

INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY

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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 $200\ \text{ma.}$ or $20\ \text{ma.}$ 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, 105-140 V, 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

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 $-30~\mathrm{db}$ point on the receiver sensitivity scale and the zerodb 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. ‡ First, see Addendum, pp. 28-29.

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 pluggèd 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 $\pm\,20\%.$

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 188A 293H 01
 - b. $50.5\text{-}75~\mathrm{kHz}$ $0.22~\mathrm{mfd.}$ S # $188\mathrm{A}293\mathrm{H}02$
 - c. 75.5-100 kHz 0.15 mfd. S# 188A293H03
 - d. 100.5-150 kHz 0.10 mfd. S # 188A293H04
 - e. $150.5\text{-}200~\mathrm{kHz} 0.047~\mathrm{mfd.} \mathrm{S} \# 188\mathrm{A} 293\mathrm{H} 05$

4. FL101 and FL102

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

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

Inductors L101, L102, and L103 in these filters are adjustable over a limited range, but 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:

		440 0 110 5
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 $5\ \mathrm{to}$ 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	St	Standby (No Signal)			With 125 M.V. Input	put
TP201 TP202 TP203 TP204 TP205	38 0 11. .03 20		1	18 0 1. 2.2		
Transistor	E*	B*	C*	E*	B*	C*
Q201 Q202 Q203 Q204 Q205 Q206 Q207 Q208	38.5 38.5 0.08 2.7 2.4 2.5 0.13 0.25	37 37.5 0 2.9 2.6 2.7 0.03 0.15	43 43.5 18.7 18.7 18.7 10.5 22.0 45.0	38.5 38.5 0.08 2.7 2.5 2.6 2.0	37 37.5 0 2.9 2.7 2.8 2.2 2.0	43 43.5 18.7 18.7 10.5 4.0 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-0	C Voltages
FL 201-IN to Gnd. FL 201-OUT to Gnd. Q203 -E to TP206 Q203 -C to TP206 Q204 -B to TP206 Q204 -C to TP206	36 kHz .075 .051 .105 .22 .015 .90	132 kHz .050 .020 .090 .035 .012 .52	Q205-B to TP206 Q205-C to TP206 Q206-B to TP206 Q206-C to TP206 TP202 to TP206	36 kHz .11 6.7 .67 1.5 0.3	132 kHz .052 3.4 .37 1.53 0.3

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

TABLE III

Transmitter D-C Measurements

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

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

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

Receiver

- Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
- 2. Receiver input filter (FL201), specify frequency.
- Resistors R211-R238 Combination See values in Fig. 7 below internal schematic.
- 4. 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 T103-4 to Gnd. T104-1 to Gnd.	4.3 1.5 1.4	TP109 to Gnd. J102 to Gnd.	50* 24.5

NOTE:

T101-3 = tap 3 of Transformer T101

Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

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.

^{*} These values may vary considerably with frequency

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)	-
	100 pf., 500 V. DC	187A695H23
C114 C115	100 pf., 500 V. DC	187A695H23
C116	0.001 mfd, 500 V. DC	187A694H11
CA	Part of FL101	Vary with Frequency
СВ		
CC	Part of FL102	Vary with Frequency
CD		
CE		
† FREQ.	C111, C113	Style Number
30- 50 kHz	0.47 mfd, 400 V. DC	188А293Н01
50.5- 75 kHz	0.22 mfd, 400 V. DC	188А293Н02
75.5-100 kHz	0.15 mfd, 400 V. DC	188А293Н03
100.5-150 kHz	0.1 mfd, 400 V. DC	188А293Н04
150.5-200 kHz	0.047 mfd, 400 V. DC	188A293H05
	1N3686B (20 V ± 5%)	185A212H06
CR101 CR102	1N457A	184A855H07
CR102	1N538	407C703H03
CR104	1N91	182A881H04
CR105	1N538	407C703H03
CR106	1N91	182A881H04
	1N2999B (56 V + 5%)	629A798H04
CR107	1N2999B (56 V + 5%)	629A798H04
CR108		632A026A01
G101	Type RVS Arrester	
J101	Closed Circuit Jack	187А606Н01

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

Symbol		Rating		Style Number
J102	Banana			
J103	Coaxia	l Cable Jack		2 of 185A431H01
J104		n Receptacle		187A633H01
J105		n Receptacle		187A669H01
L101	Part of			629A205H02
L102		Trap Coil (2nd Harn	nonia)	
L103		Trap Coil (3rd Harm		Vary with Frequency
L104	400 mh.			
L105	FL102	Coil (part of series uned to fundamenta	-resonant l freq.)	292B096G01 Vary with Frequency
Q101	2N 274		<u> </u>	187A270H01
Q102	2N 274			187A270H01
Q103	2N525			184A638H13
Q104	2N 657			
Q105	2N657			184A638H15
Q106	TI-481			184A638H15 184A638H11
Q107	2N1908	0		
Q108	2N 1908 Matched Pair - Texas Instrument 2N 1908 Co Identif. GP 2151			187А673Н02
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	
R115	150	5	0.5	187A641H51
Sensistor - omitted with	30 - 60 k	Hz, 2.2 K ± 10%, ¼		184A763H07
temp. comp.		Hz, $1.8 \text{ K} \pm 10\%$, $\frac{1}{4}$		187A685H01
per p. 28).		Hz, 1.2 K ± 10%, ¼		187A685H02

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

Symbol	Ohms	± Tol. %	Watts	Style Number
R116	100	5	0.5	184А763Н03
10210	1,000 48 V dc	5	25	1202588
R117	3,750 125 V dc	5	25	1202955
	8,500 250 V dc	5	25	1267310
R118	8,200	5	2	185A207H49
R119	100	5	0.5	184A763H03
	10,000	5	2	185A207H51
R120 R121	10	5	2	187A683H01
	10	5	0.5	187А290Н01
R122	10	10	0.5	187А290Н01
R123	100	10	1	187A644H03
R124		10	0.5	187A641H27
R125	1,000	10	1	187A644H43
R126	4,700	10	0.5	187A640H01
R127	10	5	1	187A644H35
R128	2,200		0.5	184A636H14
R129	2.7	10	0.5	187A640H01
R130	10	5	1	187A644H43
R131	4,700		0.5	184A636H14
R132	0.27	10	1	184A636H18
R133	0.27	10		184A636H18
R134	0.27	10	1	188A317H01
R135	3,000	10	5	184A763H53
R136	12,000	10	0.5	187A642H55
R137	15,000	10	2	187A641H27
R138	1,000	10	0.5	187A641H27
R139	1,000	10	0.5	Style Number
Symbol		Rating		
T101	10,000	10,000/400 ohms		
T102		0/400 c.t.		205C043G04
T103	1930/	30/60 ohms L633000		1962694
T104	Turns	ratio, 1/0.5,	Pri./each sec.	292B526G01
T105	10/50	0 ohms		292B526G02
T106	500/5	0-60-70 ohms		292B526G03
Y101	30-20	0 kHz crystal per	328C083	Specify Frequen

ELECTRICAL PARTS LIST Receiver Section

	Receiver Section	
Symbol	Rating	Style Numbe
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	
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	187A624H02
C212	0.25 mfd., 200 V. DC	187A624H01
C213	2.0 mfd., 200 V. DC	187A624H02
C214	0.25 mfd., 200 V. DC	187A624H05
C215	39 pfd., 500 V. DC	187A624H02
CR201	1N3027B (20V ± 5%)	187A695H12
CR202	1N91	184A449H07
CR203	1N91	182A881H04
CR204	1N538	182A881H04
CR205	1N538	407C703H03
CR206		407C703H03
FL201	1N1789 (56V. ± 10%)	584C434H08
FL202	Receiver Input Filter 30-200 kHz	Specify Frequency
J201	Receiver i.f. Filter-20kHz (2 Sections)	187A590G02
J202	Receiver Coax. Input Jack	187A638H01
J203	Closed Circuit Jack (20MA)	187A606H01
L201	Closed Circuit Jack (200MA)	187А606Н01
Q201	33 mh.	187А599Н01
Q202	2N274	187A270H01
Q203	2N274	187А270Н01
	2N 274	187A270H01
Q204	2N 274	187A270H01
Q205	2N 274	187А270Н01
Q206	2N 274	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	1 87A641H35
R203	10,000	10	0.5	187A641H51
R204	100,000	5	0.5	184A763H75
R205	390	5	0.5	184A763H17
R206	1,200	5	0.5	184A763H29
R207	25 K Pot.	10	2	185А086Н07
R208	10,000	10	0.5	187A641H51
R209	100,000	5	0.5	184A763H75
R210	390	5	0.5	184A763H17
† R211	_	_	_	See † Note Below
R212	1 K Pot.	20	0.25	629А430Н02
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	184 A763H22
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	184А763Н34
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)

			m (commueu)	
Symbol		Rating		G(1 27
	Ohms	± Tol. %	Watts	. Style Number
R234	5,100	5	0.5	184 A 763 H44
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 C	rystal per 328C083		Specify Frequency

Power Supply Section

	т		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	Overl	load Protection	1.5a, 48/125 VDC	11D9195H26
F1, F2	Overl	load Protection	2.0a. 250 VDC	478067
PL1	Neon 125/2	Pilot Light 250 Volts	120 Volts	183A955H01
PL1	Filan for 48	nent-type 3 Volts	55 Volts	187A133H02
Q1	Series	s Regulator	Type 2N1015C Silicon Transistor	187A342H02
R1		Series dropping	26.5 ohms, 3½"	04D1299H44
R2	125 V	Series dropping	Same as R1	04D1299H44
R3		Current limiting	500 ohms, 3½"	1268047
	48V	For 48 VDC, R1 = R2 0	_	_
		R3 = 26.5 ohms	3½''	04D1299H44
R4	Curre	nt limiting	100K, 0.5 watt	184A763H75
SW1	Power Switch		3a, 250V. AC-DC 6a, 125V. AC-DC	880A357H01
SW101	Carrie	er Test	Same as SW1	880A357H01
TP1	Test l	Point (+)	Pin Jack - red	187A332H01
TP2	Test I	Point (-)	Pin Jack - black	187A332H02
VR1	Voltag	ge Regulator	1N2828B (45V.)	184A854H06
VR2	Surge	Protection	1N3009A (130V.) Zener Diodes	184A617H12
VR3	Voltag	ge Regulator	1N2813B (15V.)	184 A854 H11

[†] R238 - omit above $50 \mathrm{kHz} - 22 \mathrm{K}$, $30\text{-}50 \mathrm{kHz}$, $\mathrm{S} 187 \mathrm{A} 641 \mathrm{H} 59$

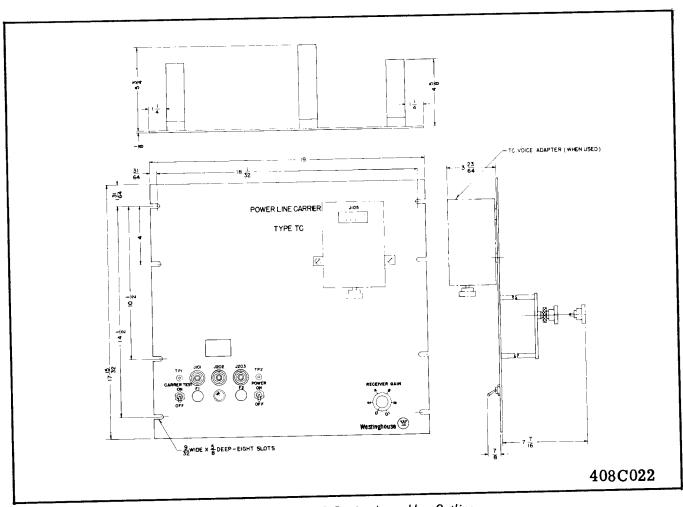


Fig. 1 Type TC Carrier Assembly — Outline

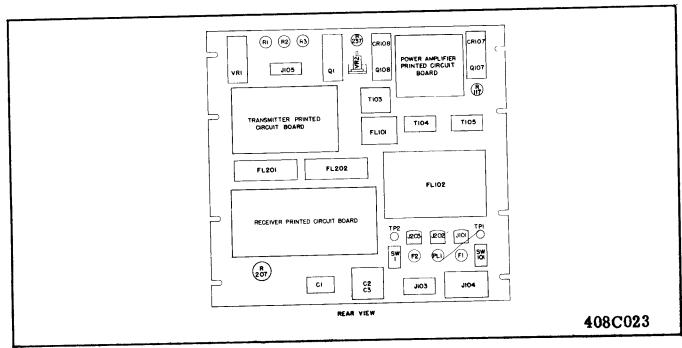


Fig. 2 Type TC Carrier Assembly - Parts Location

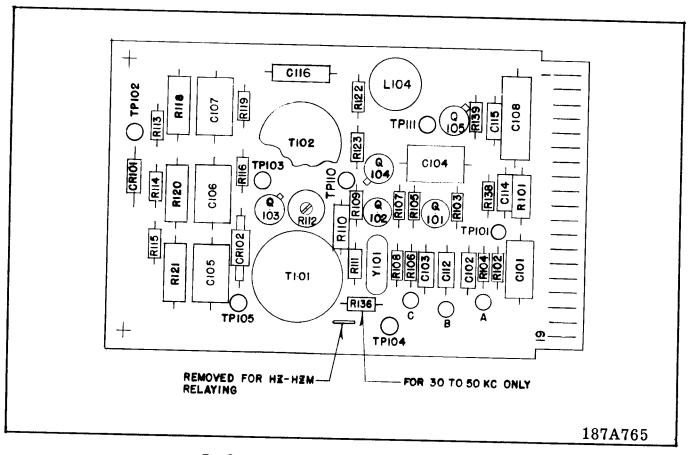


Fig. 3 Transmitter Printed Circuit - Parts Location

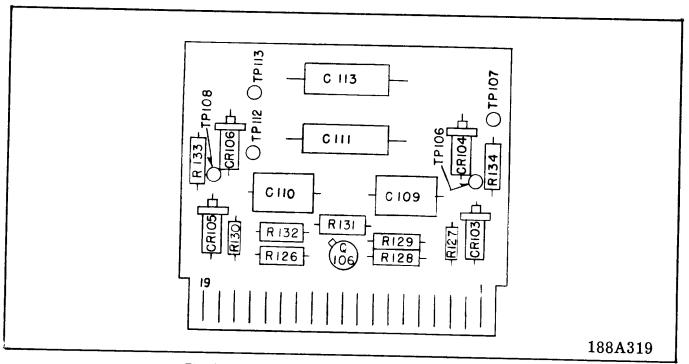


Fig. 4 Power Amplifier Printed Circuit - Parts Location

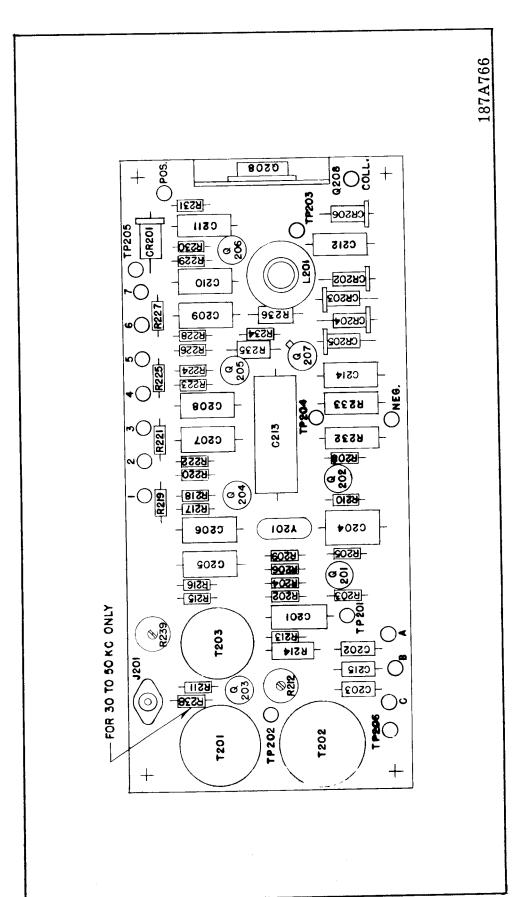


Fig. 5 Receiver Printed Circuit — Parts Location

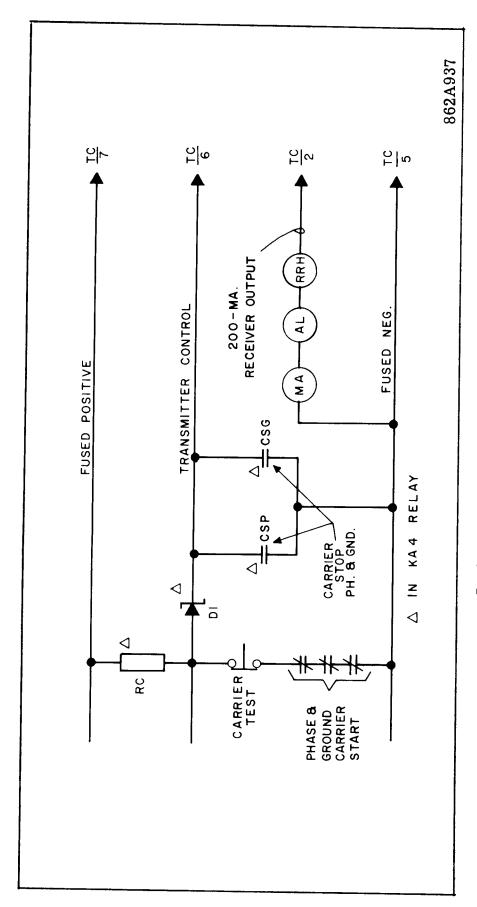
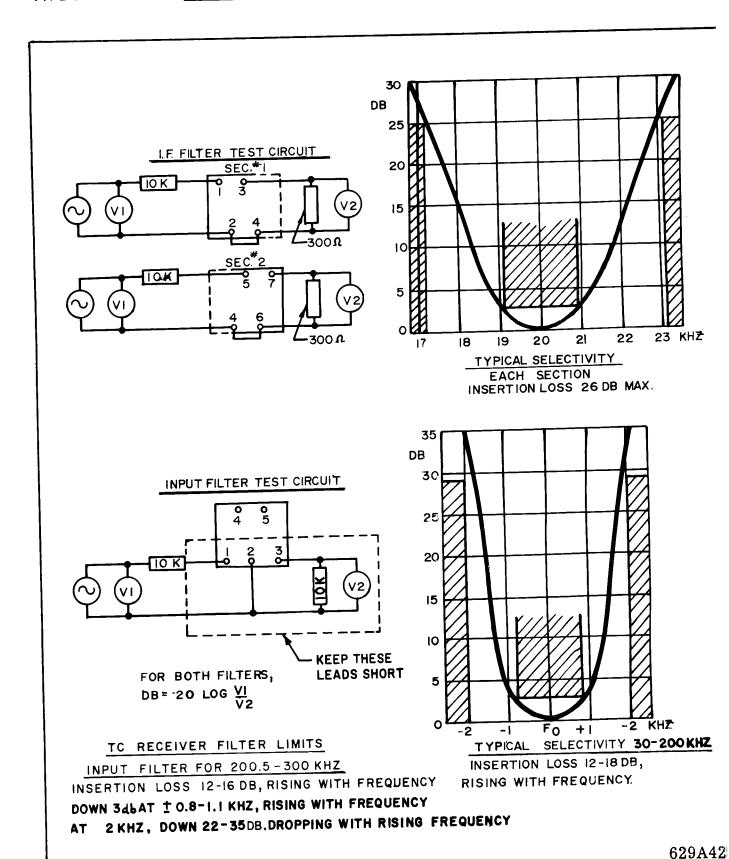
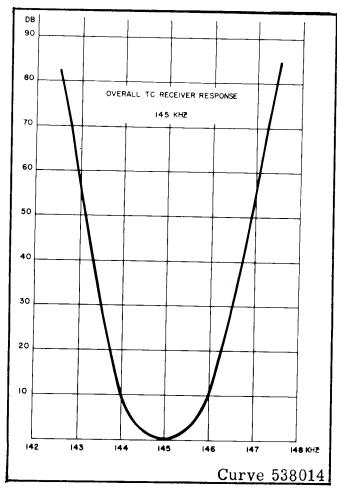


Fig. 6 Elementary K-Dar Carrier Control Circuits.



* Fig. 8 Type TC Receiver Filter Characteristics



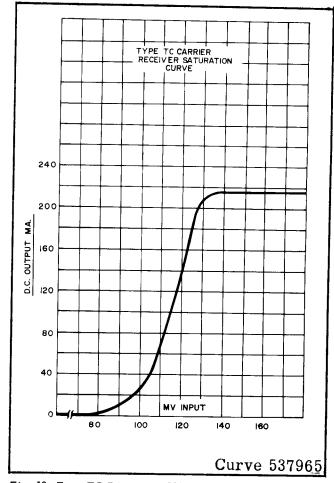
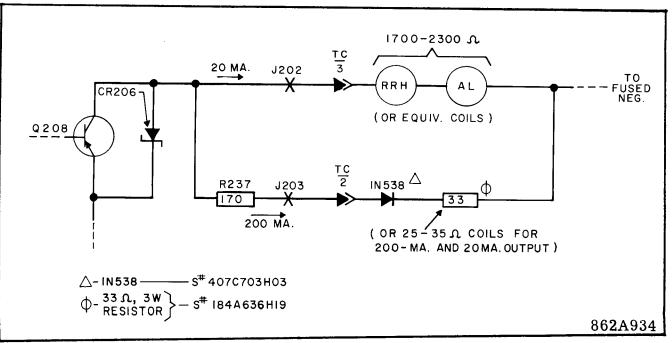


Fig. 9 Type TC Receiver Overall Selectivity Curve

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



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

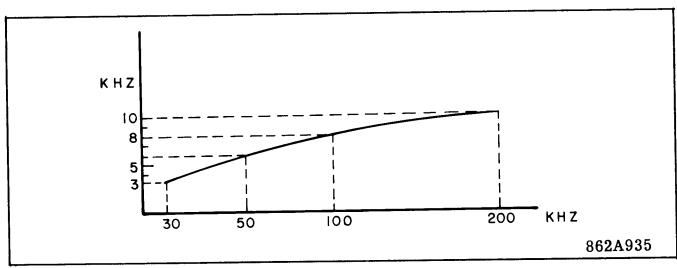


Fig. 12 Minimum Frequency Spacing For Two 10-watt Transmitters Operated in Parallel.

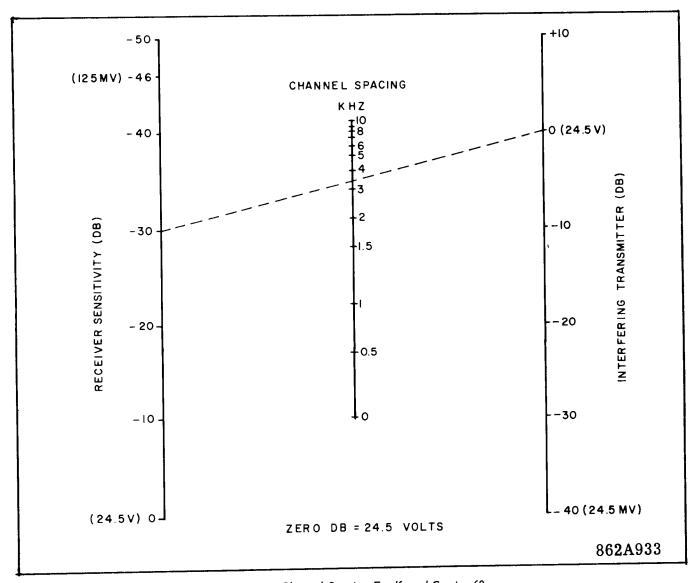


Fig. 13 Minimum Channel Spacing For Keyed Carrier 60 p.p.s.

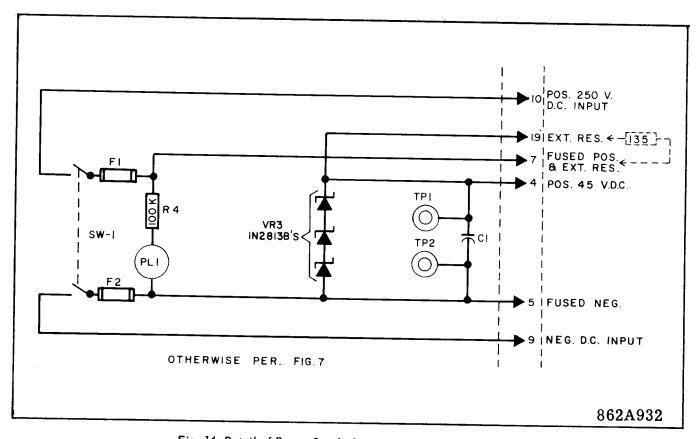


Fig. 14 Detail of Power Supply Section For 250-volt Supply

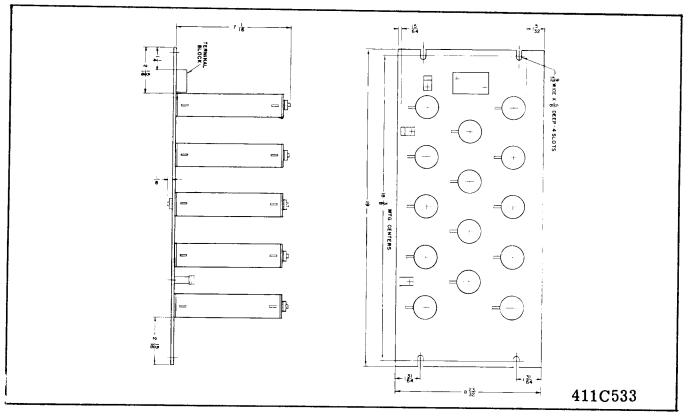


Fig. 15 Outline of External Resistor Unit For 250-volt Operation

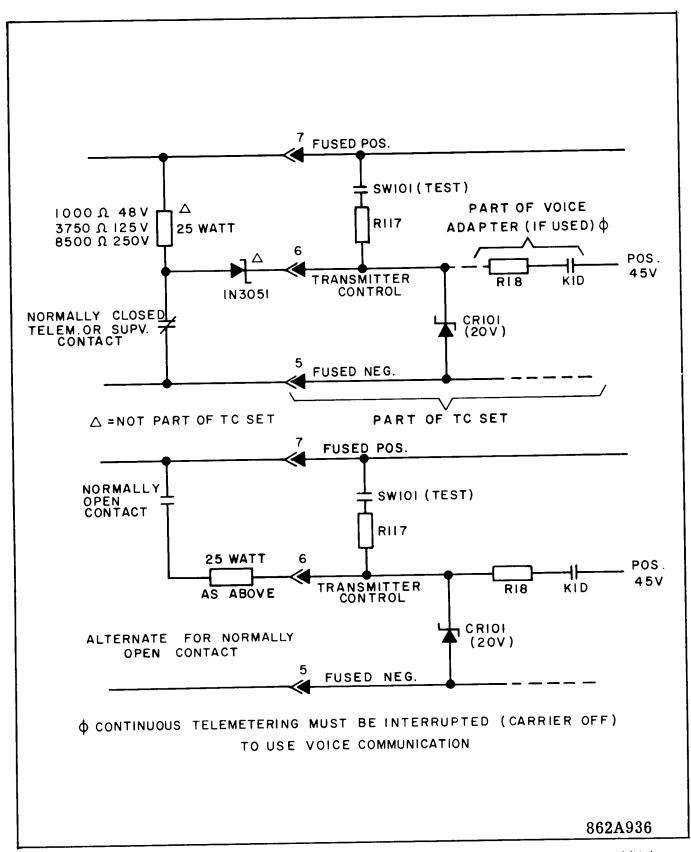


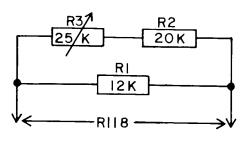
Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact

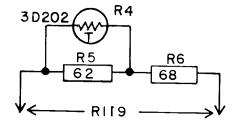
ADDENDUM

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 baseemitter 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, 1/2W 2%	629A531H03
R6	Resistor 68, ½W 2%	629A531H04

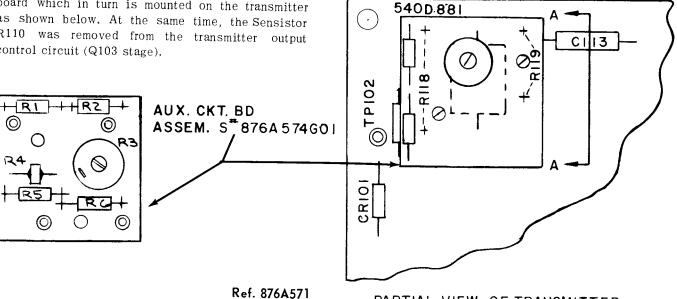
Adjustment of R3 on Auxiliary Circuit Board

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~mAd.c. \pm 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 JUSTMENTS section.

PARTIAL VIEW OF TRANSMITTER

CIRCUIT BOARD



876A746

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 $30\ -\ 50 \text{kHz.} -\ \text{S\#}\ 540 D876 G01 \\ 50.5-300 \text{kHz.} -\ \text{S\#}\ 540 D876 G02$

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

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

* Receiver Circuit board:

Component	Changed From	То	Style No.
Q201 to Q206	2N274	2N2905A	762A672H10
Q207	2N398A	2N3645	849A441H01
Q208	2N1362	2N4903	187A673H13
CR201	1M20Z10	1N3027B	188А302Н07
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.





INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY

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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 $42-56\,\mathrm{V},\ 105-140\,\mathrm{V},\,210-280\,\mathrm{V}$

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 $-30\ \mathrm{db}$ (relative to a 24.5-volt, 10-watt signal). The interfering signal is assumed to be a 10-watt transmitter at the same location. To determine the minimum frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the $-30~\mathrm{db}$ point on the receiver sensitivity scale and the zerodb 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 $4\ \mathrm{kHz}$ 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.

* ‡ First, see Addendum, pp. 28-29.

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 $\pm\,20\%$.

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 188A 293H 03
 - d. $100.5-150 \text{ kHz} 0.10 \text{ mfd.} \text{S} \pm 188\text{A} 293\text{H} 04$ e. $150.5-200 \text{ kHz} 0.047 \text{ mfd.} \text{S} \pm 188\text{A} 293\text{H} 05$
 - 4. FL101 and FL102

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

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

Inductors L101, L102, and L103 in these filters are adjustable over a limited range, but 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	
0		

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

A signal generator, a frequency counter, and a vacuum-tube voltmeter are required for readjustment of FL101. The signal generator and the counter should be connected across terminals 4 and 5 of transformer T103 and the voltmeter across terminals 1 and 2 of transformer T104. The signal generator should be set at the channel center frequency and at 2 at 3 volts output. The core screw of the small inductor should be turned to the position that gives a true maximum reading on the VTVM. Turning the

screw to either side of this position should definitely reduce the reading. The change in inductance with core position is less at either end of the travel than when near the center and consequently the effect of core screw rotation on the VTVM reading will be less when the resonant inductance occurs near the end of core travel.

The procedure for readjustment of the 2nd and 3rd harmonic traps of filter FL102 is somewhat similar. A signal generator and a counter should be connected to terminals 3 and 4 of transformer T105 and a 500-ohm resistor and a VTVM to the terminals of protective gap G101. The ground or shield lead of all instruments should be connected to the grounded terminal of the transformer. Set the signal generator at exactly twice the channel center frequency and at 5 to 10 volts output. Turn the core screw of the large inductor, L102, to the position that gives a definite minimum reading on the VTVM. Similarly, with the signal generator set at exactly three times the channel center frequency and 5 to 10 volts output, set the core screw of the small inductor, L103, to the position that gives a definite minimum reading on the VTVM. Then remove the instruments and the 500-ohm resistor.

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

After all the tabulated changes have been made for the new frequency, the transmitter can be operated with a 50 to 70-ohm load (depending on which tap of T106 is used) connected to its output, and inductor L105 can be readjusted for maximum output at the changed channel frequency by the procedure described in the ADJUSTMENT section.

If a frequency-sensitive voltmeter is available, the second and third harmonic traps may be adjusted (or checked) without using an oscillator as a source of double and triple the channel frequency. Connect the frequency-sensitive voltmeter from TP109 to ground and adjust the transmitter for rated output into the selected load resistor. Set the voltmeter at twice the channel frequency and, using its tuning dial and db range switch, obtain a maximum on-scale reading of the second harmonic. Then vary the core position of L102 until a minimum voltmeter reading is obtained. Similarly, tune the voltmeter to the third harmonic and adjust L103 for minimum voltmeter reading. It should be noted that this procedure may not give the true magnitude of the harmonics

because of the large value of fundamental frequency voltage present at the tuned voltmeter input terminals. This condition will overload the input circuit of some commercial instruments. However, the procedure is satisfactory for adjusting the traps for maximum harmonic rejection.

If accurate measurement of the harmonic levels

is desired, the frequency-selective voltmeter is connected, through a rejection filter, to the terminals of the 60-ohm load resistor. The filter must provide high rejection of the fundamental. A twin-Tfilter 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	put	
TP201 TP202 TP203 TP204 TP205		38 0 11. .03 20			38 0 1. 2.2 0	N
Transistor	E*	В*	C*	E*	B*	C*
Q201 Q202 Q203 Q204 Q205 Q206 Q207 Q208	38.5 38.5 0.08 2.7 2.4 2.5 0.13 0.25	37 37.5 0 2.9 2.6 2.7 0.03 0.15	43 43.5 18.7 18.7 18.7 10.5 22.0 45.0	38.5 38.5 0.08 2.7 2.5 2.6 2.0	37 37.5 0 2.9 2.7 2.8 2.2 2.0	43 43.5 18.7 18.7 10.5 4.0 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		ages Test Point	Typical A-C Voltages	
FL 201-IN to Gnd. FL 201-OUT to Gnd. Q203 -E to TP 206 Q203 -C to TP 206 Q204 -B to TP 206 Q204 -C to TP 206	36 kHz .075 .051 .105 .22 .015 .90	132 kHz .050 .020 .090 .035 .012 .52	Q205-B to TP206 Q205-C to TP206 Q206-B to TP206 Q206-C to TP206 TP202 to TP206	36 kHz .11 6.7 .67 1.5 0.3	132 kHz .052 3.4 .37 1.53 0.3

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

TABLE III

Transmitter D-C Measurements

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

Test Point	Carrier Off	Carrier On
TP 101 TP 102 TP 103 TP 105 TP 106 TP 107 TP 108 TP 110 TP 111 TP 112 TP 113 J101 (Front Panel)	7 volts d.c. 0 0 0 44 44 45 .5 .5 0 45 5 ma. max.	7 volts d.c. 20 19.5 9 22 22.2 44.8 .6 .6 0 45 0.6 amp.

Transistor	E	В	С	E	В	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

- Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
- 2. Receiver input filter (FL201), specify frequency.
- Resistors R211-R238 Combination See values in Fig. 7 below internal schematic.
- 4. 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 TP103 to TP102 Q103-C to TP104	1.1 volts, rms. 0.2 0.7	Q107-B to TP107 Q108-B to TP113 Q107-C to TP107	.5 volts, rms. .5	
TP110 to T102-4 TP111 to T102-4 Q104-C to TP104	0.2 0.2 4.3	Q108-C to TP113 T105-4 to Gnd. T106-2 to Gnd.	14.5 105 155*	
Q105-C to TP104 T103-4 to Gnd. T104-1 to Gnd.	4.3 1.5 1.4	TP109 to Gnd. J102 to Gnd.	50* 24.5	

T101-3 = tap 3 of Transformer T101

Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

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.

^{*} These values may vary considerably with frequency

ELECTRICAL PARTS LIST Transmitter Section

Gumbol	Rating	Style Number	
Symbol C101	0.1 mfd, 200 V. DC	187A624H01	
	.005 mfd, 300 V. DC	187A694H29	
C102	180 pf. 500 V. DC	187A695H29	
C103	0,25 mfd, 200 V. DC	187A624H02	
C104	0.25 mfd, 200 V. DC	187A624H02	
C105		187A624H02	
C106	0.25 mfd, 200 V. DC 0.25 mfd, 200 V. DC	187A624H02	
C107		187A624H03	
C108	0.50 mfd, 200 V. DC	187A624H02	
C109	0.25 mfd, 200 V. DC	187A624H02	
C110	0.25 mfd, 200 V. DC	10740211102	
† C111	(See Table Below)	187A695H12	
C112	39 pfd, 500 V. DC	187A093H12	
† C113	(See Table Below)		
C114	100 pf., 500 V. DC	187A695H23	
C115	100 pf., 500 V. DC	187A695H23 187A694H11	
C116	0.001 mfd 500 V DC		
CA	Part of FL101	Vary with Frequency	
СВ		Vary with Frequency	
CC	Part of FL102		
CD			
CE PREC	C111, C113	Style Number	
† FREQ. 30- 50 kHz	0.47 mfd, 400 V. DC	188А293Н01	
50.5- 75 kHz	0.22 mfd, 400 V. DC	188А293Н02	
75.5-100 kHz	0.15 mfd, 400 V. DC	188A293H03	
100.5-150 kHz	0.1 mfd, 400 V. DC	188A293H04	
	0.047 mfd, 400 V. DC	188A293H05	
150.5-200 kHz	1N3686B (20 V ± 5%)	185A212H06	
CR101	1N457A	184A855H07	
CR102		407С703Н03	
	CR 103 1N538 1N91		
CR104		407C703H03	
CR105	1N538	182A881H04	
CR106	1N91	629A798H04	
CR107	1N2999B (56 V + 5%)	629A798H04	
CR108	1N2999B (56 V + 5%)		
G101	Type RVS Arrester	632A026A01	
J101	Closed Circuit Jack	187A606H01	

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

Symbol		Rating			
J102	Banana Plug Jack			Style Number 2 of 185A431H01	
J103		Coaxial Cable Jack			
J104		24-Term Receptacle			
J105		12-Term Receptacle			
L101		Part of FL101			
L102					
L103		FL102 Trap Coil (2nd Harmonic)			
L104	400 ml	FL102 Trap Coil (3rd Harmonic)			
L105				292B096G01	
	FL 102 circuit	FL102 Coil (part of series-resonant circuit tuned to fundamental freq.)			
Q101	2N 274			Vary with Frequency 187A270H01	
Q102	2N 274		187A270H01		
Q103	2N525		184A638H13		
Q104	2N657	2N657			
Q105	2N657		184A638H15		
Q106	TI-481			184A638H15	
Q107	2N1908	Matched Pair - T	Ovog Trake	184A638H11	
Q108	2N 1908	Matched Pair - Texas Instrument Co Identif. GP2151		187А673Н02	
Symbol	Ohms	± Tol. %	Watts	Style Number	
R101	5,600	5	1	187A643H45	
R102	2,200	10	0.5	T	
R103	10,000	10	0.5	187A641H35 187A641H51	
R104	100,000	5	0.5	T	
R105	390	5	0.5	184A763H75	
R106	1,200	5	0.5	184A763H17	
R107	10,000	10	0.5	184A763H29	
R108	100,000	5	0.5	187A641H51	
R109	390	5	0.5	184A763H75	
R110 *				184A763H17	
R111	1,200	5	0.5	At End of List	
R112	1 K Pot	20	0.25	187A763H29	
R113	4,700	5		629А430Н02	
R114	10,000	10	0.5	184А763Н43	
R115	150	5	0.5	187A641H51	
Sensistor -	30 - 60 k	184А763Н07			
omitted with	60.5-120 k	187A685H01			
emp. comp. 60.5-120 kHz, 1.8 K ± 10%, ¼ watt er p. 28). 120.5-200 kHz, 1.2 K ± 10%, ¼ watt				187A685H02	
	120.0-200 K	$1.2 \text{ K} \pm 10\%, \frac{1}{4}$	watt	187А685Н03	

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

Gamb ol	Ohms	± Tol. %	Watts	Style Number		
Symbol	100	5	0.5	184A763H03		
R116	1,000	5	25	1202588		
R117	48 V dc 3,750	5	25	1202955		
KIII	125 V dc 8,500	 5	25	1267310		
	250 V dc		2	185A207H49		
R118	8,200	5 5	0.5	184A763H03		
R119	100		2	185A207H51		
R120	10,000	5	2	187A683H01		
R121	10	5		187A290H01		
R122	10	5	0.5	187A290H01		
R123	10	10	0.5	187A644H03		
R124	100	10	1			
R125	1,000	10	0.5	187A641H27 187A644H43		
R126	4,700	10	1			
R127	10	10	0.5	187A640H01		
R128	2,200	5	1	187A644H35		
R129	2.7	10	0.5	184 A 63 6 H 14		
R130	10	1.0	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	11	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 205C043G01		
T101	10,000	10.000/400 ohms				
T102		0/400 c.t.		205C043G04		
T103		1930/60 ohms L633000				
T104		ratio, 1/0.5,	Pri./each sec.	292B526G01		
T104		10/500 ohms				
		50-60-70 ohms		292B526G03		
T106 Y101		30-200 kHz crystal per 328C083				

ELECTRICAL PARTS LIST Receiver Section

	Werelive Jection	
Symbol	Rating	Style Numbe
C201	0.1 mfd., 200 V. DC	
C202	300 pf. 500 V. DC	187A624H01
C203	180 pf. 500 V. DC	1 87A695H35
C204	0.25 mfd., 200 V. DC	187A695H29
C205	0.25 mfd., 200 V. DC	187A624H02
C206	0.25 mfd., 200 V. DC	187A624H02
C207	0.25 mfd., 200 V. DC	187A624H02
C208	0.25 mfd., 200 V. DC	187A624H02
C209	0.25 mfd., 200 V. DC	187A624H02
C210	0.25 mfd., 200 V. DC	187A624H02
C211	0.1 mfd., 200 V. DC	187A624H02
C212	0.25 mfd., 200 V. DC	187A624H01
C213		187A624H02
C214	2.0 mfd., 200 V. DC 0.25 mfd., 200 V. DC	187A624H05
C215		187A624H02
CR201		187A695H12
CR202	1N3027B (20V ± 5%)	184A449H07
CR203	1N91	182A881H04
CR204	1N91	182A881H04
CR205	1N538	407С703Н03
CR206	1N538	407C703H03
FL201	1N1789 (56V. ± 10%)	584С434Н08
	Receiver Input Filter 30-200 kHz	Specify Frequency
FL202 J201	Receiver i.f. Filter-20kHz(2 Sections)	187A590G02
J202	Receiver Coax. Input Jack	187A638H01
J203	Closed Circuit Jack (20MA)	187A606H01
L201	Closed Circuit Jack (200MA)	187А606Н01
Q201	33 mh.	187A599H01
	2N 274	187A270H01
Q202	2N 274	187A270H01
Q203	2N274	187A270H01
Q204	2N274	187A270H01
Q205	2N 274	187A270H01
Q206	2N 274	187A270H01
Q207	2N398A	184A638H12
Q208	2N1362	10171030112

ELECTRICAL PARTS LIST Receiver Section (Cont.)

Symbol		Style Number			
Resistors	Ohms	± Tol. %	Watts		
R201	10,000	10	0.5	187A641H51	
R202	2,200	10	0.5	1 87A641H35	
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	184 A 763 H 34	
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)

			ion (continued)	
Symbol	Rating			
	Ohms	± Tol. %	Watts	. Style Number
R234	5,100	5	0.5	194 4500 1144
R235	470	10	1	184A763H44
R236	4,700	10	1	187A644H19
R237	170	5	10	187A644H43
† R238	_	<u> </u>	40	1336074
R239	1 K Pot.	20	0.25	See † Note Below
T201	10,000/10,000	629A430H02		
T202		Ohms		714B677G01
T203	10,000/400	205C043G01		
	25,000/300	Ohms		205C043G03
Y201	50-220 kHz Cr	ystal per 328C083		Specify Frequency

Power Supply Section

Symbol	T		Power Supply Section	
Symbol	 	Function	Description or Rating	Style Number
C1	(+) to	O(-) bypass	0.45 mfd. 330 VAC	1723408
C2	A-C grounding		0.5 mfd. 1500 VDC	1877962
	A-C	grounding	0.5 mfd. 1500 VDC	1877962
F1, F2	Over	load Protection	1.5a, 48/125 VDC	11D9195H26
F1, F2	Over	load Protection	2.0a. 250 VDC	478067
PL1	Neon 125/2	Pilot Light 250 Volts	120 Volts	183A955H01
PL1		nent-type 3 Volts	55 Volts	187A133H02
Q1	Serie	s Regulator	Type 2N1015C Silicon Transistor	187A342H02
R1		Series dropping	26.5 ohms, 3½"	04D1299H44
R2	125 V	Series dropping	Same as R1	04D1299H44
R3		Current limiting	500 ohms, 3½"	1268047
	48V	For 48 VDC, R1 = R2 0	_	_
	į	R3 = 26.5 ohms	3½,,	04D1299H44
R4	Currer	nt limiting	100K, 0.5 watt	184A763H75
SW1	Powe	r Switch	3a, 250V. AC-DC 6a, 125V. AC-DC	880A357H01
SW101	Carrie	r Test	Same as SW1	880A357H01
TP1	Test I	Point (+)	Pin Jack — red	187A332H01
TP2	Test I	Point (-)	Pin Jack – black	187A332H02
VR1	Voltag	e Regulator	1N2828B (45V.)	184A854H06
VR2	Surge	Protection	1N3009A (130V.) Zener Diodes	184A617H12
VR3	Voltag	e Regulator	1N2813B (15V.)	184A854H11

[†] R238 - omit above $50 \mathrm{kHz} - 22 \mathrm{K}$, $30\text{-}50 \mathrm{kHz}$, $\mathrm{S} *187\,\mathrm{A} 641\mathrm{H} 59$

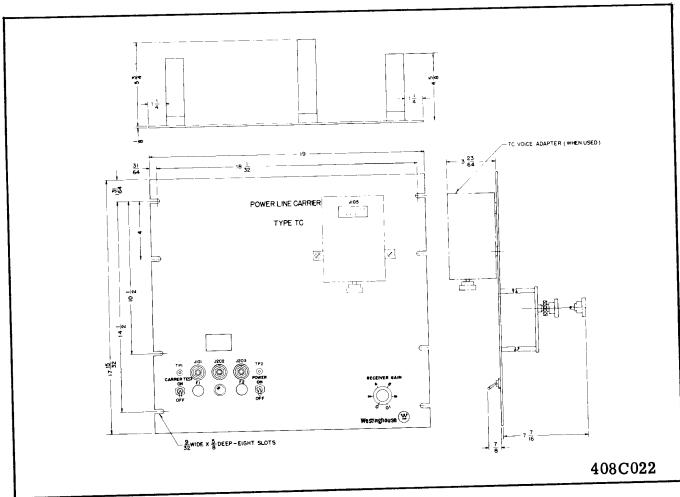


Fig. 1 Type TC Carrier Assembly - Outline

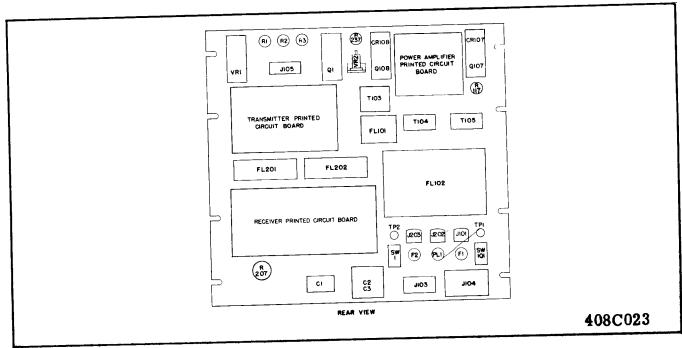


Fig. 2 Type TC Carrier Assembly - Parts Location

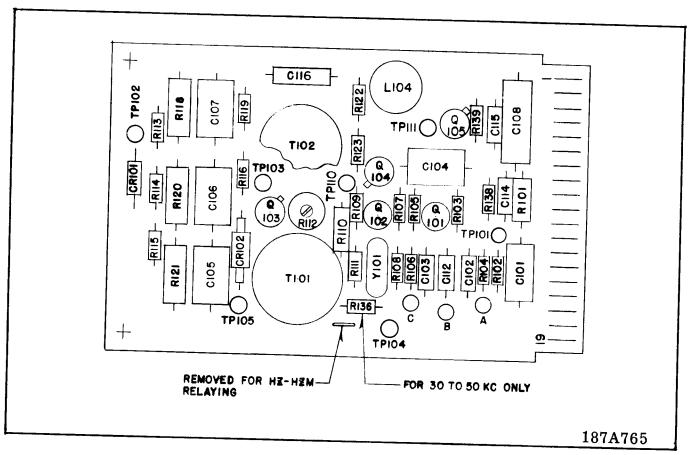


Fig. 3 Transmitter Printed Circuit - Parts Location

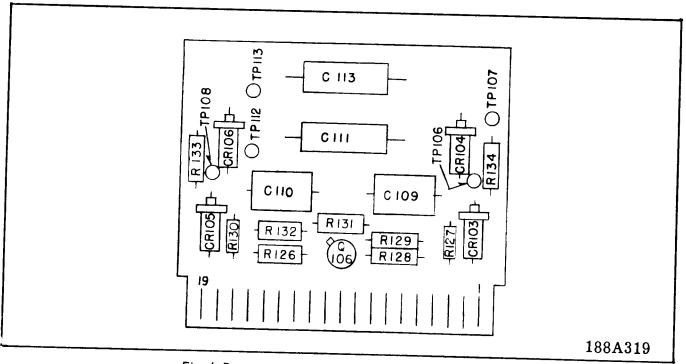


Fig. 4 Power Amplifier Printed Circuit - Parts Location

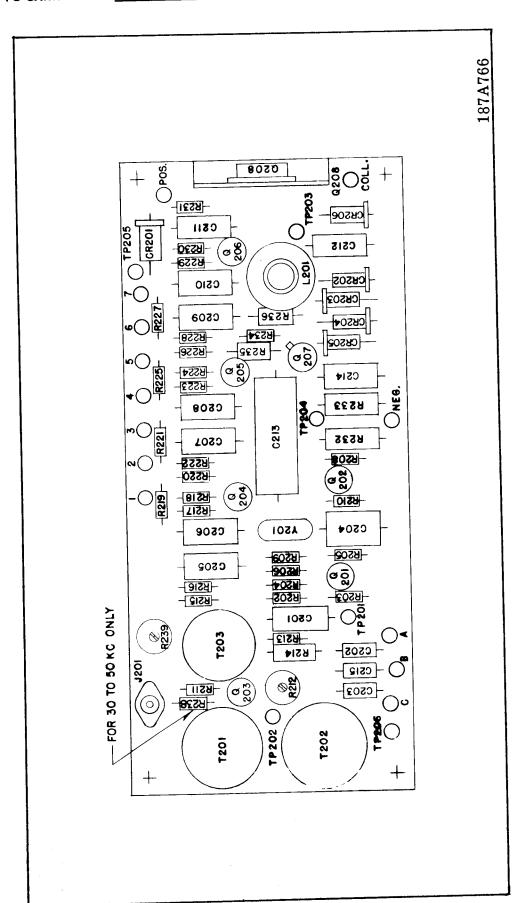


Fig. 5 Receiver Printed Circuit - Parts Location

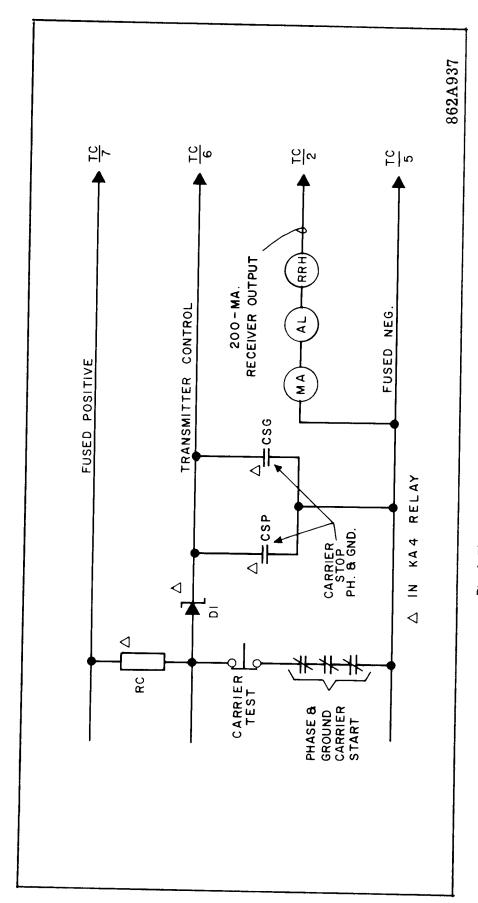
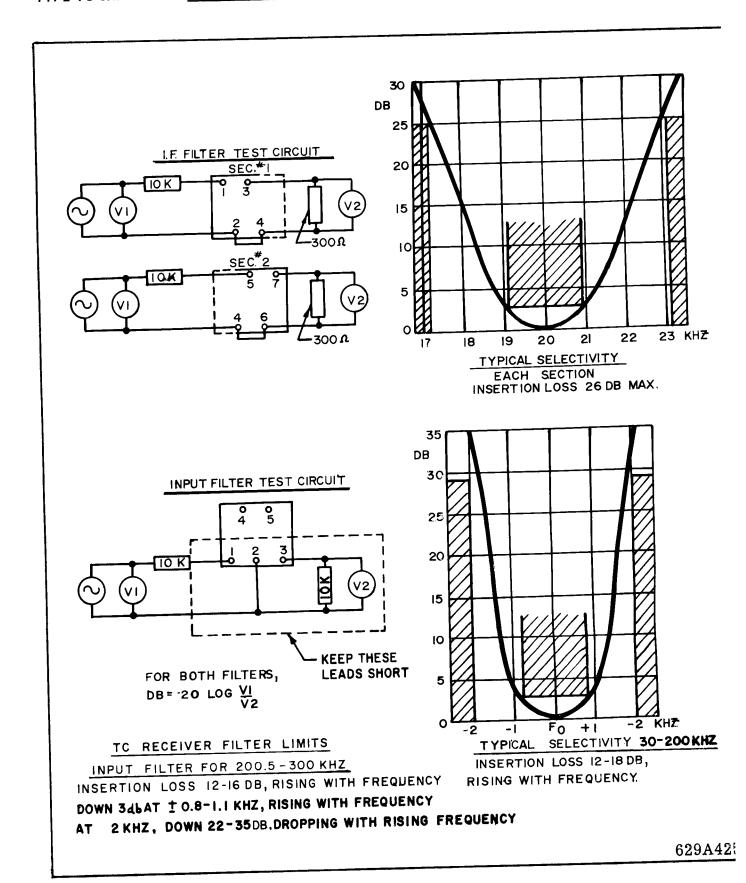
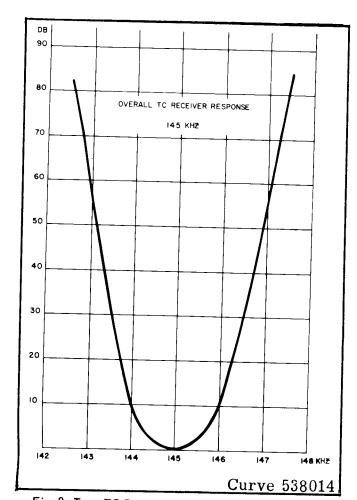


Fig. 6 Elementary K.Dar Carrier Control Circuits.



* Fig. 8 Type TC Receiver Filter Characteristics



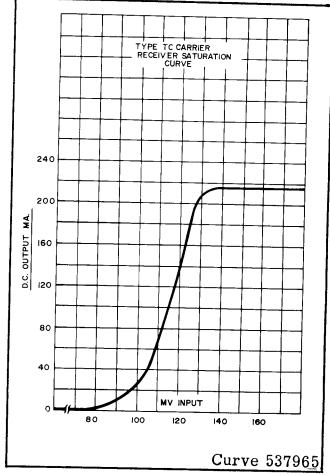
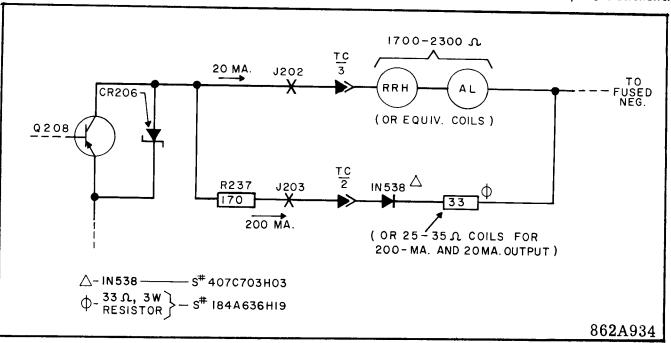


Fig. 9 Type TC Receiver Overall Selectivity Curve

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



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

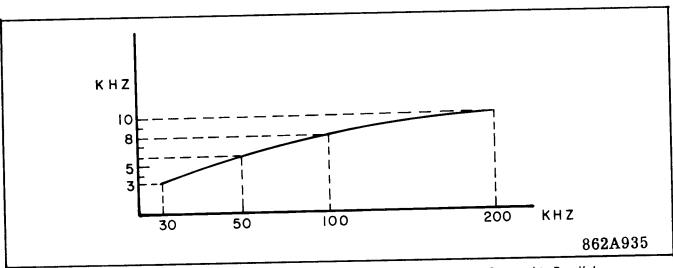


Fig. 12 Minimum Frequency Spacing For Two 10-watt Transmitters Operated in Parallel.

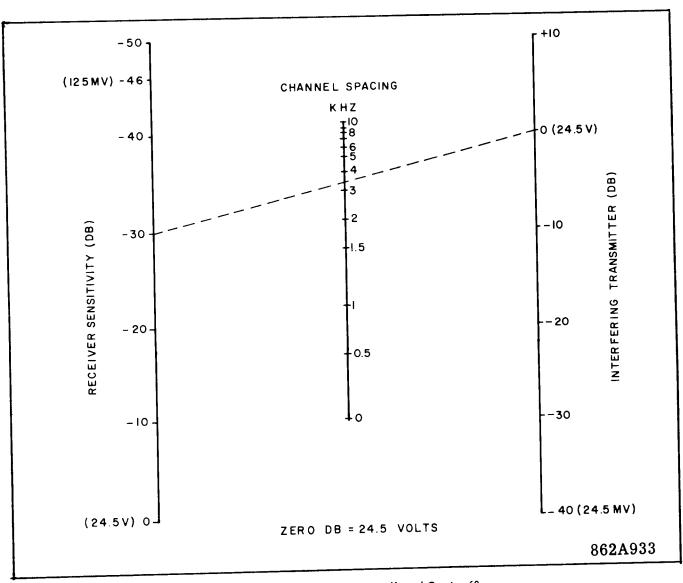


Fig. 13 Minimum Channel Spacing For Keyed Carrier 60 p.p.s.

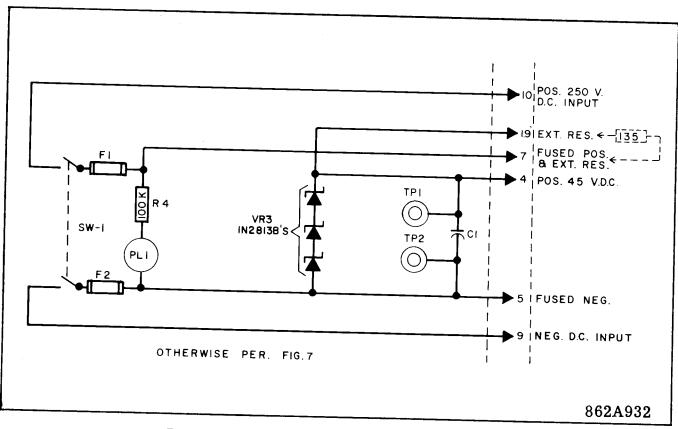


Fig. 14 Detail of Power Supply Section For 250-volt Supply

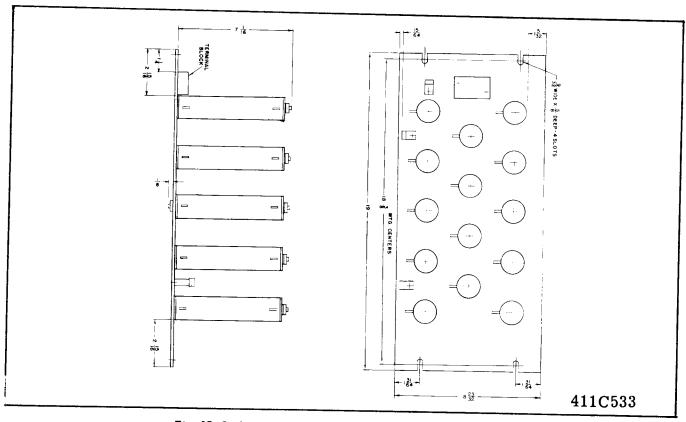


Fig. 15 Outline of External Resistor Unit For 250-volt Operation

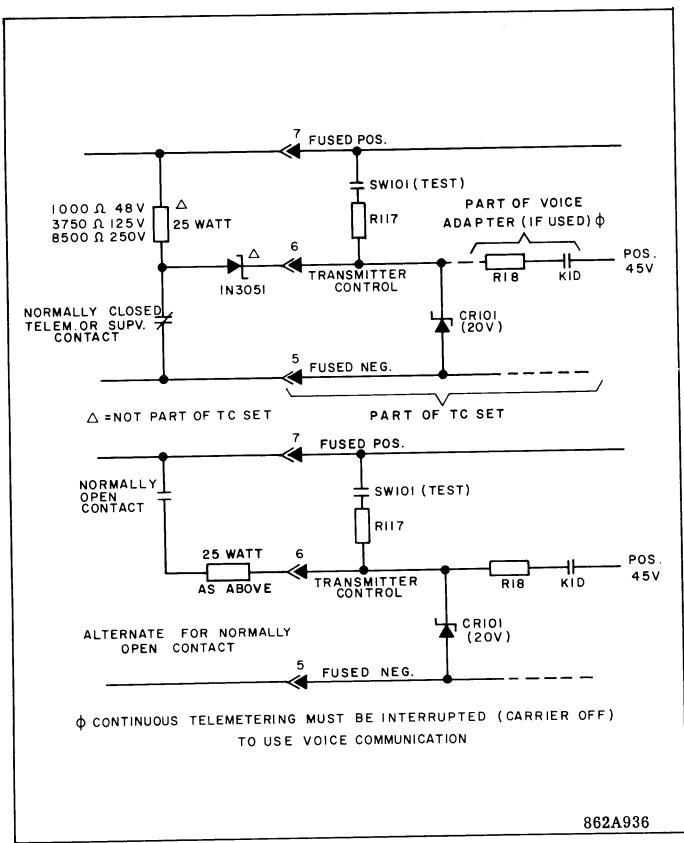


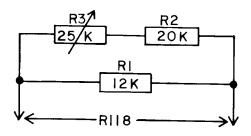
Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact

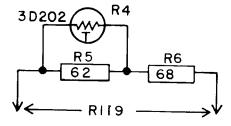
ADDENDUM

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).

Resistor 12K, ½W 2%	629A531H58
Resistor 20K, 1/2W 2%	629A531H63
Potentiometer 25K	584C276H23
Thermistor (3D202)	185A211H06
Resistor 62, ½W 2%	629A531H03
Resistor 68, ½W 2%	629A531H04
t of R3 on Auxiliary Circu	it Board
	Resistor 20K, ½W 2% Potentiometer 25K Thermistor (3D202) Resistor 62, ½W 2%

Description

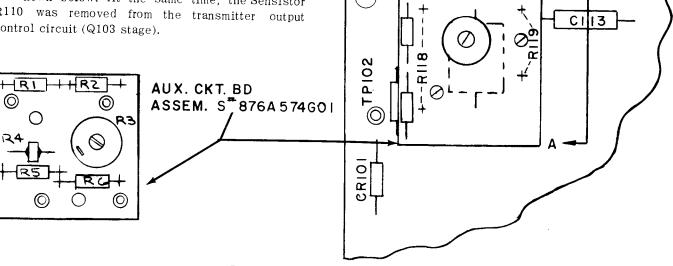
Style No.

Symbol

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.

540D.881



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 $200-300 \mathrm{kHz}$. was S# 5482D24G01, but this was superseded by S# 540D876G02 early in 1971 by modifying the latter assembly to operate up to $300 \mathrm{kHz}$.

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:

Changed From	То	Style No.
2N274	2N2905A	762A672H10
2N657	2N2726, 2N3712	762A672H07
1N3686B	1N5357B	862A288H03
	2N274 2N657	From 2N274 2N2905A 2N2726, 2N3712

* Receiver Circuit board:

Component	Changed From	То	Style No.		
Q201 to Q206	1 to Q206 2N274		762A672H10		
Q207	2N398A	2N3645	849A441H01		
Q208 2N1362		2N4903	187A673H13		
CR201	1M20Z10	1N3027B	188A302H07		
CR202, 203	1N91	1N457A	184A855H07		
CR204, 205	1N538	1N4818	188А342Н06		
R230	Changed from 62 ohms (nominal) to a 10-ohm, ½ watt resistor, style 187A290H01 in series with a 50-ohr 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.



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY

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CAUTION

It is recommended that the user of this equipment become thoroughly acquainted with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

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

APPLICATION

The type TC carrier equipment is designed for 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.

 ${\it J101-Transmitter}$ 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 $C_{\rm E}$ is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, resulting in a reverse impedance free of possible "across-the-line" resonances.

Receiver

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

The fixed input filter rejects undesired signals while accepting a wide enough band of frequencies to assure fast operation. The receiver sensitivity is adjusted by means of the continuously variable input control R207. The receiver oscillator (Q201 and Q202) is basically the same as the transmitter oscillator. The oscillator frequency is 20 kHz above the incoming signal frequency. The receiver channel frequency is determined by the input filter and the oscillator 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 Q1from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

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 $\mathbf{R}_{\mathbf{C}}$ and the diode $\mathbf{D}_{\mathbf{1}}$ 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

48, 125, or 250 V. d-c

Input voltage
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 $-30\ \mathrm{db}$ (relative to a 24.5-volt, 10-watt signal). The interfering signal is assumed to be a 10-watt transmitter at the same location. To determine the minimum frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the $-30~\mathrm{db}$ point on the receiver sensitivity scale and the zerodb 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 $\pm\ 20\%.$

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 \$187A685H01b. 60.5-120 kHz - 1800 ohms - \$187A685H02
- c. 120.5-200 kHz 1200 ohms S # 187A685H03

3. Capacitors C111 and C113

- a. 30-50 kHz 0.47 mfd. S 188A 293H 01
- b. 50.5-75 kHz 0.22 mfd. S 188A293H02
- c. 75.5-100 kHz 0.15 mfd. S 188A 293H 03
- d. $100.5\text{-}150 \text{ kHz} 0.10 \text{ mfd.} \text{S} \approx 188\text{A} 293\text{H} 04$
- e. $150.5\text{-}200~\mathrm{kHz} 0.047~\mathrm{mfd.} 8 \# 188A293H05$

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
54.0-57.0 57.5-60.5	100.5-106.0 106.5-112.5	192.0-200.0

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

A signal generator, a frequency counter, and a vacuum-tube voltmeter are required for readjustment of FL101. The signal generator and the counter should be connected across terminals 4 and 5 of transformer T103 and the voltmeter across terminals 1 and 2 of transformer T104. The signal generator should be set at the channel center frequency and at 2 at 3 volts output. The core screw of the small inductor should be turned to the position that gives a true maximum reading on the VTVM. Turning the

screw to either side of this position should definitely reduce the reading. The change in inductance with core position is less at either end of the travel than when near the center and consequently the effect of core screw rotation on the VTVM reading will be less when the resonant inductance occurs near the end of core travel.

The procedure for readjustment of the 2nd and 3rd harmonic traps of filter FL102 is somewhat similar. A signal generator and a counter should be connected to terminals 3 and 4 of transformer T105 and a 500-ohm resistor and a VTVM to the terminals of protective gap G101. The ground or shield lead of all instruments should be connected to the grounded terminal of the transformer. Set the signal generator at exactly twice the channel center frequency and at 5 to 10 volts output. Turn the core screw of the large inductor, L102, to the position that gives a definite minimum reading on the VTVM. Similarly, with the signal generator set at exactly three times the channel center frequency and 5 to 10 volts output, set the core screw of the small inductor, L103, to the position that gives a definite minimum reading on the VTVM. Then remove the instruments and the 500-ohm resistor.

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

After all the tabulated changes have been made for the new frequency, the transmitter can be operated with a 50 to 70-ohm load (depending on which tap of T106 is used) connected to its output, and inductor L105 can be readjusted for maximum output at the changed channel frequency by the procedure described in the ADJUSTMENT section.

If a frequency-sensitive voltmeter is available, the second and third harmonic traps may be adjusted (or checked) without using an oscillator as a source of double and triple the channel frequency. Connect the frequency-sensitive voltmeter from TP109 to ground and adjust the transmitter for rated output into the selected load resistor. Set the voltmeter at twice the channel frequency and, using its tuning dial and db range switch, obtain a maximum on-scale reading of the second harmonic. Then vary the core position of L102 until a minimum voltmeter reading is obtained. Similarly, tune the voltmeter to the third harmonic and adjust L103 for minimum voltmeter reading. It should be noted that this procedure may not give the true magnitude of the harmonics

because of the large value of fundamental frequency voltage present at the tuned voltmeter input terminals. This condition will overload the input circuit of some commercial instruments. However, the procedure is satisfactory for adjusting the traps for maximum harmonic rejection.

If accurate measurement of the harmonic levels

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

TABLE I
Receiver D.C. Measurements

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

Test Point	Standby (No Signal)			With 125 M.V. Input		put
TP201 TP202 TP203 TP204 TP205	*	38 0 * 11. .03 20			38 0 1. 2.2	
Transistor	E*	B*	C*	E*	B*	C*
Q201 Q202 Q203 Q204 Q205 Q206 Q207 Q208	38.5 38.5 0.08 2.7 2.4 2.5 0.13 0.25	37 37.5 0 2.9 2.6 2.7 0.03 0.15	43 43.5 18.7 18.7 18.7 10.5 22.0 45.0	38.5 38.5 0.08 2.7 2.5 2.6 2.0	37 37.5 0 2.9 2.7 2.8 2.2 2.0	43 43.5 18.7 18.7 18.7 10.5 4.0 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 Test Point		Typical A-C Voltages	
FL 201-IN to Gnd. FL201-OUT to Gnd. Q203 -E to TP206 Q203 -C to TP206 Q204 -B to TP206 Q204 -C to TP206	36 kHz .075 .051 .105 .22 .015 .90	132 kHz .050 .020 .090 .035 .012 .52	Q205-B to TP206 Q205-C to TP206 Q206-B to TP206 Q206-C to TP206 TP202 to TP206	36 kHz .11 6.7 .67 1.5 0.3	32 kHz .052 3.4 .37 1.53 0.3	

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

TABLE III

Transmitter D-C Measurements

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

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

Transistor	E	В	C	E	В	С
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

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

oltage Test Point	A-C Voltage
Q107-B to TP107 Q108-B to TP113 Q107-C to TP107	.5 volts, rms. .5
Q108-C to TP113 T105-4 to Gnd. T106-2 to Gnd.	14.5 105 155*
TP109 to Gnd. J102 to Gnd.	50* 24.5
	Q107-B to TP107 Q108-B to TP113 Q107-C to TP107 Q108-C to TP113 T105-4 to Gnd. T106-2 to Gnd.

* T101-3 = tap 3 of Transformer T101

Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

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.

^{*} These values may vary considerably with frequency

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)	
	100 pf., 500 V. DC	187A695H23
C114 C115	100 pf., 500 V. DC	187A695H23
C116	0.001 mfd, 500 V. DC	187A694H11
CA	Part of FL101	Vary with Frequency
СВ		
CC	Part of FL102	Vary with Frequency
CD		
CE		
† FREQ.	C111, C113	Style Number
30- 50 kHz	0.47 mfd, 400 V. DC	188А293Н01
50.5- 75 kHz	0.22 mfd, 400 V. DC	188А293Н02
75.5-100 kHz	0.15 mfd, 400 V. DC	188А293Н03
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	407С703Н03
CR104	1N91	182A881H04
CR105	1N538	407С703Н03
CR106	1N91	182A881H04
CR107	1N 2999A (56 V ± 10%)	184A617H13
CR108	1N 2999 A (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	Style Number 54B159H02				
J103		Coaxial Cable Jack				
J104	 	n Receptacle		187A633H01		
J105		n Receptacle		187А669Н01		
L101	Part of			629A205H02		
L102	 	Trap Coil (2nd Harn				
L103		Trap Coil (3rd Harn		Vary with Frequency		
L104	400 mh.		nonie)			
L105	FL102	Coil (part of series uned to fundamenta	-resonant l freq.)	292B096G01 Vary with Frequency		
Q101	2N 274					
Q102	2N 274			187A270H01		
Q103	2N525			187A270H01		
Q104	2N657			184A638H13		
Q105	2N657			184A638H15		
Q106	TI-481			184A638H15		
Q107	2N 1908	Motohod Doir =		184A638H11		
Q108	2N1908	Matched Pair - Tex Co Identif. GP21	as Instrument 51	187А673Н02		
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 k	Hz, 2.2K ± 10%, ¼		187A685H01		
	187A685H02					
	187A685H03					

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

Symbol	Ohms	± Tol. %	Watts	Style Number		
R116	100	5	0.5	184А763Н03		
	1,000 48 V dc	5	25	1202588		
R117	3,750 125 V dc	5	25	1202955		
	8,500 250 V dc	5	25	1267310		
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	187А290Н01		
R123	10	10	0.5	187А290Н01		
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	187А640Н01		
R131	4,700	5	1	187A644H43		
R132	0.27	10	0.5	184A636H14		
R133	0.27	10	1	184A636H18		
	0.27	10	1	184A636H18		
R134 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	2,000	Rating		Style Number		
T101	10.000/	400 ohms	L633003	1962797		
T101		′400 c.t.	L592170	1962698		
T103		1930/60 ohms L633000				
T103		Turns ratio, 1/0.5, Pri./each sec.				
T104		10/500 ohms				
T106		-60-70 ohms		292B526G03		
Y101		30-200 kHz crystal per 328C083				

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ELECTRICAL PARTS LIST Receiver Section

Symbol	Rating	Style Number
C201	0.1 mfd., 200 V. DC	187A624H01
C202	300 pf. 500 V. DC	1 87A695H35
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-20kHz(2 Sections)	187A5 90G02
J201	Receiver Coax. Input Jack	187A638H01
J202	Closed Circuit Jack (20MA)	187A606H01
J203	Closed Circuit Jack (200MA)	187А606Н01
L201	33 mh.	187А599Н01
Q201	2N 274	187A270H01
Q202	2N 274	187A270H01
Q203	2N274	187A270H01
Q204	2N274	187A270H01
Q205	2N 274	187A270H01
Q206	2N 274	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	1 87A641H35
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	629А430Н02
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	184А763Н40
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						
	Ohms	rs ± Tol. %		Watts	Style Number	
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	10,000/10,00	00 Ohms	L633	005	1962798	
T202	10,000/400	1962797				
T203	25,000/300	Ohms	L633		1962697	
Y201	50-220 kHz Cı	Specify Frequency				

* Power Supply Section

Symbol	Function Description or Pating			
C1	4.2.4		Description or Rating	Style Number
		o (-) 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	Over	load Protection	1.5a, 48/125 VDC	11D9195H26
F1,F2	Over	load Protection	2.0a. 250 VDC	478067
PL1	Neon 125/	Pilot Light 250 Volts	120 Volts	183А955Н01
PL1	Filan for 48	nent-type 3 Volts	55 Volts	187А133Н02
Q1	Series Regulator		Type 2N1015C Silicon Transistor	187A342H02
R1	Series dropping		26.5 ohms, 3½"	04D1299H44
R2	125V	125V Series dropping Same as R1		04D1299H44
R3		Current limiting	500 ohms, 3½"	1268047
	48V	For 48 VDC, R1=R2 0	_	-
		R3 = 26.5 ohms	3½"	04D1299H44
R4	Currer	nt limiting	100K, 0.5 watt	184A763H75
TP1	Test p	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	Voltag	e Regulator	1N2813B (15V.)	184A854H11

 $[\]dagger$ R238 - omit - above 50kHz

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

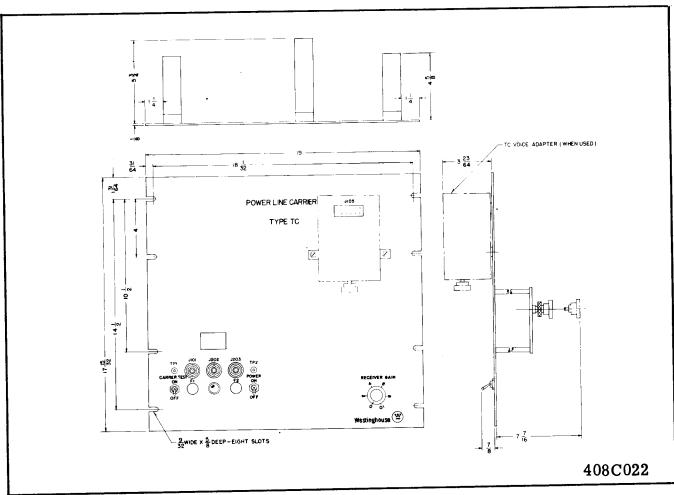


Fig. 1 Type TC Carrier Assembly - Outline

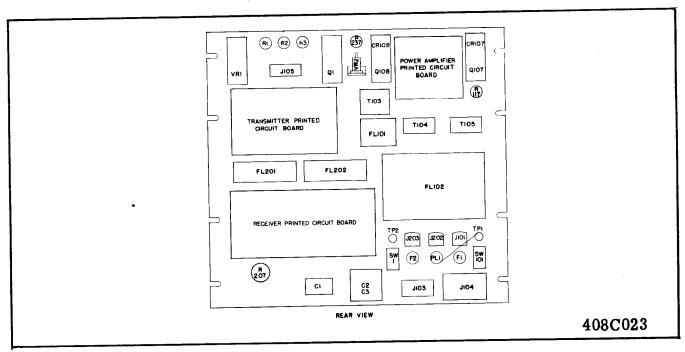


Fig. 2 Type TC Carrier Assembly - Parts Location

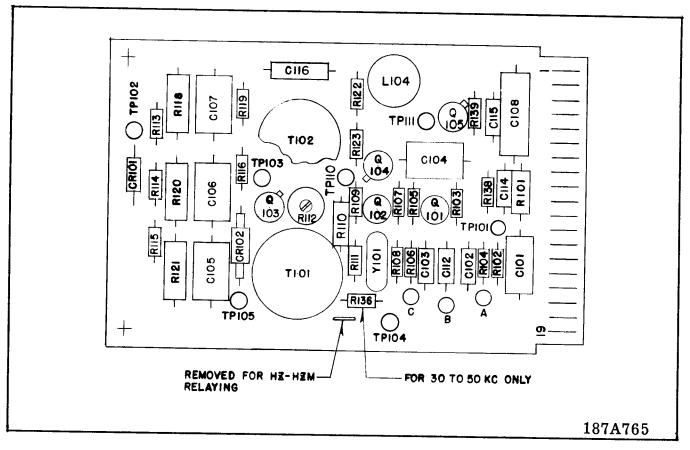


Fig. 3 Transmitter Printed Circuit - Parts Location

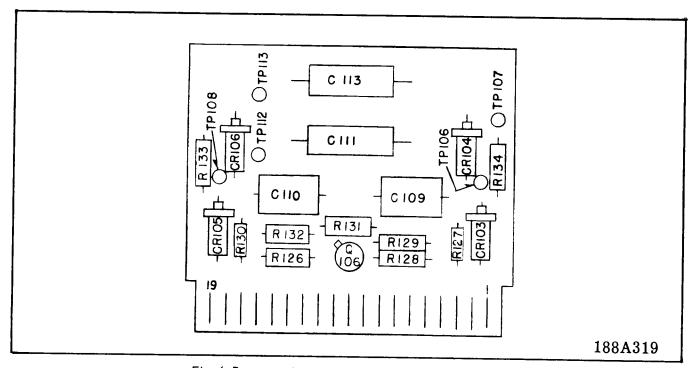


Fig. 4 Power Amplifier Printed Circuit - Parts Location

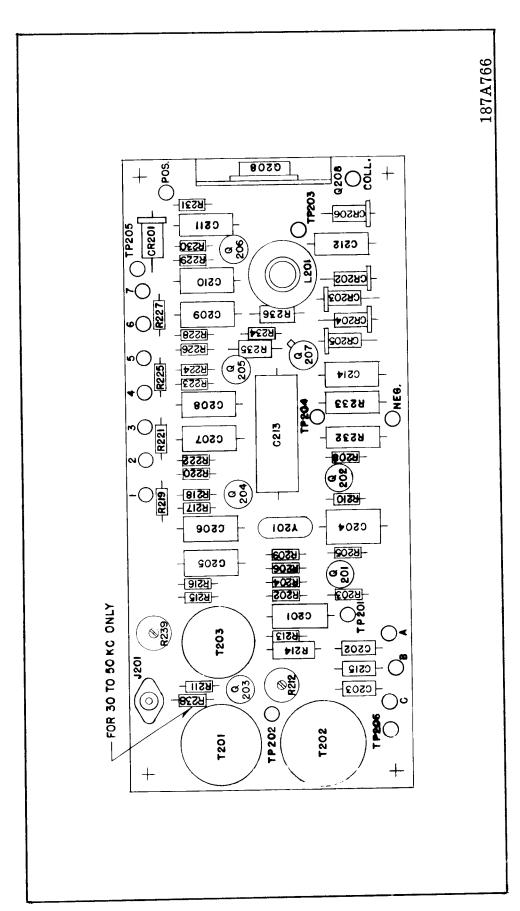


Fig. 5 Receiver Printed Circuit - Parts Location

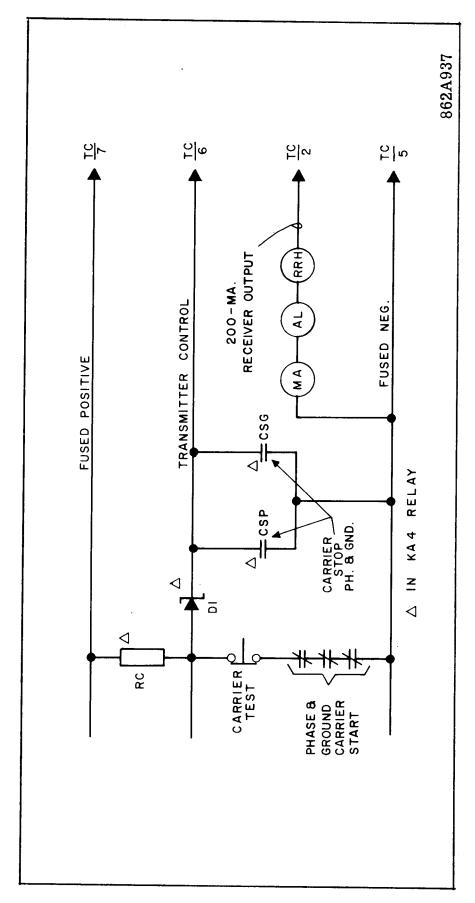


Fig. 6 Elementary K-Dar Carrier Control Circuits.

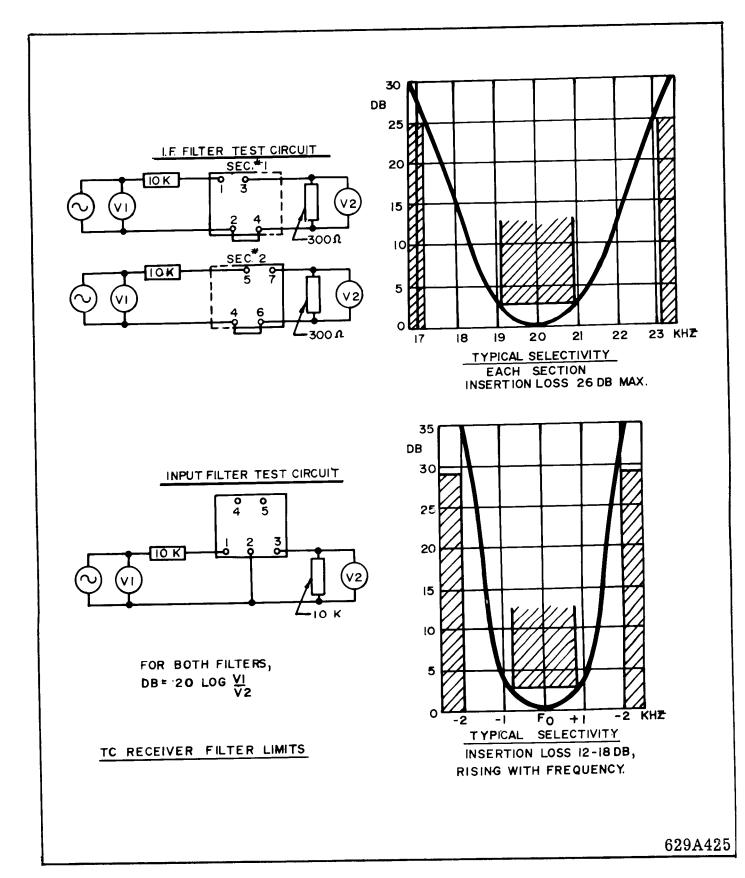
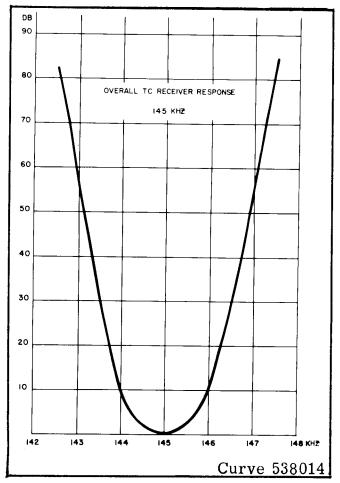


Fig. 8 Type TC Receiver Filter Characteristics



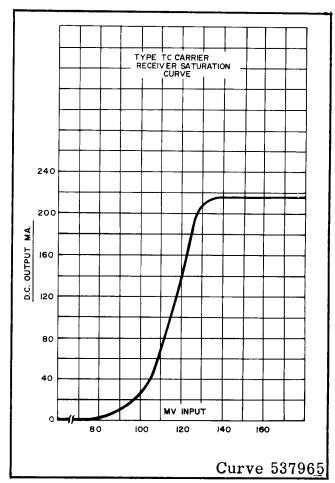


Fig. 9 Type TC Receiver Overall Selectivity Curve

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

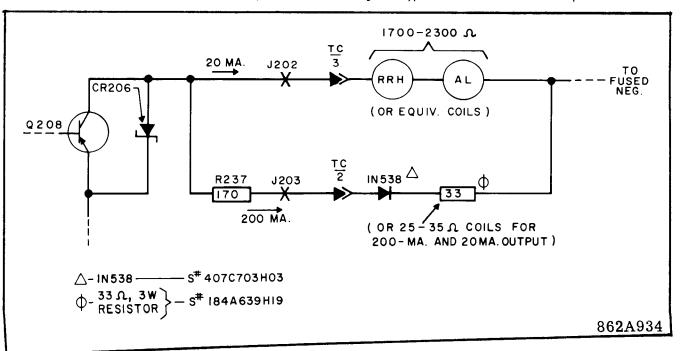


Fig. 11. TC Receiver Output For 20-ma. Operation

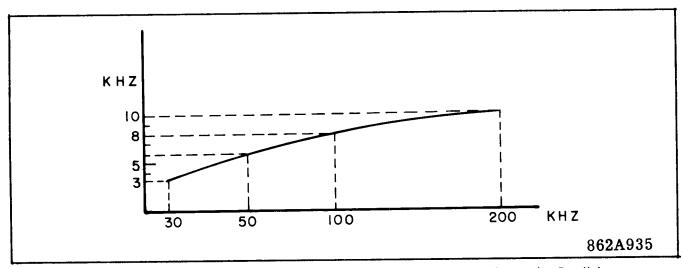


Fig. 12 Minimum Frequency Spacing For Two 10-watt Transmitters Operated in Parallel.

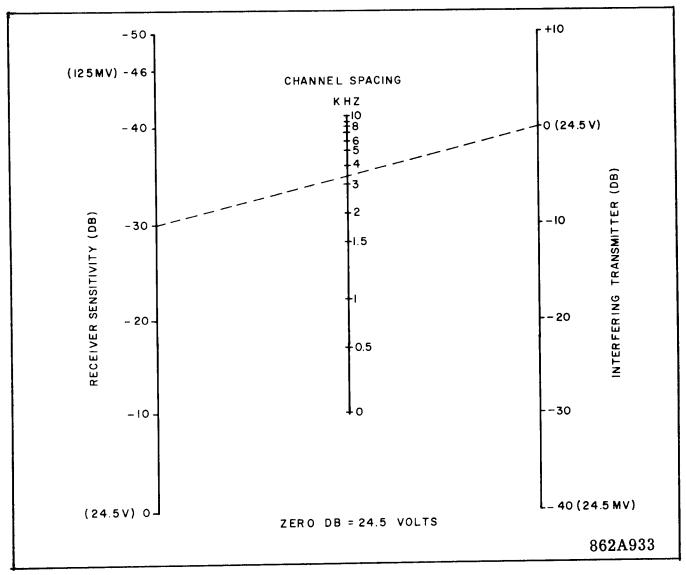


Fig. 13 Minimum Channel Spacing For Keyed Carrier 60 p.p.s.

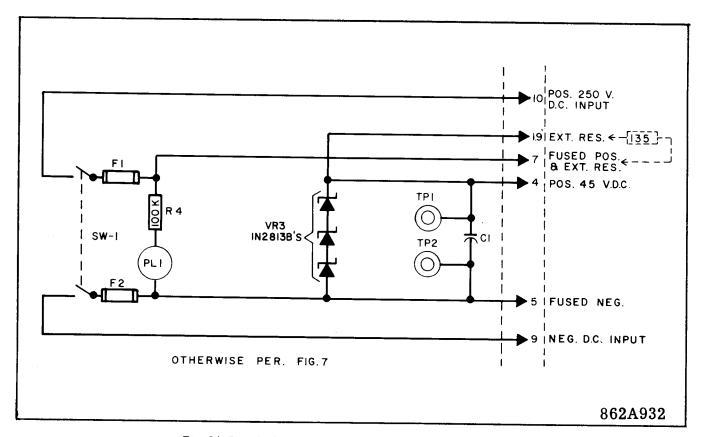


Fig. 14 Detail of Power Supply Section For 250-volt Supply

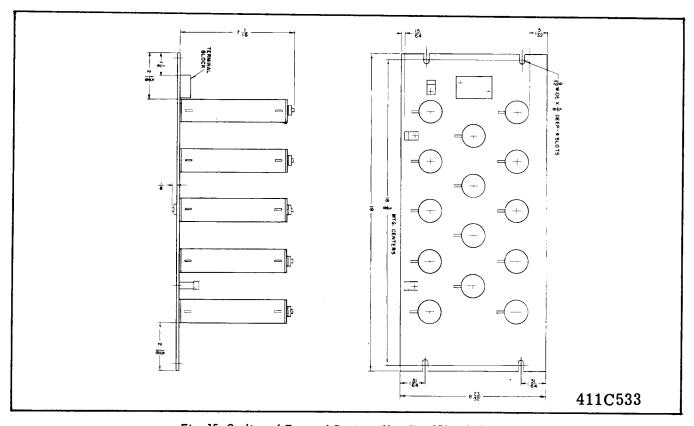


Fig. 15 Outline of External Resistor Unit For 250-volt Operation

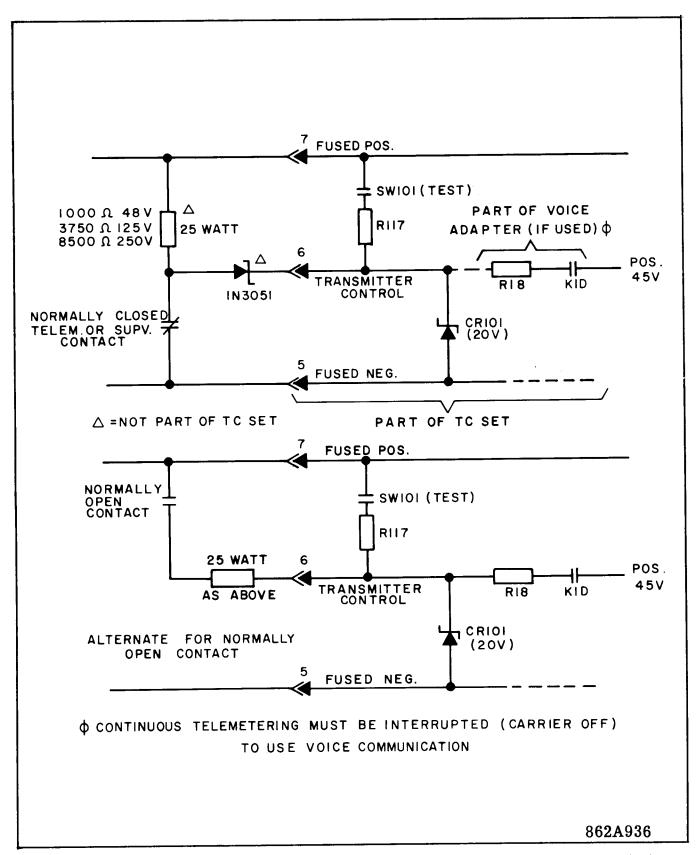


Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact

			gen .

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INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY

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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 $\pm 3kHz$.

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℃ 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 $-30\ \mathrm{db}$ (relative to a 24.5-volt, 10-watt signal). The interfering signal is assumed to be a 10-watt transmitter at the same location. To determine the minimum frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the $-30~
m{db}$ point on the receiver sensitivity scale and the zerodb 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 $\pm\ 20\%.$

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 # 188A 293H 01
- b. 50.5-75 kHz 0.22 mfd. S 188A293H02
- c. 75.5-100 kHz 0.15 mfd. S 188A 293H 03
- d. $100.5-150 \text{ kHz} 0.10 \text{ mfd.} \text{S} \pm 188\text{A} 293\text{H} 04$
- 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:

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

Test Point	Typical A-	C Voltages	Test Point	Typical A-(. Voltages
FL 201-IN to Gnd. FL 201-OUT to Gnd. Q203 -E to TP206 Q203 -C to TP206 Q204 -B to TP206 Q204 -C to TP206	36 kHz .075 .051 .105 .22 .015 .90	132 kHz .050 .020 .090 .035 .012 .52	Q205-B to TP206 Q205-C to TP206 Q206-B to TP206 Q206-C to TP206 TP202 to TP206	36 kHz .11 6.7 .67 1.5 0.3	132 kHz .052 3.4 .37 1.53 0.3

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

TABLE III

Transmitter D-C Measurements

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

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

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

Receiver

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

A-C Voltage	Test Point	
1.1 volts, rms. 0.2 0.7	Q107-B to TP107 Q108-B to TP113 Q107-C to TP107	A-C Voltage .5 volts, rms5 14.5
0.2 0.2 4.3	Q108-C to TP113 T105-4 to Gnd. T106-2 to Gnd.	14.5 105 155*
4.3 1.5 1.4	TP109 to Gnd. J102 to Gnd.	50* 24.5
	1.1 volts, rms. 0.2 0.7 0.2 0.2 4.3 4.3	1.1 volts, rms. 0.2 0.7 Q107-B to TP107 Q108-B to TP113 Q107-C to TP107 Q108-C to TP113 T105-4 to Gnd. T106-2 to Gnd. 4.3 1.5 1.4 TP109 to Gnd.

* T101-3 = tap 3 of Transformer T101

Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

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.

^{*} These values may vary considerably with frequency

ELECTRICAL PARTS LIST

Transmitter Section

	Transmitter Section	
	Rating	Style Number
Symbol	0.1 mfd, 200 V. DC	187A624H01
C101	.005 mfd, 300 V. DC	187A694H29
C102	180 pf. 500 V. DC	187A695H29
C103	0.25 mfd, 200 V. DC	187A624H02
C104		187A624H02
C105	0.25 mfd, 200 V. DC	187A624H02
C106	0.25 mfd, 200 V. DC	187A624H02
C107	0.25 mfd, 200 V. DC	187A624H03
C108	0.50 mfd, 200 V. DC	187A624H02
C109	0.25 mfd, 200 V. DC	187A624H02
C110	0.25 mfd, 200 V. DC	10111021110
† C111	(See Table Below)	187A695H12
C112	39 pfd, 500 V. DC	101/40301112
† C113	(See Table Below)	
C114	100 pf., 500 V. DC	187A695H23 187A695H23
C115	100 pf., 500 V. DC	
C116	0.001 mfd, 500 V. DC	187A694H11
CA	Part of FL101	Vary with Frequency
СВ		
CC	Part of FL102	Vary with Frequency
CD		
CE CE		
† FREQ.	C111, C113	Style Number
30- 50 kH	C1 400 V DC	188А293Н01
50.5- 75 k	0.22 mfd 400 V DC	188А293Н02
75.5-100 k	0.15 mfd 400 V DC	188А293Н03
100.5-150 k	01 400 M DO	188A293H04
150.5-200 k		188A293H05
	1N3686B (20 V ± 5%)	185A212H06
CR101	1N457A	184A855H07
CR102	1N538	407C703H03
CR103	1N91	182A881H04
CR104	1N538	407C703H03
CR105	1N91	182A881H04
CR106	1N2999A (56 V ± 10%)	184A617H13
CR107		184A617H13
CR108	1N2999A (56 V ± 10%)	637A026A01
G101	Type TVS Arrester	187A606H01
J101	Closed Circuit Jack	10.123

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

Symbol		Transmitter Section Rating	· · · · · · · · · · · · · · · · · · ·		
J102	Banan	a Plug Jack		Style Number 54B159H02	
J103		Coaxial Cable Jack			
J104		24-Term Receptacle			
J105		12-Term Receptacle			
L101		f FL101		629A205H02	
L102	————				
L103		Trap Coil (2nd Ha		Vary with Frequenc	
L104	400 mh		irmonic)		
L105				292B096G01	
1 2100	rL102 circuit	Coil (part of seri tuned to fundamen	es-resonant		
Q101	2N 274	- Tanatanen	tar freq.)	Vary with Frequency	
Q102	2N274 2N274			187А270Н01	
Q103	2N525			187А270Н01	
Q104	2N657			184A638H13	
Q105	2N657			184A638H15	
Q106				184A638H15	
Q107	TI-481			184A638H11	
Q108	2N 1908 2N 1908	matched Fair - Texas Instrument		197 4 672770 2	
Symbol	Ohms		Z151	187A673H02	
R101	5,600	± Tol. %	Watts	Style Number	
R102	2,200	5	1	187A643H45	
R103	10,000	10	0.5	187A641H35	
R104	100,000	10	0.5	187A641H51	
R105	390	5	0.5	184A763H75	
R106	1,200	5	0.5	184A763H17	
R107	10,000	5	0.5	184A763H29	
R108	100,000	10	0.5	187A641H51	
R109	390	5	0.5	184A763H75	
R110 *		5	0.5	184A763H17	
R111	1,200			At End of List	
R112	1 K Pot	5	0.5	187А763Н29	
R113		20	0.25	629А430Н02	
R114	4,700	5	0.5	184A763H43	
R115	10,000	10	0.5	187A641H51	
ensistor-	150	5	0.5	184A763H07	
	ου - 60 k	Hz, $2.2 \text{ K} \pm 10\%$, $\frac{1}{4}$	watt	187A685H01	
		Hz, 1.8K ± 10%, ¼		187A685H02	
	120.5-200 kF	$12, 1.2 \text{ K} \pm 10\%, \frac{1}{4}$	watt	187А685Н03	

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

Cymbol	Ohms	± Tol. %	Watts	Style Number
Symbol	100	5	0.5	184A763H03
R116	1,000	 5	25	1202588
D117	48 V dc 3,750	 5	25	1202955
R117	125 V dc 8,500	 5	25	1267310
_	250 V dc		2	185A207H49
R118	8,200	5	0.5	184 A 763 H 03
R119	100	5	2	185A207H51
R120	10,000	5	2	187A683H01
R121	10	5		187A290H01
R122	10	5	0.5	187A290H01
R123	10	10	0.5	187A644H03
R124	100	10	1	
R125	1,000	10	0.5	187A641H27
R126	4,700	10	1	187A644H43
R127	10	10	0.5	187A640H01
R128	2,200	5	1	187A644H35
	2.7	10	0.5	184 A 636H 14
R129 R130	10	10	0.5	187A640H01
	4,700	5	1	187A644H43
R131	0.27	10	0.5	184A636H14
R132	0.27	10	1	184A636H18
R133		10	1	184A636H18
R134	0.27	10	5	188A317H01
R135	3,000	10	0.5	184A763H53
R136	12,000	10	2	187A642H55
R137	15,000	10	0.5	187A641H27
R138	1,000	10	0.5	187A641H27
R139	1,000	Rating		Style Number
Symbol			L633003	1962797
T101		0/400 ohms	L592170	1962698
T102		00/400 c.t.	L633000	1962694
T103		/60 ohms	Pri./each sec.	292B526G01
T104		s ratio, 1/0.5,	PII./ eacil Sec.	292B526G02
T105		00 ohms		292B526G03
T106		50-60-70 ohms		Specify Frequenc
Y101	30-2	00 kHz crystal pe	328C083	Specify Frequenc

ELECTRICAL PARTS LIST Receiver Section

	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	
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	187A624H02
C212	0.25 mfd., 200 V. DC	187A624H01
C213	2.0 mfd., 200 V. DC	187A624H02
C214	0.25 mfd., 200 V. DC	187A624H05
C215	39 pfd., 500 V. DC	187А624Н02
CR201	1N3027B (20V ± 5%)	187A695H12
CR202	1N91	184А449Н07
CR203	1N91	182A881H04
CR204	1N538	182A881H04
CR205	1N538	407С703Н03
CR206	1N1789 (56V. ± 10%)	407С703Н03
FL201	Receiver Input Filter 30-200 kHz	584C434H08
FL202		Specify Frequency
J201	Receiver i.f. Filter-20kHz (2 Sections)	187A590G02
J202	Receiver Coax. Input Jack Closed Circuit Jack (20MA)	187A638H01
J203		187А606Н01
L201	Closed Circuit Jack (200MA) 33 mh.	187А606Н01
Q201	2N274	187A599H01
Q202	2N274 2N274	187А270Н01
Q203	2N274	187А270Н01
Q204		187А270Н01
Q205	2N274	187A270H01
Q206	2N274	187A270H01
Q207	2N 274	187A270H01
Q208	2N398A	184A638H12
4200	2N1362	187А673Н01

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	1 87A641H35
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
R212	1,200	5	0.5	184A763H29
R214	5,600	5	1	187A643H45
R215	20,000	5	0.5	184A763H58
	3,600	5	0.5	184A763H40
R216	620	5	0.5	184A763H22
R217	62	5	0.5	187A290H20
R218	10,000	10	0.5	187A641H51
R219 R220	20,000	5	0.5	184A763H58
R221	300	5	0.5	184A763H14
	3,600	5	0.5	184A763H40
R222	620	5	0.5	184A763H22
R223	62	5	0.5	187A290H20
R225	10,000	10	0.5	187A641H51
R226	20,000	5	0.5	184A763H58
	300	5	0.5	184A763H14
R227 R228	3,600	5	0.5	184A763H40
	620	5	0.5	184A763H22
R229	62	5	0.5	187A290H20
R230	2,000	5	0.5	184A763H34
R231		5	2	185A207H29
R232 R233	1,200	10	2	187A642H43

†R211 - 10K - above 50kHz- S# 187A641H51

- 22K - 30-50kHz - S# 187A641H59

ELECTRICAL PARTS LIST Receiver Section (Cont.)

Symbol		Rating			
	Ohms	± Tol. %		Watts	Style Number
R234 R235	5,100	5		0.5	104 4 7 7 0 7 7 4 4
	470	10		1	184A763H44
R236	4,700	10		1	187A644H19
R237	170			1	187A644H43
† R238	110	5		40	1336074
	_				See † Note Below
R239	1 K Pot.	20		0.25	629A430H02
T201	10,000/10,00	0 Ohms	L63	1962798	
T202	10,000/400	Ohms	L63		
T203	25,000/300	Ohms			1962797
Y201		Ohms L592171 ystal per 328C083			1962697
		ystar per 32	8C083		Specify Frequency

* Power Supply Section

			oppiy Section		
Symbol		Function	Description or Rating	Style Number	
C1	(+)	to (-) bypass	0.45 mfd. 330 VAC		
C2	A-C	grounding	0.5 mfd. 1500 VDC	1723408	
C3	A-C	grounding		1877962	
F1,F2	Ove	erload Protection	1000 VDC	1877962	
F1,F2		rload Protection	1.5a, 48/125 VDC	11D9195H26	
			2.0a. 250 VDC	478067	
PL1	125/	n Pilot Light 250 Volts	120 Volts	183A955H01	
PL1	Fila for 4	ment-type 8 Volts	55 Volts	187A133H02	
Q1 R1	Serie	es Regulator	Type 2N1015C Silicon Transistor	187A342H02	
	_	Series dropping	26.5 ohms, 3½"	04D1299H44	
R2	125V	125V Series dropping Same as R1		04D1299H44	
R3	 	Current limiting	500 ohms, 3½"	1268047	
	48V	For 48 VDC, R1 = R2 0	_	-	
		R3 = 26.5 ohms	3½"	04D1299H44	
R4	Curre	nt limiting	100K, 0.5 watt		
TP1	Test	point (+)	Pin Jack - red	184A763H75	
TP2	 	point (-)		187A332H01	
VR1	 		Pin Jack - black	187A332H02	
- 101	Voitag	ge Regulator	1N2828B (45V.)	184A854H06	
VR2	Surge Protection		1N3009A (130V.) Zener Diodes	184A617H12	
VR3	Voltag	e Regulator	1N2813B (15V.)	184A854H11	

 $[\]dagger$ R238 - omit - above 50 kHz

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

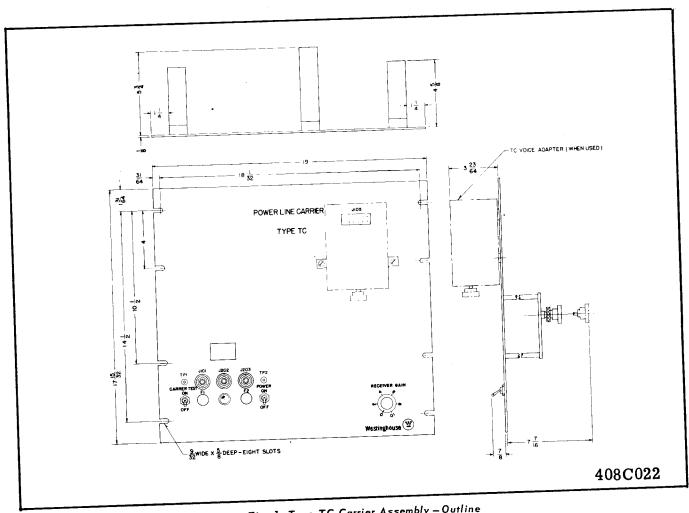


Fig. 1 Type TC Carrier Assembly - Outline

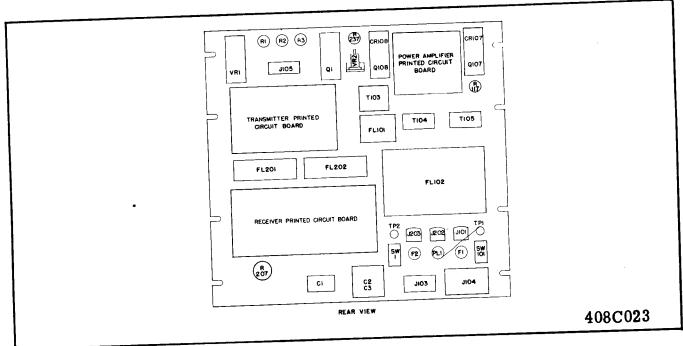


Fig. 2 Type TC Carrier Assembly - Parts Location

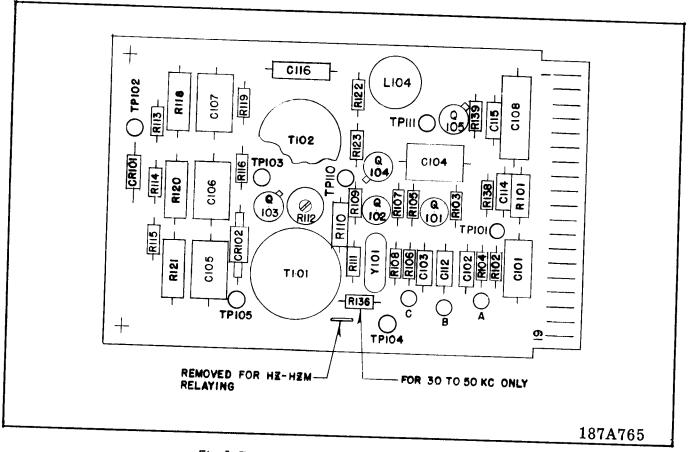


Fig. 3 Transmitter Printed Circuit - Parts Location

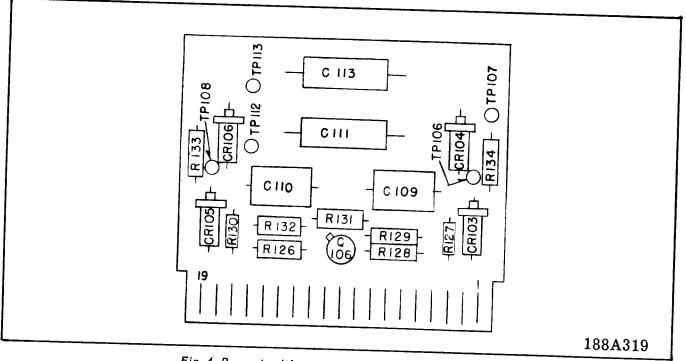


Fig. 4 Power Amplifier Printed Circuit - Parts Location

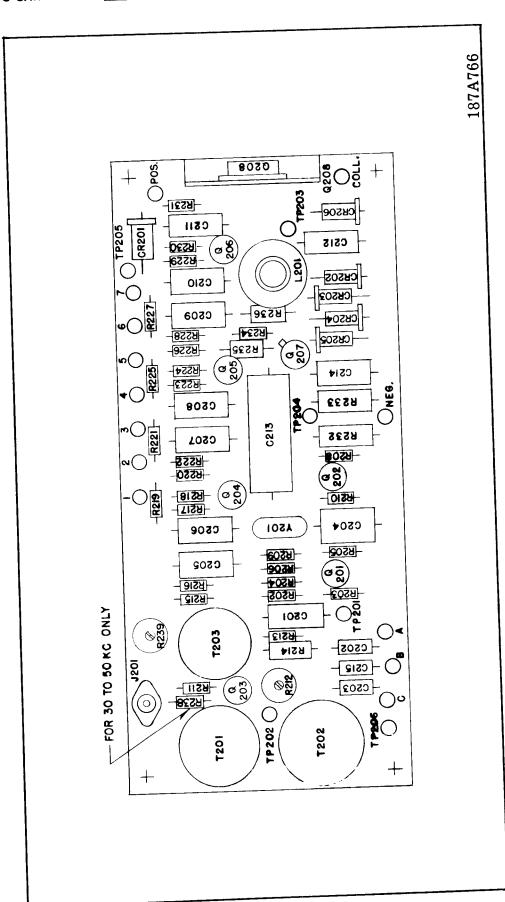


Fig. 5 Receiver Printed Circuit - Parts Location

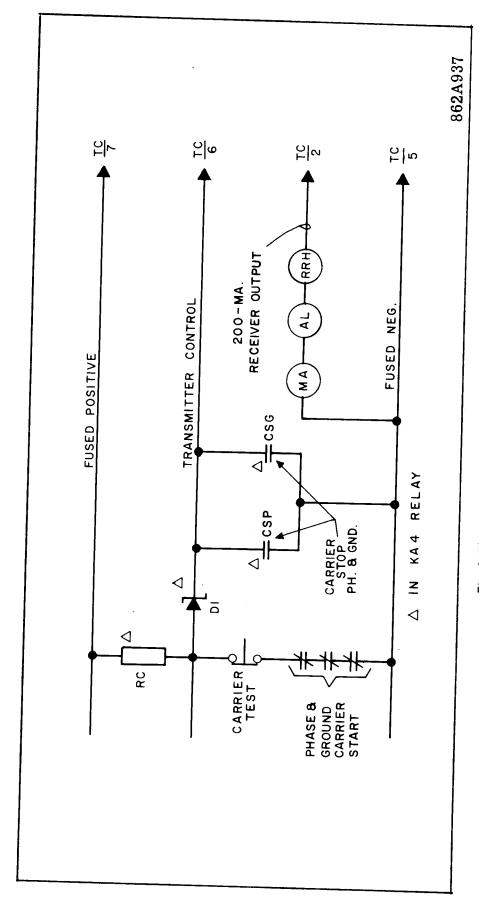


Fig. 6 Elementary K-Dar Carrier Control Circuits.

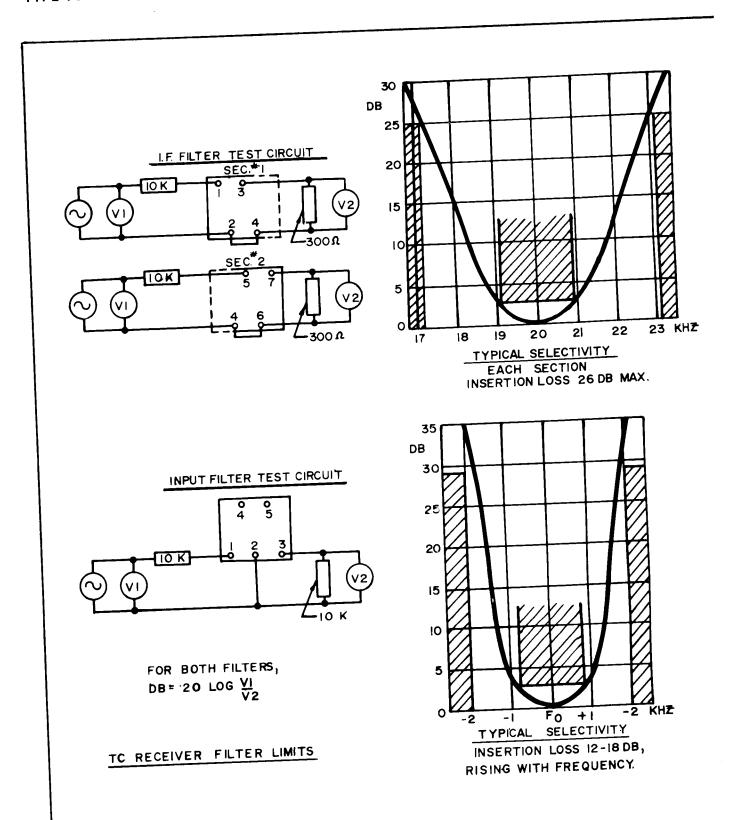
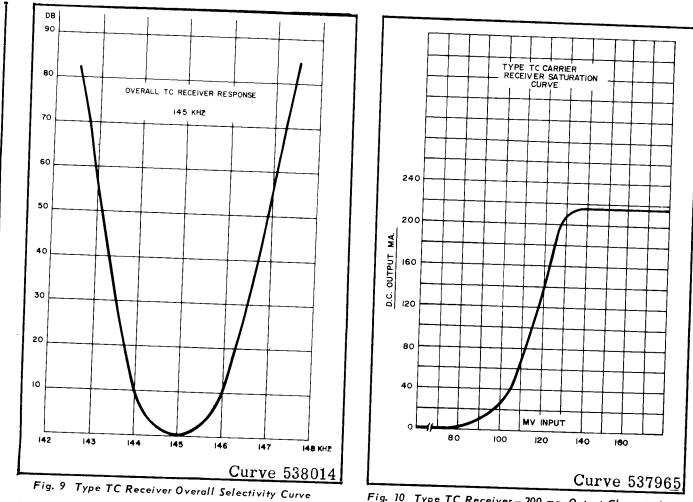


Fig. 8 Type TC Receiver Filter Characteristics

629A425



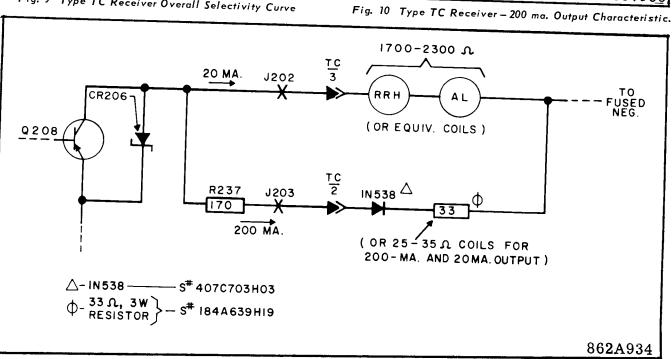


Fig. 11. TC Receiver Output For 20-ma. Operation

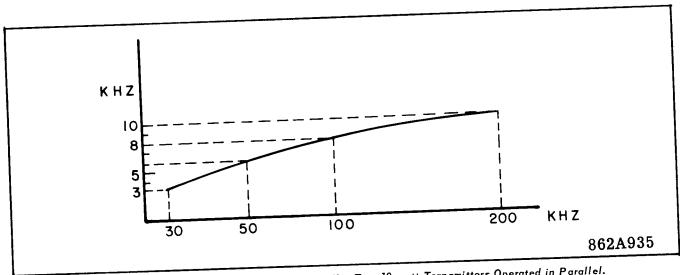


Fig. 12 Minimum Frequency Spacing For Two 10-watt Transmitters Operated in Parallel.

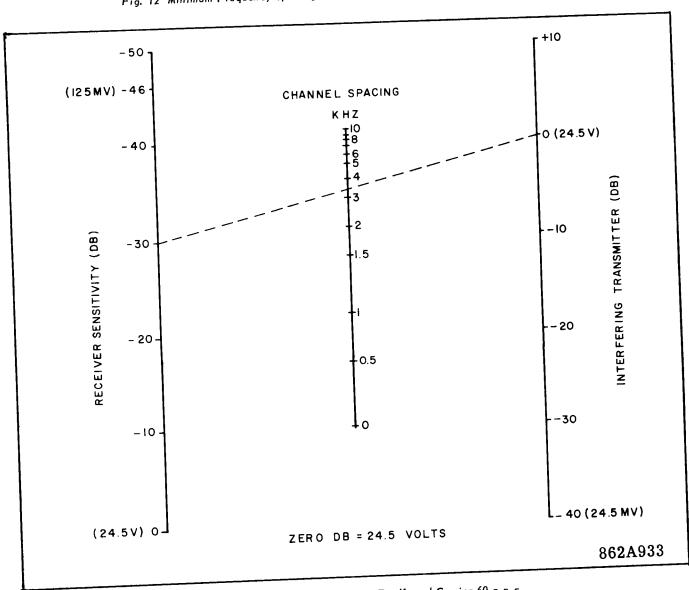


Fig. 13 Minimum Channel Spacing For Keyed Carrier 60 p.p.s.

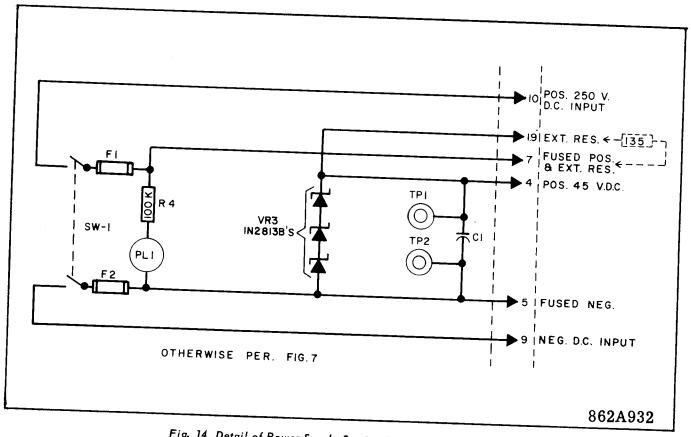


Fig. 14 Detail of Power Supply Section For 250-volt Supply

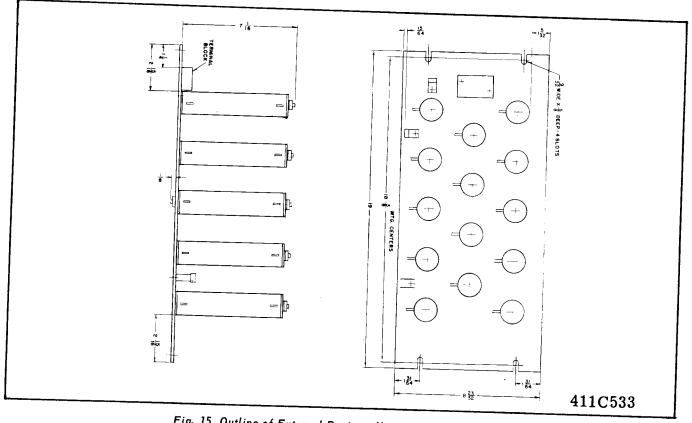


Fig. 15 Outline of External Resistor Unit For 250-volt Operation

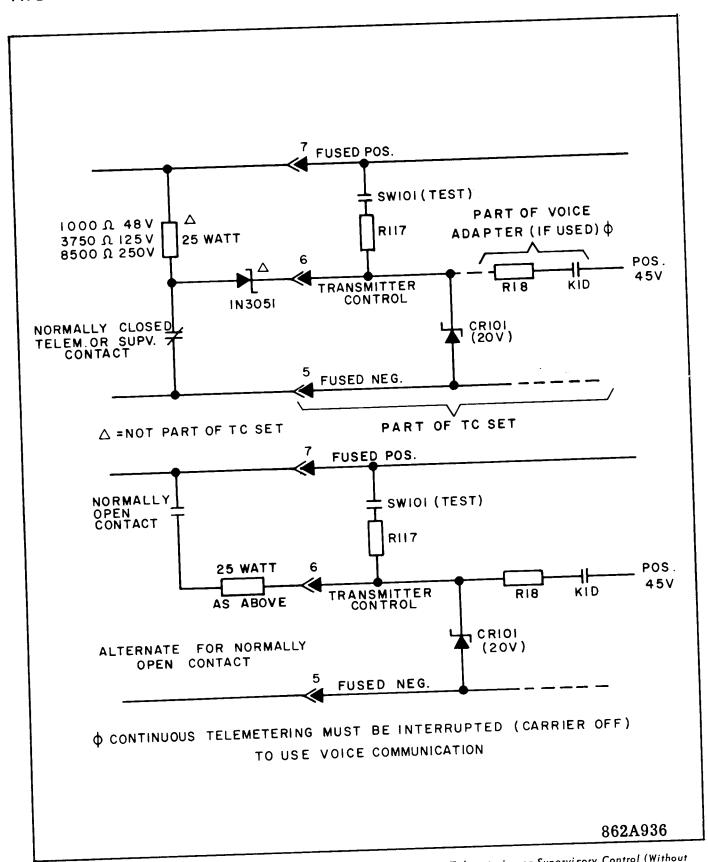


Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact

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



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY

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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 $C_{\rm E}$ is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and is used for measuring the r.f. output current of the transmitter into the coaxial cable. It should be noted that the filter contains no shunt reactive elements, resulting in a reverse impedance free of possible "across-the-line" resonances.

Receiver

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

The fixed input filter rejects undesired signals while accepting a wide enough band of frequencies to assure fast operation. The receiver sensitivity is adjusted by means of the continuously variable input control R207. The receiver oscillator (Q201 and Q202) is basically the same as the transmitter oscillator. The oscillator frequency is 20 kHz above the incoming signal frequency. The receiver channel frequency is determined by the input filter and the oscillator 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 $\boldsymbol{R}_{\boldsymbol{C}}$ and the diode \boldsymbol{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 $-30~\mathrm{db}$ point on the receiver sensitivity scale and the zerodb 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 $\pm\,20\%.$

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. $50.5\text{-}75~\mathrm{kHz}$ $0.22~\mathrm{mfd.}$ S # 188A293H02
- c. 75.5-100 kHz 0.15 mfd. S*188A293H03
- d. $100.5-150 \text{ kHz} 0.10 \text{ mfd.} \text{S} \pm 188\text{A} 293\text{H} 04$
- e. 150.5-200 kHz 0.047 mfd. S # 188A 293H 05

4. FL101 and FL102

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

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

Inductors L101, L102, and L103 in these filters are adjustable over a limited range, but 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:

61.0- 64.0	113.0-119.5
64.5- 68.0	120.0-127.0
68.5- 72.0	127.5-135.0
72.5- 76.0	135.5-143.0
76.5-80.0	143.5-151.0
80.5- 84.5	151.5-159.5
85.0-89.0	160.0-169.5
89.5- 94.5	170.0-180.0
95.0-100.0	180.5-191.5
100.5-106.0	192.0-200.0
106.5-112.5	
	64.5- 68.0 68.5- 72.0 72.5- 76.0 76.5- 80.0 80.5- 84.5 85.0- 89.0 89.5- 94.5 95.0-100.0 100.5-106.0

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 $5\ \mathrm{to}$ 10 volts output, set the core screw of the small inductor, L103, to the position that gives a definite minimum reading on the VTVM. Then remove the instruments and the 500-ohm resistor.

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

After all the tabulated changes have been made for the new frequency, the transmitter can be operated with a 50 to 70-ohm load (depending on which tap of T106 is used) connected to its output, and inductor L105 can be readjusted for maximum output at the changed channel frequency by the procedure described in the ADJUSTMENT section.

If a frequency-sensitive voltmeter is available, the second and third harmonic traps may be adjusted (or checked) without using an oscillator as a source of double and triple the channel frequency. Connect the frequency-sensitive voltmeter from TP109 to ground and adjust the transmitter for rated output into the selected load resistor. Set the voltmeter at twice the channel frequency and, using its tuning dial and db range switch, obtain a maximum on-scale reading of the second harmonic. Then vary the core position of L102 until a minimum voltmeter reading is obtained. Similarly, tune the voltmeter to the third harmonic and adjust L103 for minimum voltmeter reading. It should be noted that this procedure may not give the true magnitude of the harmonics

because of the large value of fundamental frequency voltage present at the tuned voltmeter input terminals. This condition will overload the input circuit of some commercial instruments. However, the procedure is satisfactory for adjusting the traps for maximum harmonic rejection.

If accurate measurement of the harmonic levels

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

TABLE |
Receiver D.C. Measurements

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

Test Point	Standby (No Signal)			w	ith 125 M.V. In	put
TP201 TP202 TP203 TP204 TP205		38 0 Q206 Collector Q207 Base 20			8 0 Gee Transistor d Values 0	l-c
Transistor	E*	B*	C*	E*	B*	C*
Q201 Q202 Q203 Q204 Q205 Q206 Q207 Q208	38.5 38.5 0.08 2.7 2.4 2.5 0.13 0.25	37 37.5 0 2.9 2.6 2.7 0.03 0.15	43 43.5 18.7 18.7 18.7 10.5 22.0 45.0	38.5 38.5 0.08 2.7 2.5 2.6 2.0	37 37.5 0 2.9 2.7 2.8 2.2 2.0	43 43.5 18.7 18.7 10.5 4.0 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-0	C Voltages
FL 201-IN to Gnd. FL 201-OUT to Gnd. Q203 -E to TP 206 Q203 -C to TP 206 Q204 -B to TP 206 Q204 -C to TP 206	36 kHz .075 .051 .105 .22 .015 .90	132 kHz .050 .020 .090 .035 .012 .52	Q205-B to TP206 Q205-C to TP206 Q206-B to TP206 Q206-C to TP206 TP202 to TP206	36 kHz .11 6.7 .67 1.5 0.3	132 kHz .052 3.4 .37 1.53 0.3

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

TABLE III

Transmitter D-C Measurements

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

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

Transistor	E	В	C	E	В	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

- Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
- 2. Receiver input filter (FL201), specify frequency.
- Resistors R211-R238 Combination See values in Fig. 7 below internal schematic.
- 4. 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 T103-4 to Gnd. T104-1 to Gnd.	4.3 1.5 1.4	TP109 to Gnd. J102 to Gnd.	50* 24.5

T103-3 = tap 3 of Transformer T101

Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

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.

^{*} These values may vary considerably with frequency

ELECTRICAL PARTS LIST Transmitter Section

	Fransmitter Section	
ghal	Rating	Style Number
Symbol	0.1 mfd, 200 V. DC	187A624H01
C101	.005 mfd, 300 V. DC	187A694H29
C102	180 pf. 500 V. DC	187A695H29
C103	0.25 mfd, 200 V. DC	187A624H02
C104	0.25 mfd, 200 V. DC	187A624H02
C105	0.25 mfd, 200 V. DC	187A624H02
C106	0.25 mfd, 200 V. DC	187A624H02
C107	0,50 mfd, 200 V. DC	187A624H03
C108	0.25 mfd, 200 V. DC	187A624H02
C109	0.25 mfd, 200 V. DC	187A624H02
C110	(See Table Below)	_
† C111	39 pfd, 500 V. DC	187A695H12
C112	(See Table Below)	
† C113		187A695H23
C114	100 pf., 500 V. DC 100 pf., 500 V. DC	187A695H23
C115		187A694H11
C116 0.001 mfd, 500 V. DC		Vary with Frequency
CA	Part of FL101	, w., w
СВ	D 4 6 DY 100	Vary with Frequency
CC	Part of FL102	vary with roquers
CD		
CE		Style Number
† FREQ.	C111, C113	188A293H01
30- 50 KC	0.47 mfd, 400 V. DC	188A293H02
50.5- 75 KC	0.22 mfd, 400 V. DC	188A293H03
75.5-100 KC	0.15 mfd, 400 V. DC	188A293H04
100.5-150 KC	0.1 mfd, 400 V. DC	188A293H05
150.5-200 KC	0.047 mfd, 400 V. DC	185A212H06
CR101	1N3686B (20 V ± 5%)	184A855H07
CR102	1N457A	407C703H03
CR103	1N538	182A881H04
CR104	1N91	407C703H03
CR105	1N538	
CR106	1N91	182A881H04
CR107	$1N2999A (56V \pm 10\%)$	184A617H13
CR108	$1N2999A (56V \pm 10\%)$	184A617H13
G101	Type TVS Arrester	637A026A01
J101	Closed Circuit Jack	187A606H01

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

Symbol		Rating		Style Number		
J102	Banan	Banana Plug Jack				
J103	Coaxia	54B159H02				
J104		m Receptacle		187A633H01		
J105		m Receptacle		187А669Н01		
L101		f FL101		629A205H02		
L102		Trap Coil (2nd Ha	Proprie)			
L103		Trap Coil (3rd Ha		Vary with Frequency		
L104	400 mh					
L105	FL102	Coil (part of seric	es-resonant tal freq.)	292B096G01 Vary with Frequency		
Q101	2N 274					
Q102	2N 274			187А270Н01		
Q103	2N525			187А270Н01		
Q104	2N657			184A638H13		
Q105	2N657			184A638H15		
Q106	TI-481			184A638H15		
Q107	2N1908	36-4-1-1-1-1		184A638H11		
Q108	2N1908	matched Fall - Texas Instrument				
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			
R113	4,700	5	0.5	629A430H02		
R114	10,000	10	0.5	184A763H43		
R115	150	5	0.5	187A641H51		
Sensistor-	30 - 60 k	Hz, 2.2 K ± 10%, ½		184A763H07		
	60.5-120 k	Hz, 1.8 K ± 10%, ½	watt	187A685H01		
		Hz, $1.2 \text{ K} \pm 10\%$, $\frac{1}{4}$		187A685H02		
		, 1.211 - 10%, 4	wall	187А685Н03		

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

Symbol	Ohms	± Tol. %	Watts	Style Number	
R116	100	5	0.5	184A763H03	
	1,000 48 V dc	5	25	1202588	
R117	3,750 125 V dc	5	25	1202955	
	8,500 250 V dc	5	25	1267310	
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	187А290Н01	
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	
	0,27	10	1	184A636H18	
R134 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	1,000	Rating		Style Number	
	10 000	10.000/400 ohms L633003			
T101		10,000/400 c.t. L592170		1962698	
		1930/60 ohms L633000		1962694	
T103		Turns ratio, 1/0.5, Pri./each sec.		292B526G01	
T104 T105		ohms		292B526G02	
		0-60-70 ohms		292B526G03	
T106 Y101		30-200 kc crystal per 328C083			

ELECTRICAL PARTS LIST Receiver Section

	Keceiver Section	
Symbol	Rating	Style Number
C201	0.1 mfd., 200 V. DC	187A624H01
C202	300 pf. 500 V. DC	1 87A695H35
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%)	184 A449 H07
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-20kHz (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	2N 274	187A270H01
Q203	2N274	
Q204	2N274	187A270H01
Q205	2N274	187A270H01
Q206	2N 274	187A270H01
Q207	2N398A	187A270H01
Q208	2N1362	184A638H12
		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	1 87A641H35
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	<u></u> .	_	-	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	184 A763H40
R229	620	5	0.5	184A763H22
R230	62	5	0.5	187A290H20
R231	2,000	5	0.5	184А763Н34
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				
	Ohms	± Tol. %	Watts	Style Number
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	10,000/10,00	0 Ohms	L633005	1962798
T202	10,000/400			
T203	25,000/300	Ohms	L592171	1962797
Y201	50-220 kHz Cr	ystal per 328C		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	Ove	rload Protection	1.5a, 48/125 VDC	11D9195H26
F1,F2	Over	load Protection	2.0a. 250 VDC	478067
PL1	Neon 125/	Pilot Light 250 Volts	120 Volts	183A955H01
PL1	Filar for 4	ment-type 8 Volts	55 Volts	187A133H02
Q1	Serie	s Regulator	Type 2N1015C Silicon Transistor	187A342H02
R1		Series dropping	26.5 ohms, 3½"	04D1299H44
R2	125V	Series dropping	Same as R1	04D1299H44
R3		Current limiting	500 ohms, 3½"	1268047
	48V	For 48 VDC, R1=R2 0	_	_
		R3 = 26.5 ohms	3½"	04D1299H44
R4	Curre	nt limiting	100K, 0.5 watt	184A763H75
TP1	Test	point (+)	Pin Jack - red	187A332H01
TP2	Test	point (-)	Pin Jack - black	187A332H02
VR1	Voltag	ge Regulator	1N2828B (45V.)	184A854H06
VR2	Surge	Protection	1N3009A (130V.) Zener Diodes	184A617H12
VR3	Voltag	ge Regulator	1N2813B (15V.)	184A854H11

[†] R238 - omit - above 50kHz

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

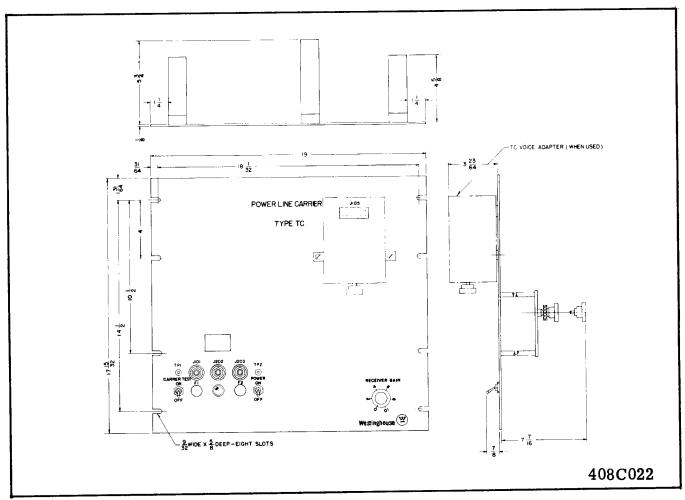


Fig. 1 Type TC Carrier Assembly - Outline

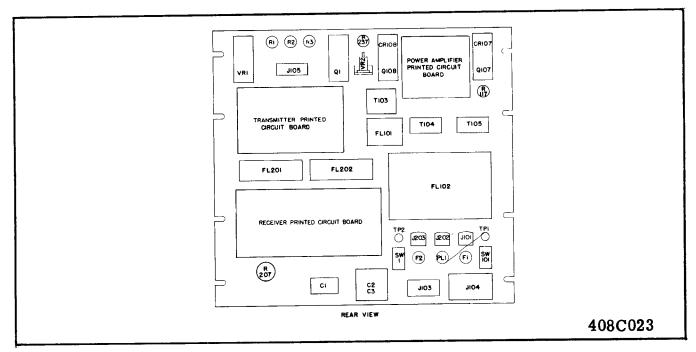


Fig. 2 Type TC Carrier Assembly - Parts Location

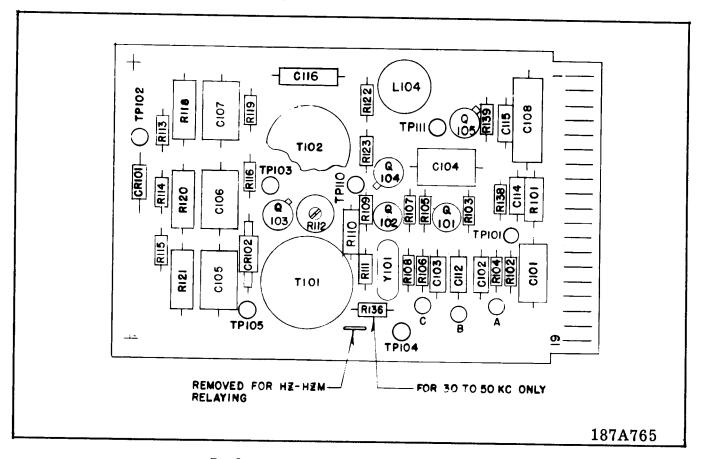


Fig. 3 Transmitter Printed Circuit - Parts Location

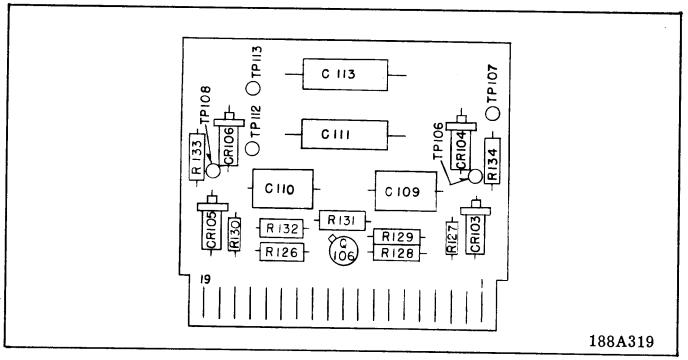
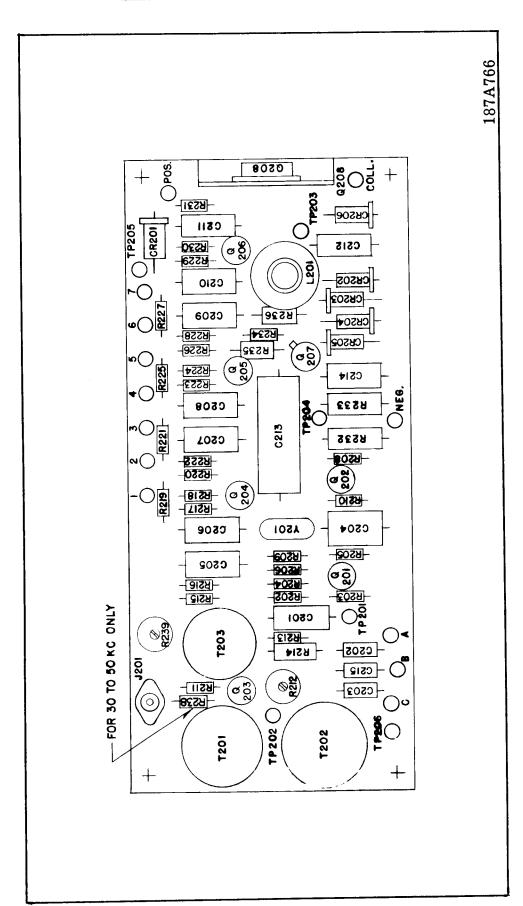


Fig. 4 Power Amplifier Printed Circuit - Parts Location



g. 5 Receiver Printed Circuit - Parts Location

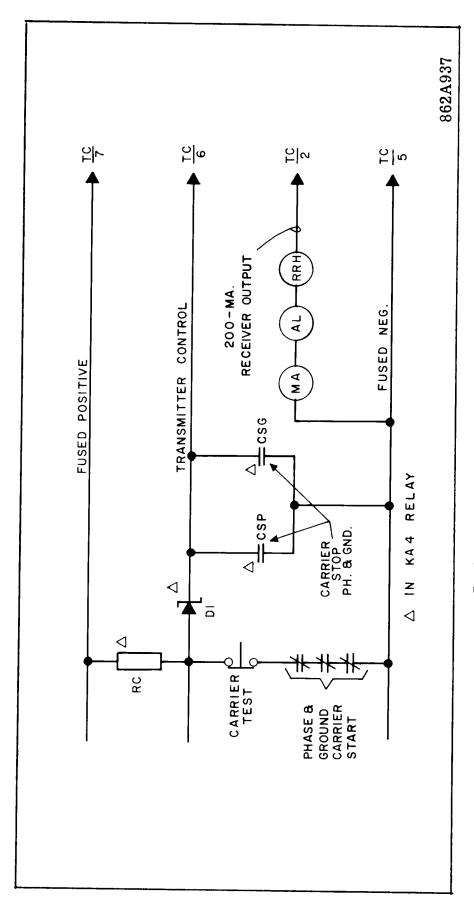


Fig. 6 Elementary K.Dar Carrier Control Circuits.

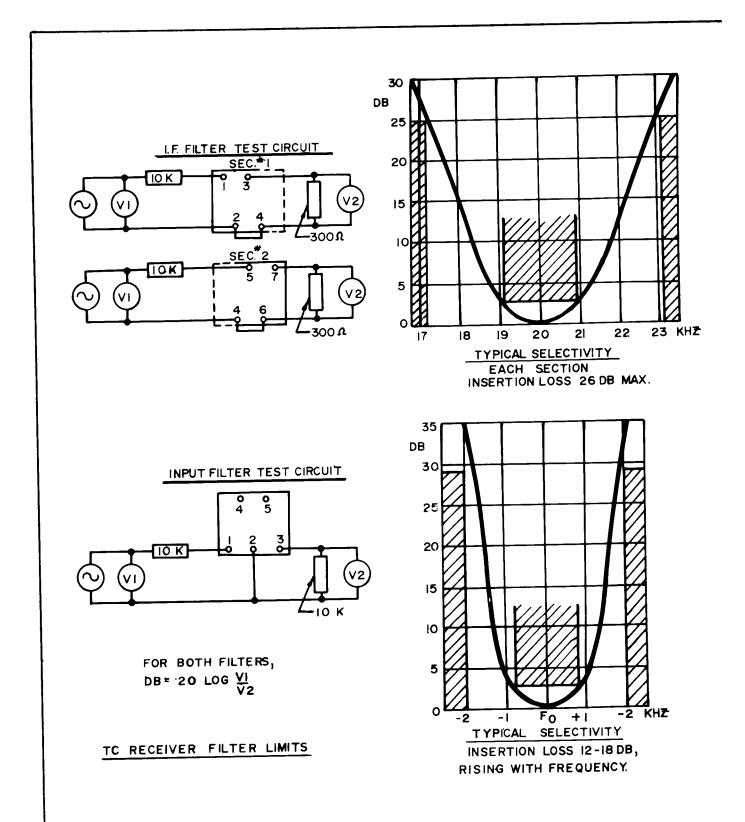
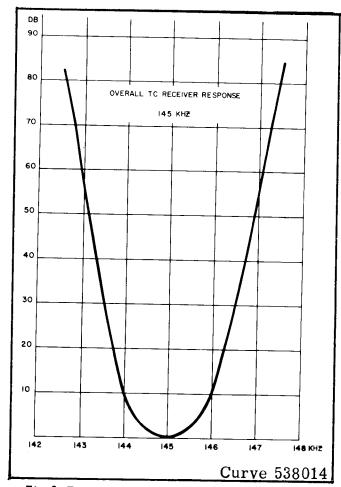


Fig. 8 Type TC Receiver Filter Characteristics

629A425



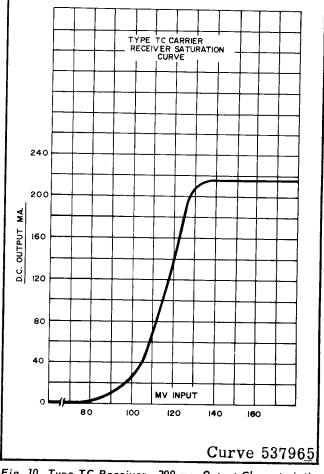


Fig. 9 Type TC Receiver Overall Selectivity Curve

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

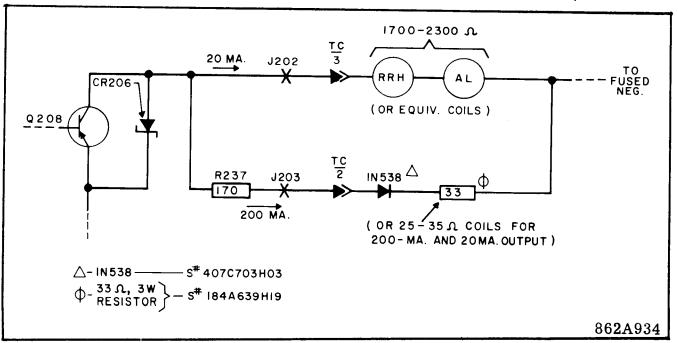


Fig. 11. TC Receiver Output For 20-ma. Operation

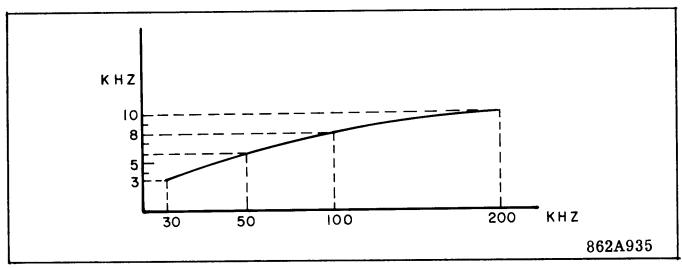


Fig. 12 Minimum Frequency Spacing For Two 10-watt Transmitters Operated in Parallel.

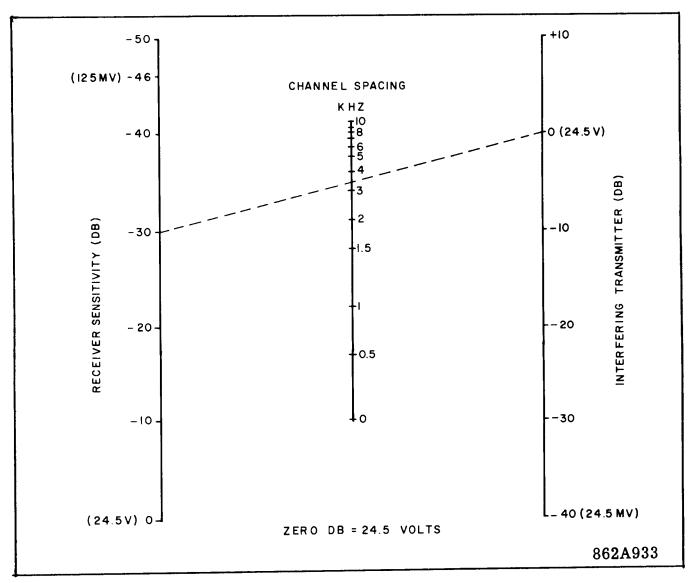


Fig. 13 Minimum Channel Spacing For Keyed Carrier 60 p.p.s.

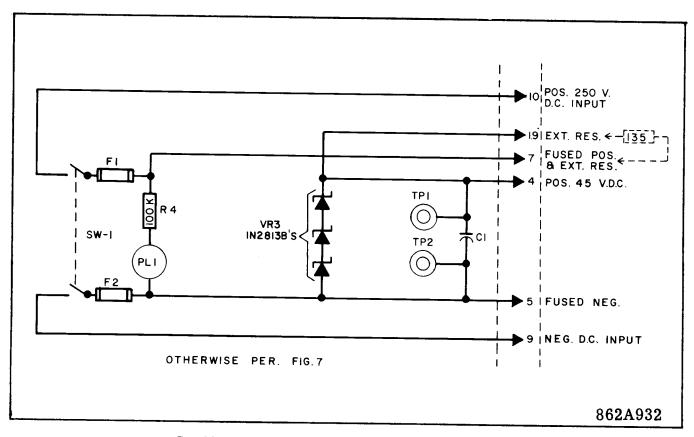


Fig. 14 Detail of Power Supply Section For 250-volt Supply

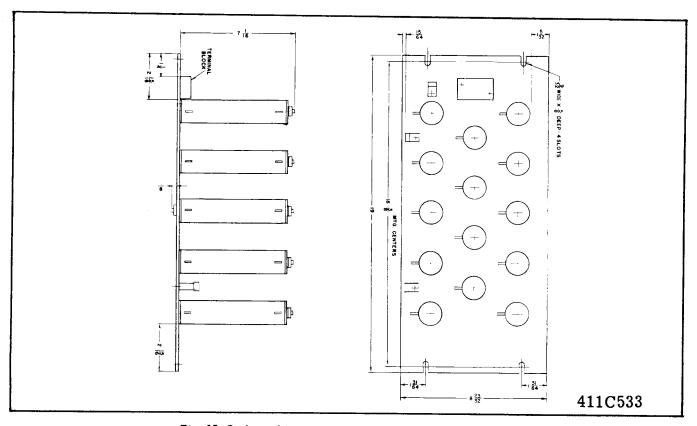


Fig. 15 Outline of External Resistor Unit For 250-volt Operation

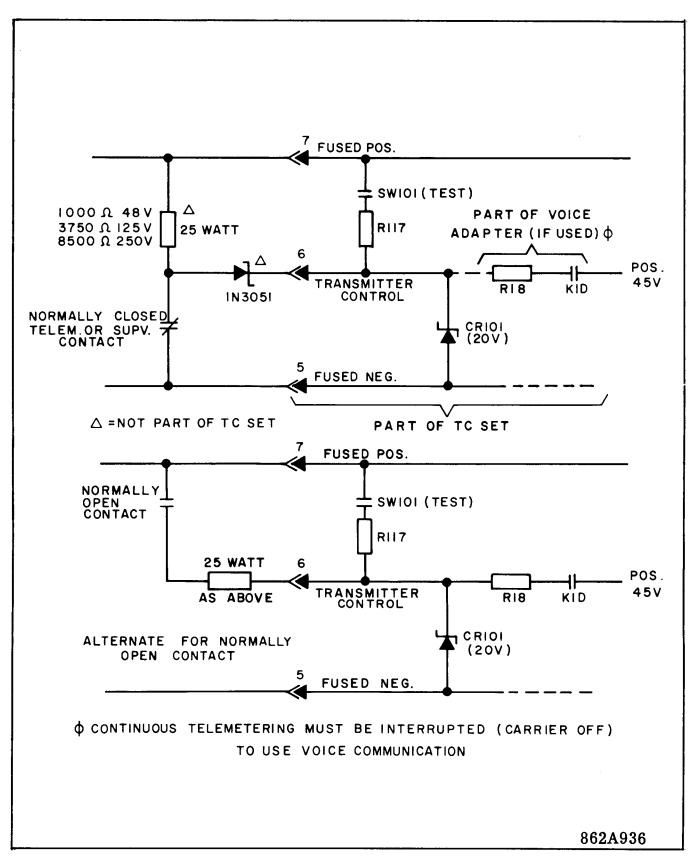


Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact

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



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY

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CAUTION

It is recommended that the user of this equipment become thoroughly acquainted with the information in this instruction leaflet before energizing the carrier assembly. Failure to observe this precaution may result in damage to the equipment.

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

APPLICATION

The type TC carrier equipment is designed for 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.

- ${
 m J101-Transmitter}$ 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, CB, and L103, CC) which are factory tuned to the second and third harmonics of the transmitter frequency. Capacitor CD approximately cancels the inductive reactance of the two trap circuits at the operating frequency. Protective gap G101 is a small lightning arrester to limit the magnitude of switching

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

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

Receiver

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

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

10 watts into 50 to 70-ohm

Transmitter output

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

-20 to +60°C around chassis Temperature range

Frequency Spacing

The minimum recommended frequency spacing between two Type TC carrier sets operated in parallel without hybrid units is shown on the curve of Fig. 12. For example, at 100 kHz, the minimum spacing is 8 kHz. Closer spacing would result in the generation of intermodulation products caused by the non-linear load presented by each transmitter to the other one.

The minimum frequency spacing between a TC carrier channel and an adjacent transmitter signal keyed on-off at a rate of 60 pulses per second can be determined from the nomograph of Fig. 13. Using the example shown by the dashed line, consider a type TC set used on a channel with a normal attenuation of 15 decibels. The TC receiver would be set to give a margin of 15 db below the normal received signal, or for a sensitivity of $-30\ \mathrm{db}$ (relative to a 24.5-volt, 10-watt signal). The interfering signal is assumed to be a 10-watt transmitter at the same location. To determine the minimum frequency spacing of the TC receiver from this interfering signal, lay a straight edge between the $-30~\mathrm{db}$ point on the receiver sensitivity scale and the zerodb 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 $\pm~20\%$.

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. $60.5\text{-}120 \text{ kHz} 1800 \text{ ohms} \text{S} \pm 187\text{A}685\text{H}02$
- c. 120.5-200 kHz 1200 ohms S # 187A685H03

3. Capacitors C111 and C113

- a. 30-50 kHz 0.47 mfd. S# 188A293H01
- b. $50.5-75~\mathrm{kHz} 0.22~\mathrm{mfd.} \mathrm{S} 188\mathrm{A} 293\mathrm{H} 02$
- c. 75.5-100 kHz 0.15 mfd. \$188A293H03
- d. $100.5\text{-}150~\mathrm{kHz} 0.10~\mathrm{mfd.} \text{S} * 188\text{A} 293\text{H} 04$
- e. 150.5-200 kHz 0.047 mfd. S # 188A 293H 05

4. FL101 and FL102

Filter FL101 is a small series-resonant tuned circuit between the driver and power amplifier ${\bf r}$

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:

	01.0 04.0	113.0-119.5
30.0-31.5	61.0- 64.0	
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 $5\ \mathrm{to}$ 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	S	Standby (No Signal)			With 125 M.V. Input		
TP201 TP202 TP203 TP204 TP205		38 0 Q206 Collector Q207 Base 20	ſ	2	38 0 Gee Transistor d Values	l-c	
Transistor	E*	В*	C*	E*	B*	C*	
Q201 Q202 Q203 Q204 Q205 Q206 Q207 Q208	38.5 38.5 0.08 2.7 2.4 2.5 0.13 0.25	37 37.5 0 2.9 2.6 2.7 0.03 0.15	43 43.5 18.7 18.7 18.7 10.5 22.0 45.0	38.5 38.5 0.08 2.7 2.5 2.6 2.0	37 37.5 0 2.9 2.7 2.8 2.2 2.0	43 43.5 18.7 18.7 18.7 10.5 4.0	

^{*}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
FL 201-IN to Gnd. FL 201-OUT to Gnd. Q203 -E to TP 206 Q203 -C to TP 206 Q204 -B to TP 206 Q204 -C to TP 206	36 kHz .075 .051 .105 .22 .015	132 kHz .050 .020 .090 .035 .012 .52	Q205-B to TP206 Q205-C to TP206 Q206-B to TP206 Q206-C to TP206 TP202 to TP206	36 kHz .11 6.7 .67 1.5 0.3	132 kHz .052 3.4 .37 1.53 0.3

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

TABLE III

Transmitter D-C Measurements

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

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

Transistor	E	В	C	E	В	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

- Receiver Oscillator Crystal (Y201), specify frequency, and modify A-B-C jumpers as required.
- 2. Receiver input filter (FL201), specify frequency.
- Resistors R211-R238 Combination See values in Fig. 7 below internal schematic.
- 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 T103-4 to Gnd. T104-1 to Gnd.	4.3 1.5 1.4	TP109 to Gnd. J102 to Gnd.	50* 24.5

T103-3 = tap 3 of Transformer T101

Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

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 230 kHz

c. Oscilloscope

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

Renewal Parts

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

^{*} These values may vary considerably with frequency

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
	(See Table Below)	
† C113	100 pf., 500 V. DC	187A695H23
C114 C115	100 pf., 500 V. DC	187A695H23
	0.001 mfd, 500 V. DC	187A694H11
C116	Part of FL101	Vary with Frequency
CA	T the of Figure	
CB	Part of FL102	Vary with Frequency
CC		
CD		
CE	C111, C113	Style Number
† FREQ.	0.47 mfd, 400 V. DC	188А293Н01
30- 50 KC	0.22 mfd, 400 V. DC	188А293Н02
50.5- 75 KC	0.15 mfd, 400 V. DC	188A293H03
75.5-100 KC		188A293H04
100.5-150 KC	0.1 mfd, 400 V. DC 0.047 mfd, 400 V. DC	188A293H05
150.5-200 KC		185A212H06
CR101	1N3686B (20 V ± 5%)	184A855H07
CR102	1N457A	407C703H03
CR103	1N538 1N91	182A881H04
CR104		407C703H03
CR105	1N538	182A881H04
CR106	1N91	184A617H13
CR107	1N 2999A (56 V ± 10%)	184A617H13
CR108	1N 2999 A (56 V ± 10%)	637A026A01
G101	Type TVS Arrester	
J101	Closed Circuit Jack	187А606Н01

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

Symbol		Rating		Ch.1
J102	Banana Plug Jack			Style Number
J103	Coaxia	54B159H02		
J104	24-Terr	187A633H01		
J105		n Receptacle		187А669Н01
L101	Part of			629A205H02
L102	 			
L103		Trap Coil (2nd Har		Vary with Frequency
L104	400 mh.	Trap Coil (3rd Han	monic)	
L105				292B096G01
	FL102 circuit	Coil (part of serie uned to fundament	s-resonant al freq.)	Vary with Frequency
Q101	2N 274			187A270H01
Q102	2N 274			187A270H01
Q103	2N525			184A638H13
Q104	2N 657			184A638H15
Q105	2N657			184A638H15
Q106	TI-481			184A638H11
Q107	2N 1908	Matched Pair - Te	Yas Instrument	104/05/01/1
Q108	2N1908	187А673Н02		
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	
R108	100,000	5	0.5	187A641H51 184A763H75
R109	390	5	0.5	184A763H75
R110 *				
R111	1,200	5	0.5	At End of List
R112	1 K Pot	20	0.25	187A763H29
R113	4,700	5	0.23	629A430H02
R114	10,000	10		184A763H43
R115	150	5	0.5	187A641H51
Sensistor-		Hz, 2.2K ± 10%, ¼	0.5	184A763H07
		Hz, 1.8 K ± 10%, ¼		187A685H01
				187A685H02
	120.0-200 KI	Hz , $1.2 K \pm 10\%$, $\frac{1}{4}$	watt	187A685H03

ELECTRICAL PARTS LIST Transmitter Section (Cont.)

Symbol	Ohms	± Tol. %	Watts	Style Number	
R116	100	5	0.5	184А763Н03	
	1,000 48 V dc	5	25	1202588	
R117	3,750 125 V dc	5	25	1202955	
	8,500 250 V dc	5	25	1267310	
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	187А290Н01	
R123	10	10	0.5	187А290Н01	
R124	100	10	1	187A644H03	
R125	1,000	10	0.5	187A641H27	
R126	4,700	10	1	187A644H43	
R127	10	10	0.5	187A640H01	
R128	2,200	5	1	187A644H35	
	2.7	10	0.5	184A636H14	
R129 R130	10	10	0.5	187A640H01	
	4,700	5	1	187A644H43	
R131	0.27	10	0.5	184A636H14	
R132	0.27	10	1	184A636H18	
R133	0.27	10	1	184A636H18	
R134		10	5	188A317H01	
R135	3,000	10	0.5	184A763H53	
R136	15,000	10	2	187A642H55	
R137	1,000	10	0.5	187A641H27	
R138	1,000	10	0.5	187A641H27	
R139	1,000	Rating		Style Number	
Symbol	10,000				
T101	_	10,000, 11		1962698	
T102		10,000/400 c.t. L592170 1930/60 ohms L633000			
T103		ratio, $1/0.5$,	Pri./each sec.	292B526G01	
T104			111.7 00011 200.	292B526G02	
T105	10/500			292B526G03	
T106		0-60-70 ohms	2200003	Specify Frequenc	
Y101	30-200	kc crystal per	040000	OF	

ELECTRICAL PARTS LIST Receiver Section

	Keceiver Section	
Symbol	Rating	Style Numbe
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	
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	187A624H02
C212	0.25 mfd., 200 V. DC	187A624H01
C213	2.0 mfd., 200 V. DC	187A624H02
C214	0.25 mfd., 200 V. DC	187A624H05
C215	39 pfd., 500 V. DC	187A624H02
CR201	1N3027B (20V ± 5%)	187A695H12
CR202	1N91	184А449Н07
CR203	1N91	182A881H04
CR204	1N538	182A881H04
CR204	1N538	407C703H03
CR 205	1N1789 (56V. ± 10%)	407С703Н03
FL201	Receiver Input Filter 30-200 kHz	584C434H08
FL202		Specify Frequency
J201	Receiver i.f. Filter-20kHz (2 Sections) Receiver Coax. Input Jack	187A590G02
J202	Closed Circuit Jack (20MA)	187A638H01
J203	Closed Circuit Jack (200MA)	187А606Н01
L201	33 mh.	187А606Н01
Q201	2N274	187А599Н01
Q202		187A270H01
Q203	2N 274	187A270H01
Q204	2N274	187А270Н01
Q204 Q205	2N274	187A270H01
	2N 274	187A270H01
Q206	2N 274	187А270Н01
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	1 87A641H35
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
R232	4,700	10	2	187A642H43

†R211 - 10K - above 50kHz- S# 187A641H51

- 22K - 30-50kHz - S# 187A641H59

ELECTRICAL PARTS LIST Receiver Section (Cont.)

Symbol	Rating					
	Ohms	± Tol. %		Watts	Style Number	
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	200000			1962797	
T203	25,000/300	Ohms	L592171			
Y201	50-220 kHz Cr	50-220 kHz Crystal per 328C083			1962697 Specify Frequency	

Symbol		Function	Description or Rating	Style Numbe
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	Ove	rload Protection	1.5a, 48/125 VDC	11D9195H26
F1,F2	Over	load Protection	2.0a. 250 VDC	478067
PL1	Neor 125/	Pilot Light 250 Volts	120 Volts	183A955H01
PL1		nent-type 8 Volts	55 Volts	187A133H02
Q1	Series Regulator		Type 2N1015C Silicon Transistor	187A342H02
R1	Series dropping		26.5 ohms, 3½"	04D1299H44
R2	125V	Series dropping	Same as R1	04D1299H44
R3		Current limiting	500 ohms, 3½"	1268047
	48V	For 48 VDC, R1=R2 0	_	_
		R3 = 26.5 ohms	3½"	04D1299H44
R4	Curre	nt 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	Voltag	e Regulator	1N2813B (15V.)	184A854H11

 $[\]dagger$ R238 - omit - above 50kHz

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

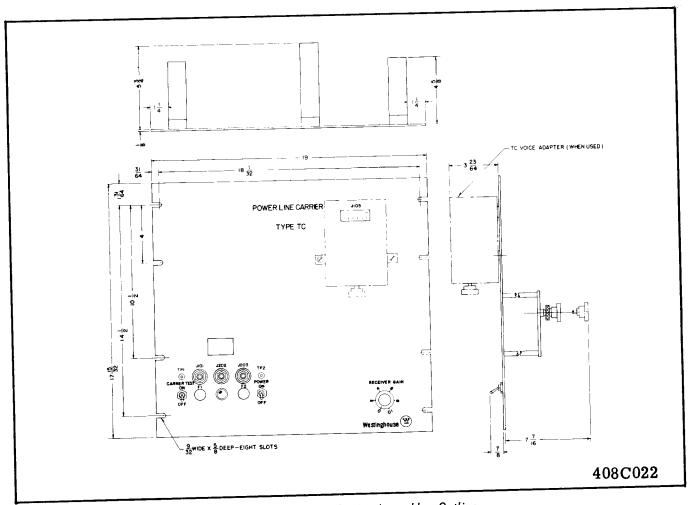


Fig. 1 Type TC Carrier Assembly - Outline

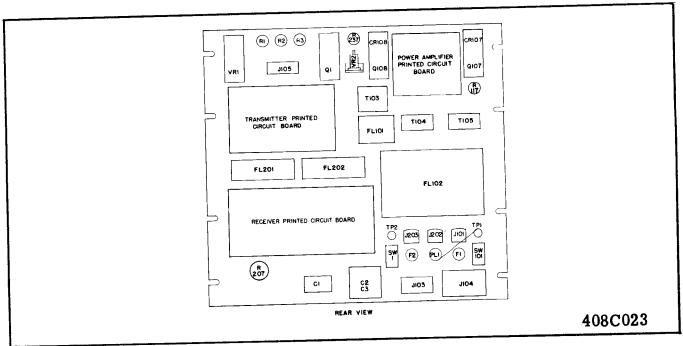


Fig. 2 Type TC Carrier Assembly - Parts Location

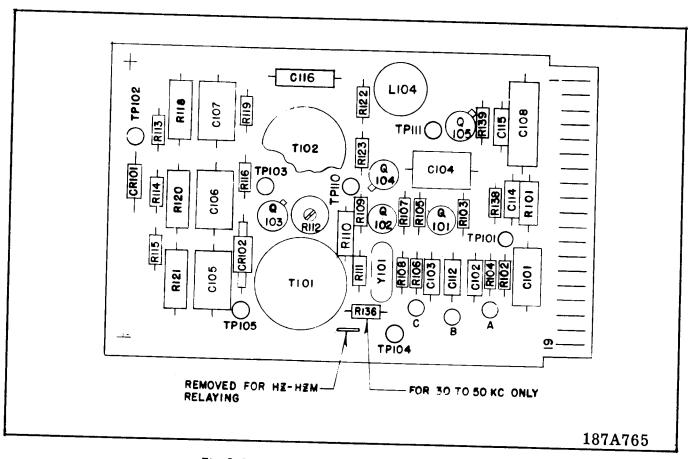


Fig. 3 Transmitter Printed Circuit - Parts Location

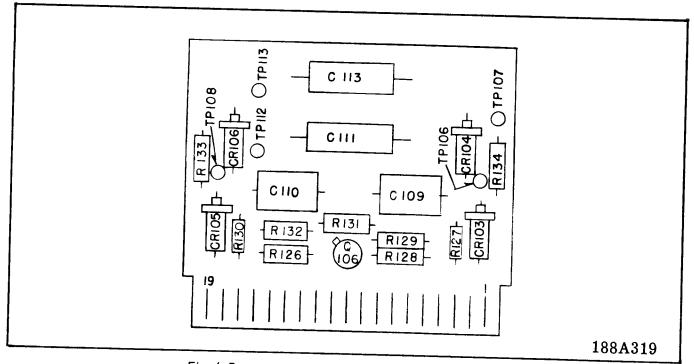


Fig. 4 Power Amplifier Printed Circuit - Parts Location

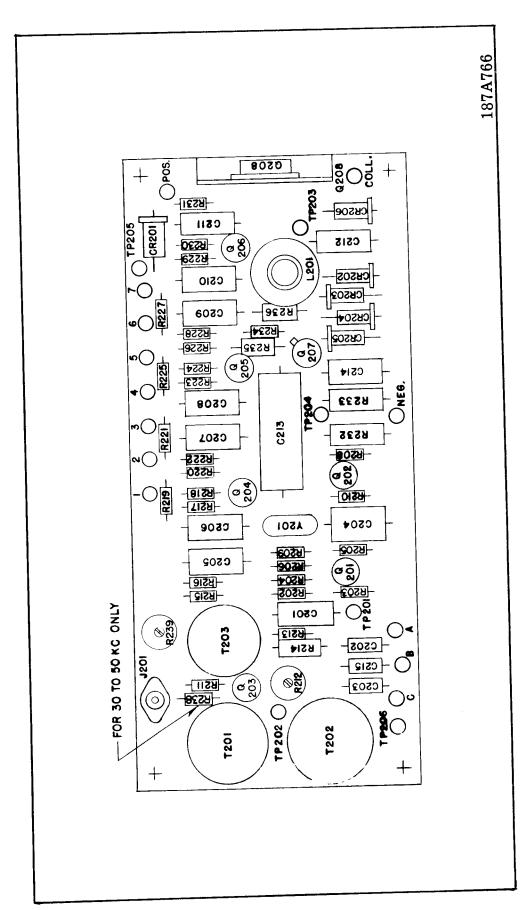


Fig. 5 Receiver Printed Circuit - Parts Location

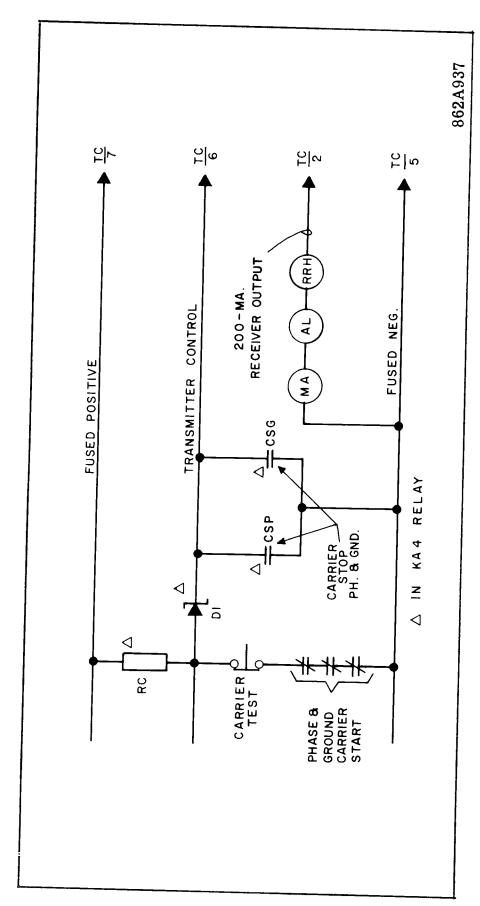
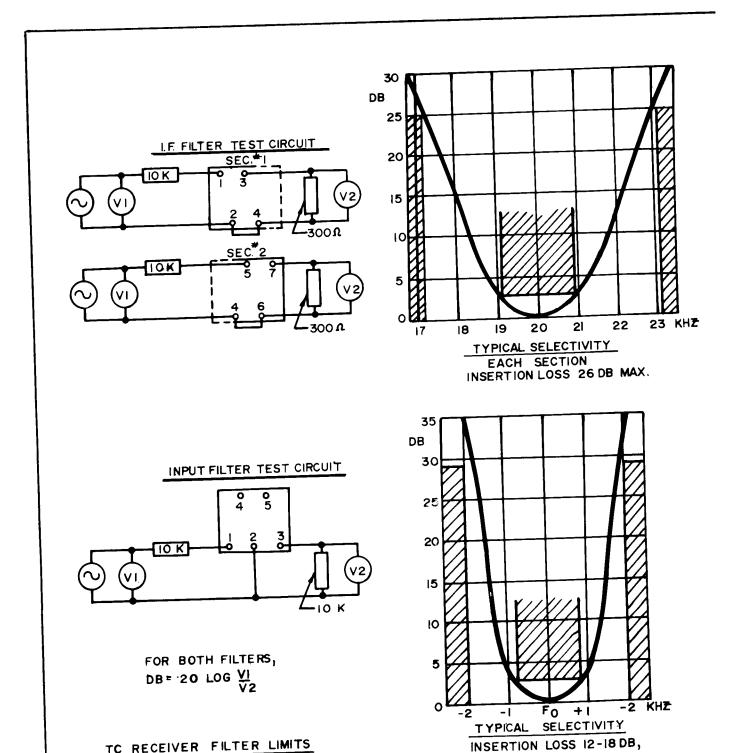


Fig. 6 Elementary K.Dar Carrier Control Circuits.

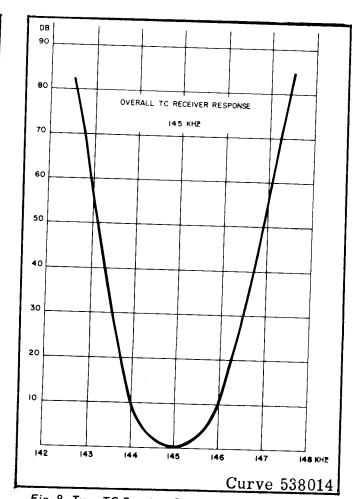


629A425

RISING WITH FREQUENCY.

Fig. 8 Type TC Receiver Filter Characteristics

TC RECEIVER FILTER LIMITS



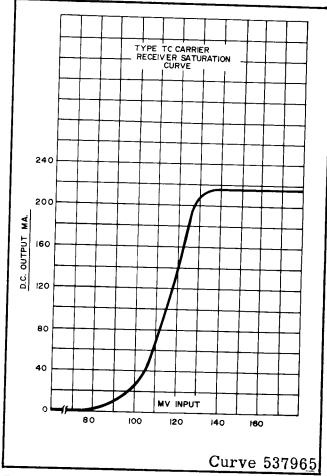


Fig. 9 Type TC Receiver Overall Selectivity Curve

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

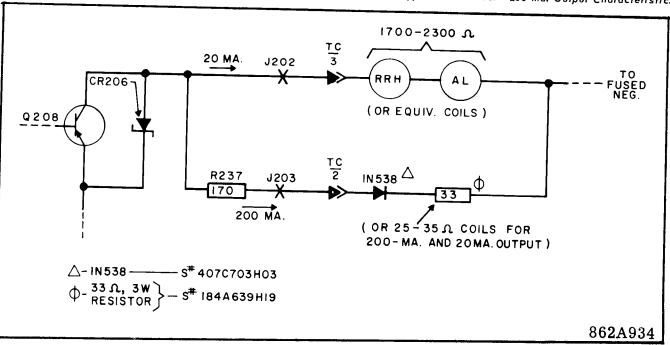


Fig. 11. TC Receiver Output For 20-ma. Operation

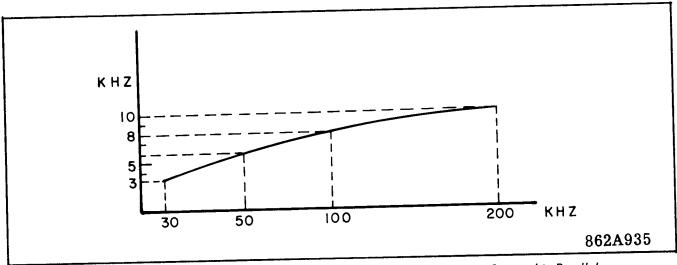


Fig. 12 Minimum Frequency Spacing For Two 10-watt Transmitters Operated in Parallel.

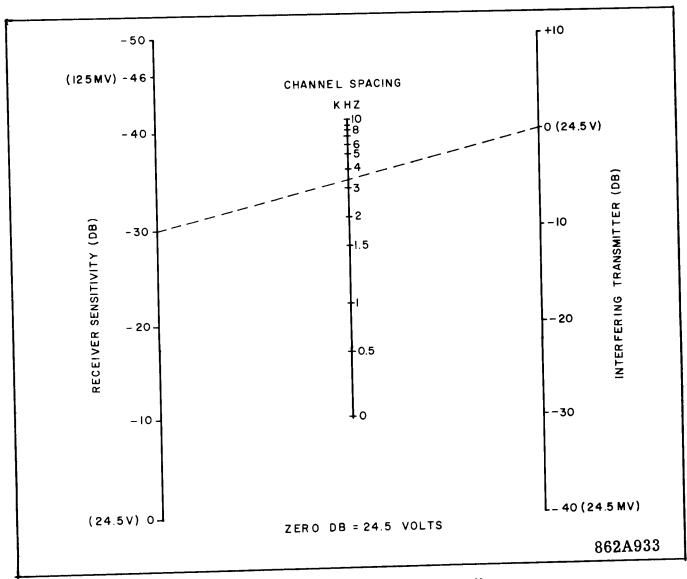


Fig. 13 Minimum Channel Spacing For Keyed Carrier 60 p.p.s.

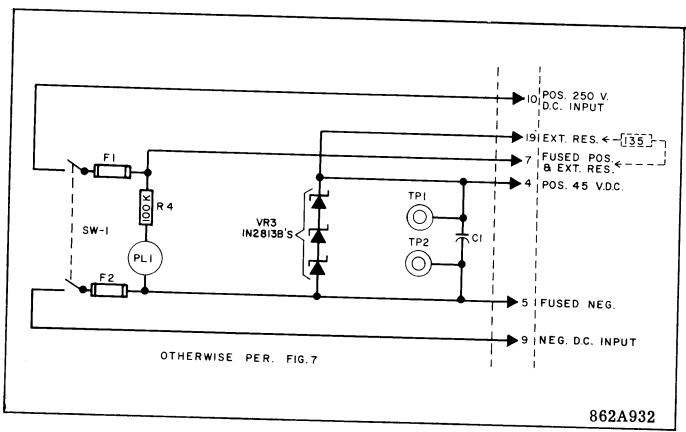


Fig. 14 Detail of Power Supply Section For 250-volt Supply

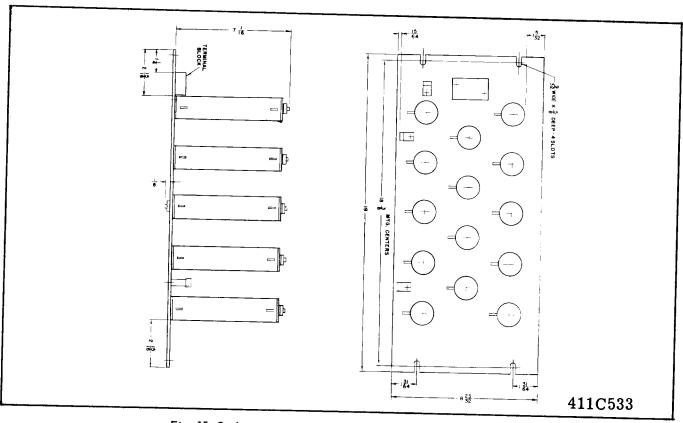


Fig. 15 Outline of External Resistor Unit For 250-volt Operation

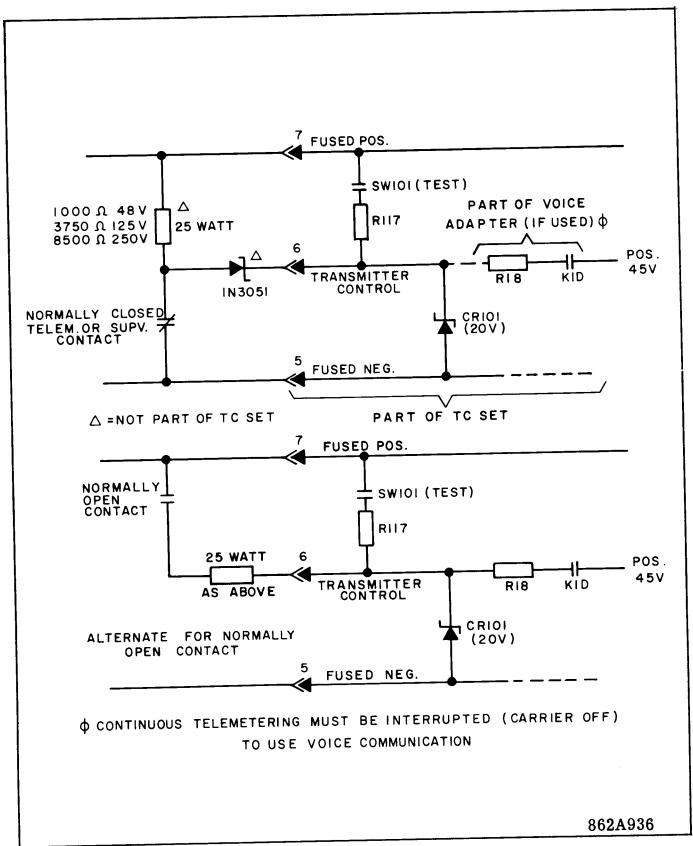


Fig. 16 External Circuitry For On-Off Keying of Type TC Transmitter For Telemetering or Supervisory Control (Without Protective Relaying) From Either Normally-Closed or Normally-Open Contact



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



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY

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CAUTION

It is recommended that the user of this equipment become thoroughly acquainted with the informain 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 bufferamplifier transistor Q103 through the potentiometer R112 which controls the transmitter power output. Keying of the transmitter output is controlled in the buffer-amplifier stage by changing the 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 $C_{\rm E}$ is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and 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

* Frequency range

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-conneced 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

30-200 kc (50-200 kc for

Transmitter output	phase comparison relaying) 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 $+60^{\circ}\mathrm{C}$ 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 volt-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 $\pm~20\%$.

TABLE I
Receiver D.C. Measurements

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

Test Point	Sta	ndby (No Sign	al)	Wit	h 125 M.V. Inpu	ıt
TP201 TP202 TP203 TP204 TP205	38 0 Q206 Collector Q207 Base 20				e Transistor d-c lues	2
Transistor	E*	В*	C*	E*	B*	C*
Q201 Q202 Q203 Q204 Q205 Q206 Q207 Q208	38.5 38.5 0.08 2.7 2.4 2.5 0.13 0.25	37 37.5 0 2.9 2.6 2.7 0.03 0.15	43 43.5 18.7 18.7 18.7 10.5 22.0 45.0	38.5 38.5 0.08 2.7 2.5 2.6 2.0	37 37.5 0 2.9 2.7 2.8 2.2 2.0	43 43.5 18.7 18.7 10.5 4.0 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	
FL201 - IN to Gnd. FL201 - OUT to Gnd. Q203 - E to TP206 Q203 - C to TP206 Q204 - B to TP206 Q204 - C to TP206	36 KC .075 .051 .105 .22 .015	132 KC .050 .020 .090 .035 .012	Q204 - B to TP206 Q205 - C to TP206 Q206 - B to TP206 Q206 - C to TP206 TP202 to TP206	36 KC .11 6.7 .67 1.5	132 KC .052 3.4 .37 1.53 0.3

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

TABLE III

Transmitter D-C Measurements

Note: All voltages are positive with respect to Neg. 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	}		
TP113	* 45	0 45		

Transistor	E	В	С	E	В	С
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 TP103 to TP102 Q103-C to TP104	1.1	Q107-B to TP107	.5
	0.2	Q108-B to TP113	.5
	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 T103-4 to Gnd. T104-1 to Gnd.	4.3 1.5 1.4	TP109 to Gnd. J102 to Gnd.	50 * 24.5

NOTE:

T101-3 = tap 3 of Transformer T101

Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

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.

^{*} These values may vary considerably with frequency

Electrical Parts List

Complete Transmitter Section

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

* <u>FREQ</u> .	C111,	C11	3_
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
			.5	R128	2200	5	1
R107	10,000	10	.5	R129	2.7	10	.5
R108	100,000	5 _		R130	10	10	.5
R109	390	5	.5	R131	4700	5	1
R110 *			.5	R132	.27	10	.5
R111	1200	5	.5	R133	0.27	10	1
R112	1K Pot.	20	. 25	R134	0.27	10	1
R113	4700	5	. 5	R135	3000	10	5
R114	10,000	10%	.5	R136	12,000	10	.5
R115	150	5	.5	R137	15,000	10	2
R116	100	5	.5	R138	1000	10	.5
10110				R139	1000	10	.5
	(1000	<i>h</i>				1	
	48V dc	[T101	10,000/400	ohms I	₄ 633003
R117	3750	5	25	T102	10,000/400	C.T. I	- 592170
	125V dc)		T103	1930/60		<u> </u>
		_		T103	Turns ratio,		Pri./each sec.
R118	8200	5	2		ļ	•	11., 04011 500.
R119	100	5	.5	T105	10/500		
R120	10,000	5	2	T106	Į.	-60-70 ohms	
R121	10	5	2	Y101	30-200 kc c	erystal per 32	28C083

^{*}Sensistor - 30-60 kc, $2.2 \pm 10\%$, $\frac{1}{4}$ watt 60.5-120 kc, 1.8 K $\pm 10\%$, $\frac{1}{4}$ watt 120.5-200 kc, 1.2 K $\pm 10\%$, $\frac{1}{4}$ watt

Complete Receiver Station

Symbol		Rating		Symbol		Rating	
C201	0.1 mfd., 200 V DC			FL201	Receive Input Filter 30-200 KC		
C202	300 pf,	500 V DC		FL202	Receiver i.f	. Filter-20 KC (2 Sections)
C203	180 pf,	500 V DC		1	S#187A590G	02	
C204		, 200 VDC					
C205		, 200 VDC		J201	Receiver co.	ax. Input Jack	
C206		, 200 VDC		J202	Closed Circ	uit Jack (20 MA	()
C207		200 V DC		J203		uit Jack (200 M.	
C208		, 200 V DC				(200 1111	,
C209 C210		, 200 V DC		L201	33 mh.		
C210 C211		, 200 V DC			oo min.		
1 1		, 200 V DC		1			
C212 C213	0.25 mfd., 200 VDC			Q201	2N274		
C213	2.0 mfd., 200 VDC 0.25 mfd., 200 VDC						
C214	39 pfd.,			Q202	2N 274		
C210	59 più.,	500 V DC		Q203	2N274		
CR201	1M20Z10	(20v ± 10%)		Q204	2N274		
CR202	1N91			Q205	2N274		
CR203	1N91			1			
CR204	1N538			Q206	2N274		
CR205	1N538			Q207	2N398A		
CR 206	1N1789 (5	56v ± 10%)		Q208	2N1362		
Resistors	Ohms	± Tol %	Watts	Resistors	Ohms	± Tol %	Watts
R201	10,000	10	.5	R206	1200	5	.5
R202	2200	10	.5	R207	25 K Pot.	10	2
R203	10,000	10	.5	R208	10,000	10	.5
R204	100,000	5	.5	R209	100,000	5	.5
R205	390	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	N231				
Syn	nbol		<u> </u>	Rat	ing			
Т	201	10,000 / 10	,000 Ohms	L633005 *F		*R211-10	*R211-10K-above 50KC	
	202	10,000 / 400 Ohms			L633003 R238-omit-ab		it-above 50KC	
	203	25,000 / 30	0 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 C2 C3	(+) to (-) bypass A-C grounding A-C grounding	0.45 mfd. 330 VAC 0.5 mfd, 1500 VDC 0.5 mfd, 1500 VDC	R1 R2 R3	Series dropping 125V Series dropping Current limiting	26.5 ohms, 3½'' Same as R1 500 ohms, 3½''
F1 F2	Overload Protection Overload Protection	1.5a, 250 volts 1.5a, 250 volts		$\begin{cases} For 48 VDC, \\ R1 = R2 = 0 \\ R3 = 26.5 \text{ ohms} \end{cases}$	
PL1	Neon pilot light (filament type for 48 VDC)		TP1 TP2	Test point (+) Test point (-)	Pin Jack - red Pin Jack - black
Q1	Series Regulator	Type 2N1015C Silicon Transistor	VR1 VR2	Voltage Regulator Surge Protection	1N2828B (45V.) 1N3009A (130V.) Zener Diodes

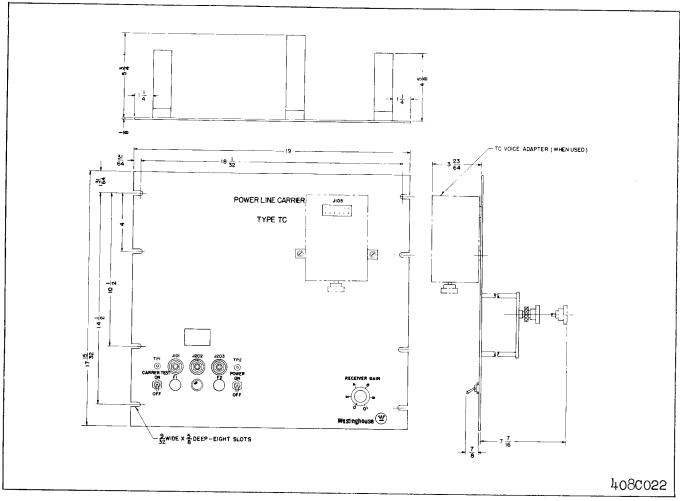


Fig. 1 Type TC Carrier Assembly - Outline

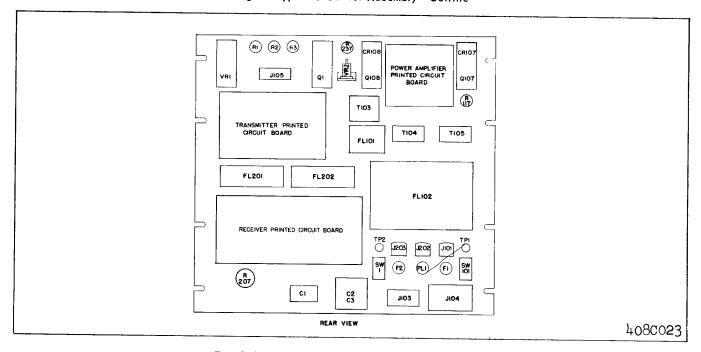


Fig. 2 Type TC Carrier Assembly - Parts Location

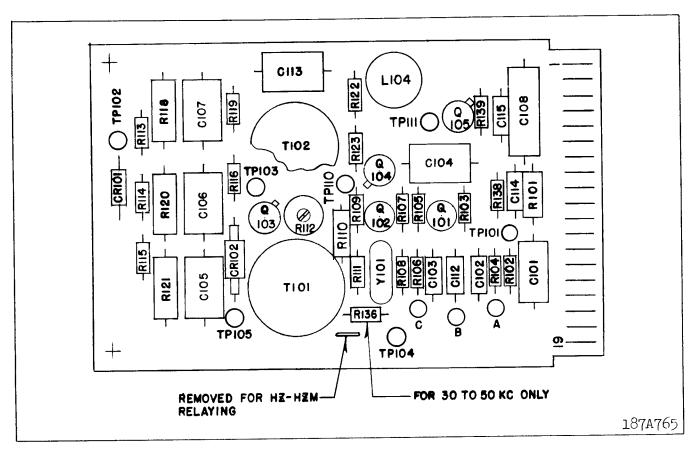


Fig. 3 Transmitter Printed Circuit - Parts Location

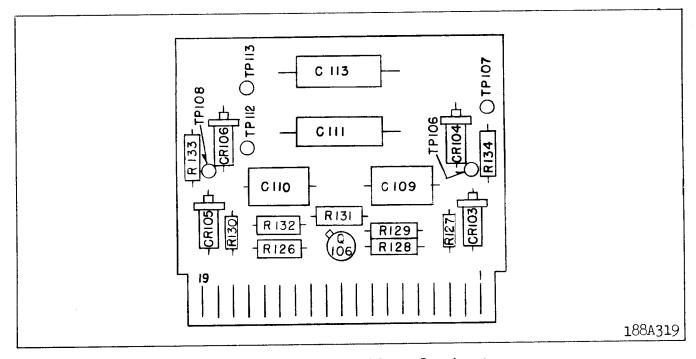


Fig. 4 Power Amplifier Printed Circuit - Parts Location

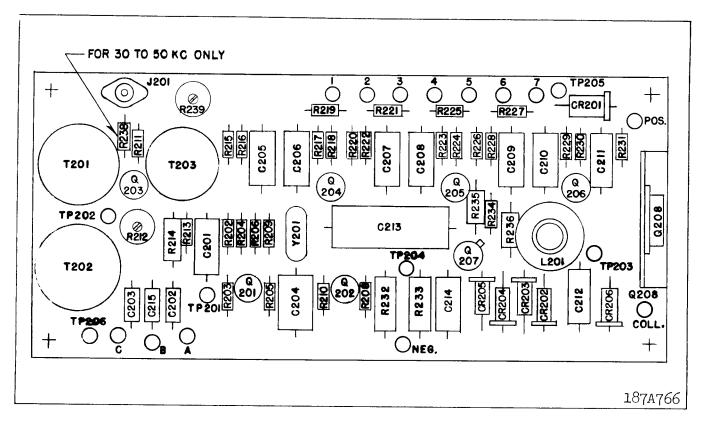


Fig. 5 Receiver Printed Circuit - Parts Location

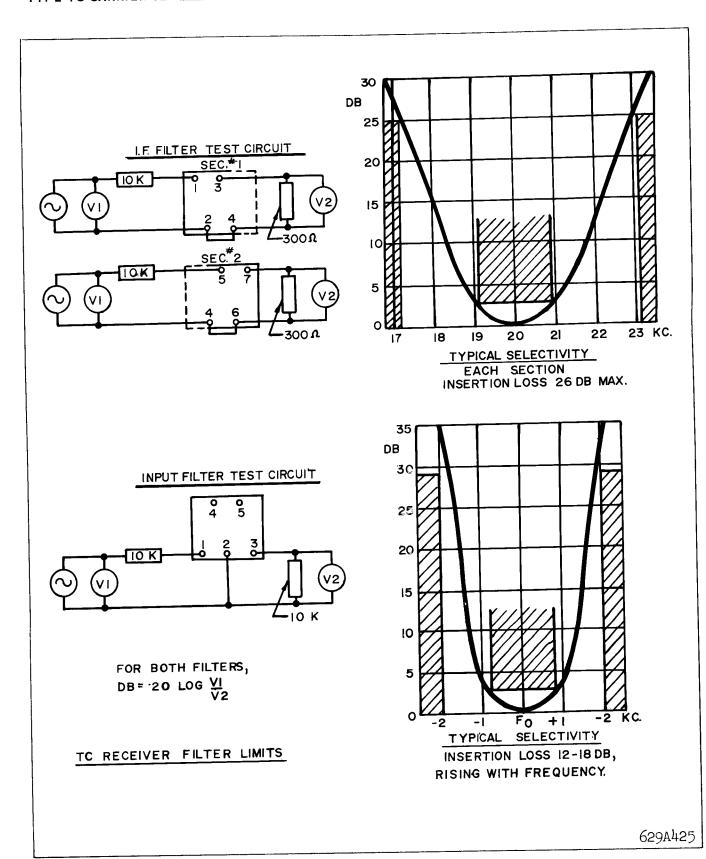


Fig. 7 Type TC Receiver Filter Characteristics

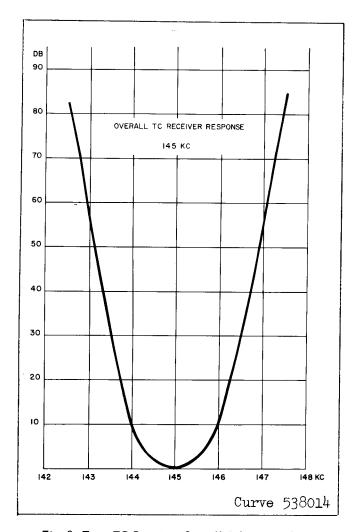


Fig. 8 Type TC Receiver Overall Selectivity Curve

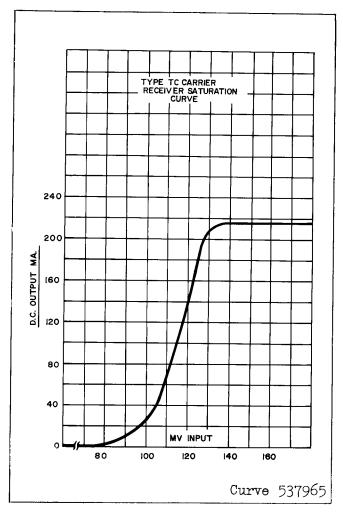


Fig. 9 Type TC Receiver - 200 ma. Output Characteristic.



INSTALLATION . OPERATION . MAINTENANCE

INSTRUCTIONS

TYPE TC POWER LINE CARRIER TRANSMITTER-RECEIVER ASSEMBLY

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CAUTION

It is recommended that the user of this equipment become thoroughly acquainted with the informain 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 bufferamplifier transistor Q103 through the potentiometer R112 which controls the transmitter power output. Keying of the transmitter output is controlled in the buffer-amplifier stage by changing the 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 $C_{\rm E}$ is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the rear panel of FL102 and 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

* Frequency range

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-conneced 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

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 $+60$ $^{\circ}$ 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 $60\,^{\circ}\mathrm{C}$.

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 $\pm~20\%$.

TABLE I
Receiver D.C. Measurements

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

Test Point	st	andby (No Sign	al)	Witl	n 125 M.V. Inpu	1t
TP201 TP202 TP203 TP204 TP205	38 0 Q206 Collector Q207 Base 20				e Transistor d-c	2
Transistor	E*	В*	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	
FL201-IN to Gnd. FL201-OUT to Gnd. Q203-E to TP206 Q203-C to TP206 Q204-B to TP206 Q204-C to TP206	36 KC .075 .051 .105 .22 .015	132 KC .050 .020 .090 .035 .012	Q204 - B to TP206 Q205 - C to TP206 Q206 - B to TP206 Q206 - C to TP206 TP202 to TP206	36 KC .11 6.7 .67 1.5 0.3	132 KC .052 3.4 .37 1.53 0.3

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

TABLE III

Transmitter D-C Measurements

Note: All voltages are positive with respect to Neg. 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	
TP111	0.1	0.9
TP112	0	0.9
TP113	* 45	$egin{array}{c} 0 \ 45 \end{array}$

Transistor	E	В	С	E	В	С
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 T103-4 to Gnd. T104-1 to Gnd.	4.3 1.5 1.4	TP109 to Gnd. J102 to Gnd.	50 * 24.5

NOTE:

T101-3 = tap 3 of Transformer T101

Q104-C = Collector of Transistor Q104

TP105 = Test point 105

All voltages read with a-c VTVM

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.

^{*} These values may vary considerably with frequency

Electrical Parts List

Complete Transmitter Section

Symbol	Rating	Symbol	Rating
Symbol C101 C102 C103 C104 C105 C106 C107 C108 C109 C110 C111 C112 C113 C114 C115 C116 CA CB CC CD CE CR101	Rating 0.1 mfd, 200 V DC .005 mfd, 300 V DC 180 pf. 500 V DC 0.25 mfd, 200 V DC 0.50 mfd, 200 V DC 0.50 mfd, 200 V DC 0.25 mfd, 500 V DC (See Table Below) 100 pf., 500 V DC 100 pf., 500 V DC 0.001 mfd, 500 V. D.C. Part of FL101 Part of FL102	Symbol CR105 CR106 CR107 CR108 G101 J101 J102 J103 J105 L101 L102 L103 L104 L105 Q101 Q102 Q103 Q104 Q105	Rating 1N538 1N91 1N2999A (56 V ± 10%) 1N2999A (56 V ± 10%) Type RVS Arrester S*632A026A01 Closed Circuit Jack Banana Plug Jack Coaxial Cable Jack 24-Term Receptacle 12-Term Receptacle Part of FL101 FL102 Trap Coil (2nd Harmonic) FL102 Trap Coil (3rd Harmonic) 400 mh. FL102 Coil (part of series-resonant circuit tuned to fundamental freq.) 2N274 2N274 2N274 2N525 2N657
CR102 CR103 CR104	1N63 1N538 1N91	Q106 Q107 Q108	TI-481 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 _
	100,000	5	.5	R129	2.7	10	.5
R108		5	.5	R130	10	10	.5
R109	390	3	.5	R131	4700	5	1
R110 *		_		R132	.27	10	.5
R111	1200	5	.5	R133	0.27	10	1
R112	1K Pot.	20	. 25	R134	0.27	10	1 -
R113	4700	5	. 5	R135	3000	10	5
R114	10,000	10%	.5	R136	12,000	10	.5
R115	150	5	.5	R137	15,000	10	2
R116	100	5	.5	R138	1000	10	.5
	/ 1000			R139	1000	10	.5
	48V dc])		T101	10,000/400	ohms L	333003
R117	3750	5	25	T102	10,000/400		592170
	125V dc	1)			1930/60		333000
				T103			
R118	8200	5	2	T104	Turns ratio,		i./each sec.
R119	100	5	.5	T105	10/500		
R120	10,000	5	2	T106	i i	-60-70 ohms	
R121	10	5	2	Y101	30-200 kc c	erystal per 328	C083

^{*}Sensistor - 30-60 kc, 2.2 \pm 10%, $\frac{1}{4}$ watt 60.5-120 kc, 1.8 K \pm 10%, $\frac{1}{4}$ watt 120.5-200 kc, 1.2 K \pm 10%, $\frac{1}{4}$ watt

Complete Receiver Station

Symbol		Rating		Symbol		Rating		
C201	0.1 mfd.,	·		FL201	Receive Input Filter 30-200 KC			
C202	300 pf,	500 V DC		FL202	Receiver i.f. Filter-20 KC (2 Sections			
C203	180 pf,	500 V DC		1	S#187A590G02			
C204		, 200 VDC		1				
C205		., 200 VDC		J201	Receiver co	ax. Input Jack		
C206	1	, 200 VDC		J202	Closed Circ	uit Jack (20 MA	.)	
C207		200 V DC		J203		uit Jack (200 M	•	
C208		, 200 V DC			010004 0110	art 6 - Ch (200 M)	.1)	
C209		, 200 VDC		L201	33 mh.			
C210		, 200 VDC			55 mm.			
C211	0.1 mfd., 200 V DC							
C212	0.25 mfd., 200 VDC			Q201	ON10574			
C213	2.0 mfd., 200 V DC			l `	2N274			
C214 C215	0.25 mfd., 200 VDC			Q202	2N274			
C215	39 pfd., 500 V DC			Q203	2N274			
CR201	1M20Z10	(20v ± 10%)		Q204	2N274			
CR202	1N91			Q205	2N274			
CR203	1N91			Q206	2N274			
CR204	1N538			· '	2N 274			
CR205	1N538			Q207	2N398A			
CR206	1N1789 (56v ± 10%)		Q208	2N1362			
Resistors	Ohms	± Tol %	Watts	Resistors	Ohms	± Tol %	Watts	
R201	10,000	10	.5	R206	1200	5	.5	
R202	2200	10	.5	R207	25 K Pot.	10	2	
R203	10,000	10	.5	R208	10,000	10	.5	
R204	100,000	5	.5	R209	100,000	5	.5	
R205	390	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		4700	10	1
R223	620	5	.5	R236	170	5	40
R224	62	5	.5	R237	170		
Syr	mbol			Rati	ng		
T 201 10,000/		10,000 / 10 10,000 / 40	,000 Ohms L633005			*R211-10K-above 50K0 R238-omit-above 50K0	
Т	T 202 10,000 / 400 Ohms T 203 25,000 / 300 Ohms Y 201 50-220 KC Crystal per		00 Ohms	L592171 328C083		For 30-50 KC, R211 = R238 = 22K	

Power Supply Section

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

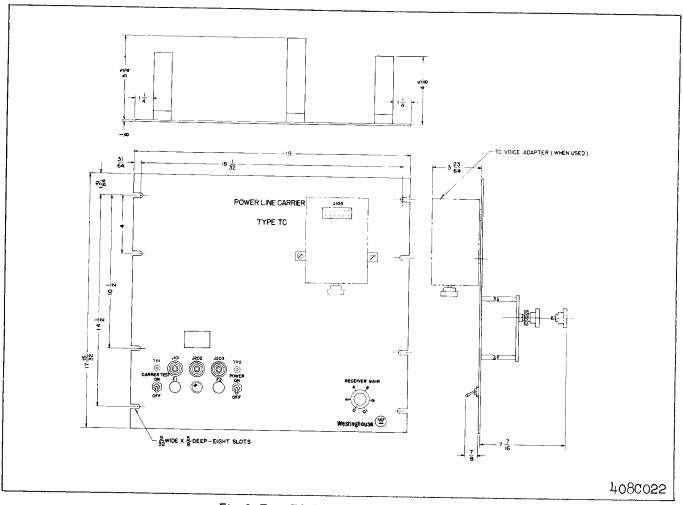


Fig. 1 Type TC Carrier Assembly - Outline

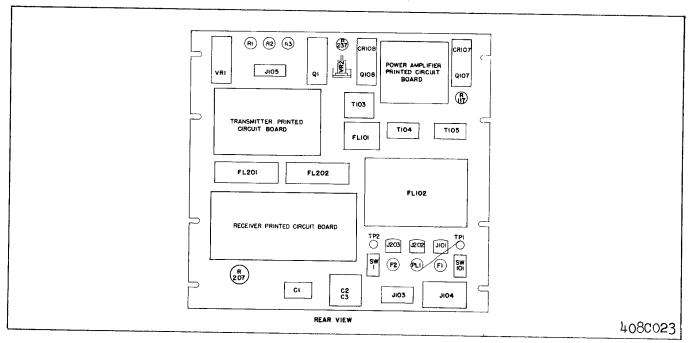


Fig. 2 Type TC Carrier Assembly - Parts Location

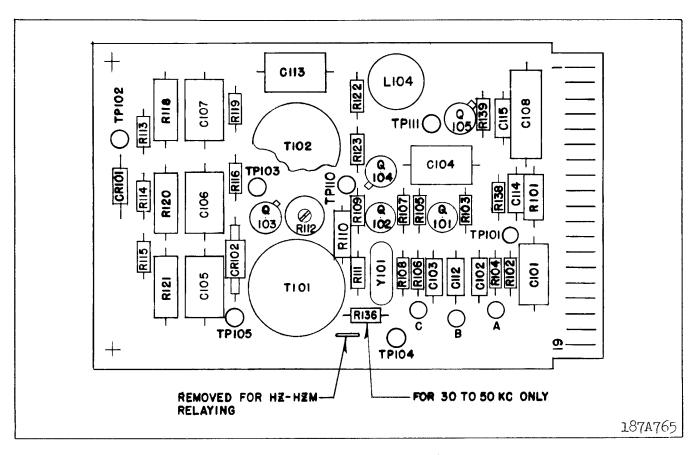


Fig. 3 Transmitter Printed Circuit - Parts Location

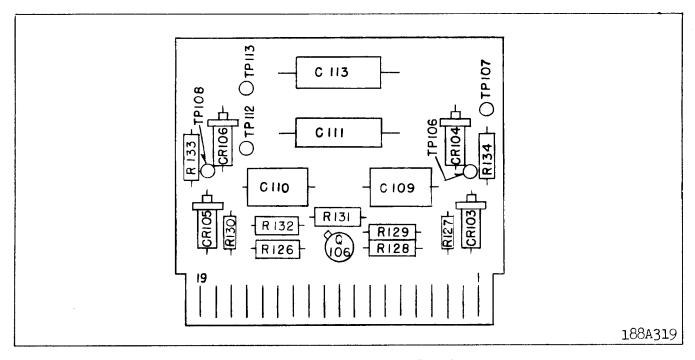


Fig. 4 Power Amplifier Printed Circuit-Parts Location

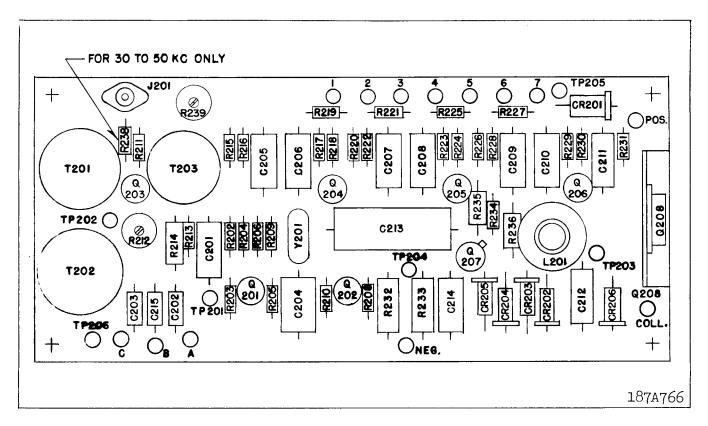


Fig. 5 Receiver Printed Circuit - Parts Location

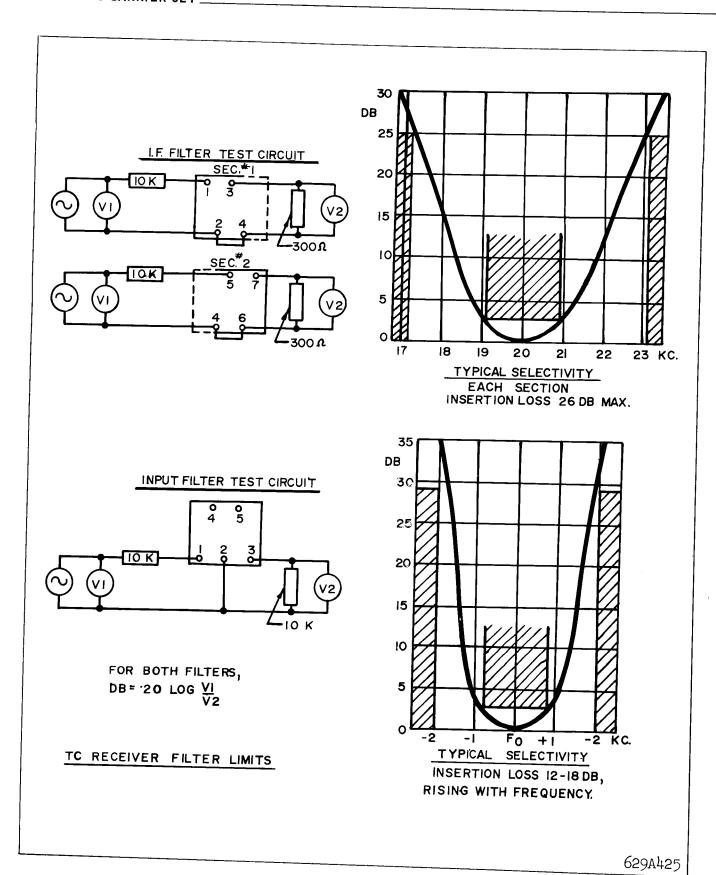


Fig. 7 Type TC Receiver Filter Characteristics

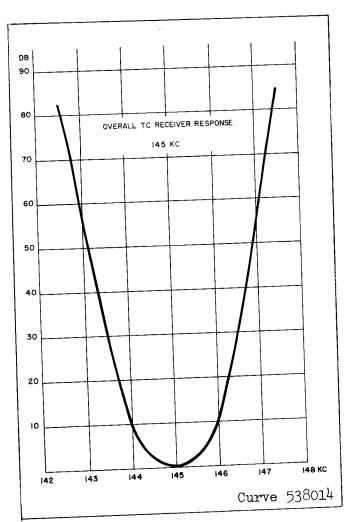


Fig. 8 Type TC Receiver Overall Selectivity Curve

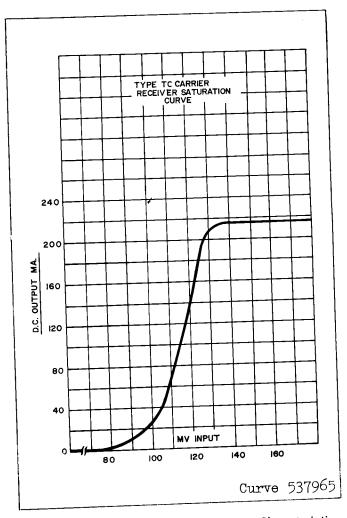


Fig. 9 Type TC Receiver - 200 ma. Output Characteristic.