

INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER
TRANSMITTER-RECEIVER ASSEMBLY - 30 to 300 kHz
For Directional and Phase Comparison Relaying
10 Watts - 48, 125, 250 V.D.C. with Optional Voice

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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 is designed for protective relaying of power transmission lines employing either of two types of blocking relaying systems: (1) directional comparison relaying, using the type KA-4 or equivalent carrier relay, or (2) phase-comparison relaying, using type SKB-TCU, SKBU-1, or type SKBU-11 relay equipment.

The type TC set can also be used for other functions including "push-to-talk" maintenance telephone communication, keyed carrier telemetering, and supervisory control.

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, fuses, power and test switches, pilot light, 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 Fig. 2. The components mounted on each printed circuit board or other sub-assembly are shown enclosed by dotted lines on the internal schematic, Fig. 7. The location of components on the three printed circuit boards are shown on separate illustrations, Figures 3, 4, and 5.

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 20-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. 7, 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 bufferamplifier 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 dc potential supplied to Q103 emitter circuit.

The buffer output energizes the driver stage which operates class B. When voice modulation is used, the transmitter mudulating 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 used two seriesconnected type 2N3792 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 may come in from the power line through the coaxial cable.

Terminals #19 and #20 on J104 are connected across a 2 ohm resistor R144, located on the power-amp module. When the transmitter is operating (carrier-on), approximately .5 amperes (dc) of current flows through R144 developing approximately 1 volt (dc). This voltage (or current) can be used to drive an indicating device such as an oscillograph or indicating relay for carrier-on indication. The value of input impedance of the device connected to these terminals will have no effect on the transmitter operation, provided that R144 remains as a shunt resistor. R144 should not be removed or value increased, in an effort to provide a higher current level for driving the indicating device, as this could jeopardize carrierstart operation.

The output transformer T105 couples the power transistors to the transmitter output filter FL102. The output filter includes two trap circuits (L102, CB, and L103, CC) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor CD approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G101 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line tuner and coaxial cable. Auto-transformer T106 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms characteristic impedance.

The series-resonant circuit composed of L105 and C_E is tuned to the transmitter frequency, and aids in providing resistive termination for the out-

put stage. Jack J102 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, 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, dc amplifier, and dc 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. 8 and 9.

The 20 kHz i.f. signal is rectified by diodes D201 and D202. The resulting dc output is amplified by transistors Q207 and Q208, giving a receiver output current of nominally 200 ma. for a 30-ohm external relay coil circuit. Where a second output current of 20 ma. is desired, an external 2000-ohm relay circuit can be connected to the receiver output as shown in Fig. 11. If only a 20-ma output is deisred, a 33-ohm resistor and diode must still be connected into the circuit as shown. Fig. 10 shows the receiver 200-ma. output characteristic.

POWER SUPPLY

The power supply circuit for 48 or 125-v. dc supply uses a series-type transistorized dc voltage regulator which has a very low standby current drain when there is not output current demand. The zener diode Z1 holds a constant base-tonegative voltage on the series-connected power transistor Q1. Depending on the load current, the dc voltage drop through the transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage of approximately 45-v. dc. The zener diode Z2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the dc output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuit.

For a 250-volt dc supply, the circuit of Fig. 14 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 Fig. 15) must be mounted at the top of a cabinet or an open rack. Bacause of the heat dissipated, no tansistorized equipment should be mounted above the resistor panel. The 250-volt TC set has a constant current drain of 1.5 amperes dc, and uses 2-amp. fuses.

When the TC set is used with solid-state protective relays (such as the SKBU-11), the pilot light PL1, power switch SW-1, and fuses F1 and F2 are omitted from the assembly. See Figures 1 and 2. Instead, the dc power to the complete relaying assembly is controlled from a single switch and set of fuses. This is done to prevent an incorrect tripping or blocking output which might result from interruption of one or both sides of the dc supply to the carrier set or protective relays. For solid-state relaying aplications, there are no connections to J104 terminals 7 or 5 (normally fused positive and fused negative). See Fig. 7.

RELAYING CONTROL CIRCUITS

The carrier control circuit for KDar relaying is shown in elementary form in Fig. 6. The "Transmitter Control" circuit is normally held at fused negative potential through the normally-closed carrier test pushbutton and the phase and ground

carrier-start relay contacts. Opening of any of these contacts allows current to flow from fused positive through resistor $R_{\rm C}$ and the Diode $D_{\rm I}$ to the transmitter control terminal TC/6, thus starting carrier transmission at full output. The potential of terminal TC/6 rises to plus 20 volts, limited by a Zener diode in the transmitter proper. The reception of carrier from either the local or remote transmitter normally causes a saturated current of about 200 ma. to flow in the alarm and holding coils (AL and RRH) in the type KA-4 (or equivalent) receiver auxiliary relay.

If the protective relays call for stopping the transmission of carrier, closing of CSP or CSG contact connects the transmitter control circuit back to fused negative, thus stopping any carrier transmission regardless of how it was started.

If a relaying carrier channel is also used for an auxiliary function such as telemetering or supervisory control, the keying contact for this function is connected into the carrier-start circuit in series with the carrier test pushbutton. Such a contact must be normally closed (in the non-operating condition). An auxiliary relay in the receiver output, usually in place of the alarm relay, energizes the telemetering or supervisory control equipment through contacts on the auxiliary relay.

CARRIER CONTROL FOR OTHER FUNCTIONS

If a type TC set is keyed on-off for telemetering or supervisory control only (no protective relaying), one of the curcuits shown in Fig. 16 can be used. Arrangements are shown for either a nrmally-closed or normally-open carrier-start contact. In the former case, a diode is required to allow using the Voice Adapter for push-to-talk voice communication between stations. Note that continuous telemetering must be interrupted when it is desired to use the carrier channel for voice communication.

The receiver output can be connected for either 200-ma. or 20-ma. operation as shown in Fig. 11. The 200-ma. output is preferable (if a choice is available) because of a slightly better time constant in the 200-ma. receiver output circuit. In some cases, both the 200-ma. and the 20-ma. outputs may be used together. For example,

the 200-ma. output can be used with a standard carrier auxiliary relay (for directional-comparison relaying), while the 20-ma. output feeds a 2000ohm receiver relay used with supervisory control eqiupment. The connections shown in Fig. 11 would be used for this case, with the receiver relay holding coil (RRH) in place of the 33-ohm resistor and the 2000-ohm supervisory relay in the 20-ma. output in place of the RRH and AL coils shown. The alarm function would be provided by the supervisory control eqiupment.

CHARACTERISTICS

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

phase comparison relaying)

10 watts into 50 to 70-ohm re-Transmitter

sistive load output

55 db below 10 watts Harmonics

125 mv. input for 180 ma. mini-Receiver

mum output current sensitivity

1500 Hz bandwidth (3 db down); Receiver

80 db at \pm 3 kHz. selectivity

Transmitter-receiver Channel rating 40 db

48, 125, or 250V dc Input Voltage

Supply voltage

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

Battery Drain:

0.5 amp standby, 1.35 amp 48V dc

transmitting

0.25 amp standby, 1.1 amp trans-125V dc

mitting

1.5 amp standby or transmitting 250V dc

Temperature

-20 to +60°C around chassis range

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. 12. 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. 13. 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 frequencys 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 dc 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. 12, 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 3terminal 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 temperture around the chassis must not exceed 60°C.

ADJUSTMENTS

TRANSMITTER

There are two adjustable controls on the transmitter printed-circuit board: (1) the power output control R112, and (2) base bias control R142 for transistors Q104 and Q105. The control R142 is factory adjusted for a quiescent (no-signal) current of 0.2 ± 0.05 ma. dc at terminal 2 of transformer T103. This applies a small amount of forward base bias to transistors Q104 and Q105 to minimize cross-over distortion. A thermistor (R141) is included for temperature compensation. This control (R142) need not be changed except as described in the MAINTENANCE section.

The other 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 ac vacuum tube voltmeter (VTVM) across the load resistor. Turn the transmitter power output control R112 to minimum (full counterclockwise).

Now turn on the power switch on the panel and note the dc 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 in 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 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.

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.

Note: For 200-300 kHz 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.

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 | 2.4 |
| 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. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection 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 of 0.5 volt. This setting can be checked by connecting an ac 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 carrierfrequency voltmeter. If a simple VTVM is used, have the remote transmitter tuned 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) de milliammeter plugged into J203, adjust the receiver gain control unit 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 exaclty 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 R207 at maximum, the i-f gain control R239 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.

MAINTENANCE

Periodic checks of the received carrier signal will indicate impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output 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 Table I through IV. 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 and 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 dc 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 dc 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 dc milliammeter reads 0.2 mA dc ± 0.05 mA. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T103. Again apply dc power and proceed with the transmitter adjustment as described in the ADJUSTMENTS seciton.

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".

Only Power Amplifier module styles 774B881G01 thru G05 and 774B541G01 thru G05 use type 2N3792 transistors. When ordering replacement transistors, be sure to check module style. Other style power amplifier modules can be modified by changing diodes D104 and D106 to type 1N4818 Diodes. Order these as two 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. 7).

2. R136 Jumper

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

3. Capacitors C111 and C113 (on Power Amp. board)

- a. 30-50kHz 0.47 mfd. S#188A293H01
 - b. 50.5-75kHz 0.22 mfd. S#188A293H02
 - c. S#188A293H03
 - d. 100.5-150kHz -0.10 mfd. S#188A293H04
 - e. S#188A293H05

4. Transmitter Moudle Mounting Plate

When changing from a frequency of 200 kHz or below to a frequency above 200 kHz, 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 200.5-300 kHz. receiver input filter FL201 mounts underneath it. See Fig. 2.

5. Zener Diode Z104

For the 200.5-300kHz. range, a type 1N2999B 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 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 adjustment ranges of the groups are:

| 30.0-31.5 32.0-33.5 34.0-36.0 36.5-38.5 39.0-41.0 41.5-44.0 44.5-47.0 47.5-50.0 | 64.5- 68.0 68.5- 72.0 72.5- 76.0 76.5- 80.0 80.5- 84.5 85.0- 89.0 89.5- 94.5 | 113.0-119.5 120.0-127.0 127.5-135.0 135.5-143.0 145.5-151.0 151.5-159.5 160.0-169.5 170.0-180.0 | 241.1-222.0 222.1-230.0 230.1-240.0 240.1-250.0 250.1-262.0 262.1-274.0 274.1-287.0 |
|--|--|--|---|
| 44.5-47.0 | 89.5- 94.5 95.0-100.0 100.5-106.0 | | 274.1-287.0 287.1-300.0 |

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 the 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 condi-

tion 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.

TABLE I Receiver DC Measurements

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

| TEST POINT | - 1 ' | STANDBY (No Signal) | | | TH 125 | |
|-----------------|-------|------------------------|------|------|--------|------|
| TP201 | | 35-38 | 3 | | 35-38 | 3 |
| TP202 | | (|) | | (|) |
| TP203 | | 11-12 | ? | | 11-12 | 1 |
| TP204 | ļ | < 0.5 | | | 2-3 | |
| TP205 | | 18-22 | | | 18-22 | |
| TRAN- SISTOR | E* | B* | C* | E* | B* | C* |
| Q201 | 36.5 | 37 | 42.0 | 36.5 | 36 | 42.0 |
| Q202 | 36.5 | 37.5 | 43.0 | 36.0 | 35.5 | 43.0 |
| Q203 | <0.5 | 0 | 18.0 | <0.5 | 0 | 18.0 |
| Q204 | 2.1 | 2.75 | 18.0 | 2.7 | 2.9 | 18.0 |
| Q205 | 2.2 | 2.8 | 18.0 | 2.5 | 2.7 | 18.0 |
| Q206 | 2.2 | 2.8 | 11.0 | 2.6 | 2.8 | 11.5 |
| Q207 | <0.5 | <0.5 | 22.0 | 2.0 | 2.2 | 5.0 |
| Q208 | <0.5 | <0.5 | 44.0 | 11.7 | 2.0 | 2.0 |

*E - Emitter, B - Base, C - Collector All voltages read with dc vacuum-tube voltmeter. <0.5 means "less than 0.5V."

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 VOLTAGE |
|-------------------|-----------------------|
| FL201-IN to Gnd. | 0.067 |
| FL201-OUT to Gnd. | 0.04 |
| Q203 - E to TP206 | 0.097 |
| Q203 - C to TP206 | 0.06 |
| Q204 - B to TP206 | 0.01 |
| Q204 - C to TP206 | 0.09 |
| Q205 - B to TP206 | 0.013 |
| Q205 - C to TP206 | 1.15 |
| Q206 - B to TP206 | 0.15 |
| Q206 - C to TP206 | 2.5 |
| TP202 to TP206 | 0.5 |

All voltages read with ac vacuum-tube voltmeter.

TABLE III Transmitter DC Measurements

Note: All voltages are positive with respect to Neg. DC. (TP104). All voltages read with dc VTVM.

| | TEST POINT | CARRIER OFF | CARRIER ON | | | |
|---|---------------|----------------|---------------|--|--|--|
| | TP101 | 8.5 volts dc | 8.5 volts dc | | | |
| | TP102 | <0.5 | 20 | | | |
| | TP103 | <0.5 | 19.5 | | | |
| | TP105 | <0.5 | 9 | | | |
| | TP106 | 44 | 24 | | | |
| | TP107 | 44 | 24 | | | |
| | TP108 | 45 | 44 | | | |
| 0 | TP110 | 0.6 | 0.75 | | | |
| 0 | TP111 | 0.6 | 0.75 | | | |
| | TP112 | 0 | <0.5 | | | |
| | TP113 | 45 | 44 | | | |
| | J101 | 5 ma. max. | 0.6 amp. | | | |
| | (Front Panel) | | | | | |

| | TRAN- SISTOR | E | В | С | E | В | С |
|---|-----------------|------|------|------|------|------|------|
| | Q101 | 7.8 | 7.9 | 2.0 | 7.8 | 7.8 | 1.8 |
| | Q102 | 8.1 | 8.7 | 1.0 | 8.1 | 8.7 | 1.0 |
| | Q103 | <0.5 | <0.5 | <0.5 | 20.0 | 20.0 | 9.0 |
| 0 | Q104 | 0.1 | 0.6 | 45 | <0.5 | 0.75 | 44 |
| 0 | Q105 | 0.1 | 0.6 | 45 | <0.5 | 0.75 | 44 |
| | Q106 | 0 | <0.5 | 44.5 | 0 | 0.8 | 1.2 |
| | Q107 | 44.3 | 44.2 | 0 | 24 | 24 | 0 |
| | Q108 | 45.0 | 44.7 | 44.5 | 44.2 | 44.0 | 24.2 |

RECEIVER

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

- 2. Receiver input filter (FL201), specify frequency.
- 3. Resistors F211-R238 Combination See values in Fig. 7 below internal schematic.
- 4. 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 may 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 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 | AC VOLTAGE |
|--|--------------------------------|
| T101-3 to TP104 TP103 to TP102 Q103-C to TP104 | 1.5 volts, rms. 0.2 1.1 ϕ |
| TP110 to T102-4 | 0.2 |
| TP111 to T102-4 | 0.2 |
| Q104-C to TP104 | 3.3 |
| Q105-C to TP104 | 3.3 |
| T103-4 to Gnd. | 1.1 |
| T104-1 to Gnd. | 1.4 |
| Q107-B to TP107 | 0.5 volts, rms. |
| Q108-B to TP113 | 0.5 |
| Q107-C to TP107 | 14-16 |
| Q108-C to TP113 | 14-16 |
| T105-4 to Gnd. | 105 |
| T106-2 to Gnd. | 100-160* |
| TP109 to Gnd. | 30-50* |
| J102 to Gnd. | 24.5 |

Note: T101-3 = tap 3 of Transformer T101 Q104-C = Collector of Transistor Q104 TP105 = Test Point 105

All voltages read with ac VTVM

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

RECOMMENDED TEST EQUIPMENT

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

Voltage Range: Input Impedance

0.1 to 300 volts 1.0 megohm, min.

II. Desirable Test Equipment for Apparatus Maintenance.

- a. All items listed in I.
- b. Signal Generator

Output Voltage: Frequency Range:

up to 10 volts r.m.s. 20 to 330 kHz

- c. Oscilloscope
- d. Ohmeter
- 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

| | Transmitter Section | | |
|----------------------|-----------------------|---------------------|--|
| average. | RATING | STYLE NUMBER | |
| SYMBOL | 0.1 mfd, 200 V. DC | 187A624H01 | |
| C101 | .005 mfd, 300 V. DC | 187A694H29 | |
| C102 | 180 pf. 500 V. DC | 187A695H29 | |
| C103 | 0.25 mfd, 200 V. DC | 187A624H02 | |
| C104 | 0.25 mfd, 200 V. DC | 187A624H02 | |
| C105 | 0.25 mfd, 200 V. DC | 187A624H02 | |
| C106 | 0.25 mfd, 200 V. DC | 187A624H02 | |
| C107 | 0.50 mfd, 200 V. DC | 187A624H03 | |
| C108 | 0.35 mfd, 200 V. DC | 187A624H02 | |
| C109 | 0.25 mfd, 200 V. DC | 187A624H02 | |
| C110 | | _ | |
| † C111 | (See Table Below) | 187A695H12 | |
| C112 | 39 pfd, 500 V. DC | _ | |
| † C113 | (See Table Below) | 187A695H23 | |
| C114 | 100 pf. 500 V. DC | 187A695H23 | |
| C115 | 100 pf. 500 V. DC | 187A694H11 | |
| C116 | 0.001 mfd, 500 V. DC. | Vary with Frequer | |
| CA | Part of FL101 | Vary with Frequence | |
| CB, CC, CD, CE | Part of FL102 | Style Number | |
| † FREQ. | C111, C113 | 188A293H01 | |
| 30 - 50 kHz | 0.47 mfd, 400 V. DC | 188A293H02 | |
| 50.5- 75 kHz | 0.22 mfd, 400 V. DC | 188A293H03 | |
| 175.5-100 kHz | 0.15 mfd, 400 V. DC | 188A293H04 | |
| 100.5-150 kHz | 0.1 mfd, 400 V. DC | 188A293H05 | |
| 150.5-300 kHz | 0.047 mfd, 400 V. DC | 184A855H07 | |
| D101 | 1N457A | 188A342H06 | |
| D103 | 1N4818 | 188A342H06 | |
| D104 | 1N4818 | 188A342H06 | |
| D105 | 1N4818 | 188A342H06 | |
| D106 | 1N4818 | 877A124H01 | |
| G101 | Type RVS Arrester | | |
| J101 | Closed Circuit Jack | 187A606H01 | |
| J102 | Banana Plug Jack | 2 of 185A431H0 | |
| J103 | Coaxial Cable Jack | 187A633H01 | |
| J104 | 24-Term Receptacle | 187A669H01 | |
| J104 | 12-Term Receptable | 629A205H02 | |

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

| SYMBOL | | RATING | | STYLE NUMBER | |
|--------|--------------------|---|---------------------------|---------------------|--|
| L101 | Par | Part of FL101 | | | |
| L102 | FL | 102 Trap Coil (2nd H | armonic) | Vary with Frequenc | |
| L103 | | 102 Trap Coil (3rd Ha | | Vary with Frequency | |
| L104 | | mh. | | 292B096G01 | |
| L105 | FL: circ | 02 Coil (part of serie uit tuned to fundame | s-resonant ntal freq.) | Vary with Frequency | |
| L106 | 2.0 | | | 2500 4 271101 | |
| Q101 | 2N2 | 905A | | 3500A37H01 | |
| Q102 | | 905A | | 762A672H10 | |
| Q103 | 2N5 | | | 762A672H10 | |
| Q104 | 2N3 | | | 184A638H13 | |
| Q105 | 2N3 | | | 762A672H07 | |
| Q106 | TI-4 | | | 762A672H07 | |
| Q107 | | | | 184A638H11 | |
| Q108 | 2N3 | 792 - Matched Pair | | 187A673H16 | |
| SYMBOL | OHMS | ± TOL. % | WATTS | | |
| R101 | 5,600 | 5 | 1 | STYLE NUMBER | |
| R102 | 2,200 | 10 | 0.5 | 187A643H45 | |
| R103 | 10,000 | 10 | 0.5 | 187A641H35 | |
| R104 | 100,000 | 5 | 0.5 | 187A641H51 | |
| R105 | 390 | 5 | 0.5 | 187A763H75 | |
| R106 | 1,200 | 5 | 0.5 | 184A763H17 | |
| R107 | 10,000 | 10 | | 184A763H29 | |
| R108 | 100,000 | 5 | 0.5 | 187A641H51 | |
| R109 | 390 | 5 | 0.5 | 184A763H75 | |
| R111 | 1,200 | 5 | 0.5 | 184A763H17 | |
| R112 | 1 K Pot | 20 | 0.5 | 187A763H29 | |
| R113 | 4,700 | 5 | 0.25 | 629A430H02 | |
| R114 | 10,000 | 10 | 0.5 | 184A763H43 | |
| R115 | 150 | 5 | 0.5 | 187A641H51 | |
| R116 | 100 | 5 | 0.5 | 184A763H07 | |
| | 1,000 | <u> </u> | 0.5 | 184A763H03 | |
| _ | 48 V. DC | 5 | 25 | 1202588 | |
| R117 | 3,750 125 V. DC | 5 | 25 | 1202955 | |
| | 8,500 250 V. DC | 5 | 25 | 1267310 | |

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

| | | ITAIR | emitter Section (| | |
|-------------|--------------|----------------|---------------------|----------------|-------------------|
| | SYMBOL | онмѕ | <u>+</u> TOL. % | WATTS | STYLE NUMBER |
| | R118 | 10,000 | 2 | 0.5 | 629A531H56 |
| | R119 | 62 | 2 | 0.5 | 629A531H03 |
| - | R120 | 10,000 | 5 | 2 | 185A207H51 |
| ļ | R121 | 10 | 5 | 2 | 187A683H01 |
| - | R122 | 10 | 5 | 0.5 | 187A290H01 |
| | R123 | 10 | 10 | 0.5 | 187A290H01 |
| <u> </u> | R124 | 100 | 10 | 1 | 187A644H03 |
| ļ | R124 | 1,000 | 10 | 0.5 | 187A641H27 |
| - | R126 | 4,700 | 10 | 1 | 187A644H43 |
| - | R127 | 10 | 10 | 0.5 | 187A640H01 |
| - | R128 | 2,200 | 5 | 1 | 187A644H35 |
| | R128 | 2.7 | 10 | 0.5 | 184A636H14 |
| - | | 10 | 10 | 0.5 | 187A640H01 |
| - | R130 | 4,700 | 5 | 1 | 187A644H43 |
| - | R131 | 2.7 | 10 | 0.5 | 184A636H14 |
| - | R132 | 0.27 | 10 | 1 | 184A636H18 |
| - | R133 | 0.27 | 10 | 1 | 184A636H18 |
| - | R134 | 3,000 | 10 | 5 | 188A317H01 |
| | R135 | 12,000 | 10 | 0.5 | 184A763H53 |
| <u> </u> | R136 | 15,000 | 10 | 2 | 187A642H55 |
| | R137 | 1,000 | 10 | 0.5 | 187A641H27 |
| <u> </u> | R138 | 1,000 | 10 | 0.5 | 187A641H27 |
| - | R139 | 68 | 2 | 0.5 | 629A531H04 |
| | R140 | 30 | | 02 Thermistor | 185A211H06 |
| _ | R141 | 25K Pot | 20 | 1/8 | 629A430H15 |
| D _ | R142 | 23K Pot 20K | 20 2 | 0.5 | 629A531H63 |
| | R143 | 2 Ω | | 3W | 762A679H13 |
| o _ | R144 | 232 | RATING | | STYLE NUMBER |
| - | SYMBOL | 10,000 |)/400 ohms | | 205C043G01 |
| \vdash | T101 | |)/400 c.t. | | 205C043G04 |
| - | T102 | l | | L63300 | 1962694 |
| - | T103 | | , 0 0 1 1 1 1 | Pri-/each sec. | 292B526G01 |
| <u> </u> | T104 | | 0 ohms | | 292B526G02 |
| _ - | T105 | | 0 - 60 - 70 ohms | | 292B526G03 |
| o L | T106 | | kHz crystal per 328 | 3C083 | Specify Frequency |
| - | Y101 | | Diode 1N5357B (20 | | 862A288H03 |
| | Z101 | 1 | Diode 1N2999B (56 | | 629A798H04 |
| | Z102 | | Diode 1N2999B (56 | | 629A798H04 |
| | Z103 | | Diode 1N2999B (56 | | 629A798H04 |
| | Z 104 | Zener | Diode INZAAAD (30 | | 02372730220 |

ELECTRICAL PARTS LIST Receiver Section

| SYMBOL RATING | | STYLE NUMBER |
|---------------------------------------|--|-------------------|
| 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 | 2N4848 | 188A342H06 |
| D204 | 1N4818 | 188A342H06 |
| FL201 | Receiver Input Filter 30-300 kHz | Specify Frequency |
| FL202 | Receiver i.f. Filter - 20 kHz (2 sections) | 187A590G02 |
| J201 | Receiver Coax. Input Jack | |
| J202 | Closed Circuit Jack(20 MA) | 187A638H01 |
| J203 | Closed Circuit Jack (200MA) | 187A606H01 |
| L201 | 33 mh. | 187A606H01 |
| Q201 | 2N2905A | 187A599H02 |
| Q202 | 2N2905A | 762A672H10 |
| Q203 | 2N2905A | 762A672H10 |
| Q204 | 2N2905A | 762A672H10 |
| Q205 | 2N2905A | 762A672H10 |
| Q206 | 2N2905A | 762A672H10 |
| Q207 | 2N3645 | 762A672H10 |
| Q208 | 2N4903 | 849A441H01 |
| 4200 | 2N49U3 | 187A673H13 |
| · · · · · · · · · · · · · · · · · · · | | 10.110/51115 |

ELECTRICAL PARTS LIST Receiver Section (Cont.)

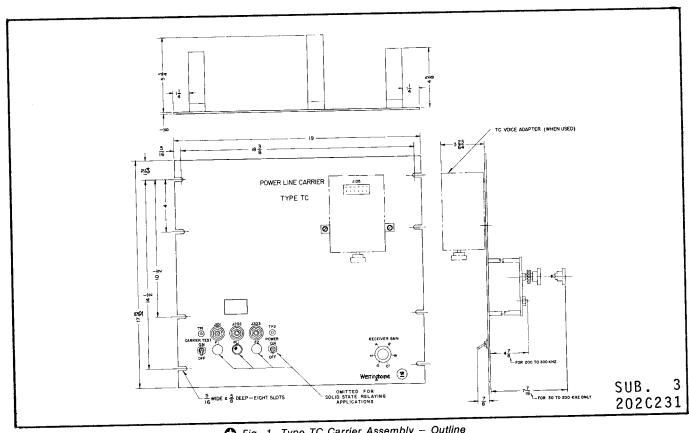
| CVMPCI | RATING | | | |
|---------------------|-----------|----------|-------|------------------|
| SYMBOL RESISTORS | OHMS | ± TOL. % | WATTS | STYLE NUMBER |
| R201 | 10,000 | 10 | 0.5 | 187A641H51 |
| R202 | 2,200 | 10 | 0.5 | 187A641H35 |
| R203 | 10,000 | 10 | 0.5 | 187A641H51 |
| R204 | 100,000 | 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 | 629H430H02 |
| R213 | 1,200 | 5 | 0.5 | 184A763H29 |
| R213 | 5,600 | 5 | 1 | 187A643H45 |
| R215 | 20,000 | 5 | 0.5 | 184A763H58 |
| R216 | 3,600 | 5 | 0.5 | 184A763H40 |
| 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 |
| R229 R230 | 10 | 5 | 0.5 | 187A290H01 |
| R230 R231 | 2,000 | 5 | 0.5 | 184A763H34 |
| | 1,200 | 5 | 2 | 185A207H29 |
| R232 R233 | 4,700 | 10 | 2 | 187A642H43 |

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

ELECTRICAL PARTS LIST Receiver Section (Cont.)

| SYMBOL OHMS | Γ | | Neceivel | Section (C | · | | |
|--|------------|----------------------|---|-------------|-------------------------------|-------------------|--|
| R234 | | SYMBOL | OHMS | | ING | 07/1 | |
| R235 | - | D224 | | TOL. % | WATTS | SIYLE NUMBER | |
| R236 | _ | | | | 0.5 | 184A763H44 | |
| R237 | ∵ ⊦ | | | | 0.5 | 184A763H21 | |
| TR238 | - | | | | 1 | 187A644H43 | |
| R239 | - | | 170 | 5 | 40 | 1336074 | |
| R240 50 Sensistor 0.25 187A430H02 | - | _ <u>-</u> | 1 | _ | | See † Note Below | |
| R280 56 5 0.5 187A685H08 T201 10,000/10,000 Ohms 714B677G01 T202 10,000/400 Ohms 205C043G01 T203 25,000/300 Ohms 205C043G01 T203 25,000/300 Ohms 205C043G01 T203 25,000/300 Ohms 205C043G03 Y201 50-320 kHz Crystal per 328C083 Specify Frequency T202 1N1789 (56 V. ± 10%) 584C434H08 T202 1N1789 (56 V. ± 10%) 584C434H08 T202 T202 | | | | | | 629A430H02 | |
| T201 | 3 | | + | | | 187A685H08 | |
| T202 | - | | + <u>-</u> | 0.3 | | 187A290H19 | |
| T203 | \vdash | | | | | 714B677G01 | |
| $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ | - | | | | | 205C043G01 | |
| Z201 | + | | | | | 205C043G03 | |
| Table | - | | 50-320 kHz Crystal per 328C083 | | | Specify Frequency | |
| Power Supply Section SYMBOL FUNCTION DESCRIPTION OR RATING STYLE NUMBER | | | | | | 184A449H07 | |
| C1 | | 2.202 | | | | 584C434H08 | |
| C1 | <u> </u> | Power Supply Section | | | | | |
| C2 | - | | + | DESCRIP' | TION OR RATING | STYLE NUMBER | |
| C2 AC grounding 0.5 mfd. 1500 V. DC 1877962 C3 AC grounding 0.5 mfd. 1500 V. DC 1877962 F1, F2 Overload Protection 1.5a, 48/125 V. DC 11D919H26 F1, F2 Overload Protection 2.0a. 250 V. DC 478067 PL1 Neon Pilot Light 125/250 Volts 120 Volts 183A955H01 PL1 Filament-type for 48 Volts 55 Volts 187A133H02 Q1 Series Regulator *Type 2N6259 Silicon Transistor 3503A41H01 R1 R2 Series dropping Same as R1 04D1299H44 R3 Current limiting Sou ohms, 3½" 04D1299H44 Current limiting Sou ohms, 3½" 1268047 R4 Current Limiting Sou ohms, 3½" 04D1299H44 R4 Current Limiting Sou ohms, 3½" 04D1299H44 SW1 Power Switch Switch Sa, 250 V. AC-DC 880A357H01 SW101 Carrier Test Same as SW1 880A357H01 TP1 Test Point (+) Pin Jack – red 187A332H01 TP2 Test Point (-) Pin Jack – black 187A332H02 Z1 Voltage Regulator 1N2828B (45 V.) 184A617H12 | _ | | | | | + | |
| C3 | | | | | | | |
| F1, F2 | | | | | | | |
| PL1 Neon Pilot Light 125 / 250 Volts 120 Volts 183A955H01 | | | | | | | |
| PL1 | | F1, F2 | | | | | |
| Series Regulator Series Regulator Series Regulator Series Regulator Series Regulator Series dropping Series dropping Series dropping Series dropping Same as R1 O4D1299H44 O4D129PH44 O4D12 | | PL1 | Neon Pilot Light 125/250 Volts | | 120 Volts | | |
| R1 | | PL1 | Filament-type for 48 Volts | | 55 Volts | 187A133H02 | |
| R2 | | Q1 | Series Regulator | *T Sili | Type 2N6259 con Transistor | 3503A41H01 | |
| $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ | | | (Series dropping | 26 | 5 ohms 216" | 04012001144 | |
| $ \begin{array}{c ccccccccccccccccccccccccccccccccccc$ | | | 125V Series dropping | | | | |
| | | R3 | Current limiting | | | | |
| R4 Current Limiting 100K, 0.5 watt 184A763H75 SW1 Power Switch 3a, 250 V. AC-DC 880A357H01 SW101 Carrier Test Same as SW1 880A357H01 TP1 Test Point (+) Pin Jack - red 187A332H01 TP2 Test Point (-) Pin Jack - black 187A332H02 Z1 Voltage Regulator 1N2828B (45 V.) 184A854H06 Z2 Surge Protection IN3009A (130 V.) 184A617H12 Z3 Voltage reg. for 250 V. 1N100PA (130 V.) 184A617H12 | | | $\frac{1}{10}$ $R1 = R2 = 0$ | | _ | _ | |
| SW1 Power Switch 3a, 250 V. AC-DC 6a, 125 V. AC-DC 880A357H01 SW101 Carrier Test Same as SW1 880A357H01 TP1 Test Point (+) Pin Jack - red 187A332H01 TP2 Test Point (-) Pin Jack - black 187A332H02 Z1 Voltage Regulator 1N2828B (45 V.) 184A854H06 Z2 Surge Protection 1N3009A (130 V.) 184A617H12 Z3 Voltage reg. for 250 V. 1N1004RP (4014) | <u> </u> | | R3 = 26.5 ohm | s 3½" | | 04D1299H44 | |
| SW1 Power Switch 3a, 250 V. AC-DC 880A357H01 SW101 Carrier Test Same as SW1 880A357H01 TP1 Test Point (+) Pin Jack - red 187A332H01 TP2 Test Point (-) Pin Jack - black 187A332H02 Z1 Voltage Regulator 1N2828B (45 V.) 184A854H06 Z2 Surge Protection 1N3009A (130 V.) 184A617H12 Z3 Voltage reg. for 250 V. 1N1004B (130 V.) 184A617H12 | <u> </u> | R4 | Current Limiting | 100K, 0 | 5 watt | | |
| SW101 Carrier Test Same as SW1 880A357H01 TP1 Test Point (+) Pin Jack - red 187A332H01 TP2 Test Point (-) Pin Jack - black 187A332H02 Z1 Voltage Regulator 1N2828B (45 V.) 184A854H06 Z2 Surge Protection 1N3009A (130 V.) 184A617H12 Z3 Voltage reg. for 250 V. 1N100PA (140 V.) 184A617H12 | | | | 1 | | | |
| TP1 Test Point (+) Pin Jack - red 187A332H01 TP2 Test Point (-) Pin Jack - black 187A332H02 Z1 Voltage Regulator 1N2828B (45 V.) 184A854H06 Z2 Surge Protection 1N3009A (130 V.) 184A617H12 Z3 Voltage reg. for 250 V. 1N100PR (4014) | <u> </u> | | Carrier Test | | | 880 A 357 HO1 | |
| Test Point (-) Pin Jack - black 187A332H02 | | | | | | | |
| Voltage Regulator | <u> </u> | | | | | | |
| Z2 Surge Protection 1N3009A (130 V.) Zener Diodes 184A617H12 Z3 Voltage reg. for 250 V. 1N3009A (130 V.) | | Zl | Voltage Regulator | | | | |
| Z3 Voltage reg. for 250 V | | | Surge Protection | 1N3009A | (130 V.) | | |
| | ! | Z 3 | Voltage reg. for 250 V. | | | | |

 $[\]dagger$ R238 - omit above 50 kHz - 23K, 30-50 kHz, S#187A641H59



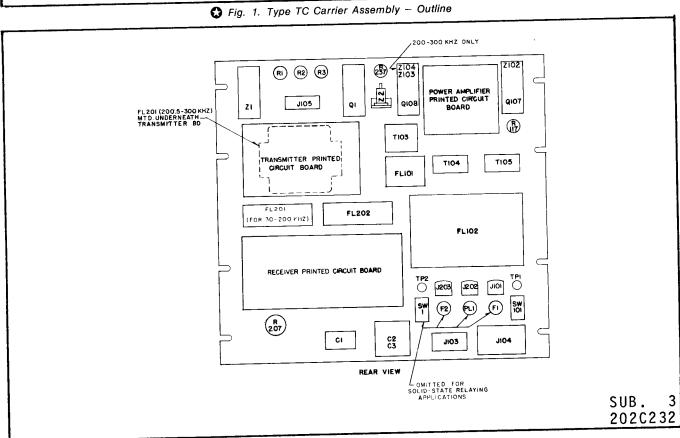


Fig. 2. Type TC Carrier Assembly - Parts Location

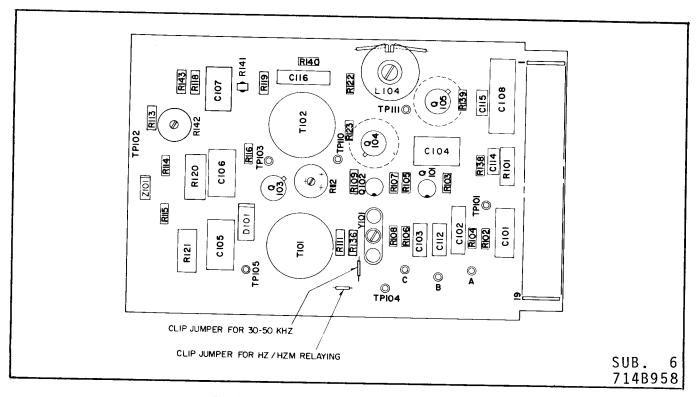
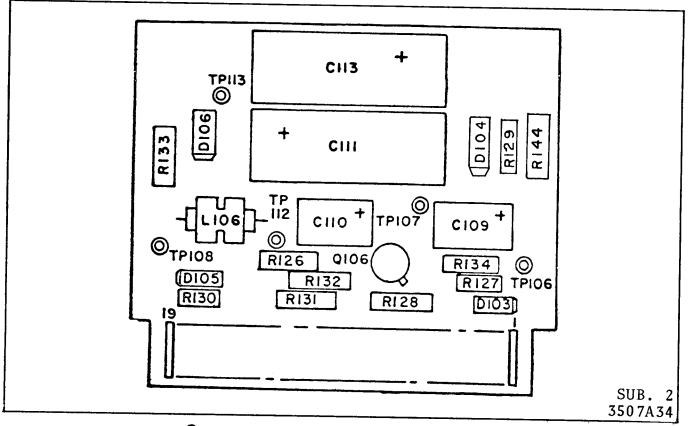


Fig. 3. Transmitter Printed Circuit - Parts Location



♀ Fig. 4. Power Amplifier Printed Circuit — Parts Location

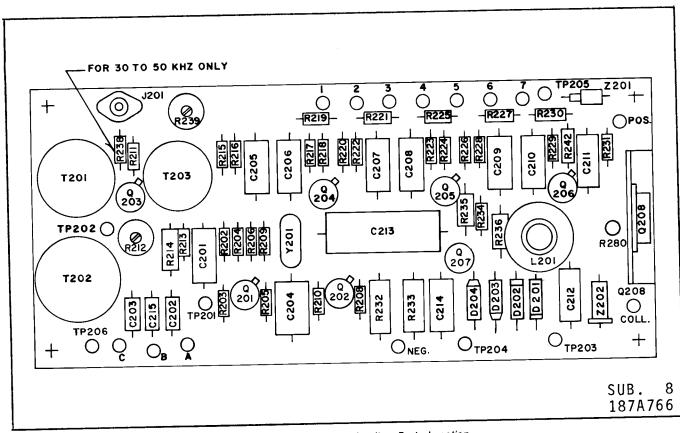


Fig. 5. Receiver Printed Circuit -- Parts Location

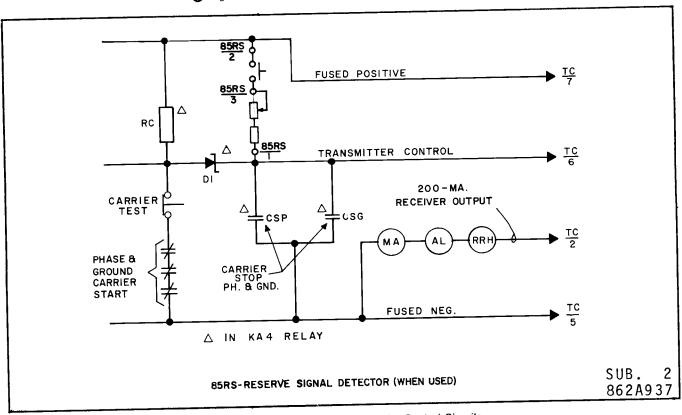


Fig. 6. Elementary K-Dar Carrier Control Circuits.

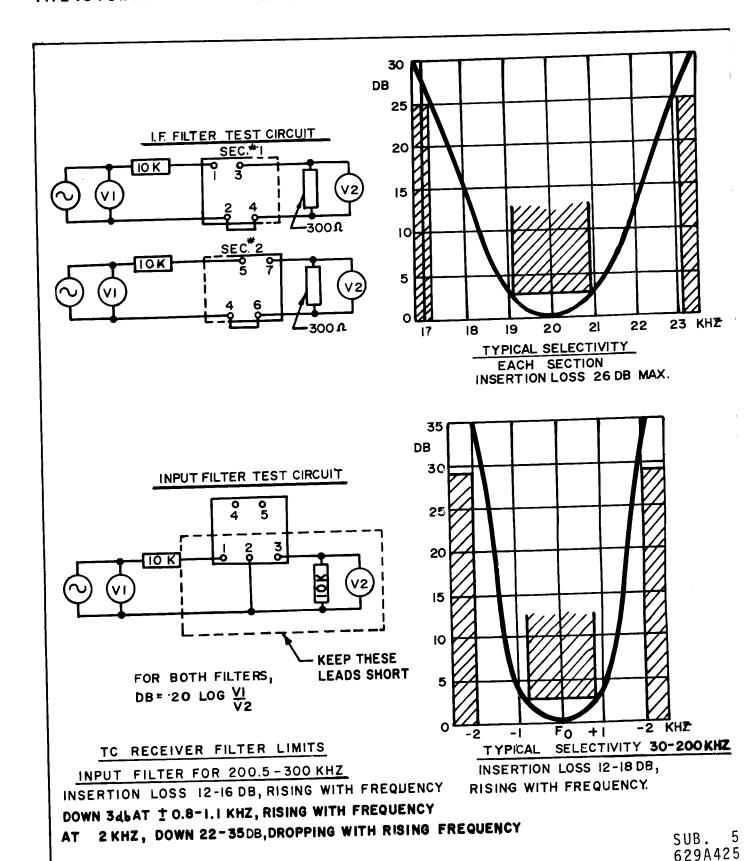
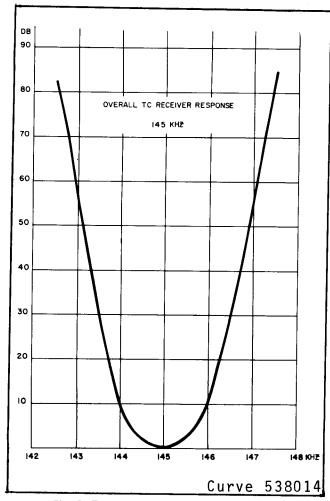


Fig. 8. Type TC Receiver Filter Characteristics



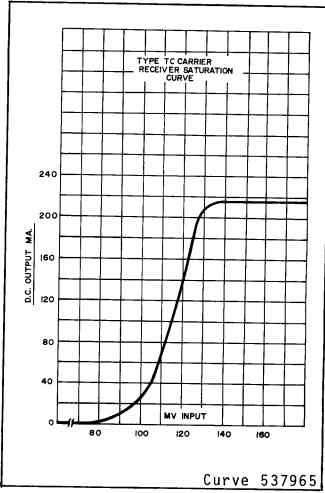
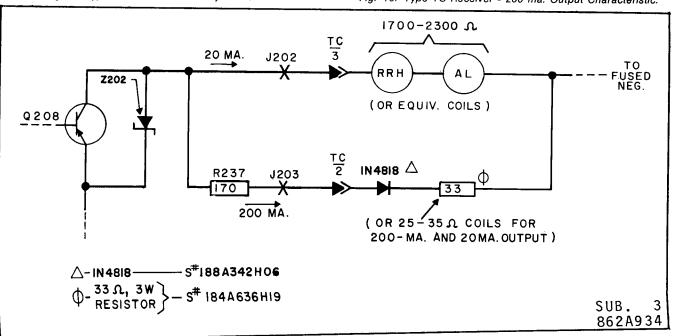


Fig. 9. Type TC Overall Selectivity Curve

Fig. 10. Type TC Receiver - 200 ma. Output Characteristic.



§ Fig. 11. TC Receiver Output For 20-ma. Operation

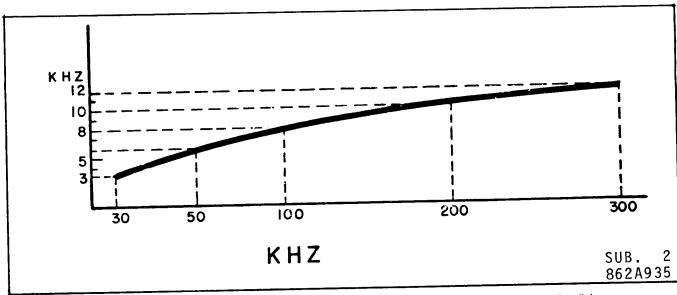


Fig. 12. Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

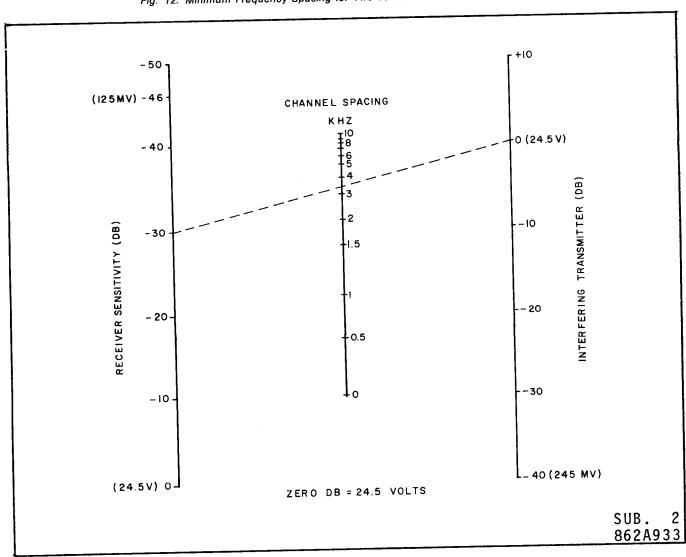


Fig. 13. Minimum Channel Spacing for Keyed Carrier 60 p.p.s.

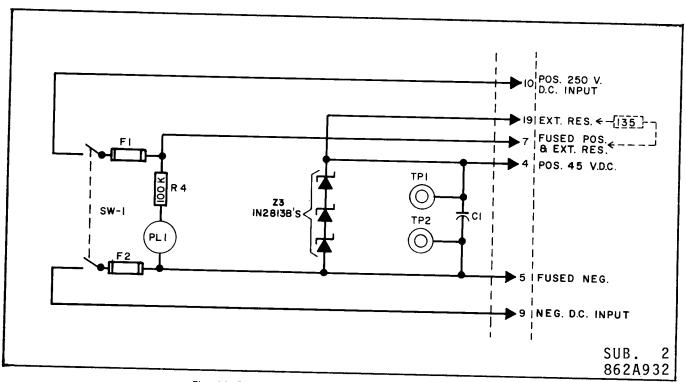


Fig. 14. Detail of Power Supply Section For 250-Volt Supply

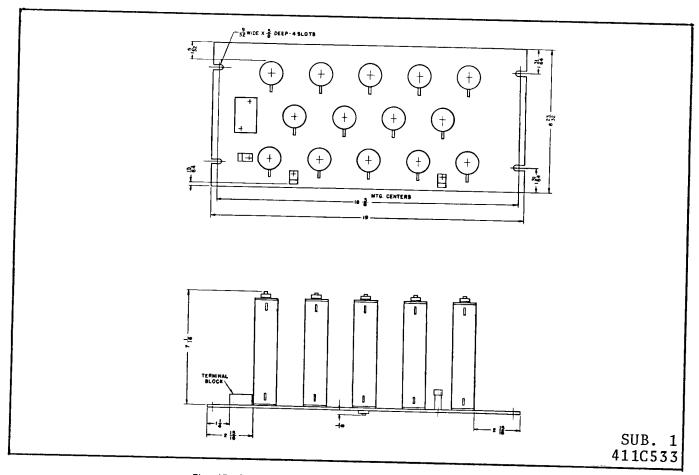


Fig. 15. Outline of External Resistor Unit for 250-volt Operation.

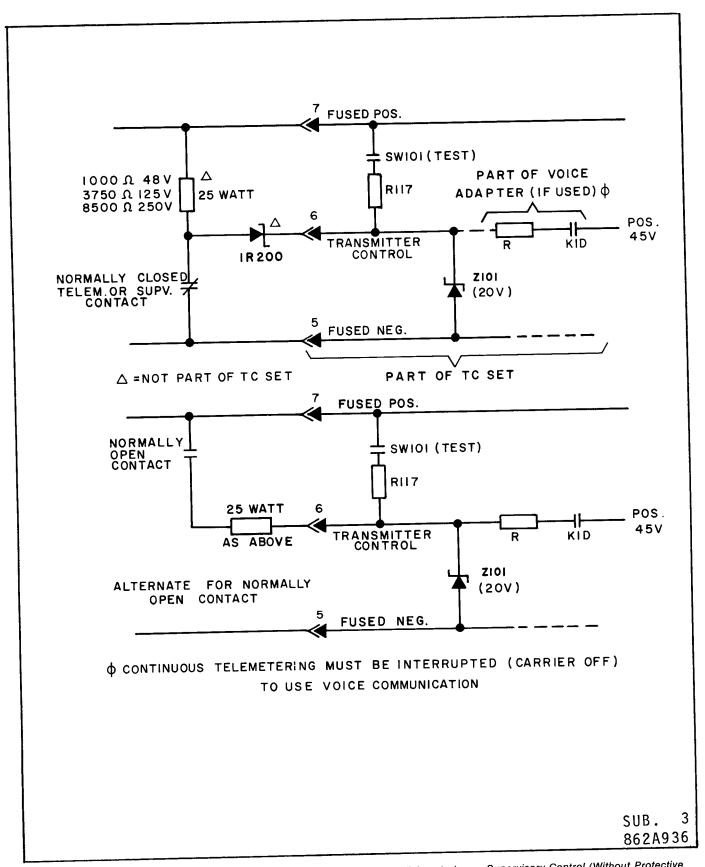


Fig. 16. External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact.



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

Printed in U.S.A.



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER

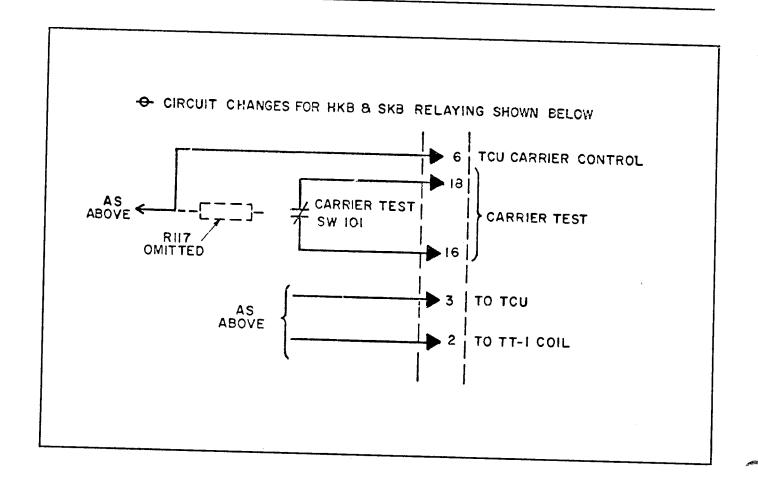
TRANSMITTER-RECEIVER ASSEMBLY — 30 to 300 kHz

For Directional and Phase Comparison Relaying

10 Watts — 48, 125, 250 V.D.C. with Optional Voice

| - | | | | |
|--------|-------------|---|--|--|
| Page | Column | Par Line | | |
| 4 | 2 | 1 of Carrier Control For Other Functions. | | |
| • | _ | 3 circuits not curcuits | | |
| | | 5 normally not nrmally | | |
| 5 | 1 | 1 5 equipment not equipment | | |
| | - | 11 equipment not equipment | | |
| 6 | 1 | 3 8 "is obtained" not "in obtained" | | |
| v | 2 | — table T106 Tap of 50 ohms should be 22.4 volts not 2.4 volts | | |
| 7 | 1 | 3 9 turned not tuned | | |
| , | - | 17 0-250 mA not 0.250 mA | | |
| 8 | 1 | 2 last word section not seciton | | |
| · · | 2 | Section 3 C & E should be | | |
| | | C. 75.5-100 KHz 0.15mfd S# 188A293H03 | | |
| | | E. 150.5-300KHz 0.047mfd S# 188A293H05 | | |
| | | Section 4 title Module not Moudle | | |
| 9 | 1 | 3 Table of Ranges of filter FL102 | | |
| | | Combination 35 in the table should be 214.1-222.0 not 241.1-222.0 | | |
| | 2 | 1 1 2 to 3 not 2 at 3 | | |
| 12 | 2 | IId Ohmmeter not ohmeter | | |
| 13 | The line un | nder CB,CC,CD,CE should be bold | | |
| | The line ur | nder 150.5-300KHz should be bold | | |
| | | 175.5-100KHz should be 75.5-100KHz | | |
| | Item | | | |
| 14 | L106 | Style # should be 3500A27HO1 | | |
| 15 | T103 | Impedance ratio is 1930/60 ohms | | |
| | | L spec L633000 | | |
| 16 | D203 | should be IN4818 | | |
| 18 | F1,F2 | Style # 11D919H26 should be 11D9195H62 | | |
| 23-24 | add | NOTE: For solid-state relaying applications SW1, | | |
| F1, F2 | | are ommitted. | | |
| | add | O circuit change to HKB & SKB relaying shown below Ref. 629A486 (See dwg. attached) | | |
| 27 | Figure 12 | | | |
| | Add to: | | | |
| | Y-AXIS | spacing | | |
| | X-AXIS | Higher center frequency of two sets. | | |
| | | | | |

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





INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER
TRANSMITTER-RECEIVER ASSEMBLY - 30 to 300 kHz
For Directional and Phase Comparison Relaying
10 Watts - 48, 125, 250 V.D.C. with Optional Voice

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POWER SUPPLY

The power supply circuit for 48 or 125-v. dc supply uses a series-type transistorized dc voltage regulator which has a very low standby current drain when there is not output current demand. The zener diode Z1 holds a constant base-tonegative voltage on the series-connected power transistor Q1. Depending on the load current, the dc voltage drop through the transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage of approximately 45-v. dc. The zener diode Z2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the dc output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuit.

For a 250-volt dc supply, the circuit of Fig. 14 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 Fig. 15) must be mounted at the top of a cabinet or an open rack. Bacause of the heat dissipated, no tansistorized equipment should be mounted above the resistor panel. The 250-volt TC set has a constant current drain of 1.5 amperes dc, and uses 2-amp. fuses.

When the TC set is used with solid-state protective relays (such as the SKBU-11), the pilot light PL1, power switch SW-1, and fuses F1 and F2 are omitted from the assembly. See Figures 1 and 2. Instead, the dc power to the complete relaying assembly is controlled from a single switch and set of fuses. This is done to prevent an incorrect tripping or blocking output which might result from interruption of one or both sides of the dc supply to the carrier set or protective relays. For solid-state relaying aplications, there are no connections to J104 terminals 7 or 5 (normally fused positive and fused negative). See Fig. 7.

RELAYING CONTROL CIRCUITS

The carrier control circuit for KDar relaying is shown in elementary form in Fig. 6. The "Transmitter Control" circuit is normally held at fused negative potential through the normally-closed carrier test pushbutton and the phase and ground carrier-start relay contacts. Opening of any of these contacts allows current to flow from fused positive through resistor $R_{\rm C}$ and the Diode $D_{\rm 1}$ to the transmitter control terminal TC/6, thus starting carrier transmission at full output. The potential of terminal TC/6 rises to plus 20 volts, limited by a Zener diode in the transmitter proper. The reception of carrier from either the local or remote transmitter normally causes a saturated current of about 200 ma. to flow in the alarm and holding coils (AL and RRH) in the type KA-4 (or equivalent) receiver auxiliary relay.

If the protective relays call for stopping the transmission of carrier, closing of CSP or CSG contact connects the transmitter control circuit back to fused negative, thus stopping any carrier transmission regardless of how it was started.

If a relaying carrier channel is also used for an auxiliary function such as telemetering or supervisory control, the keying contact for this function is connected into the carrier-start circuit in series with the carrier test pushbutton. Such a contact must be normally closed (in the non-operating condition). An auxiliary relay in the receiver output, usually in place of the alarm relay, energizes the telemetering or supervisory control equipment through contacts on the auxiliary relay.

CARRIER CONTROL FOR OTHER FUNCTIONS

If a type TC set is keyed on-off for telemetering or supervisory control only (no protective relaying), one of the curcuits shown in Fig. 16 can be used. Arrangements are shown for either a nrmally-closed or normally-open carrier-start contact. In the former case, a diode is required to allow using the Voice Adapter for push-to-talk voice communication between stations. Note that continuous telemetering must be interrupted when it is desired to use the carrier channel for voice communication.

The receiver output can be connected for either 200-ma. or 20-ma. operation as shown in Fig. 11. The 200-ma. output is preferable (if a choice is available) because of a slightly better time constant in the 200-ma. receiver output circuit. In some cases, both the 200-ma. and the 20-ma. outputs may be used together. For example,

the 200-ma. output can be used with a standard carrier auxiliary relay (for directional-comparison relaying), while the 20-ma. output feeds a 2000ohm receiver relay used with supervisory control eqiupment. The connections shown in Fig. 11 would be used for this case, with the receiver relay holding coil (RRH) in place of the 33-ohm resistor and the 2000-ohm supervisory relay in the 20-ma. output in place of the RRH and AL coils shown. The alarm function would be provided by the supervisory control eqiupment.

CHARACTERISTICS

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

phase comparison relaying)

10 watts into 50 to 70-ohm re-Transmitter

sistive load output

55 db below 10 watts Harmonics

125 mv. input for 180 ma. mini-Receiver

mum output current sensitivity

1500 Hz bandwidth (3 db down); Receiver

80 db at \pm 3 kHz. selectivity

Transmitter-receiver Channel rating 40 db

48, 125, or 250V dc Input Voltage

Supply voltage

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

Battery Drain:

0.5 amp standby, 1.35 amp 48V dc

transmitting

0.25 amp standby, 1.1 amp trans-125V dc

mitting

1.5 amp standby or transmitting 250V dc

Temperature

-20 to +60°C around chassis range

FREQUENCY SPACING

minimum recommended frequency The spacing between two Type TC carrier sets

operated in parallel without hybrid units is shown on the curve of Fig. 12. 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. 13. 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 frequencys 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 dc 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. 12, 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 3terminal 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 temperture around the chassis must not exceed 60°C.

ADJUSTMENTS

TRANSMITTER

There are two adjustable controls on the transmitter printed-circuit board: (1) the power output control R112, and (2) base bias control R142 for transistors Q104 and Q105. The control R142 is factory adjusted for a quiescent (no-signal) current of 0.2 ± 0.05 ma. dc at terminal 2 of transformer T103. This applies a small amount of forward base bias to transistors Q104 and Q105 to minimize cross-over distortion. A thermistor (R141) is included for temperature compensation. This control (R142) need not be changed except as described in the MAINTENANCE section.

The other 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 ac vacuum tube voltmeter (VTVM) across the load resistor. Turn the transmitter power output control R112 to minimum (full counterclockwise).

Now turn on the power switch on the panel and note the dc 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 in 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 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.

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.

Note: For 200-300 kHz 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.

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 | 2.4 |
| 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. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection 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 of 0.5 volt. This setting can be checked by connecting an ac 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 carrierfrequency voltmeter. If a simple VTVM is used, have the remote transmitter tuned 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) de milliammeter plugged into J203, adjust the receiver gain control unit 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 exactty 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 R207 at maximum, the i-f gain control R239 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.

MAINTENANCE

Periodic checks of the received carrier signal will indicate impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output 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 Table I through IV. Voltages should be measured with a VTVM. Readings may vary as much as \pm 20%.

ADJUSTMENT OF R142 ON TRANSMITTER BOARD

The small adjustable resistor (pot.) R142 sets the forward base bias on transmitter transistors Q104 and Q105 to the proper point for class-B operation. This is a factory adjustment and need not be changed unless transistors Q104 and 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 dc 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 dc 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 dc milliammeter reads 0.2 mA dc ± 0.05 mA. Turn off the power, remove the milliammeter, and solder the lead back on terminal 2 of T103. Again apply dc power and proceed with the transmitter adjustment as described in the ADJUSTMENTS seciton.

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".

Only Power Amplifier module styles 774B881G01 thru G05 and 774B541G01 thru G05 use type 2N3792 transistors. When ordering replacement transistors, be sure to check module style. Other style power amplifier modules can be modified by changing diodes D104 and D106 to type 1N4818 Diodes. Order these as two 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. 7).

2. R136 Jumper

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

3. Capacitors C111 and C113 (on Power Amp. board)

- a. 30-50kHz 0.47 mfd. S#188A293H01
 - b. 50.5-75kHz 0.22 mfd. S#188A293H02
 - c. S#188A293H03
 - d. 100.5-150kHz 0.10 mfd. S#188A293H04
 - e. S#188A293H05

4. Transmitter Moudle Mounting Plate

When changing from a frequency of 200 kHz or below to a frequency above 200 kHz, 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 200.5-300 kHz. receiver input filter FL201 mounts underneath it. See Fig. 2.

5. Zener Diode Z104

For the 200.5-300kHz. range, a type 1N2999B 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 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 adjustment ranges of the groups are:

| 30.0-31.5 32.0-33.5 34.0-36.0 36.5-38.5 39.0-41.0 41.5-44.0 44.5-47.0 47.5-50.0 50.5-53.5 54.0-57.0 | 64.5- 68.0 68.5- 72.0 72.5- 76.0 76.5- 80.0 80.5- 84.5 85.0- 89.0 89.5- 94.5 95.0-100.0 100.5-106.0 | 127.5-135.0 135.5-143.0 145.5-151.0 151.5-159.5 160.0-169.5 170.0-180.0 180.5-191.5 192.0-200.0 | 241.1-222.0 222.1-230.0 230.1-240.0 240.1-250.0 250.1-262.0 262.1-274.0 274.1-287.0 287.1-300.0 |
|--|---|--|--|
| - | 100.5-106.0 106.5-112.5 | 192.0-200.0 200.1-207.0 | |

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 the 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 condi-

tion 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.

TABLE I Receiver DC Measurements

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

| TES1 POIN | | STANDBY (No Signal) | | | TH 12 | |
|-----------------|------|------------------------|------|------|-------|-------|
| TP201 | | 35-38 | | | 35-3 | R |
| TP202 | : | 0 | | | |) |
| TP203 | | 11-12 | 2 | | 11-12 | - |
| TP204 | | < 0.5 | | | 2-3 | |
| TP205 | | 18-22 | 2 | | 18-22 | |
| TRAN- SISTOR | | B* | C* | E* | B* | C* |
| Q201 | 36.5 | 37 | 42.0 | 36.5 | 36 | 42.0 |
| Q202 | 36.5 | 37.5 | 43.0 | 36.0 | 35.5 | 43.0 |
| Q203 | <0.5 | 0 | 18.0 | <0.5 | 0 | 18.0 |
| Q204 | 2.1 | 2.75 | 18.0 | 2.7 | 2.9 | 18.0 |
| Q205 | 2.2 | 2.8 | 18.0 | 2.5 | 2.7 | 18.0 |
| Q206 | 2.2 | 2.8 | 11.0 | 2.6 | 2.8 | 11.5 |
| Q207 | <0.5 | <0.5 | 22.0 | 2.0 | 2.2 | 5.0 |
| Q208 | <0.5 | <0.5 | 44.0 | 11.7 | 2.0 | 2.0 |

^{*}E - Emitter, B - Base, C - Collector All voltages read with dc vacuum-tube voltmeter. <0.5 means "less than 0.5V."

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.

| , approducty. | | | | | |
|-------------------|-----------------------|--|--|--|--|
| TEST POINT | TYPICAL AC VOLTAGE | | | | |
| FL201-IN to Gnd. | 0.067 | | | | |
| FL201-OUT to Gnd. | 0.04 | | | | |
| Q203 - E to TP206 | 0.097 | | | | |
| Q203 - C to TP206 | 0.06 | | | | |
| Q204 - B to TP206 | 0.01 | | | | |
| Q204 - C to TP206 | 0.09 | | | | |
| Q205 - B to TP206 | 0.013 | | | | |
| Q205 - C to TP206 | 1.15 | | | | |
| Q206 - B to TP206 | 0.15 | | | | |
| Q206 - C to TP206 | 2.5 | | | | |
| TP202 to TP206 | 0.5 | | | | |

All voltages read with ac vacuum-tube voltmeter.

TABLE III Transmitter DC Measurements

Note: All voltages are positive with respect to Neg. DC. (TP104). All voltages read with dc VTVM.

| | de vivi. | | |
|---|---------------|----------------|---------------|
| | TEST POINT | CARRIER OFF | CARRIER ON |
| | TP101 | 8.5 volts dc | 8.5 volts dc |
| | TP102 | <0.5 | 20 |
| | TP103 | <0.5 | 19.5 |
| | TP105 | <0.5 | 9 |
| | TP106 | 44 | 24 |
| | TP107 | 44 | 24 |
| | TP108 | 45 | 44 |
| 0 | TP110 | 0.6 | 0.75 |
| 0 | TP111 | 0.6 | 0.75 |
| | TP112 | 0 | <0.5 |
| | TP113 | 45 | 44 |
| | J101 | 5 ma. max. | 0.6 amp. |
| | (Front Panel) | | |

| | | | | | === | | | |
|---|-----------------|------|------|------|------|------|------|---|
| | TRAN- SISTOR | E | В | С | E | В | С | |
| | Q101 | 7.8 | 7.9 | 2.0 | 7.8 | 7.8 | 1.8 | |
| | Q102 | 8.1 | 8.7 | 1.0 | 8.1 | 8.7 | 1.0 | ١ |
| | Q103 | <0.5 | <0.5 | <0.5 | 20.0 | 20.0 | 9.0 | |
| 0 | Q104 | 0.1 | 0.6 | 45 | <0.5 | 0.75 | 44 | |
| 0 | Q105 | 0.1 | 0.6 | 45 | <0.5 | 0.75 | 44 | |
| | Q106 | 0 | <0.5 | 44.5 | 0 | 0.8 | 1.2 | |
| | Q107 | 44.3 | 44.2 | 0 | 24 | 24 | 0 | |
| | Q108 | 45.0 | 44.7 | 44.5 | 44.2 | 44.0 | 24.2 | |

RECEIVER

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

- 2. Receiver input filter (FL201), specify frequency.
- Resistors F211-R238 Combination See values in Fig. 7 below internal schematic.
- 4. 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 may 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 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 | AC VOLTAGE |
|--|--------------------------------|
| T101-3 to TP104 TP103 to TP102 Q103-C to TP104 | 1.5 volts, rms. 0.2 1.1 ϕ |
| TP110 to T102-4 | 0.2 |
| TP111 to T102-4 | 0.2 |
| Q104-C to TP104 | 3.3 |
| Q105-C to TP104 | 3.3 |
| T103-4 to Gnd. | 1.1 |
| T104-1 to Gnd. | 1.4 |
| Q107-B to TP107 | 0.5 volts, rms. |
| Q108-B to TP113 | 0.5 |
| Q107-C to TP107 | 14-16 |
| Q108-C to TP113 | 14-16 |
| T105-4 to Gnd. | 105 |
| T106-2 to Gnd. | 100-160* |
| TP109 to Gnd. | 30-50 * |
| J102 to Gnd. | 24.5 |

Note: T101-3 = tap 3 of Transformer T101 Q104-C = Collector of Transistor Q104 TP105 = Test Point 105

All voltages read with ac VTVM

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

RECOMMENDED TEST EQUIPMENT

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

Voltage Range: Input Impedance

0.1 to 300 volts 1.0 megohm, min.

II. Desirable Test Equipment for Apparatus Maintenance.

- a. All items listed in I.
- b. Signal Generator

Output Voltage: Frequency Range:

up to 10 volts r.m.s. 20 to 330 kHz

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

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

Transmitter Section

| | | STYLE NUMBER |
|----------------------|-----------------------|--------------------------|
| SYMBOL | RATING | 187A624H01 |
| C101 | 0.1 mfd, 200 V. DC | 187A694H29 |
| C102 | .005 mfd, 300 V. DC | 187A695H29 |
| C103 | 180 pf. 500 V. DC | 187A624H02 |
| 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 | 187A624H03 |
| C108 | 0.50 mfd, 200 V. DC | 187A624H02 |
| C109 | 0.25 mfd, 200 V. DC | 187A624H02 |
| C110 | 0.25 mfd, 200 V. DC | 16/A0241102 |
| † C111 | (See Table Below) | 187A695H12 |
| C112 | 39 pfd, 500 V. DC | 18/A0/31112 |
| † C113 | (See Table Below) | 187A695H23 |
| C114 | 100 pf. 500 V. DC | 187A695H23 |
| C115 | 100 pf. 500 V. DC | 187A694H11 |
| C116 | 0.001 mfd, 500 V. DC. | |
| CA | Part of FL101 | Vary with Frequency |
| CB, CC, CD, CE | Part of FL102 | Vary with Frequency |
| | C111, C113 | Style Number 188A293H01 |
| † FREQ. | 0.47 mfd, 400 V. DC | 188A293H01 188A293H02 |
| 50.5- 75 kHz | 0.22 mfd, 400 V. DC | |
| 175.5-100 kHz | 0.15 mfd, 400 V. DC | 188A293H03 |
| 1/3.5-100 kHz | 0.1 mfd, 400 V. DC | 188A293H04 |
| | 0.047 mfd, 400 V. DC | 188A293H05 |
| 150.5-300 kHz | 1N457A | 184A855H07 |
| D101 D103 | 1N4818 | 188A342H06 |
| | 1N4818 | 188A342H06 |
| D104 | 1N4818 | 188A342H06 |
| D105 | 1N4818 | 188A342H06 |
| D106 | Type RVS Arrester | 877A124H01 |
| G101 | Closed Circuit Jack | 187A606H01 |
| J101 | Banana Plug Jack | 2 of 185A431H0 |
| J102 | Coaxial Cable Jack | 187A633H01 |
| J103 | 24-Term Receptacle | 187A669H01 |
| J104 | 12-Term Receptable | 629A205H02 |

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

| SYMBOL | | RATING | | 07111 | | |
|--------|--------------------|---|-----------|---------------------|--|--|
| L101 | Pa | rt of FL101 | | STYLE NUMBER | | |
| L102 | | .102 Trap Coil (2nd I | Jarmonio) | Vary with Frequence | | |
| L103 | FL | FL102 Trap Coil (3rd Harmonic) | | | | |
| L104 | |) mh. | iarmonic) | Vary with Frequence | | |
| L105 | | | | 292B096G01 | | |
| | circ | FL102 Coil (part of series-resonant circuit tuned to fundamental freq.) | | | | |
| L106 | 2.0 | mh. | | 3500A37H01 | | |
| Q101 | 2N2 | 2905A | | | | |
| Q102 | 2N2 | 2905A | | 762A672H10 | | |
| Q103 | 2N: | 525 | | 762A672H10 | | |
| Q104 | 2N3 | 3712 | | 184A638H13 | | |
| Q105 | 2N3 | 712 | | 762A672H07 | | |
| Q106 | TI-4 | l81 | | 762A672H07 | | |
| Q107 | | | | 184A638H11 | | |
| Q108 | 7 	 2N3 | 792 - Matched Pair | | 187A673H16 | | |
| SYMBOL | OHMS | ± TOL. % | WATTS | | | |
| R101 | 5,600 | 5 | 1 | STYLE NUMBER | | |
| R102 | 2,200 | 10 | 0.5 | 187A643H45 | | |
| R103 | 10,000 | 10 | 0.5 | 187A641H35 | | |
| R104 | 100,000 | 5 | <u> </u> | 187A641H51 | | |
| R105 | 390 | 5 | 0.5 | 187A763H75 | | |
| R106 | 1,200 | 5 | 0.5 | 184A763H17 | | |
| R107 | 10,000 | 10 | 0.5 | 184A763H29 | | |
| R108 | 100,000 | 5 | 0.5 | 187A641H51 | | |
| R109 | 390 | 5 | 0.5 | 184A763H75 | | |
| R111 | 1,200 | 5 | 0.5 | 184A763H17 | | |
| R112 | 1 K Pot | 20 | 0.5 | 187A763H29 | | |
| R113 | 4,700 | | 0.25 | 629A430H02 | | |
| R114 | 10,000 | 5 | 0.5 | 184A763H43 | | |
| R115 | 150 | 10 | 0.5 | 187A641H51 | | |
| R116 | 100 | 5 | 0.5 | 184A763H07 | | |
| | | 5 | 0.5 | 184A763H03 | | |
| - | 1,000 48 V. DC | 5 | 25 | 1202588 | | |
| R117 | 3,750 125 V. DC | 5 | 25 | 1202955 | | |
| | 8,500 250 V. DC | 5 | 25 | 1267310 | | |

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

| | | Trans | mitter Section (| Cont.) | |
|---|--------------|---------|-----------------------|--------------------|-------------------|
| | | OHMS | ± TOL. % | WATTS | STYLE NUMBER |
| | SYMBOL | 10,000 | 2 | 0.5 | 629A531H56 |
| | R118 | 62 | 2 | 0.5 | 629A531H03 |
| | R119 | | 5 | 2 | 185A207H51 |
| | R120 | 10,000 | 5 | 2 | 187A683H01 |
| | R121 | 10 | 5 | 0.5 | 187A290H01 |
| | R122 | 10 | 10 | 0.5 | 187A290H01 |
| | R123 | 10 | 10 | 1 | 187A644H03 |
| | R124 | 100 | 10 | 0.5 | 187A641H27 |
| | R125 | 1,000 | 10 | 1 | 187A644H43 |
| | R126 | 4,700 | 10 | 0.5 | 187A640H01 |
| | R127 | 10 | 5 | 1 | 187A644H35 |
| | R128 | 2,200 | | 0.5 | 184A636H14 |
| | R129 | 2.7 | 10 | 0.5 | 187A640H01 |
| | R130 | 10 | 10 | 1 | 187A644H43 |
| | R131 | 4,700 | 5 | 0.5 | 184A636H14 |
| | R132 | 2.7 | 10 | 1 | 184A636H18 |
| | R133 | 0.27 | 10 | 1 | 184A636H18 |
| | R134 | 0.27 | 10 | 5 | 188A317H01 |
| | R135 | 3,000 | 10 | 0.5 | 184A763H53 |
| | R136 | 12,000 | 10 | 0.3 | 187A642H55 |
| | R137 | 15,000 | 10 | 0.5 | 187A641H27 |
| | R138 | 1,000 | 10 | 0.5 | 187A641H27 |
| | R139 | 1,000 | 10 | 0.5 | 629A531H04 |
| | R140 | 68 | 2 | | 185A211H06 |
| | R141 | 30 | | 202 Thermistor | 629A430H15 |
| | R142 | 25K Pot | 20 | 0.5 | 629A531H63 |
| - | R143 | 20K | 2 | | 762A679H13 |
| , | R144 | 2 Ω | | 3W | STYLE NUMBER |
| - | SYMBOL | | RATING | | 205C043G01 |
| | T101 | 10,00 | 0/400 ohms | | 205C043G04 |
| - | T102 | 10,00 | 0/400 c.t | | 1962694 |
| | T103 | 1930. | 60 ohms | L63300 | 292B526G01 |
| - | T104 | Turn | s ratio, 1/0.5, | Pri-/each sec. | 292B526G02 |
| - | T105 | 10/50 | 00 ohms | | 292B526G03 |
| - | T106 | 500/ | 50 - 60 - 70 ohms | | |
| - | Y101 | 30-30 | 00 kHz crystal per 32 | 28C083 | Specify Frequency |
| - | Z101 | Zene | r Diode 1N5357B (2 | 20 V. ± 5%) | 862A288H03 |
| - | Z101 Z102 | Zene | r Diode 1N2999B (5 | 66 V. ±5%) | 629A798H04 |
| - | Z102 Z103 | Zene | r Diode 1N2999B (5 | 56 V. <u>± 5%)</u> | 629A798H04 |
| <u> </u> | Z103 Z104 | 7ene | er Diode 1N2999B (| 56 V. + 5% | 629A798H04 |

ELECTRICAL PARTS LIST Receiver Section

| SYMBOL | RATING | CTVI F ALLES |
|--------|--|-------------------|
| C201 | 0.1 mfd., 200 V. DC | STYLE NUMBER |
| C202 | 300 pf. 500 V. DC | 187A624H01 |
| C203 | 180 pf. 500 V. DC | 187A695H35 |
| C204 | 0.25 mfd., 200 V. DC | 187A695H29 |
| 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 | | 187A624H02 |
| C210 | 0.25 mfd., 200 V. DC | 187A624H02 |
| C211 | 0.25 mfd., 200 V. DC | 187A624H02 |
| C212 | 0.1 mfd., 200 V. DC | 187A624H01 |
| C213 | 0.25 mfd., 200 V. DC | 187A624H02 |
| C214 | 2.0 mfd., 200 V. DC | 187A624H05 |
| C215 | 0.25 mfd., 200 V. DC | 187A624H02 |
| D201 | 39 pfd., 500 V. DC | 187A695H12 |
| D201 | 1N457A | 184A855H07 |
| D202 | 1N457A | 184A855H07 |
| | 2N4848 | 188A342H06 |
| D204 | 1N4818 | 188A342H06 |
| FL201 | Receiver Input Filter 30-300 kHz | Specify Frequency |
| FL202 | Receiver i.f. Filter - 20 kHz (2 sections) | 187A590G02 |
| J201 | Receiver Coax. Input Jack | 187A638H01 |
| J202 | Closed Circuit Jack(20 MA) | 187A606H01 |
| J203 | Closed Circuit Jack (200MA) | 187A606H01 |
| L201 | 33 mh. | |
| Q201 | 2N2905A | 187A599H02 |
| Q202 | 2N2905A | 762A672H10 |
| Q203 | 2N2905A | 762A672H10 |
| Q204 | 2N2905A | 762A672H10 |
| Q205 | 2N2905A | 762A672H10 |
| Q206 | 2N2905A | 762A672H10 |
| Q207 | 2N3645 | 762A672H10 |
| Q208 | 2N4903 | 849A441H01 |
| | 2.1705 | 187A673H13 |

Receiver Section (Cont.)

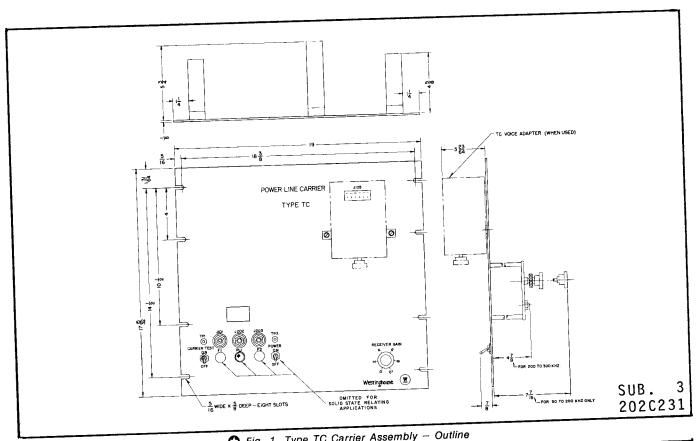
| | | RATING | | STYLE NUMBER | |
|-----------|-----------|----------|-------|------------------|--|
| SYMBOL | OHMS | + TOL. % | WATTS | | |
| RESISTORS | 10,000 | 10 | 0.5 | 187A641H51 | |
| R201 | 2,200 | 10 | 0.5 | 187A641H35 | |
| R202 | 10,000 | 10 | 0.5 | 187A641H51 | |
| R203 | 100,000 | 5 | 0.5 | 184A763H75 | |
| R204 | 390 | 5 | 0.5 | 184A763H17 | |
| R205 | 1,200 | 5 | 0.5 | 184A763H29 | |
| R206 | 25 K Pot. | 10 | 2 | 185A086H07 | |
| R207 | 10,000 | 10 | 0.5 | 187A641H51 | |
| R208 | 100,000 | 5 | 0.5 | 184A763H75 | |
| R209 | 390 | 5 | 0.5 | 184A763H17 | |
| R210 | 390 | | _ | See † Note Below | |
| † R211 | 1 K Pot. | 20 | 0.25 | 629H430H02 | |
| R212 | 1,200 | 5 | 0.5 | 184A763H29 | |
| R213 | 5,600 | 5 | 1 | 187A643H45 | |
| R214 | 20,000 | 5 | 0.5 | 184A763H58 | |
| R215 | 3,600 | 5 | 0.5 | 184A763H40 | |
| R216 | 620 | 5 | 0.5 | 184A763H22 | |
| R217 | 33 | 5 | 0.5 | 187A290H13 | |
| R218 | | 10 | 0.5 | 187A641H51 | |
| R219 | 10,000 | 5 | 0.5 | 184A763H58 | |
| R220 | 20,000 | 5 | 0.5 | 184A763H14 | |
| R221 | 300 | 5 | 0.5 | 184A763H40 | |
| R222 | 3,600 | 5 | 0.5 | 184A763H22 | |
| R223 | 620 | | 0.5 | 187A290H13 | |
| R224 | 33 | 10 | 0.5 | 187A641H51 | |
| R225 | 10,000 | 5 | 0.5 | 184A763H58 | |
| R226 | 20,000 | 5 | 0.5 | 184A763H14 | |
| R227 | 300 | 5 | 0.5 | 184A763H40 | |
| R228 | 3,600 | 5 | 0.5 | 184A763H22 | |
| R229 | 620 | 5 | 0.5 | 187A290H01 | |
| R230 | 10 | 5 | 0.5 | 184A763H34 | |
| R231 | 2,000 | 5 | 2 | 185A207H29 | |
| R232 | 1,200 | 10 | 2 | 187A642H43 | |
| R233 | 4,700 | 10 | | | |

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

ELECTRICAL PARTS LIST Receiver Section (Cont.)

| | | Section (Cont | ··) | | |
|----------------------------------|--|--|----------------------------------|--|--|
| SYMBOL | OHMS | RATING | 3 | | |
| R234 | ± 5 100 | TOL. % | WATTS | STYLE NUMBER | |
| R235 | 5,100 | 5 | 0.5 | 184A763H44 | |
| R236 | 1,500 | 5 | 0.5 | 184A763H21 | |
| R237 | 4,700 | 10 | 1 | 187A644H43 | |
| † R238 | 170 | 5 | 40 | 1336074 | |
| R239 | 1 1 1 1 | | _ | See † Note Below | |
| R240 | 1 K Pot. | 20 | 0.25 | 629A430H02 | |
| R280 | 50 S | ensistor | 0.25 | 187A685H08 | |
| T201 | 56 | 5 | 0.5 | 187A290H19 | |
| T202 | 10,000/10,00 | | | 714B677G01 | |
| T203 | 10,000/400 (| | | 205C043G01 | |
| Y201 | 25,000/300 C | Ohms | | 205C043G01 205C043G03 | |
| Z201 | 50-320 kHz (| Crystal per 328C08 | 3 | Specify Frequency | |
| Z201 Z202 | 1N3027B (20 | V. ± 5%) | | 184A449H07 | |
| <u> </u> | 1N1789 (56 | $1N1789 (56 \text{ V.} \pm 10\%)$ | | | |
| | Power Supply Section | | | | |
| SYMBOL | FUNCTION | DESCRIPTION | 1000 | T | |
| C1 | (+) to (-) bypass | DESCRIPTION | ORRATING | | |
| C2 | AC grounding | 0.45 mfd. 330 V. AC 0.5 mfd. 1500 V. DC | | 1723408 | |
| C3 | AC grounding | 0.5 mid. | 1500 V. DC | 1877962 | |
| F1, F2 | Overload Protection | | 1500 V. DC | 1877962 | |
| F1, F2 | Overload Protection | | 125 V. DC | 11D919H26 | |
| PL1 | Neon Pilot Light | 2.0a. 2. | 50 V. DC | 478067 | |
| | 125/250 Volts | 120 | Volts | 183A955H01 | |
| PLI | Filament-type | | | | |
| | for 48 Volts | 55 ' | Volts | 187A133H02 | |
| Q1 | | | | | |
| | Series Regulator | *Type 2 | 2N6259 | 3503A41H01 | |
| R1 | (Series dropping | *Type 2N6259 Silicon Transistor | | 3303A41H01 | |
| R2 | f peries arobbing | 26.5 ohms, 3½" | | | |
| | 125V Series dropping | 20.3 011 | $ms, 3\frac{1}{2}$ " | 04D1299H44 | |
| R3 | 125V Series dropping | Same | as R1 | 04D1299H44 04D1299H44 | |
| | 125V Series dropping Current limiting (For 48 V. DC) | Same | ms, 3½" as R1 ns,. 3½" | 04D1299H44 04D1299H44 1268047 | |
| | $ \frac{125V}{Current limiting} \begin{cases} \frac{Series dropping}{Current limiting} \\ For 48 V. DC, \\ R1 = R2 = 0 \end{cases} $ | Same 500 ohn | as R1 | 04D1299H44 | |
| R3 | $ \frac{125V}{Current limiting} \begin{cases} \frac{Series dropping}{Current limiting} \\ For 48 V. DC, \\ R1 = R2 = 0 \end{cases} $ | Same 500 ohn | as R1 | 04D1299H44 1268047 — | |
| | 125V Series dropping Current limiting (For 48 V. DC) | Same 500 ohm — 3½" | as R1 ns,. 3½" | 04D1299H44 1268047 - 04D1299H44 | |
| R3 | $\frac{125V}{Current limiting}$ $\frac{For 48 \text{ V. DC,}}{R1 = R2 = 0}$ $\frac{R3 = 26.5 \text{ ohms}}{Current Limiting}$ | Same 500 ohn - 3½" 100K, 0.5 watt | as R1 ns,. 3½" | 04D1299H44 1268047 — | |
| R3 R4 SW1 | $\frac{125V}{Current limiting}$ $\frac{For 48 \text{ V. DC,}}{R1 = R2 = 0}$ $\frac{R3 = 26.5 \text{ ohms}}{Current Limiting}$ Power Switch | Same 500 ohn - 3½" 100K, 0.5 watt 3a, 250 V. AC | as R1 ns,. 3½" t | 04D1299H44 1268047 - 04D1299H44 184A763H75 | |
| R3 R4 SW1 SW101 | $\frac{125V}{Current limiting}$ $\frac{For 48 \text{ V. DC,}}{R1 = R2 = 0}$ $\frac{R3 = 26.5 \text{ ohms}}{Current Limiting}$ | Same 500 ohn - 3½" 100K, 0.5 watt 3a, 250 V. AC 6a, 125 V. AC | as R1 ns,. 3½" t | 04D1299H44 1268047 - 04D1299H44 184A763H75 880A357H01 | |
| R3 R4 SW1 SW101 TP1 | $\frac{125V}{Current limiting}$ $\frac{48V}{A} = \frac{For 48 \text{ V. DC,}}{R1 = R2 = 0}$ $\frac{R1 = R2 = 0}{R3 = 26.5 \text{ ohms}}$ $\frac{Current Limiting}{Current Limiting}$ $\frac{Current Test}{Carrier Test}$ $\frac{Test Point (+)}{Carrier (+)}$ | Same 500 ohm - 3½" 100K, 0.5 watt 3a, 250 V. AC 6a, 125 V. AC Same as SW1 | as R1 ns,. 3½" t -DC -DC | 04D1299H44 1268047 - 04D1299H44 184A763H75 880A357H01 | |
| R3 R4 SW1 SW101 TP1 TP2 | $\frac{125V}{Current limiting}$ $\frac{48V}{R1 = R2 = 0}$ $\frac{R1 = R2 = 0}{R3 = 26.5 \text{ ohms}}$ $\frac{Current Limiting}{Current Limiting}$ $\frac{Current Test}{Test Point (+)}$ $\frac{Test Point (-)}{Test Point (-)}$ | Same 500 ohn - 3½" 100K, 0.5 watt 3a, 250 V. AC 6a, 125 V. AC Same as SW1 Pin Jack – red | as R1 ns,. 3½" t -DC -DC | 04D1299H44 1268047 - 04D1299H44 184A763H75 880A357H01 880A357H01 187A332H01 | |
| R3 R4 SW1 SW101 TP1 | $\frac{125V}{Current limiting}$ $\frac{48V}{R1 = R2 = 0}$ $\frac{R1 = R2 = 0}{R3 = 26.5 \text{ ohms}}$ $\frac{Current Limiting}{Current Limiting}$ $\frac{Current Test}{Test Point (+)}$ $\frac{Test Point (-)}{Test Point (-)}$ | Same 500 ohm | as R1 ns,. 3½" t -DC -DC ck | 04D1299H44 1268047 - 04D1299H44 184A763H75 880A357H01 880A357H01 187A332H01 187A332H02 | |
| R3 R4 SW1 SW101 TP1 TP2 Z1 | $\frac{125V}{Current limiting}$ $\frac{48V}{A} = \frac{For 48 \text{ V. DC,}}{R1 = R2 = 0}$ $\frac{R1 = R2 = 0}{R3 = 26.5 \text{ ohms}}$ $\frac{Current Limiting}{Current Limiting}$ $\frac{Current Test}{Carrier Test}$ $\frac{Test Point (+)}{Test Point (-)}$ $\frac{Voltage Regulator}{Voltage Regulator}$ | Same 500 ohm | as R1 ns,. 3½" t -DC -DC ck 7.) | 04D1299H44 1268047 - 04D1299H44 184A763H75 880A357H01 880A357H01 187A332H01 | |
| R3 R4 SW1 SW101 TP1 TP2 | $\frac{125V}{Current limiting}$ $\frac{48V}{R1 = R2 = 0}$ $\frac{R1 = R2 = 0}{R3 = 26.5 \text{ ohms}}$ $\frac{Current Limiting}{Current Limiting}$ $\frac{Current Test}{Test Point (+)}$ $\frac{Test Point (-)}{Test Point (-)}$ | Same 500 ohm | as R1 ns,. 3½" t -DC -DC ck 7.) | 04D1299H44 1268047 - 04D1299H44 184A763H75 880A357H01 880A357H01 187A332H01 187A332H02 | |

[†] R238 - omit above 50 kHz - 23K, 30-50 kHz, S#187A641H59



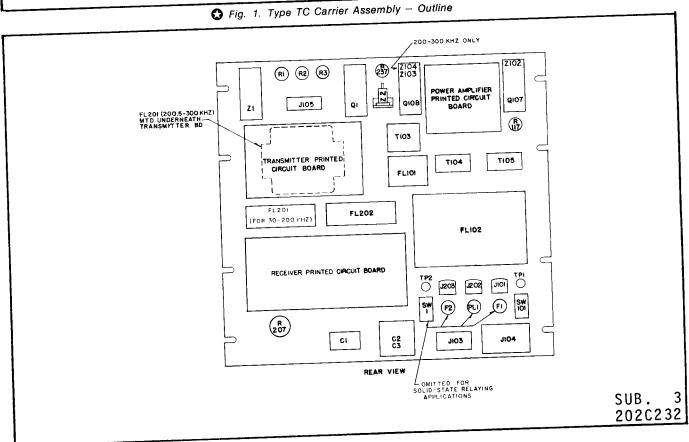


Fig. 2. Type TC Carrier Assembly -- Parts Location

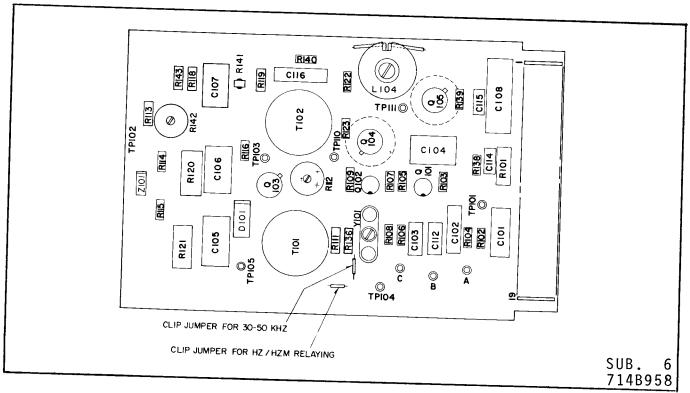


Fig. 3. Transmitter Printed Circuit - Parts Location

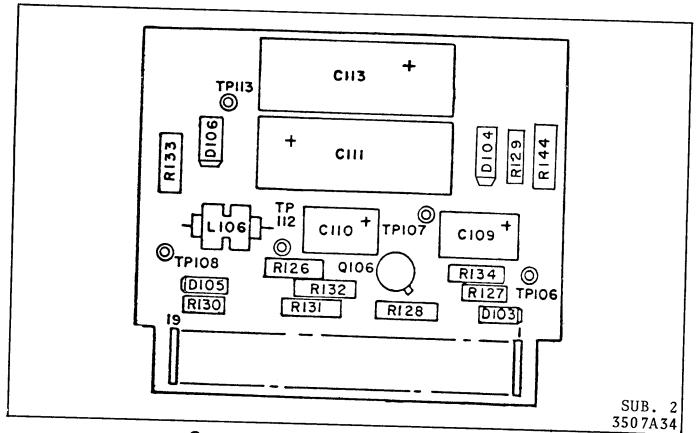


Fig. 4. Power Amplifier Printed Circuit - Parts Location

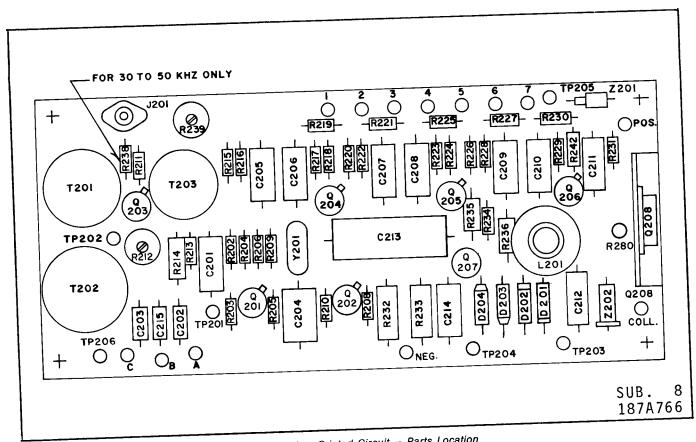


Fig. 5. Receiver Printed Circuit - Parts Location ▶ 뜻 FUSED POSITIVE 85RS 3 RC 85RS TRANSMITTER CONTROL 200-MA. RECEIVER OUTPUT CARRIER TEST -CSG CSP RRH PHASE & CARRIER GROUND STOP PH. & GND. CARRIER START FUSED NEG. △ IN KA4 RELAY 2 SUB. 85RS-RESERVE SIGNAL DETECTOR (WHEN USED) 862A937

Fig. 6. Elementary K-Dar Carrier Control Circuits.

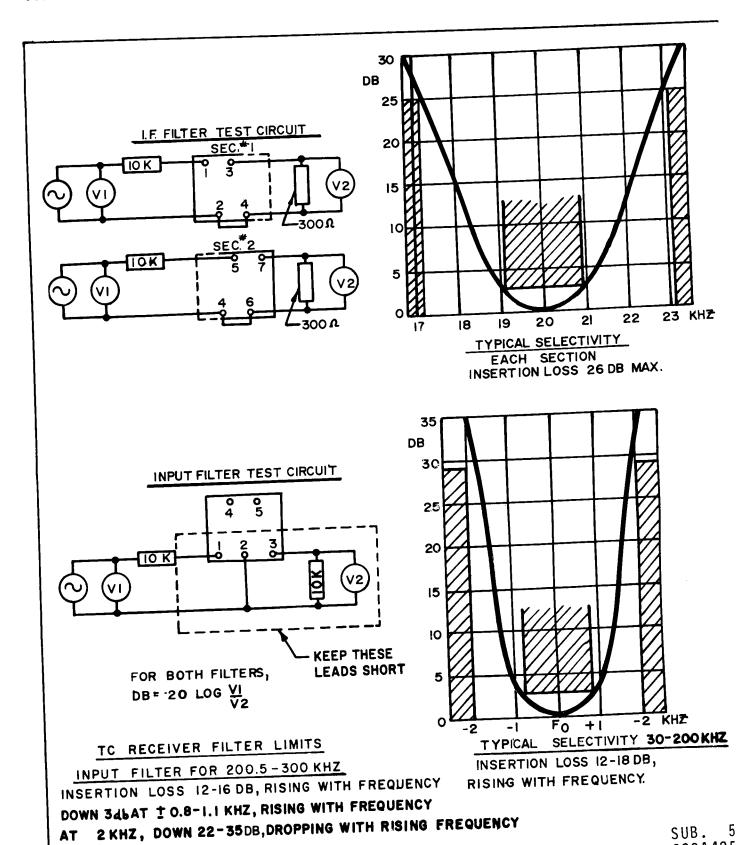
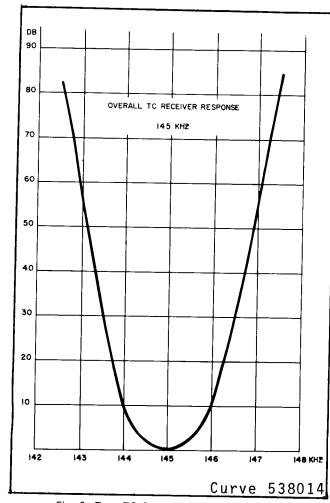


Fig. 8. Type TC Receiver Filter Characteristics

629A425



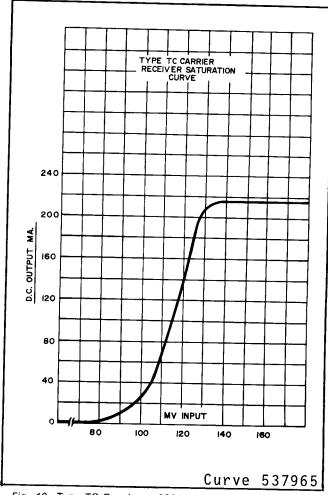
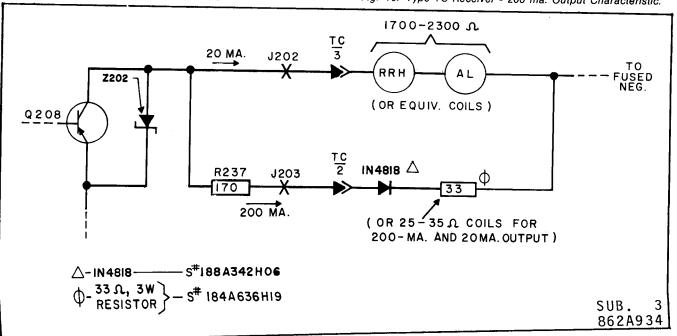


Fig. 9. Type TC Overall Selectivity Curve

Fig. 10. Type TC Receiver - 200 ma. Output Characteristic.



♣ Fig. 11. TC Receiver Output For 20-ma. Operation

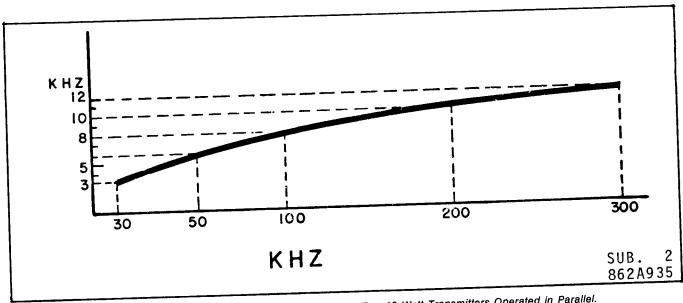


Fig. 12. Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

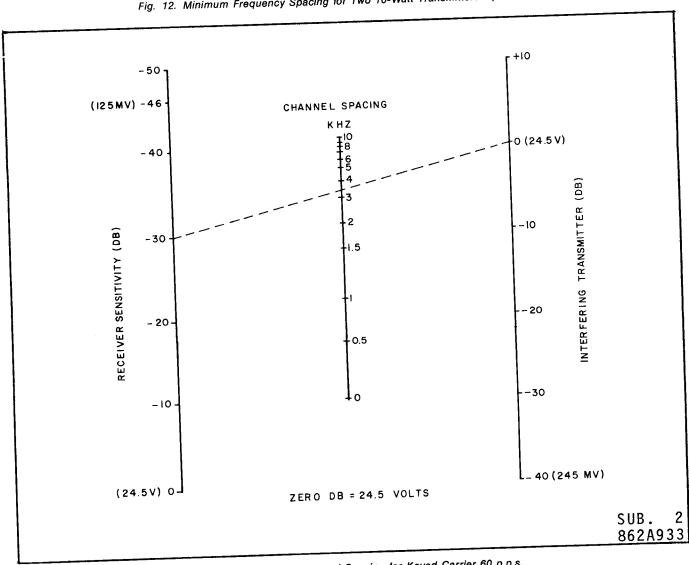


Fig. 13. Minimum Channel Spacing for Keyed Carrier 60 p.p.s.

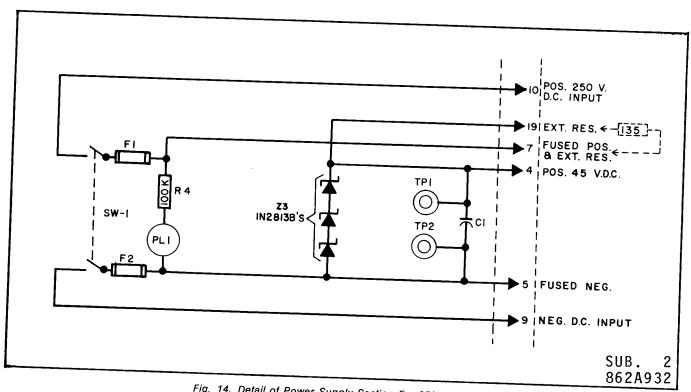


Fig. 14. Detail of Power Supply Section For 250-Volt Supply

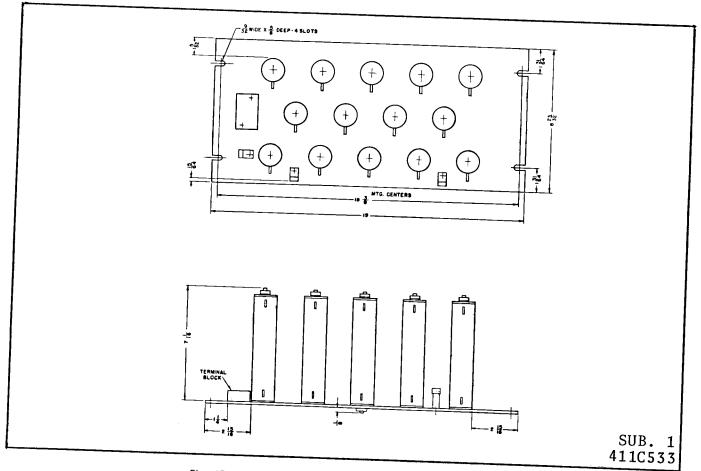


Fig. 15. Outline of External Resistor Unit for 250-volt Operation.

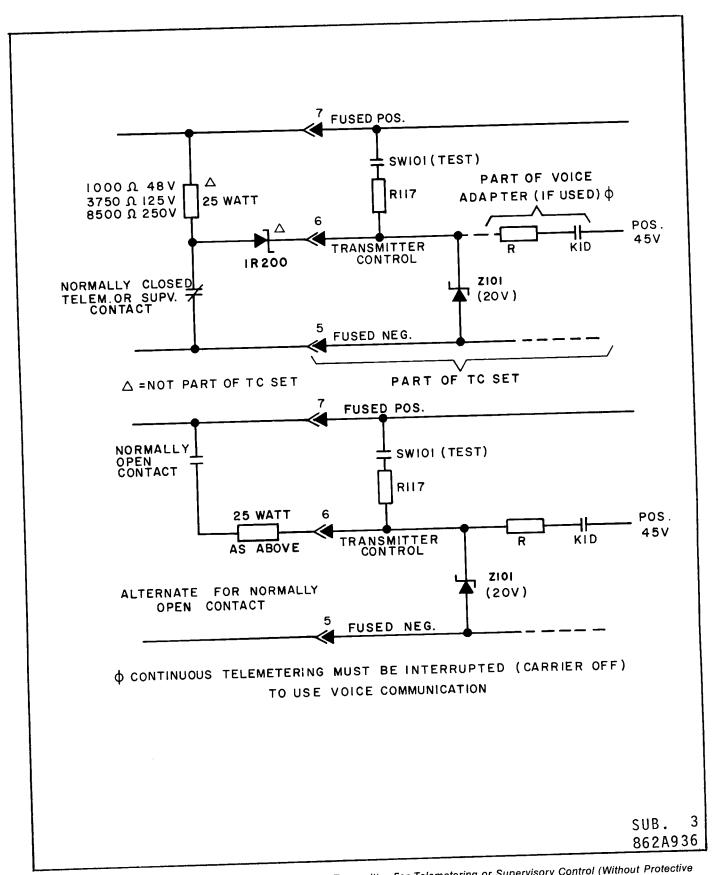


Fig. 16. External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact.



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



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY - 30 to 300 kHz For Directional and Phase Comparison Relaying 10 Watts - 48, 125, 250 V.D.C. with Optional Voice

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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.

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 | | | |

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. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection 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 of 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 voltmeter. If a simple VTVM is used, have the remote transmitter tuned 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 unit 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 R207 at maximum, the i-f gain control R239 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.

MAINTENANCE

Periodic checks of the received carrier signal will indicate impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output 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 Table I through IV. Voltages should be measured with a VTVM. Readings may vary as much as $\pm~20\%$.

Adjustment of R142 on Transmitter Board

The small adjustable resistor (pot.) R142 sets the forward base bias on transmitter transistors Q104 and Q105 to the proper point for class-B operation. This is a factory adjustment and need not be changed unless transistors Q104 or Q105 (or both) are replaced. However, if these 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. ± 0.05 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 acceptabely low value. The pair of transistors should be ordered as "2 of style 187A673H16 transistors".

CHANGE OF OPERATING FREQUENCY

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

Transmitter

- Oscillator Crystal (Y101), specify frequency
 NOTE: Modify A-B-C jumpers on transmitter
 - board if required for new frequency. See table marked "‡" under internal schematic (Fig. 7).
- 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. 39-50 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 follow-

ing 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 1N2999B 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 | 241.1-222.0 |
| 34.0-36.0 | 68.5- 72.0 | 127.5-135.0 | 222.1-230.0 |
| 36.5-38.5 | 72.5-776.0 | 135.5-143.0 | 230.1-240.0 |
| 39.0-41.0 | 76.5- 80.0 | 145.5-151.0 | 240.1-250.0 |
| 39.0-41.0 | 76.5- 80.0 | 145.5-151.0 | |
| 41.5-44.0 | 80.5- 84.5 | 151.5-159.5 | |
| 44.5-47.0 | 85.0- 89.0 | 160.0-169.5 | |
| 47.5-50.0 | 89.5- 94.5 | 170.0-180.0 | |
| 50.5-53.5 | 95.0-100.0 | 180.5-191.5 | |
| 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 T105and 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.

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.

TABLE I
Receiver D.C. Measurements

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

| 437. (11 200). | | | | | | |
|-----------------|------------------------|-------|------|-------|-------|--------|
| TEST POINT | STANDBY (No Signal) | | | | | /· |
| TP201 | ; | 35-38 | | | 35-38 | |
| TP202 | | 0 | | | 0 | |
| TP 203 | | 11-12 | | | 11-12 | |
| TP204 | | < 0.5 | | | 2-3 | Ì |
| TP205 | | 18-22 | | | 18-22 | |
| TRAN- SISTOR | E* | в* | c* | E* | в* | c* |
| Q201 | 36.5 | 37 | 42.0 | 36.5 | 36 | 42.0 |
| Q202 | 36.5 | 37.5 | 43.0 | 36.0 | 35.5 | 43.0 |
| Q203 | <0.5 | 0 | 18.0 | < 0.5 | 0 | 18.0 |
| Q204 | 2.1 | 2.75 | 18.0 | 2.7 | 2.9 | 18.0 |
| Q205 | 2.2 | 2.8 | 18.0 | 2.5 | 2.7 | 18.0 |
| Q206 | 2.2 | 2.8 | 11.0 | 2.6 | 2.8 | 11.5 |
| Q207 | < 0.5 | < 0.5 | 22.0 | 2.0 | 2.2 | 5.0 |
| Q208 | <0.5 | <0.5 | 44.0 | 11.7 | 2.0 | 2.0 |

^{*}E - Emitter, B - Base, C - Collector

TABLE II
Receiver RF Measurements

Note: Taken with 100kHz 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 A-C VOLTAGE |
|--|---------------------|
| FL201-IN to Gnd. | 0.067 |
| FL201-OUT to Gnd. | 0.04 |
| Q203 - E to TP206 Q203 - C to TP206 | 0.06 |
| Q204 - B to TP206 | 0.01 |
| Q204 - C to TP206 | 0.09 |
| Q205 - B to TP206 | 0.013 |
| Q205 - C to TP206 Q206 - B to TP206 | 1.15 |
| Q206 - B to TP206 | 2.5 |
| TP202 to TP206 | 0.5 |

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

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

< 0.5 means "less than 0.5V."

TABLE III
Transmitter D-C Measurements

Note: All voltages are positive with respect to Neg. DC. (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 | 0.65 | 0.7 |
| TP111 | 0.65 | 0.7 |
| TP112 | 0 | <0.5 |
| TP113 | 45 | 44 |
| J101 (Front Panel) | 5 ma. max. | 0.6 amp. |

| TRAN- SISTOR | E | В | С | Е | В | С |
|-----------------|-------|-------|-------|------|------|------|
| Q101 | 7.8 | 7.9 | 2.0 | 7.8 | 7.8 | 1.8 |
| Q102 | 8.1 | 8.7 | 1.0 | 8.1 | 8.7 | 1.0 |
| Q103 | < 0.5 | < 0.5 | < 0.5 | 20.0 | 20.0 | 9.0 |
| Q104 | <0.5 | 0.6 | 45 | <0.5 | 0.75 | 44 |
| Q105 | < 0.5 | 0.6 | 45 | <0.5 | 0.75 | 44 |
| Q106 | 0 | <0.5 | 44.5 | 0 | 0.8 | 1.2 |
| Q107 | 44.3 | 44.2 | 0 | 24 | 24 | 0 |
| Q108 | 45.0 | 44.7 | 44.5 | 44.2 | 44.0 | 24.2 |

Receiver

- Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
- 2. Receiver input filter (FL201), specify frequency.
- Resistors R211-R238 Combination
 See values in Fig. 7 below internal schematic.
- 4. 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 may 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 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 |
| Q103-C 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.

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

 $60~\mathrm{Hz}$ to $330~\mathrm{kHz}$, input impedance — one megohm, minimum.

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

Voltage Range:

0.1 to 300 volts

Input Impedance:

1.0 megohm, min.

II. Desirable Test Equipment for Apparatus Maintenance.

- a. All items listed in I.
- b. Signal Generator

Output Voltage:

up to 10 volts r.m.s.

Frequency Range:

20 to 330 kHz

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

Renewal Parts

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

Transmitter Section

| 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 | 187A624H02 |
| C109 | 0.25 mfd, 200 V. DC | |
| C110 | 0.25 mfd, 200 V. DC | 187A624H02 |
| † C111 | (See Table Below) | 187A624H02 |
| C112 | 39 pfd, 500 V. DC | 197 ACOETTI O |
| † C113 | (See Table Below) | 187A695H12 |
| C114 | 100 pf. 500 V. DC | |
| C115 | 100 pf. 500 V. DC | 187A695H23 |
| C116 | 0.001 mfd, 500 V. DC | 187A695H23 |
| CA | Part of FL101 | 187A694H11 |
| CB, CC, CD, CE | Part of FL102 | Vary with Frequency |
| † FREQ. | C111, C113 | Vary with Frequency |
| 30 - 50 kHz | 0.47 mfd, 400 V. DC | Style Number |
| 50.5- 75 kHz | 0.47 mtd, 400 V. DC | 188А293Н01 |
| 175.5-100 kHz | 0.15 mfd, 400 V. DC | 188A293H02 |
| 100.5-150 kHz | 0.1 mfd, 400 V. DC | 188А293Н03 |
| 150.5-300 kHz | 0.047 mfd, 400 V. DC | 188А293Н04 |
| D101 | 1N457A | 188A293H05 |
| D103 | 1N4818 | 184A855H07 |
| D104 | | 188A342H06 |
| D105 | | 188A342H06 |
| D106 | 1N4818 | 188A342H06 |
| G101 | * 1N4818 | 188A342H06 |
| J101 | Type RVS Arrester | 632A026A01 |
| J102 | Closed Circuit Jack | 187А606Н01 |
| J103 | Banana Plug Jack | 2 of 185A431H01 |
| J104 | Coaxial Cable Jack | 187A633H01 |
| | 24-Term Receptacle | 187A669H01 |
| J105 | 12-Term Receptacle | 629A205H02 |

Transmitter Section (Cont.)

| SYMBOL | | RATING | | STYLE NUMBER |
|--------|-------------------|---|-----------------|---------------------|
| L101 | Part of F | L101 | | |
| L102 | FL102 T | rap Coil (2nd Harmon | ic) | Vary with Frequency |
| L102 | | rap Coil (3rd Harmoni | | Vary with Frequency |
| L104 | 400 mh. | | | 292B096G01 |
| L105 | FL102 C | Coil (part of series-resuned to fundamental f | sonant req.) | Vary with Frequency |
| | 2.0 mh. | | | 3500A27H01 |
| L106 | | | | 762A672H10 |
| ହା 01 | 2N2905 | | | 762A672H10 |
| Q102 | 2N2905 | 3 | | 184A638H13 |
| Q1 03 | 2N 525 | | | 762A672H07 |
| Q104 | 2N3712 | | | 762A672H07 |
| Q105 | 2N3712 | | | 184A638H11 |
| Q106 | TI-481 | | | .0.2 |
| Q107 | 2N3792 | - Matched Pair | | 187A673H16 |
| Q108 | | | WATTS | STYLE NUMBER |
| SYMBOL | OHMS | ± TOL. % | 1 | 187A643H45 |
| R101 | 5,600 | 5 | 0.5 | 187A641H35 |
| R102 | 2,200 | 10 | 0.5 | 187A641H51 |
| R103 | 10,000 | 10 | 0.5 | 184A763H75 |
| R104 | 100,000 | 5 | 0.5 | 184A763H17 |
| R105 | 390 | 5 | | 184A763H29 |
| R106 | 1,200 | 5 | 0.5 | 187A641H51 |
| R107 | 10,000 | 10 | 0.5 | 184A763H75 |
| R108 | 100,000 | 5 | 0.5 | 184A763H17 |
| R109 | 390 | 5 | 0.5 | 187A763H29 |
| R111 | 1,200 | 5 | 0.5 | |
| 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 |
| R116 | 100 | 5 | 0.5 | 184A763H03 |
| 10110 | 1,000 48 V dc | 5 | 25 | 1202588 |
| R117 | 3,750 125 V dc | 5 | 25 | 1202955 |
| | 8,500 250 V dc | 5 | 25 | 1267310 |

Transmitter Section (Cont.)

| SYMBOL | OHMS | ± TOL. % | WATTS | STYLE NUMBER |
|--------------|--|---|------------|-------------------|
| 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 | 187А290Н01 |
| R123 | 10 | 10 | 0.5 | |
| R124 | 100 | 10 | 1 | 187A290H01 |
| R125 | 1,000 | 10 | 0.5 | 187A644H03 |
| R126 | 4,700 | 10 | 1 | 187A641H27 |
| R127 | 10 | 10 | | 187A644H43 |
| R128 | 2,200 | 5 | 0.5 | 187A640H01 |
| R129 | 2.7 | 10 | 1 | 187A644H35 |
| R130 | 10 | 10 | 0.5 | 184A636H14 |
| R131 | 4,700 | 5 | 0.5 | 187A640H01 |
| R132 | 2.7 | | 1 | 187A644H43 |
| R133 | 0.27 | 10 | 0.5 | 184A636H14 |
| R134 | 0.27 | 10 | 1 | 184A636H18 |
| R135 | 3,000 | 10 | 1 | 184A636H18 |
| R136 | 12,000 | 10 | 5 | 188A317H01 |
| R137 | | 10 | 0.5 | 184A763H53 |
| R138 | 15,000 | 10 | 2 | 187A642H55 |
| | 1,000 | 10 | 0.5 | 187A641H27 |
| R139 | 1,000 | 10 | 0.5 | 187A641H27 |
| R140 | 68 | 2 | 0.5 | 629A531H04 |
| R141 | 30 | Type 3D202 Th | ermistor | 185A211H06 |
| R142 R143 | 25K Pot 20K | 20 | 1/8 | 584C276H23 |
| SYMBOL | 2013 | 2 RATING | 0.5 | 629A531H63 |
| T101 | 10.000/ | 400 ohms | | STYLE NUMBER |
| T102 | 10,000/4 | | | 205C043G01 |
| T103 | 1930/60 | -1 | | 205C043G04 |
| T104 | | 11036 | | 1962694 |
| T105 | 10/500 (| | each sec. | 292B526G01 |
| T106 | | 292B526G02 | | |
| Y101 | 500/50 - | | 292B526G02 | |
| Z101 | | Hz crystal per 328C083 ode 1N5357B (20V. ±5% | | Specify Frequency |
| Z102 | | | 862A288H03 | |
| Z102 Z103 | ∠ener Di | ode 1N2999B (56 V. ±59 | %) | 629A798H04 |
| Z104 | Zener Diode 1N2999B (56 V. ±5%) 629A798H04 Zener Diode 1N2999B (56 V. ±5%) 629A798H04 | | | |

Receiver Section

| SYMBOL | RATING | STYLE NUMBER |
|--------|---|-------------------|
| | 0.1 mfd., 200 V. DC | 187A624H01 |
| C201 | | 187A695H35 |
| C202 | | 187A695H29 |
| C203 | 180 pf. 500 V. DC 0.25 mfd., 200 V. DC | 187A624H02 |
| C204 | | 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 | |
| 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 |
| | 1N457A | 184A855H07 |
| D201 | 1N457A | 184A855H07 |
| D202 | 1N4818 | 188A342H06 |
| D203 | 1N4818 | 188A342H06 |
| D204 | Receiver Input Filter 30-300 kHz | Specify Frequency |
| FL201 | Receiver i.f. Filter - 20kHz (2 sections) | 187A590G02 |
| FL202 | Receiver Coax. Input Jack | 187A638H01 |
| J201 | | 187A606H01 |
| J202 | Closed Circuit Jack (20MA) | 187A606H01 |
| J203 | Closed Circuit Jack (200MA) | 187A599H02 |
| L 201 | 33 mh. | 762A672H10 |
| Q201 | 2N2905A | 762A672H10 |
| Q202 | 2N2905A | 762A672H10 |
| Q203 | 2N2905A | 762A672H10 |
| Q204 | 2N2905A | |
| Q205 | 2N2905A | 762A672H10 |
| Q206 | 2N2905A | 762A672H10 |
| Q207 | 2N3645 | 849A441H01 |
| Q207 | 2N4903 | 187A673H13 |

Receiver Section (Cont.)

| SYMBOL RESISTORS | | | | |
|---------------------|-----------|----------|-------|--------------------------|
| | OHMS | ± TOL. % | WATTS | STYLE NUMBER |
| 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 | |
| R206 | 1,200 | 5 | 0.5 | 184A763H17 |
| R207 | 25 K Pot. | 10 | 2 | 184A763H29 |
| R208 | 10,000 | 10 | 0.5 | 185A086H07 |
| R209 | 100,000 | 5 | 0.5 | 187A641H51 |
| R210 | 390 | 5 | 0.5 | 184A763H75 |
| † R211 | _ | | | 184A763H17 |
| R212 | 1 K Pot. | 20 | 0.25 | See † Note Below |
| R213 | 1,200 | 5 | 0.25 | 629A430H02 |
| R214 | 5,600 | 5 | 0.5 | 184A763H29 |
| R215 | 20,000 | | 1 | 187A643H45 |
| R216 | 3,600 | 5 | 0.5 | 184A763H58 |
| R217 | 620 | 5 | 0.5 | 184A763H40 |
| R218 | 33 | 5 | 0.5 | 184A763H22 |
| R219 | 10,000 | 5 | 0.5 | 187А290Н13 |
| R220 | | 10 | 0.5 | 187A641H51 |
| R221 | 20,000 | 5 | 0.5 | 184A763H58 |
| R222 | 300 | 5 | 0.5 | 184A763H14 |
| R223 | 3,600 | 5 | 0.5 | 184A763H40 |
| R224 | 620 | 5 | 0.5 | 184A763H22 |
| R225 | 33 | 5 | 0.5 | 187A290H13 |
| | 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 | 185A207H29 187A642H43 |

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

Receiver Section (Cont.)

| SYMBOL | A5 | | RATING | | STYLE NUMBER |
|-----------------|---------------------------------|-------------------------|----------------------------------|----------------------|------------------|
| | OHMS | ± TOL. % | | WATTS | |
| R234 | 5,100 | 5 | | 0.5 | 184A763H44 |
| R235 | 470 | 10 | | 1 | 187A644H19 |
| R236 | 4,700 | 10 | | 1 | 187A644H43 |
| | 170 | 5 | | 40 | 1336074 |
| R237 | | _ | | _ | See † Note Below |
| R238 | 1 K Pot. | 20 | 0.25 | | 629A430H02 |
| R239 | 50 | Sensisto | stor 0.25 | | 187A685H08 |
| R240 | 10.000/10,000 | | | 714B677G01 | |
| T201 | 10.000/10,000 10.000/400 O | | 205C043G01 | | |
| T202 | | | 205C043G03 | | |
| Т203 | 25,000/300 O | nms ystal per 328C08 | Specify Frequency | | |
| Y201 | | | 184A449H07 | | |
| Z201 | 1N3027B (20V | | 584C434H08 | | |
| Z202 | 1N1789 (56V | | | | |
| | | Power Supply | | TION OR RATING | STYLE NUMBER |
| SYMBOL | FUNCTION | | | 330 VAC | 1723408 |
| C1 | (+) to (-) bypa: | ss | | | 1877962 |
| C2 | A-C grounding | | | 1500 VDC | 1887962 |
| C3 | A-C grounding | | 0.5 mfd. 1500 VDC | | 11D9195H26 |
| F1, F2 | Overload Prote | ection | 1.5a, 48/125 VDC | | 478067 |
| F1, F2 | Overload Prote | | 2.0a. 250 VDC | | |
| PL1 | Neon Pilot Lig 125/250 Volts | ght | 120 Volts | | 183A955H01 |
| PL1 | Filament-type for 48 Volts | | 55 Volts | | 187A133H02 |
| Q1 | Series Regula | tor | * Type 2N6259 Silicon Transistor | | 3503A41H01 |
| | | dropping | 26.5 ohms, 3½" | | 04D1299H44 |
| R1 | 1 | dropping | Same as | R1 | 04D1299H44 |
| R2 R3 | | t limiting | 500 ohms, 3½'' | | 1268047 |
| 103 | For 48 VDC, R1 = R2 = 0 | | _ | | 04D1299H44 |
| | | 26.5 ohms | 3½" | | 184A763H75 |
| R4 | Current limiti | ng | 100K, 0.5 watt | | 104111001110 |
| SW1 | Power Switch | | 6a, 125 | V. AC-DC V. AC-DC | 880A357H01 |
| SW101 | Carrier Test | | Same as | | 880A357H01 |
| TP1 | Test point (+ |) | Pin Jack - red | | 187A332H01 |
| TP2 | Test point (- | | Pin Jack - black | | 187A332H02 |
| | Voltage Regu | | 1N2828B (45V.) | | 184A854H06 |
| $\frac{Z1}{Z2}$ | Surge Protec | | 1N3009A (130V.) Zener Diodes | | 184A617H12 |
| | Voltage Reg. | for 250V | 3B (15V.) | 184A854H11 | |

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

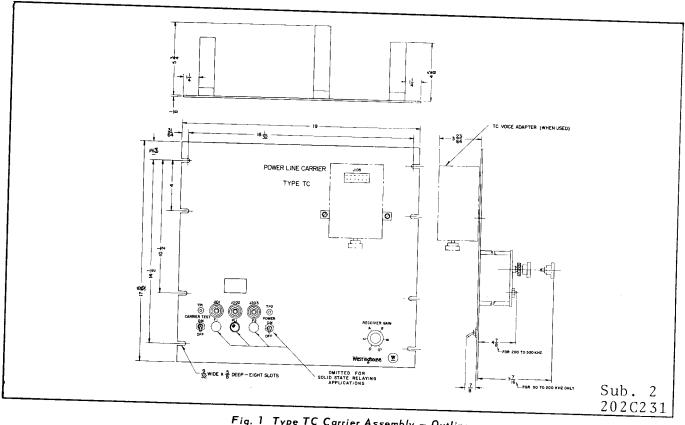


Fig. 1 Type TC Carrier Assembly - Outline

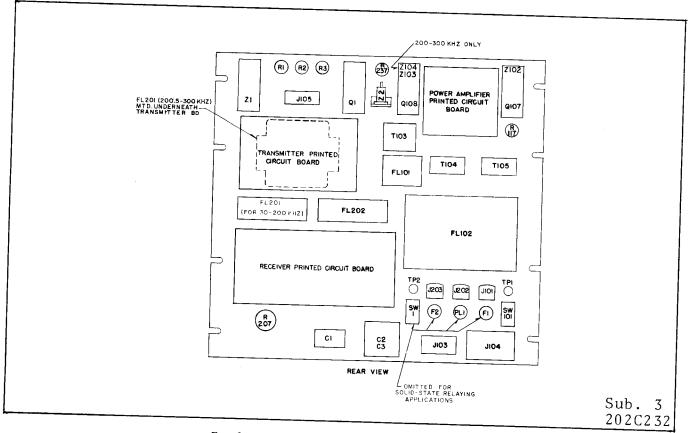


Fig. 2 Type TC Carrier Assembly - Parts Location

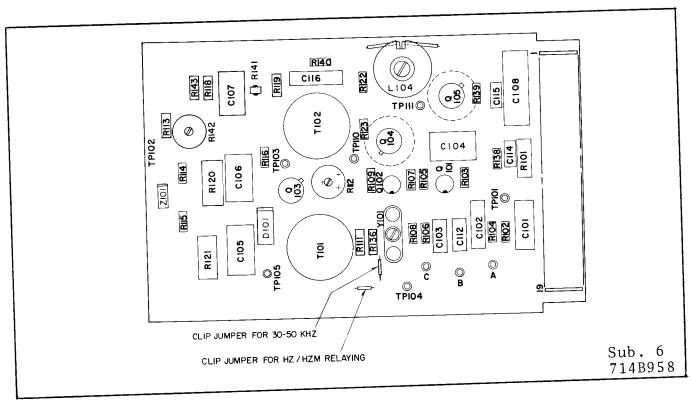
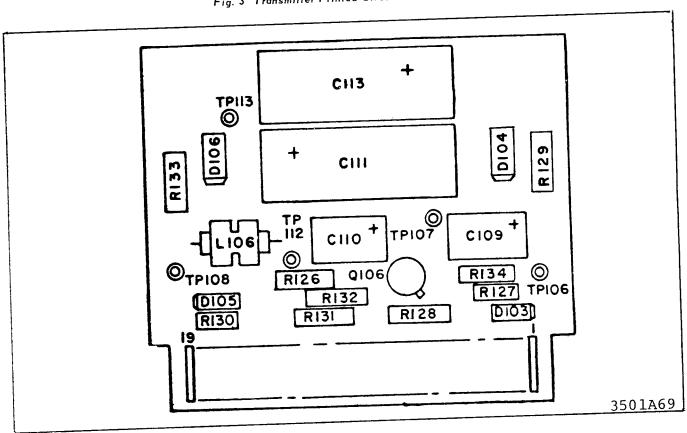
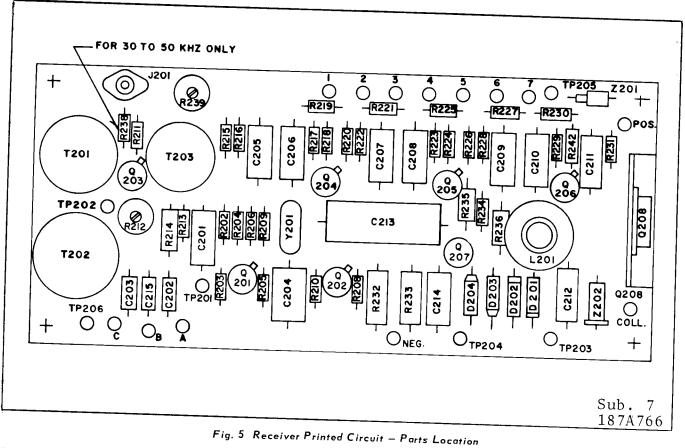


Fig. 3 Transmitter Printed Circuit — Parts Location



* Fig. 4 Power Amplifier Printed Circuit — Parts Location



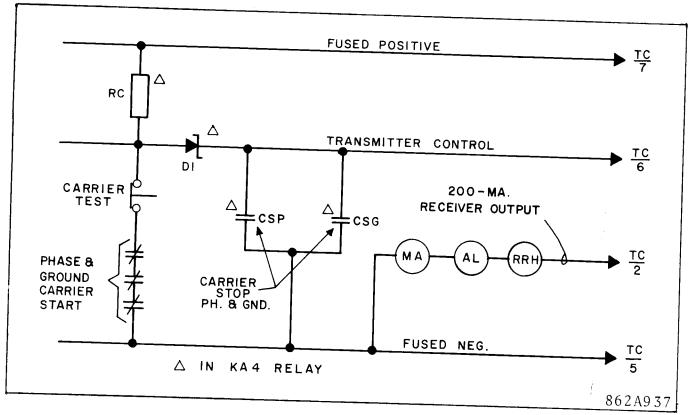


Fig. 6 Elementary K-Dar Carrier Control Circuits.

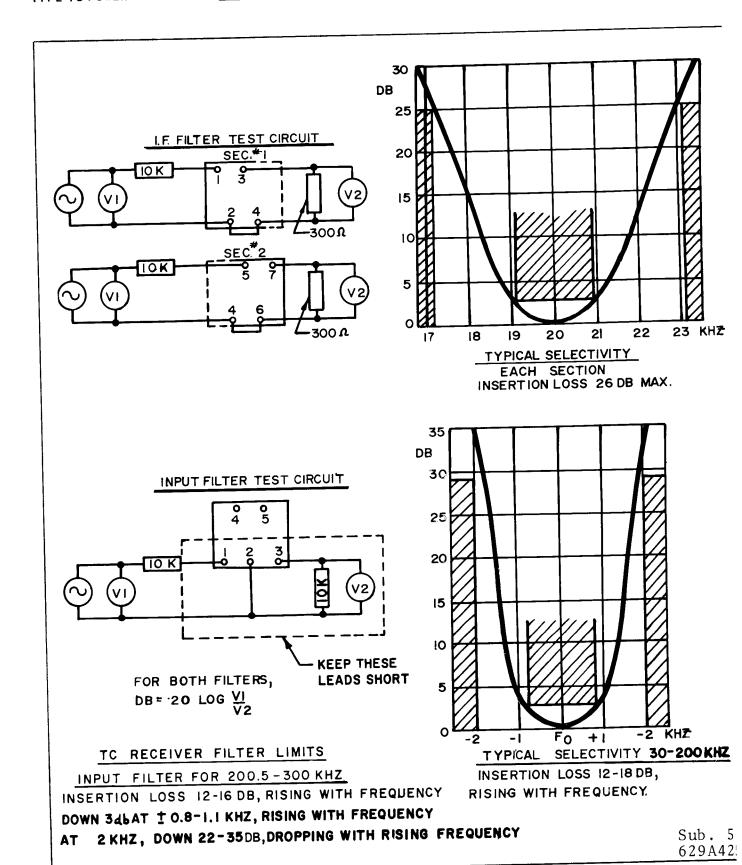
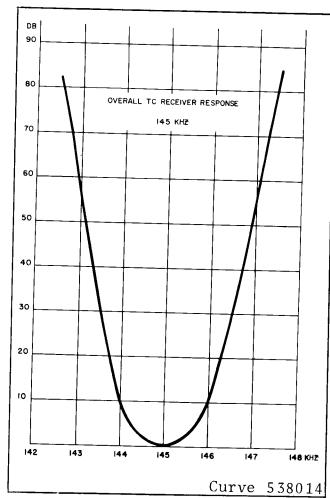


Fig. 8 Type TC Receiver Filter Characteristics



TYPE TC CARRIER
RECEIVER SATURATION
CURVE 240 200 OUTPUT 160 0 120 80 40 MV INPUT 80 100 120 140 160 Curve 537965 Fig. 10 Type TC Receiver - 200 ma. Output Characteristic.

Fig. 9 Type TC Overall Selectivity Curve

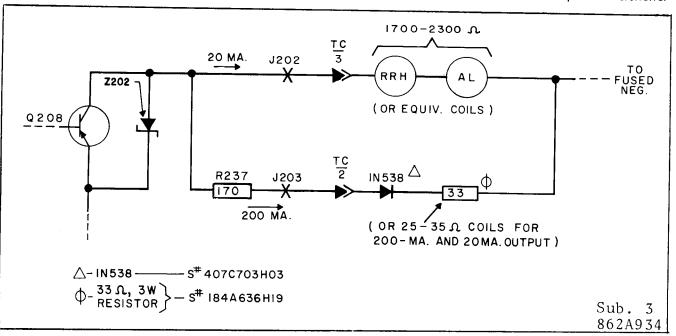


Fig. 11 TC Receiver Output For 20-ma. Operation

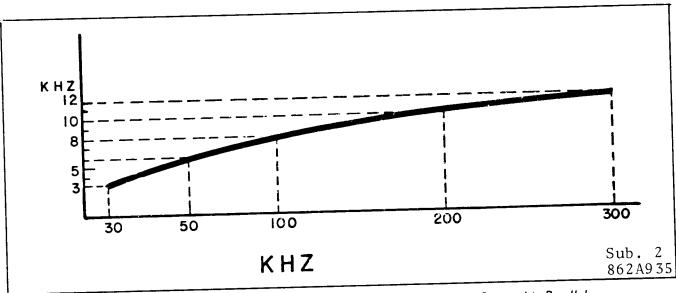


Fig. 12 Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

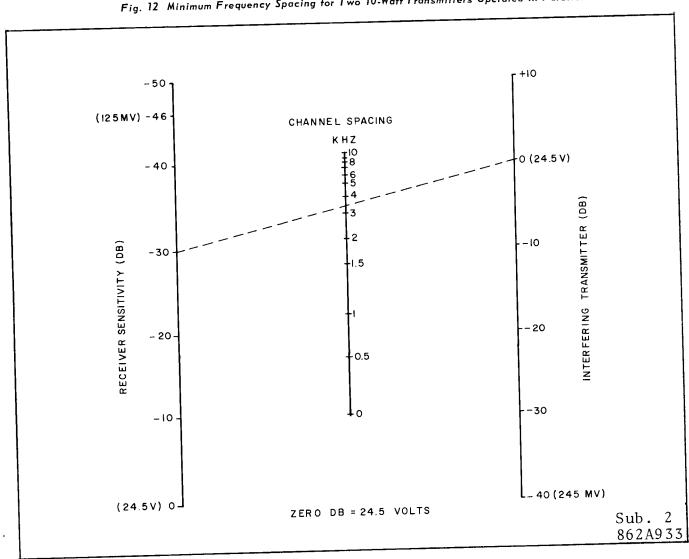


Fig. 13. Minimum Channel Spacing for Keyed Carrier 60p.p.s.

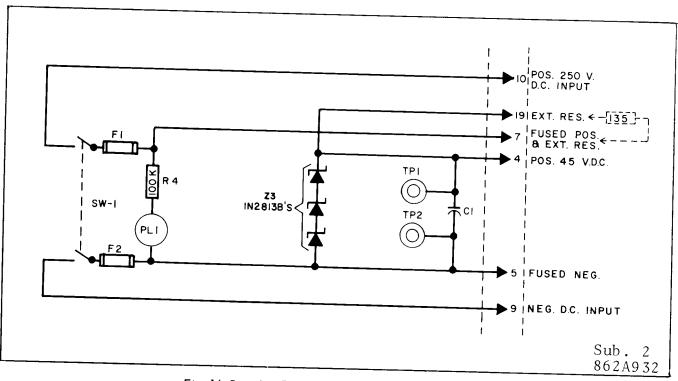


Fig. 14 Detail of Power Supply Section For 250-volt Supply

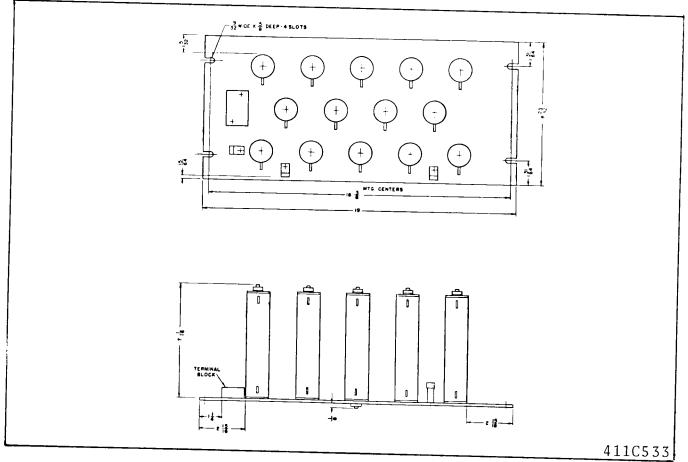


Fig. 15 Outline of External Resistor Unit for 250-Volt Operation.

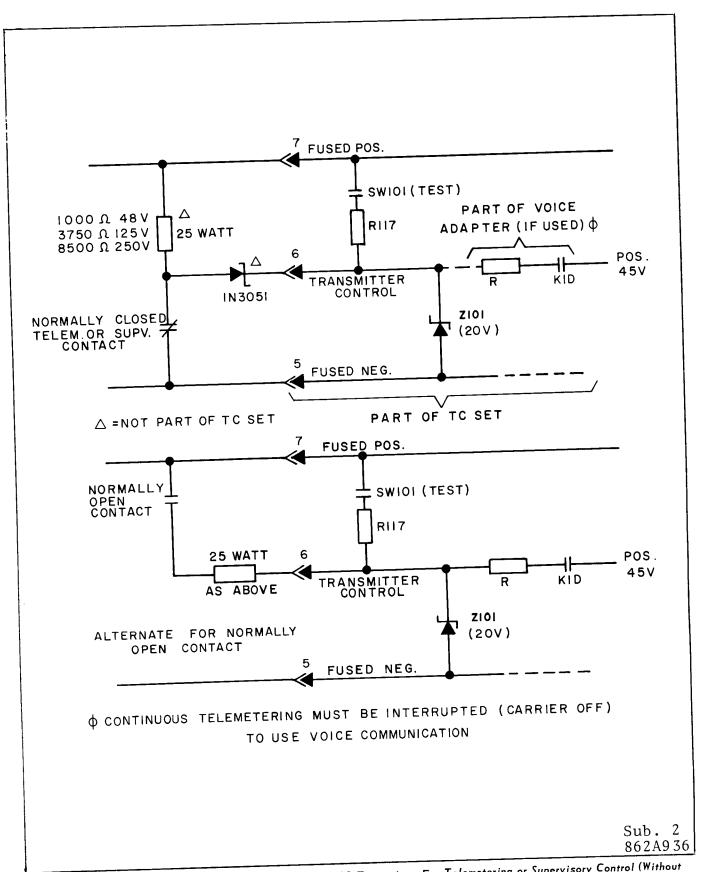


Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact.

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



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER
TRANSMITTER-RECEIVER ASSEMBLY – 30 to 300 kHz
For Directional and Phase Comparison Relaying
10 Watts – 48, 125, 250 V.D.C. with Optional Voice

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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 is designed for protective relaying of power transmission lines employing either of two types of blocking relaying systems: (1) directional comparison relaying, using the type KA-4 or equivalent carrier relay, or (2) phase-comparison relaying, using type SKB-TCU, SKBU-1, or type SKBU-11 relay equipment.

* The type TC set can also be used for other functions including "push-to-talk" maintenance telephone communication, keyed carrier telemetering, and supervisory control.

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, fuses, power and test switches, pilot light, 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. 7. The location of components on the three printed circuit boards are shown on separate illustrations, Figures 3, 4, and 5.

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 20-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. 7, 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.

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 used two series-connected type 2N3792 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 may come in from the power line through the coaxial cable.

The output transformer T105 couples the power transistors to the transmitter output filter FL102. The output filter includes two trap circuits (L102, CB, and L103, CC) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor CD approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G101 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line tuner and coaxial cable. Auto-transformer T106 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms characteristic impedance.

The series-resonant circuit composed of L105 and $C_{\rm E}$ is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, 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 cyrstal.

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. 8 and 9.

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 relay coil circuit. Where a second output current of 20 ma. is desired, an external 2000-ohm relay circuit can be connected to the receiver output as shown in Fig. 11. If only a 20-ma output is desired, a 33-ohm resistor and diode must still be connected into the circuit as shown. Fig. 10 shows the receiver 200-ma. output characteristic.

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 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 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 circuit.

For a 250-volt d-c supply, the circuit of Figure 14 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 15) 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, and uses 2-amp. fuses.

When the TC set is used with solid-state protective relays (such as the SKBU-11), the pilot light PL1, power switch SW-1, and fuses F1 and F2 are omitted from the assembly. See Fig's. 1 and 2. Instead, the d-c power to the complete relaying assembly is controlled from a single switch and set of fuses. This is done to prevent an incorrect tripping or blocking output which might result from interruption of one or both sides of the d-c supply to the carrier set or protective relays. For solid-state relaying applications, there are no connections to J104 terminals 7 or 5 (normally fused positive and fused negative). See Fig. 7.

Relaying Control Circuits

The carrier control circuit for KDar relaying is shown in elementary form in Figure 6. The "Transmitter Control" circuit is normally held at fused negative potential through the normally-closed carrier test pushbutton and the phase and ground carrier-start relay contacts. Opening of any of these contacts allows current to flow from fused positive through resistor R_C and the diode D_1 to the transmitter control terminal TC/6, thus starting carrier transmission at full output. The potential of terminal TC/6 rises to plus 20 volts, limited by a Zener diode in the transmitter proper. The reception of carrier from either the local or remote transmitter normally causes a saturated current of about 200 ma. to flow in the alarm and holding coils (AL and RRH) in the type KA-4 (or equivalent) receiver auxiliary relay.

If the protective relays call for stopping the transmission of carrier, closing of CSP or CSG contact connects the transmitter control circuit back to fused negative, thus stopping any carrier transmission regardles of how it was started.

If a relaying carrier channel is also used for an auxiliary function such as telemetering or supervisory control, the keying contact for this function is connected into the carrier-start circuit in series with the carrier test pushbutton. Such a contact must be normally closed (in the non-operating condition). An auxiliary relay in the receiver output, usually in place of the alarm relay, energizes the telemetering or supervisory control equipment through contacts on the auxiliary relay.

Carrier Control For Other Functions

If a type TC set is keyed on-off for telemetering or supervisory control only (no protective relaying).

one of the circuits shown in Figure 16 can be used. Arrangements are shown for either a normally-closed or normally-open carrier-start contact. In the former case, a diode is required to allow using the Voice Adapter for push-to-talk voice communication between stations. Note that continuous telemetering must be interrupted when it is desired to use the carrier channel for voice communication.

The receiver output can be connected for either 200 ma. or 20 ma. operation as shown in Figure 11. The 200-ma. output is preferable (if a choice is available) because of a slightly better time constant in the 200-ma. receiver output circuit. In some cases, both the 200-ma. and 20-ma. outputs may be used together. For example, the 200-ma, output can be used with a standard carrier auxiliary relay (for directional-comparison relaying), while the 20-ma. output feeds a 2000-ohm receiver relay used with supervisory control equipment. The connections shown in Fig. 11 would be used for this case, with the receiver relay holding coil (RRH) in place of the 33-ohm resistor and the 2000-ohm supervisory relay in the 20-ma, output in place of the RRH and AL coils shown. The alarm function would be provided by the supervisory control equipment.

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 |

| Harmonics | 55 db below 10 watts |
|-------------|---------------------------------|
| Receiver | 125 mv. input for 180 ma. mini- |
| sensitivity | mum output current |

Receiver 1500 Hz bandwidth (3 db down); selectivity 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. 12. 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. 13. 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 frequencys 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-dc 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. 12, 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 chassic must not exceed 60° C.

ADJUSTMENTS

Transmitter

There are two adjustable controls on the transmitter printed-circuit board: (1) the power output control R112, and (2) base bias control R142 for transistors Q104 and Q105. The control R142 is factory adjusted for a quiescent (no-signal) current of 0.2 ± 0.05 ma. d.c. at terminal 2 of transformer T103. This applies a small amount of forward base bias to transistors Q104 and Q105 to minimize cross-over distortion. A thermistor (R141) is included for temperature compensation. This control (R142) need not be changed except as described in the MAINTENANCE section.

The other 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 turn on the power switch on the panel 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.

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.

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.

Turn off the carrier test switch SW101, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

| | 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. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection 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 of 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 voltmeter. If a simple VTVM is used, have the remote transmitter tuned 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 unit 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 R207 at maximum, the i-f gain control R239 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.

MAINTENANCE

Periodic checks of the received carrier signal will indicate impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output 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 Table I through IV. Voltages should be measured with a VTVM. Readings may vary as much as $\pm 20\%$.

Adjustment of R142 on Transmitter Board

The small adjustable resistor (pot.) R142 sets the forward base bias on transmitter transistors Q104 and Q105 to the proper point for class-B operation. This is a factory adjustment and need not be changed unless transistors Q104 or Q105 (or both) are replaced. However, if these 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. ± 0.05 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 acceptabely low value. The pair of transistors should be ordered as "2 of style 187A673H16 transistors".

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. 7).

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. 39-50 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 follow-

ing 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 1N2999B 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 | 1 01 0 01 0 | 1 | |
|-----------|-------------|-------------|-------------|
| 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 | 241.1-222.0 |
| 34.0-36.0 | 68.5- 72.0 | 127.5-135.0 | 222.1-230.0 |
| 36.5-38.5 | 72.5-776.0 | 135.5-143.0 | 230.1-240.0 |
| 39.0-41.0 | 76.5- 80.0 | 145.5-151.0 | 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.

TABLE I
Receiver D.C. Measurements

Note: All voltages are negative with respect to Pos. $45V.\ (TP\,206).$

| TEST POINT | STANDBY (No Signal) | | | | H 125 M.V | <i>'</i> . |
|------------------|------------------------|-------|------|-------|------------|------------|
| TP201 | 35-38 0 | | | | 35-38 0 | |
| TP 202 TP 203 | | 11-12 | | | 11-12 | |
| TP204 | | <0.5 | | | 2-3 | |
| TP205 | 18-22 | | | | 18-22 | |
| TRAN- SISTOR | E* | в* | c* | E* | в* | c* |
| Q201 | 36.5 | 37 | 42.0 | 36.5 | 36 | 42.0 |
| Q202 | 36.5 | 37.5 | 43.0 | 36.0 | 35.5 | 43.0 |
| Q203 | <0.5 | 0 | 18.0 | < 0.5 | 0 | 18.0 |
| Q204 | 2.1 | 2.75 | 18.0 | 2.7 | 2.9 | 18.0 |
| Q205 | 2.2 | 2.8 | 18.0 | 2.5 | 2.7 | 18.0 |
| Q206 | 2.2 | 2.8 | 11.0 | 2.6 | 2.8 | 11.5 |
| Q207 | < 0.5 | < 0.5 | 22.0 | 2.0 | 2.2 | 5.0 |
| Q208 | <0.5 | < 0.5 | 44.0 | 11.7 | 2.0 | 2.0 |

^{*}E - Emitter, B - Base, C - Collector

TABLE II
Receiver RF Measurements

Note: Taken with 100kHz 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 A-C VOLTAGE |
|-------------------|---------------------|
| FL201-IN to Gnd. | 0.067 |
| FL201-OUT to Gnd. | 0.04 |
| Q203 - E to TP206 | 0.097 |
| Q203 - C to TP206 | 0.06 |
| Q204 - B to TP206 | 0.01 |
| Q204 - C to TP206 | 0.09 |
| Q205 - B to TP206 | 0.013 |
| Q205 - C to TP206 | 1.15 |
| Q206 - B to TP206 | 0.15 |
| Q206 - C to TP206 | 2.5 |
| TP202 to TP206 | 0.5 |

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

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

< 0.5 means "less than 0.5V."

TABLE III
Transmitter D-C Measurements

Note: All voltages are positive with respect to Neg. DC. (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 | 0.65 | 0.7 |
| TP111 | 0.65 | 0.7 |
| TP112 | 0 | <0.5 |
| TP113 | 45 | 44 |
| J101 (Front Panel) | 5 ma. max. | 0.6 amp. |

| TRAN- SISTOR | E | В | С | E | В | С |
|-----------------|-------|-------|-------|------|------|------|
| Q101 | 7.8 | 7.9 | 2.0 | 7.8 | 7.8 | 1.8 |
| Q102 | 8.1 | 8.7 | 1.0 | 8.1 | 8.7 | 1.0 |
| Q103 | < 0.5 | < 0.5 | < 0.5 | 20.0 | 20.0 | 9.0 |
| Q104 | <0.5 | 0.6 | 45 | <0.5 | 0.75 | 44 |
| Q105 | < 0.5 | 0.6 | 45 | <0.5 | 0.75 | 44 |
| Q106 | 0 | < 0.5 | 44.5 | 0 | 0.8 | 1.2 |
| Q107 | 44.3 | 44.2 | 0 | 24 | 24 | 0 |
| Q108 | 45.0 | 44.7 | 44.5 | 44.2 | 44.0 | 24.2 |

Receiver

- Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
- 2. Receiver input filter (FL201), specify frequency.
- Resistors R211-R238 Combination
 See values in Fig. 7 below internal schematic.
- 4. 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 may 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 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 |
| Q103-C to TP104 | 1.1 ¢ |
| 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.

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

Input Impedance:

1.0 megohm, min.

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

b. Signal Generator

Output Voltage:

up to 10 volts r.m.s.

Frequency Range:

20 to 330 kHz

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

Renewal Parts

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

Transmitter Section

| 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 | |
| C104 | 0.25 mfd, 200 V. DC | 187A695H29 |
| 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 | 187A624H02 |
| C109 | | 187A624H03 |
| C110 | 0.25 mfd, 200 V. DC | 187A624H02 |
| † C111 | 0.25 mfd, 200 V. DC | 187A624H02 |
| C112 | (See Table Below) | _ |
| † C113 | 39 pfd, 500 V. DC | 187A695H12 |
| C114 | (See Table Below) | |
| C114 | 100 pf. 500 V. DC | 187A695H23 |
| | 100 pf. 500 V. DC | 187A695H23 |
| C116 | 0.001 mfd, 500 V. DC | 187A694H11 |
| CA | Part of FL101 | Vary with Frequency |
| B, CC, CD, CE | Part of FL102 | Vary with Frequency |
| † FREQ. | C111, C113 | Style Number |
| 30 - 50 kHz | 0.47 mfd, 400 V. DC | 188A293H01 |
| 50.5- 75 kHz | 0.22 mfd, 400 V. DC | 188A293H02 |
| 175.5-100 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 |
| D101 | 1N457A | 184A855H07 |
| D103 | 1N4818 | 188A342H06 |
| D104 | * 1N4818 | 188A342H06 |
| D105 | 1N4818 | 188A342H06 |
| D106 | * 1N4818 | |
| G101 | Type RVS Arrester | 188A342H06 |
| J101 | Closed Circuit Jack | 632A026A01 |
| J102 | Banana Plug Jack | 187А606Н01 |
| J103 | Coaxial Cable Jack | 2 of 185A431H01 |
| J104 | | 187A633H01 |
| J105 | 24-Term Receptacle | 187A669H01 |
| | 12-Term Receptacle | 629A205H02 |

Transmitter Section (Cont.)

| | Transm | RATING | | STYLE NUMBER | |
|--------|-------------------|---|-----------------|---------------------|--|
| SYMBOL | | 311E NOMBER | | | |
| L101 | Part of F | Tr. :- H. Elraguanas | | | |
| L102 | FL102 T | Vary with Frequency | | | |
| L103 | FL102 T | rap Coil (3rd Harmon | ic) | Vary with Frequency | |
| L104 | 400 mh. | | | 292B096G01 | |
| L105 | FL102 Ccircuit t | Coil (part of series-re: uned to fundamental f | sonant req.) | Vary with Frequency | |
| 7.100 | 2.0 mh. | | | 3500A27H01 | |
| L106 | 2N2905 | Δ | | 762A672H10 | |
| ରୁ 101 | 2N 2905 | | | 762A672H10 | |
| Q102 | 2N 525 | | | 184A638H13 | |
| Q1 03 | 2N323 2N3712 | | | 762A672H07 | |
| Q104 | | | | 762A672H07 | |
| Q105 | 2N3712 | | | 184A638H11 | |
| Q106 | TI-481 | | | | |
| Q107 | 2N3792 | - Matched Pair | | 187A673H16 | |
| Q108 | | ± TOL. % | WATTS | STYLE NUMBER | |
| SYMBOL | OHMS | | 1 | 187A643H45 | |
| R101 | 5,600 | 5 | 0.5 | 187A641H35 | |
| R102 | 2,200 | 10 | 0.5 | 187A641H51 | |
| R103 | 10,000 | 10 | | 184A763H75 | |
| R104 | 100,000 | 5 | 0.5 | 184A763H17 | |
| R105 | 390 | 5 | 0.5 | 184A763H29 | |
| R106 | 1,200 | 5 | 0.5 | 187A641H51 | |
| R107 | 10,000 | 10 | 0.5 | 184A763H75 | |
| R108 | 100,000 | 5 | 0.5 | | |
| 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 | |
| | 150 | 5 | 0.5 | 184A763H07 | |
| R115 | 100 | 5 | 0.5 | 184A763H03 | |
| R116 | 1,000 48 V dc | 5 | 25 | 1202588 | |
| R117 | 3,750 125 V dc | 5 | 25 | 1202955 | |
| | 8,500 250 V dc | 5 | 25 | 1267310 | |

Transmitter Section (Cont.)

| SYMBOL | OHMS | ± TOL. % | WATTS | STYLE NUMBER |
|--------|--------------------------------|---------------------------------|-------|--------------------------|
| 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 | |
| R123 | 10 | 10 | 0.5 | 187A290H01 |
| R124 | 100 | 10 | | 187A290H01 |
| R125 | 1,000 | 10 | 1 | 187A644H03 |
| R126 | 4,700 | 10 | 0.5 | 187A641H27 |
| R127 | 10 | 10 | 1 | 187A644H43 |
| R128 | 2,200 | | 0.5 | 187А640Н01 |
| R129 | 2.7 | 5 | 1 | 187A644H35 |
| R130 | 10 | 10 | 0.5 | 184A636H14 |
| R131 | | 10 | 0.5 | 187A640H01 |
| R132 | 4,700 | 5 | 1 | 187A644H43 |
| R133 | 2.7 | 10 | 0.5 | 184A636H14 |
| | 0.27 | 10 1 | | 184A636H18 |
| R134 | 0.27 | 10 | 1 | 184A636H18 |
| R135 | 3,000 | 10 | 5 | 188A317H01 |
| R136 | 12,000 | 10 | 0.5 | 184A763H53 |
| 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 T | | 185A211H06 |
| R142 | 25K Pot | 20 | 1/8 | 584C276H23 |
| R143 | 20 K | 2 | 0.5 | 629A531H63 |
| T101 | 40.00-7 | RATING | | STYLE NUMBER |
| T102 | | 400 ohms | | 205C043G01 |
| T103 | 10,000/4 | | | 205C043G04 |
| | 1930/60 | 1100 | 3000 | 1962694 |
| T104 | Turns ra | 292B526G01 | | |
| T105 | 10/500 c | 292B526G02 | | |
| T106 | 500/50 - 60 - 70 ohms | | | 292B526G02 |
| Y101 | 30-300 kHz crystal per 328C083 | | | Specify Frequency |
| Z101 | Zener Diode 1N5357B (20V. ±5%) | | | 862A288H03 |
| Z102 | | ode 1N2999B (56 V. ±5 | | |
| Z103 | | ode 1N2999B (56 V. ±5 | | 629A798H04 629A798H04 |
| Z104 | | Zener Diode 1N2999B (56 V. ±5%) | | |

Receiver Section

| SYMBOL | RATING | STYLE NUMBER |
|--------|---|-------------------|
| | 0.1 mfd., 200 V. DC | 187A624H01 |
| C201 | 300 pf. 500 V. DC | 187A695H35 |
| C202 | 180 pf. 500 V. DC | 187A695H29 |
| C203 | 0.25 mfd., 200 V. DC | 187A624H02 |
| C204 | 0.25 mfd., 200 V. DC | 187A624H02 |
| C205 | | 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 | 187A624H01 |
| C211 | 0.1 mfd., 200 V. DC | |
| 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 |
| D201 | 1N457A | 184A855H07 |
| D203 | 1N4818 | 188A342H06 |
| D204 | 1N4818 | 188A342H06 |
| | Receiver Input Filter 30-300 kHz | Specify Frequency |
| FL201 | Receiver i.f. Filter - 20kHz (2 sections) | 187A590G02 |
| FL202 | Receiver Coax. Input Jack | 187A638H01 |
| J201 | Closed Circuit Jack (20MA) | 187A606H01 |
| J202 | Closed Circuit Jack (200MA) | 187A606H01 |
| J203 | | 187A599H02 |
| L201 | 33 mh. | 762A672H10 |
| Q201 | 2N2905A | 762A672H10 |
| Q202 | 2N2905A | 762A672H10 |
| Q203 | 2N2905A | 762A672H10 |
| Q204 | 2N2905A | 762A672H10 |
| Q205 | 2N2905A | |
| Q206 | 2N2905A | 762A672H10 |
| Q207 | 2N3645 | 849A441H01 |
| Q208 | 2N4903 | 187A673H13 |

Receiver Section (Cont.)

| SYMBOL RESISTORS | | | | |
|---------------------|-----------|----------|-------|------------------|
| | OHMS | ± TOL. % | WATTS | STYLE NUMBER |
| 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 | |
| R216 | 3,600 | 5 | 0.5 | 184A763H58 |
| R217 | 620 | 5 | 0.5 | 184A763H40 |
| R218 | 33 | 5 | 0.5 | 184A763H22 |
| R219 | 10,000 | 10 | 0.5 | 187A290H13 |
| R220 | 20,000 | 5 | 0.5 | 187A641H51 |
| R221 | 300 | 5 | 0.5 | 184A763H58 |
| R222 | 3,600 | 5 | 0.5 | 184A763H14 |
| R223 | 620 | 5 | 0.5 | 184A763H40 |
| R224 | 33 | 5 | 0.5 | 184A763H22 |
| R225 | 10,000 | 10 | | 187A290H13 |
| R226 | 20,000 | 5 | 0.5 | 187A641H51 |
| R227 | 300 | 5 | 0.5 | 184A763H58 |
| R228 | 3,600 | | 0.5 | 184A763H14 |
| R229 | 620 | 5 | 0.5 | 184A763H40 |
| R230 | | 5 | 0.5 | 184A763H22 |
| R231 | 10 | 5 | 0.5 | 187А290Н01 |
| R232 | 2,000 | 5 | 0.5 | 184 A 763 H 34 |
| R233 | 1,200 | 5 | 2 | 185A207H29 |
| 10200 | 4,700 | 10 | 2 | 187A642H43 |

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

Receiver Section (Cont.)

| | OHMS ± TOL. 9 | | RATING | | STYLE NUMBER | | | | | | |
|---------------|----------------------------------|-----------------|------------------------------------|----------------------|--------------------------|--|------------|--|--|--|--------------|
| SYMBOL | | | % WATTS | | | | | | | | |
| R234 | 5,100 | 5 | 0.5 | | 5 0.5 | | 184A763H44 | | | | |
| R235 | 470 | 10 | 1 | | 10 1 | | 187A644H19 | | | | |
| | 4,700 | 10 | | 1 | 187A644H43 | | | | | | |
| R236 | 170 | 5 | | 40 | 1336074 | | | | | | |
| R237 | 110 | | | | See † Note Below | | | | | | |
| R238 | | 20 | | 0.25 | 629A430H02 | | | | | | |
| R239 | 1 K Pot. | | | 0.25 | 187A685H08 | | | | | | |
| R240 | 50 10.000/10,000 | | OCHOID IDEA | | 714B677G01 | | | | | | |
| T201 | | | | | 205C043G01 | | | | | | |
| T202 | 10,000/400 Oh | | | | 205C043G03 | | | | | | |
| Т203 | 25,000/300 Oh | | | | Specify Frequency | | | | | | |
| Y201 | | stal per 328C08 | 33 | | 184A449H07 | | | | | | |
| Z201 | 1N3027B (20V | ± 5%) | | | 584C434H08 | | | | | | |
| Z202 | 1N1789 (56V | ±10%) | | | 38404341108 | | | | | | |
| | | Power Supply | | | | | | | | | |
| SYMBOL | FUNCTION | | DESCRIPTION OR RATING | | | | | | | | STYLE NUMBER |
| C1 | (+) to (-) bypas | s | 0.45 mfd. 330 VAC | | | | 1723408 | | | | |
| C2 | A-C grounding | | 0.5 mfd. 1500 VDC | | 0.5 mfd. 1500 VDC | | 1877962 | | | | |
| | A-C grounding | | 0.5 mfd. 1500 VDC | | 1887962 | | | | | | |
| C3 F1, F2 | Overload Protec | etion | 1.5a, 48/125 VDC | | 11D9195H26 | | | | | | |
| | Overload Protec | | 2.0a. 250 VDC | | 478067 | | | | | | |
| F1, F2 PL1 | Neon Pilot Ligh 125/250 Volts | | 120 Volts | | 120 Volts | | 183A955H01 | | | | |
| PL1 | Filament-type for 48 Volts | | 55 Volts | | 187A133H02 | | | | | | |
| Q1 | Series Regulato | or | * Type 2N6259 Silicon Transistor | | 3503A41H01 | | | | | | |
| R1 | (Series | dropping | | ns, 3½" | 04D1299H44 04D1299H44 | | | | | | |
| R2 | | dropping | Same as | | 1268047 | | | | | | |
| R3 | | limiting | 500 ohn | 1S, 3 ⁷ 2 | | | | | | | |
| | For 48 $R1 = R$ | VDC, 2 = 0 | _ | | | | | | | | |
| | 40 V } | 6.5 ohms | 3½" | | 04D1299H44 | | | | | | |
| | Current limitin | | 100K, 0.5 watt | | 184A763H75 | | | | | | |
| R4 SW1 | Power Switch | | 3a, 250V. AC-DC 6a, 125V. AC-DC | | 880A357H01 | | | | | | |
| SW101 | Carrier Test | | Same as SW1 | | 880A357H01 | | | | | | |
| | Test point (+) | | Pin Jack - red | | 187A332H01 | | | | | | |
| TP1 | Test point (-) | | Pin Jac | ck – black | 187A332H02 | | | | | | |
| TP2 | Voltage Regul | | 1N2828B (45V.) | | 184A854H06 | | | | | | |
| Z1 Z2 | Surge Protecti | | | 9A (130V.) | 184A617H12 | | | | | | |
| | Voltage Reg. | C== 250X7 | 1N2813B (15V.) | | 184A854H11 | | | | | | |

[†] R238 - omit above $50 \mathrm{kHz} - 22 \mathrm{K}$, $30-50 \mathrm{kHz}$, S#187A641H59

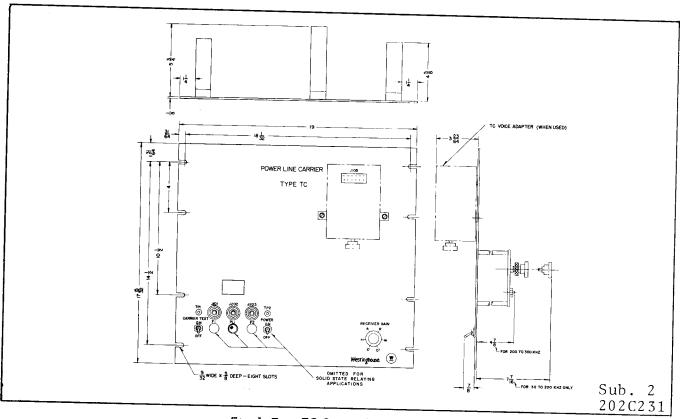


Fig. 1 Type TC Carrier Assembly - Outline

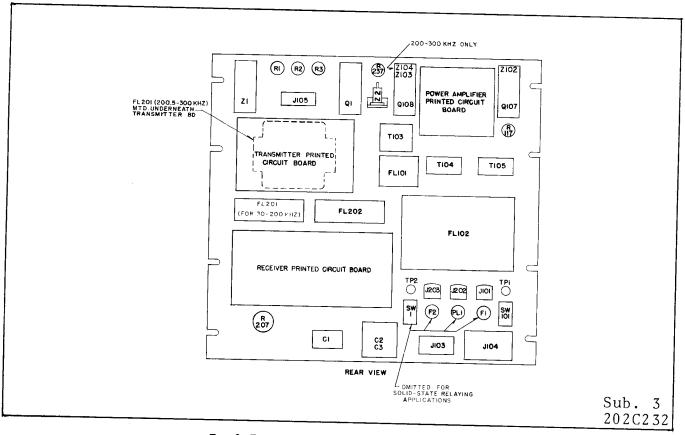


Fig. 2 Type TC Carrier Assembly - Parts Location

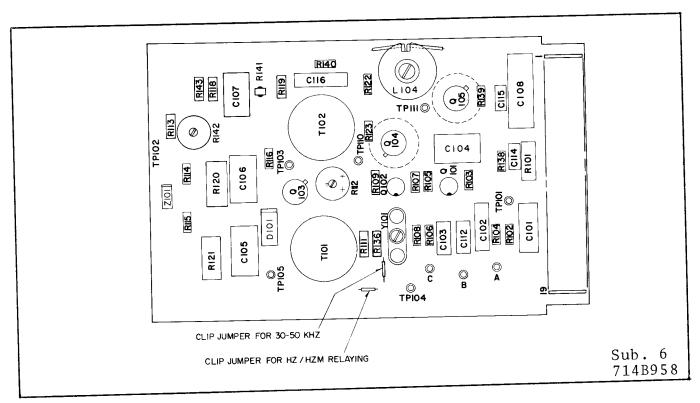
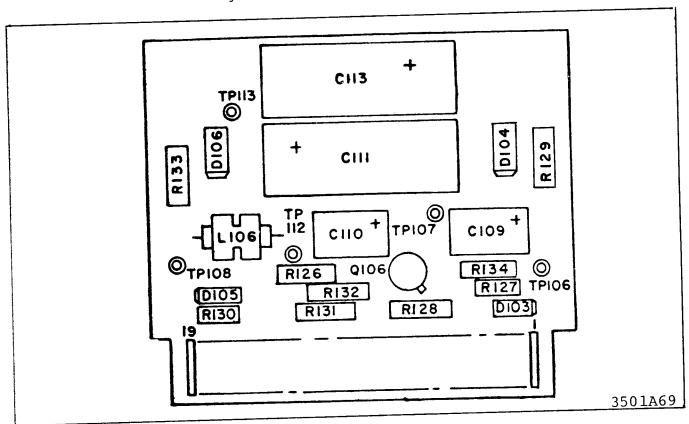


Fig. 3 Transmitter Printed Circuit — Parts Location



* Fig. 4 Power Amplifier Printed Circuit — Parts Location

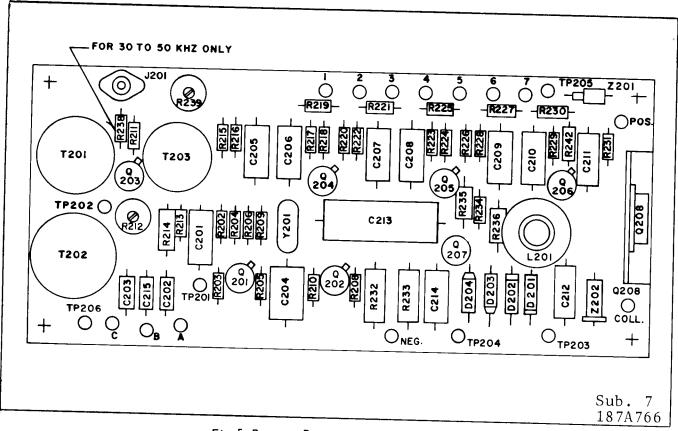


Fig. 5 Receiver Printed Circuit - Parts Location

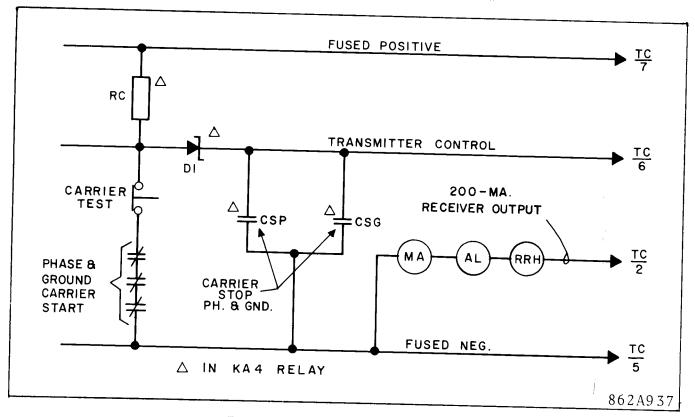


Fig. 6 Elementary K-Dar Carrier Control Circuits.

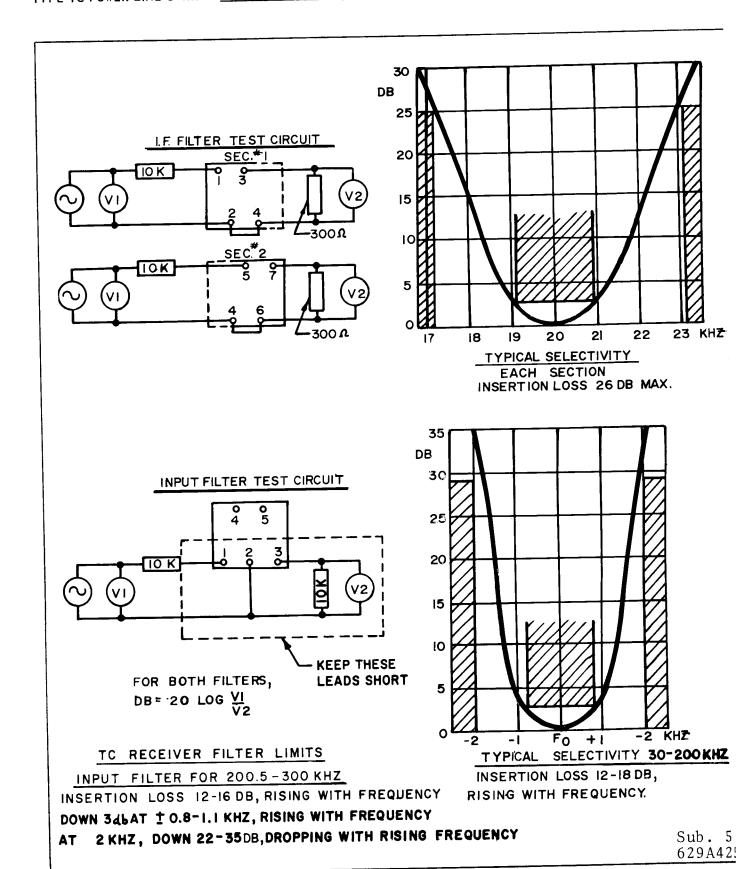
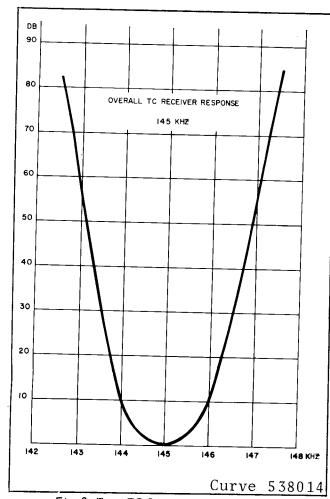


Fig. 8 Type TC Receiver Filter Characteristics



TYPE TC CARRIER RECEIVER SATURATION CURVE 240 200 OUTPUT MA. 160 ن ا ا 80 40 MV INPUT 80 100 120 140 160 Curve 537965 Fig. 10 Type TC Receiver - 200 ma. Output Characteristic.



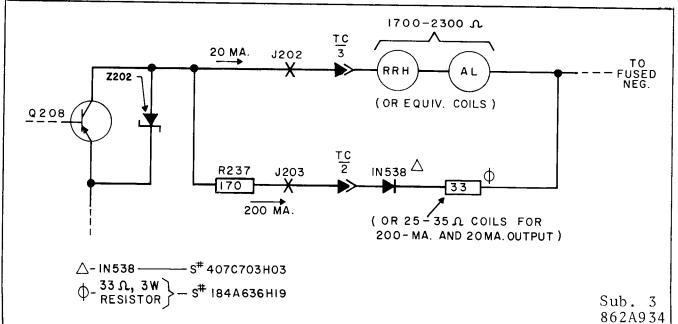


Fig. 11 TC Receiver Output For 20-ma. Operation

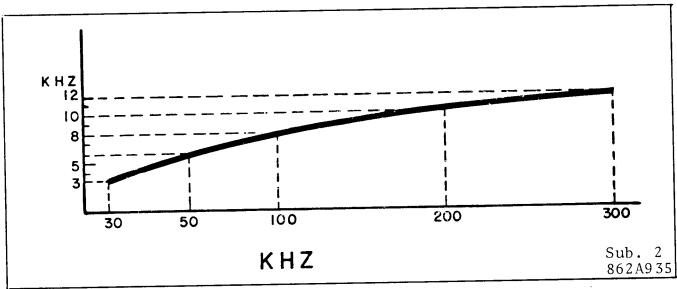


Fig. 12 Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

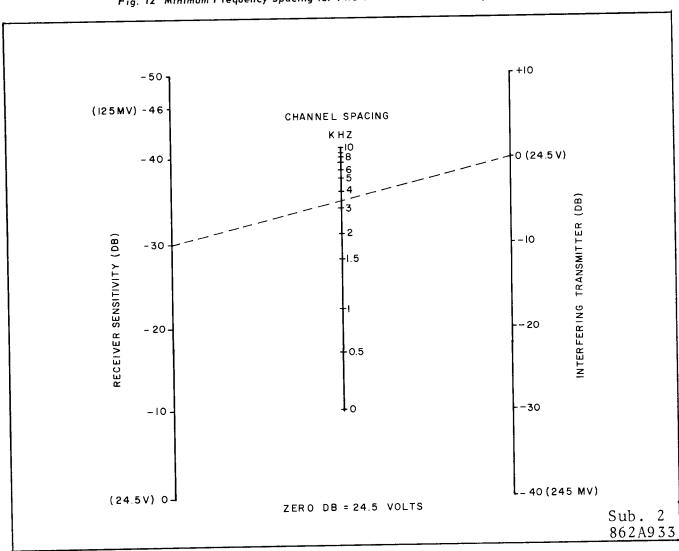


Fig. 13. Minimum Channel Spacing for Keyed Carrier 60p.p.s.

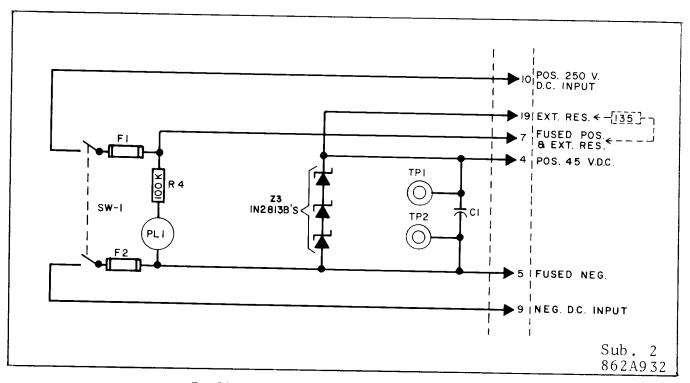


Fig. 14 Detail of Power Supply Section For 250-volt Supply

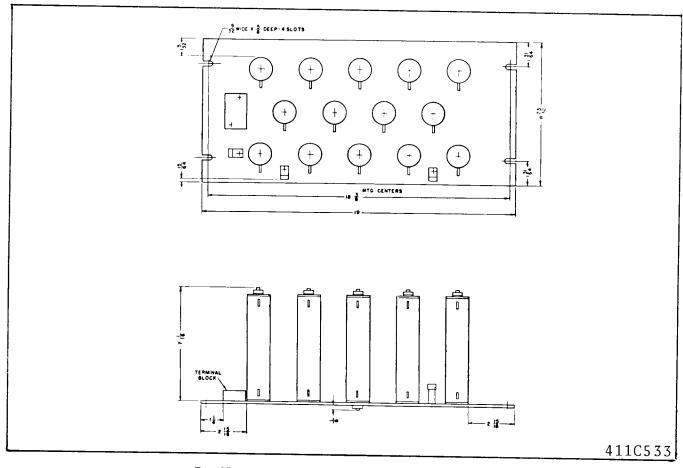


Fig. 15 Outline of External Resistor Unit for 250-Volt Operation.

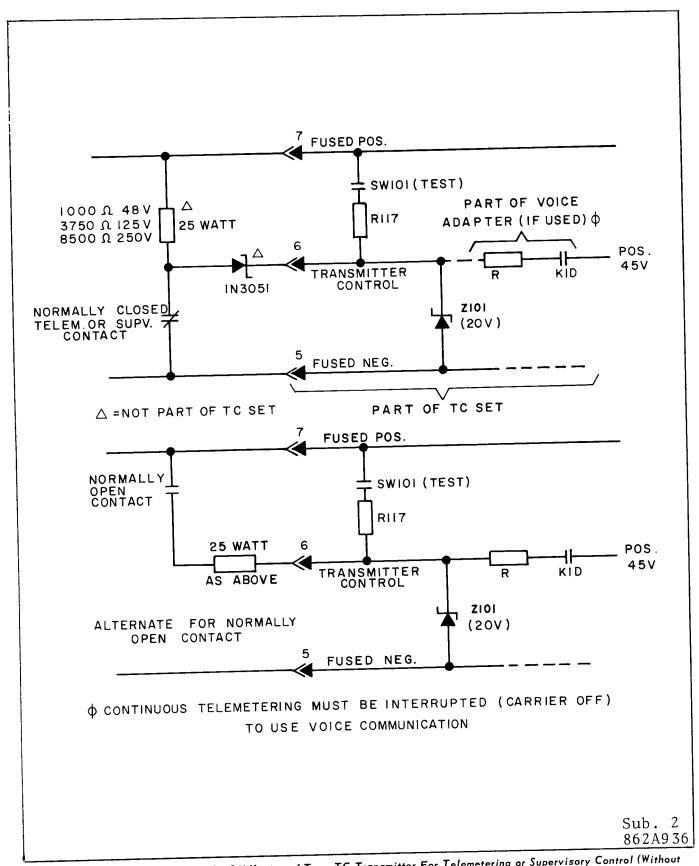


Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact.

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INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER
TRANSMITTER-RECEIVER ASSEMBLY – 30 to 300 kHz
For Directional and Phase Comparison Relaying
10 Watts – 48, 125, 250 V.D.C. with Optional Voice

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When the TC set is used with solid-state protective relays (such as the SKBU-11), the pilot light PL1, power switch SW-1, and fuses F1 and F2 are omitted from the assembly. See Fig's. 1 and 2. Instead, the d-c power to the complete relaying assembly is controlled from a single switch and set of fuses. This is done to prevent an incorrect tripping or blocking output which might result from interruption of one or both sides of the d-c supply to the carrier set or protective relays. For solid-state relaying applications, there are no connections to J104 terminals 7 or 5 (normally fused positive and fused negative). See Fig. 7.

Relaying Control Circuits

The carrier control circuit for KDar relaying is shown in elementary form in Figure 6. The "Transmitter Control" circuit is normally held at fused negative potential through the normally-closed carrier test pushbutton and the phase and ground carrier-start relay contacts. Opening of any of these contacts allows current to flow from fused positive through resistor \mathbf{R}_{c} and the diode \mathbf{D}_{1} to the transmitter control terminal TC/6, thus starting carrier transmission at full output. The potential of terminal TC/6 rises to plus 20 volts, limited by a Zener diode in the transmitter proper. The reception of carrier from either the local or remote transmitter normally causes a saturated current of about 200 ma. to flow in the alarm and holding coils (AL and RRH) in the type KA-4 (or equivalent) receiver auxiliary relay.

If the protective relays call for stopping the transmission of carrier, closing of CSP or CSG contact connects the transmitter control circuit back to fused negative, thus stopping any carrier transmission regardles of how it was started.

If a relaying carrier channel is also used for an auxiliary function such as telemetering or supervisory control, the keying contact for this function is connected into the carrier-start circuit in series with the carrier test pushbutton. Such a contact must be normally closed (in the non-operating condition). An auxiliary relay in the receiver output, usually in place of the alarm relay, energizes the telemetering or supervisory control equipment through contacts on the auxiliary relay.

Carrier Control For Other Functions

If a type TC set is keyed on-off for telemetering or supervisory control only (no protective relaying).

one of the circuits shown in Figure 16 can be used. Arrangements are shown for either a normally-closed or normally-open carrier-start contact. In the former case, a diode is required to allow using the Voice Adapter for push-to-talk voice communication between stations. Note that continuous telemetering must be interrupted when it is desired to use the carrier channel for voice communication.

The receiver output can be connected for either 200 ma. or 20 ma. operation as shown in Figure 11. The 200-ma. output is preferable (if a choice is available) because of a slightly better time constant in the 200-ma. receiver output circuit. In some cases, both the 200-ma. and 20-ma. outputs may be used together. For example, the 200-ma, output can be used with a standard carrier auxiliary relay (for directional-comparison relaying), while the 20-ma. output feeds a 2000-ohm receiver relay used with supervisory control equipment. The connections shown in Fig. 11 would be used for this case, with the receiver relay holding coil (RRH) in place of the 33-ohm resistor and the 2000-ohm supervisory relay in the 20-ma, output in place of the RRH and AL coils shown. The alarm function would be provided by the supervisory control equipment.

CHARACTERISTICS

| Frequency range | 30-300 | kHz | (50-300 | kHz | for |
|-----------------|--------|------|---------|-------|------|
| | phase | comp | parison | relay | ing) |

Transmitter output 10 watts into 50 to 70-ohm

resistive load

Harmonics 55 db below 10 watts

Receiver 125 mv. input for 180 ma. mini-

sensitivity mum output current

Receiver 1500 Hz bandwidth (3 db down);

selectivity 80 db at \pm 3kHz.

Transmitter-receiver

Channel rating 40 db

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

Supply voltage

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

Battery Drain:

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 ℃ 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. 12. 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. 13. 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 frequencys 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-dc 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. 12, 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 chassic must not exceed 60° C.

ADJUSTMENTS

Transmitter

There are two adjustable controls on the transmitter printed-circuit board: (1) the power output control R112, and (2) base bias control R142 for transistors Q104 and Q105. The control R142 is factory adjusted for a quiescent (no-signal) current of 0.2 ± 0.05 ma. d.c. at terminal 2 of transformer T103. This applies a small amount of forward base bias to transistors Q104 and Q105 to minimize cross-over distortion. A thermistor (R141) is included for temperature compensation. This control (R142) need not be changed except as described in the MAINTENANCE section.

The other 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 turn on the power switch on the panel 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.

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.

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.

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 |

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. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection 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 of 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 voltmeter. If a simple VTVM is used, have the remote transmitter tuned 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 unit 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 R207 at maximum, the i-f gain control R239 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.

MAINTENANCE

Periodic checks of the received carrier signal will indicate impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output 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 Table I through IV. Voltages should be measured with a VTVM. Readings may vary as much as $\pm 20\%$.

Adjustment of R142 on Transmitter Board

The small adjustable resistor (pot.) R142 sets the forward base bias on transmitter transistors Q104 and Q105 to the proper point for class-B operation. This is a factory adjustment and need not be changed unless transistors Q104 or Q105 (or both) are replaced. However, if these 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. ± 0.05 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 acceptabely low value. The pair of transistors should be ordered as "2 of style 187A673H02 transistors, type GP2151".

CHANGE OF OPERATING FREQUENCY

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

Transmitter

- Oscillator Crystal (Y101), specify frequency
 NOTE: Modify A-B-C jumpers on transmitter board if required for new frequency. See table marked "‡" under internal schematic (Fig. 7).
- 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. 39-50 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 follow-

ing 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 1N2999B 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 | 241.1-222.0 |
| 34.0-36.0 | 68.5- 72.0 | 127.5-135.0 | 222.1-230.0 |
| 36.5-38.5 | 72.5-776.0 | 135.5-143.0 | 230.1-240.0 |
| 39.0-41.0 | 76.5- 80.0 | 145.5-151.0 | 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.

TABLE | Receiver D.C. Measurements

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

| TEST POINT | STANDBY (No Signal) | | | | H 125 M. INPUT | ٧. |
|-----------------|------------------------|-------------|------|-------|-------------------|------|
| TP201 | | 35-38 35-38 | | | | |
| TP202 | | 0 | | | 0 | |
| TP 203 | | 11-12 | | | 11-12 | |
| TP204 | | < 0.5 | | | 2-3 | |
| TP205 | | 18-22 | | 18-22 | | |
| TRAN- SISTOR | E* | В* | c * | E* | В* | c* |
| Q201 | 36.5 | 37 | 42.0 | 36.5 | 36 | 42.0 |
| Q202 | 36.5 | 37.5 | 43.0 | 36.0 | 35.5 | 43.0 |
| Q203 | <0.5 | 0 | 18.0 | < 0.5 | 0 | 18.0 |
| Q204 | 2.1 | 2.75 | 18.0 | 2.7 | 2.9 | 18.0 |
| Q205 | 2.2 | 2.8 | 18.0 | 2.5 | 2.7 | 18.0 |
| Q206 | 2.2 | 2.8 | 11.0 | 2.6 | 2.8 | 11.5 |
| Q207 | < 0.5 | < 0.5 | 22.0 | 2.0 | 2.2 | 5.0 |
| Q208 | <0.5 | < 0.5 | 44.0 | 11.7 | 2.0 | 2.0 |

^{*}E - Emitter, B - Base, C - Collector

TABLE II
Receiver RF Measurements

Note: Taken with 100kHz 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 A-C VOLTAGE |
|-------------------|---------------------|
| FL201-IN to Gnd. | 0.067 |
| FL201-OUT to Gnd. | 0.04 |
| Q203 - E to TP206 | 0.097 |
| Q203 - C to TP206 | 0.06 |
| Q204 - B to TP206 | 0.01 |
| Q204 - C to TP206 | 0.09 |
| Q205 - B to TP206 | 0.013 |
| Q205 - C to TP206 | 1.15 |
| Q206 - B to TP206 | 0.15 |
| Q206 - C to TP206 | 2.5 |
| TP202 to TP206 | 0.5 |

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

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

< 0.5 means "less than 0.5V."

TABLE III
Transmitter D-C Measurements

Note: All voltages are positive with respect to Neg. DC. (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 | 0.65 | 0.7 |
| TP111 | 0.65 | 0.7 |
| TP112 | 0 | <0.5 |
| TP113 | 45 | 44 |
| J101 (Front Panel) | 5 ma. max. | 0.6 amp. |

| TRAN- SISTOR | E | В | С | E | В | С |
|-----------------|-------|-------|------|------|------|------|
| Q101 | 7.0 | 7.0 | 2.0 | 7.0 | 7.0 | 1.0 |
| ØIOI | 7.8 | 7.9 | 2.0 | 7.8 | 7.8 | 1.8 |
| Q102 | 8.1 | 8.7 | 1.0 | 8.1 | 8.7 | 1.0 |
| Q103 | < 0.5 | < 0.5 | <0.5 | 20.0 | 20.0 | 9.0 |
| Q104 | <0.5 | 0.6 | 45 | <0.5 | 0.75 | 44 |
| Q105 | < 0.5 | 0.6 | 45 | <0.5 | 0.75 | 44 |
| Q106 | 0 | <0.5 | 44.5 | 0 | 0.8 | 1.2 |
| Q107 | 44.3 | 44.2 | 0 | 24 | 24 | 0 |
| Q108 | 45.0 | 44.7 | 44.5 | 44.2 | 44.0 | 24.2 |

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. 7 below internal schematic.
- 4. 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 may 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 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 |
| Q103-C to TP104 | 1.1 ¢ |
| 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.

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

 $60~\mathrm{Hz}$ to $330~\mathrm{kHz}$, input impedance — one megohm, minimum.

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

Voltage Range:

0.1 to 300 volts

Input Impedance:

1.0 megohm, min.

II. Desirable Test Equipment for Apparatus Maintenance.

- a. All items listed in I.
- b. Signal Generator

Output Voltage:

up to 10 volts r.m.s.

Frequency Range:

20 to 330 kHz

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

Renewal Parts

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

Transmitter Section

| 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) | 101710241102 |
| C112 | 39 pfd, 500 V. DC | 187 A695H12 |
| † C113 | (See Table Below) | 101110301112 |
| C114 | 100 pf. 500 V. DC | 1074 0051100 |
| C115 | 100 pf. 500 V. DC | 187A695H23 |
| C116 | 0.001 mfd, 500 V. DC | 187A695H23 |
| CA | Part of FL101 | 187A694H11 |
| CB, CC, CD, CE | Part of FL102 | Vary with Frequency |
| † FREQ. | C111, C113 | Vary with Frequency |
| 30 - 50 kHz | 0.47 mfd, 400 V. DC | Style Number |
| 50.5- 75 kHz | 0.22 mfd, 400 V. DC | 188A293H01 |
| 175.5-100 kHz | 0.15 mfd, 400 V. DC | 188A293H02 188A293H03 |
| 100.5-150 kHz | 0.1 mfd, 400 V. DC | |
| 150.5-300 kHz | 0.047 mfd, 400 V. DC | 188A293H04 |
| D101 | 1N457A | 188A293H05 |
| D103 | 1N4818 | 184A855H07 |
| D104 | 1N91 | 188A342H06 |
| D105 | 1N4818 | 182A881H04 |
| D106 | | 188A342H06 |
| G101 | 1N91 | 182A881H04 |
| J101 | Type RVS Arrester | 632A026A01 |
| J102 | Closed Circuit Jack | 187А606Н01 |
| J102 | Banana Plug Jack | 2 of 185A431H01 |
| | Coaxial Cable Jack | 187A633H01 |
| J104 | 24-Term Receptacle | 187A669H01 |
| J105 | 12-Term Receptacle | 629A205H02 |

Transmitter Section (Cont.)

| SYMBOL | RATING | | | STYLE NUMBER |
|--------|-------------------|--|-----------------|---------------------|
| L101 | Part of 1 | Part of FL101 | | |
| L102 | FL102 7 | Vary with Frequency | | |
| L103 | FL102 | Trap Coil (3rd Harmon | ic) | vary with Frequency |
| L 104 | 400 mh. | | | 292B096G01 |
| L105 | | Coil (part of series-reuned to fundamental f | | Vary with Frequency |
| Q101 | 2N29054 | P | | 762A672H10 |
| Q102 | 2N2905 | A | | 762A672H10 |
| Q103 | 2N525 | | | 184A638H13 |
| Q104 | 2N3712 | | | 762A672H07 |
| Q105 | 2N3712 | | | 762A672H07 |
| Q106 | TI-481 | | | 184A638H11 |
| Q107 | 2N1908 | Matched Pair - T | exas Instrument | 187A673H02 |
| Q108 | 2N1908 | Co. – Identif. GF | | 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 | 184A763H75 |
| R105 | 390 | 5 | 0.5 | 184A763H17 |
| R106 | 1,200 | 5 | 0.5 | 184A763H29 |
| R107 | 10,000 | 10 | 0.5 | 187A641H51 |
| 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 |
| R116 | 100 | 5 | 0.5 | 184A763H03 |
| | 1,000 48 V dc | 5 | 25 | 1202588 |
| R117 | 3,750 125 V dc | 5 | 25 | 1202955 |
| | 8,500 250 V dc | 5 | 25 | 1267310 |

Transmitter Section (Cont.)

| SYMBOL | OHMS | ± TOL. % | WATTS | STYLE NUMBER |
|--------|----------|-----------------------|------------------|--------------|
| 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 | 10 | 0.5 | 184A763H53 |
| 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 T | | 185A211H06 |
| R142 | 25K Pot | 20 | 1/8 | 584C276H23 |
| R143 | 20 K | 2 | 0.5 | 629A531H63 |
| SYMBOL | | RATING | | STYLE NUMBER |
| T101 | 10,000/4 | 100 ohms | | 205C043G01 |
| T102 | 10,000/4 | 100 c.t. | | 205C043G04 |
| T103 | 1930/60 | ohms L63 | 33000 | 1962694 |
| T104 | Tums ra | 292B526G01 | | |
| T105 | 10/500 0 | 292B526G02 | | |
| T106 | 500/50 - | 292B526G02 | | |
| Y101 | 30-300 k | 3 | Specify Frequenc | |
| Z101 | Zener Di | 862A288H03 | | |
| Z102 | Zener Di | ode 1N2999B (56 V. ± | 5%) | 629A798H04 |
| Z103 | | ode 1N2999B (56 V. ± | | 629A798H04 |
| Z104 | Zener Di | ode 1N2999B (56 V. ±5 | 5%) | 629A798H04 |

Receiver Section

| SYMBOL | RATING | STYLE NUMBER | |
|--------|---|-------------------|--|
| 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 | |
| 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 (20MA) | 187A606H01 | |
| J203 | Closed Circuit Jack (200MA) | 187А606Н01 | |
| L 201 | 33 mh. | 187A599H02 | |
| Q201 | 2N2905A | 762A672H10 | |
| Q202 | 2N2905A | 762A672H10 | |
| Q203 | 2N2905A | 762A672H10 | |
| Q204 | 2N2905A | 762A672H10 | |
| Q205 | 2N2905A | 762A672H10 | |
| Q206 | 2N2905 A | 762A672H10 | |
| Q207 | 2N3645 | 849A441H01 | |
| Q208 | 2N4903 | 187A673H13 | |

Receiver Section (Cont.)

| SYMBOL | | RATING | | |
|-----------|-----------|----------|-------|-----------------|
| RESISTORS | OHMS | ± TOL. % | WATTS | STYLE NUMBER |
| 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 | 185А086Н07 |
| R208 | 10,000 | 10 | 0.5 | 187A641H51 |
| R209 | 100,000 | 5 | 0.5 | 184A763H75 |
| R210 | 390 | 5 | 0.5 | 184A763H17 |
| † R211 | - | _ | _ | See † Note Belo |
| 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 |
| 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 | 187А290Н01 |
| R231 | 2,000 | 5 | 0.5 | 184A763H34 |
| R232 | 1,200 | 5 | 2 | 185A207H29 |
| R233 | 4,700 | 10 | 2 | 187A642H43 |

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

Receiver Section (Cont.)

| 6V H D O I | OTTUE | RATING | | STYLE NUMBER | | |
|------------|--|-------------------------|------------------------------------|--------------|-------------------|--|
| SYMBOL | ОНМЅ | ± TOL. % | ± TOL. % | | JITEE NOMBER | |
| 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 | Sensist | or | 0.25 | 187A685H08 | |
| T201 | 10.000/10,000 | Ohms | | | 714B677G01 | |
| T202 | 10,000/400 Ohr | ns | | | 205C043G01 | |
| T203 | 25,000/300 Ohr | | | | 205C043G03 | |
| Y201 | 50-320kHz Crys | | 83 | | Specify Frequency | |
| Z201 | 1N3027B (20V | | | | 184A449H07 | |
| Z202 | 1N1789 (56V | | | | 584C434H08 | |
| 2202 | 111100 (001 | Power Supply | Section | | | |
| SYMBOL | FUNCTION | Томог обрргу | DESCRIPTION OR RATING | | STYLE NUMBER | |
| C1 | (+) to (-) bypass | | | . 330 VAC | 1723408 | |
| C2 | A-C grounding | | | 1500 VDC | 1877962 | |
| C3 | A-C grounding | | 0.5 mfd. 1500 VDC | | 1887962 | |
| F1, F2 | Overload Protect | ion | 1.5a, 48/125 VDC | | 11D9195H26 | |
| F1, F2 | Overload Protect | | 2.0a. 250 VDC | | 478067 | |
| PL1 | Neon Pilot Light 125/250 Volts | | 120 Volts | | 183A955H01 | |
| PL1 | Filament-type for 48 Volts | | 55 Volts | | 187A133H02 | |
| Q1 | Series Regulator | | Type 2N1015C Silicon Transistor | | 187A342H02 | |
| R1 | Series dr | | 26.5 ohms, 3½" | | 04D1299H44 | |
| R2 | 125V Series dr | | Same as | · | 04D1299H44 | |
| R3 | Current 1 | DC, | 500 ohms, 3½'' | | 1268047 | |
| | $48V \begin{cases} R1 = R2 \\ R3 = 26.5 \end{cases}$ | | 3½,, | | 04D1299H44 | |
| R4 | Current limiting | Omns | 100K, 0.5 watt | | 184A763H75 | |
| SW1 | Power Switch | 20 250V AC-DC | | 7. AC-DC | 880A357H01 | |
| SW101 | Carrier Test | 6a, 125 V. Same as S | | | 880A357H01 | |
| TP1 | Test point (+) | | | | 187A332H01 | |
| TP2 | Test point (-) | | | k – black | 187A332H02 | |
| Z1 | Voltage Regulate | or | | 3 (45V.) | 184A854H06 | |
| Z1 Z2 | Surge Protection | | | A (130V.) | 184A617H12 | |
| Z3 | Voltage Reg. for | 250V. | | 3 (15V.) | 184A854H11 | |

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

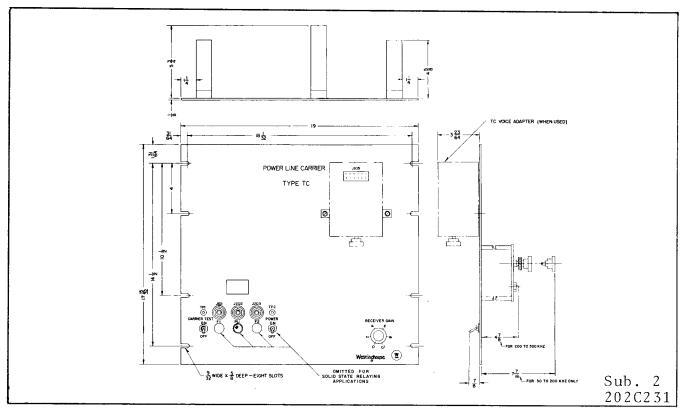


Fig. 1 Type TC Carrier Assembly - Outline

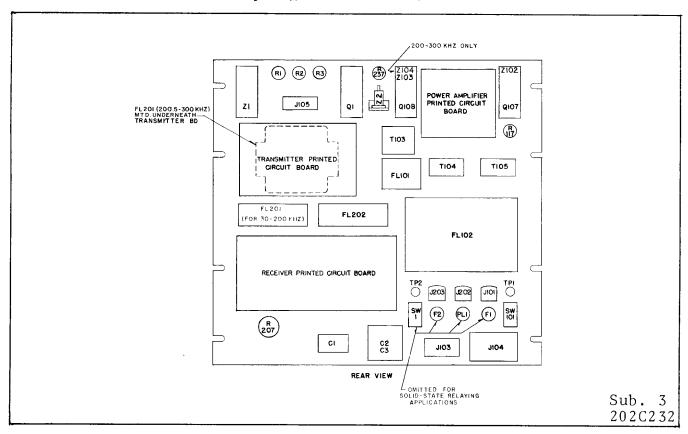


Fig. 2 Type TC Carrier Assembly - Parts Location

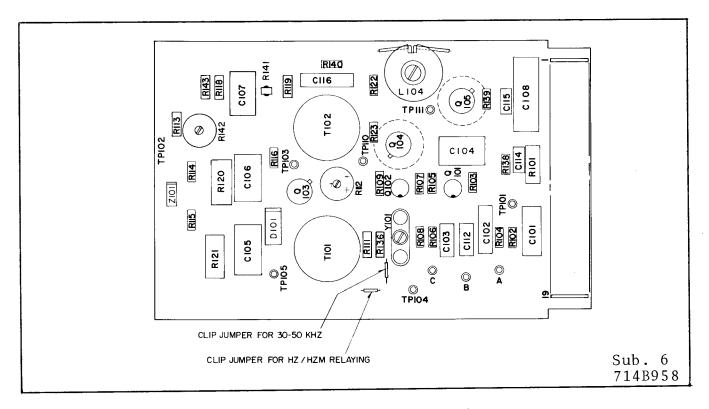


Fig. 3 Transmitter Printed Circuit — Parts Location

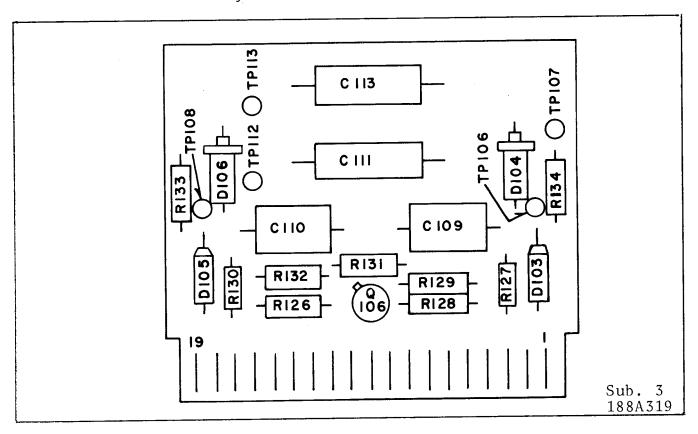


Fig. 4 Power Amplifier Printed Circuit - Parts Location

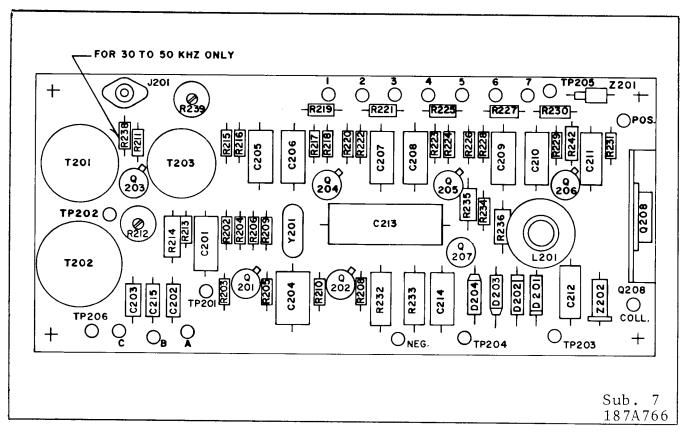


Fig. 5 Receiver Printed Circuit - Parts Location

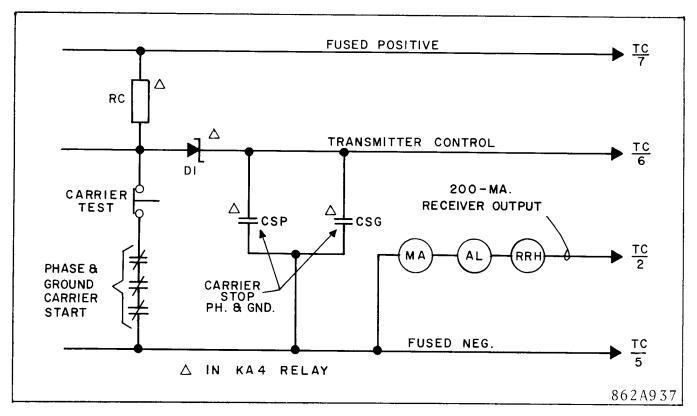


Fig. 6 Elementary K-Dar Carrier Control Circuits.

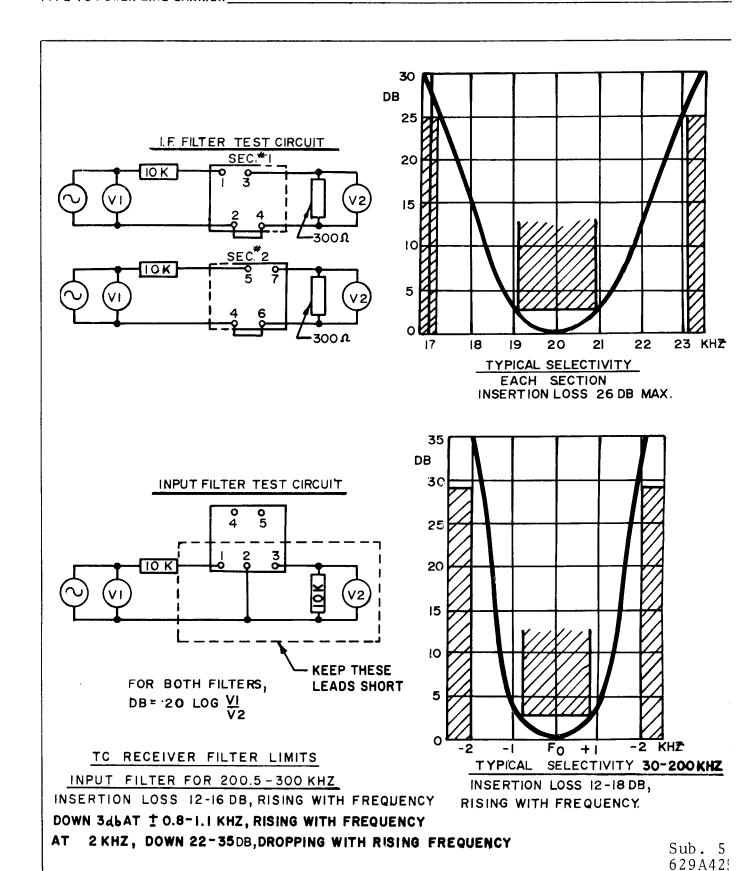
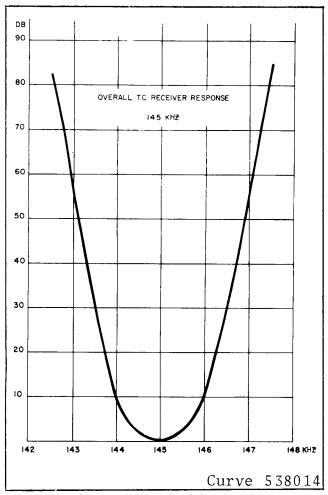


Fig. 8 Type TC Receiver Filter Characteristics



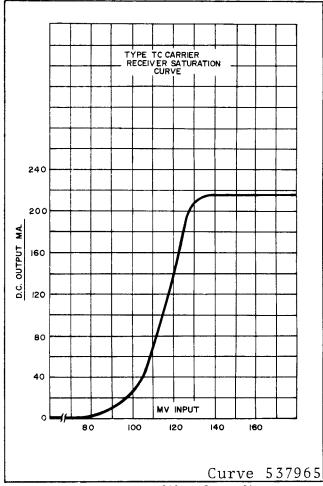


Fig. 9 Type TC Overall Selectivity Curve

Fig. 10 Type TC Receiver - 200 ma. Output Characteristic.

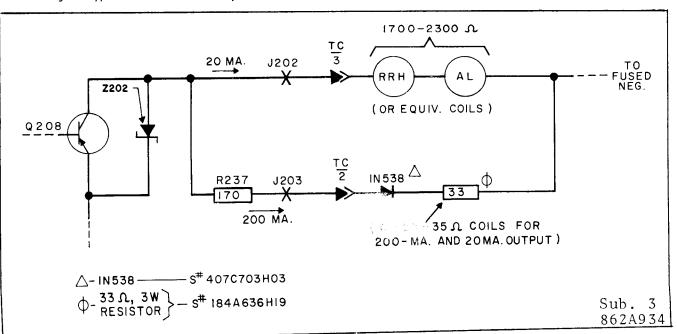


Fig. 11 TC Receiver Output For 20-ma. Operation

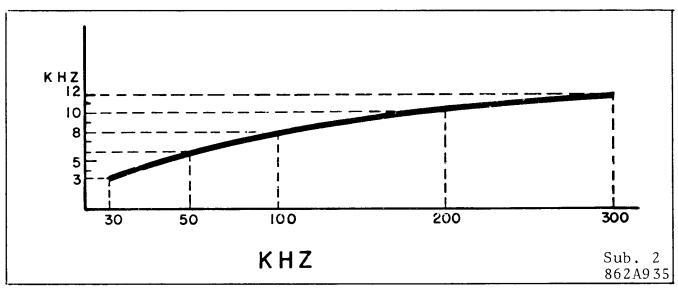


Fig. 12 Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

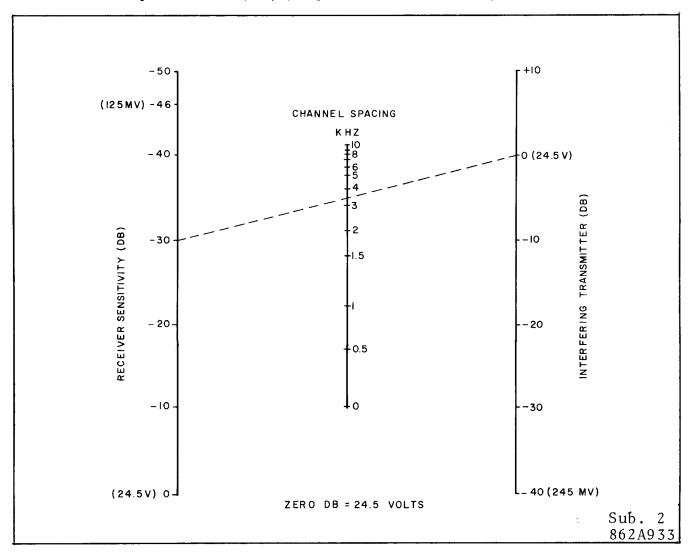


Fig. 13. Minimum Channel Spacing for Keyed Carrier 60p.p.s.

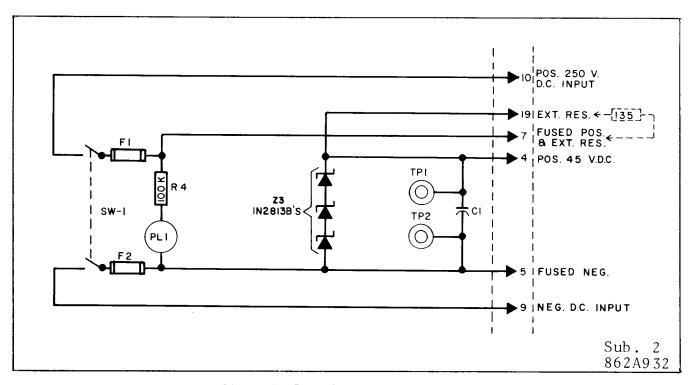


Fig. 14 Detail of Power Supply Section For 250-volt Supply

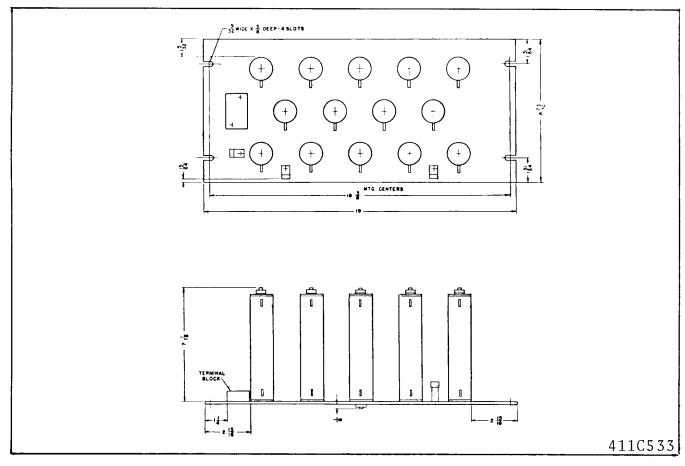


Fig. 15 Outline of External Resistor Unit for 250-Volt Operation.

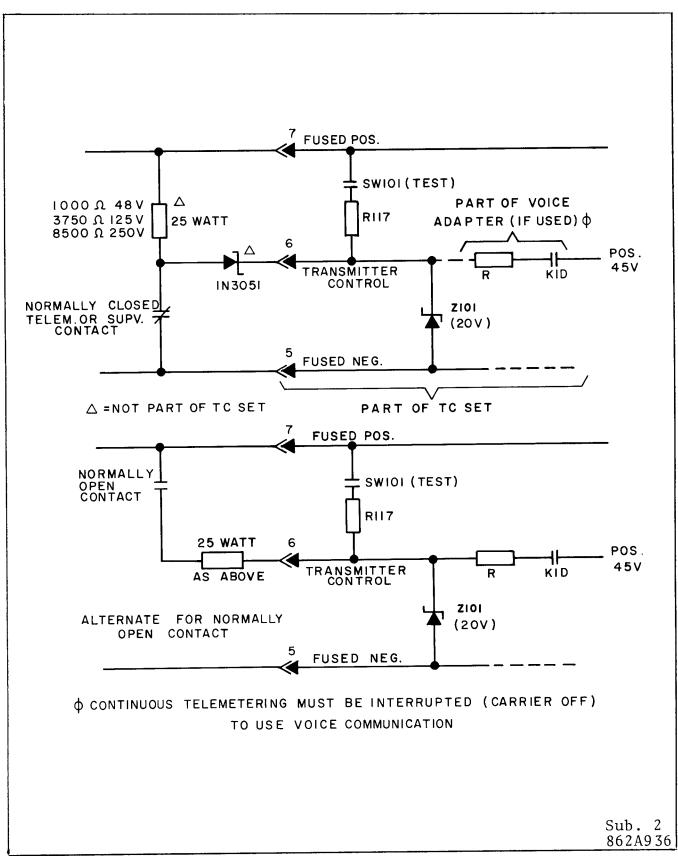


Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact.



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



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER
TRANSMITTER-RECEIVER ASSEMBLY – 30 to 300 kHz
For Directional and Phase Comparison Relaying
10 Watts – 48, 125, 250 V.D.C. with Optional Voice

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| II Receiver R-F Measurements | 9 | | of Type TC Transmitter For Tele- | |
| III Transmitter D-C Measurements | 1.0 | | metering or Supervisory Control (Without Protective Relaying) From | |
| III Transmitter D-C Measurements | 10 | | Either Normally-Closed or Normally- | |
| IV Transmitter R-F Measurements | 10 | | Open Contact | 27 |

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.

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 |

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. A small amount of reactance in the transmitter output load circuit may be tuned out by readjustment of the movable core of L105. This may be necessary with some types of line coupling equipment. The adjustable cores of L102 and L103 have been set for maximum harmonic rejection 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 of 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 voltmeter. If a simple VTVM is used, have the remote transmitter tuned 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 unit 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 R2 9 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 R207 at maximum, the i-f gain control R239 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.

MAINTENANCE

Periodic checks of the received carrier signal will indicate impending failure so that the equipment can be taken out of service for correction. At regular maintenance intervals, any accumulated dust should be removed, particularly from the heat sinks. It is also desirable to check the transmitter power output 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 Table I through IV. Voltages should be measured with a VTVM. Readings may vary as much as $\pm~20\%$.

Adjustment of R142 on Transmitter Board

The small adjustable resistor (pot.) R142 sets the forward base bias on transmitter transistors Q104 and Q105 to the proper point for class-B operation. This is a factory adjustment and need not be changed unless transistors Q104 or Q105 (or both) are replaced. However, if these 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. ± 0.05 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 acceptabely 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. 7).

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. 39-50 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 follow-

ing 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 1N2999B 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 | 241.1-222.0 |
| 34.0-36.0 | 68.5- 72.0 | 127.5-135.0 | 222.1-230.0 |
| 36.5-38.5 | 72.5-776.0 | 135.5-143.0 | 230.1-240.0 |
| 39.0-41.0 | 76.5- 80.0 | 145.5-151.0 | 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.

TABLE I
Receiver D.C. Measurements

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

| TEST POINT | STANDBY (No Signal) | | | WIT | TH 125 M INPUT | .v. |
|-----------------|------------------------|------------|------|-------|-------------------|------|
| TP201 TP202 | | 35-38 0 | | | 35-38 0 | |
| TP203 | | 11-12 | | | 11-12 | |
| TP204 | | < 0.5 | | | 2-3 | |
| TP205 | | 18-22 | | | 18-22 | |
| TRAN- SISTOR | E* | в* | c* | E* | В* | c * |
| Q201 | 36.5 | 37 | 42.0 | 36.5 | 36 | 42.0 |
| Q202 | 36.5 | 37.5 | 43.0 | 36.0 | 35.5 | 43.0 |
| Q203 | <0.5 | 0 | 18.0 | < 0.5 | 0 | 18.0 |
| Q204 | 2.1 | 2.75 | 18.0 | 2.7 | 2.9 | 18.0 |
| Q205 | 2.2 | 2.8 | 18.0 | 2.5 | 2.7 | 18.0 |
| Q206 | 2.2 | 2.8 | 11.0 | 2.6 | 2.8 | 11.5 |
| Q207 | < 0.5 | < 0.5 | 22.0 | 2.0 | 2.2 | 5.0 |
| Q208 | <0.5 | < 0.5 | 44.0 | 11.7 | 2.0 | 2.0 |

^{*}E - Emitter, B - Base, C - Collector

TABLE II
Receiver RF Measurements

Note: Taken with 100kHz 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 A-C VOLTAGE |
|-------------------|---------------------|
| FL201-IN to Gnd. | 0.067 |
| FL201-OUT to Gnd. | 0.04 |
| Q203 - E to TP206 | 0.097 |
| Q203 - C to TP206 | 0.06 |
| Q204 - B to TP206 | 0.01 |
| Q204 - C to TP206 | 0.09 |
| Q205 - B to TP206 | 0.013 |
| Q205 - C to TP206 | 1.15 |
| Q206 - B to TP206 | 0.15 |
| Q206 - C to TP206 | 2.5 |
| TP202 to TP206 | 0.5 |

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

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

< 0.5 means "less than 0.5V."

TABLE III
Transmitter D-C Measurements

Note: All voltages are positive with respect to Neg. DC. (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 |
| TP 103 | <0.5 | 19.5 |
| TP105 | <0.5 | 9 |
| TP106 | 44 | 24 |
| TP107 | 44 | 24 |
| TP108 | 45 | 44 |
| TP110 | 0.65 | 0.7 |
| TP111 | 0.65 | 0.7 |
| TP112 | 0 | <0.5 |
| TP113 | 45 | 44 |
| J101 (Front Panel) | 5 ma. max. | 0.6 amp. |

| TRAN- SISTOR | E | В | С | E | В | С |
|-----------------|------|-------|-------|------|------|------|
| Q101 | 7.8 | 7.9 | 2.0 | 7.8 | 7.8 | 1.8 |
| Q102 | 8.1 | 8.7 | 1.0 | 8.1 | 8.7 | 1.0 |
| Q103 | <0.5 | < 0.5 | < 0.5 | 20.0 | 20.0 | 9.0 |
| Q104 | <0.5 | 0.6 | 45 | <0.5 | 0.75 | 44 |
| Q105 | <0.5 | 0.6 | 45 | <0.5 | 0.75 | 44 |
| Q106 | 0 | < 0.5 | 44.5 | 0 | 0.8 | 1.2 |
| Q107 | 44.3 | 44.2 | 0 | 24 | 24 | 0 |
| Q108 | 45.0 | 44.7 | 44.5 | 44.2 | 44.0 | 24.2 |

Receiver

- Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
- 2. Receiver input filter (FL201), specify frequency.
- Resistors R211-R238 Combination
 See values in Fig. 7 below internal schematic.
- 4. 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 may 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 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 | |
| Q103-C to TP104 | 1.1ϕ | |
| 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.

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

 $60~\mathrm{Hz}$ to $330~\mathrm{kHz}$, input impedance — one megohm, minimum.

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

Voltage Range:

0.1 to 300 volts

Input Impedance:

1.0 megohm, min.

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

b. Signal Generator

Output Voltage:

up to 10 volts r.m.s.

Frequency Range:

20 to 330 kHz

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

Renewal Parts

Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data.

Transmitter Section

| 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 | 187 A695H12 |
| † 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 |
| † FREQ. | C111, C113 | Style Number |
| 30 - 50 kHz | 0.47 mfd, 400 V. DC | 188A293H01 |
| 50.5- 75 kHz | 0.22 mfd, 400 V. DC | 188A293H02 |
| 175.5-100 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 |
| D101 | 1N457A | 184A855H07 |
| D103 | 1N4818 | 188A342H06 |
| D104 | 1N91 | 182A881H04 |
| D105 | 1N4818 | 188A342H06 |
| D106 | 1N91 | 182A881H04 |
| G101 | Type RVS Arrester | 632A026A01 |
| J101 | Closed Circuit Jack | 187А606Н01 |
| J102 | Banana Plug Jack | 2 of 185A431H01 |
| J103 | Coaxial Cable Jack | 187A633H01 |
| J104 | 24-Term Receptacle | 187A669H01 |
| J105 | 12-Term Receptacle | 629A205H02 |

Transmitter Section (Cont.)

| SYMBOL | RATING | | | STYLE NUMBER |
|--------|--|---------------------|-------|---------------------|
| L101 | Part | Part of FL101 | | |
| L102 | FL102 Trap Coil (2nd Harmonic) | | | Vary with Frequency |
| L103 | FL10 | | | |
| L104 | 400 n | nh. | | 292B096G01 |
| L105 | FL10 circu | Vary with Frequency | | |
| Q101 | 2N29 | 05A | | 762A672H10 |
| Q102 | 2N29 | 05A | | 762A672H10 |
| Q103 | 2N52 | 5 | | 184A638H13 |
| Q104 | 2N37 | 12 | | 762A672H07 |
| Q105 | 2N37 | 12 | | 762A672H07 |
| Q106 | TI-48 | 1 | | 184A638H11 |
| Q107 | 2N1908 Matched Pair - Texas Instrument | | | 187A673H02 |
| Q108 | 2N1908 Co. – Identif. GP2151 | | | 187A673H02 |
| SYMBOL | ОНМЅ | ± 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 | 184A763H75 |
| R105 | 390 | 5 | 0.5 | 184A763H17 |
| R106 | 1,200 | 5 | 0.5 | 184A763H29 |
| R107 | 10,000 | 10 | 0.5 | 187A641H51 |
| 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 |
| R116 | 100 | 5 | 0.5 | 184A763H03 |
| | 1,000 48 V dc | 5 | 25 | 1202588 |
| R117 | 3,750 125 V dc | 5 | 25 | 1202955 |
| | 8,500 250 V dc | 5 | 25 | 1267310 |

Transmitter Section (Cont.)

| SYMBOL | онмѕ | ± TOL. % | WATTS | STYLE NUMBER |
|----------------|--|-----------------------|-------|---------------------------------|
| 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 |
| | 2,200 | 10 | 0.5 | 184A636H14 |
| R129 R130 | 10 | 10 | 0.5 | 187A640H01 |
| | 4,700 | 5 | 1 | 187A644H43 |
| R131 | | 10 | 0.5 | 184A636H14 |
| R132 | 0.27 | 10 | 1 | 184A636H18 |
| R133 | 0.27 | 10 | 1 | 184A636H18 |
| R134 | 3,000 | 10 | 5 | 188A317H01 |
| R135 | | | 0.5 | 184A763H53 |
| R136 | 12,000 | 10 | | 187A642H55 |
| R137 | 15,000 | 10 | 2 | 187A641H27 |
| R138 | 1,000 | 10 | 0.5 | |
| R139 | 1,000 | 10 | 0.5 | 187A641H27 |
| R140 | 68 | 2 0.5 | | 629A531H04 |
| R141 | 30 | Type 3D202 Thermistor | | 185A211H06 |
| R142 | 25K Pot | 20 | 0.5 | 584C276H23 629A531H63 |
| R143 SYMBOL | 20K | | 0.5 | STYLE NUMBER |
| T101 | 10,000/400 ohms | | | 205C043G01 |
| T102 | <u> </u> | | | 205C043G04 |
| T102 | 10,000/400 c.t. | | | 1962694 |
| | 1930/60 ohms L633000 Turns ratio 1/0.5. Pri-/each sec. | | | 292B526G01 |
| T104 | Tunio (avio, 1/ 0.0) | | | 292B526G02 |
| T105 | 10/500 ohms | | | |
| T106 | 500/50 - 60 - 70 ohms | | | 292B526G02 Specify Frequency |
| Y101 | 30-300 kHz crystal per 328C083 | | | 862A288H03 |
| Z101 | Zener Diode 1N5357B (20V. ±5%) | | | |
| Z102 | Zener Diode 1N2999B (56 V. ±5%) | | | 629A798H04 629A798H04 |
| Z103 Z104 | Zener Diode 1N2999B (56 V. ±5%) Zener Diode 1N2999B (56 V. ±5%) | | | 629A798H04 |

ELECTRICAL PARTS LIST

Receiver Section

| SYMBOL | RATING | STYLE NUMBER |
|--------|---|-------------------|
| 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 |
| 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 (20MA) | 187А606Н01 |
| J203 | Closed Circuit Jack (200MA) | 187A606H01 |
| L201 | 33 mh. | 187А599Н02 |
| Q201 | 2N2905A | 762A672H10 |
| Q202 | 2N2905A | 762A672H10 |
| Q203 | 2N2905A | 762A672H10 |
| Q204 | 2N 2905 A | 762A672H10 |
| Q205 | 2N2905A | 762A672H10 |
| Q206 | 2N2905A | 762A672H10 |
| Q207 | 2N3645 | 849A441H01 |
| Q208 | 2N4903 | 187A673H13 |

ELECTRICAL PARTS LIST

Receiver Section (Cont.)

| SYMBOL | | STYLE NUMBER | | |
|-----------|-----------|--------------|-------|------------------|
| RESISTORS | OHMS | ± TOL. % | WATTS | 31112 NOMBER |
| 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 Belov |
| 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 |
| 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 | 187А290Н01 |
| R231 | 2,000 | 5 | 0.5 | 184A763H34 |
| R232 | 1,200 | 5 | 2 | 185A207H29 |
| R233 | 4,700 | 10 | 2 | 187A642H43 |

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

ELECTRICAL PARTS LIST

Receiver Section (Cont.)

| SYMBOL | ОНМ5 | RATING | | | STYLE NUMBER | |
|------------|--|---|------------------------------------|----------------------|-------------------|--|
| 31 11 10 1 | OHMO | ± TOL. % | | WATTS | JITEL NOMBER | |
| R234 | 5,100 | 5 | 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 | Sensist | tor | 0.25 | 187A685H08 | |
| T201 | 10.000/10,000 | Ohms | | | 714B677G01 | |
| Т202 | 10,000/400 Ohn | ns | | | 205C043G01 | |
| T203 | 25,000/300 Ohn | ns | | | 205C043G03 | |
| Y201 | 50-320kHz Crys | | 83 | | Specify Frequency | |
| Z201 | 1N3027B (20V | ± 5%) | | | 184A449H07 | |
| Z202 | 1N1789 (56V | ±10%) | | | 584C434H08 | |
| | | Power Supply | Section | | | |
| SYMBOL | FUNCTION | | | IPTION OR RATING | STYLE NUMBER | |
| C1 | (+) to (-) bypass | | 0.45 mi | fd. 330 VAC | 1723408 | |
| C2 | A-C grounding | | 0.5 mfd. 1500 VDC | | 1877962 | |
| C3 | A-C grounding | | 0.5 mfd. 1500 VDC | | 1887962 | |
| F1, F2 | Overload Protect: | ion | 1.5a, 48/125 VDC | | 11D9195H26 | |
| F1, F2 | Overload Protect | ion | 2.0a. 250 VDC | | 478067 | |
| PL1 | Neon Pilot Light 125/250 Volts | | 120 Volts | | 183A955H01 | |
| PL1 | Filament-type for 48 Volts | | 55 Volts | | 187A133H02 | |
| Q1 | Series Regulator | | Type 2N1015C Silicon Transistor | | 187A342H02 | |
| R1 | Series dro | | 26.5 ohms, 3½'' | | 04D1299H44 | |
| R2 | 125V Series dro | | Same as R1 | | 04D1299H44 | |
| R3 | Current li | | 500 ohms, 3½'' | | 1268047 | |
| | $ 48V \begin{cases} For 48 VI \\ R1 = R2 \end{cases} $ | | _ | - | _ | |
| | R3 = 26.5 | | 3½" | | 04D1299H44 | |
| R4 | Current limiting | | 100K, | 0.5 watt | 184A763H75 | |
| SW1 | Power Switch | | 3a, 250V. AC-DC 6a, 125V. AC-DC | | 880A357H01 | |
| SW101 | Carrier Test | | Same as SW1 | | 880A357H01 | |
| TP1 | Test point (+) | Pin Jack — red | | ck - red | 187A332H01 | |
| TP2 | Test point (-) | | Pin Ja | ck - black | 187A332H02 | |
| Z1 | Voltage Regulato | | | 8B (45V.) | 184A854H06 | |
| Z2 | Surge Protection | 1N3 | | 9A (130V.) Diodes | 184A617H12 | |
| Z3 | Voltage Reg. for | Zener Diodes 1 250V. 1 1 2813 B (15V.) | | 184A854H11 | | |

 $[\]dagger$ R238 - omit above 50kHz - 22K, 30-50kHz, S#187A641H59

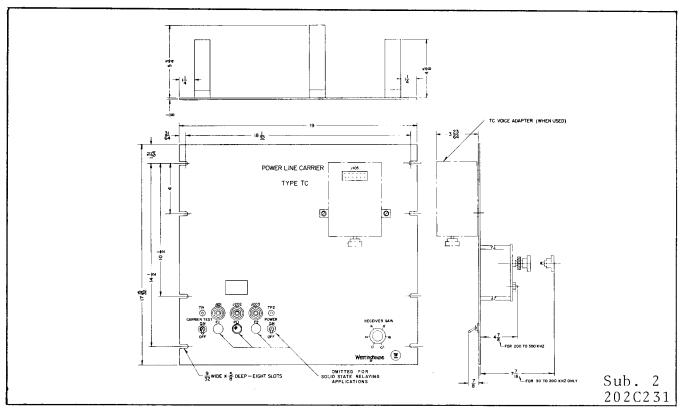


Fig. 1 Type TC Carrier Assembly - Outline

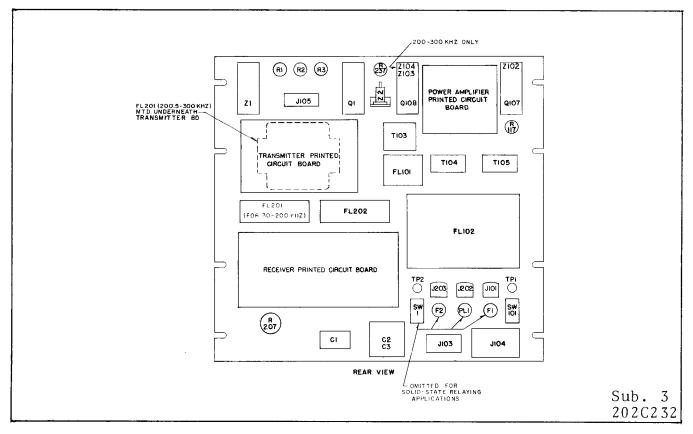


Fig. 2 Type TC Carrier Assembly - Parts Location

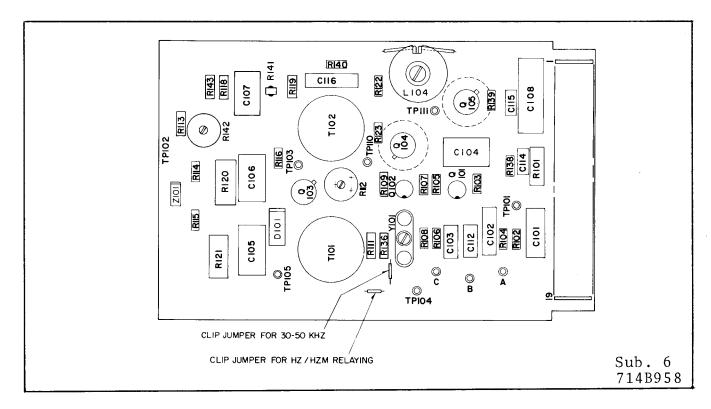


Fig. 3 Transmitter Printed Circuit - Parts Location

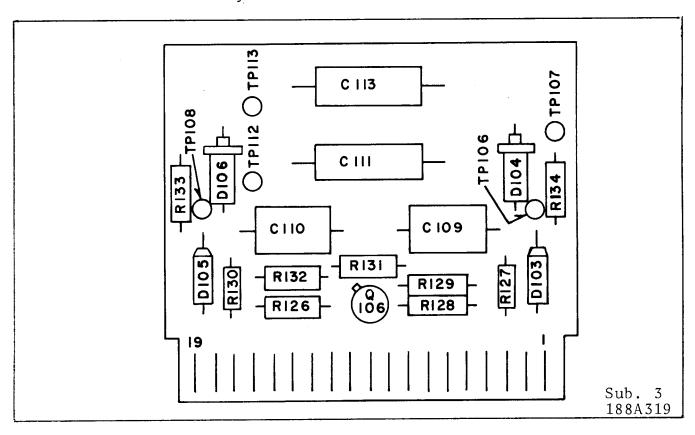


Fig. 4 Power Amplifier Printed Circuit - Parts Location

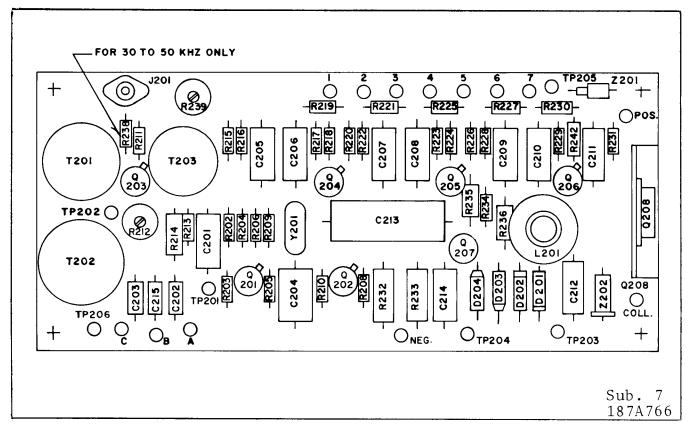


Fig. 5 Receiver Printed Circuit - Parts Location

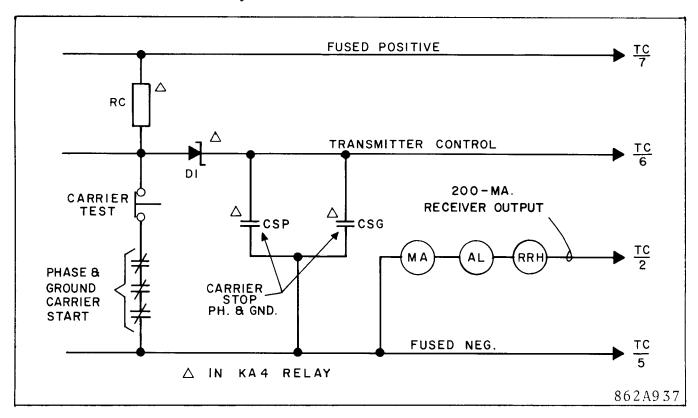


Fig. 6 Elementary K-Dar Carrier Control Circuits.

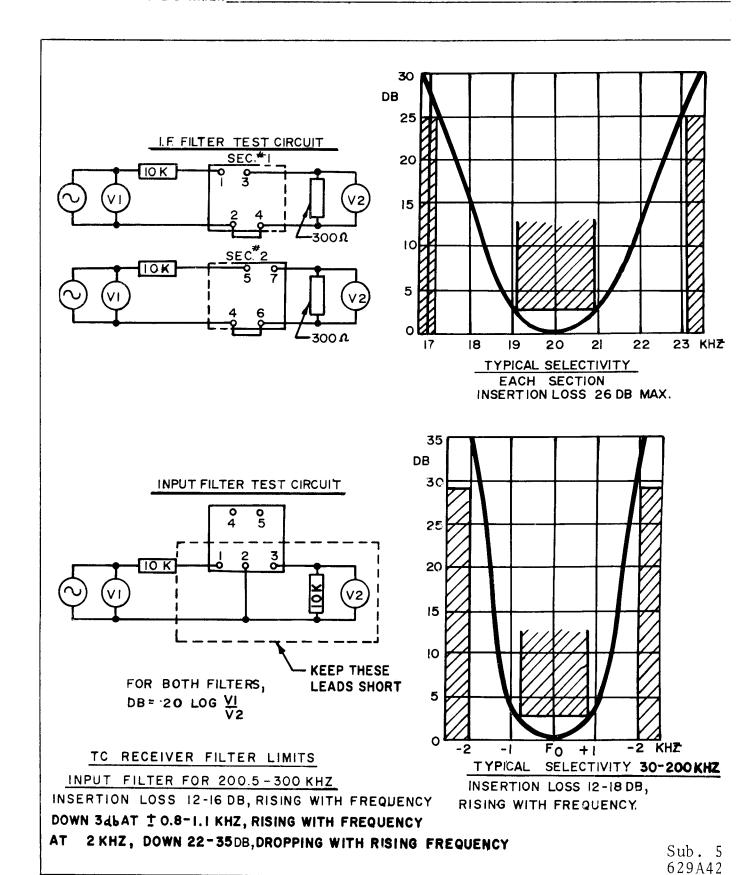
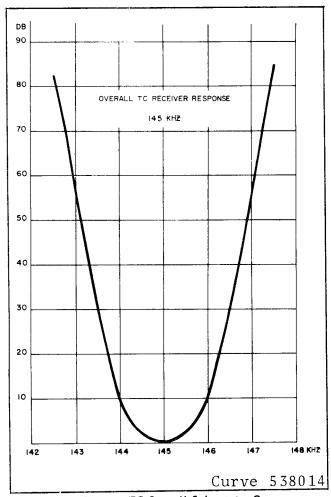


Fig. 8 Type TC Receiver Filter Characteristics



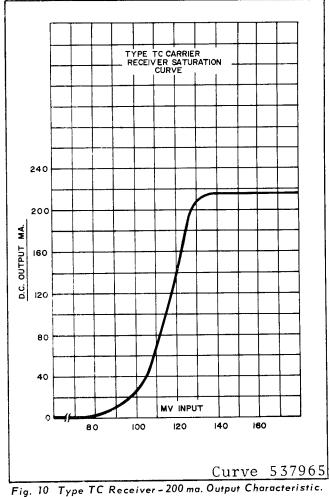


Fig. 9 Type TC Overall Selectivity Curve

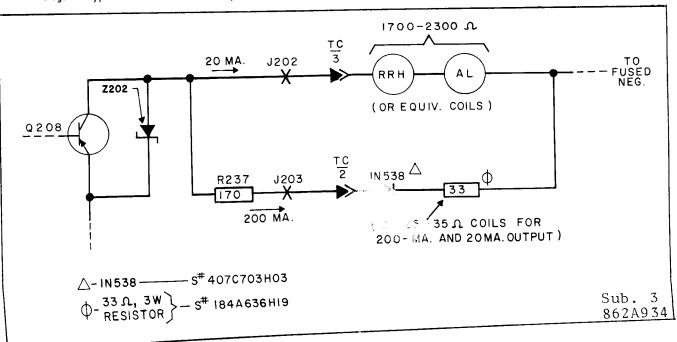


Fig. 11 TC Receiver Output For 20-ma. Operation

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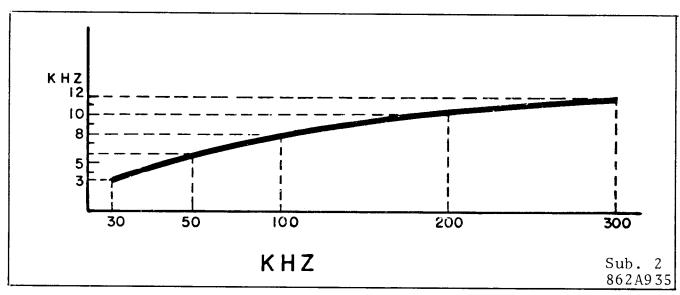


Fig. 12 Minimum Frequency Spacing for Two 10-Watt Transmitters Operated in Parallel.

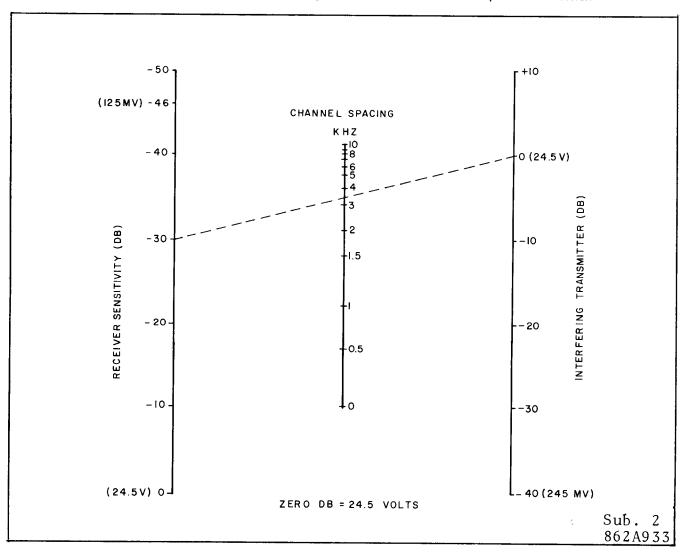


Fig. 13. Minimum Channel Spacing for Keyed Carrier 60p.p.s.

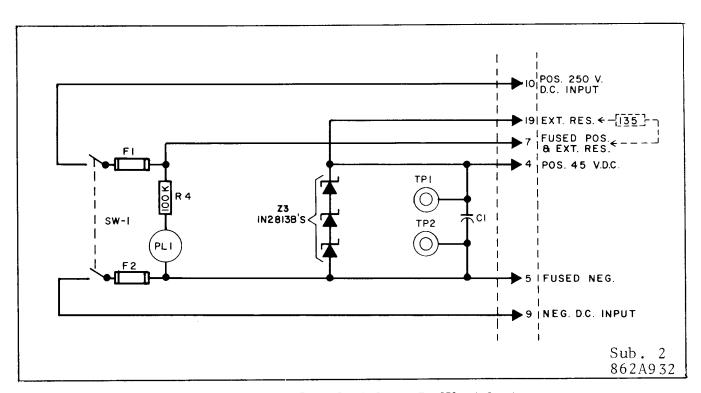


Fig. 14 Detail of Power Supply Section For 250-volt Supply

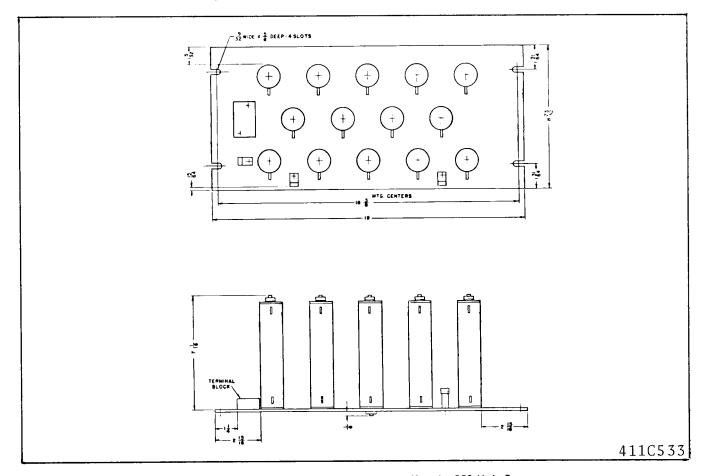


Fig. 15 Outline of External Resistor Unit for 250-Volt Operation.

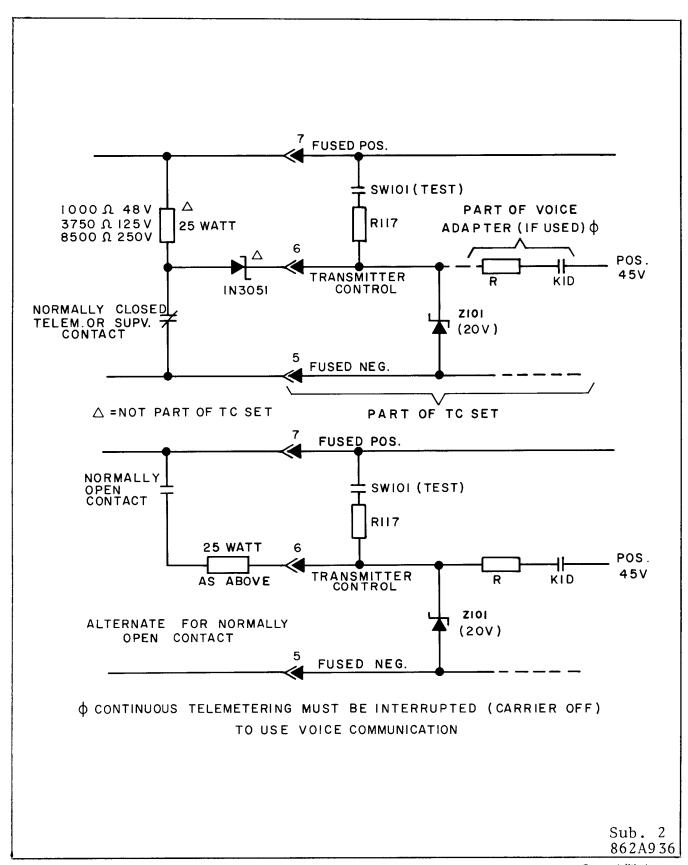


Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact.

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INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER
TRANSMITTER-RECEIVER ASSEMBLY — 30 to 300 kHz
For Directional and Phase Comparison Relaying
10 Watts — 48, 125, 250 V.D.C. with Optional Voice

| Pag | e Colum | in Par Line |
|---------|------------|---|
| 4 | | 1 of Carrier Control For Other Functions. |
| | | 3 circuits not curcuits |
| | | 5 normally not nrmally |
| 5 | 1 | 1 5 equipment not equipment |
| | | equipment not equipment |
| 6 | 1 | 3 8 "is obtained" not "in obtained" |
| | 2 | - table T106 Tap of 50 ohms should be 22.4 volts not 2.4 volts |
| 7 | 1 | 3 9 turned not tuned |
| | | 17 0-250 mA not 0.250 mA |
| 8 | 1 | 2 last word section not section |
| | 2 | Section 3 C & E should be |
| | | 0 55 5 400 |
| | | E 150 5 000000 |
| | | E. 150.5-300KHz 0.047mfd S# 188A293H05 Section 4 title Module not Moudle |
| 9 | 1 | 3 Table of Ranges of filter FL102 |
| | | Combination 35 in the table should be 214.1-222.0 not 241.1-222.0 |
| | 2 | 1 1 2 to 3 not 2 at 3 |
| 12 | 2 | IId Ohmmeter not ohmeter |
| 13 | The line u | nder CB,CC,CD,CE should be bold |
| | The line u | nder 150.5-300KHz should be bold |
| | | 175.5-100KHz should be 75.5-100KHz |
| | Item | 50 / 5.5-100KHZ |
| 14 | L106 | Style # should be 3500A27HO1 |
| 15 | T103 | Impedance ratio is 1930/60 ohms |
| | | L spec L633000 |
| 16 | D203 | should be IN4818 |
| 18 | F1,F2 | Style # 11D919H26 should be 11D9195H62 |
| 23-24 | add | NOTE: For solid-state relaying applications SW1 |
| F1, F2, | , and PLI | are ommitted. |
| | add | Ocircuit change to HKB & SKB relaying shown below |
| | | Ref. 629A486 (See dwg. attached) |
| | Figure 12 | |
| | Add to: | |
| | Y-AXIS | spacing |
| | X-AXIS | Higher center frequency of two sets. |
| | | 1 |

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

