INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY – SHIFT RECEIVER EQUIPMENT – WITH RELAY OUTPUT FOR SUPERVISORY CONTROL AND TELEMETERING

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 supervisory control and certain telemetering applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard frequency is 100 cycles above the center frequency of the channel (which can be selected within the range of 30KC to 200KC), and it is transmitted continuously when conditions are normal and no information is to be conveyed over the channel. Its reception indicates that the channel is operative. The Trip frequency (so called because in frequency-shift relaying applications the reception of this frequency causes closure of relay contacts in the trip circuit of a circuit breaker) is 100 cycles below the channel center frequency. When supervisory control or telemetering information is to be conveyed over the channel, the transmitter at one end of the channel is switched alternately between Guard and Trip so as to produce at the receiving end a desired number of operations of a relay activated by the trip frequency. Control of the durations of the intervals that the relay contacts are open and closed also can be utilized to convey information over the channel.

CONSTRUCTION

The TCF receiver unit for supervisory control and telemetering 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, and a jack for metering the discriminator output current are accessible from the front of the panel. Refer to Fig. 3.

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. 4. 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.

TCF receivers for transfer trip relaying require a logic circuit board and may require a carrier level indicator circuit board, which are contained in the third-from-right and right hand compartments respectively. These are not required for the TCF receiver for supervisory control and telemetering and the compartments are vacant.

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 is 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 20V.D.C. 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.C.D.

External connections to the receiver are made through a 24-circuit receptacle, J3 on 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. 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. Figure 2 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 press 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 cycles. The adjustment for zero output at fc 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). It should be observed that although the higher signal frequency is fc + 100 cycles, after leaving the mixer stage and as seen by the discriminator the corresponding frequency is 20KC-100 cycles. Similarly, the lower signal frequency is converted to 20KC + 100 cycles.

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.

Output Circuits

The output circuit board of the receiver contains output relay HG. The contacts of this relay are the mercury-wetted type, which assures bounceless operation. It also contains telephone-type relay AL, the contacts of which can be used to energize an alarm.

When Trip signal is received, terminal 8 of Output printed circuit board is at approximately +20 volts potential and transistor Q101 becomes conductive, which energizes relay HG. When Guard signal is present, terminal 1 of the Output board is at approximately +20 volts potential. The base of transistor Q102 is connected to terminal 1 and 8 through resistors R103 and R104. Consequently when either Guard or Trip signal is present this transistor is conductive.

When neither Guard nor Trip signal is present, indicating a loss of channel, Q102 is not conductive and capacitor C101 begins to charge through resistors R106 and R107. When the capacitor voltage reaches the breakdown level of zener diode CR102 (in approximately 150 milliseconds) transistor Q103 receives base input and becomes conductive. This removes base input from Q104 and the alarm relay AL drops out and energizes an alarm through its normally-closed contacts. A copper slug on the core of the alarm relay adds an additional delay of approximately 40 milliseconds before the alarm contacts close. When Guard signal reappears and Q102 becomes conductive, capacitor C101 discharges rapidly through the low resistance of R107. This quick-reset feature of the RC time-delay reduces the possibility of operation of the loss-of-channel alarm by noise signal, which may override and cancel the Guard signal briefly but repetitively or may appear as a false Trip signal.

It should be noted that relay HG has Form D contacts, and only the normally-open or the normally-closed contacts should be used unless there is no objection to having both contacts momentarily closed simultaneously when the relay is energized or deenergized. Also, for protection of the HG relay contacts, the external device controlled should contain series resistance and capacitance (of values suitable for the load voltage and current) across the terminals that are externally connected to the HG relay terminals. With such protection the HG contacts have maximum ratings of 2 amperes, 500 volts, and 100 volt-amperes. The HG relay will pick up at approximately 20 volts.

The AL relay contacts are rated at 4 amps., 150 watts, for an a-c non-inductive load. The relay will pick at 35 to 40 volts.

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	30-200KC
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 zero output at channel center frequency and for max. outputs at 100 cycles above and below center frequency.
Operating Time	9 ms. channel (transm. and recvr.) 2 ms. HG relay operate and release times
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 $+60^\circ$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 lb.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as a 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°.

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; frequency spacing and magnitude of discriminator output peaks.

After the receiver has been installed, the input attenuator R5 must be set for the desired operating margin. 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 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 factory adjustments have been accidentally disturbed or components have been replaced, it may be necessary to readjust the oscillator and mixer, the limiter, or the discriminator, and procedures for these adjustments are described in the following paragraphs.

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 signal 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. Apply to the receiver input a 5 mv. signal taken from an oscillator set at the center frequency of the channel. (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 100 cycles above and below center frequency.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. 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 the following tables. 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 (+20v.). Receiver adjusted for 15 db operating margin with input signal down 50 db from 1 watt. Unless otherwise indicated, voltage will not vary appreciably whether signal is high, low or fc frequency.

Collector of Transistor	Volts (-)
Q11	20
Q12	14.5 (No signal)
Q12	14.0 (High or low freq. signal)
Q13	17.0 (No signal)
Q13	15.0 (High or low freq. signal)
Q31	18.5
Q32	18.5
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q81	20 (No signal or fc – 100 cy.)
Q81	< 0.5 (fc + 100 cy.)
Q82 and Q101	20 (No signal or fc + 100 cy.)
Q82 and Q101	< 0.5 (fc – 100 cy.)
Q103	20.5 (No signal)
Q104	< 0.5 (No signal)
Q105	45 (No signal)

TABLE II

RECEIVER RF MEASUREMENTS

Collector of Transistor	Volts (fc + cy.)
Q32	.25
Q51	.3
Q52	.4
Q53	2.1
Q54	4.8

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
Input Impedance: 7.5 megohms

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.

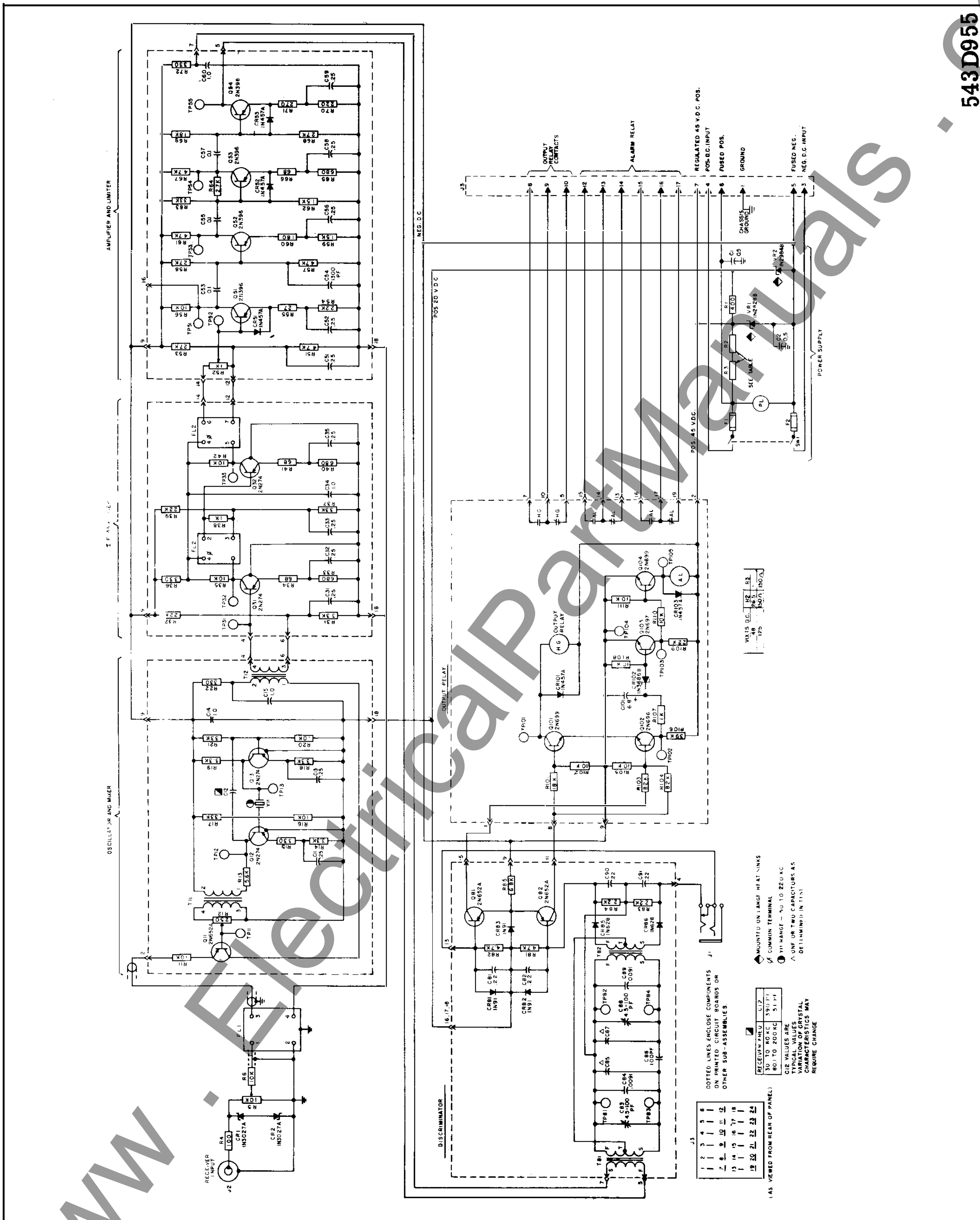

Fig. 1. Internal Schematic of the Type TCF Receiver for Supervisory Control and Telemetering.

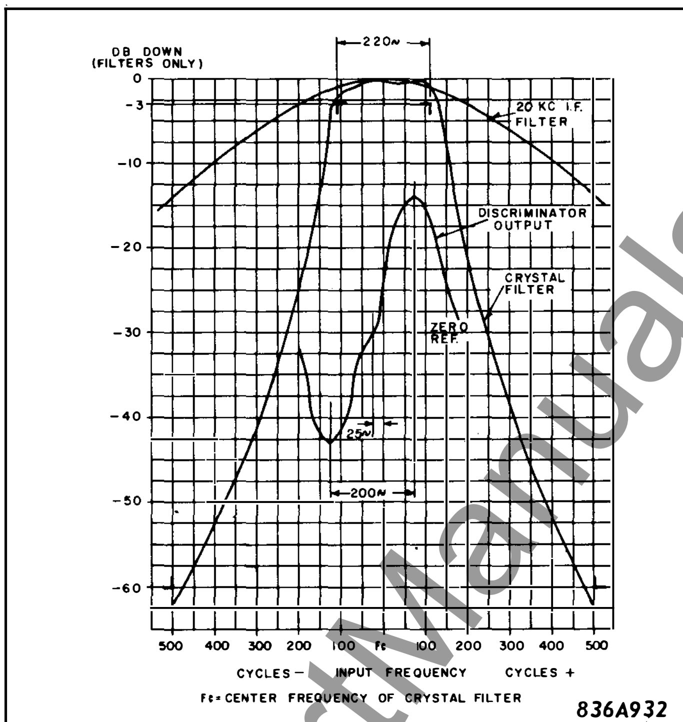

Fig. 2. Filter and Discriminator Characteristics of the Type TCF Receiver.

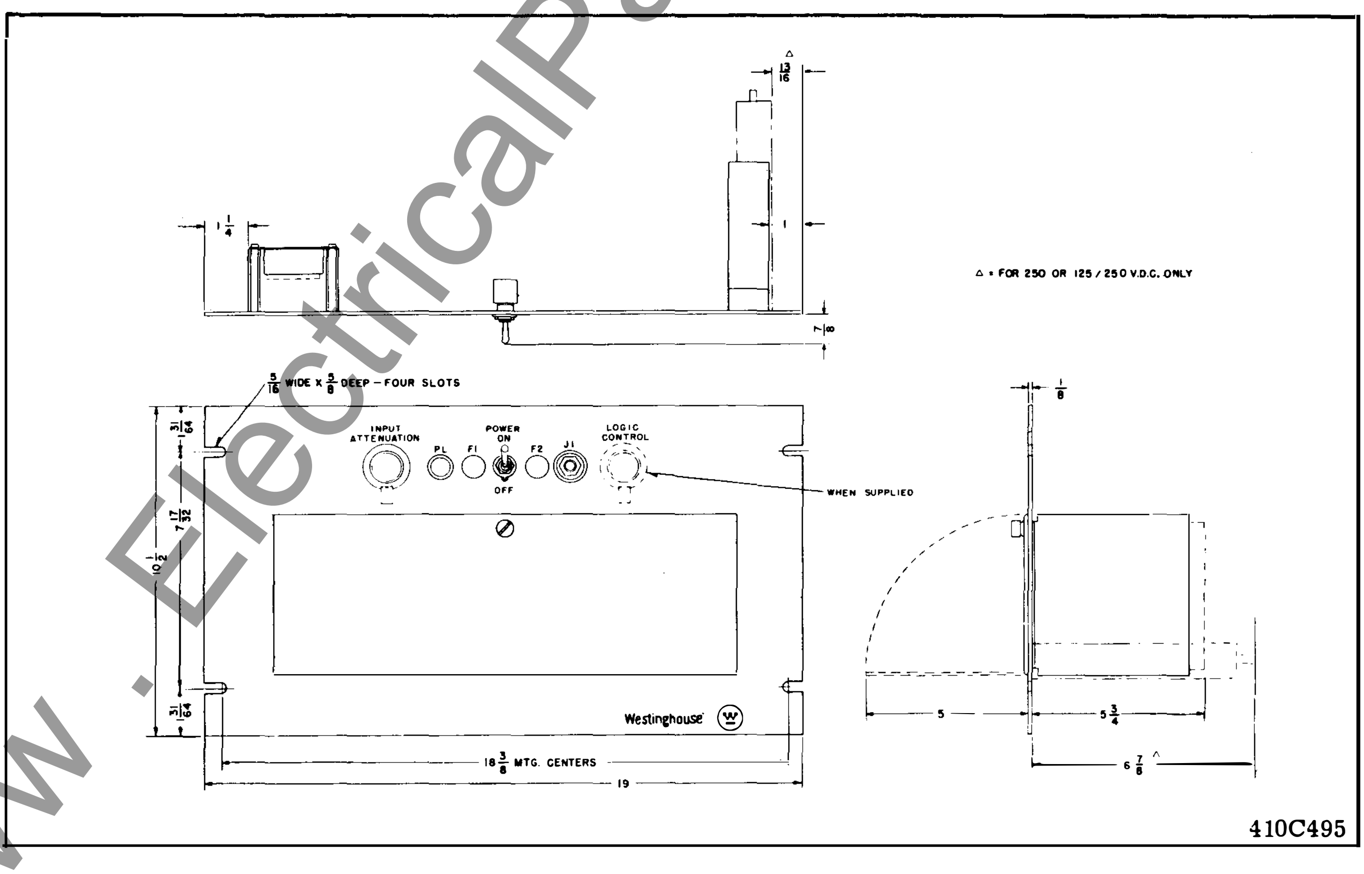

Fig. 3. Outline and Drilling Plan for the Type TCF Receiver Assembly.

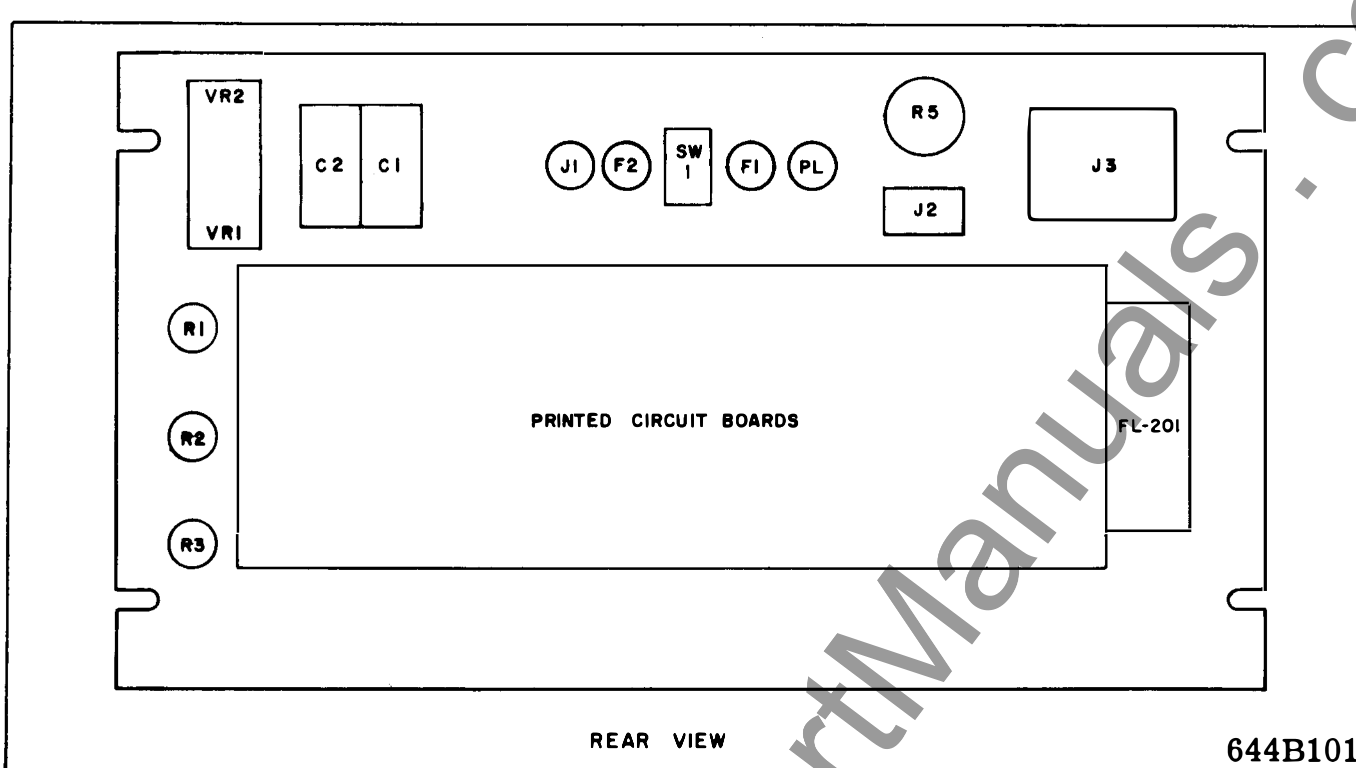

Fig. 4. Component Locations on the TCF Receiver Panel.

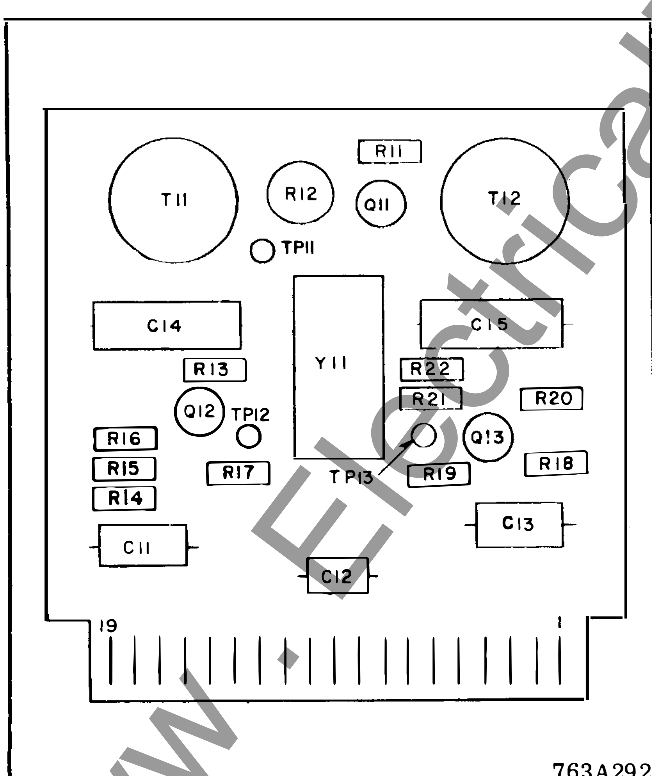

Fig. 5. Component Locations on the Oscillator and Mixer Printed Circuit Board.

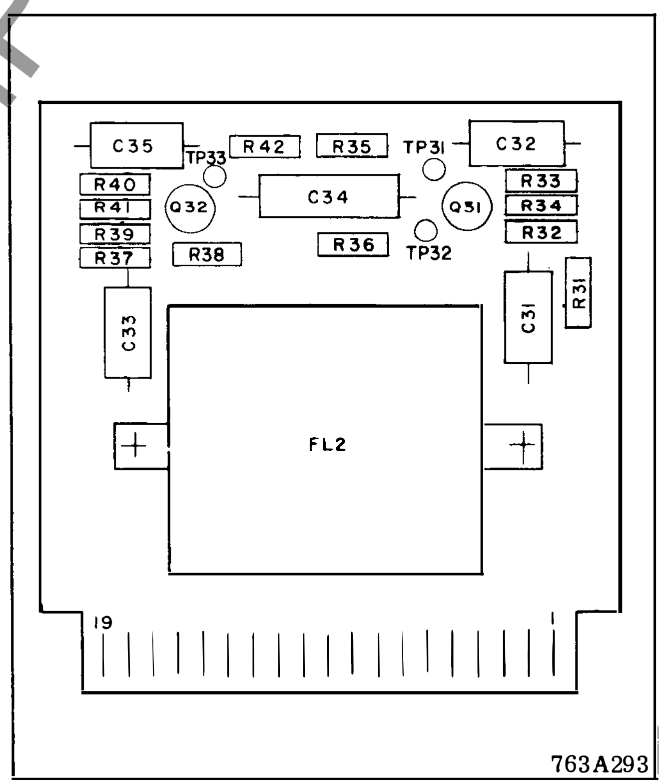

Fig. 6. Component Locations on the I.F. Amplifier Printed Circuit Board.

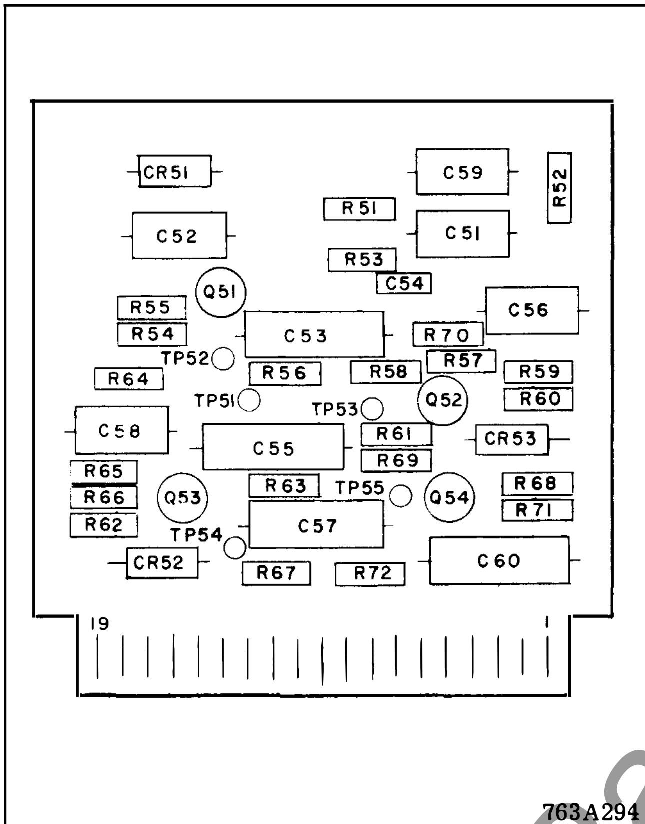

Fig. 7. Component Locations on the Amplifier and Limiter Printed Circuit Board.

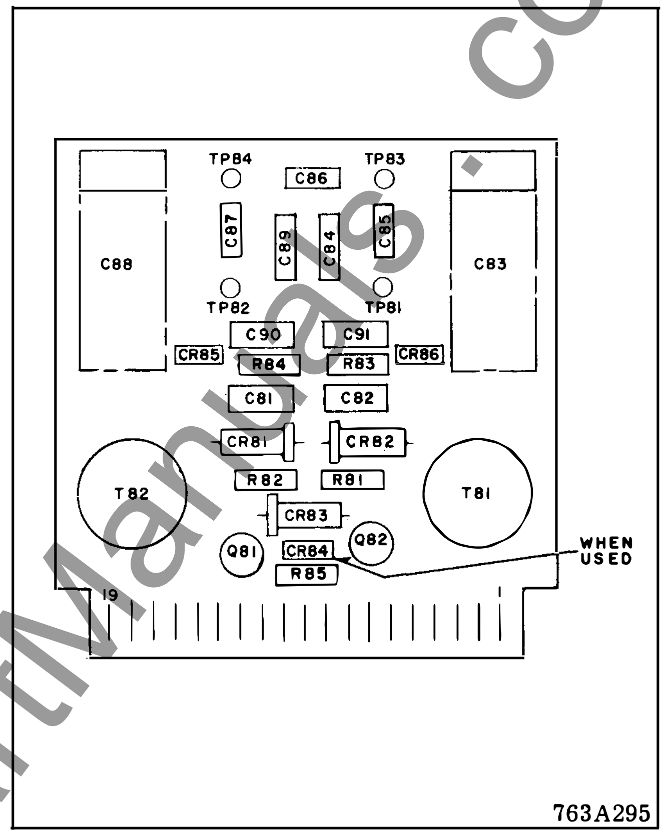

Fig. 8. Component Locations on the Discriminator Printed Circuit Board.

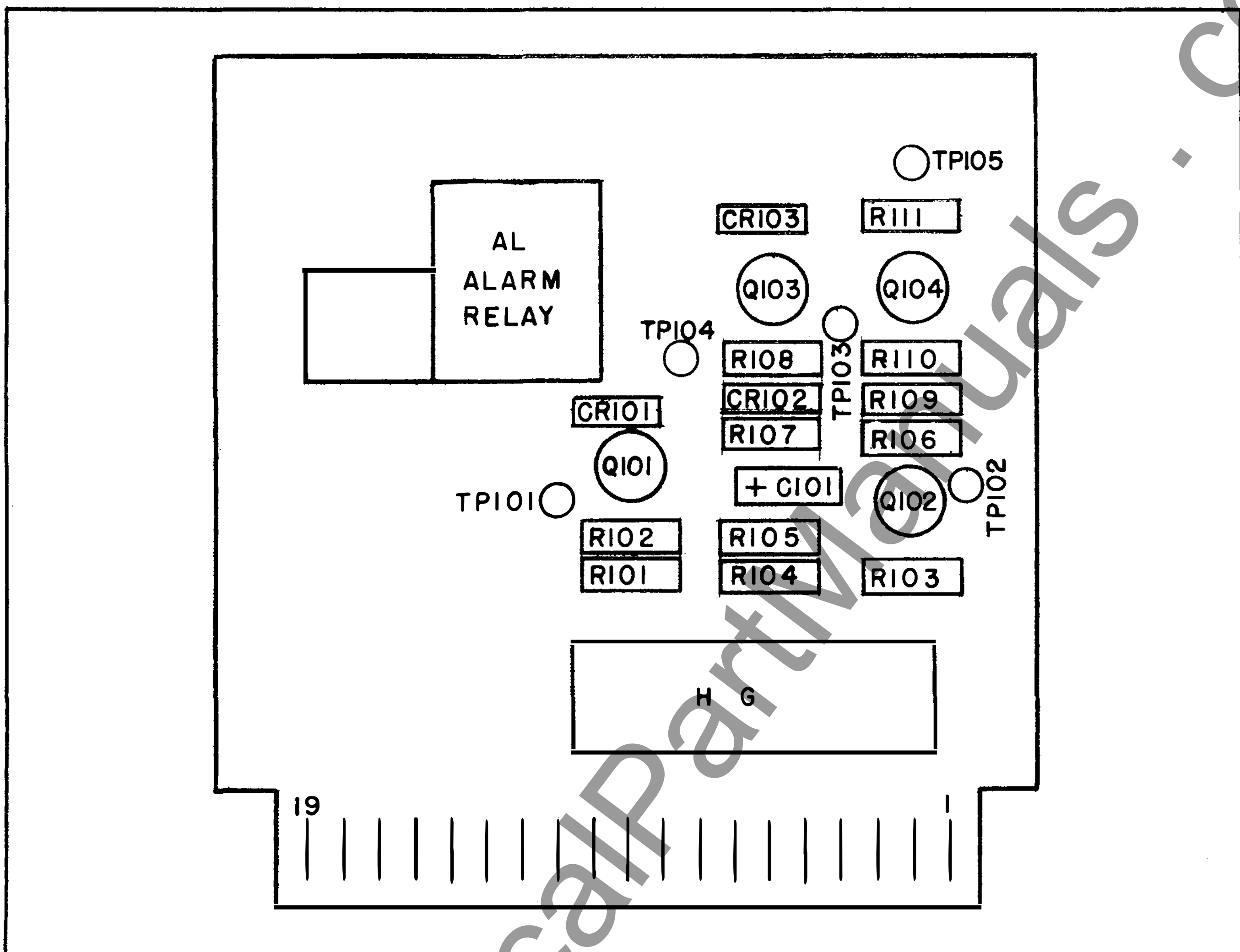

Fig. 9. Component Locations on the Relay Output Printed Circuit Board.

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

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*Denotes change from superseded issue.

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The output circuit board of the receiver contains output relay HG. The contacts of this relay are the mercury-wetted type, which assures bounceless operation. It also contains telephone-type relay AL, the contacts of which can be used to energize an alarm.

When Trip signal is received, terminal 8 of Output printed circuit board is at approximately +20 volts potential and transistor Q101 becomes conductive, which energizes relay HG. When Guard signal is present, terminal 1 of the Output board is at approximately +20 volts potential. The base of transistor Q102 is connected to terminal 1 and 8 through resistors R103 and R104. Consequently when either Guard or Trip signal is present this transistor is conductive.

When neither Guard nor Trip signal is present, indicating a loss of channel, Q102 is not conductive and capacitor C101 begins to charge through resistors R106 and R107. When the capacitor voltage reaches the breakdown level of zener diode CR102 (in approximately 150 milliseconds) transistor Q103 receives base input and becomes conductive. This removes base input from Q104 and the alarm relay AL drops out and energizes an alarm through its normally-closed contacts. A copper slug on the core of the alarm relay adds an additional delay of approximately 40 milliseconds before the alarm contacts close. When Guard signal reappears and Q102 becomes conductive, capacitor C101 discharges rapidly through the low resistance of R107. This quick-reset feature of the RC time-delay reduces the possibility of operation of the loss-of-channel alarm by noise signal, which may override and cancel the Guard signal briefly but repetitively or may appear as a false Trip signal.

It should be noted that relay HG has Form D contacts, and only the normally-open or the normally-closed contacts should be used unless there is no objection to having both contacts momentarily closed simultaneously when the relay is energized or deenergized. Also, for protection of the HG relay contacts, the external device controlled should contain series resistance and capacitance (of values suitable for the load voltage and current) across the terminals that are externally connected to the HG relay terminals. With such protection the HG contacts have maximum ratings of 2 amperes, 500 volts, and 100 volt-amperes. The HG relay will pick up at approximately 20 volts.

The AL relay contacts are rated at 4 amps., 150 watts, for an a-c non-inductive load. The relay will pick at 35 to 40 volts.

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 - 200KC
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 zero output at channel center frequency and for max. outputs at 100 cycles above and below center frequency.
Operating Time	9 ms. channel (transm. and recvr.) 2 ms. HG relay operate and release times

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 lb.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as a 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°.

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; frequency spacing and magnitude of discriminator output peaks.

After the receiver has been installed, the input attenuator R5 must be set for the desired operating margin. 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 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 factory adjustments have been accidentally disturbed or components have been replaced, it may be necessary to readjust the oscillator and mixer, the limiter, or the discriminator, and procedures for these adjustments are described in the following paragraphs.

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 signal 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. Apply to the receiver input a 5 mv. signal taken from an oscillator set at the center frequency of the channel. (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 100 cycles above and below center frequency.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. 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 the following tables. 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 input signal down 50 db from 1 watt. Unless otherwise indicated, voltage will not vary appreciably whether signal is high, low or fc frequency.

Collector of Transistor	Volts (–)
Q11	20
Q12	14.5 (No signal)
Q12	14.0 (High or low freq. signal)
Q13	17.0 (No signal)
Q13	15.0 (High or low freq. signal)
Q31	18.5
Q32	18.5
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q81	20 (No signal or fc – 100 cy.)
Q81	< 0.5 (fc + 100 cy.)
Q82 and Q101	20 (No signal or fc + 100 cy.)
Q82 and Q101	< 0.5 (fc – 100 cy.)
Q103	20.5 (No signal)
Q104	< 0.5 (No signal)
Q105	45 (No signal)

TABLE II
RECEIVER RF MEASUREMENTS

Collector of Transistor	Volts (fc + cy.)
Q32	.25
Q51	.3
Q52	.4
Q53	2.1
Q54	4.8

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 Fig. 9 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 2 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 sec-

tions, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 2 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 (Fig. 9) 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
Input Impedance: 7.5 megohms

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 and Westinghouse Designation on the Electrical Part List.

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, 6.8 mfd.; 35 V.D.C.	184A661H25

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
CR51	1N457A; 60 V.; 200 MA.	184A855H07
CR52	1N457A; 60 V.; 200 MA.	184A855H07
CR53	1N457A; 60 V.; 200 MA.	184A855H07
CR81	1N91; 100 V.; 150 MA.	182A881H04
CR82	1N91; 100 V.; 150 MA.	182A881H04
CR83	1N91; 100 V.; 150 MA.	182A881H04
CR85	1N628; 125 V.; 20 MA.	184A844H12
CR86	1N628; 125 V.; 30 MA.	184A855H12
CR101	1N457A; 60 V.; 200 MA.	184A885H07
CR103	1N457A; 60 V.; 200 MA.	184A885H07
	DIODES – ZENER	
CR1	1N3027A; 20 V. ±10%; 1 W.	188A307H10
CR2	1N3027A; 20 V. ±10%; 1 W.	188A307H10
CR102	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
VR1	1N2828B; 45 V. ±5%; 50 W.	184A854H06
VR2	1N2984B; 20 V. ±5%; 10 W.	762A631H01
	POTENTIOMETERS	
R5	10K; 2W.	185A086H10
R7	250K; 2W.	185A086H11
R12	1K; ¼W.	629A430H02
R52	1K; ¼W.	629A645H04
	RESISTORS	
R1	400 ohms ±5%; 25W.	1202587
R2	26.5 ohms ±5%; 40W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1W. Composition	187A643H03
R6	10K ±5%; ½W. Composition	184A763H51
R8	100K ±5%; 1W. Composition	187A643H75
R11	10K ±5%; ½W. Composition	184A763H51
R13	5.6K ±5%; ½W. Composition	184A763H45
R14	3.3K ±5%; ½W. Composition	184A763H39
R15	330 ohms ±5%; ½W. Composition	184A763H15
R16	10K ±5%; ½W. Composition	184A763H51
R17	33K ±5%; ½W. Composition	184A763H63
R18	3.3K ±5%; ½W. Composition	184A763H39
R19	3.3K ±5%; ½W. Composition	184A763H39
R20	10K ±5%; ½W. Composition	184A763H51

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R21	33K ±5%; ½W. Composition	184A763H63
R22	330 ohms ±5%; ½W. Composition	184A763H15
R23	10K ±5%; ½W. Composition	184A763H51
R31	3.3K ±5%; ½W. Composition	184A763H39
R32	22K ±5%; ½W. Composition	184A763H59
R33	680 ohms ±5%; ½W. Composition	184A763H23
R34	68 ohms ±5%; ½W. Composition	187A290H21
R35	10K ±5%; ½W. Composition	184A763H51
R36	330 ohms ±5%; ½W. Composition	184A763H15
R37	3.3K ±5%; ½W. Composition	184A763H39
R38	1000 ohms ±5%; ½W. Composition	184A763H27
R39	22K ±5%; ½W. Composition	184A763H59
R40	680 ohms ±5%; ½W. Composition	184A763H23
R41	68 ohms ±5%; ½W. Composition	187A290H21
R42	10K ±5%; ½W. Composition	184A763H51
R51	4.7K ±5%; ½W. Composition	184A763H43
R53	27K ±5%; ½W. Composition	184A763H61
R54	2.2K ±5%; ½W. Composition	184A763H35
R55	27 ohms ±5%; ½W. Composition	187A290H11
R56	10K ±5%; ½W. Composition	184A763H51
R57	4.7K ±5%; ½W. Composition	184A763H43
R58	27K ±5%; ½W. Composition	184A763H61
R59	1.5K ±5%; W. Composition	184A763H31
R60	180 ohms ±5%; ½W. Composition	184A763H09
R61	4.7K ±5%; ½W. Composition	184A763H43
R62	1.5K ±5%; ½W. Composition	184A763H31
R63	3.3K ±5%; ½W. Composition	184A763H63
R64	2.7K ±5%; ½W. Composition	184A763H37
R65	680 ohms ±5%; ½W. Composition	184A763H23
R66	68 ohms ±5%; ½W. Composition	187A290H21
R67	4.7K ±5%; ½W. Composition	184A763H43
R68	2.7K ±5%; ½W. Composition	184A763H37
R69	18K ±5%; ½W. Composition	184A763H57
R70	220 ohms ±5%; ½W. Composition	184A763H11
R71	270 ohms ±5%; ½W. Composition	184A763H13
R72	330 ohms ±5%; ½W. Composition	184A763H15
R81	4.7K ±5%; ½W. Composition	184A763H43
R82	4.7K ±5%; ½W. Composition	184A763H43
R83	2.2K ±5%; ½W. Composition	184A763H35
R84	2.2K ±5%; ½W. Composition	184A763H35

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R85	6.8K ±5%; ½W. Composition	184A763H47
R101	18K ±5%; ½W. Composition	184A763H57
R102	10K ±5%; ½W. Composition	184A763H51
R103	82K ±5%; ½W. Composition	184A763H73
R104	82K ±5%; ½W. Composition	184A763H73
R105	10K ±5%; 1W. Composition	187A643H51
R106	39K ±5%; ½W. Composition	184A763H65
R107	1000 ohms ±5%; ½W. Composition	185A763H27
R108	10K ±5%; ½W. Composition	184A763H51
R109	22K ±5%; ½W. Composition	184A763H23
R110	27K ±5%; ½W. Composition	184A763H61
R111	10K ±5%; ½W. Composition	184A763H51
	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	2N699	184A638H19
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 KC above Channel Frequency)	762A800H01 + (Reg. Freq.)
FL1	Crystal Input Filter	410C466 + (Reg. 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, 1.5A	11D919H26
AL	Alarm Relay	408C062H07
HG	Mercury Weted Contact Relay; 2 amp, 500 V., 100 V.A.	188A573H04

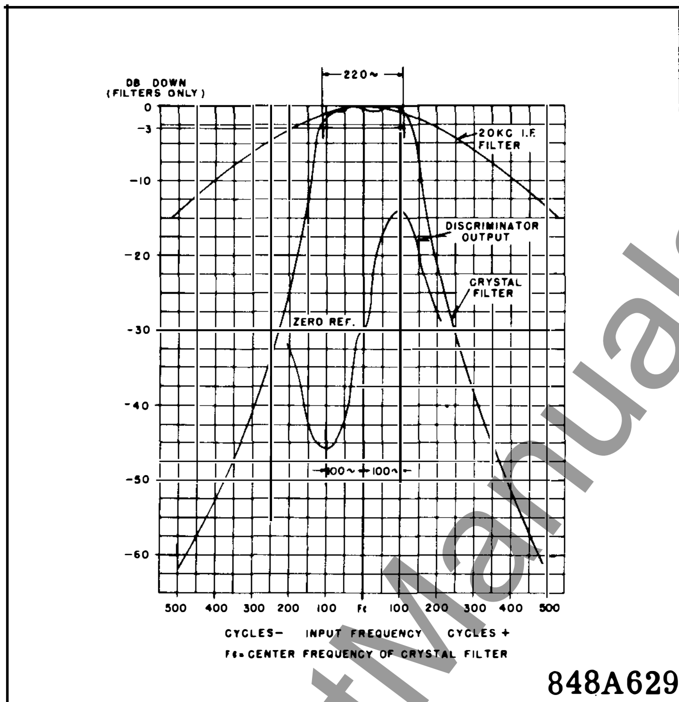

Fig. 2. Filter and Discriminator Characteristics of the Type TCF Receiver.

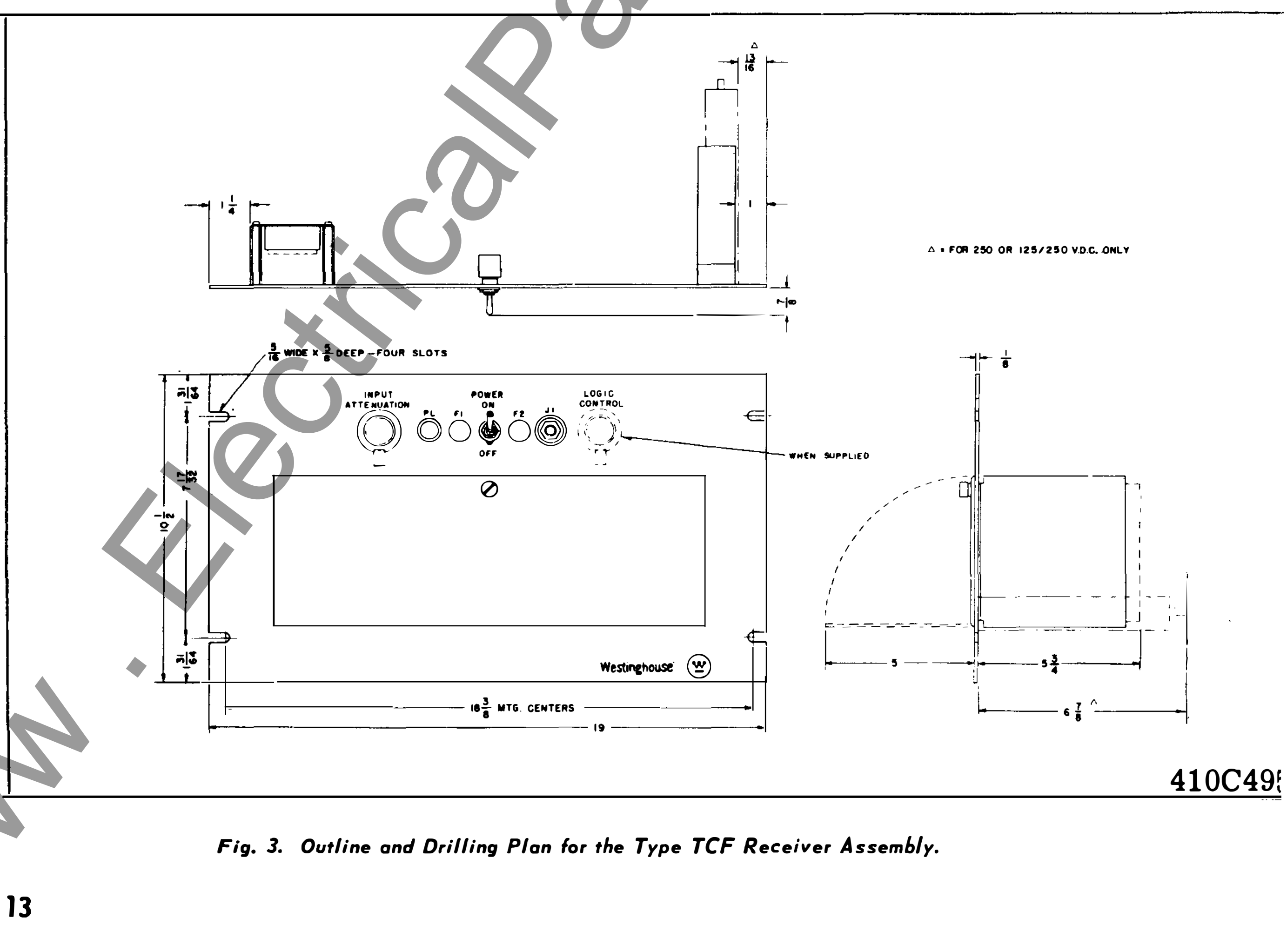

Fig. 3. Outline and Drilling Plan for the Type TCF Receiver Assembly.

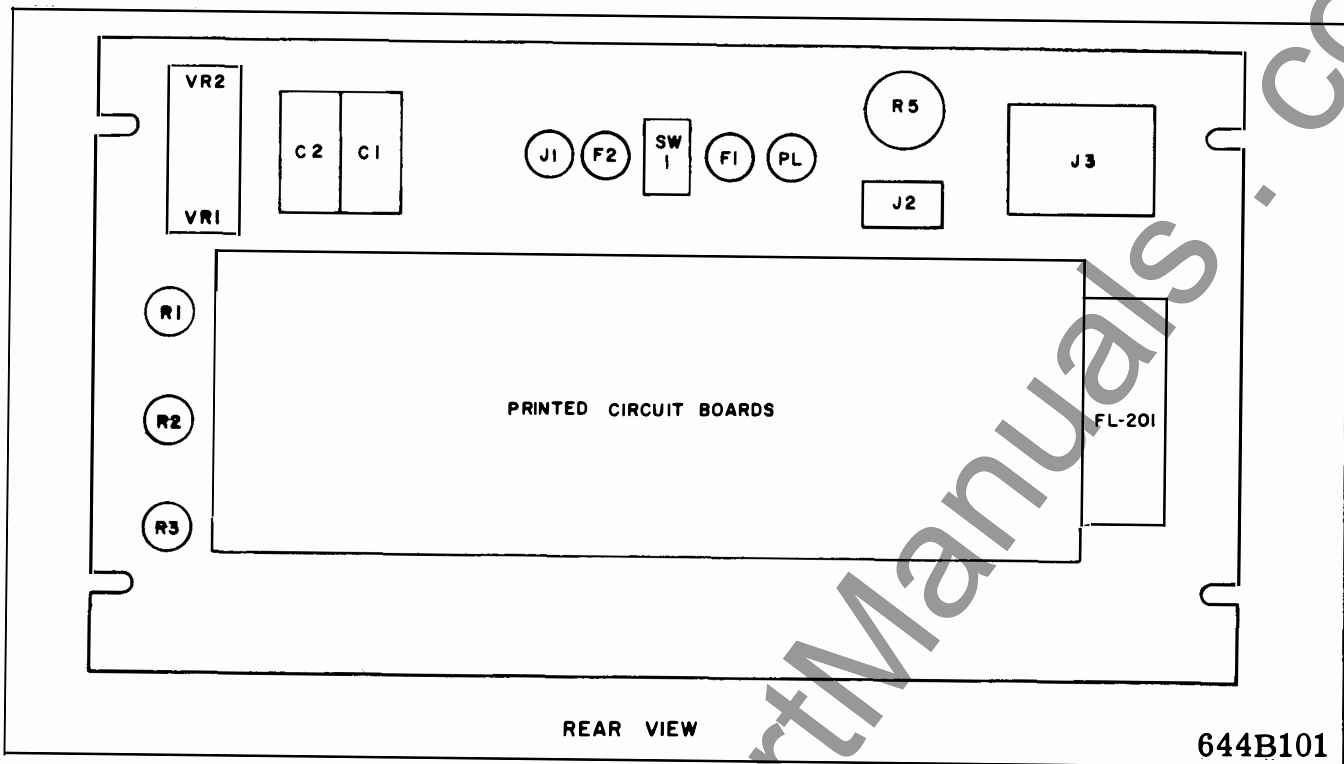

Fig. 4. Component Locations on the TCF Receiver Panel.

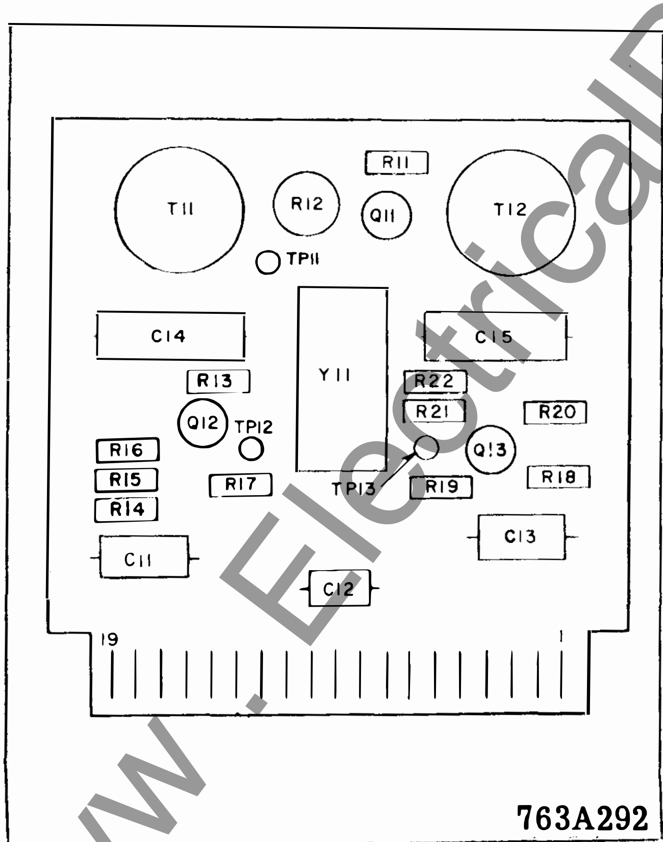

Fig. 5. Component Locations on the Oscillator and Mixer Printed Circuit Board.

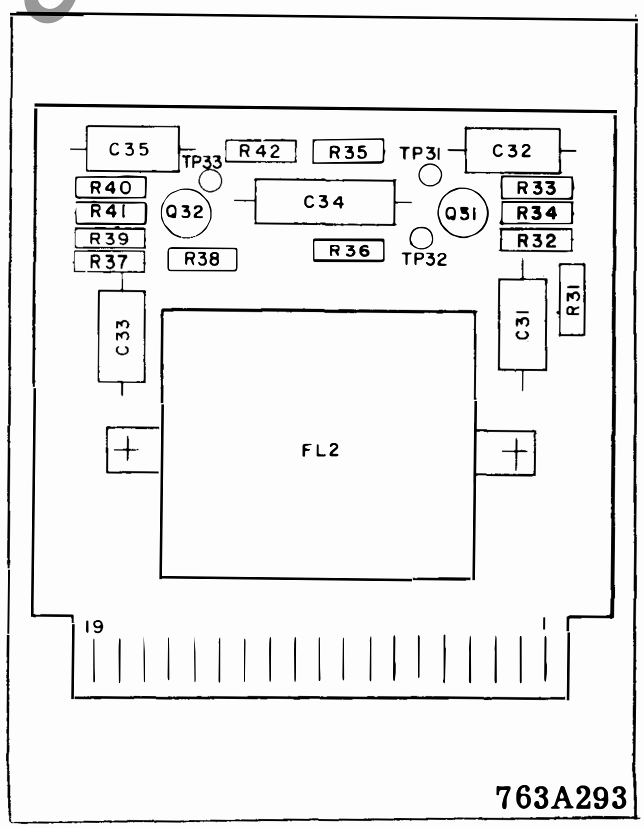

Fig. 6. Component Locations on the I.F. Amplifier Printed Circuit Board.

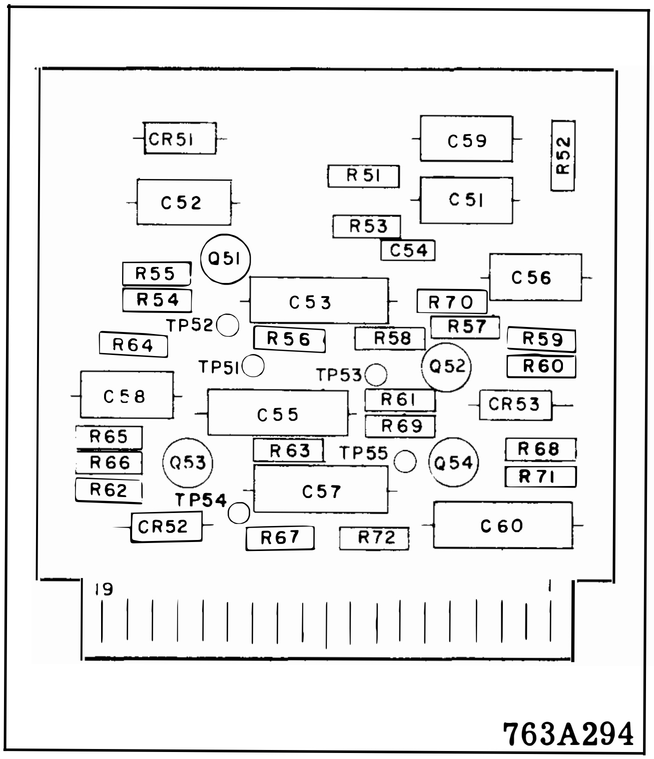

Fig. 7. Component Locations on the Amplifier and Limiter Printed Circuit Board.

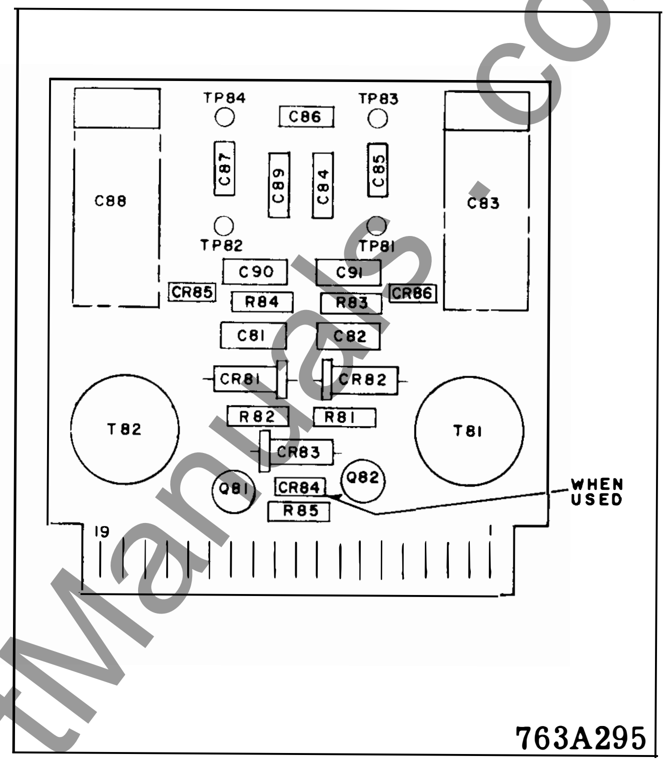

Fig. 8. Component Locations on the Discriminator Printed Circuit Board.

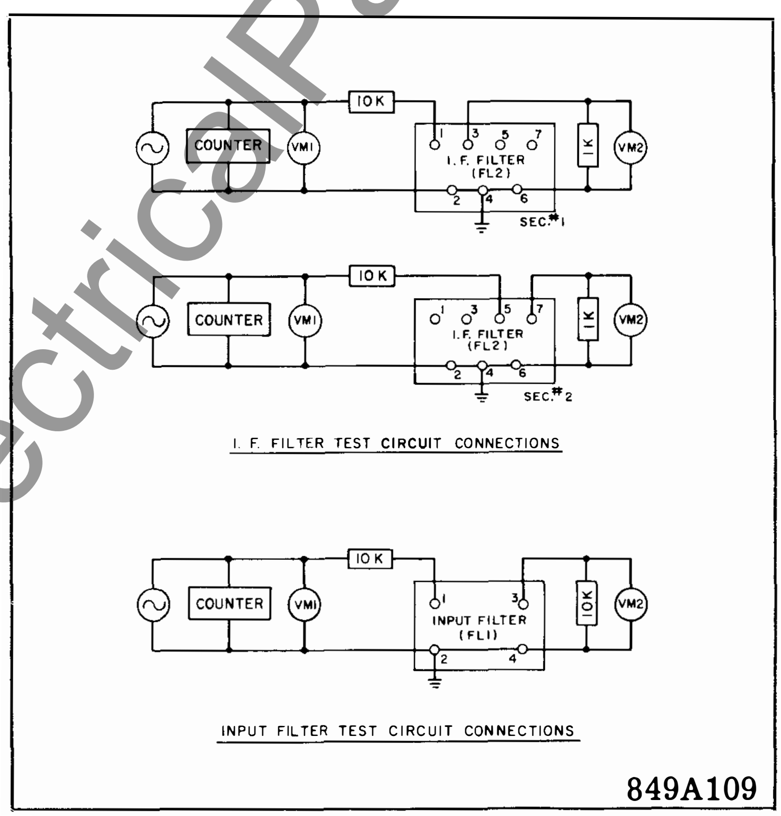

Fig. 9. Test Circuits for TCF Frequency Shift Receiver Filters

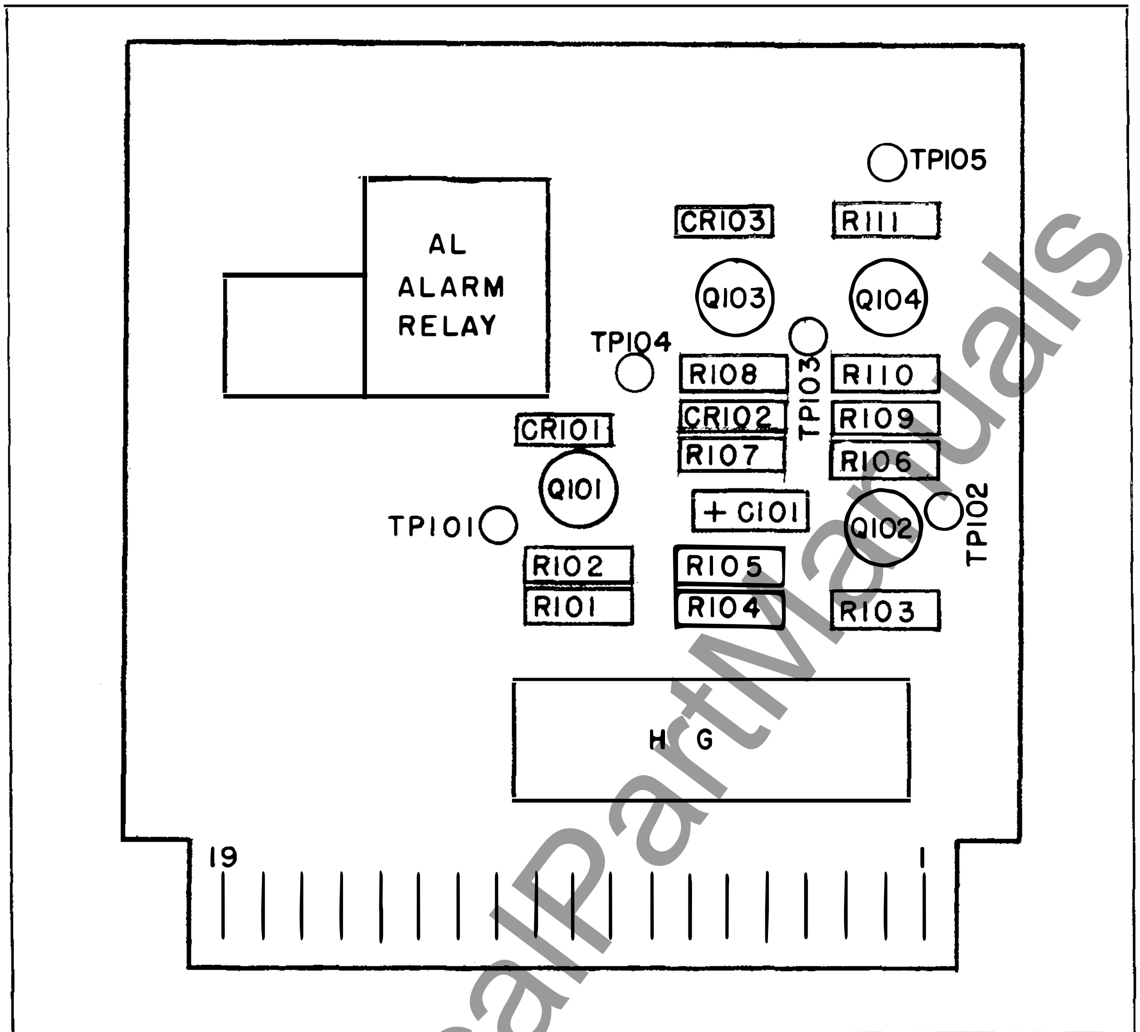

Fig. 10. Component Locations on the Relay Output Printed Circuit Board.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT – WITH RELAY OUTPUT FOR SUPERVISORY CONTROL AND TELEMETERING

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 supervisory control and certain telemetering applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard frequency is 100 cycles above the center frequency of the channel (which can be selected within the range of 30KC to 200KC), and it is transmitted continuously when conditions are normal and no information is to be conveyed over the channel. Its reception indicates that the channel is operative. The Trip frequency (so called because in frequency-shift relaying applications the reception of this frequency causes closure of relay contacts in the trip circuit of a circuit breaker) is 100 cycles below the channel center frequency. When supervisory control or telemetering information is to be conveyed over the channel, the transmitter at one end of the channel is switched alternately between Guard and Trip so as to produce at the receiving end a desired number of operations of a relay activated by the trip frequency. Control of the durations of the intervals that the relay contacts are open and closed also can be utilized to convey information over the channel.

* CONSTRUCTION

The TCF receiver unit for supervisory control and telemetering 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, and a jack for metering the discriminator output current are accessible from the front of the panel. Refer to Fig. 3.

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. 4. 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.

TCF receivers for transfer trip relaying require a logic circuit board and may require a carrier level indicator circuit board, which are contained in the third-from-right and right hand compartments respectively. These are not required for the TCF receiver for supervisory control and telemetering and the compartments are vacant.

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 is 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

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*Denotes change from superseded issue.

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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 V.D.C. 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 on 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. 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. Figure 2 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 and fc + 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 cycles. The adjustment for zero output at fc 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). It should be observed that although the higher signal frequency is fc + 100 cycles, after leaving the mixer stage and as seen by the discriminator the corresponding frequency is 20KC-100 cycles. Similarly, the lower signal frequency is converted to 20KC + 100 cycles.

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.

Output Circuits

The output circuit board of the receiver contains output relay HG. The contacts of this relay are the mercury-wetted type, which assures bounceless operation. It also contains telephone-type relay AL, the contacts of which can be used to energize an alarm.

When Trip signal is received, terminal 8 of Output printed circuit board is at approximately +20 volts potential and transistor Q101 becomes conductive, which energizes relay HG. When Guard signal is present, terminal 1 of the Output board is at approximately +20 volts potential. The base of transistor Q102 is connected to terminal 1 and 8 through resistors R103 and R104. Consequently when either Guard or Trip signal is present this transistor is conductive.

When neither Guard nor Trip signal is present, indicating a loss of channel, Q102 is not conductive and capacitor C101 begins to charge through resistors R106 and R107. When the capacitor voltage reaches the breakdown level of zener diode CR102 (in approximately 150 milliseconds) transistor Q103 receives base input and becomes conductive. This removes base input from Q104 and the alarm relay AL drops out and energizes an alarm through its normally-closed contacts. A copper slug on the core of the alarm relay adds an additional delay of approximately 40 milliseconds before the alarm contacts close. When Guard signal reappears and Q102 becomes conductive, capacitor C101 discharges rapidly through the low resistance of R107. This quick-reset feature of the RC time-delay reduces the possibility of operation of the loss-of-channel alarm by noise signal, which may override and cancel the Guard signal briefly but repetitively or may appear as a false Trip signal.

It should be noted that relay HG has Form D contacts, and only the normally-open or the normally-closed contacts should be used unless there is no objection to having both contacts momentarily closed simultaneously when the relay is energized or deenergized. Also, for protection of the HG relay contacts, the external device controlled should contain series resistance and capacitance (of values suitable for the load voltage and current) across the terminals that are externally connected to the HG relay terminals. With such protection the HG contacts have maximum ratings of 2 amperes, 500 volts, and 100 volt-amperes. The HG relay will pick up at approximately 20 volts.

The AL relay contacts are rated at 4 amps., 150 watts, for an a-c non-inductive load. The relay will pick at 35 to 40 volts.

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	30-200KC
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 zero output at channel center frequency and for max. outputs at 100 cycles above and below center frequency.
Operating Time	9 ms. channel (transm. and recvr.) 2 ms. HG relay operate and release times

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 lb.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as a 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°.

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; frequency spacing and magnitude of discriminator output peaks.

After the receiver has been installed, the input attenuator R5 must be set for the desired operating margin. 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 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 factory adjustments have been accidentally disturbed or components have been replaced, it may be necessary to readjust the oscillator and mixer, the limiter, or the discriminator, and procedures for these adjustments are described in the following paragraphs.

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 signal 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. Apply to the receiver input a 5 mv. signal taken from an oscillator set at the center frequency of the channel. (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 100 cycles above and below center frequency.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. 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 the following tables. 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 input signal down 50 db from 1 watt. Unless otherwise indicated, voltage will not vary appreciably whether signal is high, low or fc frequency.

Collector of Transistor	Volts (–)
Q11	20
Q12	14.5 (No signal)
Q12	14.0 (High or low freq. signal)
Q13	17.0 (No signal)
Q13	15.0 (High or low freq. signal)
Q31	18.5
Q32	18.5
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q81	20 (No signal or fc – 100 cy.)
Q81	< 0.5 (fc + 100 cy.)
Q82 and Q101	20 (No signal or fc + 100 cy.)
Q82 and Q101	< 0.5 (fc – 100 cy.)
Q103	20.5 (No signal)
Q104	< 0.5 (No signal)
Q105	45 (No signal)

TABLE II
RECEIVER RF MEASUREMENTS

Collector of Transistor	Volts (fc + cy.)
Q32	.25
Q51	.3
Q52	.4
Q53	2.1
Q54	4.8

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 Fig. 9 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 2 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 sec-

tions, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 2 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 (Fig. 9) 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
Input Impedance: 7.5 megohms

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 and Westinghouse Designation on the Electrical Part List.

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, 6.8 mfd.; 35 V.D.C.	184A661H25

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
CR51	1N457A; 60 V.; 200 MA.	184A855H07
CR52	1N457A; 60 V.; 200 MA.	184A855H07
CR53	1N457A; 60 V.; 200 MA.	184A855H07
CR81	1N91; 100 V.; 150 MA.	182A881H04
CR82	1N91; 100 V.; 150 MA.	182A881H04
CR83	1N91; 100 V.; 150 MA.	182A881H04
CR85	1N628; 125 V.; 20 MA.	184A844H12
CR86	1N628; 125 V.; 30 MA.	184A855H12
CR101	1N457A; 60 V.; 200 MA.	184A885H07
CR103	1N457A; 60 V.; 200 MA.	184A885H07
	DIODES – ZENER	
CR1	1N3027A; 20 V. ±10%; 1 W.	188A307H10
CR2	1N3027A; 20 V. ±10%; 1 W.	188A307H10
CR102	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
VR1	1N2828B; 45 V. ±5%; 50 W.	184A854H06
VR2	1N2984B; 20 V. ±5%; 10 W.	762A631H01
	POTENTIOMETERS	
R5	10K; 2W.	185A086H10
R7	250K; 2W.	185A086H11
R12	1K; ¼W.	629A430H02
R52	1K; ¼W.	629A645H04
	RESISTORS	
R1	400 ohms ±5%; 25W.	1202587
R2	26.5 ohms ±5%; 40W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1W. Composition	187A643H03
R6	10K ±5%; ½W. Composition	184A763H51
R8	100K ±5%; 1W. Composition	187A643H75
R11	10K ±5%; ½W. Composition	184A763H51
R13	5.6K ±5%; ½W. Composition	184A763H45
R14	3.3K ±5%; ½W. Composition	184A763H39
R15	330 ohms ±5%; ½W. Composition	184A763H15
R16	10K ±5%; ½W. Composition	184A763H51
R17	33K ±5%; ½W. Composition	184A763H63
R18	3.3K ±5%; ½W. Composition	184A763H39
R19	3.3K ±5%; ½W. Composition	184A763H39
R20	10K ±5%; ½W. Composition	184A763H51

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R21	33K ±5%; ½W. Composition	184A763H63
R22	330 ohms ±5%; ½W. Composition	184A763H15
R23	10K ±5%; ½W. Composition	184A763H51
R31	3.3K ±5%; ½W. Composition	184A763H39
R32	22K ±5%; ½W. Composition	184A763H59
R33	680 ohms ±5%; ½W. Composition	184A763H23
R34	68 ohms ±5%; ½W. Composition	187A290H21
R35	10K ±5%; ½W. Composition	184A763H51
R36	330 ohms ±5%; ½W. Composition	184A763H15
R37	3.3K ±5%; ½W. Composition	184A763H39
R38	1000 ohms ±5%; ½W. Composition	184A763H27
R39	22K ±5%; ½W. Composition	184A763H59
R40	680 ohms ±5%; ½W. Composition	184A763H23
R41	68 ohms ±5%; ½W. Composition	187A290H21
R42	10K ±5%; ½W. Composition	184A763H51
R51	4.7K ±5%; ½W. Composition	184A763H43
R53	27K ±5%; ½W. Composition	184A763H61
R54	2.2K ±5%; ½W. Composition	184A763H35
R55	27 ohms ±5%; ½W. Composition	187A290H11
R56	10K ±5%; ½W. Composition	184A763H51
R57	4.7K ±5%; ½W. Composition	184A763H43
R58	27K ±5%; ½W. Composition	184A763H61
R59	1.5K ±5%; W. Composition	184A763H31
R60	180 ohms ±5%; ½W. Composition	184A763H09
R61	4.7K ±5%; ½W. Composition	184A763H43
R62	1.5K ±5%; ½W. Composition	184A763H31
R63	3.3K ±5%; ½W. Composition	184A763H63
R64	2.7K ±5%; ½W. Composition	184A763H37
R65	680 ohms ±5%; ½W. Composition	184A763H23
R66	68 ohms ±5%; ½W. Composition	187A290H21
R67	4.7K ±5%; ½W. Composition	184A763H43
R68	2.7K ±5%; ½W. Composition	184A763H37
R69	18K ±5%; ½W. Composition	184A763H57
R70	220 ohms ±5%; ½W. Composition	184A763H11
R71	270 ohms ±5%; ½W. Composition	184A763H13
R72	330 ohms ±5%; ½W. Composition	184A763H15
R81	4.7K ±5%; ½W. Composition	184A763H43
R82	4.7K ±5%; ½W. Composition	184A763H43
R83	2.2K ±5%; ½W. Composition	184A763H35
R84	2.2K ±5%; ½W. Composition	184A763H35

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R85	6.8K ±5%; ½W. Composition	184A763H47
R101	18K ±5%; ½W. Composition	184A763H57
R102	10K ±5%; ½W. Composition	184A763H51
R103	82K ±5%; ½W. Composition	184A763H73
R104	82K ±5%; ½W. Composition	184A763H73
R105	10K ±5%; 1W. Composition	187A643H51
R106	39K ±5%; ½W. Composition	184A763H65
R107	1000 ohms ±5%; ½W. Composition	185A763H27
R108	10K ±5%; ½W. Composition	184A763H51
R109	22K ±5%; ½W. Composition	184A763H23
R110	27K ±5%; ½W. Composition	184A763H61
R111	10K ±5%; ½W. Composition	184A763H51
	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	2N699	184A638H19
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 KC above Channel Frequency)	762A800H01 + (Reg. Freq.)
FL1	Crystal Input Filter	410C466 + (Reg. 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, 1.5A	11D919H26
AL	Alarm Relay	408C062H07
HG	Mercury Weted Contact Relay; 2 amp, 500 V., 100 V.A.	188A573H04

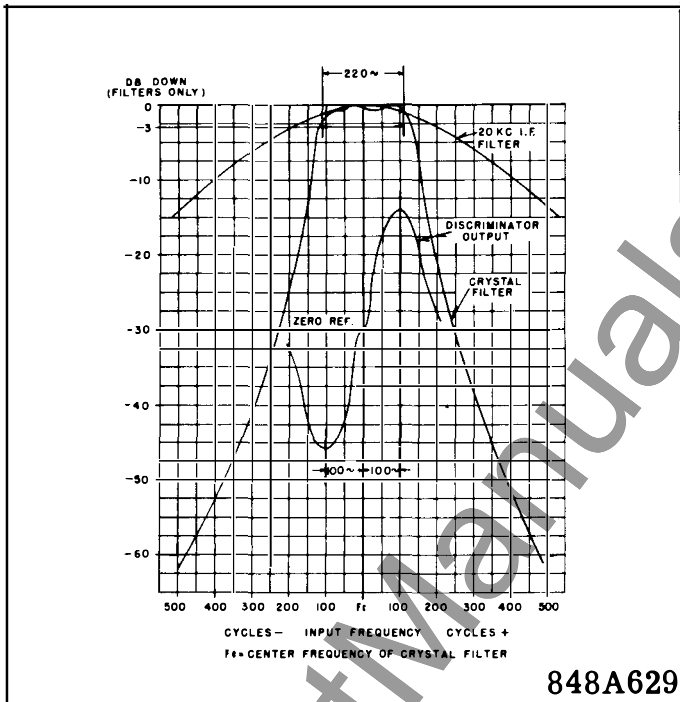


Fig. 2. Filter and Discriminator Characteristics of the Type TCF Receiver.

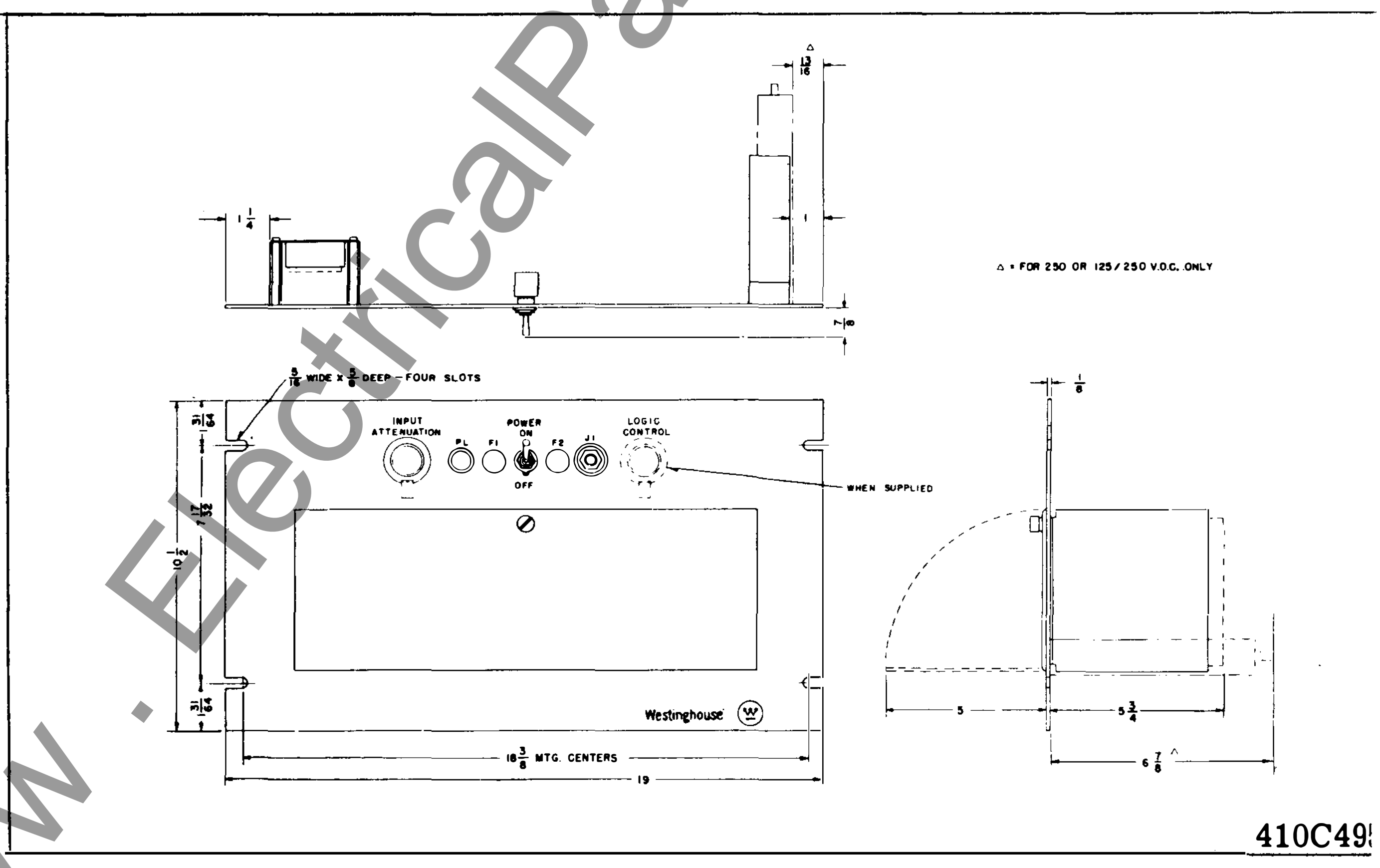


Fig. 3. Outline and Drilling Plan for the Type TCF Receiver Assembly.

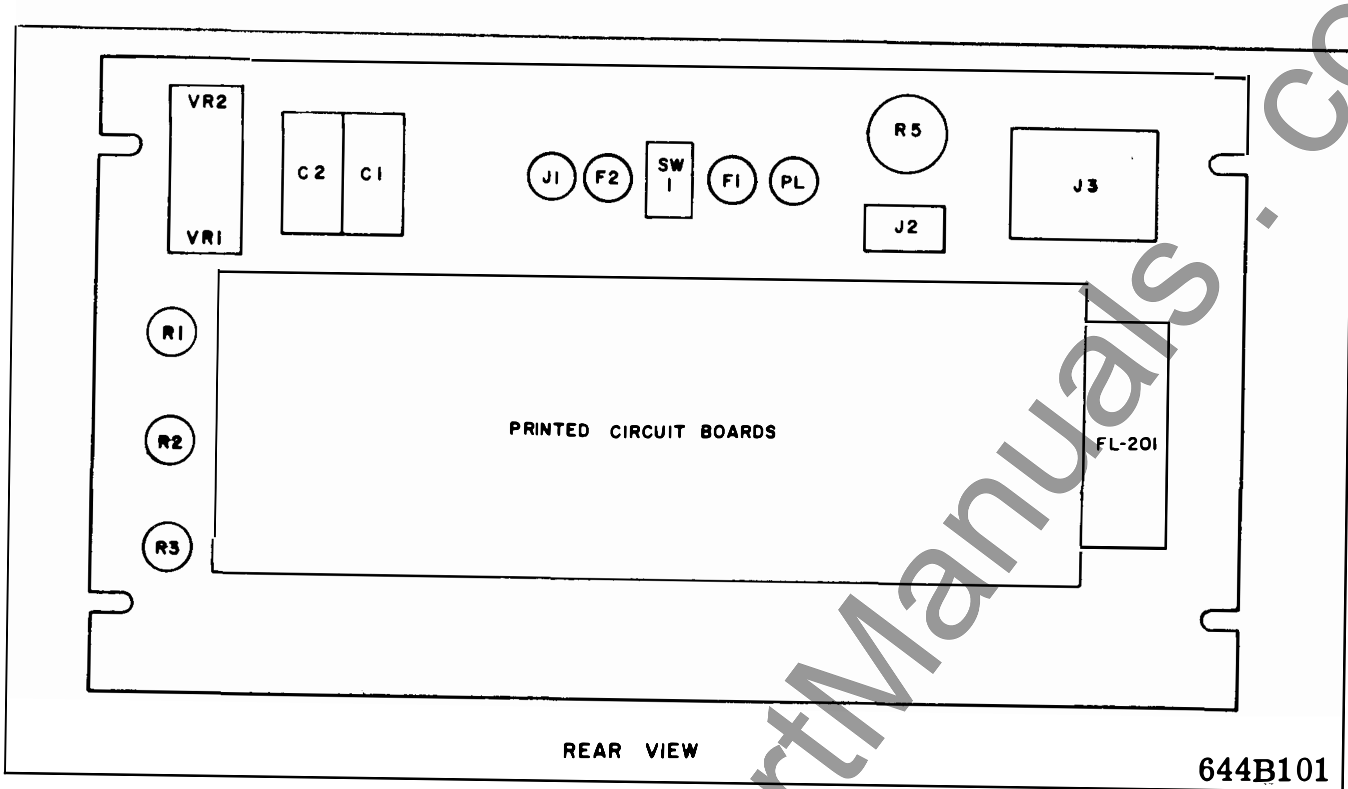


Fig. 4. Component Locations on the TCF Receiver Panel.

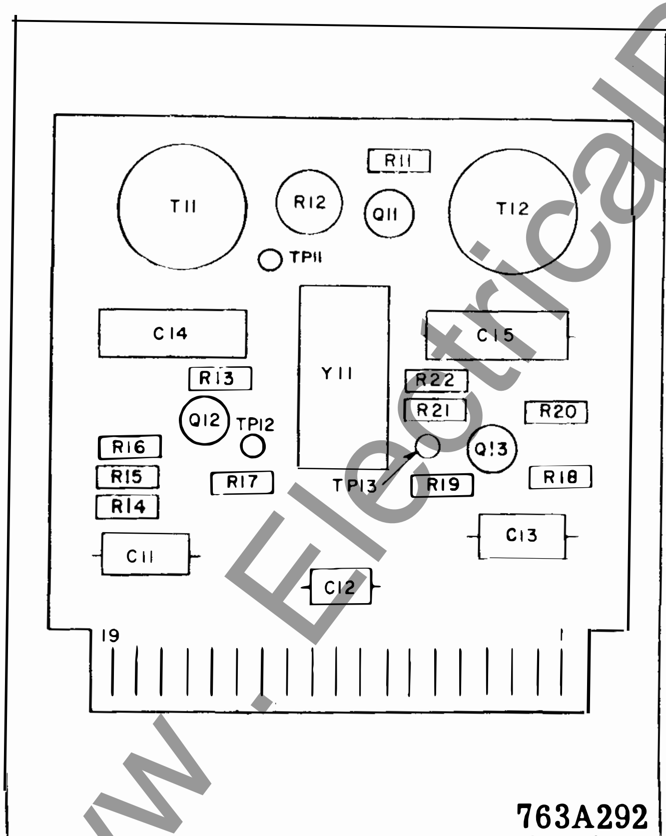


Fig. 5. Component Locations on the Oscillator and Mixer Printed Circuit Board.

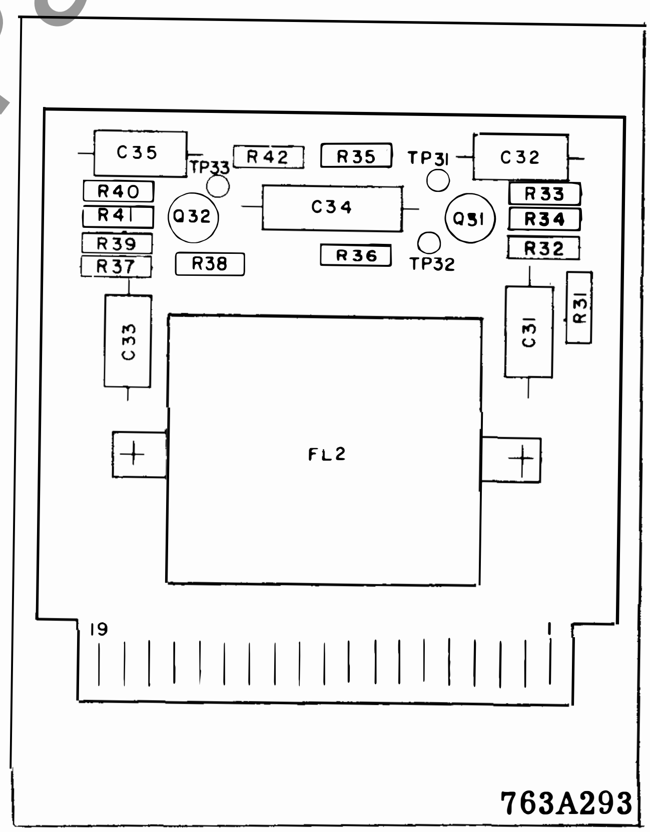


Fig. 6. Component Locations on the I.F. Amplifier Printed Circuit Board.

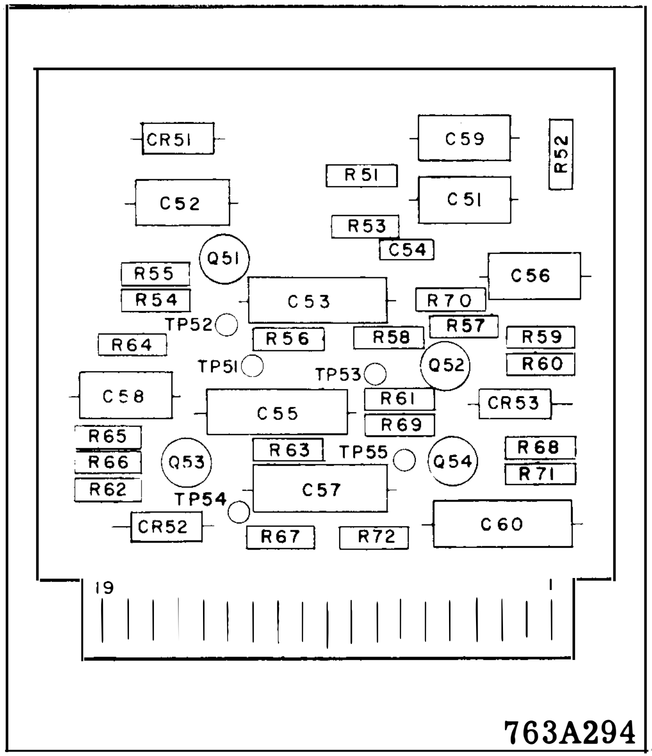


Fig. 7. Component Locations on the Amplifier and Limiter Printed Circuit Board.

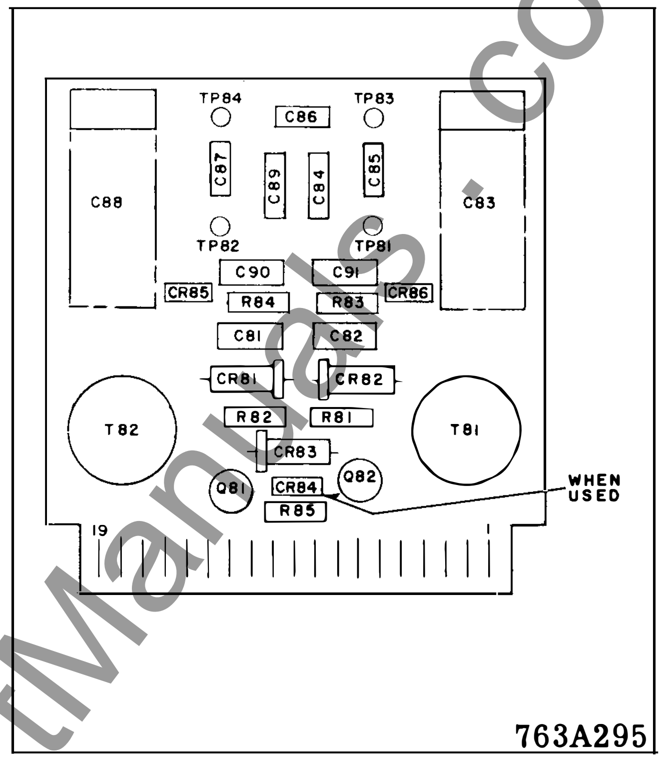


Fig. 8. Component Locations on the Discriminator Printed Circuit Board.

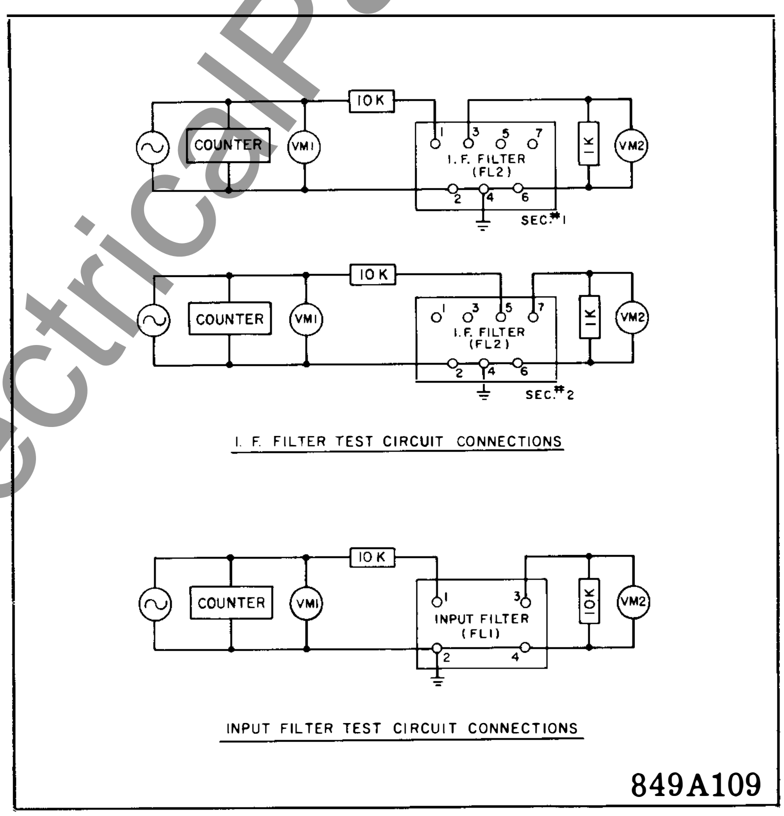


Fig. 9. Test Circuits for TCF Frequency Shift Receiver Filters

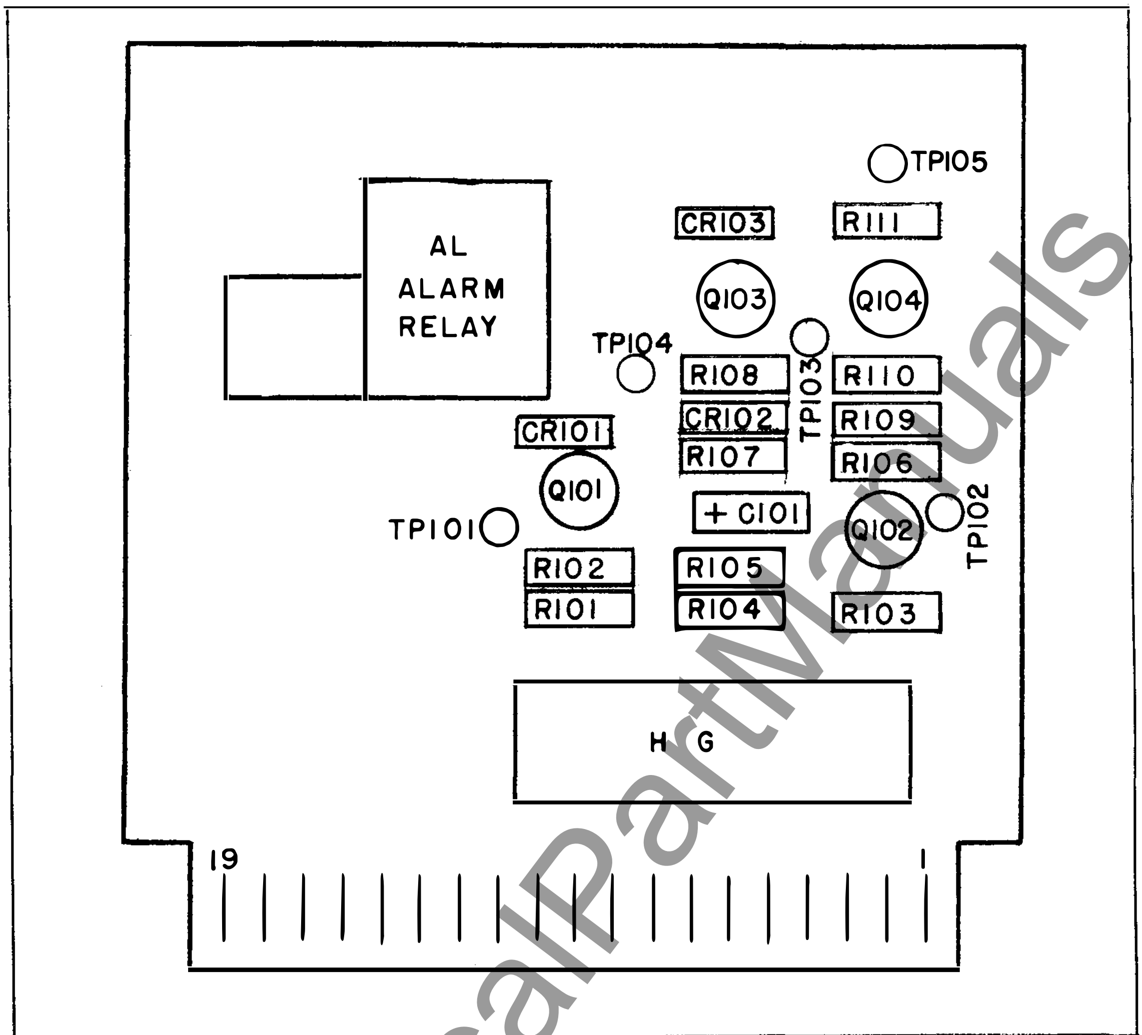


Fig. 10. Component Locations on the Relay Output Printed Circuit Board.

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 – WITH RELAY OUTPUT FOR SUPERVISORY CONTROL AND TELEMETERING

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 supervisory control and certain telemetering applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard frequency is 100 cycles above the center frequency of the channel (which can be selected * within the range of 30KC to 300 KC), and it is transmitted continuously when conditions are normal and no information is to be conveyed over the channel. Its reception indicates that the channel is operative. The Trip frequency (so called because in frequency-shift relaying applications the reception of this frequency causes closure of relay contacts in the trip circuit of a circuit breaker) is 100 cycles below the channel center frequency. When supervisory control or telemetering information is to be conveyed over the channel, the transmitter at one end of the channel is switched alternately between Guard and Trip so as to produce at the receiving end a desired number of operations of a relay activated by the trip frequency. Control of the durations of the intervals that the relay contacts are open and closed also can be utilized to convey information over the channel.

CONSTRUCTION

The TCF receiver unit for supervisory control and telemetering 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, and a jack for metering the discriminator output current are accessible from the front of the panel. Refer to Fig. 3.

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. 4. 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.

TCF receivers for transfer trip relaying require a logic circuit board and may require a carrier level indicator circuit board, which are contained in the third-from-right and right hand compartments respectively. These are not required for the TCF receiver for supervisory control and telemetering and the compartments are vacant.

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 is 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

SUPERSEDES I.L. 41-945.53A
*Denotes change from superseded issue.

EFFECTIVE SEPTEMBER 1970

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 V.D.C. 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 on 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. 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. Figure 2 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 and fc + 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 cycles. The adjustment for zero output at fc 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). It should be observed that although the higher signal frequency is fc + 100 cycles, after leaving the mixer stage and as seen by the discriminator the corresponding frequency is 20KC-100 cycles. Similarly, the lower signal frequency is converted to 20KC + 100 cycles.

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.

Output Circuits

The output circuit board of the receiver contains output relay HG. The contacts of this relay are the mercury-wetted type, which assures bounceless operation. It also contains telephone-type relay AL, the contacts of which can be used to energize an alarm.

When Trip signal is received, terminal 8 of Output printed circuit board is at approximately +20 volts potential and transistor Q101 becomes conductive, which energizes relay HG. When Guard signal is present, terminal 1 of the Output board is at approximately +20 volts potential. The base of transistor Q102 is connected to terminal 1 and 8 through resistors R103 and R104. Consequently when either Guard or Trip signal is present this transistor is conductive.

When neither Guard nor Trip signal is present, indicating a loss of channel, Q102 is not conductive and capacitor C101 begins to charge through resistors R106 and R107. When the capacitor voltage reaches the breakdown level of zener diode CR102 (in approximately 150 milliseconds) transistor Q103 receives base input and becomes conductive. This removes base input from Q104 and the alarm relay AL drops out and energizes an alarm through its normally-closed contacts. A copper slug on the core of the alarm relay adds an additional delay of approximately 40 milliseconds before the alarm contacts close. When Guard signal reappears and Q102 becomes conductive, capacitor C101 discharges rapidly through the low resistance of R107. This quick-reset feature of the RC time-delay reduces the possibility of operation of the loss-of-channel alarm by noise signal, which may override and cancel the Guard signal briefly but repetitively or may appear as a false Trip signal.

It should be noted that relay HG has Form D contacts, and only the normally-open or the normally-closed contacts should be used unless there is no objection to having both contacts momentarily closed simultaneously when the relay is energized or deenergized. Also, for protection of the HG relay contacts, the external device controlled should contain series resistance and capacitance (of values suitable for the load voltage and current) across the terminals that are externally connected to the HG relay terminals. With such protection the HG contacts have maximum ratings of 2 amperes, 500 volts, and 100 volt-amperes. The HG relay will pick up at approximately 20 volts.

The AL relay contacts are rated at 4 amps., 150 watts, for an a-c non-inductive load. The relay will pick at 35 to 40 volts.

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 - 200KC
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 zero output at channel center frequency and for max. outputs at 100 cycles above and below center frequency.
Operating Time	9 ms. channel (transm. and recvr.) 2 ms. HG relay operate and release times

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 lb.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as a 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°.

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; frequency spacing and magnitude of discriminator output peaks.

After the receiver has been installed, the input attenuator R5 must be set for the desired operating margin. 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 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 factory adjustments have been accidentally disturbed or components have been replaced, it may be necessary to readjust the oscillator and mixer, the limiter, or the discriminator, and procedures for these adjustments are described in the following paragraphs.

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 signal 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. Apply to the receiver input a 5 mv. signal taken from an oscillator set at the center frequency of the channel. (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 100 cycles above and below center frequency.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. 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 the following tables. 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 input signal down 50 db from 1 watt. Unless otherwise indicated, voltage will not vary appreciably whether signal is high, low or fc frequency.

Collector of Transistor	Volts (–)
Q11	20
Q12	14.5 (No signal)
Q12	14.0 (High or low freq. signal)
Q13	17.0 (No signal)
Q13	15.0 (High or low freq. signal)
Q31	18.5
Q32	18.5
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q81	20 (No signal or fc – 100 cy.)
Q81	< 0.5 (fc + 100 cy.)
Q82 and Q101	20 (No signal or fc + 100 cy.)
Q82 and Q101	< 0.5 (fc – 100 cy.)
Q103	20.5 (No signal)
Q104	< 0.5 (No signal)
Q105	45 (No signal)

TABLE II
RECEIVER RF MEASUREMENTS

Collector of Transistor	Volts (fc + cy.)
Q32	.25
Q51	.3
Q52	.4
Q53	2.1
Q54	4.8

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 Fig. 9 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 2 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 sec-

tions, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 2 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 (Fig. 9) 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
Input Impedance: 7.5 megohms

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 and Westinghouse Designation on the Electrical Part List.

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, 6.8 mfd.; 35 V.D.C.	184A661H25

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
CR51	1N457A; 60 V.; 200 MA.	184A855H07
CR52	1N457A; 60 V.; 200 MA.	184A855H07
CR53	1N457A; 60 V.; 200 MA.	184A855H07
CR81	1N91; 100 V.; 150 MA.	182A881H04
CR82	1N91; 100 V.; 150 MA.	182A881H04
CR83	1N91; 100 V.; 150 MA.	182A881H04
CR85	1N628; 125 V.; 20 MA.	184A844H12
CR86	1N628; 125 V.; 30 MA.	184A855H12
CR101	1N457A; 60 V.; 200 MA.	184A885H07
CR103	1N457A; 60 V.; 200 MA.	184A885H07
	DIODES – ZENER	
CR1	1N3027A; 20 V. ±10%; 1 W.	188A307H10
CR2	1N3027A; 20 V. ±10%; 1 W.	188A307H10
CR102	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
VR1	1N2828B; 45 V. ±5%; 50 W.	184A854H06
VR2	1N2984B; 20 V. ±5%; 10 W.	762A631H01
	POTENTIOMETERS	
R5	10K; 2W.	185A086H10
R7	250K; 2W.	185A086H11
R12	1K; ¼W.	629A430H02
R52	1K; ¼W.	629A645H04
	RESISTORS	
R1	400 ohms ±5%; 25W.	1202587
R2	26.5 ohms ±5%; 40W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1W. Composition	187A643H03
R6	10K ±5%; ½W. Composition	184A763H51
R8	100K ±5%; 1W. Composition	187A643H75
R11	10K ±5%; ½W. Composition	184A763H51
R13	5.6K ±5%; ½W. Composition	184A763H45
R14	3.3K ±5%; ½W. Composition	184A763H39
R15	330 ohms ±5%; ½W. Composition	184A763H15
R16	10K ±5%; ½W. Composition	184A763H51
R17	33K ±5%; ½W. Composition	184A763H63
R18	3.3K ±5%; ½W. Composition	184A763H39
R19	3.3K ±5%; ½W. Composition	184A763H39
R20	10K ±5%; ½W. Composition	184A763H51

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R21	33K ±5%; ½W. Composition	184A763H63
R22	330 ohms ±5%; ½W. Composition	184A763H15
R23	10K ±5%; ½W. Composition	184A763H51
R31	3.3K ±5%; ½W. Composition	184A763H39
R32	22K ±5%; ½W. Composition	184A763H59
R33	680 ohms ±5%; ½W. Composition	184A763H23
R34	68 ohms ±5%; ½W. Composition	187A290H21
R35	10K ±5%; ½W. Composition	184A763H51
R36	330 ohms ±5%; ½W. Composition	184A763H15
R37	3.3K ±5%; ½W. Composition	184A763H39
R38	1000 ohms ±5%; ½W. Composition	184A763H27
R39	22K ±5%; ½W. Composition	184A763H59
R40	680 ohms ±5%; ½W. Composition	184A763H23
R41	68 ohms ±5%; ½W. Composition	187A290H21
R42	10K ±5%; ½W. Composition	184A763H51
R51	4.7K ±5%; ½W. Composition	184A763H43
R53	27K ±5%; ½W. Composition	184A763H61
R54	2.2K ±5%; ½W. Composition	184A763H35
R55	27 ohms ±5%; ½W. Composition	187A290H11
R56	10K ±5%; ½W. Composition	184A763H51
R57	4.7K ±5%; ½W. Composition	184A763H43
R58	27K ±5%; ½W. Composition	184A763H61
R59	1.5K ±5%; W. Composition	184A763H31
R60	180 ohms ±5%; ½W. Composition	184A763H09
R61	4.7K ±5%; ½W. Composition	184A763H43
R62	1.5K ±5%; ½W. Composition	184A763H31
R63	3.3K ±5%; ½W. Composition	184A763H63
R64	2.7K ±5%; ½W. Composition	184A763H37
R65	680 ohms ±5%; ½W. Composition	184A763H23
R66	68 ohms ±5%; ½W. Composition	187A290H21
R67	4.7K ±5%; ½W. Composition	184A763H43
R68	2.7K ±5%; ½W. Composition	184A763H37
R69	18K ±5%; ½W. Composition	184A763H57
R70	220 ohms ±5%; ½W. Composition	184A763H11
R71	270 ohms ±5%; ½W. Composition	184A763H13
R72	330 ohms ±5%; ½W. Composition	184A763H15
R81	4.7K ±5%; ½W. Composition	184A763H43
R82	4.7K ±5%; ½W. Composition	184A763H43
R83	2.2K ±5%; ½W. Composition	184A763H35
R84	2.2K ±5%; ½W. Composition	184A763H35

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R85	6.8K ±5%; ½W. Composition	184A763H47
R101	18K ±5%; ½W. Composition	184A763H57
R102	10K ±5%; ½W. Composition	184A763H51
R103	82K ±5%; ½W. Composition	184A763H73
R104	82K ±5%; ½W. Composition	184A763H73
R105	10K ±5%; 1W. Composition	187A643H51
R106	39K ±5%; ½W. Composition	184A763H65
R107	1000 ohms ±5%; ½W. Composition	185A763H27
R108	10K ±5%; ½W. Composition	184A763H51
R109	22K ±5%; ½W. Composition	184A763H23
R110	27K ±5%; ½W. Composition	184A763H61
R111	10K ±5%; ½W. Composition	184A763H51
	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	2N699	184A638H19
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 KC above Channel Frequency)	762A800H01 + (Reg. Freq.)
FL1	Crystal Input Filter	410C466 + (Reg. 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, 1.5A	11D919H26
AL	Alarm Relay	408C062H07
HG	Mercury Weted Contact Relay; 2 amp, 500 V., 100 V.A.	188A573H04

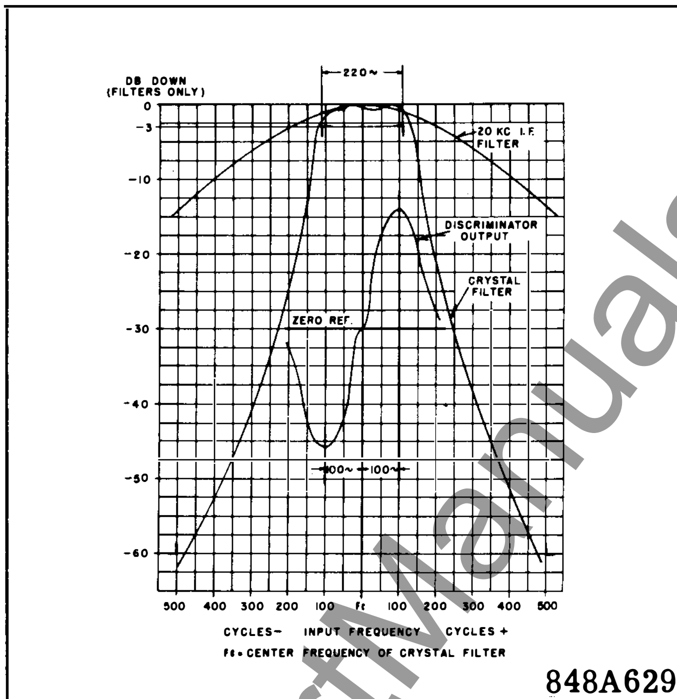


Fig. 2. Filter and Discriminator Characteristics of the Type TCF Receiver.

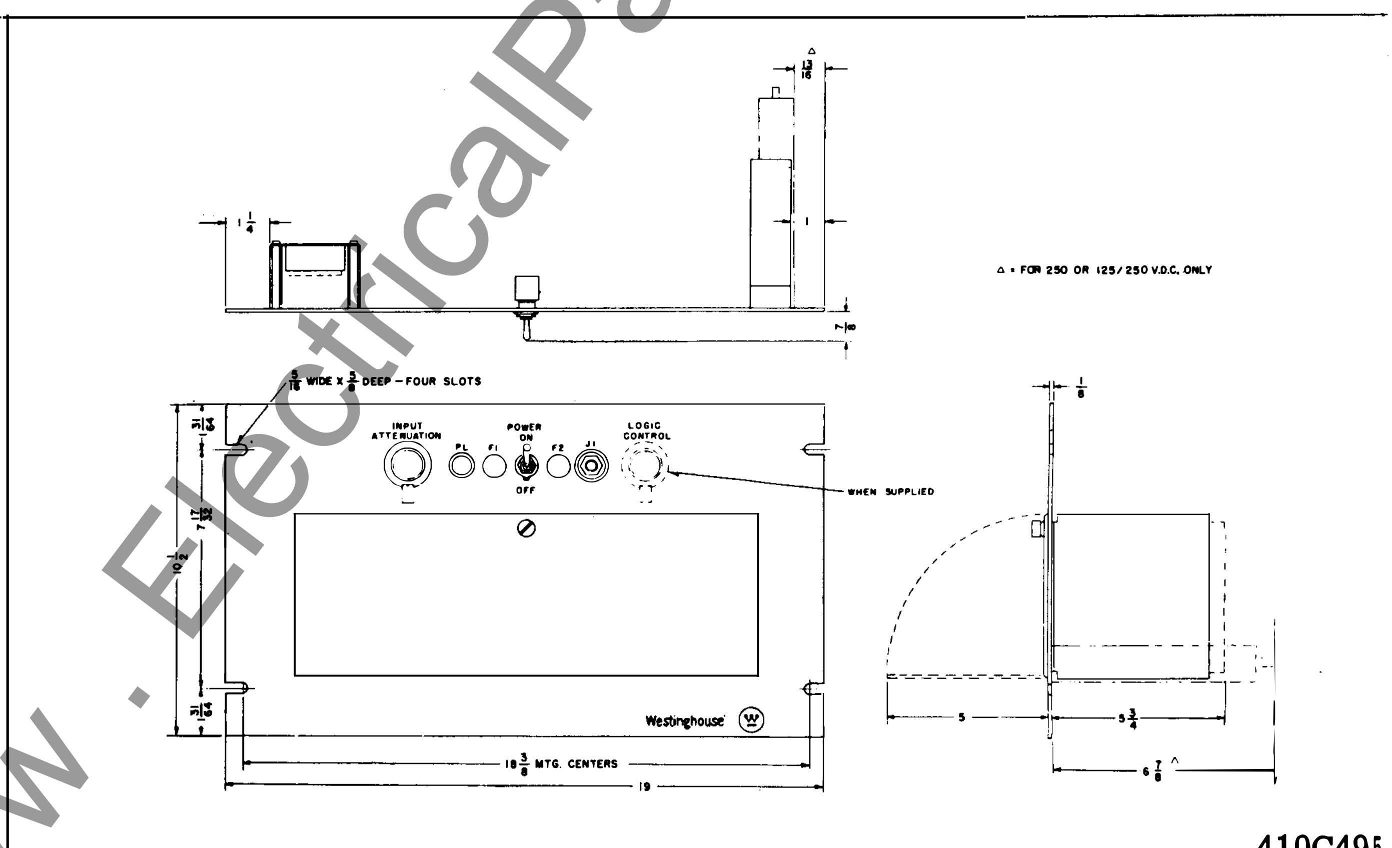
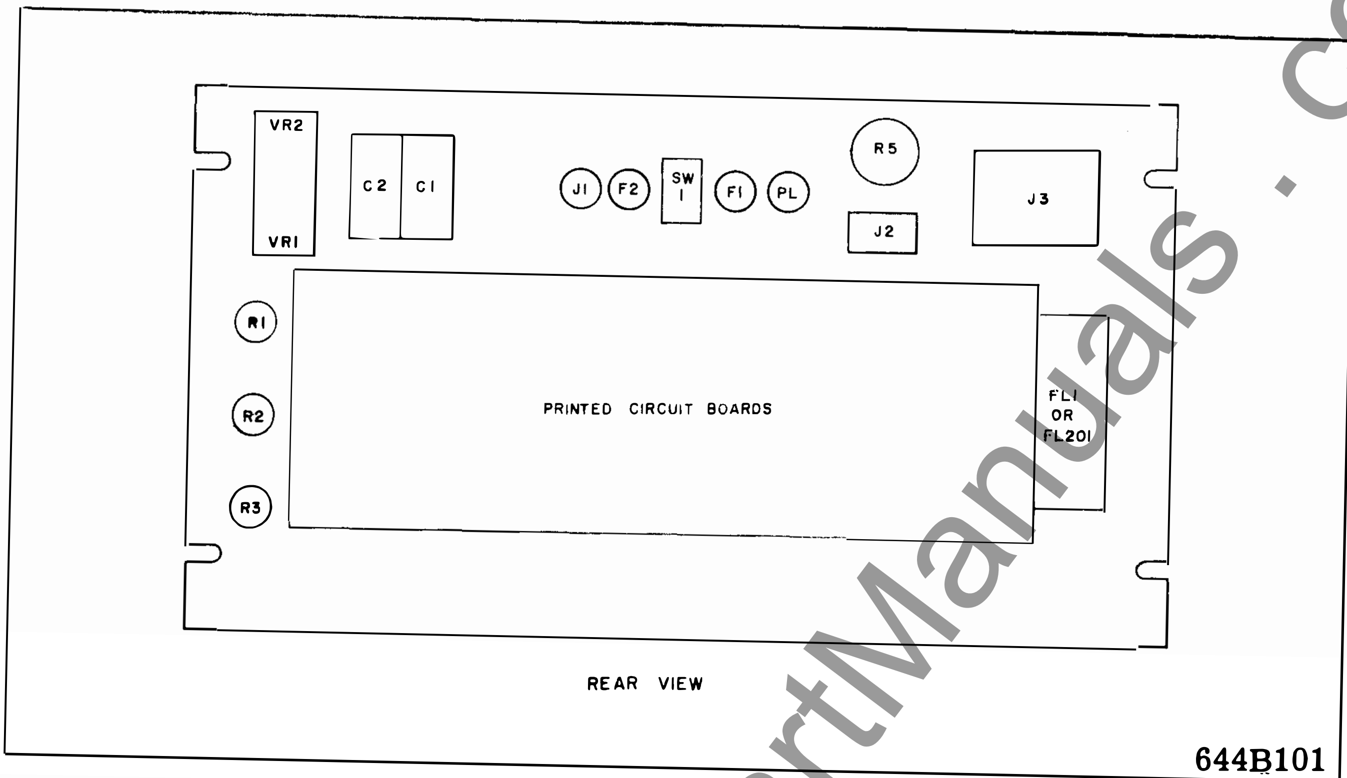


Fig. 3. Outline and Drilling Plan for the Type TCF Receiver Assembly.



* *Fig. 4. Component Locations on the TCF Receiver Panel.*

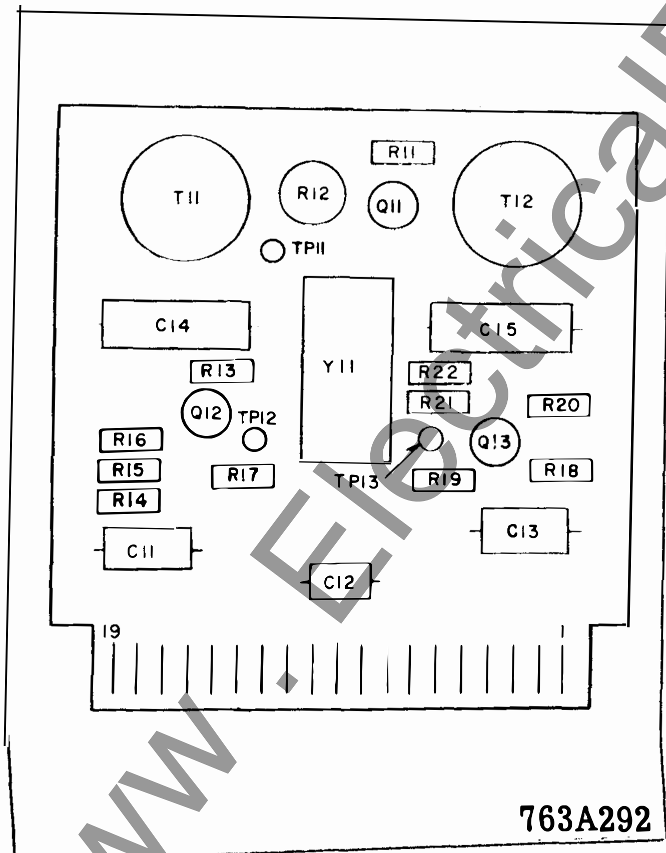


Fig. 5. Component Locations on the Oscillator and Mixer Printed Circuit Board.

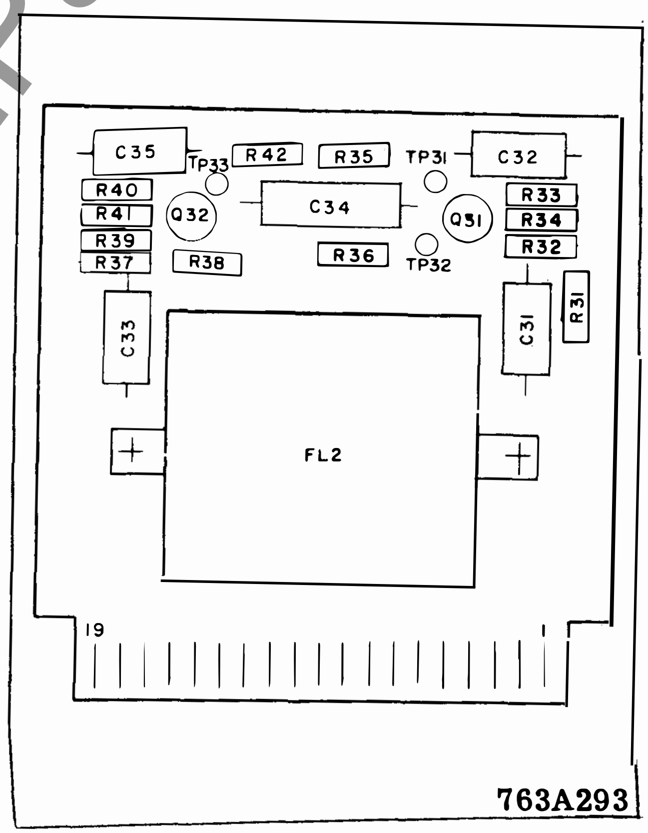


Fig. 6. Component Locations on the I.F. Amplifier Printed Circuit Board.

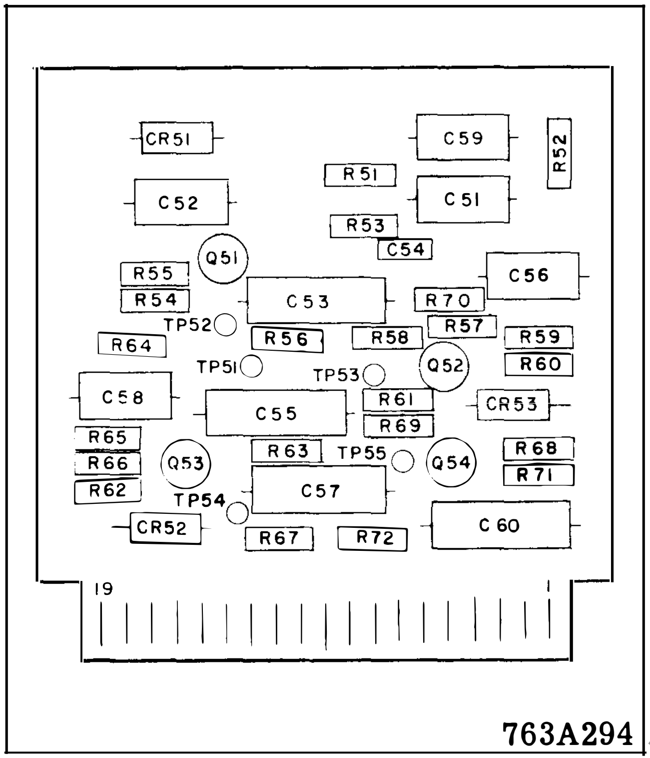


Fig. 7. Component Locations on the Amplifier and Limiter Printed Circuit Board.

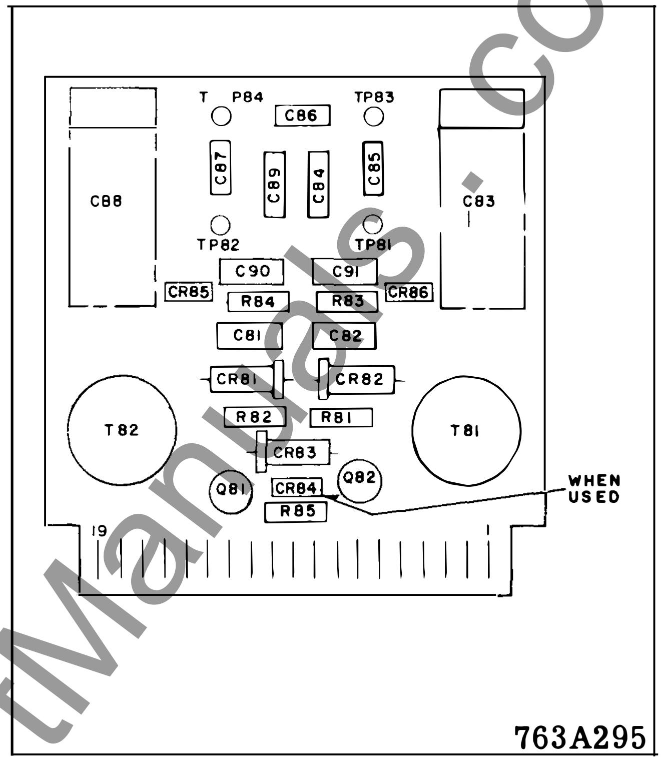


Fig. 8. Component Locations on the Discriminator Printed Circuit Board.

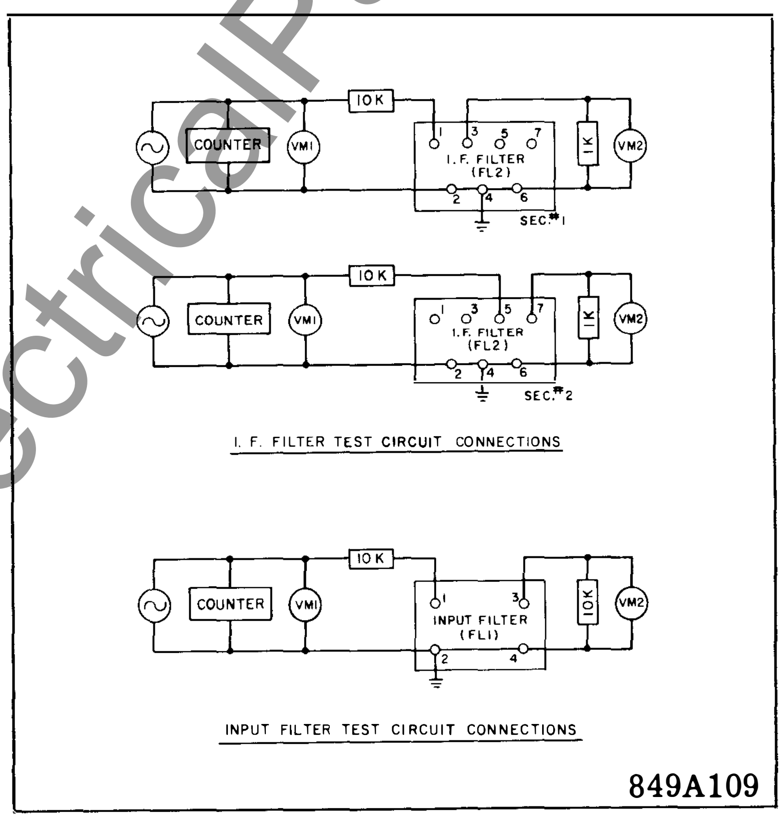


Fig. 9. Test Circuits for TCF Frequency Shift Receiver Filters

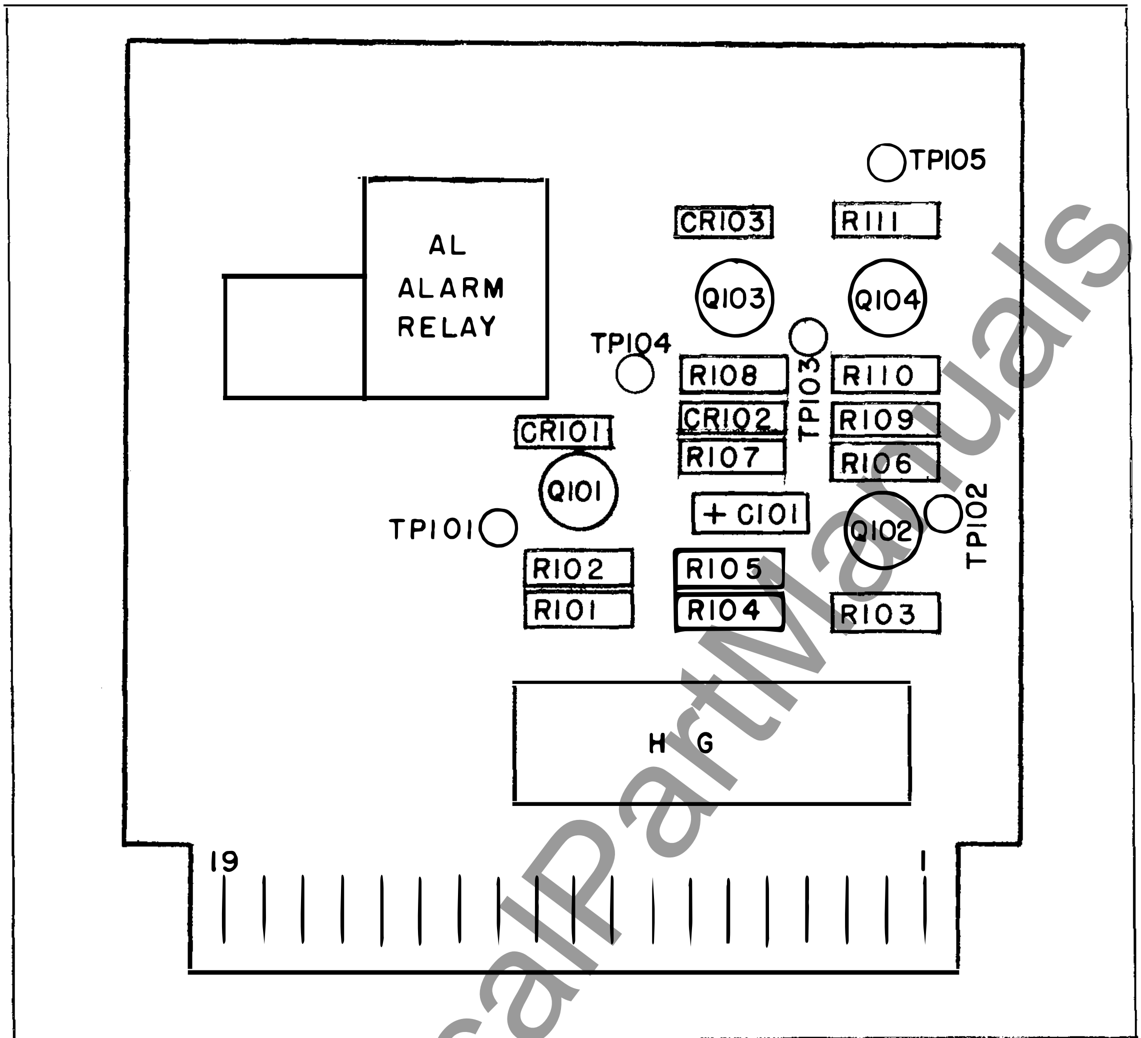


Fig. 10. Component Locations on the Relay Output Printed Circuit Board.

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 – WITH RELAY OUTPUT FOR SUPERVISORY CONTROL AND TELEMETERING

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 supervisory control and certain telemetering applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard frequency is 100 cycles above the center frequency of the channel (which can be selected * within the range of 30KC to 300 KC), and it is transmitted continuously when conditions are normal and no information is to be conveyed over the channel. Its reception indicates that the channel is operative. The Trip frequency (so called because in frequency-shift relaying applications the reception of this frequency causes closure of relay contacts in the trip circuit of a circuit breaker) is 100 cycles below the channel center frequency. When supervisory control or telemetering information is to be conveyed over the channel, the transmitter at one end of the channel is switched alternately between Guard and Trip so as to produce at the receiving end a desired number of operations of a relay activated by the trip frequency. Control of the durations of the intervals that the relay contacts are open and closed also can be utilized to convey information over the channel.

CONSTRUCTION

The TCF receiver unit for supervisory control and telemetering 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, and a jack for metering the discriminator output current are accessible from the front of the panel. Refer to Fig. 3.

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. 4. 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.

TCF receivers for transfer trip relaying require a logic circuit board and may require a carrier level indicator circuit board, which are contained in the third-from-right and right hand compartments respectively. These are not required for the TCF receiver for supervisory control and telemetering and the compartments are vacant.

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 is 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

SUPERSEDES I.L. 41-945.53A
*Denotes change from superseded issue.

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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 V.D.C. 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 on 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. 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. Figure 2 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 and fc + 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 cycles. The adjustment for zero output at fc 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). It should be observed that although the higher signal frequency is fc + 100 cycles, after leaving the mixer stage and as seen by the discriminator the corresponding frequency is 20KC-100 cycles. Similarly, the lower signal frequency is converted to 20KC + 100 cycles.

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.

Output Circuits

The output circuit board of the receiver contains output relay HG. The contacts of this relay are the mercury-wetted type, which assures bounceless operation. It also contains telephone-type relay AL, the contacts of which can be used to energize an alarm.

When Trip signal is received, terminal 8 of Output printed circuit board is at approximately +20 volts potential and transistor Q101 becomes conductive, which energizes relay HG. When Guard signal is present, terminal 1 of the Output board is at approximately +20 volts potential. The base of transistor Q102 is connected to terminal 1 and 8 through resistors R103 and R104. Consequently when either Guard or Trip signal is present this transistor is conductive.

When neither Guard nor Trip signal is present, indicating a loss of channel, Q102 is not conductive and capacitor C101 begins to charge through resistors R106 and R107. When the capacitor voltage reaches the breakdown level of zener diode CR102 (in approximately 150 milliseconds) transistor Q103 receives base input and becomes conductive. This removes base input from Q104 and the alarm relay AL drops out and energizes an alarm through its normally-closed contacts. A copper slug on the core of the alarm relay adds an additional delay of approximately 40 milliseconds before the alarm contacts close. When Guard signal reappears and Q102 becomes conductive, capacitor C101 discharges rapidly through the low resistance of R107. This quick-reset feature of the RC time-delay reduces the possibility of operation of the loss-of-channel alarm by noise signal, which may override and cancel the Guard signal briefly but repetitively or may appear as a false Trip signal.

It should be noted that relay HG has Form D contacts, and only the normally-open or the normally-closed contacts should be used unless there is no objection to having both contacts momentarily closed simultaneously when the relay is energized or deenergized. Also, for protection of the HG relay contacts, the external device controlled should contain series resistance and capacitance (of values suitable for the load voltage and current) across the terminals that are externally connected to the HG relay terminals. With such protection the HG contacts have maximum ratings of 2 amperes, 500 volts, and 100 volt-amperes. The HG relay will pick up at approximately 20 volts.

The AL relay contacts are rated at 4 amps., 150 watts, for an a-c non-inductive load. The relay will pick at 35 to 40 volts.

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 - 200KC
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 zero output at channel center frequency and for max. outputs at 100 cycles above and below center frequency.
Operating Time	9 ms. channel (transm. and recvr.) 2 ms. HG relay operate and release times

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 lb.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as a 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°.

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; frequency spacing and magnitude of discriminator output peaks.

After the receiver has been installed, the input attenuator R5 must be set for the desired operating margin. 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 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 factory adjustments have been accidentally disturbed or components have been replaced, it may be necessary to readjust the oscillator and mixer, the limiter, or the discriminator, and procedures for these adjustments are described in the following paragraphs.

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 signal 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. Apply to the receiver input a 5 mv. signal taken from an oscillator set at the center frequency of the channel. (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 100 cycles above and below center frequency.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. 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 the following tables. 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 input signal down 50 db from 1 watt. Unless otherwise indicated, voltage will not vary appreciably whether signal is high, low or fc frequency.

Collector of Transistor	Volts (–)
Q11	20
Q12	14.5 (No signal)
Q12	14.0 (High or low freq. signal)
Q13	17.0 (No signal)
Q13	15.0 (High or low freq. signal)
Q31	18.5
Q32	18.5
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q81	20 (No signal or fc — 100 cy.)
Q81	<0.5 (fc + 100 cy.)
Q82 and Q101	20 (No signal or fc + 100 cy.)
Q82 and Q101	<0.5 (fc — 100 cy.)
Q103	20.5 (No signal)
Q104	<0.5 (No signal)
Q105	45 (No signal)

TABLE II
RECEIVER RF MEASUREMENTS

Collector of Transistor	Volts (fc + cy.)
Q32	.25
Q51	.3
Q52	.4
Q53	2.1
Q54	4.8

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL 1) and the IF filter (FL 2) 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 Fig. 9 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 2 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 sec-

tions, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 2 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 (Fig. 9) 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
Input Impedance: 7.5 megohms

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 and Westinghouse Designation on the Electrical Part List.

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, 6.8 mfd.; 35 V.D.C.	184A661H25

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
CR51	1N457A; 60 V.; 200 MA.	184A855H07
CR52	1N457A; 60 V.; 200 MA.	184A855H07
CR53	1N457A; 60 V.; 200 MA.	184A855H07
CR81	1N91; 100 V.; 150 MA.	182A881H04
CR82	1N91; 100 V.; 150 MA.	182A881H04
CR83	1N91; 100 V.; 150 MA.	182A881H04
CR85	1N628; 125 V.; 20 MA.	184A844H12
CR86	1N628; 125 V.; 30 MA.	184A855H12
CR101	1N457A; 60 V.; 200 MA.	184A885H07
CR103	1N457A; 60 V.; 200 MA.	184A885H07
	DIODES – ZENER	
CR1	1N3027A; 20 V. ±10%; 1 W.	188A307H10
CR2	1N3027A; 20 V. ±10%; 1 W.	188A307H10
CR102	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
VR1	1N2828B; 45 V. ±5%; 50 W.	184A854H06
VR2	1N2984B; 20 V. ±5%; 10 W.	762A631H01
	POTENTIOMETERS	
R5	10K; 2W.	185A086H10
R7	250K; 2W.	185A086H11
R12	1K; ¼W.	629A430H02
R52	1K; ¼W.	629A645H04
	RESISTORS	
R1	400 ohms ±5%; 25W.	1202587
R2	26.5 ohms ±5%; 40W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1W. Composition	187A643H03
R6	10K ±5%; ½W. Composition	184A763H51
R8	100K ±5%; 1W. Composition	187A643H75
R11	10K ±5%; ½W. Composition	184A763H51
R13	5.6K ±5%; ½W. Composition	184A763H45
R14	3.3K ±5%; ½W. Composition	184A763H39
R15	330 ohms ±5%; ½W. Composition	184A763H15
R16	10K ±5%; ½W. Composition	184A763H51
R17	33K ±5%; ½W. Composition	184A763H63
R18	3.3K ±5%; ½W. Composition	184A763H39
R19	3.3K ±5%; ½W. Composition	184A763H39
R20	10K ±5%; ½W. Composition	184A763H51

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R21	33K ±5%; ½W. Composition	184A763H63
R22	330 ohms ±5%; ½W. Composition	184A763H15
R23	10K ±5%; ½W. Composition	184A763H51
R31	3.3K ±5%; ½W. Composition	184A763H39
R32	22K ±5%; ½W. Composition	184A763H59
R33	680 ohms ±5%; ½W. Composition	184A763H23
R34	68 ohms ±5%; ½W. Composition	187A290H21
R35	10K ±5%; ½W. Composition	184A763H51
R36	330 ohms ±5%; ½W. Composition	184A763H15
R37	3.3K ±5%; ½W. Composition	184A763H39
R38	1000 ohms ±5%; ½W. Composition	184A763H27
R39	22K ±5%; ½W. Composition	184A763H59
R40	680 ohms ±5%; ½W. Composition	184A763H23
R41	68 ohms ±5%; ½W. Composition	187A290H21
R42	10K ±5%; ½W. Composition	184A763H51
R51	4.7K ±5%; ½W. Composition	184A763H43
R53	27K ±5%; ½W. Composition	184A763H61
R54	2.2K ±5%; ½W. Composition	184A763H35
R55	27 ohms ±5%; ½W. Composition	187A290H11
R56	10K ±5%; ½W. Composition	184A763H51
R57	4.7K ±5%; ½W. Composition	184A763H43
R58	27K ±5%; ½W. Composition	184A763H61
R59	1.5K ±5%; W. Composition	184A763H31
R60	180 ohms ±5%; ½W. Composition	184A763H09
R61	4.7K ±5%; ½W. Composition	184A763H43
R62	1.5K ±5%; ½W. Composition	184A763H31
R63	3.3K ±5%; ½W. Composition	184A763H63
R64	2.7K ±5%; ½W. Composition	184A763H37
R65	680 ohms ±5%; ½W. Composition	184A763H23
R66	68 ohms ±5%; ½W. Composition	187A290H21
R67	4.7K ±5%; ½W. Composition	184A763H43
R68	2.7K ±5%; ½W. Composition	184A763H37
R69	18K ±5%; ½W. Composition	184A763H57
R70	220 ohms ±5%; ½W. Composition	184A763H11
R71	270 ohms ±5%; ½W. Composition	184A763H13
R72	330 ohms ±5%; ½W. Composition	184A763H15
R81	4.7K ±5%; ½W. Composition	184A763H43
R82	4.7K ±5%; ½W. Composition	184A763H43
R83	2.2K ±5%; ½W. Composition	184A763H35
R84	2.2K ±5%; ½W. Composition	184A763H35

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R85	6.8K ±5%; ½W. Composition	184A763H47
R101	18K ±5%; ½W. Composition	184A763H57
R102	10K ±5%; ½W. Composition	184A763H51
R103	82K ±5%; ½W. Composition	184A763H73
R104	82K ±5%; ½W. Composition	184A763H73
R105	10K ±5%; 1W. Composition	187A643H51
R106	39K ±5%; ½W. Composition	184A763H65
R107	1000 ohms ±5%; ½W. Composition	185A763H27
R108	10K ±5%; ½W. Composition	184A763H51
R109	22K ±5%; ½W. Composition	184A763H23
R110	27K ±5%; ½W. Composition	184A763H61
R111	10K ±5%; ½W. Composition	184A763H51
	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	2N699	184A638H19
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 KC above Channel Frequency)	762A800H01 + (Reg. Freq.)
FL1	Crystal Input Filter	410C466 + (Reg. 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, 1.5A	11D919H26
AL	Alarm Relay	408C062H07
HG	Mercury Weted Contact Relay; 2 amp, 500 V., 100 V.A.	188A573H04

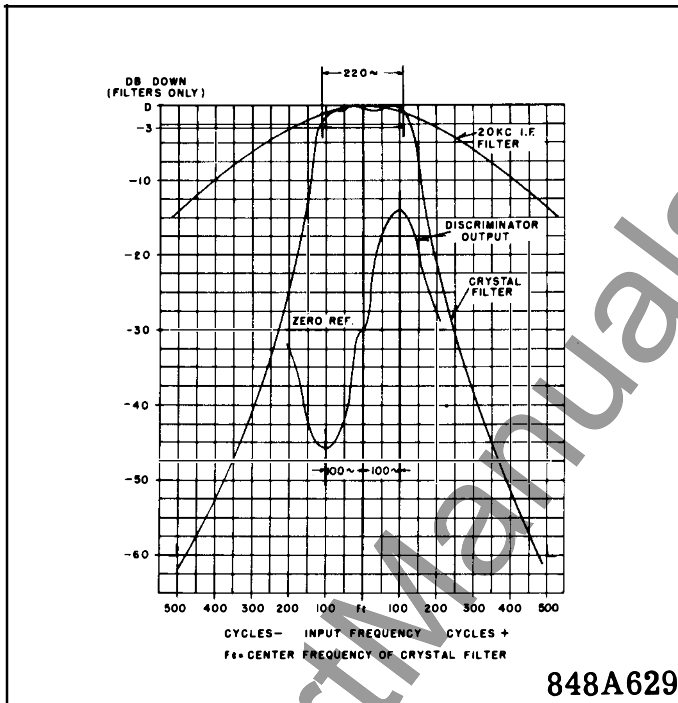


Fig. 2. Filter and Discriminator Characteristics of the Type TCF Receiver.

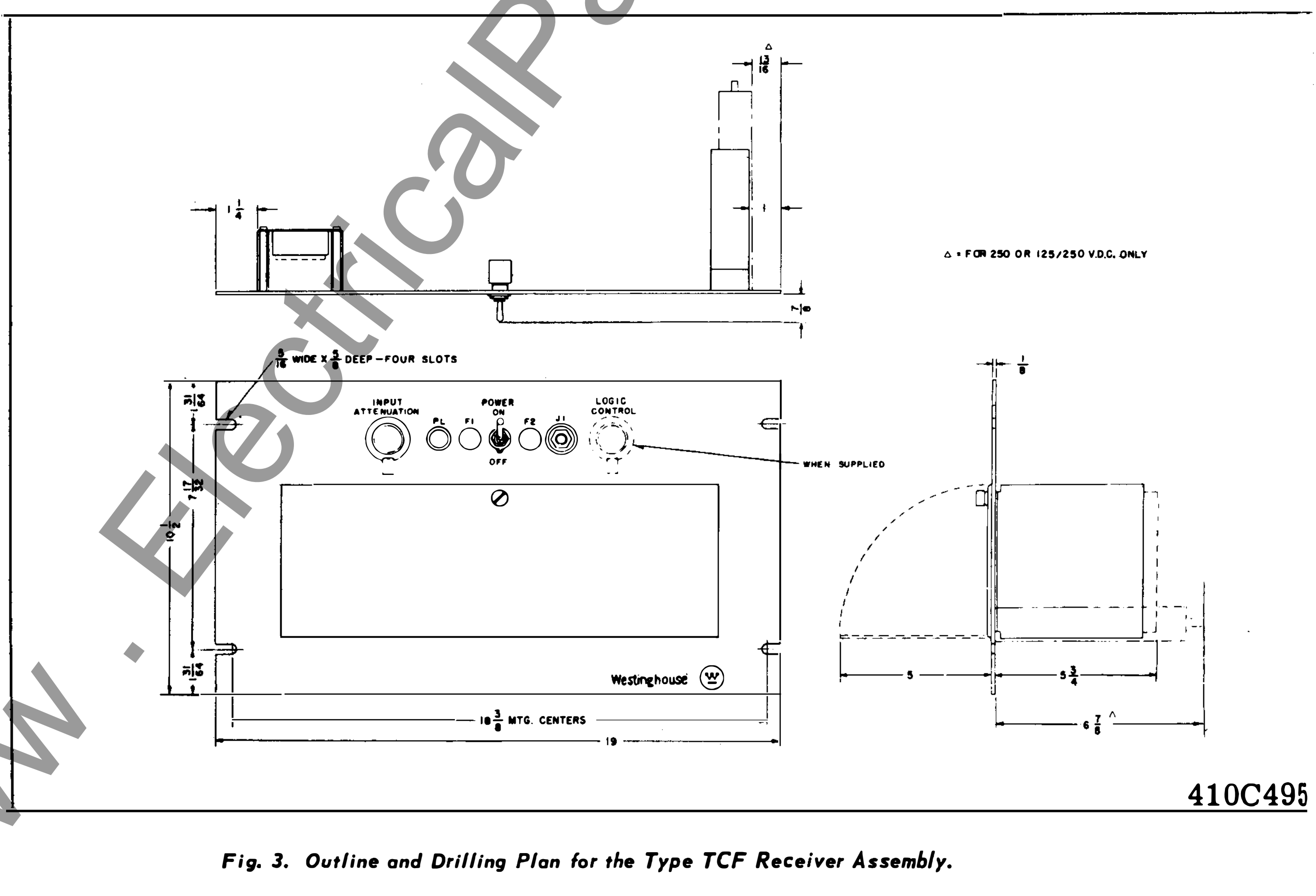
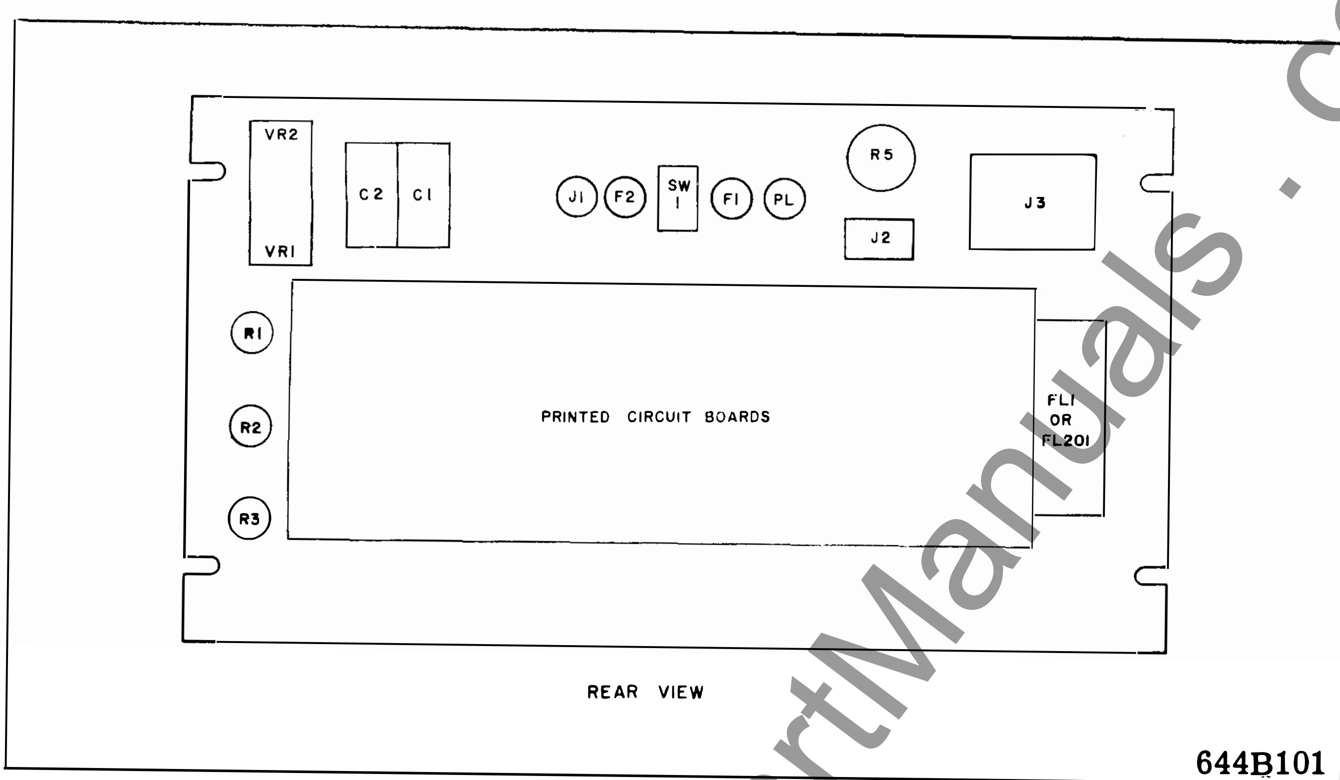


Fig. 3. Outline and Drilling Plan for the Type TCF Receiver Assembly.



* *Fig. 4. Component Locations on the TCF Receiver Panel.*

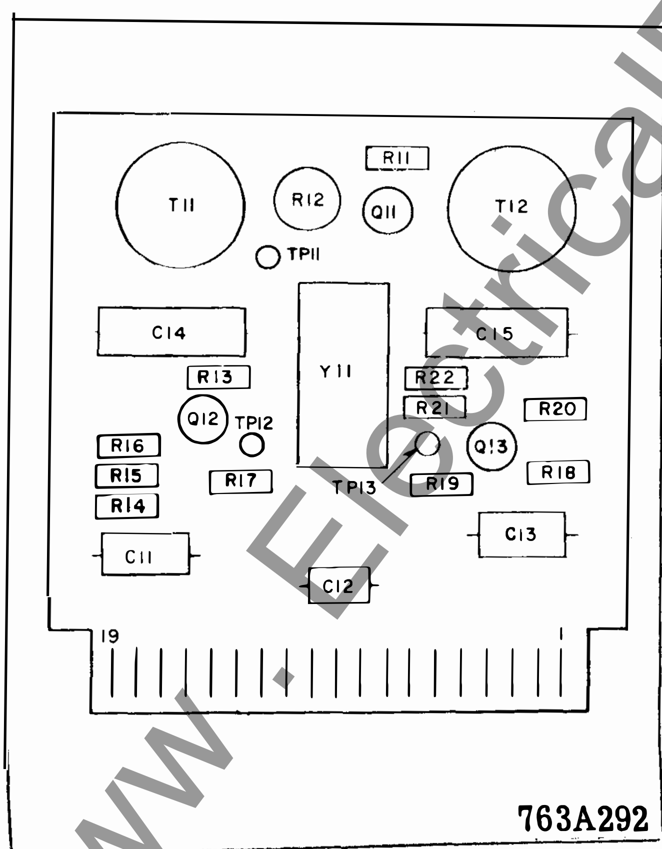


Fig. 5. Component Locations on the Oscillator and Mixer Printed Circuit Board.

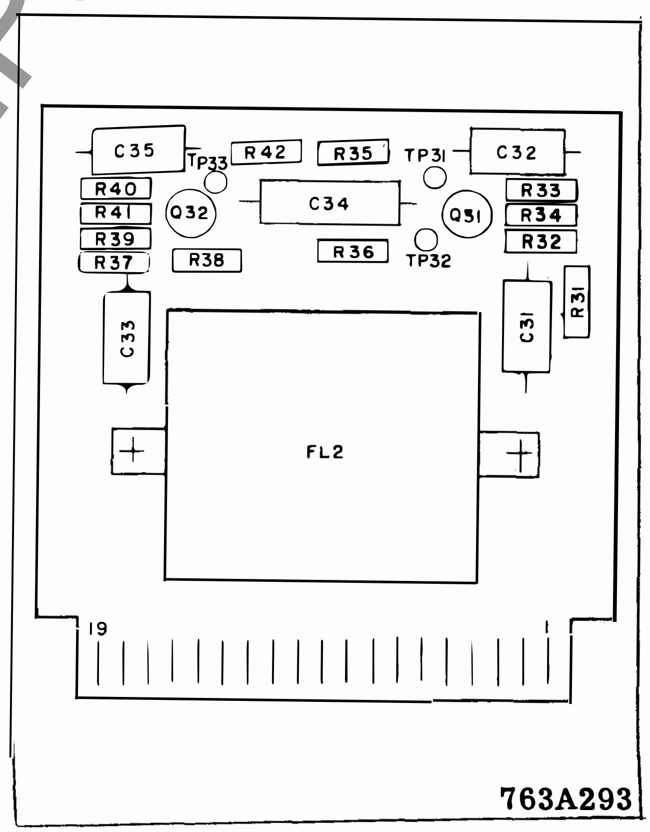


Fig. 6. Component Locations on the I.F. Amplifier Printed Circuit Board.

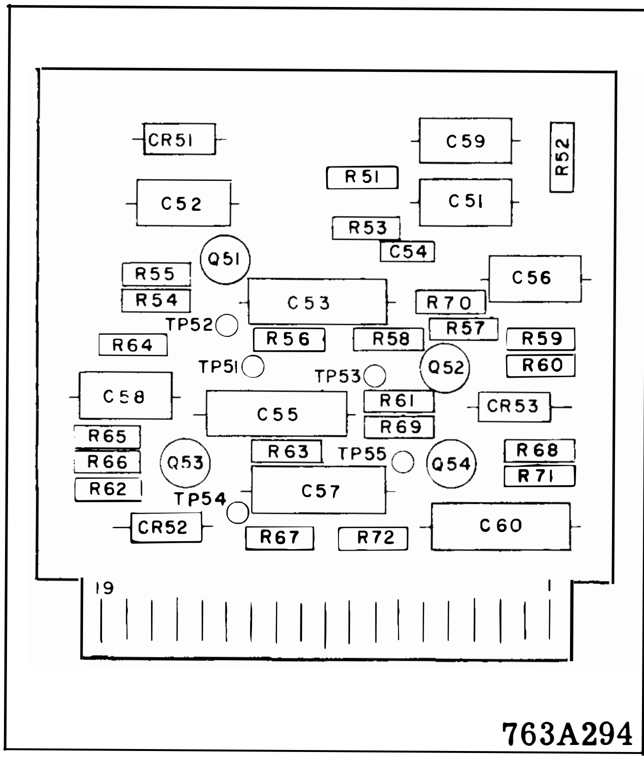


Fig. 7. Component Locations on the Amplifier and Limiter Printed Circuit Board.

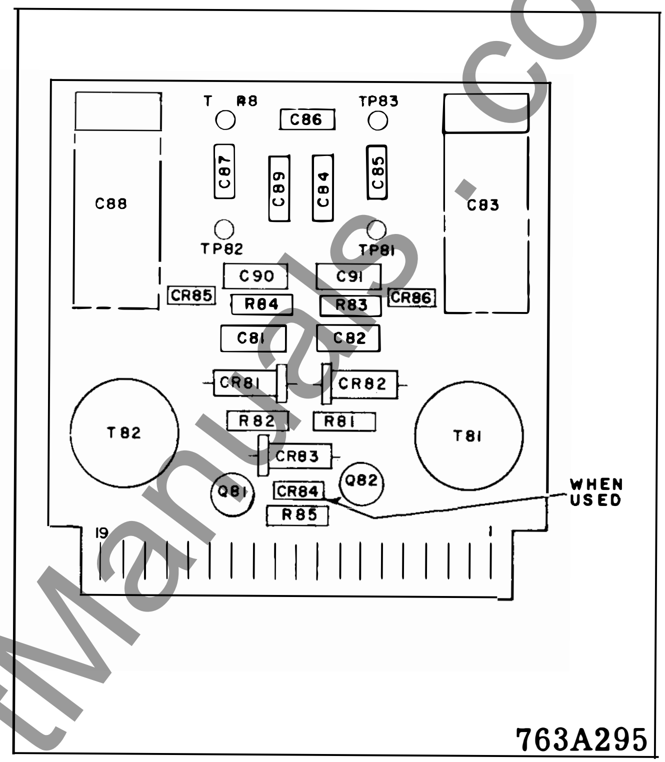


Fig. 8. Component Locations on the Discriminator Printed Circuit Board.

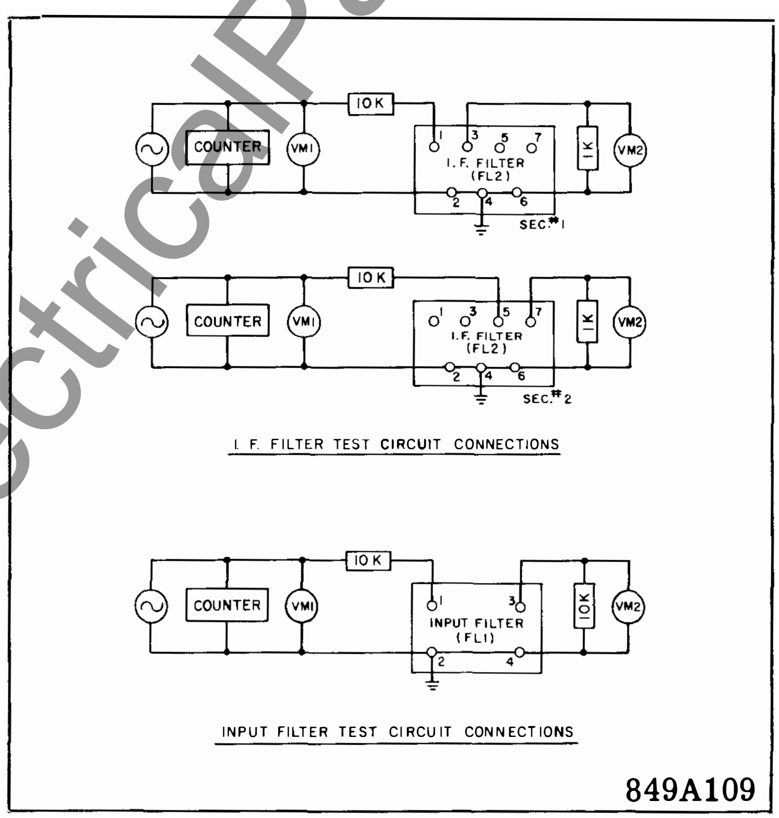


Fig. 9. Test Circuits for TCF Frequency Shift Receiver Filters

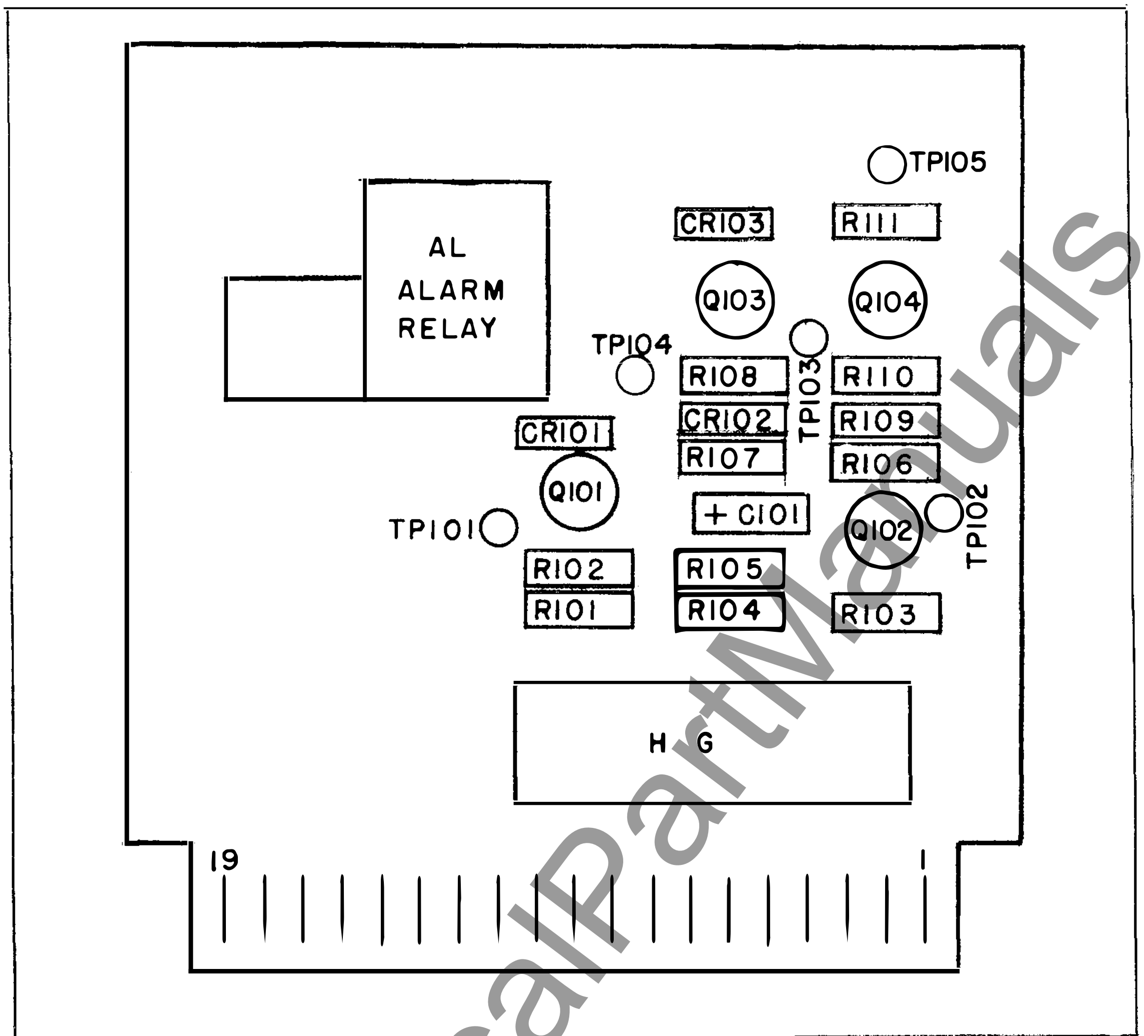


Fig. 10. Component Locations on the Relay Output Printed Circuit Board.

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 – WITH RELAY OUTPUT FOR SUPERVISORY CONTROL AND TELEMETERING

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 supervisory control and certain telemetering applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard frequency is 100 hertz above the center frequency of the channel (which can be selected within the range of 30KHz to 300KHz), and it is transmitted continuously when conditions are normal and no information is to be conveyed over the channel. Its reception indicates that the channel is operative. The Trip frequency (so called because in frequency-shift relaying applications the reception of this frequency causes closure of relay contacts in the trip circuit of a circuit breaker) is 100 hertz below the channel center frequency. When supervisory control or telemetering information is to be conveyed over the channel, the transmitter at one end of the channel is switched alternately between Guard and Trip so as to produce at the receiving end a desired number of operations of a relay activated by the trip frequency. Control of the durations of the intervals that the relay contacts are open and closed also can be utilized to convey information over the channel.

◆ CONSTRUCTION

The TCF receiver unit for supervisory control and telemetering 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, and a jack for metering the discriminator output current are accessible from the front of the panel. Refer to Fig. 3.

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. 4. 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.

TCF receivers for transfer trip relaying require a logic circuit board and may require a carrier level indicator circuit board, which are contained in the third-from-right and right hand compartments respectively. These are not required for the TCF receiver for supervisory control and telemetering and the compartments are vacant.

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 is 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

SUPERSEDES I.L. 41-945.53C
*Denotes change from superseded issue.

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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 V.D.C. 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 on 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. 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 hertz above or below the center frequency (fc) of the channel are greatly attenuated. Figure 2 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 20KHz 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 20KHz, 2fc + 20KHz, fc and fc + 20KHz.

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 hertz. The adjustment for zero output at fc hertz is made by capacitor C88. X83 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 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). It should be observed that although the higher signal frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the corresponding frequency is 20KHz-100 hertz. Similarly, the lower signal frequency is converted to 20KHz + 100 hertz.

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.

Output Circuits

The output circuit board of the receiver contains output relay HG. The contacts of this relay are the mercury-wetted type, which assures bounceless operation. It also contains telephone-type relay AL, the contacts of which can be used to energize an alarm.

When Trip signal is received, terminal 8 of Output printed circuit board is at approximately +20 volts potential and transistor Q101 becomes conductive, which energizes relay HG. When Guard signal is present, terminal 1 of the Output board is at approximately +20 volts potential. The base of transistor Q102 is connected to terminal 1 and 8 through resistors R103 and R104. Consequently when either Guard or Trip signal is present this transistor is conductive.

When neither Guard nor Trip signal is present, indicating a loss of channel, Q102 is not conductive and capacitor C101 begins to charge through resistors R106 and R107. When the capacitor voltage reaches the breakdown level of zener diode CR102 (in approximately 150 milliseconds) transistor Q103 receives base input and becomes conductive. This removes base input from Q104 and the alarm relay AL drops out and energizes an alarm through its normally-closed contacts. A copper slug on the core of the alarm relay adds an additional delay of approximately 40 milliseconds before the alarm contacts close. When Guard signal reappears and Q102 becomes conductive, capacitor C101 discharges rapidly through the low resistance of R107. This quick-reset feature of the RC time-delay reduces the possibility of operation of the loss-of-channel alarm by noise signal, which may override and cancel the Guard signal briefly but repetitively or may appear as a false Trip signal.

It should be noted that relay HG has Form D contacts, and only the normally-open or the normally-closed contacts should be used unless there is no objection to having both contacts momentarily closed simultaneously when the relay is energized or deenergized. Also, for protection of the HG relay contacts, the external device controlled should contain series resistance and capacitance (of values suitable for the load voltage and current) across the terminals that are externally connected to the HG relay terminals. With such protection the HG contacts have maximum ratings of 2 amperes, 500 volts, and 100 volt-amperes. The HG relay will pick up at approximately 20 volts.

The AL relay contacts are rated at 4 amps., 150 watts, for an a-c non-inductive load. The relay will pick at 35 to 40 volts.

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	30-300KHz
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 Hz. down > 60 db at 1000 Hz.
Discriminator	Set for zero output at channel center frequency and for max. outputs at 100 hertz above and below center frequency.
Operating Time	9 ms. channel (transm. and recvr.) 2 ms. HG relay operate and release times

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 lb.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as a 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; frequency spacing and magnitude of discriminator output peaks.

After the receiver has been installed, the input attenuator R5 must be set for the desired operating margin. 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 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 factory adjustments have been accidentally disturbed or components have been replaced, it may be necessary to readjust the oscillator and mixer, the limiter, or the discriminator, and procedures for these adjustments are described in the following paragraphs.

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 20KHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few hertz 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 hertz 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 signal 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. Apply to the receiver input a 5 mv. signal taken from an oscillator set at the center frequency of the channel. (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 100 hertz above and below center frequency.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. 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 the following tables. 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 input signal down 50 db from 1 watt. Unless otherwise indicated, voltage will not vary appreciably whether signal is high, low or fc frequency.

Collector of Transistor	Volts (–)
Q11	20
Q12	14.5 (No signal)
Q12	14.0 (High or low freq. signal)
Q13	17.0 (No signal)
Q13	15.0 (High or low freq. signal)
Q31	18.5
Q32	18.5
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q81	20 (No signal or fc — 100 Hz.)
Q81	< 0.5 (fc + 100 Hz.)
Q82 and Q101	20 (No signal of fc + 100 Hz.)
Q82 and Q101	< 0.5 (fc — 100 Hz.)
Q103	20.5 (No signal)
Q104	< 0.5 (No signal)
Q105	45 (No signal)

TABLE II
RECEIVER RF MEASUREMENTS

Collector of Transistor	Volts (fc + cy.)
Q32	.25
Q51	.3
Q52	.4
Q53	2.1
Q54	4.8

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 Fig. 9 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 2 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 sec-

tions, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 2 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 (Fig. 9) 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 hertz to 330 KHz, input impedance 7.5 megohms.

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

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

b. Signal Generator
Output Voltage: Up to 8 volts
Frequency Range: 20KHz to 330KHz

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 and Westinghouse Designation on the Electrical Part List.

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 with the germanium 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.

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, 6.8 mfd.; 35 V.D.C.	184A661H25

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
CR51	1N457A; 60 V.; 200 MA.	184A855H07
CR52	1N457A; 60 V.; 200 MA.	184A855H07
CR53	1N457A; 60 V.; 200 MA.	184A855H07
CR81	1N91; 100 V.; 150 MA.	182A881H04
CR82	1N91; 100 V.; 150 MA.	182A881H04
CR83	1N91; 100 V.; 150 MA.	182A881H04
CR85	1N628; 125 V.; 20 MA.	184A844H12
CR86	1N628; 125 V.; 30 MA.	184A855H12
CR101	1N457A; 60 V.; 200 MA.	184A885H07
CR103	1N457A; 60 V.; 200 MA.	184A885H07
	DIODES – ZENER	
CR1	1N3027A; 20 V. ±10%; 1 W.	188A307H10
CR2	1N3027A; 20 V. ±10%; 1 W.	188A307H10
CR102	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
VR1	1N2828B; 45 V. ±5%; 50 W.	184A854H06
VR2	1N2984B; 20 V. ±5%; 10 W.	762A631H01
	POTENTIOMETERS	
R5	10K; 2W.	185A086H10
R7	250K; 2W.	185A086H11
R12	1K; ¼W.	629A430H02
R52	1K; ¼W.	629A645H04
	RESISTORS	
R1	400 ohms ±5%; 25W.	1202587
R2	26.5 ohms ±5%; 40W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1W. Composition	187A643H03
R6	10K ±5%; ½W. Composition	184A763H51
R8	100K ±5%; 1W. Composition	187A643H75
R11	10K ±5%; ½W. Composition	184A763H51
R13	5.6K ±5%; ½W. Composition	184A763H45
R14	3.3K ±5%; ½W. Composition	184A763H39
R15	330 ohms ±5%; ½W. Composition	184A763H15
R16	10K ±5%; ½W. Composition	184A763H51
R17	33K ±5%; ½W. Composition	184A763H63
R18	3.3K ±5%; ½W. Composition	184A763H39
R19	3.3K ±5%; ½W. Composition	184A763H39
R20	10K ±5%; ½W. Composition	184A763H51

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R21	33K ±5%; ½W. Composition	184A763H63
R22	330 ohms ±5%; ½W. Composition	184A763H15
R23	10K ±5%; ½W. Composition	184A763H51
R31	3.3K ±5%; ½W. Composition	184A763H39
R32	22K ±5%; ½W. Composition	184A763H59
R33	680 ohms ±5%; ½W. Composition	184A763H23
R34	68 ohms ±5%; ½W. Composition	187A290H21
R35	10K ±5%; ½W. Composition	184A763H51
R36	330 ohms ±5%; ½W. Composition	184A763H15
R37	3.3K ±5%; ½W. Composition	184A763H39
R38	1000 ohms ±5%; ½W. Composition	184A763H27
R39	22K ±5%; ½W. Composition	184A763H59
R40	680 ohms ±5%; ½W. Composition	184A763H23
R41	68 ohms ±5%; ½W. Composition	187A290H21
R42	10K ±5%; ½W. Composition	184A763H51
R51	4.7K ±5%; ½W. Composition	184A763H43
R53	27K ±5%; ½W. Composition	184A763H61
R54	2.2K ±5%; ½W. Composition	184A763H35
R55	27 ohms ±5%; ½W. Composition	187A290H11
R56	10K ±5%; ½W. Composition	184A763H51
R57	4.7K ±5%; ½W. Composition	184A763H43
R58	27K ±5%; ½W. Composition	184A763H61
R59	1.5K ±5%; ½W. Composition	184A763H31
R60	180 ohms ±5%; ½W. Composition	184A763H09
R61	4.7K ±5%; ½W. Composition	184A763H43
R62	1.5K ±5%; ½W. Composition	184A763H31
R63	3.3K ±5%; ½W. Composition	184A763H63
R64	2.7K ±5%; ½W. Composition	184A763H37
R65	680 ohms ±5%; ½W. Composition	184A763H23
R66	68 ohms ±5%; ½W. Composition	187A290H21
R67	4.7K ±5%; ½W. Composition	184A763H43
R68	2.7K ±5%; ½W. Composition	184A763H37
R69	18K ±5%; ½W. Composition	184A763H57
R70	220 ohms ±5%; ½W. Composition	184A763H11
R71	270 ohms ±5%; ½W. Composition	184A763H13
R72	330 ohms ±5%; ½W. Composition	184A763H15
R81	4.7K ±5%; ½W. Composition	184A763H43
R82	4.7K ±5%; ½W. Composition	184A763H43
R83	2.2K ±5%; ½W. Composition	184A763H35
R84	2.2K ±5%; ½W. Composition	184A763H35

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R85	6.8K ±5%; ½W. Composition	184A763H47
R101	18K ±5%; ½W. Composition	184A763H57
R102	10K ±5%; ½W. Composition	184A763H51
R103	82K ±5%; ½W. Composition	184A763H73
R104	82K ±5%; ½W. Composition	184A763H73
R105	10K ±5%; 1W. Composition	187A643H51
R106	39K ±5%; ½W. Composition	184A763H65
R107	1000 ohms ±5%; ½W. Composition	185A763H27
R108	10K ±5%; ½W. Composition	184A763H51
R109	22K ±5%; ½W. Composition	184A763H23
R110	27K ±5%; ½W. Composition	184A763H61
R111	10K ±5%; ½W. Composition	184A763H51
	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	2N699	184A638H19
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 KC above Channel Frequency)	762A800H01 + (Reg. Freq.)
FL1	Crystal Input Filter	410C466 + (Reg. 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, 1.5A	11D919H26
AL	Alarm Relay	408C062H07
HG	Mercury Weted Contact Relay; 2 amp, 500 V., 100 V.A.	188A573H04

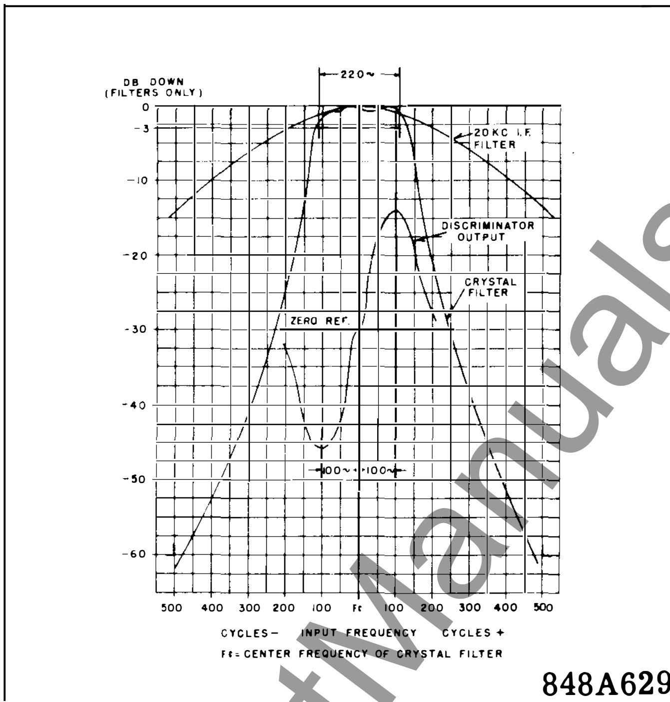


Fig. 2. Filter and Discriminator Characteristics of the Type TCF Receiver.

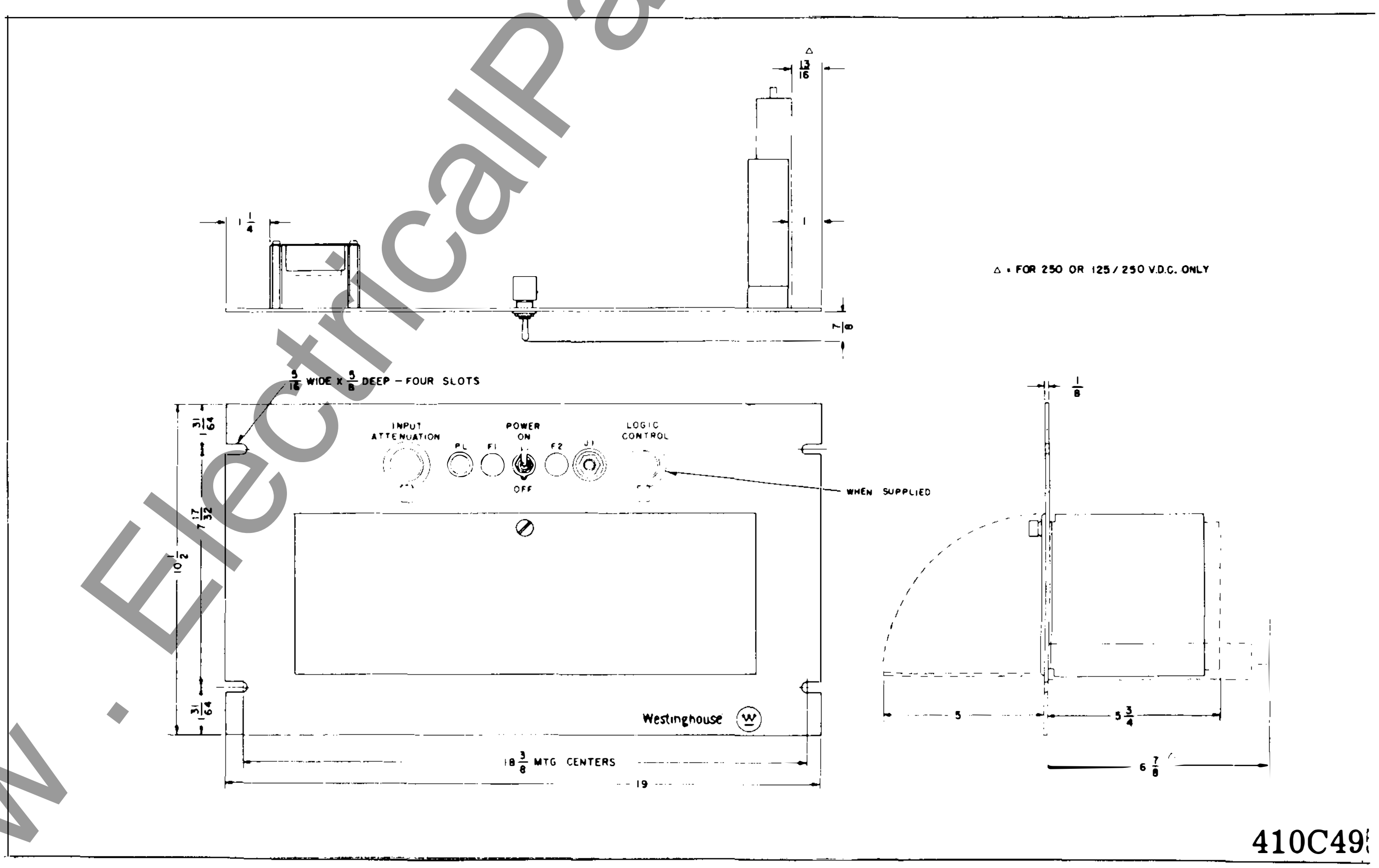


Fig. 3. Outline and Drilling Plan for the Type TCF Receiver Assembly.

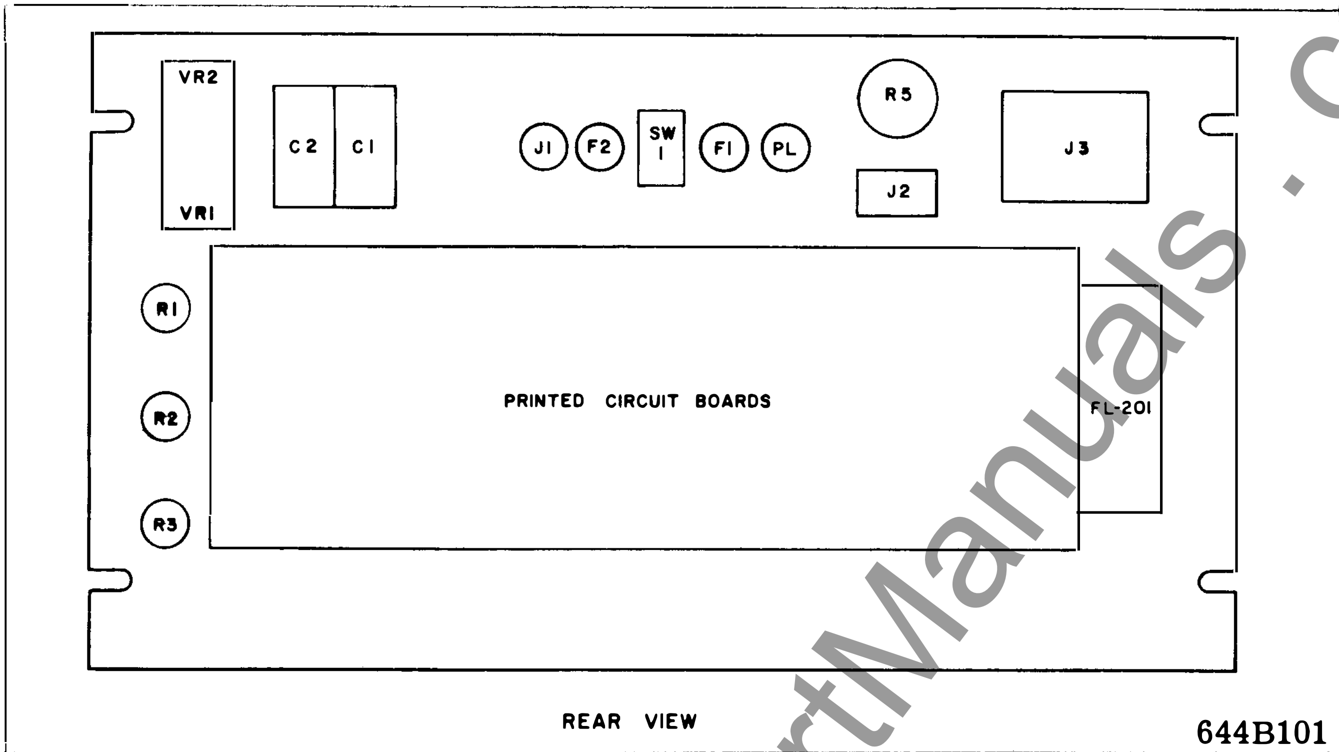


Fig. 4. Component Locations on the TCF Receiver Panel.

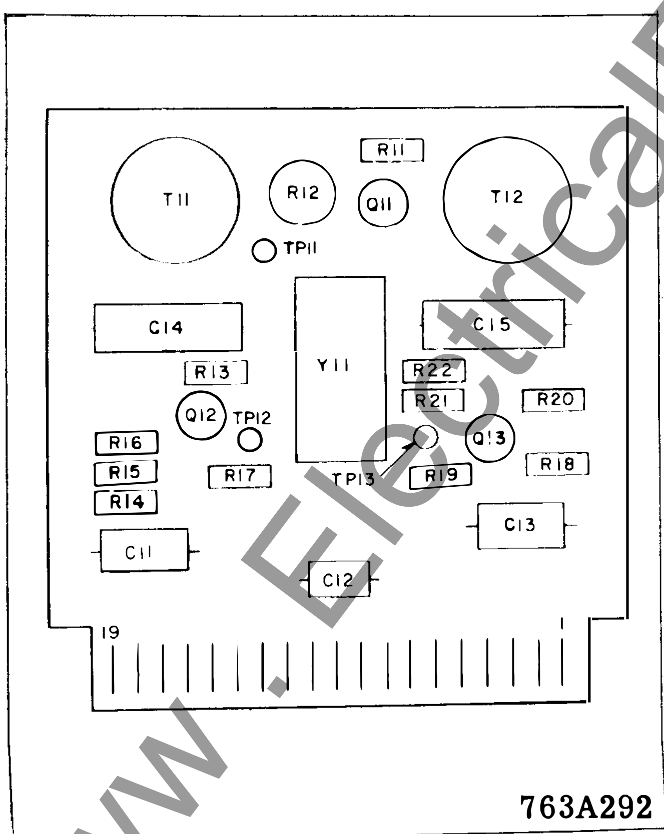


Fig. 5. Component Locations on the Oscillator and Mixer Printed Circuit Board.

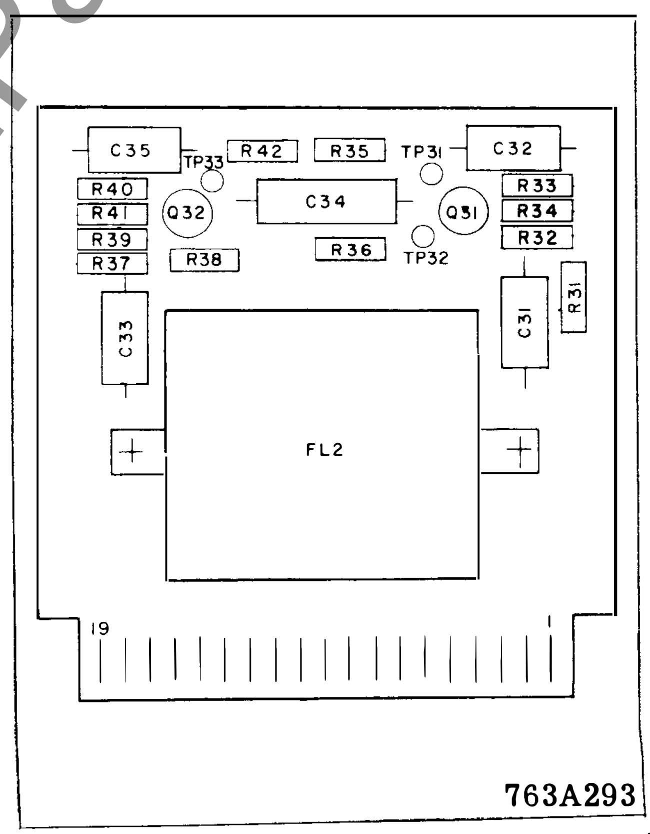


Fig. 6. Component Locations on the I.F. Amplifier Printed Circuit Board.

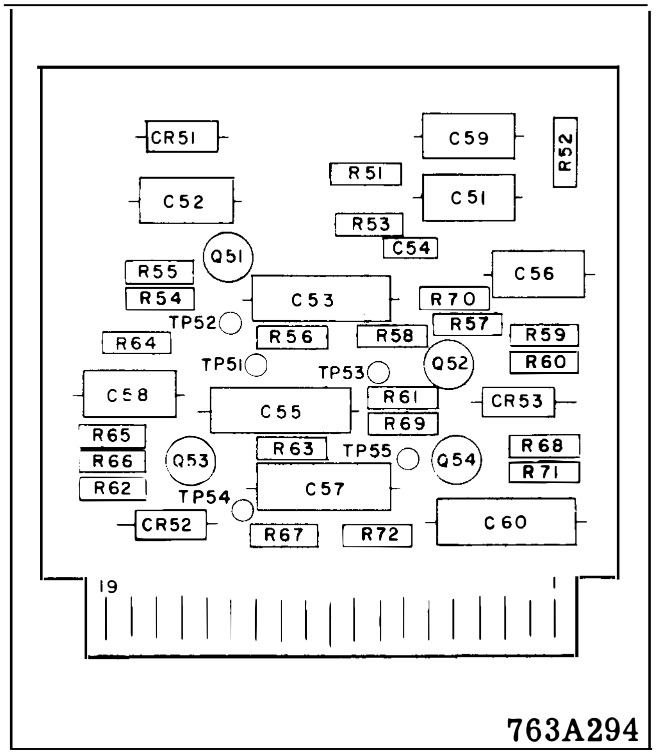


Fig. 7. Component Locations on the Amplifier and Limiter Printed Circuit Board.

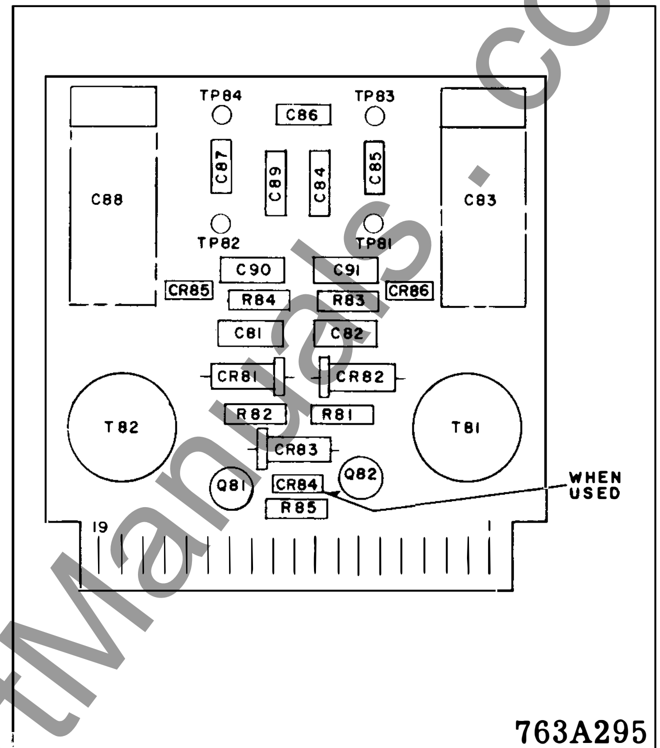


Fig. 8. Component Locations on the Discriminator Printed Circuit Board.

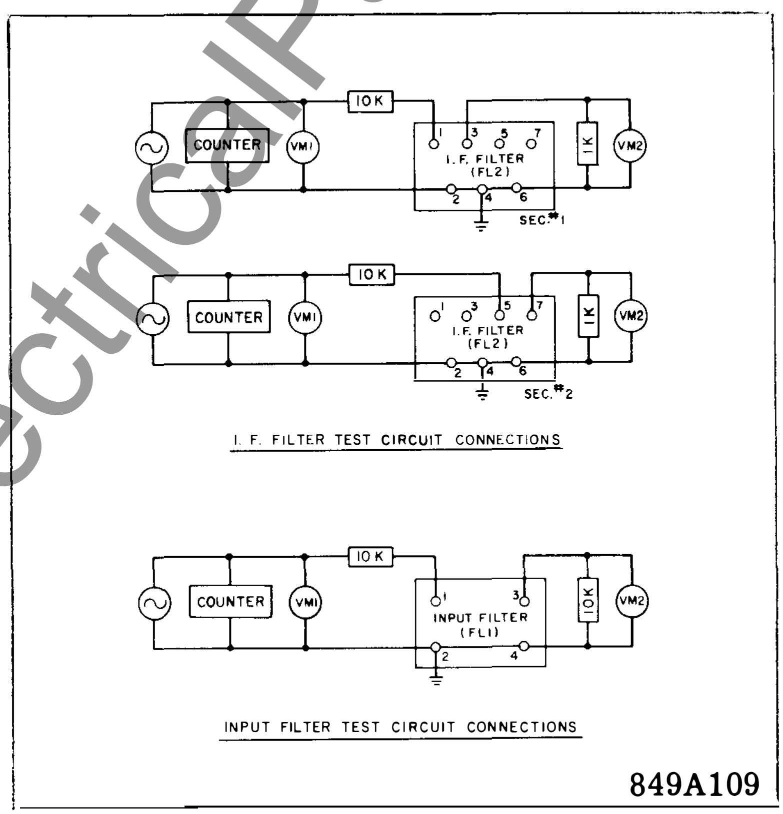


Fig. 9. Test Circuits for TCF Frequency Shift Receiver Filters

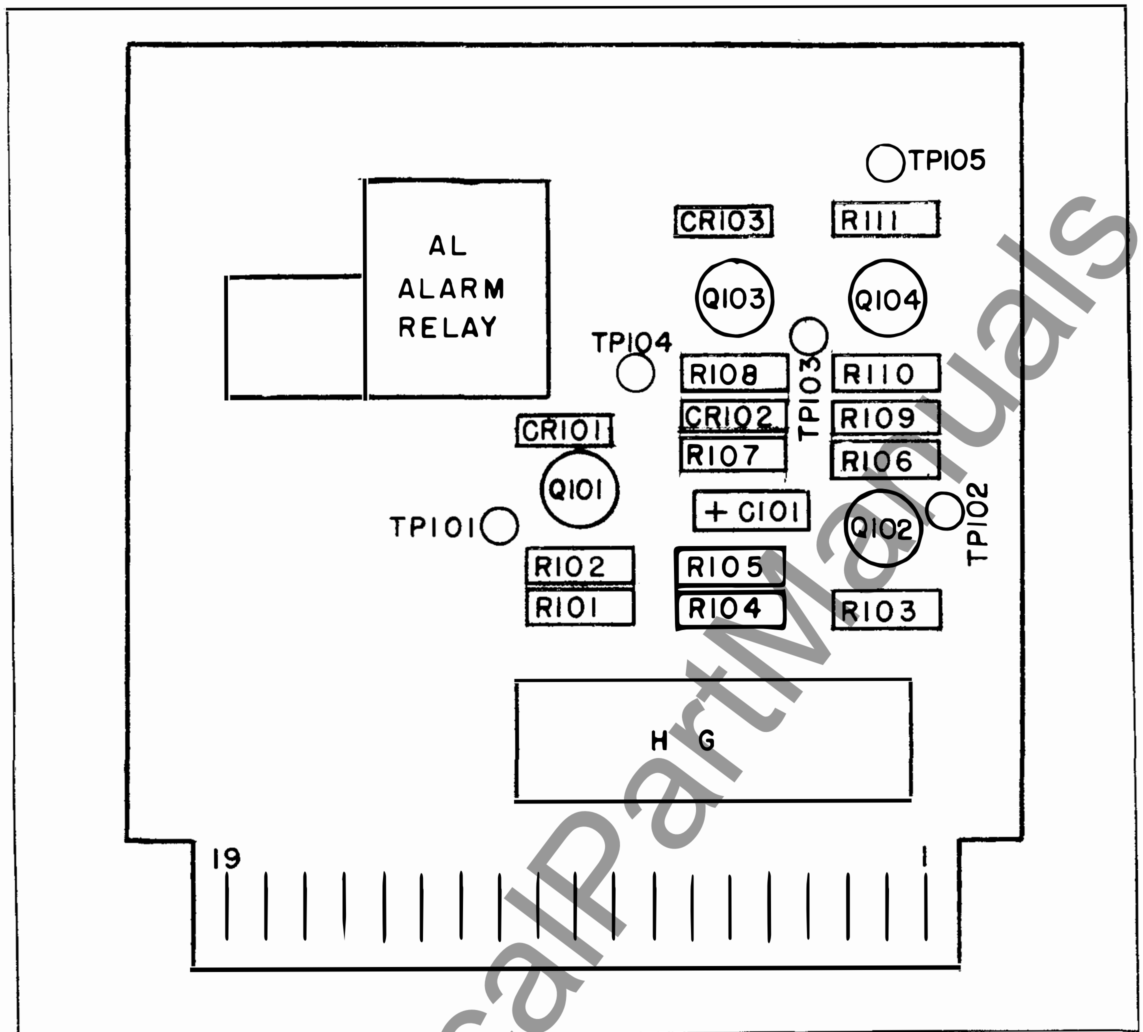


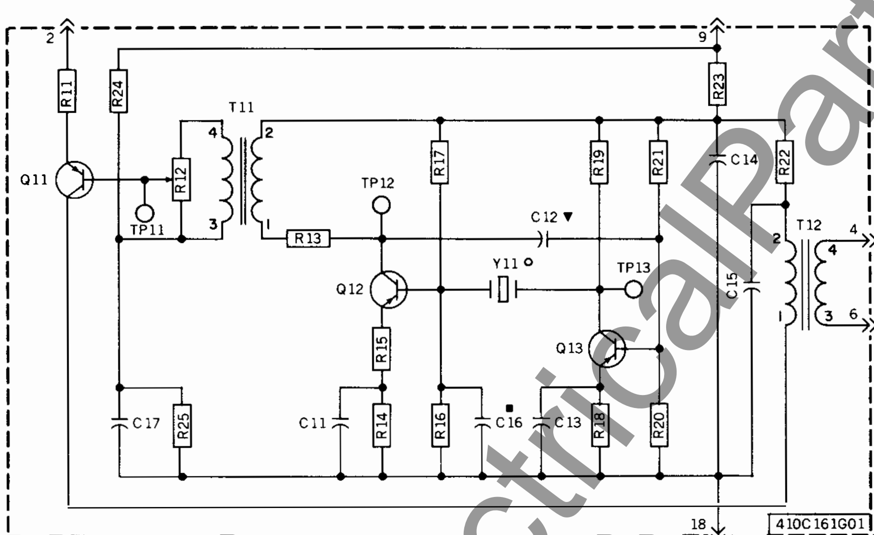
Fig. 10. Component Locations on the Relay Output Printed Circuit Board.

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.

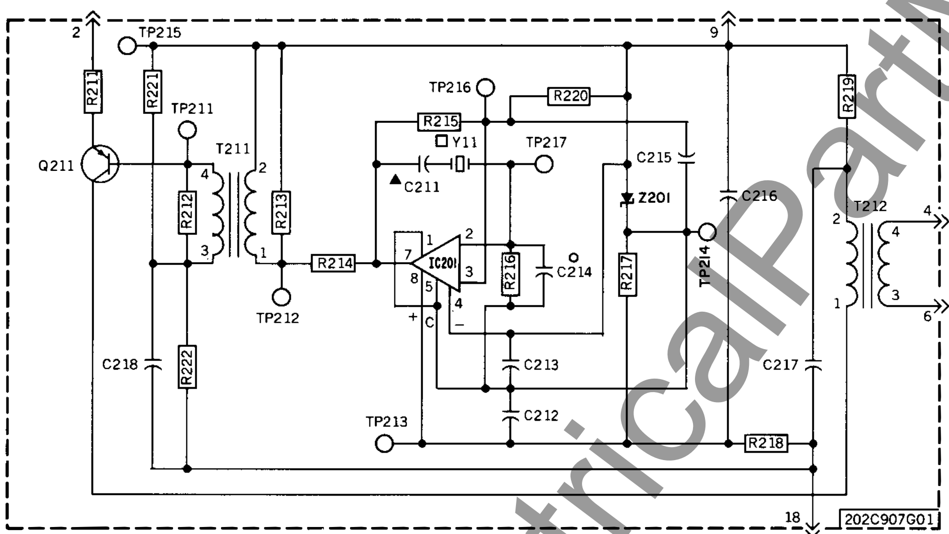
■ =C16 RANGE 22 TO 100Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

o =Y11 RANGE–50 TO 220 KHZ.



264C855

Fig. 11. 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	

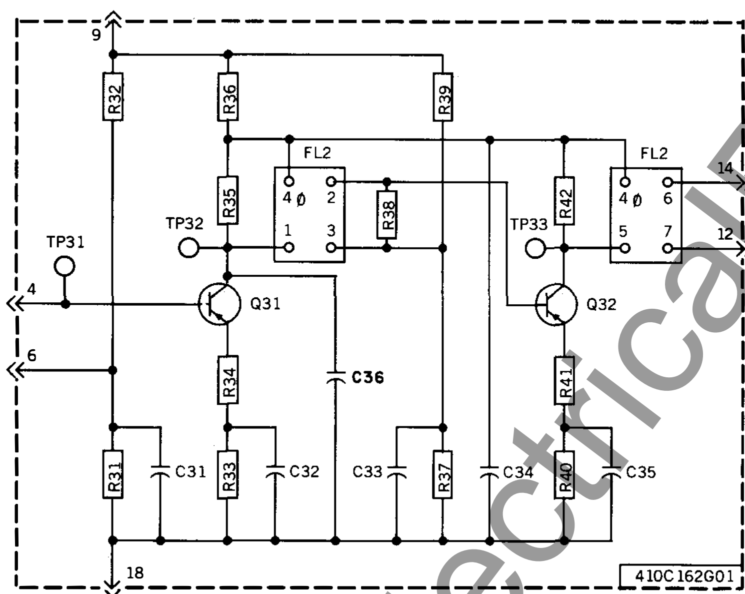
▲= C211 RANGES FROM 100Pf. TO 1,000Pf.

O =C214 STYLE NO. 187A695H17 .56Pf. BUT MAY VARY UP TO 100Pf.

□= Y11 FREQUENCY EQUALS RECEIVER (CHANNEL) FREQUENCY PLUS **20 KHZ.**

264C844

* ***Fig. 12. Internal Schematic 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version***

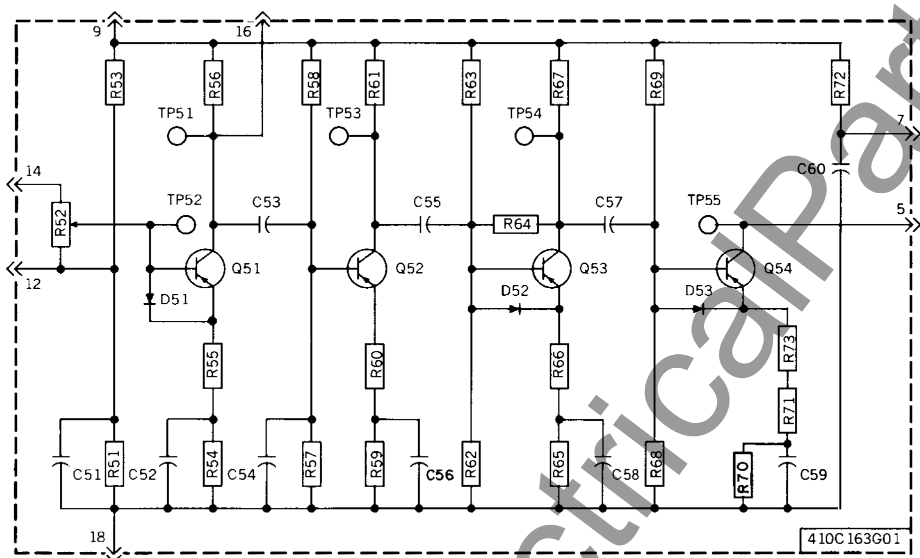


COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q31–Q32	849A441H03	2	2N4249
RESISTOR			
R34-R41	187A290H21	2	68Ω 1/2W ±5%
R36	184A763H15	1	330Ω 1/2W ±5%
R33–R40	184A763H23	2	680Ω 1/2W ±5%
R38	184A763H27	1	1K 1/2W ±5%
R31–R37	184A763H39	2	3.3K 1/2W ±5%
R35–R42	184A763H51	2	10K 1/2W ±5%
R32–R39	184A763H59	2	22K 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	

∅ = COMMON TERMINAL

264C856

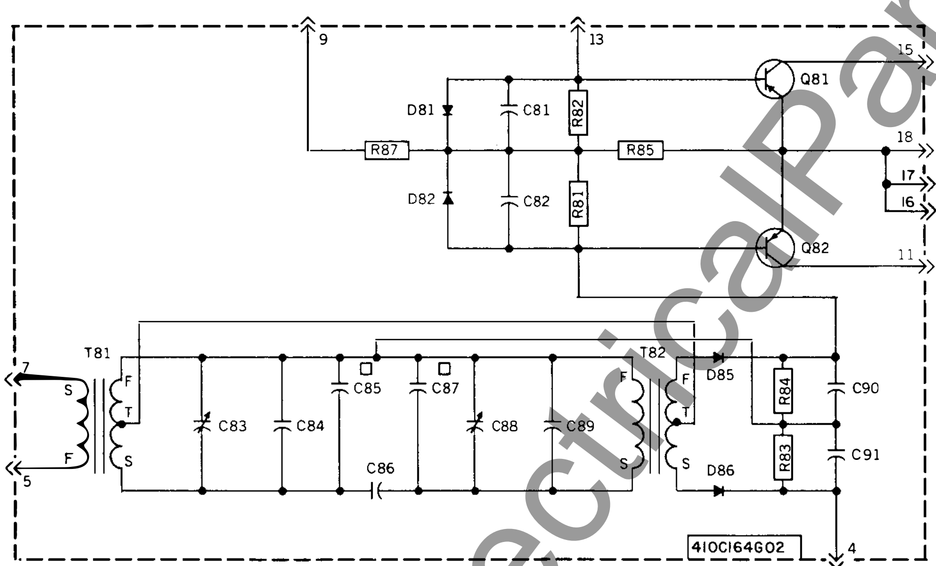
* *Fig. 13. Internal Schematic I.F. Amplifier – Silicon Transistor Version*



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

264C841

* *Fig. 14.* ***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%
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	184A855H07	2	1N457A
D85–D86	184A855H12	2	1N628
TRANSFORMER			
T81	606B533G01	1	
T82	606B533G02	1	

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

264C843

* *Fig. 15. Internal Schematic Discriminator – Silicon Transistor Version*

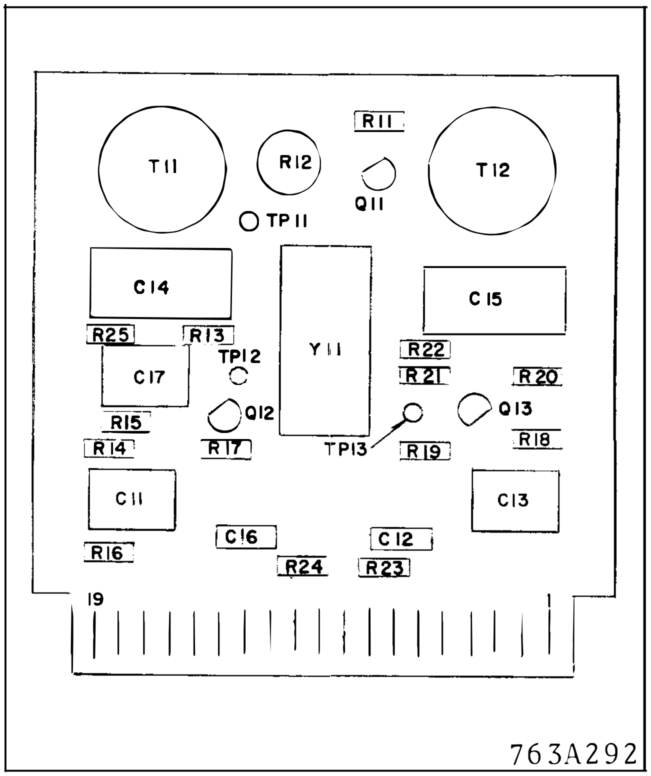


Fig. 16. Component Locations 30-200KHz. Oscillator and Mixer Silicon Transistor Version

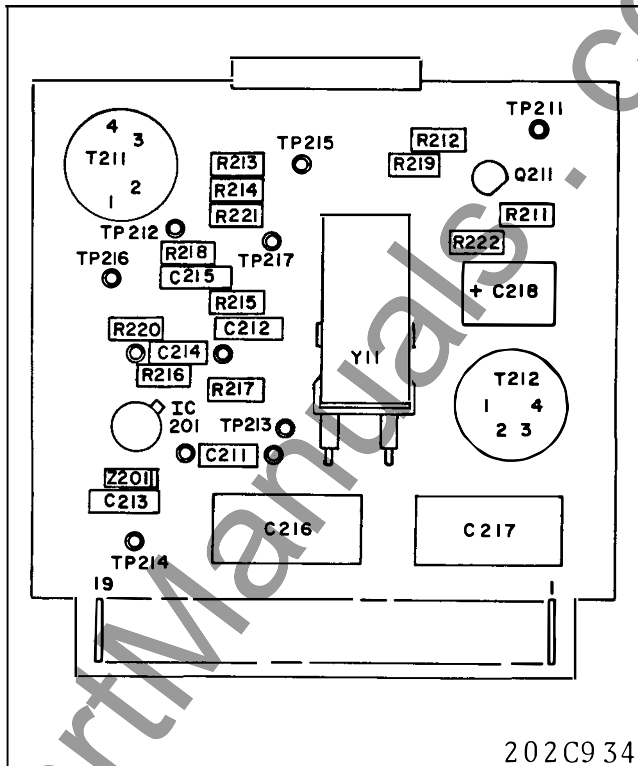


Fig. 17. Component Locations 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version

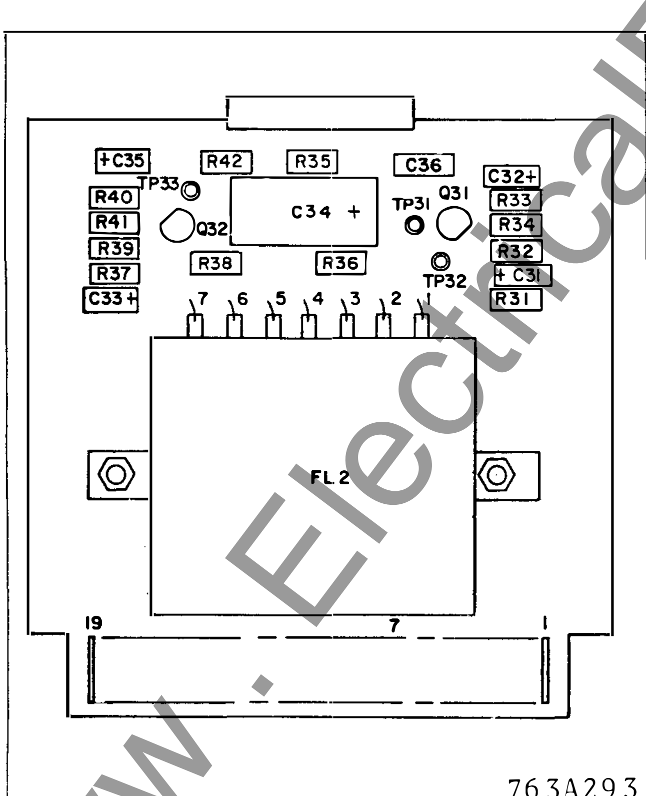


Fig. 18. Component Locations I.F. Amplifier – Silicon Transistor Version

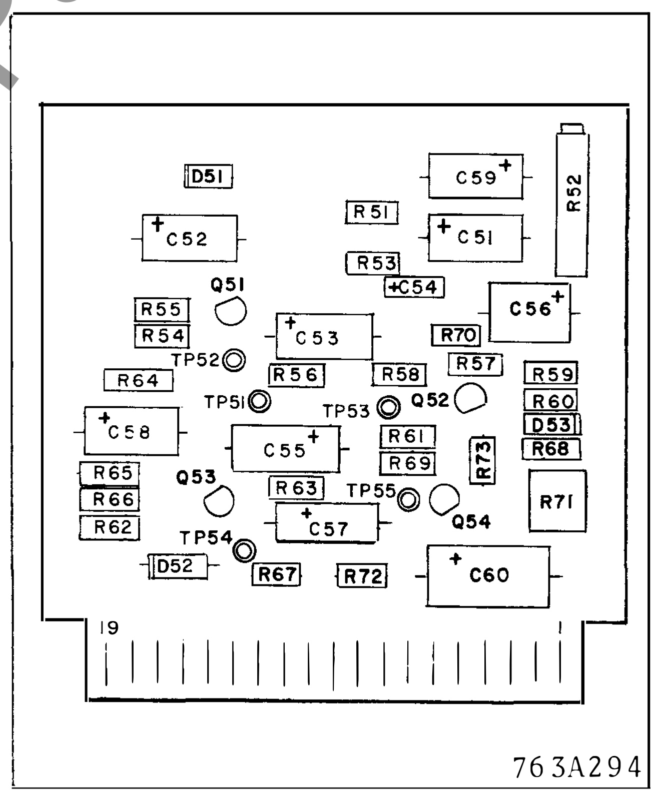


Fig. 19. Component Locations Amplifier and Limiter – Silicon Transistor Version

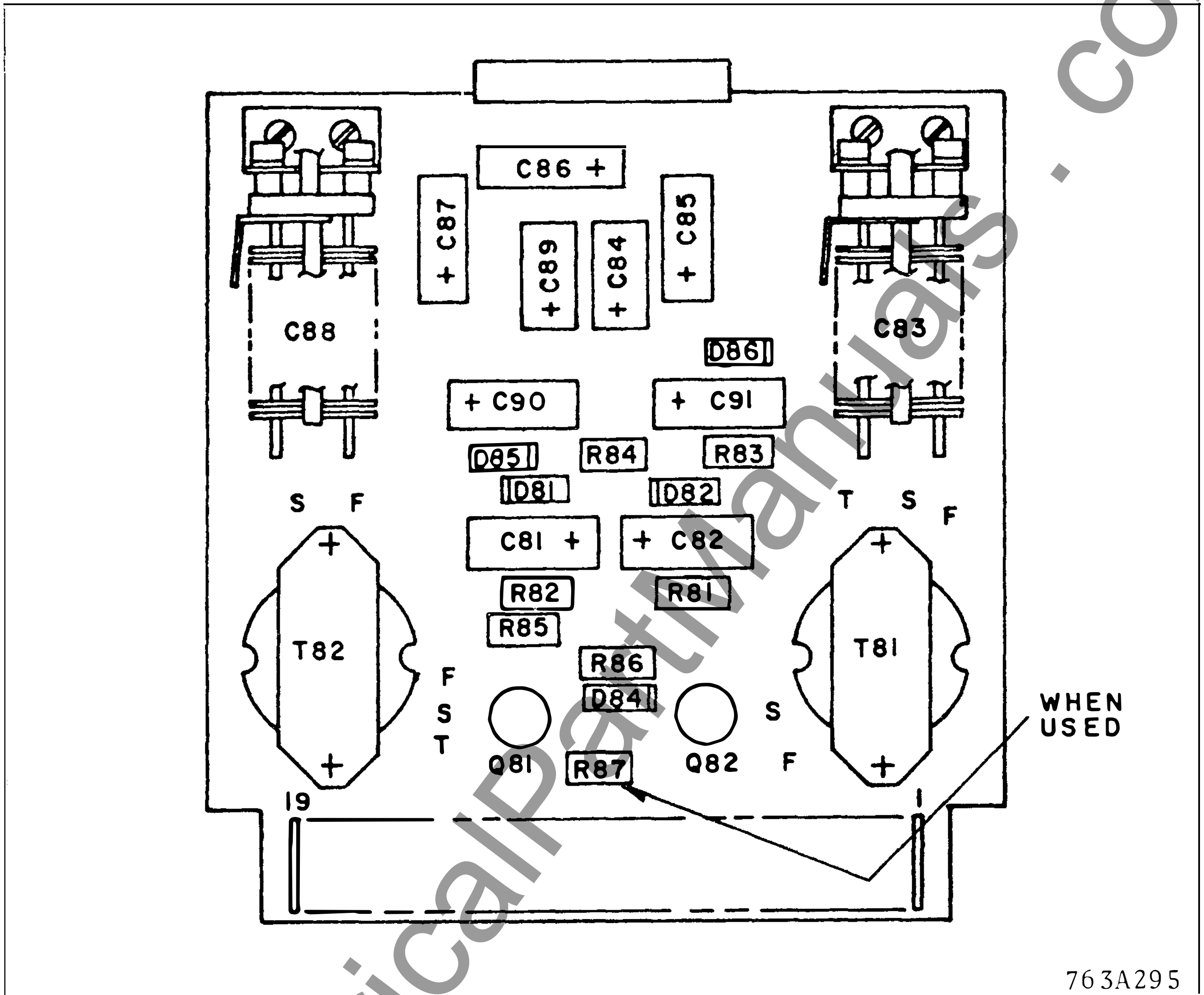


Fig. 20. Component Locations Discriminator – Silicon Transistor Version

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 – WITH RELAY OUTPUT FOR SUPERVISORY CONTROL AND TELEMETERING

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 supervisory control and certain telemetering applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard frequency is 100 hertz above the center frequency of the channel (which can be selected within the range of 30KHz to 300KHz), and it is transmitted continuously when conditions are normal and no information is to be conveyed over the channel. Its reception indicates that the channel is operative. The Trip frequency (so called because in frequency-shift relaying applications the reception of this frequency causes closure of relay contacts in the trip circuit of a circuit breaker) is 100 hertz below the channel center frequency. When supervisory control or telemetering information is to be conveyed over the channel, the transmitter at one end of the channel is switched alternately between Guard and Trip so as to produce at the receiving end a desired number of operations of a relay activated by the trip frequency. Control of the durations of the intervals that the relay contacts are open and closed also can be utilized to convey information over the channel.

CONSTRUCTION

The TCF receiver unit for supervisory control and telemetering 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, and a jack for metering the discriminator output current are accessible from the front of the panel. Refer to Fig. 3.

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. 4. 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.

TCF receivers for transfer trip relaying require a logic circuit board and may require a carrier level indicator circuit board, which are contained in the third-from-right and right hand compartments respectively. These are not required for the TCF receiver for supervisory control and telemetering and the compartments are vacant.

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 is 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

SUPERSEDES I.L. 41-945.53C
*Denotes change from superseded issue.

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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 V.D.C. 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 on 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. 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 hertz above or below the center frequency (fc) of the channel are greatly attenuated. Figure 2 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 20KHz 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 20KHz, 2fc + 20KHz, fc and fc + 20KHz.

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 hertz. The adjustment for zero output at fc hertz is made by capacitor C88. X83 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 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). It should be observed that although the higher signal frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the corresponding frequency is 20KHz-100 hertz. Similarly, the lower signal frequency is converted to 20KHz + 100 hertz.

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.

Output Circuits

The output circuit board of the receiver contains output relay HG. The contacts of this relay are the mercury-wetted type, which assures bounceless operation. It also contains telephone-type relay AL, the contacts of which can be used to energize an alarm.

When Trip signal is received, terminal 8 of Output printed circuit board is at approximately +20 volts potential and transistor Q101 becomes conductive, which energizes relay HG. When Guard signal is present, terminal 1 of the Output board is at approximately +20 volts potential. The base of transistor Q102 is connected to terminal 1 and 8 through resistors R103 and R104. Consequently when either Guard or Trip signal is present this transistor is conductive.

When neither Guard nor Trip signal is present, indicating a loss of channel, Q102 is not conductive and capacitor C101 begins to charge through resistors R106 and R107. When the capacitor voltage reaches the breakdown level of zener diode CR102 (in approximately 150 milliseconds) transistor Q103 receives base input and becomes conductive. This removes base input from Q104 and the alarm relay AL drops out and energizes an alarm through its normally-closed contacts. A copper slug on the core of the alarm relay adds an additional delay of approximately 40 milliseconds before the alarm contacts close. When Guard signal reappears and Q102 becomes conductive, capacitor C101 discharges rapidly through the low resistance of R107. This quick-reset feature of the RC time-delay reduces the possibility of operation of the loss-of-channel alarm by noise signal, which may override and cancel the Guard signal briefly but repetitively or may appear as a false Trip signal.

It should be noted that relay HG has Form D contacts, and only the normally-open or the normally-closed contacts should be used unless there is no objection to having both contacts momentarily closed simultaneously when the relay is energized or deenergized. Also, for protection of the HG relay contacts, the external device controlled should contain series resistance and capacitance (of values suitable for the load voltage and current) across the terminals that are externally connected to the HG relay terminals. With such protection the HG contacts have maximum ratings of 2 amperes, 500 volts, and 100 volt-amperes. The HG relay will pick up at approximately 20 volts.

The AL relay contacts are rated at 4 amps., 150 watts, for an a-c non-inductive load. The relay will pick at 35 to 40 volts.

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	30-300KHz
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 Hz. down > 60 db at 1000 Hz.
Discriminator	Set for zero output at channel center frequency and for max. outputs at 100 hertz above and below center frequency.
Operating Time	9 ms. channel (transm. and recvr.) 2 ms. HG relay operate and release times

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 lb.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as a 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; frequency spacing and magnitude of discriminator output peaks.

After the receiver has been installed, the input attenuator R5 must be set for the desired operating margin. 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 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 factory adjustments have been accidentally disturbed or components have been replaced, it may be necessary to readjust the oscillator and mixer, the limiter, or the discriminator, and procedures for these adjustments are described in the following paragraphs.

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 20KHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few hertz 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 hertz 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 signal 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. Apply to the receiver input a 5 mv. signal taken from an oscillator set at the center frequency of the channel. (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 100 hertz above and below center frequency.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. 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 the following tables. Voltages should be measured with a VTVM. Some readings may vary as much as $\pm$ 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 input signal down 50 db from 1 watt. Unless otherwise indicated, voltage will not vary appreciably whether signal is high, low or fc frequency.

Collector of Transistor	Volts (–)
Q11	20
Q12	14.5 (No signal)
Q12	14.0 (High or low freq. signal)
Q13	17.0 (No signal)
Q13	15.0 (High or low freq. signal)
Q31	18.5
Q32	18.5
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q81	20 (No signal or fc – 100 Hz.)
Q81	$<$ 0.5 (fc + 100 Hz.)
Q82 and Q101	20 (No signal of fc + 100 Hz.)
Q82 and Q101	$<$ 0.5 (fc – 100 Hz.)
Q103	20.5 (No signal)
Q104	$<$ 0.5 (No signal)
Q105	45 (No signal)

TABLE II
RECEIVER RF MEASUREMENTS

Collector of Transistor	Volts (fc + cy.)
Q32	.25
Q51	.3
Q52	.4
Q53	2.1
Q54	4.8

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 Fig. 9 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 2 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 sec-

tions, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 2 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 (Fig. 9) 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 hertz to 330 KHz, input impedance 7.5 megohms.

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

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

b. Signal Generator
Output Voltage: Up to 8 volts
Frequency Range: 20KHz to 330KHz

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 and Westinghouse Designation on the Electrical Part List.

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 with the germanium 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.

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, 6.8 mfd.; 35 V.D.C.	184A661H25

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
CR51	1N457A; 60 V.; 200 MA.	184A855H07
CR52	1N457A; 60 V.; 200 MA.	184A855H07
CR53	1N457A; 60 V.; 200 MA.	184A855H07
CR81	1N91; 100 V.; 150 MA.	182A881H04
CR82	1N91; 100 V.; 150 MA.	182A881H04
CR83	1N91; 100 V.; 150 MA.	182A881H04
CR85	1N628; 125 V.; 20 MA.	184A844H12
CR86	1N628; 125 V.; 30 MA.	184A855H12
CR101	1N457A; 60 V.; 200 MA.	184A885H07
CR103	1N457A; 60 V.; 200 MA.	184A885H07
	DIODES – ZENER	
CR1	1N3027A; 20 V. ±10%; 1 W.	188A307H10
CR2	1N3027A; 20 V. ±10%; 1 W.	188A307H10
CR102	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
VR1	1N2828B; 45 V. ±5%; 50 W.	184A854H06
VR2	1N2984B; 20 V. ±5%; 10 W.	762A631H01
	POTENTIOMETERS	
R5	10K; 2W.	185A086H10
R7	250K; 2W.	185A086H11
R12	1K; ¼W.	629A430H02
R52	1K; ¼W.	629A645H04
	RESISTORS	
R1	400 ohms ±5%; 25W.	1202587
R2	26.5 ohms ±5%; 40W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1W. Composition	187A643H03
R6	10K ±5%; ½W. Composition	184A763H51
R8	100K ±5%; 1W. Composition	187A643H75
R11	10K ±5%; ½W. Composition	184A763H51
R13	5.6K ±5%; ½W. Composition	184A763H45
R14	3.3K ±5%; ½W. Composition	184A763H39
R15	330 ohms ±5%; ½W. Composition	184A763H15
R16	10K ±5%; ½W. Composition	184A763H51
R17	33K ±5%; ½W. Composition	184A763H63
R18	3.3K ±5%; ½W. Composition	184A763H39
R19	3.3K ±5%; ½W. Composition	184A763H39
R20	10K ±5%; ½W. Composition	184A763H51

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R21	33K ±5%; ½W. Composition	184A763H63
R22	330 ohms ±5%; ½W. Composition	184A763H15
R23	10K ±5%; ½W. Composition	184A763H51
R31	3.3K ±5%; ½W. Composition	184A763H39
R32	22K ±5%; ½W. Composition	184A763H59
R33	680 ohms ±5%; ½W. Composition	184A763H23
R34	68 ohms ±5%; ½W. Composition	187A290H21
R35	10K ±5%; ½W. Composition	184A763H51
R36	330 ohms ±5%; ½W. Composition	184A763H15
R37	3.3K ±5%; ½W. Composition	184A763H39
R38	1000 ohms ±5%; ½W. Composition	184A763H27
R39	22K ±5%; ½W. Composition	184A763H59
R40	680 ohms ±5%; ½W. Composition	184A763H23
R41	68 ohms ±5%; ½W. Composition	187A290H21
R42	10K ±5%; ½W. Composition	184A763H51
R51	4.7K ±5%; ½W. Composition	184A763H43
R53	27K ±5%; ½W. Composition	184A763H61
R54	2.2K ±5%; ½W. Composition	184A763H35
R55	27 ohms ±5%; ½W. Composition	187A290H11
R56	10K ±5%; ½W. Composition	184A763H51
R57	4.7K ±5%; ½W. Composition	184A763H43
R58	27K ±5%; ½W. Composition	184A763H61
R59	1.5K ±5%; ½W. Composition	184A763H31
R60	180 ohms ±5%; ½W. Composition	184A763H09
R61	4.7K ±5%; ½W. Composition	184A763H43
R62	1.5K ±5%; ½W. Composition	184A763H31
R63	3.3K ±5%; ½W. Composition	184A763H63
R64	2.7K ±5%; ½W. Composition	184A763H37
R65	680 ohms ±5%; ½W. Composition	184A763H23
R66	68 ohms ±5%; ½W. Composition	187A290H21
R67	4.7K ±5%; ½W. Composition	184A763H43
R68	2.7K ±5%; ½W. Composition	184A763H37
R69	18K ±5%; ½W. Composition	184A763H57
R70	220 ohms ±5%; ½W. Composition	184A763H11
R71	270 ohms ±5%; ½W. Composition	184A763H13
R72	330 ohms ±5%; ½W. Composition	184A763H15
R81	4.7K ±5%; ½W. Composition	184A763H43
R82	4.7K ±5%; ½W. Composition	184A763H43
R83	2.2K ±5%; ½W. Composition	184A763H35
R84	2.2K ±5%; ½W. Composition	184A763H35

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R85	6.8K ±5%; ½W. Composition	184A763H47
R101	18K ±5%; ½W. Composition	184A763H57
R102	10K ±5%; ½W. Composition	184A763H51
R103	82K ±5%; ½W. Composition	184A763H73
R104	82K ±5%; ½W. Composition	184A763H73
R105	10K ±5%; 1W. Composition	187A643H51
R106	39K ±5%; ½W. Composition	184A763H65
R107	1000 ohms ±5%; ½W. Composition	185A763H27
R108	10K ±5%; ½W. Composition	184A763H51
R109	22K ±5%; ½W. Composition	184A763H23
R110	27K ±5%; ½W. Composition	184A763H61
R111	10K ±5%; ½W. Composition	184A763H51
	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	2N699	184A638H19
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 KC above Channel Frequency)	762A800H01 + (Reg. Freq.)
FL1	Crystal Input Filter	410C466 + (Reg. 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, 1.5A	11D919H26
AL	Alarm Relay	408C062H07
HG	Mercury Weted Contact Relay; 2 amp, 500 V., 100 V.A.	188A573H04

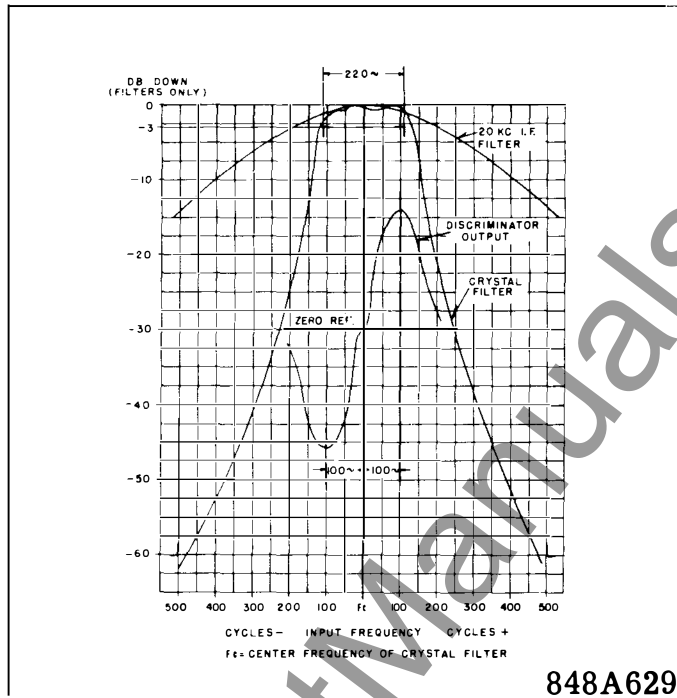


Fig. 2. Filter and Discriminator Characteristics of the Type TCF Receiver.

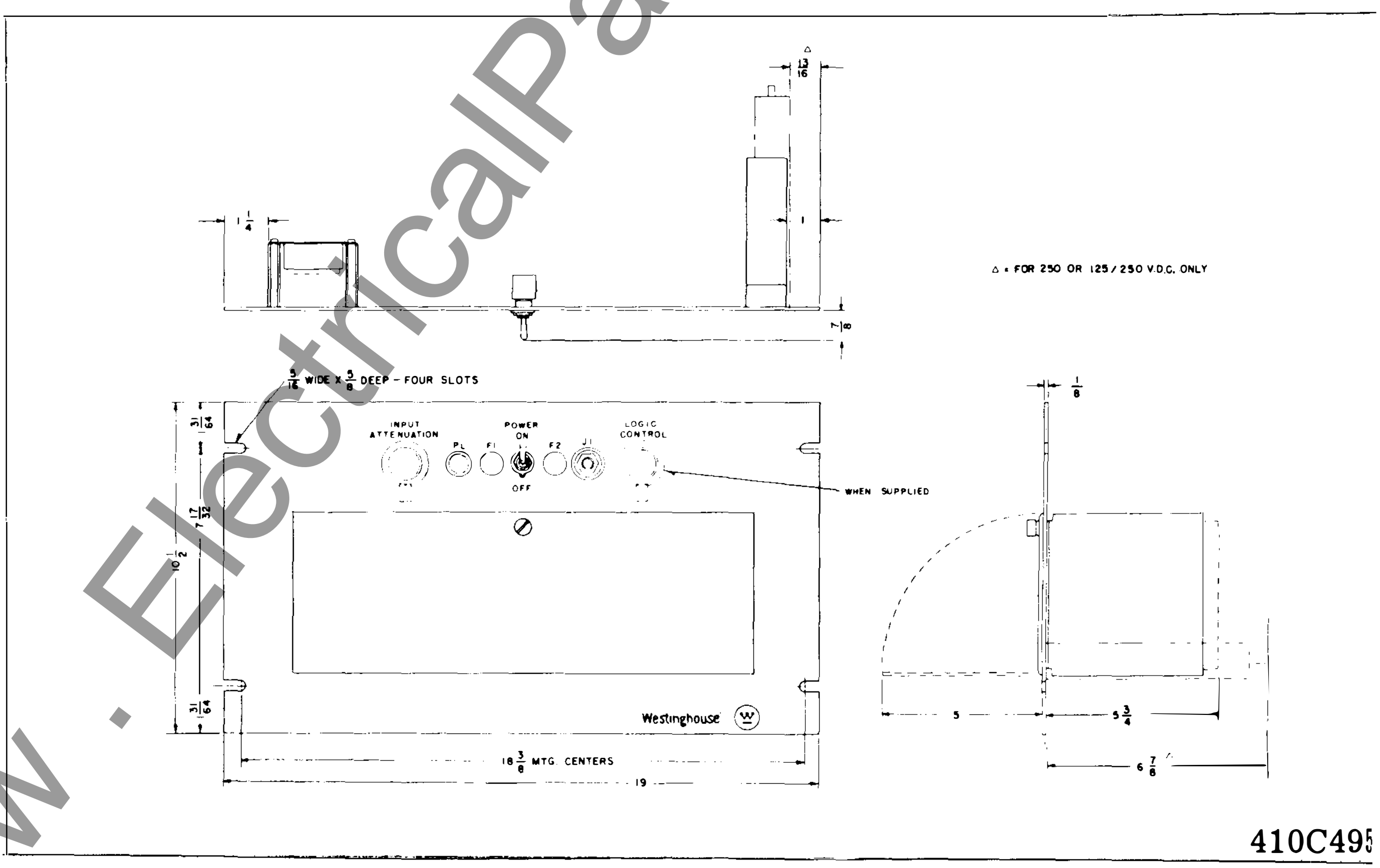


Fig. 3. Outline and Drilling Plan for the Type TCF Receiver Assembly.

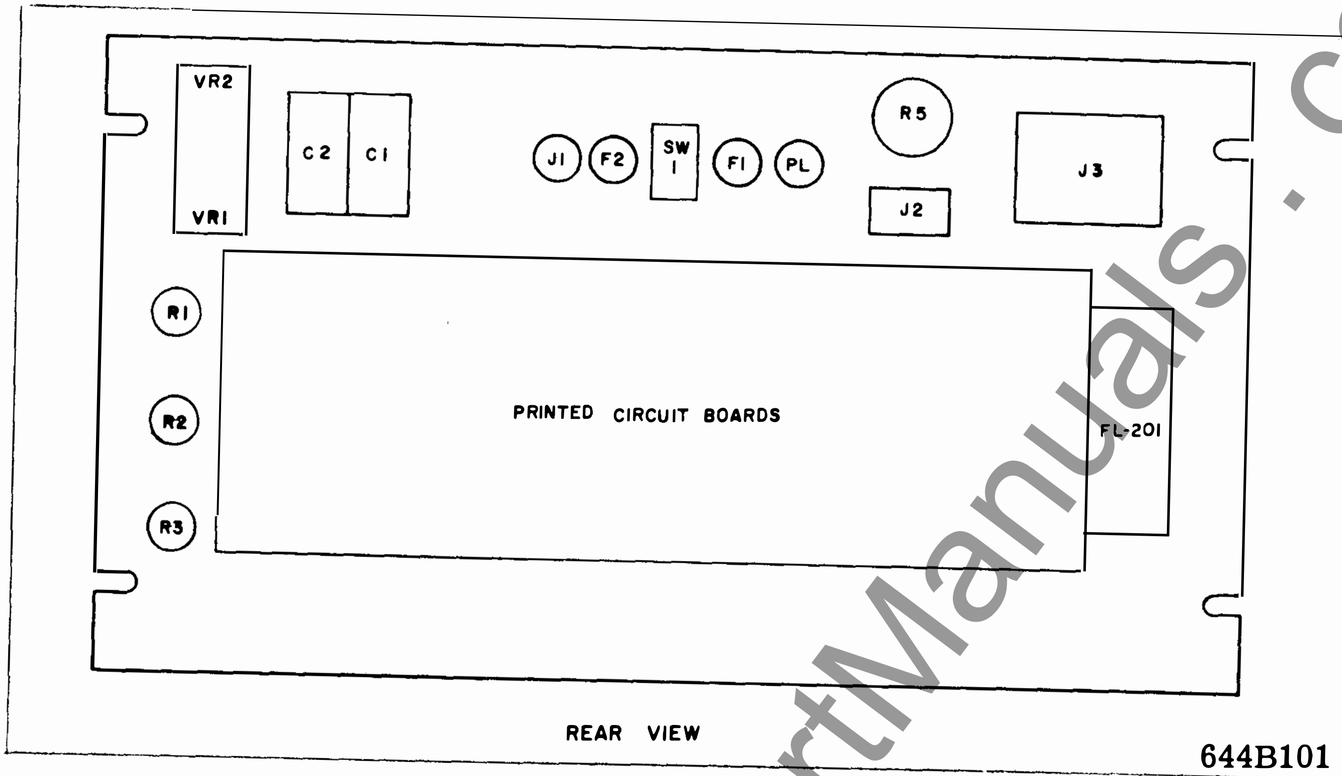


Fig. 4. Component Locations on the TCF Receiver Panel.

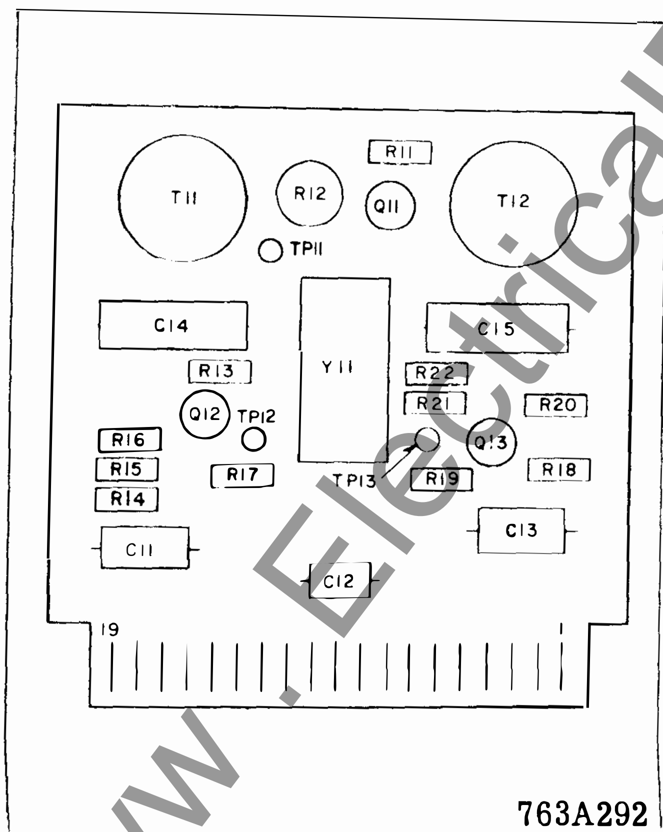


Fig. 5. Component Locations on the Oscillator and Mixer Printed Circuit Board.

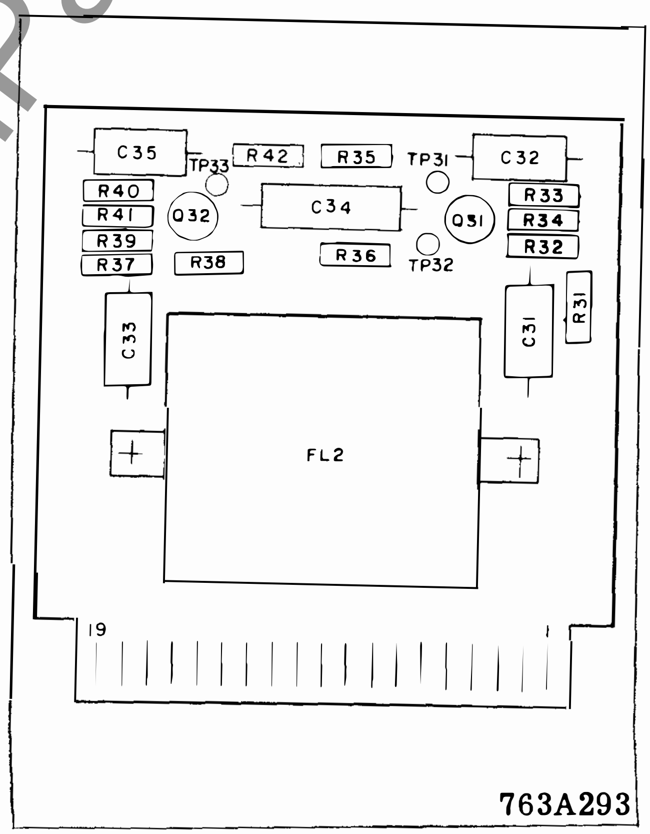


Fig. 6. Component Locations on the I.F. Amplifier Printed Circuit Board.

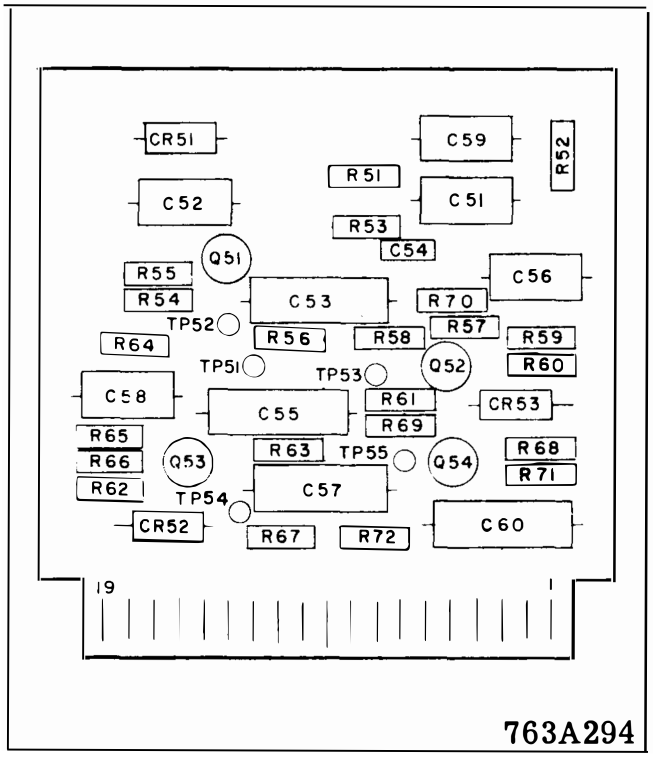


Fig. 7. Component Locations on the Amplifier and Limiter Printed Circuit Board.

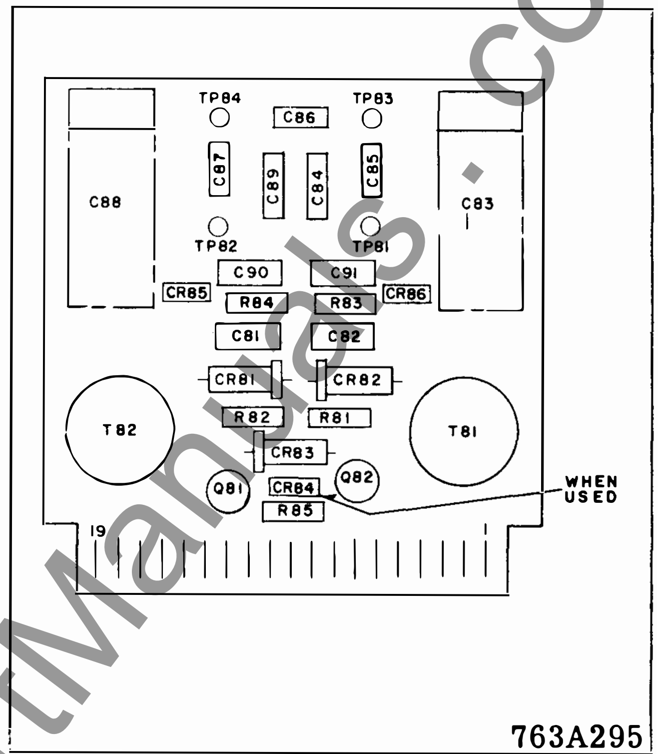


Fig. 8. Component Locations on the Discriminator Printed Circuit Board.

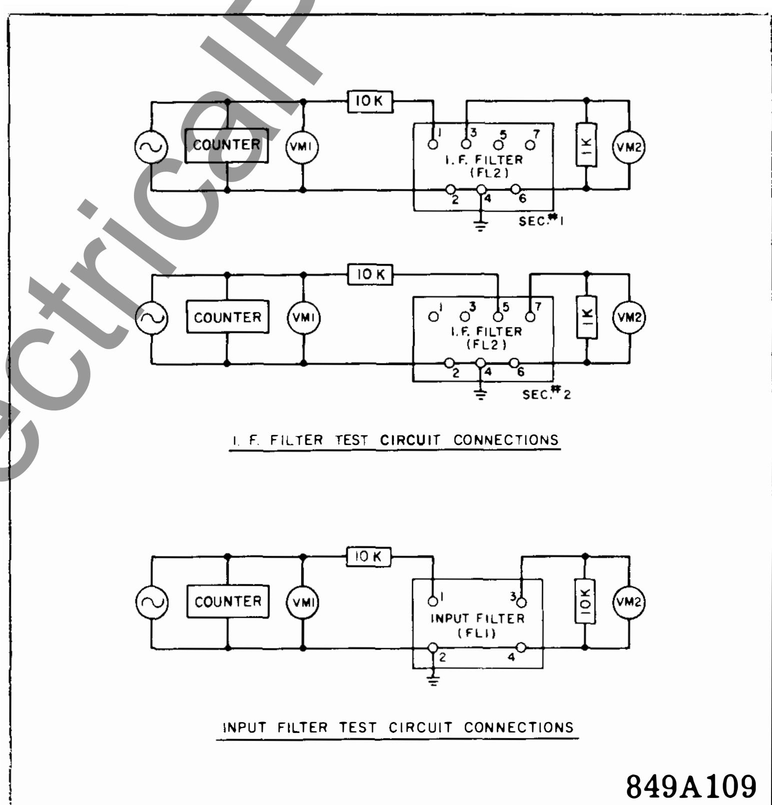


Fig. 9. Test Circuits for TCF Frequency Shift Receiver Filters

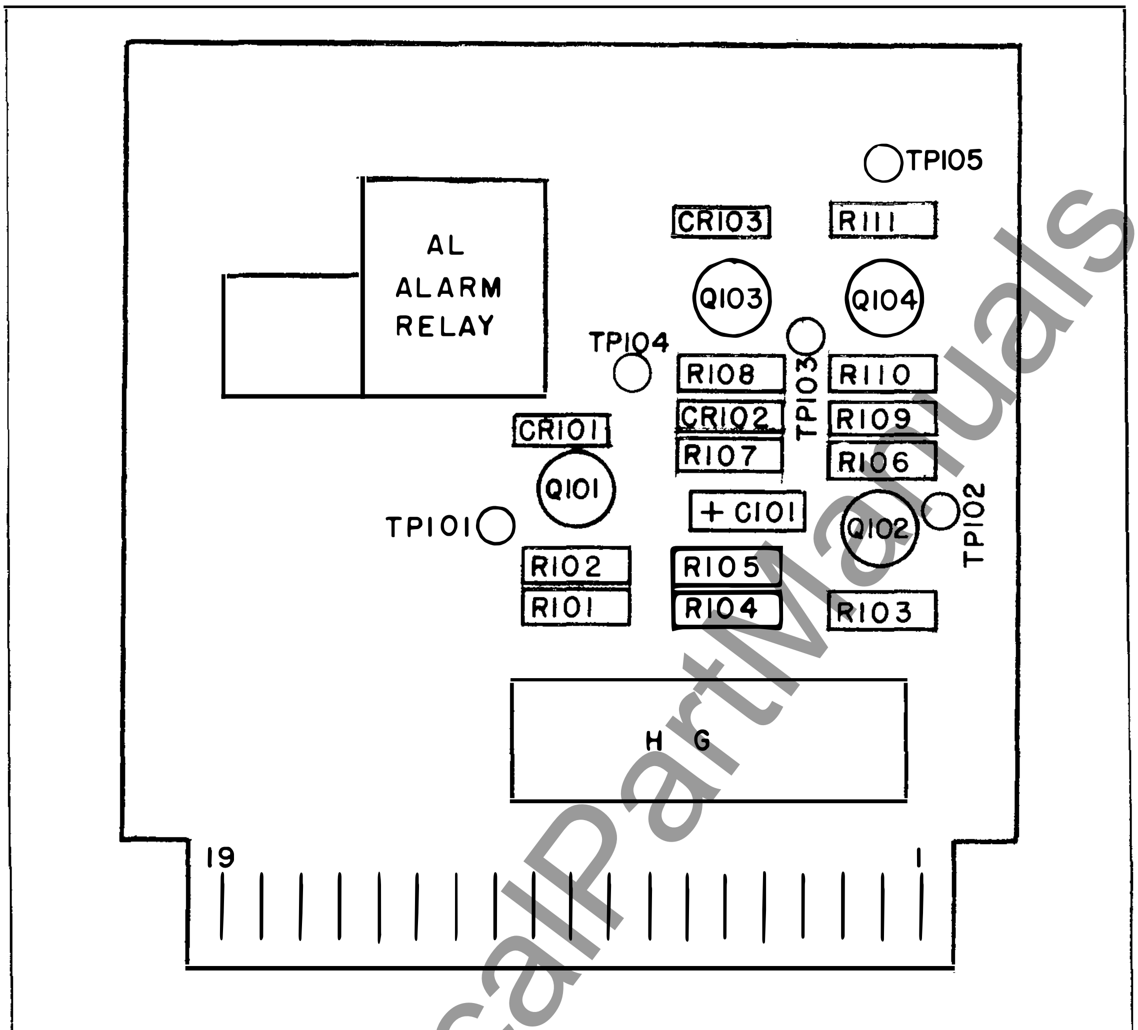
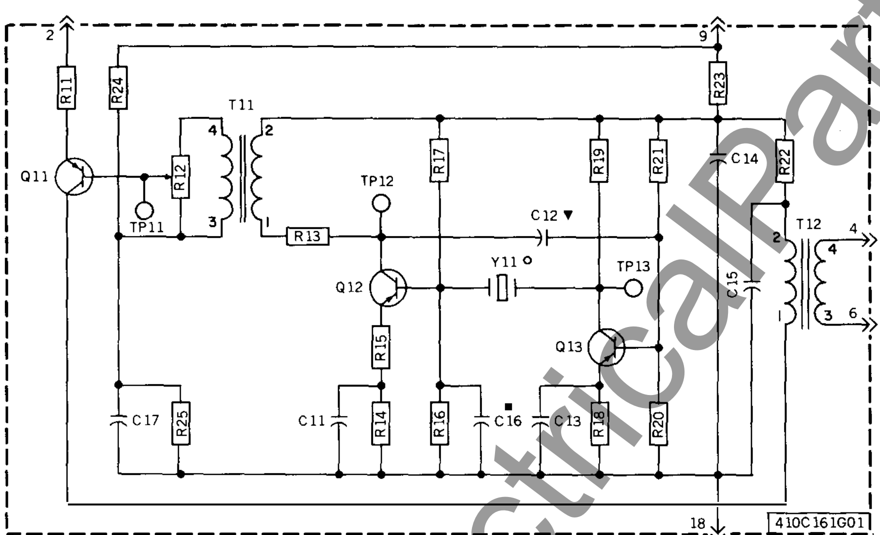


Fig. 10. Component Locations on the Relay Output Printed Circuit Board.



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.

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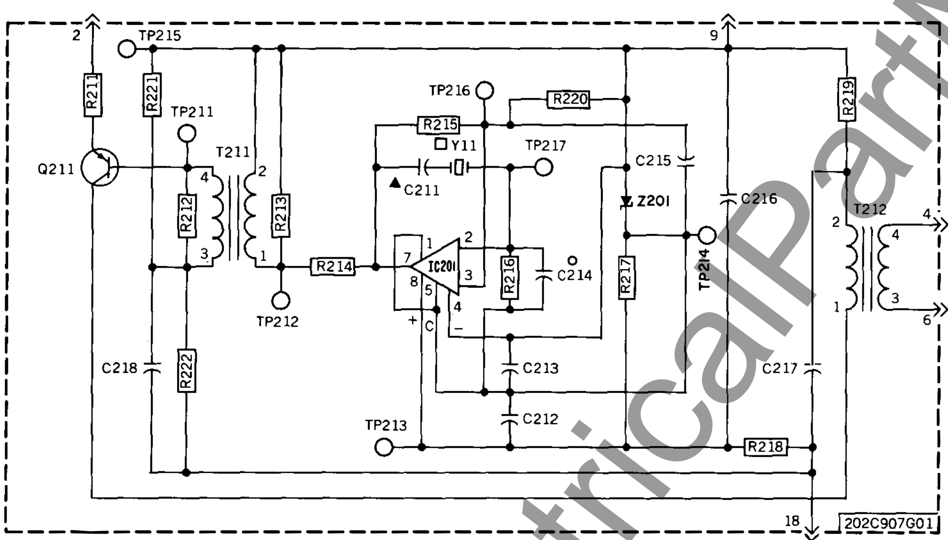
* *Fig. 11. Internal Schematic 30-200KHz Oscillator and Mixer Silicon Transistor Version*



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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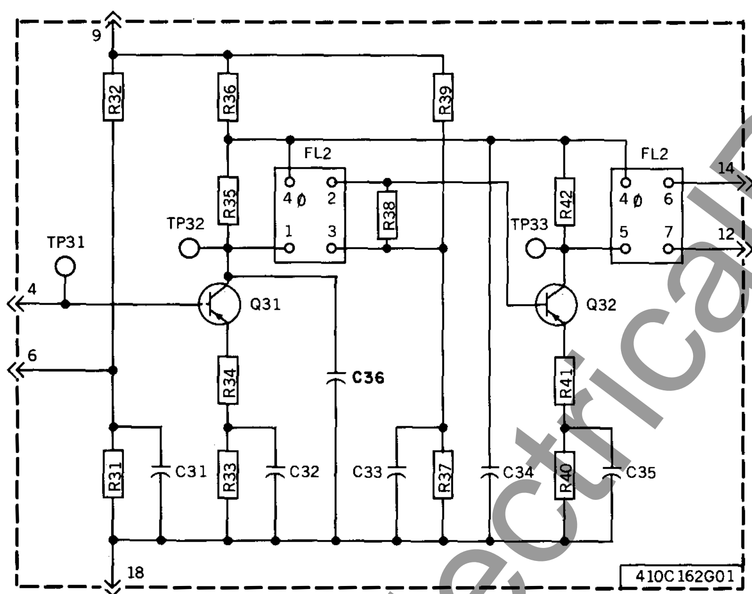
* ***Fig. 12. Internal Schematic 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version***



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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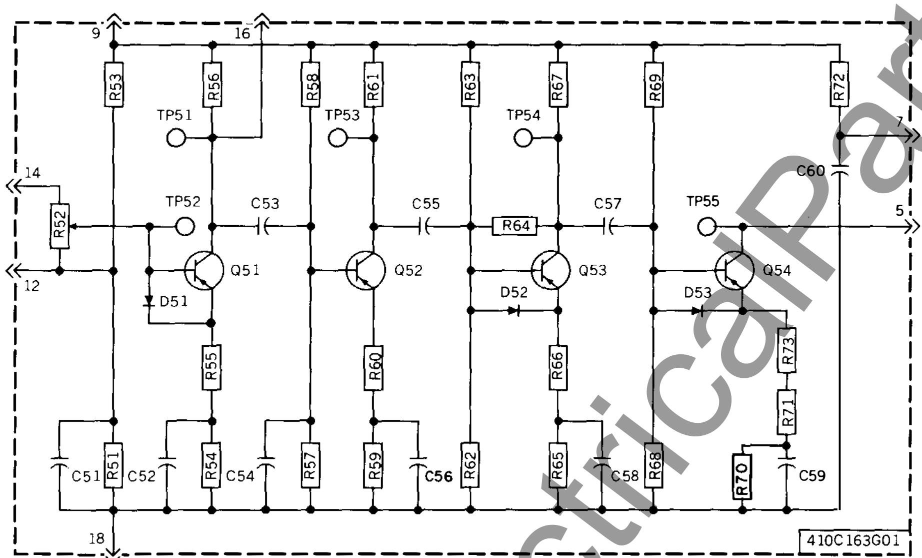
* *Fig. 13. Internal Schematic I.F. Amplifier – Silicon Transistor Version*



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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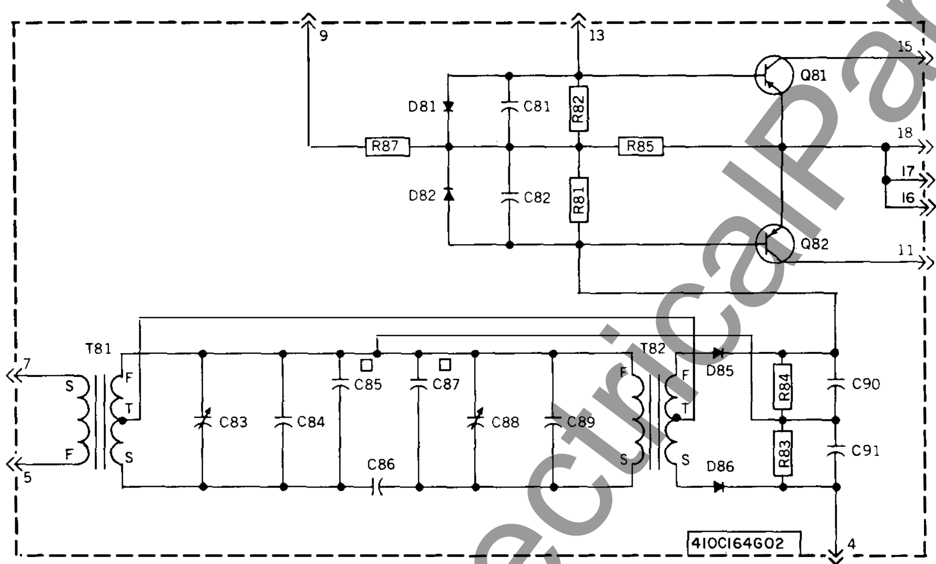
** Fig. 14. Internal Schematic Amplifier and Limiter – Silicon Transistor Version*



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%
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	184A855H07	2	1N457A
D85–D86	184A855H12	2	1N628
TRANSFORMER			
T81	606B533G01	1	
T82	606B533G02	1	

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

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* *Fig. 15.* **Internal Schematic Discriminator – Silicon Transistor Version**

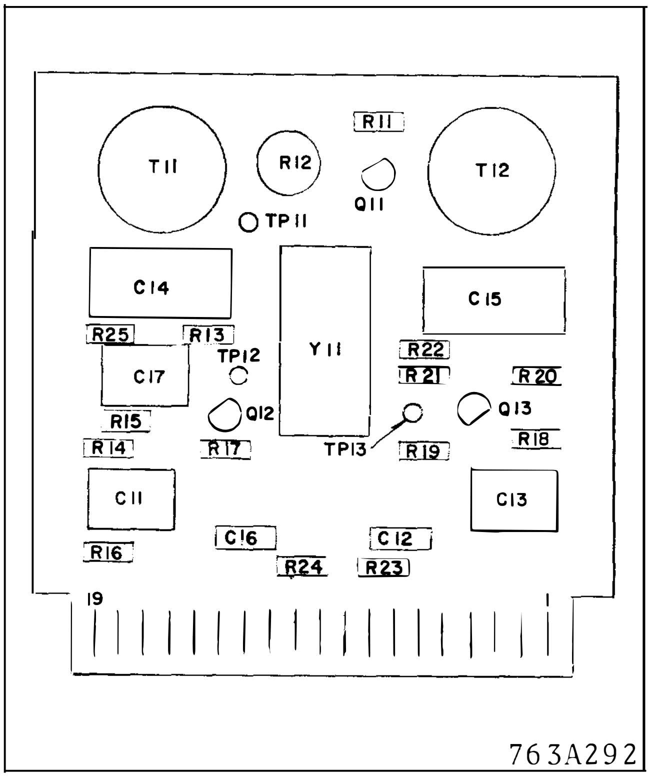

Fig. 16. Component Locations 30-200KHz. Oscillator and Mixer Silicon Transistor Version

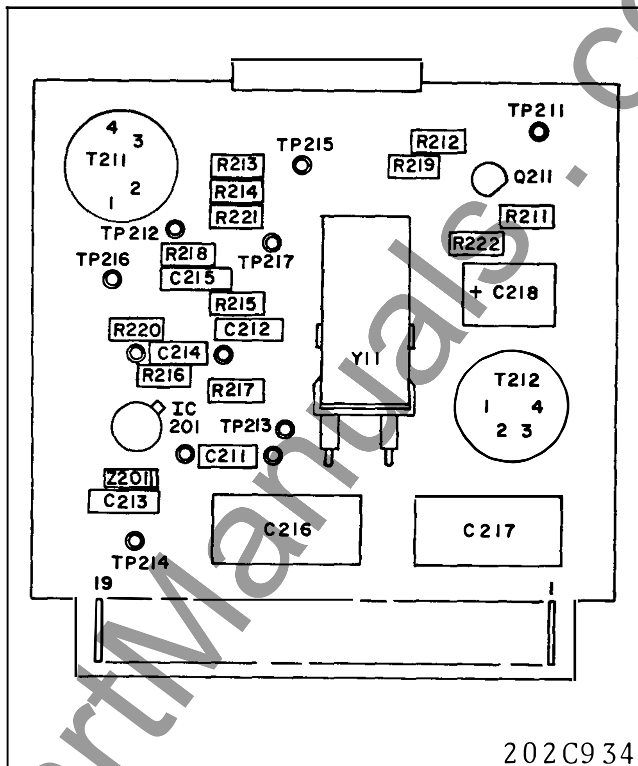

Fig. 17. Component Locations 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version

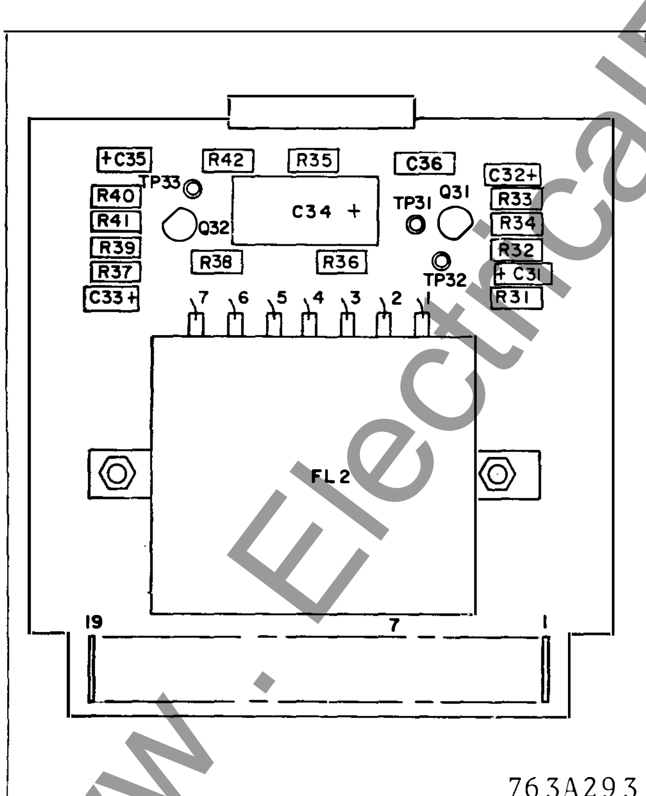

Fig. 18. Component Locations I.F. Amplifier – Silicon Transistor Version

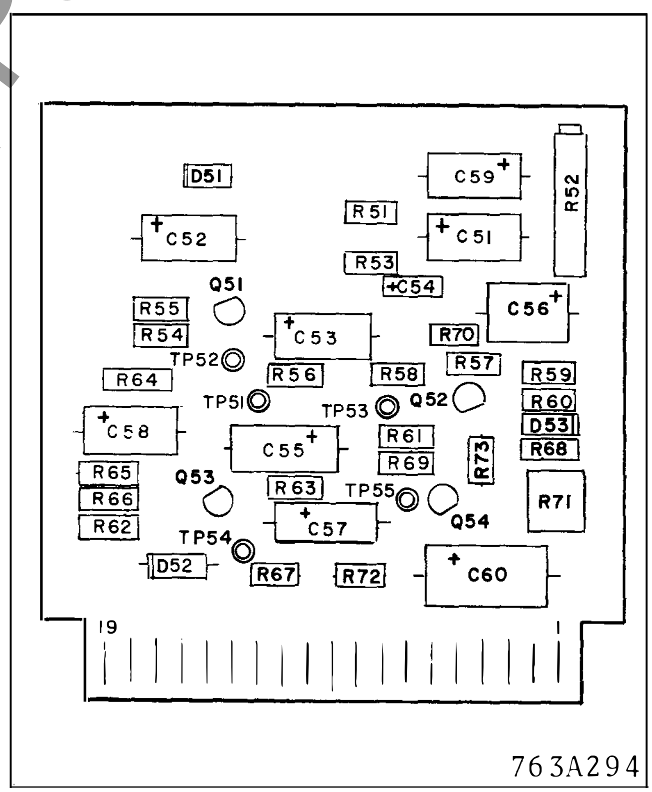

Fig. 19. Component Locations Amplifier and Limiter – Silicon Transistor Version

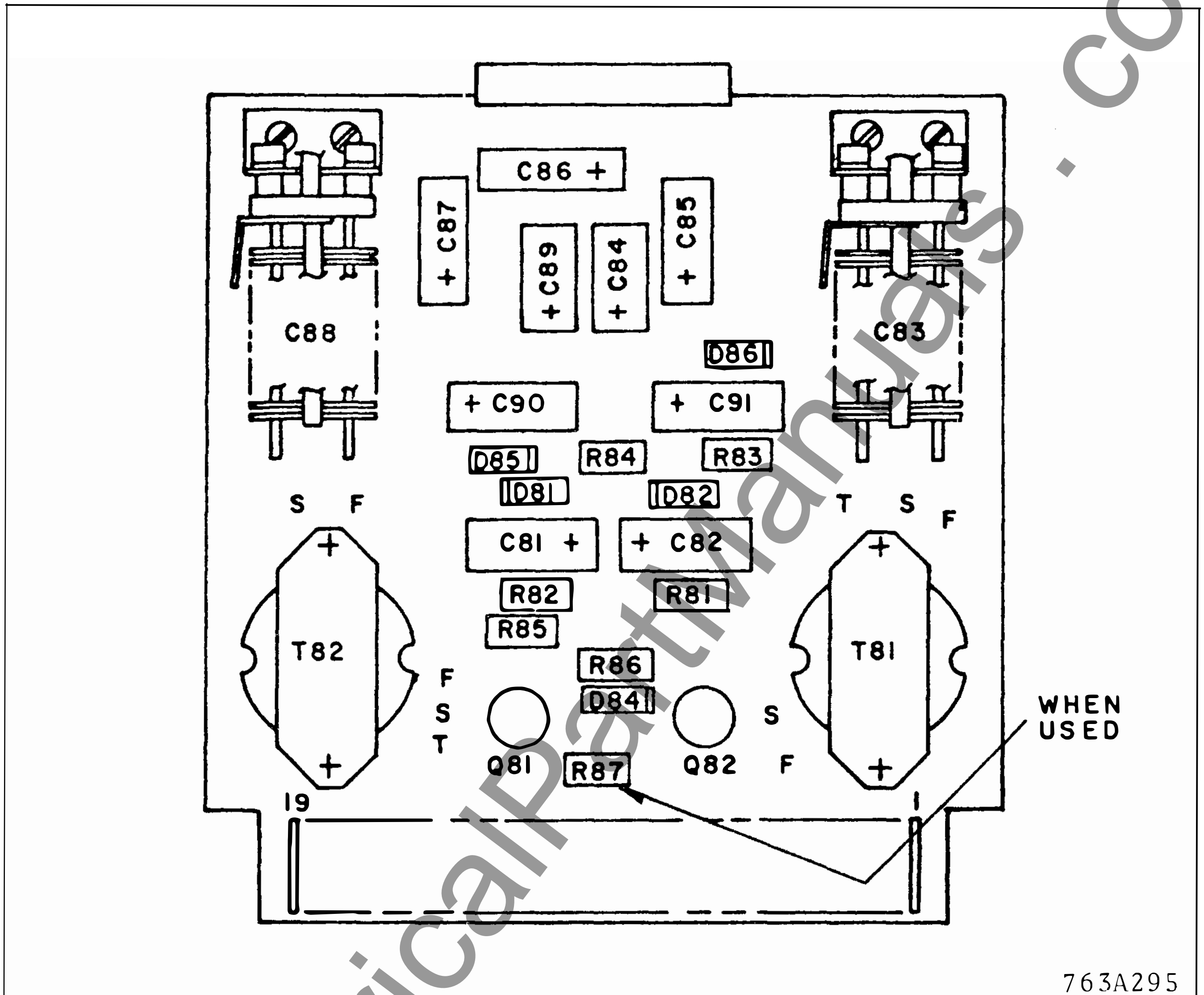

Fig. 20. Component Locations Discriminator – Silicon Transistor Version

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