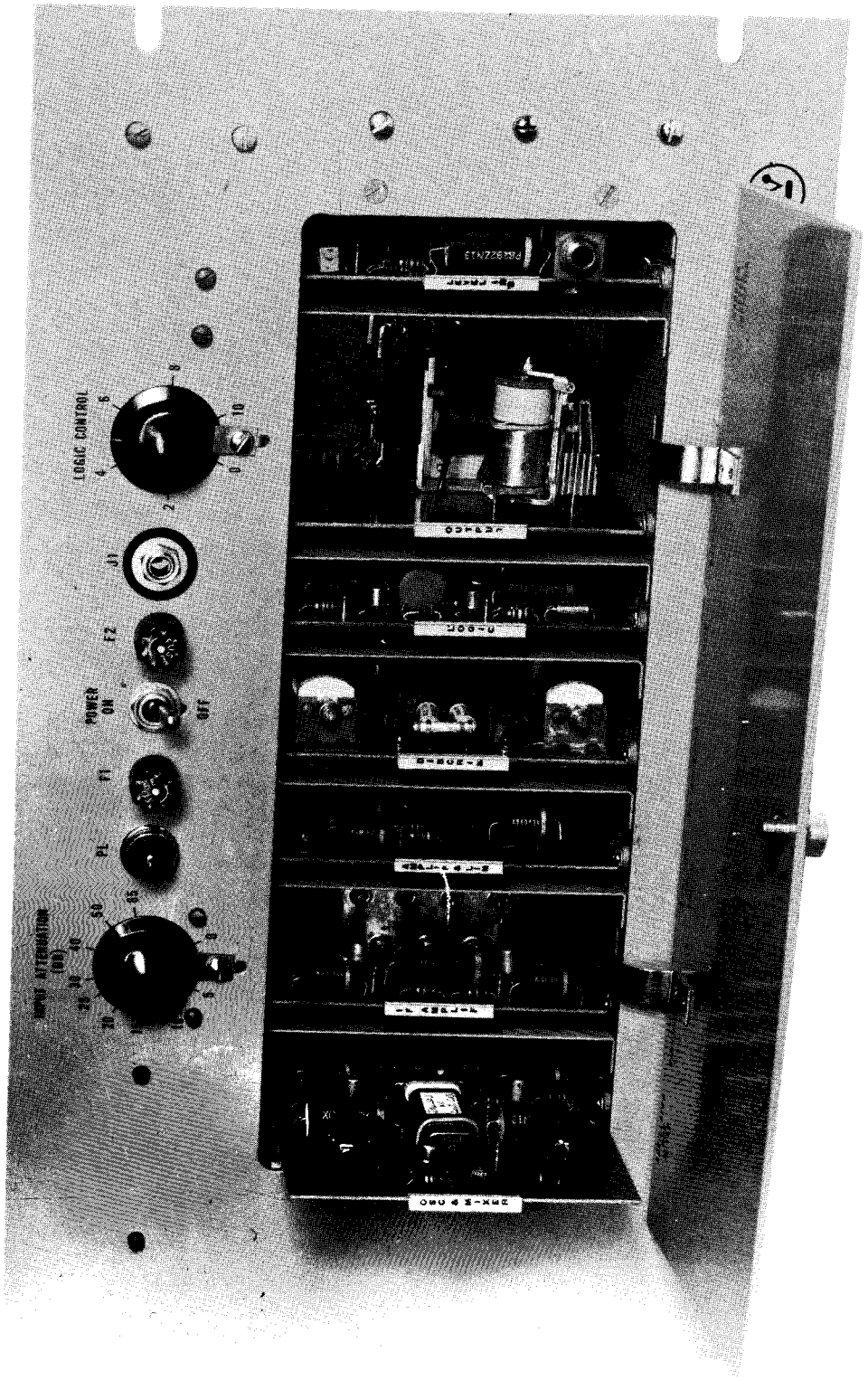
The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

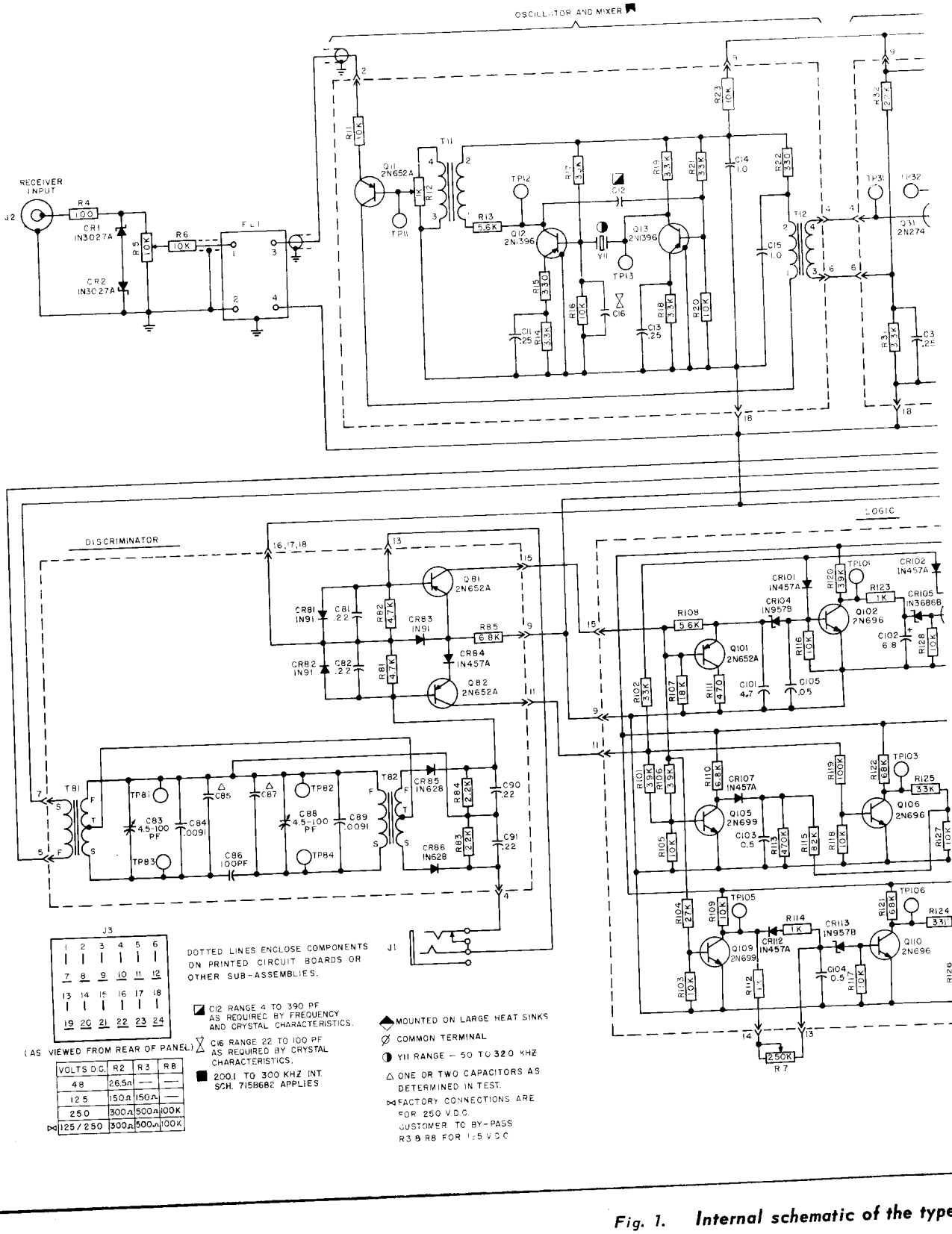
In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

* ADDENDUM

With shipments of sets starting in early 1973, the germanium transistors used in the various modules were replaced with silicon transistors. In addition, due to the nature of silicon transistors, some resistor values in the circuits had to be changed In order to correctly bias these transistors. Therefore the transistors are not replaceable on a pin for pin basis throughout the receiver. Before attempting to replace a germanium transistor with a silicon transistor on older sets using germanium, please check the schematics on the following pages to see if the location where the replacement is desired has additional component changes. If that is the case, then the replacement can only be made by the same designation transistor or the additional component changes must also be made. It should be pointed out that the modules containing the silicon transistors are completely interchangeable with the modules containing germanium transistors. Therefore, there is no problem with intermixing the silicon transistor modules in the same receiver. Thus complete new modules containing silicon transistors can be ordered and used as replacements in older receivers having germanium transistor modules. The new modules have the same style numbers as the old germanium transistor modules they replace.

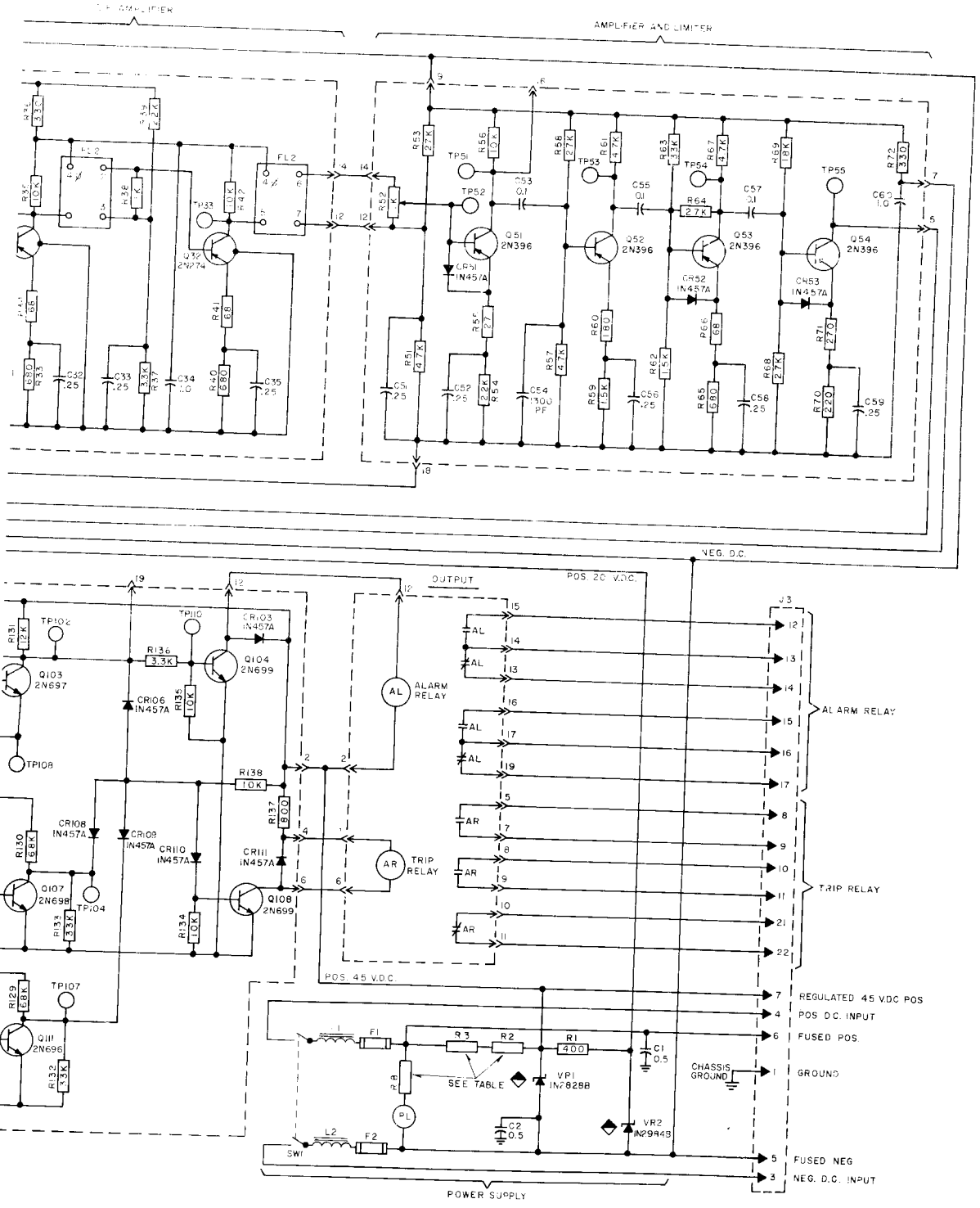


Type TCF Receiver (Front View).



VOLTS D.C.	R2	R3	R8
48	26.5Ω	—	—
125	150Ω	150Ω	—
250	300Ω	500Ω	100K
⋈ 125/250	300Ω	500Ω	100K

Fig. 1. Internal schematic of the type



543D637

TCF receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Imput Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf, 50 v.d.c.	184A663H04
C213	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A855H07
CR156	IN457A; 60 V.; 200 MA.	
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. ± 5%; 400 MW.	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
* R71	270 ohms ± 5%; Wire Wound	09D832G19
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

ELECTRICAL PARTS LIST (Cont'd.)

	CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
		TRANSFORMERS	
	T11	Toroidal type, 10000/400 ohms	205C043G03
	T12	Toroidal type, 25000/300 ohms	205C043G03
	T81	Pot. Core type	606B533G01
	T82	Pot. Core type	606B533G02
	T211	10K:10K	714B677G01
	T212	25K:300	205C043G01
		TRANSISTORS	
	Q11	2N652A	184A638H16
	Q12	2N1396	848A892H01
	Q13	2N1396	848A892H01
	Q31	2N274	187A270H01
	Q32	2N274	187A270H01
	Q51	2N396	762A575H03
	Q52	2N396	762A575H03
	Q53	2N396	762A575H03
	Q54	2N396	762A585H03
	Q81	2N652A	184A638H16
	Q82	2N652A	184A638H16
	Q101	2N652A	184A638H16
	Q102	2N696	762A585H01
	Q103	2N697	184A638H18
	Q104	2N699	184A638H19
	Q105	2N699	184A638H19
	Q106	2N696	762A585H01
	Q107	2N698	762A585H02
	Q108	2N699	184A638H19
	Q109	2N699	184A638H19
	Q110	2N696	762A585H01
	Q111	2N696	762A585H01
	Q151	2N396	762A585H03
	Q152	2N396	762A585H03
	Q153	2N396	762A585H03
	Q154	2N699	184A638H19
	Q211	2N652A	184A638H16
		MISCELLANEOUS	
	Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01+(Req.Freq.)
	FL1	Crystal input Filter	401C466 + (Req. Freq.)
	FL2	I.F. Filter	762A613G01
	PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
		Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
	F1, F2	Fuse, 1.5 A.	11D9195H26
	AL	Alarm Relay	408C062H07
*	AR	Trip Relay	408C845G03
	L1-L2	Choke	292B096G02
	IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

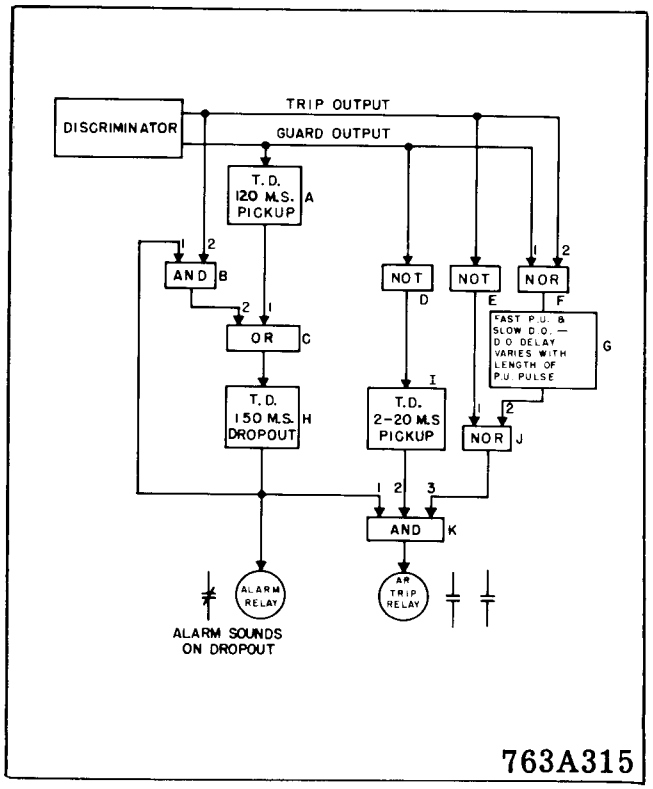


Fig. 3 Block diagram of output logic circuit

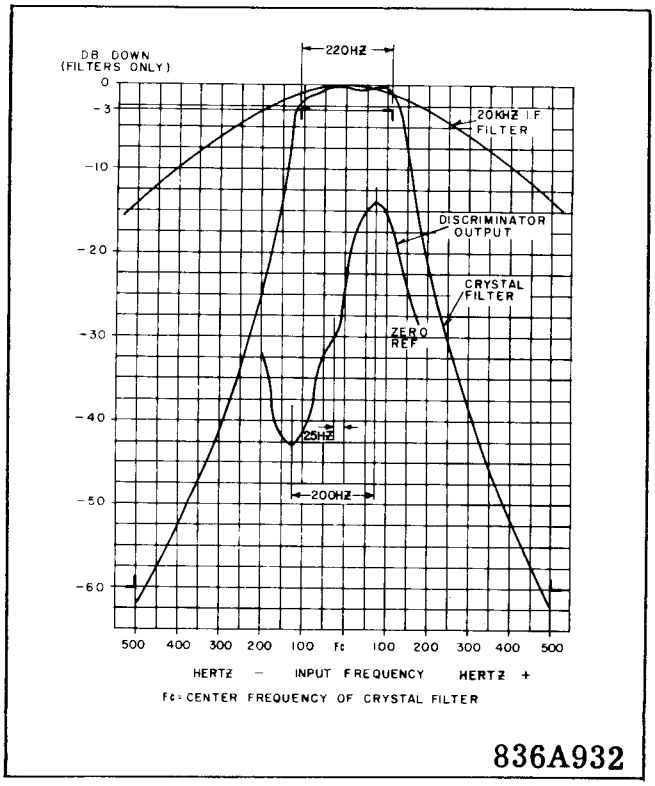
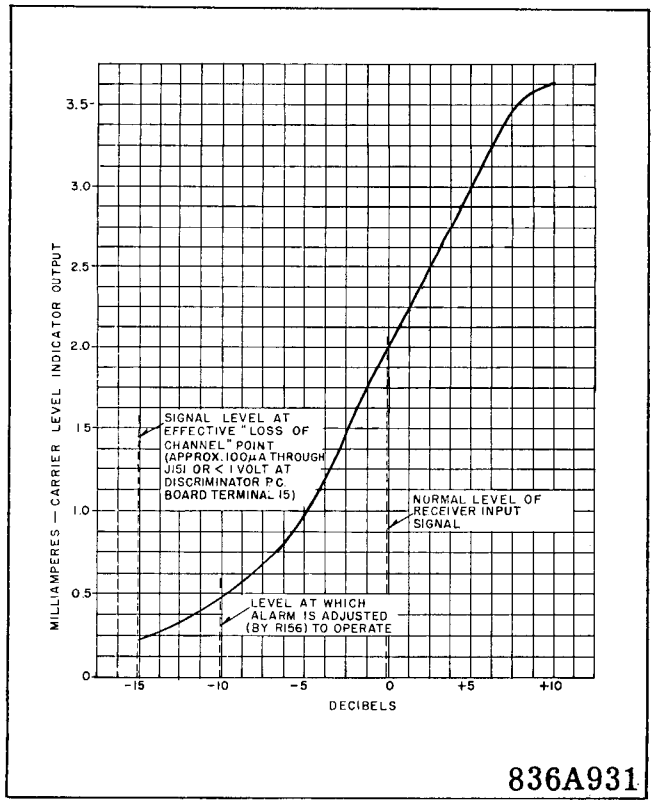


Fig. 4 Filter and discriminator characteristics of the type TCF receiver



* *Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.*

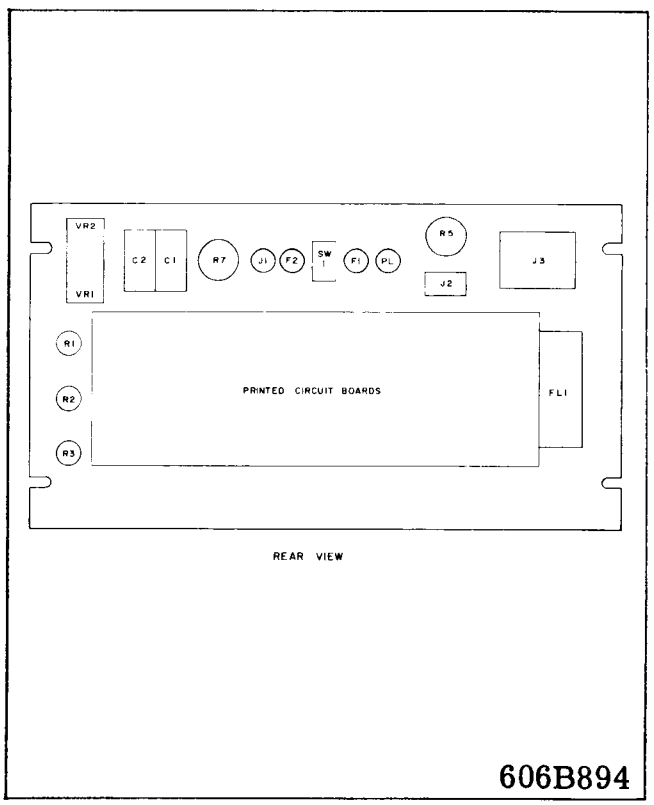


Fig. 6 Component locations on the type TCF receiver panel

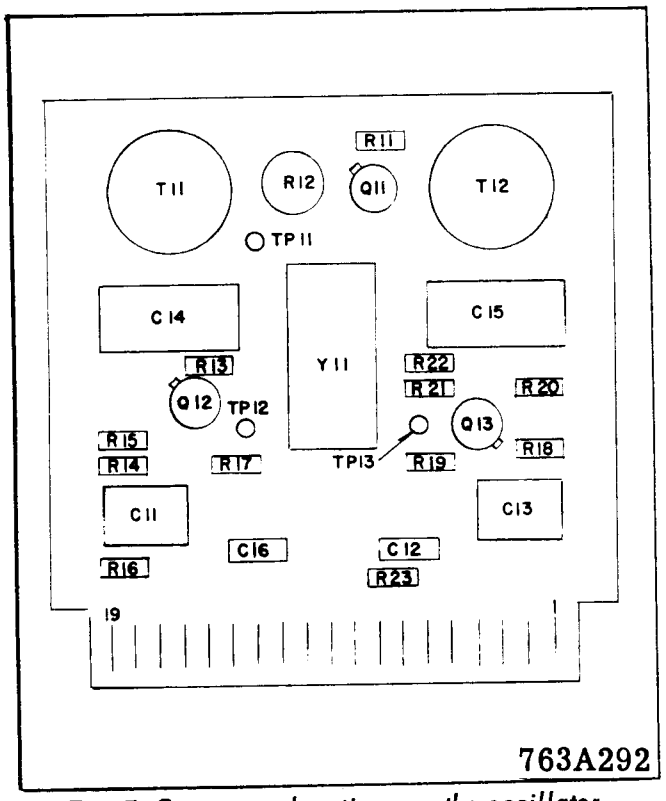


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

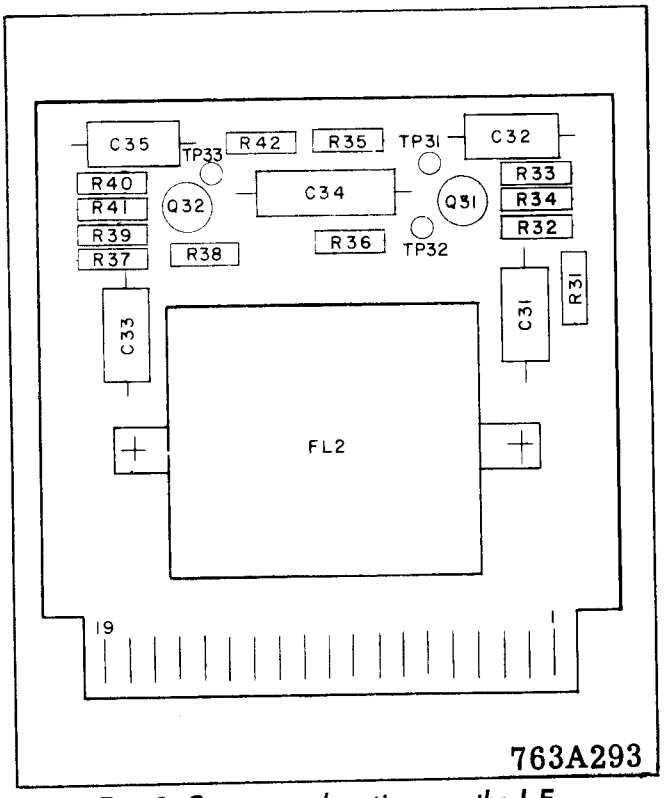


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

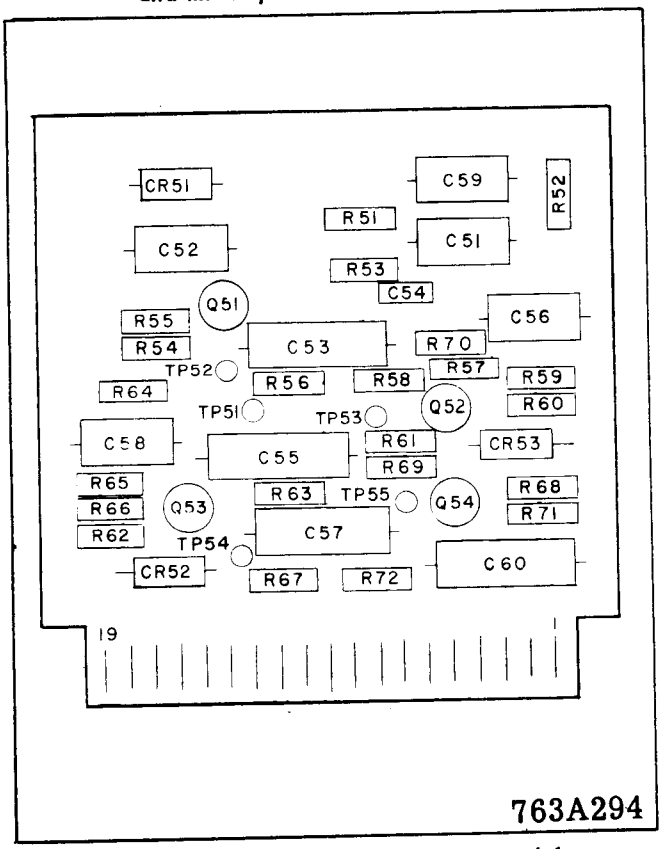


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

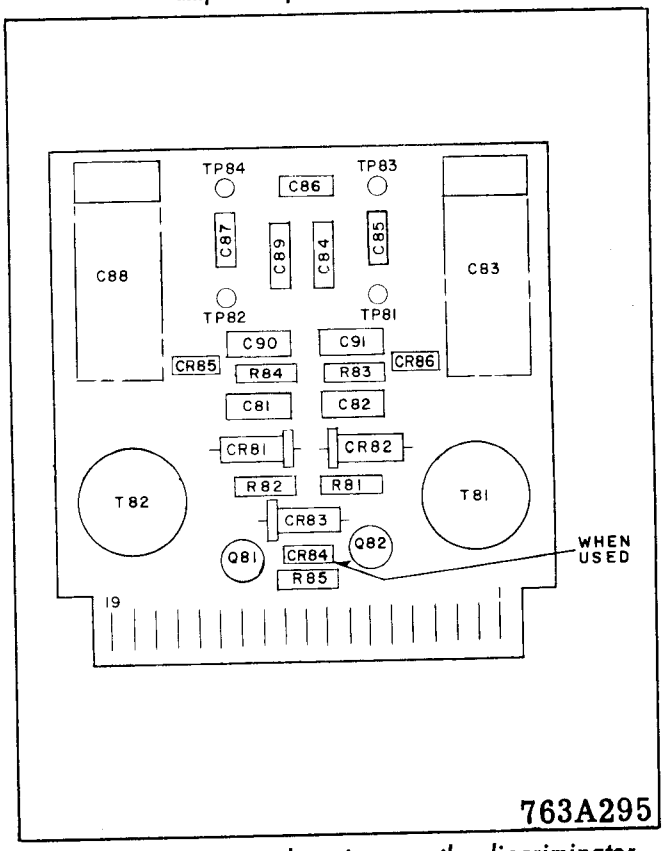


Fig. 10 Component locations on the discriminator printed circuit board.

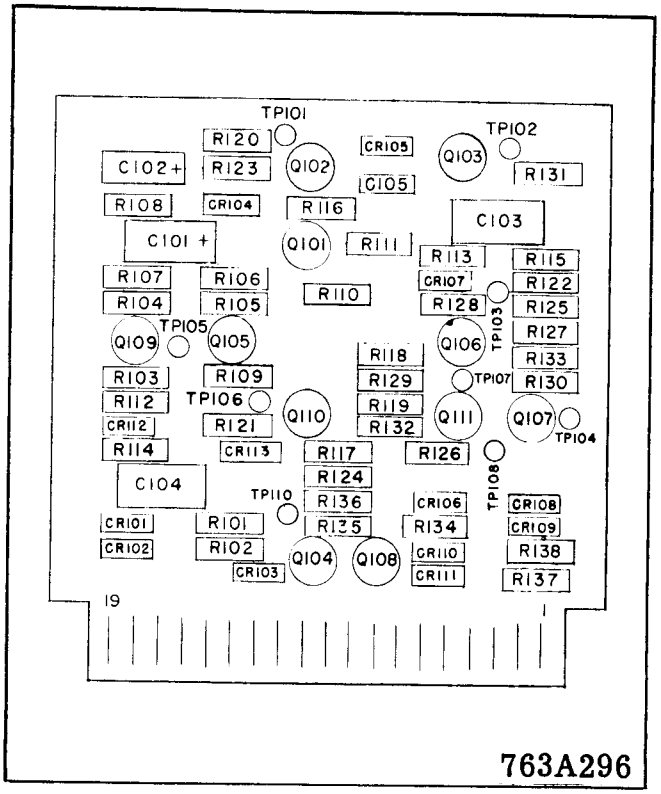


Fig. 11 Component locations on the logic printed circuit board.

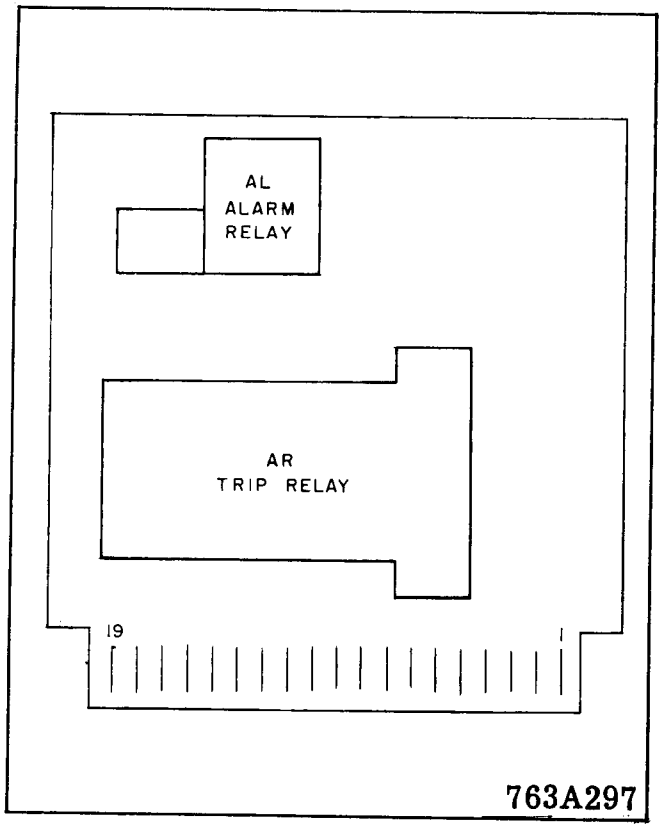


Fig. 12 Component locations on the output printed circuit board.

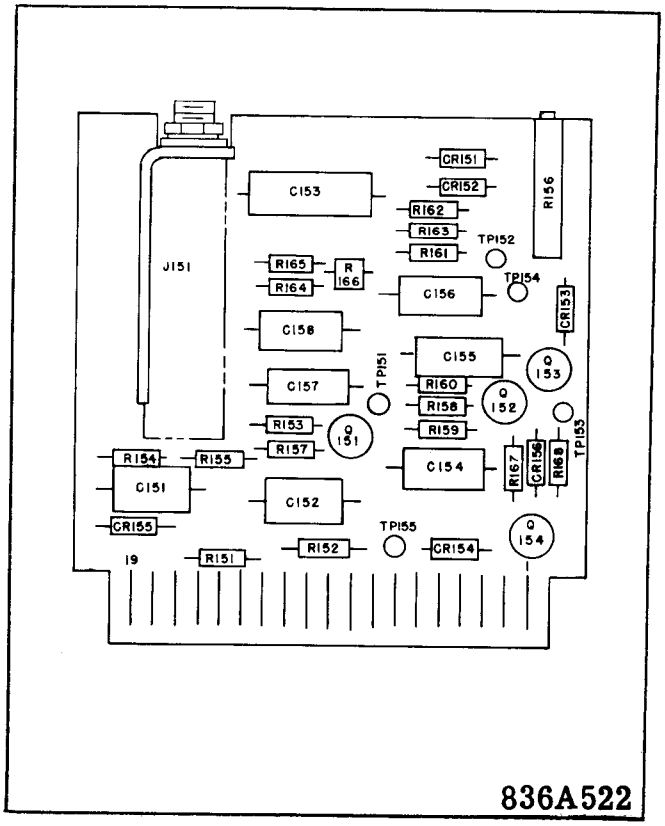


Fig. 13 Component locations on the carrier level indicator printed circuit board.

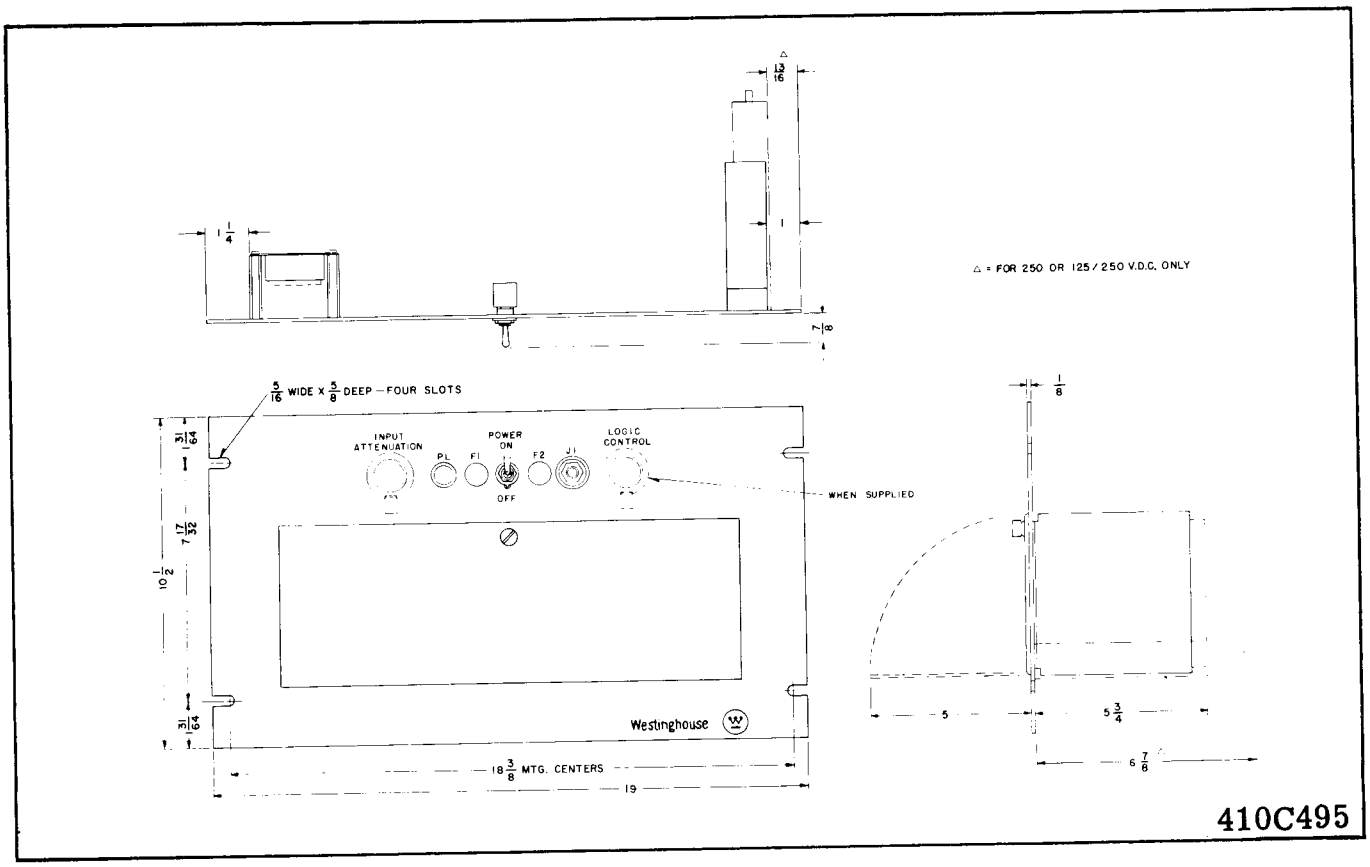


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

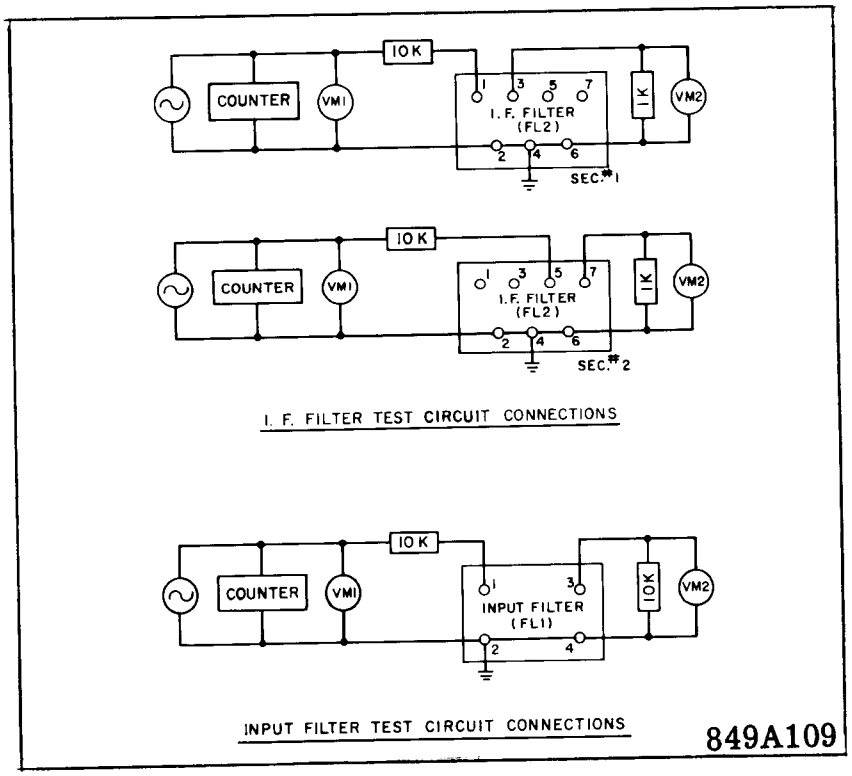


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.

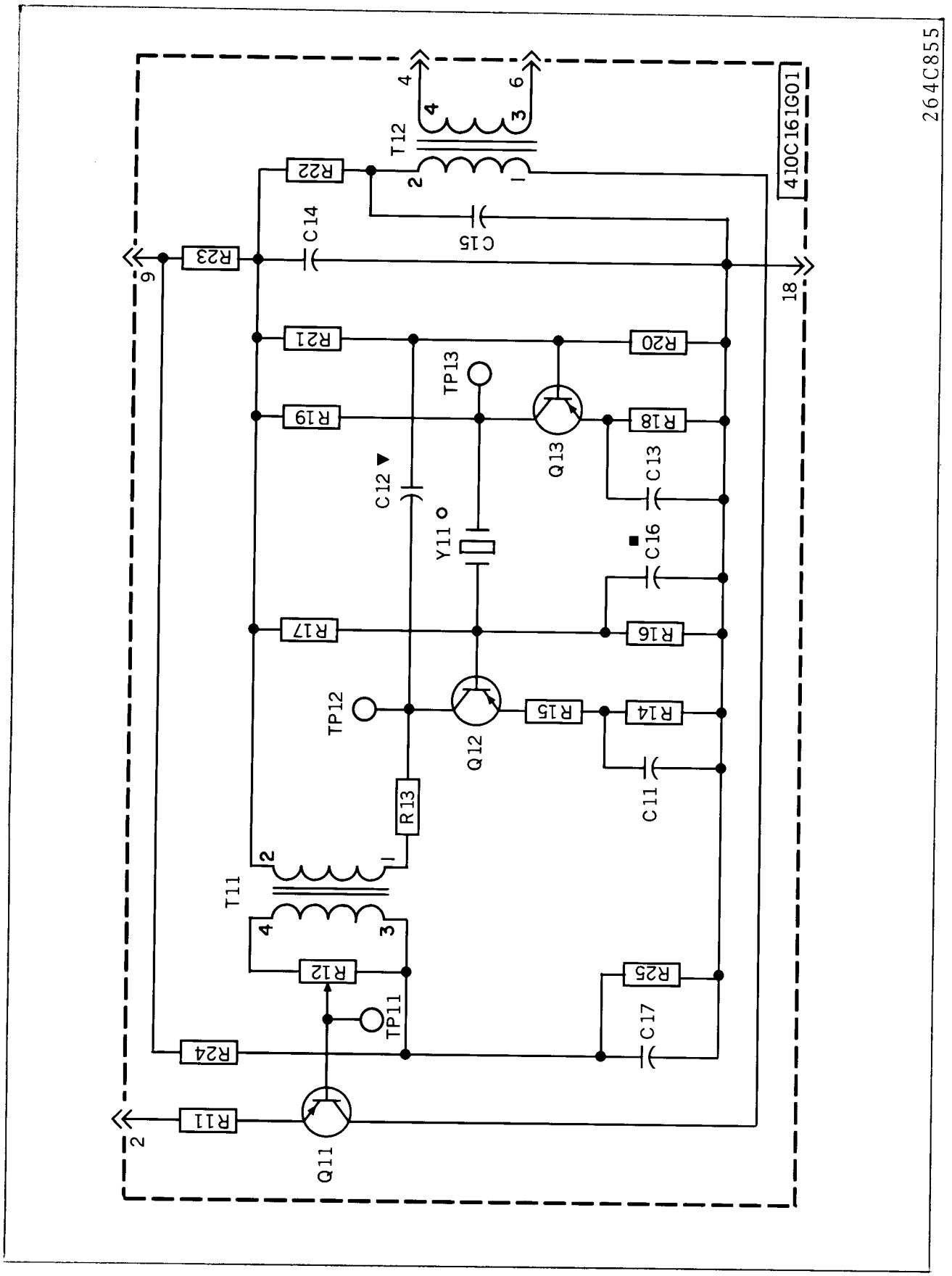


Fig. 18. Internal Schematic 30-200KHz Oscillator and Mixer Silicon Transistor Version

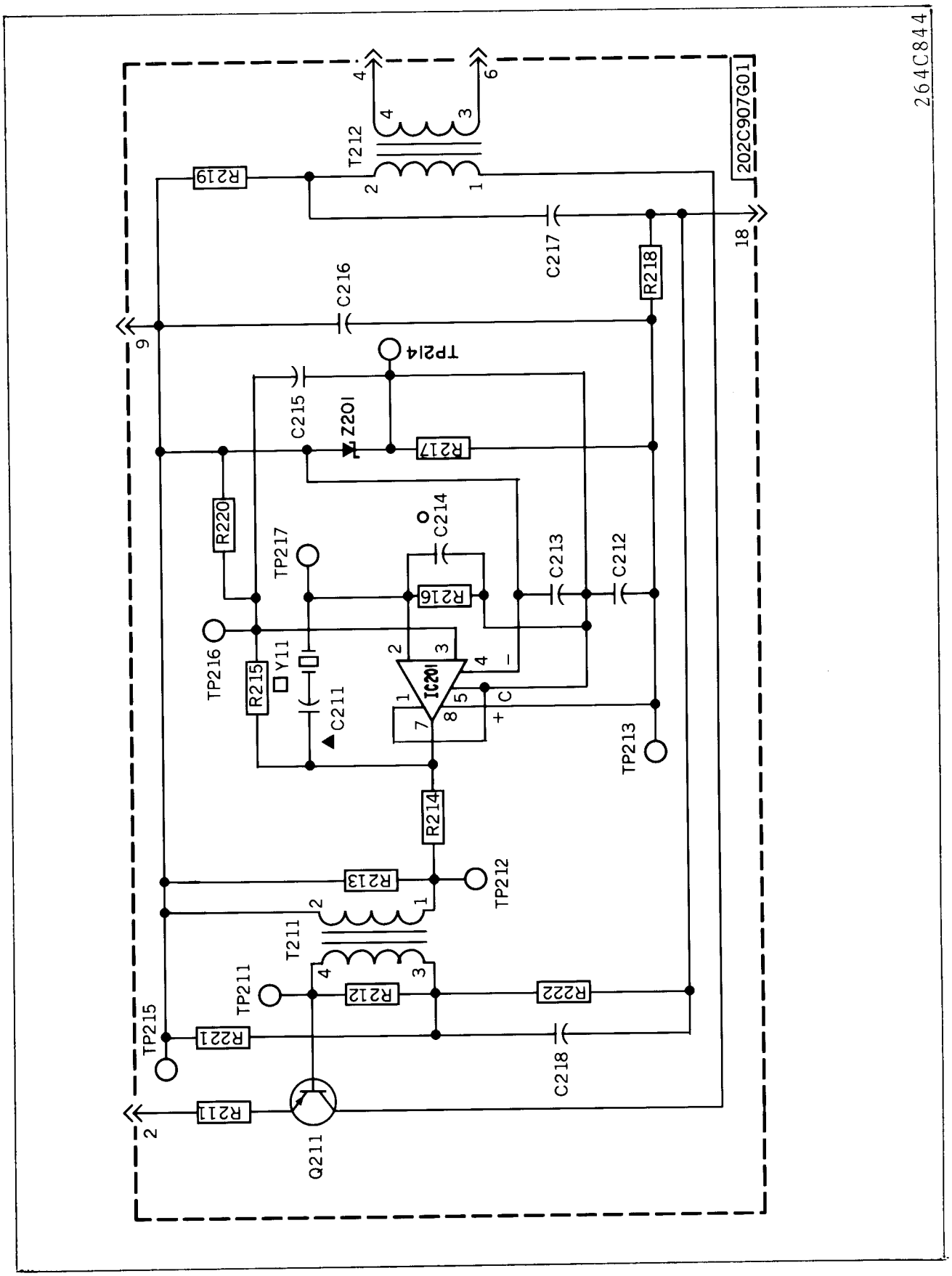


Fig. 19. Internal Schematic 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version

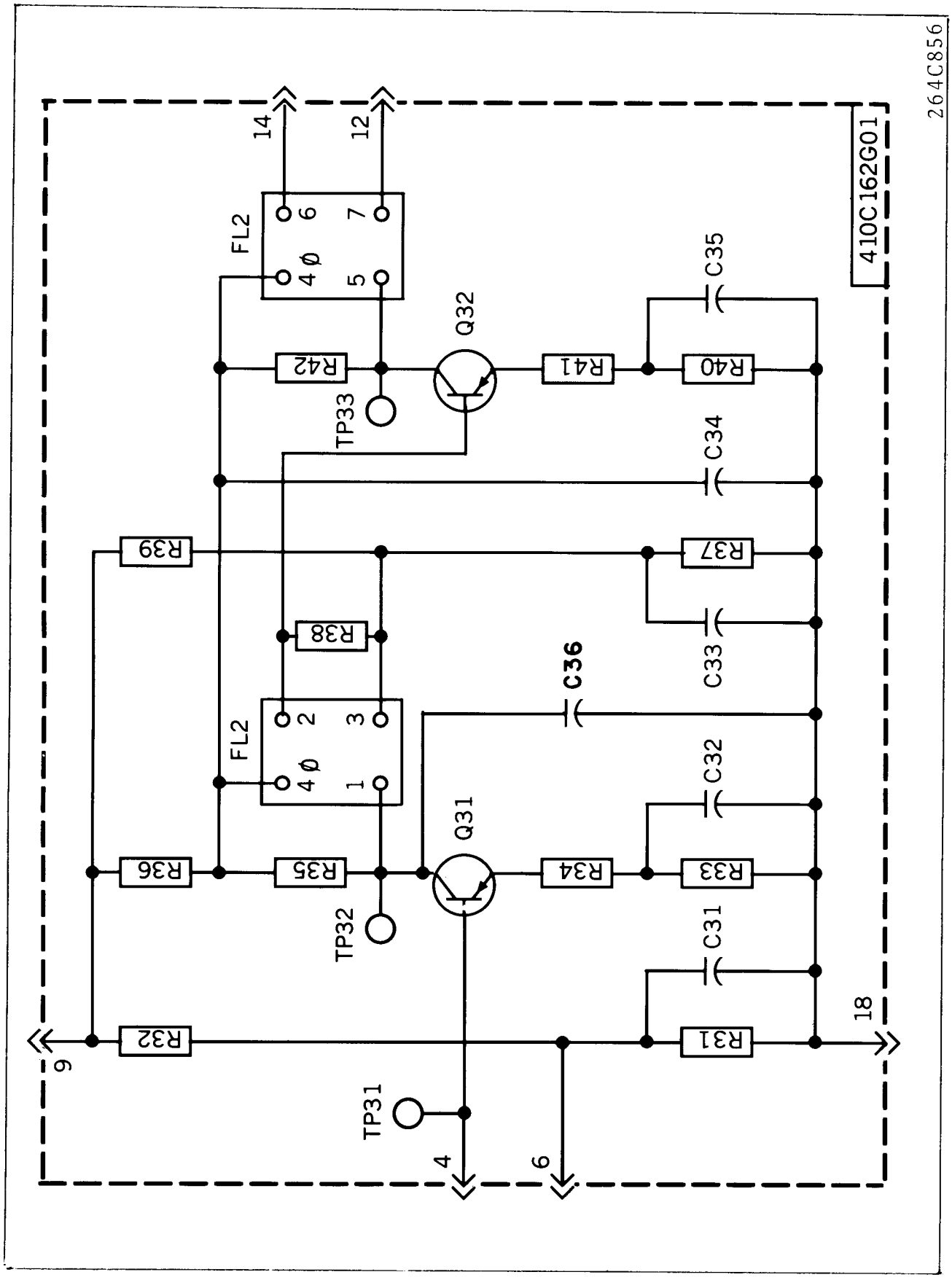


Fig. 20. Internal Schematic I.F. Amplifier – Silicon Transistor Version

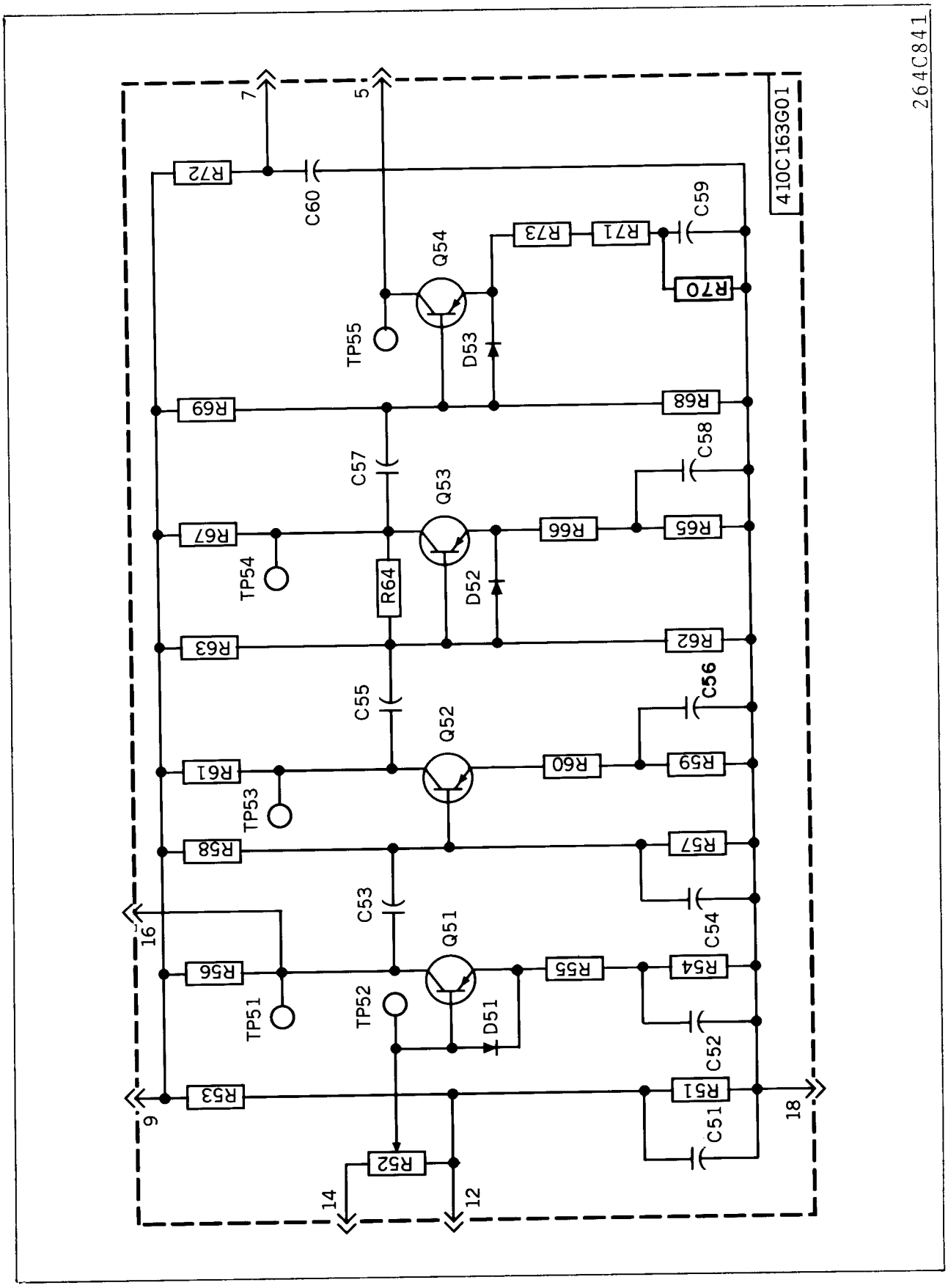


Fig. 21. Internal Schematic Amplifier and Limiter – Silicon Transistor Version

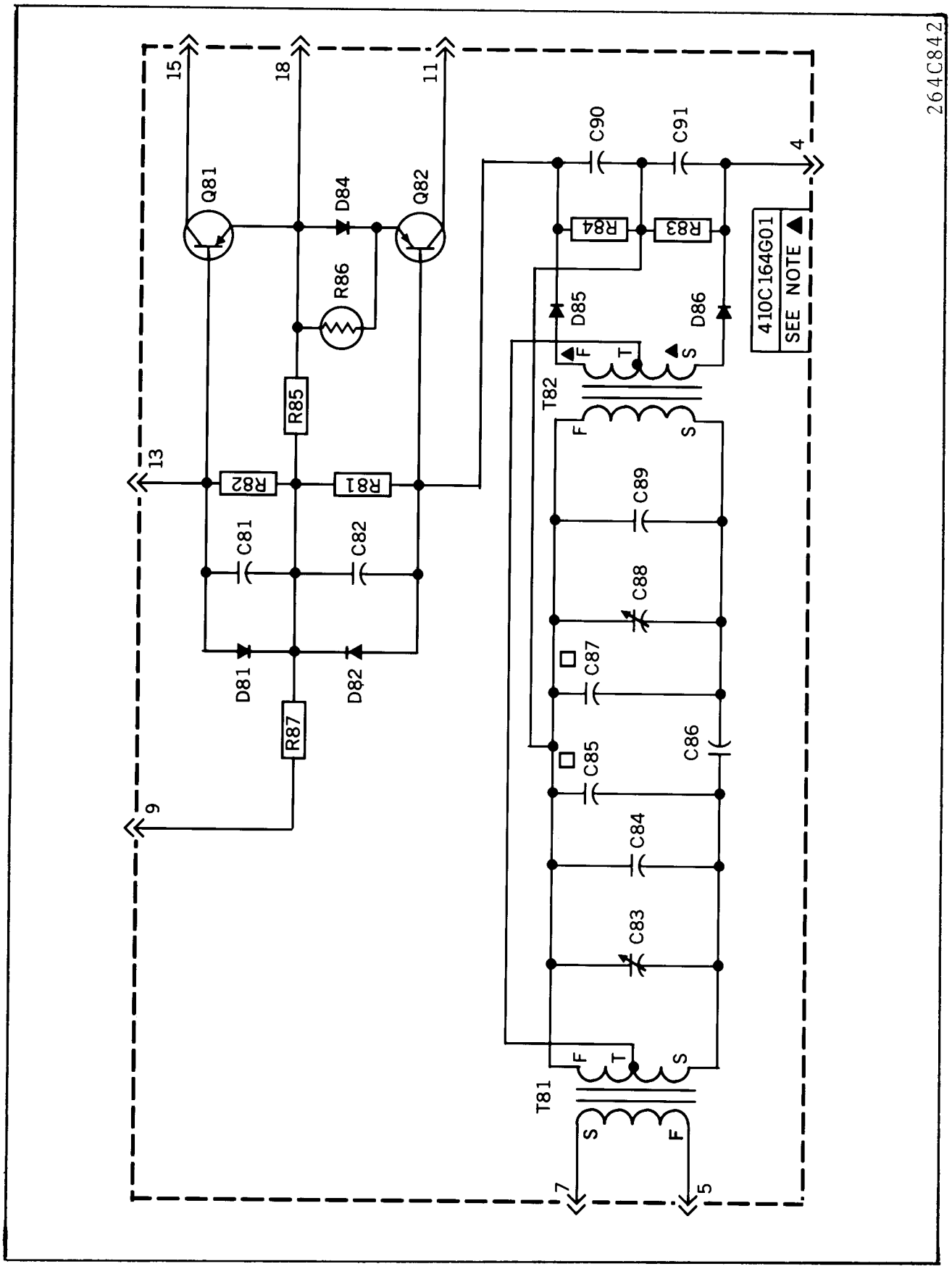


Fig. 22. Internal Schematic Discriminator – Silicon Transistor Version

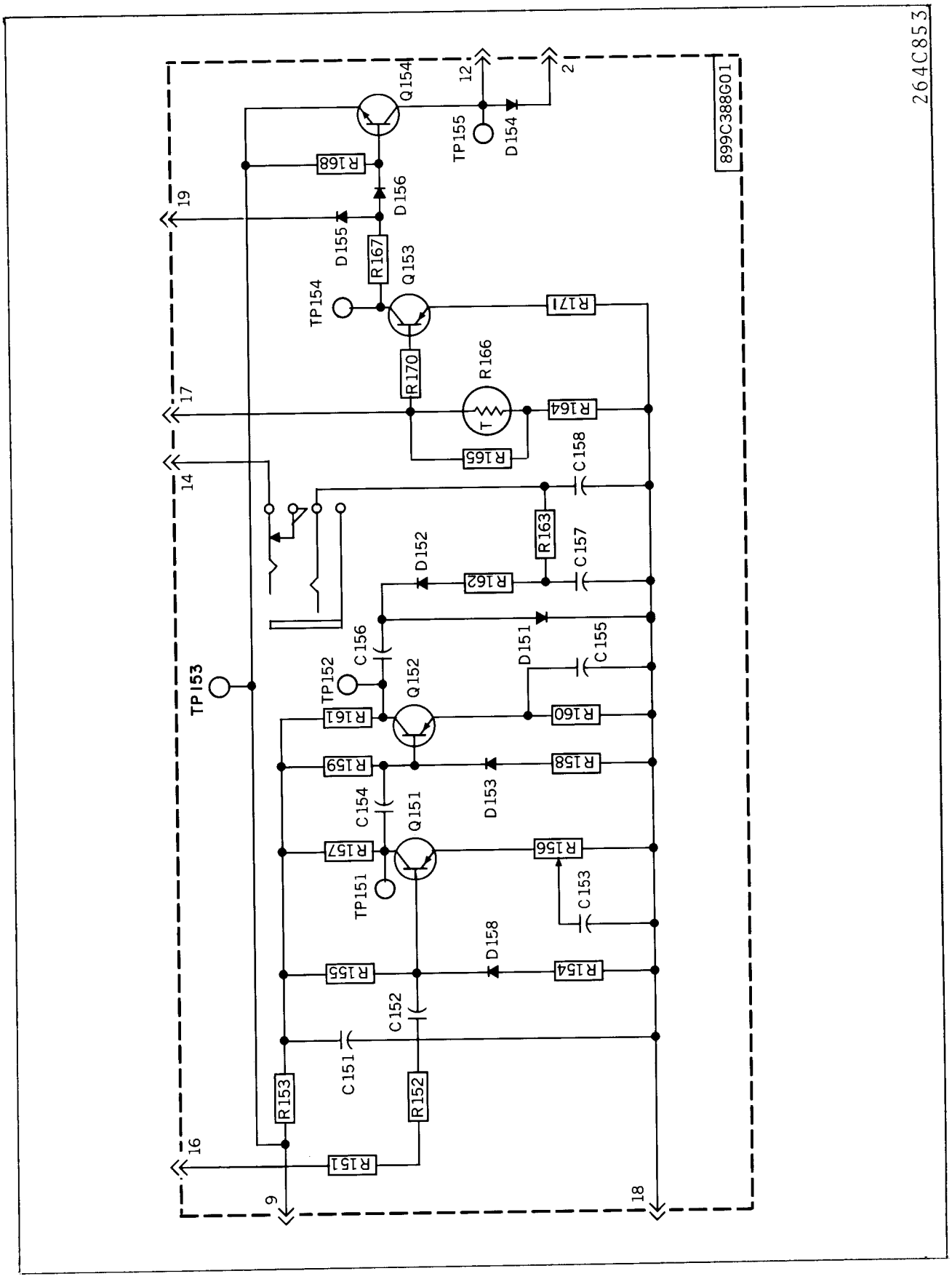


Fig. 23. Internal Schematic Carrier Level Indicator – Silicon Transistor Version

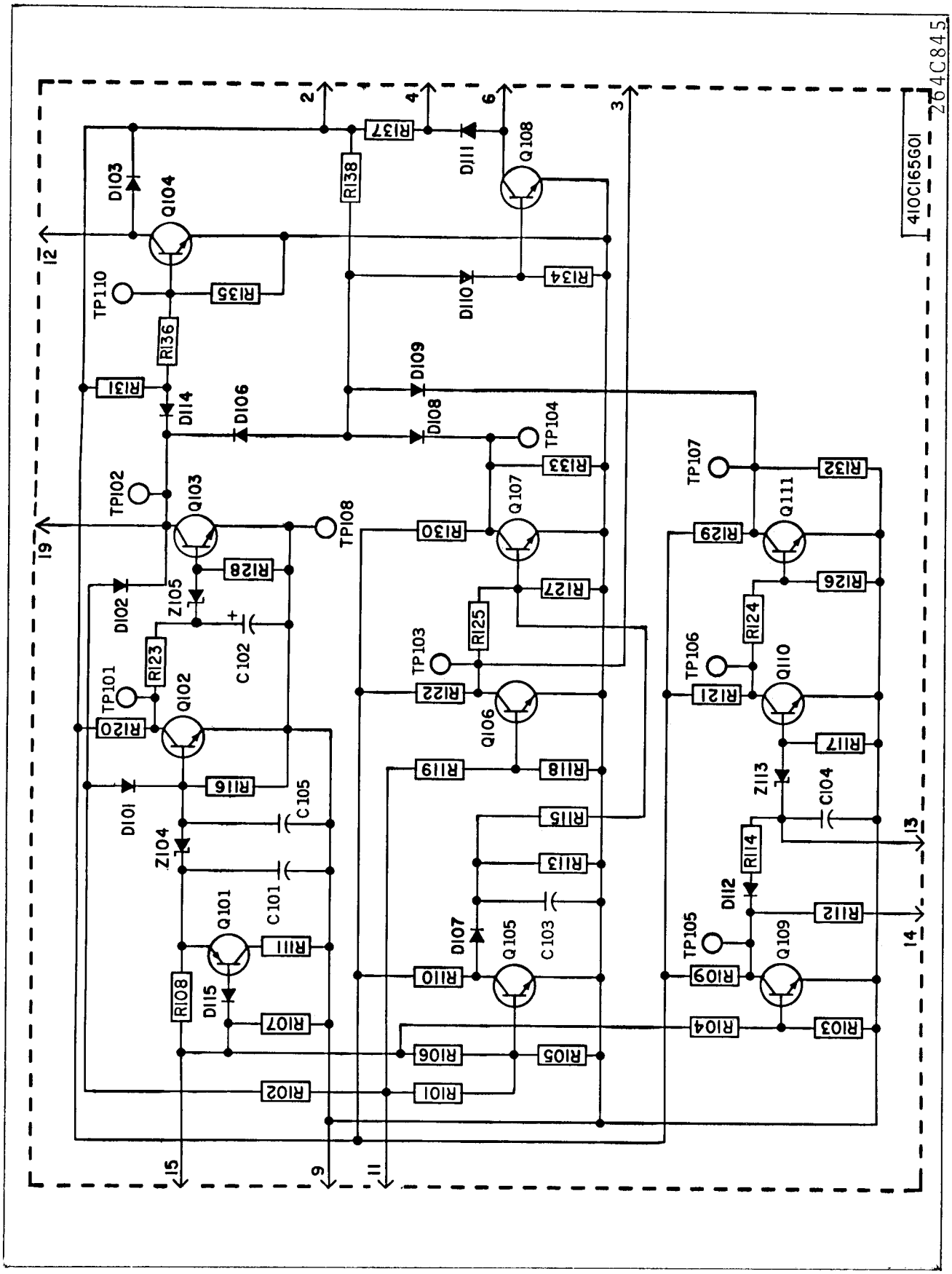


Fig. 24. Internal Schematic Logic Board – Silicon Transistor Version

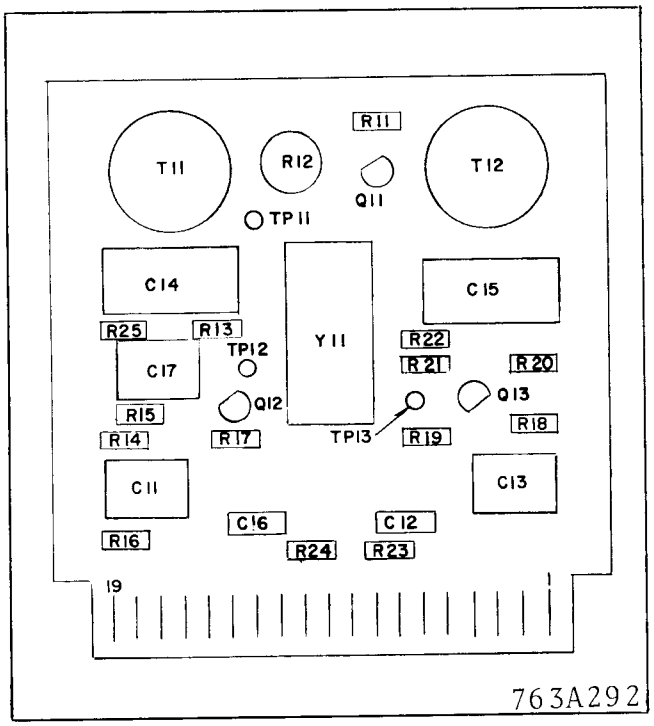


Fig. 25. Component Locations 30-200KHz. Oscillator and Mixer Silicon Transistor Version

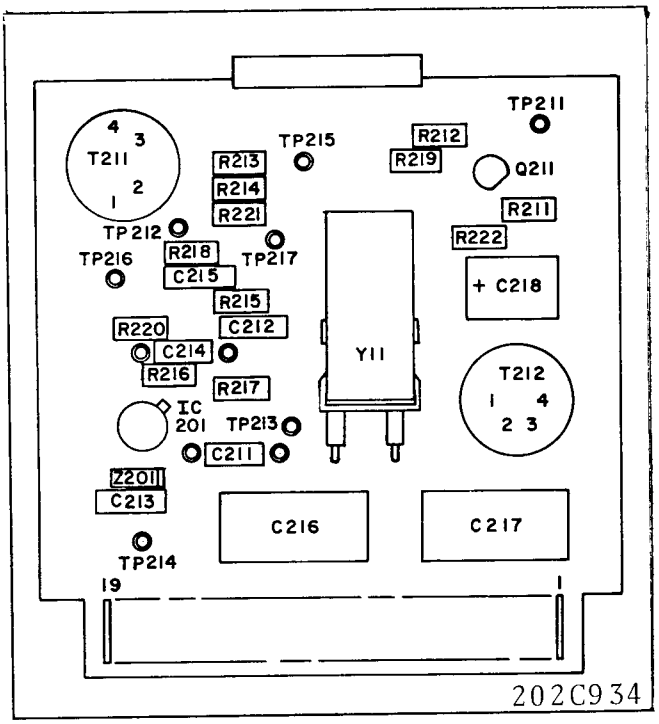


Fig. 26. Component Locations 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version

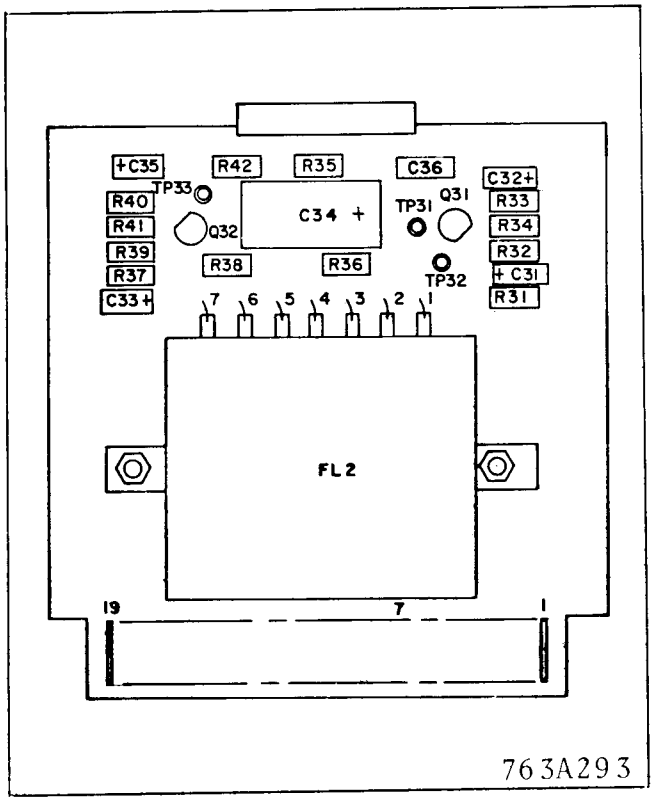


Fig. 27. Component Locations I.F. Amplifier – Silicon Transistor Version

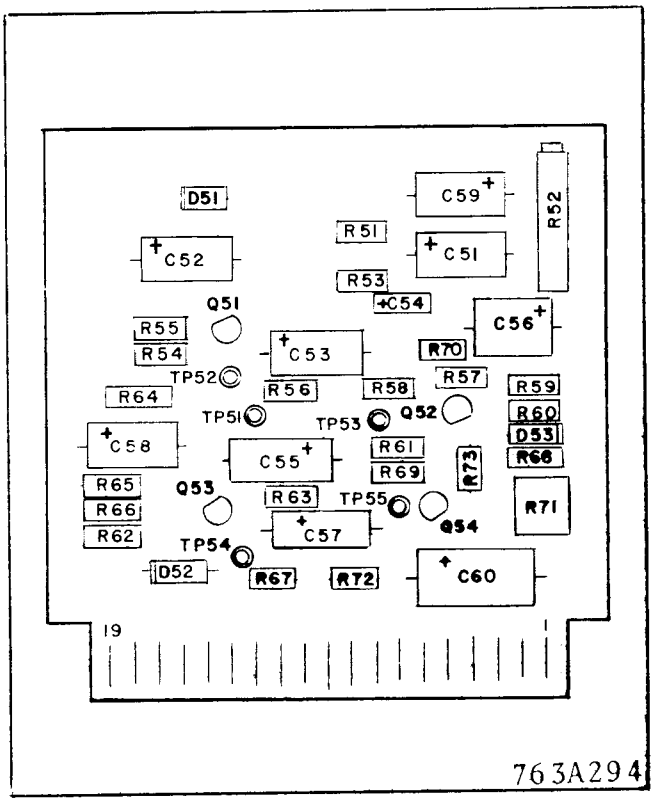


Fig. 28. Component Locations Amplifier and Limiter – Silicon Transistor Version

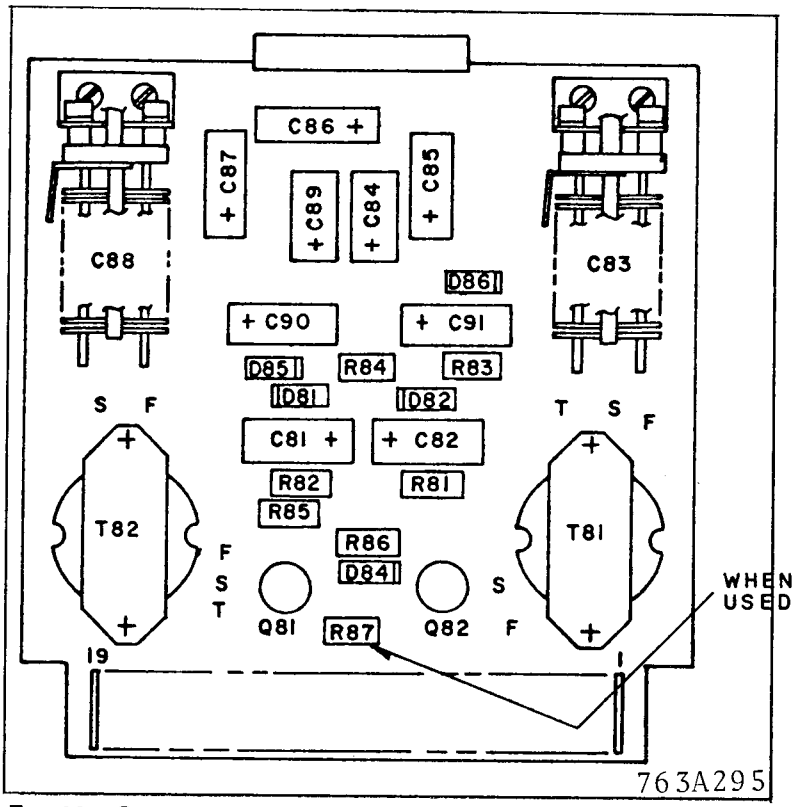


Fig. 29. Component Locations Discriminator – Silicon Transistor Version

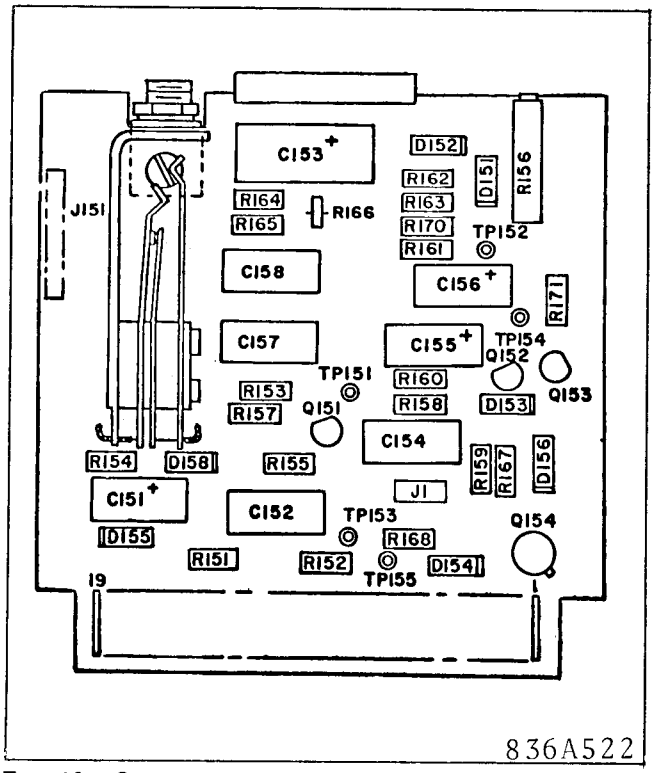


Fig. 30. Component Locations Carrier Level Indicator – Silicon Transistor Version

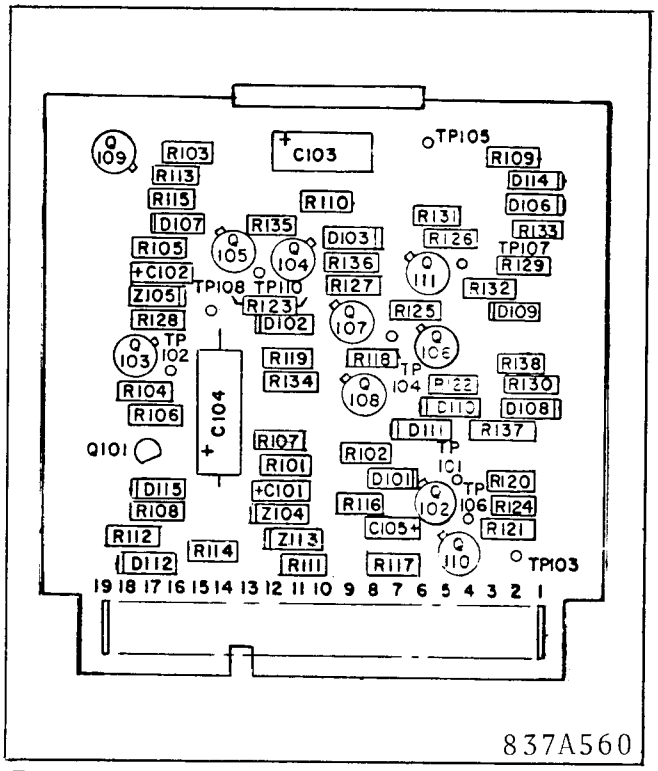


Fig. 31. Component Locations Logic Board – Silicon Transistor Version

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.

Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

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*Denotes change from superseded issue.

terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, or IC201 (Fig. 16) and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 kHz above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the later is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20kHz, 2fc + 20kHz, fc + 20kHz and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero output frequency. This separation of 200 hertz between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 hertz in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20 kHz-100 hertz. Similarly, the Trip frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears, the discriminator output at term. 15 will turn Q101 off. C101 will change and after 120 ms. it will reach the breakdown voltage of CR104 and turn Q102 on. This will allow C102 to quickly discharge through R123 and Q102 and provide the full 150 ms. time delay to be effective on any subsequent loss of guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 2.25 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.6 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental inserting of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	* 1000 hertz, minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42 - 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

* ADDENDUM

With shipments of sets starting in early 1973, the germanium transistors used in the various modules were replaced with silicon transistors. In addition, due to the nature of silicon transistors, some resistor values in the circuits had to be changed In order to correctly bias these transistors. Therefore the transistors are not replaceable on a pin for pin basis throughout the receiver. Before attempting to replace a germanium transistor with a silicon transistor on older sets using germanium, please check the schematics on the following pages to see if the location where the replacement is desired has additional component changes. If that is the case, then the replacement can only be made by the same designation transistor or the additional component changes must also be made. It should be pointed out that the modules containing the silicon transistors are completely interchangeable with the modules containing germanium transistors. Therefore, there is no problem with intermixing the silicon transistor modules in the same receiver. Thus complete new modules containing silicon transistors can be ordered and used as replacements in older receivers having germanium transistor modules. The new modules have the same style numbers as the old germanium transistor modules they replace.

Type TCF Receiver (Front View).

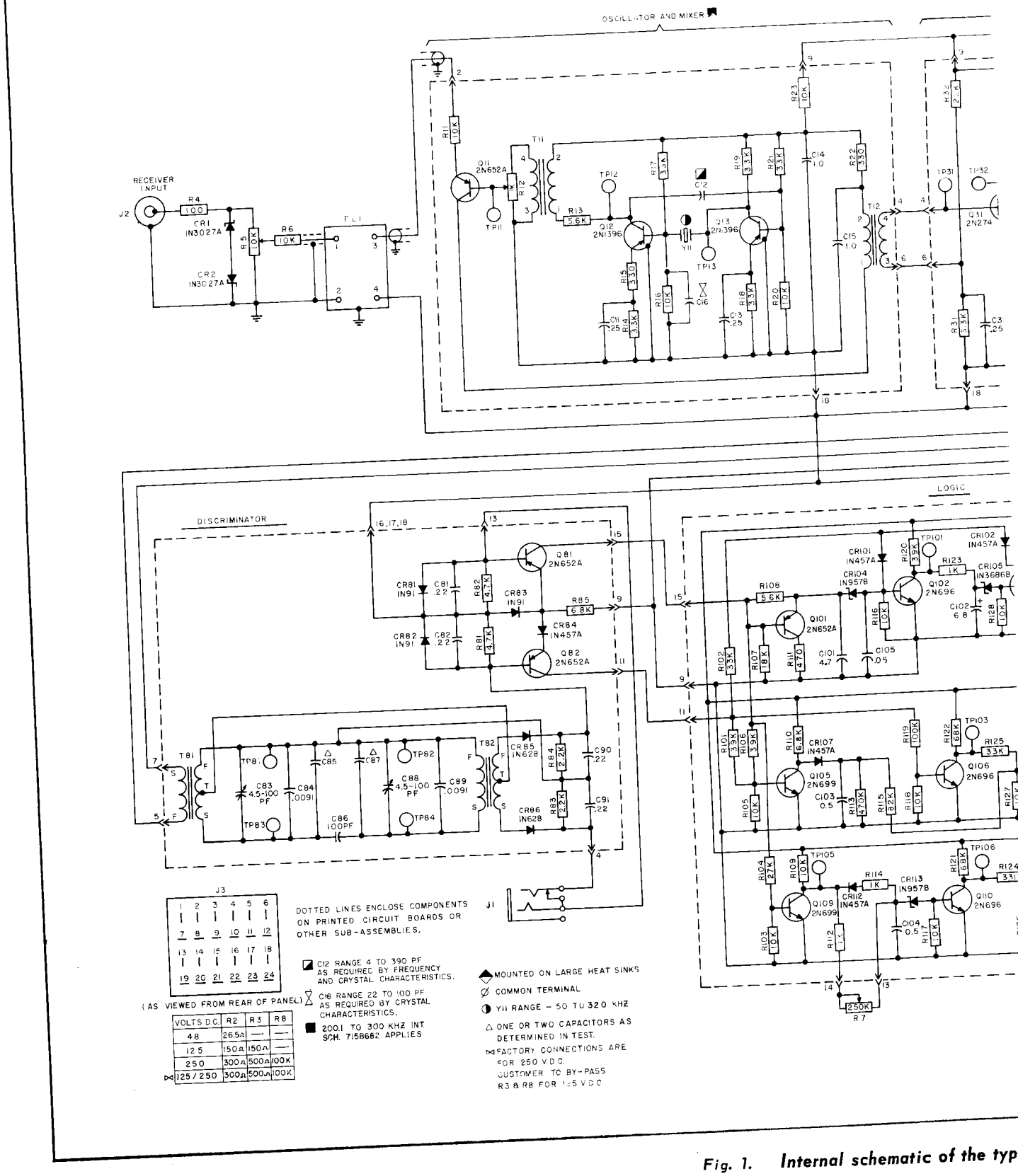
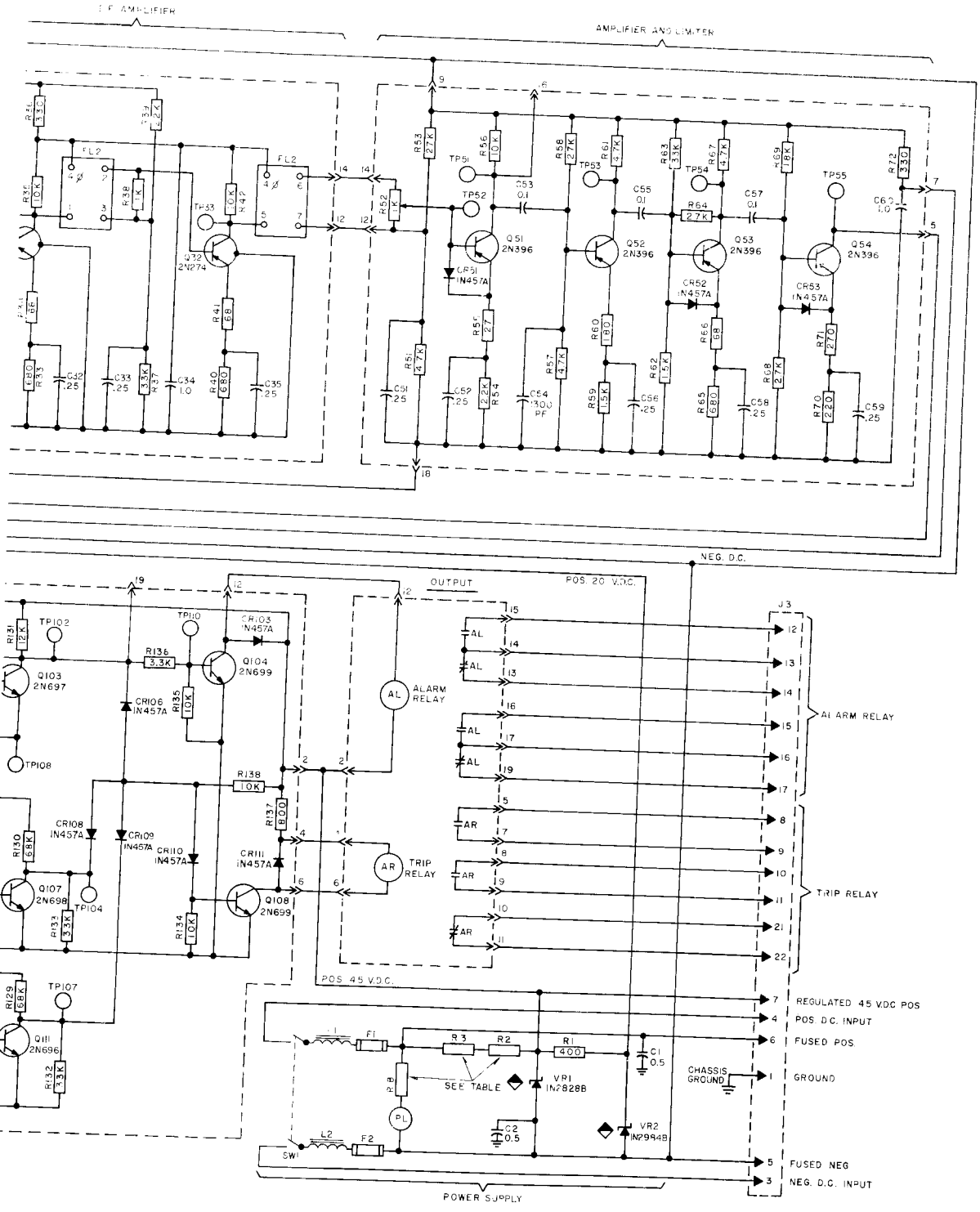


Fig. 1. ***Internal schematic of the type***



543D637

TCF receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Imput Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf, 50 v.d.c.	184A663H04
C213	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A855H07
CR156	IN457A; 60 V.; 200 MA.	
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. ± 5%; 400 MW.	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
* R71	270 ohms ± 5%; Wire Wound	09D832G19
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	205C043G03
T12	Toroidal type, 25000/300 ohms	205C043G03
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	205C043G01
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01+(Req.Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
* AR	Trip Relay	408C845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

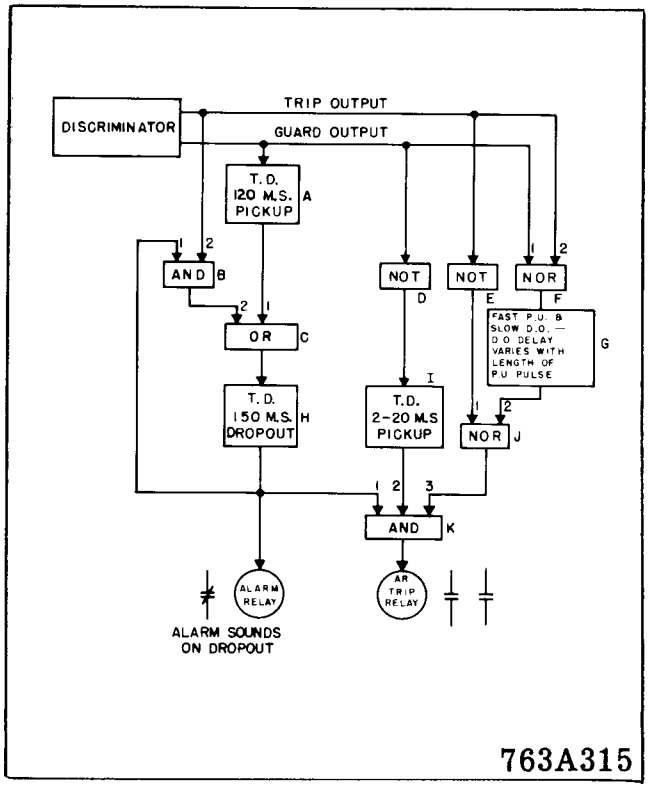


Fig. 3 Block diagram of output logic circuit

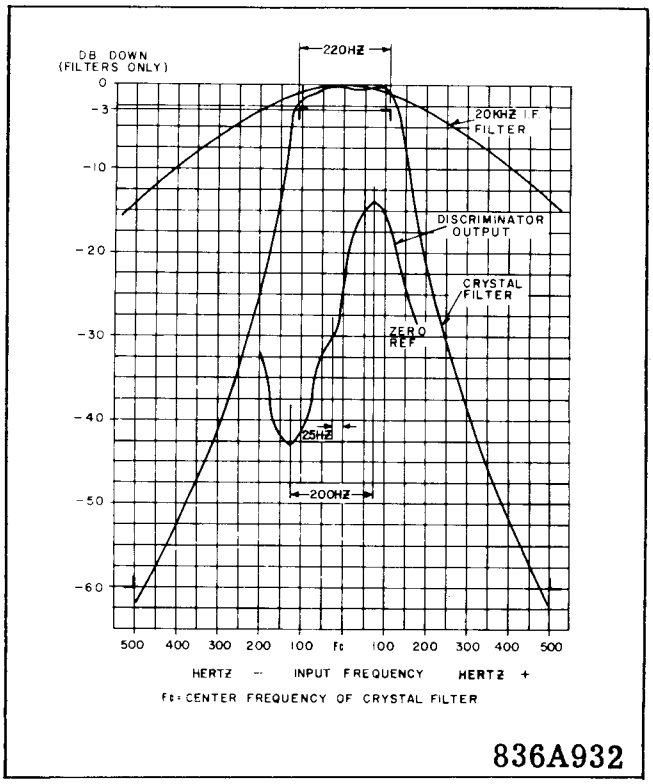
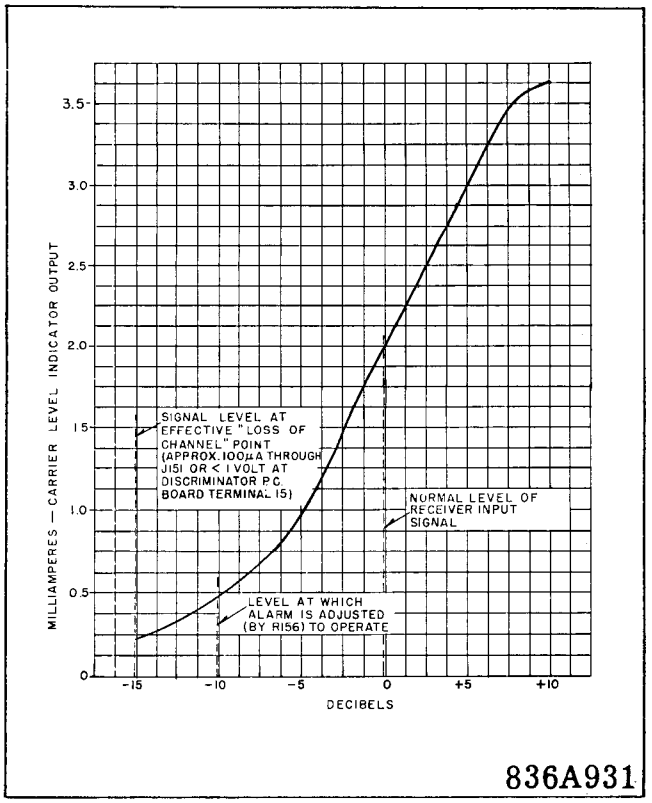


Fig. 4 Filter and discriminator characteristics of the type TCF receiver



* *Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.*

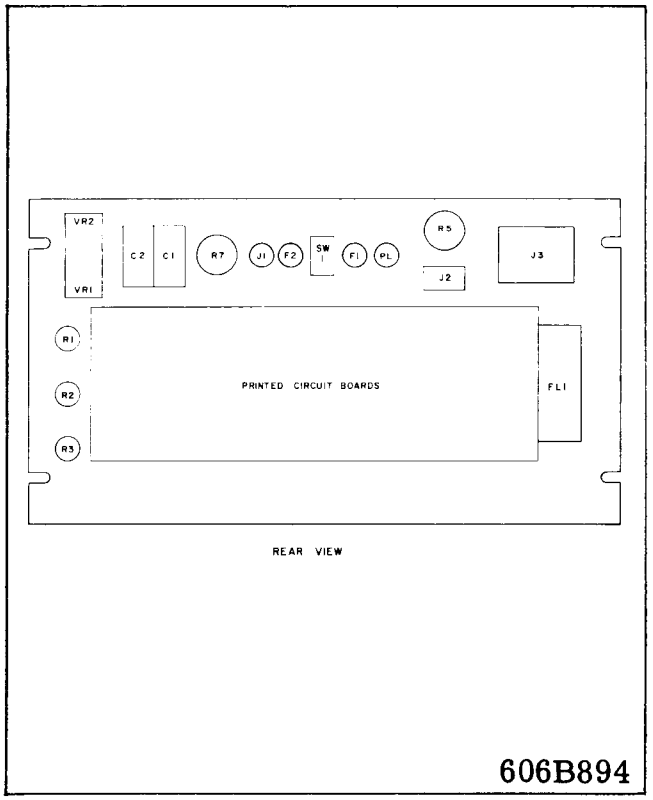


Fig. 6 Component locations on the type TCF receiver panel

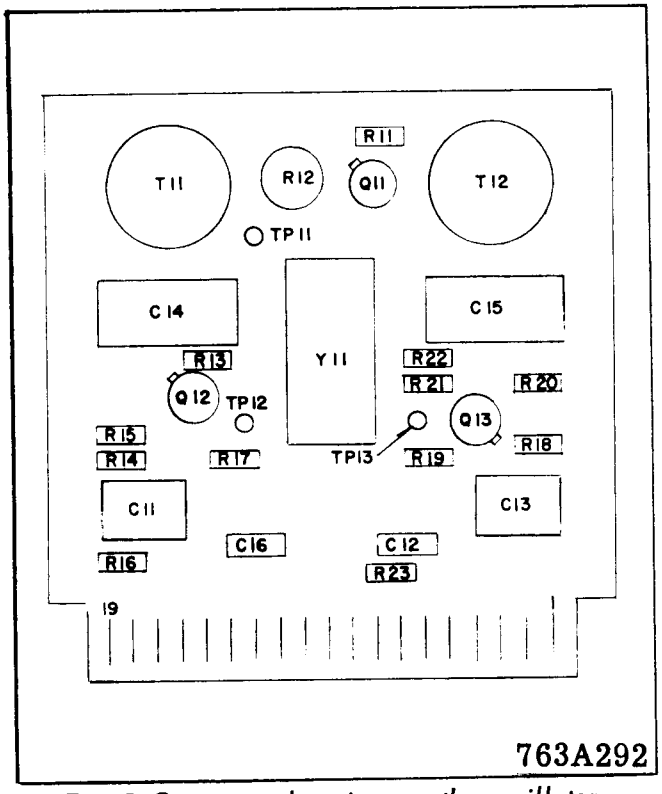


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

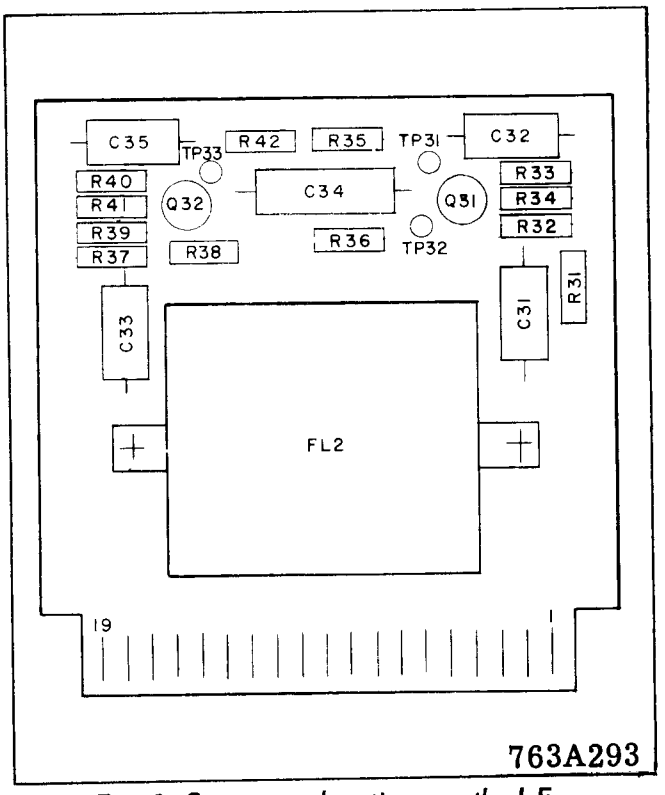


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

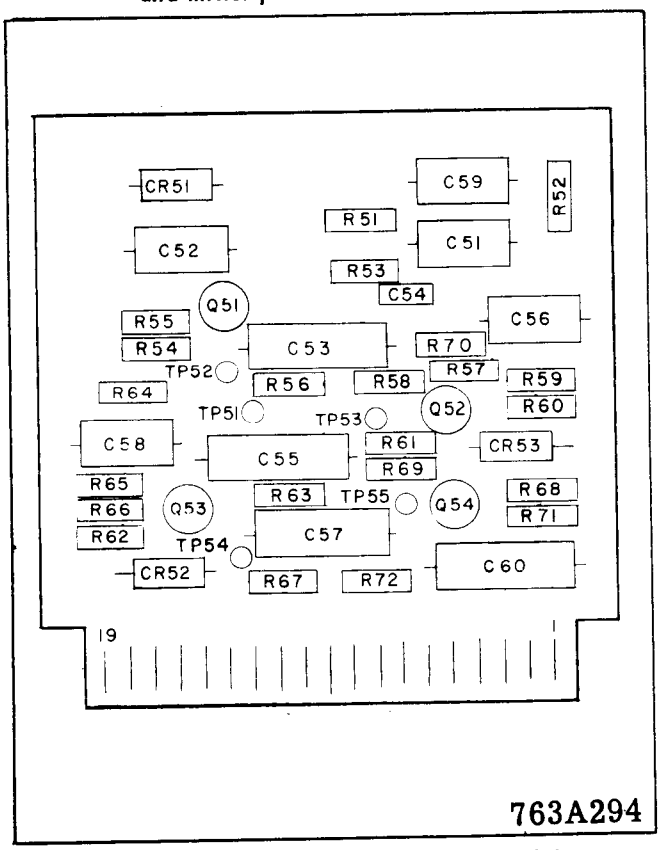


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

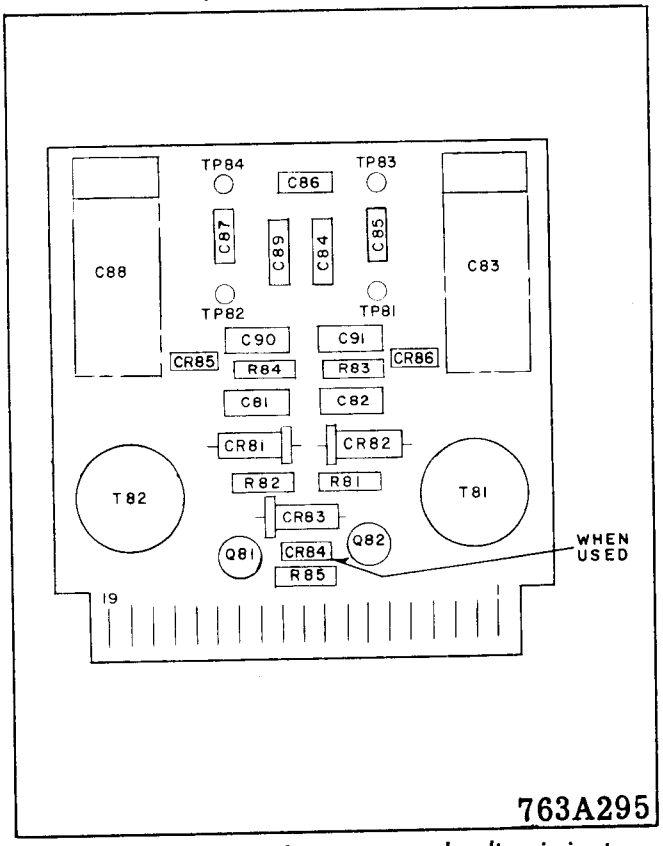


Fig. 10 Component locations on the discriminator printed circuit board.

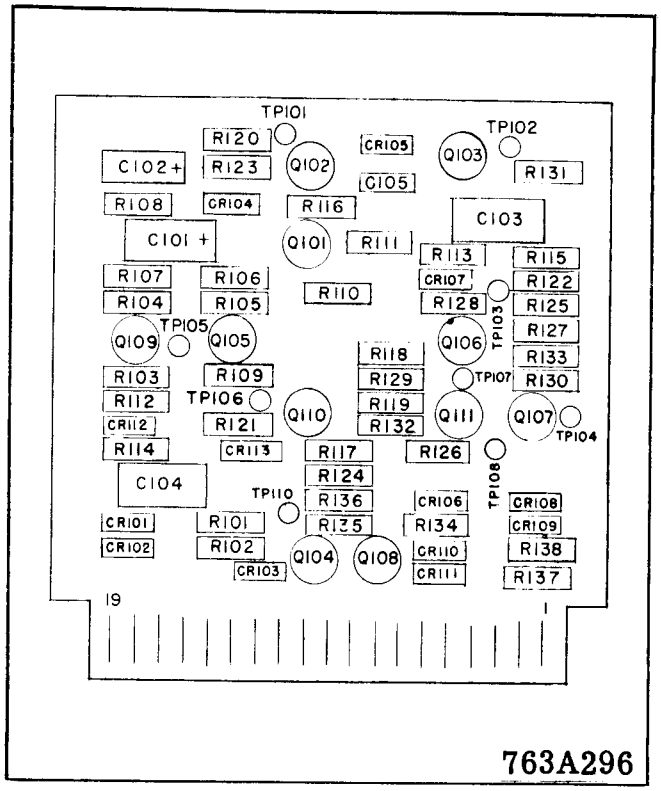


Fig. 11 Component locations on the logic printed circuit board.

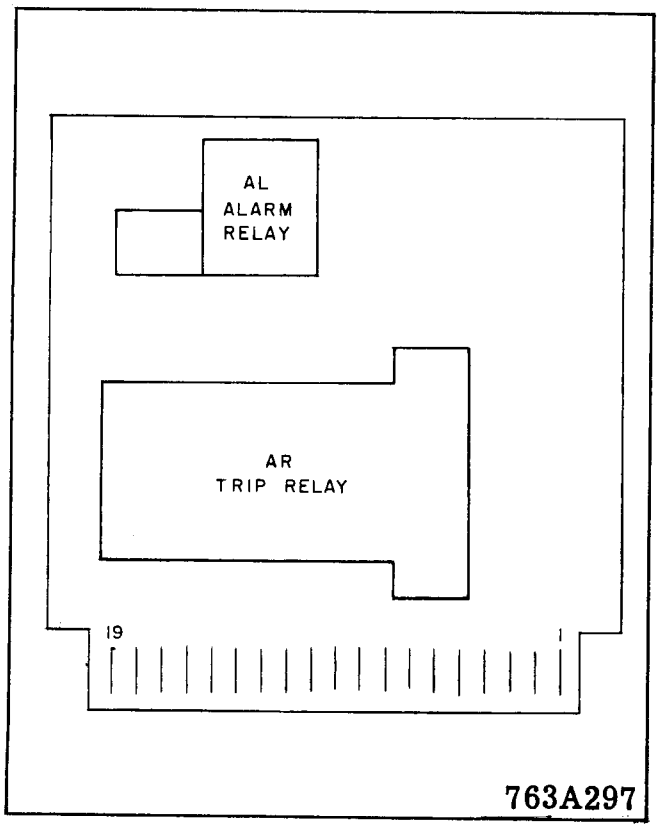


Fig. 12 Component locations on the output printed circuit board.

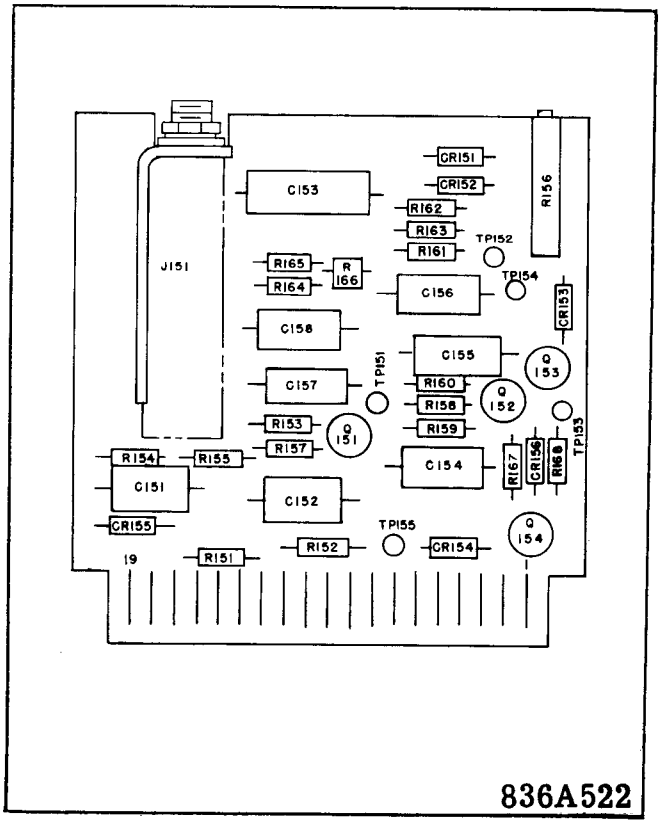


Fig. 13 Component locations on the carrier level indicator printed circuit board.

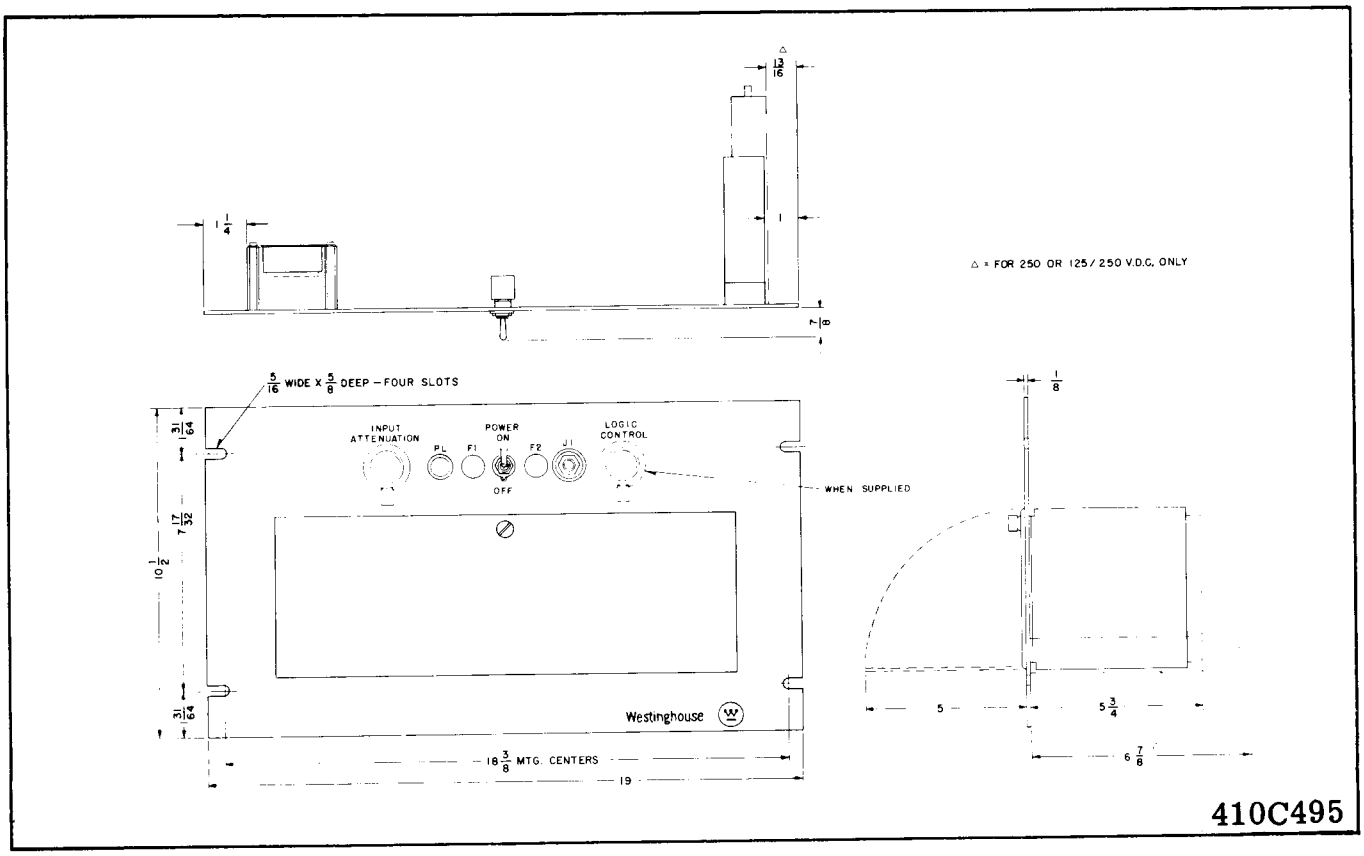


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

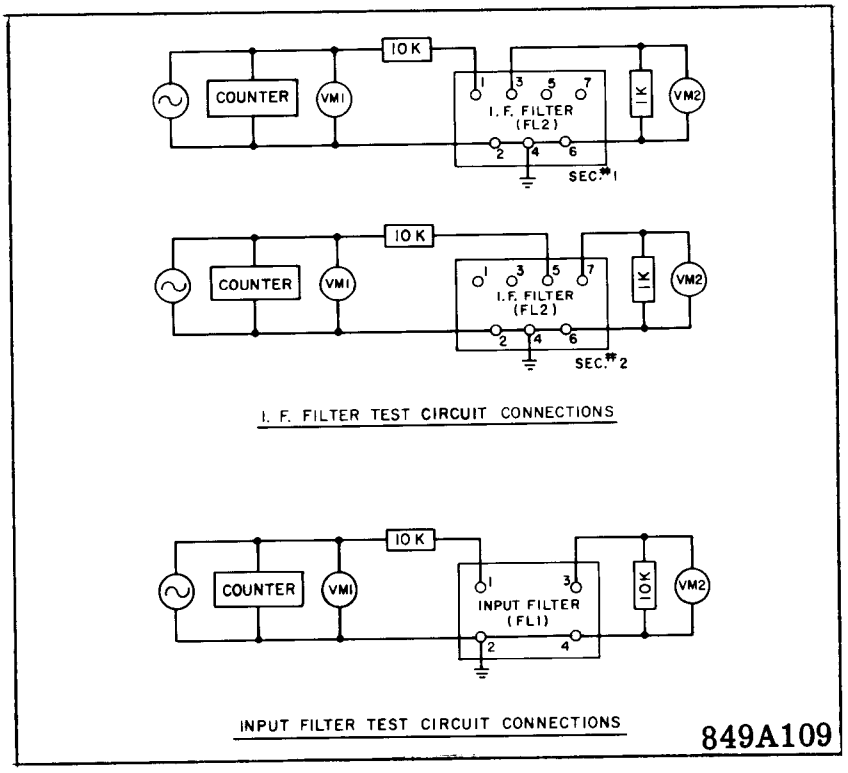


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.

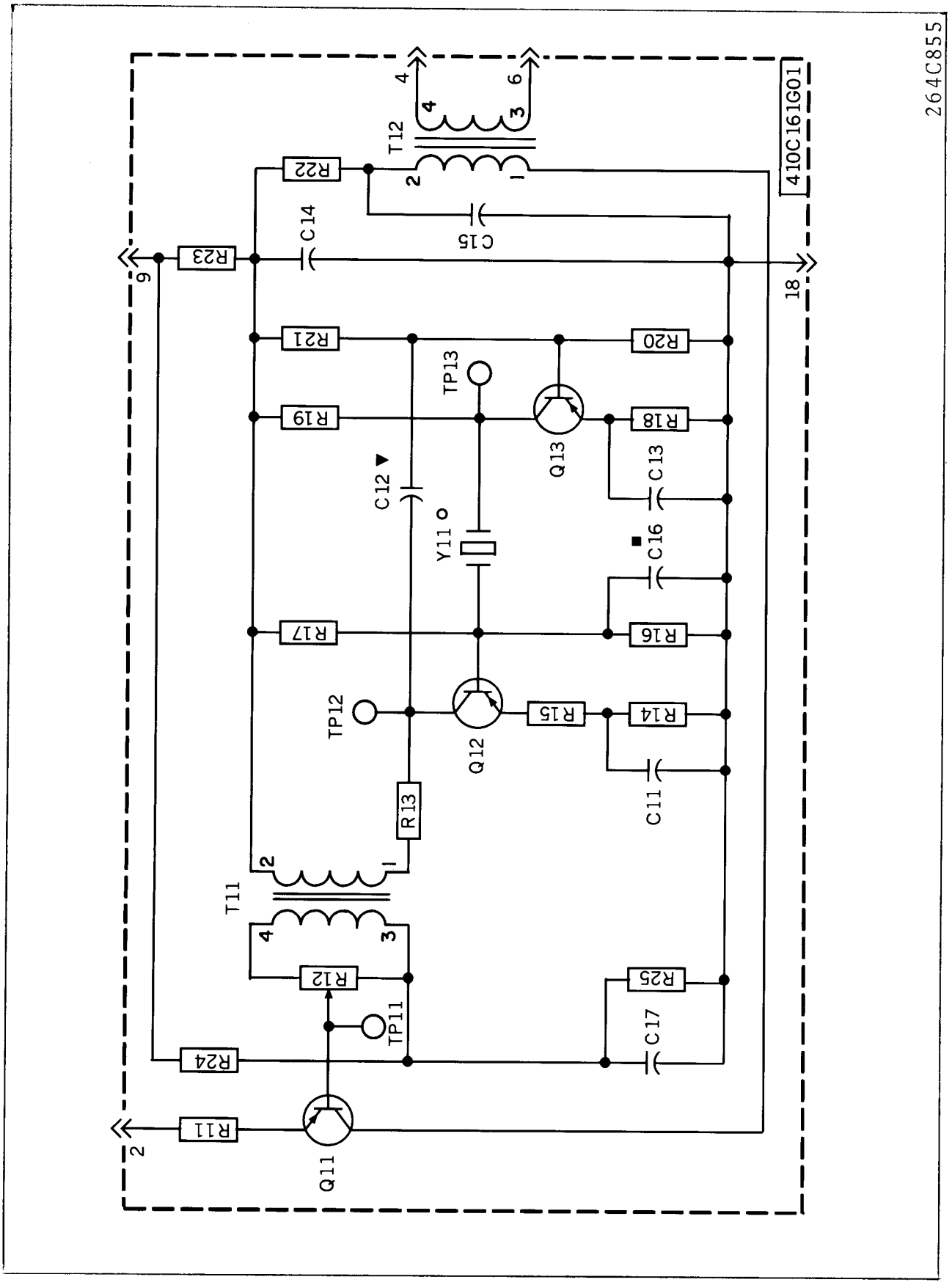


Fig. 18. Internal Schematic 30-200KHz Oscillator and Mixer Silicon Transistor Version

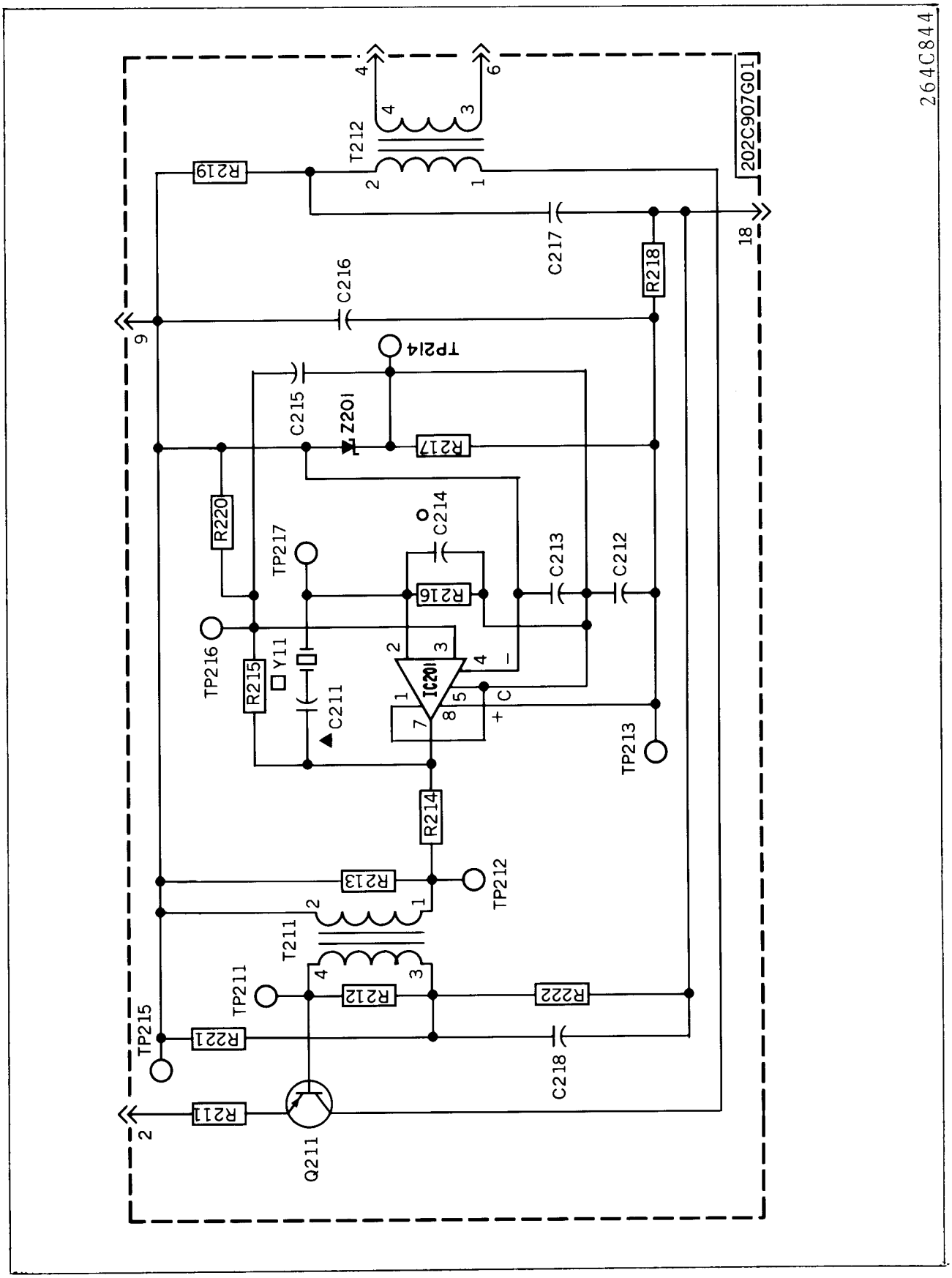


Fig. 19. Internal Schematic 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version

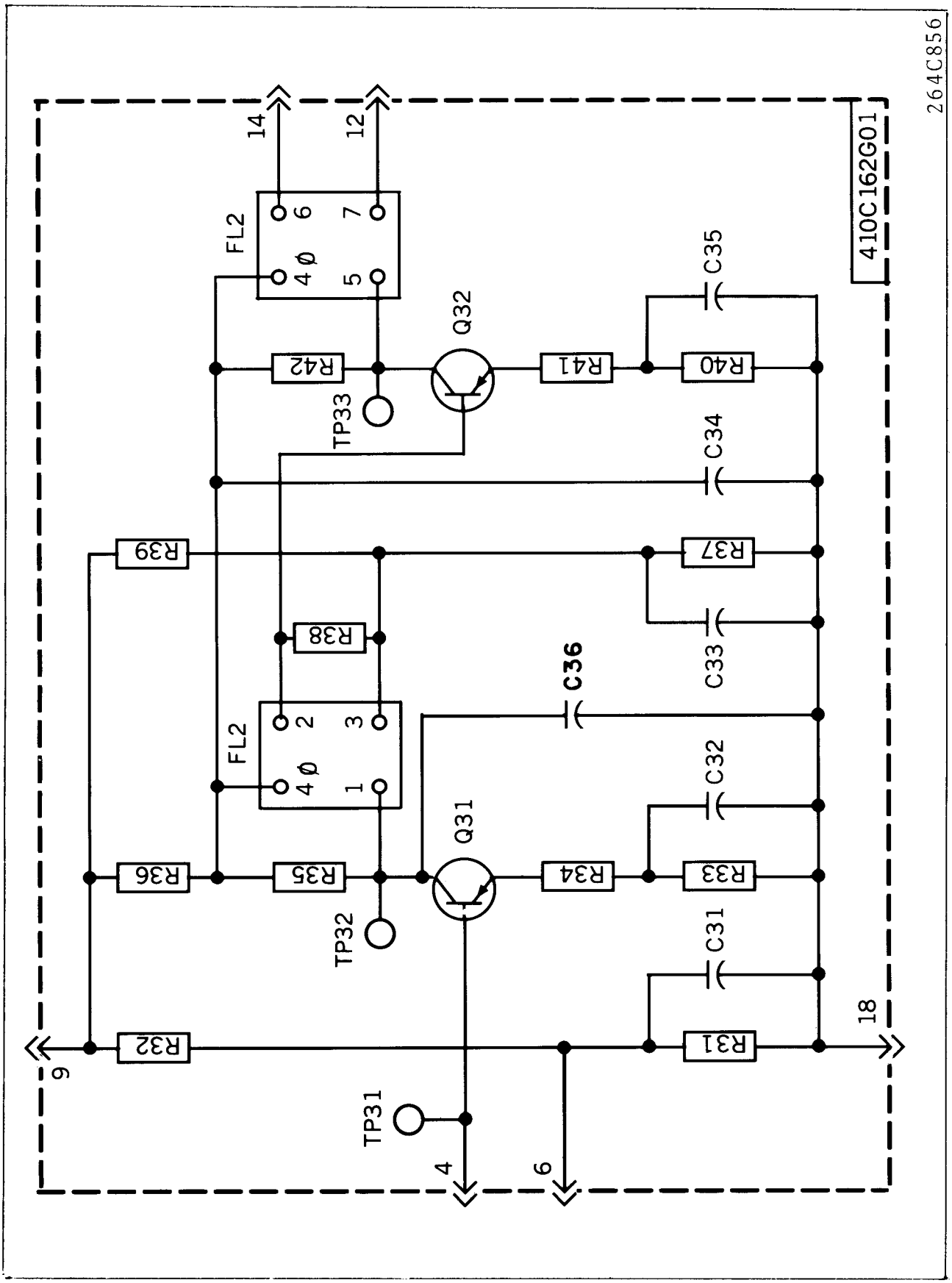


Fig. 20. Internal Schematic I.F. Amplifier – Silicon Transistor Version

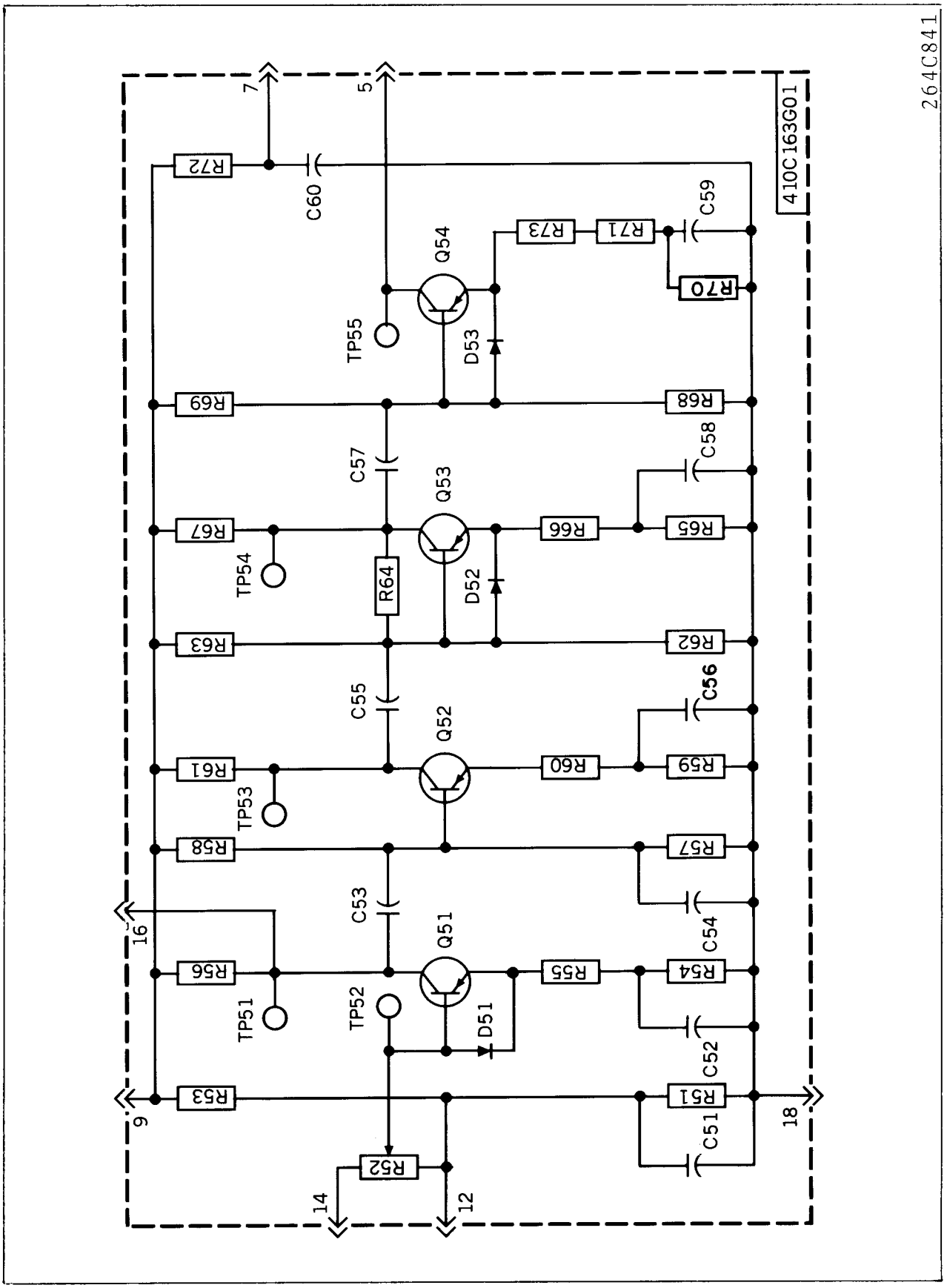


Fig. 21. Internal Schematic Amplifier and Limiter – Silicon Transistor Version

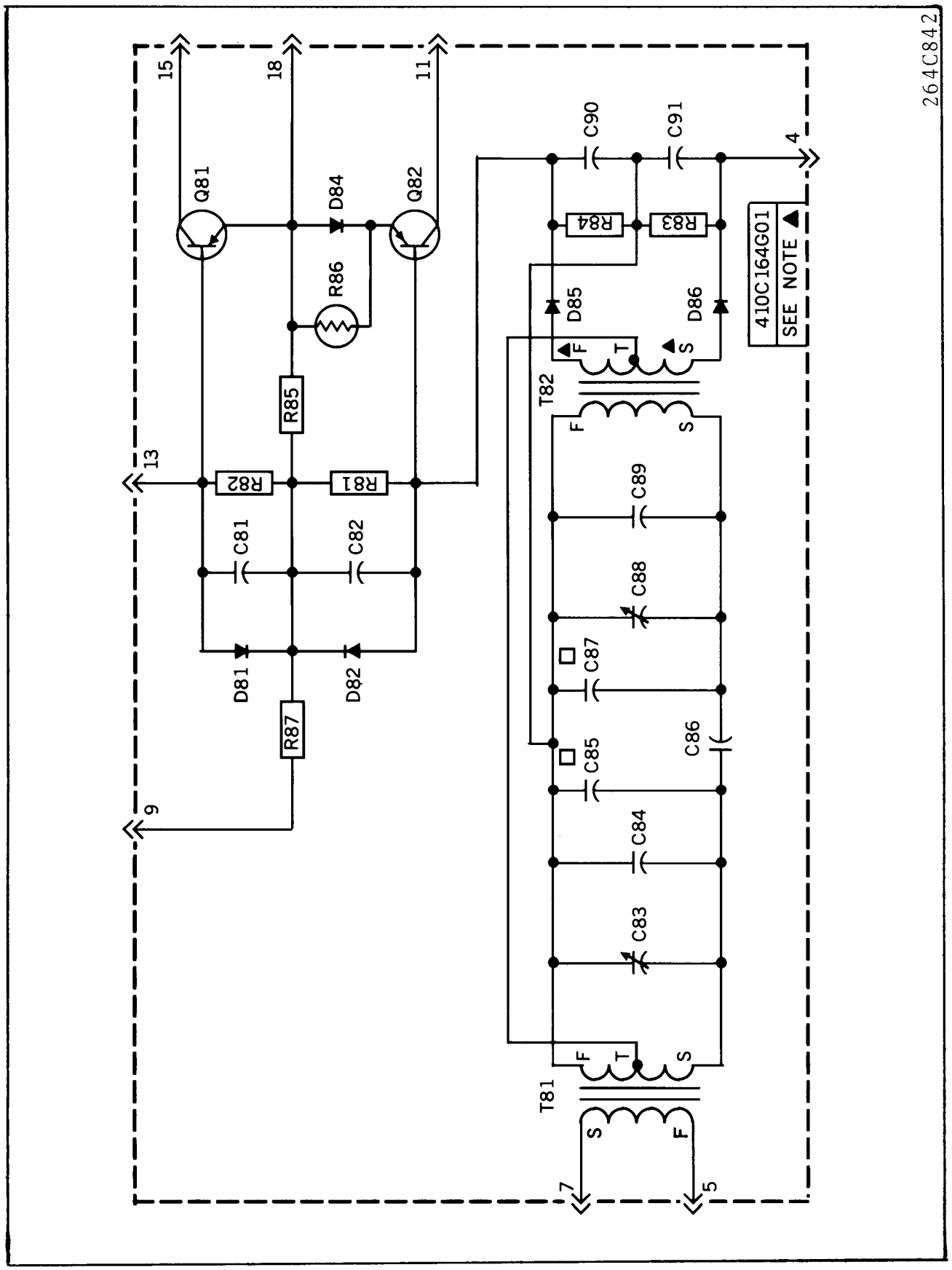


Fig. 22. Internal Schematic Discriminator – Silicon Transistor Version

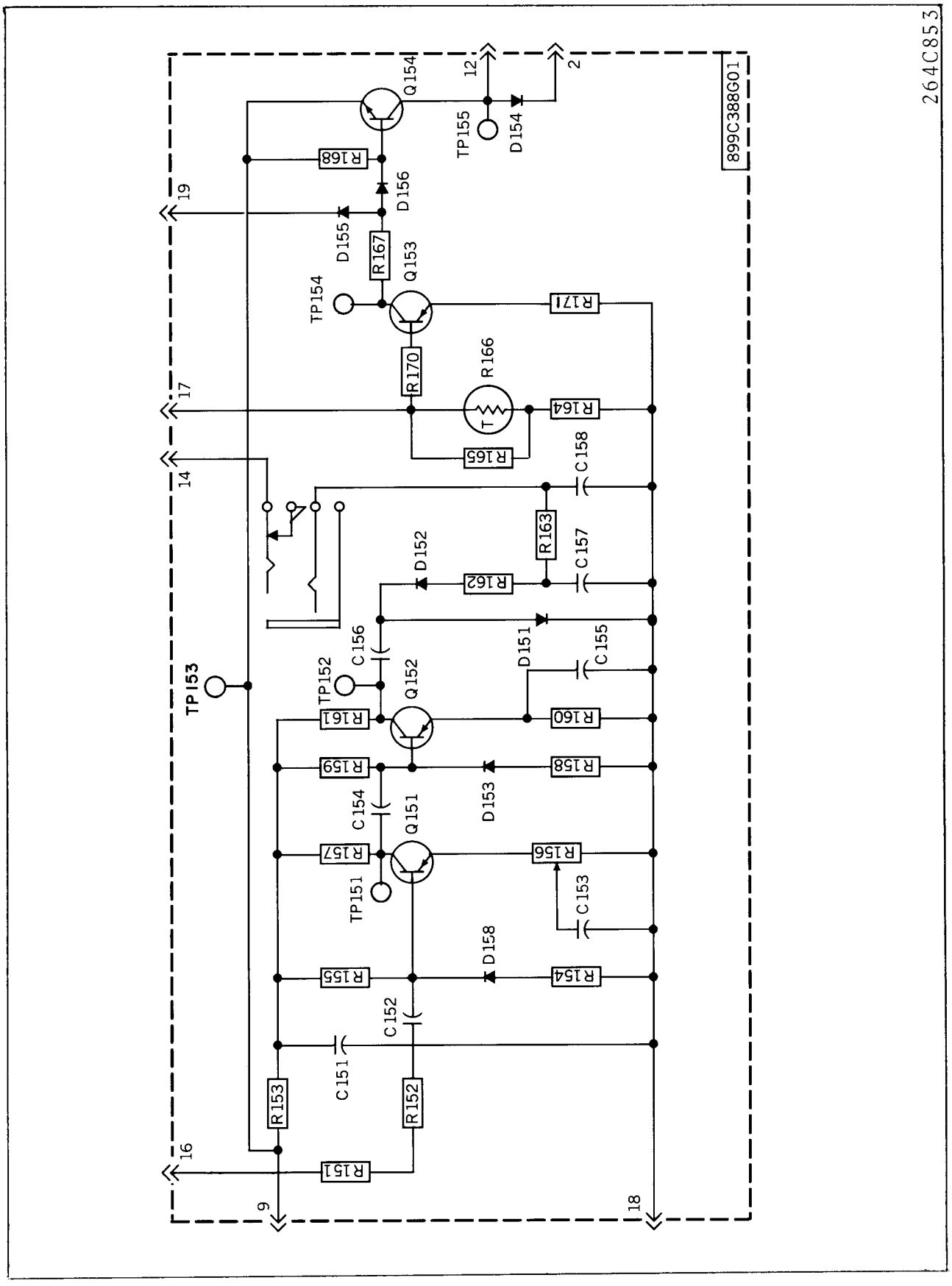


Fig. 23. Internal Schematic Carrier Level Indicator – Silicon Transistor Version

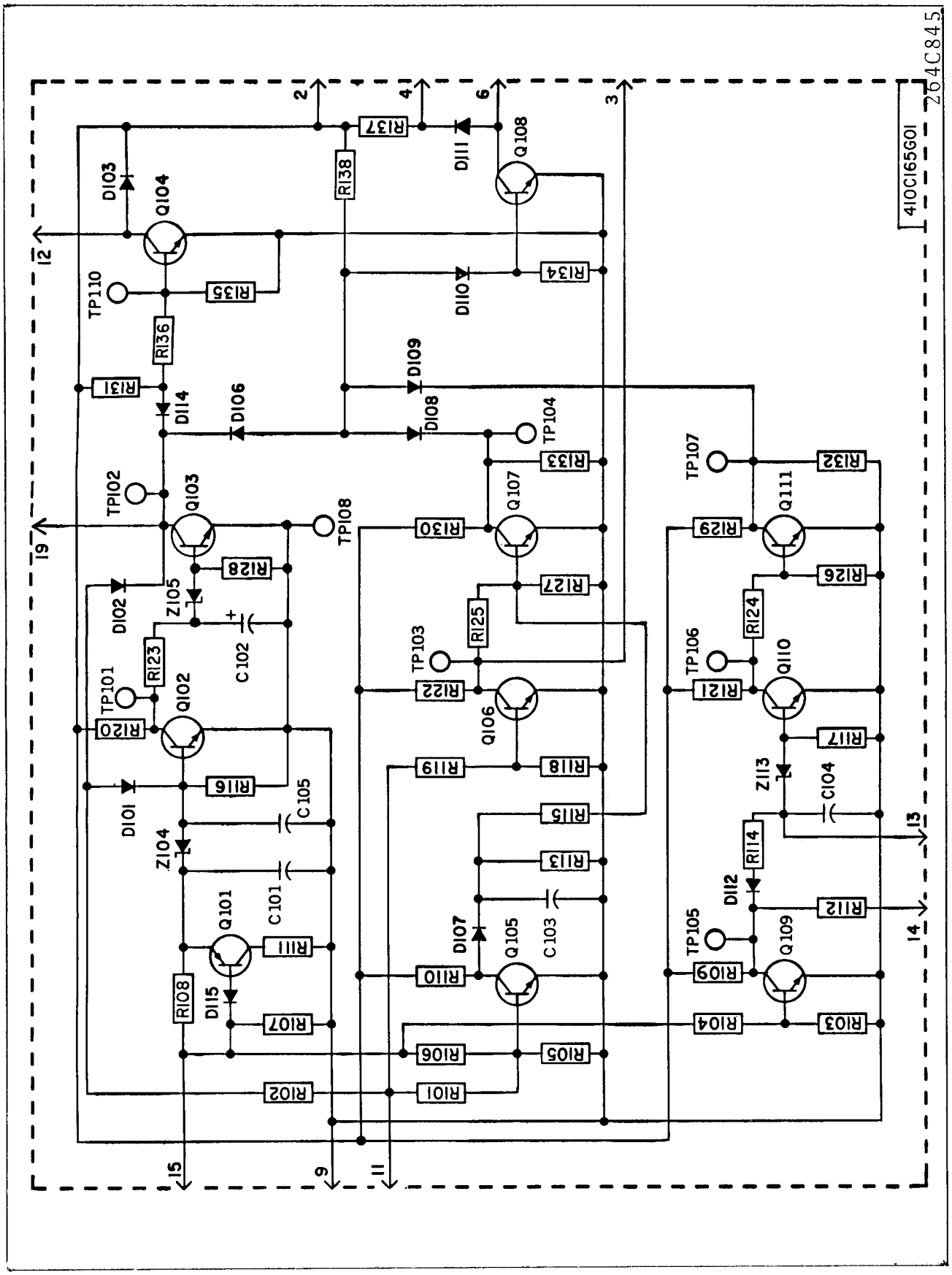


Fig. 24. Internal Schematic Logic Board – Silicon Transistor Version

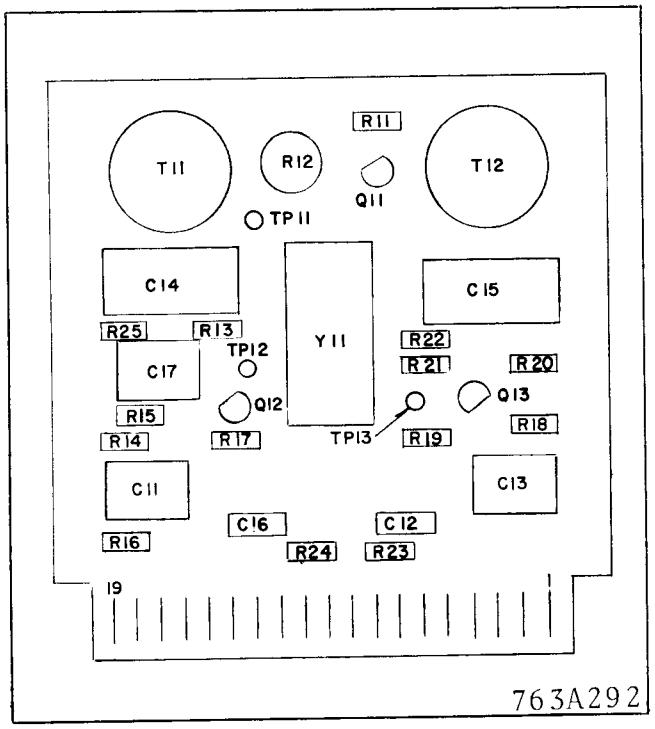


Fig. 25. Component Locations 30-200KHz. Oscillator and Mixer Silicon Transistor Version

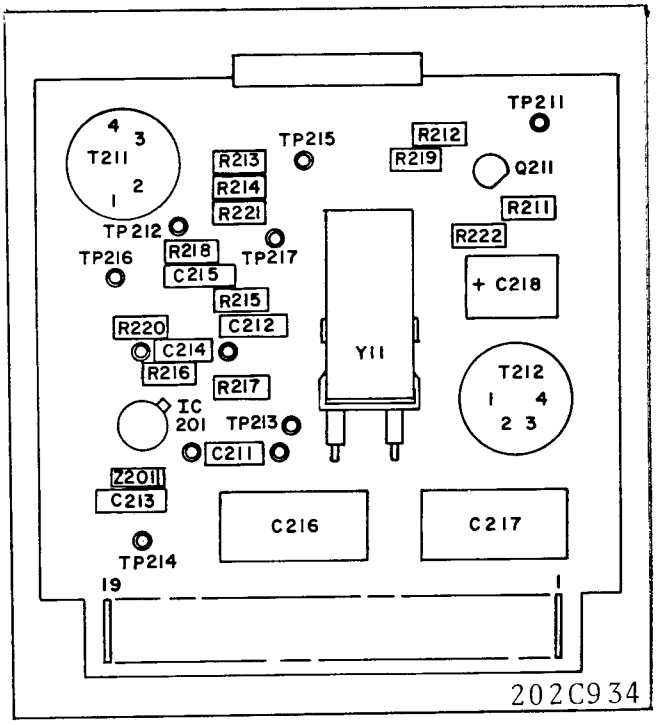


Fig. 26. Component Locations 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version

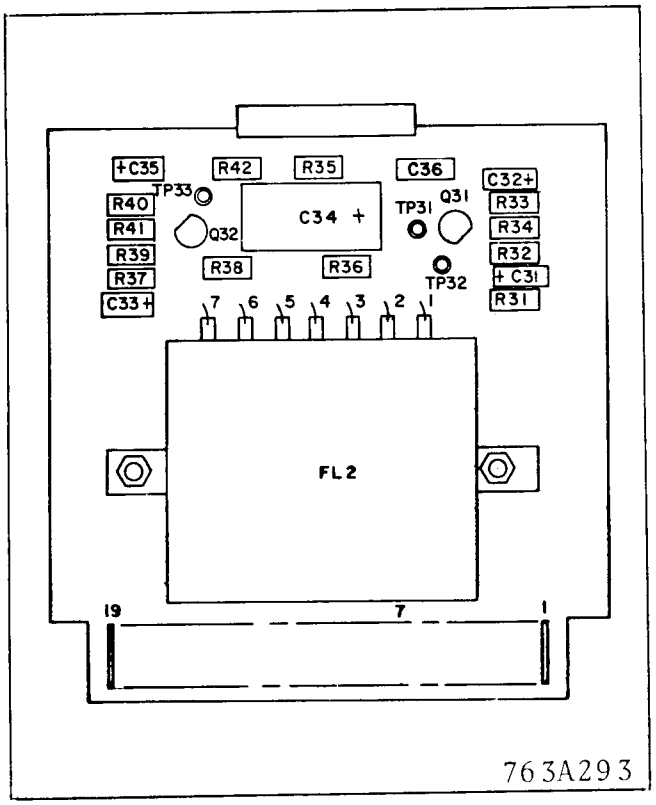


Fig. 27. Component Locations I.F. Amplifier – Silicon Transistor Version

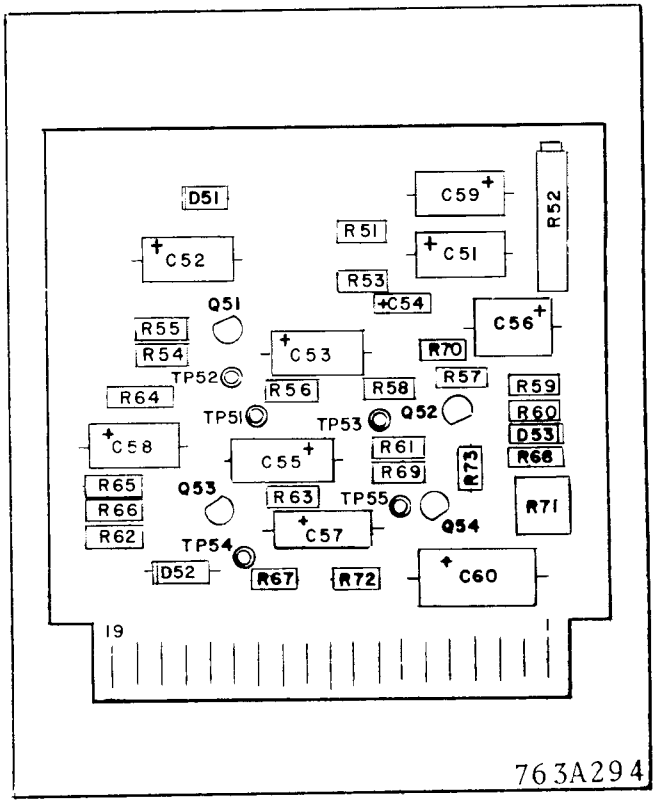


Fig. 28. Component Locations Amplifier and Limiter – Silicon Transistor Version

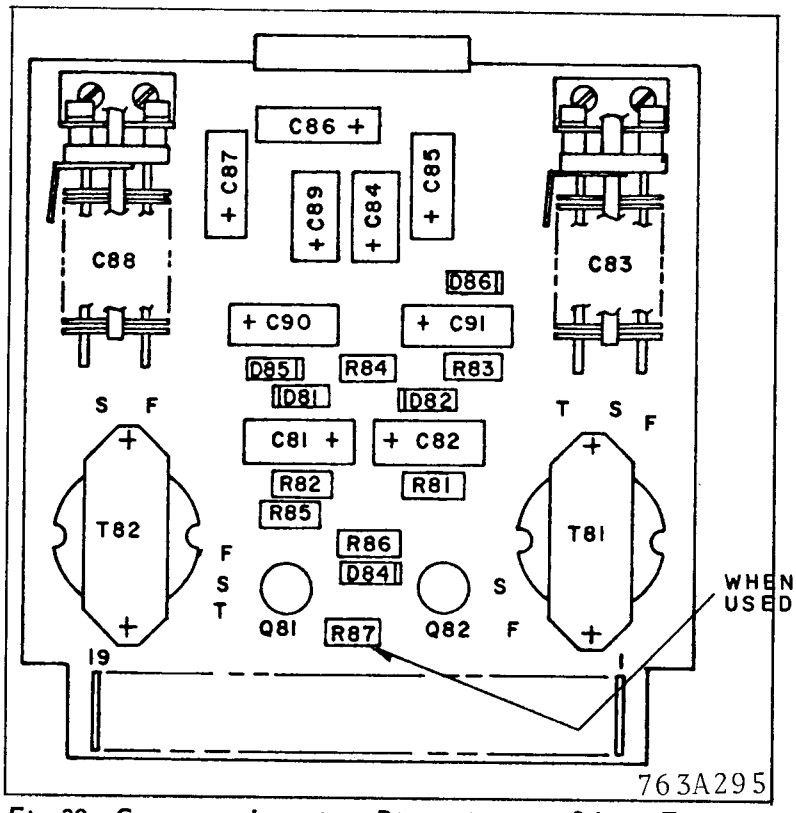


Fig. 29. Component Locations Discriminator – Silicon Transistor Version

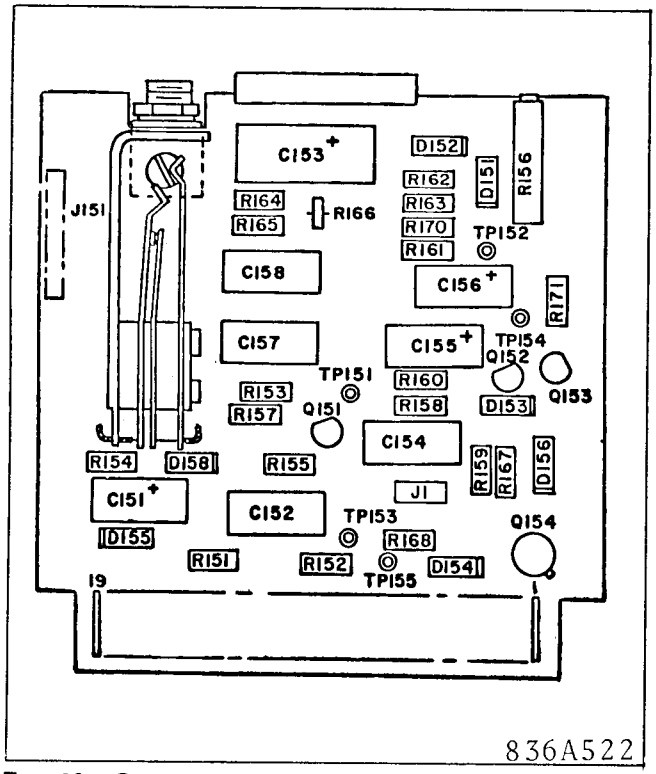


Fig. 30. Component Locations Carrier Level Indicator – Silicon Transistor Version

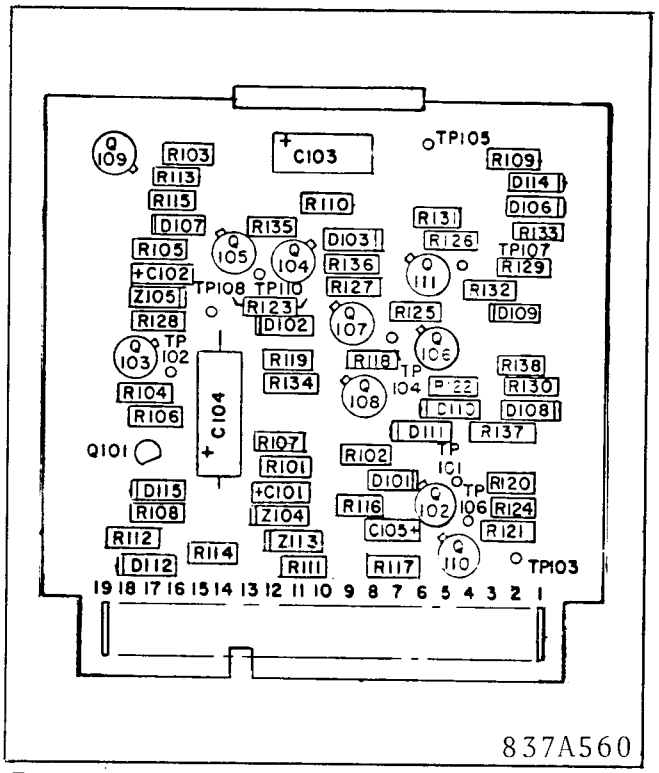


Fig. 31. Component Locations Logic Board – Silicon Transistor Version

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.

Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is *not* operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such * settings the carrier level indicator current would be approximately 2.25 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.6 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental inserting of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	1500 hertz minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

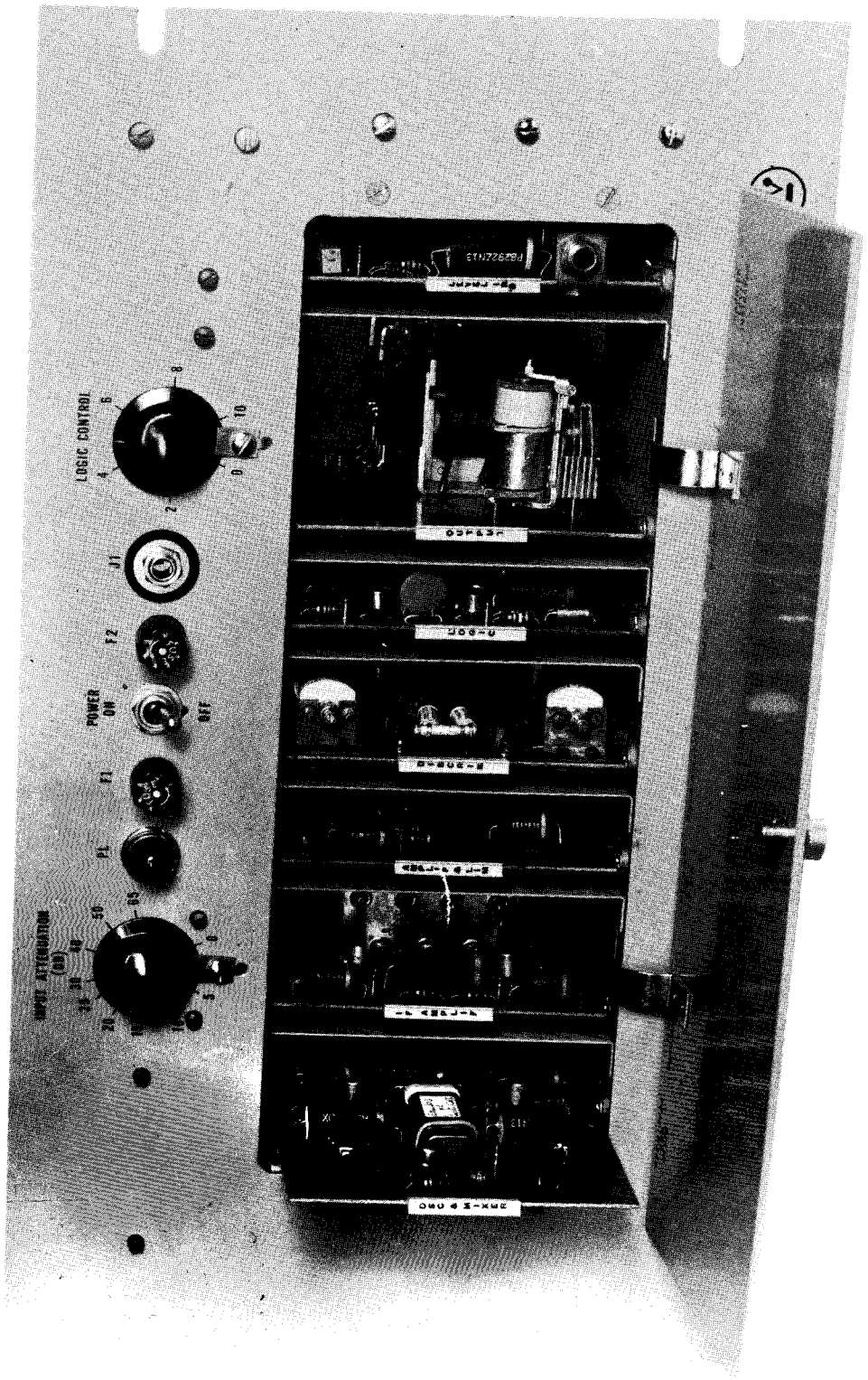
Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

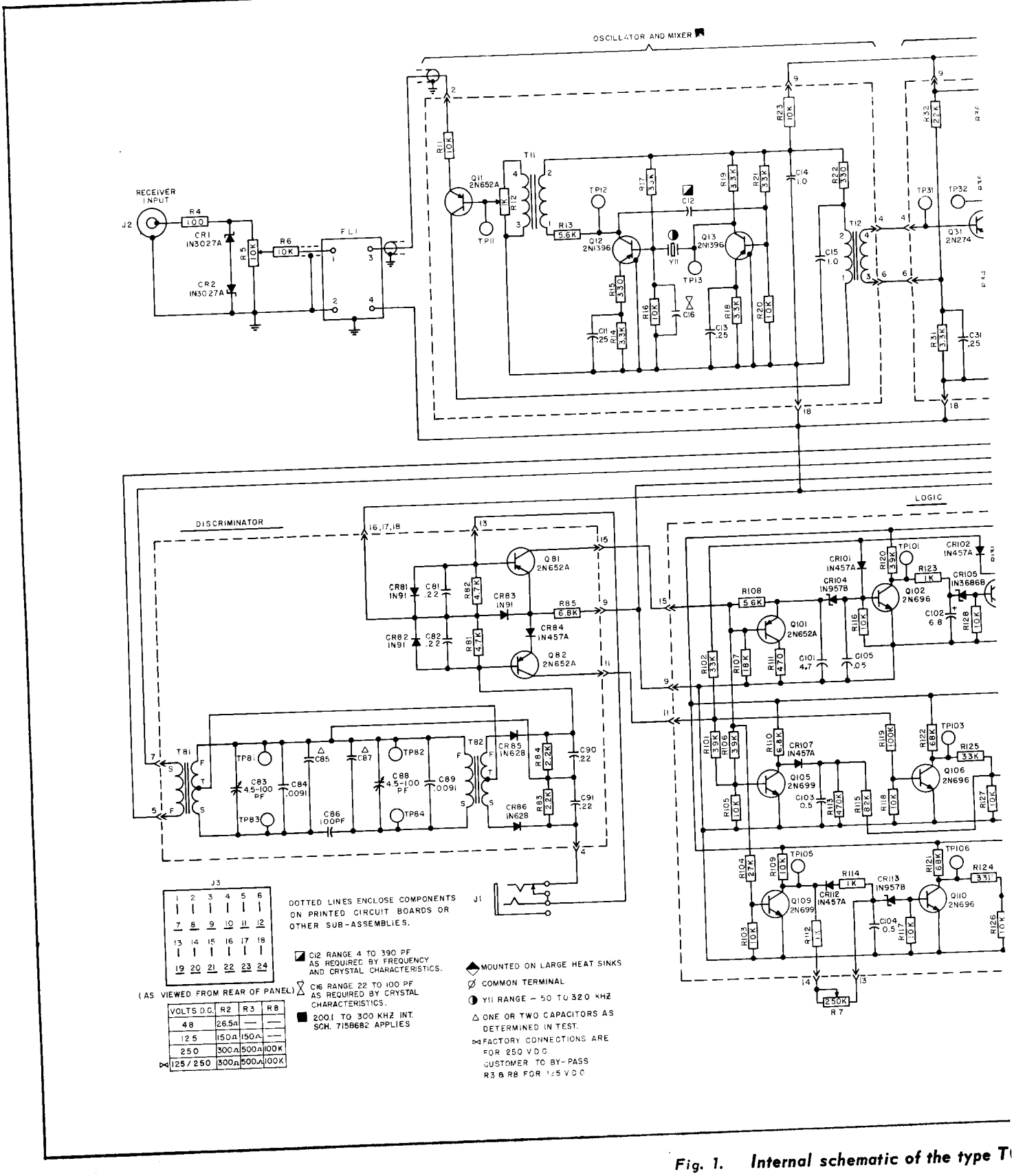
The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

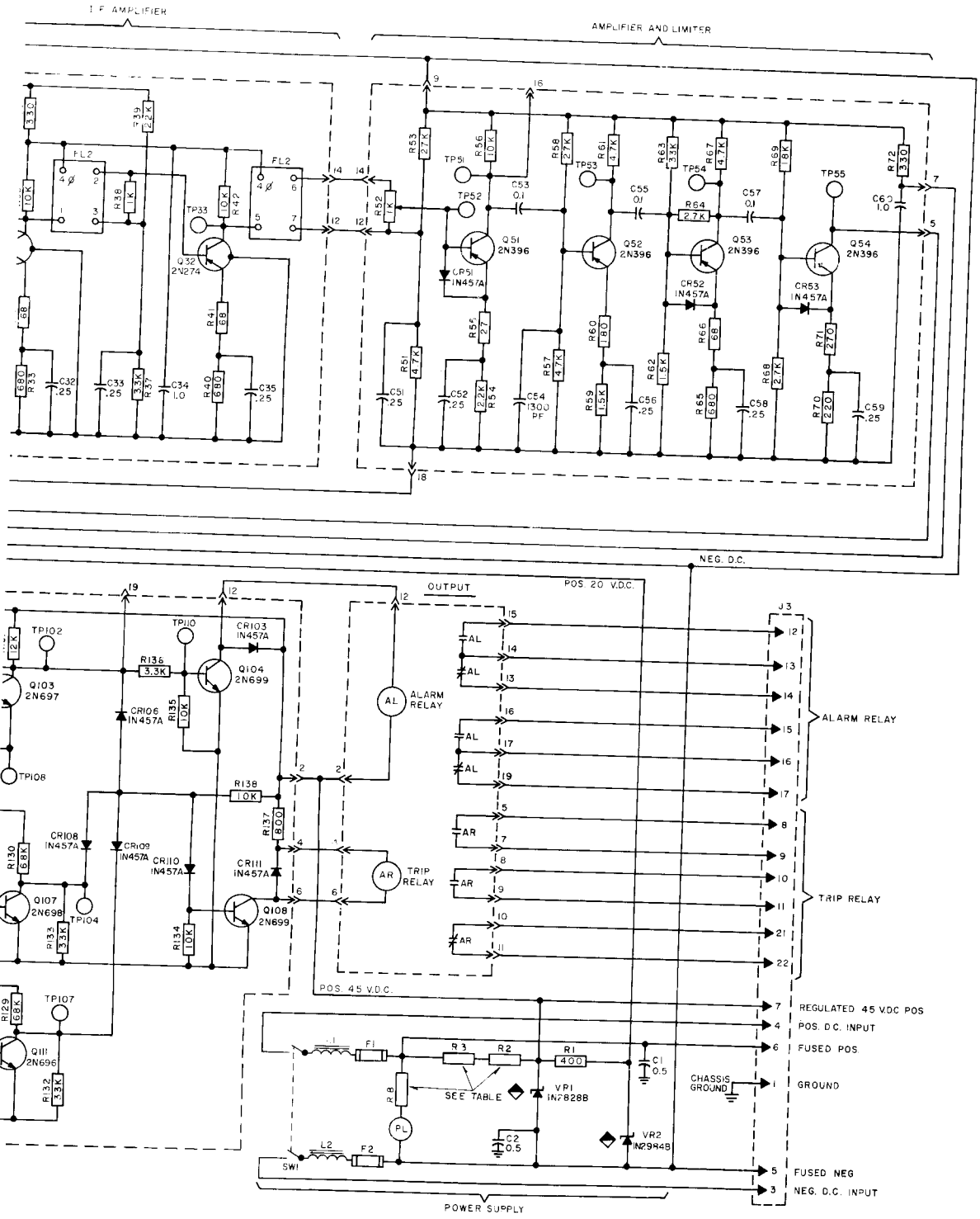


Type TCF Receiver (Front View).



VOLTS D.C.	R2	R3	R8
48	26.5Ω	—	—
125	150Ω	150Ω	—
250	300Ω	500Ω	100K
125/250	300Ω	500Ω	100K

Fig. 1. Internal schematic of the type T



543D637

IF receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Imput Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf, 50 v.d.c.	184A663H04
C213	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A855H07
CR156	IN457A; 60 V.; 200 MA.	
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. ± 5%; 400 MW.	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ±5%; ½ W. Composition	184A763H13
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	205C043G03
T12	Toroidal type, 25000/300 ohms	205C043G03
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	205C043G01
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01 + (Req. Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408A845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

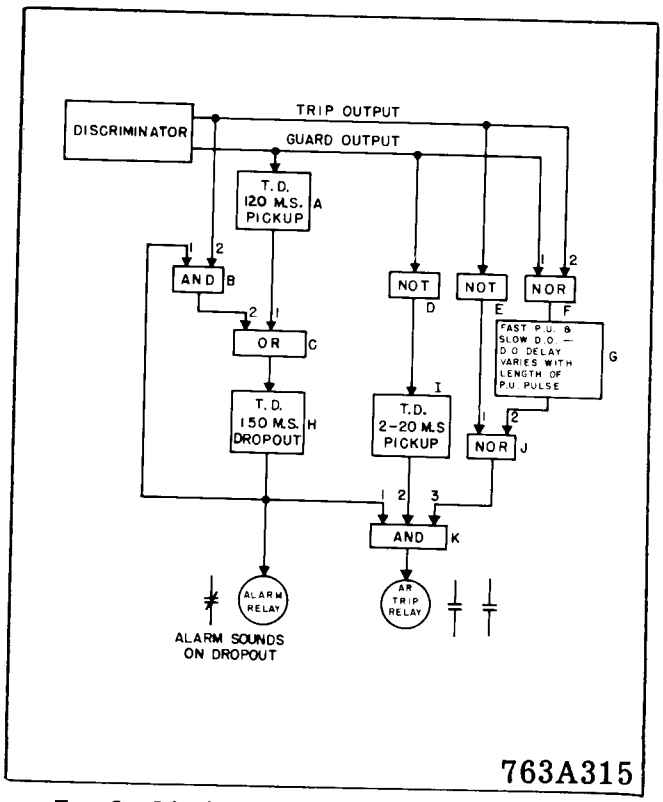


Fig. 3 Block diagram of output logic circuit

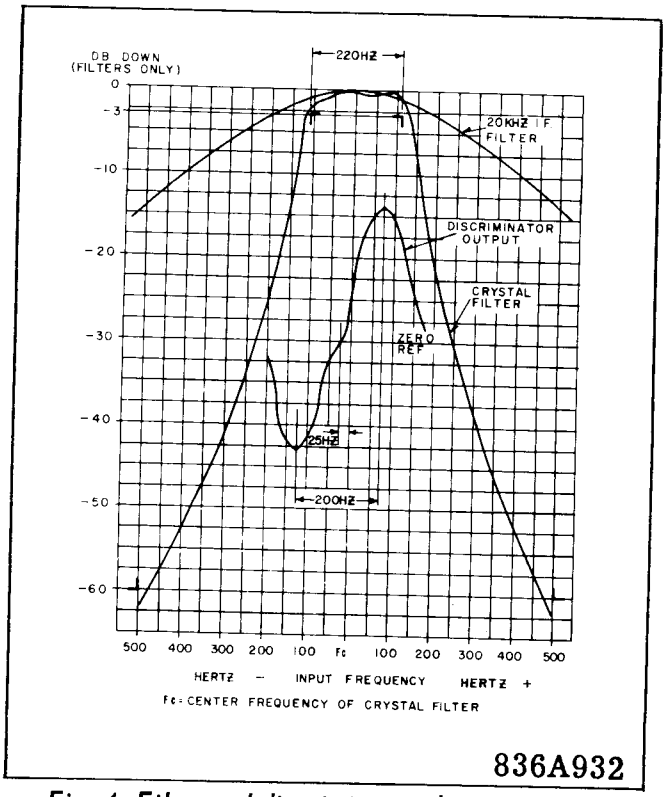
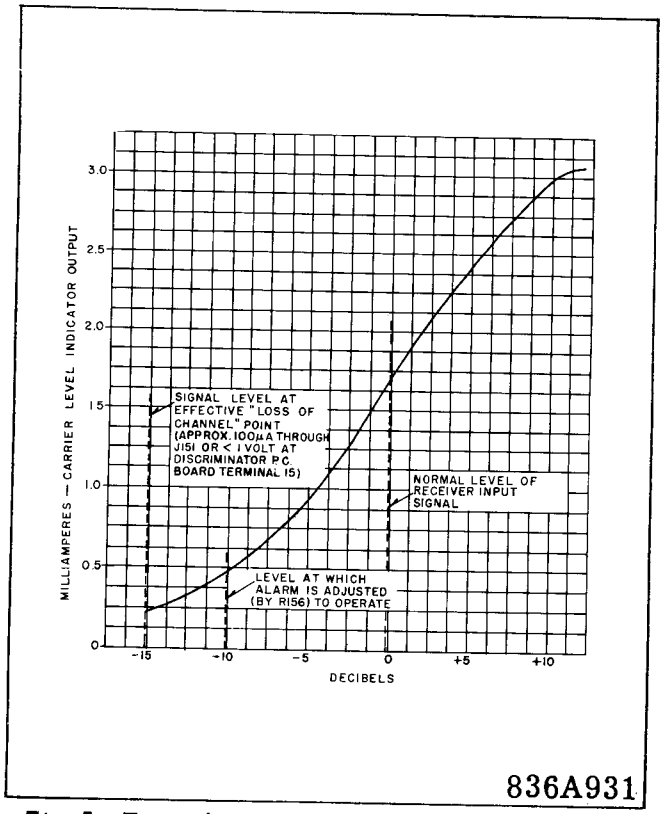


Fig. 4 Filter and discriminator characteristics of the type TCF receiver



* *Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.*

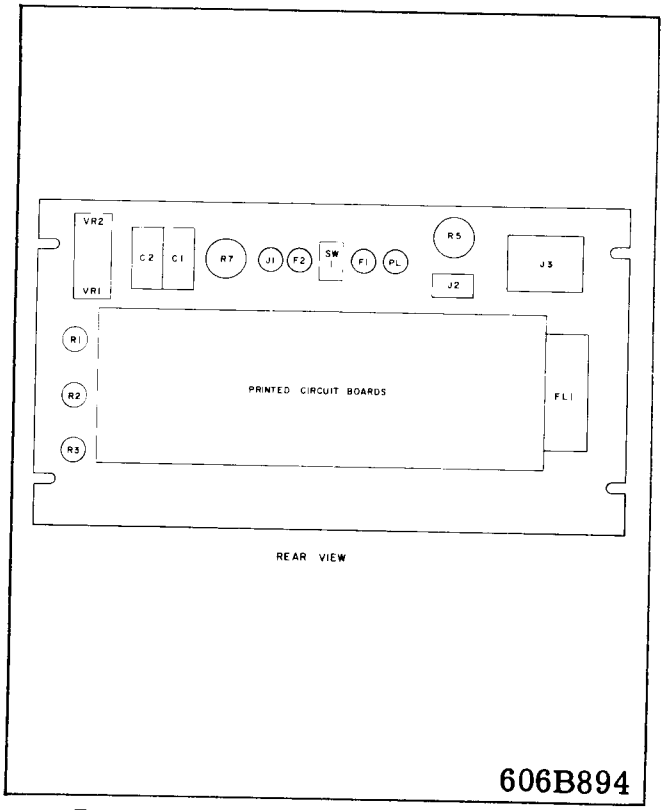


Fig. 6 Component locations on the type TCF receiver panel

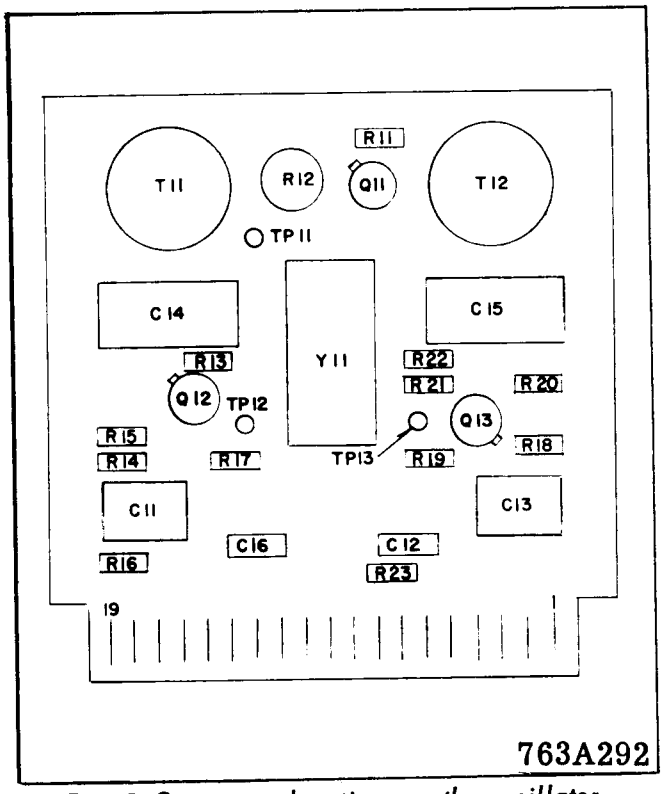


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

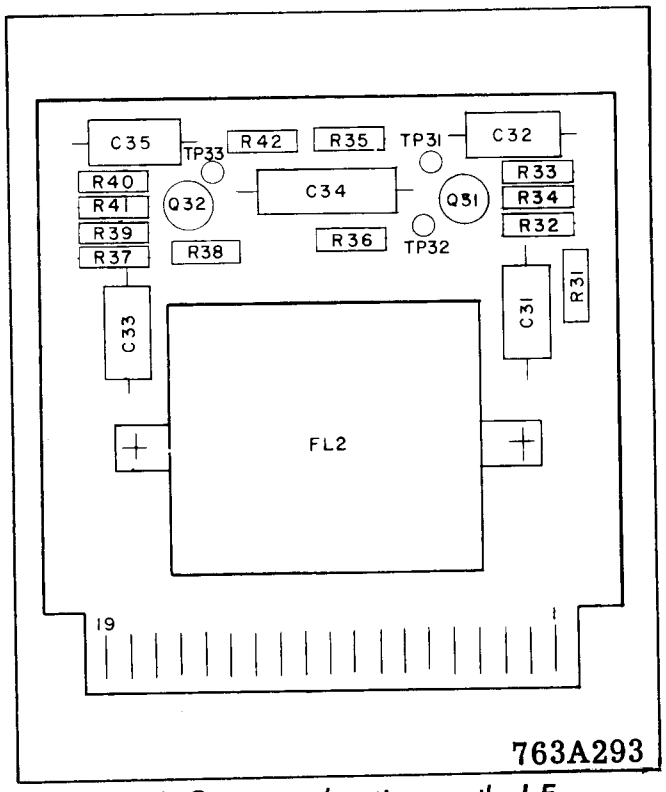


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

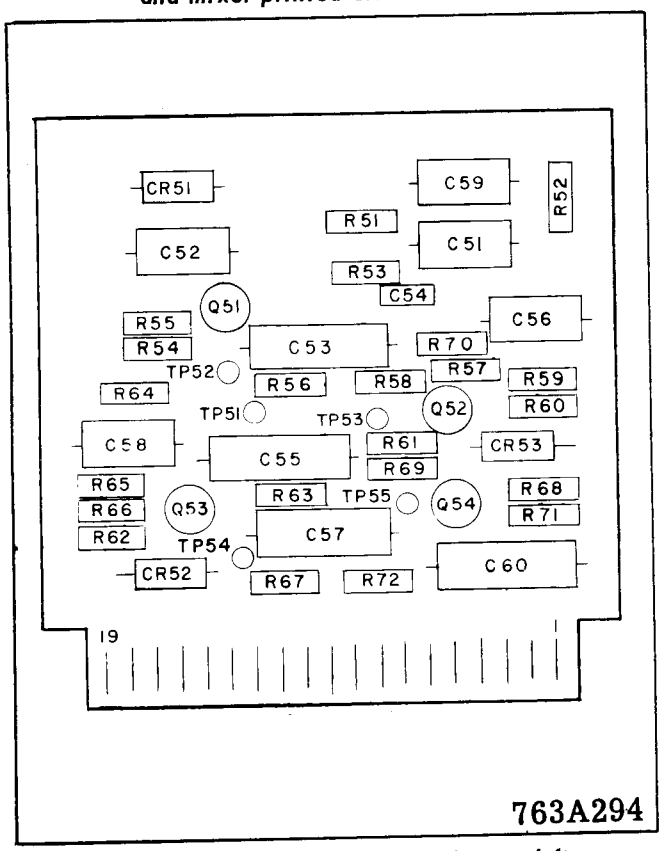


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

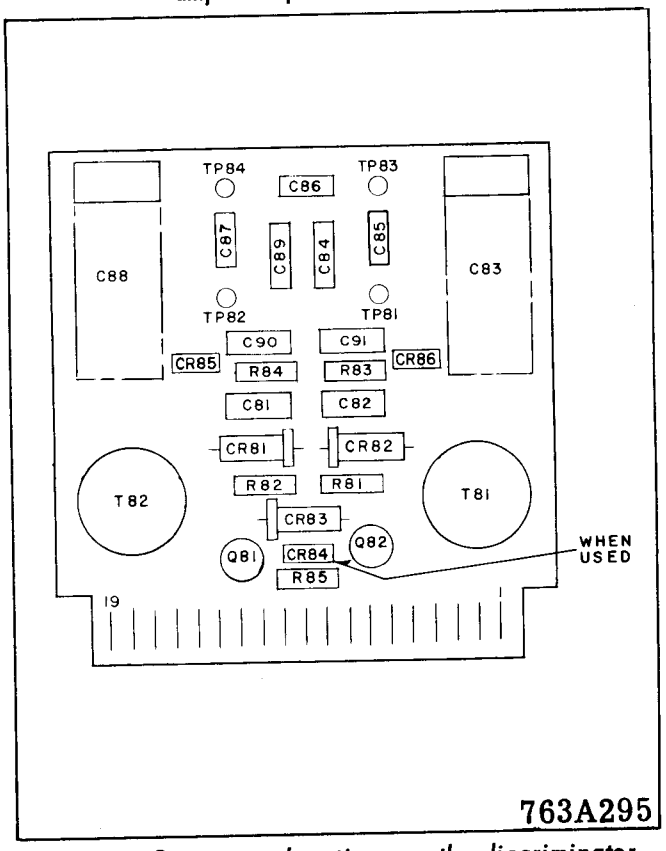


Fig. 10 Component locations on the discriminator printed circuit board.

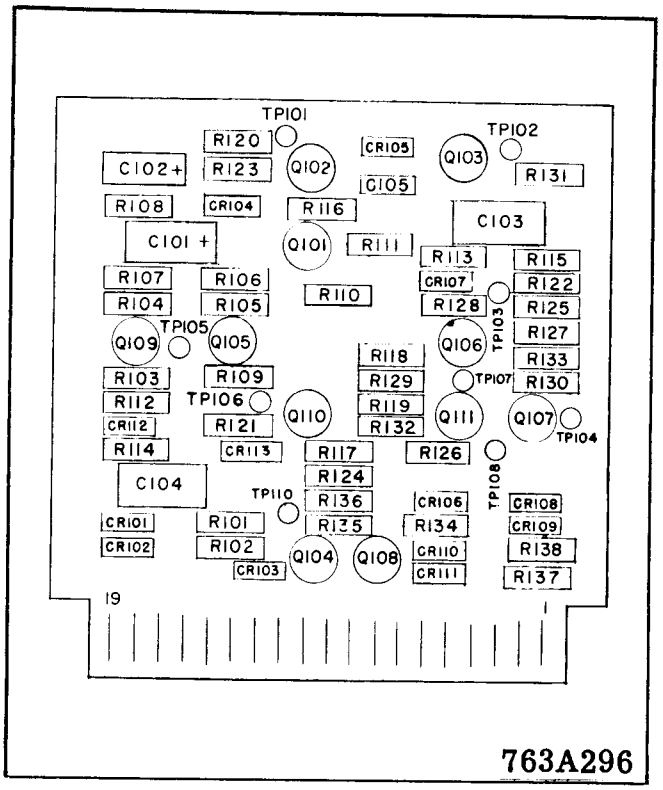


Fig. 11 Component locations on the logic printed circuit board.

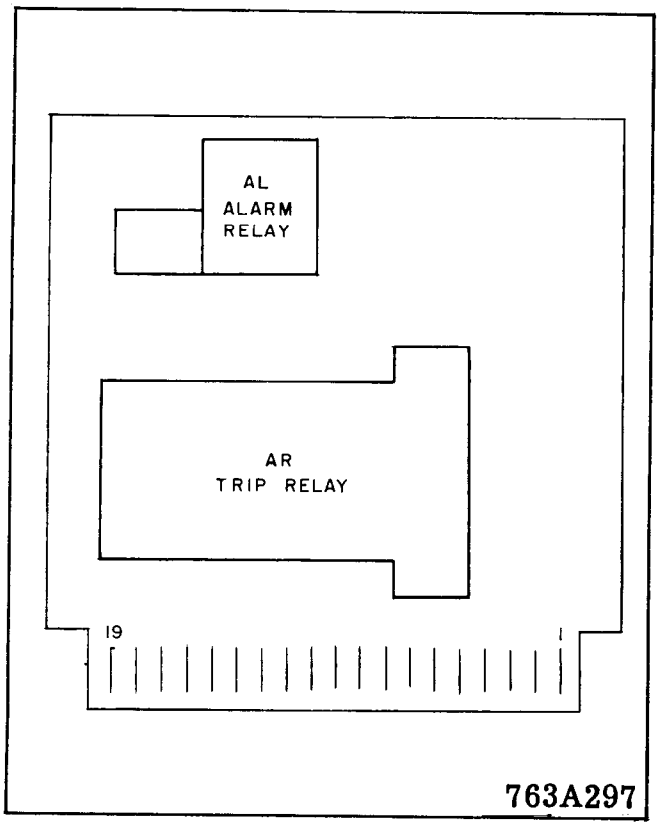


Fig. 12 Component locations on the output printed circuit board.

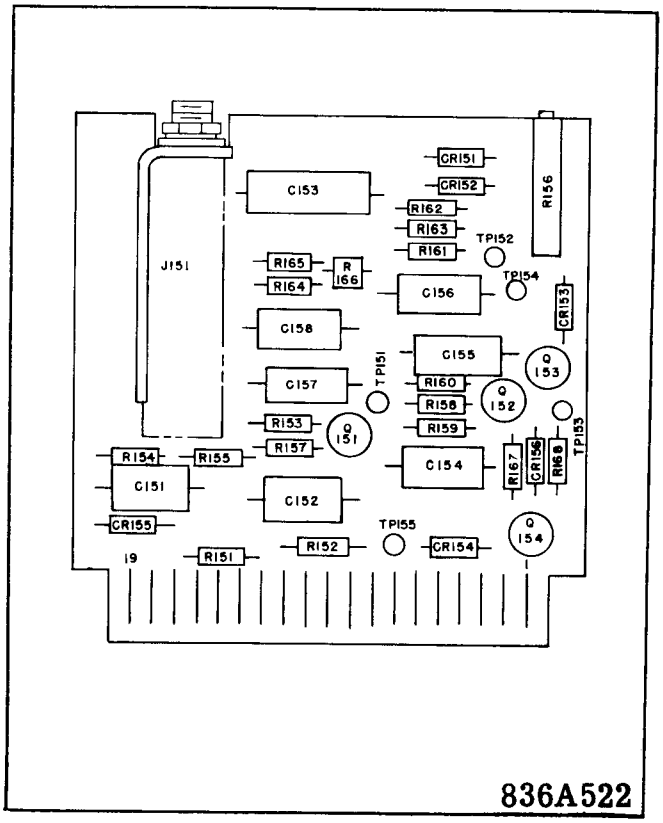


Fig. 13 Component locations on the carrier level indicator printed circuit board.

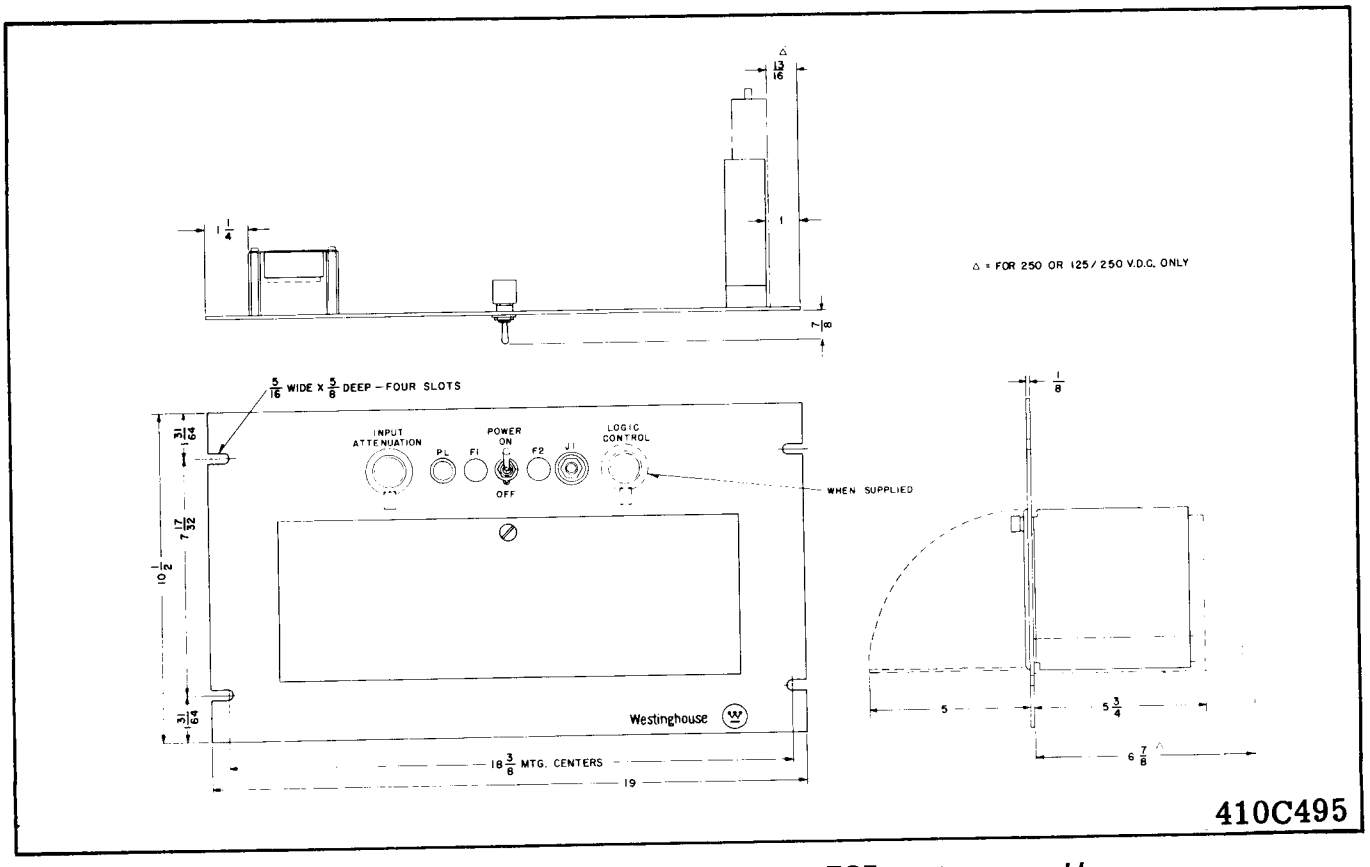


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

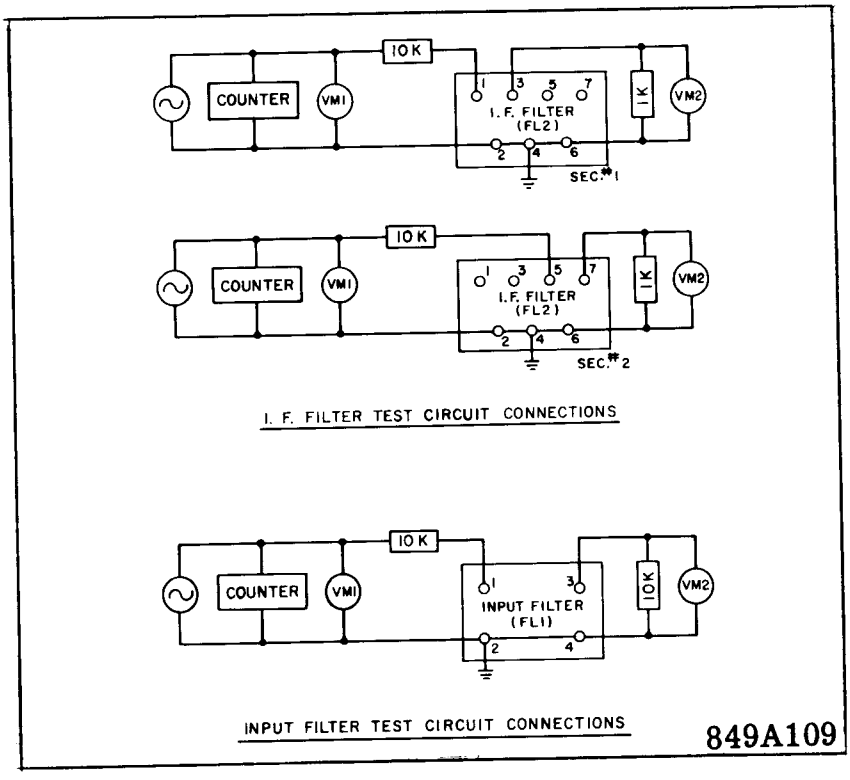


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.

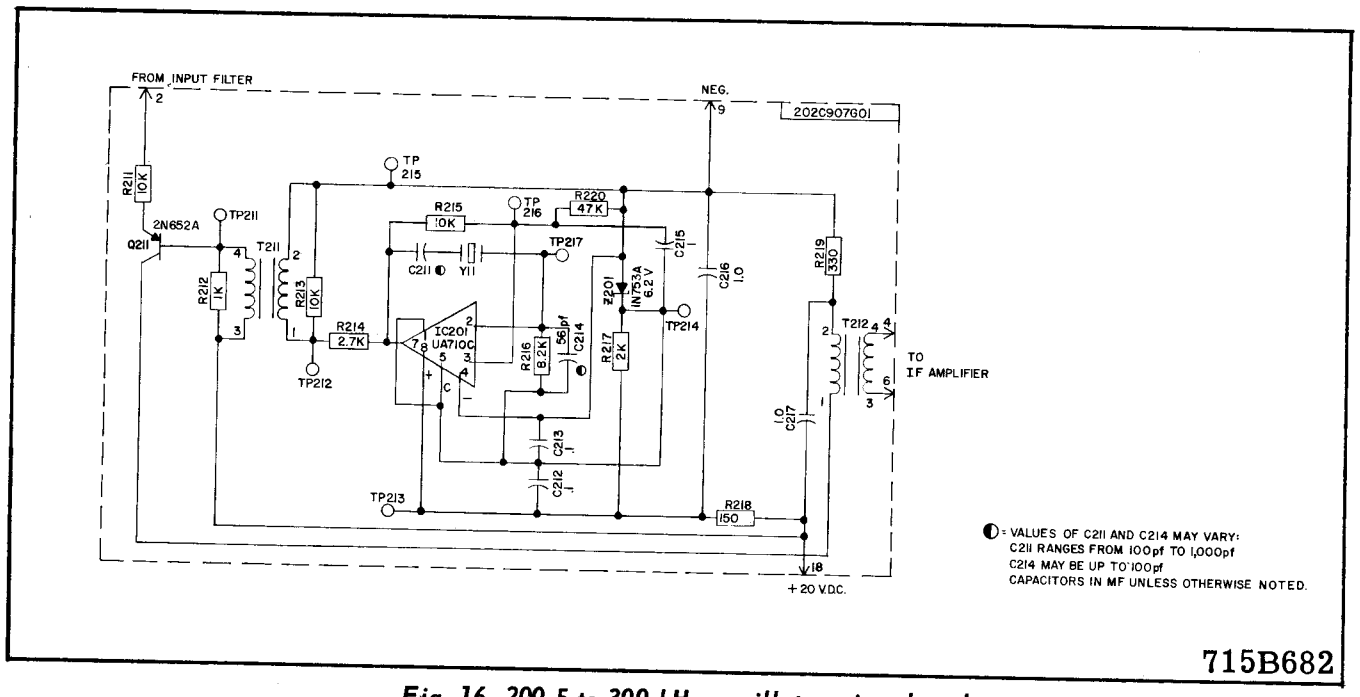


Fig. 16. 200.5 to 300 kHz oscillator mixer board

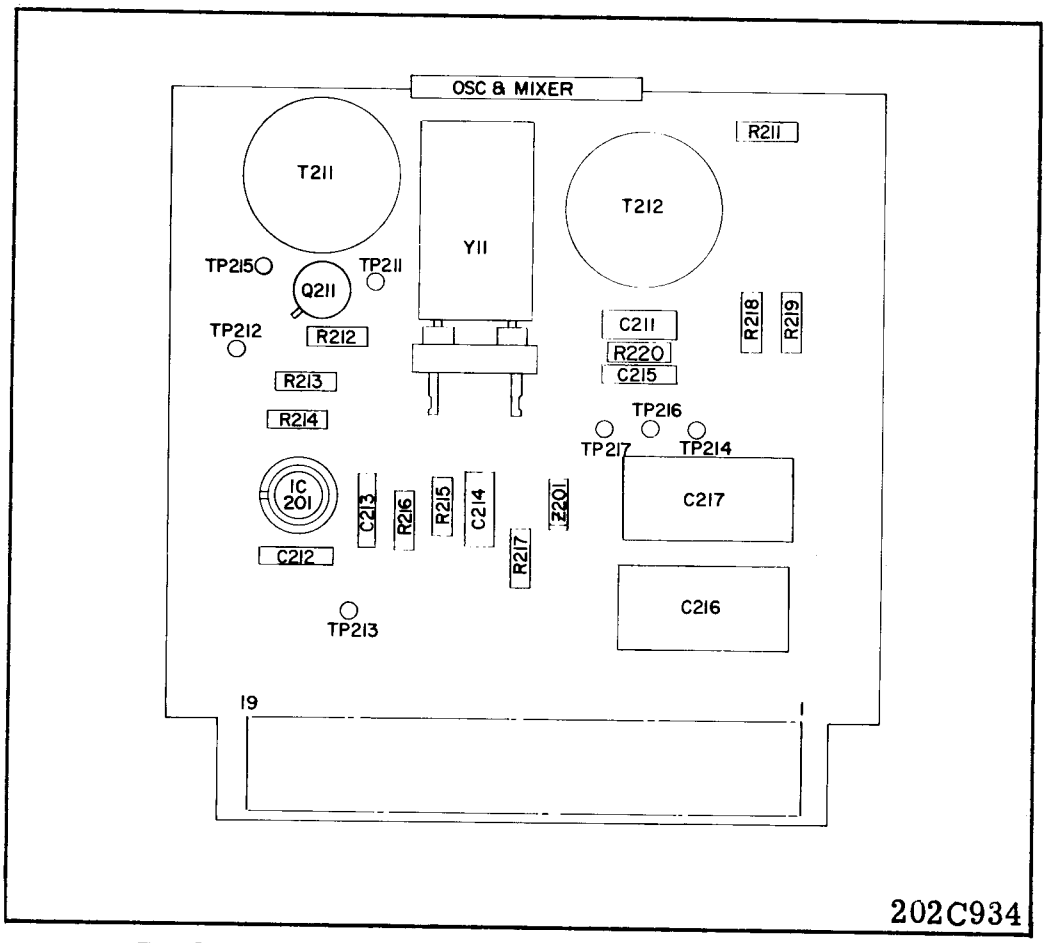


Fig. 17. Component Location 200.5 to 300 kHz oscillator mixer board.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.
Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, or IC201 (Fig. 16) and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 kHz above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the later is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20kHz, 2fc + 20kHz, fc + 20kHz and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero output frequency. This separation of 200 hertz between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 hertz in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20 kHz-100 hertz. Similarly, the Trip frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears, the discriminator output at term. 15 will turn Q101 off. C101 will change and after 120 ms. it will reach the breakdown voltage of CR104 and turn Q102 on. This will allow C102 to quickly discharge through R123 and Q102 and provide the full 150 ms. time delay to be effective on any subsequent loss of guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such
* settings the carrier level indicator current would be approximately 2.25 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.6 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental ininsertion of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	1500 hertz minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½'' or 6 r.u. Panel width - 19''
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

– "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible, because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

Type TCF Receiver (Front View).

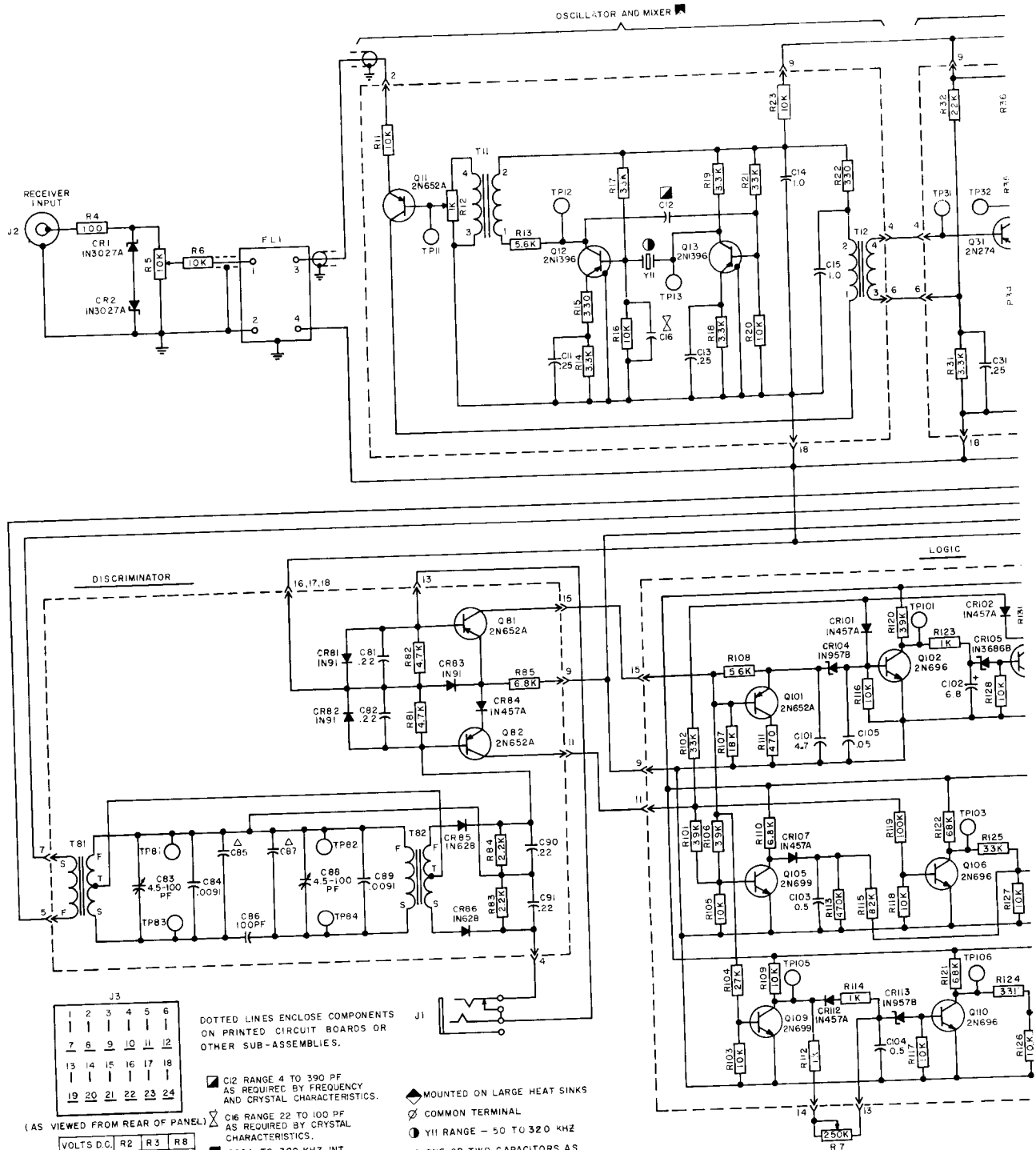
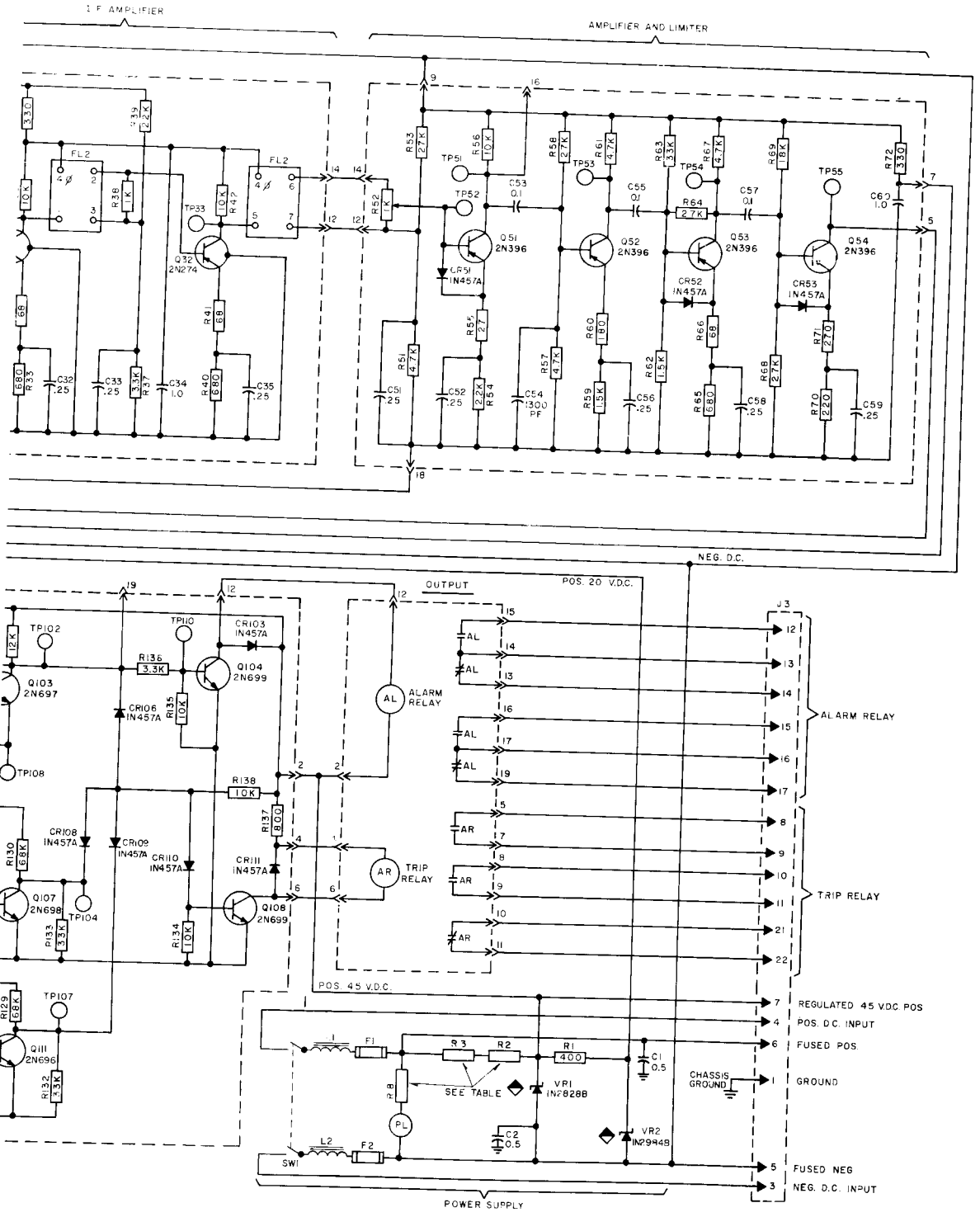


Fig. 1. Internal schematic of the type T



543D637

:F receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Imput Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A695H
C211	Durmica; 100 mmf to 1000 mmf	184A663H04
C212	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C213	Ceramic; .1 mf, 50 v.d.c.	187A695H17
C214	Durmica; .56 mmf	184A663 H04
C215	Ceramic; .1 mf, 50 v.d.c.	187A624H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A855H07
CR156	IN457A; 60 V.; 200 MA.	
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. v 5%; 400 MW.	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ±5%; ½ W. Composition	184A763H13
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	205C043G03
T12	Toroidal type, 25000/300 ohms	205C043G03
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	205C043G01
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585E03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01 + (Req. Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408A845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

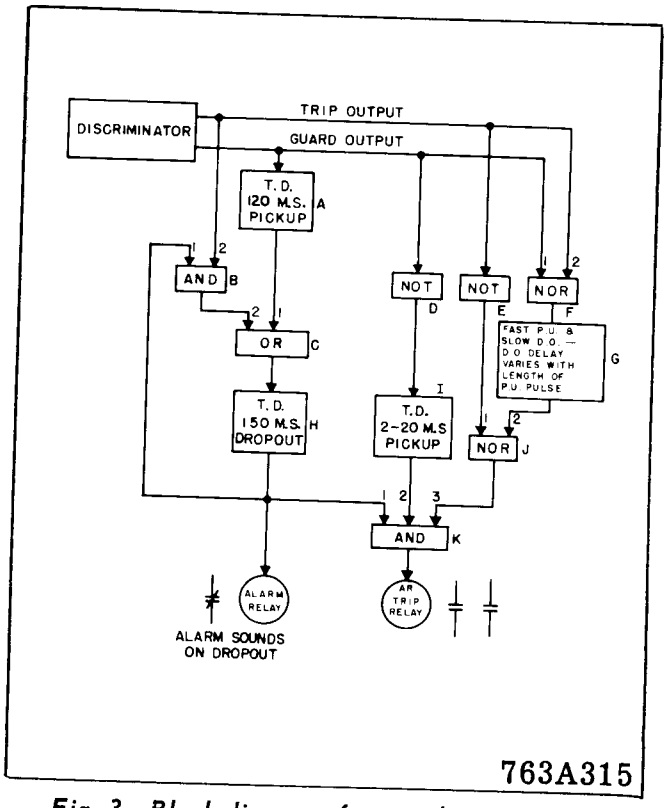


Fig. 3 Block diagram of output logic circuit

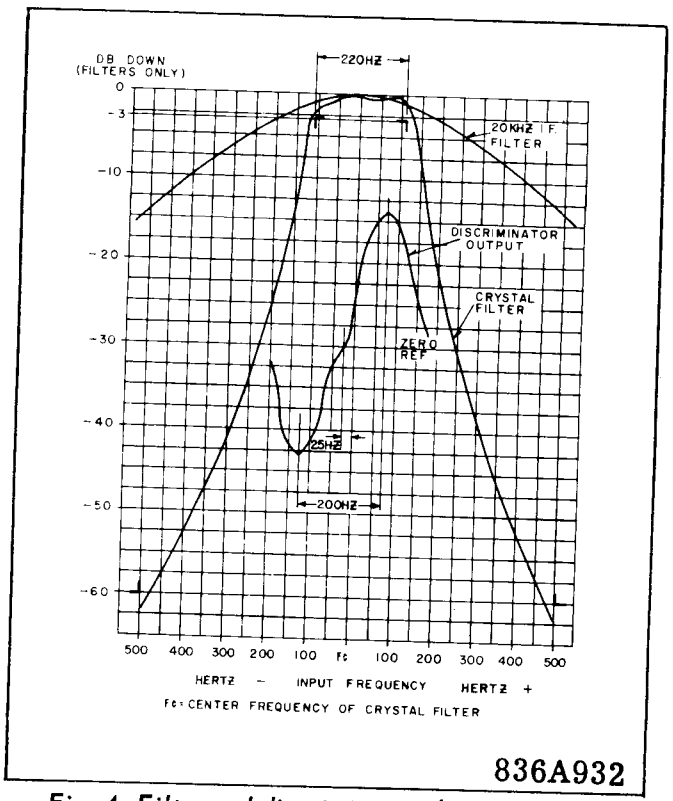
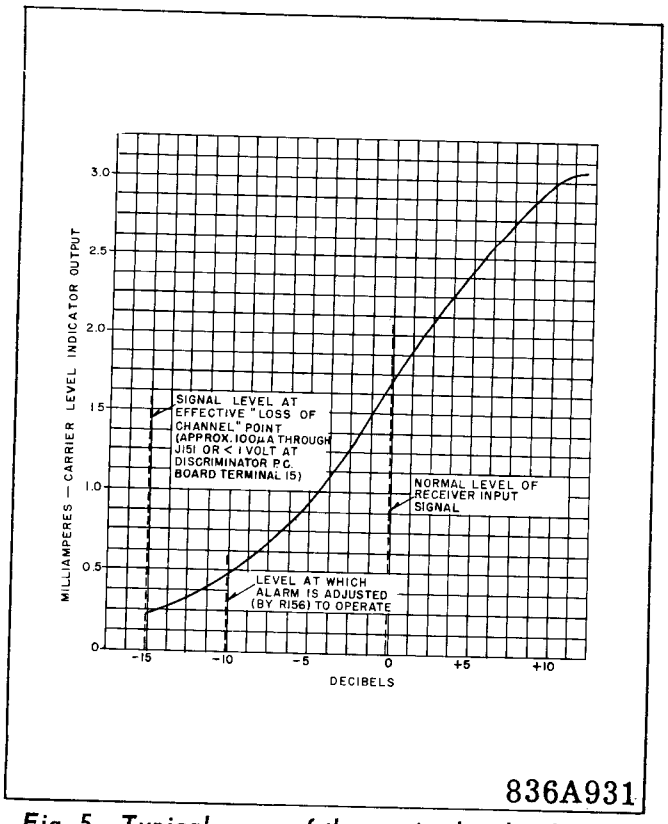


Fig. 4 Filter and discriminator characteristics of the type TCF receiver



* *Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.*

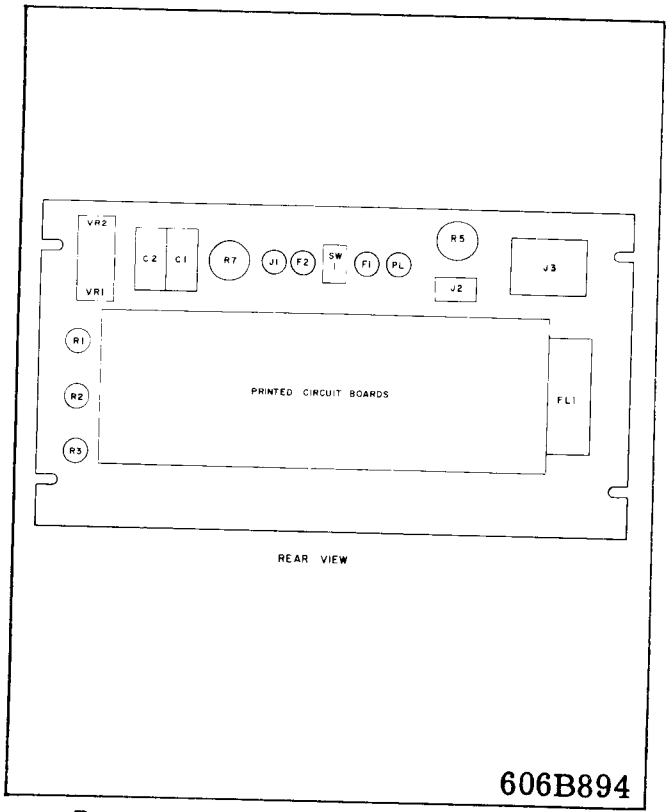


Fig. 6 Component locations on the type TCF receiver panel

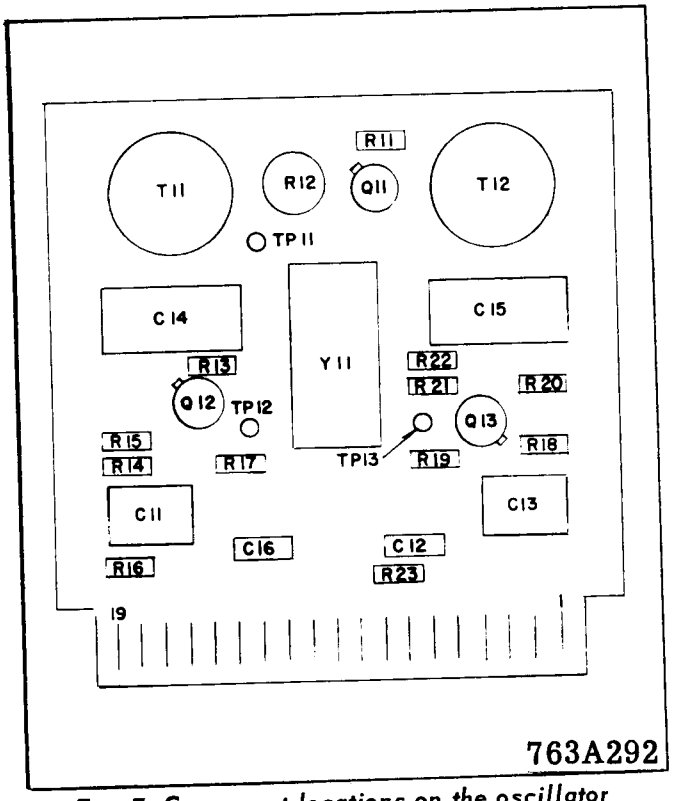


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

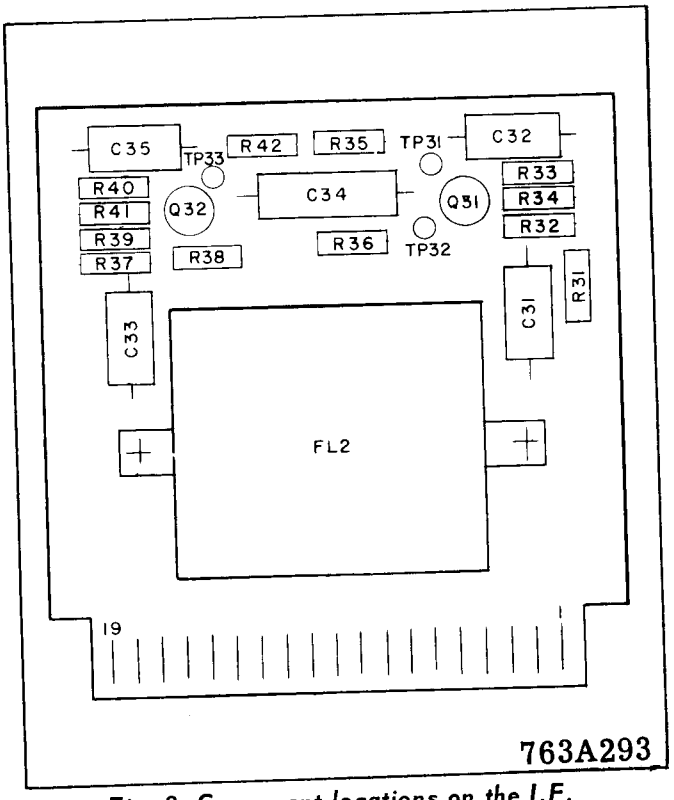


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

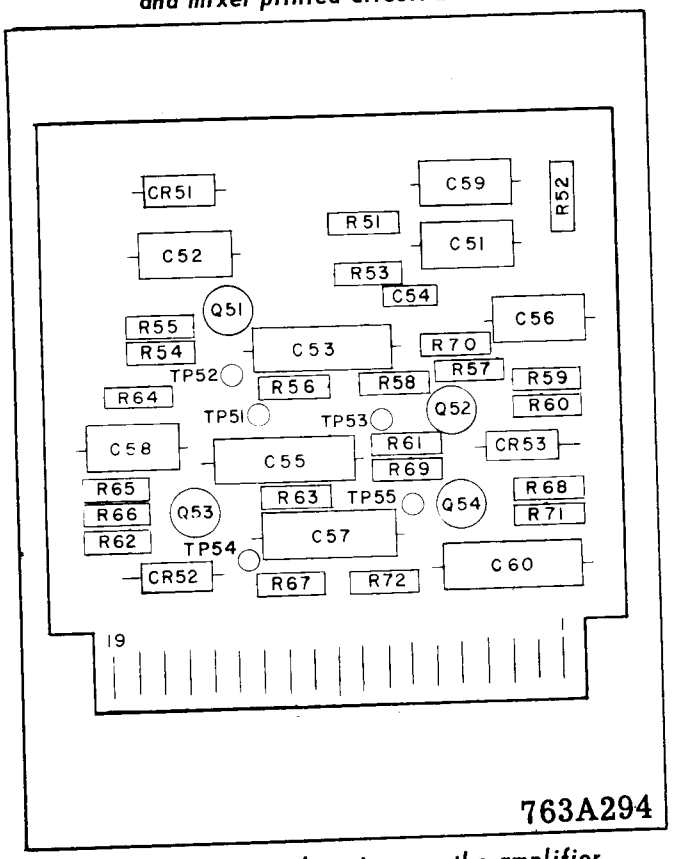


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

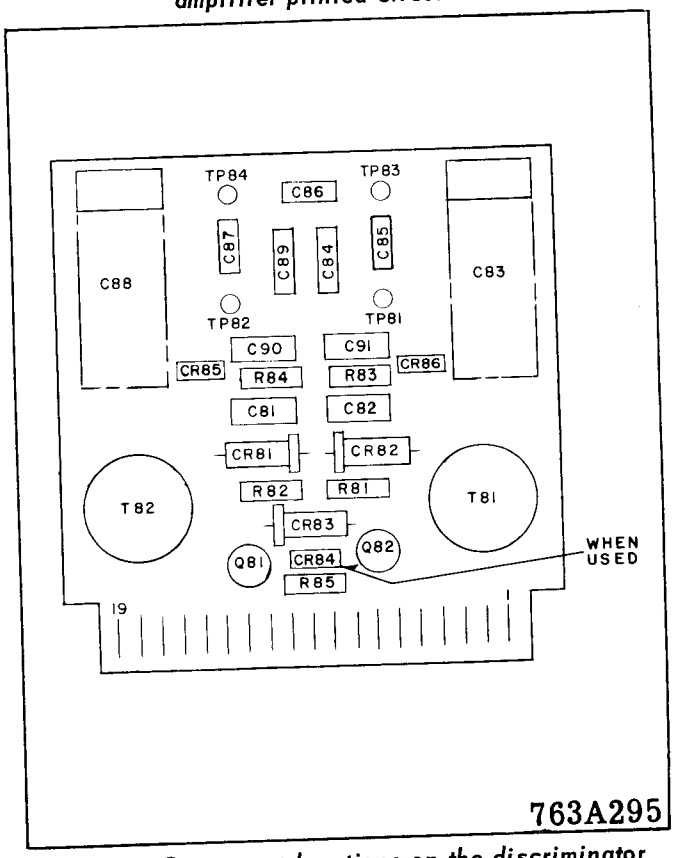


Fig. 10 Component locations on the discriminator printed circuit board.

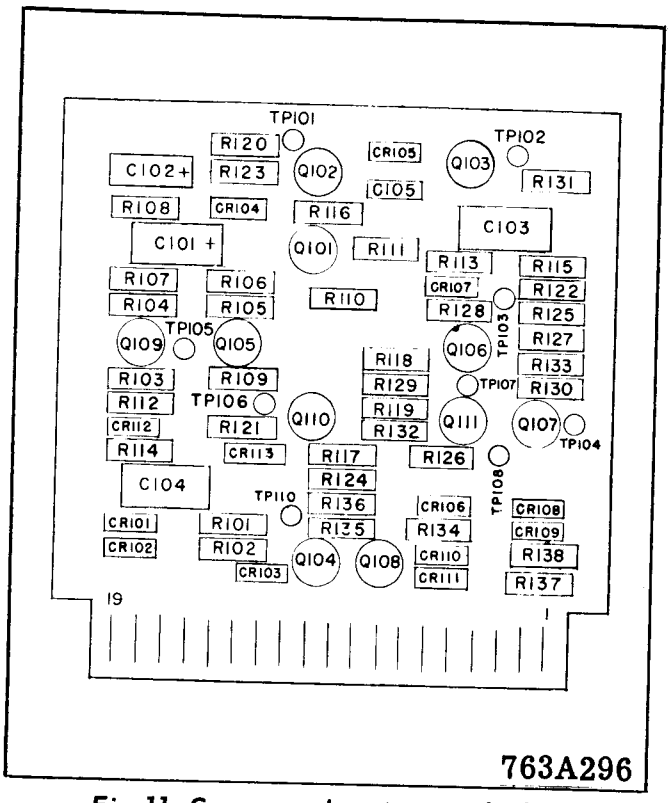


Fig. 11 Component locations on the logic printed circuit board.

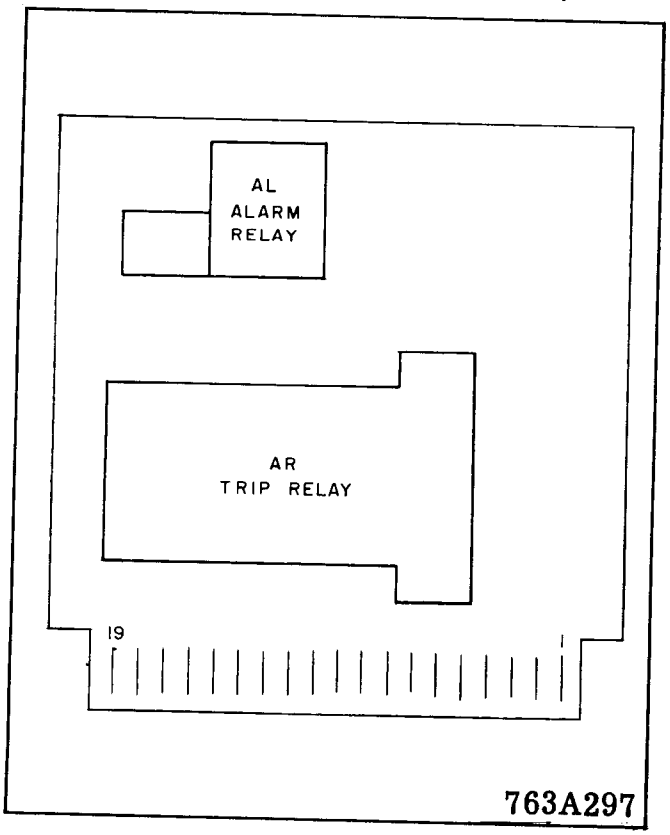


Fig. 12 Component locations on the output printed circuit board.

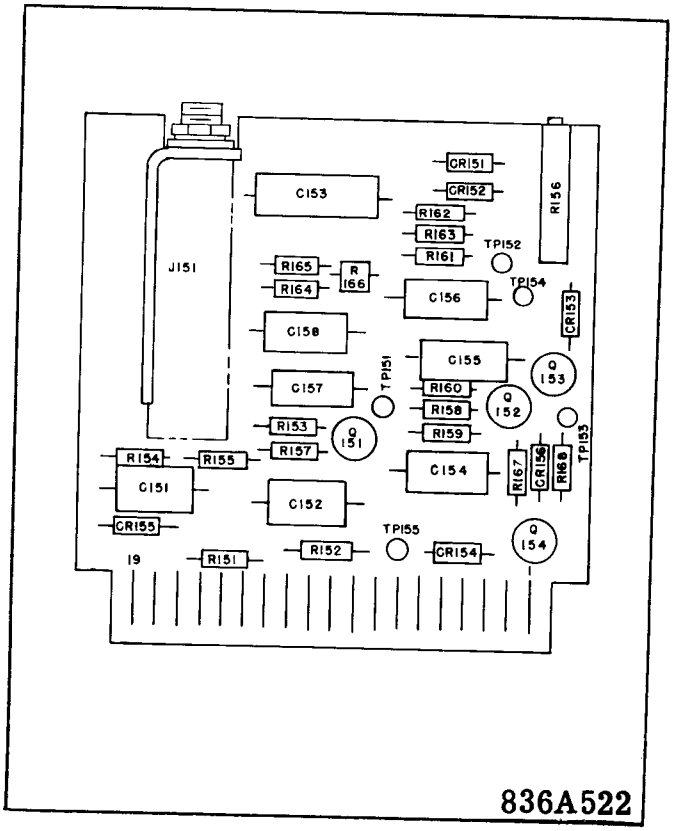


Fig. 13 Component locations on the carrier level indicator printed circuit board.

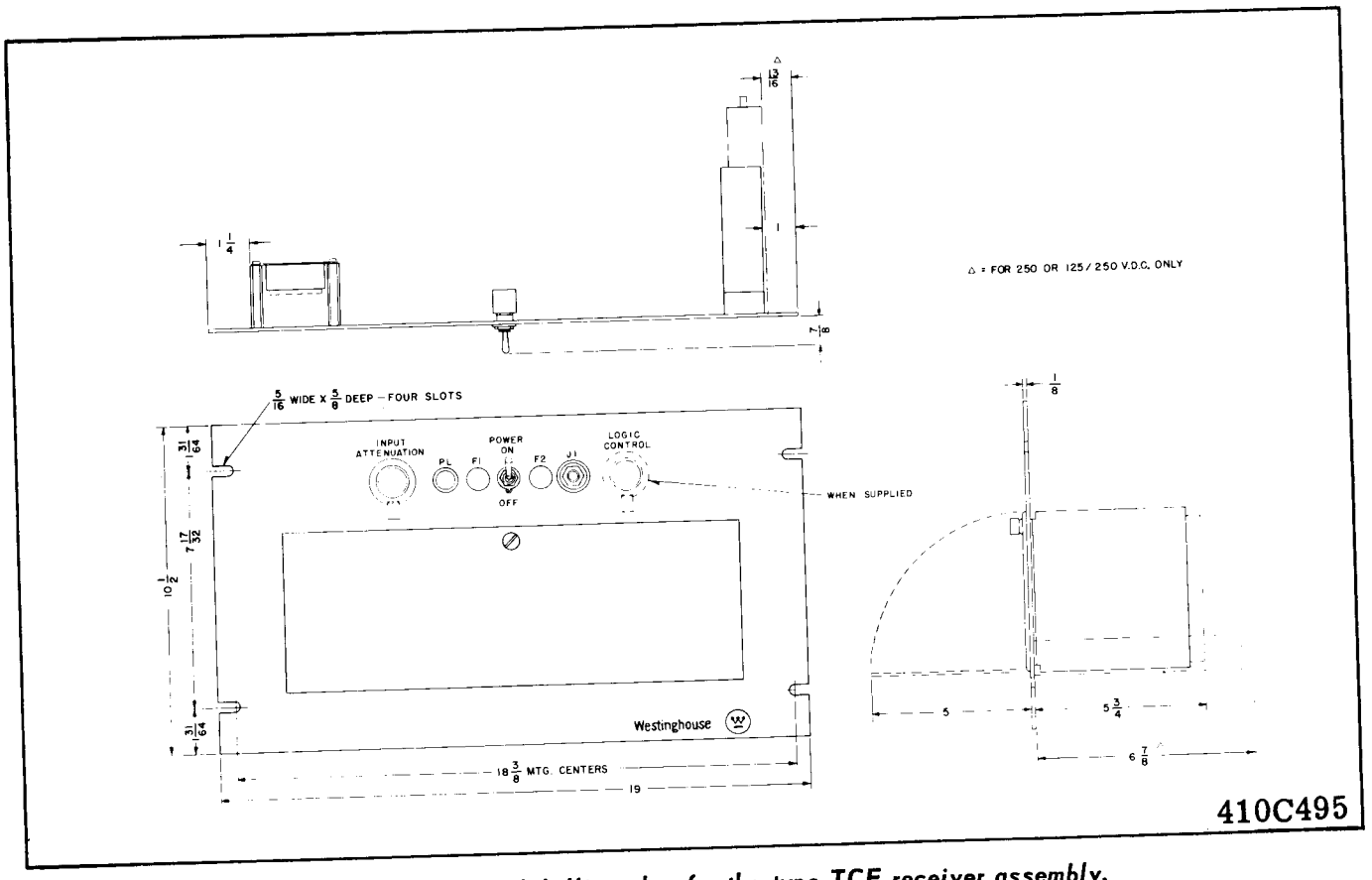


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

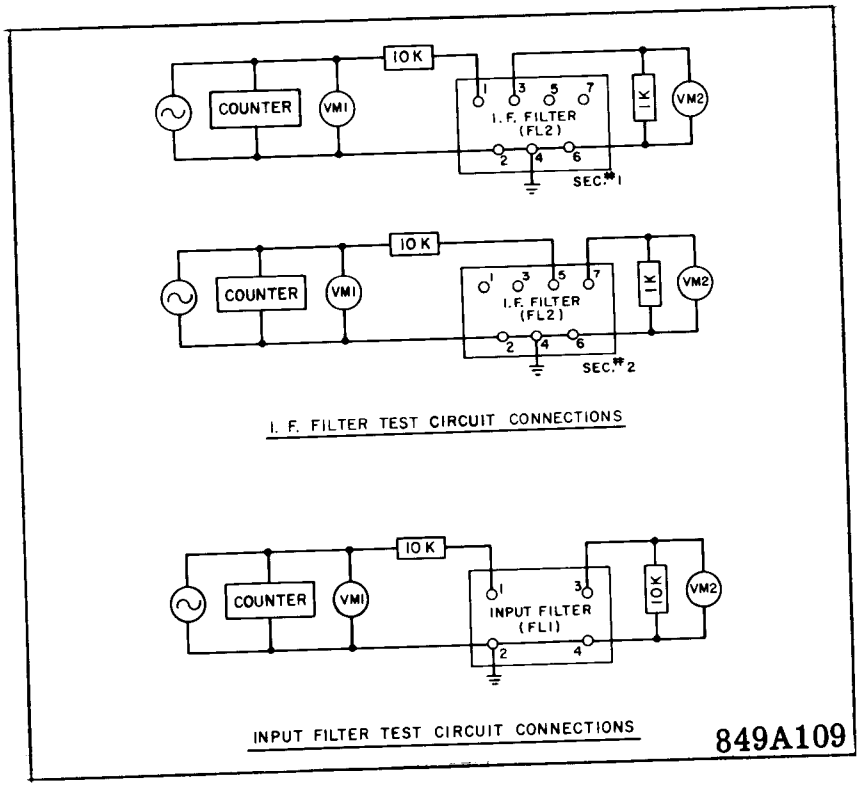


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.

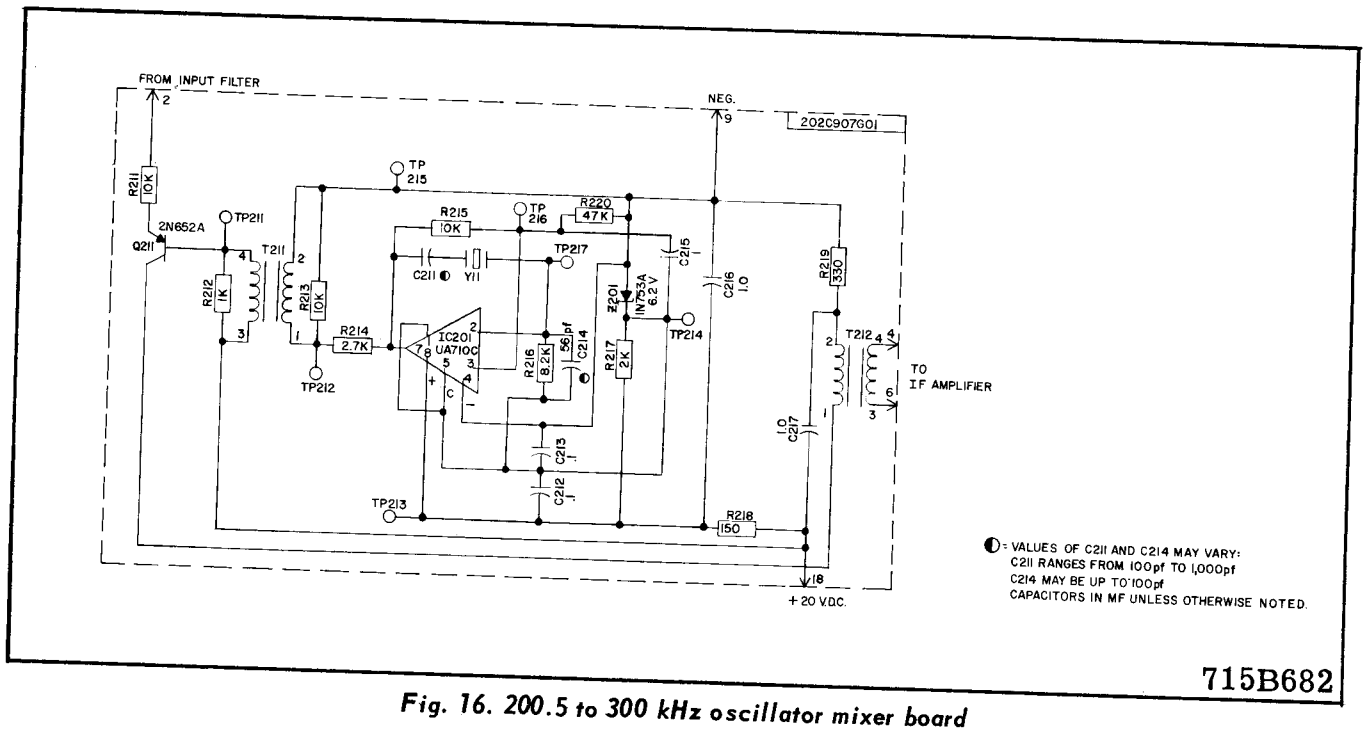


Fig. 16. 200.5 to 300 kHz oscillator mixer board

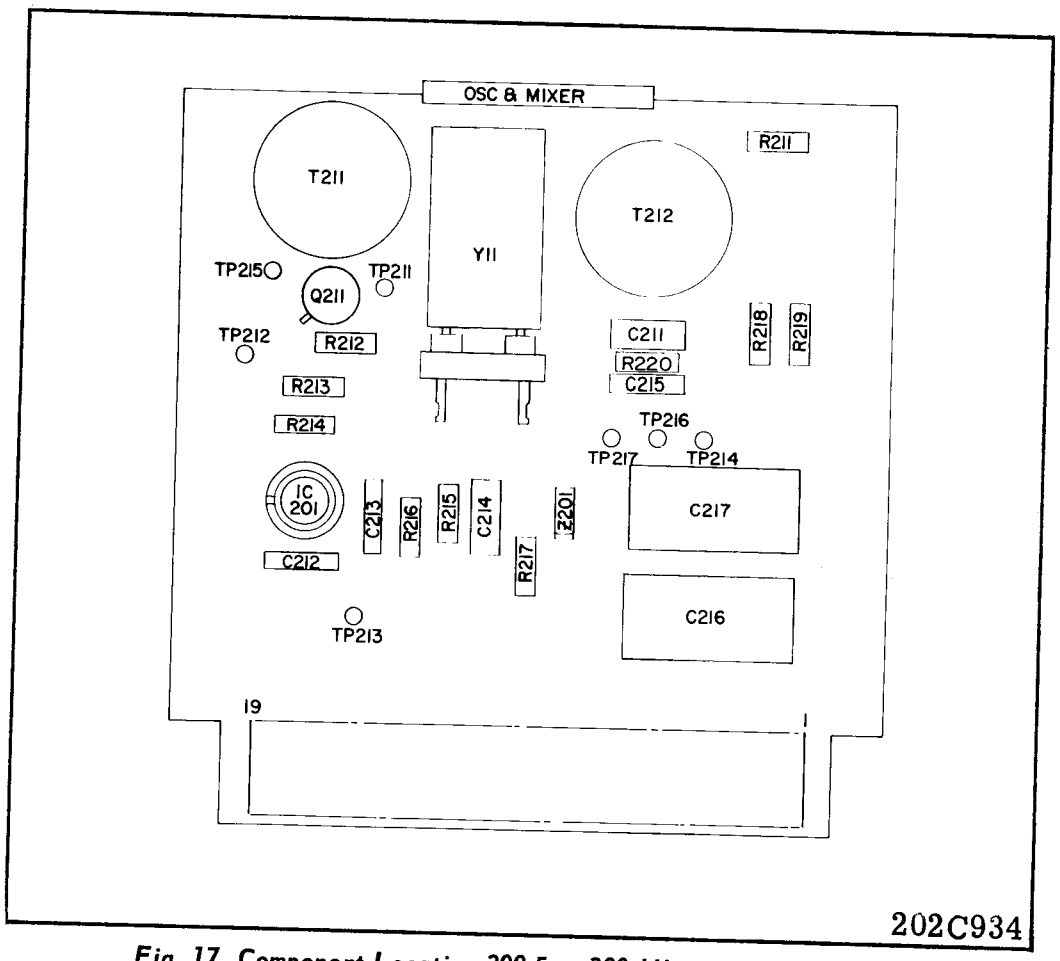


Fig. 17. Component Location 200.5 to 300 kHz oscillator mixer board.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.

Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.5 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental ininsertion of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	1500 hertz minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

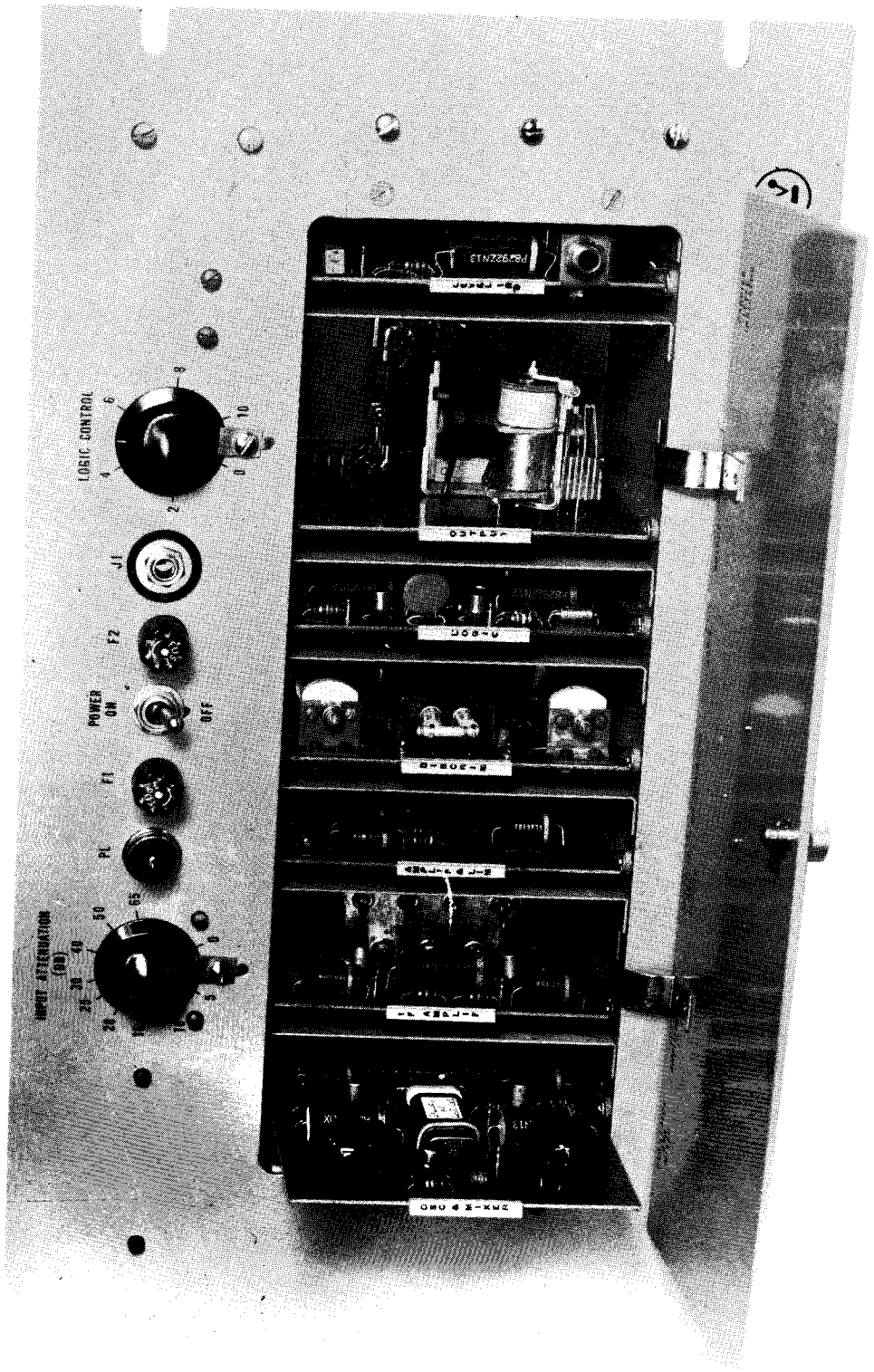
The adjustment procedure for the AR relay (which should be attempted only if suitable tools are available) is as follows:

a) Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.

b) On relays with two normally-open and two normally-closed contacts, adjust each contact spring so that 8 grams force at the very end of each spring will just move it away from the edge of the slotted insulation attached to the armature. Relays with four normally-open contacts should be adjusted so that a 4 gram force similarly applied will just move each spring away from the edge of the insulation.

c) Adjust each normally-open contact screw to obtain a gap of 0.020 to 0.022 inch. With the relay energized the normally-open contacts should have 15 to 30 grams pressure. The normally-closed contacts, if present, should have a contact gap of 0.015 inch.

The AR relay with its 800 ohm series resistor should pick up at approximately 30 volts.



Type TCF Receiver (Front View).

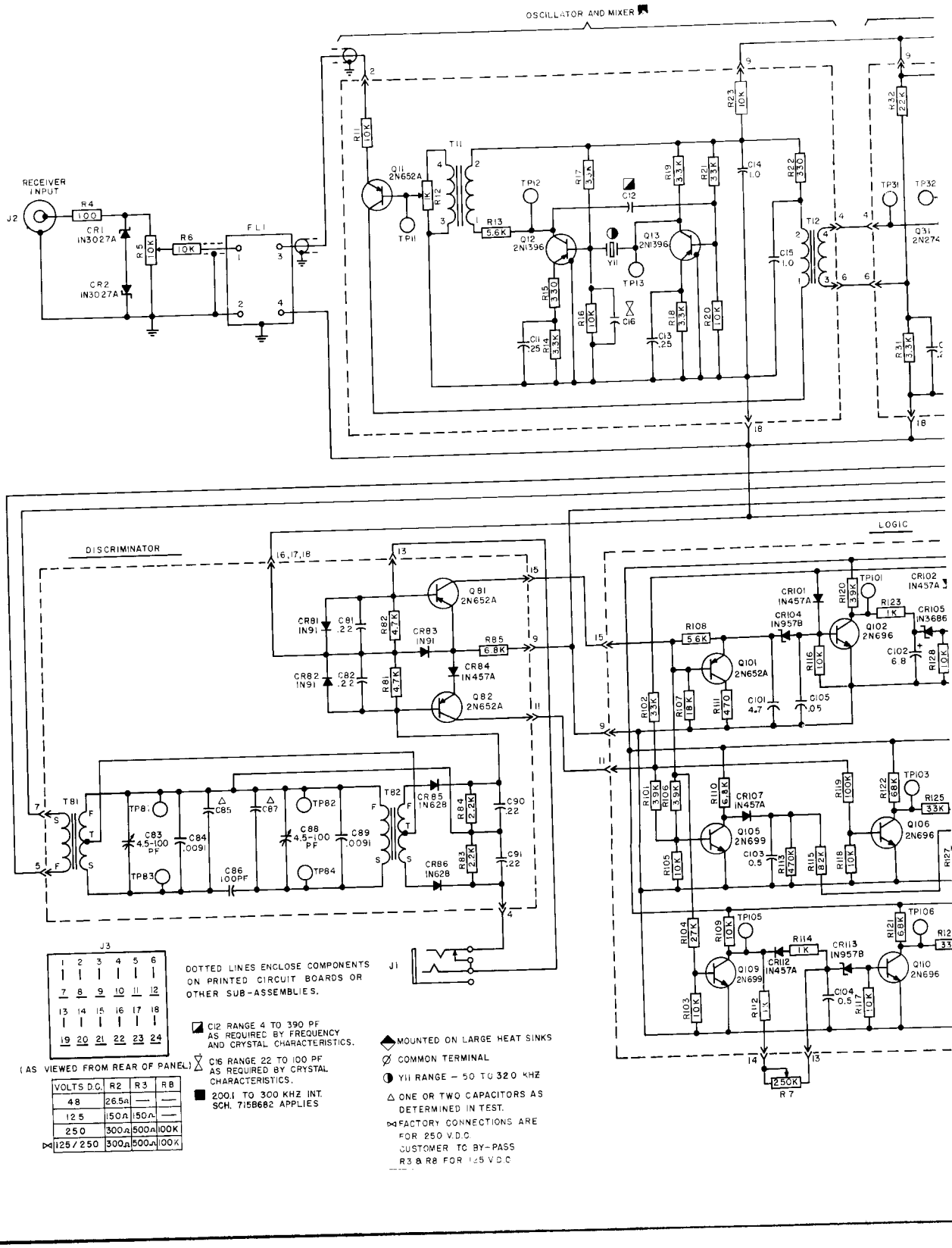
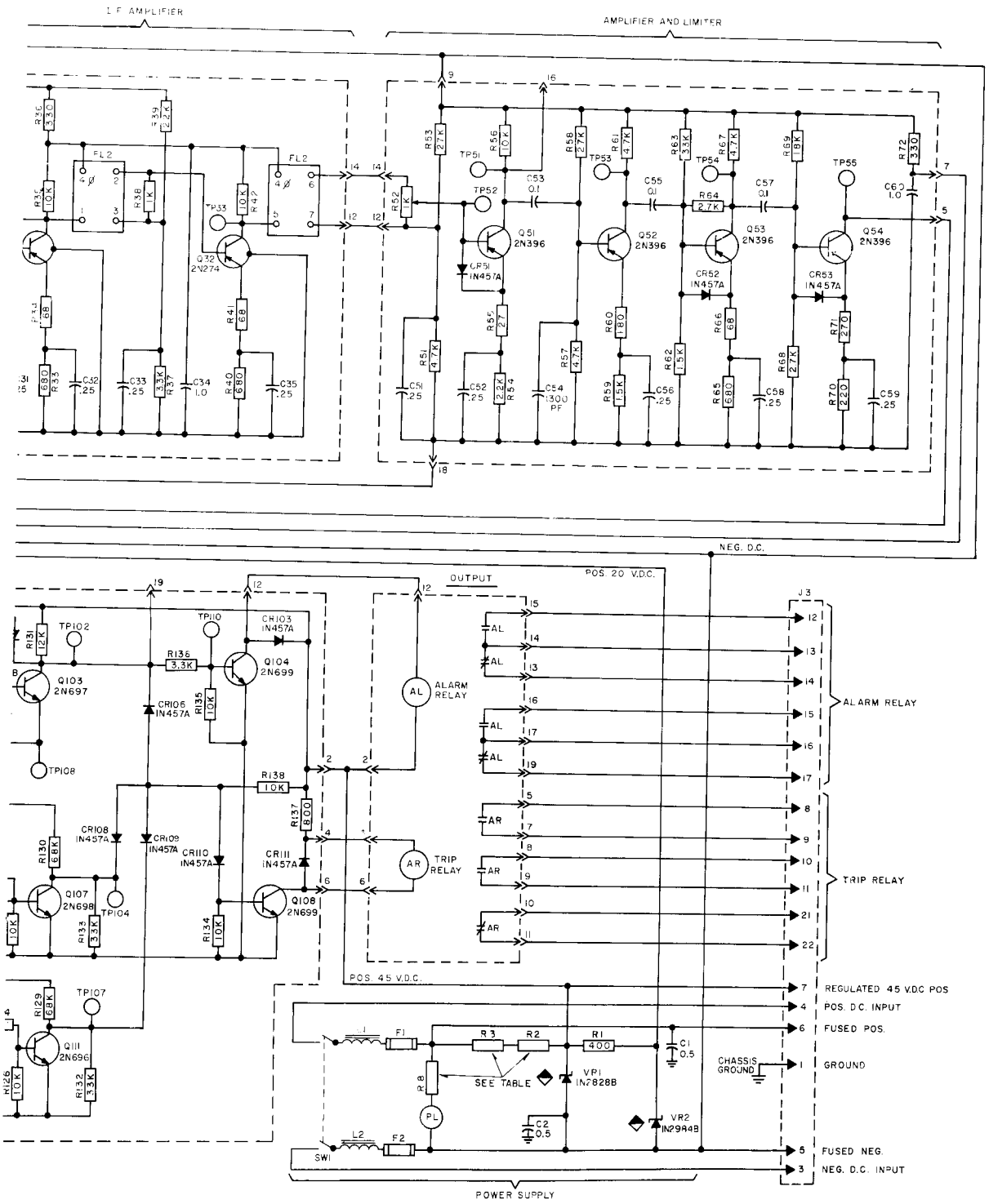


Fig. 1. Internal schematic of the type



543D637

TCF receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Imput Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator
* Output Voltage: up to 8 volts
Frequency Range: 20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

* ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf, 50 v.d.c.	184A663H04
C213	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V.; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. v 5%; 400 MW.	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ±5%; ½ W. Composition	184A763H13
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

* ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	205C043G03
T12	Toroidal type, 25000/300 ohms	205C043G03
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	205C043G01
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01 + (Req.Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408A845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

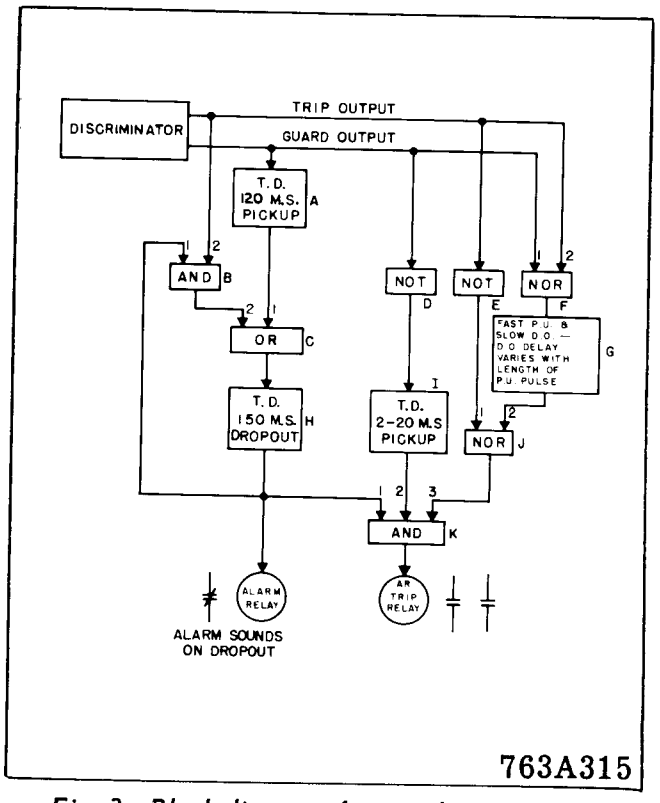


Fig. 3 Block diagram of output logic circuit

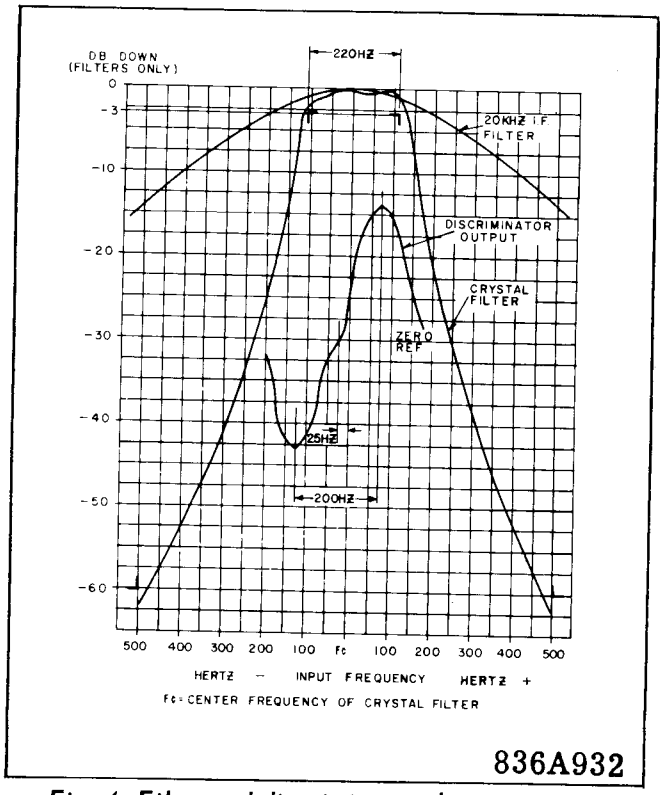


Fig. 4 Filter and discriminator characteristics of the type TCF receiver

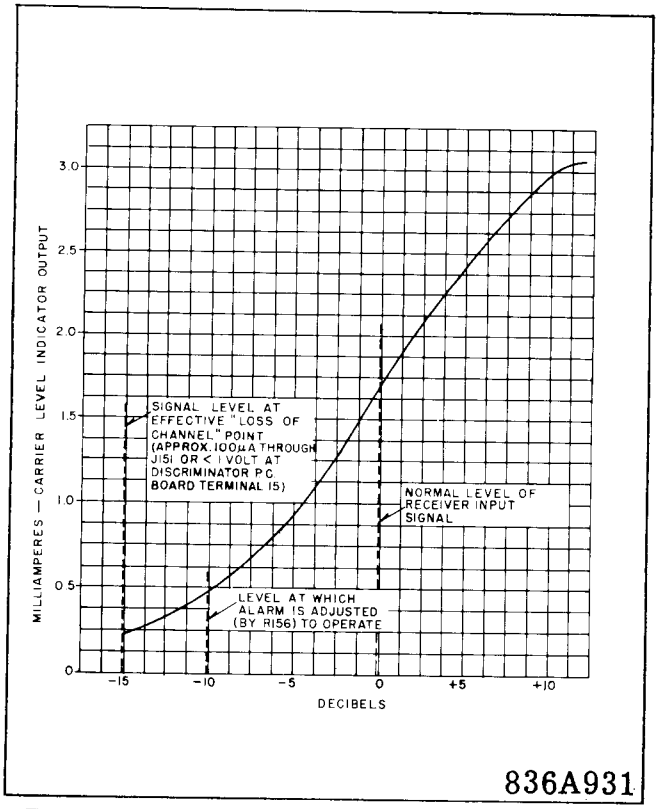


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

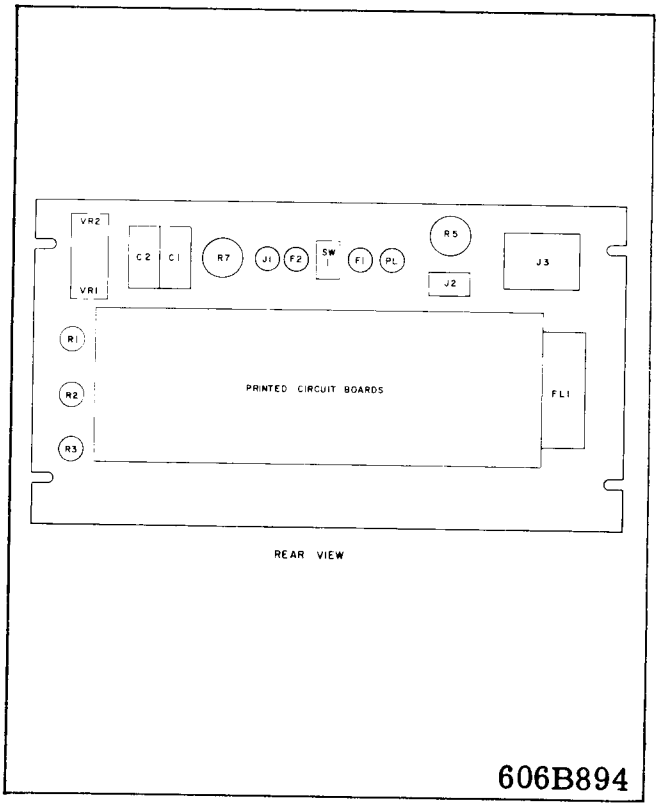


Fig. 6 Component locations on the type TCF receiver panel

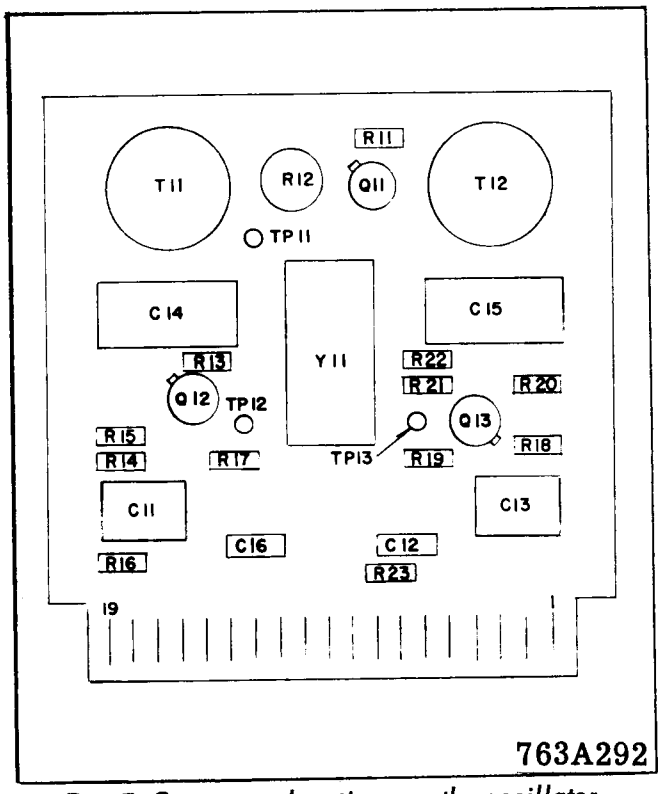


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

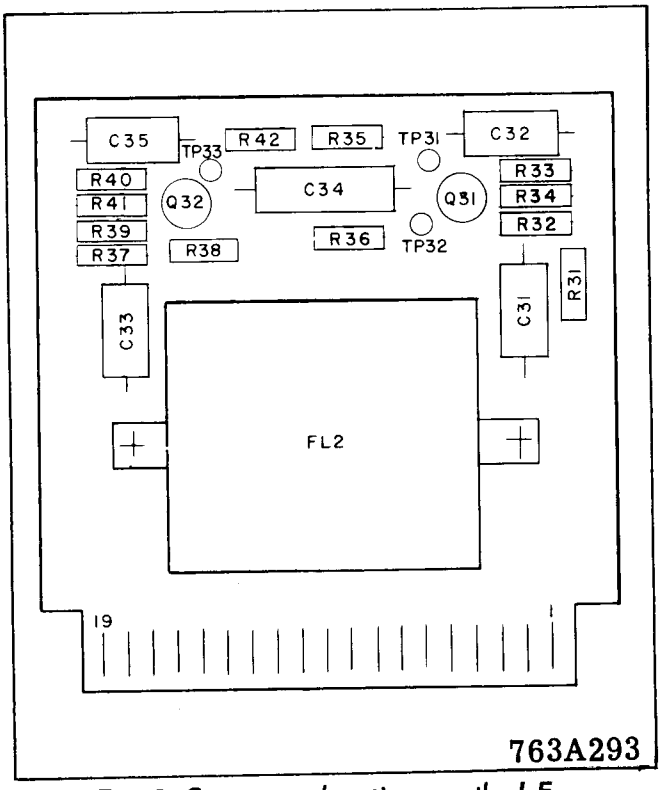


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

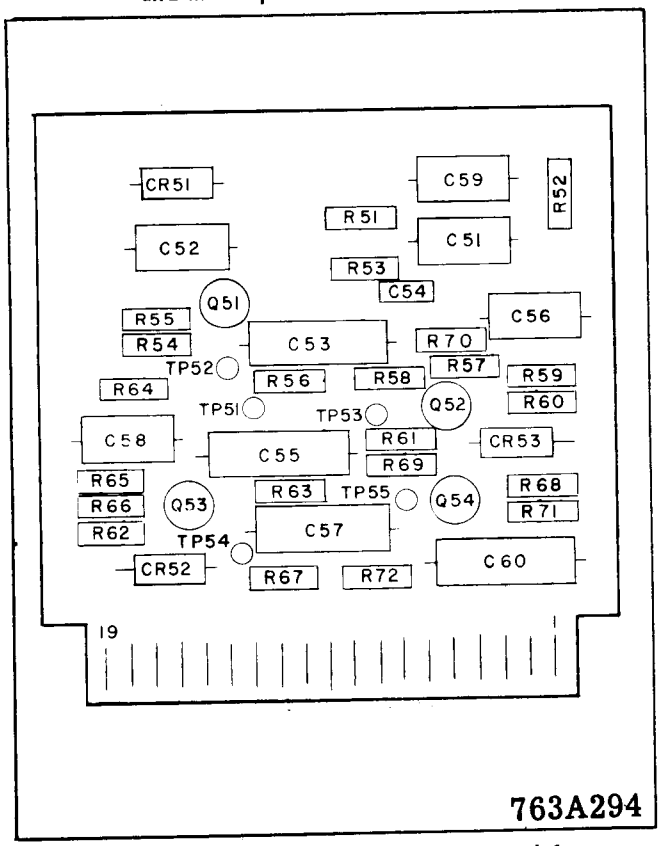


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

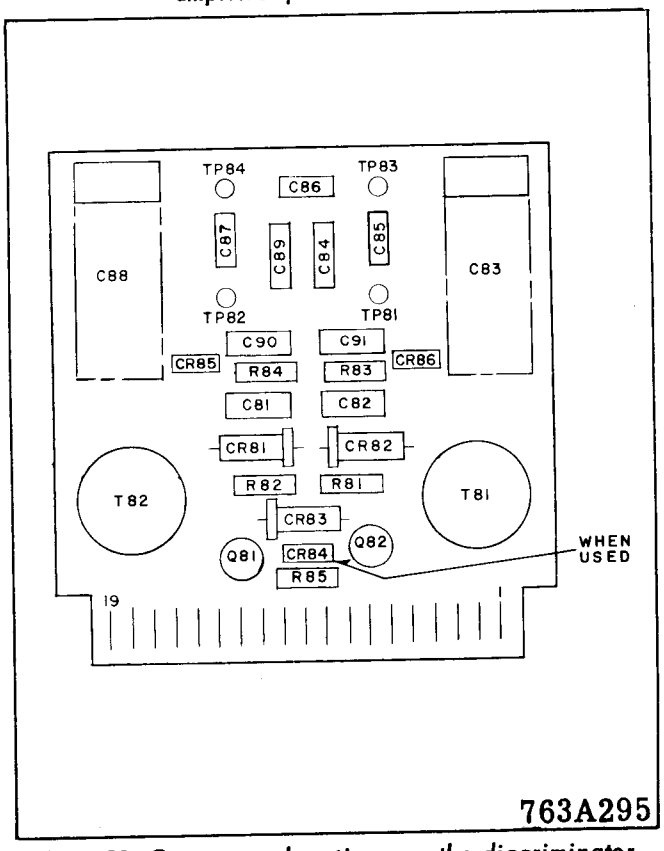


Fig. 10 Component locations on the discriminator printed circuit board.

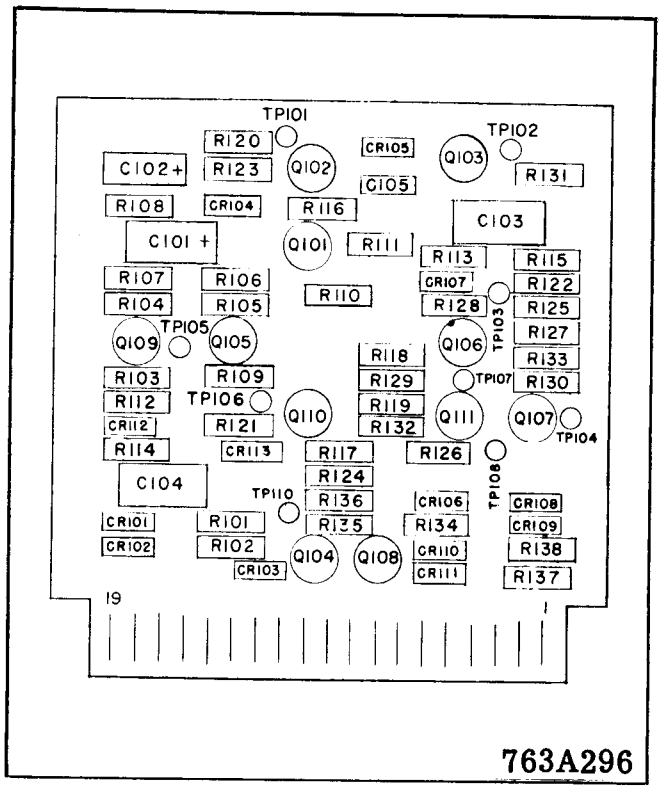


Fig. 11 Component locations on the logic printed circuit board.

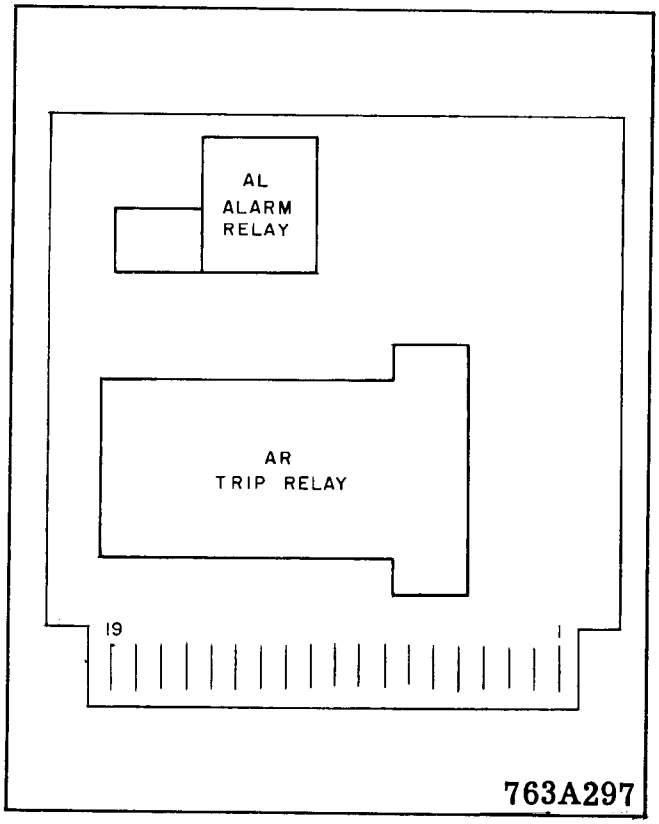


Fig. 12 Component locations on the output printed circuit board.

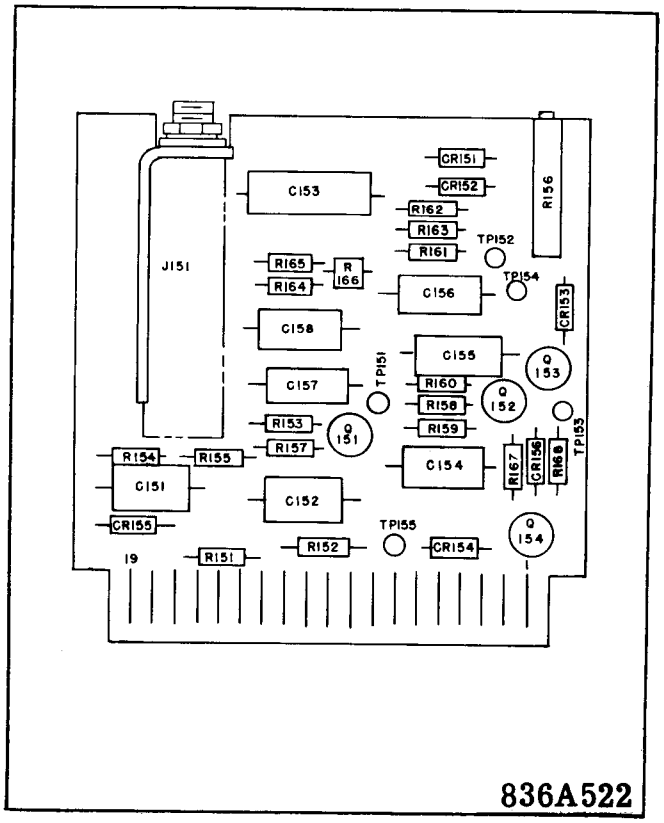


Fig. 13 Component locations on the carrier level indicator printed circuit board.

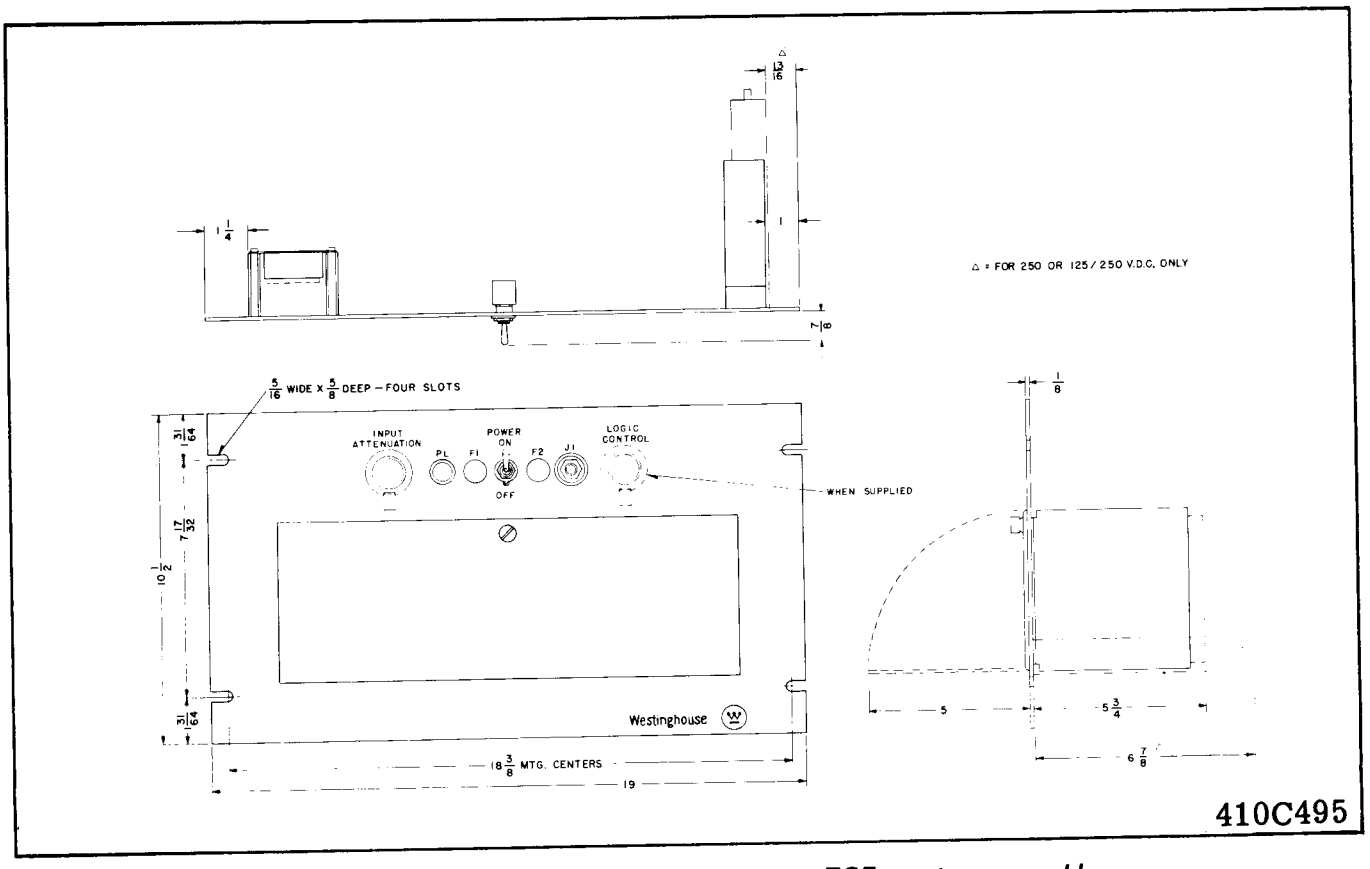


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

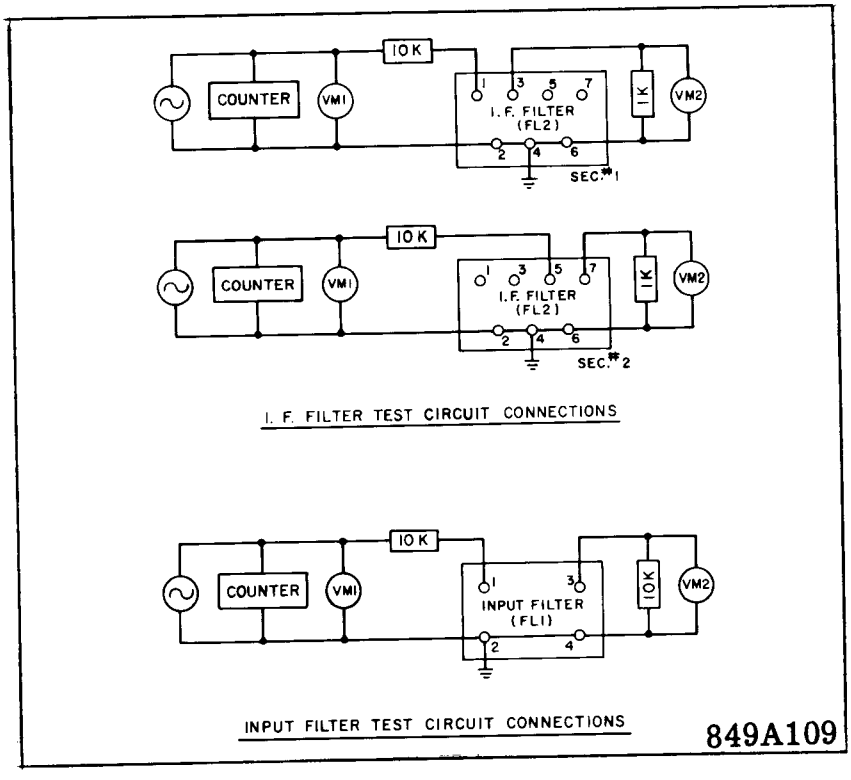
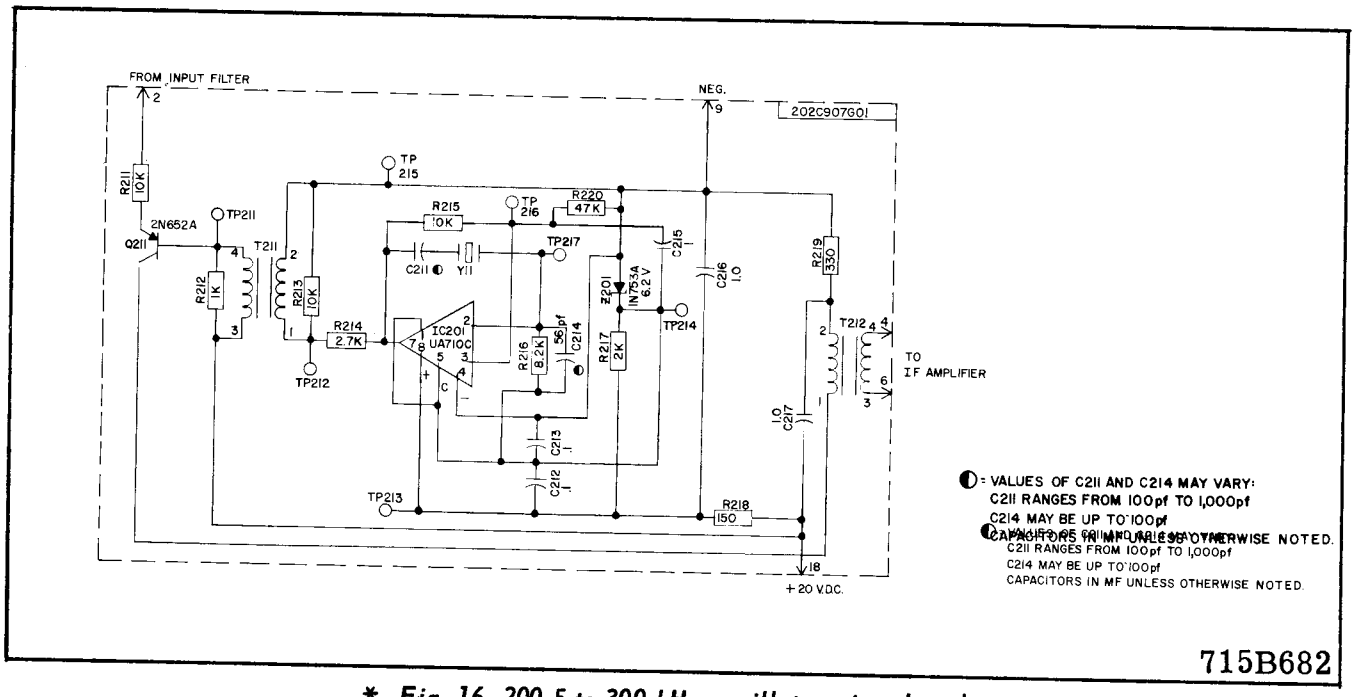


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.



* *Fig. 16. 200.5 to 300 kHz oscillator mixer board*

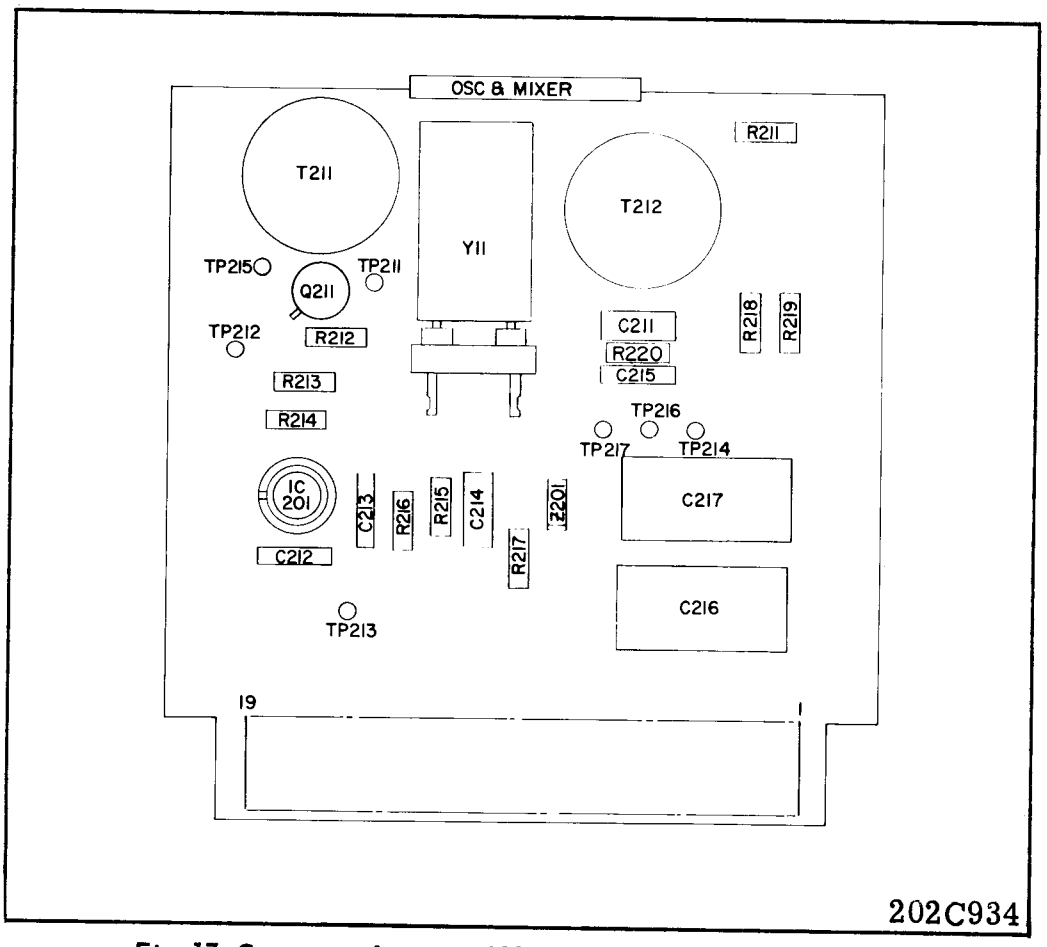


Fig. 17. Component Location 200.5 to 300 kHz oscillator mixer board.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.

Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

SUPERSEDES I.L. 41-945.51F
*Denotes change from superseded issue.

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terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, or IC201 (Fig. 16) and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 kHz above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the later is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20kHz, 2fc + 20kHz, fc + 20kHz and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero output frequency. This separation of 200 hertz between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 hertz in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20 kHz-100 hertz. Similarly, the Trip frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears, the discriminator output at term. 15 will turn Q101 off. C101 will change and after 120 ms. it will reach the breakdown voltage of CR104 and turn Q102 on. This will allow C102 to quickly discharge through R123 and Q102 and provide the full 150 ms. time delay to be effective on any subsequent loss of guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.5 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental inserting of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	1500 hertz minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

The adjustment procedure for the AR relay (which should be attempted only if suitable tools are available) is as follows:

a) Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.

b) On relays with two normally-open and two normally-closed contacts, adjust each contact spring so that 8 grams force at the very end of each spring will just move it away from the edge of the slotted insulation attached to the armature. Relays with four normally-open contacts should be adjusted so that a 4 gram force similarly applied will just move each spring away from the edge of the insulation.

c) Adjust each normally-open contact screw to obtain a gap of 0.020 to 0.022 inch. With the relay energized the normally-open contacts should have 15 to 30 grams pressure. The normally-closed contacts, if present, should have a contact gap of 0.015 inch.

The AR relay with its 800 ohm series resistor should pick up at approximately 30 volts.

Type TCF Receiver (Front View).

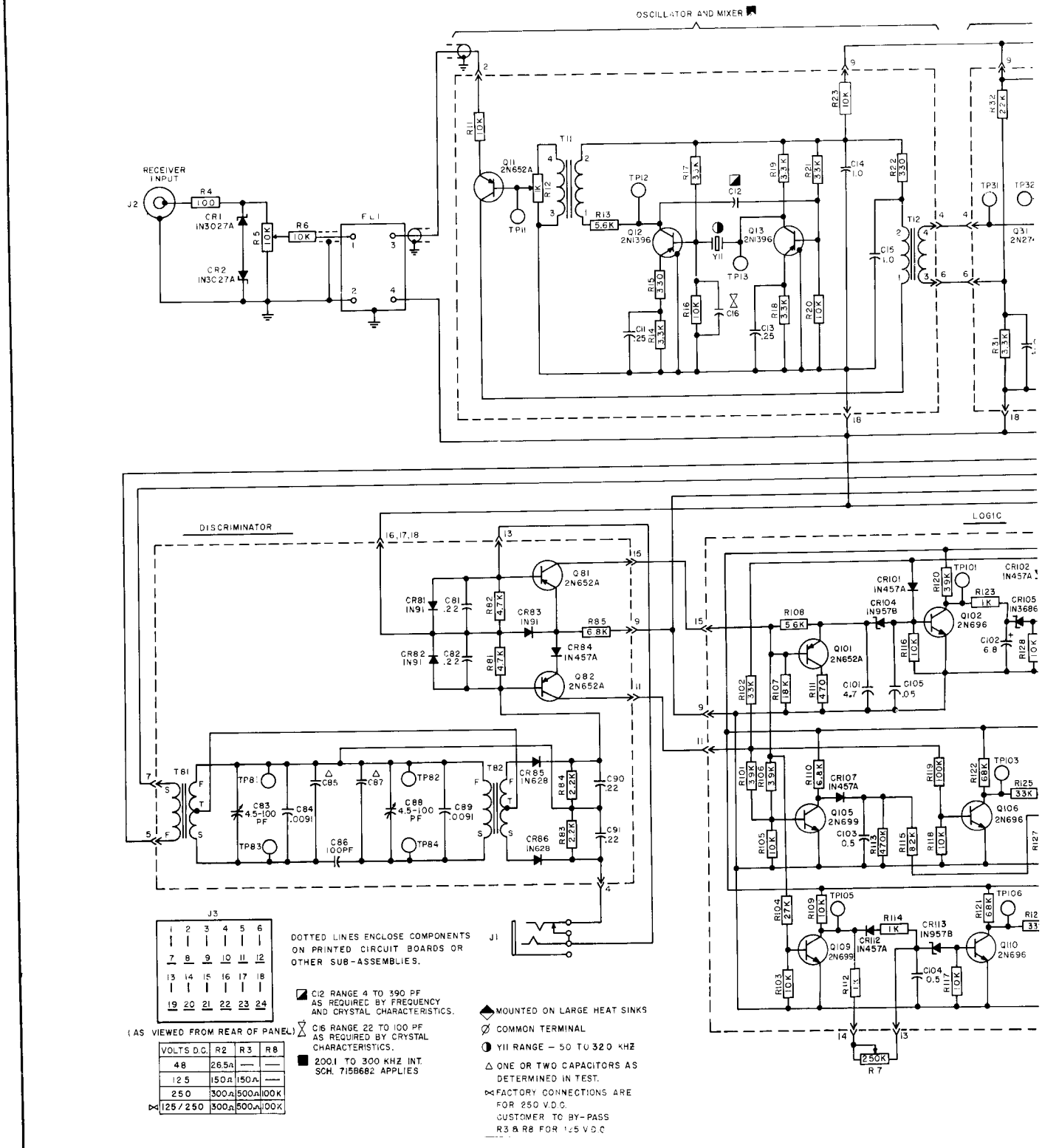
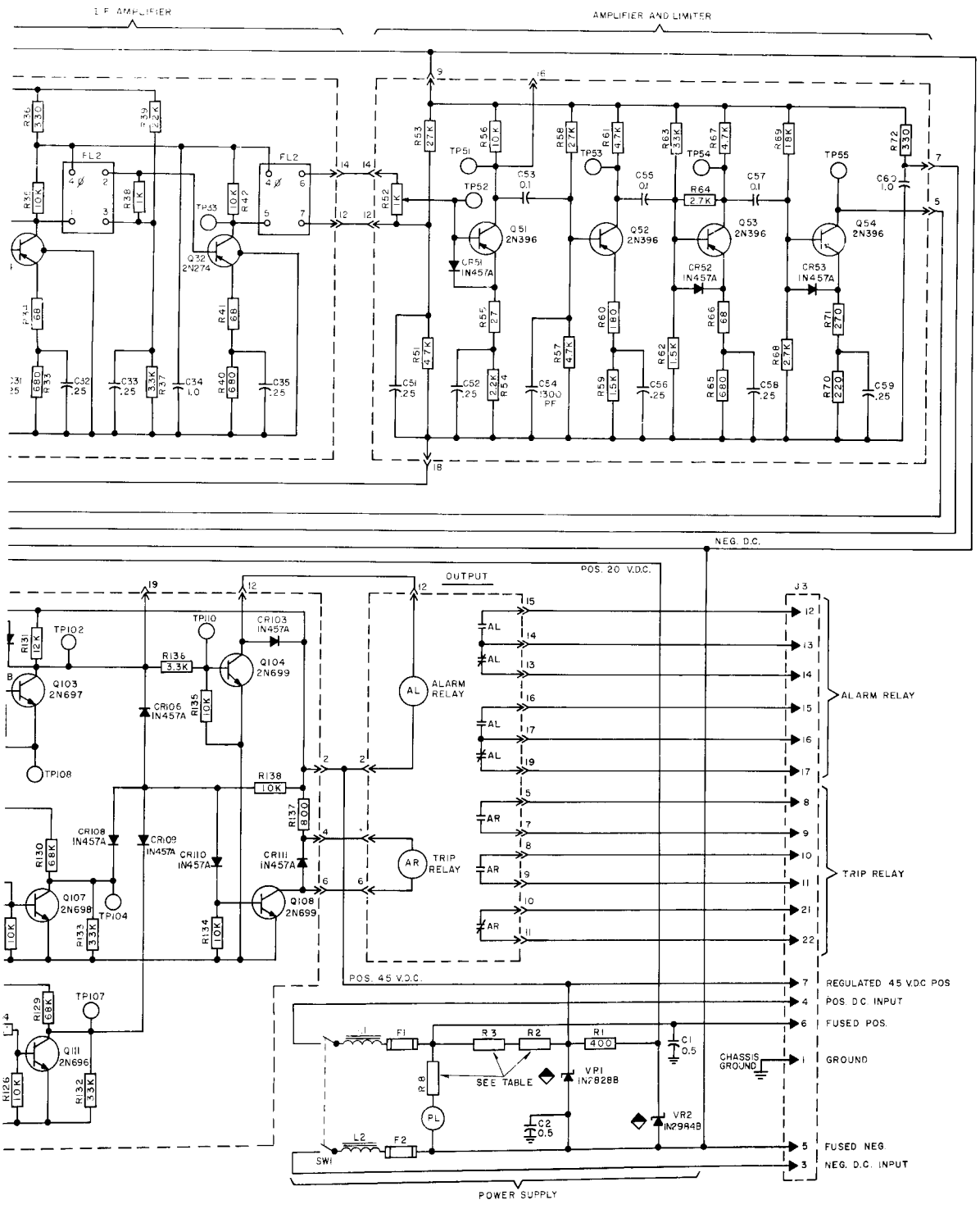


Fig. 1. Internal schematic of the type



543D637

TCF receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).

Voltage Range:	1.5 to 300 volts
Imput Impedance:	7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

* b. Signal Generator

Output Voltage:	up to 8 volts
Frequency Range:	20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

* ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf, 50 v.d.c.	184A663H04
C213	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. v 5%; 400 MW.	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ±5%; ½ W. Composition	184A763H13
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

* ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	205C043G03
T12	Toroidal type, 25000/300 ohms	205C043G03
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	205C043G01
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01 + (Req. Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408A845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

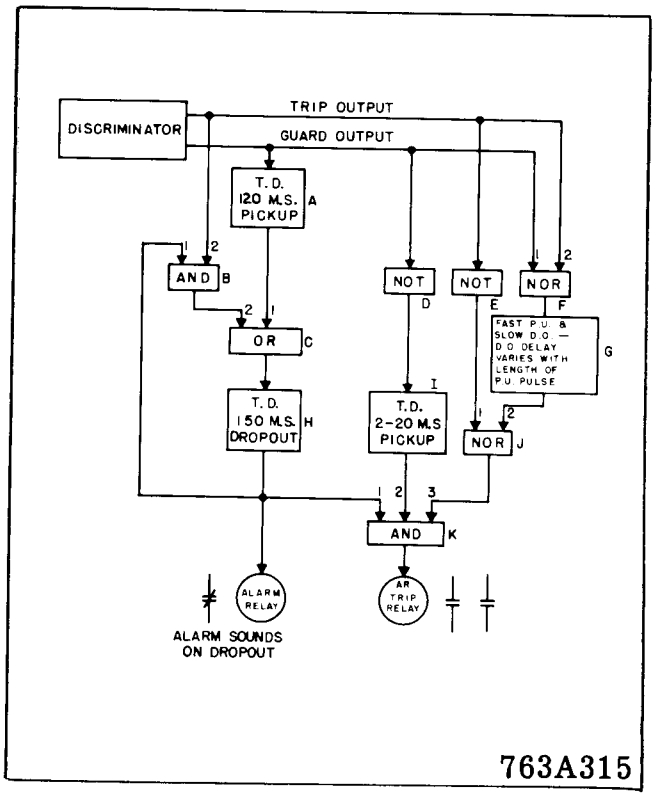


Fig. 3 Block diagram of output logic circuit

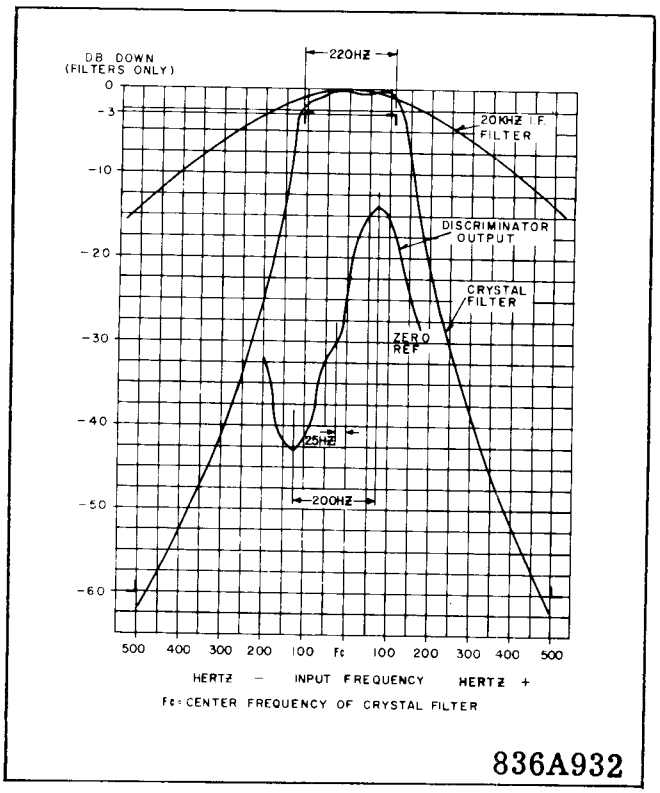


Fig. 4 Filter and discriminator characteristics of the type TCF receiver

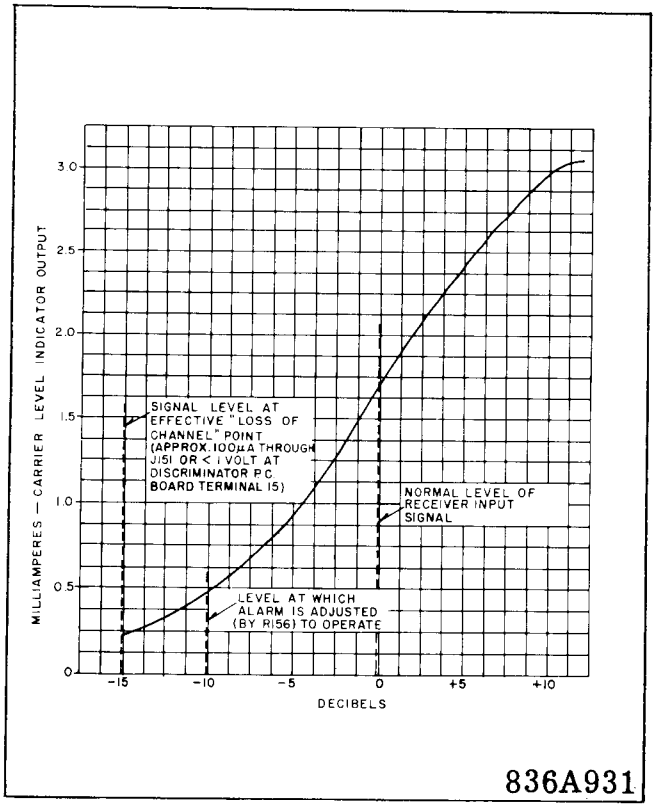


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

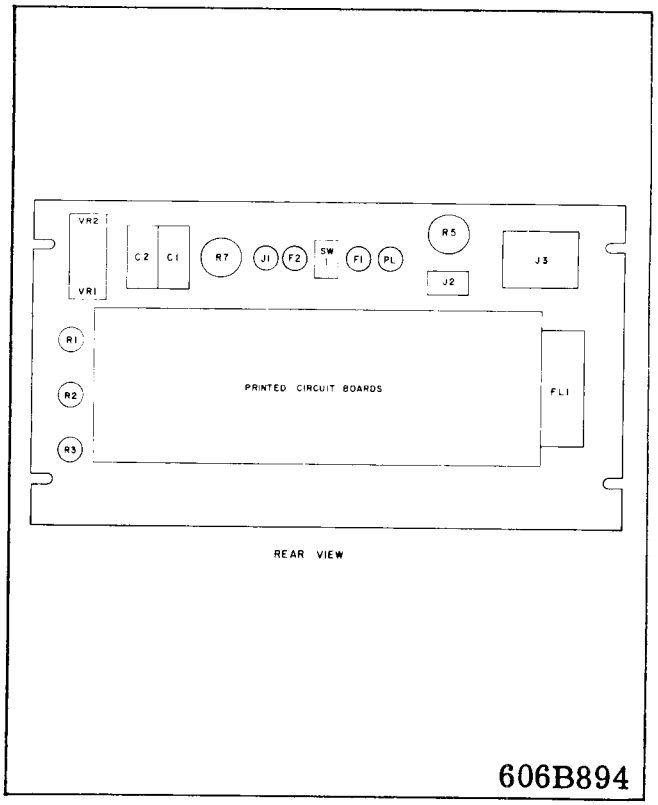


Fig. 6 Component locations on the type TCF receiver panel

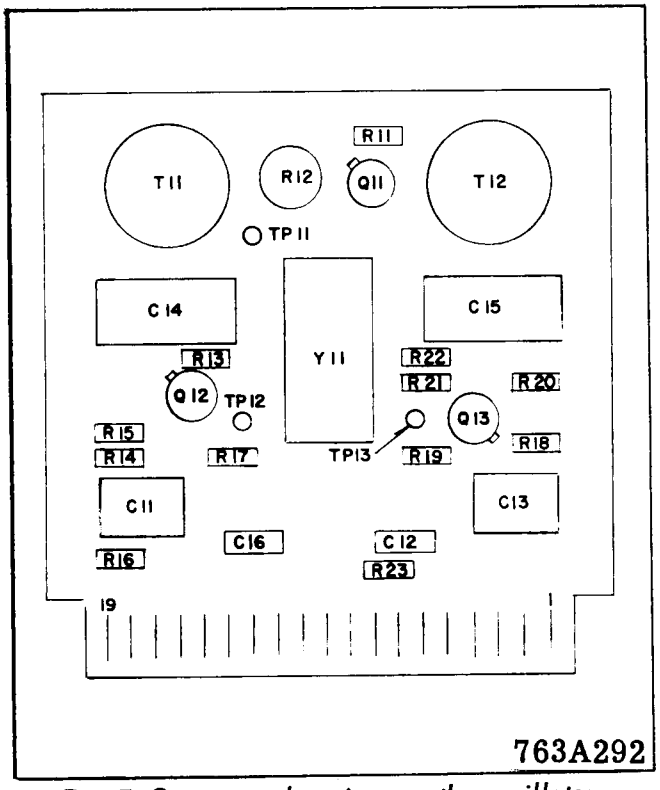


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

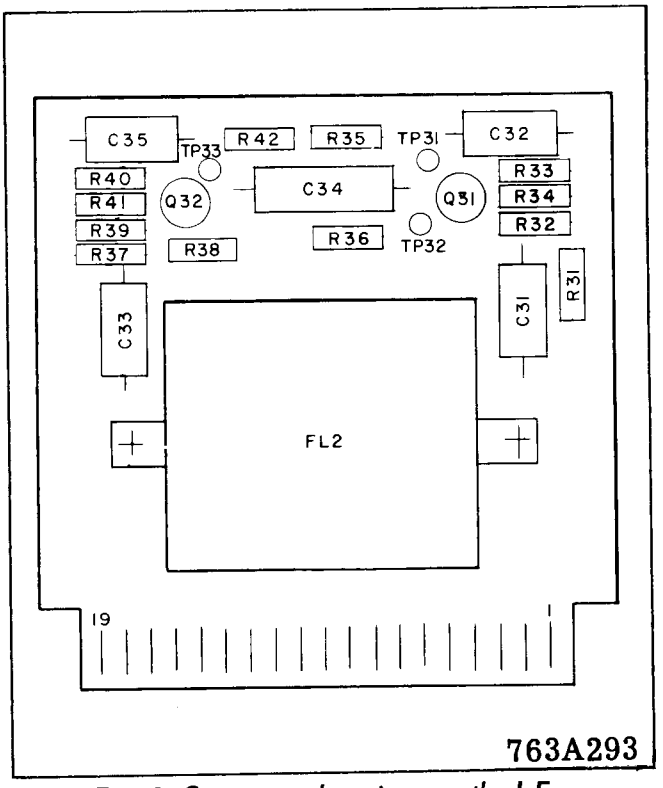


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

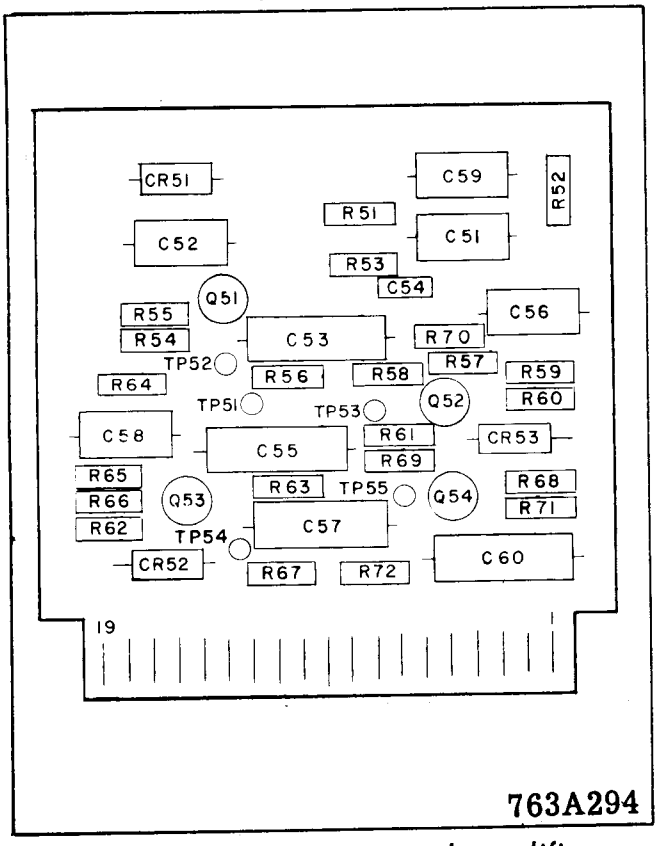


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

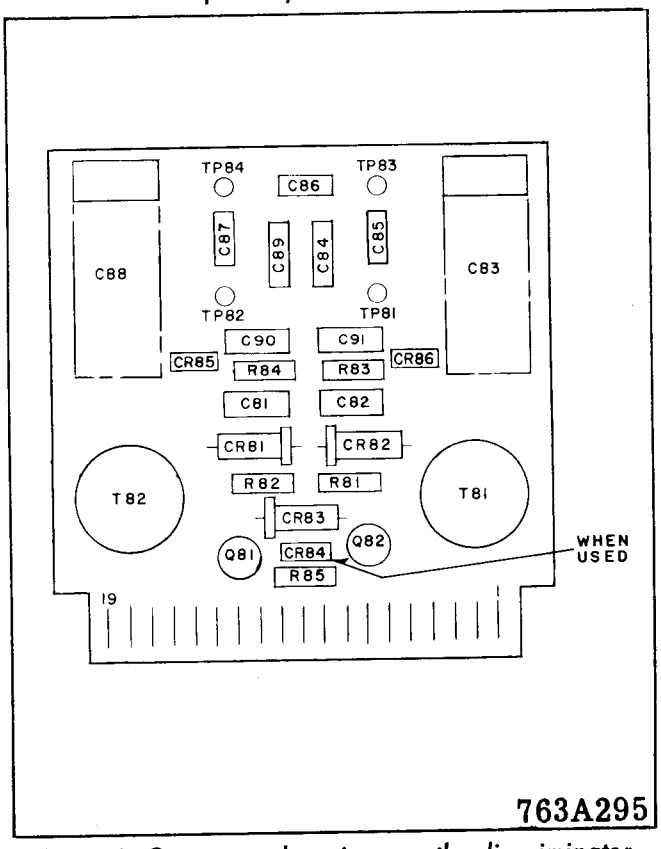


Fig. 10 Component locations on the discriminator printed circuit board.

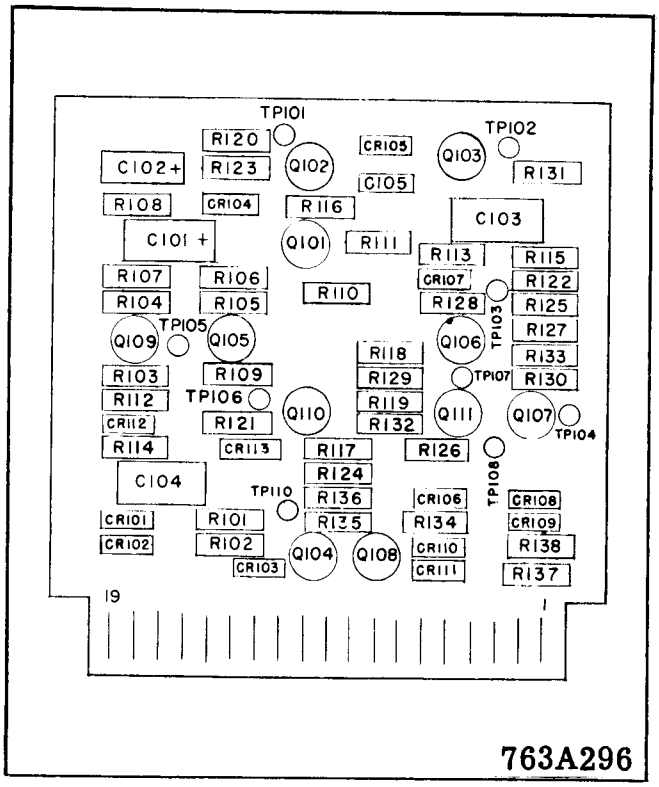


Fig. 11 Component locations on the logic printed circuit board.

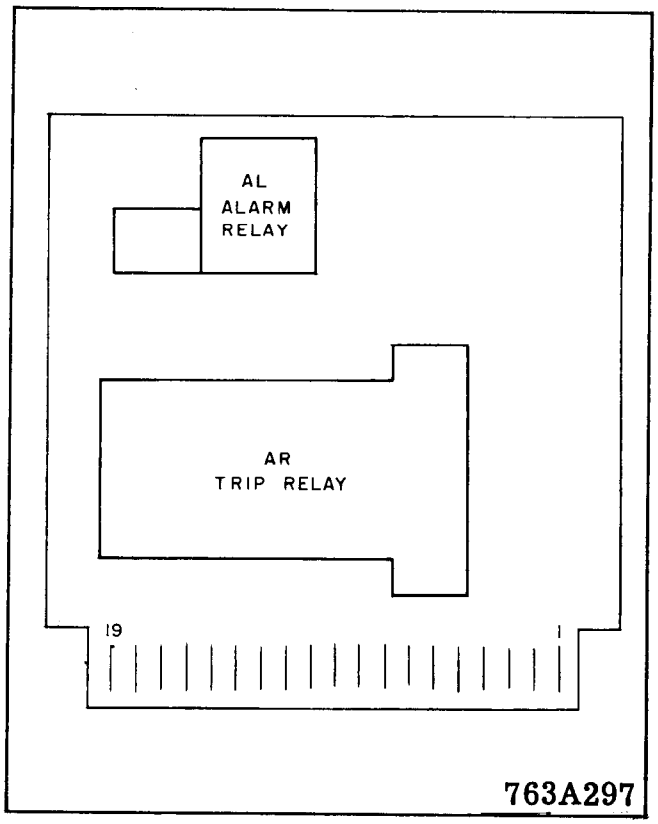


Fig. 12 Component locations on the output printed circuit board.

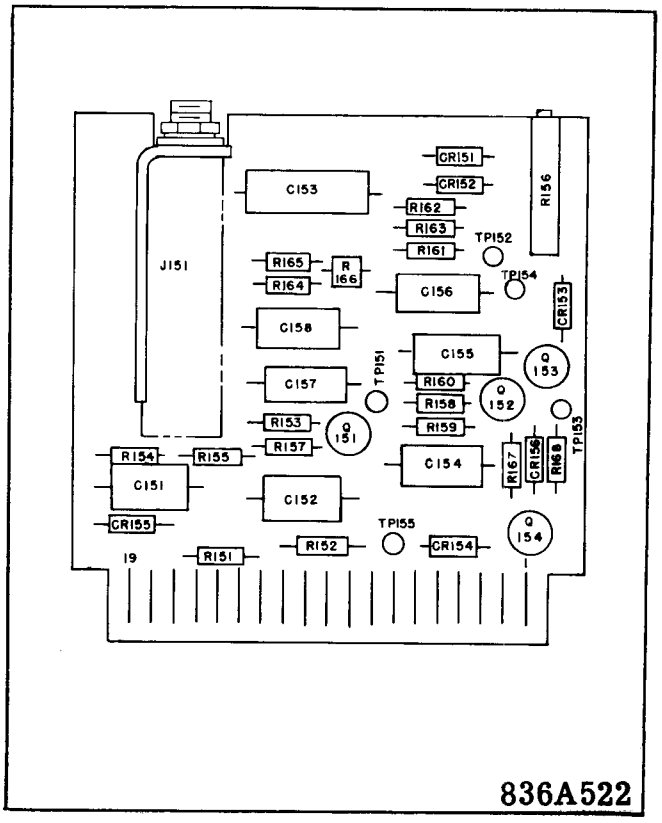


Fig. 13 Component locations on the carrier level indicator printed circuit board.

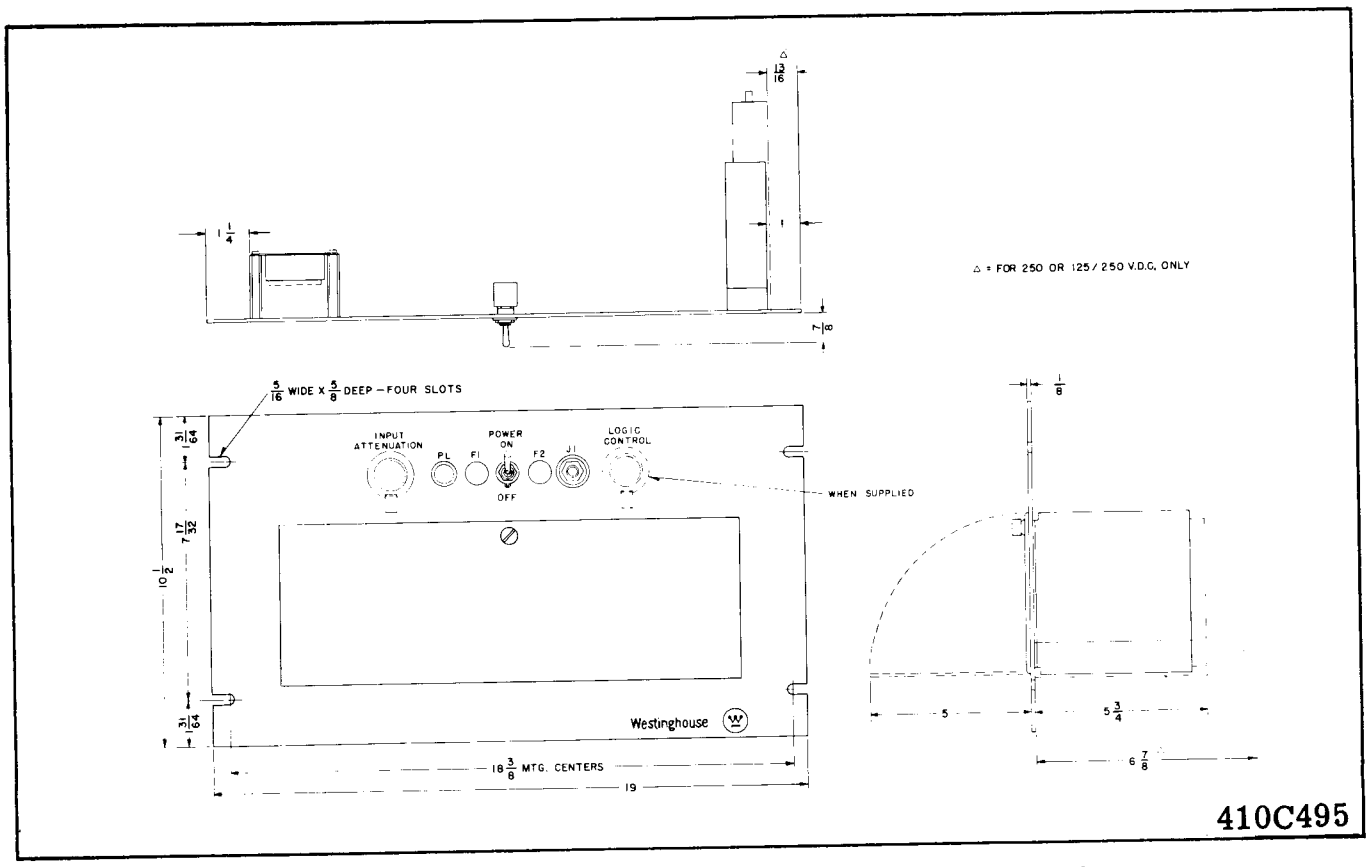


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

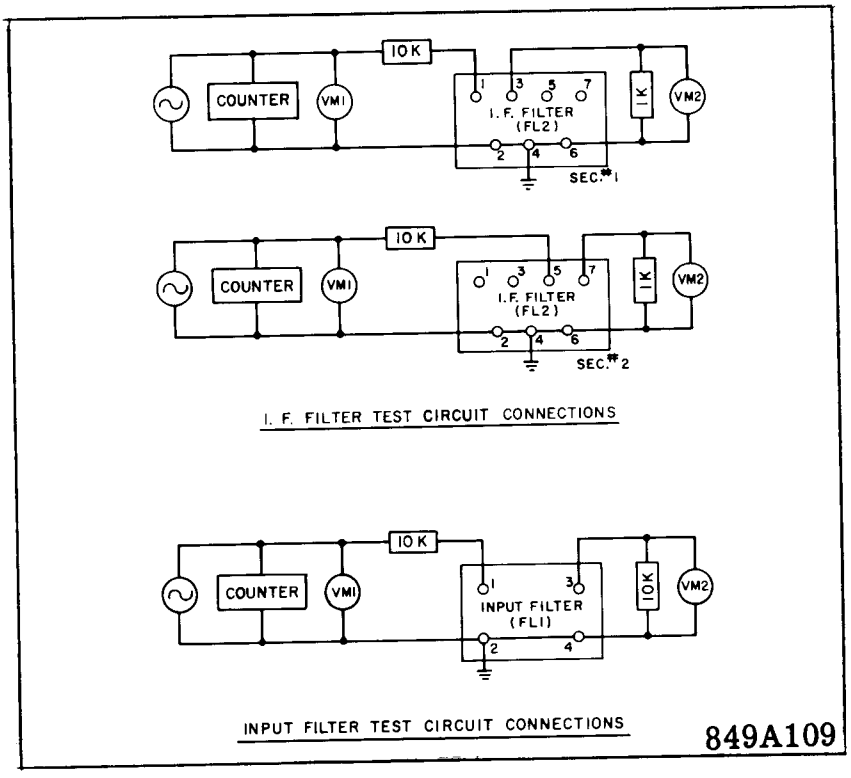
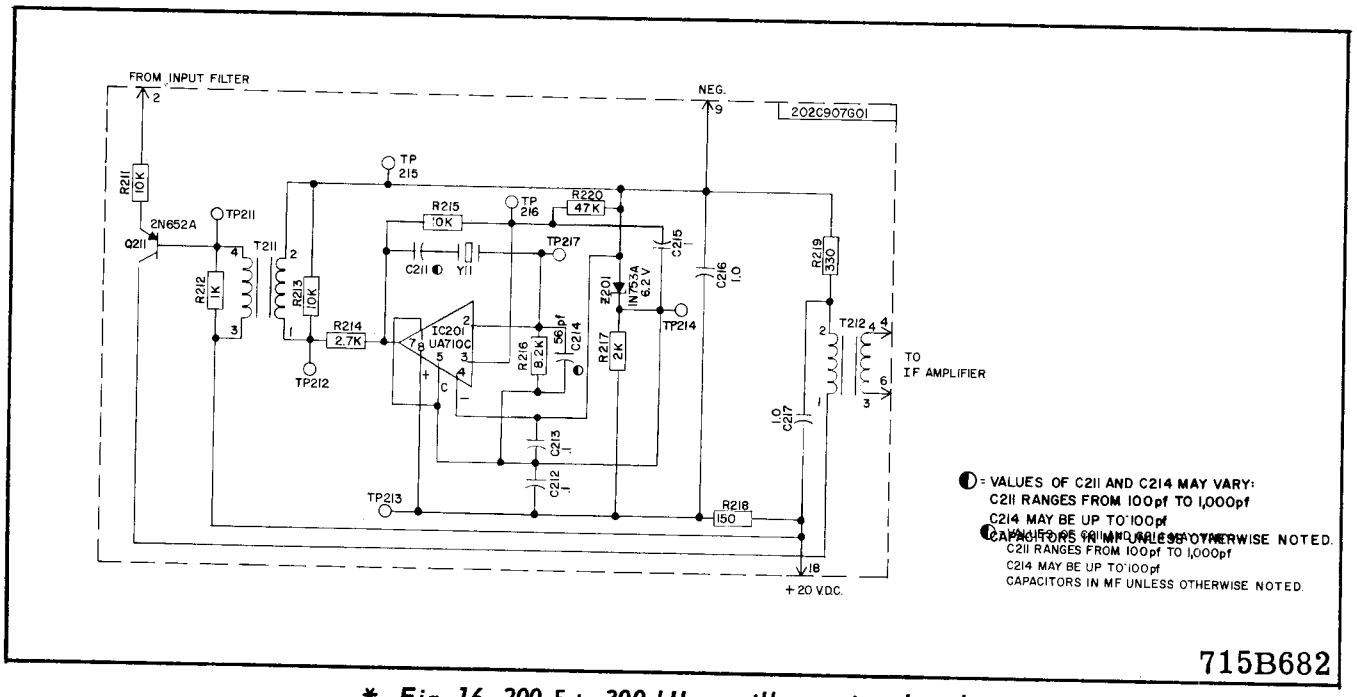


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.



* *Fig. 16. 200.5 to 300 kHz oscillator mixer board*

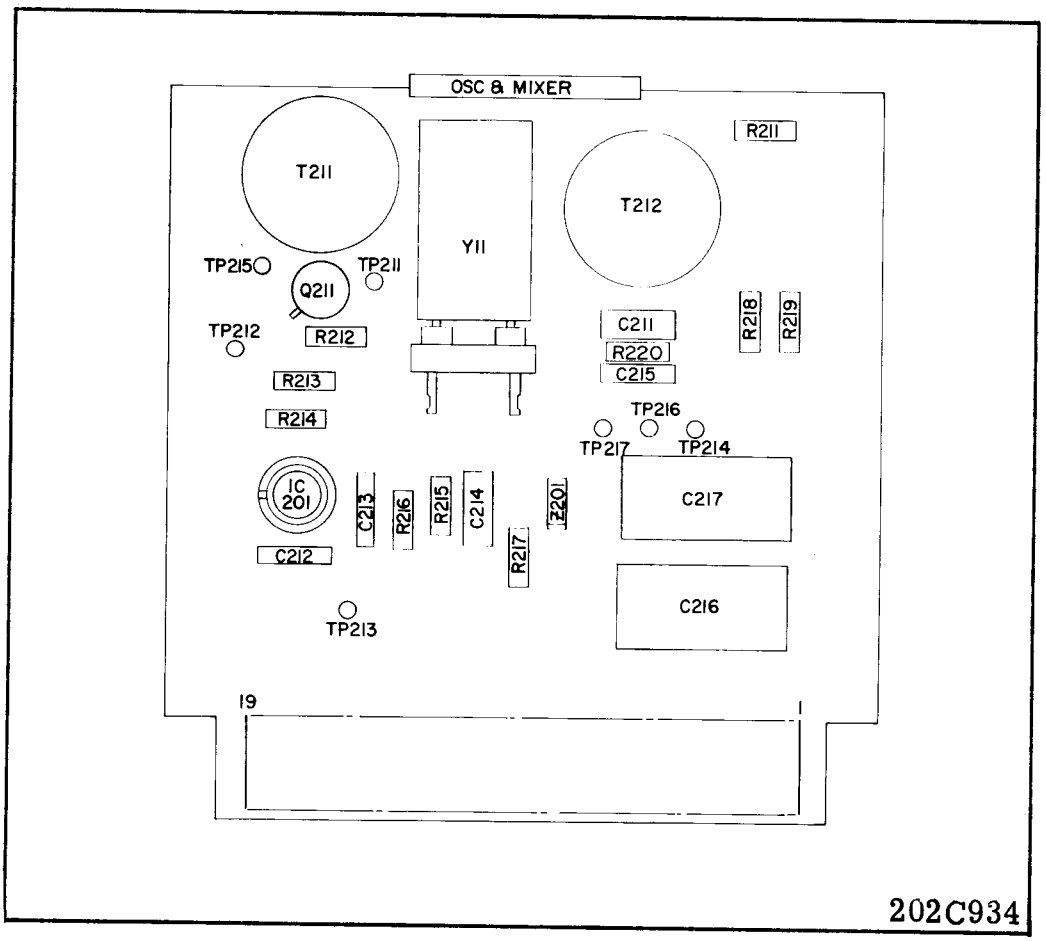


Fig. 17. Component Location 200.5 to 300 kHz oscillator mixer board.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

* Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.
Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, or IC201 (Fig. 16) and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 kHz above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the later is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20kHz, 2fc + 20kHz, fc + 20kHz and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero output frequency. This separation of 200 hertz between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 hertz in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard
* frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20 kHz-100 hertz. Similarly, the Trip frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears, the discriminator output at term. 15 will turn Q101 off. C101 will change and after 120 ms. it will reach the breakdown voltage of CR104 and turn Q102 on. This will allow C102 to quickly discharge through R123 and Q102 and provide the full 150 ms. time delay to be effective on any subsequent loss of guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.5 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental ininsertion of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	1500 hertz minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42 - 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

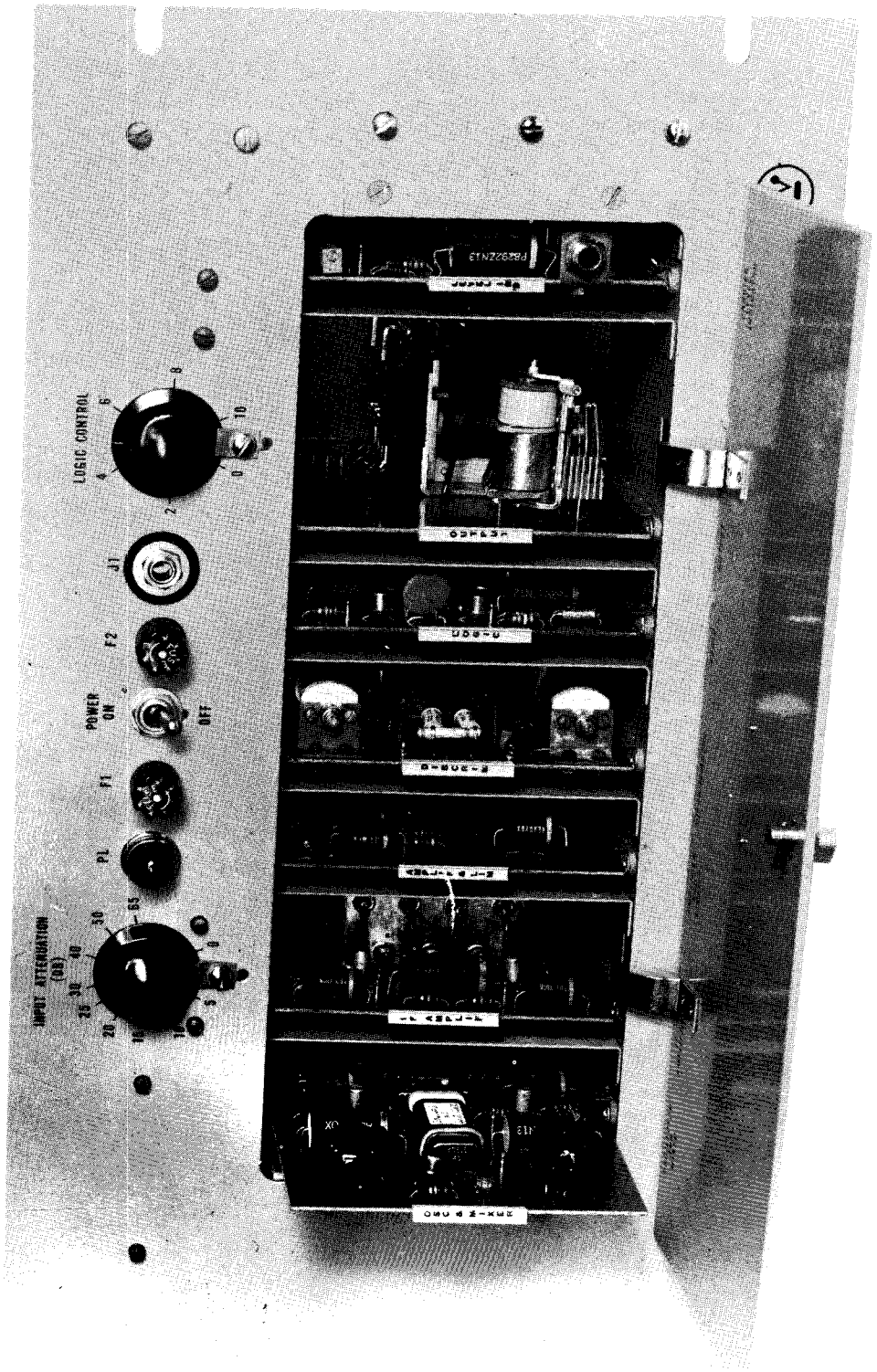
The adjustment procedure for the AR relay (which should be attempted only if suitable tools are available) is as follows:

a) Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.

b) On relays with two normally-open and two normally-closed contacts, adjust each contact spring so that 8 grams force at the very end of each spring will just move it away from the edge of the slotted insulation attached to the armature. Relays with four normally-open contacts should be adjusted so that a 4 gram force similarly applied will just move each spring away from the edge of the insulation.

c) Adjust each normally-open contact screw to obtain a gap of 0.020 to 0.022 inch. With the relay energized the normally-open contacts should have 15 to 30 grams pressure. The normally-closed contacts, if present, should have a contact gap of 0.015 inch.

The AR relay with its 800 ohm series resistor should pick up at approximately 30 volts.



Type TCF Receiver (Front View).

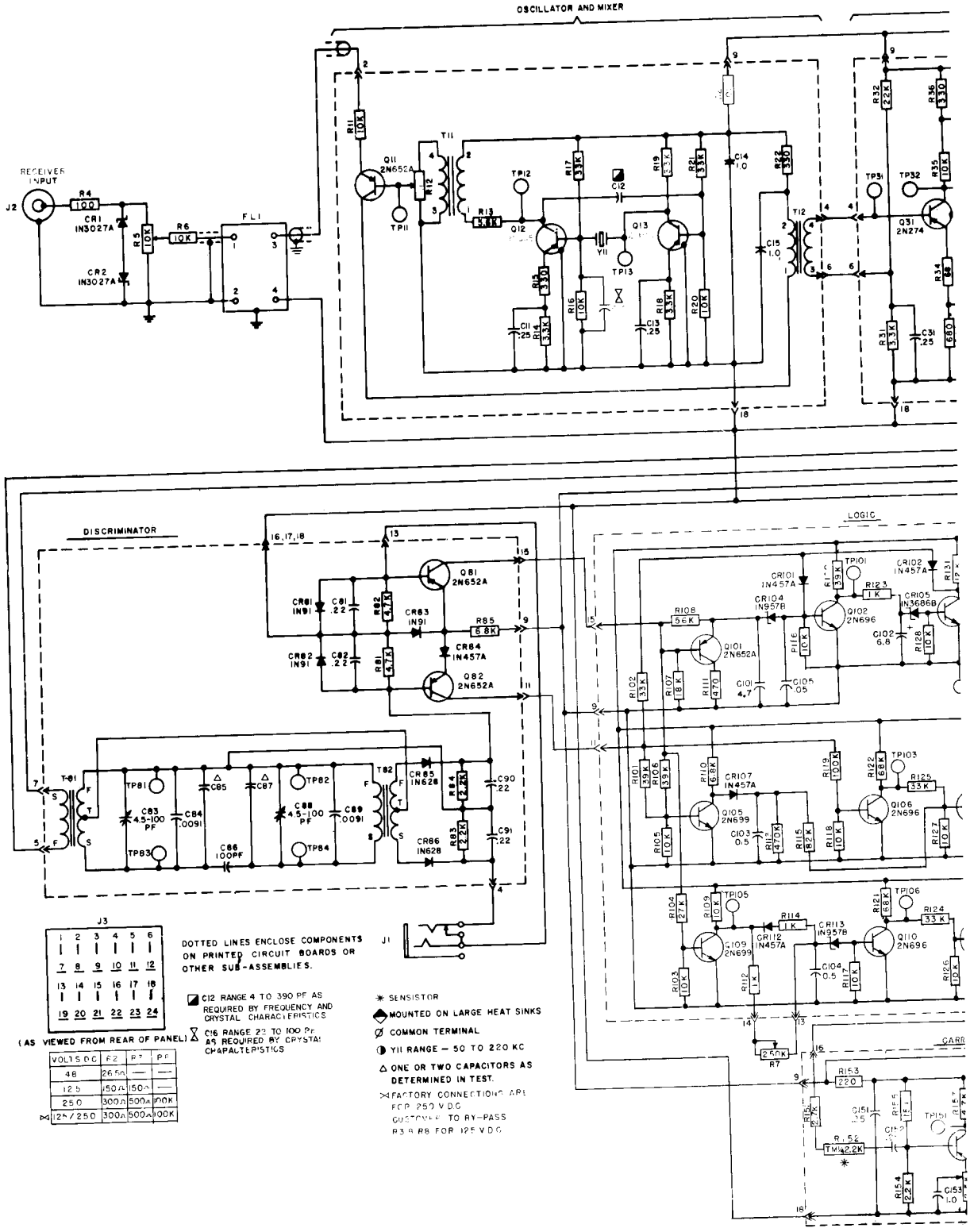
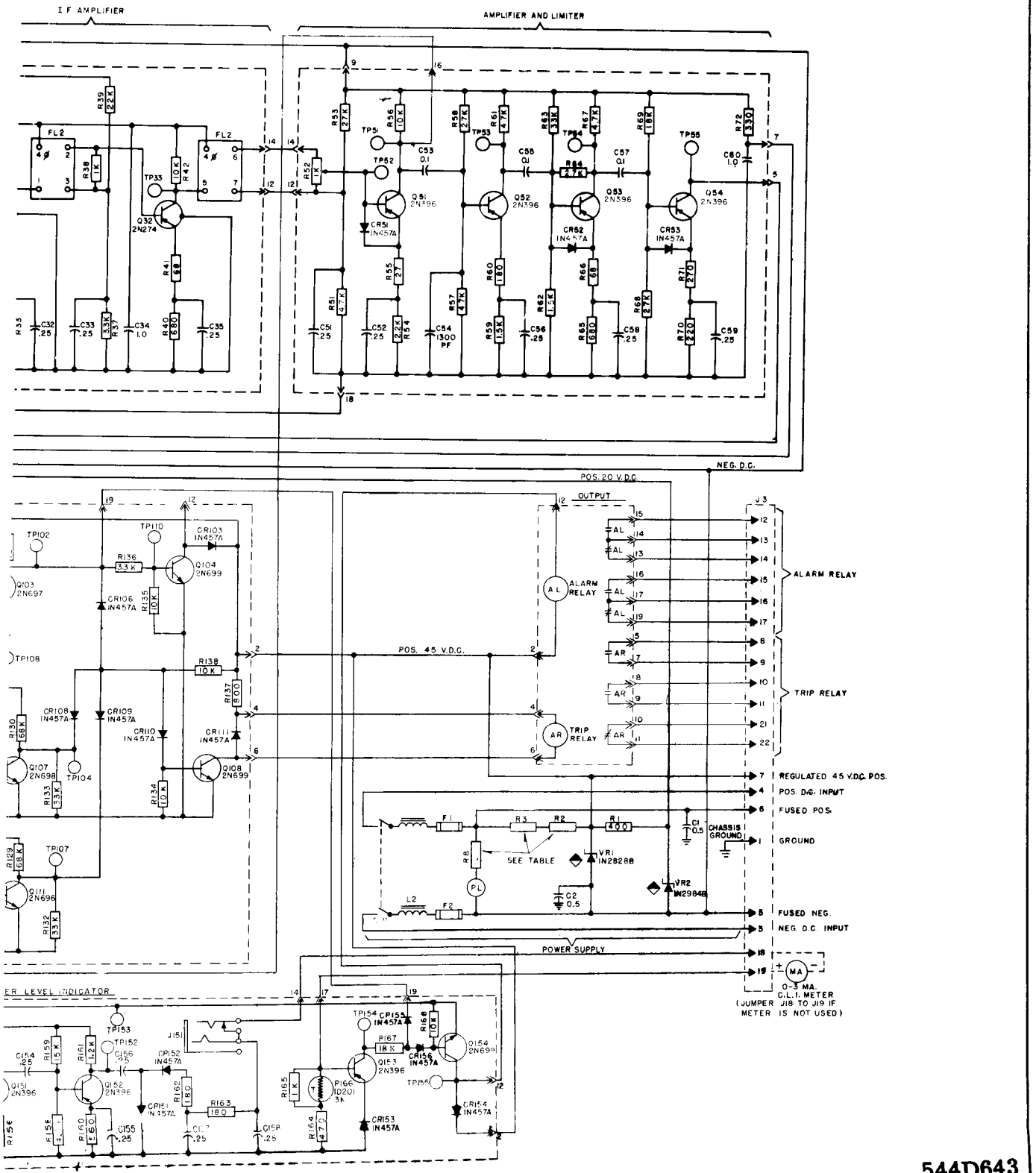


Fig. 2 Internal schematic of the type T



544D643

CF receiver with the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Imput Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf	184A663H04
C213	Ceramic; .1 mf	184A663H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic;	184A663H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. ± 5%	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ±5%; ½ W. Composition	184A763H13
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	1962797
T12	Toroidal type, 25000/300 ohms	1962697
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	196297
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01+(Req.Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408A845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

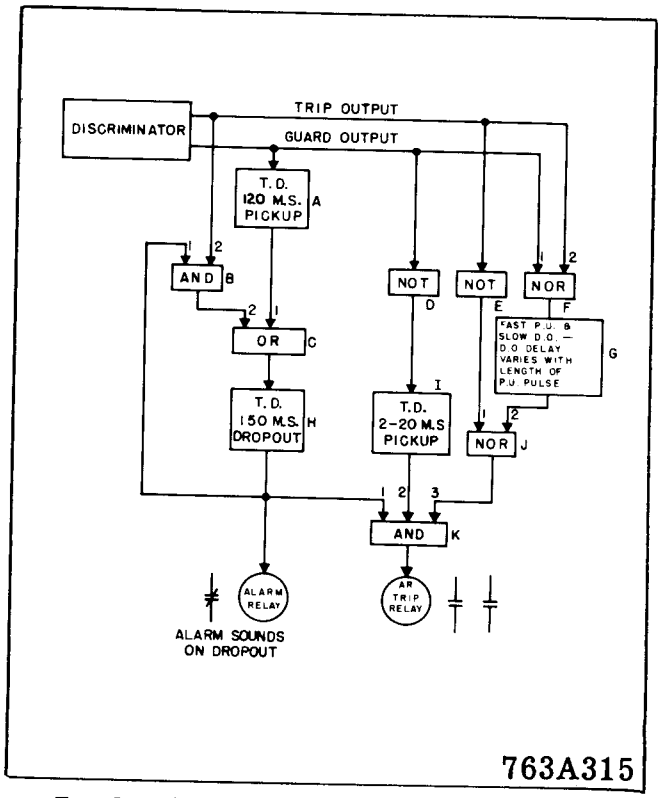


Fig. 3 Block diagram of output logic circuit

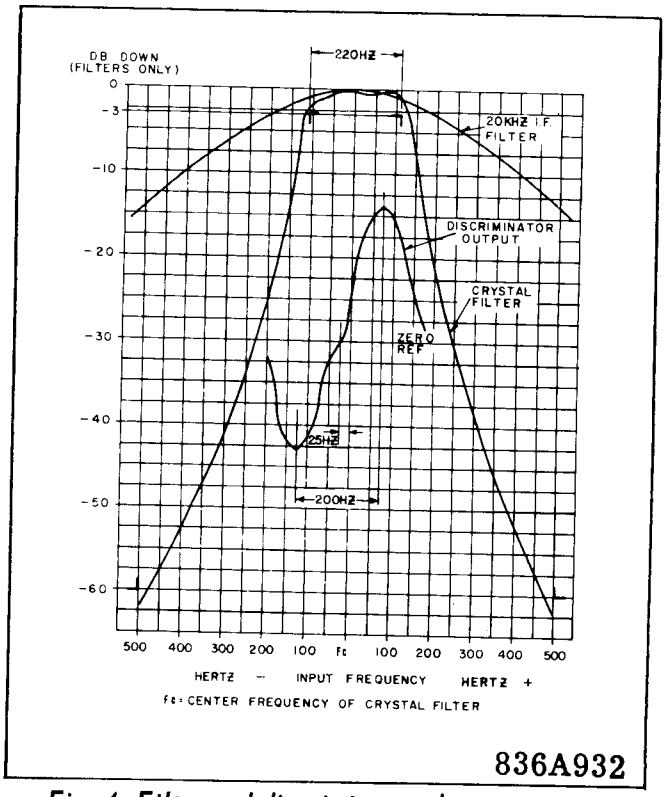


Fig. 4 Filter and discriminator characteristics of the type TCF receiver

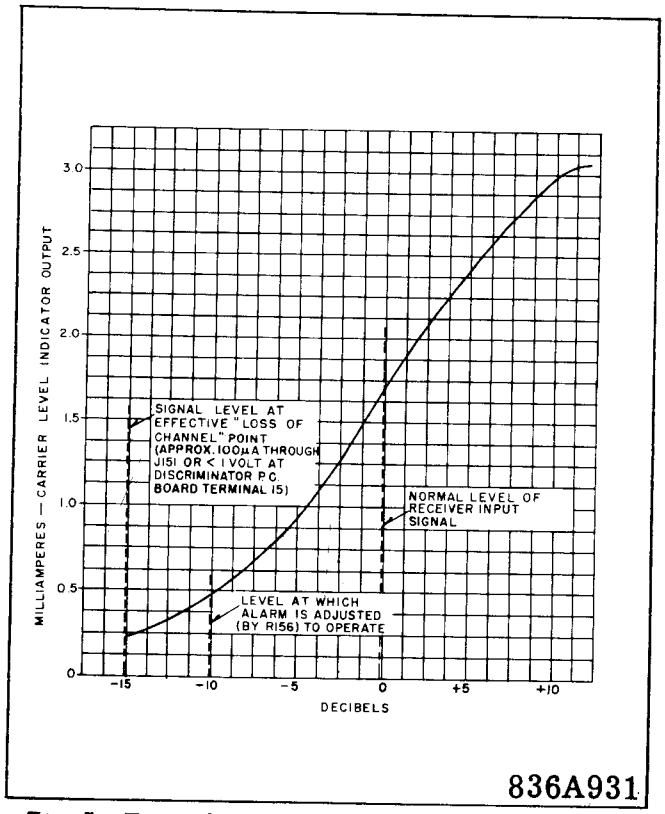


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

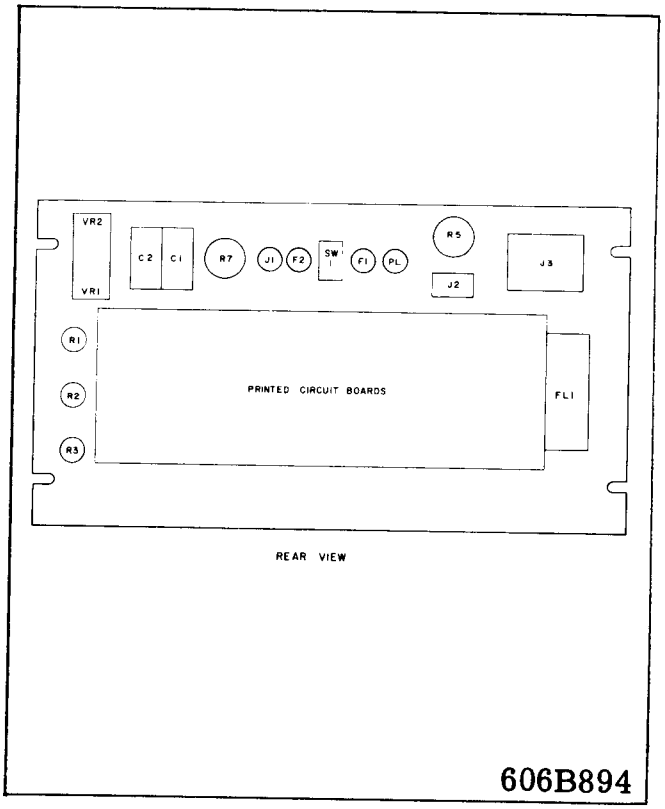


Fig. 6 Component locations on the type TCF receiver panel

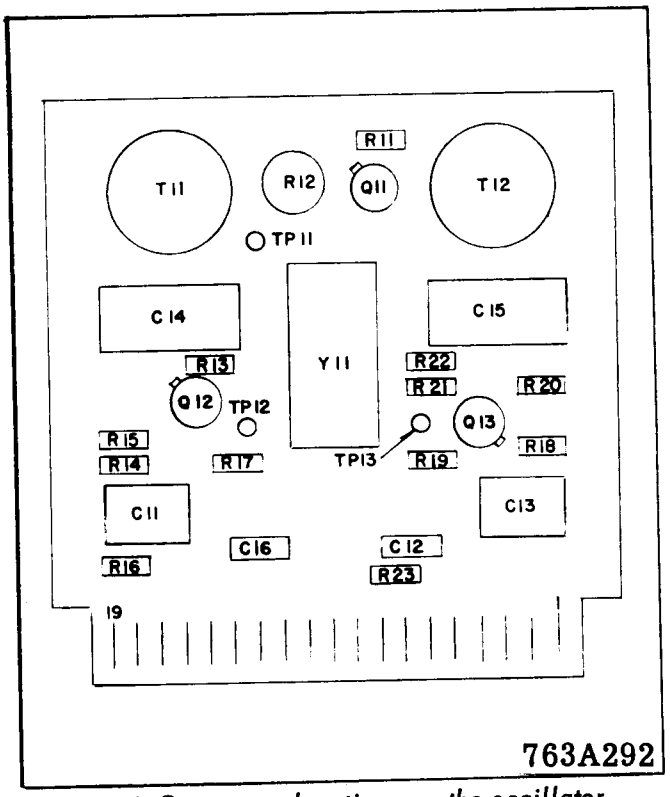


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

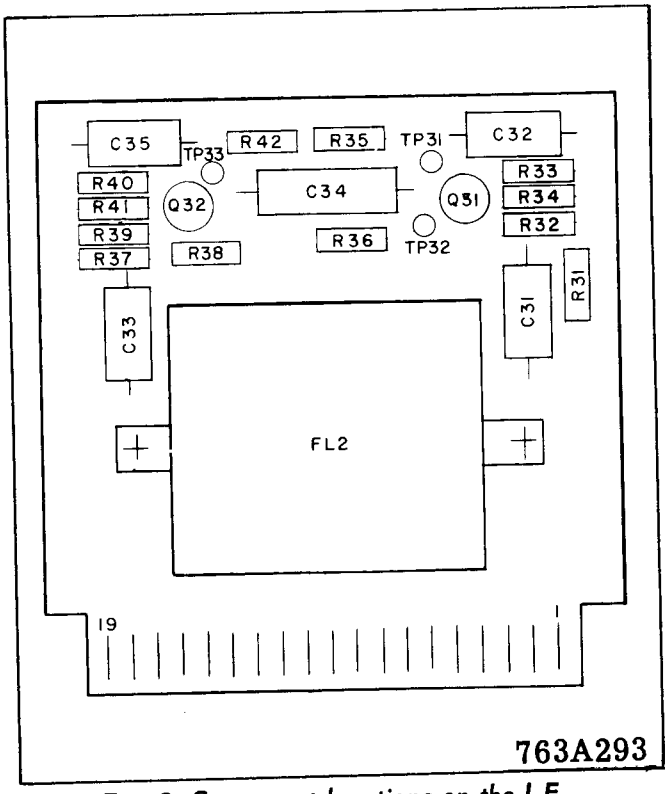


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

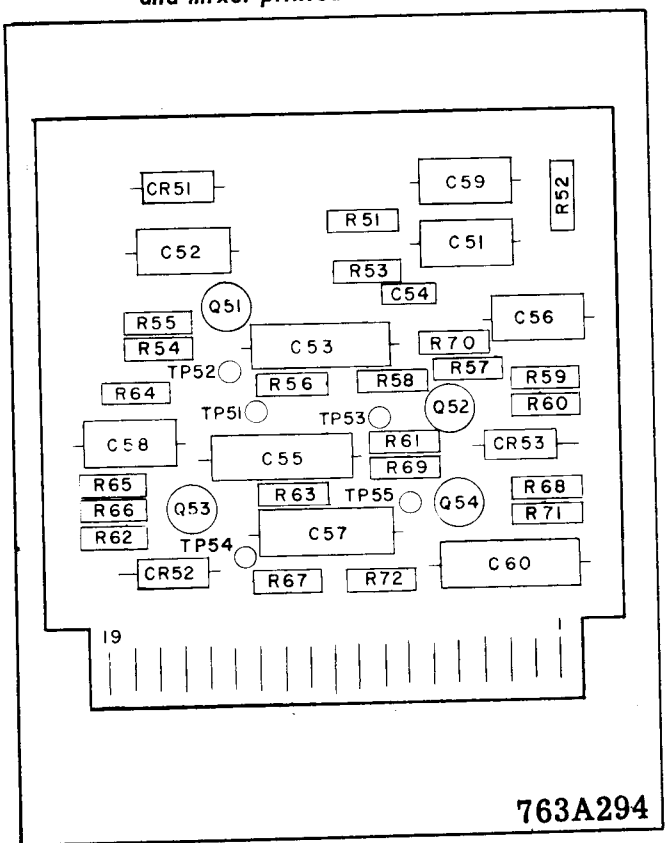


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

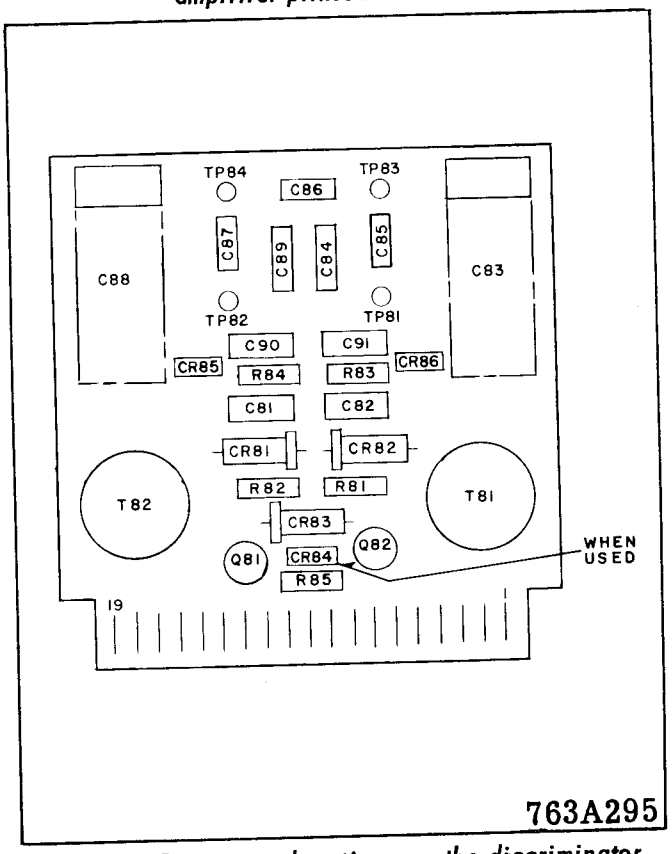


Fig. 10 Component locations on the discriminator printed circuit board.

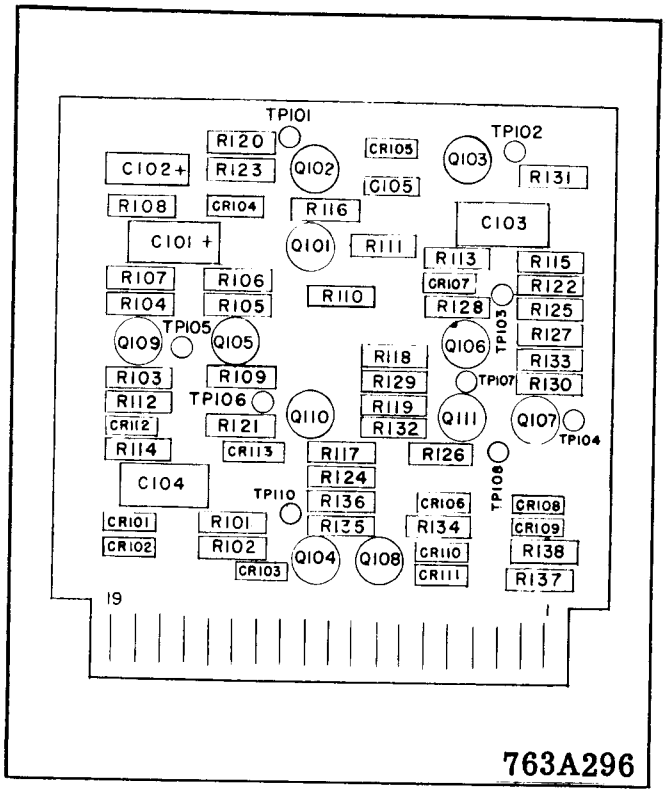


Fig. 11 Component locations on the logic printed circuit board.

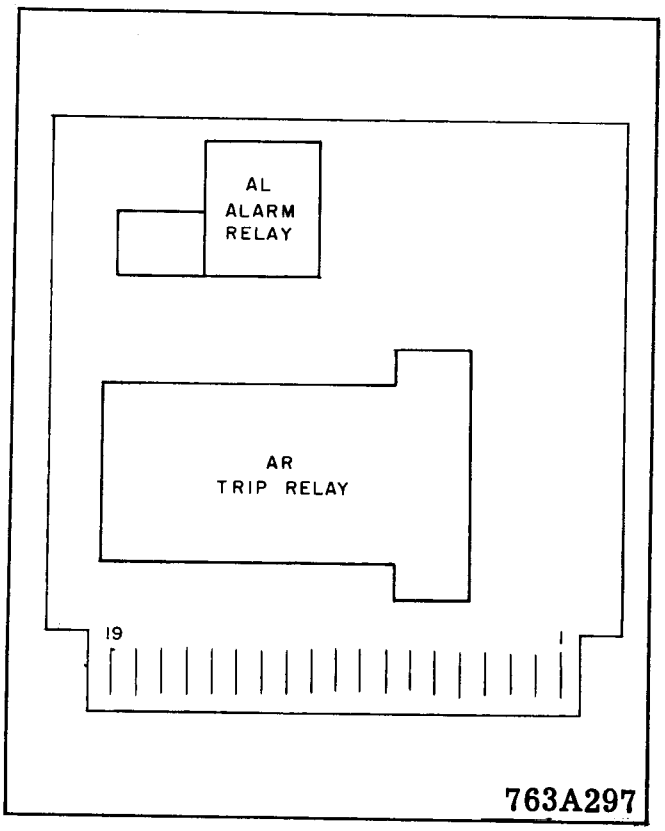


Fig. 12 Component locations on the output printed circuit board.

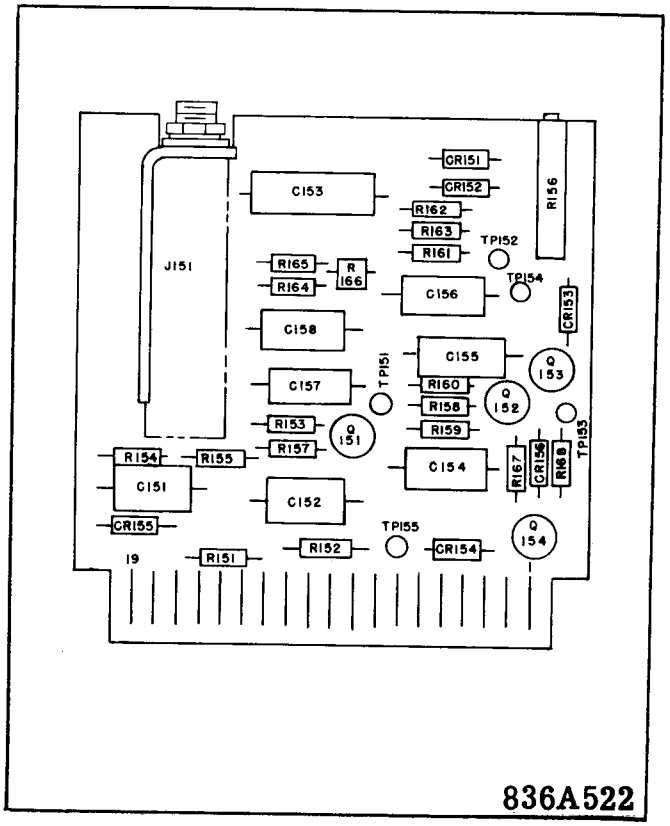


Fig. 13 Component locations on the carrier level indicator printed circuit board.

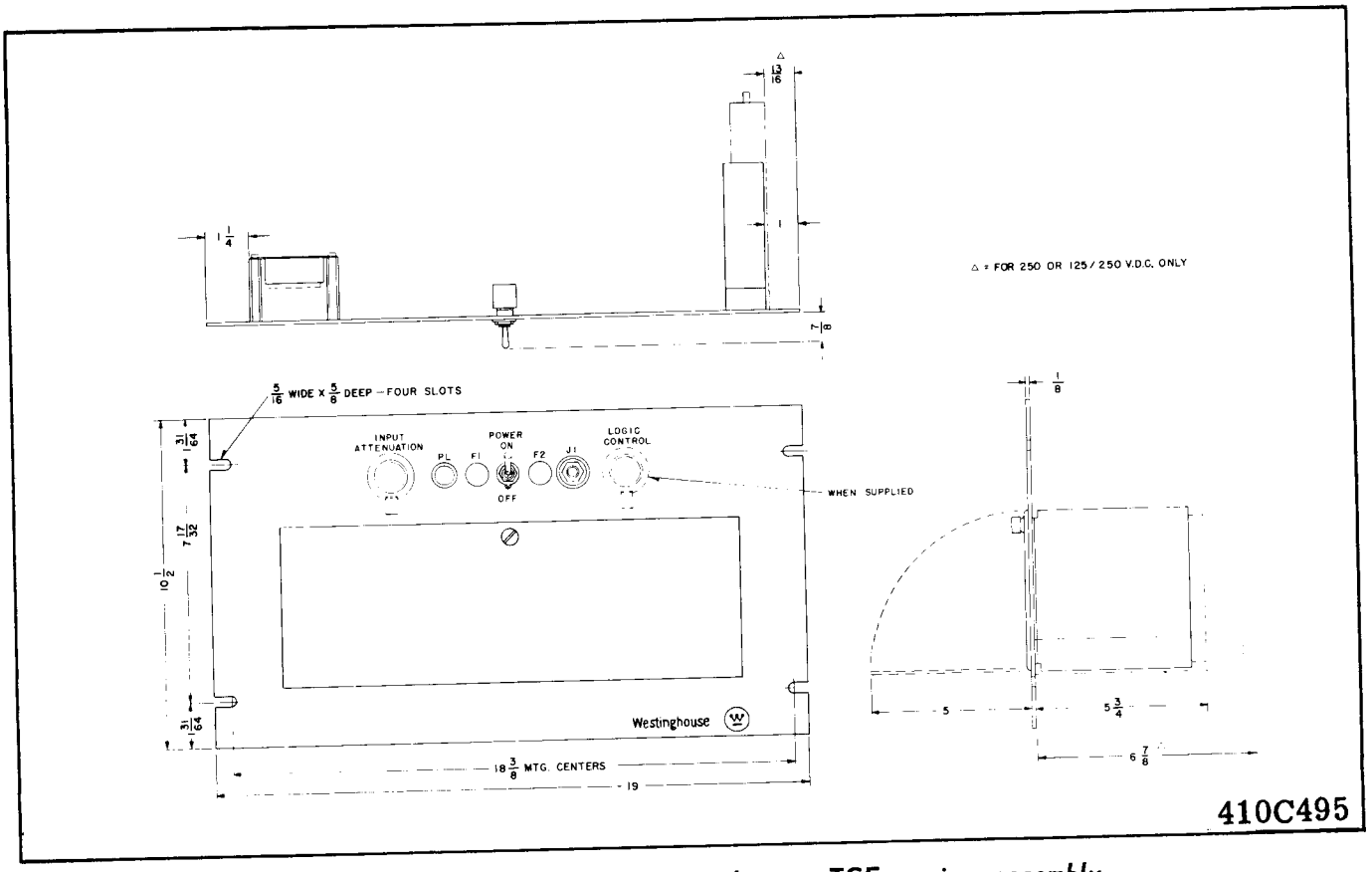


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

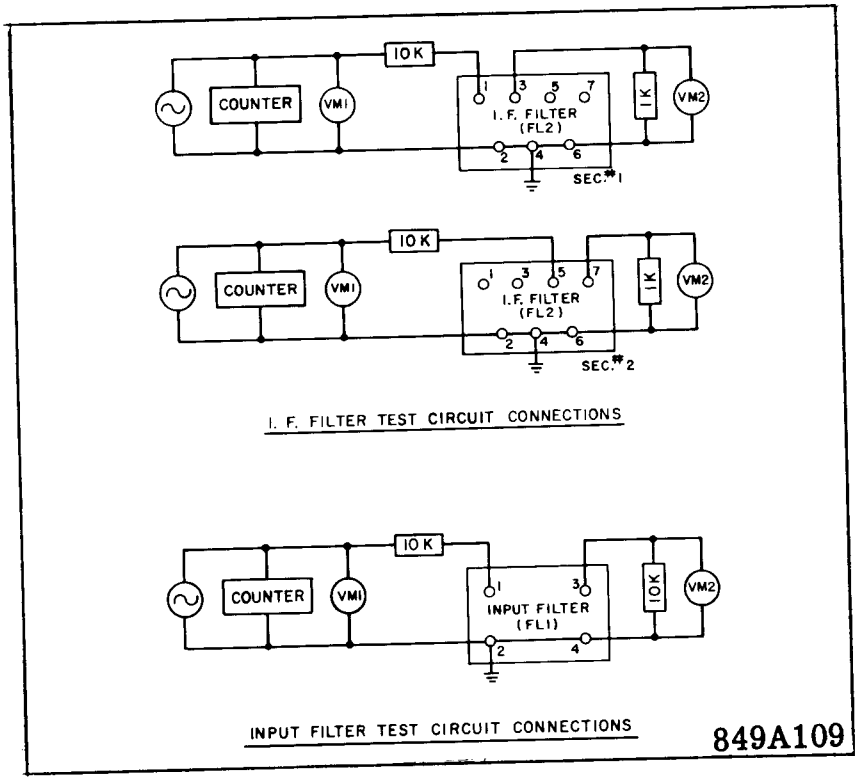
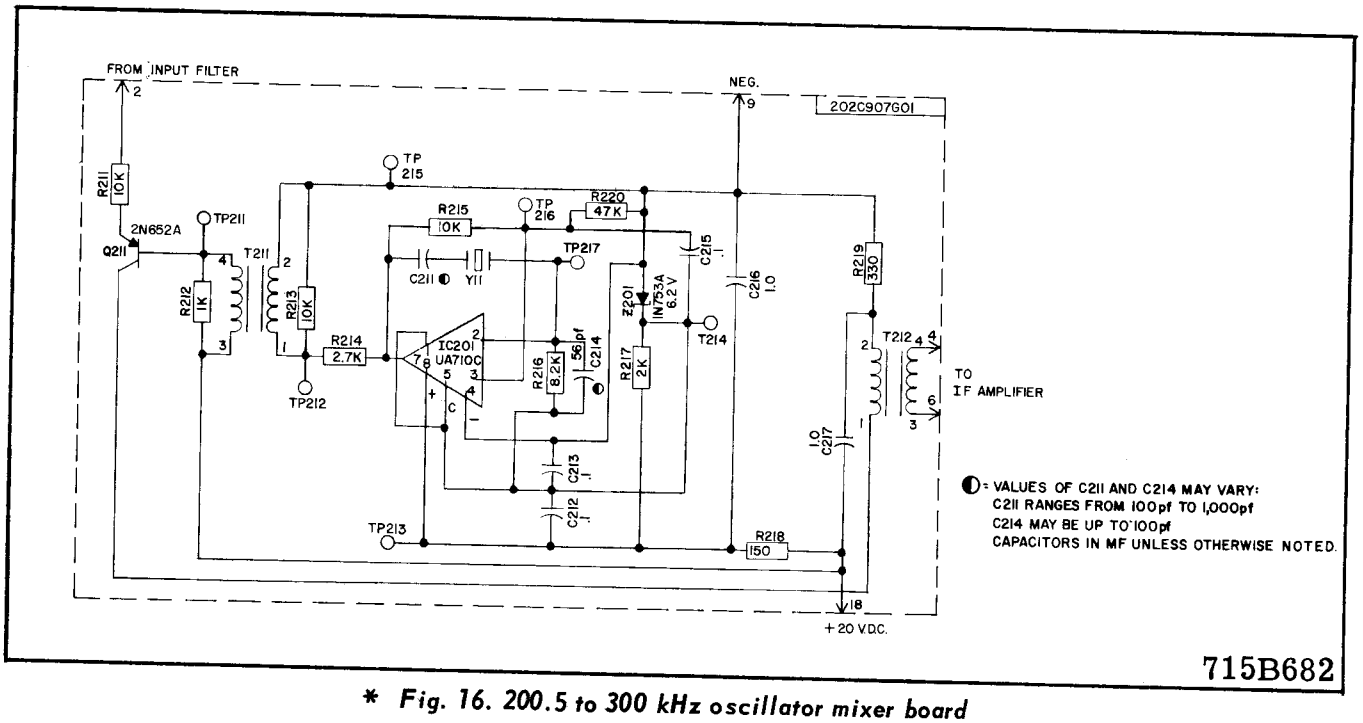


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.



* *Fig. 16. 200.5 to 300 kHz oscillator mixer board*

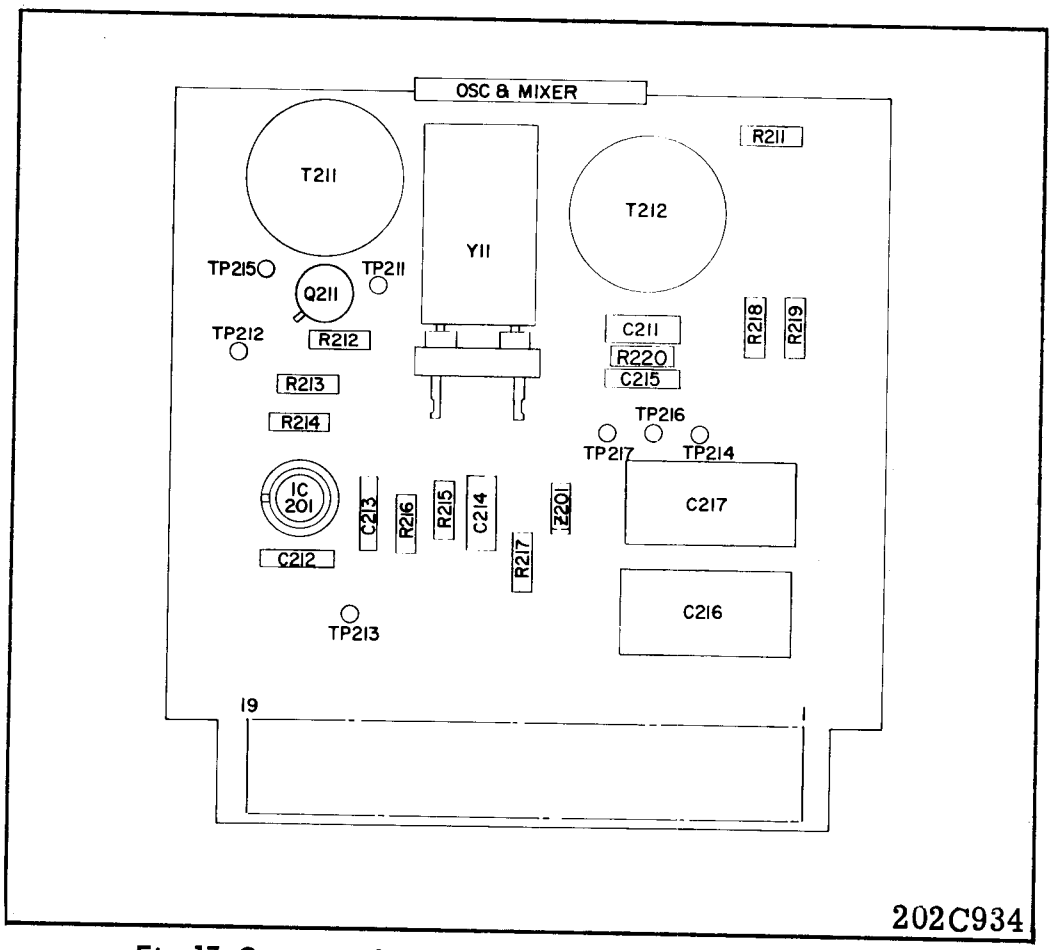


Fig. 17. Component Location 200.5 to 300 kHz oscillator mixer board.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

* Caution: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet and in the system instruction leaflet before energizing the system.
Printed circuit modules should not be removed or inserted when the relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

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*Denotes change from superseded issue.

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Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.5 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental inserting of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 hertz minimum
B. For two-way channel	1500 hertz minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42 - 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 55°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20kHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I
RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

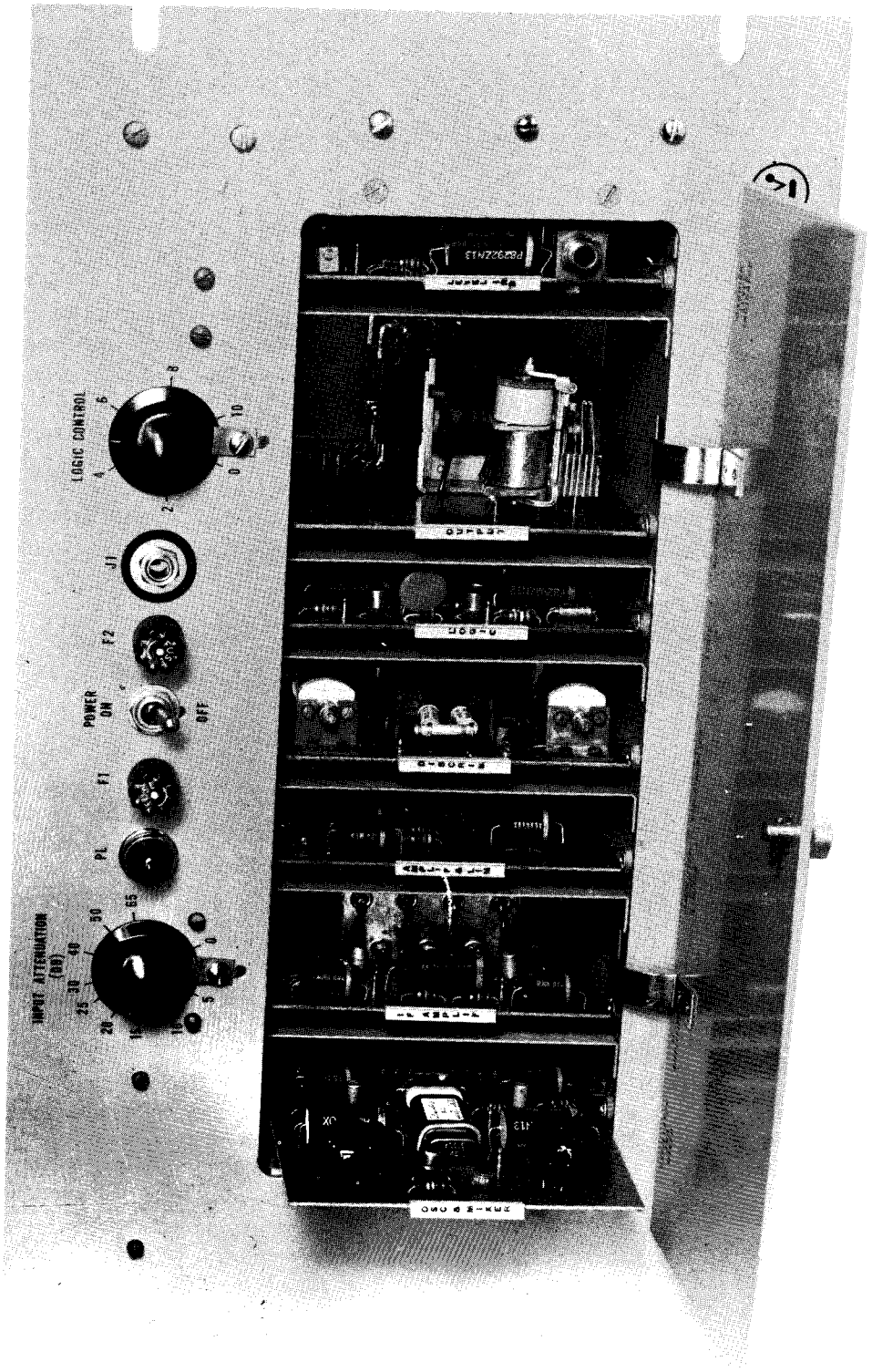
The adjustment procedure for the AR relay (which should be attempted only if suitable tools are available) is as follows:

a) Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.

b) On relays with two normally-open and two normally-closed contacts, adjust each contact spring so that 8 grams force at the very end of each spring will just move it away from the edge of the slotted insulation attached to the armature. Relays with four normally-open contacts should be adjusted so that a 4 gram force similarly applied will just move each spring away from the edge of the insulation.

c) Adjust each normally-open contact screw to obtain a gap of 0.020 to 0.022 inch. With the relay energized the normally-open contacts should have 15 to 30 grams pressure. The normally-closed contacts, if present, should have a contact gap of 0.015 inch.

The AR relay with its 800 ohm series resistor should pick up at approximately 30 volts.



Type TCF Receiver (Front View).

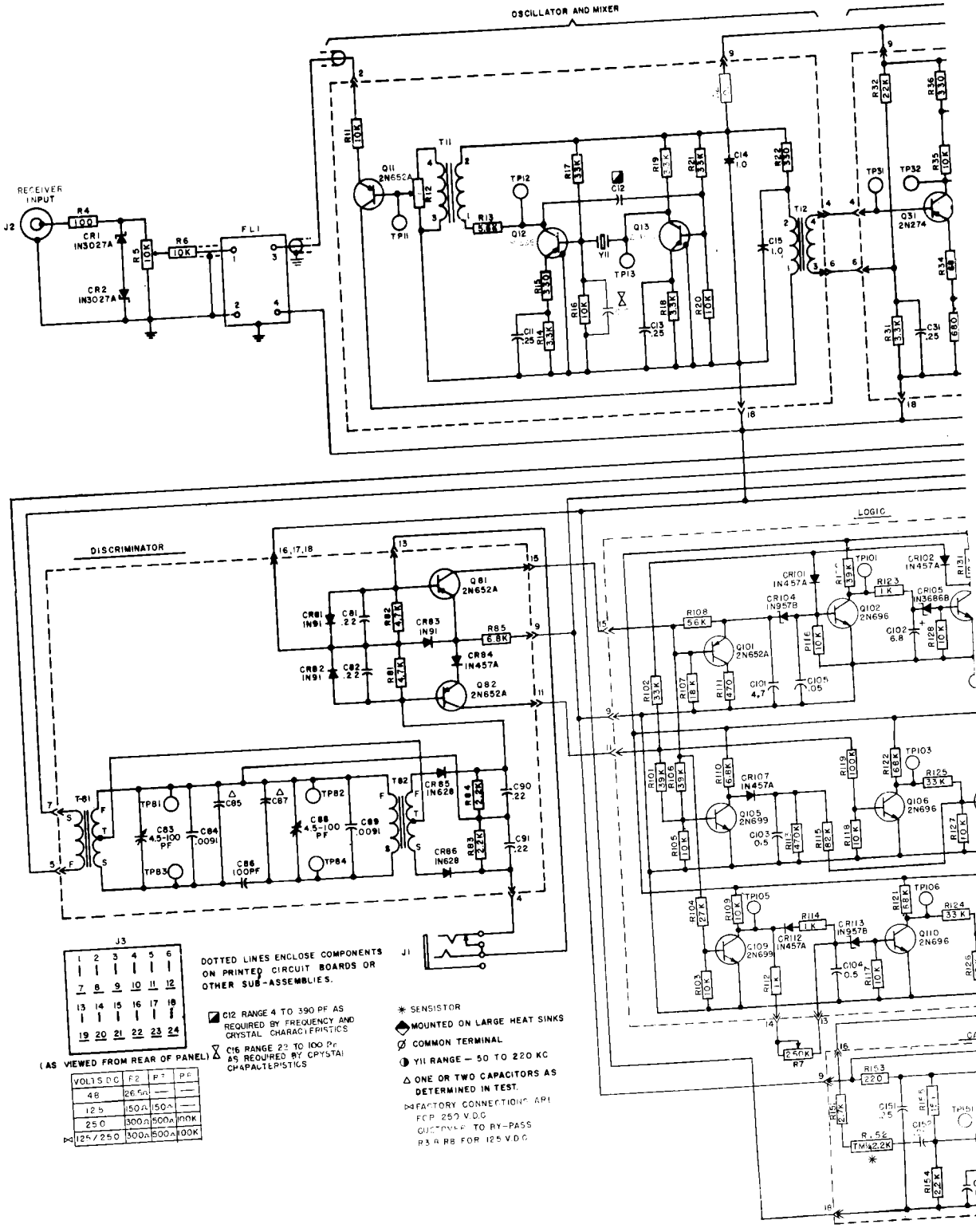
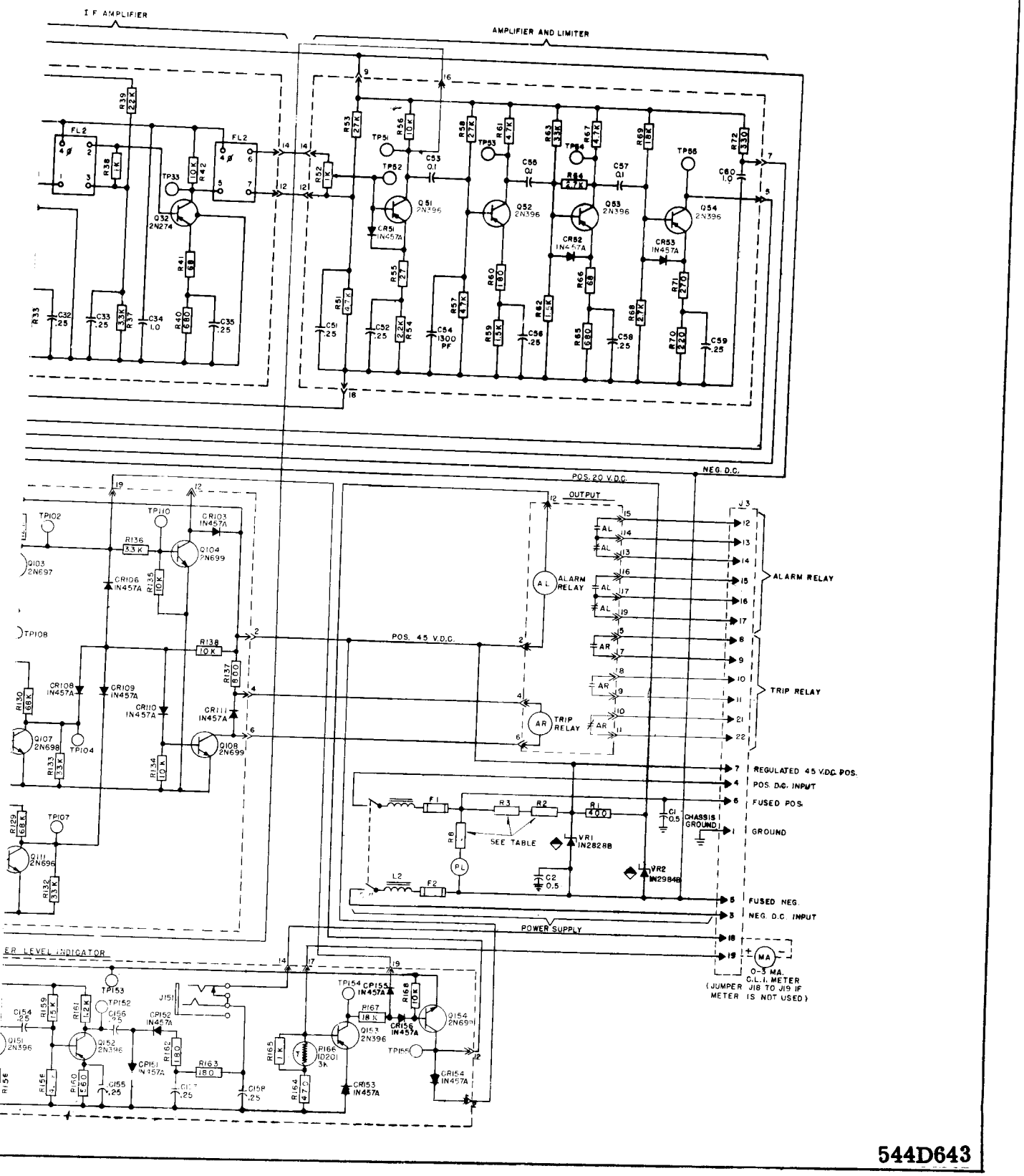


Fig. 2 Internal schematic of the type



544D643

CF receiver with the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).

Voltage Range:	1.5 to 300 volts
Imput Impedance:	7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator

Output Voltage:	up to 8 volts
Frequency Range:	20-kHz to 330-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf	184A663H04
C213	Ceramic; .1 mf	184A663H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic;	184A663H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V.; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. ± 5%	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ±5%; ½ W. Composition	184A763H13
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	1962797
T12	Toroidal type, 25000/300 ohms	1962697
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	196297
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01+(Req.Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408A845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

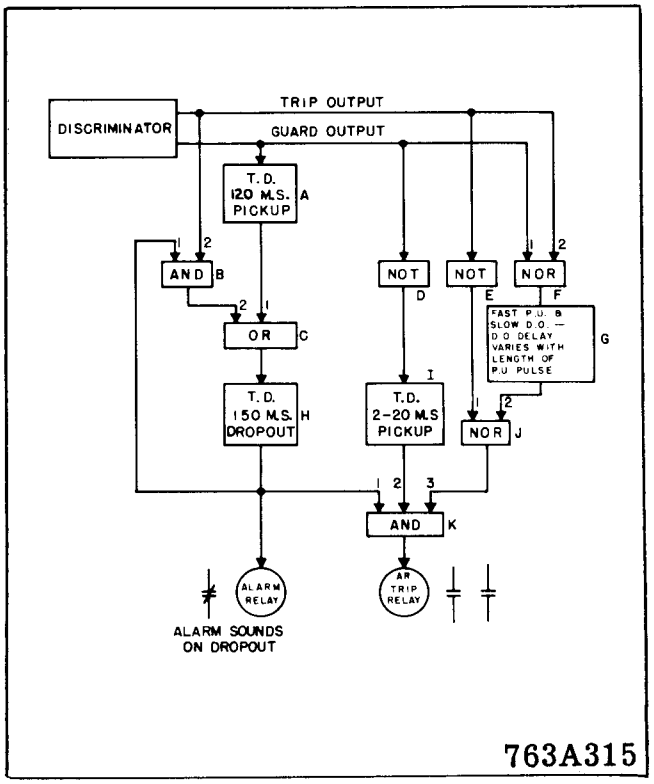


Fig. 3 Block diagram of output logic circuit

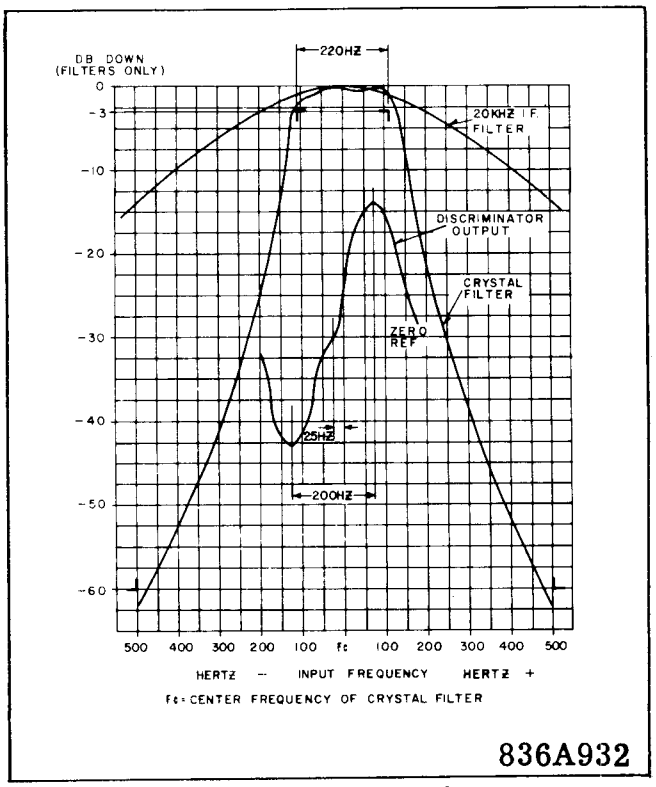


Fig. 4 Filter and discriminator characteristics of the type TCF receiver

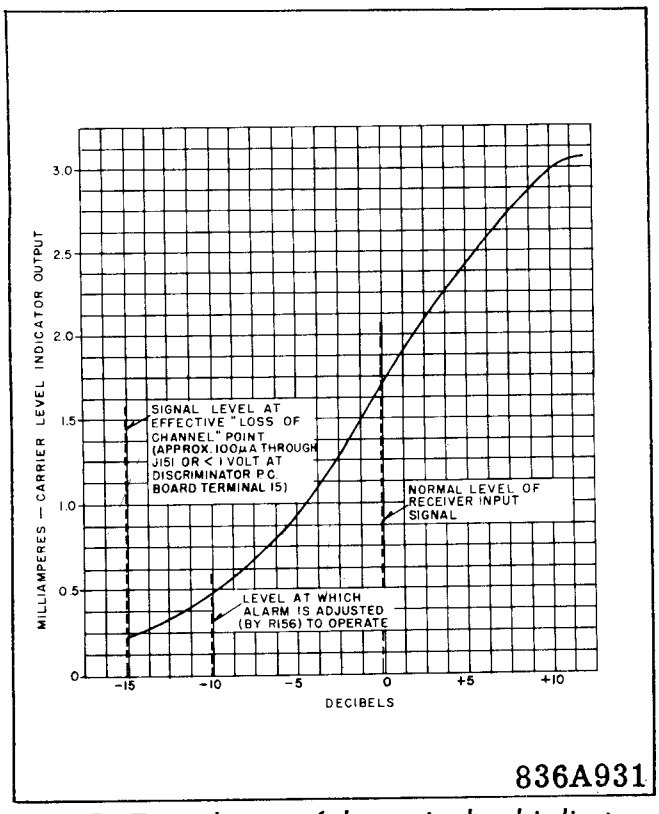


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

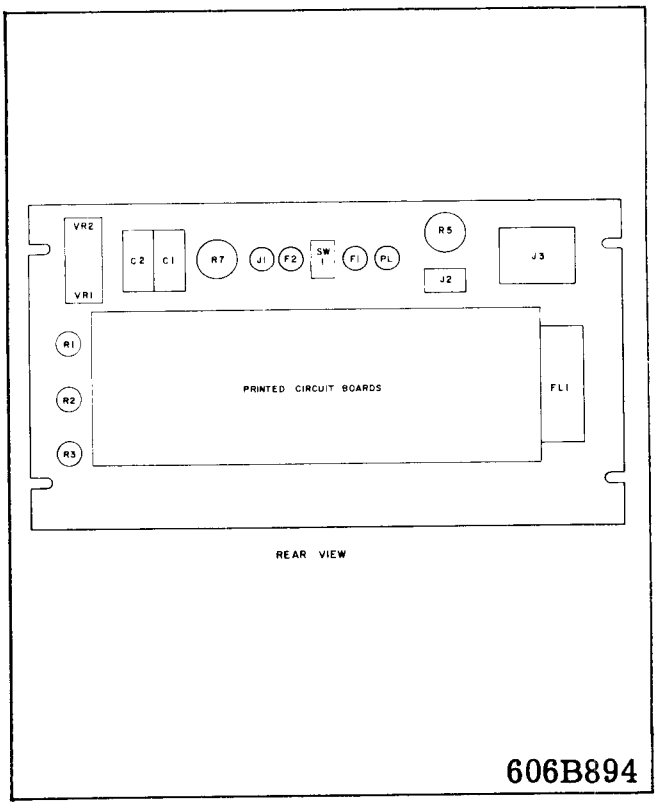


Fig. 6 Component locations on the type TCF receiver panel

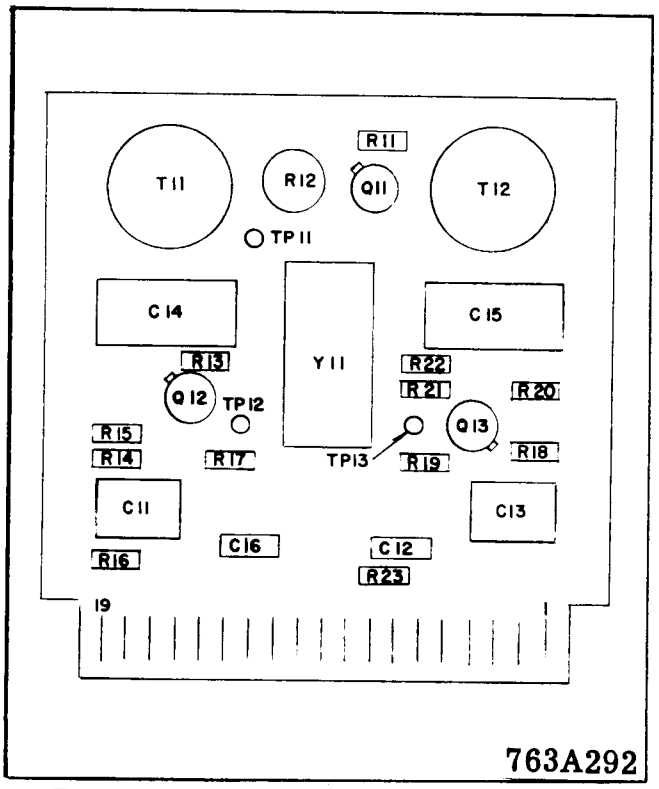


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

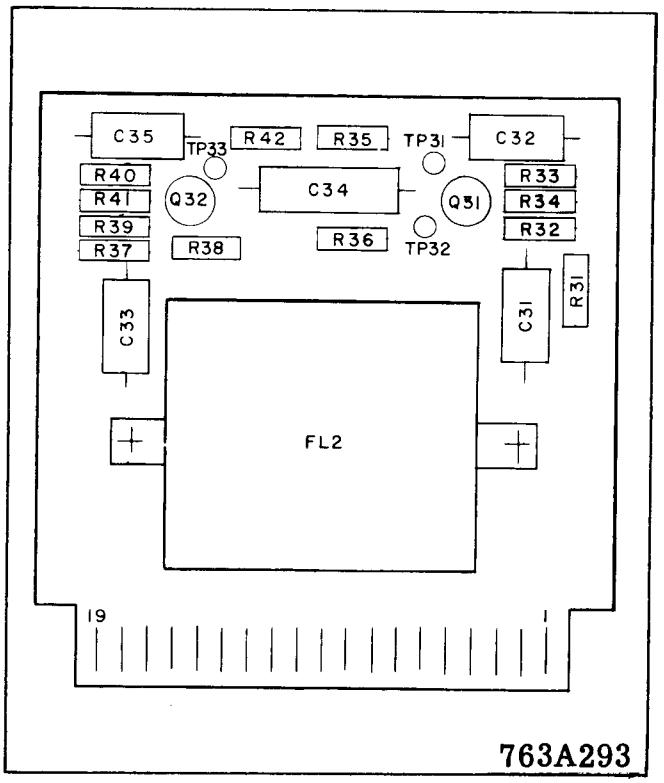


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

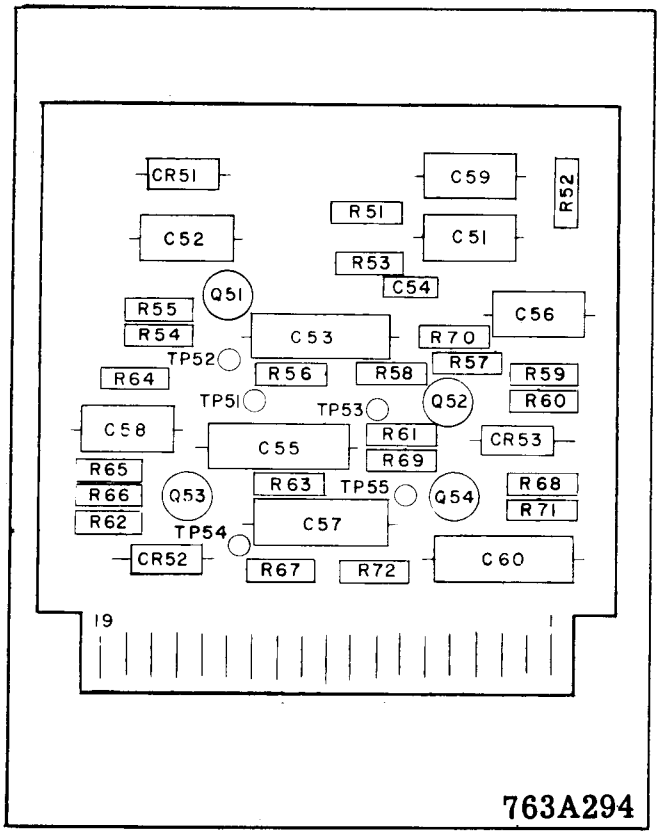


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

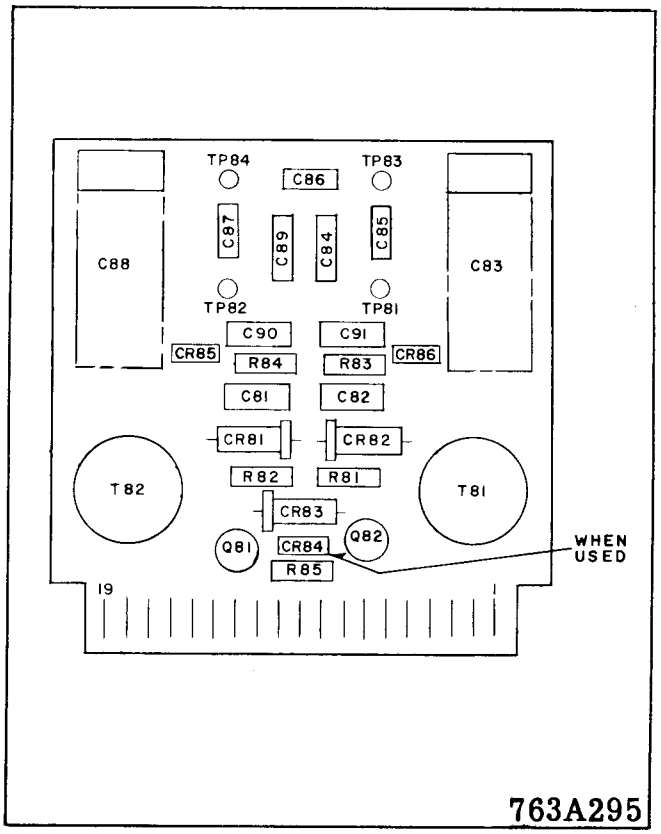


Fig. 10 Component locations on the discriminator printed circuit board.

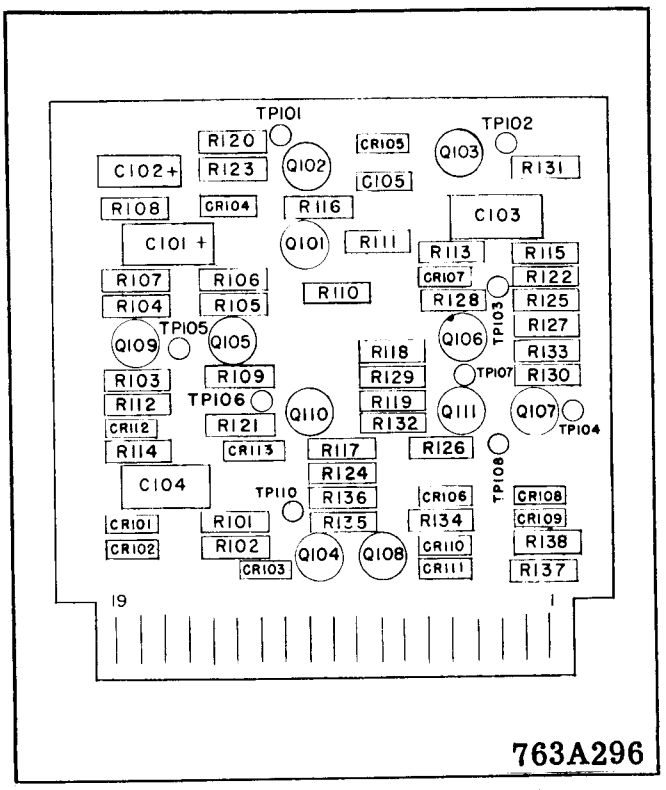


Fig. 11 Component locations on the logic printed circuit board.

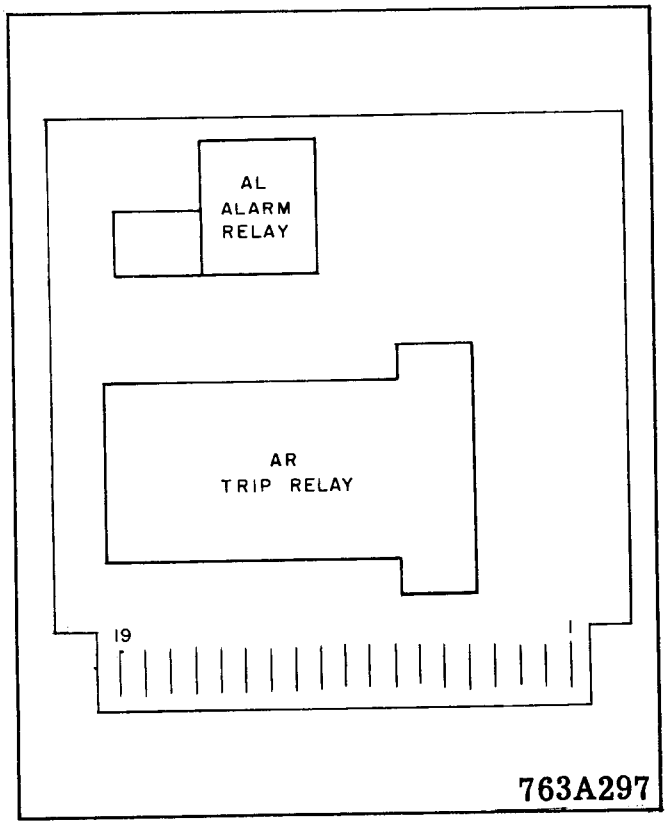


Fig. 12 Component locations on the output printed circuit board.

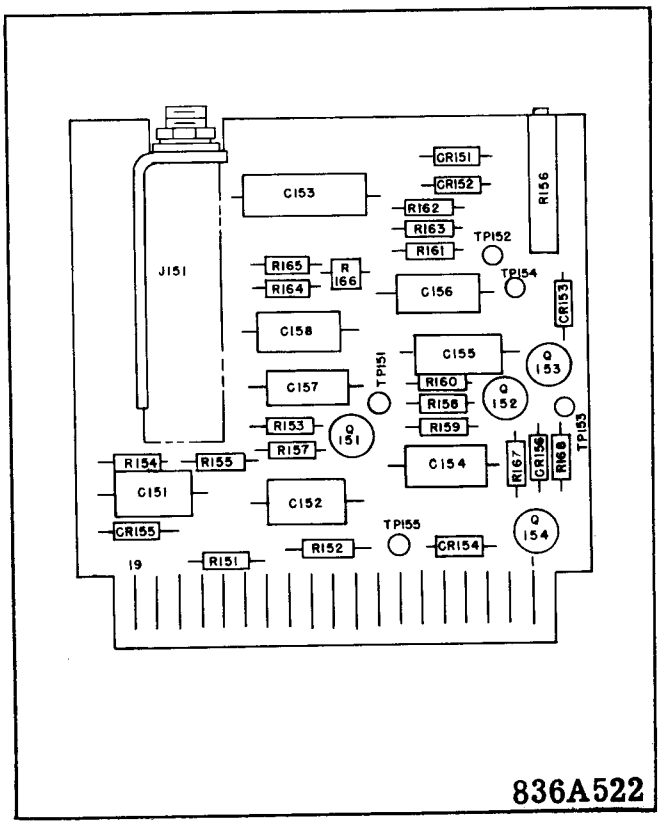


Fig. 13 Component locations on the carrier level indicator printed circuit board.

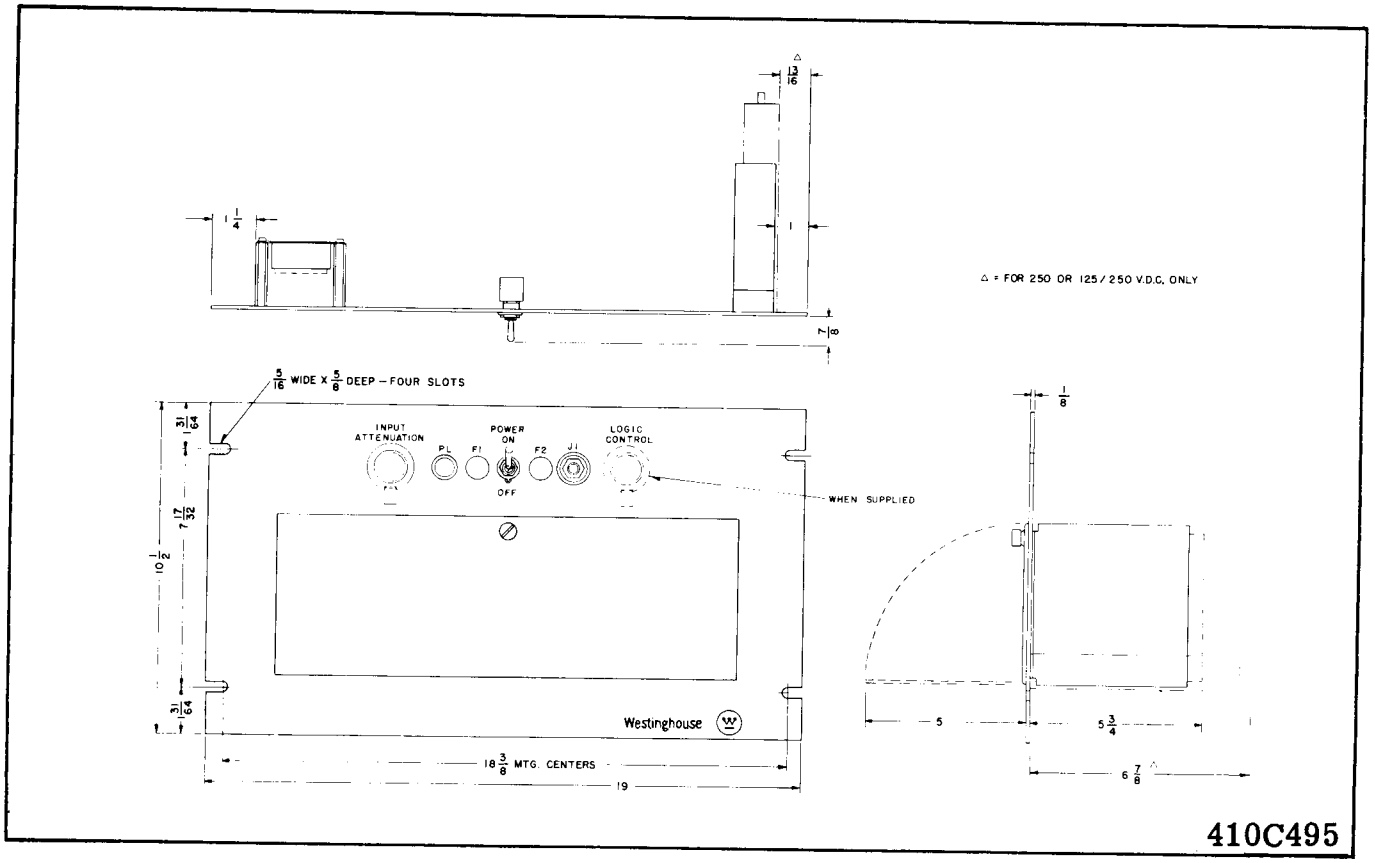


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

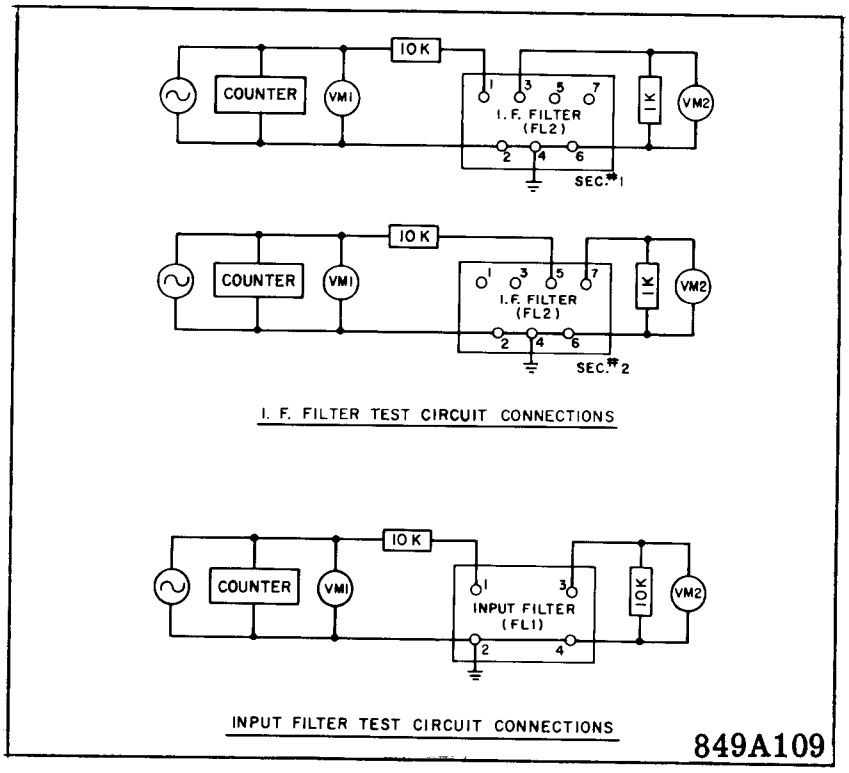
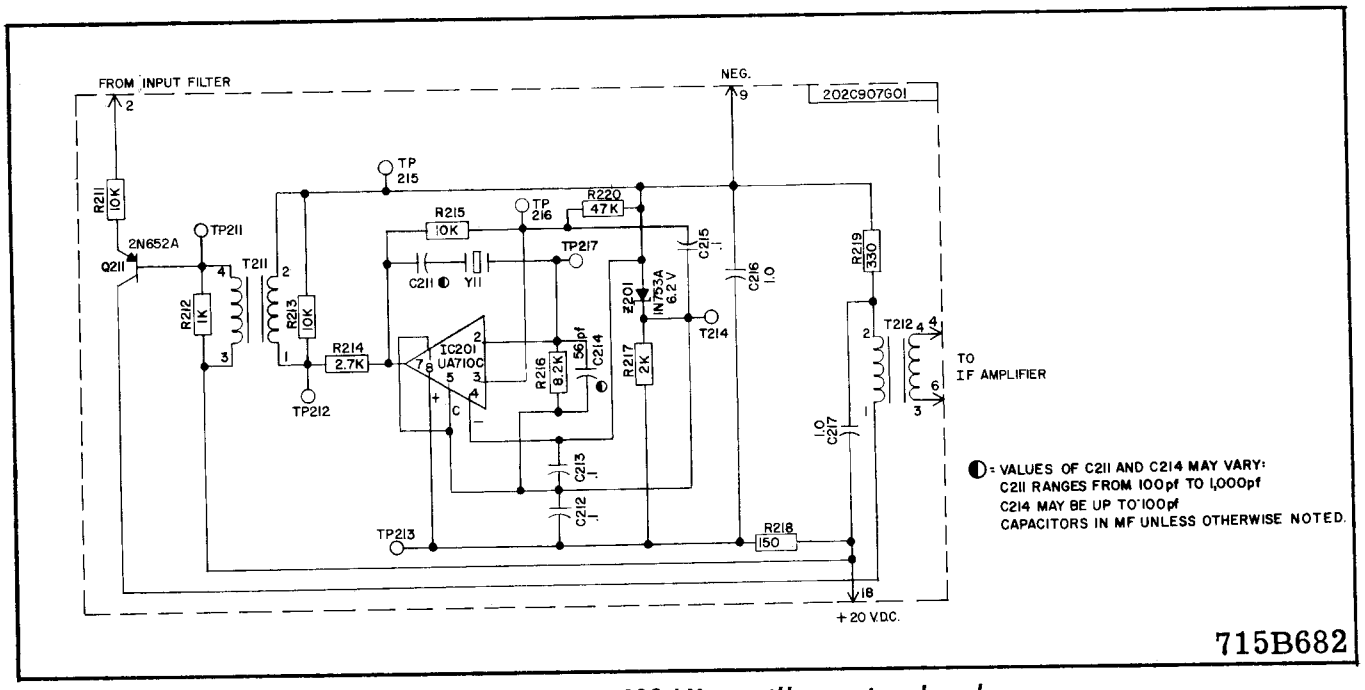


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.



* *Fig. 16. 200.5 to 300 kHz oscillator mixer board*

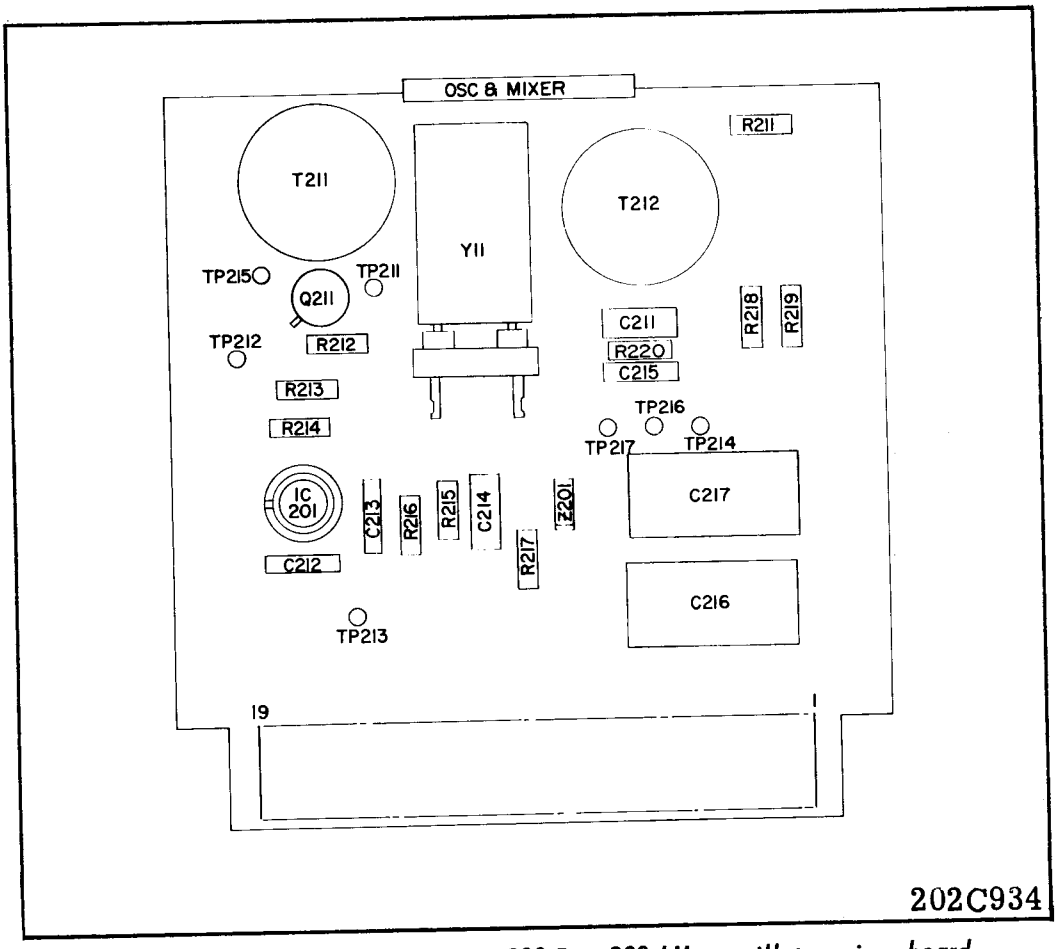


Fig. 17. Component Location 200.5 to 300 kHz oscillator mixer board.

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION
NEWARK, N. J.
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

CAUTION It is recommended that the user of this equipment become thoroughly acquainted with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment.
* The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip fre-
* quency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken * from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to * jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass * band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, or IC201 (Fig. 16) and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 kHz above the channel frequency, fc. The output from this local oscillator is fed * through transformer T11 to potentiometer R12, and the later is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20kHz, 2fc + 20kHz, fc + 20kHz and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. * While its passband is much wider than that of the crystal filter, it eliminates the frequencies present * at its input that are substantially higher than 20kHz.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 * hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero output frequency. This separation of 200 * hertz between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output fre- * quency of the discriminator by 25 hertz in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency if fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the Guard * frequency is 20 kHz-100 hertz. Similarly, the Trip frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor * C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard * signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears 15 ms. before C102 has reached the breakdown voltage of CR105, the charge is quickly dissipated through the 1K resistor R123, and the full time-delay will be effective on any subsequent loss of Guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.5 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental ininsertion of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	* 30-300 kHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	* 500 hertz minimum
B. For two-way channel	* 1500 hertz minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20 °C to + 60 °C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½''or 6 r.u. Panel width - 19''
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60 °C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected * to the same points for a check on the frequency, which should be 20KC above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capaciotr C12 ORC. Reducing C12 ORC increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature exterems.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

– "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

The adjustment procedure for the AR relay (which should be attempted only if suitable tools are available) is as follows:

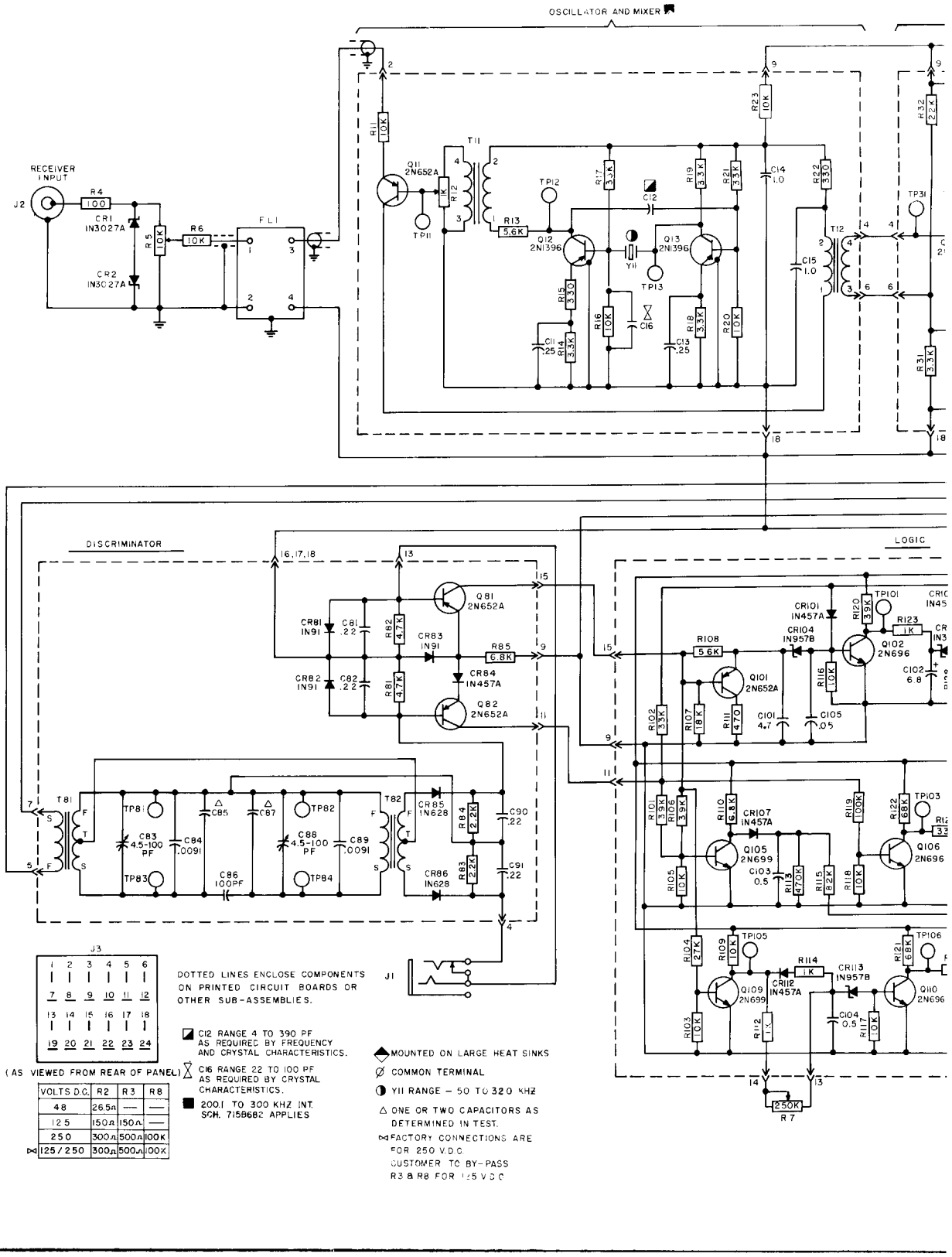
a) Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.

b) On relays with two normally-open and two normally-closed contacts, adjust each contact spring so that 8 grams force at the very end of each spring will just move it away from the edge of the slotted insulation attached to the armature. Relays with four normally-open contacts should be adjusted so that a 4 gram force similarly applied will just move each spring away from the edge of the insulation.

c) Adjust each normally-open contact screw to obtain a gap of 0.020 to 0.022 inch. With the relay energized the normally-open contacts should have 15 to 30 grams pressure. The normally-closed contacts, if present, should have a contact gap of 0.015 inch.

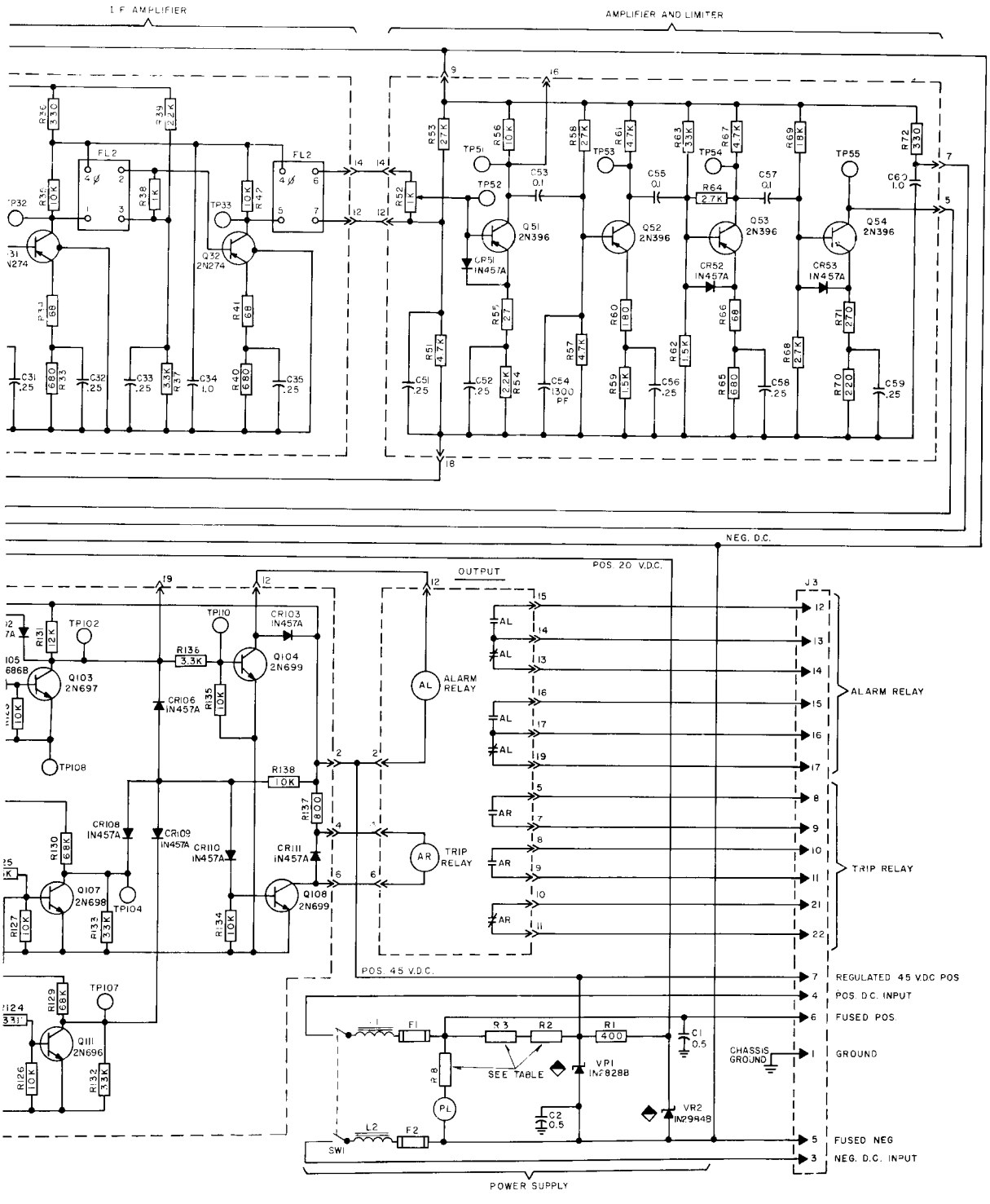
The AR relay with its 800 ohm series resistor should pick up at approximately 30 volts.

Type TCF Receiver (Front View).



VOLTS D.C.	R2	R3	R8
48	26.5Ω	—	—
125	150Ω	150Ω	—
250	300Ω	500Ω	100K
125/250	300Ω	500Ω	100K

* *Fig. 1. Internal schematic of the typ*



543D637

; TCF receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the * stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequen-
* cy range 60 cycles/sec. to 230-kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).

Voltage Range:	1.5 to 300 volts
Imput Impedance:	7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator

* Output Voltage:	up to 8 volts
Frequency Range:	20-kHz to 230-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

* ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf	184A663H04
C213	Ceramic; .1 mf	184A663H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic;	184A663H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V.; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. ± 5%	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ±5%; ½ W. Composition	184A763H13
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

* ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

* ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	1962797
T12	Toroidal type, 25000/300 ohms	1962697
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	196297
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01 + (Req.Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408A845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

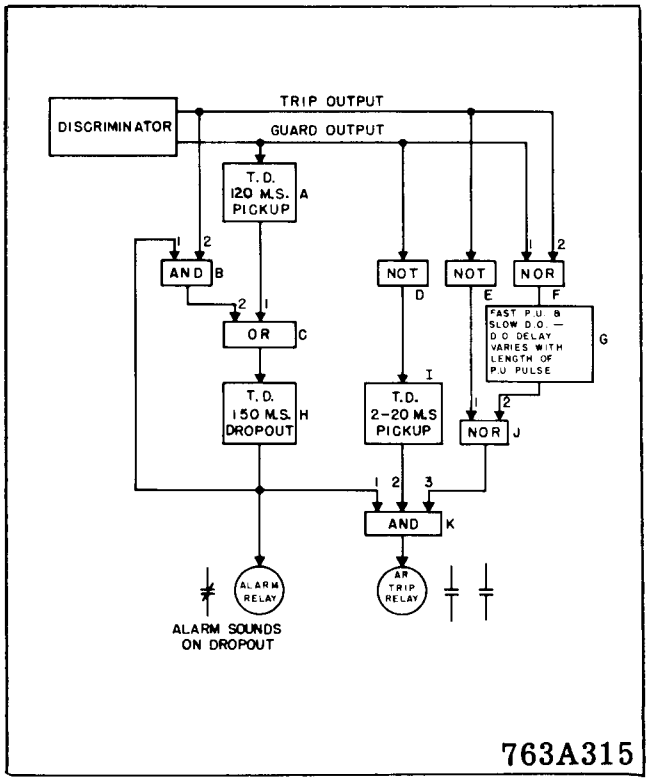
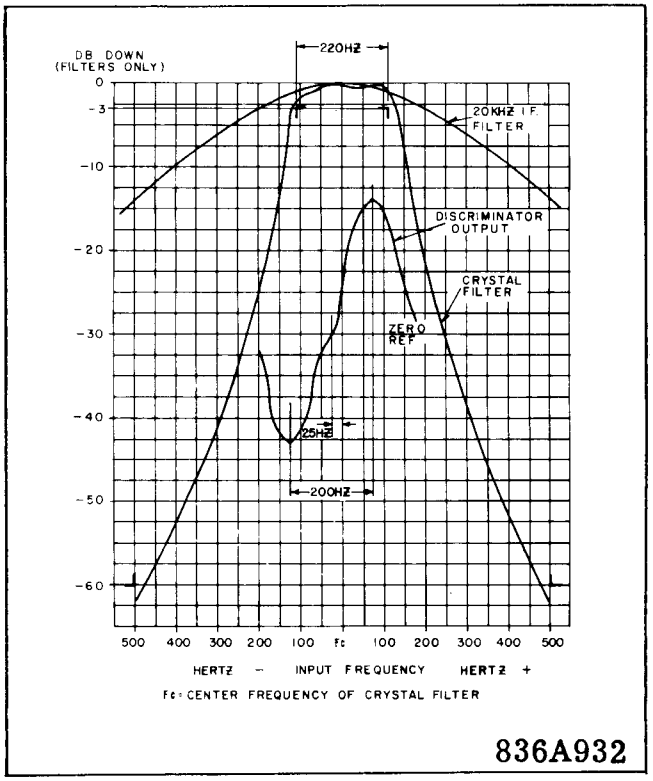


Fig. 3 Block diagram of output logic circuit



** Fig. 4 Filter and discriminator characteristics of the type TCF receiver*

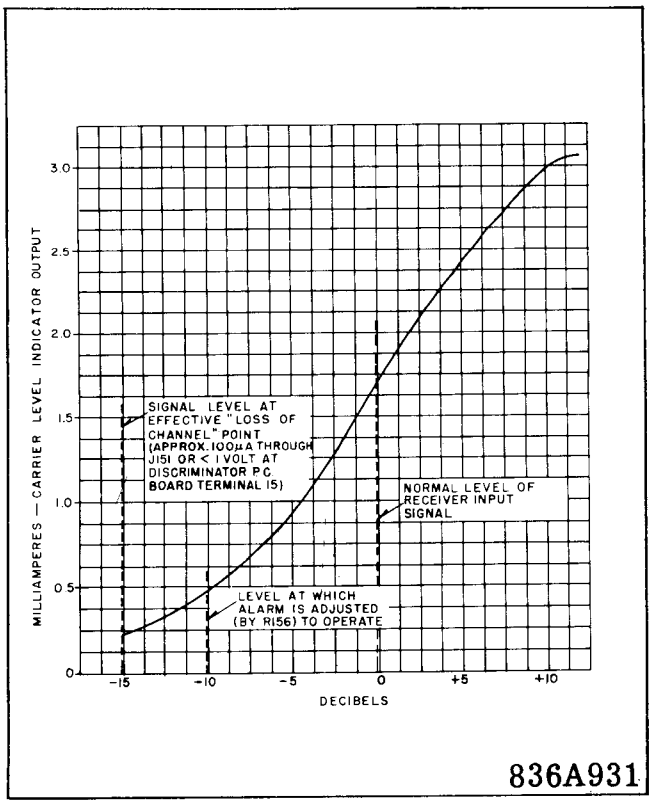


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

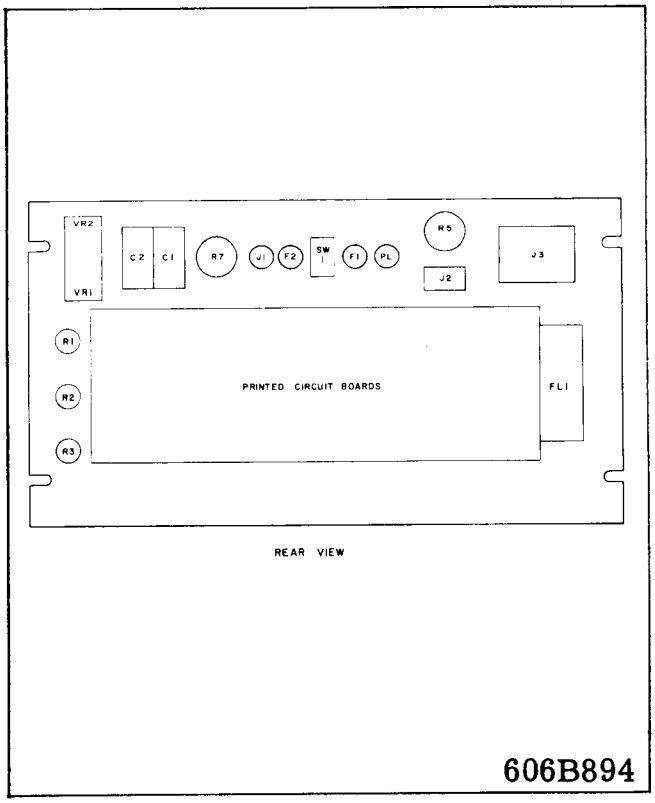


Fig. 6 Component locations on the type TCF receiver panel

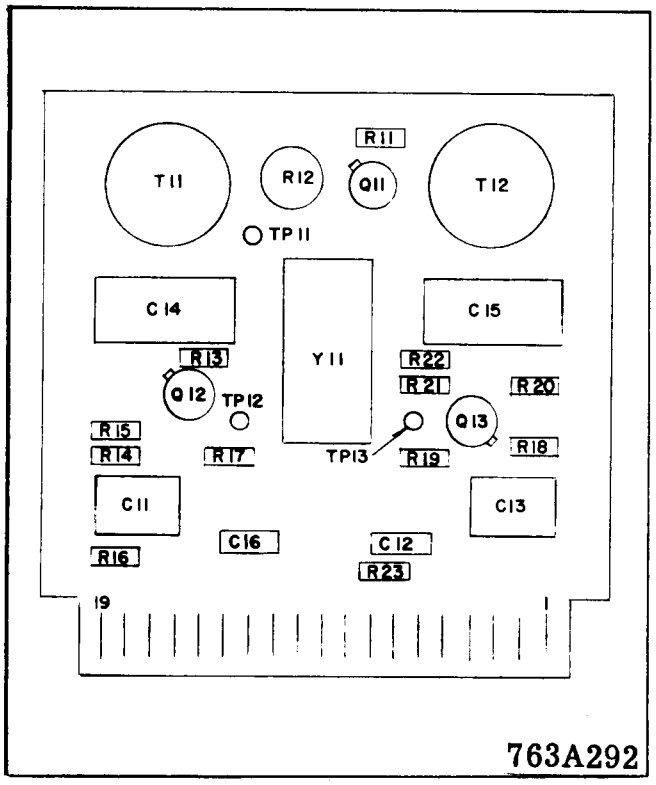


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

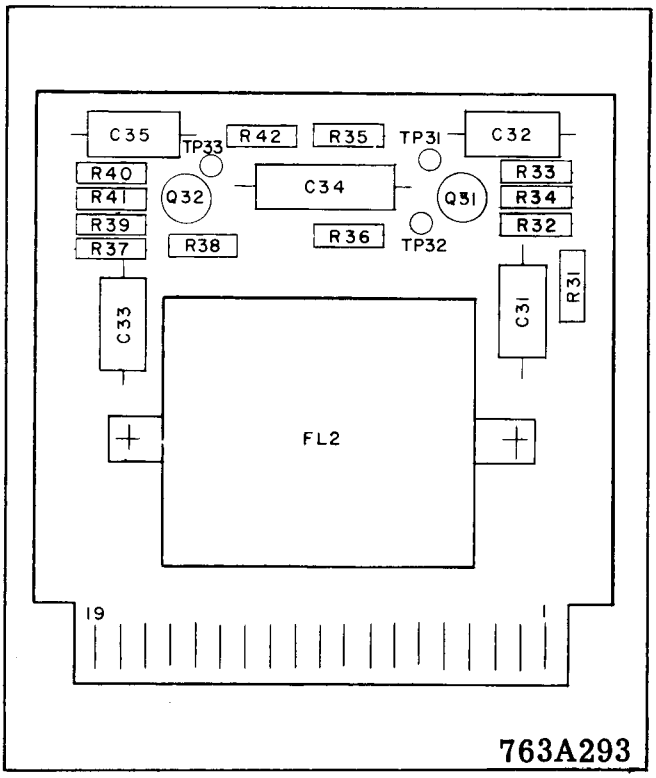


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

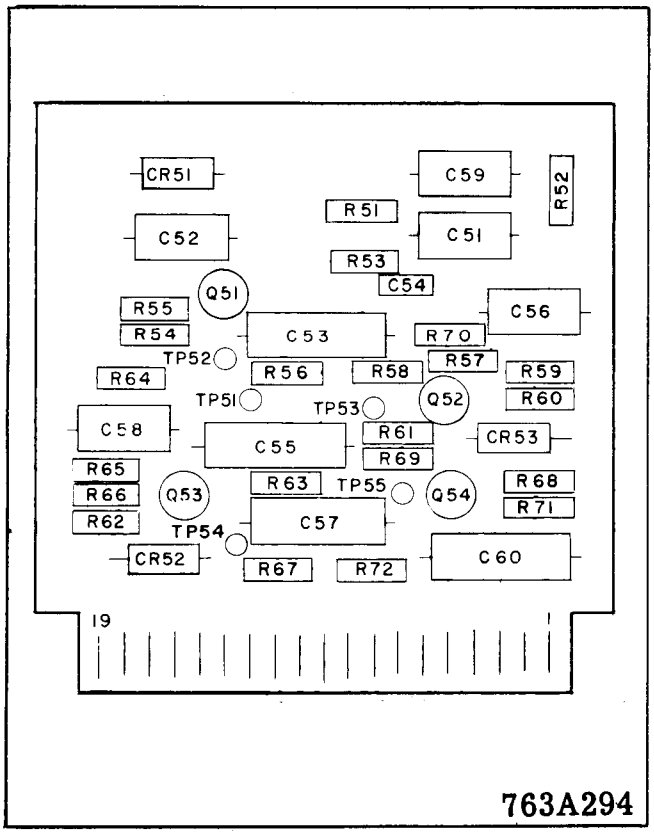


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

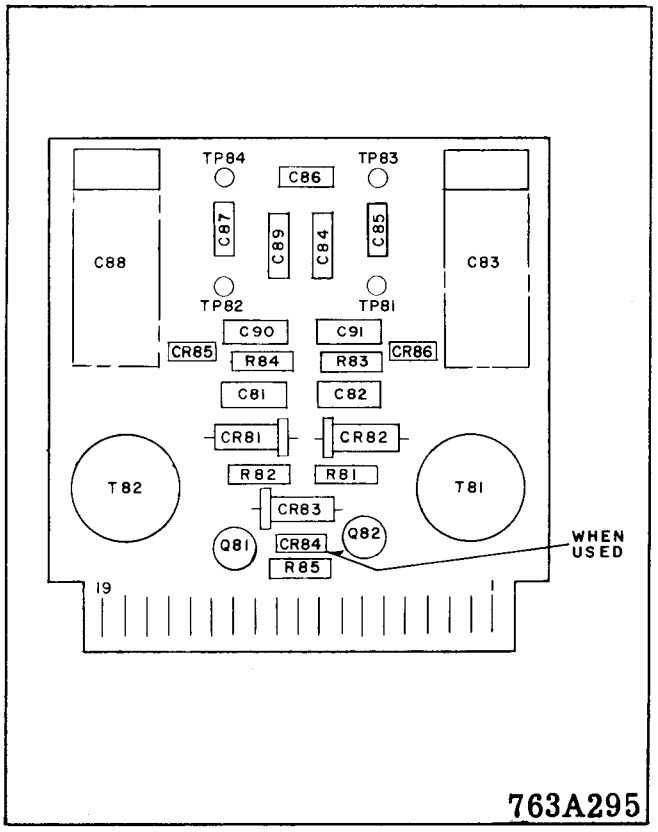


Fig. 10 Component locations on the discriminator printed circuit board.

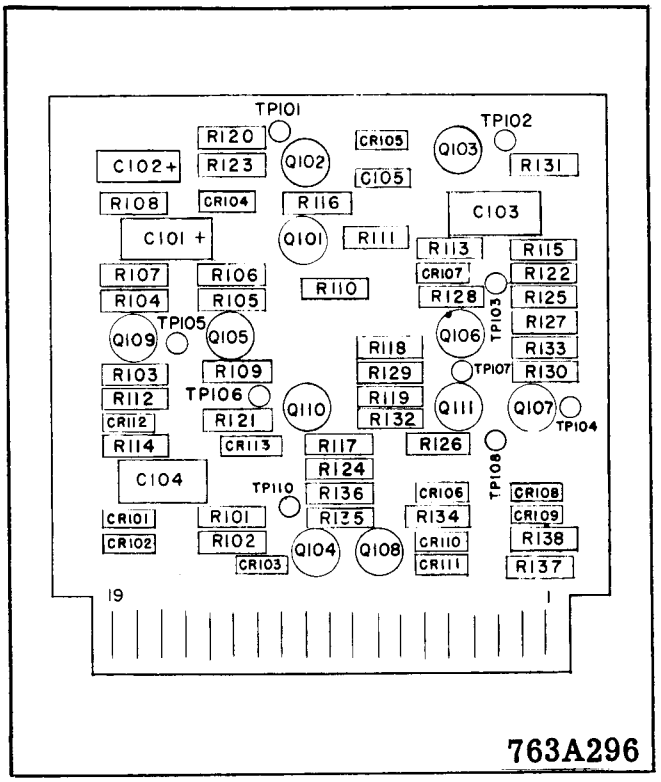


Fig. 11 Component locations on the logic printed circuit board.

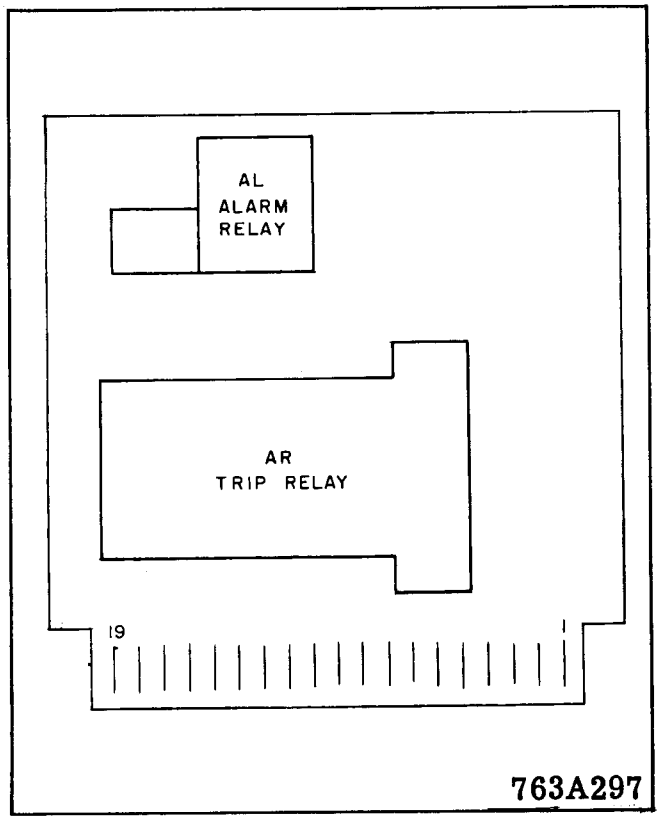


Fig. 12 Component locations on the output printed circuit board.

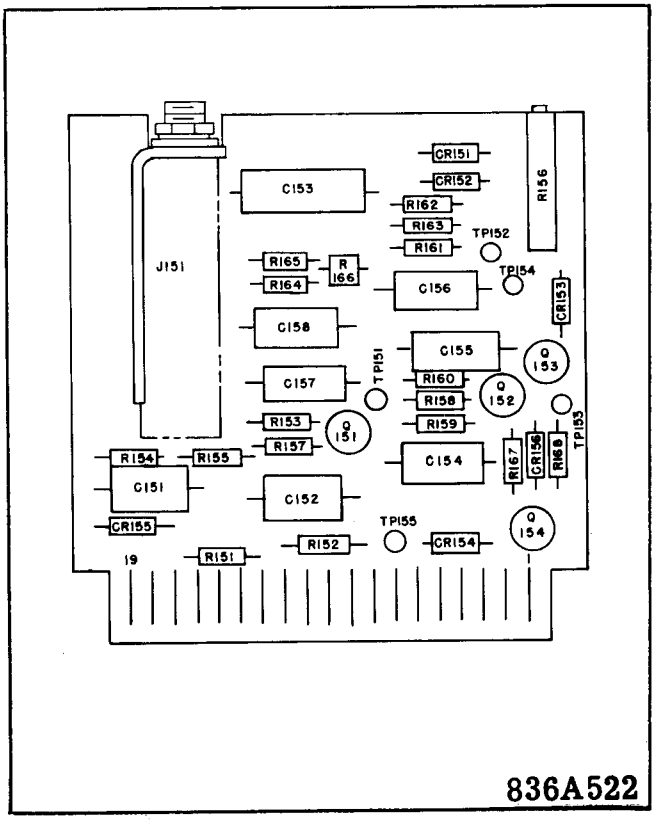


Fig. 13 Component locations on the carrier level indicator printed circuit board.

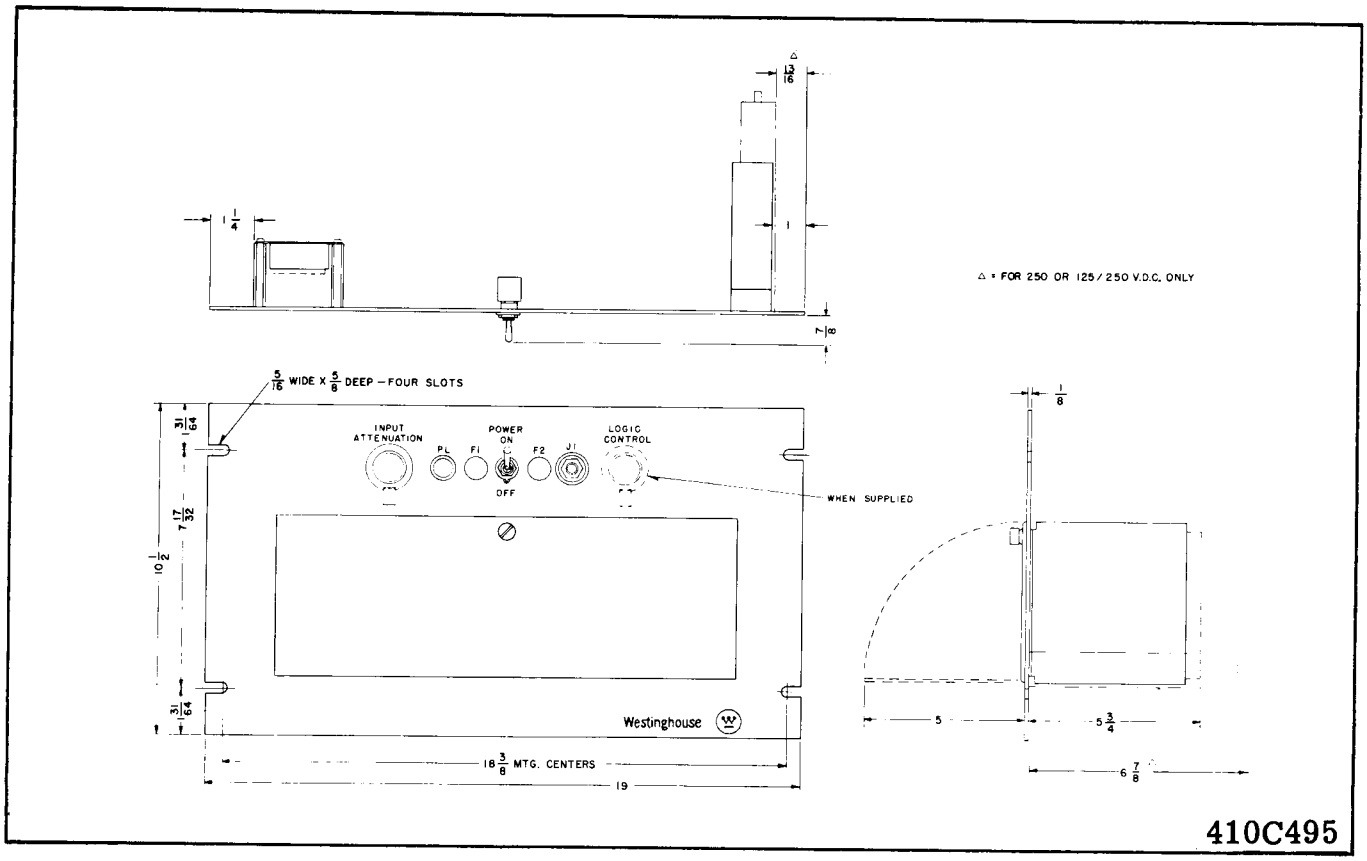


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

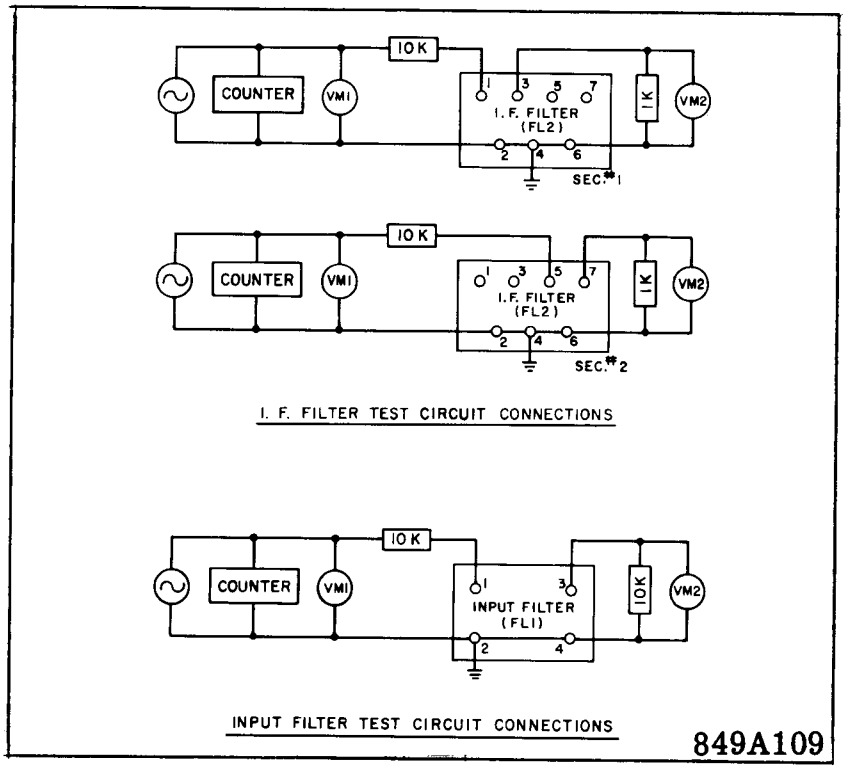
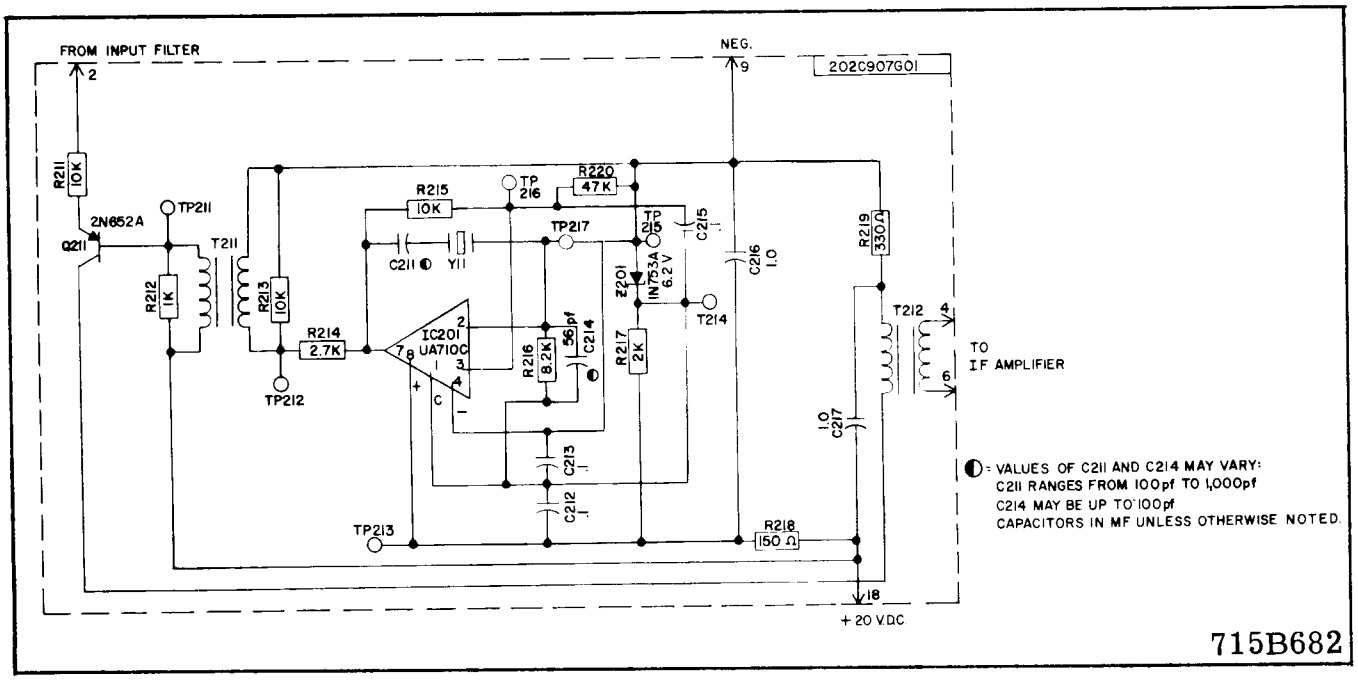
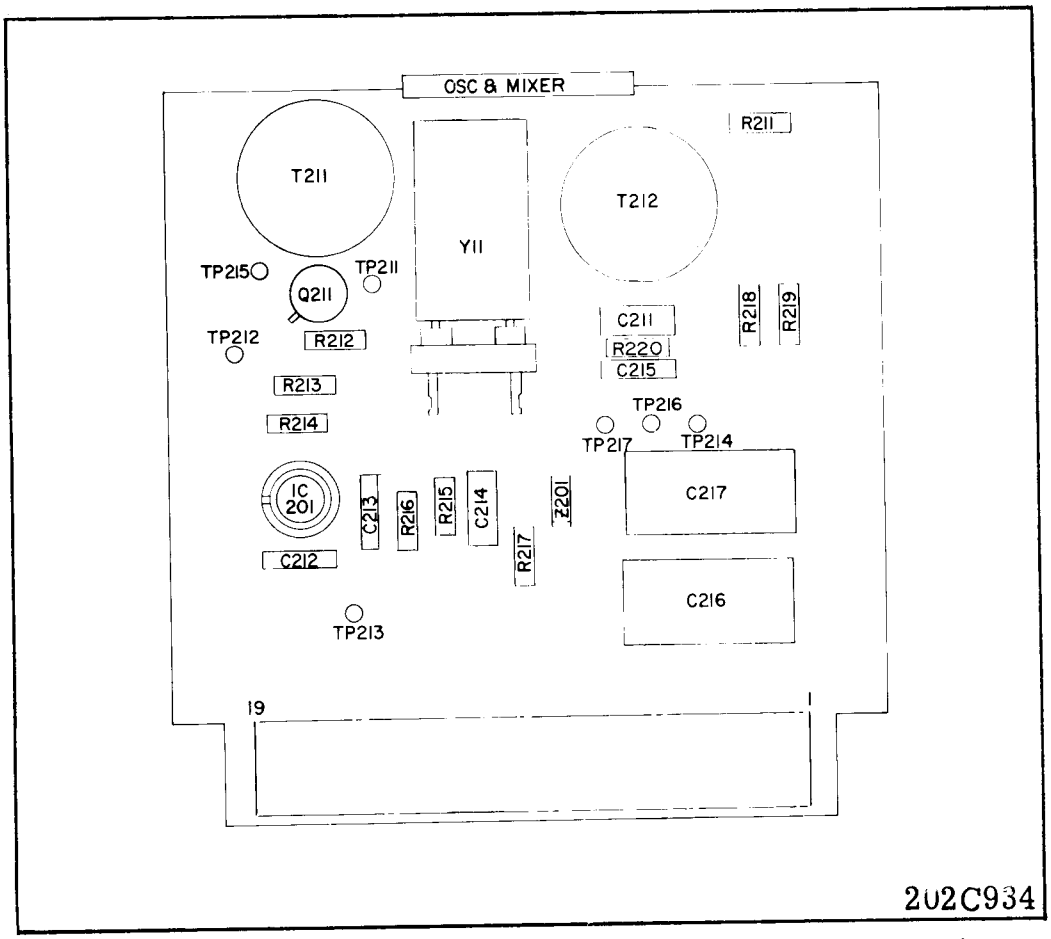


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.



* *Fig. 16. 200.1 to 300 kHz oscillator mixer board*



* *Fig. 17. Component Location 200.1 to 300 kHz oscillator mixer board.*

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

CAUTION It is recommended that the user of this equipment become thoroughly acquainted with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment.
* The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip fre-
* quency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

SUPERSEDES I.L. 41-945.51C
*Denotes change from superseded issue.

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terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, or IC201 (Fig. 16) and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 kHz above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the later is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20kHz, 2fc + 20kHz, fc + 20kHz and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below
* the zero output frequency. This separation of 200 hertz between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output fre-
* quency of the discriminator by 25 hertz in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency if fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the Guard
* frequency is 20 kHz-100 hertz. Similarly, the Trip frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor
* C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard
* signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears 15 ms. before C102 has reached the breakdown voltage of CR105, the charge is quickly dissipated through the 1K resistor R123, and the full time-delay will be effective on any subsequent loss of Guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.5 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental ininsertion of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	*	30-300 kHz
Sensitivity (noise-free channel)		0.005 volt (65 db below 1 watt for limiting)
Input Impedance		5000 ohms minimum
Bandwidth (crystal filter)		down < 3 db at 220 hertz down > 60 db at 1000 hertz
Discriminator	*	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications.
Operating time		9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing		
A. For two or more signals over one-way channel	*	500 hertz minimum
B. For two-way channel	*	1500 hertz minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range		-20 °C to + 60 °C temperature around chassis.
Battery voltage variations		
Rated voltage		Allowable variation
48 V.D.C.		42- 56 V.D.C.
125 V.D.C.		105 - 140 V.D.C.
250 V.D.C.		210 - 280 V.D.C.
Battery drain		0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions		Panel height - 10½'' or 6 r.u. Panel width - 19''
Weight		13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60 °C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected * to the same points for a check on the frequency, which should be 20KC above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capaciotr C12 ORC. Reducing C12 ORC increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature exterems.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

The adjustment procedure for the AR relay (which should be attempted only if suitable tools are available) is as follows:

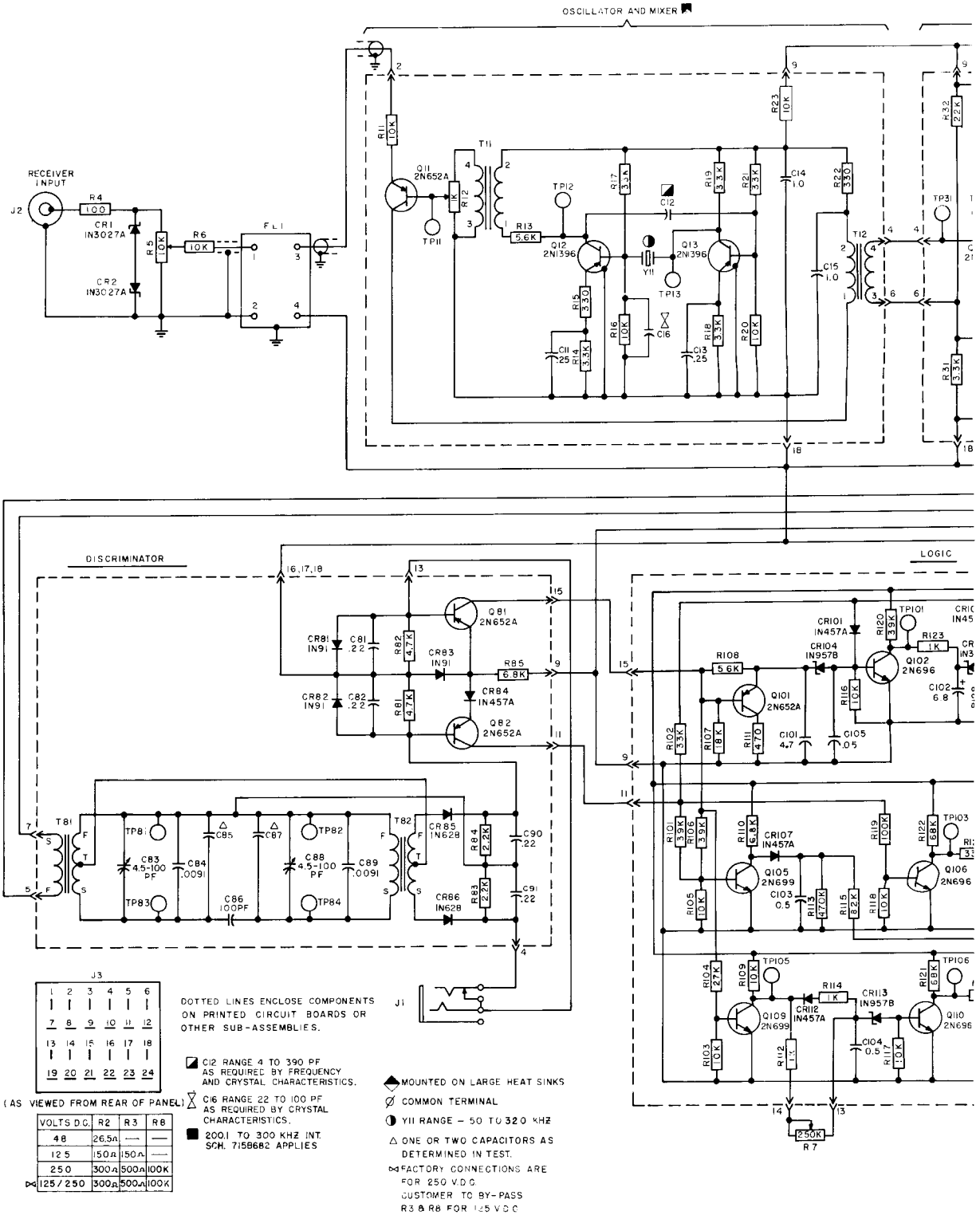
a) Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.

b) On relays with two normally-open and two normally-closed contacts, adjust each contact spring so that 8 grams force at the very end of each spring will just move it away from the edge of the slotted insulation attached to the armature. Relays with four normally-open contacts should be adjusted so that a 4 gram force similarly applied will just move each spring away from the edge of the insulation.

c) Adjust each normally-open contact screw to obtain a gap of 0.020 to 0.022 inch. With the relay energized the normally-open contacts should have 15 to 30 grams pressure. The normally-closed contacts, if present, should have a contact gap of 0.015 inch.

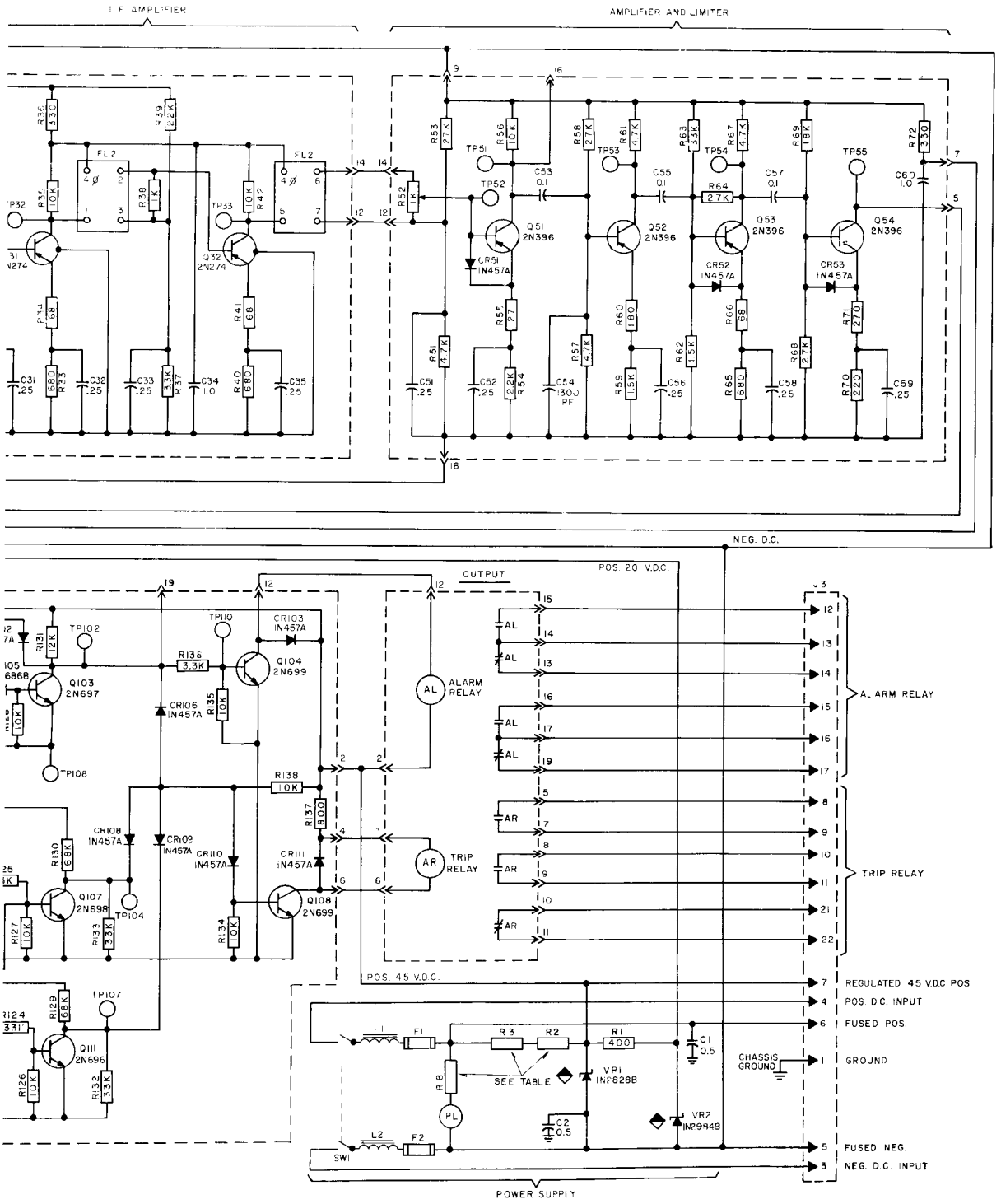
The AR relay with its 800 ohm series resistor should pick up at approximately 30 volts.

Type TCF Receiver (Front View).



VOLTS D.C.	R2	R3	R8
48	26.5Ω	—	—
125	150Ω	150Ω	—
250	300Ω	500Ω	100K
125/250	300Ω	500Ω	100K

* *Fig. 1. Internal schematic of the typ*



543D637

* TCF receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the * stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequen-
* cy range 60 cycles/sec. to 230-kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).

Voltage Range:	1.5 to 300 volts
Imput Impedance:	7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator

* Output Voltage:	up to 8 volts
Frequency Range:	20-kHz to 230-kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

* ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf	184A663H04
C213	Ceramic; .1 mf	184A663H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic;	184A663H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. ± 5%	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ±5%; ½ W. Composition	184A763H13
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

* ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3 W. Composition	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ±5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W- Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E. Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51
R211	10K ±5%; Composition	184A763H51
R212	1K ±5%; Composition	184A763H27
R213	10K ±5%; Composition	184A763H51
R214	2.7K ±5%; Composition	184A763H37
R215	10K ±5%; Composition	184A763H51
R216	8.2K ±5%; Composition	184A763H73
R217	2K ±5%; Composition	184A763H34
R218	150 ohms ±5%; Composition	184A763H07
R219	330 ohms ±5%; Composition	184A763H15
R220	47K ±5%; Composition	184A763H67

* ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	1962797
T12	Toroidal type, 25000/300 ohms	1962697
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K:10K	714B677G01
T212	25K:300	196297
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 kHz above Channel Frequency)	762A800H01+(Req.Freq.)
FL1	Crystal input Filter	401C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408A845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

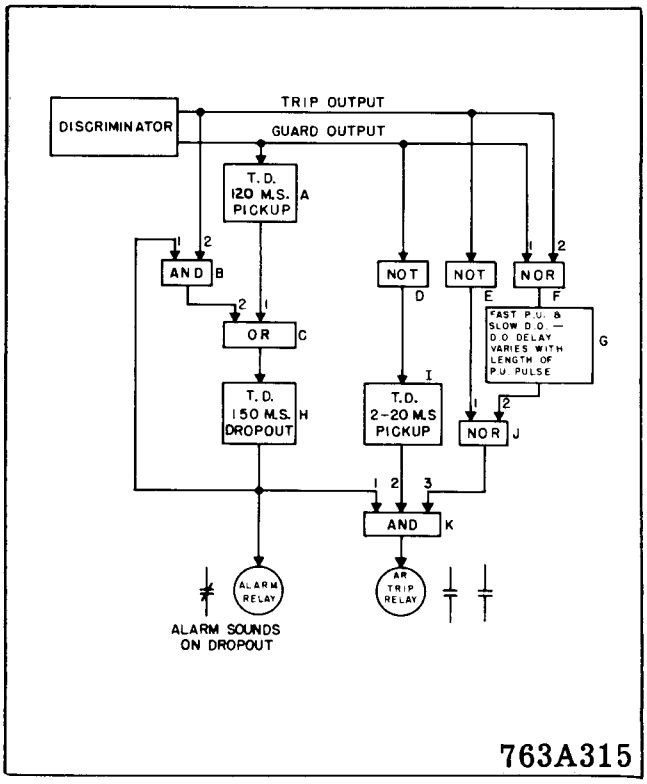
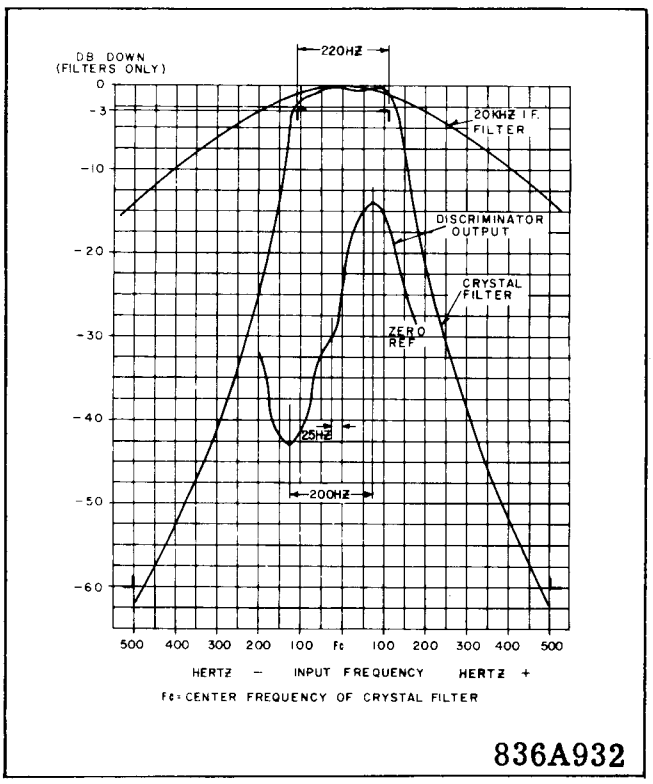


Fig. 3 Block diagram of output logic circuit



** Fig. 4 Filter and discriminator characteristics of the type TCF receiver*

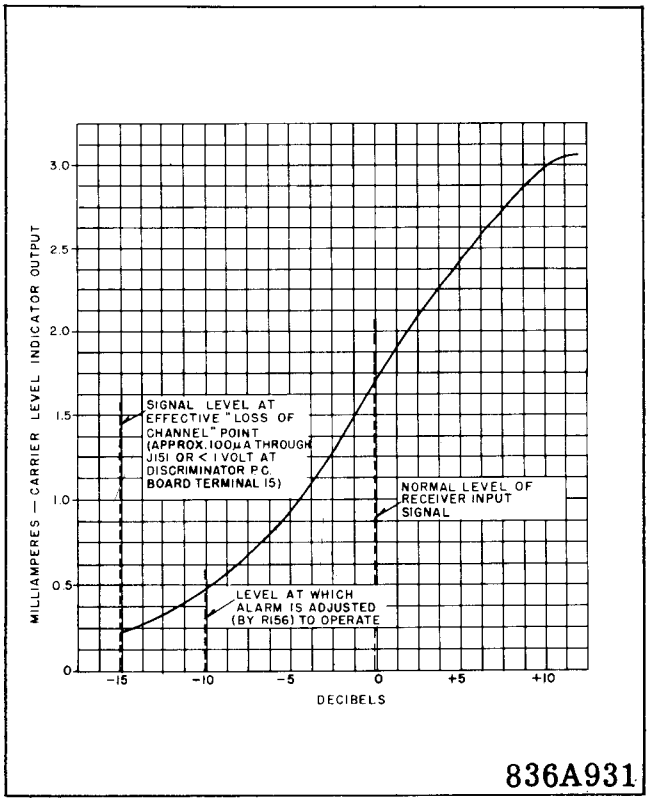


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

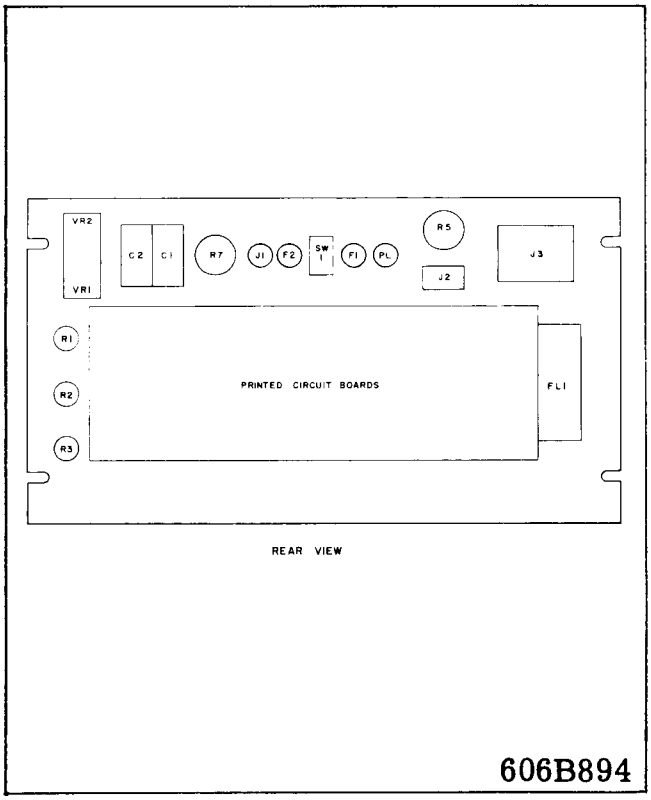


Fig. 6 Component locations on the type TCF receiver panel

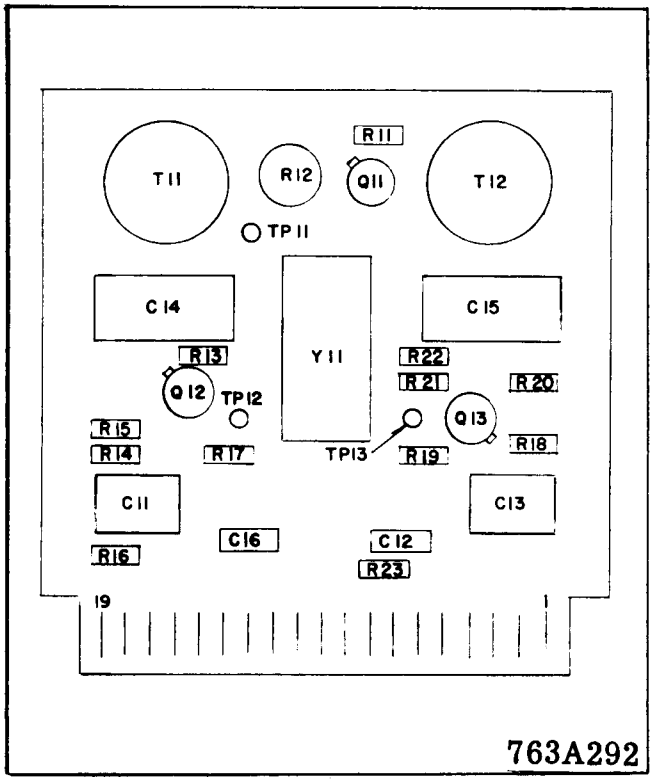


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

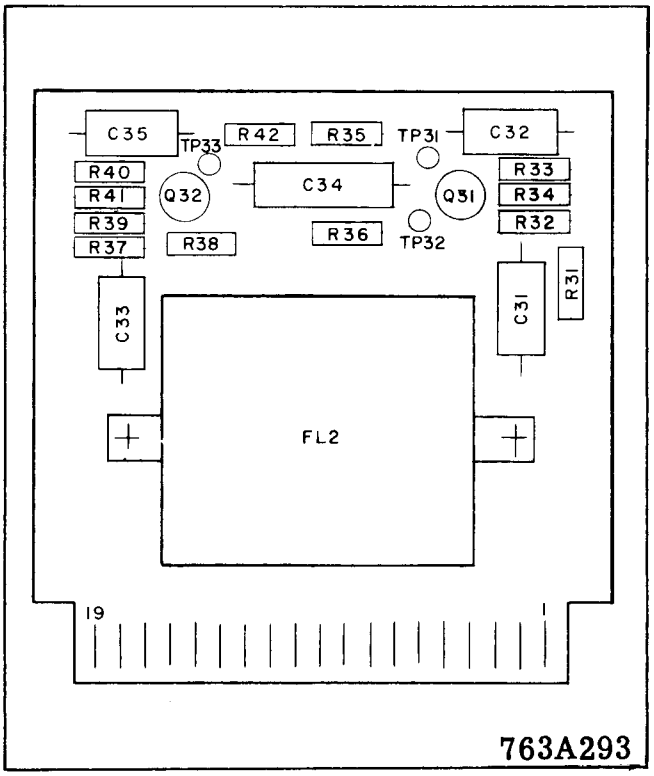


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

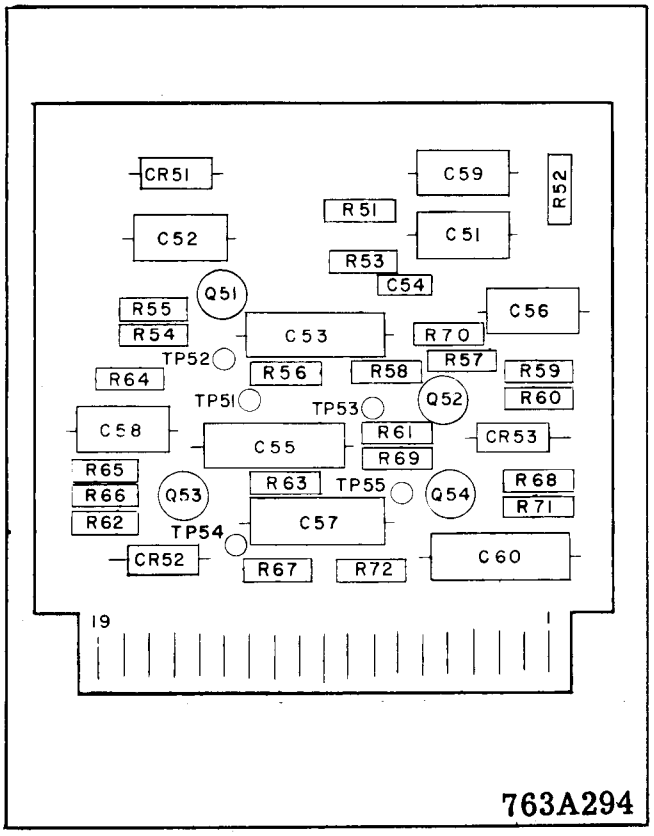


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

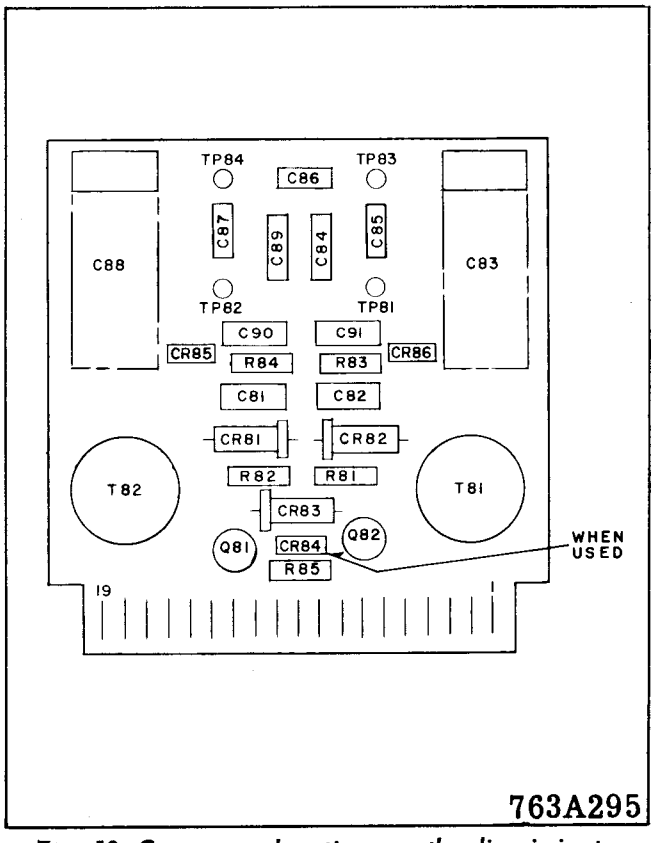


Fig. 10 Component locations on the discriminator printed circuit board.

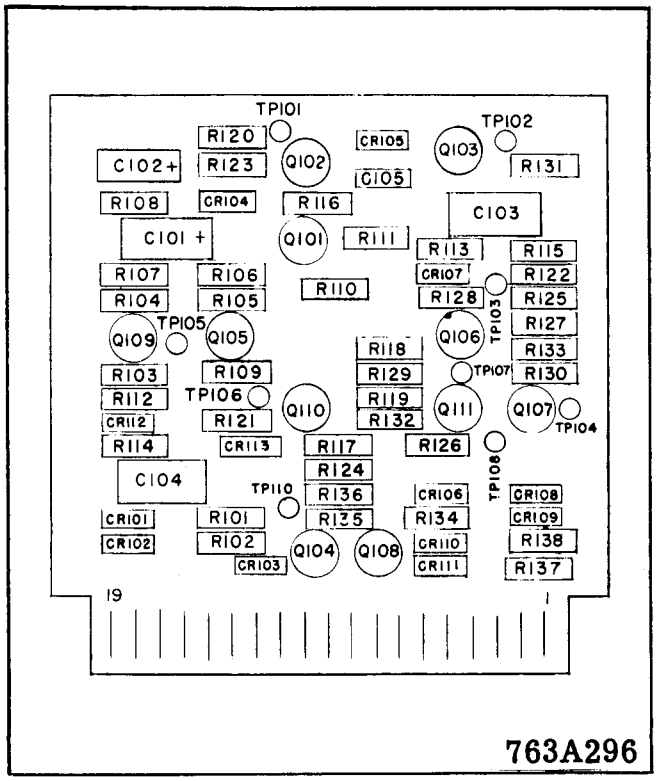


Fig. 11 Component locations on the logic printed circuit board.

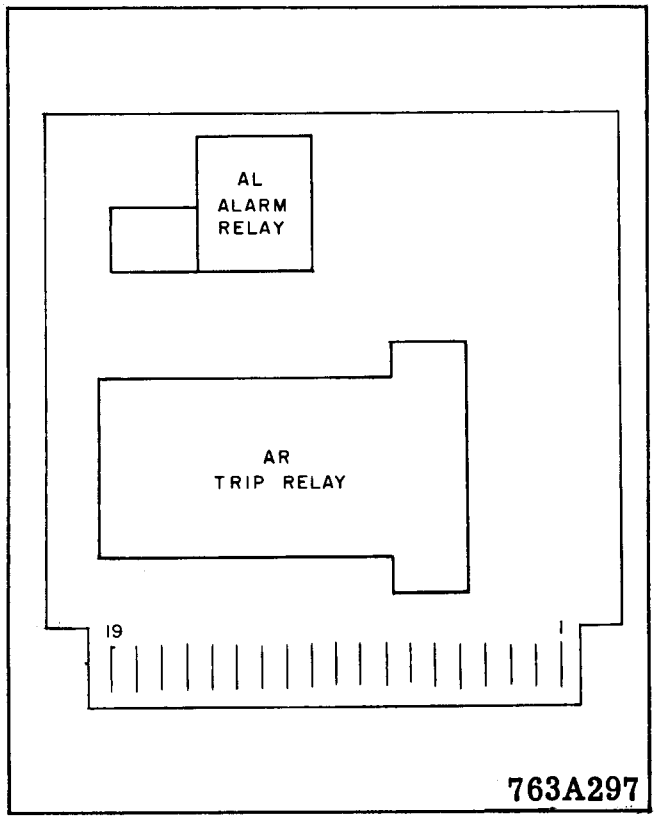


Fig. 12 Component locations on the output printed circuit board.

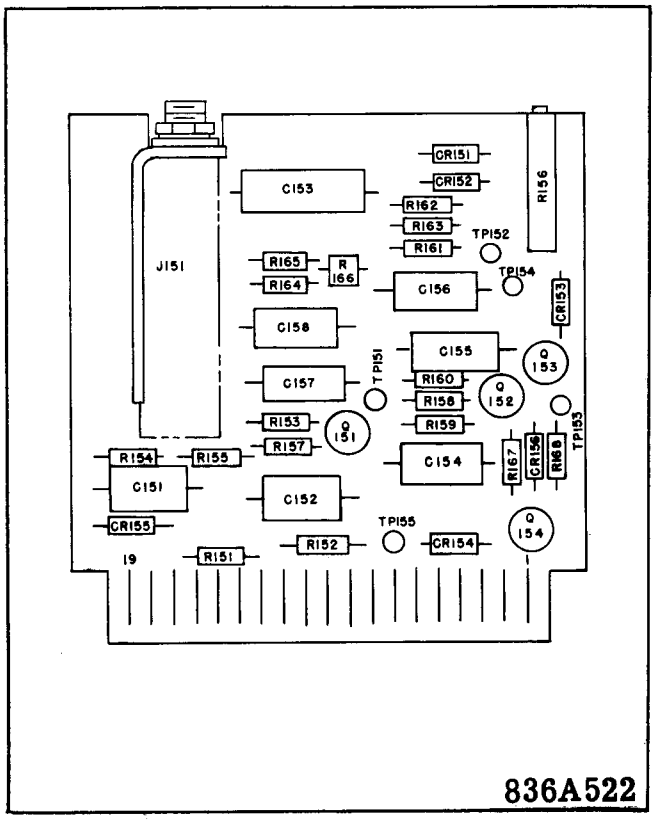


Fig. 13 Component locations on the carrier level indicator printed circuit board.

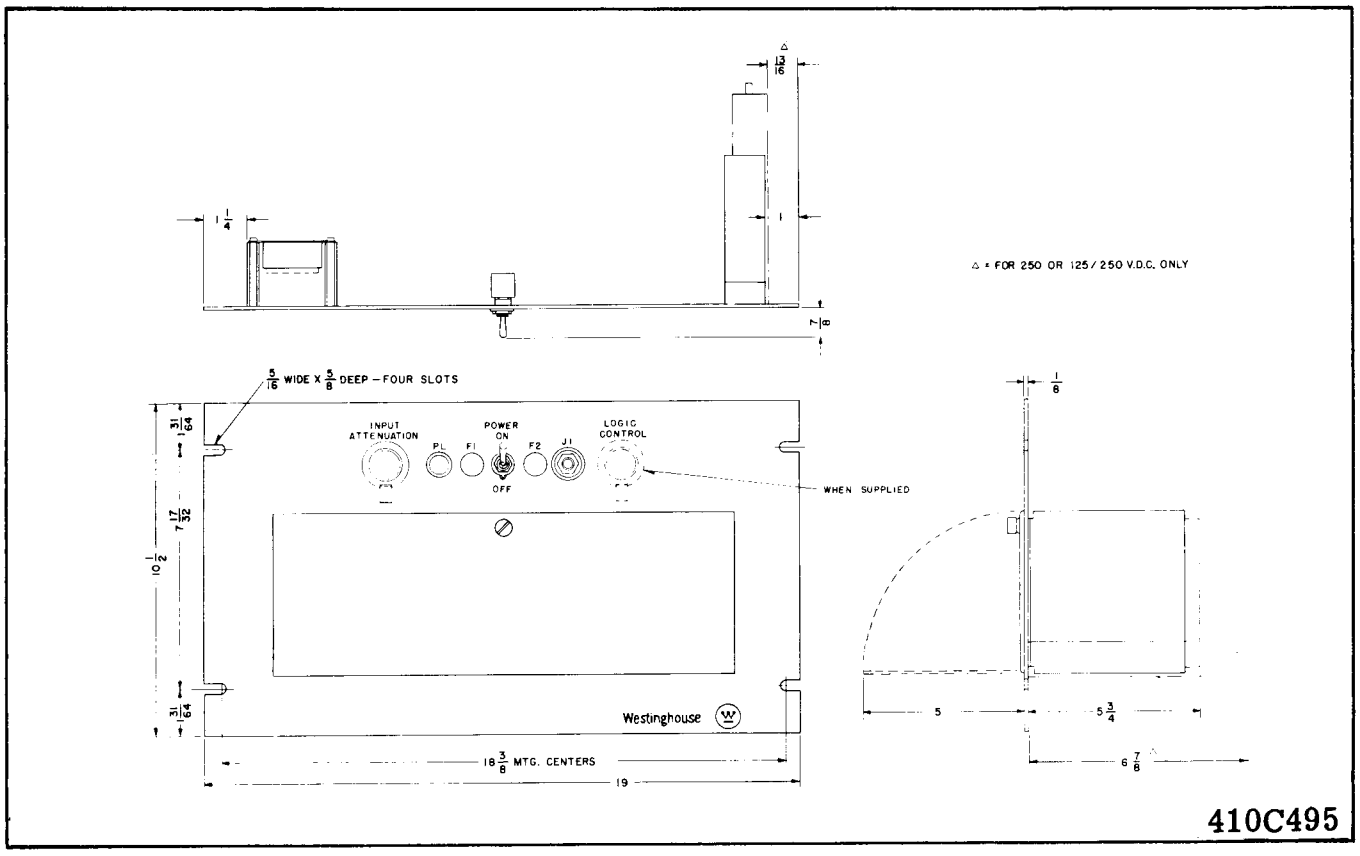


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

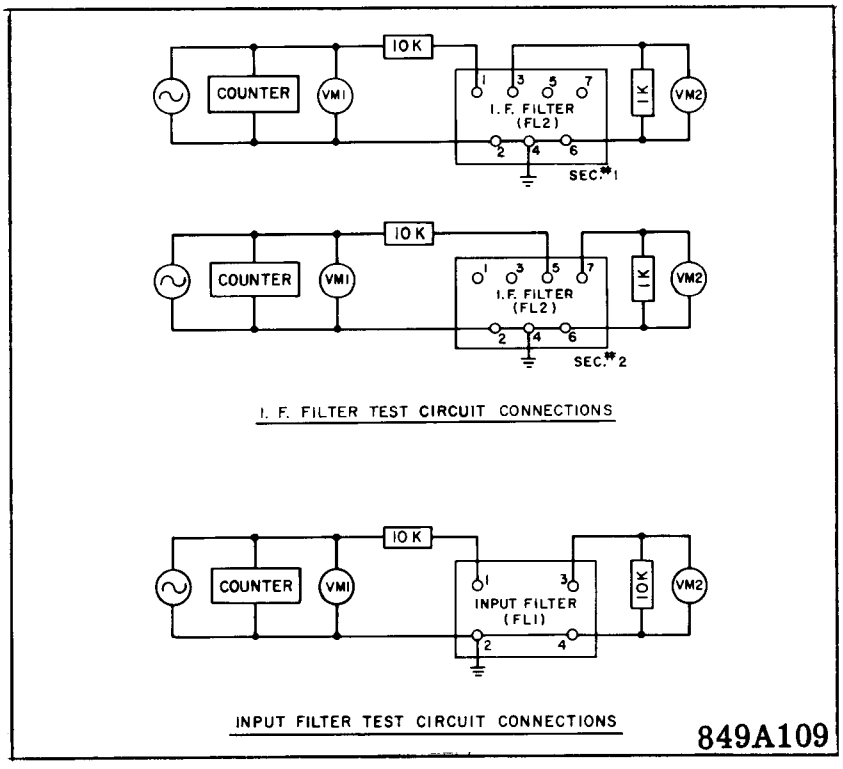
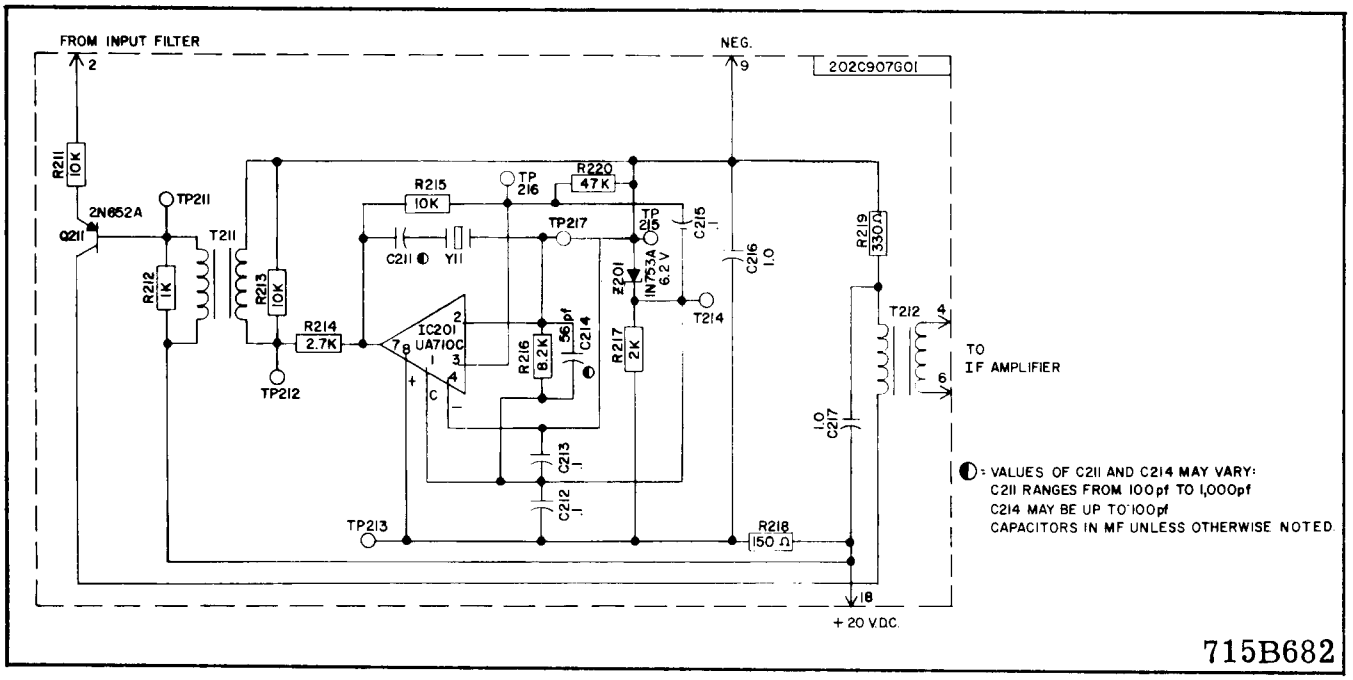
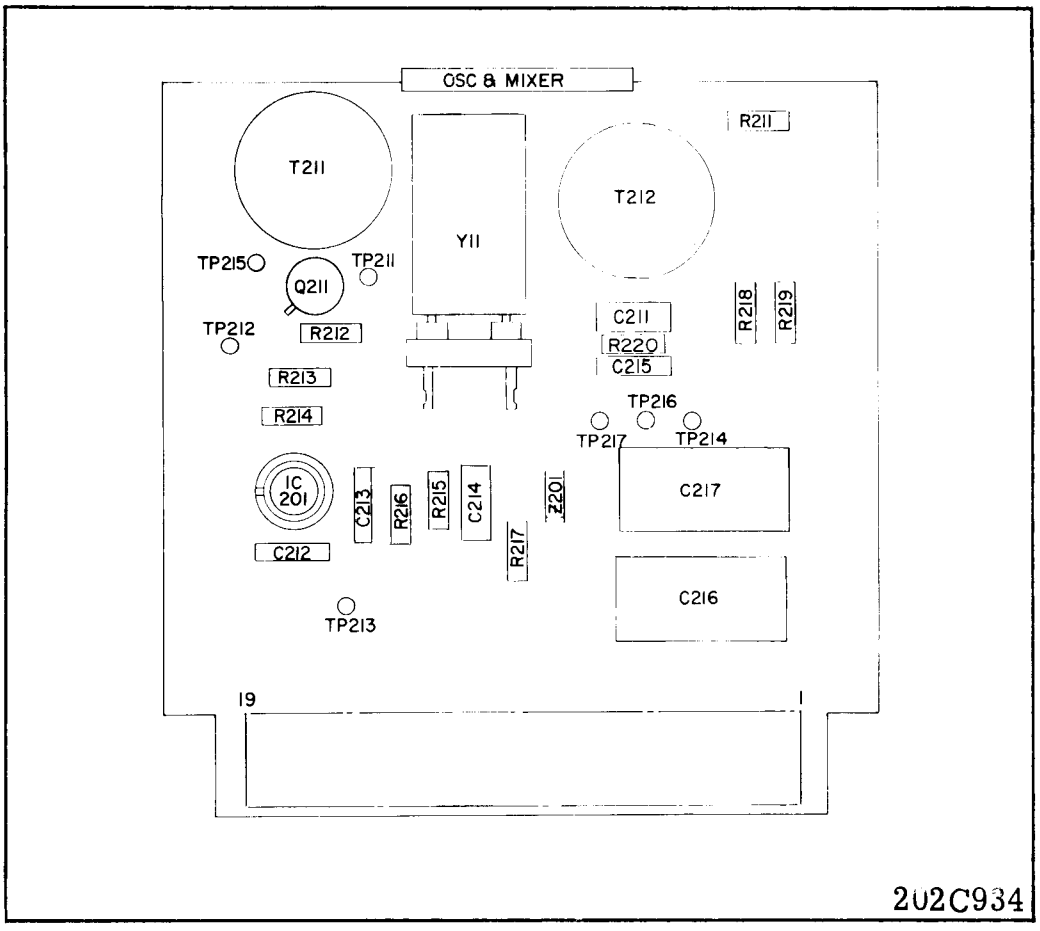


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.



* *Fig. 16. 200.1 to 300 kHz oscillator mixer board*



* *Fig. 17. Component Location 200.1 to 300 kHz oscillator mixer board.*

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

CAUTION It is recommended that the user of this equipment become thoroughly acquainted with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 cycles above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 cycles below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 KC above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the latter is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20KC, 2fc + 20KC, fc + 20KC and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20KC. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20KC.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 cycles. The adjustment for zero output at fc-25 cycles is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 cycles above or below the zero output frequency. This separation of 200 cycles between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 cycles in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 cycles, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20KC-100 cycles. Similarly, the Trip frequency is 20KC + 100 cycles. The intermediate frequency at which the discriminator has zero output then is 20.025 KC.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 15 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 15 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears 15 ms. before C102 has reached the breakdown voltage of CR105, the charge is quickly dissipated through the 1K resistor R123, and the full time-delay will be effective on any subsequent loss of Guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an * alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.5 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental inserting of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-200 KC
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 cycles down > 60 db at 1000 cycles
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 cycles to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 cycles minimum
B. For two-way channel	1500 cycles minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20 °C to + 60 °C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60 °C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12 in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20KC above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Guard or Trip)
Q13	15	(Guard or Trip)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

The adjustment procedure for the AR relay (which should be attempted only if suitable tools are available) is as follows:

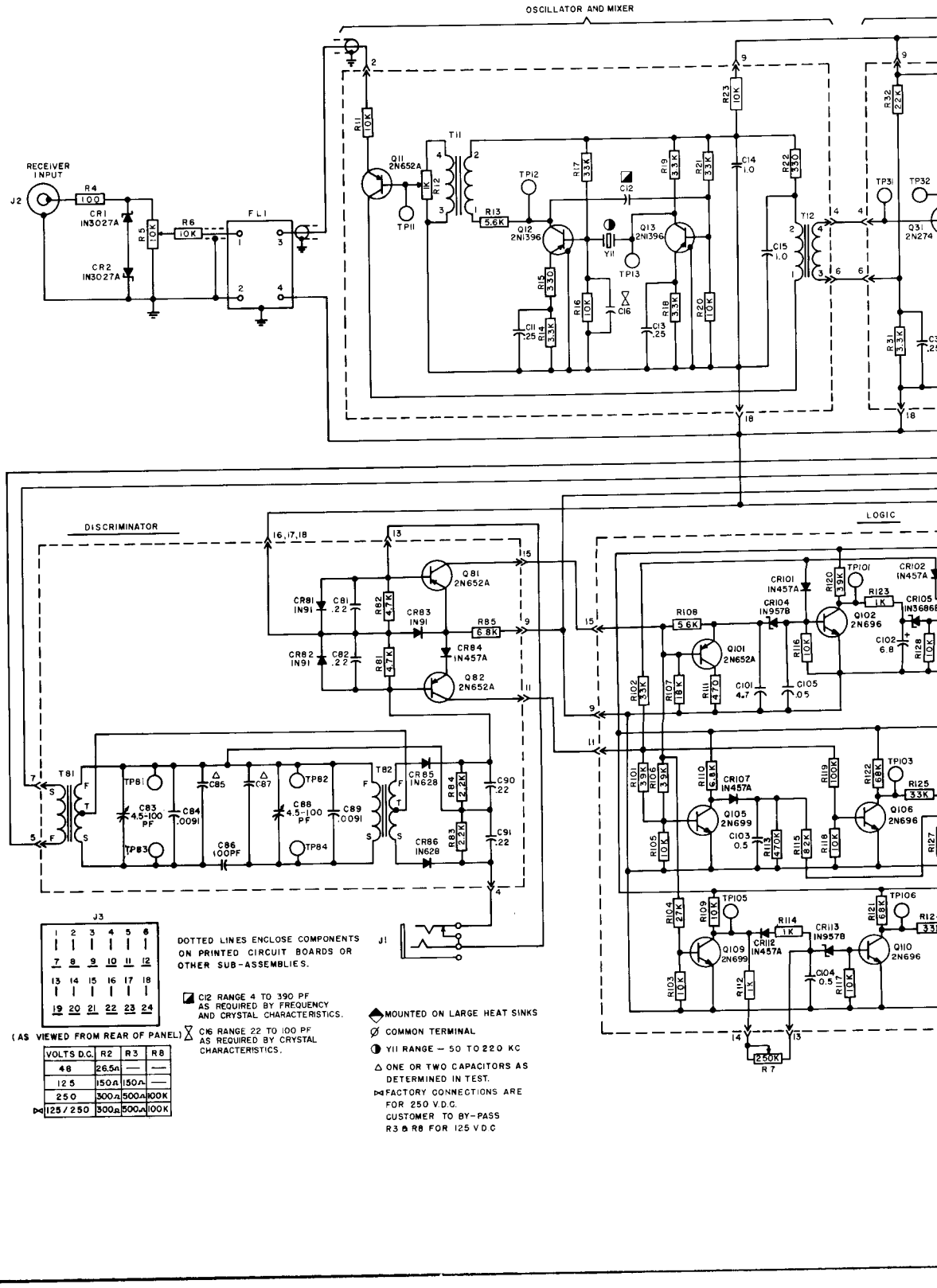
a) Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.

b) On relays with two normally-open and two normally-closed contacts, adjust each contact spring so that 8 grams force at the very end of each spring will just move it away from the edge of the slotted insulation attached to the armature. Relays with four normally-open contacts should be adjusted so that a 4 gram force similarly applied will just move each spring away from the edge of the insulation.

c) Adjust each normally-open contact screw to obtain a gap of 0.020 to 0.022 inch. With the relay energized the normally-open contacts should have 15 to 30 grams pressure. The normally-closed contacts, if present, should have a contact gap of 0.015 inch.

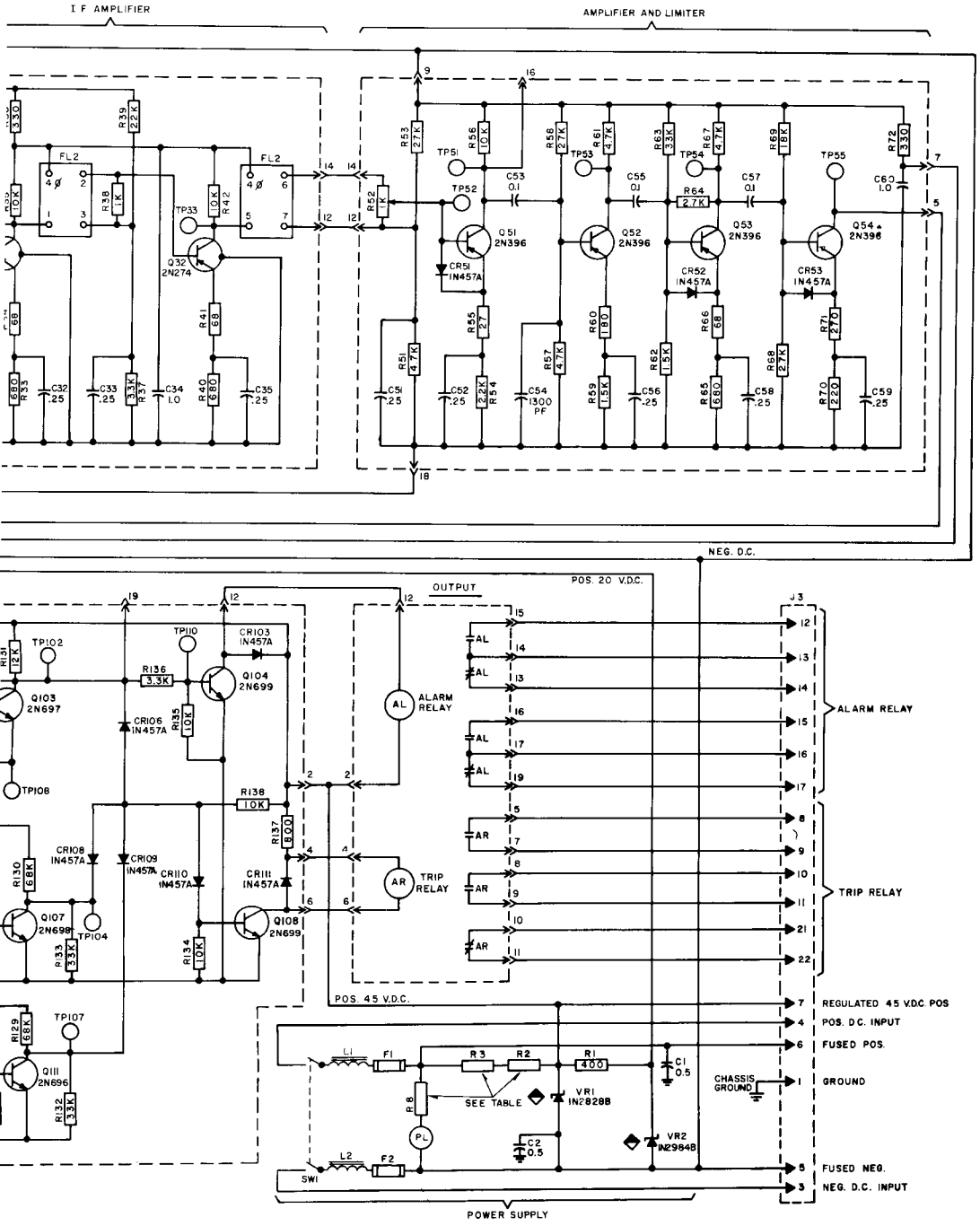
The AR relay with its 800 ohm series resistor should pick up at approximately 30 volts.

Type TCF Receiver (Front View).



VOLTS D.C.	R2	R3	R8
48	26.5Ω	—	—
125	150Ω	150Ω	—
250	300Ω	500Ω	100K
125/250	300Ω	500Ω	100K

* *Fig. 1. Internal schematic of the typ*



543D637

TCF receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 KC", and for the stop band are "down 18 db minimum at 19.00 and 21.00 KC". The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 cycles/sec. to 230-kc., input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Imput Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kc to 230-kc

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
* C101	Tantalum, 4.7 mfd., 35 V.D.C.	184A661H12
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
	DIODES - GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN457A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN457A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V.; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES - ZENER	
CR1	IN3027A; 20 V. ±10%; 1 W.	188A307H10
CR2	IN3027A; 20 V. ±10%; 1 W.	188A307H10
CR104	IN957B; 6.8 V. ±5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ±5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ±5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ±5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ±5%; 10 W.	762A631H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

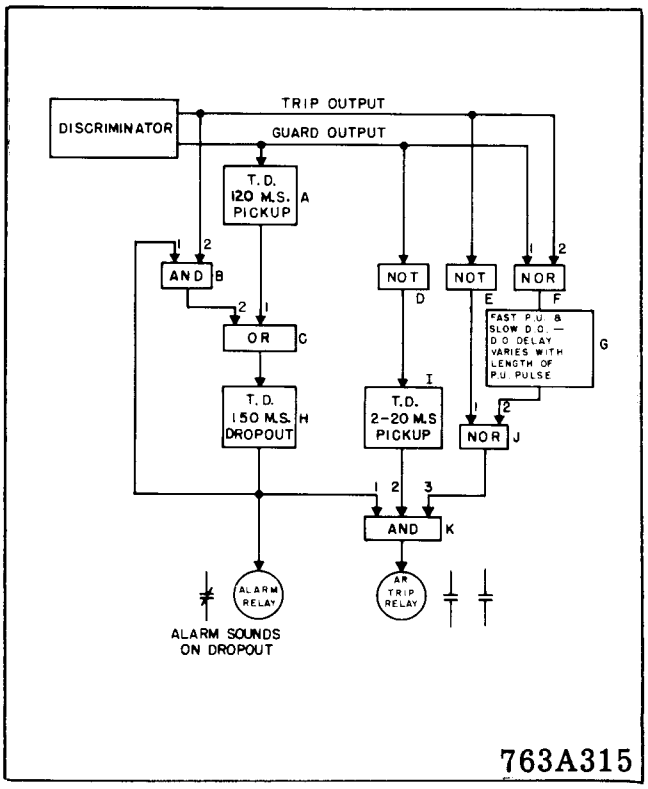
CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ±5%; ½ W. Composition	184A763H13
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3W. Wire Wound	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ± 5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W. Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E.Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	1962797
T12	Toroidal type, 25000/300 ohms	1962697
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 KC above Channel Frequency)	762A800H01 +(Req. Freq.)
FL1	Crystal Input Filter	410C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb - For 48 V. Supply	187A133H02
	Pilot Light Bulb - For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408C845G03
L1-L2	Choke	292B096G02



* *Fig. 3 Block diagram of output logic circuit*

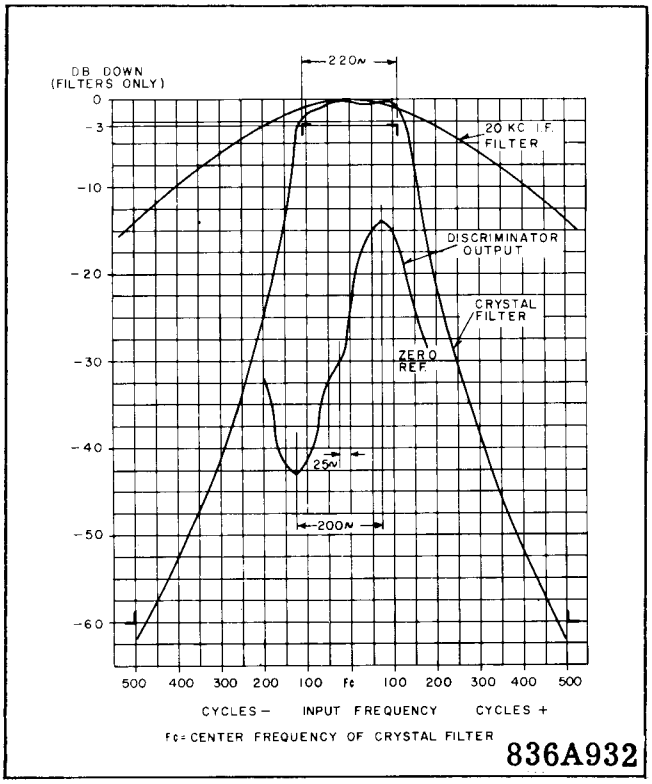


Fig. 4 Filter and discriminator characteristics of the type TCF receiver

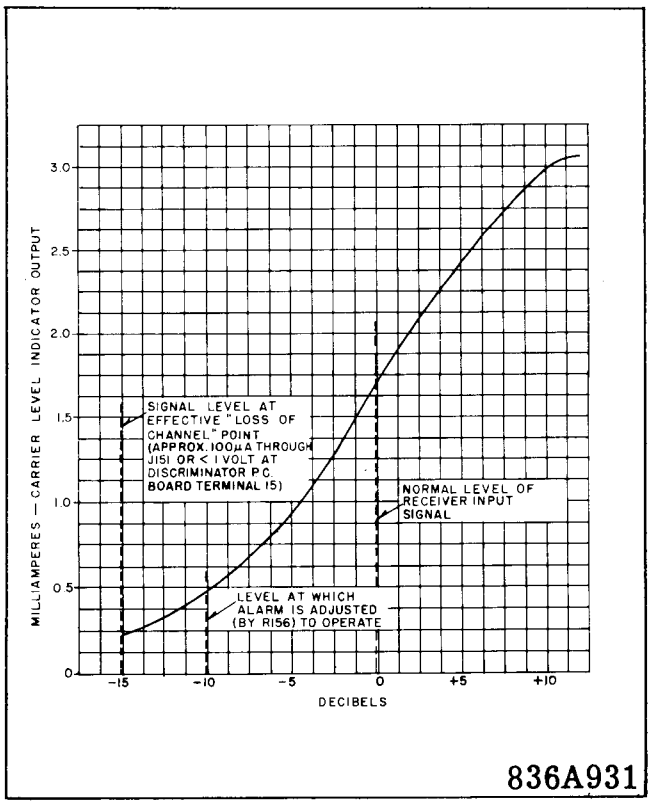


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

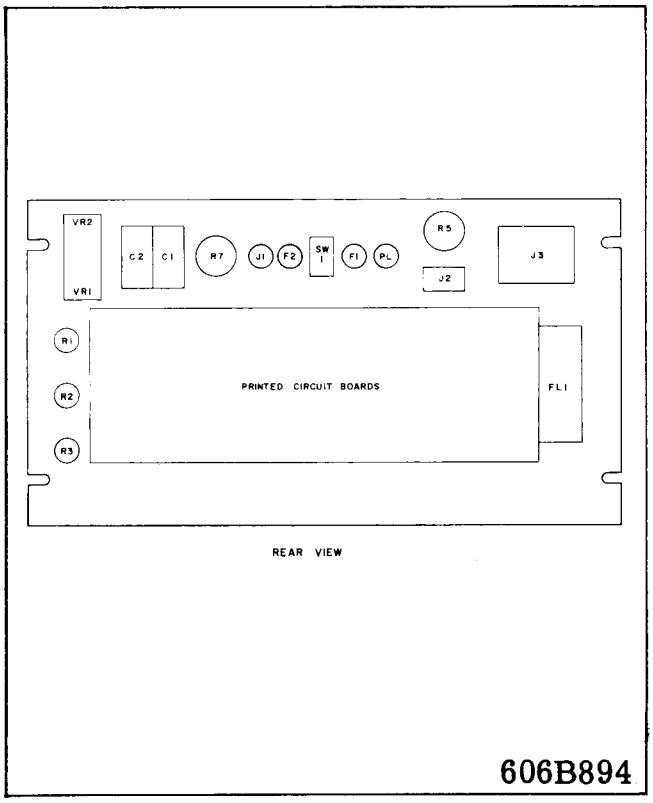


Fig. 6 Component locations on the type TCF receiver panel

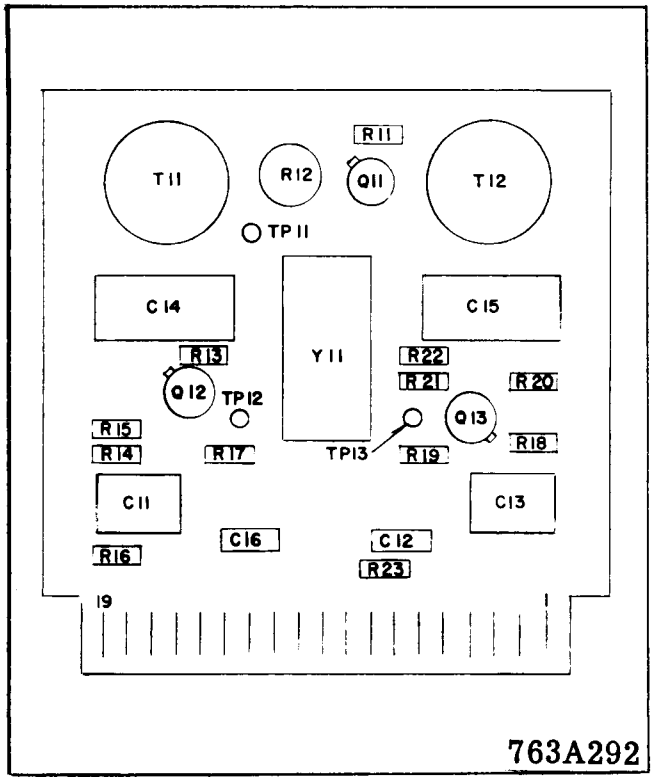


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

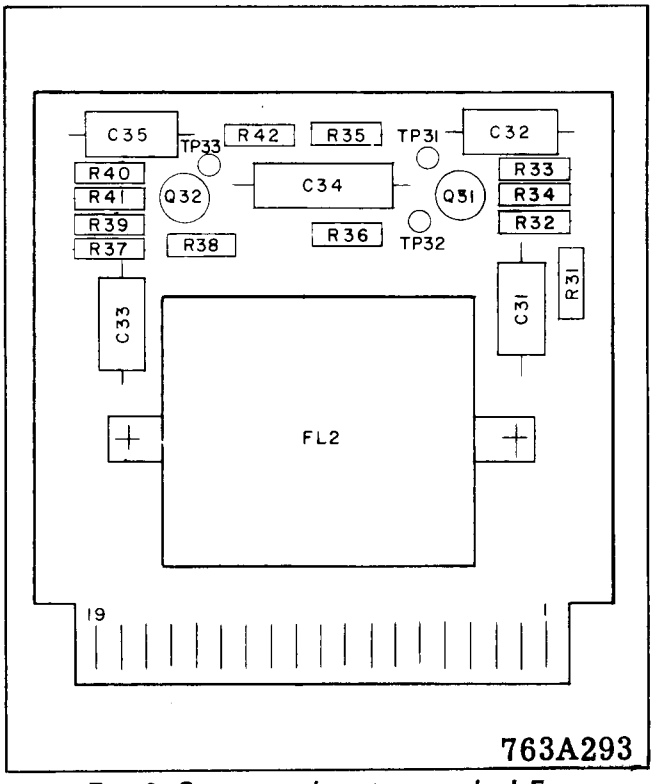


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

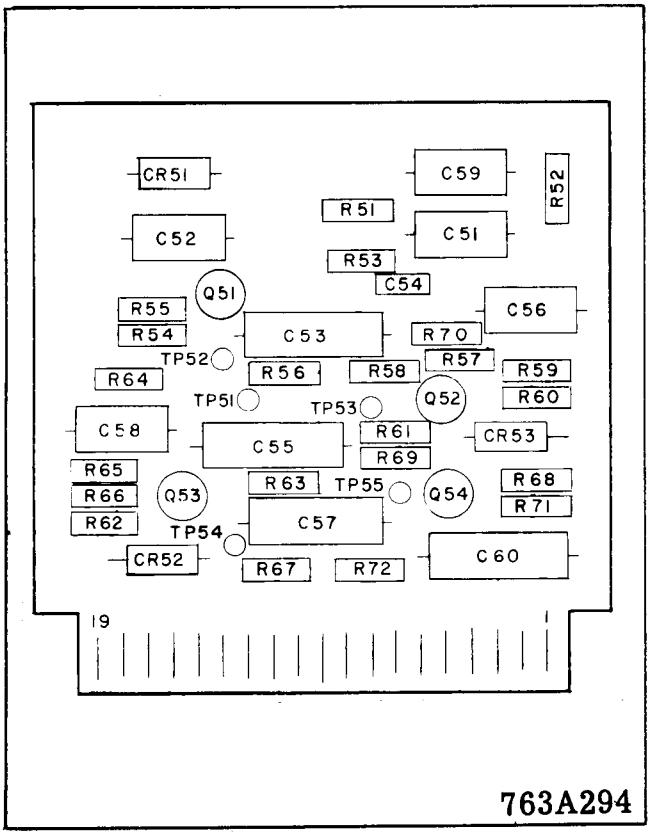


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

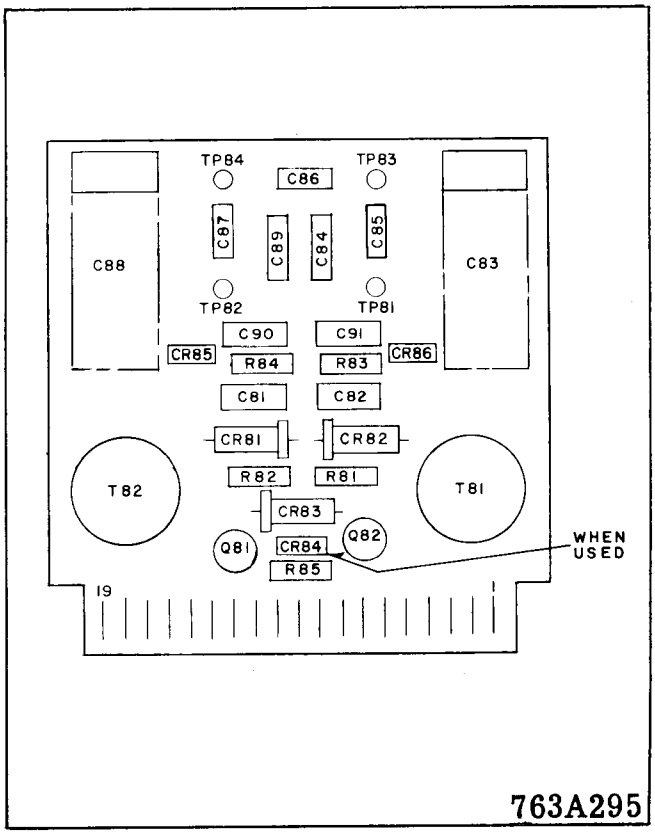
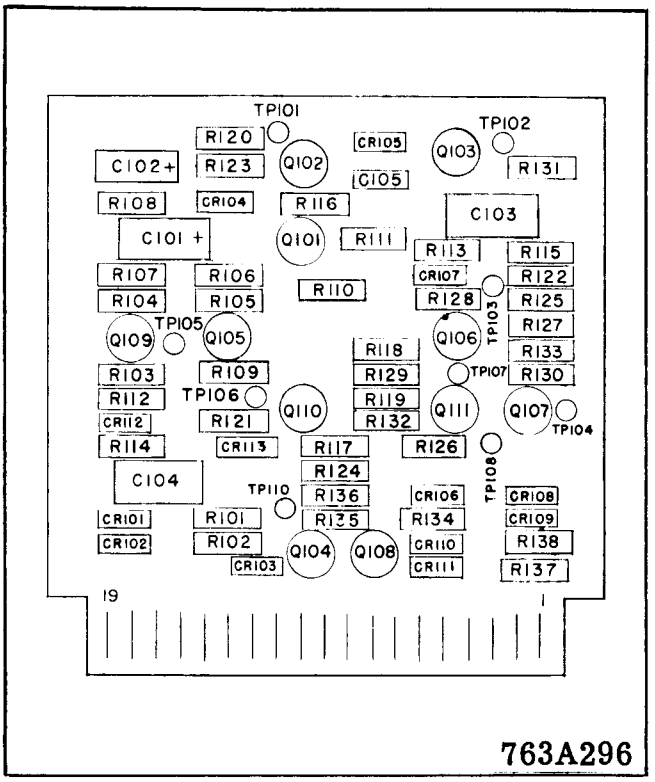


Fig. 10 Component locations on the discriminator printed circuit board.



* *Fig. 11 Component locations on the logic printed circuit board.*

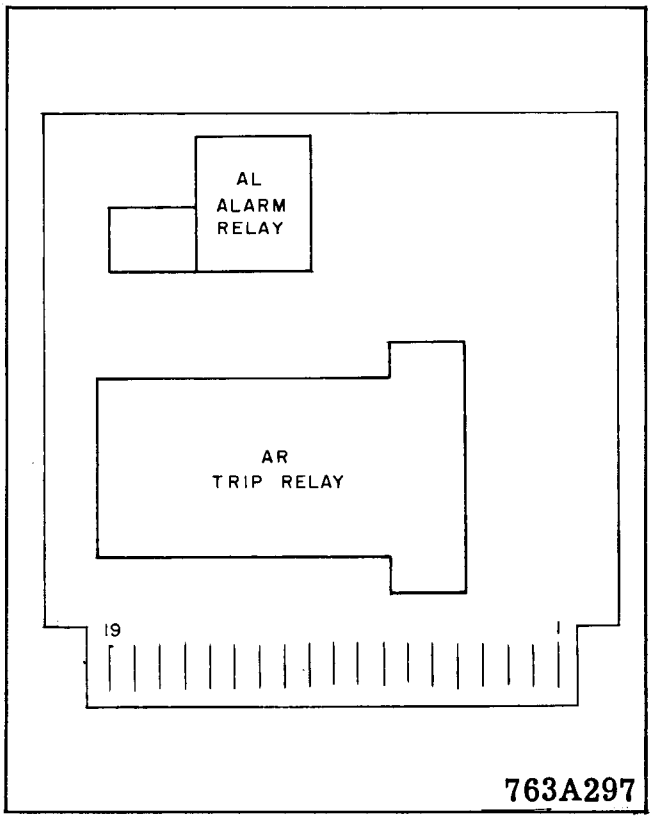


Fig. 12 Component locations on the output printed circuit board.

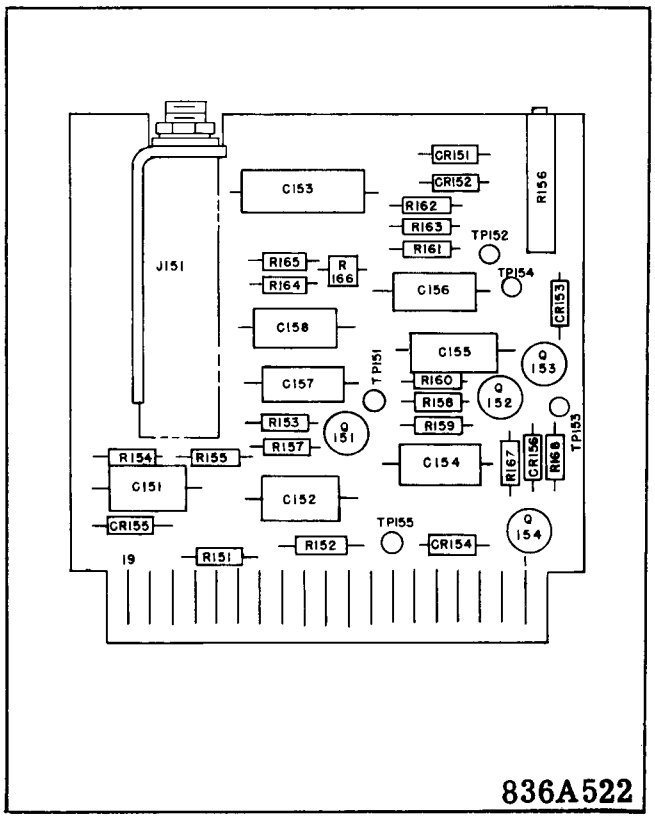


Fig. 13 Component locations on the carrier level indicator printed circuit board.

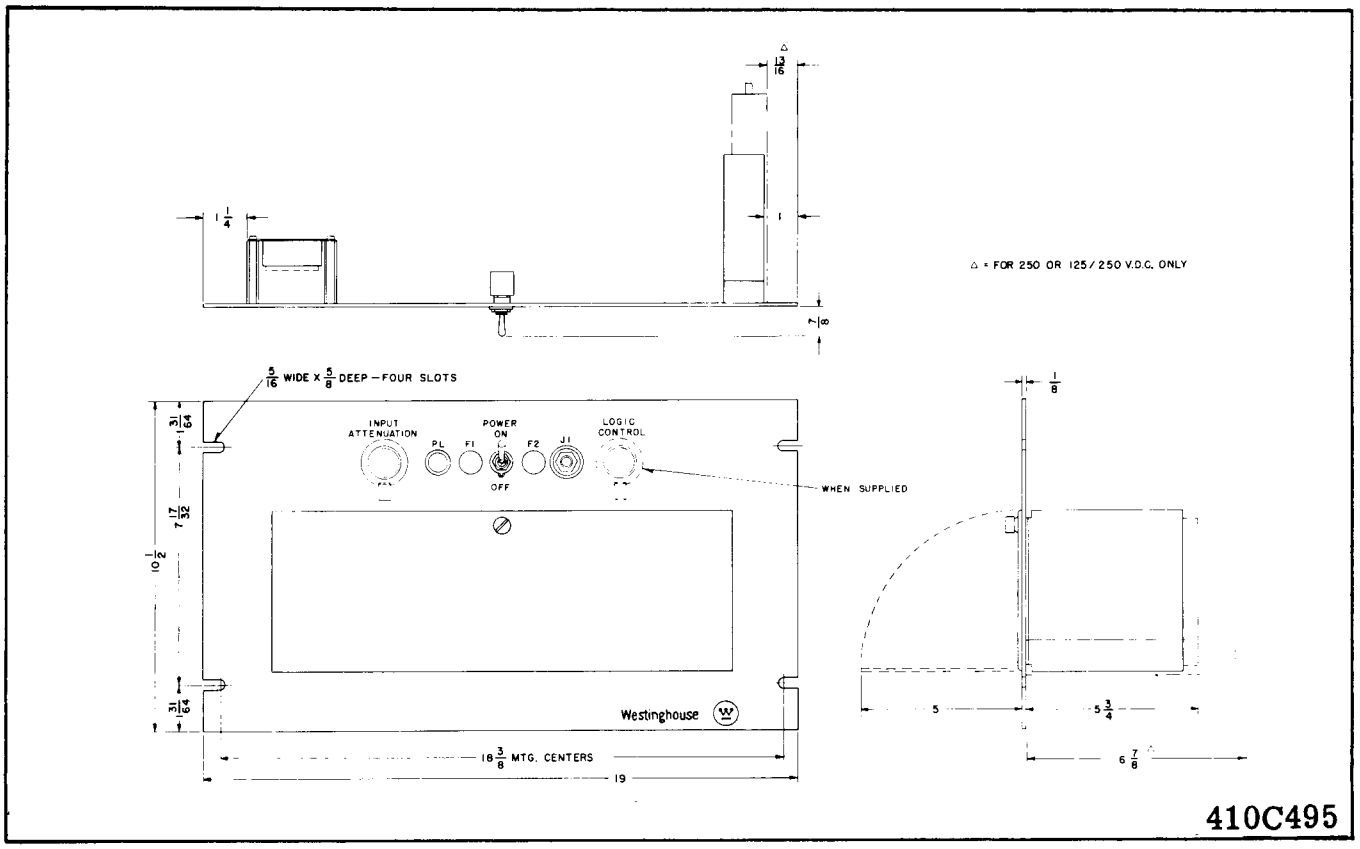


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

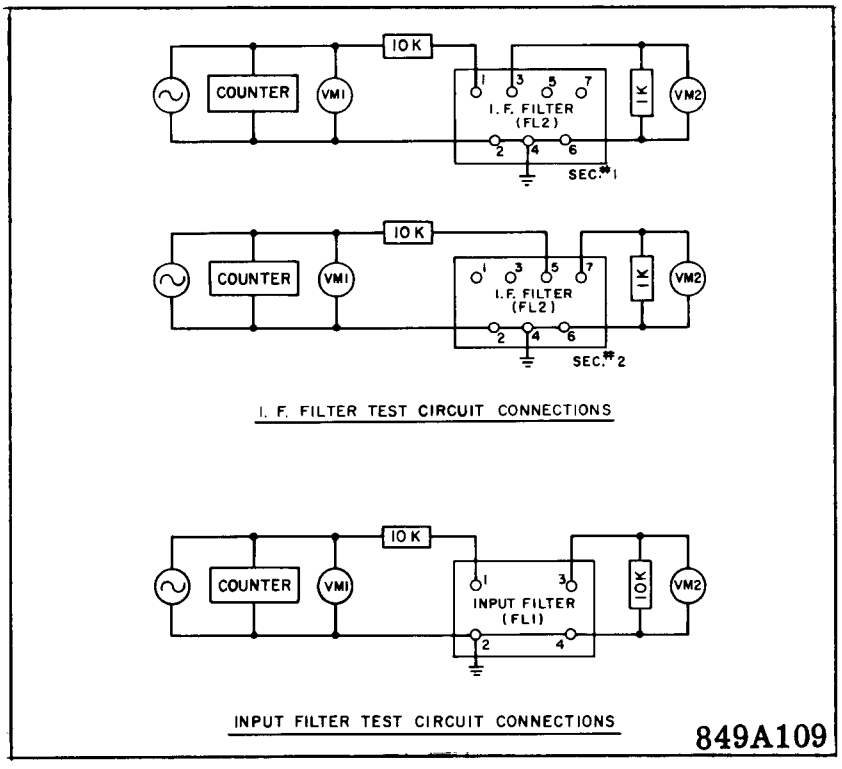
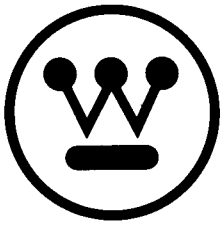


Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.



WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

CAUTION It is recommended that the user of this equipment become thoroughly acquainted with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 cycles above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 cycles below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 KC above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the latter is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20KC, 2fc + 20KC, fc + 20KC and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20KC. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20KC.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 cycles. The adjustment for zero output at fc-25 cycles is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 cycles above or below the zero output frequency. This separation of 200 cycles between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 cycles in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 cycles, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20KC-100 cycles. Similarly, the Trip frequency is 20KC + 100 cycles. The intermediate frequency at which the discriminator has zero output then is 20.025 KC.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 15 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 15 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears 15 ms. before C102 has reached the breakdown voltage of CR105, the charge is quickly dissipated through the 1K resistor R123, and the full time-delay will be effective on any subsequent loss of Guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Buard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.5 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental ininsertion of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-200 KC
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 cycles down > 60 db at 1000 cycles
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 cycles to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 cycles minimum
B. For two-way channel	1500 cycles minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20 °C to + 60 °C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60 °C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12 in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20KC above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 5 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting. The R52 adjusting screw then should be turned one turn farther in the direction to produce limiting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 cycles in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 cycles (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe
* the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 cycles and fc −125 cycles, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 18 (+ 20 v.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< .5	
Q12	1.8	(Guard or Trip)
Q13	1.8	(Guard or Trip)
Q31	1.5	
Q32	1.5	
Q51	11.5	
Q52	6.5	
Q53	15.5	
Q54	2	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

The adjustment procedure for the AR relay (which should be attempted only if suitable tools are available) is as follows:

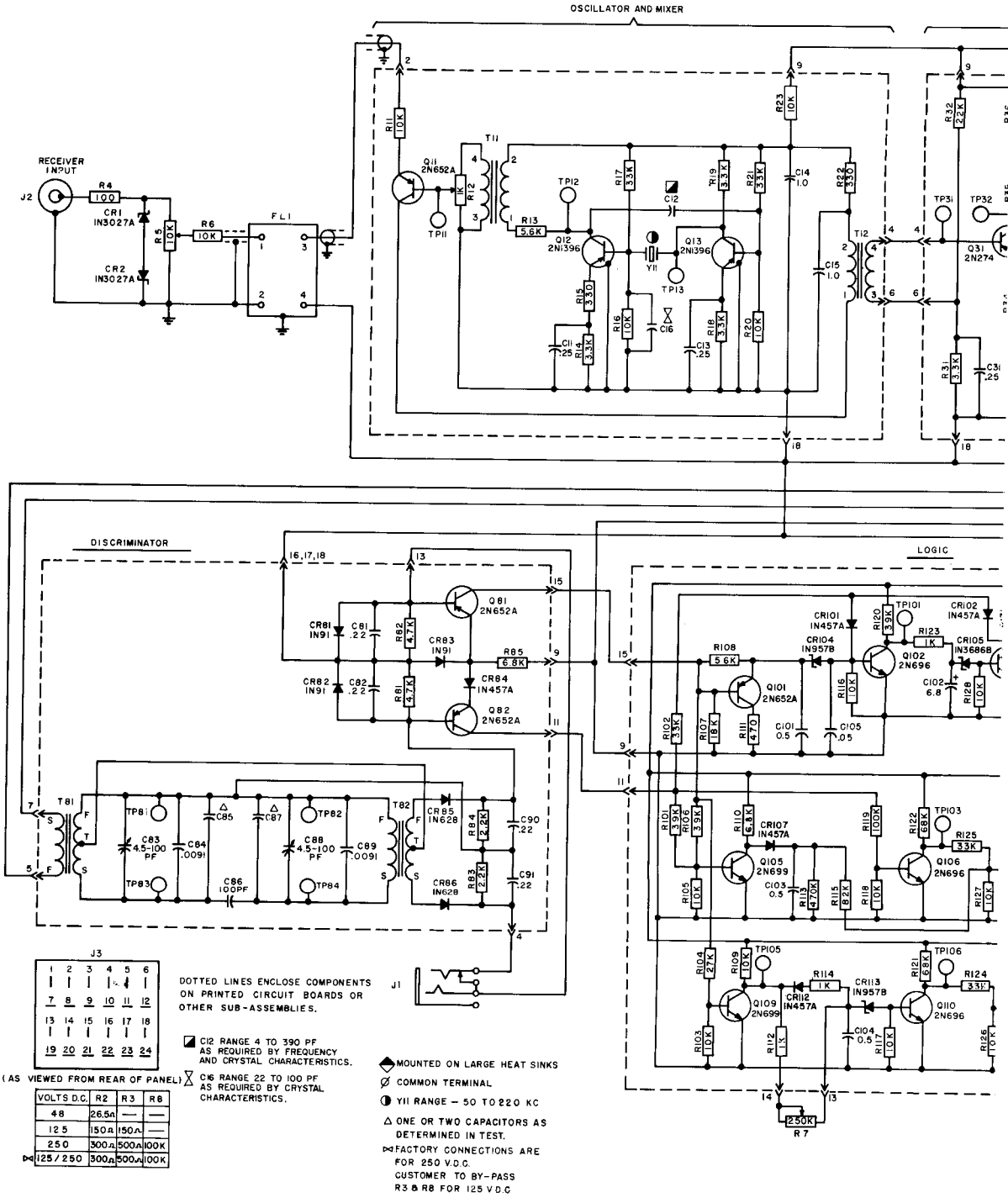
a) Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.

b) On relays with two normally-open and two normally-closed contacts, adjust each contact spring so that 8 grams force at the very end of each spring will just move it away from the edge of the slotted insulation attached to the armature. Relays with four normally-open contacts should be adjusted so that a 4 gram force similarly applied will just move each spring away from the edge of the insulation.

c) Adjust each normally-open contact screw to obtain a gap of 0.020 to 0.022 inch. With the relay energized the normally-open contacts should have 15 to 30 grams pressure. The normally-closed contacts, if present, should have a contact gap of 0.015 inch.

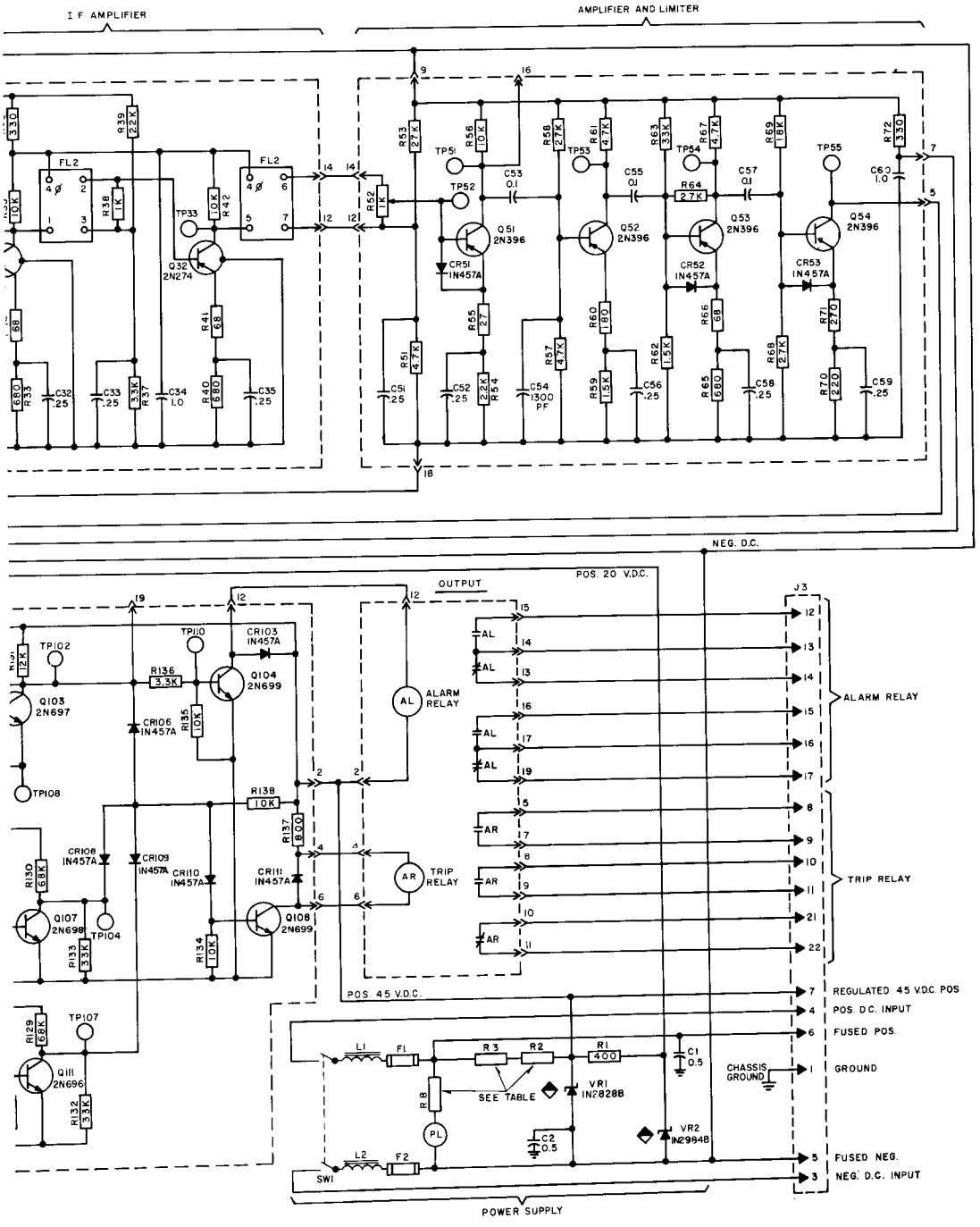
The AR relay with its 800 ohm series resistor should pick up at approximately 30 volts.

Fig. 1 Type TCF Receiver (Front View).



VOLTS D.C.	R2	R3	R8
48	26.5Ω	—	—
125	150Ω	150Ω	—
250	300Ω	500Ω	100K
125/250	300Ω	500Ω	100K

Fig. 2. Internal schematic of the type 1



543D637

'CF receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 KC", and for the stop band are "down 18 db minimum at 19.00 and 21.00 KC". The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 cycles/sec. to 230-kc., input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Imput Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kc to 230-kc

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
	DIODES - GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN457A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN457A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V.; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES - ZENER	
CR1	IN3027A; 20 V. ±10%; 1 W.	188A307H10
CR2	IN3027A; 20 V. ±10%; 1 W.	188A307H10
CR104	IN957B; 6.8 V. ±5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ±5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ±5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ±5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ±5%; 10 W.	762A631H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ±5%; ½ W. Composition	184A763H13
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3W. Wire Wound	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ± 5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W. Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E.Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	1962797
T12	Toroidal type, 25000/300 ohms	1962697
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 KC above Channel Frequency)	762A800H01 +(Req. Freq.)
FL1	Crystal Input Filter	410C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408C845G03
L1-L2	Choke	292B096G02

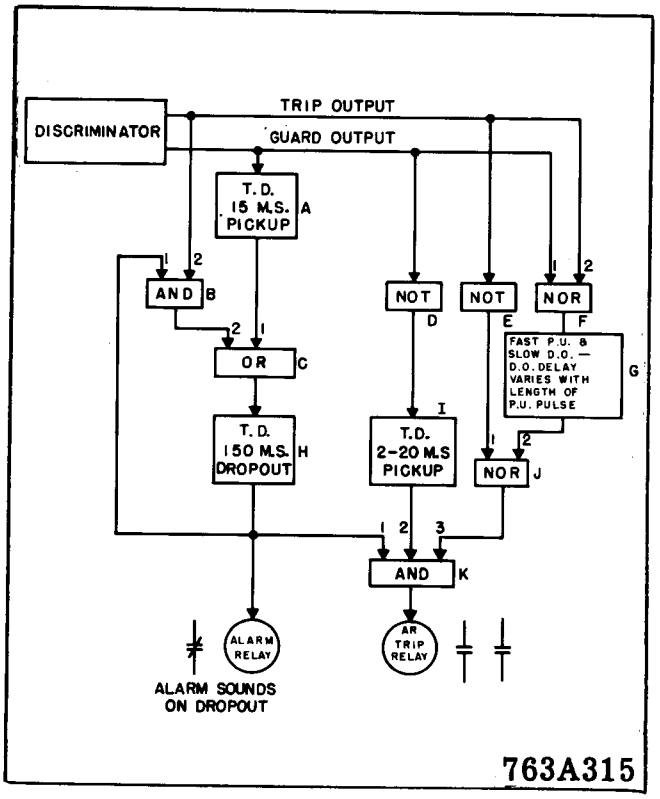


Fig. 4. Block diagram of output logic circuit

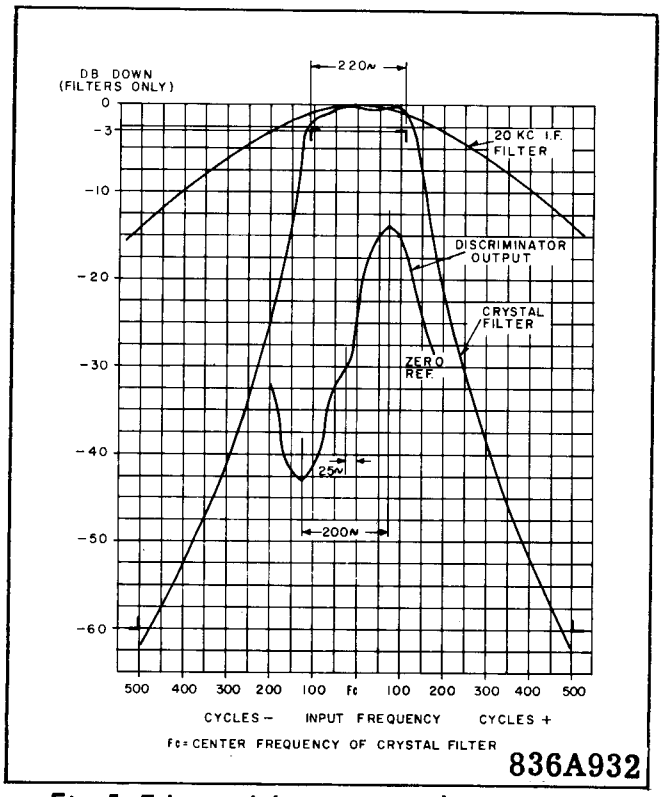


Fig. 5 Filter and discriminator characteristics of the type TCF receiver

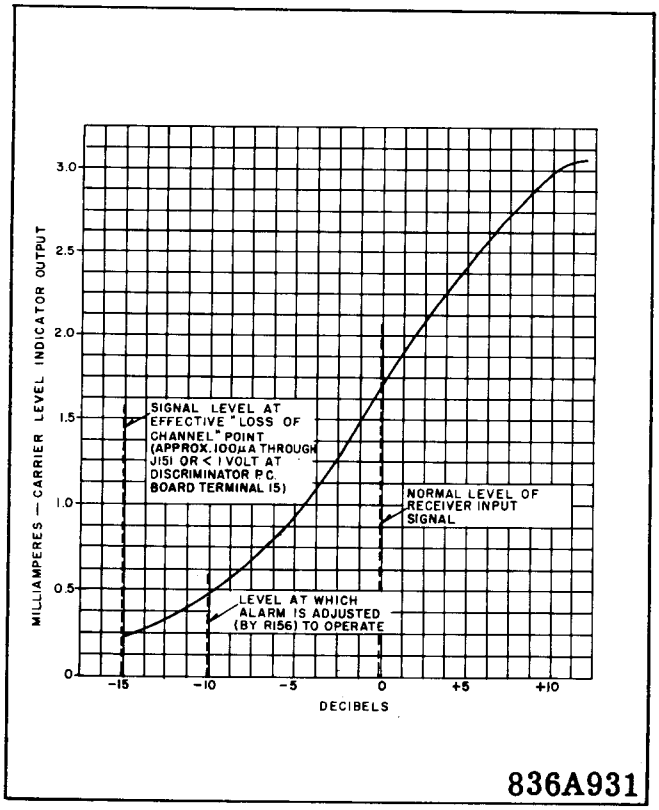


Fig. 6. Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

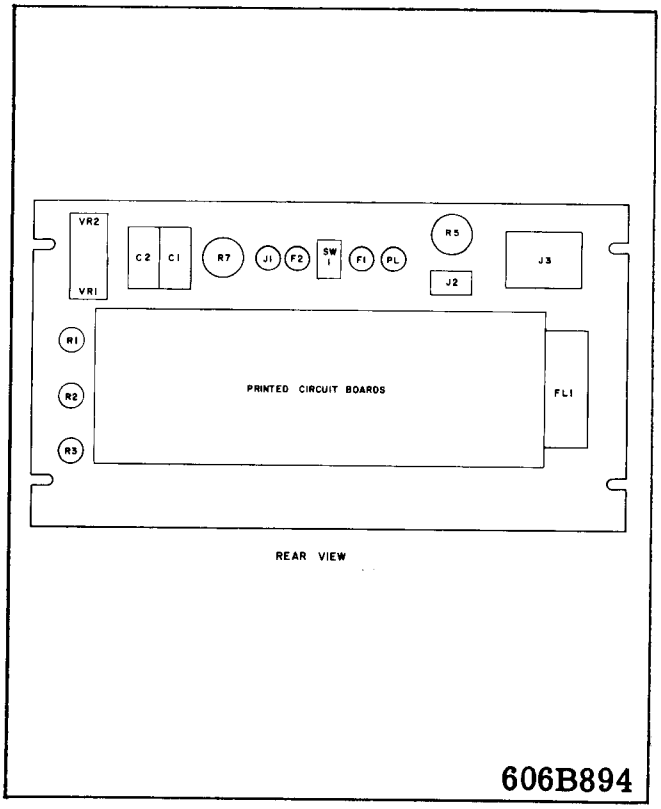


Fig. 7. Component locations on the type TCF receiver panel

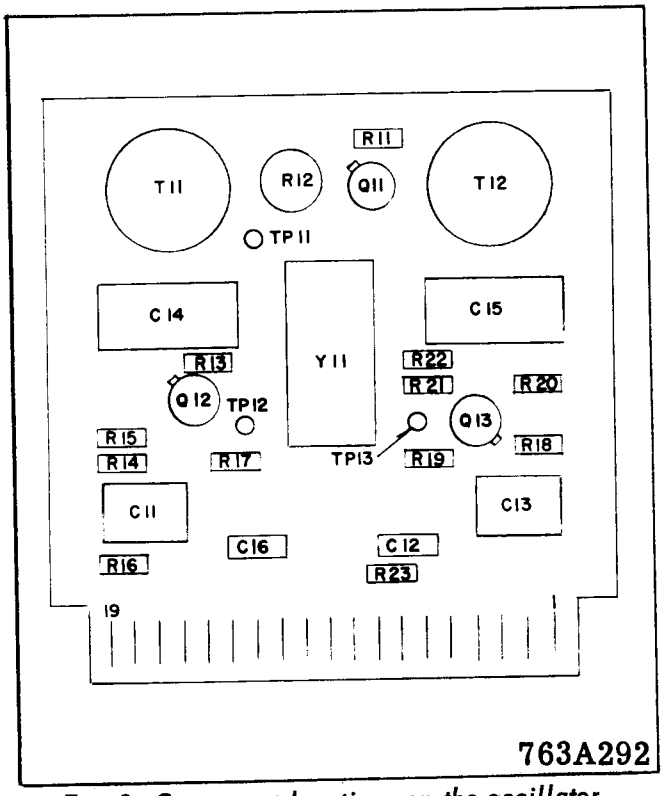


Fig. 8. Component locations on the oscillator and mixer printed circuit board.

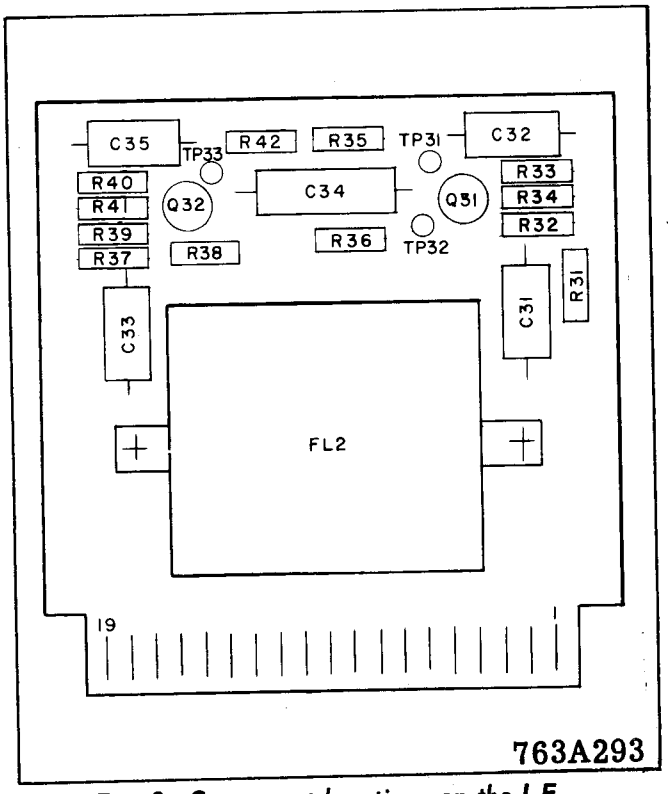


Fig. 9. Component locations on the I.F. amplifier printed circuit board.

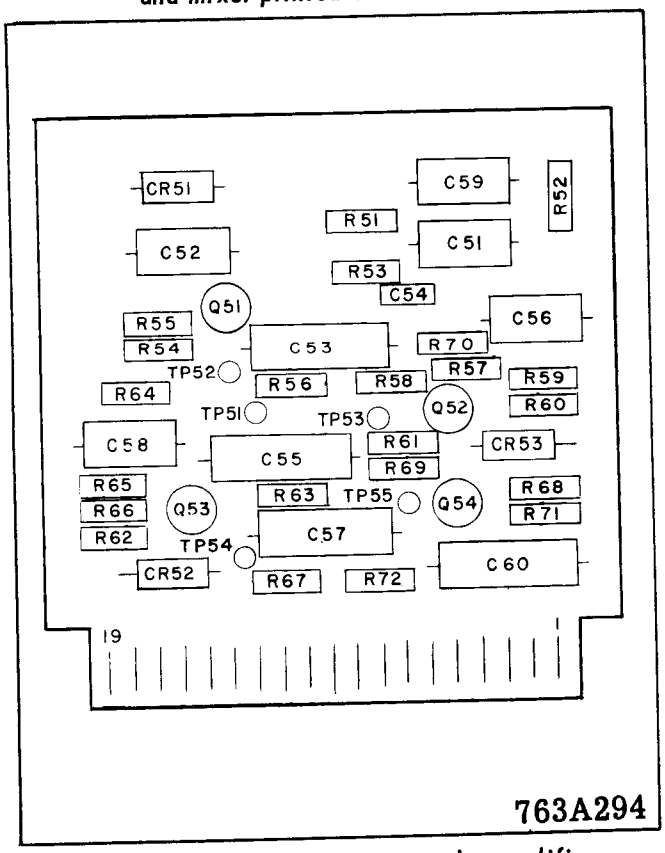


Fig. 10. Component locations on the amplifier and limiter printed circuit board.

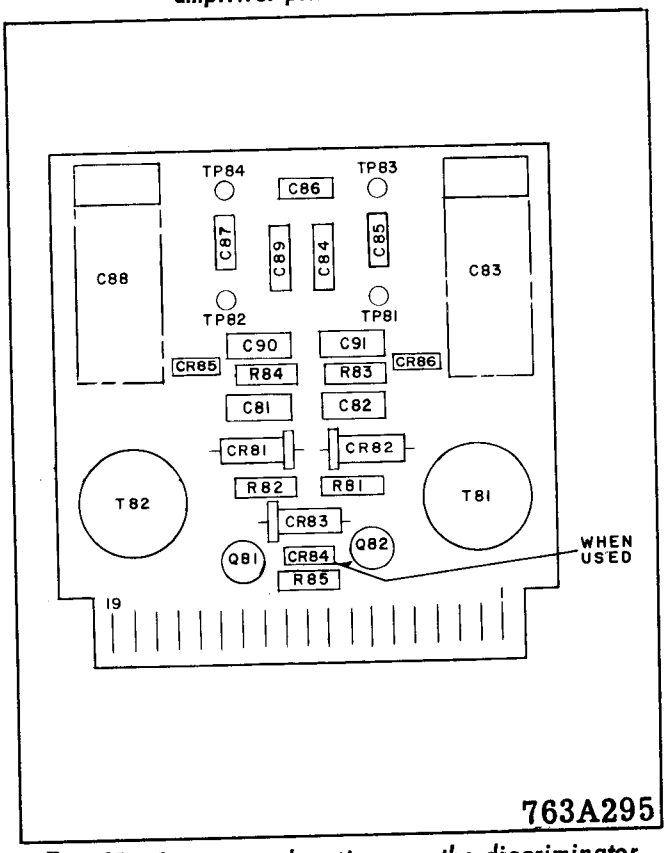


Fig. 11. Component locations on the discriminator printed circuit board.

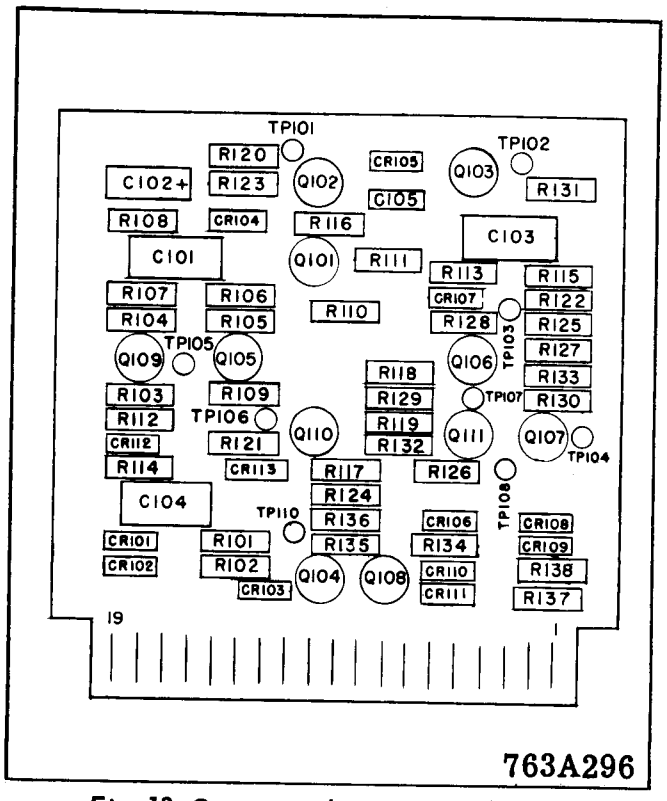


Fig. 12. Component locations on the logic printed circuit board.

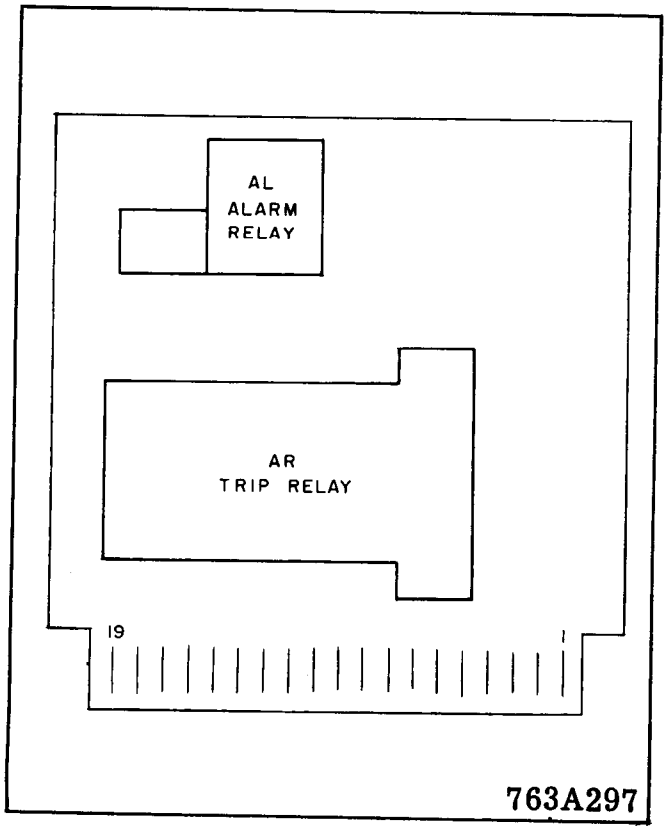


Fig. 13. Component locations on the output printed circuit board.

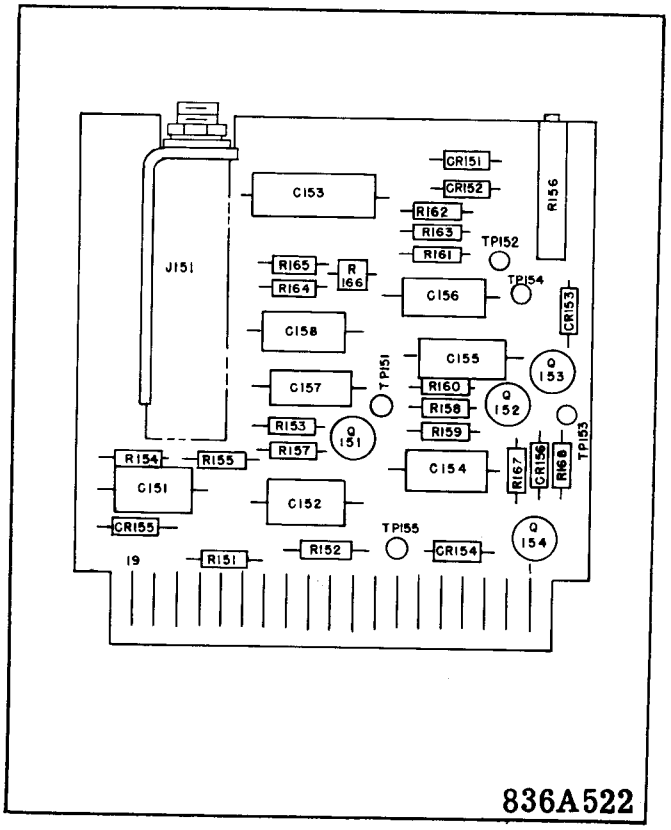


Fig. 14. Component locations on the carrier level indicator printed circuit board.

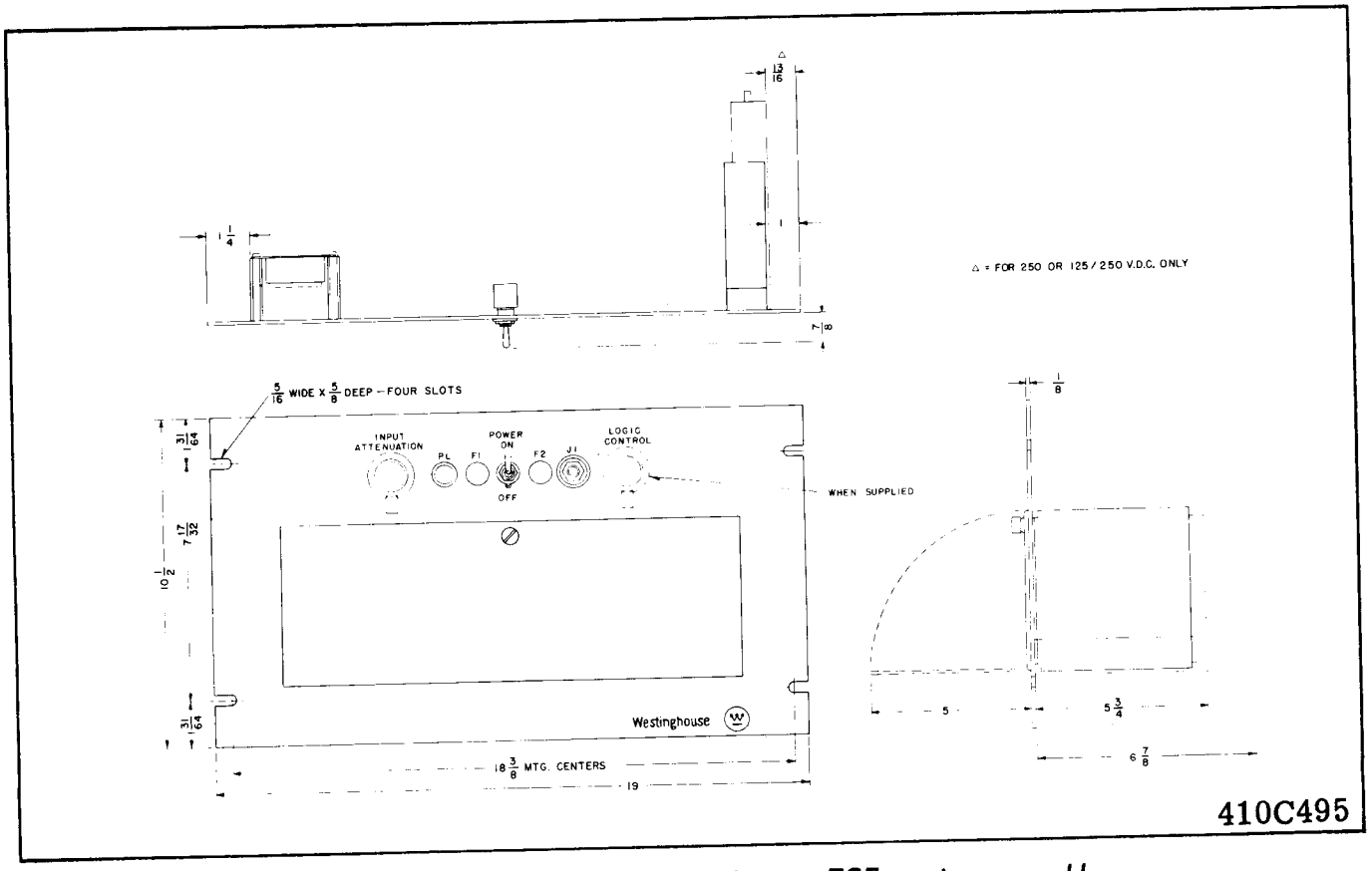


Fig. 15. Outline and drilling plan for the type TCF receiver assembly.

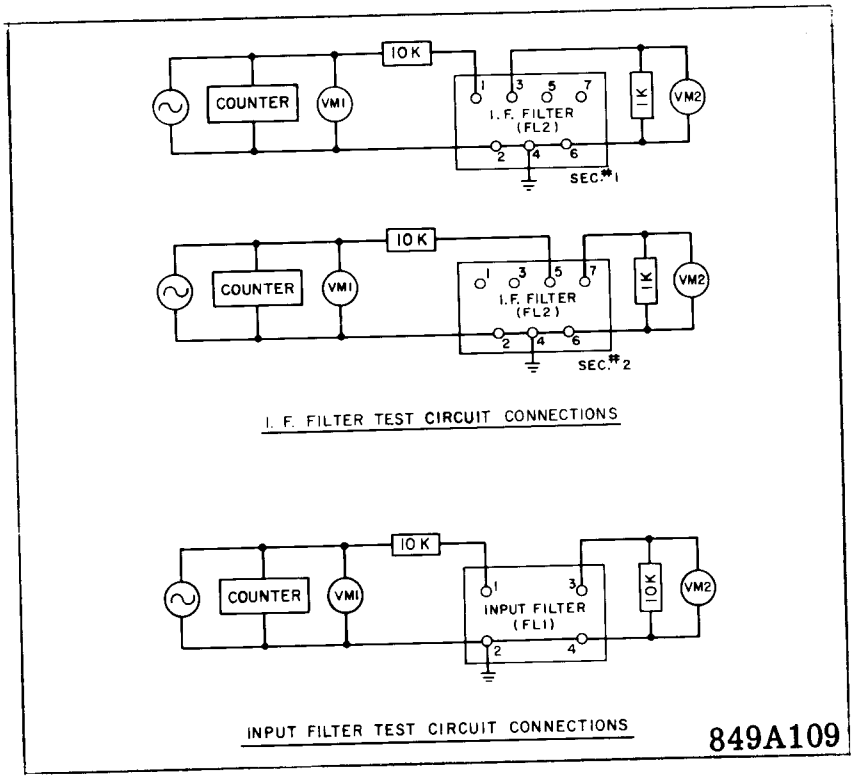
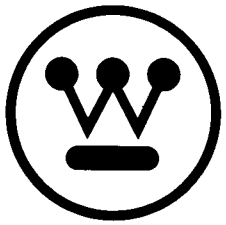


Fig. 16. Test Currents for TCF Frequency Shift Receiver Filters.



WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION
NEWARK, N. J.
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

CAUTION It is recommended that the user of this equipment become thoroughly acquainted with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 cycles above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 cycles below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 KC above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the latter is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20KC, 2fc + 20KC, fc + 20KC and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20KC. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20KC.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 cycles. The adjustment for zero output at fc-25 cycles is made by capacitor C88. C83 also is ad-

justed to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 cycles above or below the zero output frequency. This separation of 200 cycles between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 cycles in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 cycles, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20KC−100 cycles. Similarly, the Trip frequency is 20KC + 100 cycles. The intermediate frequency at which the discriminator has zero output then is 20.025 KC.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 15 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 15 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears 15 ms. before C102 has reached the breakdown voltage of CR105, the charge is quickly dissipated through the 1K resistor R123, and the full time-delay will be effective on any subsequent loss of Guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Buard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.5 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental ininsertion of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

CHARACTERISTICS

Frequency range	30-200 KC
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 cycles down > 60 db at 1000 cycles
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 cycles to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay 14 ms. minimum time + 18 ms. max. added logic time (if req'd. by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 cycles minimum
B. For two-way channel	1500 cycles minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	-20 °C to + 60 °C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105 - 140 V.D.C.
250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60 °C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12 in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20KC above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should

be connected from the base of transistor Q54 to terminal 18 of the limiter. With 5 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting. The R52 adjusting screw then should be turned one turn farther in the direction to produce limiting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 cycles in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 cycles (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe * the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 cycles and fc −125 cycles, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 18 (+ 20 v.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (+)	
Q11	< .5	
Q12	1.8	(Guard or Trip)
Q13	1.8	(Guard or Trip)
Q31	1.5	
Q32	1.5	
Q51	11.5	
Q52	6.5	
Q53	15.5	
Q54	2	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Guard)
Q82	< 1	(No sig. or Guard)
Q82	19.5	(Trip)
Q101	< 1	(No sig. or Trip)
Q101	7	(Guard)
Q102	21	(No signal)
Q102	< 1	(Guard or keyed Trip #)

Q103	< 1	(No signal)
Q103	10	(Guard or keyed Trip)
Q104	45	(No signal)
Q104	< 1	(Guard or keyed Trip)
Q105	40	(No signal)
Q105	< 1	(Guard or Trip)
Q106	15	(No sig. or Guard)
Q106	< 1	(Trip)
Q107	< 1	(No sig. or Guard)
Q107	15	(Trip)
Q108	45	(No sig. or Guard)
Q108	< 1	(Keyed Trip)
Q109	10	(No sig. or Trip)
Q109	< 1	(Guard)
Q110	< 1	(No sig. or Trip)
Q110	15	(Guard)
Q111	15	(No sig. or Trip)
Q111	< 1	(Guard)
Q151	6	(No signal)
Q151	6	(Guard)
Q152	9.8	(No signal)
Q152	10	(Guard)
Q153	< 1	(No signal)
Q153	19	(Guard)
Q154	45	(No signal)
Q154	< 1	(Guard)

- "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

The adjustment procedure for the AR relay (which should be attempted only if suitable tools are available) is as follows:

a) Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.

b) On relays with two normally-open and two normally-closed contacts, adjust each contact spring so that 8 grams force at the very end of each spring will just move it away from the edge of the slotted insulation attached to the armature. Relays with four normally-open contacts should be adjusted so that a 4 gram force similarly applied will just move each spring away from the edge of the insulation.

c) Adjust each normally-open contact screw to obtain a gap of 0.020 to 0.022 inch. With the relay energized the normally-open contacts should have 15 to 30 grams pressure. The normally-closed contacts, if present, should have a contact gap of 0.015 inch.

The AR relay with its 800 ohm series resistor should pick up at approximately 30 volts.

Fig. 1 Type TCF Receiver (Front View).

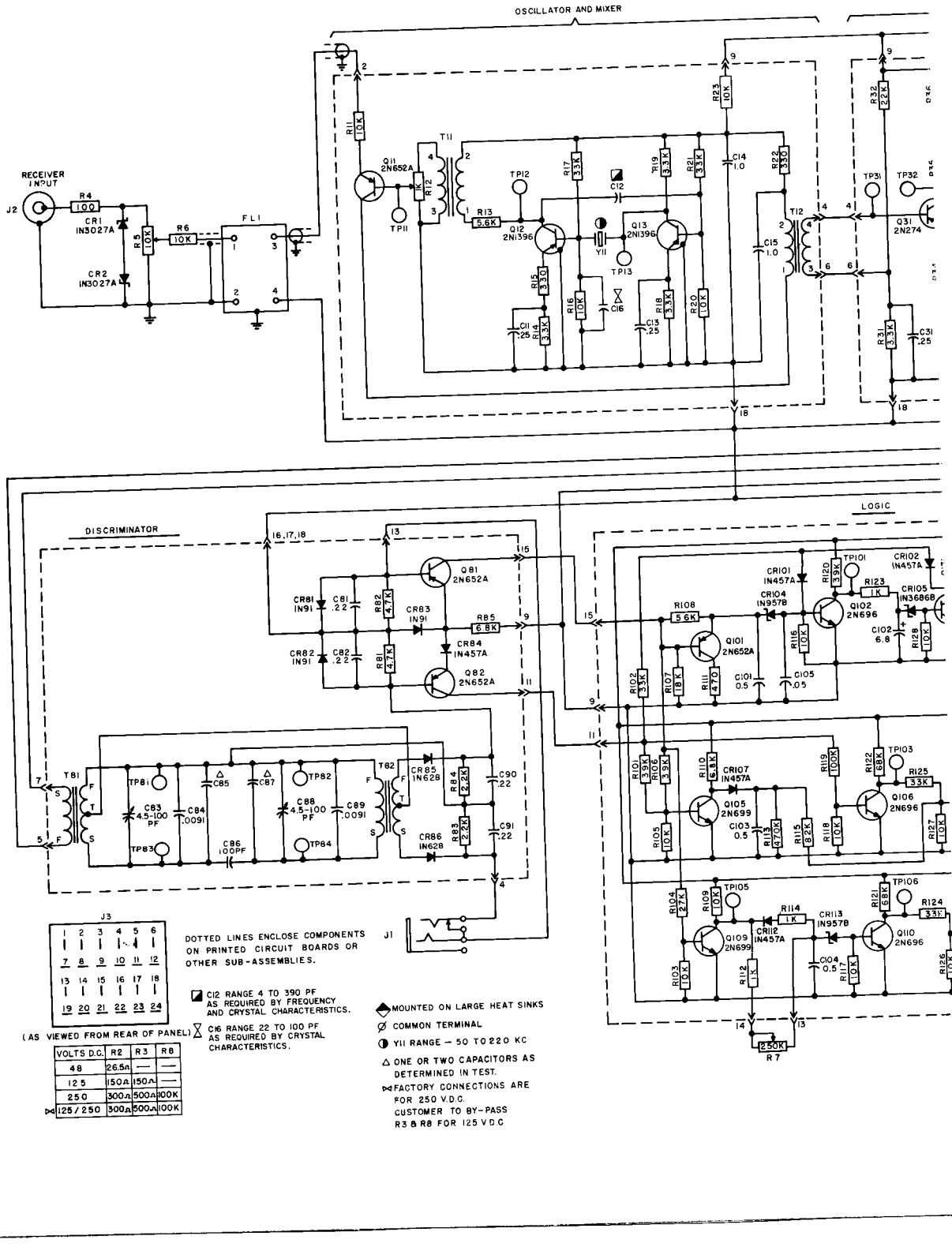
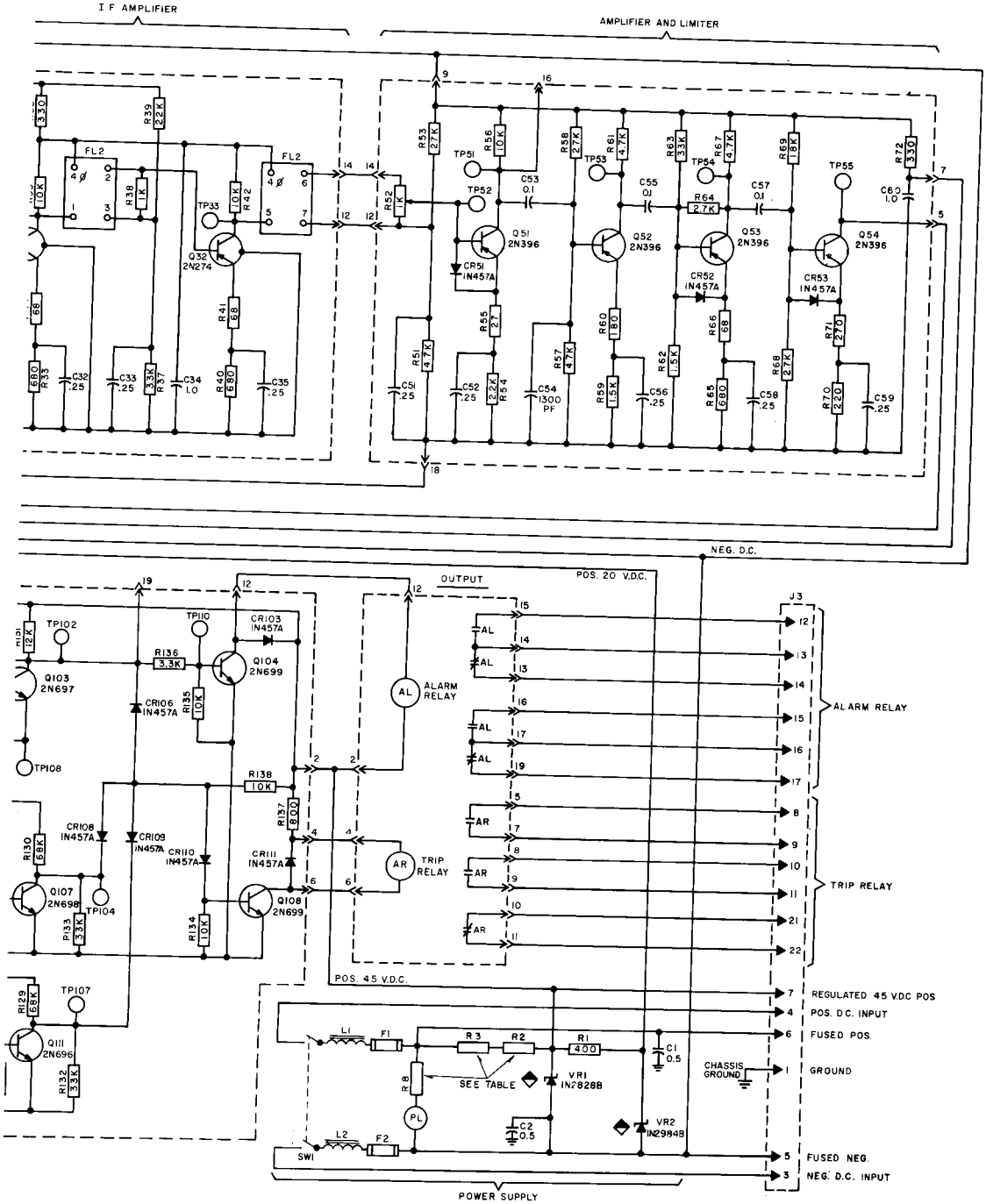


Fig. 2. Internal schematic of the type T



543D637

'CF receiver without the carrier level indicator.

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 KC", and for the stop band are "down 18 db minimum at 19.00 and 21.00 KC". The signal generator voltage must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency but should not be more than 11db below the reading of VM1. (The filter insertion loss is approximately 6db less than the difference in readings.)

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 cycles/sec. to 230-kc., input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 to 300 volts
Imput Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kc to 230-kc

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C12-C16	Mica, capacity as required; 500 V.D.C.	
C13	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C14	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C15	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C31	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C32	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C33	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C34	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C35	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C51	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C52	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C53	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C54	Dur-Mica, 1300 pf.; 500 V.D.C.	187A584H15
C55	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C56	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C57	Metallized paper; 0.1 mfd.; 200 V.D.C.	187A624H01
C58	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C60	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C81	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C82	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C83	Variable; 4.5 - 100 pf.	762A736H02
C84	Polystyrene, 9100 pf.; 200 V.D.C.	187A624H16
C85	Temp. compensating; 150 V.D.C.; pf. as required	
C86	100 pf.; zero temp. coef.	187A684H08
C87	Temp. compensating; 150 V.D.C.; pf. as required	
C88	Variable; 4.5 - 100 pf.	762A736H02
C89	Polystyrene; 9100 pf.; 200 V.D.C.	187A624H16
C90	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C91	Mylar; 0.22 mfd.; 50 V.D.C.	762A703H01
C101	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C102	Tantalum, 6.8 mfd.; 35 V.D.C.	184A661H25
C103	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C104	Metallized paper; 0.5 mfd.; 200 V.D.C.	187A624H11
C105	Ceramic, 0.05 mfd.; 50 V.D.C.	184A663H02
C151	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C152	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
	DIODES - GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN457A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN457A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184A855H12
CR86	IN628; 125 V.; 30 MA.	184A855H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V.; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES - ZENER	
CR1	IN3027A; 20 V. ±10%; 1 W.	188A307H10
CR2	IN3027A; 20 V. ±10%; 1 W.	188A307H10
CR104	IN957B; 6.8 V. ±5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ±5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ±5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ±5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ±5%; 10 W.	762A631H01

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K; 2 W.	185A086H10
R7	250K; 2 W.	185A086H11
R12	1K; ¼ W.	629A430H02
R52	1K; ¼ W.	629A645H04
R156	2.5K; ¼ W.	629A645H07
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5% ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ±5%; ½ W. Composition	184A763H13
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R116	10K ±5%; ½ W. Composition	184A763H51
R117	10K ±5%; ½ W. Composition	184A763H51
R118	10K ±5%; ½ W. Composition	184A763H51
R119	100K ±5%; ½ W. Composition	184A763H75
R120	39K ±5%; ½ W. Composition	184A763H65
R121	68K ±5%; ½ W. Composition	184A763H71
R122	68K ±5%; ½ W. Composition	184A763H71
R123	1000 ohms ±5%; ½ W. Composition	184A763H27
R124	33K ±5%; ½ W. Composition	184A763H63
R125	33K ±5%; ½ W. Composition	184A763H63
R126	10K ±5%; ½ W. Composition	184A763H51
R127	10K ±5%; ½ W. Composition	184A763H51
R128	10K ±5%; ½ W. Composition	184A763H51
R129	68K ±5%; ½ W. Composition	184A763H71
R130	68K ±5%; ½ W. Composition	184A763H71
R131	12K ±5%; ½ W. Composition	184A763H53
R132	33K ±5%; ½ W. Composition	184A763H63
R133	33K ±5%; ½ W. Composition	184A763H63
R134	10K ±5%; ½ W. Composition	184A763H51
R135	10K ±5%; ½ W. Composition	184A763H51
R136	3.3K ±5%; ½ W. Composition	184A763H39
R137	800 ohms ±5%; 3W. Wire Wound	184A859H06
R138	10K ±5%; ½ W. Composition	184A763H51
R151	2.7K ±5%; ½ W. Composition	184A763H37
R152	2.2K Sensistor Type TM¼ (Tex. Inst. Co.)	187A685H01
R153	220 ohms ±5%; ½ W. Composition	184A763H11
R154	2.2K ±5%; ½ W. Composition	184A763H35
R155	15K ± 5%; ½ W. Composition	184A763H55
R157	4.7K ±5%; ½ W. Composition	184A763H43
R158	4.7K ±5%; ½ W. Composition	184A763H43
R159	15K ±5%; ½ W. Composition	184A763H55
R160	560 ohms ±5%; ½ W. Composition	184A763H21
R161	1.2K ±5%; ½ W. Composition	184A763H29
R162	180 ohms ±5%; ½ W. Composition	184A763H09
R163	180 ohms ±5%; ½ W. Composition	184A763H09
R164	470 ohms ±5%; ½ W. Composition	184A763H19
R165	1000 ohms ±5%; ½ W. Composition	184A763H27
R166	3K Thermistor Type ID201 (G.E.Co.)	185A211H08
R167	18K ±5%; ½ W. Composition	184A763H57
R168	10K ±5%; ½ W. Composition	184A763H51

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	1962797
T12	Toroidal type, 25000/300 ohms	1962697
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H01
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 KC above Channel Frequency)	762A800H01 +(Req. Freq.)
FL1	Crystal Input Filter	410C466 + (Req. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb - For 48 V. Supply	187A133H02
	Pilot Light Bulb - For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408C845G03
L1-L2	Choke	292B096G02

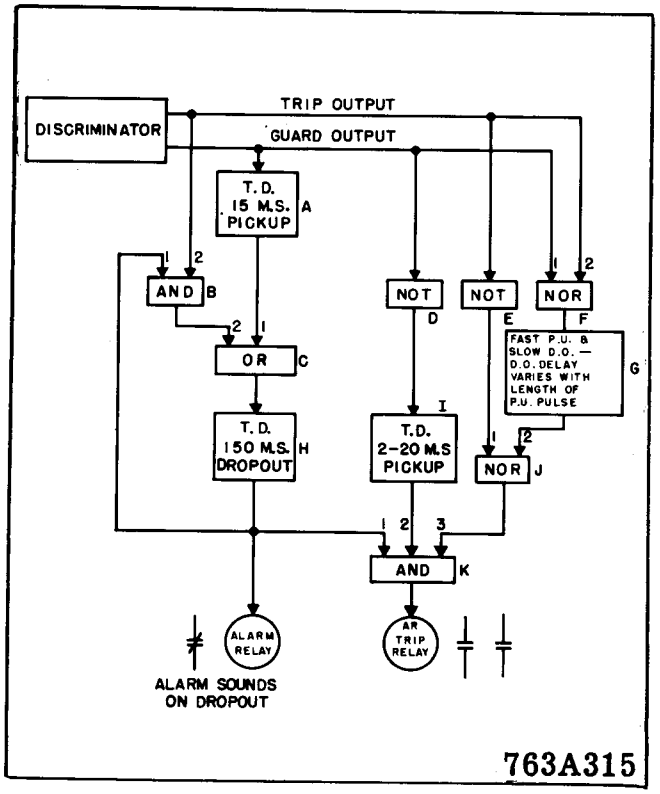


Fig. 4. Block diagram of output logic circuit

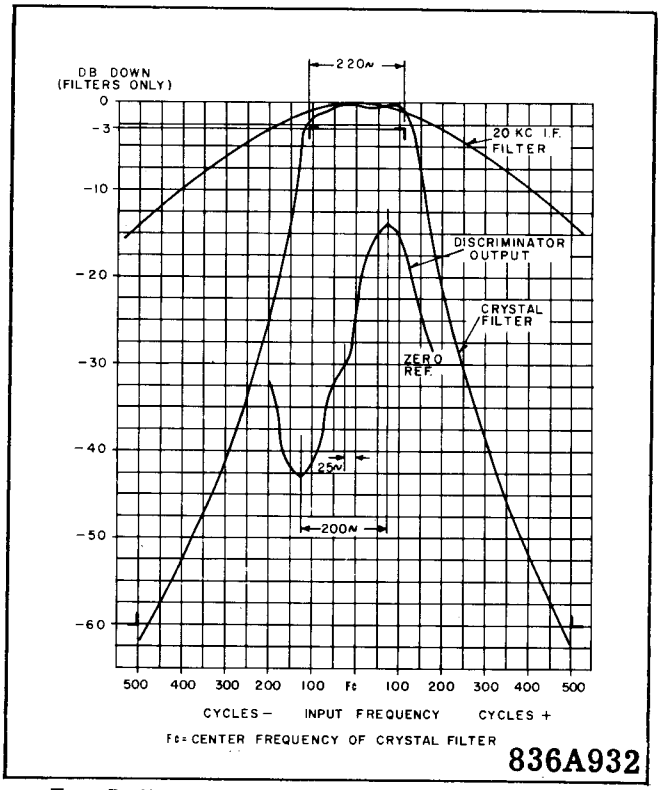


Fig. 5 Filter and discriminator characteristics of the type TCF receiver

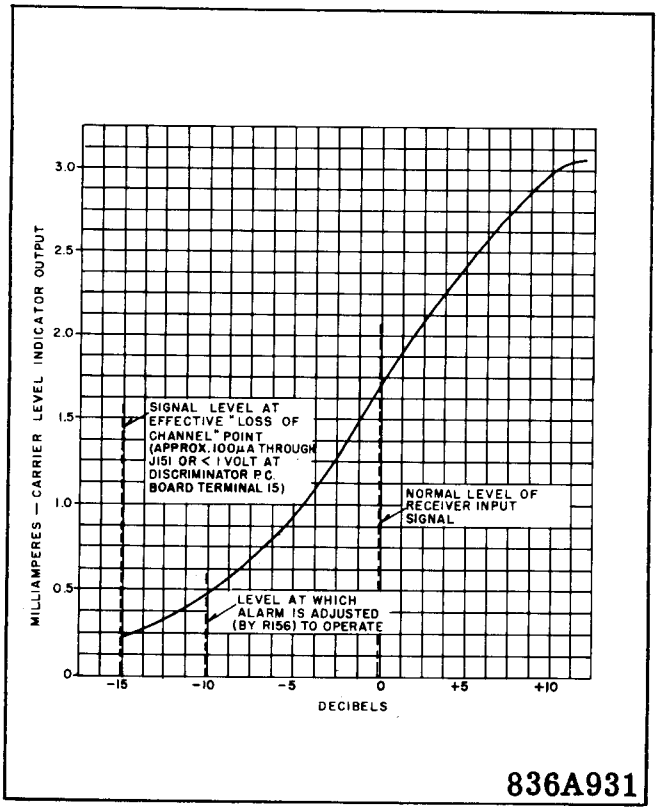


Fig. 6. Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

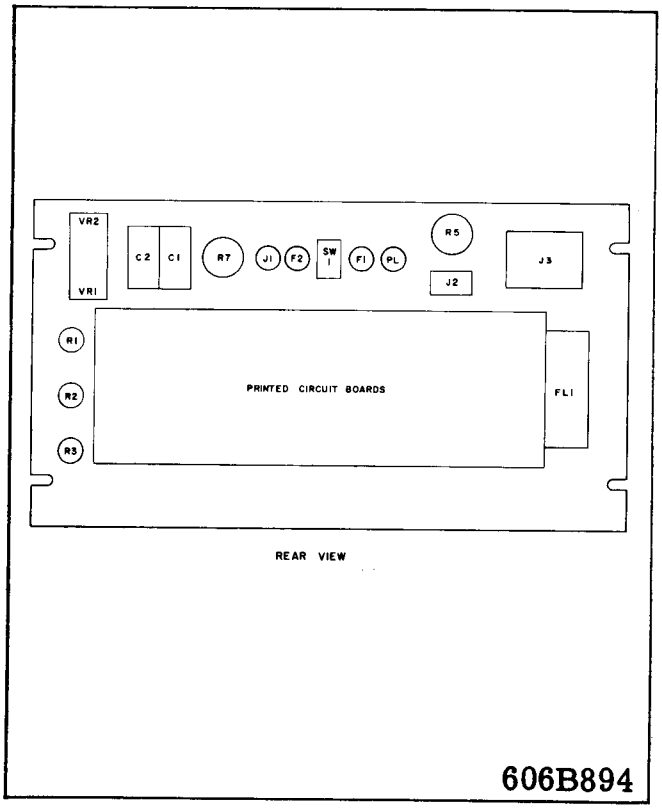


Fig. 7. Component locations on the type TCF receiver panel

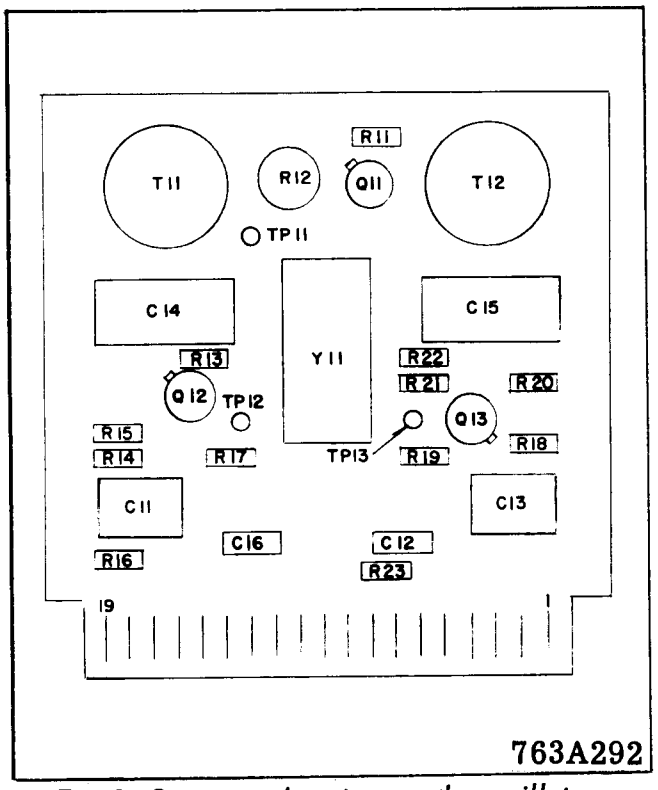


Fig. 8. Component locations on the oscillator and mixer printed circuit board.

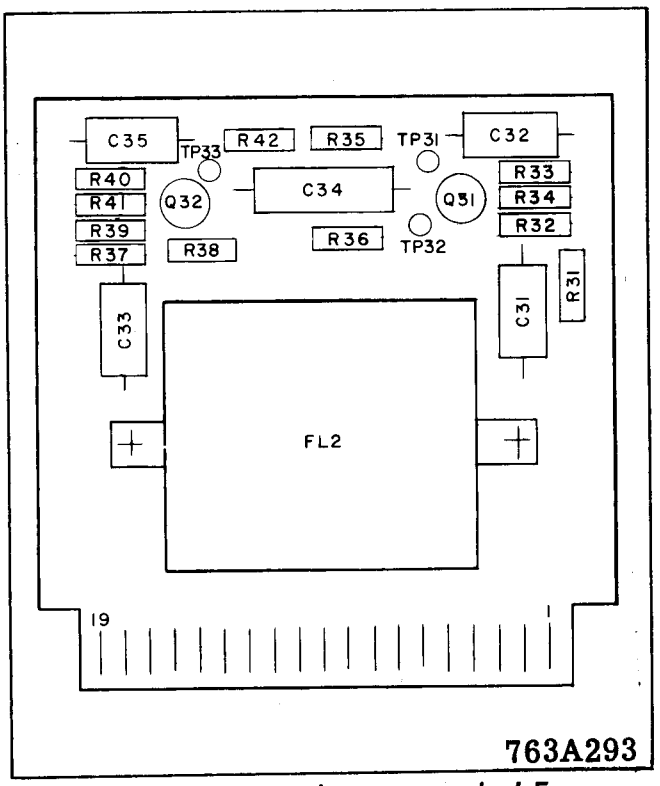


Fig. 9. Component locations on the I.F. amplifier printed circuit board.

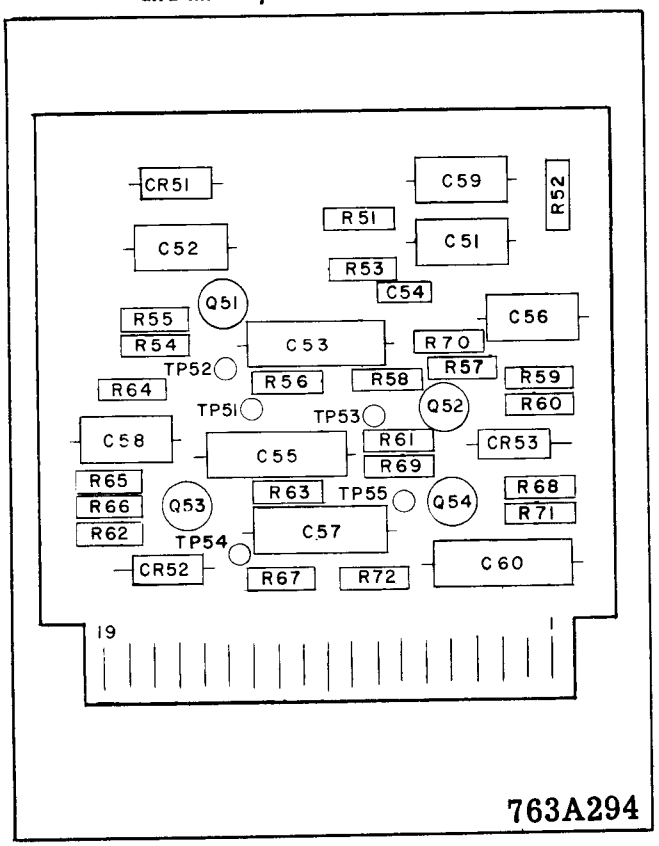


Fig. 10. Component locations on the amplifier and limiter printed circuit board.

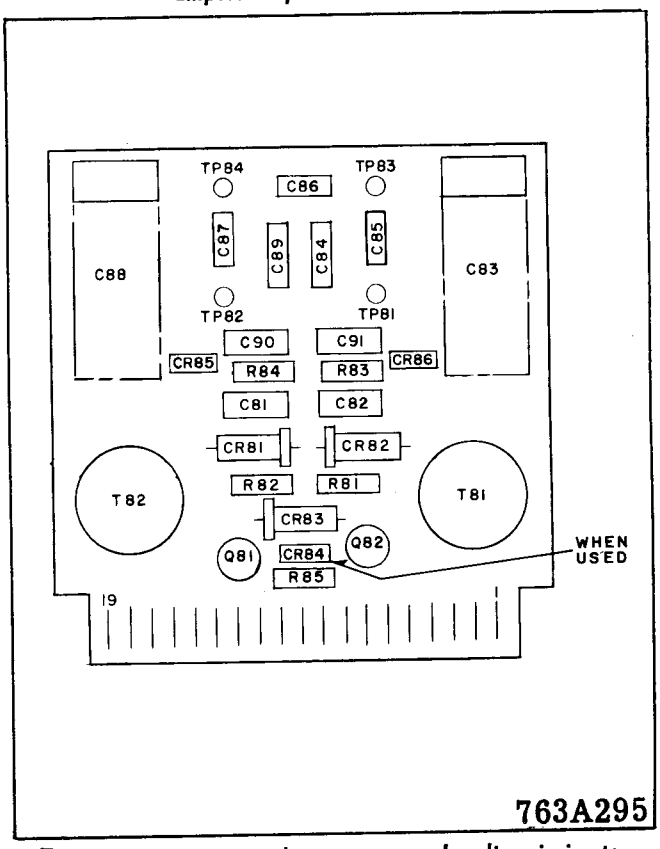


Fig. 11. Component locations on the discriminator printed circuit board.

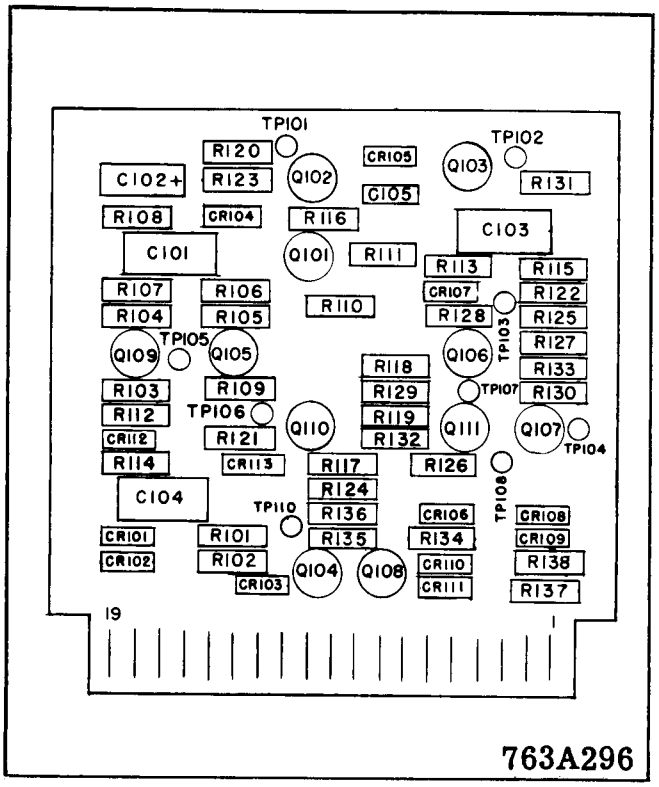


Fig. 12. Component locations on the logic printed circuit board.

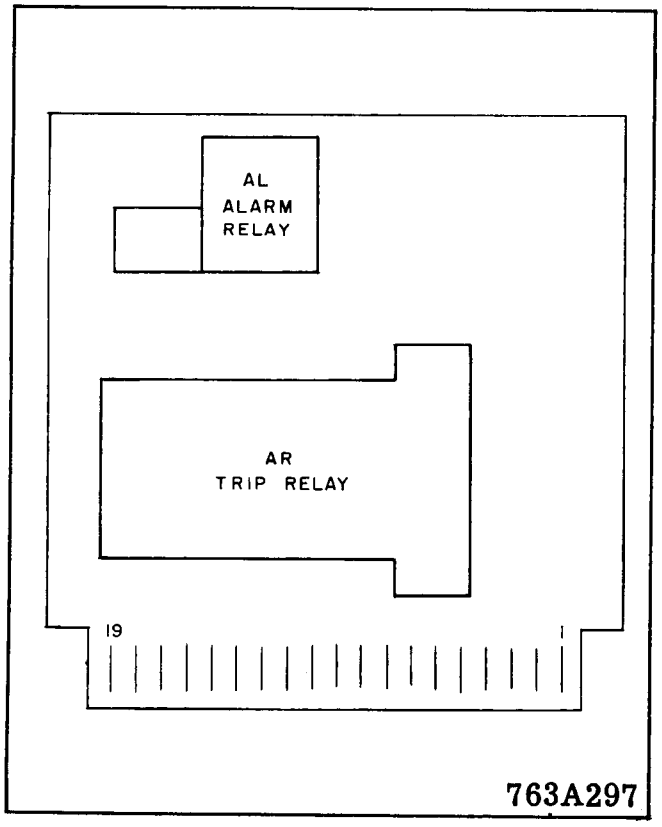


Fig. 13. Component locations on the output printed circuit board.

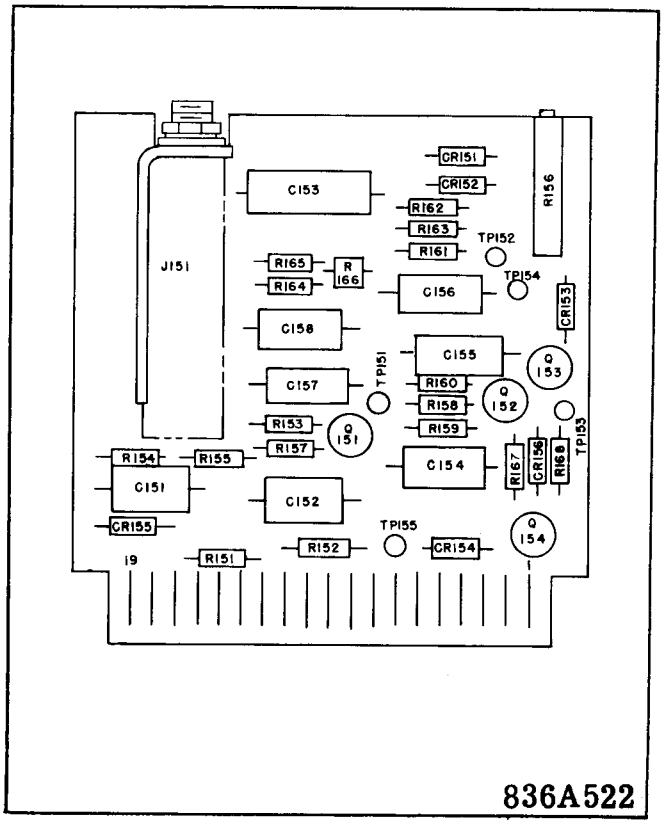


Fig. 14. Component locations on the carrier level indicator printed circuit board.

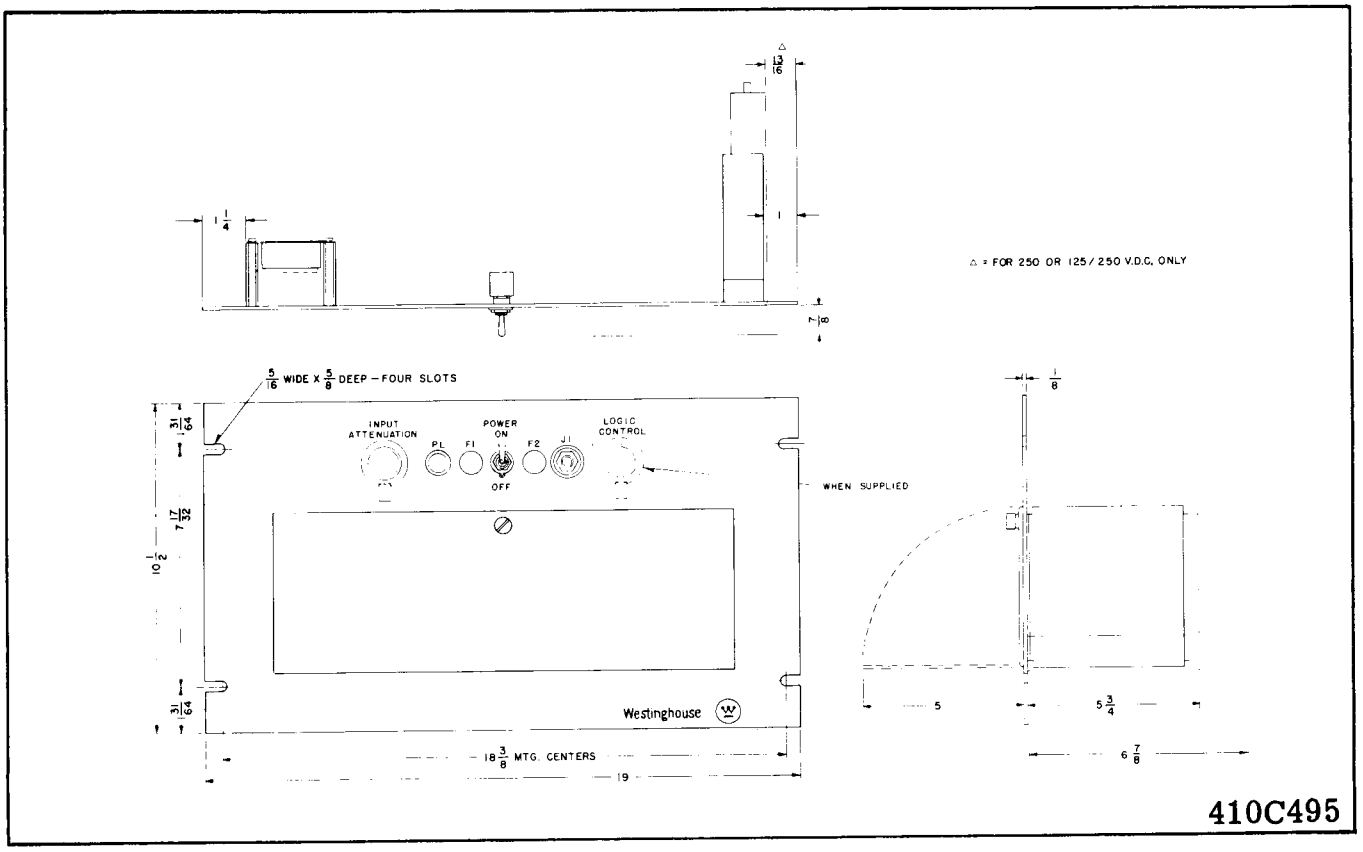


Fig. 15. Outline and drilling plan for the type TCF receiver assembly.

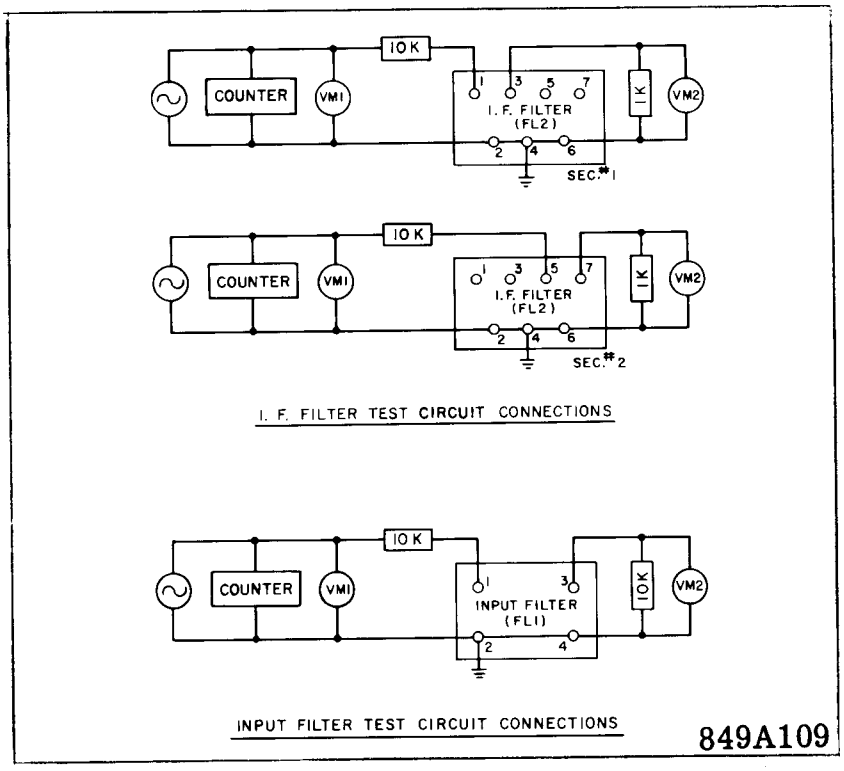
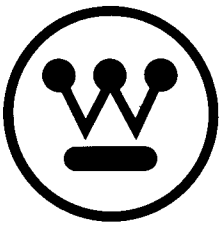


Fig. 16. Test Currents for TCF Frequency Shift Receiver Filters.



WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT - TRANSFER TRIP

CAUTION It is recommended that the user of this equipment become thoroughly acquainted with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 cycles above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 cycles below the center frequency, and may also increase the power output of the transmitter (from1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electro-mechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14.

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

SUPERSEDES I.L. 41-945.51
*Denotes change from superseded issue

EFFECTIVE MARCH 1966

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125 or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signal to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 KC above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the latter is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of
* 20KC, 2fc + 20KC, and fc.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20KC. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20KC.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 cycles. The

adjustment for zero output at fc-25 cycles is made by capacitor C88. C83 also is adjusted to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 cycles above or below the zero output frequency. This separation of 200 cycles between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 cycles in the trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 cycles, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20KC-100 cycles. Similarly, the trip frequency is 20KC + 100 cycles. The intermediate frequency at which the discriminator has zero output then is 20.025 KC.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when terminal 4 is positive with respect to terminal 13 (which occurs with trip output) and Q81 is made conductive when terminal 4 is negative with respect to 13. Consequently, terminal 15 is at a potential of approximately +20 volts at Guard frequency and terminal 11 is at +20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not * encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuit

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to block A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 15 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 15 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears 15 ms. before C102 has reached the breakdown voltage of CR105, the charge is quickly dissipated through the 1K resistor R123, and the full time-delay will be effective on any subsequent loss of Guard signal.

* Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors

Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is
* energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator -- Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become non-conductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.5 ma.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C.

battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f or transient voltages to ground.

CHARACTERISTICS

Frequency range	30-200 KC
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 cycles down > 60 db at 1000 cycles down > 85 db at 3000 cycles
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 cycles to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay + 3 ms. AR relay * 14 ms. minimum time + 18 ms. max. added logic time (if req'd by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 cycles minimum
B. For two-way channel	1500 cycles minimum between transmitter and adjacent receiver frequencies
Ambient temperature range	-20 °C to +60°C temperature around chassis
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C	42 - 56 V.D.C.
125 V.D.C	105 -140 V.D.C.
250 V.D.C.	210 -280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation

are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximun expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed, the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

The adjustments described above are those normally required when putting a new receiver in service. However, in case factory adjustments have been accidently disturbed or components have been replaced, it may be necessary to readjust the oscillator and mixer, the limiter, or the discriminator.

Potentiometer R12 in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20KC above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should be connected from the base of transistor Q54 to terminal 18 of the limiter. With 5 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting. The R52 adjusting screw then should be turned one turn farther in the direction to produce limiting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 cycles in the trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 cycles. (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe
* the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 cycles and fc – 125 cycles, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points or terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

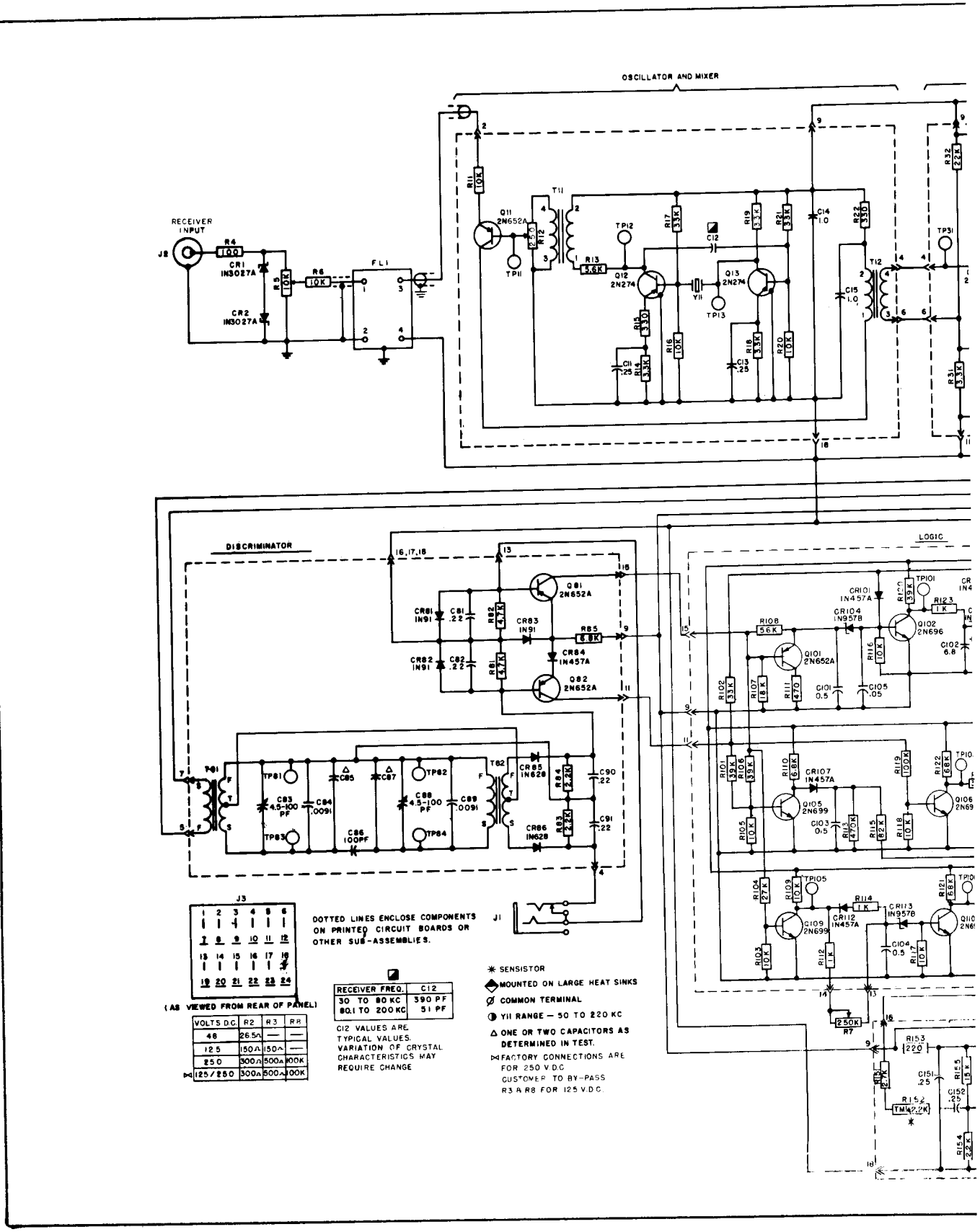
TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 18 (+20 v.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (-)
Q11	20
Q12	14.5 (No signal)
Q12	14.0 (Guard or Trip)
Q13	17.0 (No signal)
Q13	15.0 (Guard or Trip)
Q31	18.5
Q32	18.5
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q81	20 (No sig. or Trip)
Q81	.25 (Guard)
Q82	20 (No sig. or Guard)
Q82	.25 (Trip)

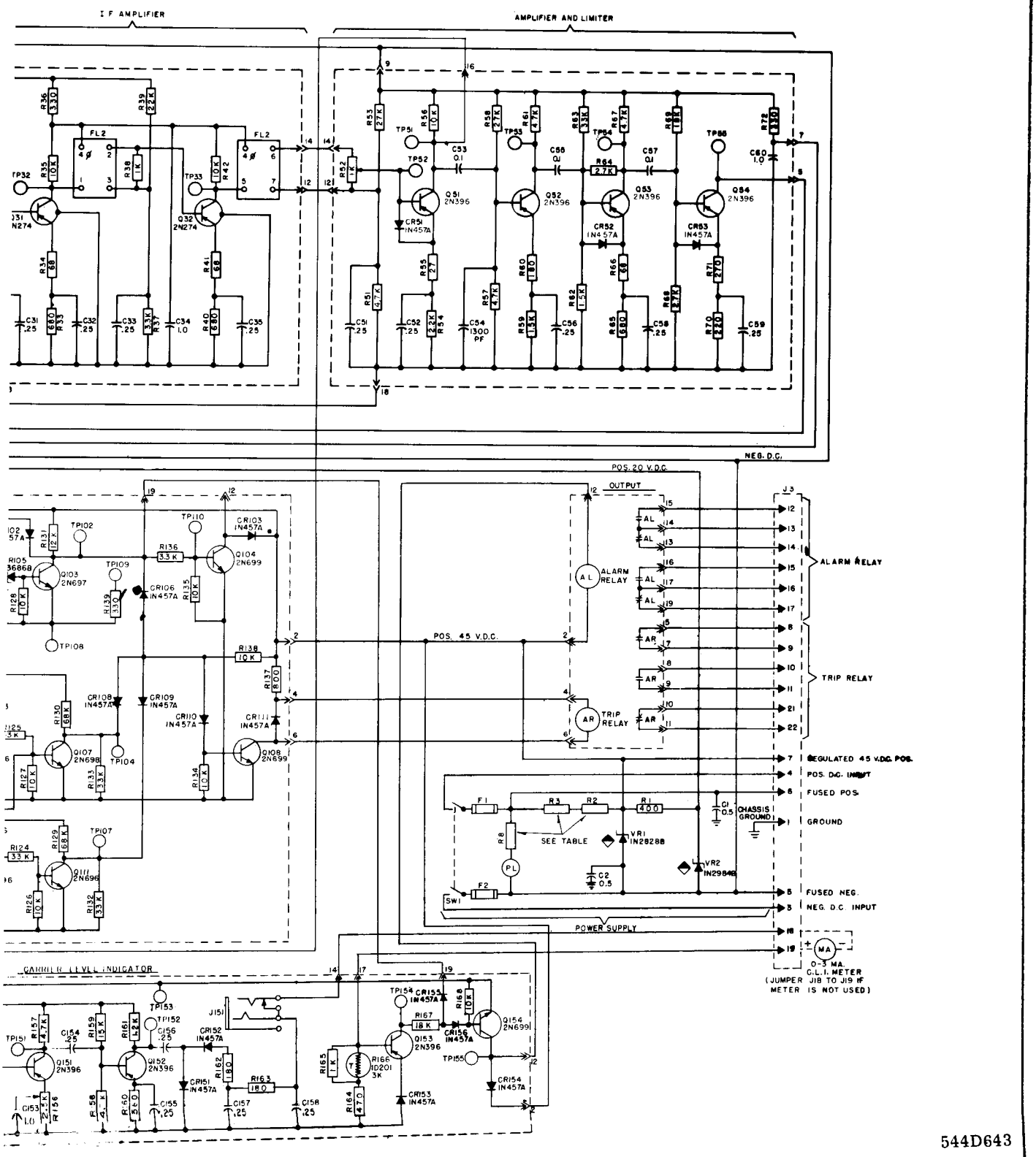
Transistors in the logic stage are operated either in saturation or cutoff. When in cutoff, the collector voltage can readily be estimated from inspection of the voltage-dividing resistors (and Zener diodes when used) associated with the transistor.



VOLTS D.C.	R2	R3	R8
48	26.5Ω	—	—
125	150Ω	150Ω	—
250	300Ω	500Ω	100K
⋈ 125/250	300Ω	500Ω	100K

RECEIVER FREQ.	C12
30 TO 80 KC	390 PF
80.1 TO 200 KC	51 PF

Fig. 2 Internal schematic of the type TCF



receiver with the carrier level indicator.

TABLE II
RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

* a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequence range 60 cycles/ sec. to 230-kc., input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 0.15 to 300 volts
Input Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kc to 230-kc

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19'' rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data and identify the part by its designation on the Internal Schematic drawing.

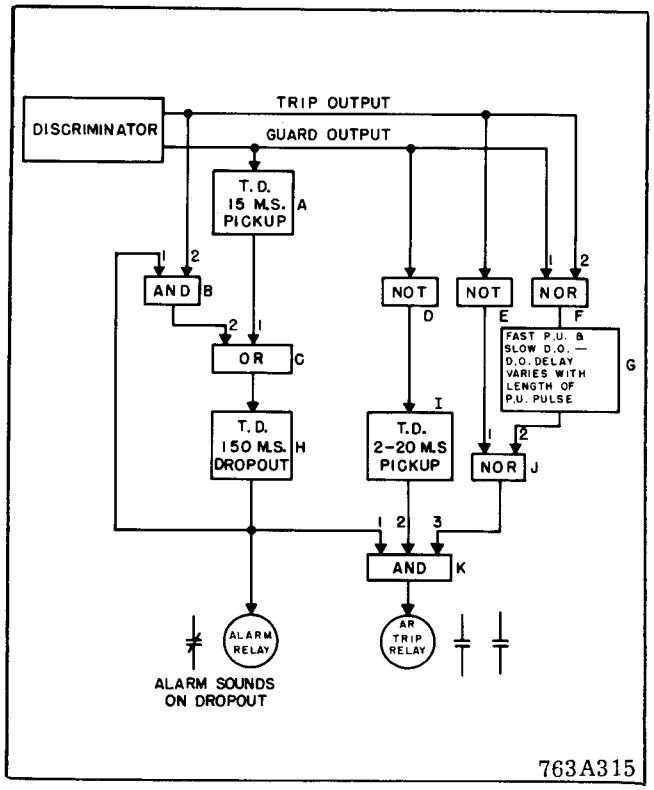


Fig. 3 Block diagram of output logic circuit

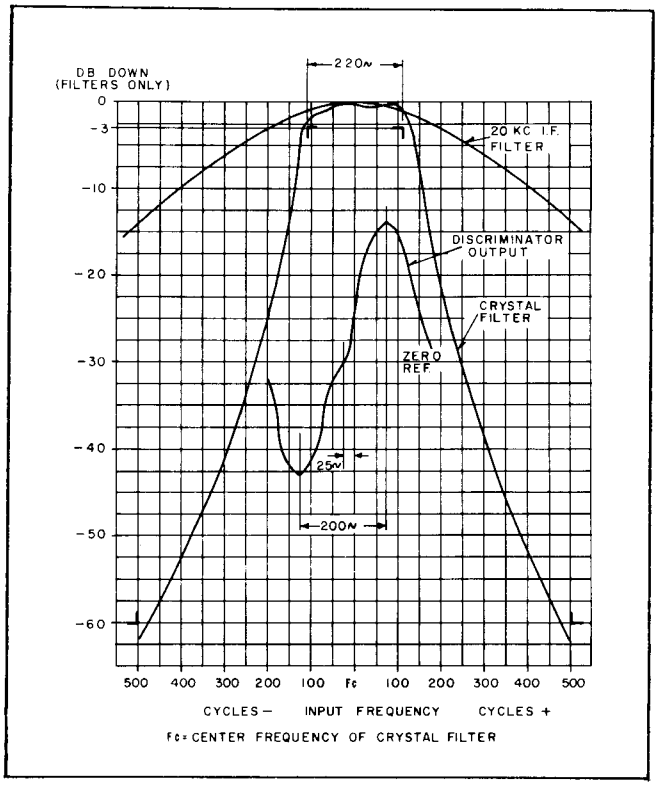


Fig. 4 Filter and discriminator characteristics of the type TCF receiver

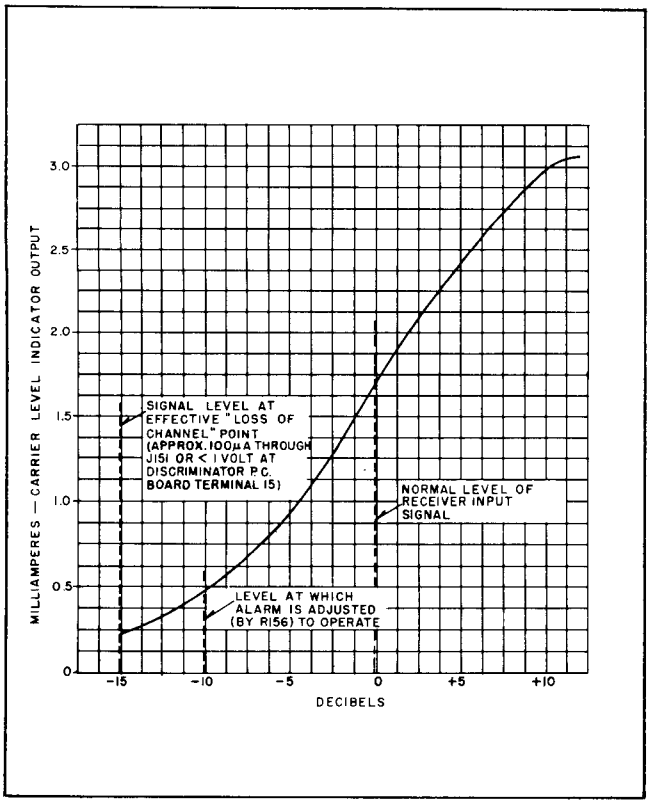


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

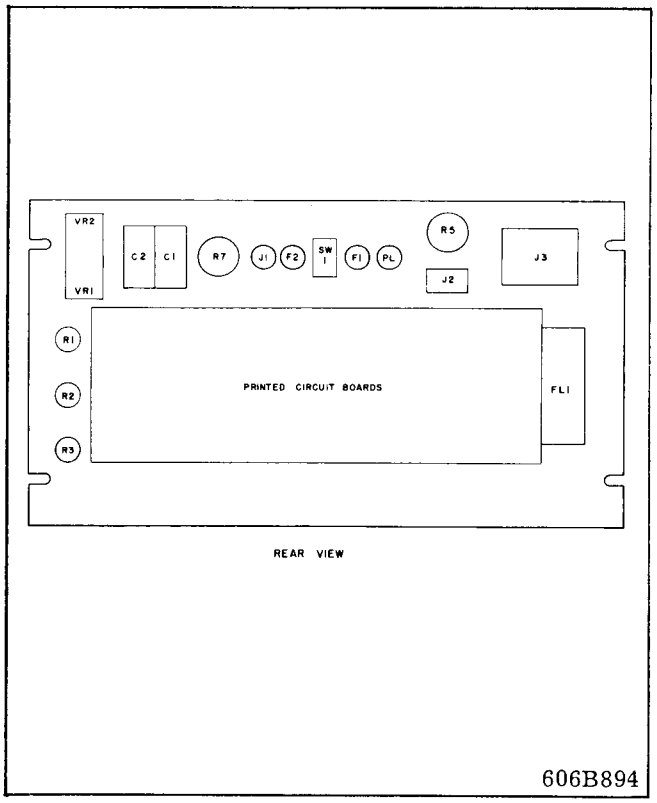


Fig. 6 Component locations on the type TCF receiver panel

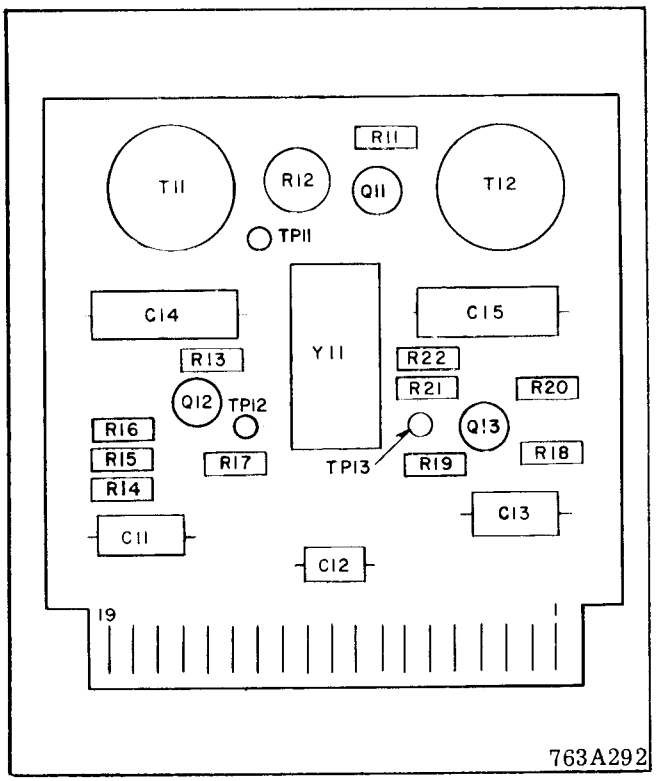


Fig. 7 Component locations on the oscillator and mixer printed circuit board.

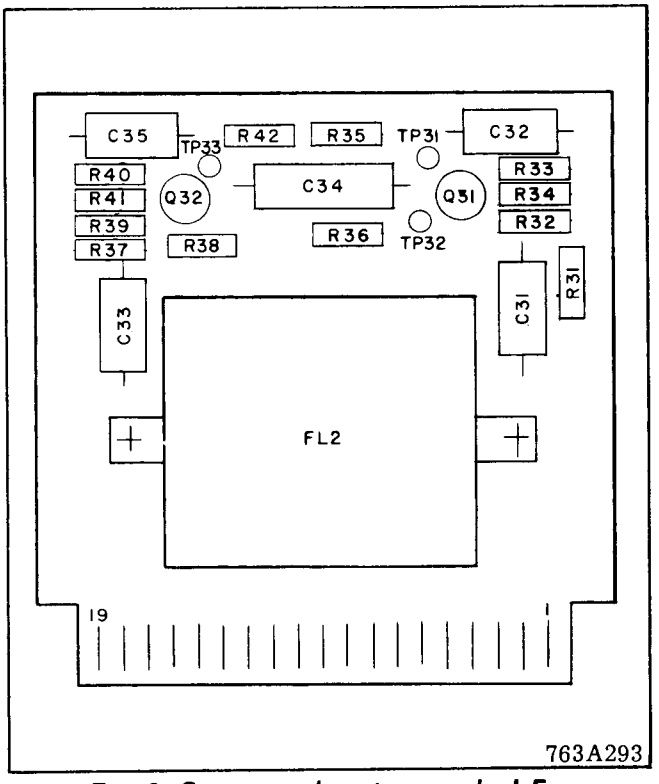


Fig. 8 Component locations on the I.F. amplifier printed circuit board.

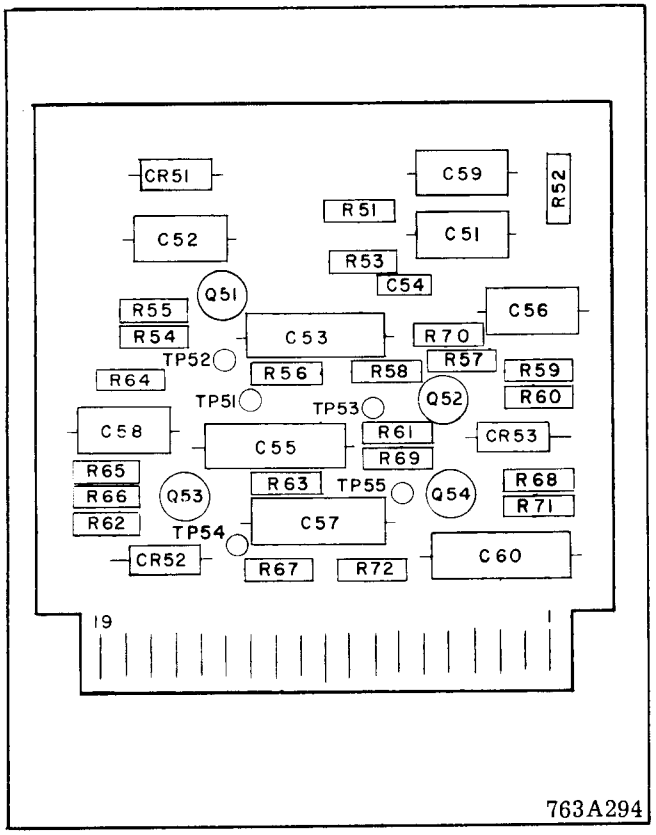


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

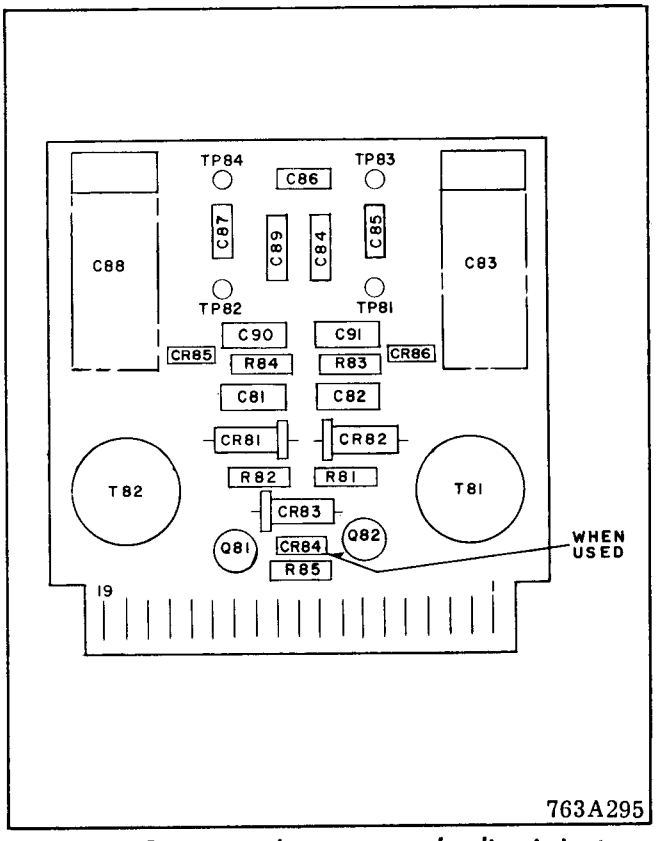


Fig. 10 Component locations on the discriminator printed circuit board.

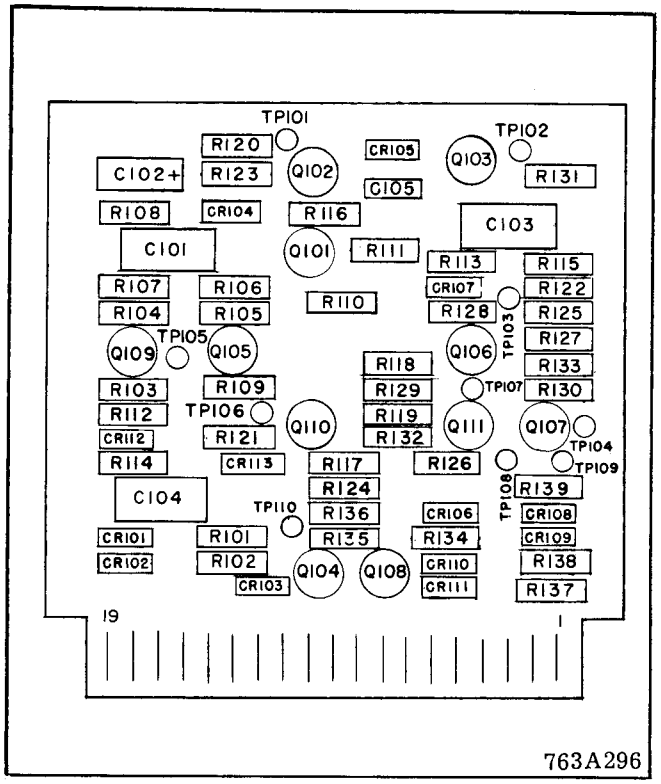


Fig. 11 Component locations on the logic printed circuit board.

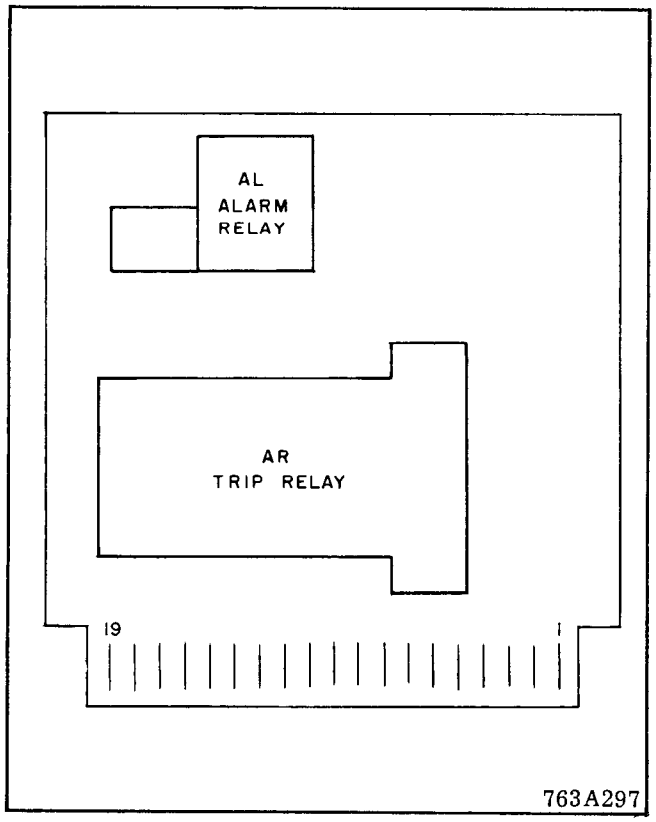


Fig. 12 Component locations on the output printed circuit board.

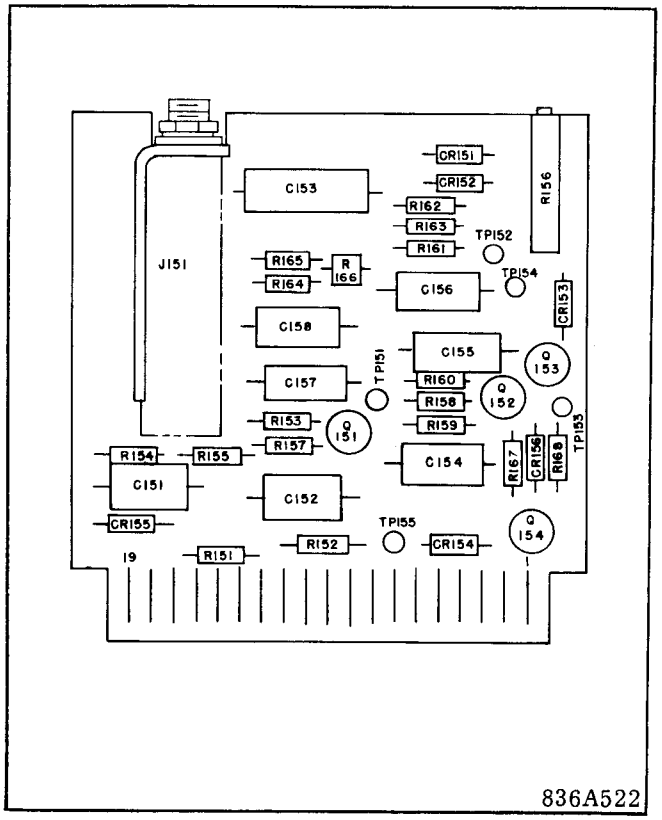


Fig. 13 Component locations on the carrier level indicator printed circuit board.

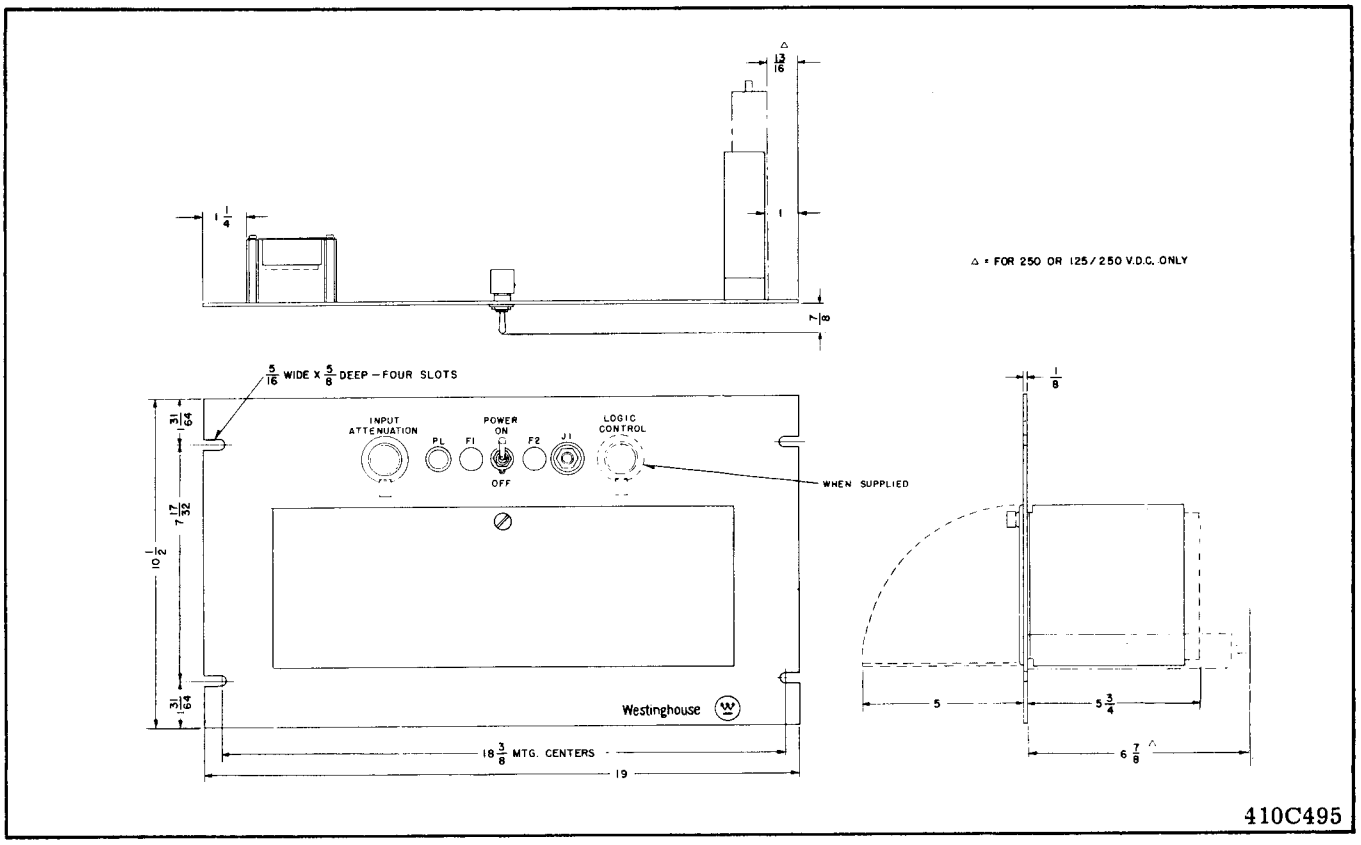


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT - TRANSFER TRIP

CAUTION It is recommended that the user of this equipment become thoroughly acquainted with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 cycles above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 cycles below the center frequency, and may also increase the power output of the transmitter (from1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electro-mechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14.

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125 or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signal to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 KC above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the latter is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of 20KC and 2fc + 20KC.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20KC. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20KC.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 cycles. The

adjustment for zero output at fc-25 cycles is made by capacitor C88. C83 also is adjusted to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 cycles above or below the zero output frequency. This separation of 200 cycles between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 cycles in the trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 cycles, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20KC-100 cycles. Similarly, the trip frequency is 20KC + 100 cycles. The intermediate frequency at which the discriminator has zero output then is 20.025 KC.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when terminal 4 is positive with respect to terminal 13 (which occurs with trip output) and Q81 is made conductive when terminal 4 is negative with respect to 13. Consequently, terminal 15 is at a potential of approximately +20 volts at Guard frequency and terminal 11 is at +20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuit

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to block A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 15 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 15 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears 15 ms. before C102 has reached the breakdown voltage of CR105, the charge is quickly dissipated through the 1K resistor R123, and the full time-delay will be effective on any subsequent loss of Guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligable voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors

Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator -- Fig. 2), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become non-conductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.5 ma.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C.

battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f or transient voltages to ground.

CHARACTERISTICS

Frequency range	30-200 KC
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 cycles down > 60 db at 1000 cycles down > 85 db at 3000 cycles
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 cycles to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay 3 ms. AR relay 14 ms. minimum time 18 ms. max. added logic time (if req'd by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 cycles minimum
B. For two-way channel	1500 cycles minimum between transmitter and adjacent receiver frequencies
Ambient temperature range	-20 °C to +60°C temperature around chassis
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C	42 - 56 V.D.C.
125 V.D.C	105 -140 V.D.C.
250 V.D.C.	210 -280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation

are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximun expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed, the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

The adjustments described above are those normally required when putting a new receiver in service. However, in case factory adjustments have been accidently disturbed or components have been replaced, it may be necessary to readjust the oscillator and mixer, the limiter, or the discriminator.

Potentiometer R12 in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20KC above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should be connected from the base of transistor Q54 to terminal 18 of the limiter. With 5 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting. The R52 adjusting screw then should be turned one turn farther in the direction to produce limiting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 cycles in the trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 cycles. (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 125 cycles, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points or terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I

RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 18 (+20 v.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (-)
Q11	20
Q12	14.5 (No signal)
Q12	14.0 (Guard or Trip)
Q13	17.0 (No signal)
Q13	15.0 (Guard or Trip)
Q31	18.5
Q32	18.5
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q81	20 (No sig. or Trip)
Q81	.25 (Guard)
Q82	20 (No sig. or Guard)
Q82	.25 (Trip)

Transistors in the logic stage are operated either in saturation or cutoff. When in cutoff, the collector voltage can readily be estimated from inspection of the voltage-dividing resistors (and Zener diodes when used) associated with the transistor.

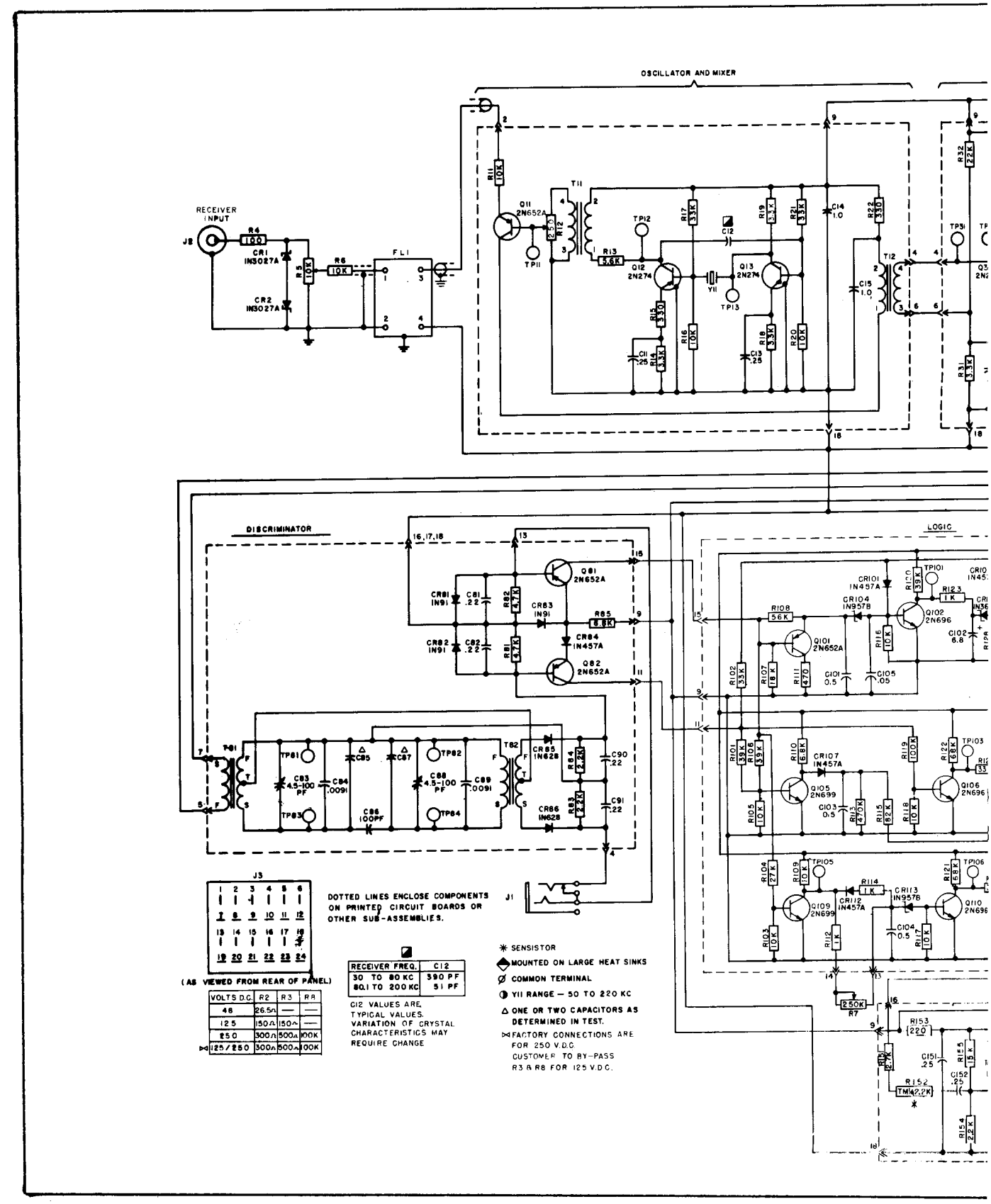
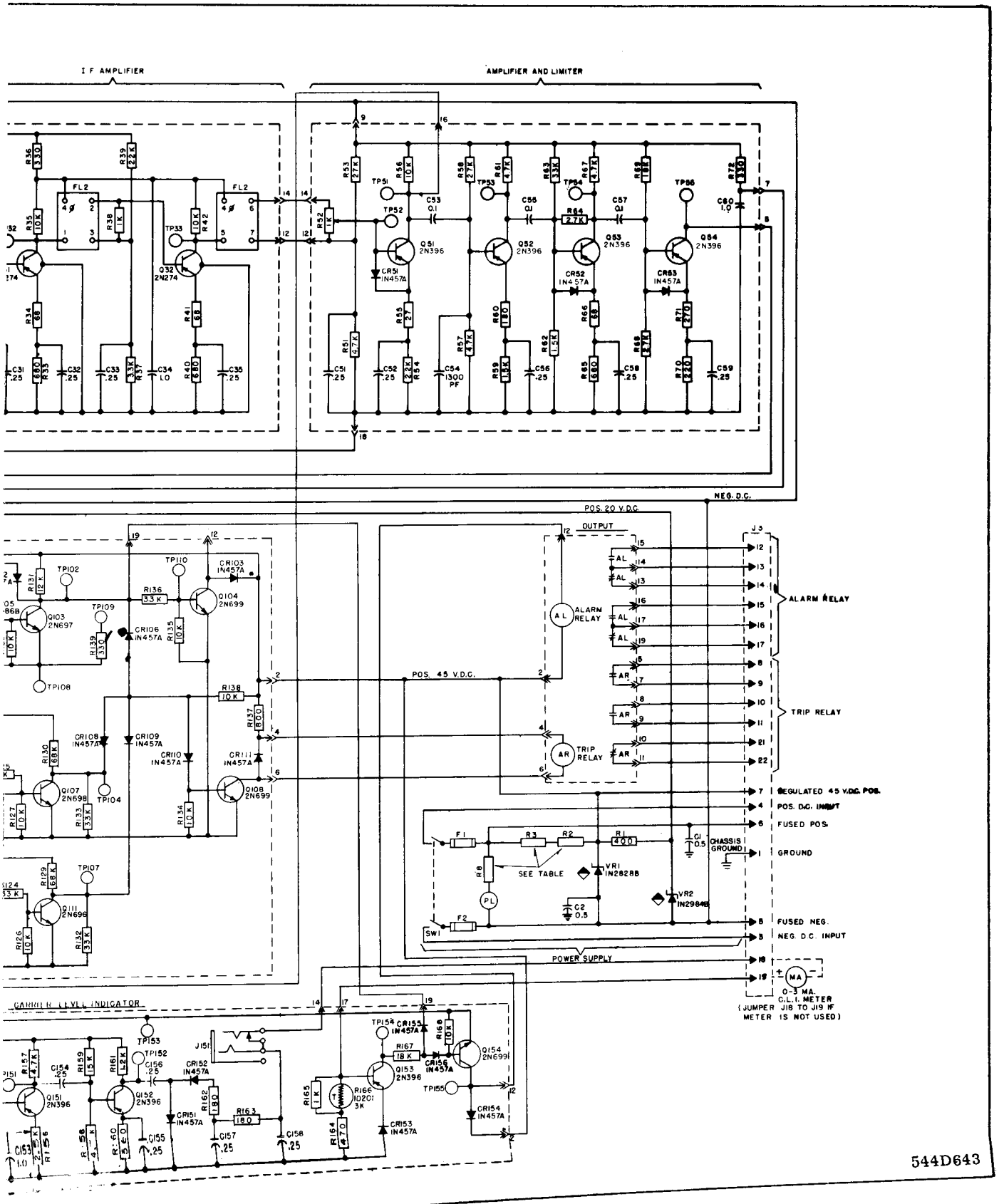


Fig. 2 Internal schematic of the type TCF



eceiver with the carrier level indicator.

TABLE II
RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM9. Voltage range 0.03 to 30 volts, frequence range 60 cycles/sec. to 230-kc., input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 0.15 to 300 volts
Input Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kc to 230-kc

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19'' rack but also can be removed and used as a portable unit.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data and identify the part by its designation on the Internal Schematic drawing.

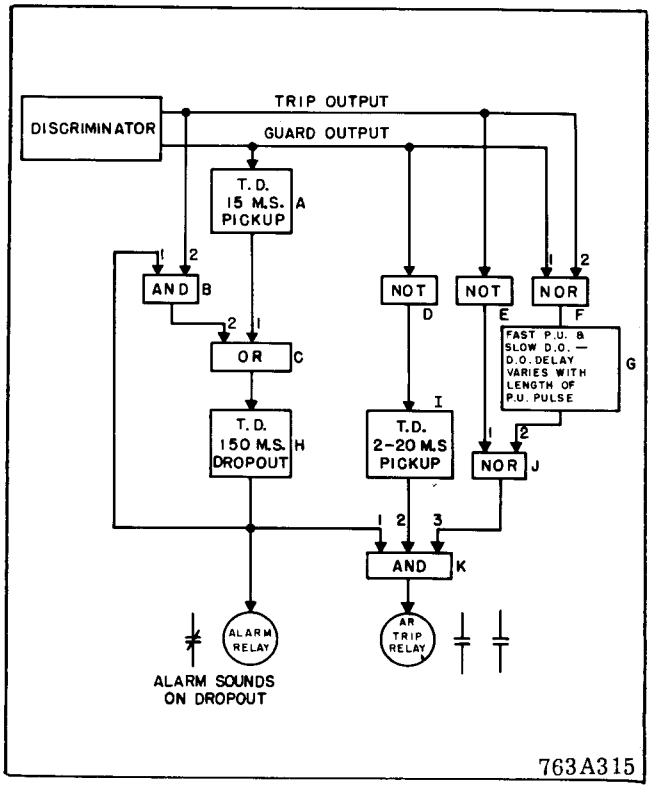


Fig. 3 Block diagram of output logic circuit

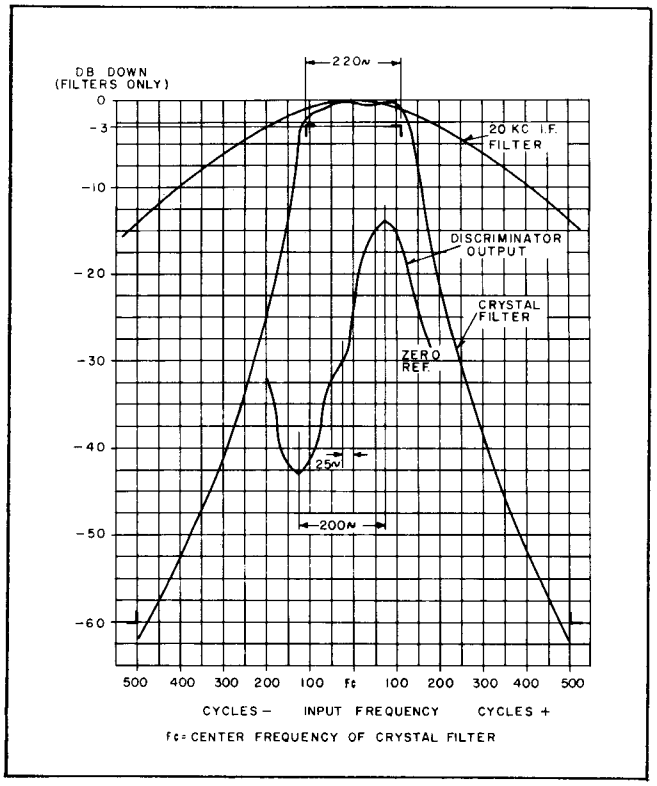


Fig. 4 Filter and Discriminator Characteristics of the type TCF receiver

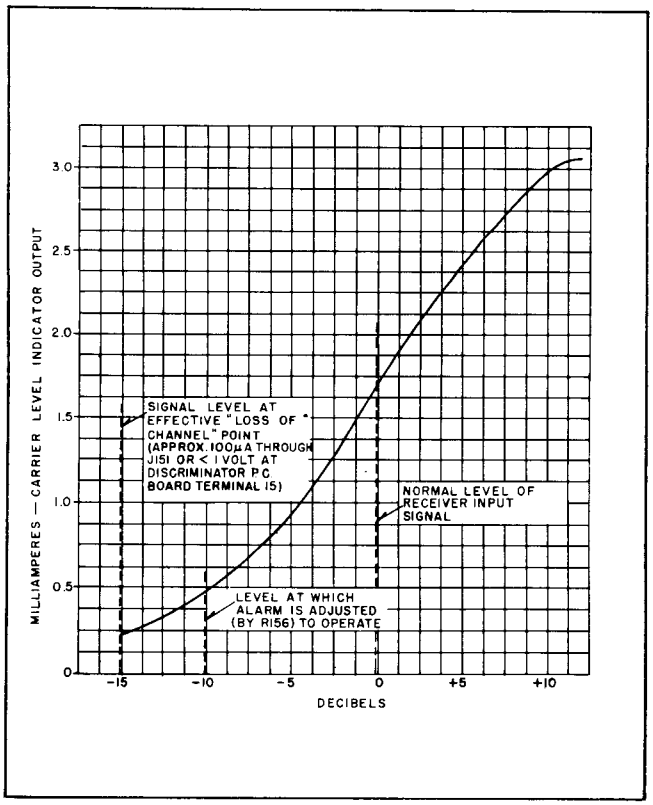


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

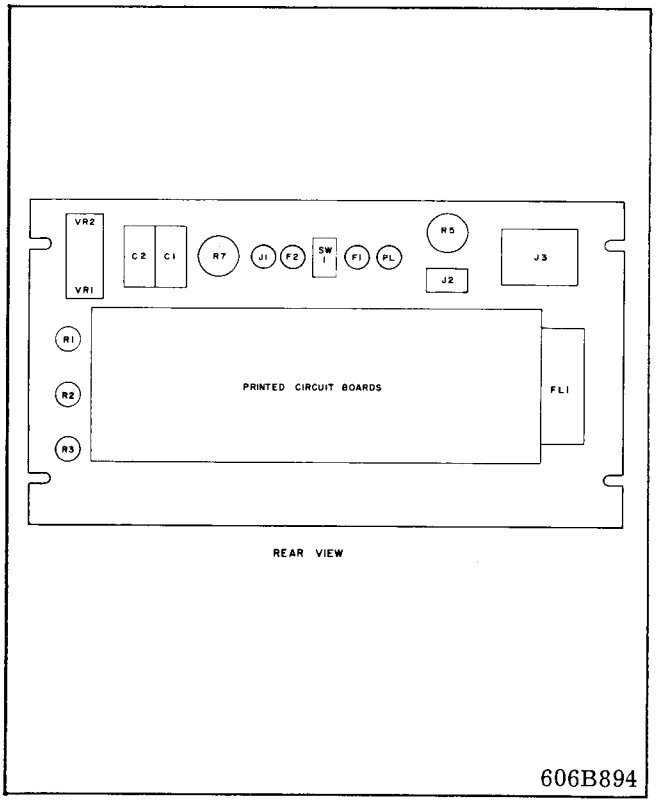


Fig. 6 Component locations on the type TCF Receiver panel

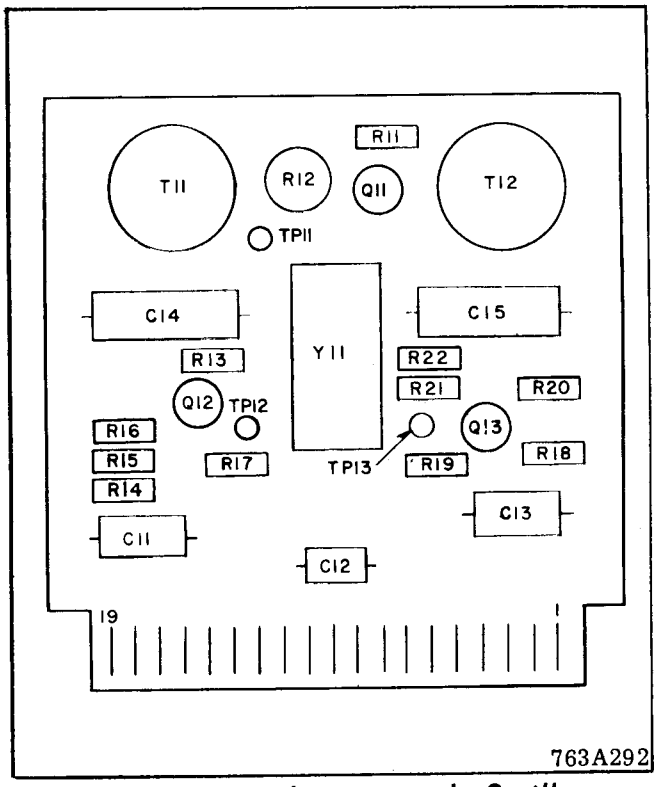


Fig. 7 Component locations on the Oscillator and Mixer printed circuit board.

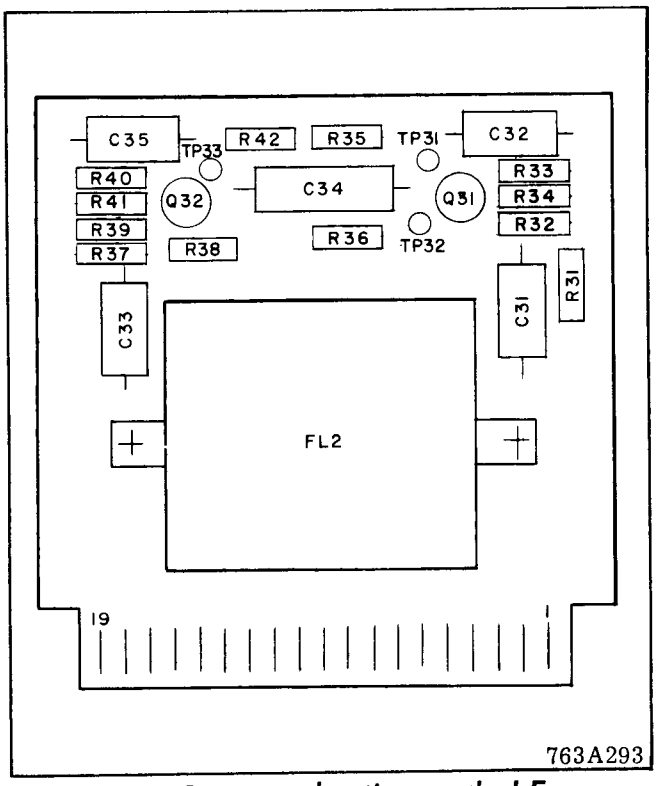


Fig. 8 Component locations on the I.F. Amplifier printed circuit board.

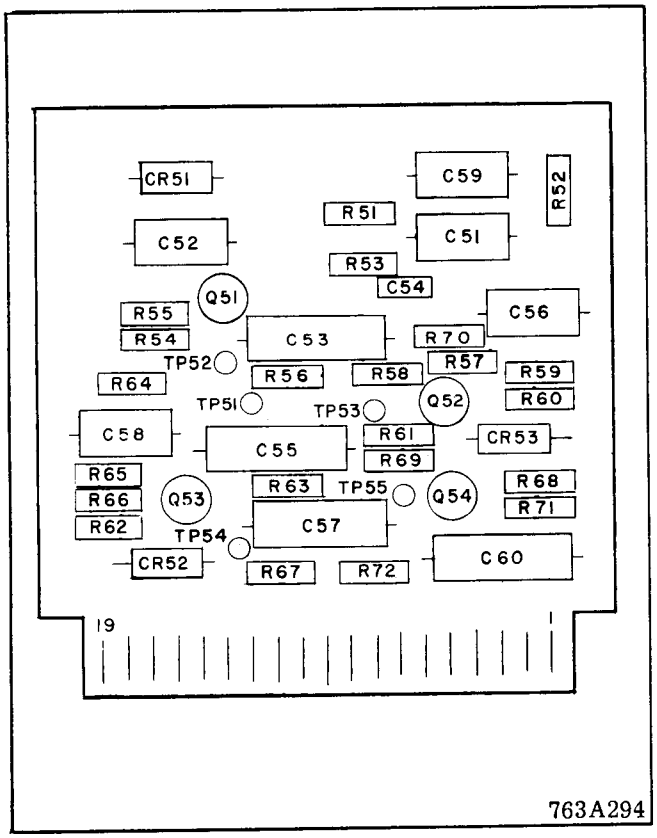


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

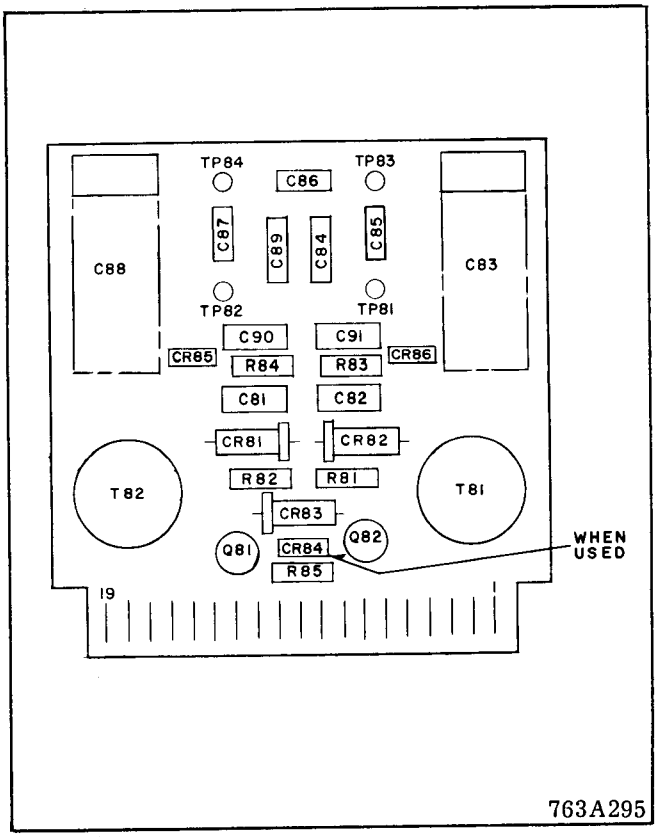


Fig. 10 Component locations on the Discriminator printed circuit board.

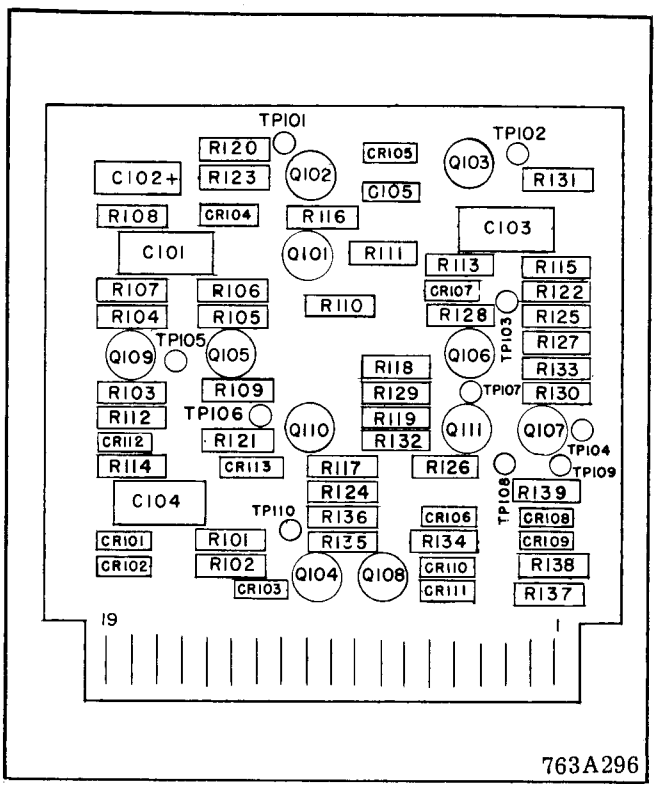


Fig. 11 Component locations on the logic printed circuit board.

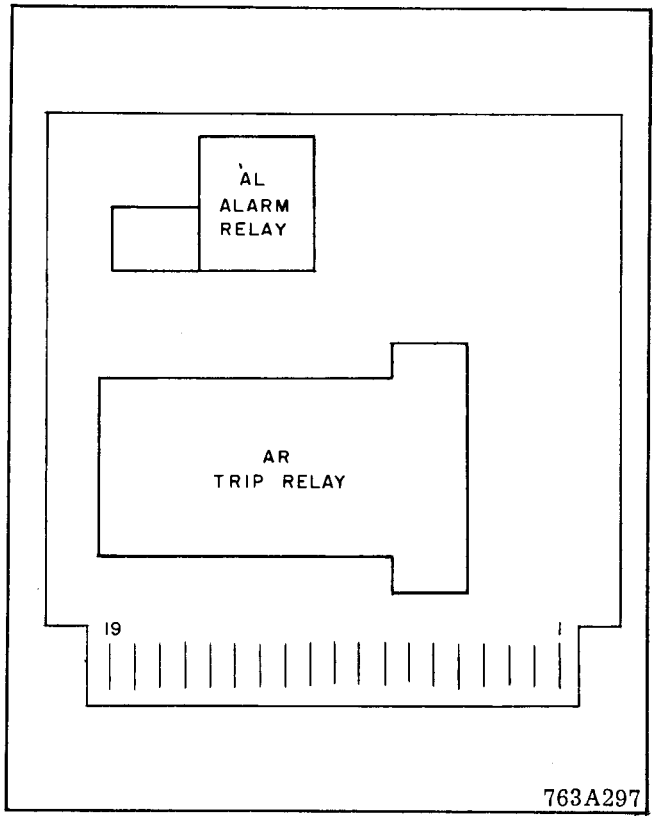


Fig. 12 Component locations on the Output printed circuit board.

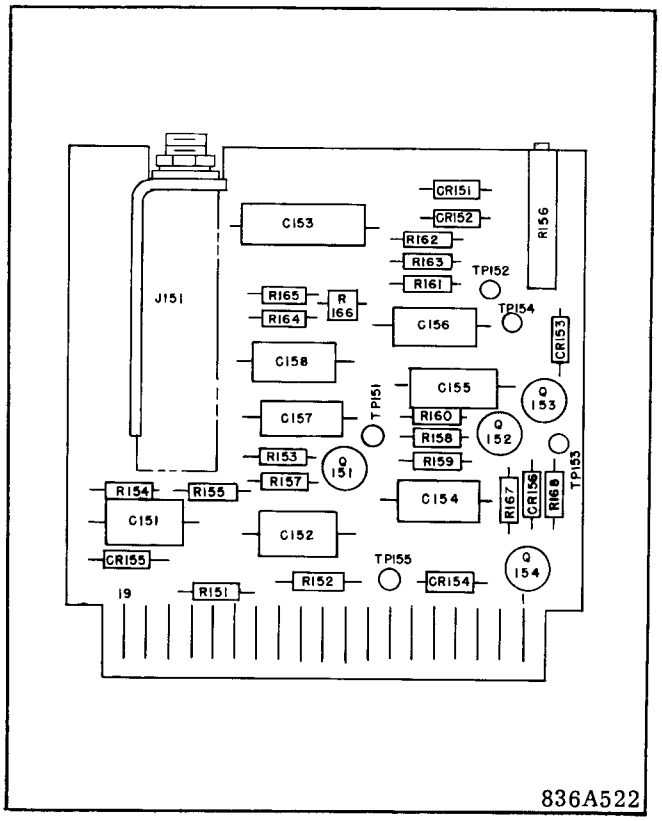


Fig. 13 Component locations on the carrier level indicator printed circuit board.

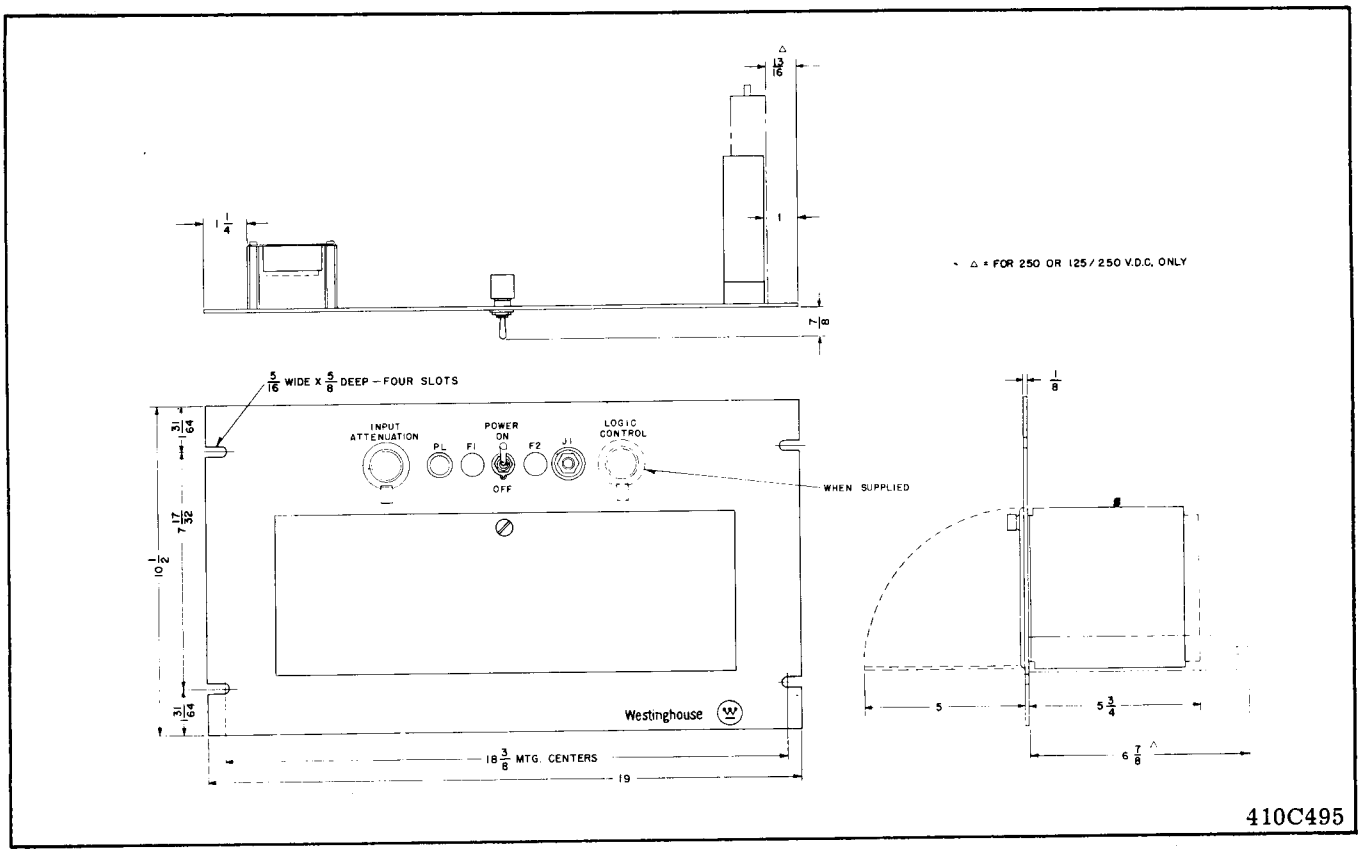


Fig. 14 Outline and Drilling plan for the type TCF Receiver assembly.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION

NEWARK, N. J.

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT - TRANSFER TRIP

CAUTION It is recommended that the user of this equipment become thoroughly acquainted with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

If the carrier set is mounted in a cabinet, it must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tipping over.

APPLICATION

The TCF frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 cycles above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 cycles below the center frequency, and may also increase the power output of the transmitter (from1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electro-mechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14.

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125 or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

The signal to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 KC above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the latter is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of 20KC and 2fc + 20KC.

IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20KC. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20KC.

Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 cycles. The

adjustment for zero output at fc-25 cycles is made by capacitor C88. C83 also is adjusted to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 cycles above or below the zero output frequency. This separation of 200 cycles between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 cycles in the trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 cycles, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20KC-100 cycles. Similarly, the trip frequency is 20KC + 100 cycles. The intermediate frequency at which the discriminator has zero output then is 20.025 KC.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when terminal 4 is positive with respect to terminal 13 (which occurs with trip output) and Q81 is made conductive when terminal 4 is negative with respect to 13. Consequently, terminal 15 is at a potential of approximately +20 volts at Guard frequency and terminal 11 is at +20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

Logic Circuit

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to block A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 15 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 15 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears 15 ms. before C102 has reached the breakdown voltage of CR105, the charge is quickly dissipated through the 1K resistor R123, and the full time-delay will be effective on any subsequent loss of Guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligable voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors

Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator -- Fig. 2), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become non-conductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 1.7 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.5 ma.

Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C.

battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f or transient voltages to ground.

CHARACTERISTICS

Frequency range	30-200 KC
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 cycles down > 60 db at 1000 cycles down > 85 db at 3000 cycles
Discriminator	Set for 200 cycles shift from Guard to Trip frequency. Offset 25 cycles to favor Guard for all relay-output applications.
Operating time	9 ms. channel (transm. and recvr.) 2 ms. min. logic delay 3 ms. AR relay 14 ms. minimum time 18 ms. max. added logic time (if req'd by noise conditions) 32 ms. maximum time
Frequency spacing	
A. For two or more signals over one-way channel	500 cycles minimum
B. For two-way channel	1500 cycles minimum between transmitter and adjacent receiver frequencies
Ambient temperature range	-20 °C to +60°C temperature around chassis
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C	42 - 56 V.D.C.
125 V.D.C	105 -140 V.D.C.
250 V.D.C.	210 -280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation

are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximun expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION - Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed, the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

The adjustments described above are those normally required when putting a new receiver in service. However, in case factory adjustments have been accidently disturbed or components have been replaced, it may be necessary to readjust the oscillator and mixer, the limiter, or the discriminator.

Potentiometer R12 in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20KC above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should be connected from the base of transistor Q54 to terminal 18 of the limiter. With 5 mv. of Guard frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting. The R52 adjusting screw then should be turned one turn farther in the direction to produce limiting.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 cycles in the trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 cycles. (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 125 cycles, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points or terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values after adjustment in order to establish reference values which will be useful when checking the apparatus. The readings will remain fairly constant over an indefinite period unless a failure occurs. However, if transistors are changed, there may be considerable difference in these readings without the overall performance being affected.

Typical voltage values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I
RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 18 (+20 v.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

Collector of Transistor	Volts (-)
Q11	20
Q12	14.5 (No signal)
Q12	14.0 (Guard or Trip)
Q13	17.0 (No signal)
Q13	15.0 (Guard or Trip)
Q31	18.5
Q32	18.5
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q81	20 (No sig. or Trip)
Q81	.25 (Guard)
Q82	20 (No sig. or Guard)
Q82	.25 (Trip)

Transistors in the logic stage are operated either in saturation or cutoff. When in cutoff, the collector voltage can readily be estimated from inspection of the voltage-dividing resistors (and Zener diodes when used) associated with the transistor.

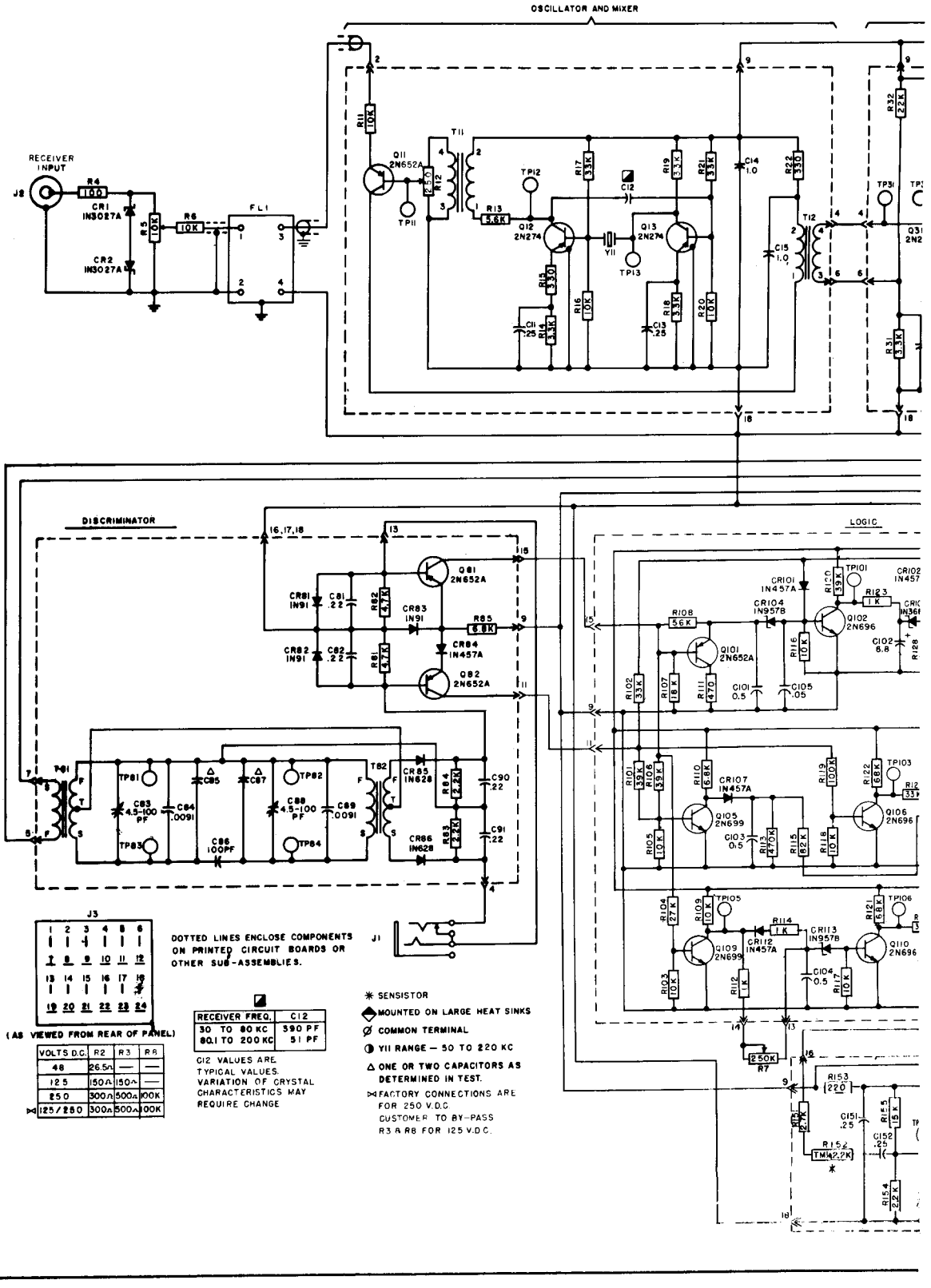
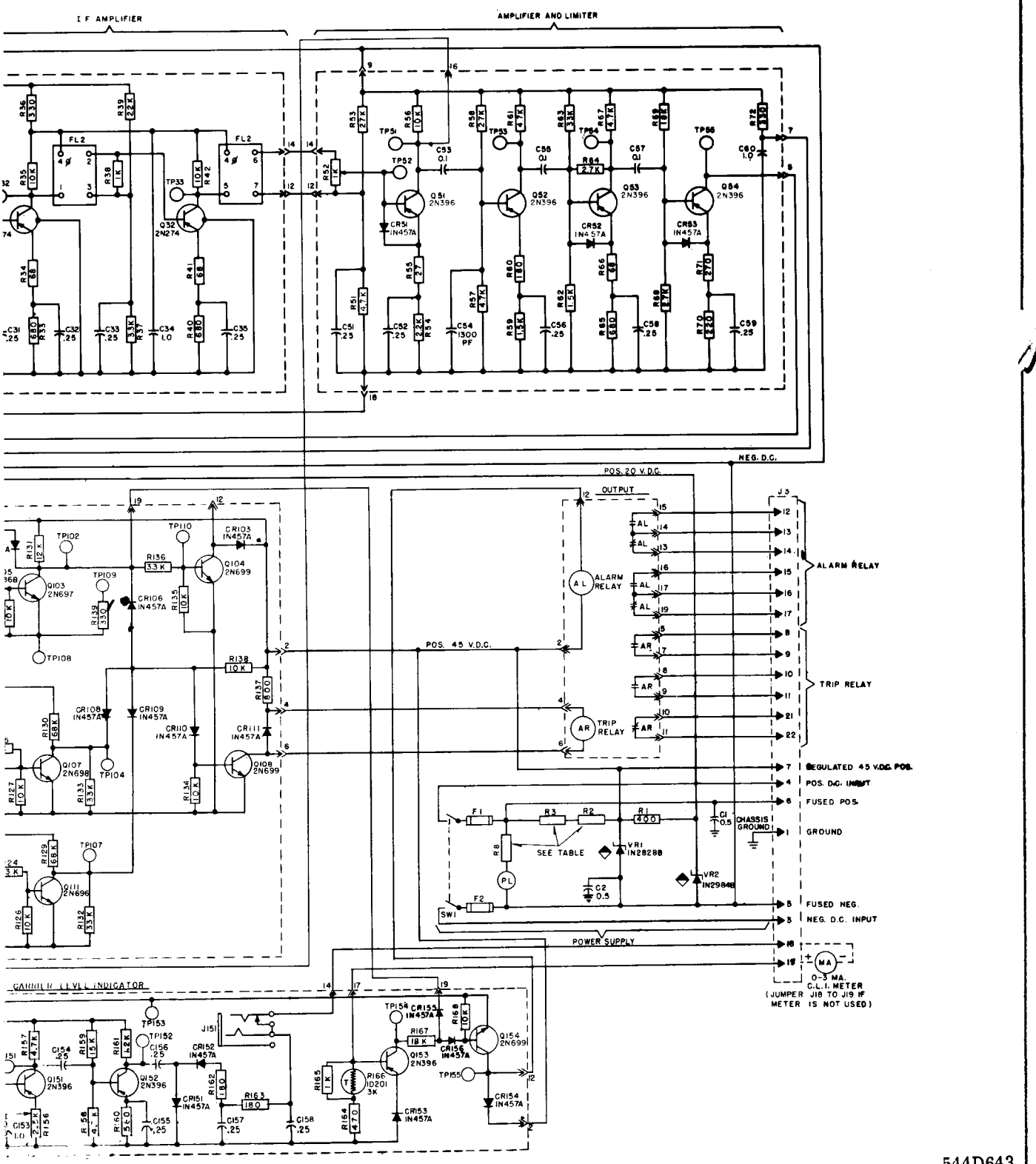


Fig. 2 Internal schematic of the type TCF r



eceiver with the carrier level indicator.

TABLE II
RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

Collector of Transistor	Volts (1 watt-Guard)	Volts (10 watts-Trip)
Q32	.25	.8
Q51	.3	.9
Q52	.4	.65
Q53	2.1	2.2
Q54	4.8	4.5

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. A-C vacuum Tube Voltmeter (VTVM9. Voltage range 0.03 to 30 volts, frequence range 60 cycles/ sec. to 230-kc., input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 0.15 to 300 volts
Input Impedance: 7.5 megohms

c. Milliammeter, 0-3 range (if receiver has carrier level indicator).

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kc to 230-kc

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

Some of the functions of the recommended test equipment are combined in the type TCT carrier test r unit, which is designed to mount on a standard 19'' rack but also can be removed and used as a portable

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be fur in most cases, to customers who are equipped for doing repair work. When ordering parts, always giv plete nameplate data and identify the part by its designation on the Internal Schematic drawing.

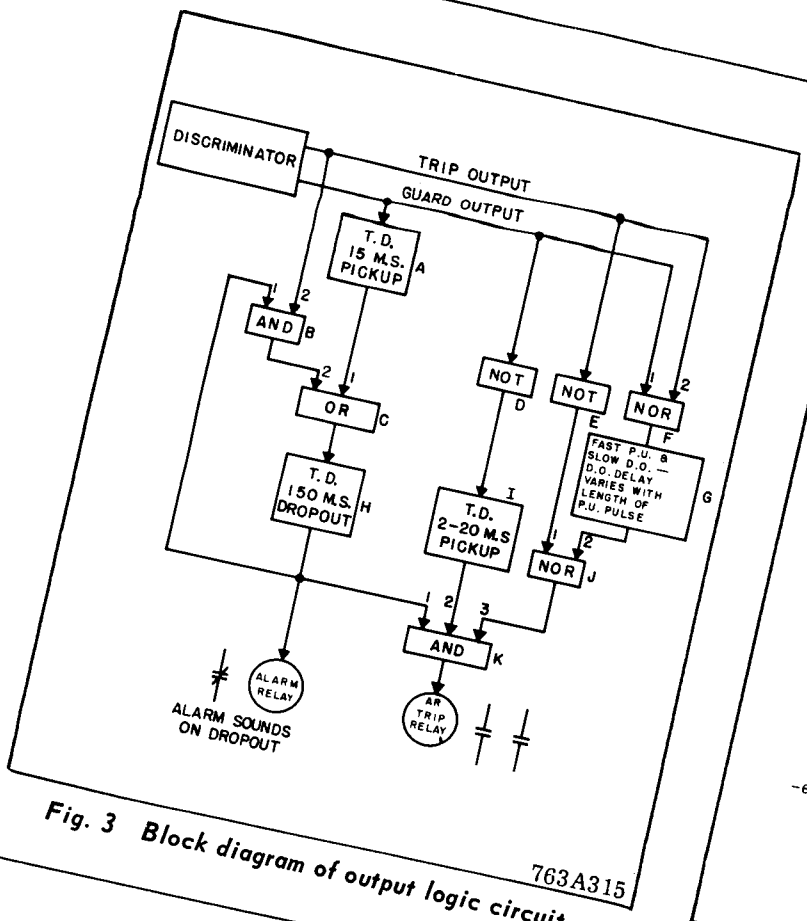


Fig. 3 Block diagram of output logic circuit

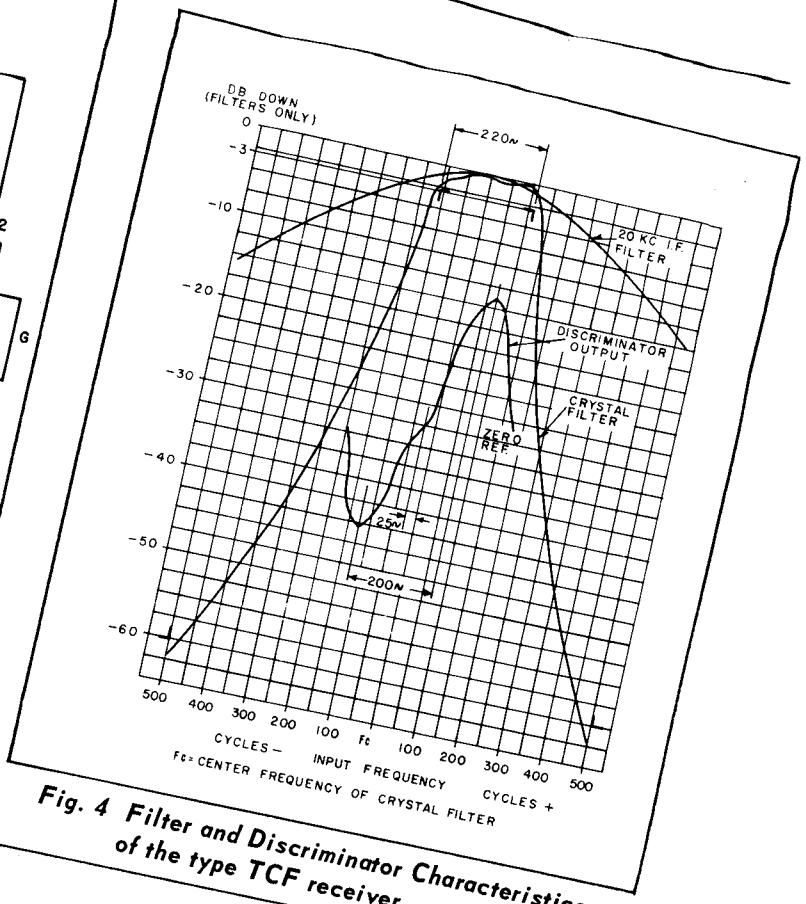
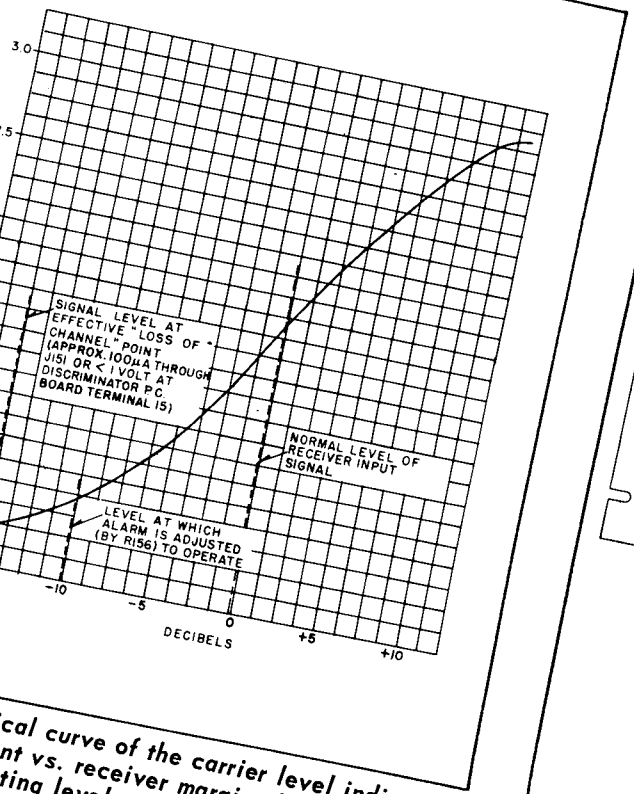


Fig. 4 Filter and Discriminator Characteristics of the type TCF receiver



cal curve of the carrier level indicator nt vs. receiver margin above minimum ting level.

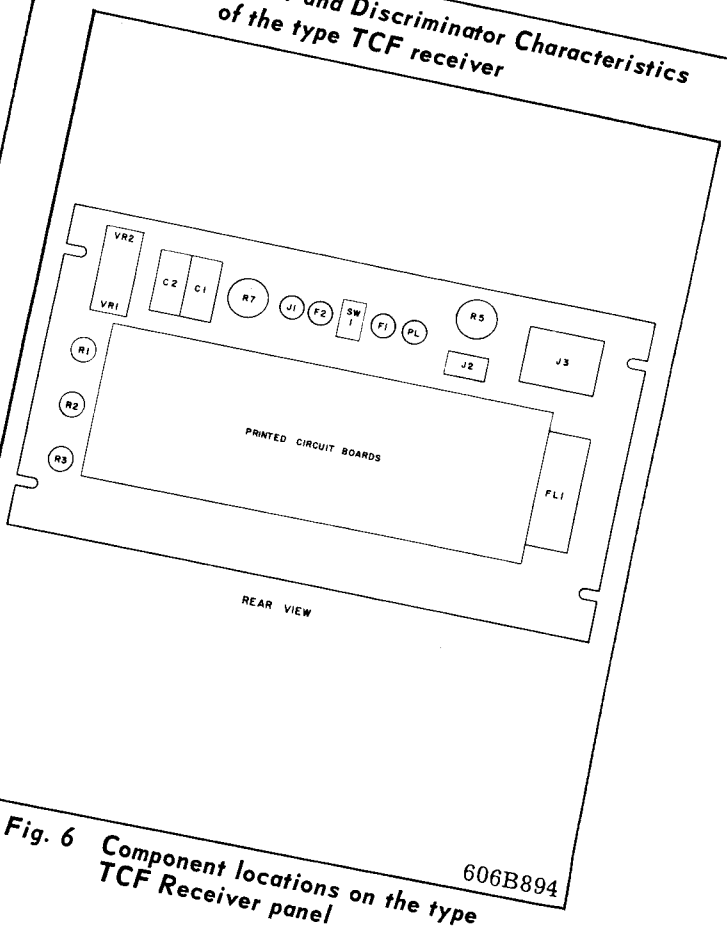


Fig. 6 Component locations on the type TCF Receiver panel

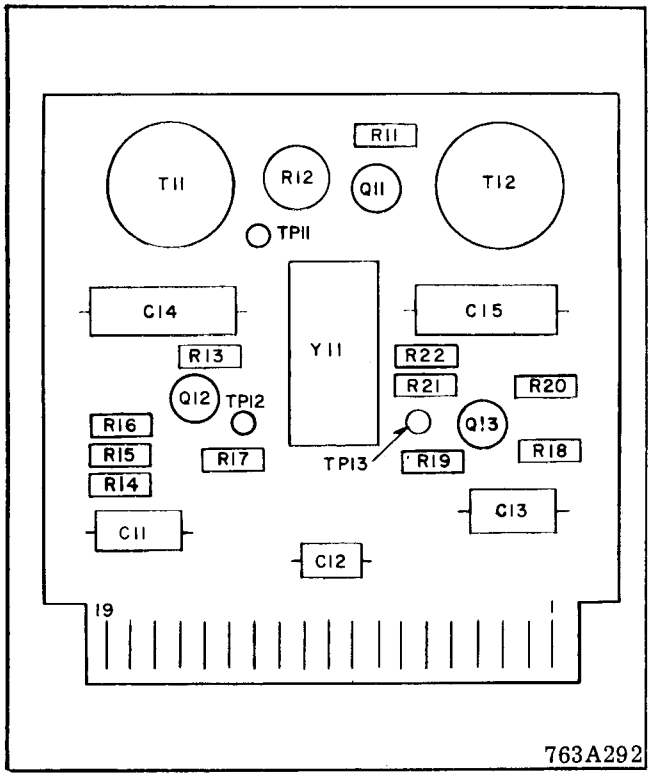


Fig. 7 Component locations on the Oscillator and Mixer printed circuit board.

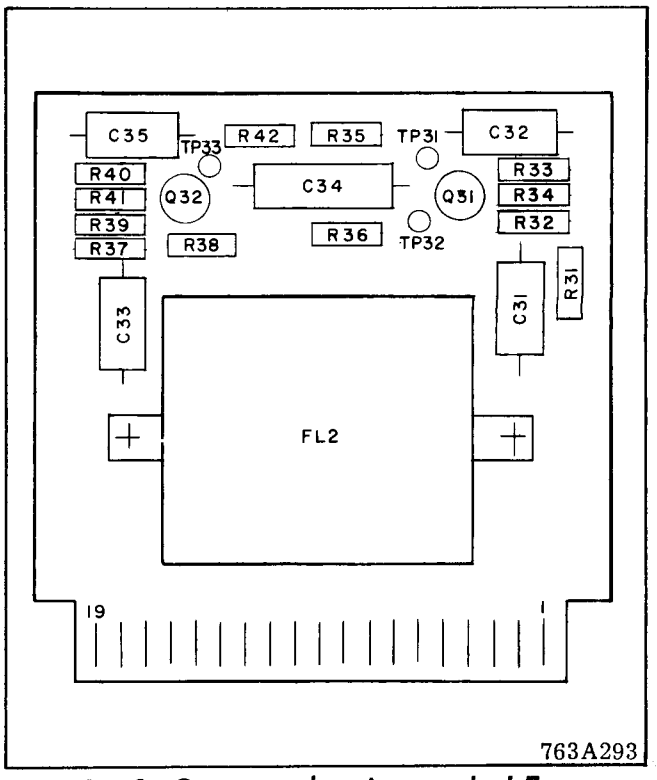


Fig. 8 Component locations on the I.F. Amplifier printed circuit board.

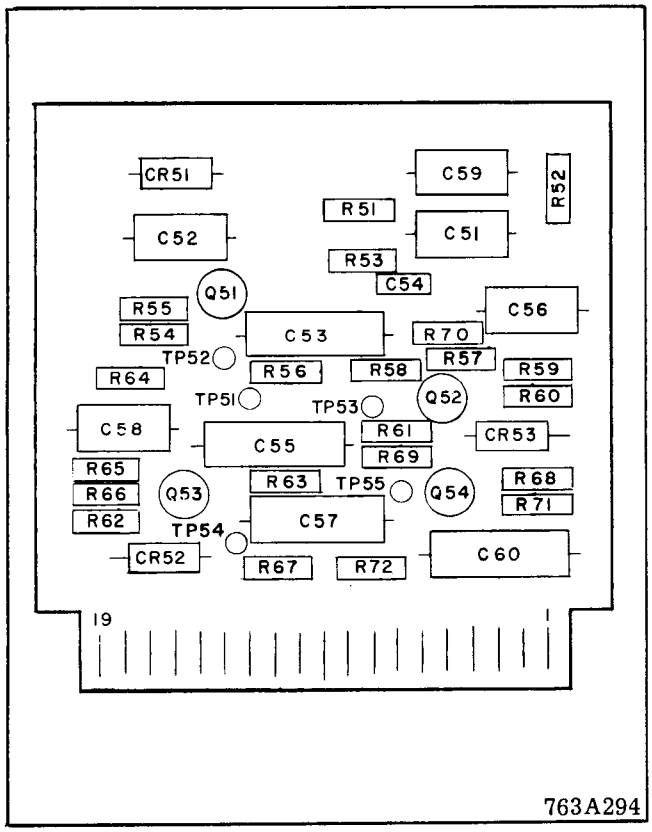


Fig. 9 Component locations on the amplifier and limiter printed circuit board.

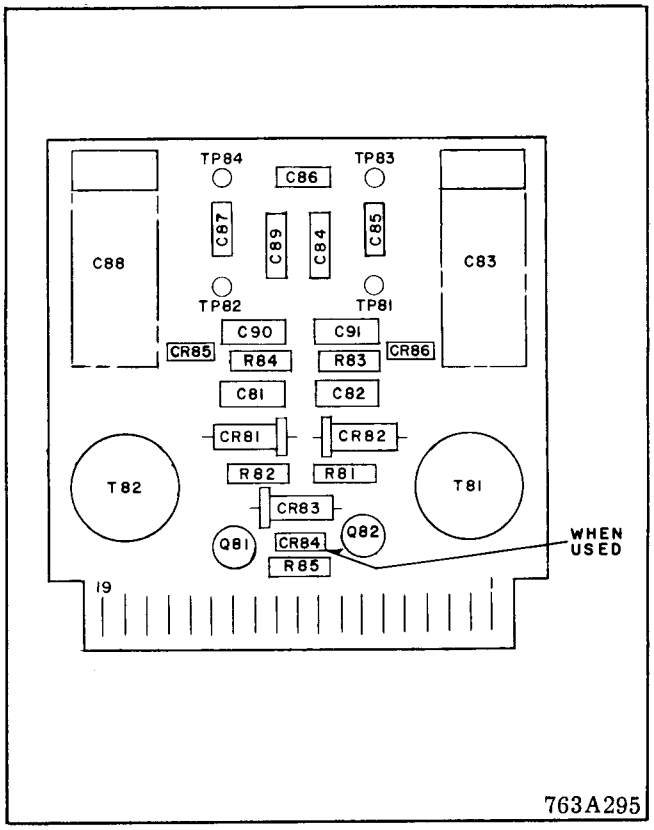


Fig. 10 Component locations on the Discriminator printed circuit board.

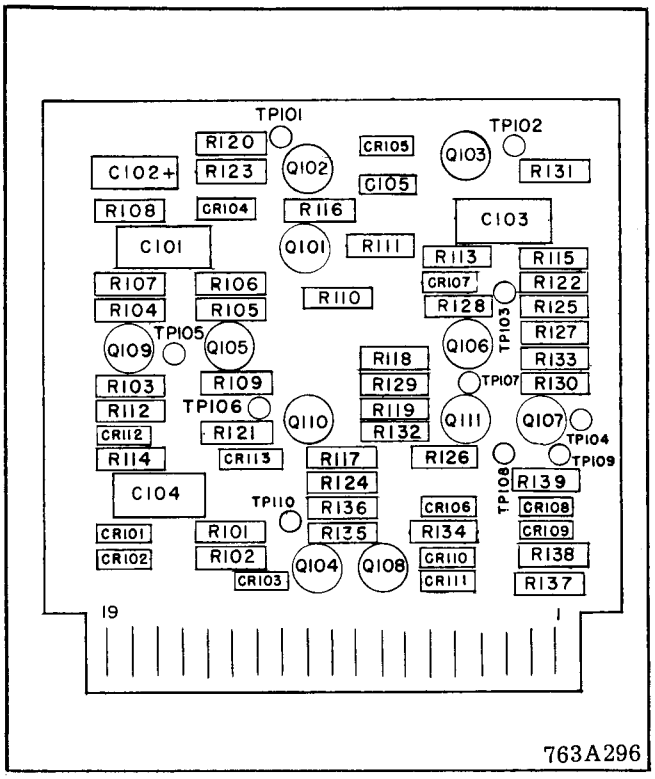


Fig. 11 Component locations on the logic printed circuit board.

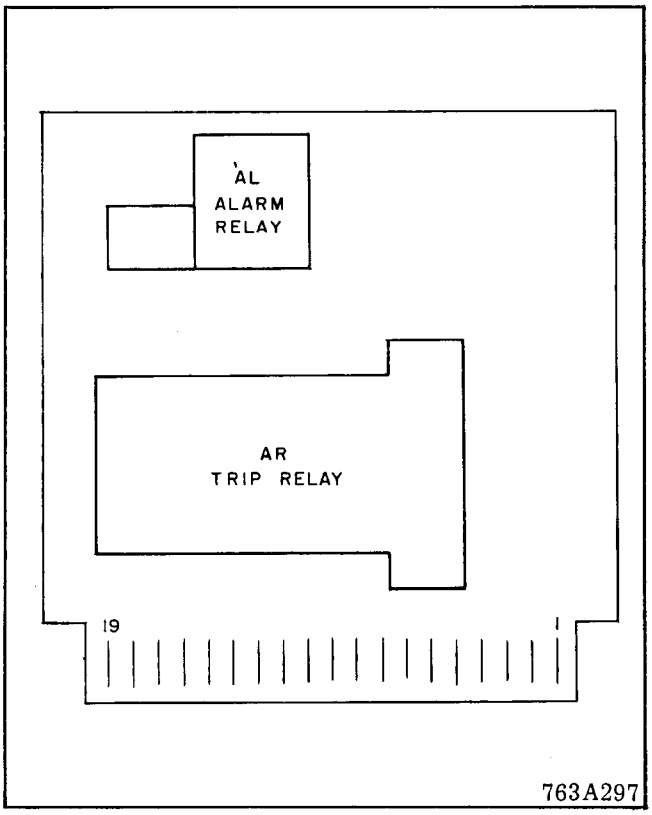


Fig. 12 Component locations on the Output printed circuit board.

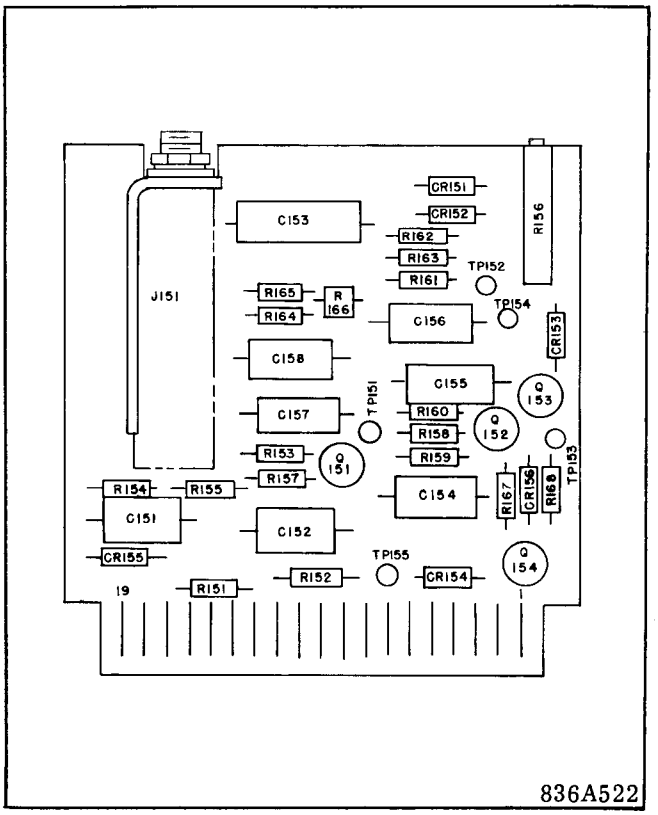


Fig. 13 Component locations on the carrier level indicator printed circuit board.

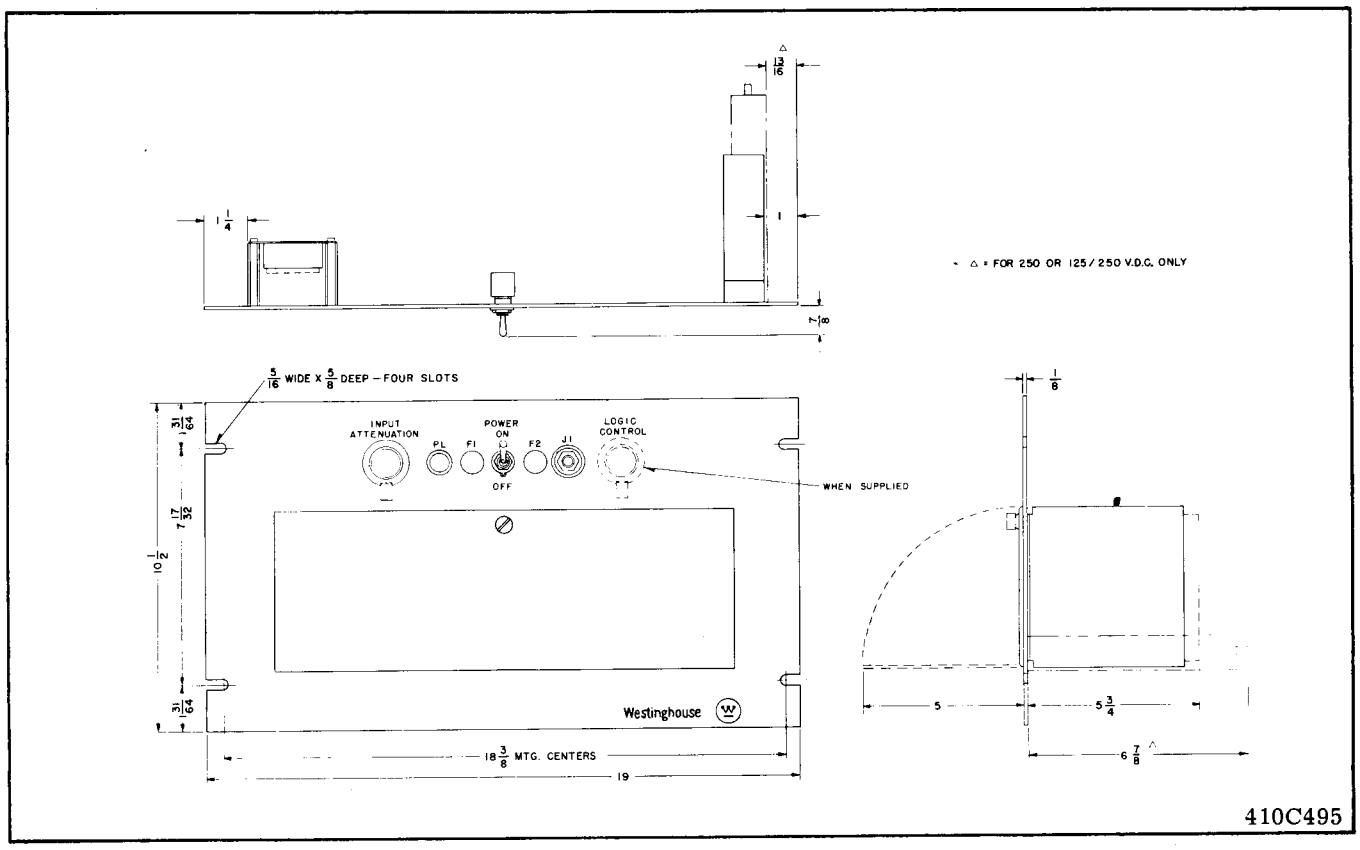


Fig. 14 Outline and Drilling plan for the type TCF Receiver assembly.

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