

INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY FOR USE WITH SOLID-STATE RELAYING SYSTEMS

OF CONTENTS		LIST OF ILLUSTRATIONS	
TABLE OF CONTENTS	Page	Figure	Page
		1 '	Type TC Carrier Assembly-Outline 18
Caution	4		Type TC Carrier Assembly — Parts
Application	2	2 ′	Location
Construction	$egin{array}{ccc} & 2 & 1 \\ & 2 & \end{array}$	3	Transmitter Printed Circuit Board—
Operation			Parts Location
Transmitter			Power Amplifier Printed Circuit
Receiver	••••	4	Board – Parts Location
Power Supply	4	l	
Relaying Control Circuits	4	5	Receiver Printed Circuit Board-
Carrier Control for Other Function		ľ	Parts Location 20
Characteristics	1	6	Transmitter Keying Board-
Installation	5		Parts Location
Adjustments	5	l	
Adjustments	5	7	Receiver CLI and Output Board— Parts Location 2
Transmitter	5		Parts Location
Transmitter Filter	5	8	Type TC Carrier Assembly for
Receiver	C	°	~ v. i grata Doloving — Internal
Maintenance	6	1	Schematic
Glarge of Operating Frequency	7	9	Type TC Receiver Filter
Manamitter			Characteristics
Receiver	8	Į.	
Receiver	10	10	Type TC Receiver Overall
Recommended Test Equipment	10		Selectivity Curve
Renewal Parts	10	11	Type TC Receiver – 200-ma.
- trical Darts List	11	1	Output Characteristic
en a mitt or		1	
Dogoivor		12	Receiver CLI — Output Characteristic
Power Supply	17		
LOwer pubbro		13	Minimum Frequency Spacing
LIST OF TABLES			Botwoon Two Type TC Carrier
	Page	_]	Sets (Without Hybrids)
Table		1.4	Minimum Channel Spacing for
I Receiver D-C Measurements	9	14	regred Type TC Carrier
- D E Mossurements		1	(Keyed at 60 p.p.s.)
- C Measurements		15	Dotail of Power Supply
III Transmitter B-C Measurements			Section for 250-volt Supply
		1	6 Outline of External Resistor
V Transmitter Keying Board Meas		16	Unit for 250-volt Operation
VI Receiver CLI Board Meas	10		

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 type TC carrier equipment covered by these instructions is designed for use with solid-state relaying systems for transmission line protection. It can also be used for maintenance communication between terminals of a line section.

CONSTRUCTION

The transmitter-receiver unit consists of a standard 19-inch wide panel 17½ inches (10 rack units) high. The panel is notched for mounting on a standard relay rack. All components are mounted on the rear of the panel. Metering jacks, a test switch, and the receiver gain control are accessible from the front of the panel. See Fig. 1. The circuitry is divided into several sub-assemblies as shown in Figure 2. The components mounted on each printed circuit board or other sub-assembly are shown enclosed by dotted lines on the internal schematic, Fig. 8. The location of components on the five printed circuit boards are shown on separate illustrations, Figures 3 through 7.

External connections to the assembly are made through a 24-circuit receptacle J104. The r-f output connection to the assembly is made through a coaxial cable jack J103. When voice communication is used, the voice adapter plugs into receptacle J105 on the front panel.

The receiver gain control R207 is accessible from the front of the panel. In addition, three current jacks are provided for measuring the following quantities.

- J101 Transmitter power-amplifier collector current.
- J202 Receiver CLI 0-3 ma. output current.
- J203 Receiver 200-ma. output current.

The receiver filter input resistor R201 is connected directly to term. #1 of FL201 and is covered with insulating sleeving.

OPERATION

Transmitter

The transmitter is made up of four main stages and two filters. The stages include a crystal oscillator, buffer-amplifier, driver, and power amplifier. With reference to internal schematic, Fig. 8, the oscillator crystal serves as a series-resonant circuit between the collector of Q101 and the base of Q102. The output of Q102 is fed back through capacitors C102, C103, and C112 to the base input of Q101, thus providing oscillation at the crystal frequency. The frequency is essentially independent of voltage or temperature changes of the transistors. Thus the frequency stability is that of the crystal itself.

The oscillator output energizes the buffer-amplifier transistor Q103 through the potentiometer R112 which controls the transmitter power output. Keying of the transmitter output is controlled in the buffer-amplifier stage by changing the d-c potential supplied to Q103 emitter circuit. This is accomplished in the two buffered-input keying circuits (transistors Q151-152 and Q153-154-155 and associated components). Normally Q152 is conducting, causing a flow of current from positive 45 v.d.c. through R117 and transistor Q152 to negative. When a d-c voltage is applied to carrier-start terminal 6 or 7 (of J104), transistor Q151 is turned on which in turn switches transistor Q152 to a non-conducting state. Then the path from pos. 45 v.d.c. goes through R117, diodes Z159 and D151, then up to the transmitter board through Zener diode Z101 to negative. The 20-volt d-c potential across Z101 supplies voltage to transistor Q103, causing transmission of carrier. Note that operation of carrier test switch SW101 applies positive 20 v.d.c. to J104 terminal 6 circuit and similarly allows the transmission of carrier.

When carrier is being transmitted for any reason, a carrier-stop request from the protective relays takes preference over any carrier-start operation. When a d-c voltage is applied to J104 terminal 8 or 9, transistor Q154 turns on, Q155 turns off, and Q153 turns on which connects the transmitter keying circuit back to negative d.c. thus stopping carrier. If carrier is started through the Voice Adapter, the diode D151 isolates the d-c carrier-start voltage from negative (through Z159, and Q152 which is normally conducting). The zener diode Z159 prevents the small forward voltage across D151 and Q153 from causing a small amount of carrier transmission under standby conditions.

The buffer output energizes the driver stage which operates class B. When voice modulation is used, the transmitter modulating voltage is applied to the base-emitter circuit of transistors Q104 and Q105.

The output of the driver stage passes through filter FL101, then to the input transformer T104 of the power amplifier stage. Filter FL101 improves the waveform of the signal applied to the power amplifier. This stage uses two series-connected amplifier. This stage uses two series-connected type 2N 3792 power transistors, Q107 and Q108, operating as a class-B push-pull amplifier with single-ended output. Transistor Q106 applies forward base bias to Q107 and Q108 when the carrier start circuit is energized. Diodes D103 and D105 provide protection for the base-emitter junction of the power transistors. Zener diodes Z102 and Z103 protect the collector-emitter junctions from surges which might come in from the power line through the coaxial cable.

The output transformer T105 couples the power transistors to the transmitter 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 G101 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 T106 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms characteristic impedance.

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 as well as attenuation for higher order harmonics. 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, resulting in a reverse impedance free of possible "across-the-line" resonances.

Receiver

The receiver is a superheterodyne type to facilitate obtaining constant bandwidth regardless of the channel frequency. The major stages include an input filter, attenuator (gain control), crystal oscillator, mixer, i.f. filters and i.f. amplifiers,

diode detector, d-c amplifier, and d-c power output stage.

The fixed input filter rejects undesired signals while accepting a wide enough band of frequencies to assure fast operation. The receiver sensitivity is adjusted by means of the continuously variable input control R207. The receiver oscillator (Q201 and Q202) is basically the same as the transmitter oscillator. The oscillator frequency is 20 kHz above the incoming signal frequency. The receiver channel frequency is determined by the input filter and the oscillator crystal.

Mixing is accomplished by feeding the incoming signal to the emitter, and the receiver oscillator signal to the base of the mixer Q203. Mixer oscillator requirements are met through adjustment of potentiometer R212. Injection into two separate elements, base and emitter, provides a circuit capable of handling greater signal level variations than one in which injection is made into only a single element such as the base. This receiver uses an intermediate frequency of 20 kHz. Typical characteristics of both filters and the complete receiver are shown on curves, Fig. 9 and 10.

The 20-kHz i.f. signal is rectified by diodes D201 and D202. The resulting d-c output is amplified by transistors Q207 and Q208, giving a receiver output current of nominally 200 ma. for a 30-ohm external alarm relay coil circuit. Fig. 11 shows the receiver 200-ma. output characteristic.

NOTE: For all applications, an alarm relay or equivalant resistive load (30-35 ohms, 3 watt) must be connected to the receiver 200-ma. output circuit.

For solid-state relaying applications, the receiver also has a 20-volt d-c buffered output (transistors Q253 and Q254 on receiver CLI and output board). At an input signal level that would give about 100-ma. output current, the receiver 20-volt output will appear at J104 terminal 18.

To provide a more accurate indication of received signal level, a carrier level indicator (CLI) is provided on the receiver auxiliary circuit board. This device includes a sensitivity adjustment (R252), two amplifier stages (Q251 and Q252), and a diode detector. The filtered output of the detector is brought out through J202 to J104 terminals 16 and 17 for connection to an external 0-3 d-c milliameter. A typical CLI curve of output milliamperes vs. receiver input signal margin is shown in Fig. 12.

Power Supply

The power supply circuit for 48 or 125-v.d-c supply uses 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 local current, the d-c voltage drop through the transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage of approximately 45-v. d-c. 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. Inductance L1 and capacitor C4 serve as a filter to prevent any appreciable carrier-frequency energy from getting onto the external d.c. supply circuits.

For a 250-volt d-c supply, the circuit of Figure 15 is used. This consists of an external voltagedropping resistor assembly (135 ohms total) in conjunction with three 15-volt Zener diodes on the TC set chassis connected in series. The resistor assembly (see Figure 16) must be mounted at the top of a cabinet or an open rack. Because of the heat dissipated, no transistorized equipment should be mounted above the resistor panel. The 250-volt TC set has a constant current drain of 1.5 amperes d-c.

Relaying Control Circuits

The transmitter start and stop control circuits and the receiver 20-volt output (previously described) allow this type TC set to be used with solid-state protective and auxiliary relays which also have 20-volt input and output "logic". In addition, these carrier control circuits are designed to absorb and limit externally generated surges so they will not damage the transistors or associated components.

For flexibility in application, provision is also made for keying the transmitter from either 48 or 125 volts d.c. Also, the 200-ma receiver output circuit is brought out to a J104 terminal for connection to a 30-ohm alarm relay, if desired.

CHARACTERISTICS

Frequency range 30-300 kHz (50-300 kHz for

phase comparison relaying)

Transmitter output 10 watts into 50 to 70-ohm

resistive load

Harmonics 55 db below 10 watts. Receiver sensitivity 125 mv. input for 180 ma. minimum output current

Receiver selectivity 1500 Hz bandwidth (3 db down);

down 80 db at $\pm 3kHz$. Transmitter-receiver

channel rating 40 db

Input Voltage 48, 125, or 250 V. d-c

Supply voltage

variation 42-56V, 105-140V, 210-280V

Battery Drain:

0.5 amp standby, 1.35 amp 48 V.D.C. transmitting

125 V.D.C. 0.25 amp standby, 1.1 amp

transmitting

250 V.D.C. 1.5 amp standby or transmitting Temperature range -20 to +60°C. around chassis.

Frequency Spacing

The minimum recommended frequency spacing between two Type TC carrier sets operated in parallel without hybrid units is shown on the curve of Fig. 13. For example, at 100 kHz. the minimum spacing is 8 kHz. Closer spacing would result in the generation of intermodulation products caused by the non-linear load presented by each transmitter to the other one.

The minimum frequency spacing between a TC carrier channel and an adjacent transmitter signal keyed on-off at a rate of 60 pulses per second can be determined from the nomograph of Fig. 14. Using the example shown by the dashed line, consider a type TC set used on a channel with a normal attenuation of 15 decibels. The TC receiver would be set to give a margin of 15 db below the normal received signal, or for a sensitivity of $-30\ db$ (relative to a 24.5 volt, 10-watt signal). The interfering signal is assumed to be a 10-watt transmitter at the same location. To determine the minimum frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the -30 db point on the receiver sensitivity scale and the zero-db point on the interfering transmitter scale. The resulting line crosses the channel spacing scale between 3 and 4 kHz. For this example, a channel spacing of at least 4 kHz should be used. (In order not to conflict with the limits of Fig. 13, an r-f hybrid may be needed between the TC set and the other transmitter, depending on the actual application.)

For protective relaying applications to 3-terminal lines, the transmitter frequencies are offset $100\ hertz$ to prevent a slow beat or cancellation of the received signal when two transmitters send blocking signals to the third terminal. The three transmitters operate

at fc, fc+100 Hz, and fc-100 Hz. All receivers operate at the channel center frequency (fc).

INSTALLATION

The type TC transmitter-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 should not exceed 60°C.

ADJUSTMENTS

Transmitter

The main adjustment on the transmitter is the power output control R112 on the transmitter printed circuit board. Disconnect the coaxial cable from the assembly terminals and replace with a 50 to 70 ohm noninductive 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 T106 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn the transmitter power output control R112 to minimum (full counterclockwise).

NOTE: Do not change the adjustment of the R142 control on the printed circuit board. See Maintenance section for R142 adjustment.

Now apply d-c power and note the d-c voltage across the two pin jacks TP1 and TP2. If this is in the range of approximately 42 to 46 volts, throw the carrier-test switch SW101 on the panel to the ON position. Slowly advance the output control R112 on the transmitter printed-circuit board until about 10 volts is obtained across the output 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. For 200-300 kHz operation, L105 is a "pot core" and has a adjustable core screw. Use a screw-driver in this case. No locking device is needed.

Now continue to advance the output control R112 until the output voltage tabulated in the following table is obtained across the load resistor. Recheck the setting of L105 to be sure it is at its maximum point for 10 watts output. Tighten the locking nut. Turn off the carrier test switch SW101, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

NOTE: For 200-300kHz sets, inductor L105 is a pot core and the foregoing adjustment check is generally

unnecessary since there is little chance of its setting being disturbed. However, if desired, the pot core setting can be checked using a screwdriver to vary the setting of the adjustable core. There is no locking device as the adjustable core is held in place by friction.

T106 Tap	Voltage for 10 Watts Output
50	22.4
60	24.5
70	27.0

Transmitter Filter

Normally, the output filter (FL102) will require no readjustment except as noted under Adjustments-Transmitter, as 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. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection at the factory, 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.

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

Receiver

The receiver board has two controls; the i.f. input control R239 which is factory-set to give a sensitivity of 125 mv. for 180 ma. output, and the local oscillator output control R212. The oscillator output is preset at the factory at 0.5 volt. This setting can be checked by connecting an a-c VTVM between receiver test points TP202 and TP206 (shield lead of VTVM.) The voltmeter reading with the equipment energized, but not transmitting, should be 0.5 volt rms. Note Fig. 5 for location of components on the receiver printed board.

The other adjustment on the receiver is the gain control R207 which is front-panel mounted. It is recommended that the receiver gain normally be set for a 15-db operating margin to allow for reasonable variations in receiver input signal level without affecting the output blocking current. This adjustment can be made in two ways, as follows:

1. First, measure the normal received signal from the remote terminal (after the line tuners have been adjusted) by starting the remote transmitter and measuring the voltage across the coaxial cable at the receiving terminal. This signal should preferably be measured with a tuned voltmeter such as the Sierra carrier-frequency volt-

meter. If a simple VTVM is used, have the remote transmitter turned on and off several times to be sure the VTVM reading is actually the remote signal. Note the reading. Now disconnect the coaxial cable, and feed a signal into the carrier assembly at the coaxial terminals from a separate signal generator. Set the signal generator to the received frequency at a level 15 db below the previously measured incoming signal. With a 0-250 ma. (minimum) d-c milliammeter plugged into J203, adjust the receiver gain control until an output current of about 100 ma. is obtained. As this point is on the steep portion of the receiver output-input curve, it may be difficult to set the gain control for exactly 100 ma. This is not necessary, however, as the signal is not normally at this value. This is the operating setting of the receiver gain control. Return the coaxial cable connections to normal.

NOTE: Do not energize the local transmitter when making the foregoing adjustment as the signal generator may be damaged.

2. As an alternate procedure if no signal generator is available, the local transmitter itself may be used as the signal generator. First determine the normal received signal from the remote terminal as explained previously under (1). Then turn off the remote transmitter.

Now turn on the local transmitter and reduce its output to a value 15 db below the normal received signal level. Then adjust the receiver gain control to give 100 ma. output as before. When this adjustment has been made, reset the local transmitter to its normal 10-watt output level.

In applications where the line attenuation is low and a strong signal is received, the adjustment of the receiver gain control R207 becomes critical. For such applications, the setting of i-f gain control R239 may be reduced to lower the overall receiver gain. The front-panel control R207 will then have a smoother and more gradual control as the knob is rotated, making it easier to obtain the 15-db margin setting.

For such a strong-signal condition, it is recommended that with R239 at maximum, the i-f gain control R237 be adjusted to give 100 ma. receiver output current for an input r-f voltage 25 db below the normal received signal level. Then the front panel control R207 is set for the normal 15-db margin as previously described.

Carrier Level Indicator (CLI)

The CLI should be adjusted on a clear dry day when line conditions are considered normal. After the receiver sensitivity has been set for a 15-db margin, turn on the remote transmitter at its normal 10-watt output. With a small screw-driver, adjust the CLI input control R252 to give a reading of 2.5 ma. on the 0-3 ma. d-c milliammeter in the CLI output circuit. This current can be read at J202 on the TC set panel for convenience. If the received signal varies for any reason, the CLI output current will change accordingly, as indicated by the curve in Fig. 12.

When carrier is transmitted from the local station, the pointer of the local CLI output milliammeter will be driven off scale. This will not in any way damage the instrument as the CLI saturation current is less than 4 ma. d.c.

MAINTENANCE

Periodic checks of the received carrier signal will indicate proper operation of the equipment. 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 and receiver sensitivity 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 and current values are given in Tables I through VI. Voltages should be measured with a VTVM. Readings may vary as much as $\pm\,20\%$.

The transmitter keying board is mounted over the power amplifier board. See Fig. 2. In order to check test-point voltages on the power-amplifier board, first remove the keying circuit-board recept-acle mounting screws and the two screws holding down the upper end of the board. Now carefully lift the transmitter keying board away from the power-amplifier board, pulling from the top, but do not disturb the chassis harness wiring any more than necessary. This will expose the test points on the power-amplifier board so that voltage readings can be taken.

Similarly, the receiver CLI and output board can be moved to uncover the right-hand portion of the receiver board. Remove the four mounting screws holding the receiver auxiliary board in place. Lift up this board from the left side and pull it away from the receiver board. This will expose the right half of the receiver board.

Adjustment of R142 on Transmitter Board

The small adjustable resistor (pot.) R142 sets the forward base bias on transmitter transistors Q104 and Q105 to the proper point for class-B operation. This is a factory adjustment and need not be changed unless transistors Q104 or Q105 (or both) are replaced. However, if these transsistors are changed, or if the R142 setting is disturbed in error, the following adjustment procedure should be followed to reset R142:

First remove d-c power from the TC carrier set assembly. Unsolder the lead from terminal 2 of transformer T103 (just above FL101) and temporarily connect a low-range d-c milliammeter (0-1.0 or so) between the removed lead (+) and T103 terminal 2 (-). Turn the slotted control on the small pot (R142) to full counterclockwise. Now, apply power to the TC carrier set, but do not transmit carrier. Advance the pot until the d-c milliammeter reads 0.2 mA d.c. \pm .05 mA. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T103. Again apply d-c power and proceed with the transmitter adjustment as described in the ADJUSTMENTS section.

Replacement of Q107-Q108

The two transistors Q107 and Q108 in the transmitter power-amplifier stage are a matched pair with the gain of the two units matched within 5%. If one of the transistors fails, both should be replaced with a new matched pair. This is necessary to keep the second harmonic of the transmitter output at an acceptably low value. The pair of transistors should be ordered as "2 of style 187A673H16 transistors Type 2N3792''.

power amplifier module styles NOTE: Only 774B541G01 through G05 are used with Type 2N3792 transistors. When ordering replacement transistors, check to see that you have this style module. If not, the existing module can be modified by changing D104and D106 to type 1N4818 Diodes. Order these diodes as "2 of style 188A342H06".

CHANGE OF OPERATING FREQUENCY

The parts required for changing the operating frequency of a type TC carrier set are as follows:

Transmitter

- 1. Oscillator Crystal (Y101), specify frequency. NOTE: Modify A-B-C jumpers on transmitter board if required for new frequency. See table marked "†" under internal schematic (Fig.8).
- 2. R136 Jumper

For operation in 30-50kHz range, clip off R136 as indicated in Fig. 3.

- 3. Capacitors C111 and C113 (on Power Amp. board) -0.47 mfd. - S#188A293H01
 - a. 30-50 kHz b. 50.5-75 kHz - 0.22 mfd. - S#188A293H02
 - c. 75.5-100 kHz 0.15 mfd. S #188A293H03
 - d. 100.5-150 kHz 0.10 mfd. S#188A293H04
 - e. 150.5-300 kHz 0.047 mfd. S#188A293H05
- 4. Transmitter Module Mounting Plate

When changing from a frequency of 200KHz or below to a frequency above 200KHz, the following is also necessary:

Transmitter module mounting plate S#691B610H01 and associated hardware.

This is necessary to raise the transmitter printed circuit board (module) away from the main panel as the 200.5-300kHz. receiver input filter FL201 mounts underneath it. See Fig. 2.

5. Zener Diode Z104

For the 200.5-300kHz. range, a type 1N2999A zener diode Z104 is mounted on the Q108 heat sink adjacent to the protective diode Z103. Remove the lead from the Q108 heat sink (see Fig. 2 for location) and connect it to the insulated terminal of zener diode Z104.

6. FL101 and FL102

Filter FL101 is a small series-resonant tuned circuit between the driver and power amplifier stages of the transmitter. It has just two terminals. Filter FL102 is a larger assembly, described under OPERATION. It has three external connections: input, output, and ground. This filter is mounted by four corner posts. To replace, unsolder the three leads, remove the nuts from the mounting posts, and lift the filter assembly from the posts. The new filter can now be installed.

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 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 groups 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	201.1 000.0
57.5-60.5	106.5-112.5	200.1-207.0	
T.C. 11.			

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 desifable 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 T103 and the voltmeter across terminals 1 and 2 of transformer T104. The signal generator should be set at the channel center frequency and at 2 at 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 T105 and a 500-ohm resistor and a VTVM to the terminals of protective gap G101. 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.

If the change in frequency is enough to require a different filter, it will come factory adjusted as described in the foregoing paragraph.

After all the tabulated changes have been made for the new frequency, the transmitter can be operated with a 50 to 70-ohm load (depending on which tap of T106 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 ADJUSTMENT section.

If a frequency-sensitive voltmeter is available, the second and third harmonic traps may be adjusted (or checked) 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 its tuning dial and db range switch, obtain a maximum on-scale reading of the second 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. It should be noted that this procedure may not give the true magnitude of the harmonics because of the large value of fundamental frequency voltage present at the tuned voltmeter input terminals. This condition will overload the input circuit of some commercial instruments. However, the procedure is satisfactory for adjusting the traps for maximum harmonic rejection.

If accurate measurement of the harmonic levels is desired, the frequency-selective voltmeter is connected, through a rejection filter, to the terminals of the 60-ohm load resistor. The filter must provide high rejection of the fundamental. A twin-T filter is suitable for this purpose. The insertion losses of this filter at the second and third harmonics must be measured and taken into account.

Receiver

- Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
- 2. Receiver input filter (FL201), specify frequency.
- Resistors R211-R238 Combination
 See values in Fig. 8 below internal schematic.
- 4. Resistors R218 and R224 may have to be reduced. See following paragraph.

The emitter resistors R218 and R224 of the i-f stages are normally 33 ohms to give the required receiver gain. If the operating frequency is reduced, the receiver gain will probably be higher. In this case, a reduction in the setting of the i-f input control R239 will give the 125-mv. sensitivity. If the new operating frequency is higher, the receiver gain will be lower. If more than 125 mv. is required to obtain 180 ma. output, the gain can be increased by reducing the value of one or both of the resistors R218 and R224. In most cases, these resistors should fall in the range of 22 to 33 ohms.

TABLE I
Receiver D.C. Measurements

Note: All voltages are negative with respect to Pos. $45 \, V. \, (TP206)$

TEST POINT	STANDBY (No Signal)	WITH 125 M.V. INPUT
TP 201	35-38	35-38
TP 202	0	0
TP 203	11-12	11-12
TP 204	< 0.5	2- 3
TP 205	18-22	18-22
TRANSISTOR	V COLL.	V COLL.
Q201	43	43
Q202	43.5	43.5
Q203	18.0	18.0
Q204	18.0	18.0
Q205	18.0	18.0
Q206	11.0	11.5
Q207	22.0	5.0
Q208	44.0	2.0

All voltages read with d-c vacuum-tube voltmeter. < 0.5 — means "less than 0.5"

TABLE II

Receiver RF Measurements

Note: Taken with 100 kHz receiver filter, 0.125-volt input signal, and gain control R207 at maximum. Depending on receiver frequency and transistor characteristics, the following values will vary appreciably.

TEST POINT	TYPICAL AC VOLTAGES
FL201-IN to Gnd. FL201-OUT to Gnd. Q203 - E to TP206 Q204 - C to TP206 Q205 - B to TP206 Q205 - C to TP206 Q206 - B to TP206 Q206 - C to TP206 TP202 to TP206	.07 .04 .10 .09 .013 1.2 .15 2.5 0.5

All voltages read with a-c vacuum-tube voltmeter.

TABLE III
Transmitter D-C Measurements

Note: All voltages are positive with respect to Neg. D.C. (TP104). All voltages read with d.c. VTVM.

TEST POINT	CARRIEROFF	CARRIER ON
TP101 TP102 TP103 TP105 TP106 TP107 TP108 TP110 TP111 TP112 TP113 J101 (Front Panel)	8.5 volts d.c. <0.5 <0.5 <0.5 44 44 45 <1.0 <1.0 0 45 5 ma. max.	8.5 volts d.c. 20 19.5 9 24 24 44 <1.0 <1.0 <0.5 44 0.6 amp.

TRANSISTOR	V COLL.	V coll.
Q101	2.0	1.8
Q102	1.0	1.0
Q103	<0.5	9.0
Q104	45	44
Q105	45	44
Q106	44.5	1.2
Q107	0	0
Q108	44.5	24.2

TABLE IV Transmitter RF Measurements

Note: "Carrier-on" voltages taken with transmitter set to 10 watts output (24.5 volts across 60 ohms). These voltages subject to variation, depending on frequency and transistor characteristics.

TEST POINT	A-C VOLTAGE
T101-3 to TP104 TP103 to TP102 TP105 to TP104 TP110 to T102-4 TP111 to T102-4 Q104-C to TP104 Q105-C to TP104 T103-4 to Gnd. T104-1 to Gnd. Q107-B to TP107 Q108-B to TP113 Q107-C to TP107 Q108-C to TP107 Q108-C to TP107 T105-4 to Gnd. T106-2 to Gnd. TP109 to Gnd. J102 to Gnd.	1.5 volts, rms. 0.2 1.1 ϕ 0.2 0.2 3.3 3.3 1.1 1.4 0.5 volts, rms. 0.5 14-16 105 100-160* 30-50*

Note: T101-3 = tap 3 of Transformer T101 Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

- * These values may vary considerably with frequency.
- ϕ High-impedance circuit. VTVM causes significant loading.

TABLE V
Transmitter Keying Board
D.C Voltages

TEST POINT	NORMAL (Carrier Off)	CARRIER ON (D.C. on J104-6 or 7)	CARRIER STOP (D.C. on J104-6 or 7 and J104-8 or 9)
TP151	16 v.d.c.	<1.0 v.d.c.	<1.0 v.d.c.
Term. 17	<1.0	24.6	4.9
TP152	16	16	<1.0
TP153	<1.0	<1.0	16
Term. 1	0 *	20	<1.0

^{*} May show <1.0 volt with VTVM

TABLE VI

Receiver CLI and Output Board (with normal received signal)

D.C VOLTAGE – TO NEG.	SIGNAL VOLTAGE (a.c.)
4.9 v.d.c.	0.3 v. rms.
9.8	2.9
< 1.0	_
19.7	_
	- TO NEG. 4.9 v.d.c. 9.8 < 1.0

Recommended Test Equipment

- I. Minimum Test Equipment for Installation
 - a. Milliammeter 0-250 ma. DC
 - b. 60-ohm 10-watt non-inductive resistor.
 - c. A-C Vacuum Tube Voltmeter (VTVM). Voltage range 0.01 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance—one megohm, minimum.
 - d. D-C Vacuum Tube Voltmeter (VTVM).

Voltage Range:

0.1 to 300 volts

Imput Impedance:

1.0 megohm, min.

- $\begin{array}{c} \text{II.} \quad \underline{\text{Desirable Test Equipment for Apparatus Maintenance.}} \end{array}$
 - a. All items listed in I.
 - b. Signal Generator

Output Voltage:

up to 10 volts r.m.s.

Frequency Range:

20 to 330 kHz

- c. Oscilloscope
- d. Ohmmeter
- e. Capacitor checker
- f. Frequency counter
- g. Frequency-selective voltmeter

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.

Transmitter Section

	RATING	STYLE NUMBER
SYMBOL	0.1 mfd, 200 V.DC	187A624H01
C201	.005 mfd, 300 V.DC	187A694H29
C102	180 pf. 500 V.DC	187A695H29
C103	0.25 mfd, 200 V.DC	187A624H02
C104		187A624H02
C105	0.25 mfd, 200 V.DC	187A624H02
C106	0.25 mfd, 200 V.DC	187A624H02
C107	0.25 mfd, 200 V.DC	187A624H03
C108	0.50 mfd, 200 V.DC	187A624H02
C109	0.25 mfd, 200 V.DC	187A624H02
C110	0.25 mfd, 200 V.DC	10/A0241102
† C111	(See Table Below)	
C112	39 pf. 500 V.D.C.	187A695H12
† C113	(See Table Below)	
C114	100 pf., 500 V.DC	187A695H23
	100 pf., 500 V.DC	187A695H23
C115	0.001 mfd, 500 V.DC	187A694H11
C116	Part of FL101	Vary with Frequency
CA GP GP	Part of FL102	Vary with Frequence
CB, CC, CD, CE	1N457A	184A855H07
D101	1N4818	188A342H06
D103	1N4818	188 A 34 2H 06
D104	1N4818	188A342H06
D105	1N4818	188 A342H06
D106		637A026A01
G101	Type RVS Arrester Closed Circuit Jack	187А606Н01
J101	Closed Circuit 3ack	

#200.5 - 300 kHz only.

	RATING	STYLE NUMBER
† FREQ. (C111, C113)	KATING	100 4 00 0 1 1 0 1
30 -50 kHz	0.47 mfd, 400 V.DC	188A293H01
	0.22 mfd, 400 V.DC	188А293Н02
50.5-75 kHz		188A293H03
75.5-100 kHz	0.15 mfd, 400 V.DC	
	0.1 mfd, 400 V.DC	188A293H04
100.5 - 150 kHz		188A293H05
150.5-300 kHz	0.047 mfd, 400 V.DC	

J102 J103 J104 J105 L101 L102 L103 L104 L106 Q101 Q102 Q103	Coaxial (24-Term 12-Term Part of F FL 102 Tr 400 mh. FL102 Cc circuit tu 2.0 mh. 2N2905A 2N2905A	RATING Plug Jack Cable Jack Receptacle Receptacle L101 rap Coil (2nd Harmorap Coil (3rd Harmorap Coil (3rd Harmorap Coil (4) tarmorap Coil (4) tarmorap Coil (5) tarmorap Coil	nic)	STYLE NUMBER 2 of 185A431H0 187A633H01 187A669H01 629A205H02 Vary with Frequency Vary with Frequency 292B096G01 Vary with Frequency 3500A27H01
J104 J105 L101 L102 L103 L104 L105 L106 Q101 Q102 Q103	Coaxial (24-Term 12-Term Part of F FL 102 Tr 400 mh. FL102 Cc circuit tu 2.0 mh. 2N2905A 2N2905A	Cable Jack Receptacle Receptacle L101 rap Coil (2nd Harmorap Coil (3rd Harmorap)	nic)	187 A 633 H 01 187 A 669 H 01 629 A 205 H 02 Vary with Frequency Vary with Frequency 29 2B 096 G 01 Vary with Frequency
J104 J105 L101 L102 L103 L104 L105 L106 Q101 Q102 Q103	24-Term 12-Term Part of F FL 102 Tr FL 102 Tr 400 mh. FL 102 Cc circuit tur 2.0 mh. 2N2905A	Receptacle Receptacle L101 rap Coil (2nd Harmorap Coil (3rd Harmorap Coil (3rd Harmorap Coil (5rd Harmorap C	nic)	187A669H01 629A205H02 Vary with Frequency Vary with Frequency 292B096G01 Vary with Frequency
L101 L102 L103 L104 L105 L106 Q101 Q102 Q103	12-Term Part of F FL102 Tr FL102 Tr 400 mh. FL102 Cc circuit tu 2.0 mh. 2N2905A 2N2905A	Receptacle L101 rap Coil (2nd Harmorap Coil (3rd Harmorap Coil (3rd Harmorap Coil (5rd Ha	nic)	Vary with Frequency Vary with Frequency Vary with Frequency 29 2B096G0 1 Vary with Frequency
L101 L102 L103 L104 L105 L106 Q101 Q102 Q103	Part of F FL 102 Tr FL 102 Tr 400 mh. FL 102 Co circuit tu 2.0 mh. 2N2905A 2N2905A	L101 rap Coil (2nd Harmor rap Coil (3rd Harmor poil (part of series-re	nic)	Vary with Frequency Vary with Frequency Vary with Frequency 292B096G01 Vary with Frequency
L102 L103 L104 L105 L106 Q101 Q102 Q103	FL 102 Tr FL 102 Tr 400 mh. FL 102 Cc circuit tu 2.0 mh. 2N2905A 2N2905A	rap Coil (2nd Harmo	nic)	Vary with Frequency Vary with Frequency 292B096G01 Vary with Frequency
L103 L104 L105 L106 Q101 Q102 Q103	FL 102 Tr 400 mh. FL 102 Co circuit tu 2.0 mh. 2N2905A 2N2905A	rap Coil (3rd Harmon	nic)	Vary with Frequency 292B096G01 Vary with Frequency
L104 L105 L106 Q101 Q102 Q103	400 mh. FL102 Cocircuit tur 2.0 mh. 2N2905A 2N2905A	oil (part of series-re	Sonant	292B096G01 Vary with Frequency
L 105 L 106 Q101 Q102 Q103	FL102 Co circuit tu 2.0 mh. 2N2905A 2N2905A	oil (part of series-re ned to fundamental i	sonant freq.)	Vary with Frequency
L 106 Q101 Q102 Q103	2.0 mh. 2N2905A 2N2905A	oil (part of series-re	sonant freq.)	
Q101 Q102 Q103	2.0 mh. 2N2905A 2N2905A		·	
Q102 Q103	2N2905A			000011211101
Q103	·			TCOA CTOATA
				762A672H10
	2N5 25			762A672H10
Q104				184 A638 H13 762A672H07
Q105		2N3712		
				762A672H07
				184A638H11
		Matched Pair		187 A67 3H 16
				187 A67 3H 16
			WATTS	STYLE NUMBER
			1	187A643H45
			0.5	187A641H35
		10	0.5	187A641H51
		5	0.5	187A763H75
		5	0.5	184A763H17
R 10 6	1,200	5	0.5	184 A763H 29
R107	10,000	10	0.5	184A641H51
R 108	100,000	5	0.5	184A763H75
R109	390	5	0.5	184A763H17
R111	1,200	5		
R112	1 K Pot	20		187 A 763 H 29
R113	4,700	5		629A430H02
R114	10,000			184A763H43
R115				187A641H51 184A763H07
	Q104 Q105 Q106 Q107 Q108 SYMBOL R101 R102 R103 R104 R105 R106 R107 R108 R109 R111 R112 R113 R114	Q104 2N3712 Q105 2N3712 Q106 TI-481 Q107 2N3792 Q108 2N3792 SYMBOL OHMS R101 5,600 R102 2,200 R103 10,000 R104 100,000 R105 390 R106 1,200 R107 10,000 R108 100,000 R108 100,000 R109 390 R111 1,200 R112 1 K Pot R113 4,700 R114 10,000	Q104 2N3712 Q105 2N3712 Q106 TI-481 Q107 2N3792 Q108 2N3792 SYMBOL OHMS ± TOL. % R101 5,600 5 R102 2,200 10 R103 10,000 10 R104 100,000 5 R105 390 5 R106 1,200 5 R107 10,000 10 R108 100,000 5 R109 390 5 R111 1,200 5 R112 1 K Pot 20 R113 4,700 5 R114 10,000 10	Q104 2N3712 Q105 2N3712 Q106 TI-481 Q107 2N3792 Matched Pair SYMBOL OHMS ± TOL. % WATTS R101 5,600 5 1 R102 2,200 10 0.5 R103 10,000 10 0.5 R104 100,000 5 0.5 R105 390 5 0.5 R106 1,200 5 0.5 R107 10,000 10 0.5 R108 100,000 5 0.5 R109 390 5 0.5 R111 1,200 5 0.5 R112 1 K Pot 20 0.25 R113 4,700 5 0.5 R114 10,000 10 0.5

Transmitter Section (Cont.)

		± TOL. %	WATTS	STYLE NUMBER
SYMBOL	OHMS		0.5	184A763H03
R116	100	5	25	1202588
R117	1,000	5	0.5	629A531H56
R118	10,000	2	0.5	629A531H03
R119	62	<u>2</u> 5	2	185A207H51
R120	10,000		2	187A683H01
R121	10	5	0.5	187A290H01
R122	10	5	0.5	187A290H01
R123	10		1	187А644Н03
R124	100	10	0.5	187A641H27
R125	1,000	10	1	187A644H43
R126	4,700	10	0.5	187A640H01
R127	10	10		187A644H35
R128	2,200	5	0.5	184A636H14
R129	2.7	10		187A640H01
R130	10	10	0.5	187A644H43
R131	4,700	5	0.5	184A636H14
R132	2.7	10		184A636H18
R133	0.27	10	1	184A636H18
R134	0.27	10	1	188A317H01
R135	3,000	10	5	629A531H58
R136	12,000	2	0.5	187A642H55
R137	15,000	10	2	187A641H27
R138	1,000	10	0.5	187A641H27
R139	1,000	10	0.5	629A531H04
R140	68	2	0.5	185A211H06
R141	30	Type 3D2	202 Thermistor	629 A430H13
R141	25K pot.	20	0.125	629A531H63
R143	20,000	2	0.5	STYLE NUMBER
SYMBOL		RATING		880A357H01
SW 101	C	arrier Test Switch		205C043G01
T101	10	,000/400 ohms		714B666G01
T102	10	,000/400 c.t.		1962694
T102	19	030/60 ohms	L633000	292B526G01
	T	urns ratio, 1/0.5	Pri./each sec.	292B526G02
T104	10)/500 ohms		292B526G03
T105	5	00/50 - 60 - 70 ohm	s	
T106		0-300 kHz crystal p		Specify Frequence 862A288H03
Y101		N5357B (20 V ±5%		
Z101	· · · · · · · · · · · · · · · · · · ·	N2999B (56 V ±5%		629A798H04
Z102		N2999B (56 V ±5%		629A798H04

ELECTRICAL PARTS LIST Transmitter Keying Board

SYMBOL	RATING	STYLE NUMBER
C151-C152	0.47 mfd., 200 V.	849A437H04
C154	47 mfd., 50 V.	
D151	1N457A	863A530H01
D152	1N4818	184A855H07
Q151 to Q155	2N3417	188A342H06
R151 - R159	47K, ½ W.	848A851H02
R152-R153-R160-R161	4.7K, ½ W.	629A531H72
R154-R162	82K, ½ W.	629A531H48
R155-R158-R163-R166-R169	10K, ½ W.	629A531H78
R156-R164-R167		629A531H56
R157-R165-R168	6.8K, ½ W.	629A531H52
R170	27K, ½ W.	629A531H66
Z151-Z152-Z155-Z156	700, 5 W.	763A129H04
Z153-Z157	1N3688A (24V)	862A288H01
Z154-Z158	1N3686B (20V)	185A212H06
Z159	1N957B (6.8V)	185A797H06
Z160	1N748A (3.9V)	185A797H13
2100	1N5357B (20V)	862A288H02
G20.1	Receiver Section	
C201	0.1 mfd., 200 V. DC	187A624H01
C202	300 pf. 500 V. DC	187A695H35
C203	180 pf. 500 V. DC	187A695H29
C204	0.25 mfd. 200 V. DC	187A624H02
C205	0.25 mfd, 200 V. DC	187A624H02
C206	0.25 mfd, 200 V. DC	187A624H02
C207	0.25 mfd., 200 V. DC	187A624H02
C208	0.25 mfd., 200 V. DC	187A624H02
C209	0.25 mfd., 200 V. DC	187A624H02
C210	0.25 mfd., 200 V. DC	187A624H02
C211	0.1 mfd., 200 V. DC	187A624H01
C212	0.25 mfd., 200 V. DC	187A624H02
C213	2.0 mfd., 200 V. DC	187A624H05
C214	0.25 mfd., 200 V. DC	
C215	39 pfd., 500 V. DC	187A624H02
D201	1N457A	187A695H12
D202	1N457A	184A855H07
D203	1N4818	184A855H07
D204	1N4818	188A342H06
		188A342H06

Receiver Section (cont.)

SYMBOL		RATING		STYLE NUMBER	
FL201	Receiver	Input Filter 30-300 kH	Z	Specify Frequency	
		i.f. Filter - 20kHz (2 s		187A590G02	
FL202		Coax, Input Jack		187A638H01	
J201		ircuit Jack (CLI)		187А606Н01	
J202		Closed Circuit Jack (200MA)			
	33 mh.				
L201	2N2905A			762A672H10	
Q201	2N2905A			762A672H10	
Q202				762A672H10	
Q203	2N2905A		-	762A672H10	
Q204	2N2905A 2N2905A			762A672H10	
Q205	2N 2905 A 2N 2905 A			762A672H10	
Q206				849A441H01	
Q207		2N3645		187A673H13	
Q208 SYMBOL	2N4903 RATING				
	OTHE	± TOL. %	WATTS	STYLE NUMBER	
	OHMS	10	0.5	187A641H51	
R201	10,000	10	0.5	187A641H35	
R202	2,200	10	0.5	187A641H51	
R203	10,000	5	0.5	184A763H75	
R204	100,000	5	0.5	184A763H17	
R205	390	5	0.5	184A763H29	
R206	1,200	10	2	185A086H07	
R207	25K Pot.	10	0.5	187A641H51	
R208	10,000		0.5	184A763H17	
R 209	100,000	5	0.5	184A763H17	
R210	390	5	0.5	See † Note Belov	
R211		20	0.25	629A430H02	
R212	1 K pot.	20	0.23	184A763H29	
R213	1,200	5		187A643H45	
R214	5,600	5	1 0.5	184A763H58	
R215	20,000	5	0.5	184A763H40	
R216	3,600	5	0.5	184A (03H40	

[†] R211 - 10K - above 50kHz - S#187A641H51 22K - 30-50kHz - S#187A641H59

Receiver Section (Cont.)

SYMBOL	RATING			
31 MBOL	OHMS	± TOL. %	WATTS	STYLE NUMBER
R217	620	5	0.5	184A763H22
R218	33	5	0.5	187A290H13
R219	10,000	10	0.5	187A641H51
R220	20,000	5	0.5	184A763H58
R221	300	5	0.5	184A763H14
R222	3,600	5	0.5	184A763H40
R223	620	5	0.5	184A763H22
R224	33	5	0.5	187A290H13
R225	10,000	10	0.5	187A641H51
R226	20,000	5	0.5	184A763H58
R227	300	5	0.5	184A763H14
R228	3,600	5	0.5	
R229	620	5	0.5	184A763H40 184A763H22
R230	10	5	0.5	
R231	2,000	5	0.5	187A290H01
R232	1,200	5	2	184A763H34
R233	4,700	10	2	185A207H29
R234	5,100	5		187A642H43
R235	1.5K	5	0.5	184A763H44
R236	4,700	10	0.5	184A763H21
R237	170	5	1	187A644H43
R238			40	1336074
R239	1 K pot.	20	0.05	See † Note Below
R240	50	Sensistor	0.25	629А430Н02
R241	100		0.25	187A685H08
R242	100	Type 3D102 Thermistor		185A211H12
R280	56	Type TM-1/4 Sen		187A685H06
T201	10,000/10,000	5 Ohma	0.5	187 A 290 H 19
T202	10,000/400	Ohms		714B677G01
T203	25,000/300			205C043G01
Y201		Ohms		205C043G03
Z201	1N3027B (20	ystal per 328C083		Specify Frequency
Z202				184A449H07
2202	1N1789 (56V			584C434H08
SYMBOL	Kece	eiver CLI and Output B	oard	
C251 to C253		RATING		STYLE NUMBER
C255 to C260	0.27 mfd, 200			188A669H05
C254	0.82 mfd, 200	V.d.c.		188A669H15
D251-D252	1N457A			184A855H07
D253	1N645A			837A692H03
Z251	1N3686B (20V	(.)		185A212H06
Z252	1N3688A (24V	·.)		862A288H01

[†] R238 - omit - above 50kHz

^{- 22}K, 30-50kHz, S#187A641H59.

ELECTRICAL PARTS LIST Receiver CLI and Output Board (Cont.)

			Receiver CLI and Out		STYLE NUMBER
	SYMBOL	2.7K, TM-1/4 Sensistor			187A685H05
	R251	5K, ¼W. pot.			629A430H07
	R252	220, ½W.			184A763H11
	R253		2.2K, ½W.		184A763H35
-	R254		15K, ½W.		184A763H55
	R255-R260		2.4K, ½W.		184A763H36
	R256		330, TM-1/4		187A685H07
	R257				184A763H43
	R258-R259		4.7K, ½W.		184A763H21
	R261		560, ½W.		184 A763H29
	R262-R265		1.2K, ½W.		184A763H09
	R263-R264		180, ½W.		629A531H66
	R266		27K, ½W.		629A531H56
	R267-R269		10K, ½W.		629 A531 H52
	R268		6.8K, ½W.		629A531H32 629A531H78
	R270		82K, ½W.		762A679H01
	R271				
	Q251-Q252	2N4356			849 A441 H02 848 A85 1H02
	Q253		2N3417		
	Q254		2N3645 Power Suppl	ly Section	
_		<u> </u>	FUNCTION	DESCRIPTION OR RATING	STYLE NUMBER
-	SYMBOL			0.45 mfd. 330 VAC	1723408
	C1	(+) to (-)		0.5 mfd, 1500 VDC	1877962
_	C2	A-C grou		0.5 mfd, 1500 VDC	1877962
_	C3	A-C grou	naing	1.8 mfd, 800 VDC	14C9400H12
-	C4	Filter		5.5 mh.	719B135G01
L	L1	Filter Series R	egulator	2N6259	3503A41H01
	Q1	Belles IV		26.5 ohms, 40W.	04D1299H44
_	R1	10577	Series dropping Series dropping	Same as R1	04D1299H44
_	R2	125V	Current limiting	500 ohms, 40W.	1268047
_	R3				
	R1		For 48 VDC, R1 = R2 0	_	_
_	R2	48V		40W.	04D1299H44
	R3		R3 = 26.5 ohms		187A332H01
L	TP1	Test po	int (+)	Pin Jack – red	187A332H01
L	TP2	Test po	int (—)	Pin Jack - black	184A854H06
	Z1	Voltage	Regulator	1N2828B (45V.)	
	Z 2	Surge P	rotection	1N3009A (130V.) Zener Diodes	184A617H12
	Z3	Voltage	Reg for 250 V.D.C.	1N2813B (15V.)	184A854H11

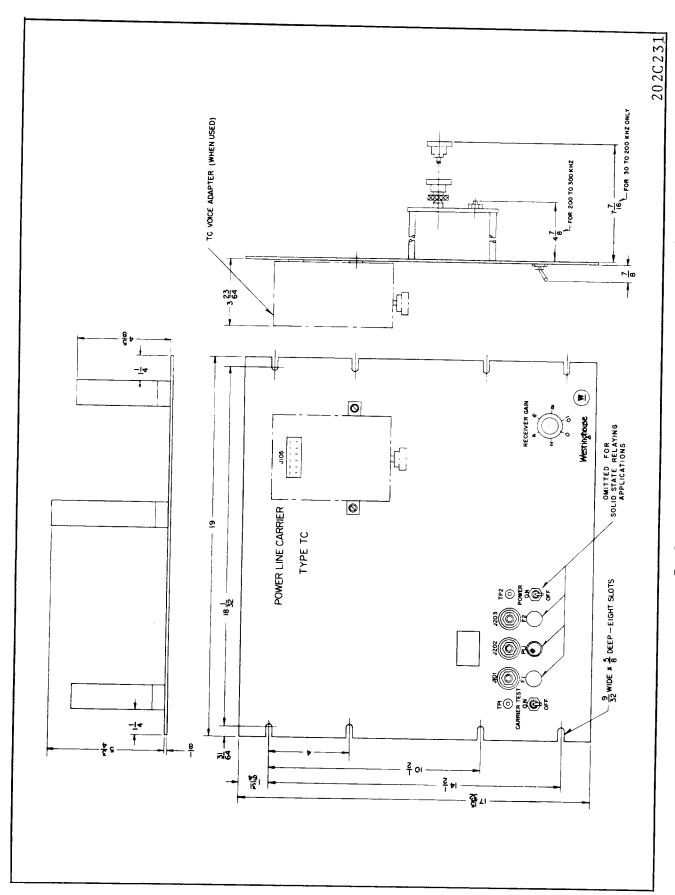


Fig. 1 Type TC Carrier Assembly - Outline

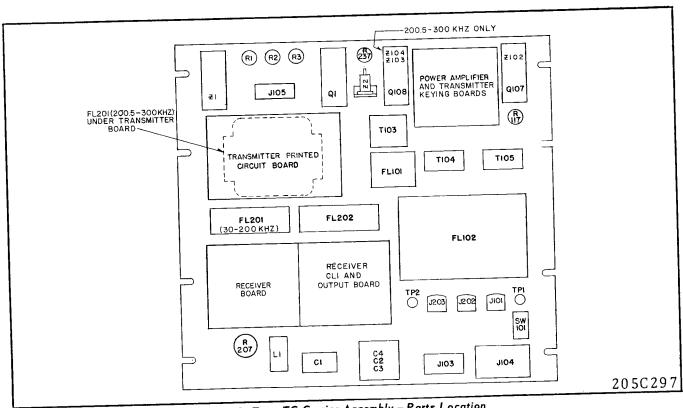


Fig. 2 Type TC Carrier Assembly - Parts Location

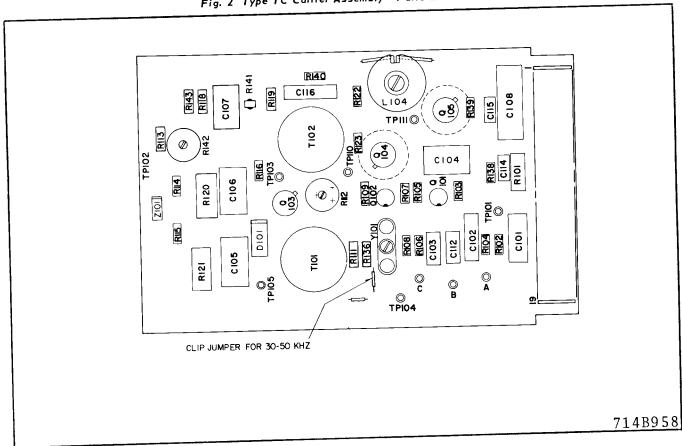
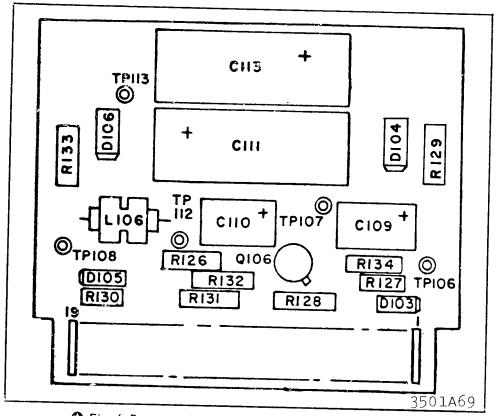


Fig. 3 Transmitter Printed Circuit - Parts Location



• Fig. 4 Power Amplifier Printed Circuit - Parts Location

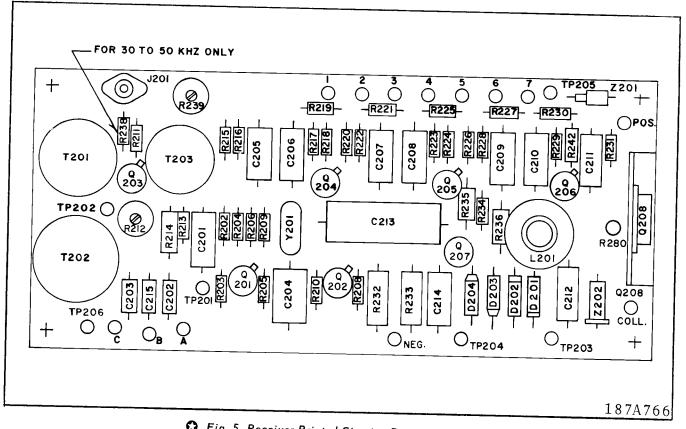
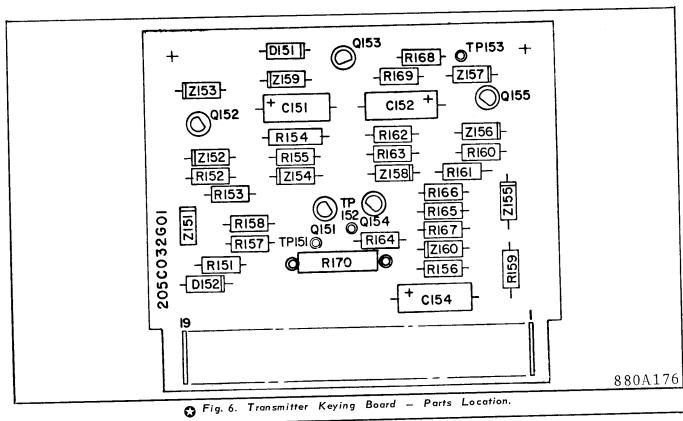


Fig. 5 Receiver Printed Circuit - Parts Location



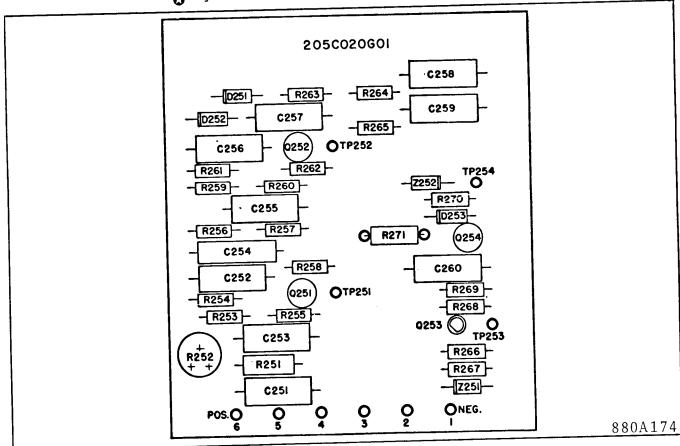


Fig. 7. Receiver CLI and Output Board — Parts Location.

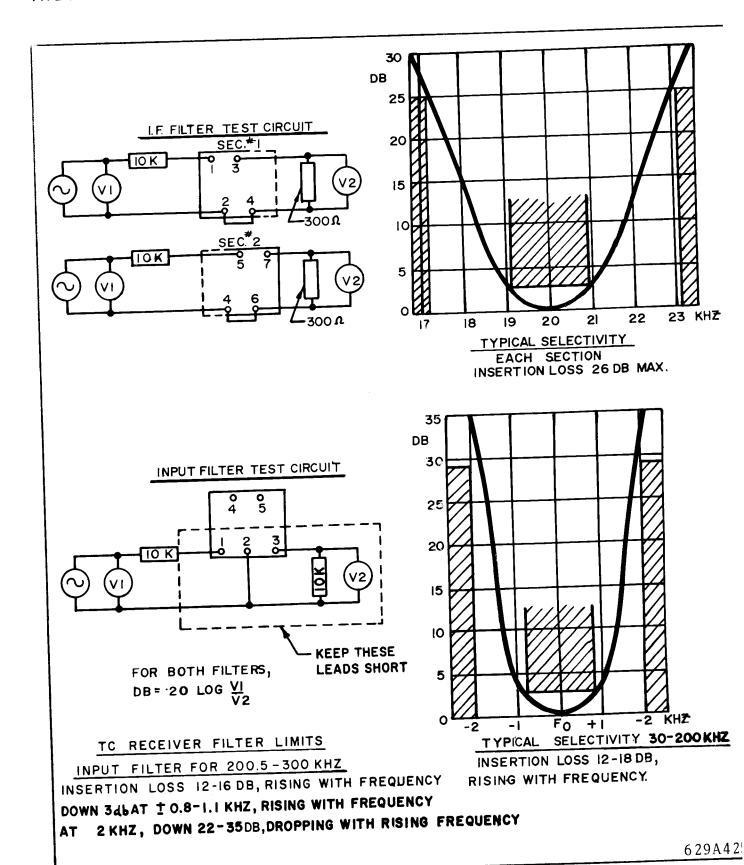


Fig. 9. Type TC Receiver Filter Characteristics

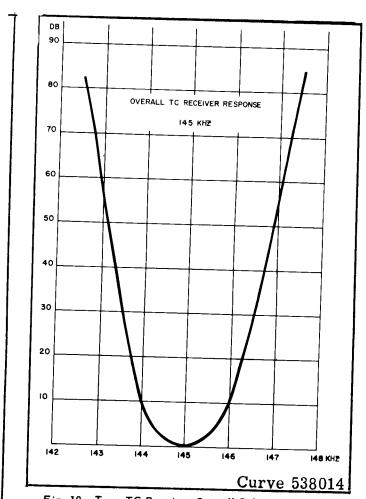


Fig. 10. Type TC Receiver Overall Selectivity Curve.

Fig. 11. Type TC Receiver — 200 ma. Output Characteristic.

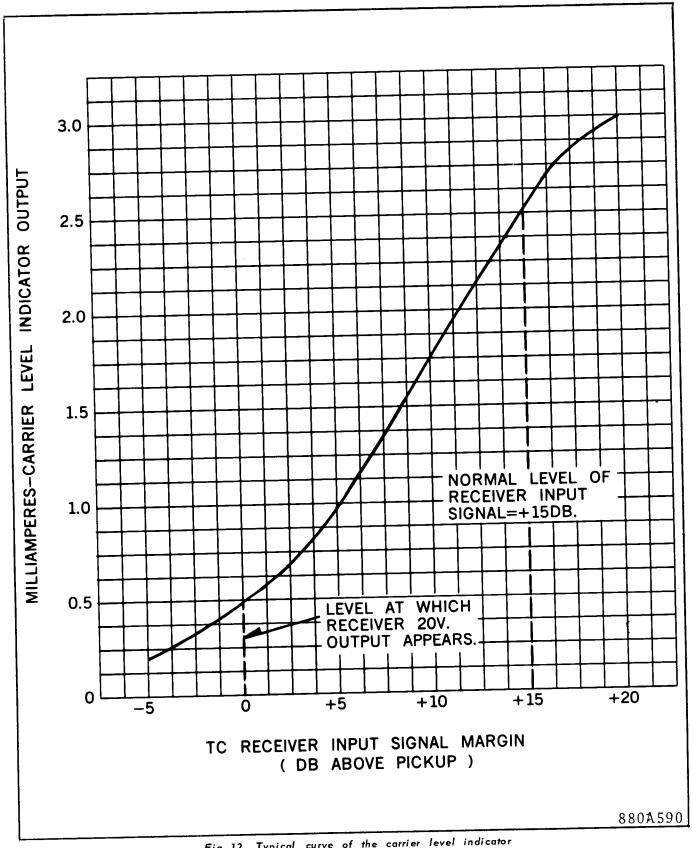


Fig. 12. Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

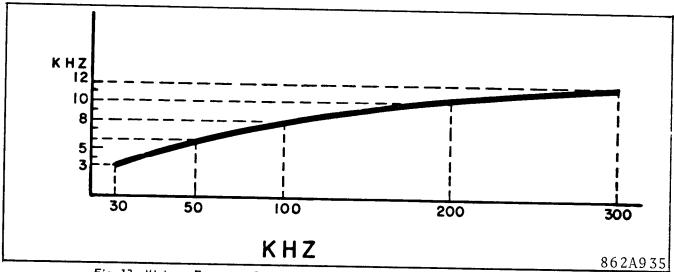


Fig. 13. Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

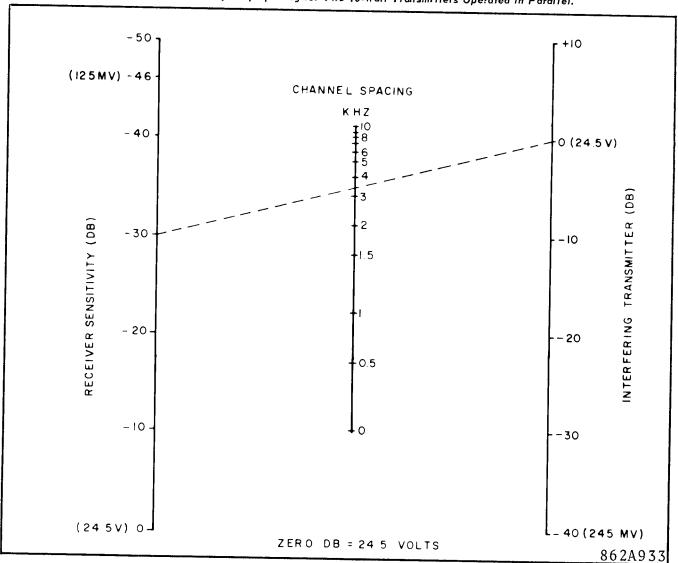


Fig. 14. Minimum Channel Spacing for Keyed Carrier 60 p.p.s.

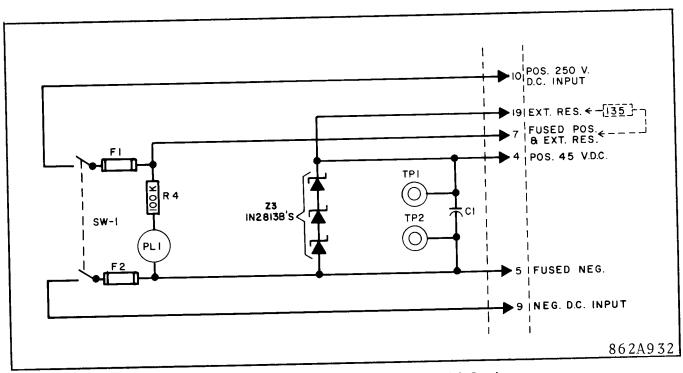


Fig. 15. Detail of Power Supply Section for 250-Volt Supply.

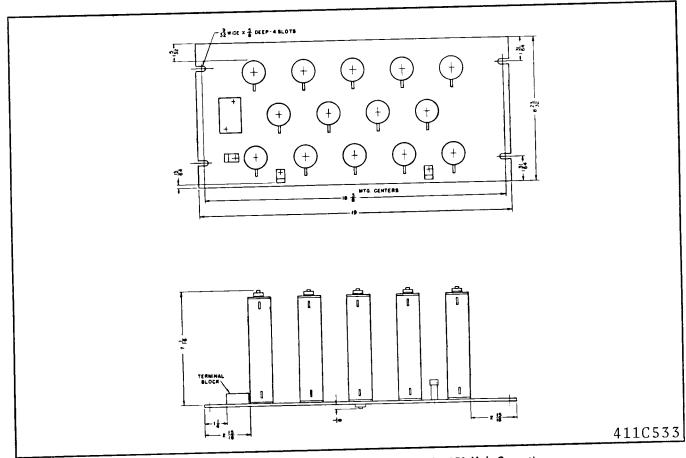


Fig. 16. Outline of External Resistor Unit for 250-Volt Operation.



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INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY FOR USE WITH SOLID-STATE RELAYING SYSTEMS

TABLE OF CONTENTS			LIST OF ILLUSTRATIONS
	Page	Figure	Page
Caution	2	1	Type TC Carrier Assembly-Outline 18
Application		2	Type TC Carrier Assembly — Parts Location
Construction	2		
Operation Transmitter	2	3	Transmitter Printed Circuit Board— Parts Location
Receiver Power Supply	4	4	Power Amplifier Printed Circuit Board — Parts Location
Relaying Control Circuits Carrier Control for Other Function	4	5	Receiver Printed Circuit Board— Parts Location
Characteristics		6	Transmitter Keying Board – Parts Location
Adjustments Transmitter	5	7	Receiver CLI and Output Board-
Transmitter FilterReceiver	5	0	Parts Location
Maintenance		8	Solid-State Relaying – Internal Schematic23-2
Change of Operating Frequency Transmitter Receiver	7	9	Type TC Receiver Filter Characteristics
Recommended Test Equipment	10	10	Type TC Receiver Overall Selectivity Curve
Renewal Parts Electrical Parts List Transmitter	11	11	Type TC Receiver — 200-ma. Output Characteristic
Receiver Power Supply	15	12	Receiver CLI – Output Characteristic 2
LIST OF TABLES		13	Minimum Frequency Spacing Between Two Type TC Carrier
Table	Page	1	Sets (Without Hybrids) 2
I Receiver D-C Measurements	9	14	Minimum Channel Spacing for
II Receiver R-F Measurements	9		Keyed Type TC Carrier (Keyed at 60 p.p.s.) 2
III Transmitter D-C Measurements	9	1.5	Detail of Power Supply
IV Transmitter R-F Measurements		15	Section for 250-volt Supply 2
V Transmitter Keying Board Meas VI Receiver CLI Board Meas	10	16	Outline of External Resistor Unit for 250-volt Operation

Power Supply

The power supply circuit for 48 or 125-v.d-c supply uses 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 local current, the d-c voltage drop through the transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage of approximately 45-v. d-c. 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. Inductance L1 and capacitor C4 serve as a filter to prevent any appreciable carrier-frequency energy from getting onto the external d.c. supply circuits.

For a 250-volt d-c supply, the circuit of Figure 15 is used. This consists of an external voltage-dropping resistor assembly (135 ohms total) in conjunction with three 15-volt Zener diodes on the TC set chassis connected in series. The resistor assembly (see Figure 16) must be mounted at the top of a cabinet or an open rack. Because of the heat dissipated, no transistorized equipment should be mounted above the resistor panel. The 250-volt TC set has a constant current drain of 1.5 amperes d-c.

Relaying Control Circuits

The transmitter start and stop control circuits and the receiver 20-volt output (previously described) allow this type TC set to be used with solid-state protective and auxiliary relays which also have 20-volt input and output 'logic'. In addition, these carrier control circuits are designed to absorb and limit externally generated surges so they will not damage the transistors or associated components.

For flexibility in application, provision is also made for keying the transmitter from either 48 or 125 volts d.c. Also, the 200-ma receiver output circuit is brought out to a J104 terminal for connection to a 30-ohm alarm relay, if desired.

CHARACTERISTICS

Frequency range 30-300 kHz (50-300 kHz for phase comparison relaying)

Transmitter output 10 watts into 50 to 70-ohm

resistive load

Harmonics 55 db below 10 watts.

Receiver sensitivity 125 mv. input for 180 ma.

minimum output current

Receiver selectivity 1500 Hz bandwidth (3 db down);

down 80 db at $\pm 3kHz$.

Transmitter-receiver

channel rating 40 db

Input Voltage 48, 125, or 250 V. d-c

Supply voltage

variation 42-56V, 105-140V, 210-280V

Battery Drain: 0.5 amp standby, 1.35 amp

48 V.D.C. transmitting

125 V.D.C. 0.25 amp standby, 1.1 amp

transmitting

250 V.D.C. 1.5 amp standby or transmitting

* Temperature range -20 to +60°C. around chassis.

Frequency Spacing

The minimum recommended frequency spacing between two Type TC carrier sets operated in parallel without hybrid units is shown on the curve of Fig. 13. For example, at 100 kHz. the minimum spacing is 8 kHz. Closer spacing would result in the generation of intermodulation products caused by the non-linear load presented by each transmitter to the other one.

The minimum frequency spacing between a TC carrier channel and an adjacent transmitter signal keyed on-off at a rate of 60 pulses per second can be determined from the nomograph of Fig. 14. Using the example shown by the dashed line, consider a type TC set used on a channel with a normal attenuation of 15 decibels. The TC receiver would be set to give a margin of 15 db below the normal received signal, or for a sensitivity of $-30\ \mathrm{db}$ (relative to a 24.5 volt, 10-watt signal). The interfering signal is assumed to be a 10-watt transmitter at the same location. To determine the minimum frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the -30 db point on the receiver sensitivity scale and the zero-db point on the interfering transmitter scale. The resulting line crosses the channel spacing scale between 3 and 4 kHz. For this example, a channel spacing of at least 4 kHz should be used. (In order not to conflict with the limits of Fig. 13, an r-f hybrid may be needed between the ${\ensuremath{ ext{TC}}}$ set and the other transmitter, depending on the actual application.)

For protective relaying applications to 3-terminal lines, the transmitter frequencies are offset 100 hertz to prevent a slow beat or cancellation of the received signal when two transmitters send blocking signals to the third terminal. The three transmitters operate

at fc, fc+100 Hz, and fc-100 Hz. All receivers operate at the channel center frequency (fc).

INSTALLATION

The type TC transmitter-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 should not exceed 60°C.

ADJUSTMENTS

Transmitter

The main adjustment on the transmitter is the power output control R112 on the transmitter printed circuit board. Disconnect the coaxial cable from the assembly terminals and replace with a 50 to 70 ohm noninductive 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 T106 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn the transmitter power output control R112 to minimum (full counterclockwise).

NOTE: Do not change the adjustment of the R142 control on the printed circuit board. See Maintenance section for R142 adjustment.

Now apply d-c power and note the d-c voltage across the two pin jacks TP1 and TP2. If this is in the range of approximately 42 to 46 volts, throw the carrier-test switch SW101 on the panel to the ON position. Slowly advance the output control R112 on the transmitter printed-circuit board until about 10 volts is obtained across the output 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. For 200-300 kHz operation, L105 is a "pot core" and has a adjustable core screw. Use a screw-driver in this case. No locking device is needed.

Now continue to advance the output control R112 until the output voltage tabulated in the following table is obtained across the load resistor. Recheck the setting of L105 to be sure it is at its maximum point for 10 watts output. Tighten the locking nut. Turn off the carrier test switch SW101, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

* NOTE: For 200-300kHz sets, inductor L105 is a pot core and the foregoing adjustment check is generally

unnecessary since there is little chance of its setting being disturbed. However, if desired, the pot core setting can be checked using a screwdriver to vary the setting of the adjustable core. There is no locking device as the adjustable core is held in place by friction.

T106 Tap	Voltage for 10 Watts Output
50	22.4
60	24.5
70	27.0

Transmitter Filter

Normally, the output filter (FL102) will require no readjustment except as noted under Adjustments-Transmitter, as 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. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection at the factory, 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.

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

Receiver

The receiver board has two controls; the i.f. input control R239 which is factory-set to give a sensitivity of 125 mv. for 180 ma. output, and the local oscillator output control R212. The oscillator output is preset at the factory at 0.5 volt. This setting can be checked by connecting an a-c VTVM between receiver test points TP202 and TP206 (shield lead of VTVM.) The voltmeter reading with the equipment energized, but not transmitting, should be 0.5 volt rms. Note Fig. 5 for location of components on the receiver printed board.

The other adjustment on the receiver is the gain control R207 which is front-panel mounted. It is recommended that the receiver gain normally be set for a 15-db operating margin to allow for reasonable variations in receiver input signal level without affecting the output blocking current. This adjustment can be made in two ways, as follows:

1. First, measure the normal received signal from the remote terminal (after the line tuners have been adjusted) by starting the remote transmitter and measuring the voltage across the coaxial cable at the receiving terminal. This signal should preferably be measured with a tuned voltmeter such as the Sierra carrier-frequency volt-

meter. If a simple VTVM is used, have the remote transmitter turned on and off several times to be sure the VTVM reading is actually the remote signal. Note the reading. Now disconnect the coaxial cable, and feed a signal into the carrier assembly at the coaxial terminals from a separate signal generator. Set the signal generator to the received frequency at a level 15 db below the previously measured incoming signal. With a 0-250 ma. (minimum) d-c milliammeter plugged into J203, adjust the receiver gain control until an output current of about 100 ma, is obtained. As this point is on the steep portion of the receiver output-input curve, it may be difficult to set the gain control for exactly 100 ma. This is not necessary, however, as the signal is not normally at this value. This is the operating setting of the receiver gain control. Return the coaxial cable connections to normal.

NOTE: Do not energize the local transmitter when making the foregoing adjustment as the signal generator may be damaged.

2. As an alternate procedure if no signal generator is available, the local transmitter itself may be used as the signal generator. First determine the normal received signal from the remote terminal as explained previously under (1). Then turn off the remote transmitter.

Now turn on the local transmitter and reduce its output to a value 15 db below the normal received signal level. Then adjust the receiver gain control to give 100 ma. output as before. When this adjustment has been made, reset the local transmitter to its normal 10-watt output level.

In applications where the line attenuation is low and a strong signal is received, the adjustment of the receiver gain control R207 becomes critical. For such applications, the setting of i-f gain control R239 may be reduced to lower the overall receiver gain. The front-panel control R207 will then have a smoother and more gradual control as the knob is rotated, making it easier to obtain the 15-db margin setting.

For such a strong-signal condition, it is recommended that with R239 at maximum, the i-f gain control R237 be adjusted to give 100 ma. receiver output current for an input r-f voltage 25 db below the normal received signal level. Then the front panel control R207 is set for the normal 15-db margin as previously described.

Carrier Level Indicator (CLI)

The CLI should be adjusted on a clear dry day when line conditions are considered normal. After the receiver sensitivity has been set for a 15-db margin, turn on the remote transmitter at its normal 10-watt output. With a small screw-driver, adjust the CLI input control R252 to give a reading of 2.5 ma. on the 0-3 ma. d-c milliammeter in the CLI output circuit. This current can be read at J202 on the TC set panel for convenience. If the received signal varies for any reason, the CLI output current will change accordingly, as indicated by the curve in Fig. 12.

When carrier is transmitted from the local station, the pointer of the local CLI output milliammeter will be driven off scale. This will not in any way damage the instrument as the CLI saturation current is less than 4 ma. d.c.

MAINTENANCE

Periodic checks of the received carrier signal will indicate proper operation of the equipment. 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 and receiver sensitivity 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 and current values are given in Tables I through VI. Voltages should be measured with a VTVM. Readings may vary as much as $\pm\,20\%$.

The transmitter keying board is mounted over the power amplifier board. See Fig. 2. In order to check test-point voltages on the power-amplifier board, first remove the keying circuit-board recept-acle mounting screws and the two screws holding down the upper end of the board. Now carefully lift the transmitter keying board away from the power-amplifier board, pulling from the top, but do not disturb the chassis harness wiring any more than necessary. This will expose the test points on the power-amplifier board so that voltage readings can be taken.

Similarly, the receiver CLI and output board can be moved to uncover the right-hand portion of the receiver board. Remove the four mounting screws holding the receiver auxiliary board in place. Lift up this board from the left side and pull it away from the receiver board. This will expose the right half of the receiver board.

Adjustment of R142 on Transmitter Board

The small adjustable resistor (pot.) R142 sets the forward base bias on transmitter transistors Q104 and Q105 to the proper point for class-B operation. This is a factory adjustment and need not be changed unless transistors Q104 or Q105 (or both) are replaced. However, if these trans sistors are changed, or if the R142 setting is disturbed in error, the following adjustment procedure should be followed to reset R142:

First remove d-c power from the TC carrier set assembly. Unsolder the lead from terminal 2 of transformer T103 (just above FL101) and temporarily connect a low-range d-c milliammeter (0-1.0 or so) between the removed lead (+) and T103 terminal 2 (-). Turn the slotted control on the small pot (R142) to full counterclockwise. Now, apply power to the TC carrier set, but do not transmit carrier. Advance the pot until the d-c milliammeter reads 0.2 mA d.c. \pm .05 mA. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T103. Again apply d-c power and proceed with the transmitter adjustment as described in the ADJUSTMENTS section.

Replacement of Q107 - Q108

The two transistors Q107 and Q108 in the transmitter power-amplifier stage are a matched pair with the gain of the two units matched within 5%. If one of the transistors fails, both should be replaced with a new matched pair. This is necessary to keep the second harmonic of the transmitter output at an acceptably low value. The pair of transistors should be ordered as "2 of style 187A673H02 transistors, type GP2151".

CHANGE OF OPERATING FREQUENCY

The parts required for changing the operating frequency of a type TC carrier set are as follows:

Transmitter

1. Oscillator Crystal (Y101), specify frequency. NOTE: Modify A-B-C jumpers on transmitter board if required for new frequency. See table marked "†" under internal schematic (Fig.8).

2. R136 Jumper

For operation in 30-50kHz range, clip off R136 as indicated in Fig. 3.

- 3. Capacitors C111 and C113 (on Power Amp. board)
 - -0.47 mfd. S#188A293H01 a. 30-50 kHz
 - b. 50.5-75 kHz 0.22 mfd. S#188A293H02
 - c. 75.5-100 kHz 0.15 mfd. S = 188A293H03
 - d. 100.5-150 kHz 0.10 mfd. S#188A293H04
 - e. 150.5-300 kHz 0.047 mfd. S#188A293H05

* 4. Transmitter Module Mounting Plate

When changing from a frequency of 200KHz or below to a frequency above 200KHz, the following is also necessary:

Transmitter module mounting plate S#691B610H01 and associated hardware.

This is necessary to raise the transmitter printed circuit board (module) away from the main panel as the 200.5-300kHz. receiver input filter FL201 mounts underneath it. See Fig. 2.

★ 5. Zener Diode Z104

For the 200.5-300kHz. range, a type 1N2999A zener diode Z104 is mounted on the Q108 heat sink adjacent to the protective diode Z103. Remove the lead from the Q108 heat sink (see Fig. 2 for location) and connect it to the insulated terminal of zener diode Z104.

6. FL101 and FL102

Filter FL101 is a small series-resonant tuned circuit between the driver and power amplifier stages of the transmitter. It has just two terminals. Filter FL102 is a larger assembly, described under OPERATION. It has three external connections: input, output, and ground. This filter is mounted by four corner posts. To replace, unsolder the three leads, remove the nuts from the mounting posts, and lift the filter assembly from the posts. The new filter can now be installed.

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 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

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 T103 and the voltmeter across terminals 1 and 2 of transformer T104. The signal generator should be set at the channel center frequency and at 2 at 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 T105 and a 500-ohm resistor and a VTVM to the terminals of protective gap G101. 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.

If the change in frequency is enough to require a different filter, it will come factory adjusted as described in the foregoing paragraph.

After all the tabulated changes have been made for the new frequency, the transmitter can be operated with a 50 to 70-ohm load (depending on which tap of T106 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 ADJUSTMENT section.

If a frequency-sensitive voltmeter is available, the second and third harmonic traps may be adjusted (or checked) 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 its tuning dial and db range switch, obtain a maximum on-scale reading of the second 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. It should be noted that this procedure may not give the true magnitude of the harmonics because of the large value of fundamental frequency voltage present at the tuned voltmeter input terminals. This condition will overload the input circuit of some commercial instruments. However, the procedure is satisfactory for adjusting the traps for maximum harmonic rejection.

If accurate measurement of the harmonic levels is desired, the frequency-selective voltmeter is connected, through a rejection filter, to the terminals of the 60-ohm load resistor. The filter must provide high rejection of the fundamental. A twin-T filter is suitable for this purpose. The insertion losses of this filter at the second and third harmonics must be measured and taken into account.

Receiver

- Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
- 2. Receiver input filter (FL201), specify frequency.
- Resistors R211-R238 Combination
 See values in Fig. 8 below internal schematic.
- Resistors R218 and R224 may have to be reduced.
 See following paragraph.

The emitter resistors R218 and R224 of the i-f stages are normally 33 ohms to give the required receiver gain. If the operating frequency is reduced, the receiver gain will probably be higher. In this case, a reduction in the setting of the i-f input control R239 will give the 125-mv. sensitivity. If the new operating frequency is higher, the receiver gain will be lower. If more than 125 mv. is required to obtain 180 ma. output, the gain can be increased by reducing the value of one or both of the resistors R218 and R224. In most cases, these resistors should fall in the range of 22 to 33 ohms.

TABLE I

* Receiver D.C. Measurements

Note: All voltages are negative with respect to Pos. 45 V. (TP206)

TEST POINT	STANDBY (No Signal)	WITH 125 M.V. INPUT
TP201	35-38	35-38
TP202	0	0
TP203	11-12	11-12
TP204	< 0.5	2- 3
TP205	18-22	18-22
TRANSISTOR	Y COLL.	V COLL.
Q201	43	43
Q202	43.5	43.5
Q203	18.0	18.0
Q204	18.0	18.0
Q205	18.0	18.0
Q206	11.0	11.5
Q207	22.0	5.0
Q208	44.0	2.0

All voltages read with d-c vacuum-tube voltmeter. < 0.5 — means "less than 0.5"

TABLE II

* Receiver RF Measurements

Note: Taken with 100 kHz receiver filter, 0.125-volt input signal, and gain control R207 at maximum. Depending on receiver frequency and transistor characteristics, the following values will vary appreciably.

TEST POINT	TYPICAL AC VOLTAGES
FL201-IN to Gnd. FL201-OUT to Gnd. Q203 - E to TP206 Q204 - C to TP206 Q205 - B to TP206 Q205 - C to TP206 Q206 - B to TP206 Q206 - C to TP206 TP202 to TP206	.07 .04 .10 .09 .013 1.2 .15 2.5

All voltages read with a-c vacuum-tube voltmeter.

* TABLE III Transmitter D-C Measurements

Note: All voltages are positive with respect to Neg. D.C. (TP104). All voltages read with d.c. VTVM.

TEST POINT	CARRIER OFF	CARRIER ON
TP101 TP102 TP103 TP105 TP106 TP107 TP108 TP110 TP111 TP112 TP113 J101 (Front Panel)	8.5 volts d.c. <0.5 <0.5 <0.5 44 44 45 <1.0 <1.0 0 45 5 ma. max.	8.5 volts d.c. 20 19.5 9 24 24 44 <1.0 <1.0 <0.5 44 0.6 amp.

TRANSISTOR	V coll.	V coll.
Q101 Q102 Q103 Q104 Q105	2.0 1.0 <0.5 45	1.8 1.0 9.0 44 44
Q106 Q107 Q108	44.5 0 44.5	1.2 0 24.2

TABLE IV

* Transmitter RF Measurements

Note: "Carrier-on" voltages taken with transmitter set to 10 watts output (24.5 volts across 60 ohms). These voltages subject to variation, depending on frequency and transistor characteristics.

TEST POINT	A-C VOLTAGE	
T101-3 to TP104 TP103 to TP102 TP105 to TP104 TP110 to T102-4 TP111 to T102-4 Q104-C to TP104	1.5 volts, rms. 0.2 1.1 φ 0.2 0.2 0.2 3.3	
Q105-C to TP104 T103-4 to Gnd. T104-1 to Gnd. Q107-B to TP107 Q108-B to TP113 Q107-C to TP107	3.3 1.1 1.4 0.5 volts, rms. 0.5	
Q108-C to TP113 T105-4 to Gnd. T106-2 to Gnd. TP109 to Gnd. J102 to Gnd.	14-16 105 100-160* 30-50* 24.5	

Note: T101-3 = tap 3 of Transformer T101

Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

- * These values may vary considerably with frequency.
- ϕ -High-impedance circuit. VTVM causes significant loading.

TABLE V Transmitter Keying Board

D.C Voltages

TEST POINT	NOR MA L (Carrier Off)	CARRIER ON (D.C. on J104-6 or 7)	CARRIER STOP (D.C. on J104-6 or 7 and J104-8 or 9)	
TP151	16 v.d.c.	<1.0 v.d.c.	<1.0 v.d.c.	
Term. 17	<1.0	24.6	4.9	
TP152	16	16	<1.0	
TP153	<1.0	<1.0	16	
Term. 1	0 *	20	<1.0	

^{*} May show <1.0 volt with VTVM

TABLE VI

Receiver CL1 and Output Board (with normal received signal)

TEST POINT	D.C VOLTAGE - TO NEG.	SIGNAL VOLTAGE (a.c.)
TP-251	4.9 v.d.c.	0.3 v. rms.
TP-252	9.8	2.9
TP-253	< 1.0	_
TP-254	19.7	_

Recommended Test Equipment

- I. Minimum Test Equipment for Installation
 - a. Milliammeter 0-250 ma. DC
 - b. 60-ohm 10-watt non-inductive resistor.
 - c. A-C Vacuum Tube Voltmeter (VTVM). Voltage range 0.01 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance—one megohm, minimum.
 - d. D-C Vacuum Tube Voltmeter (VTVM).

Voltage Range:

0.1 to 300 volts

Imput Impedance:

1.0 megohm, min.

- II. Desirable Test Equipment for Apparatus Maintenance.
 - a. All items listed in I.
 - b. Signal Generator

Output Voltage:

up to 10 volts r.m.s.

Frequency Range:

20 to 330 kHz

- c. Oscilloscope
- d. Ohmmeter
- e. Capacitor checker
- f. Frequency counter
- g. Frequency-selective voltmeter

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.

* Transmitter Section

CYMPOL	RATING	STYLE NUMBER
SYMBOL	0.1 mfd, 200 V.DC	187A624H01
C201	.005 mfd, 300 V.DC	187A694H29
C102	180 pf. 500 V.DC	187A695H29
C103	0.25 mfd, 200 V.DC	187A624H02
C104	0.25 mfd, 200 V.DC	187A624H02
C105		187A624H02
C106	0.25 mfd, 200 V.DC	187A624H02
C107	0.25 mfd, 200 V.DC	187A624H03
C108	0.50 mfd, 200 V.DC	187A624H02
C109	0.25 mfd, 200 V.DC	187A624H02
C110	0.25 mfd, 200 V.DC	101110211102
† C111	(See Table Below)	1054051119
C112	39 pf. 500 V.D.C.	187A695H12
† C113	(See Table Below) .	
C114	100 pf., 500 V.DC	187A695H23
C115	100 pf., 500 V.DC	187A695H23
C116	0.001 mfd, 500 V.DC	187A694H11
CA	Part of FL101	Vary with Frequency
CB, CC, CD, CE	Part of FL102	Vary with Frequency
D101	1N457A	184A855H07
D103	1N4818	188A342H06
	1N91	182A881H04
D104	1N4818	188A342H06
D105	1N91	182A881H04
D106	Type RVS Arrester	637A026A01
J101	Closed Circuit Jack	187A606H01

#200.5 - 300 kHz only.

	RATING	STYLE NUMBER
† FREQ. (C111, C113)	RATING	
30 -50 kHz	0.47 mfd, 400 V.DC	188A293H01
	0.22 mfd, 400 V.DC	188A293H02
50.5-75 kHz		100 1 000 1100
75.5-100 kHz	0.15 mfd, 400 V.DC	188А293Н03
	0.1 mfd, 400 V.DC	188A293H04
100.5 - 150 kHz	0.1 mid, 400 v.DC	188A293H05
150.5-300 kHz	0.047 mfd, 400 V.DC	188A293H03

* ELECTRICAL PARTS LIST Transmitter Section (Cont.)

SYMBOL		RATING			
J102	Banana F	Banana Plug Jack			
J103	Coaxial (Cable Jack		2 of 185A431H01 187A633H01	
J104	24-Term 1	Receptacle		187A669H01	
J105	12-Term I	Receptacle		629 A 20 5 H 0 2	
L101	Part of F	L101		Vary with Frequency	
L102	FL102 Tr	ap Coil (2nd Harmon	nic)	Vary with Frequency	
L103		ap Coil (3rd Harmor		Vary with Frequency	
L104	400 mh.			29 2B 096G 01	
L 105	FL102 Co	oil (part of series-re ned to fundamental f	sonant req.)	Vary with Frequency	
Q101	2N2905A			762A672H10	
Q102	2N2905A			762A672H10	
Q103	2N5 25			184 A 638 H 13	
Q104	2N3712			762A672H07	
Q105	2N3712				
Q106	TI-481				
Q107	2N1908	Matched Pair -	Texas Instrument	184A638H11 187A673H02	
Q108	2N1908	Co Identif. G			
SYMBOL	OHMS	± TOL. %		187А673Н02	
R101	5,600	5	WATTS	STYLE NUMBER	
R 10 2	2,200	10	0.5	187A643H45	
R103	10,000	10		187A641H35	
R104	100,000		0.5	187 A 64 1H 5 1	
R 105	390	5	0.5	187A763H75	
R 10 6	1,200	5	0.5	184A763H17	
R107	10,000	5	0.5	184 A763H 29	
R 108		10	0.5	184A641H51	
R109	100,000	5	0.5	184А763Н75	
	390	5	0.5	184A763H17	
R111	1,200	5	0.5	187 A 763 H 29	
R112	1 K Pot	20	0.25	629А430Н02	
R113	4,700	5	0.5	184A763H43	
R114	10,000	10	0.5	187A641H51	
R115	150	5	0.5	184 А7 63 НО7	

* Transmitter Section (Cont.)

cyupOl	OHMS	± TOL. %	WATTS	STYLE NUMBER
SYMBOL	100	5	0.5	184A763H03
R116		5	25	1202588
R117	1,000	2	0.5	629A531H56
R118	10,000	2	0.5	629A531H03
R119	62 10,000	5	2	185A207H51
R120		5	2	187A683H01
R121	10	5	0.5	187A290H01
R122	10	10	0.5	187A290H01
R123	10	10	1	187A644H03
R124	100	10	0.5	187A641H27
R125	1,000		1	187A644H43
R126	4,700		0.5	187A640H01
R127	10	10	1	187A644H35
R128	2,200	5	0.5	184A636H14
R129	2.7	10	0.5	187A640H01
R130	10	10		187A644H43
R131	4,700	5	0.5	184A636H14
R132	2.7	10		184A636H18
R133	0.27	10	1	184A636H18
R134	0.27	10	11	188A317H01
R135	3,000	10	5	629A531H58
R136	12,000	2	0.5	187A642H55
R137	15,000	10	2	187A641H27
R138	1,000	10	0.5	187A641H27
R139	1,000	10	0.5	629A531H04
R140	68	2	0.5	
R141	30	Type 3D20	2 Thermistor	185A211H06
R142	25K pot.	20	0.25	584C276H23
R143	20,000	2	0.5	629A531H63
SYMBOL		RATING		STYLE NUMBER
SW 101	Car	rier Test Switch		880A357H01
T101	10,0	000/400 ohms		205C043G01 714B666G01
T102	10,0	10,000/400 c.t.		
T103	1930/60 ohms L633000			1962694
T104	Turns ratio, 1/0.5 Pri./each sec.			292B526G01
	10/500 ohms			292B526G02 292B526G03
T105		500/50 - 60 - 70 ohms		
T106	_	300 kHz crystal per	328C083	Specify Frequenc
Y101	•	5357B (20 V ±5%)		862A288H03
Z101		2999B (56 V ±5%)		629A798H04
Z102		2999B (56 V ±5%)		629A798H04

ELECTRICAL PARTS LIST * Transmitter Keying Board

SYMBOL	RATING	STYLE NUMBER	
C151-C152	0.47 mfd., 200 V.	849A437H04	
C153	25 mfd., 125 V.	184A637H01	
C154	47 mfd., 50 V.	863A530H01	
D151	1N457A	184A855H07	
D152	1N4818	188A342H06	
Q151 to Q155	2N3417	848A851H02	
R151 - R159	47K, ½ W.	629A531H72	
R152-R153-R160-R161	4.7K, ½ W.	629A531H48	
R154-R162	82K, ½ W.	629A531H78	
R155-R158-R163-R166-R169	10K, ½ W.	629A531H56	
R156-R164-R167	6.8K, ½ W.	629A531H52	
R157-R165-R168	27K, ½ W.	629A531H66	
R170	700, 5 W.	763A129H04	
Z151-Z152-Z155-Z156	1N3688A (24V)	862A288H01	
Z153-Z157	1N3686A (20V)	185A212H06	
Z154-Z158	1N957B (6.8V)	185A797H06	
Z159	1N748A (3.9V)	185A797H08	
Z160	1N5357B (20V)	862A288H02	
	Receiver Section	002A200H02	
C201	0.1 mfd., 200 V. DC	187A624H01	
C202	300 pf. 500 V. DC		
C203	180 pf. 500 V. DC	187A695H35	
C204	0.25 mfd. 200 V. DC	187A695H29 187A624H02	
C205	0.25 mfd, 200 V. DC		
C206	0.25 mfd, 200 V. DC	187A624H02 187A624H02	
C207	0.25 mfd., 200 V. DC		
C208	0.25 mfd., 200 V. DC	187A624H02 187A624H02	
C209	0.25 mfd., 200 V. DC	187A624H02	
C210	0.25 mfd., 200 V. DC	187A624H02	
C211	0.1 mfd., 200 V. DC	187A624H01	
C212	0.25 mfd., 200 V. DC	187A624H01	
C213	2.0 mfd., 200 V. DC	187A624H05	
C214	0.25 mfd., 200 V. DC	187A624H02	
C215	39 pfd., 500 V. DC	187A695H12	
D201	1N457A		
D202	1N457A	184A855H07	
0203	1N4818	184A855H07	
0204	1N4818	188A342H06 188A342H06	

* Receiver Section (cont.)

SYMBOL		RATING		STYLE NUMBER
FL201	Receiver Input Filter 30-300 kHz			Specify Frequency
		i.f. Filter - 20kHz (2		187A590G02
FL202 •		Coax, Input Jack		187A638H01
J201		Circuit Jack (CLI)		187A606H01
J202		Circuit Jack (200MA)		187A606H01
J203	33 mh.	mean (200)		187A599H02
L201	2N2905A			762A672H10
Q201				762A672H10
Q202	2N 2905 A			762A672H10
Q203	2N 2905 A			762A672H10
Q204	2N 2905 A			762A672H10
Q205	2N 2905 A	1		762A672H10
Q206	2N 2905 A	<u> </u>		
Q207	2N3645			849A441H01
Q208	2N4903			187A673H13
SYMBOL	RATING			STYLE NUMBER
	онмѕ	± TOL. %	WATTS	
R201	10,000	10	0.5	187A641H51
R202	2,200	10	0.5	187A641H35
R203	10,000	10	0.5	187A641H51
R204	100,000	5	0.5	184A763H75
R205	390	5	0.5	184A763H17
R206	1,200	5	0.5	184A763H29
R207	25K Pot.	10	2	185А086Н07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H17
R210	390	5	0.5	184A763H17
R211	_	_	_	See † Note Belov
	1 K pot.	20	0.25	629A430H02
R212	1,200	5	0.5	184A763H29
R213		5	1	187A643H45
R214	5,600	5	0.5	184A763H58
R215				

[†] R211 – 10K - above 50kHz - S#187A641H51 22K - 30-50kHz - S#187A641H59

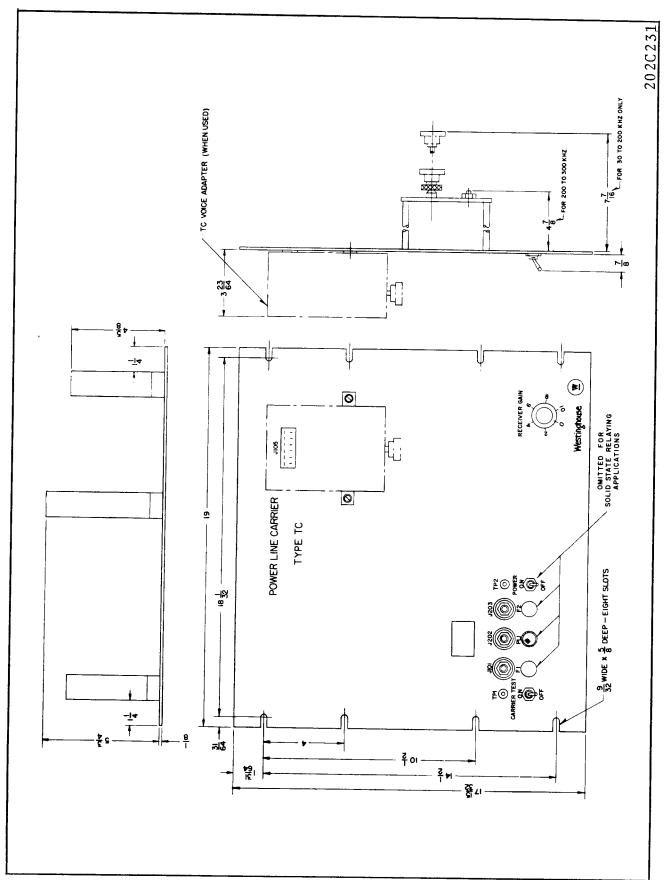
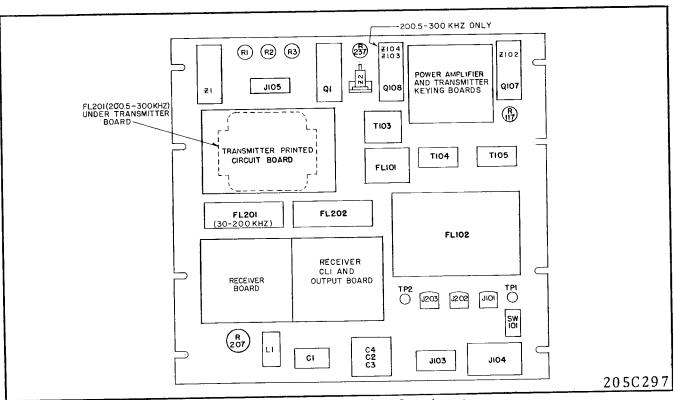
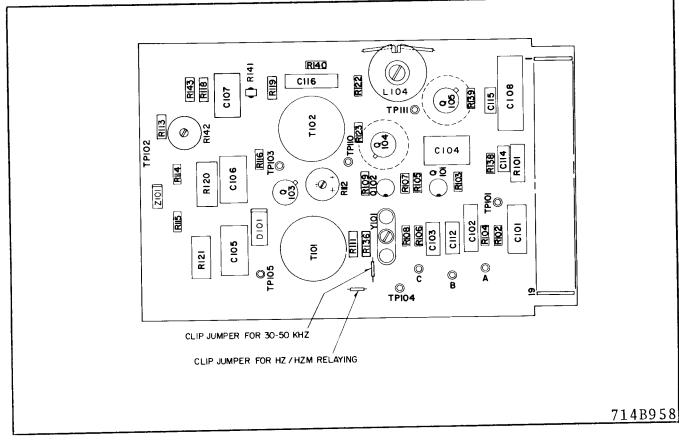


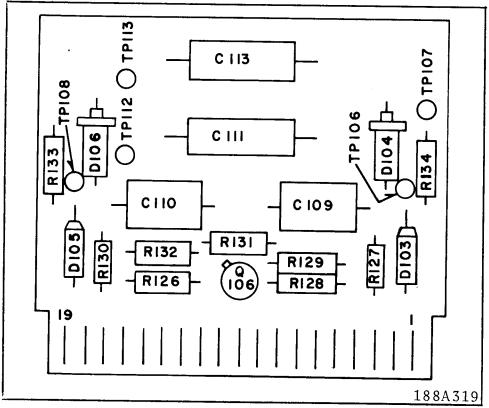
Fig. 1 Type TC Carrier Assembly - Outline



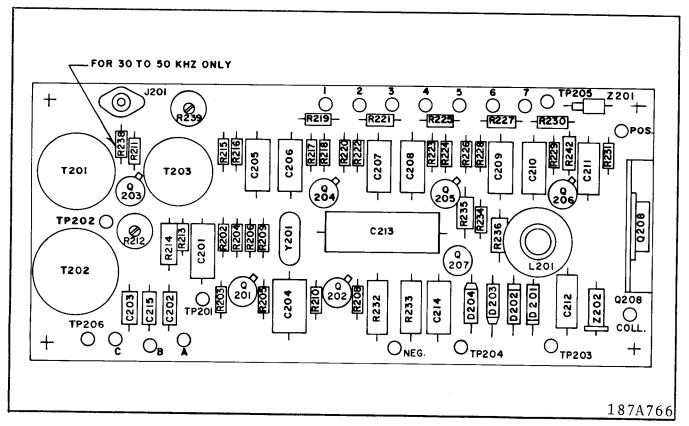
* Fig. 2 Type TC Carrier Assembly - Parts Location



* Fig. 3 Transmitter Printed Circuit - Parts Location



* Fig. 4 Power Amplifier Printed Circuit - Parts Location



* Fig. 5 Receiver Printed Circuit - Parts Location

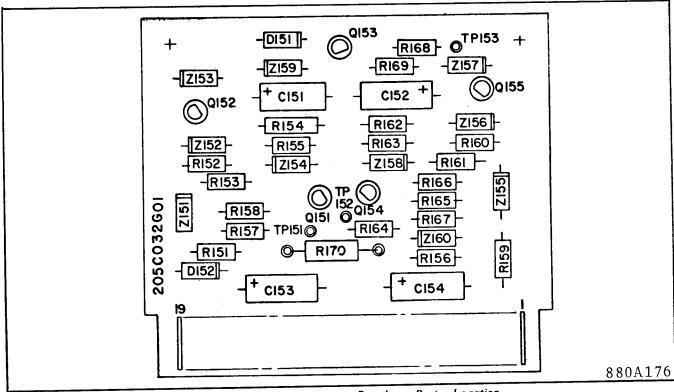


Fig. 6. Transmitter Keying Board — Parts Location.

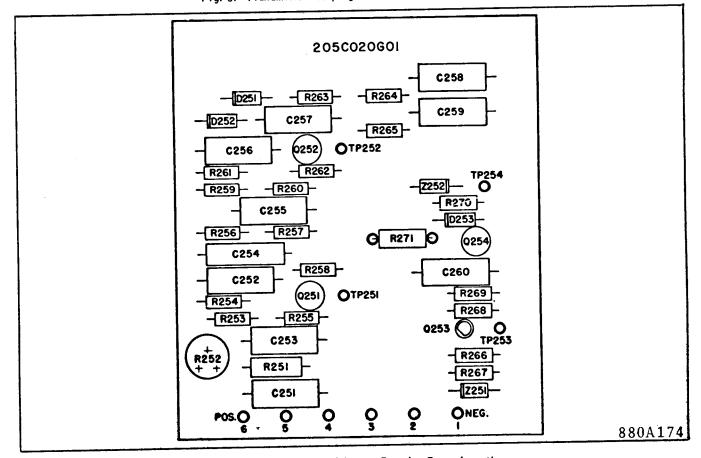
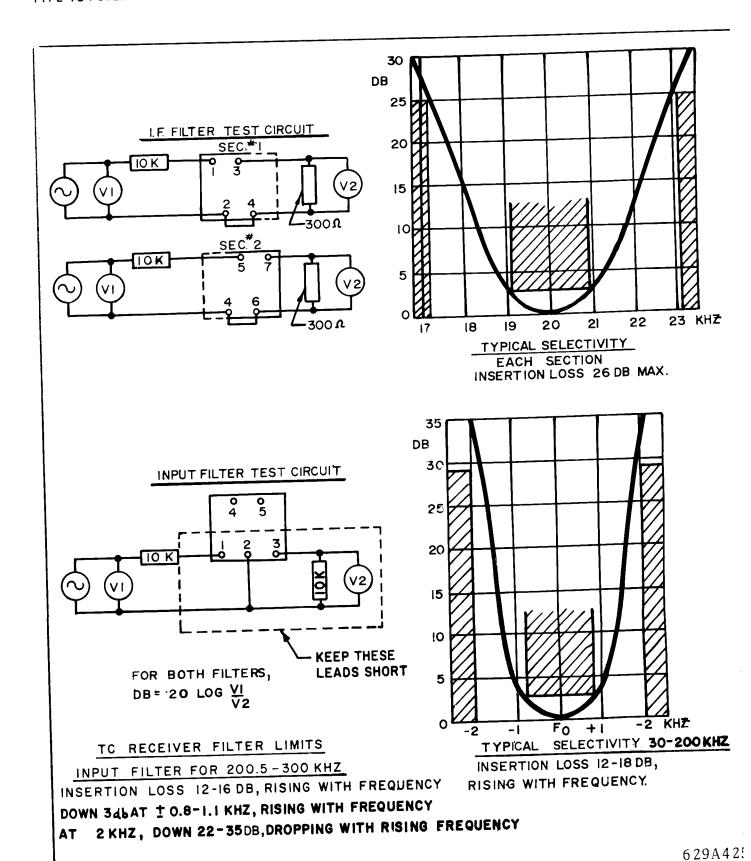
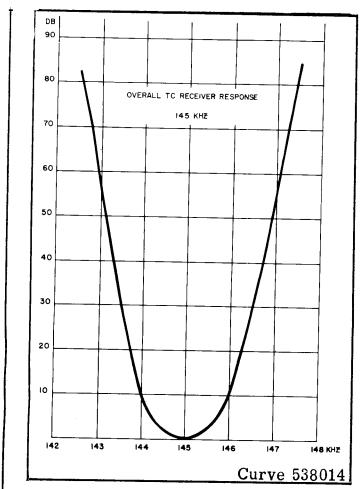
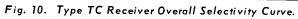


Fig. 7. Receiver CLI and Output Board — Parts Location.



* Fig. 9. Type TC Receiver Filter Characteristics





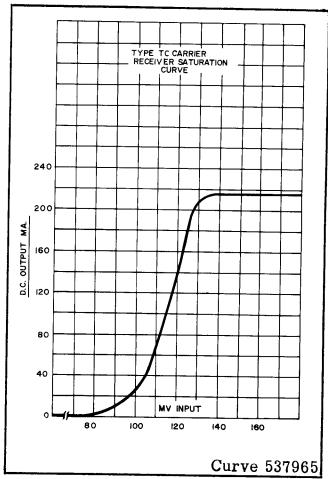


Fig. 11. Type TC Receiver - 200 ma. Output Characteristic.

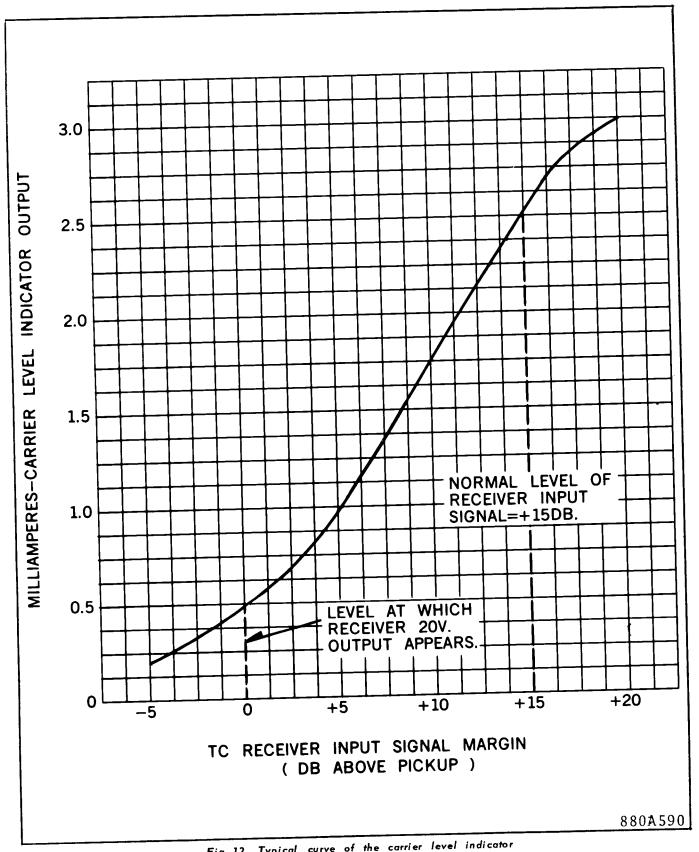


Fig. 12. Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

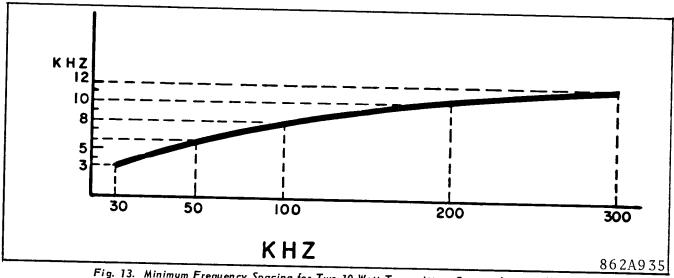


Fig. 13. Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

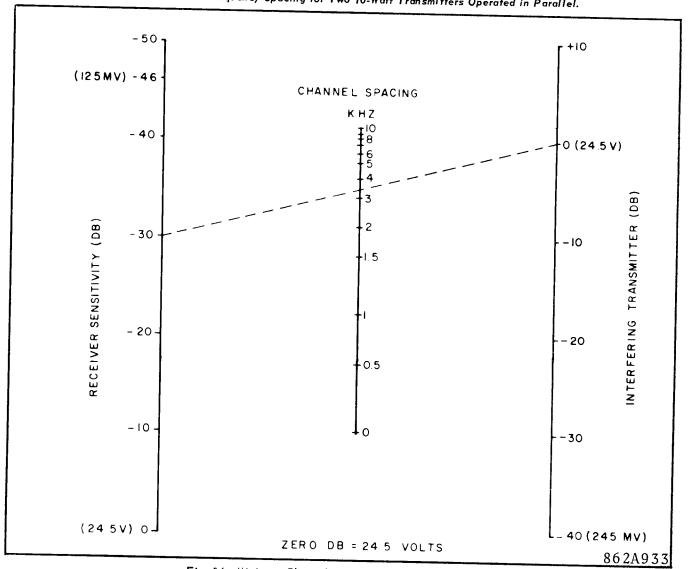
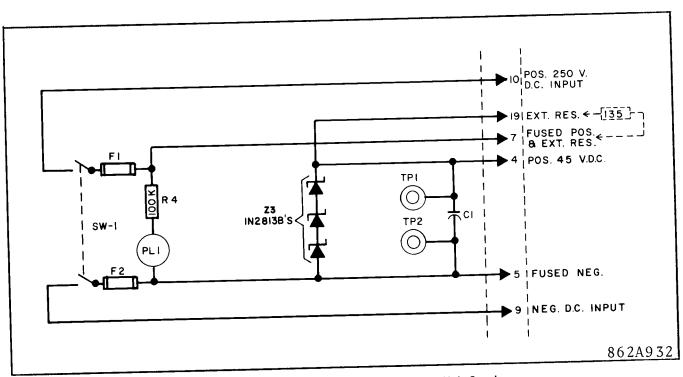
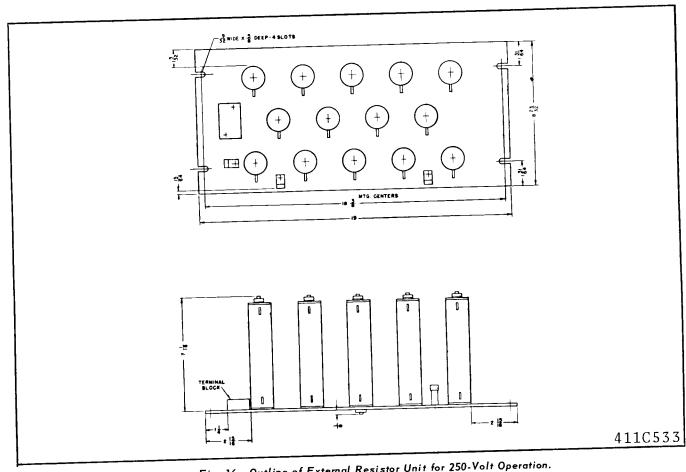


Fig. 14. Minimum Channel Spacing for Keyed Carrier 60 p.p.s.



* Fig. 15. Detail of Power Supply Section for 250-Volt Supply.



* Fig. 16. Outline of External Resistor Unit for 250-Volt Operation.



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



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY FOR USE WITH SOLID-STATE RELAYING SYSTEMS

TABLE OF CONTENTS			LIST OF ILLUSTRATIONS	
		age	Figure	Page
Contic	ın	2	1	Type TC Carrier Assembly-Outline 18
	eation	2	2	Type TC Carrier Assembly — Parts Location
Const	ruction	2 .		
	ansmitter	2 2	3	Transmitter Printed Circuit Board— Parts Location
Re	eceiver	3 4	4	Power Amplifier Printed Circuit Board – Parts Location 20
C	elaying Control Circuits	4 4	5	Receiver Printed Circuit Board— Parts Location
Chara	cteristics	4		
	lation	5	6	Transmitter Keying Board – Parts Location
Т	tmentsransmitter	5	7	Receiver CLI and Output Board— Parts Location
	ransmitter Filtereceiver	5 5	8	Type TC Carrier Assembly for
	enance	6		Solid-State Relaying — Internal Schematic23-2
Т	ge of Operating Frequency ransmittereceiver	7 7 8	9	Type TC Receiver Filter Characteristics
Reco	mmended Test Equipment	10	10	Type TC Receiver Overall Selectivity Curve
	wal Parts	10	11	Type TC Receiver – 200-ma.
Elect	rical Parts List	11 11	11	Output Characteristic
B	Power Supply	15 17	12	Receiver CLI — Output Characteristic27
	LIST OF TABLES		13	Minimum Frequency Spacing Between Two Type TC Carrier
Tabl	e	Page		Sets (Without Hybrids)
I	Receiver D-C Measurements	9	14	Minimum Channel Spacing for Keyed Type TC Carrier
II	Receiver R-F Measurements	9		(Keyed at 60 p.p.s.) 28
III	Transmitter D-C Measurements	9	15	Detail of Power Supply
IV	Transmitter R-F Measurements	10		Section for 250-volt Supply 29
V	Transmitter Keying Board Meas	10	16	Outline of External Resistor Unit for 250-volt Operation
VI	Receiver CLI Board Meas.	10	<u> </u>	

Power Supply

The power supply circuit for 48 or 125-v.d-c supply uses 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 local current, the d-c voltage drop through the transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage of approximately 45-v. d-c. The zener diode Z2 serves to protect the collector-base junction of Q1from 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. Inductance L1 and capacitor C4 serve as a filter to prevent any appreciable carrier-frequency energy from getting onto the external d.c. supply circuits.

For a 250-volt d-c supply, the circuit of Figure 15 is used. This consists of an external voltage-dropping resistor assembly (135 ohms total) in conjunction with three 15-volt Zener diodes on the TC set chassis connected in series. The resistor assembly (see Figure 16) must be mounted at the top of a cabinet or an open rack. Because of the heat dissipated, no transistorized equipment should be mounted above the resistor panel. The 250-volt TC set has a constant current drain of 1.5 amperes d-c.

Relaying Control Circuits

The transmitter start and stop control circuits and the receiver 20-volt output (previously described) allow this type TC set to be used with solid-state protective and auxiliary relays which also have 20-volt input and output "logic". In addition, these carrier control circuits are designed to absorb and limit externally generated surges so they will not damage the transistors or associated components.

For flexibility in application, provision is also made for keying the transmitter from either 48 or 125 volts d.c. Also, the 200-ma receiver output circuit is brought out to a J104 terminal for connection to a 30-ohm alarm relay, if desired.

CHARACTERISTICS

Frequency range 30-300 kHz (50-300 kHz for phase comparison relaying)

Transmitter output 10 watts into 50 to 70-ohm

resistive load

Harmonics 55 db below 10 watts.

Receiver sensitivity 125 mv. input for 180 ma. minimum output current

Receiver selectivity 1500 Hz bandwidth (3 db down);

 $\mbox{down 80 db at $\pm 3 k Hz}. \\ \mbox{Transmitter-receiver}$

channel rating 40 db

Input Voltage 48, 125, or 250 V. d-c

Supply voltage

variation 42-56V, 105-140V, 210-280V

Battery Drain: 0.5 amp standby, 1.35 amp

transmitting

125 V.D.C. 0.25 amp standby, 1.1 amp

transmitting

250 V.D.C. 1.5 amp standby or transmitting

* Temperature range -20 to +60°C. around chassis.

Frequency Spacing

The minimum recommended frequency spacing between two Type TC carrier sets operated in parallel without hybrid units is shown on the curve of Fig. 13. For example, at 100 kHz. the minimum spacing is 8 kHz. Closer spacing would result in the generation of intermodulation products caused by the non-linear load presented by each transmitter to the other one.

The minimum frequency spacing between a TC carrier channel and an adjacent transmitter signal keyed on-off at a rate of 60 pulses per second can be determined from the nomograph of Fig. 14. Using the example shown by the dashed line, consider a type TC set used on a channel with a normal attenuation of 15 decibels. The TC receiver would be set to give a margin of 15 db below the normal received signal, or for a sensitivity of -30 db (relative to a 24.5 volt, 10-watt signal). The interfering signal is assumed to be a 10-watt transmitter at the same location. To determine the minimum frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the -30 db point on the receiver sensitivity scale and the zero-db point on the interfering transmitter scale. The resulting line crosses the channel spacing scale between 3 and 4 kHz. For this example, a channel spacing of at least 4 kHz should be used. (In order not to conflict with the limits of Fig. 13, an t-f hybrid may be needed between the TC set and the other transmitter, depending on the actual application.)

For protective relaying applications to 3-terminal lines, the transmitter frequencies are offset 100 hertz to prevent a slow beat or cancellation of the received signal when two transmitters send blocking signals to the third terminal. The three transmitters operate

at fc, fc+100 Hz, and fc-100 Hz. All receivers operate at the channel center frequency (fc).

INSTALLATION

The type TC transmitter-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 should not exceed 60°C.

ADJUSTMENTS

Transmitter

The main adjustment on the transmitter is the power output control R112 on the transmitter printed circuit board. Disconnect the coaxial cable from the assembly terminals and replace with a 50 to 70 ohm noninductive 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 T106 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn the transmitter power output control R112 to minimum (full counterclockwise).

NOTE: Do not change the adjustment of the R142 control on the printed circuit board. See Maintenance section for R142 adjustment.

Now apply d-c power and note the d-c voltage across the two pin jacks TP1 and TP2. If this is in the range of approximately 42 to 46 volts, throw the carrier-test switch SW101 on the panel to the ON position. Slowly advance the output control R112 on the transmitter printed-circuit board until about 10 volts is obtained across the output 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. For 200-300 kHz operation, L105 is a "pot core" and has a adjustable core screw. Use a screw-driver in this case. No locking device is needed.

Now continue to advance the output control R112 until the output voltage tabulated in the following table is obtained across the load resistor. Recheck the setting of L105 to be sure it is at its maximum point for 10 watts output. Tighten the locking nut. Turn off the carrier test switch SW101, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

* NOTE: For 200-300kHz sets, inductor L105 is a pot core and the foregoing adjustment check is generally

unnecessary since there is little chance of its setting being disturbed. However, if desired, the pot core setting can be checked using a screwdriver to vary the setting of the adjustable core. There is no locking device as the adjustable core is held in place by friction.

T106 Tap	Voltage for 10 Watts Output
50	22.4
60	24.5
70	27.0

Transmitter Filter

Normally, the output filter (FL102) will require no readjustment except as noted under Adjustments-Transmitter, as 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. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection at the factory, 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.

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

Receiver

The receiver board has two controls; the i.f. input control R239 which is factory-set to give a sensitivity of 125 mv. for 180 ma. output, and the local oscillator output control R212. The oscillator output is preset at the factory at 0.5 volt. This setting can be checked by connecting an a-c VTVM between receiver test points TP202 and TP206 (shield lead of VTVM.) The voltmeter reading with the equipment energized, but not transmitting, should be 0.5 volt rms. Note Fig. 5 for location of components on the receiver printed board.

The other adjustment on the receiver is the gain control R207 which is front-panel mounted. It is recommended that the receiver gain normally be set for a 15-db operating margin to allow for reasonable variations in receiver input signal level without affecting the output blocking current. This adjustment can be made in two ways, as follows:

1. First, measure the normal received signal from the remote terminal (after the line tuners have been adjusted) by starting the remote transmitter and measuring the voltage across the coaxial cable at the receiving terminal. This signal should preferably be measured with a tuned voltmeter such as the Sierra carrier-frequency volt-

meter. If a simple VTVM is used, have the remote transmitter turned on and off several times to be sure the VTVM reading is actually the remote signal. Note the reading. Now disconnect the coaxial cable, and feed a signal into the carrier assembly at the coaxial terminals from a separate signal generator. Set the signal generator to the received frequency at a level 15 db below the previously measured incoming signal. With a 0-250 ma. (minimum) d-c milliammeter plugged into J203, adjust the receiver gain control until an output current of about 100 ma, is obtained. As this point is on the steep portion of the receiver output-input curve, it may be difficult to set the gain control for exactly 100 ma. This is not necessary, however, as the signal is not normally at this value. This is the operating setting of the receiver gain control. Return the coaxial cable connections to normal.

NOTE: Do not energize the local transmitter when making the foregoing adjustment as the signal generator may be damaged.

2. As an alternate procedure if no signal generator is available, the local transmitter itself may be used as the signal generator. First determine the normal received signal from the remote terminal as explained previously under (1). Then turn off the remote transmitter.

Now turn on the local transmitter and reduce its output to a value 15 db below the normal received signal level. Then adjust the receiver gain control to give 100 ma. output as before. When this adjustment has been made, reset the local transmitter to its normal 10-watt output level.

In applications where the line attenuation is low and a strong signal is received, the adjustment of the receiver gain control R207 becomes critical. For such applications, the setting of i-f gain control R239 may be reduced to lower the overall receiver gain. The front-panel control R207 will then have a smoother and more gradual control as the knob is rotated, making it easier to obtain the 15-db margin setting.

For such a strong-signal condition, it is recommended that with R239 at maximum, the i-f gain control R237 be adjusted to give 100 ma. receiver output current for an input r-f voltage 25 db below the normal received signal level. Then the front panel control R207 is set for the normal 15-db margin as previously described.

Carrier Level Indicator (CLI)

The CLI should be adjusted on a clear dry day when line conditions are considered normal. After the receiver sensitivity has been set for a 15-db margin, turn on the remote transmitter at its normal 10-watt output. With a small screw-driver, adjust the CLI input control R252 to give a reading of 2.5 ma. on the 0-3 ma. d-c milliammeter in the CLI output circuit. This current can be read at J202 on the TC set panel for convenience. If the received signal varies for any reason, the CLI output current will change accordingly, as indicated by the curve in Fig. 12.

When carrier is transmitted from the local station, the pointer of the local CLI output milliammeter will be driven off scale. This will not in any way damage the instrument as the CLI saturation current is less than 4 ma. d.c.

MAINTENANCE

Periodic checks of the received carrier signal will indicate proper operation of the equipment. 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 and receiver sensitivity 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 and current values are given in Tables I through VIC Voltages should be measured with a VTVM. Readings may vary as much as $\pm\,20\%$.

The transmitter keying board is mounted over the power amplifier board. See Fig. 2. In order to check test-point voltages on the power-amplifier board, first remove the keying circuit-board receptacle mounting screws and the two screws holding down the upper end of the board. Now carefully lift the transmitter keying board away from the power-amplifier board, pulling from the top, but do not disturb the chassis harness wiring any more than necessary. This will expose the test points on the power-amplifier board so that voltage readings can be taken.

Similarly, the receiver CLI and output board can be moved to uncover the right-hand portion of the receiver board. Remove the four mounting screws holding the receiver auxiliary board in place. Lift up this board from the left side and pull it away from the receiver board. This will expose the right half of the receiver board.

Adjustment of R142 on Transmitter Board

The small adjustable resistor (pot.) R142 sets the forward base bias on transmitter transistors Q104 and Q105 to the proper point for class-B operation. This is a factory adjustment and need not be changed unless transistors Q104 or Q105 (or both) are replaced. However, if these transsistors are changed, or if the R142 setting is disturbed in error, the following adjustment procedure should be followed to reset R142:

First remove d-c power from the TC carrier set as sembly. Unsolder the lead from terminal 2 of transformer T103 (just above FL101) and temporarily connect a low-range d-c milliammeter (0-1.0 or so) between the removed lead (+) and T103 terminal 2 (-). Turn the slotted control on the small pot (R142) to full counterclockwise. Now, apply power to the TC carrier set, but do not transmit carrier. Advance the pot until the d-c milliammeter reads 0.2 mA d.c. \pm .05 mA. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T103. Again apply d-c power and proceed with the transmitter adjustment as described in the ADJUSTMENTS section.

* Replacement of Q107 - Q108

The two transistors Q107 and Q108 in the transmitter power-amplifier stage are a matched pair with the gain of the two units matched within 5%. If one of the transistors fails, both should be replaced with a new matched pair. This is necessary to keep the second harmonic of the transmitter output at an acceptably low value. The pair of transistors should be ordered as "2 of style 187A673H02 transistors, type GP2151".

CHANGE OF OPERATING FREQUENCY

The parts required for changing the operating frequency of a type TC carrier set are as follows:

Transmitter

Oscillator Crystal (Y101), specify frequency.
 NOTE: Modify A-B-C jumpers on transmitter board if required for new frequency. See table marked "†" under internal schematic (Fig. 8).

2. R136 Jumper

For operation in 30-50kHz range, clip off R136 as indicated in Fig. 3.

- 3. Capacitors C111 and C113 (on Power Amp. board)
 - a. 30-50 kHz 0.47 mfd. S#188A293H01
 - b. 50.5-75 kHz 0.22 mfd. S#188A293H02
 - c. 75.5-100 kHz 0.15 mfd. S # 188A293H03
 - d. $100.5-150 \text{ kHz} 0.10 \text{ mfd.} \text{S} \pm 188\text{A} 293\text{H} 04$
 - e. 150.5-300 kHz 0.047 mfd. S#188A293H05

* 4. Transmitter Module Mounting Plate

When changing from a frequency of 200KHz or below to a frequency above 200KHz, the following is also necessary:

Transmitter module mounting plate S#691B610H01 and associated hardware.

This is necessary to raise the transmitter printed circuit board (module) away from the main panel as the 200.5-300kHz. receiver input filter FL201 mounts underneath it. See Fig. 2.

* 5. Zener Diode Z104

For the 200.5-300kHz. range, a type 1N2999A zener diode Z104 is mounted on the Q108 heat sink adjacent to the protective diode Z103. Remove the lead from the Q108 heat sink (see Fig. 2 for location) and connect it to the insulated terminal of zener diode Z104.

6. FL101 and FL102

Filter FL101 is a small series-resonant tuned circuit between the driver and power amplifier stages of the transmitter. It has just two terminals. Filter FL102 is a larger assembly, described under OPERATION. It has three external connections: input, output, and ground. This filter is mounted by four corner posts. To replace, unsolder the three leads, remove the nuts from the mounting posts, and lift the filter assembly from the posts. The new filter can now be installed.

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 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

* groups 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	201.1 500.0
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 T103 and the voltmeter across terminals 1 and 2 of transformer T104. The signal generator should be set at the channel center frequency and at 2 at 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 T105 and a 500-ohm resistor and a VTVM to the terminals of protective gap G101. 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.

If the change in frequency is enough to require a different filter, it will come factory adjusted as described in the foregoing paragraph.

After all the tabulated changes have been made for the new frequency, the transmitter can be operated with a 50 to 70-ohm load (depending on which tap of T106 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 ADJUSTMENT section.

If a frequency-sensitive voltmeter is available, the second and third harmonic traps may be adjusted (or checked) 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 its tuning dial and db range switch, obtain a maximum on-scale reading of the second 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. It should be noted that this procedure may not give the true magnitude of the harmonics because of the large value of fundamental frequency voltage present at the tuned voltmeter input terminals. This condition will overload the input circuit of some commercial instruments. However, the procedure is satisfactory for adjusting the traps for maximum harmonic rejection.

If accurate measurement of the harmonic levels is desired, the frequency-selective voltmeter is connected, through a rejection filter, to the terminals of the 60-ohm load resistor. The filter must provide high rejection of the fundamental. A twin-T filter is suitable for this purpose. The insertion losses of this filter at the second and third harmonics must be measured and taken into account.

Receiver

- Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
- 2. Receiver input filter (FL201), specify frequency.
- Resistors R211-R238 Combination
 See values in Fig. 8 below internal schematic.
- 4. Resistors R218 and R224 may have to be reduced. See following paragraph.

The emitter resistors R218 and R224 of the i-f stages are normally 33 ohms to give the required receiver gain. If the operating frequency is reduced, the receiver gain will probably be higher. In this case, a reduction in the setting of the i-f input control R239 will give the 125-mv. sensitivity. If the new operating frequency is higher, the receiver gain will be lower. If more than 125 mv. is required to obtain 180 ma. output, the gain can be increased by reducing the value of one or both of the resistors R218 and R224. In most cases, these resistors should fall in the range of 22 to 33 ohms.

TABLE I

* Receiver D.C. Measurements

Note: All voltages are negative with respect to Pos. $45\,V.\ (TP206)$

TEST POINT	STANDBY (No Signal)	WITH 125 M.V. INPUT
TP201 TP202 TP203 TP204 TP205	35-38 0 11-12 < 0.5 18-22	35-38 0 11-12 2- 3 18-22
TRANSISTOR	V coll.	V COLL.
Q201 Q202 Q203 Q204 Q205 Q206 Q207 Q208	43 43.5 18.0 18.0 18.0 11.0 22.0 44.0	43 43.5 18.0 18.0 11.5 5.0 2.0

All voltages read with d-c vacuum-tube voltmeter. < 0.5 — means "less than 0.5"

* Receiver RF Measurements

Note: Taken with 100 kHz receiver filter, 0.125-volt input signal, and gain control R207 at maximum. Depending on receiver frequency and transistor characteristics, the following values will vary appreciably.

TEST POINT	TYPICAL AC VOLTAGES
FL201-IN to Gnd. FL201-OUT to Gnd. Q203 - E to TP206 Q204 - C to TP206 Q205 - B to TP206 Q205 - C to TP206 Q206 - B to TP206 Q206 - C to TP206 TP202 to TP206	.07 .04 .10 .09 .013 1.2 .15 2.5 0.5

All voltages read with a-c vacuum-tube voltmeter.

* TABLE III
Transmitter D-C Measurements

Note: All voltages are positive with respect to Neg. D.C. (TP104). All voltages read with d.c. VTVM.

TEST POINT	CARRIEROFF	CARRIER ON
TP101 TP102 TP103 TP105 TP106 TP107 TP108 TP110 TP111 TP112 TP113 J101 (Front Panel)	8.5 volts d.c. <0.5 <0.5 <0.5 44 44 45 <1.0 <1.0 0 45 5 ma. max.	8.5 volts d.c. 20 19.5 9 24 24 44 <1.0 <1.0 <0.5 44 0.6 amp.

TRANSISTOR	V COLL.	V coll.
Q101	2.0	1.8
Q101	1.0	1.0
Q103	< 0.5	9.0
Q104	45	44
Q105	45	44
Q106	44.5	1.2
Q107	0	0
Q108	44.5	24.2

TABLE IV

* Transmitter RF Measurements

Note: "Carrier-on" voltages taken with transmitter set to 10 watts output (24.5 volts across 60 ohms). These voltages subject to variation, depending on frequency and transistor characteristics.

TEST POINT	
1231 1 01141	A-C VOLTAGE
T101-3 to TP104 TP103 to TP102 TP105 to TP104	1.5 volts, rms. 0.2 1.1 ϕ
TP110 to T102-4	0.2
TP111 to T102-4	0.2
Q104-C to TP104	3.3
Q105-C to TP104	3.3
T103-4 to Gnd.	1.1
T104-1 to Gnd.	1.4
Q107-B to TP107	0.5 volts, rms.
Q108-B to TP113	0.5
Q107-C to TP107	14-16
Q108-C to TP113	14-16
T105-4 to Gnd.	105
T106-2 to Gnd.	100-160*
TP109 to Gnd.	30-50 *
J102 to Gnd.	24.5

Note: T101-3 = tap 3 of Transformer T101

Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

- * These values may vary considerably with frequency.
- ϕ High-impedance circuit. VTVM causes significant loading.

TABLE V
Transmitter Keying Board

D.C Voltages

r		_	
TEST POINT	NORMAL (Carrier Off)	CARRIER ON (D.C. on J104-6 or 7)	CARRIER STOP (D.C. on J104-6 or 7 and J104-8 or 9)
TP151	16 v.d.c.	<1.0 v.d.c.	<1.0 v.d.c.
Term. 17	<1.0	24.6	4.9
TP152	16	16	<1.0
TP153	<1.0	<1.0	16
Term. 1	0 *	20	<1.0

^{*} May show <1.0 volt with VTVM

TABLE VI

Receiver CLI and Output Board (with normal received signal)

D.C VOLTAGE - TO NEG.	SIGNAL VOLTAGE (a.c.)
4.9 v.d.c.	0.3 v. rms.
9.8	2.9
< 1.0	
19.7	_
	- TO NEG. 4.9 v.d.c. 9.8 < 1.0

Recommended Test Equipment

- I. Minimum Test Equipment for Installation
 - a. Milliammeter 0-250 ma. DC
 - b. 60-ohm 10-watt non-inductive resistor.
 - c. A-C Vacuum Tube Voltmeter (VTVM). Voltage range 0.01 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance—one megohm, minimum.
 - d. D-C Vacuum Tube Voltmeter (VTVM).

Voltage Range:

0.1 to 300 volts

Imput Impedance:

1.0 megohm, min.

- II. Desirable Test Equipment for Apparatus Maintenance.
 - a. All items listed in I.
 - b. Signal Generator

Output Voltage:

up to 10 volts r.m.s.

Frequency Range:

20 to 330 kHz

- c. Oscilloscope
- d. Ohmmeter
- e. Capacitor checker
- f. Frequency counter
- g. Frequency-selective voltmeter

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.

* Transmitter Section

	RATING	STYLE NUMBER
SYMBOL	0.1 mfd, 200 V.DC	187A624H01
C201	.005 mfd, 300 V.DC	187A694H29
C102	.005 mid, 300 V.DC	187A695H29
C103	0.25 mfd, 200 V.DC	187A624H02
C104		187A624H02
C105	0.25 mfd, 200 V.DC	187A624H02
C106	0.25 mfd, 200 V.DC	187A624H02
C107	0.25 mfd, 200 V.DC	187A624H03
C108	0.50 mfd, 200 V.DC	187A624H02
C109	0.25 mfd, 200 V.DC	187A624H02
C110	0.25 mfd, 200 V.DC	18/1/0241102
† C111	(See Table Below)	40540051119
C112	39 pf. 500 V.D.C.	187A695H12
† C113	(See Table Below) .	-
C114	100 pf., 500 V.DC	187A695H23
C115	100 pf., 500 V.DC	187A695H23
C116	0.001 mfd, 500 V.DC	187A694H11
	Part of FL101	Vary with Frequenc
CA CD CE	Part of FL102	Vary with Frequenc
CB, CC, CD, CE	1N457A	184A855H07
D101	1N4818	188A342H06
D103	1N91	182A881H04
D104	1N4818	188A342H06
D105	1N91	182A881H04
D106	Type RVS Arrester	637A026A01
G101	Closed Circuit Jack	187A606H01
J101	Closed Official	

#200.5 - 300 kHz only.

	7.7110	STYLE NUMBER
† FREQ. (C111, C113)	RATING	
	0.47 mfd, 400 V.DC	188A293H01
30 -50 kHz		188A293H02
50.5-75 kHz	0.22 mfd, 400 V.DC	
75.5-100 kHz	0.15 mfd, 400 V.DC	188A293H03
75.5-100 KHZ		188A293H04
100.5 - 150 kHz	0.1 mfd, 400 V.DC	
	0.047 mfd, 400 V.DC	188A293H05
150.5-300 kHz	0.041 mra, 400 v.be	

* ELECTRICAL PARTS LIST Transmitter Section (Cont.)

SYMBOL		RATING		CTV	LE NUMBER
J102	Banana	Banana Plug Jack			185A431H0
J103	Coaxial	Coaxial Cable Jack			7A633H01
J104	24-Term	24-Term Receptacle			
J105	12-Term	Receptacle			7A669H01
L101		Part of FL101			9 A 20 5 H 0 2
L102	FI.102 T	rap Coil (2nd Harm			ith Frequenc
L103		rap Coil (3rd Harmo			ith Frequency
L104	400 mh.	Tap Coll (3rd Harmo	onic)		ith Frequency
L 105	FL102 C	oil (part of series-raned to fundamental	esonant freq.)		2B096G01 ith Frequency
Q101	2N2905A				
Q102	2N2905A			762	A672H10
Q103				762	A672H10
Q104	2N3712	2N5 25			A638H13
Q105				762	A672H07
Q106		2N3712			A672H07
Q107	TI-481			184	A638H11
Q108	2N1908		Texas Instrument	187	A673H02
	2N1908	Co Identif. C	GP 2151	187	A673H02
SYMBOL	OHMS	± TOL. %	WATTS	STYLE	NUMBER
R101	5,600	5	1	187	A 643H45
R 10 2	2,200	10	0.5	1877	A 64 1H35
R103	10,000	10	0.5	187	A 64 1H 5 1
R104	100,000	5	0.5	187	A763H75
R 10 5	390	5	0.5		763H17
R 10 6	1,200	5	0.5		763H29
R107	10,000	10	0.5		
R 108	100,000	5	0.5		.641H51
R109	390	5	0.5		763H75
R111	1,200	5	0.5		763H17
R112	1 K Pot	20			763H 29
R113	4,700	5	0.25		430 НО 2
R114	10,000	10	0.5	184A	763Н43
R115	150		0.5	187A	641H51
		5	0.5	184 A7	763Н07

* Transmitter Section (Cont.)

	OHMS	± TOL. %	WATTS	STYLE NUMBER
SYMBOL			0.5	184A763H03
R116	100	5	25	1202588
R117	1,000	5	0.5	629A531H56
R118	10,000	2	0.5	629A531H03
R119	62	<u>2</u> 5	2	185A207H51
R120	10,000		2	187A683H01
R121	10	5	0.5	187A290H01
R122	10	5	0.5	187A290H01
R123	10		1	187A644H03
R124		10	0.5	187A641H27
R125	1,000		1	187A644H43
R126	4,700		0.5	187A640H01
R127	10	10	1	187A644H35
R128	2,200	5	0.5	184A636H14
R129	2.7	10	0.5	187A640H01
R130	10	10	1	187A644H43
R131	4,700	5	0.5	184A636H14
R132	2.7	10		184A636H18
R133	0.27	10	11	184A636H18
R134	0.27	10	1 =	188A317H01
R135	3,000	10	5	629A531H58
R136	12,000	2	0.5	187A642H55
R137	15,000	10	2	187A641H27
R138	1,000	10	0.5	187A641H27
R139	1,000	10	0.5	629A531H04
R140	68	2	0.5	185A211H06
R141	30	Type 3D2	02 Thermistor	584C276H23
R142	25K pot.	20	0.25	629A531H63
R143	20,000	2	0.5	STYLE NUMBER
SYMBOL		RATING		880A357H01
SW 101	Car	rrier Test Switch		205C043G01
T101	10,	000/400 ohms		714B666G01
T102	10,	000/400 c.t.		1962694
T103	193	30/60 ohms	L633000	
	Tu	rns ratio, 1/0.5	Pri./each sec.	292B526G01 292B526G02
T104	10,	10/500 ohms		
T105	500	500/50 - 60 - 70 ohms		
T106		30-300 kHz crystal per 328C083		
Y101		(5357B (20 V ±5%)		862A288H03
Z101		12999B (56 V ±5%)		629A798H04
Z102		12999B (56 V ±5%)		629A798H04

ELECTRICAL PARTS LIST * Transmitter Keying Board

SYMBOL	RATING	STYLE NUMBER
C151-C152	0.47 mfd., 200 V.	849A437H04
C153	25 mfd., 125 V.	
C154	47 mfd., 50 V.	184A637H01
D151	1N457A	863A530H01
D152	1N4818	184A855H07
Q151 to Q155	2N3417	188A342H06
R151-R159	47K, ½ W.	848A851H02
R152-R153-R160-R161	4.7K, ½ W.	629A531H72
R154-R162	82K, ½ W.	629A531H48
R155-R158-R163-R166-R169	10K, ½ W.	629A531H78
R156-R164-R167		629A531H56
R157-R165-R168	6.8K, ½ W. 27K, ½ W.	629A531H52
R170		629A531H66
Z151-Z152-Z155-Z156	700, 5 W.	763A129H04
Z153-Z157	1N3688A (24V)	862A288H01
Z154-Z158	1N3686A (20V)	185A212H06
Z159	1N957B (6.8V)	185A797H06
Z160	1N748A (3.9V)	185A797H13
	1N5357B (20V)	862A288H02
C201	Receiver Section	
C202	0.1 mfd., 200 V. DC	187A624H01
	300 pf. 500 V. DC	187A695H35
C203 C204	180 pf. 500 V. DC	187A695H29
C205	0.25 mfd. 200 V. DC	187A624H02
C206	0.25 mfd, 200 V. DC	187A624H02
	0.25 mfd, 200 V. DC	187A624H02
C207 C208	0.25 mfd., 200 V. DC	187A624H02
C209	0.25 mfd., 200 V. DC	187A624H02
C210	0.25 mfd., 200 V. DC	187A624H02
C211	0.25 mfd., 200 V. DC	187A624H02
C212	0.1 mfd., 200 V. DC	187A624H01
C212	0.25 mfd., 200 V. DC	187A624H02
C214	2.0 mfd., 200 V. DC	187A624H05
	0.25 mfd., 200 V. DC	187A624H02
C215	39 pfd., 500 V. DC	187A695H12
D201	1N457A	184A855H07
D202	1N457A	184A855H07
D203	1N4818	188A342H06
D204	1N4818	188A342H06

* Receiver Section (cont.)

		STYLE NUMBER			
SYMBOL		Specify Frequency			
FL201	Receiver Input Filter 30-300 kHz			187A590G02	
FL202 *	Receiver i.f. Filter - 20kHz (2 sections) Receiver Coax, Input Jack			187A638H01	
J201				187A606H01	
J202	Closed Ci	187A606H01			
J203	Closed Ci	Closed Circuit Jack (200MA)			
L201	33 mh.			187A599H02 762A672H10	
Q201	2N2905A			762A672H10	
Q202	2N2905A			762A672H10	
Q203	2N2905A			762A672H10	
Q204	2N 2905 A			762A672H10	
Q205	2N2905A			762A672H10	
Q206	2N2905A			849A441H01	
Q207	2N3645			187A673H13	
Q208	2N4903	1874673113			
	RATING			STYLE NUMBER	
SYMBOL	ОНМЅ	± TOL. %	WATTS		
R201	10,000	10	0.5	187A641H51	
R202	2,200	10	0.5	187A641H35	
R203	10,000	10	0.5	187A641H51	
R204	100,000	5	0.5	184A763H75	
R204 R205	390	5	0.5	184A763H17	
R206	1,200	5	0.5	184A763H29	
	25K Pot.	10	2	185A086H07	
R207	10,000	10	0.5	187A641H51	
R208	100,000	5	0.5	184A763H17	
R209	390	5	0.5	184A763H17	
R210		_	_	See † Note Belov	
R211		20	0.25	629A430H02	
R212	1 K pot.	5	0.5	184A763H29	
R213	1,200	5	1	187A643H45	
R214	5,600	5	0.5	184A763H58	
R215	20,000	5	0.5	184A763H40	
R216	3,600	J			

[†] R211 – 10K - above 50kHz - S#187A641H51 22K - 30-50kHz - S#187A641H59

* Receiver Section (Cont.)

SYMBOL		RATING	·	
R217	OHMS	± TOL. %	WATTS	STYLE NUMBER
R218	620	5	0.5	184A763H22
	33	5	0.5	187A290H13
R219 R220	10,000	10	0.5	187A641H51
R221	20,000	5	0.5	184A763H58
	300	5	0.5	184A763H14
R222	3,600	5	0.5	184A763H40
R223	620	5	0.5	184A763H22
R224	33	5	0.5	187A290H13
R225	10,000	10	0.5	187A641H51
R226	20,000	5	0.5	
R227	300	5	0.5	184A763H58
R228	3,600	5	0.5	184A763H14
R229	620	5	0.5	184A763H40
R230	10	5	0.5	184A763H22
R231	2,000	5	0.5	187А290Н01
R232	1,200	5		184A763H34
R233	4,700	10	2 2	185A207H29
R234	5,100	5		187A642H43
R235	470	10	0.5	184A763H44
R236	4,700	10	1	187A644H19
R237	170	5	1	187A644H43
R238	_	J	40	1336074
R239	1 K pot.	20	-	See † Note Below
R240	50	Sensistor	0.25	629A430H02
R241	100	Type 3D102 Th	0.25	187A685H08
R242	100			185A211H12
T201	10,000/10,000	Type TM-1/4 Sens	sistor	187A685H06
T202	10,000/400	Ohms		714B677G01
T203.	25,000/300	Ohms		205C043G01
Y201		stal per 328C083		205C043G03
Z201	1N3027B (20V	7 +5%\		Specify Frequency
Z202		±10%)		184А449Н07
				584C434H08
SYMBOL		ver CLI and Output B	oard	
C251 to C253 C255 to C260	0.27 mfd, 200 v	RATING V.d.c.		STYLE NUMBER 188A669H05
C254	0.82 mfd, 200 v	I d c		100V003H02
D251-D252	1N457A	·······		188A669H15
D253	1N645A			184A855H07
Z251	1N3686B (20V.	\		837A692H03
Z252				185A212H06
38 - omit - above 50	1N3688A (24V.))	· · · · · · · · · · · · · · · · · · ·	862A288H01

^{- 22}K, 30-50kHz, S#187A641H59.

ELECTRICAL PARTS LIST * Receiver CLI and Output Board (Cont.)

	<u>-</u>	Receiver CLI and Outp		STYLE NUMBER	
SYMBOL	2.7K, TM-1/4 Sensistor			187A685H05	
R251				629A430H07	
R252		5K, ¼W. pot.			
R253	220, ½W.			184A763H35	
R254	2.2K, ½W.			184A763H55	
R255-R260		15K, ½W.			
R256		2.4K, ½W.	Songistor	187A685H07	
R257		330, TM-1/4	Selisistoi	184A763H43	
R258-R259		4.7K, ½W.		184A763H21	
R261		560, ½W.		184A763H29	
R262-R265		1.2K, ½W.		184A763H09	
R263-R264		180, ½W.		629A531H66	
R266		27K, ½W.		629A531H56	
R267-R269		10K, ½W.			
R268		6.8K, ½W.		629 A531 H52	
R270	82K, ½W.			629 A531H78	
	, , , , , , , , , , , , , , , , , , , ,	150, 3W.		762A679H01	
R271		849 A441H02			
Q251-Q252		848A851H01 849A441H01			
Q253 Q254		2N3645		04311111101	
Q201	<u> </u>	Power Suppl		STYLE NUMBER	
SYMBOL		FUNCTION	DESCRIPTION OR RATING		
C1	(+) to (-)) bypass	0.45 mfd. 330 VAC	1723408 1877962	
C2	A-C grou	nding	0.5 mfd, 1500 VDC	1877962	
C3	A-C grou	nding	0.5 mfd, 1500 VDC	14C9400H12	
C4	Filter		1.8 mfd, 800 VDC	719B135G01	
L1	Filter		5.5 mh.	187A342H02	
Q1	Series R	egulator	Type 2N1015C Silicon Transistor		
R1		Series dropping	26.5 ohms, 40W.	04D1299H44	
R2	125V	Series dropping	Same as R1	04D1299H44	
R3	-	Current limiting	500 ohms, 40W.	1268047	
R1		For 48 VDC,	_	_	
		R1 = R2 0			
R2	-	R3 = 26.5 ohms	40W.	04D1299H44	
R3	Test po		Pin Jack — red	187A332H01	
TP1	Test po		Pin Jack - black	187A332H02	
TP2			1N2828B (45V.)	184A854H06	
Z1		Regulator	1N3009A (130V.) Zener Diodes	184A617H12	
$\mathbf{Z}2$	Surge Protection Voltage Reg for 250 V.D.C.		1N2813B (15V.)	184A854H11	

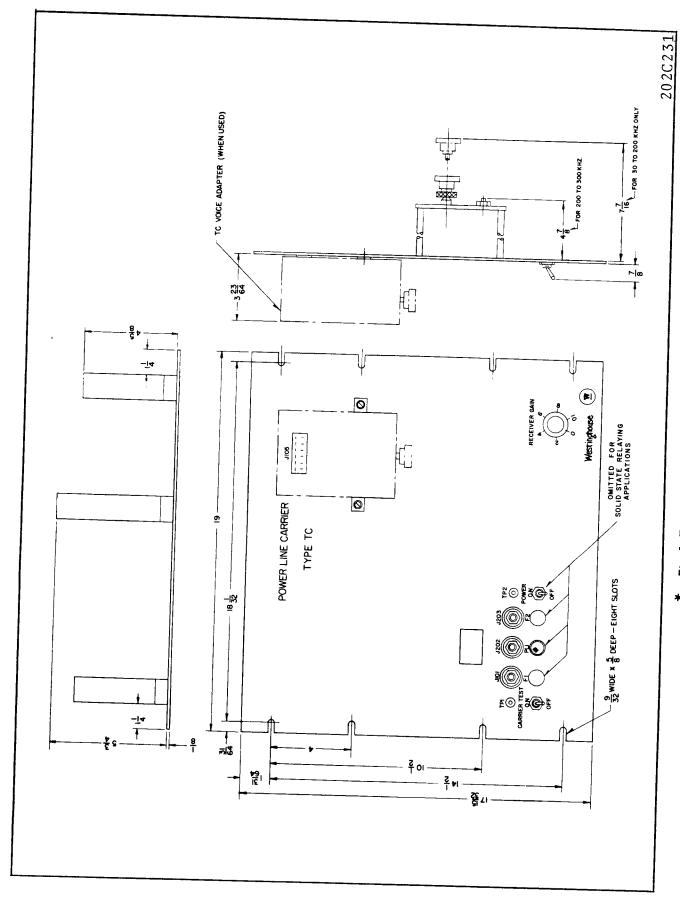
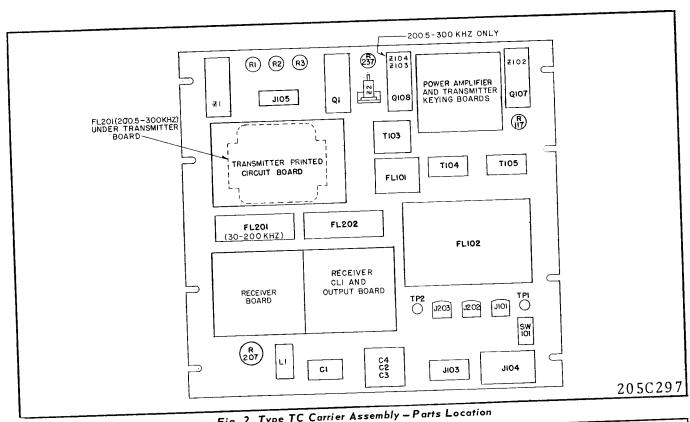
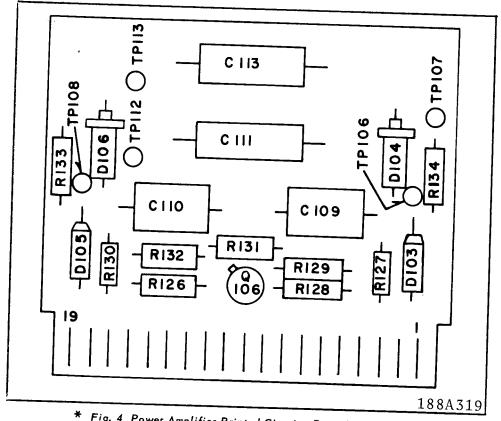


Fig. 1 Type TC Carrier Assembly - Outline

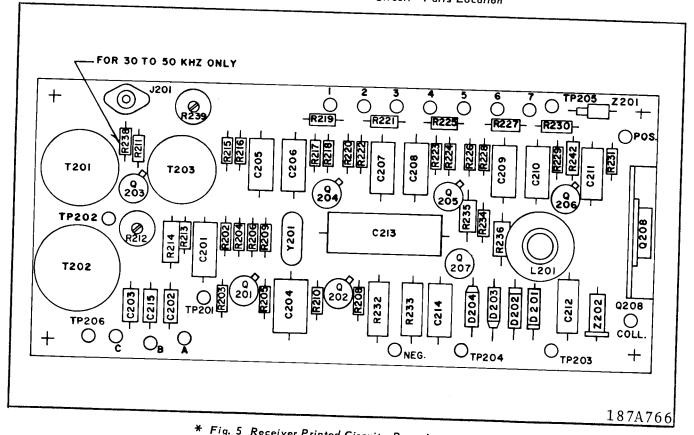


* Fig. 2 Type TC Carrier Assembly - Parts Location - M-= **RI40** R141 R122 CII6 RII9 R143 6010 (9<u>8</u>) CIIS L104 TPIII 🔘 T102 ©TPIIO Ø 00 TPI02 C104 R138 RIIG TP103 σō RIA 0106 RI 20 **-**Ø 00 1012 <u>ĕ</u>© RIIS C102 <u>0</u> 010 C 105 Ē RIZI () A © TPI05 **◎ B** © TPI04 õί CLIP JUMPER FOR 30-50 KHZ CLIP JUMPER FOR HZ / HZM RELAYING 714B958

* Fig. 3 Transmitter Printed Circuit - Parts Location



* Fig. 4 Power Amplifier Printed Circuit - Parts Location



* Fig. 5 Receiver Printed Circuit - Parts Location

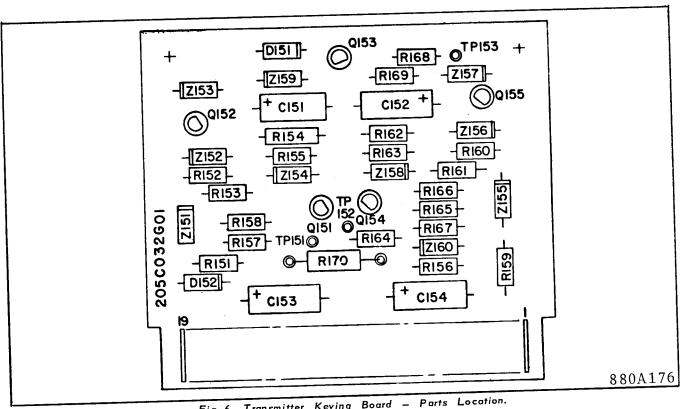


Fig. 6. Transmitter Keying Board -

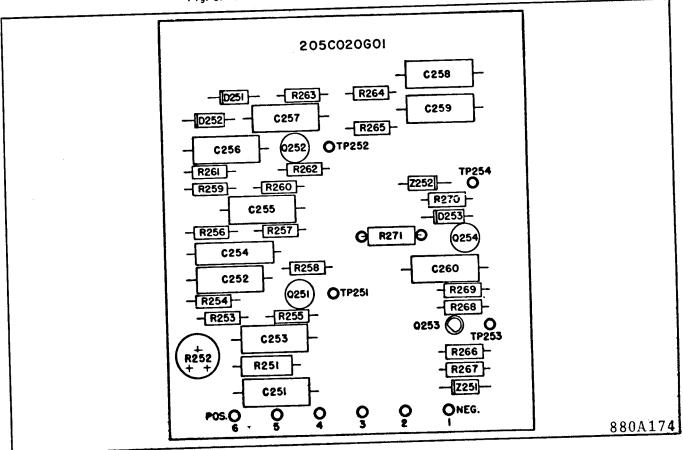
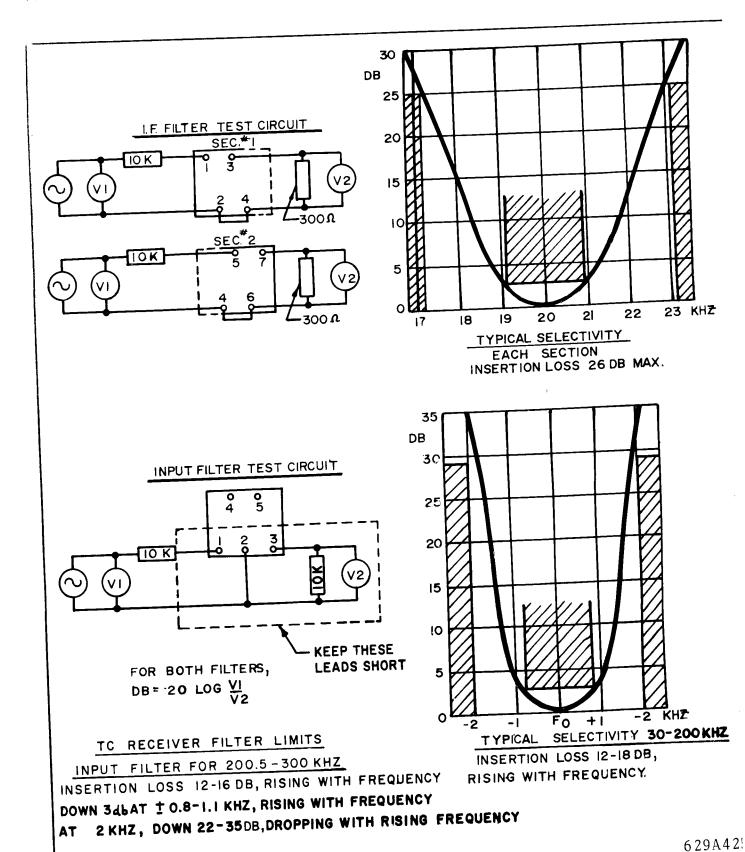


Fig. 7. Receiver CLI and Output Board — Parts Location.



* Fig. 9. Type TC Receiver Filter Characteristics

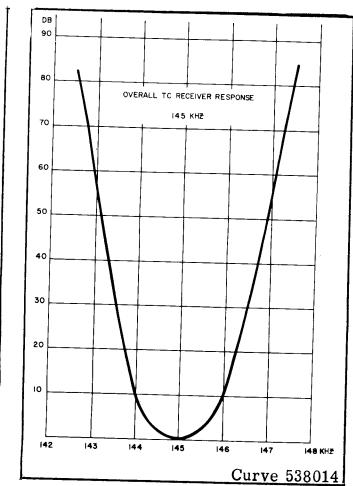


Fig. 10. Type TC Receiver Overall Selectivity Curve.

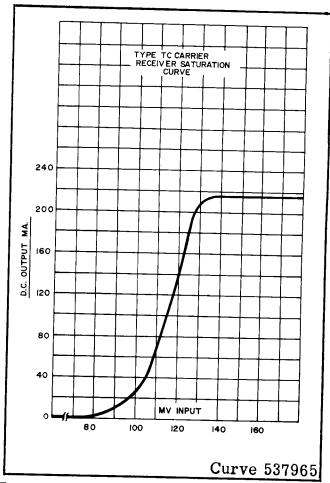


Fig. 11. Type TC Receiver — 200 ma. Output Characteristic.

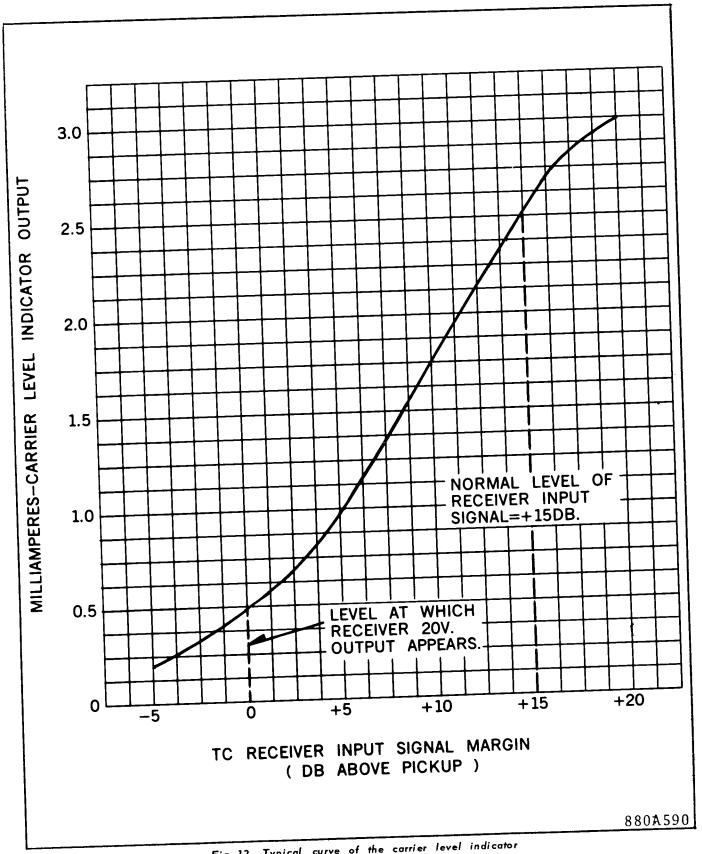


Fig. 12. Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

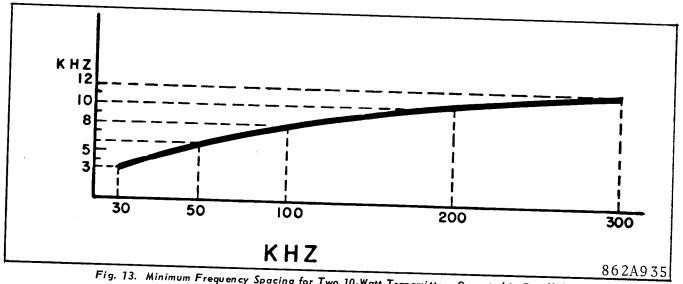


Fig. 13. Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

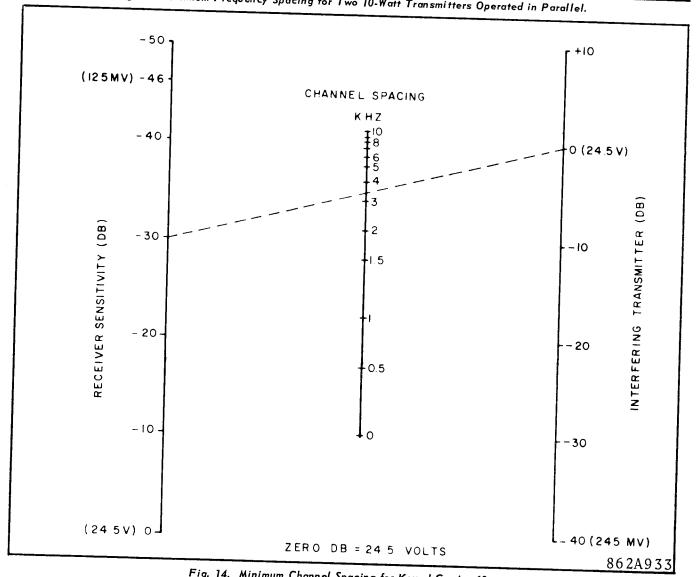
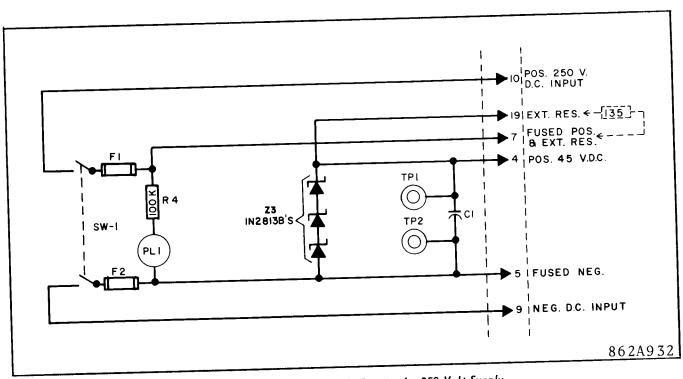
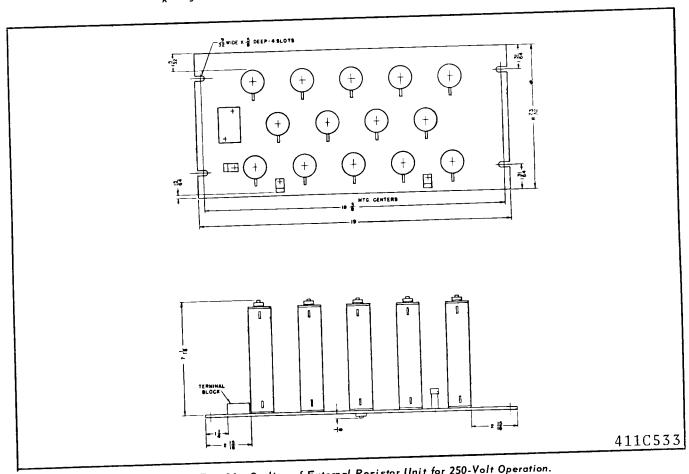


Fig. 14. Minimum Channel Spacing for Keyed Carrier 60 p.p.s.



* Fig. 15. Detail of Power Supply Section for 250-Volt Supply.



* Fig. 16. Outline of External Resistor Unit for 250-Volt Operation.



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



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY FOR USE WITH SOLID-STATE RELAYING SYSTEMS

TABLE OF CONTENTS			LIST OF ILLUSTRATIONS
	age	Figure	Page
Caution	2	1	Type TC Carrier Assembly-Outline 18
Application	2	2	Type TC Carrier Assembly — Parts Location
Construction	2		Transmitter Printed Circuit Board—
Operation	2 2	3	Parts Location
Receiver	3	4	Power Amplifier Printed Circuit
Power Supply	4		Board - Parts Location 20
Relaying Control Circuits Carrier Control for Other Function	4	5	Receiver Printed Circuit Board— Parts Location
Characteristics	4		_
Installation	5	6	Transmitter Keying Board — Parts Location
Adjustments	5		
Transmitter	5	7	Receiver CLI and Output Board— Parts Location
Transmitter Filter	5		Parts Location
Receiver	5	8	Type TC Carrier Assembly for
Maintenance	6	ē	Solid-State Relaying — Internal Schematic23-24
Change of Operating Frequency	7 7	9	Type TC Receiver Filter
Transmitter	8		Characteristics
Recommended Test Equipment	10	10	Type TC Receiver Overall
Renewal Parts	10		Selectivity Curve
	11	11	Type TC Receiver - 200-ma.
Electrical Parts List	11		Output Characteristic
Transmitter	15	12	Receiver CLI - Output
Power Supply	17		Characteristic
		13	Minimum Frequency Spacing
LIST OF TABLES		1	Between Two Type TC Carrier Sets (Without Hybrids)
Table	Page		
I Receiver D-C Measurements	8	14	Minimum Channel Spacing for Keyed Type TC Carrier
II Receiver R-F Measurements	9		(Keyed at 60 p.p.s.) 28
III Transmitter D-C Measurements	9	15	Detail of Power Supply
IV Transmitter R-F Measurements	9	-0	Section for 250-volt Supply 29
V Transmitter Keying Board Meas	10	16	Outline of External Resistor Unit for 250-volt Operation
VI Receiver CLI Board Meas	10	_	Unit for 250-voit Operation2

Power Supply

The power supply circuit for 48 or 125-v.d-csupply uses 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 VR1 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 the transistor Q1 and resistors R1 and R2 $\,$ varies to maintain a constant output voltage of approximately 45-v. d-c. The zener diode VR2serves 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. Inductance L1 and capacitor C4 serve as a filter to prevent any appreciable carrier-frequency energy from getting onto the external d.c. supply circuits.

For a 250-volt d-c supply, the circuit of Figure 15 is used. This consists of an external voltagedropping resistor assembly (135 ohms total) in conjunction with three 15-volt Zener diodes on the TC set chassis connected in series. The resistor assembly (see Figure 16) must be mounted at the top of a cabinet or an open rack. Because of the heat dissipated, no transistorized equipment should be mounted above the resistor panel. The 250-volt ${\ensuremath{\mathrm{TC}}}$ set has a constant current drain of 1.5 amperes d-c.

Relaying Control Circuits

The transmitter start and stop control circuits and the receiver 20-volt output (previously described) allow this type TC set to be used with solid-state protective and auxiliary relays which also have 20-volt input and output 'logic'. In addition, these carrier control circuits are designed to absorb and limit externally generated surges so they will not damage the transistors or associated components.

For flexibility in application, provision is also made for keying the transmitter from either 48 or 125 volts d.c. Also, the 200-ma receiver output circuit is brought out to a J104 terminal for connection to a 30-ohm alarm relay, if desired.

CHARACTERISTICS

Frequency range 30-300 kHz (50-300 kHz for

phase comparison relaying)

Transmitter output 10 watts into 50 to 70-ohm

resistive load

Harmonics 55 db below 10 watts. Receiver sensitivity 125 mv. input for 180 ma.

minimum output current

Receiver selectivity 1500 Hz bandwidth (3 db down); down 80 db at ±3kHz.

Transmitter-receiver

channel rating 40 db

Input Voltage 48, 125, or 250 V. d-c

Supply voltage

variation 42-56V, 105-140V, 210-280V

Battery Drain: 0.5 amp standby, 1.35 amp 48 V.D.C.

transmitting

125 V.D.C. 0.25 amp standby, 1.1 amp

transmitting

250 V.D.C. 1.5 amp standby or transmitting

Temperature range -20 to +55°C around chassis

Frequency Spacing

The minimum recommended frequency spacing between two Type TC carrier sets operated in parallel without hybrid units is shown on the curve of Fig. 13. For example, at 100 kHz. the minimum spacing is 8 kHz. Closer spacing would result in the generation of intermodulation products caused by the non-linear load presented by each transmitter to the other one.

The minimum frequency spacing between a TC carrier channel and an adjacent transmitter signal keyed on-off at a rate of 60 pulses per second can be determined from the nomograph of Fig. 14. Using the example shown by the dashed line, consider a type TC set used on a channel with a normal attenuation of 15 decibels. The TC receiver would be set to give a margin of 15 db below the normal received signal, or for a sensitivity of -30 db (relative to a 24.5 volt, 10-watt signal). The interfering signal is assumed to be a 10-watt transmitter at the same location. To determine the minimum frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the -30 db point on the receiver sensitivity scale and the zero-db point on the interfering transmitter scale. The resulting line crosses the channel spacing scale between 3 and 4 kHz. For this example, a channel spacing of at least 4 kHz should be used. (In order not to conflict with the limits of Fig. 13, an r-f hybrid may be needed between the TCset and the other transmitter, depending on the actual application.)

For protective relaying applications to 3-terminal lines, the transmitter frequencies are offset $100\ hertz$ to prevent a slow beat or cancellation of the received signal when two transmitters send blocking signals to the third terminal. The three transmitters operate

at fc, fc+100 Hz, and fc-100 Hz. All receivers operate at the channel center frequency (fc).

INSTALLATION

The type TC transmitter-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 should not exceed 55°C.

ADJUSTMENTS

Transmitter

The main adjustment on the transmitter is the power output control R112 on the transmitter printed circuit board. Disconnect the coaxial cable from the assembly terminals and replace with a 50 to 70 ohm noninductive 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 T106 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn the transmitter power output control R112 to minimum (full counterclockwise).

Now apply d-c power and note the d-c voltage across the two pin jacks TP1 and TP2. If this is in the range of approximately 42 to 46 volts, throw the carrier-test switch SW101 on the panel to the ON position. Slowly advance the output control R112 on the transmitter printed-circuit board until about 10 volts is obtained across the output 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. For 200-300 kHz operation, L105 is a "pot core" and has a adjustable core screw. Use a screw-driver in this case. No locking device is needed.

Now continue to advance the output control R112 until the output voltage tabulated in the following table is obtained across the load resistor. Recheck the setting of L105 to be sure it is at its maximum point for 10 watts output. Tighten the locking nut. Turn off the carrier test switch SW101, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

 $\frac{\text{NOTE:}}{\text{control}}$ Do not change the adjustment of the R142 control on the printed circuit board. See Maintenance section for R142 adjustment.

T106 Tap	Voltage for 10 Watts Output
50	$22 {}_{\circ}4$
60	24.5
70	27.0

Transmitter Filter

Normally, the output filter (FL102) will require no readjustment except as noted under Adjustments-Transmitter, as 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. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection at the factory, 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.

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

Receiver

The receiver board has two controls; the i.f. input control R239 which is usually factory-set at maximum giving a sensitivity of 125 mv. or less for 180 ma. output, and the local oscillator output control R212. The oscillator output is preset at the factory at 0.3 volt. This setting can be checked by connecting an a-c VTVM between receiver test points TP202 and TP206 (shield lead of VTVM). The voltmeter reading with the equipment energized, but not transmitting, should be 0.3 volt. Note Fig. 5 for location of components on the receiver printed board.

The other adjustment on the receiver is the gain control R207 which is front-panel mounted. It is recommended that the receiver gain normally be set for a 15-db operating margin to allow for reasonable variations in receiver input signal level without affecting the output blocking current. This adjustment can be made in two ways, as follows:

1. First, measure the normal received signal from the remote terminal (after the line tuners have been adjusted) by starting the remote transmitter and measuring the voltage across the coaxial cable at the receiving terminal. This signal should preferably be measured with a tuned voltmeter such as the Sierra carrier-frequency voltmeter. If a simple VTVM is used, have the

remote transmitter turned on and off several times to be sure the VTVM reading is actually the remote signal. Note the reading. Now disconnect the coaxial cable, and feed a signal into the carrier assembly at the coaxial terminals from a separate signal generator. Set the signal generator to the received frequency at a level 15 db below the previously measured incoming signal. With a 0-250 ma. (minimum) d-c milliammeter plugged into J203, adjust the receiver gain control until an output current of about 100 ma, is obtained. As this point is on the steep portion of the receiver output-input curve, it may be difficult to set the gain control for exactly 100 ma. This is not necessary, however, as the signal is not normally at this value. This is the operating setting of the receiver gain control. Return the coaxial cable connections to normal.

NOTE: Do not energize the local transmitter when making the foregoing adjustment as the signal generator may be damaged.

2. As an alternate procedure if no signal generator is available, the local transmitter itself may be used as the signal generator. First determine the normal received signal from the remote terminal as explained previously under (1). Then turn off the remote transmitter.

Now turn on the local transmitter and reduce its output to a value 15 db below the normal received signal level. Then adjust the receiver gain control to give 100 ma. output as before. When this adjustment has been made, reset the local transmitter to its normal 10-watt output level.

In applications where the line attenuation is low and a strong signal is received, the adjustment of the receiver gain control R207 becomes critical. For such applications, the setting of i-f gain control R239 may be reduced to lower the overall receiver gain. The front-panel control R207 will then have a smoother and more gradual control as the knob is rotated, making it easier to obtain the 15-db margin setting.

Carrier Level Indicator (CLI)

The CLI should be adjusted on a clear dry day when line conditions are considered normal. After the receiver sensitivity has been set for a 15-db margin, turn on the remote transmitter at its normal 10-watt output. With a small screw-driver, adjust the CLI input control R252 to give a reading of 2.5 ma. on the 0-3 ma. d-c milliammeter in the CLI output circuit. This current can be read at J202 on the TC set panel for convenience. If the received signal varies for any reason, the CLI output current will change accordingly, as indicated by the curve in Fig. 12.

When carrier is transmitted from a given station, the pointer of the local CLI output milliammeter will be driven off scale. This will not in any way damage the instrument as the CLI saturation current is less than 4 ma. d.c.

MAINTENANCE

Periodic checks of the received carrier signal will indicate proper operation of the equipment. 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 and receiver sensitivity 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 and current values are given in Tables I through VI. Voltages should be measured with a VTVM. Readings may vary as much as $\pm\,20\%$.

Adjustment of R142 on Transmitter Board

The small adjustable resistor (pot.) R142 sets the forward base bias on transmitter transistors Q104 and Q105 to the proper point for class-B operation. This is a factory adjustment and need not be changed unless transistors Q104 or Q105 (or both) are replaced. However, if these transsistors are changed, or if the R142 setting is disturbed in error, the following adjustment procedure should be followed to reset R142:

First remove d-c power from the TC carrier set assembly. Unsolder the lead from terminal 2 of transformer T103 (just above FL101) and tem-

porarily connect a low-range d-c milliammeter (0-1.0 or so) between the removed lead (+) and T103 terminal 2 (-). Turn the slotted control on the small pot (R142) to full counterclockwise. Now, apply power to the TC carrier set, but do not transmit carrier. Advance the pot until the d-c milliammeter reads 0.2 mA d.c. ± .05 mA. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T103. Again apply d-c power and proceed with the transmitter adjustment as described in the ADJUSTMENTS section.

CHANGE OF OPERATING FREQUENCY

The parts required for changing the operating frequency of a type TC carrier set are as follows:

Transmitter

1. Oscillator Crystal (Y101), specify frequency. NOTE: Modify A-B-C jumpers on transmitter board if required for new frequency. See table marked "†" under internal schematic (Fig.8).

2. R136 Jumper

For operation in 30-50kHz range, clip off R136 as indicated in Fig. 3.

- 3. Capacitors C111 and C113 (on Power Amp. board)
 - -0.47 mfd. S#188A293H01 a. 30-50 kHz
 - b. 50.5-75 kHz 0.22 mfd. S#188A293H02
 - c. 75.5-100 kHz 0.15 mfd. S #188A293H03
 - d. 100.5-150 kHz 0.10 mfd. S#188A293H04
 - e. 150.5-300 kHz 0.047 mfd. S#188A293H05

4. FL101 and FL102

Filter FL101 is a small series-resonant tuned circuit between the driver and power amplifier stages of the transmitter. It has just two terminals. Filter FL102 is a larger assembly, described under OPERATION. It has three external connections: input, output, and ground. This filter is mounted by four corner posts. To replace, unsolder the three leads, remove the nuts from the mounting posts, and lift the filter assembly from the posts. The new filter can now be installed.

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 kHz to 300 $k\mathrm{Hz}.$ 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
	64.5 - 68.0	120.0-127.0	214.1-222.0
32.0-33.5	1	127.5-135.0	222.1-230.0
34.0-36.0	68.5- 72.0		2221= ===
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
	80.5-84.5	151.5-159.5	250.1-262.0
41.5-44.0		ì	262.1-274.0
44.5 - 47.0	85.0-89.0	160.0-169.5	I
47.5-50.0	89.5- 94.5	170.0-180.0	274.1-287.0
* • • • •	95.0-100.0	180.5-191.5	287.1-300.0
50.5-53.5	1 -	192.0-200.0	į
54.0-57.0	100.5-106.0	1	1
57.5-60.5	106.5-112.5	200.1-207.0	1

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 T103 and the voltmeter across terminals 1 and 2 of transformer T104. The signal generator should be set at the channel center frequency and at 2 at 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 T105 and a 500-ohm resistor and a VTVM to the terminals of protective gap G101. 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.

If the change in frequency is enough to require a different filter, it will come factory adjusted as described in the foregoing paragraph.

After all the tabulated changes have been made for the new frequency, the transmitter can be operated with a 50 to 70-ohm load (depending on which tap of T106 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 ADJUSTMENT section.

If a frequency-sensitive voltmeter is available, the second and third harmonic traps may be adjusted (or checked) 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 its tuning dial and db range switch, obtain a maximum on-scale reading of the second 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. It should be noted that this procedure may not give the true magnitude of the harmonics because of the large value of fundamental frequency voltage present at the tuned voltmeter input terminals. This condition will overload the input circuit of some commercial instruments. However, the procedure is satisfactory for adjusting the traps for maximum harmonic rejection.

If accurate measurement of the harmonic levels is desired, the frequency-selective voltmeter is connected, through a rejection filter, to the terminals of the 60-ohm load resistor. The filter must provide high rejection of the fundamental. A twin-T filter is suitable for this purpose. The insertion losses of this filter at the second and third harmonics must be measured and taken into account.

Receiver

Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.

- 2. Receiver input filter (FL201), specify frequency.
- Resistors R211-R238 Combination
 See values in Fig. 8 below internal schematic.
- 4. Resistors R218 and R224 may have to be reduced. See following paragraph.

The emitter resistors R218 and R224 of the i-f stages are selected during factory test to give the required receiver gain. This is desirable since the insertion loss of the input filter FL201 increases with frequency. If the operating frequency is reduced, the receiver gain will probably be higher. In this case, a reduction in the setting of the i-f input control R239 will give the 125-mv. sensitivity. If the new operating frequency is higher, the receiver gain will be lower. If more than 125 mv. is required to obtain 180 ma. output, the gain can be increased by reducing the value of one or both of the resistors R218 and R224. In most cases, these resistors should fall in the range of 22 to 150 ohms. These two resistors are soldered to small terminal posts on the printed circuit board.

TABLE I
Receiver D.C. Measurements

Note: All voltages are negative with respect to Pos. $45\,\mathrm{V.}$ (TP206)

TEST POINT	STANDBY (No Signal)	WITH 125 M V. INPUT
TP201	38	38
TP202	0	0
TP203	11	11
TP204	.03	2.2
TP205	20	20
TRANSISTOR	V COLL.	V COLL.
Q201	43	43
Q202	43.5	43.5
Q203	18.7	18.7
Q204	18.7	18.7
Q205	18.7	18.7
Q206	10.5	10.5
Q207	22.0	4.0
Q208	45.0	2.0

All voltages read with d-c vacuum-tube voltmeter.

TABLE II

Receiver RF Measurements

Note: Taken with 36 kHz and 132 kHz receiver filters, 0.125 volt input signal, and gain control R207 at maximum. Depending on receiver frequency and transistor characteristics, the following values will vary appreciably.

	TYPICAL A-C VOLTAGES	
TEST POINT	36 kHz.	132 kHz.
FL201-IN to Gnd. FL201-OUT to Gnd. Q203 - E to TP206 Q204 - C to TP206 Q205 - B to TP206 Q205 - C to TP206 Q206 - B to TP206 Q206 - C to TP206	.075 .051 .105 .90 .11 6.7 .67 1.5	.050 .020 .090 .52 .052 3.4 .37 1.53

All voltages read with a-c vacuum-tube voltmeter.

TABLE III
Transmitter D-C Measurements

Note: All voltages are positive with respect to Neg. 45 V. (TP104). All voltages read with d.c. VTVM.

	ALTRIED OFF	CARRIER ON
TEST POINT	CARRIER OFF	
TP101 TP102 TP103 TP105 TP106 TP107 TP108 TP110 TP111 TP112 TP113 J101 (Front Panel)	7 volts d.c. 0 0 44 44 45 <1.0 <1.0 0 45 5 ma. max.	7 volts d.c. 20 19.5 9 22 22.2 44.8 < 1.0 < 1.0 0 45 0.6 amp.

TRANSISTOR	V COLL.	V coll.
	0.5	2.5
Q101	2.5	
Q102	1.2	1.1
Q103	0	9.0
	45	45
Q104		45
Q105	45	1
Q106	44	1.2
Q107	0	0
	44.7	22.3
Q108	11.1	

TABLE IV
Transmitter RF Measurements

Note: "Carrier-on" voltages taken with transmitter set to 10 watts output (24.5 volts across 60 ohms). These voltages subject to variation, depending on frequency and transistor characteristics.

TEST POINT	A-C VOLTAGE
T101-3 to TP104 TP103 to TP102 TP105 to TP104	1.1 volts, rms. 0.2 0.7
TP110 to T102-4 TP111 to T102-4 Q104-C to TP104	0.2 0.2 4.3
Q105-C to TP104 T103-4 to Gnd. T104-1 to Gnd.	4.3 1.5 1.4
Q107-B to TP107 Q108-B to TP113 Q107-C to TP107	.5 volts, rms. .5 14.5
Q108-C to TP113 T105-4 to Gnd. T106-2 to Gnd.	14.5 105 155 *
TP109 to Gnd. J102 to Gnd.	50 * 24.5

Note: T101-3 = tap 3 of Transformer T101

Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

*These values may vary considerably with frequency.

TABLE V

Transmitter Keying Board D.C Voltages

TEST POINT	NORMAL (Carrier Off)	CARRIER ON (D.C. on J104-6 or 7)	CARRIER STOP (D.C. on J104-6 or 7 and J104-8 or 9)
TP151	16 v.d.c.	<1.0 v.d.c.	
Term. 17	<1.0	24.6	<1.0 v.d.c. 4.9
TP152	16	16	<1.0
TP153	<1.0	<1.0	16
Term. 1	0 *	20	<1.0
* 3.5			.1.0

^{*} May show <1.0 volt with VTVM

TABLE VI

Receiver CLI and Output Board (with normal received signal)

TEST POINT	D.C VOLTAGE ~ TO NEG.	SIGNAL VOLTAGE (a.c.)
TP-251 TP-252	4.9 v.d.c. 9.8	0.3 v. rms. 2.9
TP-253 TP-254	< 1.0 19.7	

Recommended Test Equipment

- I. Minimum Test Equipment for Installation
 - a. Milliammeter 0-250 ma. DC
 - b. 60-ohm 10-watt non-inductive resistor.
 - c. A-C Vacuum Tube Voltmeter (VTVM). Voltage range 0.01 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance—one megohm, minimum.
 - d. D-C Vacuum Tube Voltmeter (VTVM).

Voltage Range:

0.1 to 300 volts

Imput Impedance:

1.0 megohm, min.

- II. Desirable Test Equipment for Apparatus Maintenance.
 - a. All items listed in I.
 - b. Signal Generator

Output Voltage:

up to 10 volts r.m.s.

Frequency Range:

20 to 330 kHz

- c. Oscilloscope
- d. Ohmmeter
- e. Capacitor checker
- f. Frequency counter
- g. Frequency-selective voltmeter

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.

Transmitter Section

	RATING	STYLE NUMBER
SYMBOL	0.1 mfd, 200 V. DC	187 A 6 24 H 0 1
C101	.005 mfd, 300 V. DC	187A694H29
C10 2	180 pf. 500 V. DC	187A695H29
C 103		187 A 624 H 0 2
C 104	0.25 mfd, 200 V. DC	187A624H02
C 105	0.25 mfd, 200 V. DC	187A624H02
C106	0.25 mfd, 200 V. DC	187A624H02
C107	0.25 mfd, 200 V. DC	187 A624 H03
C 108	0.50 mfd, 200 V. DC	187 A624H0 2
C 109	0.25 mfd, 200 V. DC	187 A 624 HO 2
C110	0.25 mfd, 200 V. DC	10(710211102
· C111	(See Table Below)	107 4 005 11 12
C112	39 pfd, 500 V. DC	187 A 695 H 12
	(See Table Below)	-
C113	100 pf., 500 V. DC	187 A695H23
C114	100 pf., 500 V. DC	187 A 695 H 23
C115	0.001 mfd, 500 V. DC	187A694H11
C116	Part of FL101	Vary with Frequenc
CA	Part of FL 102	Vary with Frequenc
CB, CC, CD, CE	1N3686B (20 V ± 5%)	185A212H06
CR101	1N457 A	184A855H07
CR102		407С703Н03
CR103	1N538	182A881H04
CR104	1N91	407С703Н03
CR105	1N538	182A881H04
CR 106	1N91	184A617H13
CR107-108	1N2999 A (56 V ± 10%)	184A617H13
CR109 #	1N 29 99 A (56 V ± 10%)	637 A0 26 A0 1
G10 1	Type RVS Arrester	187 A 60 6H0 1
J 10 1	Closed Circuit Jack	

0.5-300 kHz only.		STYLE NUMBER
FREQ.(C111,C113)	RATING	188A293H01
	0.47 mfd, 400 V. DC	1001120 0110
30 - 50 kHz	0.22 mfd, 400 V. DC	188A293H02
50.5-75 kHz		188A293H03
	0.15 mfd, 400 V. DC	
75.5-100 kHz	0.1 mfd, 400 V. DC	188A293H04
100.5-150 kHz		188A293H05
	0.047 mfd, 400 V. DC	1001120 011
150.5-200 kHz		

Transmitter Section (Cont.)

SYMBOL		RATING		STYLE NUMBER		
J102	Banana I	Banana Plug Jack				
J103	Coaxial	Coaxial Cable Jack				
J104		24-Term Receptacle				
J105		12-Term Receptacle				
L101	Part of F			629 A 20 5 H 0 2		
L102				Vary with Frequency		
L103		cap Coil (2nd Harmo		Vary with Frequency		
L104	400 mh.	ap Coil (3rd Harmon	nic)	Vary with Frequency		
L 105	FL102 Co	oil (part of series-re	esonant frea	292B096G01 Vary with Frequency		
Q101	2N 274					
Q102	2N 274			187A270H01		
Q103				187А270Н01		
Q104		2N5 25				
Q105		2N657				
Q106		2N657				
Q107	T	TI-481				
Q108		2N1908 Matched Pair - Texas Instrument				
		2N1908 Co Identif. GP2151		187А673Н02		
SYMBOL	OHMS	± TOL. %	WATTS	STYLE NUMBER		
R 10 1 R 10 2	5,600	5	1	187A643H45		
	2,200	10	0.5	187A641H35		
R103	10,000	10	0.5	187 A 64 1H 51		
R104	100,000	5	0.5	187A763H75		
R 10 5	390	5	0.5	184A763H17		
R 10 6	1,200	5	0.5	184 A763H 29		
R107	10,000	10	0.5	184A641H51		
R 108	100,000	5	0.5			
R109	390	5	0.5	184A763H75		
R111	1,200	5	0.5	184A763H17		
R112	1 K Pot	20	0.25	187 A763H 29		
R113	4,700	5	0.5	629A430H02		
R114	10,000	10	0.5	184A763H43		
R115	150	5		187A641H51		
			0.5	184 A763H07		

Transmitter Section (Cont.)

	OHMS	±TOL. %	WATTS	STYLE NUMBER
SYMBOL		5	0.5	184 A7 63 H03
R116	100	<u>5</u>	25	1202588
R117	1,000	2	0.5	629 A 531 H 58
R118	12,000	2	0.5	629A531H03
R1 19	62		2	185A207H51
R120	10,000	<u>5</u> 	2	187A683H01
R121			0.5	187 A290H01
R122	10	5	0.5	187A290H01
R123	10	10	1	187A644H03
R124	100		0.5	187A641H27
R125	1,000			187A644H43
R126	4,700	10	1 0.5	187A640H01
R127	10	10	0.5	187A644H35
R128	2,200	5	1	184 A636H14
R129	2.7	10	0.5	187A640H01
R130	10	10		
R131	4,700	5	1	187A644H43
R132	2.7	10	0.5	184 A 63 6 H 14
R133	0.27	10	1	184A636H14
R134	0.27	10	1	184A636H18
	3,000	10	5	188A317H01
R135	12,000	2	0.5	629 A 53 1 H 58
R136	15,000	10	2	187A642H55
R137	1,000	10	0.5	187A641H27
R138	1,000	10	0.5	187A641H27
R139	68	2	0.5	629A531H04
R140	30	Type 3D202	Thermistor	185A211H06
R 141		20	0.25	584C276H23
R142	25K pot.	2	0.5	629A531H63
R143	20,000	RATING		STYLE NUMBER
SYMBOL	10.0			205C043G01
T101		10,000/400 ohms		714B666G01
T102		10,000/400 c.t.		
T103		1930/60 ohms L633000 Turns ratio 1/0.5 Pri./each sec.		
T104		ns ratio, 1/0.5	FII./ each see.	292B526G02
T105		'500 ohms		292B526G03
T106		0/50 - 60 - 70 ohms		Specify Frequence
Y101	30-	300 kHz crystal pe	r 328C083	Spoots 110 trans

Transmitter Keying Board

SYMBOL	RATING	STYLE NUMBER	
C151-C152	.047 mfd., 200 V.	849A437H04	
C153	25 mfd., 125 V.	184A637H01	
C 154	47 mfd., 50 V.	863A530H01	
D151	1N457A	184A855H07	
D152	1N4818	188 A34 2H0 6	
Q151 to Q155	2N3417	848A851H02	
R151 - R159	47K, ½ W.	629A531H72	
R152-R153-R160-R161	4.7K, ½ W.	629 A53 1H48	
R154 - R162	82K, ½ W.	629 A5 31H78	
R155-R158-R163-R166-R169	10K, ½ W.	629A531H56	
R156-R164-R167	6.8K, ½ W.	629A531H52	
R 157-R 165-R 168	27K, ½ W.	629 A53 1H66	
R170	700, 5 W.	763 A129H04	
Z151-Z152-Z155-Z156	1N3688A (24V)	862A288H01	
Z153-Z157	1N3686A (20V)	185A212H06	
Z154-Z158	1N957B (6.8V)	185A797H06	
Z159	1N748A (3.9V)	185A797H13	
Z160	1N5357B (20V)	862A288H02	
	Receiver Section	002A200H02	
C201	0.1 mfd., 200 V. DC	187A624H01	
C202	300 pf. 500 V. DC	187A695H35	
C203	180 pf. 500 V. DC	187A695H29	
C204	0.25 mfd. 200 V. DC	187A624H02	
C205	0.25 MFD. 200 V. DC	187A624H02	
C206	0.25 mfd., 200 V. DC	187A624H02	
C207	0.25 mfd., 200 V. DC	187A624H02	
C208	0.25 mfd., 200 V. DC	187A624H02	
C209	0.25 mfd., 200 V. DC	187A624H02	
C210	0.25 mfd., 200 V. DC	187A624H02	
2211	0.1 mfd., 200 V. DC	187A624H01	
C212	0.25 mfd., 200 V. DC		
C213	2.0 mfd., 200 V. DC	187A624H02	
2214	0.25 mfd., 200 V. DC	187A624H05	
2215	39 pfd., 500 V. DC	187A624H02	
CR201	1N30 27B (20V ± 5%)	187A695H12	
CR 20 2	1N91	184A449H07	
R203	1N91	182A881H04	
	11101	182A881H04	

Receiver Section (cont.)

		STYLE NUMBER		
SYMBOL	RATING			407С703Н03
CR204	1N538	407C703H03		
CR205	1N538	484C434H08		
CR206	1N1789 (5	Specify Frequency		
FL201		Input Filter 30-300 kH		187A590G02
FL202		i.f. Filter-20kHz (2 se		187A638H01
J201		Coax. Input Jack		187A606H01
J202		Circuit Jack (CLI)		187A606H01
J203	Closed C	Circuit Jack (200MA)		187А599Н01
L201	33 mh.			187A270H01
Q201	2N274			187A270H01
Q202	2N274			187A270H01
Q203	2N274			187A270H01
Q204	2N274			187A270H01
Q205	2N274	187A270H01		
Q206	2N274	184A638H12		
Q207	2N398A	187A673H01		
Q208	2N1362			
		STYLE NUMBER		
SYMBOL	OHMS	± TOL. %	WATTS 0.5	187A641H51
R201	10,000	10,000 10		187A641H35
R202	2,200	2,200		187A641H51
R203	10,000	10,000		184A763H75
R204	100,000	5	0.5	184A763H17
R205	390	5	$\frac{0.5}{0.5}$	184A763H29
R206	1,200	1,200		185A086H07
R207	25 K Pot.	10	2	187A641H51
R208	10,000	10	0.5	184 A 763 H 75
	100,000	5	0.5	184A763H17
D200	390 5 0.5			See † Note Below
R209	390	1	1	See Note Below
R210	390			COO 4420HO2
R210 † R211		20	0.25	629 A430 H02
R210 † R211 R212	1 K Pot.	20 5	0.25	184A763H29
R210 † R211 R212 R213	1 K Pot. 1,200		0.5	184A763H29 187A643H45
R210 † R211 R212	1 K Pot.	5	0.5	184A763H29

[†] R211 - 10K - above 50kHz - S#187A641H51 22K - 30-50kHz - S#187A641H59

Receiver Section (Cont.)

SYMBOL				
	OHMS ± TOL. %		WATTS	STYLE NUMBER
R217	620	5	0.5	184A763H22
R218	62	5	0.5	187A290H20
R219	10,000	10	0.5	
R220	20,000 5		0.5	187A641H51
R221	300	5	0.5	184A763H58
R222	3,600	5	0.5	184A763H14
R223	620	5	0.5	184 A763 H40
R224	62	5	0.5	184A763H22
R225	10,000	10		187A290H20
R226	20,000	5	0.5	187A641H51
R227	300	5	0.5	184A763H58
R228	3,600	5	0.5	184A763H14
R229	620	5	 	184 A763H40
R230	27	5	0.5	184A763H22
R231	2,000		0.5	187A290H11
R232	1,200	5	0.5	184A763H34
R233	4,700	5	2	185A207H29
R234	5 100		$\begin{bmatrix} & 2 & & \\ & & & & & \end{bmatrix}$	187A642H43
R235	5,100	5	0.5	184A763H44
R236	4,700	10	1	187A644H19
R237		10	1	187A644H43
† R238	170	5	40	1336074
R239		_		See † Note Below
R241	1 K pot.	20	0.25	629A430H02
R242	100	Type 3D102 Ther		185A211H12
T201	100	Type TM-1/4 Sens	sistor	187A685H06
T202	10,000/10,000			714B677G01
T203	10,000/400	Ohms		205C043G01
Y201	25,000/300	Ohms		205C043G03
1201		stal per 328C083		Specify Frequency
SYMBOL	Recei	ver CLI and Output Boo	ırd	
		RATING		STYLE NUMBER
C251 to C253 C255 to C260	0.27 mfd, 200 V.d.c.			188A669H05
C254	0.82 mfd, 200 v.d.c.			
D251-D252	1N457A			188A669H15
D253	1N645A			184A855H07
Z251				837A692H03
Z252	1N3686B (20V.)			185A212H06
2202	1N3688A (24V,)			862A288H01

^{- 22}K, 30-50KHz, S#187A641H59.

ELECTRICAL PARTS LIST Receiver CLI and Output Board (Cont.)

	Receiver CL1 and Outp			STYLE NUMBER
SYMBOL		2.7K, TM-1/		187A685H05
R251	5K, ¼W, pot.			629A430H07
R252				184A763H11
R253	220, ½W.			184A763H35
R254	2.2K, ½W.			184A763H55
R255-R260		15K, ½W.		184A763H36
R256		2.4K, ½W.		184A763H15
R257		$330, \frac{1}{2}W$		184A763H43
R258-R259		4.7K, ½W.		184A763H21
R261		560, ½W.		184A763H29
R262-R265		1.2K, ½W.		184A763H09
R263-R264		180, ½W.		629A531H66
R266		27K, ½W.		
R267-R269		10K, ½W.		629A531H56
R268		6.8K, ½W.		629 A531 H52
R270	82K, ½W.			629A531H78
	150, 3W.			762A679H01
R271	2N4356			849 A441 H02
Q251-Q252	2N3417			848A851H01 849A441H01
Q253 Q254		2N3645		849A4411101
Q204		Power Supp		STYLE NUMBER
SYMBOL	FUNCTION		DESCRIPTION OR RATING	
C1	(+) to () bypass		0.45 mfd. 330 VAC	1723408
C2	A-C grounding		0.5 mfd, 1500 VDC	1877962
	A-C grounding		0.5 mfd, 1500 VDC	1877962
	Filter		1.8 mfd, 800 VDC	14C9400H12 719B135G01
L1	Filter		5.5 mh.	
Q1	Series R	legulator	Type 2N1015C Silicon Transistor	187A342H02_
R1		Series dropping	26.5 ohms, 40W.	04D1299H44
$\frac{R^1}{R^2}$ —— —— —	125V	Series dropping	Same as R1	04D1299H44
	_	Current limiting	500 ohms, 40W.	1268047
		For 48 VDC,	_	_
R1		$\begin{cases} R1 = R2 & 0 \end{cases}$		
R2	- 10 V	R3 = 26.5 ohms	40W.	04D1299H44
R3	To at no		Pin Jack — red	187A332H01
TP1	Test po		Pin Jack – black	187A332H02
TP2	Test po		1N2828B (45V.)	184A854H06
VR1		Regulator	1N3009A (130V.) Zener Diodes	184A617H12
VR2		Protection	1N2813B (15V.)	184A854H11
VR3	Voltage	e Regulator	111/201010 (10 + 5)	

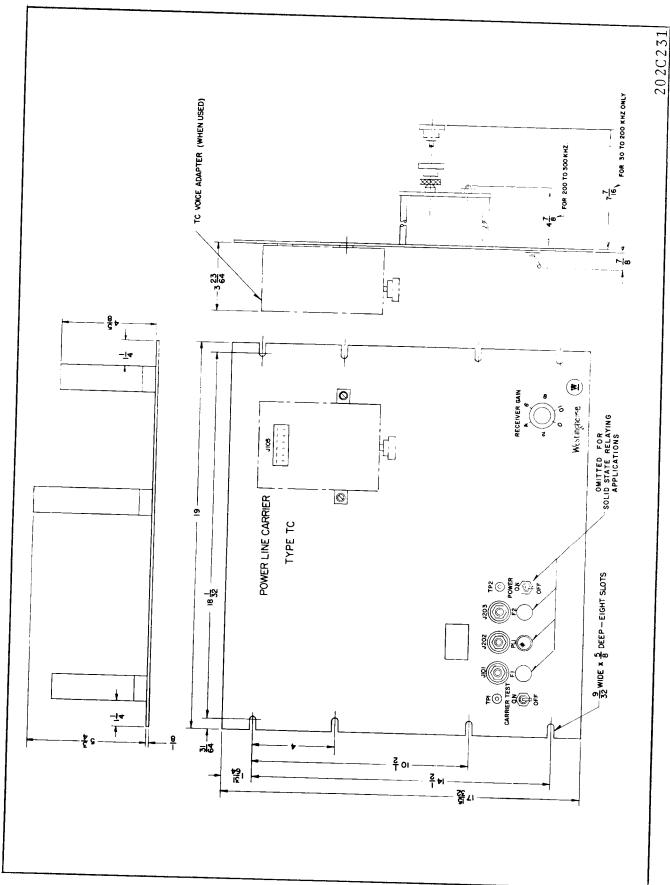
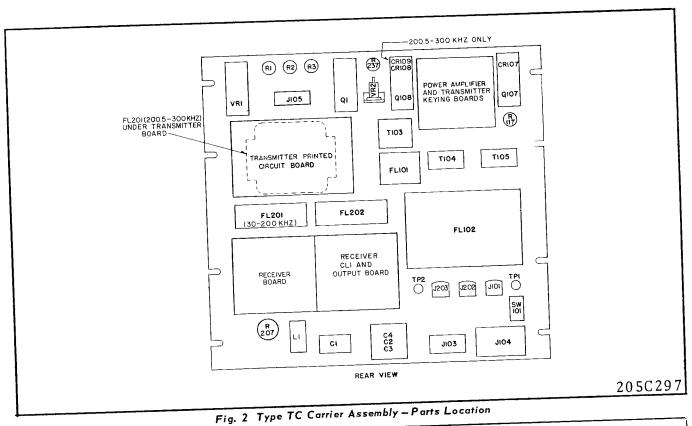


Fig. 1 Type TC Carrier Assembly - Outline



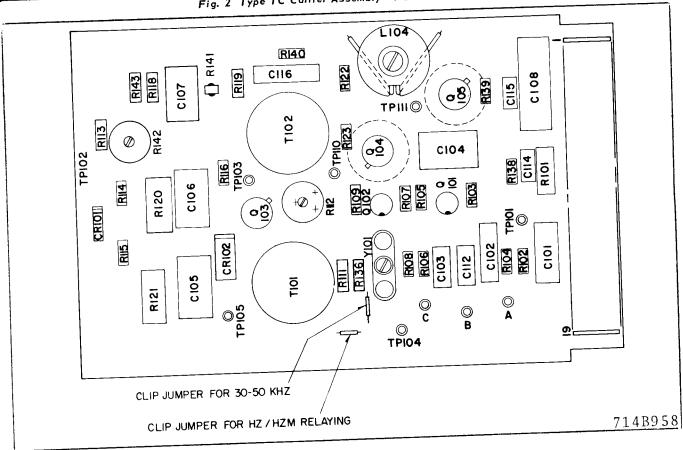


Fig. 3 Transmitter Printed Circuit - Parts Location

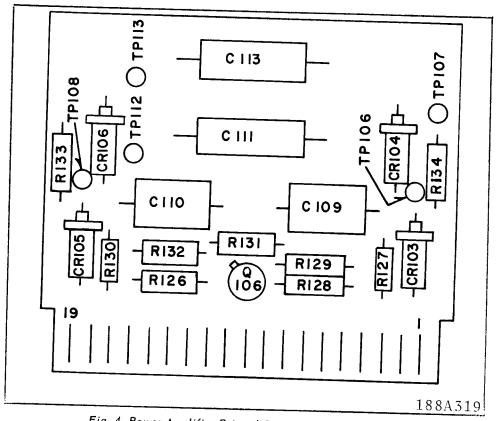


Fig. 4 Power Amplifier Printed Circuit - Parts Location

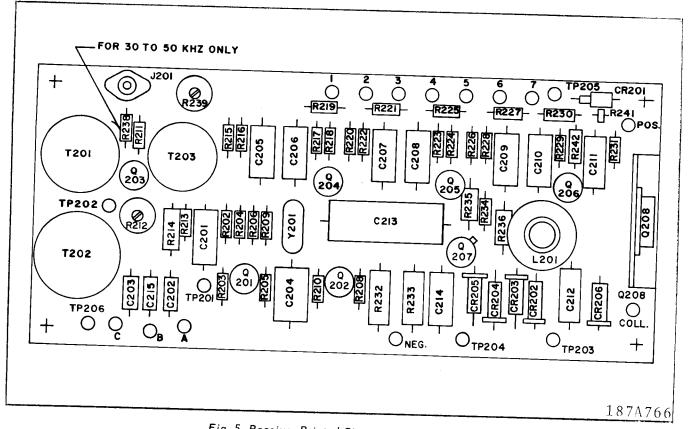


Fig. 5 Receiver Printed Circuit - Parts Location

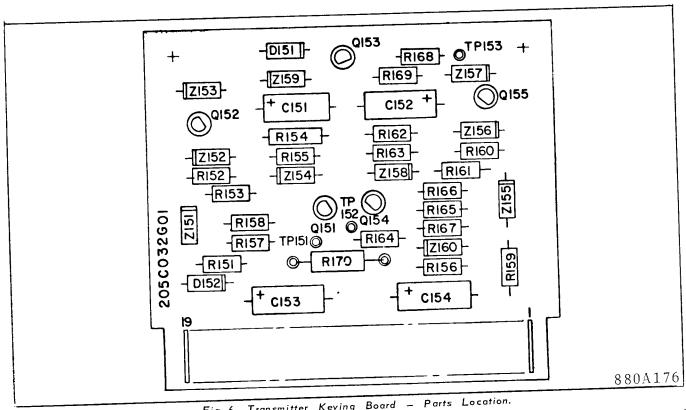


Fig. 6. Transmitter Keying Board - Parts Location.

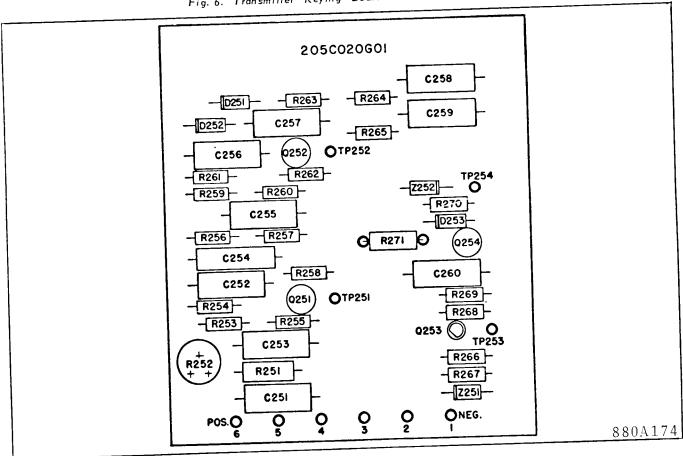


Fig. 7. Receiver CLI and Output Board — Parts Location.

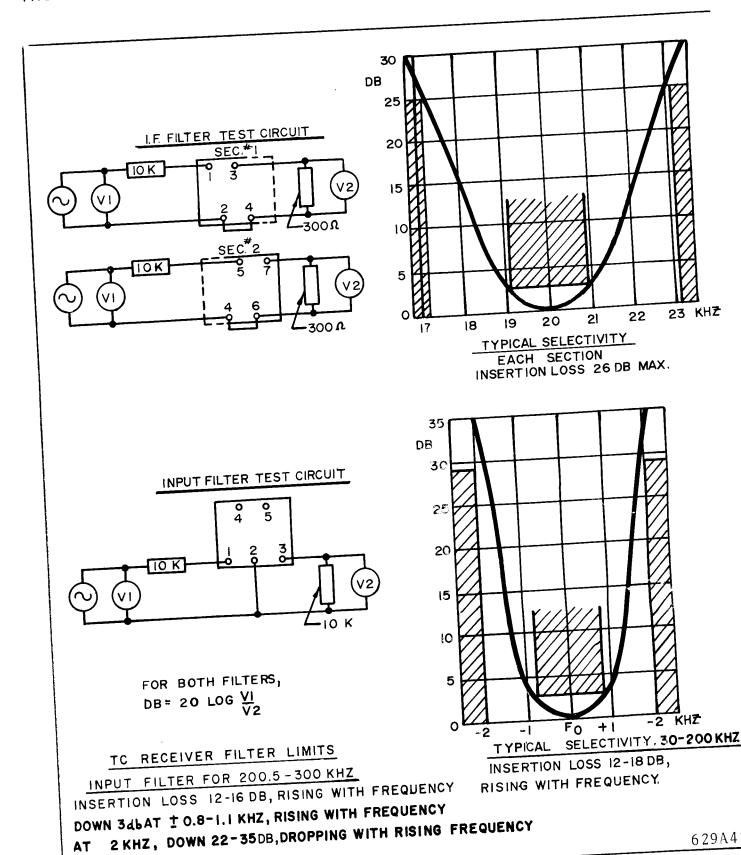
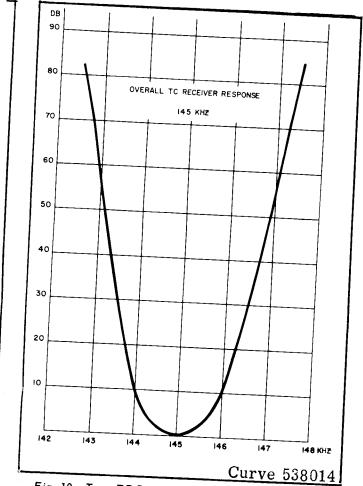


Fig. 9. Type TC Receiver Filter Characteristics



TYPE TC CARRIER RECEIVER SATURATION CURVE 240 200 D.C. OUTPUT MA. 80 40 MV INPUT 80 100 120 140 160 Curve 537965 Fig. 11. Type TC Receiver — 200 ma. Output Characteristic.

Fig. 10. Type TC Receiver Overall Selectivity Curve.

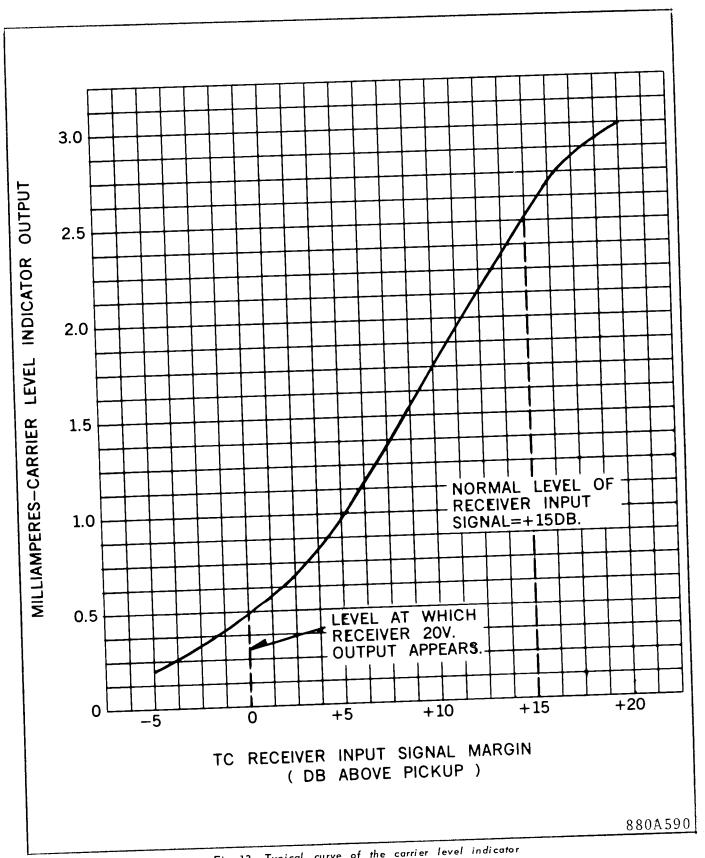


Fig. 12. Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

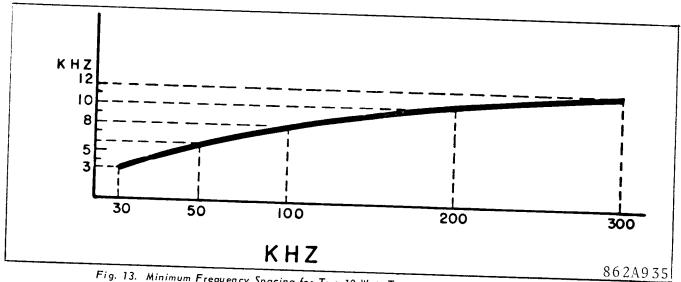


Fig. 13. Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

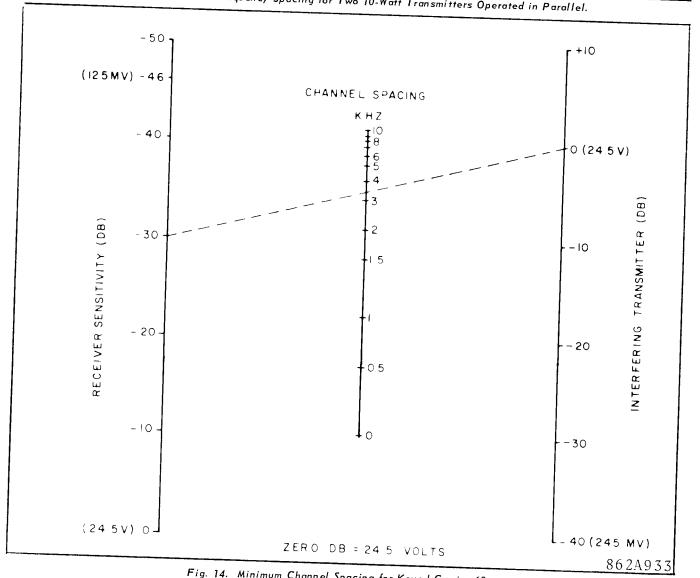


Fig. 14. Minimum Channel Spacing for Keyed Carrier 60 p.p.s.

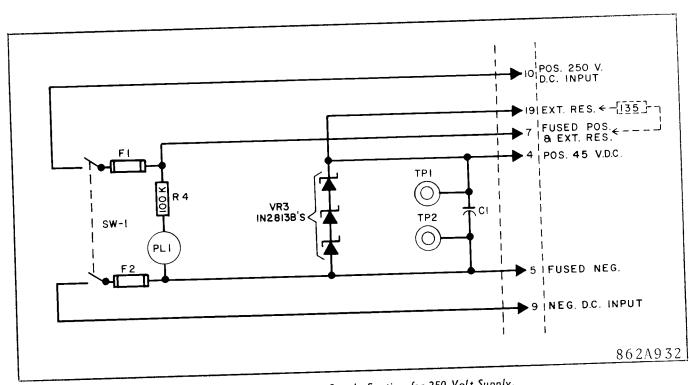


Fig. 15. Detail of Power Supply Section for 250-Volt Supply.

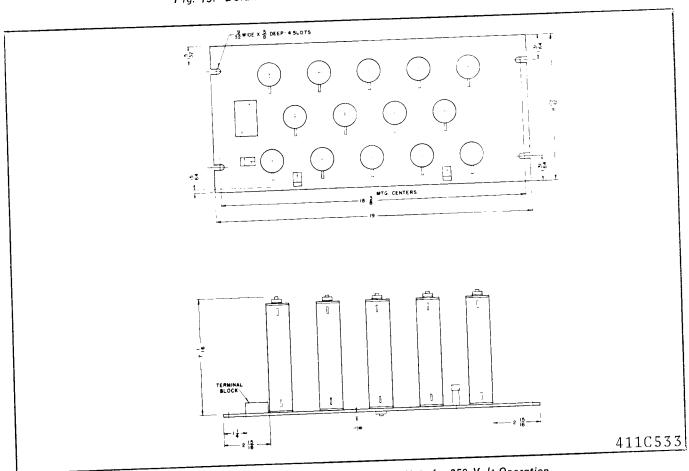


Fig. 16. Outline of External Resistor Unit for 250-Volt Operation.



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



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY FOR USE WITH SOLID-STATE RELAYING SYSTEMS

TIPLE OF CONTENTS	l		LIST OF ILLUSTRATIONS
TABLE OF CONTENTS Pa	ge.	Figure	Page
	2		Type TC Carrier Assembly-Outline 18
Caution		0	Type TC Carrier Assembly - Parts
Application	2	2	Location
Construction	2	_	Transmitter Printed Circuit Board-
Operation	2	3	Parts Location
Transmitter	2		
Receiver	3	4	Power Amplifier Printed Circuit
Power Supply	4		Board - Parts Location 20
Relaying Control Circuits	4		Receiver Printed Circuit Board-
Carrier Control for Other Function	4	5	Parts Location
	4		Parts Location
Characteristics	_	6	Transmitter Keying Board -
Installation	5	U	Parts Location
Adjustments	5		
Adjustments	5	7	Receiver CLI and Output Board—
Transmitter	5		Parts Location 21
Transmitter Filter	5		Type TC Carrier Assembly for
Receiver		8	Galid State Relaying — Internal
Maintenance	6		Schematic23-5
Change of Operating Frequency	7	9	Type TC Receiver Filter
Transmitter	7	9	Characteristics
Receiver	8]	
	10	10	Type TC Receiver Overall
Recommended Test Equipment]	Selectivity Curve
Renewal Parts	10	11	Type TC Receiver - 200-ma.
Electrical Parts List	11	1 11	Output Characteristic
Transmitter	11	ŀ	
Receiver	15	12	Receiver CLI — Output Characteristic
Power Supply	17	1	
7 0 1101 10-12 0		13	Minimum Frequency Spacing
LIST OF TABLES		1	Between Two Type TC Carrier
Table	Page		Sets (Without Hybrids)
D G Mongurements	8	14	Minimum Channel Spacing for
-	9		Keyed Type TC Carrier
II Receiver R-F Measurements		1	(Keyed at 60 p.p.s.)
III Transmitter D-C Measurements		15	Detail of Power Supply
IV Transmitter R-F Measurements	9	1	Section for 250-voit Supply
V Transmitter Keying Board Meas		16	Outline of External Resistor Unit for 250-volt Operation
VI Receiver CLI Board Meas		1	Unit for 250-voil Operation

Power Supply

The power supply circuit for 48 or 125-v.d-c supply uses 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 VR1 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 the transistor Q1 and resistors R1 and R2 $\,$ varies to maintain a constant output voltage of approximately 45-v. d-c. The zener diode VR2 serves to protect the collector-base junction of Q1from 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. Inductance L1 and capacitor C4 serve as a filter to prevent any appreciable carrier-frequency energy from getting onto the external d.c. supply circuits.

For a 250-volt d-c supply, the circuit of Figure 15 is used. This consists of an external voltage-dropping resistor assembly (135 ohms total) in conjunction with three 15-volt Zener diodes on the TC set chassis connected in series. The resistor assembly (see Figure 16) must be mounted at the top of a cabinet or an open rack. Because of the heat dissipated, no transistorized equipment should be mounted above the resistor panel. The 250-volt TC set has a constant current drain of 1.5 amperes d-c.

Relaying Control Circuits

The transmitter start and stop control circuits and the receiver 20-volt output (previously described) allow this type TC set to be used with solid-state protective and auxiliary relays which also have 20-volt input and output 'logic'. In addition, these carrier control circuits are designed to absorb and limit externally generated surges so they will not damage the transistors or associated components.

For flexibility in application, provision is also made for keying the transmitter from either 48 or 125 volts d.c. Also, the 200-ma receiver output circuit is brought out to a J104 terminal for connection to a 30-ohm alarm relay, if desired.

CHARACTERISTICS

Frequency range 30-300 kHz (50-300 kHz for

phase comparison relaying)

Transmitter output 10 watts into 50 to 70-ohm

resistive load

Harmonics 55 db below 10 watts.

Receiver sensitivity 125 mv. input for 180 ma. minimum output current

Receiver selectivity 1500 Hz bandwidth (3 db down);

down 80 db at ±3kHz.

Transmitter-receiver

channel rating

Input Voltage 48, 125, or 250 V. d-c

40 db

Supply voltage

variation 42-56V, 105-140V, 210-280V

Battery Drain: 0.5 amp standby, 1.35 amp

transmitting

125 V.D.C.

0.25 amp. standle

125 V.D.C. 0.25 amp standby, 1.1 amp

transmitting

250 V.D.C. 1.5 amp standby or transmitting
Temperature range -20 to +55°C around chassis

Frequency Spacing

The minimum recommended frequency spacing between two Type TC carrier sets operated in parallel without hybrid units is shown on the curve of Fig. 13. For example, at 100 kHz. the minimum spacing is 8 kHz. Closer spacing would result in the generation of intermodulation products caused by the non-linear load presented by each transmitter to the other one.

The minimum frequency spacing between a TC carrier channel and an adjacent transmitter signal keyed on-off at a rate of 60 pulses per second can be determined from the nomograph of Fig. 14. Using the example shown by the dashed line, consider a type TC set used on a channel with a normal attenuation of 15 decibels. The TC receiver would be set to give a margin of 15 db below the normal received signal, or for a sensitivity of $-30\ db$ (relative to a 24.5 volt, 10-watt signal). The interfering signal is assumed to be a 10-watt transmitter at the same location. To determine the minimum frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the -30 db point on the receiver sensitivity scale and the zero-db point on the interfering transmitter scale. The resulting line crosses the channel spacing scale between 3 and 4 kHz. For this example, a channel spacing of at least 4 kHz should be used. (In order not to conflict with the limits of Fig. 13, an t-f hybrid may be needed between the TC set and the other transmitter, depending on the actual application.)

For protective relaying applications to 3-terminal lines, the transmitter frequencies are offset 100 hertz to prevent a slow beat or cancellation of the received signal when two transmitters send blocking signals to the third terminal. The three transmitters operate

at fc, fc+100 Hz, and fc-100 Hz. All receivers operate at the channel center frequency (fc).

INSTALLATION

The type TC transmitter-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 should not exceed 55°C.

ADJUSTMENTS

Transmitter

The main adjustment on the transmitter is the power output control R112 on the transmitter printed circuit board. Disconnect the coaxial cable from the assembly terminals and replace with a 50 to 70 ohm noninductive 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 T106 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn the transmitter power output control R112 to minimum (full counterclockwise).

Now apply d-c power and note the d-c voltage across the two pin jacks TP1 and TP2. If this is in the range of approximately 42 to 46 volts, throw the carrier-test switch SW101 on the panel to the ON position. Slowly advance the output control R112 on the transmitter printed-circuit board until about 10 volts is obtained across the output 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. For 200-300 kHz operation, L105 is a "pot core" and has a adjustable core screw. Use a screw-driver in this case. No locking device is needed.

Now continue to advance the output control R112 until the output voltage tabulated in the following table is obtained across the load resistor. Recheck the setting of L105 to be sure it is at its maximum point for 10 watts output. Tighten the locking nut. Turn off the carrier test switch SW101, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

 $\frac{\text{NOTE:}}{\text{control}}$ Do not change the adjustment of the R142 control on the printed circuit board. See Maintenance section for R142 adjustment.

T106 Tap	Voltage for 10 Watts Output
50	22.4
60	24.5
70	27.0

Transmitter Filter

Normally, the output filter (FL102) will require no readjustment except as noted under Adjustments-Transmitter, as 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. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection at the factory, 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.

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

Receiver

The receiver board has two controls; the i.f. input control R239 which is usually factory-set at maximum giving a sensitivity of 125 mv. or less for 180 ma. output, and the local oscillator output control R212. The oscillator output is preset at the factory at 0.3 volt. This setting can be checked by connecting an a-c VTVM between receiver test points TP202 and TP206 (shield lead of VTVM). The voltmeter reading with the equipment energized, but not transmitting, should be 0.3 volt. Note Fig. 5 for location of components on the receiver printed board.

The other adjustment on the receiver is the gain control R207 which is front-panel mounted. It is recommended that the receiver gain normally be set for a 15-db operating margin to allow for reasonable variations in receiver input signal level without affecting the output blocking current. This adjustment can be made in two ways, as follows:

1. First, measure the normal received signal from the remote terminal (after the line tuners have been adjusted) by starting the remote transmitter and measuring the voltage across the coaxial cable at the receiving terminal. This signal should preferably be measured with a tuned voltmeter such as the Sierra carrier-frequency voltmeter. If a simple VTVM is used, have the

remote transmitter turned on and off several times to be sure the VTVM reading is actually the remote signal. Note the reading. Now disconnect the coaxial cable, and feed a signal into the carrier assembly at the coaxial terminals from a separate signal generator. Set the signal generator to the received frequency at a level 15 db below the previously measured incoming signal. With a 0-250 ma. (minimum) d-c milliammeter plugged into J203, adjust the receiver gain control until an output current of about 100 ma, is obtained. As this point is on the steep portion of the receiver output-input curve, it may be difficult to set the gain control for exactly 100 ma. This is not necessary, however, as the signal is not normally at this value. This is the operating setting of the receiver gain control. Return the coaxial cable connections to normal.

NOTE: Do not energize the local transmitter when making the foregoing adjustment as the signal generator may be damaged.

2. As an alternate procedure if no signal generator is available, the local transmitter itself may be used as the signal generator. First determine the normal received signal from the remote terminal as explained previously under (1). Then turn off the remote transmitter.

Now turn on the local transmitter and reduce its output to a value 15 db below the normal received signal level. Then adjust the receiver gain control to give 100 ma. output as before. When this adjustment has been made, reset the local transmitter to its normal 10-watt output level.

In applications where the line attenuation is low and a strong signal is received, the adjustment of the receiver gain control R207 becomes critical. For such applications, the setting of i-f gain control R239 may be reduced to lower the overall receiver gain. The front-panel control R207 will then have a smoother and more gradual control as the knob is rotated, making it easier to obtain the 15-db margin setting.

Carrier Level Indicator (CLI)

The CLI should be adjusted on a clear dry day when line conditions are considered normal. After the receiver sensitivity has been set for a 15-db margin, turn on the remote transmitter at its normal 10-watt output. With a small screw-driver, adjust the CLI input control R252 to give a reading of 2.5 ma. on the 0-3 ma. d-c milliammeter in the CLI output circuit. This current can be read at J202 on the TC set panel for convenience. If the received signal varies for any reason, the CLI output current will change accordingly, as indicated by the curve in Fig. 12.

When carrier is transmitted from a given station, the pointer of the local CLI output milliammeter will be driven off scale. This will not in any way damage the instrument as the CLI saturation current is less than 4 ma. d.c.

MAINTENANCE

Periodic checks of the received carrier signal will indicate proper operation of the equipment. 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 and receiver sensitivity 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 and current values are given in Tables I through VI. Voltages should be measured with a VTVM. Readings may vary as much as $\pm\,20\%$.

Adjustment of R142 on Transmitter Board

The small adjustable resistor (pot.) R142 sets the forward base bias on transmitter transistors Q104 and Q105 to the proper point for class-B operation. This is a factory adjustment and need not be changed unless transistors Q104 or Q105 (or both) are replaced. However, if these transsistors are changed, or if the R142 setting is disturbed in error, the following adjustment procedure should be followed to reset R142:

First remove d-c power from the TC carrier set assembly. Unsolder the lead from terminal 2 of transformer T103 (just above FL101) and tem-

porarily connect a low-range d-c milliammeter (0-1.0 or so) between the removed lead (+) and T103 terminal 2 (-). Turn the slotted control on the small pot (R142) to full counterclockwise. Now, apply power to the TC carrier set, but do <u>not</u> transmit carrier. Advance the pot until the d-c milliammeter reads 0.2 mA d.c. \pm .05 mA. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T103. Again apply d-c power and proceed with the transmitter adjustment as described in the ADJUSTMENTS section.

CHANGE OF OPERATING FREQUENCY

The parts required for changing the operating frequency of a type TC carrier set are as follows:

Transmitter

Oscillator Crystal (Y101), specify frequency.
 NOTE: Modify A-B-C jumpers on transmitter board if required for new frequency. See table marked "†" under internal schematic (Fig. 8).

2. R136 Jumper

For operation in 30-50kHz range, clip off R136 as indicated in Fig. 3.

- 3. Capacitors C111 and C113 (on Power Amp. board)
 - a. 30-50 kHz 0.47 mfd. S#188A293H01
 - b. 50.5-75 kHz 0.22 mfd. S#188A293H02
 - c. 75.5-100 kHz 0.15 mfd. S #188A293H03
 - d. 100.5-150 kHz 0.10 mfd. S#188A293H04
 - e. 150.5-300 kHz 0.047 mfd. S # 188A 293H 05

4. FL101 and FL102

Filter FL101 is a small series-resonant tuned circuit between the driver and power amplifier stages of the transmitter. It has just two terminals. Filter FL102 is a larger assembly, described under OPERATION. It has three external connections: input, output, and ground. This filter is mounted by four corner posts. To replace, unsolder the three leads, remove the nuts from the mounting posts, and lift the filter assembly from the posts. The new filter can now be installed.

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 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 32.0-33.5 34.0-36.0 36.5-38.5 39.0-41.0 41.5-44.0 44.5-47.0 47.5-50.0 50.5-53.5	61.0- 64.0 64.5- 68.0 68.5- 72.0 72.5- 76.0 76.5- 80.0 80.5- 84.5 85.0- 89.0 89.5- 94.5	113.0-119.5 120.0-127.0 127.5-135.0 135.5-143.0 143.5-151.0 151.5-159.5 160.0-169.5 170.0-180.0 180.5-191.5	207.1-214.0 214.1-222.0 222.1-230.0 230.1-240.0 240.1-250.0 250.1-262.0 262.1-274.0 274.1-287.0 287.1-300.0
50.5-53.5 54.0-57.0 57.5-60.5	95.0-100.0 100.5-106.0 106.5-112.5	180.5-191.5 192.0-200.0 200.1-207.0	287.1-300.0
27.3-00.5	1 100.0 122.0	•	

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 T103 and the voltmeter across terminals 1 and 2 of transformer T104. The signal generator should be set at the channel center frequency and at 2 at 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 T105 and a 500-ohm resistor and a VTVM to the terminals of protective gap G101. 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.

If the change in frequency is enough to require a different filter, it will come factory adjusted as described in the foregoing paragraph.

After all the tabulated changes have been made for the new frequency, the transmitter can be operated with a 50 to 70-ohm load (depending on which tap of T106 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 ADJUSTMENT section.

If a frequency-sensitive voltmeter is available, the second and third harmonic traps may be adjusted (or checked) 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 its tuning dial and db range switch, obtain a maximum on-scale reading of the second 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. It should be noted that this procedure may not give the true magnitude of the harmonics because of the large value of fundamental frequency voltage present at the tuned voltmeter input terminals. This condition will overload the input circuit of some commercial instruments. However, the procedure is satisfactory for adjusting the traps for maximum harmonic rejection.

If accurate measurement of the harmonic levels is desired, the frequency-selective voltmeter is connected, through a rejection filter, to the terminals of the 60-ohm load resistor. The filter must provide high rejection of the fundamental. A twin-T filter is suitable for this purpose. The insertion losses of this filter at the second and third harmonics must be measured and taken into account.

Receiver

Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.

- 2. Receiver input filter (FL201), specify frequency.
- Resistors R211-R238 Combination
 See values in Fig. 8 below internal schematic.
- 4. Resistors R218 and R224 may have to be reduced. See following paragraph.

The emitter resistors R218 and R224 of the i-f stages are selected during factory test to give the required receiver gain. This is desirable since the insertion loss of the input filter FL201 increases with frequency. If the operating frequency is reduced, the receiver gain will probably be higher. In this case, a reduction in the setting of the i-f input control R239 will give the 125-mv. sensitivity. If the new operating frequency is higher, the receiver gain will be lower. If more than 125 mv. is required to obtain 180 ma. output, the gain can be increased by reducing the value of one or both of the resistors R218 and R224. In most cases, these resistors should fall in the range of 22 to 150ohms. These two resistors are soldered to small terminal posts on the printed circuit board.

TABLE | Receiver D.C. Measurements

Note: All voltages are negative with respect to Pos. $45\,V_{\rm \cdot}\ ({\rm TP206})$

TEST POINT	STANDBY (No Signal)	WITH 125 M V. INPUT	
TP201 TP202 TP203 TP204 TP205	38 0 11 .03 20	38 0 11 2.2 20	
TRANSISTOR	V COLL.	V COLL.	
Q201 Q202 Q203 Q204 Q205 Q206 Q207 Q208	43 43.5 18.7 18.7 18.7 10.5 22.0	43 43.5 18.7 18.7 18.7 10.5 4.0	

All voltages read with d-c vacuum-tube voltmeter.

TABLE II

Receiver RF Measurements

Note: Taken with 36 kHz and 132 kHz receiver filters, 0.125 volt input signal, and gain control R207 at maximum. Depending on receiver frequency and transistor characteristics, the following values will vary appreciably.

	TYPICAL A-C VOLTAGES		
TEST POINT	36 kHz.	132 kHz.	
FL201-IN to Gnd. FL201-OUT to Gnd. Q203 - E to TP206 Q204 - C to TP206 Q205 - B to TP206 Q205 - C to TP206 Q206 - B to TP206 Q206 - C to TP206	.075 .051 .105 .90 .11 6.7 .67	.050 .020 .090 .52 .052 3.4 .37 1.53	

All voltages read with a-c vacuum-tube voltmeter.

TABLE III
Transmitter D-C Measurements

Note: All voltages are positive with respect to Neg. $45\,\mathrm{V}.$ (TP104). All voltages read with d.c. VTVM.

TEST POINT	CARRIER OFF	CARRIER ON	
TP101 TP102 TP103 TP105 TP106 TP107 TP108 TP110 TP111 TP112 TP113 J101 (Front Panel)	7 volts d.c. 0 0 44 44 45 <1.0 <1.0 0 45 5 ma. max.	7 volts d.c. 20 19.5 9 22 22.2 44.8 < 1.0 < 1.0 0 45 0.6 amp.	

TRANSISTOR	V COLL.	V coll.
0101	2,5	2.5
Q101	1.2	1.1
Q102	0	9.0
Q103	45	45
Q104	45	45
Q105		1,2
Q106	44	0
Q107	0	22.3
Q108	44.7	44.5

TABLE IV
Transmitter RF Measurements

Note: "Carrier-on" voltages taken with transmitter set to 10 watts output (24.5 volts across 60 ohms). These voltages subject to variation, depending on frequency and transistor characteristics.

TEST POINT	A-C VOLTAGE	
T101-3 to TP104	1.1 volts, rms.	
TP103 to TP102	0.2	
TP105 to TP104	0.7	
TP110 to T102-4	0.2	
TP111 to T102-4	0.2	
Q104-C to TP104	4.3	
Q105-C to TP104	4.3	
T103-4 to Gnd.	1.5	
T104-1 to Gnd.	1.4	
Q107-B to TP107	.5 volts, rms.	
Q108-B to TP113	.5	
Q107-C to TP107	14.5	
Q108-C to TP113	14.5	
T105-4 to Gnd.	105	
T106-2 to Gnd.	155 *	
TP109 to Gnd. J102 to Gnd.	50 * 24.5	

Note: T101-3 = tap 3 of Transformer T101

Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

*These values may vary considerably with frequency.

TABLE V

Transmitter Keying Board D.C Voltages

TEST POINT	NORMAL (Carrier Off)	CARRIER ON (D.C. on J104-6 or 7)	CARRIER STOP (D.C. on J104-6 or 7 and J104-8 or 9)
TP151	16 v.d.c.	<1.0 v.d.c.	<1.0 v.d.c.
Term. 17	<1.0	24.6	4.9
TP152	16	16	<1.0
TP153	<1.0	<1.0	16
Term. 1	0 *	20	<1.0

^{*} May show $<_{1.0}$ volt with VTVM

TABLE VI

Receiver CL1 and Output Board (with normal received signal)

TEST POINT	D.C VOLTAGE - TO NEG.	SIGNAL VOLTAGE (a.c.)
TP-251	4.9 v.d.c.	0.3 v. rms.
TP-252	9.8	2.9
TP-253	< 1.0	<u> </u>
TP-254	19.7	

Recommended Test Equipment

- I. Minimum Test Equipment for Installation
 - a. Milliammeter 0-250 ma. DC
 - b. 60-ohm 10-watt non-inductive resistor.
 - c. A-C Vacuum Tube Voltmeter (VTVM). Voltage range 0.01 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance—one megohm, minimum.
 - d. D-C Vacuum Tube Voltmeter (VTVM).

Voltage Range:

0.1 to 300 volts

Imput Impedance:

1.0 megohm, min.

- II. Desirable Test Equipment for Apparatus Maintenance.
 - a. All items listed in I.
 - b. Signal Generator

Output Voltage:

up to 10 volts r.m.s.

Frequency Range:

20 to 330 kHz

- c. Oscilloscope
- d. Ohmmeter
- e. Capacitor checker
- f. Frequency counter
- g. Frequency-selective voltmeter

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.

Transmitter Section

	RATING	STYLE NUMBER
SYMBOL	0.1 mfd, 200 V. DC	187A624H01
C 10 1	.005 mfd, 300 V. DC	187A694H29
C10 2	180 pf. 500 V. DC	187A695H29
C 103		187 A 624 H 0 2
C 104	0.25 mfd, 200 V. DC	187A624H02
C 105	0.25 mfd, 200 V. DC	187A624H02
C 10 6	0.25 mfd, 200 V. DC	187A624H02
C107	0.25 mfd, 200 V. DC	187 A624 H03
C 108	0.50 mfd, 200 V. DC	187 A624H0 2
C 109	0.25 mfd, 200 V.DC	187 A 624 H0 2
C110	0.25 mfd, 200 V. DC	-
† C111	(See Table Below)	187 A 695 H 12
C112	39 pfd, 500 V. DC	
† C113	(See Table Below)	187 A695H23
C114	100 pf., 500 V. DC	
C115	100 pf., 500 V. DC	187 A 695 H 23
C116	0.001 mfd, 500 V. DC	187A694H11
CA	Part of FL 101	Vary with Frequency
CB, CC, CD, CE	Part of FL 102	Vary with Frequency
	1N3686B (20 V ± 5%)	185A212H06
CR 101	1N457 A	184A855H07
CR102	1N538	407С703Н03
CR103	1N91	182A881H04
CR104	1N538	407С703Н03
CR105	1 N9 1	182A881H04
CR 106	1N2999 A (56 V ± 10%)	184A617H13
CR107-108	1N 29 99 A (56 V ± 10%)	184A617H13
CR109 #	Type RVS Arrester	637 A0 26 A0 1
G10 1	Closed Circuit Jack	187 A 60 6H0 1
Ј 10 1	Closed Circuit Jack	

#200.5 - 300 kHz only.

00.5 - 300 kHz only.	D. TING	STYLE NUMBER
FREQ.(C111,C113)	RATING	188A293H01
30 - 50 kHz	0.47 mfd, 400 V. DC	
	0.22 mfd, 400 V. DC	188A293H02
50.5-75 kHz		188A293H03
75.5-100 kHz	0.15 mfd, 400 V. DC	188A293H04
	0.1 mfd, 400 V. DC	
100.5-150 kHz	0.047 mfd, 400 V. DC	188A293H05
150.5-200 kHz	U.047 inta, 100 7. 20	

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

SYMBOL	RATING			STYLE NUMBER
J102	Banana P	lug Jack		54B159H02
J103	Coaxial C	Cable Jack		187 A 633 H 0 1
J104	24-Term I	Receptacle		187A669H01
J105	12-Term I	Receptacle		629 A 20 5 H 0 2
L 101	Part of F	L101		Vary with Frequency
L102	FL102 Tr	ap Coil (2nd Harmo	nic)	
L103		ap Coil (3rd Harmor		Vary with Frequency Vary with Frequency
L104	400 mh.			29 2B 09 6G 0 1
L 105	FL102 Co circuit tur	il (part of series-re	sonant freq.)	Vary with Frequency
Q101	2N 274			187A270H01
Q102	2N 27 4			187A270H01
Q103	2N5 25		·	
Q104	2N657			184 A 638 H 13
Q105	2N657			184A638H15
Q106	TI-481			184A638H15
Q107	2N1908	Matched Pair	Texas Instrument	184A638H11
Q108	2N1908	Co Identif. G		187A673H02
SYMBOL	OHMS			
R101	5,600	± TOL. %	WATTS	STYLE NUMBER
R 10 2	2, 200	10	1	187A643H45
R103	10,000	10	0.5	187A641H35
R104	100,000		0.5	187 A 64 1H 5 1
R 105	390		0.5	187A763H75
R 10 6	1,200	5	0.5	184A763H17
R107		5	0.5	184 A763H 29
	10,000	10	0.5	184A641H51
R 108	100,000	5	0.5	184A763H75
R109	390	5	0.5	184A763H17
R111	1,200	5	0.5	187 A763H 29
R112	1 K Pot	20	0.25	629A430H02
R113	4,700	5	0.5	184A763H43
R114	10,000	10	0.5	187A641H51
R115	150	5	0.5	184 A7 63 H 07

Transmitter Section (Cont.)

	OHMS	± TOL. %	WATTS	STYLE NUMBER	
SYMBOL		5	0.5	184 A7 63 H03	
R116	100	5	25	1202588	
R117	1,000	2	0.5	629A531H58	
R118	12,000	2	0.5	629A531H03	
R1 19	62	5	2	185A207H51	
R120	10,000	5	2	187A683H01	
R121	10		0.5	187 А290Н01	
R122	10		0.5	187A290H01	
R123	10	10	1	187A644H03	
R124	100	10	0.5	187A641H27	
R125	1,000	10	1	187A644H43	
R126	4,700	10	0.5	187A640H01	
R127	10		1	187A644H35	
R128	2,200		0.5	184 A636H14	
R129	2.7	10	0.5	187A640H01	
R130	10	10		187A644H43	
R131	4,700	5	1	184 A636H14	
R132	2.7	10	0.5	184A636H14	
R133	0.27	10		184A636H18	
R134	0.27	10		188A317H01	
R135	3,000	10	5	629 A 53 1 H 58	
R136	12,000	2	0.5	187A642H55	
R137	15,000	10		187A641H27	
R138	1,000	10	0.5	187A641H27	
R139	1,000	10	0.5	629A531H04	
R140	68	2	0.5	185A211H06	
R 141	30	Type 3D202		584C276H23	
R142	25K pot.	20	0.25		
R143	20,000	2	0.5	629A531H63 STYLE NUMBER	
SYMBOL		RATING		205C043G01	
T101	10,	10,000/400 ohms			
T102	10,	10,000/400 c.t.			
	193	1930/60 ohms L633000			
T103		Turns ratio, 1/0.5 Pri./each sec.			
T104	10.	10/500 ohms			
T105		0/50 - 60 - 70 ohms		292B526G03	
T106	30-300 kHz crystal per 328C083			Specify Frequenc	

Transmitter Keying Board

SYMBOL	RATING	STYLE NUMBER
C151-C152	.047 mfd., 200 V.	849A437H04
C153	25 mfd., 125 V.	184A637H01
C 154	47 mfd., 50 V.	8 63 A5 30 HO 1
D151	1N457A	184A855H07
D152	1N4818	
Q151 to Q155	2N3417	188 A34 2H0 6
R 151 - R159	47K, ½ W.	848A851H02
R152-R153-R160-R161	4.7K, ½ W.	629A531H72
R154 - R162	82K, ½ W.	629 A53 1H48
R155-R158-R163-R166-R169	10K, ½ W.	629 A5 31H 78
R156-R164-R167	6.8K, ½ W.	629A531H56
R 157-R165-R168	27K, ½ W.	629A531H52
R170	700, 5 W.	629 A53 1H66 763 A129H04
Z151-Z152-Z155-Z156	7151 7150 7155 7150	
Z153-Z157	7157	
Z154-Z158	1N3686A (20V)	185A212H06
Z159	1N957B (6.8V)	185A797H06
Z160	1N748A (3.9V)	185A797H13
	1N5357B (20 V)	862A288H02
C20 1	Receiver Section	
C202	0.1 mfd., 200 V. DC	187 A 624 H 0 1
	300 pf. 500 V. DC	187A695H35
C203	180 pf. 500 V. DC	187A695H29
	0.25 mfd. 200 V. DC	187A624H02
C205	0.25 MFD. 200 V. DC	187A624H02
C206	0.25 mfd., 200 V. DC	187A624H02
C207	0.25 mfd., 200 V. DC	187A624H02
C208	0.25 mfd., 200 V. DC	187A624H02
C209	0.25 mfd., 200 V. DC	187A624H02
2210	0.25 mfd., 200 V. DC	187A624H02
2211	0.1 mfd., 200 V. DC	187A624H01
2212	0.25 mfd., 200 V. DC	
2213	2.0 mfd., 200 V. DC	187A624H02
214	0.25 mfd., 200 V. DC	187A624H05
215	39 pfd., 500 V. DC	187A624H02
R201	1N30 27B (20V ± 5%)	187A695H12
R202	1N91	184А449Н07
R203		182A881H04
	1 N9 1	182A881H04

Receiver Section (cont.)

		RATING		STYLE NUMBER
SYMBOL	4375.00			407C703H03
CR204	1N538			407C703H03
CR205	1N1789 (56 V. ±10%)			484C434H08
CR206				Specify Frequency
FL201		input Filter 30-300 kH		187A590G02
FL202		i.f. Filter-20kHz (2 s		187A638H01
J201		Coax. Input Jack		187A606H01
J202		rcuit Jack (CLI)		187A606H01
J203	Closed C	ircuit Jack (200MA)		187A599H01
L201	33 mh.			187A270H01
Q201	2N274			187A270H01
Q202	2N274			187A270H01
Q203	2N274			187A270H01
Q204	2N 274			187A270H01
Q205	2N 274			187А270Н01
Q206	2N274			184A638H12
Q207	2N398A			187A673H01
Q208	2N1362			
Q 200	RATING			STYLE NUMBER
SYMBOL	OHMS	± TOL. %	WATTS	187A641H51
R201	10,000	10	0.5	187A641H35
R202	2,200	10	0.5	187A641H51
R202 R203	10,000	10	0.5	184A763H75
	100,000	5	0.5	
R204	390	5	0.5	184A763H17
R205	1,200	5	0.5	184A763H29
R206	25 K Pot.	10	2	185A086H07
R207	10,000	10	0.5	187A641H51
R208	100,000	5	0.5	184 A 7 63 H 75
R209	390	5	0.5	184A763H17
R210		_		See † Note Belov
† R211	1 K Pot.	20	0.25	629 A430H02
R212	1,200	5	0.5	184A763H29
R213	1,200		1	187A643H45
R214	3,000		0.5	184A763H58
R215	20,000	5	0.5	184A763H40
R216	3,600	J		

[†] R211 – 10K - above 50kHz - S#187A641H51 22K - 30-50kHz - S#187A641H59

Receiver Section (Cont.)

SYMBOL	RATING			
	OHMS	±TOL. %	WATTS	STYLE NUMBE
R217	620	5	0.5	184A763H22
R218	62	5	0.5	187A290H20
R219	10,000	10	0.5	
R220	20,000	5	0.5	187A641H51
R221	300	5	0.5	184A763H58
R222	3,600	5	0.5	184A763H14
R223	620	5	0.5	184 A763 H40
R224	62	5	0.5	184A763H22
R225	10,000	10	0.5	187A290H20
R226	20,000	5	0.5	187A641H51
R227	300	5	0.5	184A763H58
R228	3,600	5	0.5	184A763H14
R229	620	5	0.5	184 A763H40
R230	27	5	0.5	184A763H22
R231	2,000	2 000		187A290H11
R232	1,200	5	0.5	184A763H34
R233	4,700	10	2	185A207H29
R234	5,100	5	$\frac{2}{2}$	187A642H43
R235	470	10	0.5	184A763H44
R236	4,700	 	1	187A644H19
R237	170	10	1	187A644H43
† R238		5 40		1336074
R239	1 K pot.	20	-	See † Note Below
R241	100	20	0.25	629A430H02
R242	100	Type 02102 The mistor		185A211H12
T201	-590 TM /4 Densistor		187A685H06	
T202	10,000/10,000 10,000/400	Ohms		714B677G01
T203		Ohms		205C043G01
Y201	25,000/300 Ohms 50-320kHz Crystal per 328C083		205C043G03	
				Specify Frequency
SYMBOL	Kecei	ver CLI and Output Boo	ard	
		RATING		STYLE NUMBER
C251 to C253 C255 to C260	0.27 mfd, 200 V.d.c.			188A669H05
C254	0.82 mfd, 200 v.d.c.			100 4 2 2 2 7 7 7
D251-D252	1N457A			188A669H15
D253	1N645A			184A855H07
Z251	1N3686B (20V.)			837A692H03
Z252				185A212H06
38- omit - above 50k	1N3688A (24V,)			862A288H01

[†] R238- omit - above 50kHz

^{- 22}K, 30-50KHz, S#187A641H59.

ELECTRICAL PARTS LIST Receiver CLI and Output Board (Cont.)

		Receiver CLI and Outp		STYLE NUMBER
SYMBOL				187A685H05
R251		2.7K, TM-1/4 Sensistor 5K, 1/4W. pot.		
R252			01.	184A763H11
R253		220, ½W		184A763H35
R254		2.2K, ½W.		184A763H55
R255-R260		15K, ½W.		184A763H36
R256		2.4K, ½W.		184A763H15
R257		330, ½W.		184A763H43
R258-R259		4.7K, ½W.		184A763H21
R261		560, ½W.		184A763H29
R262-R265		1.2K, ½W.		184A763H09
R263-R264		180, ½W		629A531H66
R266		27K, ½W.		629A531H56
R267-R269		10K, ½W.		
	6.8K, ½W.			629 A531H52
R268	82K, ½W.			629A531H78 762A679H01
R270		150, 3W.		
R271		2N4356		
Q251-Q252		2N3417		
Q253		2N3645		849A441H01
Q254		Power Supp		STYLE NUMBER
SYMBOL		FUNCTION	DESCRIPTION OR RATING	
C1	(+) to (-) bypass	0.45 mfd. 330 VAC	1723408
	A-C grou		0.5 mfd, 1500 VDC	1877962
<u>C2</u>	A-C grounding		0.5 mfd, 1500 VDC	1877962
<u>C3</u>	Filter		1.8 mfd, 800 VDC	14C9400H12
<u>C4</u> 	Filter		5.5 mh.	719B135G01
Q1	Series Regulator		Type 2N1015C Silicon Transistor	187A342H02
		Series dropping	26.5 ohms, 40W.	04D1299H44
R1	125V	Series dropping	Same as R1	04D1299H44
<u>R2</u>	-	Current limiting	500 ohms, 40W.	1268047
R3		For 48 VDC,	_	_
R1	4037	R1 = R2 0		
R2	48V	R3 = 26.5 ohms	40W.	04D1299H44
R3			Pin Jack - red	187A332H01
TP1	Test point (+)		Pin Jack - black	187A332H02
TP2	Test point (-)		1N2828B (45V.)	184A854H06
VR1	Voltage Regulator		1N3009A (130V.) Zener Diodes	184A617H12
VR2	Surge Protection		1N2813B (15V.)	184A854H11
VR3	Voltage Regulator		1N2013D (10 v.)	

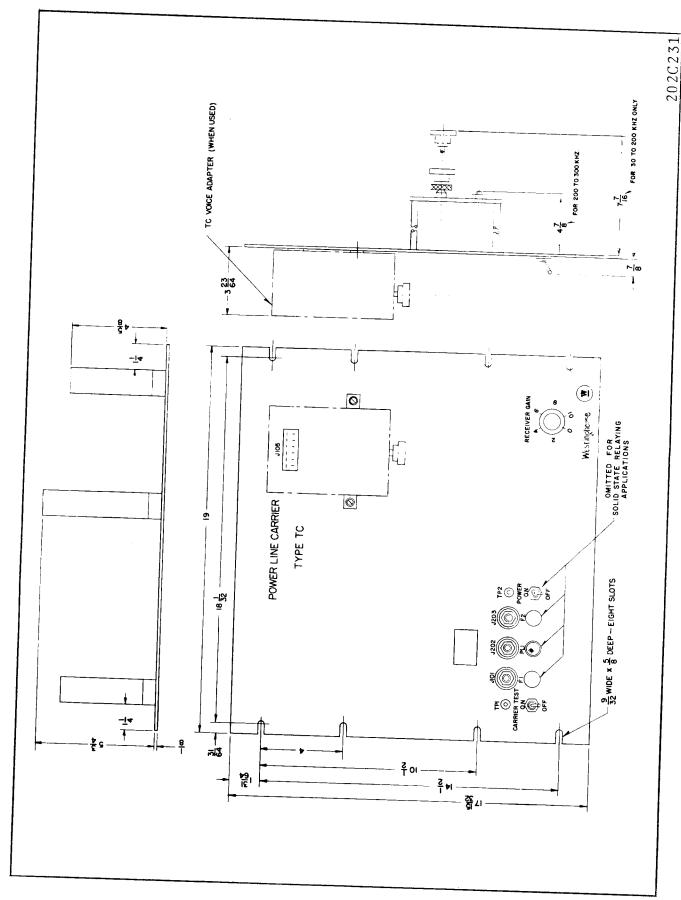
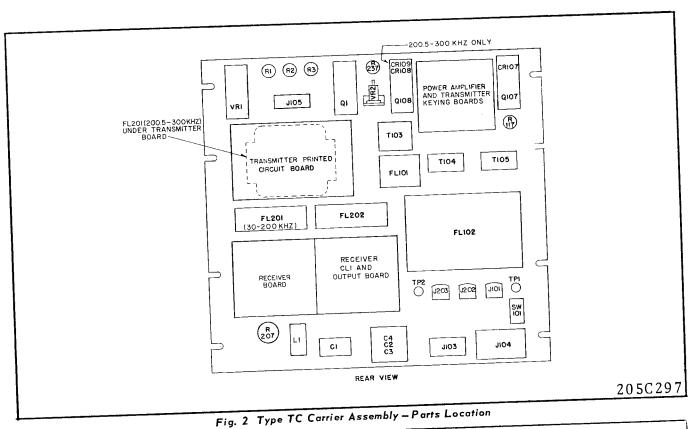


Fig. 1 Type TC Carrier Assembly - Outline



L104 **RI40** R14 R122 RII9 **C116** R143 RI39 CIIS C107 <u>08</u> TPIII O T102 Ø **CI04 TP102** RI38 C114 R101 RII6 TP103 RII4 9010 RI 20 CRIO RIIS CR102 500 RIO4 CII2 503 RIII C105 힏 R121 © © 0 © TPI05 **◎ B** © TPI04 o l CLIP JUMPER FOR 30-50 KHZ CLIP JUMPER FOR HZ / HZM RELAYING 714B9<u>58</u>

Fig. 3 Transmitter Printed Circuit - Parts Location

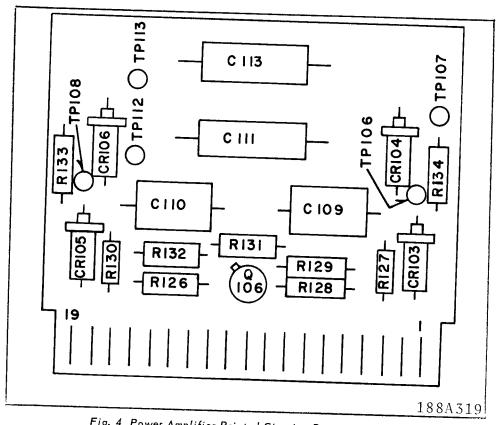


Fig. 4 Power Amplifier Printed Circuit - Parts Location

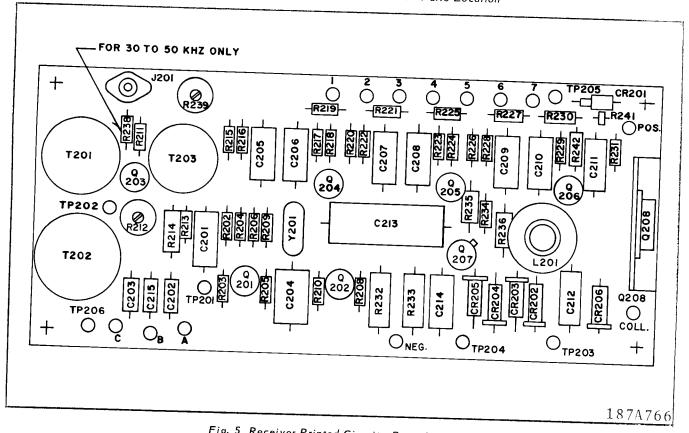
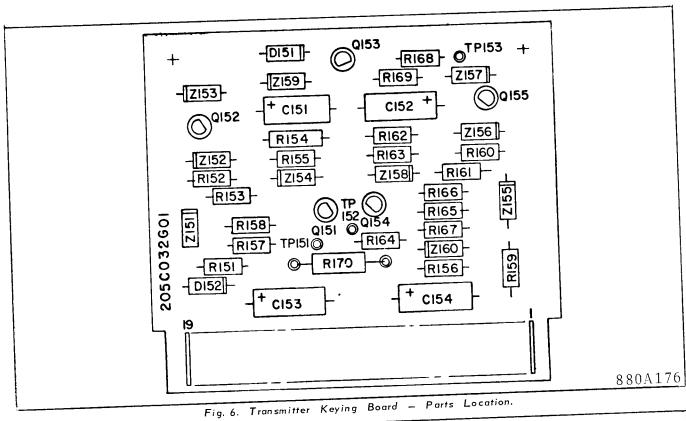


Fig. 5 Receiver Printed Circuit - Parts Location



205C020G0I C258 - R264 - D251 - R263 C259 D252 C257 -R265 **OTP252** (0252) C256 - R262 R261 --[R260]--[R259]-R270 C255 D253 -R257 R256 R271 C254 R258 C260 C252 - R269 **OTP25**1 (Q251 R254 R268 - R255 R253 C253 - R266 R251 -R267 Z251 C251 ONEG. Q POS.O 880A174

Fig. 7. Receiver CLI and Output Board — Parts Location.

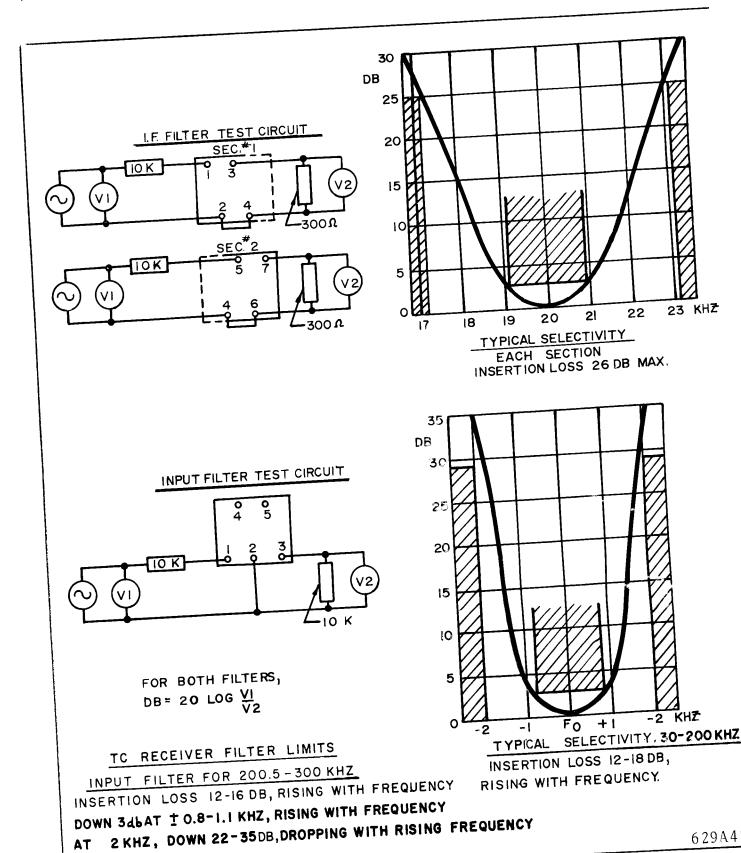
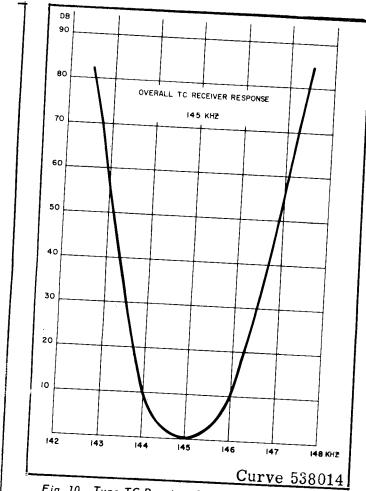


Fig. 9. Type TC Receiver Filter Characteristics



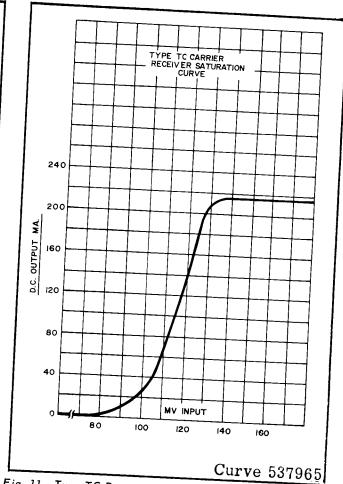


Fig. 10. Type TC Receiver Overall Selectivity Curve.

Fig. 11. Type TC Receiver - 200 ma. Output Characteristic.

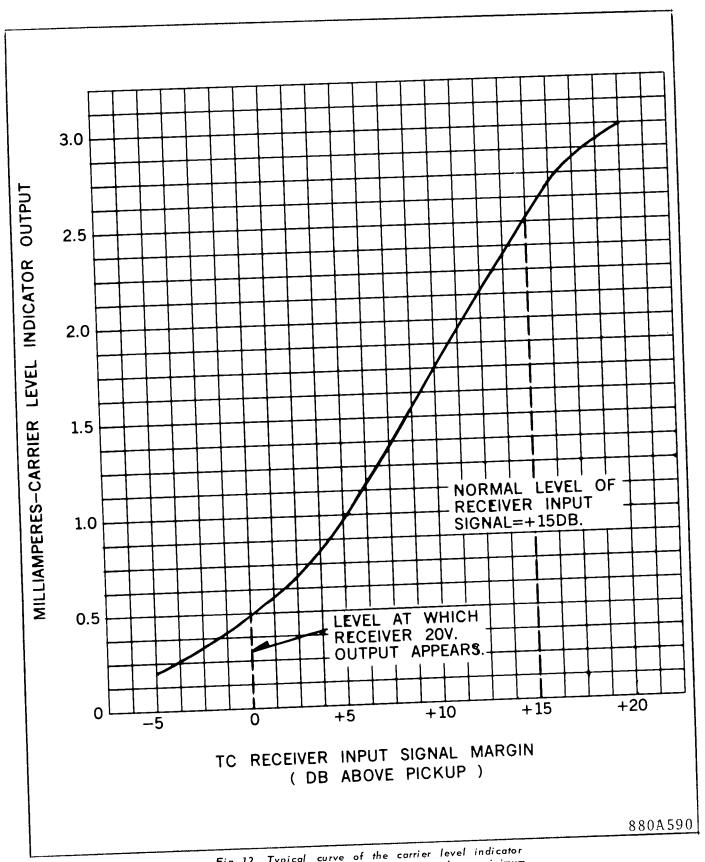


Fig. 12. Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

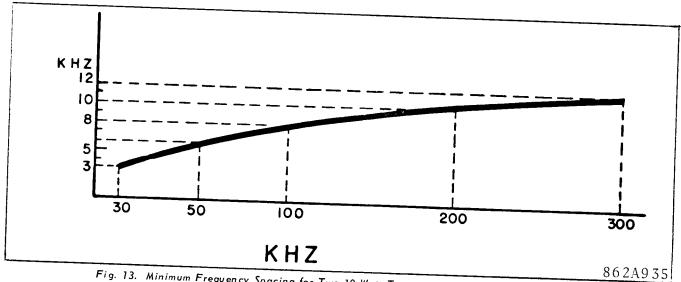


Fig. 13. Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

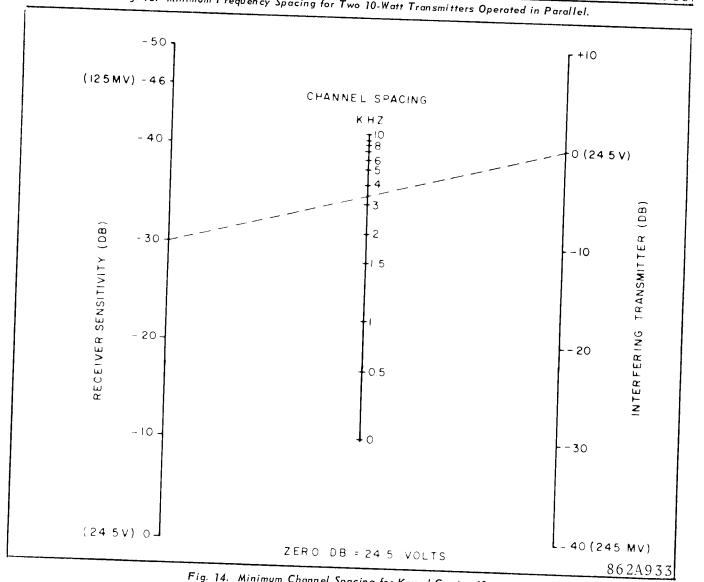


Fig. 14. Minimum Channel Spacing for Keyed Carrier 60 p.p.s.

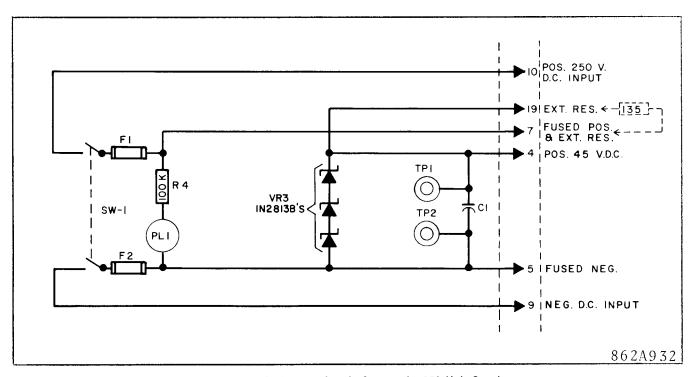


Fig. 15. Detail of Power Supply Section for 250-Volt Supply.

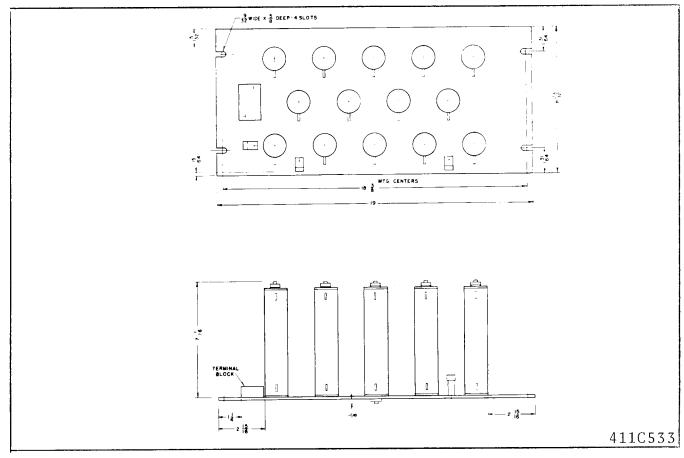


Fig. 16. Outline of External Resistor Unit for 250-Volt Operation.



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