INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT – WITH VOLTAGE OUTPUT FOR 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 as adapted for telemetering applications produces at its output terminals an alternating voltage of approximately square waveform, and of the same frequency as the voltage which keys its associated TCF transmitter to produce a signal which is alternately 100 cycles above and 100 cycles below the center frequency of the channel on which the transmitter and receiver are designed to operate. This center frequency can be selected within the range of 30 KC to 200 KC, and the high frequencies are carried from transmitter to receiver over a power line and through coupling capacitors and line tuners at each end. The varying frequency keying, or modulating, voltage for the TCF transmitter is obtained from a telemetering transmitter which converts a millivolt signal to a proportional frequency. The varying frequency output of the TCF receiver is converted by a telemetering receiver to a millivolt signal identical to that at the transmitting end.

CONSTRUCTION

The TCF receiver unit for voltage output 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 figure 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of figure 1 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 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 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 figure 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 figure 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 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 terminal 4 is positive with respect to terminal 13 (which occurs with trip output) and Q81 is made conductive when terminal 4 is negative with respect to 13. Consequently, terminal 15 is at a potential of approximately +20 volts at Guard frequency and terminal 11 is at +20 volts at trip frequency.

Output Circuits

The output circuit board of the receiver contains transistors Q101 and Q102 which receive and amplify the discriminator output. Their collectors are connected to the outer ends of the mid-tapped primary winding of transformer T1, and the alternate conduction and cutoff of these transistors causes a-c voltages of approximate square waveform to appear on the secondary windings of the transformer. The winding connected to terminals 18 and 19 of J3 supplies approximately 45 volts peak-to-peak to a 10K load, and the winding connected to terminals 23 and 24 supplies approximately 12 volts peak-to-peak to a 600 ohm load.

The two discriminator outputs also are connected through resistors R103 and R104 to the base of transistor Q103. Either output from the discriminator will keep Q103 fully conductive and current fed from the 45 volt d-c supply will flow to negative through Q103. If the discriminator has neither output, capacitor C103 charges to the breakdown voltage of Zener diode CR103 in approximately 160 ms. Q104 then receives base current and becomes conductive, thus removing base current from Q105 and causing alarm relay AL to drop out. An alarm is energized through normally-closed contacts of this relay. A copper slug on the core of relay AL adds about 40 ms. to make the total delay about 200 ms. between disappearance of discriminator output and energization of the alarm. If discriminator output should reappear before the alarm becomes energized, C103 will be discharged very rapidly through the low resistance of R109 and substantially the full delay would be effective on an immediately subsequent loss of discriminator output.

The telemetering transmitter has a lower frequency output with a zero millivolt input signal and a higher frequency output at maximum or full scale input signal, a typical range being 15 to 35 cycles. Consequently, the alarm will not be energized unless there is failure in equipment or interruption of the power line channel.

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.)
Keying rate	10-50 cps.
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.
Receiver Output	Output transformer supplies the following square-wave voltages (peak-to-peak): A. Terminals 18-19: 45 volts into 10,000 ohms. B. Terminals 23-24: 12 volts into 600 ohms.
Ambient temperature range	−20 °C to +60 °C temperature around chassis.
Battery voltage variations	
Rated Voltage	Allowable variation
48 V.D.C.	42 – 56 V.D.C.
125 V.D.C.	105 – 140 V.D.C.
250 V.D.C.	210 – 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height – 10½'' or 6 r.u. Panel width – 19''
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; 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 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 accidently 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 and Q101	20 (No signal or fc-100 cy.)
Q81 and Q101	.25 (fc + 100 cy.)
Q82 and Q102	20 (No signal or fc + 100 cy.)
Q82 and Q102	.25 (fc — 100 cy.)
Q103	20.5 (No signal)
Q104	.25 (No signal)
Q105	45 (No signal)

TABLE II
RECEIVER RF MEASUREMENTS

Collector of Transistor	Volts (fc + 100 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 0.03 to 30 volts, frequency range 60 cycles/sec. to 230-kc., input impedance 7.5 megohms.

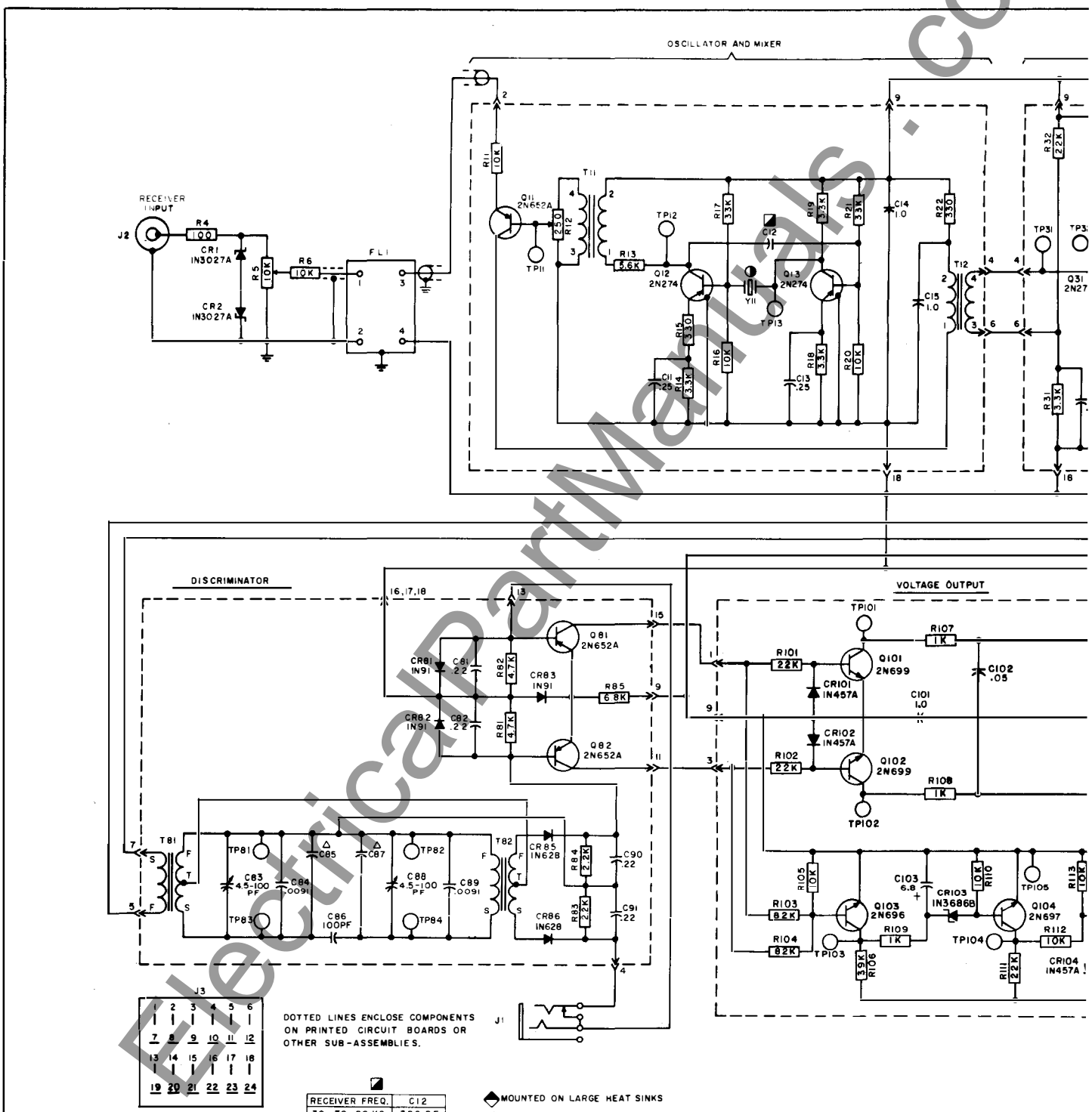
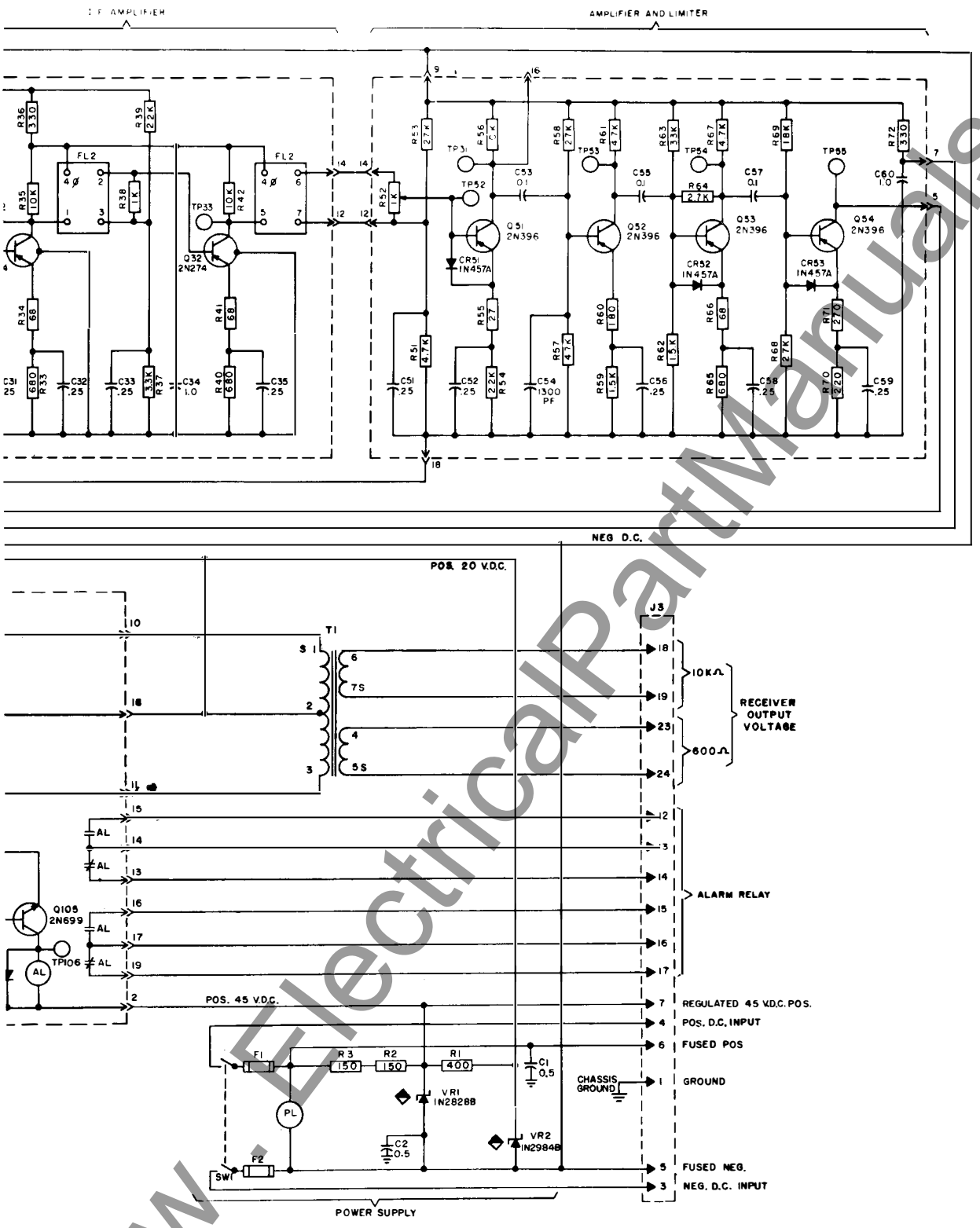


Fig. 1 Internal Schematic of the Type TCF Receiv



rs with voltage output for telemetering.

b. D-C Vacuum Tube Voltmeter (VTVM)

Voltage Range: 0.15 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.

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.

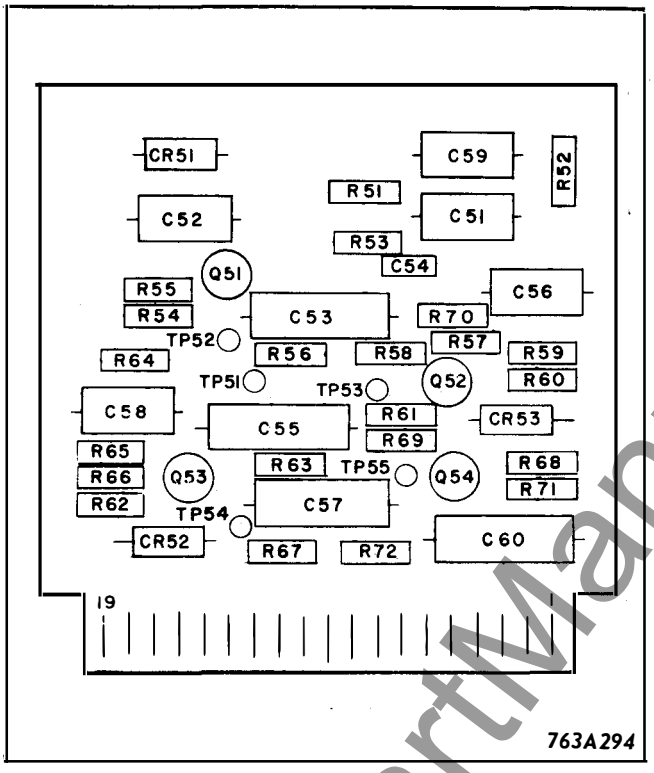


Fig. 7 Component locations on Amplifier and limiter printed Circuit Board.

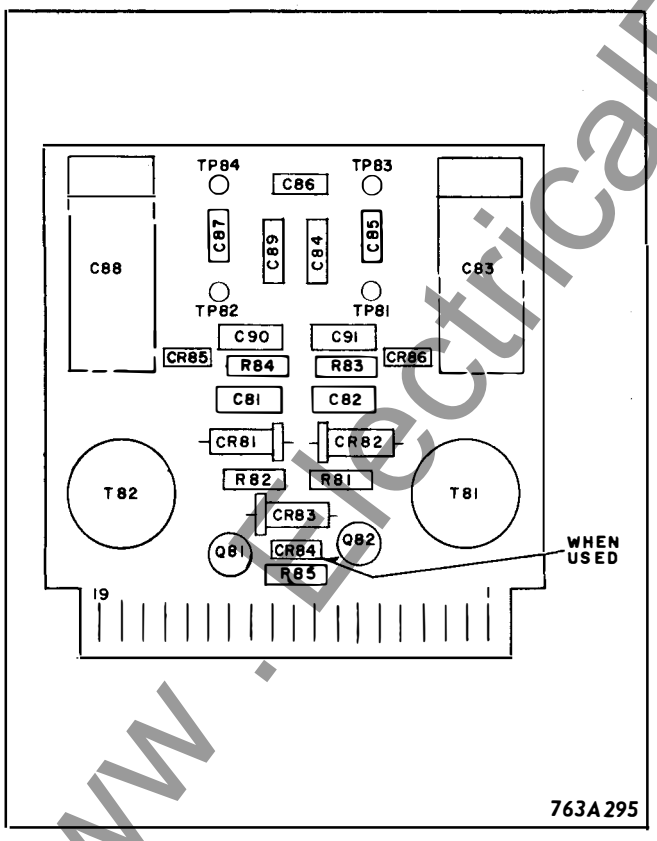


Fig. 8 Component locations on Discriminator Printed Circuit Board.

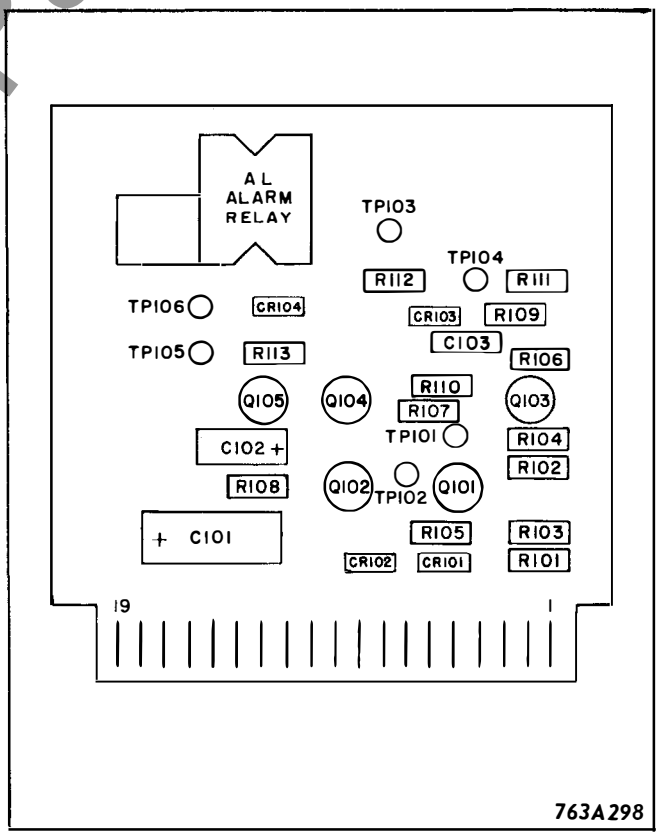


Fig. 9 Component locations on Output Printed Circuit Board.

WESTINGHOUSE ELECTRIC CORPORATION

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

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SUPERSEDES I.L. 41-945.52
*Denotes change from superseded issue

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Operating Time	9 ms. channel (transm. and recvr.)
Keying rate	10-50 cps.
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.
Receiver Output	Output transformer supplies the following square-wave voltages (peak-to-peak): A. Terminals 18-19: 45 volts into 10,000 ohms. B. Terminals 23-24: 12 volts into 600 ohms.
Ambient temperature range	−20 °C to +60 °C temperature around chassis.
Battery voltage variations	
Rated Voltage	Allowable variation
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250 V.D.C.	210 - 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height – 10½'' or 6 r.u. Panel width – 19''
Weight	13 lbs.

INSTALLATION

The TCF receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60°C.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; 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 accidently 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 and Q101	20 (No signal or fc-100 cy.)
Q81 and Q101	.25 (fc + 100 cy.)
Q82 and Q102	20 (No signal or fc + 100 cy.)
Q82 and Q102	.25 (fc — 100 cy.)
Q103	20.5 (No signal)
Q104	.25 (No signal)
Q105	45 (No signal)

TABLE II
RECEIVER RF MEASUREMENTS

Collector of Transistor	Volts (fc + 100 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 0.03 to 30 volts, frequency range 60 cycles/sec. to 230-kc., input impedance 7.5 megohms.

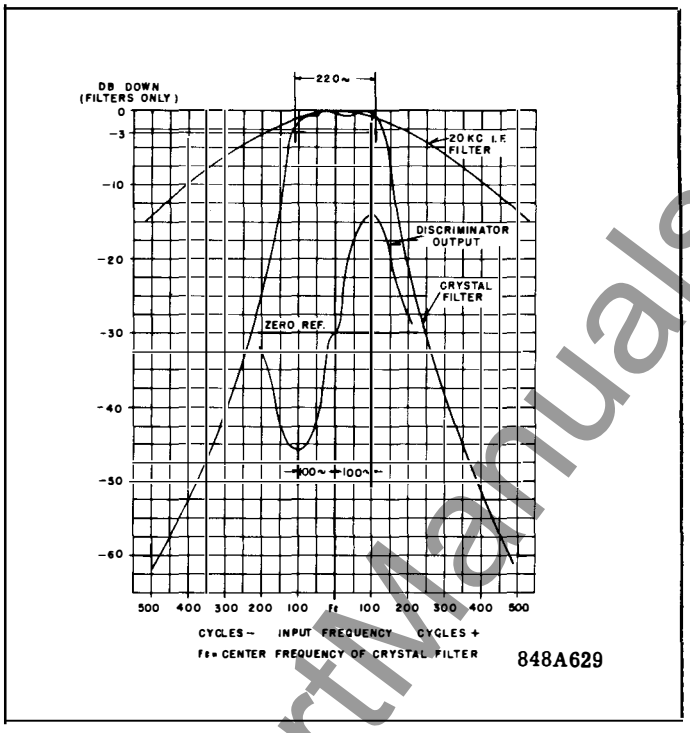

Fig. 2 Filter and discriminator characteristics of TCF receivers.

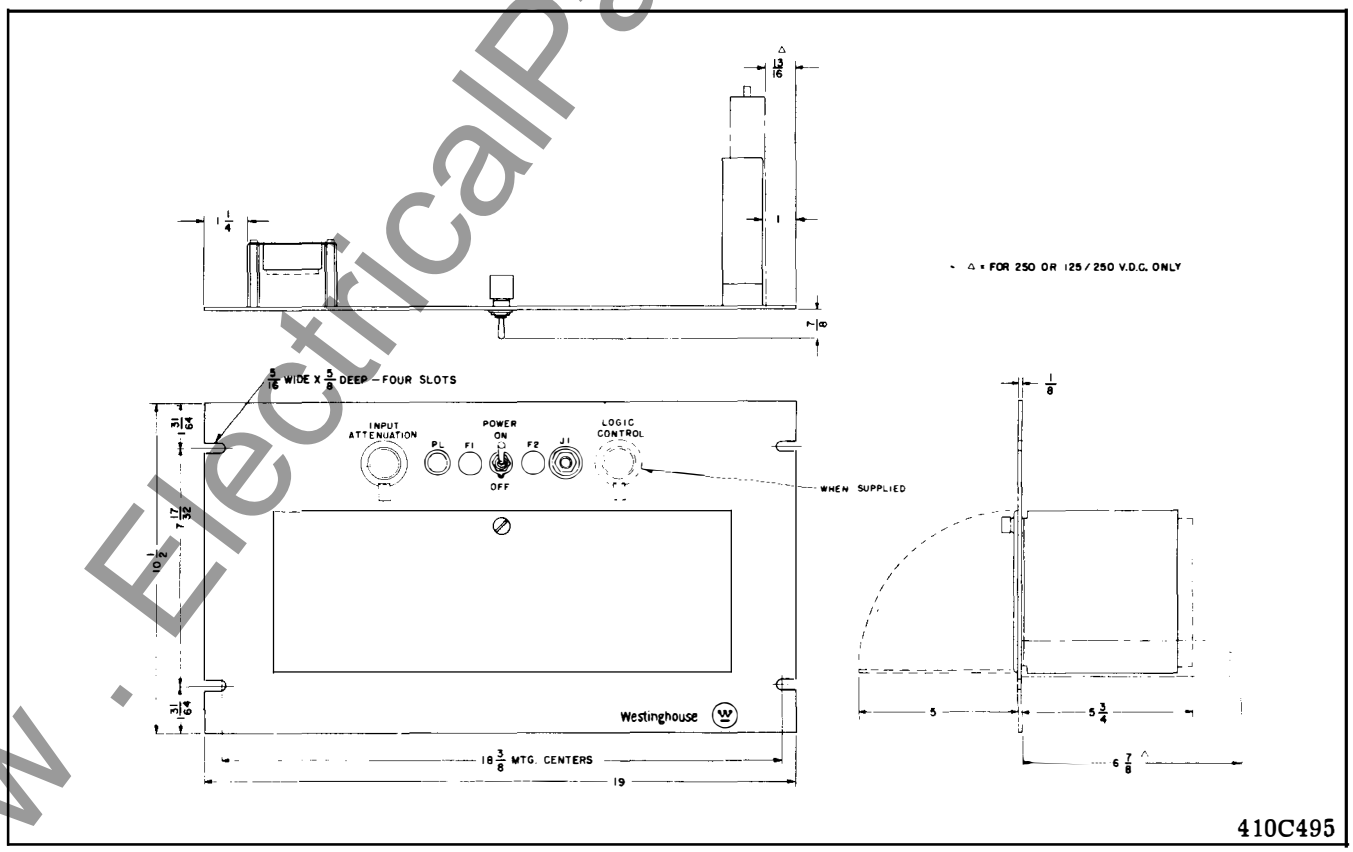

Fig. 3 Outline of the type TCF receiver assembly.

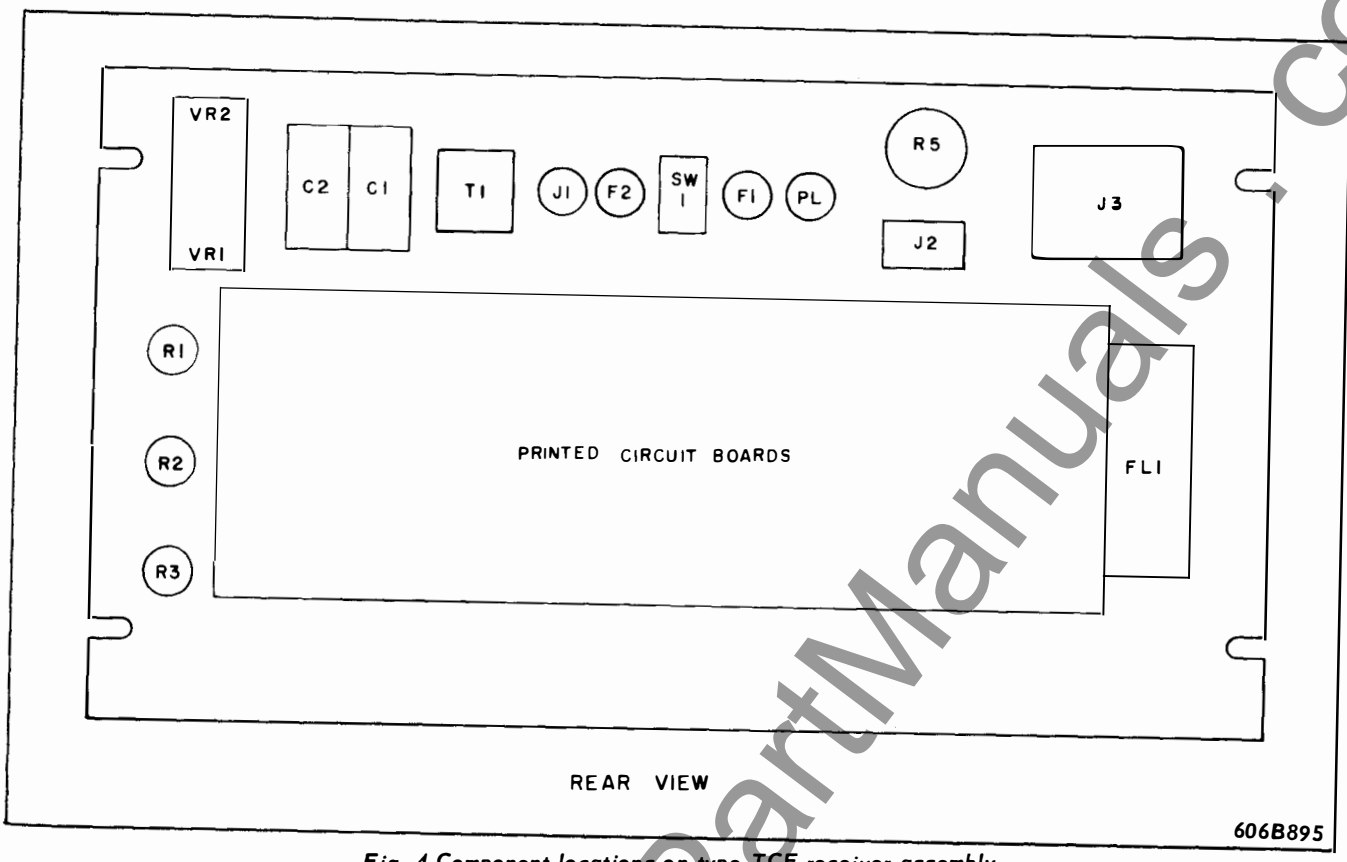

Fig. 4 Component locations on type TCF receiver assembly.

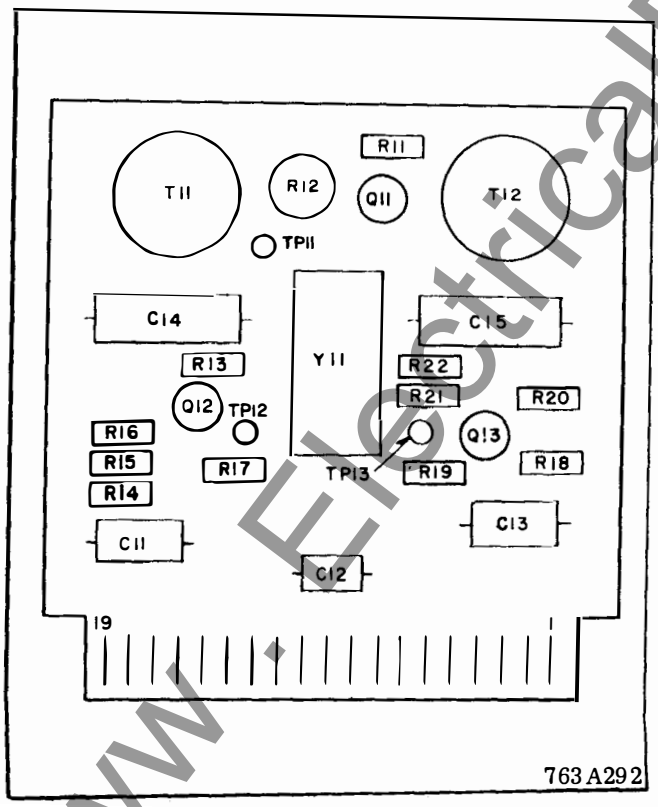

Fig. 5 Component locations on oscillator and mixer printed circuit board.

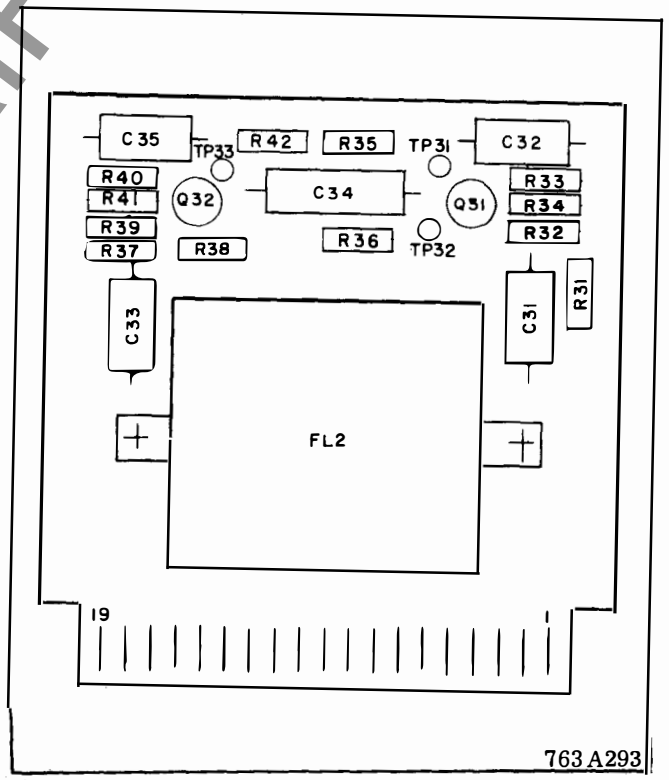

Fig. 6 Component locations on I.F. amplifier printed circuit board.

b. D-C Vacuum Tube Voltmeter (VTVM)

Voltage Range: 0.15 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.

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.

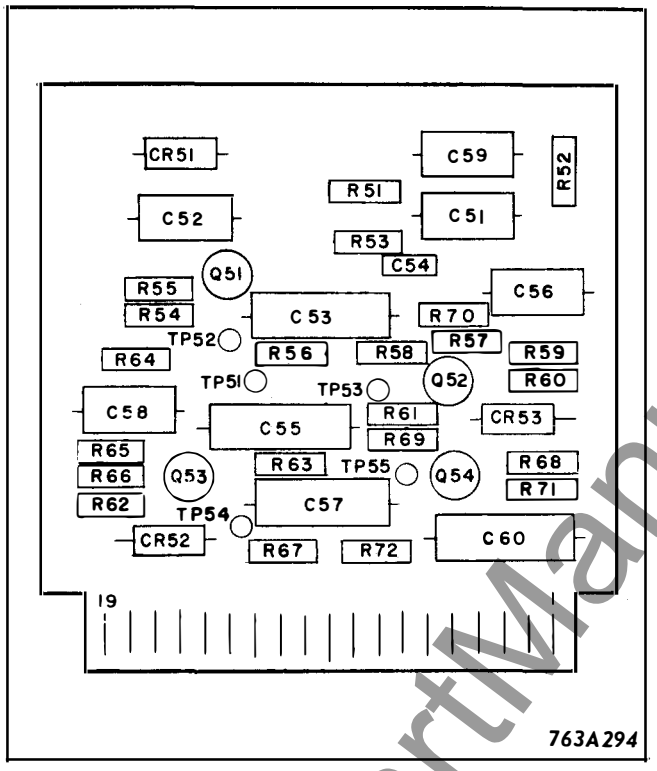

Fig. 7 Component locations on amplifier and limiter printed circuit board.

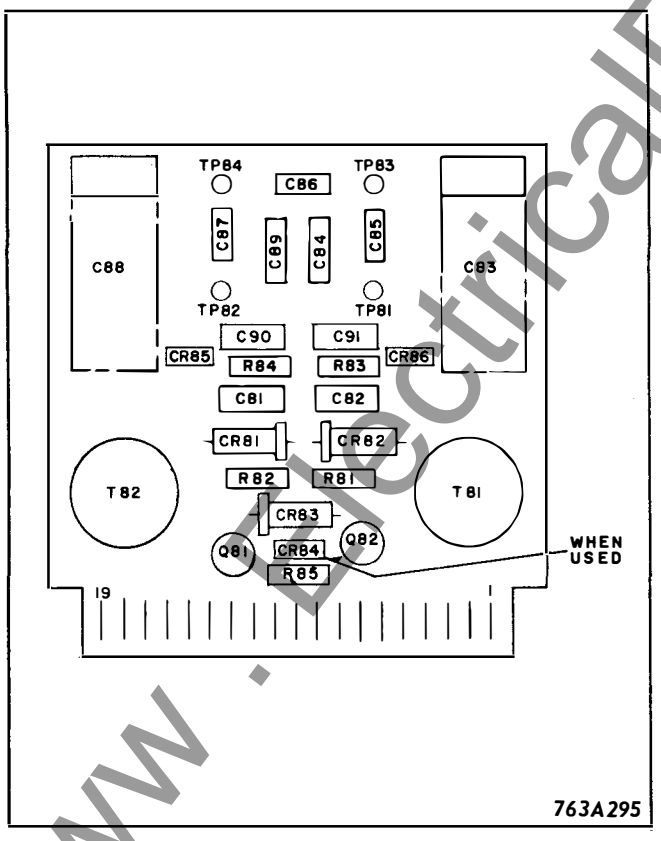

Fig. 8 Component locations on discriminator printed circuit board.

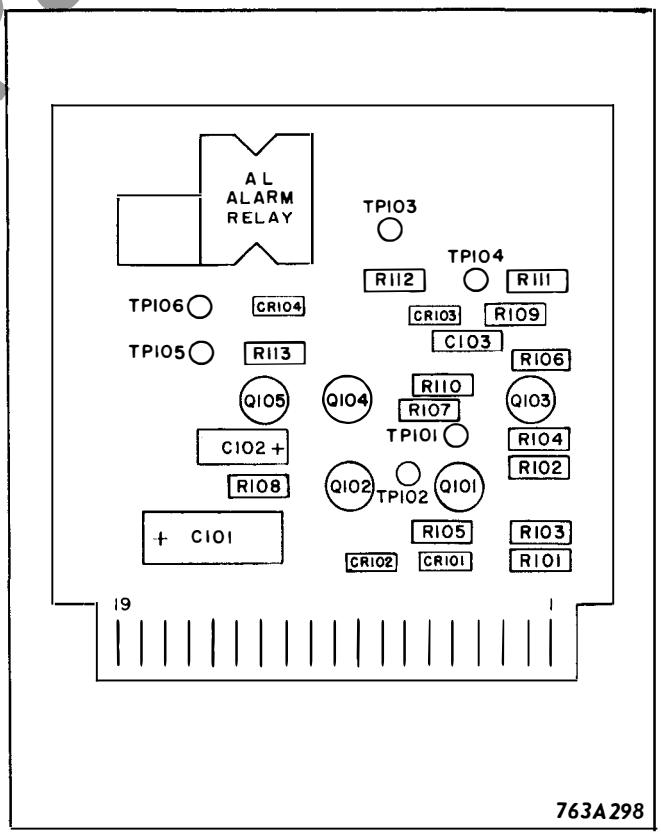

Fig. 9 Component locations on output printed circuit board.

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