INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

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✪Denotes change from superseded issue.

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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 ✪ 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, C_B, and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap 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 C_E 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 <u>all</u> applications, an alarm relay or equivalant resistive load (30-35 ohms, 3 watt) <u>must</u> 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 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	40 db
Input Voltage	48, 125, or 250 V. d-c
Supply voltage variation	42-56V, 105-140V, 210-280V
Battery Drain: 48 V.D.C.	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 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 ±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 transistors 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. ± .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".

NOTE: Only power amplifier module styles 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 D104 and 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)
   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#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	
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

1. Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
2. Receiver input filter (FL201), specify frequency.
3. 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	35-38	35-38
TP202	0	0
TP203	11-12	11-12
TP204	< 0.5	2- 3
TP205	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.	.07
FL201-OUT to Gnd.	.04
Q203 - E to TP206	.10
Q204 - C to TP206	.09
Q205 - B to TP206	.013
Q205 - C to TP206	1.2
Q206 - B to TP206	.15
Q206 - C to TP206	2.5
TP202 to TP206	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	CARRIER OFF	CARRIER ON
TP101	8.5 volts d.c.	8.5 volts d.c.
TP102	<0.5	20
TP103	<0.5	19.5
TP105	<0.5	9
TP106	44	24
TP107	44	24
TP108	45	44
TP110	<1.0	< 1.0
TP111	<1.0	< 1.0
TP112	0	<0.5
TP113	45	44
J101 (Front Panel)	5 ma. max.	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	1.5 volts, rms.
TP103 to TP102	0.2
TP105 to TP104	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

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)

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.

ELECTRICAL PARTS LIST

Transmitter Section

SYMBOL	RATING	STYLE NUMBER
C201	0.1 mfd, 200 V.DC	187A624H01
C102	.005 mfd, 300 V.DC	187A694H29
C103	180 pf. 500 V.DC	187A695H29
C104	0.25 mfd, 200 V.DC	187A624H02
C105	0.25 mfd, 200 V.DC	187A624H02
C106	0.25 mfd, 200 V.DC	187A624H02
C107	0.25 mfd, 200 V.DC	187A624H02
C108	0.50 mfd, 200 V.DC	187A624H03
C109	0.25 mfd, 200 V.DC	187A624H02
C110	0.25 mfd, 200 V.DC	187A624H02
† C111	(See Table Below)	–
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
✪ D104	1N4818	188A342H06
D105	1N4818	188A342H06
✪ D106	1N4818	188A342H06
G101	Type RVS Arrester	637A026A01
J101	Closed Circuit Jack	187A606H01

#200.5 – 300 kHz only.

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

ELECTRICAL PARTS LIST

Transmitter Section (Cont.)

SYMBOL	RATING	STYLE NUMBER
J102	Banana Plug Jack	2 of 185A431H01
J103	Coaxial Cable Jack	187A633H01
J104	24-Term Receptacle	187A669H01
J105	12-Term Receptacle	629A205H02
L101	Part of FL101	Vary with Frequency
L102	FL102 Trap Coil (2nd Harmonic)	Vary with Frequency
L103	FL102 Trap Coil (3rd Harmonic)	Vary with Frequency
L104	400 mh.	292B096G01
L105	FL102 Coil (part of series-resonant circuit tuned to fundamental freq.)	Vary with Frequency
✪ L106	2.0 mh.	3500A27H01
Q101	2N2905A	762A672H10
Q102	2N2905A	762A672H10
Q103	2N525	184A638H13
Q104	2N3712	762A672H07
Q105	2N3712	762A672H07
Q106	TI-481	184A638H11
✪ Q107	2N3792 Matched Pair	187A673H16
Q108	2N3792	187A673H16

SYMBOL	OHMS	± TOL. %	WATTS	STYLE NUMBER
R101	5,600	5	1	187A643H45
R102	2,200	10	0.5	187A641H35
R103	10,000	10	0.5	187A641H51
R104	100,000	5	0.5	187A763H75
R105	390	5	0.5	184A763H17
R106	1,200	5	0.5	184A763H29
R107	10,000	10	0.5	184A641H51
R108	100,000	5	0.5	184A763H75
R109	390	5	0.5	184A763H17
R111	1,200	5	0.5	187A763H29
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	184A763H07

ELECTRICAL PARTS LIST

Transmitter Section (Cont.)

SYMBOL	OHMS	± TOL. %	WATTS	STYLE NUMBER
R116	100	5	0.5	184A763H03
R117	1,000	5	25	1202588
R118	10,000	2	0.5	629A531H56
R119	62	2	0.5	629A531H03
R120	10,000	5	2	185A207H51
R121	10	5	2	187A683H01
R122	10	5	0.5	187A290H01
R123	10	10	0.5	187A290H01
R124	100	10	1	187A644H03
R125	1,000	10	0.5	187A641H27
R126	4,700	10	1	187A644H43
R127	10	10	0.5	187A640H01
R128	2,200	5	1	187A644H35
R129	2.7	10	0.5	184A636H14
R130	10	10	0.5	187A640H01
R131	4,700	5	1	187A644H43
R132	2.7	10	0.5	184A636H14
R133	0.27	10	1	184A636H18
R134	0.27	10	1	184A636H18
R135	3,000	10	5	188A317H01
R136	12,000	2	0.5	629A531H58
R137	15,000	10	2	187A642H55
R138	1,000	10	0.5	187A641H27
R139	1,000	10	0.5	187A641H27
R140	68	2	0.5	629A531H04
R141	30	Type 3D202 Thermistor		185A211H06
R142	25K pot.	20	0.125	629A430H13
R143	20,000	2	0.5	629A531H63

SYMBOL	RATING	STYLE NUMBER
SW101	Carrier Test Switch	880A357H01
T101	10,000/400 ohms	205C043G01
T102	10,000/400 c.t.	714B666G01
T103	1930/60 ohms L633000	1962694
T104	Turns ratio, 1/0.5 Pri./each sec.	292B526G01
T105	10/500 ohms	292B526G02
T106	500/50 - 60 - 70 ohms	292B526G03
Y101	30-300 kHz crystal per 328C083	Specify Frequency
Z101	1N5357B (20 V ±5%)	862A288H03
Z102	1N2999B (56 V ±5%)	629A798H04
Z103	1N2999B (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.	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	1N3686B (20V)	185A212H06
Z154-Z158	1N957B (6.8V)	185A797H06
Z159	1N748A (3.9V)	185A797H13
Z160	1N5357B (20V)	862A288H02
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	187A624H02
C215	39 pfd., 500 V. DC	187A695H12
D201	1N457A	184A855H07
D202	1N457A	184A855H07
D203	1N4818	188A342H06
D204	1N4818	188A342H06

ELECTRICAL PARTS LIST

Receiver Section (cont.)

SYMBOL	RATING	STYLE NUMBER
FL201	Receiver Input Filter 30-300 kHz	Specify Frequency
FL202	Receiver i.f. Filter - 20kHz (2 sections)	187A590G02
J201	Receiver Coax, Input Jack	187A638H01
J202	Closed Circuit Jack (CLI)	187A606H01
J203	Closed Circuit Jack (200MA)	187A606H01
L201	33 mh.	187A599H02
Q201	2N2905A	762A672H10
Q202	2N2905A	762A672H10
Q203	2N2905A	762A672H10
Q204	2N2905A	762A672H10
Q205	2N2905A	762A672H10
Q206	2N2905A	762A672H10
Q207	2N3645	849A441H01
Q208	2N4903	187A673H13

SYMBOL	RATING			STYLE NUMBER
	OHMS	± 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	185A086H07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H17
R210	390	5	0.5	184A763H17
† R211	—	—	—	See † Note Below
R212	1 K pot.	20	0.25	629A430H02
R213	1,200	5	0.5	184A763H29
R214	5,600	5	1	187A643H45
R215	20,000	5	0.5	184A763H58
R216	3,600	5	0.5	184A763H40

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

ELECTRICAL PARTS LIST

Receiver Section (Cont.)

SYMBOL	RATING			STYLE NUMBER
	OHMS	± TOL. %	WATTS	
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	184A763H40
R229	620	5	0.5	184A763H22
R230	10	5	0.5	187A290H01
R231	2,000	5	0.5	184A763H34
R232	1,200	5	2	185A207H29
R233	4,700	10	2	187A642H43
R234	5,100	5	0.5	184A763H44
✪ R235	1.5K	5	0.5	184A763H21
R236	4,700	10	1	187A644H43
R237	170	5	40	1336074
† R238	—	—	—	See † Note Below
R239	1 K pot.	20	0.25	629A430H02
R240	50	Sensistor	0.25	187A685H08
R241	100	Type 3D102 Thermistor		185A211H12
R242	100	Type TM-¼ Sensistor		187A685H06
✪ R280	56	5	0.5	187A290H19
T201	10,000/10,000 Ohms			714B677G01
T202	10,000/400 Ohms			205C043G01
T203	25,000/300 Ohms			205C043G03
Y201	50-320kHz Crystal per 328C083			Specify Frequency
Z201	1N3027B (20V. ±5%)			184A449H07
Z202	1N1789 (56V. ±10%)			584C434H08

Receiver CLI and Output Board

SYMBOL	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.	188A669H15
D251-D252	1N457A	184A855H07
D253	1N645A	837A692H03
Z251	1N3686B (20V.)	185A212H06
Z252	1N3688A (24V.)	862A288H01

† R238 - omit - above 50kHz
- 22K, 30-50kHz, S#187A641H59.

ELECTRICAL PARTS LIST

Receiver CLI and Output Board (Cont.)

SYMBOL	RATING	STYLE NUMBER
R251	2.7K, TM-¼ Sensistor	187A685H05
R252	5K, ¼W. pot.	629A430H07
R253	220, ½W.	184A763H11
R254	2.2K, ½W.	184A763H35
R255-R260	15K, ½W.	184A763H55
R256	2.4K, ½W.	184A763H36
R257	330, TM-¼ Sensistor	187A685H07
R258-R259	4.7K, ½W.	184A763H43
R261	560, ½W.	184A763H21
R262-R265	1.2K, ½W.	184A763H29
R263-R264	180, ½W.	184A763H09
R266	27K, ½W.	629A531H66
R267-R269	10K, ½W.	629A531H56
R268	6.8K, ½W.	629A531H52
R270	82K, ½W.	629A531H78
R271	150, 3W.	762A679H01
Q251-Q252	2N4356	849A441H02
✪ Q253	2N3417	848A851H02
Q254	2N3645	849A441H01

Power Supply Section

SYMBOL	FUNCTION		DESCRIPTION OR RATING	STYLE NUMBER
C1	(+) to (−) bypass		0.45 mfd. 330 VAC	1723408
C2	A-C grounding		0.5 mfd, 1500 VDC	1877962
C3	A-C grounding		0.5 mfd, 1500 VDC	1877962
C4	Filter		1.8 mfd, 800 VDC	14C9400H12
L1	Filter		5.5 mh.	719B135G01
✪ Q1	Series Regulator		2N6259	3503A41H01
R1	125V	Series dropping	26.5 ohms, 40W.	04D1299H44
R2	125V	Series dropping	Same as R1	04D1299H44
R3	125V	Current limiting	500 ohms, 40W.	1268047
R1	48V	For 48 VDC, R1 = R2 0	—	—
R2	48V	For 48 VDC, R1 = R2 0	—	—
R3	48V	R3 = 26.5 ohms	40W.	04D1299H44
TP1	Test point (+)		Pin Jack — red	187A332H01
TP2	Test point (−)		Pin Jack — black	187A332H02
Z1	Voltage Regulator		1N2828B (45V.)	184A854H06
Z2	Surge Protection		1N3009A (130V.) Zener Diodes	184A617H12
Z3	Voltage Reg. — for 250 V.D.C.		1N2813B (15V.)	184A854H11

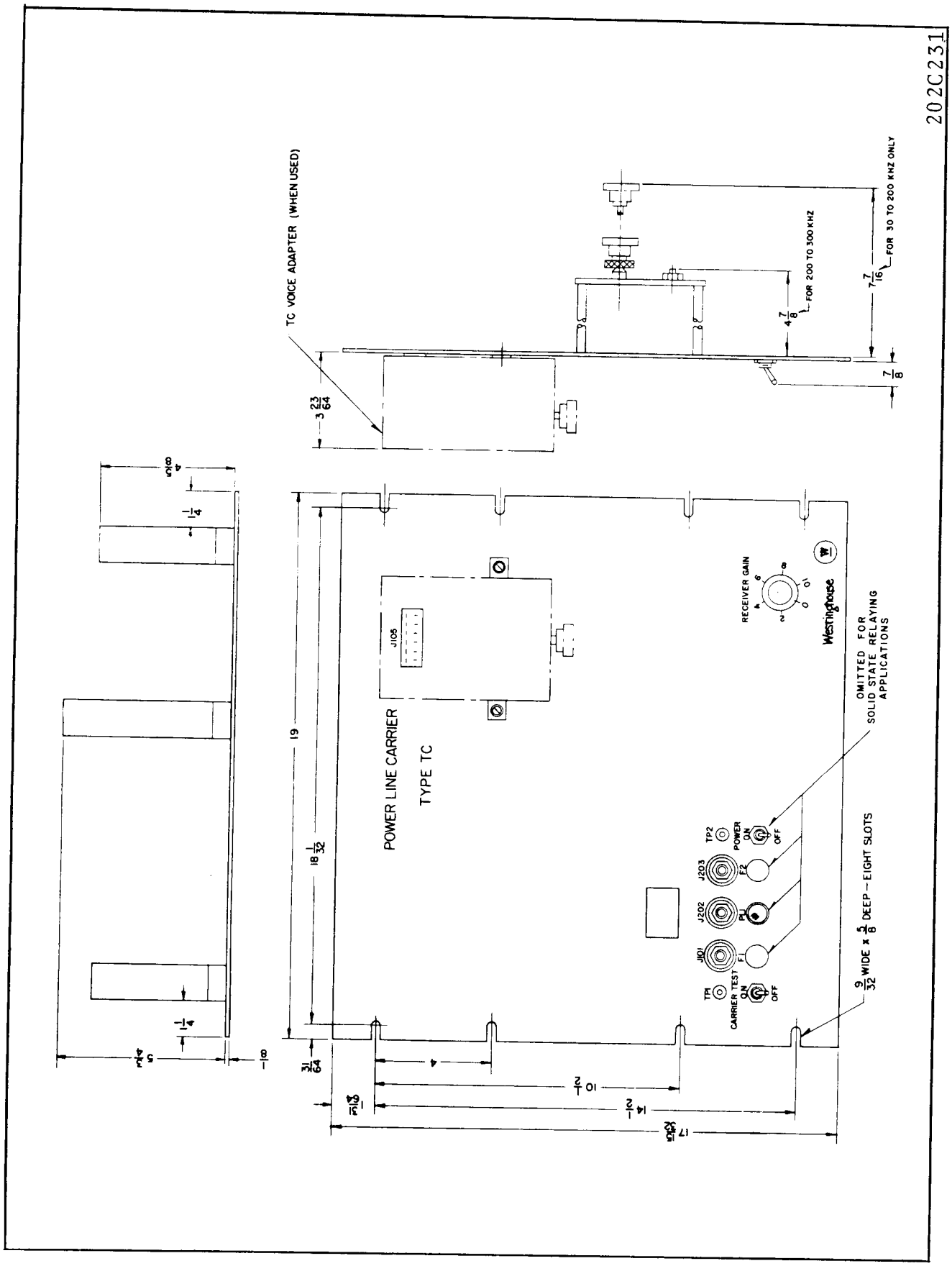


Fig. 1 Type TC Carrier Assembly – Outline

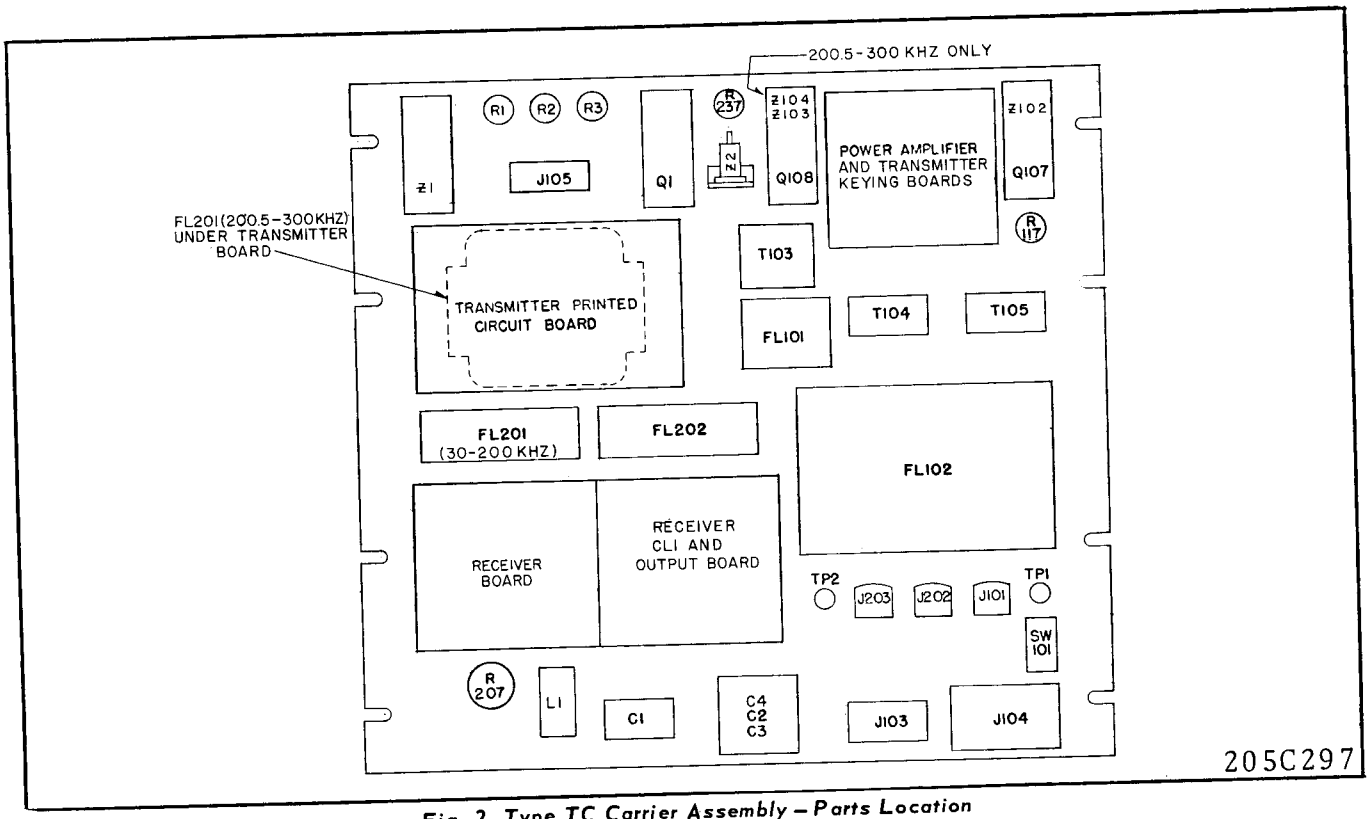


Fig. 2 Type TC Carrier Assembly – Parts Location

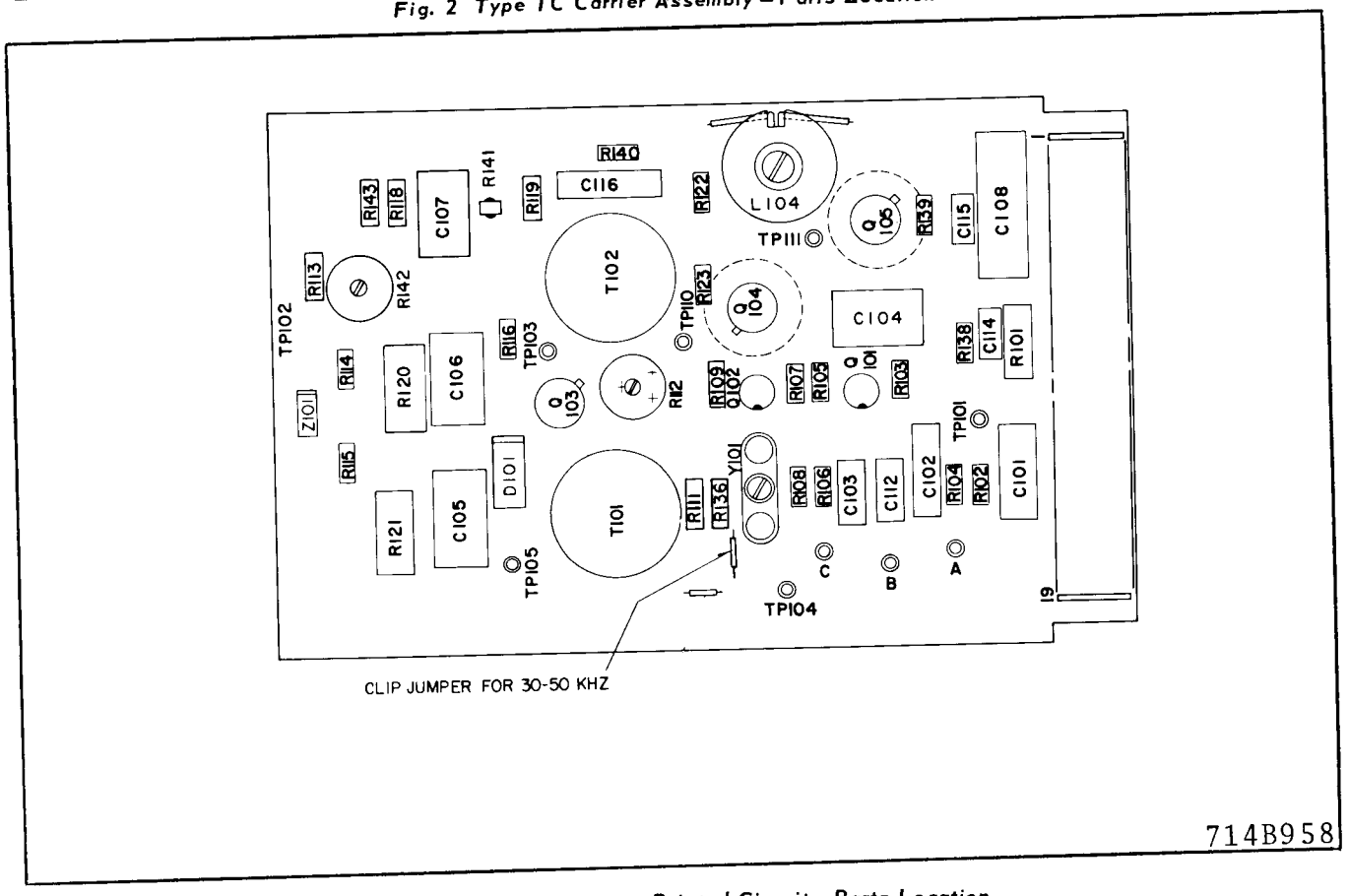
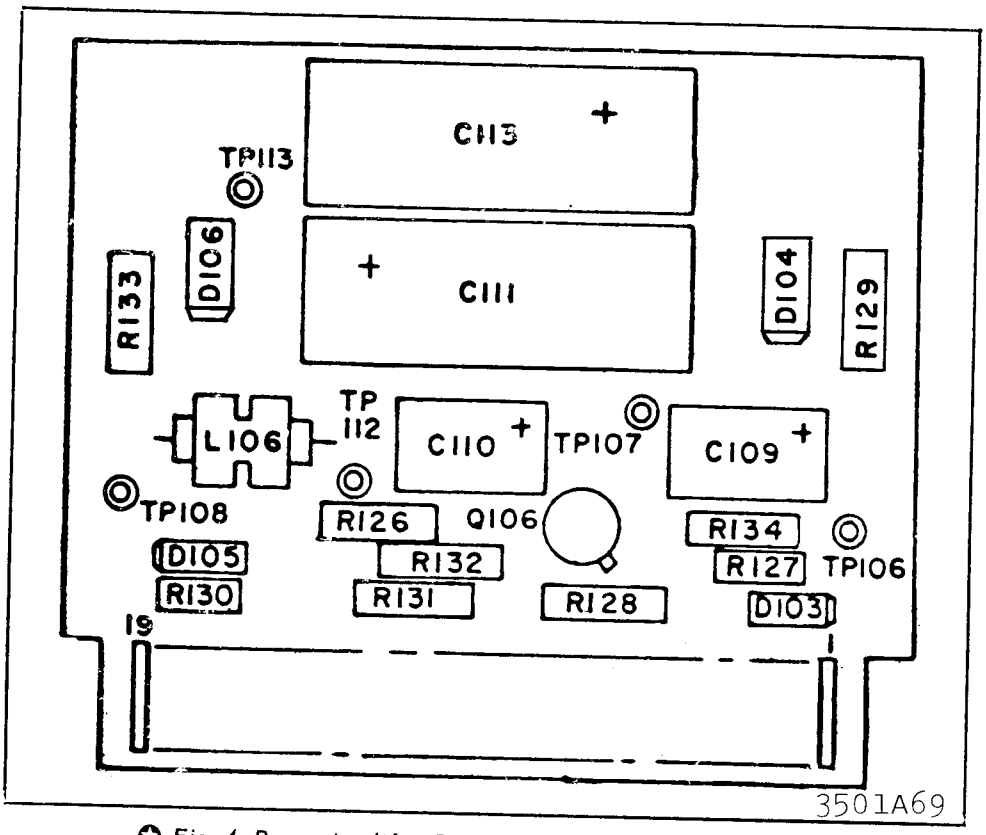
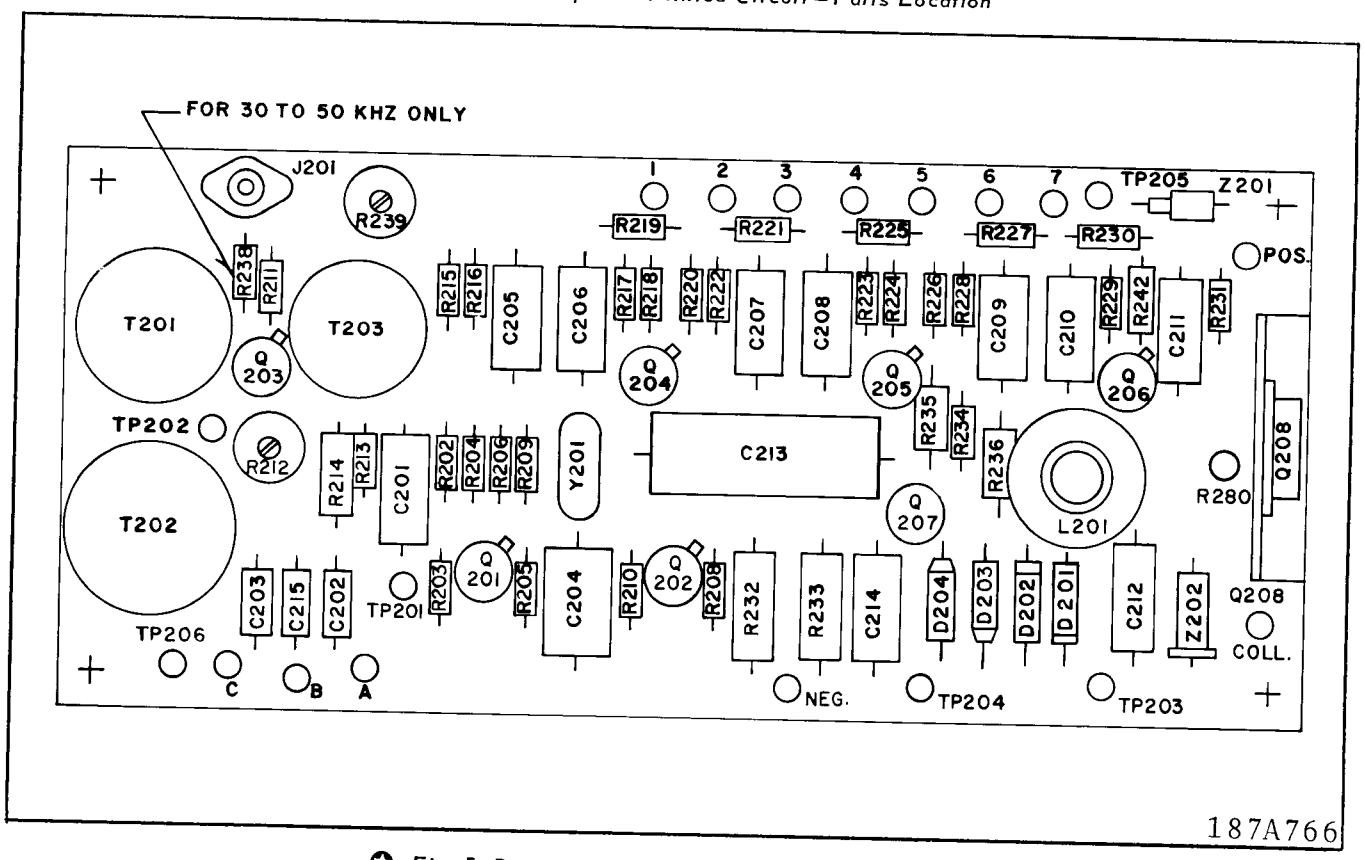


Fig. 3 Transmitter Printed Circuit – Parts Location



✪ *Fig. 4 Power Amplifier Printed Circuit – Parts Location*



✪ *Fig. 5 Receiver Printed Circuit – Parts Location*

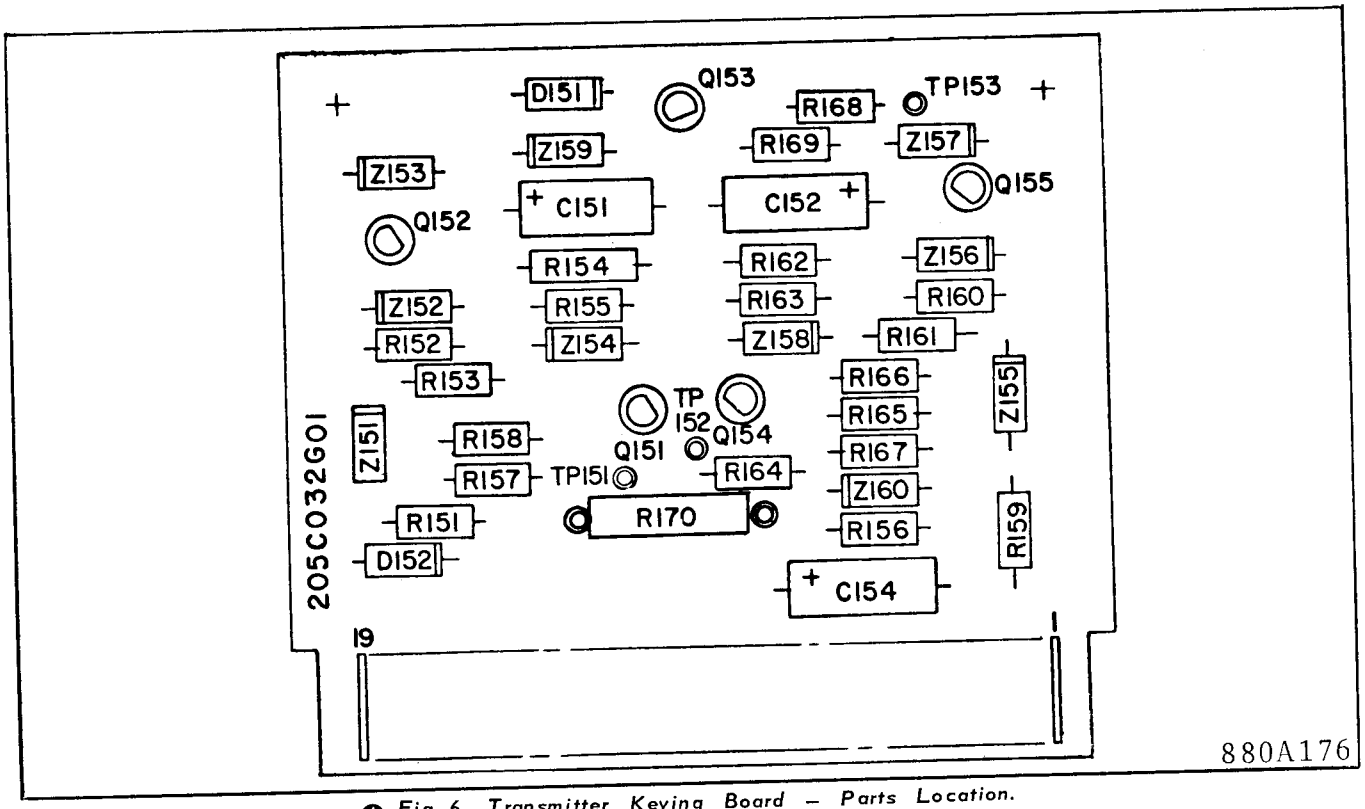


Fig. 6. Transmitter Keying Board – Parts Location.

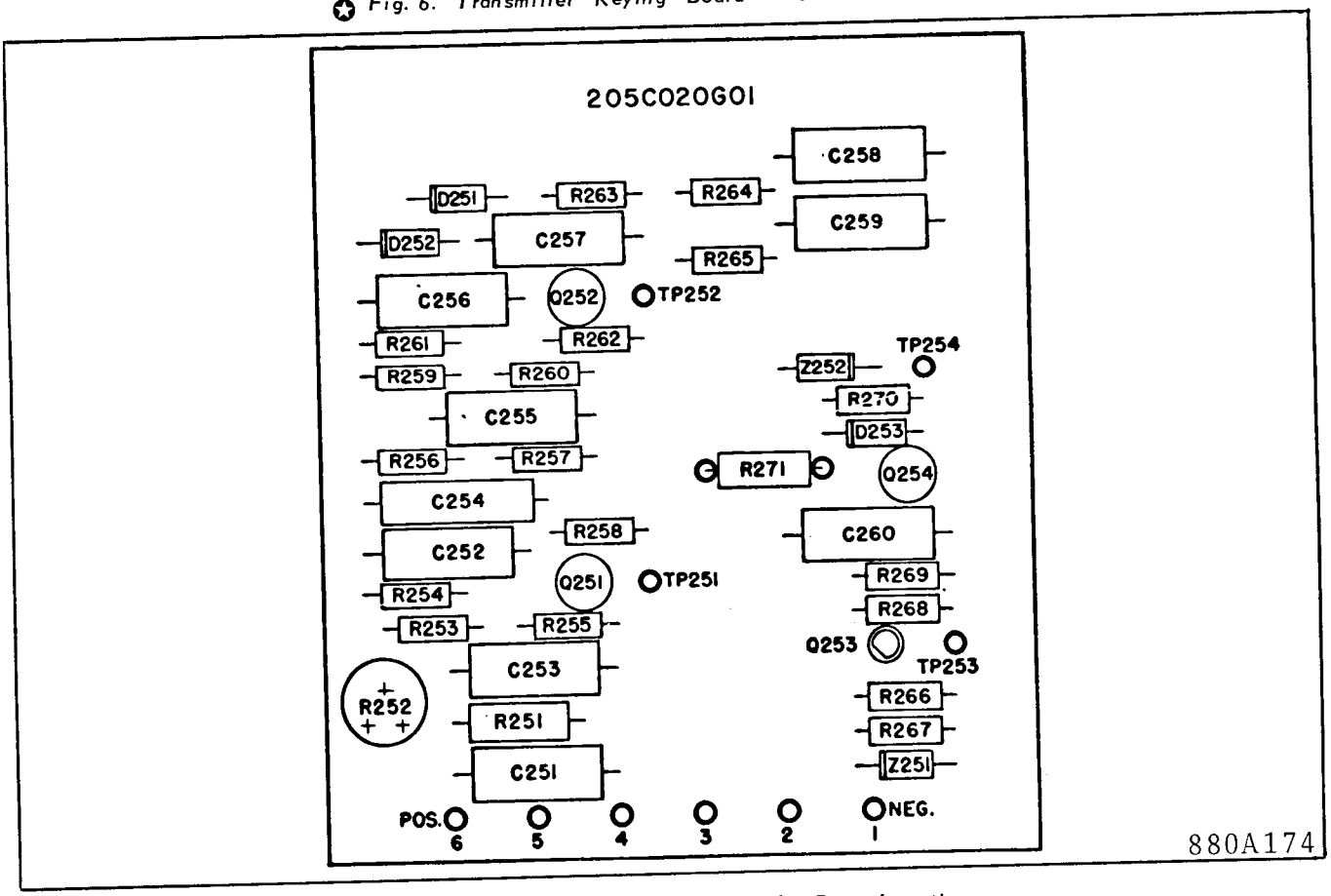
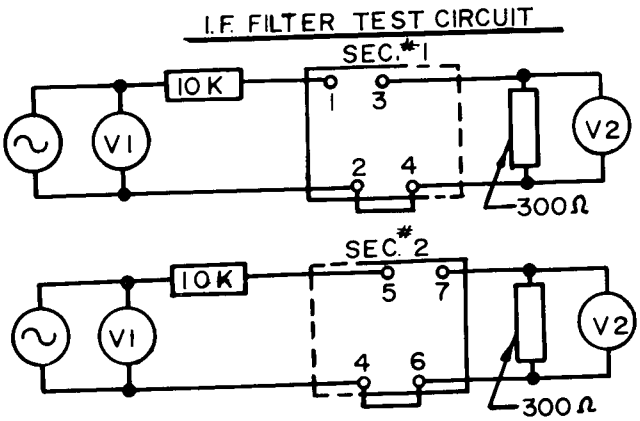
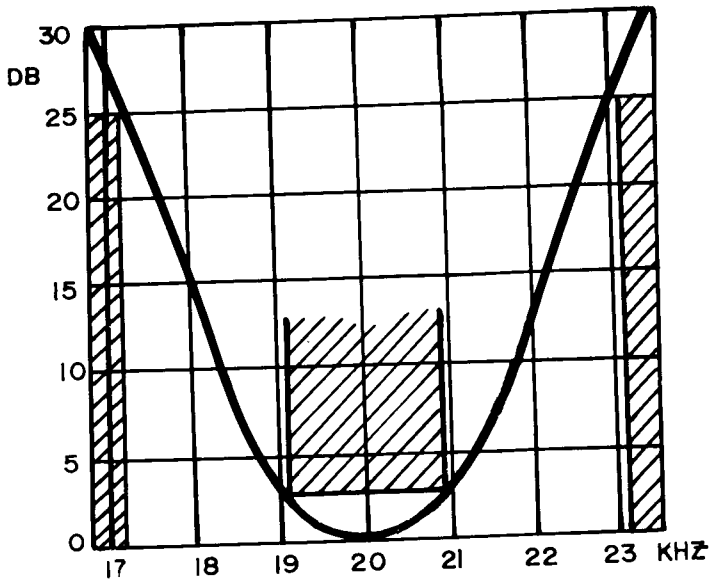
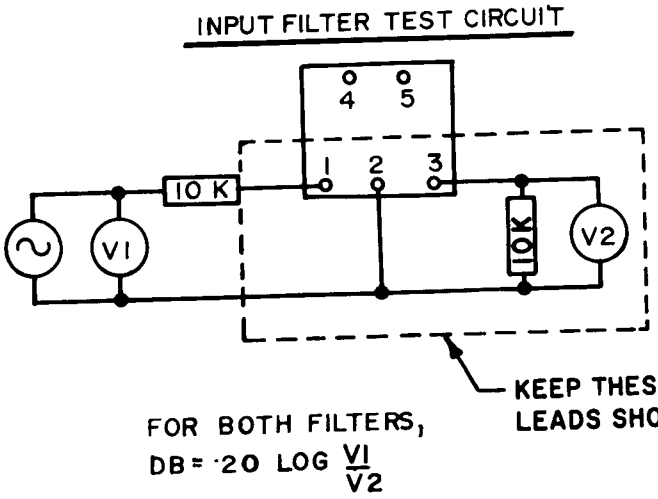


Fig. 7. Receiver CLI and Output Board – Parts Location.

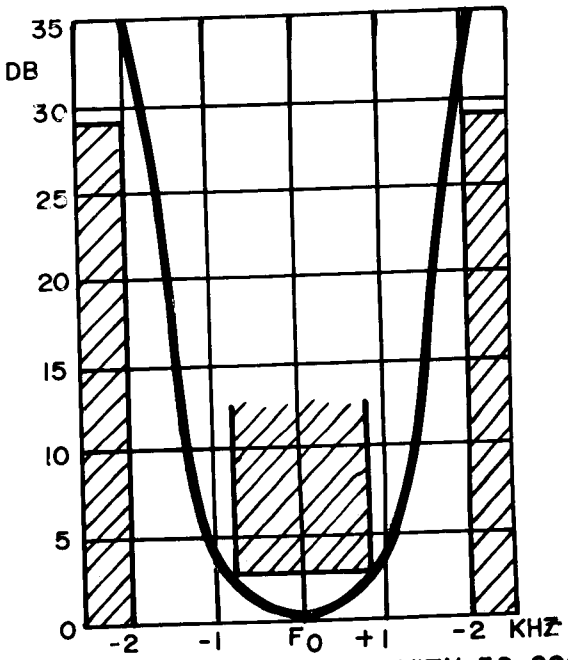




TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.



FOR BOTH FILTERS,
$DB = 20 \log \frac{V1}{V2}$



TYPICAL SELECTIVITY **30-200KHZ**
INSERTION LOSS 12-18 DB,
RISING WITH FREQUENCY.

TC RECEIVER FILTER LIMITS

INPUT FILTER FOR 200.5-300 KHZ
INSERTION LOSS 12-16 DB, RISING WITH FREQUENCY

DOWN 3db AT ± 0.8-1.1 KHZ, RISING WITH FREQUENCY
AT 2 KHZ, DOWN 22-35 DB, DROPPING WITH RISING FREQUENCY

629A42

Fig. 9. Type TC Receiver Filter Characteristics

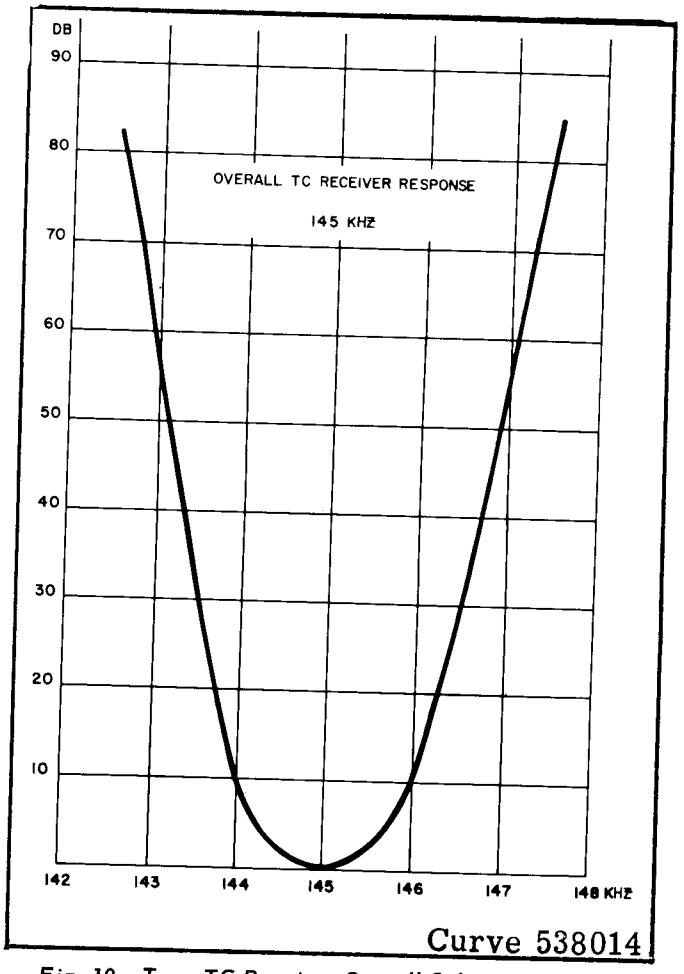


Fig. 10. Type TC Receiver Overall Selectivity Curve.

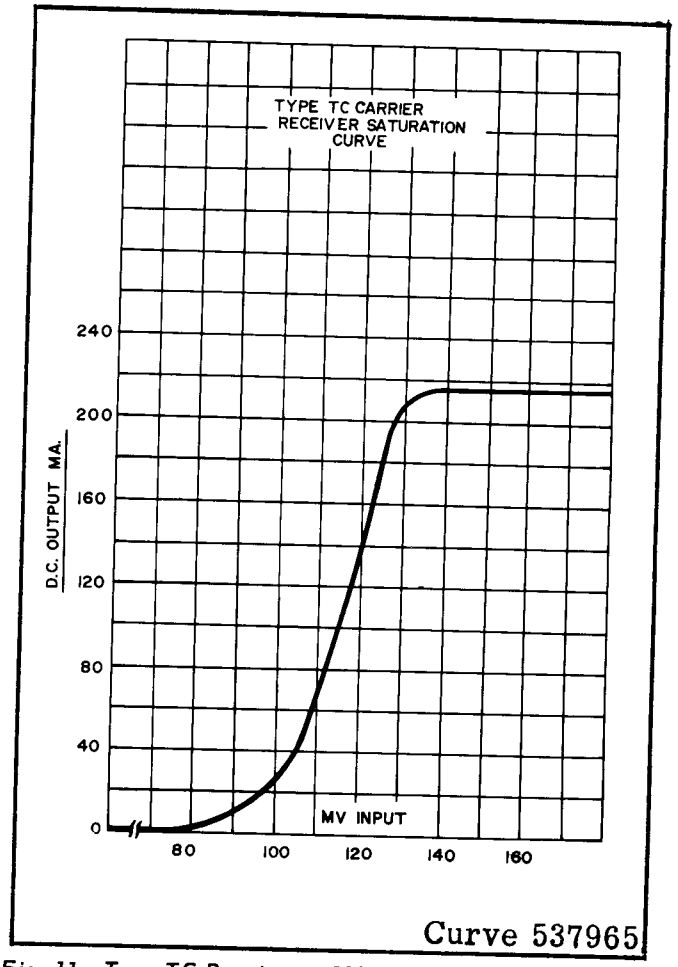


Fig. 11. Type TC Receiver – 200 ma. Output Characteristic.

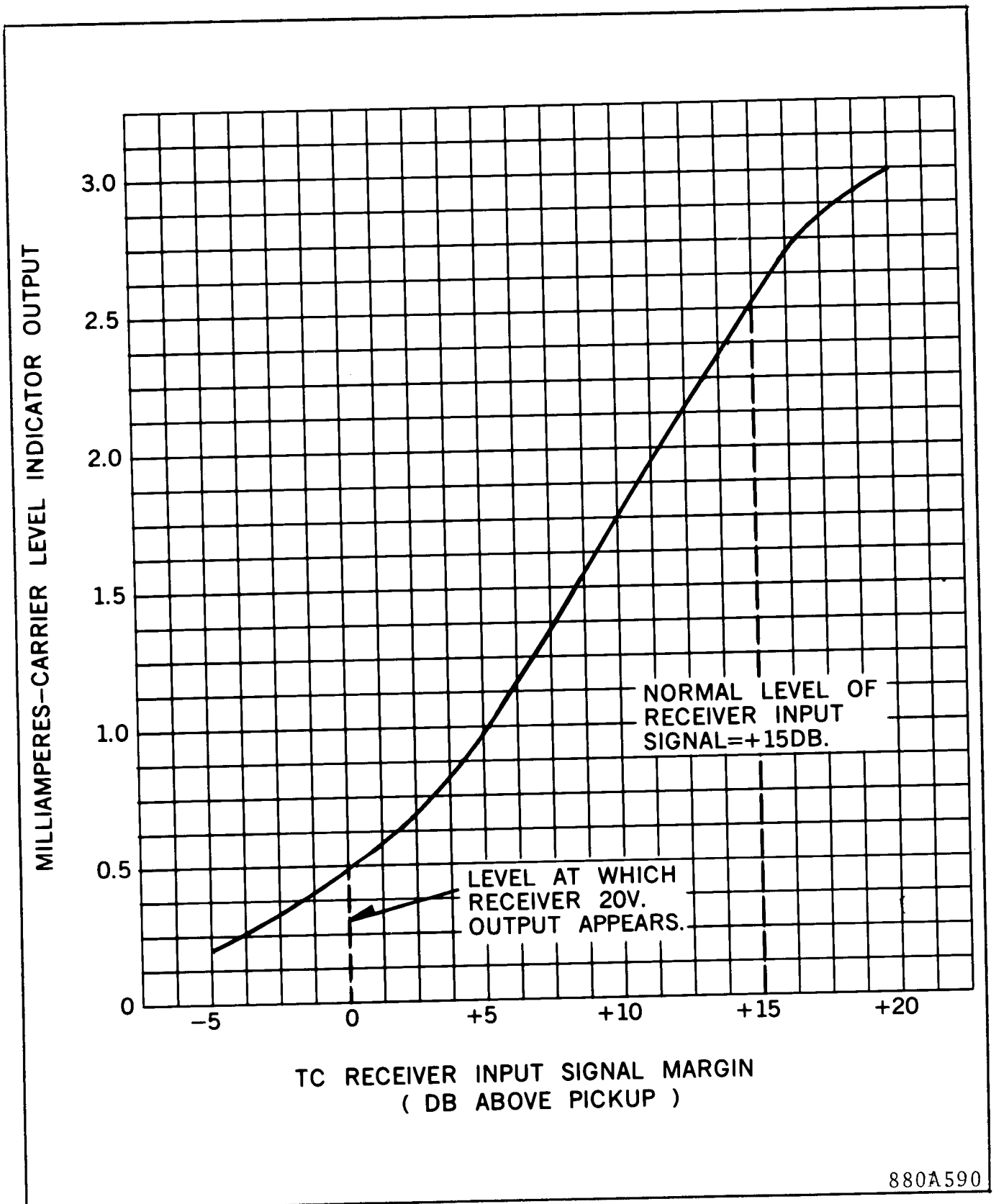


Fig. 12. Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

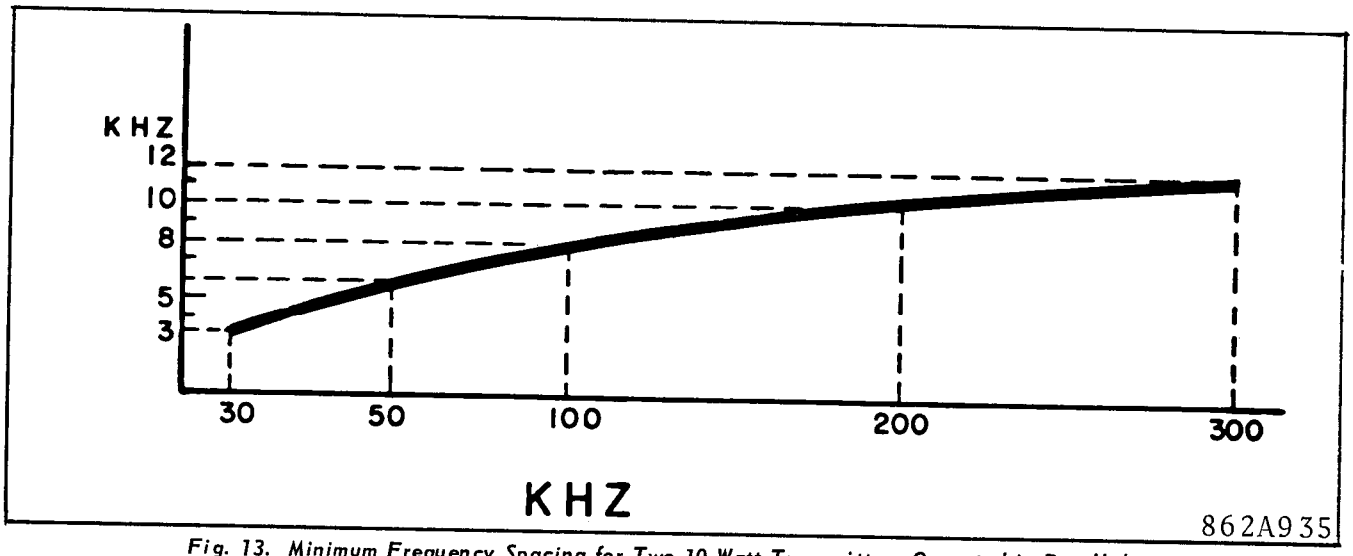


Fig. 13. Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

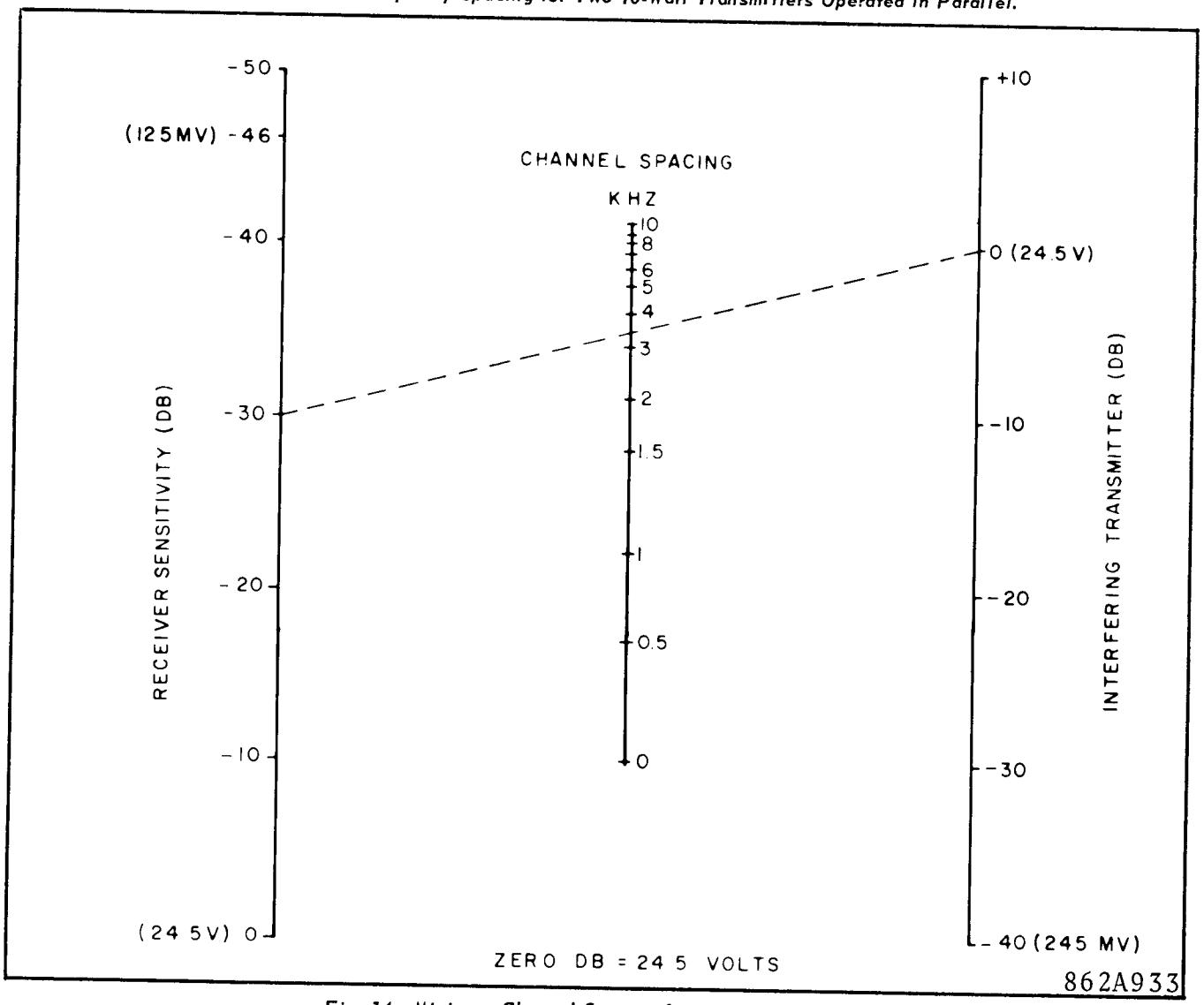


Fig. 14. Minimum Channel Spacing for Keyed Carrier 60 p.p.s.

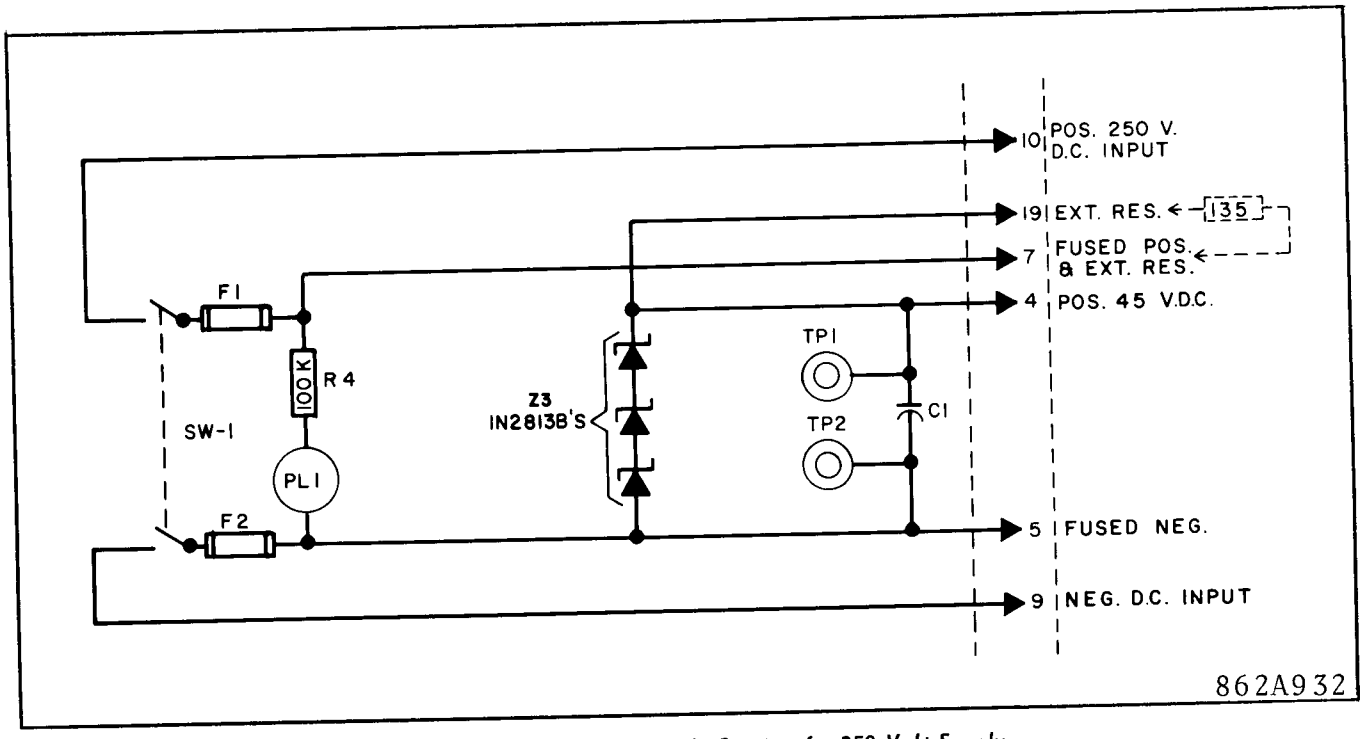


Fig. 15. Detail of Power Supply Section for 250-Volt Supply.

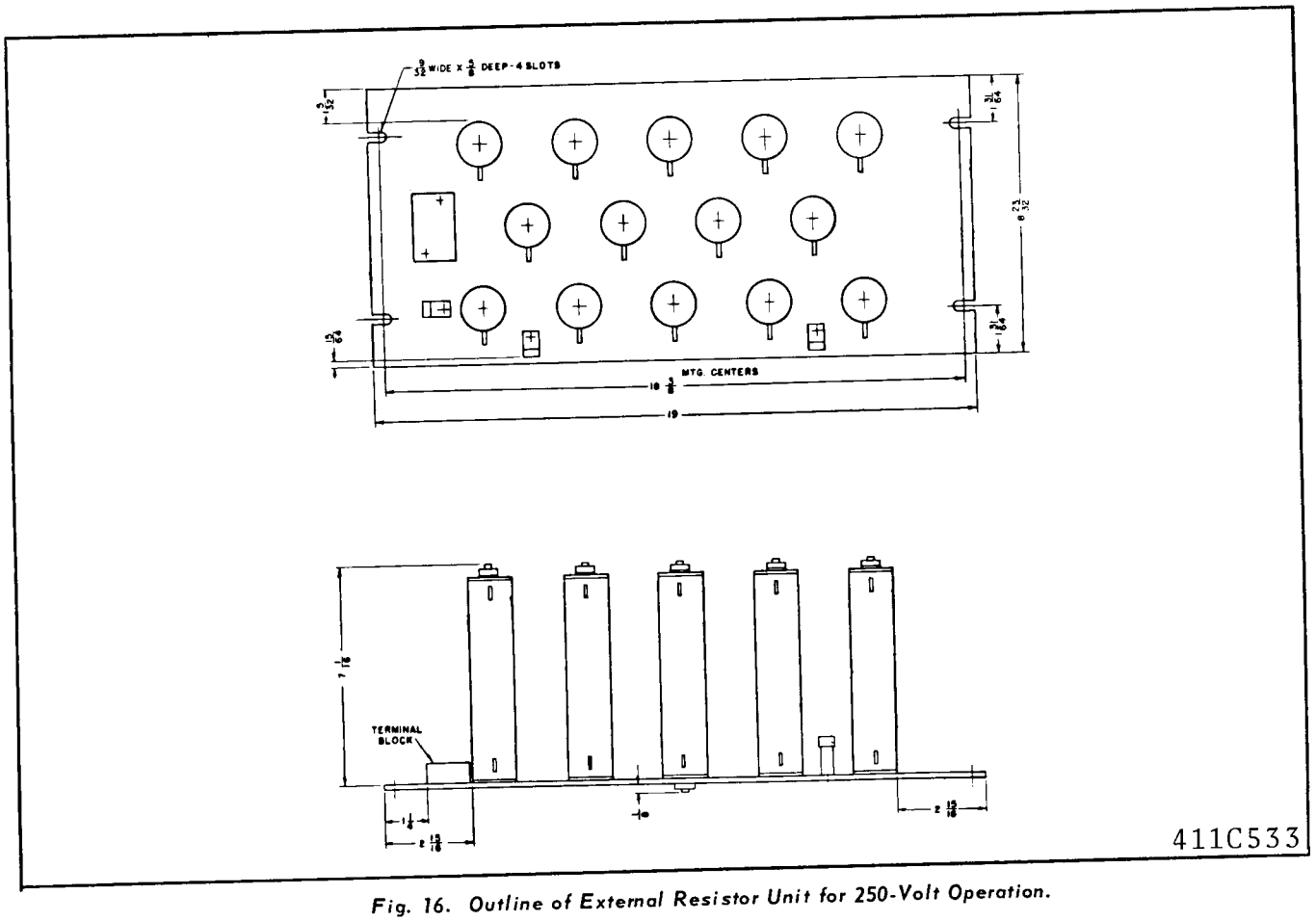
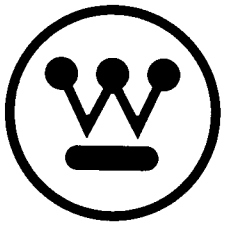


Fig. 16. Outline of External Resistor Unit for 250-Volt Operation.



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

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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 TABLES

LIST OF ILLUSTRATIONS

SUPERSEDES I.L. 41-944.32
*Denotes change from superseded issue.

EFFECTIVE JUNE 1973

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 ±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: 48 V.D.C.	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 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 ±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 transistors 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. ± .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)
   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#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	
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

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

2. Receiver input filter (FL201), specify frequency.

3. 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	35-38	35-38
TP202	0	0
TP203	11-12	11-12
TP204	< 0.5	2- 3
TP205	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.	.07
FL201-OUT to Gnd.	.04
Q203 - E to TP206	.10
Q204 - C to TP206	.09
Q205 - B to TP206	.013
Q205 - C to TP206	1.2
Q206 - B to TP206	.15
Q206 - C to TP206	2.5
TP202 to TP206	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	CARRIER OFF	CARRIER ON
TP101	8.5 volts d.c.	8.5 volts d.c.
TP102	<0.5	20
TP103	<0.5	19.5
TP105	<0.5	9
TP106	44	24
TP107	44	24
TP108	45	44
TP110	<1.0	< 1.0
TP111	<1.0	< 1.0
TP112	0	<0.5
TP113	45	44
J101 (Front Panel)	5 ma. max.	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	1.5 volts, rms.
TP103 to TP102	0.2
TP105 to TP104	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

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)

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.

ELECTRICAL PARTS LIST

* Transmitter Section

SYMBOL	RATING	STYLE NUMBER
C201	0.1 mfd, 200 V.DC	187A624H01
C102	.005 mfd, 300 V.DC	187A694H29
C103	180 pf. 500 V.DC	187A695H29
C104	0.25 mfd, 200 V.DC	187A624H02
C105	0.25 mfd, 200 V.DC	187A624H02
C106	0.25 mfd, 200 V.DC	187A624H02
C107	0.25 mfd, 200 V.DC	187A624H02
C108	0.50 mfd, 200 V.DC	187A624H03
C109	0.25 mfd, 200 V.DC	187A624H02
C110	0.25 mfd, 200 V.DC	187A624H02
† C111	(See Table Below)	—
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
D104	1N91	182A881H04
D105	1N4818	188A342H06
D106	1N91	182A881H04
G101	Type RVS Arrester	637A026A01
J101	Closed Circuit Jack	187A606H01

#200.5 — 300 kHz only.

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

* ELECTRICAL PARTS LIST

Transmitter Section (Cont.)

SYMBOL	RATING	STYLE NUMBER
J102	Banana Plug Jack	2 of 185A431H01
J103	Coaxial Cable Jack	187A633H01
J104	24-Term Receptacle	187A669H01
J105	12-Term Receptacle	629A205H02
L101	Part of FL101	Vary with Frequency
L102	FL102 Trap Coil (2nd Harmonic)	Vary with Frequency
L103	FL102 Trap Coil (3rd Harmonic)	Vary with Frequency
L104	400 mh.	292B096G01
L105	FL102 Coil (part of series-resonant circuit tuned to fundamental freq.)	Vary with Frequency
Q101	2N2905A	762A672H10
Q102	2N2905A	762A672H10
Q103	2N525	184A638H13
Q104	2N3712	762A672H07
Q105	2N3712	762A672H07
Q106	TI-481	184A638H11
Q107	2N1908 Matched Pair - Texas Instrument	187A673H02
Q108	2N1908 Co. - Identif. GP2151	187A673H02

SYMBOL	OHMS	± TOL. %	WATTS	STYLE NUMBER
R101	5,600	5	1	187A643H45
R102	2,200	10	0.5	187A641H35
R103	10,000	10	0.5	187A641H51
R104	100,000	5	0.5	187A763H75
R105	390	5	0.5	184A763H17
R106	1,200	5	0.5	184A763H29
R107	10,000	10	0.5	184A641H51
R108	100,000	5	0.5	184A763H75
R109	390	5	0.5	184A763H17
R111	1,200	5	0.5	187A763H29
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	184A763H07

ELECTRICAL PARTS LIST

* Transmitter Section (Cont.)

SYMBOL	OHMS	± TOL. %	WATTS	STYLE NUMBER
R116	100	5	0.5	184A763H03
R117	1,000	5	25	1202588
R118	10,000	2	0.5	629A531H56
R119	62	2	0.5	629A531H03
R120	10,000	5	2	185A207H51
R121	10	5	2	187A683H01
R122	10	5	0.5	187A290H01
R123	10	10	0.5	187A290H01
R124	100	10	1	187A644H03
R125	1,000	10	0.5	187A641H27
R126	4,700	10	1	187A644H43
R127	10	10	0.5	187A640H01
R128	2,200	5	1	187A644H35
R129	2.7	10	0.5	184A636H14
R130	10	10	0.5	187A640H01
R131	4,700	5	1	187A644H43
R132	2.7	10	0.5	184A636H14
R133	0.27	10	1	184A636H18
R134	0.27	10	1	184A636H18
R135	3,000	10	5	188A317H01
R136	12,000	2	0.5	629A531H58
R137	15,000	10	2	187A642H55
R138	1,000	10	0.5	187A641H27
R139	1,000	10	0.5	187A641H27
R140	68	2	0.5	629A531H04
R141	30	Type 3D202 Thermistor		185A211H06
R142	25K pot.	20	0.25	584C276H23
R143	20,000	2	0.5	629A531H63

SYMBOL	RATING		STYLE NUMBER
SW101	Carrier Test Switch		880A357H01
T101	10,000/400 ohms		205C043G01
T102	10,000/400 c.t.		714B666G01
T103	1930/60 ohms	L633000	1962694
T104	Turns ratio, 1/0.5	Pri./each sec.	292B526G01
T105	10/500 ohms		292B526G02
T106	500/50 - 60 - 70 ohms		292B526G03
Y101	30-300 kHz crystal per 328C083		Specify Frequency
Z101	1N5357B (20 V ±5%)		862A288H03
Z102	1N2999B (56 V ±5%)		629A798H04
Z103	1N2999B (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)	185A797H13
Z160	1N5357B (20V)	862A288H02
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	187A624H02
C215	39 pfd., 500 V. DC	187A695H12
D201	1N457A	184A855H07
D202	1N457A	184A855H07
D203	1N4818	188A342H06
D204	1N4818	188A342H06

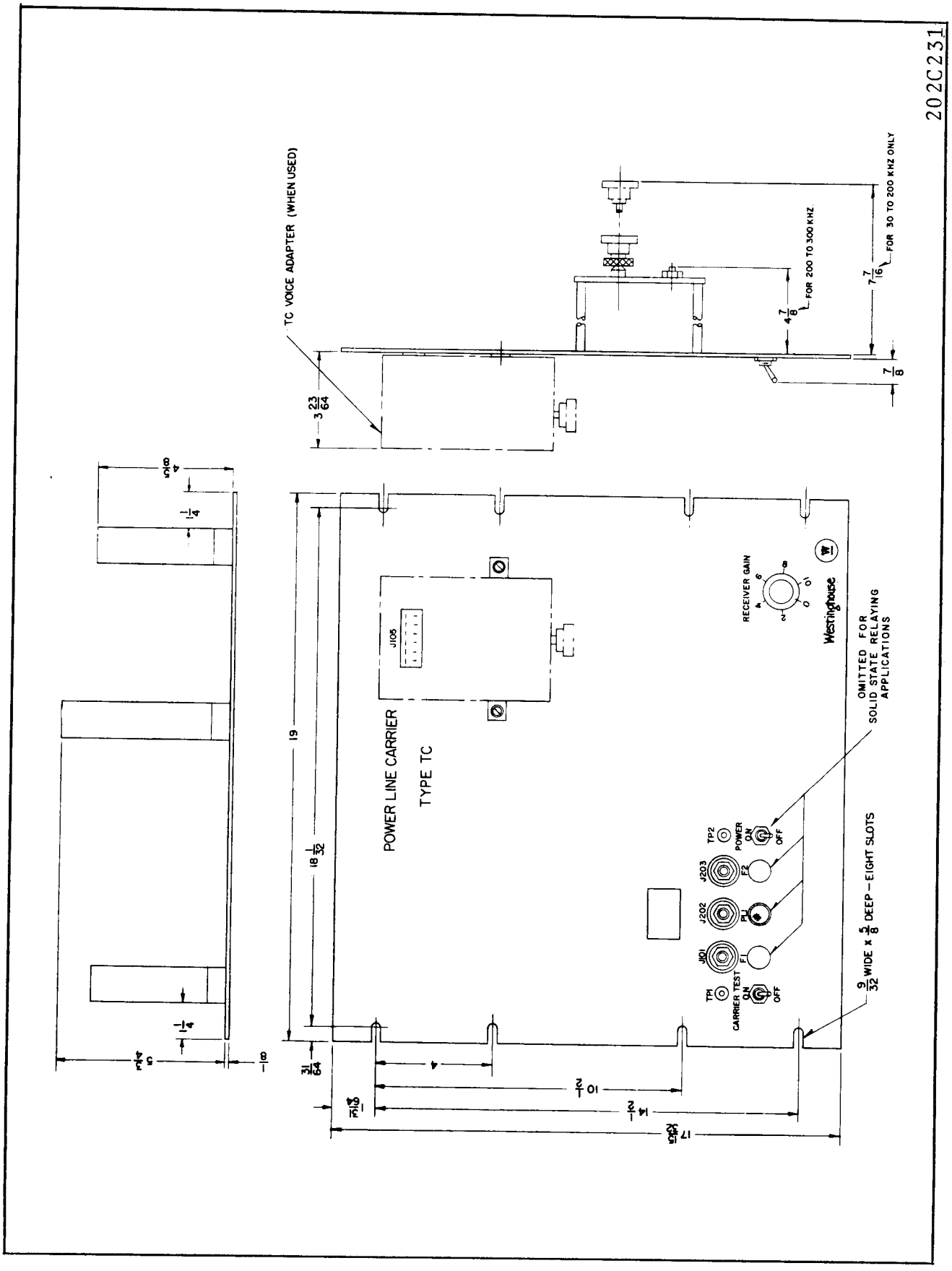
ELECTRICAL PARTS LIST

* Receiver Section (cont.)

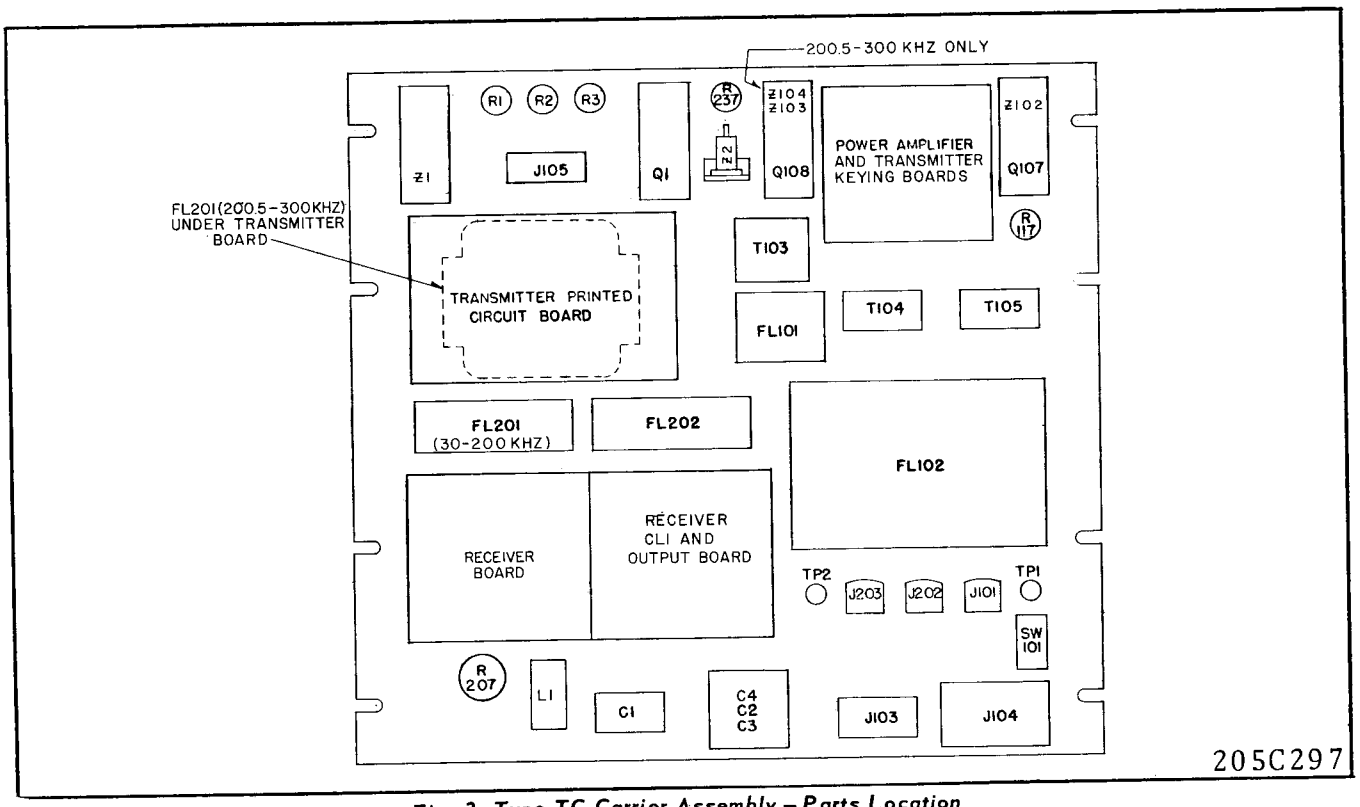
SYMBOL	RATING	STYLE NUMBER
FL201	Receiver Input Filter 30-300 kHz	Specify Frequency
FL202 *	Receiver i.f. Filter - 20kHz (2 sections)	187A590G02
J201	Receiver Coax, Input Jack	187A638H01
J202	Closed Circuit Jack (CLI)	187A606H01
J203	Closed Circuit Jack (200MA)	187A606H01
L201	33 mh.	187A599H02
Q201	2N2905A	762A672H10
Q202	2N2905A	762A672H10
Q203	2N2905A	762A672H10
Q204	2N2905A	762A672H10
Q205	2N2905A	762A672H10
Q206	2N2905A	762A672H10
Q207	2N3645	849A441H01
Q208	2N4903	187A673H13

SYMBOL	RATING			STYLE NUMBER
	OHMS	± 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	185A086H07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H17
R210	390	5	0.5	184A763H17
† R211	—	—	—	See † Note Below
R212	1 K pot.	20	0.25	629A430H02
R213	1,200	5	0.5	184A763H29
R214	5,600	5	1	187A643H45
R215	20,000	5	0.5	184A763H58
R216	3,600	5	0.5	184A763H40

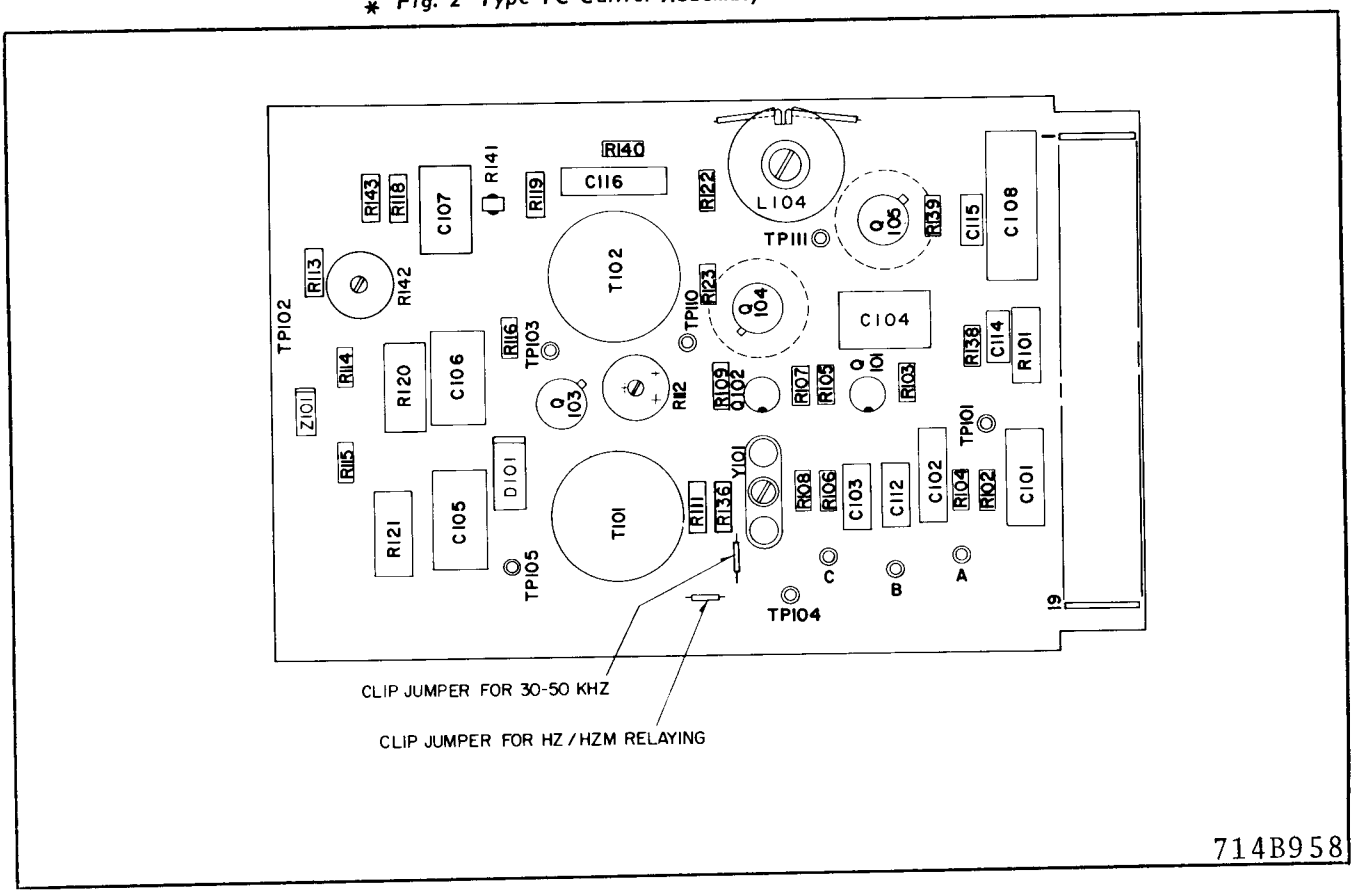
† R211 — 10K - above 50kHz - S#187A641H51
22K - 30-50kHz - S#187A641H59



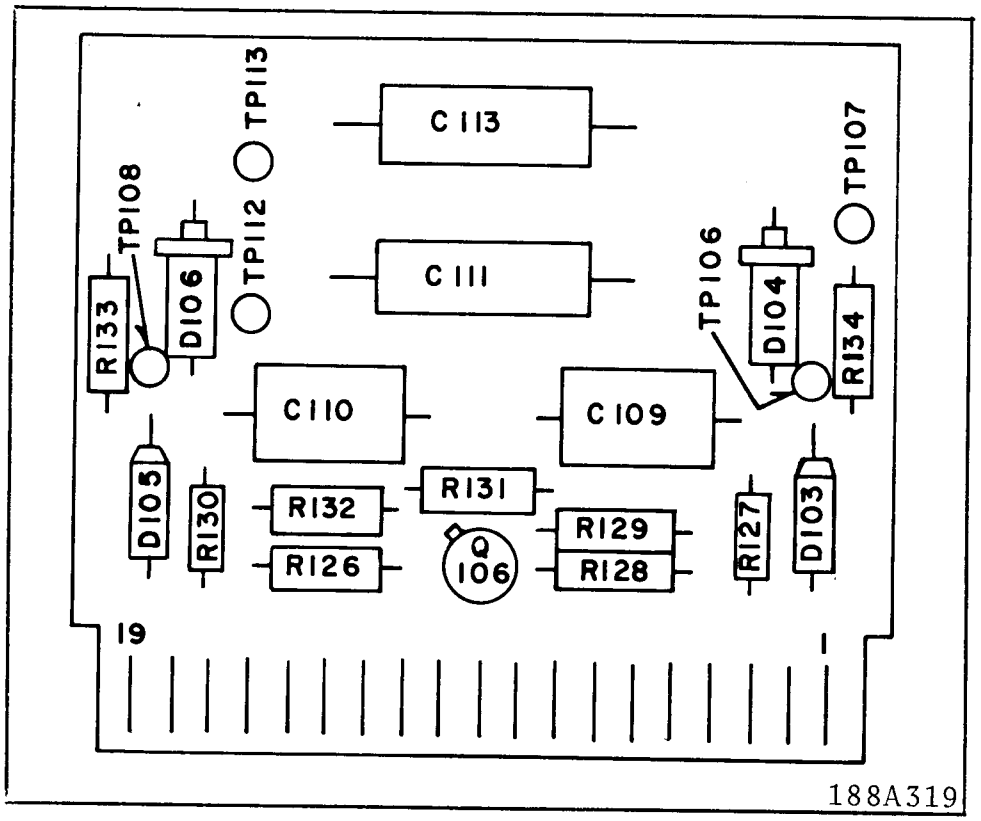
* *Fig. 1 Type TC Carrier Assembly — Outline*



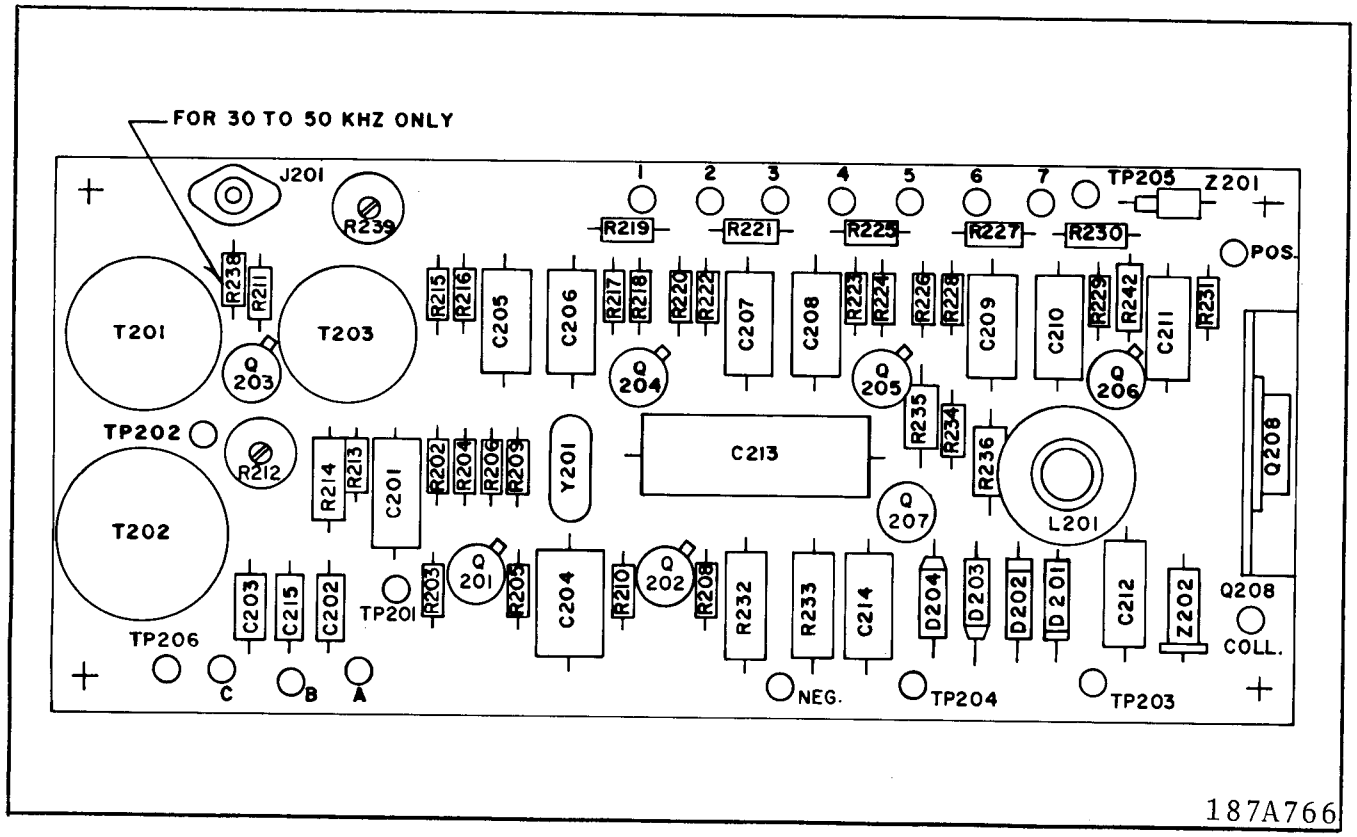
* *Fig. 2 Type TC Carrier Assembly – Parts Location*



* *Fig. 3 Transmitter Printed Circuit – Parts Location*



* *Fig. 4 Power Amplifier Printed Circuit – Parts Location*



* *Fig. 5 Receiver Printed Circuit – Parts Location*

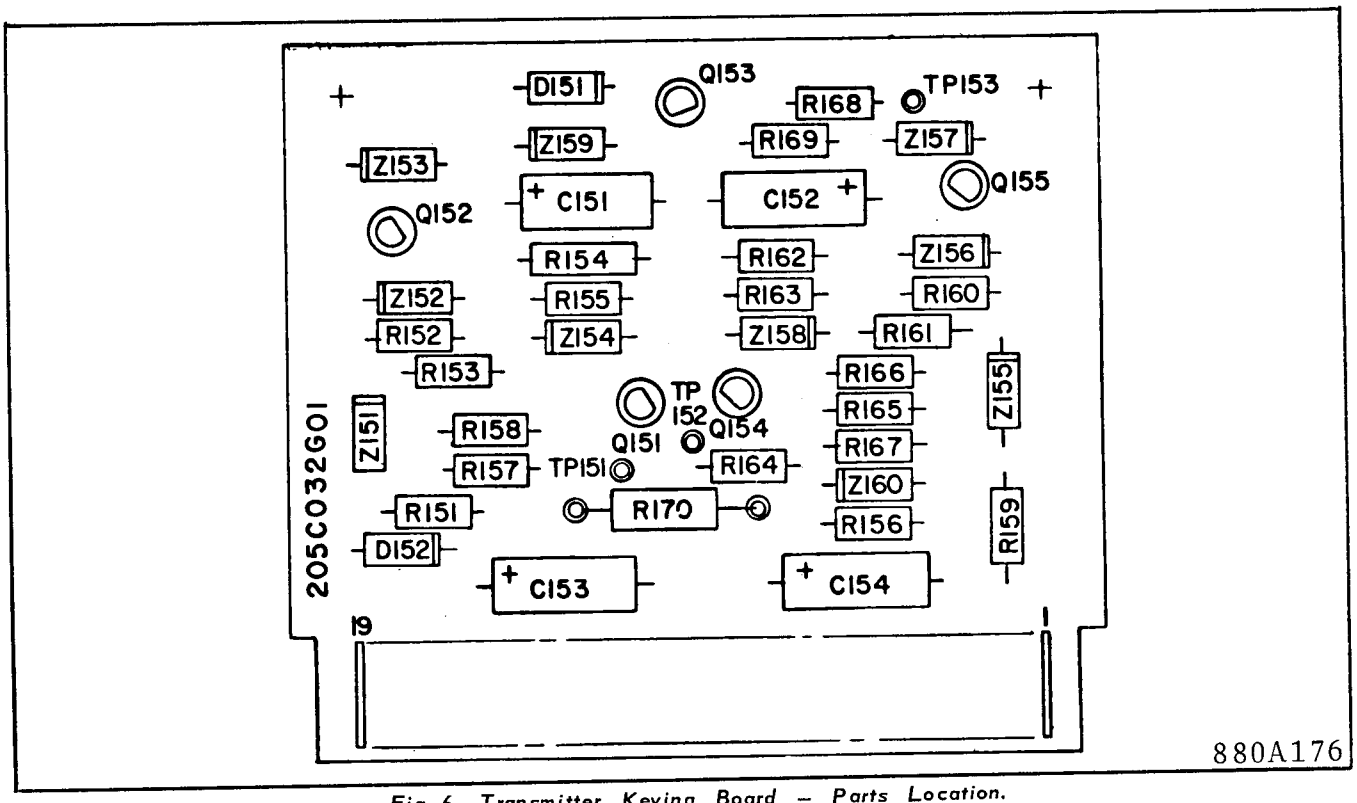


Fig. 6. Transmitter Keying Board – Parts Location.

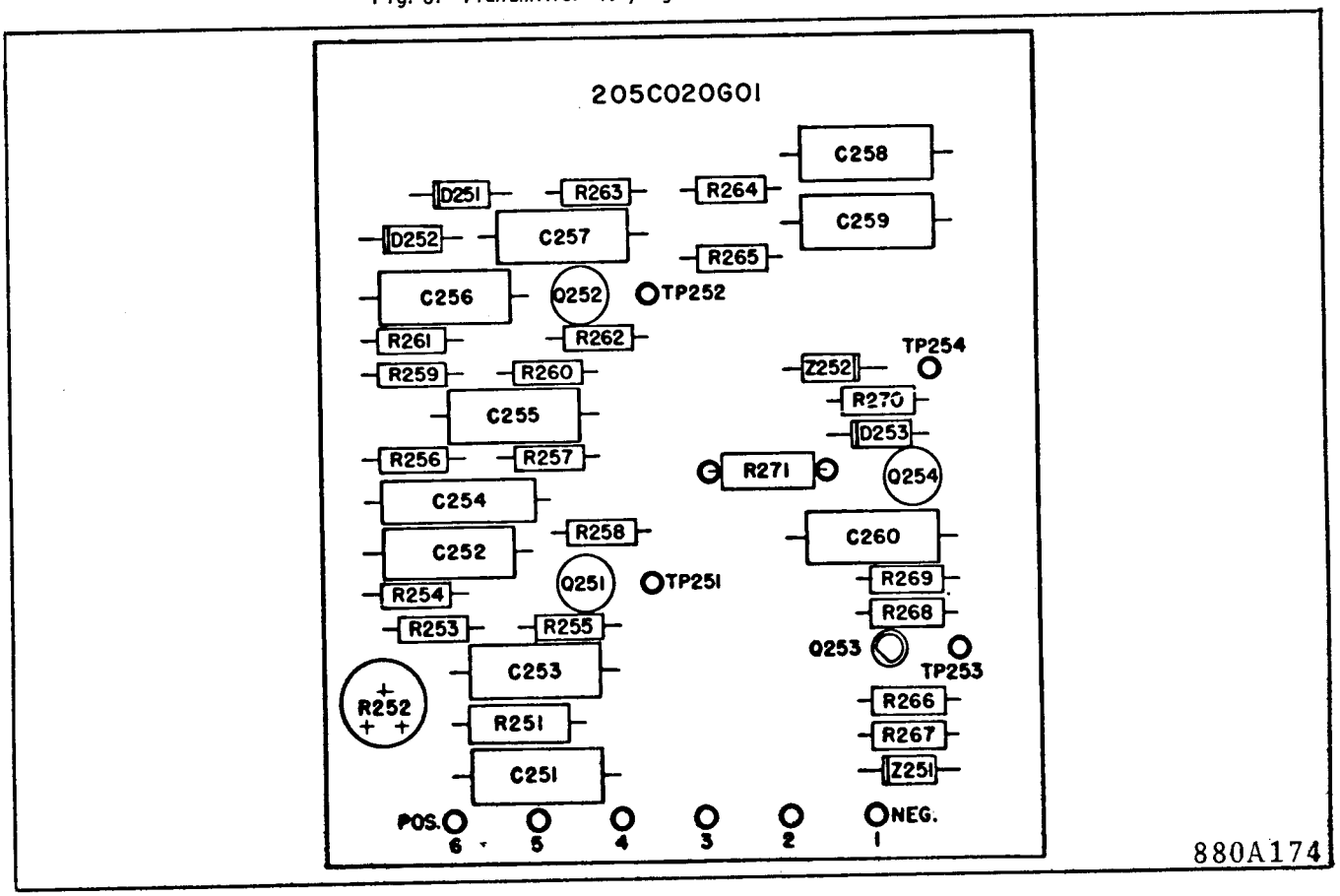
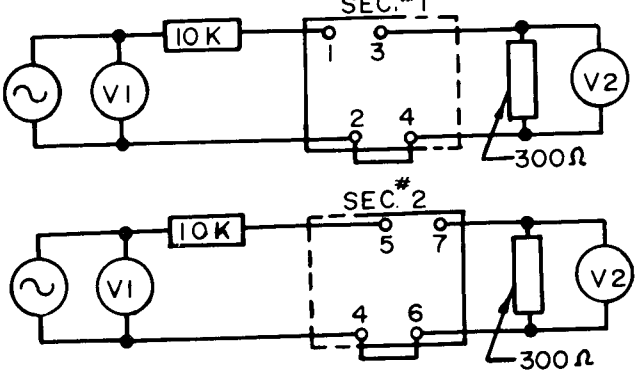
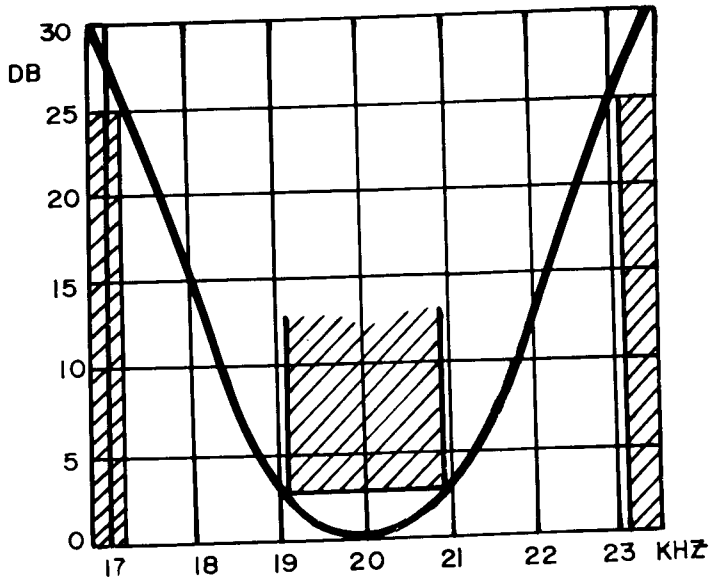


Fig. 7. Receiver CLI and Output Board – Parts Location.

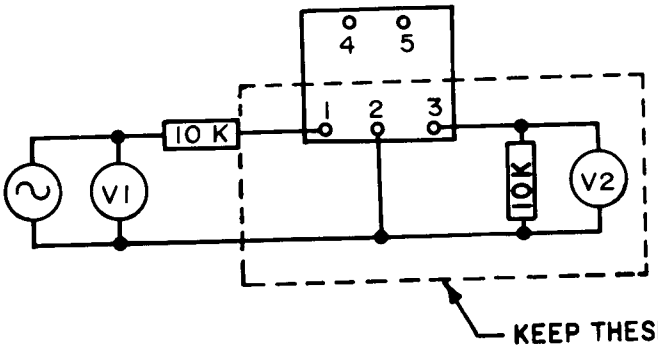
I.F. FILTER TEST CIRCUIT



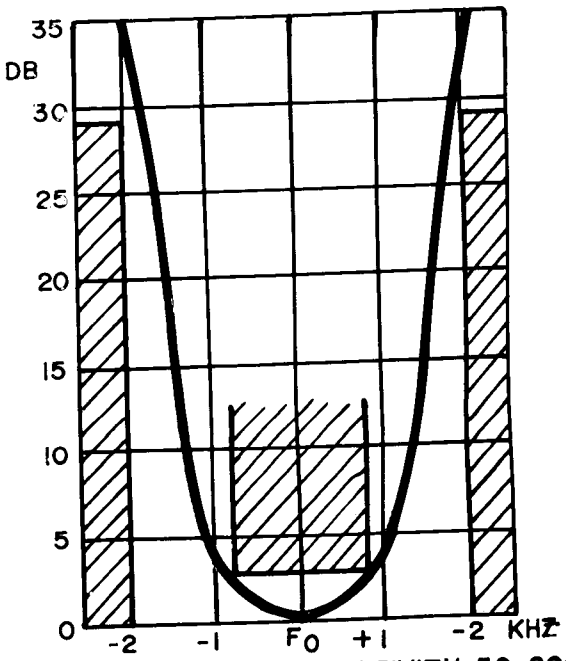


TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.

INPUT FILTER TEST CIRCUIT



FOR BOTH FILTERS,
$DB = 20 \log \frac{V1}{V2}$



TYPICAL SELECTIVITY **30-200KHZ**
INSERTION LOSS 12-18 DB,
RISING WITH FREQUENCY.

TC RECEIVER FILTER LIMITS

INPUT FILTER FOR 200.5-300 KHZ
INSERTION LOSS 12-16 DB, RISING WITH FREQUENCY
DOWN 3db AT ± 0.8-1.1 KHZ, RISING WITH FREQUENCY
AT 2 KHZ, DOWN 22-35 DB, DROPPING WITH RISING FREQUENCY

629A42

* *Fig. 9. Type TC Receiver Filter Characteristics*

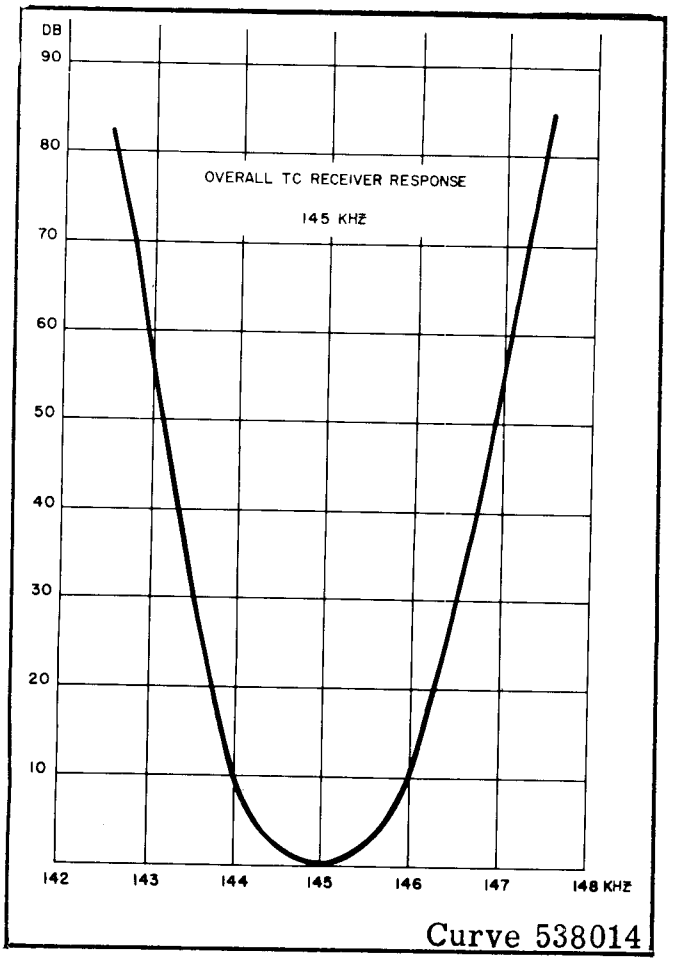


Fig. 10. Type TC Receiver Overall Selectivity Curve.

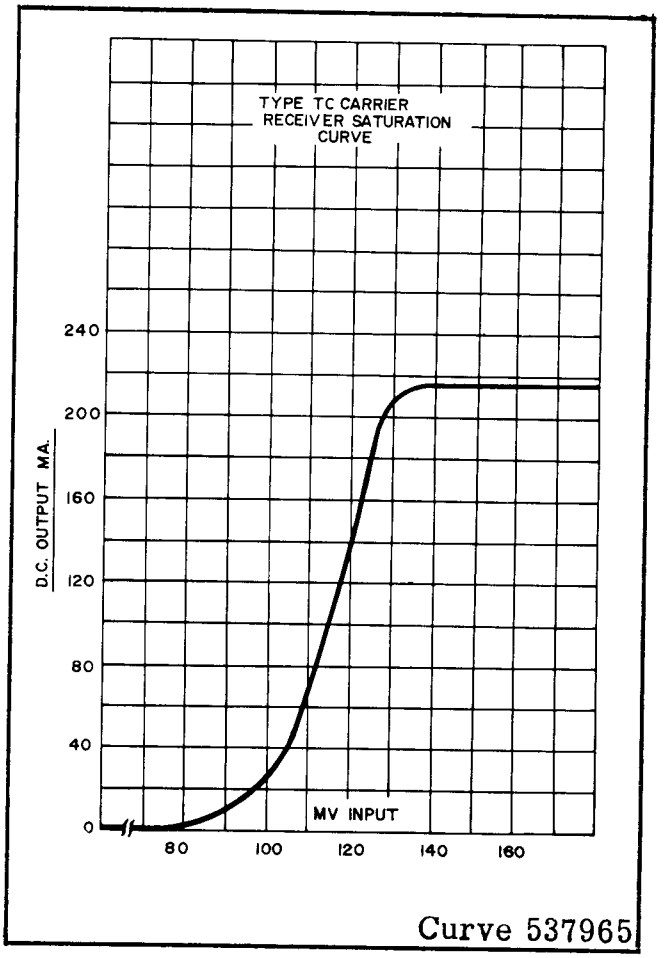


Fig. 11. Type TC Receiver – 200 ma. Output Characteristic.

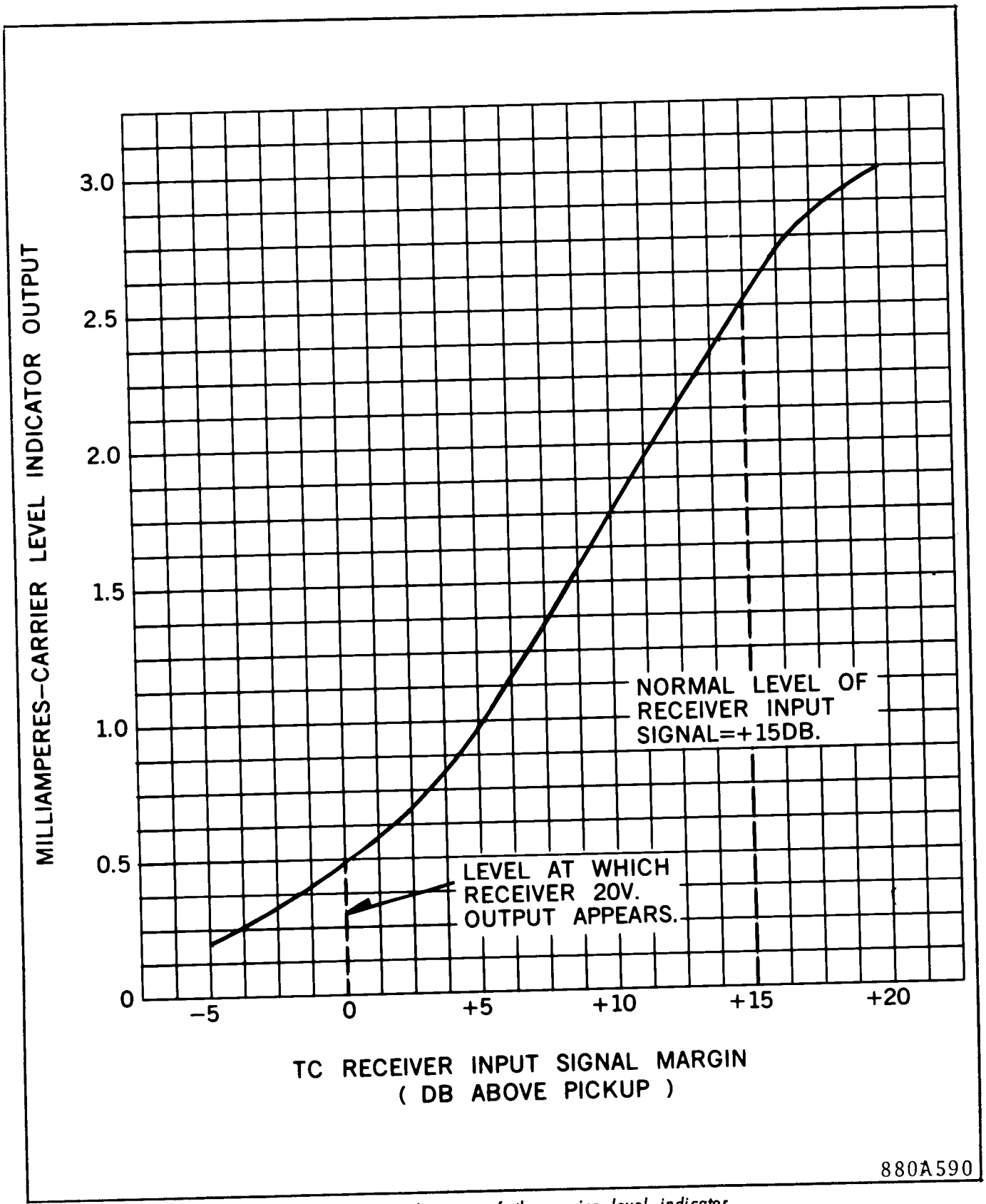


Fig. 12. Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

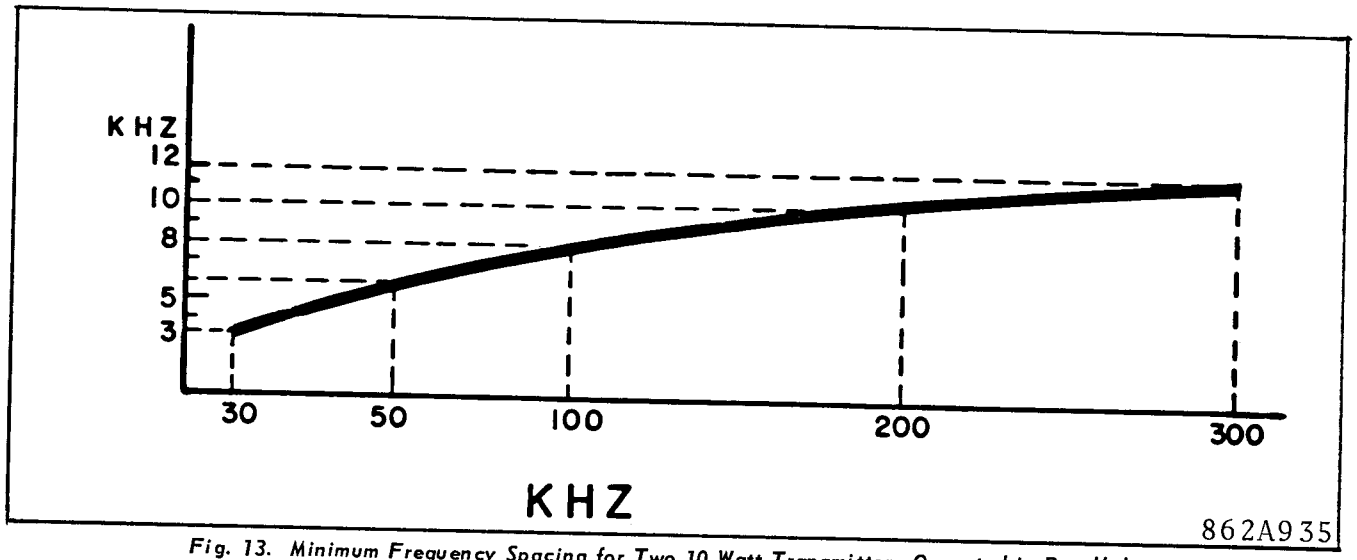


Fig. 13. Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

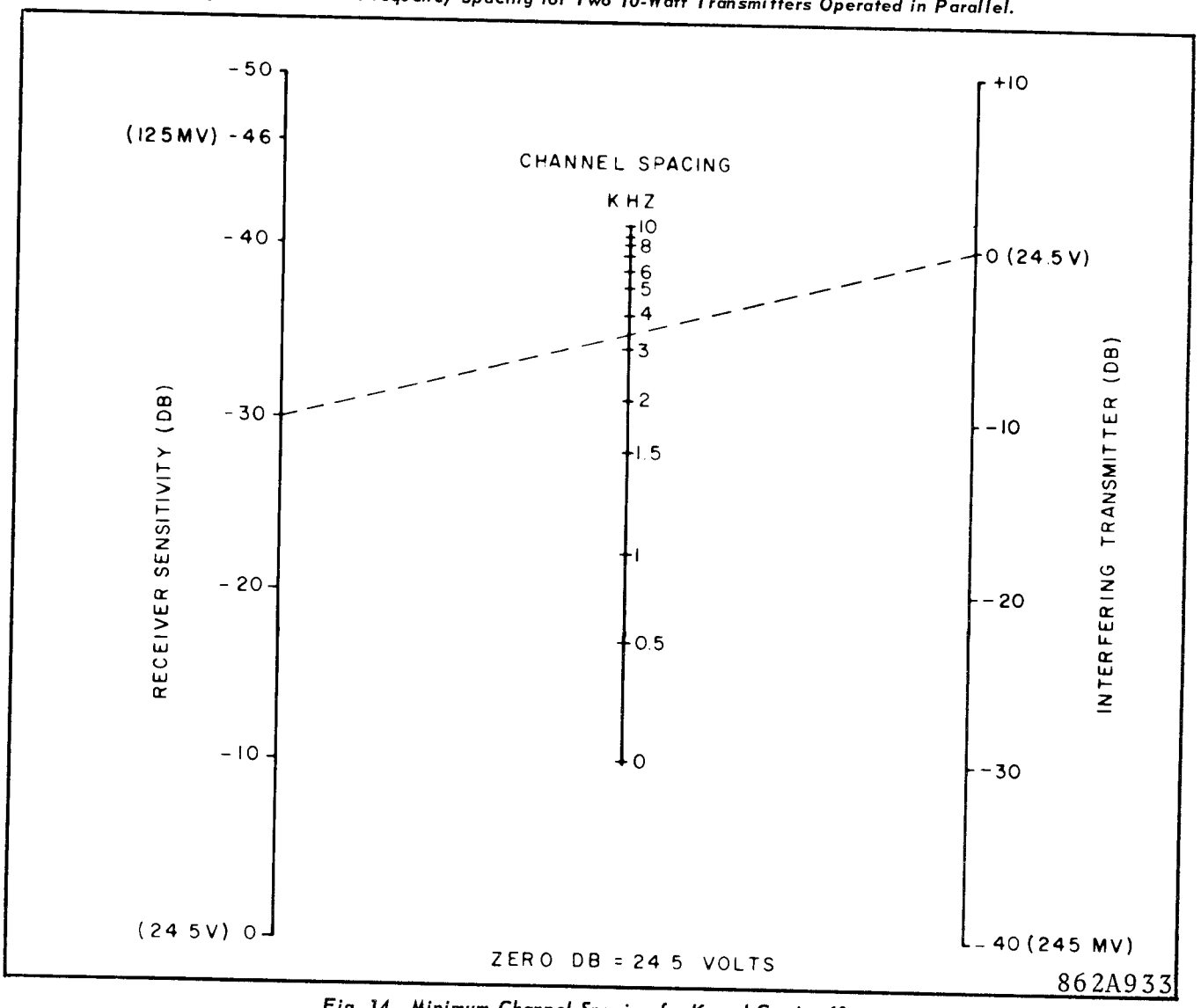
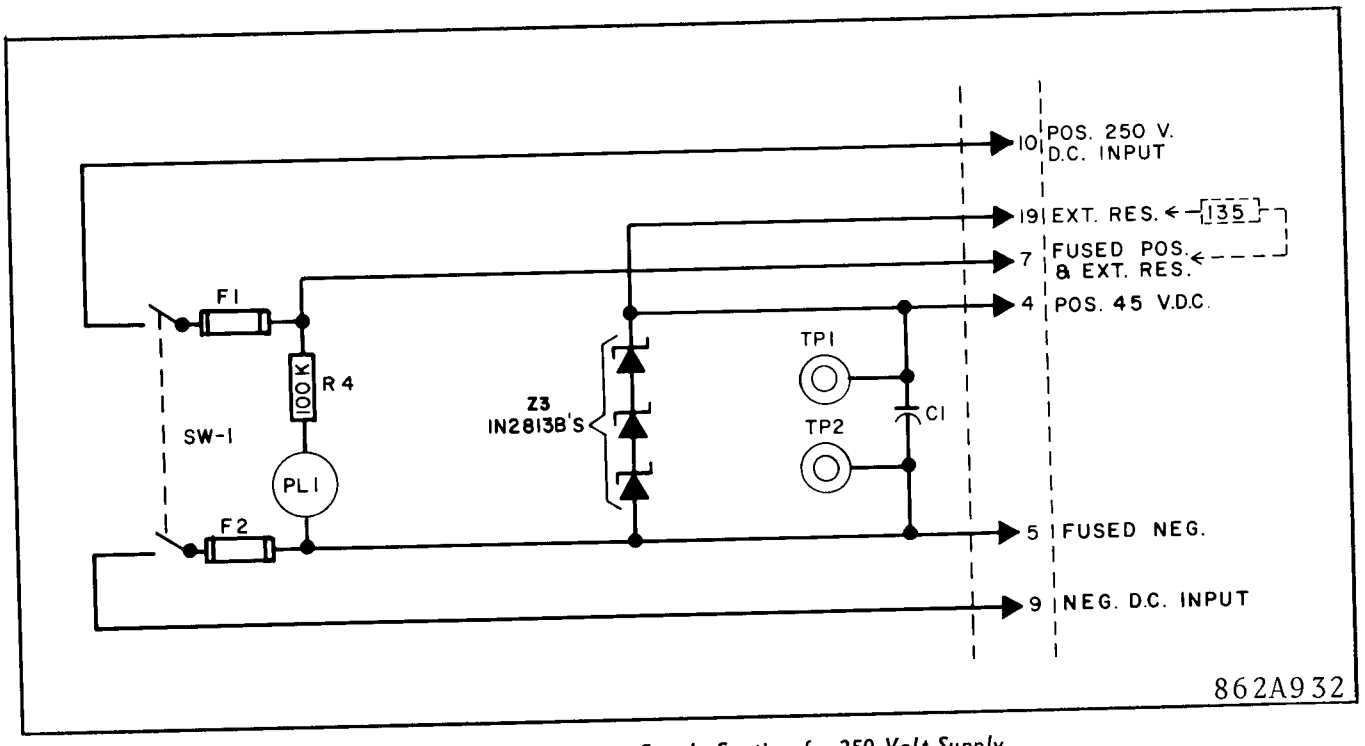
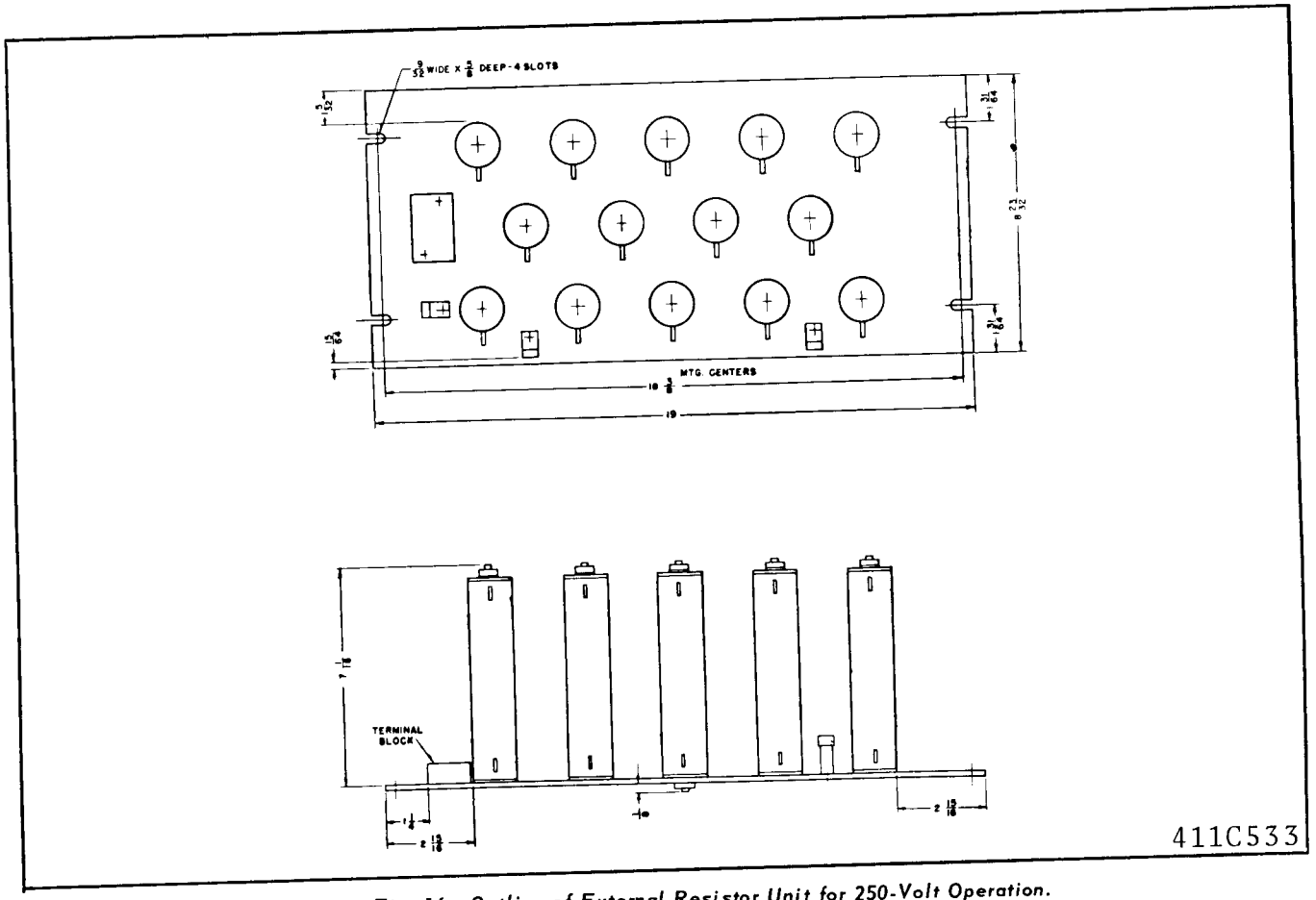


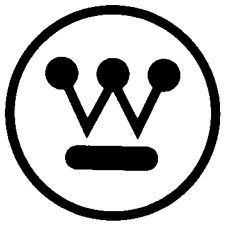
Fig. 14. Minimum Channel Spacing for Keyed Carrier 60 p.p.s.



* *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.
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

SUPERSEDES I.L. 41-944.32
*Denotes change from superseded issue.

EFFECTIVE JUNE 1973

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 ±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: 48 V.D.C.	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 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 ±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 transistors 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. ± .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)
   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#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	
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

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

2. Receiver input filter (FL201), specify frequency.

3. 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	35-38	35-38
TP202	0	0
TP203	11-12	11-12
TP204	< 0.5	2- 3
TP205	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.	.07
FL201-OUT to Gnd.	.04
Q203 - E to TP206	.10
Q204 - C to TP206	.09
Q205 - B to TP206	.013
Q205 - C to TP206	1.2
Q206 - B to TP206	.15
Q206 - C to TP206	2.5
TP202 to TP206	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	CARRIER OFF	CARRIER ON
TP101	8.5 volts d.c.	8.5 volts d.c.
TP102	<0.5	20
TP103	<0.5	19.5
TP105	<0.5	9
TP106	44	24
TP107	44	24
TP108	45	44
TP110	<1.0	< 1.0
TP111	<1.0	< 1.0
TP112	0	<0.5
TP113	45	44
J101 (Front Panel)	5 ma. max.	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	1.5 volts, rms.
TP103 to TP102	0.2
TP105 to TP104	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

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)

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.

ELECTRICAL PARTS LIST

* Transmitter Section

SYMBOL	RATING	STYLE NUMBER
C201	0.1 mfd, 200 V.DC	187A624H01
C102	.005 mfd, 300 V.DC	187A694H29
C103	180 pf. 500 V.DC	187A695H29
C104	0.25 mfd, 200 V.DC	187A624H02
C105	0.25 mfd, 200 V.DC	187A624H02
C106	0.25 mfd, 200 V.DC	187A624H02
C107	0.25 mfd, 200 V.DC	187A624H02
C108	0.50 mfd, 200 V.DC	187A624H03
C109	0.25 mfd, 200 V.DC	187A624H02
C110	0.25 mfd, 200 V.DC	187A624H02
† C111	(See Table Below)	—
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
D104	1N91	182A881H04
D105	1N4818	188A342H06
D106	1N91	182A881H04
G101	Type RVS Arrester	637A026A01
J101	Closed Circuit Jack	187A606H01

#200.5 — 300 kHz only.

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

* ELECTRICAL PARTS LIST

Transmitter Section (Cont.)

SYMBOL	RATING	STYLE NUMBER
J102	Banana Plug Jack	2 of 185A431H01
J103	Coaxial Cable Jack	187A633H01
J104	24-Term Receptacle	187A669H01
J105	12-Term Receptacle	629A205H02
L101	Part of FL101	Vary with Frequency
L102	FL102 Trap Coil (2nd Harmonic)	Vary with Frequency
L103	FL102 Trap Coil (3rd Harmonic)	Vary with Frequency
L104	400 mh.	292B096G01
L105	FL102 Coil (part of series-resonant circuit tuned to fundamental freq.)	Vary with Frequency
Q101	2N2905A	762A672H10
Q102	2N2905A	762A672H10
Q103	2N525	184A638H13
Q104	2N3712	762A672H07
Q105	2N3712	762A672H07
Q106	TI-481	184A638H11
Q107	2N1908 Matched Pair - Texas Instrument	187A673H02
Q108	2N1908 Co. - Identif. GP2151	187A673H02

SYMBOL	OHMS	± TOL. %	WATTS	STYLE NUMBER
R101	5,600	5	1	187A643H45
R102	2,200	10	0.5	187A641H35
R103	10,000	10	0.5	187A641H51
R104	100,000	5	0.5	187A763H75
R105	390	5	0.5	184A763H17
R106	1,200	5	0.5	184A763H29
R107	10,000	10	0.5	184A641H51
R108	100,000	5	0.5	184A763H75
R109	390	5	0.5	184A763H17
R111	1,200	5	0.5	187A763H29
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	184A763H07

ELECTRICAL PARTS LIST

* Transmitter Section (Cont.)

SYMBOL	OHMS	± TOL. %	WATTS	STYLE NUMBER
R116	100	5	0.5	184A763H03
R117	1,000	5	25	1202588
R118	10,000	2	0.5	629A531H56
R119	62	2	0.5	629A531H03
R120	10,000	5	2	185A207H51
R121	10	5	2	187A683H01
R122	10	5	0.5	187A290H01
R123	10	10	0.5	187A290H01
R124	100	10	1	187A644H03
R125	1,000	10	0.5	187A641H27
R126	4,700	10	1	187A644H43
R127	10	10	0.5	187A640H01
R128	2,200	5	1	187A644H35
R129	2.7	10	0.5	184A636H14
R130	10	10	0.5	187A640H01
R131	4,700	5	1	187A644H43
R132	2.7	10	0.5	184A636H14
R133	0.27	10	1	184A636H18
R134	0.27	10	1	184A636H18
R135	3,000	10	5	188A317H01
R136	12,000	2	0.5	629A531H58
R137	15,000	10	2	187A642H55
R138	1,000	10	0.5	187A641H27
R139	1,000	10	0.5	187A641H27
R140	68	2	0.5	629A531H04
R141	30	Type 3D202 Thermistor		185A211H06
R142	25K pot.	20	0.25	584C276H23
R143	20,000	2	0.5	629A531H63

SYMBOL	RATING		STYLE NUMBER
SW101	Carrier Test Switch		880A357H01
T101	10,000/400 ohms		205C043G01
T102	10,000/400 c.t.		714B666G01
T103	1930/60 ohms	L633000	1962694
T104	Turns ratio, 1/0.5	Pri./each sec.	292B526G01
T105	10/500 ohms		292B526G02
T106	500/50 - 60 - 70 ohms		292B526G03
Y101	30-300 kHz crystal per 328C083		Specify Frequency
Z101	1N5357B (20 V ±5%)		862A288H03
Z102	1N2999B (56 V ±5%)		629A798H04
Z103	1N2999B (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)	185A797H13
Z160	1N5357B (20V)	862A288H02
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	187A624H02
C215	39 pfd., 500 V. DC	187A695H12
D201	1N457A	184A855H07
D202	1N457A	184A855H07
D203	1N4818	188A342H06
D204	1N4818	188A342H06

ELECTRICAL PARTS LIST

* Receiver Section (cont.)

SYMBOL	RATING	STYLE NUMBER
FL201	Receiver Input Filter 30-300 kHz	Specify Frequency
FL202 *	Receiver i.f. Filter - 20kHz (2 sections)	187A590G02
J201	Receiver Coax, Input Jack	187A638H01
J202	Closed Circuit Jack (CLI)	187A606H01
J203	Closed Circuit Jack (200MA)	187A606H01
L201	33 mh.	187A599H02
Q201	2N2905A	762A672H10
Q202	2N2905A	762A672H10
Q203	2N2905A	762A672H10
Q204	2N2905A	762A672H10
Q205	2N2905A	762A672H10
Q206	2N2905A	762A672H10
Q207	2N3645	849A441H01
Q208	2N4903	187A673H13

SYMBOL	RATING			STYLE NUMBER
	OHMS	± 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	185A086H07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H17
R210	390	5	0.5	184A763H17
† R211	—	—	—	See † Note Below
R212	1 K pot.	20	0.25	629A430H02
R213	1,200	5	0.5	184A763H29
R214	5,600	5	1	187A643H45
R215	20,000	5	0.5	184A763H58
R216	3,600	5	0.5	184A763H40

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

ELECTRICAL PARTS LIST

* Receiver Section (Cont.)

SYMBOL	RATING			STYLE NUMBER
	OHMS	± TOL. %	WATTS	
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	184A763H40
R229	620	5	0.5	184A763H22
R230	10	5	0.5	187A290H01
R231	2,000	5	0.5	184A763H34
R232	1,200	5	2	185A207H29
R233	4,700	10	2	187A642H43
R234	5,100	5	0.5	184A763H44
R235	470	10	1	187A644H19
R236	4,700	10	1	187A644H43
R237	170	5	40	1336074
† R238	—	—	—	See † Note Below
R239	1 K pot.	20	0.25	629A430H02
R240	50	Sensistor	0.25	187A685H08
R241	100	Type 3D102 Thermistor		185A211H12
R242	100	Type TM-¼ Sensistor		187A685H06
T201	10,000/10,000 Ohms			714B677G01
T202	10,000/400 Ohms			205C043G01
T203	25,000/300 Ohms			205C043G03
Y201	50-320kHz Crystal per 328C083			Specify Frequency
Z201	1N3027B (20V. ±5%)			184A449H07
Z202	1N1789 (56V. ±10%)			584C434H08

Receiver CLI and Output Board

SYMBOL	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.	188A669H15
D251-D252	1N457A	184A855H07
D253	1N645A	837A692H03
Z251	1N3686B (20V.)	185A212H06
Z252	1N3688A (24V.)	862A288H01

† R238 - omit - above 50kHz
- 22K, 30-50kHz, S#187A641H59.

ELECTRICAL PARTS LIST

* Receiver CLI and Output Board (Cont.)

SYMBOL	RATING	STYLE NUMBER
R251	2.7K, TM-¼ Sensistor	187A685H05
R252	5K, ¼W. pot.	629A430H07
R253	220, ½W.	184A763H11
R254	2.2K, ½W.	184A763H35
R255-R260	15K, ½W.	184A763H55
R256	2.4K, ½W.	184A763H36
R257	330, TM-¼ Sensistor	187A685H07
R258-R259	4.7K, ½W.	184A763H43
R261	560, ½W.	184A763H21
R262-R265	1.2K, ½W.	184A763H29
R263-R264	180, ½W.	184A763H09
R266	27K, ½W.	629A531H66
R267-R269	10K, ½W.	629A531H56
R268	6.8K, ½W.	629A531H52
R270	82K, ½W.	629A531H78
R271	150, 3W.	762A679H01
Q251-Q252	2N4356	849A441H02
Q253	2N3417	848A851H01
Q254	2N3645	849A441H01

Power Supply Section

SYMBOL	FUNCTION	DESCRIPTION OR RATING	STYLE NUMBER
C1	(+) to (−) bypass	0.45 mfd. 330 VAC	1723408
C2	A-C grounding	0.5 mfd, 1500 VDC	1877962
C3	A-C grounding	0.5 mfd, 1500 VDC	1877962
C4	Filter	1.8 mfd, 800 VDC	14C9400H12
L1	Filter	5.5 mh.	719B135G01
Q1	Series Regulator	Type 2N1015C Silicon Transistor	187A342H02
R1	125V — Series dropping	26.5 ohms, 40W.	04D1299H44
R2	125V — Series dropping	Same as R1	04D1299H44
R3	125V — Current limiting	500 ohms, 40W.	1268047
R1	48V — For 48 VDC, R1 = R2 0	—	—
R2	48V — For 48 VDC, R1 = R2 0	—	—
R3	48V — R3 = 26.5 ohms	40W.	04D1299H44
TP1	Test point (+)	Pin Jack — red	187A332H01
TP2	Test point (−)	Pin Jack — black	187A332H02
Z1	Voltage Regulator	1N2828B (45V.)	184A854H06
Z2	Surge Protection	1N3009A (130V.) Zener Diodes	184A617H12
Z3	Voltage Reg. — for 250 V.D.C.	1N2813B (15V.)	184A854H11

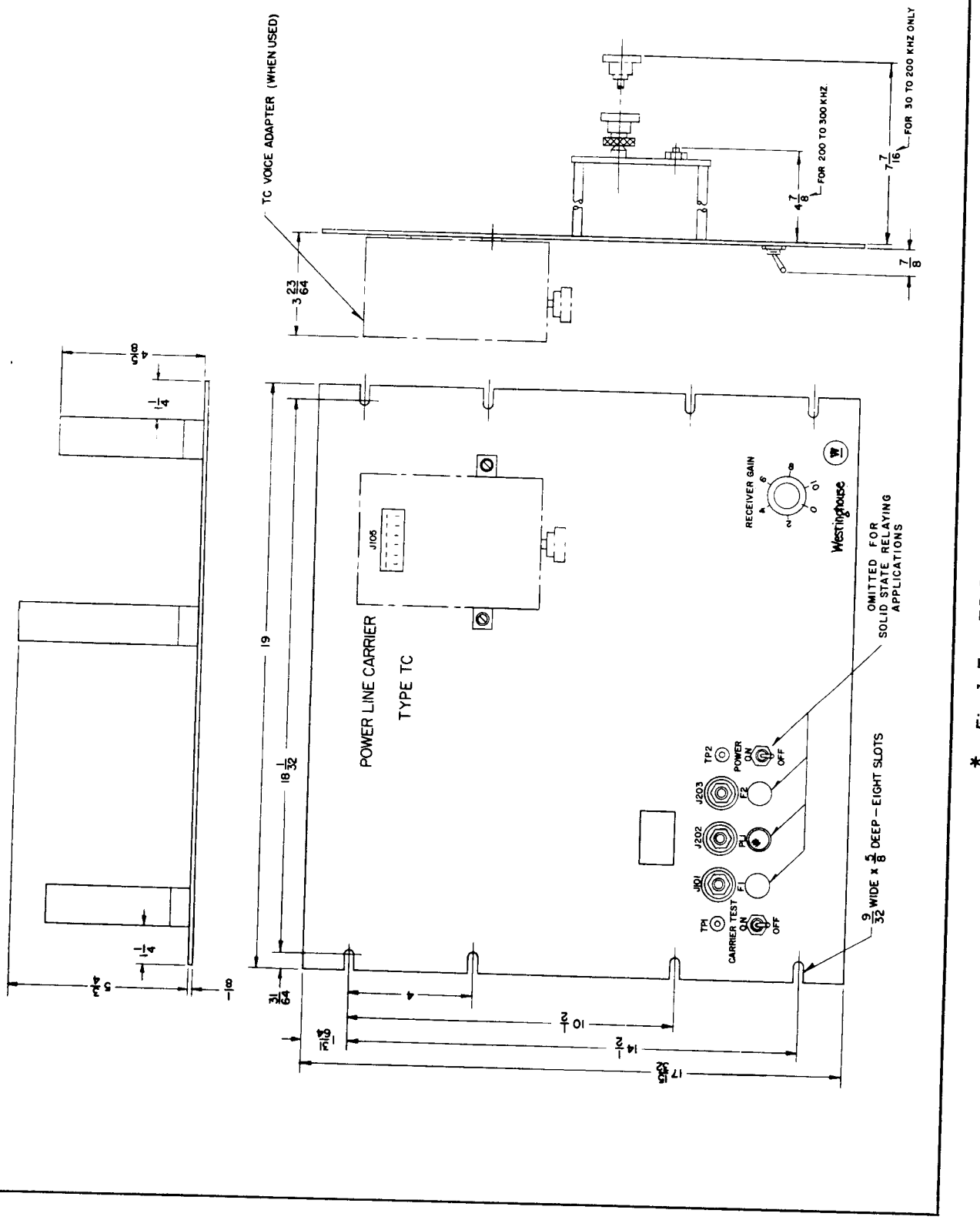
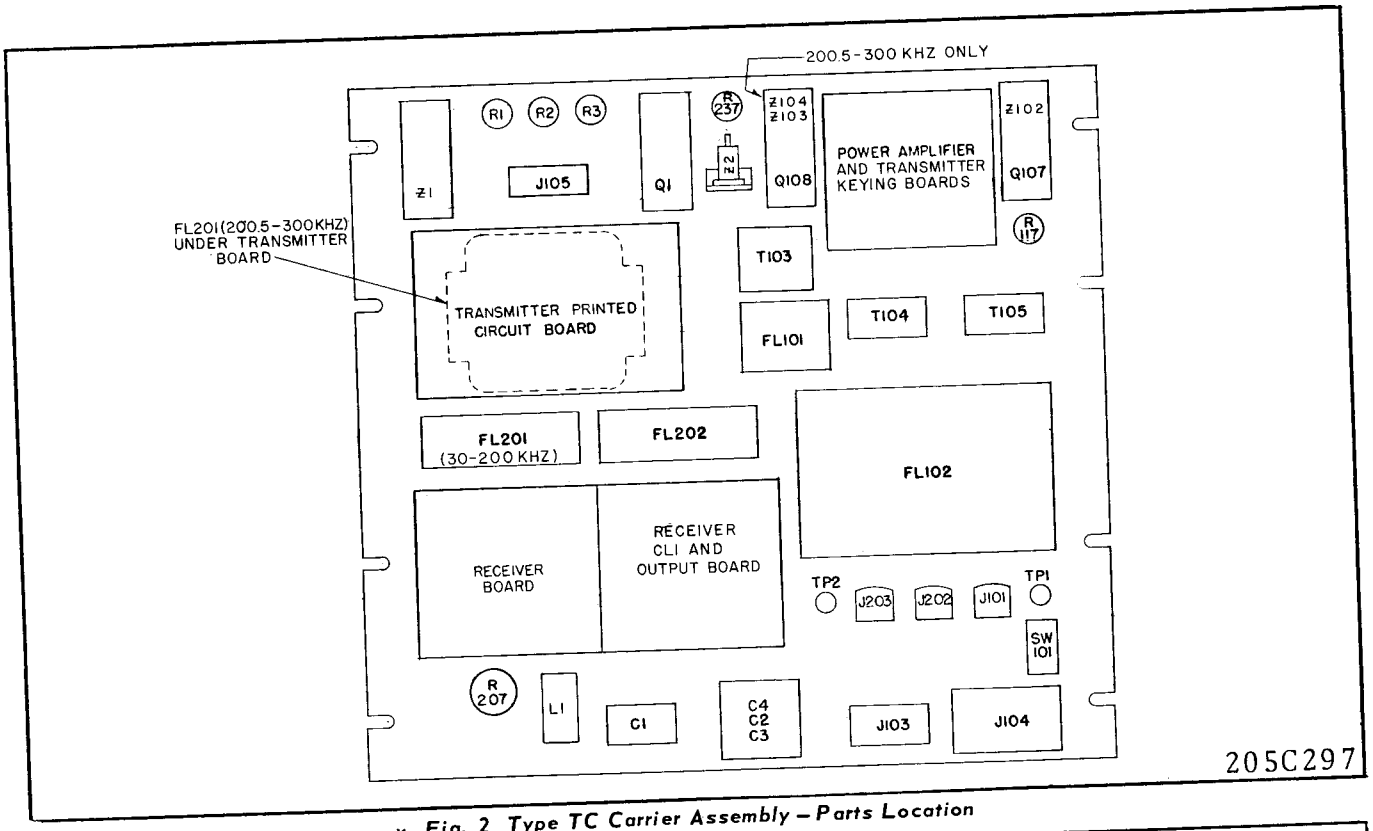
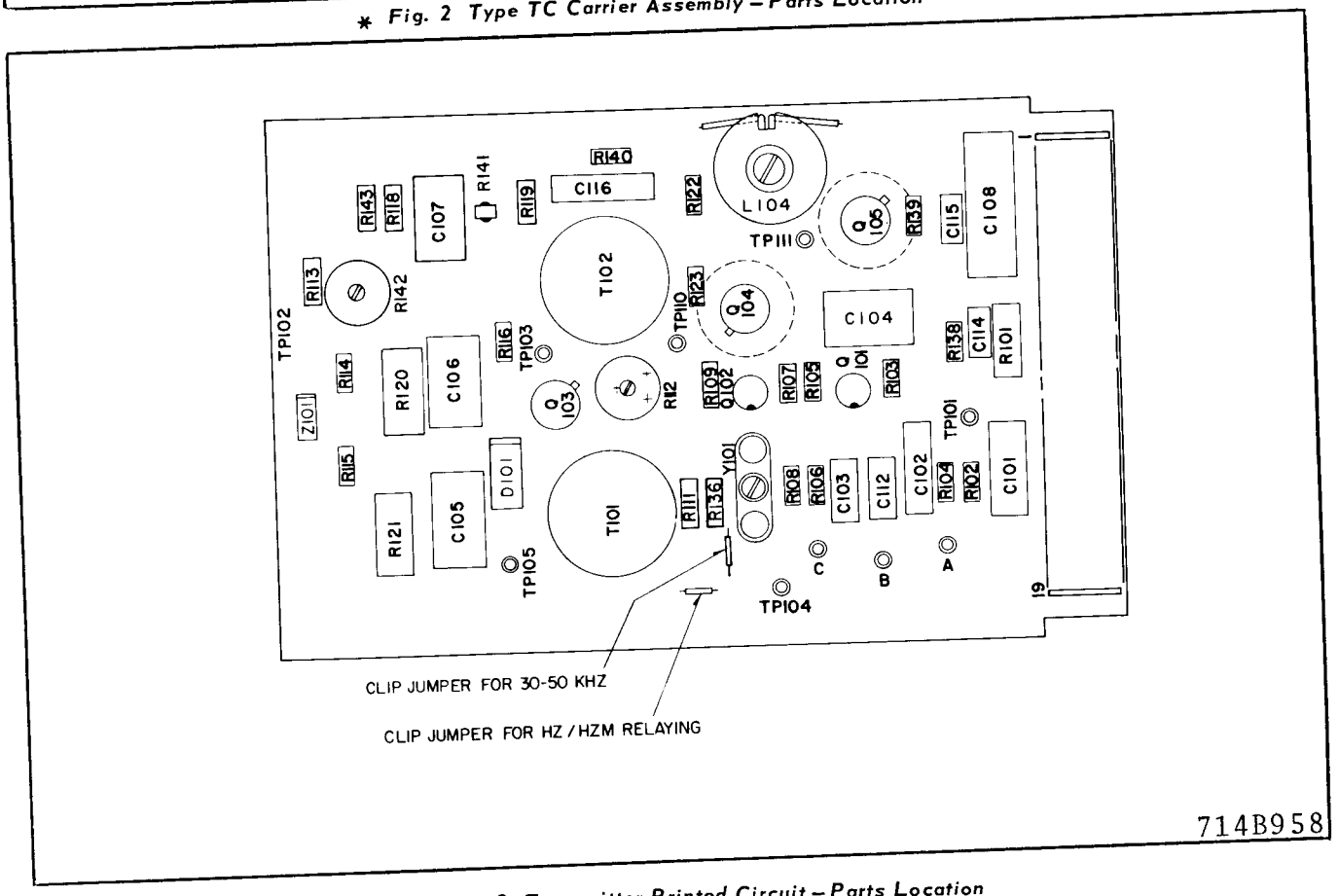


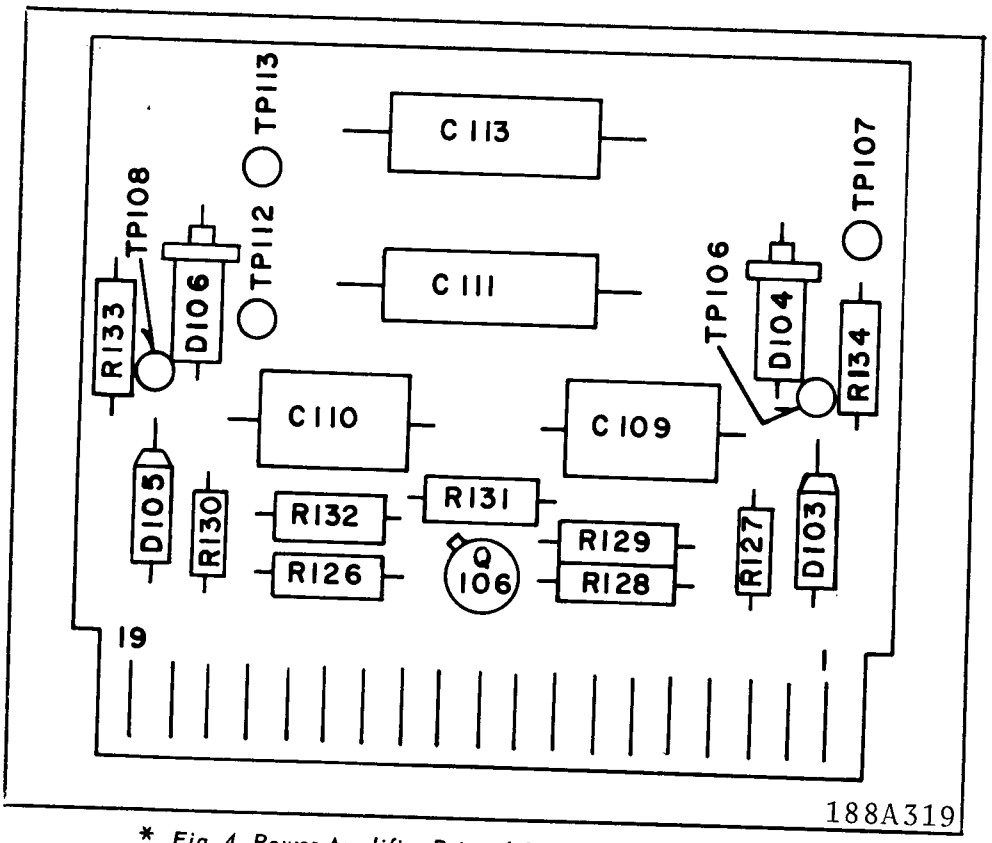
Fig. 1 Type TC Carrier Assembly – Outline



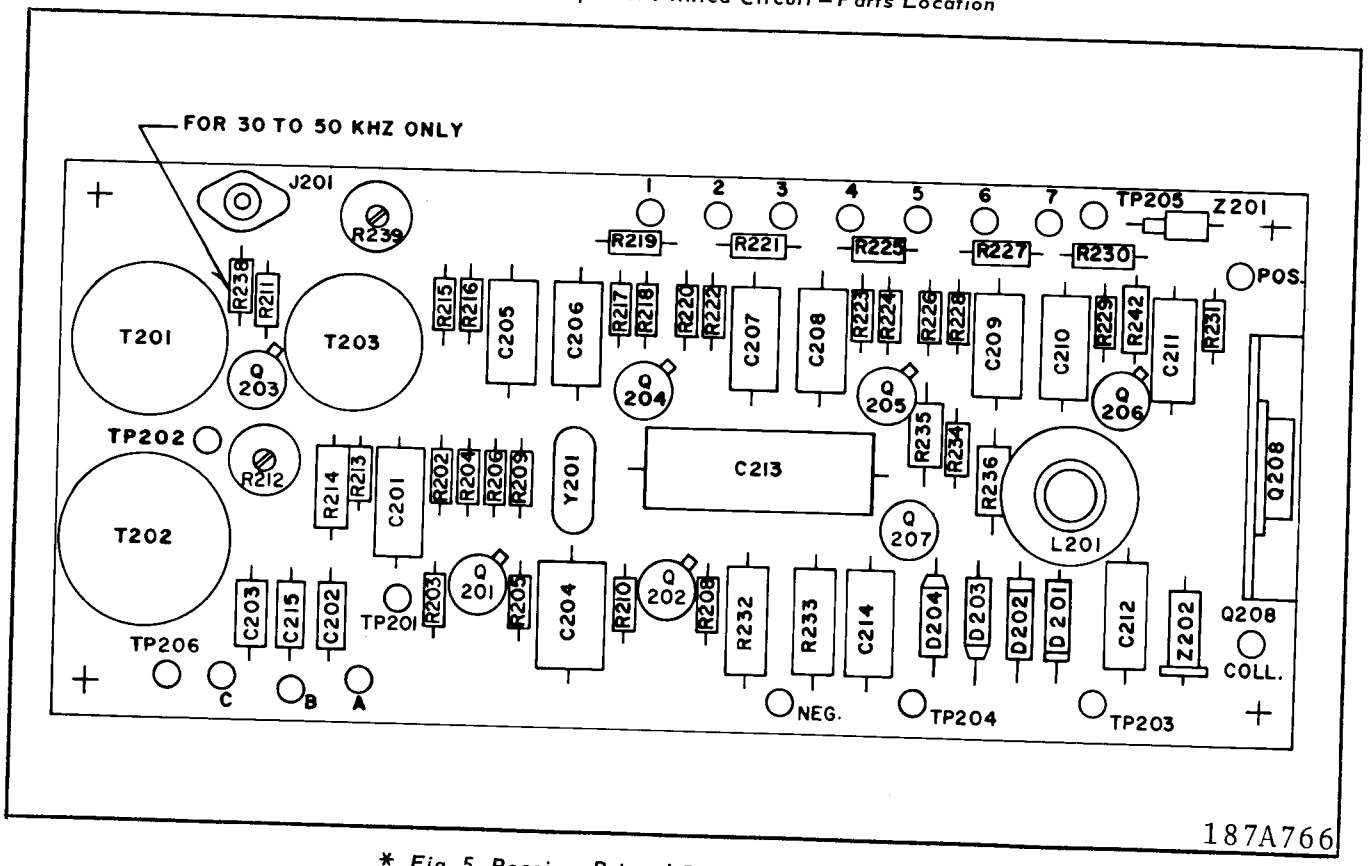
* *Fig. 2 Type TC Carrier Assembly – Parts Location*



* *Fig. 3 Transmitter Printed Circuit – Parts Location*



* *Fig. 4 Power Amplifier Printed Circuit – Parts Location*



* *Fig. 5 Receiver Printed Circuit – Parts Location*

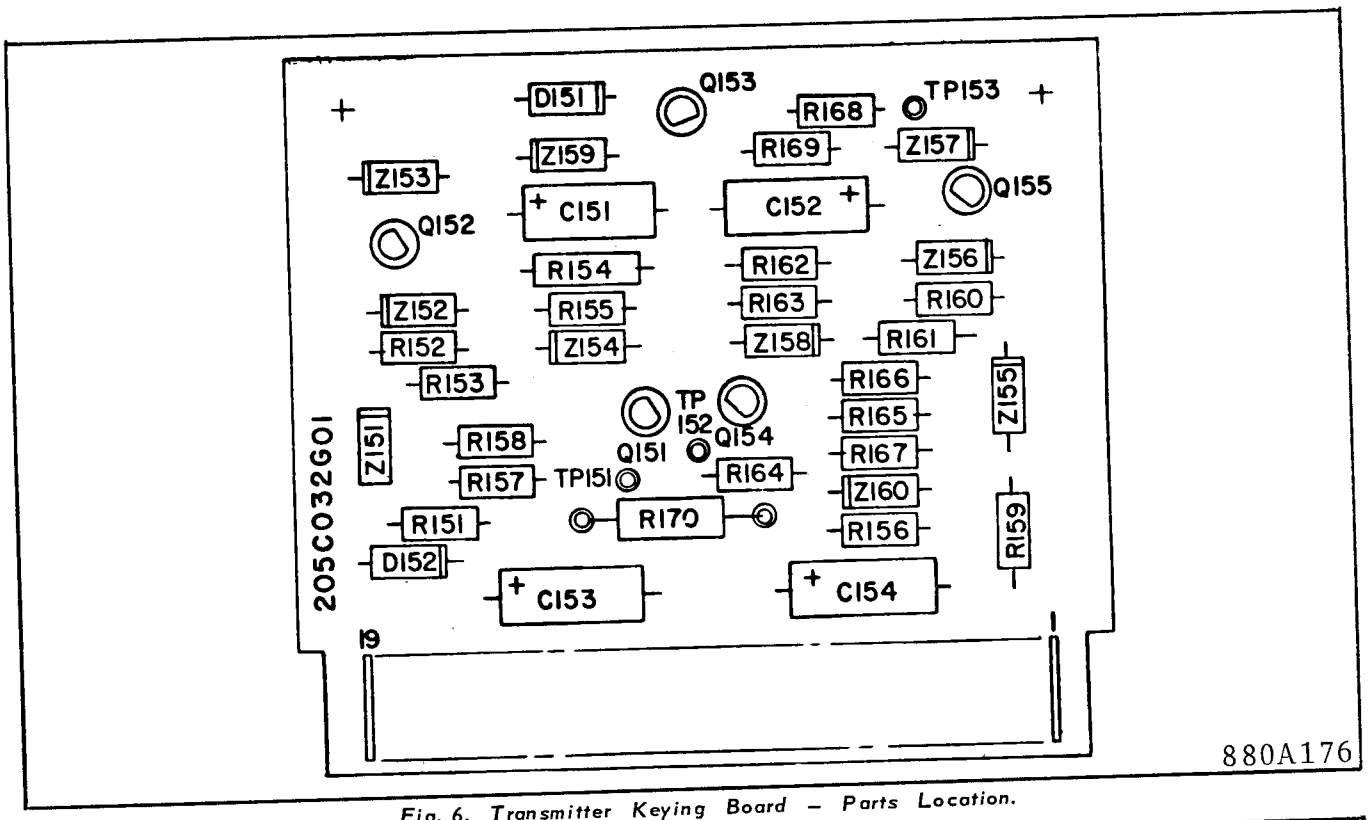


Fig. 6. Transmitter Keying Board – Parts Location.

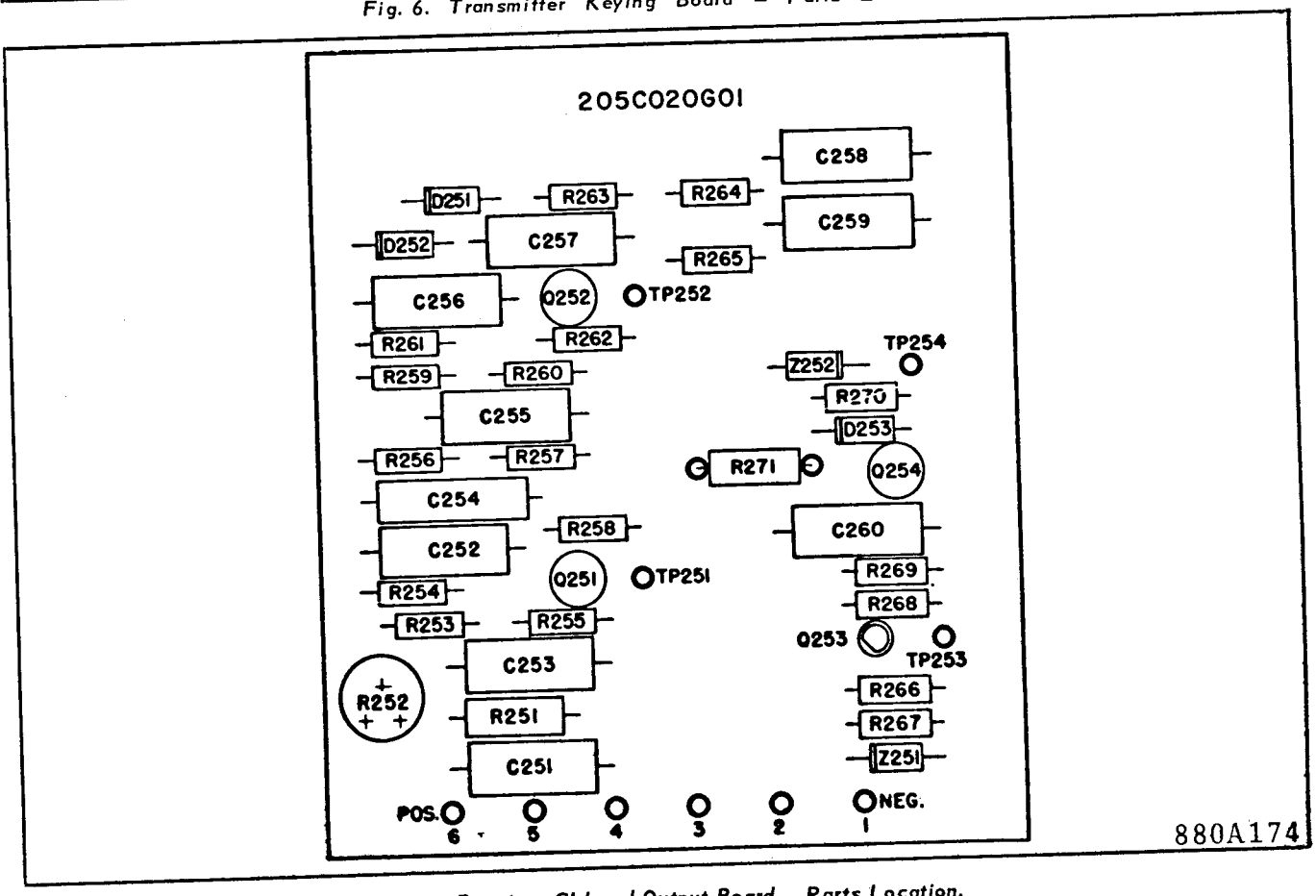
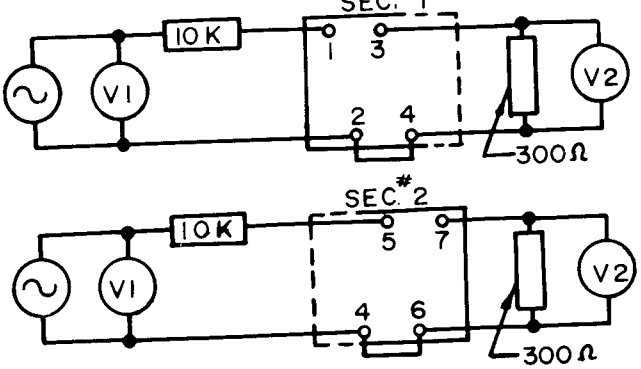
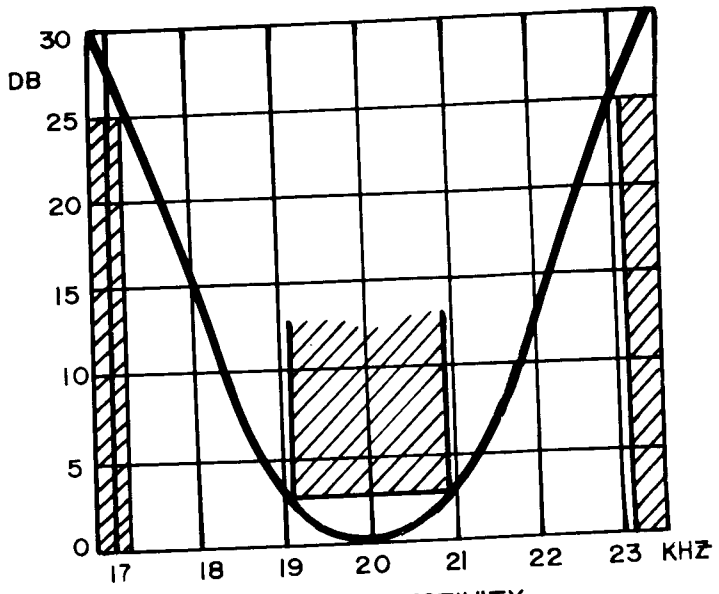


Fig. 7. Receiver CLI and Output Board – Parts Location.

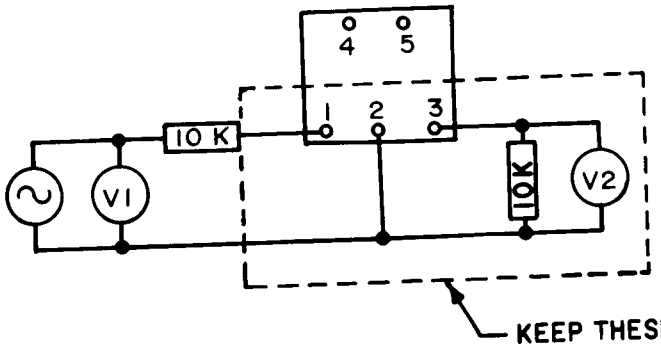
I.F. FILTER TEST CIRCUIT



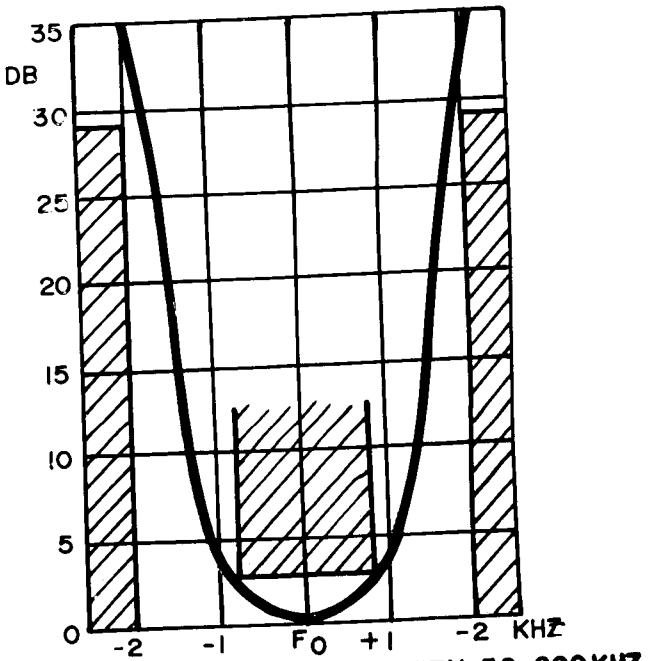


TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.

INPUT FILTER TEST CIRCUIT



FOR BOTH FILTERS,
DB = 20 LOG $\frac{V1}{V2}$



TYPICAL SELECTIVITY **30-200KHZ**
INSERTION LOSS 12-18 DB,
RISING WITH FREQUENCY.

TC RECEIVER FILTER LIMITS

INPUT FILTER FOR 200.5 - 300 KHZ
INSERTION LOSS 12-16 DB, RISING WITH FREQUENCY
DOWN 3db AT ± 0.8-1.1 KHZ, RISING WITH FREQUENCY
AT 2 KHZ, DOWN 22-35 DB, DROPPING WITH RISING FREQUENCY

629A42

* *Fig. 9. Type TC Receiver Filter Characteristics*

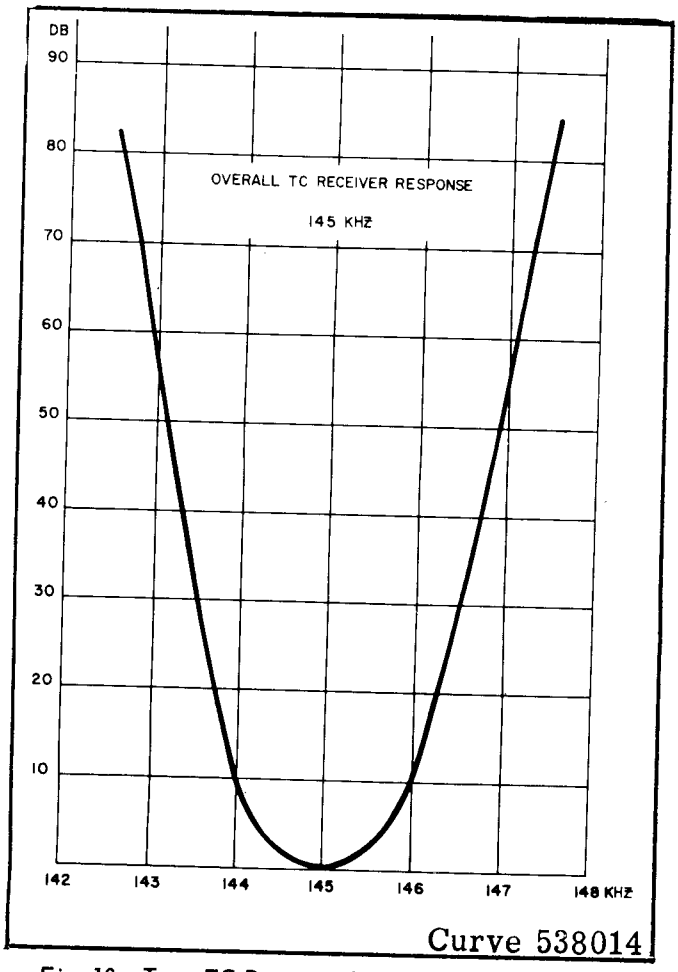


Fig. 10. Type TC Receiver Overall Selectivity Curve.

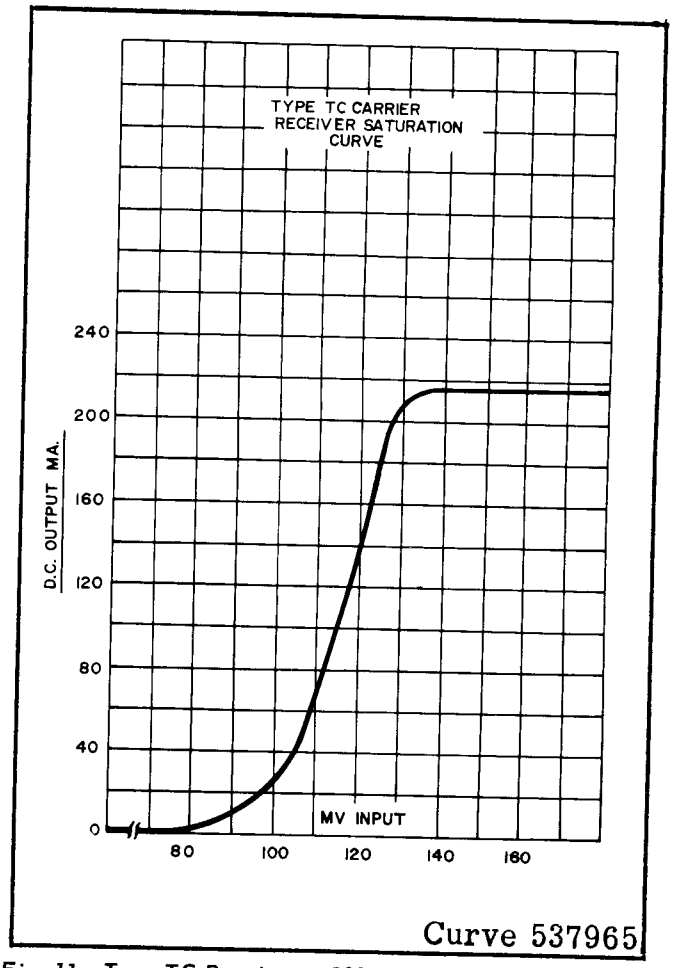


Fig. 11. Type TC Receiver – 200 ma. Output Characteristic.

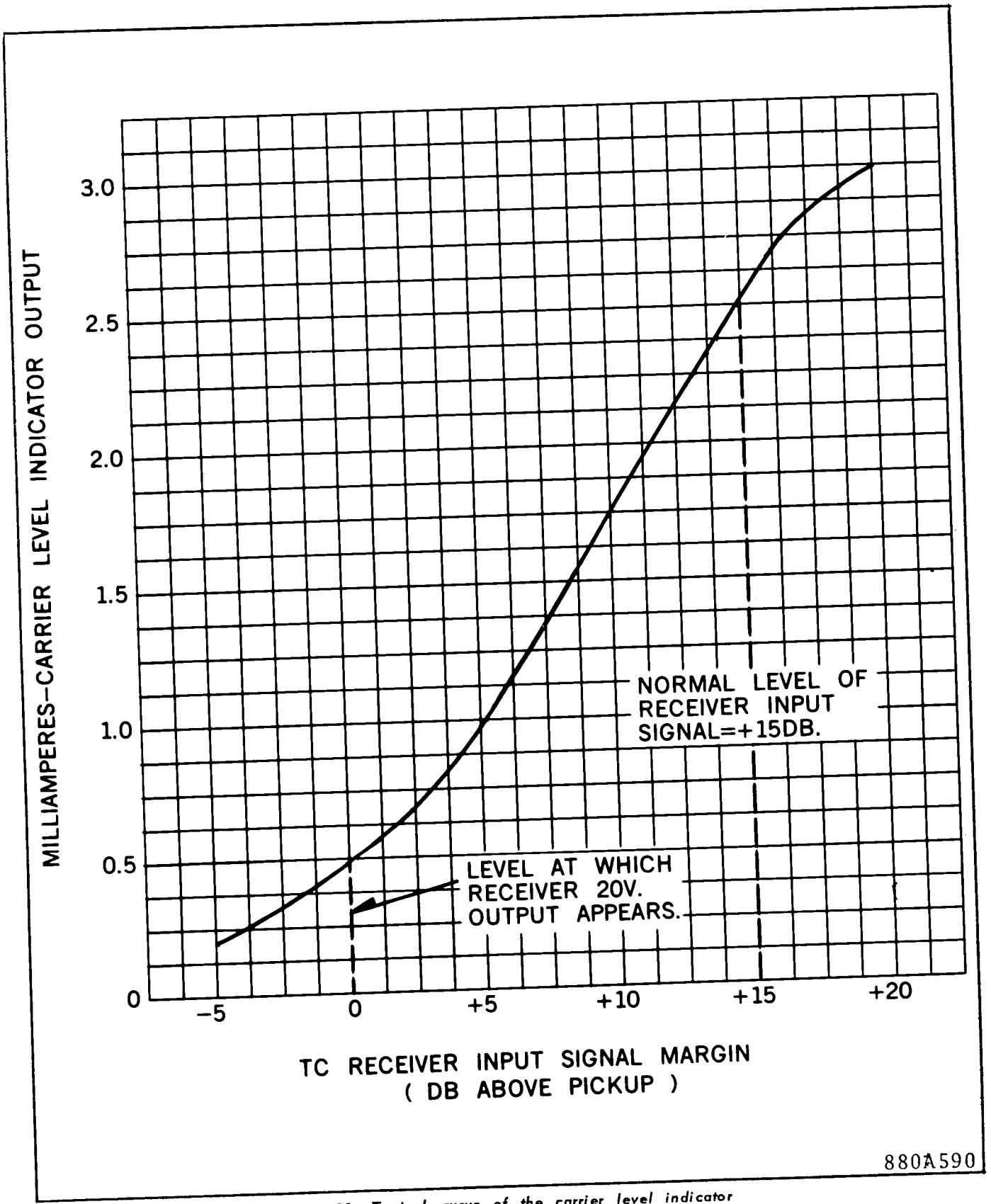


Fig. 12. Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

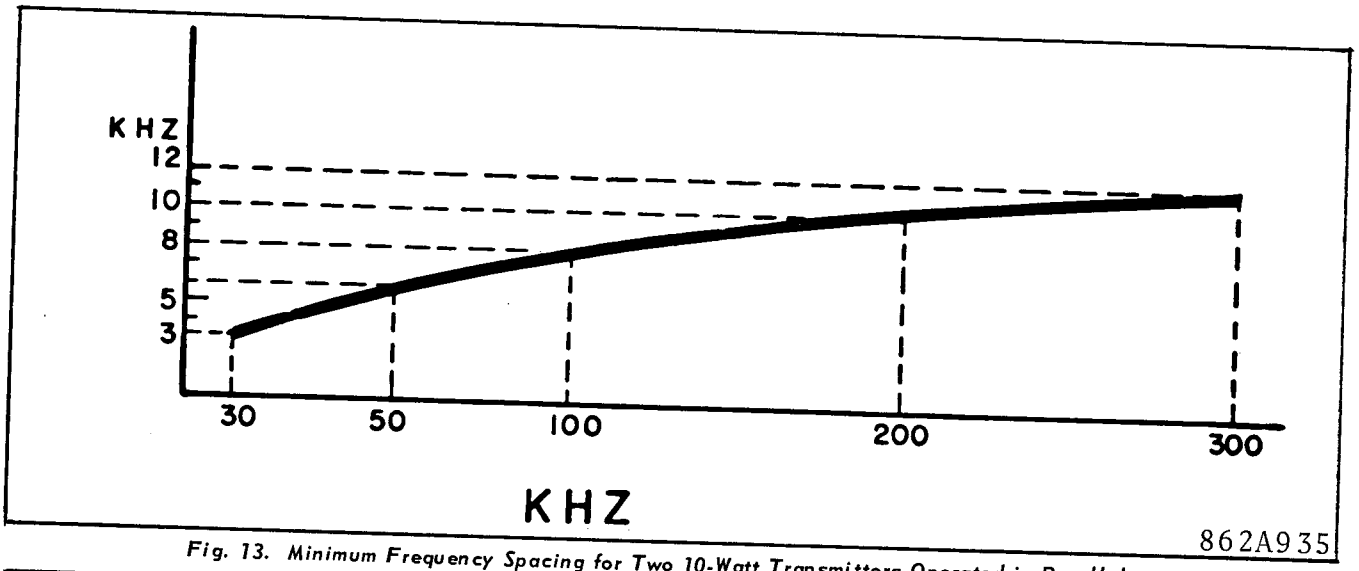


Fig. 13. Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

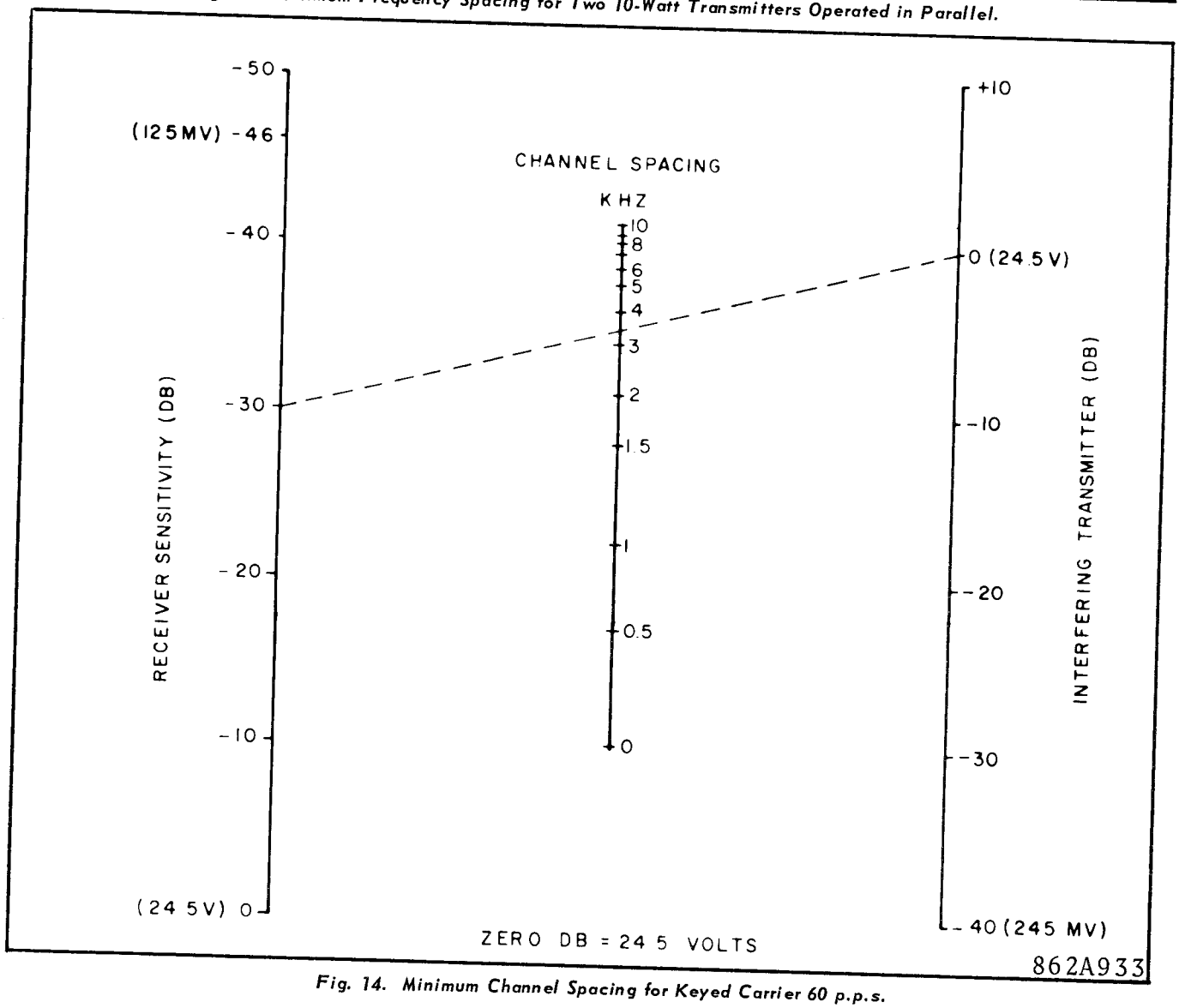
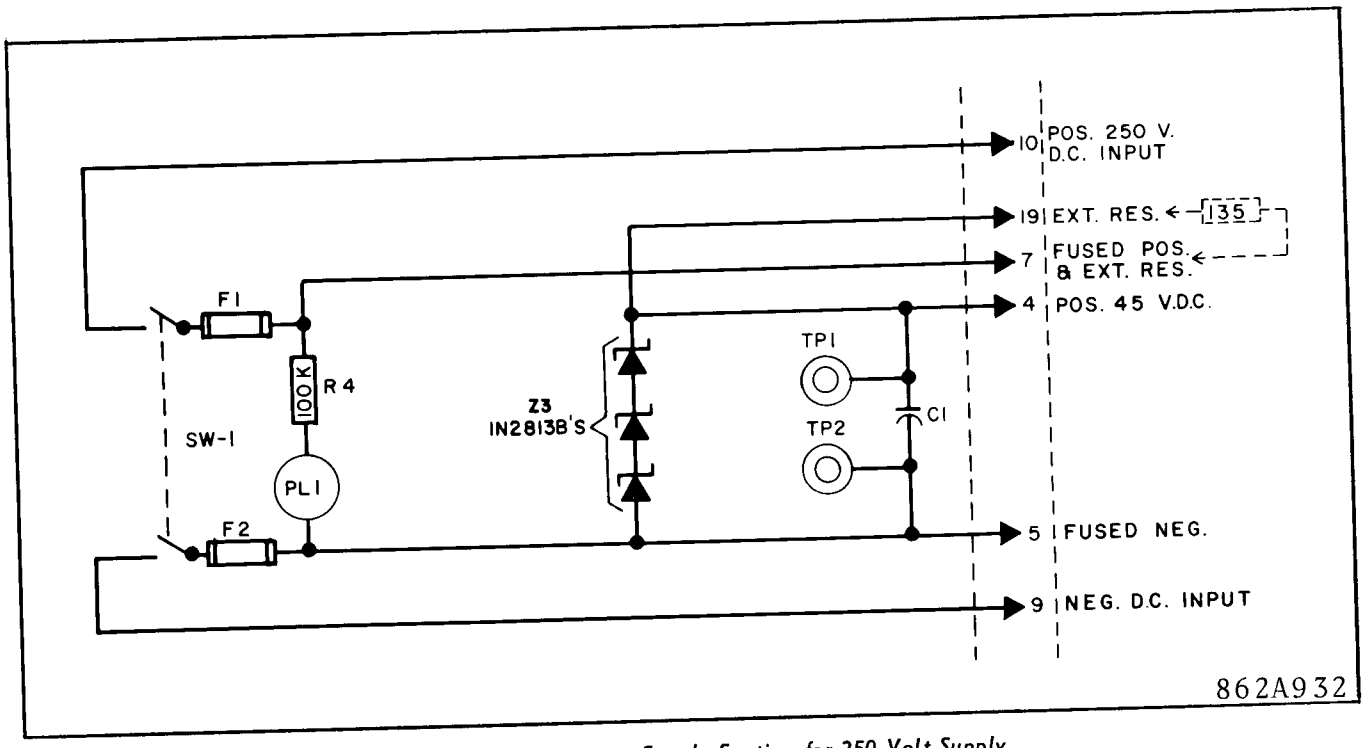
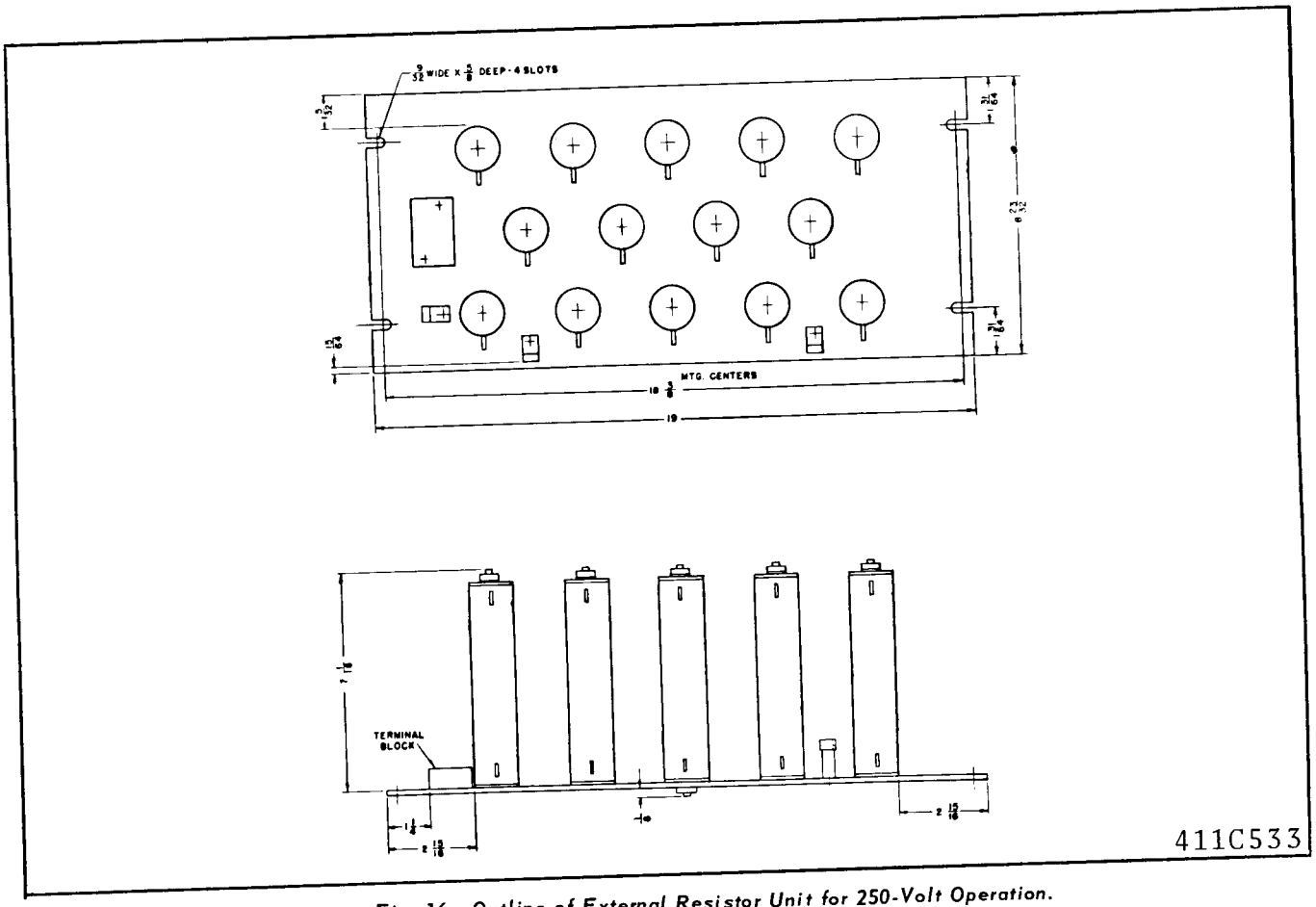


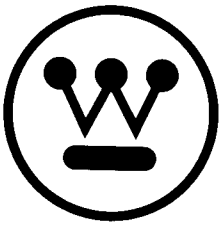
Fig. 14. Minimum Channel Spacing for Keyed Carrier 60 p.p.s.



* *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.
Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

NEW INFORMATION

EFFECTIVE NOVEMBER 1971

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 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 ±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: 48 V.D.C.	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 +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 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.

NOTE: 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 ± 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 transistors 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)
   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#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 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

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

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

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

1. Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
2. Receiver input filter (FL201), specify frequency.
3. 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 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.

TEST POINT	TYPICAL A-C VOLTAGES	
	36 kHz.	132 kHz.
FL201-IN to Gnd.	.075	.050
FL201-OUT to Gnd.	.051	.020
Q203 - E to TP206	.105	.090
Q204 - C to TP206	.90	.52
Q205 - B to TP206	.11	.052
Q205 - C to TP206	6.7	3.4
Q206 - B to TP206	.67	.37
Q206 - C to TP206	1.5	1.53
TP202 to TP206	0.3	0.3

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.

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

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

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.	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.

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)

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.

ELECTRICAL PARTS LIST

Transmitter Section

SYMBOL	RATING	STYLE NUMBER
C101	0.1 mfd, 200 V. DC	187A624H01
C102	.005 mfd, 300 V. DC	187A694H29
C103	180 pf. 500 V. DC	187A695H29
C104	0.25 mfd, 200 V. DC	187A624H02
C105	0.25 mfd, 200 V. DC	187A624H02
C106	0.25 mfd, 200 V. DC	187A624H02
C107	0.25 mfd, 200 V. DC	187A624H02
C108	0.50 mfd, 200 V. DC	187A624H03
C109	0.25 mfd, 200 V. DC	187A624H02
C110	0.25 mfd, 200 V. DC	187A624H02
† C111	(See Table Below)	—
C112	39 pfd, 500 V. DC	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
CR101	1N3686B (20 V ± 5%)	185A212H06
CR102	1N457A	184A855H07
CR103	1N538	407C703H03
CR104	1N91	182A881H04
CR105	1N538	407C703H03
CR106	1N91	182A881H04
CR107-108	1N2999A (56 V ±10%)	184A617H13
CR109 #	1N2999A (56 V ±10%)	184A617H13
G101	Type RVS Arrester	637A026A01
J101	Closed Circuit Jack	187A606H01

#200.5 – 300 kHz only.

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

ELECTRICAL PARTS LIST

Transmitter Section (Cont.)

SYMBOL	RATING	STYLE NUMBER
J102	Banana Plug Jack	54B159H02
J103	Coaxial Cable Jack	187A633H01
J104	24-Term Receptacle	187A669H01
J105	12-Term Receptacle	629A205H02
L101	Part of FL101	Vary with Frequency
L102	FL102 Trap Coil (2nd Harmonic)	Vary with Frequency
L103	FL102 Trap Coil (3rd Harmonic)	Vary with Frequency
L104	400 mh.	292B096G01
L105	FL102 Coil (part of series-resonant circuit tuned to fundamental freq.)	Vary with Frequency
Q101	2N274	187A270H01
Q102	2N274	187A270H01
Q103	2N525	184A638H13
Q104	2N657	184A638H15
Q105	2N657	184A638H15
Q106	TI-481	184A638H11
Q107	2N1908 Matched Pair - Texas Instrument	187A673H02
Q108	2N1908 Co. - Identif. GP2151	

SYMBOL	OHMS	± TOL. %	WATTS	STYLE NUMBER
R101	5,600	5	1	187A643H45
R102	2,200	10	0.5	187A641H35
R103	10,000	10	0.5	187A641H51
R104	100,000	5	0.5	187A763H75
R105	390	5	0.5	184A763H17
R106	1,200	5	0.5	184A763H29
R107	10,000	10	0.5	184A641H51
R108	100,000	5	0.5	184A763H75
R109	390	5	0.5	184A763H17
R111	1,200	5	0.5	187A763H29
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	184A763H07

ELECTRICAL PARTS LIST

Transmitter Section (Cont.)

SYMBOL	OHMS	±TOL. %	WATTS	STYLE NUMBER
R116	100	5	0.5	184A763H03
R117	1,000	5	25	1202588
R118	12,000	2	0.5	629A531H58
R119	62	2	0.5	629A531H03
R120	10,000	5	2	185A207H51
R121	10	5	2	187A683H01
R122	10	5	0.5	187A290H01
R123	10	10	0.5	187A290H01
R124	100	10	1	187A644H03
R125	1,000	10	0.5	187A641H27
R126	4,700	10	1	187A644H43
R127	10	10	0.5	187A640H01
R128	2,200	5	1	187A644H35
R129	2.7	10	0.5	184A636H14
R130	10	10	0.5	187A640H01
R131	4,700	5	1	187A644H43
R132	2.7	10	0.5	184A636H14
R133	0.27	10	1	184A636H14
R134	0.27	10	1	184A636H18
R135	3,000	10	5	188A317H01
R136	12,000	2	0.5	629A531H58
R137	15,000	10	2	187A642H55
R138	1,000	10	0.5	187A641H27
R139	1,000	10	0.5	187A641H27
R140	68	2	0.5	629A531H04
R141	30	Type 3D202 Thermistor		185A211H06
R142	25K pot.	20	0.25	584C276H23
R143	20,000	2	0.5	629A531H63

SYMBOL	RATING		STYLE NUMBER
T101	10,000/400 ohms		205C043G01
T102	10,000/400 c.t.		714B666G01
T103	1930/60 ohms	L633000	1962694
T104	Turns ratio, 1/0.5	Pri./each sec.	292B526G01
T105	10/500 ohms		292B526G02
T106	500/50 - 60 - 70 ohms		292B526G03
Y101	30-300 kHz crystal per 328C083		Specify Frequency

ELECTRICAL PARTS LIST

Transmitter Keying Board

SYMBOL	RATING	STYLE NUMBER
C151-C152	.047 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)	185A797H13
Z160	1N5357B (20V)	862A288H02
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	187A624H02
C215	39 pfd., 500 V. DC	187A695H12
CR201	1N3027B (20V ± 5%)	184A449H07
CR202	1N91	182A881H04
CR203	1N91	182A881H04

ELECTRICAL PARTS LIST

Receiver Section (cont.)

SYMBOL	RATING	STYLE NUMBER
CR204	1N538	407C703H03
CR205	1N538	407C703H03
CR206	1N1789 (56 V. ±10%)	484C434H08
FL201	Receiver Input Filter 30-300 kHz	Specify Frequency
FL202	Receiver i.f. Filter-20kHz (2 sections)	187A590G02
J201	Receiver Coax. Input Jack	187A638H01
J202	Closed Circuit Jack (CLI)	187A606H01
J203	Closed Circuit Jack (200MA)	187A606H01
L201	33 mh.	187A599H01
Q201	2N274	187A270H01
Q202	2N274	187A270H01
Q203	2N274	187A270H01
Q204	2N274	187A270H01
Q205	2N274	187A270H01
Q206	2N274	187A270H01
Q207	2N398A	184A638H12
Q208	2N1362	187A673H01

SYMBOL	RATING			STYLE NUMBER
	OHMS	± 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	25 K Pot.	10	2	185A086H07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H75
R210	390	5	0.5	184A763H17
† R211	—	—	—	See † Note Below
R212	1 K Pot.	20	0.25	629A430H02
R213	1,200	5	0.5	184A763H29
R214	5,600	5	1	187A643H45
R215	20,000	5	0.5	184A763H58
R216	3,600	5	0.5	184A763H40

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

ELECTRICAL PARTS LIST

Receiver Section (Cont.)

SYMBOL	RATING			STYLE NUMBER
	OHMS	±TOL. %	WATTS	
R217	620	5	0.5	184A763H22
R218	62	5	0.5	187A290H20
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	62	5	0.5	187A290H20
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	184A763H40
R229	620	5	0.5	184A763H22
R230	27	5	0.5	187A290H11
R231	2,000	5	0.5	184A763H34
R232	1,200	5	2	185A207H29
R233	4,700	10	2	187A642H43
R234	5,100	5	0.5	184A763H44
R235	470	10	1	187A644H19
R236	4,700	10	1	187A644H43
R237	170	5	40	1336074
† R238	—	—	—	See † Note Below
R239	1 K pot.	20	0.25	629A430H02
R241	100	Type 3D102 Thermistor		185A211H12
R242	100	Type TM-¼ Sensistor		187A685H06
T201	10,000/10,000	Ohms		714B677G01
T202	10,000/400	Ohms		205C043G01
T203	25,000/300	Ohms		205C043G03
Y201	50-320kHz Crystal per 328C083			Specify Frequency

Receiver CLI and Output Board

SYMBOL	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.	188A669H15
D251-D252	1N457A	184A855H07
D253	1N645A	837A692H03
Z251	1N3686B (20V.)	185A212H06
Z252	1N3688A (24V,)	862A288H01

† R238- omit - above 50kHz
- 22K, 30-50KHz, S#187A641H59.

ELECTRICAL PARTS LIST

Receiver CLI and Output Board (Cont.)

SYMBOL	RATING	STYLE NUMBER
R251	2.7K, TM-¼ Sensistor	187A685H05
R252	5K, ¼W. pot.	629A430H07
R253	220, ½W.	184A763H11
R254	2.2K, ½W.	184A763H35
R255-R260	15K, ½W.	184A763H55
R256	2.4K, ½W.	184A763H36
R257	330, ½W.	184A763H15
R258-R259	4.7K, ½W.	184A763H43
R261	560, ½W.	184A763H21
R262-R265	1.2K, ½W.	184A763H29
R263-R264	180, ½W.	184A763H09
R266	27K, ½W.	629A531H66
R267-R269	10K, ½W.	629A531H56
R268	6.8K, ½W.	629A531H52
R270	82K, ½W.	629A531H78
R271	150, 3W.	762A679H01
Q251-Q252	2N4356	849A441H02
Q253	2N3417	848A851H01
Q254	2N3645	849A441H01

Power Supply Section

SYMBOL	FUNCTION	DESCRIPTION OR RATING	STYLE NUMBER
C1	(+) to (−) bypass	0.45 mfd. 330 VAC	1723408
C2	A-C grounding	0.5 mfd, 1500 VDC	1877962
C3	A-C grounding	0.5 mfd, 1500 VDC	1877962
C4	Filter	1.8 mfd, 800 VDC	14C9400H12
L1	Filter	5.5 mh.	719B135G01
Q1	Series Regulator	Type 2N1015C Silicon Transistor	187A342H02
R1	125V Series dropping	26.5 ohms, 40W.	04D1299H44
R2	125V Series dropping	Same as R1	04D1299H44
R3	125V Current limiting	500 ohms, 40W.	1268047
R1	48V For 48 VDC, R1 = R2 0	—	—
R2	48V For 48 VDC, R1 = R2 0	—	—
R3	48V R3 = 26.5 ohms	40W.	04D1299H44
TP1	Test point (+)	Pin Jack — red	187A332H01
TP2	Test point (−)	Pin Jack — black	187A332H02
VR1	Voltage Regulator	1N2828B (45V.)	184A854H06
VR2	Surge Protection	1N3009A (130V.) Zener Diodes	184A617H12
VR3	Voltage Regulator	1N2813B (15V.)	184A854H11

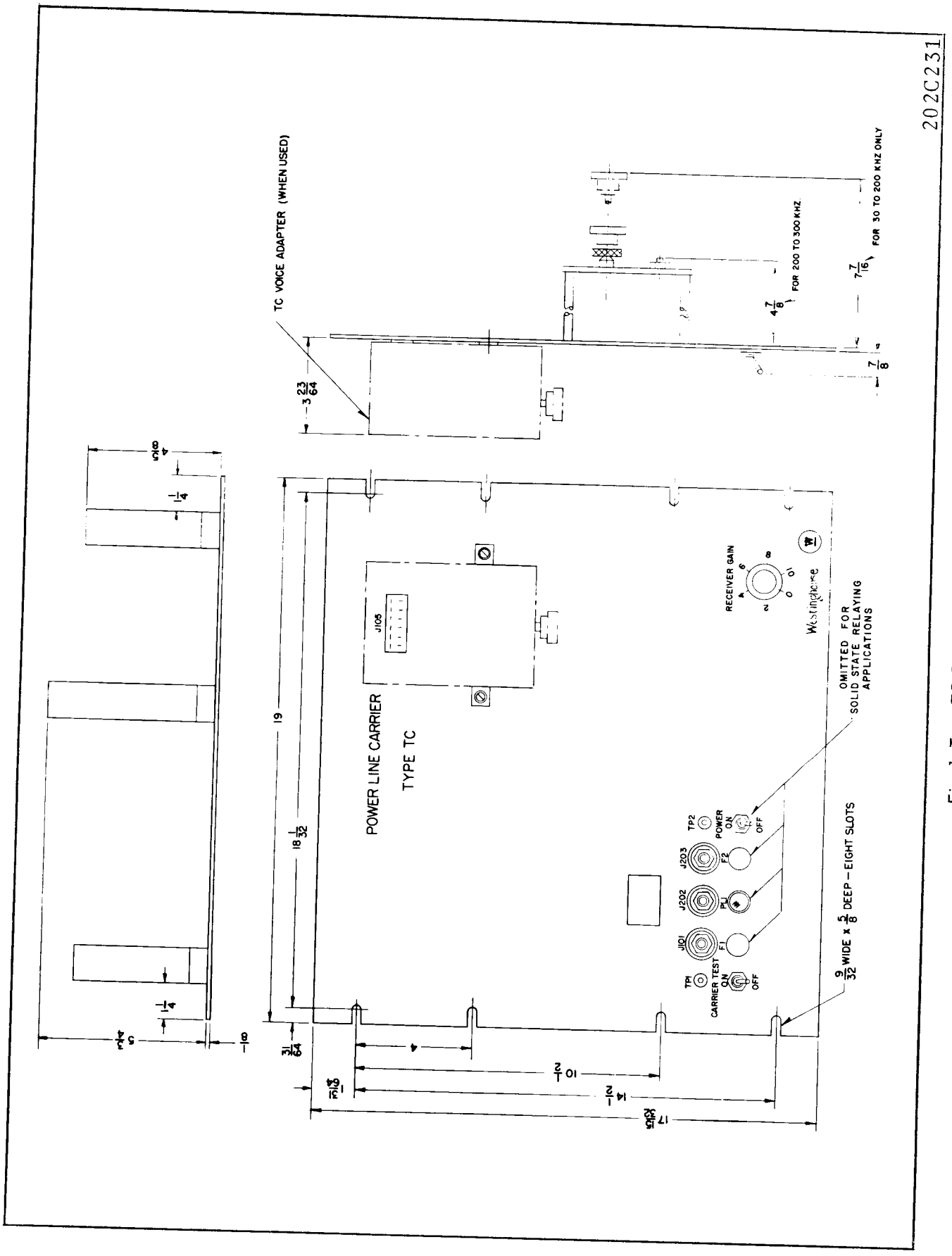


Fig. 1 Type TC Carrier Assembly – Outline

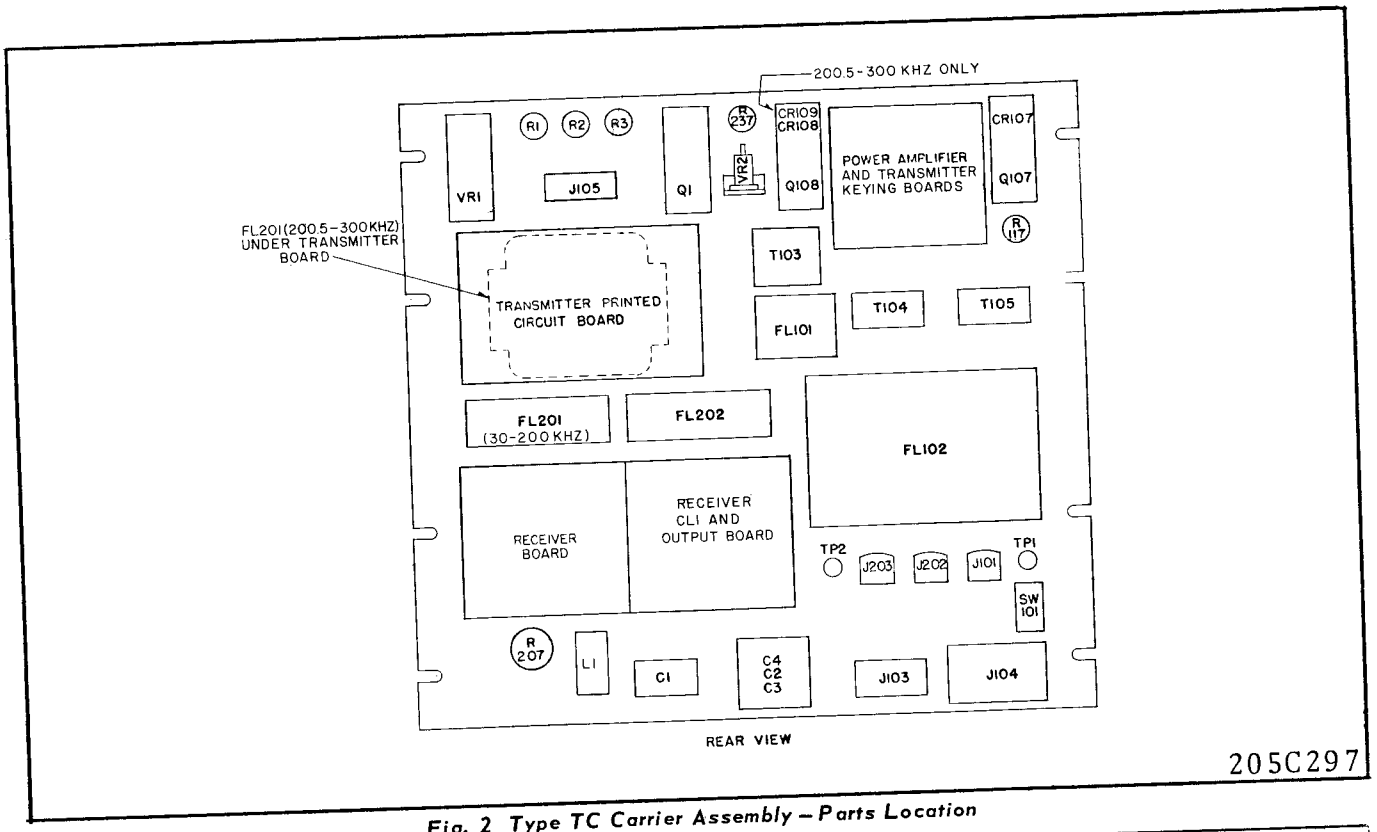


Fig. 2 Type TC Carrier Assembly – Parts Location

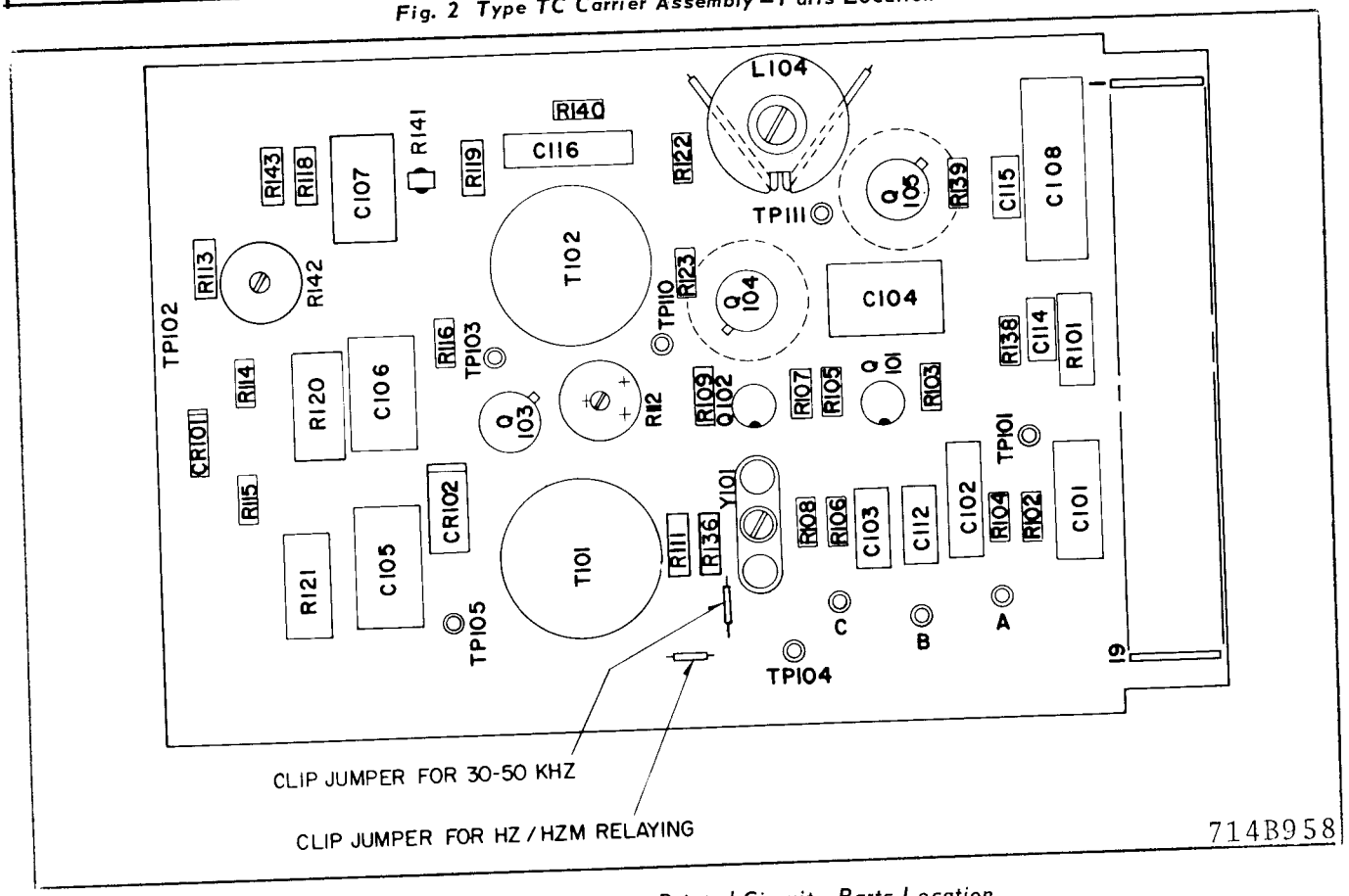


Fig. 3 Transmitter Printed Circuit – Parts Location

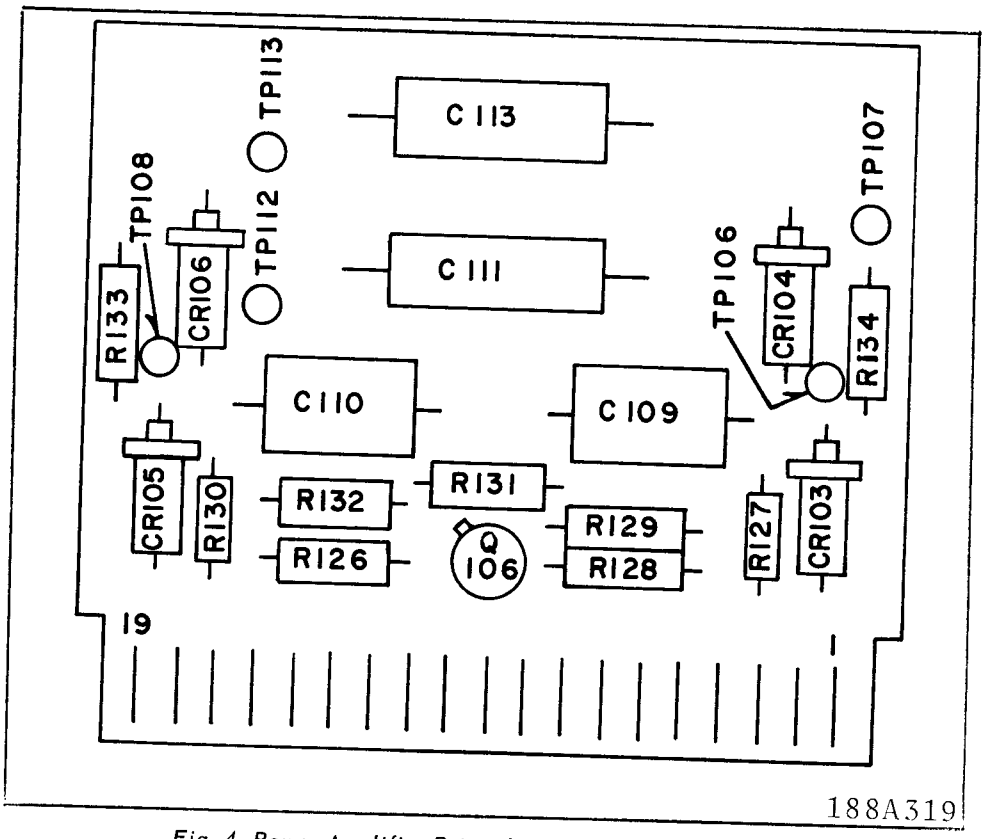


Fig. 4 Power Amplifier Printed Circuit – Parts Location

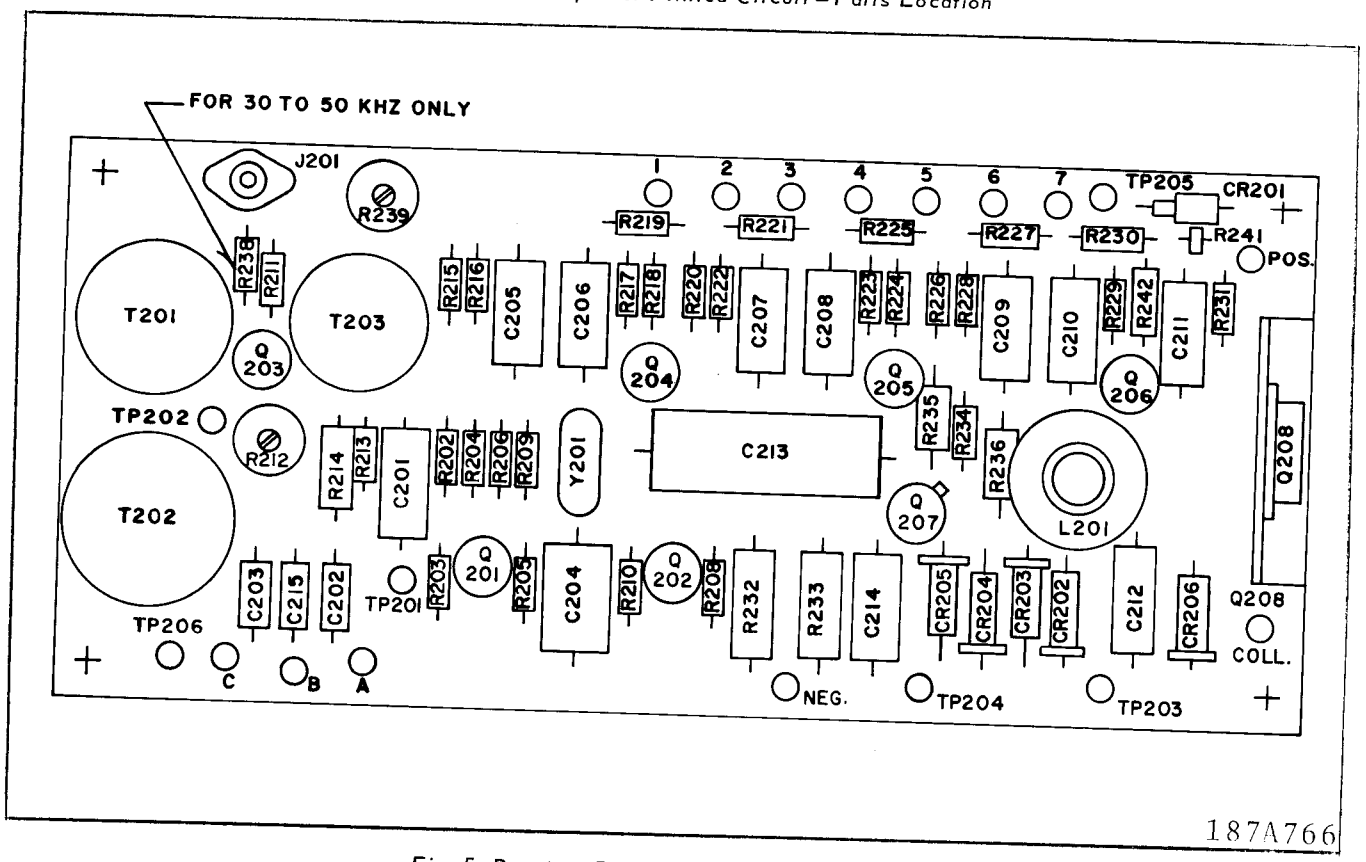


Fig. 5 Receiver Printed Circuit – Parts Location

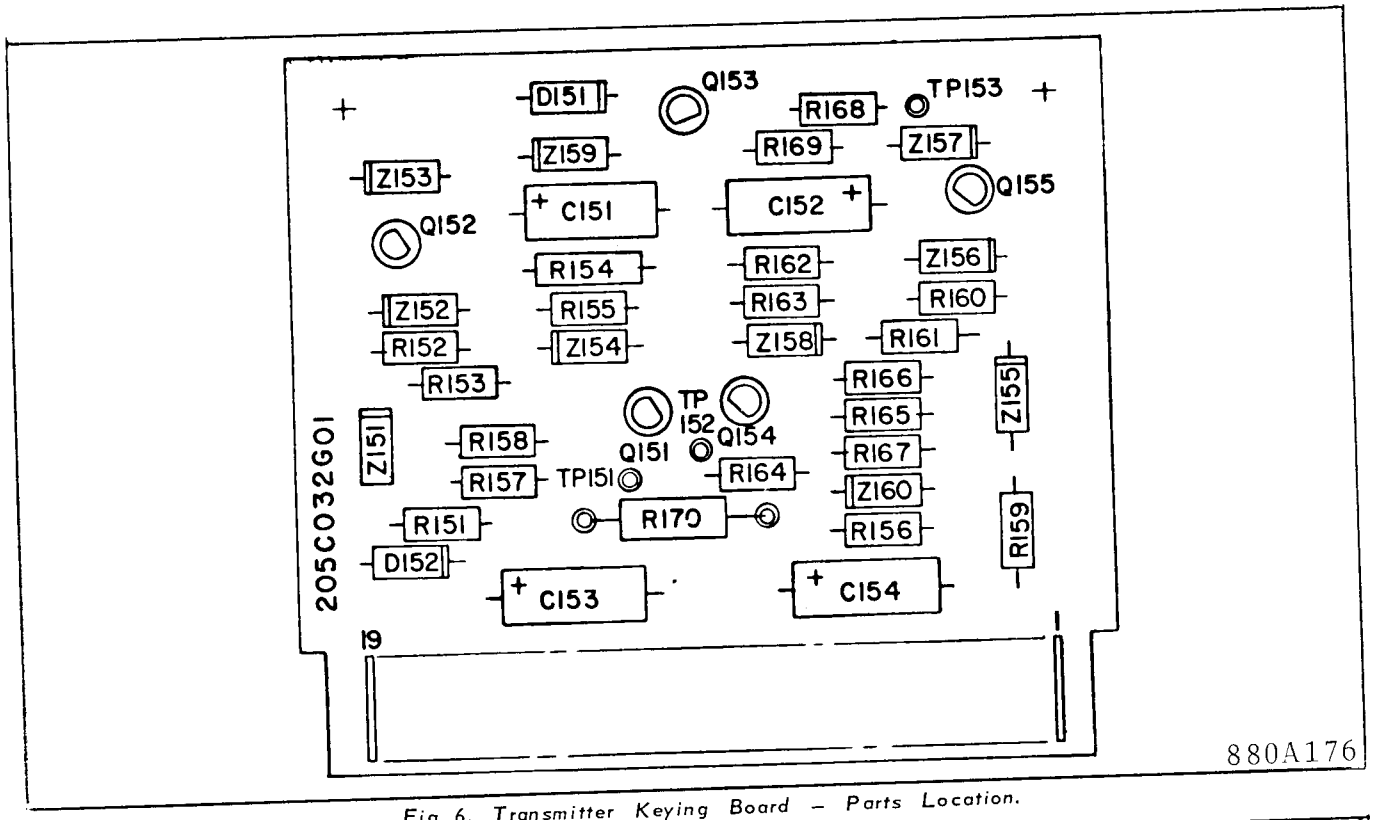


Fig. 6. Transmitter Keying Board – Parts Location.

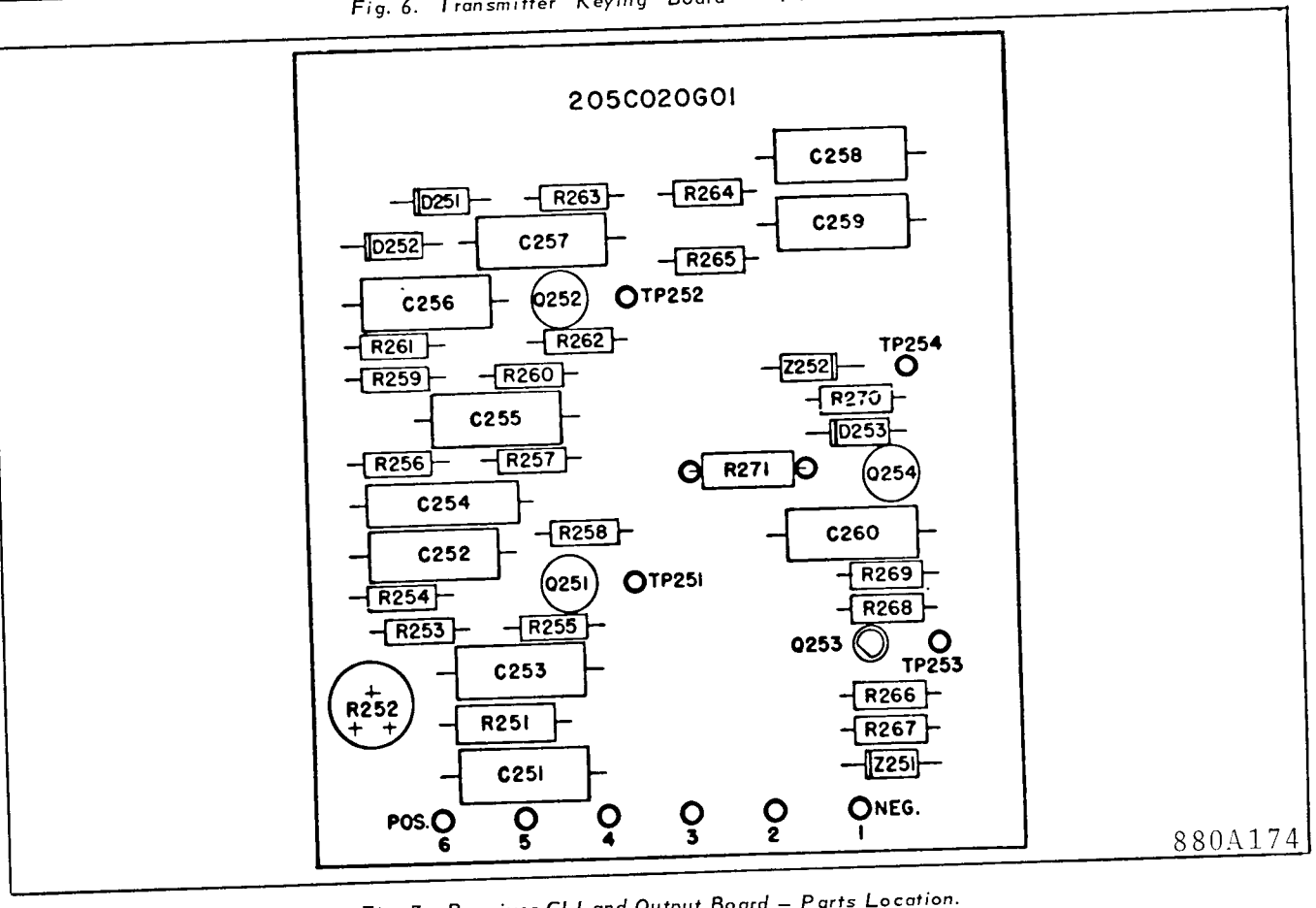
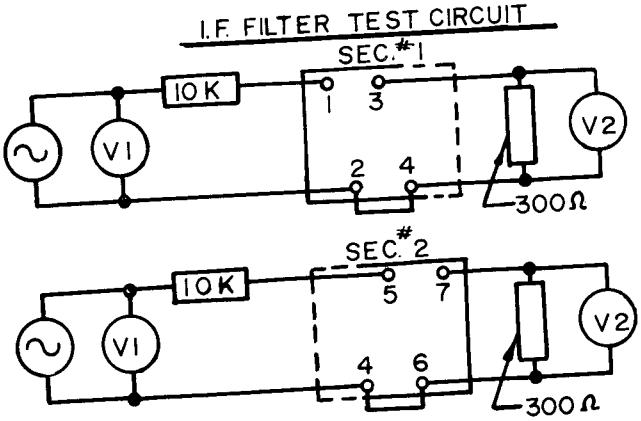
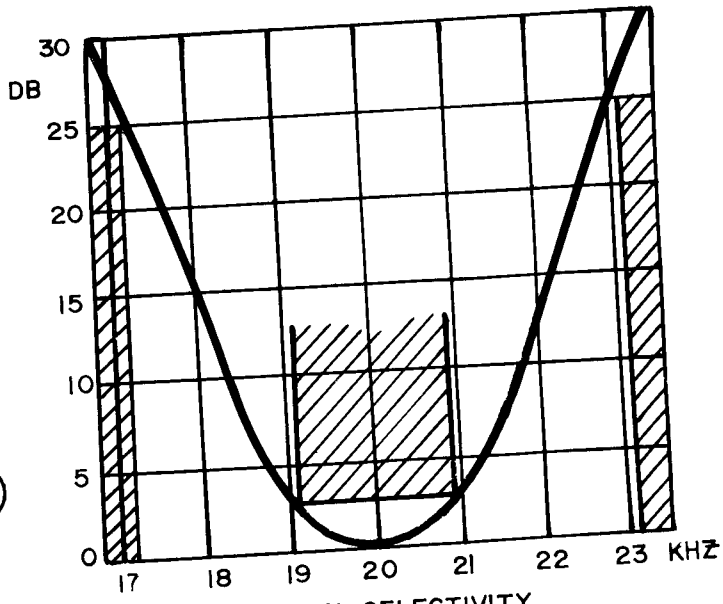
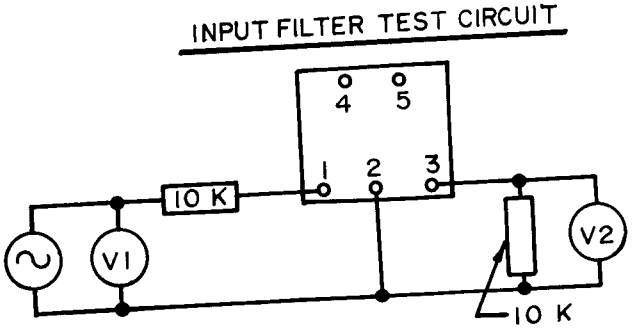


Fig. 7. Receiver CLI and Output Board – Parts Location.

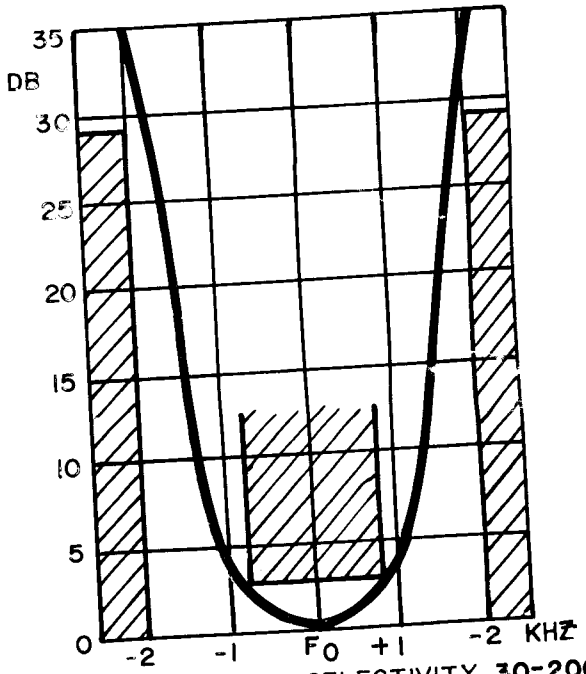




TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.



FOR BOTH FILTERS,
$DB = 20 \log \frac{V1}{V2}$



TYPICAL SELECTIVITY. 30-200 KHZ
INSERTION LOSS 12-18 DB,
RISING WITH FREQUENCY.

TC RECEIVER FILTER LIMITS

INPUT FILTER FOR 200.5 - 300 KHZ

INSERTION LOSS 12-16 DB, RISING WITH FREQUENCY

DOWN 3db AT ± 0.8-1.1 KHZ, RISING WITH FREQUENCY

AT 2 KHZ, DOWN 22-35 DB, DROPPING WITH RISING FREQUENCY

629A4

Fig. 9. Type TC Receiver Filter Characteristics

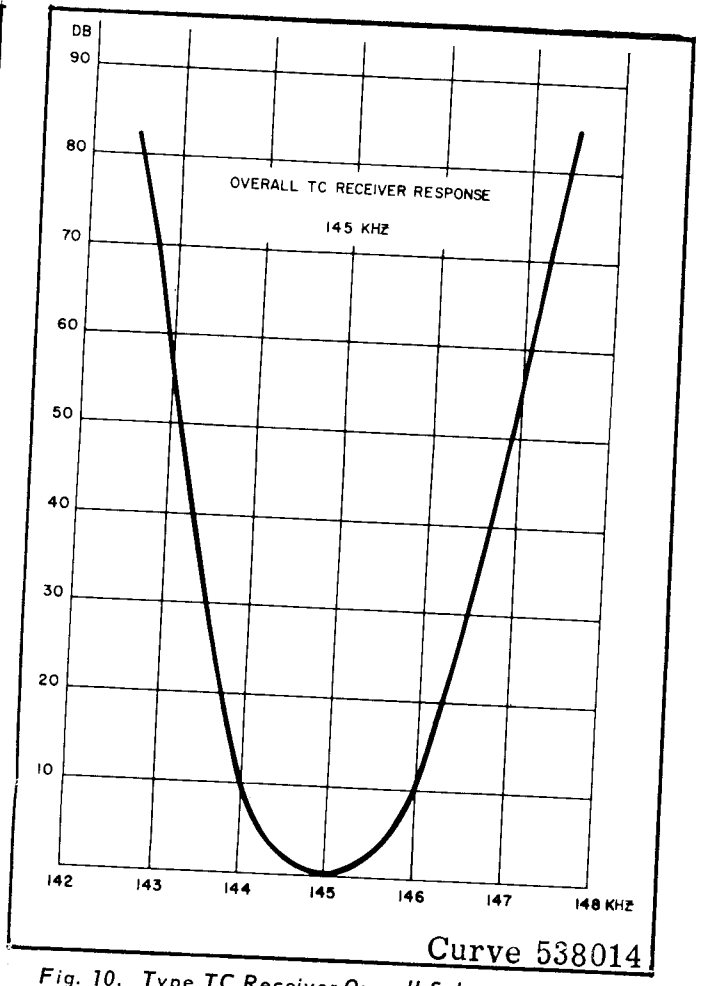


Fig. 10. Type TC Receiver Overall Selectivity Curve.

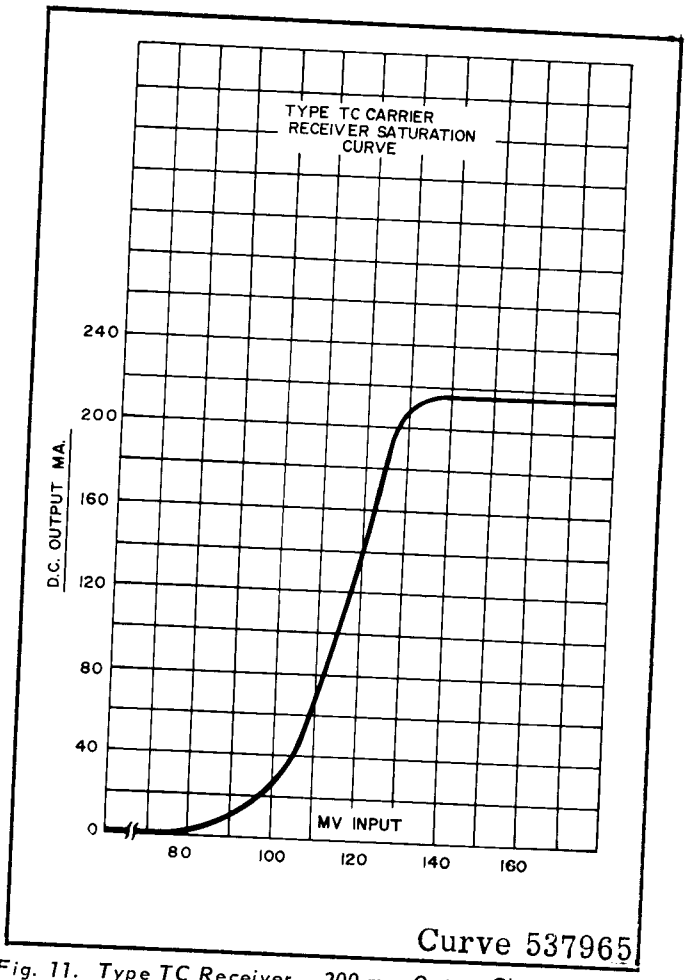


Fig. 11. Type TC Receiver – 200 ma. Output Characteristic.

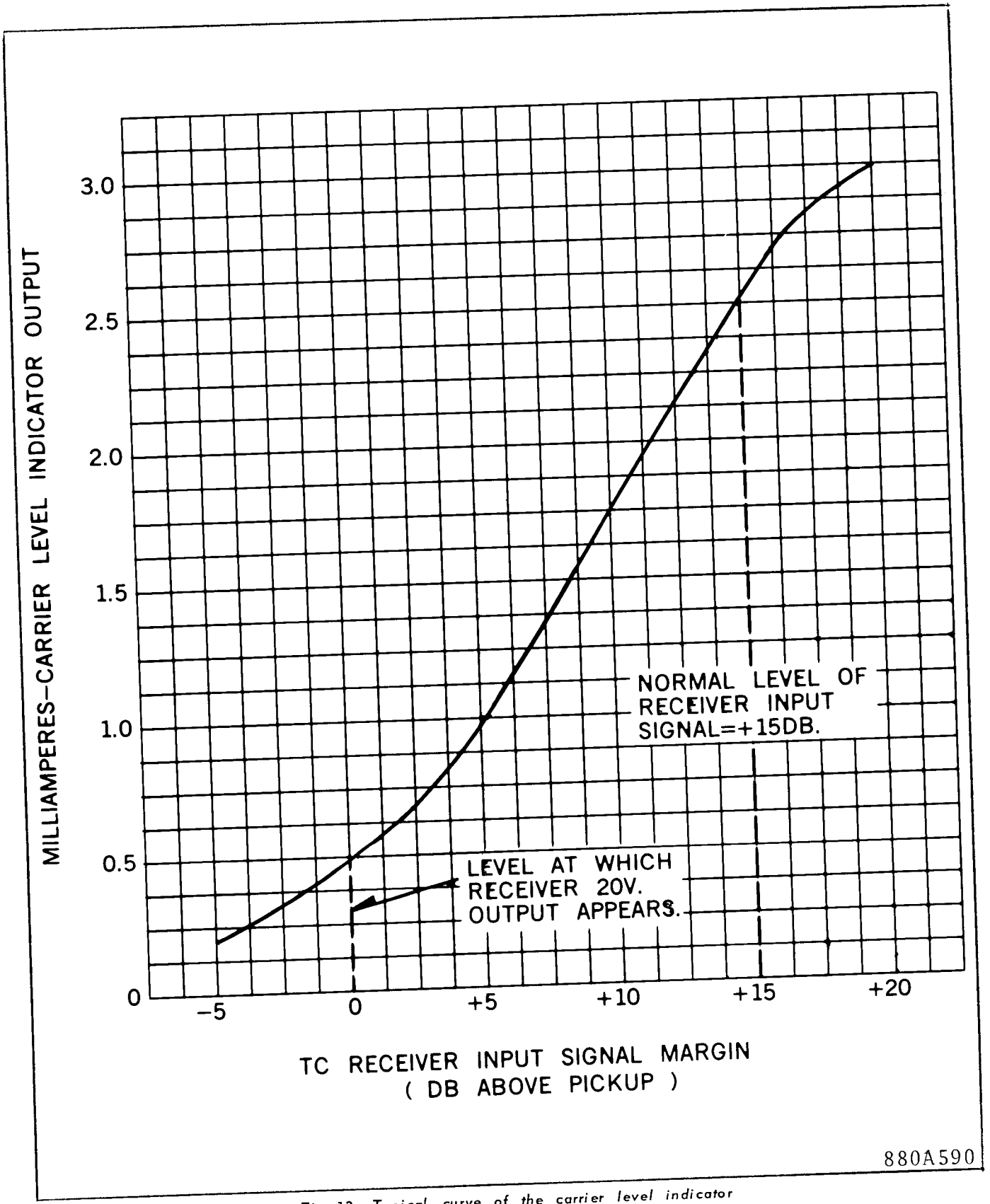


Fig. 12. Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

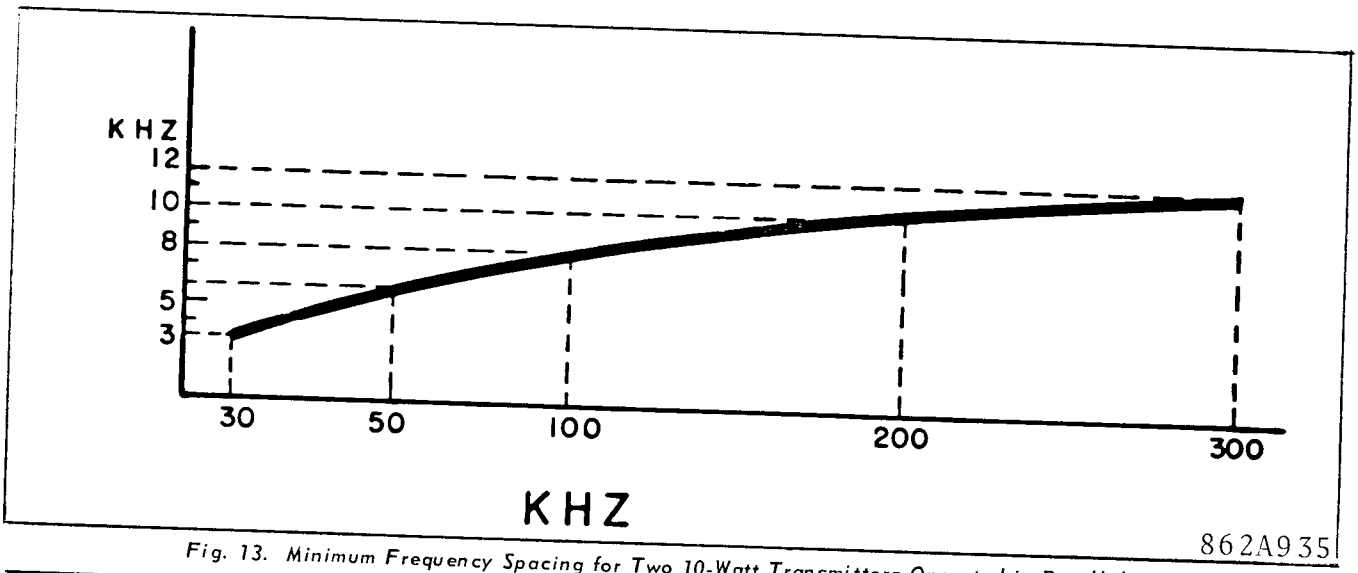


Fig. 13. Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

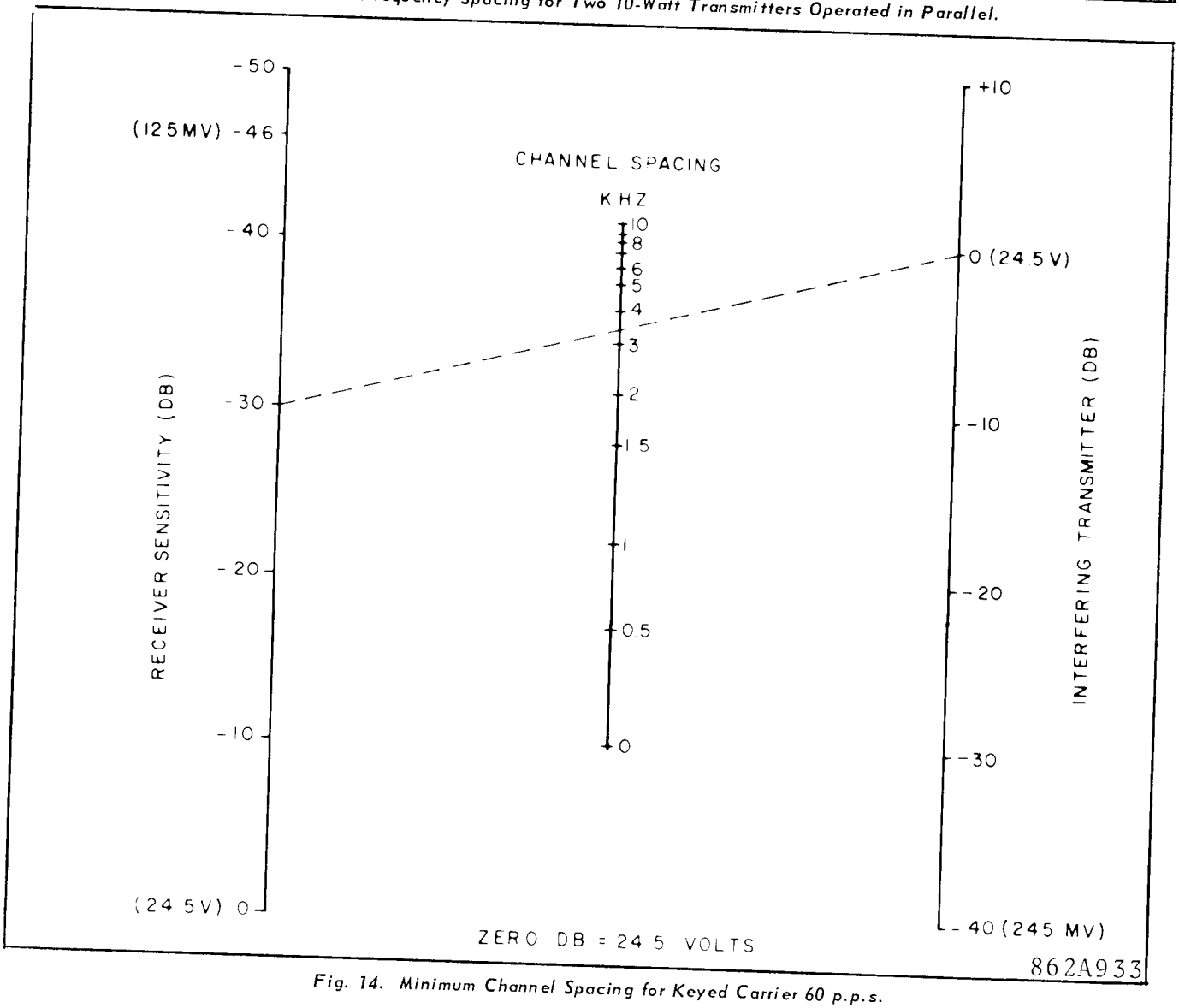


Fig. 14. Minimum Channel Spacing for Keyed Carrier 60 p.p.s.

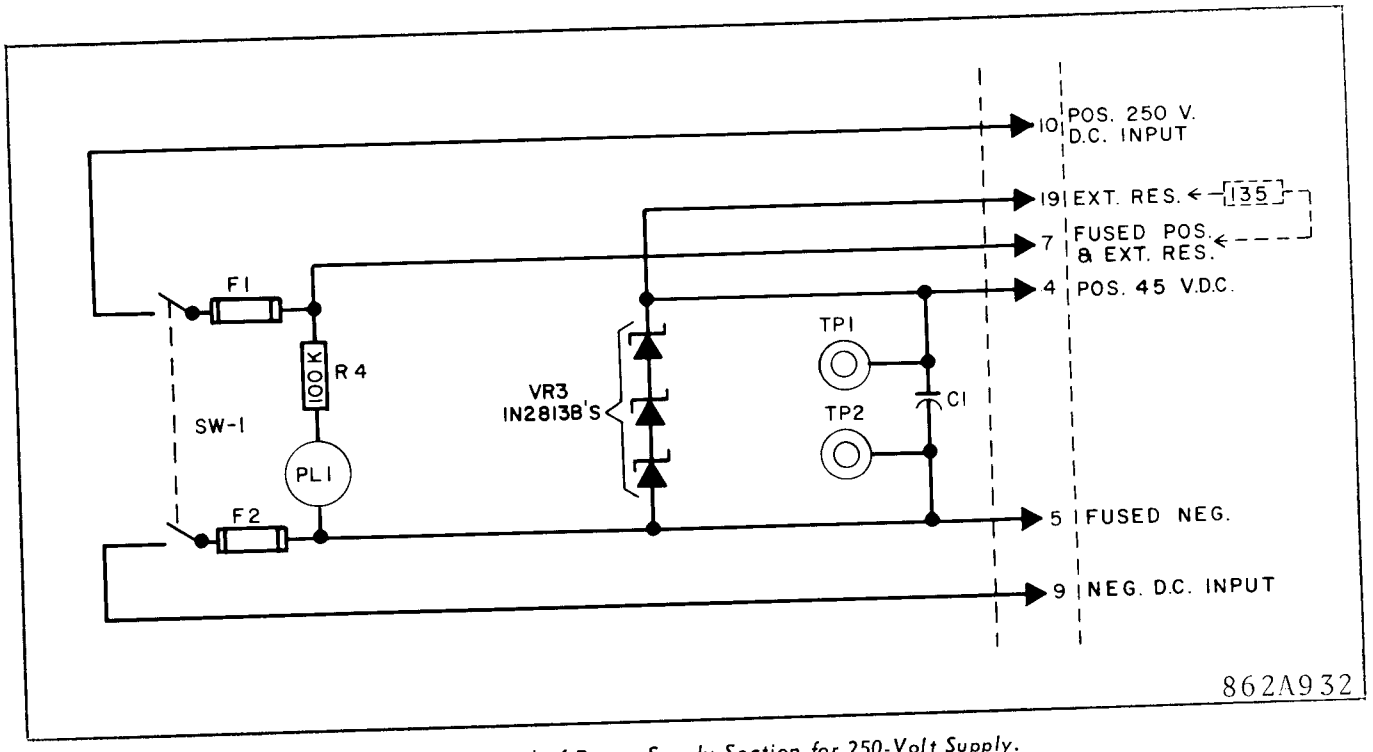


Fig. 15. Detail of Power Supply Section for 250-Volt Supply.

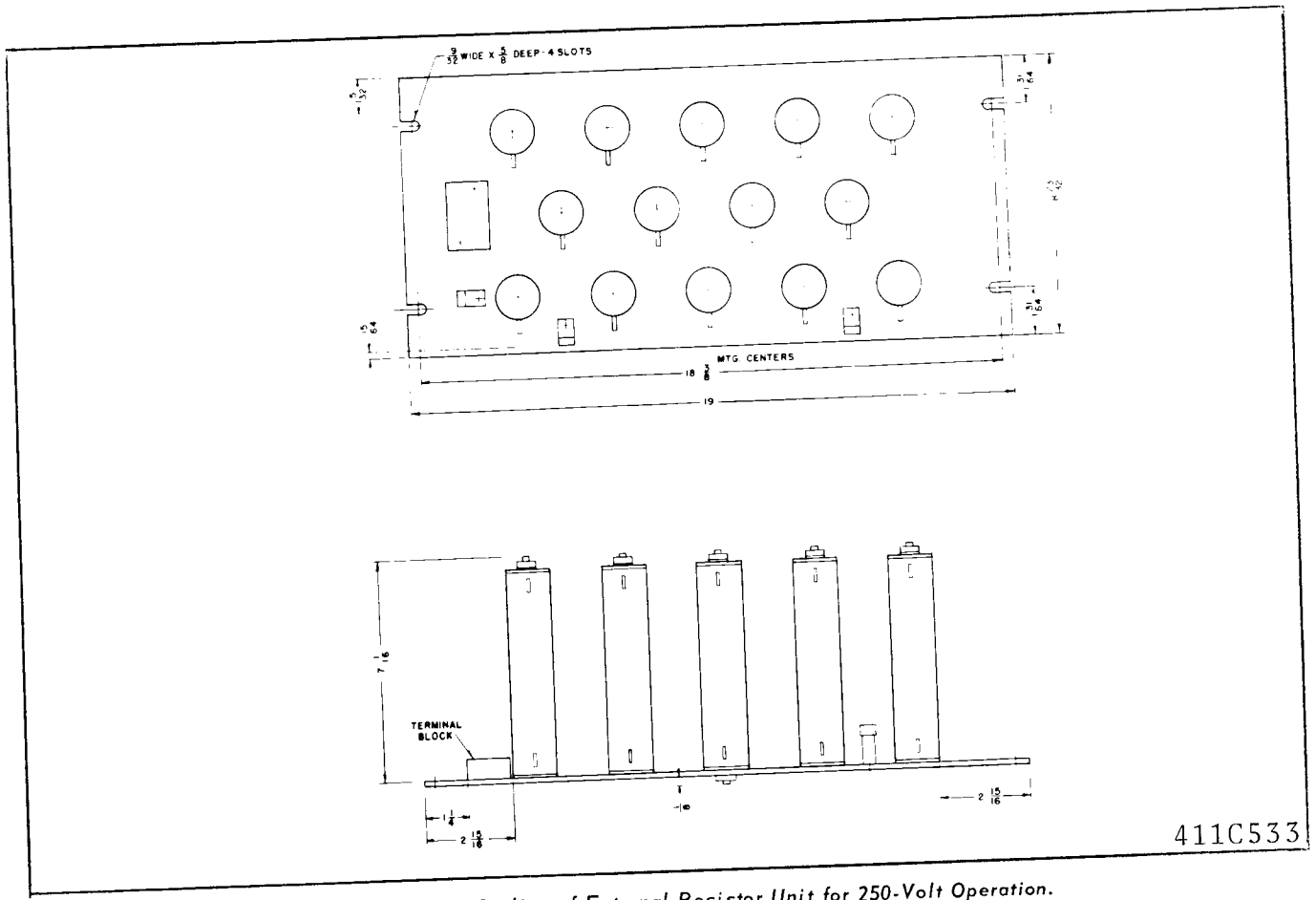
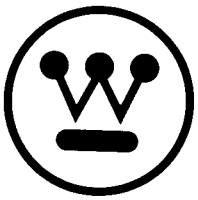


Fig. 16. Outline of External Resistor Unit for 250-Volt Operation.



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

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

NEW INFORMATION

EFFECTIVE NOVEMBER 1971

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 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 ±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: 48 V.D.C.	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 +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 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.

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

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

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 ±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 transistors 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)
   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#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 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

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

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

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

1. Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
2. Receiver input filter (FL201), specify frequency.
3. 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 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.

TEST POINT	TYPICAL A-C VOLTAGES	
	36 kHz.	132 kHz.
FL201-IN to Gnd.	.075	.050
FL201-OUT to Gnd.	.051	.020
Q203 - E to TP206	.105	.090
Q204 - C to TP206	.90	.52
Q205 - B to TP206	.11	.052
Q205 - C to TP206	6.7	3.4
Q206 - B to TP206	.67	.37
Q206 - C to TP206	1.5	1.53
TP202 to TP206	0.3	0.3

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.

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

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

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.	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.

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)

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.

ELECTRICAL PARTS LIST

Transmitter Section

SYMBOL	RATING	STYLE NUMBER
C101	0.1 mfd, 200 V. DC	187A624H01
C102	.005 mfd, 300 V. DC	187A694H29
C103	180 pf. 500 V. DC	187A695H29
C104	0.25 mfd, 200 V. DC	187A624H02
C105	0.25 mfd, 200 V. DC	187A624H02
C106	0.25 mfd, 200 V. DC	187A624H02
C107	0.25 mfd, 200 V. DC	187A624H02
C108	0.50 mfd, 200 V. DC	187A624H03
C109	0.25 mfd, 200 V. DC	187A624H02
C110	0.25 mfd, 200 V. DC	187A624H02
† C111	(See Table Below)	—
C112	39 pfd, 500 V. DC	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
CR101	1N3686B (20 V ± 5%)	185A212H06
CR102	1N457A	184A855H07
CR103	1N538	407C703H03
CR104	1N91	182A881H04
CR105	1N538	407C703H03
CR106	1N91	182A881H04
CR107-108	1N2999A (56 V ± 10%)	184A617H13
CR109 #	1N2999A (56 V ± 10%)	184A617H13
G101	Type RVS Arrester	637A026A01
J101	Closed Circuit Jack	187A606H01

#200.5 – 300 kHz only.

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

ELECTRICAL PARTS LIST

Transmitter Section (Cont.)

SYMBOL	RATING	STYLE NUMBER
J102	Banana Plug Jack	54B159H02
J103	Coaxial Cable Jack	187A633H01
J104	24-Term Receptacle	187A669H01
J105	12-Term Receptacle	629A205H02
L101	Part of FL101	Vary with Frequency
L102	FL102 Trap Coil (2nd Harmonic)	Vary with Frequency
L103	FL102 Trap Coil (3rd Harmonic)	Vary with Frequency
L104	400 mh.	292B096G01
L105	FL102 Coil (part of series-resonant circuit tuned to fundamental freq.)	Vary with Frequency
Q101	2N274	187A270H01
Q102	2N274	187A270H01
Q103	2N525	184A638H13
Q104	2N657	184A638H15
Q105	2N657	184A638H15
Q106	TI-481	184A638H11
Q107	2N1908 Matched Pair - Texas Instrument	187A673H02
Q108	2N1908 Co. - Identif. GP2151	

SYMBOL	OHMS	± TOL. %	WATTS	STYLE NUMBER
R101	5,600	5	1	187A643H45
R102	2,200	10	0.5	187A641H35
R103	10,000	10	0.5	187A641H51
R104	100,000	5	0.5	187A763H75
R105	390	5	0.5	184A763H17
R106	1,200	5	0.5	184A763H29
R107	10,000	10	0.5	184A641H51
R108	100,000	5	0.5	184A763H75
R109	390	5	0.5	184A763H17
R111	1,200	5	0.5	187A763H29
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	184A763H07

ELECTRICAL PARTS LIST

Transmitter Section (Cont.)

SYMBOL	OHMS	±TOL. %	WATTS	STYLE NUMBER
R116	100	5	0.5	184A763H03
R117	1,000	5	25	1202588
R118	12,000	2	0.5	629A531H58
R119	62	2	0.5	629A531H03
R120	10,000	5	2	185A207H51
R121	10	5	2	187A683H01
R122	10	5	0.5	187A290H01
R123	10	10	0.5	187A290H01
R124	100	10	1	187A644H03
R125	1,000	10	0.5	187A641H27
R126	4,700	10	1	187A644H43
R127	10	10	0.5	187A640H01
R128	2,200	5	1	187A644H35
R129	2.7	10	0.5	184A636H14
R130	10	10	0.5	187A640H01
R131	4,700	5	1	187A644H43
R132	2.7	10	0.5	184A636H14
R133	0.27	10	1	184A636H14
R134	0.27	10	1	184A636H18
R135	3,000	10	5	188A317H01
R136	12,000	2	0.5	629A531H58
R137	15,000	10	2	187A642H55
R138	1,000	10	0.5	187A641H27
R139	1,000	10	0.5	187A641H27
R140	68	2	0.5	629A531H04
R141	30	Type 3D202 Thermistor		185A211H06
R142	25K pot.	20	0.25	584C276H23
R143	20,000	2	0.5	629A531H63

SYMBOL	RATING	STYLE NUMBER
T101	10,000/400 ohms	205C043G01
T102	10,000/400 c.t.	714B666G01
T103	1930/60 ohms L633000	1962694
T104	Turns ratio, 1/0.5 Pri./each sec.	292B526G01
T105	10/500 ohms	292B526G02
T106	500/50 - 60 - 70 ohms	292B526G03
Y101	30-300 kHz crystal per 328C083	Specify Frequency

ELECTRICAL PARTS LIST

Transmitter Keying Board

SYMBOL	RATING	STYLE NUMBER
C151-C152	.047 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)	185A797H13
Z160	1N5357B (20V)	862A288H02
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	187A624H02
C215	39 pfd., 500 V. DC	187A695H12
CR201	1N3027B (20V ± 5%)	184A449H07
CR202	1N91	182A881H04
CR203	1N91	182A881H04

ELECTRICAL PARTS LIST

Receiver Section (cont.)

SYMBOL	RATING	STYLE NUMBER
CR204	1N538	407C703H03
CR205	1N538	407C703H03
CR206	1N1789 (56 V. ±10%)	484C434H08
FL201	Receiver Input Filter 30-300 kHz	Specify Frequency
FL202	Receiver i.f. Filter-20kHz (2 sections)	187A590G02
J201	Receiver Coax. Input Jack	187A638H01
J202	Closed Circuit Jack (CLI)	187A606H01
J203	Closed Circuit Jack (200MA)	187A606H01
L201	33 mh.	187A599H01
Q201	2N274	187A270H01
Q202	2N274	187A270H01
Q203	2N274	187A270H01
Q204	2N274	187A270H01
Q205	2N274	187A270H01
Q206	2N274	187A270H01
Q207	2N398A	184A638H12
Q208	2N1362	187A673H01

SYMBOL	RATING			STYLE NUMBER
	OHMS	± 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	25 K Pot.	10	2	185A086H07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H75
R210	390	5	0.5	184A763H17
† R211	—	—	—	See † Note Below
R212	1 K Pot.	20	0.25	629A430H02
R213	1,200	5	0.5	184A763H29
R214	5,600	5	1	187A643H45
R215	20,000	5	0.5	184A763H58
R216	3,600	5	0.5	184A763H40

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

ELECTRICAL PARTS LIST

Receiver Section (Cont.)

SYMBOL	RATING			STYLE NUMBER
	OHMS	±TOL. %	WATTS	
R217	620	5	0.5	184A763H22
R218	62	5	0.5	187A290H20
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	62	5	0.5	187A290H20
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	184A763H40
R229	620	5	0.5	184A763H22
R230	27	5	0.5	187A290H11
R231	2,000	5	0.5	184A763H34
R232	1,200	5	2	185A207H29
R233	4,700	10	2	187A642H43
R234	5,100	5	0.5	184A763H44
R235	470	10	1	187A644H19
R236	4,700	10	1	187A644H43
R237	170	5	40	1336074
† R238	—	—	—	See † Note Below
R239	1 K pot.	20	0.25	629A430H02
R241	100	Type 3D102 Thermistor		185A211H12
R242	100	Type TM-¼ Sensistor		187A685H06
T201	10,000/10,000	Ohms		714B677G01
T202	10,000/400	Ohms		205C043G01
T203	25,000/300	Ohms		205C043G03
Y201	50-320kHz Crystal per 328C083			Specify Frequency

Receiver CLI and Output Board

SYMBOL	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.	188A669H15
D251-D252	1N457A	184A855H07
D253	1N645A	837A692H03
Z251	1N3686B (20V.)	185A212H06
Z252	1N3688A (24V,)	862A288H01

† R238- omit - above 50kHz
- 22K, 30-50KHz, S#187A641H59.

ELECTRICAL PARTS LIST

Receiver CLI and Output Board (Cont.)

SYMBOL	RATING	STYLE NUMBER
R251	2.7K, TM-¼ Sensistor	187A685H05
R252	5K, ¼W. pot.	629A430H07
R253	220, ½W.	184A763H11
R254	2.2K, ½W.	184A763H35
R255-R260	15K, ½W.	184A763H55
R256	2.4K, ½W.	184A763H36
R257	330, ½W.	184A763H15
R258-R259	4.7K, ½W.	184A763H43
R261	560, ½W.	184A763H21
R262-R265	1.2K, ½W.	184A763H29
R263-R264	180, ½W.	184A763H09
R266	27K, ½W.	629A531H66
R267-R269	10K, ½W.	629A531H56
R268	6.8K, ½W.	629A531H52
R270	82K, ½W.	629A531H78
R271	150, 3W.	762A679H01
Q251-Q252	2N4356	849A441H02
Q253	2N3417	848A851H01
Q254	2N3645	849A441H01

Power Supply Section

SYMBOL	FUNCTION	DESCRIPTION OR RATING	STYLE NUMBER
C1	(+) to (−) bypass	0.45 mfd. 330 VAC	1723408
C2	A-C grounding	0.5 mfd, 1500 VDC	1877962
C3	A-C grounding	0.5 mfd, 1500 VDC	1877962
C4	Filter	1.8 mfd, 800 VDC	14C9400H12
L1	Filter	5.5 mh.	719B135G01
Q1	Series Regulator	Type 2N1015C Silicon Transistor	187A342H02
R1	125V Series dropping	26.5 ohms, 40W.	04D1299H44
R2	125V Series dropping	Same as R1	04D1299H44
R3	125V Current limiting	500 ohms, 40W.	1268047
R1	48V For 48 VDC, R1 = R2	—	—
R2	48V For 48 VDC, R1 = R2	—	—
R3	48V R3 = 26.5 ohms	40W.	04D1299H44
TP1	Test point (+)	Pin Jack — red	187A332H01
TP2	Test point (−)	Pin Jack — black	187A332H02
VR1	Voltage Regulator	1N2828B (45V.)	184A854H06
VR2	Surge Protection	1N3009A (130V.) Zener Diodes	184A617H12
VR3	Voltage Regulator	1N2813B (15V.)	184A854H11

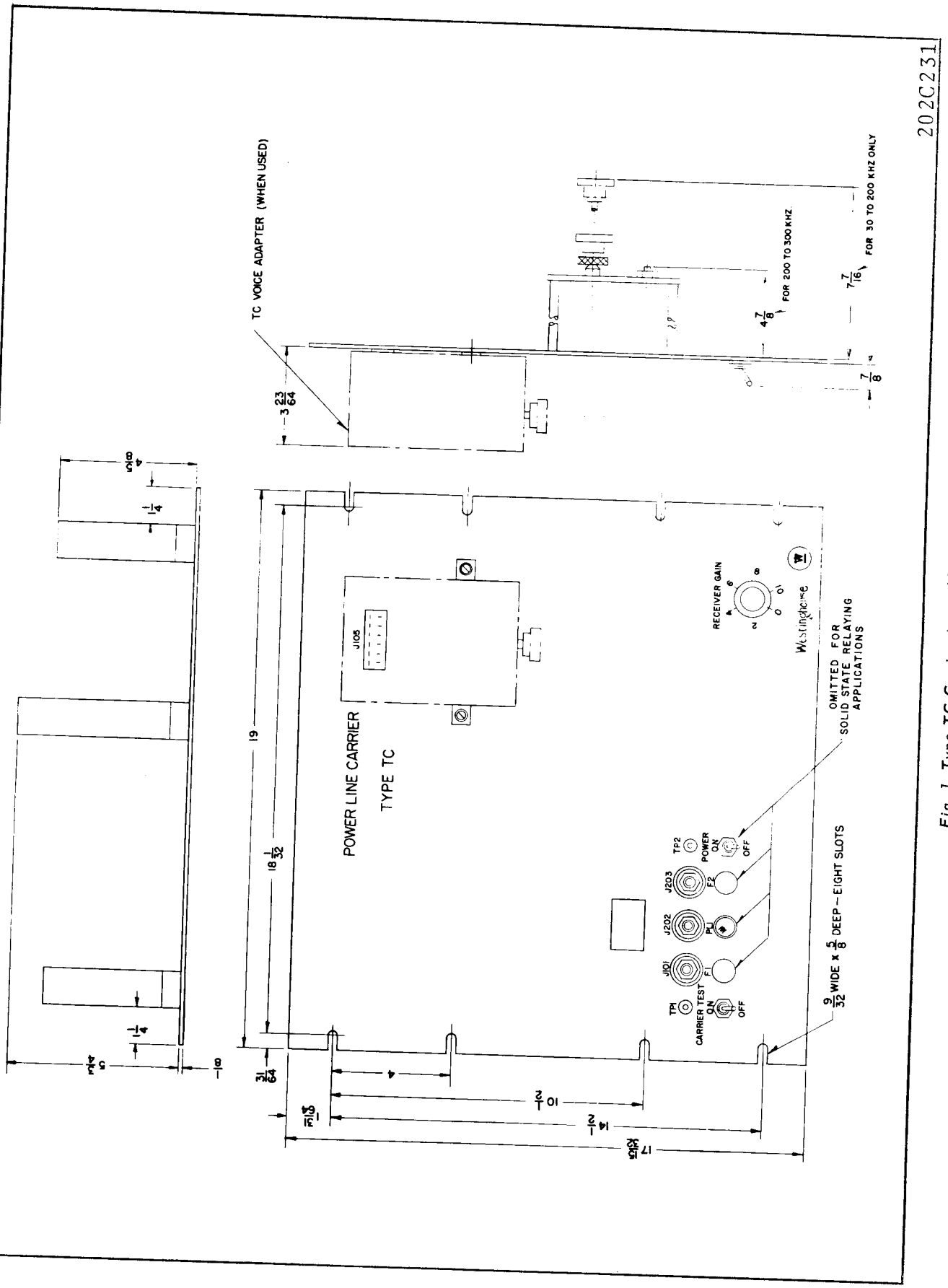


Fig. 1 Type TC Carrier Assembly – Outline

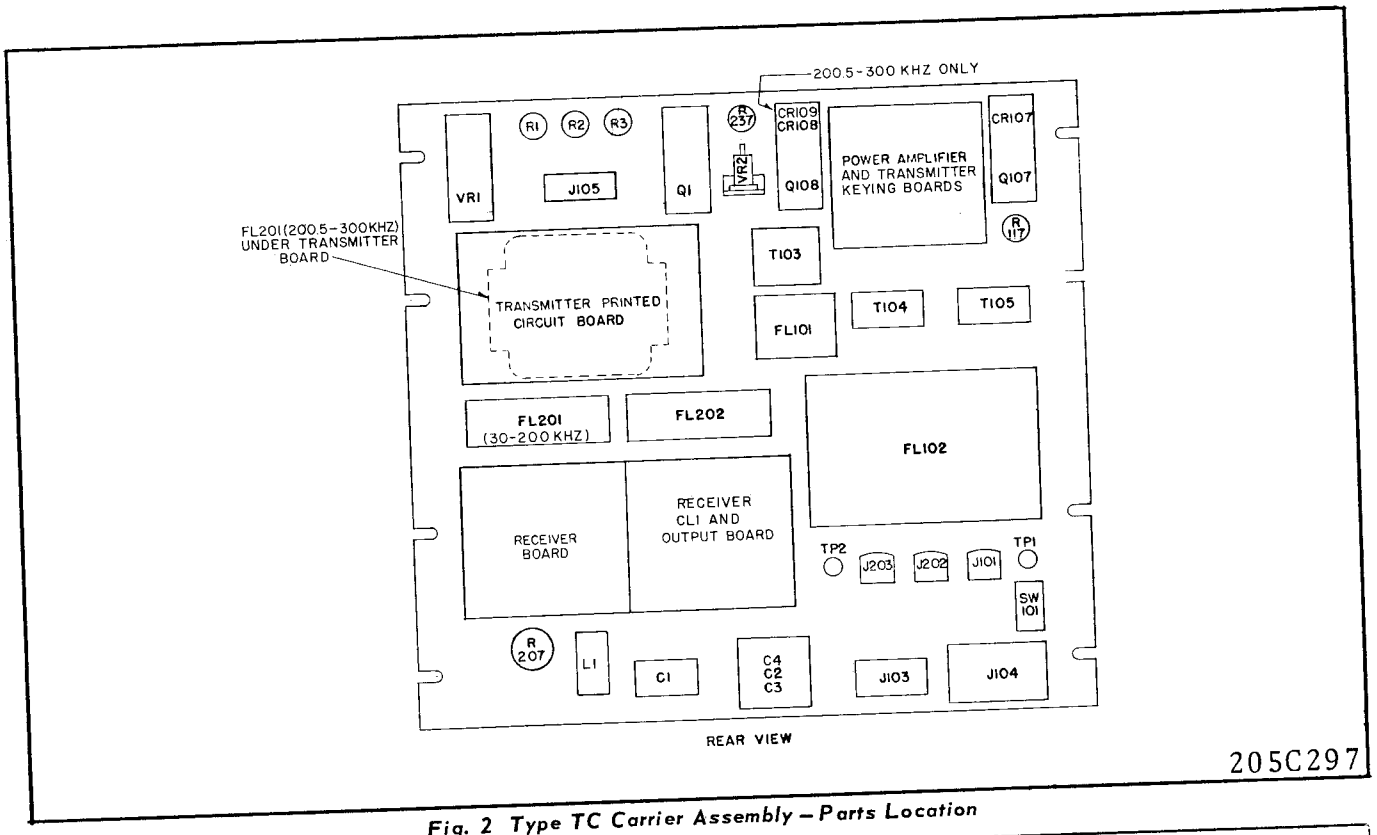


Fig. 2 Type TC Carrier Assembly – Parts Location

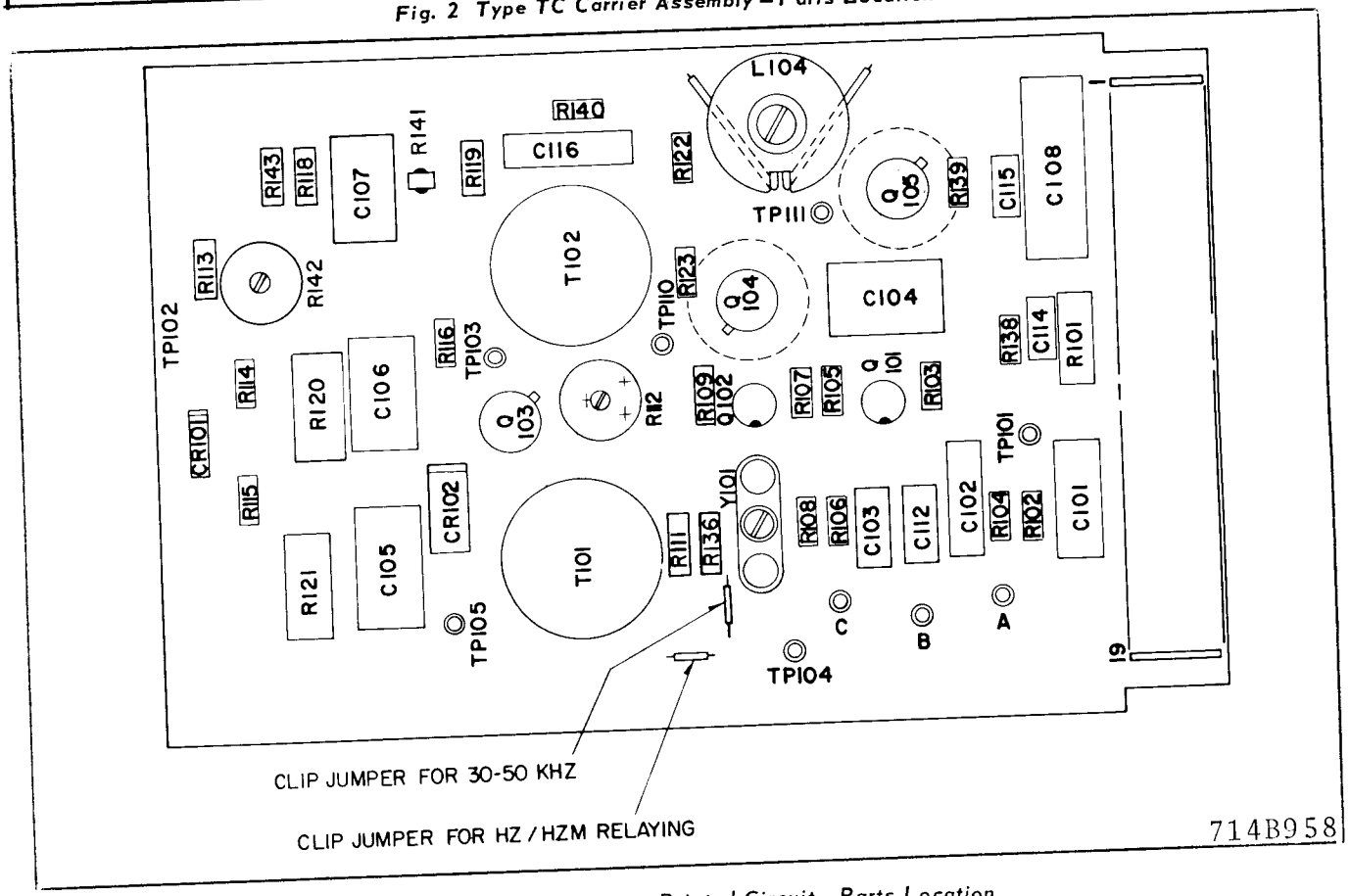


Fig. 3 Transmitter Printed Circuit – Parts Location

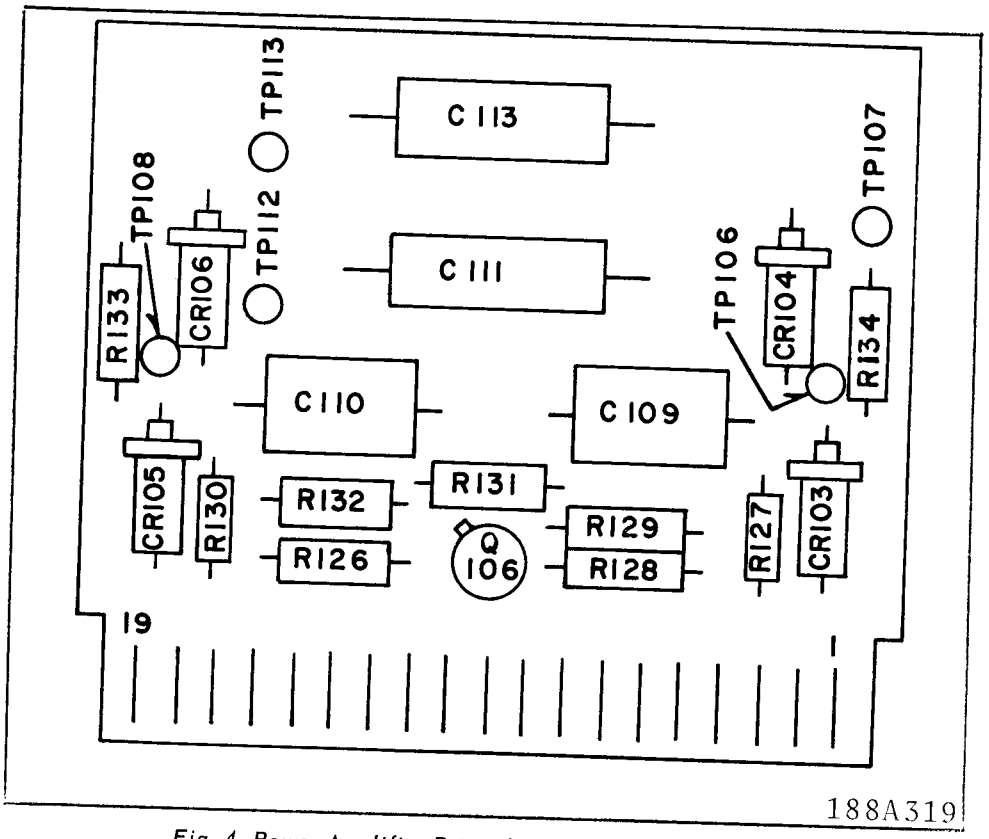


Fig. 4 Power Amplifier Printed Circuit – Parts Location

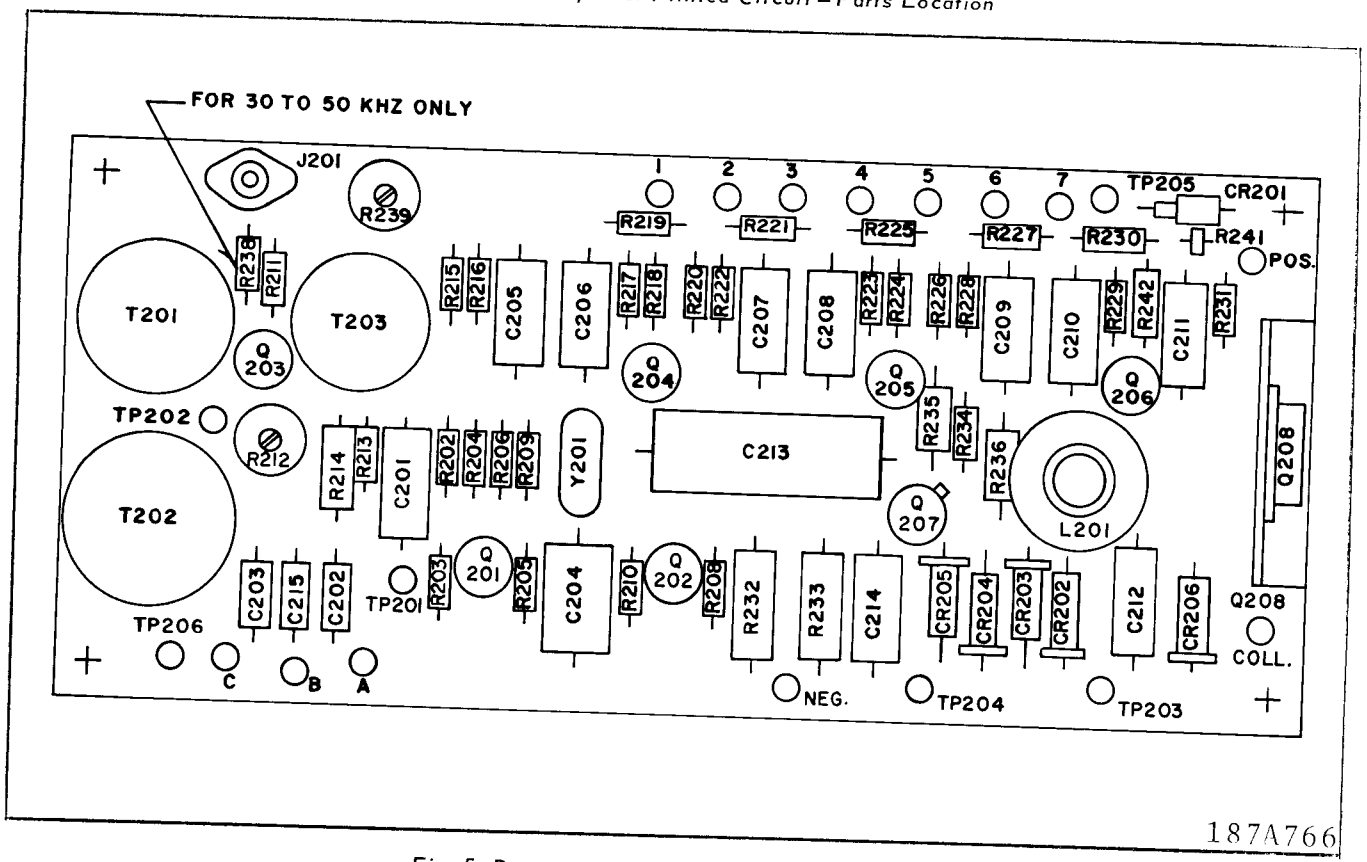


Fig. 5 Receiver Printed Circuit – Parts Location

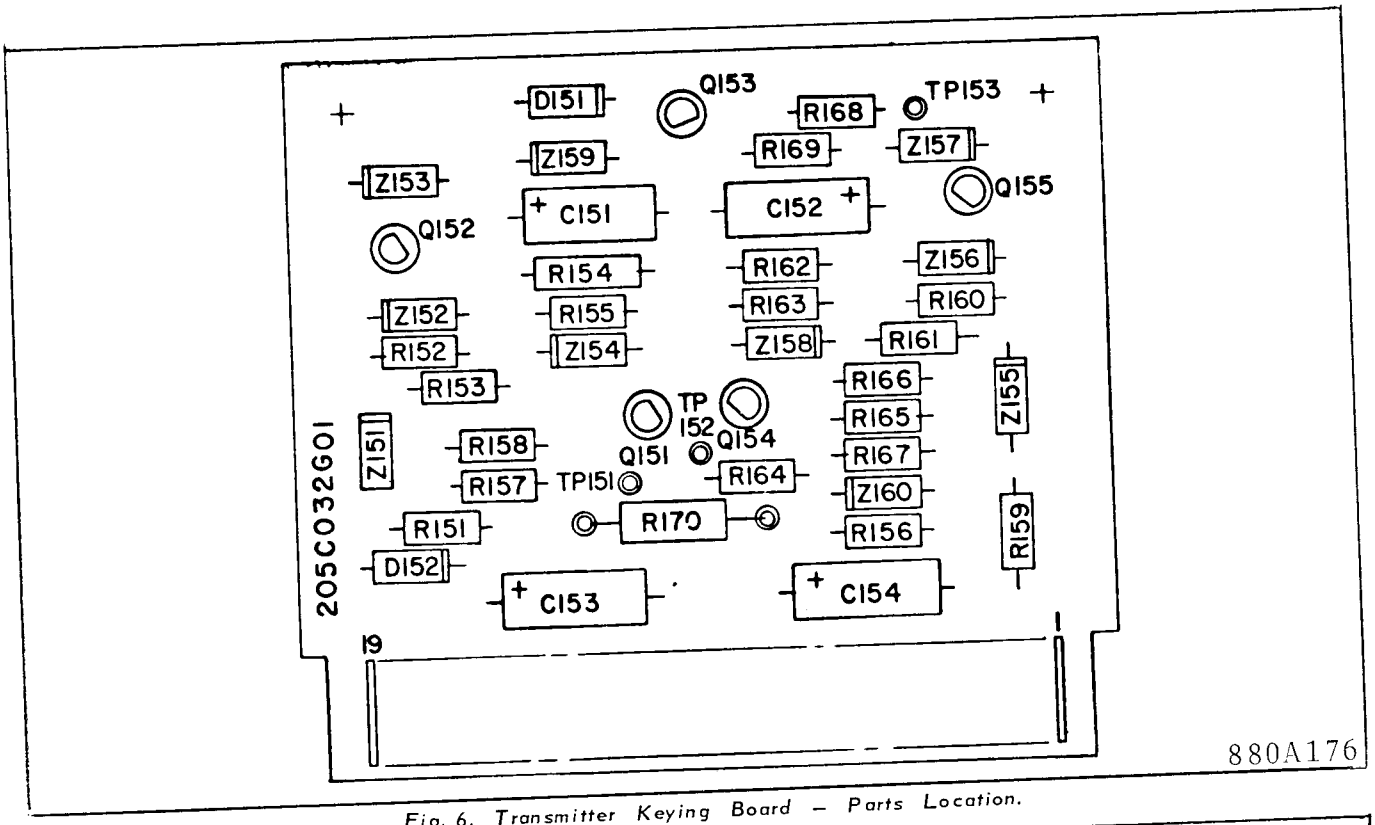


Fig. 6. Transmitter Keying Board – Parts Location.

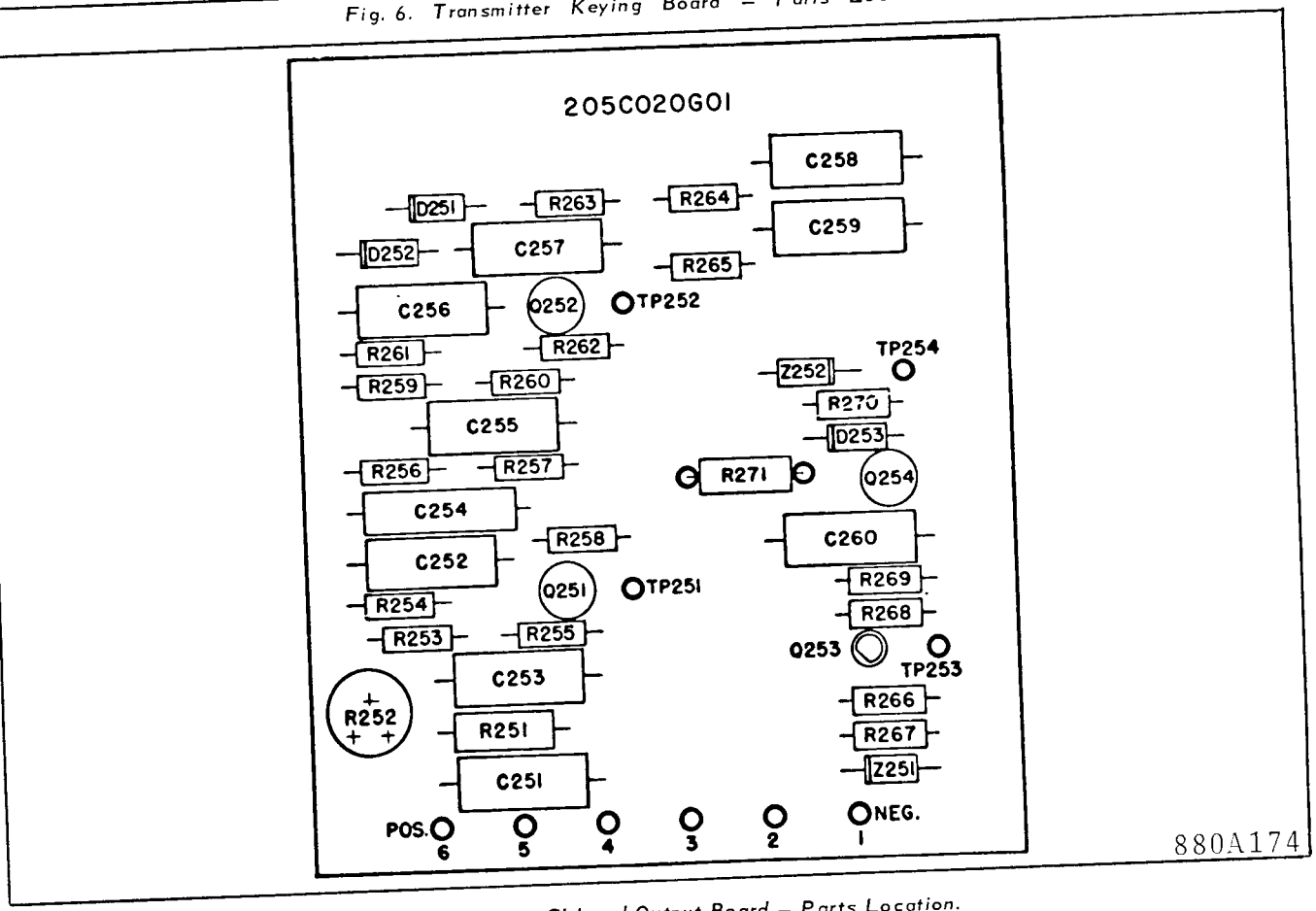
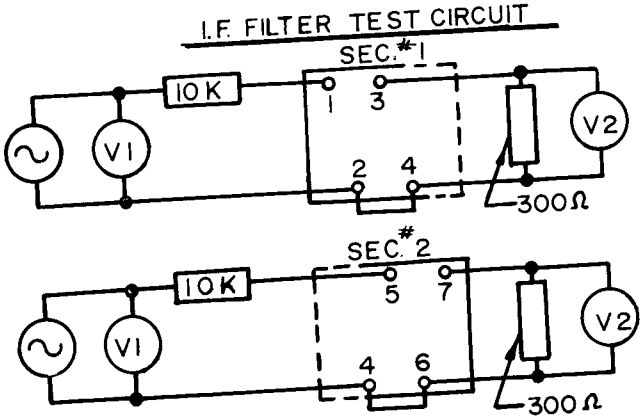
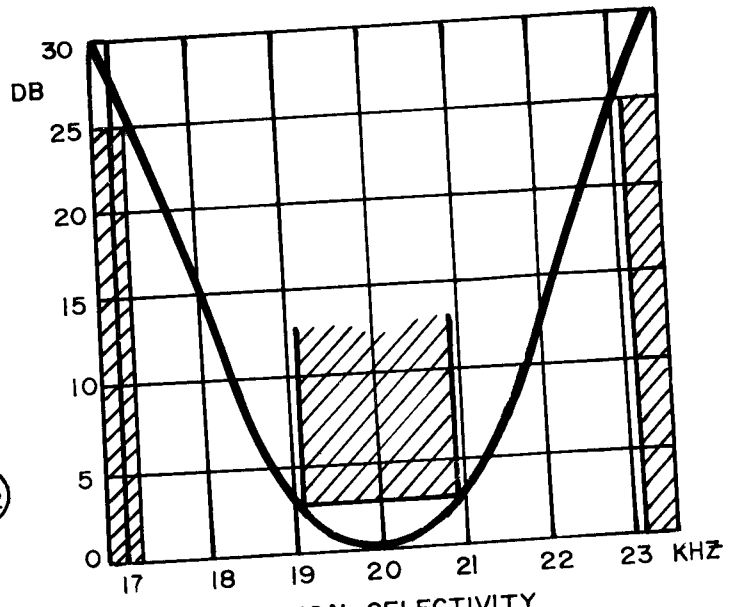
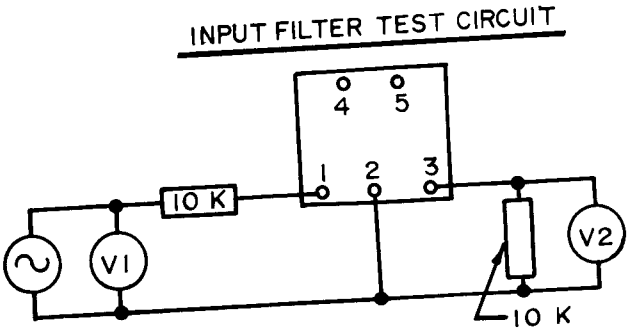


Fig. 7. Receiver CLI and Output Board – Parts Location.

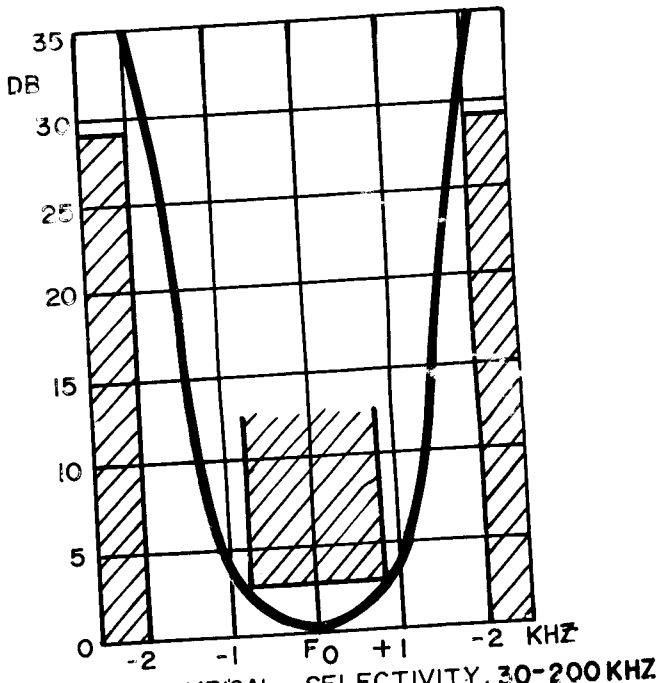




TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.



FOR BOTH FILTERS,
$DB = 20 \log \frac{V1}{V2}$



TYPICAL SELECTIVITY, 30-200 KHZ
INSERTION LOSS 12-18 DB,
RISING WITH FREQUENCY.

TC RECEIVER FILTER LIMITS

INPUT FILTER FOR 200.5 - 300 KHZ

INSERTION LOSS 12-16 DB, RISING WITH FREQUENCY

DOWN 3db AT ± 0.8-1.1 KHZ, RISING WITH FREQUENCY

AT 2 KHZ, DOWN 22-35 DB, DROPPING WITH RISING FREQUENCY

629A4

Fig. 9. Type TC Receiver Filter Characteristics

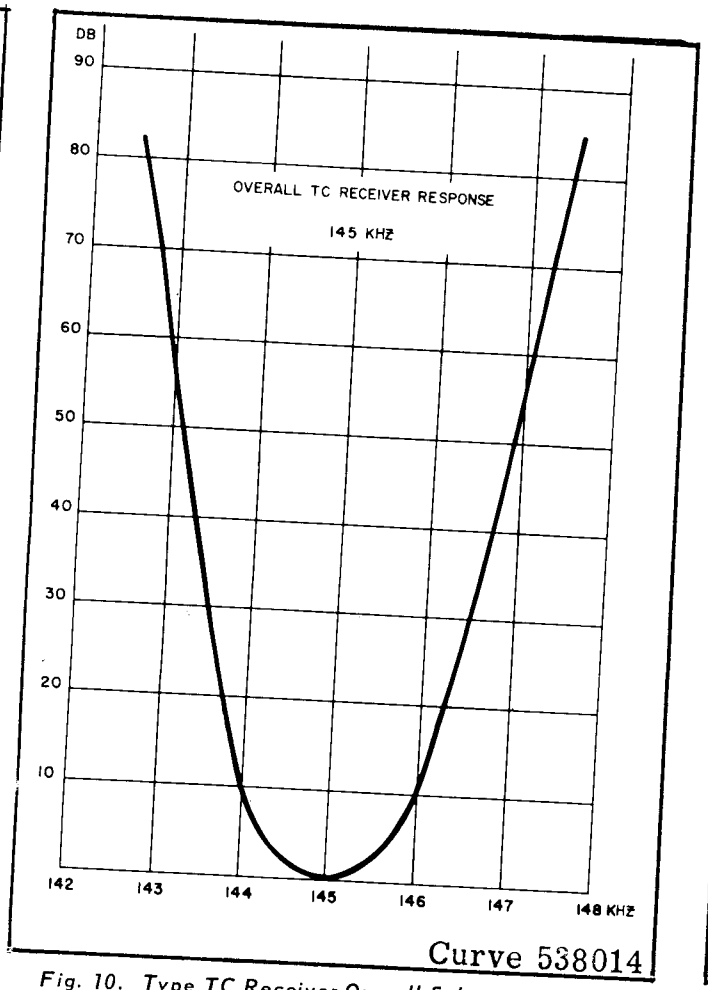


Fig. 10. Type TC Receiver Overall Selectivity Curve.

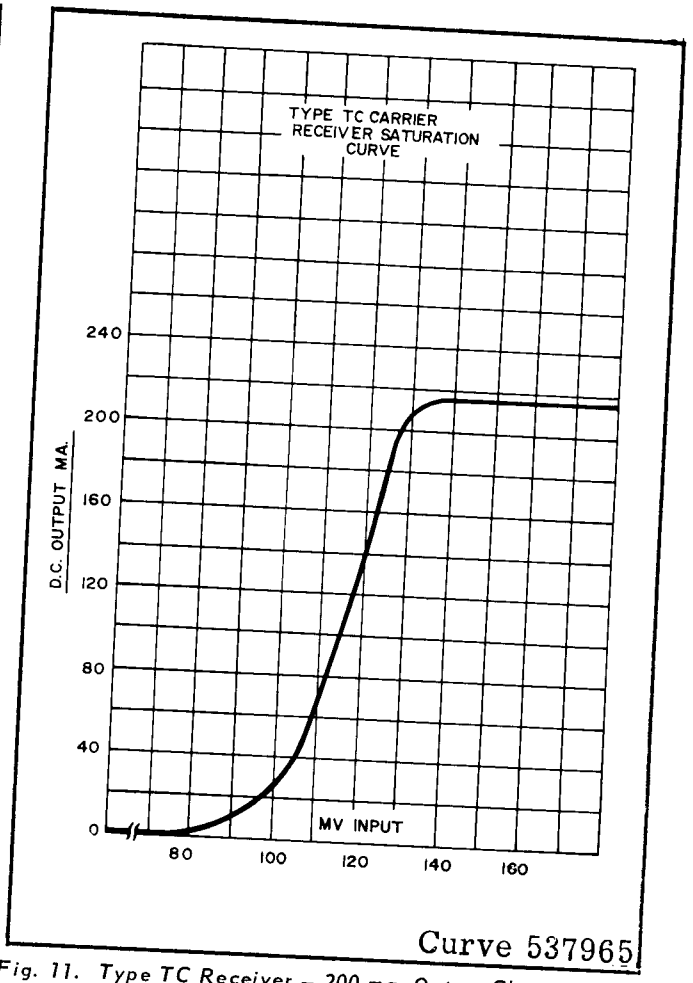


Fig. 11. Type TC Receiver – 200 ma. Output Characteristic.

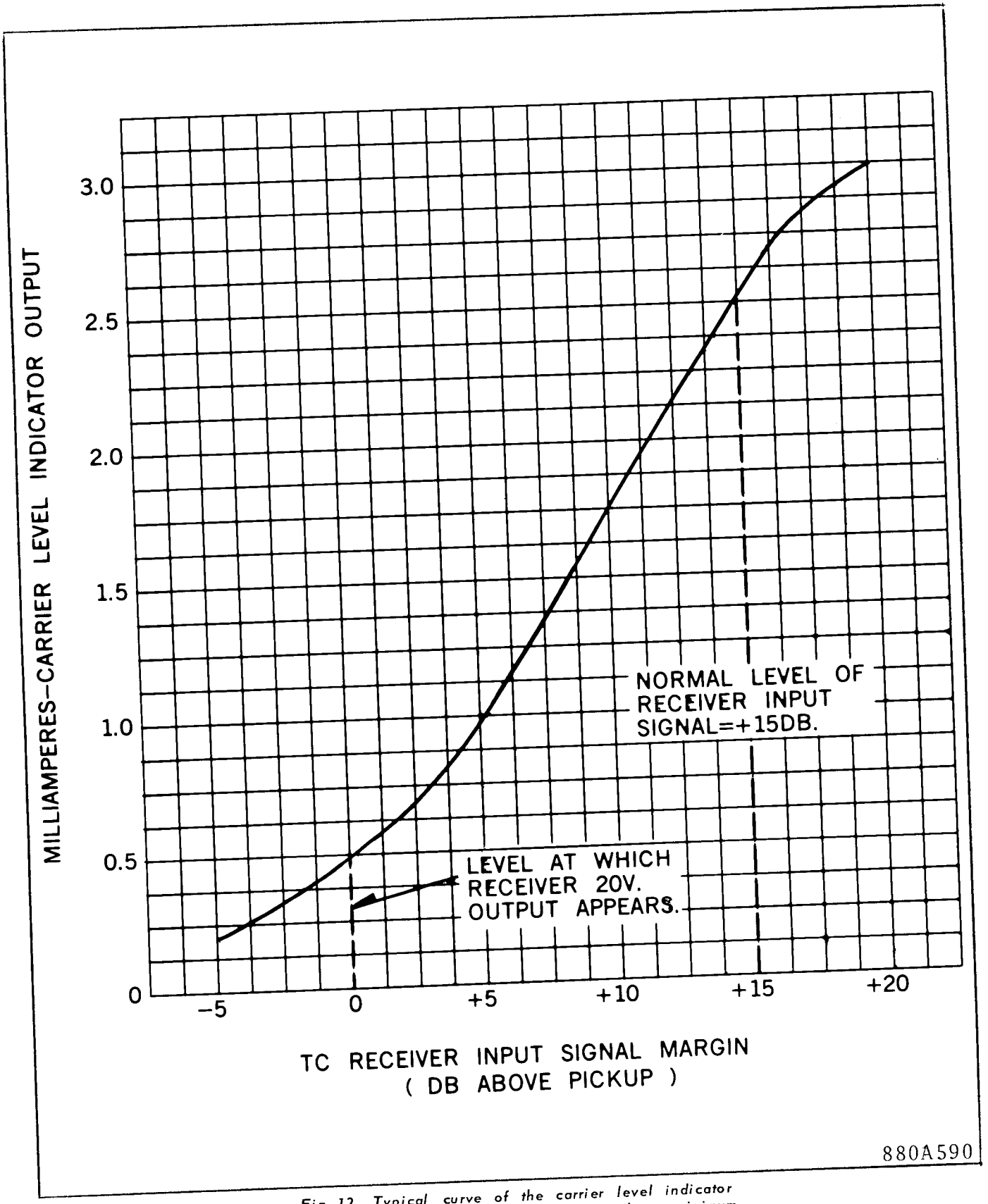


Fig. 12. Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.

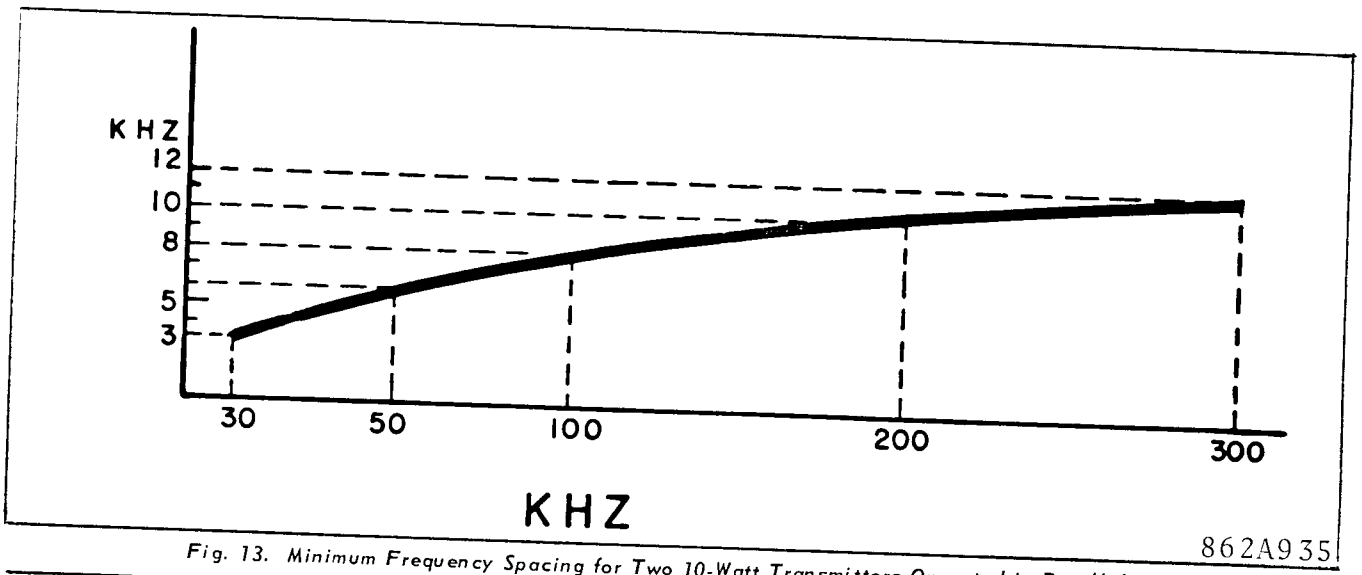


Fig. 13. Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

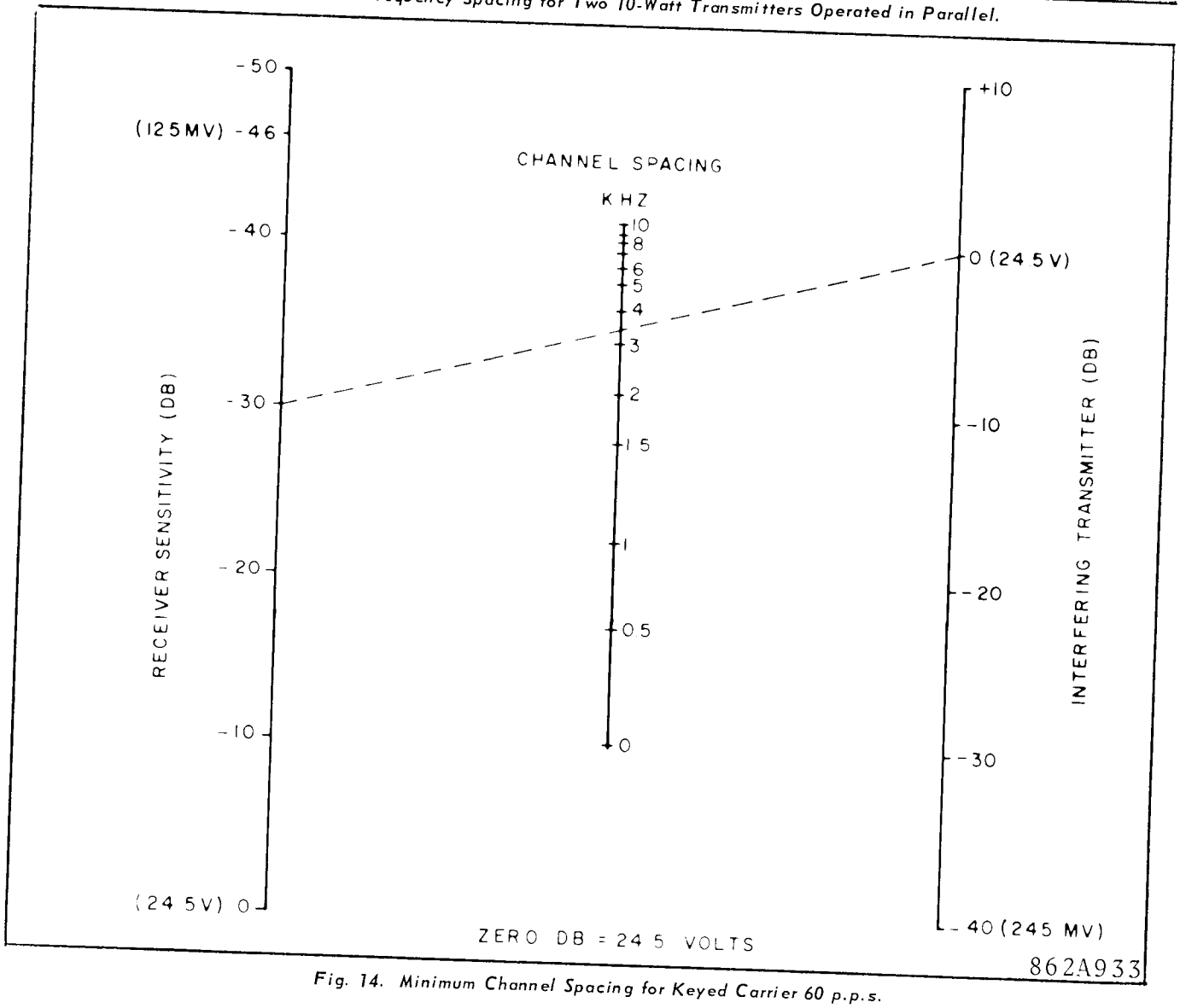


Fig. 14. Minimum Channel Spacing for Keyed Carrier 60 p.p.s.

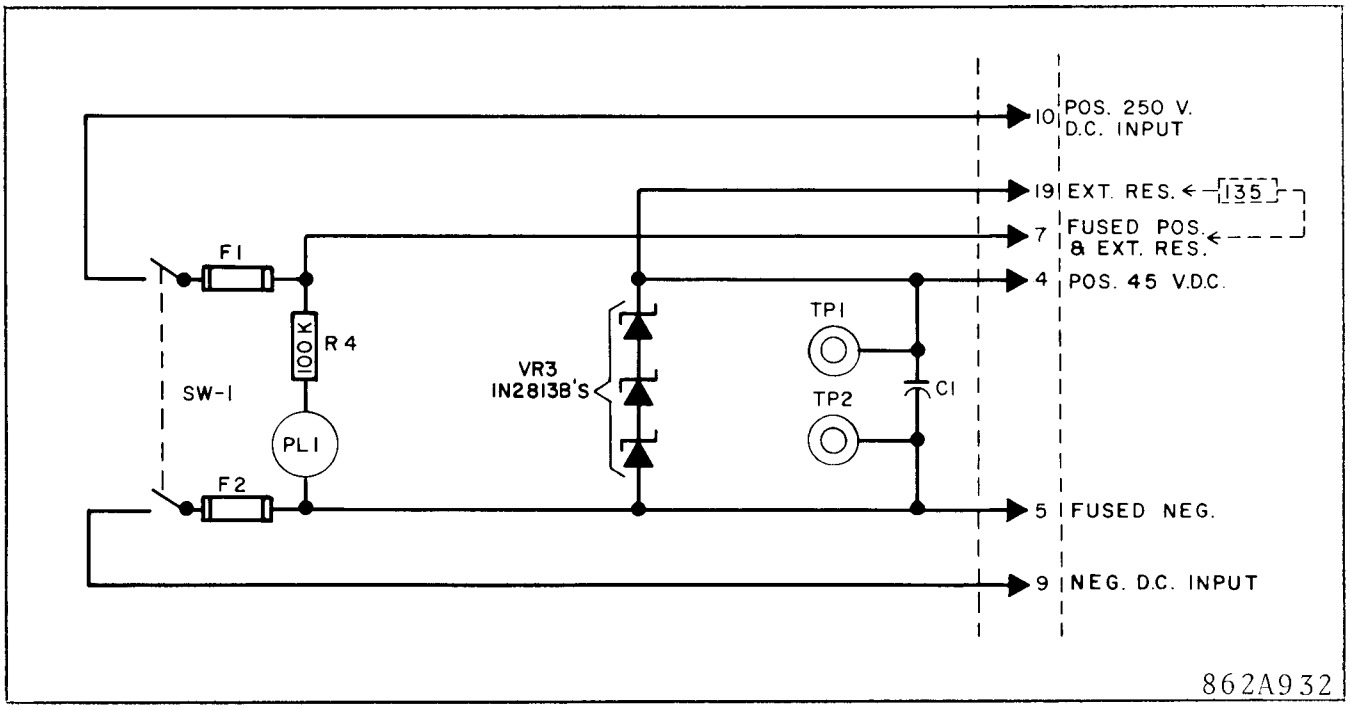


Fig. 15. Detail of Power Supply Section for 250-Volt Supply.

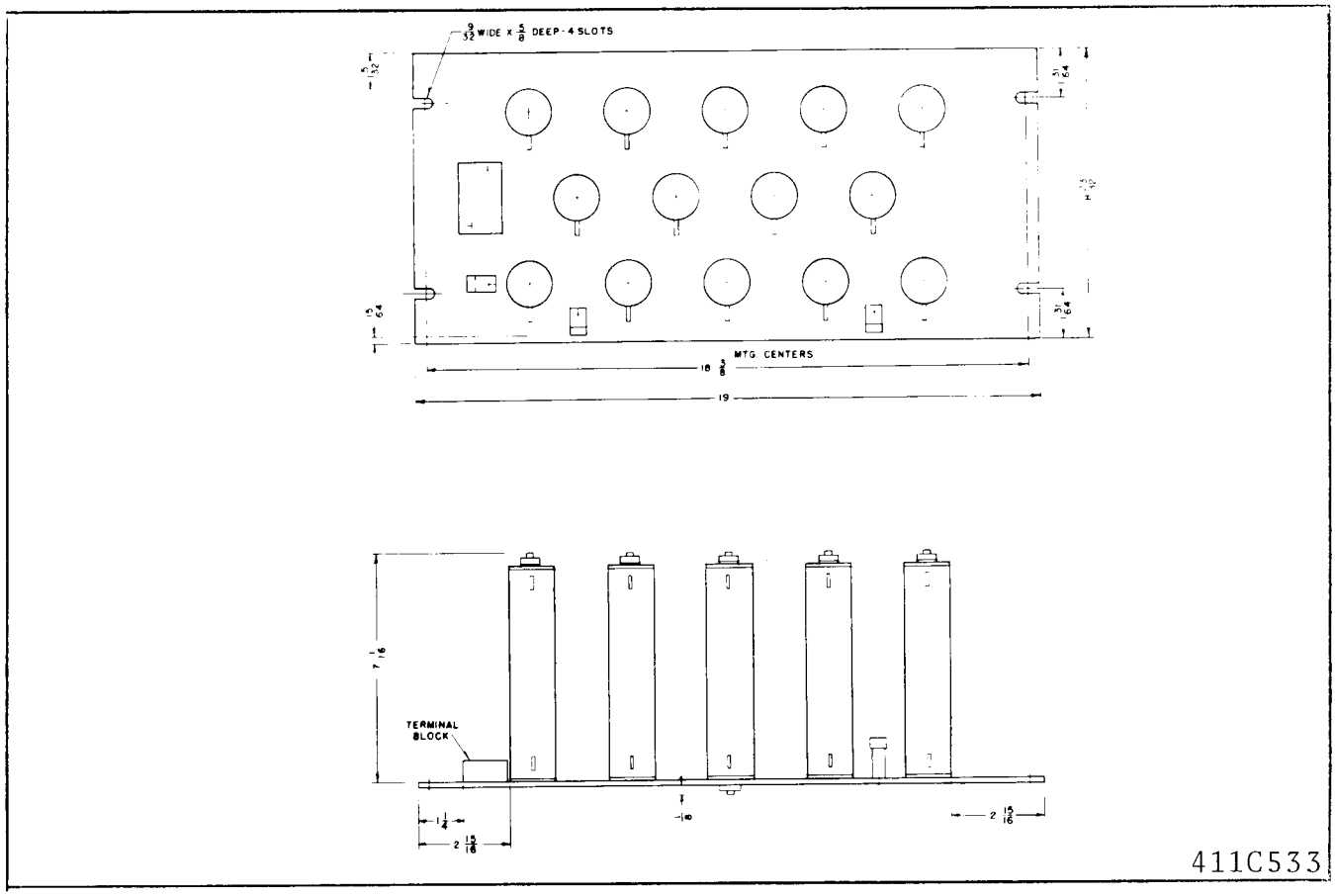


Fig. 16. Outline of External Resistor Unit for 250-Volt Operation.

WESTINGHOUSE ELECTRIC CORPORATION

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

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