INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF-10 POWER LINE CARRIER FREQUENCY SHIFT RECEIVER EQUIPMENT FOR DUAL PHASE – COMPARISON CARRIER RELAYING (SPCU, SKBU, OR SIMILAR SYSTEMS)

CAUTION

It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet, and in the system instruction leaflet before energizing the system.

Printed circuit modules should not be removed or inserted when the equipment is energized. Failure to observe this precaution may result in an undesired tripping output or cause component damage. Care should also be exercised when replacing modules to assure that they are replaced in the same chassis position from which they either were removed or the module they are replacing was removed.

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 TCF-10 Receiver described is for use with either the SPCU or SKBU Dual Phase Comparison relaying systems or similar systems utilizing frequency-shift keying (FSK). The TCF-10 frequency shift receiver responds to carrier-frequency signals transmitted from the distant end of a power line, and carried on the power line conductors. The space frequency (sometimes referred to as trip negative) is 100 hertz above the center frequency of the channel (which can be selected within the range of 30 kHz to 300 kHz). The mark frequency (sometimes referred to as trip positive) is 100 hertz below the channel center frequency. Generally, phase comparison information is conveyed over the channel during load current flow or fault conditions. The transmitter at each end of the channel is switched at a 60-hertz rate between space (or trip negative) and mark (or trip positive) so as to produce at the receiving end, the desired operation of the relaying system.

CONSTRUCTION

The TCF-10 receiver unit for dual phase comparison relaying applications such as the SPCU or SKBU systems, is mounted on a standard 19 inch wide chassis 5¼ inches high (3 rack units) with edge slots for mounting on a standard relay rack.

All of the circuitry that is suitable for mounting on printed circuit boards is contained on printed circuit modules that plug into the chassis from the front and are readily accessible by removing the transparent cover on the front of the chassis. The power supply components and external connectors are located at the rear of the chassis as shown in Figure 9. Reference to the internal schematic connections of Figure 1 will show the location of these components in the circuit.

The printed circuit modules slide into position in slotted guides at the top and bottom of the chassis, and the module terminals engage a terminal block at the rear of the chassis. A handle on the front of each module is labeled to identify its function, and also identify adjustments and indicating lights if any are available at the front of the module. Of particular significance, is the input attentuator contained on the front of the filter module which is used in adjusting the input receiver signal during initial field installation.

A module extender (Style No. 1447C86G01) is available for facilitating circuit measurements or major adjustments. After withdrawing any one of the circuit modules, the extender is inserted in that position. The module is then inserted into the terminal block on the front of the extender. This restores all circuit connections and renders all components and test points on the module readily accessible.

The receiver operates from a regulated +20V supply and a +10V supply operating from a regulated +45dc supply. These voltages are taken from three zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated dc supply, and the 45 volt zener adapt the receiver for operation on 48 or 125 volts dc.

External connections to the receiver are made through a 36 terminal recepticle, J3. The r-f input connection to the receiver is made through a coaxial cable jack J2.

OPERATION

INPUT MODULE

The input module contains the input control and the input filter. The signals to which the TCF-10 receiver responds are

The low signal level clamp operates off the carrier level signal of the S/N detection module which is basically the same signal fed to the CLI instrument.

It is fed through terminal 7 into the voltage comparator circuit built around operational amplifier IC21B. This comparator compares this signal level with the voltage reference from IC21A, and if the signal level is greater than the low level at which clamping is desired, the output of IC21B will be negative causing the yellow LED to glow indicating OK level and there will consequently be no low signal clamping. If the signal level is below the level at which clamping is desired, then the output of IC21B will be positive causing the red LED to glow indicating low level. In addition, both transistors Q67 and Q64 will become conducting. Transistor Q64 conducting will prevent mark and space signals from appearing on the outputs going to the relays by preventing transistors Q65 and Q62 from conducting. Transistor Q67 conducting causes Q68 to become non-conducting and thus removes the not low signal output from terminal 1. Under good or OK signal level, this not low signal output at terminal 1 of this module is plus 20 volts.

The S/N clamp output from the S/N detection module is fed into terminal 35 of this module. At low signal-to-noise ratio level, this +16 volt signal will cause transistors Q70 and Q61 to conduct. Transistor Q70 conducting will cause both the red LED to glow indicating low S/N and transistor Q71 to conduct supplying plus 20 volts out of terminal 13 to the protective relays. Transistor Q61 conducting will prevent both transistors Q62 and Q65 from conducting, and thus prevent either a mark or space signal from appearing at their respective outputs to the protective relays. It should be noted that the S/N clamp also operates for a high signal level of approximately plus 25dB above normal when set to operate at 10dB signal to noise ratio.

POWER SUPPLY

The regulated 45 volt dc, 20V dc, and 10V dc circuits of the receiver are supplied from zener regulators mounted on a common heat sink at the rear of the chassis. Resistors R3 and R7 of suitable value are connected between the station battery supply and the 45 volt zener regulator to adapt the receiver for use on 48 or 125 volt dc battery circuits. Capacitor C1 and C2 bypass rf or transient voltages to ground. Choke L1 with capacitor C3 form a trap to isolate the receiver from transient voltages in the 20kHz range that may appear on the dc supply and which could affect the receiver.

CHARACTERISTICS

Center Frequencies Available	30kHz to 300kHz in 0.5kHz increments
Sensitivity (Noise free channel)	0.005 volts (65dB below 1 watt for limiting)
Input Impedence	5000 ohms minimum
Bandwidth (Input L C Filter)	Down 3dB at ±800 hertz Down 30dB at ±5000 hertz
Overall receiver selectivity	Down 3dB at ±225 hertz Down 35dB at ±1000 hertz
Operating Time	4 milliseconds channel (Transmitter and receiver back to back)
Signal-to-noise ratio clamp setting	10dB SNR (as shipped)
Ambient Temperature Range	−20°C to +75°C
Battery Voltage Variations	
Nominal 48V dc	42V dc − 56V dc
Nominal 125V dc	105V dc − 140V dc
Battery Drain	0.25 amperes
Dimensions	Panel Height = 5¼ inches (3RU) Panel Width = 19 inches
Weight	13 pounds

INSTALLATION

The TCF receiver is generally supplied in a cabinet or a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. In particular equipment which generates excessive heat such as power supplies should not be mounted directly beneath it as this heat in rising will tend to raise the ambient temperature immediately around the chassis above acceptable levels. The maximum ambient temperature around the chassis must not exceed 75 C. In addition, sudden fluctuations in ambient temperature caused by these power supplies due to variations in load can cause variations in performance due to uneven heating of the receiver introducing abnormal temperature variations in the receiver.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; frequency spacing and magnitude of discriminator output peaks; pickup of signal to noise ratio clamp; and pickup of low signal level clamp. The adjustment that must be made at time of installation is the setting of input attenuator R5. The input attenuator adjustment is made by a knob on the front of the panel of the input module.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation to attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15dB below the maximum expected signal. After installation of the receiver and the corresponding transmitter, and with a normal space signal level being received, input attenuator R5 should be adjusted to the position at which the receiver clamps into neither a mark nor space output. The attenuator R5 should then be readjusted to increase the voltage supplied to the receiver by 15dB. The scale markings for R5 permit approximate settings to be made, but it is preferable to make this setting by means of the dB scales of an ac VTVM connected across the terminals indicated at the front panel of the input module. The red terminal is connected to the wiper arm of R5 and the black terminal is connected to ground. With this setting, a 15dB drop in signal will cause a low signal level clamp operation which will lock the output of the receiver into neither a mark nor a space output at the point at which the receiver just drops out of limiting.

The only other adjustment which may be necessary at the time of initial installation is the adjustment of the CL1 instrument to correspond to proper variation of signal level from normal. This may be necessary if the instrument was not supplied with the receiver and was not adjusted by the factory. If this instrument was supplied and adjusted by the factory, then it could be used in adjusting R5. In this case, it would be necessary only to adjust R5 with a normal signal being received so that the instrument indicates 0dB.

If the instrument was not previously adjusted by the factory, then the following procedure should be used in adjusting the instrument.

1. Set incoming level into receiver at +10dB above normal level
2. Adjust span adjustment, R147, so that the voltage at TP72 with respect to TP62 (common) is +3.000 volts.
3. Reduce incoming signal into receiver by 25dB.
4. Adjust full scale adjustment, R153, so that instrument now reads −15dB. (This is approximately 16.7 microamperes).
5. Increase signal to nominal level. Instrument should now read 0dB. (This is 66.7 microamperes). If not, repeat Step 2.

FACTORY ADJUSTMENTS

In case the factory adjustments have been altered or there is suspicion of improper adjustments or malfunctioning, then the following procedures can be used. In addition, alterations to the settings used by the factory for low signal level clamping and low signal-to-noise ratio clamping can be made using these procedures if desired.

Potentiometer R12 in the oscillator and mixer should be set for 0.3 volts, measured with a VTVM connected between TP11 and terminal 33 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency which should be 20kHz above the channel center frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that assures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should be connected from TP56 at the base of Q54 to terminal 33 of the limiter. With 5 millivolts of space frequency on the receiver input (R5 set at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

The adjustment of the signal to noise ratio clamp for clamping at 10dB signal to noise ratio is as follows:

1. Set the incoming signal into receiver at nominal level (28 mv.)
2. Adjust I.F. input with R111 so that signal at TP68 of the S/N detector module is +100 mv d.c. (with respect to TP62).
3. Adjust RF input with R94 so that signal at TP63 is +120 mv d.c. (with respect to TP62).
4. Measure level at TP66. It should be +100 mv d.c. If not, readjust R94 to obtain this value with respect to TP62.
5. Adjust log amplifier balance potentiometer R129 so that S/N clamps operates. This will be +16 volts dc at TP75. This will also appear as +20 volts at TP91 of the output board and the red S/N level indicator will light.
6. Go back and readjust RF input with R94 so that signal level at TP63 is now 74.4 mv d.c.

The adjustments above are for operation of the clamp at 10dB or less signal to noise ratios. If it is desired to clamp at other than 10dB or less, the following values can be used in place of the 74.4 mv value in step 6.

For S/N of 0dB set TP63 to 55mv.

5dB set TP63 to 64mv.

15dB set TP63 to 84.7mv.

20dB set TP63 to 93.1mv.

Note: When the SNR clamp is set to clamp at a 10dB signal to noise ratio, the receiver will also clamp at a high signal level of approximately 25dB above normal.

The low signal level clamp is set to operate at the signal level where the receiver just drops out of limiting. This is accomplished as follows:

1. With a normal space frequency signal being received and with an oscilloscope connected across TP56 and terminal 33 of the limiter module, adjust input attenuator R5 to the point where the peaks of the oscilloscope trace just begin to flatten. (An alternate adjustment would be to set incoming signal level into receiver at 5mv with R5 set at zero which is the point at which limiting should begin).
2. Adjust the -V Ref. adjustment R178 on the output module so that the low level clamp just picks up. This will be indicated by the red low level light on the output module coming on. There also will be +20 volts at TP86 on the output module.
3. Adjust input attenuator R5 to increase signal into receiver by desired margin of operation. This normally should be 15dB. This is done by reducing the R5 attenuator setting.

MAINTENANCE

Periodic checks of the received carrier signal level and the receiver sentitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control, R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to cause a low signal level clamp to operate as indicated by the red LED becoming lit. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal level or loss in receiver sensitivity.

All adjustable components for normal field adjustments on the printed circuit modules are accessible when the front cover on the chassis is removed. All other adjustable components on the printed circuit modules may be made entirely accessible while permitting electrical operation by using module extender style number 1447C86G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

TABLE I
RECEIVER D-C MEASUREMENTS

NOTE: All voltage readings taken with ground of dc VTVM on terminal 17 (negative dc). Receiver adjusted for 15dB operating margin with Space and Mark signals down 50dB from 1 watt or 60dB down from 10 watts. Unless indicated otherwise, voltage will not vary appreciably whether signal is mark, space or zero.

Collector of Transistor or Test Point	Voltage (Positive)
Q11	< 13
Q12 (TP12)	15 (Mark or Space)
Q13 (TP13)	15 (Mark or Space)
Q14 (TP14)	2.5
Q15 (TP15)	2.5
TP11	18
TP52	16
Q51 (TP51)	11.5
Q52 (TP53)	12
Q53 (TP54)	15.5
Q54 (TP55)	2.5
TP56	16
Q55	< 1 (Mark or No Signal)
Q55	19.5 (Space)
Q56	19.5 (Mark)
Q56	< 1 (Space or No Signal)
TP61	10.4
TP62	10
TP63	10.4
TP64	18
TP65	0
TP66	10
TP67	10.5
TP68	10.5
TP69	10
TP70	4
TP71	16
TP72	11.4
TP73	10.8
TP74	10.3
TP81	20 (Space)
TP81	0 (Mark or No Signal)
TP82	20 (Mark)

Collector of Transistor or Test Point	Voltage (Positive)
TP82	0 (Space or No Signal)
TP83	20 (Space)
TP83	0 (Mark, No Signal, or clamp)
TP84	20 (Mark)
TP84	0 (Space, No Signal or clamp)
TP85	10.3
TP86	20 (Low level clamp)
TP86	0 (No clamp)
TP87	16V (Low SNR Clamp)
TP87	4V (No SNR Clamp)
TP88	20
TP89	0
TP90	20 (Good Signal Level)
TP90	0 (Low Signal Level clamp)

TABLE II
RECEIVER RF MEASUREMENTS

NOTE: Voltmeter readings taken at any point from receiver input to stage involving transistor Q15 are neither meaningful or feasible because of either waveform variations or the effect of instrument loading on the readings. Receiver adjusted as Table I.

Collector of Transistor or Test Point	Volts with Signal At +10dB Above Normal Level
Q15 (TP15)	0.8
Q51 (TP51)	0.9
Q52 (TP53)	0.65
Q53 (TP54)	2.2
Q54 (TP55)	4.5
TP61	.013
TP67	.275

FILTER RESPONSE MEASUREMENTS

The LC input filter (FL201) and the IF Filter (FL2) are in sealed containers, and repairs can only be made by the factory. The stability of the original response characteristics is such that in normal usage, no appreciable change in response will occur. However, the test circuits of Figure 16 can be used in case there is reason to suspect that either of the filters is not performing correctly.

Figure 15 shows the −3dB and −35dB checkpoints for the IF filter, and the −3dB checkpoints for the input filter. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Figure 15 was chosen to show the IF filter response, which permitted only a portion of the input filter curve to be shown. The checkpoints for the passband of each section of each section of the IF filter are down 3dB maximum at 19.75 and 20.25kHz, and for the stop band are down 18dB minimum at 19.00 and 21.00kHz for each section. The signal generator voltage (Figure 16) must be held constant throughout the entire check. A value of 7.8 volts is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22dB below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only, and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16dB less than the measured difference because of the input resistance and the difference in input and output impedances of the filter.

In testing the LC filter, a value of approximately 2.45V is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency, but should not be more than 18dB below the reading of VM1. (The filter insertion loss is approximately 6dB less than the difference in readings).

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY.

The parts required for converting a TCF receiver for operating at a different channel frequency consist of a new LC input filter (FL201), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). There are two ways of effecting this change. The easiest and preferred method is to order a new input filter module and a new oscillator mixer module for the new frequencies from the factory. The new modules would then just have to be plugged in as replacements for the original modules. The second method would involve ordering just replacement filter, FL201, and new local oscillator crystal for the new frequencies and making the substitution on the modules. These substitutions on the modules are not difficult as the crystal plugs in and the filter has five leads to be soldered. However, testing of the local oscillator for easy starting will have to be made, and the value of C12 chosen to assure this easy starting of oscillation. The whole receiver should then be checked out for correct performance.

RECOMMENDED TEST EQUIPMENT

I. **Minimum Test Equipment for Installation**

a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60Hz to 330kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
   Voltage Range: 1.5 to 300 volts
   Input Impedance: 7.5 megohms

c. Milliammeter, 0-3 range, (if receiver has carrier level indicator).

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-kHz to 330kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

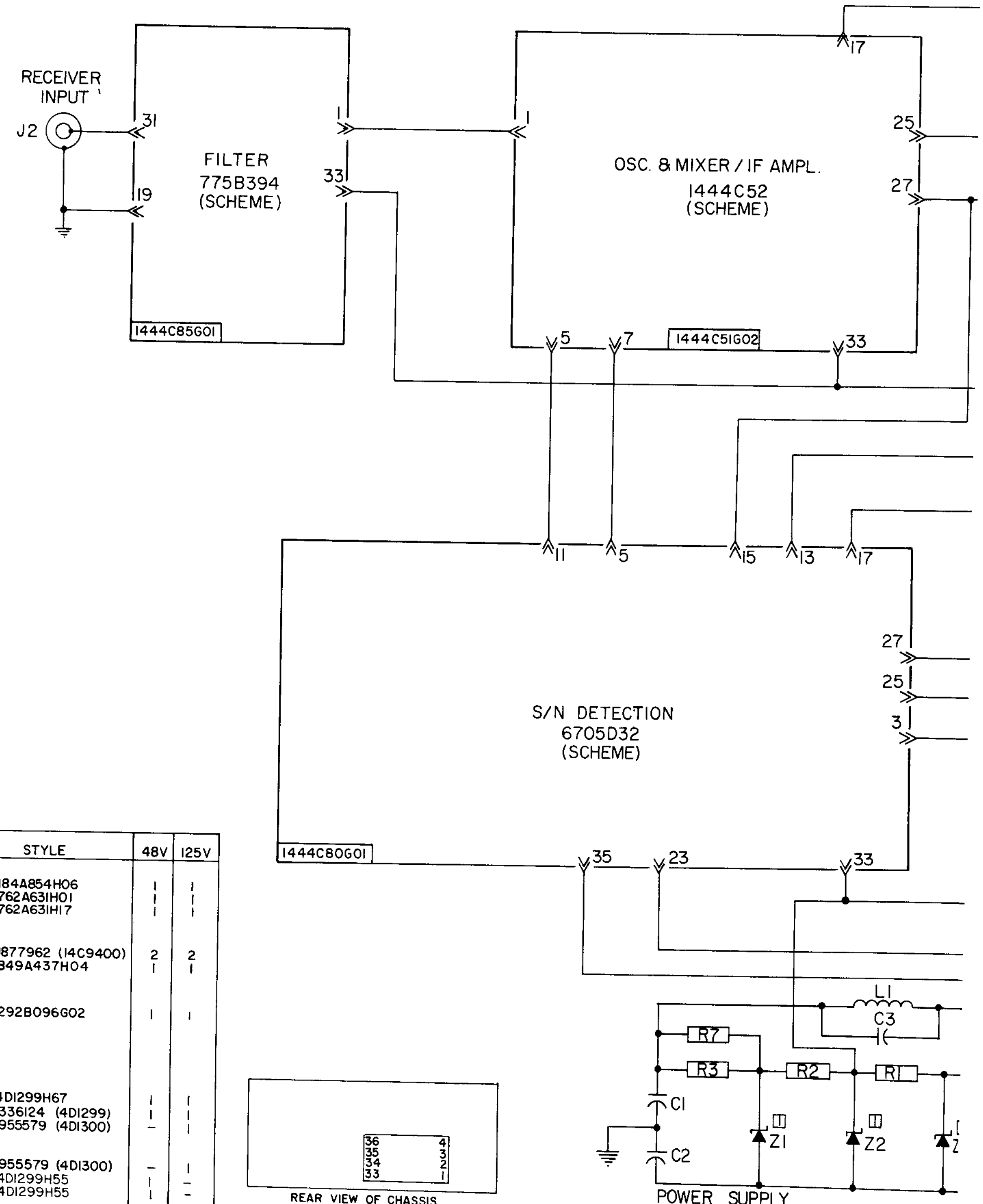
f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

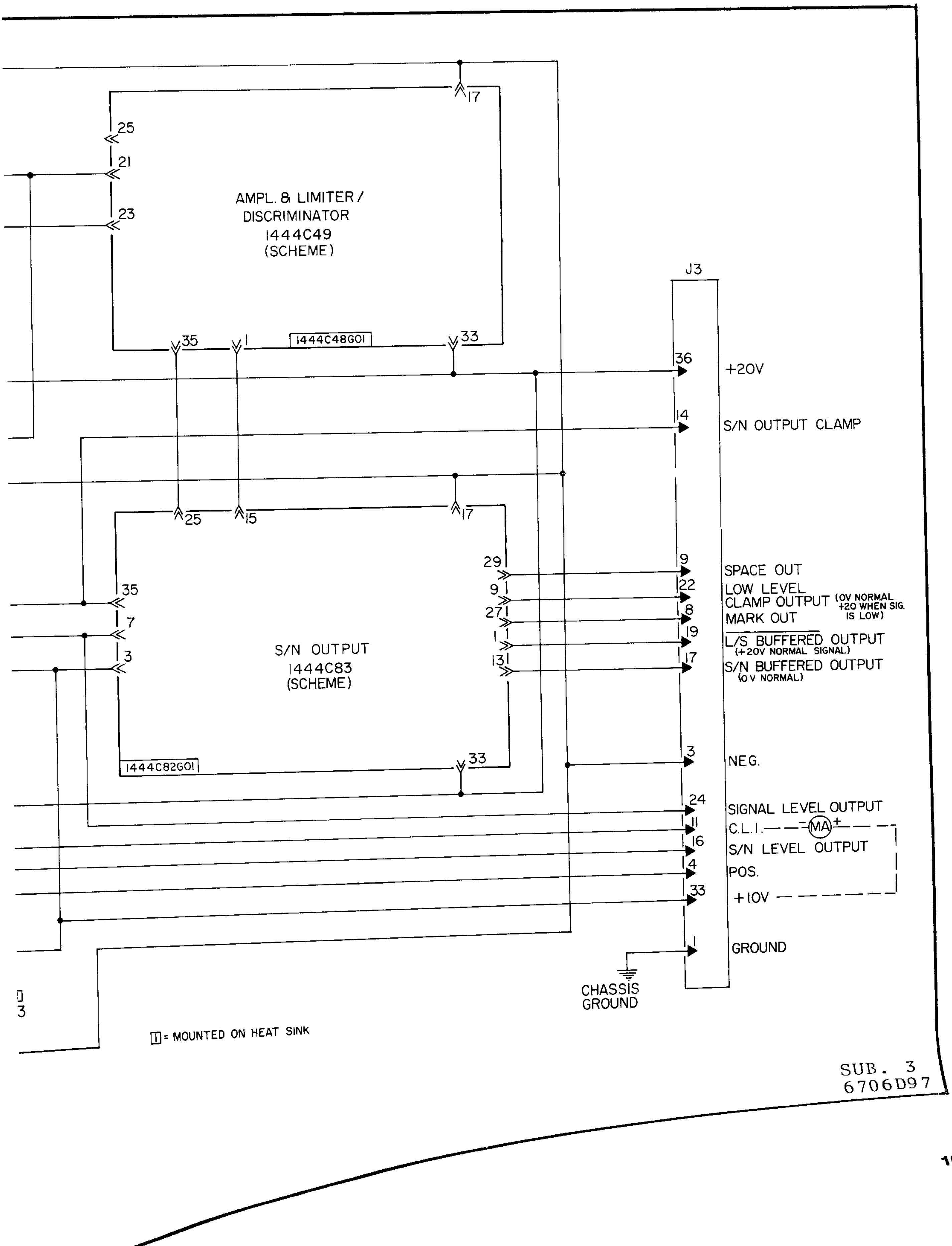
RENEWAL PARTS

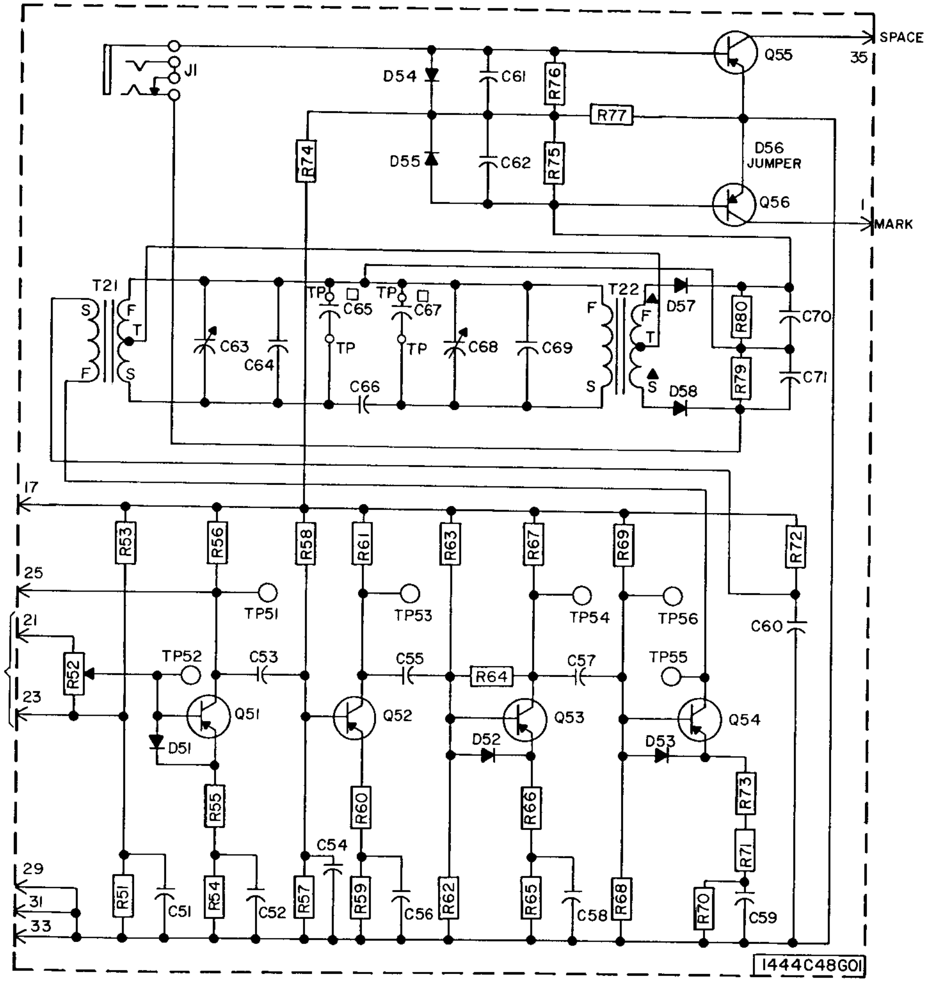
Repair work can be done most satisfactorily at the factory. However, replacement parts can be furnished, in most cases, to customers who are equipped for doing repair work. When ordering parts, always give the complete nameplate data, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.



COMPONENT	STYLE	48V	125V
ZENER			
Z1 (IN2828B)	184A854H06	1	1
Z2 (IN2984B)	762A631H01	1	1
Z3 (IN2974B)	762A631H17	1	1
CAPACITOR			
C1-C2 (.5MFD)	1877962 (14C9400)	2	2
C3 (.047MFD)	849A437H04	1	1
CHOKE			
L1	292B096G02	1	1
RESISTOR			
R1 100Ω	4D1299H67	1	1
R2 75Ω	1336124 (4D1299)	1	1
R3 400Ω	1955579 (4D1300)	—	1
R7 400Ω	1955579 (4D1300)	—	1
R3 50Ω	4D1299H55	1	—
R7 50Ω	4D1299H55	1	—
CONNECTOR			
J3	3508A35H01	1	1

Fig. 1


AMPL. & LIMITER / DISCRIMINATOR
1444C49
(SCHEME)
1444C48G01
S/N OUTPUT
1444C83
(SCHEME)
1444C82G01
J3
+20V
S/N OUTPUT CLAMP
SPACE OUT
LOW LEVEL CLAMP OUTPUT (0V NORMAL +20 WHEN SIG. IS LOW)
MARK OUT
L/S BUFFERED OUTPUT (+20V NORMAL SIGNAL)
S/N BUFFERED OUTPUT (0 V NORMAL)
NEG.
SIGNAL LEVEL OUTPUT
C.L.I.
MA
S/N LEVEL OUTPUT
POS.
+10V
GROUND
CHASSIS GROUND
= MOUNTED ON HEAT SINK
SUB. 3
6706D97



COMPONENT		DESCRIPTION	STYLE NO.
C51	CAPACITOR	.250UF 200V	187A624H02
C52	CAPACITOR	.250UF 200V	187A624H02
C53	CAPACITOR	.100UF 200V	187A624H01
C54	CAPACITOR	1300.000PF 500V	187A584H15
C55	CAPACITOR	.100UF 200V	187A624H01
C56	CAPACITOR	.250UF 200V	187A624H02
C57	CAPACITOR	.100UF 200V	187A624H01
C58	CAPACITOR	.250UF 200V	187A624H02
C59	CAPACITOR	.250UF 200V	187A624H02
C60	CAPACITOR	1.000UF 200V	187A624H04
C61	CAPACITOR	.220UF 50V	762A703H01
C62	CAPACITOR	.220UF 50V	762A703H01
C63	CAPACITOR	4.5 TO 100PF	762A736H02
C64	CAPACITOR	9100.000PF 200V	187A624H16
C65	CAPACITOR	SEE NOTE □	
C66	CAPACITOR	100.000PF 500V	187A684H08
C67	CAPACITOR	SEE NOTE □	
C68	CAPACITOR	4.5 TO 100PF	762A736H02
C69	CAPACITOR	9100.000PF 200V	187A624H16
C70	CAPACITOR	.220UF 50V	762A703H01
C71	CAPACITOR	.220UF 50V	762A703H01
D51	DIODE	1N457A	184A855H07
D52	DIODE	1N457A	184A855H07
D53	DIODE	1N457A	184A855H07
D54	DIODE	1N457A	184A855H07
D55	DIODE	1N457A	184A855H07
D56	JUMPER		862A478H01
D57	DIODE	1N628	184A855H12
D58	DIODE	1N628	184A855H12
R51	RESISTOR	4700.0 .50W 5%	184A763H43
R53	RESISTOR	27.0K .50W 5%	184A763H61
R54	RESISTOR	2200.0 .50W 5%	184A763H35
R55	RESISTOR	27.0 .50W 5%	187A290H11
R56	RESISTOR	10.0K .50W 5%	184A763H51
R57	RESISTOR	4700.0 .50W 5%	184A763H43
R58	RESISTOR	27.0K .50W 5%	184A763H61
R59	RESISTOR	1500.0 .50W 5%	184A763H31
R60	RESISTOR	180.0 .50W 5%	184A763H09
R61	RESISTOR	4700.0 .50W 5%	184A763H43
R62	RESISTOR	2200.0 .50W 5%	184A763H35
R63	RESISTOR	33.0K .50W 5%	184A763H63
R64	RESISTOR	2700.0 .50W 5%	184A763H37
R65	RESISTOR	680.0 .50W 5%	184A763H23
R66	RESISTOR	68.0 .50W 5%	187A290H21
R67	RESISTOR	4700.0 .50W 5%	184A763H43
R68	RESISTOR	2700.0 .50W 5%	184A763H37
R69	RESISTOR	18.0K .50W 5%	184A763H57
R70	RESISTOR	220.0 .50W 5%	184A763H11
R71	RESISTOR	68.0 .50W 2%	629A531H04
R72	RESISTOR	330.0 .50W 5%	184A763H15
R73	RESISTOR	56.0 .50W 2%	629A531H02
R74	RESISTOR	12.0K .50W 5%	184A763H53
R75	RESISTOR	3000.0 .50W 5%	184A763H38
R76	RESISTOR	3000.0 .50W 5%	184A763H38
R77	RESISTOR	220.0 .50W 5%	184A763H11
R79	RESISTOR	2200.0 .50W 5%	184A763H35
R80	RESISTOR	2200.0 .50W 5%	184A763H35
R52	POT	1.0K .50W	629A645H04
Q51	TRANSISTOR	2N4249	849A441H03
Q52	TRANSISTOR	2N4249	849A441H03
Q53	TRANSISTOR	2N4249	849A441H03
Q54	TRANSISTOR	2N4249	849A441H03
Q55	TRANSISTOR	2N3645	849A441H01
Q56	TRANSISTOR	2N3645	849A441H01
T21	TRANSFORMER		606B533G01
T22	TRANSFORMER		606B533G02
J1	TELEPHONE JACK		187A606H01

□ – ONE OR TWO CAPACITORS USED; VALUES DETERMINED IN TEST.

▲ – FOR STYLE 1444C48G03 REVERSE START AND FINISH LEADS OF T22.

SUB. 2
14449C49

Fig. 6. Internal Schematic Amplifier Limiter-Discriminator Module

COMPONENT	DESCRIPTION				STYLE NO.
R81	RESISTOR	1000.0	.50W	1%	848A819H48
R82	RESISTOR	2210.0	.50W	1%	848A819H81
R83	RESISTOR	10.2K	.25W	1%	848A820H46
R84	RESISTOR	10.0K	.25W	1%	848A820H45
R85	RESISTOR	56.2K	.25W	1%	848A821H18
R86	RESISTOR	10.0K	.50W	1%	848A820H45
R87	RESISTOR	2210.0	.50W	1%	848A819H81
R88	RESISTOR	10.2K	.25W	1%	848A820H46
R89	RESISTOR	10.0K	.25W	1%	848A820H45
R90	RESISTOR	82.5K	.50W	1%	848A821H34
R91	RESISTOR	10.0K	.50W	1%	848A820H45
R92	RESISTOR	6190.0	.50W	1%	848A820H25
R93	RESISTOR	4990.0	.50W	1%	848A820H16
R95	RESISTOR	4750.0	.25W	1%	848A820H14
R96	RESISTOR	4750.0	.25W	1%	848A820H14
R97	RESISTOR	4990.0	.50W	1%	848A820H16
R98	RESISTOR	15.0K	.50W	1%	848A820H62
R99	RESISTOR	4990.0	.50W	1%	848A820H16
R100	RESISTOR	4990.0	.50W	1%	848A820H16
R101	RESISTOR	4990.0	.50W	1%	848A820H16
R102	RESISTOR	10.0K	.50W	1%	848A820H45
R103	RESISTOR	10.0K	.50W	1%	848A820H45
R104	RESISTOR	10.0K	.50W	1%	848A820H45
R105	RESISTOR	10.0K	.50W	1%	848A820H45
R106	RESISTOR	10.0K	.50W	1%	848A820H45
R107	RESISTOR	10.0K	.50W	1%	848A820H45
R108	RESISTOR	100.0K	.50W	1%	848A821H42
R109	RESISTOR	10.0K	.50W	1%	848A820H45
R110	RESISTOR	1000.0	.50W	1%	848A819H48
R112	RESISTOR	4750.0	.25W	1%	848A820H14
R113	RESISTOR	4750.0	.25W	1%	848A820H14
R114	RESISTOR	15.0K	.50W	1%	848A820H62
R115	RESISTOR	4990.0	.50W	1%	848A820H16
R116	RESISTOR	4990.0	.50W	1%	848A820H16
R117	RESISTOR	4990.0	.50W	1%	848A820H16
R118	RESISTOR	4990.0	.50W	1%	848A820H16
R119	RESISTOR	10.0K	.50W	1%	848A820H45
R120	RESISTOR	1000.0	.50W	1%	848A819H48
R121	RESISTOR	15.0K	.50W	1%	848A820H62
R122	RESISTOR	15.0K	.50W	1%	848A820H62
R123	RESISTOR	10.0K	.50W	1%	848A820H45
R124	RESISTOR	10.0K	.50W	1%	848A820H45
R125	RESISTOR	10.0K	.50W	1%	848A820H45
R126	RESISTOR	10.0K	.50W	1%	848A820H45
R127	RESISTOR	2.0K	.50W	1%	848A819H77
R128	RESISTOR	9530.0	.50W	1%	848A820H43
R130	RESISTOR	9530.0	.50W	1%	848A820H43
R131	RESISTOR	10.0K	.50W	1%	848A820H45
R132	RESISTOR	10.0K	.50W	1%	848A820H45
R133	RESISTOR	10.0K	.50W	1%	848A820H45
R134	RESISTOR	10.0K	.50W	1%	848A820H45
R135	RESISTOR	10.0K	.50W	1%	848A820H45
R136	RESISTOR	15.0K	.50W	1%	848A820H62
R137	RESISTOR	10.0K	.50W	1%	848A820H45
R138	RESISTOR	10.0K	.50W	1%	848A820H45
R139	RESISTOR	10.0K	.50W	1%	848A820H45
R140	RESISTOR	475.0K	.25W	1%	848A822H08
R141	RESISTOR	698.0K	.50W	1%	848A822H24
R142	RESISTOR	150.0	.50W	1%	848A818H68
R144	RESISTOR	750.0	.50W	1%	848A819H36
R145	RESISTOR	18.7K	.50W	1%	848A820H71
R146	RESISTOR	4990.0	.50W	1%	848A820H16
R148	RESISTOR	1000.0	.50W	1%	848A819H48
R149	RESISTOR	15.0K	.50W	1%	848A820H62
R150	RESISTOR	2.0K	.50W	1%	848A819H77
R151	RESISTOR	2.0K	.50W	1%	848A819H77
R152	RESISTOR	17.8K	.25W	1%	848A820H69
R154	RESISTOR	681.0	.50W	1%	848A819H32
R155	RESISTOR	150.0	.50W	1%	848A818H68
R156	RESISTOR	150.0	.50W	1%	848A818H68
R157	RESISTOR	20.0K	.50W	1%	848A820H74
R158	RESISTOR	20.0K	.50W	1%	848A820H74

COMPONENT		DESCRIPTION		STYLE NO.
R94	POT	20.0K	.50W	629A645H05
R111	POT	50.0K	.50W	629A645H06
R129	POT	2.5K	.25W	629A645H07
R147	POT	250.0K	.75W	880A826H10
R153	POT	2.5K	.25W	629A645H07
C81	CAPACITOR	2000.000PF	500V	187A584H01
C82	CAPACITOR	1000.000PF	200V	880A397H07
C83	CAPACITOR	220.000PF	200V	879A989H17
C84	CAPACITOR	.010UF	50V	184A663H01
C85	CAPACITOR	1.000UF	50V	3512A08H01
C86	CAPACITOR	.010UF	50V	184A663H01
C87	CAPACITOR	2000.000PF	500V	187A584H01
C88	CAPACITOR	1000.000PF	200V	880A397H07
C89	CAPACITOR	33.000PF	200V	879A989H07
C90	CAPACITOR	.010UF	50V	184A663H01
C91	CAPACITOR	.010UF	50V	184A663H01
C92	CAPACITOR	1.000UF	50V	3512A08H01
C93	CAPACITOR	.010UF	50V	184A663H01
C94	CAPACITOR	33.000PF	200V	879A989H07
C95	CAPACITOR	.010UF	50V	184A663H01
C96	CAPACITOR	.010UF	50V	184A663H01
C97	CAPACITOR	.470UF	50V	762A680H04
C98	CAPACITOR	33.000PF	200V	879A989H07
C99	CAPACITOR	.010UF	50V	184A663H01
C100	CAPACITOR	.010UF	50V	184A663H01
C101	CAPACITOR	33.000PF	200V	879A989H07
C102	CAPACITOR	.010UF	50V	184A663H01
C103	CAPACITOR	33.000PF	200V	879A989H07
C104	CAPACITOR	.010UF	50V	184A663H01
C105	CAPACITOR	.010UF	50V	184A663H01
C106	CAPACITOR	.047UF	50V	848A646H07
C107	CAPACITOR	33.000PF	200V	879A989H07
C108	CAPACITOR	.010UF	50V	184A663H01
C109	CAPACITOR	.010UF	50V	184A663H01
C110	CAPACITOR	1.000UF	50V	3512A08H01
IC1	INT CKT	SE531T		3512A10H01
IC2	INT CKT	SE531T		3512A10H01
IC3	INT CKT	SE531T		3512A10H01
IC4	INT CKT	SE531T		3512A10H01
IC5	INT CKT	SE531T		3512A10H01
IC6	INT CKT	747DM		1443C52H01
IC7	INT CKT	SE531T		3512A10H01
IC8	INT CKT	SE531T		3512A10H01
IC9	INT CKT	SN56502		3512A09H01
IC10	INT CKT	747DM		1443C52H01
IC11	INT CKT	747DM		1443C52H01
IC12	INT CKT	SN56502		3512A09H01
IC13	INT CKT	747DM		1443C52H01
D61	DIODE	1N4148		836A928H06
D62	DIODE	1N4148		836A928H06
D63	DIODE	1N4148		836A928H06
D64	DIODE	1N4148		836A928H06
D65	DIODE	1N4148		836A928H06
Z11	ZENER	1N748A	3.9V	186A797H13
Z12	ZENER	1N748A	3.9V	186A797H13
Z113	ZENER	1N825A	6.2V	862A288H06
J111	JUMPER	0 OHM RESISTOR		862A478H01
J112	JUMPER	0 OHM RESISTOR		862A478H01
J113	JUMPER	0 OHM RESISTOR		862A478H01
J114	JUMPER	0 OHM RESISTOR		862A478H01

SUB. 4
SHEET 2
6705D32

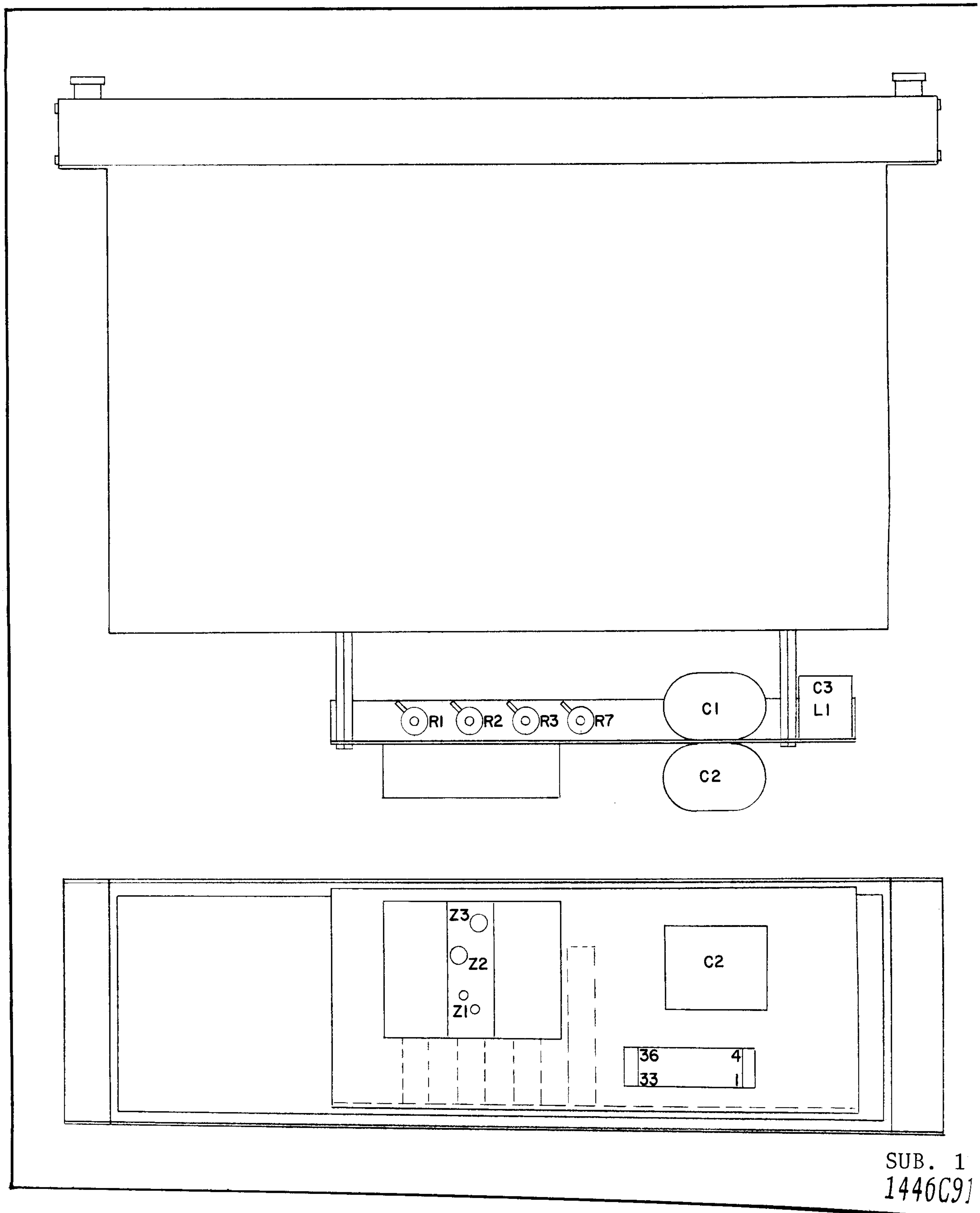


Fig. 9. Component Location TCF-10 Receiver

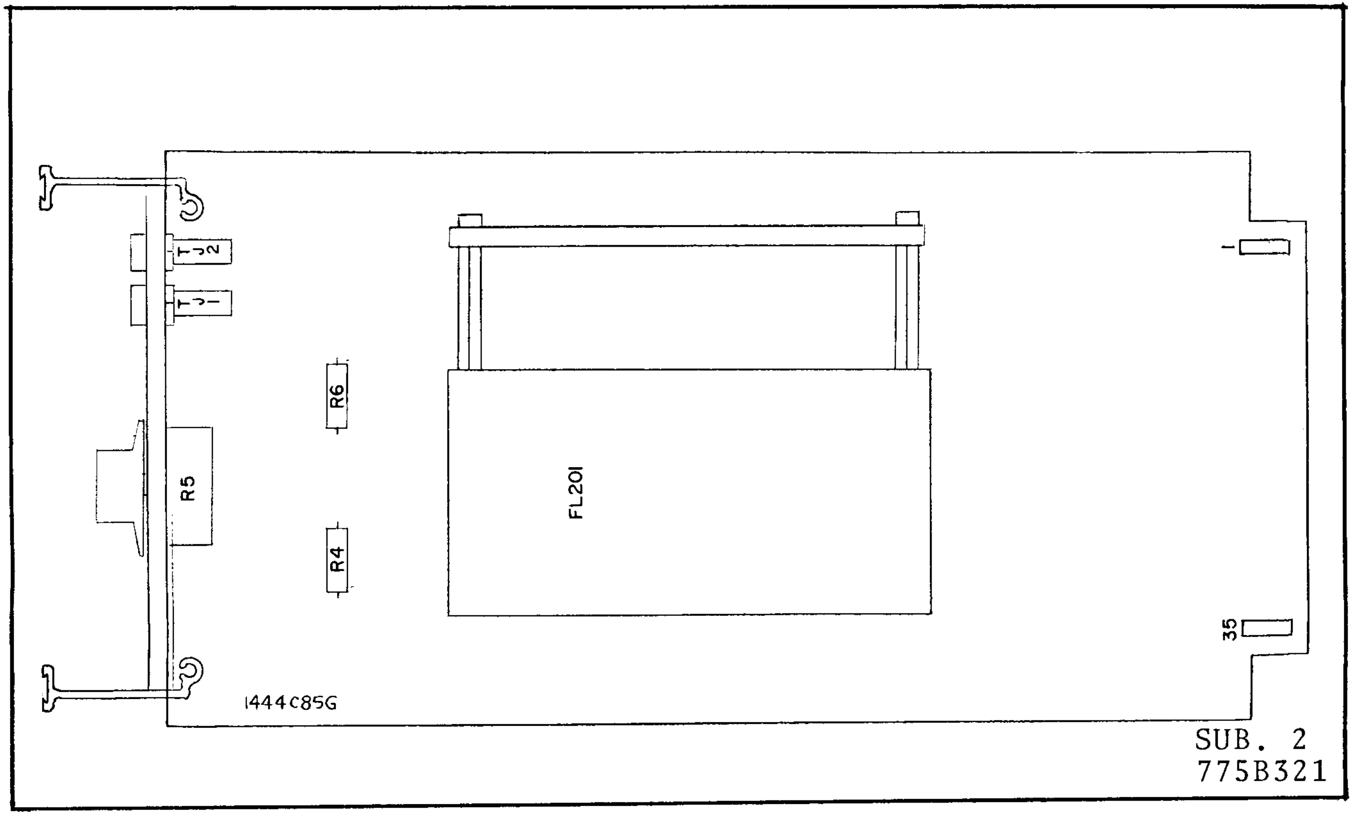


Fig. 10. Component Location Input Filter Module

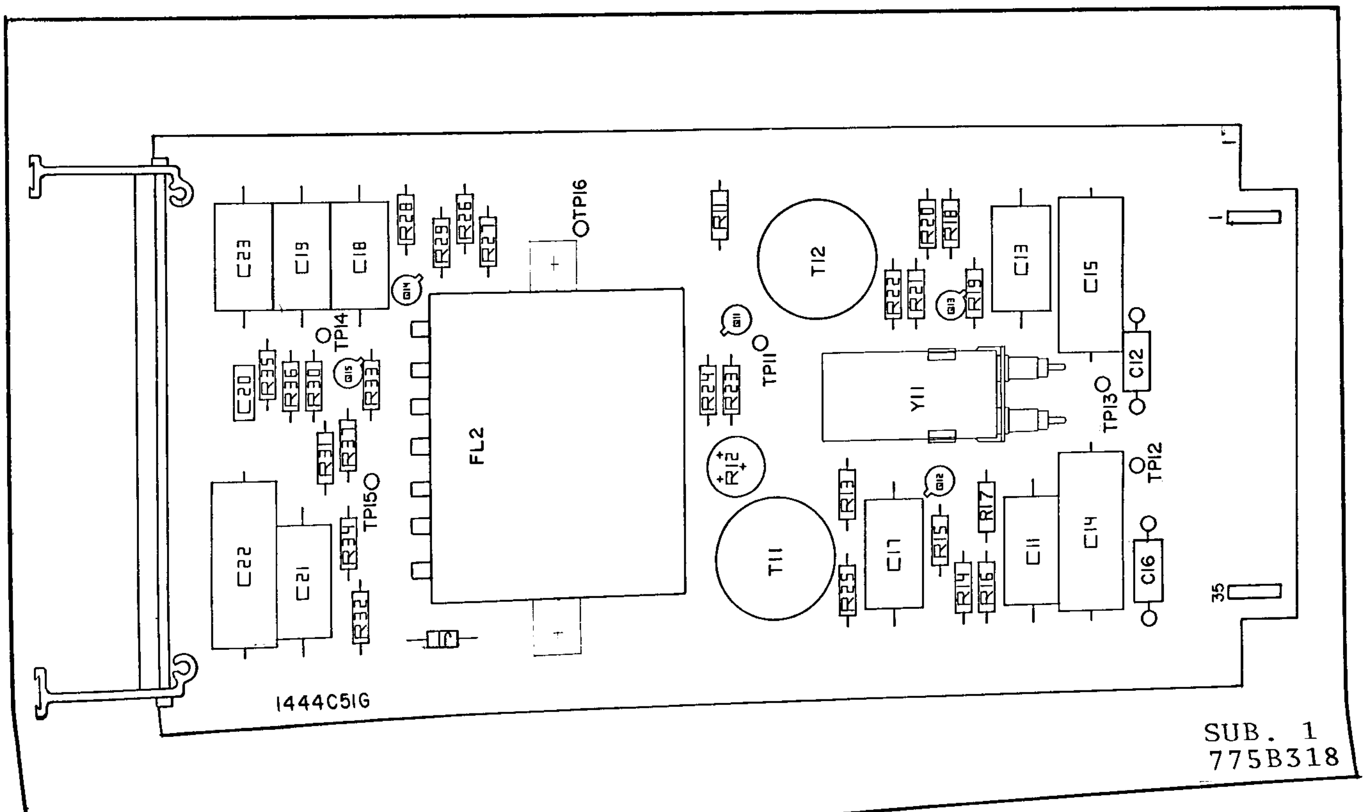


Fig. 11. Component Location Oscillator Mixer IF Amplifier Module

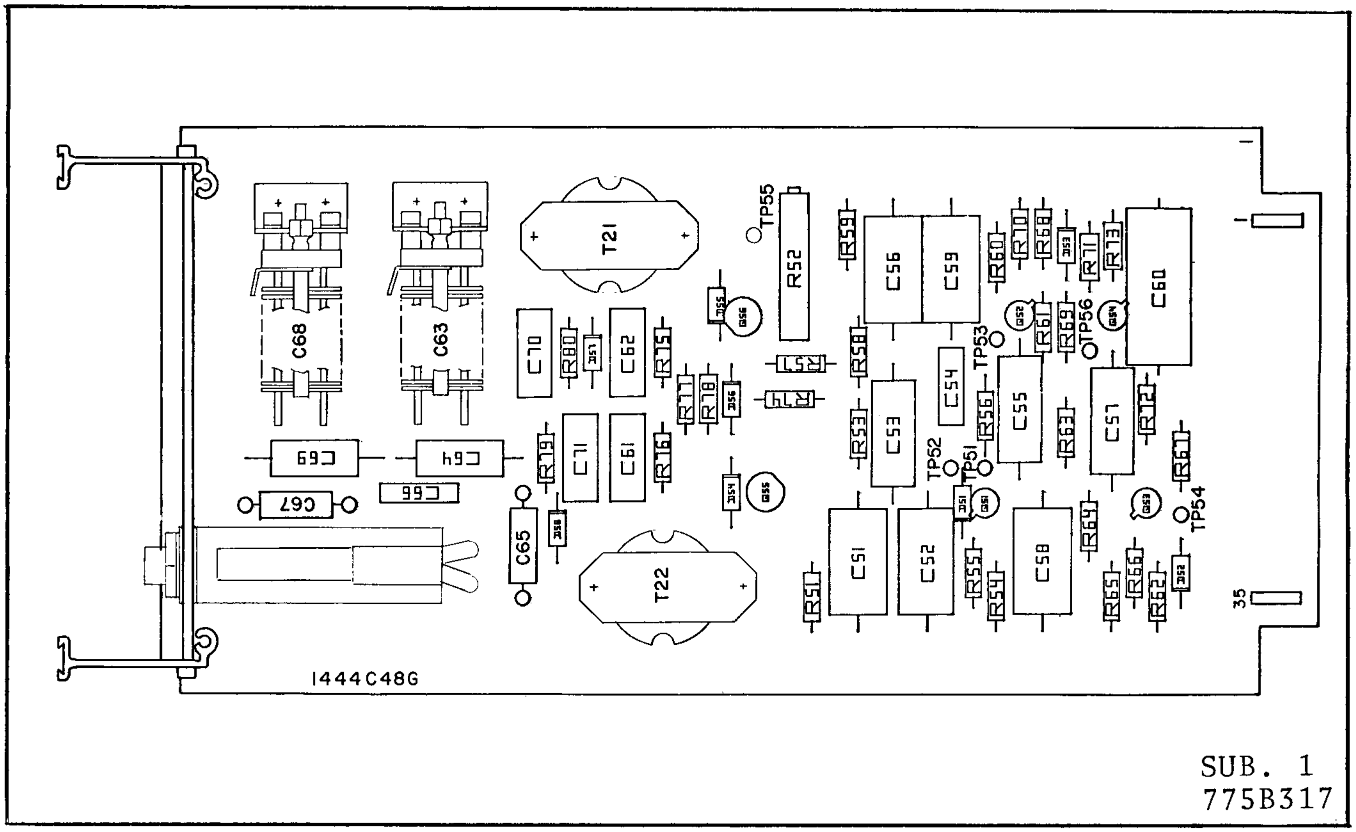


Fig. 12. Component Location Amplifier Limiter-Discriminator Module

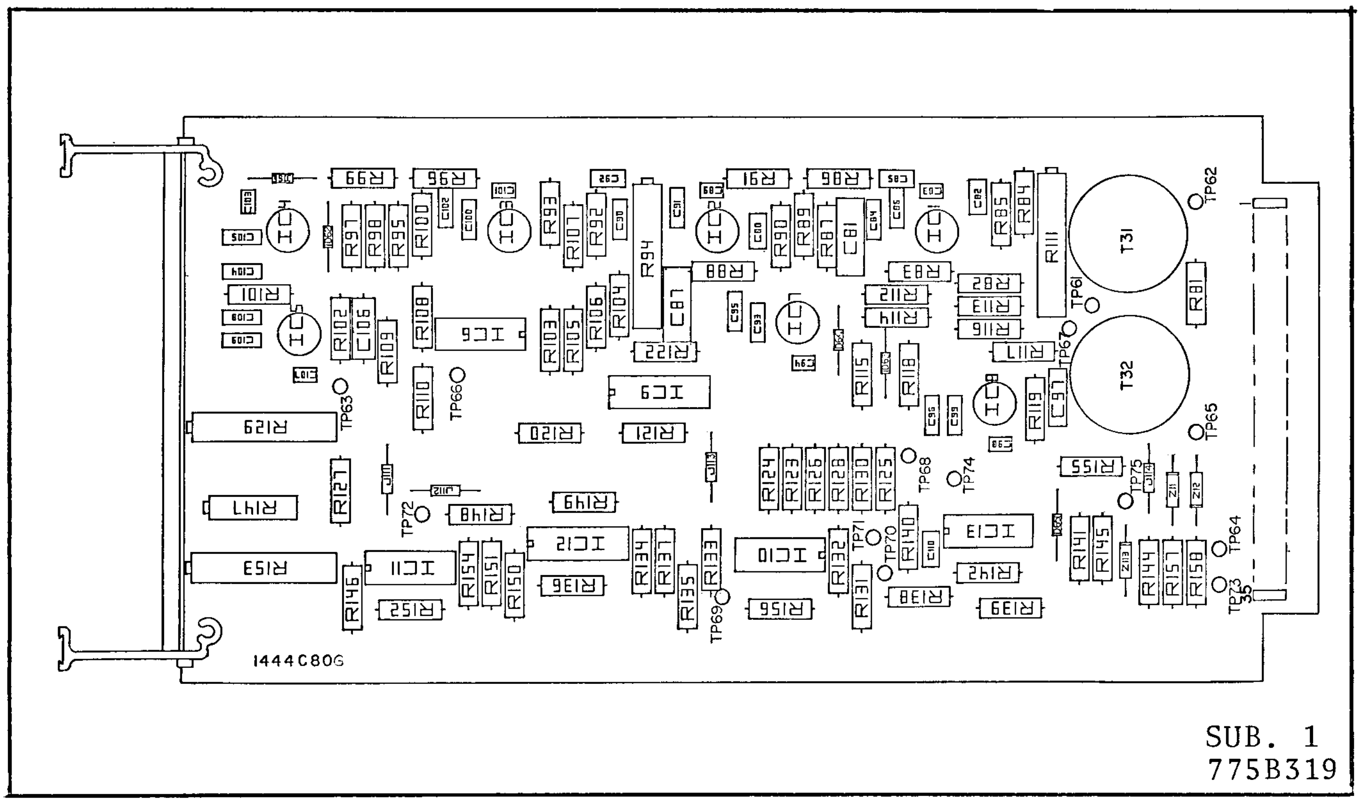


Fig. 13. Component Location SNR Detection Module

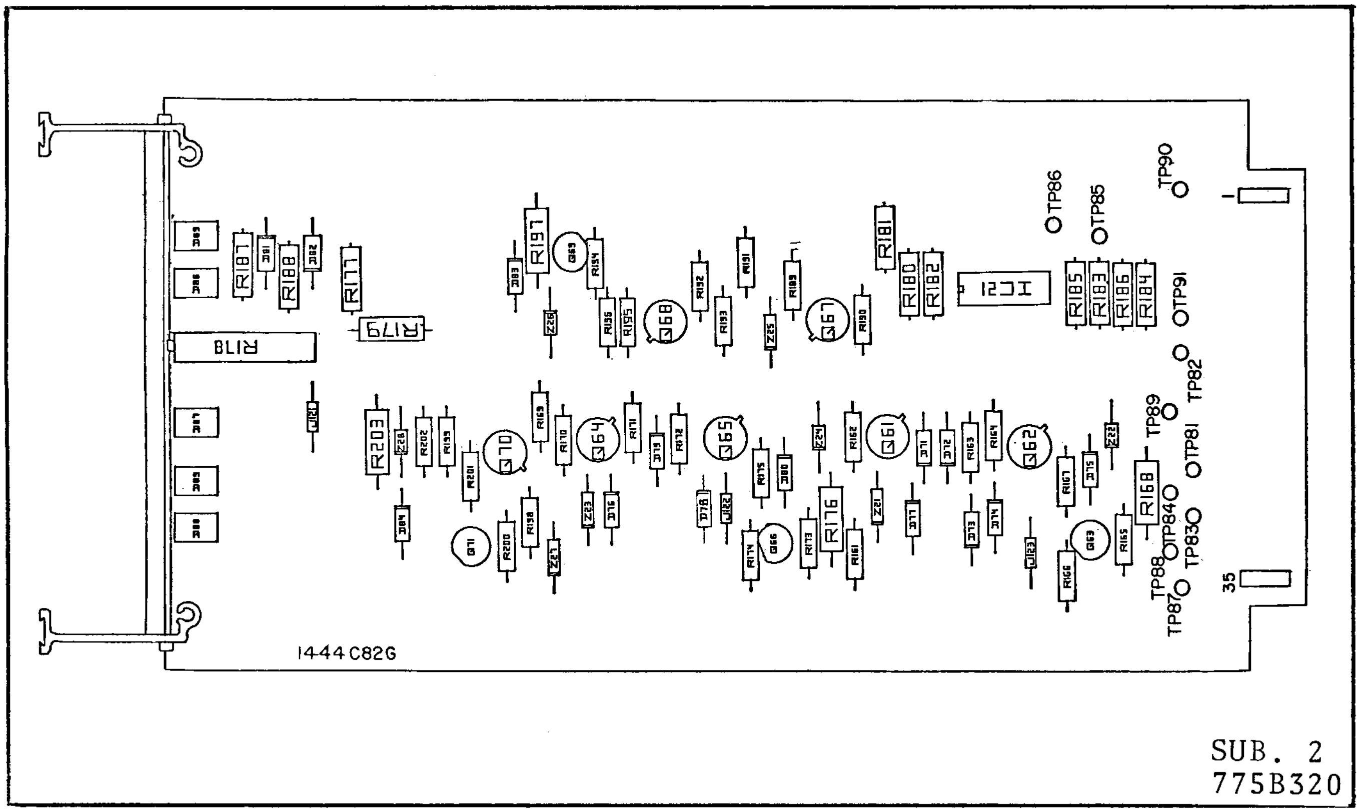


Fig. 14. Component Location Output Module

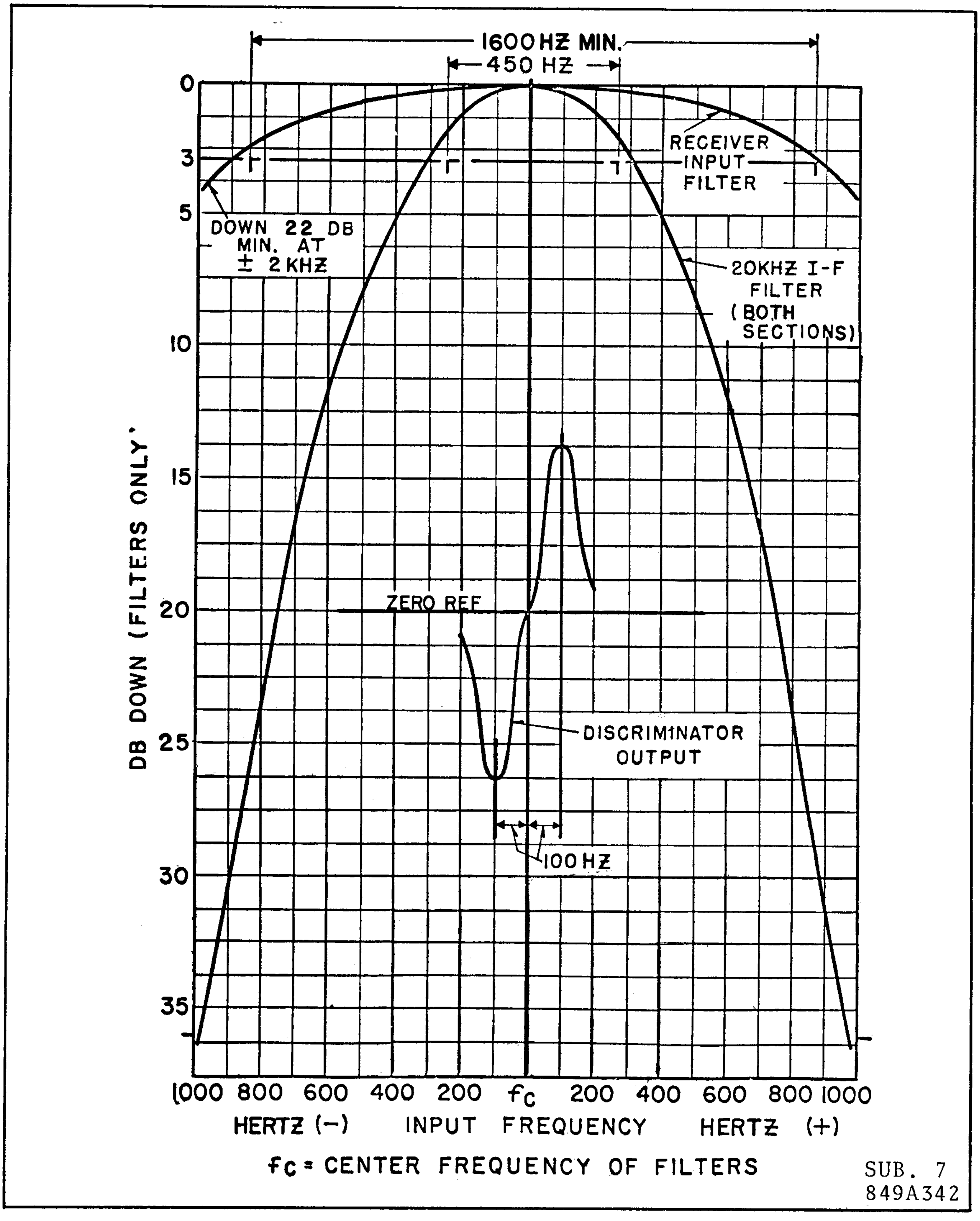


Fig. 15. Filter and Discriminator Characteristics of the Type TCF-10 Receiver

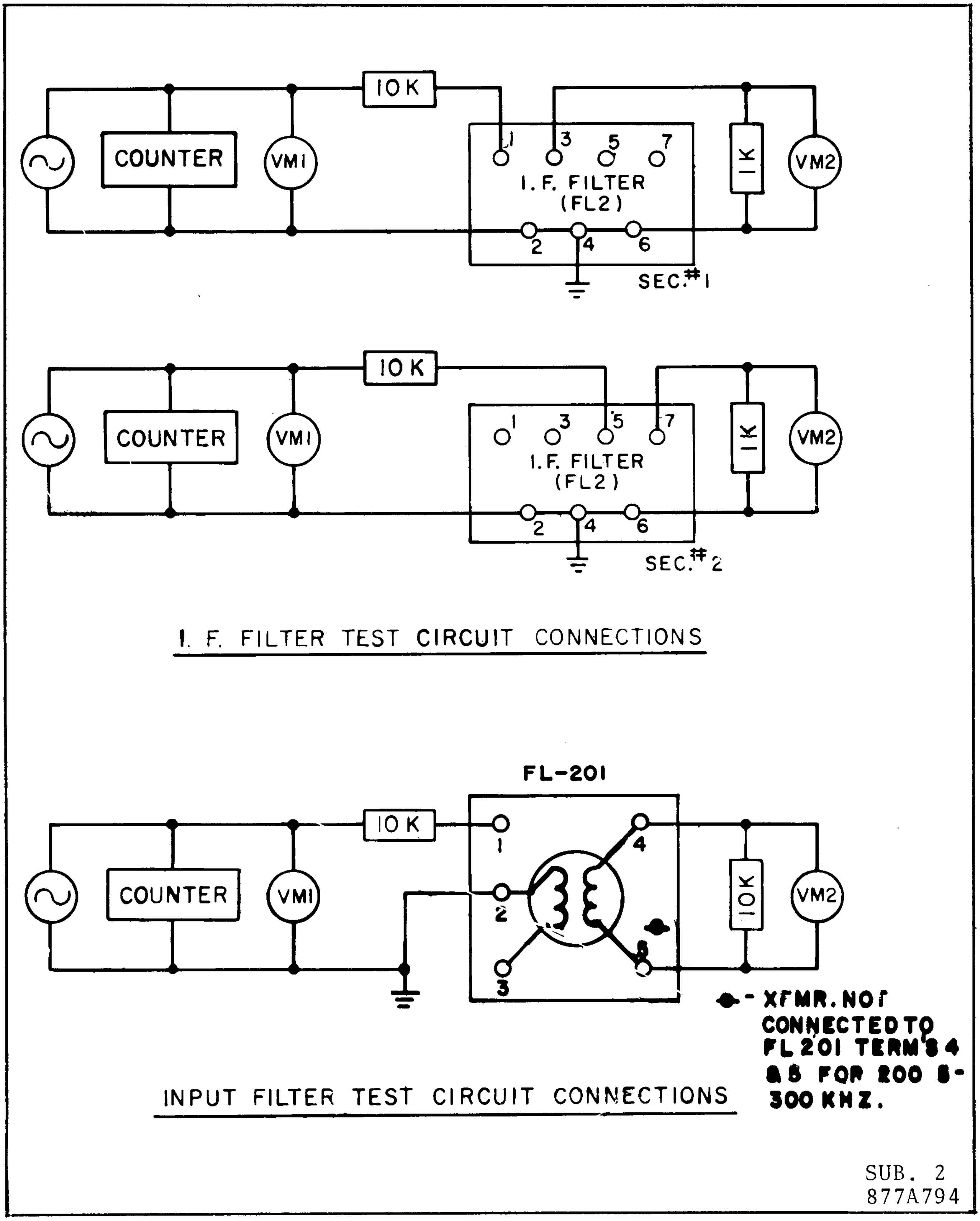


Fig. 16. Test Circuits for TCF-10 Receiver Filters

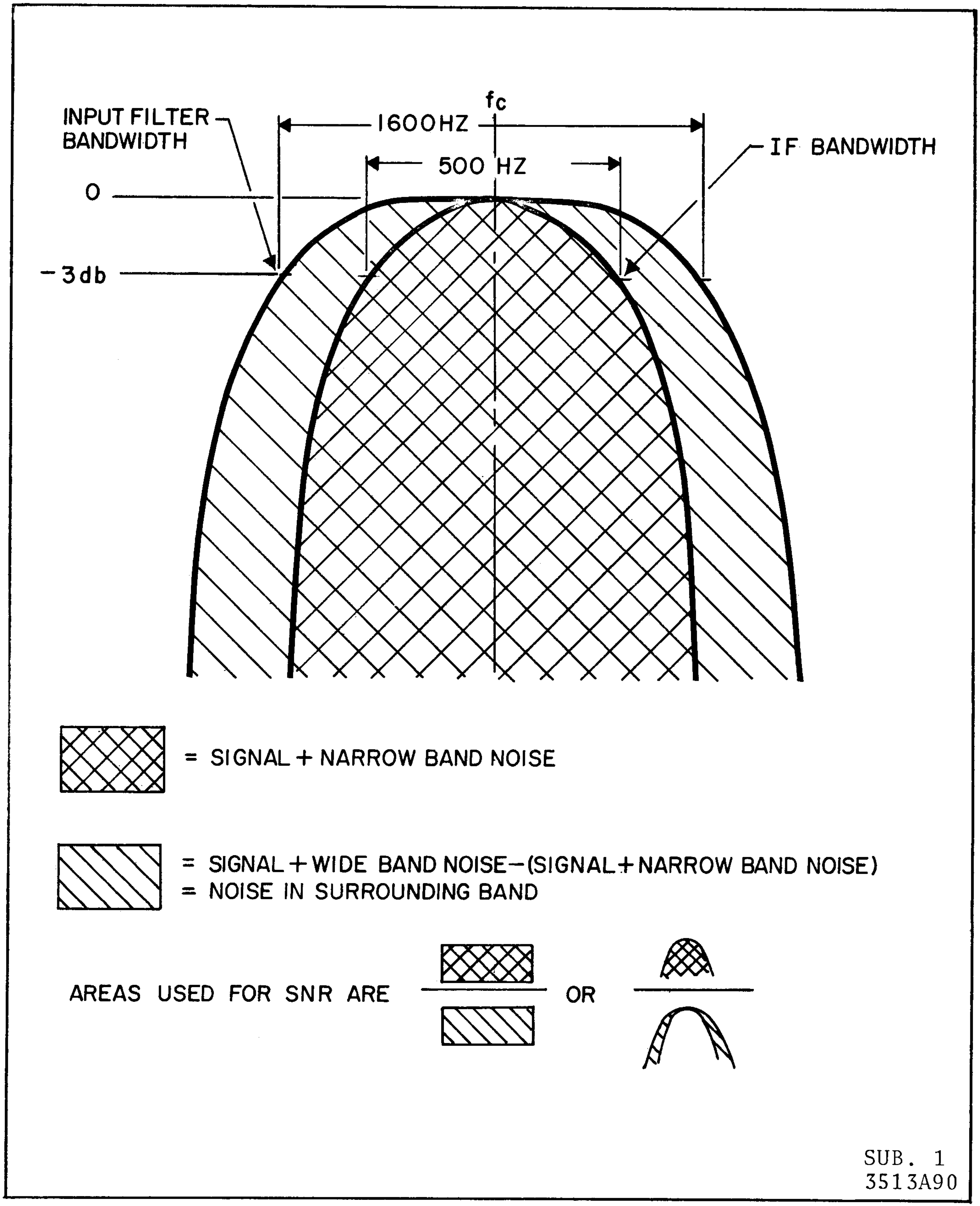


Fig. 17. Signal to Noise Ratio Characteristics

WESTINGHOUSE ELECTRIC CORPORATION

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

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TCF-10 POWER LINE CARRIER FREQUENCY SHIFT RECEIVER EQUIPMENT FOR DUAL PHASE – COMPARISON CARRIER RELAYING (SPCU, SKBU, OR SIMILAR SYSTEMS)

CAUTION

It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet, and in the system instruction leaflet before energizing the system.

Printed circuit modules should not be removed or inserted when the equipment is energized. Failure to observe this precaution may result in an undesired tripping output or cause component damage. Care should also be exercised when replacing modules to assure that they are replaced in the same chassis position from which they either were removed or the module they are replacing was removed.

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 TCF-10 Receiver described is for use with either the SPCU or SKBU Dual Phase Comparison relaying systems or similar systems utilizing frequency-shift keying (FSK). The TCF-10 frequency shift receiver responds to carrier-frequency signals transmitted from the distant end of a power line, and carried on the power line conductors. The space frequency (sometimes referred to as trip negative) is 100 hertz above the center frequency of the channel (which can be selected within the range of 30 kHz to 300 kHz). The mark frequency (sometimes referred to as trip positive) is 100 hertz below the channel center frequency. Generally, phase comparison information is conveyed over the channel during load current flow or fault conditions. The transmitter at each end of the channel is switched at a 60-hertz rate between space (or trip negative) and mark (or trip positive) so as to produce at the receiving end, the desired operation of the relaying system.

CONSTRUCTION

The TCF-10 receiver unit for dual phase comparison relaying applications such as the SPCU or SKBU systems, is mounted on a standard 19 inch wide chassis 5¼ inches high (3 rack units) with edge slots for mounting on a standard relay rack.

All of the circuitry that is suitable for mounting on printed circuit boards is contained on printed circuit modules that plug into the chassis from the front and are readily accessible by removing the transparent cover on the front of the chassis. The power supply components and external connectors are located at the rear of the chassis as shown in Figure 9. Reference to the internal schematic connections of Figure 1 will show the location of these components in the circuit.

The printed circuit modules slide into position in slotted guides at the top and bottom of the chassis, and the module terminals engage a terminal block at the rear of the chassis. A handle on the front of each module is labeled to identify its function, and also identify adjustments and indicating lights if any are available at the front of the module. Of particular significance, is the input attentuator contained on the front of the filter module which is used in adjusting the input receiver signal during initial field installation.

A module extender (Style No. 1447C86G01) is available for facilitating circuit measurements or major adjustments. After withdrawing any one of the circuit modules, the extender is inserted in that position. The module is then inserted into the terminal block on the front of the extender. This restores all circuit connections and renders all components and test points on the module readily accessible.

The receiver operates from a regulated +20V supply and a +10V supply operating from a regulated +45dc supply. These voltages are taken from three zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated dc supply, and the 45 volt zener adapt the receiver for operation on 48 or 125 volts dc.

External connections to the receiver are made through a 36 terminal recepticle, J3. The r-f input connection to the receiver is made through a coaxial cable jack J2.

OPERATION

INPUT MODULE

The input module contains the input control and the input filter. The signals to which the TCF-10 receiver responds are

The low signal level clamp operates off the carrier level signal of the S/N detection module which is basically the same signal fed to the CLI instrument.

It is fed through terminal 7 into the voltage comparator circuit built around operational amplifier IC21B. This comparator compares this signal level with the voltage reference from IC21A, and if the signal level is greater than the low level at which clamping is desired, the output of IC21B will be negative causing the yellow LED to glow indicating OK level and there will consequently be no low signal clamping. If the signal level is below the level at which clamping is desired, then the output of IC21B will be positive causing the red LED to glow indicating low level. In addition, both transistors Q67 and Q64 will become conducting. Transistor Q64 conducting will prevent mark and space signals from appearing on the outputs going to the relays by preventing transistors Q65 and Q62 from conducting. Transistor Q67 conducting causes Q68 to become non-conducting and thus removes the not low signal output from terminal 1. Under good or OK signal level, this not low signal output at terminal 1 of this module is plus 20 volts.

The S/N clamp output from the S/N detection module is fed into terminal 35 of this module. At low signal-to-noise ratio level, this +16 volt signal will cause transistors Q70 and Q61 to conduct. Transistor Q70 conducting will cause both the red LED to glow indicating low S/N and transistor Q71 to conduct supplying plus 20 volts out of terminal 13 to the protective relays. Transistor Q61 conducting will prevent both transistors Q62 and Q65 from conducting, and thus prevent either a mark or space signal from appearing at their respective outputs to the protective relays. It should be noted that the S/N clamp also operates for a high signal level of approximately plus 25dB above normal when set to operate at 10dB signal to noise ratio.

POWER SUPPLY

The regulated 45 volt dc, 20V dc, and 10V dc circuits of the receiver are supplied from zener regulators mounted on a common heat sink at the rear of the chassis. Resistors R3 and R7 of suitable value are connected between the station battery supply and the 45 volt zener regulator to adapt the receiver for use on 48 or 125 volt dc battery circuits. Capacitor C1 and C2 bypass rf or transient voltages to ground. Choke L1 with capacitor C3 form a trap to isolate the receiver from transient voltages in the 20kHz range that may appear on the dc supply and which could affect the receiver.

CHARACTERISTICS

Center Frequencies Available	30kHz to 300kHz in 0.5kHz increments
Sensitivity (Noise free channel)	0.005 volts (65dB below 1 watt for limiting)
Input Impedence	5000 ohms minimum
Bandwidth (Input L C Filter)	Down 3dB at ±800 hertz Down 30dB at ±5000 hertz
Overall receiver selectivity	Down 3dB at ±225 hertz Down 35dB at ±1000 hertz
Operating Time	4 milliseconds channel (Transmitter and receiver back to back)
Signal-to-noise ratio clamp setting	10dB SNR (as shipped)
Ambient Temperature Range	−20°C to +75°C
Battery Voltage Variations	
Nominal 48V dc	42V dc − 56V dc
Nominal 125V dc	105V dc − 140V dc
Battery Drain	0.25 amperes
Dimensions	Panel Height = 5¼ inches (3RU) Panel Width = 19 inches
Weight	13 pounds

INSTALLATION

The TCF receiver is generally supplied in a cabinet or a relay rack as part of a complete carrier assembly. The location must be free from dust, excessive humidity, vibration, corrosive fumes, or heat. In particular equipment which generates excessive heat such as power supplies should not be mounted directly beneath it as this heat in rising will tend to raise the ambient temperature immediately around the chassis above acceptable levels. The maximum ambient temperature around the chassis must not exceed 75 C. In addition, sudden fluctuations in ambient temperature caused by these power supplies due to variations in load can cause variations in performance due to uneven heating of the receiver introducing abnormal temperature variations in the receiver.

ADJUSTMENTS

All factory adjustments of the TCF receiver have been carefully made and should not be altered unless there is evidence of damage or malfunctioning. Such adjustments are: frequency and output level of the oscillator and mixer; input to the amplifier and limiter; frequency spacing and magnitude of discriminator output peaks; pickup of signal to noise ratio clamp; and pickup of low signal level clamp. The adjustment that must be made at time of installation is the setting of input attenuator R5. The input attenuator adjustment is made by a knob on the front of the panel of the input module.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation to attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15dB below the maximum expected signal. After installation of the receiver and the corresponding transmitter, and with a normal space signal level being received, input attenuator R5 should be adjusted to the position at which the receiver clamps into neither a mark nor space output. The attenuator R5 should then be readjusted to increase the voltage supplied to the receiver by 15dB. The scale markings for R5 permit approximate settings to be made, but it is preferable to make this setting by means of the dB scales of an ac VTVM connected across the terminals indicated at the front panel of the input module. The red terminal is connected to the wiper arm of R5 and the black terminal is connected to ground. With this setting, a 15dB drop in signal will cause a low signal level clamp operation which will lock the output of the receiver into neither a mark nor a space output at the point at which the receiver just drops out of limiting.

The only other adjustment which may be necessary at the time of initial installation is the adjustment of the CL1 instrument to correspond to proper variation of signal level from normal. This may be necessary if the instrument was not supplied with the receiver and was not adjusted by the factory. If this instrument was supplied and adjusted by the factory, then it could be used in adjusting R5. In this case, it would be necessary only to adjust R5 with a normal signal being received so that the instrument indicates OdB.

If the instrument was not previously adjusted by the factory, then the following procedure should be used in adjusting the instrument.

1. Set incoming level into receiver at +10dB above normal level
2. Adjust span adjustment, R147, so that the voltage at TP72 with respect to TP62 (common) is +3.000 volts.
3. Reduce incoming signal into receiver by 25dB.
4. Adjust full scale adjustment, R153, so that instrument now reads −15dB. (This is approximately 16.7 microamperes).
5. Increase signal to nominal level. Instrument should now read OdB. (This is 66.7 microamperes). If not, repeat Step 2.

FACTORY ADJUSTMENTS

In case the factory adjustments have been altered or there is suspicion of improper adjustments or malfunctioning, then the following procedures can be used. In addition, alterations to the settings used by the factory for low signal level clamping and low signal-to-noise ratio clamping can be made using these procedures if desired.

Potentiometer R12 in the oscillator and mixer should be set for 0.3 volts, measured with a VTVM connected between TP11 and terminal 33 on the circuit board (ground terminal of voltmeter). A frequency counter can be connected to the same points for a check on the frequency which should be 20kHz above the channel center frequency. The frequency is fixed by the crystal used, except that it may be changed a few cycles by the value of capacitor C12. Reducing C12 increases the frequency, but the capacity should never be less than a value that assures reliable starting of oscillation. The frequency at room temperature is usually several cycles above the crystal nominal frequency as this reduces the frequency deviation at the temperature extremes.

The adjustment of the amplifier and limiter is made by potentiometer R52. An oscilloscope should be connected from TP56 at the base of Q54 to terminal 33 of the limiter. With 5 millivolts of space frequency on the receiver input (R5 set at zero), R52 should be adjusted to the point where the peaks of the oscilloscope trace begin to flatten. This should appear on the upper and lower peaks at approximately the same setting.

The adjustment of the signal to noise ratio clamp for clamping at 10dB signal to noise ratio is as follows:

1. Set the incoming signal into receiver at nominal level (28 mv.)
2. Adjust I.F. input with R111 so that signal at TP68 of the S/N detector module is +100 mv d.c. (with respect to TP62).
3. Adjust RF input with R94 so that signal at TP63 is +120 mv d.c. (with respect to TP62).
4. Measure level at TP66. It should be +100 mv d.c. If not, readjust R94 to obtain this value with respect to TP62.
5. Adjust log amplifier balance potentiometer R129 so that S/N clamps operates. This will be +16 volts dc at TP75. This will also appear as +20 volts at TP91 of the output board and the red S/N level indicator will light.
6. Go back and readjust RF input with R94 so that signal level at TP63 is now 74.4 mv d.c.

The adjustments above are for operation of the clamp at 10dB or less signal to noise ratios. If it is desired to clamp at other than 10dB or less, the following values can be used in place of the 74.4 mv value in step 6.

For S/N of 0dB set TP63 to 55mv.

5dB set TP63 to 64mv.

15dB set TP63 to 84.7mv.

20dB set TP63 to 93.1mv.

Note: When the SNR clamp is set to clamp at a 10dB signal to noise ratio, the receiver will also clamp at a high signal level of approximately 25dB above normal.

The low signal level clamp is set to operate at the signal level where the receiver just drops out of limiting. This is accomplished as follows:

1. With a normal space frequency signal being received and with an oscilloscope connected across TP56 and terminal 33 of the limiter module, adjust input attenuator R5 to the point where the peaks of the oscilloscope trace just begin to flatten. (An alternate adjustment would be to set incoming signal level into receiver at 5mv with R5 set at zero which is the point at which limiting should begin).
2. Adjust the -V Ref. adjustment R178 on the output module so that the low level clamp just picks up. This will be indicated by the red low level light on the output module coming on. There also will be +20 volts at TP86 on the output module.
3. Adjust input attenuator R5 to increase signal into receiver by desired margin of operation. This normally should be 15dB. This is done by reducing the R5 attenuator setting.

MAINTENANCE

Periodic checks of the received carrier signal level and the receiver sentitivity will detect gradual deterioration and permit its correction before failure can result. The carrier level indicator, when provided, permits ready observation of the received signal level. With or without a carrier level indicator, an overall check can be made with the attenuation control, R5. A change in operating margin from the original setting can be detected by observing the change in the dial setting required to cause a low signal level clamp to operate as indicated by the red LED becoming lit. If there is a substantial reduction in margin, the signal voltage at the receiver input should be checked to see whether the reduction is due to loss of signal level or loss in receiver sensitivity.

All adjustable components for normal field adjustments on the printed circuit modules are accessible when the front cover on the chassis is removed. All other adjustable components on the printed circuit modules may be made entirely accessible while permitting electrical operation by using module extender style number 1447C86G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

TABLE I
RECEIVER D-C MEASUREMENTS

NOTE: All voltage readings taken with ground of dc VTVM on terminal 17 (negative dc). Receiver adjusted for 15dB operating margin with Space and Mark signals down 50dB from 1 watt or 60dB down from 10 watts. Unless indicated otherwise, voltage will not vary appreciably whether signal is mark, space or zero.

Collector of Transistor or Test Point	Voltage (Positive)
Q11	< 13
Q12 (TP12)	15 (Mark or Space)
Q13 (TP13)	15 (Mark or Space)
Q14 (TP14)	2.5
Q15 (TP15)	2.5
TP11	18
TP52	16
Q51 (TP51)	11.5
Q52 (TP53)	12
Q53 (TP54)	15.5
Q54 (TP55)	2.5
TP56	16
Q55	< 1 (Mark or No Signal)
Q55	19.5 (Space)
Q56	19.5 (Mark)
Q56	< 1 (Space or No Signal)
TP61	10.4
TP62	10
TP63	10.4
TP64	18
TP65	0
TP66	10
TP67	10.5
TP68	10.5
TP69	10
TP70	4
TP71	16
TP72	11.4
TP73	10.8
TP74	10.3
TP81	20 (Space)
TP81	0 (Mark or No Signal)
TP82	20 (Mark)

Collector of Transistor or Test Point	Voltage (Positive)
TP82	0 (Space or No Signal)
TP83	20 (Space)
TP83	0 (Mark, No Signal, or clamp)
TP84	20 (Mark)
TP84	0 (Space, No Signal or clamp)
TP85	10.3
TP86	20 (Low level clamp)
TP86	0 (No clamp)
TP87	16V (Low SNR Clamp)
TP87	4V (No SNR Clamp)
TP88	20
TP89	0
TP90	20 (Good Signal Level)
TP90	0 (Low Signal Level clamp)

TABLE II
RECEIVER RF MEASUREMENTS

NOTE: Voltmeter readings taken at any point from receiver input to stage involving transistor Q15 are neither meaningful or feasible because of either waveform variations or the effect of instrument loading on the readings. Receiver adjusted as Table I.

Collector of Transistor or Test Point	Volts with Signal At +10dB Above Normal Level
Q15 (TP15)	0.8
Q51 (TP51)	0.9
Q52 (TP53)	0.65
Q53 (TP54)	2.2
Q54 (TP55)	4.5
TP61	.013
TP67	.275

FILTER RESPONSE MEASUREMENTS

The LC input filter (FL201) and the IF Filter (FL2) are in sealed containers, and repairs can only be made by the factory. The stability of the original response characteristics is such that in normal usage, no appreciable change in response will occur. However, the test circuits of Figure 16 can be used in case there is reason to suspect that either of the filters is not performing correctly.

Figure 15 shows the −3dB and −35dB checkpoints for the IF filter, and the −3dB checkpoints for the input filter. The response curve of the IF filter shows the combined effect of the two sections, and was obtained by adding the attenuation of each section for identical frequencies. The scale of Figure 15 was chosen to show the IF filter response, which permitted only a portion of the input filter curve to be shown. The checkpoints for the passband of each section of each section of the IF filter are down 3dB maximum at 19.75 and 20.25kHz, and for the stop band are down 18dB minimum at 19.00 and 21.00kHz for each section. The signal generator voltage (Figure 16) must be held constant throughout the entire check. A value of 7.8 volts is suitable. The reading of VM2 at the frequency of minimum attenuation should not be more than 22dB below the reading of VM1. It should be noted that a limit measured in this manner is for convenience only, and does not indicate actual insertion loss of the filter. The insertion loss would be approximately 16dB less than the measured difference because of the input resistance and the difference in input and output impedances of the filter.

In testing the LC filter, a value of approximately 2.45V is suitable for the constant voltage at which to hold VM1 throughout the check. The reading of VM2 at the frequency of minimum attenuation will vary somewhat with the channel frequency, but should not be more than 18dB below the reading of VM1. (The filter insertion loss is approximately 6dB less than the difference in readings).

CONVERSION OF RECEIVER FOR CHANGED CHANNEL FREQUENCY.

The parts required for converting a TCF receiver for operating at a different channel frequency consist of a new LC input filter (FL201), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). There are two ways of effecting this change. The easiest and preferred method is to order a new input filter module and a new oscillator mixer module for the new frequencies from the factory. The new modules would then just have to be plugged in as replacements for the original modules. The second method would involve ordering just replacement filter, FL201, and new local oscillator crystal for the new frequencies and making the substitution on the modules. These substitutions on the modules are not difficult as the crystal plugs in and the filter has five leads to be soldered. However, testing of the local oscillator for easy starting will have to be made, and the value of C12 chosen to assure this easy starting of oscillation. The whole receiver should then be checked out for correct performance.

RECOMMENDED TEST EQUIPMENT

1. **Minimum Test Equipment for Installation**

   a. A-C vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60Hz to 330kHz, input impedance 7.5 megohms.

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

Voltage Range:	1.5 to 300 volts
Input Impedance:	7.5 megohms

c. Milliammeter, 0-3 range, (if receiver has carrier level indicator).

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-kHz to 330kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

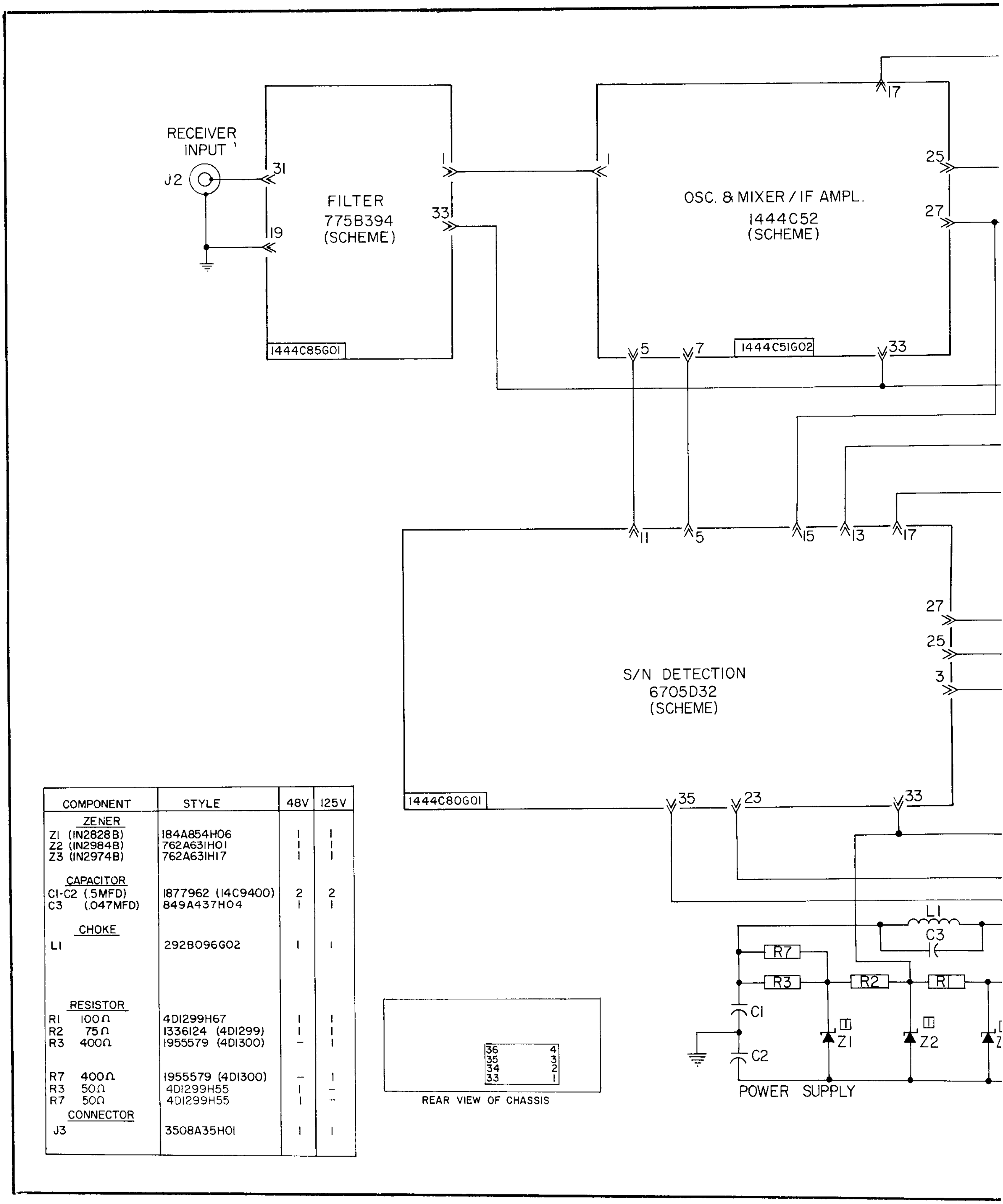
f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5

Some of the functions of the recommended test equipment are combined in the type TCT carrier test meter unit which is designed to mount on a standard 19" rack but also can be removed and used as a portable unit.

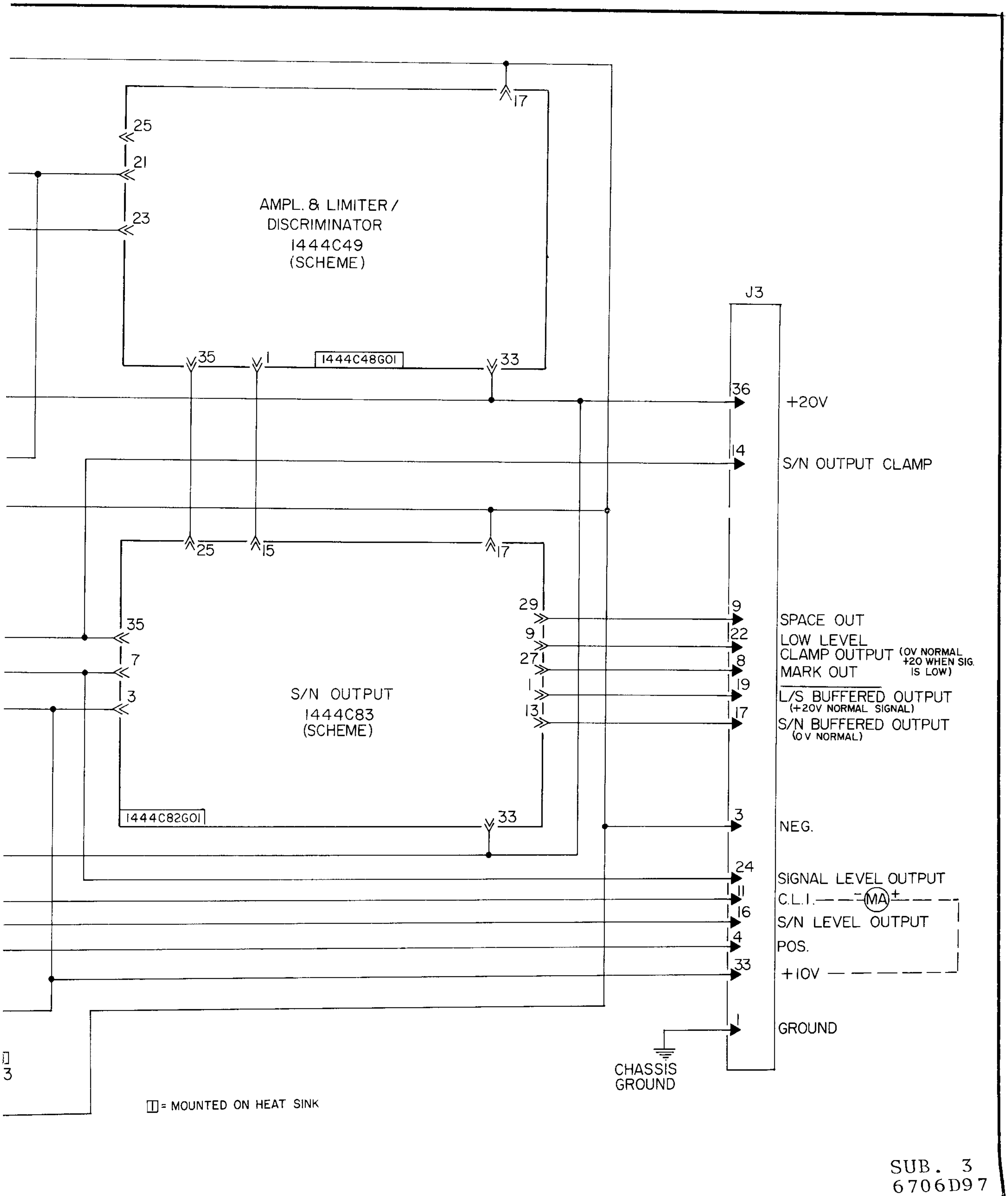
RENEWAL PARTS

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, the electrical value, style number, and identify the part by its designation on the Internal Schematic drawing.

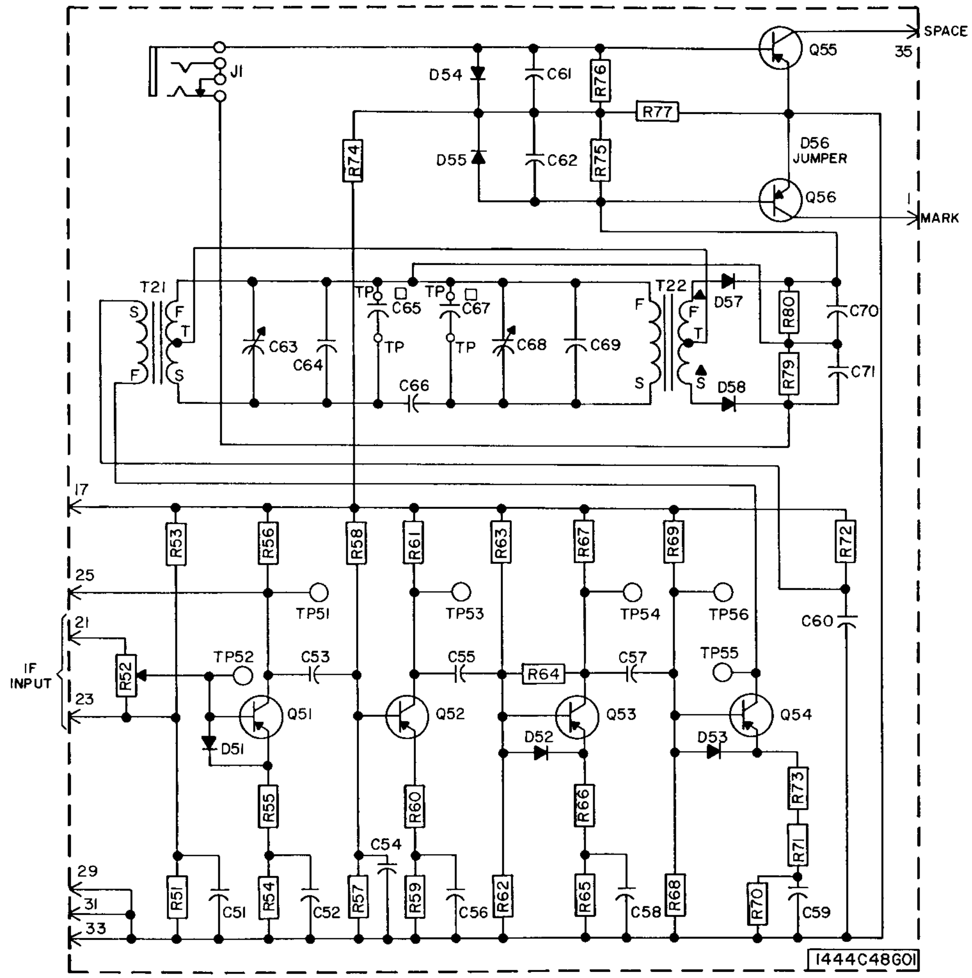


COMPONENT	STYLE	48V	125V
ZENER			
Z1 (IN2828B)	184A854H06	1	1
Z2 (IN2984B)	762A631H01	1	1
Z3 (IN2974B)	762A631H17	1	1
CAPACITOR			
C1-C2 (.5MFD)	1877962 (14C9400)	2	2
C3 (.047MFD)	849A437H04	1	1
CHOKE			
L1	292B096G02	1	1
RESISTOR			
R1 100Ω	4D1299H67	1	1
R2 75Ω	1336124 (4D1299)	1	1
R3 400Ω	1955579 (4D1300)	–	1
R7 400Ω	1955579 (4D1300)	–	1
R3 50Ω	4D1299H55	1	–
R7 50Ω	4D1299H55	1	–
CONNECTOR			
J3	3508A35H01	1	1

Fig. 1. Schematic of TC


AMPL. & LIMITER / DISCRIMINATOR
1444C49
(SCHEME)
1444C48G01
S/N OUTPUT
1444C83
(SCHEME)
1444C82G01
J3
+20V
S/N OUTPUT CLAMP
SPACE OUT
LOW LEVEL CLAMP OUTPUT (0V NORMAL +20 WHEN SIG. IS LOW)
MARK OUT
L/S BUFFERED OUTPUT (+20V NORMAL SIGNAL)
S/N BUFFERED OUTPUT (0 V NORMAL)
NEG.
SIGNAL LEVEL OUTPUT
C.L.I.
MA
S/N LEVEL OUTPUT
POS.
+10V
GROUND
CHASSIS GROUND
= MOUNTED ON HEAT SINK
SUB. 3
6706D97

-10 Receiver



COMPONENT		DESCRIPTION	STYLE NO.
C51	CAPACITOR	.250UF 200V	187A624H02
C52	CAPACITOR	.250UF 200V	187A624H02
C53	CAPACITOR	.100UF 200V	187A624H01
C54	CAPACITOR	1300.000PF 500V	187A584H15
C55	CAPACITOR	.100UF 200V	187A624H01
C56	CAPACITOR	.250UF 200V	187A624H02
C57	CAPACITOR	.100UF 200V	187A624H01
C58	CAPACITOR	.250UF 200V	187A624H02
C59	CAPACITOR	.250UF 200V	187A624H02
C60	CAPACITOR	1.000UF 200V	187A624H04
C61	CAPACITOR	.220UF 50V	762A703H01
C62	CAPACITOR	.220UF 50V	762A703H01
C63	CAPACITOR	4.5 TO 100PF	762A736H02
C64	CAPACITOR	9100.000PF 200V	187A624H16
C65	CAPACITOR	SEE NOTE □	
C66	CAPACITOR	100.000PF 500V	187A684H08
C67	CAPACITOR	SEE NOTE □	
C68	CAPACITOR	4.5 TO 100PF	762A736H02
C69	CAPACITOR	9100.000PF 200V	187A624H16
C70	CAPACITOR	.220UF 50V	762A703H01
C71	CAPACITOR	.220UF 50V	762A703H01
D51	DIODE	1N457A	184A855H07
D52	DIODE	1N457A	184A855H07
D53	DIODE	1N457A	184A855H07
D54	DIODE	1N457A	184A855H07
D55	DIODE	1N457A	184A855H07
D56	JUMPER		862A478H01
D57	DIODE	1N628	184A855H12
D58	DIODE	1N628	184A855H12
R51	RESISTOR	4700.0 .50W 5%	184A763H43
R53	RESISTOR	27.0K .50W 5%	184A763H61
R54	RESISTOR	2200.0 .50W 5%	184A763H35
R55	RESISTOR	27.0 .50W 5%	187A290H11
R56	RESISTOR	10.0K .50W 5%	184A763H51
R57	RESISTOR	4700.0 .50W 5%	184A763H43
R58	RESISTOR	27.0K .50W 5%	184A763H61
R59	RESISTOR	1500.0 .50W 5%	184A763H31
R60	RESISTOR	180.0 .50W 5%	184A763H09
R61	RESISTOR	4700.0 .50W 5%	184A763H43
R62	RESISTOR	2200.0 .50W 5%	184A763H35
R63	RESISTOR	33.0K .50W 5%	184A763H63
R64	RESISTOR	2700.0 .50W 5%	184A763H37
R65	RESISTOR	680.0 .50W 5%	184A763H23
R66	RESISTOR	68.0 .50W 5%	187A290H21
R67	RESISTOR	4700.0 .50W 5%	184A763H43
R68	RESISTOR	2700.0 .50W 5%	184A763H37
R69	RESISTOR	18.0K .50W 5%	184A763H57
R70	RESISTOR	220.0 .50W 5%	184A763H11
R71	RESISTOR	68.0 .50W 2%	629A531H04
R72	RESISTOR	330.0 .50W 5%	184A763H15
R73	RESISTOR	56.0 .50W 2%	629A531H02
R74	RESISTOR	12.0K .50W 5%	184A763H53
R75	RESISTOR	3000.0 .50W 5%	184A763H38
R76	RESISTOR	3000.0 .50W 5%	184A763H38
R77	RESISTOR	220.0 .50W 5%	184A763H11
R79	RESISTOR	2200.0 .50W 5%	184A763H35
R80	RESISTOR	2200.0 .50W 5%	184A763H35
R52	POT	1.0K .50W	629A645H04
Q51	TRANSISTOR	2N4249	849A441H03
Q52	TRANSISTOR	2N4249	849A441H03
Q53	TRANSISTOR	2N4249	849A441H03
Q54	TRANSISTOR	2N4249	849A441H03
Q55	TRANSISTOR	2N3645	849A441H01
Q56	TRANSISTOR	2N3645	849A441H01
T21	TRANSFORMER		606B533G01
T22	TRANSFORMER		606B533G02
J1	TELEPHONE JACK		187A606H01

□–ONE OR TWO CAPACITORS USED; VALUES DETERMINED IN TEST.

▲–FOR STYLE 1444C48G03 REVERSE START AND FINISH LEADS OF T22.

SUB. 2
14449C49

Fig. 6. Internal Schematic Amplifier Limiter-Discriminator Module

COMPONENT		DESCRIPTION			STYLE NO.
R81	RESISTOR	1000.0	.50W	1%	848A819H48
R82	RESISTOR	2210.0	.50W	1%	848A819H81
R83	RESISTOR	10.2K	.25W	1%	848A820H46
R84	RESISTOR	10.0K	.25W	1%	848A820H45
R85	RESISTOR	56.2K	.25W	1%	848A821H18
R86	RESISTOR	10.0K	.50W	1%	848A820H45
R87	RESISTOR	2210.0	.50W	1%	848A819H81
R88	RESISTOR	10.2K	.25W	1%	848A820H46
R89	RESISTOR	10.0K	.25W	1%	848A820H45
R90	RESISTOR	82.5K	.50W	1%	848A821H34
R91	RESISTOR	10.0K	.50W	1%	848A820H45
R92	RESISTOR	6190.0	.50W	1%	848A820H25
R93	RESISTOR	4990.0	.50W	1%	848A820H16
R95	RESISTOR	4750.0	.25W	1%	848A820H14
R96	RESISTOR	4750.0	.25W	1%	848A820H14
R97	RESISTOR	4990.0	.50W	1%	848A820H16
R98	RESISTOR	15.0K	.50W	1%	848A820H62
R99	RESISTOR	4990.0	.50W	1%	848A820H16
R100	RESISTOR	4990.0	.50W	1%	848A820H16
R101	RESISTOR	4990.0	.50W	1%	848A820H16
R102	RESISTOR	10.0K	.50W	1%	848A820H45
R103	RESISTOR	10.0K	.50W	1%	848A820H45
R104	RESISTOR	10.0K	.50W	1%	848A820H45
R105	RESISTOR	10.0K	.50W	1%	848A820H45
R106	RESISTOR	10.0K	.50W	1%	848A820H45
R107	RESISTOR	10.0K	.50W	1%	848A820H45
R108	RESISTOR	100.0K	.50W	1%	848A821H42
R109	RESISTOR	10.0K	.50W	1%	848A820H45
R110	RESISTOR	1000.0	.50W	1%	848A819H48
R112	RESISTOR	4750.0	.25W	1%	848A820H14
R113	RESISTOR	4750.0	.25W	1%	848A820H14
R114	RESISTOR	15.0K	.50W	1%	848A820H62
R115	RESISTOR	4990.0	.50W	1%	848A820H16
R116	RESISTOR	4990.0	.50W	1%	848A820H16
R117	RESISTOR	4990.0	.50W	1%	848A820H16
R118	RESISTOR	4990.0	.50W	1%	848A820H16
R119	RESISTOR	10.0K	.50W	1%	848A820H45
R120	RESISTOR	1000.0	.50W	1%	848A819H48
R121	RESISTOR	15.0K	.50W	1%	848A820H62
R122	RESISTOR	15.0K	.50W	1%	848A820H62
R123	RESISTOR	10.0K	.50W	1%	848A820H45
R124	RESISTOR	10.0K	.50W	1%	848A820H45
R125	RESISTOR	10.0K	.50W	1%	848A820H45
R126	RESISTOR	10.0K	.50W	1%	848A820H45
R127	RESISTOR	2.0K	.50W	1%	848A819H77
R128	RESISTOR	9530.0	.50W	1%	848A820H43
R130	RESISTOR	9530.0	.50W	1%	848A820H43
R131	RESISTOR	10.0K	.50W	1%	848A820H45
R132	RESISTOR	10.0K	.50W	1%	848A820H45
R133	RESISTOR	10.0K	.50W	1%	848A820H45
R134	RESISTOR	10.0K	.50W	1%	848A820H45
R135	RESISTOR	10.0K	.50W	1%	848A820H45
R136	RESISTOR	15.0K	.50W	1%	848A820H62
R137	RESISTOR	10.0K	.50W	1%	848A820H45
R138	RESISTOR	10.0K	.50W	1%	848A820H45
R139	RESISTOR	10.0K	.50W	1%	848A820H45
R140	RESISTOR	475.0K	.25W	1%	848A822H08
R141	RESISTOR	698.0K	.50W	1%	848A822H24
R142	RESISTOR	150.0	.50W	1%	848A818H68
R144	RESISTOR	750.0	.50W	1%	848A819H36
R145	RESISTOR	18.7K	.50W	1%	848A820H71
R146	RESISTOR	4990.0	.50W	1%	848A820H16
R148	RESISTOR	1000.0	.50W	1%	848A819H48
R149	RESISTOR	15.0K	.50W	1%	848A820H62
R150	RESISTOR	2.0K	.50W	1%	848A819H77
R151	RESISTOR	2.0K	.50W	1%	848A819H77
R152	RESISTOR	17.8K	.25W	1%	848A820H69
R154	RESISTOR	681.0	.50W	1%	848A819H32
R155	RESISTOR	150.0	.50W	1%	848A818H68
R156	RESISTOR	150.0	.50W	1%	848A818H68
R157	RESISTOR	20.0K	.50W	1%	848A820H74
R158	RESISTOR	20.0K	.50W	1%	848A820H74

COMPONENT		DESCRIPTION		STYLE NO.
R94	POT	20.0K	.50W	629A645H05
R111	POT	50.0K	.50W	629A645H06
R129	POT	2.5K	.25W	629A645H07
R147	POT	250.0K	.75W	880A826H10
R153	POT	2.5K	.25W	629A645H07
C81	CAPACITOR	2000.000PF	500V	187A584H01
C82	CAPACITOR	1000.000PF	200V	880A397H07
C83	CAPACITOR	220.000PF	200V	879A989H17
C84	CAPACITOR	.010UF	50V	184A663H01
C85	CAPACITOR	1.000UF	50V	3512A08H01
C86	CAPACITOR	.010UF	50V	184A663H01
C87	CAPACITOR	2000.000PF	500V	187A584H01
C88	CAPACITOR	1000.000PF	200V	880A397H07
C89	CAPACITOR	33.000PF	200V	879A989H07
C90	CAPACITOR	.010UF	50V	184A663H01
C91	CAPACITOR	.010UF	50V	184A663H01
C92	CAPACITOR	1.000UF	50V	3512A08H01
C93	CAPACITOR	.010UF	50V	184A663H01
C94	CAPACITOR	33.000PF	200V	879A989H07
C95	CAPACITOR	.010UF	50V	184A663H01
C96	CAPACITOR	.010UF	50V	184A663H01
C97	CAPACITOR	.470UF	50V	762A680H04
C98	CAPACITOR	33.000PF	200V	879A989H07
C99	CAPACITOR	.010UF	50V	184A663H01
C100	CAPACITOR	.010UF	50V	184A663H01
C101	CAPACITOR	33.000PF	200V	879A989H07
C102	CAPACITOR	.010UF	50V	184A663H01
C103	CAPACITOR	33.000PF	200V	879A989H07
C104	CAPACITOR	.010UF	50V	184A663H01
C105	CAPACITOR	.010UF	50V	184A663H01
C106	CAPACITOR	.047UF	50V	848A646H07
C107	CAPACITOR	33.000PF	200V	879A989H07
C108	CAPACITOR	.010UF	50V	184A663H01
C109	CAPACITOR	.010UF	50V	184A663H01
C110	CAPACITOR	1.000UF	50V	3512A08H01
IC1	INT CKT	SE531T		3512A10H01
IC2	INT CKT	SE531T		3512A10H01
IC3	INT CKT	SE531T		3512A10H01
IC4	INT CKT	SE531T		3512A10H01
IC5	INT CKT	SE531T		3512A10H01
IC6	INT CKT	747DM		1443C52H01
IC7	INT CKT	SE531T		3512A10H01
IC8	INT CKT	SE531T		3512A10H01
IC9	INT CKT	SN56502		3512A09H01
IC10	INT CKT	747DM		1443C52H01
IC11	INT CKT	747DM		1443C52H01
IC12	INT CKT	SN56502		3512A09H01
IC13	INT CKT	747DM		1443C52H01
D61	DIODE	1N4148		836A928H06
D62	DIODE	1N4148		836A928H06
D63	DIODE	1N4148		836A928H06
D64	DIODE	1N4148		836A928H06
D65	DIODE	1N4148		836A928H06
Z11	ZENER	1N748A	3.9V	186A797H13
Z12	ZENER	1N748A	3.9V	186A797H13
Z113	ZENER	1N825A	6.2V	862A288H06
J111	JUMPER	0 OHM RESISTOR		862A478H01
J112	JUMPER	0 OHM RESISTOR		862A478H01
J113	JUMPER	0 OHM RESISTOR		862A478H01
J114	JUMPER	0 OHM RESISTOR		862A478H01

SUB. 4
SHEET 2
6705D32

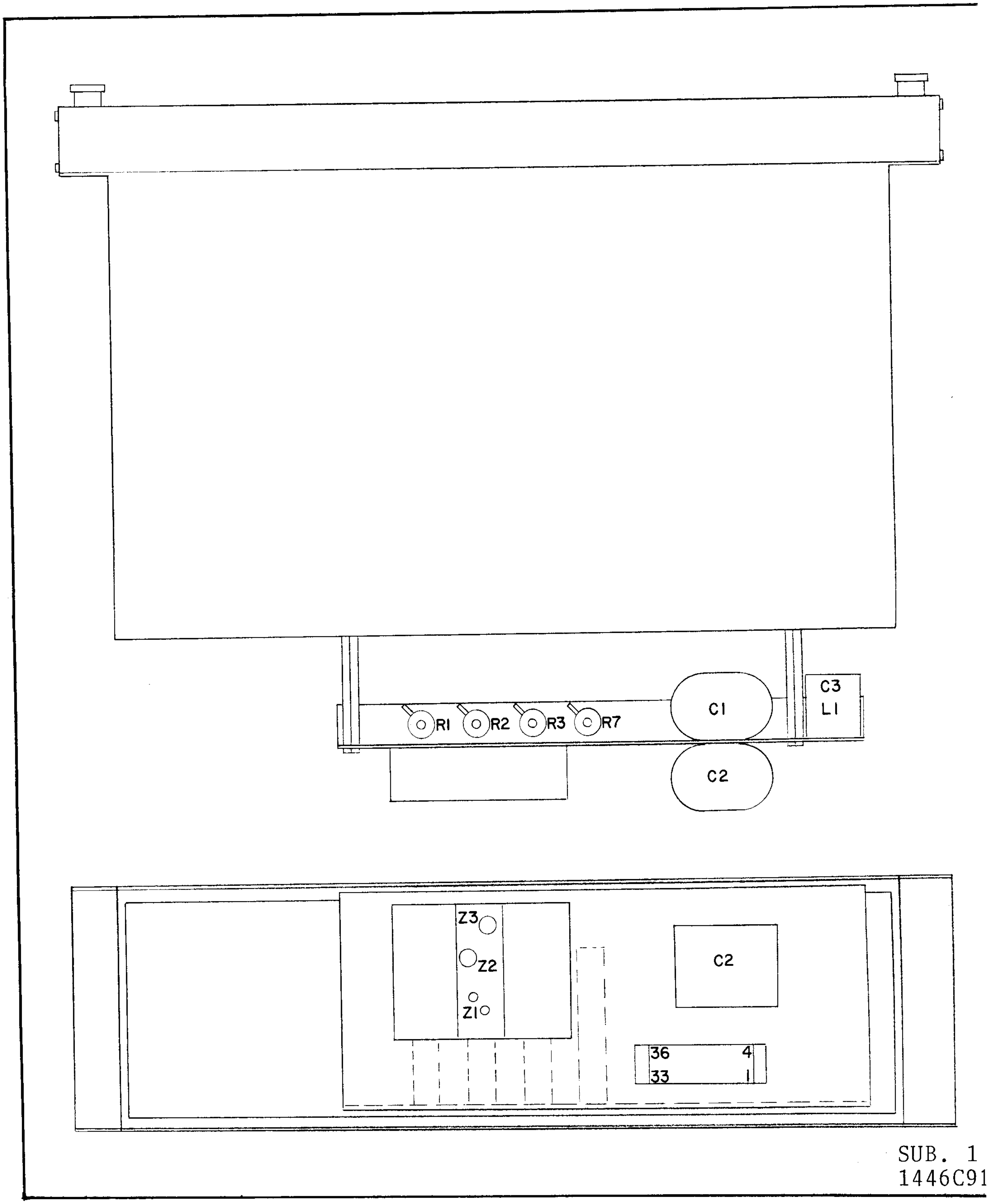


Fig. 9. Component Location TCF-10 Receiver

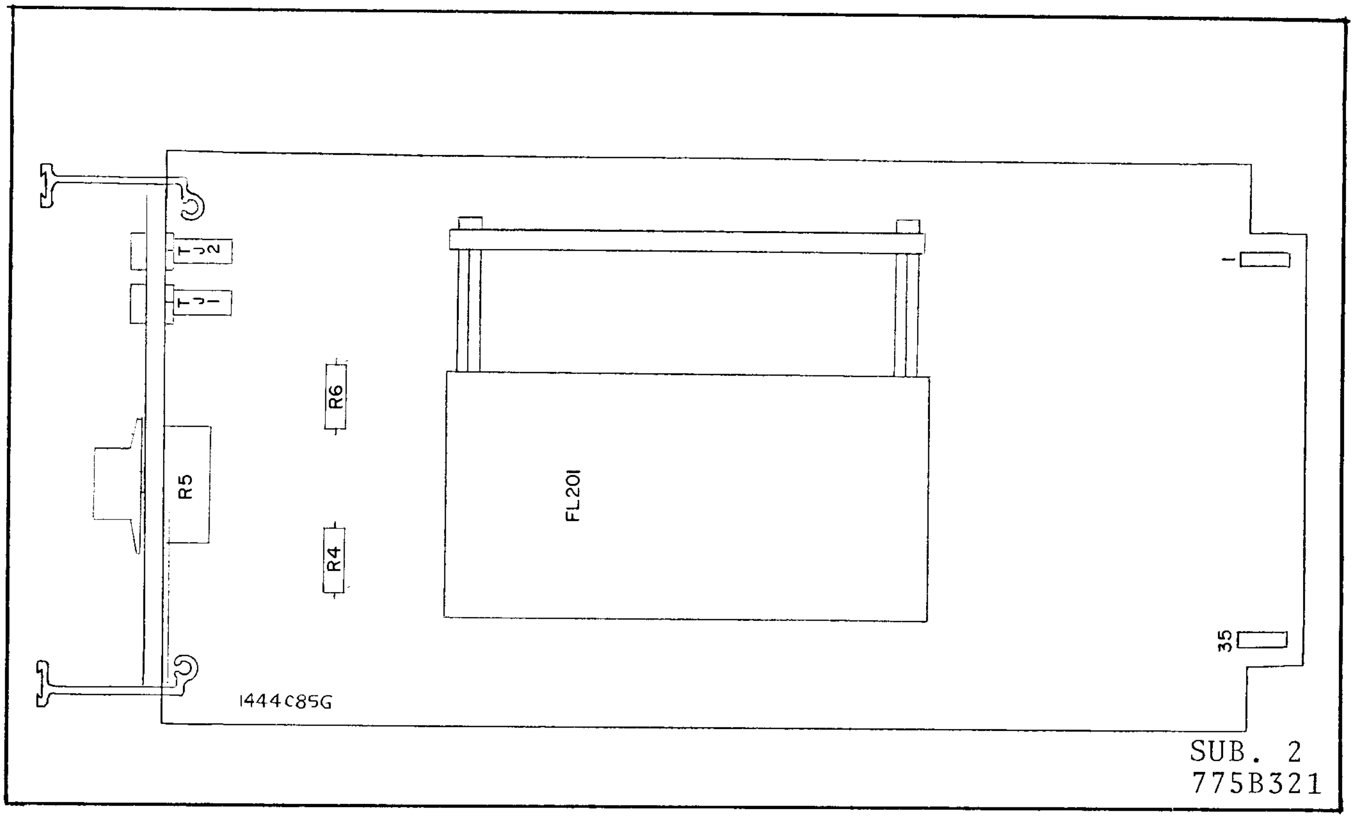


Fig. 10. Component Location Input Filter Module

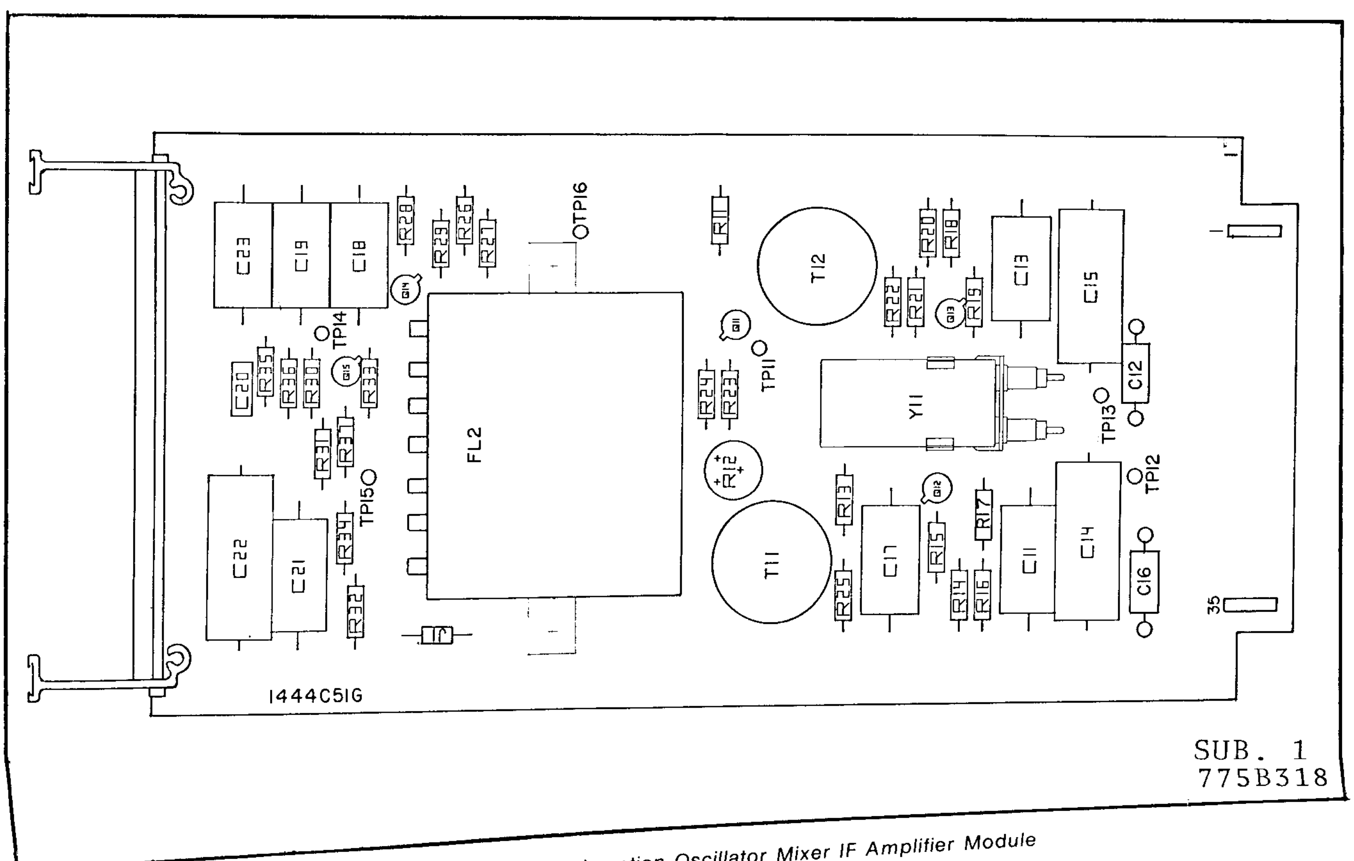


Fig. 11. Component Location Oscillator Mixer IF Amplifier Module

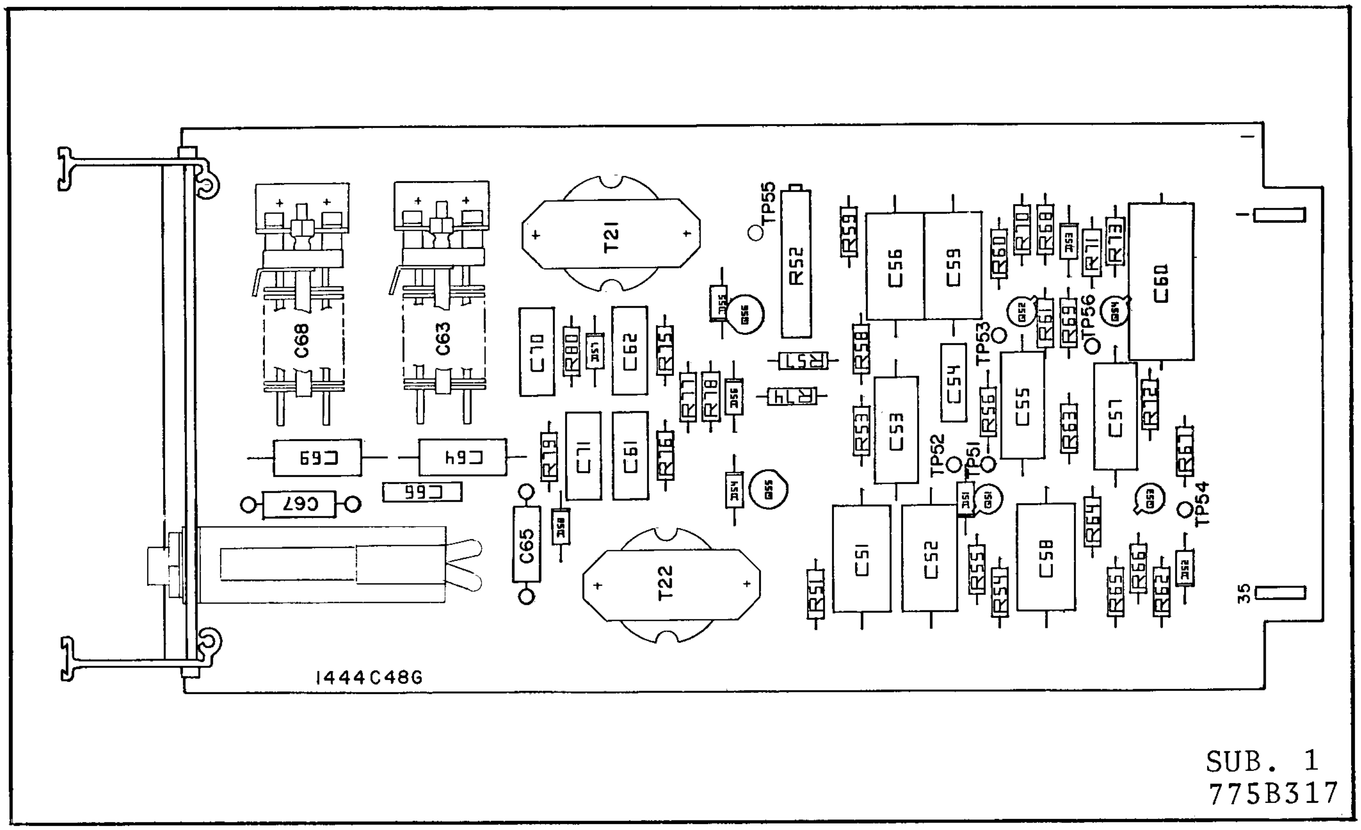


Fig. 12. Component Location Amplifier Limiter-Discriminator Module

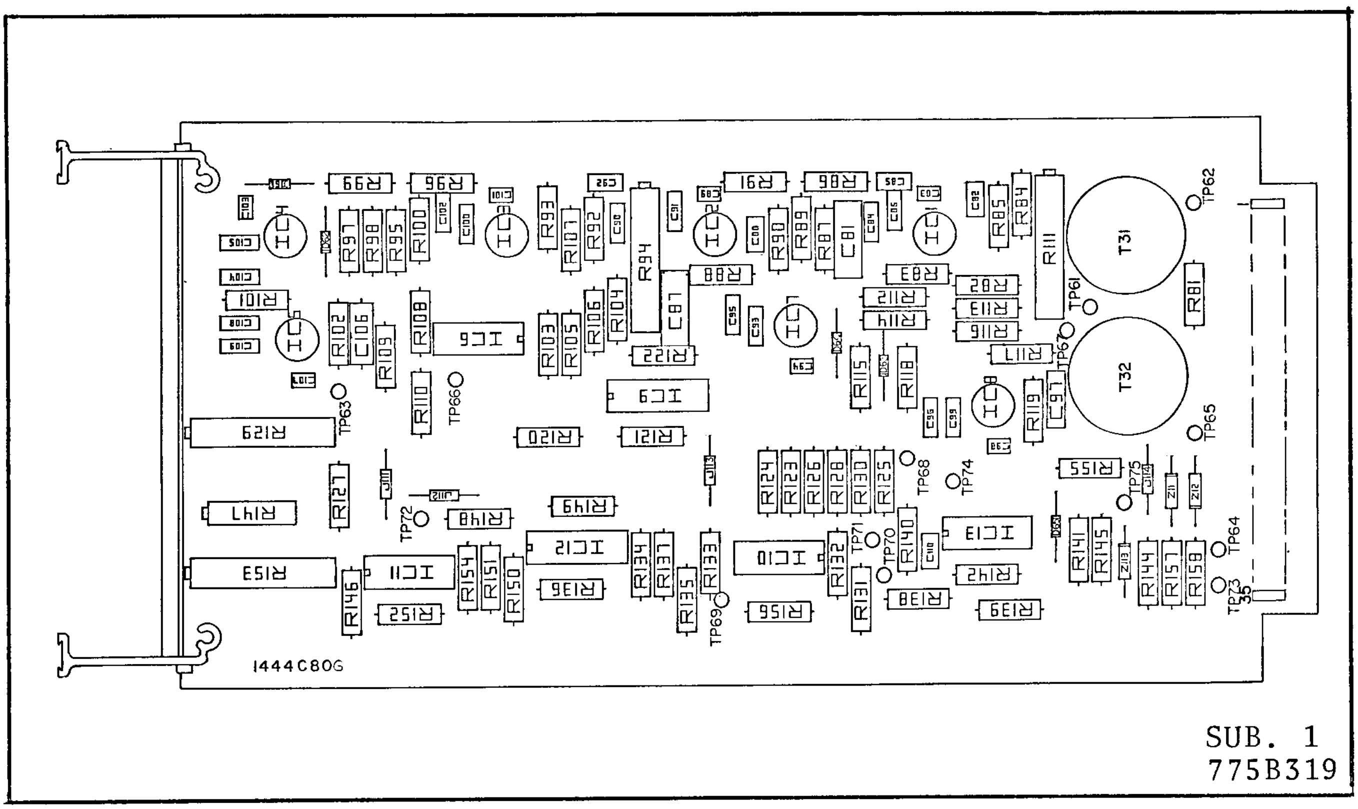


Fig. 13. Component Location SNR Detection Module

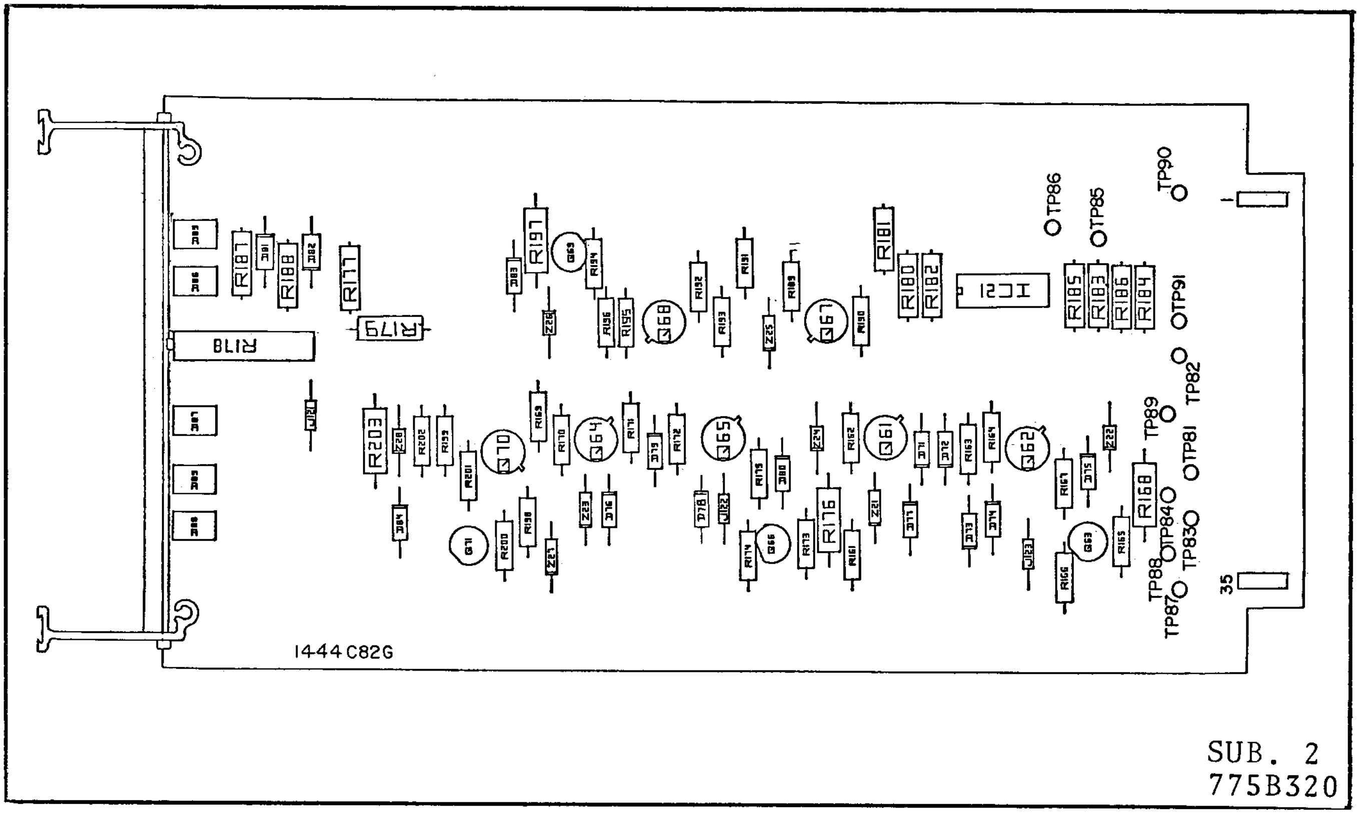


Fig. 14. Component Location Output Module

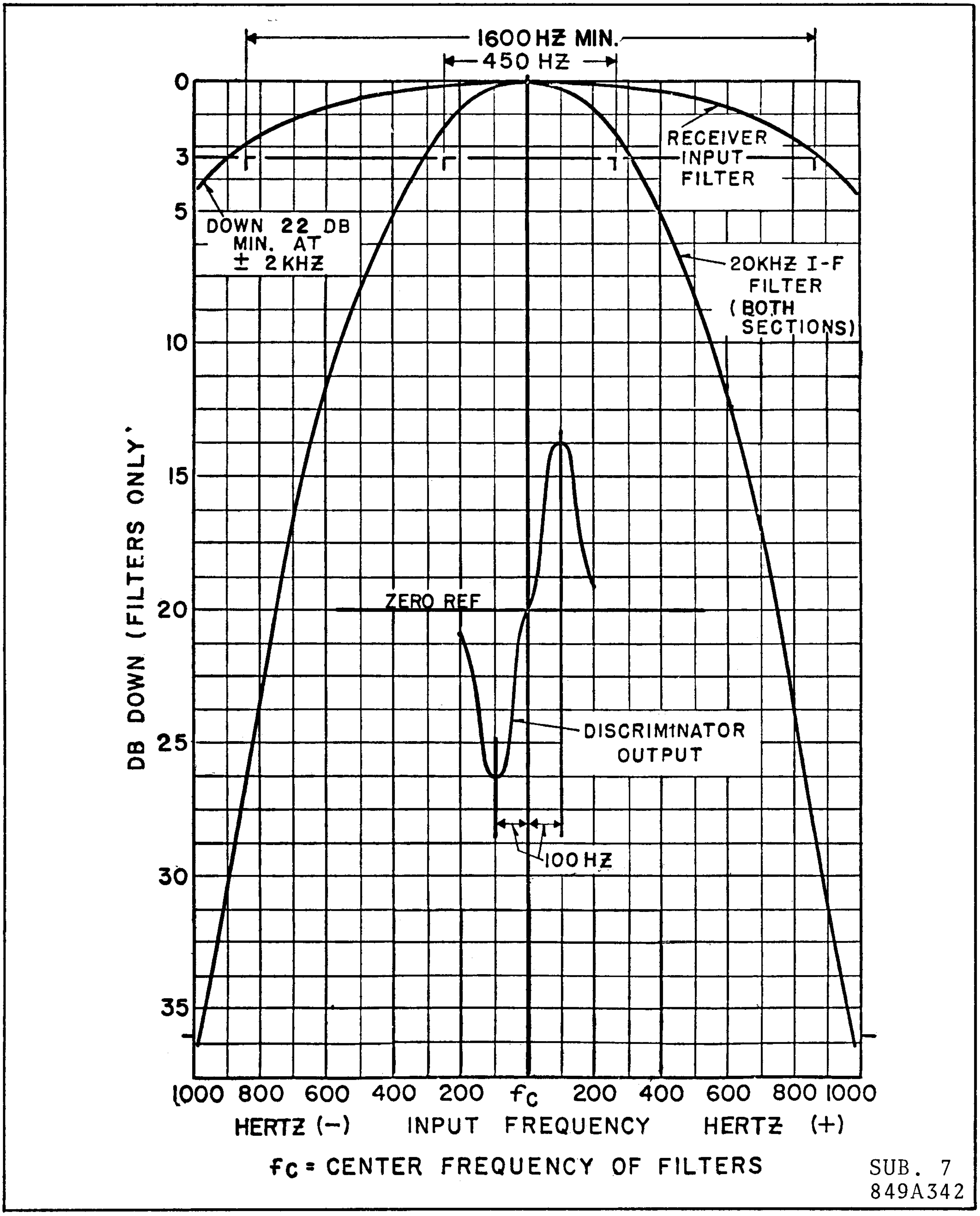


Fig. 15. Filter and Discriminator Characteristics of the Type TCF-10 Receiver

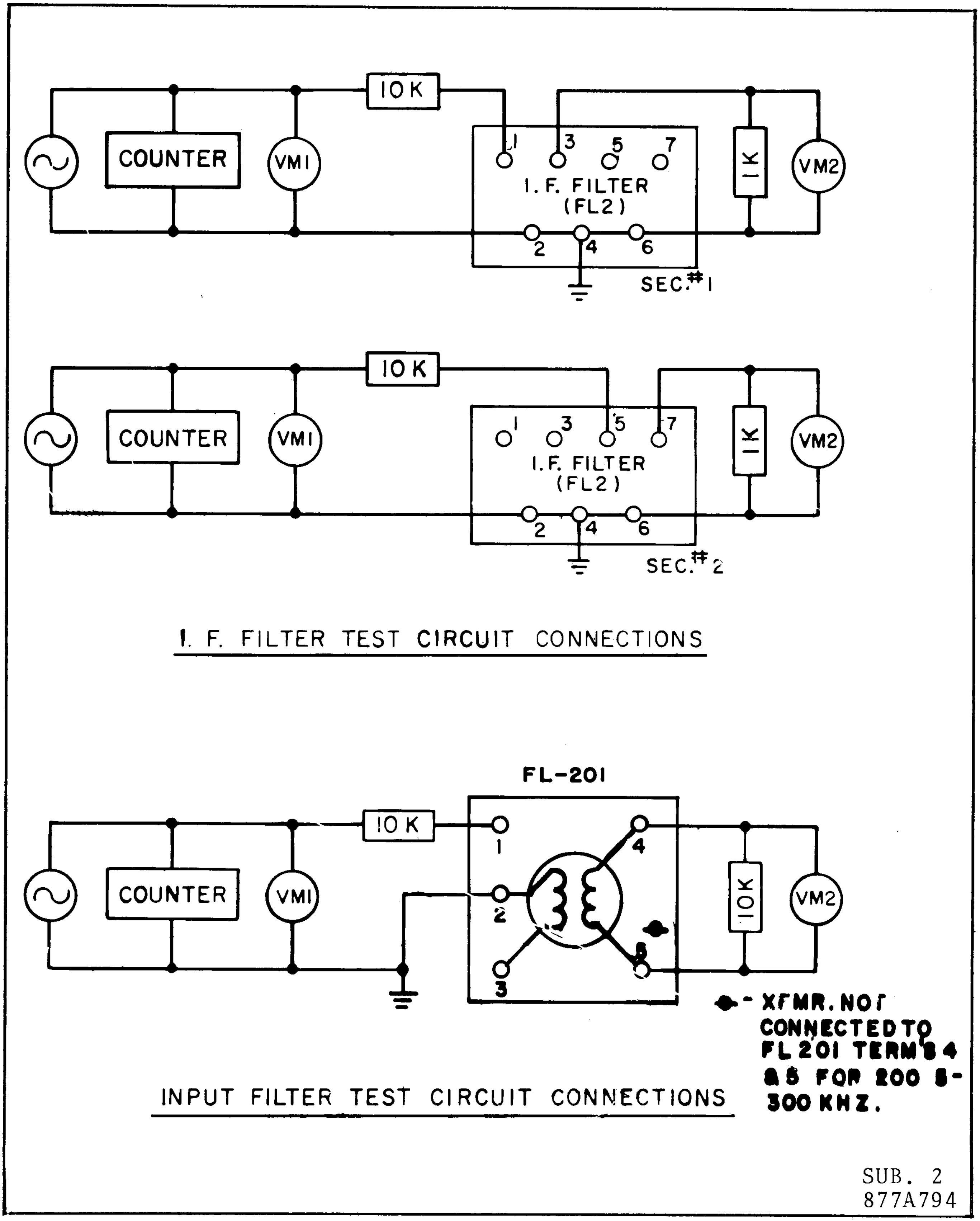


Fig. 16. Test Circuits for TCF-10 Receiver Filters

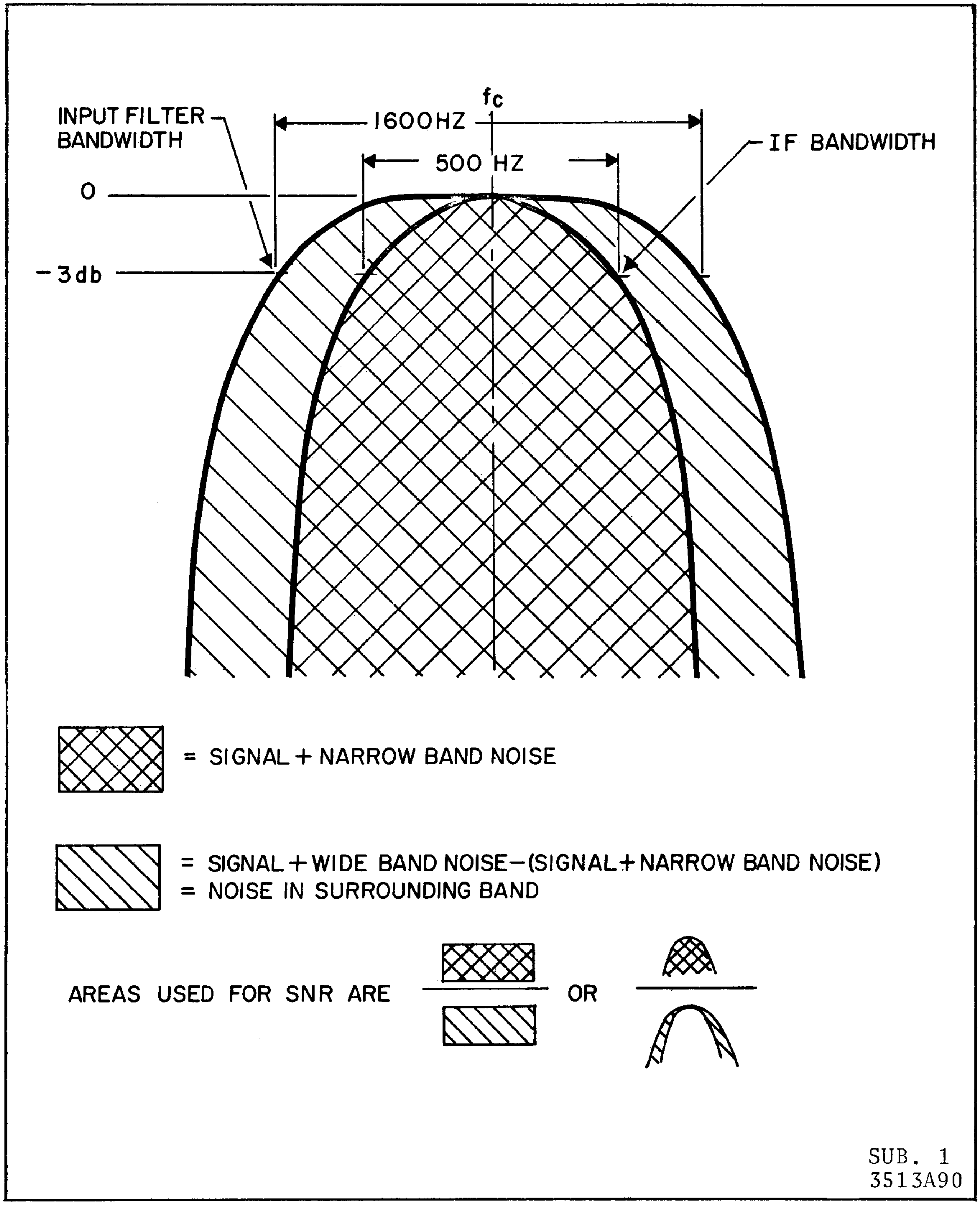


Fig. 17. Signal to Noise Ratio Characteristics

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Printed in U.S.A.