INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER RECEIVER EQUIPMENT FOR MULTI-STATION SUPERVISORY CONTROL

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

In multi-station supervisory control operation, a common channel and a common set of equipment at the master station are used for two or more remote stations, whereas in single-station operation a separate channel and separate set of equipment are used at the master station for each remote station.

The TCF power line carrier receiver equipment for multi-station supervisory control applications is similar in appearance to the TCF frequency-shift receiver with relay output for two-station supervisory control and telemetering applications. However, because a Guard frequency cannot be used in multi-station supervisory control applications, the receiver cannot be provided with a loss-of-channel alarm, and it must be operated at considerably less than its maximum sensitivity to avoid false operation due to line noise. Also, the narrow pass-band input filter used in other TCF receivers cannot be used when the filter input changes power level abruptly from off to on (rather than changing frequency a relatively small amount at an approximately constant power level) because there would be excessive ringing of the filter. For this reason, the input filter is the same as that used in the TC receiver. However, the TCF i-f filter is more selective than the corresponding TC filter, and the use of a discriminator also aids the selectivity.

The range of channel frequencies for which the TCF receiver can be supplied is 30 to 200 KC, in 0.5 KC steps. The transmitter signal is 100 cycles below the channel center frequency, corresponding to the Trip frequency used for frequency shift

transfer-trip relaying applications. Reception of this signal causes operation of a mercury-wetted contact relay in the TCF receiver.

CONSTRUCTION

The TCF receiver unit for multi-station supervisory control applications is mounted on a standard 19-inch wide panel 10-1/2 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 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 VDC supply, and the remainder from a regulated 45 VDC 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 DC supply and the 45 volt zener adapt the receiver for operation on 48, 125 or 250 VDC.

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.

Input Filter

From the attenuator, the signal passes through the input filter, FL-201, which has a selectivity characteristic as shown in Fig. 2. The input filter rejects undesired signals while accepting a wide enough band of frequencies to assure fast operation. A 1/1 ratio toroidal-core transformer mounted externally on the filter isolates the filter output from ground.

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. The fc + 20KC frequency predominates, but there is appreciable attenuation of the higher frequencies in passing through transformer T12.

I-F 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, and 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 the same as that used in the two-frequency TCF receivers, although in this application the input to the receiver is either zero or Trip frequency. As is shown in Fig. 2, the discriminator will have output only at or near Trip frequency, and this characteristic greatly increases the frequency selectivity of the receiver.

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. In this application, of course, no connection is made to terminal 15.

Output Circuit Board

Terminal 11 of the discriminator circuit board is connected to terminal 8 of the output circuit board. Transistor Q101 amplifies the input received from the discriminator when the receiver has Trip input, and energizes relay HG. The contacts of this relay are the mercury-wetted type, which assures bounceless operation. Diode CR101 is connected across the coil of relay HG so that a high voltage will not be induced across the coil terminals when it is de-energized, as this might damage transistor Q101.

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 de-energized. 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.

Power Supply

The regulated 20 VDC and 45 VDC 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 VDC battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the DC circuits are energized. Capacitors C1 and C2 bypass r-f or transient voltages to ground.

CHARACTERISTICS

Frequency range	30-200KC
Sensitivity (on-off operation)	0.044 volt (55 db below 10 watts for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (input filter)	down <3 db at ±850 cycles down >28 db at ±2000 cycles
Bandwidth (i-f filter)	down <3 db at ±250 cycles down >36 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. (See Fig. 2)
Operating Time	7 ms. channel (transm. and recvr.)
Frequency spacing	4KC minimum
Ambient temperature range	-20°C to +60°C temperature around chassis.
Battery voltage variations	
Rated Voltage	Allowable variation
48 VDC	42 - 56 VDC
125 VDC	105 - 140 VDC
250 VDC	210 - 280 VDC
Battery drain	0.20 a. at 48 VDC 0.27 a. at 125 or 250 VDC
Dimensions	Panel height - 10-1/2" 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 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 output 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 44 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 44 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 40 db from 10 watts. Unless otherwise indicated, voltage will not vary appreciably whether signal is Trip or fc frequency.

Collector of Transistor	Volts (-)
Q11	.20
Q12	14.5 (No signal)
Q12	14.0 (Trip signal)
Q13	17.0 (No signal)
Q13	15.0 (Trip signal)
Q31	18.5
Q32	18.5

Collector of Transistor	Volts (-)
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q82 and Q101	20 (No signal)
Q82 and Q101	<0.5 (fc - 100 cy.)

TABLE II
Receiver R-F 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 0.003 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: 20kc to 230kc

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter 0-1.5 or preferable 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 testmeter 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.

ELECTRICAL PARTS LIST

Circuit Symbol	Description	Westinghouse Designation
	CAPACITORS	
C1,C2	Oil filled, 0.5 mfd, 1500 VDC	1877962
C11	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C12	Mica, capacity as required, 500 VDC	
C13	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C14,C15	Metallized paper, 1.0 mfd, 200 VDC	187A624H04
C31,C32, C33	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C34	Metallized paper, 1.0 mfd, 200 VDC	187A624H04
C35,C51, C52	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C53	Metallized paper, 0.1 mfd, 200 VDC	187A624H01
C54	Dur-Mica, 1300 pf, 500 VDC	187A584H15
C55	Metallized paper, 0.1 mfd, 200 VDC	187A624H01
C56	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C57	Metallized paper, 0.1 mfd, 200 VDC	187A624H01
C58,C59	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C60	Metallized paper, 1.0 mfd, 200 VDC	187A624H04
C81,C82	Mylar, 0.22 mfd, 50 VDC	762A703H01
C83	Variable, 4.5-100 pf	762A736H02
C84	Polystyrene, 9100 pf, 200 VDC	187A624H16
C85	Temp. compensating, 150 VDC pf as required	
C86	100 pf, zero temp. coef.	187A684H08
C87	Temp. compensating, 150 VDC pf as required	
C88	Variable, 4.5-100 pf	762A736H02
C89	Polystyrene, 9100 pf, 200 VDC	187A624H16
C90,C91, C104	Mylar, 0.22 mfd, 50 VDC	762A703H01
C105	Ceramic, 0.05 mfd, 50 VDC	184A663H02
C151,C152	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C153	Metallized paper, 1.0 mfd, 200 VDC	187A624H04
C154,C155, C156,C157, C158	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
	DIODES - General Purpose	
CR51,CR52, CR53	1N457A, 60V, 200 MA	184A855H07
CR81,CR82 CR83	1N91, 100V, 150 MA	182A881H04

ELECTRICAL PARTS LIST

Circuit Symbol	Description	Westinghouse Designation
	DIODES - General Purpose (cont'd.)	
CR85,CR86	1N628, 125V, 30 MA	184A855H12
CR101	1N457A, 60V, 200 MA	184A855H07
	DIODES - ZENER	
CR1,CR2	1N3027A, 20V ± 10%, 1W	188A302H10
VR1	1N2828B, 45V ± 5%, 50W	184A854H06
VR2	1N2984B, 20V ± 5%, 10W	762A631H01
	POTENTIOMETERS	
R5	10K, 2W	185A086H10
R12	250 ohms, 1/4 W	629A430H06
R52	1K, 1/4 W	629A645H04
	RESISTORS	
R1	400 ohms ± 5%, 25W	1202587
R2	26.5 ohms ± 5%, 40W (for 48V supply)	04D1299H44
R2	150 ohms ± 5%, 40W (for 125V supply)	1202499
R3	150 ohms ± 5%, 40W (for 125V supply)	1202499
R4	100 ohms ± 5%, 1W composition	187A643H03
R6	10K ± 5%, 1/2 W composition	184A763H51
R11	10K ± 5%, 1/2 W composition	184A763H51
R13	5.6K ± 5%, 1/2 W composition	184A763H45
R14	3.3K ± 5%, 1/2 W composition	184A763H39
R15	330 ohms ± 5%, 1/2 W composition	184A763H15
R16	10K ± 5%, 1/2 W composition	184A763H51
R17	33K ± 5%, 1/2 W composition	184A763H63
R18,R19	3.3K ± 5%, 1/2 W composition	184A763H39
R20	10K ± 5%, 1/2 W composition	184A763H51
R21	33K ± 5%, 1/2 W composition	184A763H63
R22	330 ohms ± 5%, 1/2 W composition	184A763H15
R31	3.3K ± 5%, 1/2 W composition	184A763H39
R32	22K ± 5%, 1/2 W composition	184A763H59
R33	680 ohms ± 5%, 1/2 W composition	184A763H23
R34	68 ohms ± 5%, 1/2 W composition	187A290H21
R35	10K ± 5%, 1/2 W composition	184A763H51
R36	330 ohms ± 5%, 1/2 W composition	184A763H15
R37	3.3K ± 5%, 1/2 W composition	184A763H39
R38	1000 ohms ± 5%, 1/2 W composition	184A763H27

ELECTRICAL PARTS LIST

Circuit Symbol	Description	Westinghouse Designation
	RESISTORS (cont'd.)	
R39	22K ± 5%, 1/2 W composition	184A763H59
R40	680 ohms ± 5%, 1/2 W composition	184A763H23
R41	68 ohms ± 5%, 1/2 W composition	187A290H21
R42	10K ± 5%, 1/2 W composition	184A763H51
R51	4.7K ± 5%, 1/2 W composition	184A763H43
R53	27K ± 5%, 1/2 W composition	184A763H61
R54	2.2K ± 5%, 1/2 W composition	184A763H35
R55	27 ohms ± 5%, 1/2 W composition	187A290H11
R56	10K ± 5%, 1/2 W composition	184A763H51
R57	4.7K ± 5%, 1/2 W composition	184A763H43
R58	27K ± 5%, 1/2 W composition	184A763H61
R59	1.5K ± 5%, 1/2 W composition	184A763H31
R60	180 ohms ± 5%, 1/2 W composition	184A763H09
R61	4.7K ± 5%, 1/2 W composition	184A763H43
R62	1.5K ± 5%, 1/2 W composition	184A763H31
R63	33K ± 5%, 1/2 W composition	184A763H63
R64	2.7K ± 5%, 1/2 W composition	184A763H37
R65	680 ohms ± 5%, 1/2 W composition	184A763H23
R66	68 ohms ± 5%, 1/2 W composition	187A290H21
R67	4.7K ± 5%, 1/2 W composition	184A763H43
R68	2.7K ± 5%, 1/2 W composition	184A763H37
R69	18K ± 5%, 1/2 W composition	184A763H57
R70	220 ohms ± 5%, 1/2 W composition	184A763H11
R71	270 ohms ± 5%, 1/2 W composition	184A763H13
R72	330 ohms ± 5%, 1/2 W composition	184A763H15
R81, R82	4.7K ± 5%, 1/2 W composition	184A763H43
R83, R84	2.2K ± 5%, 1/2 W composition	184A763H35
R85	6.8K ± 5%, 1/2 W composition	184A763H47
R101	18K ± 5%, 1/2 W composition	184A763H57
R102	10K ± 5%, 1/2 W composition	184A763H51
	TRANSFORMERS	
T11	Toroidal type, 10,000/400 ohms	1962797
T12	Toroidal type, 25,000/300 ohms	1962697
T81	Pot. core type	606B533G01
T82	Pot. core type	606B533G02

ELECTRICAL PARTS LIST

Circuit Symbol	Description	Westinghouse Designation
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12, Q13, Q31, Q32	2N274	187A270H01
Q51, Q52 Q53, Q54	2N396	762A585H03
Q81, Q82	2N652A	184A638H16
Q101	2N699	184A638H18
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20KC above Channel Freq.)	762A800H01 + Required Freq.
FL-201	Input Filter	670B258 + Required Freq.
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb - for 48V Supply	187A133H02
PL	Pilot Light Bulb - for 250V Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
HG	Output Relay (Mercury-Wetted Contact)	188A573H04

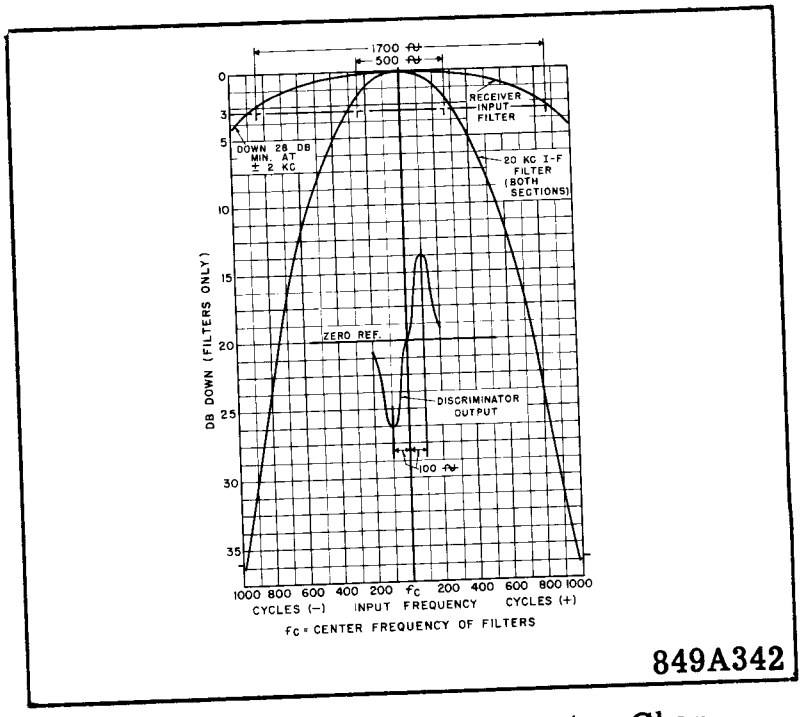


Fig. 2 Filter and Discriminator Characteristics of the TCF Receiver

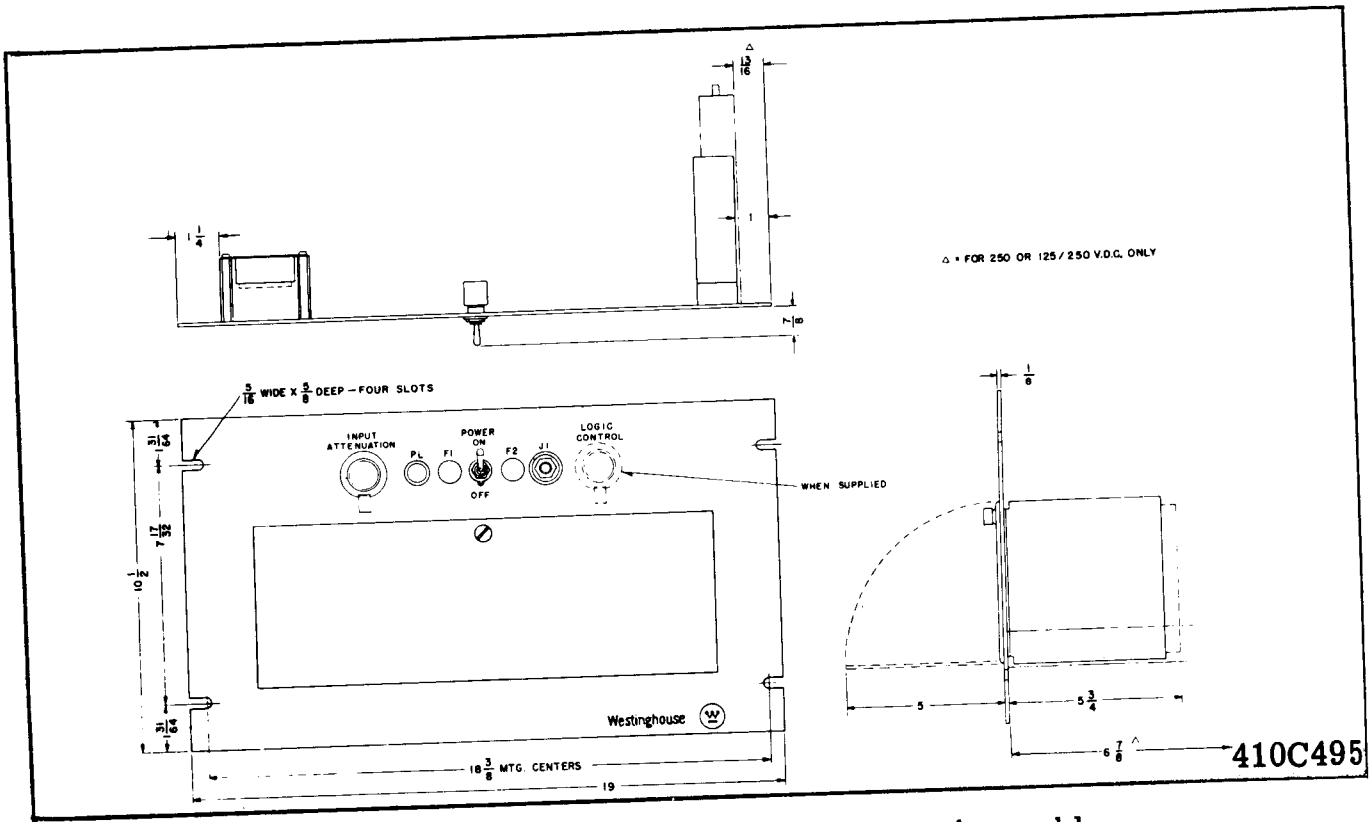


Fig. 3 Outline of the Type TCF Receiver Assembly.

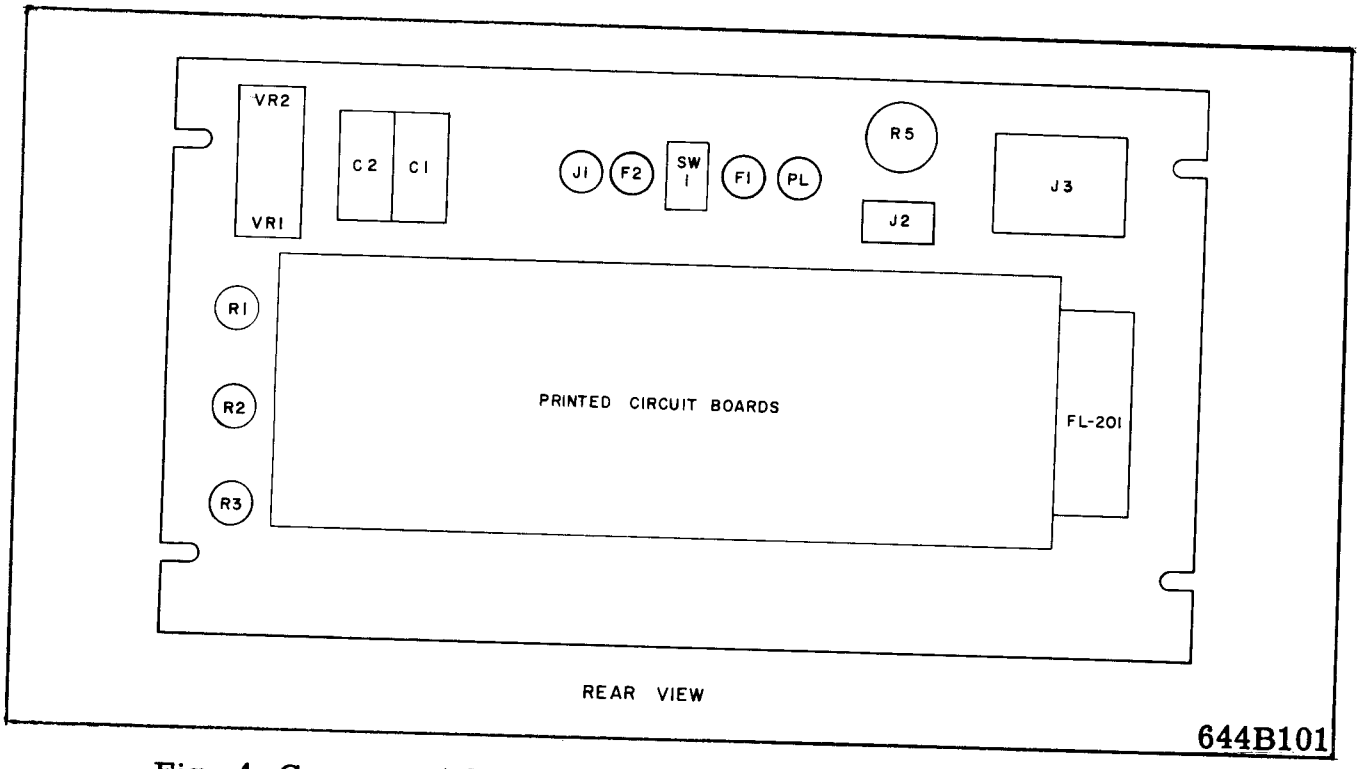


Fig. 4 Component Locations on the Type TCF Receiver Panel.

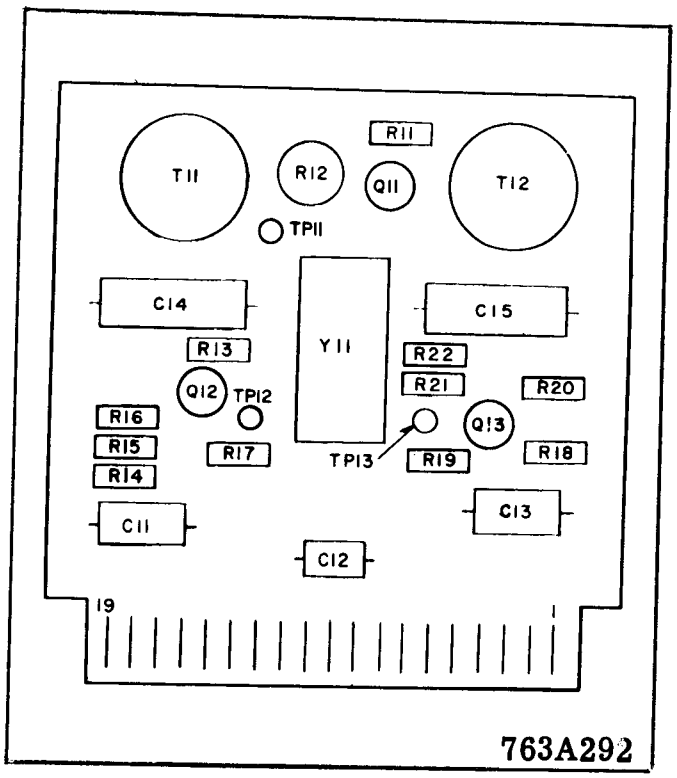


Fig. 5 Component Locations on Oscillator and Mixer Printed Circuit Board.

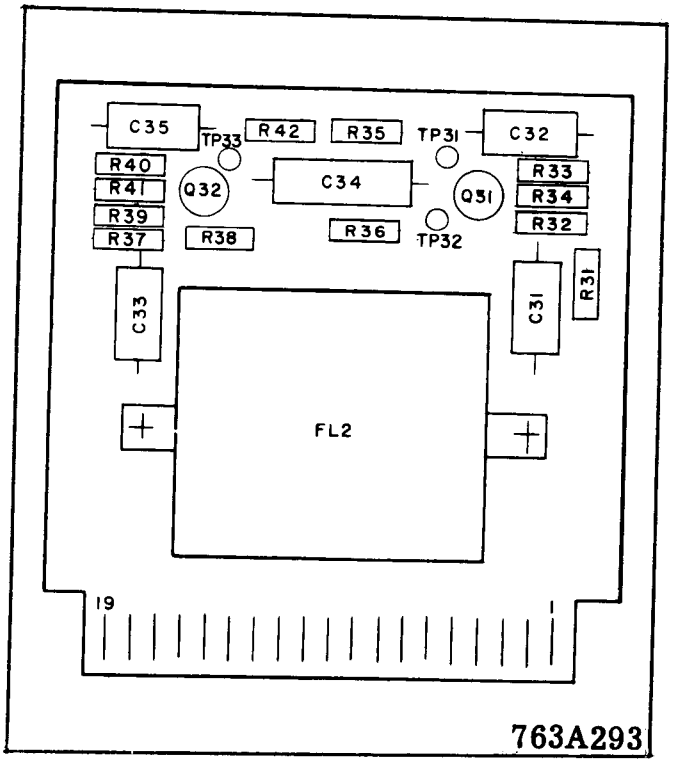


Fig. 6 Component Locations on I-F Amplifier Printed Circuit Board.

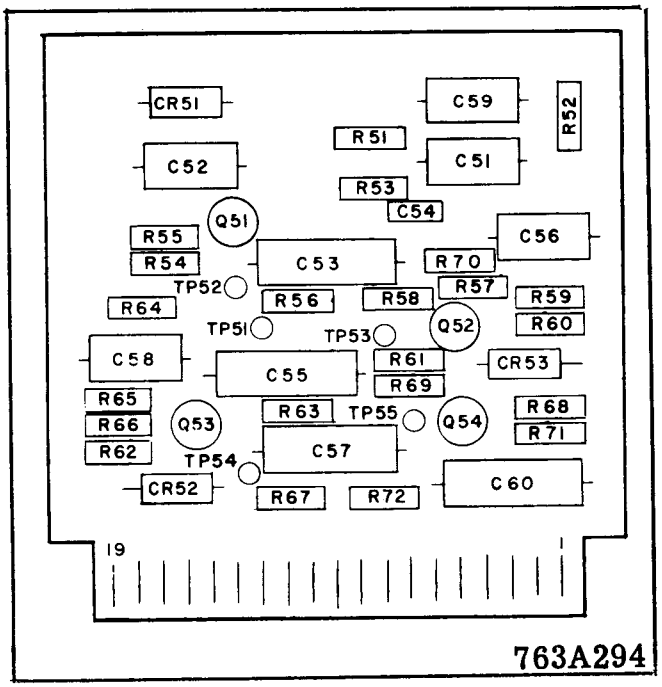


Fig. 7 Component Locations on Amplifier and Limiter Printed Circuit Board.

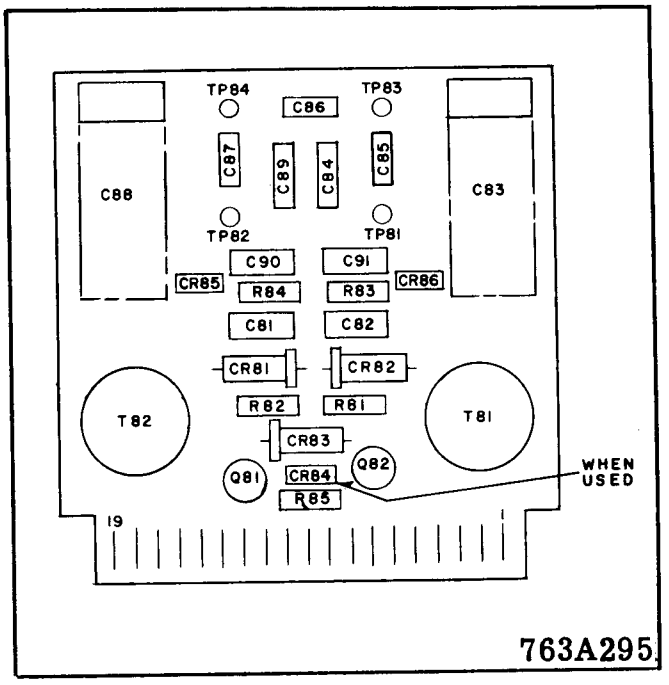


Fig. 8 Component Locations on Discriminator Printed Circuit Board.

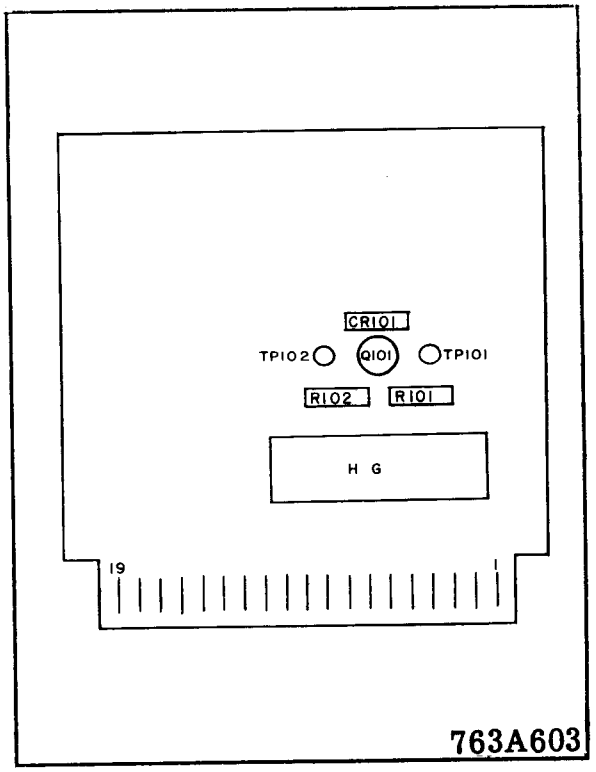
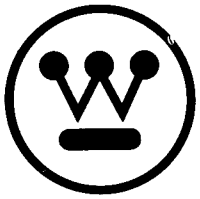


Fig. 9 Component Locations on Output Printed Circuit Board.



WESTINGHOUSE ELECTRIC CORPORATION

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

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWERLINE CARRIER RECEIVER EQUIPMENT FOR MULTI-STATION SUPERVISORY CONTROL

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

In multi-station supervisory control operation, a common channel and a common set of equipment at the master station are used for two or more remote stations, whereas in single-station operation a separate channel and separate set of equipment are used at the master station for each remote station.

The TCF power line carrier receiver is a wide band frequency shift receiver used in an ON-OFF mode for multi-station supervisory control systems. A receiver designed for frequency-shift operation used in an ON-OFF mode will provide better noise rejection than a receiver designed with AM demodulation. The TCF receiver described should then be considered where high line attenuation results in a low signal-to-noise ratio.

The range of channel frequencies for which the TCF receiver can be supplied is 30 to 300 kHz in 0.5 kHz steps. The transmitter signal is 100 hertz below the channel center frequency, corresponding to the Trip frequency used for frequency shift transfer-trip relaying applications. Reception of this signal causes operation of a mercury-wetted contact relay in the TCF receiver.

CONSTRUCTION

The TCF receiver unit for multi-station supervisory control 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 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

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or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 VDC 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 DC supply and the 45 volt zener adapt the receiver for operation on 48, 125 or 250 VDC.

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.

Input Filter

From the attenuator, the signal passes through the input filter, FL-201, which has a selectivity characteristic as shown in Fig. 2. The input filter rejects undesired signals while accepting a wide enough band of frequencies to assure fast operation. A 1/1 ratio toroidal-core transformer mounted externally on the filter isolates the filter output from ground.

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 oscilator 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 20 kHz, 2fc + 20 kHz, fc and fc + 20 kHz. The fc + 20 kHz frequency predominates, but there is appreciable attenuation of the higher frequencies in passing through transformer T12.

I-F 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 20 kHz, and it eliminates the frequencies present at its input that are substantially higher than 20 kHz.

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 the same as that used in the two-frequency TCF receivers, although in this application the input to the receiver is either zero or Trip frequency. As is shown in Fig. 2, the discriminator will have output only at or near Trip frequency, and this characteristic greatly increases the frequency selectivity of the receiver.

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. 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

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 20 kHz – 100 hertz. Similarly, the lower signal frequency is converted to 20 kHz + 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. In this application, of course, no connection is made to terminal 15.

Output Circuit Board

Terminal 11 of the discriminator circuit board is connected to terminal 8 of the output circuit board. Transistor Q101 amplifies the input received from the discriminator when the receiver has Trip input, and energizes relay HG. The contacts of this relay are the mercury-wetted type, which assures bounceless operation. Diode CR101 is connected across the coil of relay HG so that a high voltage will not be induced across the coil terminals when it is de-energized, as this might damage transistor Q101.

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 de-energized. 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.

Power Supply

The regulated 20 VDC and 45 VDC 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 VDC battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the DC circuits are energized. Capacitors C1 and C2 bypass r-f- or transient voltages to ground.

CHARACTERISTICS

Frequency range	30 - 300 kHz
Sensitivity (on-off operation)	0.044 volt (55 db below 10 watts for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (input filter)	down <3 db at ±850 hertz down >28 db at ±2000 hertz
Bandwidth (i-f filter)	down <3 db at ±250 hertz down >36 db at ±1000 hertz
Discriminator	Set for zero output at channel center frequency and for max. outputs at 100 hertz above and below center frequency. (See Fig. 2)
Operating Time	7 ms channel (transm. and recvr.)
*Frequency spacing	1.5 kHz Adjacent receiver
	3 kHz Adjacent transmitter
Ambient temperature range	-20°C to +60°C temperature around chassis.
Battery voltage variations	
Rated Voltage	Allowable variation
48 VDC	42 – 56 VDC
125 VDC	105 – 140 VDC
250 VDC	210 – 280 VDC
Battery drain	0.20 a. at 48 VDC 0.27 a. at 125 or 250 VDC
Dimensions	Panel height – 10½" or 6 r.u. Panel width – 19"
Weight	13 lbs.
*Max. Keying Rate	40 pulses per sec.

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 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 output 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 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 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 44 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 44 mv. signal taken from an oscillator set at the center frequency of the channel. (R5 at zero.) Connect a 1.5-0-1.5 milliameter 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 milliameter 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 T5. 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 rereceiver 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 de-

scribed under "CONSTRUCTION," any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 622B315G01. 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 40 db from 10 watts. Unless otherwise indicated, voltage will not vary appreciably whether signal is on or off.

Collector of Transistor	Volts (-)
Q11	.20
Q12	14.5 (No signal)
Q12	14.0 (Trip signal)
Q13	17.0 (No signal)
Q13	15.0 (Trip signal)
Q31	18.5
Q32	18.5
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q82 and Q101	20 (No signal)
Q82 and Q101	< 0.5 (Trip signal)

TABLE II

RECEIVER R-F 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 0.003 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: 20 kHz to 330 kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliameter 0-1.5 or preferable 1.5-0-1.5 range, for checking discriminator.

Some of the functions fo 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.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1, C2	Oil filled, 0.5 mfd, 1500 VDC	1877962
C11	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C12	Mica, capacity as required, 500 VDC	
C13	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C14, C15	Metallized paper, 1.0 mfd, 200 VDC	187A624H04
C31, C32, C33	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C34	Metallized paper, 1.0 mfd, 200 VDC	187A624H04
C35, C51, C52	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C53	Metallized paper, 0.1 mfd, 200 VDC	187A624H01
C54	Dur-Mica, 1300 pf, 500 VDC	187A584H15
C55	Metallized paper, 0.1 mfd, 200 VDC	187A624H01
C56	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C57	Metallized paper, 0.1 mfd, 200 VDC	187A624H01
C58, C59	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C60	Metallized paper, 1.0 mfd, 200 VDC	187A624H04
C81, C82	Mylar, 0.22 mfd, 50 VDC	762A703H01
C83	Variable, 4.5-100pf,	762A736H02
C84	Polystyrene, 9100 pf, 200 VDC	187A624H16
C85	Temp. compensating, 150 VDC, pf as required	
C86	100 pf, zero temp. coef.	187A684H08
C87	Temp. compensating, 150 VDC, pf as required	
C88	Variable, 4.5-100 pf,	762A736H02
C89	Polystyrene, 9100 pf, 200 VDC	187A624H16
C90, C91, C104	Mylar, 0.22 mfd, 50 VDC	762A703H01
C105	Ceramic, 0.05 mfd, 50 VDC	184A663H02
C151, C152	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C153	Metallized paper, 1.0 mfd, 200 VDC	187A624H04
C154, C155, C156, C157, C158	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
	DIODES – GENERAL PURPOSE	
CR51, CR52, CR53	1N457A, 60V, 200 MA	184A855H07
CR81, CR82, CR83	1N91, 100V, 150 MA	182A881H04
CR85, CR86	1N628, 125V, 30 MA	184A855H12
CR101	1N457A, 60V, 200 MA	184A855H07
	DIODES – ZENER	
CR1, CR2	1N3027A, 20V ± 10%, 1W	188A302H10
VR1	1N2828B, 45V ± 5%, 50W	184A854H06
VR2	1N2984B, 20V ± 5%, 10W	762A631H01

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K, 2 W	185A086H10
R12	250 ohms, 1/2 W	629A430H06
R52	1K, 1/4 W	629A645H04
	RESISTORS	
R1	400 ohms ± 5%, 25W	1202587
R2	26.5 ohms ± 5%, 40W (for 48V supply)	04D1299H44
R2	150 ohms ± 5%, 40W (for 125V supply)	1202499
R3	150 ohms ± 5%, 40W (for 125V supply)	1202499
R4	100 ohms ± 5%, 1W composition	187A643H03
R6	10K ± 5%, 1/2 W composition	187A763H51
R11	10K ± 5%, 1/2 W composition	184A763H51
R13	5.6K ± 5%, 1/2 W composition	184A763H45
R14	3.3K ± 5%, 1/2 W composition	184A763H39
R15	330 ohms ± 5%, 1/2 W composition	184A763H15
R16	10K ± 5%, 1/2 W composition	184A763H51
R17	33K ± 5%, 1/2 W composition	184A763H63
R18, R19	3.3K ± 5%, 1/2 W composition	184A763H39
R20	10K ± 5%, 1/2 W composition	184A763H51
R21	33K ± 5%, 1/2 W composition	184A763H63
R22	330 ohms ± 5%, 1/2 W composition	184A763H15
R31	3.3K ± 5%, 1/2 W composition	184A763H39
R32	22K ± 5%, 1/2 W composition	184A763H59
R33	680 ohms ± 5%, 1/2 W composition	184A763H23
R34	68 ohms ± 5%, 1/2 W composition	187A290H21
R35	10K ± 5%, 1/2 W composition	184A763H51
R36	330 ohms ± 5%, 1/2 W composition	184A763H15
R37	3.3K ± 5%, 1/2 W composition	184A763H39
R38	1000 ohms ± 5%, 1/2 W composition	184A763H27
R39	22K ± 5%, 1/2 W composition	184A763H59
R40	680 ohms ± 5%, 1/2 W composition	184A763H23
R41	68 ohms ± 5%, 1/2 W composition	187A290H21
R42	10K ± 5%, 1/2 W composition	184A763H51
R51	4.7K ± 5%, 1/2 W composition	184A763H43
R53	27K ± 5%, 1/2 W composition	184A763H61
R54	2.2K ± 5%, 1/2 W composition	184A763H35
R55	27 ohms ± 5%, 1/2 W composition	187A290H11
R56	10K ± 5%, 1/2 W composition	184A763H51
R57	4.7K ± 5%, 1/2 W composition	184A763H43
R58	27K ± 5%, 1/2 W composition	184A763H61
R59	1.5K ± 5%, 1/2 W composition	184A763H31

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Continued)	
R60	180 ohms ± 5%, 1/2 W composition	184A763H09
R61	4.7K ± 5%, 1/2 W composition	184A763H43
R62	1.5K ± 5%, 1/2 W composition	184A763H31
R63	33K ± 5%, 1/2 W composition	184A763H63
R64	2.7K ± 5%, 1/2 W composition	184A763H37
R65	680 ohms ± 5%, 1/2 W composition	184A763H23
R66	68 ohms ± 5%, 1/2 W composition	187A290H21
R67	4.7K ± 5%, 1/2 W composition	184A763H43
R68	2.7K ± 5%, 1/2 W composition	184A763H37
R69	18K ± 5%, 1/2 W composition	184A763H57
R70	220 ohms ± 5%, 1/2 W composition	184A763H11
R71	270 ohms ± 5%, 1/2 W composition	184A763H13
R72	330 ohms ± 5%, 1/2 W composition	184A763H15
R81, R82	4.7K ± 5%, 1/2 W composition	184A763H43
R83, R84	2.7K ± 5%, 1/2W composition	184A763H35
R85	6.8K ± 5%, 1/2 W composition	184A763H47
R101	18K + 5%, 1/2 W composition	184A763H57
R102	10K ± 5%, 1/2 W composition	184A763H51
	TRANSFORMERS	
T11	Toroidal type, 10,000/400 ohms	1962797 (30-200 kHz) 714B666G01 (200-300 kHz)
T12	Toroidal type, 25,000/300 ohms	1962697
T81	Pot. core type	606B533G01
T82	Pot. core type	606B533G02
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12, Q13, Q31, Q32	2N274	187A270H01
Q51, Q52, Q53, Q54	2N396	762A585H03
Q81, Q82	2N652A	184A638H16
Q101	2N699	184A638H18
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20KC above Channel Freq.	762A800H01 + Required Freq.
FL-201	Input Filter	670B258 + Required Freq.
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb - for 48V supply	187A133H02
PL	Pilot Light Bulb - for 250V supply	183A955H01
F1, F2	Fuse, 1.5A	11D9195H26
HG	Output Relay (Mercury-Wetted Contact)	188A573H04

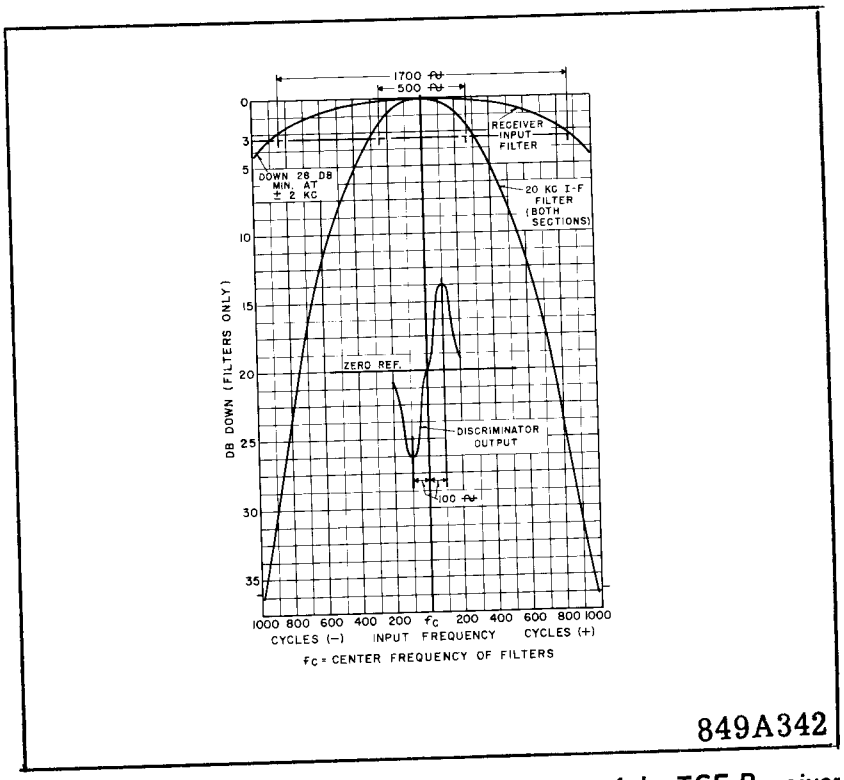


Fig. 2. Filter and Discriminator Characteristics of the TCF Receiver

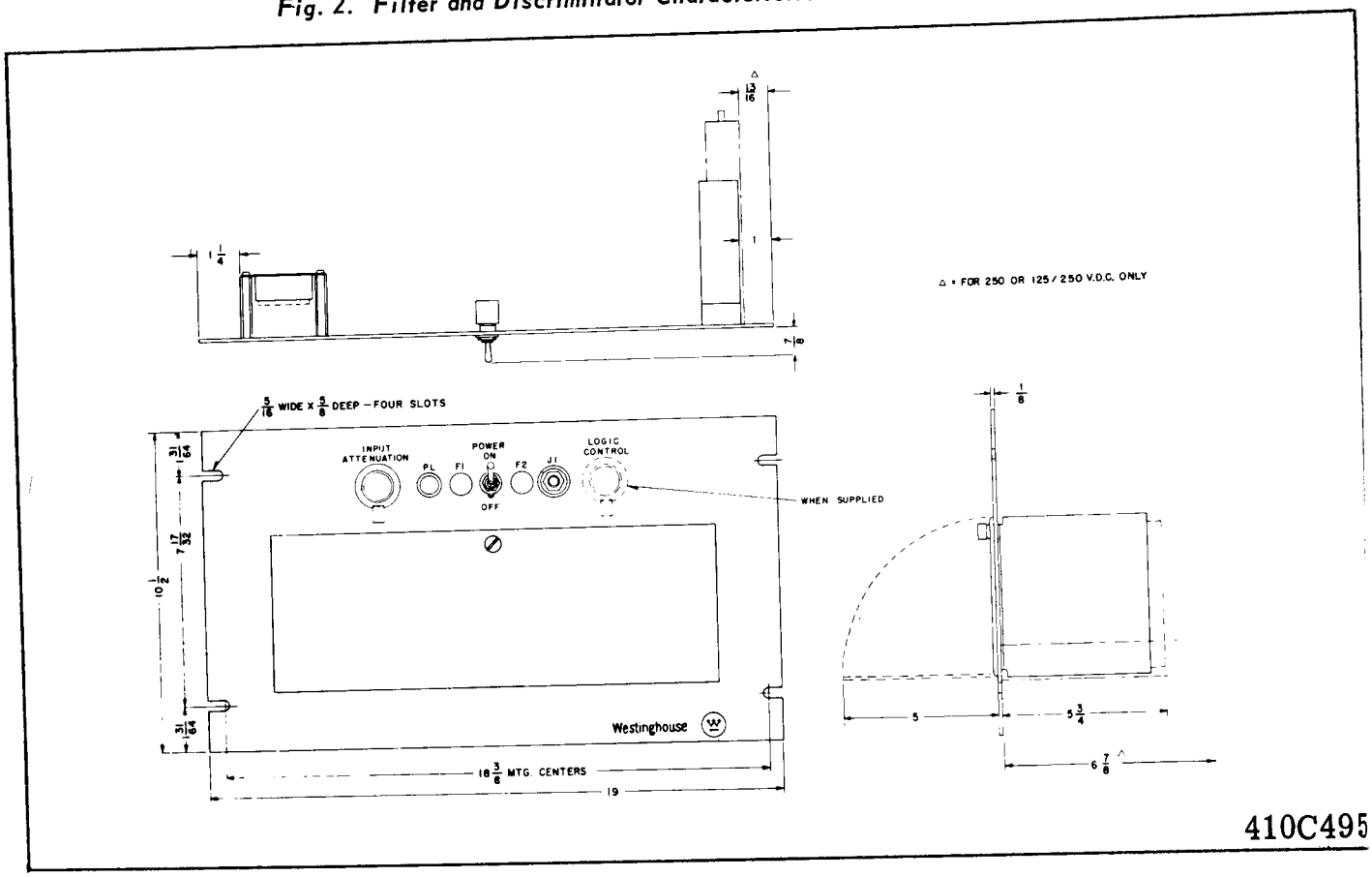


Fig. 3. Outline of the Type TCF Receiver Assembly.

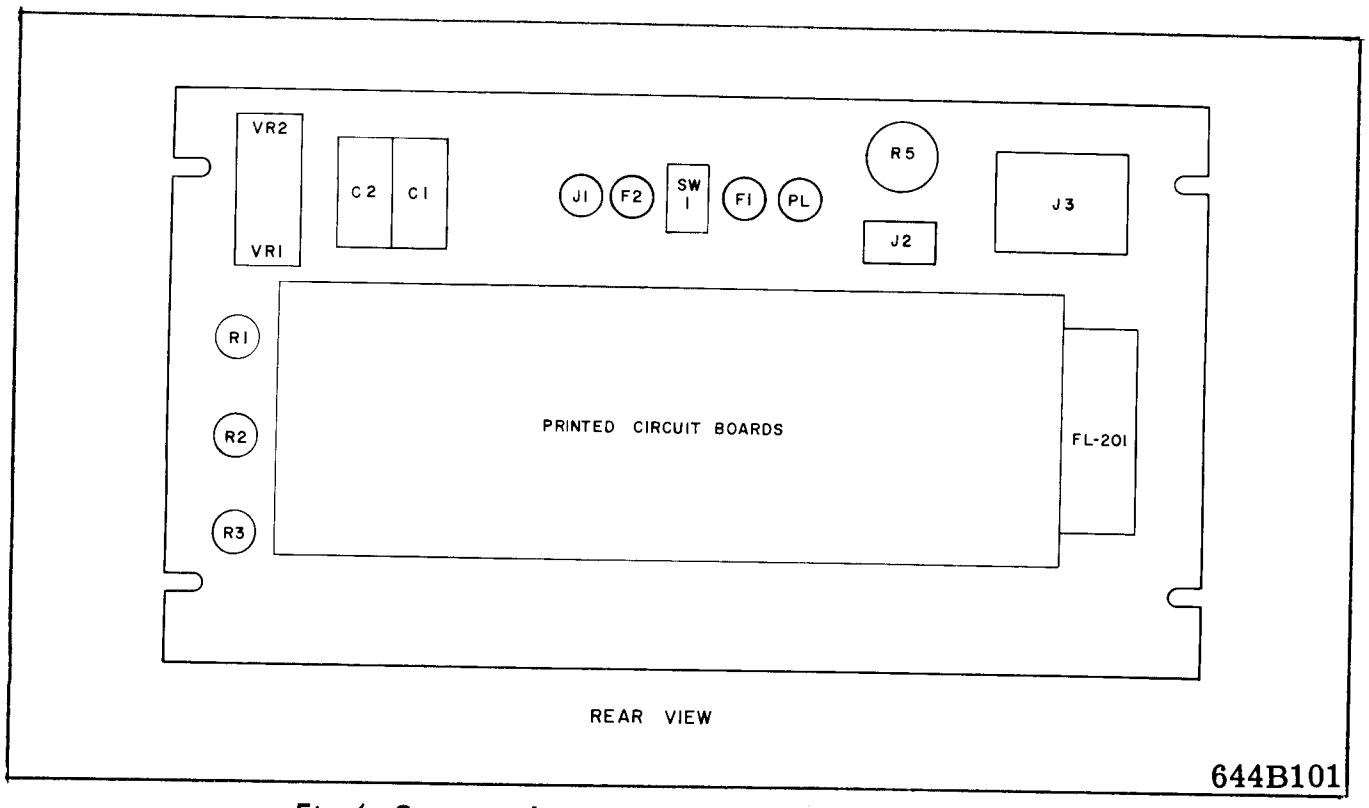


Fig. 4. Component Locations on the Type TCF Receiver Pane.

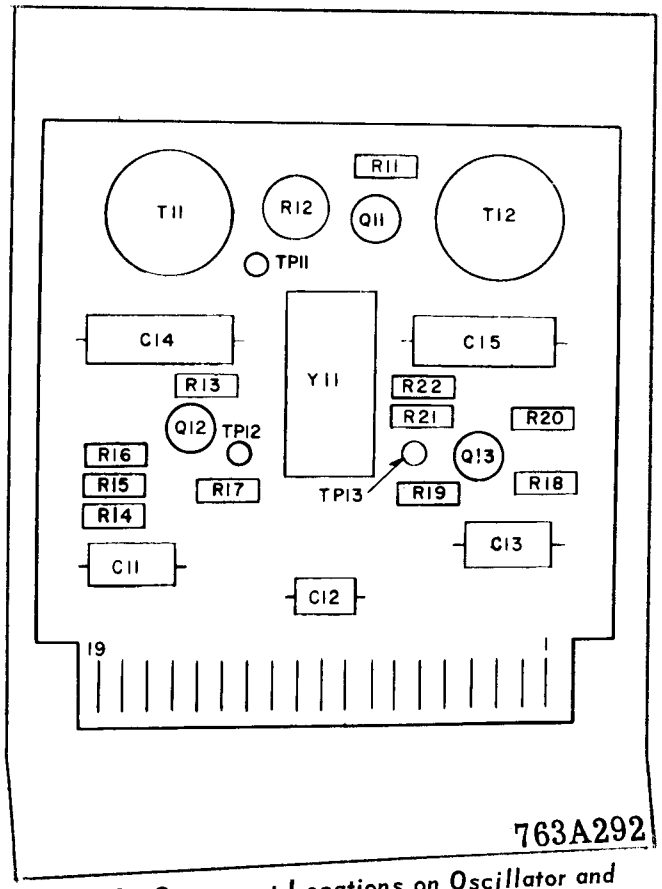


Fig. 5. Component Locations on Oscillator and Mixer Printed Circuit Board.

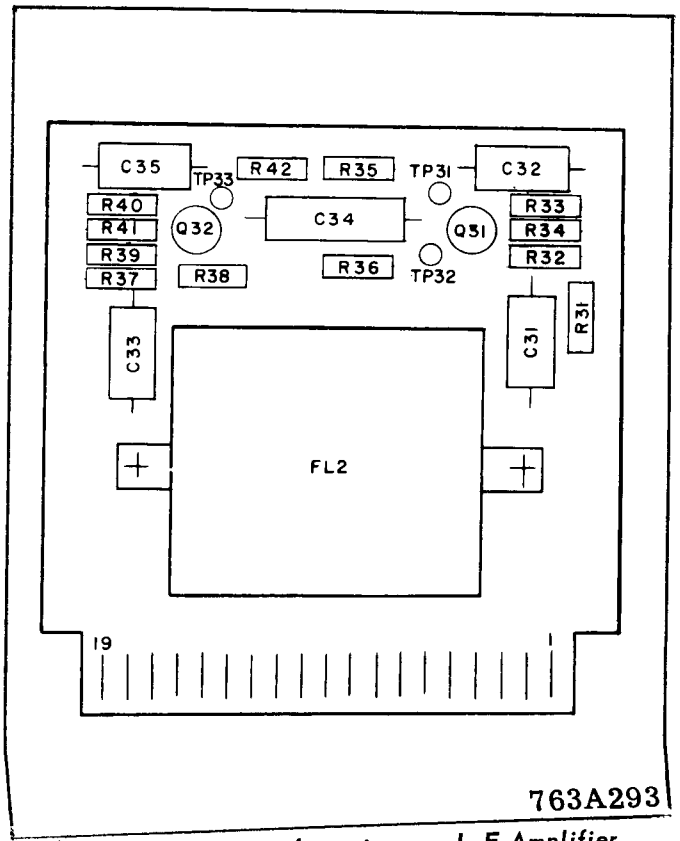


Fig. 6. Component Locations on I-F Amplifier Printed Circuit Board.

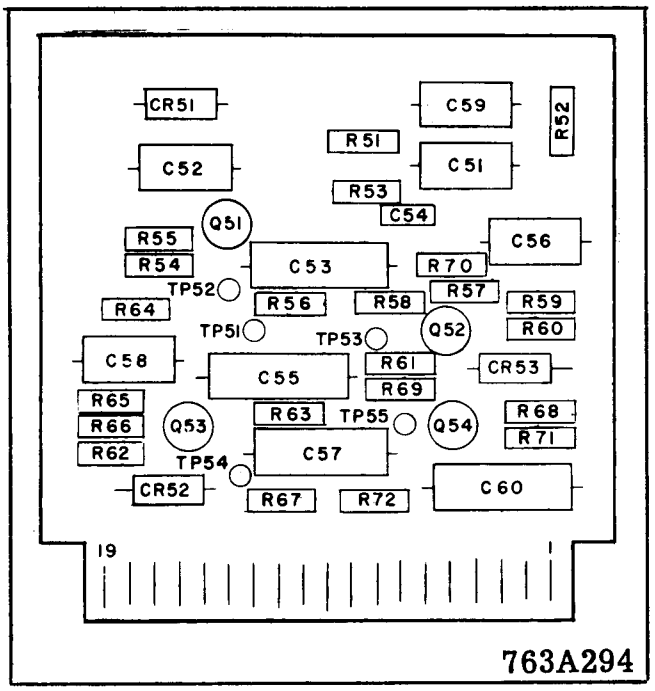


Fig. 7. Component Locations on Amplifier and Limiter Printed Circuit Board

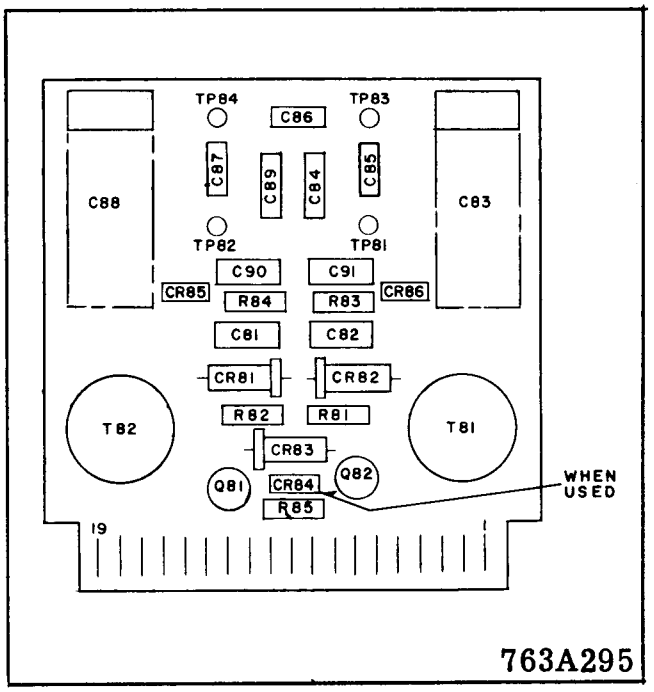


Fig. 8. Component Locations on Discriminator Printed Circuit Board.

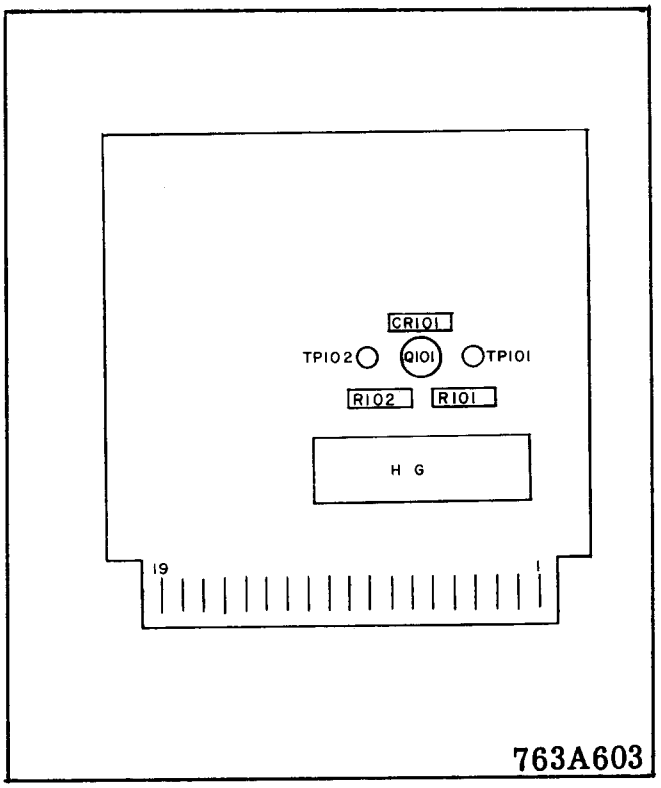
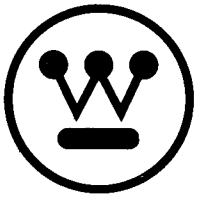


Fig. 9. Component Locations on Output Printed Circuit Board



WESTINGHOUSE ELECTRIC CORPORATION

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

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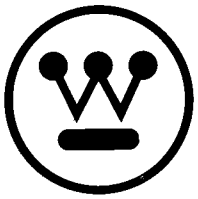

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION

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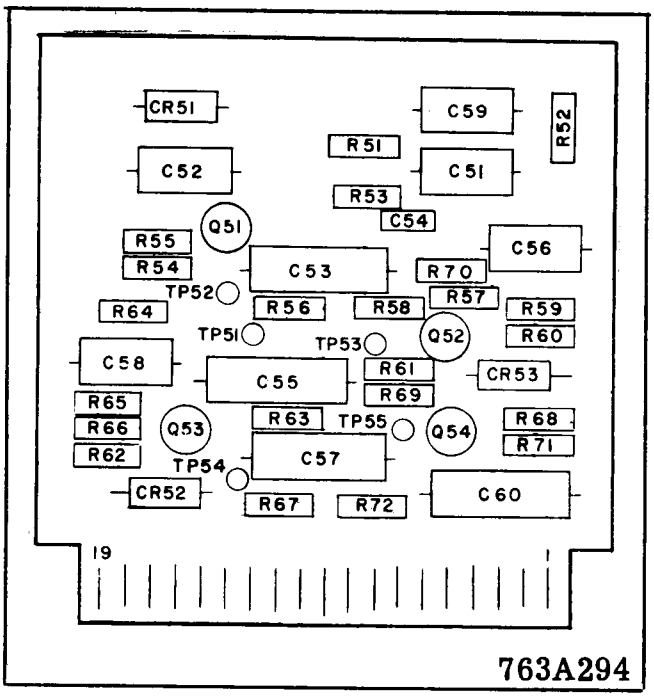

Fig. 7. Component Locations on Amplifier and Limiter Printed Circuit Board

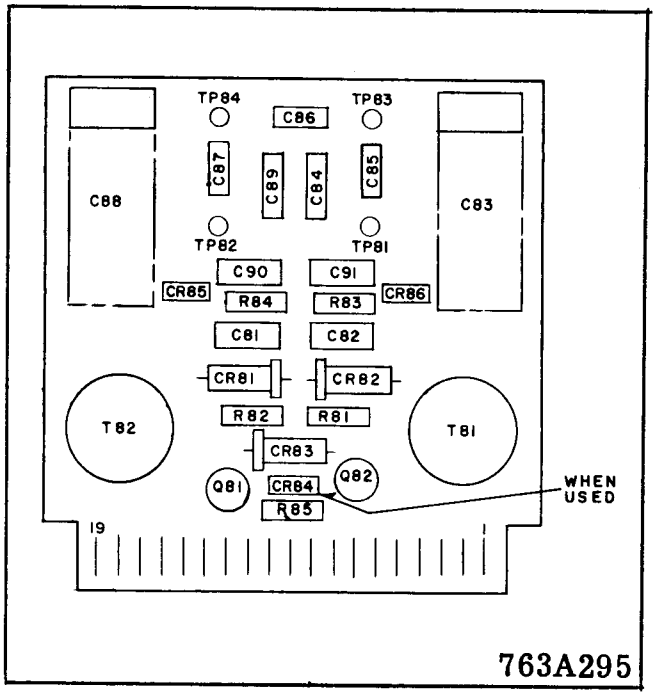

Fig. 8. Component Locations on Discriminator Printed Circuit Board.

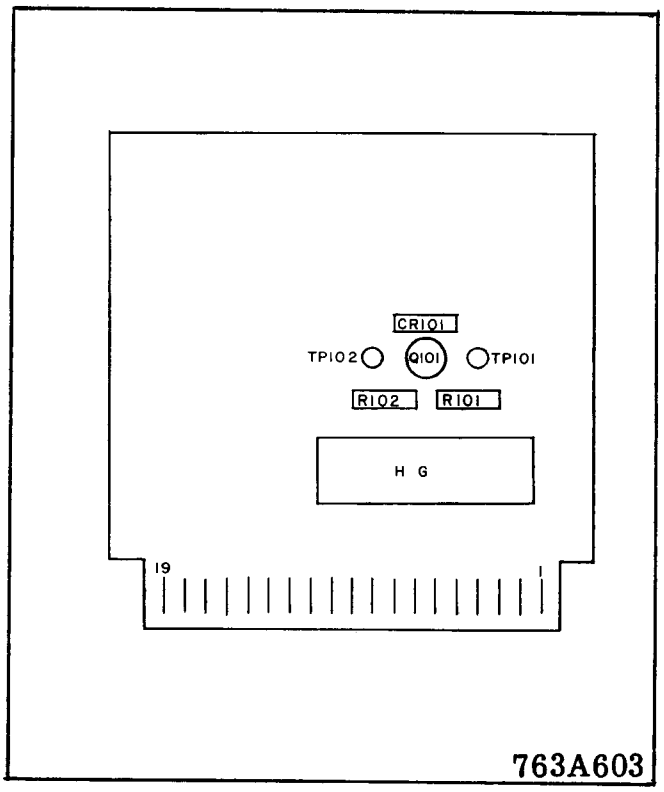

Fig. 9. Component Locations on Output Printed Circuit Board

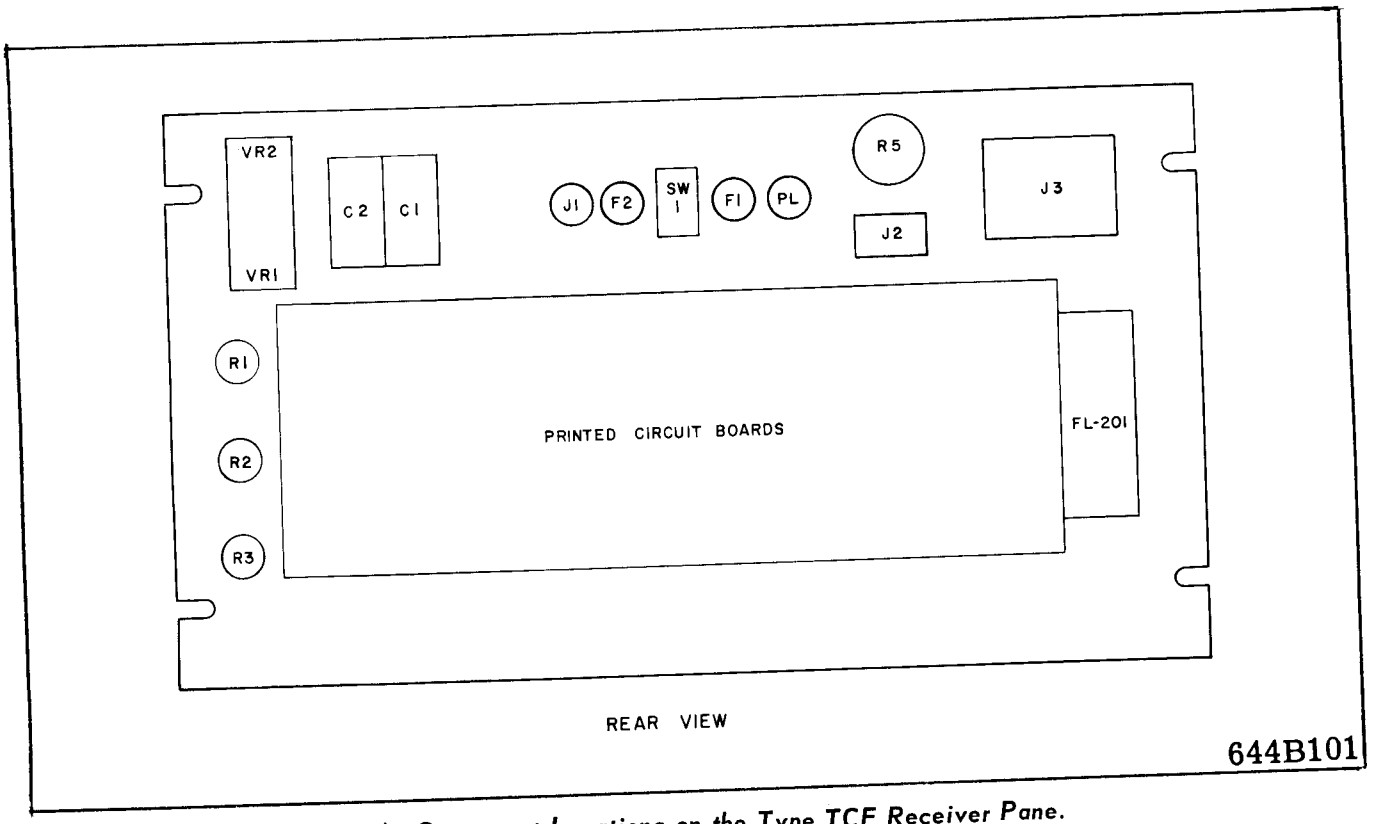

Fig. 4. Component Locations on the Type TCF Receiver Pane.

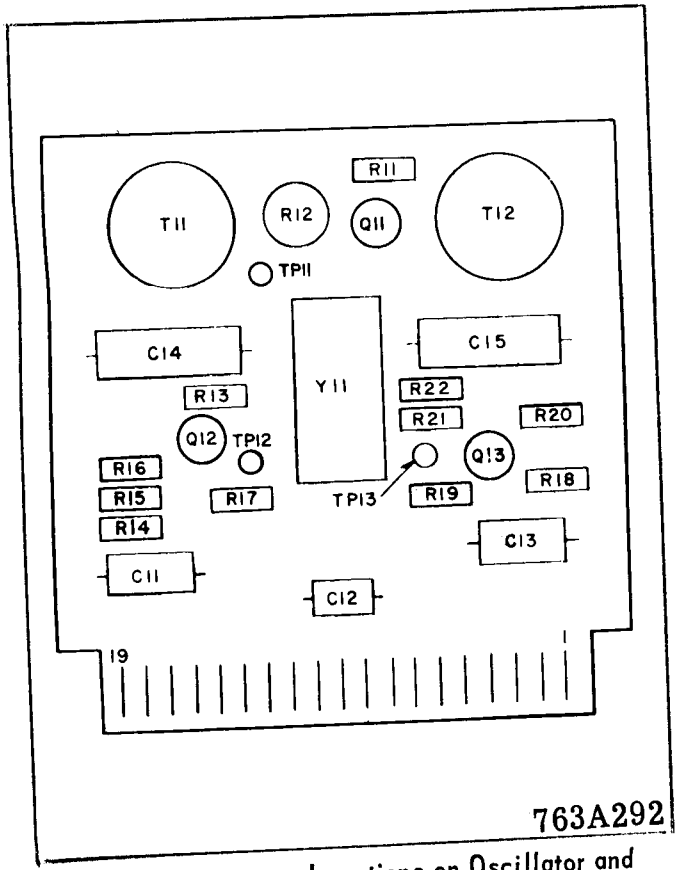

Fig. 5. Component Locations on Oscillator and Mixer Printed Circuit Board.

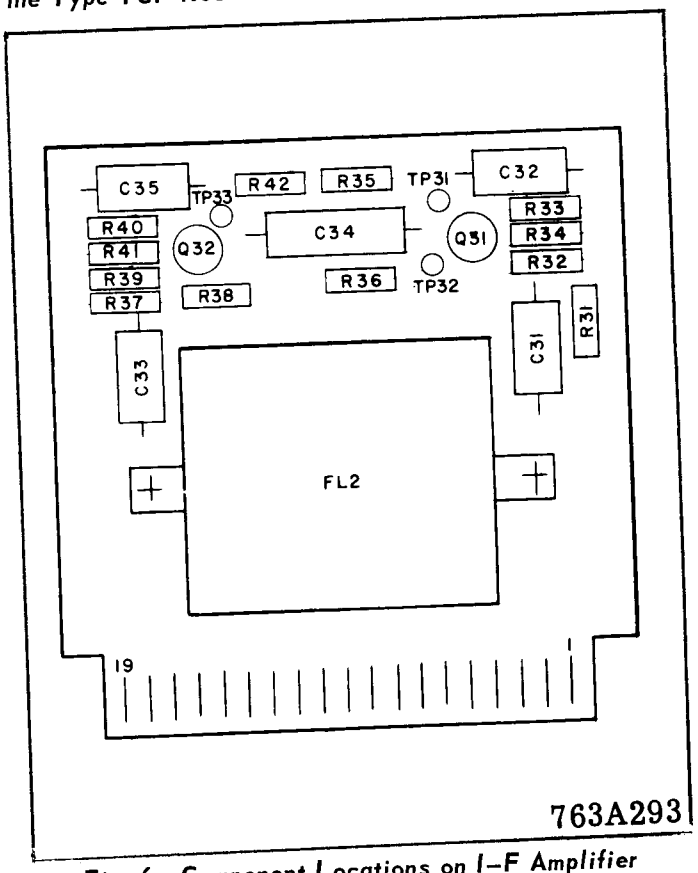

Fig. 6. Component Locations on I-F Amplifier Printed Circuit Board.

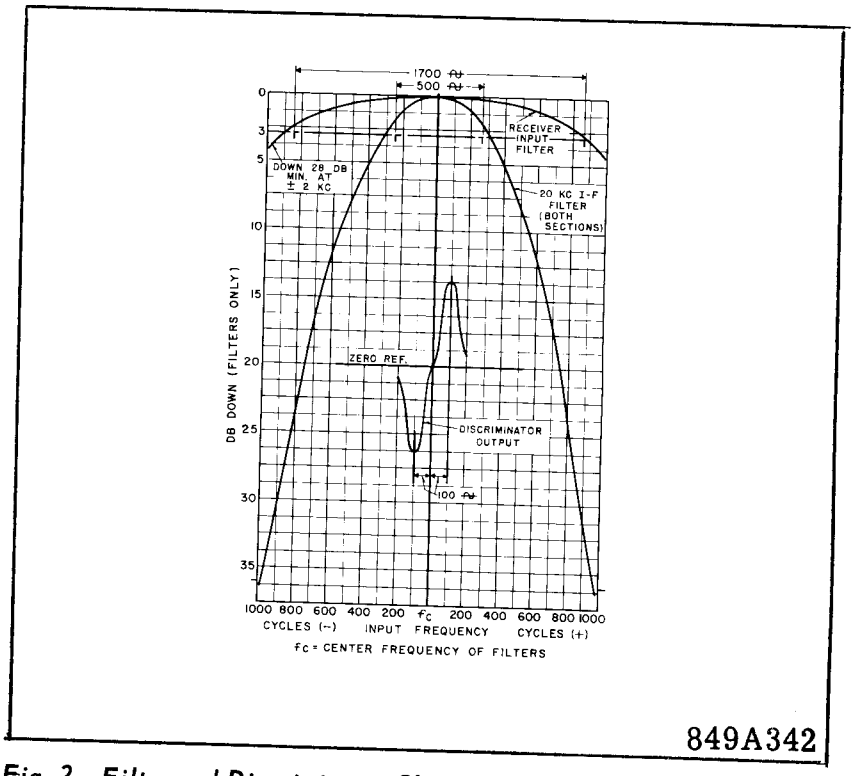

Fig. 2. Filter and Discriminator Characteristics of the TCF Receiver

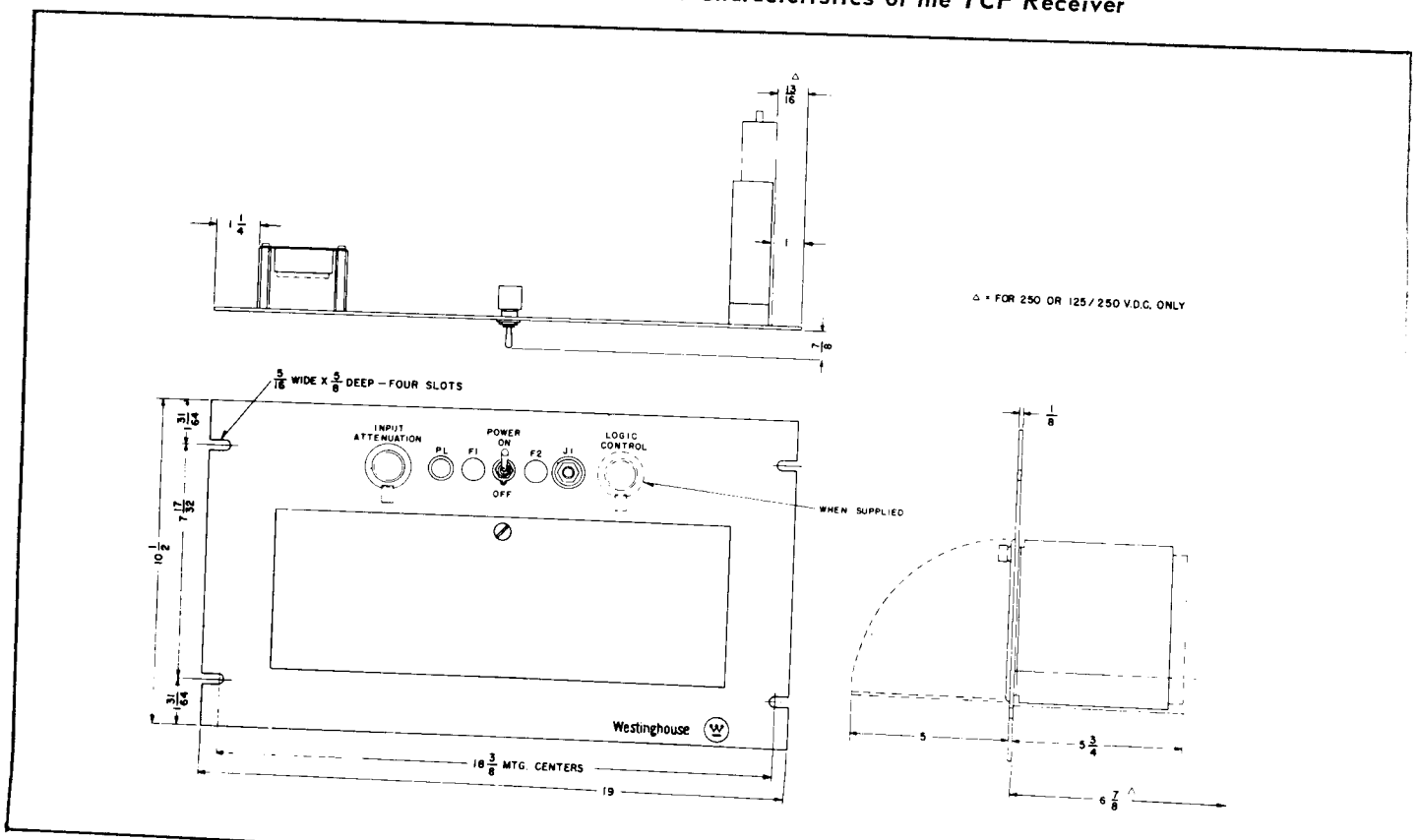

Fig. 3. Outline of the Type TCF Receiver Assembly.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Continued)	
R60	180 ohms ± 5%, 1/2 W composition	184A763H09
R61	4.7K ± 5%, 1/2 W composition	184A763H43
R62	1.5K ± 5%, 1/2 W composition	184A763H31
R63	33K ± 5%, 1/2 W composition	184A763H63
R64	2.7K ± 5%, 1/2 W composition	184A763H37
R65	680 ohms ± 5%, 1/2 W composition	184A763H23
R66	68 ohms ± 5%, 1/2 W composition	187A290H21
R67	4.7K ± 5%, 1/2 W composition	184A763H43
R68	2.7K ± 5%, 1/2 W composition	184A763H37
R69	18K ± 5%, 1/2 W composition	184A763H57
R70	220 ohms ± 5%, 1/2 W composition	184A763H11
R71	270 ohms ± 5%, 1/2 W composition	184A763H13
R72	330 ohms ± 5%, 1/2 W composition	184A763H15
R81, R82	4.7K ± 5%, 1/2 W composition	184A763H43
R83, R84	2.7K ± 5%, 1/2W composition	184A763H35
R85	6.8K ± 5%, 1/2 W composition	184A763H47
R101	18K + 5%, 1/2 W composition	184A763H57
R102	10K ± 5%, 1/2 W composition	184A763H51
	TRANSFORMERS	
T11	Toroidal type, 10,000/400 ohms	1962797 (30-200 kHz) 714B666G01 (200-300 kHz)
T12	Toroidal type, 25,000/300 ohms	1962697
T81	Pot. core type	606B533G01
T82	Pot. core type	606B533G02
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12, Q13, Q31, Q32	2N274	187A270H01
Q51, Q52, Q53, Q54	2N396	762A585H03
Q81, Q82	2N652A	184A638H16
Q101	2N699	184A638H18
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20KC above Channel Freq.)	762A800H01 + Required Freq.
FL-201	Input Filter	670B258 + Required Freq.
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb - for 48V supply	187A133H02
PL	Pilot Light Bulb - for 250V supply	183A955H01
F1, F2	Fuse, 1.5A	11D9195H26
HG	Output Relay (Mercury-Wetted Contact)	188A573H04

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	POTENTIOMETERS	
R5	10K, 2 W	185A086H10
R12	250 ohms, 1/2 W	629A430H06
R52	1K, 1/4 W	629A645H04
	RESISTORS	
R1	400 ohms ± 5%, 25W	1202587
R2	26.5 ohms ± 5%, 40W (for 48V supply)	04D1299H44
R2	150 ohms ± 5%, 40W (for 125V supply)	1202499
R3	150 ohms ± 5%, 40W (for 125V supply)	1202499
R4	100 ohms ± 5%, 1W composition	187A643H03
R6	10K ± 5%, 1/2 W composition	187A763H51
R11	10K ± 5%, 1/2 W composition	184A763H51
R13	5.6K ± 5%, 1/2 W composition	184A763H45
R14	3.3K ± 5%, 1/2 W composition	184A763H39
R15	330 ohms ± 5%, 1/2 W composition	184A763H15
R16	10K ± 5%, 1/2 W composition	184A763H51
R17	33K ± 5%, 1/2 W composition	184A763H63
R18, R19	3.3K ± 5%, 1/2 W composition	184A763H39
R20	10K ± 5%, 1/2 W composition	184A763H51
R21	33K ± 5%, 1/2 W composition	184A763H63
R22	330 ohms ± 5%, 1/2 W composition	184A763H15
R31	3.3K ± 5%, 1/2 W composition	184A763H39
R32	22K ± 5%, 1/2 W composition	184A763H59
R33	680 ohms ± 5%, 1/2 W composition	184A763H23
R34	68 ohms ± 5%, 1/2 W composition	187A290H21
R35	10K ± 5%, 1/2 W composition	184A763H51
R36	330 ohms ± 5%, 1/2 W composition	184A763H15
R37	3.3K ± 5%, 1/2 W composition	184A763H39
R38	1000 ohms ± 5%, 1/2 W composition	184A763H27
R39	22K ± 5%, 1/2 W composition	184A763H59
R40	680 ohms ± 5%, 1/2 W composition	184A763H23
R41	68 ohms ± 5%, 1/2 W composition	187A290H21
R42	10K ± 5%, 1/2 W composition	184A763H51
R51	4.7K ± 5%, 1/2 W composition	184A763H43
R53	27K ± 5%, 1/2 W composition	184A763H61
R54	2.2K ± 5%, 1/2 W composition	184A763H35
R55	27 ohms ± 5%, 1/2 W composition	187A290H11
R56	10K ± 5%, 1/2 W composition	184A763H51
R57	4.7K ± 5%, 1/2 W composition	184A763H43
R58	27K ± 5%, 1/2 W composition	184A763H61
R59	1.5K ± 5%, 1/2 W composition	184A763H31

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1, C2	Oil filled, 0.5 mfd, 1500 VDC	1877962
C11	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C12	Mica, capacity as required, 500 VDC	
C13	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C14, C15	Metallized paper, 1.0 mfd, 200 VDC	187A624H04
C31, C32, C33	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C34	Metallized paper, 1.0 mfd, 200 VDC	187A624H04
C35, C51, C52	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C53	Metallized paper, 0.1 mfd, 200 VDC	187A624H01
C54	Dur-Mica, 1300 pf, 500 VDC	187A584H15
C55	Metallized paper, 0.1 mfd, 200 VDC	187A624H01
C56	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C57	Metallized paper, 0.1 mfd, 200 VDC	187A624H01
C58, C59	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C60	Metallized paper, 1.0 mfd, 200 VDC	187A624H04
C81, C82	Mylar, 0.22 mfd, 50 VDC	762A703H01
C83	Variable, 4.5-100pf,	762A736H02
C84	Polystyrene, 9100 pf, 200 VDC	187A624H16
C85	Temp. compensating, 150 VDC, pf as required	
C86	100 pf, zero temp. coef.	187A684H08
C87	Temp. compensating, 150 VDC, pf as required	
C88	Variable, 4.5-100 pf,	762A736H02
C89	Polystyrene, 9100 pf, 200 VDC	187A624H16
C90, C91, C104	Mylar, 0.22 mfd, 50 VDC	762A703H01
C105	Ceramic, 0.05 mfd, 50 VDC	184A663H02
C151, C152	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
C153	Metallized paper, 1.0 mfd, 200 VDC	187A624H04
C154, C155, C156, C157, C158	Metallized paper, 0.25 mfd, 200 VDC	187A624H02
	DIODES – GENERAL PURPOSE	
CR51, CR52, CR53	1N457A, 60V, 200 MA	184A855H07
CR81, CR82, CR83	1N91, 100V, 150 MA	182A881H04
CR85, CR86	1N628, 125V, 30 MA	184A855H12
CR101	1N457A, 60V, 200 MA	184A855H07
	DIODES – ZENER	
CR1, CR2	1N3027A, 20V ± 10%, 1W	188A302H10
VR1	1N2828B, 45V ± 5%, 50W	184A854H06
VR2	1N2984B, 20V ± 5%, 10W	762A631H01

scribed under "CONSTRUCTION," any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 622B315G01. 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 40 db from 10 watts. Unless otherwise indicated, voltage will not vary appreciably whether signal is on or off.

Collector of Transistor	Volts (-)
Q11	.20
Q12	14.5 (No signal)
Q12	14.0 (Trip signal)
Q13	17.0 (No signal)
Q13	15.0 (Trip signal)
Q31	18.5
Q32	18.5
Q51	8.4
Q52	13.5
Q53	4.4
Q54	18
Q82 and Q101	20 (No signal)
Q82 and Q101	< 0.5 (Trip signal)

TABLE II

RECEIVER R-F 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 0.003 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: 20 kHz to 330 kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliameter 0-1.5 or preferable 1.5-0-1.5 range, for checking discriminator.

Some of the functions fo 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.

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 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 output 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 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 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 44 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 44 mv. signal taken from an oscillator set at the center frequency of the channel. (R5 at zero.) Connect a 1.5-0-1.5 milliameter 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 milliameter 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 T5. 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 rereceiver 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 de-

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 20 kHz – 100 hertz. Similarly, the lower signal frequency is converted to 20 kHz + 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. In this application, of course, no connection is made to terminal 15.

Output Circuit Board

Terminal 11 of the discriminator circuit board is connected to terminal 8 of the output circuit board. Transistor Q101 amplifies the input received from the discriminator when the receiver has Trip input, and energizes relay HG. The contacts of this relay are the mercury-wetted type, which assures bounceless operation. Diode CR101 is connected across the coil of relay HG so that a high voltage will not be induced across the coil terminals when it is de-energized, as this might damage transistor Q101.

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 de-energized. 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.

Power Supply

The regulated 20 VDC and 45 VDC 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 VDC battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the DC circuits are energized. Capacitors C1 and C2 bypass r-f or transient voltages to ground.

CHARACTERISTICS

Frequency range	30 - 300 kHz
Sensitivity (on-off operation)	0.044 volt (55 db below 10 watts for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (input filter)	down <3 db at ±850 hertz down >28 db at ±2000 hertz
Bandwidth (i-f filter)	down <3 db at ±250 hertz down >36 db at ±1000 hertz
Discriminator	Set for zero output at channel center frequency and for max. outputs at 100 hertz above and below center frequency. (See Fig. 2)
Operating Time	7 ms channel (transm. and recvr.)
*Frequency spacing	1.5 kHz Adjacent receiver
	3 kHz Adjacent transmitter
Ambient temperature range	–20°C to +60°C temperature around chassis.
Battery voltage variations	
Rated Voltage	Allowable variation
48 VDC	42 – 56 VDC
125 VDC	105 – 140 VDC
250 VDC	210 – 280 VDC
Battery drain	0.20 a. at 48 VDC 0.27 a. at 125 or 250 VDC
Dimensions	Panel height – 10½" or 6 r.u. Panel width – 19"
Weight	13 lbs.
*Max. Keying Rate	40 pulses per sec.

or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 VDC 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 DC supply and the 45 volt zener adapt the receiver for operation on 48, 125 or 250 VDC.

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.

Input Filter

From the attenuator, the signal passes through the input filter, FL-201, which has a selectivity characteristic as shown in Fig. 2. The input filter rejects undesired signals while accepting a wide enough band of frequencies to assure fast operation. A 1/1 ratio toroidal-core transformer mounted externally on the filter isolates the filter output from ground.

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 oscilator 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 20 kHz, 2fc + 20 kHz, fc and fc + 20 kHz. The fc + 20 kHz frequency predominates, but there is appreciable attenuation of the higher frequencies in passing through transformer T12.

I-F 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 20 kHz, and it eliminates the frequencies present at its input that are substantially higher than 20 kHz.

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 the same as that used in the two-frequency TCF receivers, although in this application the input to the receiver is either zero or Trip frequency. As is shown in Fig. 2, the discriminator will have output only at or near Trip frequency, and this characteristic greatly increases the frequency selectivity of the receiver.

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. 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

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWERLINE CARRIER RECEIVER EQUIPMENT FOR MULTI-STATION SUPERVISORY CONTROL

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

In multi-station supervisory control operation, a common channel and a common set of equipment at the master station are used for two or more remote stations, whereas in single-station operation a separate channel and separate set of equipment are used at the master station for each remote station.

The TCF power line carrier receiver is a wide band frequency shift receiver used in an ON-OFF mode for multi-station supervisory control systems. A receiver designed for frequency-shift operation used in an ON-OFF mode will provide better noise rejection than a receiver designed with AM demodulation. The TCF receiver described should then be considered where high line attenuation results in a low signal-to-noise ratio.

The range of channel frequencies for which the TCF receiver can be supplied is 30 to 300 kHz in 0.5 kHz steps. The transmitter signal is 100 hertz below the channel center frequency, corresponding to the Trip frequency used for frequency shift transfer-trip relaying applications. Reception of this signal causes operation of a mercury-wetted contact relay in the TCF receiver.

CONSTRUCTION

The TCF receiver unit for multi-station supervisory control 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 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

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