INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF-10 POWER LINE CARRIER FREQUENCY SHIFT RECEIVER EQUIPMENT FOR DUAL PHASE COMPARISON CARRIER RELAYING (SPCU, SKBU, OR SIMILAR SYSTEMS)

CAUTION

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

Printed circuit modules should not be removed or inserted when the equipment is energized. Failure to observe this precaution may result in an undesired tripping output or cause component damage. Care should also be exercised when replacing modules to assure that they are replaced in the same chassis position from which they either were removed or the module they are replacing was removed.

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-10 Receiver described is for use with either the SPCU or SKBU Dual Phase Comparison relaying systems or similar systems utilizing frequency-shift keying (FSK). The TCF-10 frequency shift receiver responds to carrier-frequency signals transmitted from the distant end of a power line, and carried on the power line conductors. The space frequency (sometimes referred to as trip negative) is 100 hertz above the center frequency of the channel (which can be selected within the range of 30 kHz to 300 kHz). The mark frequency (sometimes referred to as trip positive) is 100 hertz below the channel center frequency. Generally, phase comparison information is conveyed over the channel during load current flow or fault conditions. The transmitter at each end of the channel is switched at a 60-hertz rate between space (or trip negative) and mark (or trip positive) so as to produce at the receiving end, the desired operation of the relaying system.

CONSTRUCTION

The TCF-10 receiver unit for dual phase comparison relaying applications such as the SPCU or SKBU systems, is mounted on a standard 19 inch wide chassis 5¼ inches high (3 rack units) with edge slots for mounting on a standard relay rack.

All of the circuitry that is suitable for mounting on printed circuit boards is contained on printed circuit modules that plug into the chassis from the front and are readily accessible by removing the transparent cover on the front of the chassis. The power supply components and external connectors are located at the rear of the chassis as shown in Figure 9. Reference to the internal schematic connections of Figure 1 will show the location of these components in the circuit.

The printed circuit modules slide into position in slotted guides at the top and bottom of the chassis, and the module terminals engage a terminal block at the rear of the chassis. A handle on the front of each module is labeled to identify its function, and also identify adjustments and indicating lights if any are available at the front of the module. Of particular significance, is the input attentuator contained on the front of the filter module which is used in adjusting the input receiver signal during initial field installation.

✪ A module extender and Test Board (Style No. 1447C86G01) is available for facilitating circuit measurements or major adjustments. After withdrawing any one of the circuit modules, the extender is inserted in that position. The module is then inserted into the terminal block on the front of the extender. This restores all circuit connections and renders all components and test points on the module readily accessible.

✪ A carrier level indicator instrument, S#606B592A26, with a linear dB scale from −20dB to +10dB is also available for external mounting.

The receiver operates from a regulated +20V supply and a +10V supply operating from a regulated +45dc supply. These voltages are taken from three 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 or 125 volts dc.

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

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External connections to the receiver are made through a 36 terminal recepticle, J3. The r-f input connection to the receiver is made through a coaxial cable jack J2.

OPERATION

INPUT MODULE

The input module contains the input control and the input filter. The signals to which the TCF-10 receiver responds are fed through a coaxial cable connected to jack J2 at the rear of the chassis to the input module. The input control R5, accessible at the front of the input module, attentuates the signal to a level suitable for the best operating range of the receiver.

A scale on the panel is graduated in dB. While this scale is typical rather than individually calibrated, it is accurate within several dB and is useful in setting approximate levels. Settings should be made more accurately utilizing a suitable ac voltmeter with a dB scale when possible.

From the attentuator, the signal passes through a band-pass LC filter, FL 201. This filter has a passband of approximately 1600Hz which is relatively wide in comparison to the IF filter which has a passband of approximately 500Hz. Still, frequencies several kHz above or below the center frequency (f_C) of the channel are greatly attentuated. Figure 15 shows a typical curve for the LC filter as well as a characteristics curve for the IF (intermediate frequency) filter, FL2, and the discriminator output. This apparently wide bandwidth for the input filter in relation to the IF filter is necessary to both achieve high speed relaying by minimizing channel delay and to achieve proper operation of the noise clamp by sampling noise in the frequency band surrounding the IF band.

OSCILLATOR, MIXER, AND IF AMPLIFIER MODULE

From the input filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20kHz above the channel center frequency, f_C. 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 filter FL201 is impressed on the emitter-collector circuit of Q11. As a result of mixing these two frequencies, the primary of transformer will contain frequencies of 20kHz, $2f_C$ +20 kHz, f_C +20kHz, and f_C.

The output from the secondary of T12 is amplified by Q31 in the intermediate frequency (IF) stage, and is impressed on FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. Since its pass band is narrower than that of the input filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz. The output of this filter is the IF output which is fed to both the amplifier-limiter and the S/N Detection module. The output from the secondary of transformer T12, the RF output, is also fed to the S/N detection module.

AMPLIFIER LIMITER AND DISCRIMINATOR MODULE

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

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 the channel center frequency, f_C. The adjustment for zero output at f_C is made by capacitor C68. In addition, C63 is adjusted for maximum voltage reading across R80 when the output current is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero current output frequency. This separation of 200 hertz between the current peaks is affected by the value of C66 (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 space frequency is f_C +100 hertz, after leaving the mixer stage, and as seen by the discriminator, the space frequency is 20kHz-100 hertz. Similarly the mark frequency as seen by the discriminator is 20kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20kHz. The discriminator is adjusted so that the mark and space outputs are of equal lengths for equal periods of mark and space signal frequencies.

The discriminator output is connected to the bases of transistors Q55 and Q56 in such a manner that transistor Q56 is made conductive when current flows, from the discriminator output, in the forward direction of diode D54, (which occurs with mark output) and Q55 is made conductive when current flows in the forward direction of diode D55 (which occurs with space output.) Consequently, terminal 35 is at a potential of approximately +20 volts at space frequency and terminal 1 is at +20 volts at mark frequency.

S/N DETECTION MODULE

The S/N detection module has three basic functions; first to determine the in-band signal to noise ratio and provide clamping output at the desired level of signal-to-noise ratio, second to measure incoming in band signal level and provide both an output to a carrier level indicating instrument and to a clamping circuit in the output module for clamping at the desired low level of signal, and third to provide a clamping output when the desired signal level exceeds the normal received level by a substantial amount, typically 25dB.

The method of determining signal to noise ratio utilizes the measurement of signal level in two different bandwidths, that of the input filter which is 1600 hertz, and that of the IF filter which is 500 hertz. The total signal plus noise in the 500 hertz bandwidth is subtracted from the signal plus noise in the 1600 hertz bandwidth and this difference is then compared with the signal plus noise in the 500 hertz bandwidth to arrive at a true in-band and signal-to-noise ratio using logarithmic circuits. See Figure 17.

If the ratio of signal to noise is less than the value selected, typically 10, then there will be a +16V out of IC13 (TP75 and terminal 27). This is a high noise condition and this voltage is used as a clamp to prevent erroneous interpretation of data being received due to high noise conditions. Under normal low noise conditions, typically signal to noise ratio greater than 10, the voltage out of IC13 (TP75) is +4V and no clamping is done.

The wide band signal of 1600 hertz bandwidth called the RF signal is fed into the S/N detection board through isolation transformer T31. Operational amplifiers IC1 and IC2 along with their associated components, R82 through R92 and C81 through C90, constitute a 4 pole low pass filter which passes the mixed band of frequencies in the bandwidth of 1600 Hz centered about the 20KHZ I. F. frequency, and blocks all the higher multiples such as in the I.F. amplifier. Operational amplifier IC3 and associated components amplifies the signal for feeding into the RMS circuit composed of IC4 and IC5 with adjustable potentiometer R94 controlling the amount of amplification. This latter circuit converts the signals into a dc voltage proportional to the rms value of the ac signals. Operational amplifier IC6A and associated components is used for inversion and isolation of this dc voltage before being fed into the summation amplifier IC6B.

The narrow-band signal of 500 hertz bandwidth called the I.F. is fed into the S/N detection board through isolation transformer T32. The amount of signal fed into the board is adjustable by means of potentiometer R111. The circuit composed of operational amplifiers IC7 and IC8 and associated components is an RMS circuit which converts the signals into a dc voltage proportional to the r.m.s. value of the ac signals present in the IF bandwidth. The output of this circuit is also then fed into the summation amplifier IC6B.

The summation amplifier takes the difference between the rms values of the IF signal and the RF signal and feeds it into one half of the logarithmic amplifier composed of IC9 and associated components. At the same time, the r.m.s. value of the IF signal is fed into the other half of this logarithmic amplifier. The logarithmic amplifier takes the logarithmic difference between these two signals (which is equivalent to IF divided by [RF-IF] from the summer). The constants of the circuits are set up so that the output of the logarithmic amplifier is positive when the ratio of the signal to noise ratio in these bandwidths is greater than 10dB, and is negative when the signal to noise ratio is less than 10dB. (Note: The point at which the change in polarity occurs can be altered to other than 10dB signal to noise ratio by altering the adjustments of R94 and R111). In addition, the output of the logarithmic amplifier is also negative when the signal level is approximately 25dB above normal for high level clamping.

The output of the logarithmic amplifier is fed through networks consisting of IC10A and IC13A to the level detector circuit IC13B which has a fast pickup and slow dropout when it receives a signal from the logarithmic amplifier indicating a lower than desired signal to noise ratio (lower than 10dB is initially set when shipped). This will put out a +16 volts out of terminal 27 for this condition. For high signal to noise ratio this output will be +4 volts. This circuit will also put out +16 volts out of terminal 27 for very high signal levels. This is a high signal clamp and occurs for signal levels approximately plus 25dB above normal received level.

The output of the IF rms circuit is also fed to the logarithmic circuit composed of IC11A, IC12A, and IC11B which puts out a dc signal level linearly proportional to signal level in dB for feeding an external microammeter calibrated with a linear dB scale with 10dB equal to 33-1/3 microamperes.

OUTPUT MODULE

The output module provides four buffered outputs to the relaying system. They are mark (or trip positive), space (or trip negative), S/N level, and not low signal with red indicating light emitting diodes for these outputs and a yellow indicating light emitting diode for normal level (satisfactory signal level). In addition, the output module has logic which will prevent either a mark or space output whenever the S/N level drops to an unsatisfactory level or the received signal level drops to an unsatisfactory level.

The space output of plus 20 volts (when present) from the discriminator is fed into the output module through terminal 25 into the "and" gate consisting of diodes D71, D72, D73, and D74, transistors Q62 and Q63, and associated components R163, R164, R165, R166, R167, R168, D88, D75, and Z22. If there is no low level signal or low signal to noise ratio signal to prevent transistor Q62 from becoming conducting, then transistor Q62 becomes conducting, causing Q63 to become conducting and a plus 20 volts signal to appear out of terminal 29 from which it is fed to the protective relay. In a similar manner, the mark output of plus 20 volts when present from the discriminator is fed into the output module through terminal 15 into the "and" gate built about transistors Q65 and Q66. Just as in the case of the space output, the mark output of plus 20 volts will appear out of terminal 27 for feeding to the relays if there is no low level clamp or low signal to noise ratio clamp.

The low signal level clamp operates off the carrier level signal of the S/N detection module which is basically the same signal fed to the CLI instrument before it is fed through IC11A and the logarithmic amplifier IC12.

It is fed through terminal 7 into the voltage comparator circuit built around operational amplifier IC21B. This comparator compares this signal level with the voltage reference from IC21A, and if the signal level is greater than the low level at which clamping is desired, the output of IC21B will be negative causing the yellow LED to glow indicating OK level and there will consequently be no low signal clamping. If the signal level is below the level at which clamping is desired, then the output of IC21B will be positive causing the red LED to glow indicating low level. In addition, both transistors Q67 and Q64 will become conducting. Transistor Q64 conducting will prevent mark and space signals from appearing on the outputs going to the relays by preventing transistors Q65 and Q62 from conducting. Transistor Q67 conducting causes Q68 to become non-conducting and thus removes the not low signal output from terminal 1. Under good or OK signal level, this not low signal output at terminal 1 of this module is plus 20 volts.

The S/N clamp output from the S/N detection module is fed into terminal 35 of this module. At low signal-to-noise ratio level, this +16 volt signal will cause transistors Q70 and Q61 to conduct. Transistor Q70 conducting will cause both the red LED to glow indicating low S/N and transistor Q71 to conduct supplying plus 20 volts out of terminal 13 to the protective relays. Transistor Q61 conducting will prevent both transistors Q62 and Q65 from conducting, and thus prevent either a mark or space signal from appearing at their respective outputs to the protective relays. It should be noted that the S/N clamp also operates for a high signal level of approximately plus 25dB above normal when set to operate at 10dB signal to noise ratio.

POWER SUPPLY

The regulated 45 volt dc, 20V dc, and 10V dc circuits of the receiver are supplied from zener regulators mounted on a common heat sink at the rear of the chassis. Resistors R3 and R7 of suitable value are connected between the station battery supply and the 45 volt zener regulator to adapt the receiver for use on 48 or 125 volt dc battery circuits. Capacitor C1 and C2 bypass rf or transient voltages to ground. Choke L1 with capacitor C3 form a trap to isolate the receiver from transient voltages in the 20kHz range that may appear on the dc supply and which could affect the receiver.

CHARACTERISTICS

Center Frequencies Available	30kHz to 300kHz in 0.5kHz increments
Sensitivity (Noise free channel)	0.016 volts normal sensitivity 0.005 volts (max sensitivity for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (Input L C Filter)	Down 3dB at ±800 hertz Down 30dB at ±5000 hertz
Overall receiver selectivity	Down 3dB at ±225 hertz Down 35dB at ±1000 hertz
Operating Time	4 milliseconds channel (Transmitter and receiver back to back)
Signal-to-noise ratio clamp setting	10dB SNR (as shipped)
Ambient Temperature Range	−20°C to +55°C
Battery Voltage Variations	
Nominal 48V dc	42V dc − 56V dc
Nominal 125V dc	105V dc − 140V dc
Battery Drain	0.4 amperes
Dimensions	Panel Height = 5¼ inches (3RU) Panel Width = 19 inches
Weight	13 pounds
CLI Accuracy	±2dB between −15dB and 0dB

INSTALLATION

The TCF receiver is generally supplied in a cabinet or a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. In particular equipment which generates excessive heat such as power supplies should not be mounted directly beneath it as this heat in rising will tend to raise the ambient temperature immediately around the chassis above acceptable levels. The maximum ambient temperature around the chassis must not exceed 75 C. In addition, sudden fluctuations in ambient temperature caused by these power supplies due to variations in load can cause variations in performance due to uneven heating of the receiver introducing abnormal temperature variations in the receiver.

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; pickup of signal to noise ratio clamp; and pickup of low signal level clamp. The adjustment that must be made at time of installation is the setting of input attenuator R5. The input attenuator adjustment is made by a knob on the front of the panel of the input module.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation to attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15dB below the maximum expected signal. After installation of the receiver and the corresponding transmitter, and with a normal space signal level being received, input attenuator R5 should be adjusted to the position at which the receiver clamps into neither a mark nor space output. The attenuator R5 should then be readjusted to increase the voltage supplied to the receiver by 15dB. The scale markings for R5 permit approximate settings to be made, but it is preferable to make this setting by means of the dB scales of an ac VTVM connected across the terminals indicated at the front panel of the input module. The red terminal is connected to the wiper arm of R5 and the black terminal is connected to ground. With this setting, a 15dB drop in signal will cause a low signal level clamp operation which will lock the output of the receiver into neither a mark nor a space output at the point at which the receiver just drops out of limiting.

The only other adjustment which may be necessary at the time of initial installation is the adjustment of the CLI instrument to correspond to proper variation of signal level from normal. This may be necessary if the instrument was not supplied with the receiver and was not adjusted by the factory. If this instrument was supplied and adjusted by the factory, then it could be used in adjusting R5. In this case, it would be necessary only to adjust R5 with a normal signal being received so that the instrument indicates 0dB.

If the instrument was not previously adjusted by the factory, then the following procedure should be used in adjusting the instrument.

1. Set incoming level into receiver at +10dB above normal level (288 mv for 16 mv clipping level. 90 mv for 5 mv clipping level).
2. Adjust span adjustment, R147, so that the voltage at TP72 with respect to TP62 (common) is +3.000 volts.
3. Reduce incoming signal into receiver by 30dB. 9 mv for 16 mv clipping level. 3 mv for 5 mv clipping level.
4. Adjust full scale adjustment, R153, so that instrument now reads −20dB. (This is approximately 0 microamperes).
5. Increase signal to +10dB level. (This is 100 microamperes).
6. Adjust slope adjustment R155 to read +10dB on CLI instrument.
7. Reduce signal to normal level (90 mv). CLI instrument should read 0dB. If desired, R155 can now be readjusted so instrument reads 0dB with sacrifice in reading accuracy for +10dB. (90 mv for 16 mv clipping level. 28 mv for 5 mv clipping level).

FACTORY ADJUSTMENTS

In case the factory adjustments have been altered or there is suspicion of improper adjustments or malfunctioning, then the following procedures can be used. In addition, alterations to the settings used by the factory for low signal level clamping and low signal-to-noise ratio clamping can be made using these procedures if desired.

Potentiometer R12 in the oscillator and mixer should be set for 0.3 volts, measured with a VTVM connected between TP11 and terminal 33 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 center 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 assures 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 TP56 at the base of Q54 to terminal 33 of the limiter. With 16 millivolts of space fequency on the receiver input (R5 set 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. (For greater sensitivity when required, the receiver can be set to 5 millivolts for beginning of limiting. However this makes the receiver more susceptible to locally generated noise within the cabinet and should not be used unless absolutely necessary and chassis is located in a noise free area.)

The adjustment of the signal to noise ratio clamp for clamping at 10dB signal to noise ration is as follows:

1. Set the incoming signal into receiver at nominal level (90 mv. for 16 mv clipping level, 28 mv. for 5 mv clipping level.)
2. Adjust I.F. input with R111 so that signal at TP68 of the S/N detector module is +100 mv dc (with respect to TP62).
3. Adjust RF input with R94 so that signal at TP63 is +145 mv dc (with respect to TP62).
4. Adjust log amplifier balance potentiometer R129 so that S/N clamps operates. This will be +16 volts dc at TP75. This will also appear as +20 volts at TP91 of the output board and the red S/N level indicator will light.

5. Go back and readjust RF input with R94 so that signal level at TP63 is now 74.4 mv dc.

The adjustments above are for operation of the clamp at 10dB or less signal to noise ratios. If it is desired to clamp at other than 10dB or less, the following values can be used in place of the 145 mv value in step 3 and repeat steps 4 and 5 as stated.

For S/N of 0dB set TP63 to 297mv.
5dB set TP63 to 200mv.
15dB set TP63 to 114mv.
20dB set TP63 to 96.6mv.

Note: When the SNR clamp is set to clamp at a 10dB signal to noise ratio, the receiver will also clamp at a high signal level of approximately 25dB above normal.

The low signal level clamp is set to operate at the signal level where the receiver just drops out of limiting. This is accomplished as follows:

1. With a normal space frequency signal being received and with an oscilloscope connected across TP56 and terminal 33 of the limiter module, adjust input attenuator R5 to the point where the peaks of the oscilloscope trace just begin to flatten. (An alternate adjustment would be to set incoming signal level into receiver at 16mv with R5 set at zero which is the point at which limiting should begin).

2. Adjust the -V Ref. adjustment R178 on the output module so that the low level clamp just picks up. This will be indicated by the red low level light on the output module coming on. There also will be +20 volts at TP86 on the output module.

3. Adjust input attenuator R5 to increase signal into receiver by desired margin of operation. This normally should be 15dB. This is done by reducing the R5 attenuator setting.

MAINTENANCE

Periodic checks of the received carrier signal level and the receiver sentitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control, R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to cause a low signal level clamp to operate as indicated by the red LED becoming lit. 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 level or loss in receiver sensitivity.

All adjustable components for normal field adjustments on the printed circuit modules are accessible when the front cover on the chassis is removed. All other adjustable components on the printed circuit modules may be made entirely accessible while permitting electrical operation by using module extender style number 1447C86G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

TABLE I
RECEIVER D-C MEASUREMENTS

NOTE: All voltage readings taken with ground of dc VTVM on terminal 17 (negative dc). Receiver adjusted for 15dB operating margin with Space and Mark signals down 40dB from 1 watt or 50dB down from 10 watts. Unless indicated otherwise, voltage will not vary appreciably whether signal is mark, space or zero.

Collector of Transistor or Test Point	Voltage (Positive)
Q11	< 13
Q12 (TP12)	15 (Mark or Space)
Q13 (TP13)	15 (Mark or Space)
Q14 (TP14)	2.5
Q15 (TP15)	2.5
TP11	18
TP52	16
Q51 (TP51)	11.5
Q52 (TP53)	12
Q53 (TP54)	15.5
Q54 (TP55)	2.5
TP56	16
Q55	< 1 (Mark or No Signal)
Q55	19.5 (Space)
Q56	19.5 (Mark)
Q56	< 1 (Space or No Signal)
TP61	10.4
TP62	10
TP63	10.4
TP64	18
TP65	0
TP66	10
TP67	10.5
TP68	10.5
TP69	10
TP70	4
TP71	16
TP72	11.4
TP73	10.8
TP74	10.3
TP81	20 (Space)
TP81	0 (Mark or No Signal)
TP82	20 (Mark)

Collector of Transistor or Test Point	Voltage (Positive)
TP82	0 (Space or No Signal)
TP83	20 (Space)
TP83	0 (Mark, No Signal, or clamp)
TP84	20 (Mark)
TP84	0 (Space, No Signal or clamp)
TP85	10.3
TP86	20 (Low level clamp)
TP86	0 (No clamp)
TP87	16V (Low SNR Clamp)
TP87	4V (No SNR Clamp)
TP88	20
TP89	0
TP90	20 (Good Signal Level)
TP90	0 (Low Signal Level clamp)

TABLE II
RECEIVER RF MEASUREMENTS

NOTE: Voltmeter readings taken at any point from receiver input to stage involving transistor Q15 are neither meaningful or feasible because of either waveform variations or the effect of instrument loading on the readings. Receiver adjusted as Table I.

Collector of Transistor or Test Point	Volts with Signal At +10dB Above Normal Level
Q15 (TP15)	0.8
Q51 (TP51)	0.9
Q52 (TP53)	0.65
Q53 (TP54)	2.2
Q54 (TP55)	4.5
TP61	.013
TP67	.275

FILTER RESPONSE MEASUREMENTS

The LC input filter (FL201) and the IF Filter (FL2) are in sealed containers, and repairs can only be made by the factory. The stability of the original response characteristics is such that in normal usage, no appreciable change in response will occur. However, the test circuits of Figure 16 can be used in case there is reason to suspect that either of the filters is not performing correctly.

Figure 15 shows the −3dB and −35dB checkpoints for the IF filter, and the −3dB checkpoints for the input filter. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Figure 15 was chosen to show the IF filter response, which permitted only a portion of the input filter curve to be shown. The checkpoints for the passband of each section of each section of the IF filter are down 3dB maximum at 19.75 and 20.25kHz, and for the stop band are down 18dB minimum at 19.00 and 21.00kHz for each section. The signal generator voltage (Figure 16) must be held constant throughout the entire check. A value of 7.8 volts is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22dB below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only, and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16dB less than the measured difference because of the input resistance and the difference in input and output impedances of the filter.

In testing the LC filter, a value of approximately 2.45V is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency, but should not be more than 18dB below the reading of VM1. (The filter insertion loss is approximately 6dB less than the difference in readings).

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY.

The parts required for converting a TCF receiver for operating at a different channel frequency consist of a new LC input filter (FL201), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). There are two ways of effecting this change. The easiest and preferred method is to order a new input filter module and a new oscillator mixer module for the new frequencies from the factory. The new modules would then just have to be plugged in as replacements for the original modules. The second method would involve ordering just replacement filter, FL201, and new local oscillator crystal for the new frequencies and making the substitution on the modules. These substitutions on the modules are not difficult as the crystal plugs in and the filter has five leads to be soldered. However, testing of the local oscillator for easy starting will have to be made, and the value of C12 chosen to assure this easy starting of oscillation. The whole receiver should then be checked out for correct performance.

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 60Hz to 330kHz, input impedance 7.5 megohms.

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

c. Microammeter 0-100 μa 700 to 900 ohms range, (if receiver has carrier level indicator). (Westinghouse S#606B592A26 is preferred as it has correct resistance and a linear dB scale from −20dB to +10dB.

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 330kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

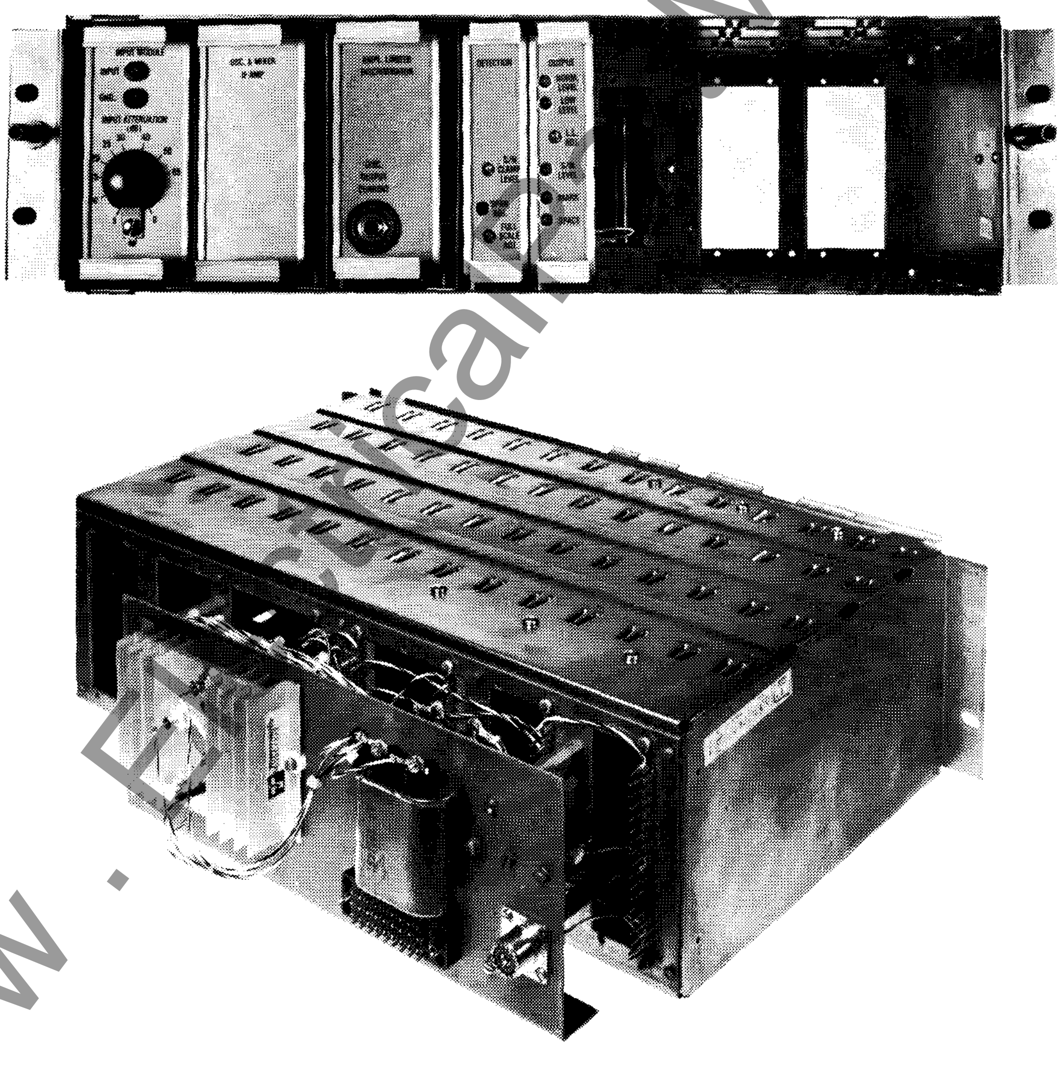
f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5

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

RENEWAL PARTS

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



TYPE TCF-10 RECEIVER

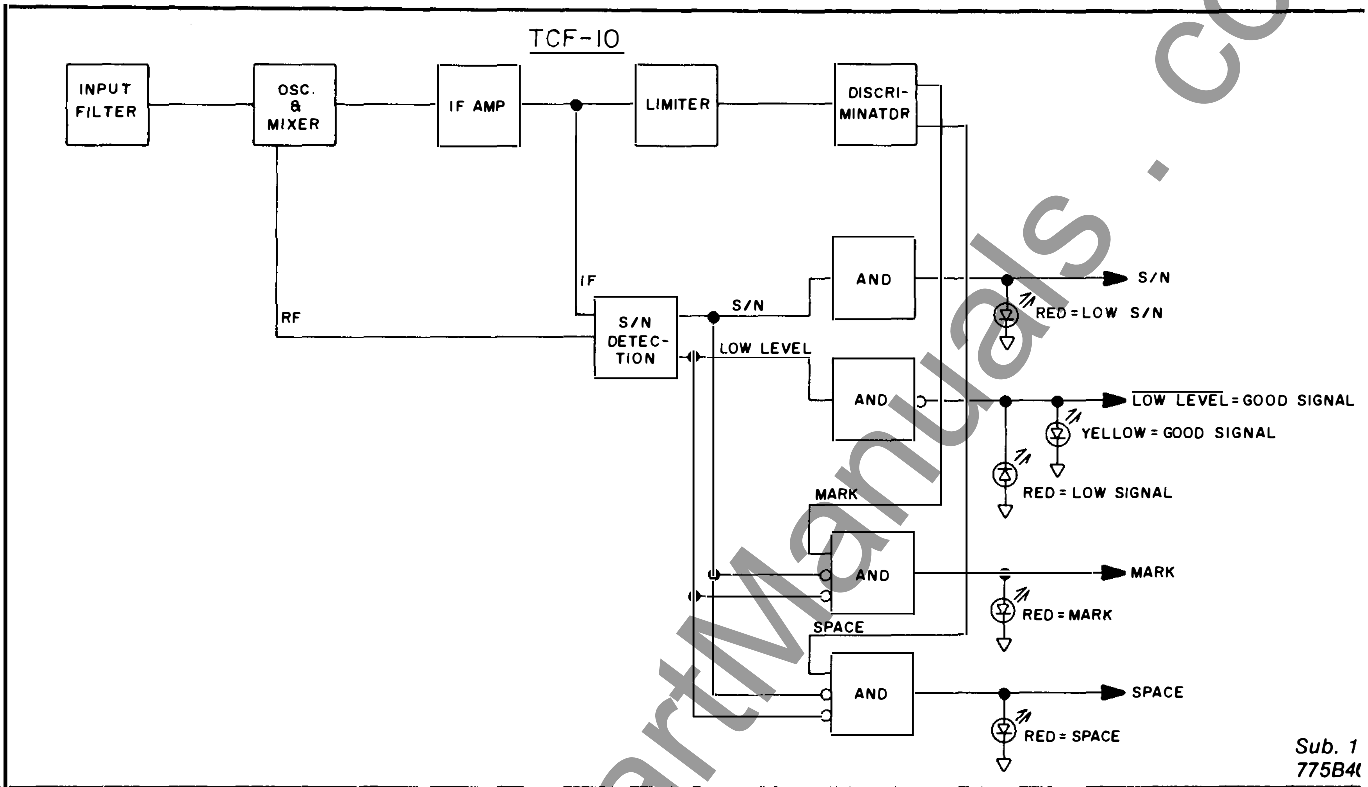


Fig. 2. Receiver Logic for Dual Phase Comparison

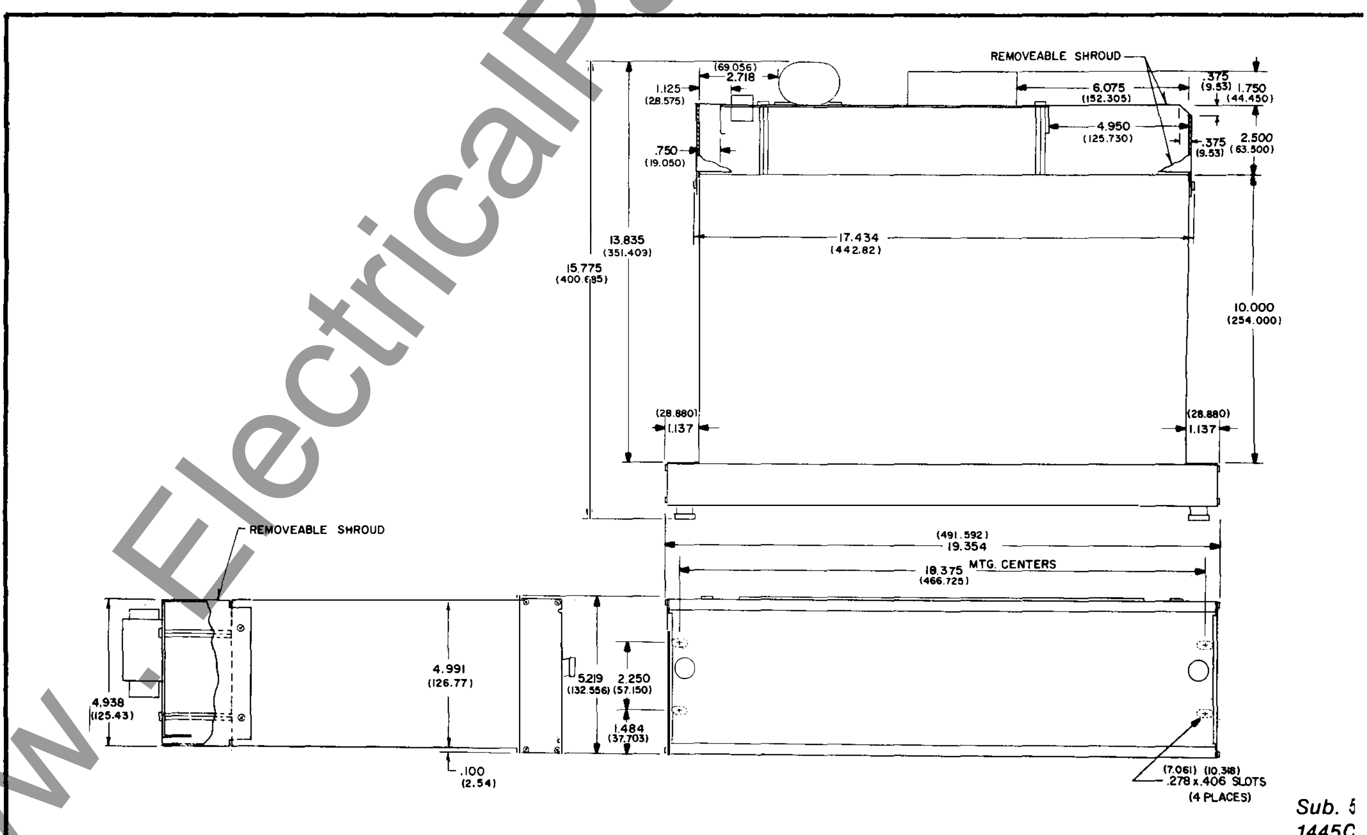
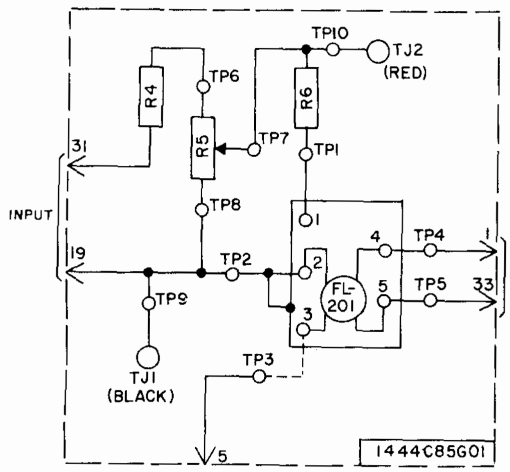


Fig. 3. Outline TCF-10 Receiver

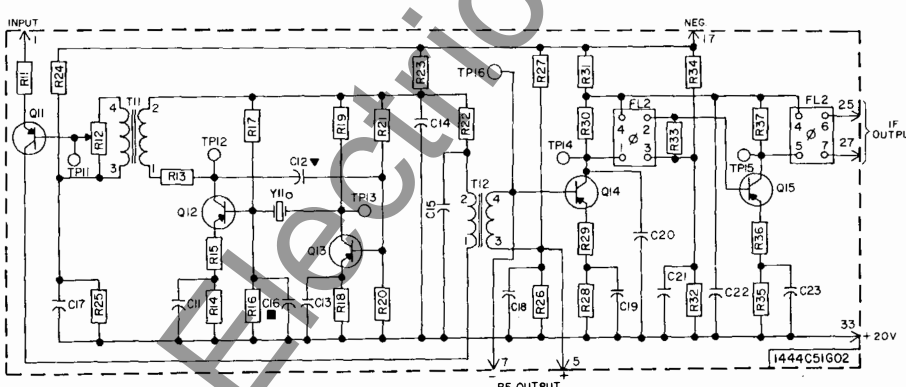


COMPONENT		DESCRIPTION	STYLE NO.
R4	RESISTOR	100.0 .50W 5%	184A763H03
R6	RESISTOR	10.0K .50W 5%	184A763H51
R5	POTENTIOMETER	10.0K 2W	185A086H10
FL201	FILTER		□
TJ1	TIP JACK	BLACK	187A332H02
TJ2	TIP JACK	RED	187A332H01

□ = TO BE DETERMINED.

Sub. 1
775B394

Fig. 4. Internal Schematic Input Filter Module



CØMPØNENT		DESCRIPTIØN	STYLE NØ.
C11	CAPACITØR	.250UF 200V	187A624H02
C12	CAPACITOR	SEE NOTE ▼	
C13	CAPACITØR	.250UF 200V	187A624H02
C14	CAPACITØR	1.000UF 200V	187A624H04
C15	CAPACITØR	1.000UF 200V	187A624H04
C16	CAPACITOR	SEE NOTE ■	
C17	CAPACITØR	.250UF 200V	187A624H02
C18	CAPACITØR	.250UF 200V	187A624H02
C19	CAPACITØR	.250UF 200V	187A624H02
C20	CAPACITØR	100.000PF 500V	762A757H01
C21	CAPACITØR	.250UF 200V	187A624H02
C22	CAPACITØR	1.000UF 200V	187A624H04
C23	CAPACITØR	.250UF 200V	187A624H02
R11	RESISTØR	10.0K .50W 5%	184A763H51
R13	RESISTØR	4700.0 .50W 5%	184A763H43
R14	RESISTØR	3300.0 .50W 5%	184A763H39
R15	RESISTØR	330.0 .50W 5%	184A763H15
R16	RESISTØR	10.0K .50W 5%	184A763H51
R17	RESISTØR	33.0K .50W 5%	184A763H63
R18	RESISTØR	3300.0 .50W 5%	184A763H39
R19	RESISTØR	3300.0 .50W 5%	184A763H39
R20	RESISTØR	10.0K .50W 5%	184A763H51
R21	RESISTØR	33.0K .50W 5%	184A763H63
R22	RESISTØR	330.0 .50W 5%	184A763H15
R23	RESISTØR	10.0K .50W 5%	184A763H51
R24	RESISTØR	220.0K .50W 5%	184A763H83
R25	RESISTØR	4700.0 .50W 5%	184A763H43
R26	RESISTØR	3300.0 .50W 5%	184A763H39
R27	RESISTØR	22.0K .50W 5%	184A763H59
R28	RESISTØR	680.0 .50W 5%	184A763H23
R29	RESISTØR	68.0 .50W 5%	187A290H21
R30	RESISTØR	10.0K .50W 5%	184A763H51
R31	RESISTØR	330.0 .50W 5%	184A763H15
R32	RESISTØR	3300.0 .50W 5%	184A763H39
R33	RESISTØR	1000.0 .50W 5%	184A763H27
R34	RESISTØR	22.0K .50W 5%	184A763H59
R35	RESISTØR	680.0 .50W 5%	184A763H23
R36	RESISTØR	68.0 .50W 5%	187A290H21
R37	RESISTØR	10.0K .50W 5%	184A763H51
R12	PØT	1.0K .12W	629A430H02
J111	JUMPER	0 ØHM RESISTØR	862A478H01
Q11	TRANSISTØR	2N4249	849A441H03
Q12	TRANSISTØR	2N4249	849A441H03
Q13	TRANSISTØR	2N4249	849A441H03
Q14	TRANSISTØR	2N4249	849A441H03
Q15	TRANSISTØR	2N4249	849A441H03
T11	TRANSFORMER		205C043G01
T12	TRANSFORMER		205C043G03
Y11	CRYSTAL	SEE NOTE ○	
FL2	FILTER		762A613G01

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

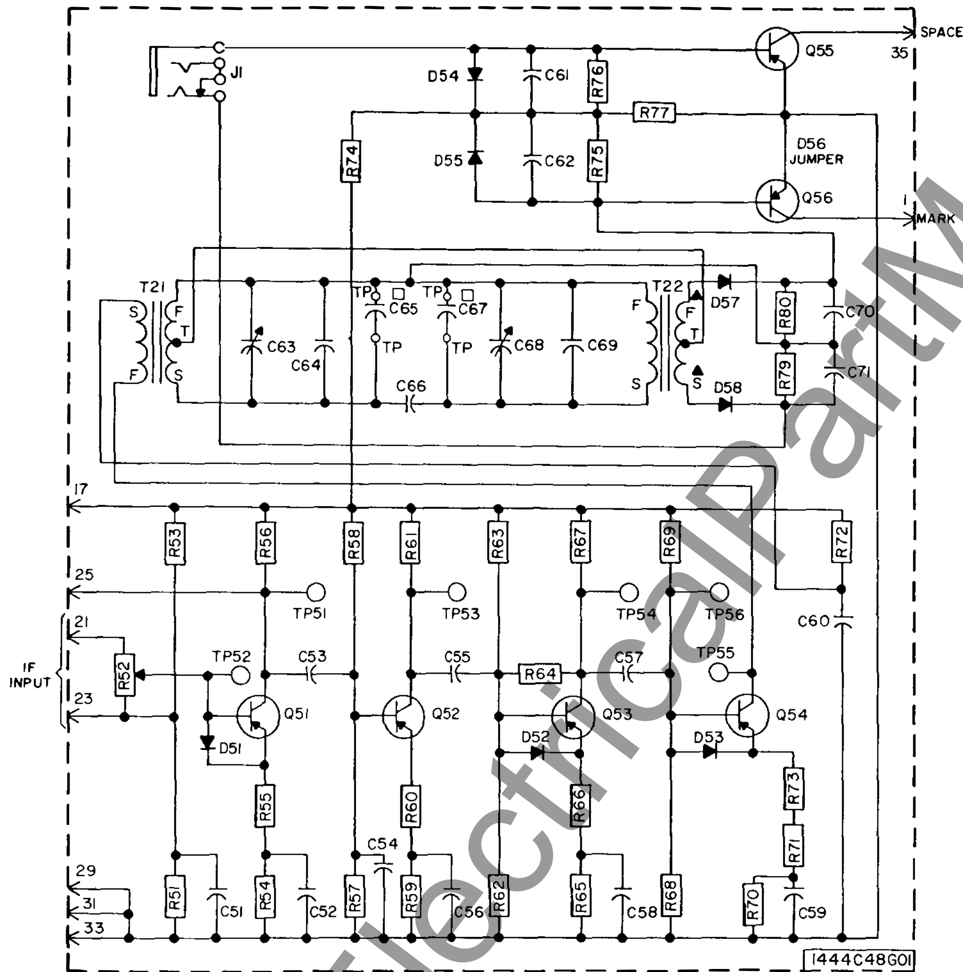
■=C16 RANGE 22 TO 100Pf AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS

○=Y11 RANGE-50 TO 220KHZ

Ø=COMMON TERMINAL

1444C52

Fig. 5. Internal Schematic Oscillator-Mixer-IF Amplifier Module



COMPONENT	DESCRIPTION	STYLE NO.
C51	CAPACITOR .250UF 200V	187A624H02
C52	CAPACITOR .250UF 200V	187A624H02
C53	CAPACITOR .100UF 200V	187A624H01
C54	CAPACITOR 1300.000PF 500V	187A584H15
C55	CAPACITOR .100UF 200V	187A624H01
C56	CAPACITOR .250UF 200V	187A624H02
C57	CAPACITOR .100UF 200V	187A624H01
C58	CAPACITOR .250UF 200V	187A624H02
C59	CAPACITOR .250UF 200V	187A624H02
C60	CAPACITOR 1.000UF 200V	187A624H04
C61	CAPACITOR .220UF 50V	762A703H01
C62	CAPACITOR .220UF 50V	762A703H01
C63	CAPACITOR 4.5 TO 100PF	762A736H02
C64	CAPACITOR 9100.000PF 200V	187A624H16
C65	CAPACITOR SEE NOTE □	
C66	CAPACITOR 100.000PF 500V	187A684H08
C67	CAPACITOR SEE NOTE □	
C68	CAPACITOR 4.5 TO 100PF	762A736H02
C69	CAPACITOR 9100.000PF 200V	187A624H16
C70	CAPACITOR .220UF 50V	762A703H01
C71	CAPACITOR .220UF 50V	762A703H01
D51	DIODE 1N457A	184A855H07
D52	DIODE 1N457A	184A855H07
D53	DIODE 1N457A	184A855H07
D54	DIODE 1N457A	184A855H07
D55	DIODE 1N457A	184A855H07
D56	JUMPER	862A478H01
D57	DIODE 1N628	184A855H12
D58	DIODE 1N628	184A855H12
R51	RESISTOR 4700.0 .50W 5%	184A763H43
R53	RESISTOR 27.0K .50W 5%	184A763H61
R54	RESISTOR 2200.0 .50W 5%	184A763H35
R55	RESISTOR 27.0 .50W 5%	187A290H11
R56	RESISTOR 10.0K .50W 5%	184A763H51
R57	RESISTOR 4700.0 .50W 5%	184A763H43
R58	RESISTOR 27.0K .50W 5%	184A763H61
R59	RESISTOR 1500.0 .50W 5%	184A763H31
R60	RESISTOR 180.0 .50W 5%	184A763H09
R61	RESISTOR 4700.0 .50W 5%	184A763H43
R62	RESISTOR 2200.0 .50W 5%	184A763H35
R63	RESISTOR 33.0K .50W 5%	184A763H63
R64	RESISTOR 2700.0 .50W 5%	184A763H37
R65	RESISTOR 680.0 .50W 5%	184A763H23
R66	RESISTOR 68.0 .50W 5%	187A290H21
R67	RESISTOR 4700.0 .50W 5%	184A763H43
R68	RESISTOR 2700.0 .50W 5%	184A763H37
R69	RESISTOR 18.0K .50W 5%	184A763H57
R70	RESISTOR 220.0 .50W 5%	184A763H11
R71	RESISTOR 68.0 .50W 2%	629A531H04
R72	RESISTOR 330.0 .50W 5%	184A763H15
R73	RESISTOR 56.0 .50W 2%	629A531H02
R74	RESISTOR 12.0K .50W 5%	184A763H53
R75	RESISTOR 3000.0 .50W 5%	184A763H38
R76	RESISTOR 3000.0 .50W 5%	184A763H38
R77	RESISTOR 220.0 .50W 5%	184A763H11
R79	RESISTOR 2200.0 .50W 5%	184A763H35
R80	RESISTOR 2200.0 .50W 5%	184A763H35
R52	POT 1.0K .50W	629A645H04
Q51	TRANSISTOR 2N4249	849A441H03
Q52	TRANSISTOR 2N4249	849A441H03
Q53	TRANSISTOR 2N4249	849A441H03
Q54	TRANSISTOR 2N4249	849A441H03
Q55	TRANSISTOR 2N3645	849A441H01
Q56	TRANSISTOR 2N3645	849A441H01
T21	TRANSFORMER	606B533G01
T22	TRANSFORMER	606B533G02
J1	TELEPHONE JACK	187A606H01

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

▲ – FOR STYLE 1444C48G03 REVERSE START AND FINISH LEADS OF T22.

Sub. 2
14449C49

Fig. 6. Internal Schematic Amplifier Limiter-Discriminator Module

COMPONENT		DESCRIPTION			STYLE NO.
R81	RESISTOR	1000.0	.50W	1%	848A819H48
R82	RESISTOR	2210.0	.50W	1%	848A819H81
R83	RESISTOR	10.2K	.25W	1%	848A820H46
R84	RESISTOR	10.0K	.25W	1%	848A820H45
R85	RESISTOR	56.2K	.25W	1%	848A821H18
R86	RESISTOR	10.0K	.50W	1%	848A820H45
R87	RESISTOR	2210.0	.50W	1%	848A819H81
R88	RESISTOR	10.2K	.25W	1%	848A820H46
R89	RESISTOR	10.0K	.25W	1%	848A820H45
R90	RESISTOR	82.5K	.50W	1%	848A821H34
R91	RESISTOR	10.0K	.50W	1%	848A820H45
R92	RESISTOR	6190.0	.50W	1%	848A820H25
R93	RESISTOR	4990.0	.50W	1%	848A820H16
R95	RESISTOR	4750.0	.25W	1%	848A820H14
R96	RESISTOR	4750.0	.25W	1%	848A820H14
R97	RESISTOR	4990.0	.50W	1%	848A820H16
R98	RESISTOR	15.0K	.50W	1%	848A820H62
R99	RESISTOR	4990.0	.50W	1%	848A820H16
R100	RESISTOR	4990.0	.50W	1%	848A820H16
R101	RESISTOR	4990.0	.50W	1%	848A820H16
R102	RESISTOR	10.0K	.50W	1%	848A820H45
R103	RESISTOR	10.0K	.50W	1%	848A820H45
R104	RESISTOR	10.0K	.50W	1%	848A820H45
R105	RESISTOR	10.0K	.50W	1%	848A820H45
R106	RESISTOR	10.0K	.50W	1%	848A820H45
R107	RESISTOR	10.0K	.50W	1%	848A820H45
R108	RESISTOR	100.0K	.50W	1%	848A821H42
R109	RESISTOR	10.0K	.50W	1%	848A820H45
R110	RESISTOR	1000.0	.50W	1%	848A819H48
R112	RESISTOR	4750.0	.25W	1%	848A820H14
R113	RESISTOR	4750.0	.25W	1%	848A820H14
R114	RESISTOR	15.0K	.50W	1%	848A820H62
R115	RESISTOR	4990.0	.50W	1%	848A820H16
R116	RESISTOR	4990.0	.50W	1%	848A820H16
R117	RESISTOR	4990.0	.50W	1%	848A820H16
R118	RESISTOR	4990.0	.50W	1%	848A820H16
R119	RESISTOR	10.0K	.50W	1%	848A820H45
R120	RESISTOR	1000.0	.50W	1%	848A819H48
R121	RESISTOR	15.0K	.50W	1%	848A820H62
R122	RESISTOR	15.0K	.50W	1%	848A820H62
R123	RESISTOR	10.0K	.50W	1%	848A820H45
R124	RESISTOR	10.0K	.50W	1%	848A820H45
R125	RESISTOR	10.0K	.50W	1%	848A820H45
R126	RESISTOR	10.0K	.50W	1%	848A820H45
R127	RESISTOR	2.0K	.50W	1%	848A819H77
R128	RESISTOR	9530.0	.50W	1%	848A820H43
R130	RESISTOR	9530.0	.50W	1%	848A820H43
R131	RESISTOR	10.0K	.50W	1%	848A820H45
R132	RESISTOR	10.0K	.50W	1%	848A820H45
R133	RESISTOR	10.0K	.50W	1%	848A820H45
R134	RESISTOR	10.0K	.50W	1%	848A820H45
R135	RESISTOR	10.0K	.50W	1%	848A820H45
R136	RESISTOR	15.0K	.50W	1%	848A820H62
R137	RESISTOR	10.0K	.50W	1%	848A820H45
R138	RESISTOR	10.0K	.50W	1%	848A820H45
R139	RESISTOR	10.0K	.50W	1%	848A820H45
R140	RESISTOR	475.0K	.25W	1%	848A822H08
R141	RESISTOR	200.0K	.50W	1%	848A821H71
R142	RESISTOR	150.0	.50W	1%	848A818H68
R144	RESISTOR	750.0	.50W	1%	848A819H36
R145	RESISTOR	18.7K	.50W	1%	848A820H71
R146	RESISTOR	4990.0	.50W	1%	848A820H16
R148	RESISTOR	1000.0	.50W	1%	848A819H48
R149	RESISTOR	15.0K	.50W	1%	848A820H62
R150	RESISTOR	2.0K	.50W	1%	848A819H77
R151	RESISTOR	2.0K	.50W	1%	848A819H77
R152	RESISTOR	17.8K	.25W	1%	848A820H69
R154	RESISTOR	1.0K	.50W	1%	848A819H48
R155	RESISTOR	1.0K	.25W	20%	629A430H02
R156	RESISTOR	150.0	.50W	1%	848A818H68
R157	RESISTOR	33Ω	3W		763A127H16
R158	RESISTOR	33Ω	3W		763A127H16

COMPONENT		DESCRIPTION		STYLE NO.
R94	POT	20.0K	.50W	629A645H05
R111	POT	50.0K	.50W	629A645H12
R129	POT	2.5K	.25W	629A645H07
R147	POT	250.0K	.75W	880A826H10
R153	POT	2.5K	.25W	629A645H07
C81	CAPACITOR	2000.000PF	500V	187A584H01
C82	CAPACITOR	1000.000PF	200V	880A397H07
C83	CAPACITOR	220.000PF	200V	879A989H17
C84	CAPACITOR	.010UF	50V	184A663H01
C85	CAPACITOR	1.000UF	50V	3512A08H01
C86	CAPACITOR	.010UF	50V	184A663H01
C87	CAPACITOR	2000.000PF	500V	187A584H01
C88	CAPACITOR	1000.000PF	200V	880A397H07
C89	CAPACITOR	33.000PF	200V	879A989H07
C90	CAPACITOR	.010UF	50V	184A663H01
C91	CAPACITOR	.010UF	50V	184A663H01
C92	CAPACITOR	1.000UF	50V	3512A08H01
C93	CAPACITOR	.010UF	50V	184A663H01
C94	CAPACITOR	33.000PF	200V	879A989H07
C95	CAPACITOR	.010UF	50V	184A663H01
C96	CAPACITOR	.010UF	50V	184A663H01
C97	CAPACITOR	.470UF	50V	762A680H04
C98	CAPACITOR	33.000PF	200V	879A989H07
C99	CAPACITOR	.010UF	50V	184A663H01
C100	CAPACITOR	.010UF	50V	184A663H01
C101	CAPACITOR	33.000PF	200V	879A989H07
C102	CAPACITOR	.010UF	50V	184A663H01
C103	CAPACITOR	33.000PF	200V	879A989H07
C104	CAPACITOR	.010UF	50V	184A663H01
C105	CAPACITOR	.010UF	50V	184A663H01
C106	CAPACITOR	.047UF	50V	848A646H07
C107	CAPACITOR	33.000PF	200V	879A989H07
C108	CAPACITOR	.010UF	50V	184A663H01
C109	CAPACITOR	.010UF	50V	184A663H01
C110	CAPACITOR	.22 UF	100V	3512A08H02
IC1	INT CKT	SE531T		3512A10H01
IC2	INT CKT	SE531T		3512A10H01
IC3	INT CKT	SE531T		3512A10H01
IC4	INT CKT	SE531T		3512A10H01
IC5	INT CKT	SE531T		3512A10H01
IC6	INT CKT	747DM		1443C52H01
IC7	INT CKT	SE531T		3512A10H01
IC8	INT CKT	SE531T		3512A10H01
IC9	INT CKT	SN56502		3512A09H01
IC10	INT CKT	747DM		1443C52H01
IC11	INT CKT	747DM		1443C52H01
IC12	INT CKT	SN56502		3512A09H01
IC13	INT CKT	747DM		1443C52H01
D61	DIODE	1N4148		836A928H06
D62	DIODE	1N4148		836A928H06
D63	DIODE	1N4148		836A928H06
D64	DIODE	1N4148		836A928H06
D65	DIODE	1N4148		836A928H06
Z11	ZENER	IN4460	6.2 V	837A693H08
Z12	ZENER	IN4460	6.2 V	837A693H08
Z113	ZENER	1N825A	6.2V	862A288H06
J111	JUMPER	0 OHM RESISTOR		862A478H01
J112	JUMPER	0 OHM RESISTOR		862A478H01
J113	JUMPER	0 OHM RESISTOR		862A478H01
J114	JUMPER	0 OHM RESISTOR		862A478H01

Sub. 9
Sheet 1
6705D32

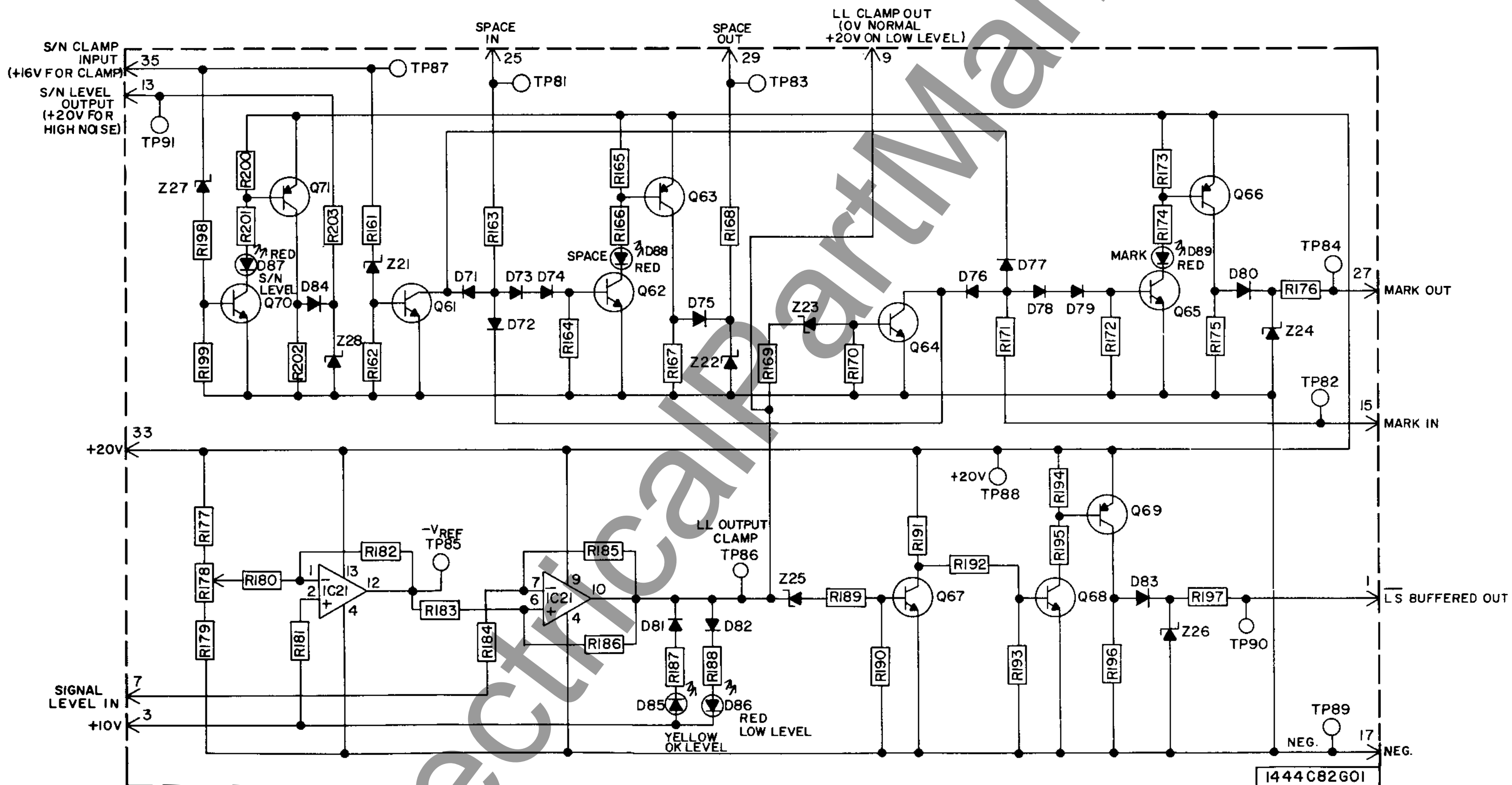


Fig. 8. Internal Schem

Sub. 3
Sheet 1
1444C83

COMPONENT		DESCRIPTION	STYLE NO.
D71	DIØDE	1N645A	837A692H03
D72	DIODE	1N645A	837A692H03
D73	DIØDE	1N645A	837A692H03
D74	DIØDE	1N645A	837A692H03
D75	DIØDE	1N645A	837A692H03
D76	DIODE	1N645A	837A692H03
D77	DIØDE	1N645A	837A692H03
D78	DIØDE	1N645A	837A692H03
D79	DIØDE	1N645A	837A692H03
D80	DIØDE	1N645A	837A692H03
D81	DIØDE	1N457A	184A855H07
D82	DIØDE	1N457A	184A855H07
D83	DIØDE	1N645A	837A692H03
D84	DIØDE	1N645A	837A692H03
D85	DIØDE	LED	3508A22H02
D86	DIODE	LED	3508A22H01
D87	DIØDE	LED	3508A22H01
R161	RESISTØR	10.0K .50W 5%	184A763H51
R162	RESISTØR	120.0K .50W 5%	184A763H77
R163	RESISTØR	33.0K .50W 5%	184A763H63
R164	RESISTØR	120.0K .50W 5%	184A763H77
R165	RESISTØR	4.7K .50W 5%	184A763H51
R166	RESISTØR	2.4K .50W 5%	184A763H57
R167	RESISTØR	82.0K .50W 5%	184A763H73
R168	RESISTØR	150.0 3.00W 5%	762A679H01
R169	RESISTØR	10.0K .50W 5%	184A763H51
R170	RESISTØR	120.0K .50W 5%	184A763H77
R171	RESISTØR	33.0K .50W 5%	184A763H63
R172	RESISTØR	120.0K .50W 5%	184A763H77
R173	RESISTØR	4.7K .50W 5%	184A763H51
R174	RESISTØR	2.4K .50W 5%	184A763H57
R175	RESISTØR	82.0K .50W 5%	184A763H73
R176	RESISTØR	150.0 3.00W 5%	762A679H01
R177	RESISTØR	10.0K .50W 1%	848A820H45
R179	RESISTØR	10.0K .50W 1%	848A820H45
R180	RESISTØR	68.1K .50W 1%	848A821H26
R181	RESISTØR	4990.0 .50W 1%	848A820H16
R182	RESISTØR	6810.0 .50W 1%	848A820H29
R183	RESISTØR	2.0K .50W 1%	848A819H77
R184	RESISTØR	2.0K .50W 1%	848A819H77
R185	RESISTØR	562.0K .25W 1%	848A822H15
R186	RESISTØR	511.0K .50W 1%	848A822H11
R187	RESISTØR	1620.0 .25W 1%	848A819H68
R188	RESISTØR	1620.0 .25W 1%	848A819H68
R189	RESISTØR	33.0K .50W 5%	184A763H63
R190	RESISTØR	68.0K .50W 5%	184A763H71
R191	RESISTØR	68.0K .50W 5%	184A763H71

COMPONENT		DESCRIPTION	STYLE NO.
R192	RESISTØR	33.0K .50W 5%	184A763H63
R193	RESISTØR	120.0K .50W 5%	184A763H77
R194	RESISTØR	10.0K .50W 5%	184A763H51
R195	RESISTØR	18.0K .50W 5%	184A763H57
R196	RESISTØR	82.0K .50W 5%	184A763H73
R197	RESISTØR	150.0 3.00W 5%	762A679H01
R198	RESISTØR	33.0K .50W 5%	184A763H63
R199	RESISTØR	68.0K .50W 5%	184A763H71
R200	RESISTØR	4700.0 .50W 5%	184A763H43
R201	RESISTØR	2400.0 .50W 5%	184A763H35
R202	RESISTØR	82.0K .50W 5%	184A763H73
R203	RESISTØR	150.0 3.00W 5%	762A679H01
Q61	TRANSISTØR	2N699	184A638H19
Q62	TRANSISTØR	2N699	184A638H19
Q63	TRANSISTØR	2N3645	849A441H01
Q64	TRANSISTØR	2N699	184A638H19
Q65	TRANSISTØR	2N699	184A638H19
Q66	TRANSISTØR	2N3645	849A441H01
Q67	TRANSISTØR	2N699	184A638H19
Q68	TRANSISTØR	2N699	184A638H19
Q69	TRANSISTØR	2N3645	849A441H01
Q70	TRANSISTØR	2N699	184A638H19
Q71	TRANSISTØR	2N3645	849A441H01
Z21	ZENER	1N961B 10.0V	186A797H07
Z22	ZENER	1N3688A 24.0V	862A288H01
Z23	ZENER	1N961B 10.0V	186A797H07
Z24	ZENER	1N3688A 24.0V	862A288H01
Z25	ZENER	1N961B 10.0V	186A797H07
Z26	ZENER	1N3688A 24.0V	862A288H01
Z27	ZENER	1N961B 10.0V	186A797H07
Z28	ZENER	1N3688A 24.0V	862A288H01
R178	PØT	2.5K .25W	629A645H07
IC21	INT CKT	747DM	1443C52H01
J121	JUMPER	0 OHM RESISTØR	862A478H01
J122	JUMPER	0 OHM RESISTOR	862A478H01
J123	JUMPER	0 OHM RESISTOR	862A478H01
D88	DIODE	LED	3508A22H01
D89	DIODE	LED	3508A22H01

Sub. 3
Sheet 2
1444C83

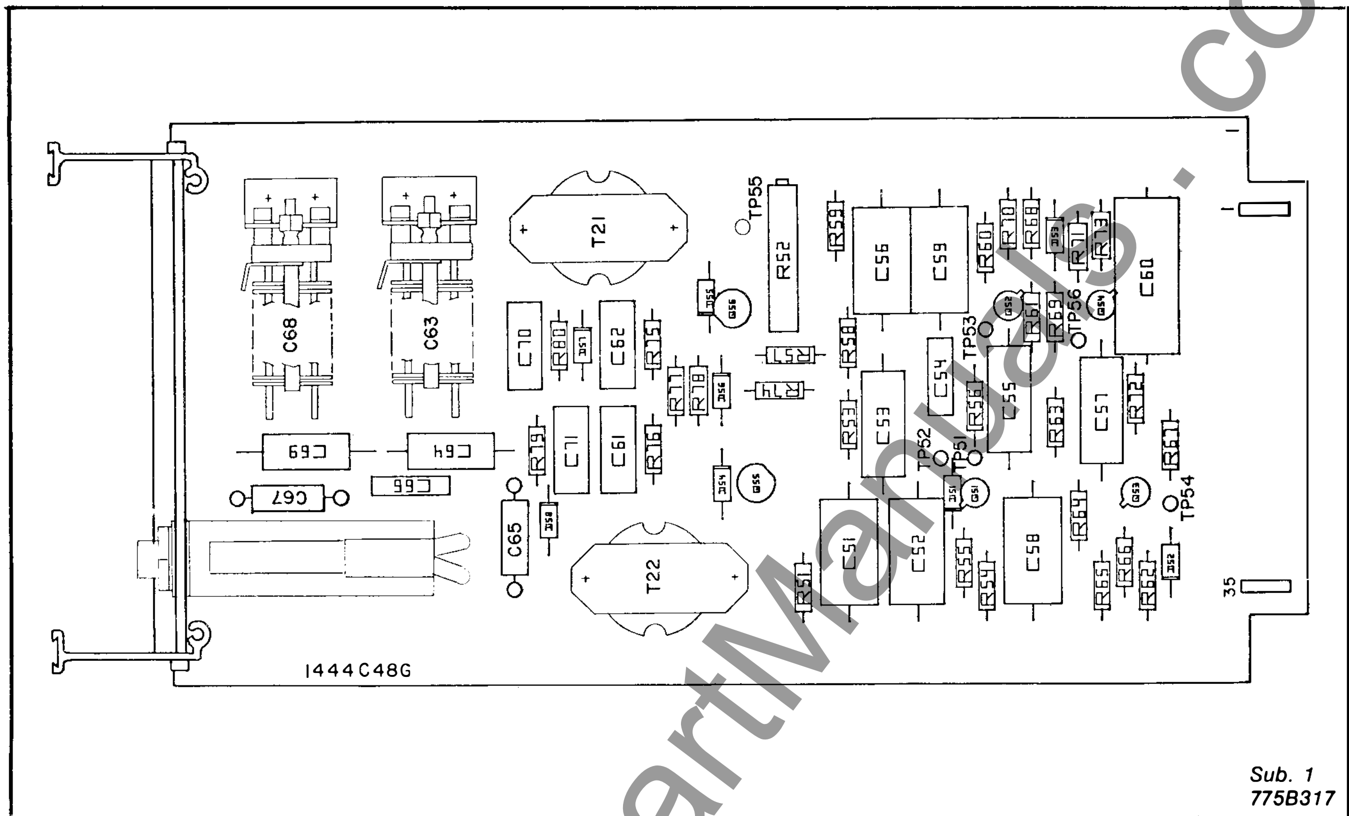
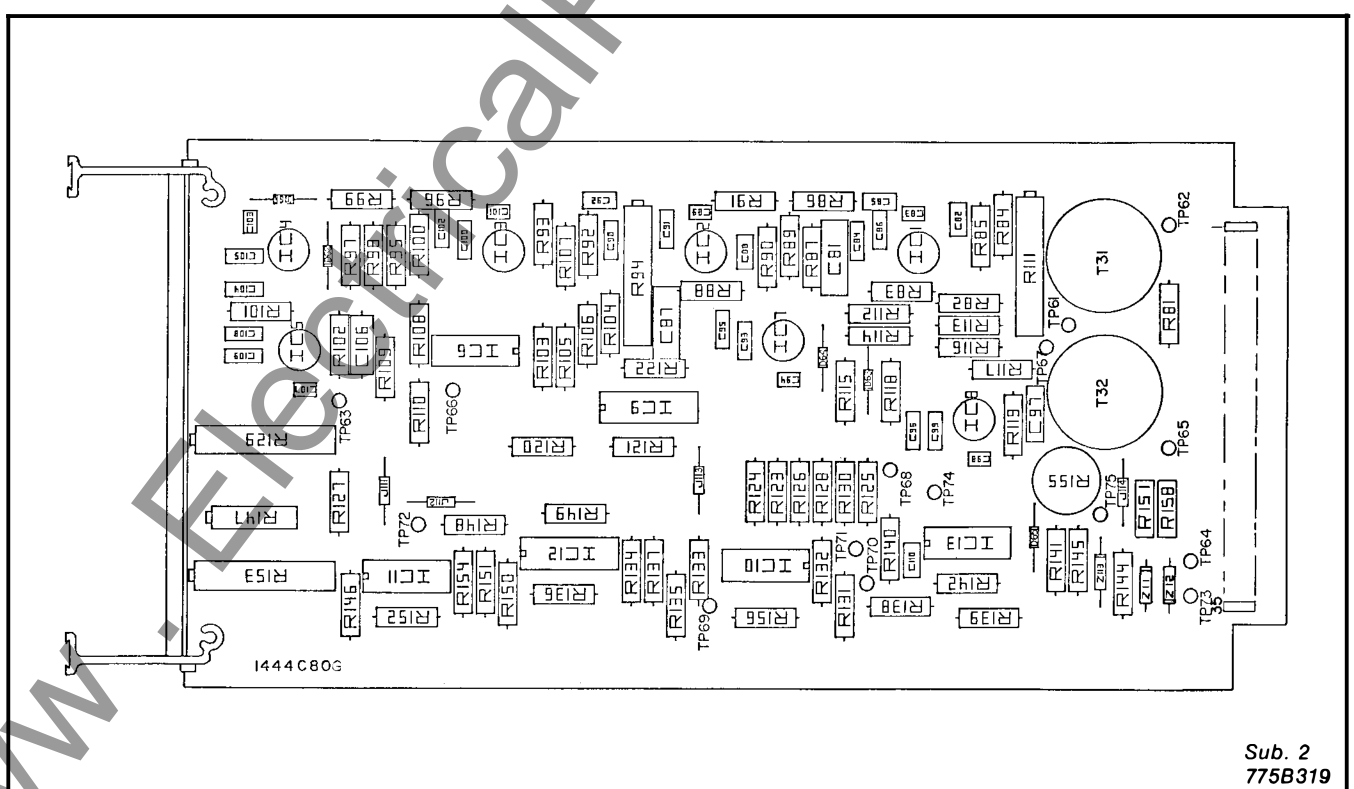
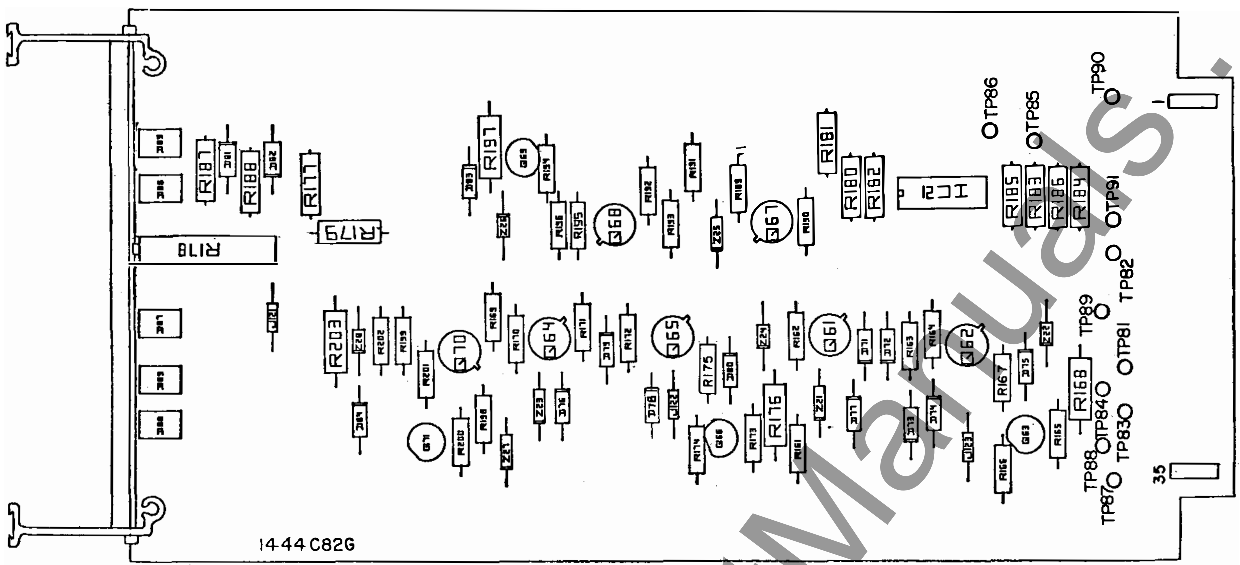


Fig. 12. Component Location Amplifier Limiter-Discriminator Module

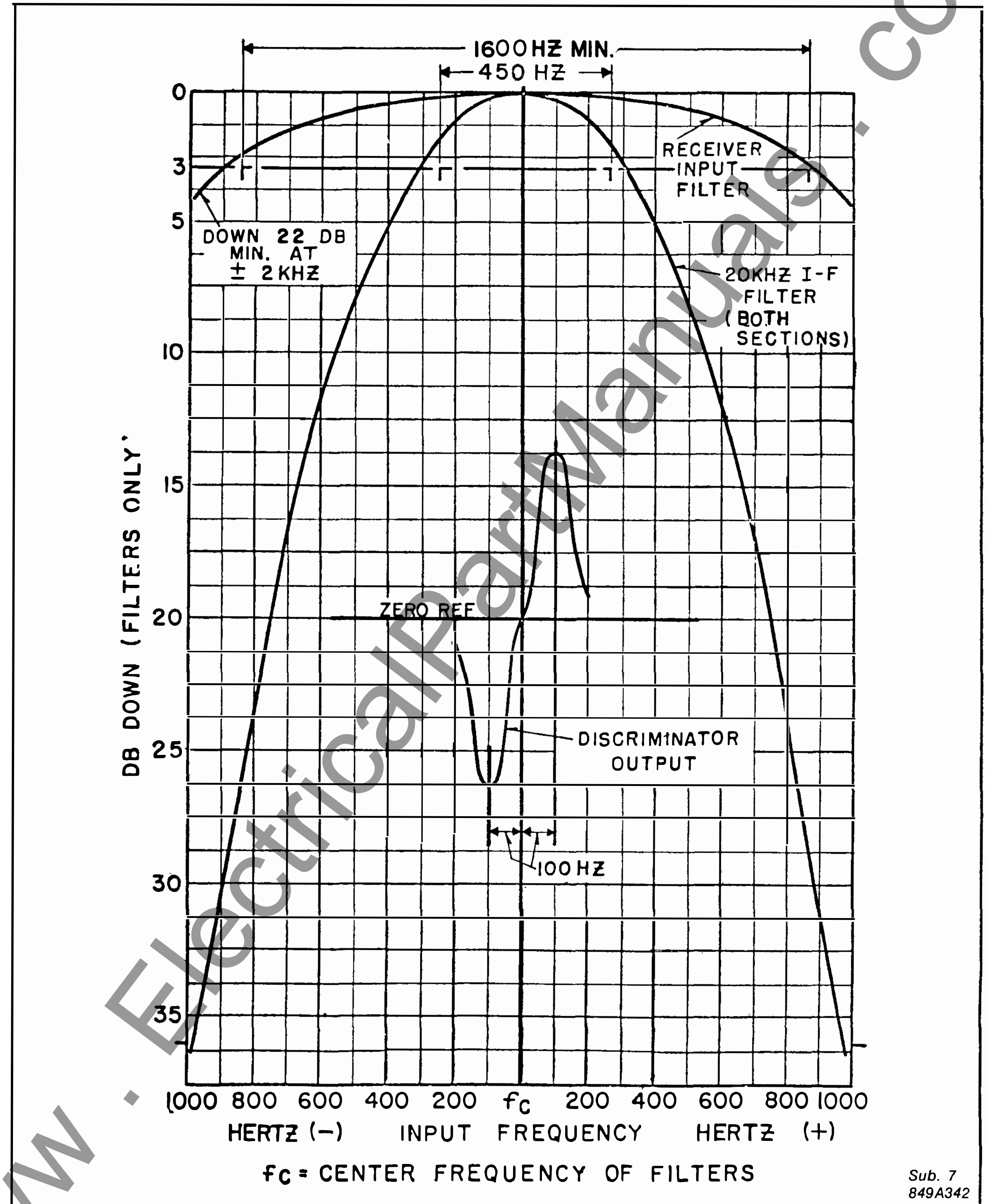


✪ *Fig. 13. Component Location SNR Detection Module*



Sub. 4
775B320

✪ *Fig. 14. Component Location Output Module*



Sub. 7
849A342

Fig. 15. Filter and Discriminator Characteristics of the Type TCF-10 Receiver

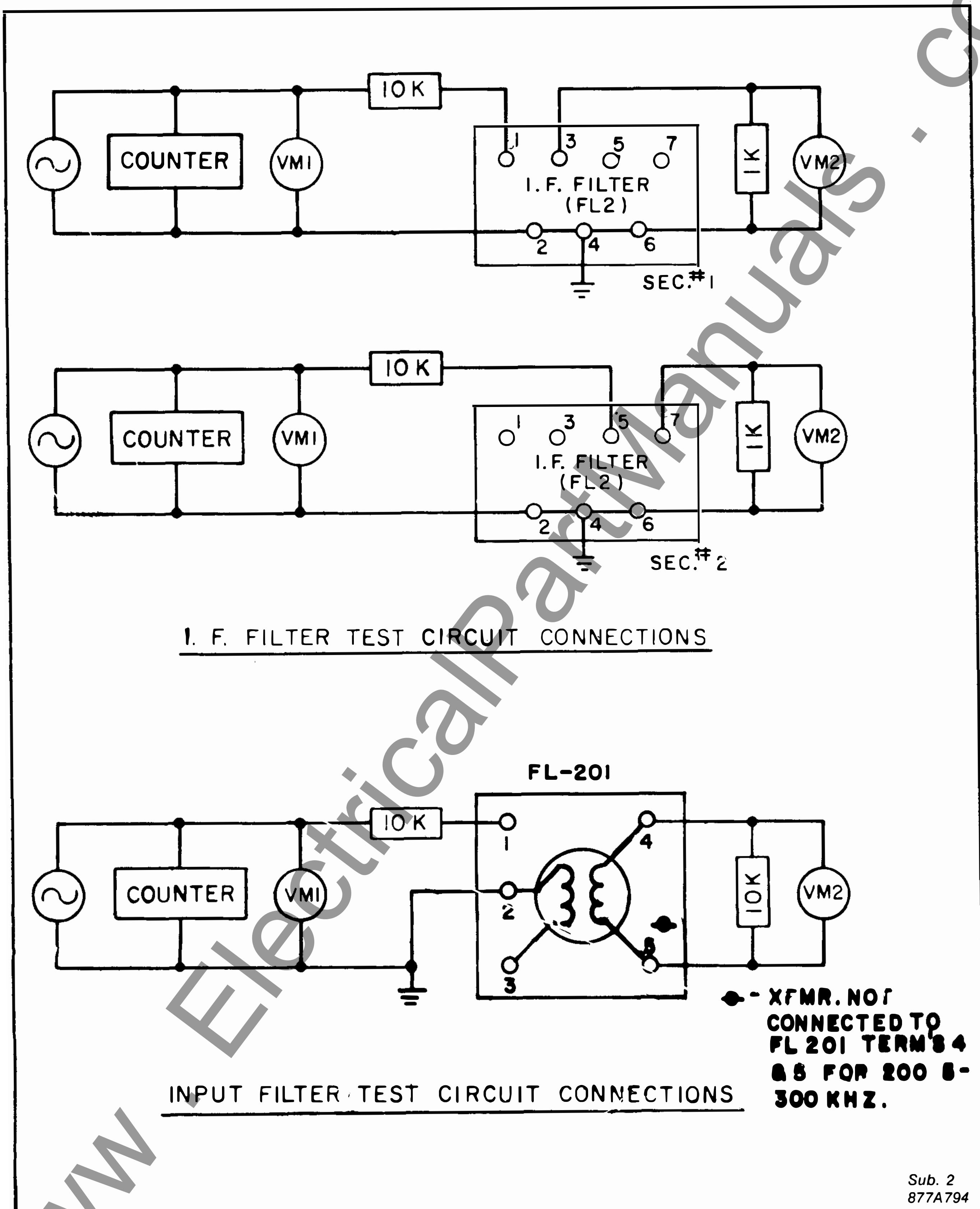
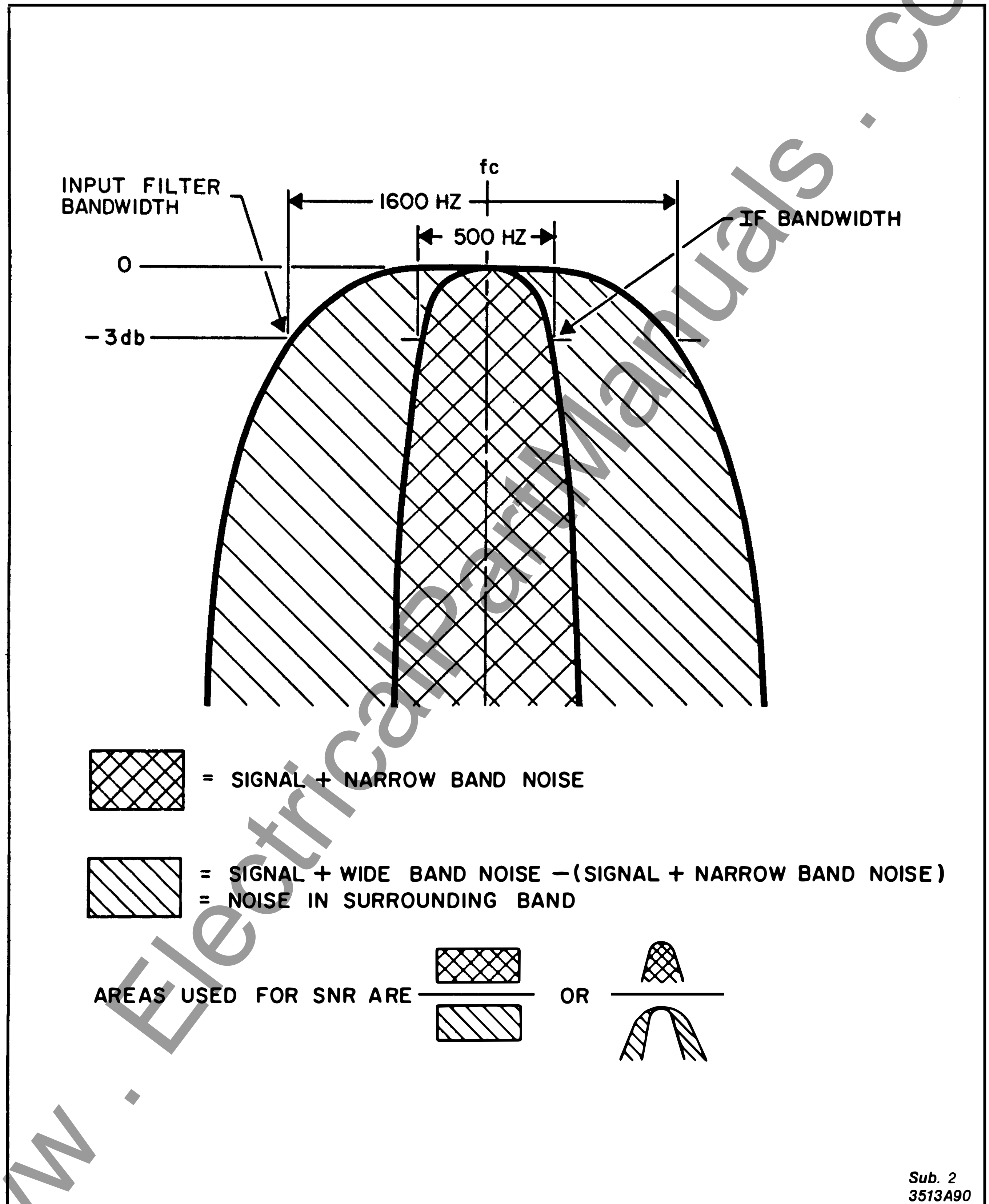


Fig. 16. Test Circuits for TCF-10 Receiver Filters



✪ *Fig. 17. Signal to Noise Ratio Characteristics*

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **CORAL SPRINGS, FL.**

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT – 1 WATT/10 WATT FOR ALL RELAYING APPLICATIONS

CAUTION: It is recommended that the user of this equipment become thoroughly familiar 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 type TCF carrier transmitter equipment provides for the transmission of either of two closely controlled discrete frequencies, both within a narrow band channel, over high-voltage transmission lines. The center frequency of the channel can vary from 30 to 300 kHz in 0.5 kHz steps. The two frequencies transmitted are separated by 200 Hz, one being at center frequency (fc) plus 100 Hz and the others at center frequency minus 100 Hz. The higher frequency, termed the Guard frequency, is transmitted continuously when conditions are normal. It indicates at the receiving end of the line that the channel is operative and it also serves to prevent false operation of the receiver by line noise. The lower frequency, termed the Trip frequency, is transmitted as a signal that an operation (such as tripping a circuit breaker) should be performed at the receiving end of the line.

When frequency-shift carrier is used in protective relaying applications, it is recommended that the trip frequency be transmitted at a higher power level to increase reliability of the system under conditions of abnormally high channel losses or line noise. The frequency is shifted from Guard to Trip by the closing of a protective relay contact and the same contact also shifts the transmitter from a 1-watt to a 10-watt output level.

When electro-mechanical relays are used for keying from guard to trip frequency, the contact used is connected to the high voltage input of a buffering keying board. This board buffers the input so that random noise does not key the circuits. When solid state relays are used, the 20 V D.C. voltage used for keying is connected to the low voltage input of the buffering keying board.

CONSTRUCTION

The 1 watt/10 watt TCF transmitter unit is mounted on a standard 19-inch wide panel 12 ¼ inches (7 rack units) high with edge slots for mounting on a standard relay rack. All components are mounted on the rear of the panel. Fuses, a pilot light, a power switch and a jack for metering the amplifier collector current are accessible from the front of the panel when supplied. See Fig. 7. All of the circuitry that is suitable for printed circuit board mounting is on three such boards, as shown in Fig. 3. The components mounted on each printed circuit board or other sub-assembly are shown enclosed by dotted lines on the internal schematic. Fig. 1 or 2. The location of components on the three printed circuit boards are shown on separate illustrations, Fig. 4, 5, and 6.

External connections to the assembly are made through a 18-circuit receptacle, J3, The r.f. output connection to the assembly is made through a coaxial cable jack, J2.

OPERATION

The transmitter is made up of four main stages and two filters. The stages include two crystal oscillators operating at frequencies that differ by the desired channel frequency, a mixer and buffer amplifier, a driver stage and a power amplifier. One filter is located between the driver and the power amplifier and the second filter removes harmonics that may be generated by distortion in the power amplifier.

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

SUPERSEDES I.L. 41-945.14B, DATED NOV. 1977
✪ DENOTES CHANGE FROM SUPERSEDED ISSUE.
EFFECTIVE DECEMBER 1978

A single crystal designed for oscillation in the 30 kHz to 300 kHz range cannot be forced to oscillate away from its natural frequency by as much as $\pm$ 100 Hz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2 MHz range. The crystals are Y1 and Y2 of Fig. 1 or 2. The frequency of Y2 is 2.00 MHz when operated with a specified amount of series capacity, and the frequency of Y1 is 2.00 MHz plus the channel frequency, or 2.03 MHz (for a 30-kHz transmitter). Capacitor C55 and crystal Y2 in series are connected between the positive side of the supply voltage and the base of transistor Q51, which operates in the emitter-follower mode. The emitter is coupled to the base through C57, and with Y2 removed the base of Q51 would be held at approximately the midpoint of the supply voltage by R51 and R52. The crystal serves as a series-resonant circuit with very high inductance and low capacitance. The circuit can be made to oscillate at other than the natural frequency of the crystal by varying the series capacitor, C55. Increasing C55 will lower the frequency of oscillations and reducing C55 will raise the frequency.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes D51 and D52. By adjustment of C52 this circuit is made to oscillate at 100 Hz above its marked frequency. Capacitor C53 is not effective until D51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the relay control contact is closed, which places 45 V.D.C. at terminal 3 of the printed circuit board. With D51 conducting, C53 is effectively in parallel with C52, and adjustment of C53 will reduce the frequency by 200 Hz. The crystals taken individually have a greater variation of frequency with temperature than would be acceptable. However, by proper matching of the two crystals, the variation in their difference frequency can be kept within limits that permit holding the frequency stability of the overall transmitter to ±10 Hz over a temperature range of −20 to +55°C.

The frequencies produced by the two oscillators are coupled to the base of mixer transistor Q53 through C62 and C63. The sum of the two frequencies is so high that a negligible amount appears on the secondary of transformer T51, but the difference frequency is accepted and amplified by Q53 and Q54.

When the relay control, or keying, contact is closed, it increases the output power from 1 watt to 10 watts as well as changing the frequency from Guard to Trip. This is effected by reducing the emitter resistance of buffer-amplifier transistor Q54. When the keying contact is open, transistor Q55 receives no base current and is non-conducting. Emitter resistor R70 therefore is effectively open-circuited. The level of output power is adjusted to 1 watt by means of R64. When Q55 is made conductive by closing the keying contact, R70 is placed in parallel with R68 and the amount of emitter resistance not bypassed by C66 can be adjusted as required to obtain a 10-watt output level.

As is shown on the Internal Schematic, Fig. 1 or 2, the voltage for the keying circuit is obtained from the 45-volt regulated supply in the transmitter, and opening the single power switch de-energizes both the transmitter and the keying circuit.

The driver stage consists of transistors Q54 and Q57 connected in a conventional push-pull circuit with input supplied from the collector of Q54 through transformer T52. Thermistor R73 and resistors R74 and R75 are connected to provide a variable bias that reduces the effect of varying ambient temperatures on the input level.

The driver filter, FL101, consists of a series-resonant inductor and capacitor connected between the driver and power amplifier stages by appropriate transformers T1 and T2. This filter greatly improves the waveform of the signal applied to the power amplifier.

The power amplifier uses two series-connected power transistors, Q101 and Q102, operating as a class B push-pull amplifier with single-ended output. Diodes D101 and D103 provide protection for the base-emitter junctions of the power transistors Zener diodes D105 and D106 protect the collector-emitter junctions from surges that might come in from the power line through the coaxial cable.

The output transformer T3 couples the power transistors to the output filter FL102. The output filter includes two trap circuits (L102, C_B and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G1 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line turner and coaxial cable. Autotransformer T4 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms.

The series resonant circuit composed of L105 and C_E is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J02 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, thus providing a reverse impedance that is free of possible "across-the-line" resonances.

The power supply is a series-type transistorized d-c voltage regulator which has a very low stand-by current drain when there is no output current demand. The Zener diode Z1 holds a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the d-c voltage drop through transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage. The Zener diode Z2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits

CHARACTERISTICS

Frequency range	30-300 kHz
Output	1 watt guard – 10 watts trip (into 50 to 70 ohm resistive load)
Frequency stability	± 10 Hz from -20°C to +55°C.
Frequency spacing	A. When used with narrow band receiver 1. One-way channel, two or more signals-500 Hz min. 2. Two-way channel, 1000 Hz min. between transmitter and adjacent receiver frequencies. B. When used with wide band receiver. 1. One-way channel, two or more signals-1000 Hz min. 2. Two-way channel, 2000 Hz min. between transmitter and adjacent receiver frequencies.
Harmonics	Down 55 db (min.) from output level.
Input Voltage	48 or 125 v.d.c.
Supply voltage variation	42-56 v. for nom. 48 v. supply. 105-140 v. for nom. 125 v.supply.
Battery drain	0.5 a. guard, 1.15 a. trip } 48 v.d.c. 0.5 a. guard, 0.9 a. trip } 125 v.d.c.
Keying circuit current	4 ma.
Temperature range	–20 to +55°C around chassis.
Dimensions	Panel height - 12¼" or 7 r.u. Panel width - 19"
Weight	12 lbs.

INSTALLATION

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

ADJUSTMENTS

The TCF 1W/10W transmitter is shipped with the power output controls R64, and R70, set for outputs of 1 watt, and 10 watts into a 60 ohm load. If it is desired to check the adjustments or if repairs have been made readjustment necessary, the coaxial cable should be disconnected from the assembly terminals and replaced with a 50 to 70 ohm non-inductive resistor of at least a 10 watt rating. Use the value of the expected input impedance of the coaxial cable and line tuner. If this is not known, assume 60 ohms. Connect the T4 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn power output control R64 to minimum (full counter-clockwise). Turn on the power switch on the panel and note the d-c voltage across terminals 5 and 7 of J3. If this is in the range of 42 to 46 volts, rotate R64 clockwise to obtain 4 or 5 volts across the load resistor used. At this point check the adjustment of the series output tuning coil L105 by loosening the knurled shaft-locking nut and moving the adjustable core in and out a small amount from its initial position. Leave it at the point of maximum voltage across the load resistor used. Then rotate R64 farther clockwise to obtain the correct voltage for 1 watt in the load resistor, as shown in the following table.

Then change to Trip frequency by connecting together terminals 2 and 3 of the transmitter printed circuit board (which is approximately equivalent to connecting together terminals 7 and 8 of J3), and rotate R70 until the voltage across the load resistor is as shown in the following table for a 10 watt output. Recheck the adjustment of L105 for maximum output voltage and readjust R70 for a 10 watt output if necessary. Tighten the locking nut on L105. Open the power switch and remove the jumper used to key the transmitter to the 10 watt level. Remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

T106 Tap	Voltage for 1 Watt Output	Voltage for 10 Watts Output
50	7.1	22.4
60	7.8	24.5
70	8.4	26.5

Follow the procedure outlined in the line tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. It is factory tuned for maximum second and third harmonic rejection, and for series resonance (maximum output at the fundamental frequency) with a 60-ohm load. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection and no change should be made in these settings unless suitable instruments are available for measuring the second and third harmonic present in the transmitter output.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals, This can be done by turning the matched pair 180° and inserting a crystal in its proper socket with the other crystal unconnected. A sensitive frequency counter with a range of at least 2.2 MHz can be connected from TP51 to TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter and avoids some error from the effect of the counter input capacitance on the oscillator circuit.) While measurement of the oscillator crystals individually is necessary for the initial adjustment of the oscillators, generally any subsequent checks may be made with a lower range counter connected at the transmitter output. If any minor adjustment of the Guard and Trip frequencies should be needed. the Guard adjustment should be made with capacitor C52 and the Trip Adjustment with C53.

Q56-Q57 Bias Adjustment

The push-pull output stages of the transmitter board are normally shipped correctly biased. If any components involved in these stages have been changed, then it may be necessary to recheck the biasing of this stage.

Unsolder the lead from terminal 2 of transformer T1 (just above FL101) and temporarily connect a low-range d-c milliammeter (0-1.0 ma) between the removed lead (+) and T1 terminal 2 (-). Turn the slotted control on the small potentiometer to full counterclockwise. Now, apply power to the TCF carrier set, but do not transmit carrier. This can be done by removing the crystals. Advance the potentiometer clockwise until the milliammeter reads 0.05 ma. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T1. Replace the crystals and again apply d-c power to reenergize the transmitter. Check output, etc. of transmitter as previously described.

CONVERSION FOR ADDING VOICE CAPABILITY

This transmitter as shipped has been internally wired so that voice can be added by merely substituting buffer keying board 265C484G01 for keying board 204C495G04. These are interchangeable plug-in modules. In addition, diode D53 should be removed from the transmitter board 6275D85G02 as noted in the schematics of Figures 1 and 2. This will now make this transmitter conform to the schematics of Figures 1 or 2 of IL41-945.13 and perform as described in that instruction leaflet. It is now only necessary to make the required external connections to connector J3 to complete the conversion to voice.

When ordering the buffer keying board 265C484G01 for conversion to voice, also request instruction leaflet IL41-945.13 as this leaflet will now contain the complete operation instructions for the transmitter after the conversion as well as the external interconnections required between the voice adapter, relaying, and transmitter.

MAINTENANCE

Periodic checks of the transmitter Guard and Trip power outputs will detect impeding failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output at such times, making any necessary readjustments to return the equipment to its initial settings.

Voltage values should be recorded 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. Readings may vary as much as +20%.

TABLE I
TRANSMITTER D-C MEASUREMENTS

Note: All voltages are positive with respect to Neg. 45 V. (TP51). All voltages read with d-c VTVM.

Test Point	Voltage at 1 watt Output	Voltage at 10 watts Output
TP52	20	20
TP53	5.4	5.4
TP54	3.4	3.4
TP55	21	18.5
TP56	21	18.5
TP57	*<1.0	*<1.0
TP58	44.3	44.1
TP59	*<1.0	*<1.0
TP101	0	0
TP103	21 ± 2	21 ± 2
TP105	44.0	44.0

TABLE II
TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages subject to variations, depending upon frequency and transistor characteristics. T51-3= Terminal 3 of transformer T51. Other transformer terminals identified similarly. All read with a-c VTVM.

Test Point	Voltage at 1 watt Output	Voltage at 10 watts Output
TP54 to TP51	0.015-0.03	0.015-0.03
TP57 to TP51	0.05 -0.09	0.3 -1.2
TP59 to TP51	0.05 -0.09	0.3 -1.2
T1-1 to TP51	1.65	5.6
T1-3 to TP51	1.45	4.9
T1-4 to Gnd.	.6	2.0
T2-1 to Gnd.	.57	1.85
TP101 to TP103	5.2	17.0
TP101 to TP105	5.2	17.0
T3-4 to Gnd.	35	112
T4-2 to Gnd.	31	110
TP109 to Gnd.	9.8	31
J102 to Gnd.	7.8	24.5

CONVERSION OF TRANSMITTER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a 1W/10W TCF transmitter for operation on a different channel frequency consist of a pair of matched crystals for the new channel frequency, new capacitors C103 and C104 on the power amplifier circuit board if the old and new frequencies are not in the same frequency group (see table on internal schematic drawing) and in general, new or modified filters FL101 and FL102. Inductors L101, L102 and L103 in these filters are adjustable over a limited range, but forty-two combinations of capacitors and inductors are required to cover the frequency range of 30 to 300 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5	207.1-214.0
32.0-33.5	64.5- 68.0	120.0-127.0	214.1-222.0
34.0-36.0	68.5- 72.0	127.5-135.0	222.1-230.0
36.5-38.5	72.5- 76.0	135.5-143.0	230.1-240.0
39.0-41.0	76.5- 80.0	143.5-151.0	240.1-250.0
41.5-44.0	80.5- 84.5	151-5-159.5	250.1-262.0
44.5-47.0	85.0- 89.0	160.0-169.5	262.1-274.0
47.5-50.0	89.5- 94.5	170.0-180.0	284.1-287.0
50.5-53.5	95.0-100.0	180.5-191.5	287.1-300.0
54.0-57.0	100.5-106.0	192.0-200.0	
57.5-60.5	106.5-112.5	200.1-207.0	

If the new frequency lies within the same frequency group as the original frequency, the filters can be readjusted. If the frequencies are in different groups, it is possible that changes only in the fixed capacitors may be required. In general, however, it is desirable to order complete filter assemblies adjusted at the factory for the specified frequency.

A signal generator, a frequency counter and a vacuum tube voltmeter are required for readjustment of FL101. The signal generator and the counter should be connected across terminals 4 and 5 of transformer T1 and the voltmeter across terminals 1 and 2 of transformer T2. The signal generator should be set at the channel center frequency and at 2 to 3 volts output. The core screw of the small inductor should be turned to the position that gives a true maximum reading on the VTVM. Turning the screw to either side of this position should definitely reduce the reading. The change in inductance with core position is less at either end of the travel then when near the center and consequently the effect of core screw rotation on the VTVM reading will be less when the resonant inductance occurs near the end of core travel.

The procedure for readjustment of the 2nd and 3rd harmonic traps of filter FL102 is somewhat similar. A signal generator and a counter should be connected to terminals 3 and 4 of transformer T3, and a 500 ohm resistor and a VTVM to the terminals of protective gap G1. The ground or shield lead of all instruments should be connected to the grounded terminal of the transformer. Set the signal generator at exactly twice the channel center frequency and at 5 to 10 volts output. Turn the core screw of the large inductor L102, to the position that gives a definite minimum reading on the VTVM. Similarly, with the signal generator set at exactly three times the channel center frequency and 5 to 10 volts output, set the core screw of the small inductor, L103, to the position that gives a definite minimum reading on the VTVM. Then remove the instruments and the 500 ohm resistor.

After the new pair of matched crystals have been adjusted, as described under "ADJUSTMENTS". the transmitter can be operated with a 50 to 70 ohm load (depending on which tap of T4 is used) connected to its output, and inductor L105 can be readjusted for maximum output at the changed channel frequency by the procedure described in the same section.

If a frequency-sensitive voltmeter is available, the 2nd and 3rd harmonic traps may be adjusted without using an oscillator as a source of double and triple the channel frequency. Connect the frequency-sensitive voltmeter from TP109 to ground and adjust the transmitter for rated output into the selected load resistor. Set the voltmeter at twice the channel frequency and, using the tuning dial and db range switch, obtain a maximum on-scale reading of the 2nd harmonic. Then vary the core position of L102 until a minimum voltmeter reading is obtained. Similarily, tune the voltmeter to the third harmonic and adjust L103 for minimum voltmeter reading. Although the transmitter frequency will differ from the channel center frequency by 100 Hz, the effect of this difference on the adjustment of the harmonic traps will be negligible. It should be noted that the true magnitude of the harmonics cannot be measured in this manner because of the preponderance of the fundamental frequency of the volt-meter terminals. Accurate measurement of the harmonics requires use of a filter between TP109 and the voltmeter that provides high rejection of the fundamental. The insertion looses of this filter for the 2nd and 3rd harmonics must be measured and taken into account.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. 60-ohm 10-watt non-inductive resistor.

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

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

II. Desirable Test Equipment for Apparatus Maintance.

a. All items listed in I.

b. Signal Generator
Output Voltage: up to 8 volts
Frequency Range: 20-kHz to 900 kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker.

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

RENEWAL PARTS

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

It should be noted that in older sets, the power regulating transistor Q1 was 2N1015C which are no longer available. These have been replaced with the 2N6259 transistor. However when replacing a 2N1015C transistor with a 2N6259 transistor, it is also necessary to replace the heat sink assembly. Therefore, in this case, order complete assembly style number 299B099G01 which consists of transistor and heat sink assembly.

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.45 mfd.; 330 V.A.C.	1723408
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C3	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized Paper, 0.47 mfd.;	849A437H04
C21	Metallized Paper, .047 mfd.;	849A437H04
C51	Dur-Mica, 1500 pf., 500 V.D.C.	762A757H03
C52	Variable, 5.5-18 pf.	879A834H01
C53	Variable, 5.5-18 pf.	879A834H01
C54	Metallized paper, .1 mfd.; 200 V.D.C.	879A834H01
C55	Variable, 5.5-18 pf.	762A736H01
C56	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C57	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C58	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C60	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C61	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C62	Dur-Mica, 4700 pf., 500 V.D.C.	762A757H04
C63	Dur-Mica, 1000 pf., 500 V.D.C.	762A757H02
C64	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C65	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C66	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C67	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C68	Metallized paper, 0.5 mfd.; 200 V.D.C.	187A624H03
C69	Metallized paper, 0.25 mfd., 200 V.D.C.	187A624H02
C70	Dur-Mica, 300 pf, 500 V.D.C.	187A584H09
C71	3 pf,	861A846H03
C72	3 pf,	861A846H03
C73	3 pf,	861A846H03
C74	Metallized paper, 1.0 mf, 200 V.D.C.	187A624H04
C75	Metallized paper, 0.5 mf, 200 V.D.C.	187A624H03
C76	Metallized paper, 0.01 mf, 200 V.D.C.	764A278H10
C77	0.47 mfd,	188A669H01
C101	Metallized paper, 0.25 mfd,; 200 V.D.C.	187A624H02
C102	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C103 & C104	(30-50 KC) – Extended foil, 0.47 mfd.; 400 V.D.C.	188A293H01
C103 & C104	(50.5-75 KC) – Extended foil, 0.22 mfd.; 400 V.D.C.	188A293H02
C103 & C104	(75.5 - 100 KC) – Extended foil, 0.15 mfd., 400 V.D.C.	188A293H03
C103 & C104	(100.5 - 150 KC) – Extended foil, 0.10 mfd., 400 V.D.C.	188A293H04
C103 & C104	(150.5 - 300 KC) – Extended foil, 0.047 mfd.; 400 V.D.C.	188A293H05
	DIODES – GENERAL PURPOSE	
D11	1N645A	837A692H03
D12	1N645A	837A692H03
D13	1N4822	188A342H11
D14	1N4822	188A342H11

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
DIODES – GENERAL PURPOSE		
D15	1N4822	188A342H11
D16	1N4822	188A342H11
D21	1N645A	837A692H03
D22	1N4822	188A342H11
D23	1N4822	188A342H11
D24	1N4822	188A342H11
D25	1N4822	188A342H11
D51	1N628; 125 V., 30 MA.	184A885H12
D52	1N628; 125 V., 30 MA.	184A885H12
D55	1N457A; 60 V., 200 MA.	184A885H07
D58	1N628; 125 V., 30 MA.	184A885H12
D101	1N538; 200 V., 750 MA.	407C703H03
D102, D104	1N91; 100 V., 150 MA. (Germanium Version used with 2N1908)	182A881H04
D103	1N538; 200 V., 750 MA.	407C703H03
D102, D104	1N4818 (Silicon Version used with 2N3792)	182A881H04
DIODES – ZENER		
Z1	1N2828B; 45V. ±5%; 50 W.	184A854H06
Z2	1N3009A; 130 V. ±10%; 10 W.	184A617H12
Z11	1N957B	186A797H06
Z12	1N3688A	862A288H01
Z13	1N3688A	862A288H01
Z14	1N3686B	185A212H06
Z21	1N957B	186A797H06
Z22	1N3688A	862A288H01
Z23	1N3688A	862A288H01
Z24	1N3688B	185A212H06
Z54	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
Z105	1N2999A; 56 V. ±10%; 10 W.	184A617H13
Z106	1N2999A; 56 V. ±10%; 10 W.	184A617H13
RESISTORS		
R1	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R2	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R3	26.5 ohms ±5%; 40 W. (For 48 V Supply)	04D1299H44
R3	500 ohms ±5%; 40 W. (For 125 V Supply)	1268047
R4	100 ohms ±10%; 1 W. Composition	187A644H03
R5	1K ±10%; ½ W. Composition	187A641H27
R6	3K ±5%; 5 W. Wire Wound	188A317H01
R7	15K ±10%; 2 W. Composition	187A642H55
R11	4.7K ±2%; ½ W. Metal Glaze	629A531H43
R12	12K ±2%; ½ W. Metal Glaze	629A531H58
R13	10K ±2%; ½ W. Metal Glaze	629A531H56

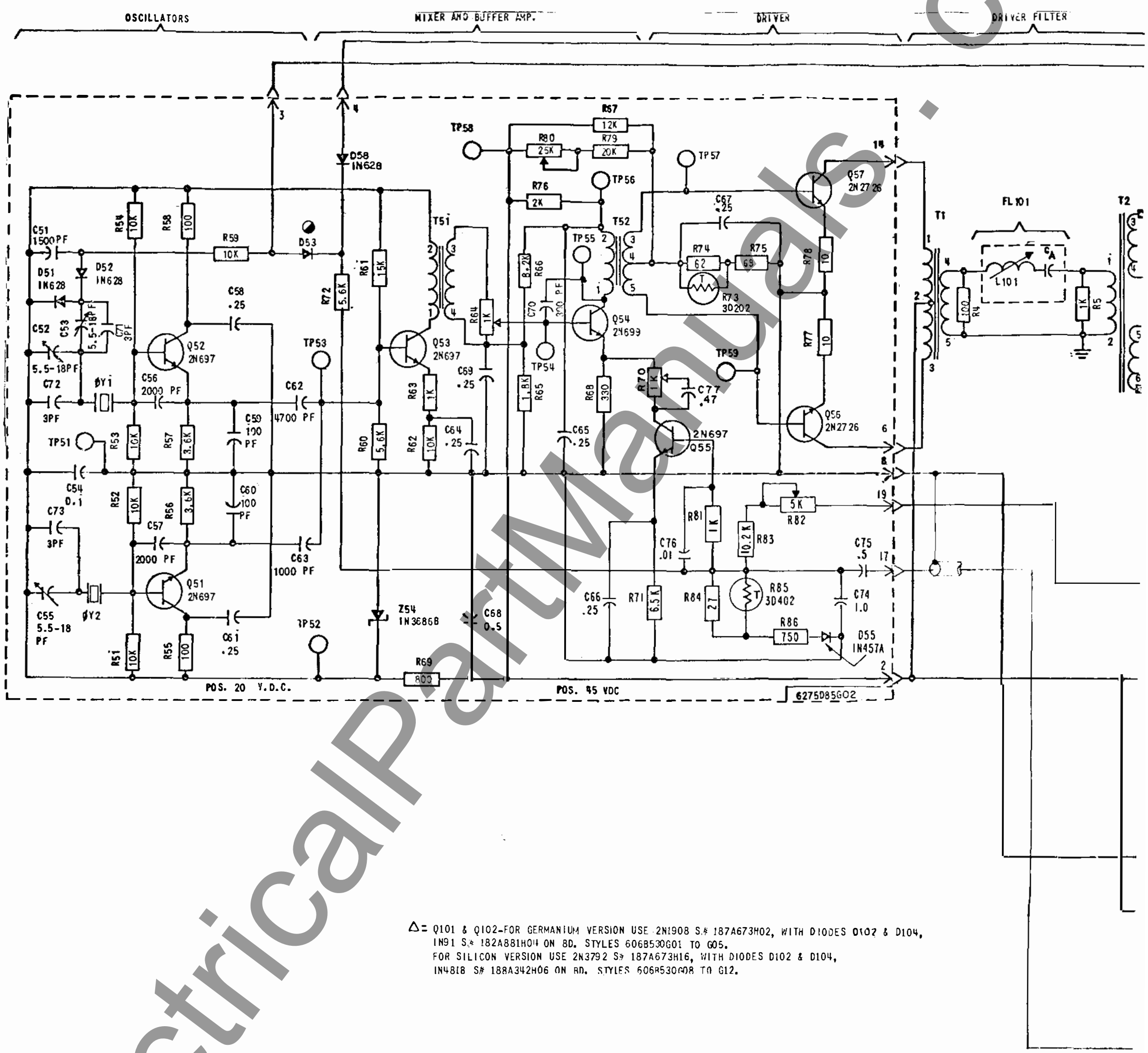
ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
RESISTORS (Continued)		
R14	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R15	1.5K ±2%; ½ W. Metal Glaze	629A531H36
R16,R26	51K ±2%; ½ W, Metal Glaze	629A531H73
R17	1.8K ±2%; ½ W. Metal Glaze	629A531H38
R21	4:7K ±2%; ½ W. Metal Glaze	629A531H48
R22	12K ±2%; ½ W. Metal Glaze	629A531H58
R23	10K ±2%; ½ W. Metal Glaze	629A531H56
R24	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R25	1.8K ±2%; ½ W. Metal Glaze	629A531H38
R18, R28	18K ±2%; ½ W. Metal Glaze	629A531H62
R27	1.5K ±2%; ½ W. Metal Glaze	629A531H36
R51	10K ±5%; ½ W. Composition	184A763H51
R52	10K ±5%; ½ W. Composition	184A763H51
R53	10K ±5%; ½ W. Composition	184A763H51
R54	10K ±5%; ½ W. Composition	184A763H51
R55	100 ohms ±5%; ½ W. Composition	184A763H03
R56	3.6K ±5%; ½ W. Composition	184A763H40
R57	3.6K ±5%; ½ W. Composition	184A763H40
R58	100 ohms ±5%; ½ W. Composition	184A763H03
R59	10K ±5%; ½ W. Composition	184A763H51
R60	5.6K ±5%; ½ W. Composition	184A763H45
R61	15K ±5%; ½ W. Composition	184A763H55
R62	10K ±5%; ½ W. Composition	184A763H51
R63	1K ±5%; ½ W. Composition	184A763H27
R64	Potentiometer, 1K; ¼ W.	629A430H02
R65	1.8K ±5%; ½ W. Composition	184A763H02
R66	8.2K ±5%; ½ W. Composition	184A763H49
R67	12K ±5%; ½ W. Composition	184A763H53
R68	330 ohms ±5%; ½ W. Composition	184A763H15
R69	800 ohms ±5%; ½ W. Composition	184A859H06
R70	Potentiometer, 1K; ¼ W.	629A430H02
R71	4.7K ±5%; ½ W. Composition	184A763H43
R72	39K ±5%; ½ W. Composition	184A763H65
R73	Thermistor, 30 ohms, Type 3D202 (G.E.C.)	185A211H06
R74	62 Ohms ±5%; ½ W. Composition	629A531H03
R75	68 Ohms ±5%; ½ W. Composition	187A290H01
R76	2K ±5%; ½ W. Composition	184A763H34
R77	10 ohms ±5%; ½ W. Composition	187A290H01
R78	10 ohms ±5%; ½ W. Composition	187A290H01
R79	20K ±2%; ½ W. Metal Glaze	629A531H63
R80	25K Potentiometer ±20%; ¼ W.	629A430H09
R81	1K ±1%; ½ W. Metal Film	848A819H48

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R82	5K Pot. ± 20%; ½ W.	629A430H07
R83	10.2K ± 1%, ½ W. Metal Film	843A820H46
R84	27 ohms ± 5%, ½ W. Composition	187A290H11
R85	Thermistor 3D402 10 ohms	185A211H03
R86	750 ohms ± 1%, ½ W. Metal Film	848A819H36
R101	10 ohms ± 5%; ½ W. Composition	187A280H01
R102	2.2K ± 10%; 1 W. Composition	187A644H35
R103	2.7 ohms ± 10%; ½ W. Wire Wound	184A636H14
R104	0.27 ohms ± 10%; 1 W. Wire Wound	184A636H18
R105	10 ohms ± 5%; ½ W. Composition	187A290H01
R106	4.7K ± 10%; 1 W. Composition	187A644H43
R107	2.7 ohms ± 10%; ½ W. Wire Wound	184A636H14
R108	0.27 ohms ± 10%; 1 W. Wire Wound	184A636H18
	TRANSFORMERS	
T1	Driver Output Transformer	606B410G01
T2	Power Amp. Input Transformer	292B526G01
T3	Power Amp. Output Transformer	292B526G02
T4	Load-Matching Auto-Transformer	292B526G03
T51	Buffer Amplifier Transformer	606B537G01
T52	Driver Input Transformer	606B537G02
	TRANSISTORS	
Q1	2N6259 ‡	3503A41H01
Q1	2N6259 with Heat Sink Assembly ‡	299B099G01
Q11	2N4356	849A441H02
Q12	2N699	184A638H19
Q21	2N4356	849A441H02
Q22	2N699	184A638H19
Q51	2N697	184A638H18
Q52	2N697	184A638H18
Q53	2N697	184A638H18
Q54	2N699	184A638H19
Q55	2N697	184A638H18
Q56	2N2726	762A672H07
Q57	2N2726	762A672H07
Q101, Q102	2N1908 (Use in Matched Pairs) (Germanium Version used with 1N91)	187A673H02
Q101, Q102	2N3792 (Use in Matched Pairs) (Silicon Version used with 1N4818)	187A673H16
	MISCELLANEOUS	
Y1-Y2 ◆	Supplied for Desired Channel Frequency in Pair Matched Per Specifications on Drawing	408C743
FL101	Driver Filter	408C261 + (Req.Freq.)
FL102	Output Filter	541S214 + (Req.Freq.)
PL	Pilot Light Bulb - For 48 V. Supply (When supplied)	187A133H02
	Pilot Light Bulb - For 125 or 259 V. Supply (When supplied)	183A955H01
F1, F2	Fuse, 1.5A (When supplied)	11D9195H26

‡ NOTE: In older sets using 2N1015C Transistor, it is necessary to replace the Heat Sink when substituting 2N6259 for the 2N1015C. Therefore order complete assembly S# 299B099G01.



△= Q101 & Q102-FOR GERMANIUM VERSION USE 2N1908 S.# 187A673H02, WITH DIODES D102 & D104, 1N91 S.# 182A881H04 ON BD. STYLES 606B530G01 TO G05.
FOR SILICON VERSION USE 2N3792 S# 187A673H16, WITH DIODES D102 & D104, IN4818 S# 188A342H06 ON BD. STYLES 606B530G08 TO G12.

DOTTED LINES ENCLOSE COMPONENTS ON PRINTED CIRCUIT BOARDS OR OTHER SUB-ASSEMBLIES (EXCEPT AS NOTED)

ALL CAPACITORS ARE IN MFD. EXCEPT AS NOTED.

ENG. REF. — TO ADD AUDIO, D53 SHOULD BE CLIPPED OUT & THIRD BUFFER ADDED.

FREQ.	C103 & C104
30-50 KHZ	0.47 MFD.
50.5-75 KHZ	0.22 MFD.
75.5-100 KHZ	0.15 MFD.
100.5-150 KHZ	0.10 MFD
150.5-300 KHZ	0.047 MFD.

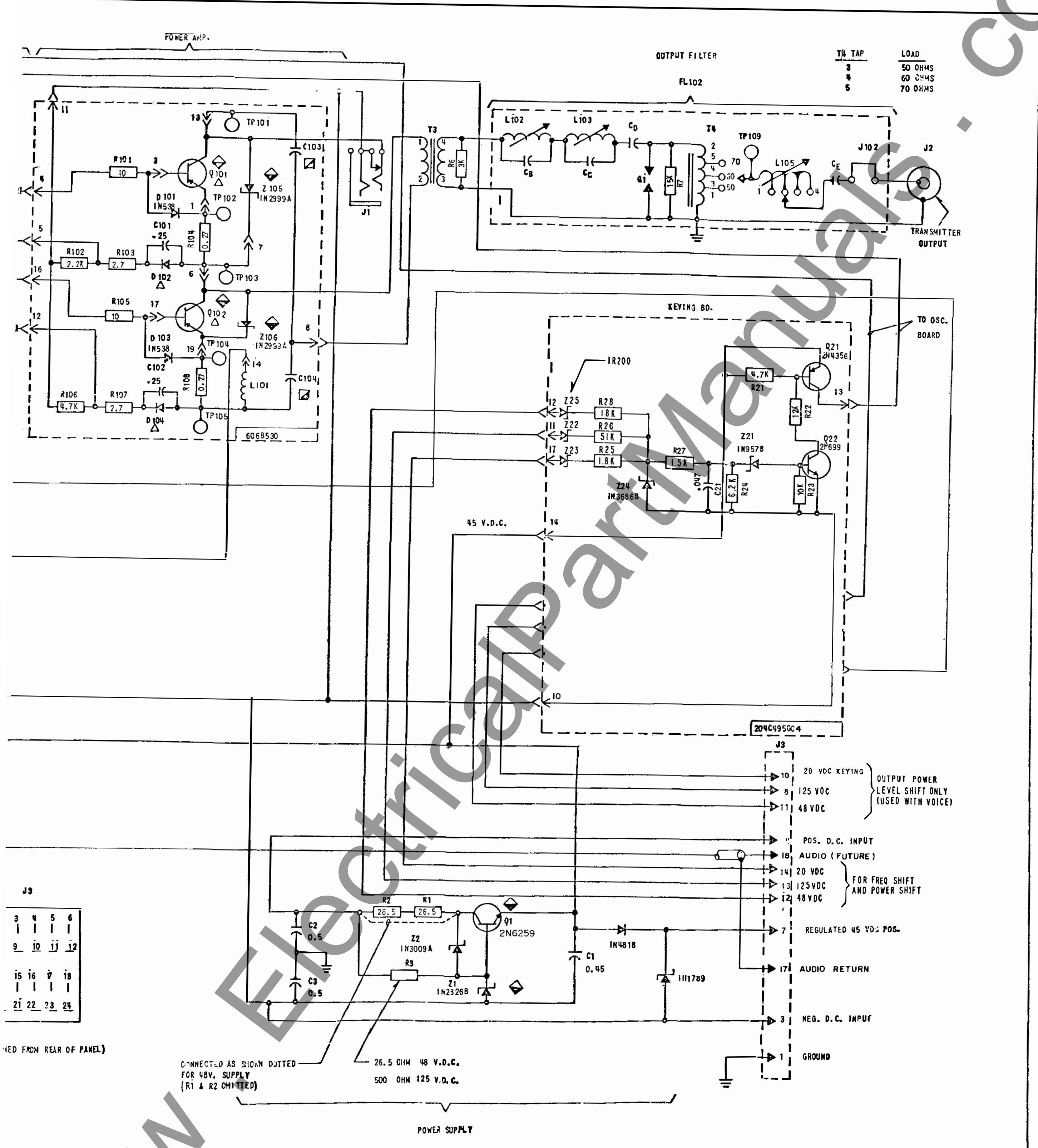
◈ = MOUNTED ON LARGE HEAT SINKS

Ø = MATCHED PAIR
Y1 - 2.03 TO 2.30 MHZ
Y2 - 2.00 MHZ

⊘ = THIS DIODE IS REMOVED FOR VOICE APPLICATIONS.

(AS VI…

Fig. 2 Internal Schematic of Type TCF 1 W…



(Dwg. 6659D31)

...tt/10 Watt Transmitter - without Switch, Pilot Light, and Fuses

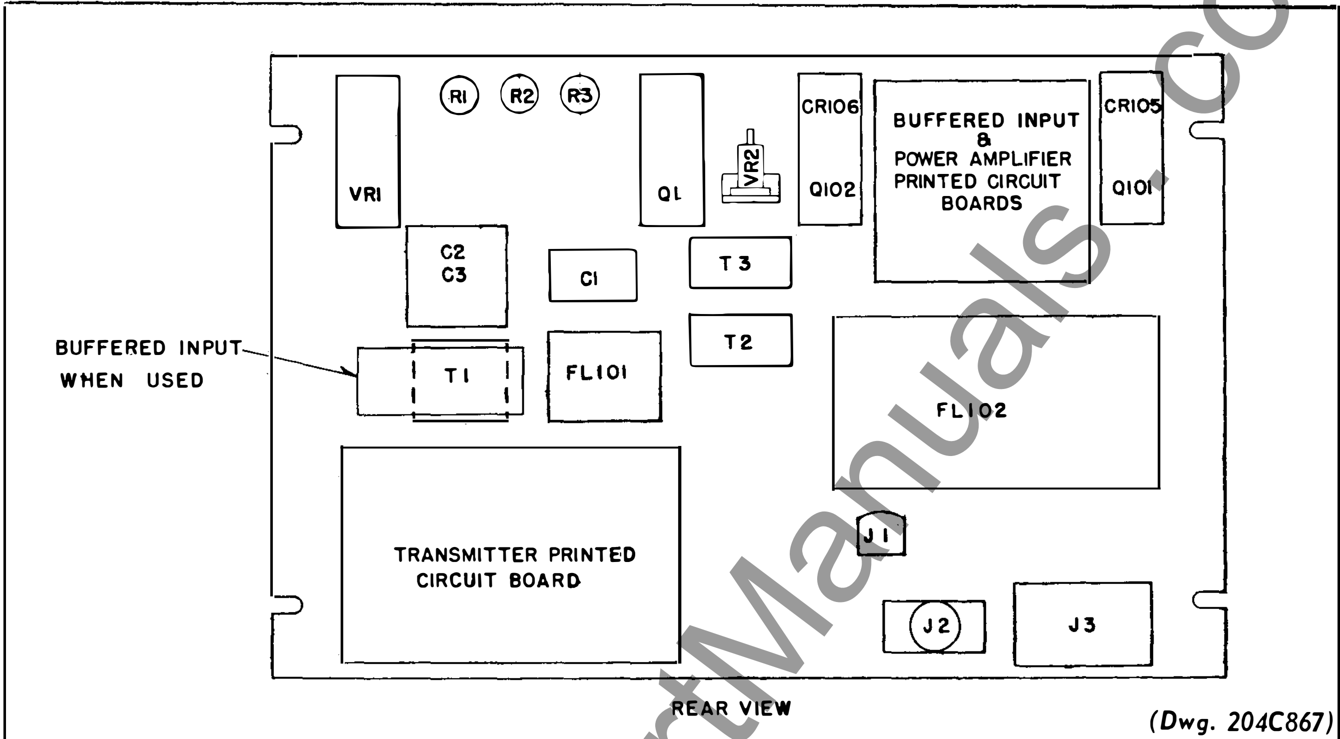


Fig. 3 Component Locations of the TCF Transmitter Assembly

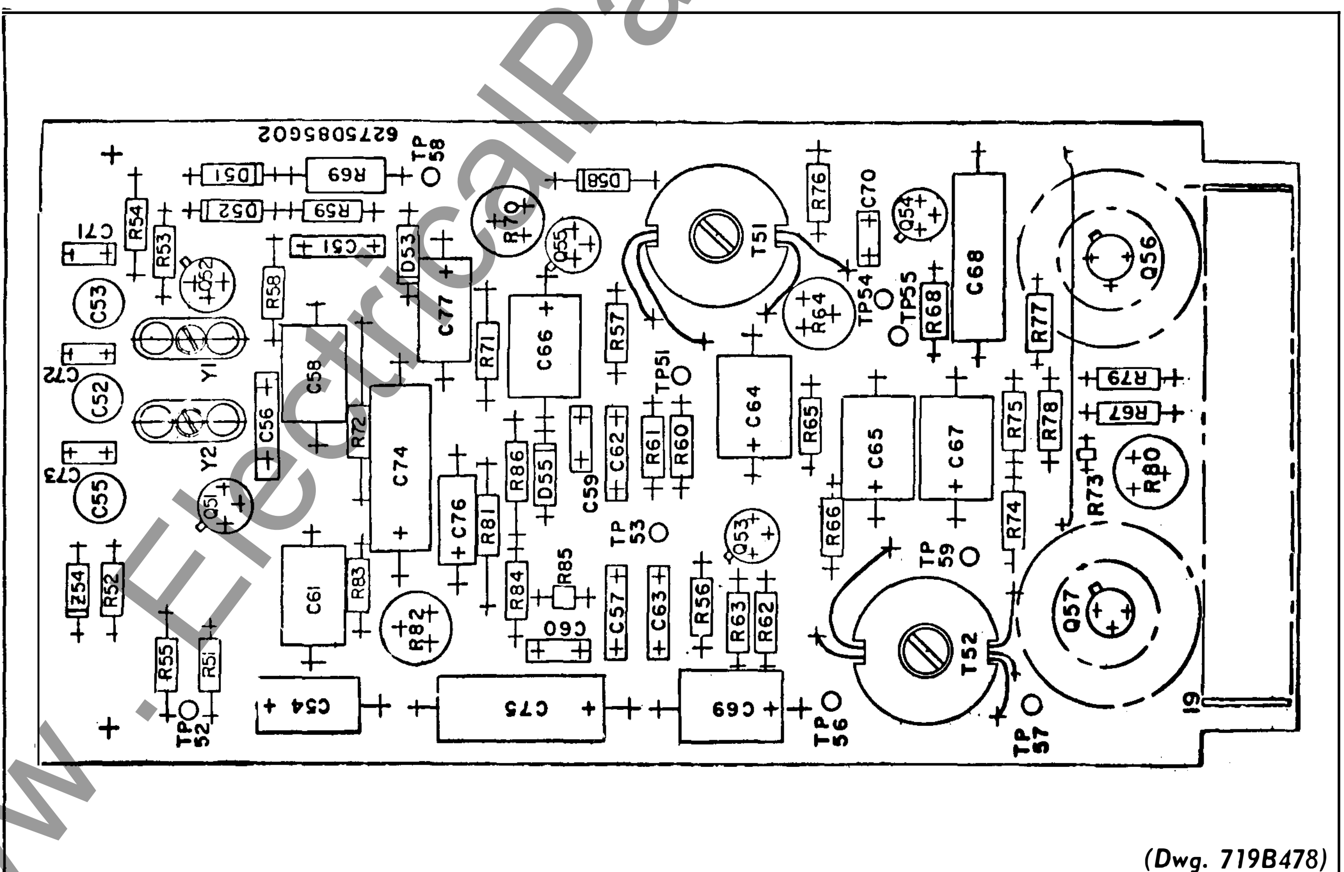


Fig. 4 Component Locations of the Transmitter Circuit Board

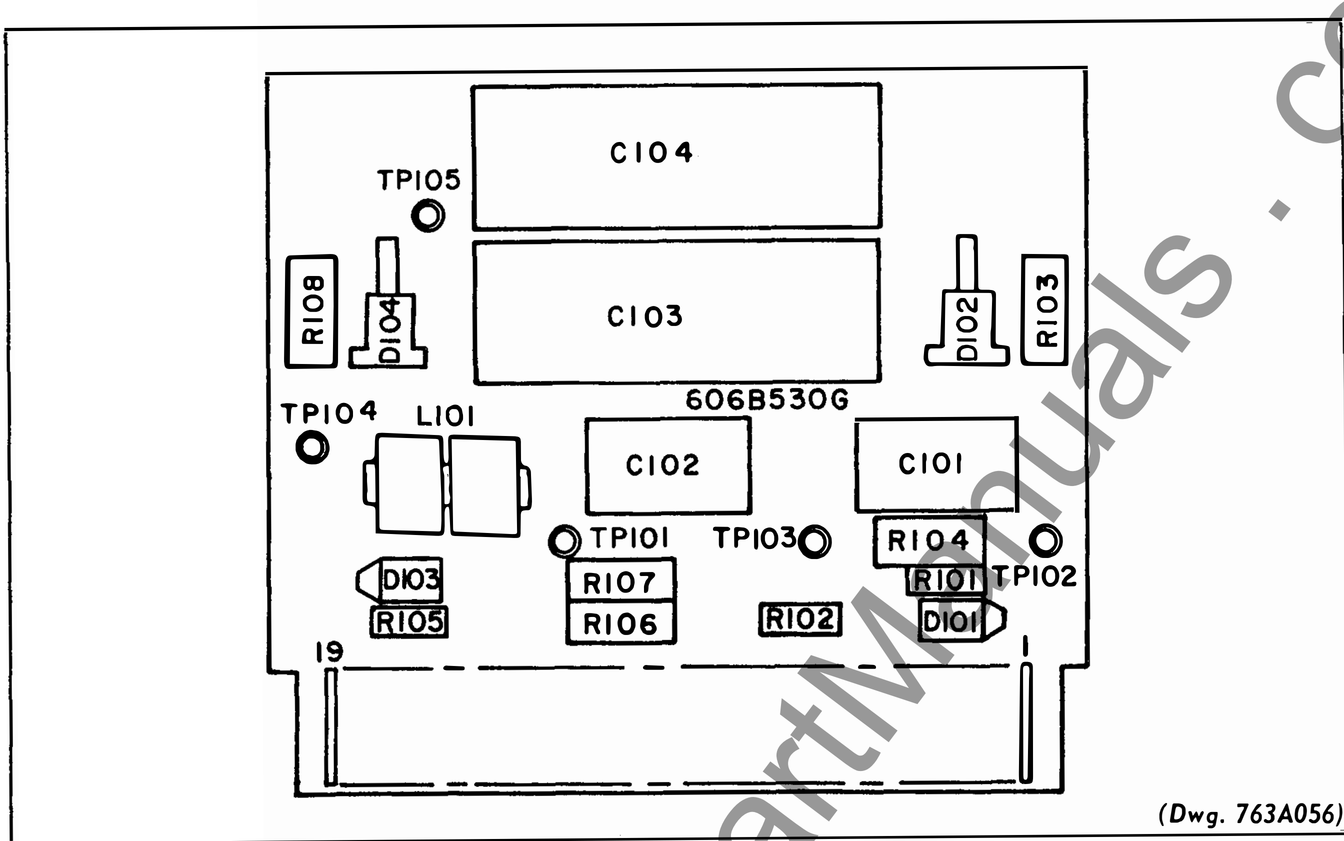


Fig. 5 Component Locations of the Power Amplifier Circuit Board

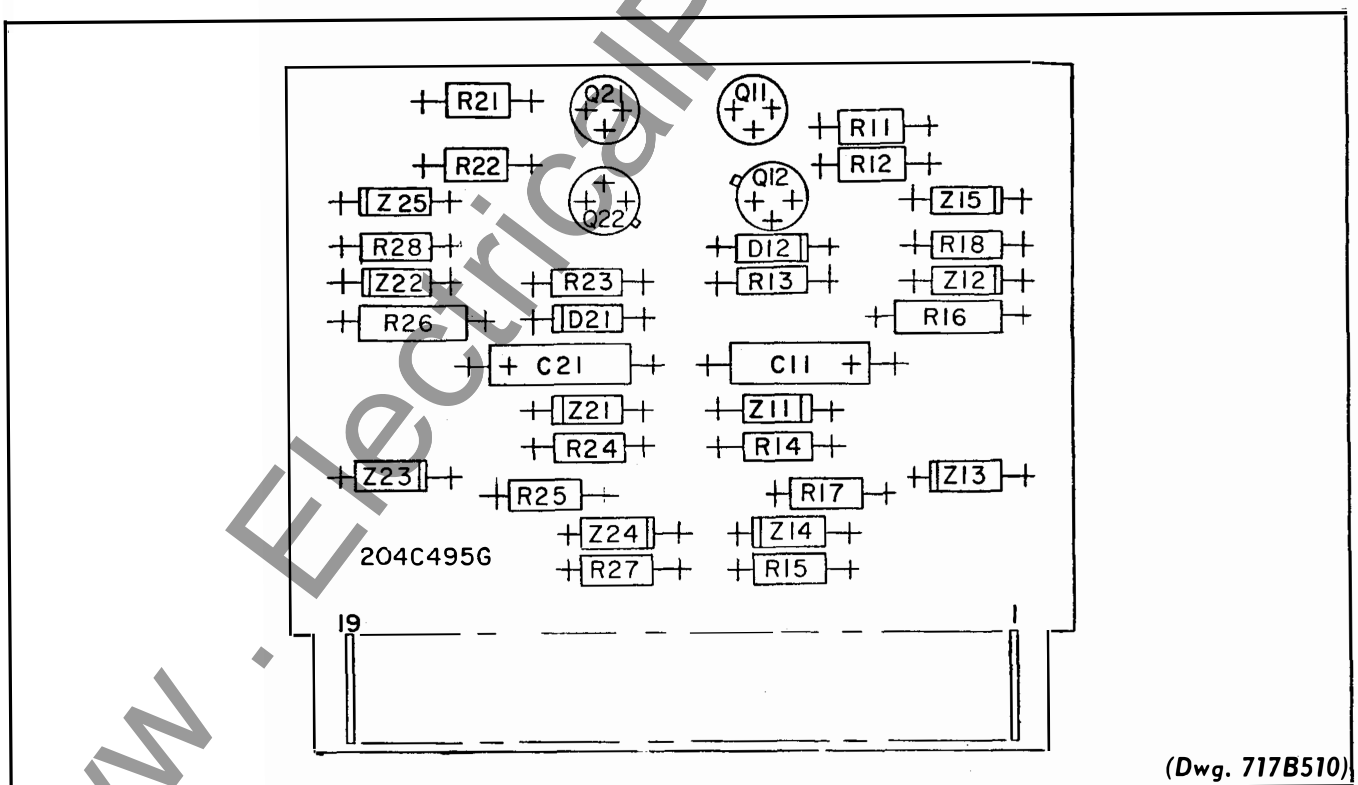


Fig. 6 Component Locations of the Buffer Keying Circuit Board

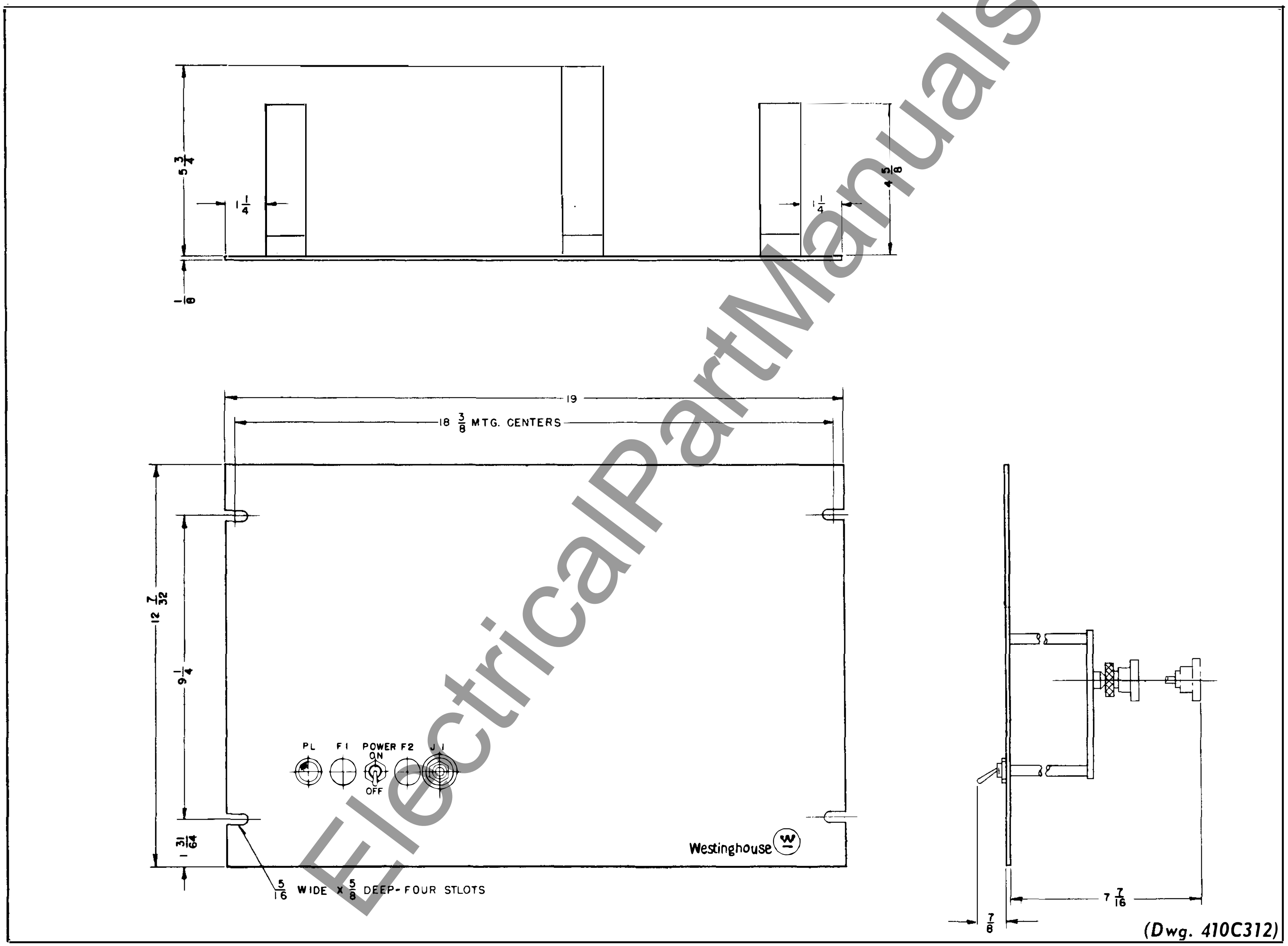


Fig. 7 Outline and Drilling Plan for TCF Transmitter Assembly

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION
CORAL SPRINGS, FL.
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 this 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 com-

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

SUPERSEDES I.L. 41-945.54A, DATED OCTOBER 1970 EFFECTIVE DECEMBER 1978
✪ DENOTES CHANGES FROM SUPERSEDED COPY

partment, 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 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 +55°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 described 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.

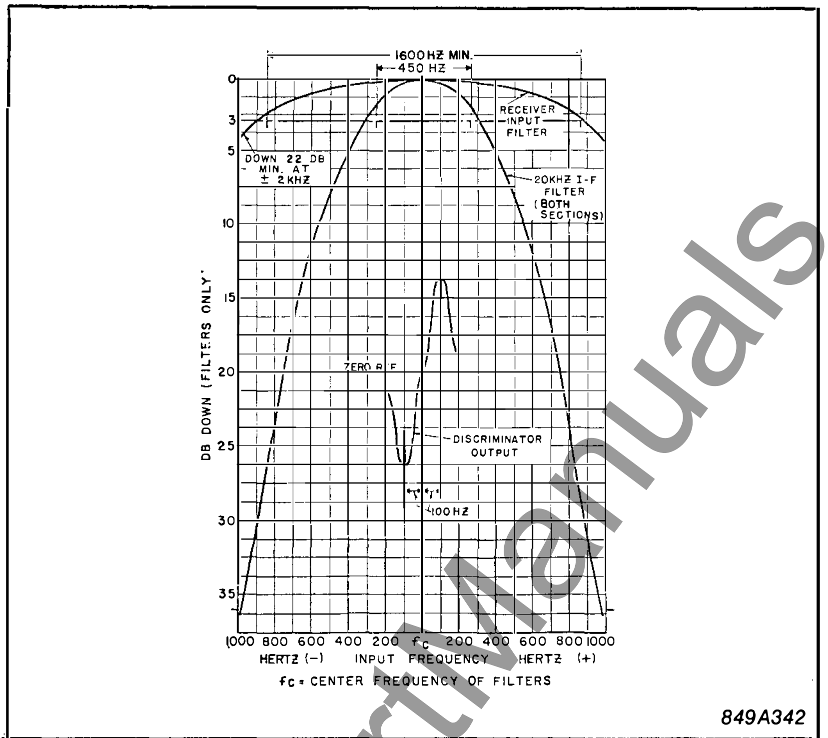


Fig. 2. Filter and Discriminator Characteristics of the TCF Receiver.

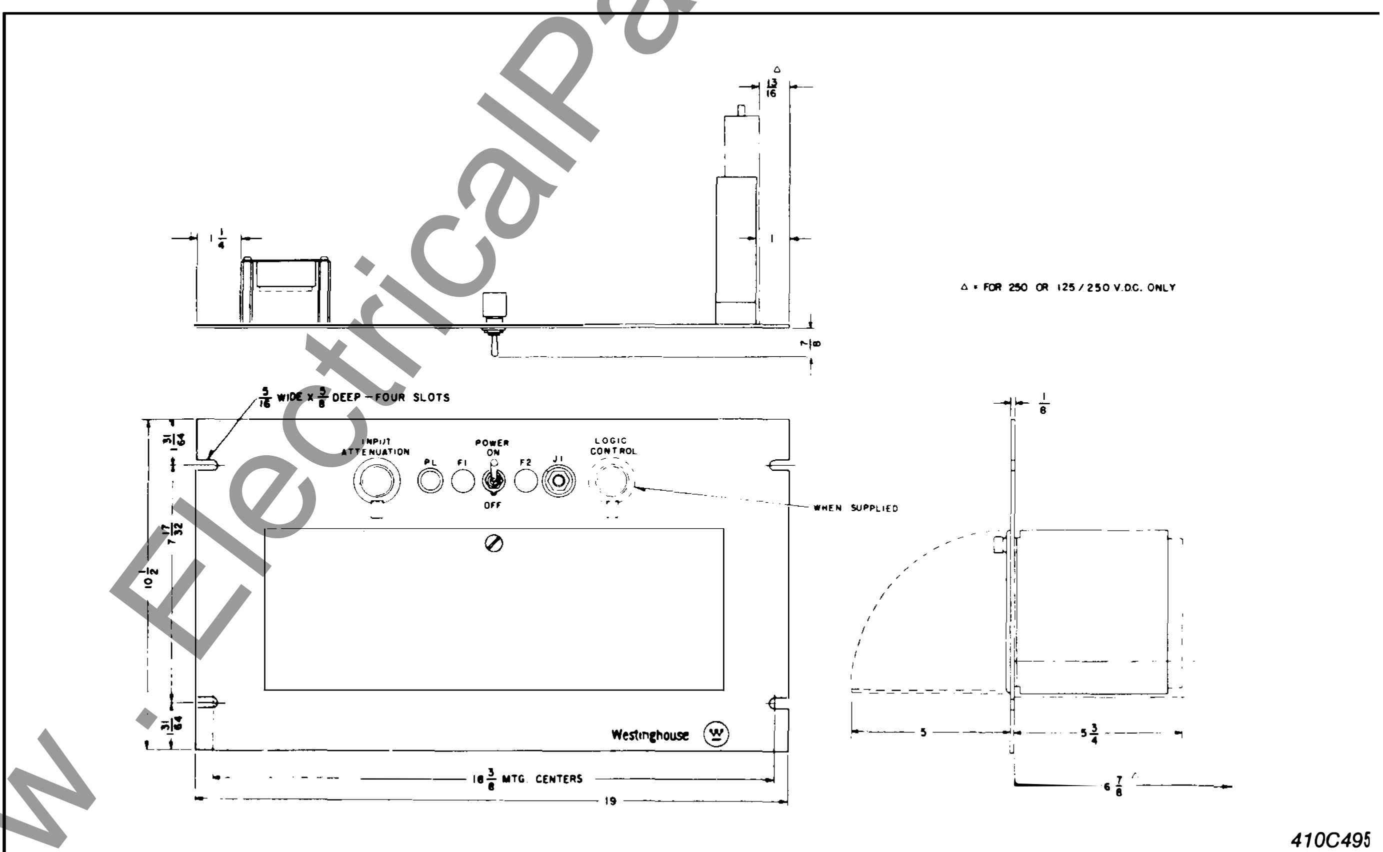


Fig. 3. Outline of the Type TCF Receiver Assembly.

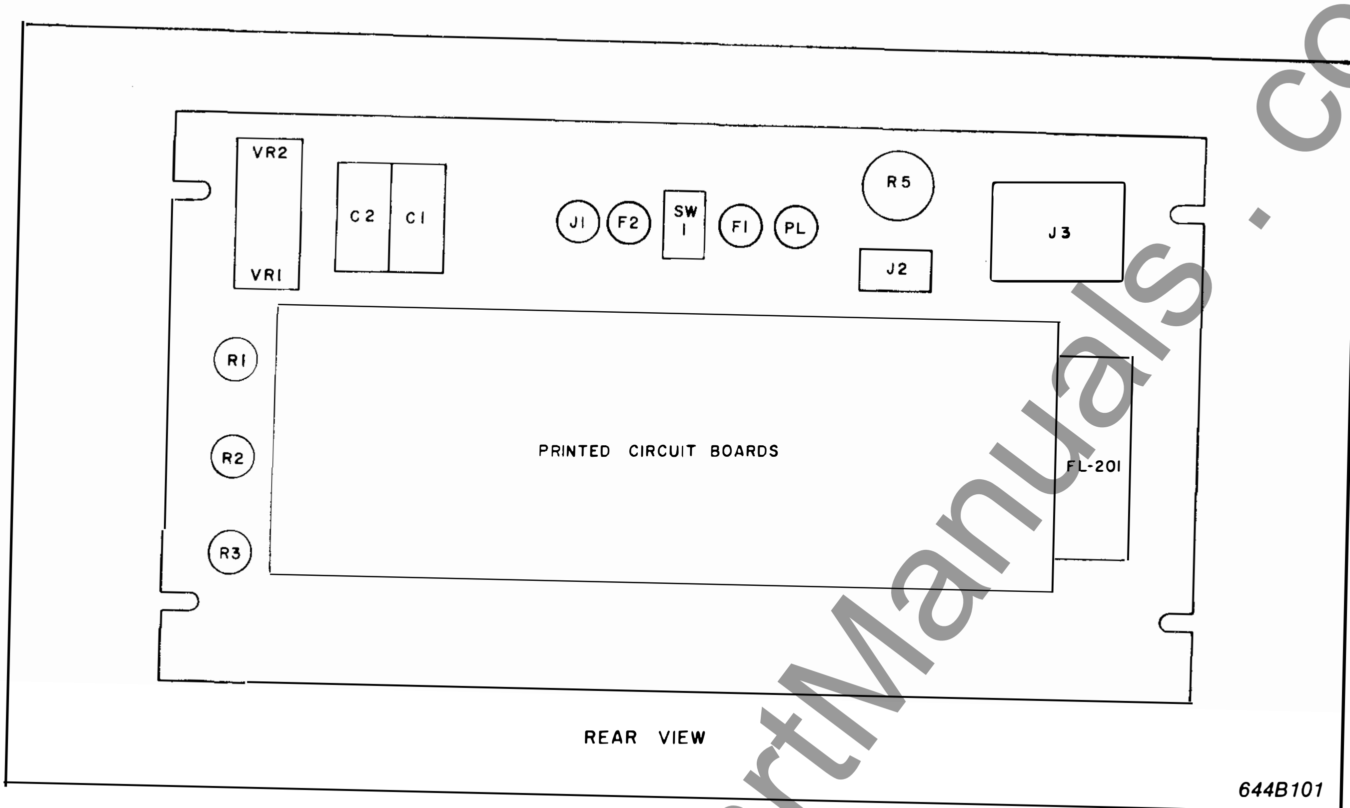
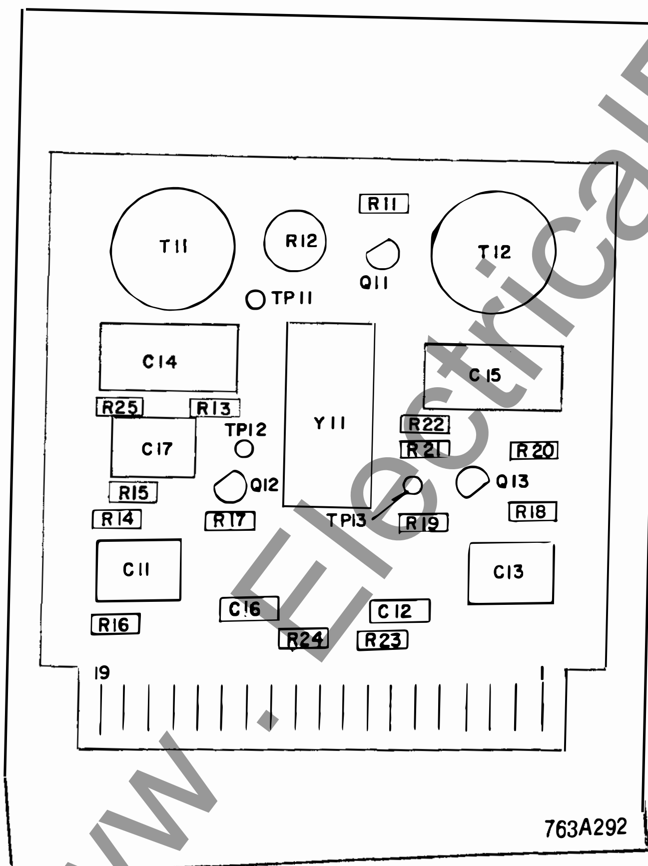


Fig. 4. Component Locations on the Type TCF Receiver Panel.



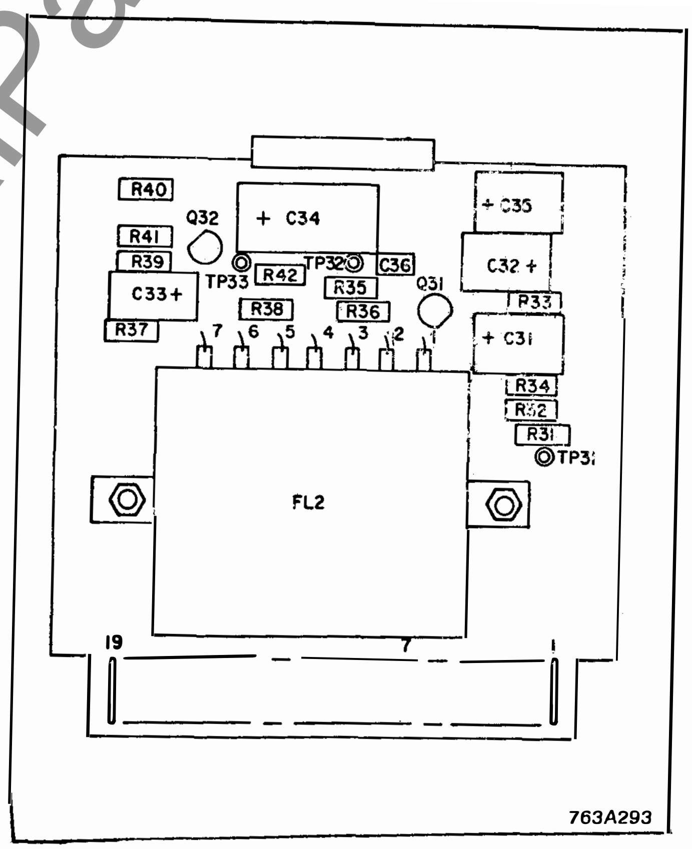
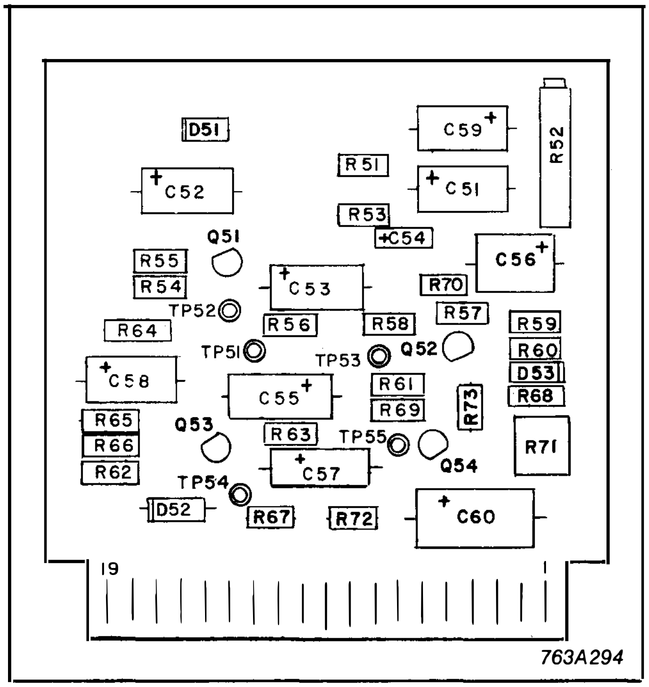
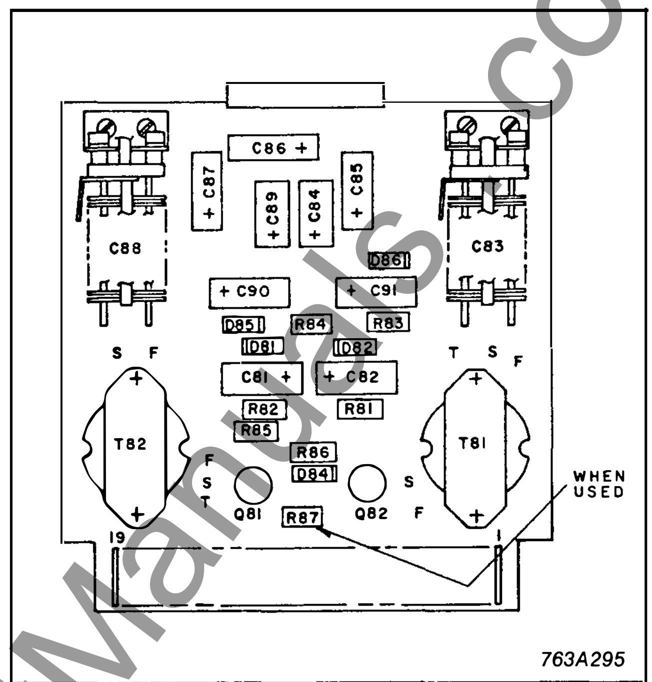


Fig. 5. Component Locations on Oscillator and Mixer Printed Circuit Board. -30-200kHz.

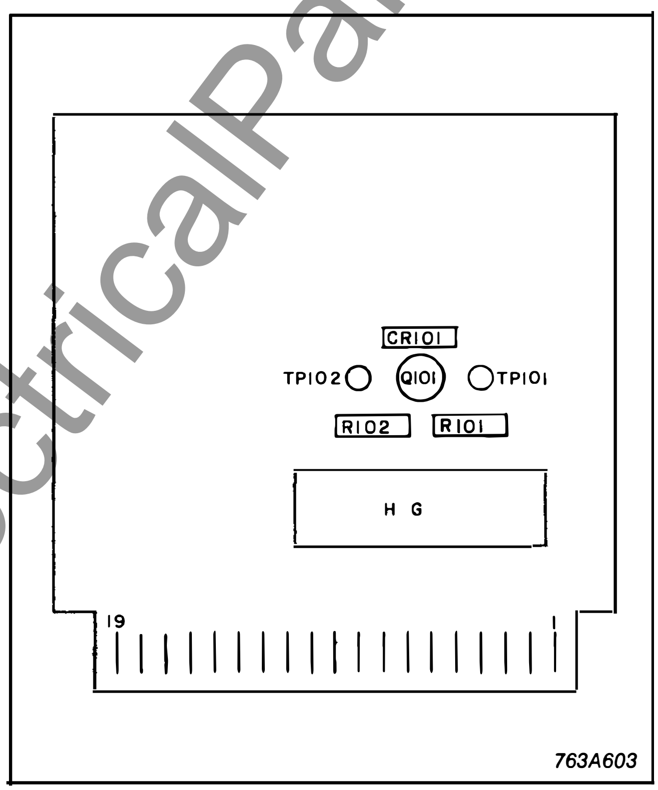
Fig. 6. Component Locations on I-F Amplifier Printed Circuit Board.



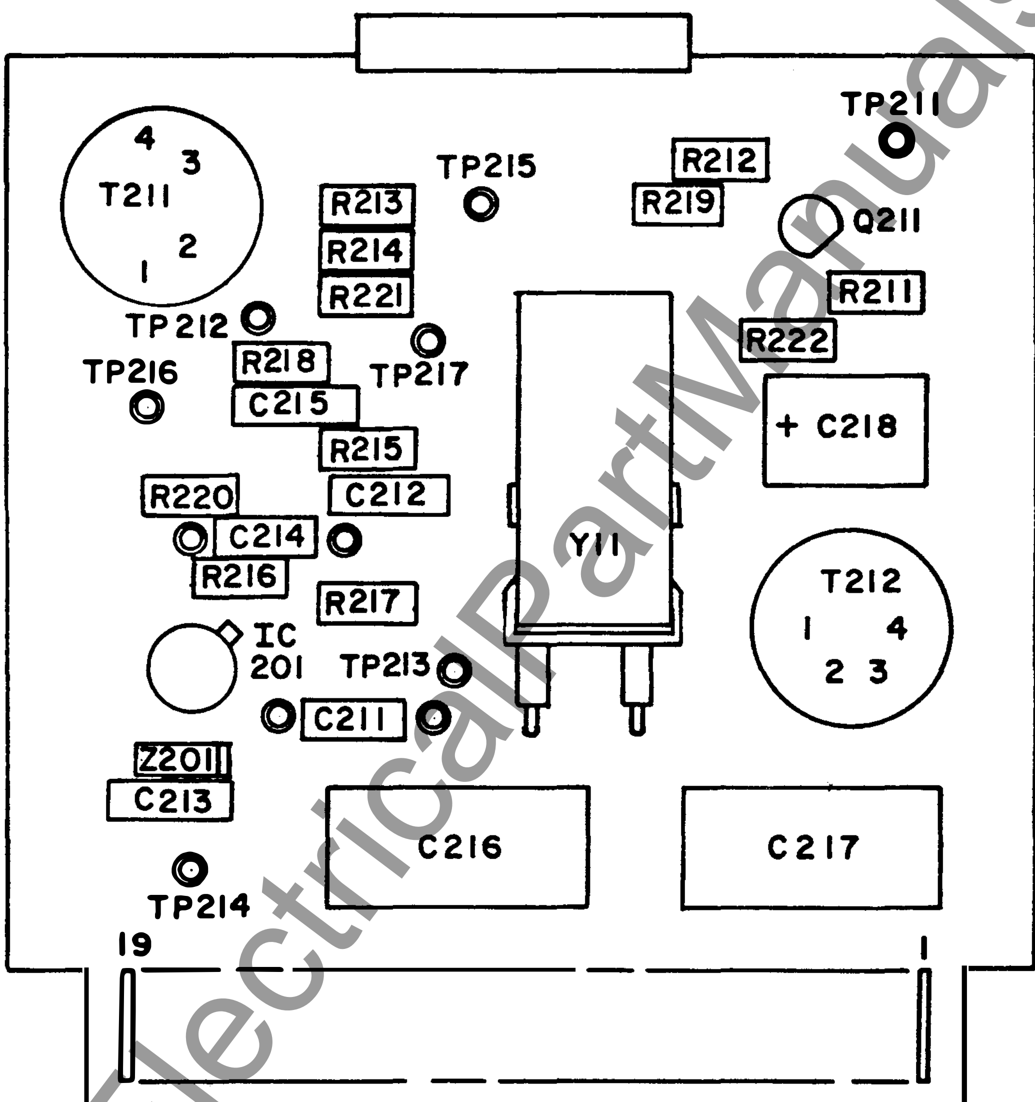
✪ *Fig. 7. Component Locations on Amplifier and Limiter Printed Circuit Board.*



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



✪ *Fig. 9. Component Locations on Output Printed Circuit Board.*



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✪ *Fig. 10. Component Location 200.5-300kHz Oscillator and Mixer.*

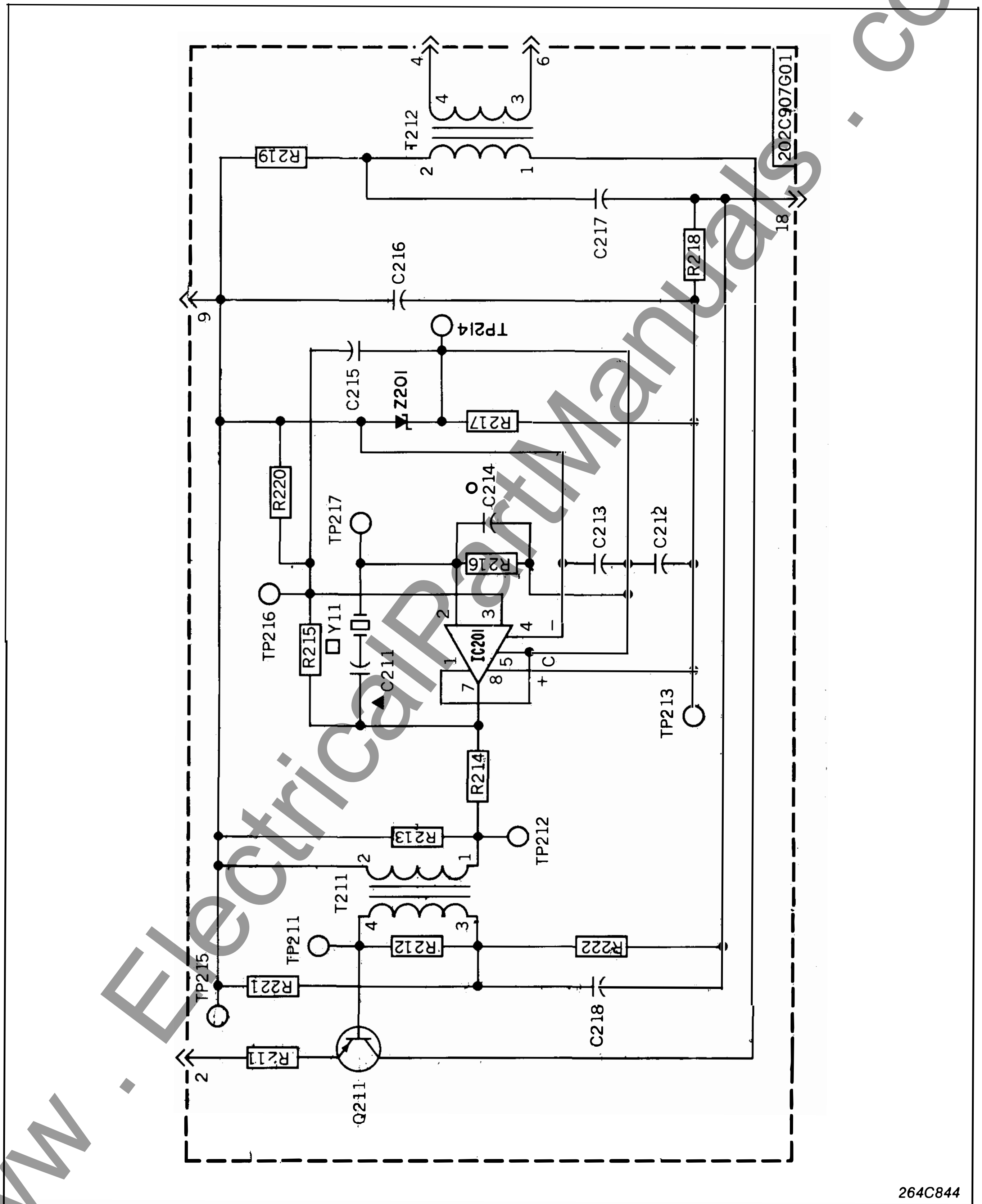


Fig. 11. Schematic Oscilllator and Mixer 200.5-300kHz

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION

CORAL SPRINGS, FL.

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT 1 WATT/10 WATT FOR KEYED AND VOICE APPLICATIONS

CAUTION: It is recommended that the user of this equipment become thoroughly familiar 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 type TCF carrier transmitter equipment provides for the transmission of either of two closely controlled discrete frequencies, both within a narrow-band channel, over high-voltage transmission lines. The center frequency of the channel can vary from 30 to 300 KHz in 0.5 KHz steps. The two frequencies transmitted are separated by 200 Hz, one being at center frequency (fc) plus 100 Hz and the others at center frequency minus 100 Hz. The higher frequency, termed the Guard frequency, is transmitted continuously when conditions are normal. It indicates at the receiving end of the line that the channel is operative and it also serves to prevent false operation of the receiver by line noise. The lower frequency, termed the Trip frequency, is transmitted as a signal that an operation (such as tripping a circuit breaker) should be performed at the receiving end of the line.

When frequency shift carrier is used in protective relaying applications, it is recommended that the trip frequency be transmitted at a higher power level to increase reliability of the system under conditions of abnormally high channel losses or line noise. The frequency is shifted from Guard to Trip by the closing of a protective relay contact, and the same contact also shifts the transmitter from a 1-watt to a 10-watt output level. •

When electro-mechanical relays are used for keying from guard to trip frequency, the contact used is connected to the high voltage input of a buffering keying board. This board buffers the input so that random noise does not key the circuits. When solid state relays are used, the 20 V D.C. voltage used for keying is connected to the low voltage input of the buffering keying board.

CONSTRUCTION

The 1 watt/10 watt TCF transmitter unit is mounted on a standard 19-inch wide panel 12¼ inches (7 rack units) high with edge slots for mounting on a standard relay rack. All components are mounted on the rear of the panel. Fuses, a pilot light, a power switch and a jack for metering the amplifier collector current are accessible from the front of the panel. See Fig. 5. All of the circuitry that is suitable for printed circuit board mounting is on two such boards, as shown in Fig. 2. The components mounted on each printed circuit board or other sub-assembly are shown enclosed by dotted lines on the internal schematic. Fig. 1. The location of components on the two printed circuit boards are shown on separate illustrations, Fig. 3 & 4.

External connections to the assembly are made through a 18-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2.

OPERATION

The transmitter is made up of four main stages and two filters. The stages include two crystal oscillators operating at frequencies that differ by the desired channel frequency, a mixer and buffer

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

SUPERSEDES I.L. 41-945.13A, DATED MARCH 1974
✪ DENOTES CHANGE FROM SUPERSEDED ISSUE.
EFFECTIVE JULY 1978

amplifier, a driver stage and a power amplifier. One filter is located between the driver and the power amplifier and the second filter removes harmonics that may be generated by distortion in the power amplifier.

A single crystal designed for oscillation in the 30 KHz to 300 KHz range cannot be forced to oscillate away from its natural frequency by as much as ± 100 Hz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2 MHz range. The crystals are Y1 and Y2 of Fig. 1. The frequency of Y2 is 2.00 MHz when operated with a specified amount of series capacity, and the frequency of Y1 is 2.00 MHz plus the channel frequency, or 2.03 MHz. Capacitor C55 and crystal Y2 in series are connected between the positive side of the supply voltage and the base of transistor Q51, which operates in the emitter follower mode. The emitter is coupled to the base through C57, and with Y2 removed the base of Q51 would be held at approximately the midpoint of the supply voltage by R51 and R52. The crystal serves as a series-resonant circuit with very high inductance and low capacitance. The circuit can be made to oscillate at other than the natural frequency of the crystal by varying the series capacitor, C55. Increasing C55 will lower the frequency of oscillations and reducing C55 will raise the frequency.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes D51 and D52. By adjustment of C52 this circuit is made to oscillate at 100 Hz above its marked frequency. Capacitor C53 is not effective until D51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the relay control contact is closed, which places 45 V.D.C. at terminal 3 of the printed circuit board. With D51 conducting, C53 is effectively in parallel with C52, and adjustment of C53 will reduce the frequency by 200 Hz. The crystals taken individually have a greater variation of frequency with temperature than would be acceptable. However, by proper matching of the two crystals, the variation in their difference frequency can be kept within limits that permit holding the frequency stability of the overall transmitter to ±10 Hz over a temperature range of −20 to ± 60°C.

The frequencies produced by the two oscillators are coupled to the base of mixer transistor Q53 through C62 and C63. The sum of the two frequencies is so high that a negligible amount appears on the secondary of transformer T51, but the difference frequency is accepted and amplified by Q53 and Q54.

When the relay control, or keying, contact is closed, it increases the output power from 1 watt to 10 watts as well as changing the frequency from Guard to Trip. This is effected by reducing the emitter resistance of buffer-amplifier transistor Q54. When the keying contact is open, transistor Q55 receives no base current and is non-conducting. Emitter resistor R70 therefore is effectively open-circuited. The level of output power is adjusted to 1 watt by means of R64. When Q55 is made conductive by closing the keying contact. R70 is placed in parallel with R68 and the amount of emitter resistance not bypassed by C66 can be adjusted as required to obtain a 10-watt output level.

As is shown on the Internal Schematic, Fig. 1, or Fig. 2, the voltage for the keying ciruit is obtained from the 45-volt regulated supply in the transmitter, and opening the single power switch de-energizes both the transmitter and the keying circuit.

The driver stage consists of transistors Q56 and Q57 connected in a conventional push-pull circuit with input supplied from the collector of Q54 through transformer T52. Thermistor R73 and resistors R74 and R75 are connected to provide a variable bias that reduces the effect of varying ambient temperatures on the input level.

The driver filter, FL101, consists of a series-resonant inductor and capacitor connected between the driver and power amplifier stages by appropriate transformers T1 and T2. This filter greatly improves the waveform of the signal applied to the power amplifier.

The power amplifier uses two series-connected power transistors, Q101 and Q102, operating as a class B push-pull amplifier with single-ended output. Diodes D101 and D103 provide protection for the base-emitter junctions of the power transistors. Zener diodes D105 and D106 protect the collector-emitter junctions from surges that might come in from the power line through the coaxial cable.

The output transformer T3 couples the power transistors to the output filter FL102. The output filter includes two trap circuits (L102, C_B and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G1 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line turner and coaxial cable. Auto-transformer T4 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms.

The series resonant circuit composed of L105 and C_E is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J02 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, thus providing a reverse impedance that is free of possible "across-the-line" resonances.

The power supply is a series-type transistorized d-c voltage regulator which has a very low stand-by current drain when there is no output current demand. The Zener diode Z1 holds a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the d-c voltage drop through transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage. The Zener diode Z2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

When keyed for voice by the voice adapter, transistor Q55 is keyed into class A operation so that its conduction can be modulated by the voice input from the voice adapter. Potentiometer R82 is adjusted so that the nominal output of carrier is 3.25 watts (14 volts across 60 ohms). The voice input modulates the carrier through this transistor by varying the amount of conduction of Q55 so that the output power of carrier varies with the voice amplitude following the voice frequency components. Since with Q55 completely non-conducting, R64 has been set to produce a 1-watt output, maximum modulation on the side to shut off Q55 will not result in an output level of less than 1-watt carrier at any time. Also since the output level has been set at 10 watts with Q55 completely conducting by the adjustment of R70, the maximum modulation on the side of turn on of Q55 will not result in a carrier output level of greater than 10 watts at any time. Thus the modulation for voice will not result in the output carrier level dropping below 1 watt and endangering the guard frequency for relaying purposes.

The buffer keying board in addition to providing proper buffering, also contains logic for the proper keying of both frequency and output level in regards to protective relaying operation, voice adapter operation, and 52b contact operation.

It should be remembered that protective relaying operation has first priorty. If the protective relay operates and puts a voltage input into any of the three input points labeled carrier auxiliary keying, the transmitter will both frequency shift to trip frequency and full 10 watts output whether voice is called for or not.

The operation of the 52b contact will remove the 10 watt keying output and permit the voice adapter to key to 3.2 Watts output for AM voice modulation. This allows voice modulation on the trip frequency after the 52b contact has operated.

CHARACTERISTICS

Frequency Range	30-300 kHz	
Output	1 watt guard - 10 watts trip - 3.2 watts voice (into 50 to 70 ohm resistive load)	
Frequency Stability	±10 Hz from -20°C to +55°C.	
Frequency spacing	Two-way channel, - See Voice Adapter Instruction Leaflet.	
Harmonics	Down 55 db (min.) from output level.	
Input voltage	48 or 125 v.d.c.	
Supply voltage variation	42-56v. for nom. 48v. supply. 105-140v. for nom. 125v. supply.	
Battery drain	0.5 a. guard 1.15a. trip	48 v.d.c.
	0.5 a. guard 0.9 a. trip	125 v.d.c.
Keying circuit current	4 ma.	
Temperature range	−20 to +60°C. around chassis.	
Dimensions	Panel height - 12¼" or 7 r.u. Panel width - 19"	
Weight	12 lbs.	

INSTALLATION

The TCF transmitter 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

The TCF 1W/10W transmitter is shipped with the power output controls R64, R82 and R70, set for outputs of 1 watt, 3.2 watts and 10 watts into a 60 ohm load. If it is desired to check the adjustments or if repairs have made readjustment necessary, the coaxial cable should be disconnected from the assembly terminals and replaced with a 50 to 70 ohm non-inductive resistor of at least a 10 watt rating. Use the value of the expected input impedance of the coaxial cable and line tuner. If this is not known, assume 60 ohms. Connect the T4 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn power output control R64 to minimum (full counter-clockwise). Turn on the power switch on the panel and note the d-c voltage across terminals 5 and 7 of J3. If this is in the range of 42 to 46 volts, rotate R64 clockwise to obtain 4 or 5 volts across the load resistor used. At this point check the adjustment of the series output tuning coil L105 by loosening the knurled shaft-locking nut and moving the adjustable core in and out a small amount from its initial position. Leave it at the point of maximum voltage across the load resistor used. Then rotate R64 farther clockwise to obtain the correct voltage for 1 watt in the load resistor, as shown in the following table.

Then change to Trip frequency by connecting together terminals 2, 3 and 4 of the transmitter printed circuit board (which is approximately equivalent to connecting together terminals 7 and 12 of J3), and rotate R70 until the voltage across the load resistor is as shown in the following table for a 10 watt output. Recheck the adjustment of L105 for maximum output voltage and readjust R70 for a 10 watt output if necessary. Tighten the locking nut on L105. Open the power switch and remove the jumper used to key the transmitter to the 10 watt level. Key for voice by opening connection between terminals 12 and 7 of J3. This is done by removing handset from telephone hook switch of corresponding voice adapter. (Another method would be to jumper terminal 2 to terminal 14 if buffer keying board). Turn the power back on. Adjust R82 for a 3.2 watt output across the load resistor (14V across 60 ohms). Open the power switch, remove the jumper, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

T106 TAP	VOLTAGE FOR		
	1 WATT OUTPUT	3.2 WATTS OUTPUT	10 WATTS OUTPUT
50	7.1	12.7	22.4
60	7.8	14	24.5
70	8.4	15	26.5

Follow the procedure outlined in the line tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. It is factory tuned for maximum second and third harmonic rejection, and for series resonance (maximum output at the fundamental frequency) with a 60-ohm load. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection and no change should be made in these settings unless suitable instruments are available for measuring the second and third harmonic present in the transmitter output.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals, this can be done by turning the matched pair 180° and inserting a crystal in its proper socket with the other crystal unconnected. A sensitive frequency counter with a range of at least 2.2 MHz can be connected from TP51 to TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter and avoids some error from the effect of the counter input capacitance on the oscillator circuit.) While measurement of the oscillator crystals individually is necessary for the initial adjustment of the oscillators, generally any subsequent checks may be made with a lower range counter connected at the transmitter output. If any minor adjustment of the Guard and Trip frequencies should be needed, the Guard adjustment should be made with capacitor C52 and the Trip Adjustment with C53.

Q56-Q57 Bias Adjustment

The push-pull output stages of the transmitter board are normally shipped correctly biased. If any components involved in these stages have been changed, then it may be necessary to recheck the biasing of this stage.

Unsolder the lead from terminal 2 of transformer T1 (just above FL101) and temporarily connect a low-range d-c milliammeter (0-1.0 ma) between the removed lead (+) and T1 terminal 2 (-). Turn the slotted control on the small potentiometer R80 to full counterclockwise. Now, apply power to the TCF carrier set, but do not transmit carrier. This can be done by removing the crystals. Advance the potentiometer clockwise until the milliammeter reads 0.2 ma. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T1. Replace the crystals and again apply d-c power to reenergize the transmitter. Check output, etc. of transmitter as previously described.

MAINTENANCE

Periodic checks of the transmitter Guard and Trip power outputs will detect impeding failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output at such times, making any necessary readjustments to return the equipment to its initial settings.

Voltage values should be recorded 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. Readings may vary as much as ±20%.

TABLE I
TRANSMITTER D-C MEASUREMENTS

Note: All voltages are positive with respect to Neg. 45 V. (TP51). All voltages read with d-c VTVM.

Test Point	Voltage at 1 Watt Output	Voltage at 10 Watts Output	Voltage at 3.2 Watts Output (For Voice)
TP52	20	20	20
TP53	5.4	5.4	5.4
TP54	3.4	3.4	3.4
TP55	21	18.5	–
TP56	21	18.5	–
TP57	*<1.0	*<1.0	–
TP58	44.3	44.1	–
TP59	*<1.0	*<1.0	–
TP101	0	0	–
TP103	21 ± 2	21 ± 2	–
TP105	44.3	44.0	–

TABLE II
TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages subject to variations, depending upon frequency and transistor characteristics. T51-3 = Terminal 3 of transformer T51. Other transformer terminals identified similarly. All read with a-c VTVM.

Test Point	Voltage at 1 watt Output	Voltage at 10 watts Output	Voltage at 3.2 Watts Output (For Voice)
TP54 to TP51	0.015-0.03	0.015-0.03	–
TP57 to TP51	0.05 -0.09	0.3 -1.2	–
TP59 to TP51	0.05 -0.09	0.3 -1.2	–
T1-1 to TP51	1.65	5.6	–
T1-3 to TP51	1.45	4.9	–
T1-4 to Gnd.	.6	2.0	–
T2-1 to Gnd.	.57	1.85	–
TP101 to TP103	5.2	17.0	–
TP103 to TP105	5.2	17.0	–
T3-4 to Gnd.	35	112	–
T4-2 to Gnd.	31	110	–
TP109 to Gnd.	9.8	31	–
J102 to Gnd.	7.8	24.5	14

CONVERSION OF TRANSMITTER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a 1W/10W TCF transmitter for operation on a different channel frequency consist of a pair of matched crystals for the new channel frequency, new capacitors C103 and C104 on the power amplifier circuit board if the old and new frequencies are not in the same frequency group (see table on internal schematic drawing) and, in general, new or modified filters FL101 and FL102. Inductors L101, L102 and L103 in these filters are adjustable over a limited range, but forty-two combinations of capacitors and inductors are required to cover the frequency range of 30 to 300 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5	207.1-214.0
32.0-33.5	64.5- 68.0	120.0-127.0	214.1-222.0
34.0-36.0	68.5- 72.0	127.5-135.0	222.1-230.0
36.5-38.5	72.5- 76.0	135.5-143.0	230.1-240.0
39.0-41.0	76.5- 80.0	143.5-151.0	240.1-250.0
41.5-44.0	80.5 -84.5	151.5-159.5	250.1-262.0
44.5-47.0	85.0- 89.0	160.0-169.5	262.1-274.0
47.5-50.0	89.5- 94.5	170.0-180.0	284.1-287.0
50.5-53.5	95.0-100.0	180.5-191.5	287.1-300.0
54.0-57.0	100.5-106.0	192.0-200.0	
57.5-60.5	106.5-112.5	200.1-207.0	

If the new frequency lies within the same frequency group as the original frequency, the filters can be readjusted. If the frequencies are in different groups, it is possible that changes only in the fixed capacitors may be required. In general, however, it is desirable to order complete filter assemblies adjusted at the factory for the specified frequency.

A signal generator, a frequency counter and a vacuum tube voltmeter are required for readjustment of FL101. The signal generator and the counter should be connected across terminals 4 and 5 of transformer T1 and the voltmeter across terminals 1 and 2 of transformer T2. The signal generator should be set at the channel center frequency and at 2 to 3 volts output. The core screw of the small inductor should be turned to the position that gives a true maximum reading on the VTVM. Turning the screw to either side of this position should definitely reduce the reading. The change in inductance with core position is less at either end of the travel than when near the center and consequently the effect of core screw rotation on the VTVM reading will be less when the resonant inductance occurs near the end of core travel.

The procedure for readjustment of the 2nd and 3rd harmonic traps of filter FL102 is somewhat similar. A signal generator and a counter should be connected to terminals 3 and 4 of transformer T3, and a 500 ohm resistor and a VTVM to the terminals of protective gap G1. The ground or shield lead of all instruments should be connected to the grounded terminal of the transformer. Set the signal generator at exactly twice the channel center frequency and at 5 to 10 volts output. Turn the core screw of the large inductor L102, to the position that gives a definite minimum reading on the VTVM. Similarly, with the signal generator set at exactly three times the channel center frequency and 5 to 10 volts output, set the core screw of the small inductor, L103, to the position that gives a definite minimum reading on the VTVM. Then remove the instruments and the 500 ohm resistor.

After the new pair of matched crystals have been adjusted, as described under "ADJUSTMENTS", the transmitter can be operated with a 50 to 70 ohm load (depending on which tap of T4 is used) connected to its output, and inductor L105 can be readjusted for maximum output at the changed channel frequency by the procedure described in the same section.

If a frequency-sensitive voltmeter is available, the 2nd and 3rd harmonic traps may be adjusted without using an oscillator as a source of double and triple the channel frequency. Connect the frequency-sensitive voltmeter from TP109 to ground and adjust the transmitter for rated output into the selected load resistor. Set the voltmeter at twice the channel frequency and, using the tuning dial and db range switch, obtain a maximum on-scale reading of the 2nd harmonic. Then vary the core position of L102 until a minimum voltmeter reading is obtained. Similarily, tune the voltmeter to the third harmonic and adjust L103 for minimum voltmeter reading. Although the transmitter frequency will differ from the channel center frequency by 100 Hz, the effect of this difference on the adjustment of the harmonic traps will be negligible. It should be noted that the true magnitude of the harmonics cannot be measured in this manner because of the preponderance of the fundamental frequency at the voltmeter terminals. Accurate measurement of the harmonics requires use of a filter between TP109 and the voltmeter that provides high rejection of the fundamental. The insertion looses of this filter for the 2nd and 3rd harmonics must be measured and taken into account.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. 60-ohm 10-watt non-inductive resistor.

b. A-C vacuum Tube Voltmeter (VTVM) or equivalent. Voltage range 0.003 to 30 volts, frequency range 60 hz to 330 kHz; impedance 7.5 megohms.

c. D-C Vacuum Tube Voltmeter (VTVM) or equivalent.

II. Desirable Test Equipment for Apparatus Maintance.

a. All items listed in I.

b. Signal Generator

Output Voltage:	up to 8 volts.
Frequency Range:	20-kHz to 900 kHz

c. Osiclloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker.

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

RENEWAL PARTS

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

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.45 mfd.; 330 V.A.C.	1723408
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C3	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
Buffer C1, C2, C3	Metallized Paper, 0.47 mfd.;	849A437H04
C21	Metallized Paper, .047 mfd.;	849A437H04
C51	Dur-Mica, 1500 pf., 500 V.D.C.	762A757H03
C52	Variable, 5.5-18 pf.	879A834H01
C53	Variable, 5.5-18 pf.	879A834H01
C54	Metallized paper, .1 mfd.; 200 V.D.C.	187A624H01
C55	Variable, 5.5-18 pf.	879A834H01 ✪
C56	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C57	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C58	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C60	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C61	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C62	Dur-Mica, 4700 pf., 500 V.D.C.	762A757H04
C63	Dur-Mica, 1000 pf., 500 V.D.C.	762A757H02
C64	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C65	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C66	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C67	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C68	Metallized paper, 0.5 mfd.; 200 V.D.C.	187A624H03
C69	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C70	Dur-Mica, 300 pf, 500 V.D.C.	187A584H09
C71	3 pf,	861A846H03
C72	3 pf,	861A846H03
C73	3 pf,	861A846H03
C74	Metallized paper, 1.0 mf, 200 V.D.C.	187A624H04
C75	Metallized paper, 0.5 mf, 200 V.D.C.	187A624H03
C76	Metallized paper, 0.01 mf, 200 V.D.C.	764A278H10
C77	0.47 mfd,	188A669H01
C101	Metallized paper, 0.25 mfd,; 200 V.D.C.	187A624H02
C102	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C103 & C104	(30-50 KC) — Extended foil, 0.47 mfd.; 400 V.D.C.	188A293H01
C103 & C104	(50.5-75 KC) — Extended foil, 0.22 mfd.; 400 V.D.C.	188A293H02
C103 & C104	(75.5 - 100 KC) — Extended foil, 0.15 mfd., 400 V.D.C.	188A293H03
C103 & C104	(100.5 - 150 KC) — Extended foil, 0.10 mfd., 400 V.D.C.	188A293H04
C103 & C104	(150.5 - 300 KC) — Extended foil, 0.047 mfd.; 400 V.D.C.	188A293H05
	DIODES — GENERAL PURPOSE	
D11	1N645A	837A692H03
D12	1N645A	837A692H03
D13	1N4822	188A342H11
D14	1N4822	188A342H11

ELECTRICAL PARTS LIST

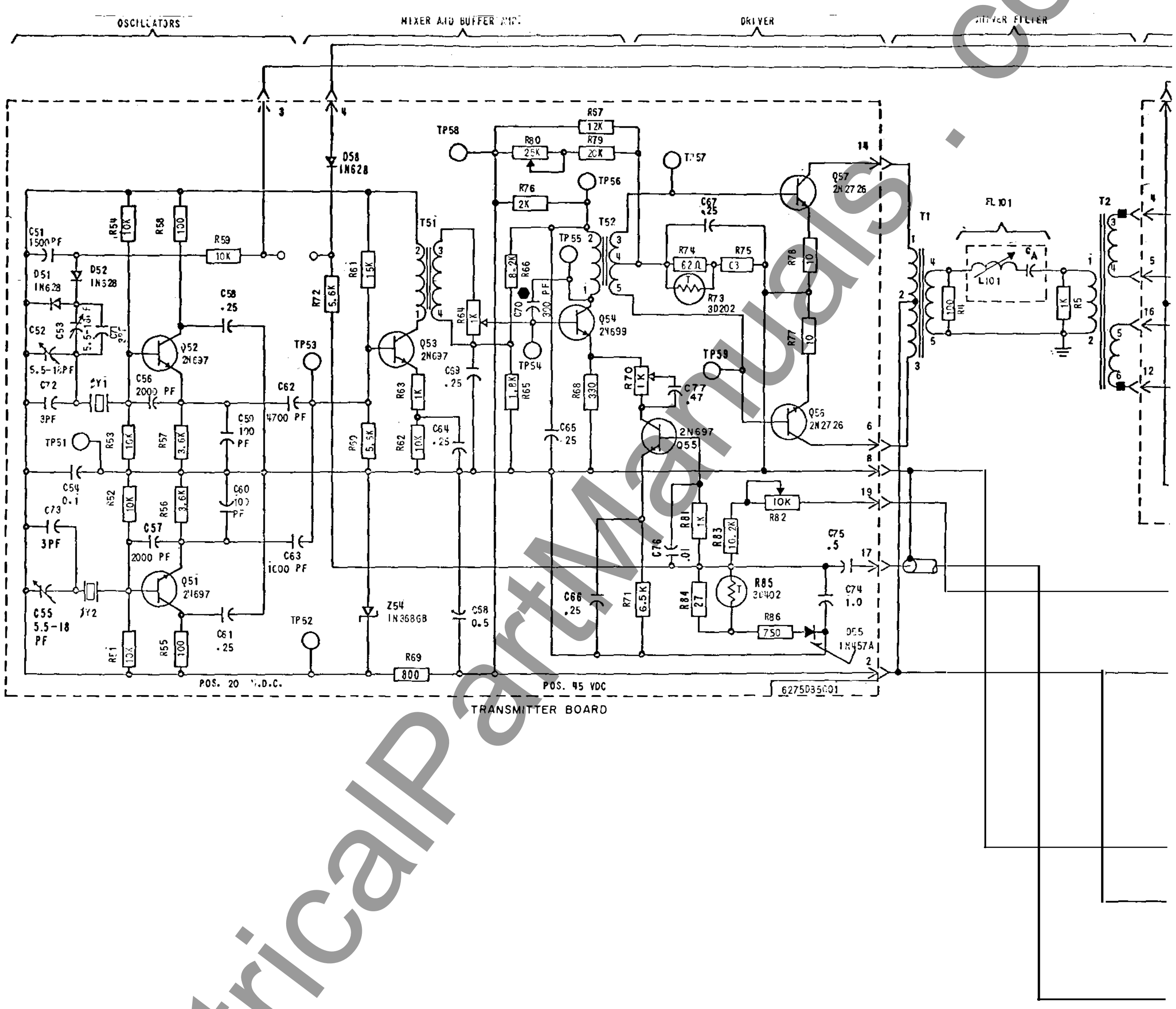
CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
D15	1N4822	188A342H11
D16	1N4822	188A342H11
D21	1N645A	837A692H03
D22	1N4822	188A342H11
D23	1N4822	188A342H11
D24	1N4822	188A342H11
D25	1N4822	188A342H11
D51	1N628; 125 V.; 30 MA.	184A885H12
D52	1N628; 125 V., 30 MA.	184A885H12
D55	1N457A; 60 V., 200 MA.	184A885H07
D58	1N628; 125 V., 30 MA.	184A885H12
D101	1N538; 200 V., 750 MA.	407C703H03
D102,D104	1N91; 100 V., 150 MA. (Germanium Version used with 2N1908)	182A881H04
D103	1N538; 200 V., 750 MA.	407C703H03
D102,D104	1N4818 (Silicon Version used with 2N3792)	188A342H06
	DIODES – ZENER	
Z1	1N2828B; 45V. ±5%; 50 W.	184A854H06
Z2	1N3009A; 130 V. ±10%; 10 W.	184A617H12
Z4, Z5, Z6	1N957B	186A797H06
Buffer, Z2, Z3	1N3688A	862A288H01
Z13	1N3688A	862A288H01
Z14	1N3686B	185A212H06
Z21	1N957B	186A797H06
Z22	1N3688A	862A288H01
Z23	1N3688A	862A288H01
Z24	1N3688B	185A212H06
Z54	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
Z105	1N2999A; 56 V. ±10%; 10 W.	184A617H13
Z106	1N2999A; 56 V. ±10%; 10 W.	184A617H13
	RESISTORS	
R1	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R2	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R3	26.5 ohms ±5%; 40 W. (For 48 V Supply)	04D1299H44
R3	500 ohms ±5%; 40 W. (For 125 V Supply)	1268047
R4	100 ohms ±10%; 1 W. Composition	187A644H03
R5	1K ±10%; ½ W. Composition	187A641H27
R6	3K ±5%; 5 W. Wire Wound	188A317H01
R7	15K ±10%; 2 W. Composition	187A642H55
Buf. R4, R6	18K ±2%; ½ W. Metal Glaze	629A531H62
Buf. R2, R5	51K ±2%; ½ W. Metal Glaze	629A531H73
Buf. R3	1.8K ±2%; ½ W. Metal Glaze	629A531H38

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Continued)	
Buf. R7, R10, R12	1.5K ±2%; ½ W. Metal Glaze	629A531H36
Buf. R8, R9, R11	6.2K ±2%; ½ W. Metal Glaze	629A531H51
Buf. R13	10K ±2%; ½ W. Metal Glaze	629A531H56
R14, 20, 21, 28, 32	10K ±2%; ½ W. Metal Glaze	629A531H56
R15,17,22,24,25	12K ±2%; ½ W. Metal Glaze	629A531H58
R16, 18, 19	27K ±2%; ½ W. Metal Glaze	629A531H66
R23, 29	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R26, 27	27K ±2%; ½ W. Metal Glaze	629A531H66
R30, 31, 33	12K ±2%; ½ W. Metal Glaze	629A531H58
R34	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R51	10K ±5%; ½ W. Composition	184A763H51
R52	10K ±5%; ½ W. Composition	184A763H51
R53	10K ±5%; ½ W. Composition	184A763H51
R54	10K ±5%; ½ W. Composition	184A763H51
R55	100 Ohms ±5%; ½ W. Composition	184A763H03
R56	3.6K ±5%; ½ W. Composition	184A763H40
R57	3.6K ±5%; ½ W. Composition	184A763H40
R58	100 ohms ±5%; ½ W. Composition	184A763H03
R59	10K ±5%; ½ W. Composition	184A763H51
R60	5.6K ±5%; ½ W. Composition	184A763H45
R61	15K ±5%; ½ W. Composition	184A763H55
R62	10K ±5%; ½ W. Composition	184A763H51
R63	1K ±5%; ½ W. Composition	184A763H27
R64	Potentiometer, 1K; ¼ W.	184A763H02
R65	1.8K ±5%; ½ W. Composition	184A763H02
R66	8.2K ±5%; ½ W. Composition	184A763H49
R67	12K ±5%; ½ W. Composition	184A763H53
R68	330 ohms ±5%; ½ W. Composition	184A763H15
R69	800 ohms ±5%; ½ W. Composition	184A859H06
R70	Potentiometer, 1K; ¼ W.	629A430H02
R71	4.7K ±5%; ½ W. Composition	184A763H43
R72	39K ±5%; ½ W. Composition	184A763H65
R73	Thermistor, 30 ohms, Type 3D202 (G.E.C.)	185A211H06
R74	180 Ohms ±5%; ½ W. Composition	184A763H02
R75	100 Ohms ±5%; ½ W. Composition	184A763H03
R76	2K ±5%; ½ W. Composition	184A763H34
R77	10 ohms ±5%; ½ W. Composition	187A290H01
R78	10 ohms ±5%; ½ W. Composition	187A290H01
R80	20K ±2%; ½ W. Metal Glaze	629A531H63
R80	25K Potentiometer ±20%; ¼ W.	629A430H09
R81	1K ±1%; ½ W. Metal Film	848A819H48

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R82	5K Pot. ±20%; ½ W.	629A430H07
R83	10.2K ±1%, ½ W. Metal Film	843A820H46
R84	27 ohms ±5%, ½ W. Composition	187A290H11
R85	Thermistor 3D402 10 ohms	185A211H03
R86	750 ohms ±1%, ½ W. Metal Film	848A819H36
R101	10 ohms ±5%; ½ W. Composition	187A280H01
R102	2.2K ±10%; 1 W. Composition	187A644H35
R103	2.7 ohms ±10%; ½ W. Wire Wound	184A636H14
R104	0.27 ohms ±10%; 1 W. Wire Wound	184A636H18
R105	10 ohms ±5%; ½ W. Composition	187A290H01
R106	4.7K ±10%; 1 W. Composition	187A644H43
R107	2.7 ohms ±10%; ½ W. Wire Wound	184A636H14
R108	0.27 ohms ±10%; 1 W. Wire Wound	184A636H18
	TRANSFORMERS	
T1	Driver Output Transformer	606B410G01
T2	Power Amp. Input Transformer	292B526G01
T3	Power Amp. Output Transformer	292B526G02
T4	Load-Matching Auto-Transformer	292B526G03
T51	Buffer Amplifier Transformer	606B537G01
T52	Driver Input Transformer	606B537G02
	TRANSISTORS	
Q1	2N1015C	187A342H02
Q11	2N4356	849A441H02
Q12	2N699	184A638H19
Q21	2N4356	849A441H02
Q22	2N699	184A638H19
Q51	2N697	184A638H18
Q52	2N697	184A638H18
Q53	2N697	184A638H18
Q54	2N699	184A638H19
Q55	2N697	184A638H18
Q56	2N2726/2N3712	762A672H07
Q57	2N2726/2N3712	762A672H07
Q101,Q102	2N1908 (Use in Matched Pairs)(Germanium Version used with 1N91	187A673H02
Q101,Q102	2N3792 (Use in Matched Pairs)(Silicon Version used with 1N4818)	187A673H16
	MISCELLANEOUS	
Y1-Y2	Supplied for Desired Channel Frequency in Pair Matched Per Specifications on Drawing	408C743
FL101	Driver Filter	408C261 + (Req.Freq.)
FL102	Output Filter	541S214 +(Req. Freq.)
PL	Pilot Light Bulb - For 48 V. Supply (When supplied)	187A133H02
	Pilot Light Bulb - For 125 or 259 V. Supply (When supplied)	183A955H01
F1, F2	Fuse, 1.5A (When supplied)	11D9195H26



DOTTED LINES ENCLOSE COMPONENTS ON PRINTED CIRCUIT BOARDS OR OTHER SUB-ASSEMBLIES (EXCEPT AS NOTED)

ALL CAPACITORS ARE IN MFD. EXCEPT AS NOTED.

● = REMOVED FOR VOICE ABOVE 60KHZ

FREQ.	C103 & C104
30-50 KHZ.	0.47 MFD.
50.5-75 KHZ	0.22 MFD.
75.5-100 KHZ	0.15 MFD.
100.5-150 KHZ	0.10 MFD
150.5-300 KHZ	0.047 MFD.

◆ = MOUNTED ON LARGE HEAT SINKS

Ø = MATCHED PAIR, Y1 = 2.03 TO 2.30 MHZ, Y2 - 2.00 MHZ

Δ = Q101 & Q102 - FOR GERMANIUM VERSION USE 2N1908 S# 187A673H02, WITH DIODES D102 & D104, IN91 S# 182A881H04 ON BD. STYLES 606B530G01 TO G05.
FOR SILICON VERSION USE 2N3792 S# 187A673H16, WITH DIODES D102 & D104, IN4818 S# 188A342H06 ON BD. STYLES 606B530G08 TO G12.

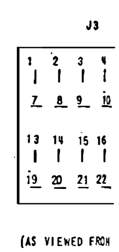
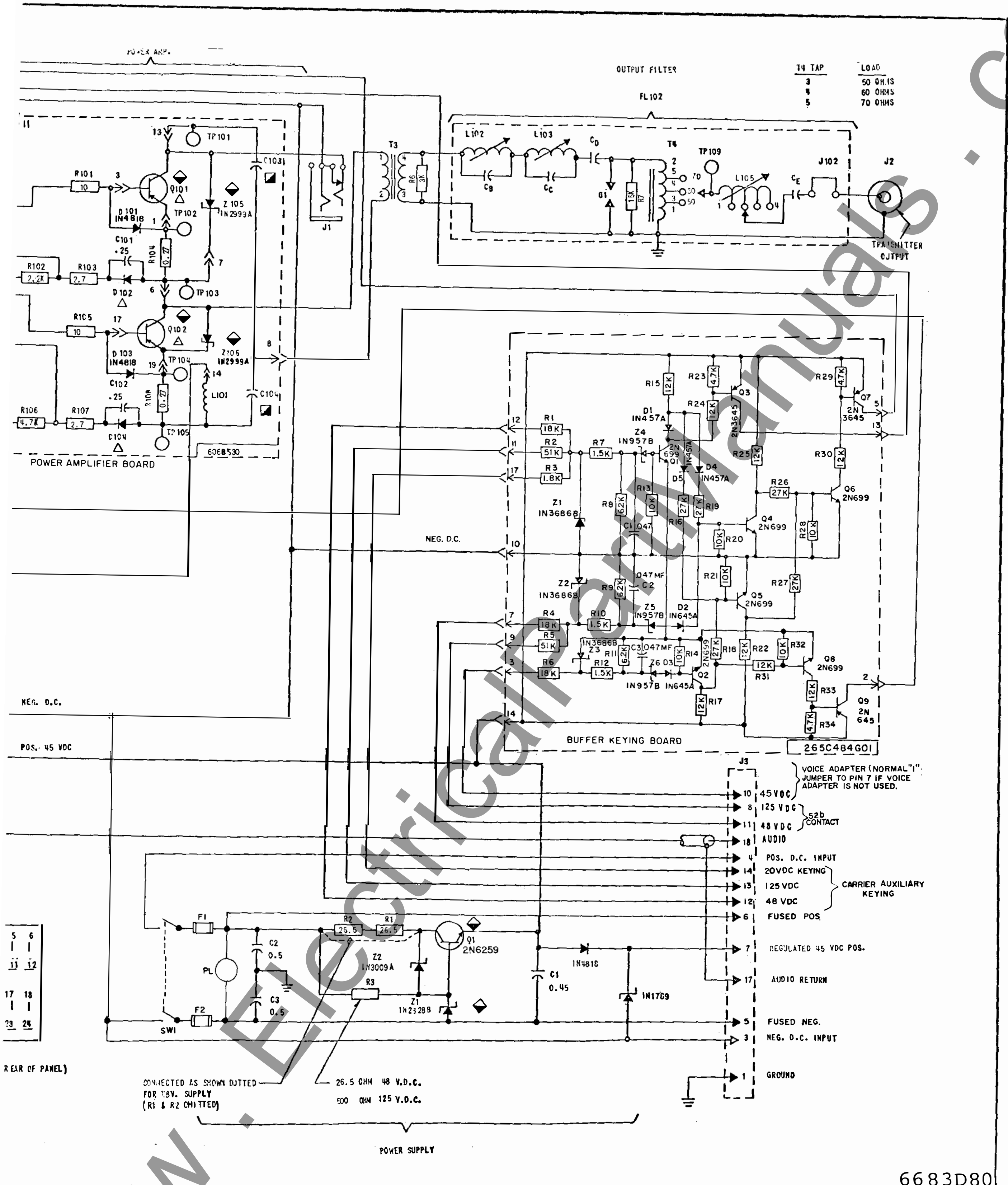


Figure 2 – Internal Schematic of the Type TCF Transmitter 1 Watt/3.2 W



...tt/10 Watt for Keyed and Voice Applications with Pilot Light, Switch, and Fuses.

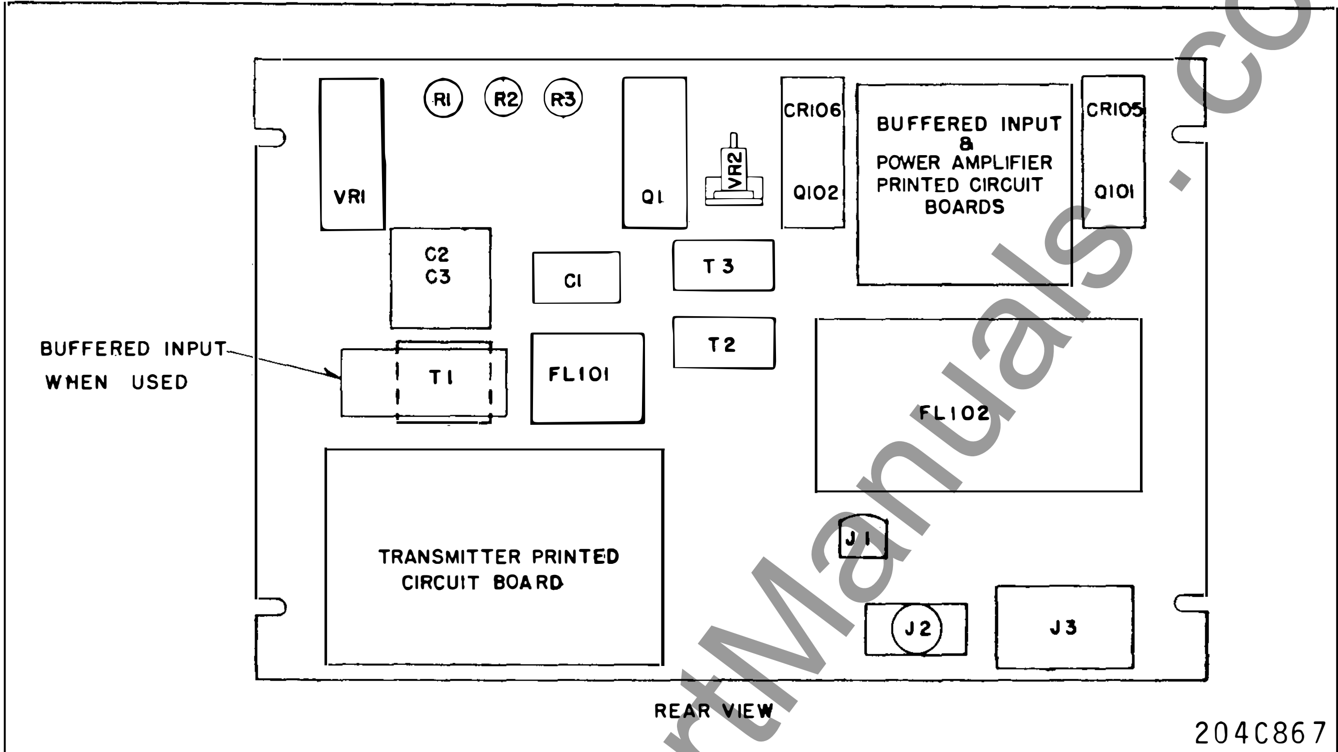


Figure 3 – Component Locations of the Type TCF Transmitter Assembly.

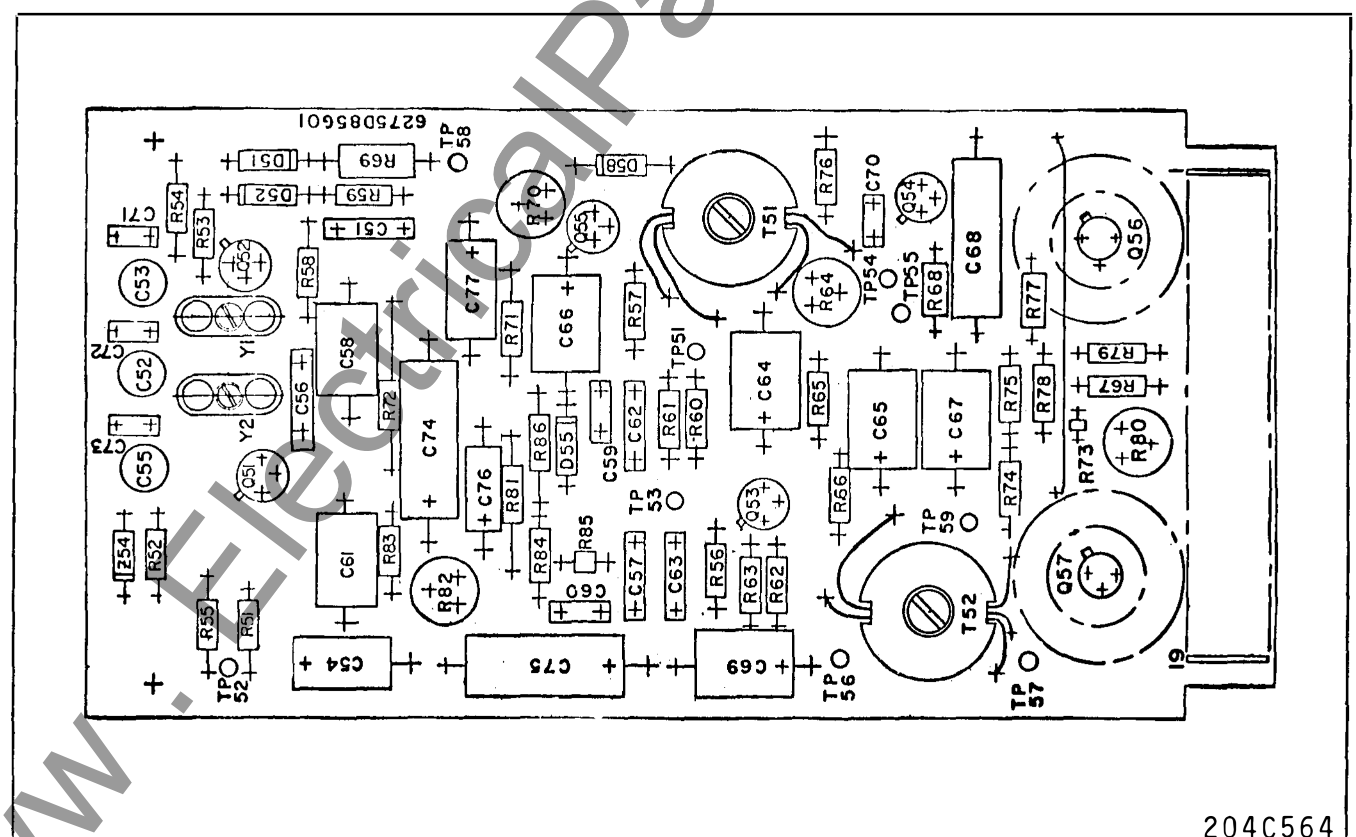


Figure 4 – Component Locations of the Transmitter Printed Circuit Board.

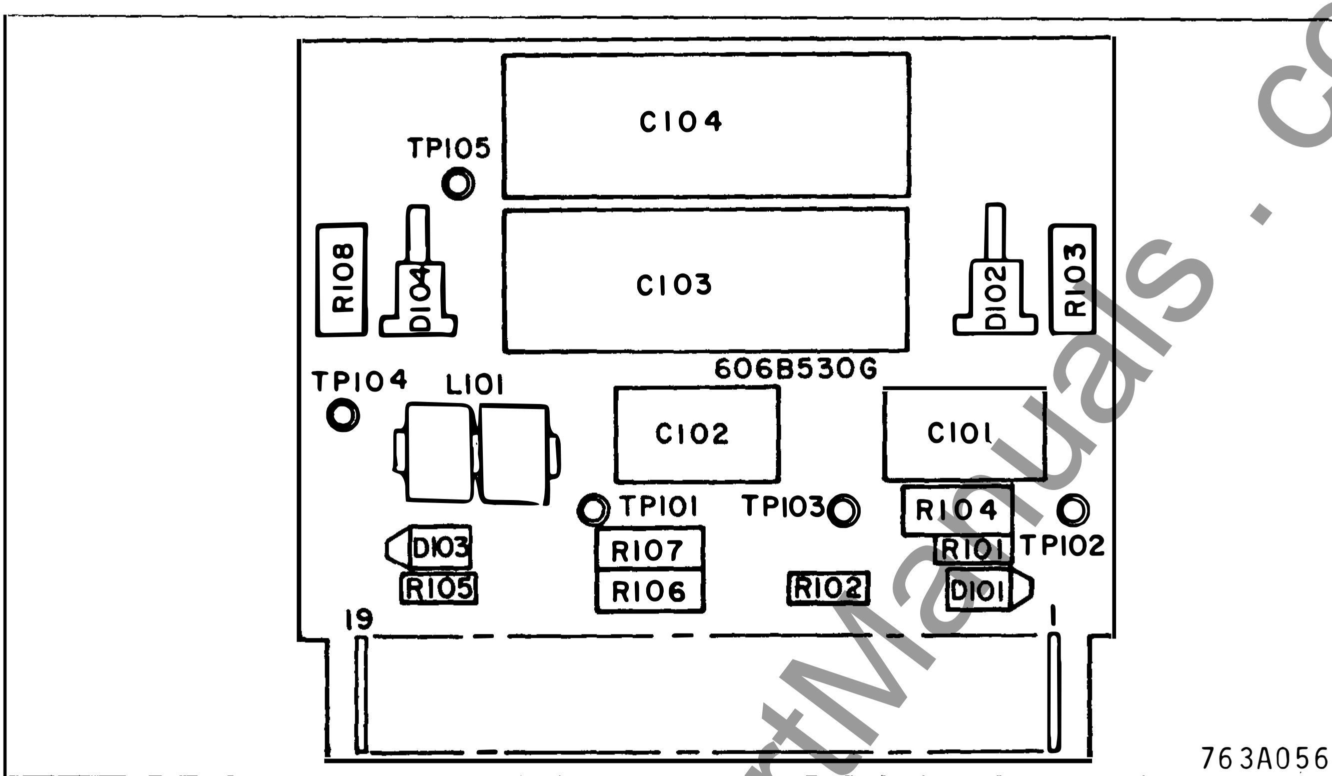


Figure 5 — Component Location of the Power Amplifier Printed Circuit Board.

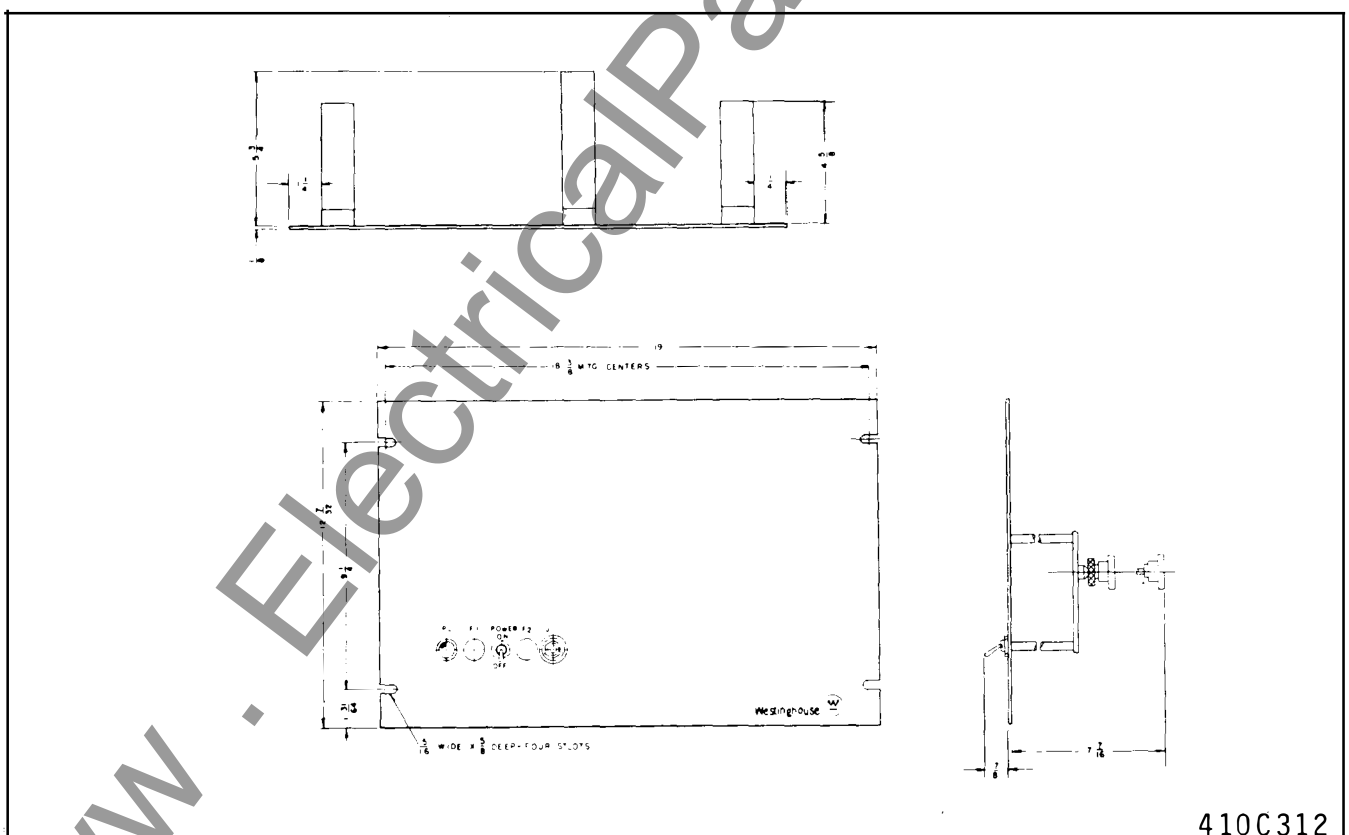


Figure 6 — Outline and Drilling Plan for the Type TCF Transmitter Assembly.

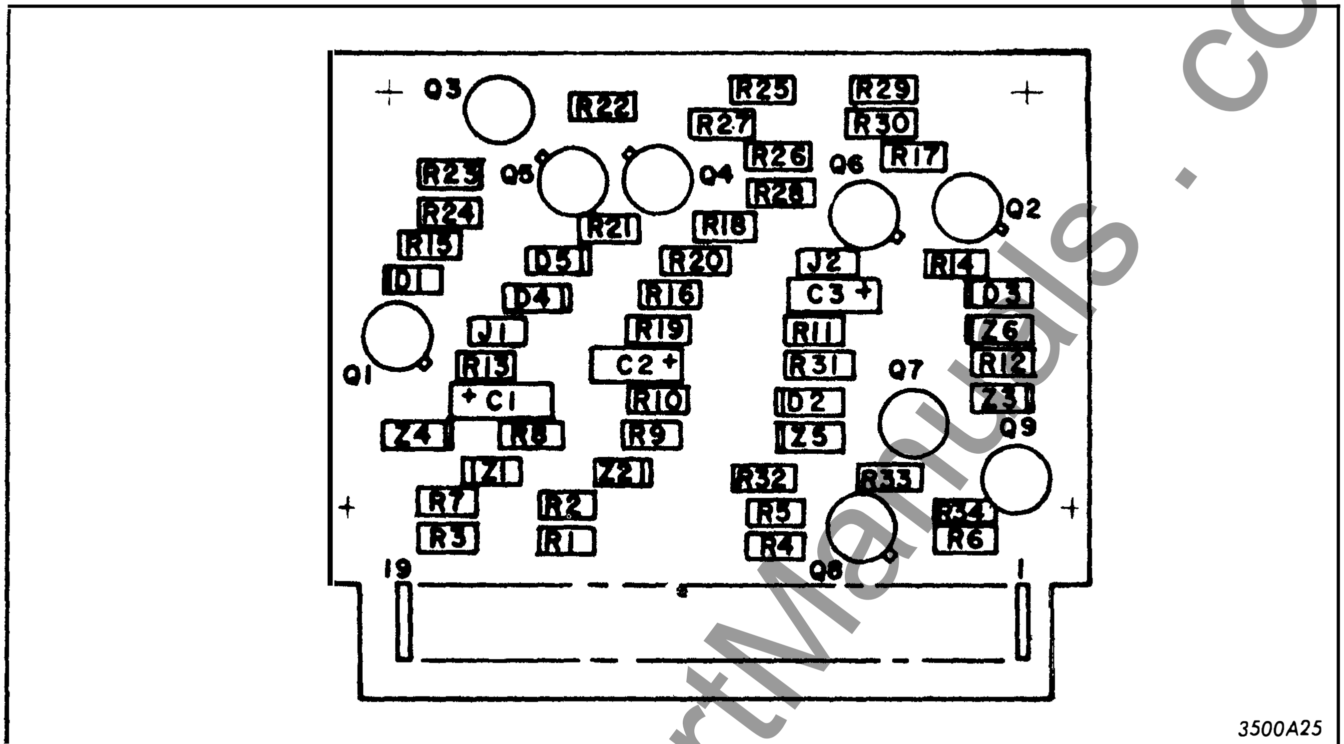


Figure 7 – Component Location of Buffer Keying Circuit Board.

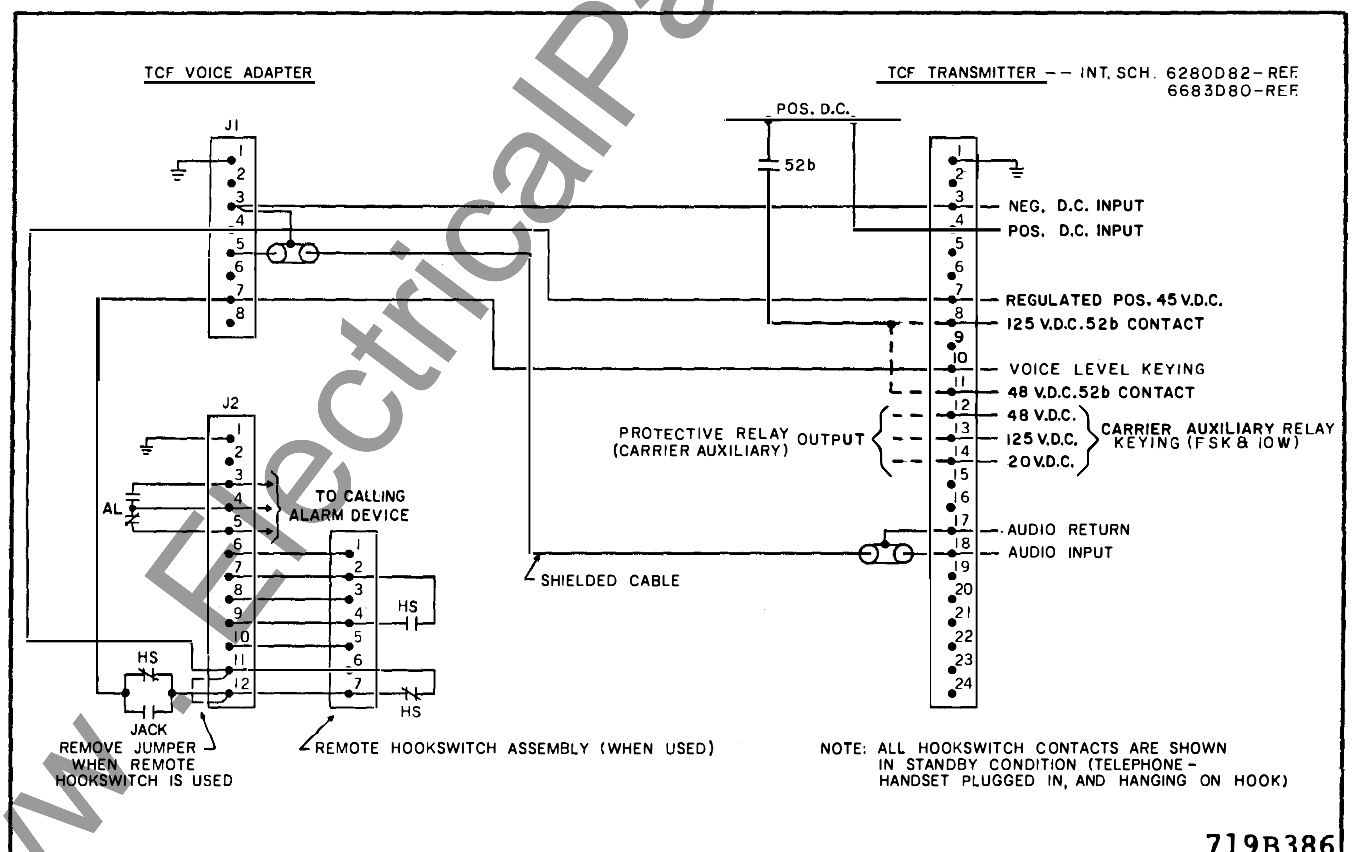


Figure 8 – TCF Voice Adapter, Relaying, and Transmitter Interconnections.

WESTINGHOUSE ELECTRIC CORPORATION

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

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT – 1 WATT/1 WATT – FOR CONTACT-KEYED FUNCTIONS

CAUTION: It is recommended that the user of this equipment become thoroughly familiar 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 type TCF carrier transmitter equipment provides for the transmission of either of two closely controlled discrete frequencies, both within a narrow-band channel, over high-voltage transmission lines. The center frequency of the channel can vary from 30 to 300 kHz in 0.5 kHz steps. The two frequencies transmitted are separated by 200 hertz, one being at center frequency (fc) plus 100 hertz and the other at center frequency minus 100 hertz. The higher frequency, termed the Guard frequency, is transmitted continuously when conditions are normal. It indicates at the receiving end of the line that the channel is operative and it also serves to prevent false operation of the receiver by line noise. The lower frequency, termed the Trip frequency, is transmitted as a signal that an operation (such as tripping a circuit breaker) should be performed at the receiving end of the line.

When frequency shift carrier is used in protective relaying applications, the transmitter usually is designed to transmit the Trip frequency at ten times the power level of the Guard frequency in order to increase the reliability of the system under conditions of abnormally high channel losses or line noise. In applications where these unfavorable ✪ conditions are not encountered, the 1-watt/1-watt transmitter may be used satisfactorily. The frequency is shifted from Guard to Trip by the closing of a protective relay contact.

CONSTRUCTION

The 1 watt/1 watt TCF transmitter unit is mounted on a standard 19-inch wide panel 8¾ inches (5 rack units) high with edge slots for mounting on a standard relay rack. All components are mounted on the rear of the panel. Fuses, a pilot light, and a power switch are accessible from the front of the panel when supplied. Refer to Fig. 6. All of the circuitry that is suitable for printed circuit board mounting is on two boards as shown in Fig. 2. The components mounted on the printed circuit boards and the output filter are shown enclosed by dotted lines on Fig. 1. The location of components on ✪ the printed circuit boards are shown on Fig. 4, 5 and 7.

External connections to the assembly are made through a 12-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2.

OPERATION

The transmitter is made up of three main stages and an output filter. The stages include two crystal oscillators operating at frequencies that differ by the desired channel frequency, a mixer and buffer amplifier, and a final amplifier connected push-pull. The output filter removes harmonics that may be generated by distortion in the power amplifier.

A single crystal designed for oscillation in the 30 kHz to 300 kHz range cannot be forced to oscillate away from its natural frequency by as much as ± 100 hertz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2 MHz range. The crystals are Y1 and Y2 of Fig. 1. The frequency of Y2 is 2.00 MHz when operated with a specified amount of series capacity and the frequency of Y1 is 2.00 MHz plus the channel fre-

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

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✪ DENOTES CHANGES FROM SUPERSEDED COPY

EFFECTIVE DECEMBER 1978

quency, or 2.03 MHz to 2.30 MHz. Capacitor C55 and crystal Y2 in series are connected between the positive side of the supply voltage and the base of transistor Q51, which operates in the emitter-follower mode. The emitter is coupled to the base through C57, and with Y2 removed the base of Q51 would be held at approximately the midpoint of the supply voltage by R51 and R52. The crystal serves as a series-resonant circuit with very high inductance and low capacitance. The circuit can be made to oscillate at other than the natural frequency of the crystal by varying the series capacitor, C55. Increasing C55 will lower the frequency of oscillations and reducing C55 will raise the frequency.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes D51 and D52. By adjustment of C52 this circuit is made to oscillate at 100 hertz above its marked frequency. Capacitor C53 is not effective until D51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the relay control contact is closed, which places 45 V.D.C. at terminal 3 of the printed circuit board. With D51 conducting, C53 is effectively in parallel with C52, and adjustment of C53 will reduce the frequency by 200 hertz. The crystals taken individually have a greater variation of frequency with temperature than would be acceptable. However, by proper matching of the two crystals, the variation in their difference frequency can be kept within limits that permit holding the frequency stability of the overall transmitter to ± 10 hertz/ over a temperature range of −20 to + 55°C.

The frequencies produced by the two oscillators are coupled to the base of mixer transistor Q53 through C62 and C63. The sum of the two frequencies is so high that negligible amount appears on the secondary of transformer T51, but the difference frequency is accepted and amplified by Q53 and Q54. The level of output power is adjusted to 1 watt by means of R64.

The amplifier stage consists of transistors Q56 and Q57 connected in a conventional push-pull circuit with input supplied from the collector of Q54 through transformer T52. Thermistor R73 and resistors R74 and R75 are connected to provide a variable bias that reduces the effect of varying ambient temperatures on the input level.

As is shown on Fig. 1 the voltage for the keying circuit is obtained from the 45-volt regulated supply in the transmitter, and opening the single power switch de-energizes both the transmitter and the keying circuit.

The output transformer T1 couples the amplifier transistors to the output filter FL102. The output filter includes two trap circuits (L102, C_B and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G1 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line tuner and coaxial cable. Auto-transformer T2 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms.

The series resonant circuit composed of L105 and C_E is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, thus providing a reverse impedance that is free of possible "across-the-line" resonances.

The regulated 45 volt power supply is obtained from a 50-watt Zener diode mounted on a heat sink and connected to the station battery supply through suitable series resistors, as shown in Fig. 1. Capacitor C68 provides a low carrier-frequency impedance across the d-c output voltage, and capacitors C1 and C2 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

CHARACTERISTICS

Frequency Range	30-300 kHz
Output	1 watt guard - 1 watt trip (into 50 to 70 ohm resistive load)
Frequency Stability	±10 cycles/sec. from −20°C to +55°C.
Frequency Spacing	1. One-way channel, two or more signals - 500 hertz min. 2. Two-way channel - 1000 hertz min. between transmitter and adjacent receiver frequencies.
Harmonics	down 55 db (min.) from output level.

Maximum Keying Frequency	100 hertz limited by receiver
Input Voltage	48, 125 or 250 V.D.C.
Supply Voltage	42-56 V. for nom. 48 V. supply
	105-140 V. for nom. 125 V. supply
	210-280 V. for nom. 250 V. supply
Battery Drain	0.12 a. at 48 v. d-c. 0.27 a. at 125 or 250 v. d-c.
Temperature Range	-20 to +55°C around chassis
Dimensions	Panel height - 8¾'' or 5 r.u. Panel width - 19''
Weight	9 lbs.

INSTALLATION

The TCF transmitter 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

The TCF 1W/1W transmitter is shipped with the power output control R64 set for an output of 1 watt into a 60 ohm load. If it is desired to check the adjustments or if repairs have made readjustment necessary, the coaxial cable should be disconnected from the assembly terminals and replaced with a 50 to 70 ohm non-inductive resistor of at least a 1 watt rating. Use the value of the expected input impedance of the coaxial cable and line tuner. If this is not known, assume 60 ohms. Connect the T2 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn power output control R64 to minimum (full counterclockwise). Turn on the power switch on the panel and note the d-c voltage across terminals 5 and 7 of J3. If this is in the range of 42 to 46 volts, rotate R64 clockwise to obtain 3 or 4 volts across the load resistor. At this point check the adjustment of the series output tuning coil L105 by loosening the knurled shaft-locking nut and moving the adjustable core in and out a small amount from its initial position. Leave it at the point of maximum voltage across the load resistor.

Continue to advance R64 until the output voltage shown in the following table is obtained across the load resistor. Recheck the setting of L105 to be sure it is at its optimum point for 1 watt output. Tighten the locking nut. Key the transmitter to Trip by connecting together terminals 2 and 3 of the printed circuit board (or terminals 7 and 8 of J3). There should be no appreciable change in the output voltage. Open the power switch, remove the jumper used to key the transmitter to Trip, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

T2 Tap	Voltage for 1 Watt Output
50	7.1
60	7.8
70	8.4

Follow the procedure outlined in the tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. It is factory tuned for maximum second and third harmonic rejection, and for series resonance (maximum output at the fundamental frequency) with a 60-ohm load. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection and no change should be made in these settings unless suitable instruments are available for measuring the second and third harmonic present in the transmitter output.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals, this can be done by turning the matched pair 180° and inserting a crystal in its proper socket with the other crystal unconnected. A sensitive frequency counter with a range of at least 2.3 megahertz can be connected from TP51 to TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter and avoids some error from the effect of the counter input capacitance on the oscillator circuit.) While measurement of the oscillator crystals individually is necessary for the initial adjustment of the oscillators, generally and subsequent checks may be made with a lower range counter connected at the transmitter output. If any minor adjustment of the Guard and Trip frequencies should be needed. The guard adjustment should be made with capacitor C52 and the Trip adjustment with C53.

Q56 - Q57 Bias Adjustment

The push-pull output stages of the transmitter board are normally shipped correctly biased. If any components involved in these stages have been changed, then it may be necessary to recheck the biasing of this stage.

Unsolder the lead from terminal 2 of transformer T1 (just above FL101) and temporarily connect a low-range d-c milliammeter (0-1.0 ma) between the removed lead (+) and T1 terminal 2 (-). Turn the slotted control on the small potentiometer to full counterclockwise. Now, apply power to the TCF carrier set, but do not transmit carrier. This can be done by removing the crystals. Advance the potentiometer clockwise until the milliammeter reads 0.05 ma. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T1. Replace the crystals and again apply d-c power to reenergize the transmitter. Check output, etc. of transmitter as previously described.

MAINTENANCE

Periodic checks of the transmitter power output will detect impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sink. It is also desirable to check the transmitter power output at such times, making any necessary readjustments to return the equipment to its initial settings.

Voltage values should be recorded 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. Readings may vary as much as ± 20%.

TABLE I

TRANSMITTER D-C MEASUREMENTS

Note: All voltages are positive with respect to Neg. 45 V. (TP51). All voltages read with d-c VTVM.

Test Points	Voltage at 1 Watt Output
TP 52	20
TP 53	5.4
TP 54	3.4
TP 55	21
TP 56	21
TP 57	.65
TP 58	44.3
TP 59	65

TABLE II

TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages subject to variations, depending upon frequency and transistor characteristics. T51-3= Terminal 3 of transformer T51. Other transformer terminals identified similarly. All voltages read with a-c VTVM.

Test Points	Voltage at 1 Watt Output
TP54 to TP51	0.12
TP57 to TP51	0.8
TP59 to TP51	0.8
T1-1 to TP51	26
T1-3 to TP51	26
T1-4 to Gnd.	36
T2-2 to Gnd.	30
TP109 to Gnd.	9.8
J102 to Gnd.	7.8

CONVERSION OF TRANSMITTER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a 1W/1W TCF transmitter for operation on a different channel frequency consist of a pair of matched crystals for the new channel frequency if the old and new frequency are not in the same frequency group (see table on internal schematic drawing) and, in general new or modified filter FL102. Inductors L102 and L103 in this filter are adjustable over a limited range, but forty-two combinations of capacitors and inductors are required to cover the frequency range of 30 kHz to 300 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5	207.1-214.0
32.0-33.5	64.5- 68.0	120.0-127.0	214.1-222.0
34.0-36.0	68.5- 72.0	127.5-135.0	222.1-230.0
36.5-38.5	72.5- 76.0	135.5-143.0	230.1-240.0
39.0-41.0	76.5- 80.0	143.5-151.0	240.1-250.0
41.5-44.0	80.5- 84.5	151.5-159.5	250.1-262.0
44.5-47.0	85.0- 89.0	160.0-169.5	262.1-274.0
47.5-50.0	89.5- 94.5	170.0-180.0	274.1-287.0
50.5-53.5	95.0-100.0	180.5-191.5	287.1-300.0
54.0-57.0	100.5-106.0	192.0-200.0	
57.5-60.5	106.5-112.5	200.1-207.0	

If the new frequency lies within the same frequency group as the original frequency, the filters can be readjusted. If the frequencies are in different groups, it is possible that changes only in the fixed capacitors may be required. In general, however, it is desirable to order complete filter assemblies adjusted at the factory for the specified frequency.

The procedure for readjustment of the 2nd and 3rd harmonic traps of filter FL102 is as follows: A signal generator and a counter should be connected to terminals 4 and 5 of transformer T1, and a 500 ohm resistor and a VTVM to the terminals of protective gap G1. The ground or shield lead of all instruments should be connected to the grounded terminal of the transformer. Set the signal generator at exactly twice the channel center frequency and at 3 to 5 volts output. Turn the core screw of the large inductor, L102, to the position that gives a definite minimum reading on the VTVM. Similarly, with the signal generator set at exactly three times the channel center frequency and 5 to 10 volts output, set the core screw of the small inductor, L103, to the position that gives a definite minimum reading on the VTVM. Then remove the instruments and the 500 ohm resistor.

After the new pair of matched crystals have been adjusted, as described under "ADJUSTMENTS", the transmitter can be operated with a 50 to 70 ohm load (depending on which tap of T2 is used) connected to its output, and inductor L105 can be readjusted for maximum output at the changed channel frequency by the procedure described in the same section.

If a frequency-sensitive voltmeter is available, the 2nd and 3rd harmonic traps may be adjusted without using an oscillator as a source of double and triple the channel frequency. Connect the frequency-sensitive voltmeter from TP109 to ground and adjust the transmitter for rated output into the selected load resistor. Set the voltmeter at twice the channel frequency and, using the tuning dial and db range switch, obtain a maximum on-scale reading of the 2nd harmonic. Then vary the core position of L102 until a minimum voltmeter reading is obtained. Similarly, tune the voltmeter to the third harmonic and adjust L103 for minimum voltmeter reading. Although the transmitter frequency will differ from the channel center frequency by 100 cycles, the effect of this difference on the adjustment of the harmonic traps will be negligible. It should be noted that the true magnitude of the harmonics cannot be measured in this manner because of the preponderance of the fundamental frequency at the voltmeter terminals. Accurate measurement of the harmonics requires use of a filter between TP109 and the voltmeter that provides high rejection of the fundamental. The insertion losses of this filter for the 2nd and 3rd harmonics must be measured and taken into account.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. 60-ohm 10-watt non-inductive resistor.

b. A-C vacuum tube voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 cycles/sec. to 330 kHz input impedance 7.5 megohms.

c. 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 900 kHz

c. Oscilloscope

d. Frequency counter; 2.5 Mhz; 50 ms.

e. Ohmmeter

f. Capacitor checker.

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

RENEWAL PARTS

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

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized Paper, .047 mfd.;	849A437H04
C51	Dur-Mica, 1500 pf., 500 V.D.C.	762A757H03
C52	Variable, 5.5-18 pf.	879A834H01
C53	Variable, 5.5-18 pf.	879A834H01
C54	Metallized paper, .1 mfd.; 200 V.D.C.	187A624H01
C55	Variable, 5.5-18 pf.	762A736H01
C56	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C57	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C58	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C60	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C61	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C62	Dur-Mica, 4700 pf., 500 V.D.C.	762A757H04
C63	Dur-Mica, 1000 pf., 500 V.D.C.	762A757H02
C64	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C65	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C66	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C67	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C68	Metallized paper, 0.5 mfd.; 200 V.D.C.	187A624H03
C69	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C70	Dur-Mica, 300 pf, 500 V.D.C.	187A584H09
C71	3 pf,	861A846H03
C72	3 pf,	861A846H03
C73	3 pf,	861A846H03
C74	Metallized paper, 1.0 mf, 200 V.D.C.	187A624H04
C75	Metallized paper, 0.5 mf, 200 V.D.C.	187A624H03
C76	Metallized paper, 0.01 mf, 200 V.D.C.	764A278H10
C77	0.47 mfd,	188A669H01
	DIODES – GENERAL PURPOSE	
D51	1N628; 125 V.; 30 MA.	184A885H12
D52	1N628; 125V., 30 MA.	184A885H12
D55	1N457A; 60 V., 200 MA.	184A885H07
D58	1N628; 125V., 30 MA.	184A885H12
D101	1N538; 200 V., 750 MA.	407C703H03
D102	1N91; 100 V., 150 MA.	182A881H04
D103	1N538; 200 V., 750 MA.	407C703H03
D104	1N91; 100 V., 150 MA.	182A881H04

ELECTRICAL PARTS LIST

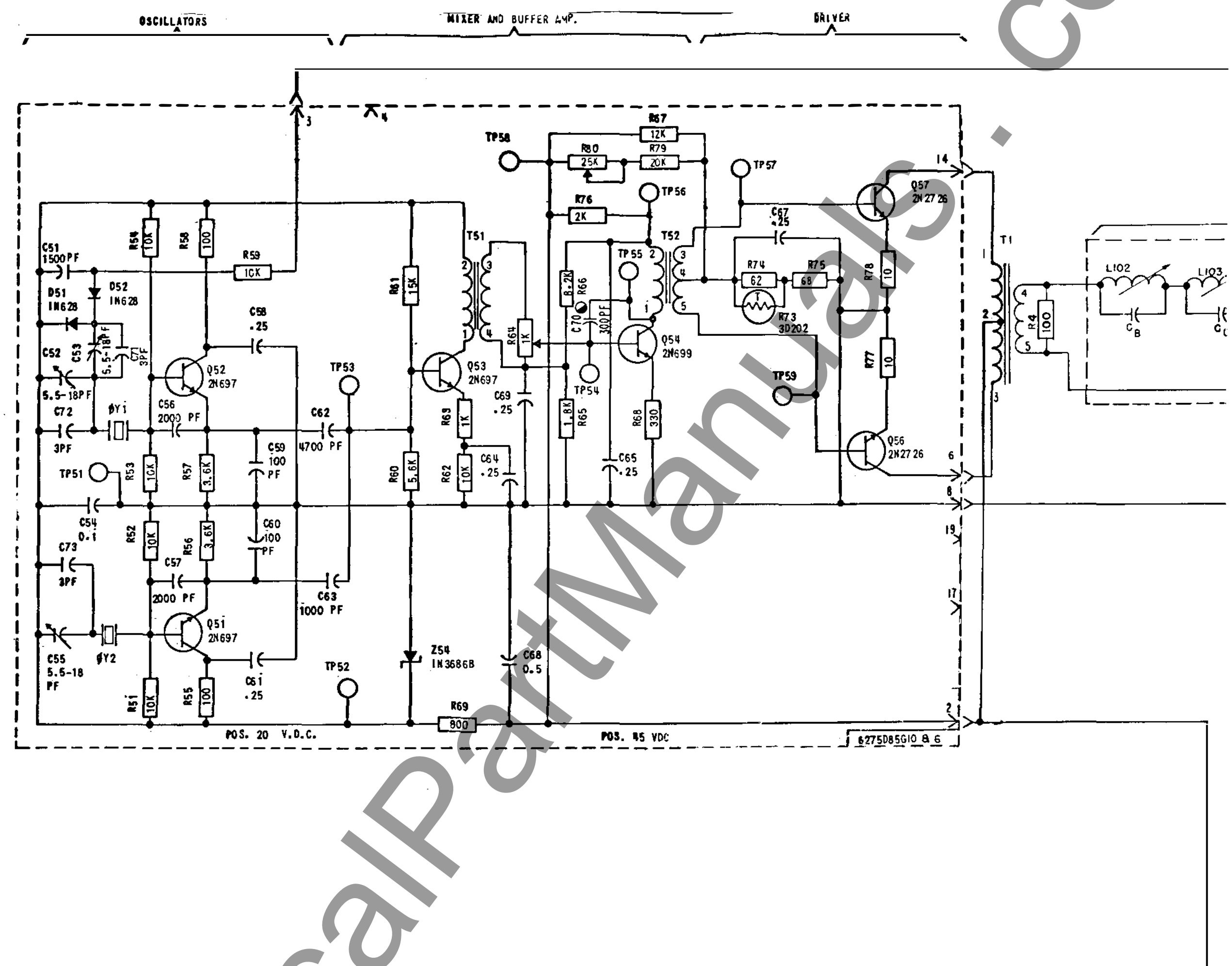
CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – ZENER	
Z1	1N2828B; 45V. ±5%; 50W.	184A854H06
Z11	1N957B	186A797H06
Z12	1N3688A	862A288H01
Z13	1N3688A	862A288H01
Z14	1N3686B	185A212H06
Z15	1N3688A	862A288H01
Z54	1N3686B; 20V. ±5%; 750MW.	185A212H06
	RESISTORS	
R1	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R2	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R3	26.5 ohms ±5%; 40 W. (For 48 V Supply)	04D1299H44
R3	500 ohms ±5%; 40 W. (For 125 V Supply)	1268047
R4	100 ohms ±10%; 1 W. Composition	187A644H03
R5	1K ±10%; ½ W. Composition	187A641H27
R6	3K ±5%; 5 W. Wire Wound	188A317H01
R7	15K ±10%; 2 W. Composition	187A642H55
R11	4.7K ±2%; ½ W. Metal Glaze	629A531H43
R12	12K ±2%; ½ W. Metal Glaze	629A531H58
R13	10K ±2%; ½ W. Metal Glaze	629A531H56
R14	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R15	1.5K ±2%; ½ W. Metal Glaze	629A531H36
R16	18K ±2%; ½ W. Metal Glaze	629A531H62
R17	1.8K ±2%; ½ W. Metal Glaze	629A531H38
R18	51K ±2%; ½ W. Metal Glaze	629A531H73
R51	10K ±5%; ½ W. Composition	184A763H51
R52	10K ±5%; ½ W. Composition	184A763H51
R53	10K ±5%; ½ W. Composition	184A763H51
R54	10K ±5%; ½ W. Composition	184A763H51
R55	100 ohms ±5%; ½ W. Composition	184A763H03
R56	3.6K ±5%; ½ W. Composition	184A763H40
R57	3.6K ±5%; ½ W. Composition	184A763H40
R58	100 ohms ±5%; ½ W. Composition	184A763H03
R59	10K ±5%; ½ W. Composition	184A763H51
R60	5.6K ±5%; ½ W. Composition	184A763H45
R61	15K ±5%; ½ W. Composition	184A763H55
R62	10K ±5%; ½ W. Composition	184A763H51
R63	1K ±5%; ½ W. Composition	184A763H27
R64	Potentiometer, 1K;¼ W.	629A430H02

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R65	1.8K ±5%; ½ W. Composition	184A763H02
R66	8.2K ±5%; ½ W. Composition	184A763H49
R67	12K ±5%; ½ W. Composition	184A763H53
R68	330 ohms ±5%; ½ W. Composition	184A763H15
R69	800 ohms ±5%; ½ W. Composition	184A859H06
R70	Potentiometer, 1K; ¼ W.	629A430H02
R71	4.7K ±5%; ½ W. Composition	184A763H43
R72	39K ±5%; ½ W. Composition	184A763H65
R73	Thermistor, 30 ohms, Type 3D202 (G.E.C.)	185A211H06
R74	62 ohms ±5%; ½ W. Composition	629A531H03
R75	68 ohms ±5%; ½ W. Composition	187A290H21
R76	2K ±5%; ½ W. Composition	184A763H34
R77	10 ohms ±5%; ½ W. Composition	187A290H01
R78	10 ohms ±5%; ½ W. Composition	187A290H01
R79	20K ±2%; ½ W. Metal Glaze	629A531H63
R80	25K Potentiometer ±20%; ¼ W.	629A430H09
	TRANSFORMERS	
T1	Driver Output Transformer	606B410G01
T4	Load-Matching Auto-Transformer	292B526G03
T51	Buffer Amplifier Transformer	292B526G03
T52	Driver Input Transformer	606B537G01
	TRANSISTORS	
Q11	2N4356	849A441H02
Q12	2N699	184A638H19
Q51	2N697	184A638H18
Q52	2N697	184A638H18
Q53	2N697	184A638H18
Q54	2N699	184A638H19
Q55	2N697	184A638H18
Q56	2N2726/2N3712	762A672H07
Q57	2N2726/2N3712	762A672H07

MISCELLANEOUS

Y1-Y2	Supplied for Desired Channel Frequency in Pair Matched Per Specifications on Drawing	408C743
FL102	Output Filter	541S214 + (Req. Freq.)
PL	Pilot Light Bulb - For 48 V. Supply (When supplied)	187A133H02 ◆
	Pilot Light Bulb - For 125 or 259 V. Supply (When supplied)	183A955H01
F1, F2	Fuse, 1.5A (When supplied)	11D9195H26



DOTTED LINES ENCLOSE COMPONENTS ON PRINTED CIRCUIT BOARDS OR OTHER SUB-ASSEMBLIES (EXCEPT AS NOTED)

ALL CAPACITORS ARE IN MFD. EXCEPT AS NOTED.

◆ = MOUNTED ON LARGE HEAT SINKS

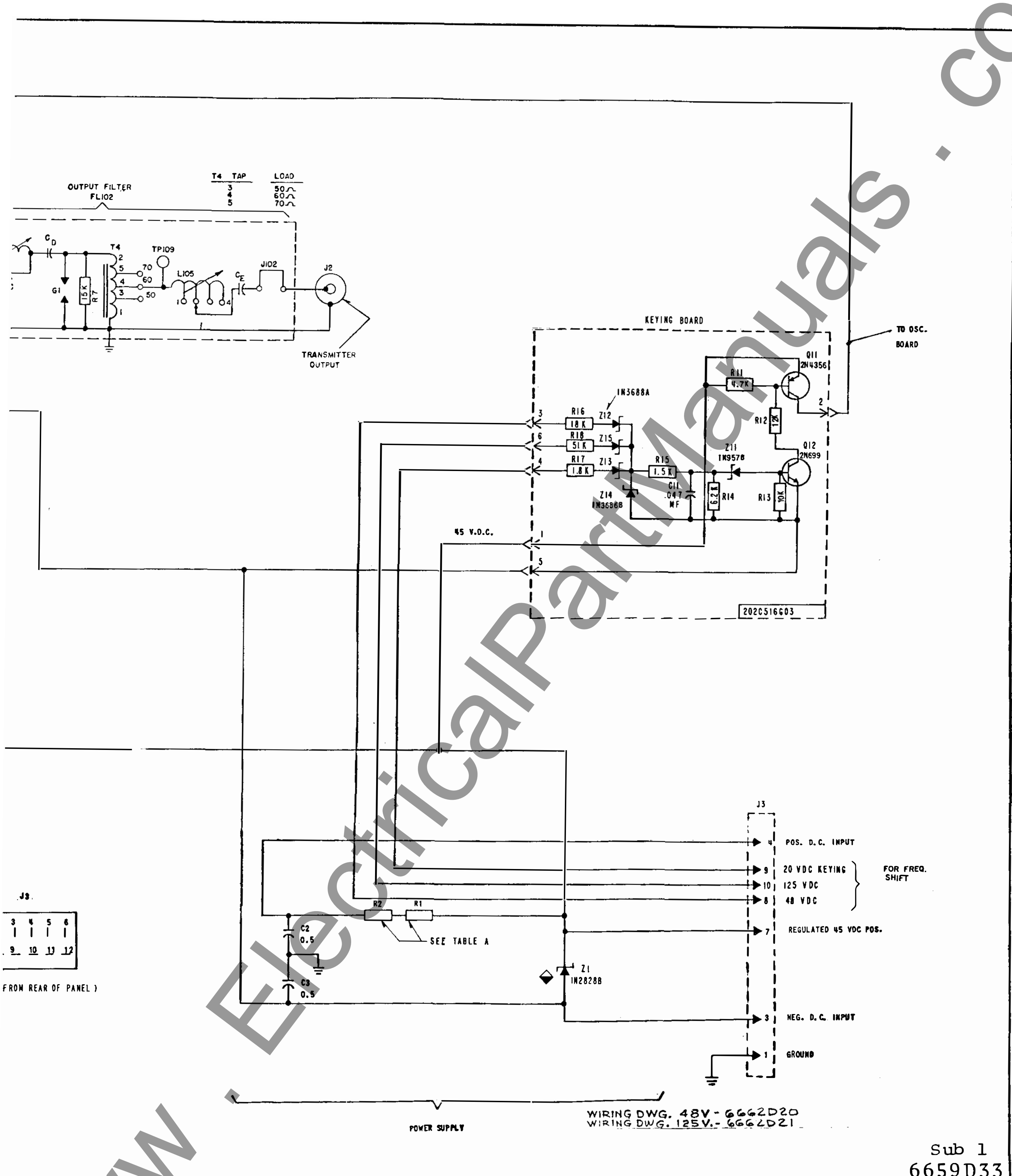
Ø = MATCHED PAIR
Y1 - 2.03 TO 2.30 MHZ
Y2 - 2.00 MHZ

◐ = C70 OMITTED ABOVE 60 KHZ
USES TRANSMITTER 6275D85G06
BELOW 60 KHZ, USE 6275D85G10

TABLE A

VOLTS D.C.	R1	R2
48 V	26.5Ω	—
125 V	150Ω	150Ω

Fig. 2. Internal Schematic of the



Type TCF 1-Watt/1-Watt Transmitter (without Switch and Fuses).

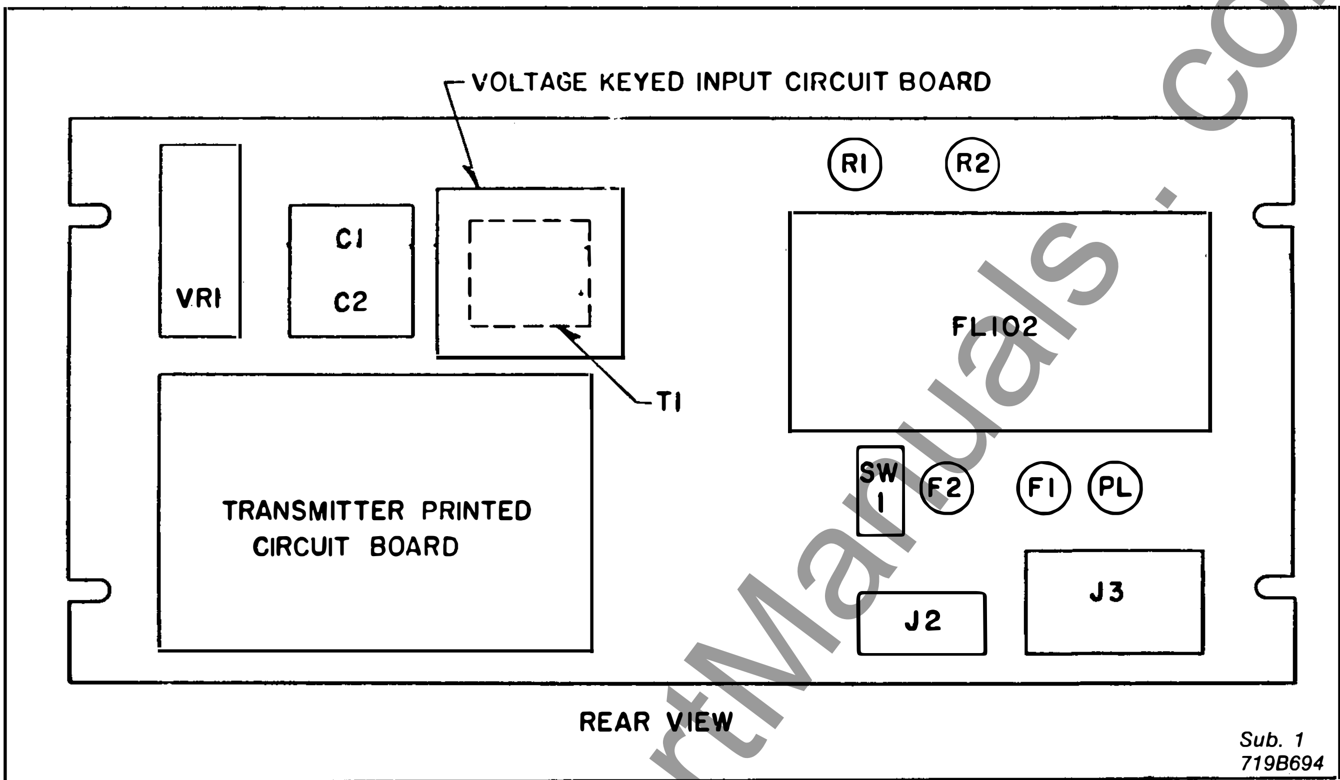


Fig. 3. Component Locations on the Type TCF Transmitter Assembly.

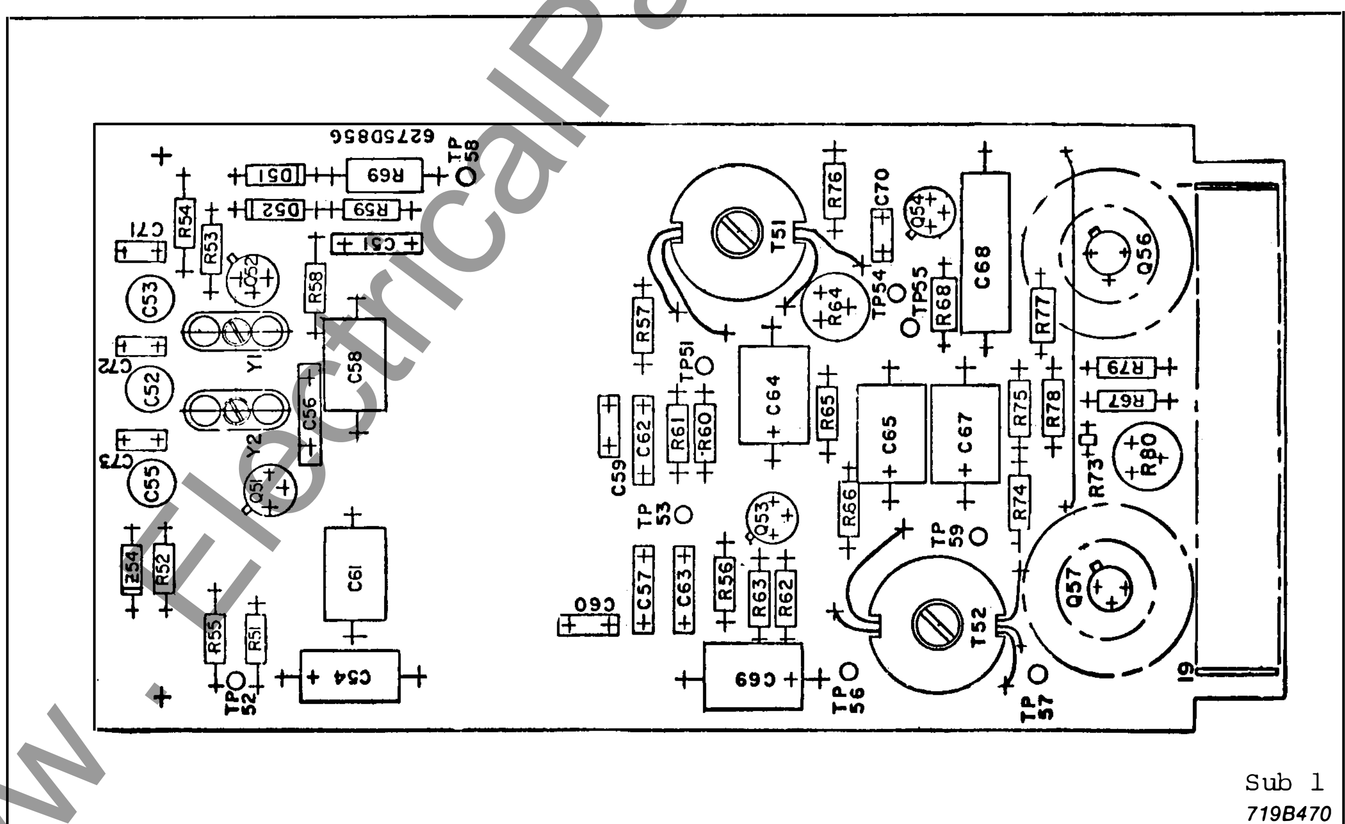


Fig. 4. Component Locations on the Transmitter Printed Circuit Board. Style 6275D85G10

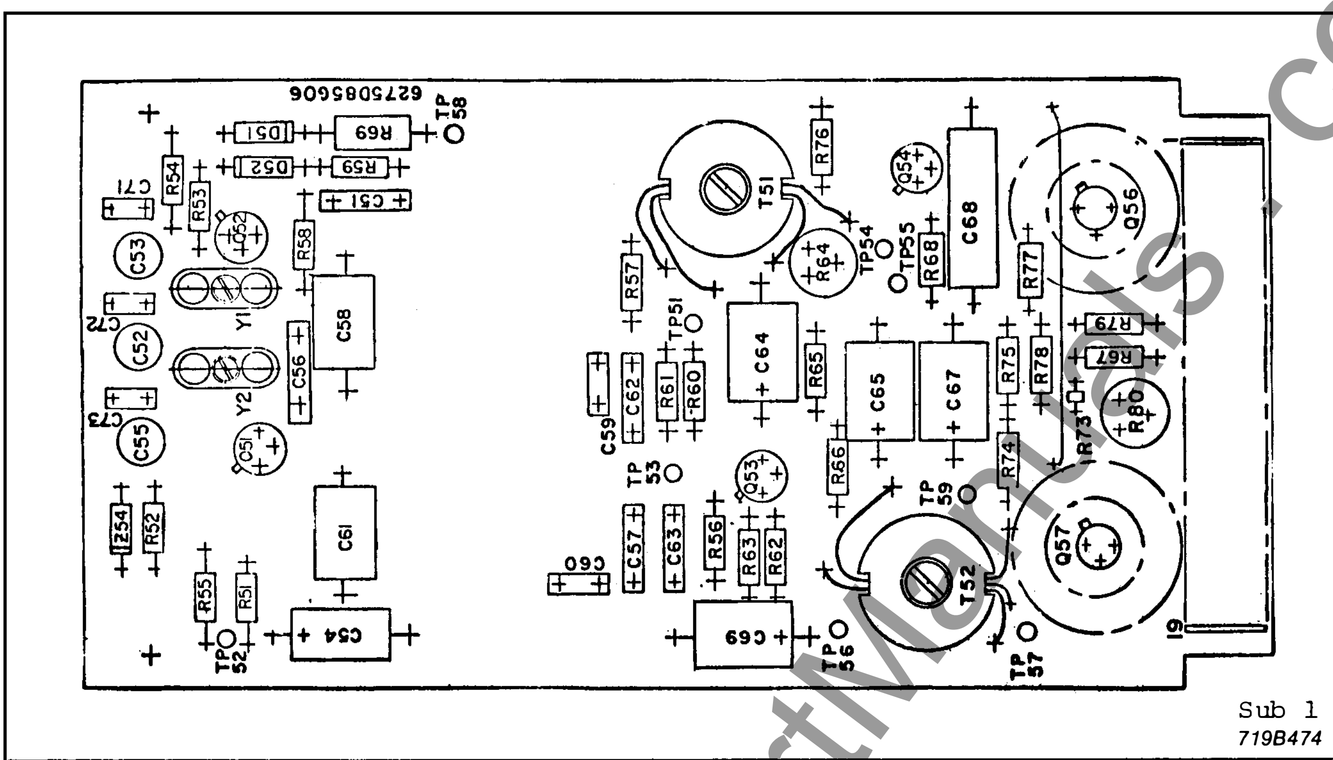


Fig. 5. Component Locations on the Transmitter Printed Circuit Board. Style 6275D85G06

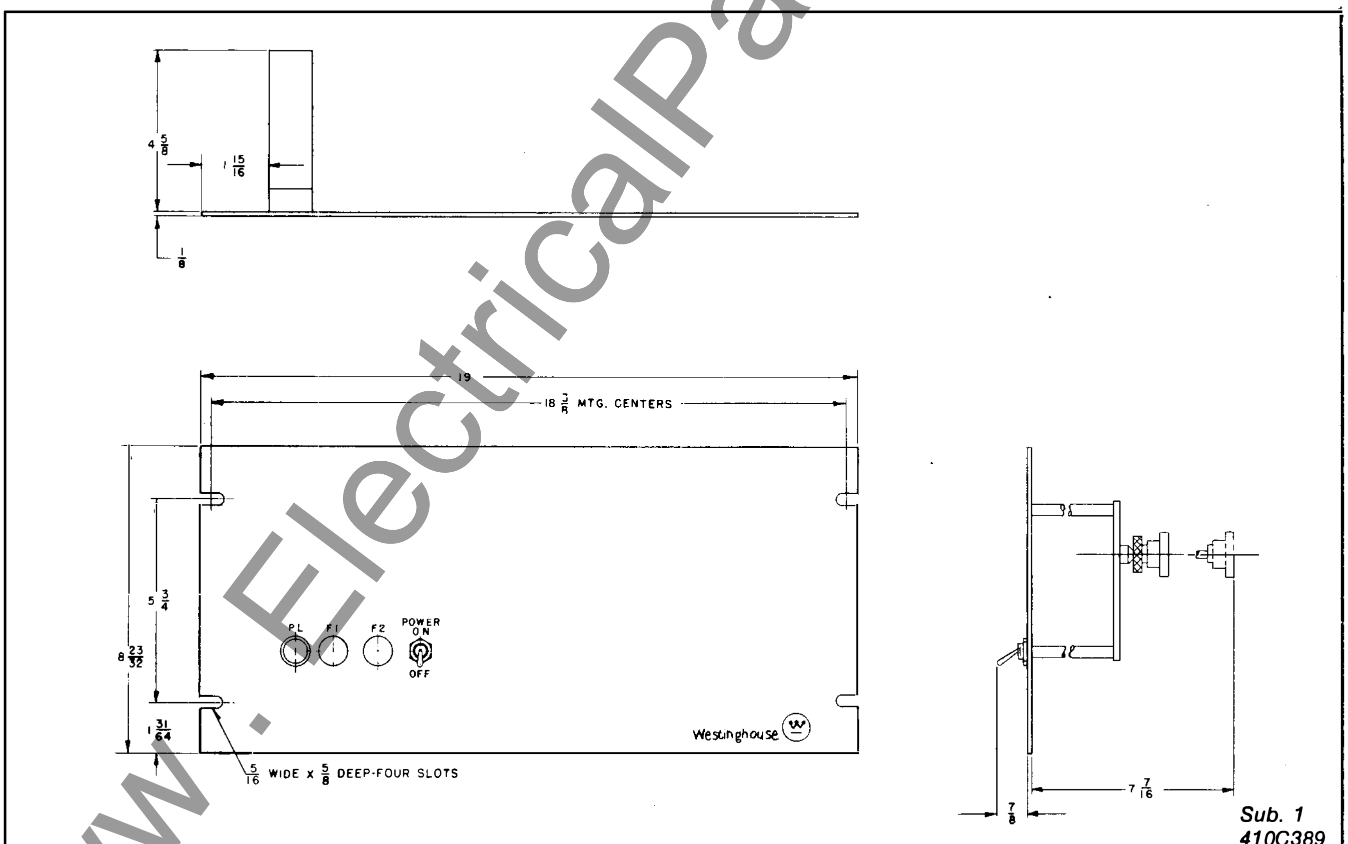


Fig. 6. Outline and Drilling Plan for the Type TCF Transmitter Assembly.
(With Pilot Light, Switch and Fuses)

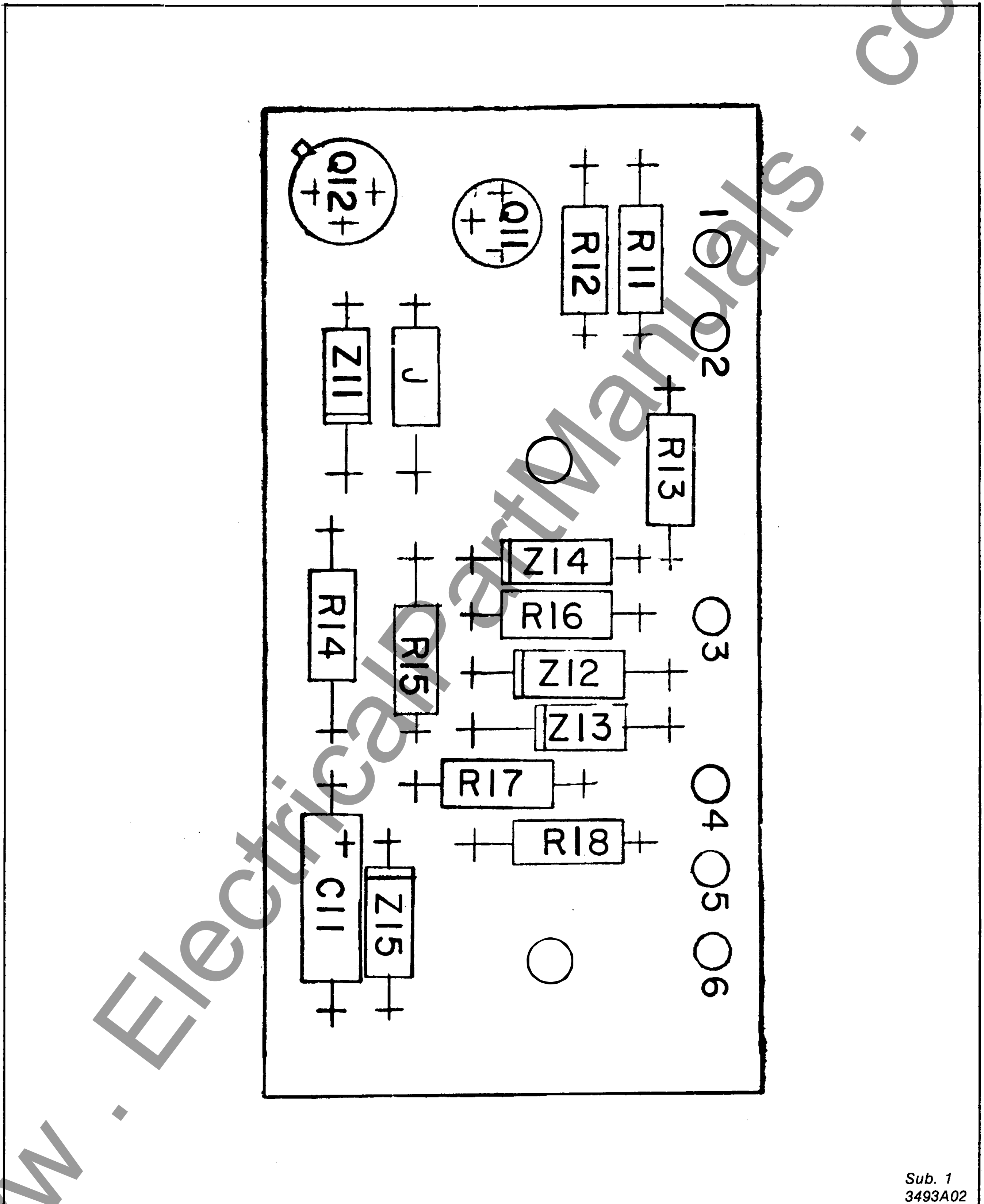


Fig. 7. Component Location on Keying Buffer Board

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION
CORAL SPRINGS, FL.
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT 3 FREQUENCY – 10 WATT / 1 WATT / 10 WATT

CAUTION: It is recommended that the user of this equipment become thoroughly familiar 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

A widely used high speed relaying system used for transmission line protection consists of directional-comparison unblock relaying plus a transfer-trip channel for breaker failure protection. Normally these systems of relaying require two frequency-shift channels, wideband for unblocking and narrowband for transfer trip. A saving in channel spectrum can be effected by using a three-frequency transmitter for the two relaying functions and two separate receivers, one for each function, as shown in Figure 7.

SYSTEM OPERATION

The three-frequency TCF carrier transmitter provides for the transmission of any of three closely controlled discrete frequencies, all within the equivalent spacing of a single wideband channel. The center frequency of the channel can vary from 30 kHz to 300 kHz in 0.5-kHz steps. The transmitter normally operates at a frequency that is 100 Hz above the channel center frequency (fc). This frequency serves as the "guard" frequency for the transfer-trip receiver and as the "block" frequency for the unblock receiver. Note that the discriminator characteristic in the unblock receiver in this case is reversed from the normal unblock receiver used with the standard two-frequency transmitter. This "guard" or "block" frequency is transmitted continuously when conditions are normal. It indicates at the receiving end of the line that the channel is operative and serves to prevent false operation of the receiver by line noise. The lowest frequency, which is 100 Hz less than fc is the "transfer trip" frequency and is transmitted as a signal that an operation (such as tripping a circuit breaker) should be performed at the receiving end of the line. The highest frequency, which is 300 Hz above fc, is the "unblock" frequency and is transmitted as an unblock signal for directional-comparison relaying. If a subsequent transfer-trip operation is called for, the transmitter will shift to fc -100 Hz which is the "trip" frequency for the transfer-trip (narrow-band) receiver.

Note that when the transmitter shifts to "unblock," the frequency is completely outside the passband of the narrow band transfer-trip receiver. Normally, this would cause a low-signal alarm output from that receiver. In order to prevent an alarm output in this case, the checkback output of the unblock receiver is cross-connected to the guard or block input of the transfer-trip receiver (through on OR logic circuit). This logic is shown in Figures 8 and 9. The checkback output is a receiver output that indicates that a proper signal has been received without going through any time delays or other logic used for the actual relaying output. With this cross-connected logic, both receivers will function when required, but will not give any incorrect output indications.

The transmitter normally operates at an output level of one watt at the "guard" or "blocking" frequency, but increases to ten watts for either "trip" or "unblock" output. An interlock is provided in the transmitter keying circuit to give transfer-trip preference. This means that even while the transmitter is shifted to the "unblock" frequency, if the transfer-trip keying circuit is energized, the transmitter will shift to the "trip" frequency without delay.

CONSTRUCTION

The 10-watt/1-watt/10-watt TCF transmitter unit is mounted on a standard 19-inch wide panel 12¼ inches

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

SUPERSEDES I.L. 41-945.12A, dated June 1976
✪Denotes change from superseded Issue.

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(7 rack units) high with edge slots for mounting on a standard relay rack. A jack for metering the ampifier collector current is accessible from the front of the panel. See Fig. 6. All of the circuitry that is suitable for printed circuit board mounting is on two such boards, as shown in Fig. 2. The components mounted on each printed circuit board or other sub-assembly are shown enclosed by dotted lines on the internal schematic. Fig. 1. The location of components on the three printed circuit boards are shown on separate illustrations, Fig. 3, 4 & 5.

External connections to the assembly are made through a 12-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2.

OPERATION

The transmitter is made up of four main stages and two filters. The stages include two crystal oscillators operaing at frequencies that differ by the desired channel center frequency, a mixer and buffer amplifier, a driver stage and a power amplifier. The interstage filter is located between the driver and the power amplifier. The output filter removes harmonics that may be generated by distortion in the power amplifier.

A single crystal designed for oscillation in the 30 kHz to 300 kHz range cannot be forced to oscillate away from its natural frequency by as much as $\pm$ 100 hz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2 MHz range. The crystals are Y1 and Y2 of Fig. 1. The frequency of Y2 is 1.00 MHz when operated with a specified amount of series capacity, and the frequency of Y1 is 2.00 MHz plus the channel center frequency, or 2.03 MHz for 30 kHz center frequency. Capacitor C55 and crystal Y2 in series are connected between the positive side of the supply voltage and the base of transistor Q51, which operates in the emitter following mode. The emitter is coupled to the base through C57. With Y2 removed the base of Q51 would be held at approximately the midpoint of the supply voltage by R51 and R52. The crystal serves as a series-resonant circuit with very high inductance and low capacitance. The circuit can be made to oscillate at other than the natural frequency of the crystal by varying the series capacitor, C55. Increasing C55 will lower the frequency of oscillations and reducing C55 will raise the frequency.

Capacitor C73 (in parallel with C70) is not effective until D55 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the keying control for unblock is closed which places 45V. dc at terminal 12 of the printed circuit board. With D55 conducting, C73 and C70 are placed in parallel with C55 and C74. The adjustment of C73 will reduce the frequency of the Y2 circuit by 200 hz. Since Y2 is the lower of the two frequencies derived from Y1 and Y2, the difference frequency, which is the frequency transmitted, is now increased by 200 hz. Thus the frequency transmitted is now 200 hz above the guard frequency or 300 hz above the center frequency.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes D51 and D52. By adjustment of C52 this circuit is made to oscillate at 100 hz above its marked frequency. Capacitors C53 and C76 are not effective until D51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the keying control is closed, which places 45V. dc at terminal 1 of the printed circuit board. With D51 conducting, C53 and C76 are effectively in parallel with C52 and C75. The adjustment of C53 will reduce the frequency by 200 hz. The crystals taken individually have a greater variation of frequency with temperature than would be acceptable. However, by proper matching of the two crystals, the variation in their difference frequency can be kept within limits that permit holding the frequency station of the overall transmitter to $\pm$ 10 hz over a temperature range of $-$ 20 to +55°C.

The frequencies produced by the two oscillators are coupled to the base of mixer transistor Q53 through C62 and C63. The sum of the two frequencies is so high that a negligible amount appears on the secondary transformer T51, but the difference frequency is accepted and amplified by Q53 and Q54.

When the keying control is closed, it increases the output power from 1 watt to 10 watts as well as changing the frequency from Guard to Transfer or Unblock Trip. This is effected by reducing the emitter resistance of buffer-amplifier transistor Q54. When the keying control is open, transistor Q55 receives no base current and is non-conducting. Emitter resistor R70 therefore is effectively open-circuited. The level of output power is adjusted to 1 watt by means of R64. When Q55 is made conductive by closing the keying control circuit, R70 is placed in parallel with R68 and the amount of emitter resistance unbypassed by C66 can be adjusted as required to obtain a 10-watt output level.

Note in the keying board that diode D12 serves as interlocking logic connection between the keying for "unblock" and the keying for "transfer trip". This logic permits the "transfer trip" keying to take preference over the "unblock" keying. That is even if we have "unblock" keying and then get "transfer trip" keying, the "transfer trip" will take immediate preference over the "unblock" keying. This is accomplished by the "transfer trip" keying causing transistor Q12 to conduct which in turn shunts out the keying voltage input to transistor Q22 through diode D12. Thus while Q12 becomes conducting and consequently Q11, effecting "transfer trip" keying, this conduction of Q12 also prevents Q22 from becoming conducting and prevents "unblocking" keying.

As is shown on the Internal Schematic, Fig. 1, the voltage for the keying circuit is obtained from the 45-volt regulated supply in the transmitter.

The driver stage consists of transistors Q56 and Q57 connected in a conventional push-pull circuit with input supplied from the collector of Q54 through transformer T52. Thermistor R73 and resistors R74 and R75 are connected to provide a variable bias that reduces the effect of varying ambient temperatures on the input level. In addition, network R67, R79, and potentiometer R80 are used in the bias circuit and are adjusted by meads of R80 to limit the quiscent current in the driver stage common to 0.2 ma. This adjustment is made by unsoldering the lead going from pin 2 of the transmitter to terminal 2 of transformer T1 and inserting a dc milliammeter (0-1.0 ma) between this pin 2 and terminal 2 of T1. The R80 is adjusted to produce 0.2 ma ± .05 in this circuit, after this, the milliammeter is removed and the lead replaced.

The driver filter, FL101, consists of a series-resonant inductor and capacitor connected between the driver and power amplifier stages by appropriate transformers T1 and T2. This filter greatly improves the waveform of this signal applied to the power amplifier.

The power amplifier uses two series-connected power transistors, Q101 and Q102, operating as a class B push-pull amplifier with single-ended output. Diodes D101 and D103 provide protection for the base-emitter junctions of the power transistors. Zener diodes Z105 and Z106 protect the collector-emitter junctions from surges that might come in from the power line through the coaxial cable.

The output transformer T3 couples the power transistors to the output filter FL102. The output filter includes two trap circuits (L102, C_B and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G1 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line turner and coaxial cable. Autotransformer T4 matches the filter impedance to coaxial cable of 50, 60, or 70 ohms.

The series resonant circuit composed of L105, and C_E is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, thus providing a reserve impedance that is free of possible "across-the-line" resonances.

The power supply is a series-type transistorized dc voltage regulator which has a very low stand-by current drain when there is no output current demand. The Zener diode Z1 holds a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the dc voltage drop through transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage. The Zener diode Z2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the dc output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuit.

CHARACTERISTICS

Frequency Range	30-300 kHz	
Output	1 watt guard- 10 watts transfer trip (into 50 to 70 ohm resistive load) – 10 watts unblock.	
Frequency Stability	±10 Hz from −20°C to +55°C.	
Frequency Spacing	2500 Hz min. between transmitter and adjacent receiver frequencies (with r.f. hybrid)	
Harmonics	Down 55 db (min.) from output level.	
Input voltage	48 or 125 v.d.c.	
Supply voltage variation	42-56 v. for nom. 48 v. supply. 105-140 v. for nom 125 v. supply.	
Battery drain	0.5 a. guard 1.15 a. trip	48 v.d.c
	0.5 a. guard 1.15a. trip	125 v.d.c.
Keying circuit current	4 ma.	
Temperature range	−20 to +55°C. Around chassis.	
Dimensions	Panel height - 12¼" or 7 r.u. Panel width - 19"	
Weight	12 lbs.	

INSTALLATION

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

ADJUSTMENTS

The TCF 10 W/1 W/10 W 3 frequency transmitter is shipped with the power output controls R64 and R70 set for outputs of 1 watt and 10 watts into a 60 ohm load. If it is desired to check these adjustments or if repairs have made readjustment necessary, the coaxial cable should be disconnected from the assembly terminals and replaced with a 50 to 70 ohm non-inductive resistor of at least a 10 watt rating. Use the value of the expected input impedance of the coaxial cable and line tuner. If this is not known, assume 60 ohms. Connect the T4 output lead to the corresponding tap. Connect an ac vacuum tube voltmeter (VTVM) across the load resistor. Turn power output control R64 to minimum (full counter-clockwise). Turn on the power switch on the panel and note the dc voltage across terminals 5 and 7 of J3. If this is in the range of 42 to 46 volts, rotate R64 clockwise to obtain 4 or 5 volts across the load resistor used. At this point check the adjustment of the series output tuning coil L105 by loosening the knurled shaft-locking nut and moving the adjustable core in and out a small amount from its initial position. Leave it at the point of maximum voltage across the load resistor used. Then rotate R64 farther clockwise to obtain the correct voltage for 1 watt in the load resistor, as shown in the following table. For above 200 kHz, tuning coil L105 is a screw type adjustment and not a plunger with kunrled shaft and locking nut.

Then change to Trip frequency by connecting together terminals 2 and 3 of the transmitter printed circuit board (which is approximately equivalent to connecting together terminals 7 and 8 of J3), and rotate R70 until the voltage across the load resistor is as shown in the following table for a 10 watt output. Recheck the adjustment of L105 for maximum output voltage and readjust R70 for a 10 watt output if necessary. Tighten the locking nut on L105. Open the power switch, remove the jumper used to key the transmitter to the 10 watt level, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

T106 Tap	Voltage for 1 Watt Output	Voltage for 10 Watts Output
50	7.1	22.4
60	7.8	24.5
70	8.4	26.5

Follow the procedure outlined in the line tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. It is factory tuned for maximum second and third harmonic rejection, and for series resonance (maximum output at the fundamental frequency) with a 60-ohm load. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L015. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection and no change should be made in these settings unless suitable instruments are available for measuring the second and third harmonic present in the transmitter output.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals, this can be done by turning the matched pair 180° and inserting a crystal in its proper socket with other crystal unconnected. A sensitive frequency counter with a range of at least 2.3 MHz can be connected from TP51 and TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter input capacitance on the oscillator circuit.) While measurement of the oscillator crystals individually is necessary for the initial adjustment of the oscillators, generally any subsequent checks may be made with a lower range counter connected at the transmitter output. If any minor adjustment of the Guard and Trip frequencies should be needed, the Guard adjustment should be made with capacitor C52 and the Trip adjustment with C53.

Q56-Q57 BIAS ADJUSTMENT

The push-pull output stages of the transmitter board are normally shipped correctly biased. If any components involved in these stages have been changed, then it may be necessary to recheck the biasing of this stage.

Unsolder the lead from terminal 2 of transformer T1 (just above FL101) and temporarily connect a low-range dc milliammeter (0-1.0 ma) between the removed lead (+) and T1 terminal 2 (−). Turn the slotted control on the small potentiometer to full counterclockwise. Now, apply power to the TCF carrier set, but do not transmit carrier. This can be done by removing the crystals. Advance the potentiometer clockwise until the milliammeter reads 0.2 ma. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T1. Replace the crystals and again apply dc power to reenergize the transmitter. Check output, etc. of transmitter as previously described.

MAINTENANCE

Periodic checks of the transmitter Guard and Trip power outputs will detect impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output at such times, making any necessary readjustments to return the equipment to its initial settings.

Voltage values should be recorded 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. Readings may vary as much as ± 20%.

TABLE I
TRANSMITTER DC MEASUREMENTS

Note: All voltages are positive with respect to Neg. 45 V. (TP51). All voltages read with dc VTVM.

Test Point	Voltage at 1 Watt Output	Voltage at 10 Watts Output
TP52	20	20
TP53	5.4	5.4
TP54	3.4	3.4
TP55	21	18.5
TP56	21	18.5
TP57	<1.0	<1.0
TP58	44.3	44.1
TP59	<1.0	<1.0
TP101	0	0
TP103	21 ± 2	21 ± 2
TP105	44.3	44.0

TABLE II
TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages subject to variations, depending upon frequency and transistor characteristics. T51-3 = Terminal 3 of transformer T51. Other transformer terminals identified similarly. All read with ac VTVM.

Test Point	Voltage at 1 Watt Output	Voltage at 10 Watts Output
TP54 to TP51	0.015 - 0.03	0.015 - 0.03
TP57 to TP51	0.05 - 0.09	0.3 - 1.2
TP59 to TP51	0.05 - 0.09	0.3 - 1.2
T1-1 to TP51	1.65	5.6
T1-3 to TP51	1.45	4.9
T1-4 to Gnd.	.6	2.0
T2-1 to Gnd.	.57	1.85
TP101 to TP103	5.2	17.0
TP103 to TP105	5.2	17.0
T3-4 to Gnd.	35	112
T4-2 to Gnd.	31	110
TP109 to Gnd.	9.8	31
J102 to Gnd.	7.8	24.5

CONVERSION OF TRANSMITTER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a 1W/10W TCF transmitter for operation on a different channel frequency consist of a pair of matched crystals for the new channel frequency, new capacitors C103 and C104 on the power amplifier circuit board if the old and new frequencies are not in the same frequency group (see table on internal schematic drawing) and, in general, new or modified filters FL101 and FL102. Inductors L101, L102 and L103 in these filters are adjustable over a limited range, but thirty-two combinations of capacitors and inductors are required to cover the frequency range of 30 to 200 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlay is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5	207.1-214.0
32.0-33.5	64.5- 68.0	120.0-127.0	214.1-222.0
34.0-36.0	68.5- 72.0	127.5-135.0	222.1-230.0
36.5-38.5	72.5- 76.0	135.5-143.0	230.1-240.0
39.0-41.0	76.5- 80.0	143.5-151.0	240.1-250.0
41.5-44.0	80.5- 84.5	151.5-159.5	250.1-262.0
44.5-47.0	85.0- 89.0	160.0-169.5	262.1-274.0
47.5-50.0	89.5- 94.5	170.0-180.0	274.1-287.0
50.5-53.5	95.0-100.0	180.5-191.5	287.1-300.0
54.0-57.0	100.5-106.0	192.0-200.0	✪
57.5-60.5	106.5-112.5	200.1-207.0	

If the new frequency lies within the same frequency group as the original frequency, the filters can be readjusted. If the frequencies are in different groups, it is possible that changes only in the fixed capacitors may be required. In general, however, it is desirable to order complete filter assemblies adjusted at the factory for the specified frequency.

A signal generator, a frequency counter and a vacuum tube voltmeter are required for readjustment of FL101. The signal generator and the counter should be connected across terminals 4 and 5 of transformer T1 and the voltmeter across terminals 1 and 2 of transformer T2. The signal generator should be set at the channel center frequency and at 2 to 3 volts output. The core screw of the small inductor should be turned to the position that gives a true maximum reading on the VTVM. Turning the screw to either side of this position should definitely reduce the reading. The change in inductance with core position is less at either end of the travel than when near the center and consequently the effect of core screw rotation on the VTVM reading will be less when the resonant inducatnce occurs near the end of core travel.

The procedure for readjustment of the 2nd and 3rd harmonic traps of filter FL102 is somewhat similar. A signal generator and a counter should be connected to terminals 3 and 4 of transformer T3, and a 500 ohm resistor and a VTVM to the terminals of protective gap G1. The ground or shield lead of all instruments should be connected to the grounded terminal of the transformer. Set the signal generator at exactly twice the channel center frequency and at 5 to 10 volts output. Turn the core screw of the large inductor, L102, to the position that gives a definite minimum reading on the VTVM. Similarly, with the signal generator set at exactly three times the channel center frequency and 5 to 10 volts output, set the core screw of the small inductor, L103, to the position that gives a definite minimum reading on the VTVM. Then remove the instruments and the 500 ohm resistor.

After the new pair of matched crystals have been adjusted, as described under "ADJUSTMENTS", the transmitter can be operated with a 50 to 70 ohm load (depending on which tap of T4 is used) connected to its output, and inductor L105 can be readjusted for maximum output at the changed channel frequency by the procedure described in the same section.

If a frequency-sensitive voltmeter is available, the 2nd and 3rd harmonic traps may be adjusted without using an oscillator as a source of double and triple the channel frequency. Connect the frequency-sensitive voltmeter from TP109 to ground and adjust the transmitter for rated output into the selected load resistor. Set the voltmeter at twice the channel frequency and, using the tuning dial and db range switch, obtain a maximum on-scale reading of the 2nd harmonic. Then vary the core position of L102 until a minimum voltmeter reading is obtained. Similarly, tune the voltmeter to the third harmonic and adjust L103 for minimum voltmeter reading. Although the transmitter frequency will differ from the channel center frequency by 100 Hz, the effect of this difference on the adjustment of the harmonic traps will be negligible. It should be noted that the true magnitude of the harmonics cannot be measured in this manner because of the preponderance of the fundamental frequency at the voltmeter terminals. Accurate measurement of the harmonics requires use of a filter between TP109 and the voltmeter that provides high rejection of the fundamental. The insertion losses of this filter for the 2nd and 3rd harmonics must be measured and taken into account.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. 60-ohm 10-watt non-inductive resistor.

b. AC vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 hz to 330-kHz; input impedance 7.5 megohms.

c. DC 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.

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

RENEWAL PARTS

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

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled, 0.45 mfd.; 330 V.A.C.	1723408
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C3	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized Paper, .047 mfd.;	849A437H04
C21	Metallized Paper, .047 mfd.;	849A437H04
C51	Dur-Mica, 1500 pf.; 500 V.D.C.	762A757H03
C52	Variable, 5.5-18 pf.	879A834H01
C53	Variable, 5.5-18 pf.	879A834H01
C54	Metallized Paper, .1 mfd.; 200 V.D.C.	187A624H01
C55	Variable, 5.5-18 pf.	762A736H01
C56	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C57	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C58	Metallized Paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C60	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C61	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C62	Dur-Mica, 4700 pf.; 500 V.D.C.	762A757H04
C63	Dur-Mica, 1000 pf.; 500 V.D.C.	762A757H02
C64	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C65	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C66	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C67	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C68	Metallized paper, 0.5 mfd.; 200 V.D.C.	187A624H03
C69	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C70	3 pf.	861A846H03
C71	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C72	Dur-Mica, 300 pf. 500 V.D.C.	187A584H09
C73	Variable, 5.5-18 pt.	879A834H01
C74	3 pf.	861A846H03
C75	3 pf.	861A846H03
C76	3 pf.	861A846H03
C101	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C102	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C103 & C104	(30-50 KC) – Extended foil, 0.47 mfd.; 400 V.D.C.	188A293H01
C103 & C104	(50.5-75 KC) – Extended foil, 0.22 mfd.; 400 V.D.C.	188A293H02
C103 & C104	(75.5-100 KC) – Extended foil, 0.15 mfd.; 400 V.D.C.	188A293H03
C103 & C104	(100.5 - 150 KC) – Extended foil, 0.10 mfd.; 400 V.D.C.	188A293H04
C103 & C104	(150.5 - 300 KC) – Extended foil, 0.047 mfd.; 400 V.D.C.	188A293H05
	DIODES – GENERAL PURPOSE	
D11	1N645A	837A692H03
D12	1N645A	837A692H03
D13	1N4822	188A342H11
D14	1N4822	188A342H11

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
D15	1N4882	188A342H11
D16	1N4822	188A342H11
D21	1N645A	837A692H03
D22	1N4822	188A342H11
D23	1N4822	188A342H11
D24	1N4822	188A342H11
D25	1N4822	188A342H11
D51	1N628; 125 V., 30 MA.	184A885H12
D52	1N628; 125 V., 30 MA.	184A885H12
D55	1N457A; 60 V., 200 MA.	184A885H07
D58	1N628; 125 V., 30 MA.	184A885H12
D101	1N538; 200 V., 750 MA.	407C703H03
D102, D104	1N91; 100 V., 150 MA. (Germanium Version used with 2N1908)	182A881H04
D103	1N538; 200 V., 750 MA.	407C703H03
D102, D104	1N4818 (Silicon Version used with 2N3792	182A881H04
	DIODES – ZENER	
Z1	1N2828B; 45 V. ±5%; 50 W.	184A854H06
Z2	1N3009A; 130 V. ±10%; 10 W.	184A617H12
Z11	1N957B	186A797H06
Z12	1N3688A	862A288H01
Z13	1N3588A	862A288H01
Z14	1N3686B	185A212H06
Z21	1N957B	186A797H06
Z22	1N3688A	862A288H01
Z23	1N3688A	862A288H01
Z24	1N3686B	185A212H06
Z54	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
Z105	1N2999A; 56 V. ±10%; 10 W.	184A617H13
Z106	1N2999A; 56 V. ±10%; 10 W.	184A617H13
	RESISTORS	
R1	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R2	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R3	26.5 ohms ±5%; 40 W. (For 48 V Supply)	04D1299H44
R3	500 ohms ±5%; 40 W. (For 125 V Supply)	1268047
R4	100 ohms ±10%; 1 W. Composition	187A644H03
R5	1K ±10%; ½ W. Composition	187A641H27
R6	3K ±5%; 5 W. Wire Wound	188A317H01
R7	15K ±10%; 2 W. Composition	187A642H55
R11	4.7k ±2%; ½ W. Metal Glaze	629A531H48
R12	12K ±2%; ½ W. Metal Glaze	629A531H58
R13	10K ±2%; ½ W. Metal Glaze	629H531H56

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Continued)	
R14	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R15	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R16	47K ±2%; ½ W. Metal Glaze (For 125 Vdc)	629A531H72
R17	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R21	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R22	12K ±2%; ½ W. Metal Glaze	629A531H58
R23	10K ±2%; ½ W. Metal Glaze	629A531H56
R24	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R25	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R26	15K ±2%; ½ W. Metal Glaze (For 48 Vdc)	629A531H60
R27	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R51	10K ±5%; ½ W. Composition	184A763H51
R52	10K ±5%; ½ W. Composition	184A763H51
R53	10K ±5%; ½ W. Composition	184A763H51
R54	10K ±5%; ½ W. Composition	184A763H51
R55	100 ohms ±5%; ½ W. Composition	184A763H03
R56	3.6K ±5%; ½ W. Composition	184A763H40
R57	3.6K ±5%; ½ W. Composition	184A763H40
R58	100 ohms ±5%; ½ W. Composition	184A763H03
R59	10K ±5%; ½ W. Composition	184A763H51
R60	5.6K ±5%; ½ W. Composition	184A763H45
R61	15K ±5%; ½ W. Composition	184A763H55
R62	10K ±5%; ½ W. Composition	184A763H51
R63	1K ±5%; ½ W. Composition	184A763H27
R64	Potentiometer, 1K; ¼ W.	629A430H02
R65	1.8K ±5%; ½ W. Composition	184A763H02
R66	8.2K ±5%; ½ W. Composition	184A763H49
R67	12K ±5%; ½ W. Composition	184A763H53
R68	330 ohms ±5%; ½ W. Composition	184A763H15
R69	800 ohms +5%; ½ W. Composition	184A859H06
R70	Potentiometer, 1K; ¼ W.	629A430H02
R71	4.7K ±5%; ½ W. Composition	184A763H43
R72	39K ±5%; ½ W. Composition	184A763H65
R73	Thermistor, 30 ohms, Type 3D202 (G.E.C.)	185A211H06
R74	180 ohms ±5%; ½ W. Composition	184A763H02
R75	100 ohms ±5%; ½ W. Composition	184A763H03
R76	2K ±5%; ½ W. Composition	184A763H34
R77	10 ohms ±5%; ½ W. Composition	187A290H01
R78	10 ohms ±5%; ½ W. Composition	187A290H01
R79	20K ±20%; ½ W. Metal Glaze	629A531H63
R80	25K Potentiometer ±20%; ¼ W.	629A430H09
R81	1K ±1%; 1½ W. Metal Film	849A819H48

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Continued)	
R82	5K Pot. ±20%; ½ W.	629A430H07
R83	10.2K ±1%; ½ W. Metal Film	848A820H46 ◆
R84	27 ohms ±5%; ½ W. Composition	187A290H11
R85	Thermistor 3D402 10 ohms	185A211H03
R86	750 ohms ±1%; ½ W. Metal Film	848A819H36
R87	10K ±5%; ½ W. Composition	184A763H51
R101	10 ohms ±5%; ½ W. Composition	187A280H01
R102	2.2K ±10%; 1 W. Composition	187A644H35
R103	2.7 ohms ±10%; ½ W. Composition	184A636H14
R104	0.27 ohms ±10%; 1 W. Wire Wound	184A636H18
R105	10 ohms ±5%; ½ W. Composition	187A290H01
R106	4.7K ±10%; 1 W. Composition	187A644H43
R107	2.7 ohms± 10%; ½ W. Wire Wound	184A636H14
R108	0.27 ohms ±10%; 1 W. Wire Wound	184A636H18
	TRANSFORMERS	
T1	Driver Output Transformer	606B410G01
T2	Power Amp. Input Transformer	292B526G01
T3	Power Amp. Output Transformer	292B526G02
T4	Load-Matching Auto-Transformer	292B526G03
T51	Buffer Amplifier Transformer	606B537G01
T52	Driver Input Transformer	606B537G02
	*** TRANSISTORS**	
Q1	2N6259 ‡	3503A41H01
Q1	2N6259 with Heat Sink Assembly ‡	299B099G01
Q11	2N4356	849A441H02
Q12	2N699	184A638H19
Q21	2N4356	849A441H02
Q22	2N699	184A638H19
Q51	2N697	184A638H18
Q52	2N697	184A638H18
Q53	2N697	184A638H18
Q54	2N699	184A638H19
Q55	2N697	184A638H18
Q56	✪ 2N2726/2N3712	762A672H07
Q57	✪ 2N2726/2N3712	762A672H07
Q101, Q102	2N1908 (Use in Matched Pairs) (Germanium Version used with 1N91)	187A673H02
Q101, Q102	2N3792 (Use in Matched Pairs) (Silicon Version used with 1N4818)	187A673H02
	MISCELLANEOUS	
Y1-Y2	Supplied for Desired Channel Frequency in ◆Pair Matched Per Specifications on Drawing	408C743
FL101	Driver Filter	408C261 + (Req. Freq.)
FL102	Output Filter	541D214 + (Req. Freq.)
PL	Pilot Light Bulb - For 48 V. Supply (When supplied)	187A133H02
	Pilot Light Bulb - For 125 or 250 V. Supply (When supplied)	183A955H01
F1, F2	Fuse, 1.5 A (When supplied)	11D9195H26

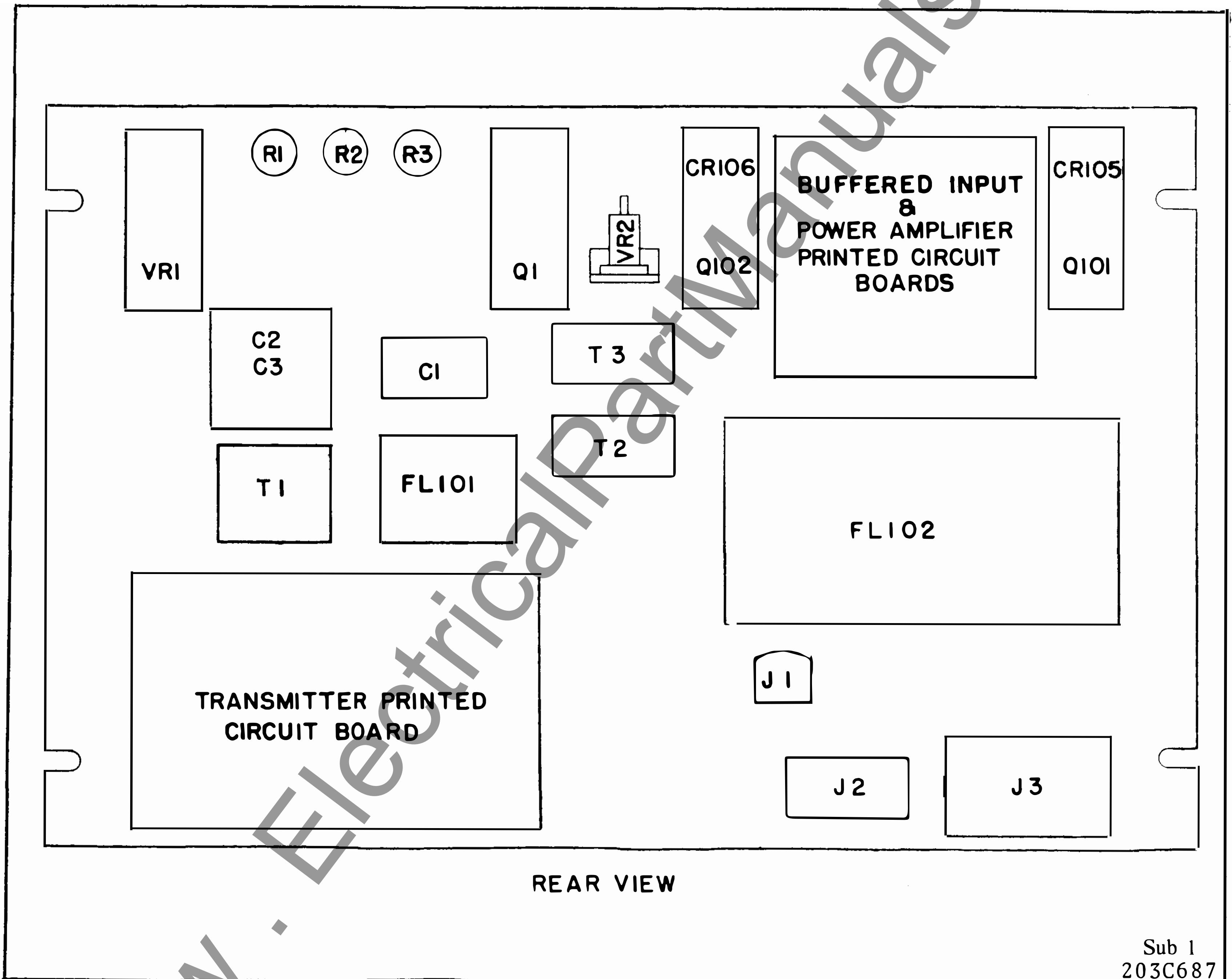


Fig. 2. Component Locations of the type TCF Transmitter Assembly.

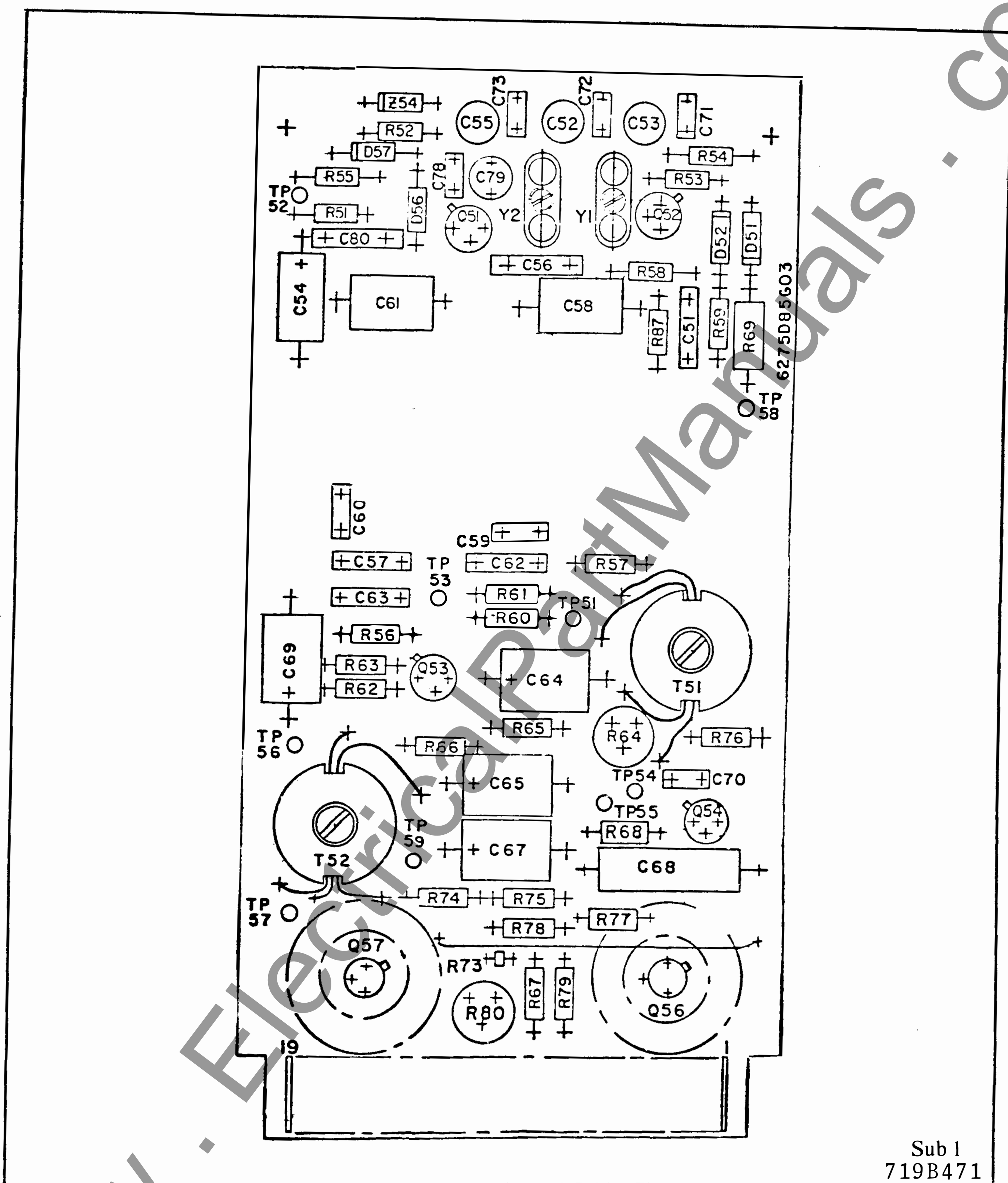


Fig. 3. Component Locations of the Transmitter Printed Circuit Board.

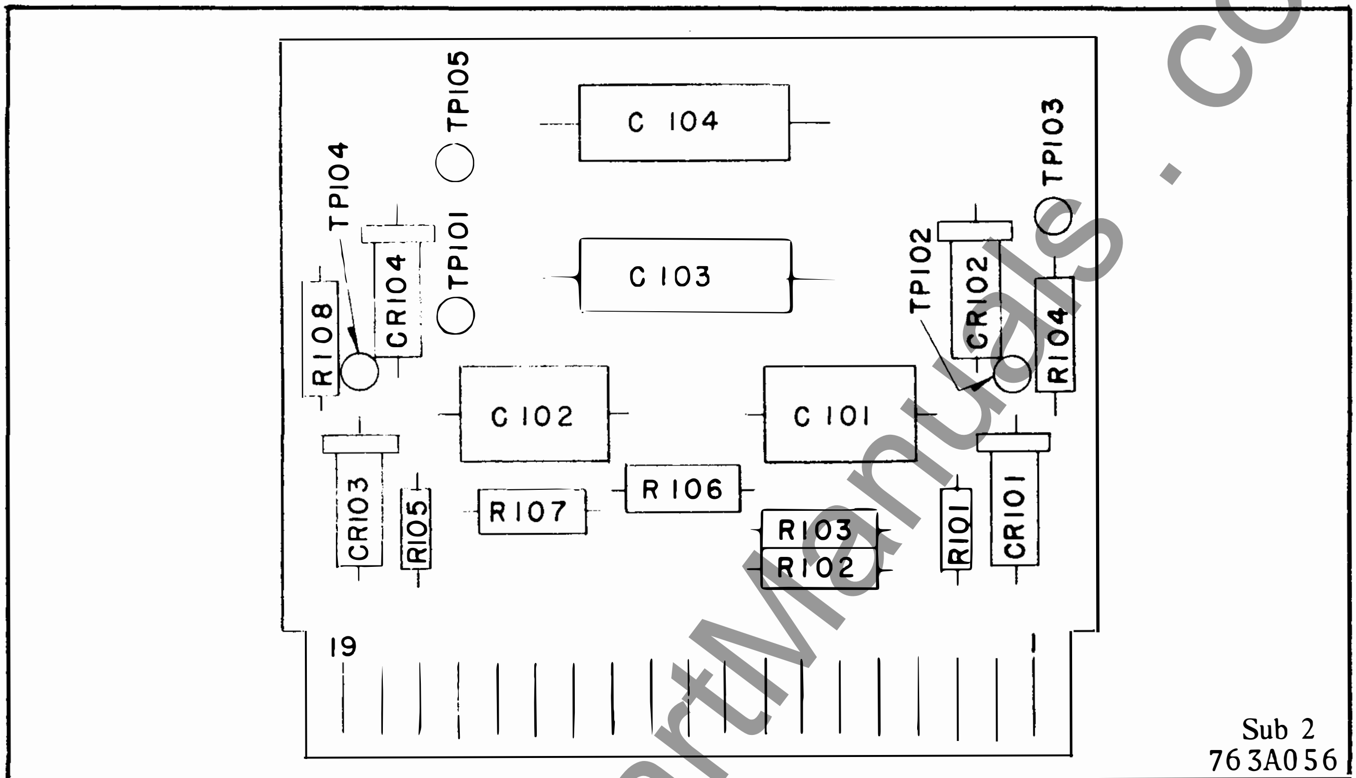


Fig. 4. Component Locations of the Power Amplifier Printed Circuit Board.

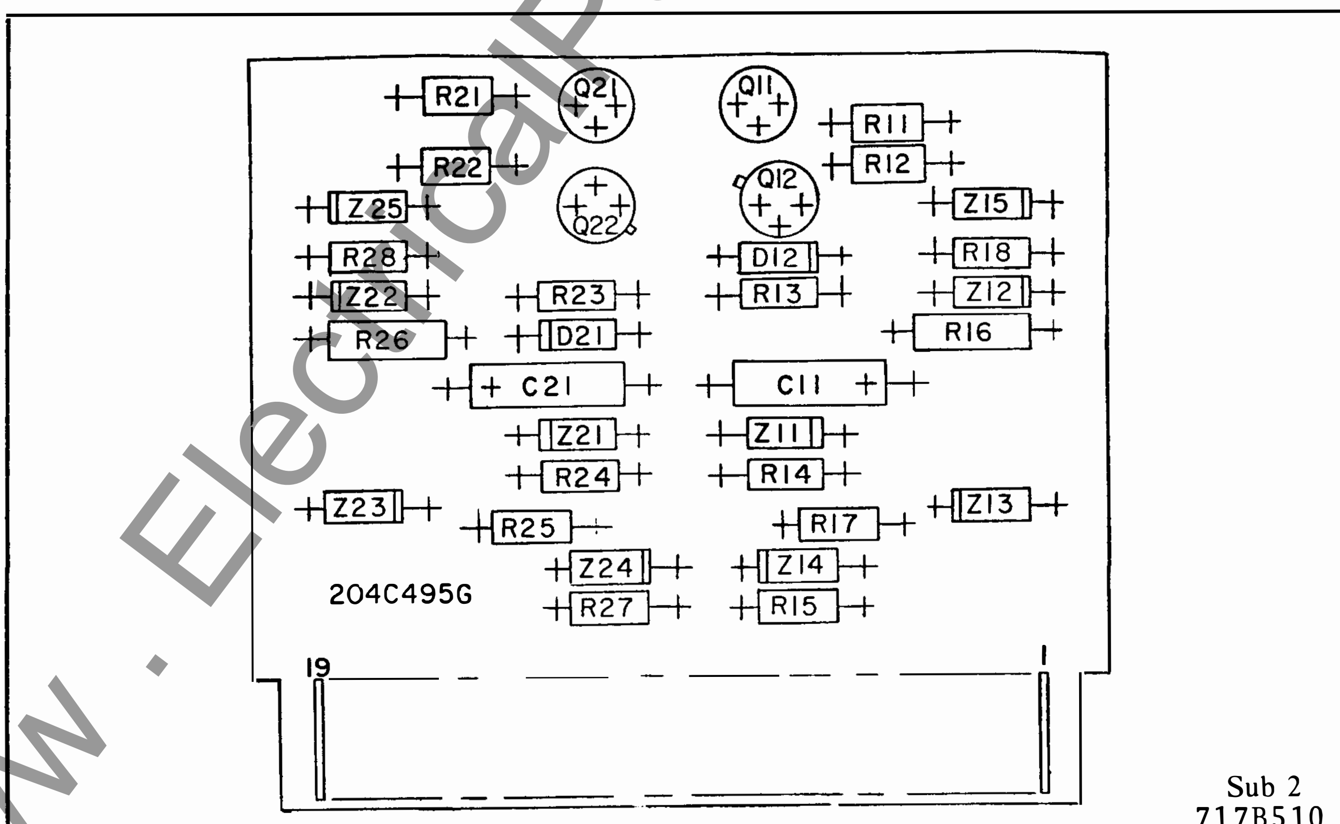


Fig. 5. Component Location of Buffer Keying Dircuit Board.

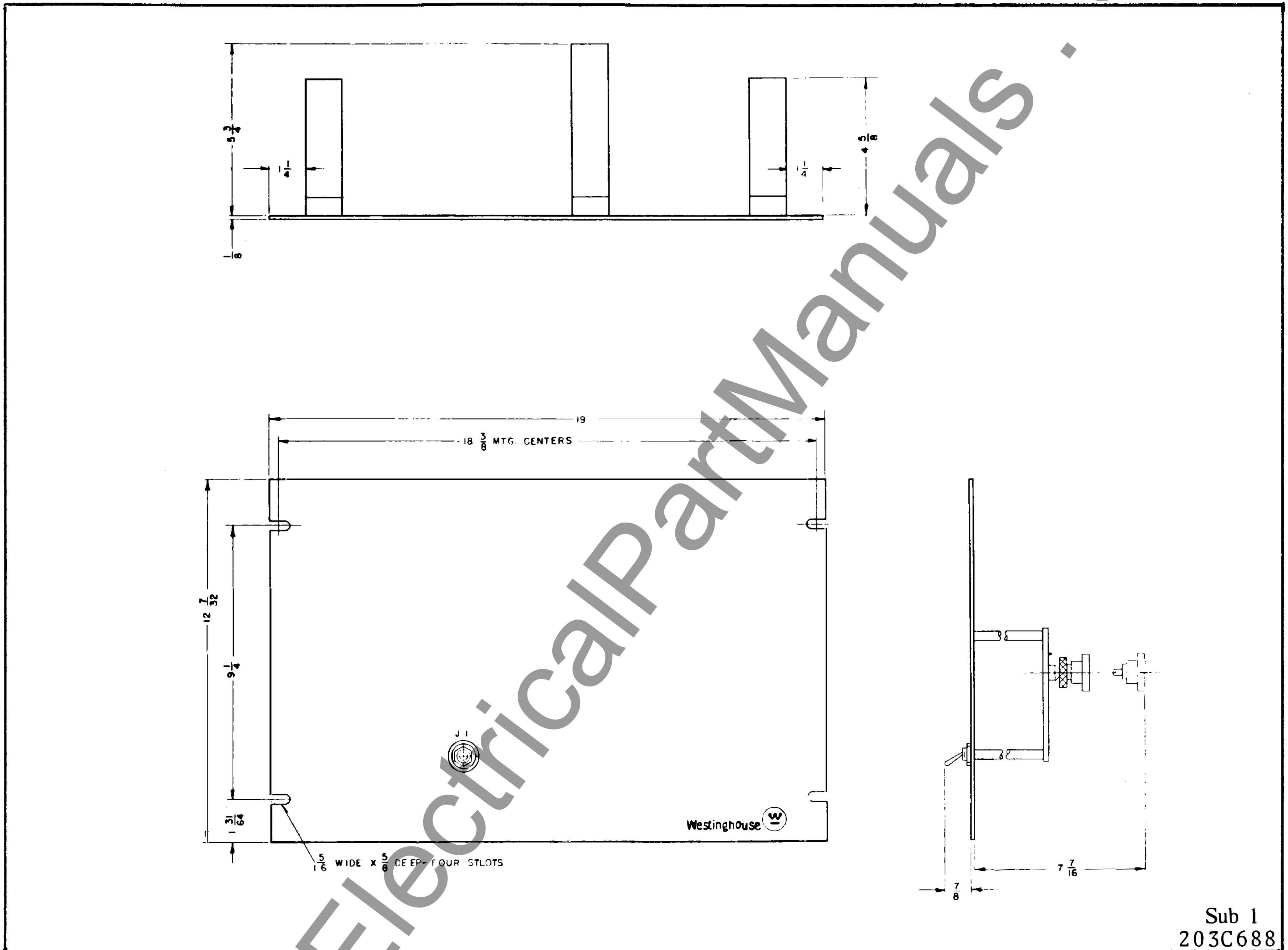


Fig. 6. Outline and Drilling Plan for the Type TCF Transmitter Assembly.

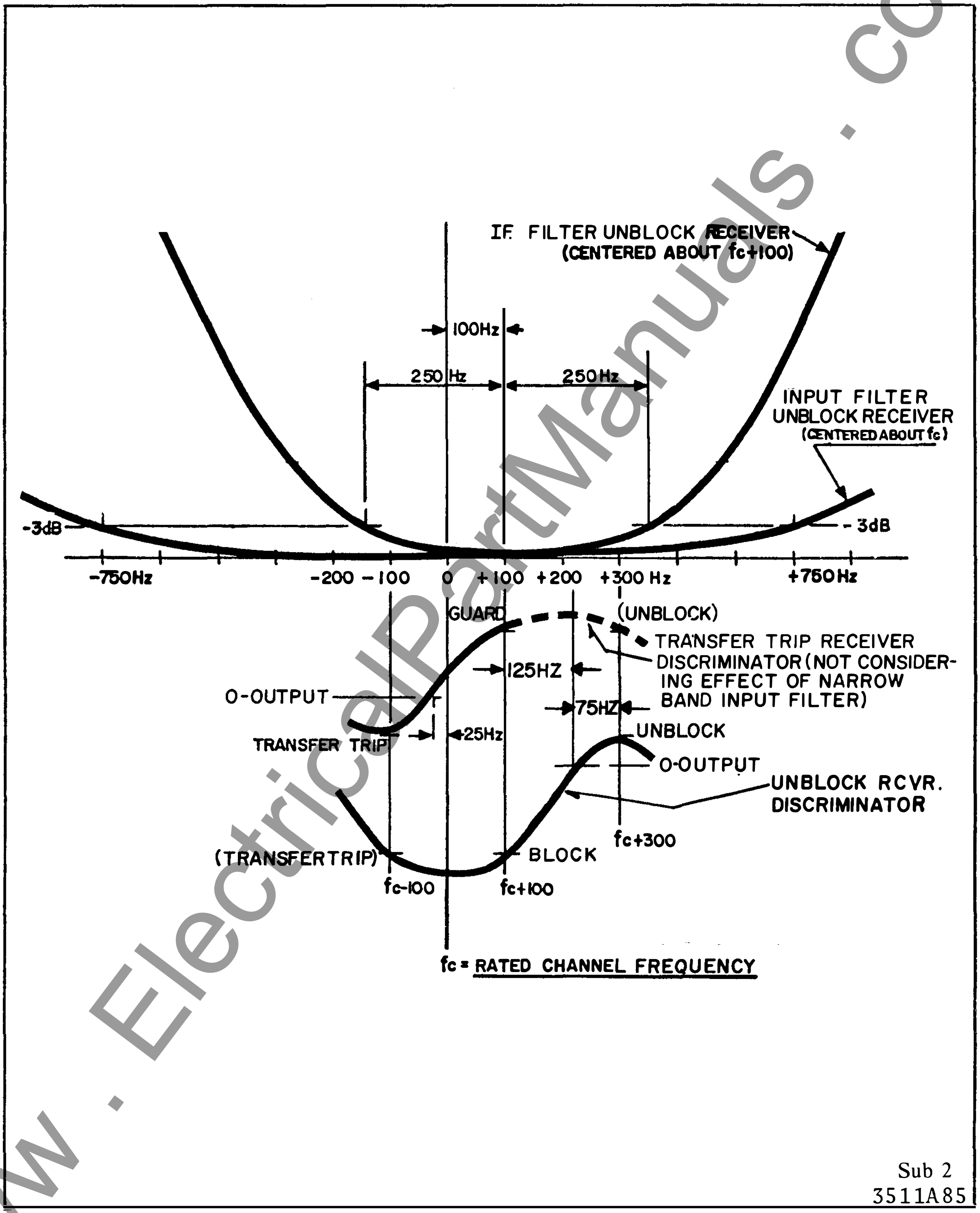


Fig. 7. Three Frequency Operation – Receiver Characteristics.

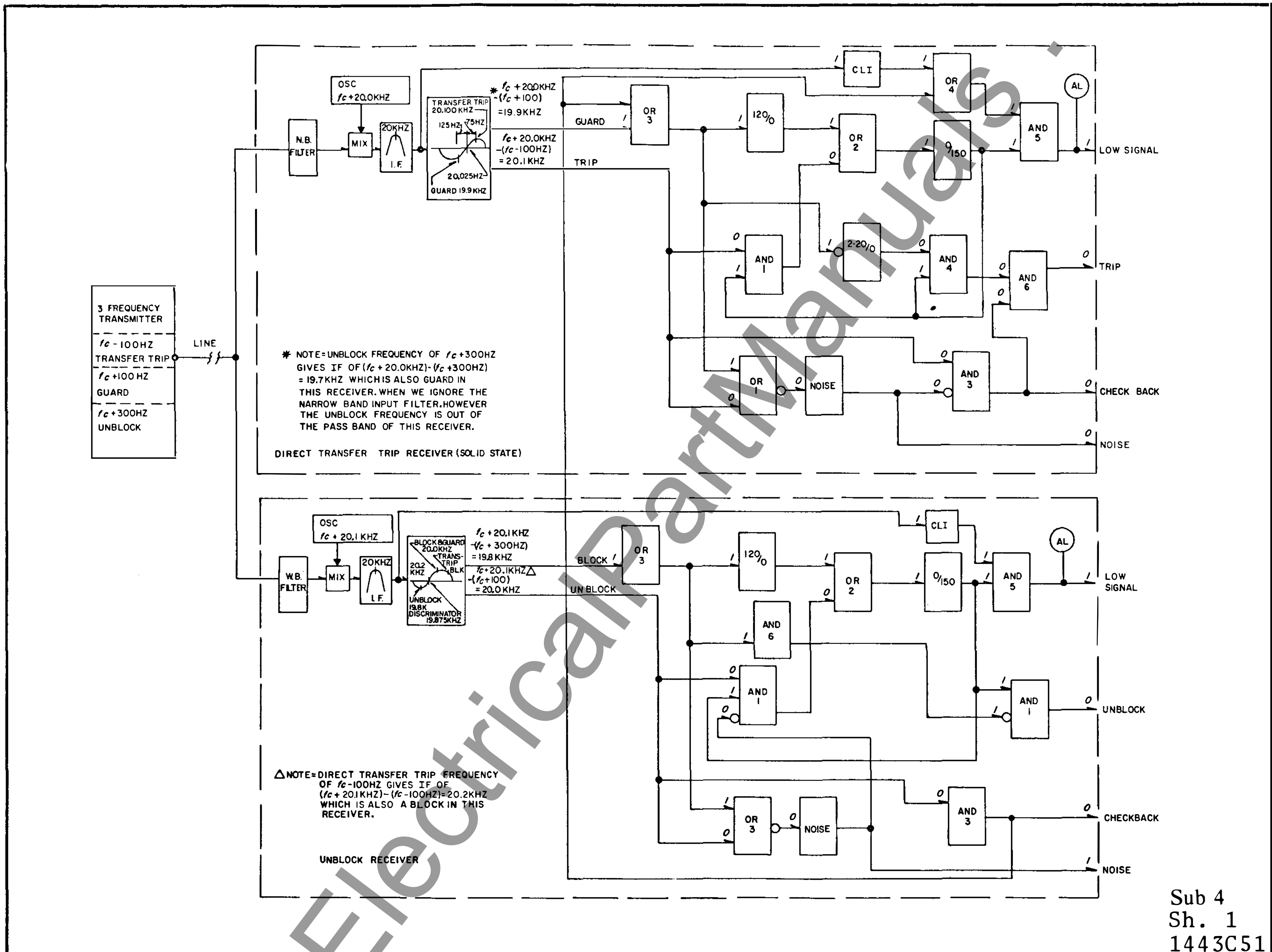


Fig. 8. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip (Solid-State Output) and Unblock Relaying.

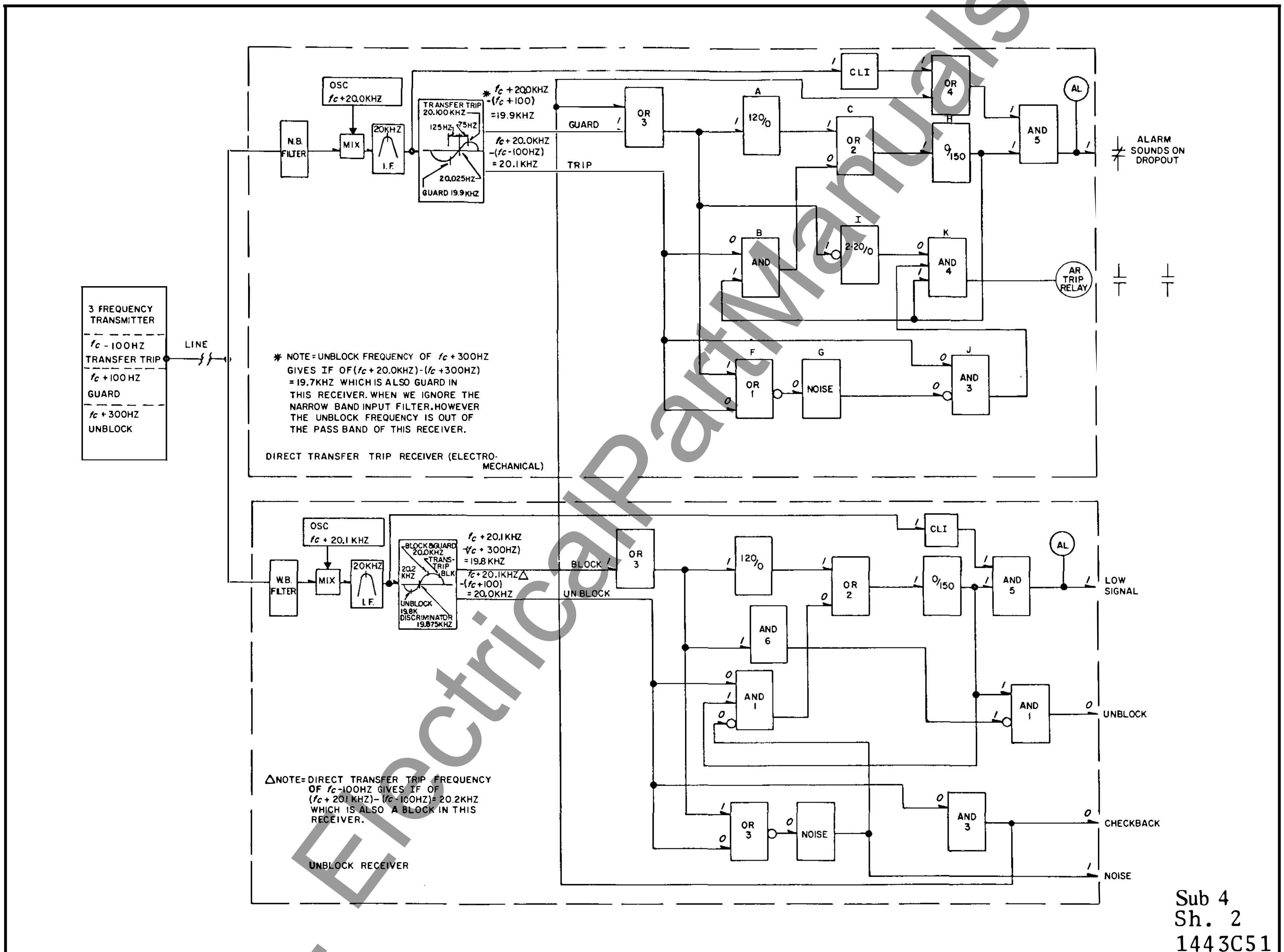


Fig. 9. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip (Contact Output) and Unblock Relaying.

WESTINGHOUSE ELECTRIC CORPORATION

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

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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

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

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

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

APPLICATION

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

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

CONSTRUCTION

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

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

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

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

SUPERSEDES I.L. 41-945.51L, dated Jan. 1976
✪ Denotes change from superseded issue.

EFFECTIVE NOVEMBER 1977

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

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

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

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

OPERATION

Input Control

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

Crystal Filter

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

Oscillator and Mixer

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

IF Amplifier

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

Amplifier and Limiter

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

Discriminator

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

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

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

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

Logic Circuits

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

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

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

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

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

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

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

In summary, the logic circuit provides the following functions:

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

Output Circuits

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

Carrier Level Indicator (When Supplied)

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

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

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

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

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

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

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

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

Power Supply

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

CHARACTERISTICS

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

INSTALLATION

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

ADJUSTMENTS

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

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

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

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

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

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

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

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

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

MAINTENANCE

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

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

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

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

TABLE I
RECEIVER D-C MEASUREMENTS

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

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

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

\# – "Keyed Trip" signifies minimum transition time from Guard to Trip.

TABLE II

RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver ✪ adjusted as in Table I. Reference to +20V.

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

RELAY MAINTENANCE AND ADJUSTMENT

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

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

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

ADDENDUM

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

Type TCF Receiver (Front View).

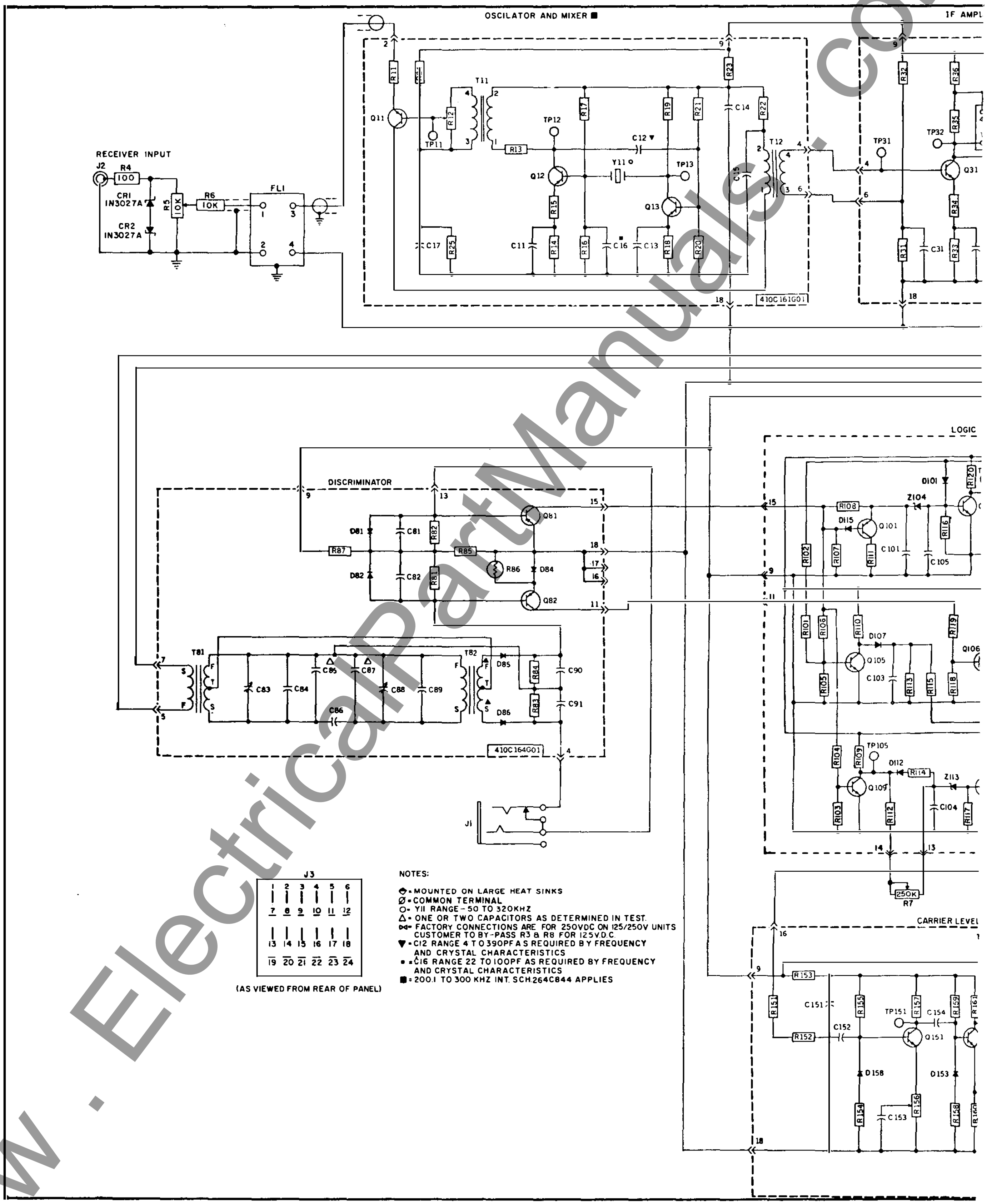
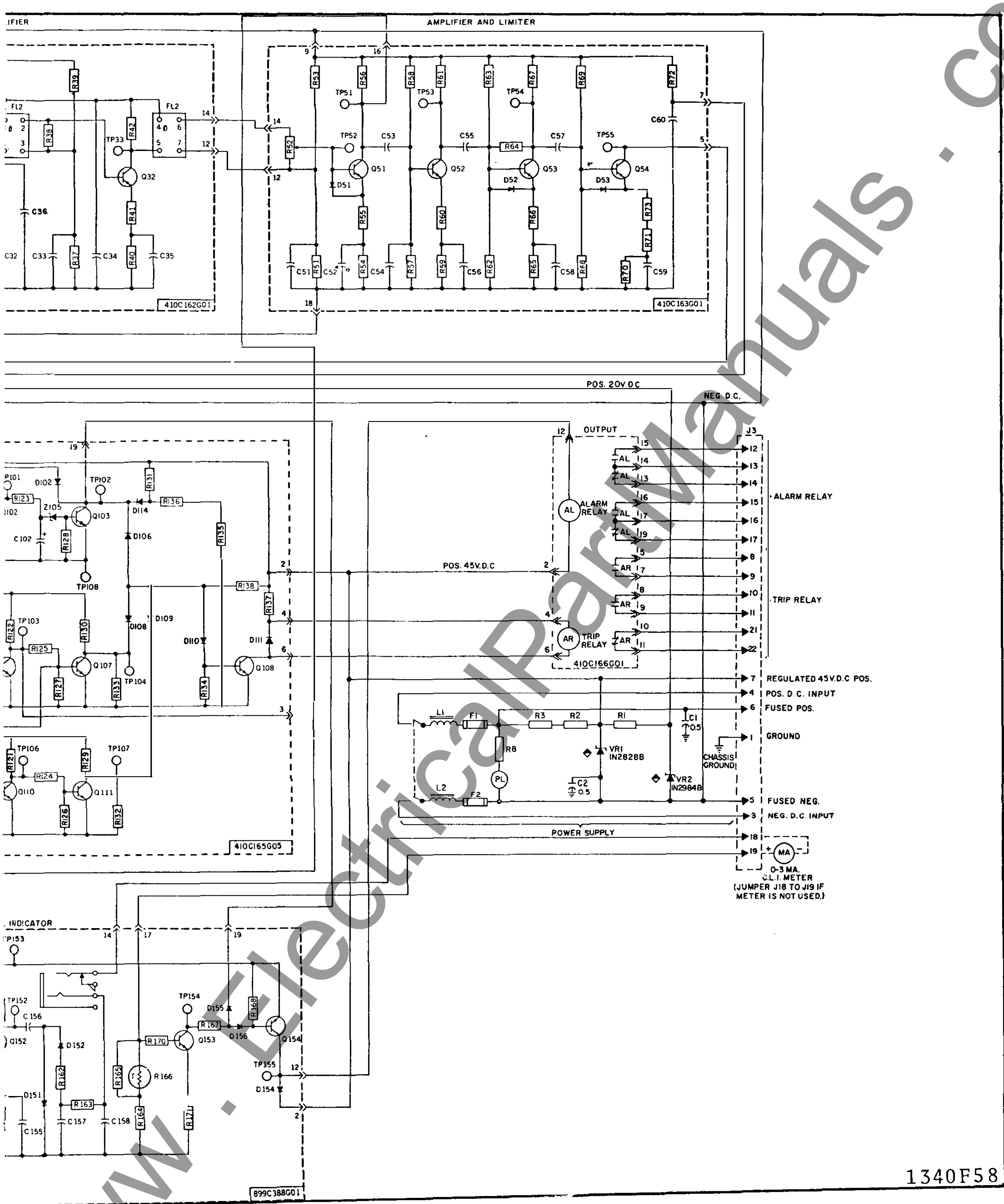


Fig. 2. Internal schematic of the type TCF



receiver with the carrier level indicator – silicon version.

FILTER RESPONSE MEASUREMENTS

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

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

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

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

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

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

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

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

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

II. Desirable Test Equipment for Apparatus Maintenance

a. All items listed in I.

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

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

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

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

RENEWAL PARTS

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

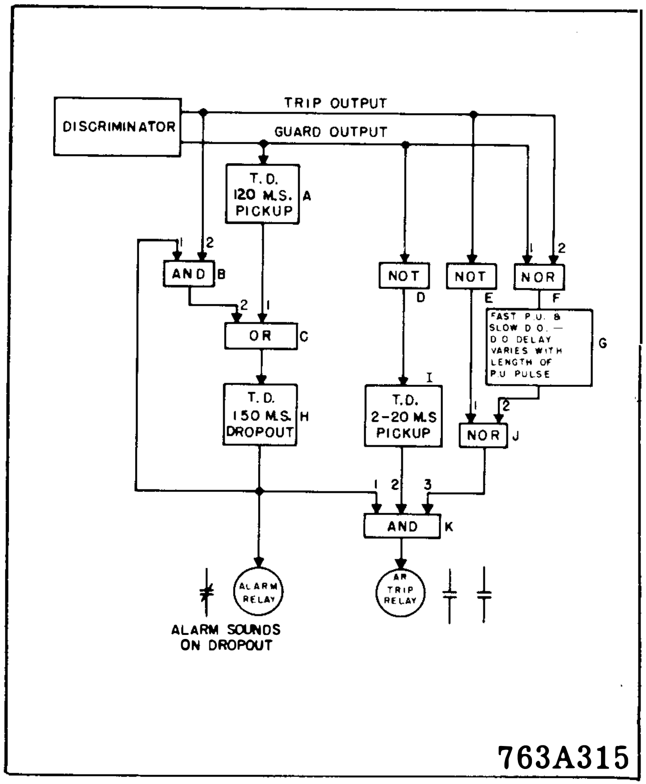


Fig. 3 Block diagram of output logic circuit

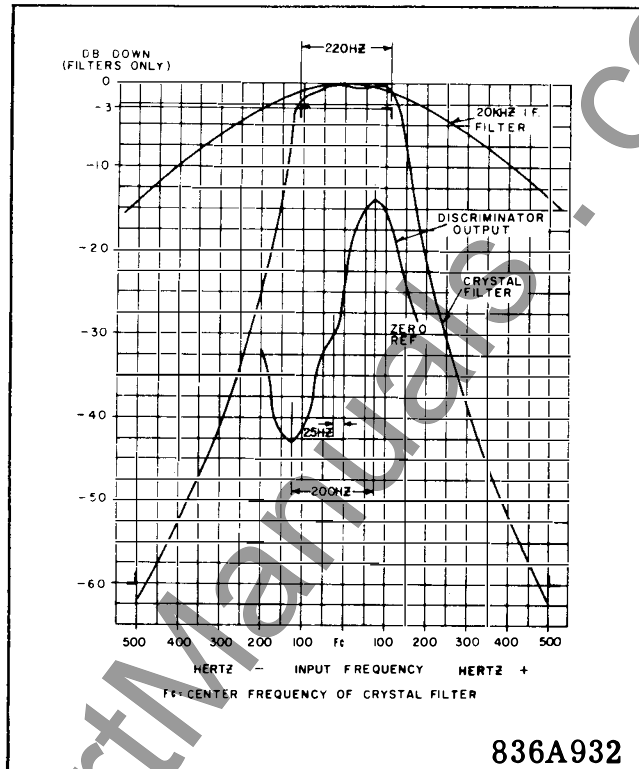


Fig. 4 Filter and discriminator characteristics of the type TCF receiver

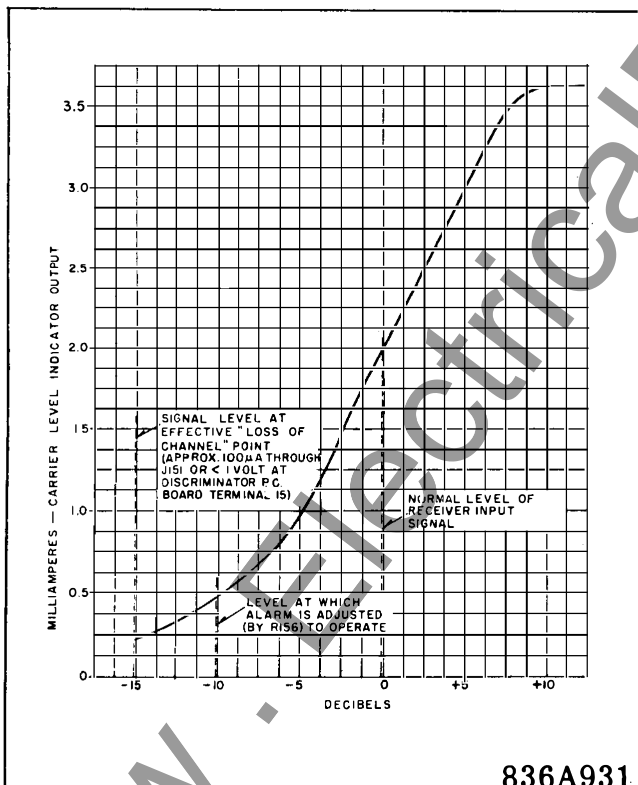


Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

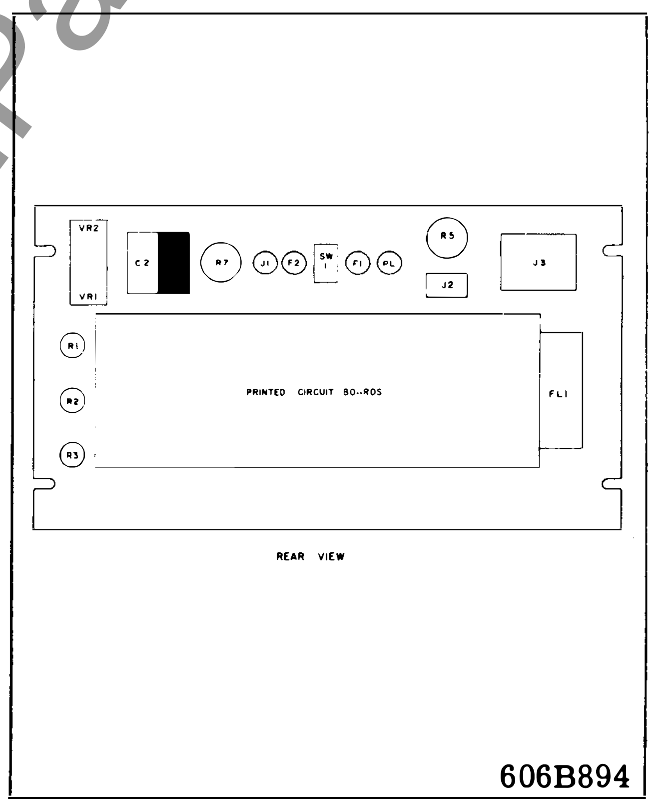


Fig. 6 Component locations on the type TCF receiver panel

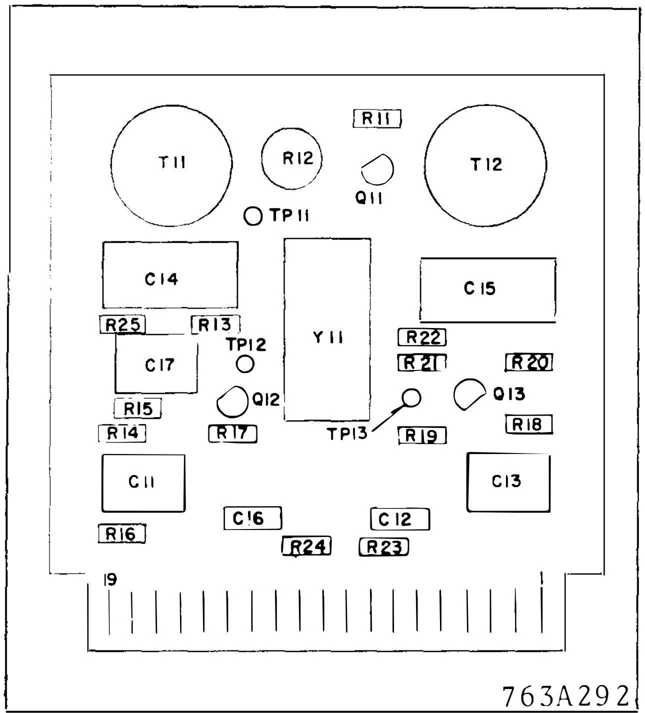


Fig. 7. Component Locations 30-200KHz. Oscillator and Mixer Silicon Transistor Version

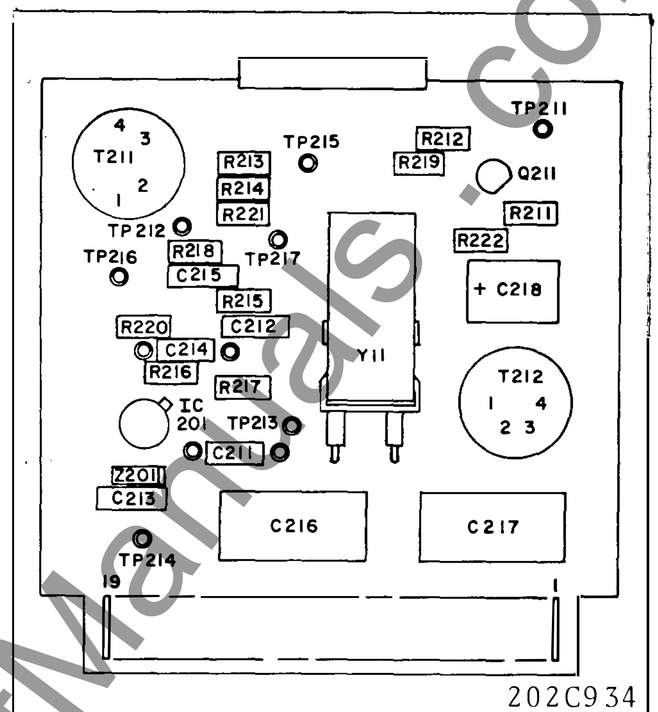


Fig. 8. Component Locations 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version

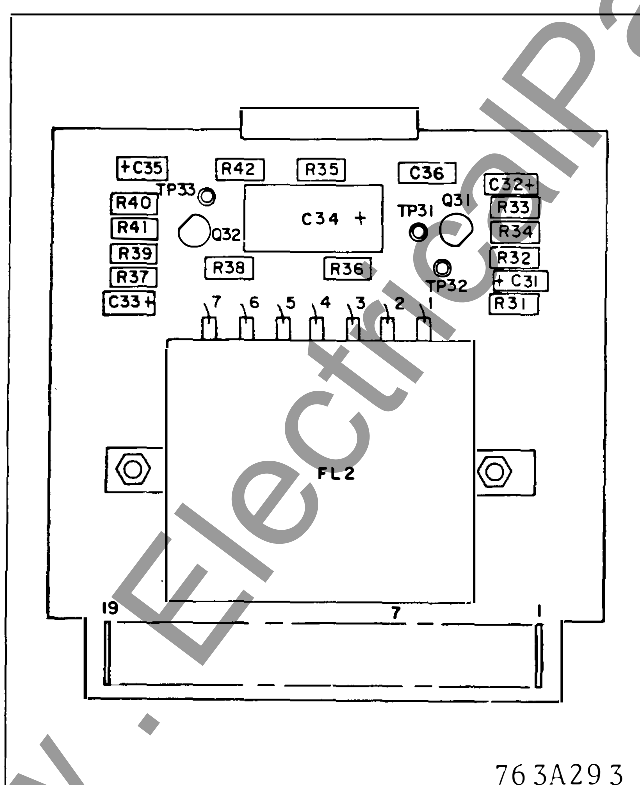


Fig. 9. Component Locations I.F. Amplifier – Silicon Transistor Version

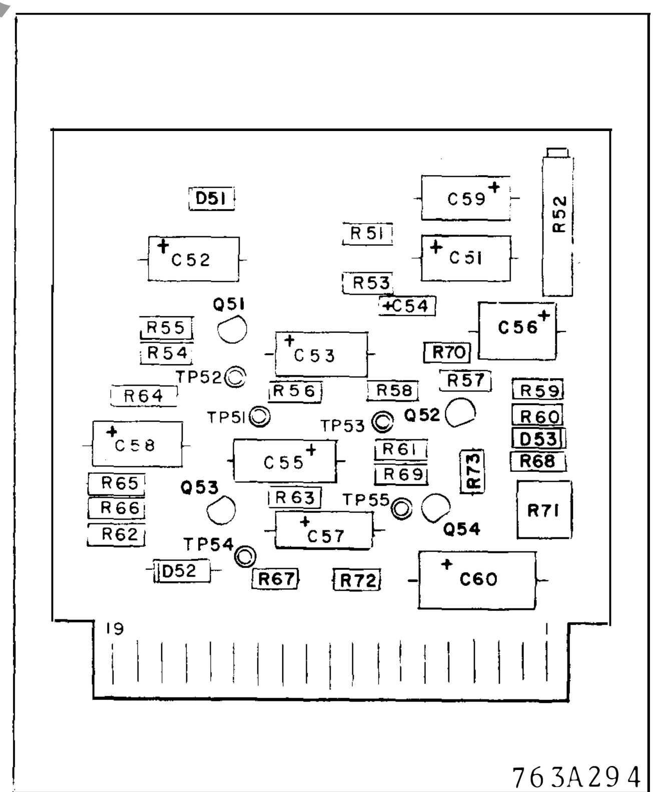


Fig. 10. Component Locations Amplifier and Limiter – Silicon Transistor Version

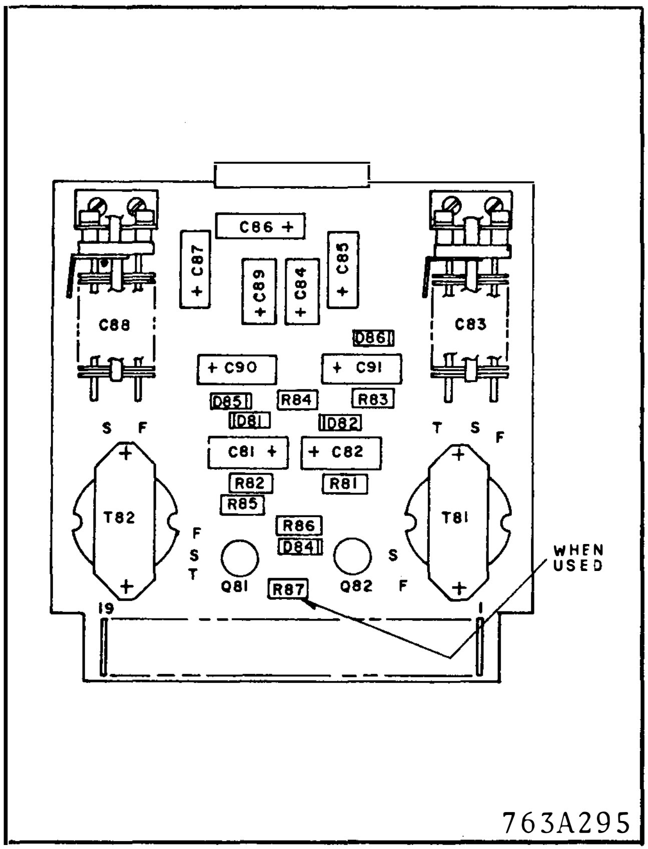


Fig. 11. Component Locations Discriminator – Silicon Transistor Version

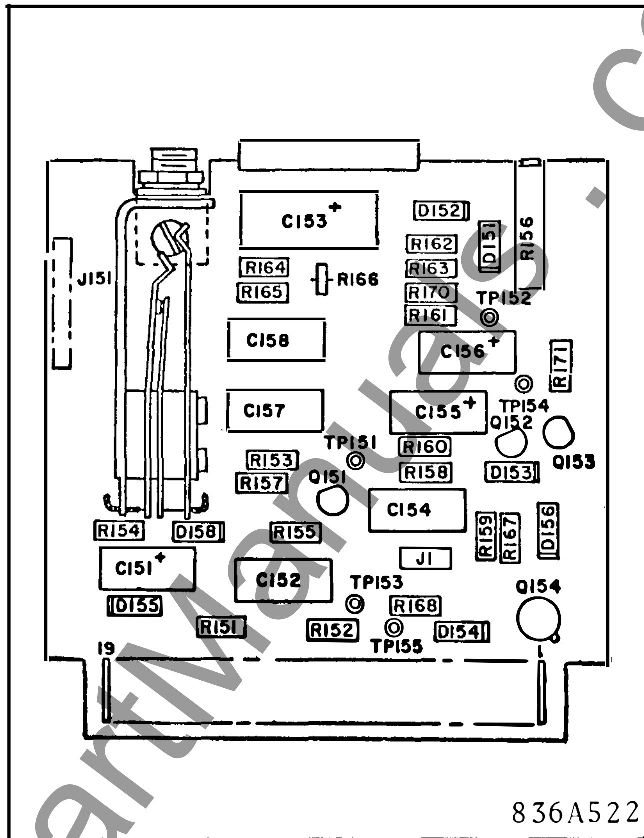


Fig. 12. Component Locations Carrier Level Indicator – Silicon Transistor Version

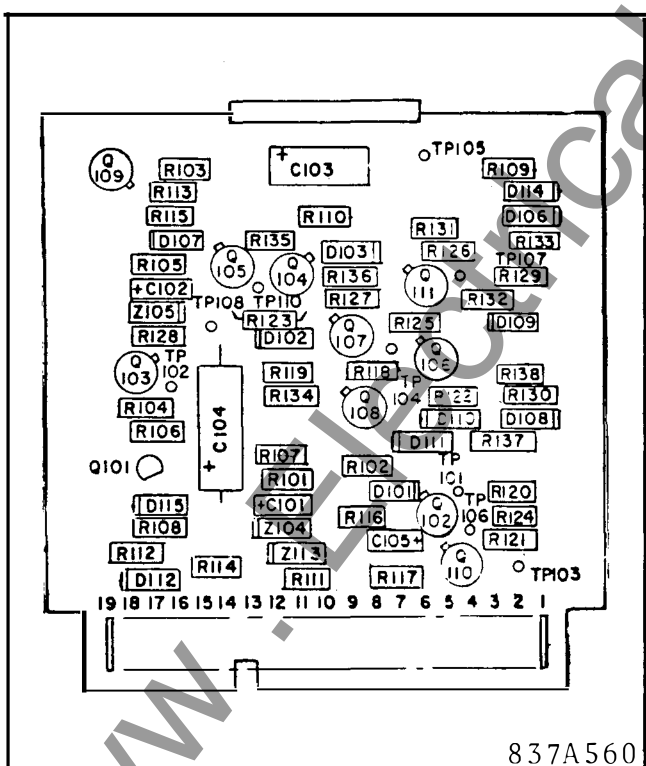


Fig. 13. Component Locations Logic Board – Silicon Transistor Version

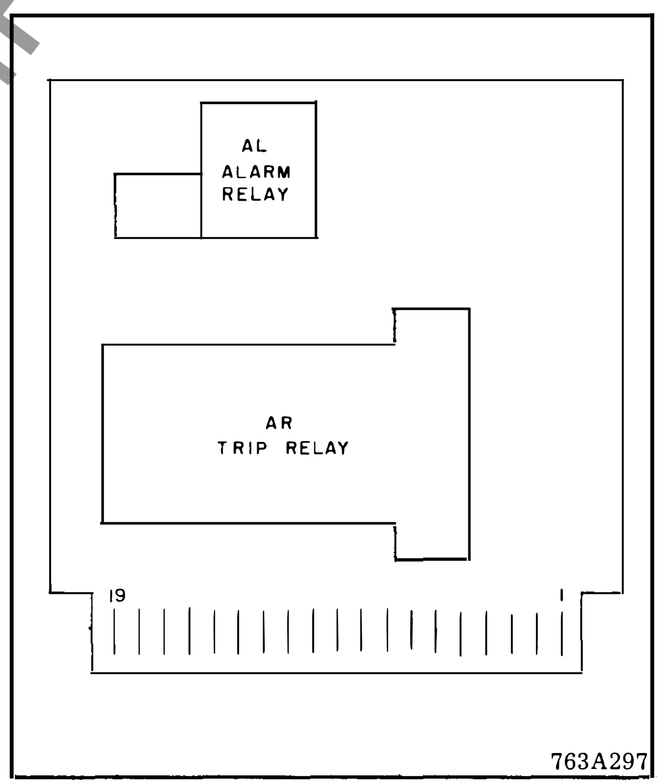


Fig. 14. Component locations on the output printed circuit board.

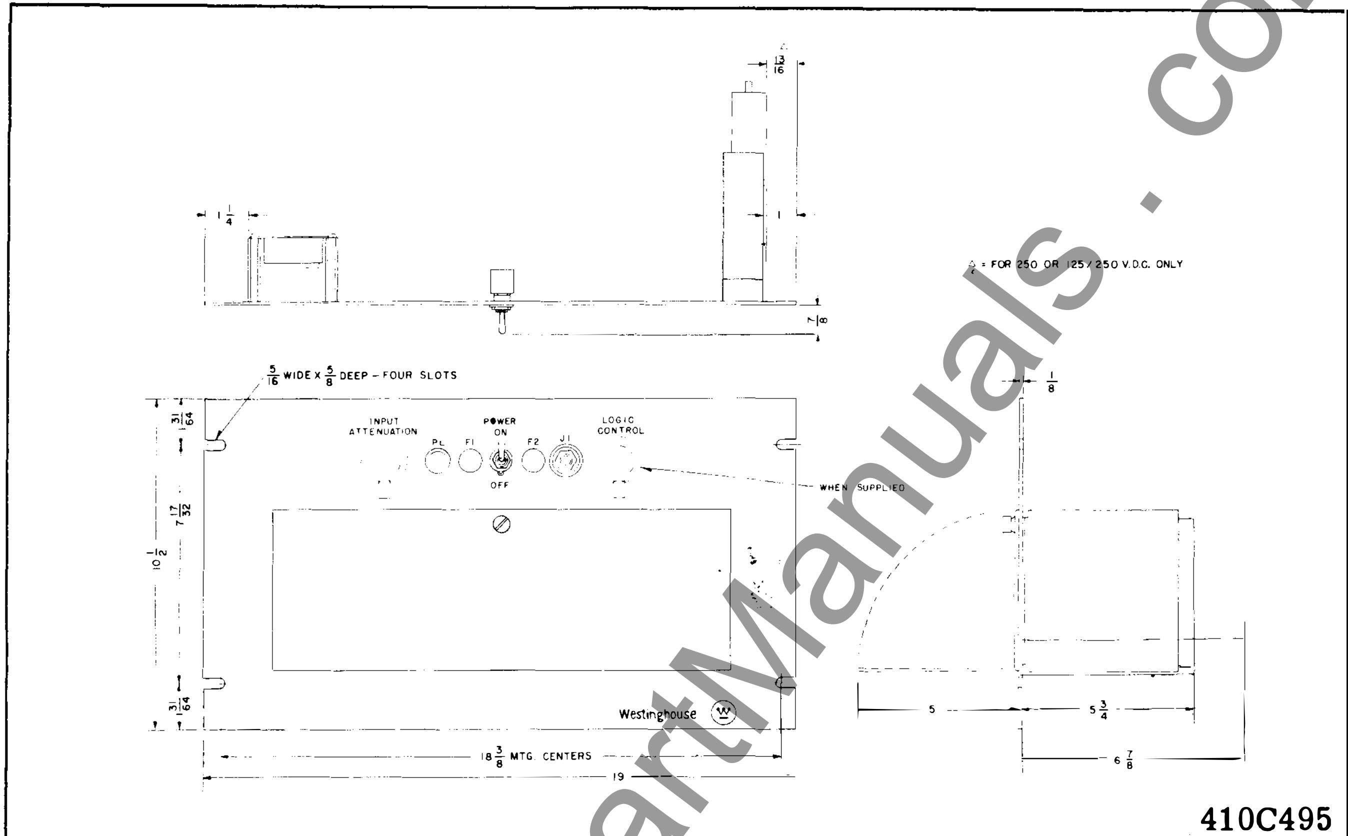


Fig. 15. Outline and drilling plan for the type TCF receiver assembly.

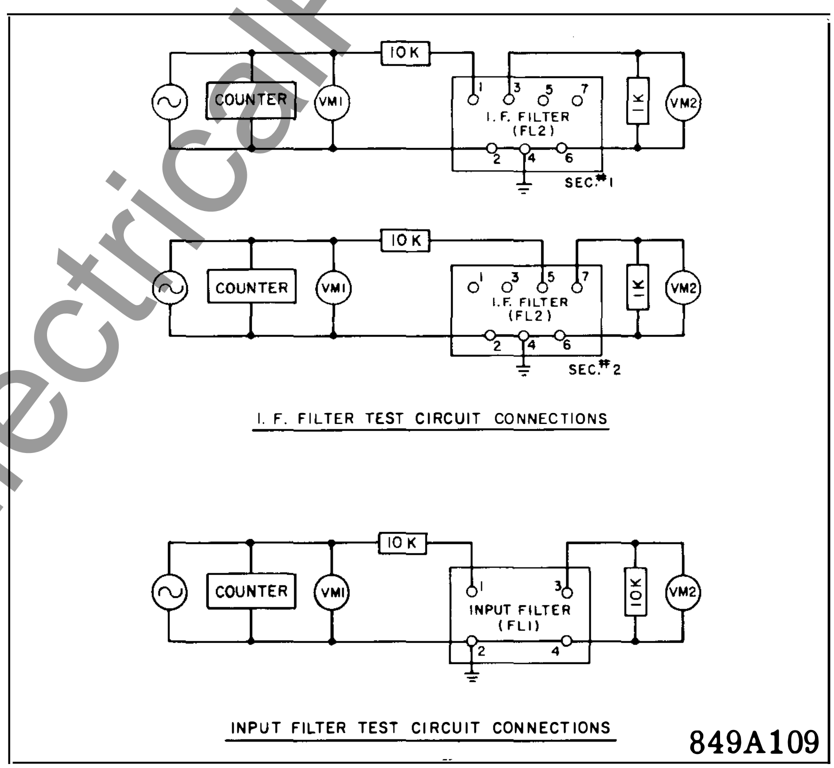
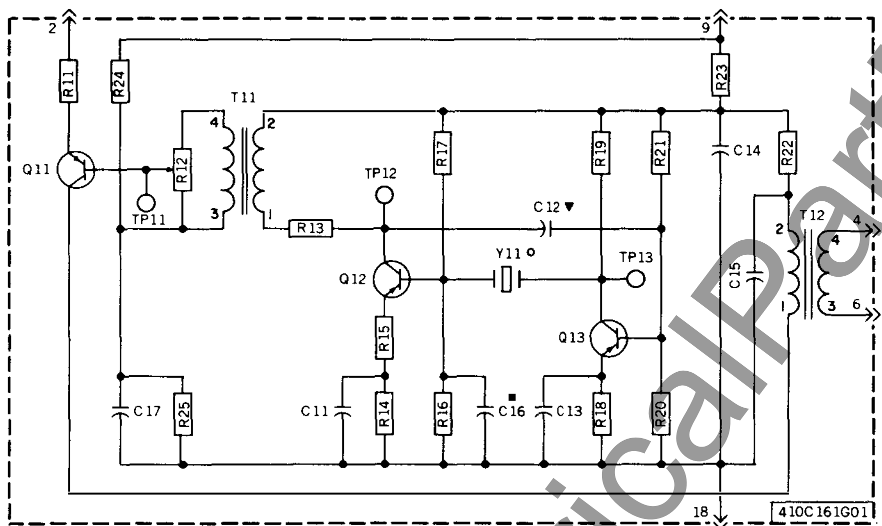


Fig. 16. Test Currents for TCF Frequency Shift Receiver Filters.



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

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

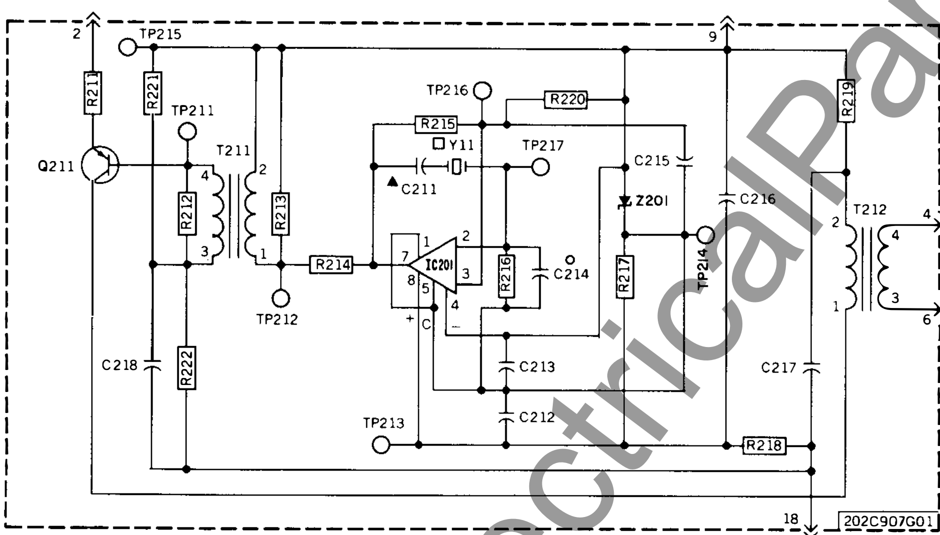
■ =C16 RANGE 22 TO 100Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

o =Y11 RANGE–50 TO 220 KHZ.

REF COMPONENT LOCATION– 763A292

264C855

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



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

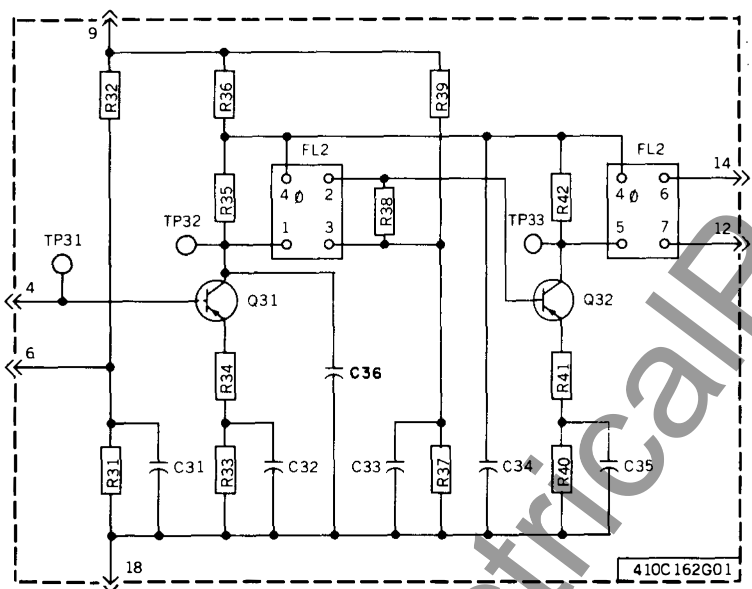
▲= C211 RANGES FROM 100Pf. TO 1,000Pf.

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

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

264C844

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

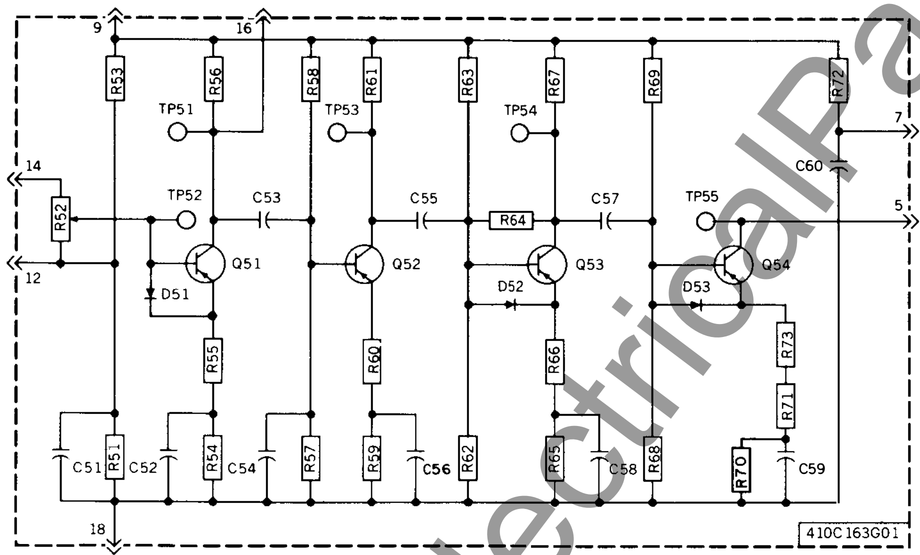


COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q31–Q32	849A441H03	2	2N4249
RESISTOR			
R34-R41	187A290H21	2	68Ω 1/2W ±5%
R36	184A763H15	1	330Ω 1/2W ±5%
R33–R40	184A763H23	2	680Ω 1/2W ±5%
R38	184A763H27	1	1K 1/2W ±5%
R31–R37	184A763H39	2	3.3K 1/2W ±5%
R35–R42	184A763H51	2	10K 1/2W ±5%
R32–R39	184A763H59	2	22K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

Ø = COMMON TERMINAL

264C856

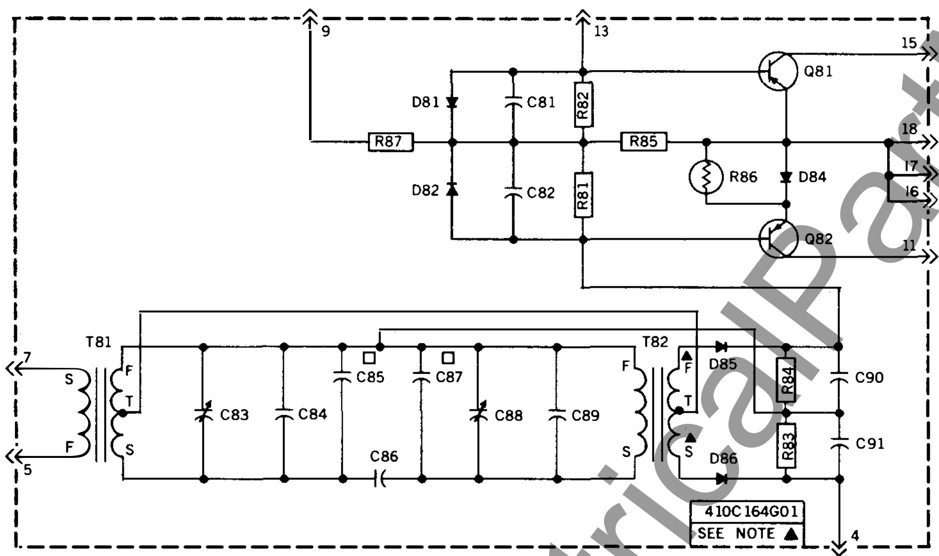
Fig. 19. Internal Schematic I.F. Amplifier – Silicon Transistor Version



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

264C841

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



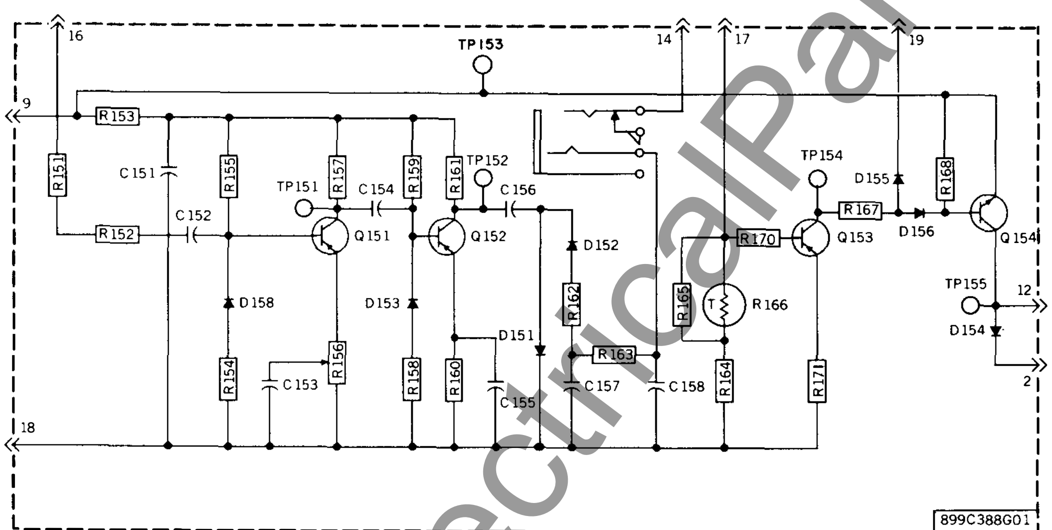
COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q81–Q82	849A441H01	2	2N3645
RESISTOR			
R81–R82	184A763H38	2	3K 1/2W ±5%
R83–R84	184A763H35	2	2.2K 1/2W ±5%
R85	184A763H11	1	220Ω 1/2W ±5%
R87	184A763H53	1	12K 1/2W ±5%
SENSISTOR			
R86	187A685H03	1	1.2K 1/4W ±10%
CAPACITOR			
C81–C82–C90–C91	762A703H01	4	.22MFD.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

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

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

264C842

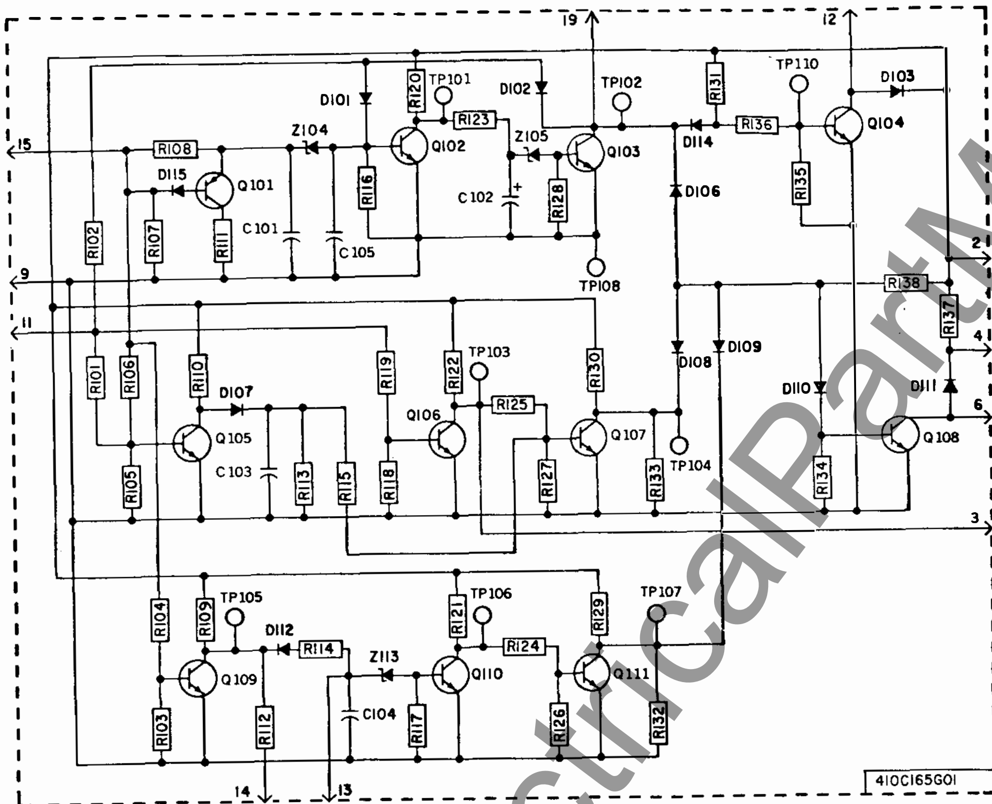
Fig. 21. Internal Schematic Discriminator – Silicon Transistor Version



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

264C853

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



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

264C845

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

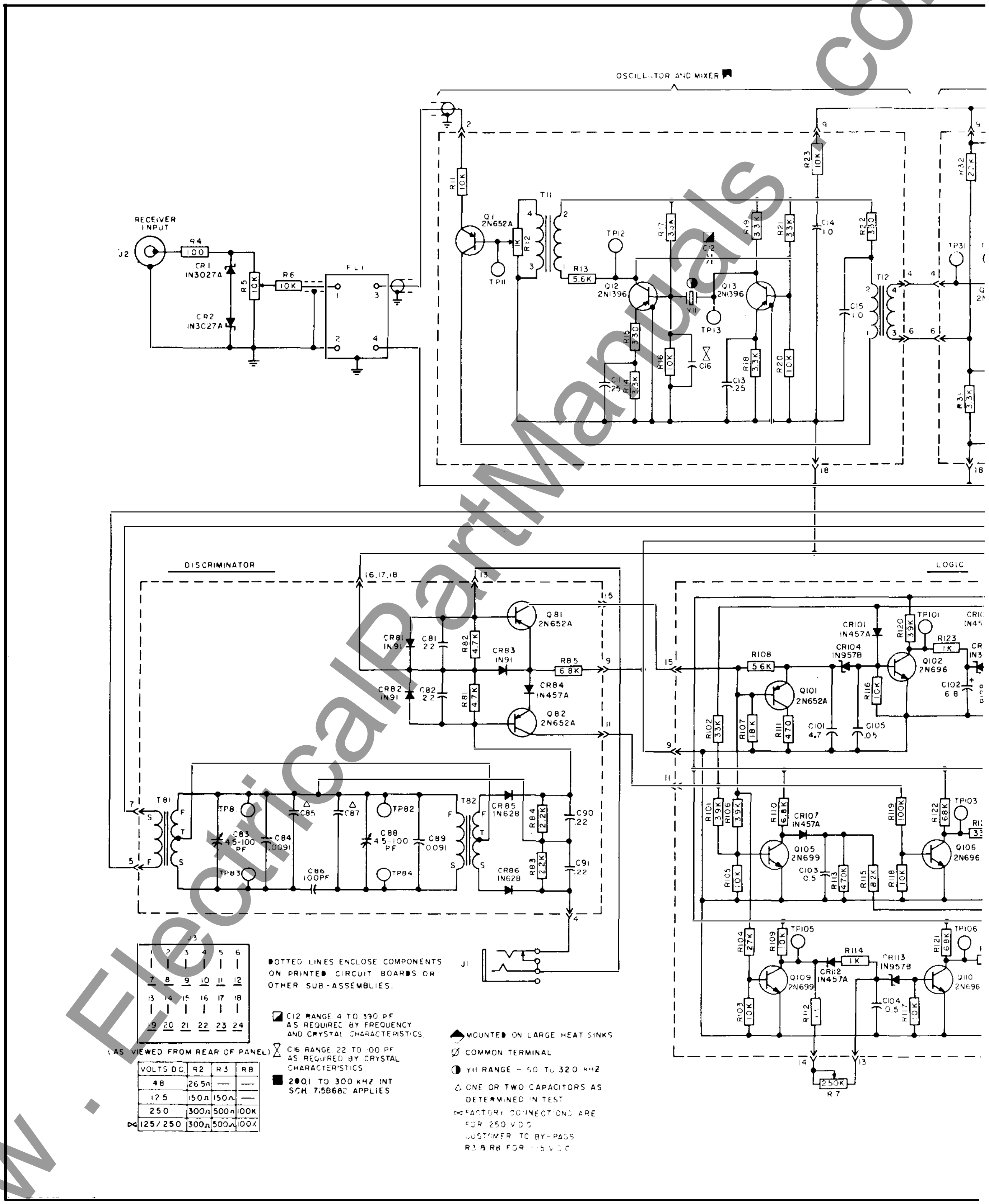
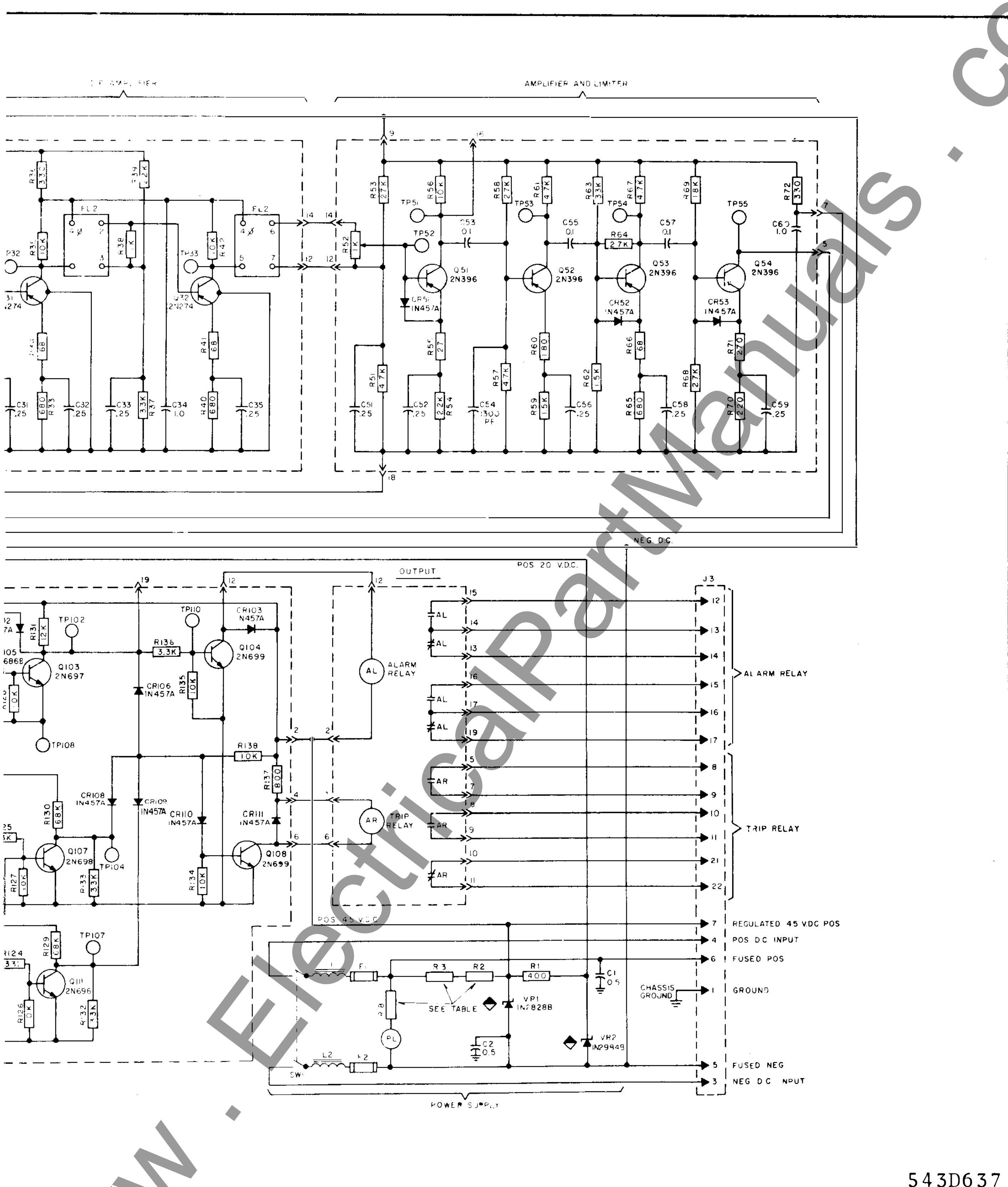


Fig. 24. Internal schematic of the type TCF receiv



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

ELECTRICAL PARTS LIST

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

ELECTRICAL PARTS LIST (Cont'd.)

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

ELECTRICAL PARTS LIST (Cont'd.)

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

ELECTRICAL PARTS LIST (Cont'd.)

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

ELECTRICAL PARTS LIST (Cont'd.)

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

ELECTRICAL PARTS LIST (Cont'd.)

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

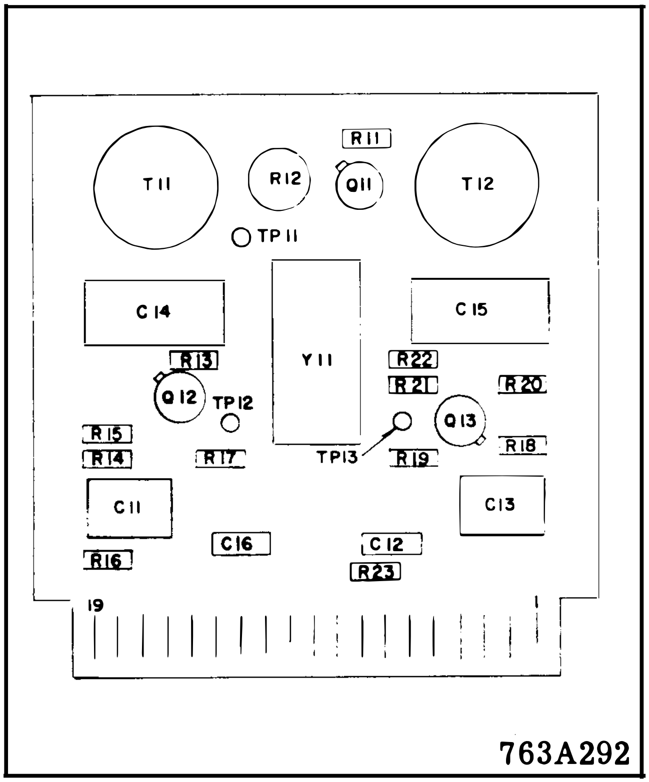


Fig. 26 Component locations on the oscillator and mixer printed circuit board - germanium version.

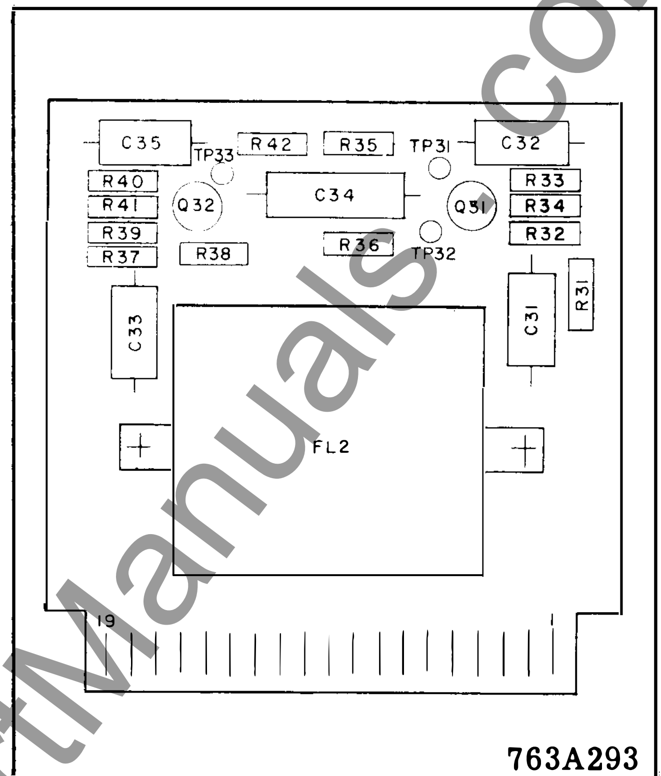


Fig. 27 Component locations on the I.F. amplifier printed circuit board - germanium version.

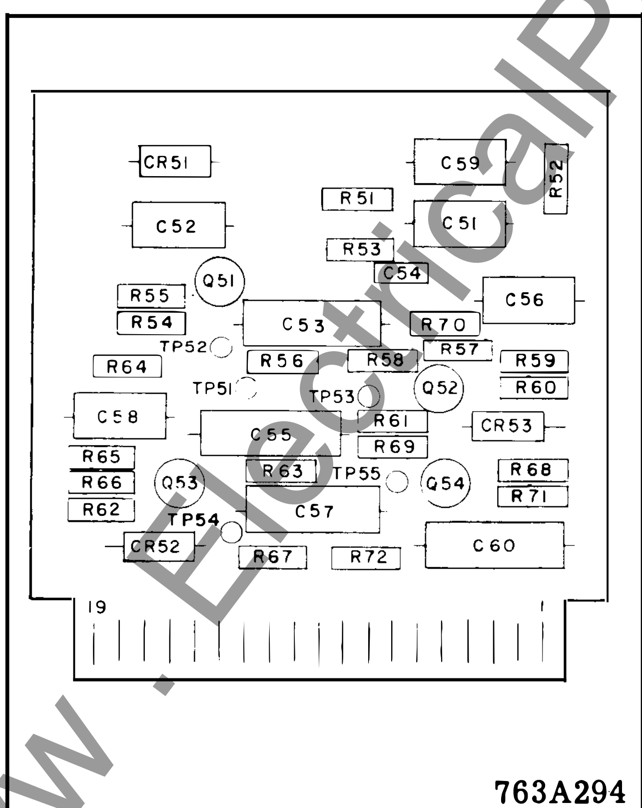


Fig. 28 Component locations on the amplifier and limiter printed circuit board - germanium version.

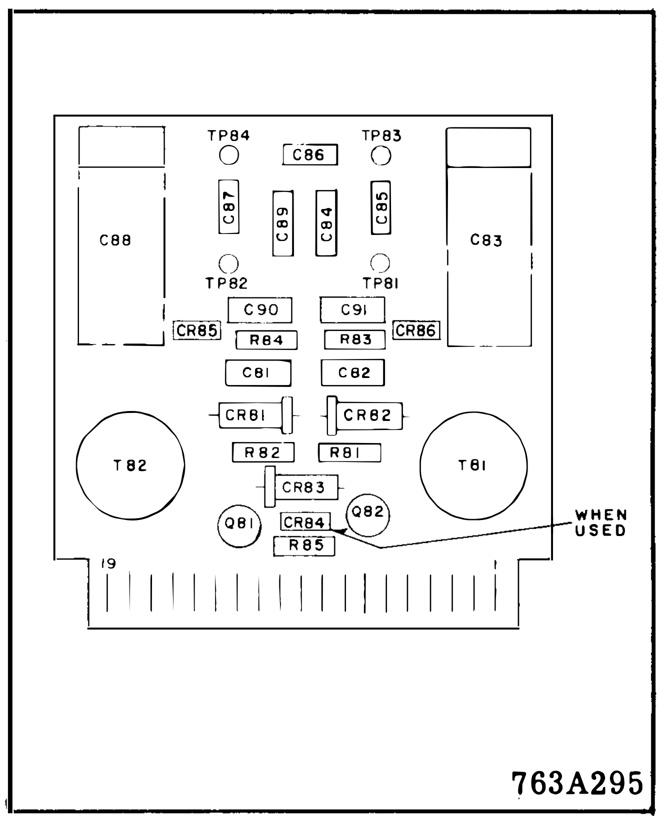


Fig. 29 Component locations on the discriminator printed circuit board - germanium version.

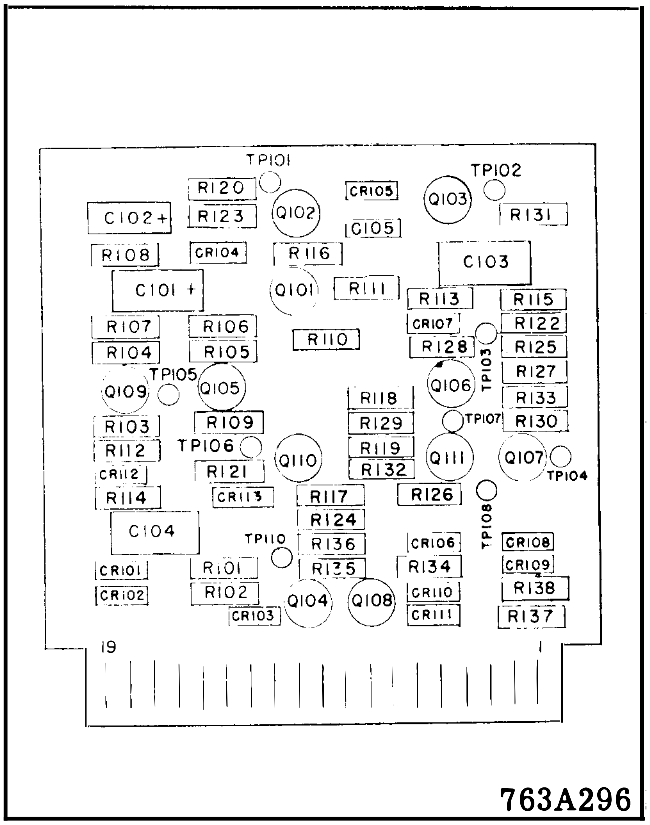


Fig. 30 Component locations on the logic printed circuit board - germanium version.

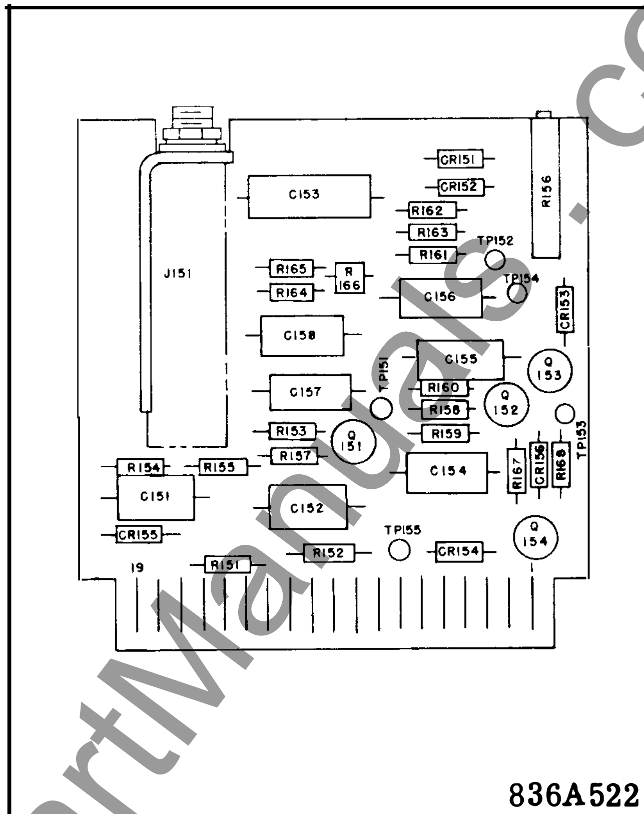


Fig. 31 Component locations on the carrier level indicator printed circuit board - germanium version.

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION **CORAL SPRINGS, FL.**

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT – 10 WATT/10 WATT FOR ALL RELAYING APPLICATIONS ✪

CAUTION: It is recommended that the user of this equipment become thoroughly familiar 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 type TCF carrier transmitter equipment provides for the transmission of either of two closely controlled discrete frequencies, both within a narrow-band channel, over high-voltage transmission lines. The center frequency of the channel can vary from 30 to 300 KHz in 0.5 KHz steps. The two frequencies transmitted are separated by 200 Hz, one being at center frequency (fc) plus 100 Hz and the others at center frequency minus 100 Hz. The higher frequency, termed the Guard frequency, is transmitted continuously when conditions are normal. It indicates at the receiving end of the line that the channel is operative and it also serves to prevent false operation of the receiver by line noise. The lower frequency, termed the Trip frequency, is transmitted as a signal that an operation (such as tripping a circuit breaker) should be performed at the receiving end of the line.

When electro-mechanical relays are used for keying from guard to trip frequency, the contact used is connected to the high voltage input of a buffering keying board. This board buffers the input so that random noise does not key the circuits. When solid state relays are used, the 20-V. D.C. voltage used for keying is connected to the low voltage input of the buffering keying board.

CONSTRUCTION

The 10-watt/10-watt TCF transmitter unit is mounted on a standard 19-inch wide panel 12¼ inches (7 rack units) high with edge slots for mounting on a standard relay rack. All components are mounted on the rear of the panel. Fuses, a pilot light, a power switch and a jack for metering the amplifier collector current are accessible from the front of the panel when supplied. See Fig. 7. All of the circuitry that is suitable for printed circuit board mounting is on three such boards, as shown in Fig. 3. The components mounted on each printed board or other sub-assembly are shown enclosed by dotted lines on the internal schematic. Fig. 1 or 2. The location of components on the two printed circuit boards are shown on separate illustrations, Fig. 4, 5, and 6.

External connections to the assembly are made through a 18-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack J2.

OPERATION

The transmitter is made up of four main stages and two filters. The stages include two crystal oscillators operating at frequencies that differ by the desired channel frequency, a mixer and buffer amplifier, a driver stage and a power amplifier. One filter is located between the driver and the power amplifier and the filter removes harmonics that may be generated by distortion in the power amplifier.

A single crystal designed for oscillation in the 30 KHz to 300 KHz range cannot be forced to oscillate away from its natural frequency by as much as ±100 Hz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2 MHz range. The crystals are Y1 and Y2 of Fig. 1. The frequency of Y2 is 2.00 MHz when operated with

All possible contingencies which may arise during installation, operation, or maintenance, and all details and variations of this equipment do not purport to be covered by these instructions. If further information is desired by purchaser regarding his particular installation, operation or maintenance of his equipment, the local Westinghouse Electric Corporation representative should be contacted.

SUPERSEDES I.L. 41-945.15, dated May 1973
✪ Denotes change from superseded issue.

EFFECTIVE NOVEMBER 1977

a specified amount of series capacity, and the frequency of Y1 is 2.00 MHz plus the channel frequency, or 2.03 MHz. Capacitor C55 and crystal Y2 in series are connected between the positive side of the supply voltage and the base of transistor Q51, which operates in the emitter follower mode. The emitter is coupled to the base through C57, and with Y2 removed the base of Q51 would be held at approximately the midpoint of the supply voltage by R51 and R52. The crystal serves as a series-resonant circuit with very high inductance and low capacitance. The circuit can be made to oscillate at other than the natural frequency of the crystal by varying the series capacitor, C55. Increasing C55 will lower the frequency of oscillations and reducing C55 will raise the frequency.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes D51 and D52. By adjustment of C52 this circuit is made to oscillate at 100 Hz above its marked frequency. Capacitor C53 is not effective until D51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the relay control contact is closed, which places 45 V.D.C. at terminal 3 of the printed circuit board. With D51 conducting, C53 is effectively in parallel with C52, and adjustment of C53 will reduce the frequency by 200 Hz. The crystals taken individually have a greater variation of frequency with temperature than would be acceptable. However, by proper matching of the two crystals, the variation in their difference frequency can be kept within limits that permit holding the frequency stability of the overall transmitter to ±10 Hz over a temperature range of −20 to +55°C.

The frequencies produced by the two oscillators are coupled to the base of mixer transistor Q53 through C62 and C63. The sum of the two frequencies is so high that a negligible amount appears on the secondary of transformer T51, but the difference frequency is accepted and amplified by Q53 and Q54.

When the relay control, or keying, contact is closed, it changes the frequency from Guard to Trip.

As is shown on the Internal Schematic, Fig. 1. the voltage for the keying circuit is obtained from the 45-volt regulated supply in the transmitter, and opening the single power switch de-energizes both the transmitter and the keying circuit.

The driver stage consists of transistors Q56 and Q57 connected in a conventional push-pull circuit with input supplied from the collector of Q54 through transformer T52. Thermistor R73 and resistors R74 and R75 are connected to provide a variable bias that reduces the effect of varying ambient temperatures on the input level.

The driver filter, FL101, consists of a series-resonant inductor and capacitor connected between the driver and power amplifier stages by appropriate transformers T1 and T2. This filter greatly improves the waveform of the signal applied to the power amplifier.

The power amplifier uses two series-connected power transistors, Q101 and Q102, operating as a class B push-pull amplifier with single-ended output. Diodes D101 and D103 provide protection for the base-emitter junctions of the power transistors. Zener diodes D105 and D106 protect the collector-emitter junctions from surges that might come in from the power line through the coaxial cable.

The output transformer T3 couples the power transistors to the output filter FL102. The output filter includes two trap circuits (L102, C_B and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G1 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line turner and coaxial cable. Auto-transformer T4 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms.

The series resonant circuit composed of L105 and C_E is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, thus providing a reverse impedance that is free of possible ''across-the-line'' resonances.

The power supply is a series-type transistorized d-c voltage regulator which has a very low stand-by current drain when there is no output current demand.

The Zener diode Z1 holds a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the d-c voltage drop through transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage. The Zener diode Z2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

CHARACTERISTICS

Frequency Range	30-300 kHz
Output	10 watt guard - 10 watts trip - (into 50 to 70 ohm resistive load)
Frequency Stability	± 10 Hz from -20°C to +55°C.
Frequency Spacing	A. When used with narrow band receiver. 1. One-way channel, two or more signals - 500 Hz min. 2. Two-way channel, 1,000 Hz min, between transmitter and adjecent receiver frequencies. B. When used with wide band receiver. 1. One-way channel, two or more signals - 1000 Hz min. 2. Two-way channel, 2000 Hz min, between transmitter and adjecent receiver frequencies.
Harmonics	Down 55 db (min.) from output level.
Input Voltage	48 or 125 v.d.c.
Supply Voltage variation	42-56v. for nom. 48v. supply. 105-140v. for nom. 125v. supply.
Battery Drain	0.5 a guard, 1.15a. trip } 48 v.d.c. 0.5 a. guard, 0.9 a. trip } 125 v.d.c.
Keying Circuit Current	4 ma.
Temperature Range	-20 to +55°C around chassis.
Dimensions	Panel height - 12¼" or 7 r.u. Panel width - 19"
Weight	12 lbs.

INSTALLATION

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

ADJUSTMENTS

The TCF 10W/10W transmitter is shipped with the power output control R64 set for output of 10 watts into a 60 ohm load. If it is desired to check the adjustments, or if repairs have made readjustment necessary, the coaxial cable should be disconnected from the assembly terminals and replaced with a 50 to 70 ohm non-inductive resistor of at least a 10 watt rating. Use the value of the expected input impedance of the coaxial cable and line tuner. If this is not known, assume 60 ohms. Connect the T4 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn power output control R64 to minimum (full counter-clockwise). Turn on the power switch on the panel and note the d-c voltage across terminals 5 and 7 of J3. If this is in the range of 42 to 46 volts, rotate R64 clockwise to obtain 4 or 5 volts across the load resistor used. At this point check the adjustment of the series output tuning coil L105 by loosening the knurled shaft-locking nut and moving the adjustable core in and out a small amount from its initial position. Leave it at the point of maximum voltage across the load resistor used. Then rotate R64 farther clockwise to obtain the correct voltage for 10 watts in the load resistor, as shown in the following table.

Then change to Trip frequency by connecting together terminals 2 and 3 of the transmitter printed circuit board (which is approximately equivalent to connecting together terminals 7 and 8 of J3), and rotate R64 until the voltage across the load resistor is as shown in the following table for a 10 watt output. Recheck the adjustment of L105 for maximum output voltage and readjust R64 for a 10 watt output if necessary. Tighten the locking nut on L105. Open the power switch and remove the jumper used to key the transmitter to the 10 watt level.

T106 Tap	Voltage for 10 Watts Output
50	22.4
60	24.5
70	26.5

Follow the procedure outlined in the line tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. It is factory tuned for maximum second and third harmonic rejection, and for series resonance (maximum output at the fundamental frequency) with a 60-ohm load. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection and no change should be made in these settings unless suitable instruments are available for measuring the second and third harmonic present in the transmitter output.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals this can be done by turning the matched pair 180° and inserting a crystal in its proper socket with the other crystal unconnected. A sensitive frequency counter with a range of at least 2.3 MHz can be connected from TP51 to TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter and avoids some error from the effect of the counter input capacitance on the oscillator circuit.) While measurement of the oscillator crystals. individually is necessary for the initial adjustment of the oscillators, generally any subsequent checks may be made with a lower range counter connected at the transmitter output. If any minor adjustment of the Guard and Trip frequencies should be needed the Guard adjustment should be made with capacitor C52 and the Trip Adjustment with C53.

Q56-Q57 Bias Adjustment

The push-pull output stages of the transmitter board are normally shipped correctly biased. If any components involved in these stages have been changed, then it may be necessary to recheck the biasing of this stage.

Unsolder the lead from terminal 2 of transformer T1 (just above FL101) and temporarily connect a low-range d-c milliammeter (0-1.0 ma) between the removed lead (+) and T1 terminal 2 (-). Turn the slotted control on the small potentiometer to full counterclockwise. Now, apply power to the TCF carrier set, but do <u>not</u> transmit carrier. This can be done by removing the crystals. Advance the potentiometer clockwise until the milliammeter reads 0.2 ma. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T1. Replace the crystals and again apply d-c power to reenergize the transmitter. Check output, etc. of transmitter as previously described.

MAINTENANCE

Periodic checks of the transmitter Guard and Trip power outputs will detect impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output at such times, making any necessary readjustments to return the equipment to its initial settings.

Voltage values should be recorded 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. Readings may vary as much as ±20%.

TABLE I
TRANSMITTER D-C MEASUREMENTS

Note: All voltages are positive with respect to Neg. 45 V. (TP51). All voltages read with d-c VTVM.

Test Point	Voltage at 10 Watts Output
TP52	20
TP53	5.4
TP54	3.4
TP55	18.5
TP56	18.5
TP57	*<1.0
TP58	44.1
TP59	*<1.0
TP101	0
TP103	21 ± 2
TP105	44.0

TABLE II
TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages subject to variations, depending upon frequency and transistor characteristics. T51-3= Terminal 3 of transformer T51. Other transformer terminals identified similarly. All read with a-c VTVM.

Test Point	Voltage at 10 watts Output
TP54 to TP51	0.015-0.03
TP57 to TP51	0.3 -1.2
TP59 to TP51	0.3 -1.2
T1-1 to TP51	5.6
T1-3 to TP51	4.9
T1-4 to Gnd.	2.0
T2-1 to Gnd.	1.85
TP101 to TP103	17.0
TP103 to TP105	17.0
T3-4 to Gnd.	112
T4-2 to Gnd.	110
TP109 to Gnd.	31
J102 to Gnd.	24.5

CONVERSION OF TRANSMITTER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a 10W/10W TCF transmitter for operation on a different channel frequency consist of a pair of matched crystals for the new channel frequency, new capacitors C103 and C104 on the power amplifier circuit board if the old and new frequencies are not in the same frequency group (see table on internal schematic drawing) and, in general, new or modified filters FL101 and FL102. Inductors L101, L102 and L103 in these filters are adjustable over a limited range, but forty-two combinations of capacitors and inductors are required to cover the frequency range of 30 to 300 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5	207.1-214.0
32.0-33.5	64.5- 68.0	120.0-127.0	214.1-222.0
34.0-36.0	68.5- 72.0	127.5-135.0	222.1-230.0
36.5-38.5	72.5- 76.0	135.5-143.0	230.1-240.0
39.0-41.0	76.5- 80.0	143.5-151.0	240.1-250.0
41.5-44.0	80.5- 84.5	151.5-159.5	250.1-262.0
44.5-47.0	85.0- 89.0	160.0-169.5	262.1-274.0
47.5-50.0	89.5- 94.5	170.0-180.0	284.1-287.0
50.5-53.5	94.0-100.0	180.5-191.5	287.1-300.0
54.0-57.0	100.5-106.0	192.0-200.0	
57.5-60.5	106.5-112.5	200.1-207.0	

If the new frequency lies within the same frequency group as the original frequency, the filters can be readjusted. If the frequencies are in different groups, it is possible that changes only in the fixed capacitors may be required. In general, however, it is desirable to order complete filter assemblies adjusted at the factory for the specified frequency.

A signal generator, a frequency counter and a vacuum tube voltmeter are required for readjustment of FL101. The signal generator and the counter should be connected across terminal 4 and 5 of transformer T1 and the voltmeter across terminals 1 and 2 of transformer T2. The signal generator should be set at the channel center frequency and at 2 to 3 volts output. The core screw of the small inductor should be turned to the position that gives a true maximum reading on the VTVM. Turning the screw to either side of this position should definitely reduce the reading. The change in inductance with core position is less at either end of the travel then when near the center and consequently the effect of core screw rotation on the VTVM reading will be less when the resonant inductance occurs near the end of core travel.

The procedure for readjustment of the 2nd and 3rd harmonic traps of filter FL102 is somewhat similar. A signal generator and a counter should be connected to terminals 3 and 4 of transformer T3, and a 500 ohm resistor and a VTVM to the terminals of protective gap G1. The ground or shield lead of all instruments should be connected to the ground terminal of the transformer. Set the signal generator at exactly twice the channel center frequency and at 5 to 10 volts output. Turn the core screw of the large inductor L102, to the position that gives a definite minimum reading on the VTVM. Similarly, with the signal generator set at exactly three times the channel center frequency and 5 to 10 volts output, set the core screw of the small inductor, L103, to the position that gives a definite minimum reading on the VTVM. Then remove the instruments and the 500 ohm resistor.

After the new pair of matched crystals have been adjusted, as described under "ADJUSTMENTS", the transmitter can be operated with a 50 to 70 ohm load (depending on which tap of T4 is used) connected to its output, and inductor L105 can be readjusted for maximum output at the changed channel frequency by the procedure described in the same section.

If a frequency-sensitive voltmeter is available, the 2nd and 3rd harmonic traps may be adjusted without using an oscillator as a source of double and triple the channel frequency. Connect the frequency-sensitive voltmeter from TP109 to ground and adjust the transmitter for rated output into the selected load resistor. Set the voltmeter at twice the channel frequency and, using the tuning dial and db range switch, obtain a maximum on-scale reading of the 2nd harmonic. Then vary the core position of L102 until a minimum voltmeter reading is obtained. Similarily, tune the voltmeter to the third harmonic and adjust L103 for minimum voltmeter reading. Although the transmitter frequency will differ from the channel center frequency by 100 Hz, the effect of this difference on the adjustment of the harmonic traps will be negligible. It should be noted that the true magnitude of the harmonics cannot be measured in this manner because of the preponderance of the fundamental frequency at the voltmeter terminals. Accurate measurement of the harmonics requires use of a filter between TP109 and the voltmeter that provides high rejection of the fundamental. The insertion losses of this filter for the 2nd and 3rd harmonics must be measured and taken into account.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

- a. 60-ohm 10-watt non-inductive resistor.
- b. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 hz to 330 kHz; impedance 7.5 megohms.
- c. D-C Vacuum Tube Voltmeter (VTVM).
  Voltage Range: 1.5 to 300 volts.
  Input Impedance: 7.5 megohms.

II. Desirable Test Equipment for Apparatus Maintance.

- a. All items listed in I.
- b. Signal Generator
  Output Voltage: up to 8 volts.
  Frequency Range: 20-kHz to 900 kHz
- c. Oscilloscope
- d. Frequency counter
- e. Ohmmeter
- f. Capacitor checker.

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

RENEWAL PARTS

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

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.45 mfd.; 330 V.A.C.	1723408
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C3	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized Paper, 0.47 mfd.;	849A437H04
C21	Metallized Paper, .047 mfd.;	849A437H04
C51	Dur-Mica, 1500 pf., 500 V.D.C.	762A757H03
C52	Variable, 5.5-18 pf.	879A834H01
C53	Variable, 5.5-18 pf.	879A834H01
C54	Metallized paper, .1 mfd.; 200 V.D.C.	✪ 879A834H01
C55	Variable, 5.5-18 pf.	762A736H01
C56	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C57	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C58	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C60	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C61	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C62	Dur-Mica, 4700 pf., 500 V.D.C.	762A757H04
C63	Dur-Mica, 1000 pf., 500 V.D.C.	762A757H02
C64	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C65	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C66	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C67	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C68	Metallized paper, 0.5 mfd.; 200 V.D.C.	187A624H03
C69	Metallized paper, 0.25 mfd., 200 V.D.C.	187A624H02
C70	Dur-Mica, 300 pf, 500 V.D.C.	187A584H09
C71	3 pf,	861A846H03
C72	3 pf,	861A846H03
C73	3 pf,	861A846H03
C74	Metallized paper, 1.0 mf, 200 V.D.C.	187A624H04
C75	Metallized paper, 0.5 mf, 200 V.D.C.	187A624H03
C76	Metallized paper, 0.01 mf, 200 V.D.C.	764A278H10
C77	0.47 mfd,	188A669H01
C101	Metallized paper, 0.25 mfd,; 200 V.D.C.	187A624H02
C102	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C103 & C104	(30-50 KC) – Extended foil, 0.47 mfd.; 400 V.D.C.	188A293H01
C103 & C104	(50.5-75 KC) – Extended foil, 0.22 mfd.; 400 V.D.C.	188A293H02
C103 & C104	(75.5 - 100 KC) – Extended foil, 0.15 mfd., 400 V.D.C.	188A293H03
C103 & C104	(100.5 - 150 KC) – Extended foil, 0.10 mfd., 400 V.D.C.	188A293H04
C103 & C104	(150.5 - 300 KC) – Extended foil, 0.047 mfd.; 400 V.D.C.	188A293H05
	DIODES – GENERAL PURPOSE	
D11	1N645A	837A692H03
D12	1N645A	837A692H03
D13	1N4822	188A342H11
D14	1N4822	188A342H11

ELECTRICAL PARTS LIST

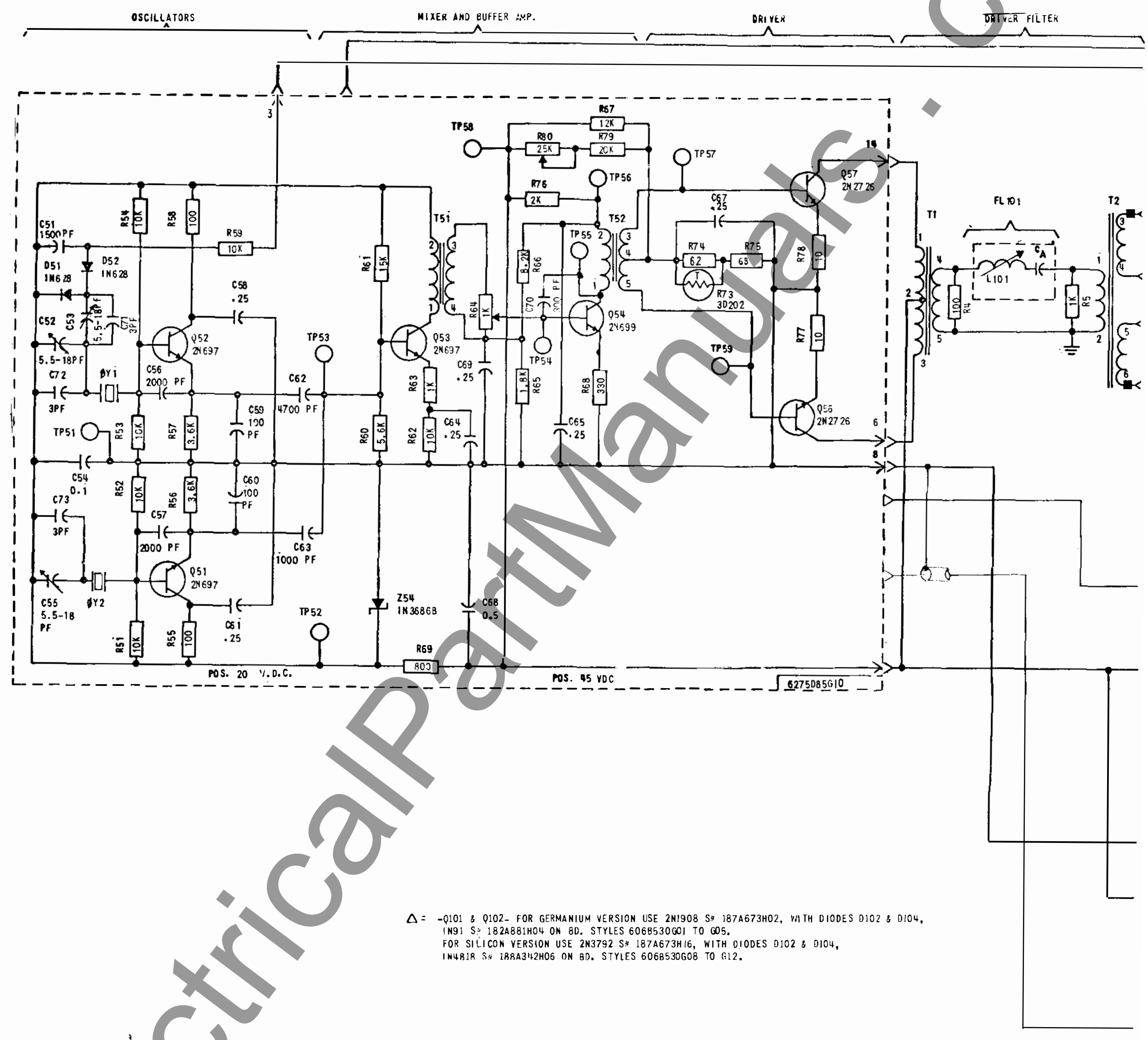
CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
D15	1N4822	188A342H11
D16	1N4822	188A342H11
D21	1N645A	837A692H03
D22	1N4822	188A342H11
D23	1N4822	188A342H11
D24	1N4822	188A342H11
D25	1N4822	188A342H11
D51	1N628; 125 V.; 30 MA.	184A885H12
D52	1N628; 125 V., 30 MA.	184A885H12
D55	1N457A; 60 V., 200 MA.	184A885H07
D58	1N628; 125 V., 30 MA.	184A885H12
D101	1N538; 200 V., 750 MA.	407C703H03
D102,D104	1N91; 100 V., 150 MA. (Germanium Version used with 2N1908)	182A881H04
D103	1N538; 200 V., 750 MA.	407C703H03
D102,D104	1N4818 (Silicon Version used with 2N3792)	188A342H06
	DIODES – ZENER	
Z1	1N2828B; 45V. ±5%; 50 W.	184A854H06
Z2	1N3009A; 130 V. ±10%; 10 W.	184A617H12
Z11	1N957B	186A797H06
Z12	1N3688A	862A288H01
Z13	1N3688A	862A288H01
Z14	1N3686B	185A212H06
Z21	1N957B	186A797H06
Z22	1N3688A	862A288H01
Z23	1N3688A	862A288H01
Z24	1N3688B	185A212H06
Z54	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
Z105	1N2999A; 56 V. ±10%; 10 W.	184A617H13
Z106	1N2999A; 56 V. ±10%; 10 W.	184A617H13
	RESISTORS	
R1	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R2	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R3	26.5 ohms ±5%; 40 W. (For 48 V Supply)	04D1299H44
R3	500 ohms ±5%; 40 W. (For 125 V Supply)	1268047
R4	100 ohms ±10%; 1 W. Composition	187A644H03
R5	1K ±10%; ½ W. Composition	187A641H27
R6	3K ±5%; 5 W. Wire Wound	188A317H01
R7	15K ±10%; 2 W. Composition	187A642H55
R11	4.7K ±2%; ½ W. Metal Glaze	629A531H43
R12	12K ±2%; ½ W. Metal Glaze	629A531H58
R13	10K ±2%; ½ W. Metal Glaze	629A531H56

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Continued)	
R14	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R15	1.5K ±2%; ½ W. Metal Glaze	629A531H36
R16,R26	51K ±2%; ½ W. Metal Glaze	629A531H73
R17	1.8K ±2%; ½ W. Metal Glaze	629A531H38
R21	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R22	12K ±2%; ½ W. Metal Glaze	629A531H58
R23	10K ±2%; ½ W. Metal Glaze	629A531H56
R24	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R25	1.8K ±2%; ½ W. Metal Glaze	629A531H38
R18, R28	18K ±2%; ½ W. Metal Glaze	629A531H62
R27	1.5K ±2%; ½ W. Metal Glaze	629A531H36
R51	10K ±5%; ½ W. Composition	184A763H51
R52	10K ±5%; ½ W. Composition	184A763H51
R53	10K ±5%; ½ W. Composition	184A763H51
R54	10K ±5%; ½ W. Composition	184A763H51
R55	100 ohms ±5%; ½ W. Composition	184A763H03
R56	3.6K ±5%; ½ W. Composition	184A763H40
R57	3.6K ±5%; ½ W. Composition	184A763H40
R58	100 ohms ±5%; ½ W. Composition	184A763H03
R59	10K ±5%; ½ W. Composition	184A763H51
R60	5.6K ±5%; ½ W. Composition	184A763H45
R61	15K ±5%; ½ W. Composition	184A763H55
R62	10K ±5%; ½ W. Composition	184A763H51
R63	1K ±5%; ½ W. Composition	184A763H27
R64	Potentiometer, 1K; ¼ W.	629A430H02
R65	1.8K ±5%; ½ W. Composition	184A763H02
R66	8.2K ±5%; ½ W. Composition	184A763H49
R67	12K ±5%; ½ W. Composition	184A763H53
R68	330 ohms ±5%; ½ W. Composition	184A763H15
R69	800 ohms ±5%; ½ W. Composition	184A859H06
R70	Potentiometer, 1K; ¼ W.	629A430H02
R71	4.7K ±5%; ½ W. Composition	184A763H43
R72	39K ±5%; ½ W. Composition	184A763H65
R73	Thermistor, 30 ohms, Type 3D202 (G.E.C.)	185A211H06
R74	62 Ohms ±5%; ½ W. Composition	629A531H03
R75	68 Ohms ±5%; ½ W. Composition	187A290H01
R76	2K ±5%; ½ W. Composition	184A763H34
R77	10 ohms ±5%; ½ W. Composition	187A290H01
R78	10 ohms ±5%; ½ W. Composition	187A290H01
R79	20K ±2%; ½ W. Metal Glaze	629A531H63
R80	25K Potentiometer ±20%; ¼ W.	629A430H09
R81	1K ±1%; ½ W. Metal Film	848A819H48

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R82	5K Pot. ±20%; ½ W.	629A430H07
R83	10.2K ±1%, ½ W. Metal Film	843A820H46
R84	27 ohms ±5%, ½ W. Composition	187A290H11
R85	Thermistor 3D402 10 ohms	185A211H03
R86	750 ohms ±1%, ½ W. Metal Film	848A819H36
R101	10 ohms ±5%; ½ W. Composition	187A280H01
R102	2.2K ±10%; 1 W. Composition	187A644H35
R103	2.7 ohms ±10%; ½ W. Wire Wound	184A636H14
R104	0.27 ohms ±10%; 1 W. Wire Wound	184A636H18
R105	10 ohms ±5%; ½ W. Composition	187A290H01
R106	4.7K ±10%; 1 W. Composition	187A644H43
R107	2.7 ohms ±10%; ½ W. Wire Wound	184A636H14
R108	0.27 ohms ±10%; 1 W. Wire Wound	184A636H18
	TRANSFORMERS	
T1	Driver Output Transformer	606B410G01
T2	Power Amp. Input Transformer	292B526G01
T3	Power Amp. Output Transformer	292B526G02
T4	Load-Matching Auto-Transformer	292B526G03
T51	Buffer Amplifier Transformer	606B537G01
T52	Driver Input Transformer	606B537G02
	TRANSISTORS	
Q1	2N1015C	187A342H02
Q11	2N4356	849A441H02
Q12	2N699	184A638H19
Q21	2N4356	849A441H02
Q22	2N699	184A638H19
Q51	2N697	184A638H18
Q52	2N697	184A638H18
Q53	2N697	184A638H18
Q54	2N699	184A638H19
Q55	2N697	184A638H18
Q56	2N2726	762A672H07
Q57	2N2726	762A672H07
Q101,Q102	2N1908 (Use in Matched Pairs) (Germanium Version)	187A673H02
Q101,Q102	2N3792 (Use in Matched Pairs) (Silicon Version)	187A673H16
	MISCELLANEOUS	
Y1-Y2	Supplied for Desired Channel Frequency in Pair Matched Per Specifications on Drawing	408C743
FL101	Driver Filter	408C261 + (Req.Freq.)
FL102	Output Filter	541S214 + (Req. Freq.)
PL	Pilot Light Bulb - For 48 V. Supply (When supplied)	187A133H02
	Pilot Light Bulb - For 125 or 259 V. Supply (When supplied)	183A955H01
F1, F2	Fuse, 1.5A (When supplied)	11D9195H26



△ = -Q101 & Q102- FOR GERMANIUM VERSION USE 2N1908 S# 187A673H02, WITH DIODES D102 & D104, 1N91 S# 182A881H04 ON BD. STYLES 606B530G01 TO G05.
FOR SILICON VERSION USE 2N3792 S# 187A673H16, WITH DIODES D102 & D104, 1N4818 S# 188A342H06 ON BD. STYLES 606B530G08 TO G12.

DOTTED LINES ENCLOSE COMPONENTS ON PRINTED CIRCUIT BOARDS OR OTHER SUB-ASSEMBLIES (EXCEPT AS NOTED)

ALL CAPACITORS ARE IN MFD. EXCEPT AS NOTED.

FREQ.	C103 & C104
30-50 KHZ	0.47 MFD.
50.5-75 KHZ	0.22 MFD.
75.5-100 KHZ	0.15 MFD.
100.5-150 KHZ	0.10 MFD
150.5-300 KHZ	0.047 MFD.

◆ = MOUNTED ON LARGE HEAT SINKS

Ø = MATCHED PAIR
Y1 - 2.03 TO 2.30 MHZ
Y2 - 2.00 MHZ

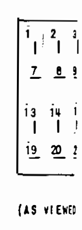
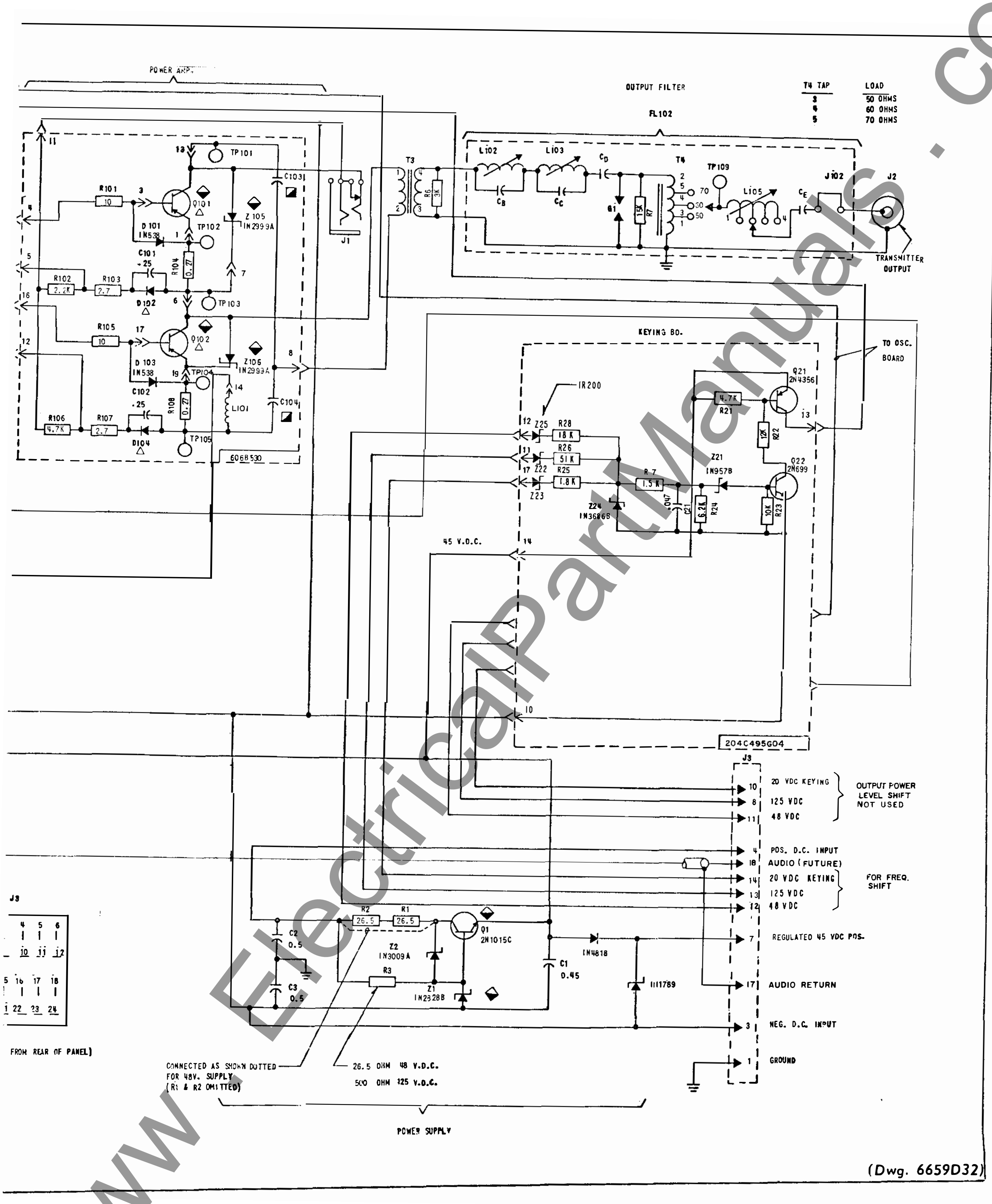


Fig. 2 — Internal Schematic of Type TCF Transmitter



Assembly – Without Switch, Pilot Light, and Fuses.

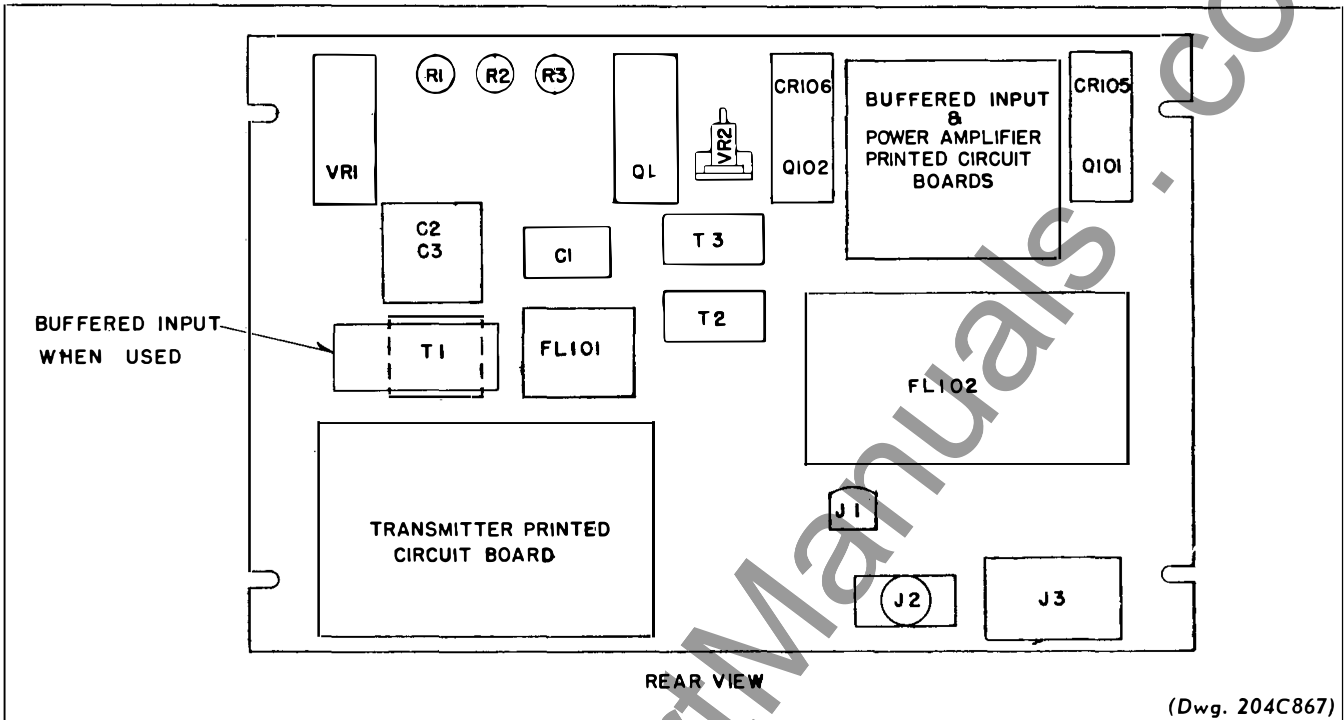


Fig. 3 — Component Locations of Type TCF Transmitter Assembly

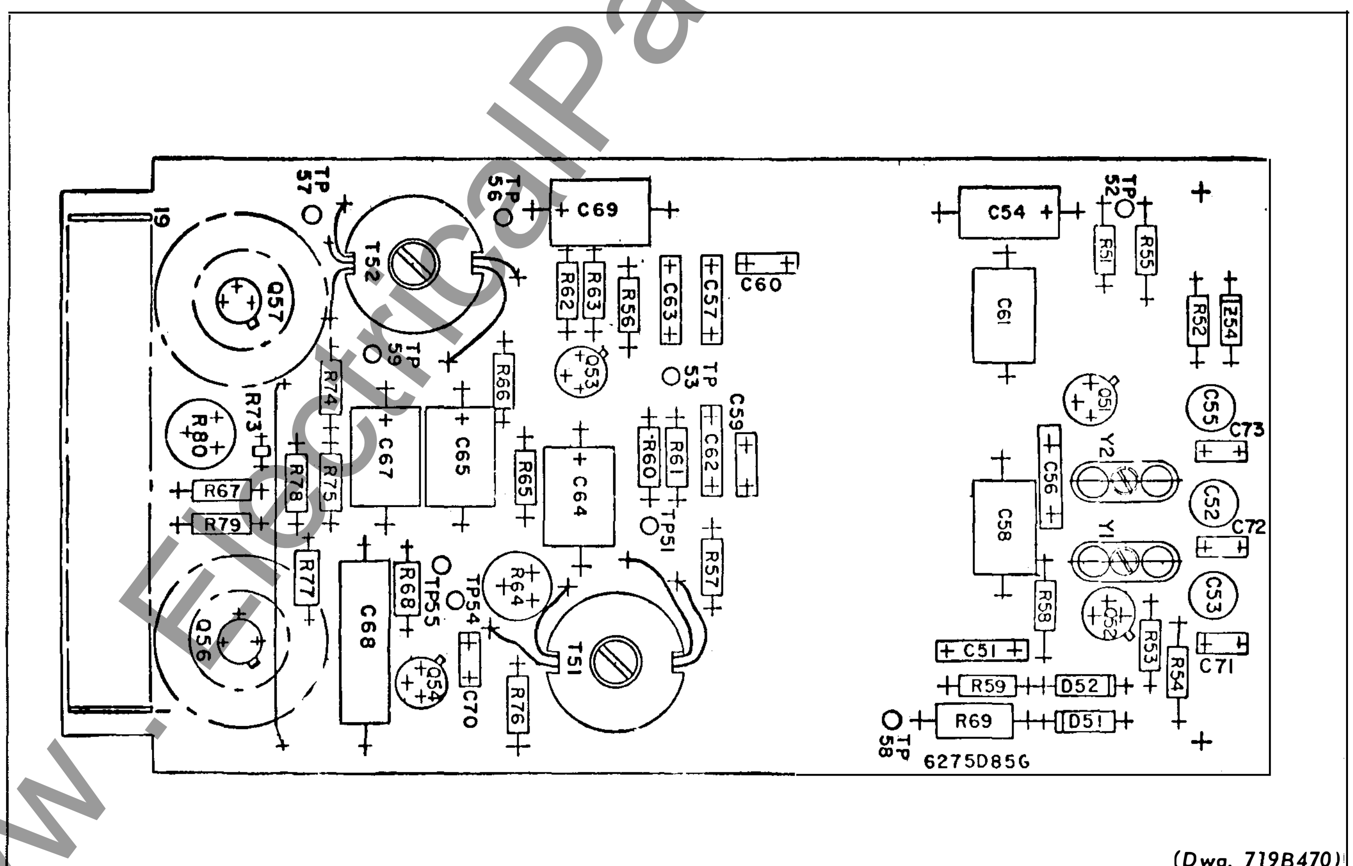
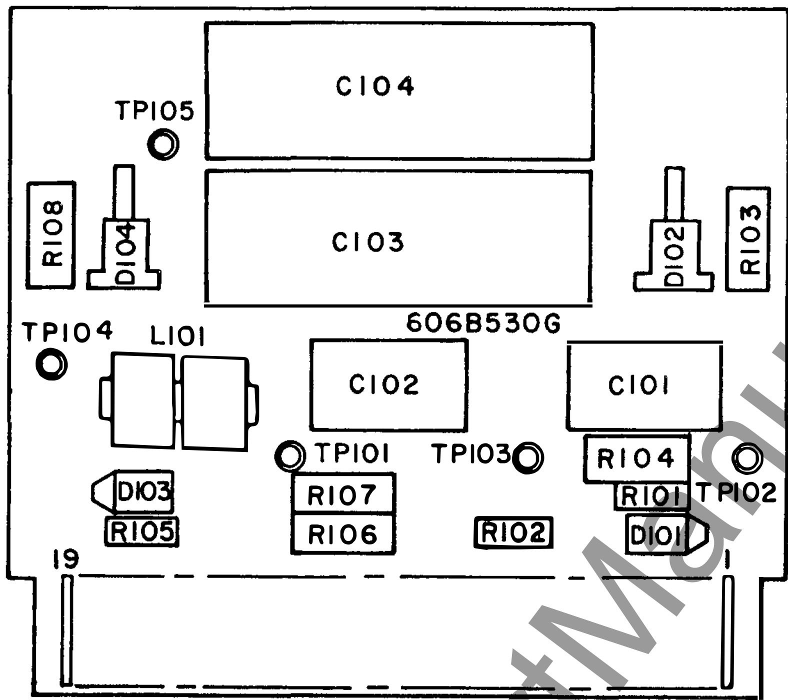
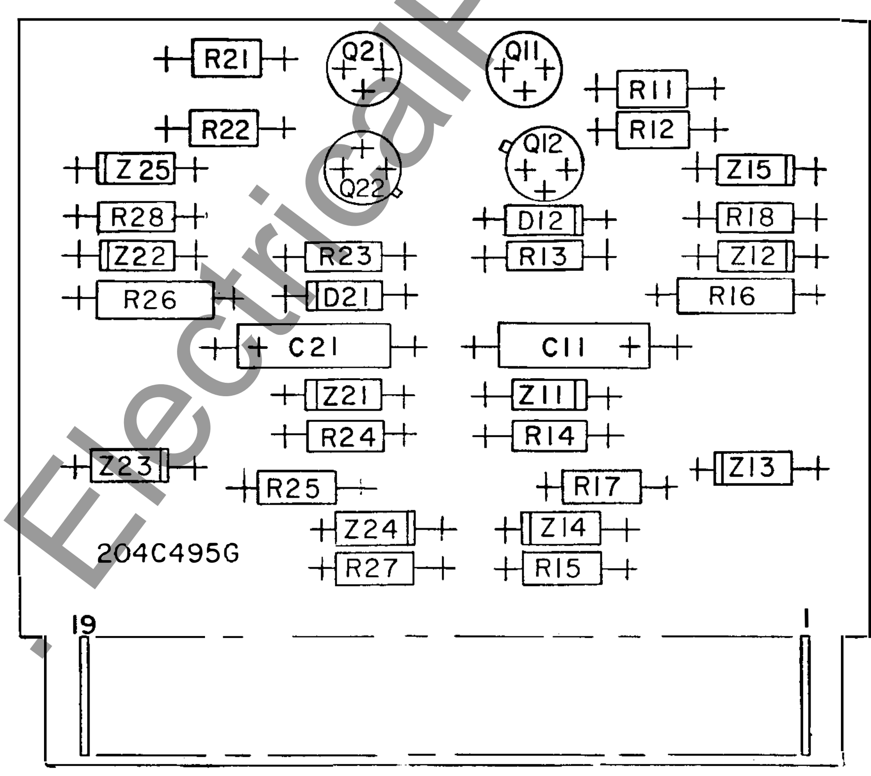


Fig. 4 — Component Locations of TCF Transmitter Circuit Board



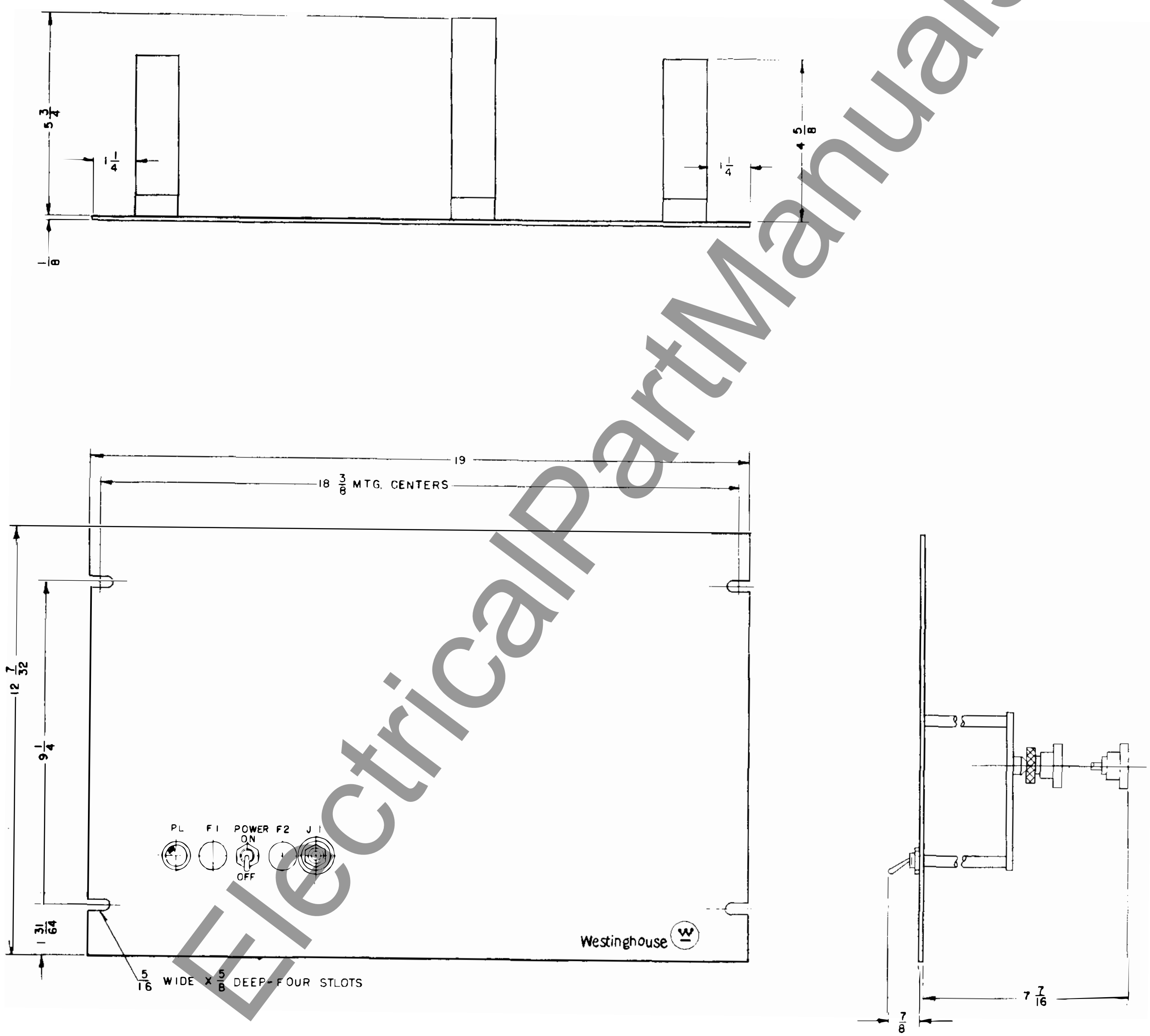
(Dwg. 763A056)

Fig. 5 – Component Locations Power Amplifier Board



(Dwg. 717B510)

Fig. 6 – Component Locations Buffer Keying Board



(Dwg. 410C312)

Fig. 7 — Outline of Type TCF Transmitter Assembly

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

Attached is a copy of "Addendum To IL 41-945.16" for the TCF transmitter. This addendum sheet should be attached to your existing copy of IL 41-945.16 dated January 1976.

To keep our Instruction Leaflets updated, we will now issue an addendum to an existing IL and mail it using the regular means.

Addendums only will be issued to cover the following conditions:

1. An existing error in an IL should be corrected at once.
2. The IL is not entirely clear, added words will make it more understandable.

Relay-Instrument Division

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT 3 FREQUENCY — 10 WATT/1-3.25 WATT/10 WATT — WITH VOICE

This sheet notes changes which should be made in instruction leaflet I.L. 41-945.16 dated January 1976.

1. On Page 1, at bottom of page:

   delete reference to "Supersedes I.L. 41-945.12 dated July 1971."

2. On Page 1 at end of APPLICATION section,

   "Figure 7" should read "Figure 9".

3. On Page 1, right hand column, eleventh line

   "This logic is shown in Figure 12"

   should read -

   "This logic is shown in Figures 12 and 13"

4. On page 17:

   "Fig. 10. Receivers Logic Diagrams - 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying"

   should read -

   "Fig. 12. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip (Solid-State Output) and Unblock Relaying"

5. On Page 18:

   "Fig. 13. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying"

   should read -

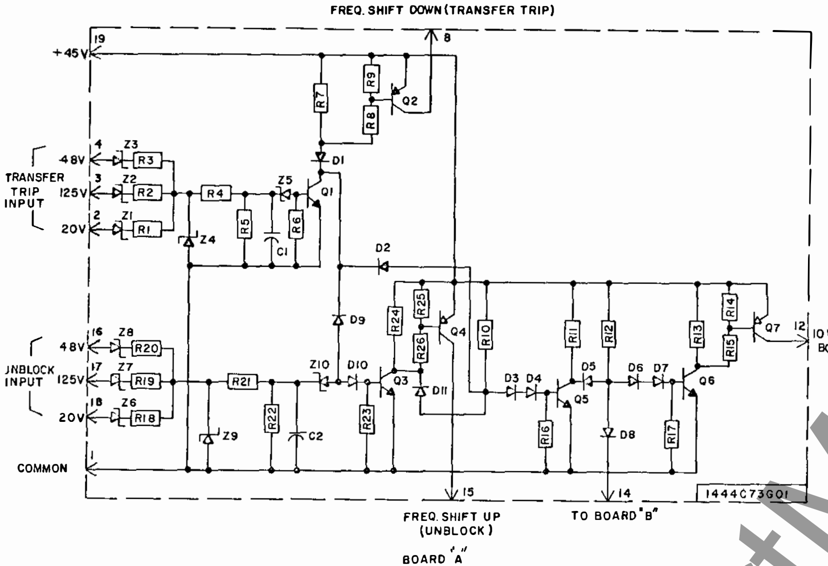
   "Fig. 13. Receiver Logic Diagram - 3 Frequency Operation for Direct Transfer Trip (Contact Output) and Unblock Relaying"

6. Add to page 19

   "Fig. 10. Schematic Buffer Keying Circuit Board "A" "

   "Fig. 11. Schematic Buffer Keying Circuit Board "B" "

NOTE: Fig. 10 and 11 are shown on other side of this sheet.

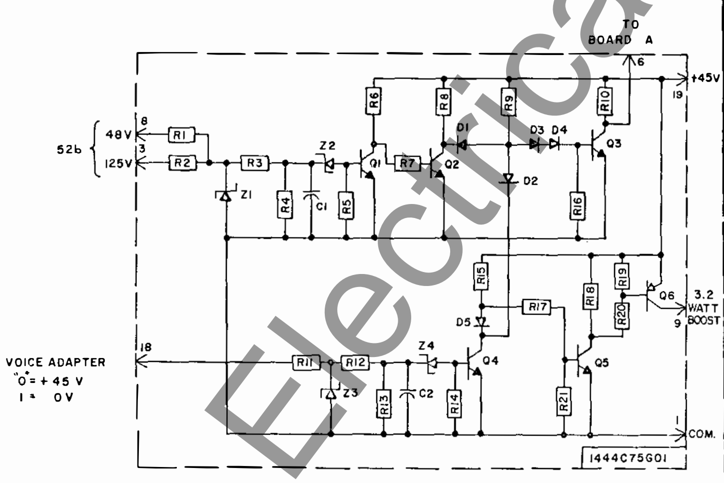


LOGIC BUFFER BD "A" (1444C73G01)

COMPONENT	STYLE	REQ.	REF.
TRANSISTORS			
Q1,Q3,Q5,Q6	184A638H19	4	(2N699)
Q2,Q4,Q7	849A441H02	3	(2N4356)
RESISTORS			
R4 – R21	629A531H36	2	1500 Ohms ½W + 2%
R1 – R18	629A531H38	2	1800 Ohms ½W + 2%
R5 – R22	629A531H51	2	6200 Ohms ½W + 2%
R6-R16-R17-R23	629A531H56	4	10K ½W + 2%
R7-R8-R11-R13-R15-R24-R26	629A531H58	7	12K ½W + 2%
R3 – R20	629A531H62	2	15K ½W +2%
R10 – R12	629A531H66	2	27K ½W +2%
R2 – R19	629A531H73	2	51K ½W +2%
R9–R14–R25	629A531H48	3	4.7K ½W +2%
[redacted]			
DIODES			
D1,D2,D3,D4,D5,D6,D7,D8,D9,	837A692H03	11	IN645A
D10, D11			
DIO ZENER			
Z4 – Z9	185A212H06	2	IN3686B
Z5 – Z10	186A797H06	2	IN957B
Z1-Z2-Z3-Z6-Z7-Z8	629A369H01	6	1R200

775B312

Fig. 10 Buffer Keying Circuit Board "A"



LOGIC BUFFER BD. "B" (1444C75G01)

COMPONENT	STYLE	REQ	REF.
TRANSISTORS			
Q1 - Q2 - Q3 - Q4 - Q5	184A638H19	5	2N699
Q6	849A441H02	1	2N4356
RESISTORS			
R3 - R12	629A531H36	2	1500 Ohms ½W +2%
R4 -- R13	629A531H51	2	6200 Ohms ½W +2%
R5-R14-R16-R21	629A531H57	4	11K ½W + 2%
R6 R8 R10-R15-R18-R20	629A531H58	6	12K ½W + 2%
R1 – R11	629A531H62	2	18K ½W + 2%
R2	629A531H73	1	51K ½W + 2%
R7-R9-R17	629A531H66	3	27K ½W + 2%
R19	629A531H48	1	4.7K ½W + 2%
CAPACITORS			
C1 – C2	849A437H04	2	.047 UF
DIODES			
D1-D2-D3-D4-D5	837A692H03	5	IN645A
DIO ZENER			
Z1 - Z2 - Z3 - Z4	185A212H06	4	IN3686B

775B314

Fig. 11 Buffer Keying Circuit Board "B"

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT 3 FREQUENCY — 10 WATT/1-3.25 WATT/10 WATT — WITH VOICE

CAUTION: It is recommended that the user of this equipment become thoroughly familiar 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

A widely used high speed relaying system used for transmission line protection consists of directional-comparison unblock relaying plus a transfer-trip channel for breaker failure protection. Normally these systems of relaying require two frequency-shift channels, wideband for unblocking and narrowband for transfer trip. A saving in channel spectrum can be effected by using a three frequency transmitter for the two relaying functions and two separate receivers, one for each function, as shown in Figure 7.

SYSTEM OPERATION

The three frequency TCF carrier transmitter provides for the transmission of any of three closely controlled discrete frequencies, all within the equivalent spacing of a single wideband channel. The center frequency of the channel can vary from 30 kHz to 300 kHz in 0.5 kHz steps. The transmitter normally operates at a frequency that is 100 Hz above the channel center frequency (fc). This frequency serves as the "guard" frequency for the transfer-trip receiver and as the "block" frequency for the unblock receiver. Note that the discriminator characteristic in the unblock receiver in this case is reversed from the normal unblock receiver used with the standard two frequency transmitter. This "guard" "block" frequency is transmitted continuously when conditions are normal. It indicates at the receiving end of the line that the channel is operative and serves to prevent false operation of the receiver by line noise. The lowest frequency, which is 100 Hz less than fc is the "transfer trip" frequency and is transmitted as a signal that an operation (such as tripping a circuit breaker) should be performed at the receiving end of the line. The highest frequency, which is 300 Hz above fc, is the "unblock" frequency and is transmitted as an unblock signal for directional comparison relaying. If a subsequent transfer-trip operation is called for, the transmitter will shift to fc -100 Hz which is the "trip" frequency for the transfer trip (narrow-band receiver.)

Note that when the transmitter shifts to "unblock," the frequency is completely outside the passband of the narrow band transfer-trip receiver. Normally, this would cause a low-signal alarm output from that receiver. In order to prevent a similar alarm output in this case, the checkback output of the unblock receiver is cross-connected to the guard or block input of the transfer trip receiver (through an OR logic circuit). This logic is shown in Figure 12. The checkback output is a receiver output that indicates that a proper signal has been received without going through any time delays or other logic used for the actual relaying output. With this cross-connected logic, both receivers will function when required, but will not give any incorrect output indications.

The transmitter normally operates at an output level of one watt at the "guard" "blocking" frequency, but increases to ten watts for either "trip" or "unblock" output. An interlock is provided in the transmitter keying circuit to give transfer-trip preference. This means that even while the transmitter is shifted to the "unblock" frequency, if the transfer-trip keying circuit is energized, the transmitter will shift to the "trip" frequency without delay.

The transmitter can also be amplitude modulated at 3.25 watts to provide a voice channel.

CONSTRUCTION

The 10 watt/1-3.25 watt/10 watt TCF transmitter unit is mounted on a standard 19-inch wide panel 12¼ inches (7 rack units) high with edge slots for mounting on a standard relay rack. A jack for metering the amplifier collector current is accessible from the front of the panel. See Fig. 8. All of the circuitry that is suitable for printed circuit board mounting is on three such boards, as shown in Fig. 2. The components mounted on each printed circuit board or other sub-assembly are shown enclosed by dotted lines on the internal schematic. Fig. 1. The location of components on the four printed circuit boards are shown on separate illustrations, Fig. 3, 4, 5, & 6.

External connections to the assembly are made through a 24-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2.

Supersedes I.L. 41-945.12, dated July 1971
New Information

EFFECTIVE January 1976

OPERATION

The transmitter is made up of four main stages and two filters. The stages include two crystal oscillators operating at frequencies that differ by the desired channel center frequency, a mixer and buffer amplifier, a driver stage and a power amplifier, a driver stage and a power amplifier. The interstage filter is located between the driver and the power amplifier. The output filter removes harmonics that may be generated by distortion in the power amplifier.

A single crystal designed for oscillation in the 30 kHz to 300 kHz range cannot be forced to oscillate away from its natural frequency by as much as ± 100 hz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2 MHz range. The crystals are Y1 and Y2 of Fig. 1. The frequency of Y2 is 2.00 MHz when operated with a specified amount of series capacity, and the frequency of Y1 is 2.00 MHz plus the channel center frequency, or 2.03 MHz for 30 kHz center frequency. Capacitor C55 and crystal Y2 in series are connected between the positive side of the supply voltage and the base of transistor Q51, which operates in the emitter following mode. The emitter is coupled to the base through C57. With Y2 removed the base of Q51 would be held at approximately the midpoint of the supply voltage by R51 and R52. The crystal serves as a series-resonant circuit with very high inductance and low capacitance. The circuit can be made to oscillate at other than the natural frequency of the crystal by varying the series capacitor, C55. Increasing C55 will lower the frequency of oscillations and reducing C55 will raise the frequency.

Capacitor C79 (in parallel with C78) is not effective until D59 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the keying control for unblock is closed which places 45V. dc at terminal 12 of the printed circuit board. With D57 conducting, C79 and C78 are placed in parallel with C55 and C73. The adjustment of C79 will reduce the frequency of the Y2 circuit by 200 hz. Since Y2 is the lower of the two frequencies derived from Y1 and Y2, the difference frequency, which is ıe frequency transmitted, is now increased by 200 hz. Thus the frequency transmitted is now 200 hz above the guard frequency or 300 hz above the center frequency.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes D51 and D52. By adjustment of C52 this circuit is made to oscillate at 100 hz above its marked frequency. Capacitors C53 and C71 are not effective until D51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the keying control is closed, which places 45 V. dc at terminal 1 of the printed circuit board. With D51 conducting, C53 and C71 are effectively in parallel with C52 and C72. The adjustment of C53 will reduce the frequency by 200 hz. The crystals taken individually have a greater variation of frequency with temperature than would be acceptable. However, by proper matching of the two crystals, the variation in their difference frequency can be kept within limits that permit holding the frequency stability of the overall transmitter to ± 10 Hz over a temperature range of − 20 to + 55° C.

The frequencies produced by the two oscillators are coupled to the base of mixer transistor Q53 through C62 and C63. The sum of the two frequencies is so high that a negligible amount appears on the secondary of transformer T51, but the difference frequency is accepted and amplified by Q53 and Q54.

When the keying control is closed, it increases the output power from 1 watt to 10 watts as well as changing the frequency from Guard to Transfer or Unblock Trip. This is effected by reducing the emitter resistance of buffer-amplifier transistor Q54. When the keying control is open, transistor Q55 receives no base current and is non-conducting. Emitter resistor R70 therefore is effectively open-circuited. The level of output power is adjusted to 1 watt by means of R64. When Q55 is made conductive by closing the keying control circuit, R70 is placed in parallel with R68 and the amount of emitter resistance unbypassed by C66 can be adjusted as required to obtain a 10-watt output level.

Note in the keying board logic there is that interlocking logic between the keying for "unblock" and the keying for "transfer trip". This logic permits the "transfer trip" keying to take preference over the "unblock" keying. That is even if we have "unlock" keying and then get "transfer trip" keying, th "transfer trip" will take immediate preference over the "unblock" keying. This is accomplished by the "transfer trip" keying causing transistor Q1 to conduct which in turn shunts out the keying voltage input to transistor Q3 through diode D9. Thus while Q1 becomes conducting and consequently Q2, effecting "transfer trip" keying, this conduction of Q1 also prevents Q3 from becoming conducting and prevents "unblocking" keying.

As is shown on the Internal Schematic, Fig. 1, the voltage for the keying circuit is obtained from the 45-volt regulated supply in the transmitter.

The driver stage consists of transistors Q56 and Q57 connected in a conventional push-pull circuit with input supplied from the collector of Q54 through transformer T52. Thermistor R73 and resistors R74 and R75 are connected to provide a variable bias that reduces the effect of varying ambient temperatures on the input level. In addition, network R67, R79, and potentiometer R80 are used in the bias circuit and are adjusted by means of R80 to limit the quiscent current in the driver stage common to 0.2 ma. This adjustment is made by unsoldering the lead going from pin 2 of the transmitter to terminal 2 of transformer T1 and inserting a d-c milliammeter (0-1.0 ma) between this pin 2 and terminal 2 of T1. The R80 is adjusted to produce 0.2 ma ± .05 in this circuit, after this, the milliameter is removed and the lead replaced.

The driver filter, FL101, consists of a series-resonant inductor and capacitor connected between the driver and power amplifier stages by appropriate transformers T1 and T2. This filter greatly improves the waveform of this signal applied to the power amplifier.

The power amplifier uses two series-connected power transistors, Q101 and Q102, operating as a class B push-pull amplifier with single-ended output. Diodes D101 and D103 provide protection for the base-emitter junctions of the power transistors. Zener diodes Z105 and Z106 protect the collector-emitter junctions from surges that might come in from the power line through the coaxial cable.

The output transformer T3 couples the power transistors to the output filter FL102. The output filter includes two trap circuits (L102, CB and L103, CC) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor CD approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G1 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line turner and coaxial cable. Auto-transformer T4 matches the filter impedance to coaxial cable of 50, 60, or 70 ohms.

The series resonant circuit composed of L105, and CE is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, thus providing a reserve impedance that is free of possible "across-the-line" resonances.

The power supply is a series-type transistorized d-c voltage regulator which has a very low stand-by current drain when there is no output current demand. The Zener diode Z1 hols a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the d-c voltage drop through transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage. The Zener diode Z2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 by pass r.f. or transient voltages to ground, thus preventing damage to the transistor circuit.

When keyed for voice by the voice adapter, transistor Q55 is keyed into class A operation so that its conduction can be modulated by the voice input from the voice adapter. Potentiometer R82 is adjusted so that the nominal output of carrier is 3.25 watts (14 volts across 60 ohms). The voice input modulates the carrier through this transistor by varying the amount of conduction of Q55 so that the output power of carrier varies with the voice amplitude following the voice frequency components. Since with Q55 completely non-conducting, R64 has been set to produce a 1 watt output, maximum modulation on the side to shut off Q55 will not result in an output level of less than 1 watt carrier at any time. Also since the output level has been set at 10 watts with Q55 completely conducting by the adjustment of R70, the maximum modulation on the side of turn on of Q55 will not result in a carrier output level of greater than 10 watts at any time. Thus the modulation for voice will not result in the output carrier level dropping below 1 watt and endangering the guard frequency for relaying purposes.

The buffer keying board in addition to providing proper buffering, also contains logic for the proper keying of both frequency and output level in regards to protective relaying operation, voice adapter operation, and 52b contact operation.

It should be remembered that protective relaying operation has first priorty. If the protective relay operates and puts a voltage input into any of the three input points labeled carrier auxiliary keying, the transmitter will both frequency shift to trip frequency and full 10 watts output whether voice is called for or not.

The operation of the 52b contact will remove the 10 watt keying output and permit the voice adapter to key to 3.2 watts output for AM voice modulation. This allows voice modulation on the trip frequency after the 52b contact has operated.

CHARACTERISTICS

Frequency Range	30-300 kHz
Output	1 watt guard — 10 watts trip — (both transfer and unblock) — 3.2 watts voice (into 50 to 70 ohm resistive load)
Frequency Stability	±10 Hz from −20°C to +55C.
Frequency spacing	Two-way channel, — See Voice Adapter Instruction Leaflet.
Harmonics	Down 55 db (min.) from output level.
Input voltage	48 or 125 v.d.c.

Supply voltage variation	42-56v. for nom. 48v. supply. 105-140v. for nom. 125v. supply.	
Battery drain	0.5 a. guard 1.15 a. trip	48 v.d.c.
	0.5 a. guard 0.9 a. trip	125 v.d.c
Keying circuit current	4 ma.	
Temperature range	–20 to +60°C. around chassis.	
Dimensions	Panel height — 12¼" or 7 r.u. Panel width — 19"	
Weight	12 lbs.	

INSTALLATION

The TCF transmitter is generally supplied in a cabinet or on a relay rack as part of a complete car ier 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

The TCF 10W/1-3.2W/10W 3 Frequency transmitter is shipped with the power output controls R64, R82 and R70, set for outputs of 1 watt, 3.2 watts and 10 watts into a 60 ohm load. If it is desired to check the adjustments or if repairs have made readjustment necessary, the coaxial cable should be disconnected from the assembly terminals and replaced with a 50 to 70 ohm non-inductive resistor of at least a 10 watt rating. Use the value of the expected input impedance of the coaxial cable and line tuner. If this is not known, assume 60 ohms. Connect the T4 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn power output control R64 to minimum (full counter-clockwise). Turn on the power switch on the panel and note the d-c voltage across terminals 3 and 7 of J3. If this is in the range of 42 to 46 volts, rotate R64 clockwise to obtain 4 or 5 volts across the load resistor used. At this point check the adjustment of the series output tuning coil L105 by loosening the knurled shaft-locking nut and moving the adjustable core in and out a small amount from its initial position. Leave it at the point of maximum voltage across the load resistor used. Then rotate R64 farther clockwise to obtain the correct voltage for 1 watt in the load resistor, as shown in the following table.

Then change to Trip frequency by connecting together terminals 7 and 12 of the transmitter connector J3, and rotate R70 until the voltage across the load resistor is as shown in the following table for a 10 watt output. Recheck the adjustment of L105 for maximum output voltage and readjust R70 for a 10 watt output if necessary. Tighten the locking nut on L105. Open the power switch and remove the jumper used to key the transmitter to the 10 watt level. Key for voice by opening any connection terminal to 10 of J3. Turn the power back on. Adjust R82 for a 3.2 watt output across the load resistor (14V across 60 ohms). Open the power switch, reconnect connection to terminal 10 of J3, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

VOLTAGE FOR

T106 TAP	1 WATT OUTPUT	3.2 WATTS OUTPUT	10 WATTS OUTPUT
50	7.1	12.7	22.4
60	7.8	14	24.5
70	8.4	15	26.5

Follow the procedure outlined in the line tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. It is factory tuned for maximum second and third harmonic rejection, and for series resonance (maximum output at the fundamental frequency) with a 60-ohm load. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection and no change should be made in these settings unless suitable instruments are available for measuring the second and third harmonic present in the transmitter output.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals, this can be done by turning the matched pair 180° and inserting a crystal in its proper socket with the other crystal unconnected. A sensitive frequency counter with a range of at least 2.3 MHz can be connected from TP51 to TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter and avoids some error from the effect of the counter input capacitance on the oscillator circuit.) While measurement of the oscillator crystals individually is necessary for the initial adjustment of the oscillators, generally any subsequent checks may be made with a lower range counter connected at the transmitter output. If any minor adjustment of the Guard and Trip frequencies should be needed, the Guard adjustment should be made with capacitor C52, the Transfer Trip Adjustment with C53, and the unblock frequency with C79.

Q56-Q57 Bias Adjustment

The push-pull output stages of the transmitter board are normally shipped correctly biased. If any components involved in these stages have been changed, then it may be necessary to recheck the biasing of this stage.

Unsolder the lead from terminal 2 of transformer T1 (just above FL101) and temporarily connect a low-range d-c milliammeter (0-1.0 ma) between the removed lead (+) and T1 terminal 2 (-). Turn the slotted control on the small potentiometer to full counterclockwise. Now, apply power to the TCF carrier set, but do *not* transmit carrier. This can be done by removing the crystals. Advance the potentiometer clockwise until the milliammeter reads 0.2 ma. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T1. Replace the crystals and again apply d-c power to reenergize the transmitter. Check output, etc. of transmitter as previously described.

MAINTENANCE

Periodic checks of the transmitter Guard and Trip power outputs will detect impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output at such times, making any necessary readjustments to return the equipment to its initial settings.

Voltage values should be recorded 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. Readings may vary as much as ±20%.

TABLE I
TRANSMITTER D-C MEASUREMENTS

Note: All voltages are positive with respect to Neg. 45 V. (TP51). All voltages read with d-c VTVM.

Test Point	Voltage at 1 Watt Output	Voltage at 10 Watts Output	Voltage at 3.2 Watts Output (For Voice)
TP52	20	20	20
TP53	5.4	5.4	5.4
TP54	3.4	3.4	3.4
TP55	21	18.5	—
TP56	21	18.5	—
TP57	*<1.0	*<1.0	—
TP58	44.3	44.1	—
TP59	*<1.0	*<1.0	—
TP101	0	0	—
TP103	21 ± 2	21 ± 2	—
TP105	44.3	44.0	—

TABLE II
TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages subject to variations, depending upon frequency and transistor characteristics. T51-3 = Terminal 3 of transformer T51. Other transformer terminals identified similarly. All read with a-c VTVM.

Test Point	Voltage at 1 watt Output	Voltage at 10 watts Output	Voltage at 3.2 watts Output (For Voice)
TP54 to TP51	0.015-0.03	0.015-0.03	—
TP57 to TP51	0.05 -0.09	0.3 -1.2	—
TP59 to TP51	0.05 -0.09	0.3 -1.2	—
T1-1 to TP51	1.65	5.6	—
T1-3 to TP51	1.45	4.9	—
T1-4 to Gnd.	.6	2.0	—
T2-1 to Gnd.	.57	1.85	—
TP101-TP103	5.2	17.0	—
TP103 to TP105	5.2	17.0	—
T3-4 to Gnd.	35	112	—
T4-2 to Gnd.	31	110	—
TP109 to Gnd.	9.8	31	—
J102 to Gnd.	7.8	24.5	14

CONVERSION OF TRANSMITTER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a 1W/10W TCF transmitter for operation on a different channel frequency consist of a pair of matched crystals for the new channel frequency, new capacitors C103 and C104 on the power amplifier circuit board if the old and new frequencies are not in the same frequency group (see table on internal schematic drawing) and, in general, new or modified filters FL101 and FL102. Inductors L101, L102 and L103 in these filters are adjustable over a limited range, but thirty-two combinations of capacitors and inductors are required to cover the frequency range of 30 to 200 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlay is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5	207.1-214.0
32.0-33.5	64.5- 68.0	120.0-127.0	214.1-222.0
34.0-36.0	68.5- 72.0	127.5-135.0	222.1-230.0
36.5-38.5	72.5- 76.0	135.5-143.0	230.1-240.0
39.0-41.0	76.5- 80.0	143.5-151.0	240.1-250.0
41.5-44.0	80.5- 84.5	151.5-159.5	250.1-262.0
44.5-47.0	85.0- 89.0	160.0-169.5	262.1-274.0
47.5-50.0	89.5- 94.5	170.0-180.0	274.1-287.0
50.5-53.5	95.0-100.0	180.5-191.5	287.1-300.0
54.0-57.0	100.5-106.0	192.0-220.0	
57.5-60.5	106.5-112.5	200.1-207.0	

If the new frequency lies within the same frequency group as the original frequency, the filters can be readjusted. If the frequencies are in different groups, it is possible that changes only in the fixed capacitors may be required. In general, however, it is desirable to order complete filter assemblies adjusted at the factory for the specified frequency.

A signal generator, a frequency counter and a vacuum tube voltmeter are required for readjustment of FL101. The signal generator and the counter should be connected across terminals 4 and 5 of transformer T1 and the voltmeter across terminals 1 and 2 of transformer T2. The signal generator should be set at the channel center frequency and at 2 to 3 volts output. The core screw of the small inductor should be turned to the position that gives a true *maximum* reading on the VTVM. Turning the screw to either side of this position should definitely reduce the reading. The change in inductance with core position is less at either end of the travel than when near the center and consequently the effect of core screw rotation on the VTVM reading will be less when the resonant inductance occurs near the end of core travel.

The procedure for readjustment of the 2nd and 3rd harmonic traps of filter FL102 is somewhat similar. A signal generator and a counter should be connected to terminals 3 and 4 of transformer T3, and a 500 ohm resistor and a VTVM to the terminals of protective gap G1. The ground or shield lead of all instruments should be connected to the grounded terminal of the transformer. Se the signal generator at exactly twice the channel center frequency and at 5 to 10 volts output. Turn the core screw of the large inductor, L102, to the position that gives a definite *minimum* reading on the VTVM. Similarly, with the signal generator set a t exactly three times the channel center frequency and 5 to 10 volts output, set the core screw of the small inductor, L103, to the position that gives a definite *minimum* reading on the VTVM. Then remove the instruments and the 500 ohm resistor.

After the new pair of matched crystals have been adjusted, as described under "ADJUSTMENTS", the transmitter can be operated with a 50 to 70 ohm load (depending on which tap of T4 is used) connected to its output, and inductor L105 can be readjusted for maximum output at the changed channel frequency by the procedure described in the same section.

If a frequency-sensitive voltmeter is available, the 2nd and 3rd harmonic traps may be adjusted without using an oscillator as a source of double and triple the channel frequency. Connect the frequency-sensitive voltmeter from TP109 to ground and adjust the transmitter for rated output into the selected load resistor. Se the voltmeter at twice the channel frequency and, using the tuning dial and db range switch, obtain a maximum on-scale reading of the 2nd harmonic. Then vary the core position of L102 until a minimum voltmeter reading is obtained. Similarly, tune the voltmeter to the third harmonic and adjust L103 for minimum voltmeter reading. Although the transmitter frequency will differ from the channel center frequency by 100 Hz, the effect of this difference on the adjustment of the harmonic traps will be negligible. It should be noted that the true magnitude of the harmonics cannot be measured in this manner because of the preponderance of the fundamental frequency at the voltmeter terminals. Accurate measurement of the harmonics requires use of a filter between TP109 and the voltmeter that provides high rejection of the fundamental. The insertion losses of this filter for the 2nd and 3rd harmonics must be measured and taken into account.

RECOMMENDED TEST EQUIPMENT

I. Mimimum Test Equipment for Installation.
  a. 60-ohm 10-watt non-inductive resistor.
  b. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 hz to 330-kHz; input impedance 7.5 megohms.
  c. 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.

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

RENEWAL PARTS

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

ELECTRICAL PARTS LIST

TRANSMITTER—(6275D85G09)

Component	*Style*	*Req.*	*Ref.*
TRANSISTORS			
Q51-Q52-Q53-Q55	184A638H18	4	2N697
Q54	184A638H19	1	2N699
Q56-Q57	762A672H07	2	2N2726/2N3712
RESISTORS			
R51 to R54-R59-R62-R87	184A763H51	7	10K 1/2W ±5%
R56-R57	184A763H40	2	36K 1/2W ±5%
R60-R72	184A763H45	2	5.6K 1/2W ±5%
R61	184A763H55	1	15K 1/2W ±5%
R63	184A763H27	1	1K 1/2W ±5%
R65	184A763H33	1	1.8K 1/2W ±5%
R66	184A763H49	1	8.2K 1/2W ±5%
R67	629A531H58	1	12K 1/2W ±2%
R68	184A763H15	1	330 Ohms 1/2W ±5%
R69	184A859H06	1	800 Ohms 3W ±5%
R71	848A820H27	1	6.49K 1/2W ±1%
R74	629A531H03	1	62 Ohms 1/2W ±2%
R75	187A290H21	1	68+ 1/2W ±5%
R76	184A763H34	2	2K 1/2W ±5%
R77-R78	187A290H01	2	10+ 1/2W ±5%
R79	629A531H63	1	20K 1/2W ±2%
R81	848A819H48	1	1K 1/2W ±1%
R83	848A820H45	1	10K 1/2W ±1%
R84	187A290H01	1	271 1/2W ±5%
R86	848A819H36	1	750 Ohms 1/2W ±1%
R55-R58	184A763H03	2	100 Ohms 1/2W ±5%
CAPACITORS			
C51-C80	762A757H03	2	(1500 MMF)
C54	187A624H01	1	(.1 MFD)
C56-C57	187A584H01	2	2000 MMF
C58-C61-C64-C65-C66-C67-C69	187A624H02	7	.25 MFD
C59-C60	762A757H01	2	100 MMF
C62	762A757H04	1	4700 MMF
C63	762A757H02	1	1000 MMF
C68-C75	187A624H03	2	.5 MFD
C74	187A624H04	1	1 MFD
C70	187A584H09	1	300 MMF
C71-C72-C73-C78	861A846H03	4	3 MMF
C76	764A278H10	1	.01 MFD
C77	188A669H01	1	.47 MFD
DIODES			
D51-D52-D56-D57-D58	184A855H12	5	(IN628)
D55	184A855H07	1	IN457A
DIO ZENER			
Z54	185A212H06	1	IN3686B
TRANSFORMER			
T51	606B537G01	1	
T52	606B537G02	1	
THERMISTOR			
R73	185A211H06	1	(3D202)
R85	185A211H03	1	3D402
POTENTIOMETER			
R64-R70	619A430H02	2	1K 1/4W ±20%
R80	629A430H09	1	25K 1/4W ±20%
R82	629A430H07	1	5K 1/4W ±20%
TRIMMER			
C52-C53-C55-C79	879A834H01	4	5.5 18PF

LOGIC BUFFER BD. "B" (1444C75G01)

Component	*Style*	*Req.*	*Ref.*
TRANSISTORS			
Q1-Q2-Q3-Q4-Q5	184A638H19	5	2N699
Q6	849A441H02	1	2N4356
RESISTORS			
R3-R12	629A531H36	2	1500 Ohms 1/2W ±2%
R4-R13	629A531H51	2	6200 Ohms 1/2W ±2%
R5-R14-R16-R21	629A531H57	4	11K 1/2W ±2%
R6-R8-R10-R15-R18-R20	629A531H58	6	12K 1/2W ±2%
R1-R11	629A531H62	2	18K 1/2W ±2%
R2	629A531H73	1	51K 1/2W ±2%
R7-R9-R17	629A531H66	3	27K 1/2W ±2%
R19	629A531H48	1	4.7K 1/2W ±2%
CAPACITORS			
C1-C2	849A437H04	2	.047 UF
DIODES			
D1-D2-D3-D4-D5	837A692H03	5	IN645A
DIO ZENER			
Z1-Z2-Z3-Z4	185A212H06	4	IN3686B

ELECTRICAL PARTS LIST (Cont'd.)

POWER AMP (606B530)

Components	*Style*	*Req.*	*Ref.*
RESISTORS			
R101-R105	187A290H01	2	10 Ohms 1/2W ±5%
R102	187A644H35	1	2.2K 1W ±10%
R103-R107	184A636H14	2	2.7Ω 1/2W ±10%
R104-R108	184A636H18	2	0.27Ω 1W ±10%
R106	187A644H43	1	4.7K 1W ±10%
CAPACITORS			
C101-C102	187A624H02	2	.25 MFD, 200V DC
C103-C104	S. No. PER S.O.	2	
DIODES			
D102-D104		2	See Note Δ
D101-D103	188A342H06	2	IN4818

LOGIC BUFFER BD. "A" (1444C73G01)

Component	*Style*	*Req.*	*Ref.*
TRANSISTORS			
Q1-Q3-Q5-Q6	184A638H19	4	(2N699)
Q2-Q4-Q7	849A441H02	3	(2N4356)
RESISTORS			
R4-R21	629A531H36	2	1500 Ohms 1/2W ±2%
R1-R18	629A531H38	2	1800 Ohms 1/2W ±2%
R5-R22	629A531H51	2	6200 Ohms 1/2W ±2%
R6-R16-R17-R23	629A531H56	4	10K 1/2W ±2%
R7-R8-R11-R13-R15-R24-R26	629A531H58	7	12K 1/2W ±2%
R3-R20	629A531H62	2	18K 1/2W ±2%
R10-R12	629A531H66	2	27K 1/2W ∓2%
R2-R19	629A531H73	2	51K 1/2W ±2%
R9-R14-R25	629A531H48	3	4.7K 1/2W ±2%
CAPACITORS			
C1-C2	849A437H04	2	.047 UF
DIODES			
D1-D2-D3-D4-D5-D6-D7-D8-D9 D10-D11	837A692H03	11	IN645A
DIO ZENER			
Z4-Z9	185A212H06	2	IN3686B
Z5-Z10	186A797H06	2	IN957B
Z1-Z2-Z3-Z6-Z7-Z8	629A369H01	6	IR200

OUTPUT FILTER

Component	*Style*	*Req.*	*Ref.*
FL-102	S. No. PER S.O.	1	541D214 200KHz
FL-102	S. No. PER S.O.	1	5481D10 200 to 300KHz

OTHER

Component	*Style*	*Req.*	*Ref.*
RESISTORS			
R1-R2	04D1299H44	2	26.5 OHMS
R3	04D1299H44	1	26.5 Ohms 48V DC
R3	1268047	1	500 Ohms 125V DC
R4	187A644H03	1	100 Ohms
R5	187A641H27	1	1K 10% 1/2W
R6	188A317H01	1	3000 Ohms 5W ±5%
CAPACITORS			
C1	1723408	1	(0.45 MFD)
C2-C3	1877962	2	(0.5 MFD)
DIODE			
D1	188A342H06	1	(IN4818)
DIODE-ZENER			
Z3	584C434H08	1	(IN1789)
Z1	184A854H06	1	(IN2828B)
Z2	184A617H12	1	(IN3009A)
TRANSISTOR			
Q1	3503A41H01	1	(2N6259)
TRANSFORMERS			
T1	606B410G01	1	
T2	292B526G01	1	
T3	292B526G02	1	
FILTER			
FL-101	S. No. PER S.O.	1	408C261 30-200KC
FL-101	S. No. PER S.O.	1	202C074 200 to 300KC
TELEPHONE JACK	187A606H01	1	J1

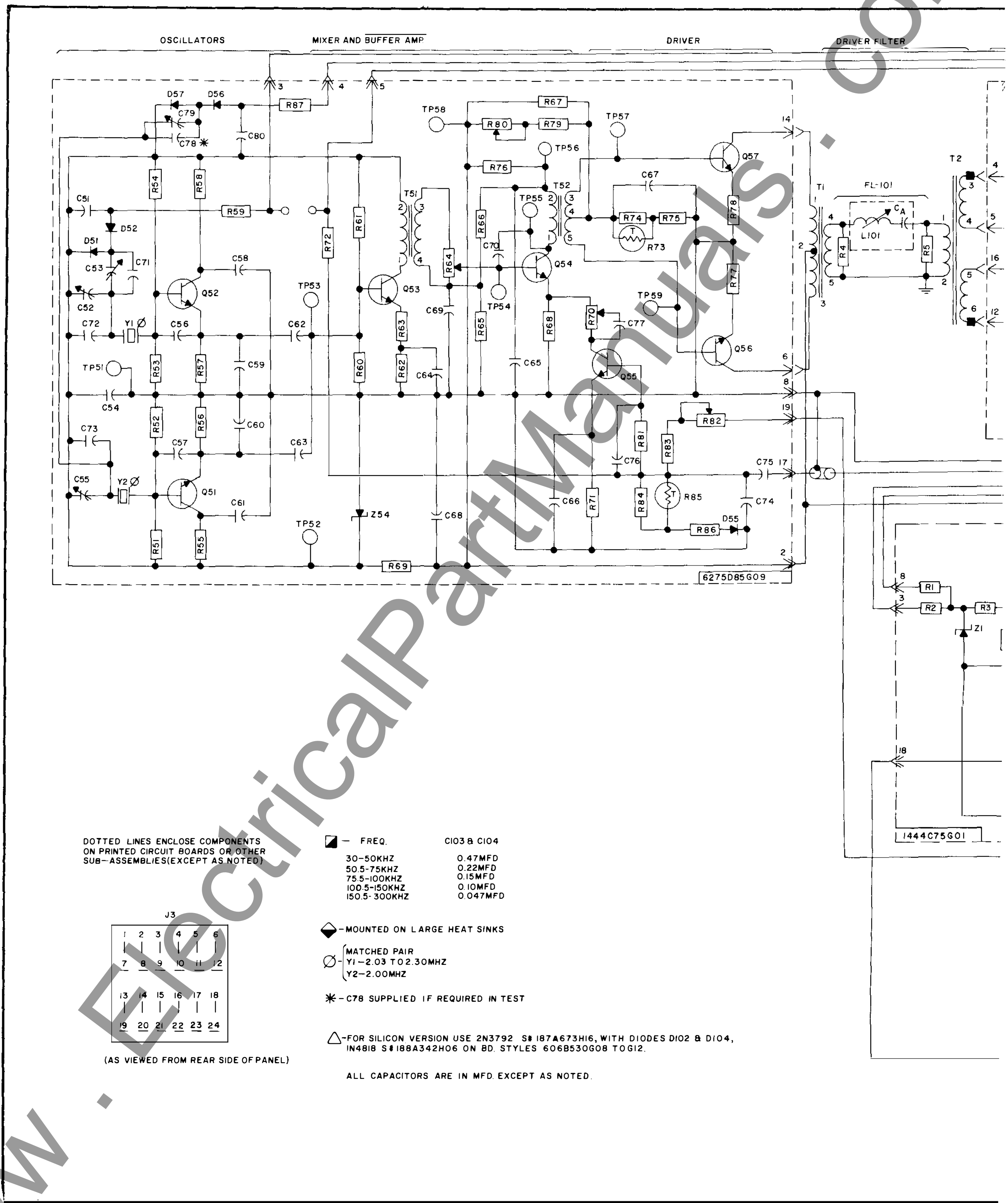
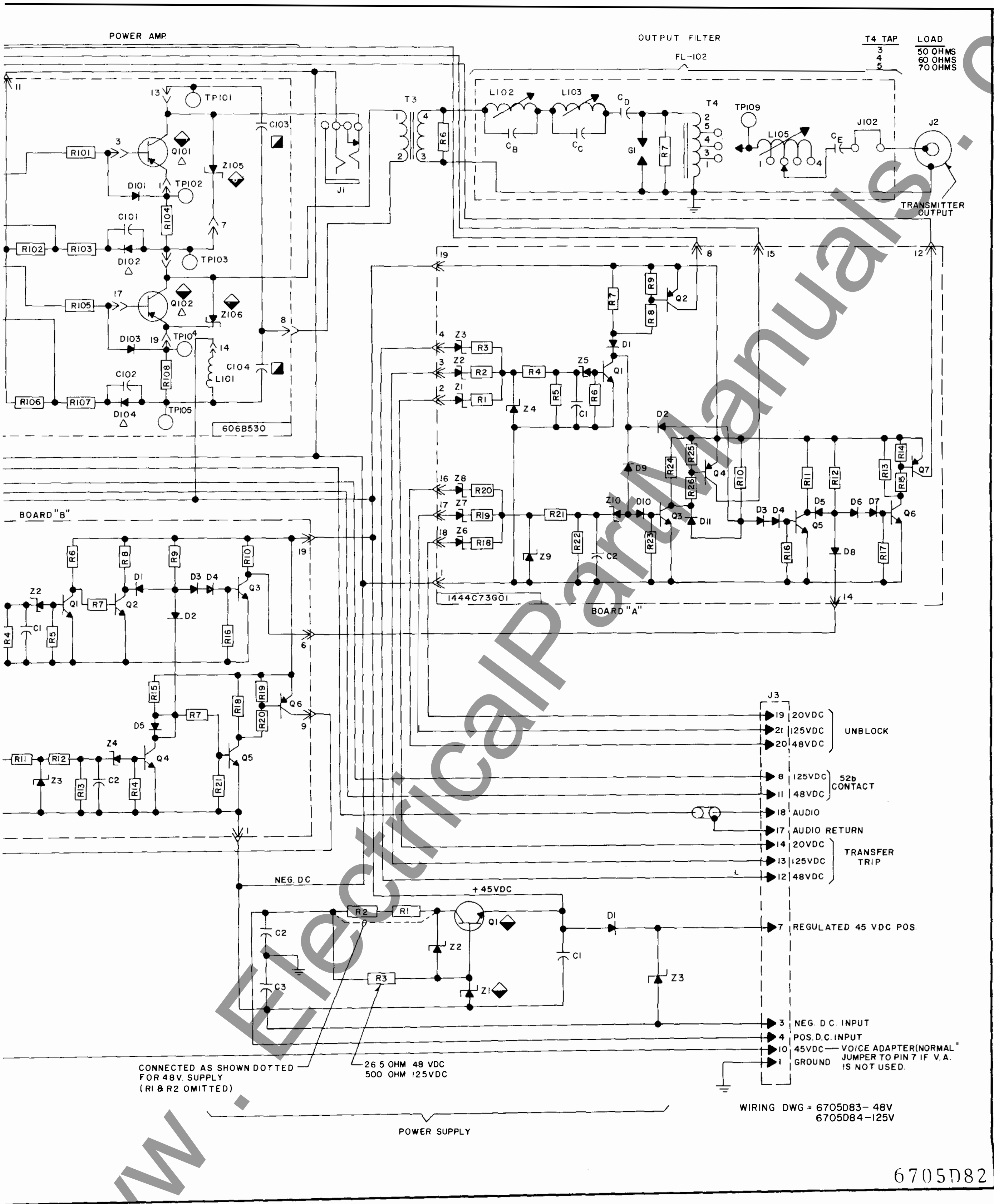


Fig. 1. Internal Schematic of the Type TCF 3-Frequen



:cy, 10 Watt/1 Watt/10 Watt Transmitter.

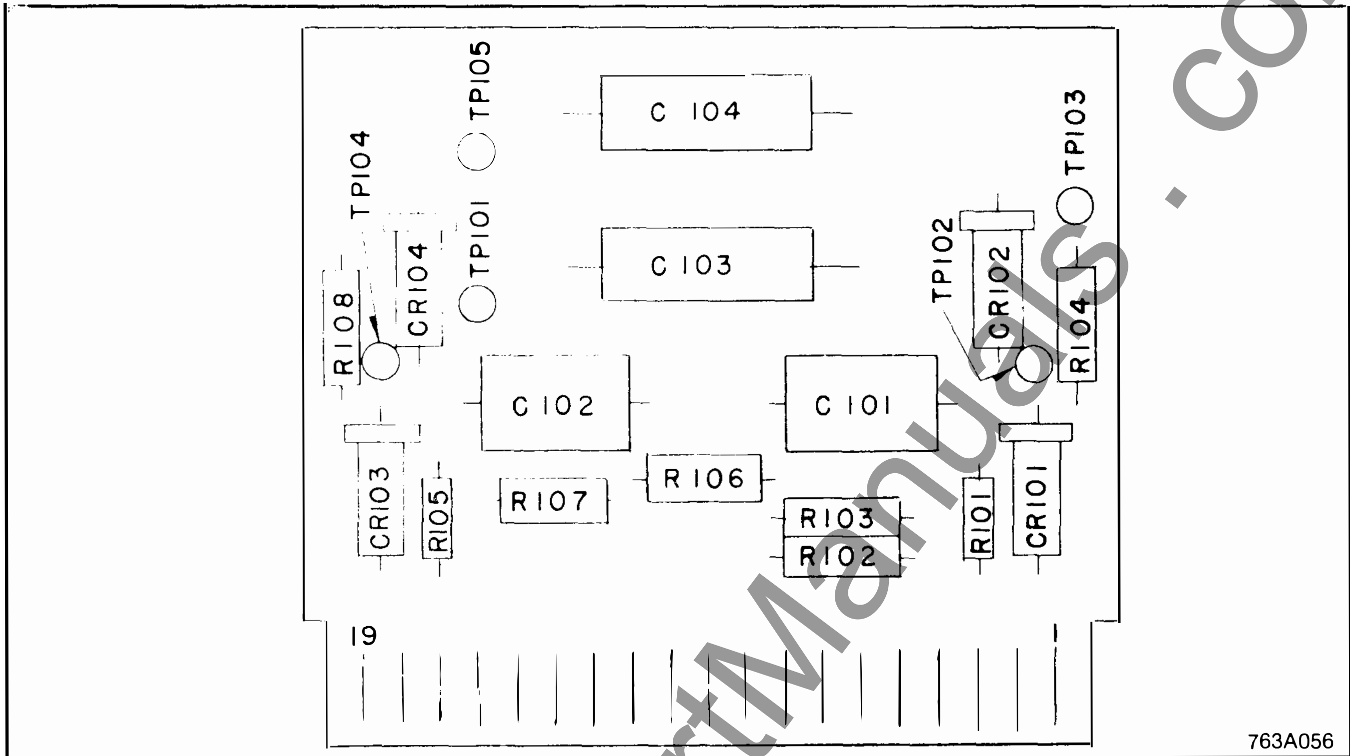


Fig. 4. Component Locations of the Power Amplifier Printed Circuit Board

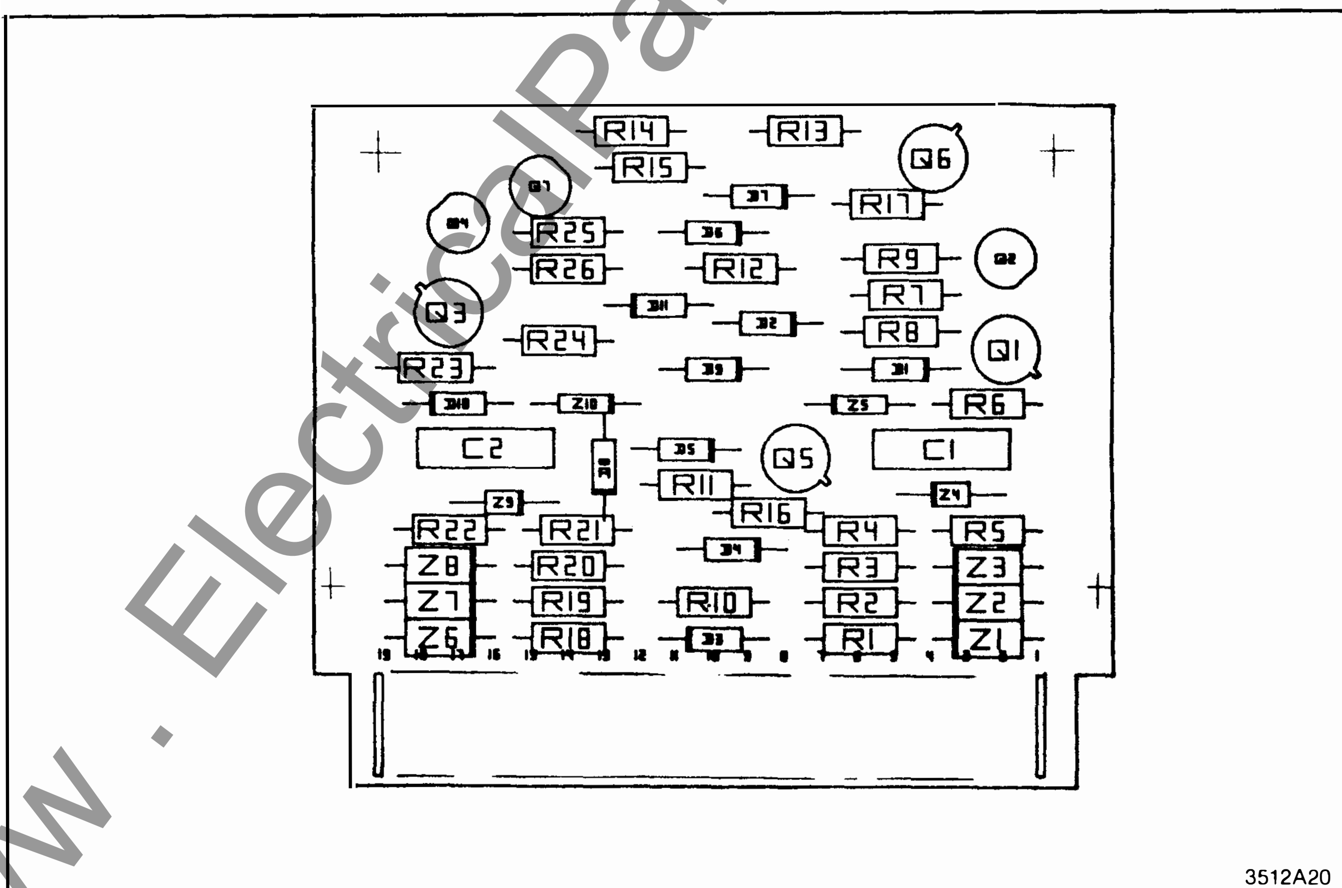


Fig. 5. Component Location of Buffer Keying Circuit Board A

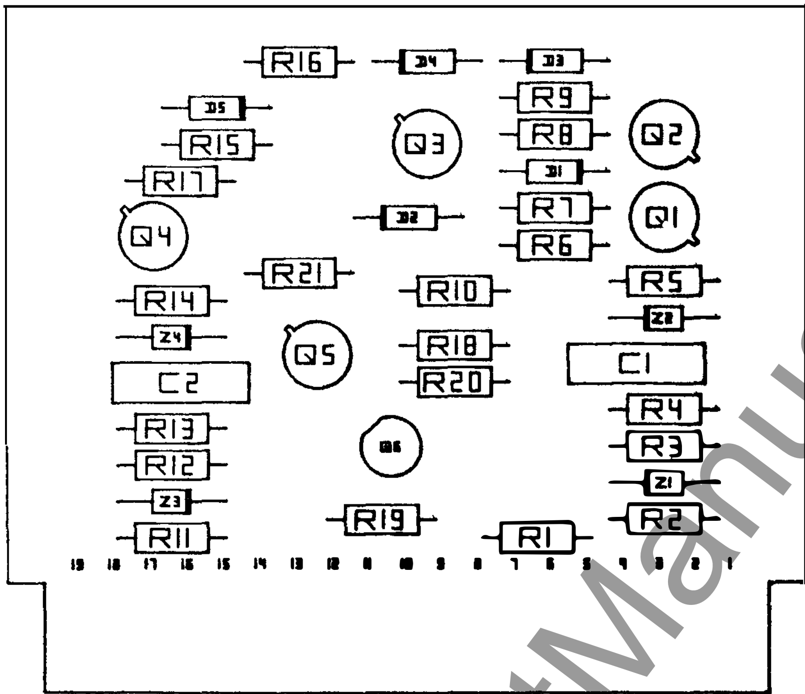
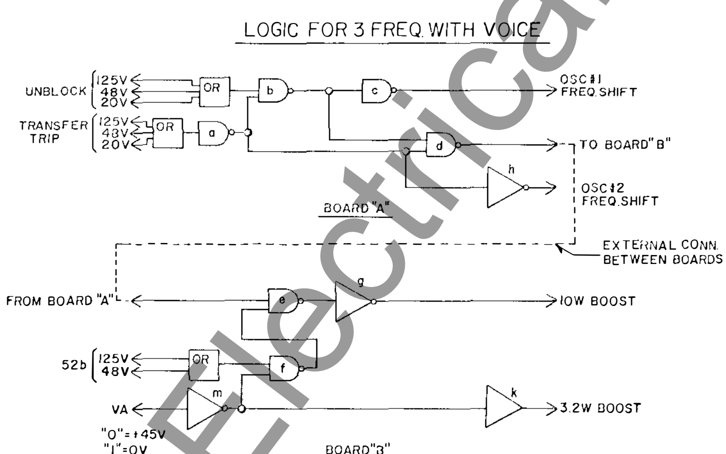


Fig. 6. Component Location of Buffer Keying Circuit Board B



TRUTH TABLE – 3 FREQ. WITH VOICE

INPUT KEYING				OUTPUTS				
UN	TT	52b	VA	TT FREQ SHIFT	UN FREQ. SHIFT	3.2W BOOST	10W BOOST	
0	0	0	0	0	0	0	0	GUARD @ 1W
1	0	0	0	0	1	0	1	UNBLK. @ 10W
1	1	0	0	1	0	0	1	T.T. @ 10W
1	0	1	0	0	1	0	1	UNBLK @ 10W
1	0	0	1	0	1	0	1	UNBLK. @ 10W
1	1	1	0	1	0	0	1	TT @ 10W
1	0	1	1	0	1	1	0	UNBLK @ 3.2W
1	1	0	1	1	0	0	1	TT @ 10W
1	1	1	1	1	0	1	0	TT @ 3.2W
0	1	0	0	1	0	0	1	TT @ 10W
0	1	1	0	1	0	0	1	TT @ 10W
0	1	0	1	1	0	0	1	TT @ 10W
0	1	1	1	1	0	1	0	TT @ 3.2W
0	0	1 *	0	0 *	1	0	1	UNBLK @ 10W
0	0	1 *	1	0 *	1	1	0	UNBLK @ 3.2W
0	0	0	1	0	0	1	0	GUARD @ 3.2W

* = STU RELAY AFTER 180MS OPERATION OF 52b WILL KEY TO UNBLOCK. IN THIS CASE, THE UNBLOCK KEYING IS NOT DONE BY THE LOGIC REPRESENTED BY THESE LOGIC BOARDS.

7758325

Fig. 7. Logic Drawing for 3 Frequency with Voice.

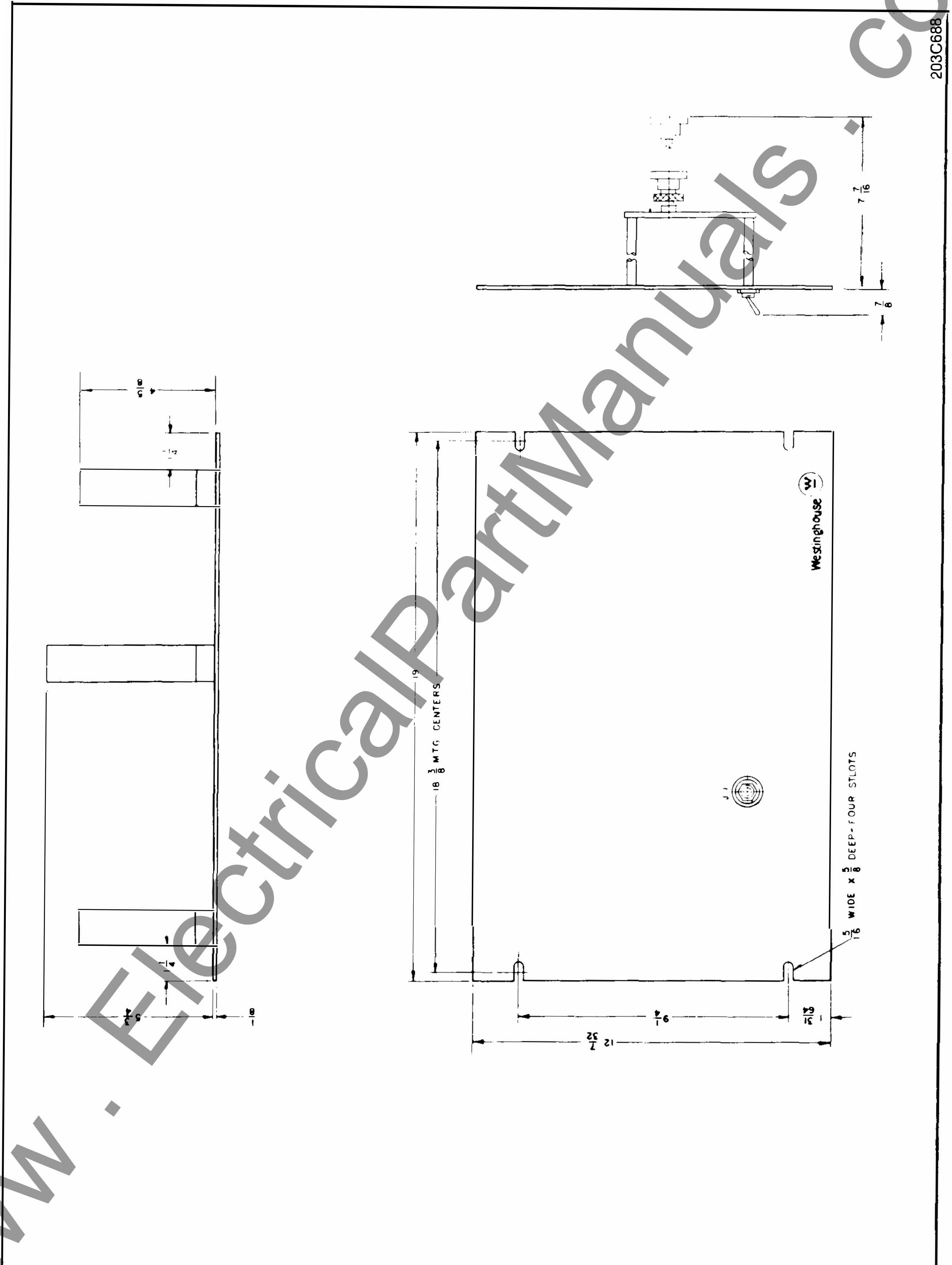


Fig. 8. Outline and Drilling Plan for the Type TCF Transmitter Assembly

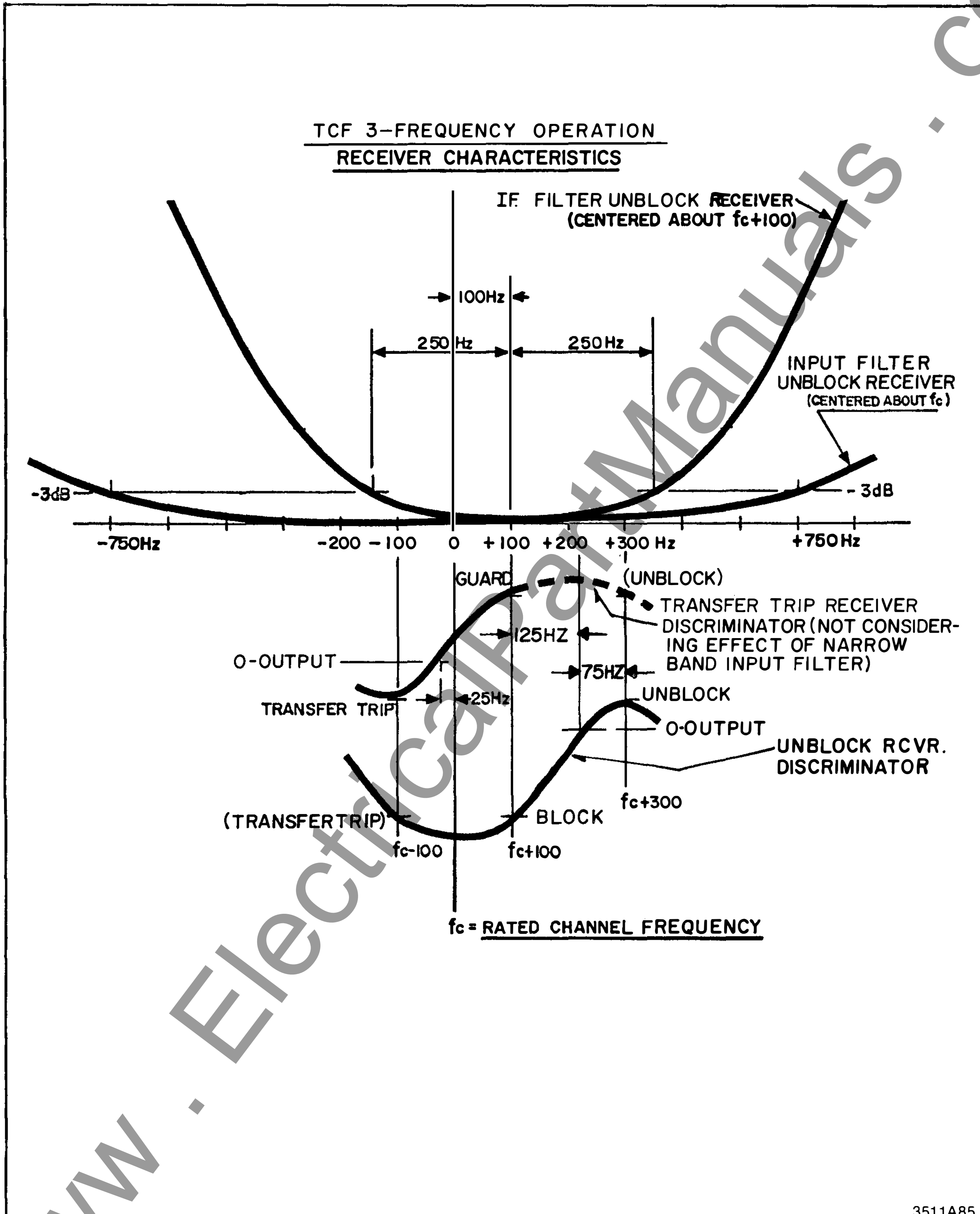


Fig. 9. Three Frequency Operation — Receiver Characteristics

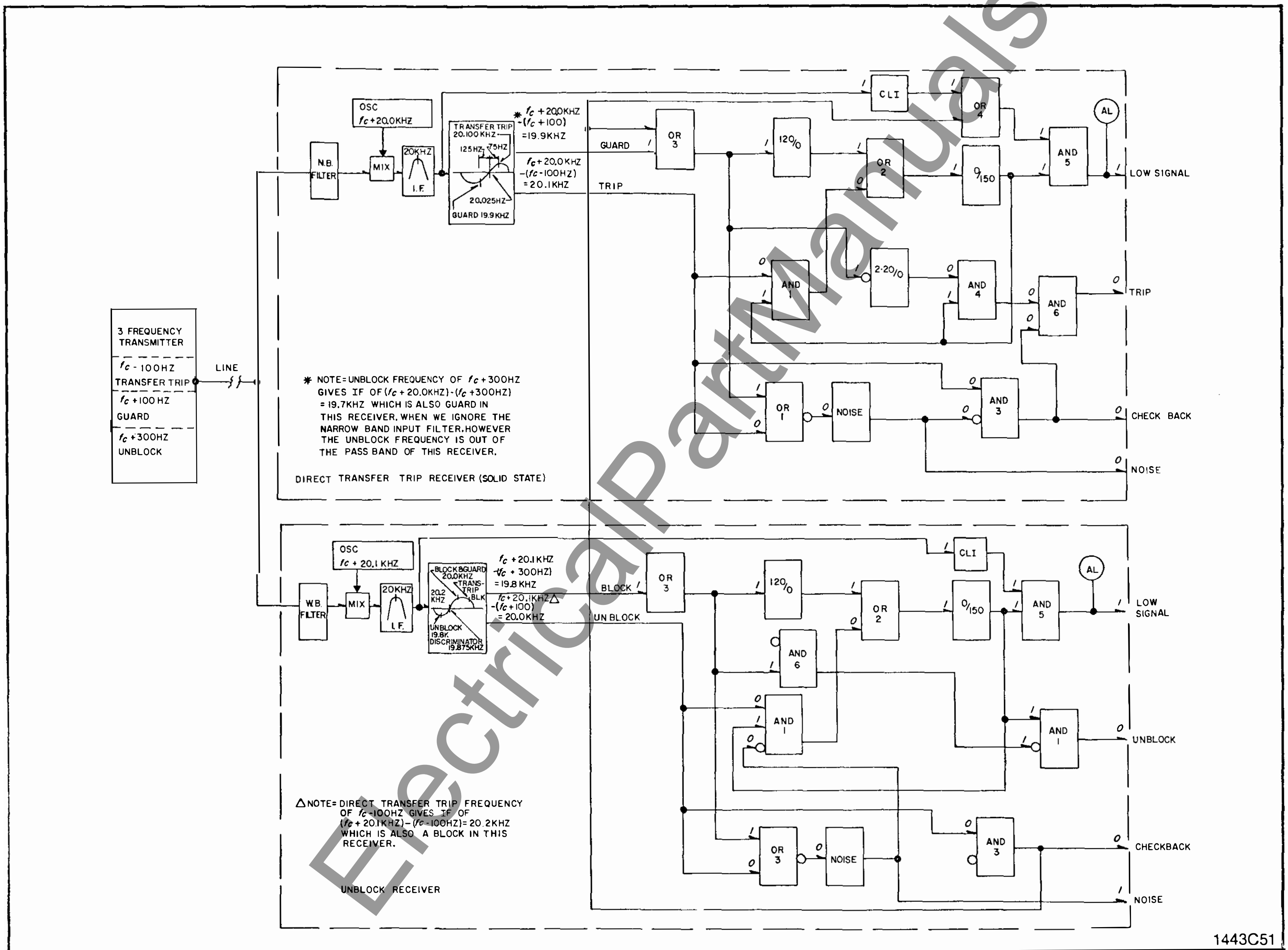


Fig. 10. Receivers Logic Diagram — 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying

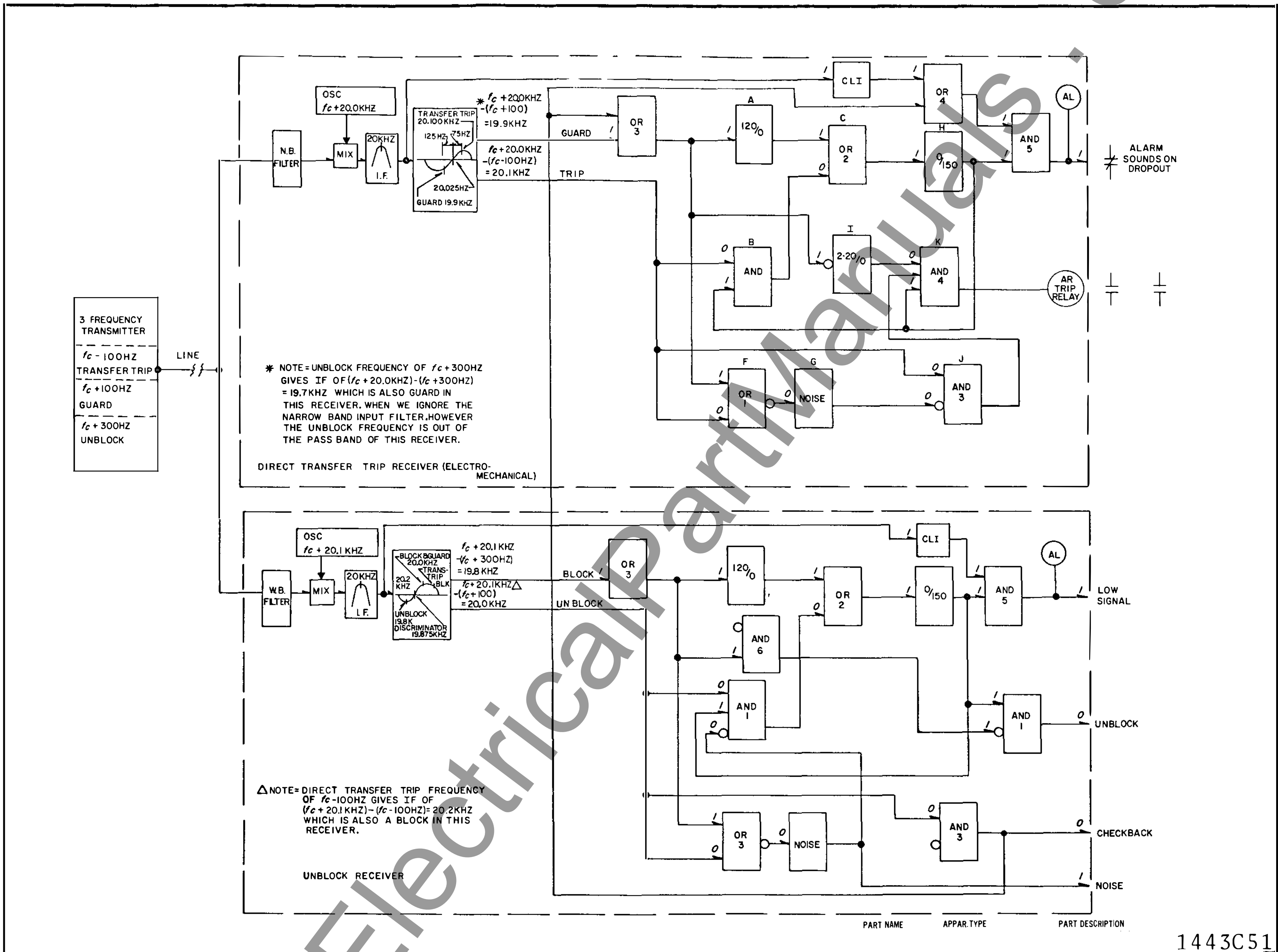


Fig. 11. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying

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

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY SHIFT RECEIVER EQUIPMENT FOR DUAL PHASE-COMPARISON CARRIER RELAYING

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

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

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

APPLICATION

The TCF Receiver described is for use with the SKBU Dual Phase Comparison relay. The TCF frequency-shift receiver equipment as adapted for dual phase comparison applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The space frequency is 100 hertz above the center frequency of the channel (which can be selected within the range of 30 kHz to 300 kHz), and it is transmitted continuously when no information is to be conveyed over the channel. Its reception indicates that the channel is operative. The Mark frequency is 100 hertz below the channel center frequency. Phase comparison information is conveyed over the channel during load current flow or fault conditions. The transmitter at each end of the channel is switched at a 60-Hz rate between space and mark so as to produce at the receiving end the desired operation of the SKBU relay.

CONSTRUCTION

The TCF receiver unit for Dual-Phase-Comparison 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. An input attenuator and a jack for metering the discriminator output current, are accessible from the front of the panel. See Fig. No. 14.

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

The enclosure that contains the printed circuit board is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for dual phase-comparison relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

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

SUPERSEDES I.L. 41-945.55B, dated May 1972
*Denotes change from superseded issue.

EFFECTIVE APRIL 1976

restores all circuit connections, and all components and test points on the board are readily accessible.

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

External connections to the receiver are made through a 12 terminal receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

OPERATION

Input Control

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

L-C Filter (Wide Band)

From the attenuator, the signal passes through an L-C filter, FL201. This filter has a relatively wide pass band, and frequencies several kHz above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the L-C filter, as well as a characteristic curve for the immediate frequency filter, FL2 and for the discriminator output. This apparently wide bandwidth is necessary to achieve high speed relaying by minimizing channel delay.

Oscillator and Mixer

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

If Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. Since its passband is narrower than that of the input filter, 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 (15 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc hertz. The adjustment for zero output at fc hertz is made by capacitor C88. C83 also is adjusted to 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 space frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the space frequency is 20 kHz-100 hertz. Similarly, the mark frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20 kHz. The discriminator is adjusted so that the mark and space outputs are of equal lengths for equal periods of mark and space signal frequencies.

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 mark output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at space frequency and terminal 11 is at + 20 volts at mark frequency.

Output Circuits

The output circuit consists of two printed circuit boards: the output board and the noise board.

The output board consists of two output transistors (Q102, Q104) and two driver (Q101, Q103) transistors for the space and mark outputs which are driven by * the discriminator space output (Figure 3). The mark and space outputs are mutually exclusive except when there is a loss of channel (C.L.I.) or an output from the noise circuit, at which time both outputs appear.

The mark and space outputs appear together when transistors Q101 and Q103 are turned on with a current through resistors R106 and R111. The noise output current flows from Q187 collector through R116 and D105 into R106 and R111; the carrier level indicator output is loaded through R118 and fed through R117 into R106 and R111.

The inversion of the mark and space outputs is accomplished through the NOR function from Q101 to Q103, through R108, R109, R110, D-102 and D103. Diodes D102 and D103 are provided to supply isolation from negative to the base of Q102.

The noise circuit detects an unsatisfactory noise condition of the receiver signal when shifted at a 60-Hz rate. This is done by detecting the error in discriminator output of the receiver. The noise output should appear at approximately a 3-db signal-to-noise ratio measured in a 1000-Hz bandwidth in the transmission band.

With reference to Figure 3, when the discriminator of the TCF receiver shifted between + 100 Hz of * center frequency, there is a 0.5 millisecond period when neither output of the discriminator appears. This generates a pulse from the negated OR, block A. The information from these pulses is then transformed through a pulse integrator into a voltage which will trigger a Schmitt trigger when it exceeds a predetermined value which indicates an intolerable noise condition.

With reference to Figure 1, the discriminator outputs are fed through R182 and R183 into transistor Q181. A lack of discriminator output will permit a flow of current into capacitor C181 through resistors R184, R185 and CR181. Diode CR181 will block the charge on capacitor C181 from flowing into transistor Q181; capacitor C181 may only discharge through R186 and R187. When the voltage across resistor R187 is enough to overcome the potential needed to turn transistor Q182 on, then transistor Q183 is turned off, and the voltage across R189 will drop proportionately to the ratio of R188 and R190 causing a drop in the voltage requirement to turn on transistor Q182. Transistor Q184 will be turned off as a result of transistor Q183 turning off, and transistor Q185 will be turned on as a result of transistor Q184 turning off. Transistors Q186 and Q187 will turn on together with Q185 giving a noise output. The Schmitt trigger is composed of transistors Q182 and Q183.

Carrier Level Indicator

The noise logic takes care of the situation when the channel fails suddenly and completely. However, a measurement of signal strength is desired for providing an indication when the signal has weakened seriously but has not reached the point of complete failure.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Figure 1 shows the connections of this circuit board and also the external connections of the board.

The r-f input to the carrier level indicator is taken from the collector of Q151, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes D151 and D152 together with capacitors C157 and C158 establish a dc voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 may be measured (see Figure 5) by a milliammeter (supplied separately) located at a point convenient for observation. This current may also be metered at the receiver by means of jack J151 on the printed-circuit board. Thermistor R166 with its associated resistors, and sensistor R152 provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and energizes an alarm relay AL (when supplied) or its equivalent resistance R118 (2.2K). When the signal at the input of the receiver drops sufficiently, the AL or low-signal indication will drop out. This signal level is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not greatly affected by frequency variations within the pass-band of the input filter and the I.F. filter, but mainly by the level of receiver input signal.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With space signal being received, the signal level just below which the discriminator space output drops to zero is the minimum operating level of the receiver. The CLI alarm should clamp the output of the receiver into both a mark and space output at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db, above the minimum operating level and set the CLI (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 2.5 ma. with the normal input signal. The CLI alarm would be energized when the indicator current dropped to slightly less then 0.75 ma.

Power Supply

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

CHARACTERISTICS

Frequency range	30-300 kHz
Sensitivity (noise-free channel)	0.015 volt (55 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (L-C filter	down < 3 db at ±800 hertz down > 30db at 5000 hertz
Operating time	4 ms. channel (transm. and receiver)
Frequency spacing For two-way channel	3000 hertz minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	−20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42 – 56 V.D.C.
125 V.D.C.	105 – 140 V.D.C.
250 V.D.C.	210 – 280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height-10½'' or 6 r.u. Panel width – 19''
Weight	13 lbs.

INSTALLATION

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

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; frequency spacing and magnitude of discriminator output peaks. The adjustment that must be made at time of installation is the setting of input attenuator R5. The input attenuator adjustment is made by a knob on the front of the panel.

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 the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal
* that is 25 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal space signal being received, input attenuator R5 should be adjusted to the position at which the receiver clamps into both mark and space outputs. R5 then should be readjusted to increase the voltage supplied to the
* receiver by 20 db. The scale markings for R5 permit 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. With this setting, a 20 db drop in signal will drop out the carrier level indicator logic to lock the output in both mark and space while the receiver is still 5 db above its dropout.

FACTORY ADJUSTMENTS

In case the factory adjustments have been altered or there is evidence of damage or malfunctioning, then the following procedures can be used.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency, which should be 20 kHz 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 10 mv. of space 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 Carrier Level Indicator adjustment is set by the control R156 on the CLI module. The procedure is as follows:

1. Set input attenuator R5 to 0.
2. Remove noise detector board.
3. With 18 mv. of space frequency applied, adjust R156 until the receiver just clamps into both space and mark outputs. This indicates that the CLI has just dropped out.

Adjustment of the discriminator is made by capacitors C83 and C88. Apply to the receiver input a 10 mv. signal taken from an oscillator set at fc Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 100 Hertz and fc-100 Hertz,

An alternate method of adjusting the carrier level Indicator and the input attenuator R5 in the field is described below. However this should be done only if there is doubt that the carrier level indicator is set wrong. Normally the only field adjustment necessary is that of R5 described under previous section "adjustments".

1. With a normal guard signal being received, connect an oscilliscope from the base of Q54 (probe) to terminal 18 (shield lead) of the amplifier-limiter board.
2. Set input attenuator R5 for the start of clipping (flattening of 20KHz signal peaks).
3. Note the R5 dial reading in dB, then reduce the attenuation by 5dB.
4. Set R156 on the carrier level indicator (CLI) board just to dropout. This is accomplished by first turning the screw-driver control of R156 clockwise until at least 2 ma. current is indicated on the associated milliammeter, then backing off until the receiver clamps into both

space and mark outputs. This indicates that the CLI has dropped out which occurs at approximately 0.75 ma.

5. Reduce the R5 dial reading by another 10 dB and tighten the locking screw. With this setting, the CLI current will be between 2.5 ma and 2.75 ma.

With the foregoing receiver setting, a 10 db drop in receiver signal will drop out the CLI for low signal indication while the receiver limiter still has a margin of 5dB before it drops out of saturation (clipping).

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

MAINTENANCE

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

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

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

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

TABLE I
RECEIVER D-C MEASUREMENTS

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

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Mark or Space)
Q13	15	(Mark or space)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No Sig. or Mark)
Q81	19.5	(Space)
Q82	< 1	(No sig. or Space)
Q82	19.5	(Mark)
Q101	< 1	(No Sig. or Space)
Q101	20	(Mark)
Q102	20	(No Sig. or Space)
Q102	< 1	(Mark)
Q103	20	(No. Sig. or Space)
Q103	< 1	(Mark)
Q104	< 1	(No Sig. or Space)
Q104	20	(Mark)
Q181	34	(No Signal)
Q181	< 1	(Space or Mark)
Q182	< 1	(No Signal)
Q182	20	(Space or Mark)
Q184	45	(No Signal)
Q184	20	(Space or Mark)
Q185	< 1	(No signal)
Q185	45	(Space or Mark)

Collector of Transistor	Volts (+)	
Q186	20	(No Signal)
Q186	< 1	(Space or Mark)
Q187	< 1	(No Signal)
Q187	20	(Space or Mark)
Q151	6	(No Signal)
Q151	6	(Space)
Q152	9.8	(No Signal)
Q152	10	(Space)
Q153	< 1	(No Signal)
Q153	19	(Space)
Q154	45	(No Signal)
Q154	< 1	(Space)

TABLE II
RECEIVER RF MEASUREMENTS

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

Collector of Transistor	Volts at 10 watts
Q32	.8
Q51	.9
Q52	.65
Q53	2.2
Q54	4.5

FILTER RESPONSE MEASUREMENTS

The L-C input filter (FL-201) and the IF filter (FL-2) are in sealed containers, and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usuage, no appreciable change in response will occur. However, the test circuits of Figure 15 can be used in case there is reason to suspect that either of the filters has been damaged.

Figure 4 shows the -3 dB and -35 dB checkpoints for the IF filters, and the -3 dB checkpoints for the input filter. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Figure 4 was chosen to show the IF filter response, which permitted only a portion of the input filter curve to be shown. The checkpoints for the passband of each section of the IF filter are down 3 dB maximum at 19.75 and 20.25 kHz, and for the stop band are down 18 dB minimum at 19.00 and 21.00 kHz for each section. The signal generator voltage (Figure 15) must be held constant throughout the entire check. A value of 7.8 volts is suitable. The reading of the VM2 at the frequency of minimum attenuation should not be more than 22 dB below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16 db less then the measured difference because of the input resistor and the difference in input and output impedances of the filter.

In testing the L-C filter, a value of approximately 2.45 V is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency, but should not be more than 18 dB below the reading of VM1. (The filter insertion loss is approximately 6 dB less than the difference in readings).

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new L-C input filter (FL201), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

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

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

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

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

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

b. Signal Generator

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

c. Oscilloscope

d Frequency counter

e. Ohmmeter

f. Capacitor checker

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

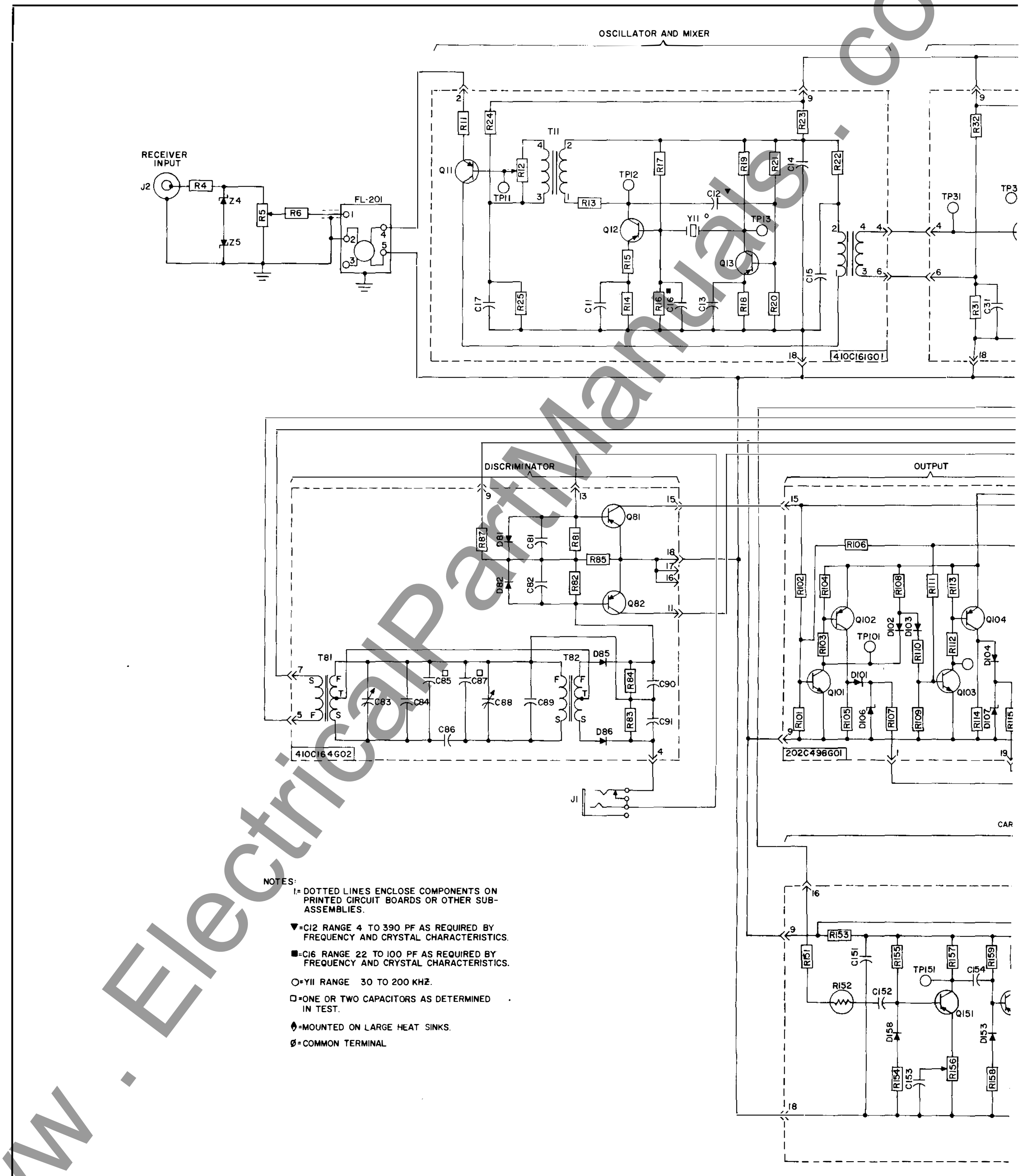
Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit, which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

RENEWAL PARTS

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

* ADDENDUM

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



NOTES:

1. = DOTTED LINES ENCLOSE COMPONENTS ON PRINTED CIRCUIT BOARDS OR OTHER SUB-ASSEMBLIES.

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

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

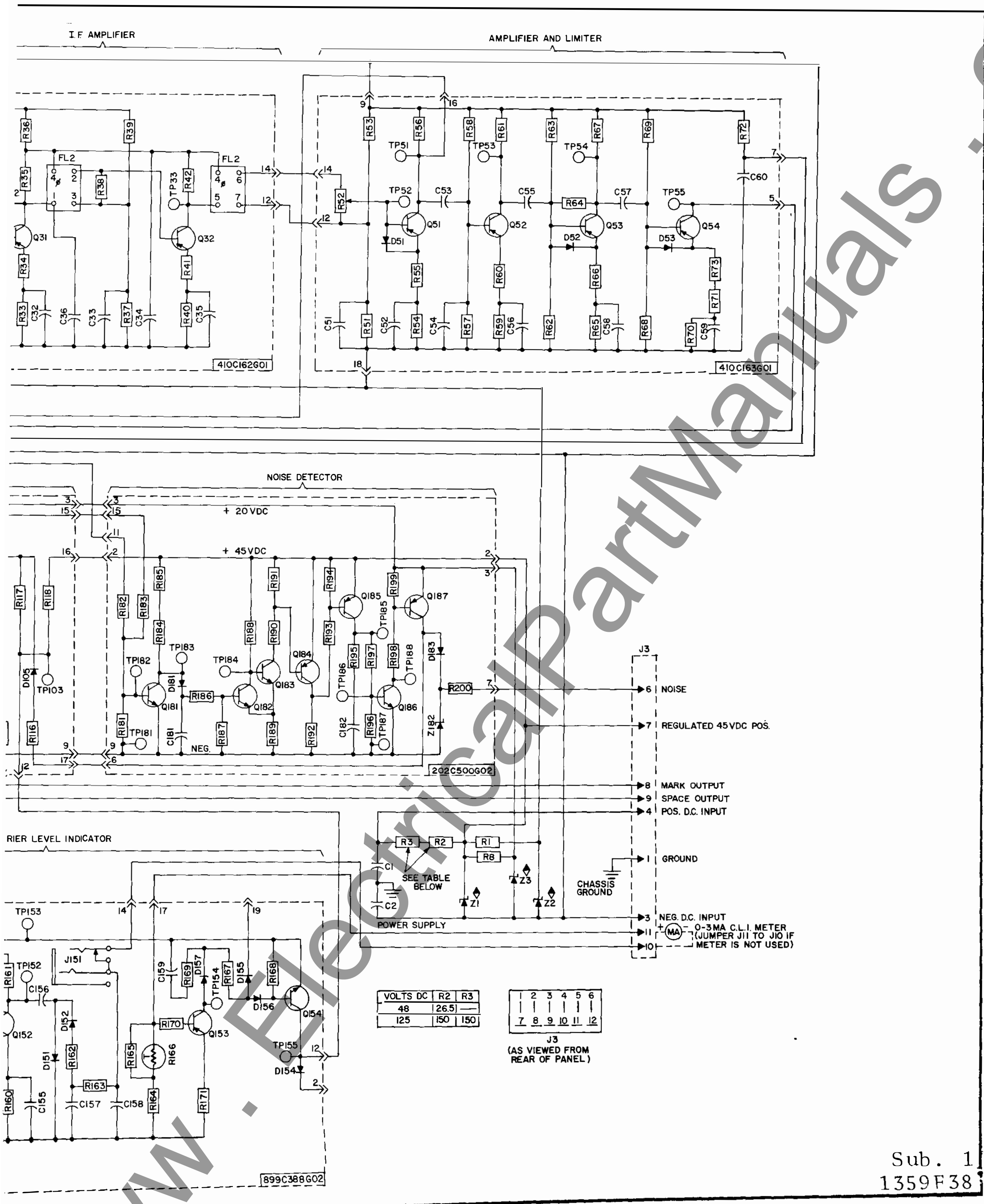
○ = Y11 RANGE 30 TO 200 KHZ.

□ = ONE OR TWO CAPACITORS AS DETERMINED IN TEST.

⧫ = MOUNTED ON LARGE HEAT SINKS.

Ø = COMMON TERMINAL

*Fig. 1 Internal schematic of the type TCF receiver under 2(



VOLTS DC	R2	R3
48	26.5	—
125	150	150

)0kHz (See pages 23-26 for electrical parts list)

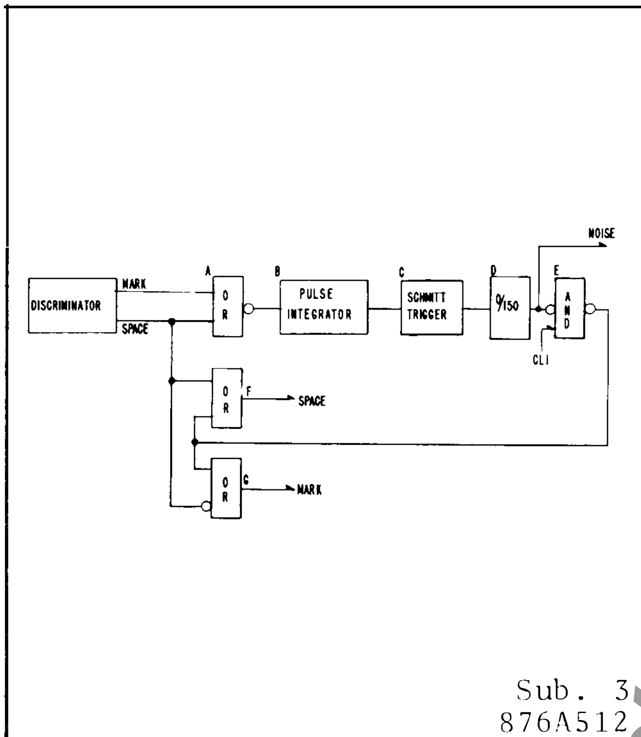
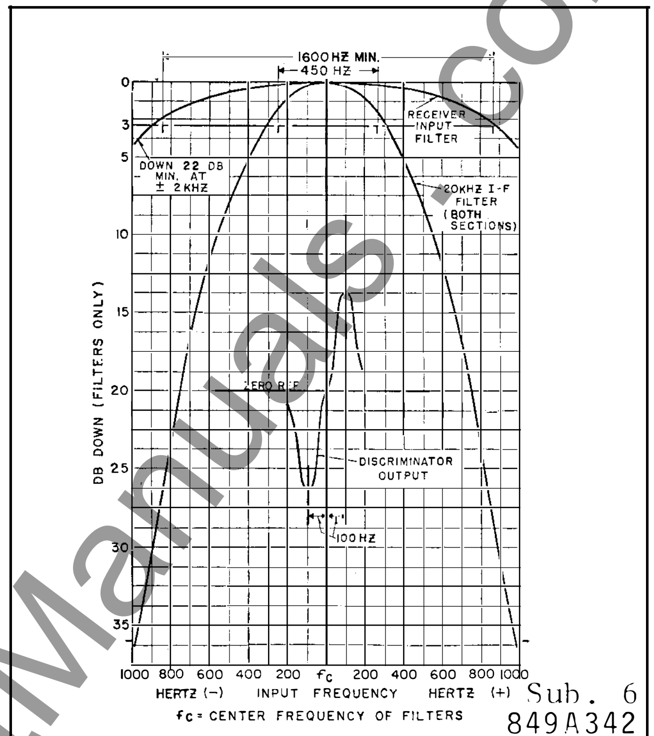
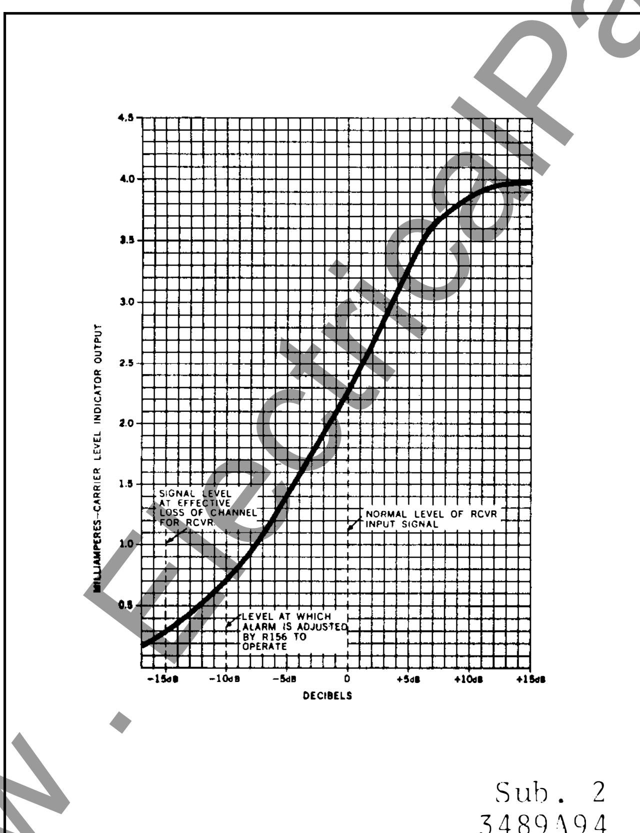


Fig. 3 Logic Diagram of Output Circuit



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



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

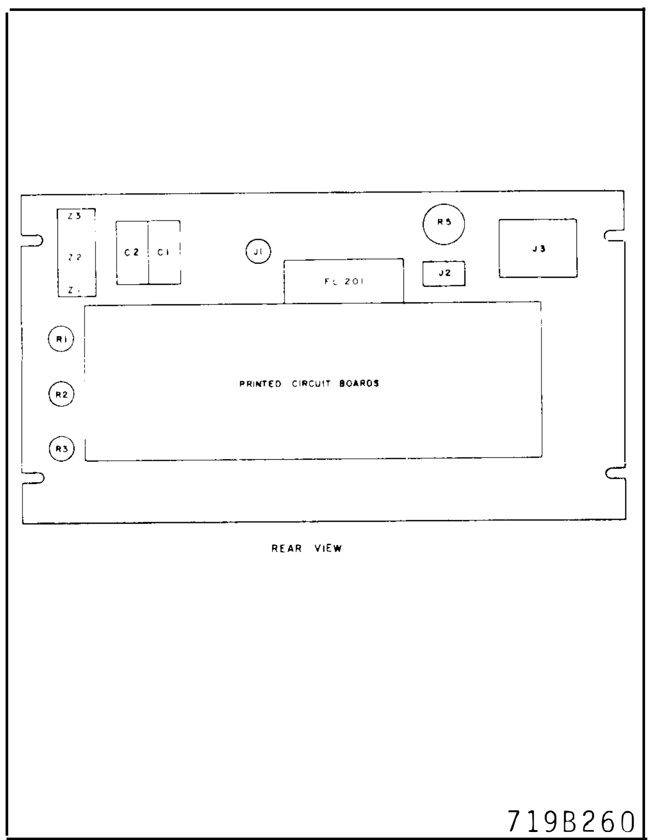
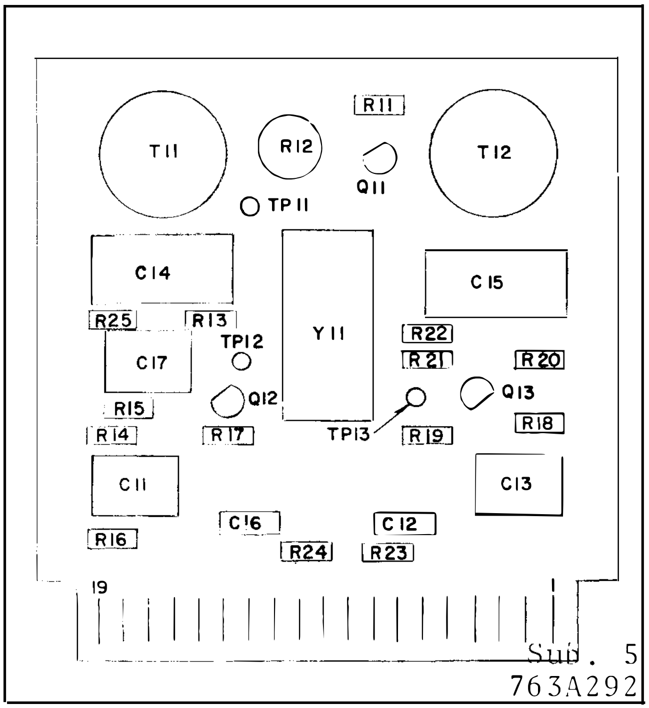
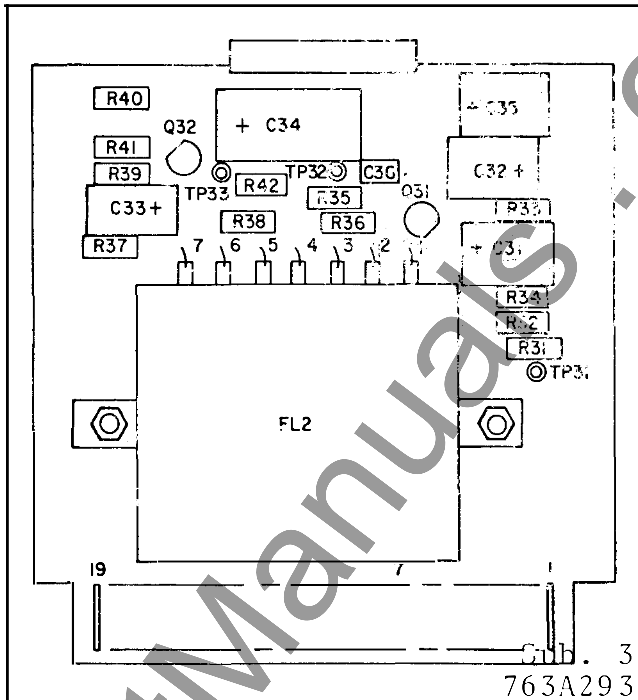


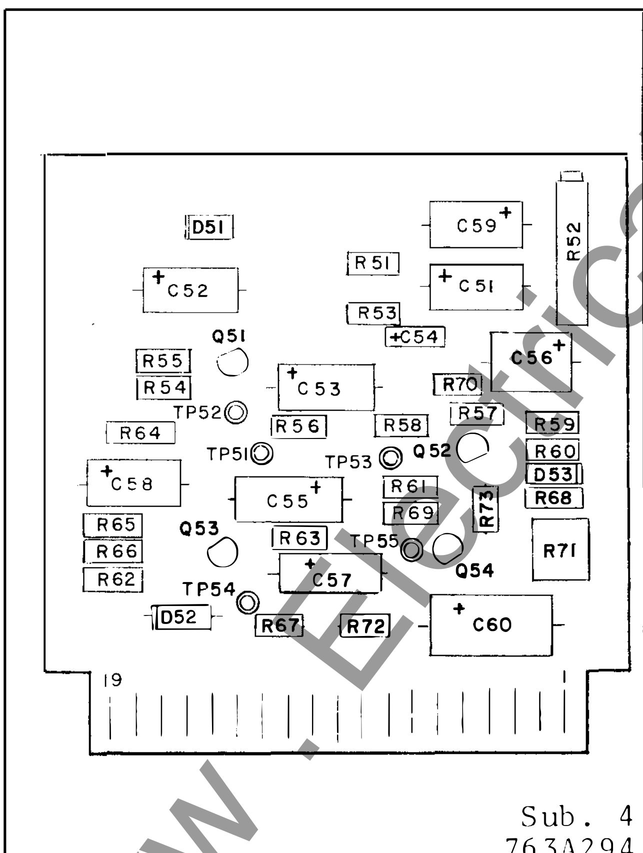
Fig. 6 Component locations on the type TCF receiver panel



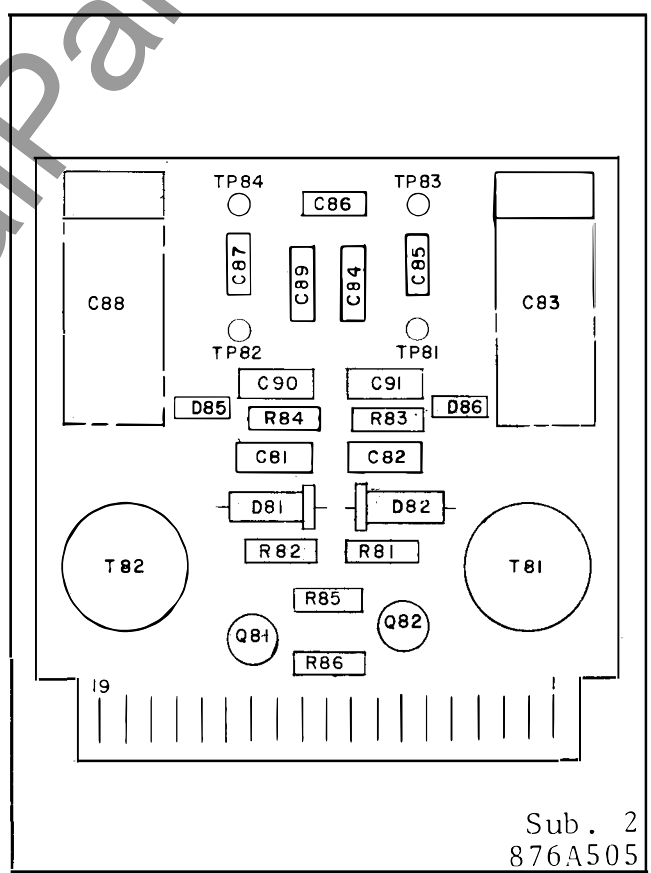
* *Fig. 7 Component locations on the oscillator and mixer printed circuit board.*



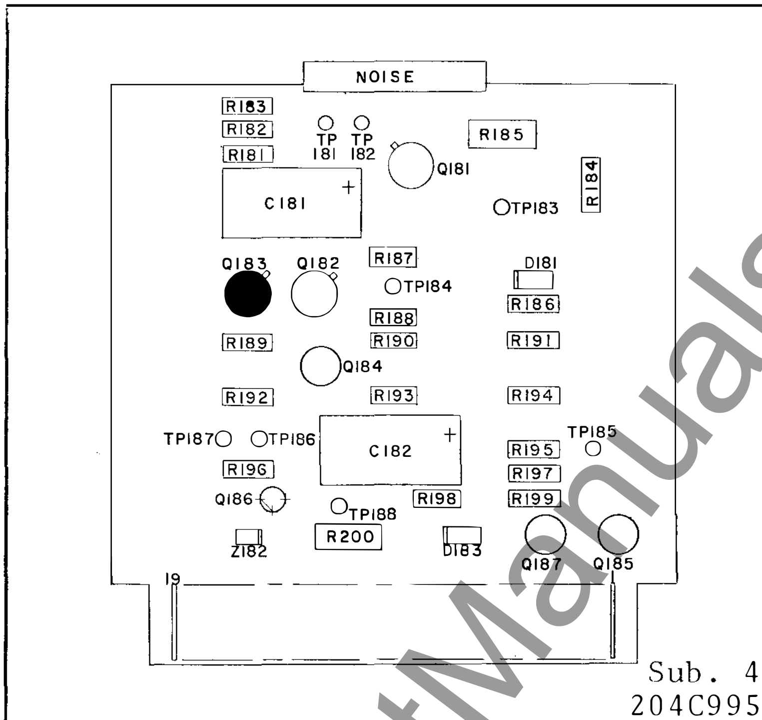
* *Fig. 8 Component locations on the I.F. amplifier printed circuit board.*



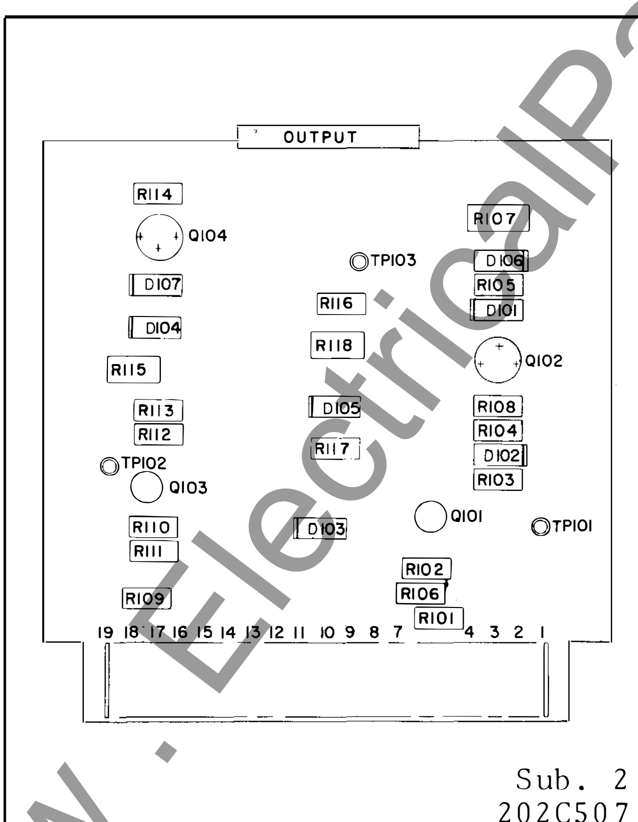
* *Fig. 9 Component locations on the amplifier and limiter printed circuit board.*



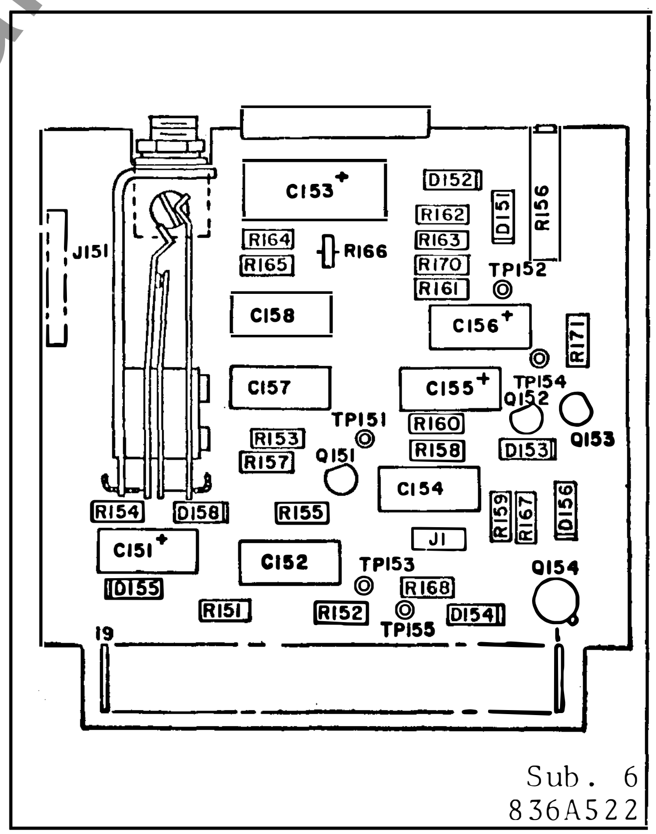
* *Fig. 10 Component locations on the discriminator printed circuit board.*



* *Fig. 11 Component Locations on the Noise Detector Printed Circuit Board.*



* *Fig. 12 Component Locations on the output printed circuit board.*



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

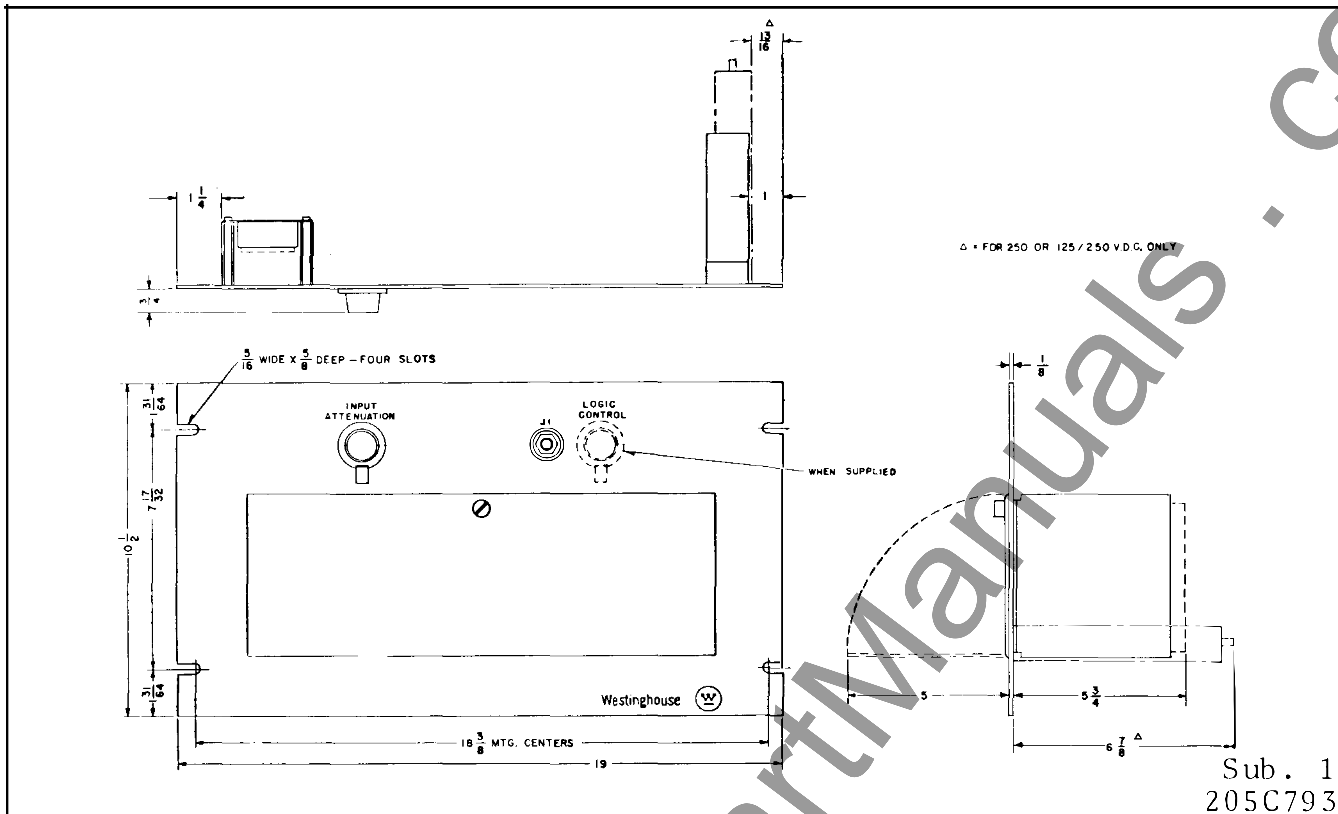


Fig. 14 Outline and drilling plan for the type TCF receiver assembly.

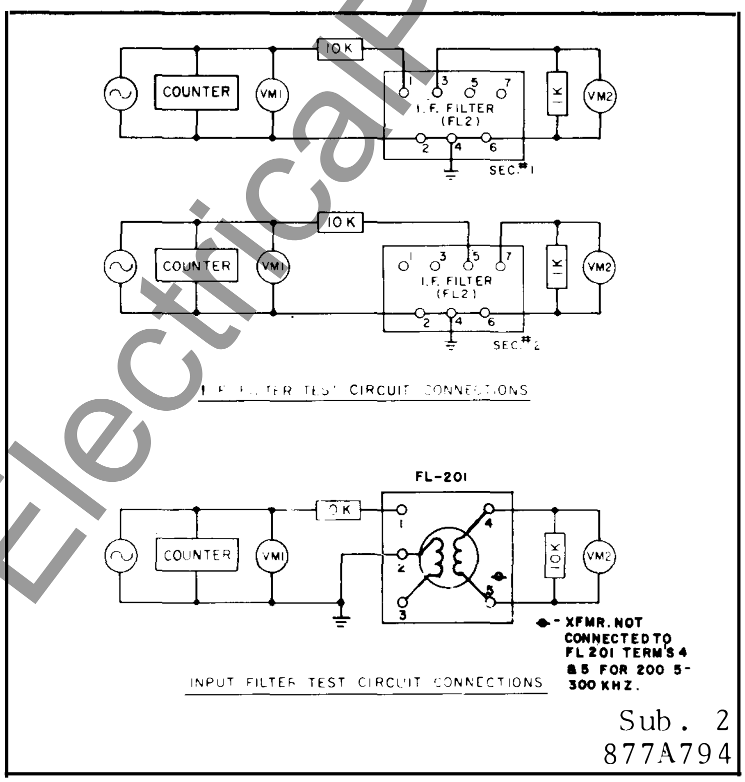
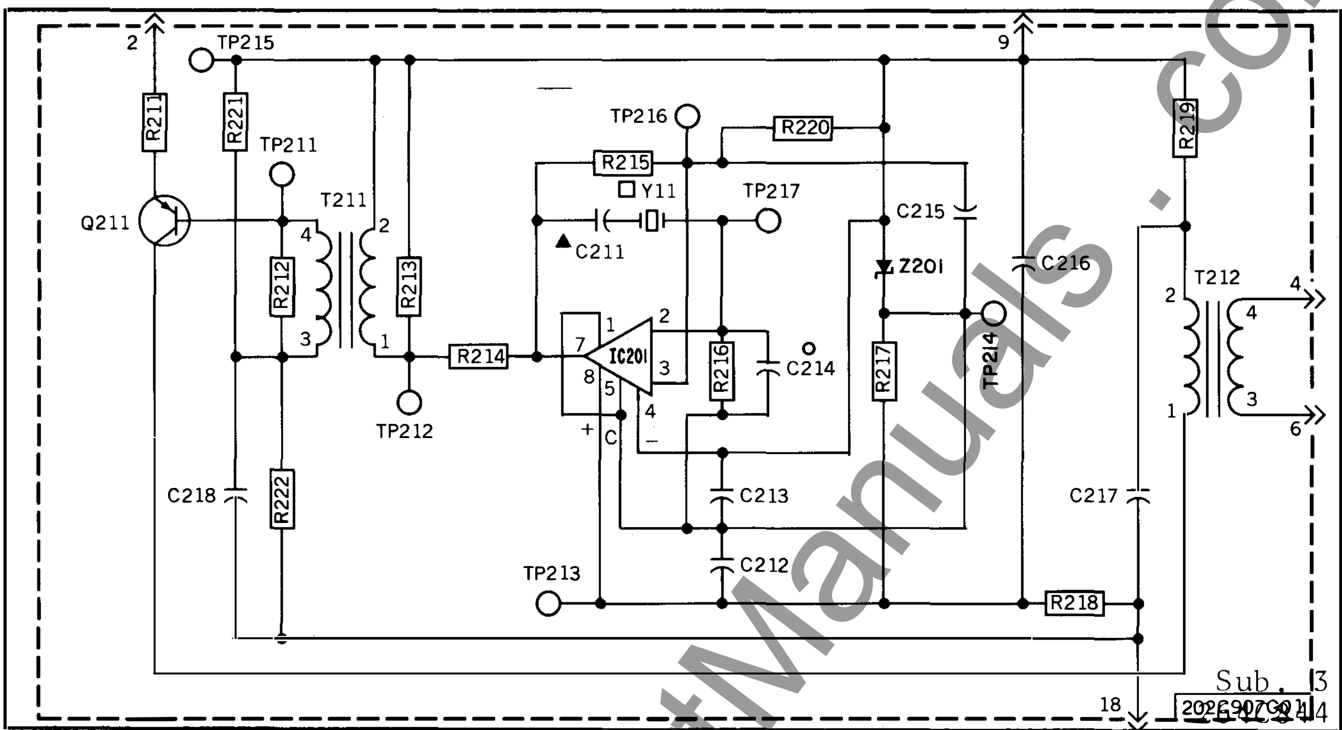
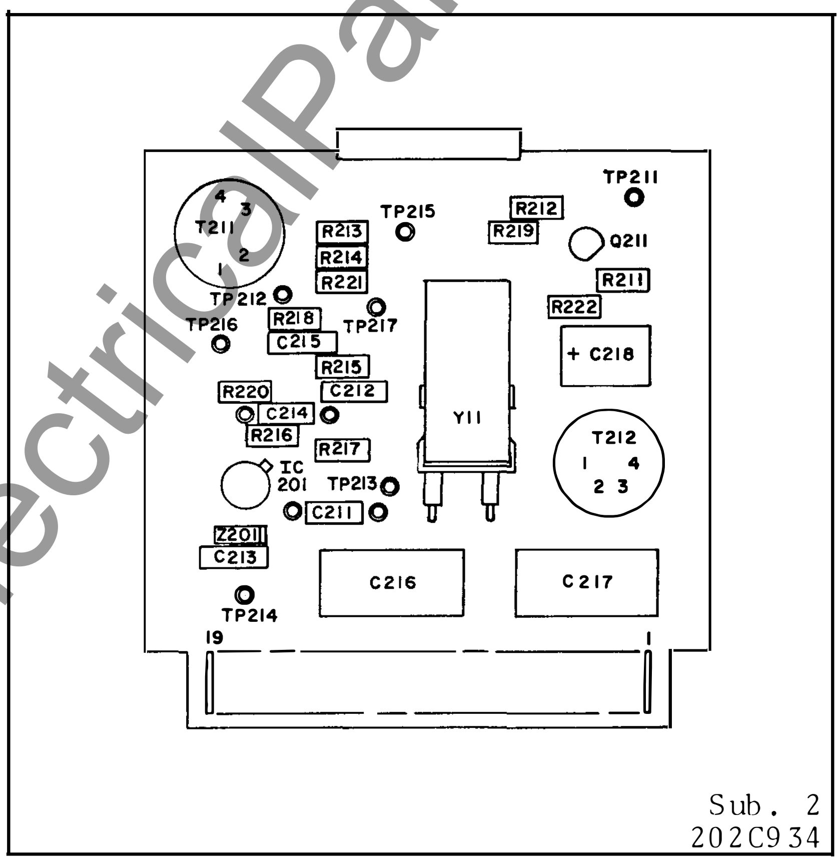


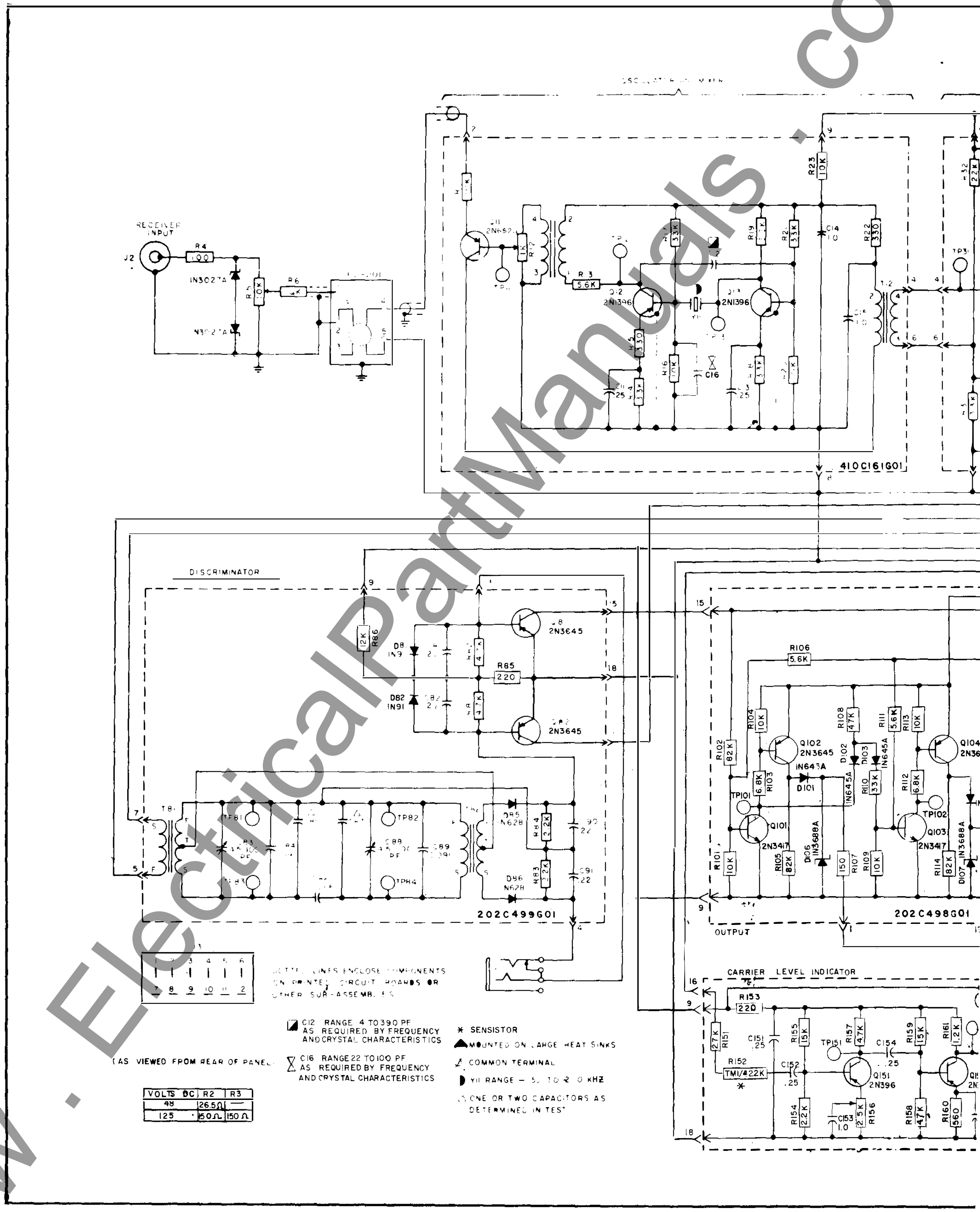
Fig. 15 Test Circuits for TCF Frequency Shift Receiver Filters.



* *Fig. 16. 200.5 to 300 kHz oscillator mixer board*

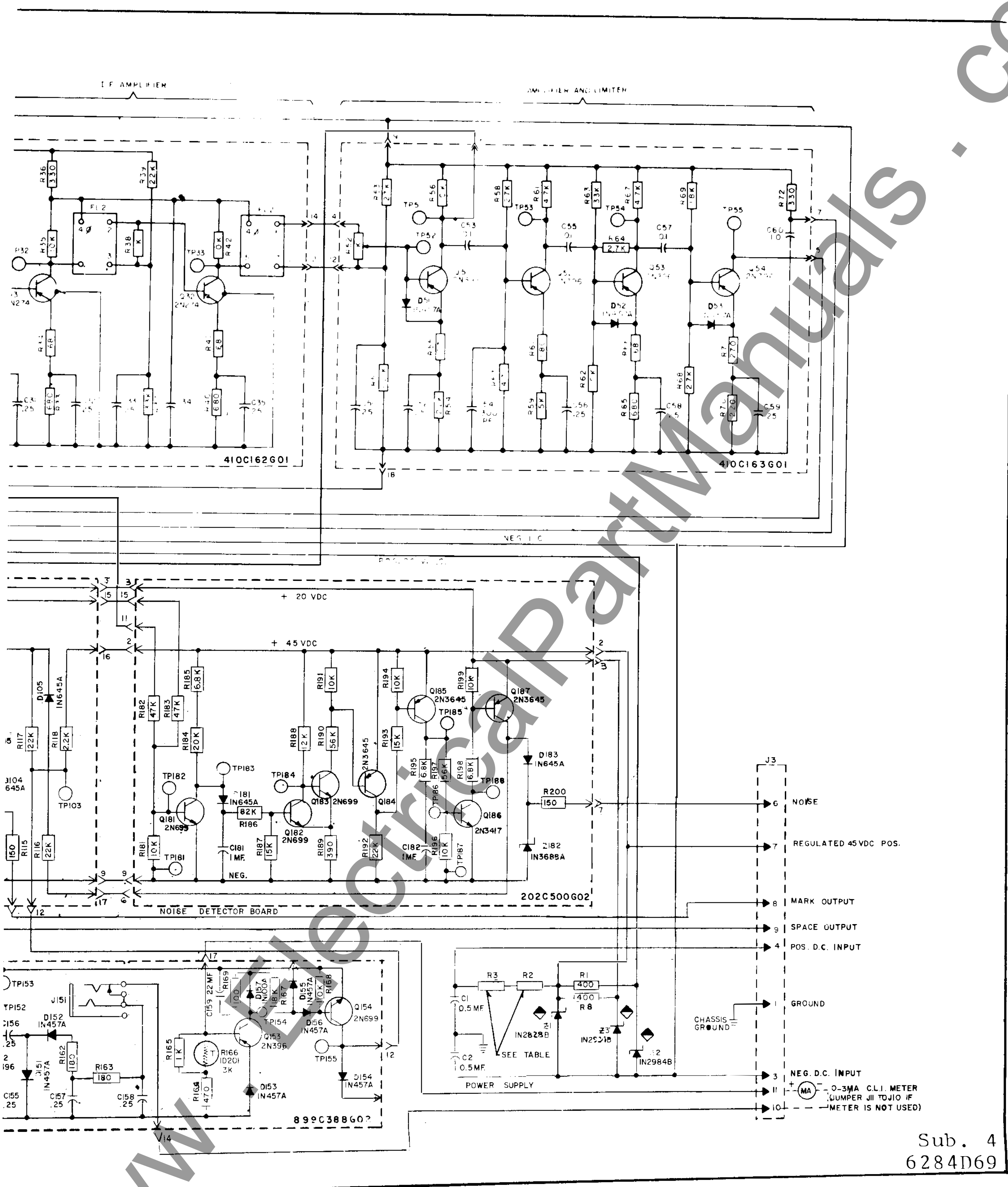


* *Fig. 17. Component Location 200.5 to 300 kHz oscillator mixer board.*



*** Fig. 19 Internal schem**

through early



…tic of the type *TCF* receiver - 1971

…973.

ELECTRICAL PARTS LIST FOR FIGURES 1 AND 2 (Cont'd)

AMPLIFIER & LIMITER-410C163G01

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q51-Q52-Q53-Q54	849A441H03	4	2N4249
RESISTOR			
R66	187A290H21	1	68Ω 1/2W ±5%
R55	187A290H11	1	27Ω 1/2W ±5%
R70	184A763H11	1	220Ω 1/2W ±5%
R72	184A763H15	1	330Ω 1/2W ±5%
R65	184A763H23	1	680Ω 1/2W ±5%
R59	184A763H31	1	1.5K 1/2W ±5%
R54-R62	184A763H35	2	2.2K 1/2W ±5%
R64-R68	184A763H37	2	2.7K 1/2W ±5%
R51-R57-R61-R67	184A763H43	4	4.7K 1/2W ±5%
R56	184A763H51	1	10K 1/2W ±5%
R69	184A763H57	1	18K 1/2W ±5%
R53-R58	184A763H61	2	27K 1/2W ±5%
R63	184A763H63	1	33K 1/2W ±5%
R71	629A531H04	1	68Ω 1/2W ±2%
R60	184A763H09	1	180Ω 1/2W ±5%
R73	629A531H02	1	56Ω 1/2W ±2%
CAPACITOR			
C54	187A584H15	1	1300MMF. 500V.
C51-C52-C56-C58-C59	187A624H02	5	.25MFD. 200V.
C53-C55-C57	187A624H01	3	0.1MFD. 200V.
C60	187A624H04	1	1.0MFD. 200V.
DIODE			
D51-D52-D53	184A855H07	3	1N457A
POTENTIOMETER			
R52	629A645H04	1	1K

NOISE DETECTOR-202C500G02

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q181-Q182-Q183	184A638H19	3	2N699
Q184-Q185-Q187	849A441H01	3	2N3645
Q186	848A851H02	1	2N3417
RESISTOR			
R181-R191-R194-R196-R199	184A763H51	5	10K.-1/2W.±5%
R182-R183	184A763H67	2	47K. 1/2W.±5%
R184	184A763H58	1	20K. 1/2W.±5%
R185	184A763H47	1	6.8 K.-1/2W.±5%
R186	629A531H78	1	82K. 1/2W.±2%
R187-R193	629A531H60	2	1.5K.-1/2W.±2%
R188	184A763H53	1	1.2K. 1/2W.±5%
R189	184A763H17	1	390 1/2W.±5%
R190	184A763H69	1	56K, 1/2W,±5%
R192	184A763H59	1	22K, 1/2W,±5%
R195-R198	184A763H47	2	6.8K, 1/2W,±5%
R197	184A763H69	1	56K, 1/2W,±5%
R200	762A679H01	1	150 3W
CAPACITOR			
C181-C182	187A624H04	2	1MFD 200 V DC
ZENER DIODE			
Z182	862A288H01	1	IN3688A
DIODE			
D181-D183	837A692H03		IN645A

OUTPUT-202C498G01

COMPONENT	STYLE	REQ	REF
Q101-Q103	848A851H02	2	2N3417
Q102-Q104	849A441H01	2	2N3645

I.F. AMPLIFIER-410C162G01

COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q31-Q32	849A441H03	2	2N4249

RESISTOR			
R101-R104-R109-R113	184A763H51	4	10K, 1/2W, 5%
R102-R105-R114	629A531H78	3	82K, 1/2W, 2%
R103-R112	184A763H47	2	6.8K, 1/2W, 5%
R106-R111	184A763H45	2	5.6K, 1/2W, 5%
R107-R115	762A679H01	2	150 3W
R108	184A763H67	1	47K, 1/2W, ±5%
R110	184A763H63	1	33K, 1/2W, ±5%
R116-R117	184A763H59	2	22K, 1/2W, ±5%
R118	763A127H11	1	2.2K, 3W, ±5%
DIODE			
D101-D102-D103-D104-D105	837A692H03	5	1N645A
ZENER DIODE			
D106-D107	862A288H01	2	1N3688A

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

OTHER-THIS DWG. SEE SHEET 1.

COMPONENT	STYLE	REQ	REF.
RESISTOR			
R1	1202587	1	400, 25W, ±5%
R2	04D1299H44	1	26.5, 40W, ±5%
R2	1202499	1	150, 40W, ±5%
R3	1202499	1	150, 40W, ±5%
R4	187A643H03	1	100, 1W, ±5%
R6	184A763H51	1	10K, 1/2W, ±5%
R8	1202537	1	400, 25W, ±5%
POTENTIOMETER			
R5	185A086H10	1	0-10K, 2W, ±10%
CAPACITOR			
C1-C2	1877962	2	0.5 MFD, 1500V
ZENER DIODE			
Z1 (IN2828B)	184A854H03	1	45V, 50W, ±5%
Z2-Z3 (IN2984B)	762A631H01	2	20V, 10W, ±5%
Z4-Z5 (IN3027A)	188A302H07	2	20V, 1W, ±10%
TELEPHONE JACK			
J1	187A606H01	1	
CONNECTOR			
J3	187A336H03	1	12 TERMS.
CRYTAL FILTER	*	1	

*= PER S.O.

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

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT – STU-UNBLOCK

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

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

APPLICATION

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

CONSTRUCTION

The TCF receiver unit for STU Unblock 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. An input attenuator and a jack for metering the discriminator output current, are accessible from the front of the panel. See Fig. No. 22.

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

The enclosure that contains the printed circuit board 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.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

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

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink.

SUPERSEDES I.L. 41-945.56A, dated Oct. 1974
✪ Denotes change from superseded issue.
EFFECTIVE NOVEMBER 1977

CHARACTERISTICS

Frequency Range	30kHz – 300kHz
Sensitivity (noise-free channel)	For crystal filter (narrow band) 0.005 volt = 65dB below 1 watt for limiting For L-C filter (wide band) 0.015 volt = 55dB below 1 watt for limiting
Input Impedance	5000 ohms minimum
Bandwidth	Crystal filter (narrow band) Down <3dB at 220 Hz B.W. Down >60dB at 1000 Hz B.W. L-C filter (wide band) Down < 3dB at 600 Hz B.W. Down >40dB at 2000 Hz B.W.
Discriminator	Set for 200 Hertz shift from block to unblock frequency. Offset 25 Hertz to favor block.
Operating Time	Narrow Band 9 ms channel (Transmitter and Receiver) Wide Band 4 ms channel (Transmitter and Receiver)
Frequency spacing	
A. For two or more signals over a one-way channel	Narrow Band 500 Hertz minimum Wide Band 1000 Hertz minimum
B. For two-way channel	Narrow Band 1000 Hertz minimum Wide Band 2000 Hertz Minimum
Ambient temperature range	-20°C to +55°C temperature around chassis.
Battery voltage variations	
Rated voltage	Allowable variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105-140 V.D.C.
250 V.D.C.	210-280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height - 10½" or 6 r.u. Panel width - 19"
Weight	13 lbs.

INSTALLATION

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

ADJUSTMENTS

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

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

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

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

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

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should be connected from the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of block frequency on the receiver input (R5 at zero), for narrow band receivers or 10 mv for wide band receivers, R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

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

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

MAINTENANCE

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

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

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

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

TABLE I

RECEIVER D-C MEASUREMENTS

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

Collector of Transistor	Volts (+)	
Q11	< 13	
Q12	15	(Block or Unblock)
Q13	15	(Block or Unblock)
Q31	2.5	
Q32	2.5	
Q51	11.5	
Q52	12	
Q53	15.5	
Q54	2.5	
Q81	< 1	(No sig. or Trip)
Q81	19.5	(Block)
Q82	< 1	(No sig. or Block)
Q82	19.5	(Unblock)
Q101	< 1	(No sig. or Unblock)
Q101	7	(Block)
Q102	21	(No signal)
Q102	< 1	(Block or keyed unblock)
Q103	< 1	(No signal)
Q103	10	(Block or keyed unblock)
Q105	40	(No signal)
Q105	< 1	(Block or unblock)
Q106	15	(No Sig. or Block)
Q106	< 1	(Unblock)
Q107	< 1	(No sig. or Block)
Q107	15	(Unblock)
Q108	45	(No sig. or Block)
Q108	< 1	(Keyed Unblock)
Q111	15	(No. sig. or Unblock)
Q111	< 1	(Block)
Q151	6	(No signal)
Q151	6	(Block)
Q152	9.8	(No Signal)
Q152	10	(Block)
Q153	< 1	(No Signal)
Q153	19	(Block)
Q154	45	(No signal)
Q154	< 1	(Block)

Q181 through Q184-See truth table in Fig. 3.

– "Keyed Trip" signifies minimum transition time from Block to Unblock.

TABLE II

RECEIVER RF MEASUREMENTS

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

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

RELAY MAINTENANCE AND ADJUSTMENTS

When the AL relay is supplied its contacts should be cleaned periodically. A contact burnisher S#182A838H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing.

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

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

FILTER RESPONSE MEASUREMENTS

The input filter (FL1) or FL201 and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Figure 23 can be used in case there is reason to suspect that either of the filters has bcen damaged.

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

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

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a TCF receiver for operating on a different channel frequency consist of a new filter (FL201), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

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

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

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

II. Desirable Test Equipment for Apparatus Maintenance

A. All items listed in I.

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

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

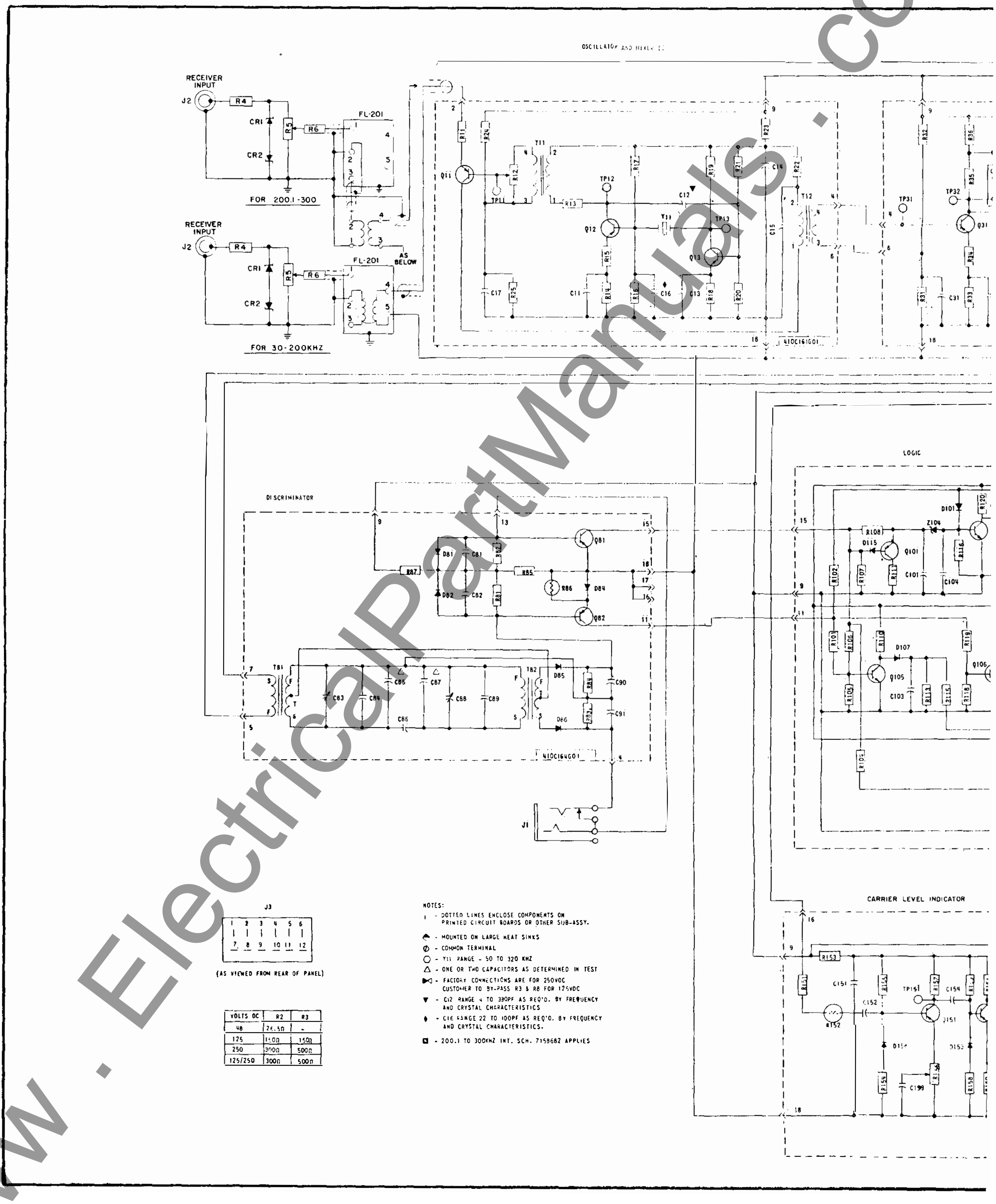
f. Capacitor checker

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

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

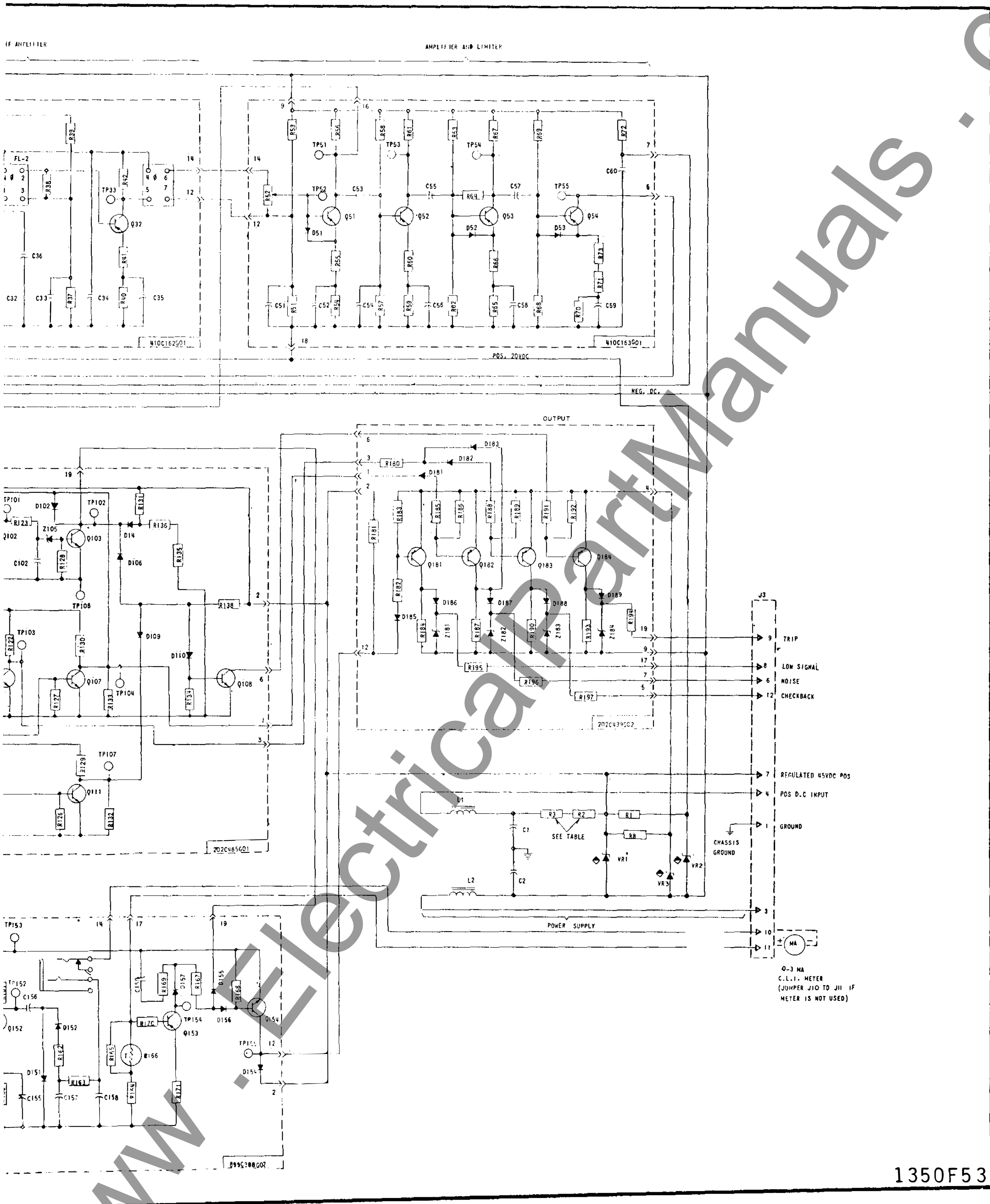
RENEWAL PARTS

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



VOLTS DC	R2	R3
48	26.5Ω	-
125	150Ω	150Ω
250	300Ω	500Ω
125/250	300Ω	500Ω

Fig. 1. a) Internal Schematic of the Type TCF Receiver for ST



U Unblock – Wide Band – Silicon Transistor Version

OSCILLATOR AND MIXER

COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q11-Q12-Q13	849A441H03	3	2N4249
RESISTOR			
R15-R22	184A763H15	2	330Ω ½W ±5%
R14-R18-R19	184A763H39	3	3.3K ½W ±5%
R13	184A763H45	1	5.6K ½W ±5%
R11-R16-R20-R23	184A763H51	4	10K ½W ±5%
R17-R21	184A763H63	2	33K ½W ±5%
R24	184A763H83	1	220K ½W ±5%
R25	184A763H43	1	4.7K ½W ±5%
CAPACITOR			
C11-C13-C17	187A624H02	3	.25 MFD 200V
C14-C15	187A624H04	2	1 MFD 200V
C12	See Note ▼		
C16	See Note ⧫		
POTENTIOMETER			
R12	629A430H02	1	1000 Ω
TRANSFORMER			
T11	205C043G01	1	10,000/400
T12	205C043G03	1	25,000/300
CRYSTAL			
Y11	See Note ●		

▼ C12 Range 4 to 390pf as required by frequency and crystal characteristics.

⧫ C16 Range 22 to 100 pf. As required by frequency and crystal characteristics.

● Y11 Range -50 to 220 KHZ.

OTHER

COMPONENT	STYLE	REQ.	REF.
RESISTORS			
R1	1202587	2	400 Ω 25W ±5%
R2	04D1299H44 ▲	1	26.5 Ω 40W ±5%
R2	1202499 ⧫	1	150 Ω 40W ±5%
R2	763A963H01 □	1	300 Ω 50W ±5%
R2	⋈ ⊕	1	300 Ω 50W ±5%
R3	1202499 ⧫	1	150 Ω 40W ±5%
R3	629A843H03 □	1	500 Ω 100W ±5%
R3	⋈ ⊕	1	500 Ω 100W ±5%
R4	187A643H03	1	100 Ω 1W ±5%
R5	185A086H10	1	10K 2W ±5%
R6	184A763H51	1	10K ½W ±5%
R8	1202587	1	400 Ω 25W ±5%
CAPACITORS			
C1	1877962		0.5 MFD 1500V
C2	1877962		0.5 MFD 1500V
ZENER DIODES			
VR1 (IN2828B)	184A854H06	1	45V 50W ±5%
VR2 - VR3 (IN2984B)	762A631H01	2	20V 10W ±5%
DIODES			
CR2-CR1 (IN3027A) ✪	188A307H07		20V 1W ±5%
CHOKE			
L1 - L2	*292B096G02*	*2*	✪ *1.5 to 2.0 mH*

⋈ *See Sheet 1* ▲ For 48V Supply ⧫ For 125V Supply □ For 250V Supply ⊕ For 125/250V Supply

IF AMPLIFIER

COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q31 - Q32	849A441H03	2	2N4249
RESISTOR			
R34 - R41	187A290H21	2	68 Ω ½W ±5%
R36	184A763H15	1	330 Ω ½W ±5%
R33 - R40	184A763H23	2	680 Ω ½W ±5%
R38	184A763H27	1	1K ½W ±5%
R31 - R37	184A763H39	2	3.3K ½W ±5%
R35 - R42	184A763H51	2	10K ½W ±5%
R32 - R39	184A763H59	2	22K ½W ±5%
CAPACITOR			
C31 - C32 - C33 - C35	187A624H02	4	.25 MFD 200V
C34	187A624H04	1	1 MFD 200V
C36	762A757H01	1	100pf
FILTER			
FL-2	762A757H01	1	

CARRIER LEVEL INDICATOR

COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q151 - Q152 - Q153	849A441H03	3	2N4249
Q154	184A638H19	1	2N699
RESISTOR			
R151-R168	184A763H51	2	10K
SENSISTOR - R152	187A685H01	1	2.2K ¼W ±10%
R153	187A763H11	1	220 Ω
R154	184A763H39	1	3.3K
R155 - R159	184A763H55	2	15K
R157 - R158	184A763H43	2	4.7K
R160	184A763H21	1	560 Ω
R161	184A763H29	1	1.2K
R162 - R163	184A763H09	2	180 Ω
R164	184A763H19	1	470 Ω
R165	184A763H27	1	1K
R167	184A763H57	1	18K
R171	184A763H07	1	150 Ω
R170	184A763H23	1	680 Ω
R169	184A763H03	1	100 Ω
POTENTIOMETER			
R156	629A645H07	1	2.5K
THERMISTOR			
R166	185A211H08	1	ID201
CAPACITOR			
C151 - C152 - C154 To C158	187A624H02	7	.25 MFD 200V
C153	187A624H04	1	1MFD 200V
C159	184A661H16	1	22MFD 35V
DIODE			
D151 To D156 - D158	184A855H07	7	IN457A
D157	182A881H07	1	IN100A
TELEPHONE JACK			
J151	187A606H01	1	

NOTE: All Resistors Are ½W ±5% Except as noted.

OUTPUT

COMPONENT	STYLE	REQ.	REF.
TRANSISTORS			
Q181-Q182-Q183-Q184	849A441H01	4	2N3645
RESISTORS			
R180-R183-R186-R189-R192	184A763H51	5	10K ½W ±5%
R182	184A763H59	1	22K ½W
R185	184A763H57	1	18K ½W
R191	184A763H47	1	6.8K ½W
R188	184A763H49	1	8.2K ½W
R184-R187-R190-R193	629A531H78	4	82K ½W
R194-R195-R196-R197	762A679H01	4	150 Ω 3W
R181	184A859H15	1	2.2K 3W
DIO ZENER			
Z181-Z182-Z183-Z184	862A288H01	4	IN3688A
DIODE			
D181-D182-D183-D185-D186-D187-D188-D189	837A692H03	8	IN645A

LOGIC

COMPONENT	STYLE	REQ.	REF.
TRANSISTORS			
Q101	849A441H03	1	(2N4249)
Q102-Q111	762A585H01	2	(2N696)
Q103	184A638H18	1	(2N697)
Q105-Q106-Q107-Q108	184A638H19	4	(2N699)
RESISTORS			
R110	187A643H51	1	10K 1W ±5%
R111	184A763H39	1	470 ½W ±5%
R123	184A763H57	1	18K ½W ±5%
R136	184A763H39	1	3.3K ½W ±5%
R131	184A763H53	1	12K ½W ±5%
R105-R126-R116-R118-R127-R128-R134-R135	184A763H51	8	10K ½W ±5%
R107	184A763H57	1	18K ½W ±5%
R104	184A763H61	1	27K ½W ±5%
R102-R130-R132	184A763H63	3	33K ½W ±5%
R101-R106	184A763H65	2	39K ½W ±5%
R108	184A763H69	1	56K ½W ±5%
R115	184A763H73	1	82K ½W ±5%
R119	184A763H75	1	100K ½W ±5%
R113	184A763H91	1	470K ½W ±5%
R122-R129-R133	184A763H71	3	68K ½W ±5%
R138	184A763H55	1	15K ½W ±5%
R120	184A763H59	1	22K ½W ±5%
CAPACITORS			
C101	184A661H12	1	4.7K 10%
C102	184A661H25	1	6.8 MFD
C103	187A624H11	1	.5 MFD ±10%
C105	184A663H02	1	.05 MFD 50V
DIODES			
D114	182A881H07	1	IN100A
D101-D102-D106-D107-D109-D110-D115-D116	184A855H07	8	IN457A
DIO ZENER			
Z105	185A212H06	1	IN3686B
Z104	186A797H06	1	IN957B

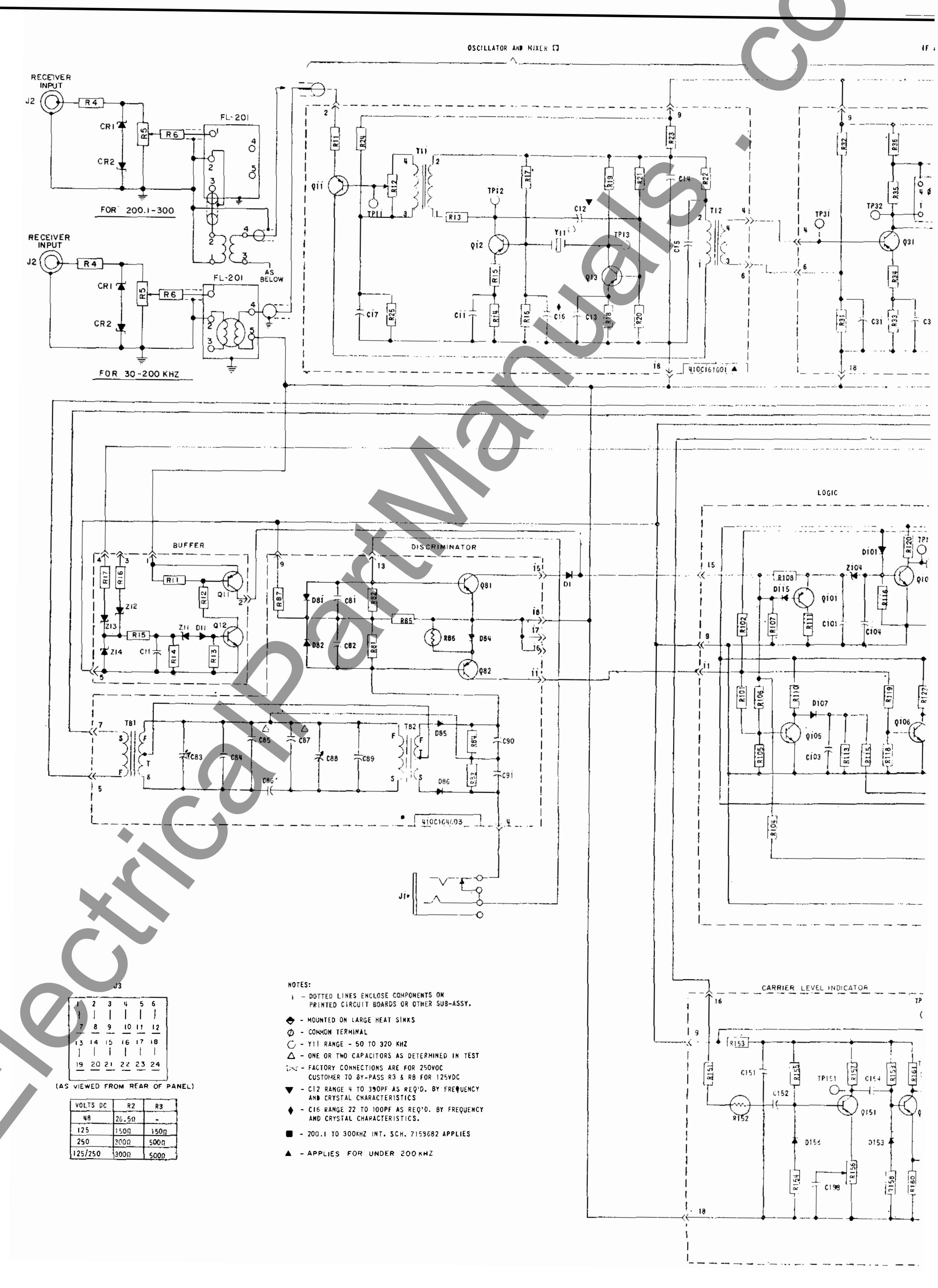
AMPLIFIER AND LIMITER

COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q51-Q52-Q53-Q54	849A441H03	4	2N4249
RESISTOR			
R66	187A290H21	1	68 Ω ½W ±5%
R55	187A290H11	1	27 Ω ½W ±5%
R70	184A763H11	1	220 Ω ½W ±5%
R72	184A763H15	1	330 Ω ½W ±5%
R65	184A763H23	1	680 Ω ½W ±5%
R59	184A763H31	1	1.5K ½W ±5%
R54-R62	184A763H35	2	2.2K ½W ±5%
R64-R68	184A763H37	2	2.7K ½W ±5%
R51-R57-R61-R67	184A763H43	4	4.7K ½W ±5%
R56	184A763H51	1	10K ½W ±5%
R69	184A763H57	1	18K ½W ±5%
R53-R58	184A763H61	2	27K ½W ±5%
R63	184A763H63	1	33K ½W ±5%
R71	09D8326G20	1	100 Ω ½W ±2%
R60	184A763H09	1	180 Ω ½W ±5%
R73	629A531H02	1	56 Ω ½W ±2%
CAPACITOR			
C54	187A584H15	1	1300 MMF 500V
C51-C52-C56-C58-C59	187A624H02	5	.25 MFD 200V
C53-C55-C57	187A624H01	3	0.1 MFD 200V
C60	187A624H04	1	1.0 MFD 200V
DIODE			
D51-D52-D53	184A855H07	3	IN457A
POTENTIOMETER			
R52	629A645H04	1	1K

DISCRIMINATOR

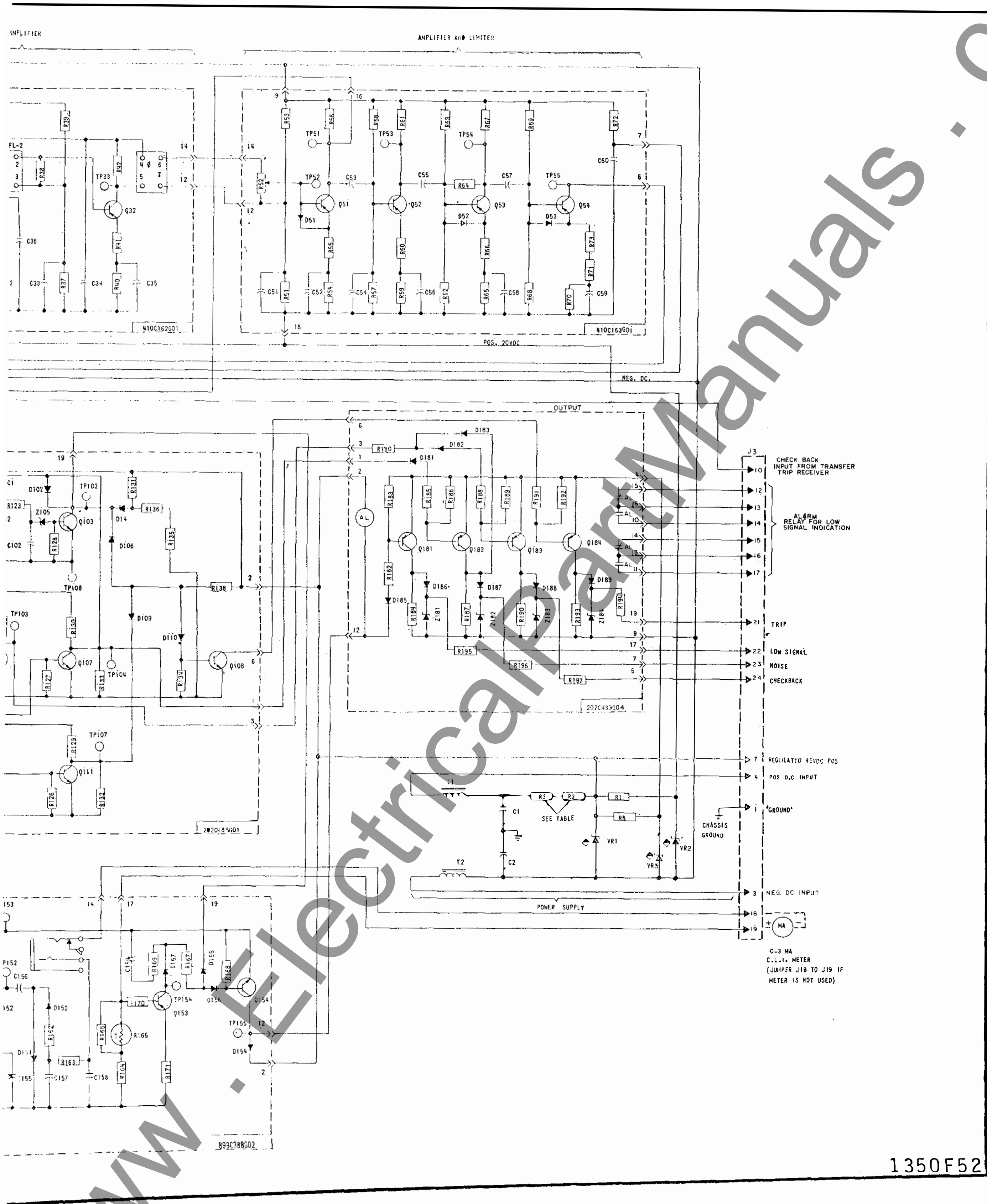
COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q81-Q82	849A441H01	2	2N3645
RESISTOR			
R81-R82	184A763H38	2	3K ½W ±5%
R83-R84	184A763H35	2	2.2K ½W ±5%
R85	184A763H11	1	220 Ω ½W ±5%
R87	184A763H53	1	12K ½W ±5%
SENSISTOR			
R86	187A685H03	1	1.2K ¼W ±10%
CAPACITOR			
C81-C82-C90-C91	762A703H01	4	.22 MFD 50V
C83-C88	762A736H02	2	4.5 To 100PF
C84-C89	187A624H16	2	.0091 MFD 200V.
C86	187A684H08	1	100PF
C85-C87	See Note □		
DIODE			
D81-D82-D84	184A855H07	3	IN457A
D85-D86	184A855H12	2	IN628
TRANSFORMER			
T81	606B533G01	1	
T82	606B533G02	1	

□ One or Two Capacitors Used. Values Determined in Test.



VOLTS DC	R2	R3
48	26.5Ω	-
125	150Ω	150Ω
250	300Ω	500Ω
125/250	300Ω	500Ω

✪ *Fig. 2. Internal Schematic of the Type TCF Receiver for STU Unl*



lock – 3 Frequency Operation – Silicon Transistor Version

OSCILLATOR AND MIXER

COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q11-Q12-Q13	849A441H03	3	2N4249
RESISTOR			
R15-R22	184A763H15	2	330 Ω ½W ±5%
R14-R18-R19	184A763H39	3	3.3K ½W ±5%
R13	184A763H45	1	5.6K ½W ±5%
R11-R16-R20-R23	184A763H51	4	10K ½W ±5%
R17-R21	184A763H63	2	33K ½W ±5%
R24	184A763H83	1	220K ½W ±5%
R25	184A763H43	1	4.7K ½W ±5%
CAPACITOR			
C11-C13-C17	187A624H02	3	.25 MFD 200V
C14-C15	187A624H04	2	1 MFD 200V
C12	See Note ▼		
C16	See Note ♦		
POTENTIOMETER			
R12	629A430H02	1	1000 Ω
TRANSFORMER			
T11	205C043G01	1	10,000/400
T12	205C043G03	1	25,000/300
CRYSTAL			
Y11	See Note □		

▼ C12 Range 4 to 390pf as required by frequency and crystal characteristics.
♦ C16 Range 22 to 100pf. as required by frequency and crystal characteristics.
□ Y11 Range -50 to 220 KHZ

OTHER

COMPONENT	STYLE	REQ.	REF.
RESISTORS			
R1	1202587	2	400 Ω 25W ±5%
R2	04D1299H44▲	1	26.5 Ω 40W ±5%
R2	1202499 ♦	1	150 Ω 40W ±5%
R2	763A963H01 □	1	300 Ω 50W ±5%
R2	⋈ ⊕	1	300 Ω 50W ±5%
R3	1202499 ♦	1	150 Ω 40W ±5%
R3	629A843H03 □	1	500 Ω 100W ±5%
R3	⋈ ⊕	1	500 Ω 100W ±5%
R4	187A643H03	1	100 Ω 1W ±5%
R5	185A086H10	1	10K 2W ±5%
R6	184A763H51	1	10K ½W ±5%
R8	1202587	1	400 Ω 25W ±5%
CAPACITORS			
C1	1877962		0.5 MFD 1500V
C2	1877962		0.5 MFD 1500V
ZENER DIODES			
VR1 (IN2828B)	184A854H06	1	45V 50W ±5%
VR2 - VR3 (IN2984B)	762A631H01	2	20V 10W ±5%
DIODES			
CR2 - CR1 (IN3027A) ✪	188A307H07	2	20V 1W ±5%
CHOKE			
L1 - L2	292B096G02	2	✪ 1.5 to 2.0 mH
DIODES			
D1	837A692H03	1	IN645A

⋈ *See Sheet 1* ▲ *For 48V Supply* ♦ *For 125V Supply* □ *For 250V Supply* ⊕ *For 125/250V Supply*

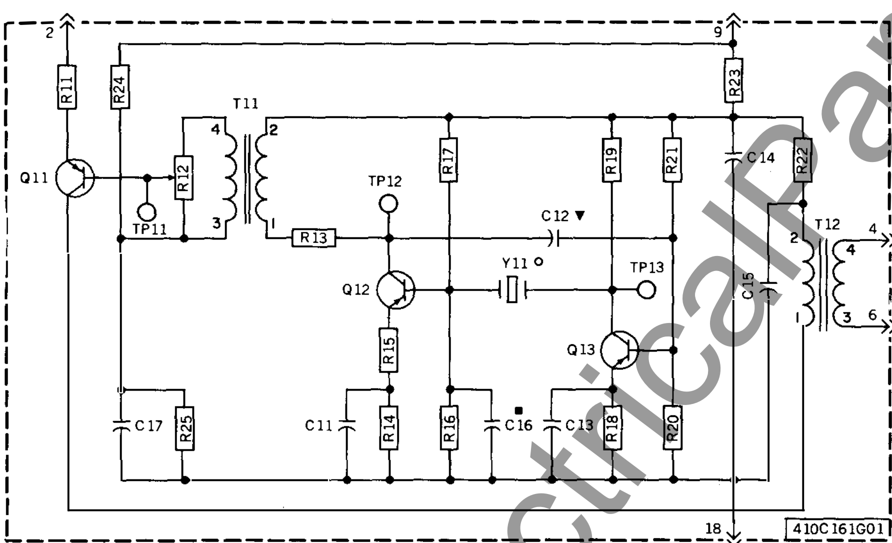
IF AMPLIFIER

COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q31-Q32	849A441H03	2	2N4249
RESISTOR			
R34-R41	187A290H21	2	68 Ω ½W ±5%
R36	184A763H15	1	330 Ω ½W ±5%
R33-R40	184A763H23	2	680 Ω ½W ±5%
R38	184A763H27	1	1K ½W ±5%
R31-R37	184A763H39	2	3.3K ½W ±5%
R35-R42	184A763H51	2	10K ½W ±5%
R32-R39	184A763H59	2	22K ½W ±5%
CAPACITOR			
C31-C32-C33-C35	187A624H02	4	.25 MFD 200V
C34	187A624H04	1	1 MFD 200V
C36	762A757H01	1	100pf
FILTER			
FL-2	762A757H01	1	

CARRIER LEVEL INDICATOR

COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q151-Q152-Q153	849A441H03	3	2N4249
Q154	184A638H19	1	2N699
RESISTOR			
R151-R168	184A763H51	2	10K
SENSISTOR - R152	187A685H01	1	2.2K ¼W ±10%
R153	184A763H11	1	220 Ω
R154	184A763H39	1	3.3K
R155-R159	184A763H55	2	15K
R157-R158	184A763H43	2	4.7K
R160	184A763H21	1	560 Ω
R161	184A763H29	1	1.2K
R162-R163	184A763H09	2	180 Ω
R164	184A763H19	1	470 Ω
R165	184A763H27	1	1K
R167	184A763H57	1	18K
R171	184A763H07	1	150 Ω
R170	184A763H23	1	680 Ω
R169	184A763H03	1	100 Ω
POTENTIOMETER			
R156	629A645H07	1	2.5K
THERMISTOR			
R166	185A211H08	1	ID201
CAPACITOR			
C151-C152-C15 To C158	187A624H02	7	.25 MFD 200V
C153	187A624H04	1	1MFD 200V
C159	184A661H16	1	22MFD 35V
DIODE			
D151 To D156 - D158	184A855H07	7	IN457A
D157	182A881H07	1	IN100A
TELEPHONE JACK			
J1	187A606H01	1	

NOTE: All Resistors are ½W ±5% Except as Noted.



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

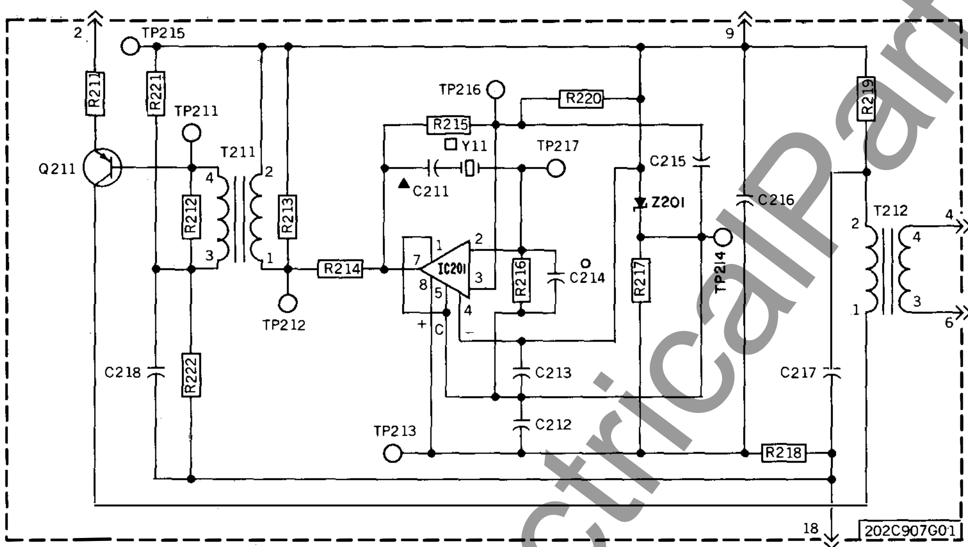
▼ =C12 RANGE 4 TO 390Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

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

○ =Y11 RANGE–50 TO 220 KHZ.

264C855

Fig. 7. Internal Schematic 30-200 kHz Oscillator and Mixer Silicon Transistor Version



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

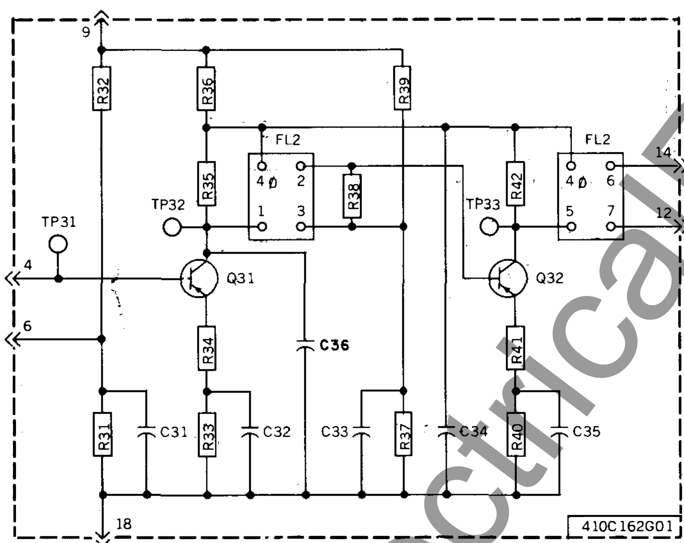
▲ = C211 RANGES FROM 100Pf. TO 1,000Pf.

O = C214 MAY VARY UP TO 100Pf. 187A695H01 THROUGH H23

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

264C844

Fig. 8. Internal Schematic 200.5 – 300 kHz Oscillator and Mixer Silicon Transistor Version



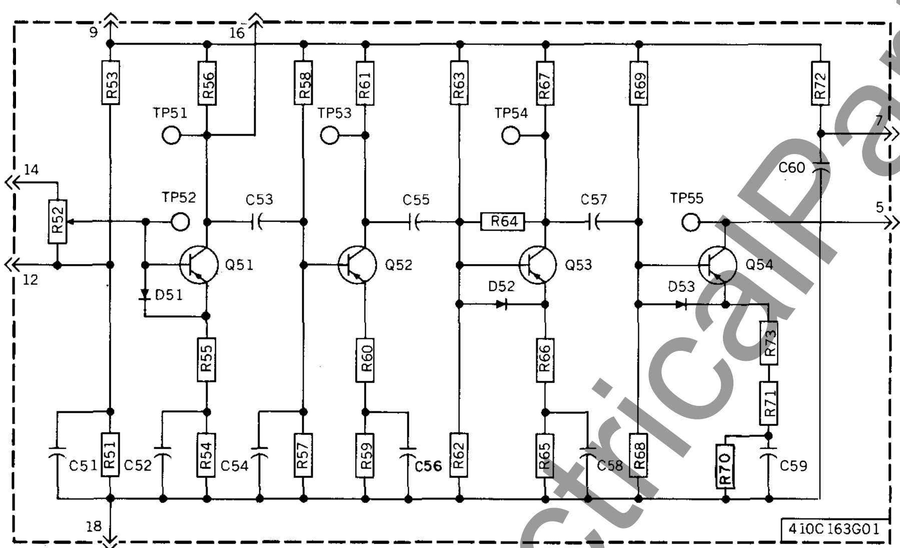
COMPONENT	STYLE	REQ.	REF
TRANSISTOR			
Q31-Q32	849A441H03	2	2N4249
RESISTOR			
R34-R41	187A290H21	2	68Ω 1/2W ±5%
R36	184A763H15	1	330Ω 1/2W ±5%
R33-R40	184A763H23	2	680Ω 1/2W ±5%
R38	184A763H27	1	1K 1/2W ±5%
R31-R37	184A763H39	2	3.3K 1/2W ±5%
R35-R42	184A763H51	2	10K 1/2W ±5%
R32-R39	184A763H59	2	22K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

∅ = COMMON TERMINAL

264C856

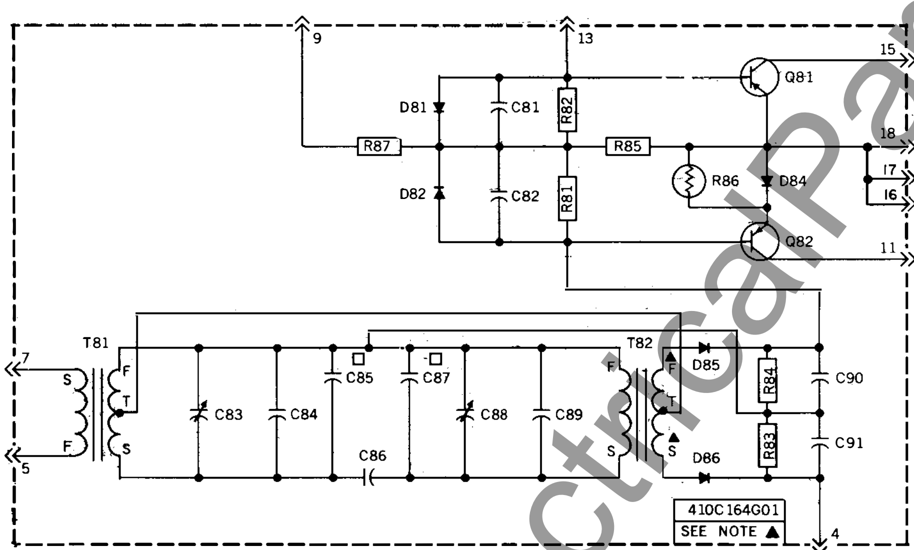
Fig. 9 Internal Schematic I.F. Amplifier – Silicon Transistor Version

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



264C841

Fig. 10. *Internal Schematic Amplifier and Limiter – Silicon Transistor Version*



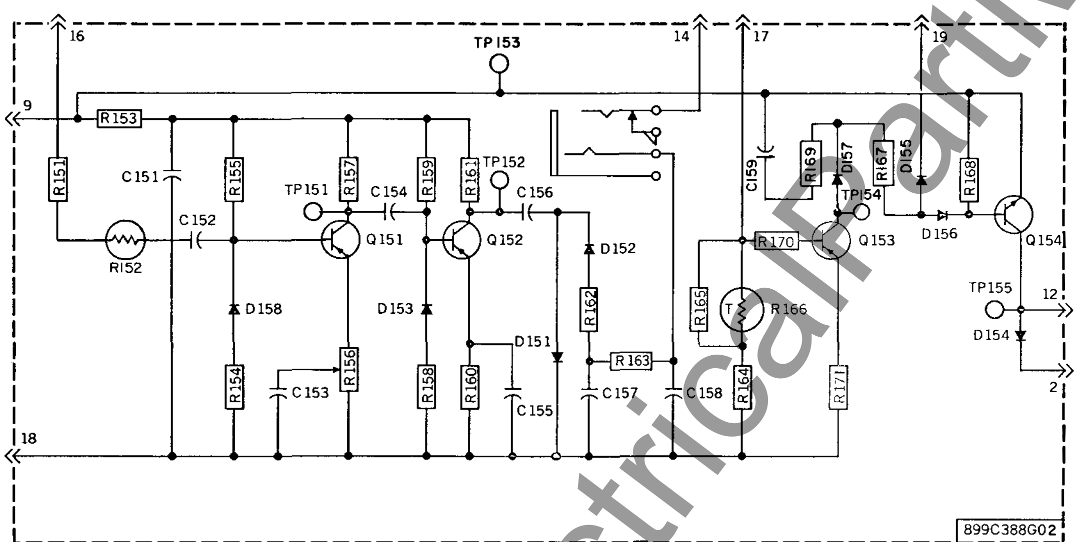
COMPONENT	STYLE	REQ	REF.
TRANSISTOR			
Q81–Q82	849A441H01	2	2N3645
RESISTOR			
R81–R82	184A763H38	2	3K 1/2W ±5%
R83–R84	184A763H35	2	2.2K 1/2W ±5%
R85	184A763H11	1	220Ω 1/2W ±5%
R87	184A763H53	1	12K 1/2W ±5%
SENSISTOR			
R86	187A685H03	1	1.2K 1/4W ±10%
CAPACITOR			
C81–C82–C90–C91	762A703H01	4	.22MFD.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

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

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

264C842

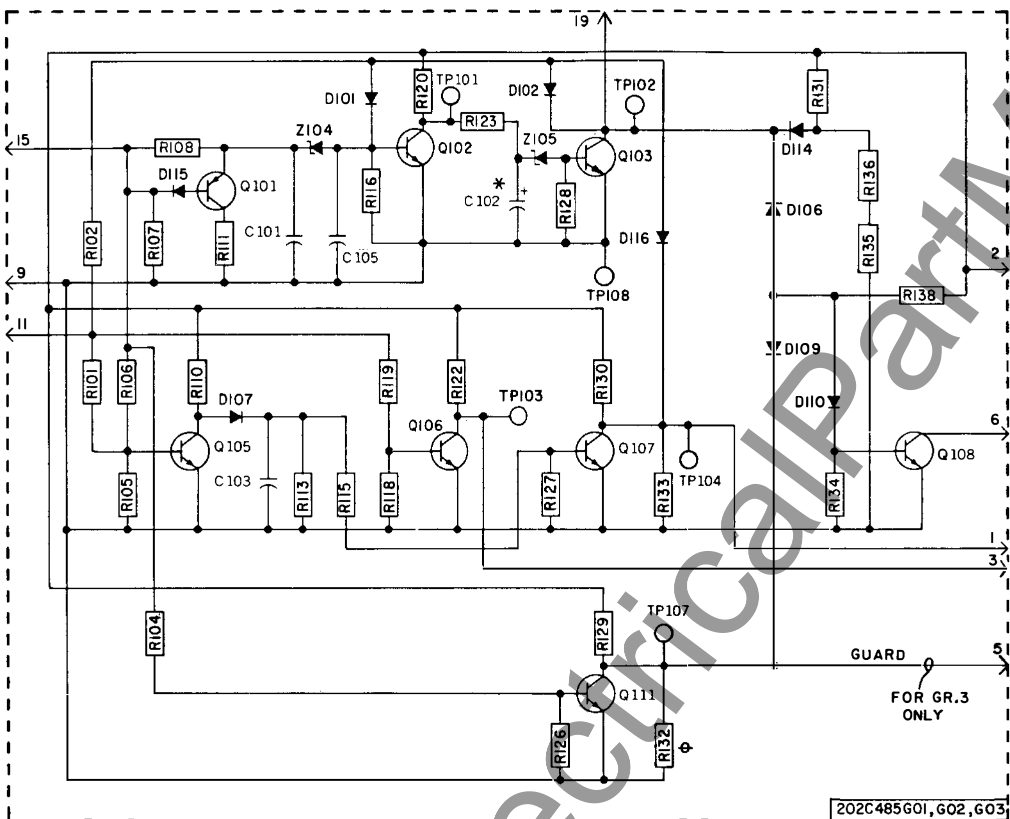
Fig. 11. Internal Schematic Discriminator – Silicon Transistor Version



COMPONENT	STYLE	REQ	REF
TRANSISTOR			
Q151–Q152–Q153	849A441H03	3	2N4249
Q154	184A638H19	1	2N699
RESISTOR			
R151-R168	184A763H51	2	10K 1/2W ±5%
SENSISTOR-R152	187A685H01	1	2.2K, 1/4W ±10%
R153	184A763H11	1	220Ω 1/2W ±5%
R154	184A763H39	1	3.3K 1/2W ±5%
R155–R159	184A763H55	2	15K 1/2W ±5%
R157–R158	184A763H43	2	4.7K 1/2W ±5%
R160	184A763H21	1	560Ω .1/2W ±5%
R161	184A763H29	1	1.2K 1/2W ±5%
R162–R163	184A763H09	2	180Ω 1/2W ±5%
R164	184A763H19	1	470Ω 1/2W ±5%
R165	184A763H27	1	1K 1/2W ±5%
R167	184A763H57	1	18K 1/2W ±5%
R171	184A763H07	1	150Ω 1/2W ±5%
R170	184A763H23	1	680Ω 1/2W ±5%
R169	184A763H03	1	100Ω 1/2W ±5%
POTENTIOMETER			
R156	629A645H07	1	2.5K
THERMISTOR			
R166	185A211H08	1	1D201
CAPACITOR			
C151–C152–C154 TO C158	187A624H02	7	.25MFD. 200V.
C153	187A624H04	1	1MFD. 200V.
C159	184A661H16	1	22 MFD. 35V.
DIODE			
D151 TO D156–D158	184A855H07	7	1N457A
D157	182A881H07	1	1N100A
TELEPHONE JACK			
J151	187A606H01	1	

264C854

Fig. 12. Internal Schematic Carrier Level Indicator – Silicon Transistor Version



*= FOR GROUP I C102=(6.8 MFD.) S-184A661H25
FOR GROUP 2 C102=(22 MFD.) S-184A661H16

⊖=FOR GROUP 1&2 R132=(33K) S-184A763H63
FOR GROUP 3 R132=(68K) S-184A763H71

COMPONENT	STYLE	REQ	REF
TRANSISTORS			
Q101	849A441H03	1	(2N4249)
Q102-111	762A585H01	2	(2N696)
Q103	184A638H18	1	(2N697)
Q105-106-107-108	184A638H19	4	(2N699)
RESISTORS			
R110	187A643H51	1	(10K 1W ±5%)
R111	184A763H19	1	(470 1/2W ±5%)
R136	184A763H39	1	(3.3K 1/2W ±5%
R105-126-116-118-127-128-134 -135	**184A763H51**	**8**	**(10K 1/2W5%)**
R131	184A763H53	1	(12K 1/2W ±5%)
R107-*R123*	184A763H57	*2*	(18K 1/2W ±5%)
R104	184A763H61	1	(27K 1/2W ±5%)
R102-130	184A763H63	2	(33K 1/2W ±5%)
R101-106	184A763H65	3	(39K 1/2W ±5%)
R108	184A763H69	1	(56K 1/2W ±5%)
R120	*184A763H59*	*1*	*(22K ½W ±5%)*
R115	184A763H73	1	(82K 1/2W ±5%)
R119	184A763H75	1	(100K 1/2W ±5%)
R113	184A763H91	1	(470K 1/2W ±5%)
R132	**184A763H63**	**1**	**(33K 1/2W± 5%)**
R132	**184A763H71**	**1**	**(68K 1/2W ±5%**
R122-129-133	184A763H71	**3**	(68K 1/2W 5%)
R138	184A763H55	1	(15K 1/2W 5%)
CAPACITORS			
C102	**184A661H16**	**1**	**(22 MFD.)**
C101	184A661H12	1	(4.7MFD. 10%)
C105	184A663H02	1	(.05MFD. 50V)
C102	184A661H25	1	(6.8MFD.)
C103	187A624H11	1	(.5MFD. ±10%)
DIODES			
D114	182A881H07	1	(IN100A)
D101-102-106-107-109-110-116-115	**184A855H07**	**8**	**(IN457A)**
DIO-ZENER			
Z105	185A212H06	1	(IN3686B)
Z104	186A797H06	1	(IN957B)

LOGIC-876A058 REF.
TYPICAL OVERALL SCHEMATIC-5489D81

264C850

Fig. 13. Internal Schematic Logic Board – Silicon Transistor Version

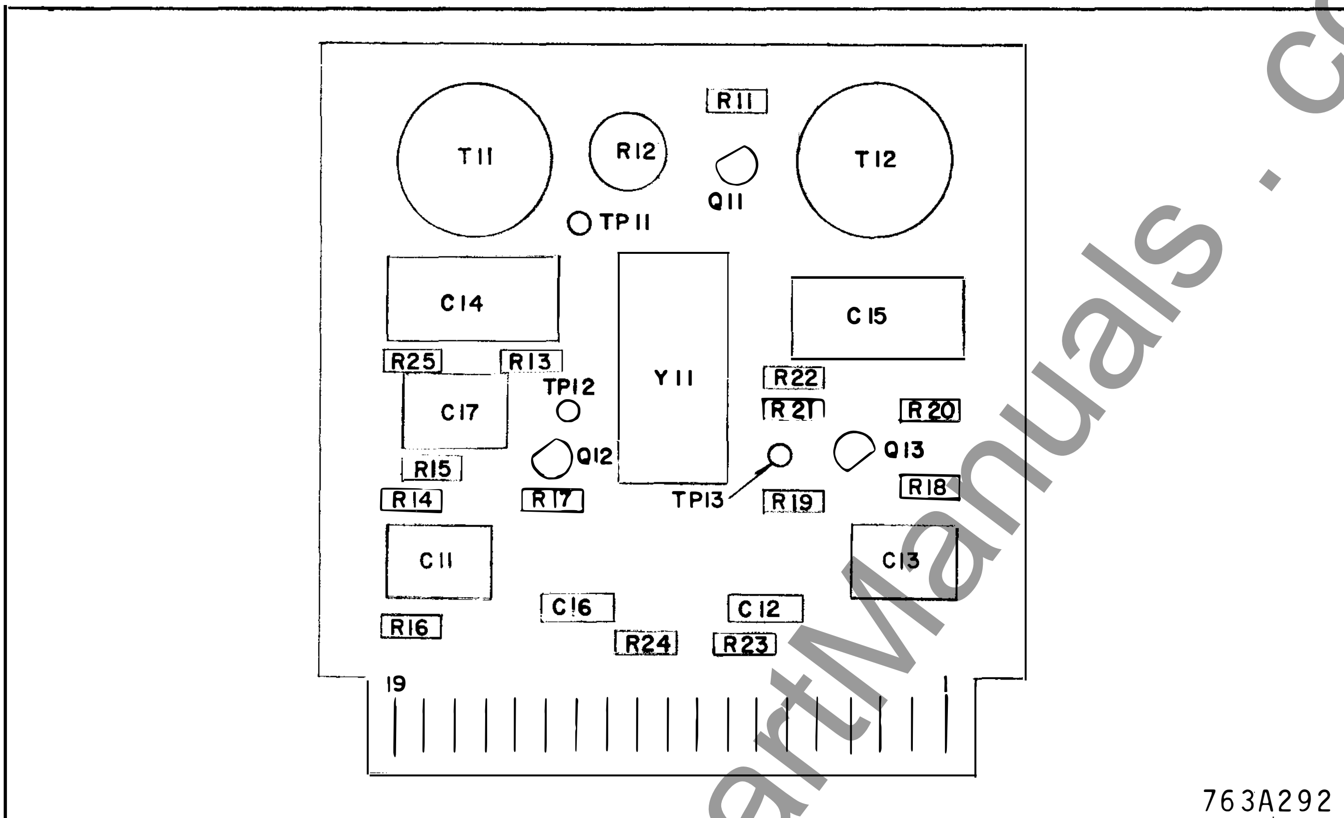


Fig. 14. Component Locations 30-200kHz Oscillator and Mixer Silicon Transistor Version

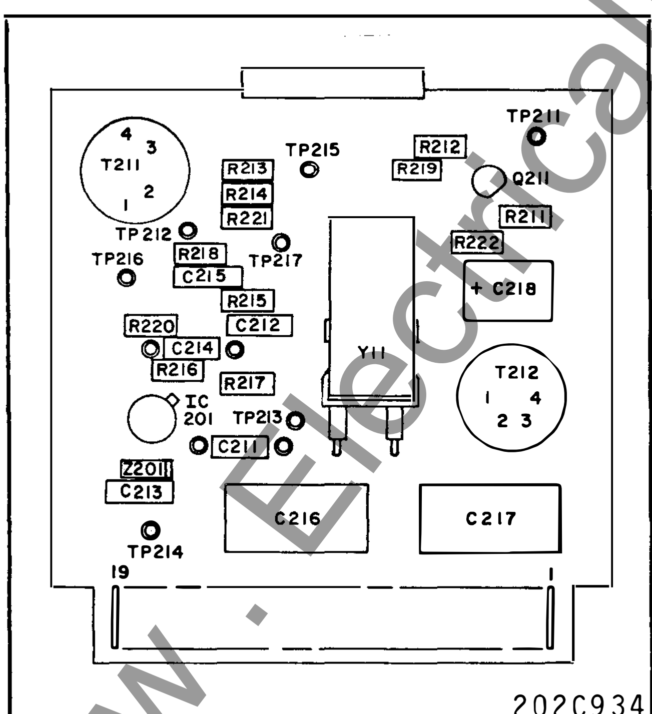


Fig. 15. Component Locations 200.5 – 300kHz Oscillator and Mixer – Silicon Transistor Version

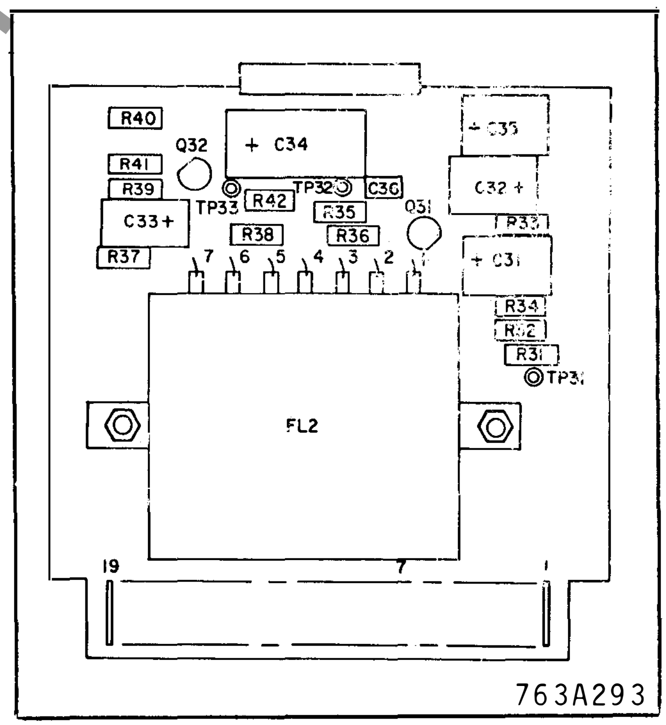


Fig. 16. Component Locations I.F. Amplifier – Silicon Transistor Version

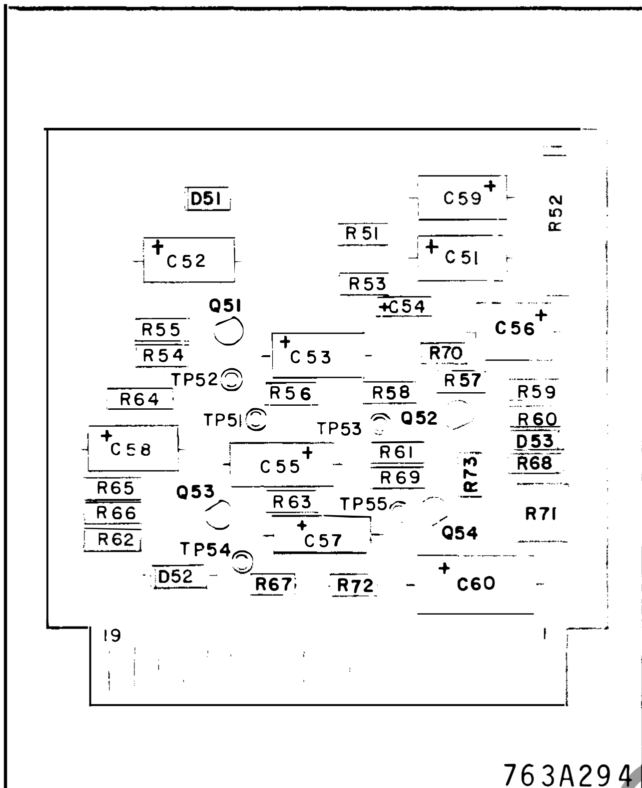


Fig. 17. Component Locations Amplifier and Limiter – Silicon Transistor Version

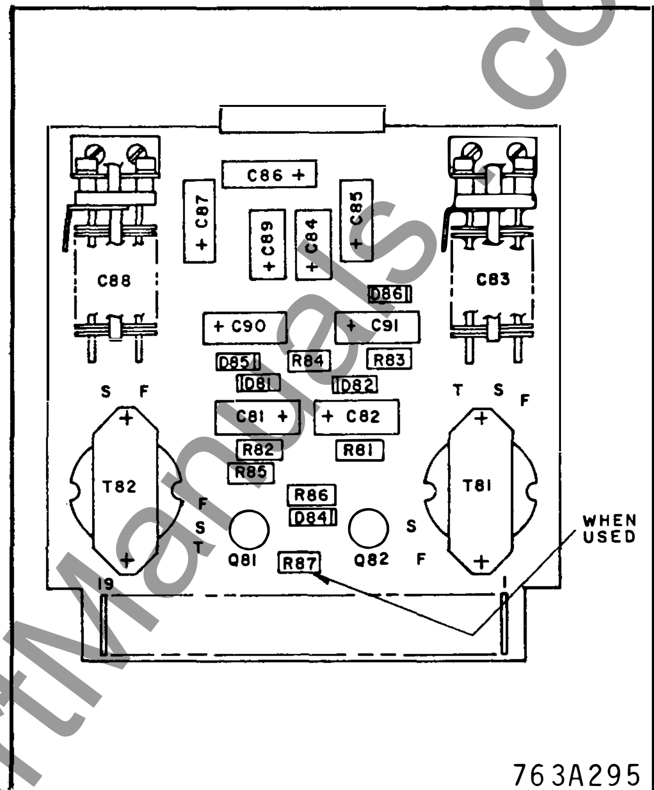


Fig. 18. Component Locations Discriminator – Silicon Transistor Version

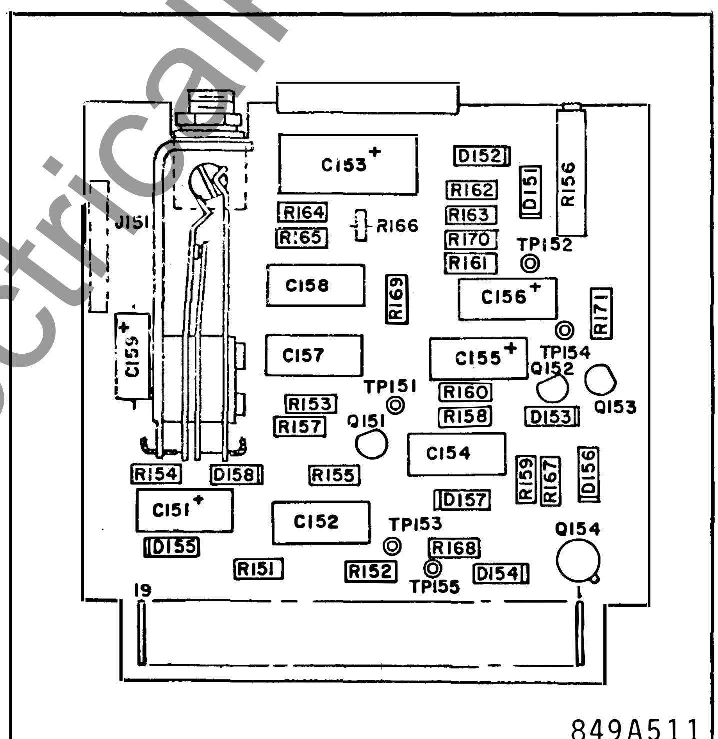


Fig. 19. Component Locations Carrier Level Indicator – Silicon Transistor Version

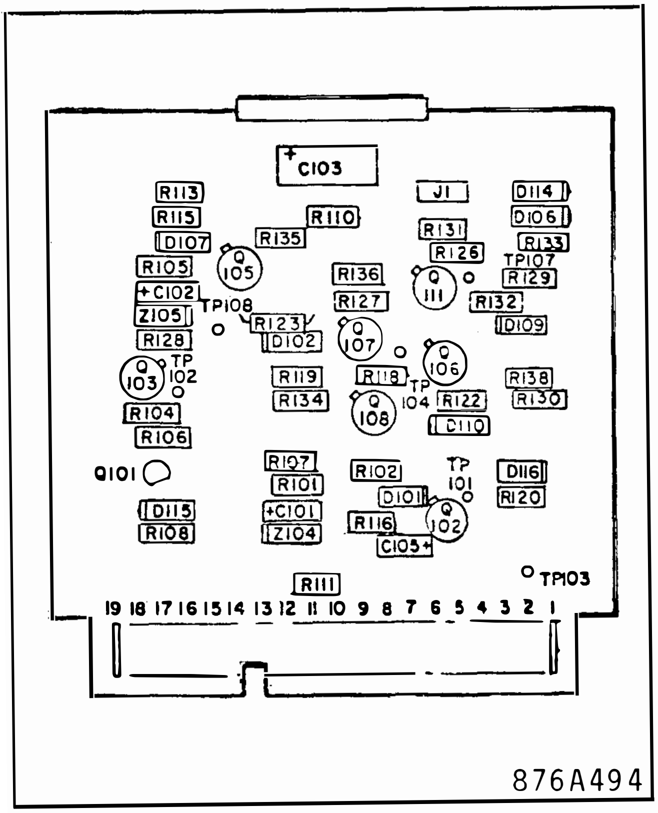


Fig. 20. Component Locations Logic Board – Silicon Transistor Version

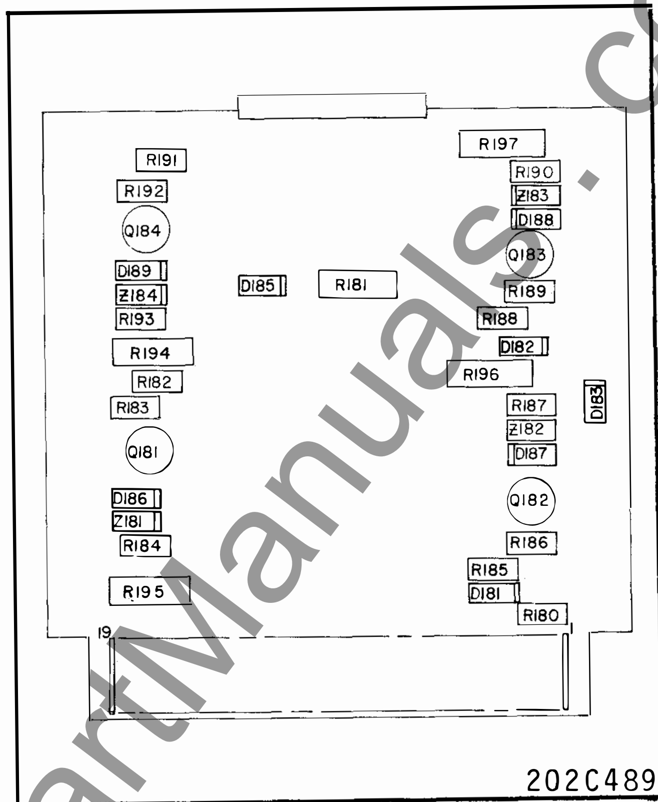


Fig. 21. Component Locations Output Printed Circuit Board – Silicon Transistor Version

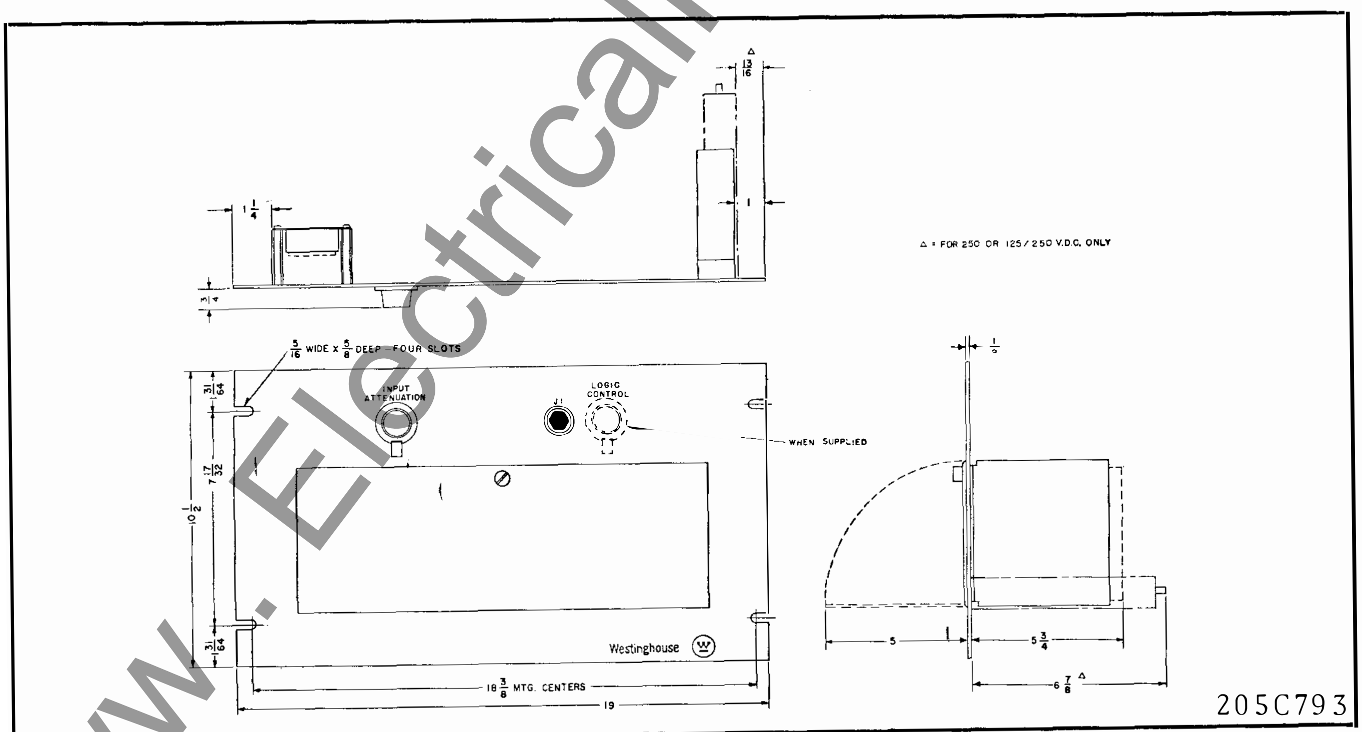


Fig. 22. Outline and Drilling Plan for the Type TCF Receiver Assembly.

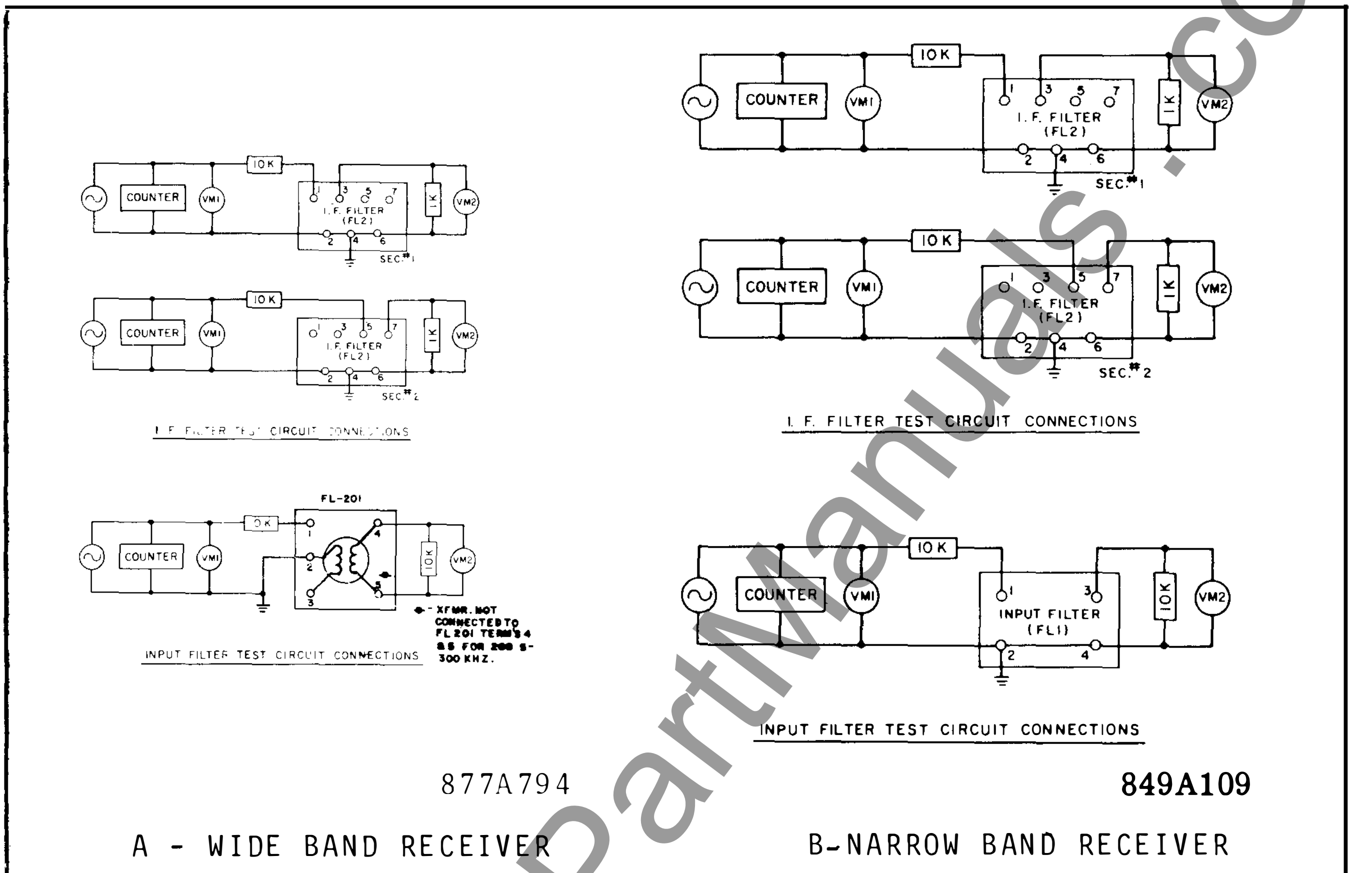


Fig. 23. Test Currents for TCF Frequency Shift Receiver Filters

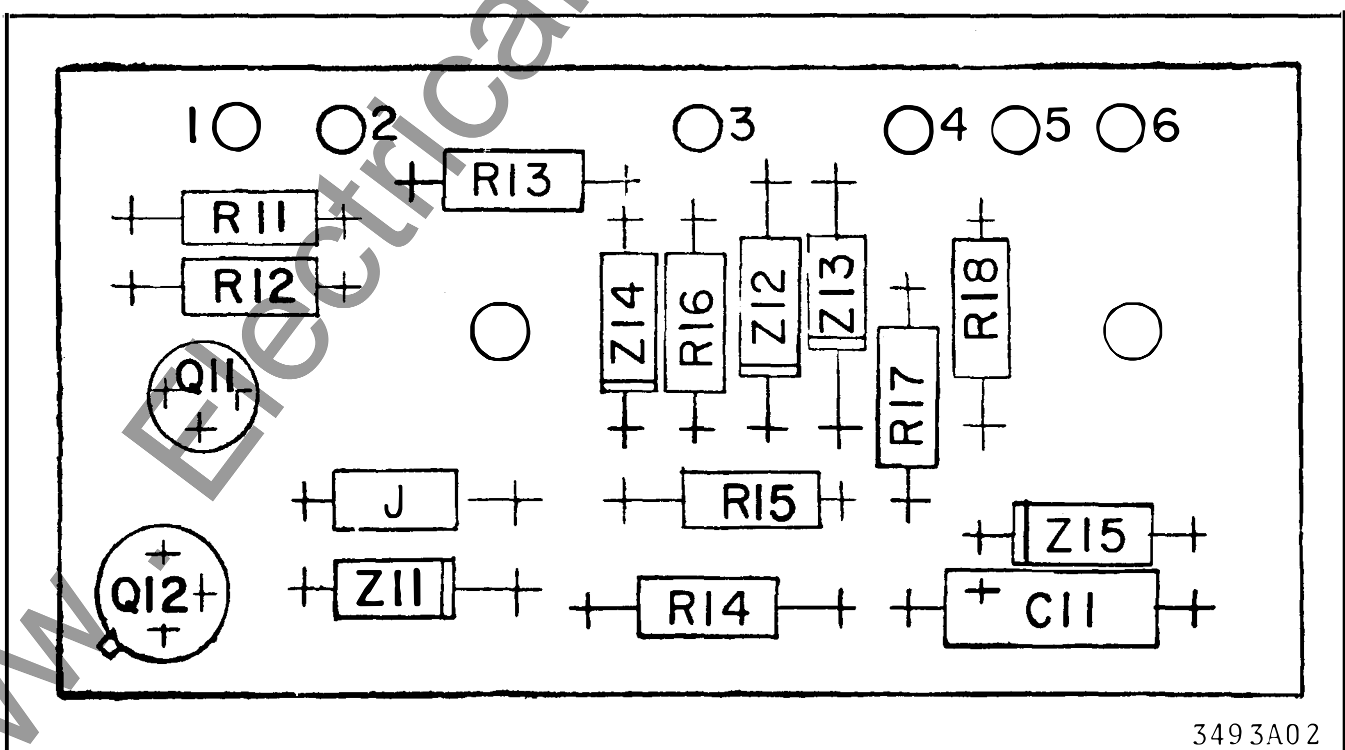


Fig. 24. Component Location – Buffered Keying Board – for 3 Frequency Operation

ADDENDUM

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

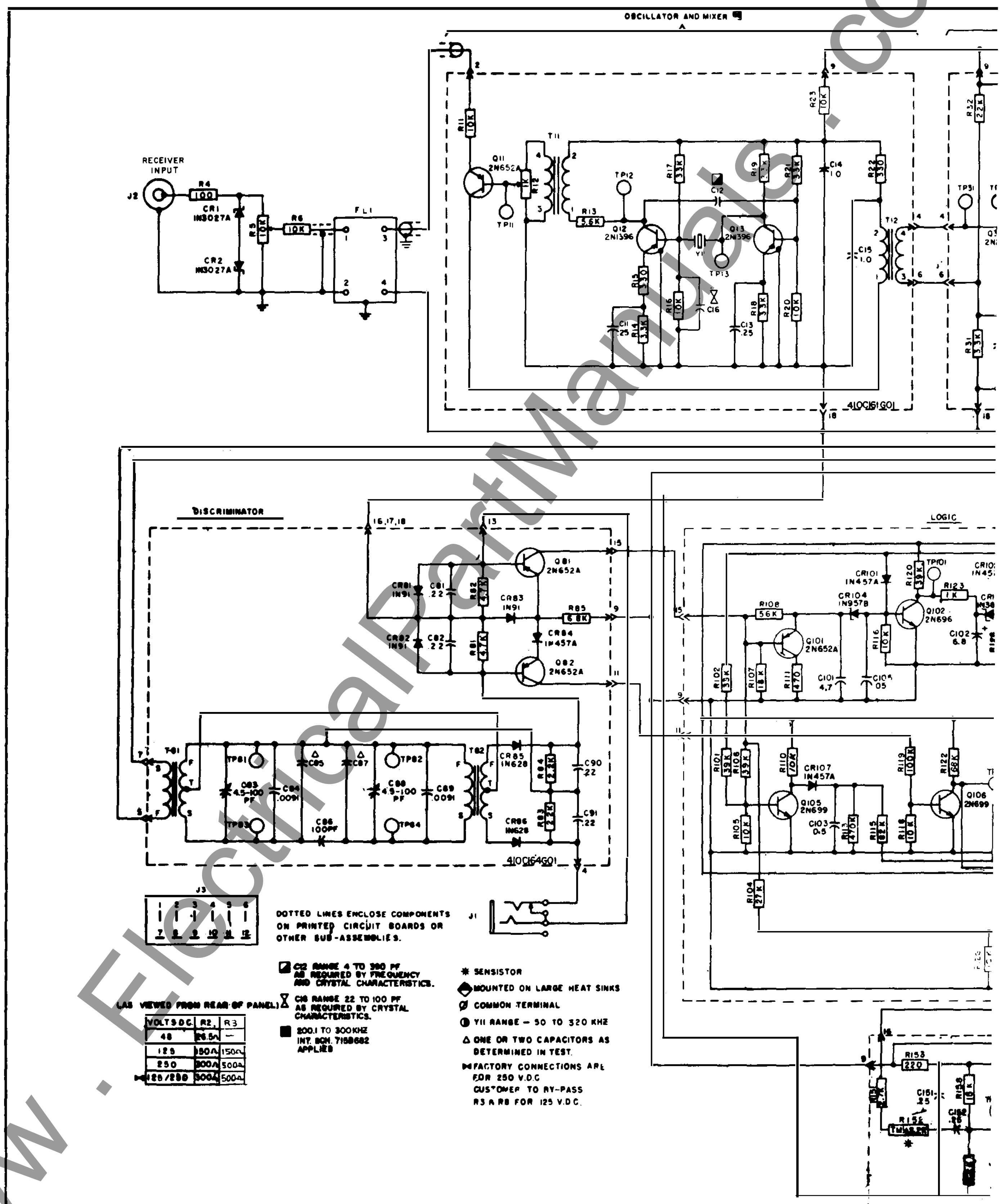
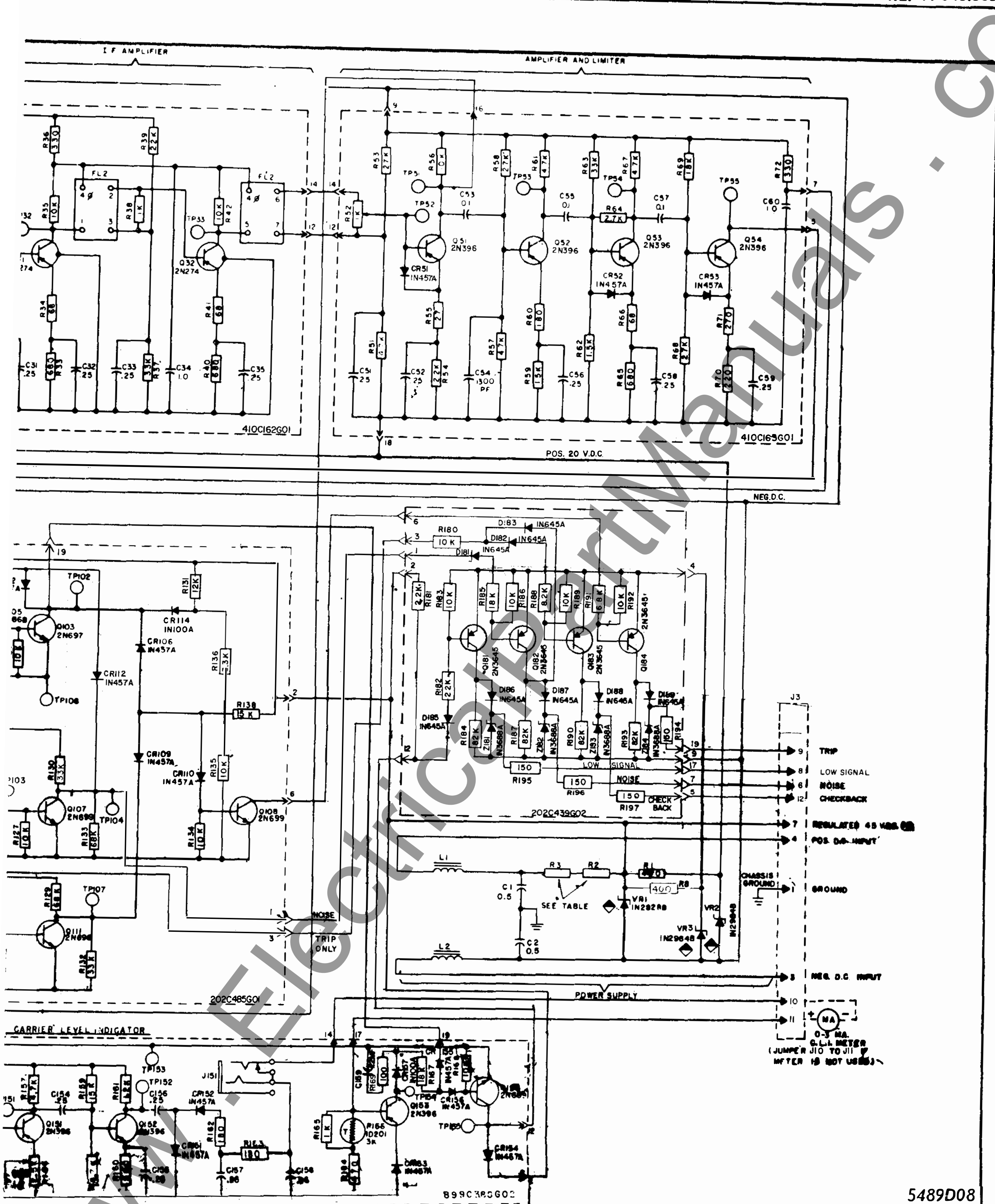


Fig. 26. Internal Schematic of the Ty
Germanium Transistor Versi



...pe TCF Receiver for STU Unblock – Narrow Band
...on – Prior 1973

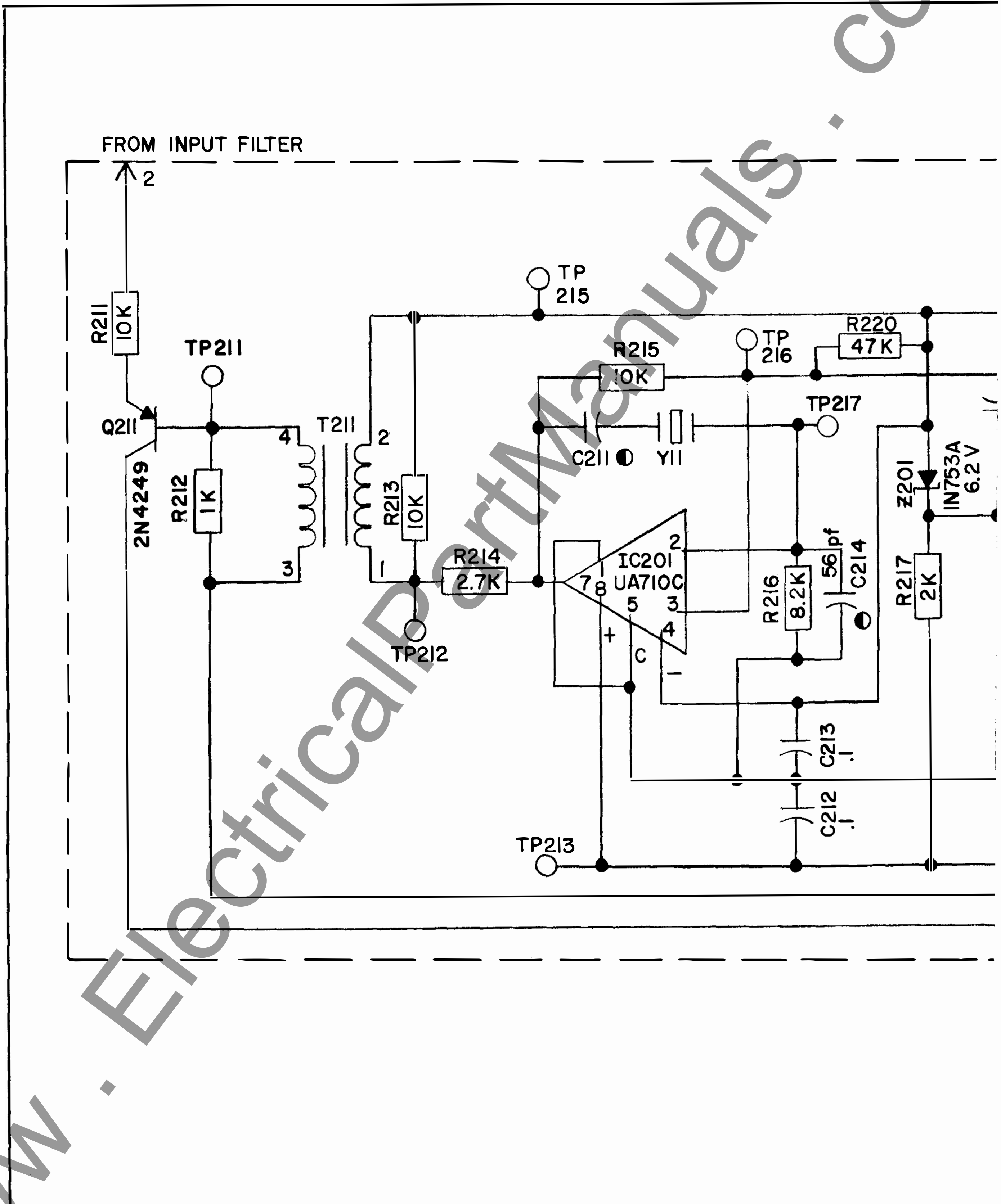
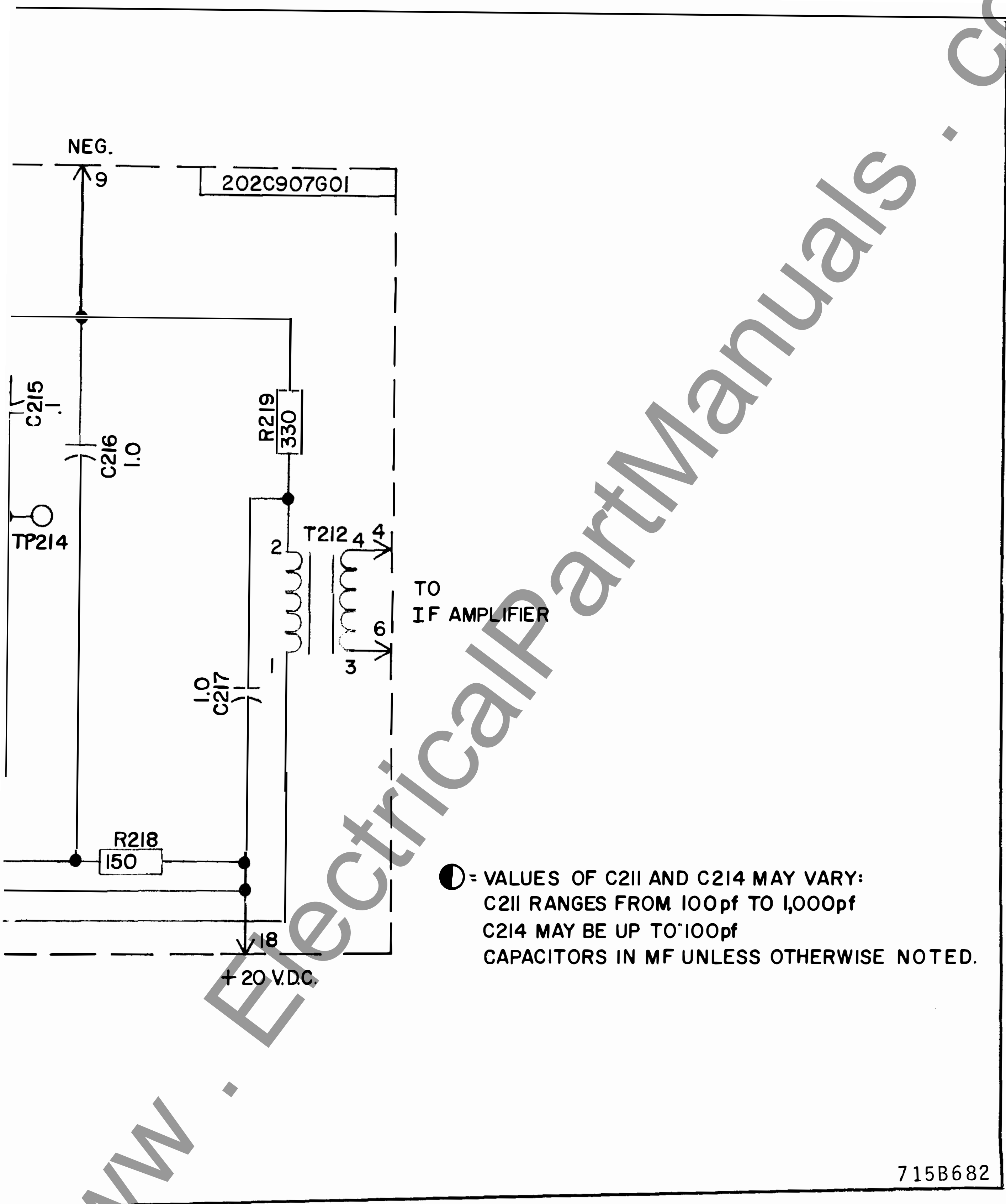


Fig. 28. Internal Schematic 20
Germanium Transisto



◐ = VALUES OF C211 AND C214 MAY VARY:
C211 RANGES FROM 100pf TO 1,000pf
C214 MAY BE UP TO 100pf
CAPACITORS IN MF UNLESS OTHERWISE NOTED.

0.5 to 300 kHz Oscillator Mixer Board
· Version – Prior 1973

ELECTRICAL PARTS LIST – GERMANIUM TRANSISTOR VERSIONS – PRIOR 1973

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

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS (Cont'd.)	
C153	Metallized paper; 1.0 mfd.; 200 V.D.C.	187A624H04
C154	Metallized paper; 0.25 mfd.; 200 V.D.C.	817A624H02
C155	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C156	Metallized paper; 0.25 mfd.; 200 V.C.C.	187A624H02
C157	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C158	Metallized paper; 0.25 mfd.; 200 V.D.C.	187A624H02
C211	Durmica; 100 mmf to 1000 mmf	187A695H
C212	Ceramic; .1 mf, 50 v.d.c.	184A663H04
C213	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C214	Durmica; .56 mmf	187A695H17
C215	Ceramic; .1 mf, 50 v.d.c.	184A663 H04
C216	Metallized paper; 1 mf	187A624H04
C217	Metallized Paper; 1 mf	187A624H04
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60 V.; 200 MA.	184A855H07
CR52	IN475A; 60 V.; 200 MA.	184A855H07
CR53	IN457A; 60 V.; 200 MA.	184A855H07
CR81	IN91; 100 V.; 150 MA.	182A881H04
CR82	IN91; 100 V.; 150 MA.	182A881H04
CR83	IN91; 100 V.; 150 MA.	182A881H04
CR84	IN475A; 60 V.; 200 MA.	184A885H07
CR85	IN628; 125 V.; 30 MA.	184 A855 H12
CR86	IN628; 125 V.; 30 MA.	184 A855 H12
CR101	IN457A; 60 V.; 200 MA.	184A885H07
CR102	IN457A; 60 V.; 200 MA.	184A885H07
CR103	IN457A; 60 V.; 200 MA.	184A885H07
CR106	IN457A; 60 V.; 200 MA.	184A885H07
CR107	IN457A; 60 V.; 200 MA.	184A885H07
CR108	IN457A; 60 V-; 200 MA.	184A885H07
CR109	IN457A; 60 V.; 200 MA.	184A885H07
CR110	IN457A; 60 V.; 200 MA.	184A885H07
CR111	IN457A; 60 V.; 200 MA.	184A885H07
CR112	IN457A; 60 V.; 200 MA.	184A885H07
CR151	IN457A; 60 V.; 200 MA.	184A885H07
CR152	IN457A; 60 V.; 200 MA.	184A885H07
CR153	IN457A; 60 V.; 200 MA.	184A885H07
CR154	IN457A.; 60 V.; 200 MA.	184A885H07
CR155	IN457A; 60 V.; 200 MA.	184A885H07
CR156	IN457A; 60 V.; 200 MA.	184A855H07
	DIODES – ZENER	
CR1	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20 V. ±10%; 1W.	188A302H10
CR104	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
CR105	IN3686B; 20 V. ± 5%; 750 MW.	185A212H06
CR113	IN957B; 6.8 V. ± 5%; 400 MW.	186A797H06
VR1	IN2828B; 45 V. ± 5%; 50 W.	184A854H06
VR2	IN2984B; 20 V. ± 5%; 10 W.	762A631H01
Z201	IN753A; 6.2 V. v 5%; 400 MW.	862A606H01

ELECTRICAL PARTS LIST (Cont'd.)

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

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	184A763H35
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ± 5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R7	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ± 2%; Nickel Iron W.W.	09D8326G19
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	39K ±5%; ½ W. Composition	184A763H65
R102	33K ±5%; ½ W. Composition	184A763H63
R103	10K ±5%; ½ W. Composition	184A763H51
R104	27K ±5%; ½ W. Composition	184A763H61
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	18K ±5%; ½ W. Composition	184A763H57
R108	56K ±5%; ½ W. Composition	184A763H69
R109	10K ±5%; 1 W. Composition	187A643H51
R110	6.8K ±5%; 1 W. Composition	187A643H47
R111	470 ohms ±5%; ½ W. Composition	184A763H19
R112	1000 ohms ±5%; ½ W. Composition	184A763H27
R113	470K ±5%; ½ W. Composition	184A763H91
R114	1000 ohms ±5%; ½ W. Composition	185A763H27
R115	82K ±5%; ½ W. Composition	184A763H73

ELECTRICAL PARTS LIST (Cont'd.)

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

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	1962797
T12	Toroidal type, 25000/300 ohms	1962697
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
T211	10K: 10K	714B677G01
T212	25K:300	196297
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N652A	184A638H16
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
Q105	2N699	184A638H19
Q106	2N696	762A585H01
Q107	2N698	762A585H02
Q108	2N699	184A638H19
Q109	2N699	184A638H19
Q110	2N696	762A585H01
Q111	2N696	762A585H03
Q151	2N396	762A585H03
Q152	2N396	762A585H03
Q153	2N396	762A585H03
Q154	2N699	184A638H19
Q211	2N652A	184A638H16

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20kHz above Channel Frequency)	762A800H01 +(Req. Freq.)
FL1	Crystal input Filter	401C466 + (Reg. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
AR	Trip Relay	408A845G03
L1-L2	Choke	292B096G02
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04
FL201	LC Wide Band Input Filter	Specify Frequency
	BUFFERED KEYING BOARD 202C516G03	
Q11	Transistor 2N4356	849A441H02
Q12	Transistor 2N699	184A638H19
Z11	Zener Diode 1N957B	186A797H06
Z12	Zener Diode 1N3688A	862A288H01
Z13	Zener Diode 1N3688A	862A288H01
Z14	Zener Diode 1N3686B	185A212H06
Z15	Zener Diode 1N3688A	862A288H01
C11	Capacitor .047 μ f,	849A437H04
R11	4.7K, ± 2%, ½ W Metal Glaze	629A531H48
R12	12K, ± 2%, ½ W Metal Glaze	629A531H58
R13	10K, ± 2%, ½ W Metal Glaze	629A531H56
R14	6.2K, ± 2%, ½ W Metal Glaze	629A531H51
R15	1.5K, ± 2%, ½ W Metal Glaze	629A531H36
R16	18K, ± 2%, ½ W Metal Glaze	629A531H62
R17	1.8K, ± 2%, ½ W Metal Glaze	629A531H38
R18	51K, ± 2%, ½ W Metal Glaze	629A531H73

WESTINGHOUSE ELECTRIC CORPORATION

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

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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

CAUTION: It is recommended that the user of this equipment become thoroughly acquainted with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

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

APPLICATION

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

◆ CONSTRUCTION

The TCF receiver unit for supervisory control and telemetering applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, and a jack for metering the discriminator output current are accessible from the front of the panel. Refer to Fig. 3.

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. 4. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields.

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

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and terminal block is keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into

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*Denotes change from superseded issue.

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the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

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

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

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. 1. Resistor R4 and 20-volt zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred hertz above or below the center frequency (fc) of the channel are greatly attenuated. Figure 2 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

Oscillator and Mixer

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

IF Amplifier

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

Amplifier and Limiter

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

Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc hertz. The adjustment for zero output at fc hertz is made by capacitor C88. X83 also is adjusted to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero output frequency. This separation of 200 hertz between the current peaks is affected by the value of C86 (the actual value of which may be changed slightly from its typical value in factory calibration if required). It should be observed that although the higher signal frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the corresponding frequency is 20KHz-100 hertz. Similarly, the lower signal frequency is converted to 20KHz + 100 hertz.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately +20 volts at Guard frequency and terminal 11 is at +20 volts at Trip frequency.

Output Circuits

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

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

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

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

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

Power Supply

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

CHARACTERISTICS

Frequency range	30-300KHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 Hz. down > 60 db at 1000 Hz.
Discriminator	Set for zero output at channel center frequency and for max. outputs at 100 hertz above and below center frequency.
Operating Time	9 ms. channel (transm. and recvr.) 2 ms. HG relay operate and release times

Frequency spacing	
A. For two or more signals over one-way channel-	500 hertz minimum
B. For two-way channel	1000 hertz minimum between transmitter and adjacent receiver frequencies.
Ambient temperature range	− 20°C to + 55°C temperature around chassis.
Battery voltage variations	
Rated Voltage	Allowable Variation
48 V.D.C.	42- 56 V.D.C.
125 V.D.C.	105-140 V.D.C.
250 V.D.C.	210-280 V.D.C.
Battery drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height – 10½" or 6 r.u. Panel width – 19"
Weight	13 lb.

INSTALLATION

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

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; frequency spacing and magnitude of discriminator output peaks.

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

In case factory adjustments have been accidentally disturbed or components have been replaced, it may be necessary to readjust the oscillator and mixer, the limiter, or the discriminator, and procedures for these adjustments are described in the following paragraphs.

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

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should be connected from the base of transistor Q54 to terminal 18 of the limiter. With 5 mv. of signal frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting. The R52 adjusting screw then should be turned one turn farther in the direction to produce limiting.

Adjustment of the discriminator is made by capacitors C83 and C88. Apply to the receiver input a 5 mv. signal taken from an oscillator set at the center frequency of the channel. (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at 100 hertz above and below center frequency.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. An overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

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

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

Typical voltage values are given in the following tables. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

TABLE I
RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 18 (+20 v.). Receiver adjusted for 15 db operating margin with input signal down 50 db from 1 watt. Unless otherwise indicated, voltage will not vary appreciably whether signal is high, low or fc frequency.

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

TABLE II
RECEIVER RF MEASUREMENTS

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

FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only by the factory. The stability of the original response characteristics is such that in normal usage no appreciable change in response will occur. However the test circuits of Fig. 9 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 2 shows the -3db and -60db check points for the crystal filters. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Fig. 2 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 KHz", and for the stop band are "down 18 db minimum at 19.00 and 21.00 KHz". The signal generator voltage (Fig. 9) must be held constant throughout the entire check. A value of 20 db (7.8 volts) is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22db below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16db less than the measured difference because of the input resistor and the difference in input and output impedances of the filter.

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

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY

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

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation

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

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

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

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

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

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

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

RENEWAL PARTS

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

ADDENDUM

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

ELECTRICAL PARTS LIST

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

ELECTRICAL PARTS LIST (Cont'd.)

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

ELECTRICAL PARTS LIST (Cont'd.)

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

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R85	6.8K ±5%; ½W. Composition	184A763H47
R101	18K ±5%; ½W. Composition	184A763H57
R102	10K ±5%; ½W. Composition	184A763H51
R103	82K ±5%; ½W. Composition	184A763H73
R104	82K ±5%; ½W. Composition	184A763H73
R105	10K ±5%; 1W. Composition	187A643H51
R106	39K ±5%; ½W. Composition	184A763H65
R107	1000 ohms ±5%; ½W. Composition	185A763H27
R108	10K ±5%; ½W. Composition	184A763H51
R109	22K ±5%; ½W. Composition	184A763H23
R110	27K ±5%; ½W. Composition	184A763H61
R111	10K ±5%; ½W. Composition	184A763H51
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	1962797
T12	Toroidal type, 25000/300 ohms	1962697
T81	Pot. Core type	606B533G01
T82	Pot. Core type	606B533G02
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	762A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N699	184A638H19
Q102	2N696	762A585H01
Q103	2N697	184A638H18
Q104	2N699	184A638H19
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20 KC above Channel Frequency)	762A800H01 + (Reg. Freq.)
FL1	Crystal Input Filter	410C466 + (Reg. Freq.)
FL2	I.F. Filter	762A613G01
PL	Pilot Light Bulb – For 48 V. Supply	187A133H02
	Pilot Light Bulb – For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5A	11D919H26
AL	Alarm Relay	408C062H07
HG	Mercury Weted Contact Relay; 2 amp, 500 V., 100 V.A.	188A573H04

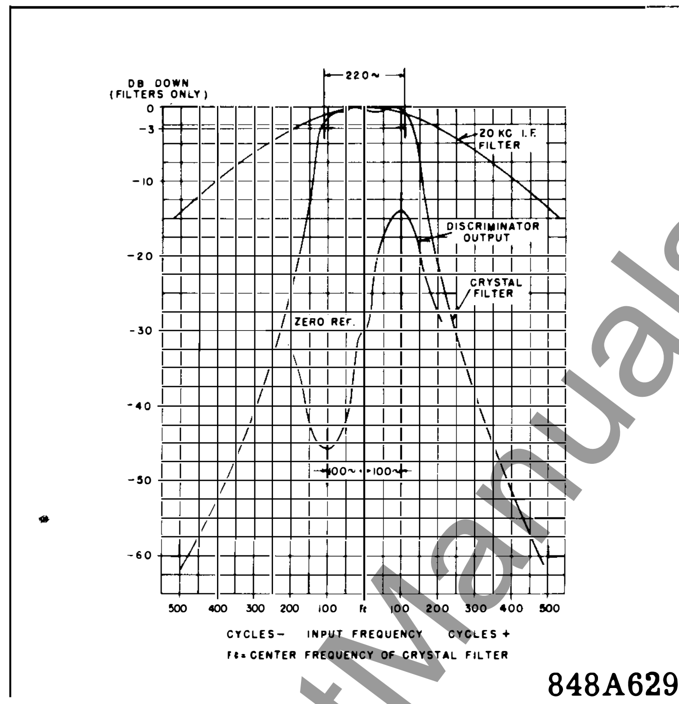


Fig. 2. Filter and Discriminator Characteristics of the Type TCF Receiver.

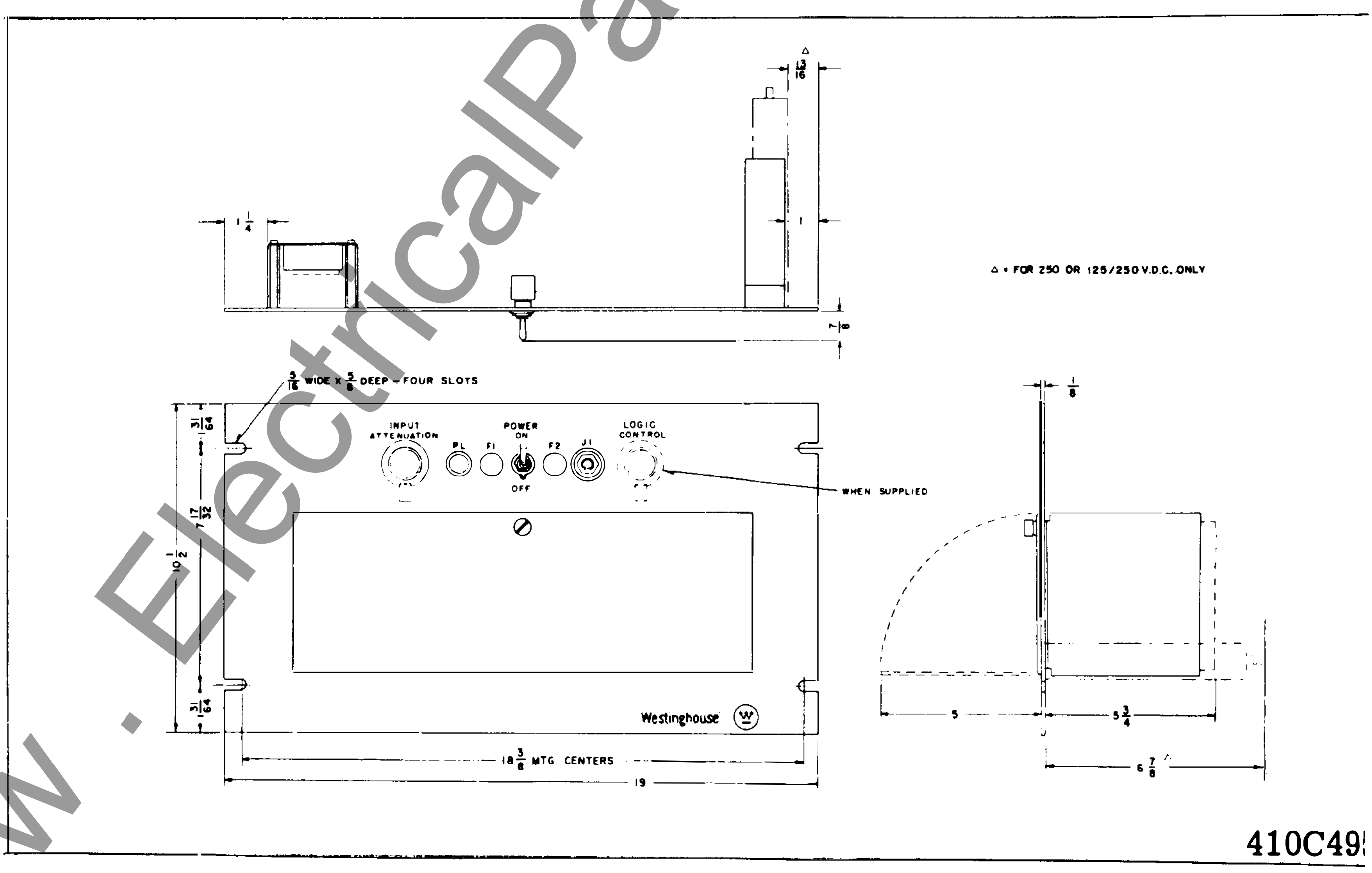


Fig. 3. Outline and Drilling Plan for the Type TCF Receiver Assembly.

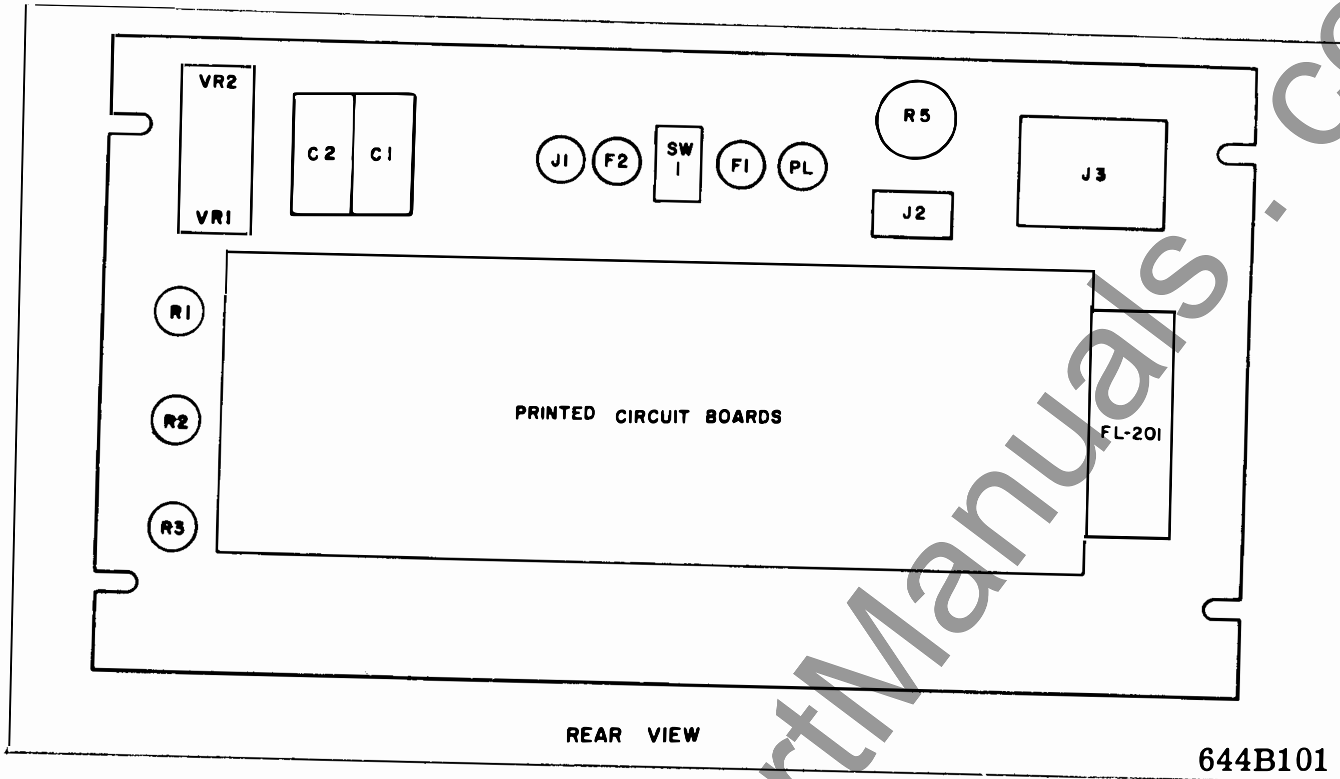


Fig. 4. Component Locations on the TCF Receiver Panel.

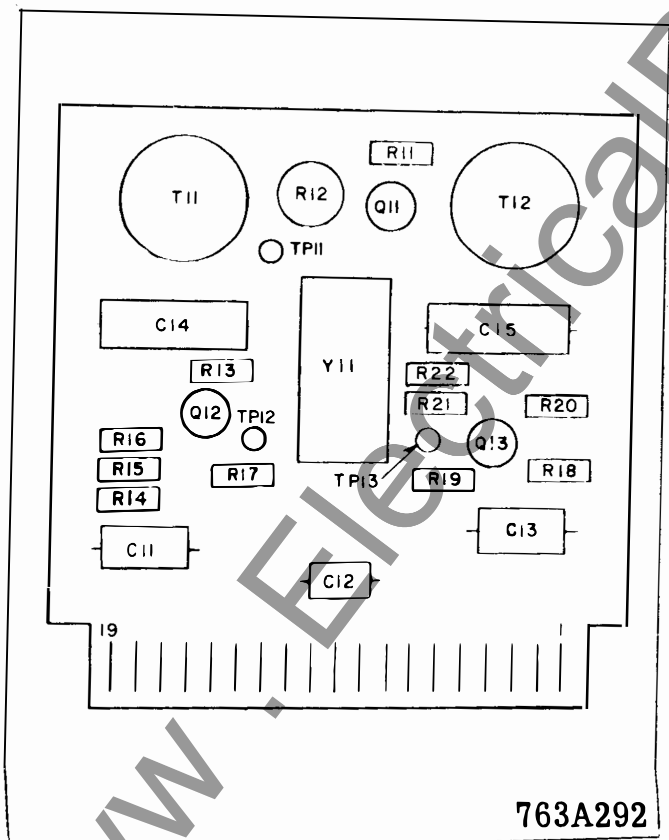


Fig. 5. Component Locations on the Oscillator and Mixer Printed Circuit Board.

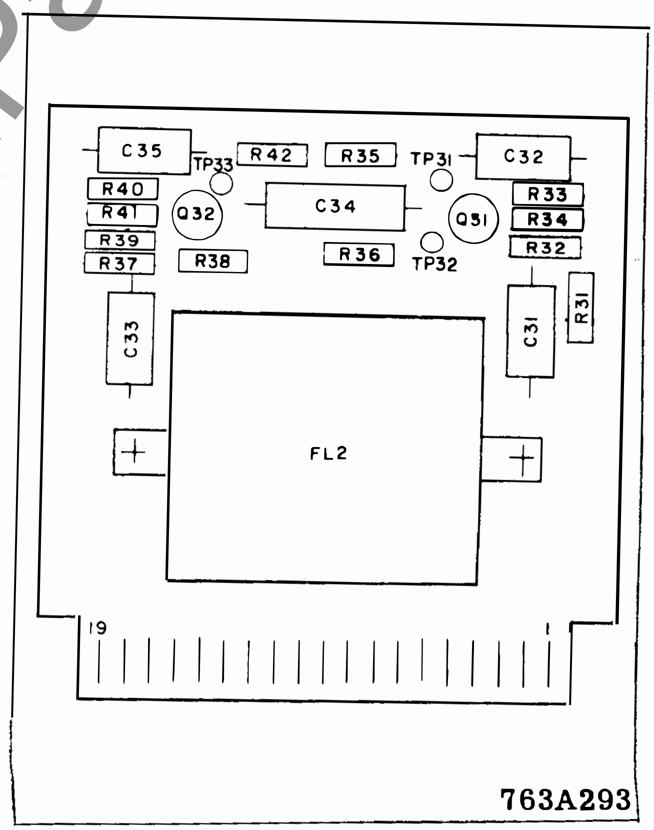


Fig. 6. Component Locations on the I.F. Amplifier Printed Circuit Board.

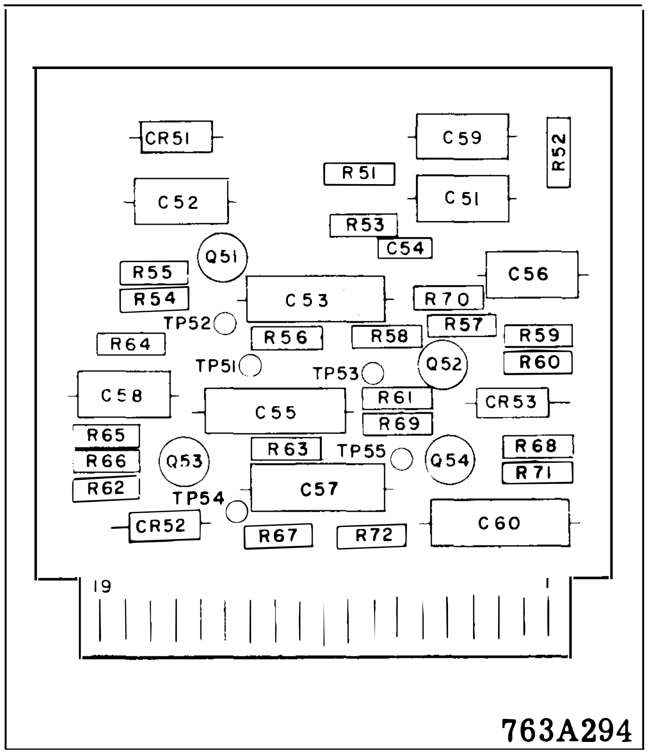


Fig. 7. Component Locations on the Amplifier and Limiter Printed Circuit Board.

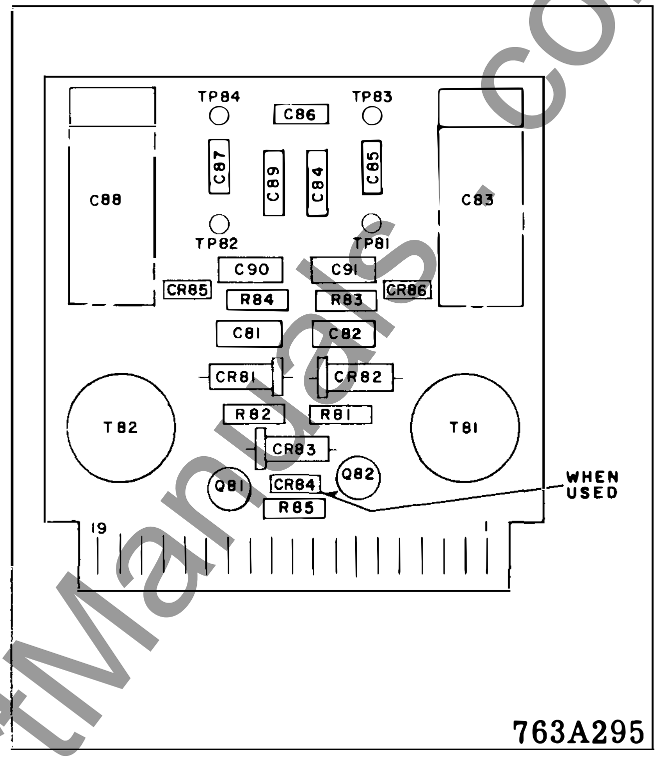


Fig. 8. Component Locations on the Discriminator Printed Circuit Board.

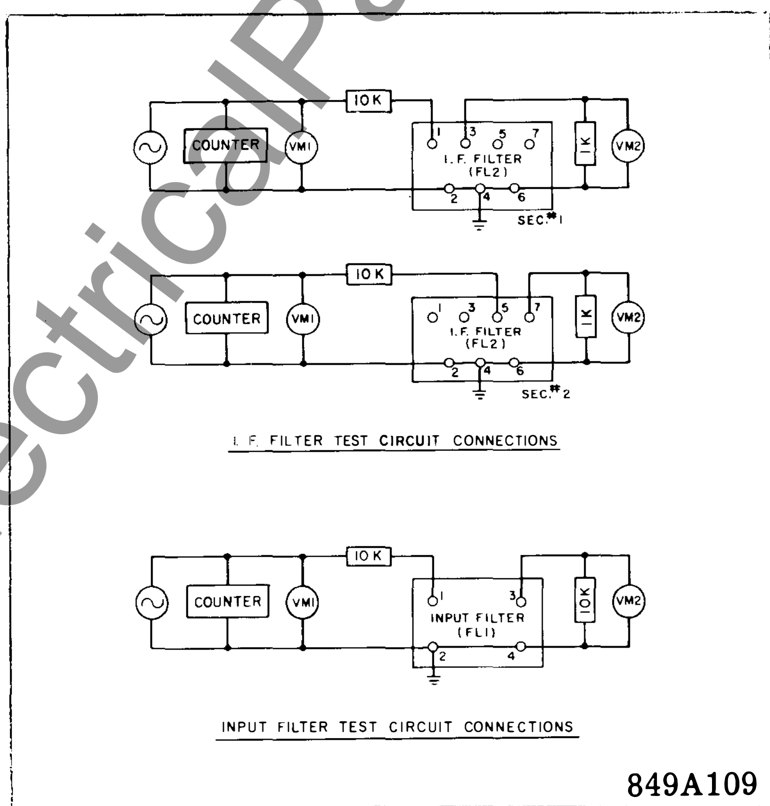


Fig. 9. Test Circuits for TCF Frequency Shift Receiver Filters

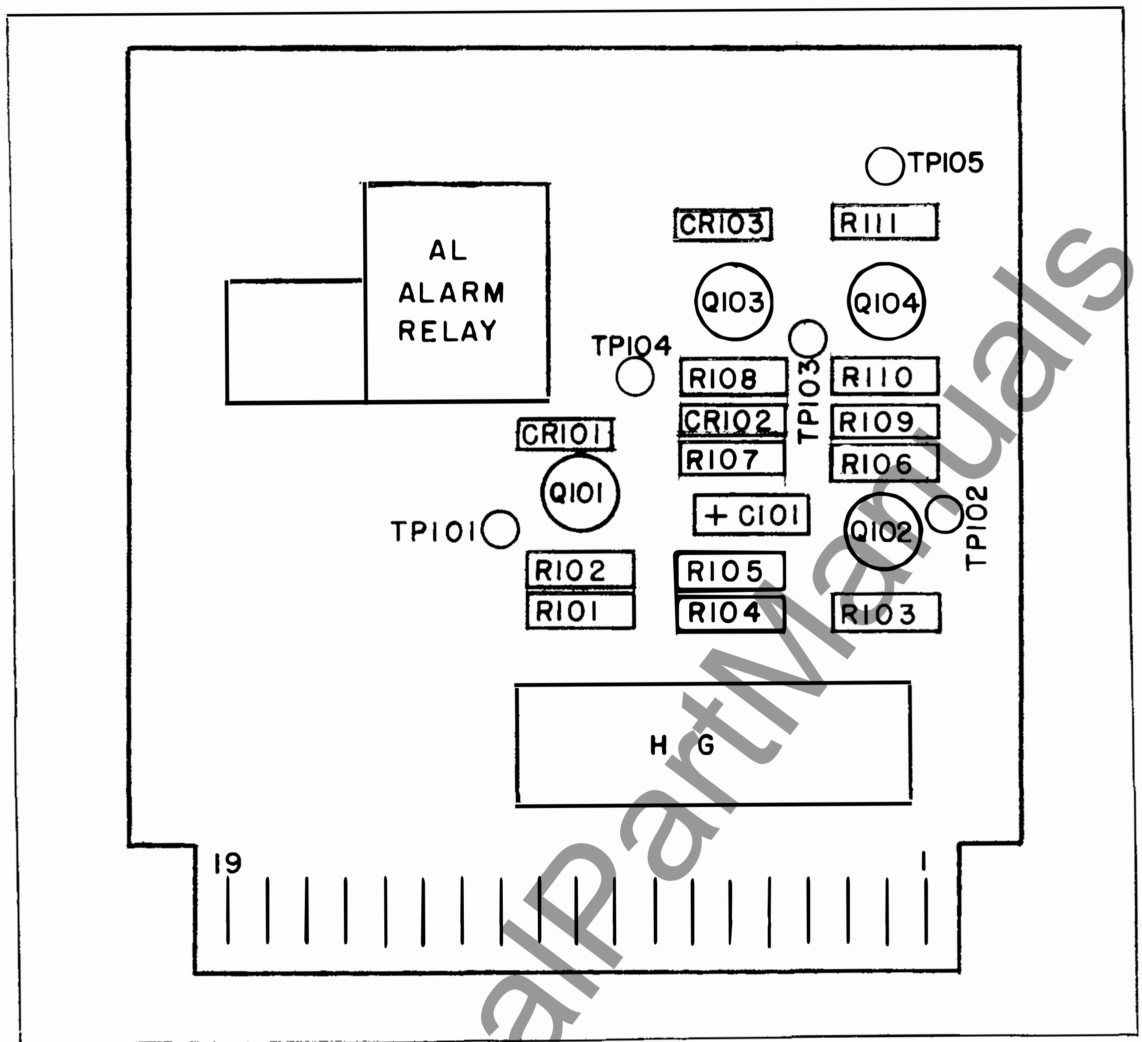
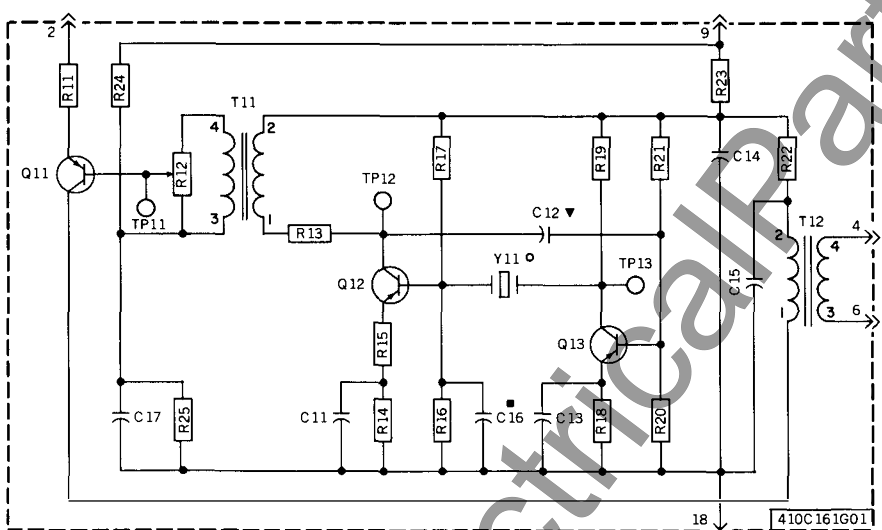


Fig. 10. Component Locations on the Relay Output Printed Circuit Board.



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

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

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

o = Y11 RANGE–50 TO 220 KHZ.

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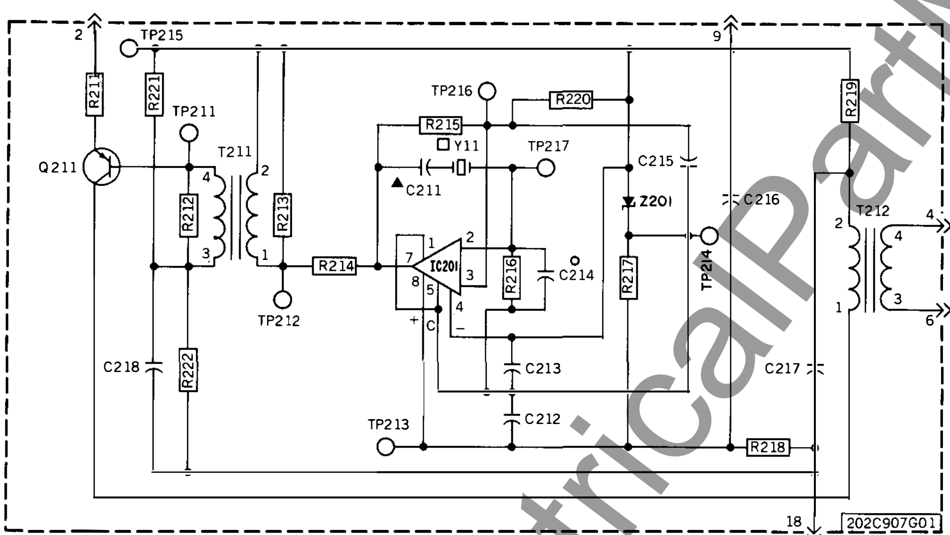
* *Fig. 11. Internal Schematic 30-200KHz Oscillator and Mixer Silicon Transistor Version*



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

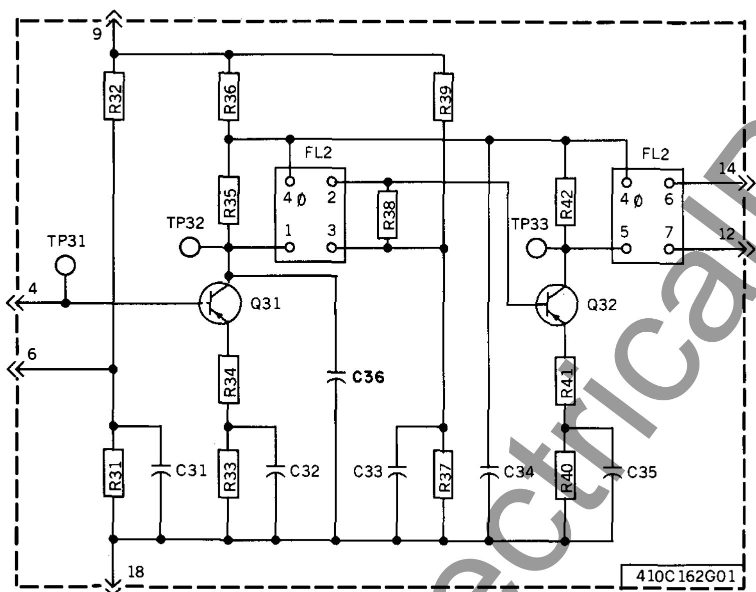
▲=C211 RANGES FROM 100Pf. TO 1,000Pf.

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

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

264C844

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



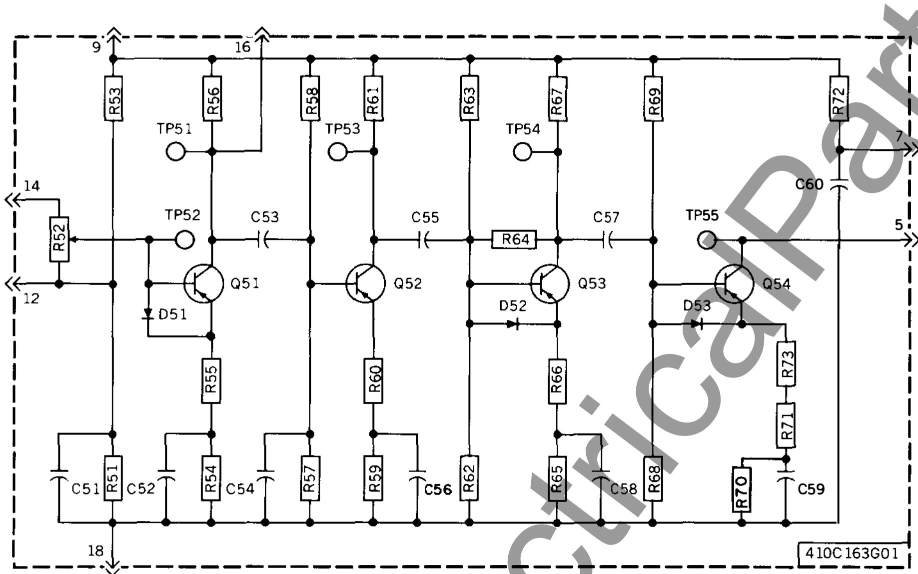
COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q31–Q32	849A441H03	2	2N4249
RESISTOR			
R34–R41	187A290H21	2	68Ω 1/2W ±5%
R36	184A763H15	1	330Ω 1/2W ±5%
R33–R40	184A763H23	2	680Ω 1/2W ±5%
R38	184A763H27	1	1K 1/2W ±5%
R31–R37	184A763H39	2	3.3K 1/2W ±5%
R35–R42	184A763H51	2	10K 1/2W ±5%
R32–R39	184A763H59	2	22K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

∅ = COMMON TERMINAL

264C856

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

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



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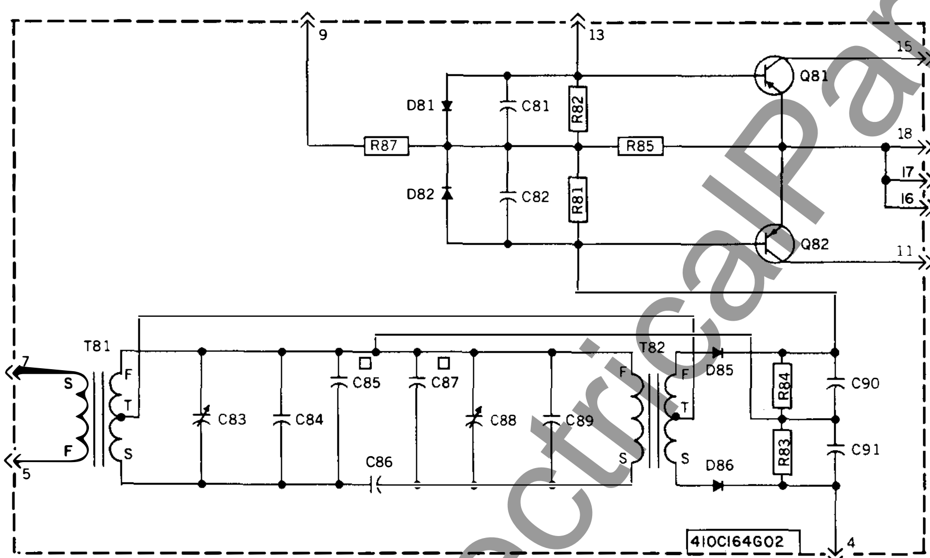
* *Fig. 14. Internal Schematic Amplifier and Limiter – Silicon Transistor Version*



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

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

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

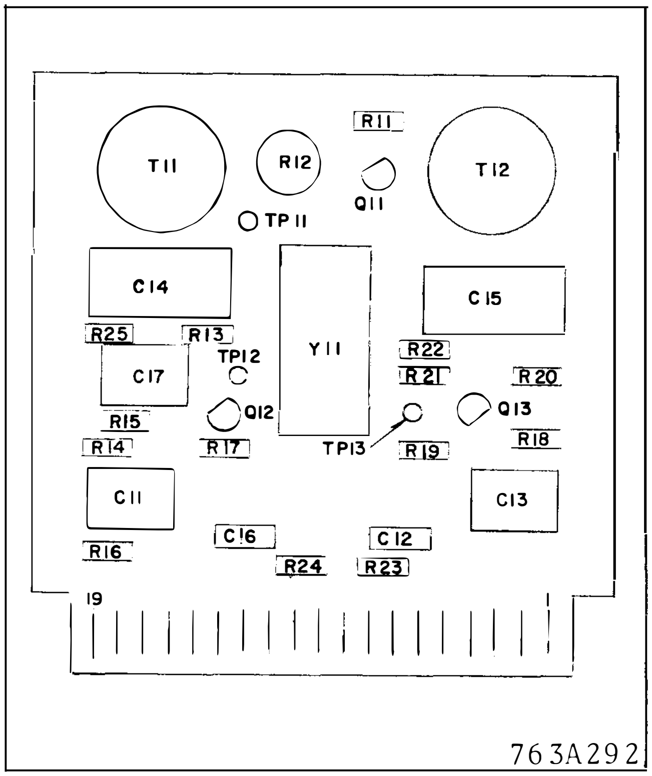

Fig. 16. Component Locations 30-200KHz. Oscillator and Mixer Silicon Transistor Version

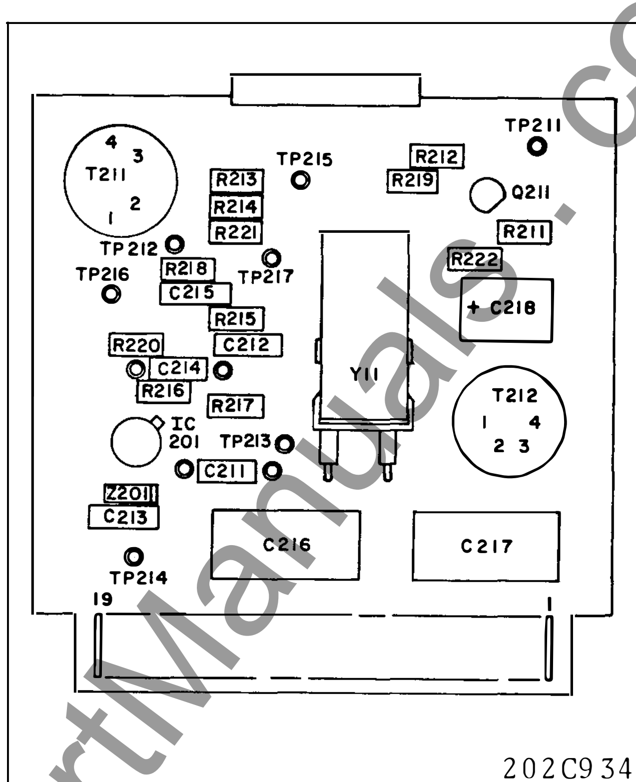

Fig. 17. Component Locations 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version

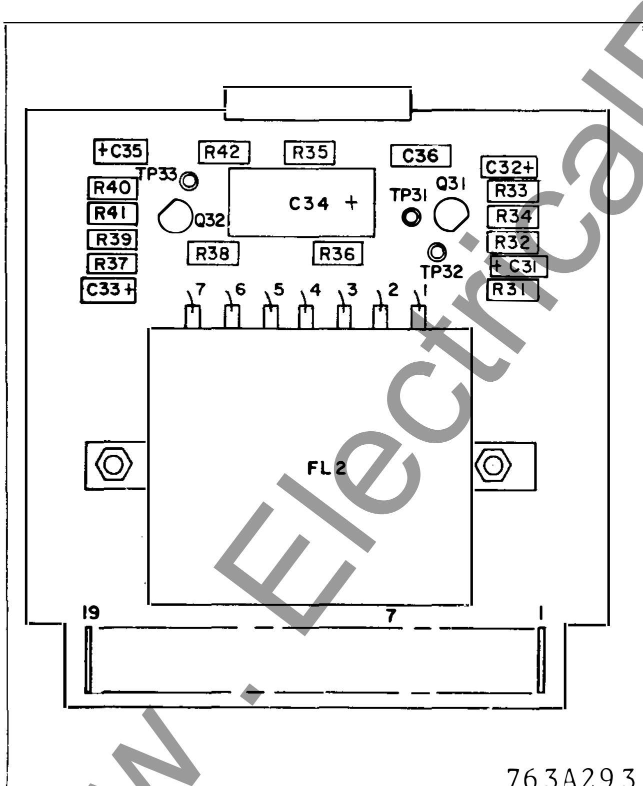

Fig. 18. Component Locations I.F. Amplifier – Silicon Transistor Version

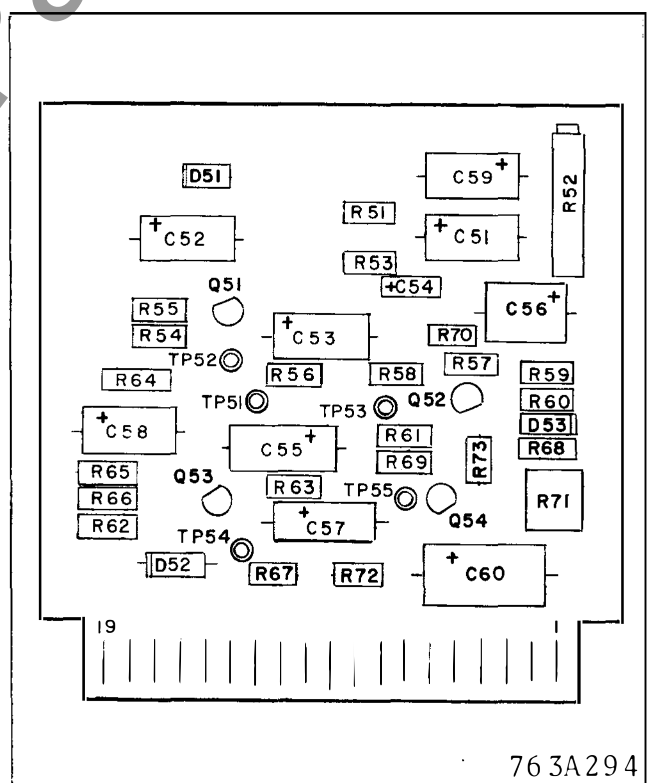

Fig. 19. Component Locations Amplifier and Limiter – Silicon Transistor Version

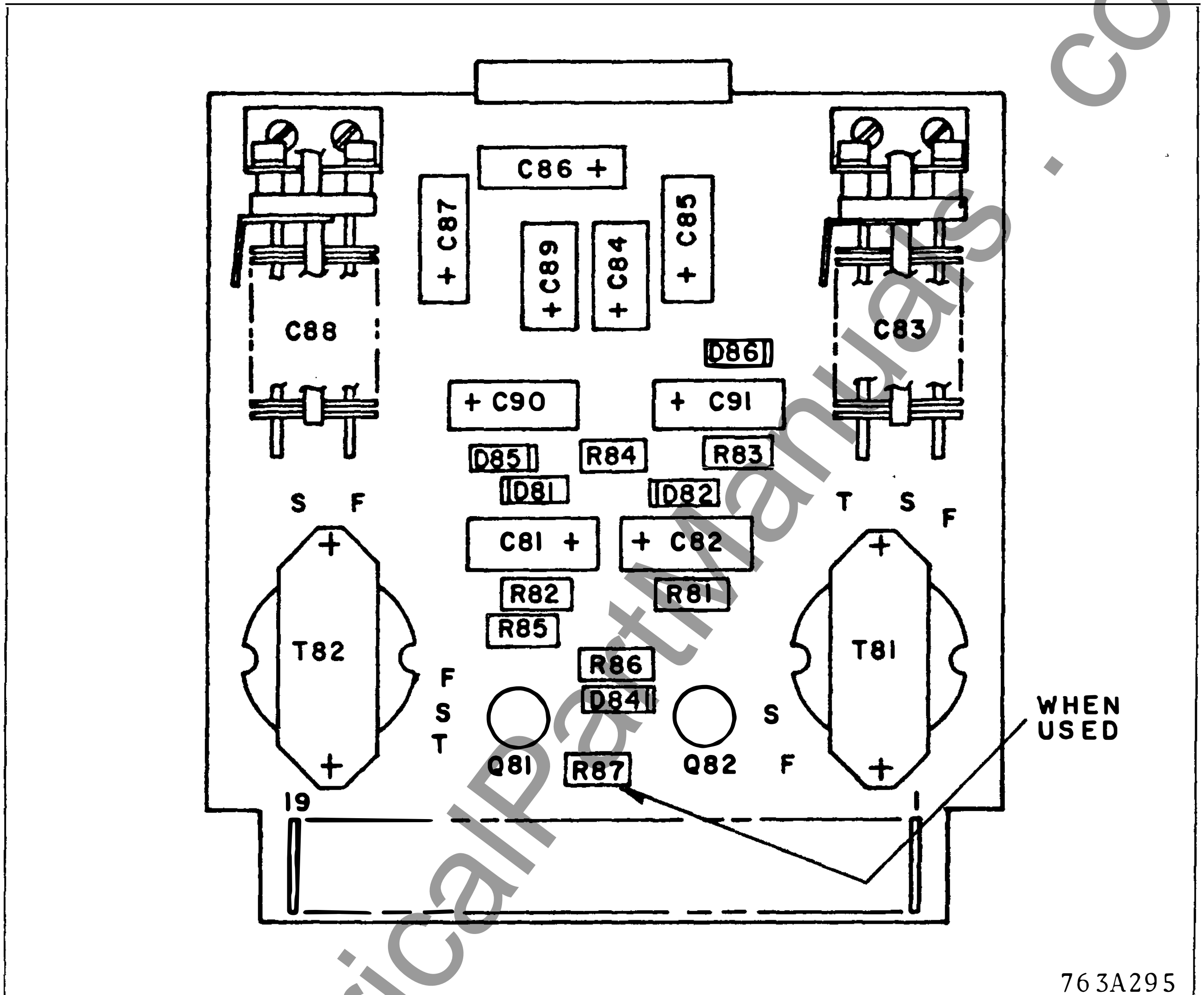

Fig. 20. Component Locations Discriminator – Silicon Transistor Version

WESTINGHOUSE ELECTRIC CORPORATION

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

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY SHIFT RECEIVER EQUIPMENT – WITH 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 kHz to 300 kHz, 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 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 Fig. 1 will show the location of these components in the circuit. The dotted lines inclosing 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 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

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

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restores all circuit connections, and all components and test points on the board are readily accessible.

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

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

OPERATION

Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of 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 KHz 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 and 2fc + 20 KHz.

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 20 KHz. 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 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 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 Hz. Similarly, the lower signal frequency is converted to 20 KHz + 100 Hz.

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 hertz. 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	30-300 KHz
Sensitivity (noise-free channel)	0.005 volt (65 db below 1 watt for limiting)
Input Impedance	5000 ohms minimum
Bandwidth (crystal filter)	down < 3 db at 220 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 Hz.
Frequency spacing	
A. For two or more signals over one-way channel.	500 Hertz minimum
B. For two-way channel.	1000 Hertz minimum between transmitter and adjacent receiver frequencies.
Receiver Output	Output transformer supplies the following squarewave 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 +55°C temperature around chassis.
Battery voltage variations	
Rated Voltage	Allowable variation
48 V.D.C.	42 – 56 V.D.C.
125 V.D.C.	105 – 140 V.D.C.
250 V.D.C.	210 – 280 V.D.C.
Battery Drain	0.20 a. at 48 V.D.C. 0.27 a. at 125 or 250 V.D.C.
Dimensions	Panel height – 10½" or 6 r.u. Panel width – 19"
Weight	13 lbs.

INSTALLATION

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

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or mal-functioning. 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 20KHz above the channel frequency. The frequency is fixed by the crystal used, except that it may be changed a few hertz by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that insures reliable starting of oscillation. The frequency at room temperature is usually several Hertz above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should be connected from the base of transistor Q54 to terminal 18 of the limiter. With 5 mv. of signal frequency on the receiver input (R5 at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting. The R52 adjusting screw then should be turned one turn farther in the direction to produce limiting.

Adjustment of the discriminator is made by capacitors C83 and C88. Apply to the receiver input a 5 mv. signal taken from an oscillator set at the center frequency of the channel. (R5 at zero.) Connect a 1.5 – 0 – 1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at 100 Hertz above and below center frequency.

MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity will detect gradual deterioration and permit its correction before failure can result. An overall check can be made with the attenuation control R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to drop out the alarm relay. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal or loss of receiver sensitivity.

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

It is advisable to record 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 Hz.)
Q81 and Q101	.25 (fc + 100 Hz.)
Q82 and Q102	20 (No signal or fc + 100 Hz.)
Q82 and Q102	.25 (fc − 100 Hz.)
Q103	20.5 (No signal)
Q104	.25 (No signal)
Q105	45 (No signal)

TABLE II

RECEIVER RF MEASUREMENTS

Collector of Transistor	Volts (fc + 100 Hz.)
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 Hertz to 330 KHz, input impedance 7.5 megohms.

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: 20KHz to 330KHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

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

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.

ADDENDUM

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

ELECTRICAL PARTS LIST

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

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
CR51	IN457A; 60V.; 200 MA.	184A855H07
CR52	IN475A; 60V.; 200 MA.	184A855H07
CR53	IN457A; 60V.; 200 MA.	184A855H07
CR81	IN91; 100V.; 150 MA.	182A881H04
CR82	IN91; 100V.; 150 MA.	182A881H04
CR83	IN91; 100V; 150 MA.	182A881H04
CR84	IN475A; 60V.; 200 MA.	184A885H07
CR85	IN628; 125V.; 30 MA.	184A855H12
CR86	IN628; 125V.; 30 MA.	184A855H12
CR101	IN457A; 60V.; 200 MA.	184A885H07
CR102	IN457A; 60V.; 200 MA.	184A885H07
CR104	IN457A; 60V.; 200 MA.	184A885H07
	DIODES – ZENER	
CR1	IN3027A; 20V. ±10%; 1W.	188A302H10
CR2	IN3027A; 20V. ±10%; 1W.	188A302H10
CR103	IN3686B; 20V. ± 5%; 750MW.	185A212H06
VR1	IN2828B; 45V. ± 5%; 50W.	184A854H06
VR2	IN2984B; 20V. ± 5%; 10W.	762A631H01
Z201	IN753A; 6.2V. ± 5%; 400 MW.	862A606H01
	POTENTIOMETERS	
R5	10K; 2W.	185A086H10
R7	250K; 2W.	185A086H11
R12	1K; ¼W.	629A430H02
R52	1K; ¼W.	629A645H04
R156	2.5K; ¼W.	629A645H07

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R1	400 ohms ±5%; 25 W.	1202587
R2	26.5 ohms ±5%; 40 W. (For 48 V. Supply)	04D1299H44
R2	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R2	300 ohms ±5%; 50 W. (For 250 V. Supply)	763A963H01
R3	150 ohms ±5%; 40 W. (For 125 V. Supply)	1202499
R3	500 ohms ±5%; 100 W. (For 250 V. Supply)	629A843H03
R4	100 ohms ±5%; 1 W. Composition	187A643H03
R6	10K ±5%; ½ W. Composition	184A763H51
R8	100K ±5%; 1 W. Composition	187A643H75
R11	10K ±5%; ½ W. Composition	184A763H51
R13	5.6K ±5%; ½ W. Composition	184A763H45
R14	3.3K ±5%; ½ W. Composition	184A763H39
R15	330 ohms ±5%; ½ W. Composition	184A763H15
R16	10K ±5%; ½ W. Composition	184A763H51
R17	33K ±5%; ½ W. Composition	184A763H63
R18	3.3K ±5%; ½ W. Composition	184A763H39
R19	3.3K ±5%; ½ W. Composition	184A763H39
R20	10K ±5%; ½ W. Composition	184A763H51
R21	33K ±5%; ½ W. Composition	184A763H63
R22	330 ohms ±5%; ½ W. Composition	184A763H15
R23	10K ±5%; ½ W. Composition	184A763H51
R31	3.3K ±5%; ½ W. Composition	184A763H39
R32	22K ±5%; ½ W. Composition	184A763H59
R33	680 ohms ±5%; ½ W. Composition	184A763H23
R34	68 ohms ±5%; ½ W. Composition	187A290H21
R35	10K ±5%; ½ W. Composition	184A763H51
R36	330 ohms ±5%; ½ W. Composition	184A763H15
R37	3.3K ±5%; ½ W. Composition	184A763H39
R38	1000 ohms ±5%; ½ W. Composition	184A763H27
R39	22K ±5%; ½ W. Composition	184A763H59
R40	680 ohms ±5%; ½ W. Composition	184A763H23
R41	68 ohms ±5%; ½ W. Composition	187A290H21
R42	10K ±5%; ½ W. Composition	184A763H51
R51	4.7K ±5%; ½ W. Composition	184A763H43
R53	27K ±5%; ½ W. Composition	184A763H61
R54	2.2K ±5%; ½ W. Composition	187A763H35

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R55	27 ohms ±5%; ½ W. Composition	187A290H11
R56	10K ±5%; ½ W. Composition	184A763H51
R57	4.7K ±5%; ½ W. Composition	184A763H43
R58	27K ±5%; ½ W. Composition	184A763H61
R59	1.5K ±5%; ½ W. Composition	184A763H31
R60	180 ohms ±5%; ½ W. Composition	184A763H09
R61	4.7K ±5%; ½ W. Composition	184A763H43
R62	1.5K ±5%; ½ W. Composition	184A763H31
R63	3.3K ±5%; ½ W. Composition	184A763H63
R64	2.7K ±5%; ½ W. Composition	184A763H37
R65	680 ohms ±5%; ½ W. Composition	184A763H23
R66	68 ohms ±5%; ½ W. Composition	187A290H21
R67	4.7K ±5%; ½ W. Composition	184A763H43
R68	2.7K ±5%; ½ W. Composition	184A763H37
R69	18K ±5%; ½ W. Composition	184A763H57
R70	220 ohms ±5%; ½ W. Composition	184A763H11
R71	270 ohms ±2%; Nickel Iron W.W.	09D8326G19
R72	330 ohms ±5%; ½ W. Composition	184A763H15
R81	4.7K ±5%; ½ W. Composition	184A763H43
R82	4.7K ±5%; ½ W. Composition	184A763H43
R83	2.2K ±5%; ½ W. Composition	184A763H35
R84	2.2K ±5%; ½ W. Composition	184A763H35
R85	6.8K ±5%; ½ W. Composition	184A763H47
R101	22K ±5%; ½ W. Composition	184A763H59
R102	22K ±5%; ½ W. Composition	184A763H59
R103	82K ±5%; ½ W. Composition	184A763H73
R104	82K ±5%; ½ W. Composition	184A763H73
R105	10K ±5%; ½ W. Composition	184A763H51
R106	39K ±5%; ½ W. Composition	184A763H65
R107	1K ±5%; ½ W. Composition	184A763H27
R108	1K ±5%; ½ W. Composition	184A763H27
R109	1K ±5%; 1 W. Composition	184A763H27
R110	10K ±5%; 1 W. Composition	184A763H51
R111	22K ±5%; ½ W. Composition	184A763H59
R112	10K ±5%; ½ W. Composition	184A763H51
R113	10K ±5%; ½ W. Composition	184A763H51

ELECTRICAL PARTS LIST (Cont'd.)

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	TRANSFORMERS	
T11	Toroidal type, 10000/400 ohms	1962797
T12	Toroidal type, 25000/300 ohms	1962697
T81	Pot. Core type	606B533G01
T82	Pot. Core Type	606B533G02
	TRANSISTORS	
Q11	2N652A	184A638H16
Q12	2N1396	848A892H01
Q13	2N1396	848A892H01
Q31	2N274	187A270H01
Q32	2N274	187A270H01
Q51	2N396	762A575H03
Q52	2N396	762A575H03
Q53	2N396	763A575H03
Q54	2N396	762A585H03
Q81	2N652A	184A638H16
Q82	2N652A	184A638H16
Q101	2N699	184A638H19
Q102	2N699	184A638H19
Q103	2N696	762A585H01
Q104	2N697	184A638H18
Q105	2N699	184A638H19
	MISCELLANEOUS	
Y11	Oscillator Crystal (Frequency 20kHz above Channel Frequency)	762A800H01 + (Req. Freq.)
FL1	Crystal Input Filter	401C466 + (Req. Freq.)
Fl2	I.F. Filter	762A613G01
PL	Pilot Light Bulb — For 48 V. Supply	187A133H02
	Pilot Light Bulb — For 125 or 250 V. Supply	183A955H01
F1, F2	Fuse, 1.5 A.	11D9195H26
AL	Alarm Relay	408C062H07
IC201	Fairchild UA 710C (Int. Ckt.)	201C826H04

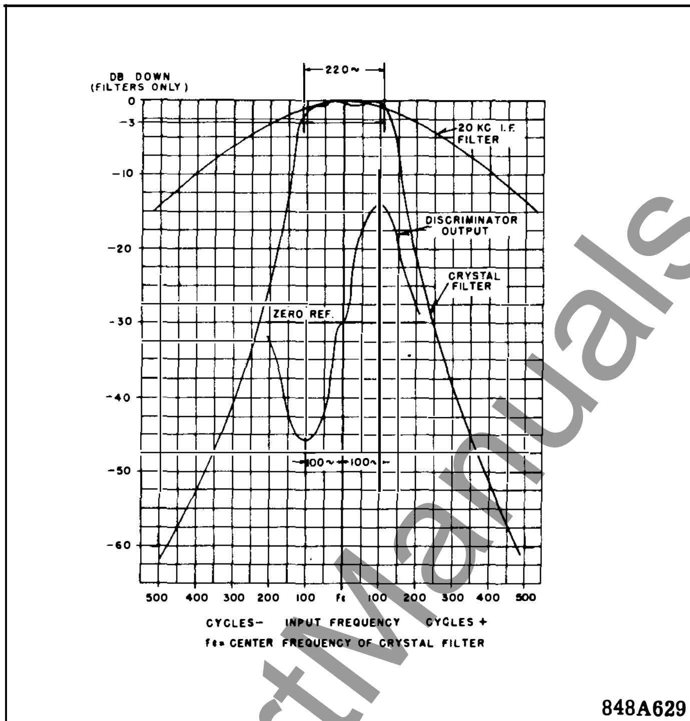


Fig. 2. Filter and discriminator characteristics of TCF receivers.

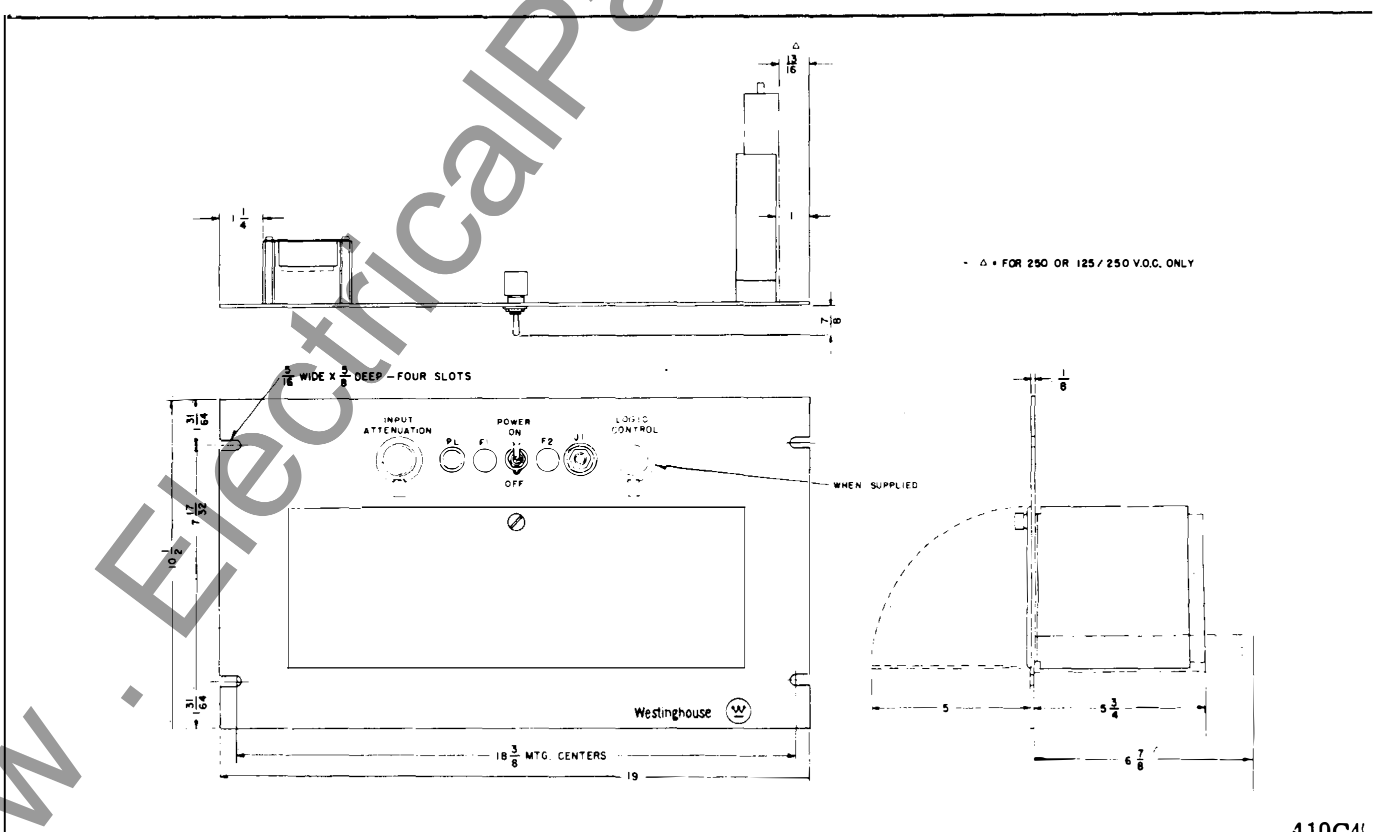


Fig. 3. Outline of the Type TCF Receiver Assembly.

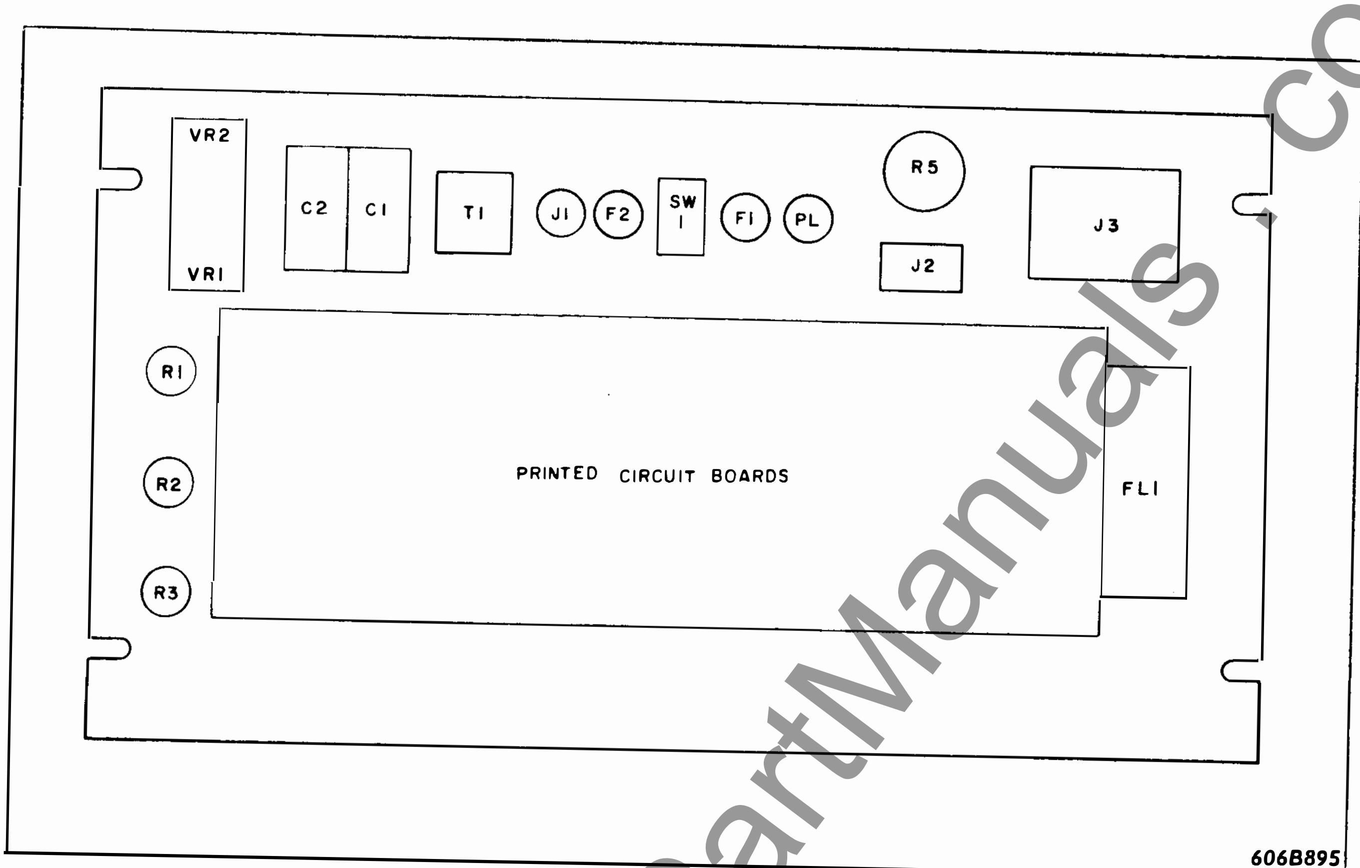


Fig. 4 Component locations on Type TCF Receiver Assembly.

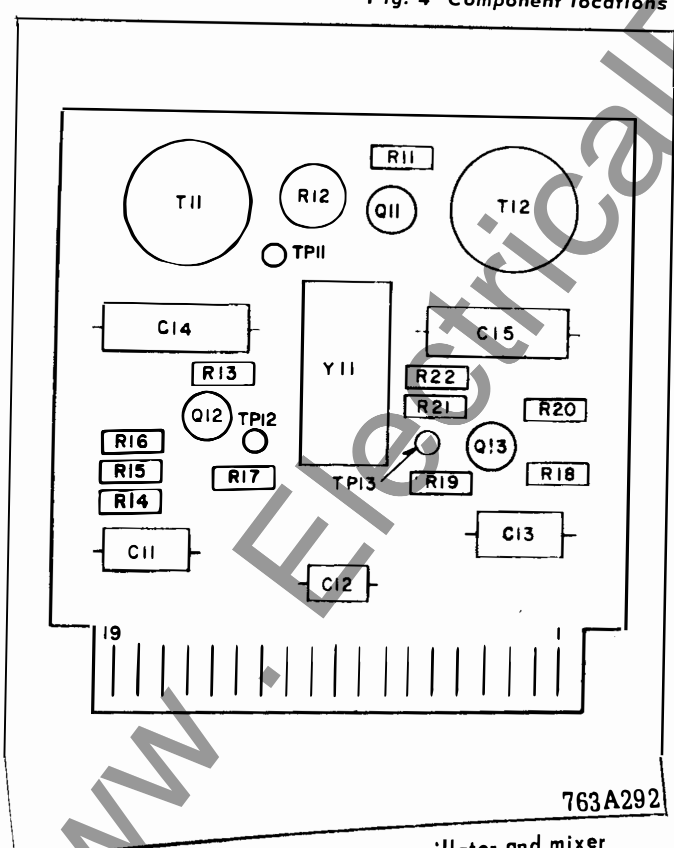


Fig. 5 Component locations on oscillator and mixer printed circuit board.

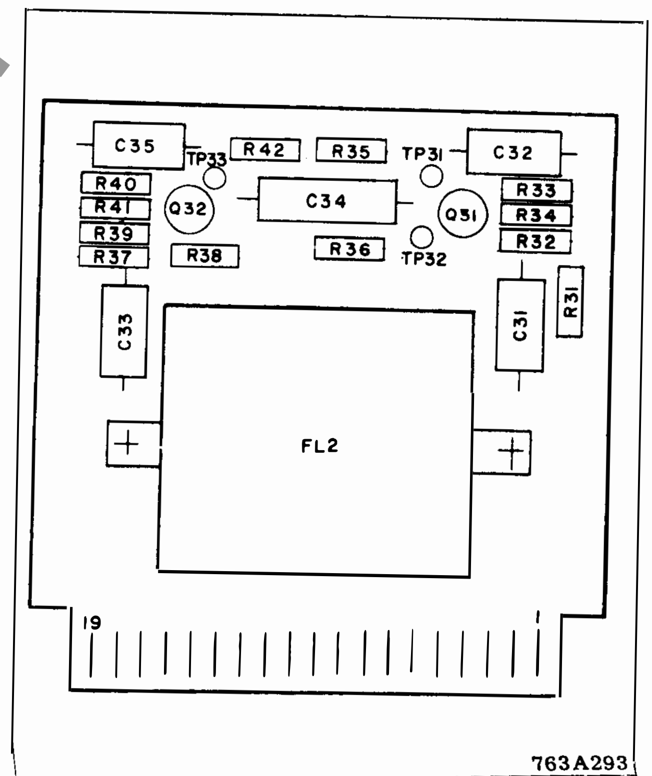


Fig. 6 Component locations on I.F. amplifier printed circuit board.

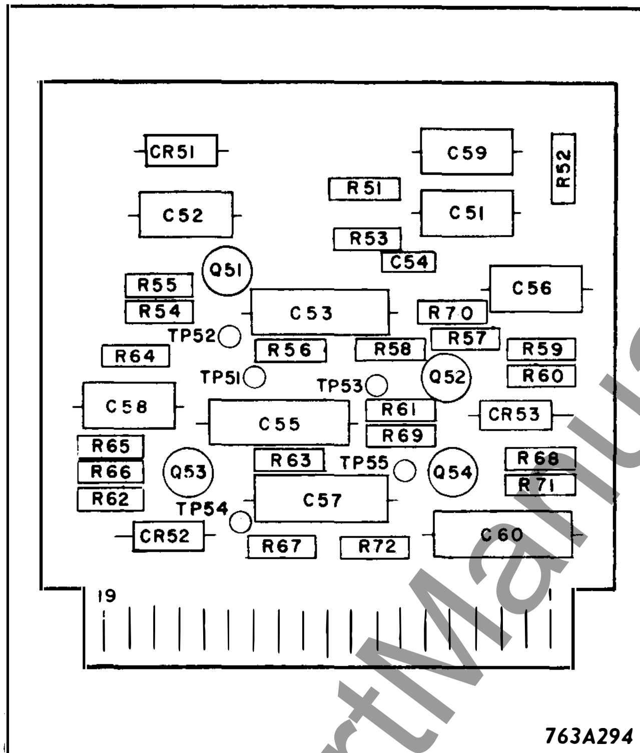


Fig. 7 Component locations on amplifier and limiter printed circuit board.

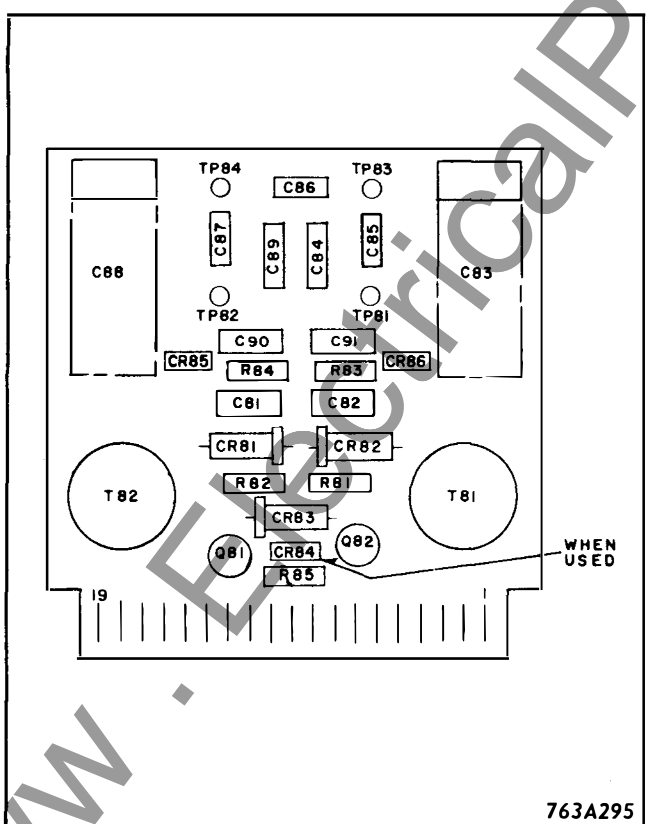


Fig. 8 Component locations on discriminator printed circuit board.

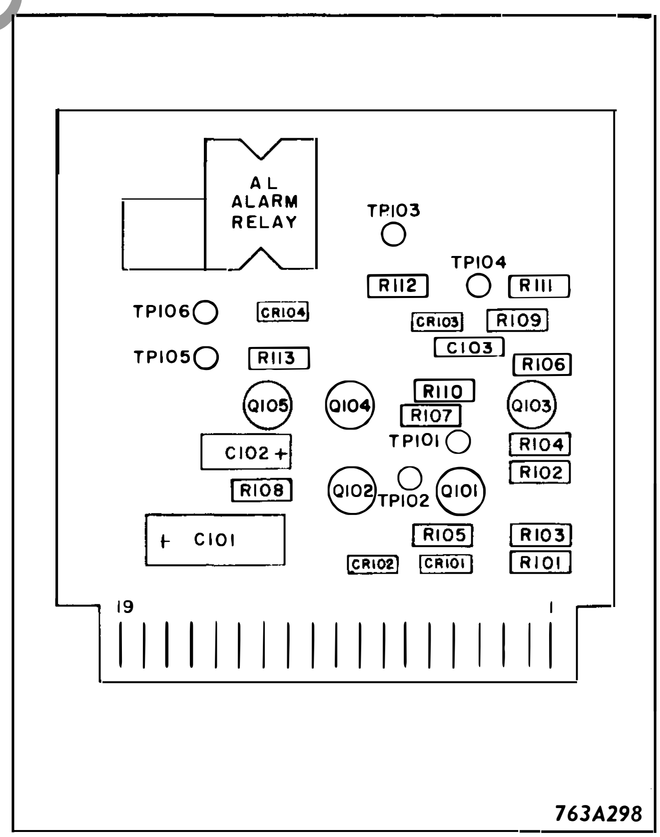
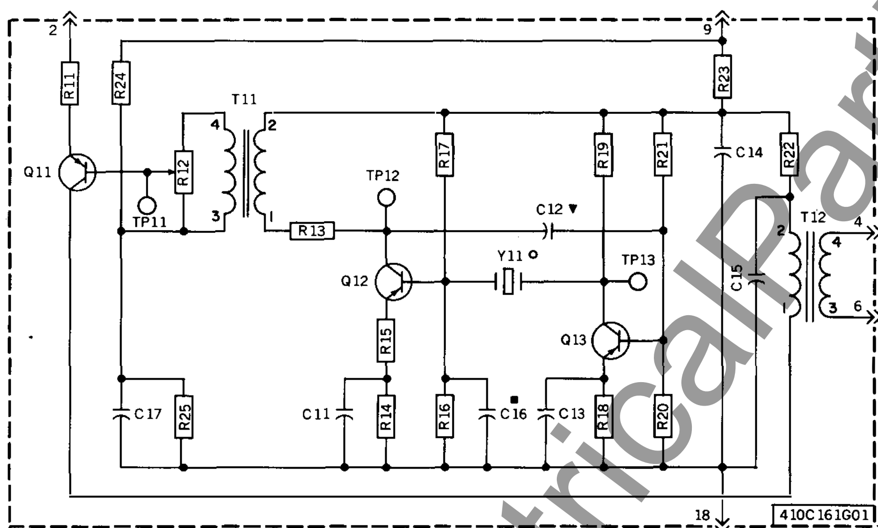


Fig. 9 Component locations on output printed circuit board.



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

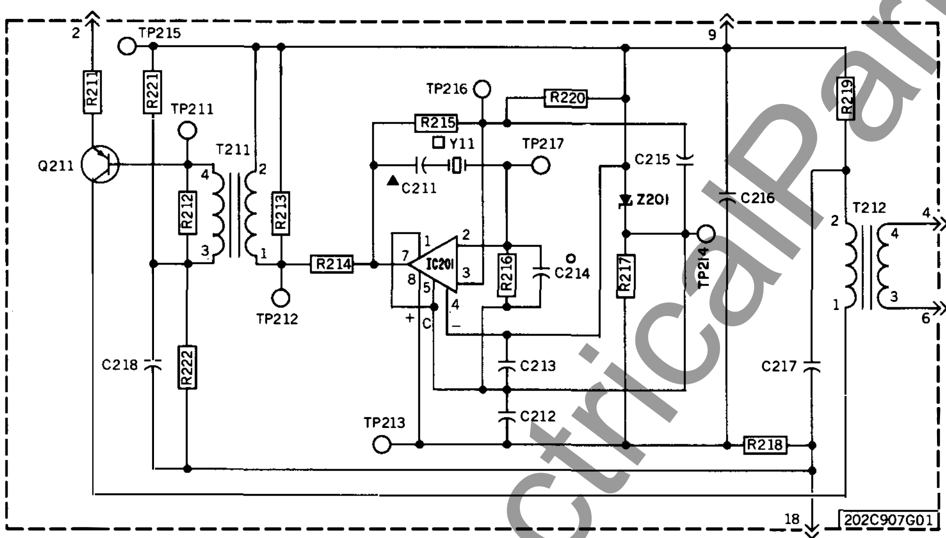
▼ =C12 RANGE 4 TO 390 Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

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

o =Y11 RANGE–50 TO 220 KHZ.

264C855

Fig. 10 Internal Schematic 30-200KHz Oscillator and Mixer Silicon Transistor Version



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

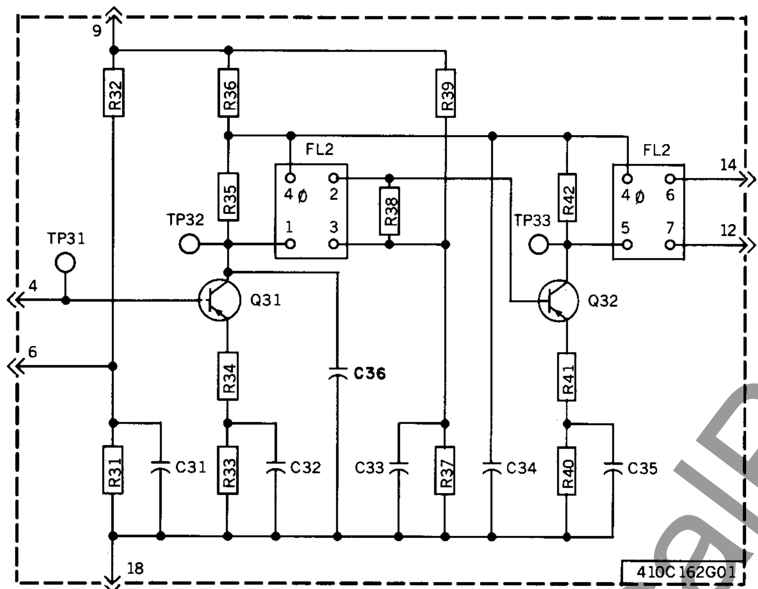
▲ = C211 RANGES FROM 100Pf. TO 1,000Pf.

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

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

264C844

Fig. 11 Internal Schematic 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version.

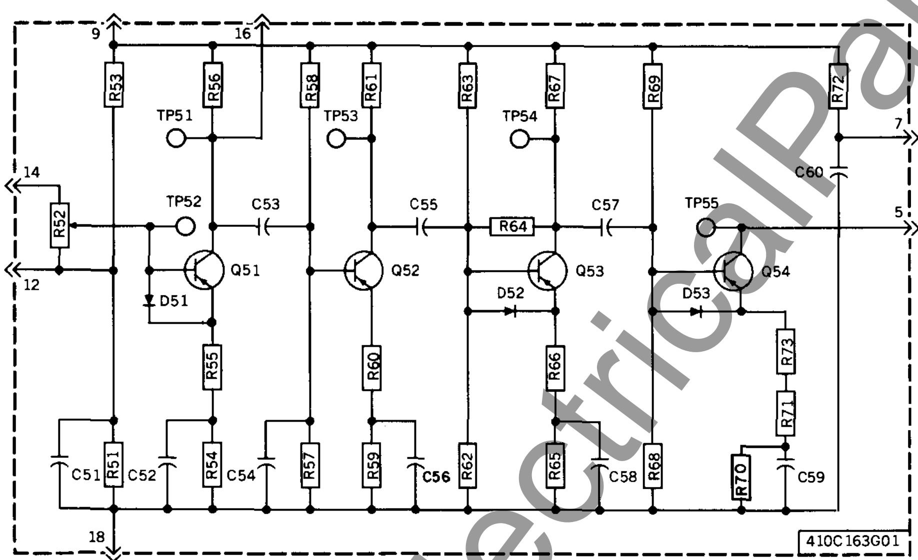


COMPONENT	STYLE	REQ.	REF.
TRANSISTOR			
Q31–Q32	849A441H03	2	2N4249
RESISTOR			
R34–R41	187A290H21	2	68Ω 1/2W ±5%
R36	184A763H15	1	330Ω 1/2W ±5%
R33–R40	184A763H23	2	680Ω 1/2W ±5%
R38	184A763H27	1	1K 1/2W ±5%
R31–R37	184A763H39	2	3.3K 1/2W ±5%
R35–R42	184A763H51	2	10K 1/2W ±5%
R32–R39	184A763H59	2	22K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

ø = COMMON TERMINAL

264C856

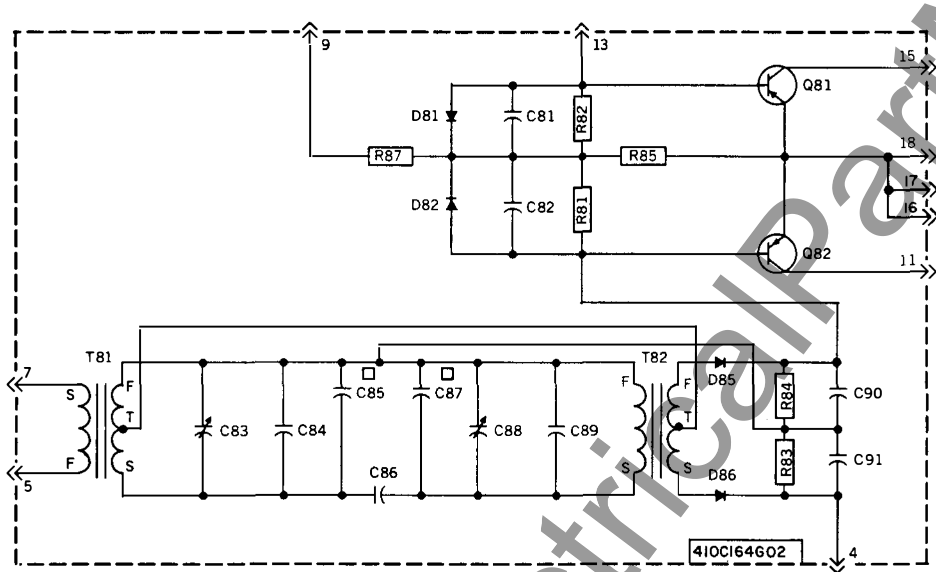
Fig. 12 Internal Schematic I.F. Amplifier – Silicon Transistor Version.



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

264C841

Fig. 13 Internal Schematic Amplifier and Limiter – Silicon Transistor Version



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

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

264C843

Fig. 14 Internal Schematic Discriminator – Silicon Transistor Version.

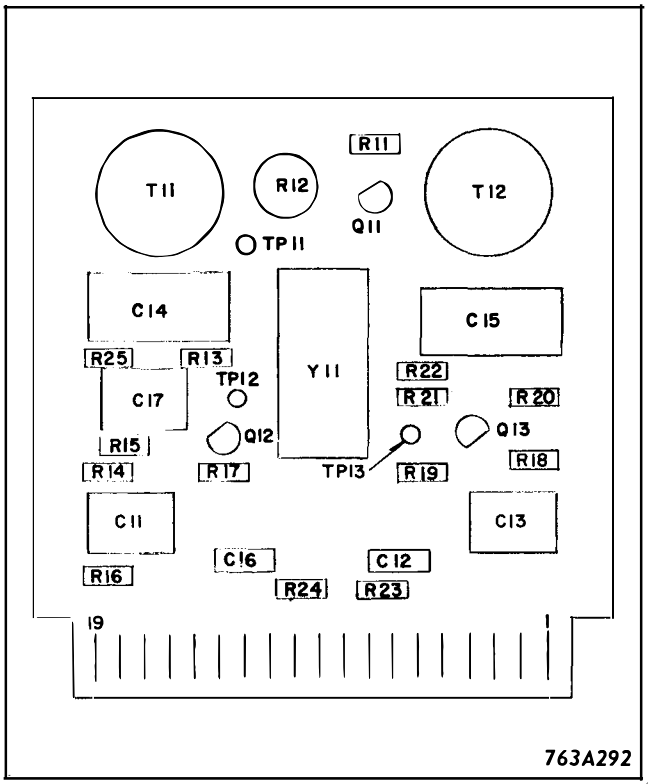


Fig. 15 Component Locations 30-200KHz. Oscillator and Mixer Silicon Transistor Version.

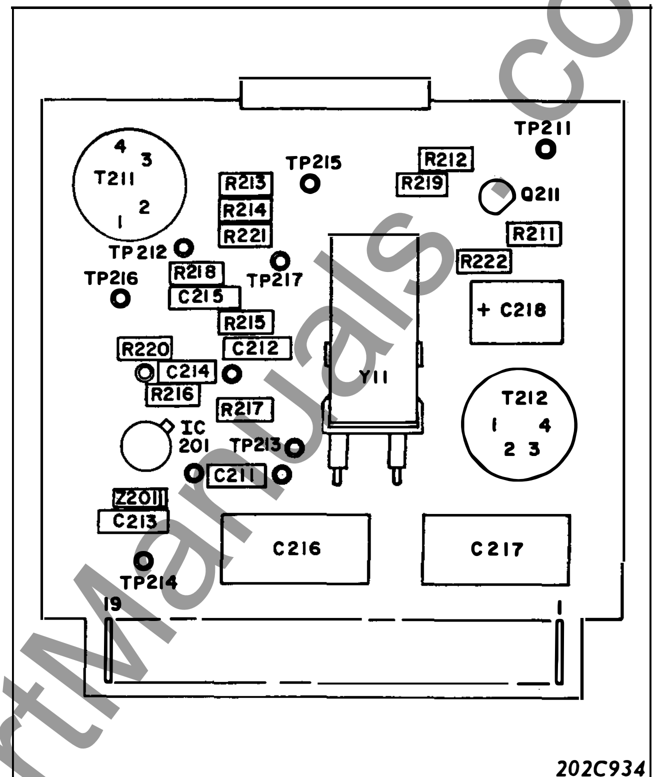


Fig. 16 Component Locations 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version.

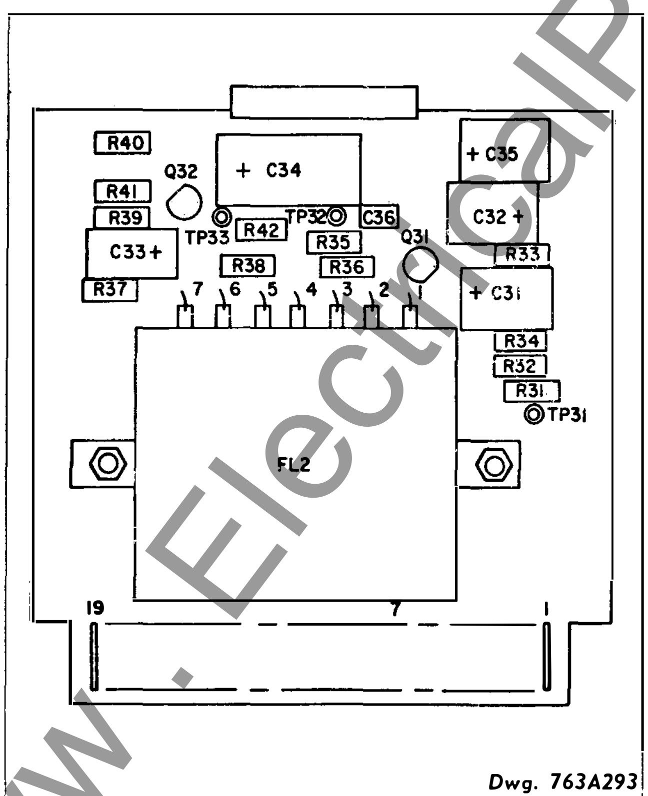


Fig. 17 Component Locations I.F. Amplifier – Silicon Transistor Version.

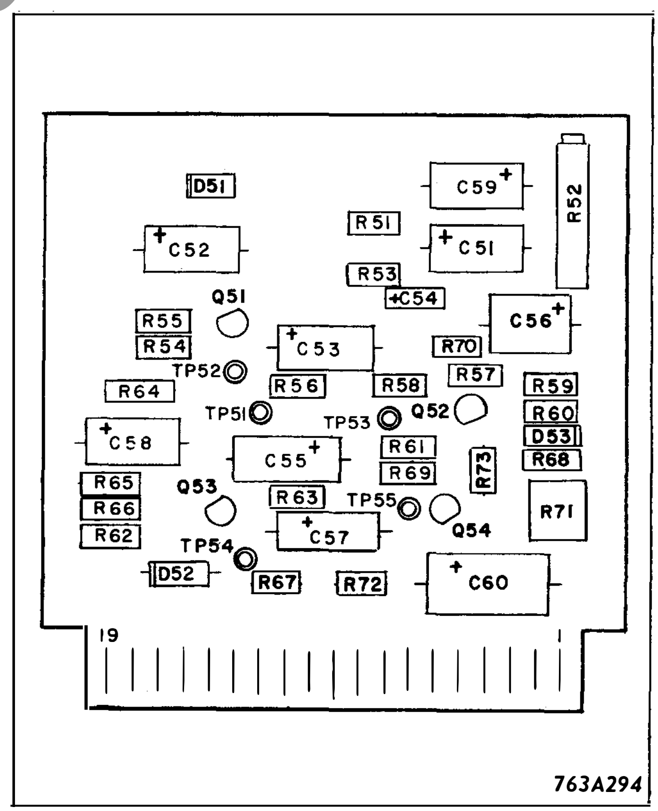


Fig. 18 Component Locations Amplifier and Limiter – Silicon Transistor Version

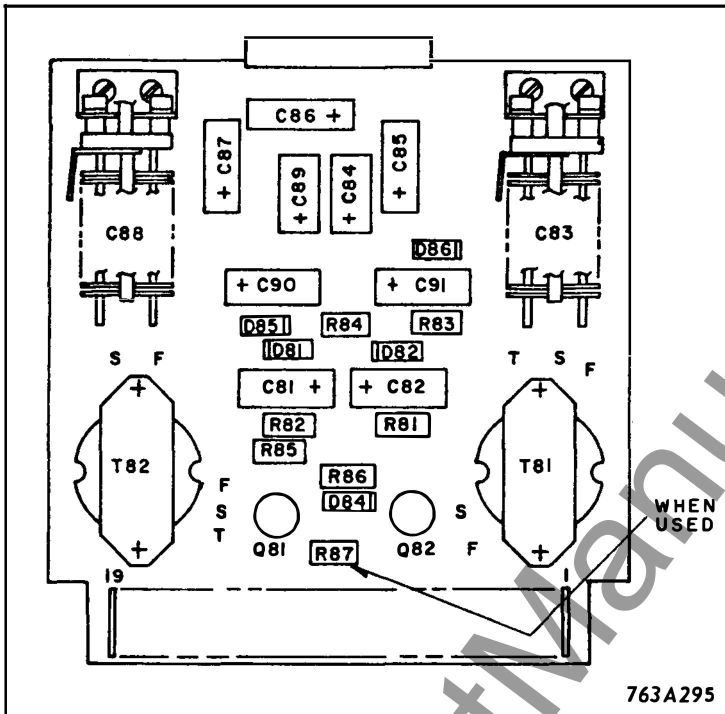


Fig. 19 Component Locations Discriminator – Silicon Transistor Version

WESTINGHOUSE ELECTRIC CORPORATION

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

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER TRANSMITTER EQUIPMENT – 10 WATT OUTPUT – FOR MULTI-STATION SUPERVISORY CONTROL

CAUTION: It is recommended that the user of this equipment become thoroughly familiar 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 power line carrier transmitter equipment for multi-station supervisory control applications is similiar in appearance to the TCF 1 watt/10 watt transmitter for transfer-trip relaying applications. However, because a Guard frequency cannot be used in multi-station supervisory control applications, the transmitter is connected so that it has no output until the keying contact is closed. It then provides 10 watts output at a frequency 100 hertz below the channel center frequency (which would be called the Trip frequency in transfer-trip applications). The center frequency (fc) of the channel can have any value between 30kHz and 300kHz in 0.5kHz steps. This high frequency is superposed on a high voltage power line through a line tuner and coupling equipment, and through similar coupling equipment at remote stations it activates receiving equipment that is tuned to the same frequency.

The transmitter is designed to hold its frequency within close limits since it is used with receiving equipment that has a high degree of frequency selectivity. This minimizes the possibility of false operation of a receiver resulting from random transient frequencies produced by line disturbances or by other causes.

CONSTRUCTION

The 10 watt TCF transmitter unit is mounted on a standard 19-inch panel 12¼ inches (7 rack units) high with edge slots for mounting on a standard relay rack. All components are mounted on the rear of the panel. Fuses, a pilot light, a power switch and a jack for metering the amplifier collector current are accessible from the front of the panel.See Fig. 5. The components mounted on each printed board or other sub-assembly are shown enclosed by dotted lines on the internal schematic, Fig. 1. The location of components on the two printed circuit boards are shown on separate illustrations, Fig. 3 & 4.

External connections to the assembly are made through a 12-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2.

OPERATION

The transmitter is made up of four main stages and two filters. The stages include two crystal oscillators operating at frequencies that differ by the desired channel frequency, a mixer and buffer amplifier, a driver stage and a power amplifier. One filter is located between the driver and the power amplifier and the final filter removes harmonics that may be generated by distortion in the power amplifier.

A single crystal designed for oscillation in the 30kHz to 300kHz range cannot be forced to oscillate away from its natural frequency by as much as ±100 hertz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2MHz range. The crystals are Y1 and Y2 of Fig. 1. The frequency of Y2 is 2.00 MHz when operated with a specified amount of series capacity, and the frequency of Y1 is 2.00 MHz plus the channel frequency, or 2.03 MHz to 2.30 MHz. Capacitor C55 and crystal Y2 in series are connected between the positive side of the supply voltage and the base of transistor Q51, which operates in the emitter follower mode. The emitter is coupled to the base through C57, and with Y2 removed the base of Q51 would be held at approximately the midpoint of the supply voltage by R51 and R52. The crystal serves as a series-resonant circuit with very high inductance and low capacitance. The circuit can be made to oscillate at other than the natural frequency of the crystal by varying the series capacitor, C55. Increasing C55 will lower the frequency of oscillations and reducing C55 will raise the frequency.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes D51 and D52. By adjustment of C52 this circuit can be made to oscillate at 100 hertz above its marked frequency. This adjustment is required when the transmitter must have a Guard frequency output. Capacitor C53 is not effective until D51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until a voltage of sufficient magnitude is applied at terminal 3 of the printed circuit board. In two-frequency applications, 45 V.D.C. is so applied by closure of a control or keying contact, but in the single-frequency application terminal 3 is permanently connected to the 45 volt supply. With D51 conducting, C53 is effectively in parallel with C52, and adjustment of C53 will reduce the frequency by 200 hertz.

The crystals taken individually have a greater variation of frequency with temperature than would be acceptable. However, by proper matching of the two crystals, the variation in their difference frequency can be kept within limits that permit holding the frequency stability of the overall transmitter to ±10 hertz over a temperature range of -20 to +55°C.

The frequencies produced by the two oscillators are coupled to the base of mixer transistor Q53 through C62 and C63. The sum of the two frequencies is so high that a negligible amount appears on the secondary of transformer T51, but the difference frequency is accepted and amplified by Q53 and Q54.

In a 1 watt/10 watt transmitter for transfer-trip relaying, the output is increased from 1 to 10 watts by closure of the same contact that changes the frequency from Guard to Trip. This contact applies 45 V.D.C. at terminal 3 of the printed circuit board, and thus supplies base input to transistor Q55 through diode D53 and resistor R72. This in effect places potentiometer R70 in parallel with emitter resistor R68, and by adjusting the amount of resistance in R70 that is not bypassed by C66 the output of buffer-amplifier transistor Q54 can be increased by the amount required to obtain 10 watts output from the transmitter. In the transmitter for multi-stations supervisory control D51 and Q55 are conductive at all times, and the transmitter will have output at the desired level and frequency when voltage is supplied to the collectors of Q54 and driver stage transistors Q56 and Q57 by closure of a control contact connected between terminals J3-7 and J3-8. As is shown on the internal schematic, Fig. 1, the voltage for the keying circuit is obtained from the 45-volt regulated supply in the transmitter, and opening the single power switch deenergizes both the transmitter and the keying circuit.

The driver stage consists of transistors Q56 and Q57 connected in a conventional push-pull circuit with input supplied from the collector of Q54 through transformer T52. Thermistor R73 and resistors R74 and R75 are connected to provide a variable bias that reduces the effect of varying ambient temperature on the input level.

The driver filter, FL101, consists of a series resonant inductor and capacitor connected between the driver and power amplifier stages by appropriate transformers T1 and T2. This filter greatly improves the waveform of the signal applied to the power amplifier.

The power amplifier uses two series-connected power transistors, Q101 and Q102, operating as a class B push-pull amplifier with single-ended output. Diodes D101 and D103 provide protection for the base-emitter junctions of the power transistors. Zener diodes D105 and D106 protect the collector-emitter junctions from surges that might come in from the power line through the coaxial cable.

The output transformer T3 couples the power transistors to the output filter FL102. The output filter includes two trap circuits (L102, C_B and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G1 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line tuner and coaxial cable. Auto-transformer T4 matches the filter impedance to coaxial cable of 50, 60, or 70 ohms.

The series resonant circuit composed of L105 and C_E is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, thus providing a reverse impedance that is free of possible "across-the-line" resonances.

The power supply is a series-type transistorized d-c voltage regulator which has a very low standby current drain when there is no output current demand. The zener diode Z1 holds a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the d-c voltage drop through transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage. The zener diode Z2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 bypass r.f. or transient voltage to ground, thus preventing damage to the transistor circuits.

CHARACTERISTICS

Frequency range	30-300 kHz
Output	10 watts (into 50 to 70 ohm resistive load)
Frequency stability	±10 hertz from -20°C to +55°C.
Frequency spacing	3 kHz min. between transmitter and adjacent receiver frequencies.
Harmonics	Down 55 db (min.) from output level.
Input Voltage	48 or 125 v.d.c.
Supply voltage variation	42-56 v. for nom. 48 v. supply 105-140 v. for nom. 125 v. supply.
Battery drain-not transmitting	0.25 a.
Battery drain-transmitting	1.15 a. for 48 v. supply 0.9 a. for 125 v. supply
Keying circuit current	0.02 a.
Temperature range	-20 to 55°C. around chassis.
Dimensions	Panel height - 12¼" or 7 r.u. Panel width - 19"
Weight	12 lbs.

INSTALLATION

The TCF transmitter 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

The TCF transmitter is shipped with the power output control R64 adjusted to the position that would be used for 10 watts Trip output into a 60 ohm load. The single 10 watt output required for multi-station supervisory control is obtained with a single setting of R64. In case repairs have made readjustment necessary the following procedure is preferred. The coaxial cable should be disconnected from the assembly terminals and replaced with a 50 to 70 ohm non-inductive resistor of at least a 10 watt rating. Use the value of the expected input impedance of the coaxial cable and line tuner. If this is not known, assume 60 ohms. Connect the T4 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn power control R64 to minimum (full counterclockwise). Turn on the power switch on the panel and note the d-c voltage across terminals 5 and 7 of J3. If this is in the range of 42 to 46 volts. rotate R64 clockwise to obtain 4 or 5 volts across the load resistor used. At this point check the adjustment of the series output tuning coil L105 by loosening the knurled shaft-locking nut and moving the adjustable core in and out a small amount from its initial position. Leave it at the point of maximum voltage across the load resistor used. Then rotate R64 farther clockwise to obtain the correct voltage for 10 watts in the load resistor, as shown in the following table.

T106 Tap	Voltage for 10 Watts Output
50	22.4
60	24.5
70	26.5

Recheck the adjustment of L105 for maximum output voltage and readjust R64 for a 10 watt output if necessary. Tighten the locking nut on L105. Open the power switch, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

Follow the procedure outlined in the line tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. It is factory tuned for maximum second and third harmonic rejection, and for series resonance (maximum output at the fundamental frequency) with a 60-ohm load. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection and no change should be made in these settings unless suitable instruments are available for measuring the second and third harmonic present in the transmitter output.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals, this can be done by turning the matched pair 180° and inserting a crystal in its proper socket with the other crystal unconnected. A sensitive frequency counter with a range of at least 2.3 megahertz can be connected from TP51 to TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter and avoids some error from the effect of the counter input capacitance on the oscillator circuit). While measurement of the oscillator crystals individually is necessary for the initial adjustment of the oscillators, generally any subsequent checks may be made with a lower range counter connected at the transmitter output. If a minor adjustment of the output frequency should be needed, this can be made with capacitor C53.

Q56-Q57 Bias Adjustment

The push-pull output stages of the transmitter board are normally shipped correctly biased. If any components involved in these stages have beem changed, then it may be necessary to recheck the biasing of this stage.

Unsolder the lead from terminal 2 of transformer T1 (just above FL101) and temporarily connect a low-range d-c milliammeter (0-1.0 ma) between the removed lead (+) and T1 terminal 2 (-). Turn the slotted control on the small potentiometer to full counterclockwise. Now apply power to the TCF carrier set, but do not transmit carrier. This can be done by removing the crystals. Advance the potentiometer clockwise until the milliammeter reads 0.2 ma. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T1. Replace the crystals and again apply d-c power to reenergize the transmitter. Check output, etc. of transmitter as previously described.

MAINTENANCE

Periodic checks of the transmitter power output will detect impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output at such times, making any necessary readjustments to return the equipment to its initial settings.

Voltage values should be recorded 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. Readings may vary as much as ±20%.

TABLE I

TRANSMITTER D-C MEASUREMENTS

Note: All voltages are positive with respect to Neg. 45 V. (TP51). All voltages read with d-c VTVM.

Test Point	Voltage at 10 watts Output
TP52	20
TP53	5.4
TP54	3.4
TP55	18.5
TP56	18.5
TP57	<1
TP58	45
TP59	<1
TP101	0
TP103	21 ± 2
TP105	44.0

TABLE II

TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages subject to variations, depending upon frequency and transistor characteristics. T51-3 = Terminal 3 of transformer T51. Other transformer terminals identified similarly. All voltages read with a-c VTVM.

Test Point	Voltage at 10 Watts Output
TP54 to TP51	0.015-0.03
TP57 to TP51	0.3 -1.2
TP59 to TP51	0.3 -1.2
T1-1 to TP51	5.6
T1-3 to TP51	4.9
T1-4 to Gnd.	2.0
T2-1 to Gnd.	1.85
TP101 to TP103	17.0
TP103 to TP105	17.0
T3-4 to Gnd.	112
T4-2 to Gnd.	110
TP109 to Gnd.	31
J102 to Gnd.	24.5

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. 60-ohm 10-watt non-inductive resistor.

b. 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.

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

II. Desirable Test Equipment for Apparatus Maintance.

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

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

RENEWAL PARTS

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

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.45 mfd.; 330 V.A.C.	1723408
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C3	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C11	Metallized Paper, 0.47 mfd.;	849A437H04
C21	Metallized Paper, 0.47 mfd.;	849A437H04
C51	Dur-Mica, 1500 pf., 500 V.D.C.	762A757H03
C52	Variable, 5.5-18 pf.	879A834H01
C53	Variable, 5.5-18 pf.	879A834H01
C54	Metallized paper, .1 mfd.; 200 V.D.C.	187A624H01
C55	Variable, 5.5-18 pf.	762A736H01
C56	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C57	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C58	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C60	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C61	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C62	Dur-Mica, 4700 pf., 500 V.D.C.	762A757H04
C63	Dur-Mica, 1000 pf., 500 V.D.C.	762A757H02
C64	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C65	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C67	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C68	Metallized paper, 0.5 mfd.; 200 V.D.C.	187A624H03
C69	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C70	Dur-Mica, 300 pf, 500 V.D.C.	187A584H09
C71	3 pf,	861A846H03
C72	3 pf,	861A846H03
C73	3 pf,	861A846H03
C101	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C102	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C103 & C104	(30-50 KC) – Extended foil, 0.47 mfd.; 400 V.D.C.	188A293H01
C103 & C104	(50.5-75 KC) – Extended foil, 0.22 mfd.; 400 V.D.C.	188A293H02
C103 & C104	(75.5 - 100 KC) – Extended foil, 0.15 mfd.; 400 V.D.C.	188A293H03
C103 & C104	(100.5-150 KC) – Extended foil, 0.10 mfd.; 400 V.D.C.	188A293H04
C103 & C104	(150.5-300 KC) – Extended foil, 0.047 mfd.; 400 V.D.C.	188A293H05

ELECTRICAL PARTS LIST

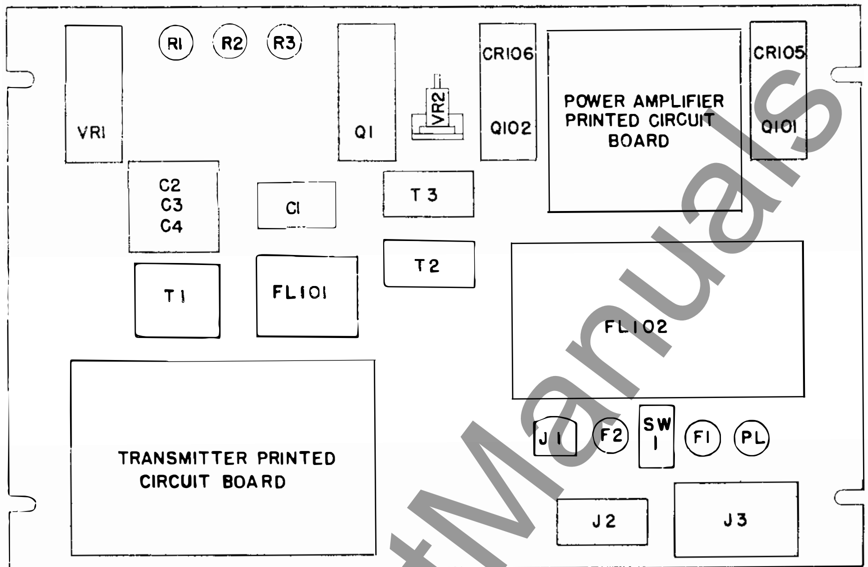
CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	DIODES – GENERAL PURPOSE	
D11	1N645A	837A692H03
D12	1N645A	837A692H03
D13	1N4822	188A342H11
D14	1N4822	188A342H11
D15	1N4822	188A342H11
D16	1N4822	188A342H11
D21	1N645A	837A692H03
D22	1N4822	188A342H11
D23	1N4822	188A342H11
D24	1N4822	188A342H11
D25	1N4822	188A342H11
D51	1N628; 125 V.; 30 MA.	184A885H12
D52	1N628; 125 V., 30 MA.	184A885H12
D58	1N628; 125 V., 30 MA.	184A885H12
D101	1N538; 200 V. 750 MA.	407C703H03
D102	1N91; 100 V., 150 MA.	182A881H04
D103	1N538; 200 V., 750 MA.	407C703H03
D104	1N91; 100 V., 150 MA.	182A881H04
	DIODES – ZENER	
Z1	1N2828B; 45V. ±5%; 50 W.	184A854H06
Z2	1N3009A; 130 V. ±10%; 10 W.	184A617H12
Z11	1N957B	186A797H06
Z12	1N3688A	862A288H01
Z13	1N3688A	862A288H01
Z14	1N3686B	185A212H06
Z21	1N957B	186A797H06
Z22	1N3688A	862A288H01
Z23	1N3688A	862A288H01
Z24	1N3686B	185A212H06
Z54	1N3686B; 20 V. ±5%; 750 MW.	185A212H06
Z105	1N2999A; 56V. ±10%; 10 W.	184A617H13
Z106	1N2999A; 56V. ±10%; 10 W.	184A617H13

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R1	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R2	26.5 ohms ±5%; 40 W. (For 125 V Supply)	04D1299H44
R3	26.5 ohms ±5%; 40 W. (For 48 V Supply)	04D1299H44
R3	500 ohms ±5%; 40 W. (For 125 V Supply)	1268047
R4	100 ohms ±10%; 1 W. Composition	187A644H03
R5	1K ±10%; ½ W. Composition	187A641H27
R6	3K ±5%; 5 W. Wire Wound	188A317H01
R7	15K ±10%; 2 W. Composition	187A642H55
R11	4.7K ± 2%; ½ W. Metal Glaze	629A531H43
R12	12K ± 2%; ½ W. Metal Glaze	629A531H58
R13	10K ±2%; ½ W. Metal Glaze	629A531H56
R14	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R15	1.5K ±2%; ½ W. Metal Glaze	629A531H36
R16, R26	51K ±2%; ½ W. Metal Glaze	629A531H73
R17	1.8K ±2%; ½ W. Metal Glaze	629A531H38
R21	4.7K ±2%; ½ W. Metal Glaze	629A531H48
R22	12K ±2%; ½ W. Metal Glaze	629A531H58
R23	10K ±2%; ½ W. Metal Glaze	629A531H56
R24	6.2K ±2%; ½ W. Metal Glaze	629A531H51
R25	1.8K ±2%; ½ W. Metal Glaze	629A531H38
R18, R28	18K ±2%; ½ W. Metal Glaze	629A531H62
R27	1.5K ±2%; ½ W. Metal Glaze	629A531H36
R51	10K ±2%; ½ W. Composition	184A763H51
R52	10K ±2%; ½ W. Composition	184A763H51
R53	10K ±2%; ½ W. Composition	184A763H51
R54	10K ±2%; ½ W. Composition	184A763H51
R55	100 ohms ±5%; ½ W. Composition	184A763H03
R56	3.6K ±5%; ½ W. Composition	184A763H40
R57	3.6K ±5%; ½ W. Composition	184A763H40
R58	100 ohms ±5%; ½ W. Composition	184A763H03
R59	10K ±5%; ½ W. Composition	184A763H51
R60	5.6K ±5%; ½ W. Composition	184A763H45
R61	15K ±5%; ½ W. Composition	184A763H55
R62	10K ±5%; ½ W. Composition	184A763H51
R63	1K ±5%; ½ W. Composition	184A763H27
R64	Potentiometer, 1K; ¼ W.	629A430H02
R65	1.8K ±5%; ½ W. Composition	184A763H02
R66	8.2K ±5%; ½ W. Composition	184A763H49
R67	12K ±5%; ½ W. Composition	184A763H53
R68	330 ohms ±5%; ½ W. Composition	184A763H15
R69	800 ohms ± 5%; ½ W. Composition	184A859H06
R72	39K ± 5%; ½ W. Composition	184A763H65
R73	Thermistor, 30 ohms, Type 3D202 (G.E.C.)	185A211H06

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Continued)	
R74	62 ohms ±5%; ½ W. Composition	629A531H03
R75	68 ohms ±5%; ½ W. Composition	187A290H01
R76	2K ±5%; ½ W. Composition	184A763H34
R77	10 ohms ±5%; ½ W. Composition	187A290H01
R78	10 ohms ±5%; ½ W. Composition	187A290H01
R79	20K ±2%; ½ W. Metal Glaze	629A531H63
R80	25K Potentiometer ±20%; ¼ W.	629A430H09
R101	10 ohms ±5%; ½ W. Composition	187A280H01
R102	2.2K ±10%; 1 W. Composition	187A644H35
R103	2.7 ohms ±10%; ½ W. Wire Wound	184A636H14
R104	0.27 ohms ±10%; 1 W. Wire Wound	184A636H18
R105	10 ohms ±5%; ½ W. Composition	187A290H01
R106	4.7K ±10%; 1 W. Composition	187A644H43
R107	2.7 ohms ±10%; ½ W. Wire Wound	184A636H14
R108	0.27 ohms ±10%; 1 W. Wire Wound	184A636H18
	TRANSFORMERS	
T1	Driver Output Transformer	606B410G01
T2	Power Amp. Input Transformer	292B526G01
T3	Power Amp. Output Transformer	292B526G02
T4	Load-Matching Auto-Transformer	292B526G03
T51	Buffer Amplifier Transformer	606B537G01
T52	Driver Input Transformer	606B537G02
	TRANSISTORS	
Q1	2N1015C	187A342H02
Q11	2N4356	849A441H02
Q12	2N699	184A638H19
Q21	2N4356	849A441H02
Q22	2N699	184A638H19
Q51	2N697	184A638H18
Q52	2N697	184A638H18
Q53	2N697	184A638H18
Q54	2N699	184A638H19
Q56	2N2726/2N3712	762A672H07
Q57	2N2726/2N3712	762A672H07
Q101	2N1908 (Use in Matched Pairs)	187A673H02
Q102	2N1908 (Use in Matched Pairs)	187A673H02
	MISCELLANEOUS	
Y1-Y2	Supplied for Desired Channel Frequency in Pair Matched Per Specifications on Drawing	408C743
FL101	Driver Filter	408C261 + (Req. Freq.)
FL102	Output Filter	541S214 + (Req. Freq.)
PL	Pilot Light Bulb - For 48 V. Supply (When supplied)	187A133H02
	Pilot Light Bulb - For 125 or 259 V. Supply (When supplied)	183A955H01
F1, F2	Fuse, 1.5A (When supplied)	11D9195H26



REAR VIEW

410C313

Fig. 2. Component Locations of the Type TCF Transmitter

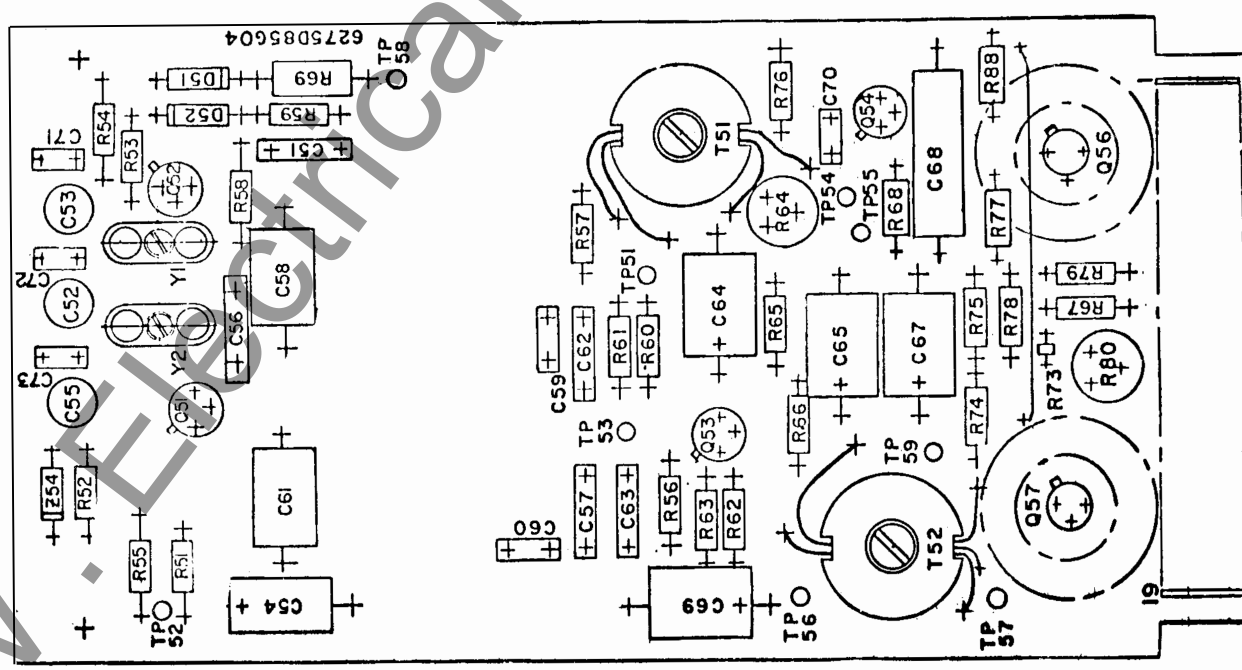


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Fig. 3. Component Locations of the Transmitter Printed Circuit Board

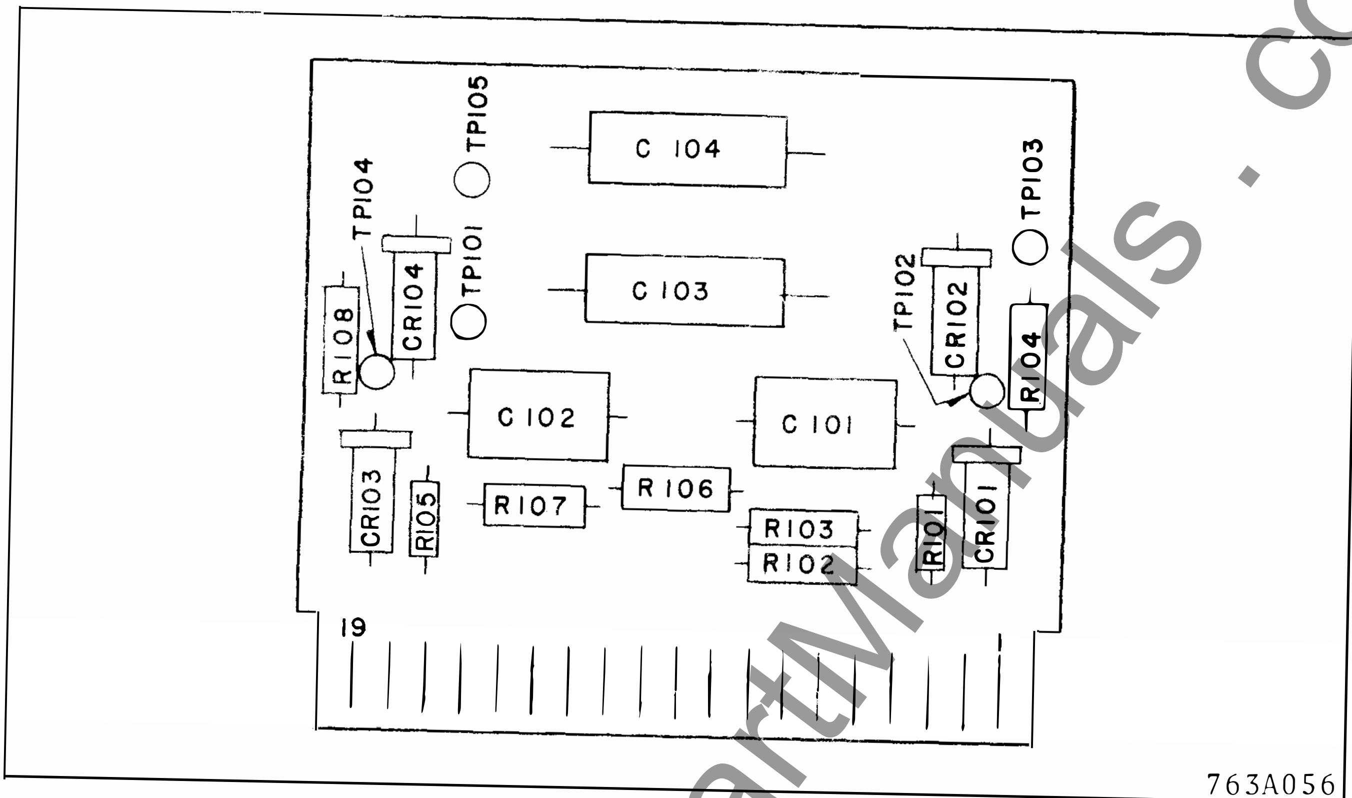

Fig. 4. Component locations of the Power Amplifier Printed Circuit Board

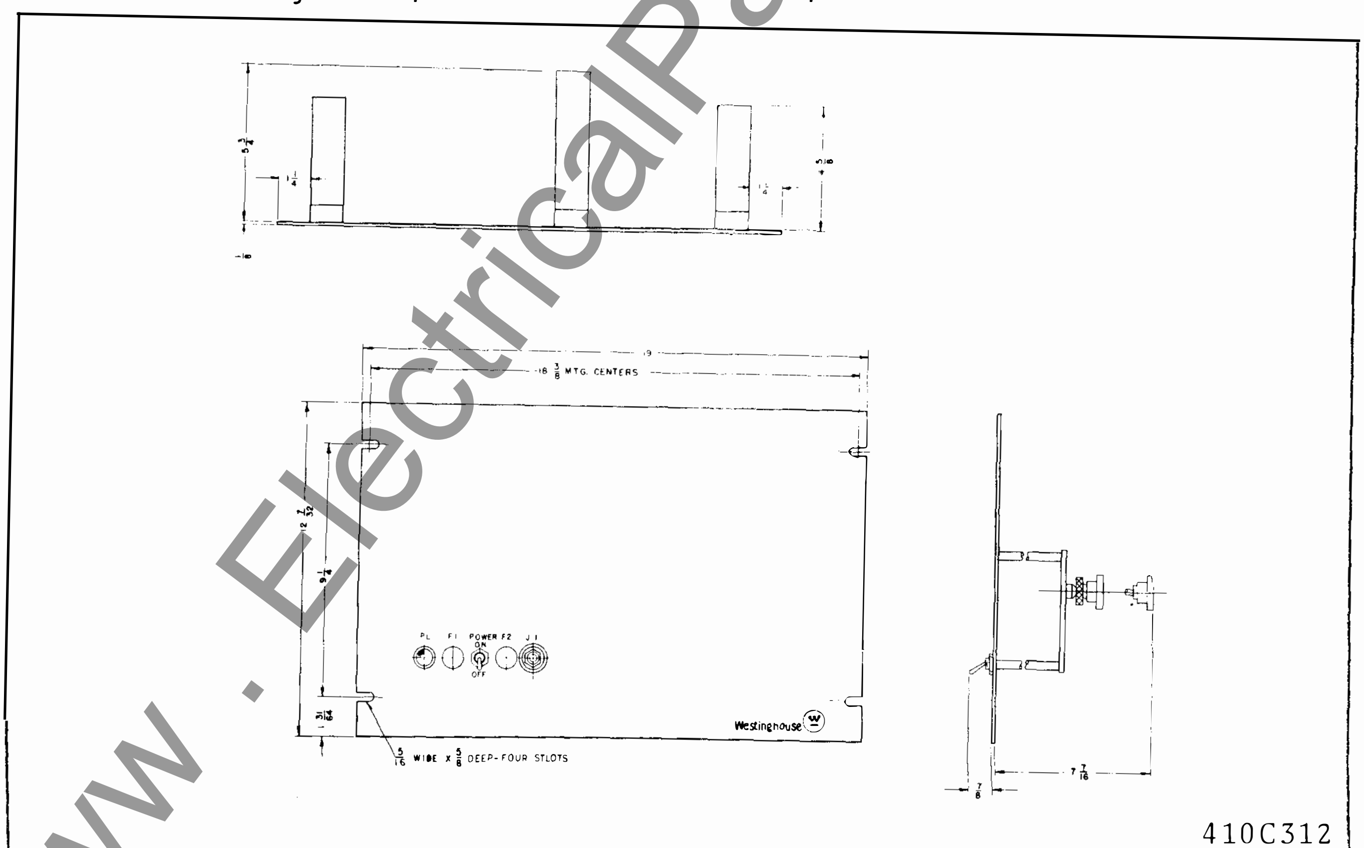

Fig. 5. Outline and Drilling Plan for the Type TCF Transmitter Assembly

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT– 1 WATT/1 WATT–VOLTAGE KEYED FOR TELEMETERING

CAUTION
It is recommended that the user of this equipment become thoroughly familiar 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 type TCF carrier transmitter equipment provides for the transmission of either of two closely controlled discrete frequencies, both within a narrow-band channel, over high-voltage transmission lines. The center frequency of the channel can vary from 30 to 300 kHz in 0.5 kHz steps. The two frequencies transmitted are separated by 200 hertz, one being at center frequency (fc) plus 100 hertz and the other at center frequency minus 100 hertz.

When the TCF transmitter is used in voltage-keyed telemetering applications, the transmission of the high or the low frequency in the channel is controlled by the positive and negative half cycles of an a-c voltage obtained from a telemetering transmitter. This transmitter converts a d-c millivolt signal to an a-c voltage of proportional frequency, which typically may have a range from 15 Hz at zero millivolts to 35 Hz at a selected maximum value of millivolts. The high frequency output of the TCF transmitter is carried to a TCF receiver over a power line and through coupling capacitors and line tuners at each end. The receiver converts the high frequency signal to an a-c voltage of frequency which varies identically with that which keys the transmitter, and a telemetering receiver converts this varying frequency to a proportional d-c millivolt output.

CONSTRUCTION

The 1 watt/1 watt TCF transmitter unit is mounted on a standard 19-inch wide panel 8-3/4 inches (5 rack units) high with edge slots for mounting on a standard relay rack. All components are mounted on the rear of the panel. Fuses, a pilot light, and a power switch are accessible from the front of the panel. See Figure No. 5. All of the circuitry that is suitable for printed circuit board mounting is contained on two such boards, located as shown on Figure No. 2. The locations of the components on the voltage-keyed input board are shown on Figure No. 4 and the locations of the components on the board containing the oscillators, mixer and buffer amplifier, and final amplifier are shown on Figure No. 3. The components included on each board are indicated also by areas enclosed by dotted lines on the internal schematic. Figure No. 1. A Zener diode mounted on a heat sink provides a regulated 45-volt d-c power supply and an output filter removes harmonics that may be generated by distortion in the amplifier. The locations of all circuit elements on the panel are shown on Figure No. 2 and their electrical connections are shown on Figure No. 1.

External connections to the assembly are made through a 12-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2 (Figure No. 1).

OPERATION

The transmitter is made up of four main stages and an output filter. The input stage receives the a-c voltage from a telemetering transmitter and amplifies it to a level sufficient for properly shifting the frequencies of the two crystal oscillators in the next stage. The two oscillator frequencies enter the mixer and buffer amplifier stage, where the difference frequency is amplified to drive the final amplifier stage. The output of this fourth stage enters the output filter, which is tuned to the difference (fundamental) frequency and contains second and third harmonic traps for further reduction of harmonics.

The a-c output voltage from the telemetering transmitter is applied to terminals 9-10 of input jack J3, and is connected through resistors R101 and R103 to the bases of transistors Q101 and Q102. These transistors are biased by resistors R102 and R106 so that a small value of a-c voltage at terminals 9-10 will make them alternately conductive. When terminal 9 is positive with respect to terminal 10, transistor Q102 conducts and when 9 is negative with respect to 10, Q101 conducts. Consequently, current flows from terminal 2 to terminal 1 of transformer T1 when 9 is positive and from 2 to 3 when 9 is negative. Zener diode Z103 has a 15-volt rating and Zener diode Z54 (on the larger circuit board) has a 20-volt rating. Thus there is a nominal 5 volt drop across resistor R110, and for a static condition (no a-c input voltage and crystals removed from sockets) the anode of diode D52 is held at +15 volts, thereby causing both D51 and D52 to be reverse biased. It will be seen that D55 and D56 are similarly reverse biased under this condition.

When Q101 and Q103 are turned on and off alternately by a-c voltage from the telemetering transmitter, voltage of approximately square waveform is induced in the secondary of transformer T1, and when secondary terminals 4 and 6 alternately become sufficiently positive with respect to terminal 5 diodes D51 and D52, or D55 and D56, become forward biased. The effect of this in shifting the frequencies of the oscillators will be explained in a later paragraph.

A single crystal designed for oscillation in the 30 kHz to 300 kHz range cannot be forced to oscillate away from its natural frequency by as much as ±100 hertz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2 MHz range. The crystals are Y1 and Y2 of Figure No.1. The frequency of Y2 is 2.00 MHz when operated with a specified amount of series capacity, and the frequency of Y1 is 2.00 MHz plus the channel frequency, or 2.03 MHz to 2.20 MHz. Capacitor C55 and crystal Y2 in series are connected between the positive side of the supply voltage and the base of transistor Q51, which operates in the emitter-follower mode. The emitter is coupled to the base through C57, and with Y2 removed the base of Q51 would be held at approximately the midpoint of the supply voltage by R51 and R52. The crystal serves as a series-resonant circuit with very high inductance and low capacitance. The circuit can be made to oscillate at other than the natural frequency of the crystal by varying the series capacitor, C55. Increasing C55 will lower the frequency of oscillations and reducing C55 will raise the frequency.

Capacitor C70 is ineffective while diode D55 is reverse biased and therefore non-conductive, but when the diode is forward biased by sufficient positive voltage at terminal 12, it becomes conductive and C70 is effectively placed in parallel with C55. This reduces the frequency of oscillation by an amount determined by the setting of C70. The frequency of the oscillator circuit in which crystal Y1 is used will be reduced in similar manner when terminal 18 becomes sufficiently positive to forward bias diode D51.

With diode D51 and D55 both reverse biased and with C52 and C55 adjusted so that their associated crystals operate at their nominal frequencies, the sum of the two frequencies impressed on the base of mixer transistor Q53 through capacitors C62 and C63 is MHz + fc and the difference frequency is fc. The sum frequency is so high that a negligible amount appears on the secondary of transformer T51 but the difference frequency is accepted and amplified by Q53 and 54. However, with an a-c voltage at input terminals 9 and 10 of J3 diodes D51 and D55 are each alternately forward biased for substantially a full half-cycle, and by adjustment of capacitors C53 and C70 difference frequencies of fc + 100 hertz and fc - 100 hertz can be obtained on alternate half cycles.

The crystals taken individually have a greater variation of frequency with temperature than would be acceptable. However, by proper matching of the two crystals, the variation in their difference frequency can be kept within limits that permit holding the frequency stability of the overall transmitter to ± 10 hertz over a temperature range of -20 to +55°C.

The amplifier stage consists of transistors Q56 and Q57 connected in a conventional push-pull circuit with input supplied from the collector of Q54 through transformer T52. Thermistor R73 and resistors R74 and R75 are connected to provide a variable bias that reduces the effect of varying ambient temperatures on the output level. The output power is adjusted to 1 watt by means of R64.

The output transformer T2 couples the amplifier transistors to the output filter FL102. The output filter includes two trap circuits (L102, C_B, and L103, CC) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G1 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line tuner and coaxial cable. Autotransformer T3 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms.

The series resonant circuit composed of L105 and C_E is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, thus providing a reverse impedance that is free of possible "across-the-line" resonances.

The regulated 45 volt power supply is obtained from a 50-watt Zener diode mounted on a heat sink and connected to the station battery supply through suitable series resistors, as shown on Figure No. 1. Capacitor C68 provides a low carrier-frequency impedance across the d-c output voltage, and capacitors C1 and C2 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

CHARACTERISTICS

Frequency Range	30-300 kHz
Output	1 watt (into 50 to 70 ohm resistive load)
Frequency Stability	±10 hertz from -20°C to +55°C
Frequency Spacing	1. One-way channel, two or more signals – 500 hertz min. 2. Two-way channel – 1000 hertz min. between transmitter and adjacent receiver frequencies.
Harmonics	down 55 db (min.) from output level.
Input Impedance of Keying Circuit	50,000 ohms
Keying Voltage	10 to 50 volts p.-p, sine or square wave
Keying Frequency	10 to 50 hertz
Supply Voltage	48, 125 or 250 V.D.C. (Separate units)
Supply Voltage	42-56 V. for nom. 48 V. supply, 105-140 V. for nom. 125 V. supply, 210-280 V. for nom. 250 V. supply
Battery Drain	0.12 a. at 48 V. d-c. 0.27 a. at 125 or 250 V. d-c.
Temperature Range	-20 to +55°C around chassis
Dimensions	Panel height – 8-3/4" or 5 r.u. Panel width – 19"
Weight	10 lbs.

INSTALLATION

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

ADJUSTMENT

The TCF 1W/1W transmitter is shipped with the power output control R64 set for an output of 1 watt into a 60 ohm load. If it is desired to check the adjustments or if repairs have made readjustment necessary, the coaxial cable should be disconnected from the assembly terminals and replaced with a 50 to 70 ohm non-inductive resistor of at least a 1 watt rating. Use the value of the expected input impedance of the coaxial cable and line tuner. If this is not known, assume 60 ohms. Connect the T3 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn power output control R64 to minimum (full counterclockwise). Turn on the power switch on the panel and note the d-c voltage across terminals 5 and 7 of J3. If this is in the range of 42 to 46 volts, rotate R64 clockwise to obtain 3 or 4 volts across the load resistor. At this point check the adjustment of the series output tuning coil L105 by loosening the knurled shaft-locking nut and moving the adjustable core in and out a small amount from its initial position. Leave it at the point of maximum voltage across the load resistor.

Continue to advance R64 until the output voltage shown in the following table is obtained across the load resistor. Recheck the setting of L105 to be sure it is at its optimum point for 1 watt output. Tighten the locking nut.

T3 * TAP	VOLTAGE FOR 1 WATT OUTPUT
50	7.1
60	7.8
70	8.4

With no a-c voltage impressed on terminals 9 and 10, the output frequency of the transmitter is fc. When the output filter is adjusted for maximum output at this frequency, the output voltage at the operating frequencies of fc ± 100 hertz will not be appreciably lower.

Follow the procedure outlined in the line tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. It is factory tuned for maximum second and third harmonic rejection, and for series resonance (maximum output at the fundamental frequency) with a 60-ohm load. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection and no change should be made in these settings unless suitable instruments are available for measuring the second and third harmonic present in the transmitter output.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals, this can be done by turning the matched pair 180° and inserting Y1 crystal in its proper socket with the other crystal unconnected. Because of proximity to capacitor C70, the crystal pair cannot be reversed to permit checking Y2 alone, but this can be done by partially withdrawing Y2 from its socket and tilting it sufficiently to open-circuit the Y1 crystal. A sensitive frequency counter with a range of at least 2.3 megahertz can be connected from TP51 to TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter and avoids some error from the effect of the counter input capacitance on the oscillator circuit.)

If for any reason, it should be necessary to replace a matched crystal pair, the following adjustments should be made.

With rated d-c voltage on the transmitter, with R64 fully clockwise to increase input to frequency counter, and with terminals 9-10 of J3 open, the frequency of Y1 alone should be its marked frequency (±3 hertz). If adjustment is necessary, adjust capacitor C52 for correct frequency. Next, apply 45v. d-c from terminal 7 of J3 (or terminal 2 of transmitter circuit board) to TP104 (on input circuit board). The frequency should drop to the marked frequency minus 85 Hz (±3 Hz). And should be adjusted to this value by C53 if necessary. If capacitor settings are changed, both steps should be rechecked until the oscillator operates at the marked frequency of Y1 (±3 hertz) before applying 45 volts to TP104, and at 85 hertz (±3 hertz) less than the marked frequency after applying 45 volts.

Similarly, check the oscillator frequency with Y2 alone in circuit, and if necessary adjust C55 for 2 MHz (±3 hertz). Then apply 45 volts from terminal 7 to TP101. The frequency should be 2 MHz minus 85 hertz (±3 hertz). If capacitor settings are changed, recheck both steps as before. Turn R64 full counterclockwise, and after inserting both crystals in their sockets, readjust R64 for 1 watt output.

With adjustments made as described, the difference frequency of the two oscillators will be fc + 100 hertz on one half-cycle of an a-c voltage on terminals 9-10, and will be fc − 100 hertz on the next half-cycle. The frequency cannot be measured when it is being continually shifted by an a-c keying voltage, and adjustments must be made by using d-c voltage for biasing diodes D51, D52, D55 and D56. However, when an a-c keying voltage is present, the connections to the mid-tapped secondary of T1 cause the reverse bias voltage that is present alternately on each set of diodes to be much greater than when a d-c voltage is applied on TP101 or TP104. The oscillator frequency with this high reverse bias voltage shifts upward approximately 15 hertz when the other oscillator with forward bias voltage shifts downward 85 hertz. The resultant difference frequencies therefore are fc + 100 hertz and fc − 100 hertz for alternate half cycles at terminals 9−10.

For routine maintenance the frequencies of the individual oscillators need not be checked. The difference frequencies can be measured directly at the transmitter output, using the proper load resistor to match the T3 tap used. With terminals 9-10 open, C52 should be adjusted for a frequency of fc ±3 hertz. Then with +45V. d-c applied to TP104, C53 should be adjusted for fc minus 85 (±3) hertz, With 45 volts applied to TP101 instead of TP104, C70 should be adjusted for fc plus 85 (±3) hertz. A similar final adjustment should be made after making the individual adjustments required when a matched pair of crystals is replaced.

Q56-Q57 Bias Adjustment

The push-pull output stages of the transmitter board are normally shipped correctly biased. If any components involved in these stages have been changed, then it may be necessary to recheck the biasing of this stage.

Unsolder the lead from terminal 2 of transformer T1 (just above FL101) and temporarily connect a low-range d-c milliammeter (0-1.0 ma) between the removed lead (+) and T1 terminal 2 (-). Turn the slotted control on the small potentiometer to full counterclockwise. Now, apply power to the TCF carrier set, but do not transmit carrier. This can be done by removing the crystals. Advance the potentiometer clockwise until the milliammeter reads 0.2 ma. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T1. Replace the crystals and again apply d-c power to reenergize the transmitter. Check output, etc. of transmitter as previously described.

MAINTENANCE

Periodic checks of the transmitter power output will detect impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sink. It is also desirable to check the transmitter power output at such times, making any necessary readjustments to return the equipment to its initial settings.

Voltage values should be recorded 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. Readings may vary as much as ±20%.

TABLE I

TRANSMITTER D-C MEASUREMENTS

Note: All voltages are positive with respect to Neg. 45 V. (TP51). All voltages read with d-c VTVM.

TEST POINTS	VOLTAGE AT 1 WATT OUTPUT
TP 52	20
TP 53	5.4
TP 54	3.4
TP 55	21
TP 56	21
TP 57	.65
TP 58	44.3
TP 59	.65
TP 102	20
TP 103	20
TP 105	15

TABLE II

TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages are subject to variations, depending upon frequency and transistor characteristics. T51-3 = Terminal 3 of transformer T51. Other transformer terminals identified similarly. All voltages read with a-v VTVM.

TEST POINTS	VOLTAGE AT 1 WATT OUTPUT
TP 54 to TP51	0.12
TP 57 to TP51	0.8
TP 59 to TP51	0.8
T2-1 to TP 51	26
T2-3 to TP 51	26
T2-4 to Gnd.	36
T3-2 to Gnd.	30
TP109 to Gnd.	9.8
J102 to Gnd.	7.8

RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation
   a. 60-ohm 10-watt non-inductive resistor.
   b. 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.
   c. 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-kHz to 900 kHz
   c. Oscilloscope
   d. Frequency counter
   e. Ohmmeter
   f. Capacitor checker

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

RENEWAL PARTS

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

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	CAPACITORS	
C1	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C2	Oil-filled; 0.5 mfd.; 1500 V.D.C.	1877962
C51	Dur-Mica, 1500 pf., 500 V.D.C.	762A757H03
C52	Variable, 5.5-18 pf.	879A834H01
C53	Variable, 5.5-18 pf.	879A834H01
C54	Metallized paper, .1 mfd.; 200 V.D.C.	187A624H01
C55	Variable, 5.5-18 pf.	762A736H01
C56	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C57	Dur-Mica, 2000 pf.; 500 V.D.C.	187A584H01
C58	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C59	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C60	Dur-Mica, 100 pf., 500 V.D.C.	762A757H01
C61	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C62	Dur-Mica, 4700 pf., 500 V.D.C.	762A757H04
C63	Dur-Mica, 1000 pf., 500 V.D.C.	762A757H02
C64	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C65	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C67	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C68	Metallized paper, 0.5 mfd.; 200 V.D.C.	187A624H03
C69	Metallized paper, 0.25 mfd.; 200 V.D.C.	187A624H02
C70	Dur-Mica, 300 pf, 500 V.D.C.	187A584H09
C71	3 pf,	861A846H03
C72	3 pf,	861A846H03
C73	3 pf,	861A846H03
C101	Metallized paper, 1.0 mfd.; 200 V.D.C.	187A624H04
C102	33 mf; 10 V.D.C.	187A508H11
	DIODES – GENERAL PURPOSE	
D51	1N628; 125 V.; 30 MA.	184A885H12
D52	1N628; 125 V.; 30 MA.	184A885H12
D56	1N628; 125V., 30 MA.	184A885H12
D57	1N628; 125 V., 30 MA.	184A885H12
D101	1N457A; 60 V, 200 MA.	184A885H07
D102	1N457A; 60 V, 200 MA.	184A885H07
	DIODES – ZENER	
Z1	1N2828B; 45V. ±5%; 50W.	184A854H06
Z54	1N3686B; 20V. ±5%; 750 MW.	185A212H06
Z103	1N3683B	185A212H07

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS	
R1	150 ohms ±5%; 40 W. (For 125 V Supply)	1202499
R2	150 ohms ±5%; 40 W. (For 125 V Supply)	1202499
R1	22.5 ohms ±5%; 40 W. (For 48 V Supply)	04D1299H41
R4	100 ohms ±10%; 1 W. Composition	187A644H03
R5	1K ±10%; ½ W. Composition	187A641H27
R6	3K ±5%; 5 W. Wire Wound	188A317H01
R7	15K ±10%; 2 W. Composition	187A642H55
R11	4.7K ±2%; ½ W. Metal Glaze	629A531H43
R12	12K ±2%; ½ W. Metal Glaze	629A531H58
R13	10K ±2%; ½ W. Metal Glaze	629A531H56
R51	10K ±5%; ½ W. Composition	184A763H51
R52	10K ±5%; ½ W. Composition	184A763H51
R53	10K ±5%; ½ W. Composition	184A763H51
R54	10K ±5%; ½ W. Composition	184A763H51
R55	100 ohms ±5%; ½ W. Composition	184A763H03
R56	3.6K ±5%; ½ W. Composition	184A763H40
R57	3.6K ±5%; ½ W. Composition	184A763H40
R58	100 ohms ±5%; ½ W. Composition	184A763H03
R59	10K ±5%; ½ W. Composition	184A763H51
R60	5.6K ±5%; ½ W. Composition	184A763H45
R61	15K ±5%; ½ W. Composition	184A763H55
R62	10K ±5%; ½ W. Composition	184A763H51
R63	1K ±5%; ½ W. Composition	184A763H27
R64	Potentiometer, 1K; ¼ W.	629A430H02
R65	1.8K ±5%; ½ W. Composition	184A763H02
R66	8.2K ±5%; ½ W. Composition	184A763H49
R67	12K ±5%; ½ W. Composition	184A763H53
R68	330 ohms ±5%; ½ W. Composition	184A763H15
R69	800 ohms ±5%; ½ W. Composition	184A859H06
R72	39K ±5%; ½ W. Composition	184A763H65
R73	Thermistor, 30 ohms, Type 3D202 (G.E.C.)	185A211H06
R74	62 ohms ±5%; ½ W. Composition	629A531H03
R75	68 ohms ±5%; ½ W. Composition	187A290H21
R76	2K ±5%; ½ W. Composition	184A763H34
R77	10 ohms ±5%; ½ W. Composition	187A290H01
R78	10 ohms ±5%; ½ W. Composition	187A290H01
R79	20K ±2%; ½ W. Metal Glaze	629A531H63
R80	25K Potentiometer ±20%; ¼ W.	629A430H09

ELECTRICAL PARTS LIST

CIRCUIT SYMBOL	DESCRIPTION	WESTINGHOUSE DESIGNATION
	RESISTORS (Cont'd.)	
R101	22K ±5%; ½ W. Composition	184A763H59
R102	680 ohms ±5%; ½ W. Composition	184A763H23
R103	22K ±5%; ½ W. Composition	184A763H59
R104	22K ±5%; ½ W. Composition	184A763H59
R105	3.3K ±5%; ½ W. Composition	184A763H39
R106	18K ±5%; ½ W. Composition	184A763H57
R107	3.3K ±5%; ½ W. Composition	184A763H39
R108	22K ±5%; ½ W. Composition	184A763H59
R109	56K ±5%; ½ W. Composition	184A763H69
R110	4.7K ±5%; ½ W. Composition	184A763H43
R111	56K ±5%; ½ W. Composition	184A763H69
	TRANSFORMERS	
T1	Input Transformer	670B248G01
T2	Output Transformer	606B410G02
T3	Load-Matching Auto-Transformer	292B526G03
T51	Buffer Amplifier Transformer	606B537G01
T52	Driver Input Transformer	606B537G02
	TRANSISTORS	
Q1	2N1015C	187A342H02
Q11	2N4356	849A441H02
Q12	2N699	184A638H19
Q21	2N4356	849A441H02
Q22	2N699	184A638H19
Q51	2N697	184A638H18
Q52	2N697	184A638H18
Q53	2N697	184A638H18
Q54	2N699	184A638H19
Q56	2N2726/2N3712	762A672H07
Q57	2N2726/2N3712	762A672H07
Q101	2N699	184A638H19
Q102	2N699	184A638H19
	MISCELLANEOUS	
Y1-Y2	Supplied for Desired Channel Frequency in Pair Matched Per Specifications on Drawing.	408C743
FL102	Output Filter	541S214 + (Req. Freq.)
PL	Pilot Light Bulb - For 48 V. Supply (When supplied)	187A133H02
	Pilot Light Bulb - For 125 or 259 V. Supply (When supplied)	183A995H01
F1, F2	Fuse, 1.5A (When supplied)	11D9195H26

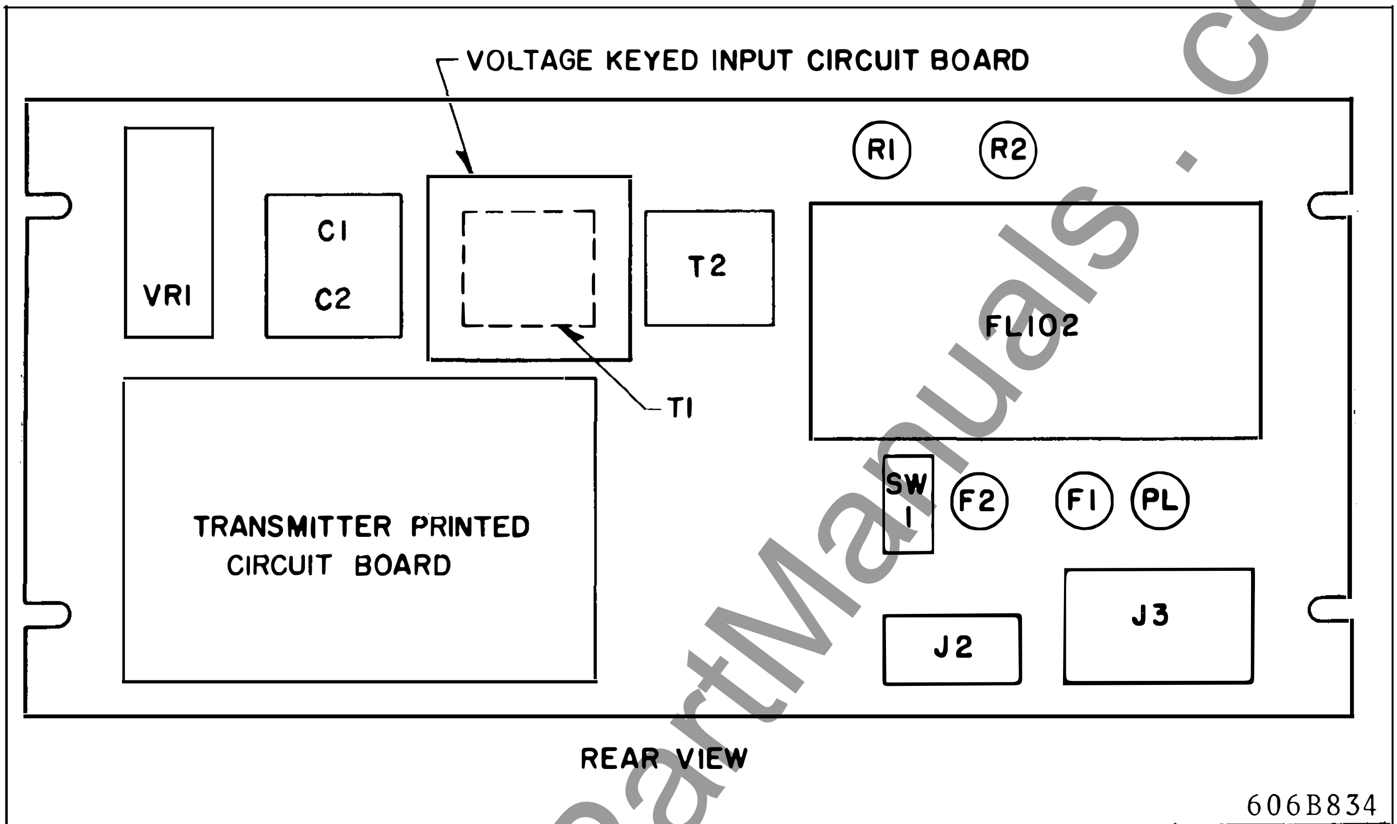

Fig. 2. Component Locations of Type TCF Transmitter Assembly.

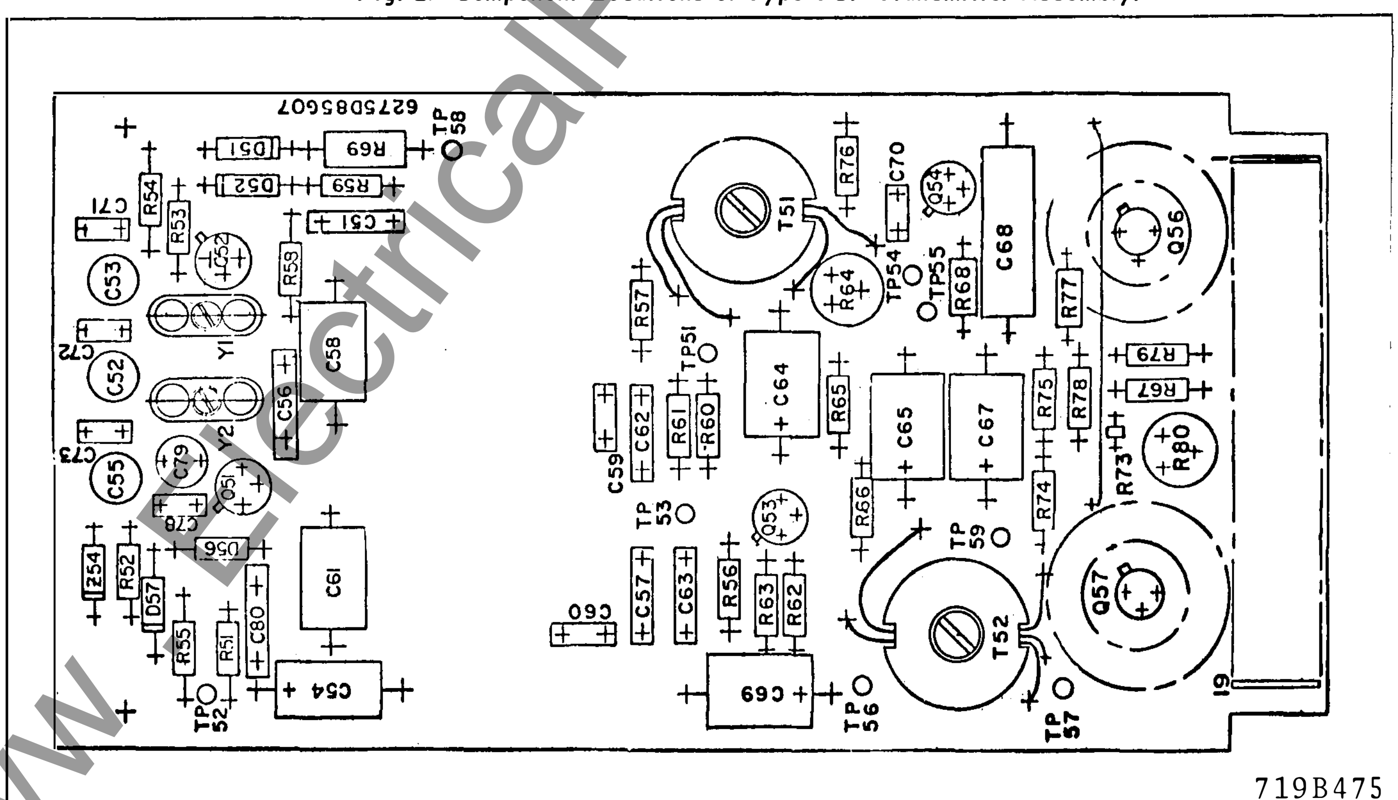

Fig. 3. Component Locations of Transmitter Printed Circuit Board.

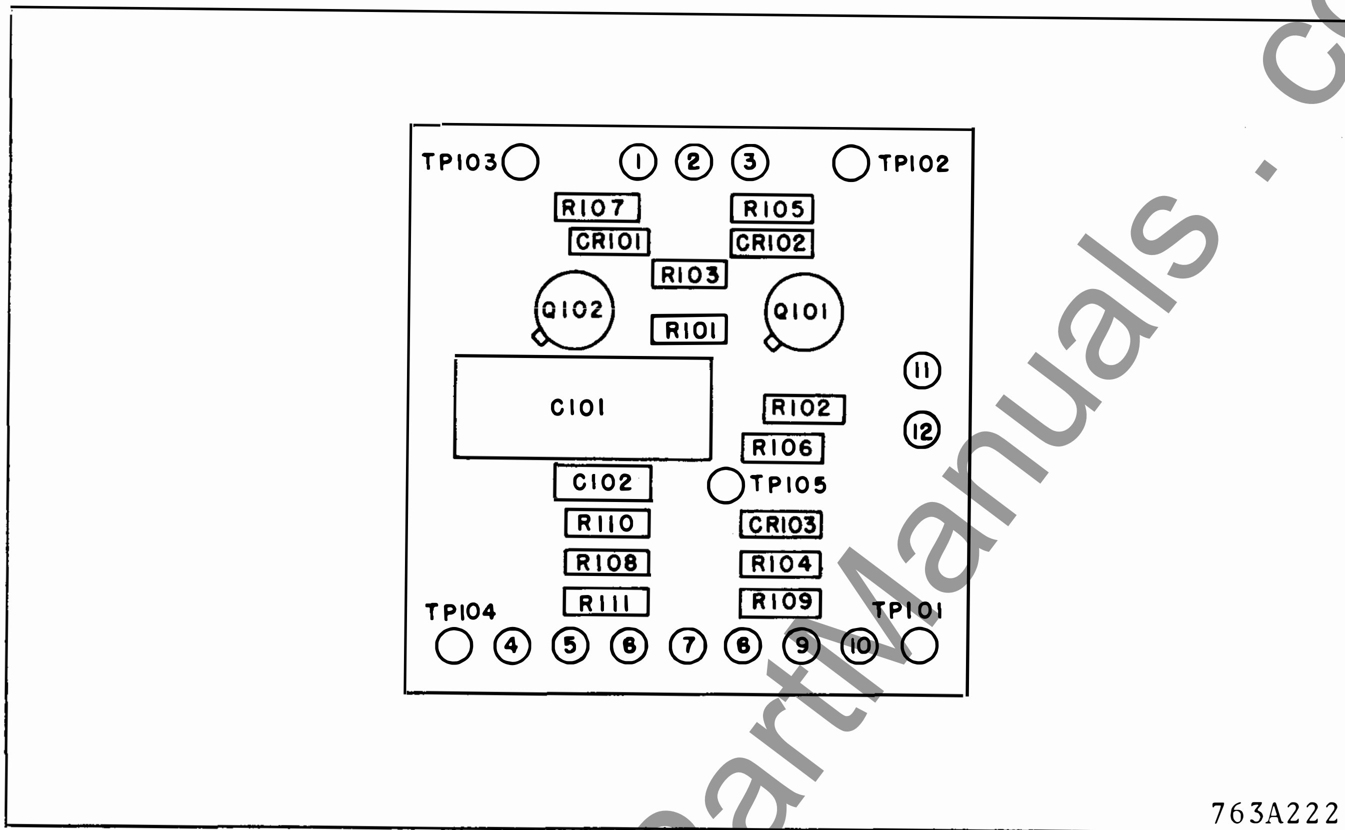

Fig. 4. Component Locations of Voltage Keyed Input Board.

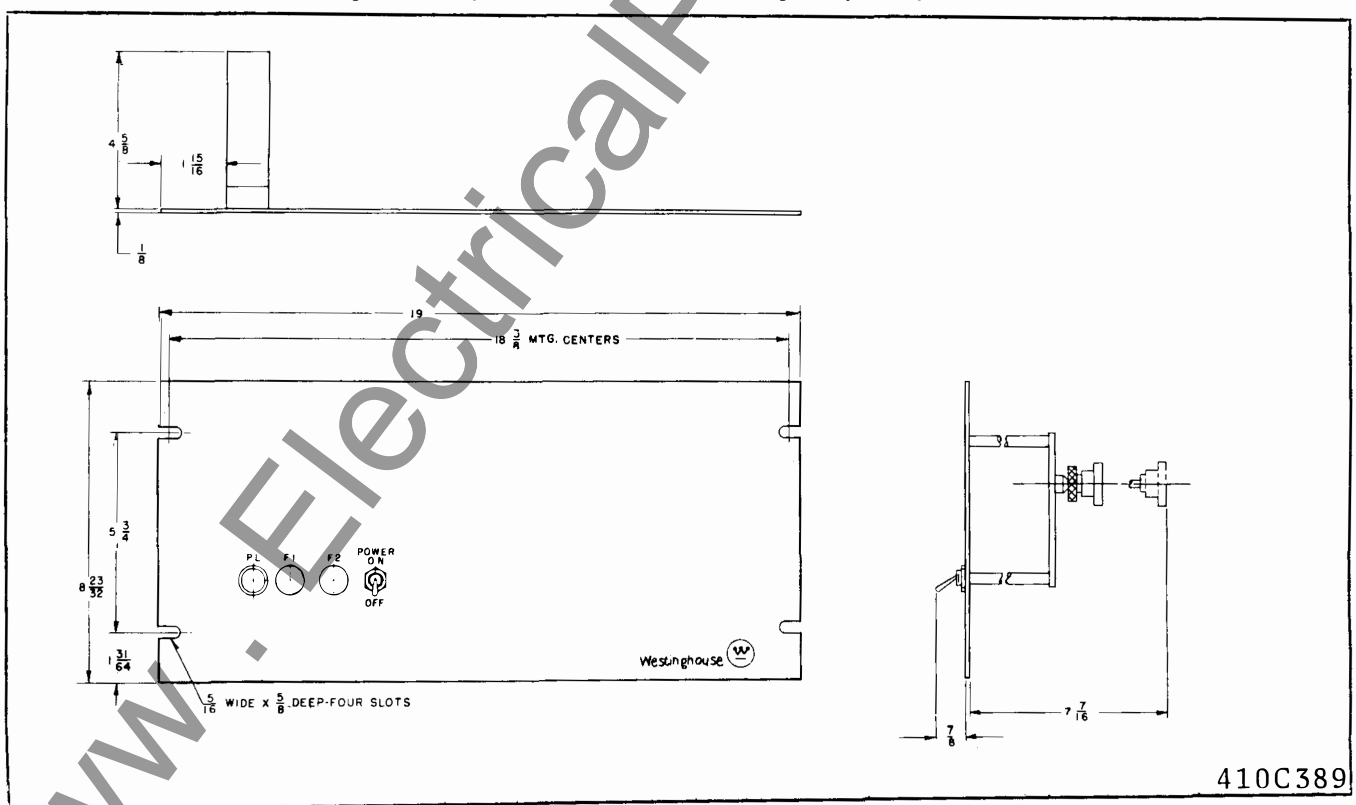

Fig. 5. Outline of Type TCF Transmitter Assembly.

WESTINGHOUSE ELECTRIC CORPORATION

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

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