INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY

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SUPERSEDES I.L. 41-944.31E

*Denotes change from superseded issue.

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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 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	30-200 kHz (50-200 kHz for phase comparison relaying)
Transmitter output	10 watts into 50 to 70-ohm resistive load
Harmonics	55 db below 10 watts
Receiver sensitivity	125 mv. input for 180 ma. minimum output current
Receiver selectivity	1500 Hz bandwidth (3 db down); down 80 db at ±3kHz.
Transmitter-receiver channel rating	40 db
Input voltage	48, 125, or 250 V. d-c
Supply voltage variation	42-56 V, 105-140V, 210-280 V
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 frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the −30 db point on the receiver sensitivity scale and the zero-db point on the interfering transmitter scale. The resulting line crosses the channel spacing scale between 3 and 4 kHz. For this example, a channel spacing of at least 4 kHz should be used. (In order not to conflict with the limits of Fig. 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 chassis must not exceed 60°C.

ADJUSTMENTS

* Transmitter ‡

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

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

1. First, measure the normal received signal from

* ‡ First, see Addendum, pp. 28-29.

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

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

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

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

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

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 Tables I through IV. Voltages should be measured with a VTVM. Readings may vary as much as ± 20%.

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. R110 Sensistor (When Used)

   a. 30-60 kHz – 2200 ohms – S# 187A685H01
   b. 60.5-120 kHz – 1800 ohms – S# 187A685H02
   c. 120.5-200 kHz – 1200 ohms – S# 187A685H03

3. Capacitors C111 and C113

   a. 30-50 kHz – 0.47 mfd. – S# 188A293H01
   b. 50.5-75 kHz – 0.22 mfd. – S# 188A293H02
   c. 75.5-100 kHz – 0.15 mfd. – S# 188A293H03
   d. 100.5-150 kHz – 0.10 mfd. – S# 188A293H04
   e. 150.5-200 kHz – 0.047 mfd. – S# 188A293H05

4. FL101 and FL102

   Filter FL101 is a small series-resonant tuned circuit between the driver and power amplifier

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

Inductors L101, L102, and L103 in these filters are adjustable over a limited range, but thirty-two combinations of capacitors and inductors are required to cover the frequency range of 30 kHz to 200 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 12 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5
32.0-33.5	64.5- 68.0	120.0-127.0
34.0-36.0	68.5- 72.0	127.5-135.0
36.5-38.5	72.5- 76.0	135.5-143.0
39.0-41.0	76.5- 80.0	143.5-151.0
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	

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. 45 V. (TP206)

Test Point	Standby (No Signal)			With 125 M.V. Input		
TP201	38			38		
TP202	0			0		
TP203	11.			11.		
TP204	.03			2.2		
TP205	20			20		
Transistor	E*	B*	C*	E*	B*	C*
Q201	38.5	37	43	38.5	37	43
Q202	38.5	37.5	43.5	38.5	37.5	43.5
Q203	0.08	0	18.7	0.08	0	18.7
Q204	2.7	2.9	18.7	2.7	2.9	18.7
Q205	2.4	2.6	18.7	2.5	2.7	18.7
Q206	2.5	2.7	10.5	2.6	2.8	10.5
Q207	0.13	0.03	22.0	2.0	2.2	4.0
Q208	0.25	0.15	45.0	1.7	2.0	2.0

*E – Emitter, B – Base, C – Collector
All voltages read with d-c vacuum-tube voltmeter.

TABLE II

Receiver RF Measurements

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

Test Point	Typical A-C Voltages		Test Point	Typical A-C Voltages	
	36 kHz	132 kHz		36 kHz	132 kHz
FL201-IN to Gnd.	.075	.050	Q205-B to TP206	.11	.052
FL201-OUT to Gnd.	.051	.020	Q205-C to TP206	6.7	3.4
Q203 -E to TP206	.105	.090	Q206-B to TP206	.67	.37
Q203 -C to TP206	.22	.035	Q206-C to TP206	1.5	1.53
Q204 -B to TP206	.015	.012	TP202 to TP206	0.3	0.3
Q204 -C to TP206	.90	.52			

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

TABLE III

Transmitter D-C Measurements

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

Test Point	Carrier Off	Carrier On
TP101	7 volts d.c.	7 volts d.c.
TP102	0	20
TP103	0	19.5
TP105	0	9
TP106	44	22
TP107	44	22.2
TP108	45	44.8
TP110	.5	.6
TP111	.5	.6
TP112	0	0
TP113	45	45
J101 (Front Panel)	5 ma. max.	0.6 amp.

Transistor	E	B	C	E	B	C
Q101	6.0	7.8	2.5	6.1	7.7	2.5
Q102	6.6	7.1	1.2	6.6	7.1	1.1
Q103	0	0	0	19.5	19.4	9.0
Q104	0.1	0.1	45	0.5	0.9	45
Q105	0.1	0.1	45	0.5	0.9	45
Q106	0	0	44	0	0.9	1.2
Q107	43.7	43.7	0	22.2	22.2	0
Q108	45.0	44.7	44.7	44.8	44.8	22.3

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. Resistors R218, R224, and R230 may have to be reduced. See following paragraph.

   The emitter resistors R218, R224, and R230 of the i-f stages are selected during factory test to give the required receiver gain. This is desirable since the insertion loss of the input filter FL201 increases with frequency. If the operating frequency is reduced, the receiver gain will probably be higher. In this case, a reduction in the setting of the i-f input control R239 will give the 125-mv. sensitivity. If the new operating frequency is higher, the receiver gain will be lower. If more than 125 mv. is required to obtain 180 ma. output, the gain can be increased by reducing the value of one or more of the resistors R218, R224, and R230. In most cases, these resistors should fall in the range of 22 to 150 ohms. These three resistors are soldered to small terminal posts on the printed circuit board.

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 230 kHz, input impedance—one megohm, minimum.

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	Test Point	A-C Voltage
T101-3 to TP104	1.1 volts, rms.	Q107-B to TP107	.5 volts, rms.
TP103 to TP102	0.2	Q108-B to TP113	.5
Q103-C to TP104	0.7	Q107-C to TP107	14.5
TP110 to T102-4	0.2	Q108-C to TP113	14.5
TP111 to T102-4	0.2	T105-4 to Gnd.	105
Q104-C to TP104	4.3	T106-2 to Gnd.	155*
Q105-C to TP104	4.3		
T103-4 to Gnd.	1.5	TP109 to Gnd.	50*
T104-1 to Gnd.	1.4	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

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 230kHz

c. Oscilloscope

d. Ohmmeter

e. Capacitor checker

f. Frequency counter

g. Frequency-selective voltmeter

Renewal Parts

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

ELECTRICAL PARTS LIST

Transmitter Section

Symbol	Rating	Style Number
C101	0.1 mfd, 200 V. DC	187A624H01
C102	.005 mfd, 300 V. DC	187A694H29
C103	180 pf. 500 V. DC	187A695H29
C104	0.25 mfd, 200 V. DC	187A624H02
C105	0.25 mfd, 200 V. DC	187A624H02
C106	0.25 mfd, 200 V. DC	187A624H02
C107	0.25 mfd, 200 V. DC	187A624H02
C108	0.50 mfd, 200 V. DC	187A624H03
C109	0.25 mfd, 200 V. DC	187A624H02
C110	0.25 mfd, 200 V. DC	187A624H02
† C111	(See Table Below)	–
C112	39 pfd, 500 V. DC	187A695H12
† C113	(See Table Below)	–
C114	100 pf., 500 V. DC	187A695H23
C115	100 pf., 500 V. DC	187A695H23
C116	0.001 mfd, 500 V. DC	187A694H11
CA	Part of FL101	Vary with Frequency
CB	Part of FL102	Vary with Frequency
CC		
CD		
CE		

† 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
75.5-100 kHz	0.15 mfd, 400 V. DC	188A293H03
100.5-150 kHz	0.1 mfd, 400 V. DC	188A293H04
150.5-200 kHz	0.047 mfd, 400 V. DC	188A293H05

CR101	1N3686B (20 V ±5%)	185A212H06
CR102	1N457A	184A855H07
CR103	1N538	407C703H03
CR104	1N91	182A881H04
CR105	1N538	407C703H03
CR106	1N91	182A881H04
CR107	1N2999B (56 V + 5%)	629A798H04
CR108	1N2999B (56 V + 5%)	629A798H04
G101	Type RVS Arrester	632A026A01
J101	Closed Circuit Jack	187A606H01

ELECTRICAL PARTS LIST

Transmitter Section (Cont.)

Symbol	Rating	Style Number
J102	Banana Plug Jack	2 of 185A431H01
J103	Coaxial Cable Jack	187A633H01
J104	24-Term Receptacle	187A669H01
J105	12-Term Receptacle	629A205H02
L101	Part of FL101	Vary with Frequency
L102	FL102 Trap Coil (2nd Harmonic)	
L103	FL102 Trap Coil (3rd Harmonic)	
L104	400 mh.	292B096G01
L105	FL102 Coil (part of series-resonant circuit tuned to fundamental freq.)	Vary with Frequency
Q101	2N274	187A270H01
Q102	2N274	187A270H01
Q103	2N525	184A638H13
Q104	2N657	184A638H15
Q105	2N657	184A638H15
Q106	TI-481	184A638H11
Q107	2N1908 Matched Pair - Texas Instrument	187A673H02
Q108	2N1908 Co. - Identif. GP2151	

Symbol	Ohms	± Tol. %	Watts	Style Number
R101	5,600	5	1	187A643H45
R102	2,200	10	0.5	187A641H35
R103	10,000	10	0.5	187A641H51
R104	100,000	5	0.5	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
R110 *				At End of List
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

Sensistor - (omitted with temp. comp. per p. 28).	30 - 60 kHz, 2.2 K ± 10%, ¼ watt	187A685H01
	60.5-120 kHz, 1.8 K ± 10%, ¼ watt	187A685H02
	120.5-200 kHz, 1.2 K ± 10%, ¼ watt	187A685H03

ELECTRICAL PARTS LIST
Transmitter Section (Cont.)

Symbol	Ohms	± Tol. %	Watts	Style Number
R116	100	5	0.5	184A763H03
R117	1,000 48 V dc	5	25	1202588
	3,750 125 V dc	5	25	1202955
	8,500 250 V dc	5	25	1267310
R118	8,200	5	2	185A207H49
R119	100	5	0.5	184A763H03
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	0.27	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

Symbol	Rating	Style Number
T101	10,000/400 ohms	205C043G01
T102	10,000/400 c.t.	205C043G04
T103	1930/60 ohms L633000	1962694
T104	Turns ratio, 1/0.5, Pri./each sec.	292B526G01
T105	10/500 ohms	292B526G02
T106	500/50-60-70 ohms	292B526G03
Y101	30-200 kHz crystal per 328C083	Specify Frequency

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
CR201	1N3027B (20V ± 5%)	184A449H07
CR202	1N91	182A881H04
CR203	1N91	182A881H04
CR204	1N538	407C703H03
CR205	1N538	407C703H03
CR206	1N1789 (56V. ± 10%)	584C434H08
FL201	Receiver Input Filter 30-200 kHz	Specify Frequency
FL202	Receiver i.f. Filter-20 kHz (2 Sections)	187A590G02
J201	Receiver Coax. Input Jack	187A638H01
J202	Closed Circuit Jack (20MA)	187A606H01
J203	Closed Circuit Jack (200MA)	187A606H01
L201	33 mh.	187A599H01
Q201	2N274	187A270H01
Q202	2N274	187A270H01
Q203	2N274	187A270H01
Q204	2N274	187A270H01
Q205	2N274	187A270H01
Q206	2N274	187A270H01
Q207	2N398A	184A638H12
Q208	2N1362	187A673H01

ELECTRICAL PARTS LIST
Receiver Section (Cont.)

Symbol	Rating			Style Number
Resistors	Ohms	± Tol. %	Watts	
R201	10,000	10	0.5	187A641H51
R202	2,200	10	0.5	187A641H35
R203	10,000	10	0.5	187A641H51
R204	100,000	5	0.5	184A763H75
R205	390	5	0.5	184A763H17
R206	1,200	5	0.5	184A763H29
R207	25 K Pot.	10	2	185A086H07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H75
R210	390	5	0.5	184A763H17
† R211	–	–	–	See † Note Below
R212	1 K Pot.	20	0.25	629A430H02
R213	1,200	5	0.5	184A763H29
R214	5,600	5	1	187A643H45
R215	20,000	5	0.5	184A763H58
R216	3,600	5	0.5	184A763H40
R217	620	5	0.5	184A763H22
R218	62	5	0.5	187A290H20
R219	10,000	10	0.5	187A641H51
R220	20,000	5	0.5	184A763H58
R221	300	5	0.5	184A763H14
R222	3,600	5	0.5	184A763H40
R223	620	5	0.5	184A763H22
R224	62	5	0.5	187A290H20
R225	10,000	10	0.5	187A641H51
R226	20,000	5	0.5	184A763H58
R227	300	5	0.5	184A763H14
R228	3,600	5	0.5	184A763H40
R229	620	5	0.5	184A763H22
R230	62	5	0.5	187A290H20
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 (continued)

Symbol	Ohms	Rating		Style Number
		± Tol. %	Watts	
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
T201	10,000/10,000 Ohms			714B677G01
T202	10,000/400 Ohms			205C043G01
T203	25,000/300 Ohms			205C043G03
Y201	50-220 kHz Crystal per 328C083			Specify Frequency

Power Supply Section

Symbol	Function	Description or Rating	Style Number
C1	(+) to (–) bypass	0.45 mfd. 330 VAC	1723408
C2	A-C grounding	0.5 mfd. 1500 VDC	1877962
C3	A-C grounding	0.5 mfd. 1500 VDC	1877962
F1, F2	Overload Protection	1.5a, 48/125 VDC	11D9195H26
F1, F2	Overload Protection	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	125V Series dropping	26.5 ohms, 3½"	04D1299H44
R2	125V Series dropping	Same as R1	04D1299H44
R3	125V Current limiting	500 ohms, 3½"	1268047
	48V For 48 VDC, R1 = R2 0	–	–
	48V R3 = 26.5 ohms	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	187A332H01
TP2	Test Point (–)	Pin Jack – black	187A332H02
VR1	Voltage Regulator	1N2828B (45V.)	184A854H06
VR2	Surge Protection	1N3009A (130V.) Zener Diodes	184A617H12
VR3	Voltage Regulator	1N2813B (15V.)	184A854H11

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

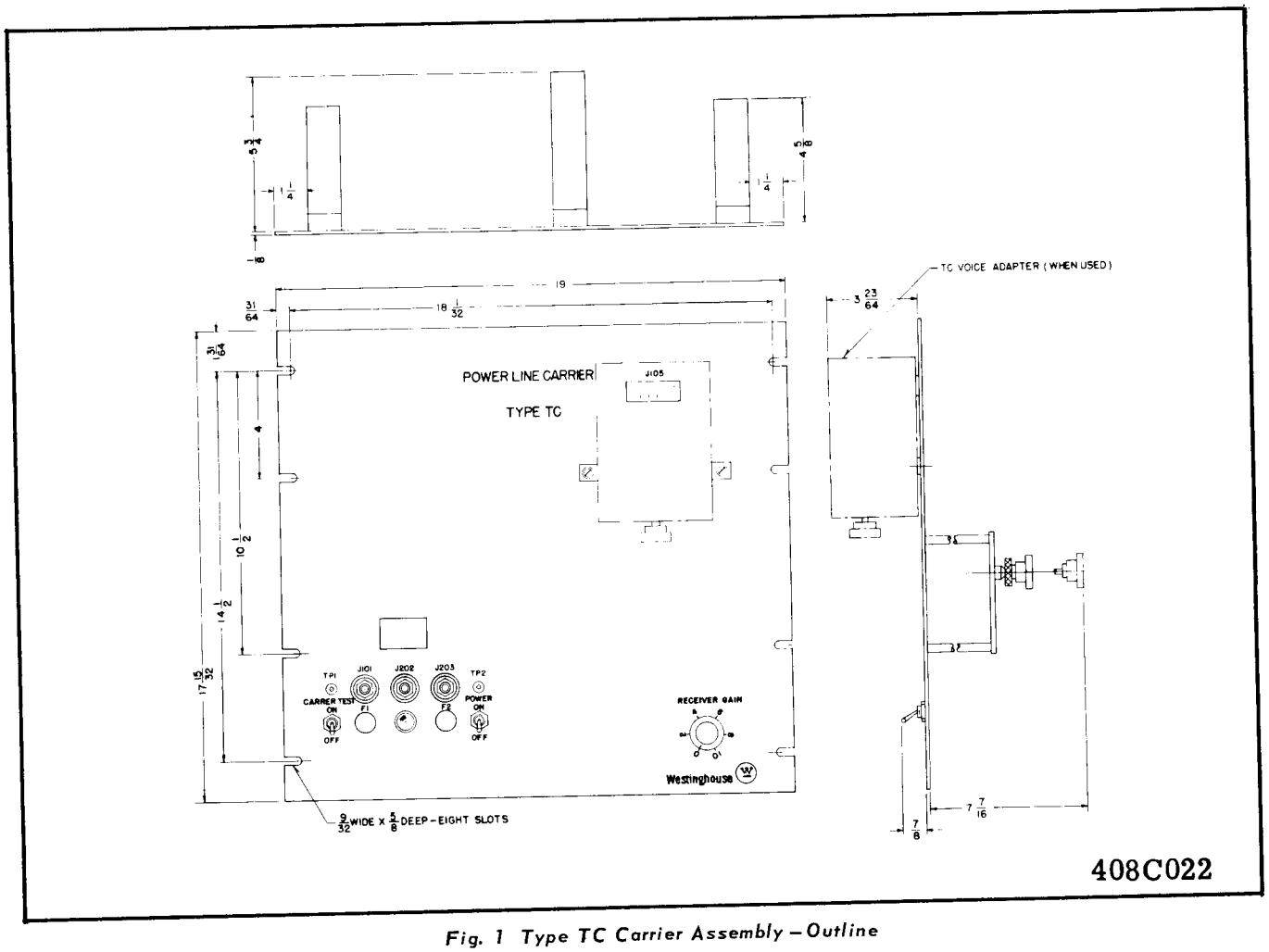


Fig. 1 Type TC Carrier Assembly – Outline

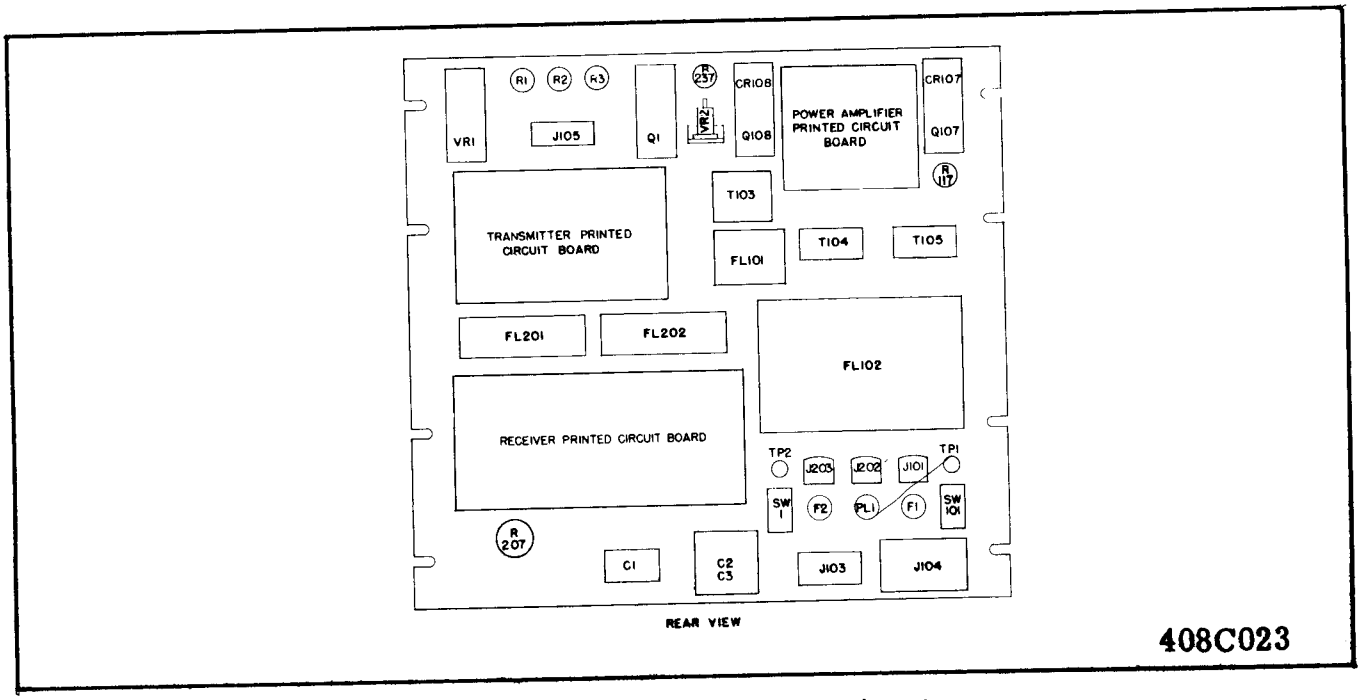


Fig. 2 Type TC Carrier Assembly – Parts Location

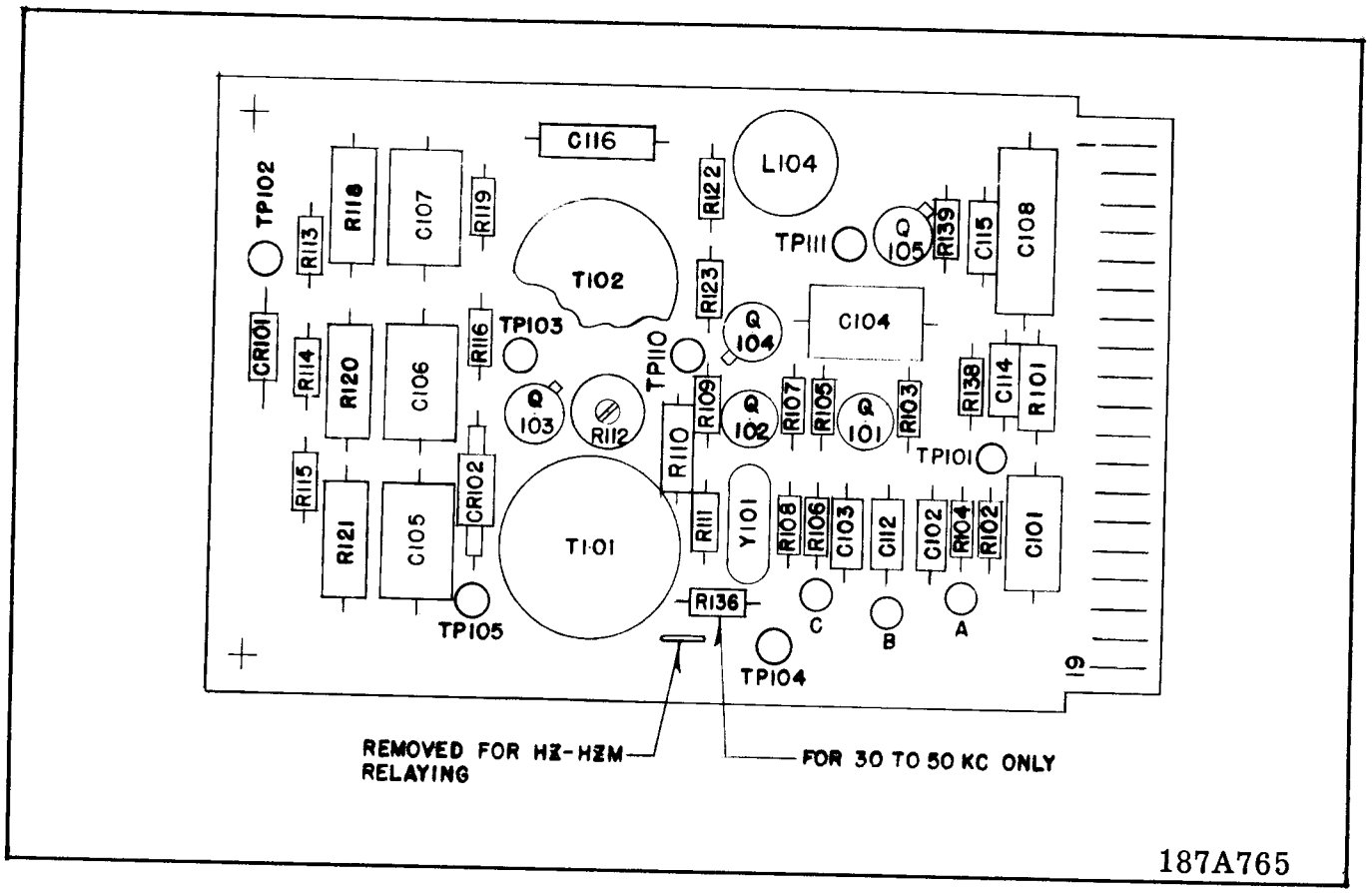


Fig. 3 Transmitter Printed Circuit – Parts Location

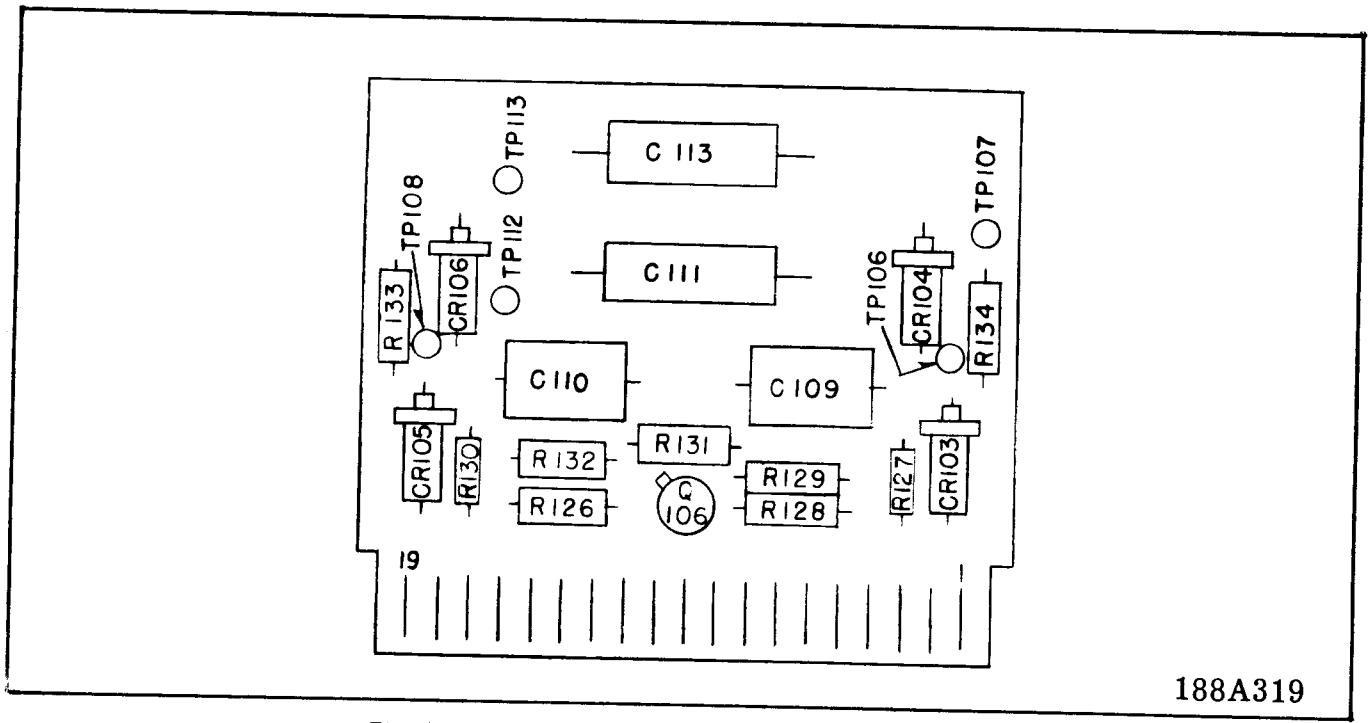


Fig. 4 Power Amplifier Printed Circuit – Parts Location

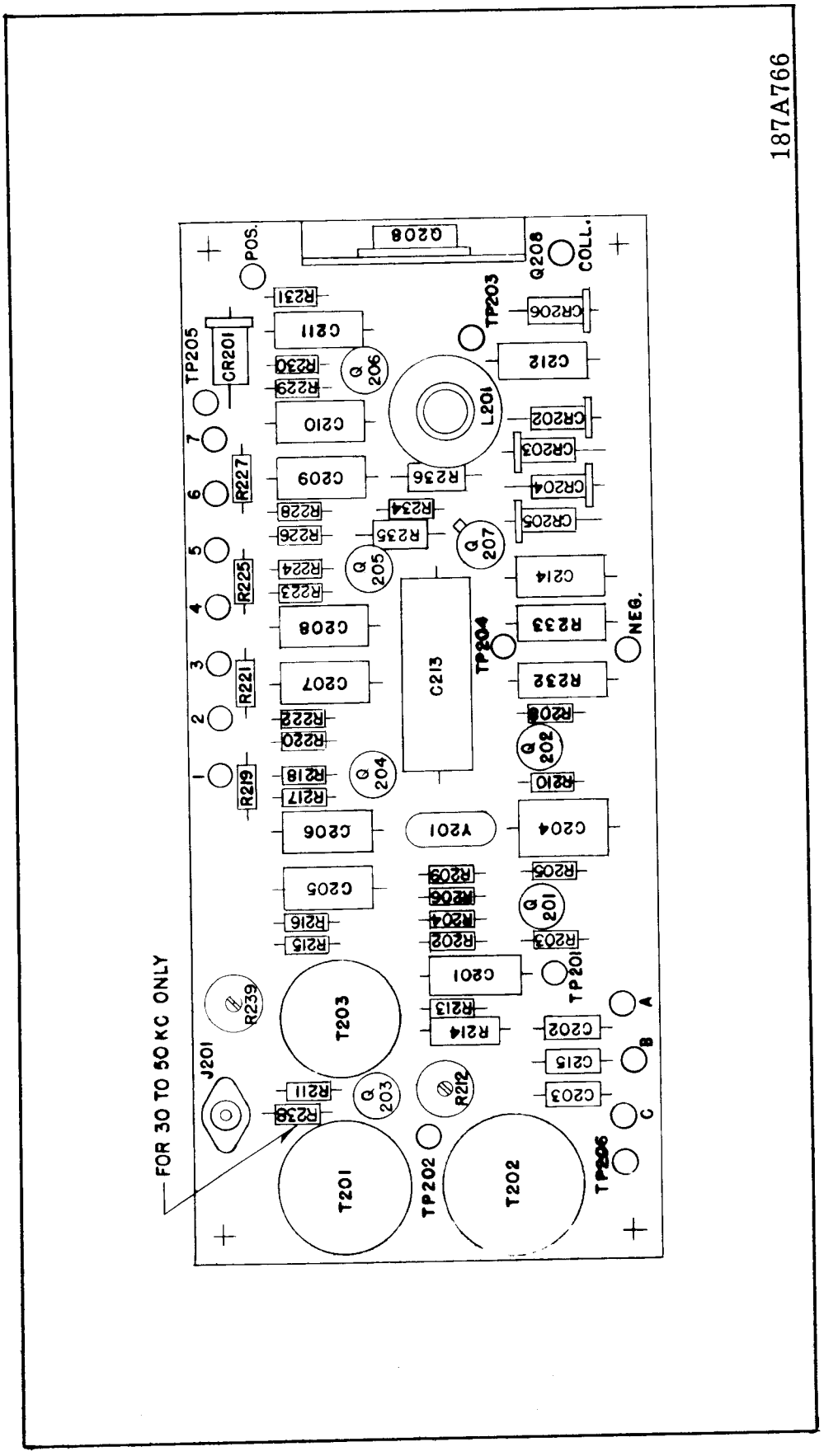


Fig. 5 Receiver Printed Circuit – Parts Location

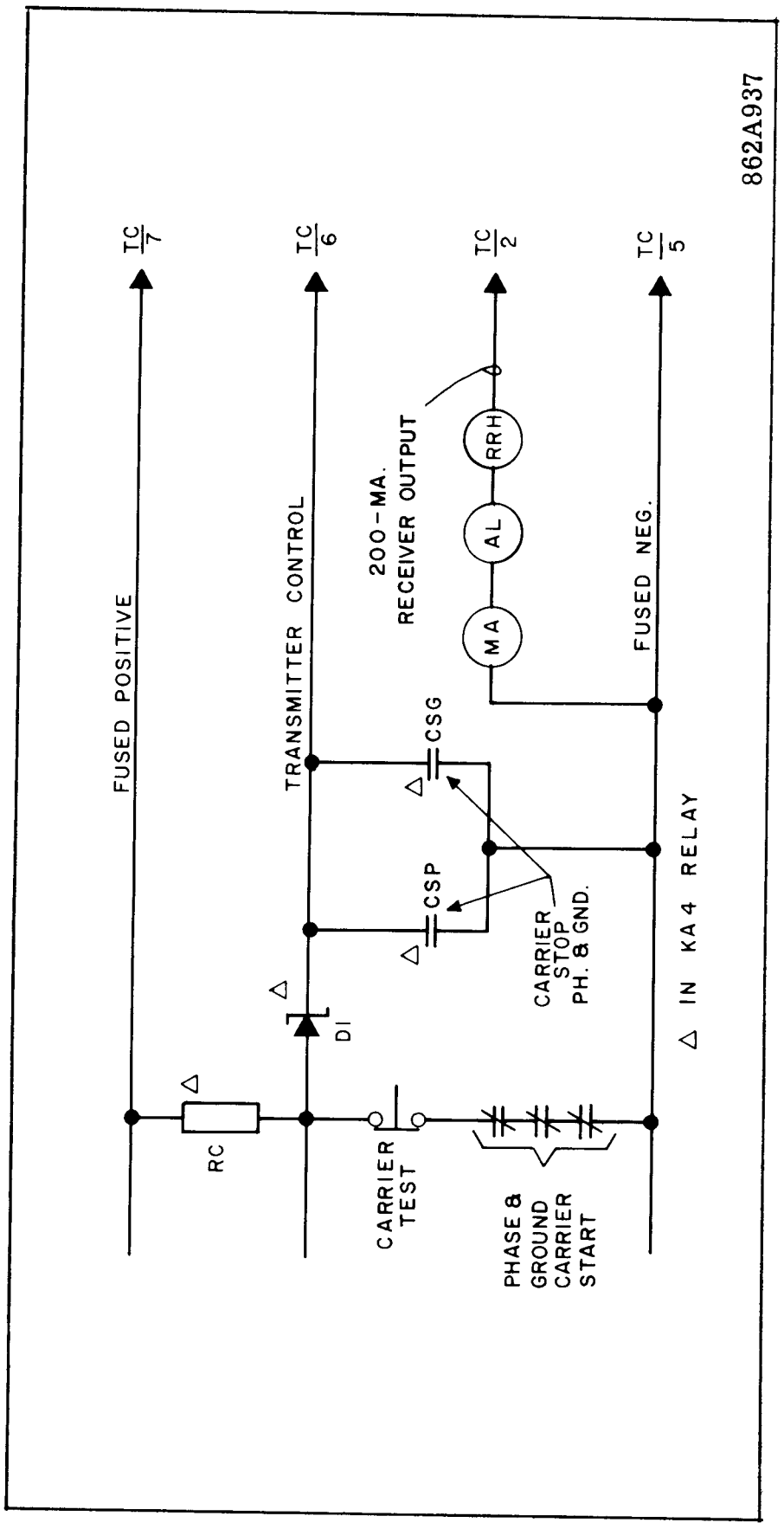
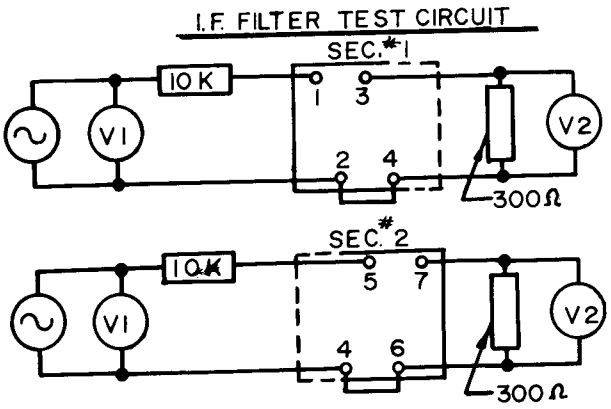
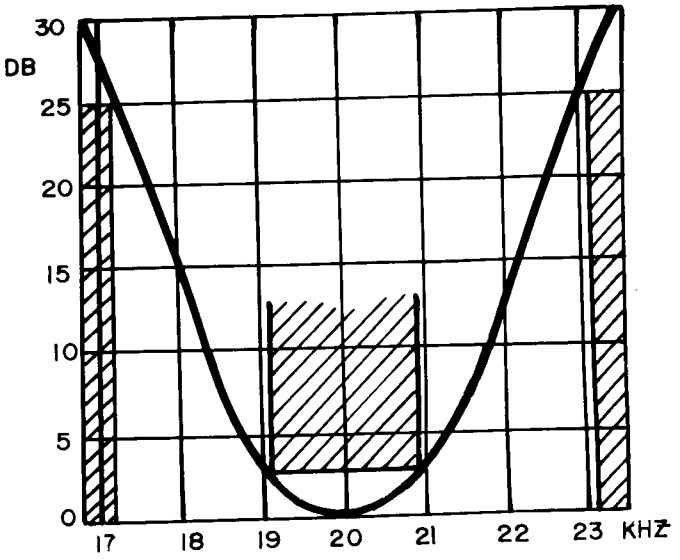
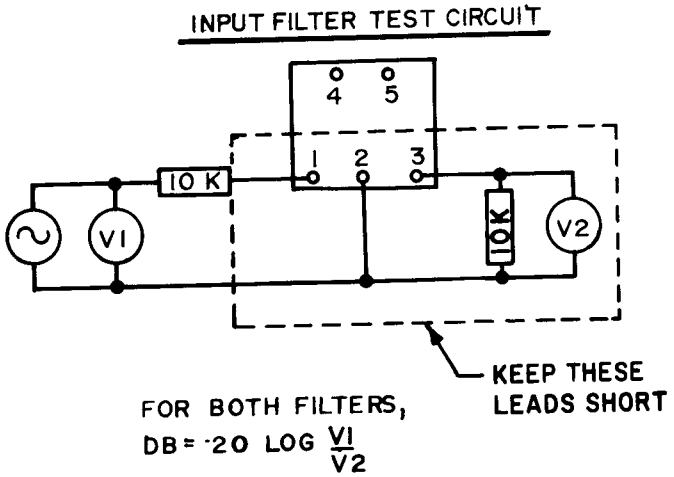


Fig. 6 Elementary K-Dar Carrier Control Circuits.

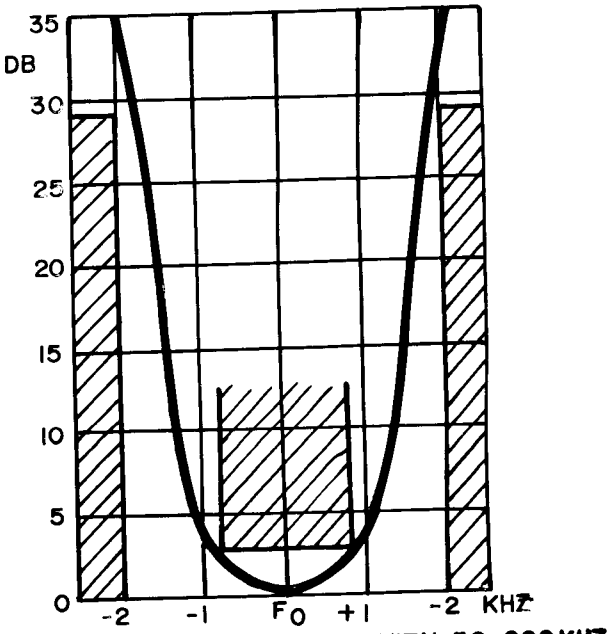




TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.



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



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

TC RECEIVER FILTER LIMITS

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

629A42

* *Fig. 8 Type TC Receiver Filter Characteristics*

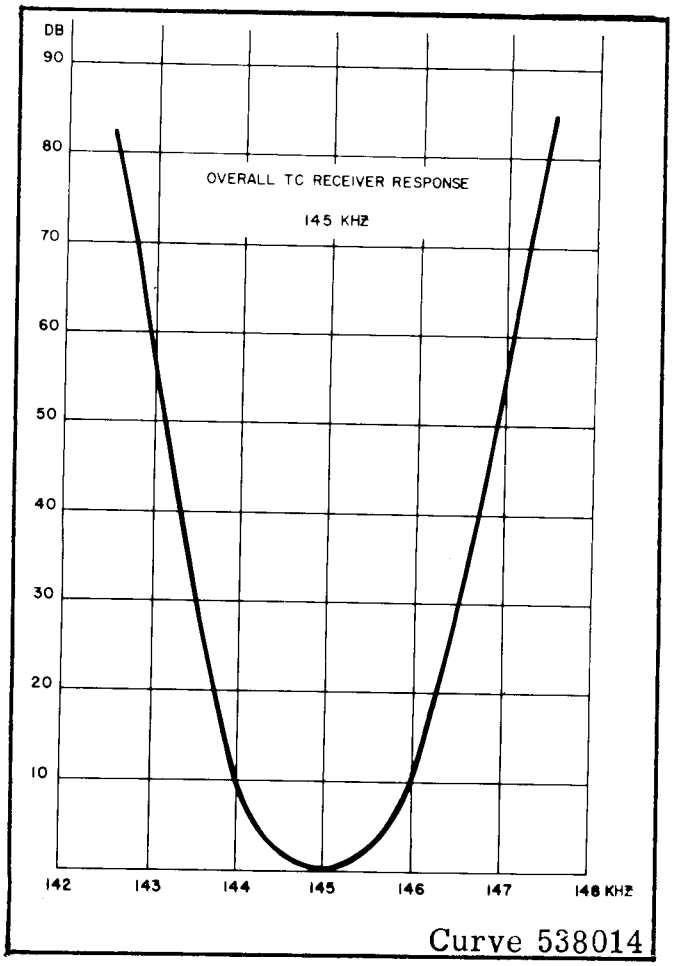


Fig. 9 Type TC Receiver Overall Selectivity Curve

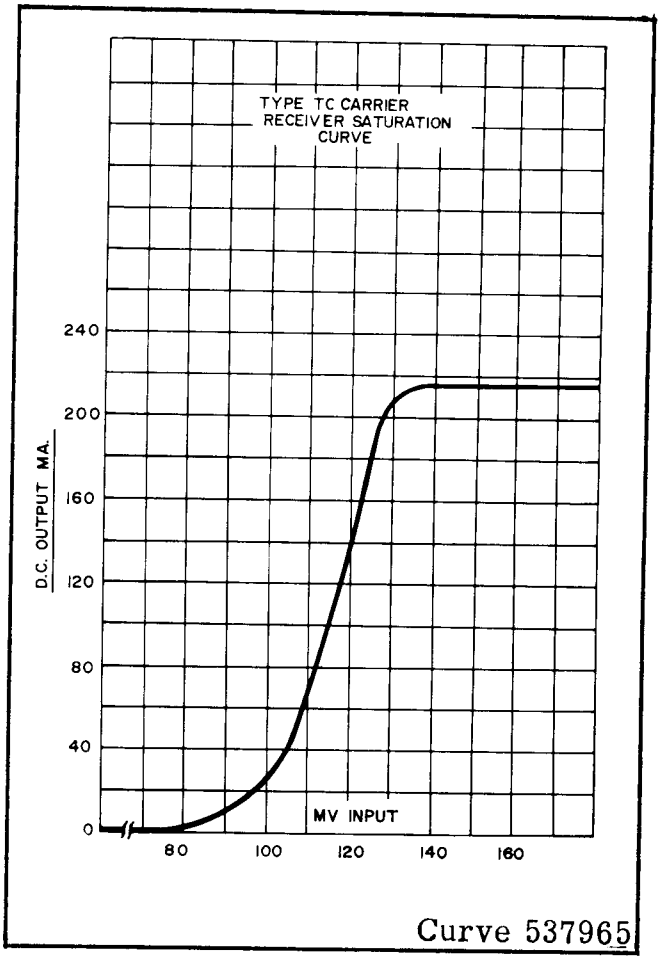
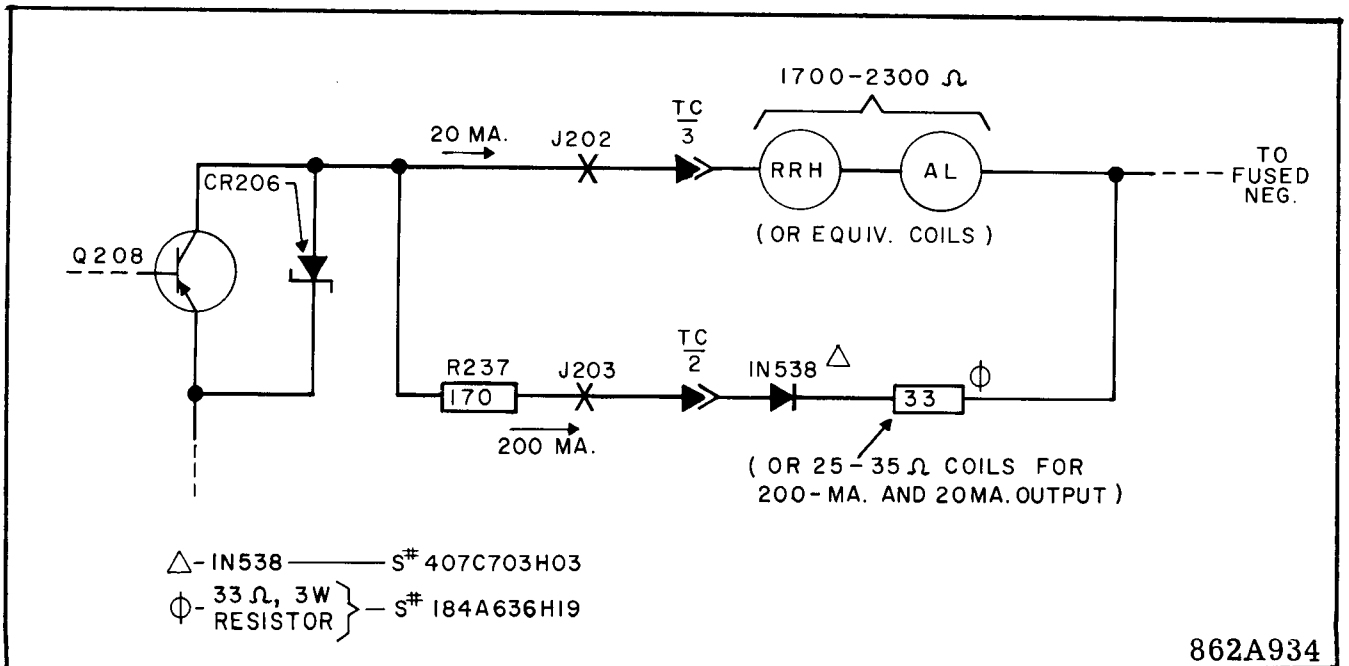


Fig. 10 Type TC Receiver – 200 ma. Output Characteristic.



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

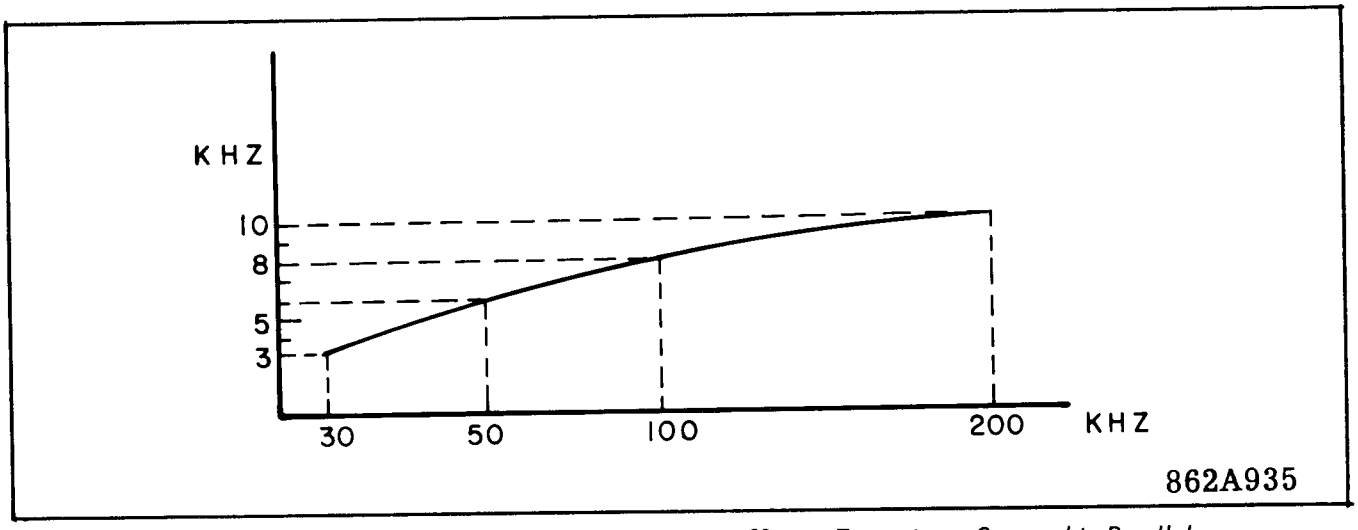


Fig. 12 Minimum Frequency Spacing For Two 10-watt Transmitters Operated in Parallel.

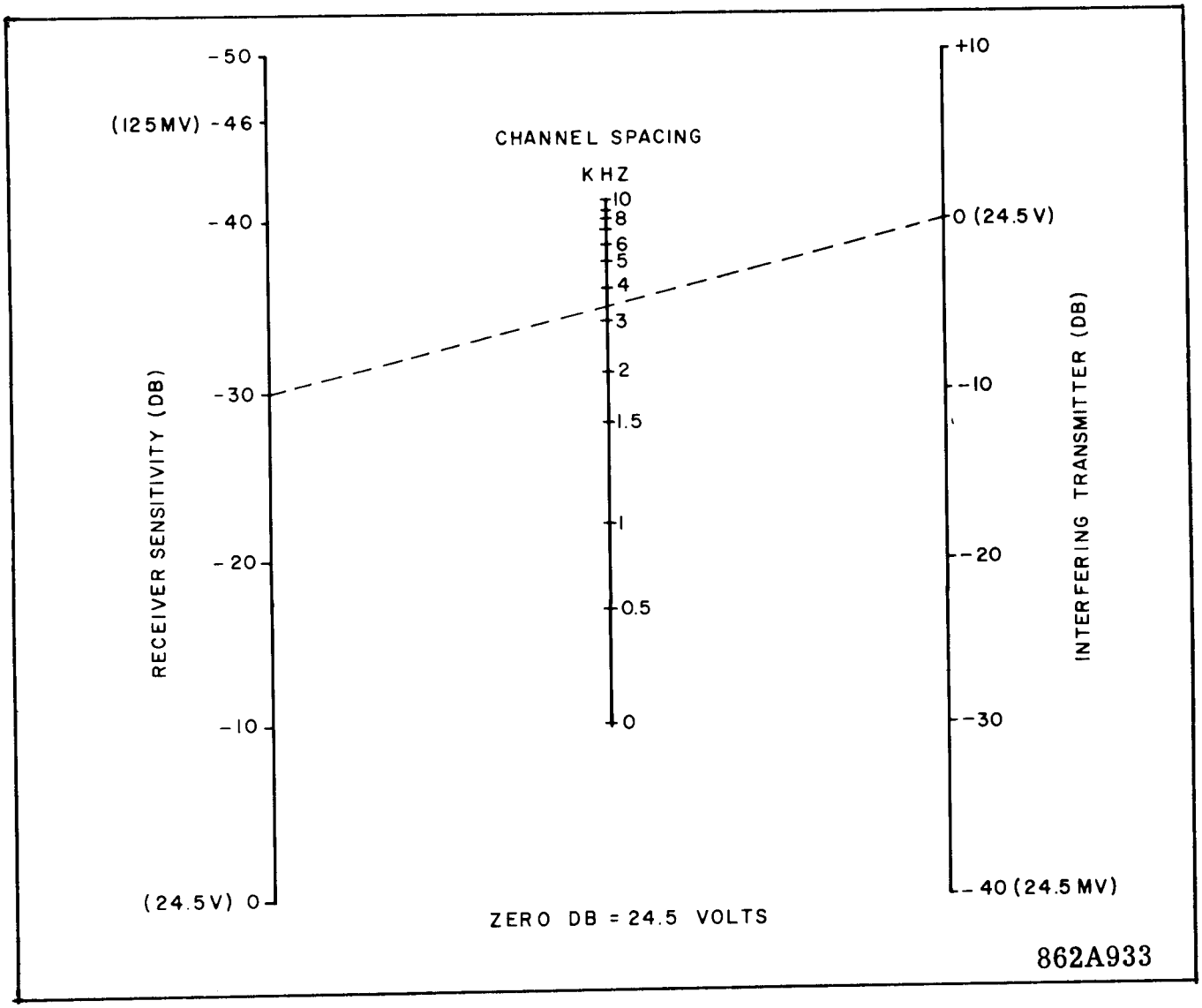


Fig. 13 Minimum Channel Spacing For Keyed Carrier 60 p.p.s.

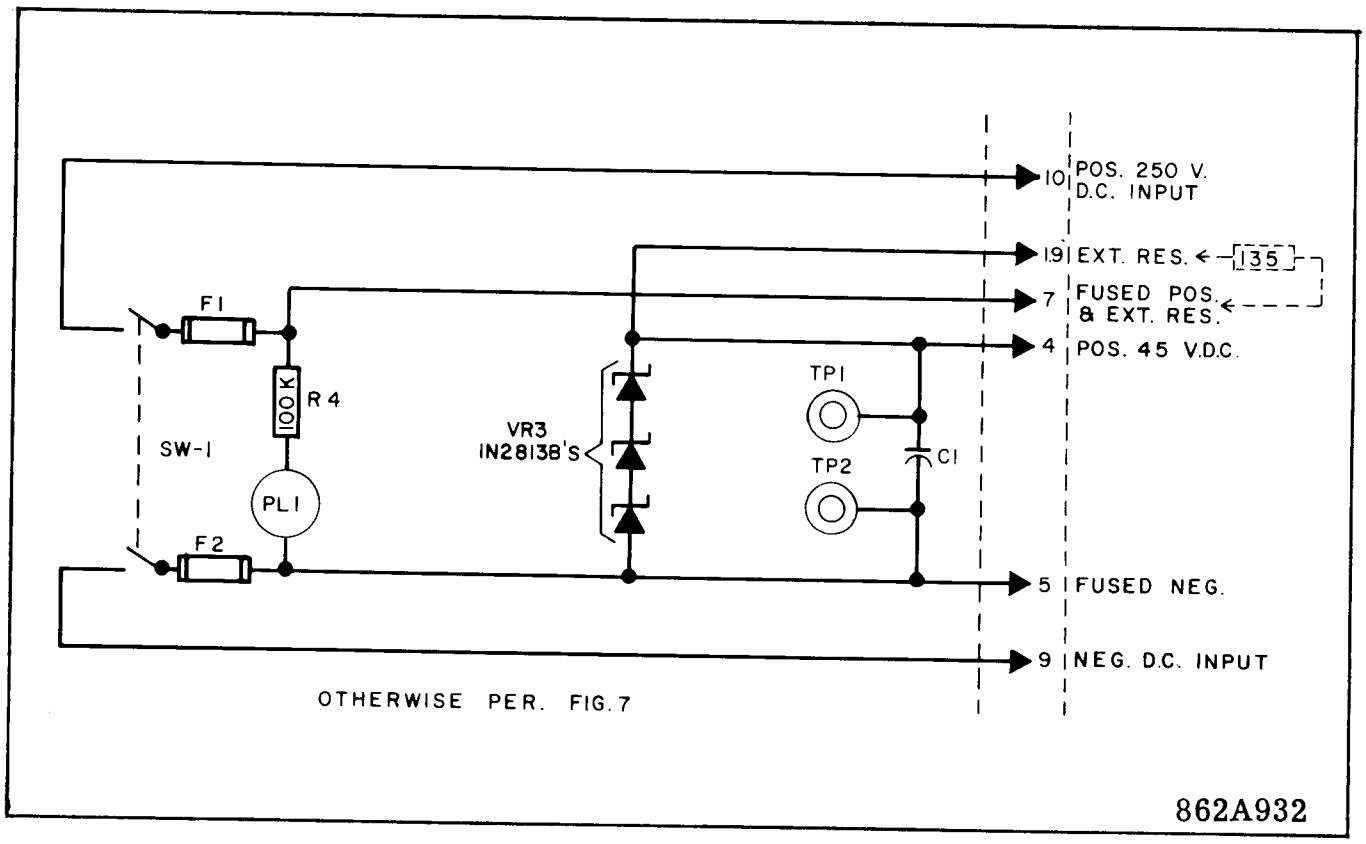


Fig. 14 Detail of Power Supply Section For 250-volt Supply

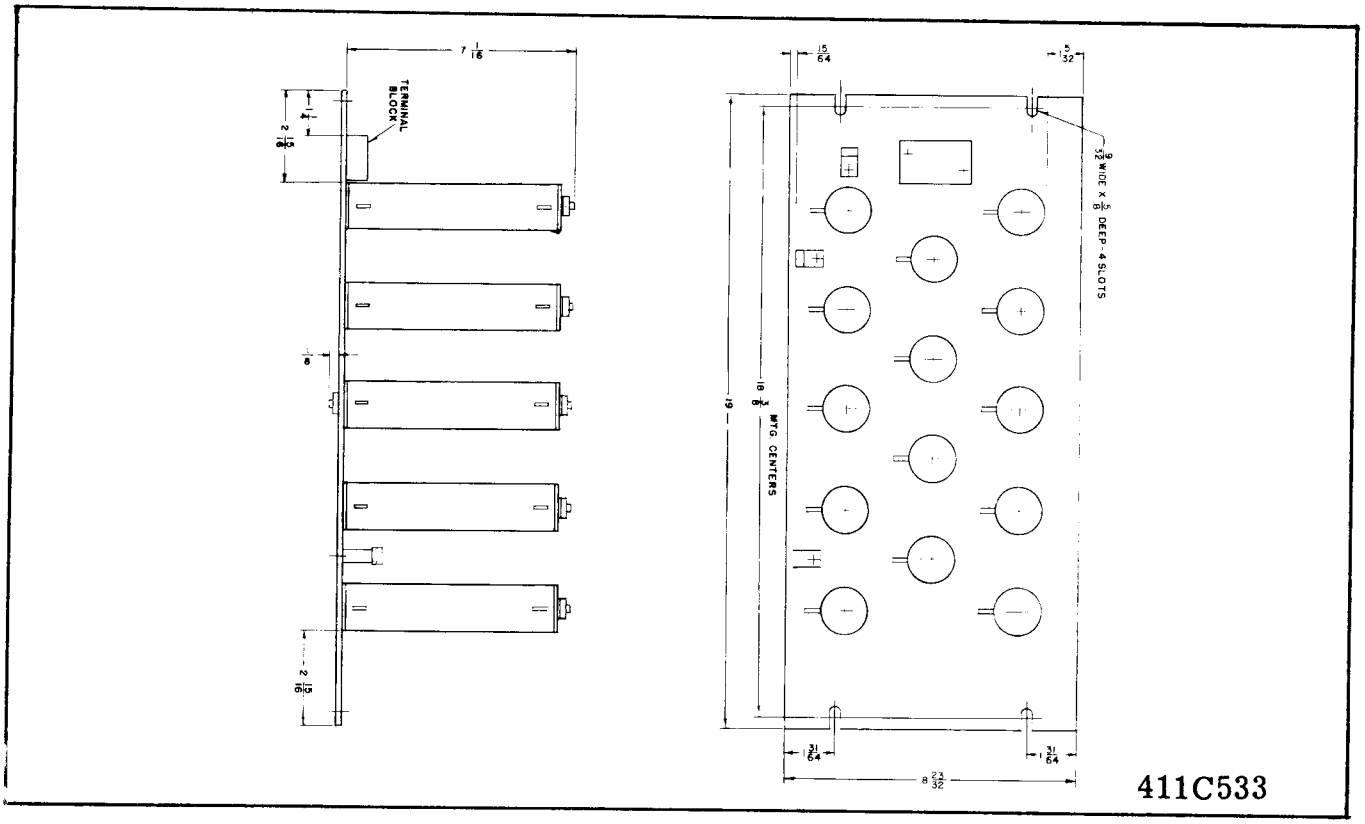


Fig. 15 Outline of External Resistor Unit For 250-volt Operation

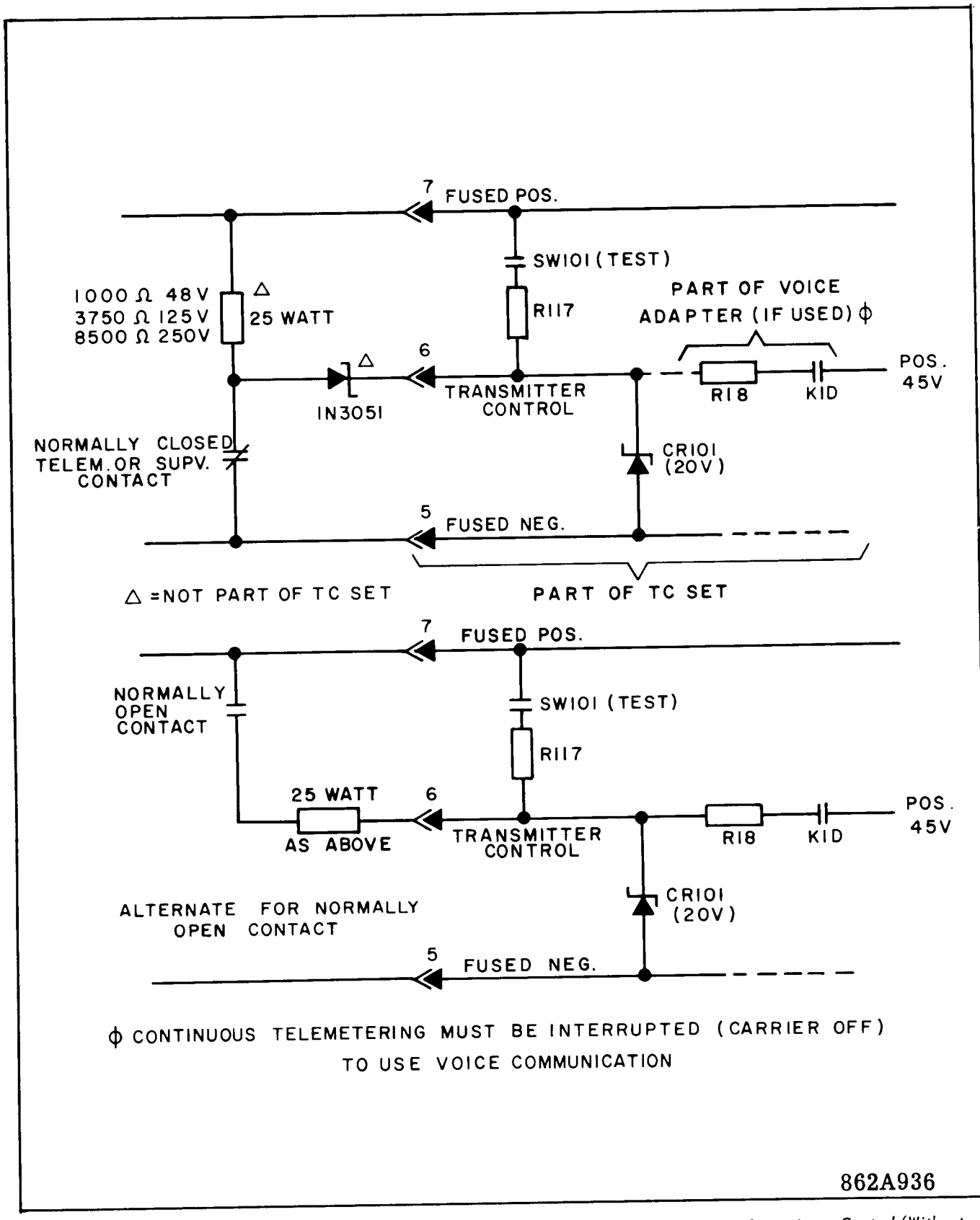


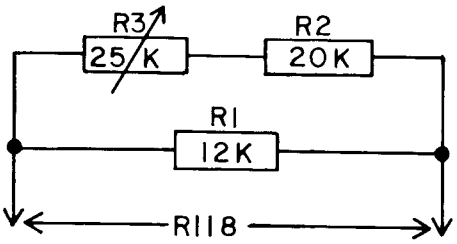
Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact

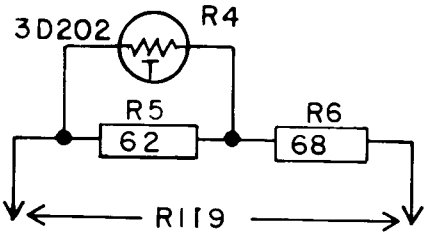
ADDENDUM

Temperature Compensation on Transistors Q104 and Q105

In late 1968, the base bias circuit of transistors Q104 and Q105 on the transmitter board was modified to provide more stable operation at high ambient temperature and provide an adjustment for the base-emitter bias voltage on these transistors.

As shown in Fig. 7, this bias was initially supplied by resistors R118 and R119. In place of these two resistors, the circuits shown below were supplied.





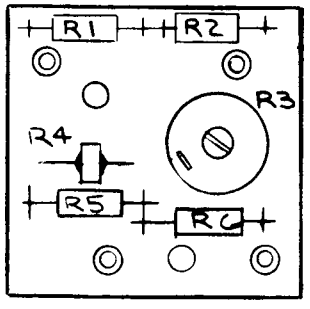
* The added components are mounted on a small board which in turn is mounted on the transmitter as shown below. At the same time, the Sensistor R110 was removed from the transmitter output control circuit (Q103 stage).

Symbol	Description	Style No.
R1	Resistor 12K, ½W 2%	629A531H58
R2	Resistor 20K, ½W 2%	629A531H63
R3	Potentiometer 25K	584C276H23
R4	Thermistor (3D202)	185A211H06
R5	Resistor 62, ½W 2%	629A531H03
R6	Resistor 68, ½W 2%	629A531H04

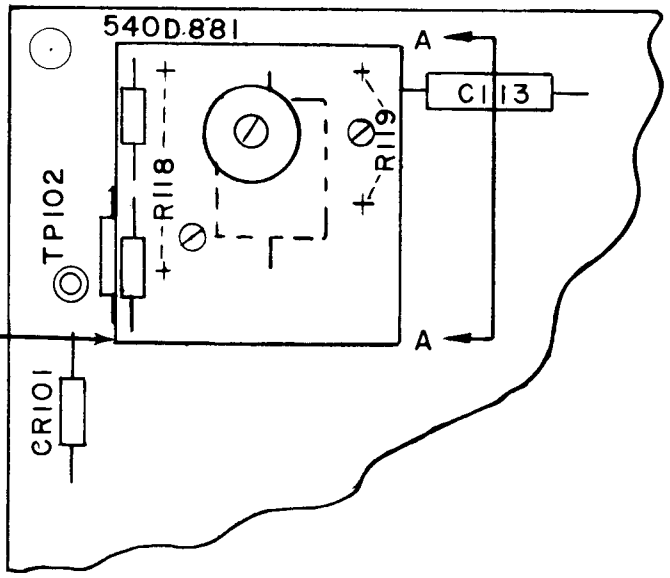
Adjustment of R3 on Auxiliary Circuit Board

The small control R3 is factory adjusted for a quiescent current of 0.2 ± 0.05 ma, and need not be changed unless transistors Q104 or Q105 (or both) are replaced. However, if these transistors are changed, or if the R3 setting is disturbed in error, the following adjustment procedure should be followed to reset R3 before setting the transmitter output with R112.

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 (R3) 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.



AUX. CKT. BD
ASSEM. S*876A574G01



Ref. 876A571
876A746

PARTIAL VIEW OF TRANSMITTER CIRCUIT BOARD

Extension of Frequency Range

The range of the type TC carrier set has been extended to cover 30 to 300kHz. For this range, the following style numbers apply:

Transmitter circuit-board assembly
S# 5482D10G01

Receiver circuit-board assembly
30 – 50kHz. – S# 540D876G01
50.5–300kHz. – S# 540D876G02

Initially, the receiver board for 200–300kHz. was S# 5482D24G01, but this was superseded by S# 540D876G02 early in 1971 by modifying the latter assembly to operate up to 300kHz.

Component Changes

In 1972 the type 2N274 germanium transistors were replaced with a silicon equivalent. In addition, a few related changes were made. Starting in August 1972, type TC carrier sets were made with the following component changes:

* **Transmitter circuit board:**

Component	Changed From	To	Style No.
Q101, 102	2N274	2N2905A	762A672H10
Q104, 105	2N657	2N2726, 2N3712	762A672H07
CR101	1N3686B	1N5357B	862A288H03

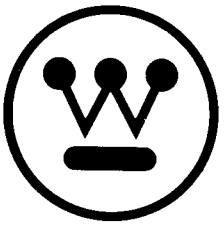
* **Receiver Circuit board:**

Component	Changed From	To	Style No.
Q201 to Q206	2N274	2N2905A	762A672H10
Q207	2N398A	2N3645	849A441H01
Q208	2N1362	2N4903	187A673H13
CR201	1M20Z10	1N3027B	188A302H07
CR202, 203	1N91	1N457A	184A855H07
CR204, 205	1N538	1N4818	188A342H06
R230	Changed from 62 ohms (nominal) to a 10-ohm, ½ watt resistor, style 187A290H01 in series with a 50-ohm ¼-watt Sensistor, style 187A685H08.		

Typical voltage values as listed in this I.L. are essentially unchanged with the new components.

NOTE: With the type 2N2905A transistor in the receiver mixer stage, set the level of the local oscillator output at TP202-206 to 0.5 volt rms. (instead of 0.3 volt).

* With the foregoing changes, the characteristics, operation, adjustment, and performance of the TC assembly are as described in this instruction leaflet.



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

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

SUPERSEDES I.L. 41-944.31E

*Denotes change from superseded issue.

EFFECTIVE DECEMBER 1972

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 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	30-200 kHz (50-200 kHz for phase comparison relaying)
Transmitter output	10 watts into 50 to 70-ohm resistive load
Harmonics	55 db below 10 watts
Receiver sensitivity	125 mv. input for 180 ma. minimum output current
Receiver selectivity	1500 Hz bandwidth (3 db down); down 80 db at ±3kHz.
Transmitter-receiver channel rating	40 db
Input voltage	48, 125, or 250 V. d-c
Supply voltage variation	42-56 V, 105-140V, 210-280 V
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 frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the −30 db point on the receiver sensitivity scale and the zero-db point on the interfering transmitter scale. The resulting line crosses the channel spacing scale between 3 and 4 kHz. For this example, a channel spacing of at least 4 kHz should be used. (In order not to conflict with the limits of Fig. 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 chassis must not exceed 60°C.

ADJUSTMENTS

* Transmitter ‡

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

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

1. First, measure the normal received signal from

* ‡ First, see Addendum, pp. 28-29.

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

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

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

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

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

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 Tables I through IV. Voltages should be measured with a VTVM. Readings may vary as much as ± 20%.

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. R110 Sensistor (When Used)

   a. 30-60 kHz – 2200 ohms – S# 187A685H01
   b. 60.5-120 kHz – 1800 ohms – S# 187A685H02
   c. 120.5-200 kHz – 1200 ohms – S# 187A685H03

3. Capacitors C111 and C113

   a. 30-50 kHz – 0.47 mfd. – S# 188A293H01
   b. 50.5-75 kHz – 0.22 mfd. – S# 188A293H02
   c. 75.5-100 kHz – 0.15 mfd. – S# 188A293H03
   d. 100.5-150 kHz – 0.10 mfd. – S# 188A293H04
   e. 150.5-200 kHz – 0.047 mfd. – S# 188A293H05

4. FL101 and FL102

   Filter FL101 is a small series-resonant tuned circuit between the driver and power amplifier

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

Inductors L101, L102, and L103 in these filters are adjustable over a limited range, but thirty-two combinations of capacitors and inductors are required to cover the frequency range of 30 kHz to 200 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 12 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5
32.0-33.5	64.5- 68.0	120.0-127.0
34.0-36.0	68.5- 72.0	127.5-135.0
36.5-38.5	72.5- 76.0	135.5-143.0
39.0-41.0	76.5- 80.0	143.5-151.0
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	

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. 45 V. (TP206)

Test Point	Standby (No Signal)			With 125 M.V. Input		
TP201	38			38		
TP202	0			0		
TP203	11.			11.		
TP204	.03			2.2		
TP205	20			20		
Transistor	E*	B*	C*	E*	B*	C*
Q201	38.5	37	43	38.5	37	43
Q202	38.5	37.5	43.5	38.5	37.5	43.5
Q203	0.08	0	18.7	0.08	0	18.7
Q204	2.7	2.9	18.7	2.7	2.9	18.7
Q205	2.4	2.6	18.7	2.5	2.7	18.7
Q206	2.5	2.7	10.5	2.6	2.8	10.5
Q207	0.13	0.03	22.0	2.0	2.2	4.0
Q208	0.25	0.15	45.0	1.7	2.0	2.0

*E – Emitter, B – Base, C – Collector

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

TABLE II

Receiver RF Measurements

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

Test Point	Typical A-C Voltages		Test Point	Typical A-C Voltages	
	36 kHz	132 kHz		36 kHz	132 kHz
FL201-IN to Gnd.	.075	.050	Q205-B to TP206	.11	.052
FL201-OUT to Gnd.	.051	.020	Q205-C to TP206	6.7	3.4
Q203 -E to TP206	.105	.090	Q206-B to TP206	.67	.37
Q203 -C to TP206	.22	.035	Q206-C to TP206	1.5	1.53
Q204 -B to TP206	.015	.012	TP202 to TP206	0.3	0.3
Q204 -C to TP206	.90	.52			

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

TABLE III

Transmitter D-C Measurements

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

Test Point	Carrier Off	Carrier On
TP101	7 volts d.c.	7 volts d.c.
TP102	0	20
TP103	0	19.5
TP105	0	9
TP106	44	22
TP107	44	22.2
TP108	45	44.8
TP110	.5	.6
TP111	.5	.6
TP112	0	0
TP113	45	45
J101 (Front Panel)	5 ma. max.	0.6 amp.

Transistor	E	B	C	E	B	C
Q101	6.0	7.8	2.5	6.1	7.7	2.5
Q102	6.6	7.1	1.2	6.6	7.1	1.1
Q103	0	0	0	19.5	19.4	9.0
Q104	0.1	0.1	45	0.5	0.9	45
Q105	0.1	0.1	45	0.5	0.9	45
Q106	0	0	44	0	0.9	1.2
Q107	43.7	43.7	0	22.2	22.2	0
Q108	45.0	44.7	44.7	44.8	44.8	22.3

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. Resistors R218, R224, and R230 may have to be reduced. See following paragraph.

   The emitter resistors R218, R224, and R230 of the i-f stages are selected during factory test to give the required receiver gain. This is desirable since the insertion loss of the input filter FL201 increases with frequency. If the operating frequency is reduced, the receiver gain will probably be higher. In this case, a reduction in the setting of the i-f input control R239 will give the 125-mv. sensitivity. If the new operating frequency is higher, the receiver gain will be lower. If more than 125 mv. is required to obtain 180 ma. output, the gain can be increased by reducing the value of one or more of the resistors R218, R224, and R230. In most cases, these resistors should fall in the range of 22 to 150 ohms. These three resistors are soldered to small terminal posts on the printed circuit board.

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 230 kHz, input impedance—one megohm, minimum.

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	Test Point	A-C Voltage
T101-3 to TP104	1.1 volts, rms.	Q107-B to TP107	.5 volts, rms.
TP103 to TP102	0.2	Q108-B to TP113	.5
Q103-C to TP104	0.7	Q107-C to TP107	14.5
TP110 to T102-4	0.2	Q108-C to TP113	14.5
TP111 to T102-4	0.2	T105-4 to Gnd.	105
Q104-C to TP104	4.3	T106-2 to Gnd.	155*
Q105-C to TP104	4.3		
T103-4 to Gnd.	1.5	TP109 to Gnd.	50*
T104-1 to Gnd.	1.4	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

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 230kHz

c. Oscilloscope

d. Ohmmeter

e. Capacitor checker

f. Frequency counter

g. Frequency-selective voltmeter

Renewal Parts

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

ELECTRICAL PARTS LIST

Transmitter Section

Symbol	Rating	Style Number
C101	0.1 mfd, 200 V. DC	187A624H01
C102	.005 mfd, 300 V. DC	187A694H29
C103	180 pf. 500 V. DC	187A695H29
C104	0.25 mfd, 200 V. DC	187A624H02
C105	0.25 mfd, 200 V. DC	187A624H02
C106	0.25 mfd, 200 V. DC	187A624H02
C107	0.25 mfd, 200 V. DC	187A624H02
C108	0.50 mfd, 200 V. DC	187A624H03
C109	0.25 mfd, 200 V. DC	187A624H02
C110	0.25 mfd, 200 V. DC	187A624H02
† C111	(See Table Below)	—
C112	39 pfd, 500 V. DC	187A695H12
† C113	(See Table Below)	—
C114	100 pf., 500 V. DC	187A695H23
C115	100 pf., 500 V. DC	187A695H23
C116	0.001 mfd, 500 V. DC	187A694H11
CA	Part of FL101	Vary with Frequency
CB	Part of FL102	Vary with Frequency
CC		
CD		
CE		

† 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
75.5-100 kHz	0.15 mfd, 400 V. DC	188A293H03
100.5-150 kHz	0.1 mfd, 400 V. DC	188A293H04
150.5-200 kHz	0.047 mfd, 400 V. DC	188A293H05

CR101	1N3686B (20 V ±5%)	185A212H06
CR102	1N457A	184A855H07
CR103	1N538	407C703H03
CR104	1N91	182A881H04
CR105	1N538	407C703H03
CR106	1N91	182A881H04
CR107	1N2999B (56 V + 5%)	629A798H04
CR108	1N2999B (56 V + 5%)	629A798H04
G101	Type RVS Arrester	632A026A01
J101	Closed Circuit Jack	187A606H01

ELECTRICAL PARTS LIST

Transmitter Section (Cont.)

Symbol	Rating	Style Number
J102	Banana Plug Jack	2 of 185A431H01
J103	Coaxial Cable Jack	187A633H01
J104	24-Term Receptacle	187A669H01
J105	12-Term Receptacle	629A205H02
L101	Part of FL101	Vary with Frequency
L102	FL102 Trap Coil (2nd Harmonic)	
L103	FL102 Trap Coil (3rd Harmonic)	
L104	400 mh.	292B096G01
L105	FL102 Coil (part of series-resonant circuit tuned to fundamental freq.)	Vary with Frequency
Q101	2N274	187A270H01
Q102	2N274	187A270H01
Q103	2N525	184A638H13
Q104	2N657	184A638H15
Q105	2N657	184A638H15
Q106	TI-481	184A638H11
Q107	2N1908 Matched Pair - Texas Instrument	187A673H02
Q108	2N1908 Co. - Identif. GP2151	

Symbol	Ohms	± Tol. %	Watts	Style Number
R101	5,600	5	1	187A643H45
R102	2,200	10	0.5	187A641H35
R103	10,000	10	0.5	187A641H51
R104	100,000	5	0.5	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
R110 *				At End of List
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

Sensistor - (omitted with temp. comp. per p. 28).	30 - 60 kHz, 2.2 K ± 10%, ¼ watt	187A685H01
	60.5-120 kHz, 1.8 K ± 10%, ¼ watt	187A685H02
	120.5-200 kHz, 1.2 K ± 10%, ¼ watt	187A685H03

ELECTRICAL PARTS LIST
Transmitter Section (Cont.)

Symbol	Ohms	± Tol. %	Watts	Style Number
R116	100	5	0.5	184A763H03
R117	1,000 48 V dc	5	25	1202588
	3,750 125 V dc	5	25	1202955
	8,500 250 V dc	5	25	1267310
R118	8,200	5	2	185A207H49
R119	100	5	0.5	184A763H03
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	0.27	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
Symbol	Rating			Style Number
T101	10,000/400 ohms			205C043G01
T102	10,000/400 c.t.			205C043G04
T103	1930/60 ohms		L633000	1962694
T104	Turns ratio, 1/0.5,		Pri./each sec.	292B526G01
T105	10/500 ohms			292B526G02
T106	500/50-60-70 ohms			292B526G03
Y101	30-200 kHz crystal per 328C083			Specify Frequency

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
CR201	1N3027B (20V ± 5%)	184A449H07
CR202	1N91	182A881H04
CR203	1N91	182A881H04
CR204	1N538	407C703H03
CR205	1N538	407C703H03
CR206	1N1789 (56V. ± 10%)	584C434H08
FL201	Receiver Input Filter 30-200 kHz	Specify Frequency
FL202	Receiver i.f. Filter-20 kHz (2 Sections)	187A590G02
J201	Receiver Coax. Input Jack	187A638H01
J202	Closed Circuit Jack (20MA)	187A606H01
J203	Closed Circuit Jack (200MA)	187A606H01
L201	33 mh.	187A599H01
Q201	2N274	187A270H01
Q202	2N274	187A270H01
Q203	2N274	187A270H01
Q204	2N274	187A270H01
Q205	2N274	187A270H01
Q206	2N274	187A270H01
Q207	2N398A	184A638H12
Q208	2N1362	187A673H01

ELECTRICAL PARTS LIST
Receiver Section (Cont.)

Symbol	Rating			Style Number
Resistors	Ohms	± Tol. %	Watts	
R201	10,000	10	0.5	187A641H51
R202	2,200	10	0.5	187A641H35
R203	10,000	10	0.5	187A641H51
R204	100,000	5	0.5	184A763H75
R205	390	5	0.5	184A763H17
R206	1,200	5	0.5	184A763H29
R207	25 K Pot.	10	2	185A086H07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H75
R210	390	5	0.5	184A763H17
† R211	–	–	–	See † Note Below
R212	1 K Pot.	20	0.25	629A430H02
R213	1,200	5	0.5	184A763H29
R214	5,600	5	1	187A643H45
R215	20,000	5	0.5	184A763H58
R216	3,600	5	0.5	184A763H40
R217	620	5	0.5	184A763H22
R218	62	5	0.5	187A290H20
R219	10,000	10	0.5	187A641H51
R220	20,000	5	0.5	184A763H58
R221	300	5	0.5	184A763H14
R222	3,600	5	0.5	184A763H40
R223	620	5	0.5	184A763H22
R224	62	5	0.5	187A290H20
R225	10,000	10	0.5	187A641H51
R226	20,000	5	0.5	184A763H58
R227	300	5	0.5	184A763H14
R228	3,600	5	0.5	184A763H40
R229	620	5	0.5	184A763H22
R230	62	5	0.5	187A290H20
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 (continued)

Symbol	Ohms	Rating		Style Number
		± Tol. %	Watts	
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
T201	10,000/10,000 Ohms			714B677G01
T202	10,000/400 Ohms			205C043G01
T203	25,000/300 Ohms			205C043G03
Y201	50-220 kHz Crystal per 328C083			Specify Frequency

Power Supply Section

Symbol	Function	Description or Rating	Style Number
C1	(+) to (–) bypass	0.45 mfd. 330 VAC	1723408
C2	A-C grounding	0.5 mfd. 1500 VDC	1877962
C3	A-C grounding	0.5 mfd. 1500 VDC	1877962
F1, F2	Overload Protection	1.5a, 48/125 VDC	11D9195H26
F1, F2	Overload Protection	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	125V Series dropping	26.5 ohms, 3½''	04D1299H44
R2	125V Series dropping	Same as R1	04D1299H44
R3	125V Current limiting	500 ohms, 3½''	1268047
	48V For 48 VDC, R1 = R2 0	–	–
	48V R3 = 26.5 ohms	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	187A332H01
TP2	Test Point (–)	Pin Jack – black	187A332H02
VR1	Voltage Regulator	1N2828B (45V.)	184A854H06
VR2	Surge Protection	1N3009A (130V.) Zener Diodes	184A617H12
VR3	Voltage Regulator	1N2813B (15V.)	184A854H11

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

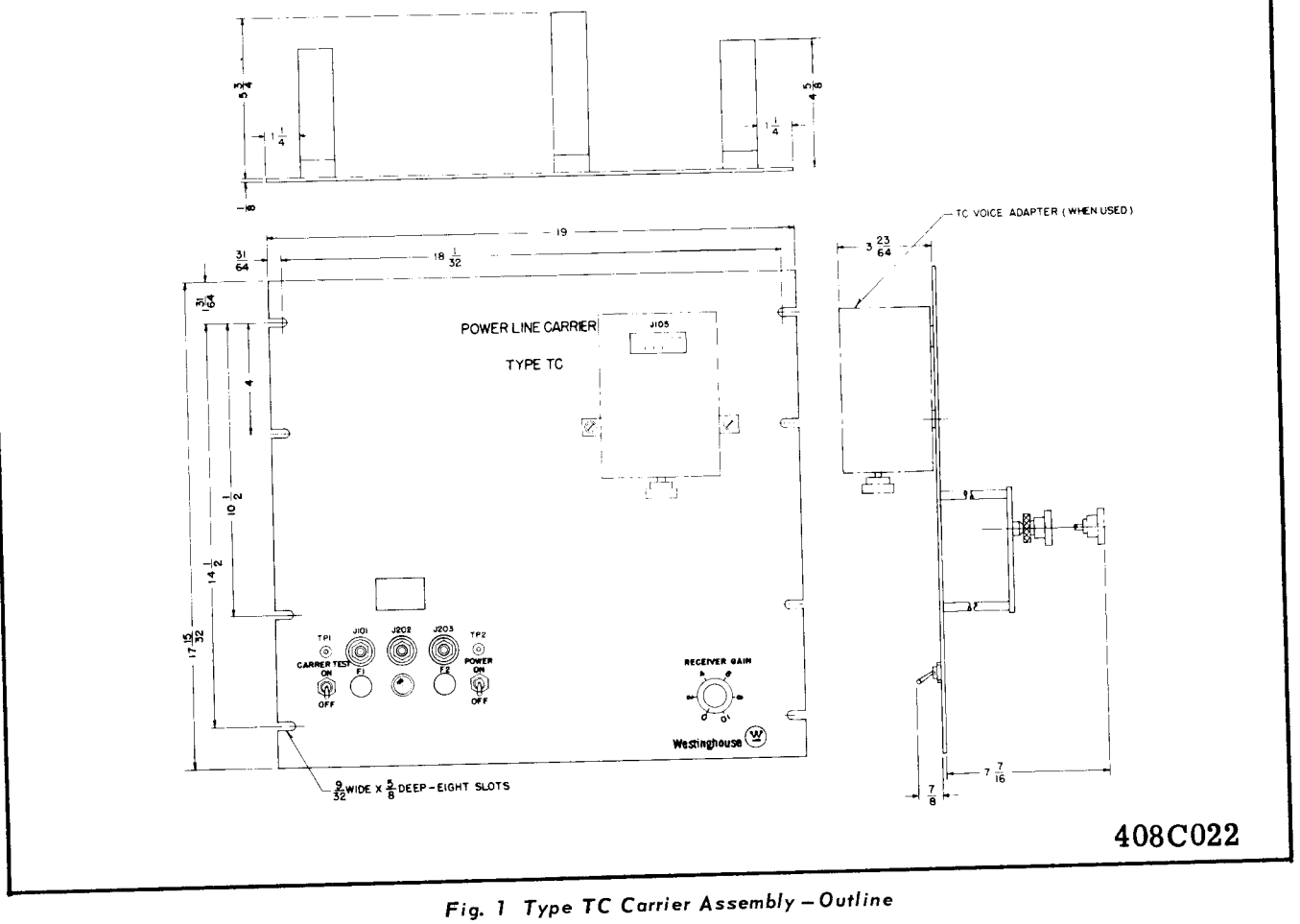


Fig. 1 Type TC Carrier Assembly – Outline

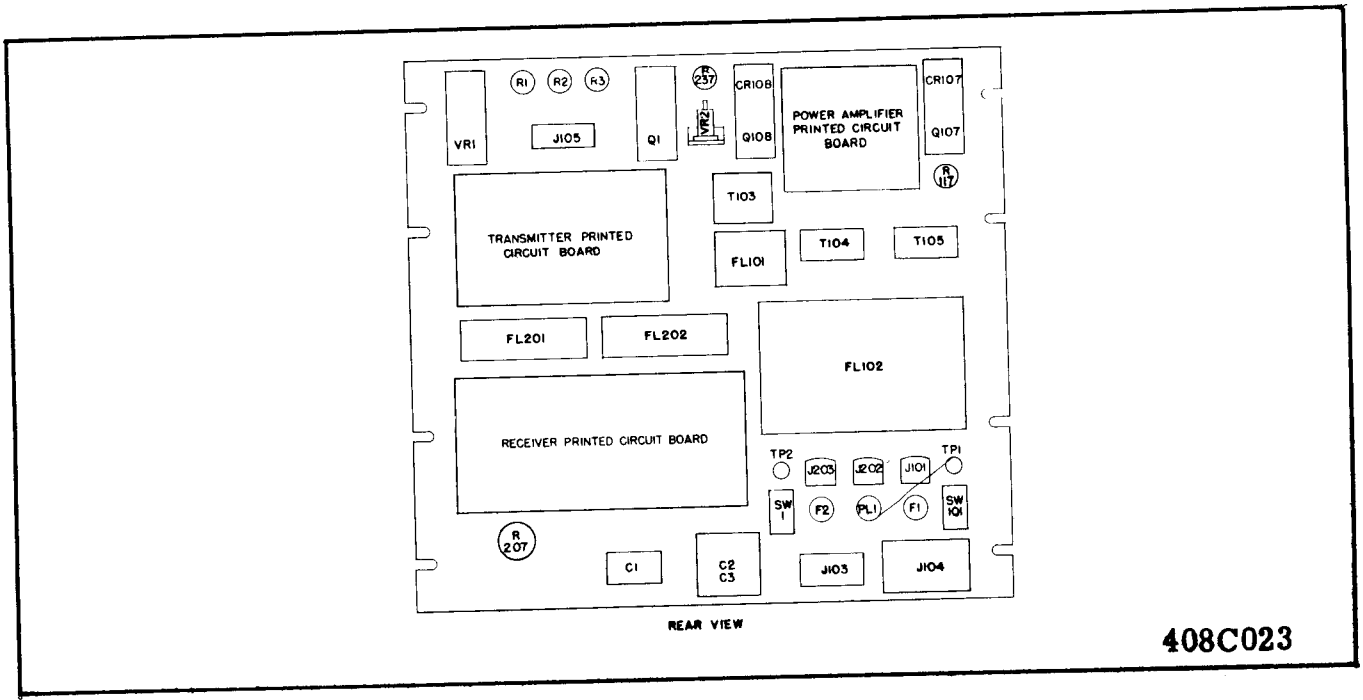


Fig. 2 Type TC Carrier Assembly – Parts Location

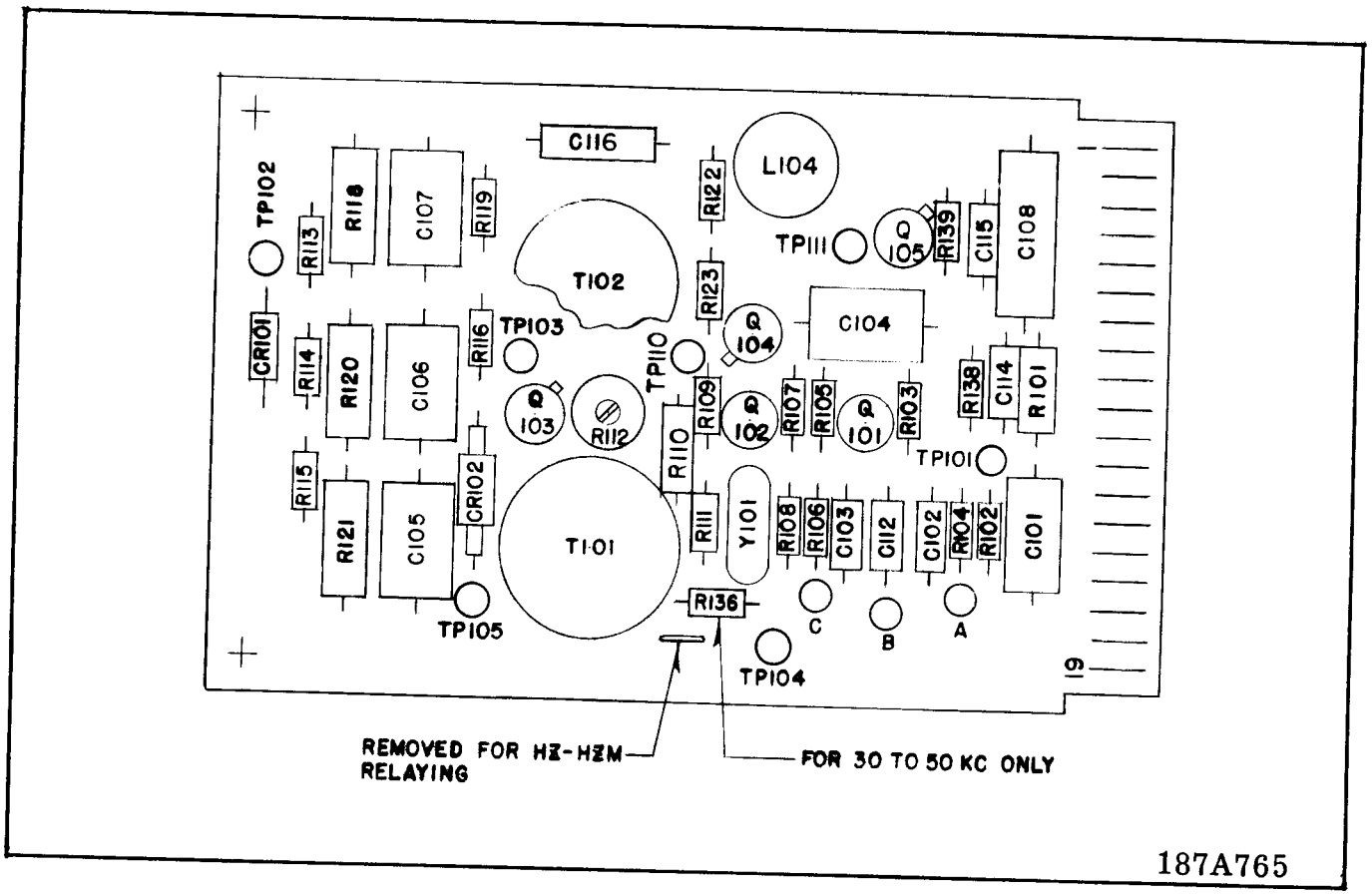


Fig. 3 Transmitter Printed Circuit – Parts Location

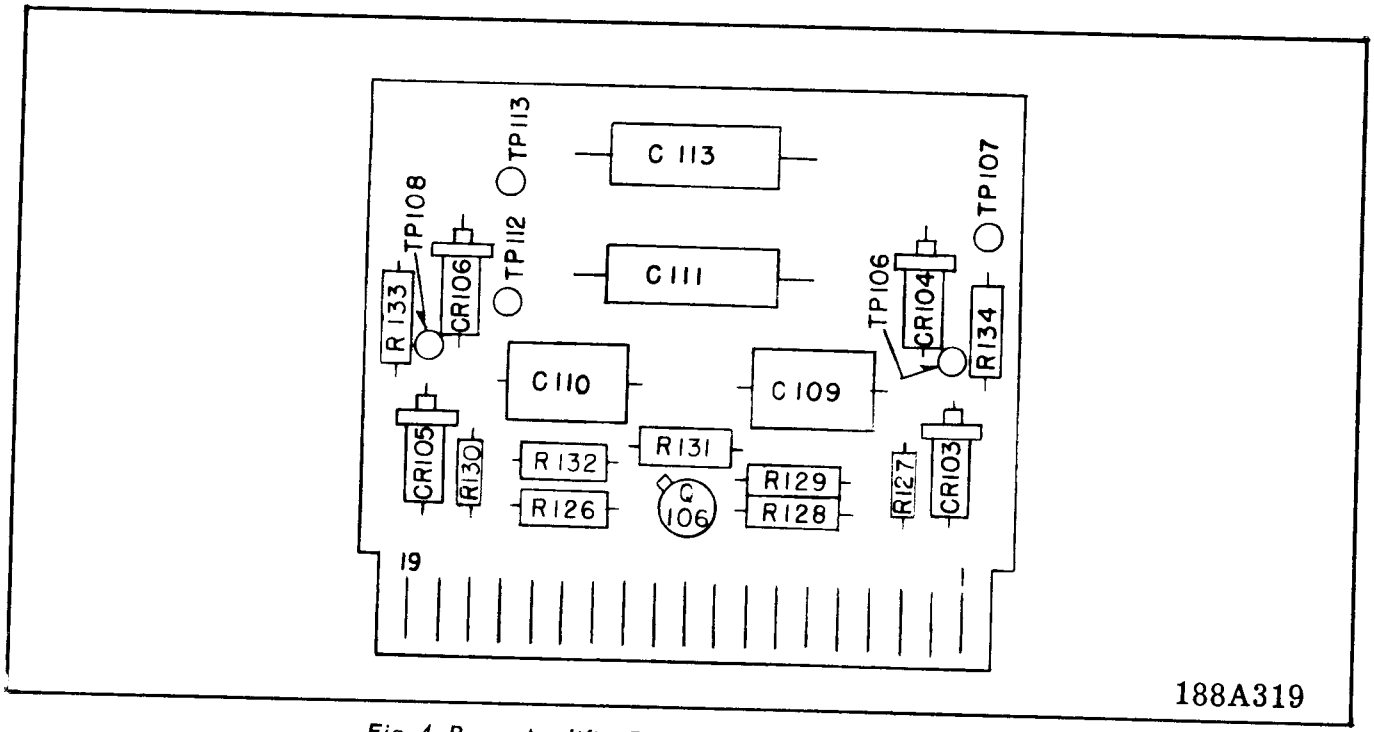


Fig. 4 Power Amplifier Printed Circuit – Parts Location

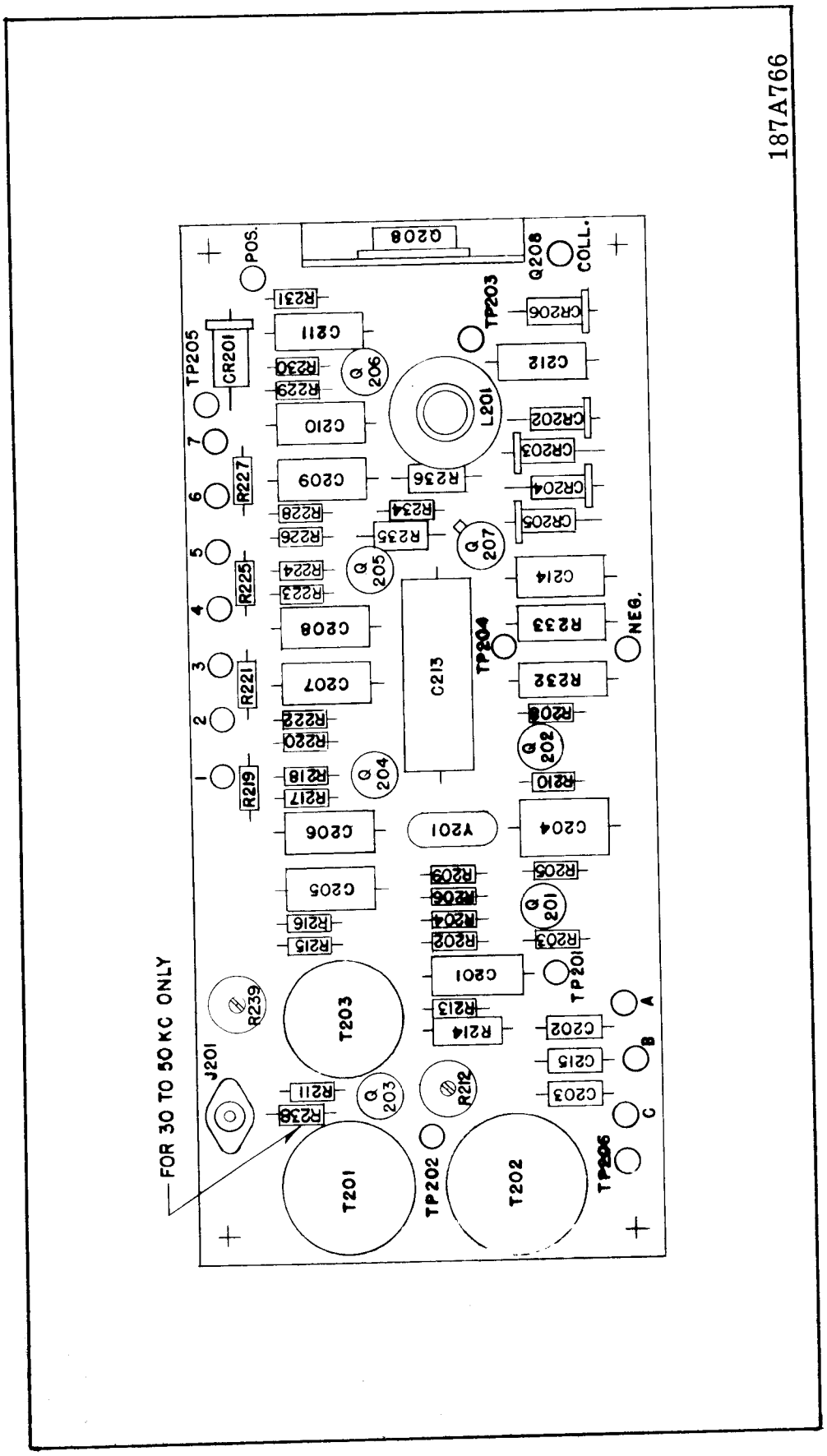


Fig. 5 Receiver Printed Circuit – Parts Location

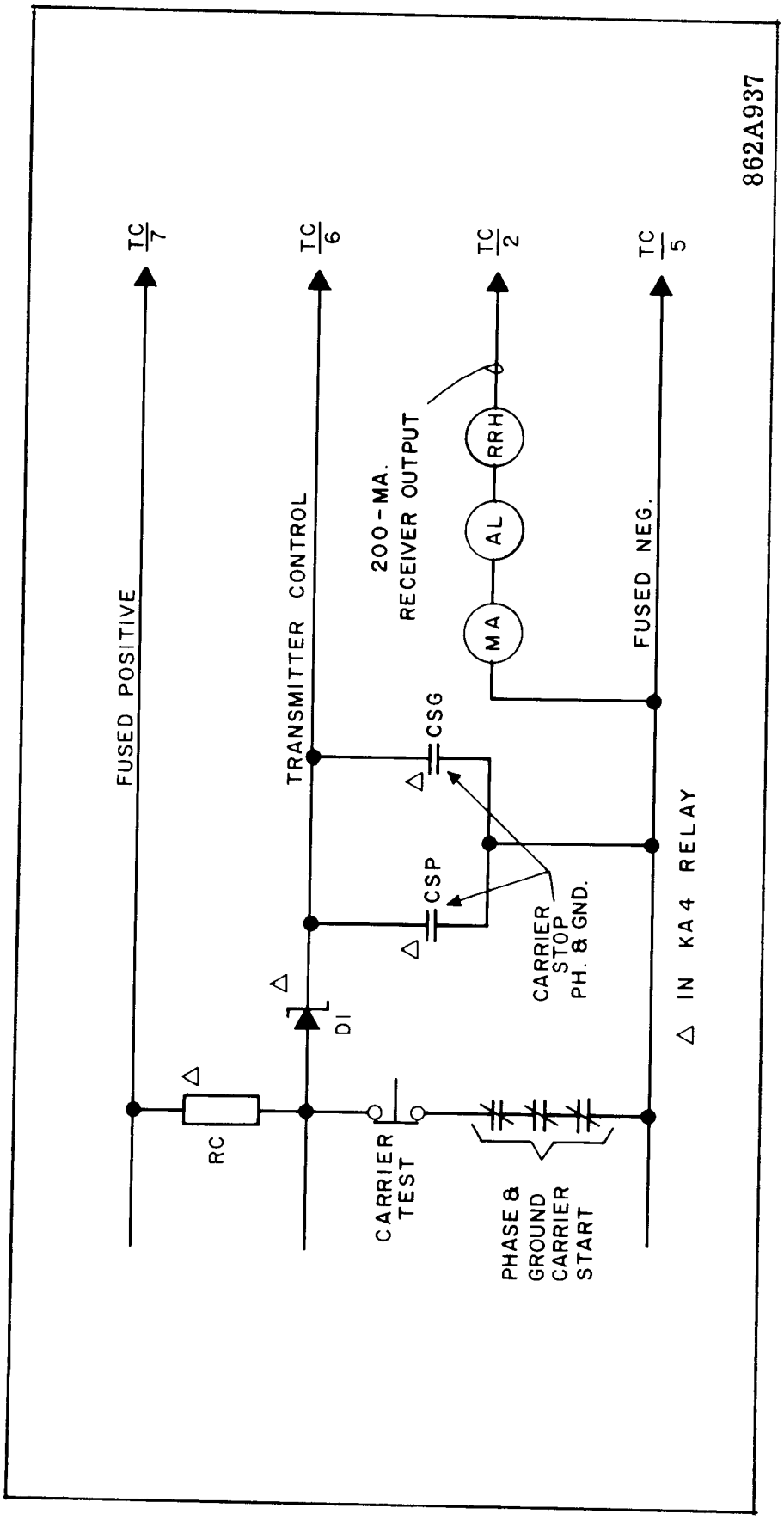
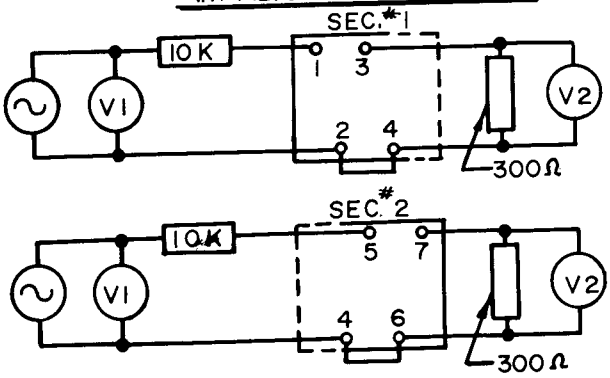
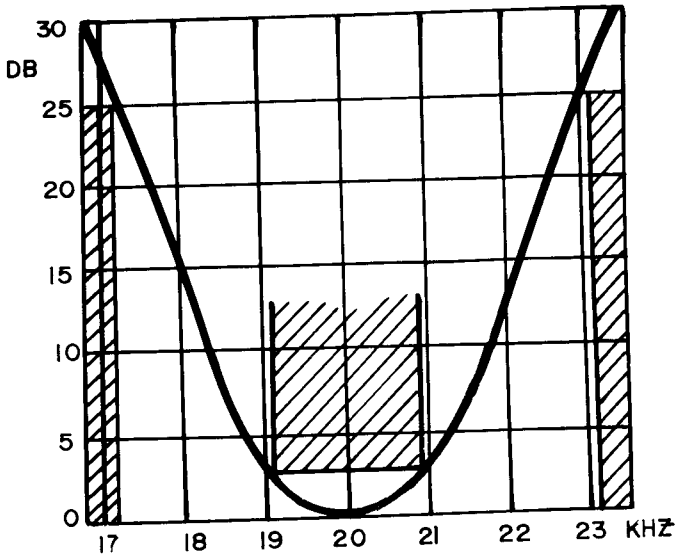


Fig. 6 Elementary K-Dar Carrier Control Circuits.

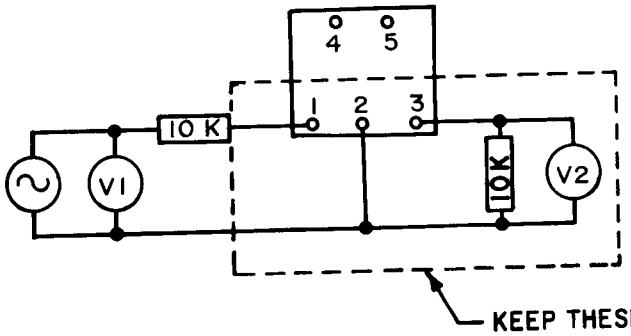
I.F. FILTER TEST CIRCUIT



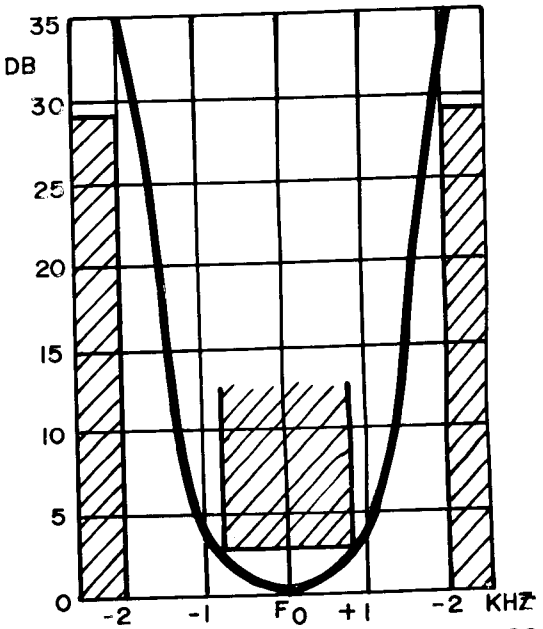


TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.

INPUT FILTER TEST CIRCUIT



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



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

TC RECEIVER FILTER LIMITS

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

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

629A42

* *Fig. 8 Type TC Receiver Filter Characteristics*

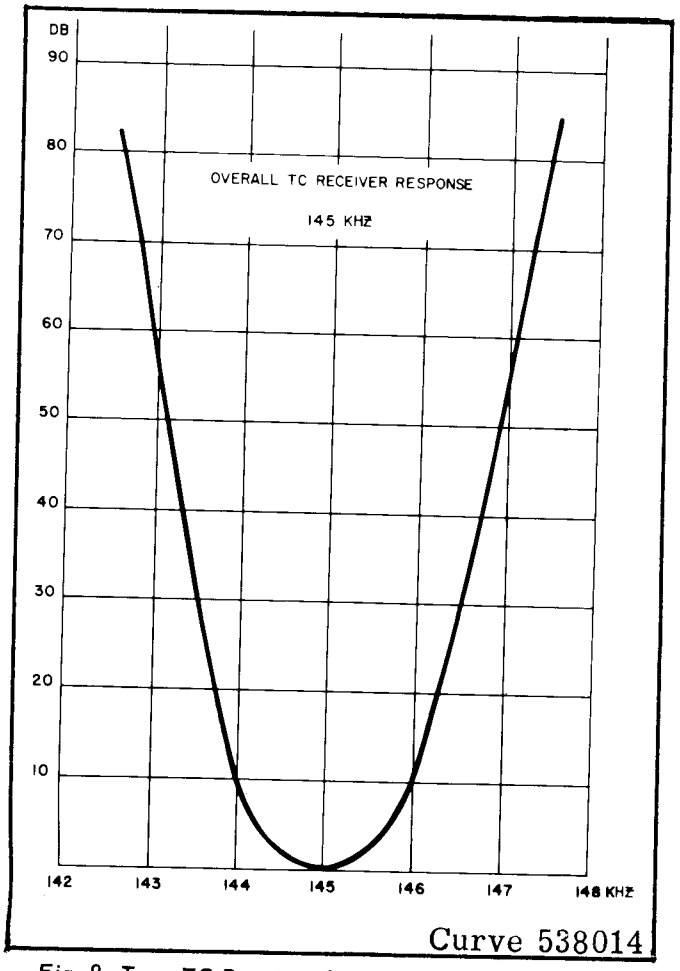


Fig. 9 Type TC Receiver Overall Selectivity Curve

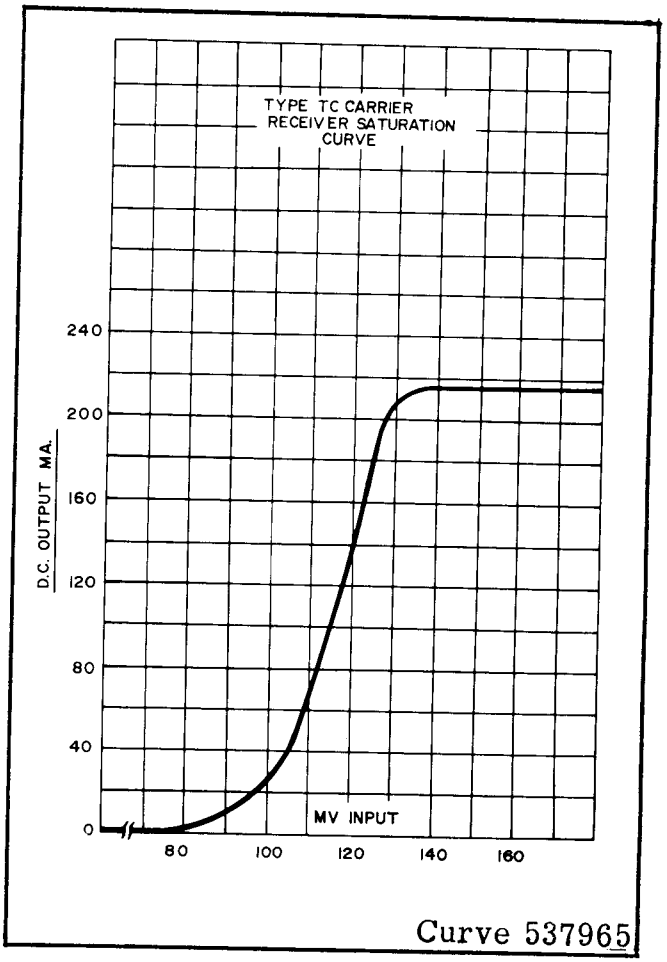
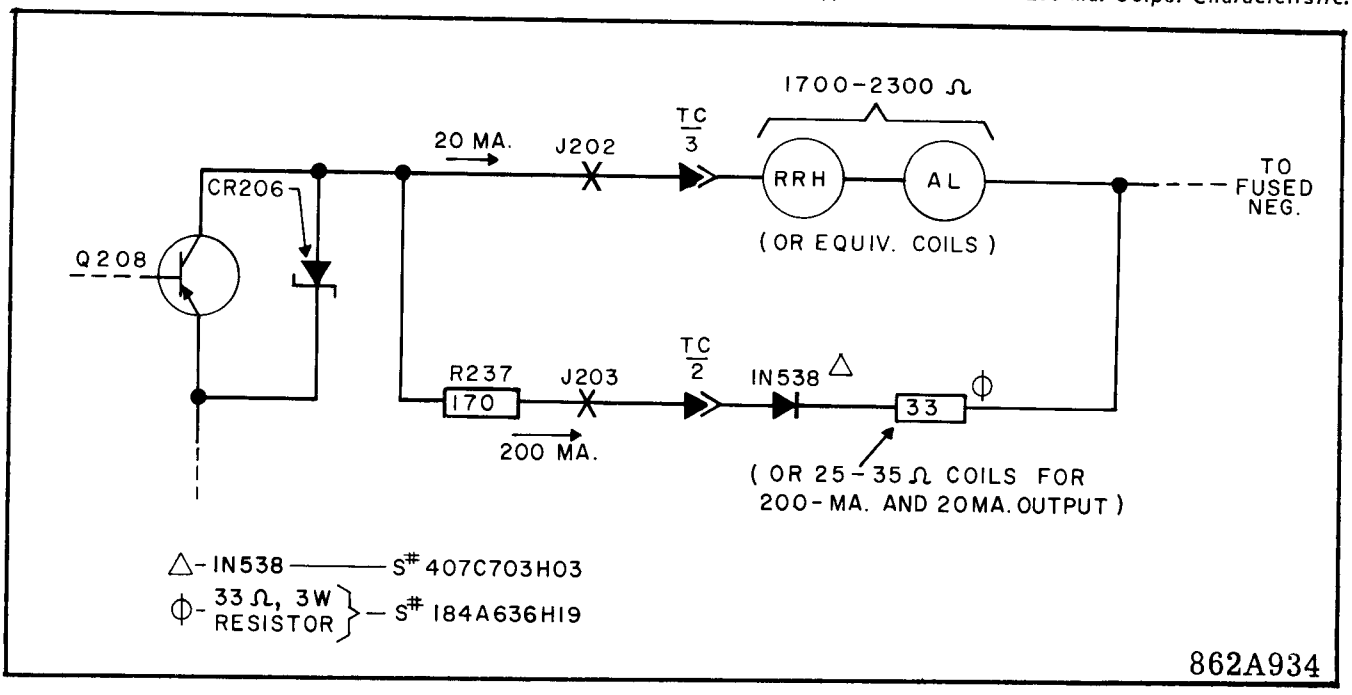


Fig. 10 Type TC Receiver – 200 ma. Output Characteristic.



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

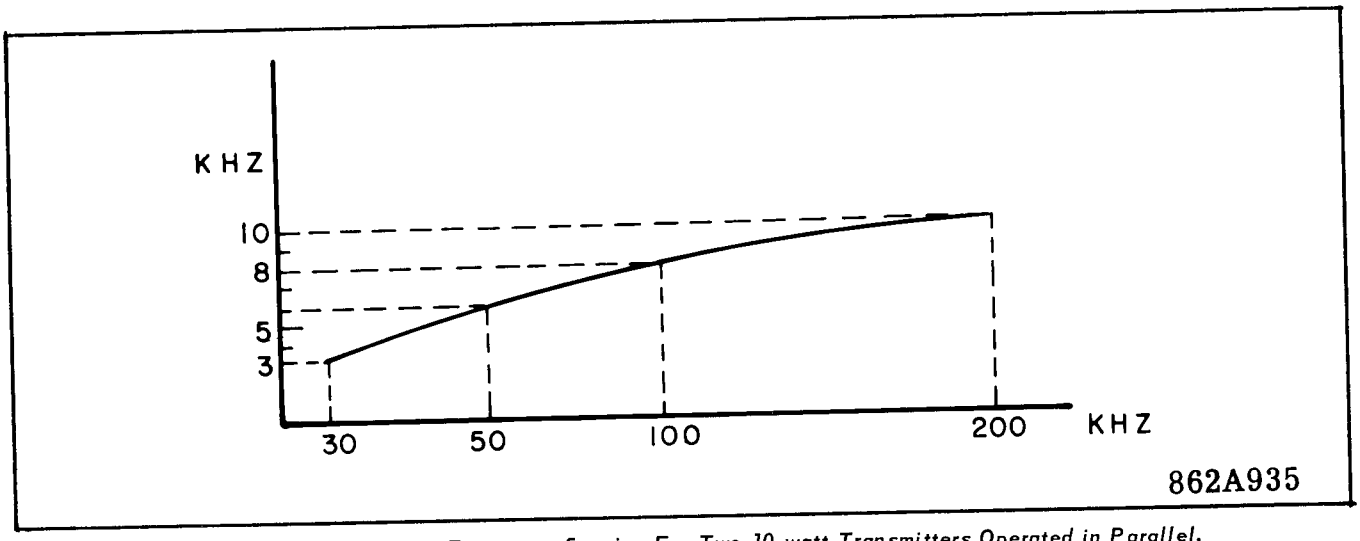


Fig. 12 Minimum Frequency Spacing For Two 10-watt Transmitters Operated in Parallel.

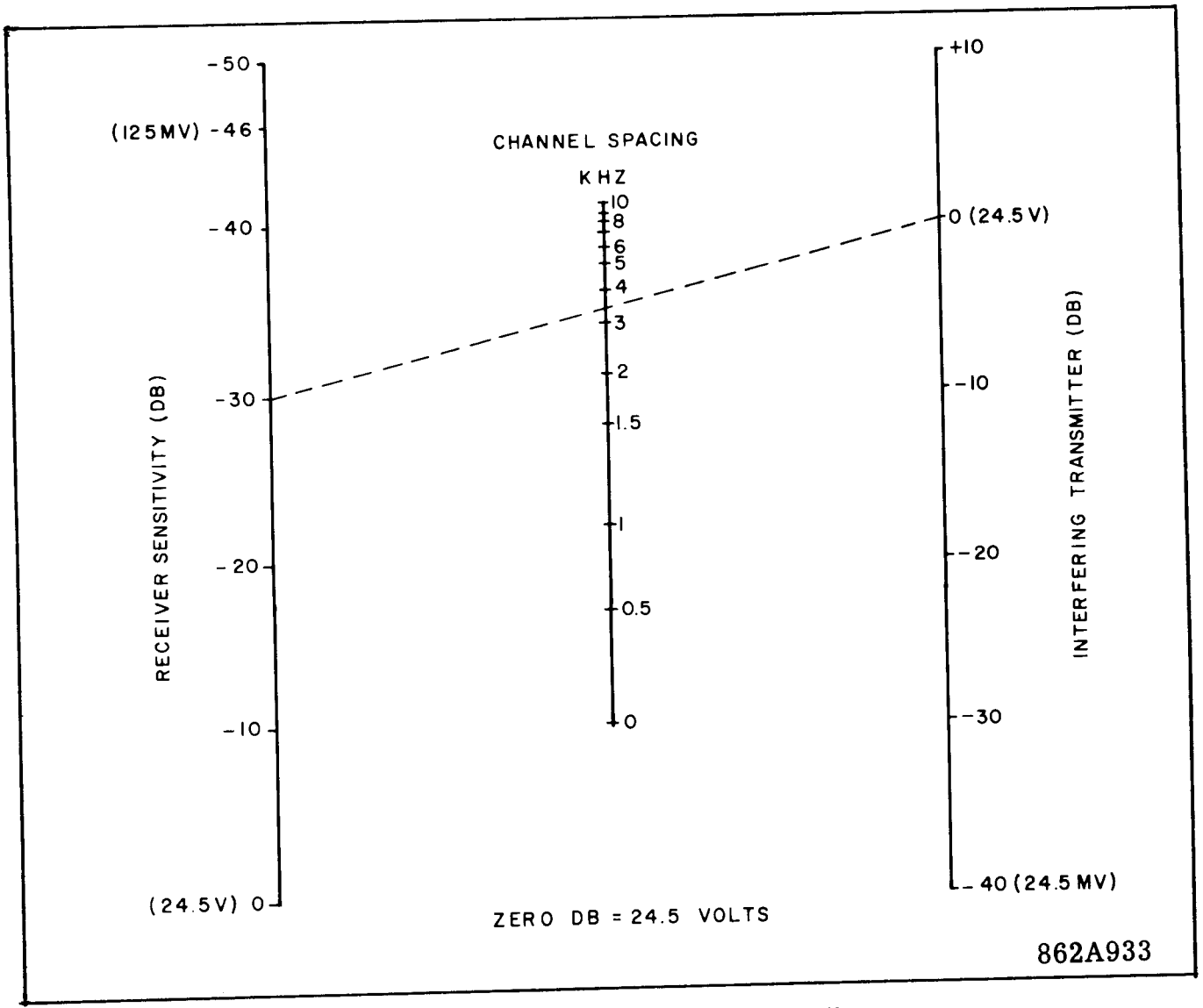


Fig. 13 Minimum Channel Spacing For Keyed Carrier 60 p.p.s.

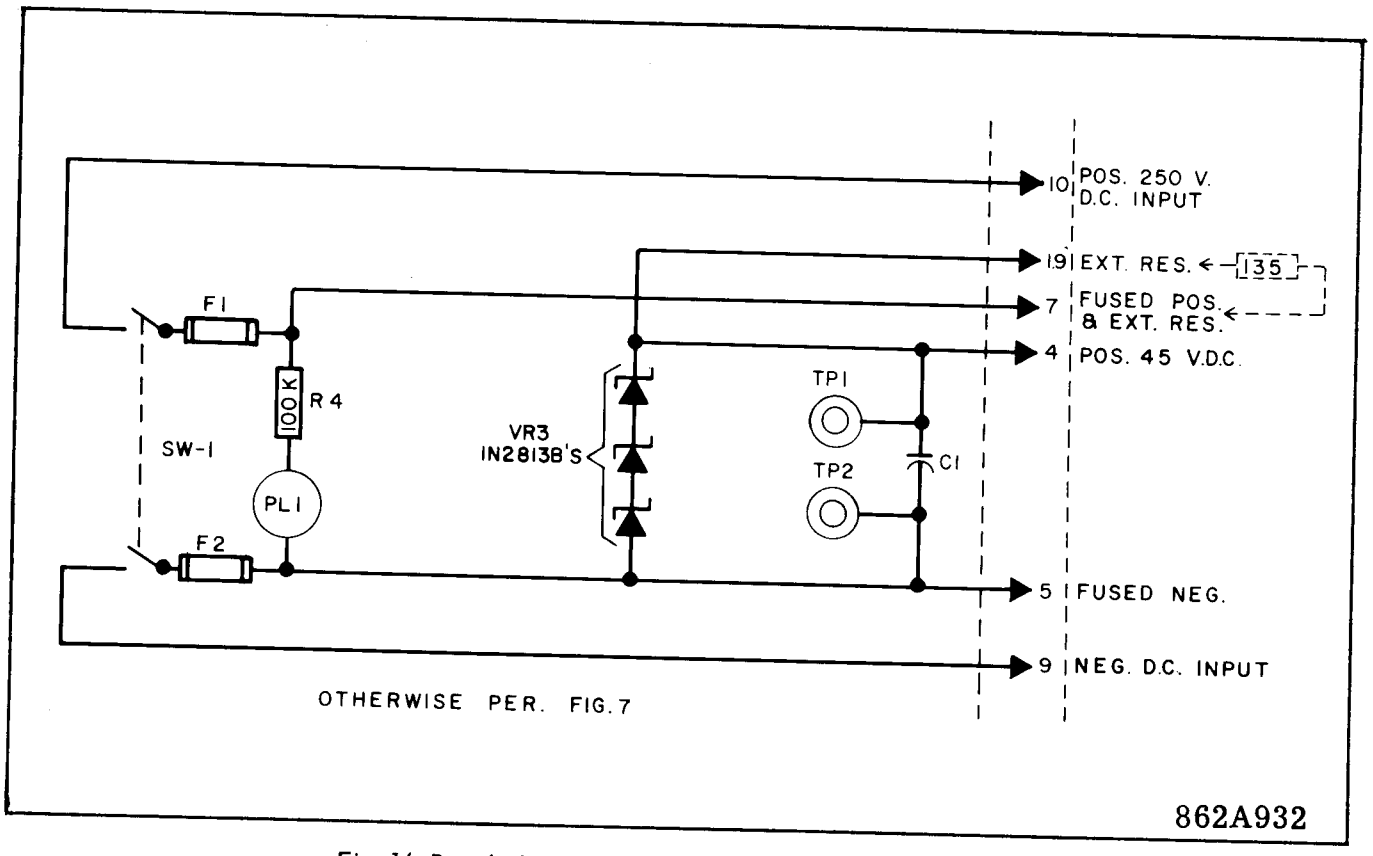


Fig. 14 Detail of Power Supply Section For 250-volt Supply

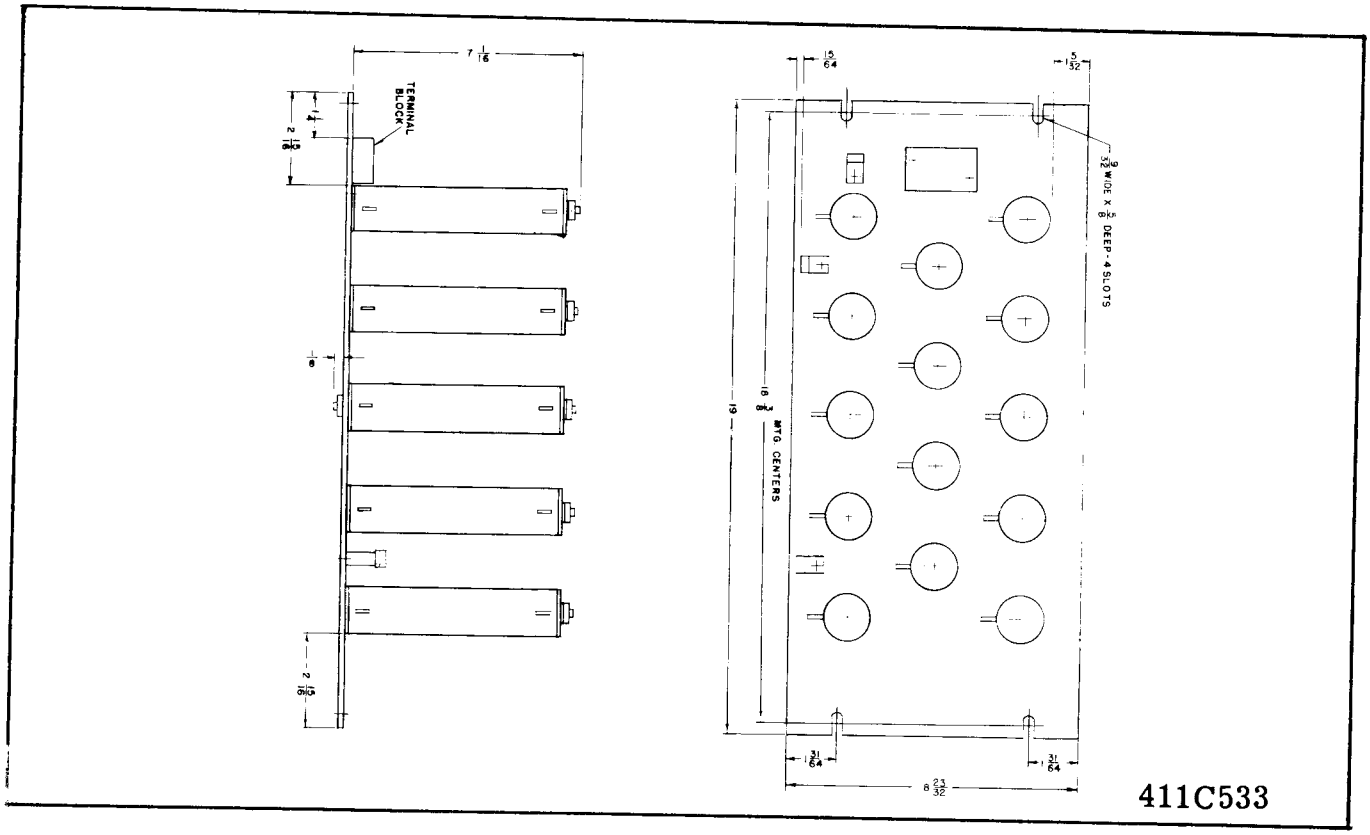


Fig. 15 Outline of External Resistor Unit For 250-volt Operation

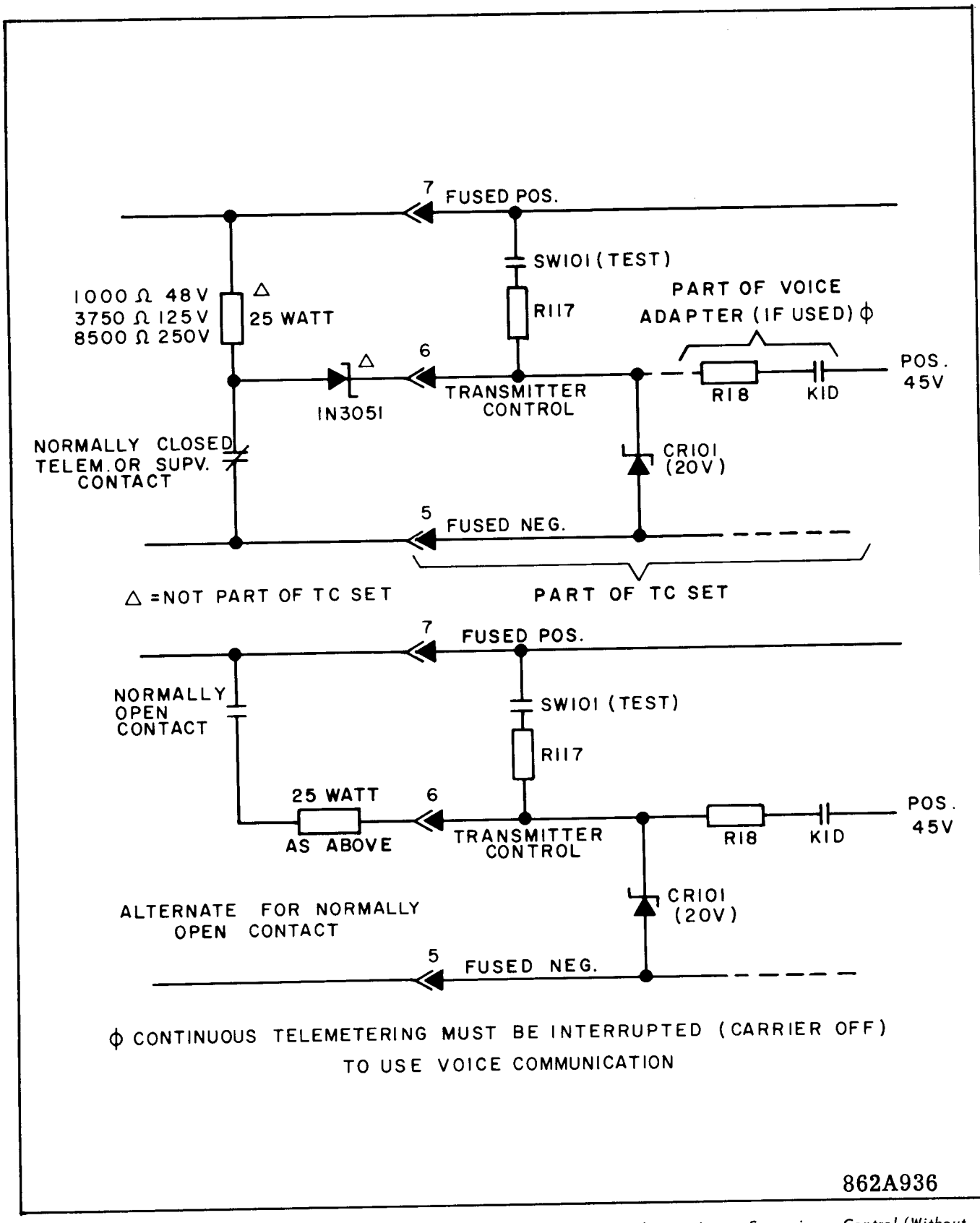


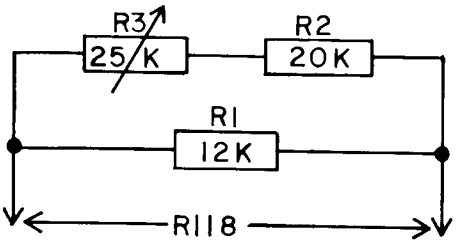
Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact

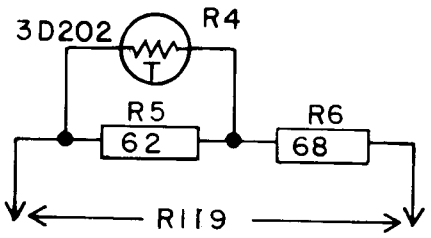
ADDENDUM

Temperature Compensation on Transistors Q104 and Q105

In late 1968, the base bias circuit of transistors Q104 and Q105 on the transmitter board was modified to provide more stable operation at high ambient temperature and provide an adjustment for the base-emitter bias voltage on these transistors.

As shown in Fig. 7, this bias was initially supplied by resistors R118 and R119. In place of these two resistors, the circuits shown below were supplied.





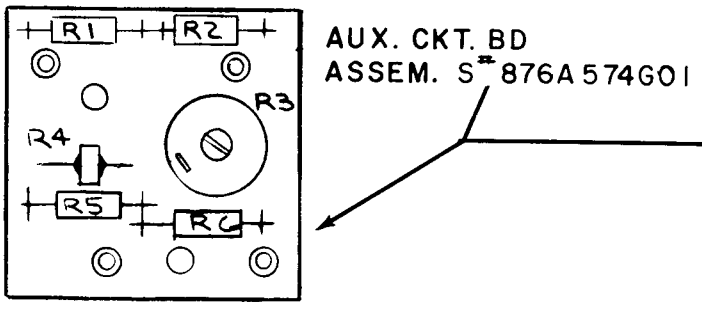
* The added components are mounted on a small board which in turn is mounted on the transmitter as shown below. At the same time, the Sensistor R110 was removed from the transmitter output control circuit (Q103 stage).

Symbol	Description	Style No.
R1	Resistor 12K, ½W 2%	629A531H58
R2	Resistor 20K, ½W 2%	629A531H63
R3	Potentiometer 25K	584C276H23
R4	Thermistor (3D202)	185A211H06
R5	Resistor 62, ½W 2%	629A531H03
R6	Resistor 68, ½W 2%	629A531H04

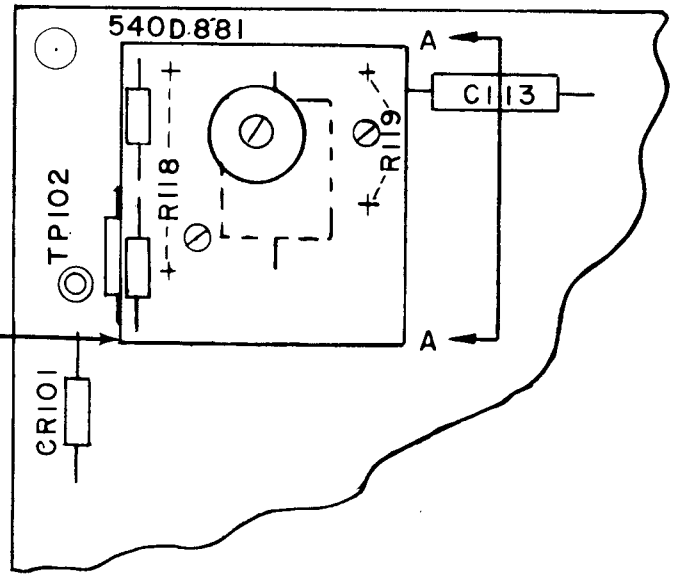
Adjustment of R3 on Auxiliary Circuit Board

The small control R3 is factory adjusted for a quiescent current of 0.2 ± 0.05 ma, and need not be changed unless transistors Q104 or Q105 (or both) are replaced. However, if these transistors are changed, or if the R3 setting is disturbed in error, the following adjustment procedure should be followed to reset R3 before setting the transmitter output with R112.

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 (R3) 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.



AUX. CKT. BD
ASSEM. S* 876A574G01



Ref. 876A571
876A746

PARTIAL VIEW OF TRANSMITTER CIRCUIT BOARD

Extension of Frequency Range

The range of the type TC carrier set has been extended to cover 30 to 300kHz. For this range, the following style numbers apply:

Transmitter circuit-board assembly
S# 5482D10G01

Receiver circuit-board assembly
30 – 50kHz. – S# 540D876G01
50.5–300kHz. – S# 540D876G02

Initially, the receiver board for 200–300kHz. was S# 5482D24G01, but this was superseded by S# 540D876G02 early in 1971 by modifying the latter assembly to operate up to 300kHz.

Component Changes

In 1972 the type 2N274 germanium transistors were replaced with a silicon equivalent. In addition, a few related changes were made. Starting in August 1972, type TC carrier sets were made with the following component changes:

* **Transmitter circuit board:**

Component	Changed From	To	Style No.
Q101, 102	2N274	2N2905A	762A672H10
Q104, 105	2N657	2N2726, 2N3712	762A672H07
CR101	1N3686B	1N5357B	862A288H03

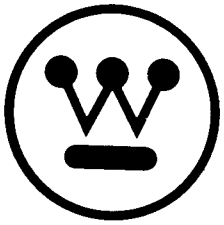
* **Receiver Circuit board:**

Component	Changed From	To	Style No.
Q201 to Q206	2N274	2N2905A	762A672H10
Q207	2N398A	2N3645	849A441H01
Q208	2N1362	2N4903	187A673H13
CR201	1M20Z10	1N3027B	188A302H07
CR202, 203	1N91	1N457A	184A855H07
CR204, 205	1N538	1N4818	188A342H06
R230	Changed from 62 ohms (nominal) to a 10-ohm, ½ watt resistor, style 187A290H01 in series with a 50-ohm ¼-watt Sensistor, style 187A685H08.		

Typical voltage values as listed in this I.L. are essentially unchanged with the new components.

NOTE: With the type 2N2905A transistor in the receiver mixer stage, set the level of the local oscillator output at TP202-206 to 0.5 volt rms. (instead of 0.3 volt).

* With the foregoing changes, the characteristics, operation, adjustment, and performance of the TC assembly are as described in this instruction leaflet.



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

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LIST OF ILLUSTRATIONS

SUPERSEDES I.L. 41-944.31C
Complete Revision

EFFECTIVE JUNE 1969

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 directional or phase comparison protective relaying of power transmission lines. It can also be used for other functions including 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.

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 Q101 is fed back through capa-
* citors C102, C102, 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 uses two series-connected type 2N1908 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 CR103 and CR105 provide protection for the base-emitter junction of the power transistors. Zener diodes CR107 and CR108 protect the collector-emitter junctions from surges which might come in from the power line through the coaxial cable.

The output transformer T105 couples the power transistors to the transmitter output filter FL102. The output filter includes two trap circuits (L102, C_B, and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G101 is a small lightning arrester to limit the magnitude of switching

surges or other line disturbances reaching the carrier set through the line tuner and coaxial cable. Auto-transformer T106 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms.

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

Receiver

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

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

Mixing is accomplished by feeding the incoming signal to the emitter, and the receiver oscillator signal to the base of the mixer Q203. Mixer oscillator requirements are met through adjustment of potentiometer R212. Injection into two separate elements, base and emitter, provides a circuit capable of handling greater signal level variations than one in which injection is made into only a single element such as the base. This receiver uses an intermediate frequency of 20 kHz. Typical characteristics of both filters and the complete receiver are shown on curves, Fig. 8 and 9.

The 20-kHz i.f. signal is rectified by diodes CR202 and CR203. 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 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 VR1 holds a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the d-c voltage drop through the transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage of approximately 45-v. d-c. The zener diode VR2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

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.

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 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 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	30-200 kHz (50-200 kHz for phase comparison relaying)
Transmitter output	10 watts into 50 to 70-ohm resistive load
Harmonics	55 db below 10 watts
Receiver sensitivity	125 mv. input for 180 ma. minimum output current
Receiver selectivity	1500 Hz bandwidth (3 db down); down 80 db at ±3kHz.
Transmitter-receiver channel rating	40 db
Input voltage	48, 125, or 250 V. d-c
Supply voltage variation	42-56 V, 105-140V, 210-280 V
Battery Drain:	
48 V.D.C.	0.5 amp standby, 1.35 amp transmitting
125 V.D.C.	0.25 amp standby, 1.1 amp transmitting
250 V.D.C.	1.5 amp standby or transmitting
* Temperature range	−20 to +55°C around chassis

Frequency Spacing

The minimum recommended frequency spacing between two Type TC carrier sets operated in parallel without hybrid units is shown on the curve of Fig. 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 frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the −30 db point on the receiver sensitivity scale and the zero-db point on the interfering transmitter scale. The resulting line crosses the channel spacing scale between 3 and 4 kHz. For this example, a channel spacing of at least 4 kHz should be used. (In order not to conflict with the limits of Fig. 12, an r-f

hybrid may be needed between the TC set and the other transmitter, depending on the actual application.)

INSTALLATION

The type TC transmitter-receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60°C.

ADJUSTMENTS

Transmitter

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

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

1. First, measure the normal received signal from

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

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

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

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

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

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 Tables I through IV. Voltages should be measured with a VTVM. Readings may vary as much as ± 20%.

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. R110 Sensistor
   a. 30-60 kHz – 2200 ohms – S# 187A685H01
   b. 60.5-120 kHz – 1800 ohms – S# 187A685H02
   c. 120.5-200 kHz – 1200 ohms – S# 187A685H03

3. Capacitors C111 and C113
   a. 30-50 kHz – 0.47 mfd. – S# 188A293H01
   b. 50.5-75 kHz – 0.22 mfd. – S# 188A293H02
   c. 75.5-100 kHz – 0.15 mfd. – S# 188A293H03
   d. 100.5-150 kHz – 0.10 mfd. – S# 188A293H04
   e. 150.5-200 kHz – 0.047 mfd. – S# 188A293H05

4. FL101 and FL102

   Filter FL101 is a small series-resonant tuned circuit between the driver and power amplifier

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

Inductors L101, L102, and L103 in these filters are adjustable over a limited range, but thirty-two combinations of capacitors and inductors are required to cover the frequency range of 30 kHz to 200 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 12 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5
32.0-33.5	64.5- 68.0	120.0-127.0
34.0-36.0	68.5- 72.0	127.5-135.0
36.5-38.5	72.5- 76.0	135.5-143.0
39.0-41.0	76.5- 80.0	143.5-151.0
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	

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. 45 V. (TP206)

Test Point	Standby (No Signal)			With 125 M.V. Input		
TP201 TP202 TP203 TP204 TP205	*	38 0 11. .03 20		*	38 0 11. 2.2 20	
Transistor	E*	B*	C*	E*	B*	C*
Q201	38.5	37	43	38.5	37	43
Q202	38.5	37.5	43.5	38.5	37.5	43.5
Q203	0.08	0	18.7	0.08	0	18.7
Q204	2.7	2.9	18.7	2.7	2.9	18.7
Q205	2.4	2.6	18.7	2.5	2.7	18.7
Q206	2.5	2.7	10.5	2.6	2.8	10.5
Q207	0.13	0.03	22.0	2.0	2.2	4.0
Q208	0.25	0.15	45.0	1.7	2.0	2.0

*E — Emitter, B — Base, C — Collector
All voltages read with d-c vacuum-tube voltmeter.

TABLE II

Receiver RF Measurements

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

Test Point	Typical A-C Voltages		Test Point	Typical A-C Voltages	
	36 kHz	132 kHz		36 kHz	132 kHz
FL201-IN to Gnd.	.075	.050	Q205-B to TP206	.11	.052
FL201-OUT to Gnd.	.051	.020	Q205-C to TP206	6.7	3.4
Q203 -E to TP206	.105	.090	Q206-B to TP206	.67	.37
Q203 -C to TP206	.22	.035	Q206-C to TP206	1.5	1.53
Q204 -B to TP206	.015	.012	TP202 to TP206	0.3	0.3
Q204 -C to TP206	.90	.52			

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

TABLE III

Transmitter D-C Measurements

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

Test Point	Carrier Off	Carrier On
TP101	7 volts d.c.	7 volts d.c.
TP102	0	20
TP103	0	19.5
TP105	0	9
TP106	44	22
TP107	44	22.2
TP108	45	44.8
TP110	* .5	* .6
TP111	.5	.6
TP112	0	0
TP113	45	45
J101 (Front Panel)	5 ma. max.	0.6 amp.

Transistor	E	B	C	E	B	C
Q101	6.0	7.8	2.5	6.1	7.7	2.5
Q102	6.6	7.1	1.2	6.6	7.1	1.1
Q103	0	0	0	19.5	19.4	9.0
Q104	0.1	0.1	45	0.5	0.9	45
Q105	0.1	0.1	45	0.5	0.9	45
Q106	0	0	44	0	0.9	1.2
Q107	43.7	43.7	0	22.2	22.2	0
Q108	45.0	44.7	44.7	44.8	44.8	22.3

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. Resistors R218, R224, and R230 may have to be reduced. See following paragraph.

   The emitter resistors R218, R224, and R230 of the i-f stages are selected during factory test to give the required receiver gain. This is desirable since the insertion loss of the input filter FL201 increases with frequency. If the operating frequency is reduced, the receiver gain will probably be higher. In this case, a reduction in the setting of the i-f input control R239 will give the 125-mv. sensitivity. If the new operating frequency is higher, the receiver gain will be lower. If more than 125 mv. is required to obtain 180 ma. output, the gain can be increased by reducing the value of one or more of the resistors R218, R224, and R230. In most cases, these resistors should fall in the range of 22 to 150 ohms. These three resistors are soldered to small terminal posts on the printed circuit board.

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 230 kHz, input impedance—one megohm, minimum.

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	Test Point	A-C Voltage
T101-3 to TP104	1.1 volts, rms.	Q107-B to TP107	.5 volts, rms.
TP103 to TP102	0.2	Q108-B to TP113	.5
Q103-C to TP104	0.7	Q107-C to TP107	14.5
TP110 to T102-4	0.2	Q108-C to TP113	14.5
* TP111 to T102-4	0.2	T105-4 to Gnd.	105
Q104-C to TP104	4.3	T106-2 to Gnd.	155*
Q105-C to TP104	4.3		
T103-4 to Gnd.	1.5	TP109 to Gnd.	50*
T104-1 to Gnd.	1.4	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

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 230kHz

c. Oscilloscope

d. Ohmmeter

e. Capacitor checker

f. Frequency counter

g. Frequency-selective voltmeter

Renewal Parts

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

ELECTRICAL PARTS LIST

Transmitter Section

Symbol	Rating	Style Number
C101	0.1 mfd, 200 V. DC	187A624H01
C102	.005 mfd, 300 V. DC	187A694H29
C103	180 pf. 500 V. DC	187A695H29
C104	0.25 mfd, 200 V. DC	187A624H02
C105	0.25 mfd, 200 V. DC	187A624H02
C106	0.25 mfd, 200 V. DC	187A624H02
C107	0.25 mfd, 200 V. DC	187A624H02
C108	0.50 mfd, 200 V. DC	187A624H03
C109	0.25 mfd, 200 V. DC	187A624H02
C110	0.25 mfd, 200 V. DC	187A624H02
† C111	(See Table Below)	–
C112	39 pfd, 500 V. DC	187A695H12
† C113	(See Table Below)	–
C114	100 pf., 500 V. DC	187A695H23
C115	100 pf., 500 V. DC	187A695H23
C116	0.001 mfd, 500 V. DC	187A694H11
CA	Part of FL101	Vary with Frequency
CB	Part of FL102	Vary with Frequency
CC		
CD		
CE		

*

† 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
75.5-100 kHz	0.15 mfd, 400 V. DC	188A293H03
100.5-150 kHz	0.1 mfd, 400 V. DC	188A293H04
150.5-200 kHz	0.047 mfd, 400 V. DC	188A293H05

CR101	1N3686B (20 V ± 5%)	185A212H06
CR102	1N457A	184A855H07
CR103	1N538	407C703H03
CR104	1N91	182A881H04
CR105	1N538	407C703H03
CR106	1N91	182A881H04
CR107	1N2999A (56 V ± 10%)	184A617H13
CR108	1N2999A (56 V ± 10%)	184A617H13
G101	Type TVS Arrester	637A026A01
J101	Closed Circuit Jack	187A606H01

ELECTRICAL PARTS LIST
Transmitter Section (Cont.)

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

Symbol	Ohms	± Tol. %	Watts	Style Number
R101	5,600	5	1	187A643H45
R102	2,200	10	0.5	187A641H35
R103	10,000	10	0.5	187A641H51
R104	100,000	5	0.5	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
R110 *				At End of List
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

*Sensistor -	30 - 60 kHz, 2.2K ± 10%, ¼ watt	187A685H01
	60.5-120 kHz, 1.8K ± 10%, ¼ watt	187A685H02
	120.5-200 kHz, 1.2K ± 10%, ¼ watt	187A685H03

ELECTRICAL PARTS LIST
Transmitter Section (Cont.)

Symbol	Ohms	± Tol. %	Watts	Style Number
R116	100	5	0.5	184A763H03
R117	1,000 48 V dc	5	25	1202588
	3,750 125 V dc	5	25	1202955
	8,500 250 V dc	5	25	1267310
R118	8,200	5	2	185A207H49
R119	100	5	0.5	184A763H03
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	0.27	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

Symbol	Rating		Style Number
T101	10,000/400 ohms	L633003	1962797
T102	10,000/400 c.t.	L592170	1962698
T103	1930/60 ohms	L633000	1962694
T104	Turns ratio, 1/0.5,	Pri./each sec.	292B526G01
T105	10/500 ohms		292B526G02
T106	500/50-60-70 ohms		292B526G03
* Y101	30-200 kHz crystal per 328C083		Specify Frequency

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
	CR201	1N3027B (20V ± 5%)	184A449H07
	CR202	1N91	182A881H04
	CR203	1N91	182A881H04
	CR204	1N538	407C703H03
*	CR205	1N538	407C703H03
*	CR206	1N1789 (56V. ± 10%)	584C434H08
	FL201	Receiver Input Filter 30-200 kHz	Specify Frequency
	FL202	Receiver i.f. Filter-20 kHz (2 Sections)	187A590G02
	J201	Receiver Coax. Input Jack	187A638H01
	J202	Closed Circuit Jack (20MA)	187A606H01
	J203	Closed Circuit Jack (200MA)	187A606H01
	L201	33 mh.	187A599H01
	Q201	2N274	187A270H01
	Q202	2N274	187A270H01
	Q203	2N274	187A270H01
	Q204	2N274	187A270H01
	Q205	2N274	187A270H01
	Q206	2N274	187A270H01
	Q207	2N398A	184A638H12
	Q208	2N1362	187A673H01

ELECTRICAL PARTS LIST
Receiver Section (Cont.)

Symbol	Rating			Style Number
Resistors	Ohms	± Tol. %	Watts	
R201	10,000	10	0.5	187A641H51
R202	2,200	10	0.5	187A641H35
R203	10,000	10	0.5	187A641H51
R204	100,000	5	0.5	184A763H75
R205	390	5	0.5	184A763H17
R206	1,200	5	0.5	184A763H29
R207	25 K Pot.	10	2	185A086H07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H75
R210	390	5	0.5	184A763H17
† R211	–	–	–	See † Note Below
R212	1 K Pot.	20	0.25	629A430H02
R213	1,200	5	0.5	184A763H29
R214	5,600	5	1	187A643H45
R215	20,000	5	0.5	184A763H58
R216	3,600	5	0.5	184A763H40
R217	620	5	0.5	184A763H22
R218	62	5	0.5	187A290H20
R219	10,000	10	0.5	187A641H51
R220	20,000	5	0.5	184A763H58
R221	300	5	0.5	184A763H14
R222	3,600	5	0.5	184A763H40
R223	620	5	0.5	184A763H22
R224	62	5	0.5	187A290H20
R225	10,000	10	0.5	187A641H51
R226	20,000	5	0.5	184A763H58
R227	300	5	0.5	184A763H14
R228	3,600	5	0.5	184A763H40
R229	620	5	0.5	184A763H22
R230	62	5	0.5	187A290H20
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	Rating			Style Number
	Ohms	± Tol. %	Watts	
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
T201	10,000/10,000 Ohms	L633005		1962798
T202	10,000/400 Ohms	L633003		1962797
T203	25,000/300 Ohms	L592171		1962697
Y201	50-220kHz Crystal per 328C083			Specify Frequency

* Power Supply Section

Symbol	Function	Description or Rating	Style Number
C1	(+) to (–) bypass	0.45 mfd. 330 VAC	1723408
C2	A-C grounding	0.5 mfd. 1500 VDC	1877962
C3	A-C grounding	0.5 mfd. 1500 VDC	1877962
F1,F2	Overload Protection	1.5a, 48/125 VDC	11D9195H26
F1,F2	Overload Protection	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	125V Series dropping	26.5 ohms, 3½"	04D1299H44
R2	125V Series dropping	Same as R1	04D1299H44
R3	125V Current limiting	500 ohms, 3½"	1268047
	48V For 48 VDC, R1=R2 0	–	–
	48V R3=26.5 ohms	3½"	04D1299H44
R4	Current limiting	100K, 0.5 watt	184A763H75
TP1	Test point (+)	Pin Jack - red	187A332H01
TP2	Test point (–)	Pin Jack - black	187A332H02
VR1	Voltage Regulator	1N2828B (45V.)	184A854H06
VR2	Surge Protection	1N3009A (130V.) Zener Diodes	184A617H12
VR3	Voltage Regulator	1N2813B (15V.)	184A854H11

† R238 - omit - above 50kHz

- 22K, 30-50kHz, s# 187A641H59

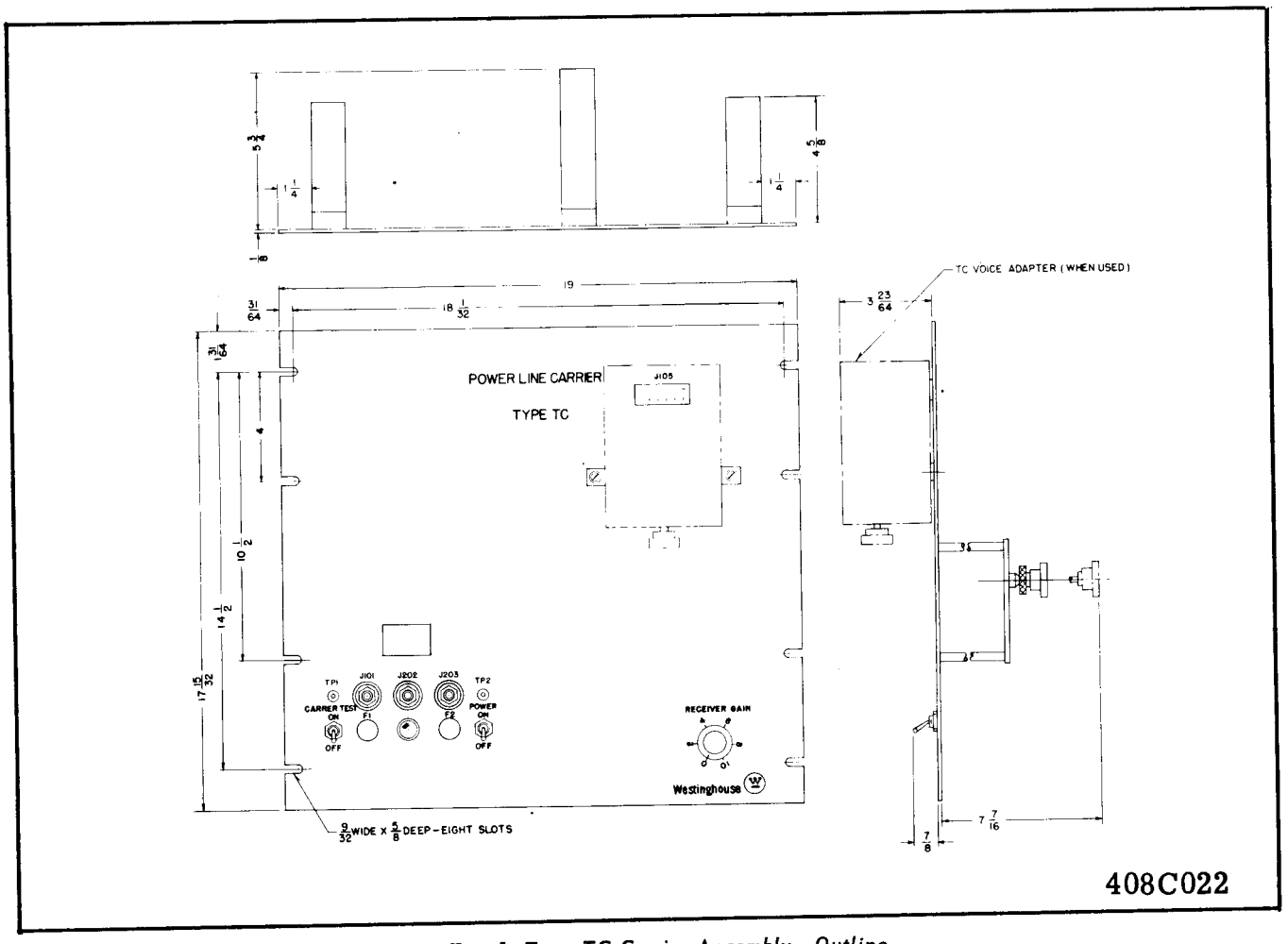


Fig. 1 Type TC Carrier Assembly – Outline

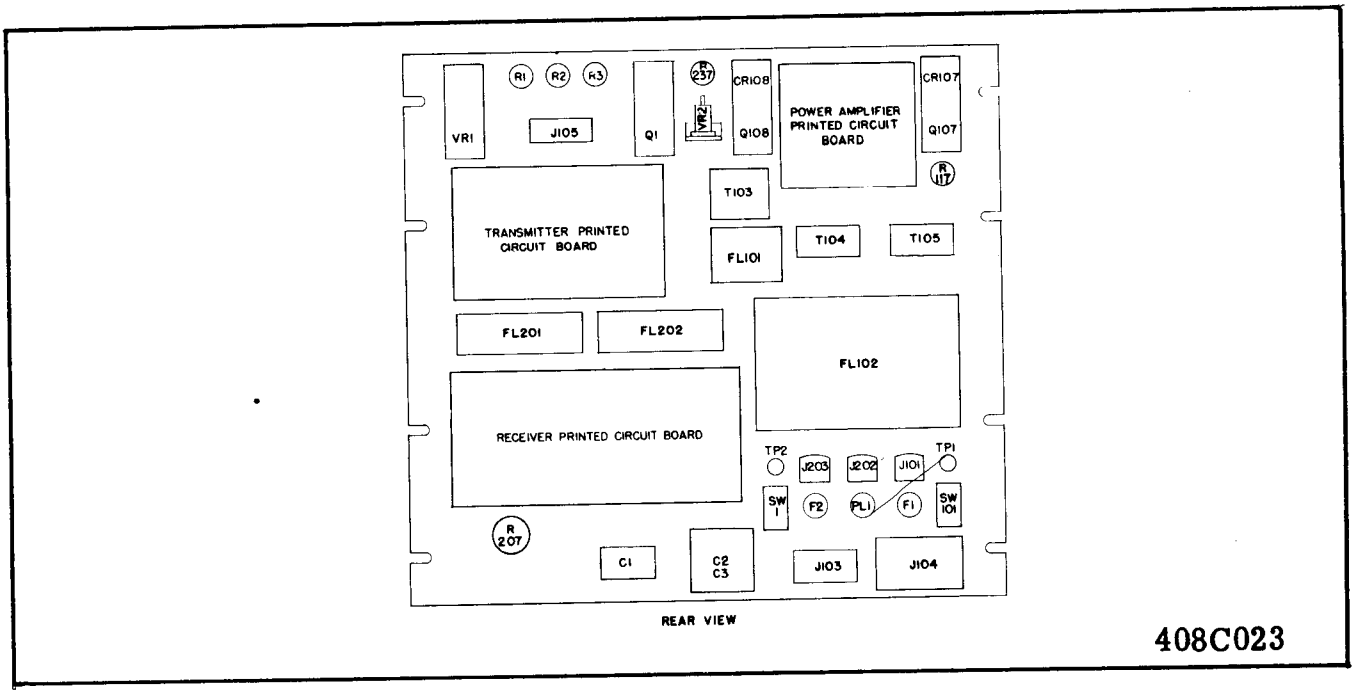


Fig. 2 Type TC Carrier Assembly – Parts Location

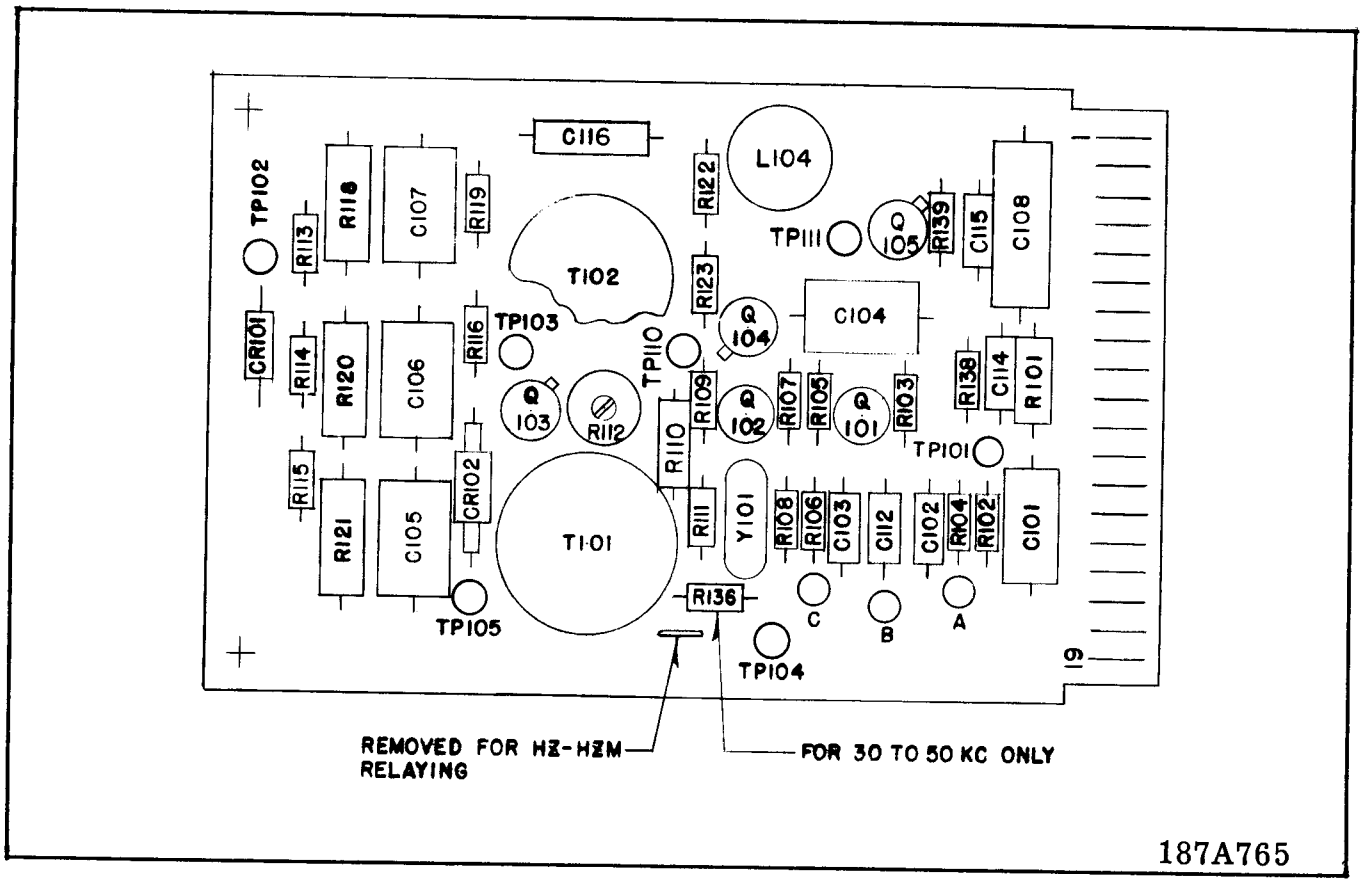


Fig. 3 Transmitter Printed Circuit – Parts Location

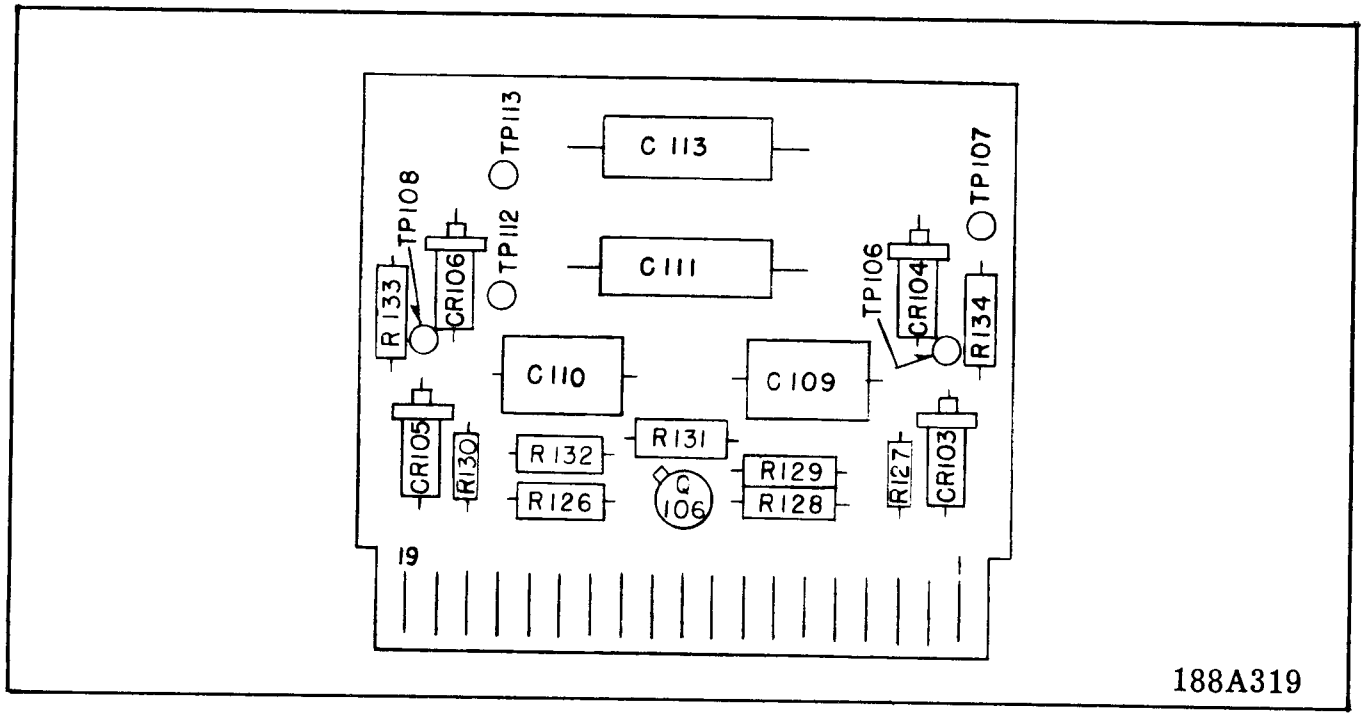


Fig. 4 Power Amplifier Printed Circuit – Parts Location

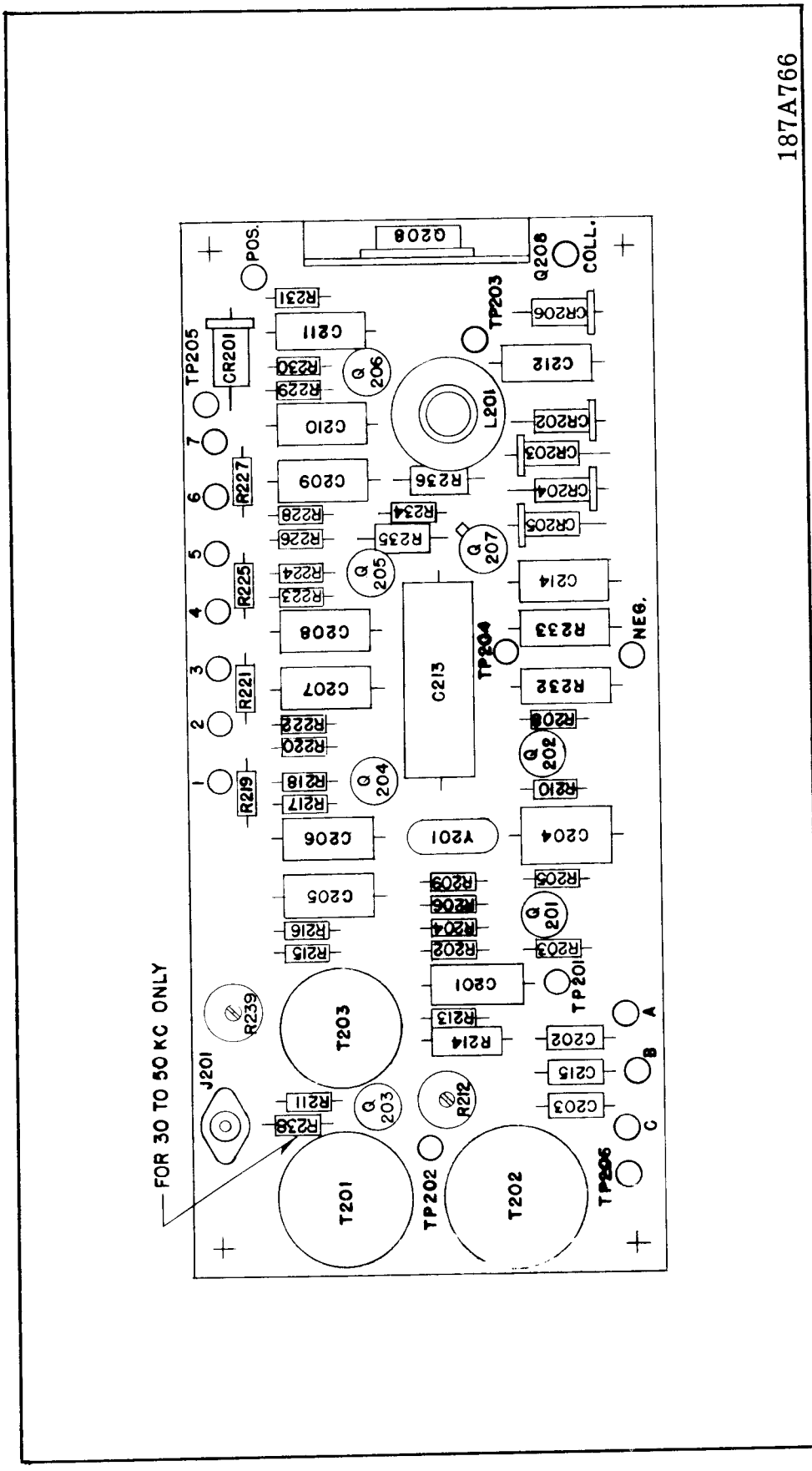


Fig. 5 Receiver Printed Circuit – Parts Location

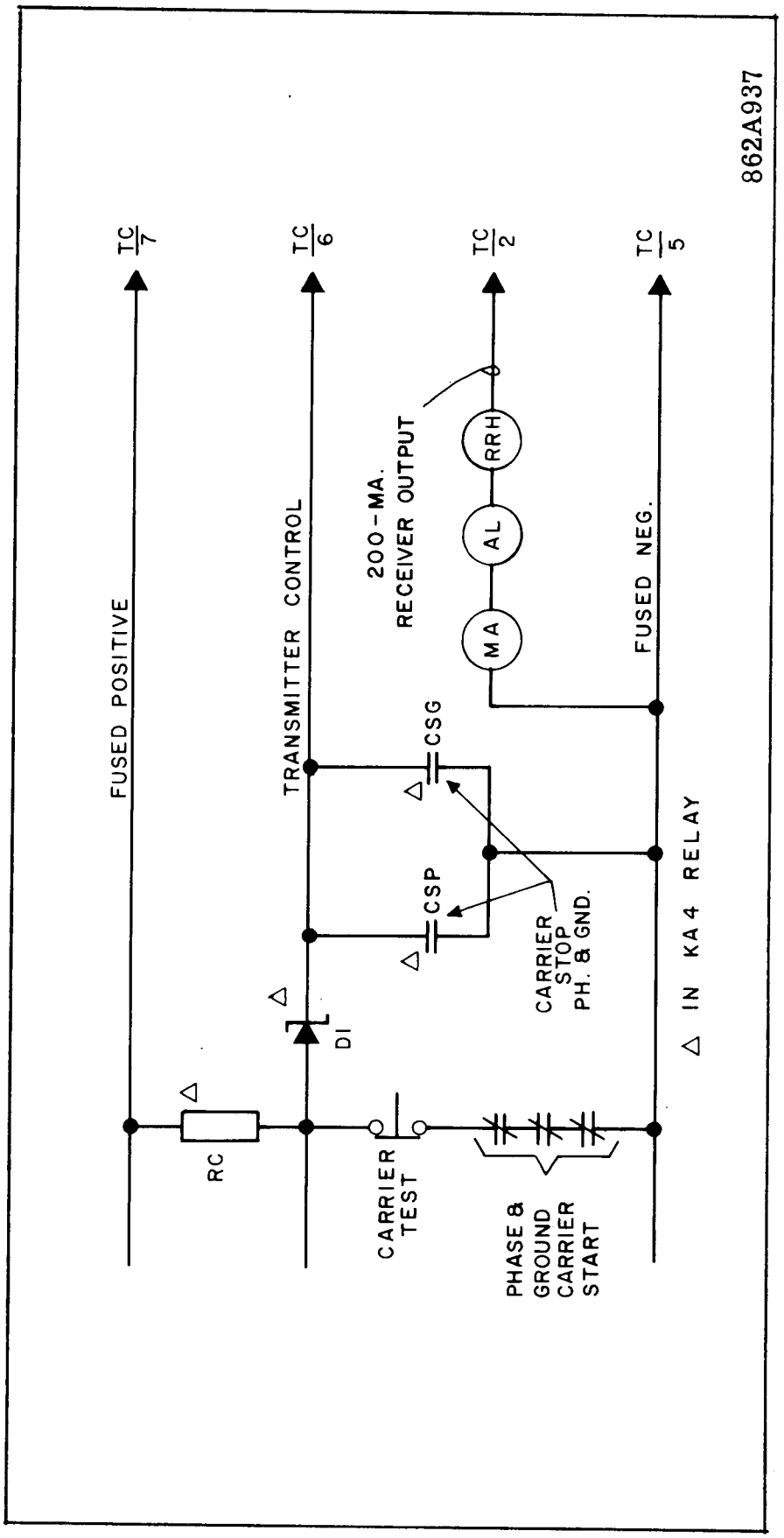
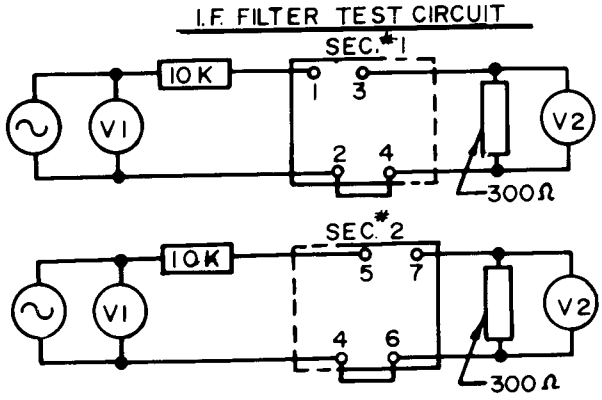
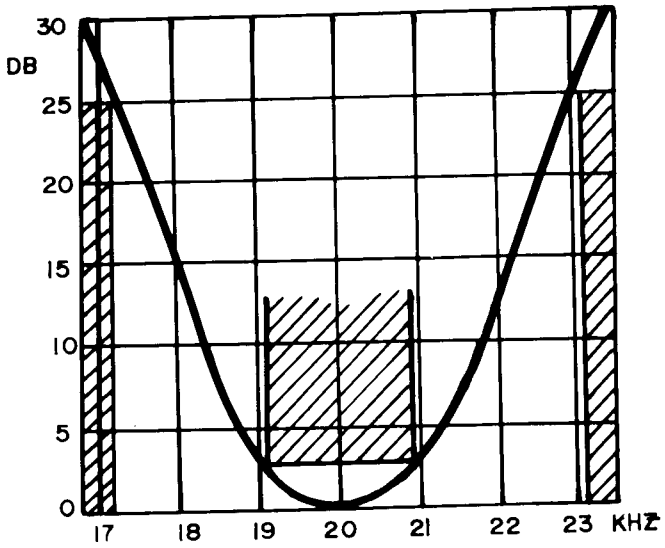


Fig. 6 Elementary K-Dar Carrier Control Circuits.

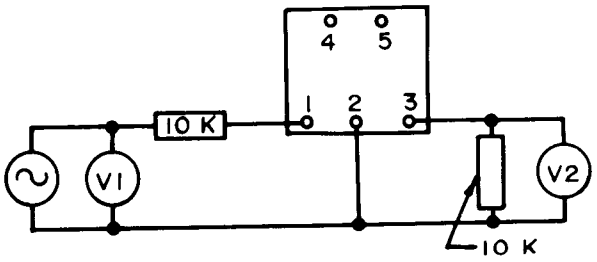
I.F. FILTER TEST CIRCUIT





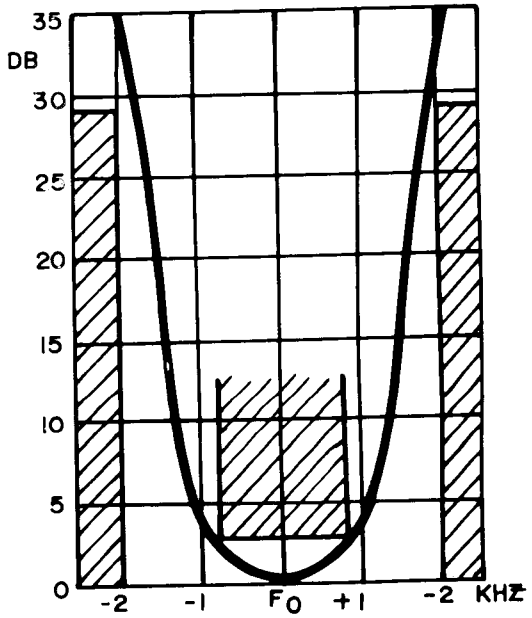
TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.

INPUT FILTER TEST CIRCUIT



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

TC RECEIVER FILTER LIMITS



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

629A425

Fig. 8 Type TC Receiver Filter Characteristics

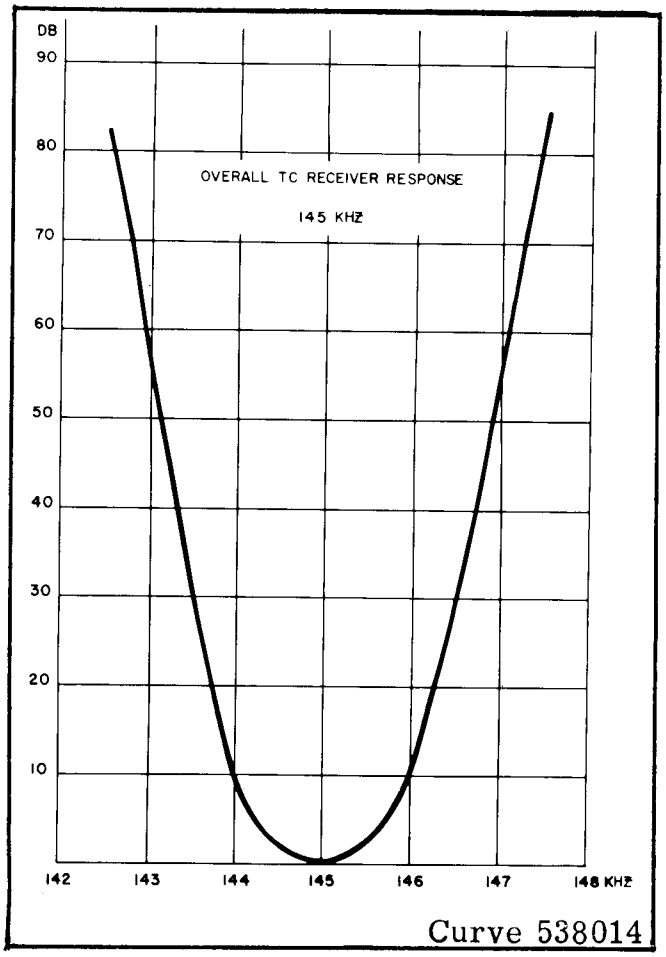


Fig. 9 Type TC Receiver Overall Selectivity Curve

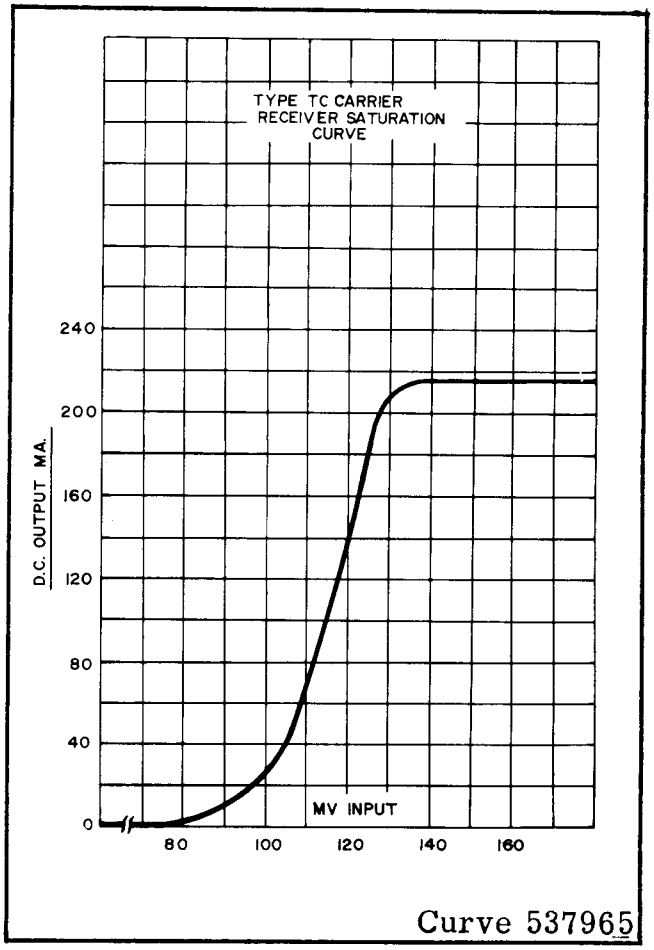


Fig. 10 Type TC Receiver – 200 ma. Output Characteristic.

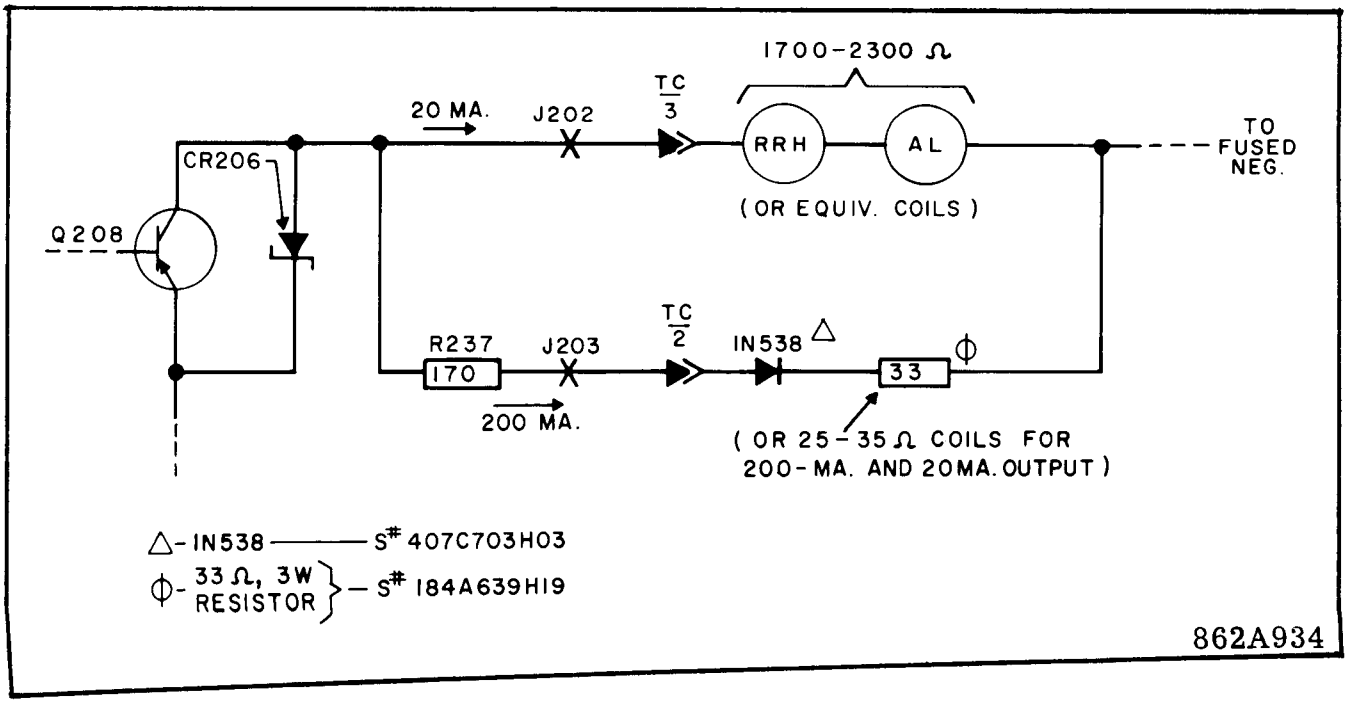


Fig. 11. TC Receiver Output For 20-ma. Operation

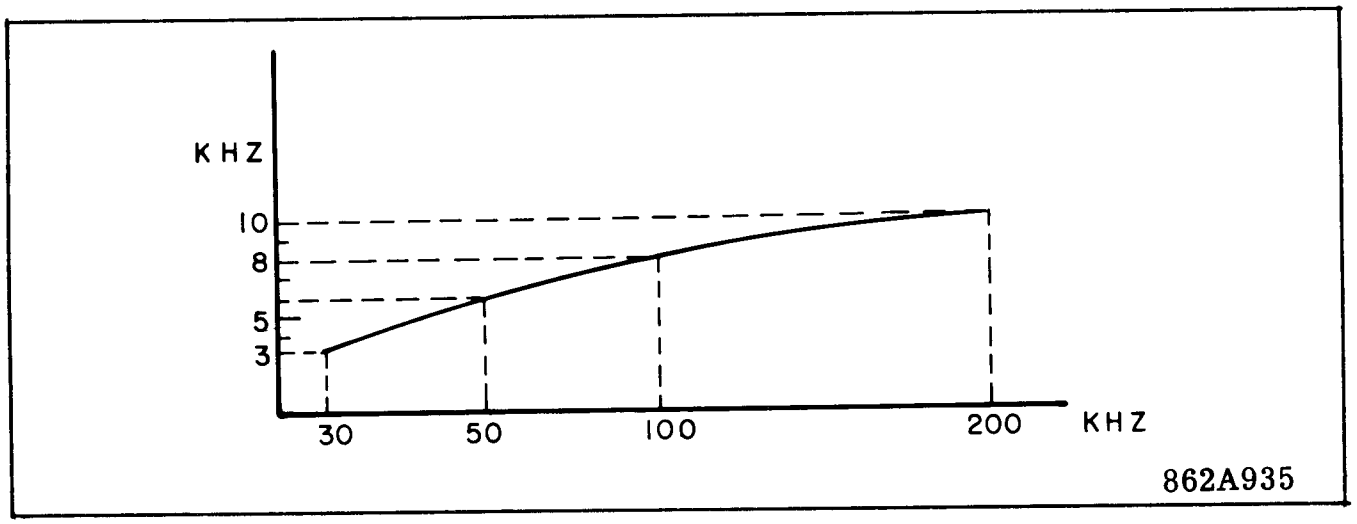


Fig. 12 Minimum Frequency Spacing For Two 10-watt Transmitters Operated in Parallel.

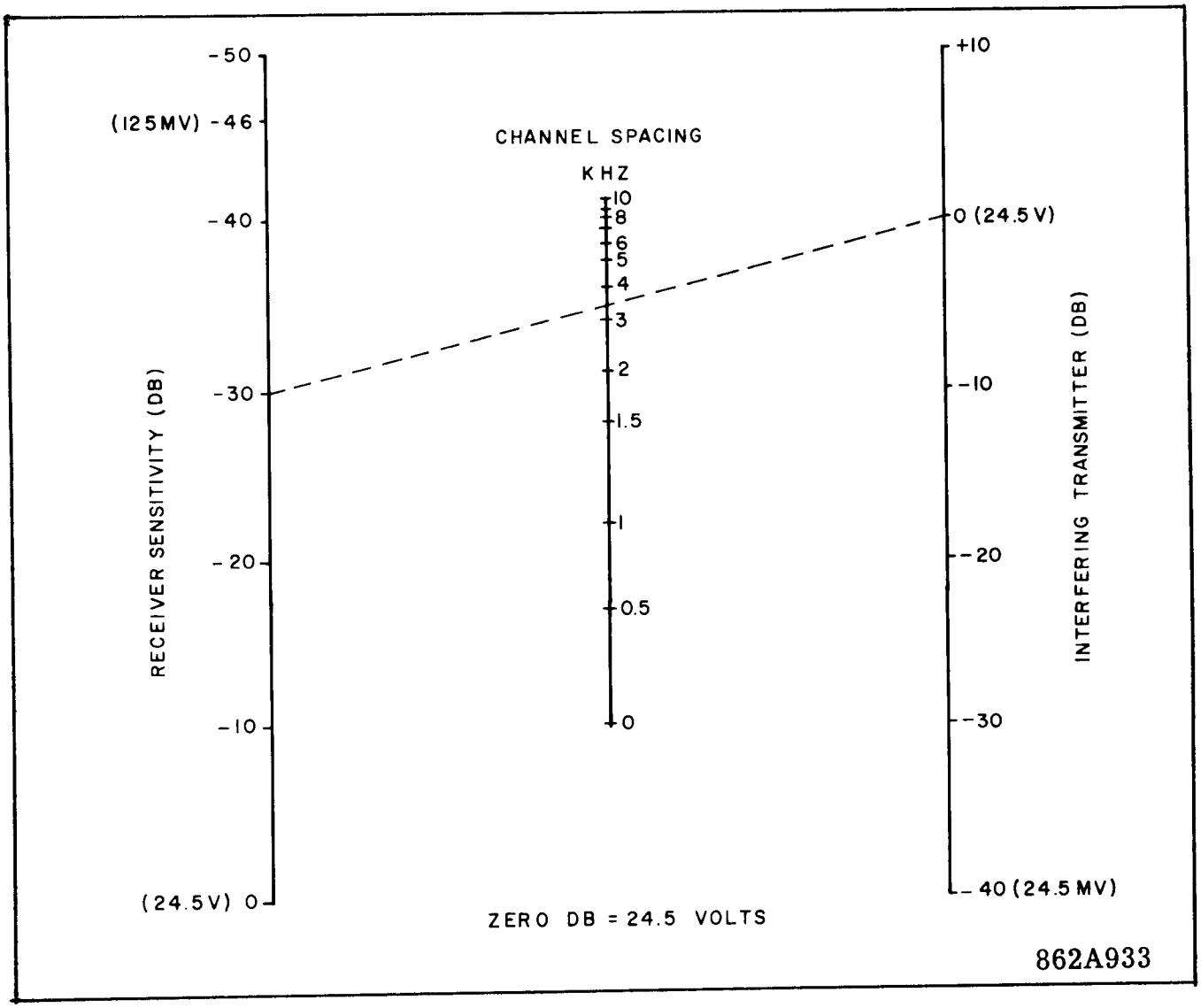


Fig. 13 Minimum Channel Spacing For Keyed Carrier 60 p.p.s.

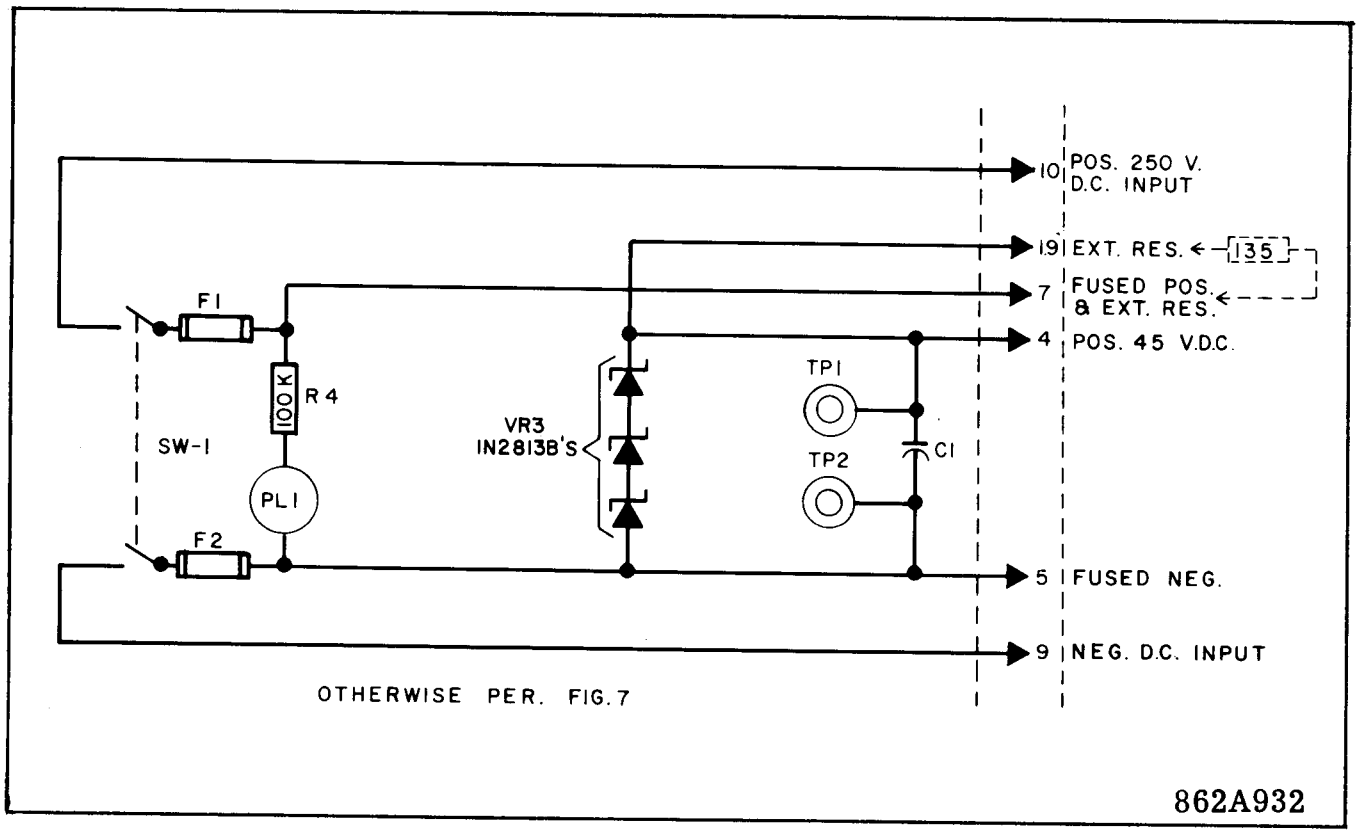


Fig. 14 Detail of Power Supply Section For 250-volt Supply

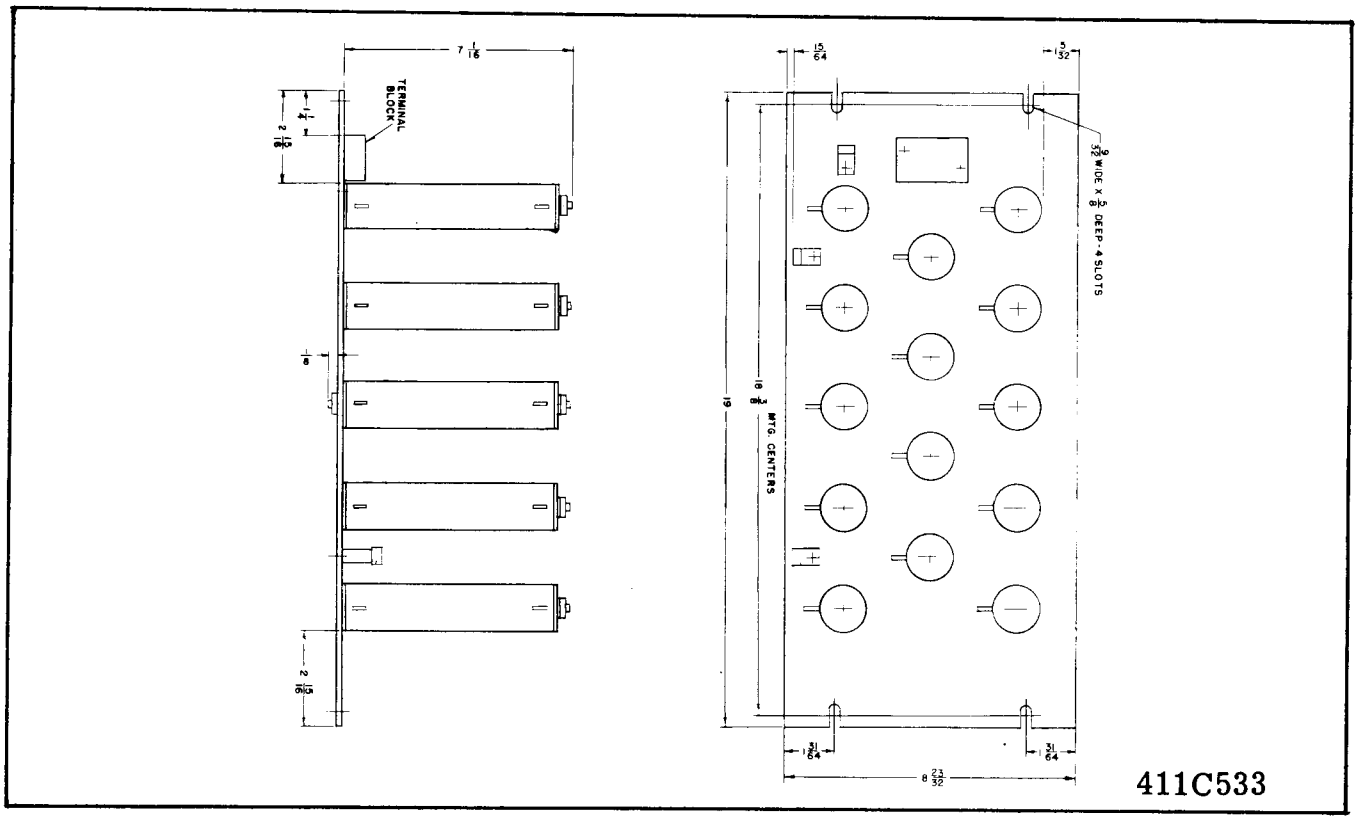


Fig. 15 Outline of External Resistor Unit For 250-volt Operation

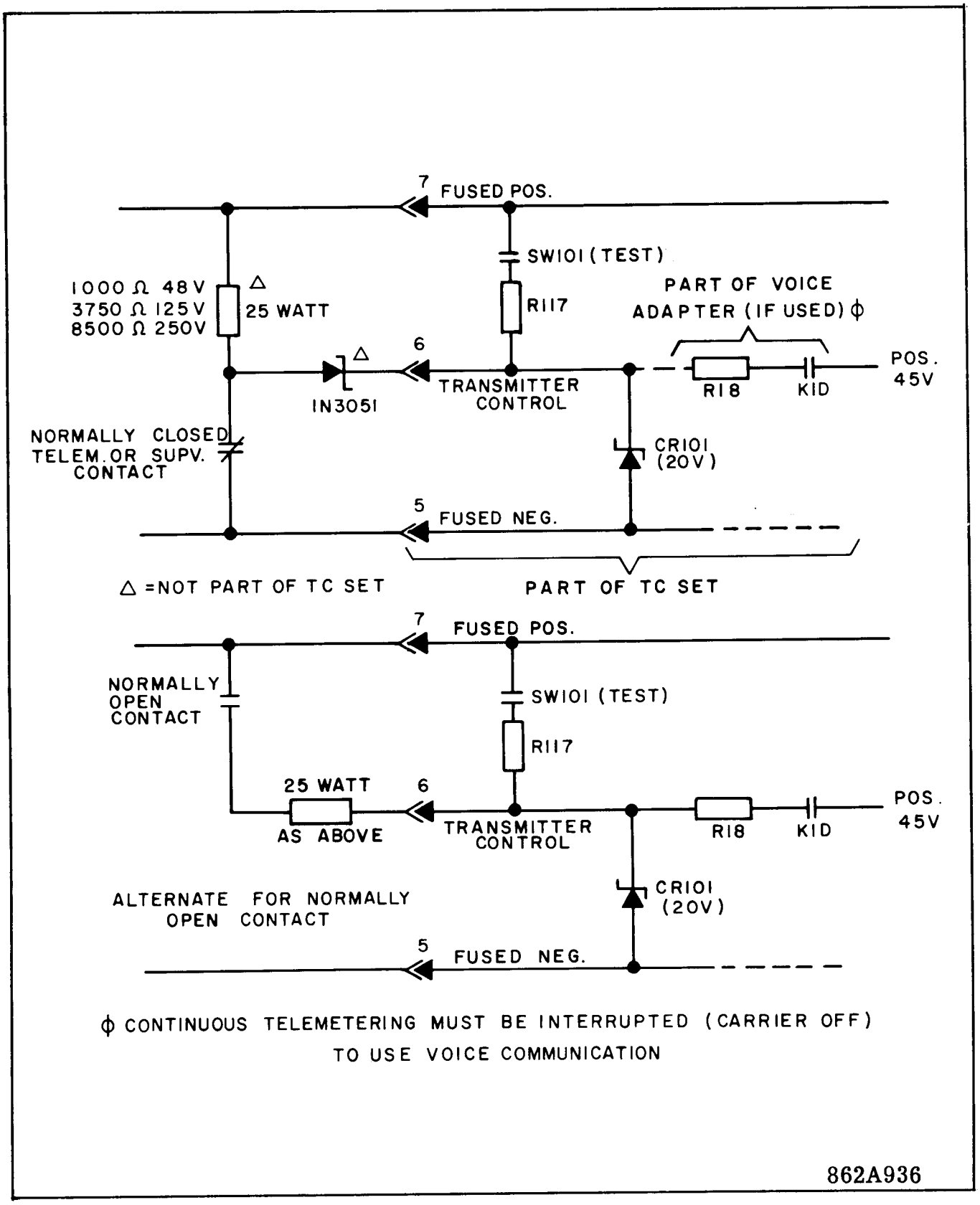
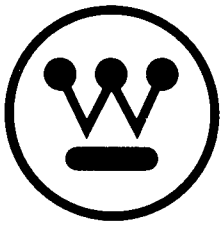


Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact



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

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LIST OF TABLES

LIST OF ILLUSTRATIONS

SUPERSEDES I.L. 41-944.31C
Complete Revision

EFFECTIVE JUNE 1969

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 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	30-200 kHz (50-200 kHz for phase comparison relaying)
Transmitter output	10 watts into 50 to 70-ohm resistive load
Harmonics	55 db below 10 watts
Receiver sensitivity	125 mv. input for 180 ma. minimum output current
Receiver selectivity	1500 Hz bandwidth (3 db down); down 80 db at ±3kHz.
Transmitter-receiver channel rating	40 db
Input voltage	48, 125, or 250 V. d-c
Supply voltage variation	42-56 V, 105-140V, 210-280 V
Battery Drain:	
48 V.D.C.	0.5 amp standby, 1.35 amp transmitting
125 V.D.C.	0.25 amp standby, 1.1 amp transmitting
250 V.D.C.	1.5 amp standby or transmitting
* Temperature range	−20 to +55°C around chassis

Frequency Spacing

The minimum recommended frequency spacing between two Type TC carrier sets operated in parallel without hybrid units is shown on the curve of Fig. 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 frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the −30 db point on the receiver sensitivity scale and the zero-db point on the interfering transmitter scale. The resulting line crosses the channel spacing scale between 3 and 4 kHz. For this example, a channel spacing of at least 4 kHz should be used. (In order not to conflict with the limits of Fig. 12, an r-f

hybrid may be needed between the TC set and the other transmitter, depending on the actual application.)

INSTALLATION

The type TC transmitter-receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60°C.

ADJUSTMENTS

Transmitter

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

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

1. First, measure the normal received signal from

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

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

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

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

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

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 Tables I through IV. Voltages should be measured with a VTVM. Readings may vary as much as ± 20%.

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. R110 Sensistor
   a. 30-60 kHz – 2200 ohms – S# 187A685H01
   b. 60.5-120 kHz – 1800 ohms – S# 187A685H02
   c. 120.5-200 kHz – 1200 ohms – S# 187A685H03

3. Capacitors C111 and C113
   a. 30-50 kHz – 0.47 mfd. – S# 188A293H01
   b. 50.5-75 kHz – 0.22 mfd. – S# 188A293H02
   c. 75.5-100 kHz – 0.15 mfd. – S# 188A293H03
   d. 100.5-150 kHz – 0.10 mfd. – S# 188A293H04
   e. 150.5-200 kHz – 0.047 mfd. – S# 188A293H05

4. FL101 and FL102

   Filter FL101 is a small series-resonant tuned circuit between the driver and power amplifier

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

Inductors L101, L102, and L103 in these filters are adjustable over a limited range, but thirty-two combinations of capacitors and inductors are required to cover the frequency range of 30 kHz to 200 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 12 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5
32.0-33.5	64.5- 68.0	120.0-127.0
34.0-36.0	68.5- 72.0	127.5-135.0
36.5-38.5	72.5- 76.0	135.5-143.0
39.0-41.0	76.5- 80.0	143.5-151.0
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	

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. 45 V. (TP206)

Test Point	Standby (No Signal)			With 125 M.V. Input		
TP201 TP202 TP203 TP204 TP205	38 0 11. .03 20			38 0 11. 2.2 20		
Transistor	E*	B*	C*	E*	B*	C*
Q201	38.5	37	43	38.5	37	43
Q202	38.5	37.5	43.5	38.5	37.5	43.5
Q203	0.08	0	18.7	0.08	0	18.7
Q204	2.7	2.9	18.7	2.7	2.9	18.7
Q205	2.4	2.6	18.7	2.5	2.7	18.7
Q206	2.5	2.7	10.5	2.6	2.8	10.5
Q207	0.13	0.03	22.0	2.0	2.2	4.0
Q208	0.25	0.15	45.0	1.7	2.0	2.0

*E — Emitter, B — Base, C — Collector

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

TABLE II

Receiver RF Measurements

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

Test Point	Typical A-C Voltages		Test Point	Typical A-C Voltages	
	36 kHz	132 kHz		36 kHz	132 kHz
FL201-IN to Gnd.	.075	.050	Q205-B to TP206	.11	.052
FL201-OUT to Gnd.	.051	.020	Q205-C to TP206	6.7	3.4
Q203 -E to TP206	.105	.090	Q206-B to TP206	.67	.37
Q203 -C to TP206	.22	.035	Q206-C to TP206	1.5	1.53
Q204 -B to TP206	.015	.012	TP202 to TP206	0.3	0.3
Q204 -C to TP206	.90	.52			

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

TABLE III

Transmitter D-C Measurements

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

Test Point	Carrier Off	Carrier On
TP101	7 volts d.c.	7 volts d.c.
TP102	0	20
TP103	0	19.5
TP105	0	9
TP106	44	22
TP107	44	22.2
TP108	45	44.8
TP110	* .5	* .6
TP111	.5	.6
TP112	0	0
TP113	45	45
J101 (Front Panel)	5 ma. max.	0.6 amp.

Transistor	E	B	C	E	B	C
Q101	6.0	7.8	2.5	6.1	7.7	2.5
Q102	6.6	7.1	1.2	6.6	7.1	1.1
Q103	0	0	0	19.5	19.4	9.0
Q104	0.1	0.1	45	0.5	0.9	45
Q105	0.1	0.1	45	0.5	0.9	45
Q106	0	0	44	0	0.9	1.2
Q107	43.7	43.7	0	22.2	22.2	0
Q108	45.0	44.7	44.7	44.8	44.8	22.3

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. Resistors R218, R224, and R230 may have to be reduced. See following paragraph.

   The emitter resistors R218, R224, and R230 of the i-f stages are selected during factory test to give the required receiver gain. This is desirable since the insertion loss of the input filter FL201 increases with frequency. If the operating frequency is reduced, the receiver gain will probably be higher. In this case, a reduction in the setting of the i-f input control R239 will give the 125-mv. sensitivity. If the new operating frequency is higher, the receiver gain will be lower. If more than 125 mv. is required to obtain 180 ma. output, the gain can be increased by reducing the value of one or more of the resistors R218, R224, and R230. In most cases, these resistors should fall in the range of 22 to 150 ohms. These three resistors are soldered to small terminal posts on the printed circuit board.

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 230 kHz, input impedance—one megohm, minimum.

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	Test Point	A-C Voltage
T101-3 to TP104	1.1 volts, rms.	Q107-B to TP107	.5 volts, rms.
TP103 to TP102	0.2	Q108-B to TP113	.5
Q103-C to TP104	0.7	Q107-C to TP107	14.5
TP110 to T102-4	0.2	Q108-C to TP113	14.5
* TP111 to T102-4	0.2	T105-4 to Gnd.	105
Q104-C to TP104	4.3	T106-2 to Gnd.	155*
Q105-C to TP104	4.3	TP109 to Gnd.	50*
T103-4 to Gnd.	1.5	J102 to Gnd.	24.5
T104-1 to Gnd.	1.4		

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

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 230kHz

c. Oscilloscope

d. Ohmmeter

e. Capacitor checker

f. Frequency counter

g. Frequency-selective voltmeter

Renewal Parts

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

ELECTRICAL PARTS LIST

Transmitter Section

Symbol	Rating	Style Number
C101	0.1 mfd, 200 V. DC	187A624H01
C102	.005 mfd, 300 V. DC	187A694H29
C103	180 pf. 500 V. DC	187A695H29
C104	0.25 mfd, 200 V. DC	187A624H02
C105	0.25 mfd, 200 V. DC	187A624H02
C106	0.25 mfd, 200 V. DC	187A624H02
C107	0.25 mfd, 200 V. DC	187A624H02
C108	0.50 mfd, 200 V. DC	187A624H03
C109	0.25 mfd, 200 V. DC	187A624H02
C110	0.25 mfd, 200 V. DC	187A624H02
† C111	(See Table Below)	–
C112	39 pfd, 500 V. DC	187A695H12
† C113	(See Table Below)	–
C114	100 pf., 500 V. DC	187A695H23
C115	100 pf., 500 V. DC	187A695H23
C116	0.001 mfd, 500 V. DC	187A694H11
CA	Part of FL101	Vary with Frequency
CB	Part of FL102	Vary with Frequency
CC		
CD		
CE		

† 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
75.5-100 kHz	0.15 mfd, 400 V. DC	188A293H03
100.5-150 kHz	0.1 mfd, 400 V. DC	188A293H04
150.5-200 kHz	0.047 mfd, 400 V. DC	188A293H05

CR101	1N3686B (20 V ± 5%)	185A212H06
CR102	1N457A	184A855H07
CR103	1N538	407C703H03
CR104	1N91	182A881H04
CR105	1N538	407C703H03
CR106	1N91	182A881H04
CR107	1N2999A (56 V ± 10%)	184A617H13
CR108	1N2999A (56 V ± 10%)	184A617H13
G101	Type TVS Arrester	637A026A01
J101	Closed Circuit Jack	187A606H01

*

ELECTRICAL PARTS LIST

Transmitter Section (Cont.)

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

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
R110 *				At End of List
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

*Sensistor -	30 - 60 kHz, 2.2K ± 10%, ¼ watt	187A685H01
	60.5-120 kHz, 1.8K ± 10%, ¼ watt	187A685H02
	120.5-200 kHz, 1.2K ± 10%, ¼ watt	187A685H03

ELECTRICAL PARTS LIST
Transmitter Section (Cont.)

Symbol	Ohms	± Tol. %	Watts	Style Number
R116	100	5	0.5	184A763H03
R117	1,000 48 V dc	5	25	1202588
	3,750 125 V dc	5	25	1202955
	8,500 250 V dc	5	25	1267310
R118	8,200	5	2	185A207H49
R119	100	5	0.5	184A763H03
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	0.27	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

Symbol	Rating		Style Number
T101	10,000/400 ohms	L633003	1962797
T102	10,000/400 c.t.	L592170	1962698
T103	1930/60 ohms	L633000	1962694
T104	Turns ratio, 1/0.5,	Pri./each sec.	292B526G01
T105	10/500 ohms		292B526G02
T106	500/50-60-70 ohms		292B526G03
* Y101	30-200 kHz crystal per 328C083		Specify Frequency

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
	CR201	1N3027B (20V ± 5%)	184A449H07
	CR202	1N91	182A881H04
	CR203	1N91	182A881H04
	CR204	1N538	407C703H03
*	CR205	1N538	407C703H03
*	CR206	1N1789 (56V. ± 10%)	584C434H08
	FL201	Receiver Input Filter 30-200 kHz	Specify Frequency
	FL202	Receiver i.f. Filter-20 kHz (2 Sections)	187A590G02
	J201	Receiver Coax. Input Jack	187A638H01
	J202	Closed Circuit Jack (20MA)	187A606H01
	J203	Closed Circuit Jack (200MA)	187A606H01
	L201	33 mh.	187A599H01
	Q201	2N274	187A270H01
	Q202	2N274	187A270H01
	Q203	2N274	187A270H01
	Q204	2N274	187A270H01
	Q205	2N274	187A270H01
	Q206	2N274	187A270H01
	Q207	2N398A	184A638H12
	Q208	2N1362	187A673H01

ELECTRICAL PARTS LIST
Receiver Section (Cont.)

Symbol	Rating			Style Number
Resistors	Ohms	± Tol. %	Watts	
R201	10,000	10	0.5	187A641H51
R202	2,200	10	0.5	187A641H35
R203	10,000	10	0.5	187A641H51
R204	100,000	5	0.5	184A763H75
R205	390	5	0.5	184A763H17
R206	1,200	5	0.5	184A763H29
R207	25 K Pot.	10	2	185A086H07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H75
R210	390	5	0.5	184A763H17
† R211	–	–	–	See † Note Below
R212	1 K Pot.	20	0.25	629A430H02
R213	1,200	5	0.5	184A763H29
R214	5,600	5	1	187A643H45
R215	20,000	5	0.5	184A763H58
R216	3,600	5	0.5	184A763H40
R217	620	5	0.5	184A763H22
R218	62	5	0.5	187A290H20
R219	10,000	10	0.5	187A641H51
R220	20,000	5	0.5	184A763H58
R221	300	5	0.5	184A763H14
R222	3,600	5	0.5	184A763H40
R223	620	5	0.5	184A763H22
R224	62	5	0.5	187A290H20
R225	10,000	10	0.5	187A641H51
R226	20,000	5	0.5	184A763H58
R227	300	5	0.5	184A763H14
R228	3,600	5	0.5	184A763H40
R229	620	5	0.5	184A763H22
R230	62	5	0.5	187A290H20
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	Rating			Style Number
	Ohms	± Tol. %	Watts	
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
T201	10,000/10,000 Ohms		L633005	1962798
T202	10,000/400 Ohms		L633003	1962797
T203	25,000/300 Ohms		L592171	1962697
Y201	50-220 kHz Crystal per 328C083			Specify Frequency

* Power Supply Section

Symbol	Function	Description or Rating	Style Number
C1	(+) to (–) bypass	0.45 mfd. 330 VAC	1723408
C2	A-C grounding	0.5 mfd. 1500 VDC	1877962
C3	A-C grounding	0.5 mfd. 1500 VDC	1877962
F1,F2	Overload Protection	1.5a, 48/125 VDC	11D9195H26
F1,F2	Overload Protection	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	125V Series dropping	26.5 ohms, 3½"	04D1299H44
R2	125V Series dropping	Same as R1	04D1299H44
R3	125V Current limiting	500 ohms, 3½"	1268047
	48V For 48 VDC, R1 = R2 0	–	–
	48V R3 = 26.5 ohms	3½"	04D1299H44
R4	Current limiting	100K, 0.5 watt	184A763H75
TP1	Test point (+)	Pin Jack - red	187A332H01
TP2	Test point (–)	Pin Jack - black	187A332H02
VR1	Voltage Regulator	1N2828B (45V.)	184A854H06
VR2	Surge Protection	1N3009A (130V.) Zener Diodes	184A617H12
VR3	Voltage Regulator	1N2813B (15V.)	184A854H11

† R238 - omit - above 50kHz

- 22K, 30-50kHz, s# 187A641H59

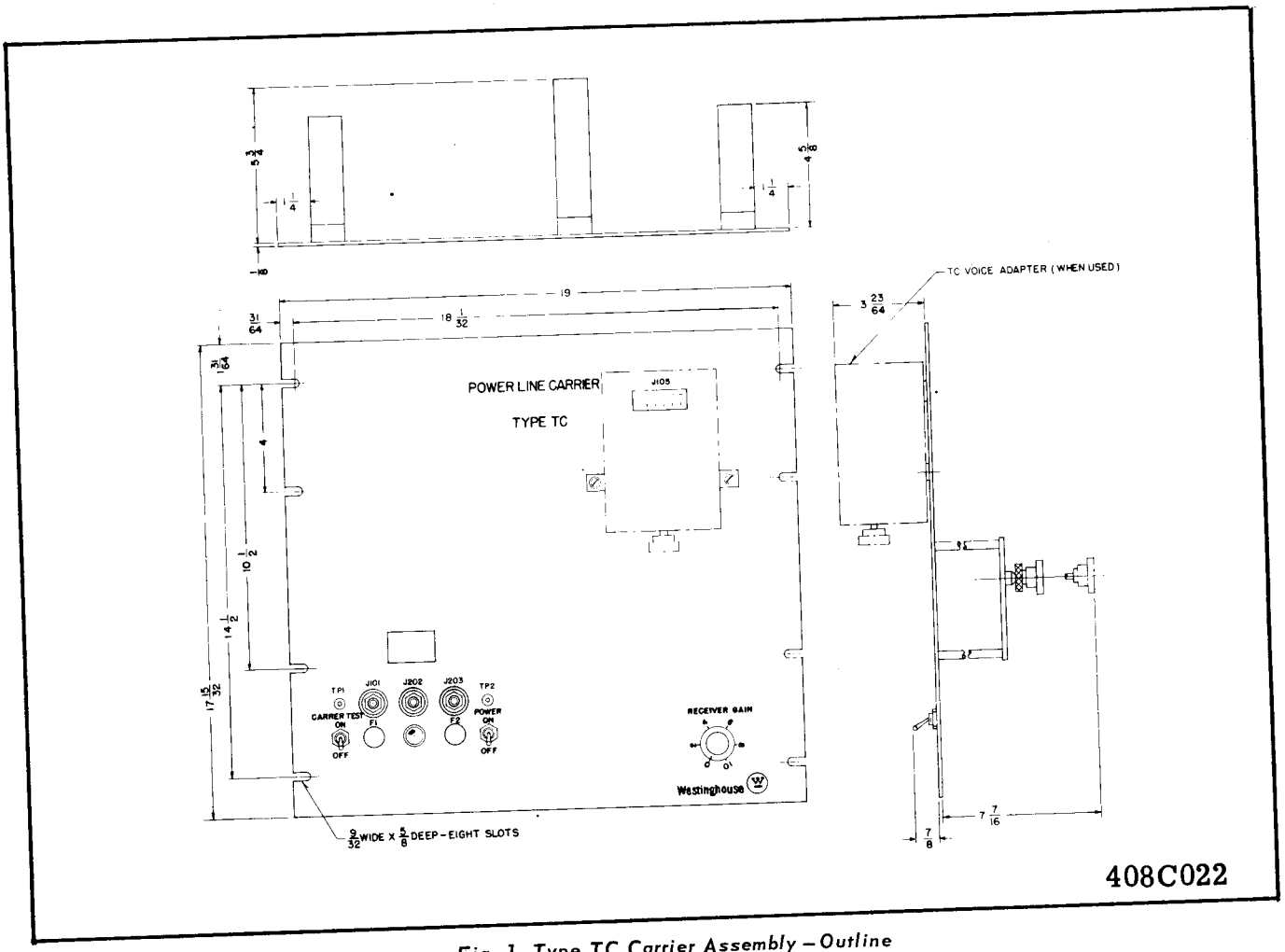


Fig. 1 Type TC Carrier Assembly – Outline

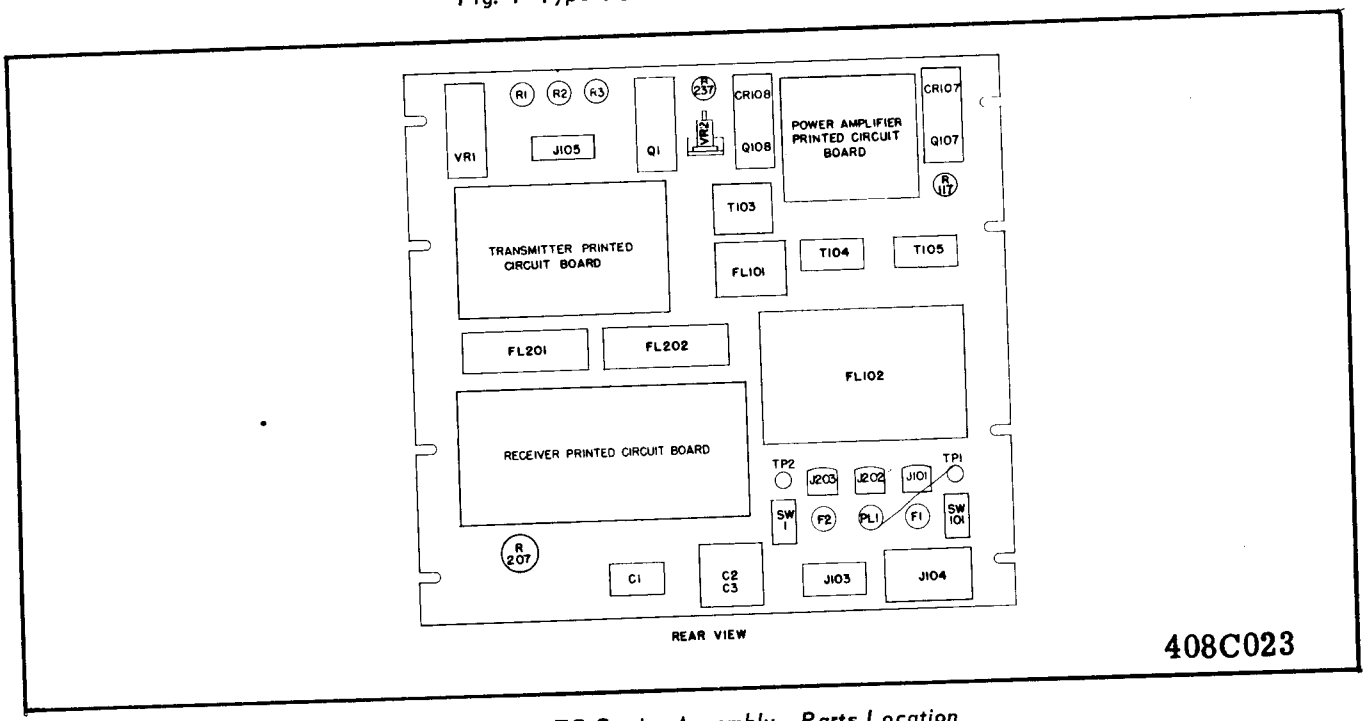


Fig. 2 Type TC Carrier Assembly – Parts Location

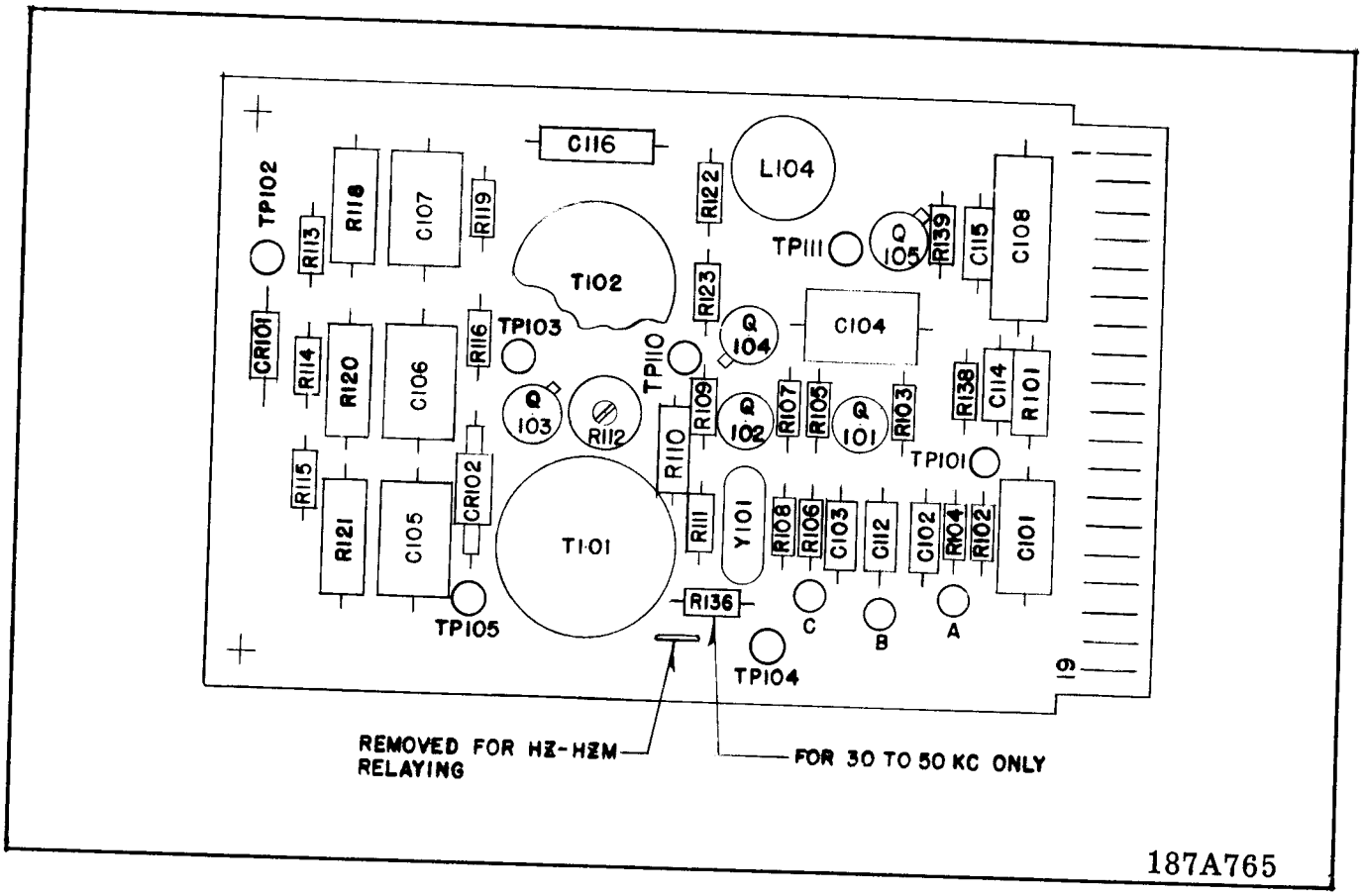


Fig. 3 Transmitter Printed Circuit – Parts Location

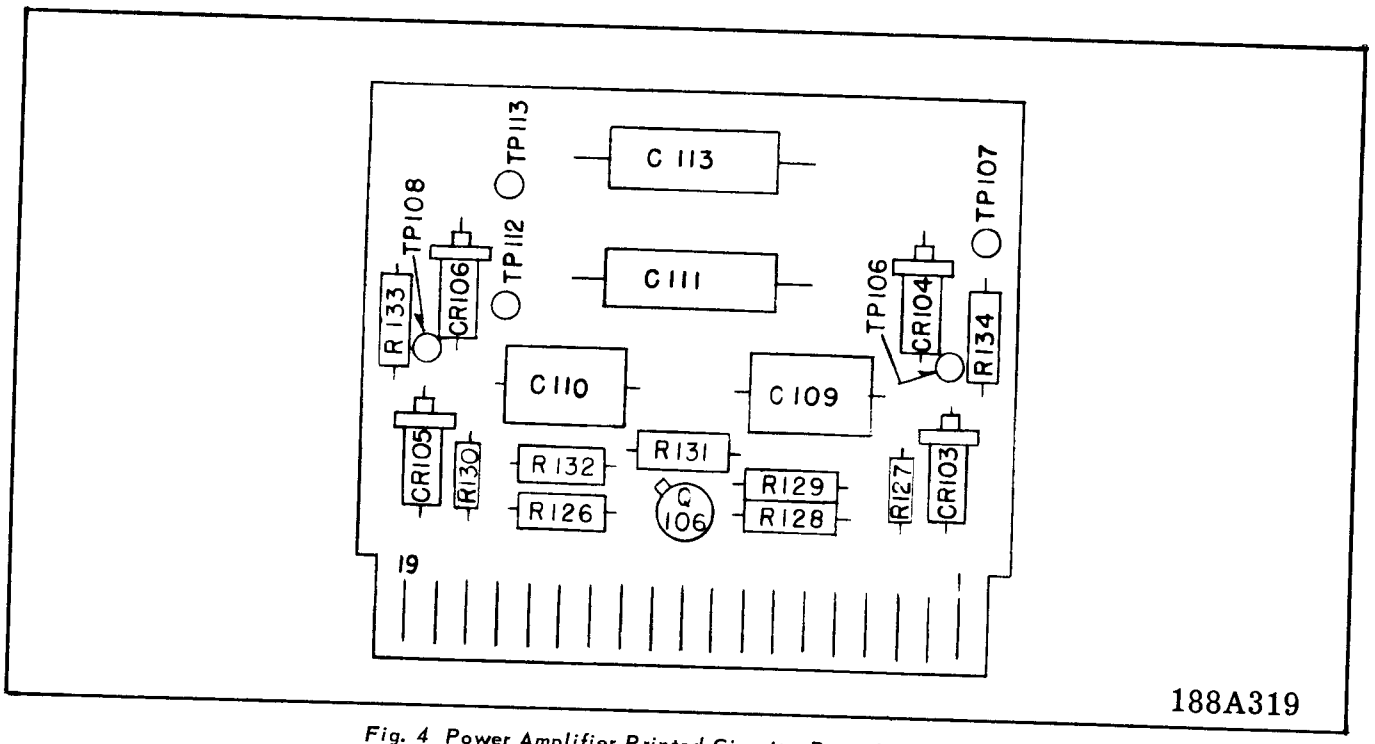


Fig. 4 Power Amplifier Printed Circuit – Parts Location

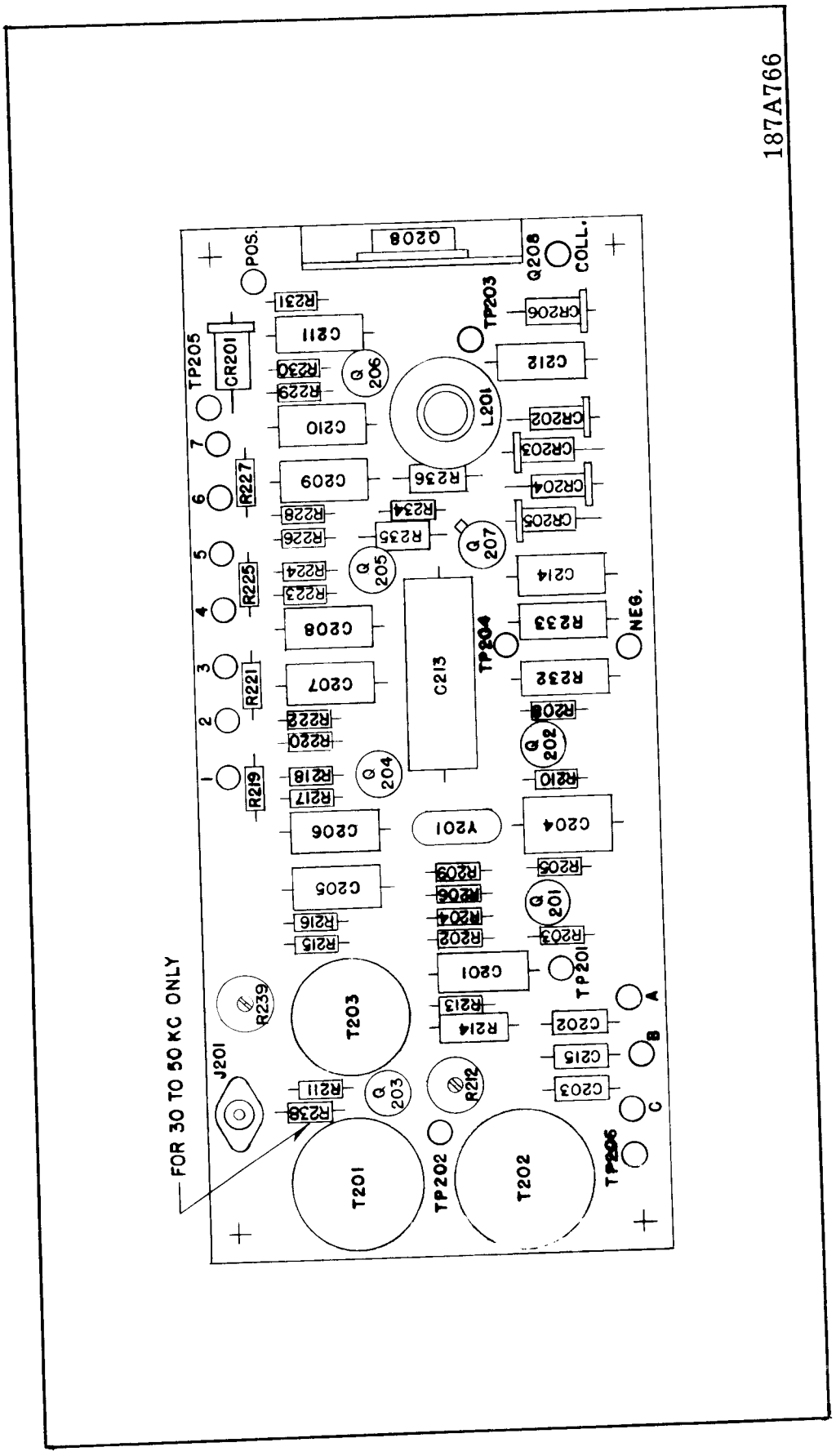


Fig. 5 Receiver Printed Circuit – Parts Location

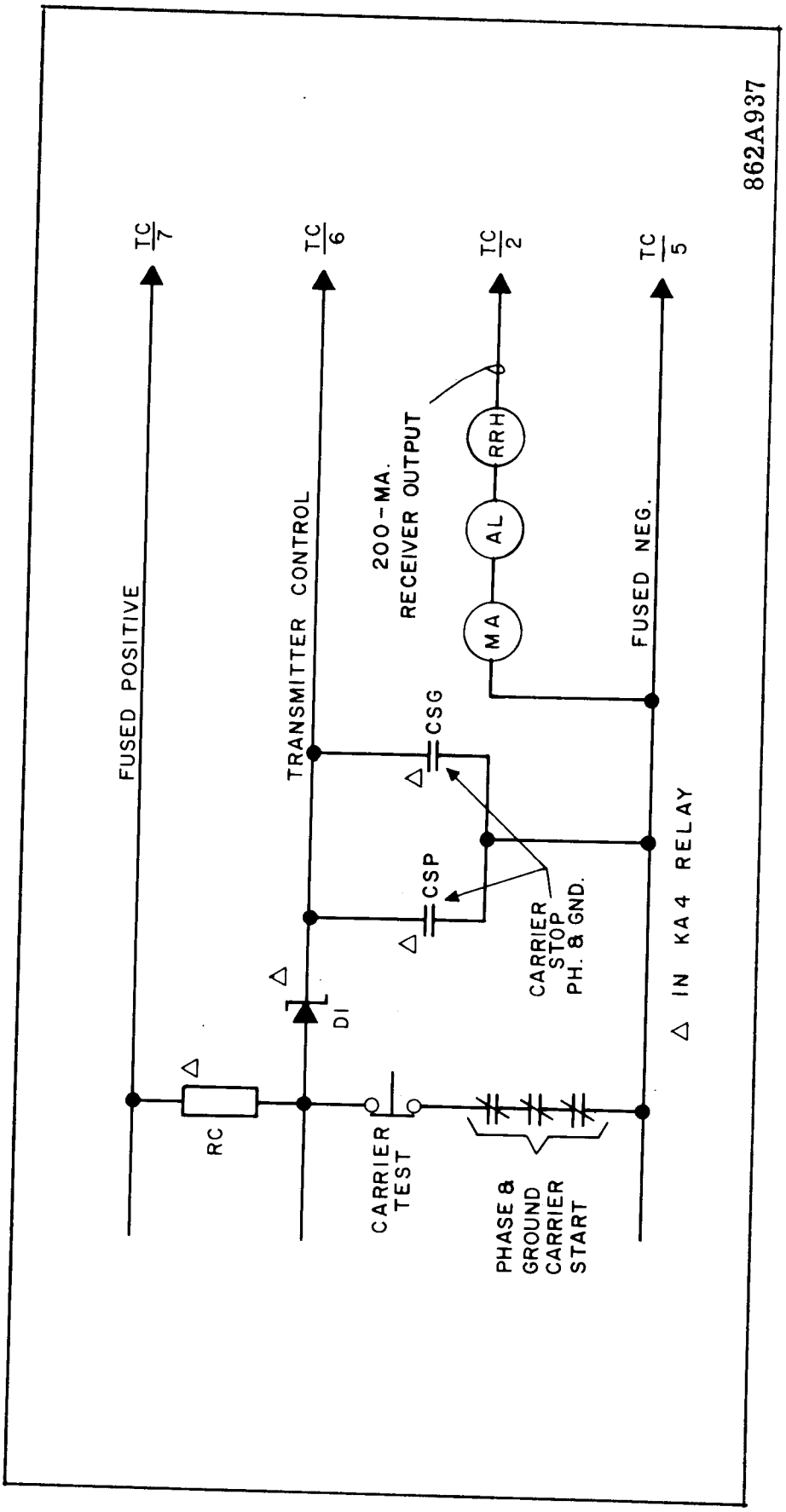
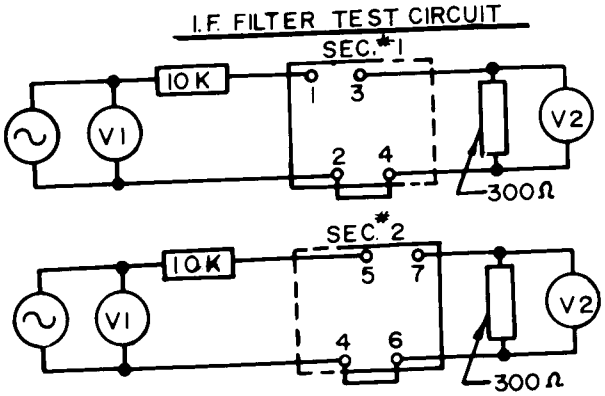
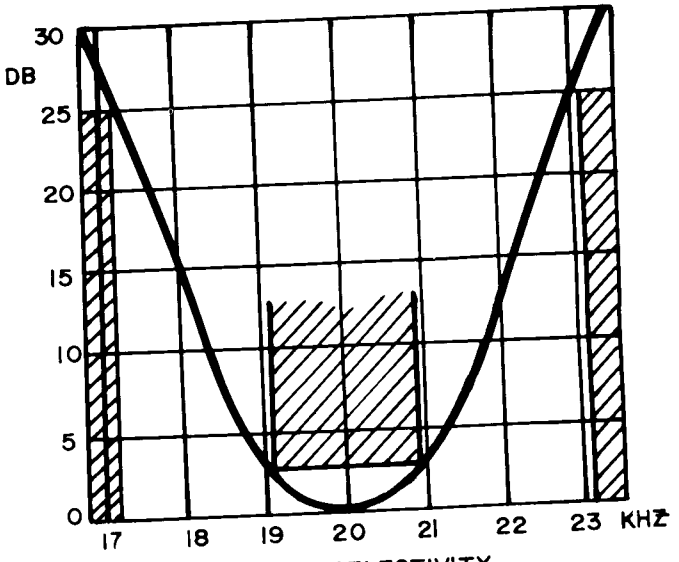


Fig. 6 Elementary K-Dar Carrier Control Circuits.

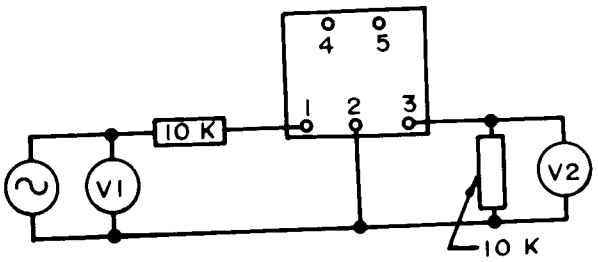
I.F. FILTER TEST CIRCUIT





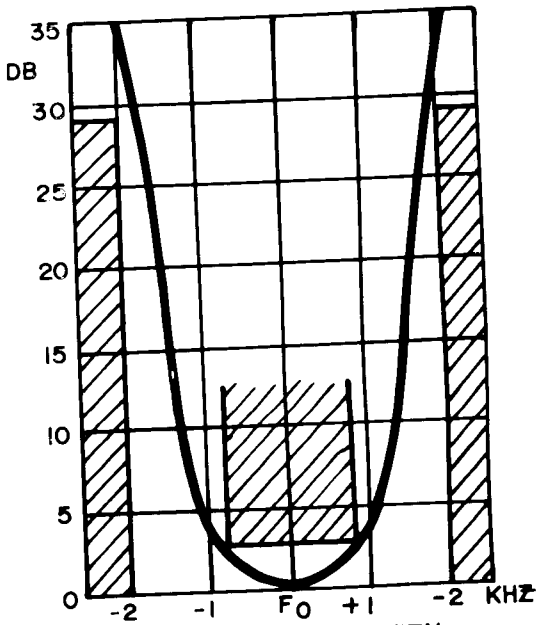
TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.

INPUT FILTER TEST CIRCUIT



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

TC RECEIVER FILTER LIMITS



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

629A425

Fig. 8 Type TC Receiver Filter Characteristics

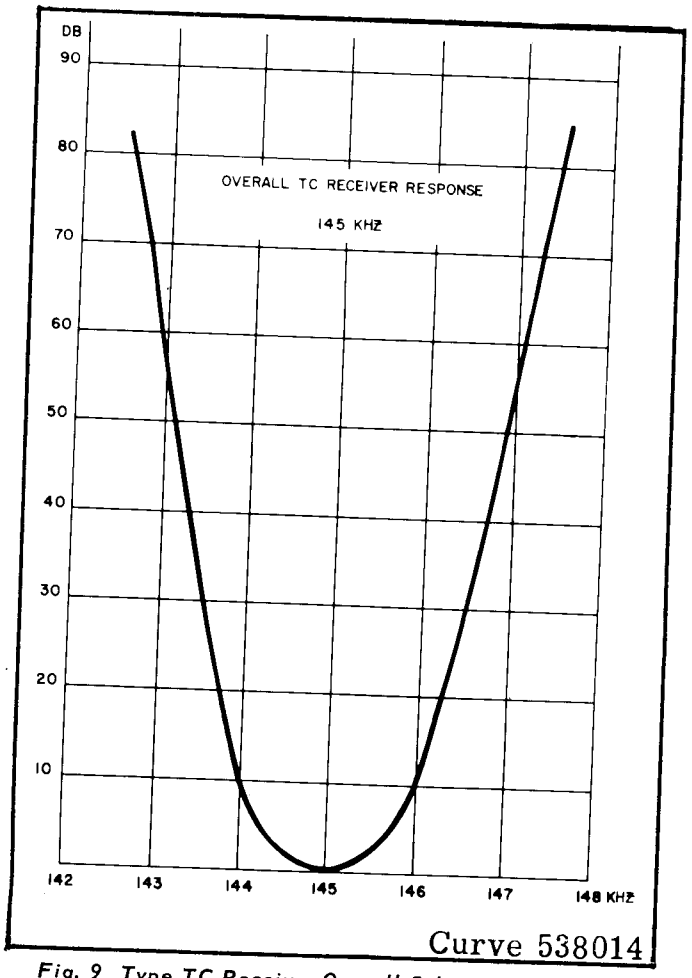


Fig. 9 Type TC Receiver Overall Selectivity Curve

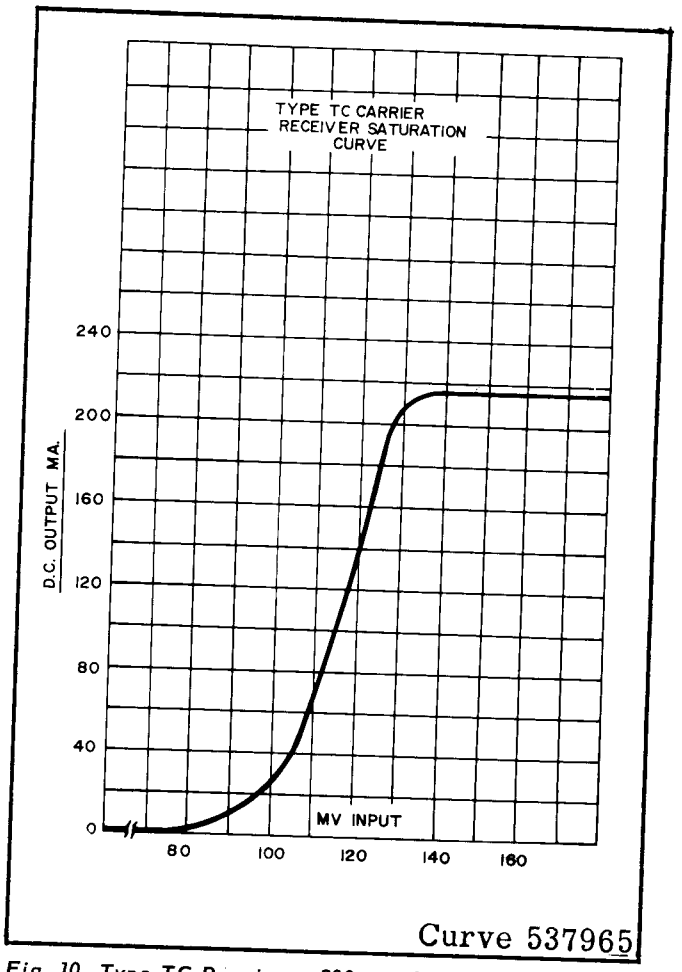


Fig. 10 Type TC Receiver – 200 ma. Output Characteristic.

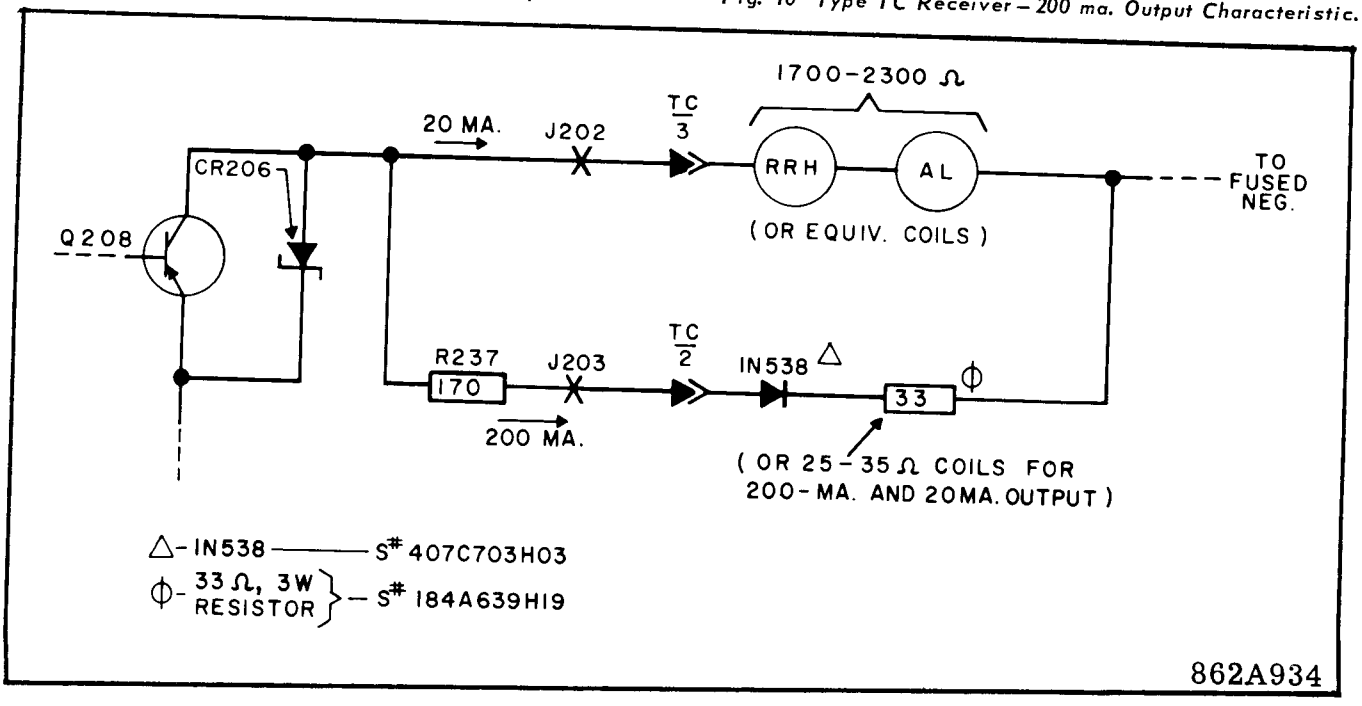


Fig. 11. TC Receiver Output For 20-ma. Operation

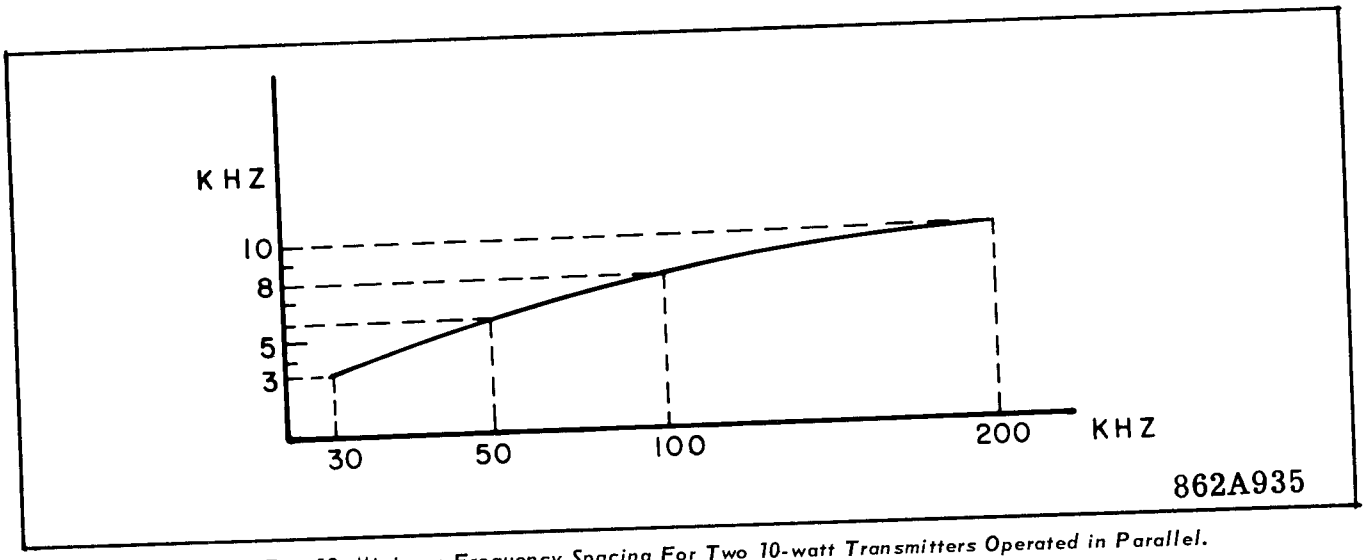


Fig. 12 Minimum Frequency Spacing For Two 10-watt Transmitters Operated in Parallel.

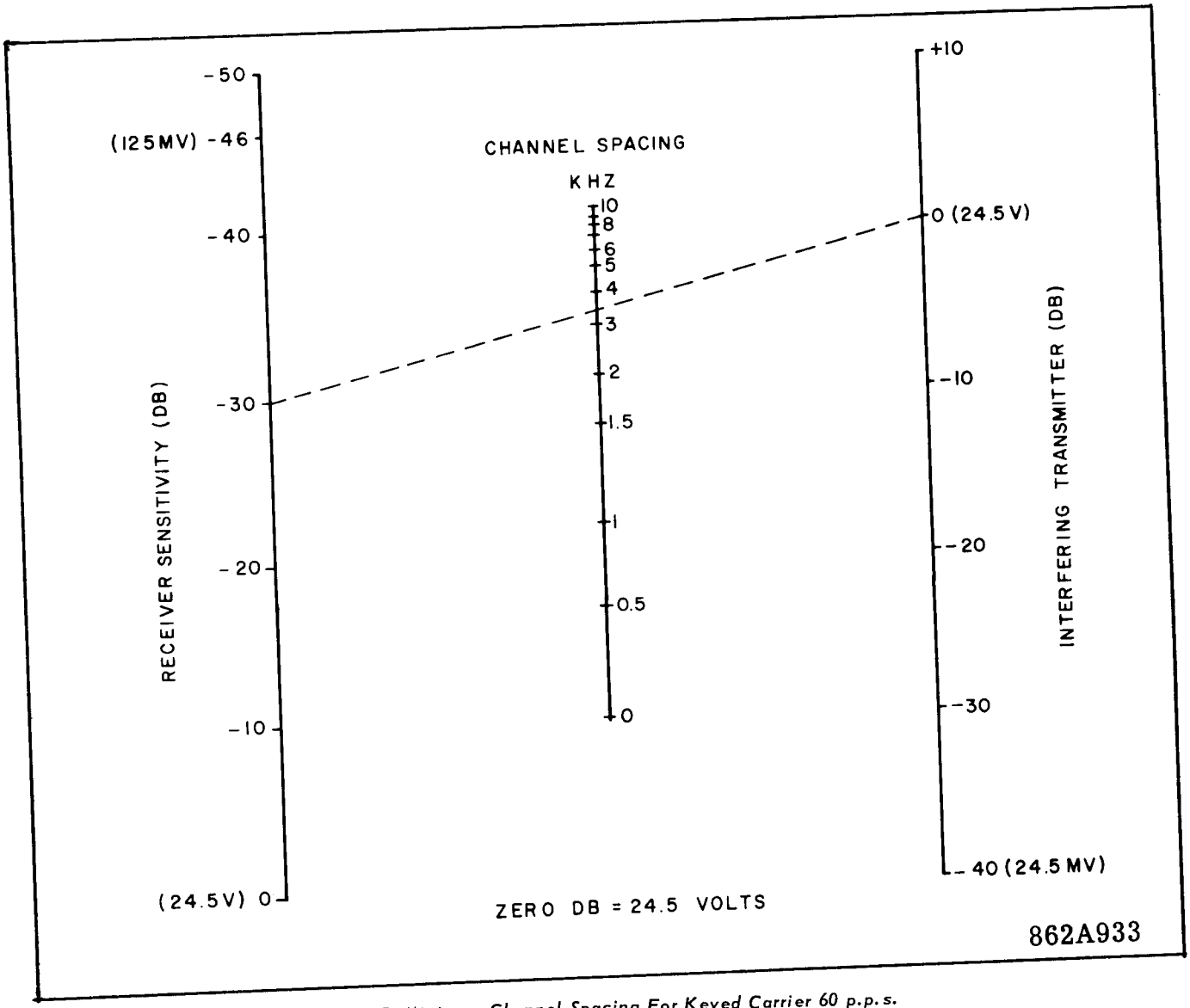


Fig. 13 Minimum Channel Spacing For Keyed Carrier 60 p.p.s.

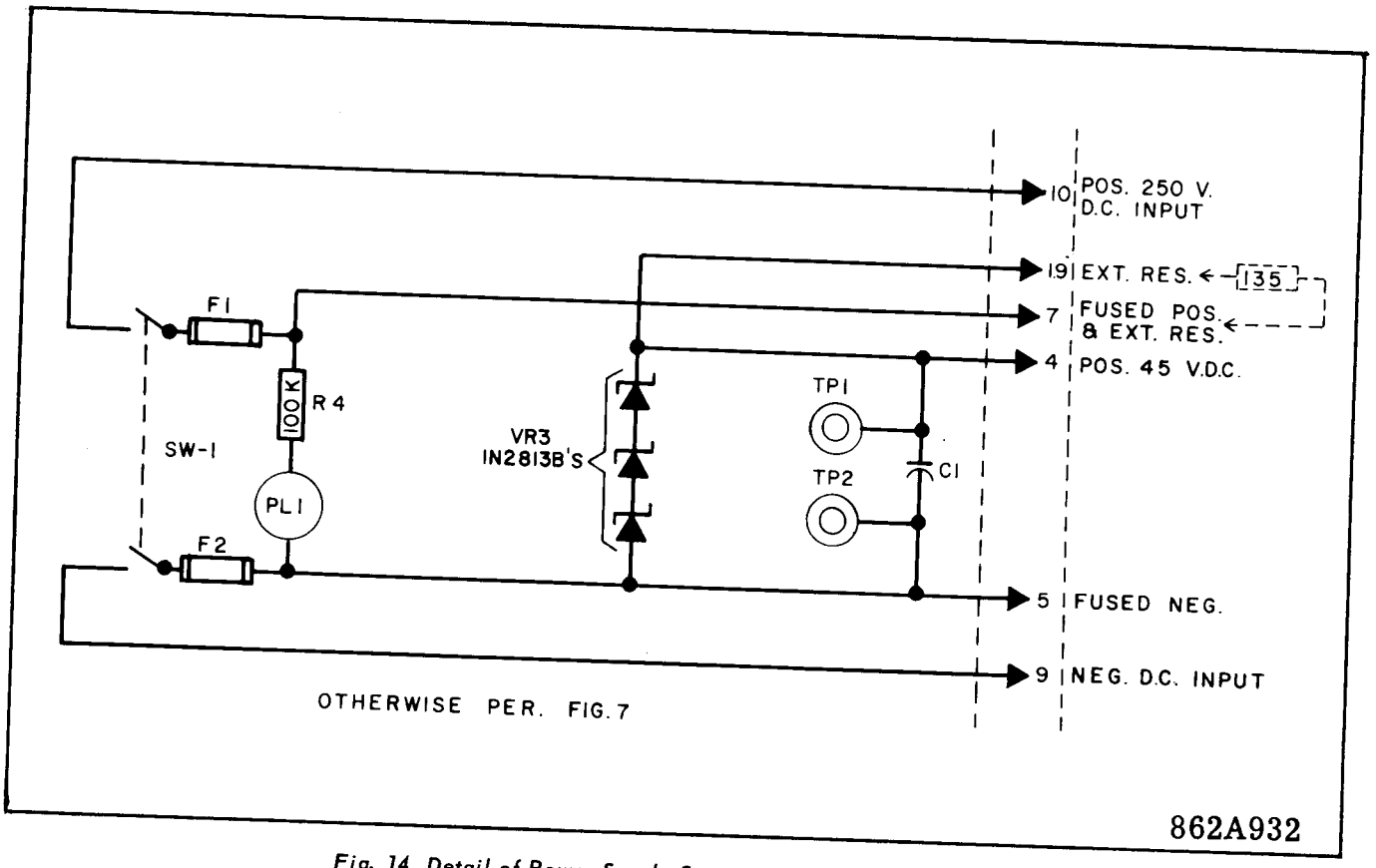


Fig. 14 Detail of Power Supply Section For 250-volt Supply

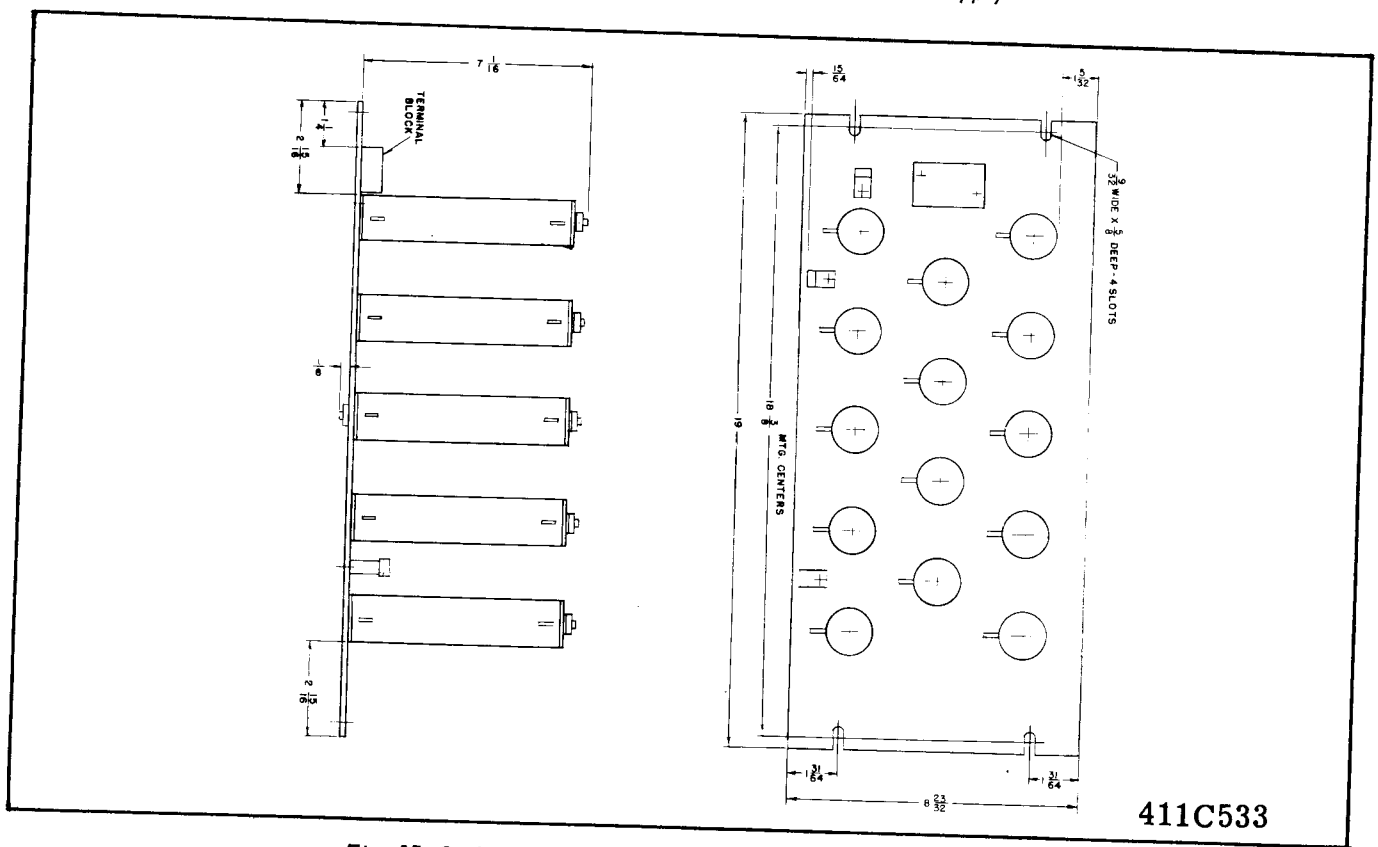


Fig. 15 Outline of External Resistor Unit For 250-volt Operation

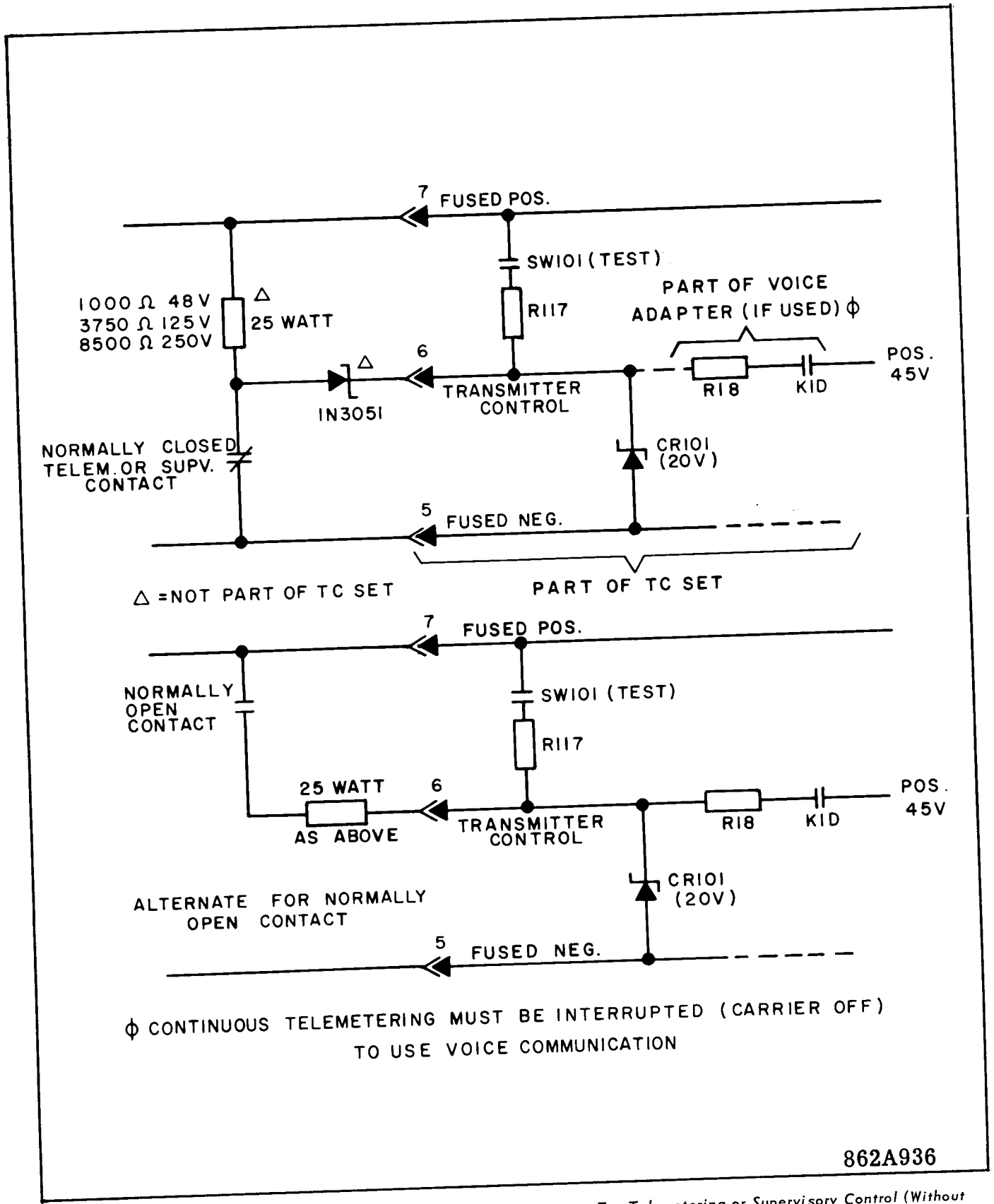
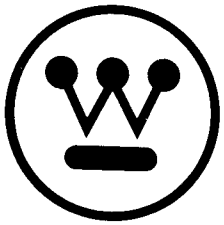


Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact



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

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SUPERSEDES I.L. 41-944.31B
Complete Revision

EFFECTIVE MARCH 1968

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 directional or phase comparison protective relaying of power transmission lines. It can also be used for other functions including 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.

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 Q101 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 uses two series-connected type 2N1908 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 CR103 and CR105 provide protection for the base-emitter junction of the power transistors. Zener diodes CR107 and CR108 protect the collector-emitter junctions from surges which might come in from the power line through the coaxial cable.

The output transformer T105 couples the power transistors to the transmitter output filter FL102. The output filter includes two trap circuits (L102, C_B, and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G101 is a small lightning arrester to limit the magnitude of switching

surges or other line disturbances reaching the carrier set through the line tuner and coaxial cable. Auto-transformer T106 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms.

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

Receiver

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

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

Mixing is accomplished by feeding the incoming signal to the emitter, and the receiver oscillator signal to the base of the mixer Q203. Mixer oscillator requirements are met through adjustment of potentiometer R212. Injection into two separate elements, base and emitter, provides a circuit capable of handling greater signal level variations than one in which injection is made into only a single element such as the base. This receiver uses an intermediate frequency of 20 kHz. Typical characteristics of both filters and the complete receiver are shown on curves, Fig. 8 and 9.

The 20-kHz i.f. signal is rectified by diodes CR202 and CR203. 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 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 VR1 holds a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the d-c voltage drop through the transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage of approximately 45-v. d-c. The zener diode VR2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

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.

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 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 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	30-200 kHz (50-200 kHz for phase comparison relaying)
Transmitter output	10 watts into 50 to 70-ohm resistive load
Harmonics	55 db below 10 watts
Receiver sensitivity	125 mv. input for 180 ma. minimum output current
Receiver selectivity	1500 Hz bandwidth (3 db down); down 80 db at ±3kHz.
Transmitter-receiver channel rating	40 db
Input voltage	48, 125, or 250 V. d-c
Supply voltage variation	42-56 V, 105-140V, 210-280 V
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 frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the −30 db point on the receiver sensitivity scale and the zero-db point on the interfering transmitter scale. The resulting line crosses the channel spacing scale between 3 and 4 kHz. For this example, a channel spacing of at least 4 kHz should be used. (In order not to conflict with the limits of Fig. 12, an r-f

hybrid may be needed between the TC set and the other transmitter, depending on the actual application.)

INSTALLATION

The type TC transmitter-receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60°C.

ADJUSTMENTS

Transmitter

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

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

1. First, measure the normal received signal from

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

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

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

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

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

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 Tables I through IV. Voltages should be measured with a VTVM. Readings may vary as much as ± 20%.

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. R110 Sensistor

   a. 30-60 kHz – 2200 ohms – S# 187A685H01
   b. 60.5-120 kHz – 1800 ohms – S# 187A685H02
   c. 120.5-200 kHz – 1200 ohms – S# 187A685H03

3. Capacitors C111 and C113

   a. 30-50 kHz – 0.47 mfd. – S# 188A293H01
   b. 50.5-75 kHz – 0.22 mfd. – S# 188A293H02
   c. 75.5-100 kHz – 0.15 mfd. – S# 188A293H03
   d. 100.5-150 kHz – 0.10 mfd. – S# 188A293H04
   e. 150.5-200 kHz – 0.047 mfd. – S# 188A293H05

4. FL101 and FL102

   Filter FL101 is a small series-resonant tuned circuit between the driver and power amplifier

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

Inductors L101, L102, and L103 in these filters are adjustable over a limited range, but thirty-two combinations of capacitors and inductors are required to cover the frequency range of 30 kHz to 200 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 12 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5
32.0-33.5	64.5- 68.0	120.0-127.0
34.0-36.0	68.5- 72.0	127.5-135.0
36.5-38.5	72.5- 76.0	135.5-143.0
39.0-41.0	76.5- 80.0	143.5-151.0
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	

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. 45 V. (TP206)

Test Point	Standby (No Signal)			With 125 M.V. Input		
TP201 TP202 TP203 TP204 TP205	38 0 Q206 Collector Q207 Base 20			38 0 See Transistor d-c Values 20		
Transistor	E*	B*	C*	E*	B*	C*
Q201	38.5	37	43	38.5	37	43
Q202	38.5	37.5	43.5	38.5	37.5	43.5
Q203	0.08	0	18.7	0.08	0	18.7
Q204	2.7	2.9	18.7	2.7	2.9	18.7
Q205	2.4	2.6	18.7	2.5	2.7	18.7
Q206	2.5	2.7	10.5	2.6	2.8	10.5
Q207	0.13	0.03	22.0	2.0	2.2	4.0
Q208	0.25	0.15	45.0	1.7	2.0	2.0

*E – Emitter, B – Base, C – Collector
All voltages read with d-c vacuum-tube voltmeter.

TABLE II

Receiver RF Measurements

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

Test Point	Typical A-C Voltages		Test Point	Typical A-C Voltages	
	36 kHz	132 kHz		36 kHz	132 kHz
FL201-IN to Gnd.	.075	.050	Q205-B to TP206	.11	.052
FL201-OUT to Gnd.	.051	.020	Q205-C to TP206	6.7	3.4
Q203 -E to TP206	.105	.090	Q206-B to TP206	.67	.37
Q203 -C to TP206	.22	.035	Q206-C to TP206	1.5	1.53
Q204 -B to TP206	.015	.012	TP202 to TP206	0.3	0.3
Q204 -C to TP206	.90	.52			

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

TABLE III

Transmitter D-C Measurements

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

Test Point	Carrier Off	Carrier On
TP101	7 volts d.c.	7 volts d.c.
TP102	0	20
TP103	0	19.5
TP105	0	9
TP106	44	22
TP107	44	22.2
TP108	45	44.8
TP110	0.1	0.9
TP111	0.1	0.9
TP112	0	0
TP113	45	45
J101 (Front Panel)	5 ma. max.	0.6 amp.

Transistor	E	B	C	E	B	C
Q101	6.0	7.8	2.5	6.1	7.7	2.5
Q102	6.6	7.1	1.2	6.6	7.1	1.1
Q103	0	0	0	19.5	19.4	9.0
Q104	0.1	0.1	45	0.5	0.9	45
Q105	0.1	0.1	45	0.5	0.9	45
Q106	0	0	44	0	0.9	1.2
Q107	43.7	43.7	0	22.2	22.2	0
Q108	45.0	44.7	44.7	44.8	44.8	22.3

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. Resistors R218, R224, and R230 may have to be reduced. See following paragraph.

   The emitter resistors R218, R224, and R230 of the i-f stages are selected during factory test to give the required receiver gain. This is desirable since the insertion loss of the input filter FL201 increases with frequency. If the operating frequency is reduced, the receiver gain will probably be higher. In this case, a reduction in the setting of the i-f input control R239 will give the 125-mv. sensitivity. If the new operating frequency is higher, the receiver gain will be lower. If more than 125 mv. is required to obtain 180 ma. output, the gain can be increased by reducing the value of one or more of the resistors R218, R224, and R230. In most cases, these resistors should fall in the range of 22 to 150 ohms. These three resistors are soldered to small terminal posts on the printed circuit board.

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 230 kHz, input impedance—one megohm, minimum.

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	Test Point	A-C Voltage
T101-3 to TP104	1.1 volts, rms.	Q107-B to TP107	.5 volts, rms.
TP103 to TP102	0.2	Q108-B to TP113	.5
Q103-C to TP104	0.7	Q107-C to TP107	14.5
T102-3 to T102-4	0.2	Q108-C to TP113	14.5
T102-5 to T102-4	0.2	T105-4 to Gnd.	105
Q104-C to TP104	4.3	T106-2 to Gnd.	155*
Q105-C to TP104	4.3		
T103-4 to Gnd.	1.5	TP109 to Gnd.	50*
T104-1 to Gnd.	1.4	J102 to Gnd.	24.5

NOTE:

T103-3 = 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

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 230kHz

c. Oscilloscope

d. Ohmmeter

e. Capacitor checker

f. Frequency counter

g. Frequency-selective voltmeter

Renewal Parts

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

ELECTRICAL PARTS LIST
Transmitter Section

Symbol	Rating	Style Number
C101	0.1 mfd, 200 V. DC	187A624H01
C102	.005 mfd, 300 V. DC	187A694H29
C103	180 pf. 500 V. DC	187A695H29
C104	0.25 mfd, 200 V. DC	187A624H02
C105	0.25 mfd, 200 V. DC	187A624H02
C106	0.25 mfd, 200 V. DC	187A624H02
C107	0.25 mfd, 200 V. DC	187A624H02
C108	0.50 mfd, 200 V. DC	187A624H03
C109	0.25 mfd, 200 V. DC	187A624H02
C110	0.25 mfd, 200 V. DC	187A624H02
† C111	(See Table Below)	–
C112	39 pfd, 500 V. DC	187A695H12
† C113	(See Table Below)	–
C114	100 pf., 500 V. DC	187A695H23
C115	100 pf., 500 V. DC	187A695H23
C116	0.001 mfd, 500 V. DC	187A694H11
CA	Part of FL101	Vary with Frequency
CB	Part of FL102	Vary with Frequency
CC		
CD		
CE		

† FREQ.	C111, C113	Style Number
30- 50 KC	0.47 mfd, 400 V. DC	188A293H01
50.5- 75 KC	0.22 mfd, 400 V. DC	188A293H02
75.5-100 KC	0.15 mfd, 400 V. DC	188A293H03
100.5-150 KC	0.1 mfd, 400 V. DC	188A293H04
150.5-200 KC	0.047 mfd, 400 V. DC	188A293H05

CR101	1N3686B (20 V ± 5%)	185A212H06
CR102	1N457A	184A855H07
CR103	1N538	407C703H03
CR104	1N91	182A881H04
CR105	1N538	407C703H03
CR106	1N91	182A881H04
CR107	1N2999A (56 V ± 10%)	184A617H13
CR108	1N2999A (56 V ± 10%)	184A617H13
G101	Type TVS Arrester	637A026A01
J101	Closed Circuit Jack	187A606H01

ELECTRICAL PARTS LIST

Transmitter Section (Cont.)

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

Symbol	Ohms	± Tol. %	Watts	Style Number
R101	5,600	5	1	187A643H45
R102	2,200	10	0.5	187A641H35
R103	10,000	10	0.5	187A641H51
R104	100,000	5	0.5	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
R110 *				At End of List
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

*Sensistor - 30 - 60 kHz, 2.2K ± 10%, ¼ watt	187A685H01
60.5-120 kHz, 1.8K ± 10%, ¼ watt	187A685H02
120.5-200 kHz, 1.2K ± 10%, ¼ watt	187A685H03

ELECTRICAL PARTS LIST
Transmitter Section (Cont.)

Symbol	Ohms	± Tol. %	Watts	Style Number
R116	100	5	0.5	184A763H03
R117	1,000 48 V dc	5	25	1202588
	3,750 125 V dc	5	25	1202955
	8,500 250 V dc	5	25	1267310
R118	8,200	5	2	185A207H49
R119	100	5	0.5	184A763H03
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	0.27	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

Symbol	Rating		Style Number
T101	10,000/400 ohms	L633003	1962797
T102	10,000/400 c.t.	L592170	1962698
T103	1930/60 ohms	L633000	1962694
T104	Turns ratio, 1/0.5,	Pri./each sec.	292B526G01
T105	10/500 ohms		292B526G02
T106	500/50-60-70 ohms		292B526G03
Y101	30-200 kc crystal per 328C083		Specify Frequency

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
CR201	1N3027B (20V ± 5%)	184A449H07
CR202	1N91	182A881H04
CR203	1N91	182A881H04
CR204	1N538	407C703H03
CR204	1N538	407C703H03
CR205	1N1789 (56V. ± 10%)	584C434H08
FL201	Receiver Input Filter 30-200 kHz	Specify Frequency
FL202	Receiver i.f. Filter-20 kHz (2 Sections)	187A590G02
J201	Receiver Coax. Input Jack	187A638H01
J202	Closed Circuit Jack (20MA)	187A606H01
J203	Closed Circuit Jack (200MA)	187A606H01
L201	33 mh.	187A599H01
Q201	2N274	187A270H01
Q202	2N274	187A270H01
Q203	2N274	187A270H01
Q204	2N274	187A270H01
Q205	2N274	187A270H01
Q206	2N274	187A270H01
Q207	2N398A	184A638H12
Q208	2N1362	187A673H01

ELECTRICAL PARTS LIST
Receiver Section (Cont.)

Symbol	Rating			Style Number
Resistors	Ohms	± Tol. %	Watts	
R201	10,000	10	0.5	187A641H51
R202	2,200	10	0.5	187A641H35
R203	10,000	10	0.5	187A641H51
R204	100,000	5	0.5	184A763H75
R205	390	5	0.5	184A763H17
R206	1,200	5	0.5	184A763H29
R207	25 K Pot.	10	2	185A086H07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H75
R210	390	5	0.5	184A763H17
† R211	—	—	—	See † Note Below
R212	1 K Pot.	20	0.25	629A430H02
R213	1,200	5	0.5	184A763H29
R214	5,600	5	1	187A643H45
R215	20,000	5	0.5	184A763H58
R216	3,600	5	0.5	184A763H40
R217	620	5	0.5	184A763H22
R218	62	5	0.5	187A290H20
R219	10,000	10	0.5	187A641H51
R220	20,000	5	0.5	184A763H58
R221	300	5	0.5	184A763H14
R222	3,600	5	0.5	184A763H40
R223	620	5	0.5	184A763H22
R224	62	5	0.5	187A290H20
R225	10,000	10	0.5	187A641H51
R226	20,000	5	0.5	184A763H58
R227	300	5	0.5	184A763H14
R228	3,600	5	0.5	184A763H40
R229	620	5	0.5	184A763H22
R230	62	5	0.5	187A290H20
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	Rating			Style Number
	Ohms	± Tol. %	Watts	
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
T201	10,000/10,000 Ohms	L633005		1962798
T202	10,000/400 Ohms	L633003		1962797
T203	25,000/300 Ohms	L592171		1962697
Y201	50-220kHz Crystal per 328C083			Specify Frequency

Symbol	Function	Description or Rating	Style Number
C1	(+) to (–) bypass	0.45 mfd. 330 VAC	1723408
C2	A-C grounding	0.5 mfd. 1500 VDC	1877962
C3	A-C grounding	0.5 mfd. 1500 VDC	1877962
F1,F2	Overload Protection	1.5a, 48/125 VDC	11D9195H26
F1,F2	Overload Protection	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	125V Series dropping	26.5 ohms, 3½"	04D1299H44
R2	125V Series dropping	Same as R1	04D1299H44
R3	125V Current limiting	500 ohms, 3½"	1268047
	48V For 48 VDC, R1=R2 0	–	–
	48V R3=26.5 ohms	3½"	04D1299H44
R4	Current limiting	100K, 0.5 watt	184A763H75
TP1	Test point (+)	Pin Jack - red	187A332H01
TP2	Test point (–)	Pin Jack - black	187A332H02
VR1	Voltage Regulator	1N2828B (45V.)	184A854H06
VR2	Surge Protection	1N3009A (130V.) Zener Diodes	184A617H12
VR3	Voltage Regulator	1N2813B (15V.)	184A854H11

† R238 - omit - above 50kHz

- 22K, 30-50kHz, s# 187A641H59

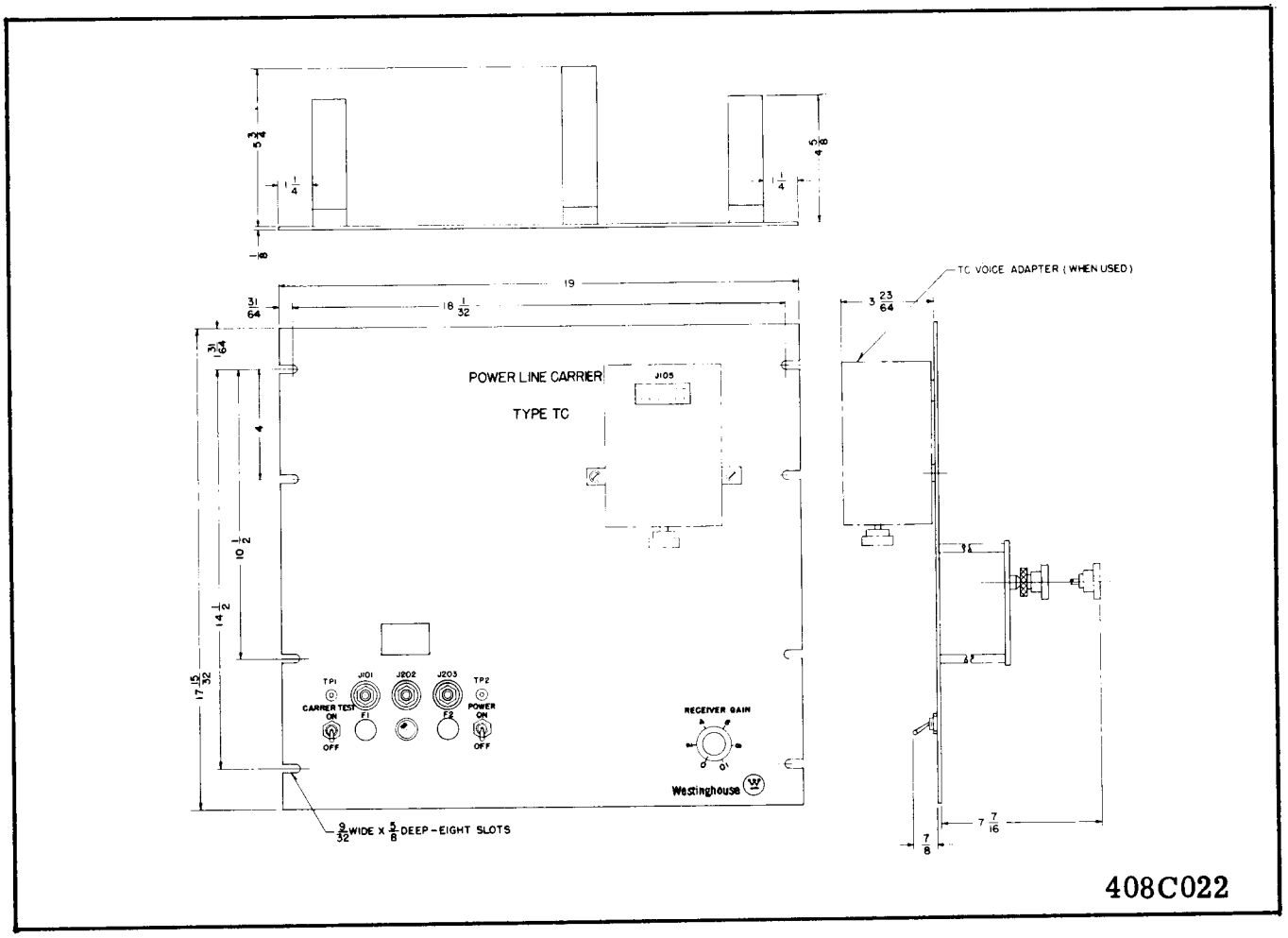


Fig. 1 Type TC Carrier Assembly – Outline

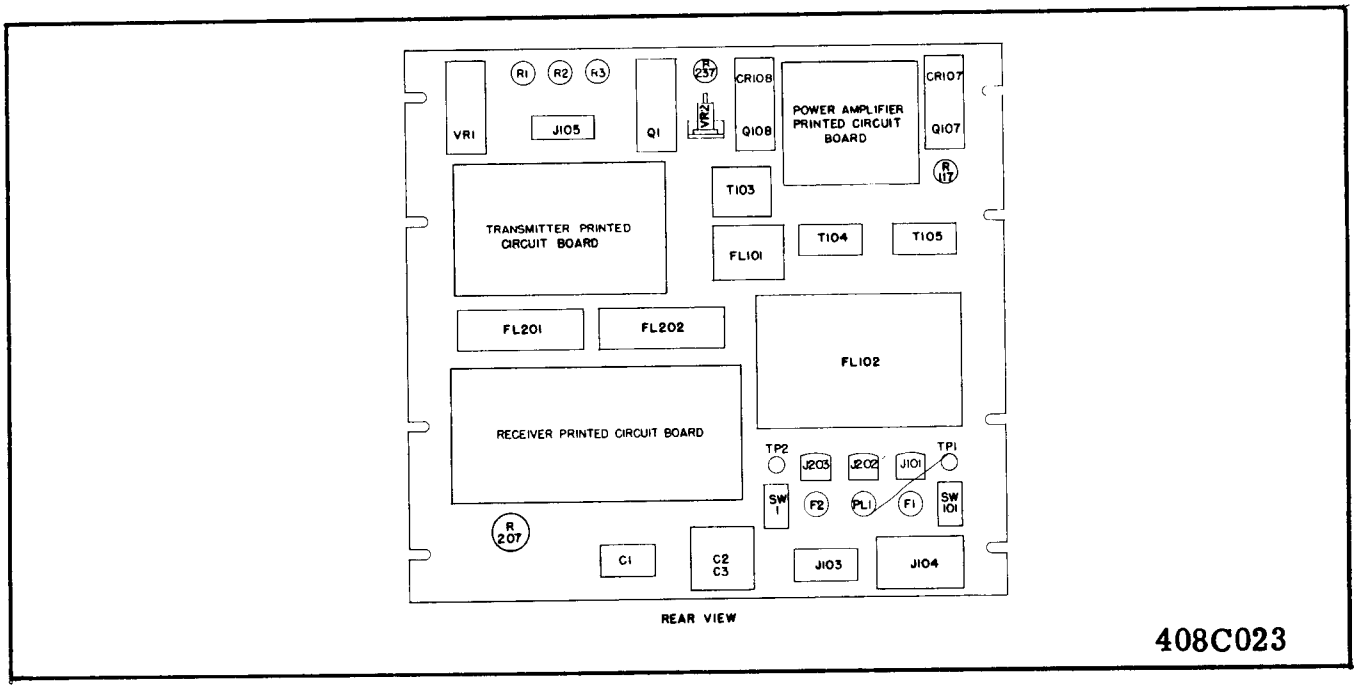


Fig. 2 Type TC Carrier Assembly – Parts Location

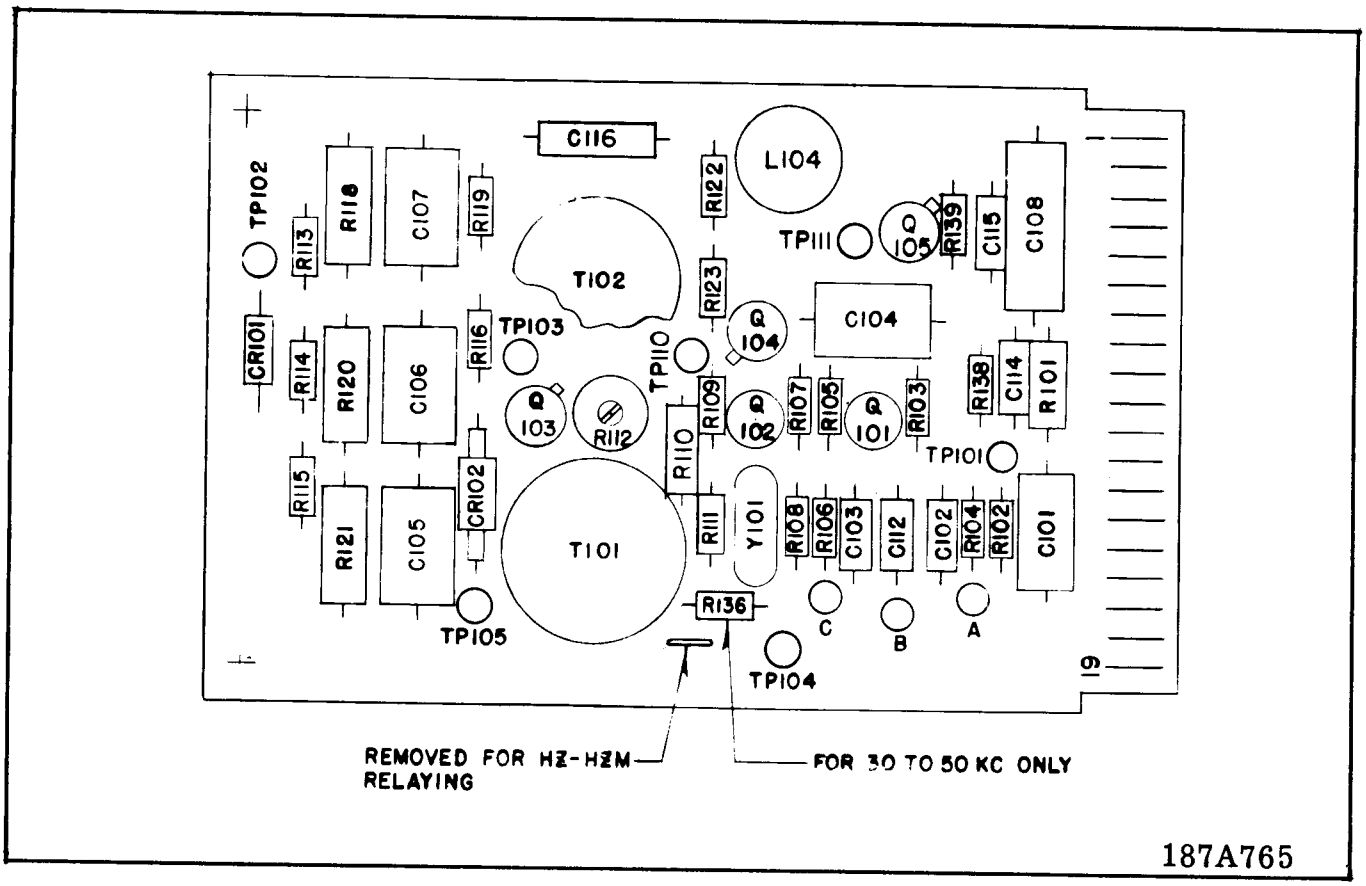


Fig. 3 Transmitter Printed Circuit – Parts Location

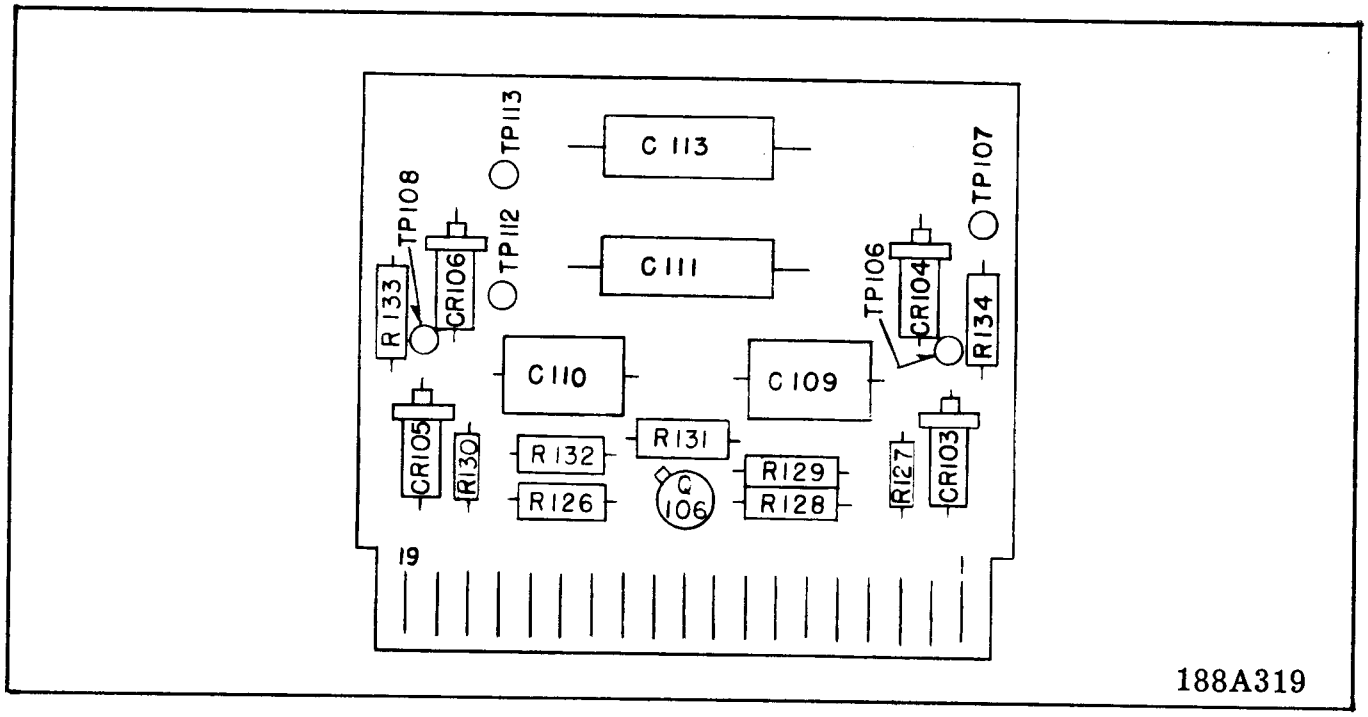


Fig. 4 Power Amplifier Printed Circuit – Parts Location

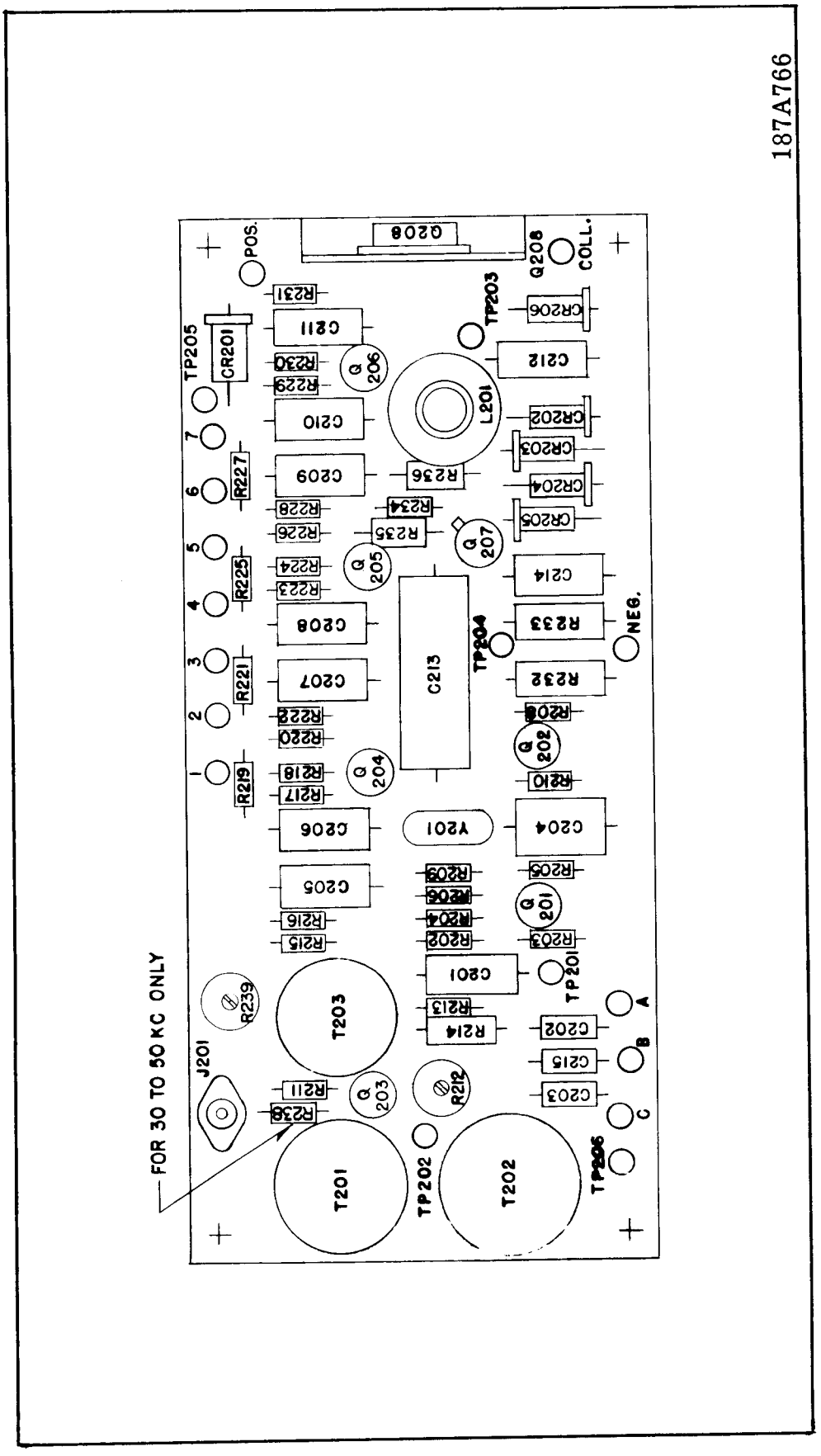


Fig. 5 Receiver Printed Circuit – Parts Location

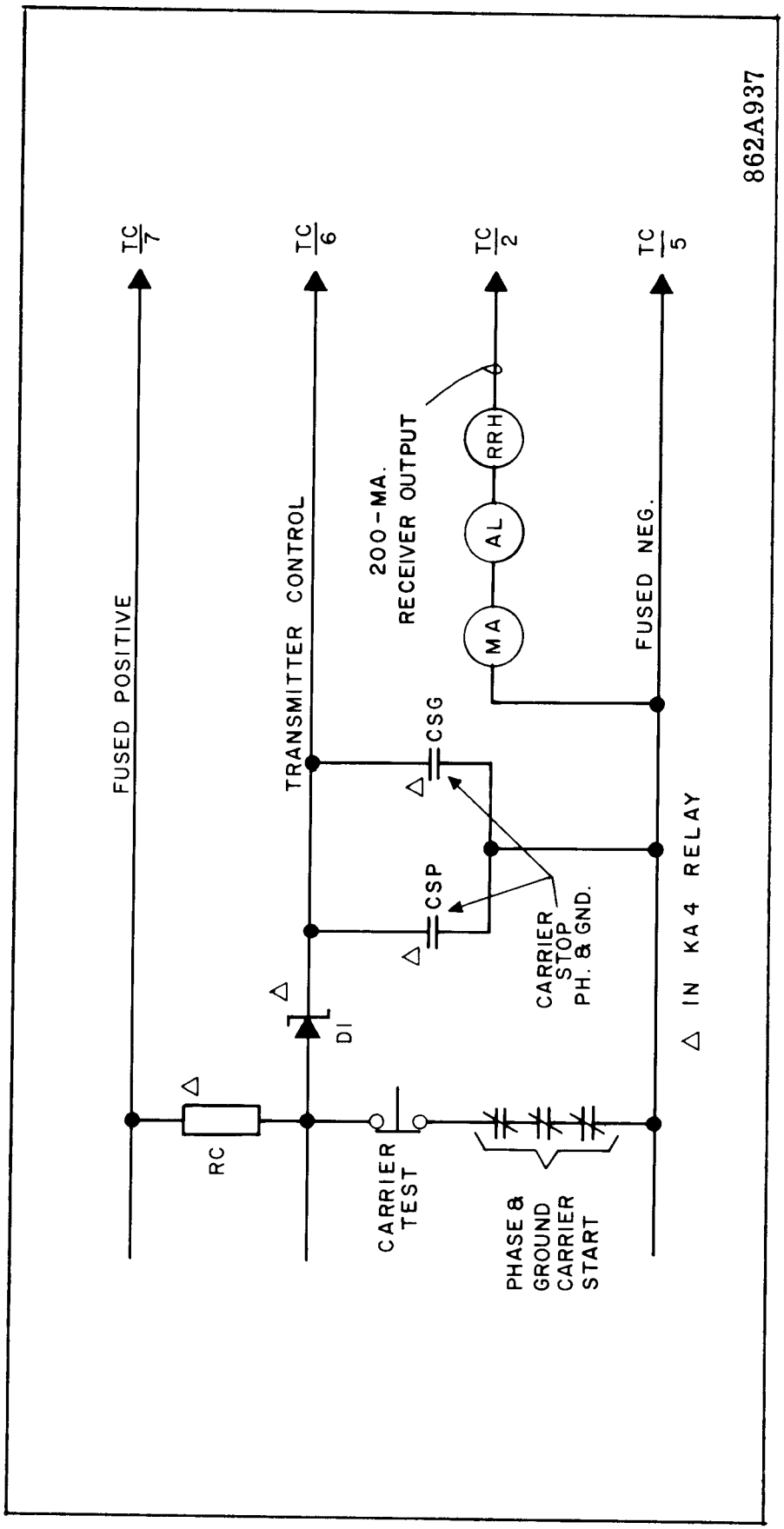
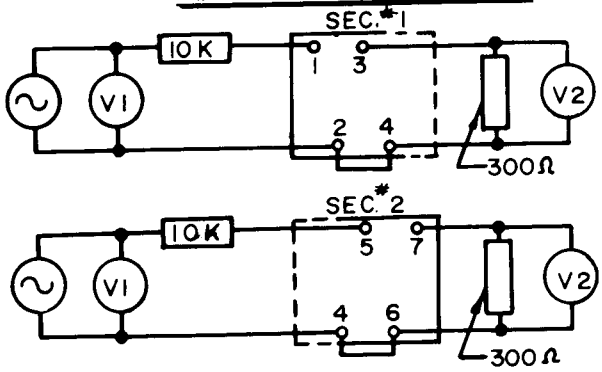
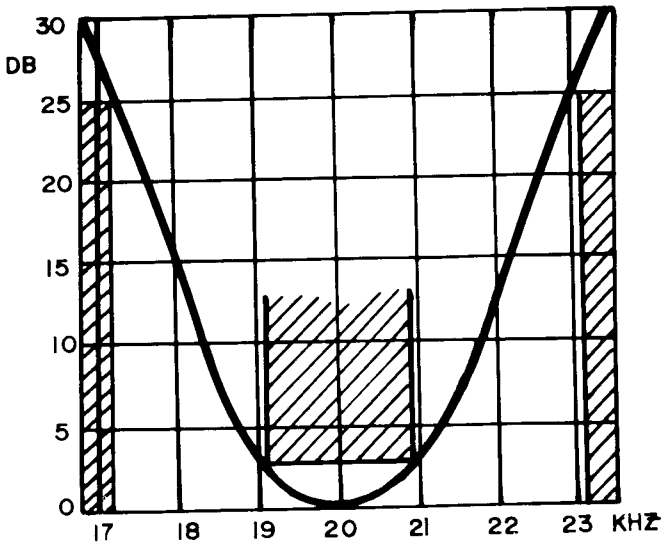


Fig. 6 Elementary K-Dar Carrier Control Circuits.

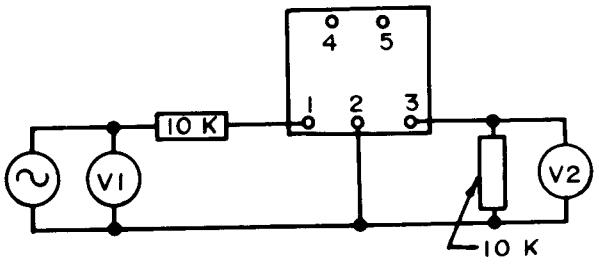
I.F. FILTER TEST CIRCUIT





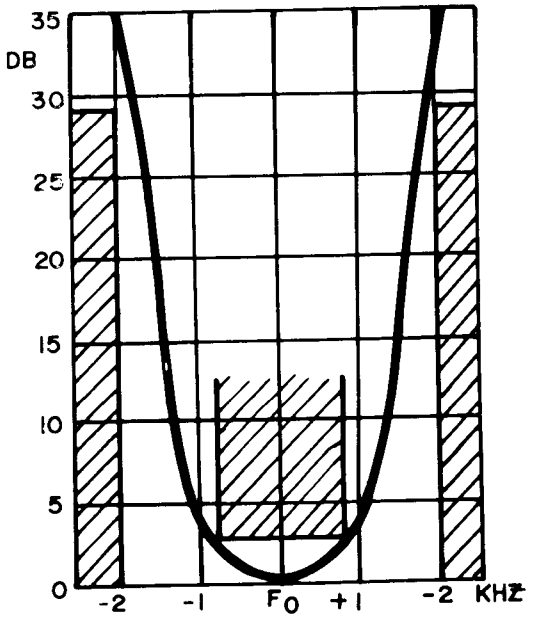
TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.

INPUT FILTER TEST CIRCUIT



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

TC RECEIVER FILTER LIMITS



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

629A425

Fig. 8 Type TC Receiver Filter Characteristics

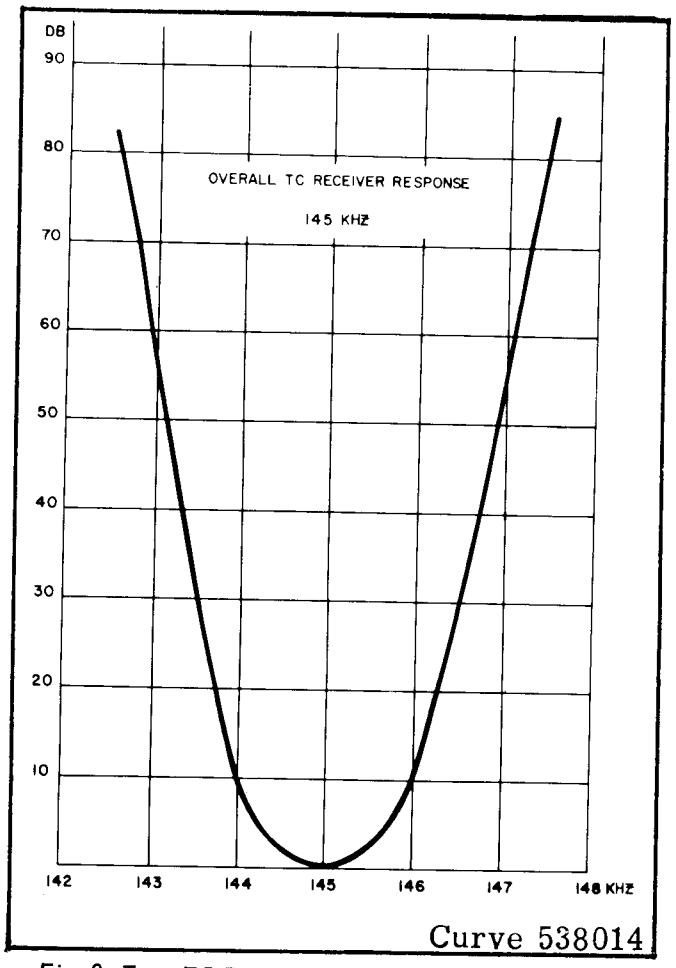


Fig. 9 Type TC Receiver Overall Selectivity Curve

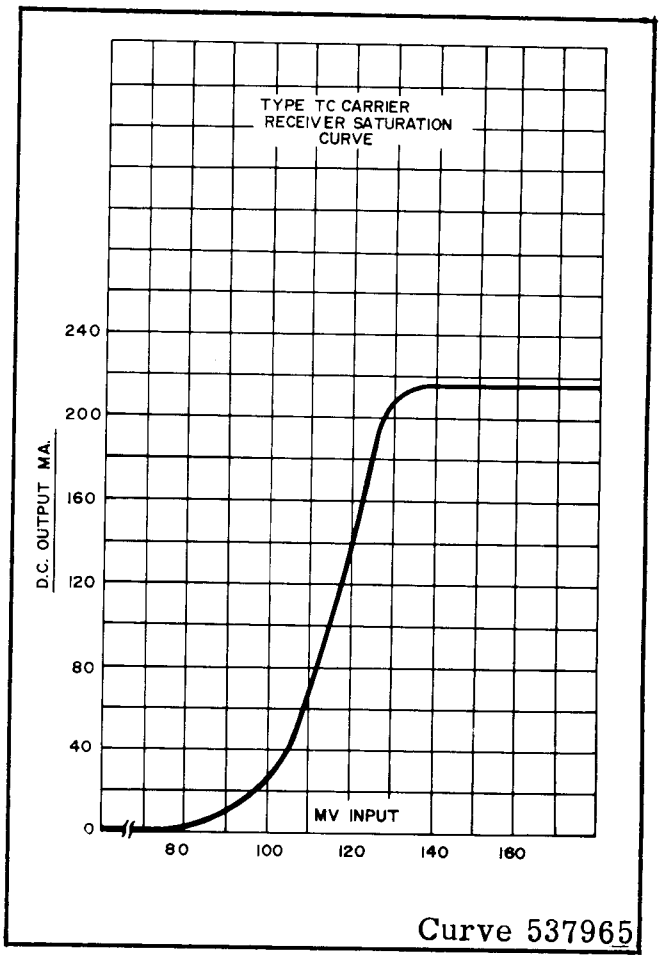


Fig. 10 Type TC Receiver – 200 ma. Output Characteristic.

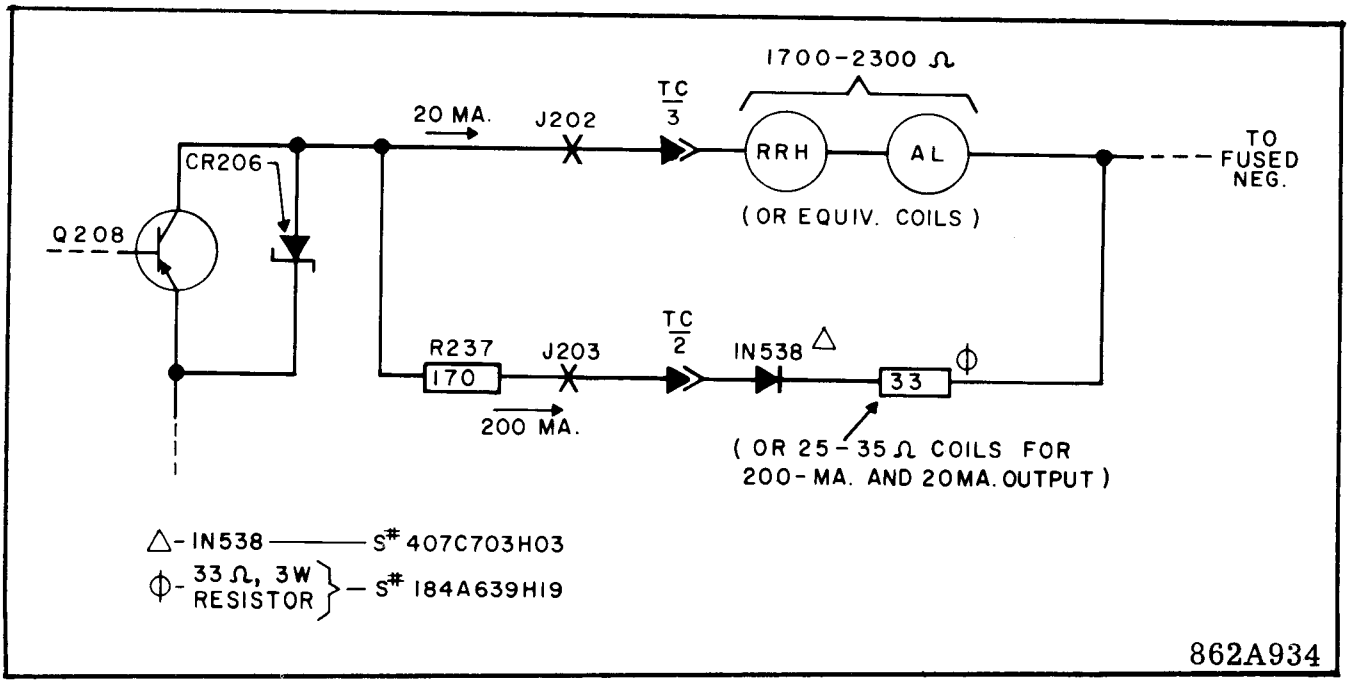


Fig. 11. TC Receiver Output For 20-ma. Operation

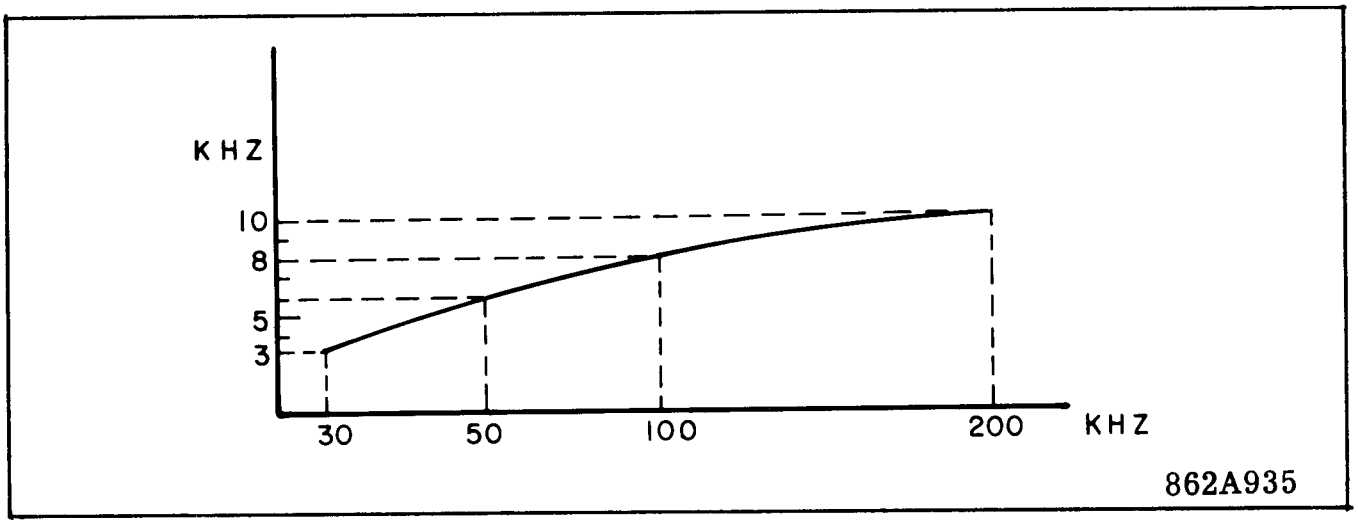


Fig. 12 Minimum Frequency Spacing For Two 10-watt Transmitters Operated in Parallel.

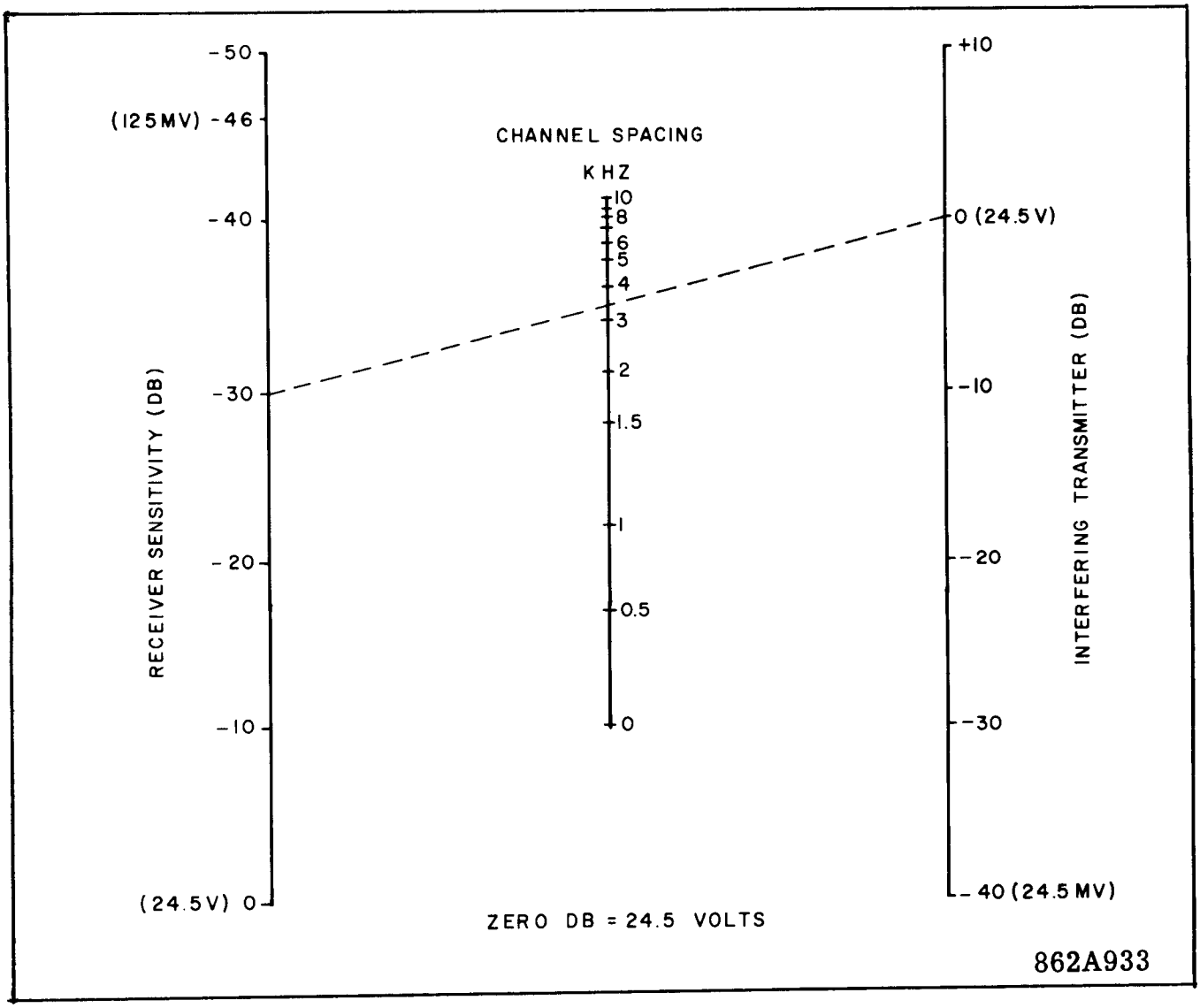


Fig. 13 Minimum Channel Spacing For Keyed Carrier 60 p.p.s.

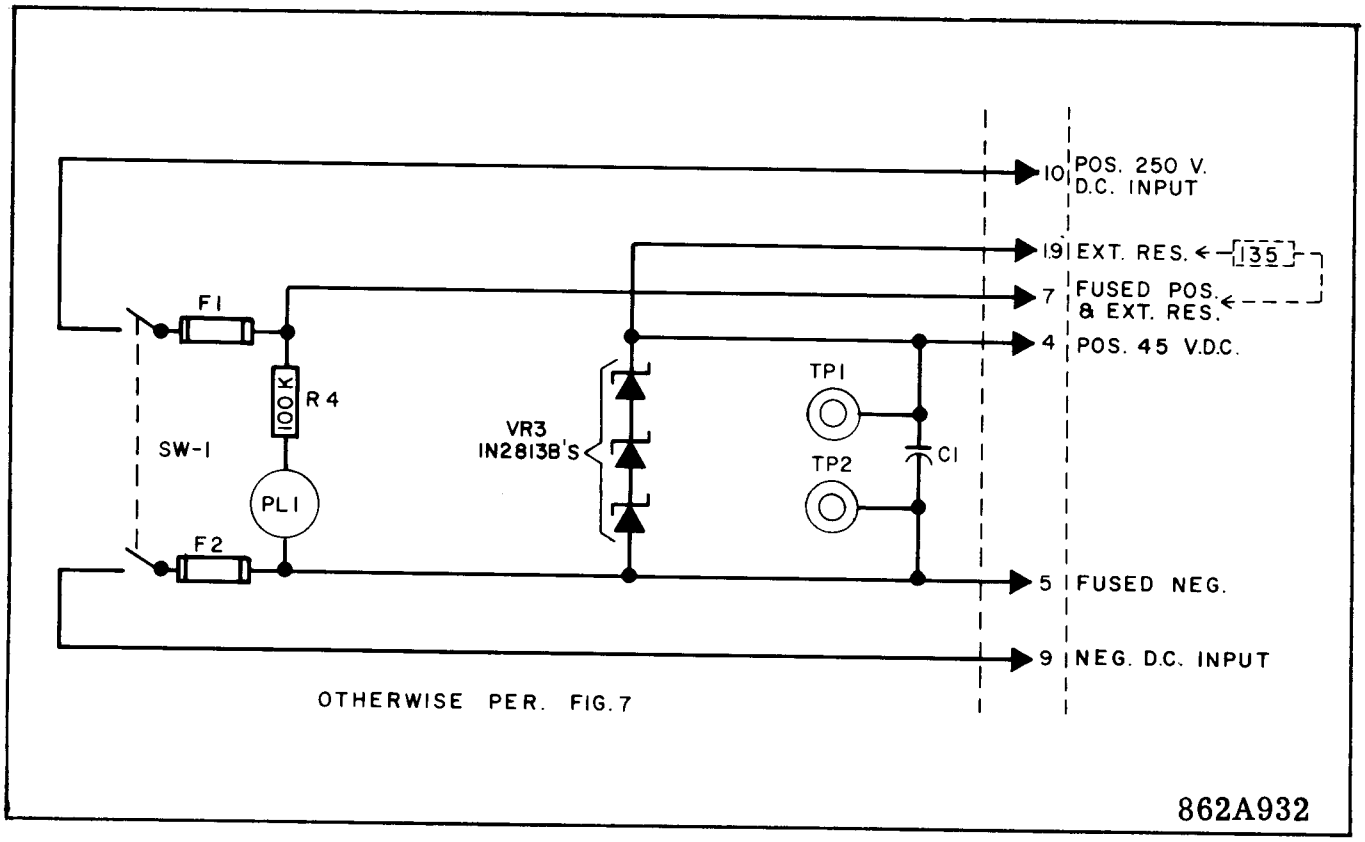


Fig. 14 Detail of Power Supply Section For 250-volt Supply

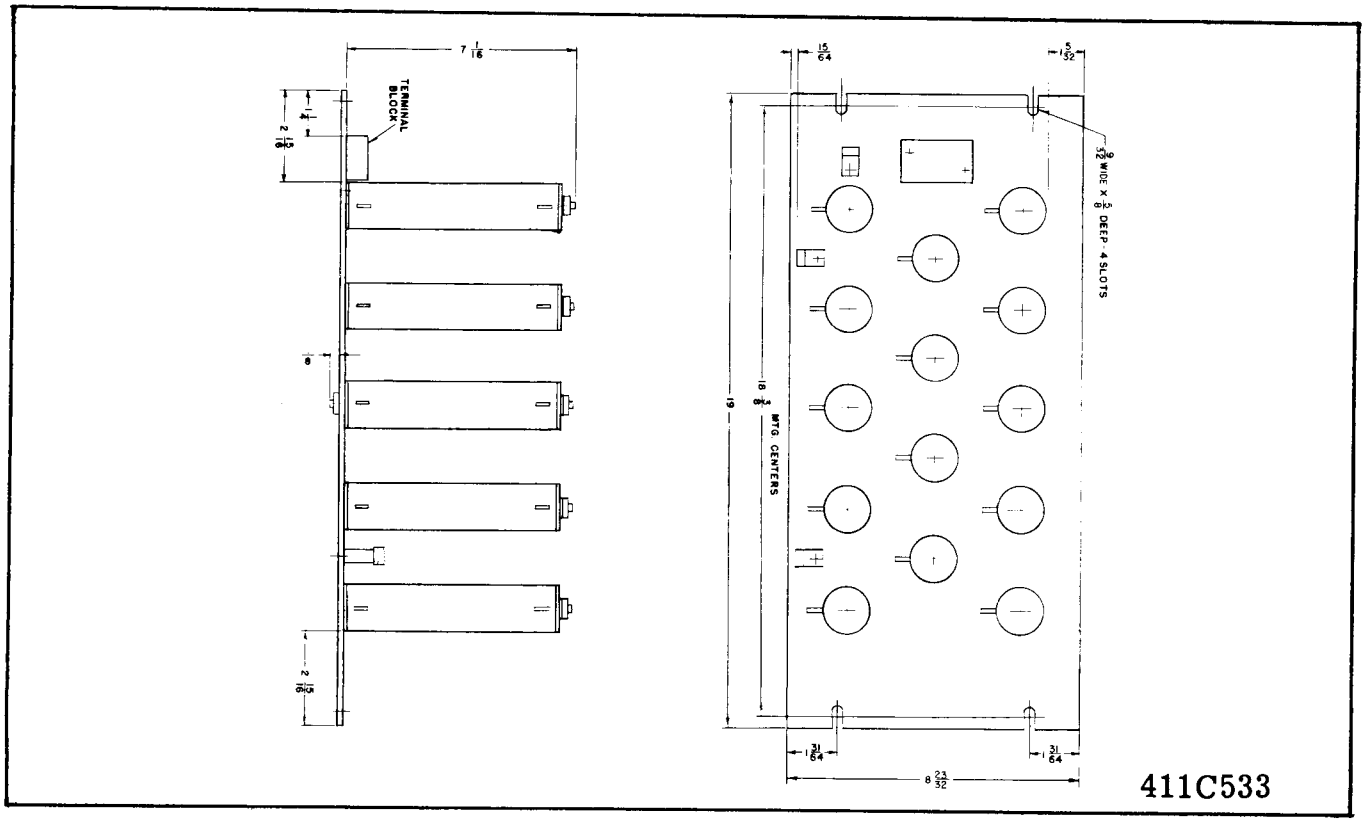


Fig. 15 Outline of External Resistor Unit For 250-volt Operation

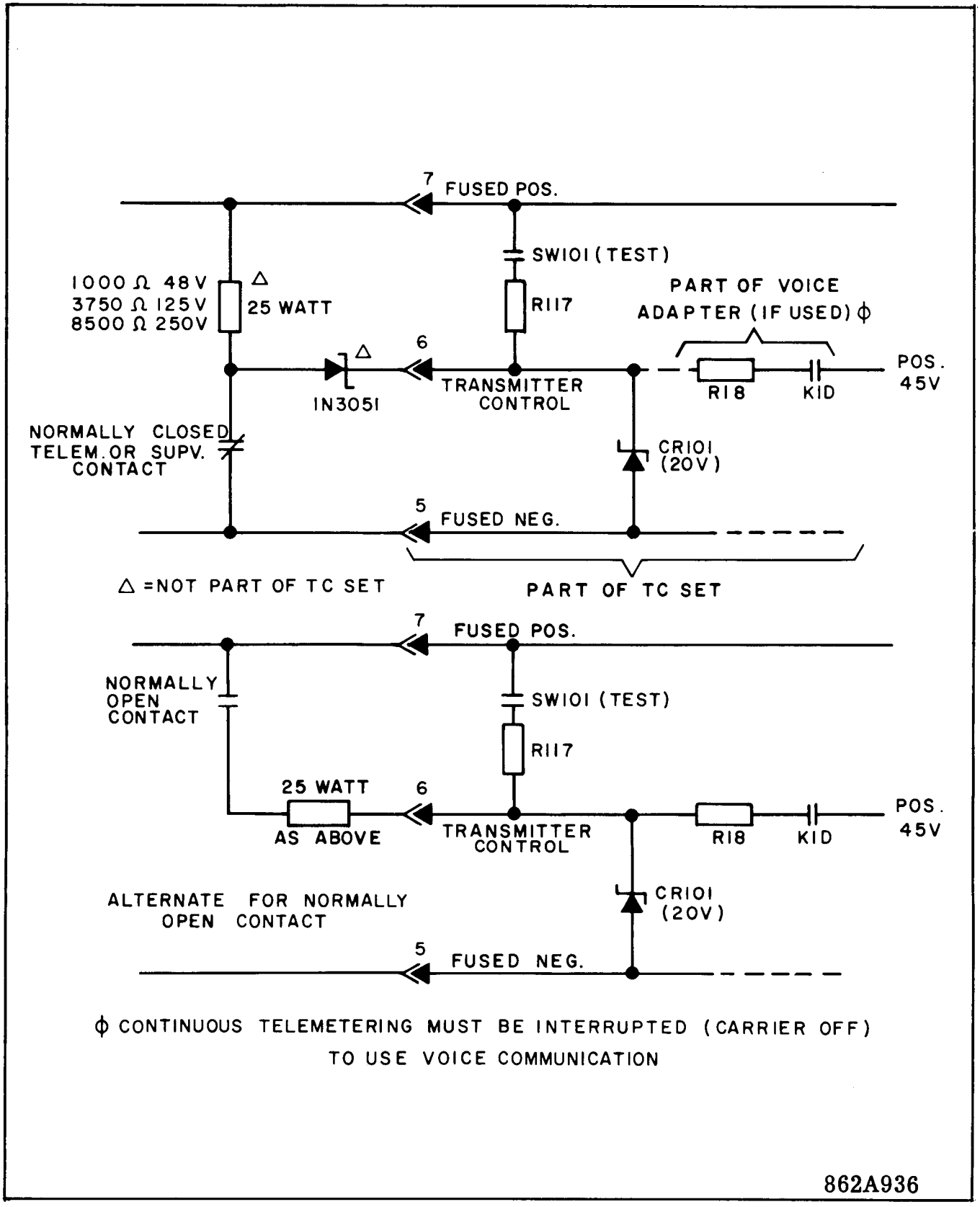


Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION

NEWARK, N. J.

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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY

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SUPERSEDES I.L. 41-944.31B
Complete Revision

EFFECTIVE MARCH 1968

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 directional or phase comparison protective relaying of power transmission lines. It can also be used for other functions including 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.

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 Q101 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 uses two series-connected type 2N1908 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 CR103 and CR105 provide protection for the base-emitter junction of the power transistors. Zener diodes CR107 and CR108 protect the collector-emitter junctions from surges which might come in from the power line through the coaxial cable.

The output transformer T105 couples the power transistors to the transmitter output filter FL102. The output filter includes two trap circuits (L102, C_B, and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G101 is a small lightning arrester to limit the magnitude of switching

surges or other line disturbances reaching the carrier set through the line tuner and coaxial cable. Auto-transformer T106 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms.

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

Receiver

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

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

Mixing is accomplished by feeding the incoming signal to the emitter, and the receiver oscillator signal to the base of the mixer Q203. Mixer oscillator requirements are met through adjustment of potentiometer R212. Injection into two separate elements, base and emitter, provides a circuit capable of handling greater signal level variations than one in which injection is made into only a single element such as the base. This receiver uses an intermediate frequency of 20 kHz. Typical characteristics of both filters and the complete receiver are shown on curves, Fig. 8 and 9.

The 20-kHz i.f. signal is rectified by diodes CR202 and CR203. 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 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 VR1 holds a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the d-c voltage drop through the transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage of approximately 45-v. d-c. The zener diode VR2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

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.

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 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 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	30-200 kHz (50-200 kHz for phase comparison relaying)
Transmitter output	10 watts into 50 to 70-ohm resistive load
Harmonics	55 db below 10 watts
Receiver sensitivity	125 mv. input for 180 ma. minimum output current
Receiver selectivity	1500 Hz bandwidth (3 db down); down 80 db at ±3kHz.
Transmitter-receiver channel rating	40 db
Input voltage	48, 125, or 250 V. d-c
Supply voltage variation	42-56 V, 105-140V, 210-280 V
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 frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the −30 db point on the receiver sensitivity scale and the zero-db point on the interfering transmitter scale. The resulting line crosses the channel spacing scale between 3 and 4 kHz. For this example, a channel spacing of at least 4 kHz should be used. (In order not to conflict with the limits of Fig. 12, an r-f

hybrid may be needed between the TC set and the other transmitter, depending on the actual application.)

INSTALLATION

The type TC transmitter-receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60°C.

ADJUSTMENTS

Transmitter

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

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

1. First, measure the normal received signal from

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

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

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

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

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

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 Tables I through IV. Voltages should be measured with a VTVM. Readings may vary as much as ± 20%.

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. R110 Sensistor
   a. 30-60 kHz – 2200 ohms – S# 187A685H01
   b. 60.5-120 kHz – 1800 ohms – S# 187A685H02
   c. 120.5-200 kHz – 1200 ohms – S# 187A685H03

3. Capacitors C111 and C113
   a. 30-50 kHz – 0.47 mfd. – S# 188A293H01
   b. 50.5-75 kHz – 0.22 mfd. – S# 188A293H02
   c. 75.5-100 kHz – 0.15 mfd. – S# 188A293H03
   d. 100.5-150 kHz – 0.10 mfd. – S# 188A293H04
   e. 150.5-200 kHz – 0.047 mfd. – S# 188A293H05

4. FL101 and FL102
   Filter FL101 is a small series-resonant tuned circuit between the driver and power amplifier

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

Inductors L101, L102, and L103 in these filters are adjustable over a limited range, but thirty-two combinations of capacitors and inductors are required to cover the frequency range of 30 kHz to 200 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 12 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

30.0-31.5	61.0- 64.0	113.0-119.5
32.0-33.5	64.5- 68.0	120.0-127.0
34.0-36.0	68.5- 72.0	127.5-135.0
36.5-38.5	72.5- 76.0	135.5-143.0
39.0-41.0	76.5- 80.0	143.5-151.0
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	

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. 45 V. (TP206)

Test Point	Standby (No Signal)			With 125 M.V. Input		
TP201 TP202 TP203 TP204 TP205	38 0 Q206 Collector Q207 Base 20			38 0 See Transistor d-c Values 20		
Transistor	E*	B*	C*	E*	B*	C*
Q201	38.5	37	43	38.5	37	43
Q202	38.5	37.5	43.5	38.5	37.5	43.5
Q203	0.08	0	18.7	0.08	0	18.7
Q204	2.7	2.9	18.7	2.7	2.9	18.7
Q205	2.4	2.6	18.7	2.5	2.7	18.7
Q206	2.5	2.7	10.5	2.6	2.8	10.5
Q207	0.13	0.03	22.0	2.0	2.2	4.0
Q208	0.25	0.15	45.0	1.7	2.0	2.0

*E – Emitter, B – Base, C – Collector

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

TABLE II

Receiver RF Measurements

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

Test Point	Typical A-C Voltages		Test Point	Typical A-C Voltages	
	36 kHz	132 kHz		36 kHz	132 kHz
FL201-IN to Gnd.	.075	.050	Q205-B to TP206	.11	.052
FL201-OUT to Gnd.	.051	.020	Q205-C to TP206	6.7	3.4
Q203 -E to TP206	.105	.090	Q206-B to TP206	.67	.37
Q203 -C to TP206	.22	.035	Q206-C to TP206	1.5	1.53
Q204 -B to TP206	.015	.012	TP202 to TP206	0.3	0.3
Q204 -C to TP206	.90	.52			

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

TABLE III

Transmitter D-C Measurements

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

Test Point	Carrier Off	Carrier On
TP101	7 volts d.c.	7 volts d.c.
TP102	0	20
TP103	0	19.5
TP105	0	9
TP106	44	22
TP107	44	22.2
TP108	45	44.8
TP110	0.1	0.9
TP111	0.1	0.9
TP112	0	0
TP113	45	45
J101 (Front Panel)	5 ma. max.	0.6 amp.

Transistor	E	B	C	E	B	C
Q101	6.0	7.8	2.5	6.1	7.7	2.5
Q102	6.6	7.1	1.2	6.6	7.1	1.1
Q103	0	0	0	19.5	19.4	9.0
Q104	0.1	0.1	45	0.5	0.9	45
Q105	0.1	0.1	45	0.5	0.9	45
Q106	0	0	44	0	0.9	1.2
Q107	43.7	43.7	0	22.2	22.2	0
Q108	45.0	44.7	44.7	44.8	44.8	22.3

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. Resistors R218, R224, and R230 may have to be reduced. See following paragraph.

   The emitter resistors R218, R224, and R230 of the i-f stages are selected during factory test to give the required receiver gain. This is desirable since the insertion loss of the input filter FL201 increases with frequency. If the operating frequency is reduced, the receiver gain will probably be higher. In this case, a reduction in the setting of the i-f input control R239 will give the 125-mv. sensitivity. If the new operating frequency is higher, the receiver gain will be lower. If more than 125 mv. is required to obtain 180 ma. output, the gain can be increased by reducing the value of one or more of the resistors R218, R224, and R230. In most cases, these resistors should fall in the range of 22 to 150 ohms. These three resistors are soldered to small terminal posts on the printed circuit board.

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 230 kHz, input impedance—one megohm, minimum.

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	Test Point	A-C Voltage
T101-3 to TP104	1.1 volts, rms.	Q107-B to TP107	.5 volts, rms.
TP103 to TP102	0.2	Q108-B to TP113	.5
Q103-C to TP104	0.7	Q107-C to TP107	14.5
T102-3 to T102-4	0.2	Q108-C to TP113	14.5
T102-5 to T102-4	0.2	T105-4 to Gnd.	105
Q104-C to TP104	4.3	T106-2 to Gnd.	155*
Q105-C to TP104	4.3		
T103-4 to Gnd.	1.5	TP109 to Gnd.	50*
T104-1 to Gnd.	1.4	J102 to Gnd.	24.5

NOTE:

T103-3 = 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

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 230kHz

c. Oscilloscope

d. Ohmmeter

e. Capacitor checker

f. Frequency counter

g. Frequency-selective voltmeter

Renewal Parts

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

ELECTRICAL PARTS LIST
Transmitter Section

Symbol	Rating	Style Number
C101	0.1 mfd, 200 V. DC	187A624H01
C102	.005 mfd, 300 V. DC	187A694H29
C103	180 pf. 500 V. DC	187A695H29
C104	0.25 mfd, 200 V. DC	187A624H02
C105	0.25 mfd, 200 V. DC	187A624H02
C106	0.25 mfd, 200 V. DC	187A624H02
C107	0.25 mfd, 200 V. DC	187A624H02
C108	0.50 mfd, 200 V. DC	187A624H03
C109	0.25 mfd, 200 V. DC	187A624H02
C110	0.25 mfd, 200 V. DC	187A624H02
† C111	(See Table Below)	–
C112	39 pfd, 500 V. DC	187A695H12
† C113	(See Table Below)	–
C114	100 pf., 500 V. DC	187A695H23
C115	100 pf., 500 V. DC	187A695H23
C116	0.001 mfd, 500 V. DC	187A694H11
CA	Part of FL101	Vary with Frequency
CB	Part of FL102	Vary with Frequency
CC		
CD		
CE		

† FREQ.	C111, C113	Style Number
30- 50 KC	0.47 mfd, 400 V. DC	188A293H01
50.5- 75 KC	0.22 mfd, 400 V. DC	188A293H02
75.5-100 KC	0.15 mfd, 400 V. DC	188A293H03
100.5-150 KC	0.1 mfd, 400 V. DC	188A293H04
150.5-200 KC	0.047 mfd, 400 V. DC	188A293H05

CR101	1N3686B (20 V ± 5%)	185A212H06
CR102	1N457A	184A855H07
CR103	1N538	407C703H03
CR104	1N91	182A881H04
CR105	1N538	407C703H03
CR106	1N91	182A881H04
CR107	1N2999A (56 V ± 10%)	184A617H13
CR108	1N2999A (56 V ± 10%)	184A617H13
G101	Type TVS Arrester	637A026A01
J101	Closed Circuit Jack	187A606H01

ELECTRICAL PARTS LIST
Transmitter Section (Cont.)

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

Symbol	Ohms	± Tol. %	Watts	Style Number
R101	5,600	5	1	187A643H45
R102	2,200	10	0.5	187A641H35
R103	10,000	10	0.5	187A641H51
R104	100,000	5	0.5	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
R110 *				At End of List
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

*Sensistor -	30 - 60 kHz, 2.2K ± 10%, ¼ watt	187A685H01
	60.5-120 kHz, 1.8K ± 10%, ¼ watt	187A685H02
	120.5-200 kHz, 1.2K ± 10%, ¼ watt	187A685H03

ELECTRICAL PARTS LIST
Transmitter Section (Cont.)

Symbol	Ohms	± Tol. %	Watts	Style Number
R116	100	5	0.5	184A763H03
R117	1,000 48 V dc	5	25	1202588
	3,750 125 V dc	5	25	1202955
	8,500 250 V dc	5	25	1267310
R118	8,200	5	2	185A207H49
R119	100	5	0.5	184A763H03
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	0.27	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

Symbol	Rating		Style Number
T101	10,000/400 ohms	L633003	1962797
T102	10,000/400 c.t.	L592170	1962698
T103	1930/60 ohms	L633000	1962694
T104	Turns ratio, 1/0.5,	Pri./each sec.	292B526G01
T105	10/500 ohms		292B526G02
T106	500/50-60-70 ohms		292B526G03
Y101	30-200 kc crystal per 328C083		Specify Frequency

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
CR201	1N3027B (20V ± 5%)	184A449H07
CR202	1N91	182A881H04
CR203	1N91	182A881H04
CR204	1N538	407C703H03
CR204	1N538	407C703H03
CR205	1N1789 (56V. ± 10%)	584C434H08
FL201	Receiver Input Filter 30-200 kHz	Specify Frequency
FL202	Receiver i.f. Filter-20 kHz (2 Sections)	187A590G02
J201	Receiver Coax. Input Jack	187A638H01
J202	Closed Circuit Jack (20MA)	187A606H01
J203	Closed Circuit Jack (200MA)	187A606H01
L201	33 mh.	187A599H01
Q201	2N274	187A270H01
Q202	2N274	187A270H01
Q203	2N274	187A270H01
Q204	2N274	187A270H01
Q205	2N274	187A270H01
Q206	2N274	187A270H01
Q207	2N398A	184A638H12
Q208	2N1362	187A673H01

ELECTRICAL PARTS LIST
Receiver Section (Cont.)

Symbol	Rating			Style Number
Resistors	Ohms	± Tol. %	Watts	
R201	10,000	10	0.5	187A641H51
R202	2,200	10	0.5	187A641H35
R203	10,000	10	0.5	187A641H51
R204	100,000	5	0.5	184A763H75
R205	390	5	0.5	184A763H17
R206	1,200	5	0.5	184A763H29
R207	25 K Pot.	10	2	185A086H07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H75
R210	390	5	0.5	184A763H17
† R211	–	–	–	See † Note Below
R212	1 K Pot.	20	0.25	629A430H02
R213	1,200	5	0.5	184A763H29
R214	5,600	5	1	187A643H45
R215	20,000	5	0.5	184A763H58
R216	3,600	5	0.5	184A763H40
R217	620	5	0.5	184A763H22
R218	62	5	0.5	187A290H20
R219	10,000	10	0.5	187A641H51
R220	20,000	5	0.5	184A763H58
R221	300	5	0.5	184A763H14
R222	3,600	5	0.5	184A763H40
R223	620	5	0.5	184A763H22
R224	62	5	0.5	187A290H20
R225	10,000	10	0.5	187A641H51
R226	20,000	5	0.5	184A763H58
R227	300	5	0.5	184A763H14
R228	3,600	5	0.5	184A763H40
R229	620	5	0.5	184A763H22
R230	62	5	0.5	187A290H20
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	Rating			Style Number
	Ohms	± Tol. %	Watts	
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
T201	10,000/10,000 Ohms L633005			1962798
T202	10,000/400 Ohms L633003			1962797
T203	25,000/300 Ohms L592171			1962697
Y201	50-220kHz Crystal per 328C083			Specify Frequency

Symbol	Function	Description or Rating	Style Number
C1	(+) to (–) bypass	0.45 mfd. 330 VAC	1723408
C2	A-C grounding	0.5 mfd. 1500 VDC	1877962
C3	A-C grounding	0.5 mfd. 1500 VDC	1877962
F1,F2	Overload Protection	1.5a, 48/125 VDC	11D9195H26
F1,F2	Overload Protection	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	125V Series dropping	26.5 ohms, 3½"	04D1299H44
R2	125V Series dropping	Same as R1	04D1299H44
R3	125V Current limiting	500 ohms, 3½"	1268047
	48V For 48 VDC, R1=R2 0	—	—
	48V R3=26.5 ohms	3½"	04D1299H44
R4	Current limiting	100K, 0.5 watt	184A763H75
TP1	Test point (+)	Pin Jack - red	187A332H01
TP2	Test point (–)	Pin Jack - black	187A332H02
VR1	Voltage Regulator	1N2828B (45V.)	184A854H06
VR2	Surge Protection	1N3009A (130V.) Zener Diodes	184A617H12
VR3	Voltage Regulator	1N2813B (15V.)	184A854H11

† R238 - omit - above 50kHz

- 22K, 30-50kHz, s# 187A641H59

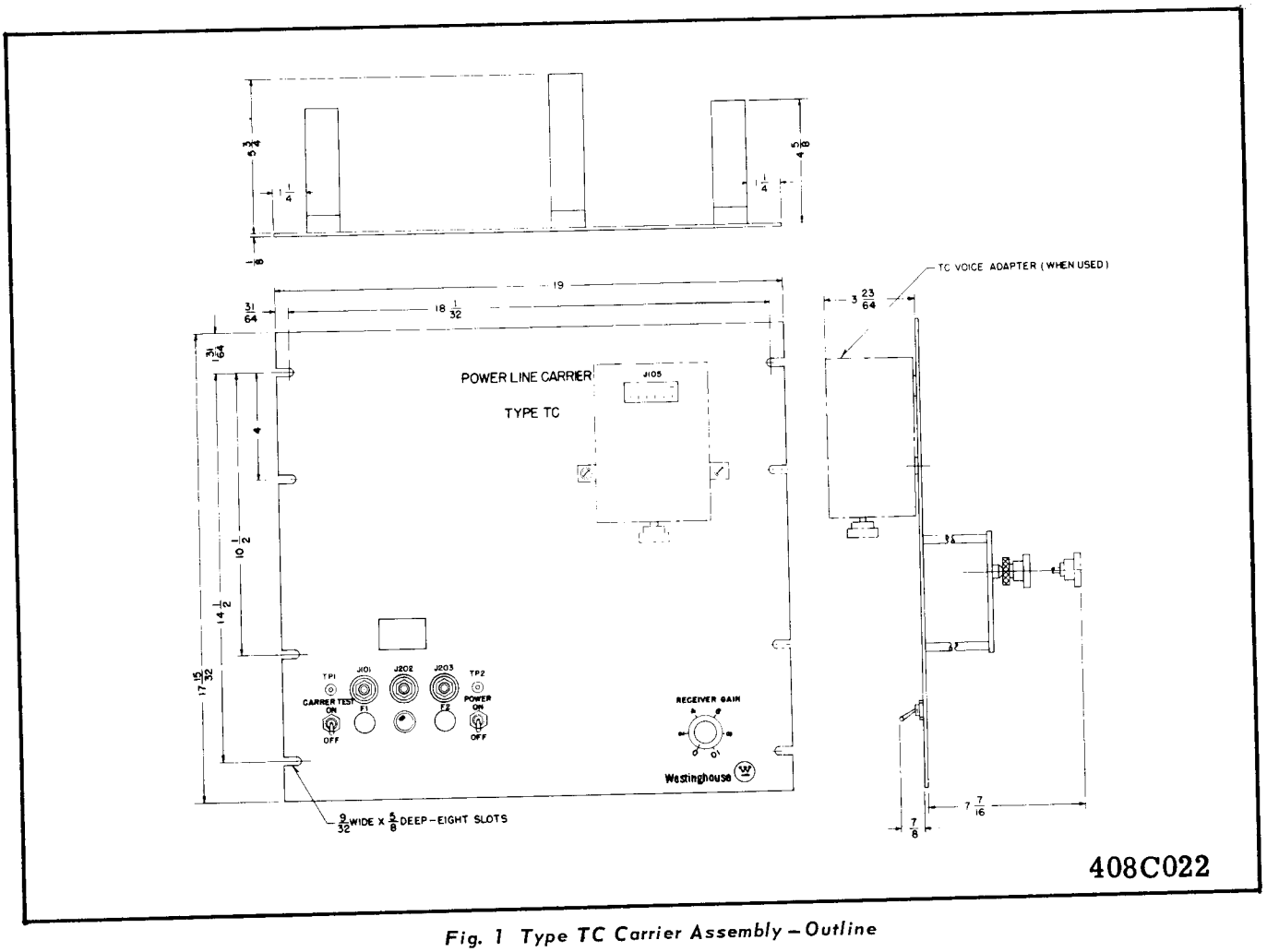


Fig. 1 Type TC Carrier Assembly – Outline

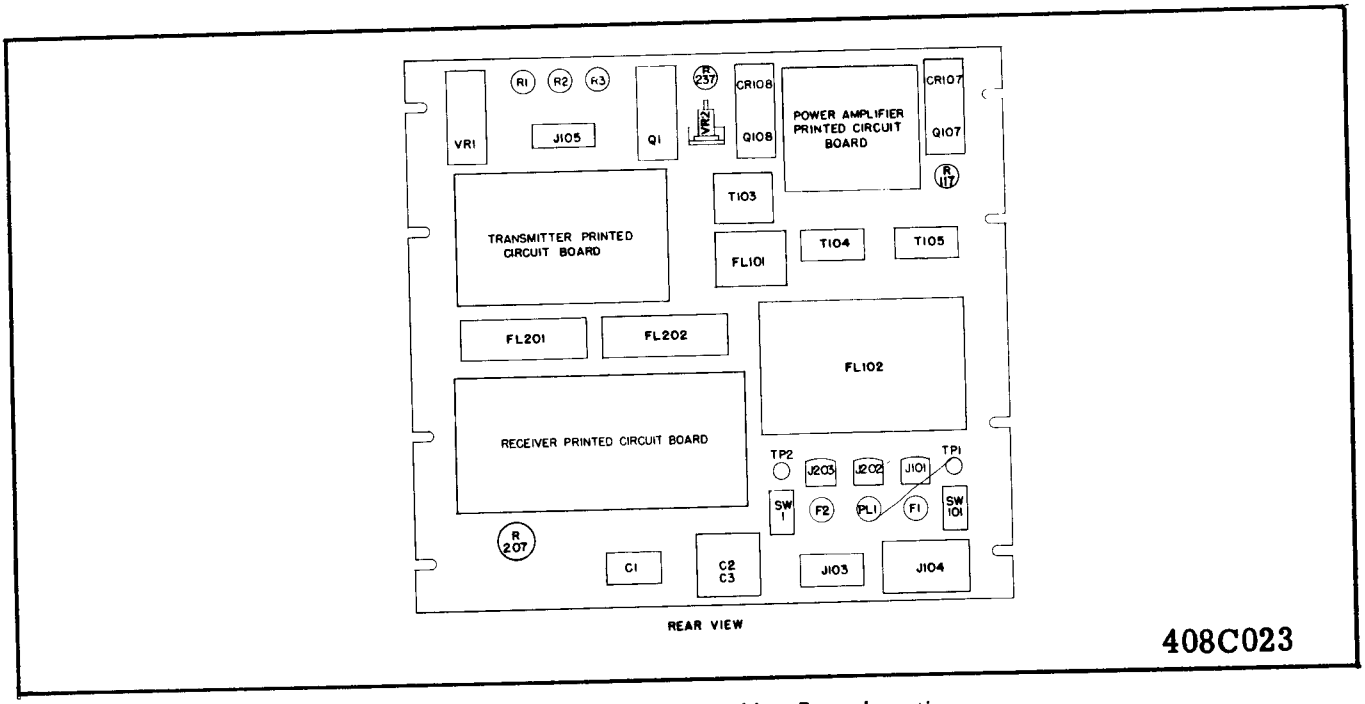


Fig. 2 Type TC Carrier Assembly – Parts Location

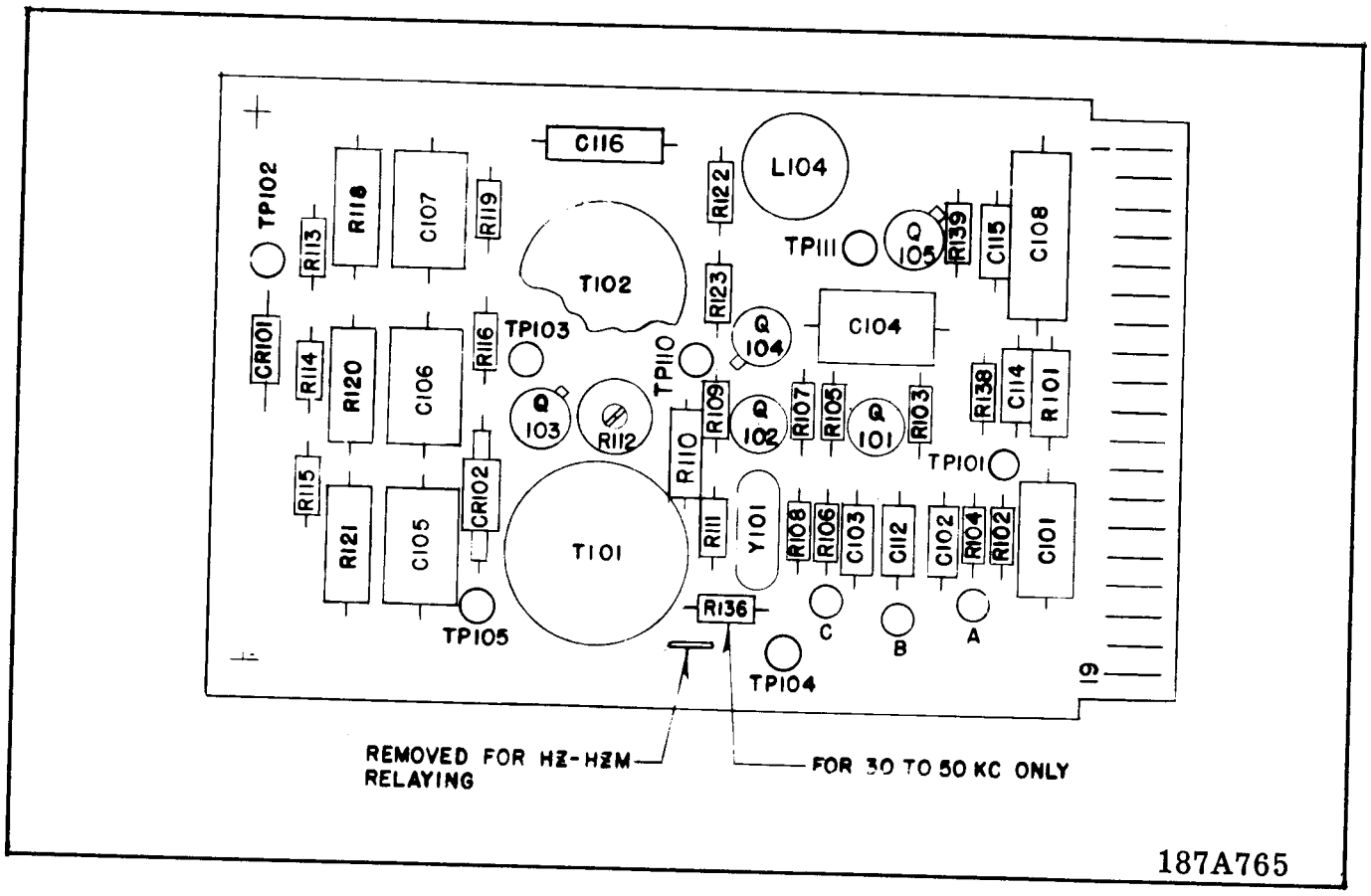


Fig. 3 Transmitter Printed Circuit – Parts Location

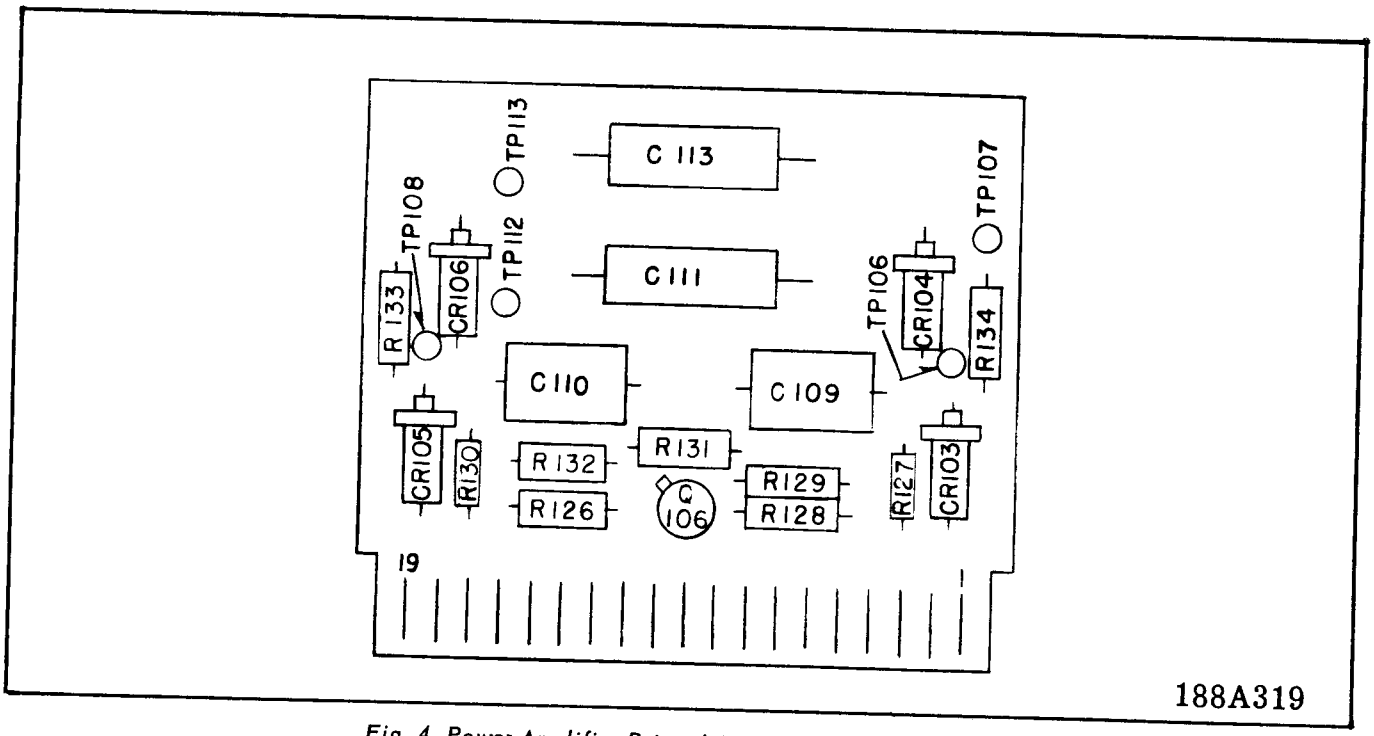


Fig. 4 Power Amplifier Printed Circuit – Parts Location

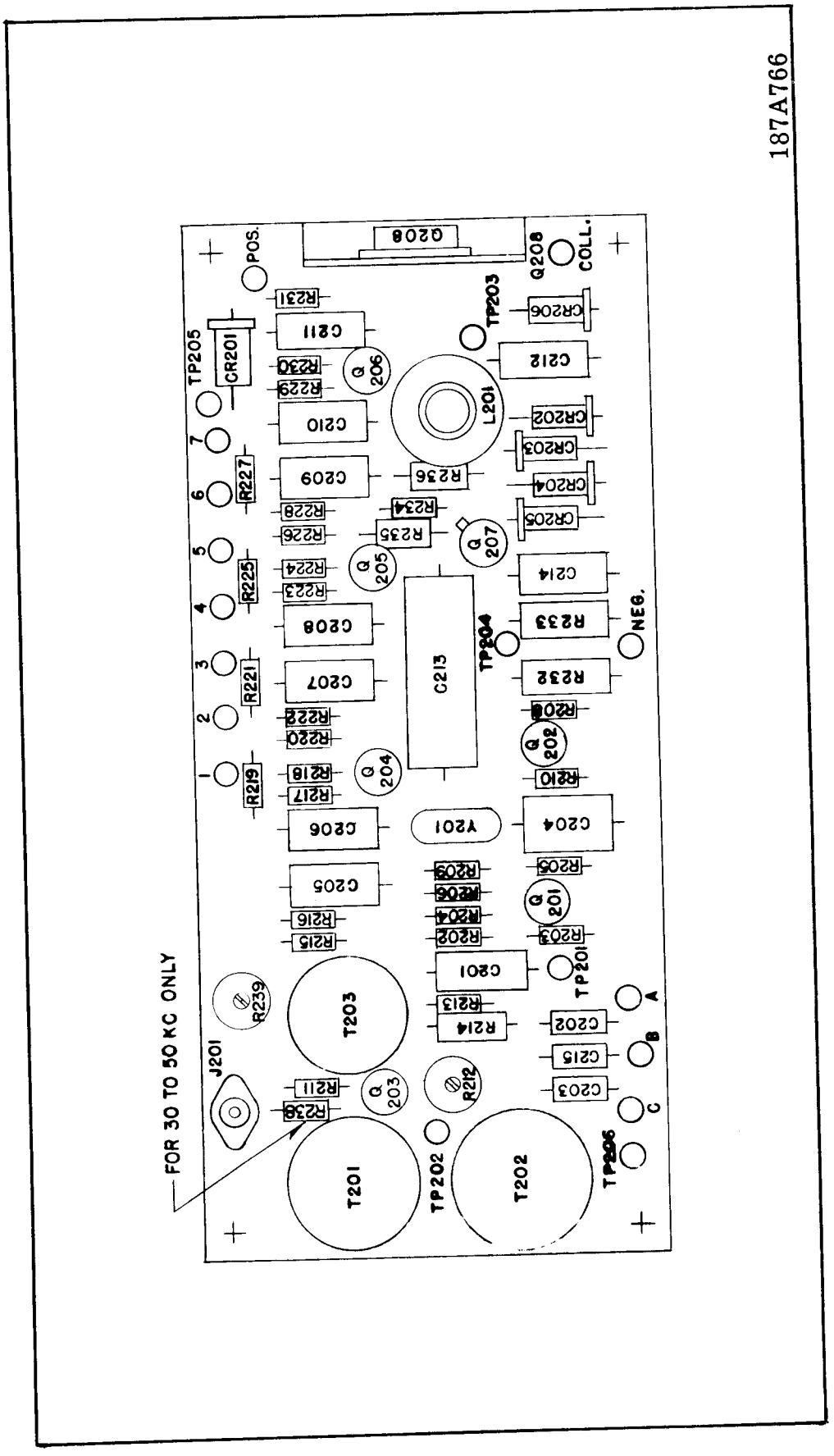


Fig. 5 Receiver Printed Circuit – Parts Location

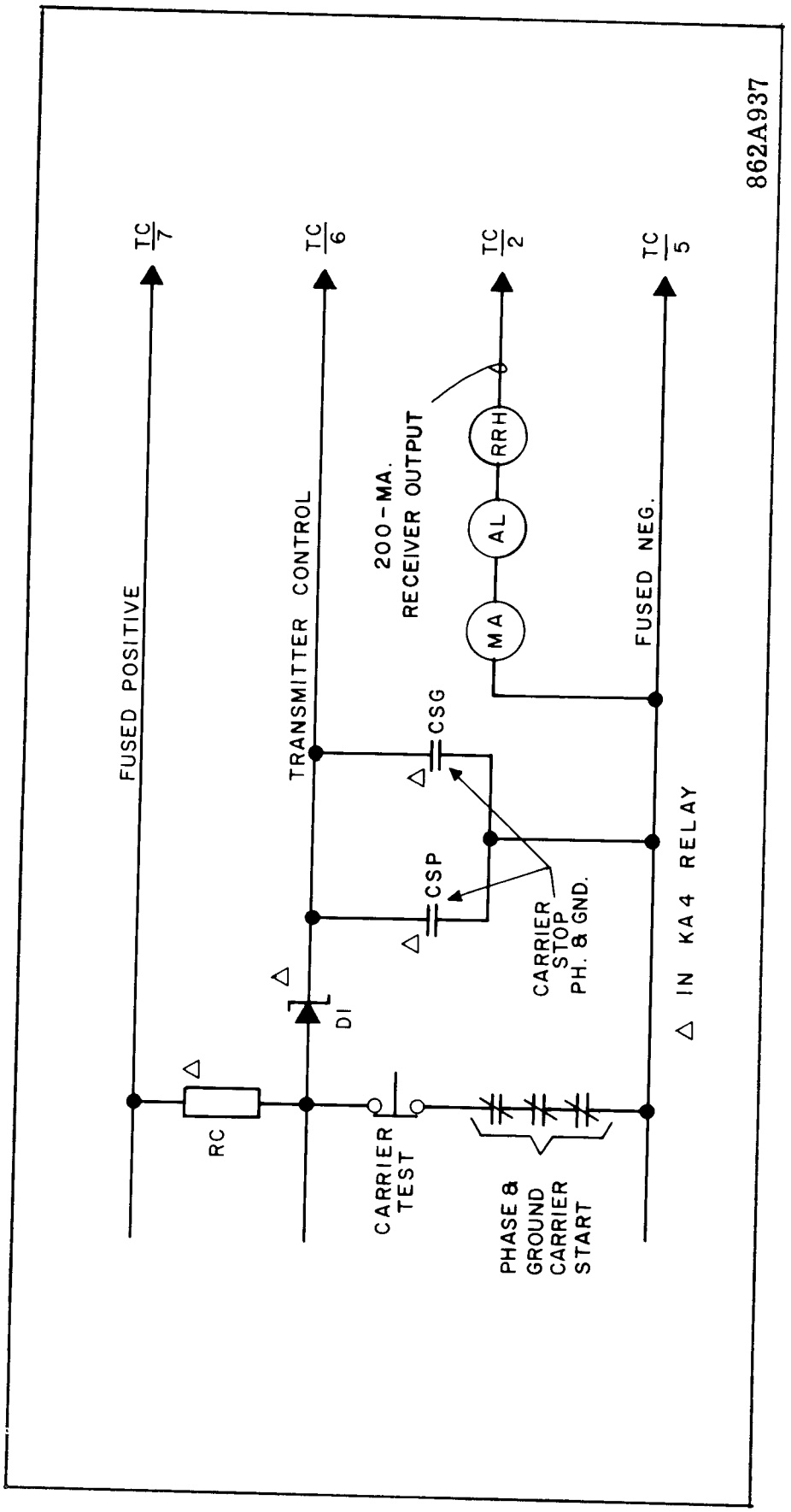
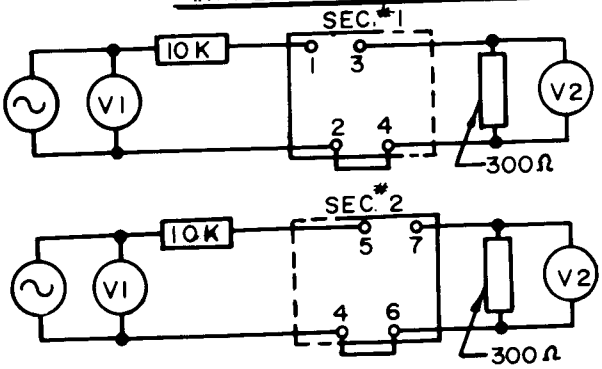
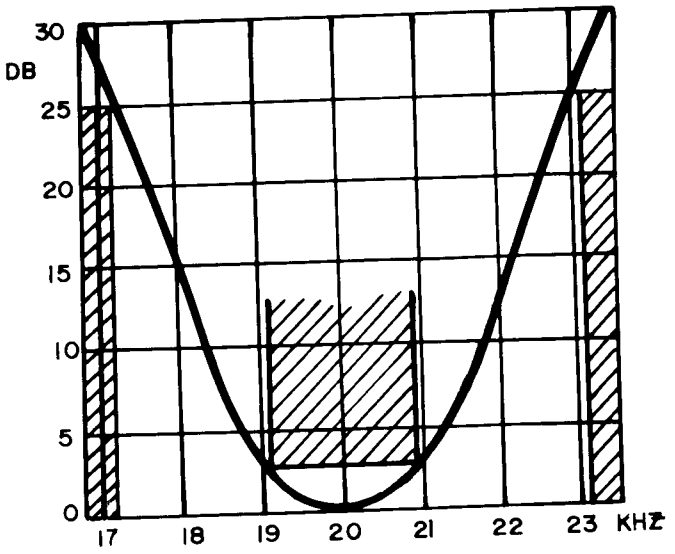


Fig. 6 Elementary K-Dar Carrier Control Circuits.

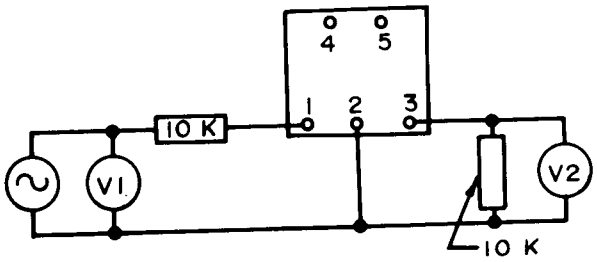
I.F. FILTER TEST CIRCUIT





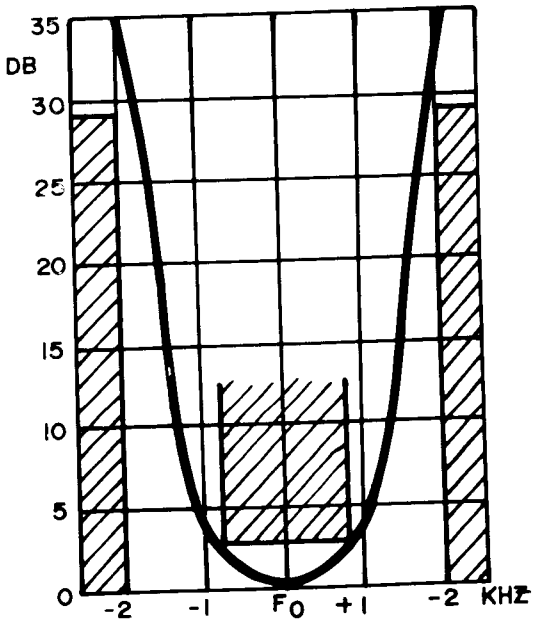
TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.

INPUT FILTER TEST CIRCUIT



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

TC RECEIVER FILTER LIMITS



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

629A425

Fig. 8 Type TC Receiver Filter Characteristics

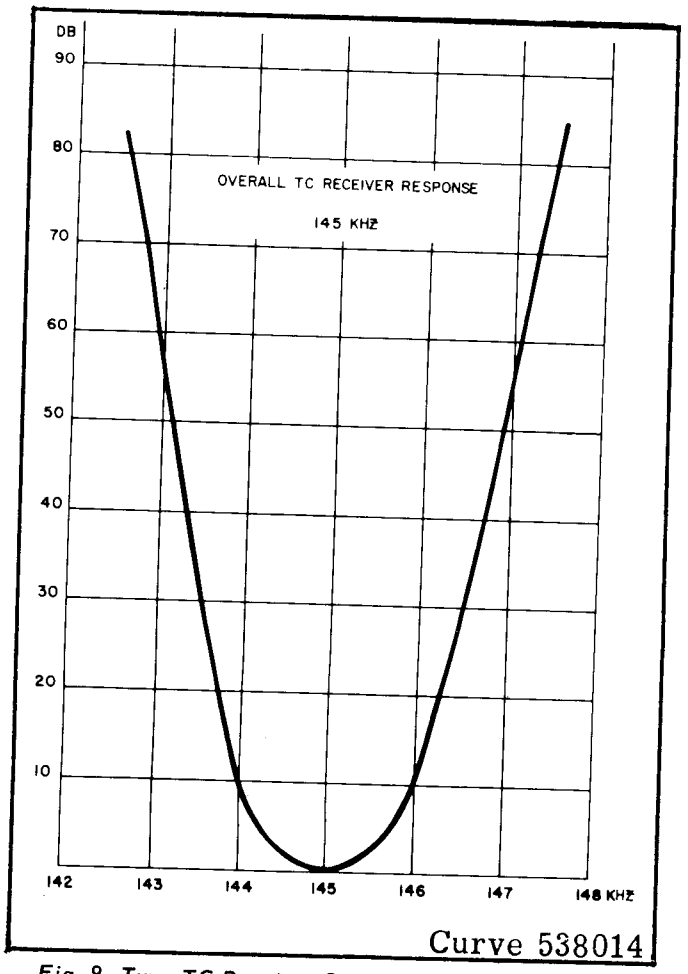


Fig. 9 Type TC Receiver Overall Selectivity Curve

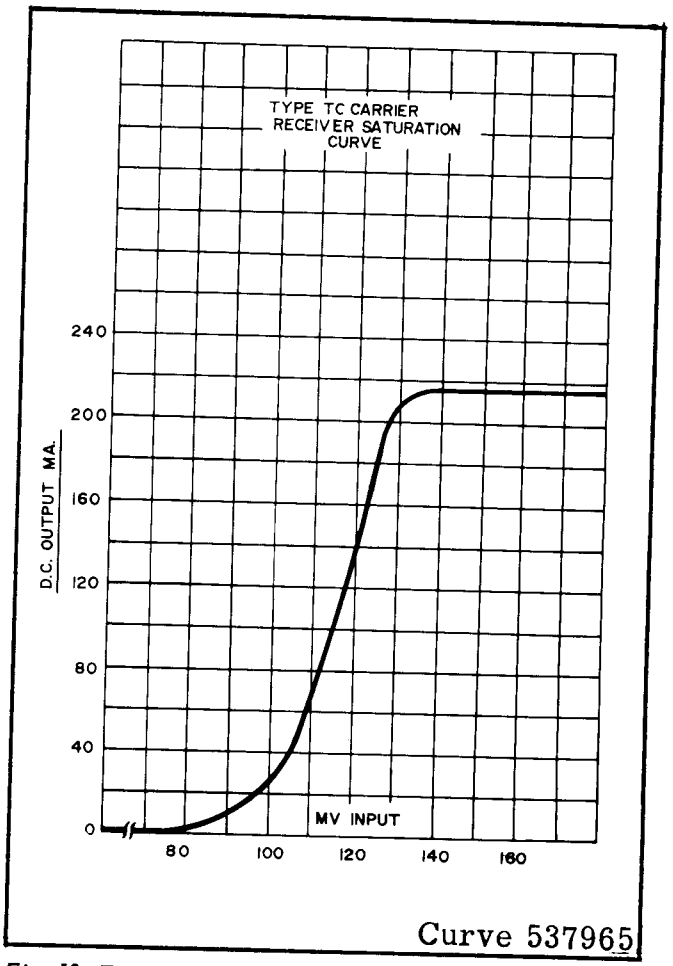


Fig. 10 Type TC Receiver – 200 ma. Output Characteristic.

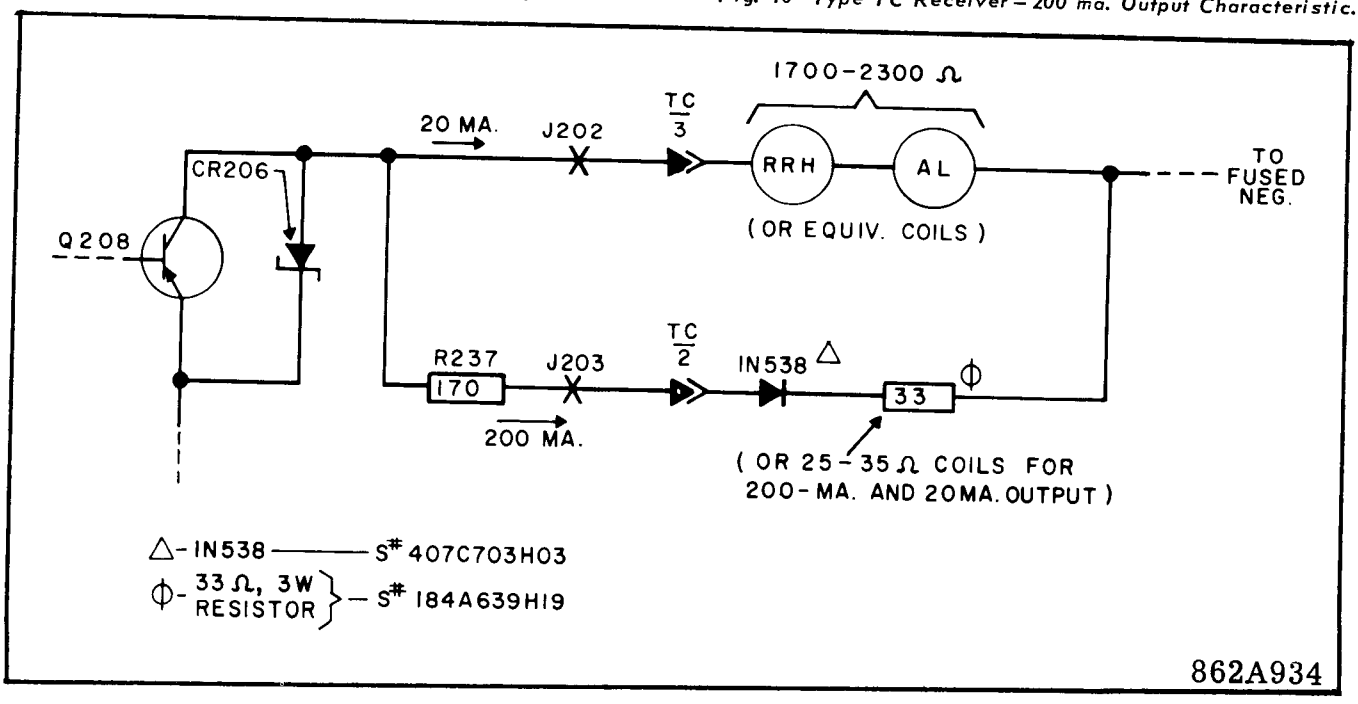


Fig. 11. TC Receiver Output For 20-ma. Operation

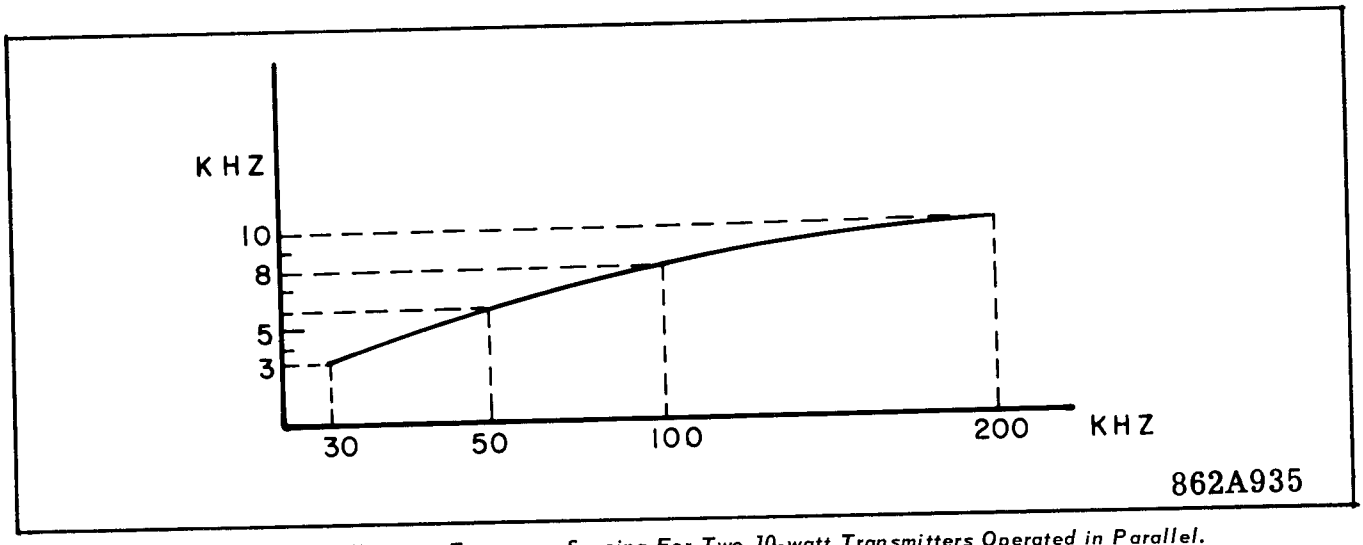


Fig. 12 Minimum Frequency Spacing For Two 10-watt Transmitters Operated in Parallel.

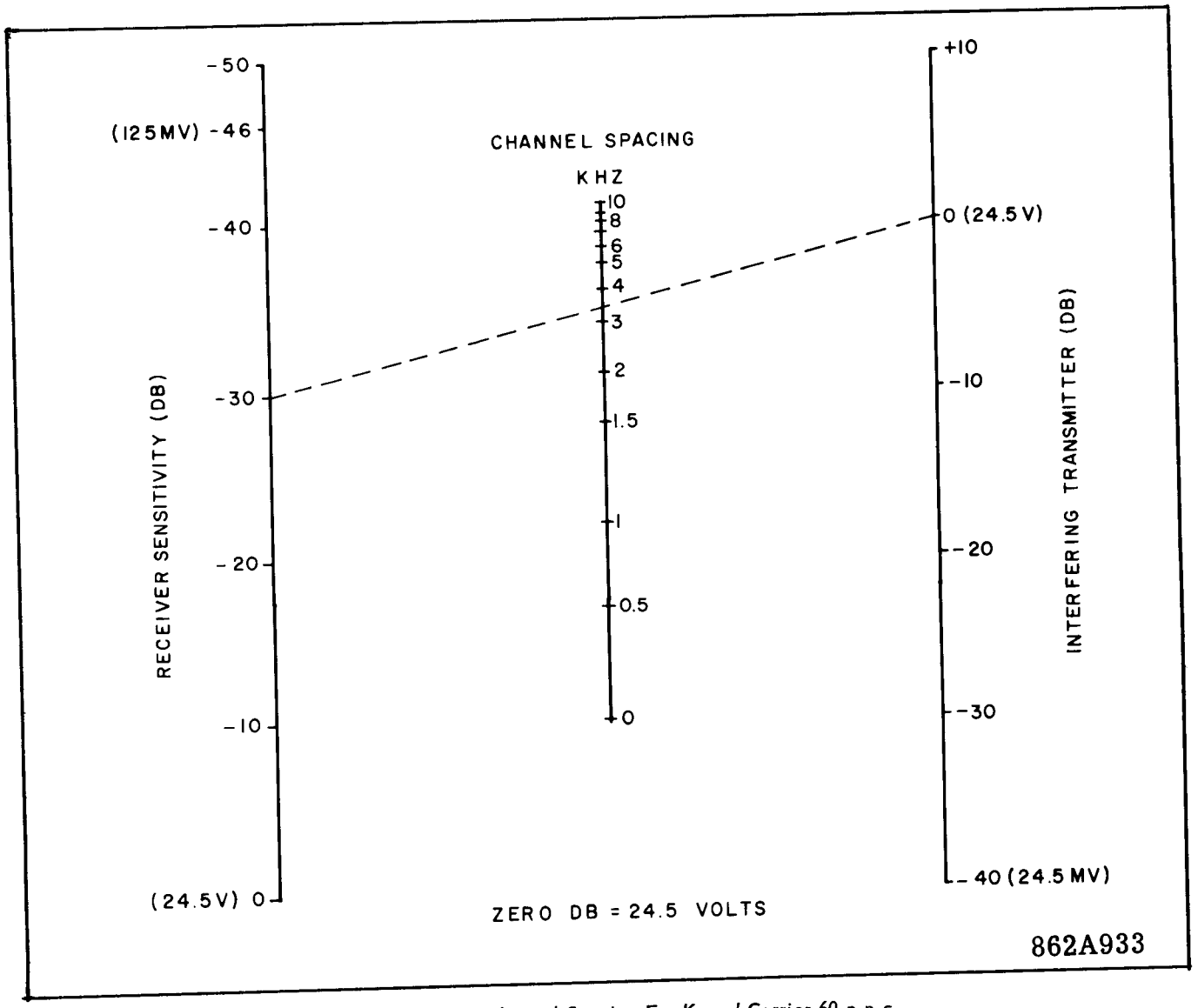


Fig. 13 Minimum Channel Spacing For Keyed Carrier 60 p.p.s.

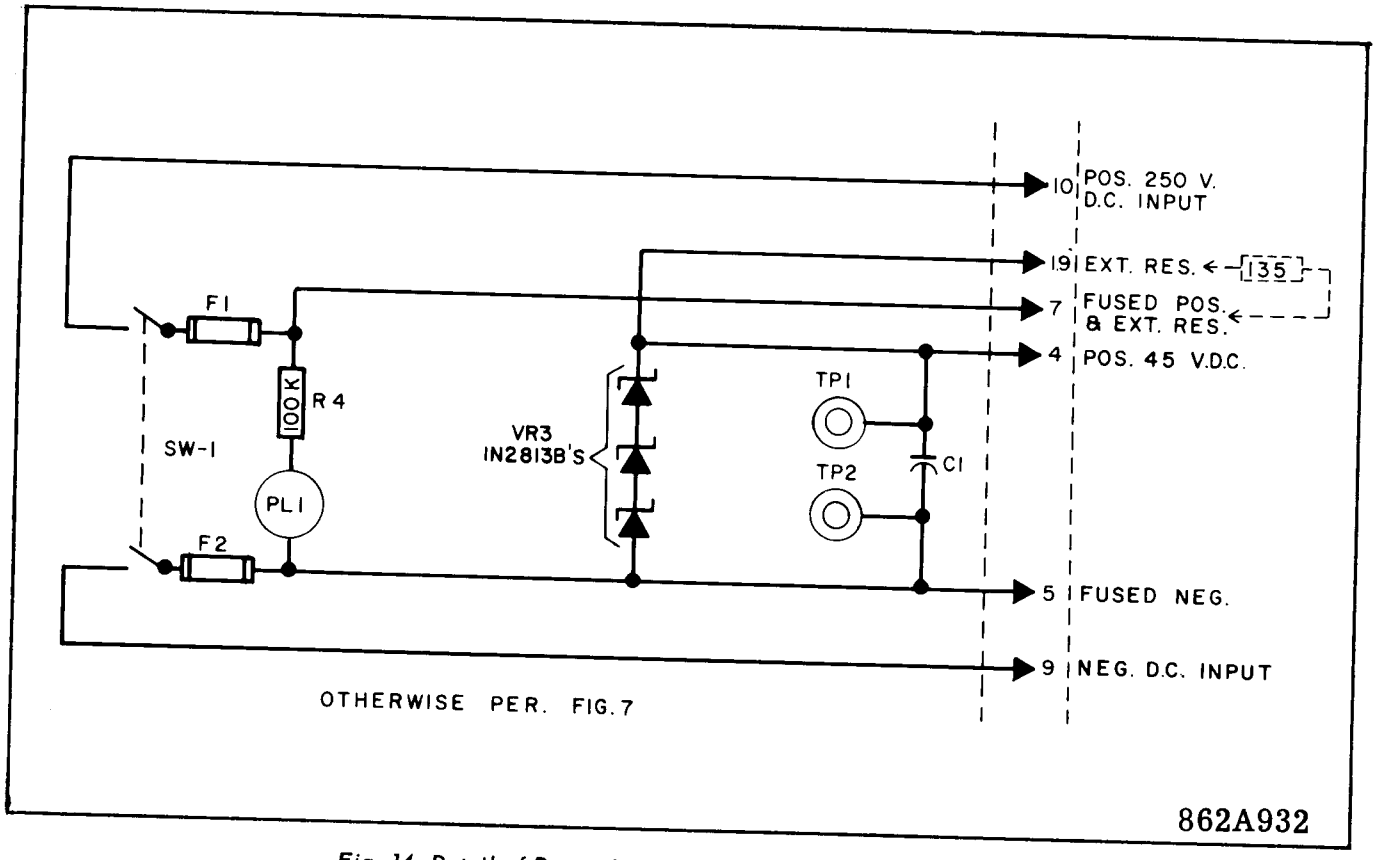


Fig. 14 Detail of Power Supply Section For 250-volt Supply

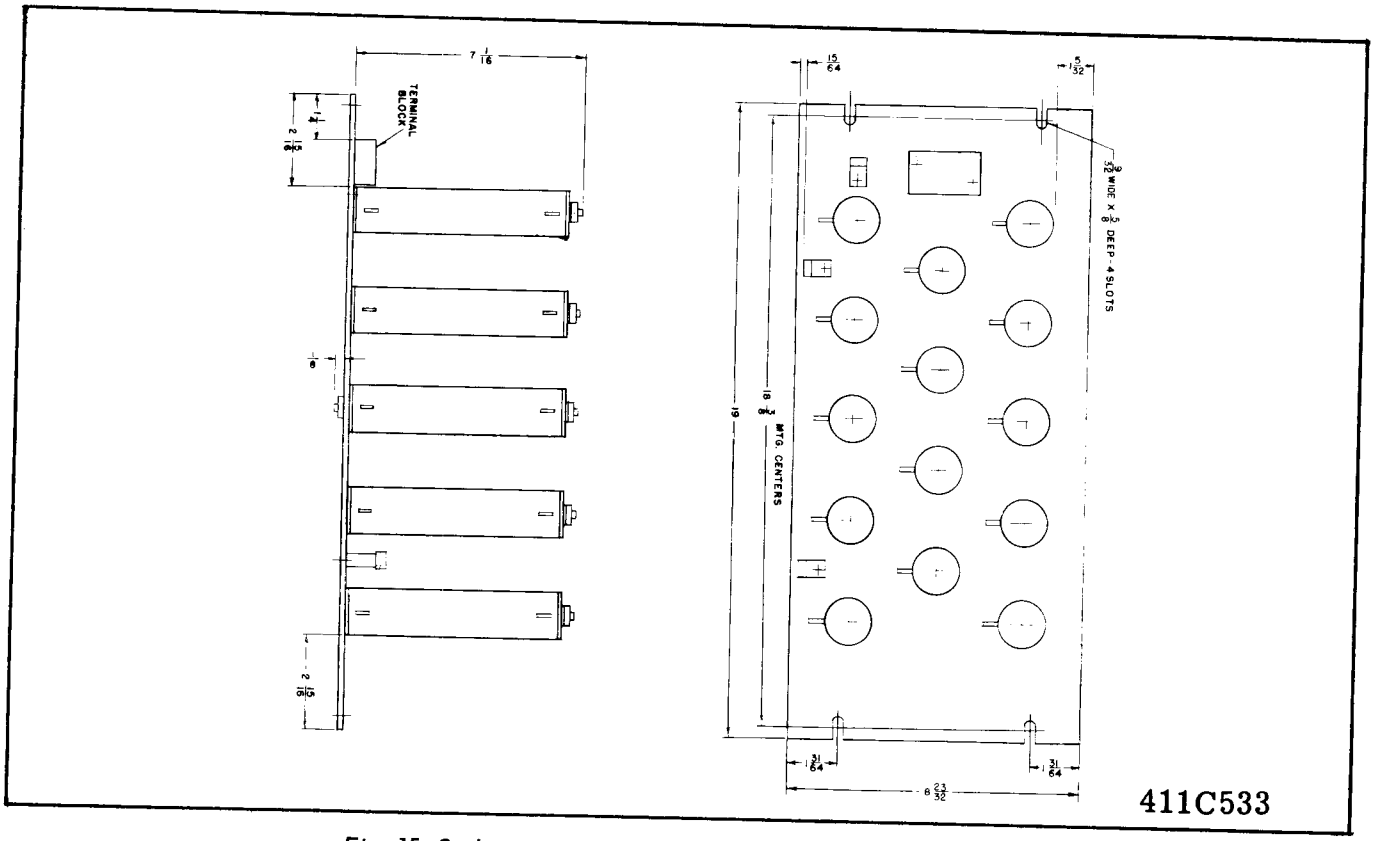


Fig. 15 Outline of External Resistor Unit For 250-volt Operation

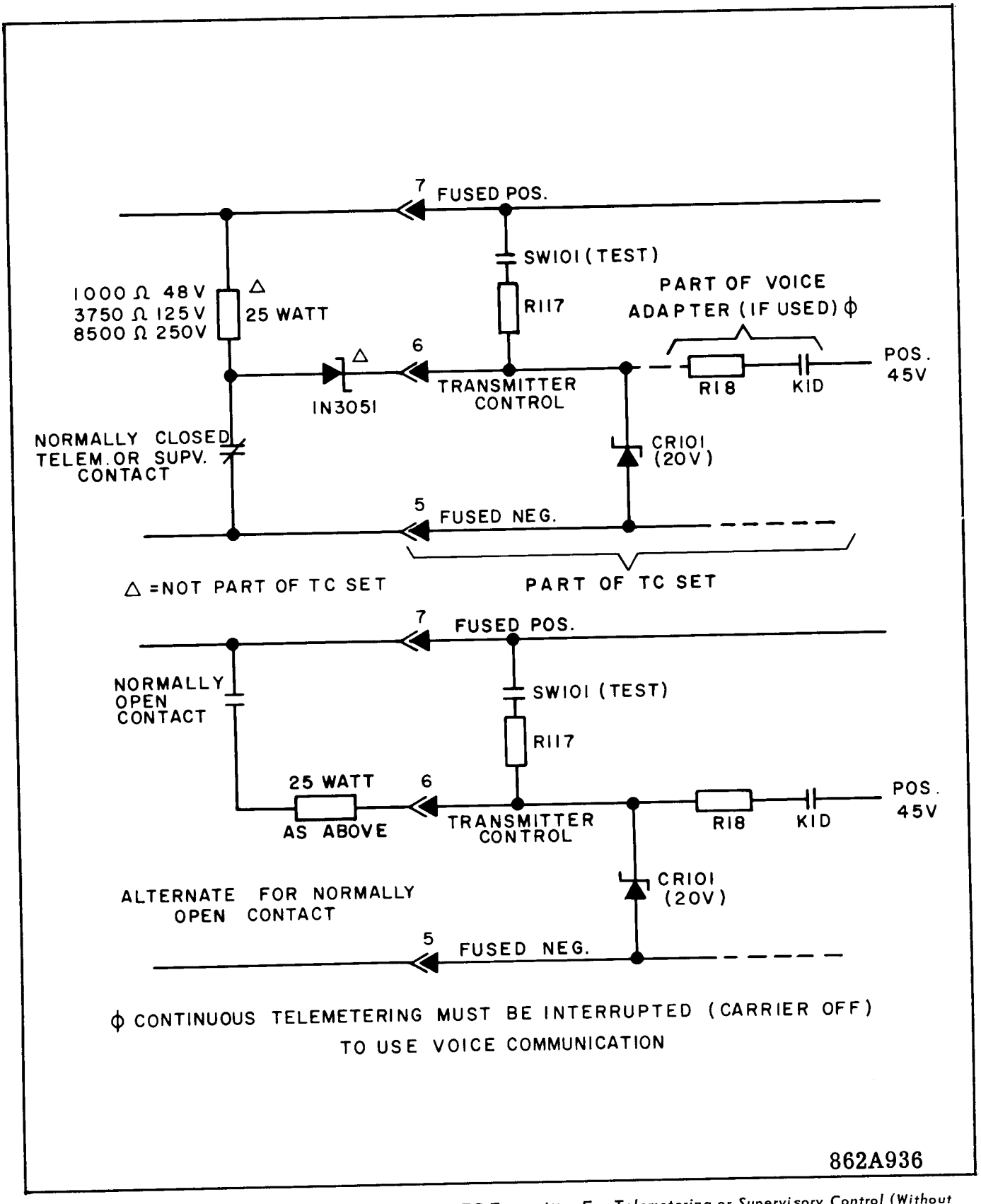


Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact

WESTINGHOUSE ELECTRIC CORPORATION
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INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY

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SUPERSEDES I.L.41-944.31A
* Denotes change from superseded issue

EFFECTIVE MARCH 1966

CAUTION

It is recommended that the user of this equipment become thoroughly acquainted with the informa- 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 directional or phase comparison protective relaying of power transmission lines. It can also be used for other functions including 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. 6. 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 collect current.

J202 - Receiver 20 - ma. output current.

J203 - Receiver 200 - ma. output current.

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. 6, 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 uses two series-connected type 2N1908 power transistors, Q107 and Q108 operating as a class B push-pull amplifier with single-ended output. Transistor Q106 applies forward bias to Q107 and Q108 when the carrier-start circuit is energized. Diodes CR103 and CR105 provide protection for the base-emitter junction of the power transistors. Zener diodes CR107 and CR108 protect the collector-emitter junctions from surges which might come in from the power line through the coaxial cable.

The output transformer T105 couples the power transistors to the transmitter output filter FL102. The output filter includes two trap circuits (L102, C_B, and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G101 is a small

lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line tuner and coaxial cable. Autotransformer T106 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms.

The series-resonant circuit composed of L105 and C_E is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and in 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 kc 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 kc. Typical characteristics of both filters and the complete receiver are shown on curves, Fig. 7 and 8.

The 20-kc i.f. signal is rectified by diodes CR202 and CR203. 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. If only a 20-ma. output is desired, a 30-ohm resistor and diode must be connected into the circuit as shown on the drawing for this particular application. Fig. 9 shows the receiver 200-ma. output characteristic.

Power Supply

The power supply circuit is a series-type transistorized d-c voltage regulator which has a very low standby current drain when there is no output current demand. The zener diode VR1 holds a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the d-c voltage drop through the transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage. The zener diode VR2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

CHARACTERISTICS

* Frequency range	30-200 kc (50-200 kc for phase comparison relaying)
Transmitter output	10 watts into 50 to 70-ohm resistive load
Harmonics	55 db below 10 watts
Receiver sensitivity	125 mv. input for 180 ma. minimum output current
Receiver selectivity	1500-cycle bandwidth (3 db down); down 80 db at ± 3 kc.
Transmitter-receiver channel rating	40 db
Input voltage	48, 125, or 250 V. d-c
Supply voltage variation	42-56 V, 105-140, 210-280 V
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

INSTALLATION

The type TC transmitter-receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60 °C.

ADJUSTMENTS

Transmitter

The only 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. 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

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 for the 125 m v. sensitivity, and the local oscillator output control R212. The oscillator output is preset at the factory to 0.3 volt. This setting can be checked by connecting an a-c VTVM between receiver test points TP202 and TP206 (shield lead of VTVM). The voltmeter reading with the equipment energized, but not transmitting, should be 0.3 volt. Note Fig. 5 for location of components on the receiver printed board.

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

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

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

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

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

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.

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 the following tables. Voltages should be measured with a VTVM. Readings may vary as much as ± 20%.

TABLE I

Receiver D.C. Measurements

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

Test Point	Standby (No Signal)			With 125 M.V. Input		
TP201	38			38		
TP202	0			0		
TP203	Q206 Collector			See Transistor d-c		
TP204	Q207 Base			Values		
TP205	20			20		
Transistor	E*	B*	C*	E*	B*	C*
Q201	38.5	37	43	38.5	37	43
Q202	38.5	37.5	43.5	38.5	37.5	43.5
Q203	0.08	0	18.7	0.08	0	18.7
Q204	2.7	2.9	18.7	2.7	2.9	18.7
Q205	2.4	2.6	18.7	2.5	2.7	18.7
Q206	2.5	2.7	10.5	2.6	2.8	10.5
Q207	0.13	0.03	22.0	2.0	2.2	4.0
Q208	0.25	0.15	45.0	1.7	2.0	2.0

*E - emitter, B - Base, C - Collector
All voltages read with d-c vacuum-tube voltmeter

TABLE II

Receiver RF Measurements

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

Test Point	Typical A-C Voltages		Test Point	Typical A-C Voltages	
	36 KC	132 KC		36 KC	132 KC
FL201-IN to Gnd.	.075	.050	Q204 - B to TP206	.11	.052
FL201-OUT to Gnd.	.051	.020	Q205 - C to TP206	6.7	3.4
Q203 - E to TP206	.105	.090	Q206 - B to TP206	.67	.37
Q203 - C to TP206	.22	.035	Q206 - C to TP206	1.5	1.53
Q204 - B to TP206	.015	.012	TP202 to TP206	0.3	0.3
Q204 - C to TP206	.90	.52			

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

TABLE III

Transmitter D-C Measurements

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

Test Point	Carrier Off	Carrier On
TP101	7	7
TP102	0	20
TP103	0	19.5
TP105	0	9
TP106	44	22
TP107	44	22.2
TP108	45	44.8
TP110	0.1	0.9
TP111	0.1	0.9
TP112	0	0
TP113	* 45	45

Transistor	E	B	C	E	B	C
Q101	6.0	7.8	2.5	6.1	7.7	2.5
Q102	6.6	7.1	1.2	6.6	7.1	1.2
Q103	0	0	0	19.5	19.4	9.0
Q104	0.1	0.1		45	0.9	45
Q105	0.1	0.1		45	0.9	45
Q106	0	0	44	0	0.9	1.2
Q107	43.7	43.7	0	22.2	22.2	0
Q108	45.0	44.7	44.7	44.8	44.8	22.3

TABLE IV

Transmitter RF Measurements

Note: "Carrier-on" voltages taken with transmitter set to 10 watts output (22.5 volts across 60 ohms). These voltages subject to variations, depending on frequency and transistor characteristics.

Test Point	A-C Voltage	Test Point	A-C Voltage
T101-3 to TP104	1.1	Q107-B to TP107	.5
TP103 to TP102	0.2	Q108-B to TP113	.5
Q103-C to TP104	0.7	Q107-C to TP107	14.5
T102-3 to T102-4	0.2	Q108-C to TP113	14.5
T102-5 to T102-4	0.2	T105-4 to Gnd.	105
Q104-C to TP104	4.3	T106-2 to Gnd.	155 *
Q105-C to TP104	4.3		
T103-4 to Gnd.	1.5	TP109 to Gnd.	50 *
T104-1 to Gnd.	1.4	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

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 0.003 to 30 volts, frequency range 60 cycles/sec. to 230-kc, input impedance 7.5 megohms.

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

Voltage Range: 0.15 to 300 volts
Input Impedance 7.5 megohms

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

b. Signal Generator

Output Voltage: up to 8 volts
Frequency Range: 20-kc to 230-kc

c. Oscilloscope

d. Ohmmeter

e. Capacitor checker

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

Complete Transmitter Section

Symbol	Rating	Symbol	Rating
C101	0.1 mfd, 200 V DC	CR105	1N538
C102	.005 mfd, 300 V DC	CR106	1N91
C103	180 pf. 500 V DC	CR107	1N2999A (56 V ± 10%)
C104	0.25 mfd, 200 V DC	CR108	1N2999A (56 V ± 10%)
C105	0.25 mfd, 200 V DC	G101	Type RVS Arrester S#632A026A01
C106	0.25 mfd, 200 V DC	J101	Closed Circuit Jack
C107	0.25 mfd, 200 V DC	J102	Banana Plug Jack
C108	0.50 mfd, 200 V DC	J103	Coaxial Cable Jack
C109	0.25 mfd, 200 V DC	J105	24-Term Receptacle
C110	0.25 mfd, 200 V DC	J105	12-Term Receptacle
C111	(See Table Below)	L101	Part of FL101
C112	39 pfd, 500 V DC	L102	FL102 Trap Coil (2nd Harmonic)
C113	(See Table Below)	L103	FL102 Trap Coil (3rd Harmonic)
C114	100 pf., 500 V DC	L104	400 mh.
C115	100 pf., 500 V DC	L105	FL102 Coil (part of series-resonant circuit tuned to fundamental freq.)
C116	0.001 mfd, 500 V. D.C.		
CA	Part of FL101	Q101	2N274
CB	Part of FL102	Q102	2N274
CC	Part of FL102	Q103	2N525
CD	Part of FL102	Q104	2N657
CE	Part of FL102	Q105	2N657
CR101	1N3686B (20 V ± 5%)	Q106	TI-481
CR102	1N63	Q107	2N1908 } Texas Instrument
CR103	1N538	Q108	2N1908 } Texas Instrument
CR104	1N91		

*FREQ.	C111, C113
30-50KC	0.47 mfd, 400 V DC
50.5-75 KC	0.22 mfd, 400 V DC
75.5-100 KC	0.15 mfd, 400 V DC
100.5-150 KC	0.1 mfd, 400 V DC
150.5-200 KC	0.047 mfd, 400 V DC

Complete Transmitter Section - Continued

Symbol	Rating			Sybmol	Rating		
	Ohms	± Tol %	Watts		Ohms	± Tol %	Watts
R101	5600	5	1	R122	10	5	.5
R102	2200	10	.5	R123	10	10	.5
R103	10,000	10	.5	R124	100	10	1
R104	100,000	5	.5	R125	1000	10	.5
R105	390	5	.5	R126	4700	10	1
R106	1200	5	.5	R127	10	10	.5
R107	10,000	10	.5	R128	2200	5	1
R108	100,000	5	.5	R129	2.7	10	.5
R109	390	5	.5	R130	10	10	.5
R110 *			.5	R131	4700	5	1
R111	1200	5	.5	R132	.27	10	.5
R112	1 K Pot.	20	.25	R133	0.27	10	1
R113	4700	5	.5	R134	0.27	10	1
R114	10,000	10%	.5	R135	3000	10	5
R115	150	5	.5	R136	12,000	10	.5
R116	100	5	.5	R137	15,000	10	2
				R138	1000	10	.5
R117	1000 48V dc 3750 125V dc	5	25	R139	1000	10	.5
R118	8200	5	2	T101	10,000/400 ohms		L633003
R119	100	5	.5	T102	10,000/400 C.T.		L592170
R120	10,000	5	2	T103	1930/60 ohms		L633000
R121	10	5	2	T104	Turns ratio, 1/0.5,		Pri./each sec.
				T105	10/500 ohms		
				T106	500/50-60-70 ohms		
				Y101	30-200 kc crystal per 328C083		

*Sensistor - 30-60 kc, 2.2 ± 10%, ¼ watt
60.5-120 kc, 1.8 K ± 10%, ¼ watt
120.5-200 kc, 1.2 K ± 10%, ¼ watt

Complete Receiver Station

Symbol	Rating
C201	0.1 mfd., 200 V DC
C202	300 pf, 500 V DC
C203	180 pf, 500 V DC
C204	0.25 mfd., 200 V DC
C205	0.25 mfd., 200 V DC
C206	0.25 mfd., 200 VDC
C207	0.25 mfd. 200 V DC
C208	0.25 mfd., 200 V DC
C209	0.25.mfd., 200 V DC
C210	0.25 mfd., 200 V DC
C211	0.1 mfd., 200 V DC
C212	0.25 mfd., 200 VDC
C213	2.0 mfd., 200 V DC
C214	0.25 mfd., 200 V DC
C215	39 pfd., 500 V DC
CR201	1M20Z10 (20v ± 10%)
CR202	1N91
CR203	1N91
CR204	1N538
CR205	1N538
CR206	1N1789 (56v ± 10%)

Symbol	Rating
FL201	Receive Input Filter 30-200 KC
FL202	Receiver i.f. Filter-20 KC (2 Sections) S#187A590G02
J201	Receiver coax. Input Jack
J202	Closed Circuit Jack (20 MA)
J203	Closed Circuit Jack (200 MA)
L201	33 mh.
Q201	2N274
Q202	2N274
Q203	2N274
Q204	2N274
Q205	2N274
Q206	2N274
Q207	2N398A
Q208	2N1362

Resistors	Ohms	± Tol %	Watts
R201	10,000	10	.5
R202	2200	10	.5
R203	10,000	10	.5
R204	100,000	5	.5
R205	390	5	.5

Resistors	Ohms	± Tol %	Watts
R206	1200	5	.5
R207	25 K Pot.	10	2
R208	10,000	10	.5
R209	100,000	5	.5
R110	390	5	.5

Complete Receiver Section - Continued

Symbol	Rating			Symbol	Rating		
	Ohms	± Tol %	Watts		Ohms	± Tol %	Watts
R211	10,000	10	.5	R225	10,000	10	.5
R212	1K Pot.	20	.25	R226	20,000	5	.5
R213	1200	5	.5	R227	300	5	.5
R214	5600	5	1	R228	3600	5	.5
R215	20,000	5	.5	R229	620	5	.5
R216	3600	5	.5	R230	62	5	.5
R217	620	5	.5	R331	2000	5	.5
R218	62	5	.5	R232	1200	5	2
R219	10,000	10	.5	R233	4700	10	2
R220	20,000	5	.5	R234	5100	5	.5
R221	300	5	.5	R235	470	10	1
R222	3600	5	.5	R236	4700	10	1
R223	620	5	.5	R237	170	5	40
R224	62	5	.5				

Symbol	Rating		
T 201	10,000 / 10,000 Ohms	L633005	*R211 - 10K - above 50KC
T 202	10,000 / 400 Ohms	L633003	R238 - omit - above 50KC
T 203	25,000 / 300 Ohms	L592171	For 30-50 KC,
Y 201	50-220 KC Crystal per 328C083		R211 = R238 = 22K

Power Supply Section

Symbol	Function	Description or Rating	Symbol	Function	Description or Rating
C1	(+) to (-) bypass	0.45 mfd. 330 VAC	R1	125V Series dropping	26.5 ohms, 3½"
C2	A-C grounding	0.5 mfd, 1500 VDC	R2	125V Series dropping	Same as R1
C3	A-C grounding	0.5 mfd, 1500 VDC	R3	125V Current limiting	500 ohms, 3½"
F1	Overload Protection	1.5a, 250 volts		48V For 48 VDC, R1 = R2 = 0 R3 = 26.5 ohms	
F2	Overload Protection	1.5a, 250 volts			
PL1	Neon pilot light - - - - (filament type for 48 V DC) - - - - - - - -	-120 volts - 55 volts	TP1	Test point (+)	Pin Jack - red
			TP2	Test point (-)	Pin Jack - black
			VR1	Voltage Regulator	1N2828B (45V.)
Q1	Series Regulator	Type 2N1015C Silicon Transistor	VR2	Surge Protection	1N3009A (130V.) Zener Diodes

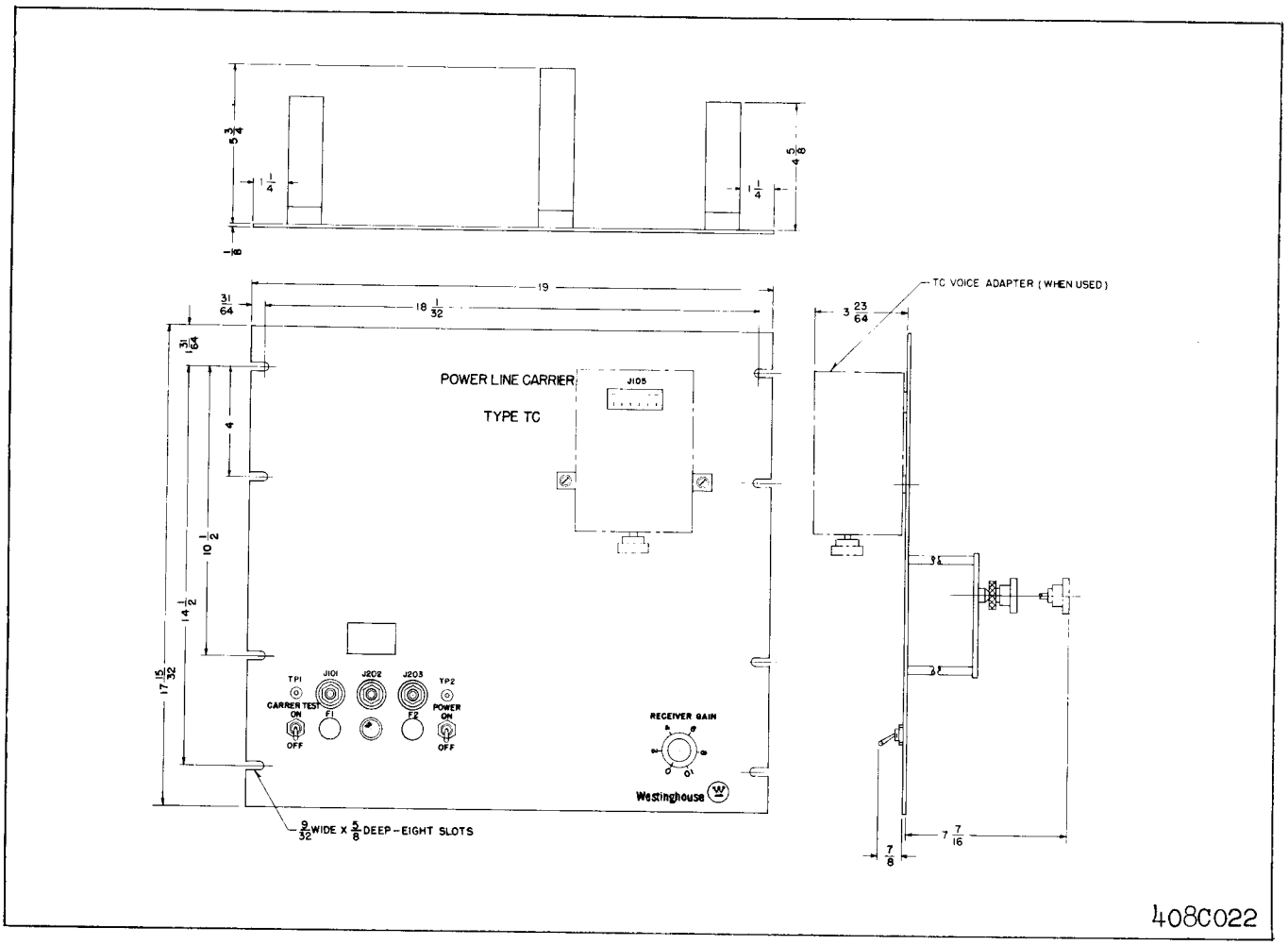


Fig. 1 Type TC Carrier Assembly - Outline

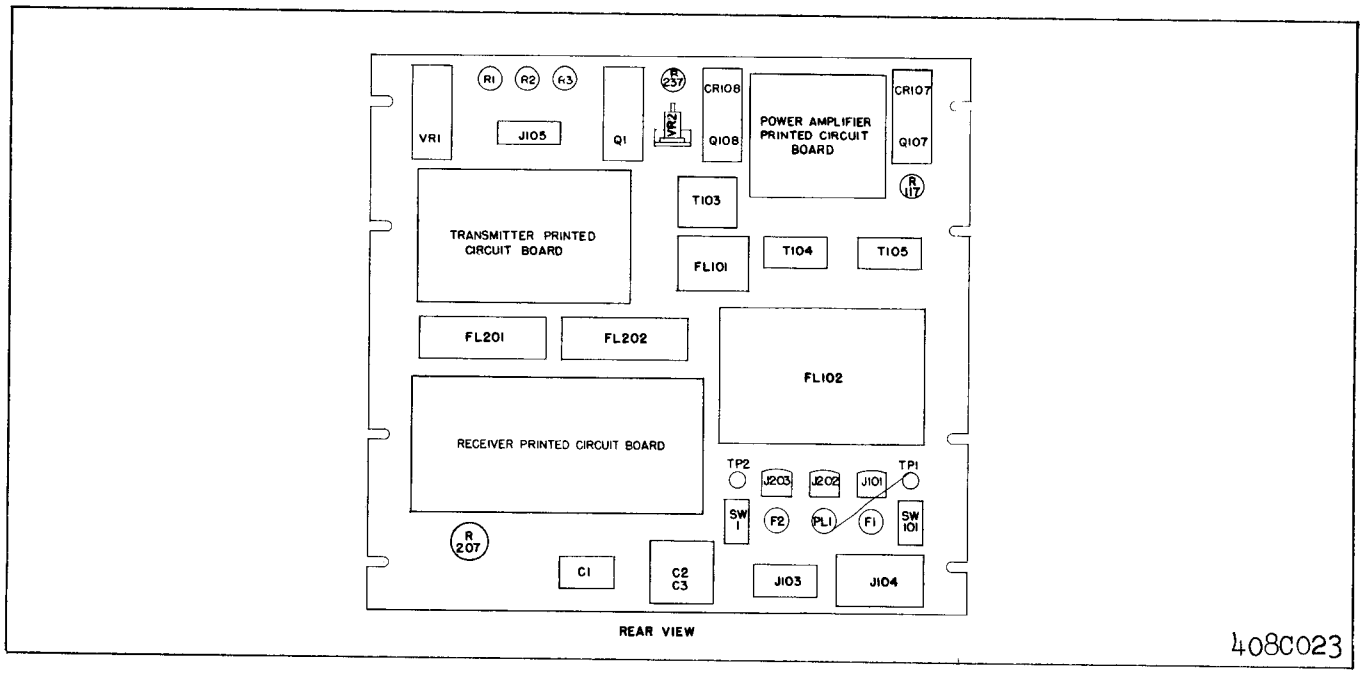


Fig. 2 Type TC Carrier Assembly - Parts Location

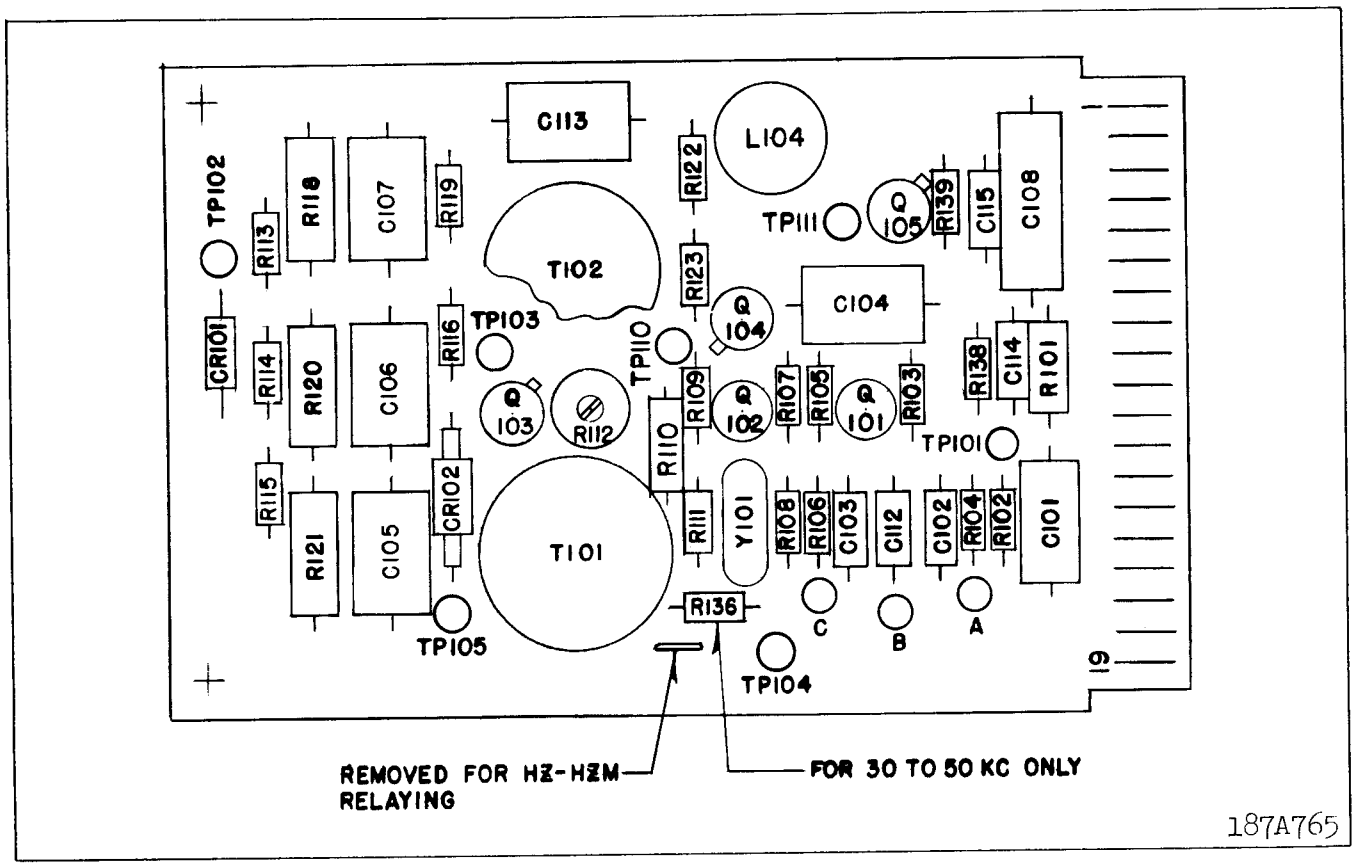


Fig. 3 Transmitter Printed Circuit - Parts Location

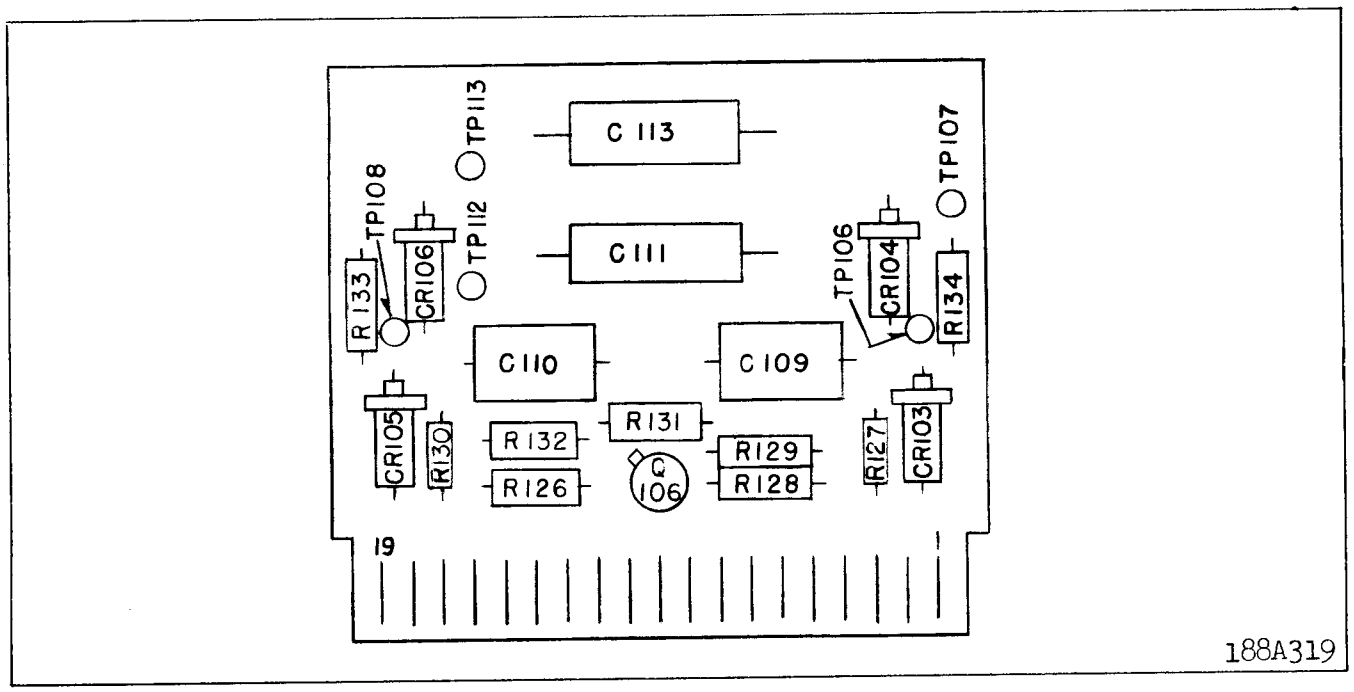


Fig. 4 Power Amplifier Printed Circuit - Parts Location

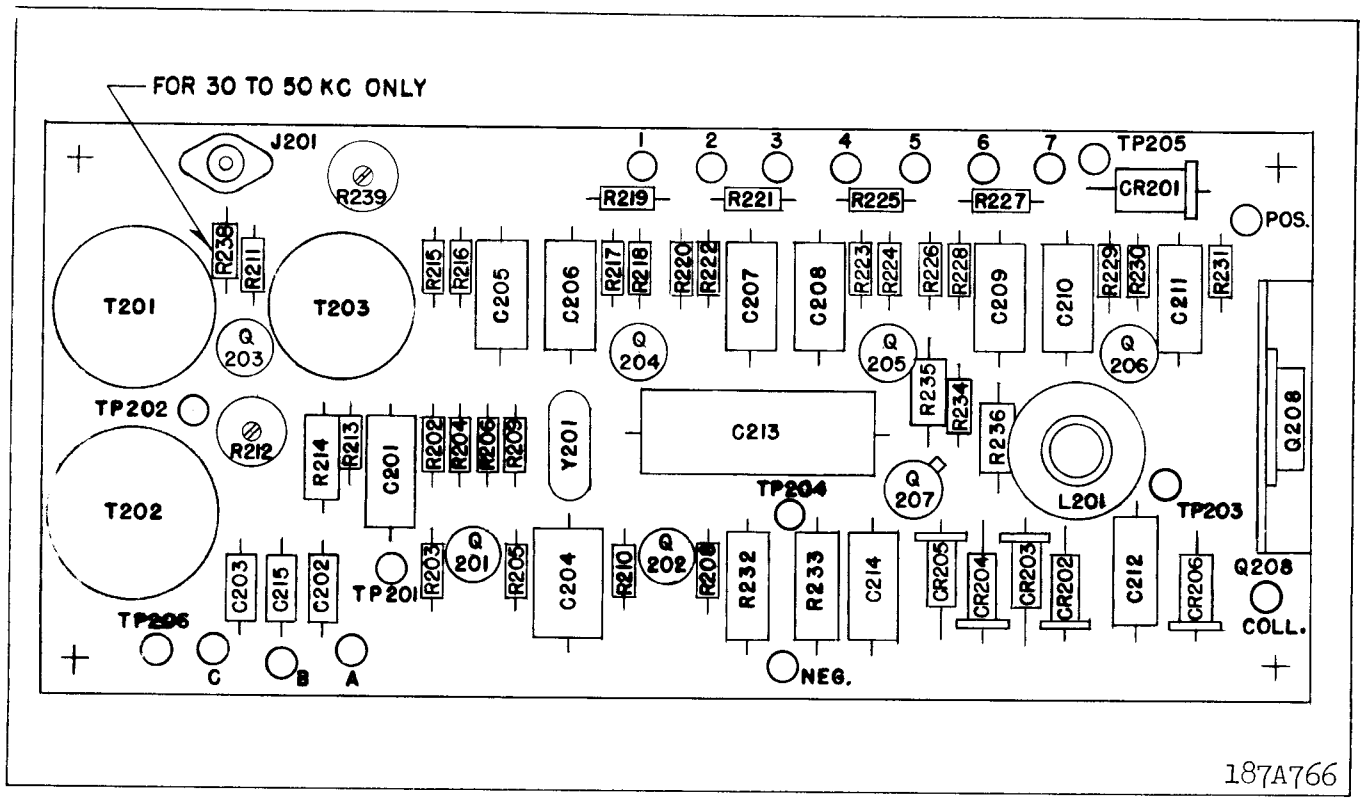
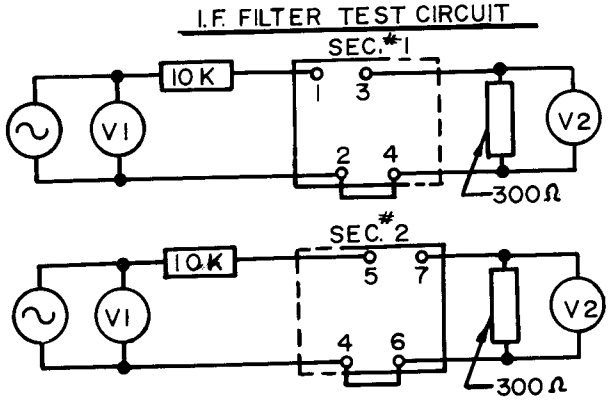
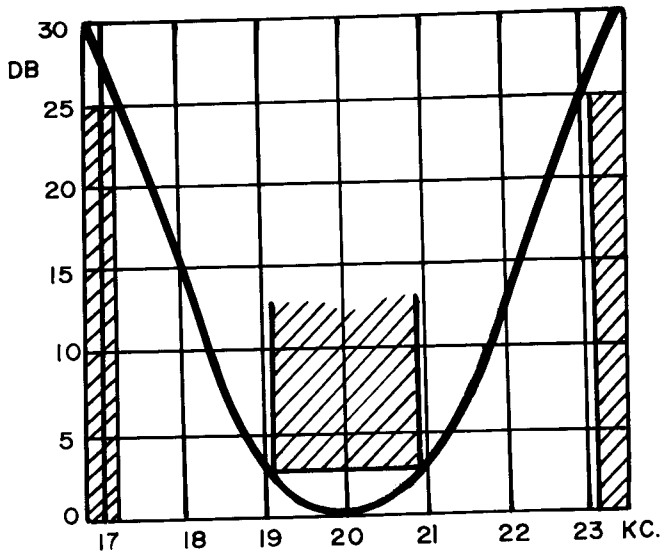
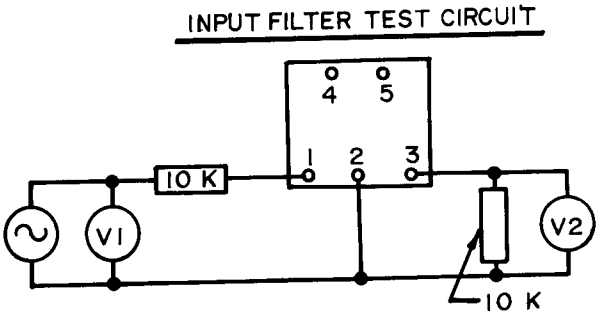


Fig. 5 Receiver Printed Circuit - Parts Location



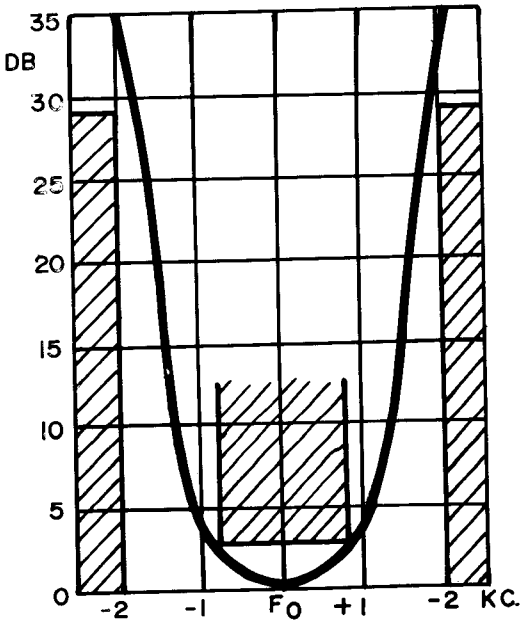


TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.



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

TC RECEIVER FILTER LIMITS



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

629A425

Fig. 7 Type TC Receiver Filter Characteristics

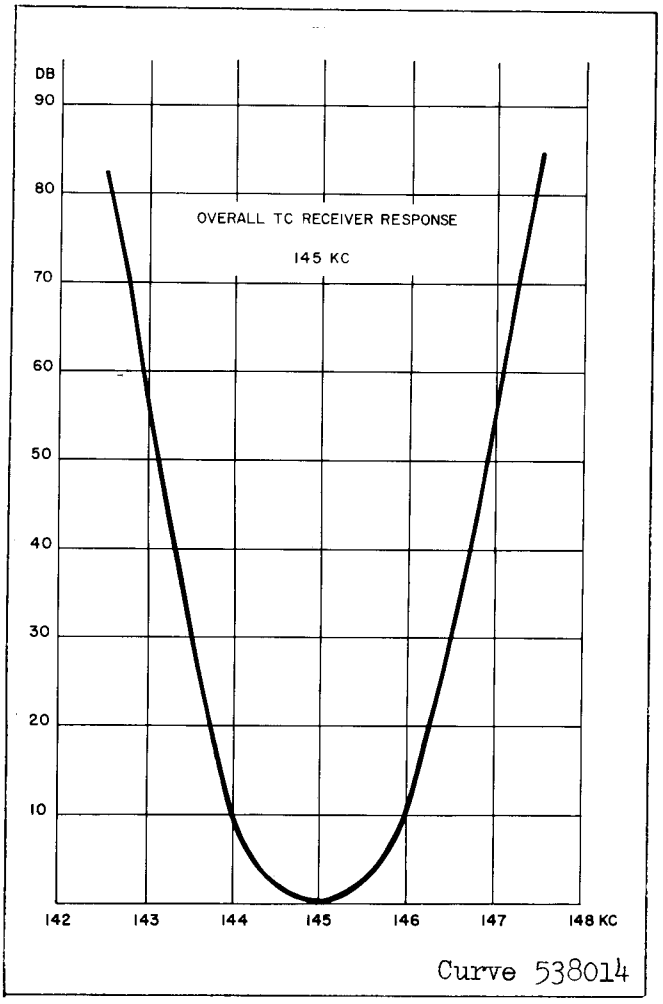


Fig. 8 Type TC Receiver Overall Selectivity Curve

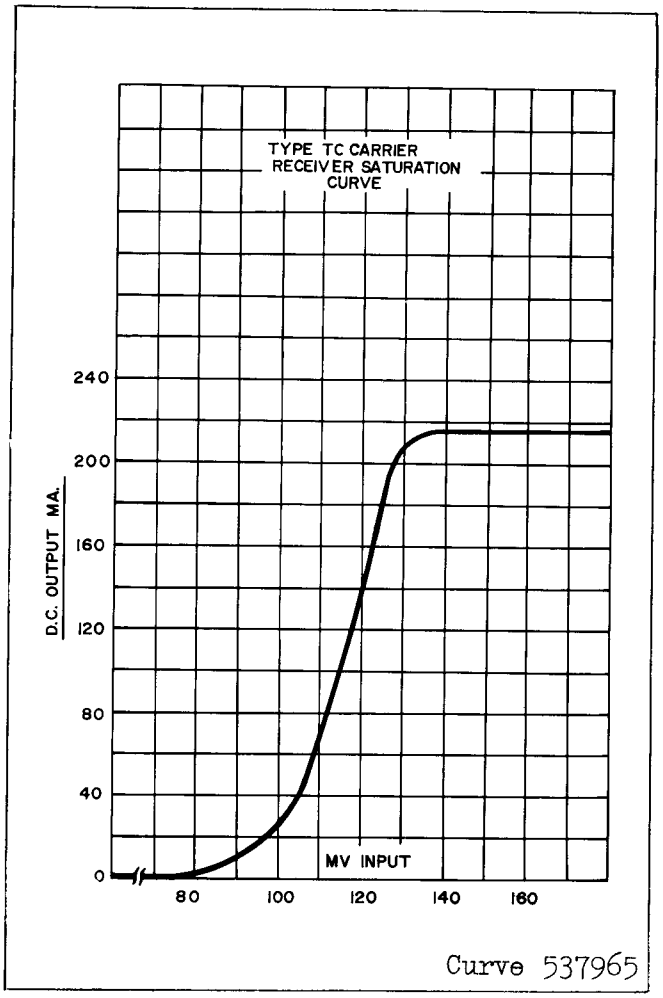


Fig. 9 Type TC Receiver - 200 ma. Output Characteristic.

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

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LIST OF ILLUSTRATIONS

SUPERSEDES I.L.41-944.31A
* Denotes change from superseded issue

EFFECTIVE MARCH 1966

CAUTION

It is recommended that the user of this equipment become thoroughly acquainted with the informa- 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 directional or phase comparison protective relaying of power transmission lines. It can also be used for other functions including 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. 6. 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 collect current.

J202 - Receiver 20-ma. output current.

J203 - Receiver 200-ma. output current.

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. 6, 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 uses two series-connected type 2N1908 power transistors, Q107 and Q108 operating as a class B push-pull amplifier with single-ended output. Transistor Q106 applies forward bias to Q107 and Q108 when the carrier-start circuit is energized. Diodes CR103 and CR105 provide protection for the base-emitter junction of the power transistors. Zener diodes CR107 and CR108 protect the collector-emitter junctions from surges which might come in from the power line through the coaxial cable.

The output transformer T105 couples the power transistors to the transmitter output filter FL102. The output filter includes two trap circuits (L102, C_B, and L103, C_C) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor C_D approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G101 is a small

lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line tuner and coaxial cable. Autotransformer T106 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms.

The series-resonant circuit composed of L105 and C_E is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and in 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 kc 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 kc. Typical characteristics of both filters and the complete receiver are shown on curves, Fig. 7 and 8.

The 20-kc i.f. signal is rectified by diodes CR202 and CR203. 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. If only a 20-ma. output is desired, a 30-ohm resistor and diode must be connected into the circuit as shown on the drawing for this particular application. Fig. 9 shows the receiver 200-ma. output characteristic.

Power Supply

The power supply circuit is a series-type transistorized d-c voltage regulator which has a very low standby current drain when there is no output current demand. The zener diode VR1 holds a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the d-c voltage drop through the transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage. The zener diode VR2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

CHARACTERISTICS

* Frequency range	30-200 kc (50-200 kc for phase comparison relaying)
Transmitter output	10 watts into 50 to 70-ohm resistive load
Harmonics	55 db below 10 watts
Receiver sensitivity	125 mv. input for 180 ma. minimum output current
Receiver selectivity	1500-cycle bandwidth (3 db down); down 80 db at ± 3 kc.
Transmitter-receiver channel rating	40 db
Input voltage	48, 125, or 250 V. d-c
Supply voltage variation	42-56 V, 105-140, 210-280 V
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

INSTALLATION

The type TC transmitter-receiver is generally supplied in a cabinet or on a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. The maximum ambient temperature around the chassis must not exceed 60 °C.

ADJUSTMENTS

Transmitter

The only 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. 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

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 for the 125 m v. sensitivity, and the local oscillator output control R212. The oscillator output is preset at the factory to 0.3 volt. This setting can be checked by connecting an a-c VTVM between receiver test points TP202 and TP206 (shield lead of VTVM). The voltmeter reading with the equipment energized, but not transmitting, should be 0.3 volt. Note Fig. 5 for location of components on the receiver printed board.

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

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

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

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

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

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.

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 the following tables. Voltages should be measured with a VTVM. Readings may vary as much as ± 20%.

TABLE I

Receiver D.C. Measurements

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

Test Point	Standby (No Signal)			With 125 M.V. Input		
TP201	38			38		
TP202	0			0		
TP203	Q206 Collector			See Transistor d-c		
TP204	Q207 Base			Values		
TP205	20			20		
Transistor	E*	B*	C*	E*	B*	C*
Q201	38.5	37	43	38.5	37	43
Q202	38.5	37.5	43.5	38.5	37.5	43.5
Q203	0.08	0	18.7	0.08	0	18.7
Q204	2.7	2.9	18.7	2.7	2.9	18.7
Q205	2.4	2.6	18.7	2.5	2.7	18.7
Q206	2.5	2.7	10.5	2.6	2.8	10.5
Q207	0.13	0.03	22.0	2.0	2.2	4.0
Q208	0.25	0.15	45.0	1.7	2.0	2.0

*E - emitter, B - Base, C - Collector
All voltages read with d-c vacuum-tube voltmeter

TABLE II

Receiver RF Measurements

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

Test Point	Typical A-C Voltages		Test Point	Typical A-C Voltages	
	36 KC	132 KC		36 KC	132 KC
FL201-IN to Gnd.	.075	.050	Q204 - B to TP206	.11	.052
FL201-OUT to Gnd.	.051	.020	Q205 - C to TP206	6.7	3.4
Q203 - E to TP206	.105	.090	Q206 - B to TP206	.67	.37
Q203 - C to TP206	.22	.035	Q206 - C to TP206	1.5	1.53
Q204 - B to TP206	.015	.012	TP202 to TP206	0.3	0.3
Q204 - C to TP206	.90	.52			

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

TABLE III

Transmitter D-C Measurements

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

Test Point	Carrier Off	Carrier On
TP101	7	7
TP102	0	20
TP103	0	19.5
TP105	0	9
TP106	44	22
TP107	44	22.2
TP108	45	44.8
TP110	0.1	0.9
TP111	0.1	0.9
TP112	0	0
TP113	* 45	45

Transistor	E	B	C	E	B	C
Q101	6.0	7.8	2.5	6.1	7.7	2.5
Q102	6.6	7.1	1.2	6.6	7.1	1.2
Q103	0	0	0	19.5	19.4	9.0
Q104	0.1	0.1		45	0.9	45
Q105	0.1	0.1		45	0.9	45
Q106	0	0	44	0	0.9	1.2
Q107	43.7	43.7	0	22.2	22.2	0
Q108	45.0	44.7	44.7	44.8	44.8	22.3

TABLE IV

Transmitter RF Measurements

Note: "Carrier-on" voltages taken with transmitter set to 10 watts output (22.5 volts across 60 ohms). These voltages subject to variations, depending on frequency and transistor characteristics.

Test Point	A-C Voltage	Test Point	A-C Voltage
T101-3 to TP104	1.1	Q107-B to TP107	.5
TP103 to TP102	0.2	Q108-B to TP113	.5
Q103-C to TP104	0.7	Q107-C to TP107	14.5
T102-3 to T102-4	0.2	Q108-C to TP113	14.5
T102-5 to T102-4	0.2	T105-4 to Gnd.	105
Q104-C to TP104	4.3	T106-2 to Gnd.	155 *
Q105-C to TP104	4.3		
T103-4 to Gnd.	1.5	TP109 to Gnd.	50 *
T104-1 to Gnd.	1.4	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

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 0.003 to 30 volts, frequency range 60 cycles/sec. to 230-kc, input impedance 7.5 megohms.

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

Voltage Range: 0.15 to 300 volts
Input Impedance 7.5 megohms

II. Desirable Test Equipment for Apparatus Maintenance.

a. All items listed in I.

b. Signal Generator

Output Voltage: up to 8 volts
Frequency Range: 20-kc to 230-kc

c. Oscilloscope

d. Ohmmeter

e. Capacitor checker

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

Complete Transmitter Section

Symbol	Rating	Symbol	Rating
C101	0.1 mfd, 200 V DC	CR105	1N538
C102	.005 mfd, 300 V DC	CR106	1N91
C103	180 pf. 500 V DC	CR107	1N2999A (56 V ± 10%)
C104	0.25 mfd, 200 V DC	CR108	1N2999A (56 V ± 10%)
C105	0.25 mfd, 200 V DC	G101	Type RVS Arrester S#632A026A01
C106	0.25 mfd, 200 V DC	J101	Closed Circuit Jack
C107	0.25 mfd, 200 V DC	J102	Banana Plug Jack
C108	0.50 mfd, 200 V DC	J103	Coaxial Cable Jack
C109	0.25 mfd, 200 V DC	J105	24-Term Receptacle
C110	0.25 mfd, 200 V DC	J105	12-Term Receptacle
C111	(See Table Below)	L101	Part of FL101
C112	39 pfd, 500 V DC	L102	FL102 Trap Coil (2nd Harmonic)
C113	(See Table Below)	L103	FL102 Trap Coil (3rd Harmonic)
C114	100 pf., 500 V DC	L104	400 mh.
C115	100 pf., 500 V DC	L105	FL102 Coil (part of series-resonant circuit tuned to fundamental freq.)
C116	0.001 mfd, 500 V. D.C.		
CA	Part of FL101		
CB	Part of FL102		
CC	Part of FL102	Q101	2N274
CD	Part of FL102	Q102	2N274
CE	Part of FL102	Q103	2N525
		Q104	2N657
CR101	1N3686B (20 V ± 5%)	Q105	2N657
CR102	1N63	Q106	TI-481
CR103	1N538	Q107	2N1908 } Texas Instrument
CR104	1N91	Q108	2N1908 }

*FREQ.	C111, C113
30-50KC	0.47 mfd, 400 V DC
50.5-75 KC	0.22 mfd, 400 V DC
75.5-100 KC	0.15 mfd, 400 V DC
100.5-150 KC	0.1 mfd, 400 V DC
150.5-200 KC	0.047 mfd, 400 V DC

Complete Transmitter Section - Continued

Symbol	Rating			Sybmol	Rating		
	Ohms	± Tol%	Watts		Ohms	± Tol%	Watts
R101	5600	5	1	R122	10	5	.5
R102	2200	10	.5	R123	10	10	.5
R103	10,000	10	.5	R124	100	10	1
R104	100,000	5	.5	R125	1000	10	.5
R105	390	5	.5	R126	4700	10	1
R106	1200	5	.5	R127	10	10	.5
R107	10,000	10	.5	R128	2200	5	1
R108	100,000	5	.5	R129	2.7	10	.5
R109	390	5	.5	R130	10	10	.5
R110 *			.5	R131	4700	5	1
R111	1200	5	.5	R132	.27	10	.5
R112	1 K Pot.	20	.25	R133	0.27	10	1
R113	4700	5	.5	R134	0.27	10	1
R114	10,000	10%	.5	R135	3000	10	5
R115	150	5	.5	R136	12,000	10	.5
R116	100	5	.5	R137	15,000	10	2
	1000			R138	1000	10	.5
R117	48V dc 3750 125V dc	5	25	R139	1000	10	.5
R118	8200	5	2	T101	10,000/400 ohms		L633003
R119	100	5	.5	T102	10,000/400 C.T.		L592170
R120	10,000	5	2	T103	1930/60 ohms		L633000
R121	10	5	2	T104	Turns ratio, 1/0.5,		Pri./each sec.
				T105	10/500 ohms		
				T106	500/50-60-70 ohms		
				Y101	30-200 kc crystal per 328C083		

*Sensistor - 30-60 kc, 2.2 ± 10%, ¼ watt
60.5-120 kc, 1.8 K ± 10%, ¼ watt
120.5-200 kc, 1.2 K ± 10%, ¼ watt

Complete Receiver Station

Symbol	Rating
C201	0.1 mfd., 200 V DC
C202	300 pf, 500 V DC
C203	180 pf, 500 V DC
C204	0.25 mfd., 200 V DC
C205	0.25 mfd., 200 V DC
C206	0.25 mfd., 200 VDC
C207	0.25 mfd. 200 V DC
C208	0.25 mfd., 200 V DC
C209	0.25.mfd., 200 V DC
C210	0.25 mfd., 200 V DC
C211	0.1 mfd., 200 V DC
C212	0.25 mfd., 200 VDC
C213	2.0 mfd., 200 V DC
C214	0.25 mfd., 200 V DC
C215	39 pfd., 500 V DC
CR201	1M20Z10 (20v ± 10%)
CR202	1N91
CR203	1N91
CR204	1N538
CR205	1N538
CR206	1N1789 (56v ± 10%)

Symbol	Rating
FL201	Receive Input Filter 30-200 KC
FL202	Receiver i.f. Filter-20 KC (2 Sections) S#187A590G02
J201	Receiver coax. Input Jack
J202	Closed Circuit Jack (20 MA)
J203	Closed Circuit Jack (200 MA)
L201	33 mh.
Q201	2N274
Q202	2N274
Q203	2N274
Q204	2N274
Q205	2N274
Q206	2N274
Q207	2N398A
Q208	2N1362

Resistors	Ohms	± Tol %	Watts
R201	10,000	10	.5
R202	2200	10	.5
R203	10,000	10	.5
R204	100,000	5	.5
R205	390	5	.5

Resistors	Ohms	± Tol %	Watts
R206	1200	5	.5
R207	25 K Pot.	10	2
R208	10,000	10	.5
R209	100,000	5	.5
R110	390	5	.5

Complete Receiver Section - Continued

Symbol	Rating			Symbol	Rating		
	Ohms	± Tol %	Watts		Ohms	± Tol %	Watts
R211	10,000	10	.5	R225	10,000	10	.5
R212	1K Pot.	20	.25	R226	20,000	5	.5
R213	1200	5	.5	R227	300	5	.5
R214	5600	5	1	R228	3600	5	.5
R215	20,000	5	.5	R229	620	5	.5
R216	3600	5	.5	R230	62	5	.5
R217	620	5	.5	R331	2000	5	.5
R218	62	5	.5	R232	1200	5	2
R219	10,000	10	.5	R233	4700	10	2
R220	20,000	5	.5	R234	5100	5	.5
R221	300	5	.5	R235	470	10	1
R222	3600	5	.5	R236	4700	10	1
R223	620	5	.5	R237	170	5	40
R224	62	5	.5				

Symbol	Rating		
T 201	10,000 / 10,000 Ohms	L633005	*R211 - 10K - above 50KC
T 202	10,000 / 400 Ohms	L633003	R238 - omit - above 50KC
T 203	25,000 / 300 Ohms	L592171	For 30-50 KC,
Y 201	50-220 KC Crystal per 328C083		R211 = R238 = 22K

Power Supply Section

Symbol	Function	Description or Rating	Symbol	Function	Description or Rating
C1	(+) to (-) bypass	0.45 mfd. 330 VAC	R1	125V Series dropping	26.5 ohms, 3½"
C2	A-C grounding	0.5 mfd, 1500 VDC	R2	125V Series dropping	Same as R1
C3	A-C grounding	0.5 mfd, 1500 VDC	R3	125V Current limiting	500 ohms, 3½"
F1	Overload Protection	1.5a, 250 volts		48V For 48 VDC, R1 = R2 = 0, R3 = 26.5 ohms	
F2	Overload Protection	1.5a, 250 volts			
PL1	Neon pilot light - - - -	120 volts	TP1	Test point (+)	Pin Jack - red
	(filament type for 48 V DC) - - - - - - - -	55 volts	TP2	Test point (-)	Pin Jack - black
			VR1	Voltage Regulator	1N2828B (45V.)
Q1	Series Regulator	Type 2N1015C Silicon Transistor	VR2	Surge Protection	1N3009A (130V.) Zener Diodes

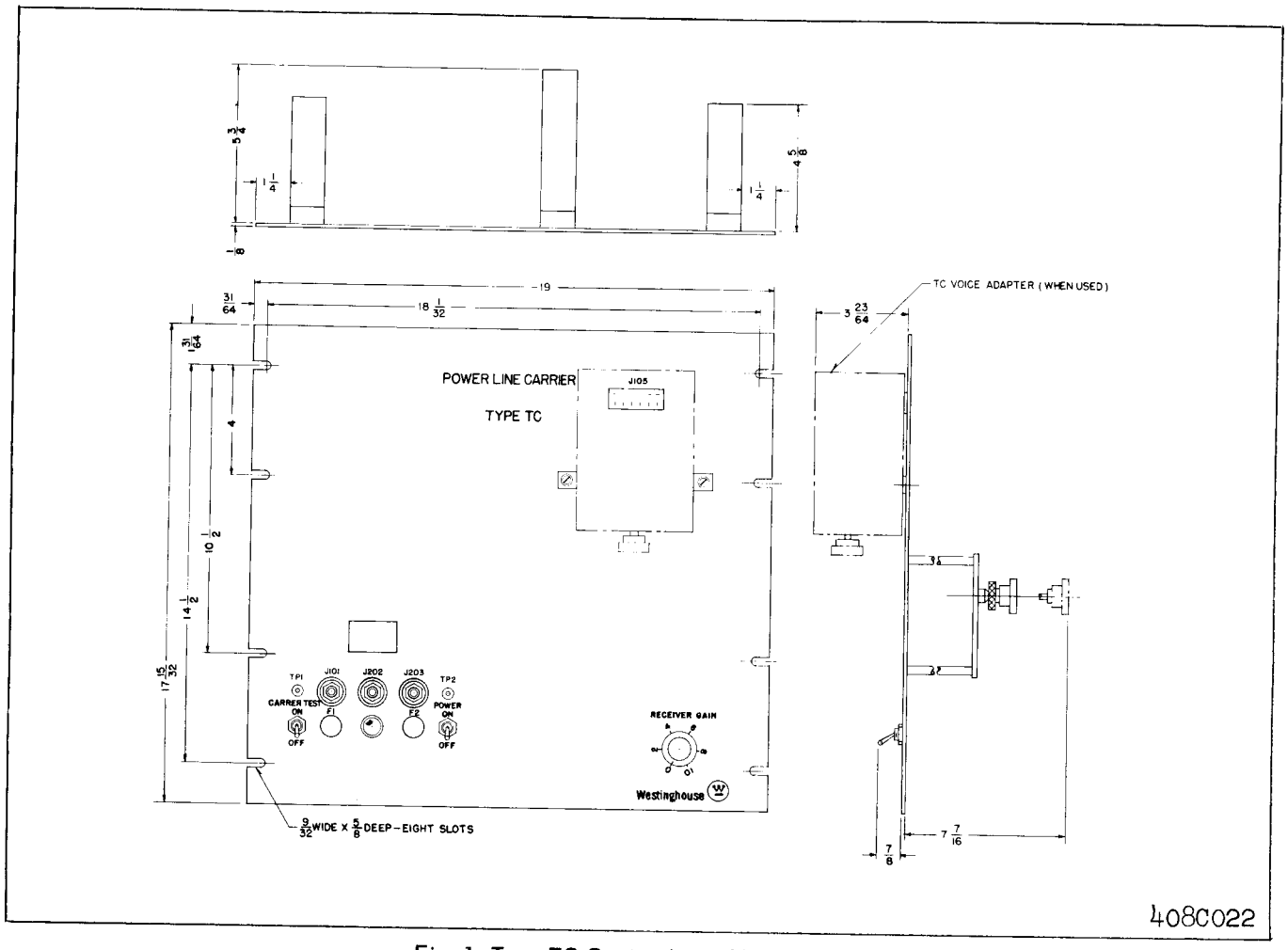


Fig. 1 Type TC Carrier Assembly - Outline

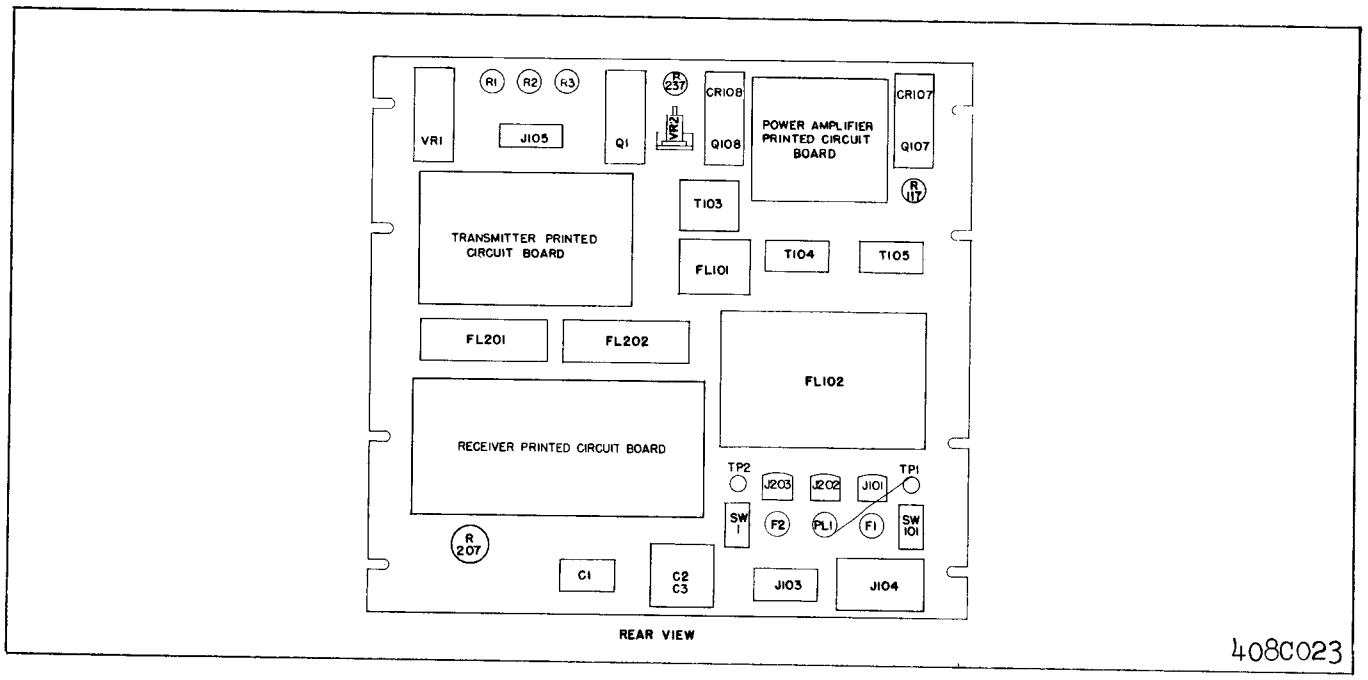


Fig. 2 Type TC Carrier Assembly - Parts Location

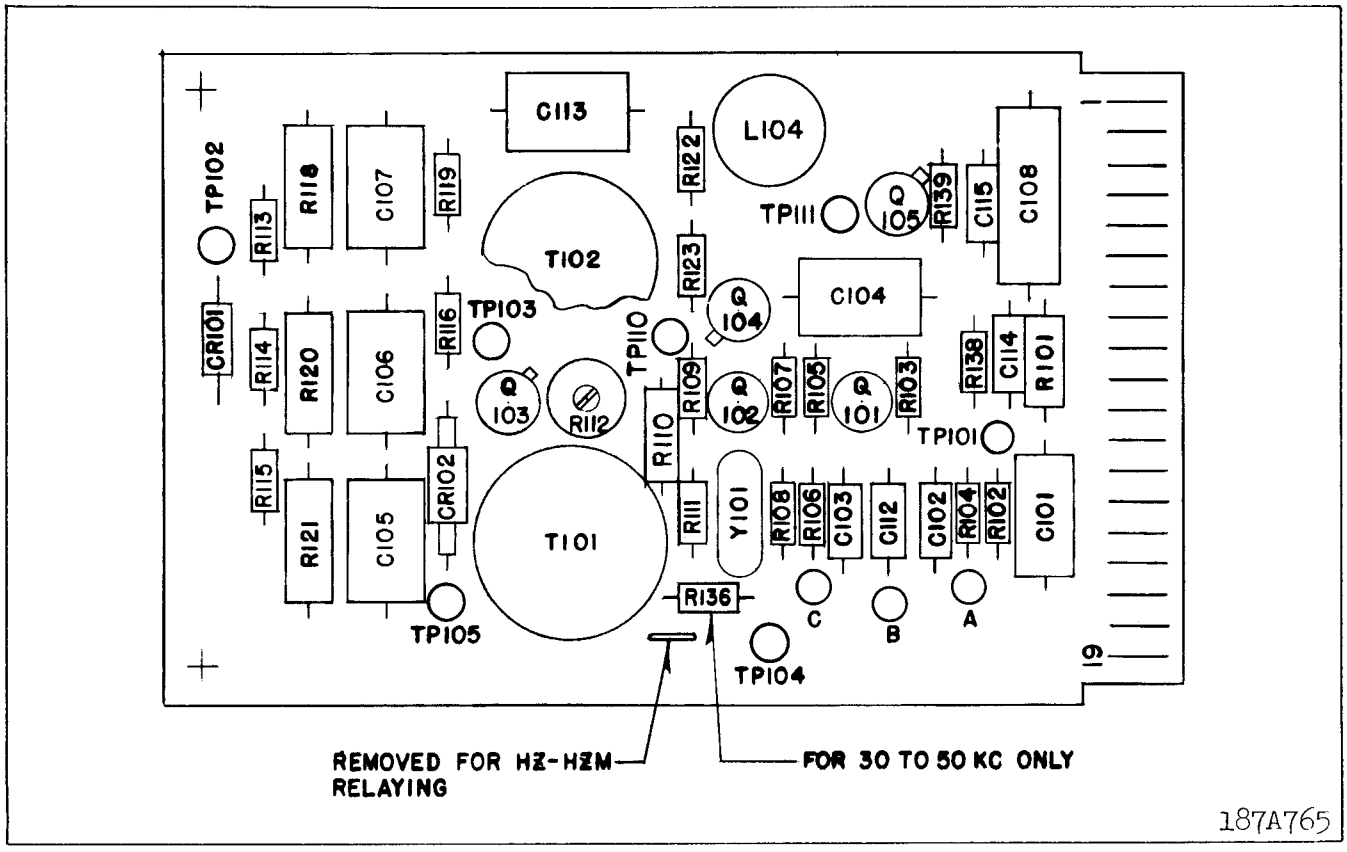


Fig. 3 Transmitter Printed Circuit - Parts Location

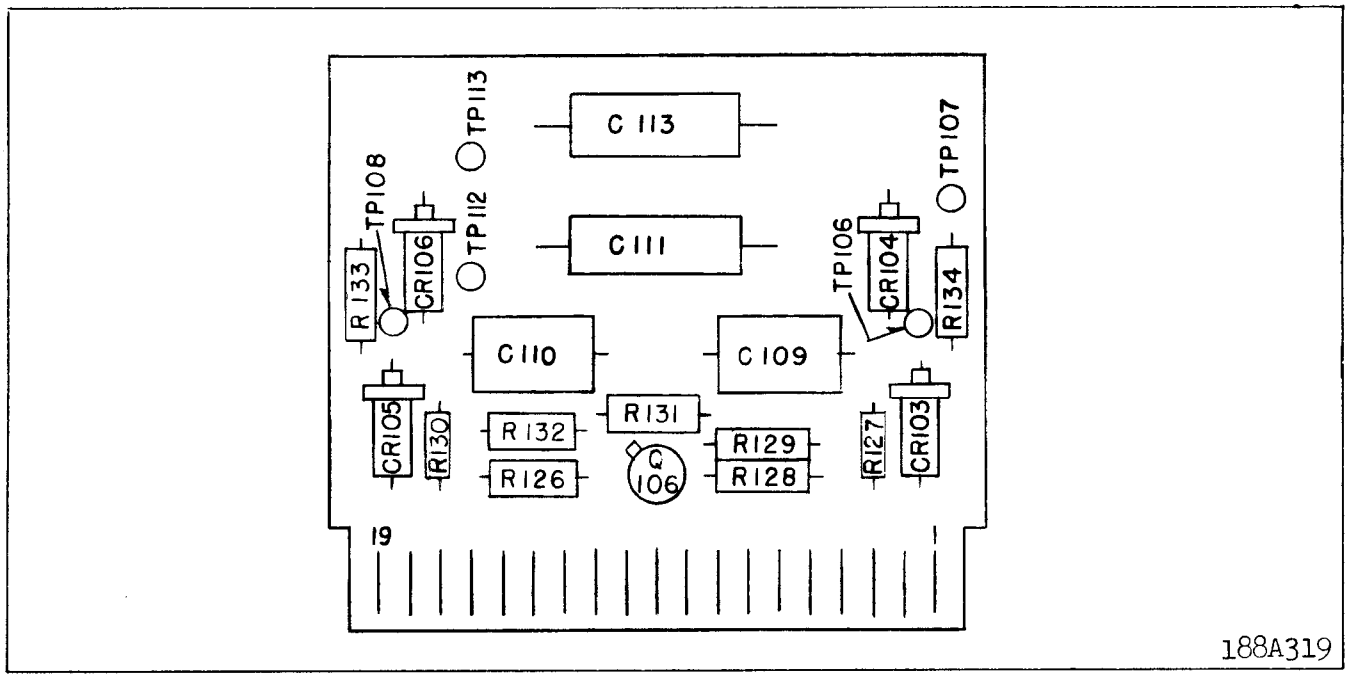


Fig. 4 Power Amplifier Printed Circuit - Parts Location

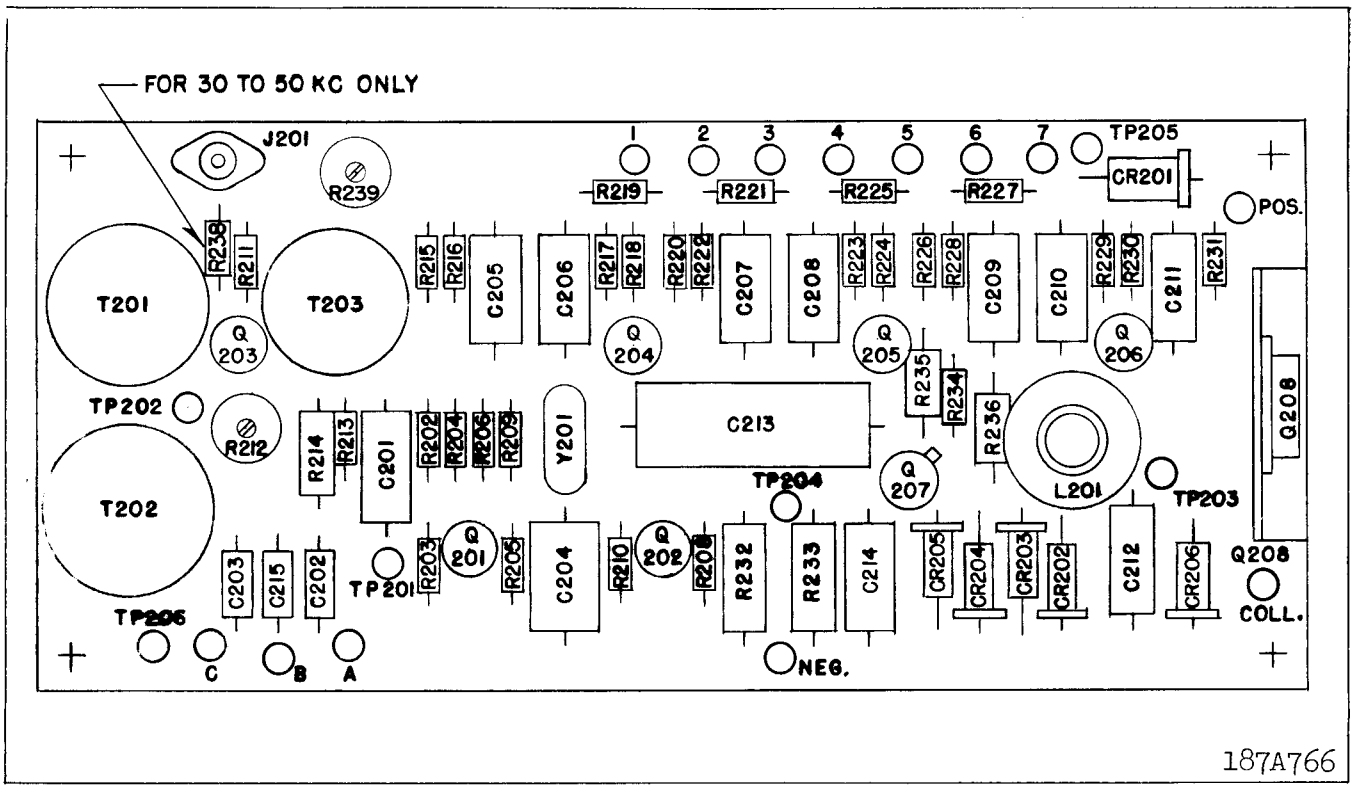
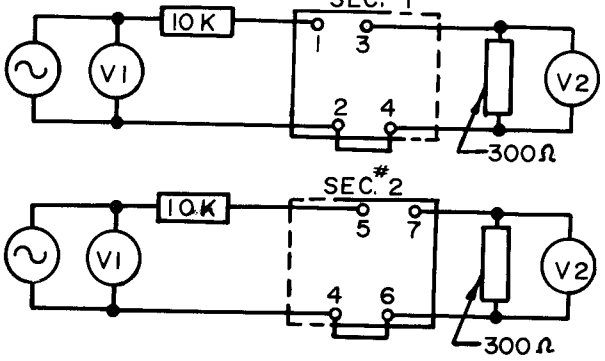
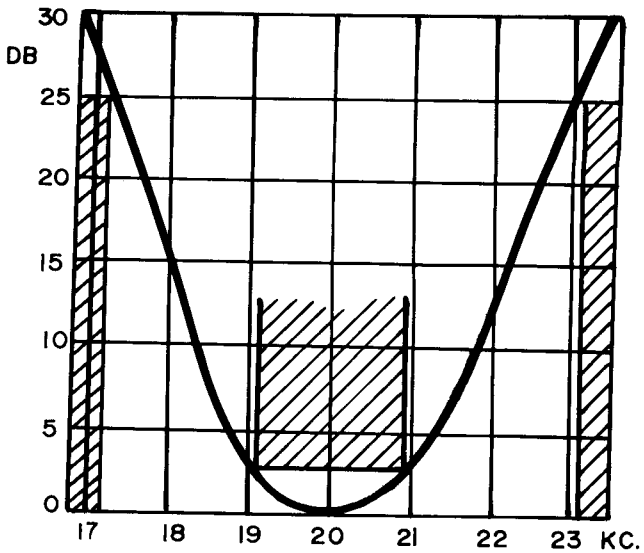


Fig. 5 Receiver Printed Circuit - Parts Location

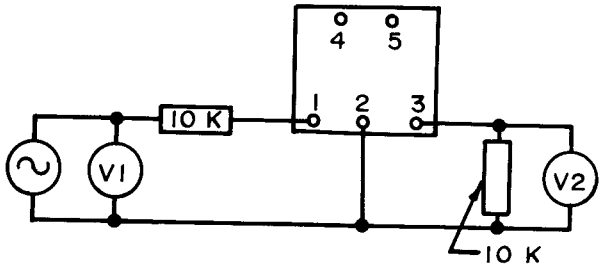
I.F. FILTER TEST CIRCUIT





TYPICAL SELECTIVITY
EACH SECTION
INSERTION LOSS 26 DB MAX.

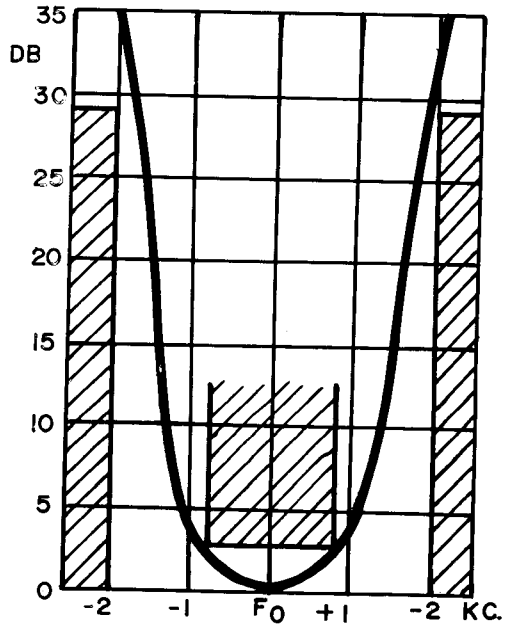
INPUT FILTER TEST CIRCUIT



FOR BOTH FILTERS,

$$DB = 20 \log \frac{V1}{V2}$$

TC RECEIVER FILTER LIMITS



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

629A425

Fig. 7 Type TC Receiver Filter Characteristics

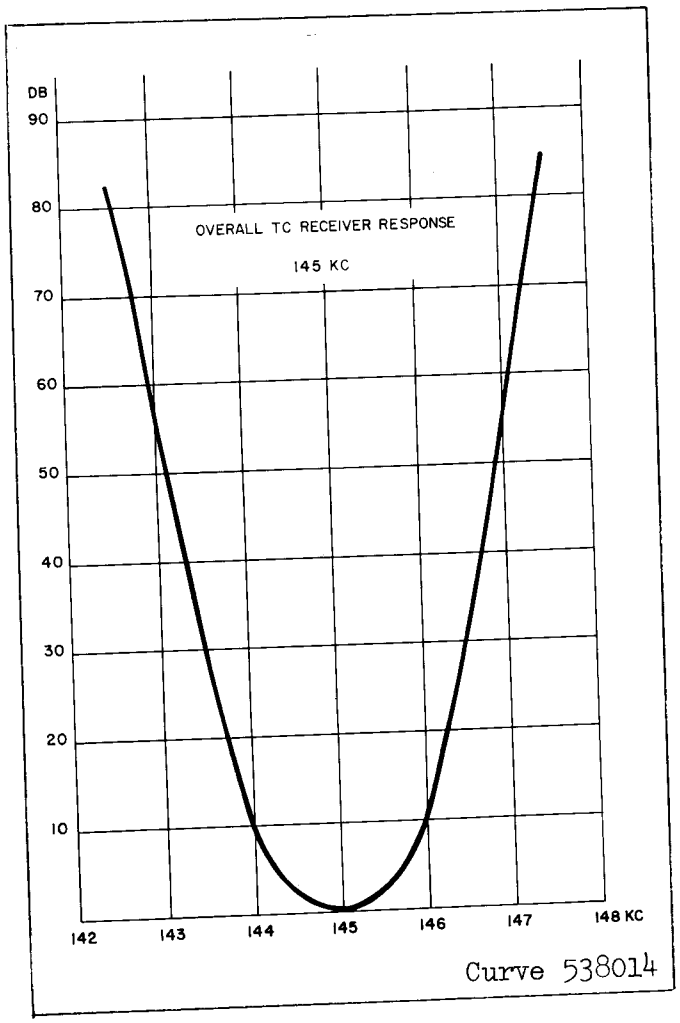


Fig. 8 Type TC Receiver Overall Selectivity Curve

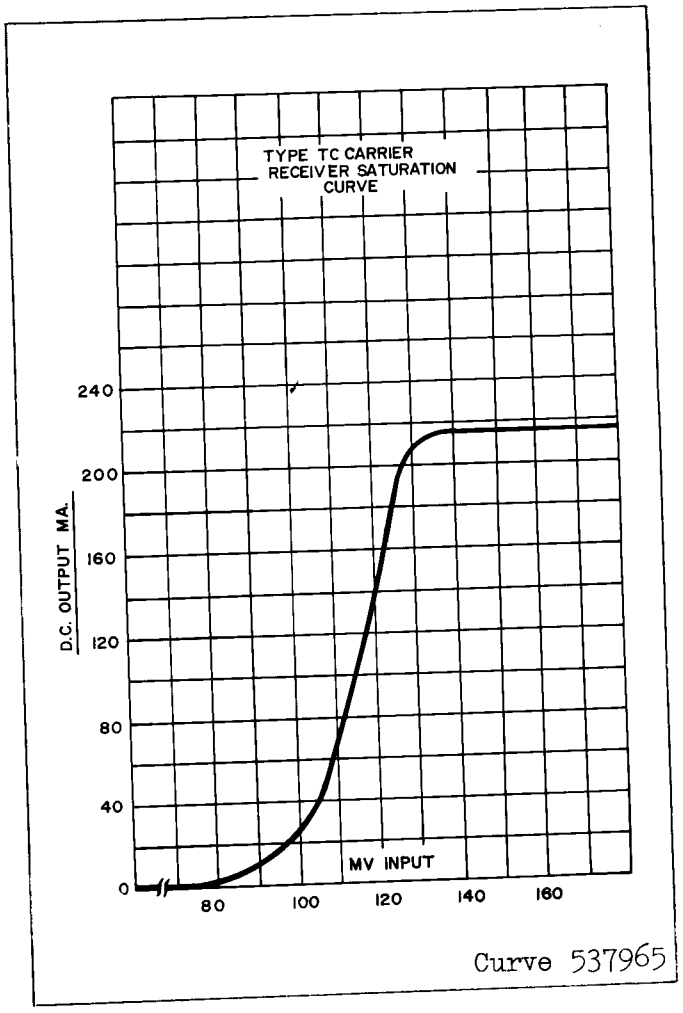


Fig. 9 Type TC Receiver - 200 ma. Output Characteristic.

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