INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

# TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT-TRANSFER TRIP

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 relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

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 frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and may also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

## CONSTRUCTION

The TCF receiver unit for transfer-trip applications is mounted on a standard 19-inch wide panel 10½ inches high (6 rack units) with edge slots for mounting on a standard relay rack. All components are mounted at the rear of the panel. Fuses, a pilot light, a power switch, an input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the panel. See Fig. No. 14

All of the circuitry that is suitable for mounting on printed circuit boards is contained in an enclosure that projects from the rear of the panel and is accessible by opening a hinged door on the front of the panel. Other components on the rear of the panel are located as shown on Fig. No. 6. Reference to the internal schematic connections on Fig. 1 will show the location of these components in the circuit. The dotted lines enclosing separate areas of Fig. 1 indicate that the components thus enclosed are all on the same printed circuit board.

The enclosure that contains the printed circuit boards is divided into seven compartments. The partitions between compartments together with the outer walls of the enclosure provide complete shielding between adjacent boards and from external fields. Frequency shift receivers for transfer-trip relaying utilize all compartments if a carrier level indicator is provided. If this is omitted, the compartment on the extreme right, front view, is left vacant. In frequency shift receivers for applications other than transfer-trip relaying, the logic circuitry is not required and the fifth compartment from the left is vacant in such cases.

The printed circuit boards slide into position in slotted guides at the top and bottom of each compartment, and the board terminals engage a terminal block at the rear of the compartment. Each board and

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*Denotes change from superseded issue.

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terminal block are keyed so that if a board is placed in the wrong compartment, it cannot be inserted into the terminal block. A handle on the front of each board is labeled to identify its function in the circuit.

A board extender (Style No. 644B315G01) is available for facilitating circuit voltage measurements or major adjustments. After withdrawing any one of the circuit boards, the extender is inserted in that compartment. The board then is inserted into the terminal block on the front of the extender. This restores all circuit connections, and all components and test points on the board are readily accessible.

A portion of the receiver operates from a regulated 20 VDC supply, and the remainder from a regulated 45 V.D.C. supply. These voltages are taken from two Zener diodes mounted on a common heat sink. Variation of the resistance value between the positive side of the unregulated D.C. supply and the 45 volt Zener adapt the receiver for operation on 48, 125, or 250 V.D.C.

External connections to the receiver are made through a 24-circuit receptacle, J3 (see Fig. 1). The r-f input connection to the receiver is made through a coaxial cable jack, J2.

## OPERATION

### Input Control

The signals to which the TCF receiver responds are received through a coaxial cable connected to jack J2 of Fig. No. 1. Resistor R4 and 20-volt Zener diodes CR1 and CR2 protect the receiver from abnormally high voltages received through the coaxial cable. Input attenuator R5 reduces the signal to a level suitable for best operation of the receiver. The attenuator is adjustable from the front of the panel and can be clamped at the desired setting. A scale on the panel is graduated in db. While this scale is typical rather than individually calibrated, it is accurate within one or two db. and is useful in setting approximate levels. Settings should be made by observation of the db. scale of a suitable a-c voltmeter when possible.

### Crystal Filter

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency (fc) of the channel are greatly attenuated. Fig. 4 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

### Oscillator and Mixer

From the crystal filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, or IC201 (Fig. 16) and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20 kHz above the channel frequency, fc. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the later is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of FL1 is impressed on the emitter-collector circuit of Q11. As the result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of *20kHz, 2fc + 20kHz, fc + 20kHz and fc.

### IF Amplifier

The output from the secondary of T12 is amplified by Q31, in the intermediate frequency amplifier stage, and is impressed on filter FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. While its passband is much wider than that of the crystal filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz.

### Amplifier and Limiter

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

### Discriminator

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C88. C83 also is adjusted to obtain a maximum voltage reading across R84 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero output frequency. This separation of 200 hertz between the current peaks is affected by the value of C86, (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 hertz in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20 kHz-100 hertz. Similarly, the Trip frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

The discriminator output is connected to the bases of transistors Q81 and Q82 in such manner that Q82 is made conductive when current flows out of terminal 4 (which occurs with trip output) and Q81 is made conductive when current flows into terminal 4. Consequently, terminal 15 is at a potential of approximately + 20 volts at Guard frequency and terminal 11 is at + 20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode CR84 is connected in the emitter circuit of Q82. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode CR84. For applications where severe noise conditions or channel deterioration are not encountered, a TCF transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode CR84.

## Logic Circuits

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and CR104 of Fig. 1. Capacitor C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener CR104 and block C (transistor Q102) then will receive input #1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input #1 or #2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through CR105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input #1 to block K is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through CR102 to the collector of Q103 but will flow through CR101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of CR105, making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through CR101 and the base-emitter junction of Q102. If Guard signal reappears, the discriminator output at term. 15 will turn Q101 off. C101 will change and after 120 ms. it will reach the breakdown voltage of CR104 and turn Q102 on. This will allow C102 to quickly discharge through R123 and Q102 and provide the full 150 ms. time delay to be effective on any subsequent loss of guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost capacitor C104 will charge to the breakdown voltage of CR113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, CR113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of CR113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input #2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input #1 to Q107 (block J). If input #2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input #3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (CR110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode CR107; capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

## Output Circuits

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The two sets of normally-open contacts and one set of normally-closed contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

## Carrier Level Indicator (When Supplied)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board and guides in the right hand compartment and making minor changes in the wiring.

The r.f. input to the carrier level indicator is taken from the collector of Q51, the first transistor in the amplifier and limiter stage. The input, which varies approximately as the signal at the receiver input, is amplified by Q151 and Q152. Diodes CR151 and CR152 together with capacitors C157 and C158 establish a d-c voltage across C158 that controls the conductivity of Q153. The base current of Q153 together with the current through R164 is measured by a milliammeter (supplied by the customer) located at a point convenient for observation. This current can also be metered at the receiver by means of jack J151 on the printed circuit board. Thermistor R166 with its associated resistors, and Sensistor R152, provide compensation to minimize the variation of the metered current with ambient temperature. When Q153 becomes conductive, it supplies base input to Q154 to turn it on and pick up alarm relay AL. When the signal at the receiver input drops sufficiently, AL will drop out and close the alarm circuit. The signal level at which this will occur is determined by the setting of R156 in the emitter of Q151.

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator — Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the #19 terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of Q154 in the carrier level indicator circuit by diode CR155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of Q153 would be diverted to negative through CR155 and Q103 rather than entering the base of Q154. The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

Fig. 5 is typical of the variation of the carrier level indicator current with the receiver input level. With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level. Fig. 5 shows that with such settings the carrier level indicator current would be approximately 2.25 ma. with the normal input signal. The alarm would be energized when the indicator current dropped to slightly less than 0.6 ma.

A TCF receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the printed circuit board, guides, and terminal block in the right-hand compartment of the circuit board enclosure, and making minor changes or additions to the wiring. The upper and lower guides are held in position by a snap fastener, and the terminal block by screws and nuts. The terminal block includes an insert located to mate with a corresponding slot in the end of the carrier level indicator circuit board only, which prevents accidental ininsertion of any other circuit board in this compartment.

Reference to the internal schematic diagrams, Figs. 1 and 2, will show the wiring changes required. Connect terminal 2 to the adjacent terminal 2 of the output board, terminal 9 to terminal 9 of the logic board, terminal 12 to terminal 12 of the output board (and remove connection from the later to terminal 12 of the logic board), terminals 14 and 17 to terminals 18 and 19 respectively of J3, terminal 16 to terminal 16 of the limiter board, terminal 18 to terminal 18 of the discriminator board and terminal 19 to terminal 19 of the logic board.

## Power Supply

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

## CHARACTERISTICS

| | |
|---|---|
| Frequency range | 30-300 kHz |
| Sensitivity (noise-free channel) | 0.005 volt (65 db below 1 watt for limiting) |
| Input Impedance | 5000 ohms minimum |
| Bandwidth (crystal filter) | down < 3 db at 220 hertz<br>down > 60 db at 1000 hertz |
| Discriminator | Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications. |
| Operating time | 9 ms. channel (transm. and recvr.)<br>2 ms. min. logic delay<br>+ 3 ms. AR relay<br>14 ms. minimum time<br>+ 18 ms. max. added logic time (if req'd. by noise conditions)<br>32 ms. maximum time |
| Frequency spacing | |
| A. For two or more signals over one-way channel | 500 hertz minimum |
| B. For two-way channel | * 1000 hertz. minimum between transmitter and adjacent receiver frequencies. |
| Ambient temperature range | -20°C to +55°C temperature around chassis. |
| Battery voltage variations | |
| Rated voltage | Allowable variation |
| 48 V.D.C. | 42 - 56 V.D.C. |
| 125 V.D.C. | 105 - 140 V.D.C. |
| 250 V.D.C. | 210 - 280 V.D.C. |
| Battery drain | 0.20 a. at 48 V.D.C.<br>0.27 a. at 125 or 250 V.D.C. |
| Dimensions | Panel height - 10½'' or 6 r.u.<br>Panel width - 19'' |
| Weight | 13 lbs. |

## INSTALLATION

The TCF 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 55°C.

## 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; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7; adjustment of R156 on the carrier level indicator (if supplied) to operate the alarm at the desired input level. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel. A screw driver adjustment of a potentiometer at the front and top of the printed circuit board sets the point at which the level indicator alarm operates.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an a-c VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode CR84 in the discriminator is not bypassed (see discussion under OPERATION-Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If CR84 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

If the receiver has a carrier level indicator, the procedure for setting R5 is somewhat different. Turn R156 to maximum clockwise position and adjust R5 to the position at which the alarm relay just drops out. At this point the signal has been attenuated to the point that the discriminator no longer has Guard output although it still would be sufficient to produce output from the carrier level indicator, and the base input to Q154 on the carrier level indicator is diverted to negative through Q103 on the logic circuit board. (Note that a milliammeter reading at J151 has no significance at this abnormal setting of R156.) Then readjust R5 to increase the input signal by 5 db and adjust R156 to the position at which the alarm relay again drops out. Again readjust R5 to increase the signal by an additional 10 db and clamp the knob in this position.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

Potentiometer R12, where applicable, in the oscillator and mixer should be set for 0.3 volt, measured with an a-c VTVM connected between TP11 and terminal 18 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 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 insures 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 the base of transistor Q54 to terminal 18 of the limiter. With 3 mv. of Guard frequency on the receiver input (R5 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.

Adjustment of the discriminator is made by capacitors C83 and C88. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R84. Adjust C88 for zero current in the milliammeter and C83 for maximum voltage across R84, rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R84 and observe the milliammeter reading as the oscillator frequency is varied. Positive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 25% lower than the former because of diode CR84 in the Trip output path.

In case a check is desired of any of the delay times of the receiver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

## MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity 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 drop out the alarm relay. 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 or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the door on the front of the panel is opened. (An offset screwdriver would be required for adjusting R12.) However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender Style No. 644B315G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks.

It is advisable to record voltage values 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 values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ± 20%.

## TABLE I

## RECEIVER D-C MEASUREMENTS

Note: All voltage readings taken with ground of d-c VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

| Collector of Transistor | Volts (+) | |
|---|---|---|
| Q11 | < 13 | |
| Q12 | 15 | (Guard or Trip) |
| Q13 | 15 | (Guard or Trip) |
| Q31 | 2.5 | |
| Q32 | 2.5 | |
| Q51 | 11.5 | |
| Q52 | 12 | |
| Q53 | 15.5 | |
| Q54 | 2.5 | |
| Q81 | < 1 | (No sig. or Trip) |
| Q81 | 19.5 | (Guard) |
| Q82 | < 1 | (No sig. or Guard) |
| Q82 | 19.5 | (Trip) |
| Q101 | < 1 | (No sig. or Trip) |
| Q101 | 7 | (Guard) |
| Q102 | 21 | (No signal) |
| Q102 | < 1 | (Guard or keyed Trip #) |

| | | |
|---|---|---|
| Q103 | < 1 | (No signal) |
| Q103 | 10 | (Guard or keyed Trip) |
| Q104 | 45 | (No signal) |
| Q104 | < 1 | (Guard or keyed Trip) |
| Q105 | 40 | (No signal) |
| Q105 | < 1 | (Guard or Trip) |
| Q106 | 15 | (No sig. or Guard) |
| Q106 | < 1 | (Trip) |
| Q107 | < 1 | (No sig. or Guard) |
| Q107 | 15 | (Trip) |
| Q108 | 45 | (No sig. or Guard) |
| Q108 | < 1 | (Keyed Trip) |
| Q109 | 10 | (No sig. or Trip) |
| Q109 | < 1 | (Guard) |
| Q110 | < 1 | (No sig. or Trip) |
| Q110 | 15 | (Guard) |
| Q111 | 15 | (No sig. or Trip) |
| Q111 | < 1 | (Guard) |
| Q151 | 6 | (No signal) |
| Q151 | 6 | (Guard) |
| Q152 | 9.8 | (No signal) |
| Q152 | 10 | (Guard) |
| Q153 | < 1 | (No signal) |
| Q153 | 19 | (Guard) |
| Q154 | 45 | (No signal) |
| Q154 | < 1 | (Guard) |

# – ''Keyed Trip'' signifies minimum transition time from Guard to Trip.

## TABLE II

## RECEIVER RF MEASUREMENTS

Note: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I.

| Collector of Transistor | Volts (1 watt-Guard) | Volts (10 watts-Trip) |
|---|---|---|
| Q32 | .25 | .8 |
| Q51 | .3 | .9 |
| Q52 | .4 | .65 |
| Q53 | 2.1 | 2.2 |
| Q54 | 4.8 | 4.5 |

## RELAY MAINTENANCE AND ADJUSTMENT

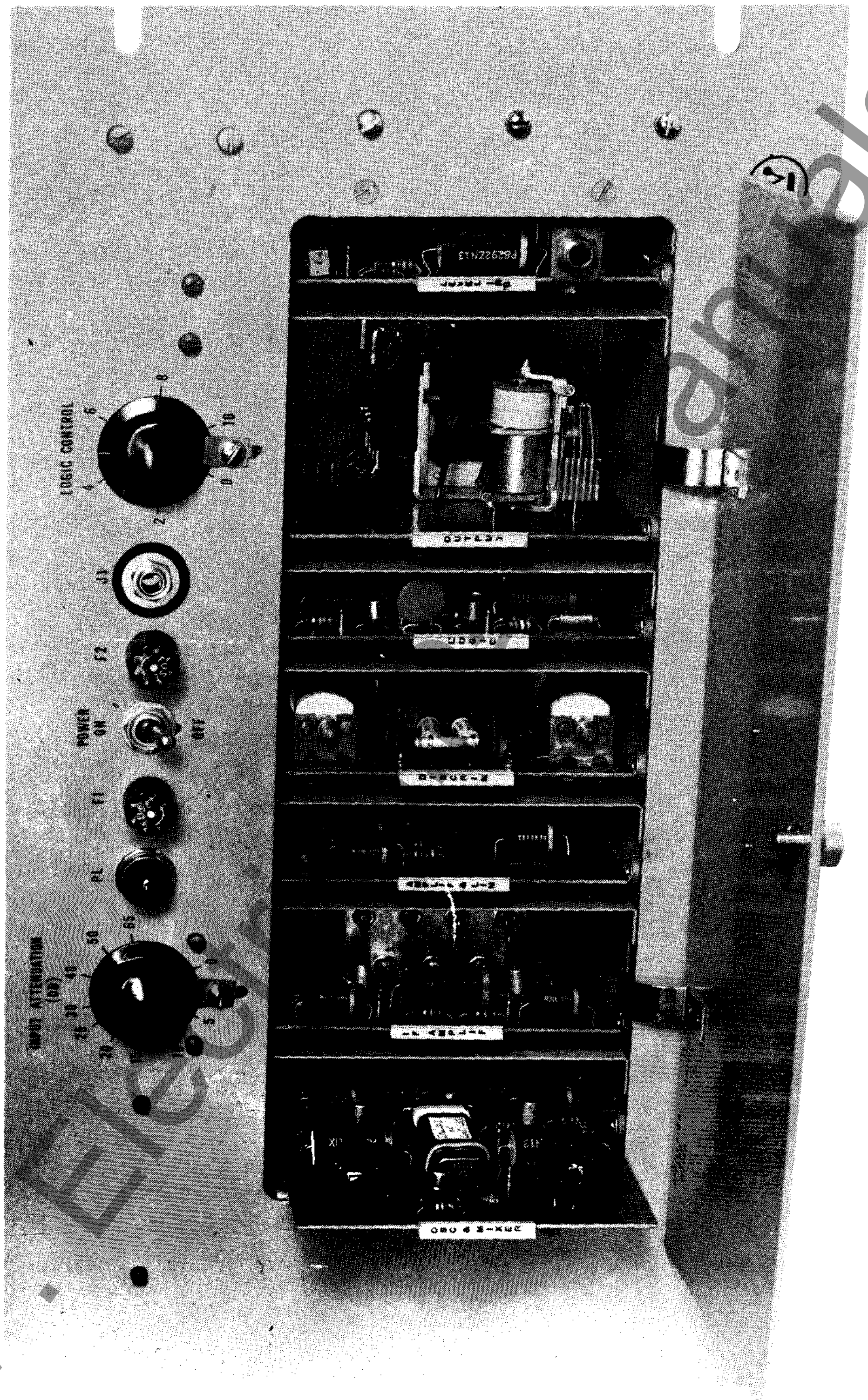
The AL and AR relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

## ADDENDUM

With shipments of sets starting in early 1973, the germanium transistors used in the various modules were replaced with silicon transistors. In addition, due to the nature of silicon transistors, some resistor values in the circuits had to be changed In order to correctly bias these transistors. Therefore the transistors are not replaceable on a pin for pin basis throughout the receiver. Before attempting to replace a germanium transistor with a silicon transistor on older sets using germanium, please check the schematics on the following pages to see if the location where the replacement is desired has additional component changes. If that is the case, then the replacement can only be made by the same designation transistor or the additional component changes must also be made. It should be pointed out that the modules containing the silicon transistors are completely interchangeable with the modules containing germanium transistors. Therefore, there is no problem with intermixing the silicon transistor modules in the same receiver. Thus complete new modules containing silicon transistors can be ordered and used as replacements in older receivers having germanium transistor modules. The new modules have the same style numbers as the old germanium transistor modules they replace.




*Type **TCF** Receiver (Front View).*

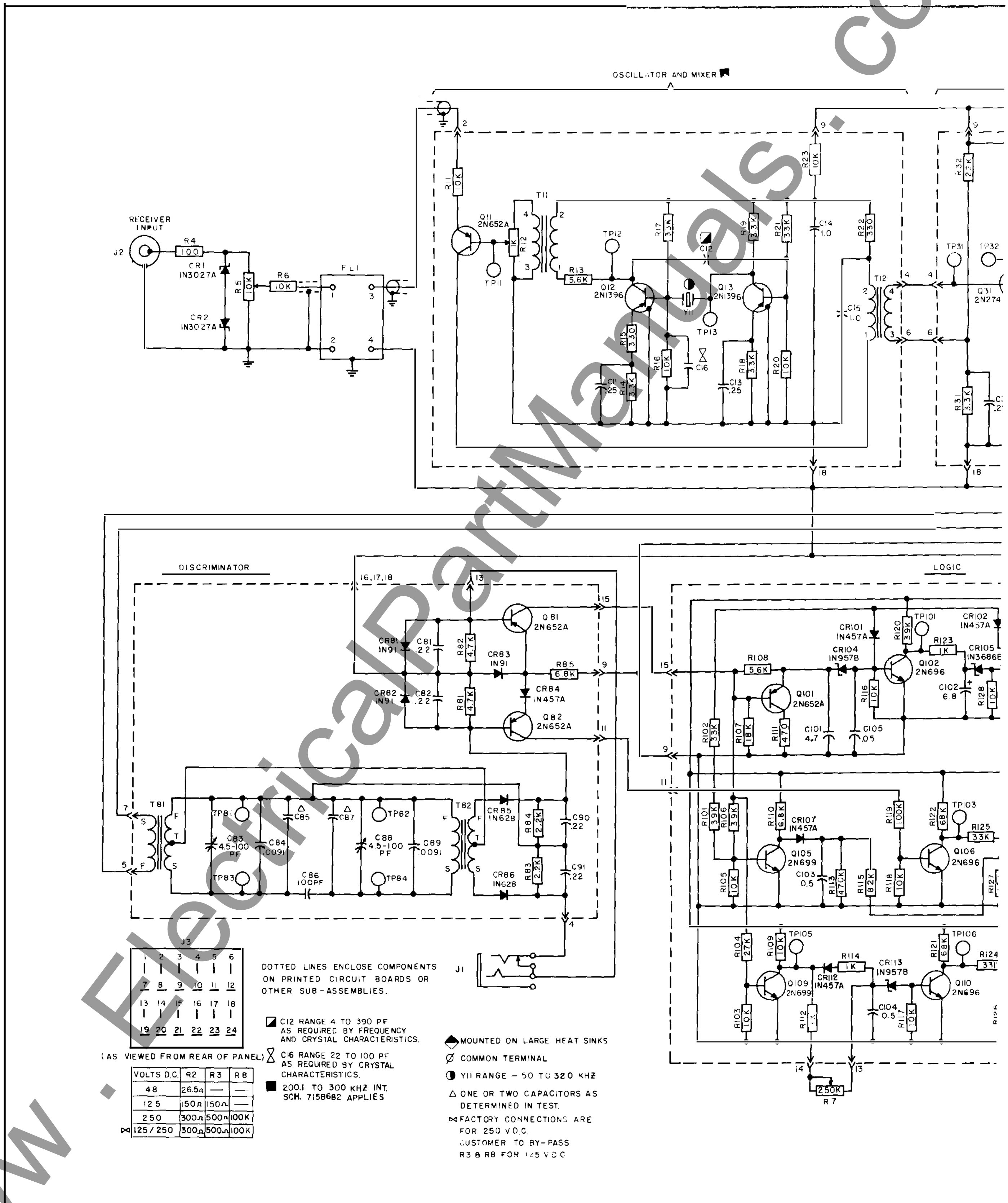
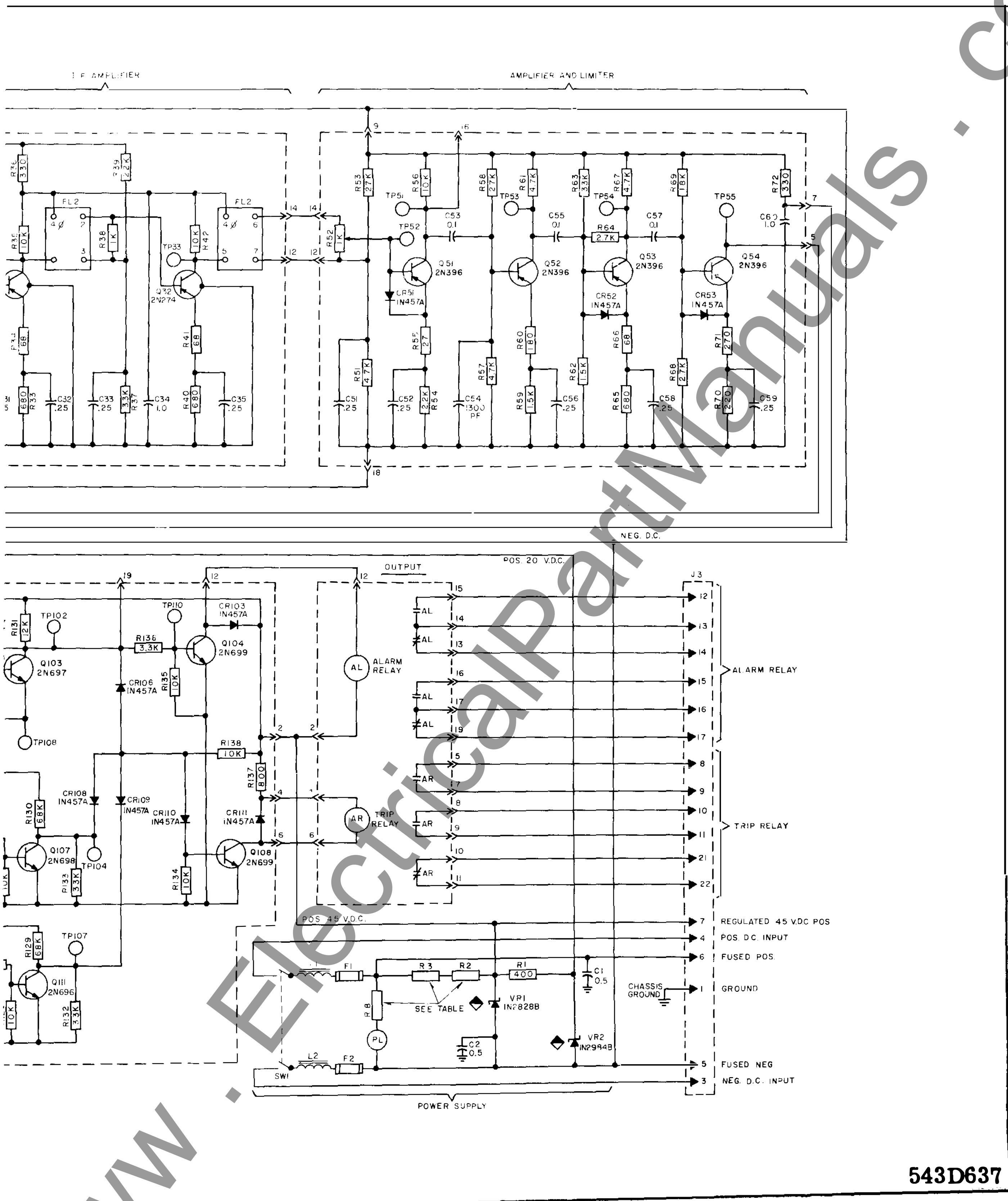



*Fig. 1.* ***Internal schematic of the type***




***TCF receiver without the carrier level indicator.***

## FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only 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 Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the -3db and -60db check points for the crystal filters. 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 Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (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 resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) 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 11db 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 on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

## 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 60 Hz to 330 kHz, input impedance 7.5 megohms.

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

| | |
|---|---|
| Voltage Range: | 1.5 to 300 volts |
| Imput 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 330-kHz |

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

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.

## ELECTRICAL PARTS LIST

| CIRCUIT SYMBOL | DESCRIPTION | WESTINGHOUSE DESIGNATION |
|---|---|---|
| | **CAPACITORS** | |
| C1 | Oil-filled; 0.5 mfd.; 1500 V.D.C. | 1877962 |
| C2 | Oil-filled; 0.5 mfd.; 1500 V.D.C. | 1877962 |
| C11 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C12-C16 | Mica, capacity as required; 500 V.D.C. | |
| C13 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C14 | Metallized paper; 1.0 mfd.; 200 V.D.C. | 187A624H04 |
| C15 | Metallized paper; 1.0 mfd.; 200 V.D.C. | 187A624H04 |
| C31 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C32 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C33 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C34 | Metallized paper; 1.0 mfd.; 200 V.D.C. | 187A624H04 |
| C35 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C51 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C52 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C53 | Metallized paper; 0.1 mfd.; 200 V.D.C. | 187A624H01 |
| C54 | Dur-Mica, 1300 pf.; 500 V.D.C. | 187A584H15 |
| C55 | Metallized paper; 0.1 mfd.; 200 V.D.C. | 187A624H01 |
| C56 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C57 | Metallized paper; 0.1 mfd.; 200 V.D.C. | 187A624H01 |
| C58 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C59 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C60 | Metallized paper; 1.0 mfd.; 200 V.D.C. | 187A624H04 |
| C81 | Mylar; 0.22 mfd.; 50 V.D.C. | 762A703H01 |
| C82 | Mylar; 0.22 mfd.; 50 V.D.C. | 762A703H01 |
| C83 | Variable; 4.5 - 100 pf. | 762A736H02 |
| C84 | Polystyrene, 9100 pf.; 200 V.D.C. | 187A624H16 |
| C85 | Temp. compensating; 150 V.D.C.; pf. as required | |
| C86 | 100 pf.; zero temp. coef. | 187A684H08 |
| C87 | Temp. compensating; 150 V.D.C.; pf. as required | |
| C88 | Variable; 4.5 - 100 pf. | 762A736H02 |
| C89 | Polystyrene; 9100 pf.; 200 V.D.C. | 187A624H16 |
| C90 | Mylar; 0.22 mfd.; 50 V.D.C. | 762A703H01 |
| C91 | Mylar; 0.22 mfd.; 50 V.D.C. | 762A703H01 |
| C101 | Tantalum, 4.7 mfd., 35 V.D.C. | 184A661H12 |
| C102 | Tantalum, 6.8 mfd.; 35 V.D.C. | 184A661H25 |
| C103 | Metallized paper; 0.5 mfd.; 200 V.D.C. | 187A624H11 |
| C104 | Metallized paper; 0.5 mfd.; 200 V.D.C. | 187A624H11 |
| C105 | Ceramic, 0.05 mfd.; 50 V.D.C. | 184A663H02 |
| C151 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C152 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |

## ELECTRICAL PARTS LIST (Cont'd.)

| CIRCUIT SYMBOL | DESCRIPTION | WESTINGHOUSE DESIGNATION |
|---|---|---|
| | **CAPACITORS (Cont'd.)** | |
| C153 | Metallized paper; 1.0 mfd.; 200 V.D.C. | 187A624H04 |
| C154 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 817A624H02 |
| C155 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C156 | Metallized paper; 0.25 mfd.; 200 V.C.C. | 187A624H02 |
| C157 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C158 | Metallized paper; 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C211 | Durmica; 100 mmf to 1000 mmf | 187A695H |
| C212 | Ceramic; .1 mf, 50 v.d.c. | 184A663H04 |
| C213 | Ceramic; .1 mf, 50 v.d.c. | 184A663 H04 |
| C214 | Durmica; .56 mmf | 187A695H17 |
| C215 | Ceramic; .1 mf, 50 v.d.c. | 184A663 H04 |
| C216 | Metallized paper; 1 mf | 187A624H04 |
| C217 | Metallized Paper; 1 mf | 187A624H04 |
| | **DIODES – GENERAL PURPOSE** | |
| CR51 | IN457A; 60 V.; 200 MA. | 184A855H07 |
| CR52 | IN475A; 60 V.; 200 MA. | 184A855H07 |
| CR53 | IN457A; 60 V.; 200 MA. | 184A855H07 |
| CR81 | IN91; 100 V.; 150 MA. | 182A881H04 |
| CR82 | IN91; 100 V.; 150 MA. | 182A881H04 |
| CR83 | IN91; 100 V.; 150 MA. | 182A881H04 |
| CR84 | IN475A; 60 V.; 200 MA. | 184A885H07 |
| CR85 | IN628; 125 V.; 30 MA. | 184A855H12 |
| CR86 | IN628; 125 V.; 30 MA. | 184A855H12 |
| CR101 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR102 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR103 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR106 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR107 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR108 | IN457A; 60 V-; 200 MA. | 184A885H07 |
| CR109 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR110 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR111 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR112 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR151 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR152 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR153 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR154 | IN457A.; 60 V.; 200 MA. | 184A885H07 |
| CR155 | IN457A; 60 V.; 200 MA. | 184A885H07 |
| CR156 | IN457A; 60 V.; 200 MA. | 184A855H07 |
| | **DIODES – ZENER** | |
| CR1 | IN3027A; 20 V. ± 10%; 1W. | 188A302H10 |
| CR2 | IN3027A; 20 V. ± 10%; 1W. | 188A302H10 |
| CR104 | IN957B; 6.8 V. ± 5%; 400 MW. | 186A797H06 |
| CR105 | IN3686B; 20 V. ± 5%; 750 MW. | 185A212H06 |
| CR113 | IN957B; 6.8 V. ± 5%; 400 MW. | 186A797H06 |
| VR1 | IN2828B; 45 V. ± 5%; 50 W. | 184A854H06 |
| VR2 | IN2984B; 20 V. ± 5%; 10 W. | 762A631H01 |
| Z201 | IN753A; 6.2 V. v 5%; 400 MW. | 862A606H01 |

## ELECTRICAL PARTS LIST (Cont'd.)

| CIRCUIT SYMBOL | DESCRIPTION | WESTINGHOUSE DESIGNATION |
|---|---|---|
| | **POTENTIOMETERS** | |
| R5 | 10K; 2 W. | 185A086H10 |
| R7 | 250K; 2 W. | 185A086H11 |
| R12 | 1K; ¼ W. | 629A430H02 |
| R52 | 1K; ¼ W. | 629A645H04 |
| R156 | 2.5K; ¼ W. | 629A645H07 |
| | **RESISTORS** | |
| R1 | 400 ohms ±5%; 25 W. | 1202587 |
| R2 | 26.5 ohms ±5%; 40 W. (For 48 V. Supply) | 04D1299H44 |
| R2 | 150 ohms ±5%; 40 W. (For 125 V. Supply) | 1202499 |
| R2 | 300 ohms ±5%; 50 W. (For 250 V. Supply) | 763A963H01 |
| R3 | 150 ohms ±5%; 40 W. (For 125 V. Supply) | 1202499 |
| R3 | 500 ohms ±5%; 100 W. (For 250 V. Supply) | 629A843H03 |
| R4 | 100 ohms ±5%; 1 W. Composition | 187A643H03 |
| R6 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R8 | 100K ±5%; 1 W. Composition | 187A643H75 |
| R11 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R13 | 5.6K ±5%; ½ W. Composition | 184A763H45 |
| R14 | 3.3K ±5%; ½ W. Composition | 184A763H39 |
| R15 | 330 ohms ±5%; ½ W. Composition | 184A763H15 |
| R16 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R17 | 33K ±5%; ½ W. Composition | 184A763H63 |
| R18 | 3.3K ±5%; ½ W. Composition | 184A763H39 |
| R19 | 3.3K ±5%; ½ W. Composition | 184A763H39 |
| R20 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R21 | 33K ±5%; ½ W. Composition | 184A763H63 |
| R22 | 330 ohms ±5%; ½ W. Composition | 184A763H15 |
| R23 | 10K ±5% ½ W. Composition | 184A763H51 |
| R31 | 3.3K ±5%; ½ W. Composition | 184A763H39 |
| R32 | 22K ±5%; ½ W. Composition | 184A763H59 |
| R33 | 680 ohms ±5%; ½ W. Composition | 184A763H23 |
| R34 | 68 ohms ±5%; ½ W. Composition | 187A290H21 |
| R35 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R36 | 330 ohms ±5%; ½ W. Composition | 184A763H15 |
| R37 | 3.3K ±5%; ½ W. Composition | 184A763H39 |
| R38 | 1000 ohms ±5%; ½ W. Composition | 184A763H27 |
| R39 | 22K ±5%; ½ W. Composition | 184A763H59 |
| R40 | 680 ohms ±5%; ½ W. Composition | 184A763H23 |
| R41 | 68 ohms ±5%; ½ W. Composition | 187A290H21 |
| R42 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R51 | 4.7K ±5%; ½ W. Composition | 184A763H43 |

## ELECTRICAL PARTS LIST (Cont'd.)

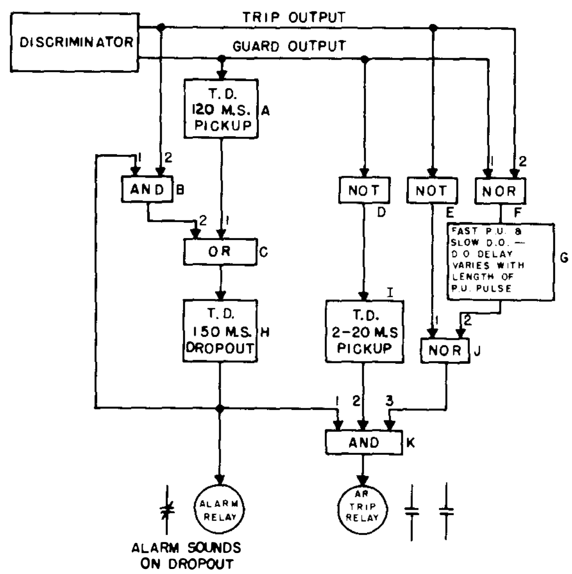
| CIRCUIT SYMBOL | DESCRIPTION | WESTINGHOUSE DESIGNATION |
|---|---|---|
| | RESISTORS (Cont'd.) | |
| R53 | 27K ±5%; ½ W. Composition | 184A763H61 |
| R54 | 2.2K ±5%; ½ W. Composition | 184A763H35 |
| R55 | 27 ohms ±5%; ½ W. Composition | 187A290H11 |
| R56 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R57 | 4.7K ±5%; ½ W. Composition | 184A763H43 |
| R58 | 27K ±5%; ½ W. Composition | 184A763H61 |
| R59 | 1.5K ±5%; ½ W. Composition | 184A763H31 |
| R60 | 180 ohms ±5%; ½ W. Composition | 184A763H09 |
| R61 | 4.7K ±5%; ½ W. Composition | 184A763H43 |
| R62 | 1.5K ±5%; ½ W. Composition | 184A763H31 |
| R63 | 3.3K ±5%; ½ W. Composition | 184A763H63 |
| R64 | 2.7K ±5%; ½ W. Composition | 184A763H37 |
| R65 | 680 ohms ± 5%; ½ W. Composition | 184A763H23 |
| R66 | 68 ohms ±5%; ½ W. Composition | 187A290H21 |
| R67 | 4.7K ±5%; ½ W. Composition | 184A763H43 |
| R68 | 2.7K ±5%; ½ W. Composition | 184A763H37 |
| R69 | 18K ±5%; ½ W. Composition | 184A763H57 |
| R70 | 220 ohms ±5%; ½ W. Composition | 184A763H11 |
| R71 | 270 ohms ± 5%; Wire Wound | 09D832G19 |
| R72 | 330 ohms ±5%; ½ W. Composition | 184A763H15 |
| R81 | 4.7K ±5%; ½ W. Composition | 184A763H43 |
| R82 | 4.7K ±5%; ½ W. Composition | 184A763H43 |
| R83 | 2.2K ±5%; ½ W. Composition | 184A763H35 |
| R84 | 2.2K ±5%; ½ W. Composition | 184A763H35 |
| R85 | 6.8K ±5%; ½ W. Composition | 184A763H47 |
| R101 | 39K ±5%; ½ W. Composition | 184A763H65 |
| R102 | 33K ±5%; ½ W. Composition | 184A763H63 |
| R103 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R104 | 27K ±5%; ½ W. Composition | 184A763H61 |
| R105 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R106 | 39K ±5%; ½ W. Composition | 184A763H65 |
| R107 | 18K ±5%; ½ W. Composition | 184A763H57 |
| R108 | 56K ±5%; ½ W. Composition | 184A763H69 |
| R109 | 10K ±5%; 1 W. Composition | 187A643H51 |
| R110 | 6.8K ±5%; 1 W. Composition | 187A643H47 |
| R111 | 470 ohms ±5%; ½ W. Composition | 184A763H19 |
| R112 | 1000 ohms ±5%; ½ W. Composition | 184A763H27 |
| R113 | 470K ±5%; ½ W. Composition | 184A763H91 |
| R114 | 1000 ohms ±5%; ½ W. Composition | 185A763H27 |
| R115 | 82K ±5%; ½ W. Composition | 184A763H73 |

## ELECTRICAL PARTS LIST (Cont'd.)

| CIRCUIT SYMBOL | DESCRIPTION | WESTINGHOUSE DESIGNATION |
|---|---|---|
| | **RESISTORS** | |
| R116 | 10K ± 5%; ½ W. Composition | 184A763H51 |
| R117 | 10K ± 5%; ½ W. Composition | 184A763H51 |
| R118 | 10K ± 5%; ½ W. Composition | 184A763H51 |
| R119 | 100K ± 5%; ½ W. Composition | 184A763H75 |
| R120 | 39K ± 5%; ½ W. Composition | 184A763H65 |
| R121 | 68K ± 5%; ½ W. Composition | 184A763H71 |
| R122 | 68K ± 5%; ½ W. Composition | 184A763H71 |
| R123 | 1000 ohms ± 5%; ½ W. Composition | 184A763H27 |
| R124 | 33K ± 5%; ½ W. Composition | 184A763H63 |
| R125 | 33K ± 5%; ½ W. Composition | 184A763H63 |
| R126 | 10K ± 5%; ½ W. Composition | 184A763H51 |
| R127 | 10K ± 5%; ½ W. Composition | 184A763H51 |
| R128 | 10K ± 5%; ½ W. Composition | 184A763H51 |
| R129 | 68K ± 5%; ½ W. Composition | 184A763H71 |
| R130 | 68K ± 5%; ½ W. Composition | 184A763H71 |
| R131 | 12K ± 5%; ½ W. Composition | 184A763H53 |
| R132 | 33K ± 5%; ½ W. Composition | 184A763H63 |
| R133 | 33K ± 5%; ½ W. Composition | 184A763H63 |
| R134 | 10K ± 5%; ½ W. Composition | 184A763H51 |
| R135 | 10K ± 5%; ½ W. Composition | 184A763H51 |
| R136 | 3.3K ± 5%; ½ W. Composition | 184A763H39 |
| R137 | 800 ohms ± 5%; 3 W. Composition | 184A859H06 |
| R138 | 10K ± 5%; ½ W. Composition | 184A763H51 |
| R151 | 2.7K ± 5%; ½ W. Composition | 184A763H37 |
| R152 | 2.2K Sensistor Type TM¼ (Tex. Inst. Co.) | 187A685H01 |
| R153 | 220 ohms ± 5%; ½ W. Composition | 184A763H11 |
| R154 | 2.2K ± 5%; ½ W. Composition | 184A763H35 |
| R155 | 15K ± 5%; ½ W. Composition | 184A763H55 |
| R157 | 4.7K ± 5%; ½ W. Composition | 184A763H43 |
| R158 | 4.7K ± 5%; ½ W. Composition | 184A763H43 |
| R159 | 15K ± 5%; ½ W- Composition | 184A763H55 |
| R160 | 560 ohms ± 5%; ½ W. Composition | 184A763H21 |
| R161 | 1.2K ± 5%; ½ W. Composition | 184A763H29 |
| R162 | 180 ohms ± 5%; ½ W. Composition | 184A763H09 |
| R163 | 180 ohms ± 5%; ½ W. Composition | 184A763H09 |
| R164 | 470 ohms ± 5%; ½ W. Composition | 184A763H19 |
| R165 | 1000 ohms ± 5%; ½ W. Composition | 184A763H27 |
| R166 | 3K Thermistor Type ID201 (G.E. Co.) | 185A211H08 |
| R167 | 18K ± 5%; ½ W. Composition | 184A763H57 |
| R168 | 10K ± 5%; ½ W. Composition | 184A763H51 |
| R211 | 10K ± 5%; Composition | 184A763H51 |
| R212 | 1K ± 5%; Composition | 184A763H27 |
| R213 | 10K ± 5%; Composition | 184A763H51 |
| R214 | 2.7K ± 5%; Composition | 184A763H37 |
| R215 | 10K ± 5%; Composition | 184A763H51 |
| R216 | 8.2K ± 5%; Composition | 184A763H73 |
| R217 | 2K ± 5%; Composition | 184A763H34 |
| R218 | 150 ohms ± 5%; Composition | 184A763H07 |
| R219 | 330 ohms ± 5%; Composition | 184A763H15 |
| R220 | 47K ± 5%; Composition | 184A763H67 |

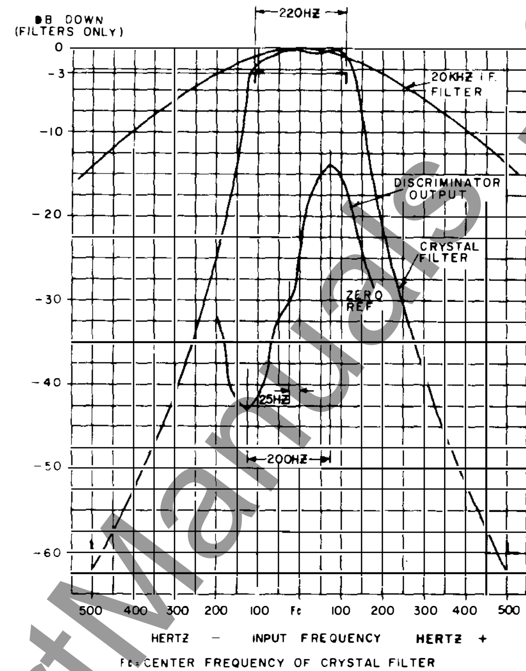
## ELECTRICAL PARTS LIST (Cont'd.)

| CIRCUIT SYMBOL | DESCRIPTION | WESTINGHOUSE DESIGNATION |
|---|---|---|
| | **TRANSFORMERS** | |
| T11 | Toroidal type, 10000/400 ohms | 205C043G03 |
| T12 | Toroidal type, 25000/300 ohms | 205C043G03 |
| T81 | Pot. Core type | 606B533G01 |
| T82 | Pot. Core type | 606B533G02 |
| T211 | 10K:10K | 714B677G01 |
| T212 | 25K:300 | 205C043G01 |
| | **TRANSISTORS** | |
| Q11 | 2N652A | 184A638H16 |
| Q12 | 2N1396 | 848A892H01 |
| Q13 | 2N1396 | 848A892H01 |
| Q31 | 2N274 | 187A270H01 |
| Q32 | 2N274 | 187A270H01 |
| Q51 | 2N396 | 762A575H03 |
| Q52 | 2N396 | 762A575H03 |
| Q53 | 2N396 | 762A575H03 |
| Q54 | 2N396 | 762A585H03 |
| Q81 | 2N652A | 184A638H16 |
| Q82 | 2N652A | 184A638H16 |
| Q101 | 2N652A | 184A638H16 |
| Q102 | 2N696 | 762A585H01 |
| Q103 | 2N697 | 184A638H18 |
| Q104 | 2N699 | 184A638H19 |
| Q105 | 2N699 | 184A638H19 |
| Q106 | 2N696 | 762A585H01 |
| Q107 | 2N698 | 762A585H02 |
| Q108 | 2N699 | 184A638H19 |
| Q109 | 2N699 | 184A638H19 |
| Q110 | 2N696 | 762A585H01 |
| Q111 | 2N696 | 762A585H01 |
| Q151 | 2N396 | 762A585H03 |
| Q152 | 2N396 | 762A585H03 |
| Q153 | 2N396 | 762A585H03 |
| Q154 | 2N699 | 184A638H19 |
| Q211 | 2N652A | 184A638H16 |
| | **MISCELLANEOUS** | |
| Y11 | Oscillator Crystal (Frequency 20 kHz above Channel Frequency) | 762A800H01+(Req.Freq.) |
| FL1 | Crystal input Filter | 401C466 + (Req. Freq.) |
| FL2 | I.F. Filter | 762A613G01 |
| PL | Pilot Light Bulb – For 48 V. Supply | 187A133H02 |
| | Pilot Light Bulb – For 125 or 250 V. Supply | 183A955H01 |
| F1, F2 | Fuse, 1.5 A. | 11D9195H26 |
| AL | Alarm Relay | 408C062H07 |
| AR | Trip Relay | 408C845G03 |
| L1-L2 | Choke | 292B096G02 |
| IC201 | Fairchild UA 710C (Int. Ckt.) | 201C826H04 |



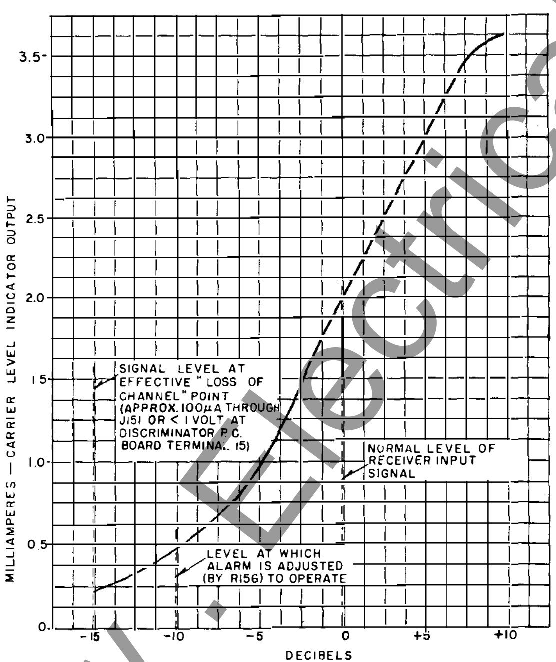

763A315

*Fig. 3 Block diagram of output logic circuit*



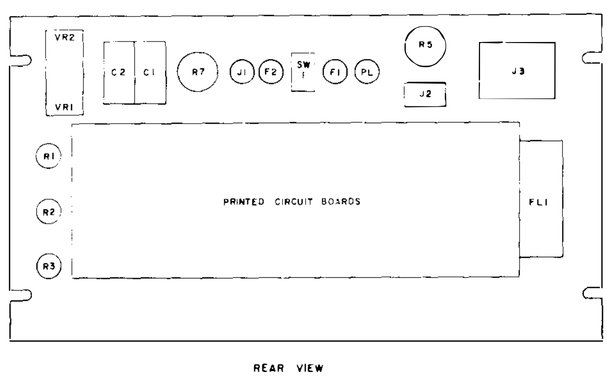

836A932

*Fig. 4 Filter and discriminator characteristics of the type TCF receiver*




836A931

*Fig. 5 Typical curve of the carrier level indicator current vs. receiver margin above minimum operating level.*




606B894

*Fig. 6 Component locations on the type TCF receiver panel*

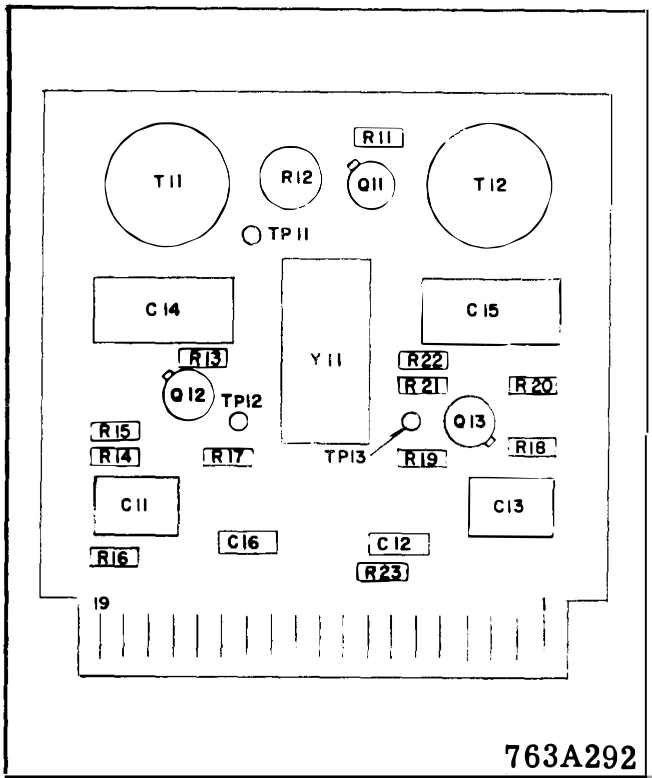



*Fig. 7 Component locations on the oscillator and mixer printed circuit board.*

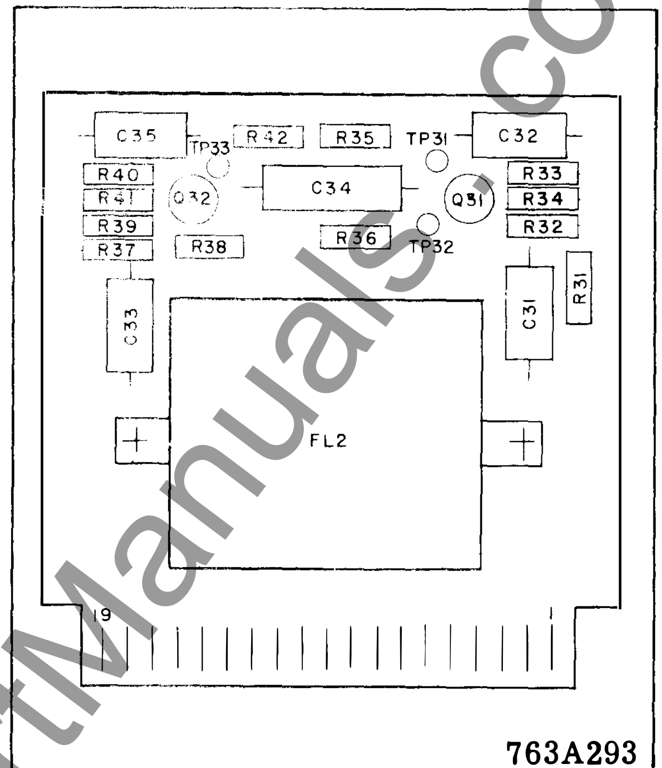



*Fig. 8 Component locations on the I.F. amplifier printed circuit board.*

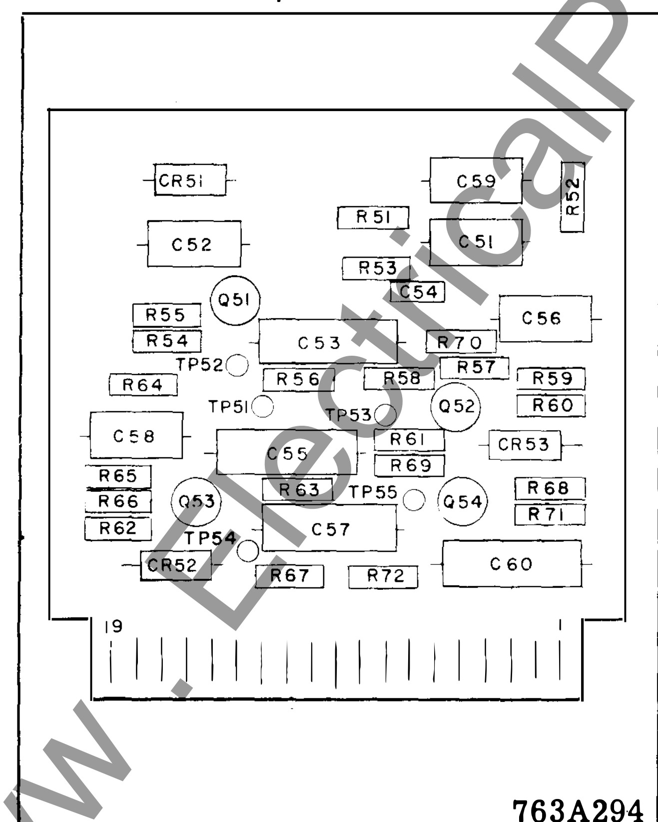



*Fig. 9 Component locations on the amplifier and limiter printed circuit board.*

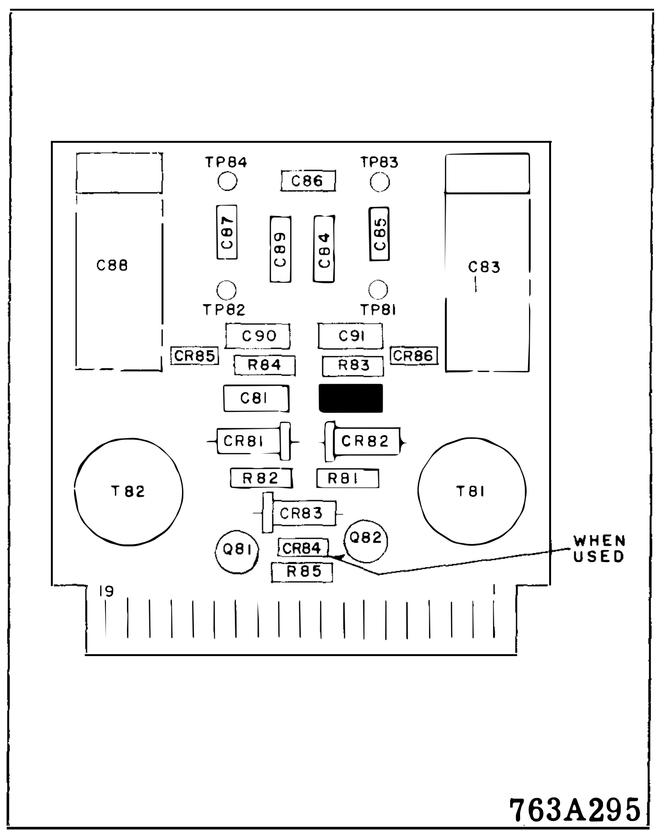



*Fig. 10 Component locations on the discriminator printed circuit board.*

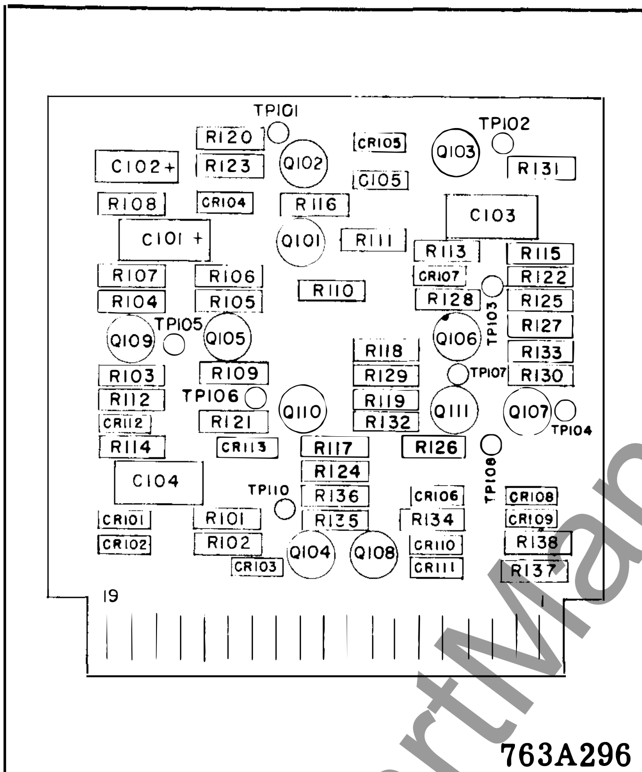



*Fig. 11 Component locations on the logic printed circuit board.*

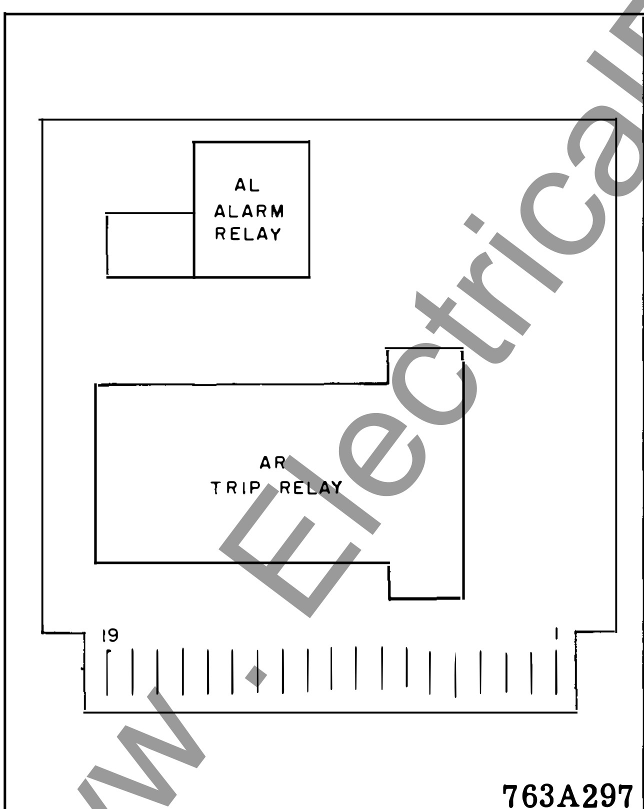



*Fig. 12 Component locations on the output printed circuit board.*

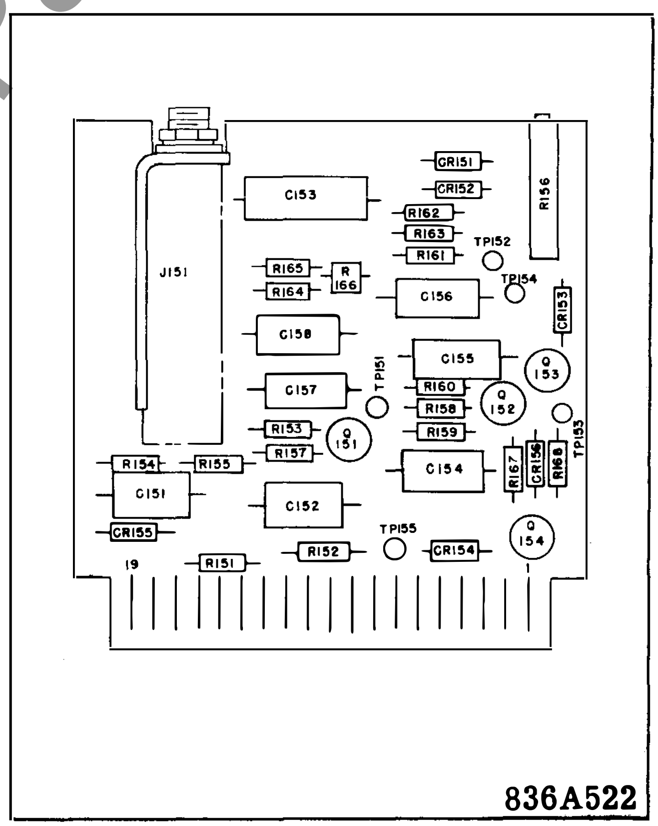



*Fig. 13 Component locations on the carrier level indicator printed circuit board.*

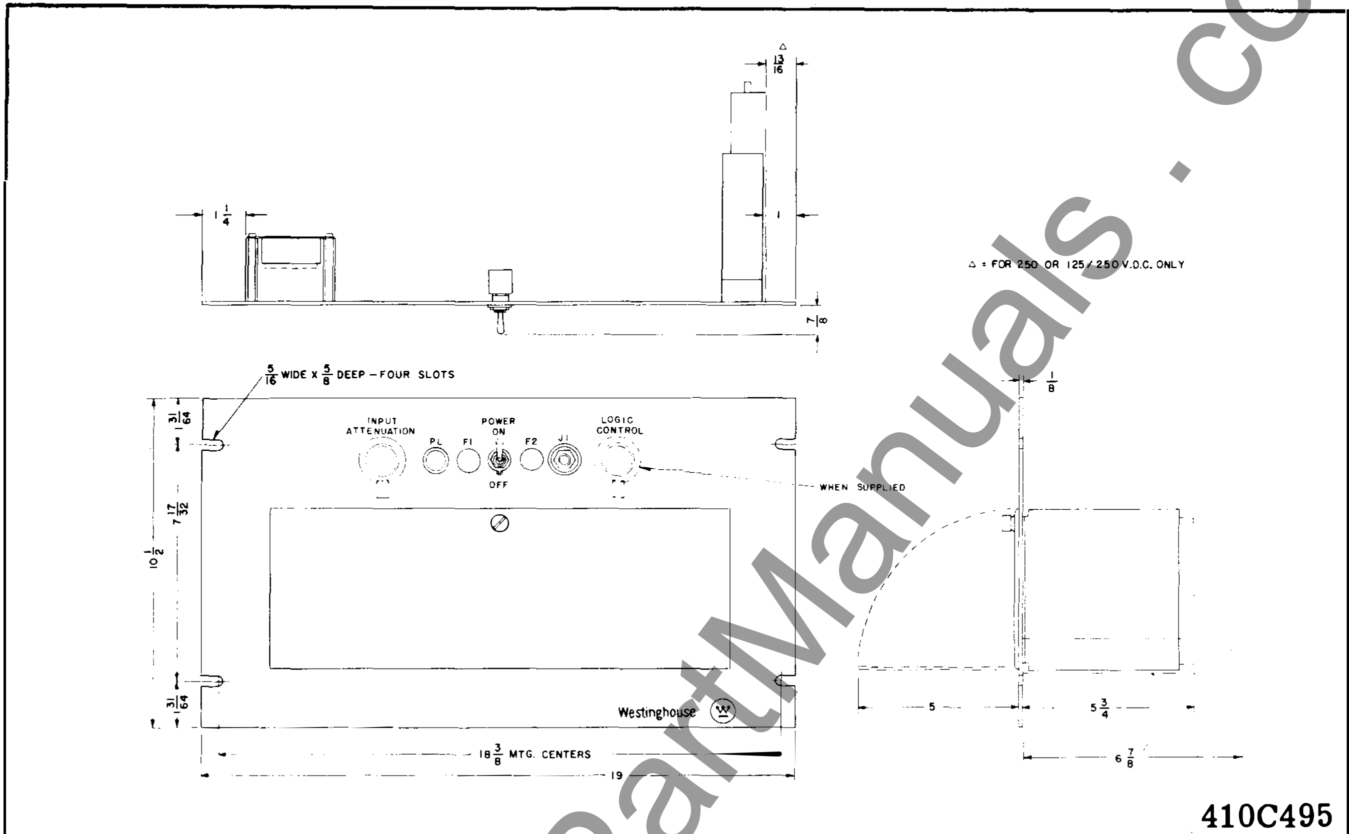



*Fig. 14 Outline and drilling plan for the type TCF receiver assembly.*

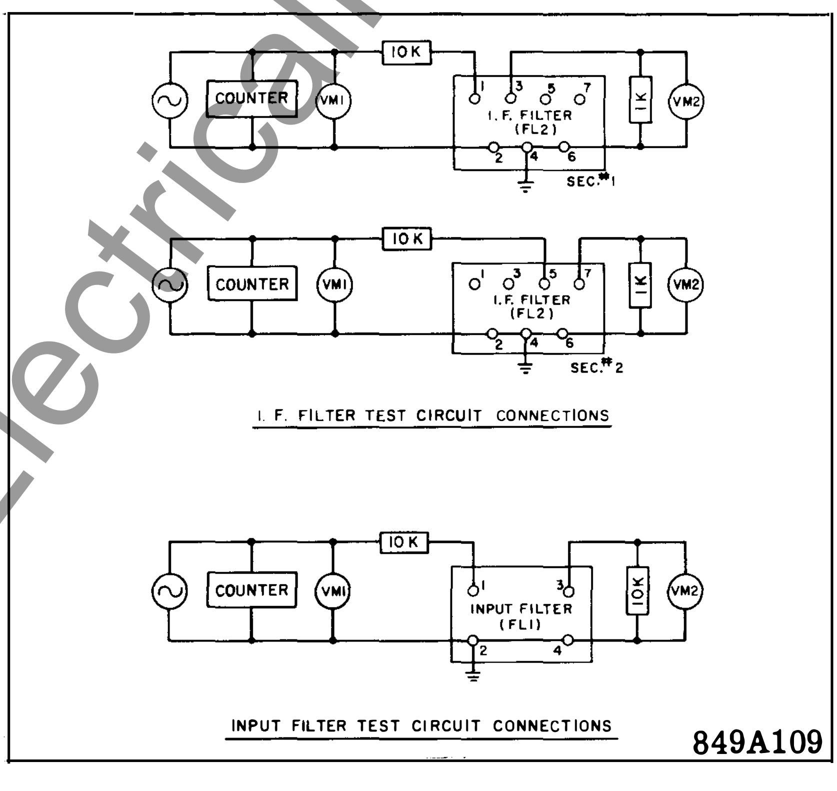
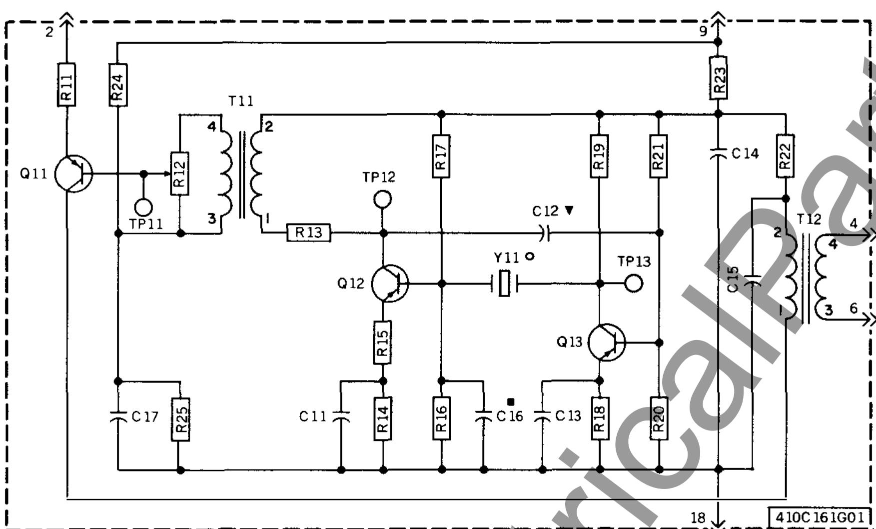



*Fig. 15. Test Currents for TCF Frequency Shift Receiver Filters.*




| COMPONENT | STYLE | REQ. | REF. |
|---|---|---|---|
| TRANSISTOR | | | |
| Q11–Q12–Q13 | 849A441H03 | 3 | 2N4249 |
| | | | |
| RESISTOR | | | |
| R15–R22 | 184A763H15 | 2 | 330Ω 1/2W ±5% |
| R14–R18–R19 | 184A763H39 | 3 | 3.3K 1/2W ±5% |
| R13 | 184A763H45 | 1 | 5.6K 1/2W ±5% |
| R11–R16–R20–R23 | 184A763H51 | 4 | 10K 1/2W ±5% |
| R17–R21 | 184A763H63 | 2 | 33K 1/2W ±5% |
| R24 | 184A763H83 | 1 | 220K 1/2W ±5% |
| R25 | 184A763H43 | 1 | 4.7K 1/2W ±5% |
| | | | |
| CAPACITOR | | | |
| C11–C13–C17 | 187A624H02 | 3 | .25MFD. 200V. |
| C14–C15 | 187A624H04 | 2 | 1MFD. 200V. |
| C12 | SEE NOTE ▼ | | |
| C16 | SEE NOTE ■ | | |
| | | | |
| POTENTIOMETER | | | |
| R12 | 629A430H02 | 1 | 1000Ω |
| | | | |
| TRANSFORMER | | | |
| T11 | 205C043G01 | 1 | 10,000/400 |
| T12 | 205C043G03 | 1 | 25,000/300 |
| | | | |
| CRYSTAL | | | |
| Y11 | SEE NOTE o | | |

▼ =C12 RANGE 4 TO 390Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

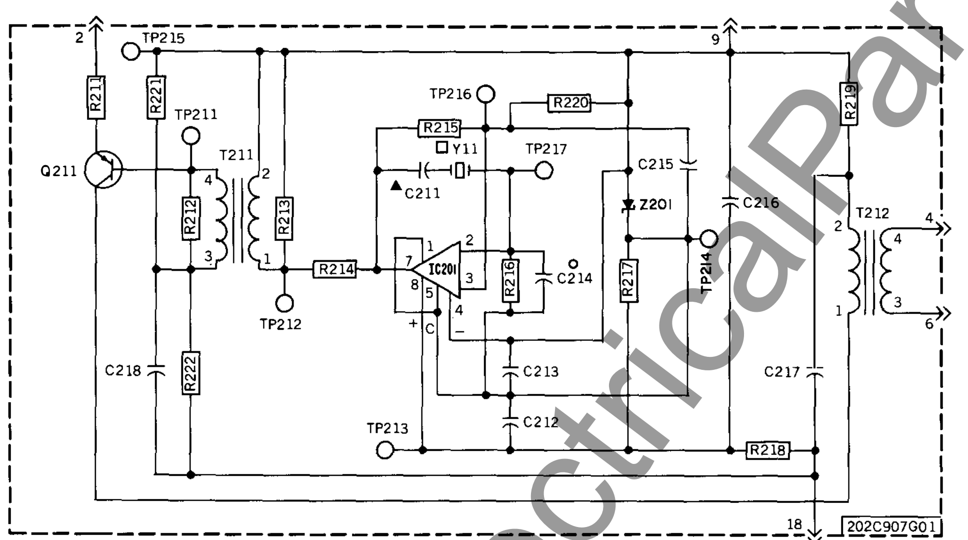
■ =C16 RANGE 22 TO 100Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

o =Y11 RANGE–50 TO 220 KHZ.

REF. COMPONENT LOCATION– 763A292

264C855

* *Fig. 18. Internal Schematic 30-200KHz Oscillator and Mixer Silicon Transistor Version*




| COMPONENT | STYLE | REQ. | REF. |
|---|---|---|---|
| TRANSISTOR | | | |
| Q211 | 849A441H03 | 1 | 2N4249 |
| | | | |
| | | | |
| RESISTOR | | | |
| R211–R213–R215 | 184A763H51 | 3 | 10K 1/2W ±5% |
| R212 | 184A763H27 | 1 | 1K 1/2W ±5% |
| R214 | 184A763H37 | 1 | 2.7K 1/2W ±5% |
| R216 | 184A763H49 | 1 | 8.2K 1/2W ±5% |
| R217 | 184A763H34 | 1 | 2K 1/2W ±5% |
| R218 | 184A763H07 | 1 | 150Ω 1/2W ±5% |
| R219 | 184A763H15 | 1 | 330Ω 1/2W ±5% |
| R220 | 184A763H67 | 1 | 47K 1/2W ±5% |
| R221 | 184A763H83 | 1 | 220K 1/2W ±5% |
| R222 | 184A763H43 | 1 | 4.7K 1/2W ±5% |
| | | | |
| | | | |
| CAPACITOR | | | |
| C211 | SEE NOTE ▲ | | |
| C212–C213–C215 | 184A663H04 | 3 | .1MFD. 50V. |
| C214 | SEE NOTE ○ | | |
| C216–C217 | 187A624H04 | 2 | 1 MFD. 200V. |
| C218 | 187A624H02 | 1 | .25 MFD. 200V. |
| | | | |
| | | | |
| ZENER DIODE | | | |
| Z201 | 862A606H01 | 1 | 1N753A |
| | | | |
| | | | |
| INTERNAL CIRCUIT | | | |
| IC201 | 201C826H04 | 1 | UA710C |
| | | | |
| | | | |
| TRANSFORMER | | | |
| T211 | 714B677G01 | 1 | |
| T212 | 205C043G03 | 1 | |
| | | | |
| | | | |
| CRYSTAL | | | |
| Y11 | SEE NOTE □ | 1 | |

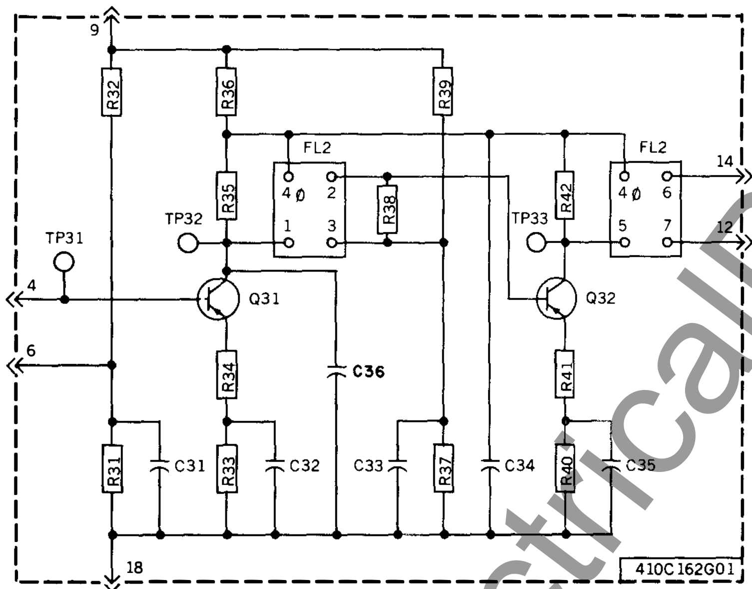
▲ = C211 RANGES FROM 100Pf. TO 1,000Pf.

○ = C214 STYLE NO. 187A695H17 .56Pf. BUT MAY VARY UP TO 100Pf.

□ = Y11 FREQUENCY EQUALS RECEIVER (CHANNEL) FREQUENCY PLUS 20 KHZ.

264C844

* *Fig. 19. Internal Schematic 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version*

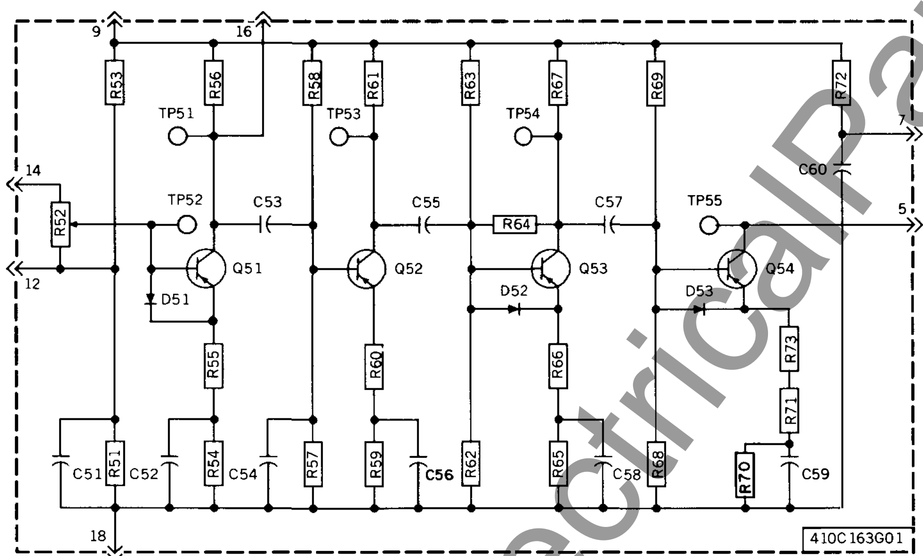



| COMPONENT | STYLE | REQ. | REF. |
|---|---|---|---|
| TRANSISTOR | | | |
| Q31–Q32 | 849A441H03 | 2 | 2N4249 |
| | | | |
| RESISTOR | | | |
| R34–R41 | 187A290H21 | 2 | 68Ω 1/2W ±5% |
| R36 | 184A763H15 | 1 | 330Ω 1/2W ±5% |
| R33–R40 | 184A763H23 | 2 | 680Ω 1/2W ±5% |
| R38 | 184A763H27 | 1 | 1K 1/2W ±5% |
| R31–R37 | 184A763H39 | 2 | 3.3K 1/2W ±5% |
| R35–R42 | 184A763H51 | 2 | 10K 1/2W ±5% |
| R32–R39 | 184A763H59 | 2 | 22K 1/2W ±5% |
| | | | |
| CAPACITOR | | | |
| C31–C32–C33–C35 | 187A624H02 | 4 | .25MFD. 200V |
| C34 | 187A624H04 | 1 | 1MFD. 200V. |
| C36 | 762A757H01 | 1 | 100 Pf. |
| | | | |
| FILTER | | | |
| FL2 | 762A613G01 | 1 | |

ø = COMMON TERMINAL

264C856

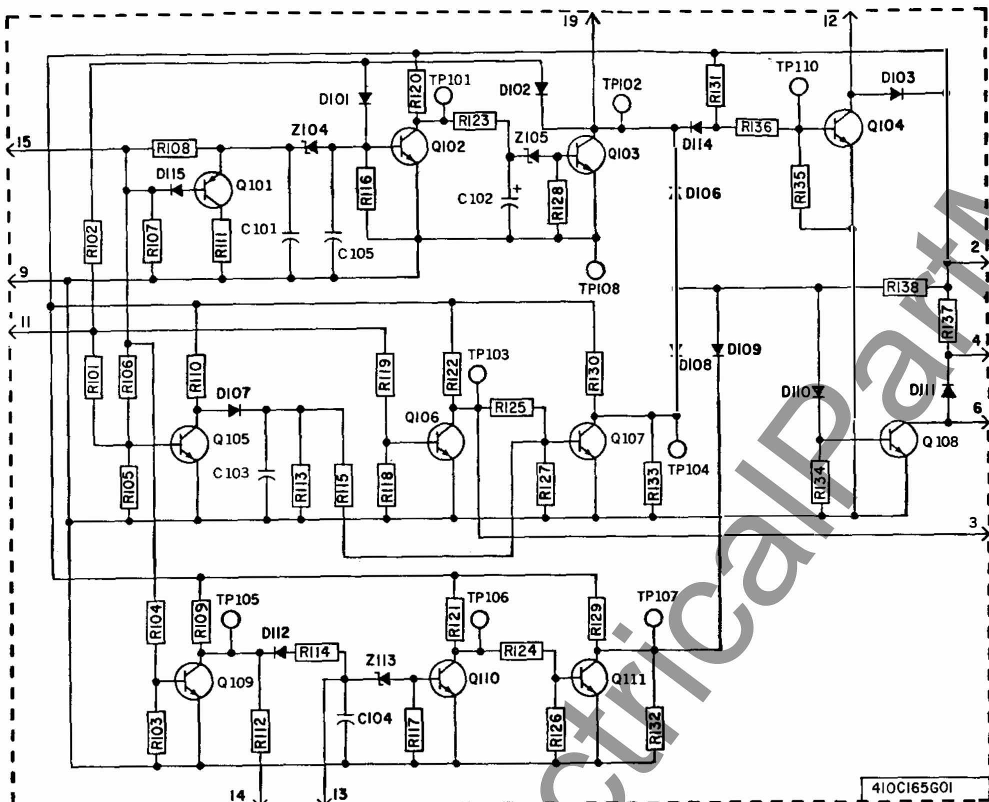
* *Fig. 20. Internal Schematic I.F. Amplifier – Silicon Transistor Version*




| COMPONENT | STYLE | REQ. | REF. |
|---|---|---|---|
| TRANSISTOR | | | |
| Q51–Q52–Q53–Q54 | 849A441H03 | 4 | 2N4249 |
| RESISTOR | | | |
| R66 | 187A290H21 | 1 | 68Ω 1/2W ±5% |
| R55 | 187A290H11 | 1 | 27Ω 1/2W ±5% |
| R70 | 184A763H11 | 1 | 220Ω 1/2W ±5% |
| R72 | 184A763H15 | 1 | 330Ω 1/2W ±5% |
| R65 | 184A763H23 | 1 | 680Ω 1/2W ±5% |
| R59 | 184A763H31 | 1 | 1.5K 1/2W ±5% |
| R54–R62 | 184A763H35 | 2 | 2.2K 1/2W ±5% |
| R64–R68 | 184A763H37 | 2 | 2.7K 1/2W ±5% |
| R51–R57–R61–R67 | 184A763H43 | 4 | 4.7K 1/2W ±5% |
| R56 | 184A763H51 | 1 | 10K 1/2W ±5% |
| R69 | 184A763H57 | 1 | 18K 1/2W ±5% |
| R53–R58 | 184A763H61 | 2 | 27K 1/2W ±5% |
| R63 | 184A763H63 | 1 | 33K 1/2W ±5% |
| R71 | 09D8326G20 | 1 | 100Ω ±2% |
| R60 | 184A763H09 | 1 | 180Ω 1/2W ±5% |
| R73 | 629A531H02 | 1 | 56 Ω 1/2W ±2% |
| CAPACITOR | | | |
| C54 | 187A584H15 | 1 | 1300MMF. 500V. |
| C51–C52–C56–C58–C59 | 187A624H02 | 5 | .25MFD. 200V. |
| C53–C55–C57 | 187A624H01 | 3 | 0.1MFD. 200V. |
| C60 | 187A624H04 | 1 | 1.0MFD. 200V. |
| DIODE | | | |
| D51–D52–D53 | 184A855H07 | 3 | 1N457A |
| POTENTIOMETER | | | |
| R52 | 629A645H04 | 1 | 1K |

264C841

* *Fig. 21. Internal Schematic Amplifier and Limiter – Silicon Transistor Version*




| COMPONENT | STYLE | REQ | REF |
|---|---|---|---|
| TRANSISTORS | | | |
| Q101 | 849A441H03 | 1 | ( 2N4249 ) |
| Q102-106-110-111 | 762A585H01 | 4 | ( 2N696 ) |
| Q103 | 184A638H18 | 1 | ( 2N697 ) |
| Q107 | 762A585H02 | 1 | ( 2N698 ) |
| Q105-108-109-104 | 184A638H19 | 4 | ( 2N699 ) |
| RESISTORS | | | |
| R110 | 187A643H47 | 1 | ( 6.8K 1W ±5%) |
| R109 | 187A643H51 | 1 | ( 10K 1W ±5%) |
| R137 | 184A859H06 | 1 | ( 800 Ω 3W) |
| R111 | 184A763H19 | 1 | ( 470 1/2W ±5%) |
| R112-R114-R123 | 184A763H27 | 3 | (1K 1/2W ±5%) |
| R136 | 184A763H39 | 1 | ( 3.3K 1/2W ±5%) |
| R103-105-116 TO 118-126 TO 128-134-135-138 | 184A763H51 | 11 | (10K 1/2W ± 5%) |
| R131 | 184A763H53 | 1 | (12K 1/2W ±5%) |
| R107 | 184A763H57 | 1 | (18K 1/2W ±5%) |
| R104 | 184A763H61 | 1 | (27K 1/2W ±5%) |
| R102-124-125-132-133 | 184A763H63 | 5 | (33K 1/2W ±5%) |
| R101-106-120 | 184A763H65 | 3 | (39K 1/2W ±5%) |
| R108 | 184A763H69 | 1 | (56K 1/2W ±5%) |
| R121-122-129-130 | 184A763H71 | 4 | (68K 1/2W ±5%) |
| R115 | 184A763H73 | 1 | (82K 1/2W ±5%) |
| R119 | 184A763H75 | 1 | (100K 1/2W ±5%) |
| R113 | 184A763H91 | 1 | (470K 1/2W ±5%) |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| CAPACITORS | | | |
| C101 | 184A661H12 | 1 | (4.7MFD. 10%) |
| C105 | 184A663H02 | 1 | (.05MFD. 50V) |
| C102 | 184A661H25 | 1 | (6.8MFD.) |
| C103-104 | 187A624H11 | 2 | ( .5MFD. ±10%) |
| DIODES | | | |
| D114 | 182A881H07 | 1 | ( IN100A ) |
| | | | |
| | | | |
| D101 TO 103-106 TO 112 115 | 184A855H07 | 11 | (IN457A) |
| DIO-ZENER | | | |
| Z105 | 185A212H06 | 1 | ( IN3686B ) |
| Z113-104 | 186A797H06 | 2 | ( IN957B ) |

264C845

* *Fig. 24. Internal Schematic Logic Board – Silicon Transistor Version*

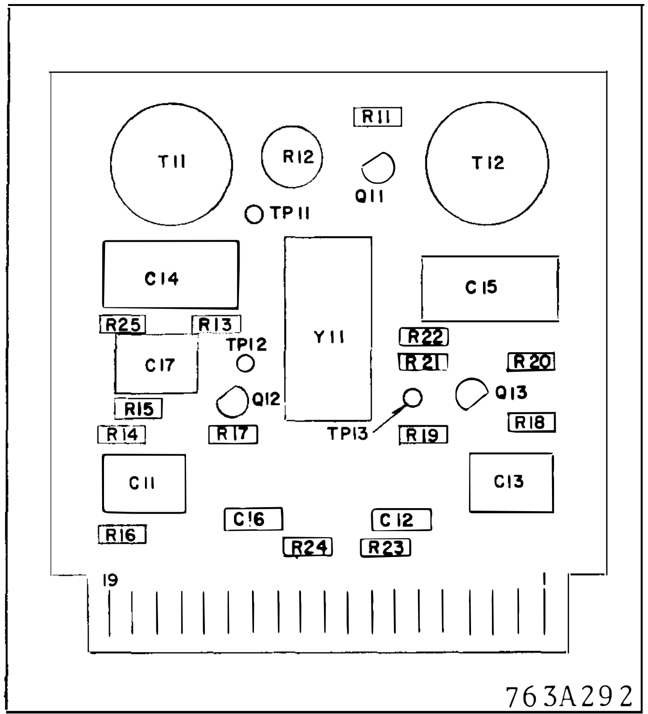



Fig. 25. Component Locations 30-200KHz. Oscillator and Mixer Silicon Transistor Version

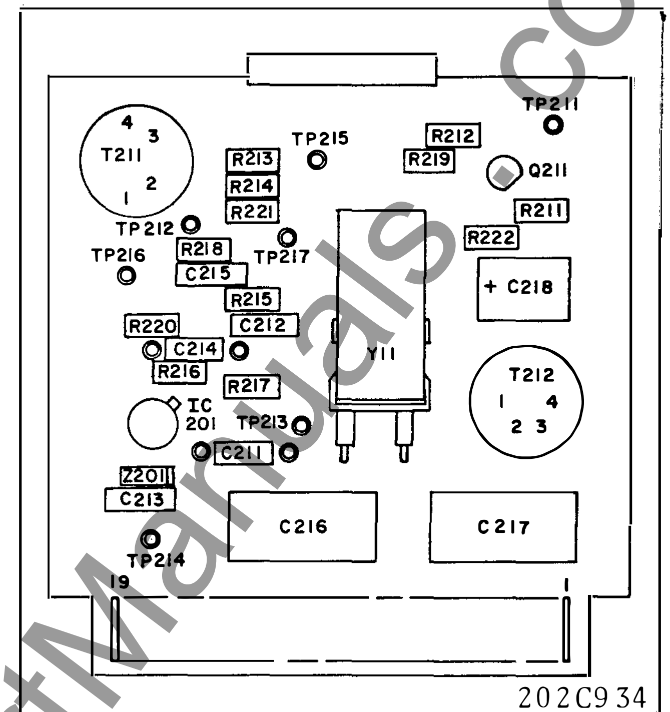



Fig. 26. Component Locations 200.5-300KHz. Oscillator and Mixer Silicon Transistor Version

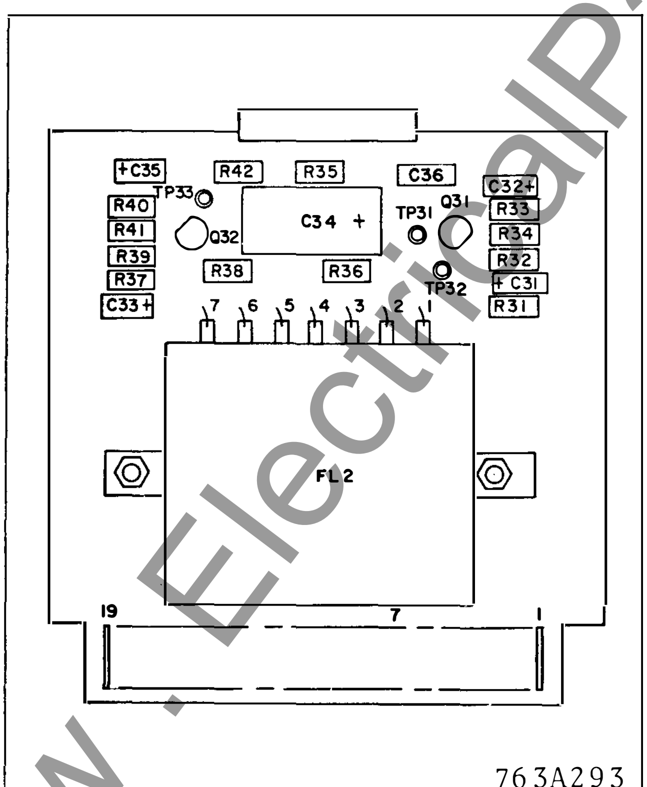



Fig. 27. Component Locations I.F. Amplifier – Silicon Transistor Version

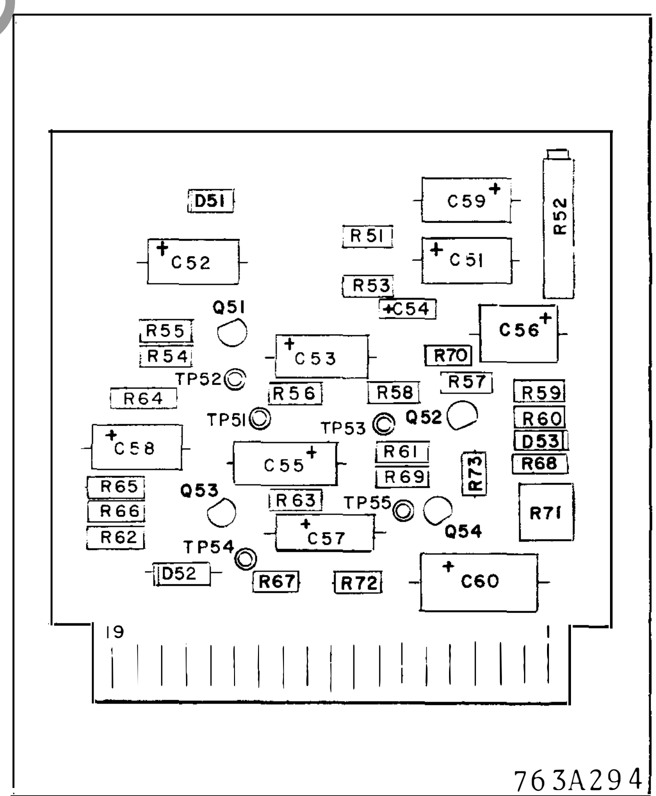



Fig. 28. Component Locations Amplifier and Limiter – Silicon Transistor Version

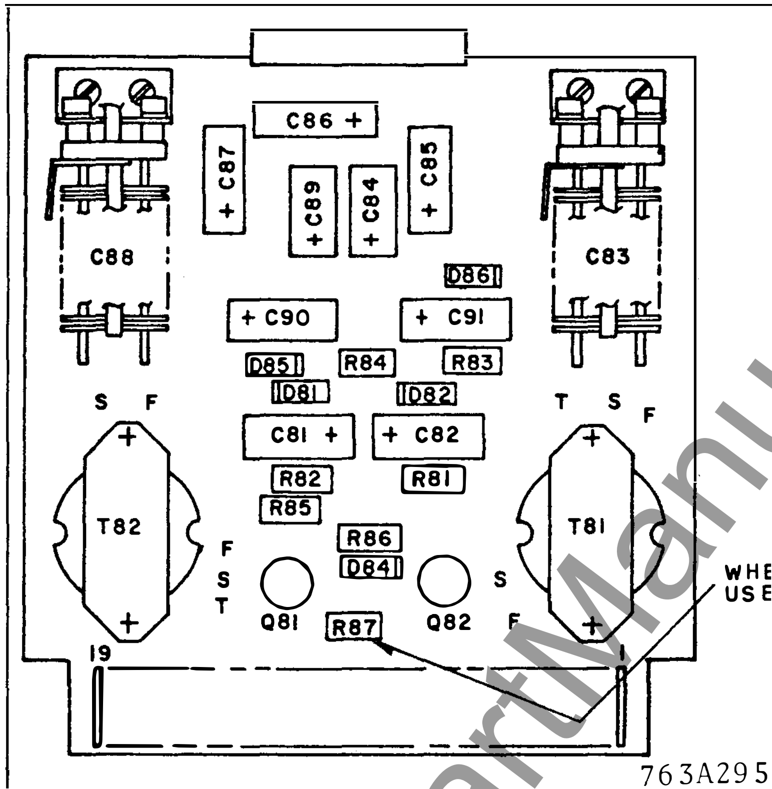



*Fig. 29. Component Locations Discriminator – Silicon Transistor Version*

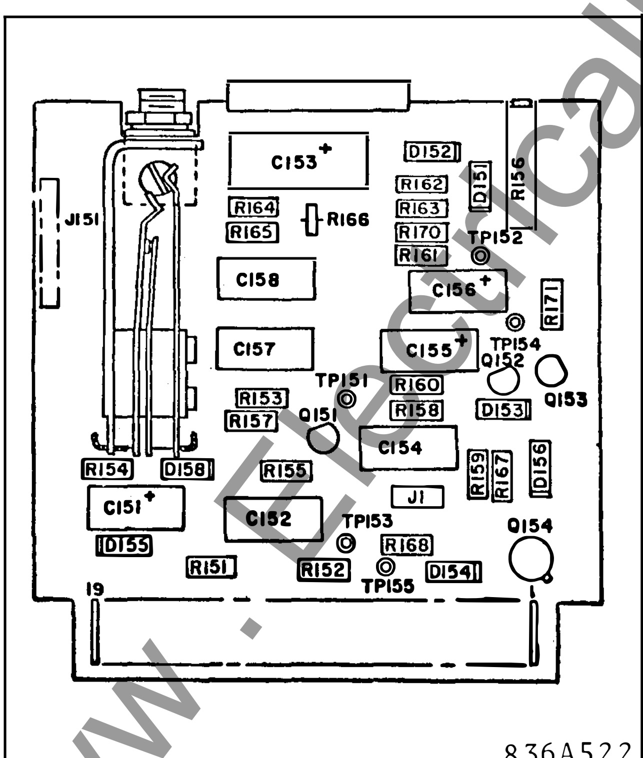



*Fig. 30. Component Locations Carrier Level Indicator – Silicon Transistor Version*

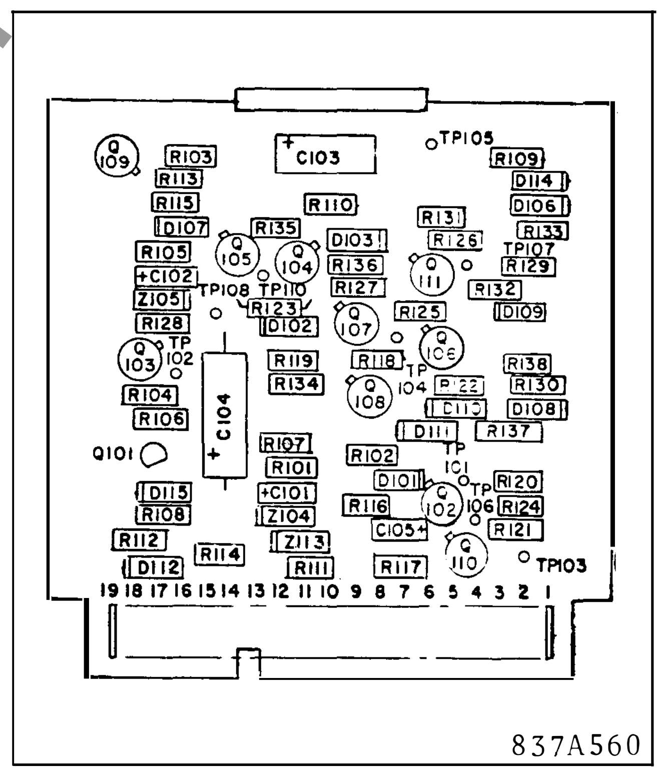



*Fig. 31. Component Locations Logic Board – Silicon Transistor Version*

**WESTINGHOUSE ELECTRIC CORPORATION**

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

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

# TYPE TCF POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT 3 FREQUENCY – 10 WATT / 1 WATT / 10 WATT

**CAUTION:** It is recommended that the user of this equipment become thoroughly familiar 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

A widely used high speed relaying system used for transmission line protection consists of directional-comparison unblock relaying plus a transfer-trip channel for breaker failure protection. Normally these systems of relaying require two frequency-shift channels, wideband for unblocking and narrow-band for transfer trip. A saving in channel spectrum can be effected by using a three frequency transmitter for the two relaying functions and two separate receivers, one for each function, as shown in Figure 7.

### SYSTEM OPERATION

The three frequency TCF carrier transmitter provides for the transmission of any of three closely controlled discrete frequencies, all within the equivalent spacing of a single wide-band channel. The center frequency of the channel can vary from from 30 kHz to 300 kHz in 0.5 kHz steps. The transmitter normally operates at a frequency that is 100 hz above the channel center frequency (fc). This frequency serves as the "guard" frequency for the transfer-trip receiver and as the "block" frequency for the unblock receiver. Note that the discriminator characteristic in the unblock receiver in this case is reversed from the normal unblock receiver used with the standard two frequency transmitter. This "guard" "block" frequency is transmitted continuously when conditions are normal. It indicates at the receiving end of the line that the channel is operative and serves to prevent false operation of the receiver by line noise. The lowest frequency, which is 100 hz less than fc, is the "transfer trip" frequency and is transmitted as a signal that an operation (such as tripping a circuit breaker) should be performed at the receiving end of the line. The highest frequency, which is 300 hz above fc, is the "unblock" frequency and is transmitted as an unblock signal for directional comparison relaying. If a subsequent transfer-trip operation is called for, the transmitter will shift to fc - 100 hz which is the "trip" frequency for the transfer trip (narrow-band receiver.

Note that when the transmitter shifts to "unblock," the frequency is completely outside the passband of the narrow band transfer-trip receiver. Normally, this would cause a low-signal alarm output from that receiver. Similarly, when the frequency is shifted to "trip" (fc-100 hz), the signal is well removed from the "block" peak of the wideband receiver discriminator. In order to prevent a similar alarm output in this case, the checkback output of each receiver is cross-connected to the guard or block input of the opposite receiver (through an OR logic circuit). This logic is shown in Figure 8. The checkback output is a receiver output that indicates that a proper signal has been received without going through any time delays or other logic used for the actual relaying output. With this cross-connected logic, both receivers will function when required, but will not give any incorrect output indications.

The transmitter normally operates at an output level of one watt at the "guard" "blocking" frequency, but increases to ten watts for either "trip" or "unblock" output. An interlock is provided in the transmitter keying circuit to give transfer-trip preference. This means that even while the transmitter is shifted to the "unblock" frequency, if the transfer-trip keying circuit is energized, the transmitter will shift to the "trip" frequency without delay.

## CONSTRUCTION

The 10 watt/1 watt/10 watt TCF transmitter unit is mounted on a standard 19-inch wide panel 12¼ inches (7 rack units) high with edge slots for mounting on a standard relay rack. A jack for metering the amplifier collector current is accessible from the front of the panel. See Fig. 6. All of the circuitry that is suitable for printed circuit board mounting is on two such boards, as shown in Fig. 2 The components mounted on each printed circuit board or other sub-assembly are shown enclosed by dotted lines on the internal schematic. Fig. 1. The location of components on the three printed circuit boards are shown on separate illustrations, Fig. 3, 4 & 5.

External connections to the assembly are made through a 12-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2.

## OPERATION

The transmitter is made up of four main stages and two filters. The stages include two crystal oscillators operating at frequencies that differ by the desired channel center frequency, a mixer and buffer amplifier, a driver stage and a power amplifier. The interstage filter is located between the driver and the power amplifier. The output filter removes harmonics that may be generated by distortion in the power amplifier.

A single crystal designed for oscillation in the 30 kHz to 300 kHz range cannot be forced to oscillate away from its natural frequency by as much as ± 100 hz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2 MHz range. The crystals are Y1 and Y2 of Fig. 1. The frequency of Y2 is 2.00 MHz when operated with a specified amount of series capacity, and the frequency of Y1 is 2.00 MHz plus the channel center frequency, or 2.03 MHz for 30 kHz center frequency. Capacitor C55 and crystal Y2 in series are connected between the positive side of the supply voltage and the base of transistor Q51, which operates in the emitter following mode. The emitter is coupled to the base through C57. With Y2 removed the base of Q51 would be held at approximately the midpoint of the supply voltage by R51 and R52. The crystal serves as a series-resonant circuit with very high inductance and low capacitance. The circuit can be made to oscillate at other than the natural frequency of the crystal by varying the series capacitor, C55. Increasing C55 will lower the frequency of oscillations and reducing C55 will raise the frequency.

Capacitor C73 (in parallel with C70) is not effective until D55 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the keying control for unblock is closed which places 45V. dc at terminal 12 of the printed circuit board. With D55 conducting, C73 and C70 are placed in parallel with C55 and C74. The adjustment of C73 will reduce the frequency of the Y2 circuit by 200 hz. Since Y2 is the lower of the two frequencies derived from Y1 and Y2, the difference frequency, which is the frequency transmitted, is now increased by 200 hz. Thus the frequency transmitted in now 200 hz above the guard frequency or 300 hz above the center frequency.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes D51 and D52. By adjustment of C52 this circuit is made to oscillate at 100 hz above its marked frequency. Capacitors C53 and C76 are not effective until D51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the keying control is closed, which places 45 V. dc at terminal 1 of the printed circuit board. With D51 conducting, C53 and C76 are effectively in parallel with C52 and C75. The adjustment of C53 will reduce the frequency by 200 hz. The crystals taken individually have a greater variation of frequency with temperature than would be acceptable. However, by proper matching of the two crystals, the variation in their difference frequency can be kept within limits that permit holding the frequency station of the overall transmitter to ± 10 hz over a temperature range of — 20 to +55°C.

The frequencies produced by the two oscillators are coupled to the base of mixer transistor Q53 through C62 and C63. The sum of the two frequencies is so high that a negligible amount appears on the secondary of transformer T51, but the difference frequency is accepted and amplified by Q53 and Q54.

When the keying control is closed, it increases the output power from 1 watt to 10 watts as well as changing the frequency from Guard to Transfer or Unblock Trip. This is effected by reducing the emitter resistance of buffer-amplifier transistor Q54 When the keying control is open, transistor Q55 receives no base current and is non-conducting. Emitter resistor R70 therefore is effectively open-circuited The level of output power is adjusted to 1 watt by means of R64. When Q55 is made conductive by closing the keying control circuit, R70 is placed in parallel with R68 and the amount of emitter resistance unbypassed by C66 can be adjusted as required to obtain a 10-watt output level.

Note in the keying board that diode D12 serves as interlocking logic connection between the keying for "unblock" and the keying for "transfer trip". This logic permits the "transfer trip" keying to take preference over the "unblock" keying. That is even if we have "unblock" keying and then get "transfer trip" keying, the "transfer trip" will take immediate preference over the "unblock" keying This is accomplished by the "transfer trip" keying causing transistor Q12 to conduct which in turn shunts out the keying voltage input to transistor Q22 through diode D12. Thus while Q12 becomes conducting and consequently Q11, effecting "transfer trip" keying, this conduction of Q12 also prevents Q22 from becoming conducting and prevents "unblocking" keying.

As is shown on the Internal Schematic, Fig. 1, the voltage for the keying circuit is obtained from the 45-volt regulated supply in the transmitter.

The driver stage consists of transistors Q56 and Q57 connected in a conventional push-pull circuit with input supplied from the collector of Q54 through transformer T52. Thermistor R73 and resistors R74 and R75 are connected to provide a variable bias that reduces the effect of varying ambient temperatures on the input level. In addition, network R67, R79, and potentiometer R80 are used in the bias circuit and are adjusted by means of R80 to limit the quiscent current in the driver stage common to 0.2 ma. This adjustment is made by unsoldering the lead going from pin 2 of the transmitter to terminal 2 of transformer T1 and inserting a d-c milliammeter (0-1.0 ma) between this pin 2 and terminal 2 of T1. The R80 is adjusted to produce 0.2 ma ± .05 in this circuit, after this, the milliammeter is removed and the lead replaced.

The driver filter, FL101, consists of a series-resonant inductor and capacitor connected between the driver and power amplifier stages by appropriate transformers T1 and T2. This filter greatly improves the waveform of this signal applied to the power amplifier.

The power amplifier uses two series-connected power transistors, Q101 and Q102, operating as a class B push-pull amplifier with single-ended output. Diodes D101 and D103 provide protection for the base-emitter junctions of the power transistors. Zener diodes Z105 and Z106 protect the collector-emitter junctions from surges that might come in from the power line through the coaxial cable.

The output transformer T3 couples the power transistors to the 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 G1 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line turner and coaxial cable. Autotransformer T4 matches the filter impedance to coaxial cable of 50, 60, or 70 ohms.

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

The power supply is a series-type transistorized d-c voltage regulator which has a very low stand-by current drain when there is no output current demand. The Zener diode Z1 holds a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the d-c voltage drop through transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage. The Zener diode Z2 serves to protect the collector-base junction of Q1 from surge voltages. Capacitor C1 provides a low carrier-frequency impedance across the d-c output voltage. Capacitors C2 and C3 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuit.

## CHARACTERISTICS

| | |
|---|---|
| Frequency Range | 30-300 kHz |
| Output | 1 watt guard - 10 watts transfer trip (into 50 to 70 ohm resistive load) — 10 watts unblock. |
| Frequency Stability | ±10 hz from -20°C to +55°C. |
| Frequency Spacing | 3000 hz min. between transmitter and adjacent receiver frequencies. |
| Harmonics | Down 55 db (min.) from output level. |
| Input voltage | 48 or 125 v.d.c. |
| Supply voltage variation | 42-56 v. for nom. 47 v. supply.<br>105-140 v. for nom. 125 v. supply. |
| Battery drain | 0.5 a. guard, 1.15 a. trip — 48 v.d.c.<br>0.5 a. guard, 1.15 a. trip — 125 v.d.c. |
| Keying circuit current | 4 ma. |
| Temperature range | -20 to +55°C. Around chassis. |
| Dimensions | Panel height - 12¼'' or 7 r.u.<br>Panel width - 19'' |
| Weight | 12 lbs. |

## INSTALLATION

The TCF transmitter 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 55°C.

## ADJUSTMENTS

The TCF 10W/1W/10W 3 frequency transmitter is shipped with the power output controls R64 and R70 set for outputs of 1 watt and 10 watts into a 60 ohm load. If it is desired to check these adjustments or if repairs have made readjustment necessary, the coaxial cable should be disconnected from the assembly terminals and replaced with a 50 to 70 ohm non-inductive 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 T4 output lead to the corresponding tap. Connect an a-c vacuum tube voltmeter (VTVM) across the load resistor. Turn power output control R64 to minimum (full counter-clockwise). Turn on the power switch on the panel and note the d-c voltage across terminals 5 and 7 of J3. If this is in the range of 42 to 46 volts, rotate R64 clockwise to obtain 4 or 5 volts across the load resistor used. 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 used. Then rotate R64 farther clockwise to obtain the correct voltage for 1 watt in the load resistor, as shown in the following table. For above 200 kHz, tuning coil L105 is a screw type adjustment and not a plunger with knurled shaft and locking nut.

Then change to Trip frequency by connecting together terminals 2 and 3 of the transmitter printed circuit board (which is approximately equivalent to connecting together terminals 7 and 8 of J3), and rotate R70 until the voltage across the load resistor is as shown in the following table for a 10 watt output. Recheck the adjustment of L105 for maximum output voltage and readjust R70 for a 10 watt output if necessary. Tighten the locking nut on L105. Open the power switch, remove the jumper used to key the transmitter to the 10 watt level, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

| T106 Tap | Voltage for 1 Watt Output | Voltage for 10 Watts Output |
|---|---|---|
| 50 | 7.1 | 22.4 |
| 60 | 7.8 | 24.5 |
| 70 | 8.4 | 26.5 |

Follow the procedure outlined in the line tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. 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 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.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals, this can be done by turning the matched pair 180° and inserting a crystal in its proper socket with other crystal unconnected. A sensitive frequency counter with a range of at least 2.3 MHz can be connected from TP51 to TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter input capacitance on the oscillator circuit.) While measurement of the oscillator crystals individually is necessary for the initial adjustment of the oscillators, generally any subsequent checks may be made with a lower range counter connected at the transmitter output. If any minor adjustment of the Guard and Trip frequencies should be needed, the Guard adjustment should be made with capacitor C52 and the Trip adjustment with C53.

## MAINTENANCE

Periodic checks of the transmitter Guard and Trip power outputs will detect 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 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 values are given in the following tables. Voltages should be measured with a VTVM. Readings may vary as much as ± 20%.

## TABLE I
## TRANSMITTER D-C MEASUREMENTS

Note: All voltages are positive with respect to Neg. 45 V. (TP51). All voltages read with d-c VTVM.

| Test Point | Voltage at 1 Watt Output | Voltage at 10 Watts Output |
|---|---|---|
| TP52 | 20 | 20 |
| TP53 | 5.4 | 5.4 |
| TP54 | 3.4 | 3.4 |
| TP55 | 21 | 18.5 |
| TP56 | 21 | 18.5 |
| TP57 | *< 1.0 | *< 1.0 |
| TP58 | 44.3 | 44.1 |
| TP59 | *< 1.0 | *< 1.0 |
| TP101 | 0 | 0 |
| TP103 | 21 ± 2 | 21 ± 2 |
| TP105 | 44.3 | 44.0 |

## TABLE II
## TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages subject to variations, depending upon frequency and transistor characteristics. T51-3 = Terminal 3 of transformer T51. Other transformer terminals identified similarly. All read with a-c VTVM.

| Test Point | Voltage at 1 Watt Output | Voltage at 10 Watts Output |
|---|---|---|
| TP54 to TP51 | 0.015-0.03 | 0.015-0.03 |
| TP57 to TP51 | 0.05 -0.09 | 0.3 - 1.2 |
| TP59 to TP51 | 0.05 -0.09 | 0.3 - 1.2 |
| T1-1 to TP51 | 1.65 | 5.6 |
| T1-3 to TP51 | 1.45 | 4.9 |
| T1-4 to Gnd. | .6 | 2.0 |
| T2-1 to Gnd. | .57 | 1.85 |
| TP101 to TP103 | 5.2 | 17.0 |
| TP103 to TP105 | 5.2 | 17.0 |
| T3-4 to Gnd. | 35 | 112 |
| T4-2 to Gnd. | 31 | 110 |
| TP109 to Gnd. | 9.8 | 31 |
| J102 to Gnd. | 7.8 | 24.5 |

## CONVERSION OF TRANSMITTER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a 1W/10W TCF transmitter for operation on a different channel frequency consist of a pair of matched crystals for the new channel frequency, new capacitors C103 and C104 on the power amplifier circuit board if the old and new frequencies are not in the same frequency group (see table on internal schematic drawing) and, in general, new or modified filters FL101 and FL102. 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 to 200 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlay is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

| | | | |
|---|---|---|---|
| 30.0-31.5 | 61.0- 64.0 | 113.0-119.5 | 207.1-214.0 |
| 32.0-33.5 | 64.5- 68.0 | 120.0-127.0 | 214.1-222.0 |
| 34.0-36.0 | 68.5- 72.0 | 127.5-135.0 | 222.1-230.0 |
| 36.5-38.5 | 72.5- 76.0 | 135.5-143.0 | 230.1-240.0 |
| 39.0-41.0 | 76.5- 80.0 | 143.5-151.0 | 240.1-250.0 |
| 41.5-44.0 | 80.5- 84.5 | 151.5-159.5 | 250.1-262.0 |
| 44.5-47.0 | 85.0- 89.0 | 160.0-169.5 | 262.1-274.0 |
| 47.5-50.0 | 89.5- 94.5 | 170.0-180.0 | 274.1-287.0 |
| 50.5-53.5 | 95.0-100.0 | 180.5-191.5 | 287.1-300.0 |
| 54.0-57.0 | 100.5-106.0 | 192.0-220.0 | |
| 57.5-60.5 | 106.5-112.5 | 200.1-207.0 | |

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

A signal generator, a frequency counter and a vacuum tube voltmeter are required for readjustment of FL101. The signal generator and the counter should be connected across terminals 4 and 5 of transformer T1 and the voltmeter across terminals 1 and 2 of transformer T2. The signal generator should be set at the channel center frequency and at 2 to 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 T3, and a 500 ohm resistor and a VTVM to the terminals of protective gap G1. 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.

After the new pair of matched crystals have been adjusted, as described under "ADJUSTMENTS", the transmitter can be operated with a 50 to 70 ohm load (depending on which tap of T4 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 same section.

If a frequency-sensitive voltmeter is available, the 2nd and 3rd harmonic traps may be adjusted 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 the tuning dial and db range switch, obtain a maximum on-scale reading of the 2nd 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. Although the transmitter frequency will differ from the channel center frequency by 100 Hz, the effect of this difference on the adjustment of the harmonic traps will be negligible. It should be noted that the true magnitude of the harmonics cannot be measured in this manner because of the preponderance of the fundamental frequency at the voltmeter terminals. Accurate measurement of the harmonics requires use of a filter between TP109 and the voltmeter that provides high rejection of the fundamental. The insertion losses of this filter for the 2nd and 3rd harmonics must be measured and taken into account.

## RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.

a. 60-ohm 10-watt non-inductive resistor.

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

c. D-C Vacuum Tube Voltmeter (VTVM).
Voltage Range: 1.5 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-kHz to 330-kHz.

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker.

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 and identify the part by its designation on the Internal Schematic drawing.

# ELECTRICAL PARTS LIST

| CIRCUIT SYMBOL | DESCRIPTION | WESTINGHOUSE DESIGNATION |
|---|---|---|
| | **CAPACITORS** | |
| C1 | Oil-filled; 0.45 mfd.; 330 V.A.C. | 1723408 |
| C2 | Oil-filled; 0.5 mfd.; 1500 V.D.C. | 1877962 |
| C3 | Oil-filled; 0.5 mfd.; 1500 V.D.C. | 1877962 |
| C11 | Metallized Paper, .047 mfd.; | 849A437H04 |
| C21 | Metallized Paper, .047 mfd.; | 849A437H04 |
| C51 | Dur-Mica, 1500 pf.; 500 V.D.C. | 762A757H03 |
| C52 | Variable, 5.5-18 pf. | 879A834H01 |
| C53 | Variable 5.5 -18 pf. | 879A834H01 |
| C54 | Metallized paper, .1 mfd.; 200 V.D.C. | 187A624H01 |
| C55 | Variable, 5.5-18 pf. | 762A736H01 |
| C56 | Dur-Mica, 2000 pf.; 500 V.D.C. | 187A584H01 |
| C57 | Dur-Mica, 2000 pf.; 500 V.D.C. | 187A584H01 |
| C58 | Metallized paper, 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C59 | Dur-Mica, 100 pf., 500 V.D.C. | 762A757H01 |
| C60 | Dur-Mica, 100 pf., 500 V.D.C. | 762A757H01 |
| C61 | Metallized paper, 0.25 mfd,; 200 V.D.C. | 187A624H02 |
| C62 | Dur-Mica, 4700 pf.; 500 V.D.C. | 762A757H04 |
| C63 | Dur-Mica, 1000 pf.; 500 V.D.C. | 762A757H02 |
| C64 | Metallized paper, 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C65 | Metallized paper, 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C66 | Metallized paper, 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C67 | Metallized paper, 0.25 mfd., 200 V.D.C. | 187A624H02 |
| C68 | Metallized paper, 0.5 mfd., 200 V.D.C. | 187A624H03 |
| C69 | Metallized paper, 0.25 mfd., 200 V.D.C. | 187A624H02 |
| C70 | 3 pf. | 861A846H03 |
| C71 | Metallized paper, 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C72 | Dur-Mica, 300 pf, 500 V.D.C. | 187A584H09 |
| C73 | Variable, 5.5-18 pt. | 879A834H01 |
| C74 | 3 pf. | 861A846H03 |
| C75 | 3 pf. | 861A846H03 |
| C76 | 3 pf. | 861A846H03 |
| C101 | Metallized paper, 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C102 | Metallized paper, 0.25 mfd.; 200 V.D.C. | 187A624H02 |
| C103 & C104 | (30-50 KC) — Extended foil, 0.47 mfd.; 400 V.D.C. | 188A293H01 |
| C103 & C104 | (50.5-75 KC) — Extended foil, 0.22 mfd.; 400 V.D.C. | 188A293H02 |
| C103 & C104 | (75.5 - 100 KC) — Extended foil, 0.15 mfd., 400 V.D.C. | 188A293H03 |
| C103 & C104 | (100.5 - 150 KC) — Extended foil, 0.10 mfd., 400 V.D.C. | 188A293H04 |
| C103 & C104 | (150.5 - 300 KC) — Extended foil, 0.047 mfd.; 400 V.D.C. | 188A293H05 |
| | **DIODES – GENERAL PURPOSE** | |
| D11 | 1N645A | 837A692H03 |
| D12 | 1N645A | 837A692H03 |
| D13 | 1N4822 | 188A342H11 |
| D14 | 1N4822 | 188A342H11 |

# ELECTRICAL PARTS LIST

| CIRCUIT SYMBOL | DESCRIPTION | WESTINGHOUSE DESIGNATION |
|---|---|---|
| | **DIODES – GENERAL PURPOSE** | |
| D15 | 1N4822 | 188A342H11 |
| D16 | 1N4822 | 188A342H11 |
| D21 | 1N645A | 837A692H03 |
| D22 | 1N4822 | 188A342H11 |
| D23 | 1N4822 | 188A342H11 |
| D24 | 1N4822 | 188A342H11 |
| D25 | 1N4822 | 188A342H11 |
| D51 | 1N628; 125 V.; 30 MA. | 184A885H12 |
| D52 | 1N628; 125 V., 30 MA. | 184A885H12 |
| D53 | 1N457A; 60 V., 200 MA. | 184A885H07 |
| D55 | 1N628; 125V; 30 MA. | 184A885H12 |
| D56 | 1N628; 125 V., 30 MA. | 184A885H12 |
| D57 | 1N457A; 60 V., 200 MA. | 184A885H07 |
| D101 | 1N538; 200 V.; 750 MA. | 407C703H03 |
| D102 | 1N91; 100 V., 150 MA. | 182A881H04 |
| D103 | 1N538; 200 V., 750 MA. | 407C703H03 |
| D104 | 1N91; 100 V.; 150 MA. | 182A881H04 |
| | **DIODES – ZENER** | |
| Z1 | 1N2828B; 45V. ±5%; 50 W. | 184A854H06 |
| Z2 | 1N3009A; 130 V. ±10%; 10 W. | 184A617H12 |
| Z11 | 1N957B | 186A797H06 |
| Z12 | 1N3688A | 862A288H01 |
| Z13 | 1N3688A | 862A288H01 |
| Z14 | 1N3686B | 185A212H06 |
| Z21 | 1N957B | 186A797H06 |
| Z22 | 1N3688A | 862A288H01 |
| Z23 | 1N3688A | 862A288H01 |
| Z24 | 1N3686B | 185A212H06 |
| Z54 | 1N3686B; 20 V. ±5%; 750 MW. | 185A212H06 |
| Z105 | 1N2999A; 56 V. ±10%; 10 W. | 184A617H13 |
| Z106 | 1N2999A; 56 V. ±10%; 10 W. | 184A617H13 |
| | **RESISTORS** | |
| R1 | 26.5 ohms ±5%; 40 W. (For 125 V Supply) | 04D1299H44 |
| R2 | 26.5 ohms ±5%; 40 W. (For 125 V Supply) | 04D1299H44 |
| R3 | 26.5 ohms ±5%; 40 W. (For 48 V Supply) | 04D1299H44 |
| R3 | 500 ohms ±5%; 40 W. (For 125 V Supply) | 1268047 |
| R4 | 100 ohms ± 10%; 1 W. Composition | 187A644H03 |
| R5 | 1K ±10%; ½ W. Composition | 187A641H27 |
| R6 | 3K ±5%; 5 W. Wire Wound | 188A317H01 |
| R7 | 15K ±10%; 2 W. Composition | 187A642H55 |
| R11 | 4.7K ±2%; ½ W. Metal Glaze | 629A531H48 |
| R12 | 12K ±2%; ½ W. Metal Glaze | 629A531H58 |
| R13 | 10K ±2%; ½ W. Metal Glaze | 629A531H56 |

# ELECTRICAL PARTS LIST

| CIRCUIT SYMBOL | DESCRIPTION | WESTINGHOUSE DESIGNATION |
|---|---|---|
| | **RESISTORS (Continued)** | |
| R14 | 6.2K ±2%; ½ W. Metal Glaze | 629A531H51 |
| R15 | 4.7K ±2%; ½ W. Metal Glaze | 629A531H48 |
| R16 | 47K ±2%; ½ W. Metal Glaze (For 125 Vdc) | 629A531H72 |
| R17 | 4.7K ±2%; ½ W. Metal Glaze | 629A531H48 |
| R21 | 4.7K ±2%; ½ W. Metal Glaze | 629A531H48 |
| R22 | 12K ±2%; ½ W. Metal Glaze | 629A531H58 |
| R23 | 10K ±2%; ½ W. Metal Glaze | 629A531H56 |
| R24 | 6.2K ±2%; ½ W. Metal Glaze | 629A531H51 |
| R25 | 4.7K ±2%; ½ W. Metal Glaze | 629A531H48 |
| R26 | 15 K ±2%; ½ W. Metal Glaze (For 48 Vdc) | 629A531H60 |
| R27 | 4.7K ±2%; ½ W. Metal Glaze | 629A531H48 |
| R51 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R52 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R53 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R54 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R55 | 100 ohms ±5%; ½ W. Composition | 184A763H03 |
| R56 | 3.6K ±5%; ½ W. Composition | 184A763H40 |
| R57 | 3.6K ±5%; ½ W. Composition | 184A763H40 |
| R58 | 100 ohms ±5%; ½ W. Composition | 184A763H03 |
| R59 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R60 | 5.6K ±5%; ½ W. Composition | 184A763H45 |
| R61 | 15K ±5%; ½ W. Composition | 184A763H55 |
| R62 | 10K ±5%; ½ W. Composition | 184A763H51 |
| R63 | 1K ±5%; ½ W. Composition | 184A763H27 |
| R64 | Potentiometer, 1K; ¼ W. | 629A430H02 |
| R65 | 1.8K ±5%; ½ W. Composition | 184A763H02 |
| R66 | 8.2K ±5%; ½ W. Composition | 184A763H49 |
| R67 | 12K ±5%; ½ W. Composition | 184A763H53 |
| R68 | 330 ohms ±5%; ½ W. Composition | 184A763H15 |
| R69 | 800 ohms ±5%; ½ W. Composition | 184A859H06 |
| R70 | Potentiometer, 1K; ¼ W. | 629A430H02 |
| R71 | 4.7K ±5%; ½ W. Composition | 184A763H43 |
| R72 | 39K ±5%; ½ W. Composition | 184A763H65 |
| R73 | Thermistor, 30 ohms, Type 3D202 (G.E.C.) | 185A211H06 |
| R74 | 180 Ohms ±5%; ½ W. Composition | 184A763H02 |
| R75 | 100 ohms ±5%; ½ W. Composition | 184A763H03 |
| R76 | 2K ±5%; ½ W. Composition | 184A763H34 |
| R77 | 10 ohms ±5%; ½ W. Composition | 187A290H01 |
| R78 | 10 ohms ±5%; ½ W. Composition | 187A290H01 |
| R79 | 20K ±20%; ½ W. Metal Glaze | 629A531H63 |
| R80 | 25K Potentiometer ± 20%; ¼ W. | 629A430H09 |
| R81 | 1K ±1%1½ W. Metal Film | 849A819H48 |

# ELECTRICAL PARTS LIST

| CIRCUIT SYMBOL | DESCRIPTION | WESTINGHOUSE DESIGNATION |
|---|---|---|
| | **RESISTORS (Cont'd.)** | |
| R82 | 5K Pot. ± 20%; ½ W. | 629A430H07 |
| R83 | 10.2K ± 1%; ½ W. Metal Film | 848A820H46 |
| R84 | 27 Ohms ± 5%; ½ W. Composition | 187A290H11 |
| R85 | Thermistor 3D402 10 ohms | 185A211H03 |
| R86 | 750 ohms ± 1%; ½ W. Metal Film | 848A819H36 |
| R87 | 10K ± 5%; ½ W. Composition | 184A763H51 |
| R101 | 10 ohms ±5%; ½ W. Composition | 187A280H01 |
| R102 | 2.2K ±10%; 1 W. Composition | 187A644H35 |
| R103 | 2.7 ohms ±10%; ½ W. Wire Wound | 184A636H14 |
| R104 | 0.27 ohms ±10%; 1 W. Wire Wound | 184A636H18 |
| R105 | 10 ohms ±5%; ½ W. Composition | 187A290H01 |
| R106 | 4.7K ±10%; 1 W. Composition | 187A644H43 |
| R107 | 2.7 ohms ±10%; ½ W. Wire Wound | 184A636H14 |
| R108 | 0.27 ohms ±10%; 1 W. Wire Wound | 184A636H18 |
| | **TRANSFORMERS** | |
| T1 | Driver Output Transformer | 606B410G01 |
| T2 | Power Amp. Input Transformer | 292B526G01 |
| T3 | Power Amp. Output Transformer | 292B526G02 |
| T4 | Load-Matching Auto-Transformer | 292B526G03 |
| T51 | Buffer Amplifier Transformer | 606B537G01 |
| T52 | Driver Input Transformer | 606B537G02 |
| | **TRANSISTORS** | |
| Q11 | 2N4356 | 849A441H02 |
| Q12 | 2N699 | 184A638H19 |
| Q21 | 2N4356 | 849A441H02 |
| Q22 | 2N699 | 184A638H19 |
| Q51 | 2N697 | 184A638H18 |
| Q52 | 2N697 | 184A638H18 |
| Q53 | 2N697 | 184A638H18 |
| Q54 | 2N699 | 184A638H19 |
| Q55 | 2N697 | 184A638H18 |
| Q56 | 2N2726 | 762A672H07 |
| Q57 | 2N2726 | 762A672H07 |
| Q101 | 2N1908 (Use in Matched Pairs) | 187A673H02 |
| Q102 | 2N1908 (Use in Matched Pairs) | 187A673H02 |
| | **MISCELLANEOUS** | |
| Y1-Y2 | Supplied for Desired Channel Frequency in Pair Matched Per Specifications on Drawing | 408C743 |
| FL101 | Driver Filter | 408C261 + (Req. Freq.) |
| FL102 | Output Filter | 541D214 + (Req. Freq.) |
| PL | Pilot Light Bulb - For 48 V. Supply (When supplied) | 187A133H02 |
| | Pilot Light Bulb - For 125 or 250 V. Supply (When supplied) | 183A955H01 |
| F1, F2 | Fuse, 1.5A (When supplied) | 11D9195H26 |

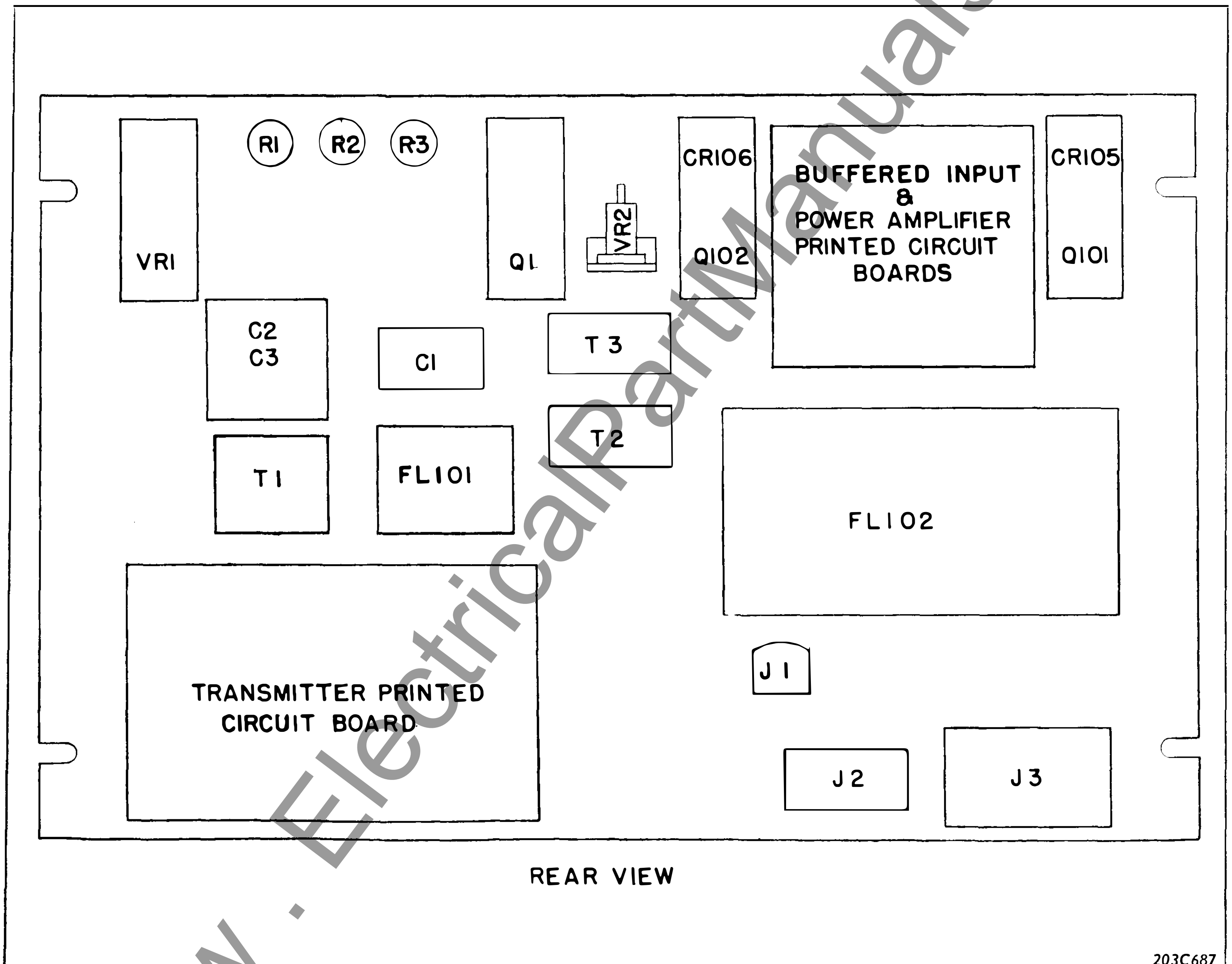



*Fig. 2. Component locations of the type TCF Transmitter Assembly.*

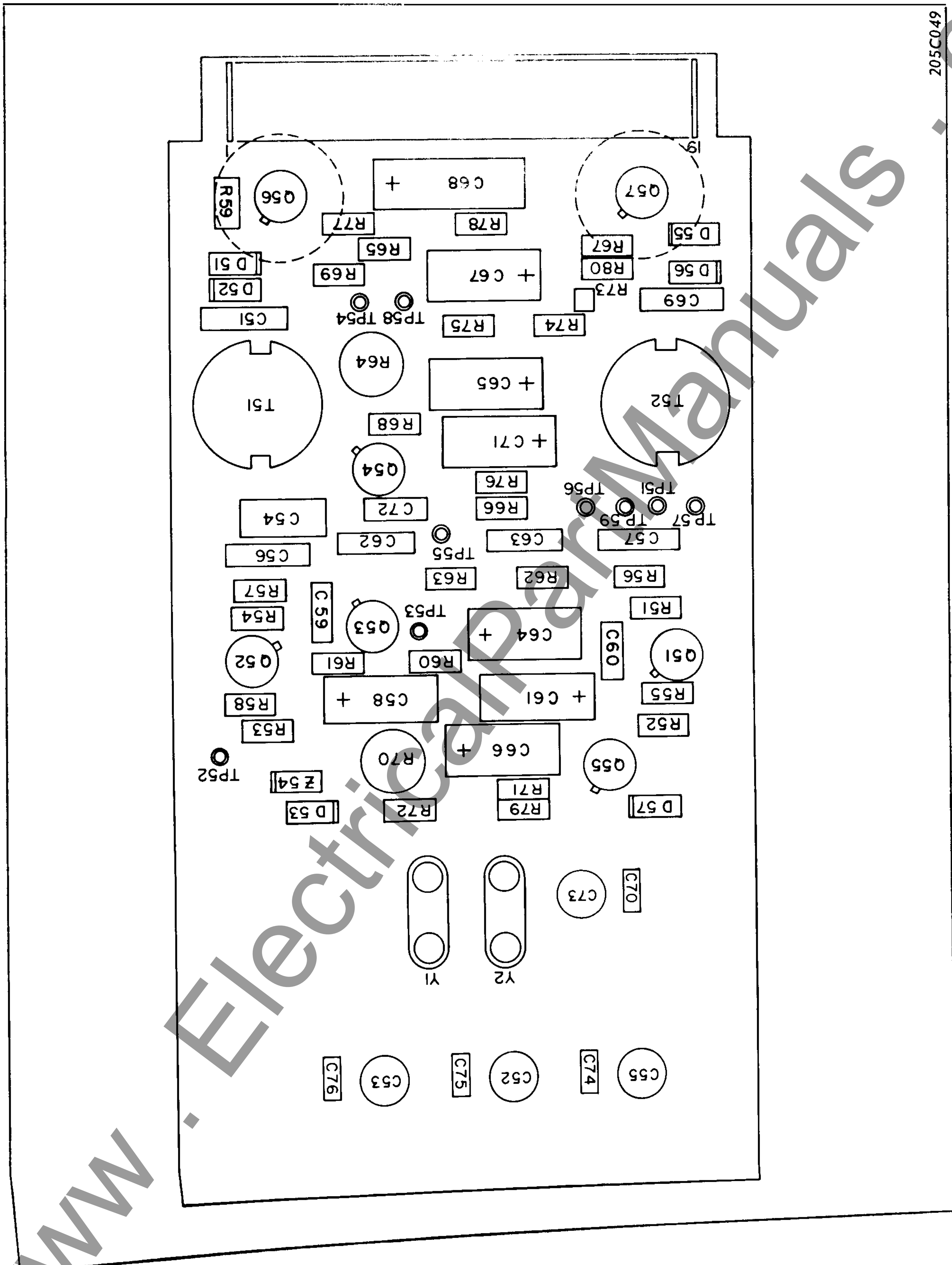



Fig. 3. Component Locations of the Transmitter Printed Circuit Board.

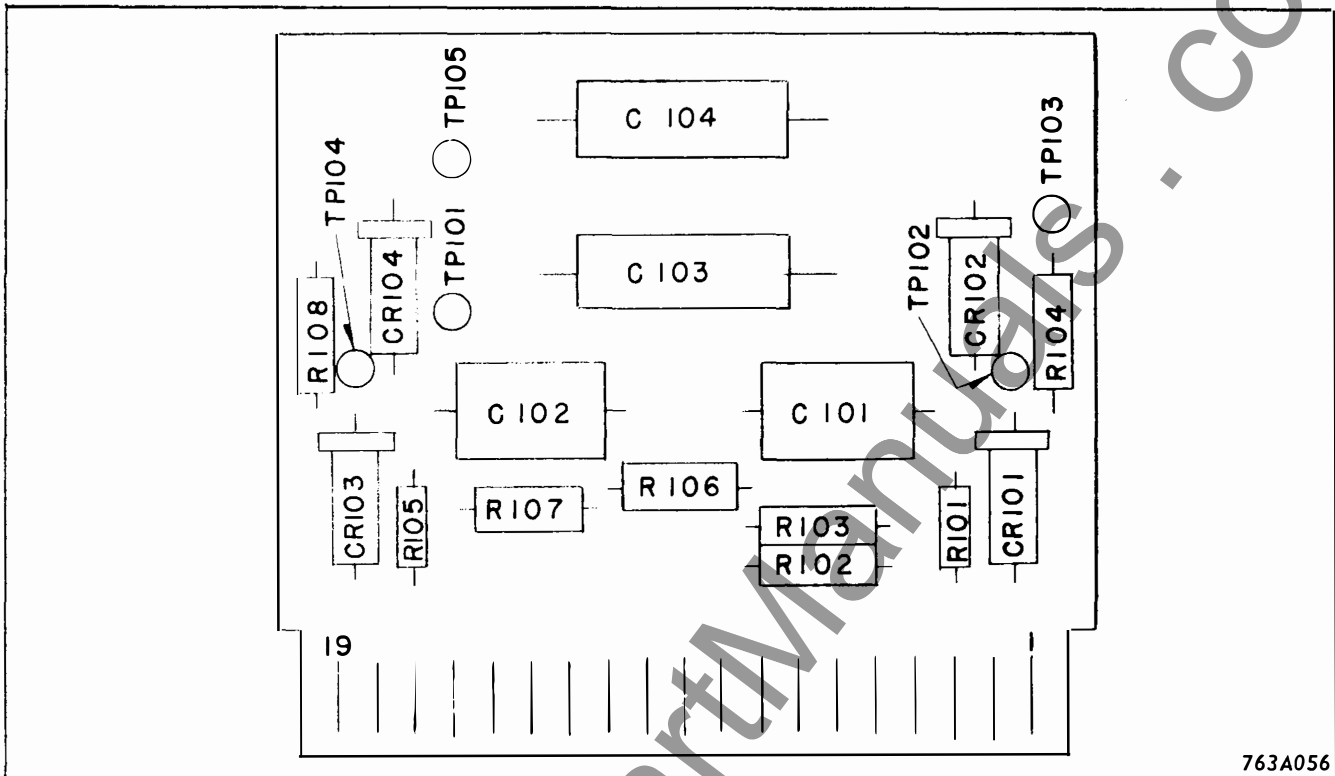



Fig. 4. Component Locations of the Power Amplifier Printed Circuit Board

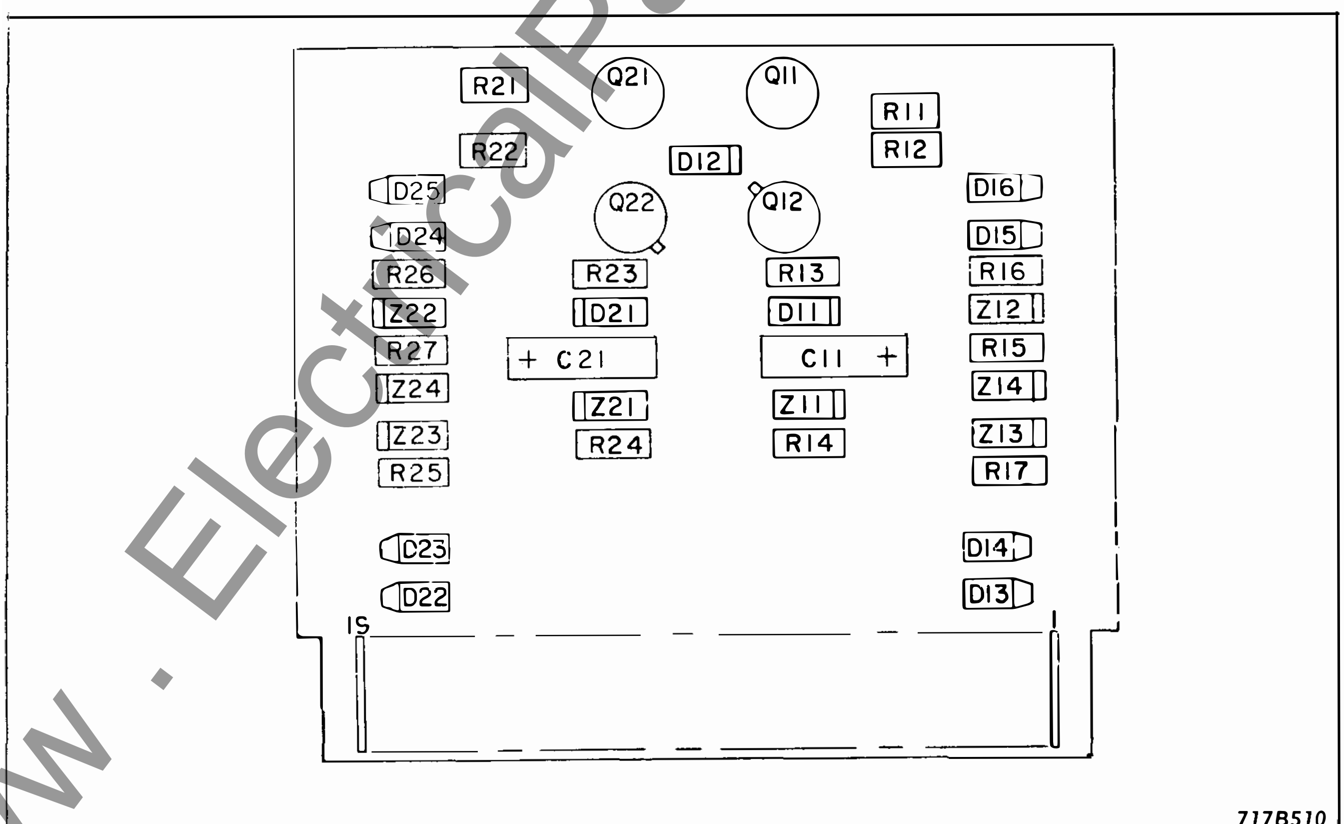



Fig. 5. Component Location of Buffer Keying Circuit Board

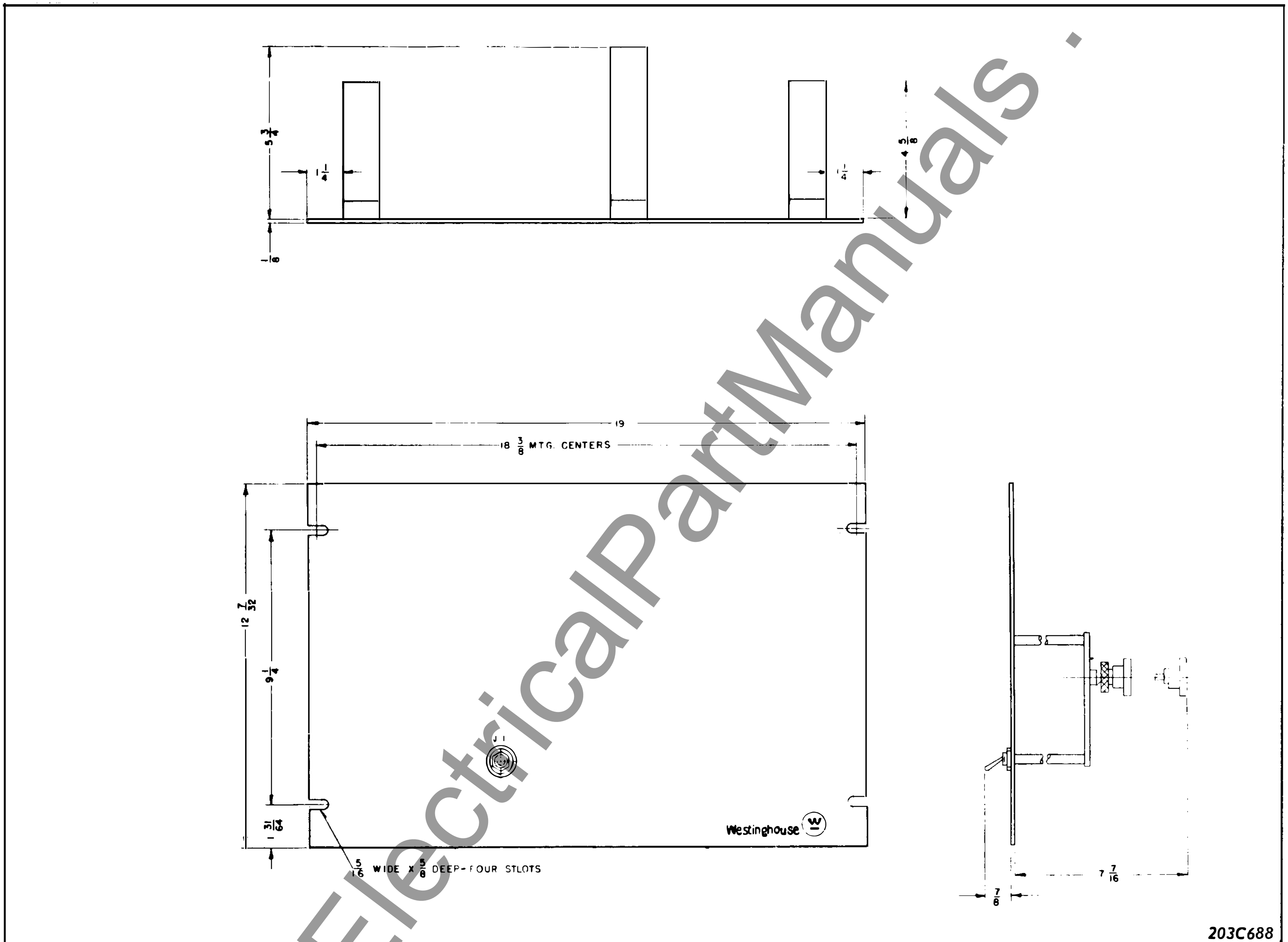



*Fig. 6. Outline and Drilling Plan for the Type TCF Transmitter Assembly*

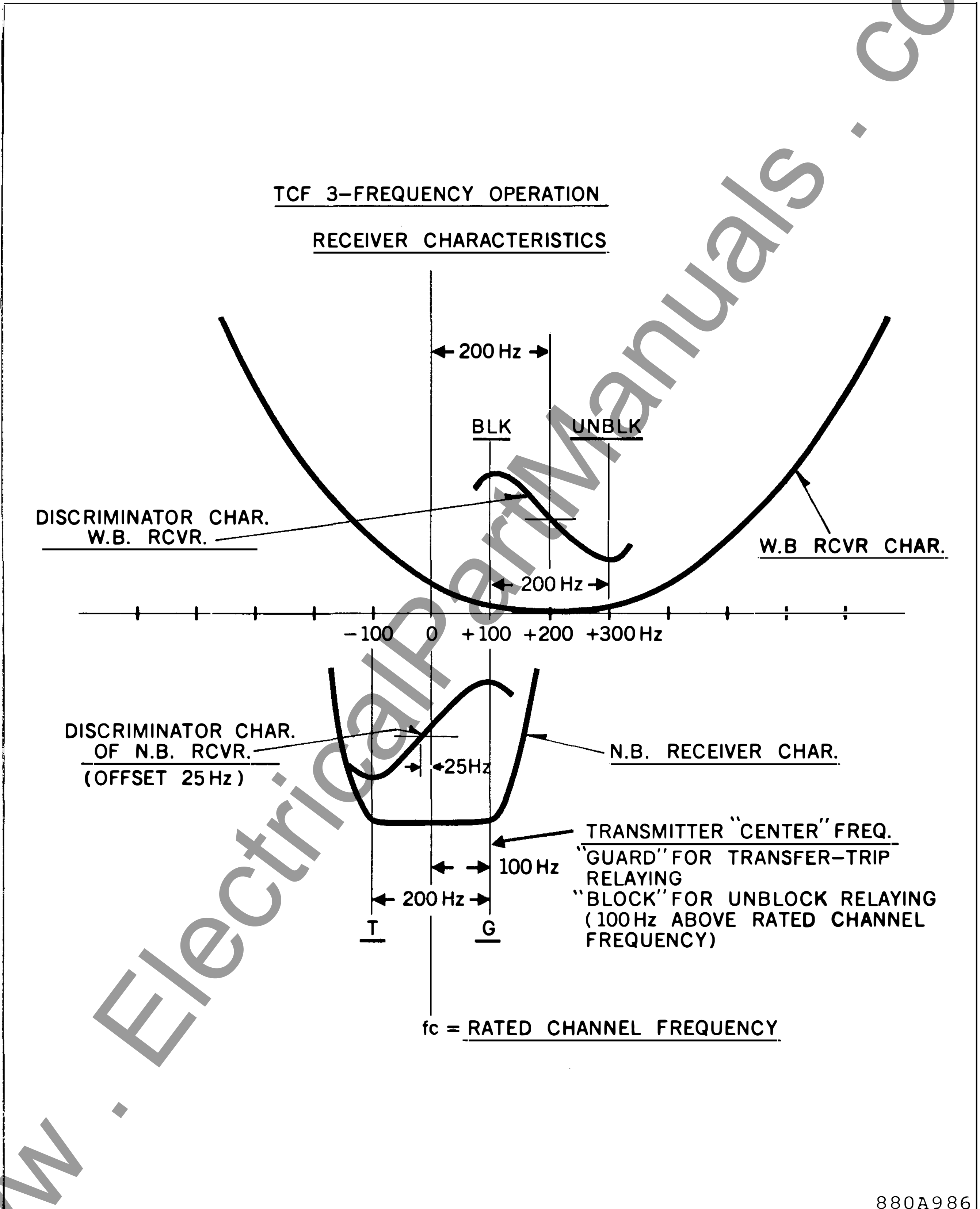



*Fig. 7. Three Frequency Operation – Receiver Characteristics*

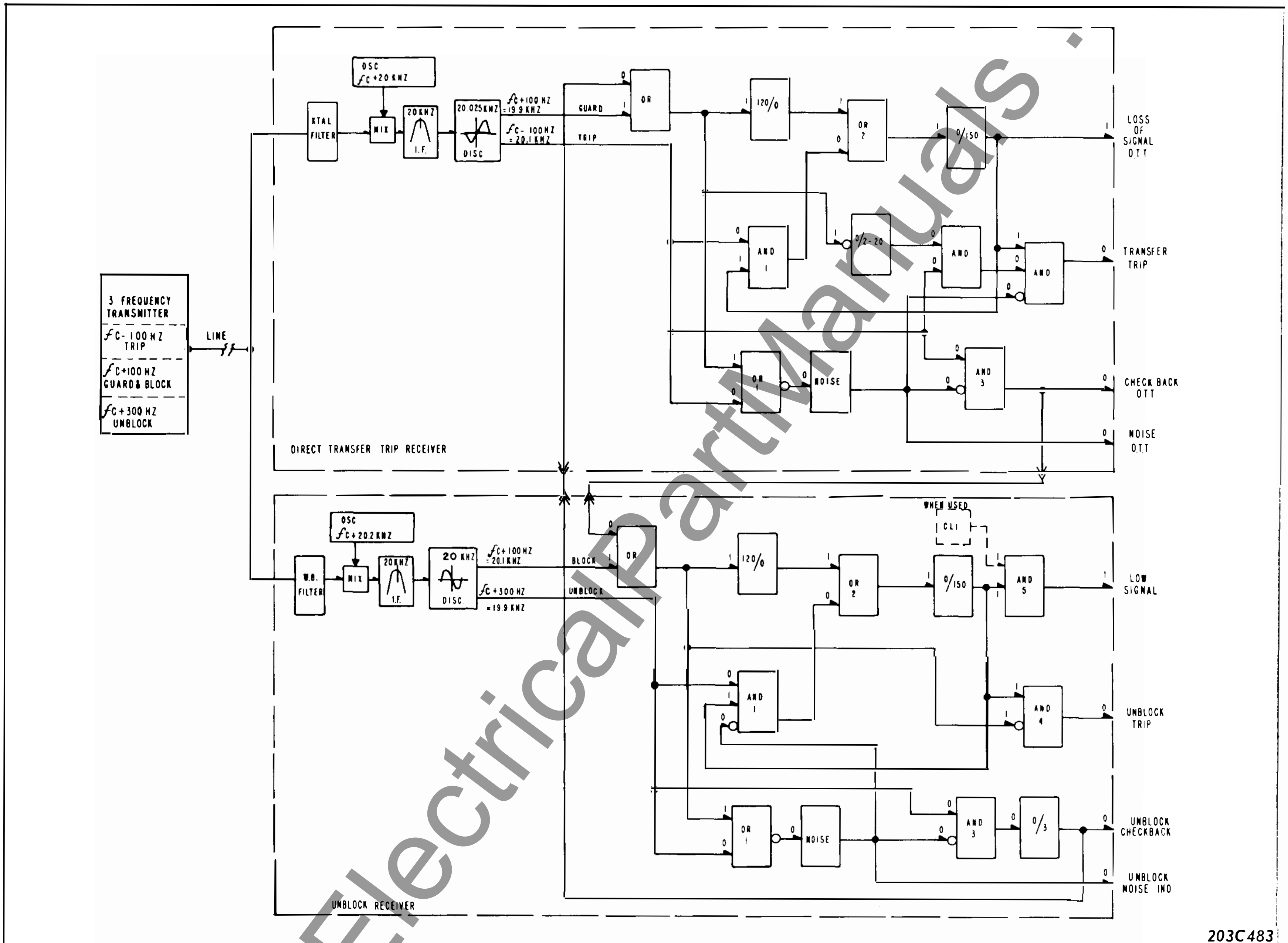



*Fig. 8. Receivers Logic Diagram - 3 Frequency Operation for Direct Transfer Trip and Unblock Relaying*

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-TRANSFER TRIP (WITHOUT CARRIER LEVEL INDICATOR)

**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 relay is energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

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 frequency-shift receiver equipment as adapted for transfer-trip applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Guard signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The Guard frequency is 100 hertz above the center frequency of the channel. When a fault occurs within the protected equipment, protective relays switch the transmitter located there to a Trip frequency, 100 hertz below the center frequency, and also increase the power output of the transmitter (from 1 watt to 10 watts).

The reception of Trip frequency within a fixed interval after disappearance of the Guard frequency causes the energization of a high-speed electromechanical relay which closes the breaker trip circuit. If trip frequency is not received within this interval, the channel is not operating normally and a second relay closes contacts to sound an alarm. Simultaneously, the Trip relay is locked out so that a spurious Trip signal resulting later from line noise cannot cause false tripping. Other circuitry, described under OPERATION, provides security against false tripping caused by severe line noise that overrides a normal Guard signal and produces a spurious Trip signal.

## CONSTRUCTION

The TCF-10 receiver unit for transfer-trip applications is mounted on a standard 19-inch wide Chassis 5 1/4 inches high (3 rack units) with edge slots for mounting on a standard relay rack. All components not mounted on Printed Circuit Modules are mounted at the rear of the panel. An input attenuator, a jack for metering the discriminator output current, and the control for the adjustable time delay in the logic circuit are accessible from the front of the Chassis See Fig. 15.

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 5. Reference to the internal schematic connections of Figure 1 will show the location of these components in the circuit.

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

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 fed through a coaxial cable connected to jack J2 at the rear of the chassis to the input module. The input control R5, accessible at the front of the input module, attenuates the signal to a level suitable for the best operating range of the receiver.

A scale on the panel is graduated in dB. While this scale is typical rather than individually calibrated, it is accurate within several dB and is useful in setting approximate levels. Settings should be made more accurately utilizing a suitable ac voltmeter with a dB scale when possible.

### CRYSTAL FILTER

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above

### OSCILLATOR, MIXER, AND IF AMPLIFIER MODULE

From the input filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20kHz above the channel center frequency, $f_c$. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the latter is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of filter FL201 is impressed on the emitter-collector circuit of Q11. As a result of mixing these two frequencies, the primary of transformer will contain frequencies of 20kHz, $2f_c$ + 20kHz, $f_c$ + 20kHz, and $f_c$.

The output from the secondary of T12 is amplified by Q31 in the intermediate frequency (IF) stage, and is impressed on FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. Since its pass band is narrower than that of the input filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz. The output of this filter is the IF output which is fed to both the amplifier-limiter and the S/N Detection module. The output from the secondary of transformer T12, the RF output, is also fed to the S/N detection module.

### AMPLIFIER LIMITER AND DISCRIMINATOR MODULE

### AMPLIFIER AND LIMITER

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

## DISCRIMINATOR

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C68. C63 is adjusted to obtain a maximum voltage reading across R80 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero output frequency. This separation of 200 hertz between the current peaks is affected by the value of C66 (the actual value of which may be changed slightly from its typical value in factory calibration if required.)

The purpose of offsetting the zero output frequency of the discriminator by 25 hertz in the Trip direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the Guard side of the discriminator center. It should be observed that although Guard frequency is $f_c$ + 100 herz, after leaving the mixer stage and as seen by the discriminator the Guard frequency is 20 kHz − 100 hertz. Similarly, the Trip frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

The discriminator output is connected to the bases of transistors Q55 and Q56 in such a manner that transistor Q56 is made conductive when current flows, from the discriminator output, in the forward direction of diode D54, (which occurs with Trip output) and Q55 is made conductive when current flows in the forward direction of diode D55 (which occurs with Guard output) Consequently, terminal 35 is at a potential of approximately +20 volts at Guard frequency and terminal 1 is at +20 volts at Trip frequency. These two outputs feed the logic circuit board, and through it they control the operation of the loss-of-channel alarm relay, AL, and the Trip relay, AR.

As a means of increasing further the security of the receiver against false tripping on noise-generated Trip frequencies, diode D56 is connected in the emitter circuit of Q56. This requires an increase of three or four db. in the minimum Trip signal that will pick up the Trip relay. However, when the transmitter is keyed to Trip, its output is increased by 10 db. to assure the reliability of tripping at times of severe channel deterioration or simultaneous noise conditions, and this amply compensates for the reduction of Trip sensitivity caused by diode D56. For applications where severe noise conditions or channel deterioration are not encountered, a TCF-10 transmitter with 1 watt output rather than 10 watts can be supplied. If in such installations it is found desirable to increase the reliability of tripping, a jumper may be connected across diode D56.

## LOGIC CIRCUITS

The logic stage of the receiver employs static circuitry that permits elimination of separate guard and lockout relays but provides all of the function of these relays as well as a unique method for minimizing the effect of noise signals. The block diagram of the logic circuits is shown on Fig. 3. When the discriminator receives Guard signal, its output terminal (15) supplies positive potential to blocks A, D, and F on the block diagram. Block A represents R108, C101 and D104 of Fig. 1. Capacitor C101 will charge in approximately 120 milliseconds to the breakdown voltage of Zener Z104 and block C (transistor Q102) then will receive input # 1. The function of Q101 is not indicated on the block diagram, but it discharges C101 quickly when Guard signal disappears, so that the full 120 ms. delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When Q102 (block C) receives input # 1 or # 2, it is made conductive and capacitor C102 receives no charge. Q103 is non-conductive since it receives no base input through Z105, and its collector is held at approximately 10 volts by the voltage divider effect of R131 and R136. Note that under this condition, input # 1 to block **K** is supplied. If Guard signal should disappear but be followed promptly by appearance of Trip signal, the trip input fed through R102 will not be diverted through D102 to the collector of Q103 but will flow through D101 to the base of Q102 to keep it conductive. However, if Guard signal disappears and Trip signal does not appear in approximately 150 ms., C102 will charge to the breakdown point of Z105 making Q103 conductive. This will remove base input from Q104 and the alarm relay will drop out, sounding the alarm through its normally-closed contacts. (The copper slug on the alarm relay adds an additional delay of approximately 40 ms. before the alarm contacts close.) When Q103 becomes conductive, the saturation voltage at its collector is so low that any current flowing through R102 as a result of a subsequent Trip signal will be diverted through Q103 to negative instead of flowing through D101 and the base-emitter junction of Q102. If Guard signal reappears, the discriminator output at term. 15 will turn Q101 off. C101 will change and after 120 ms. it will reach the breakdown voltage of Z104 and turn Q102 on. This will allow C102 to quickly discharge through R123 and Q102 and provide the full 150 ms. time delay to be effective on any subsequent loss of guard signal.

Guard signal also produces input to transistor Q109 (block D). With base input to Q109 it has negligible voltage on its collector, but if Guard signal is lost, capacitor C104 will charge to the breakdown voltage of Z113 in a time ranging from about 2 to 20 ms., as determined by the setting of R7. This time delay also is quickly reset on reappearance of Guard signal, as C104 discharges through R114, Z113 and Q109. Transistors Q110 and Q111 are a part of logic block I. When C104 reaches the conduction voltage of Z113, Q110 conducts and removes base input from Q111. This raises the voltage on the collector of Q111 to about 15 volts, which constitutes input # 2 to block K. The purpose of logic blocks D and I is to provide an adjustable delay between the loss of Guard signal and the pickup of the Trip relay. It is possible that a noise burst might momentarily cancel the Guard signal and produce a spurious Trip signal. Provision of this adjustable delay provides a considerable degree of protection against such incorrect operations. Resistor R7 is adjustable by means of a knob on the front of the panel, and the knob can be clamped at any desired setting.

When Trip signal appears, input is fed to transistor Q106 (block E) through R119. Under this condition Q106 becomes conducting and does not supply input # 1 to Q107 (block J). If input # 2 (supplied through R115) also is lacking for Q107, the latter is non-conductive and its collector voltage is approximately 15 volts. This constitutes input # 3 to AND block K. Block K is a three-input diode-AND, with the inputs contributed by the collectors of transistors Q103, Q107 and Q111. When one or more of these transistors is conducting, input fed from the 45 volt supply through R138 cannot reach the base of Q108 to cause pickup of the Trip relay because the voltage drop across any of the three diodes plus the saturation resistance of a transistor is substantially less than the voltage drop across one diode (D110) plus the base-emitter voltage required to make Q108 conductive.

The logic blocks F and G provide further protection against incorrect tripping under noise conditions. Transistor Q105 is represented by block F; and diode D107 capacitor C103 and resistor R115 are represented by block G. Q105 receives input from either Trip or Guard signals through R101 or R106, and when either signal is present its collector voltage is a small fraction of a volt. When the transmitter is shifted from Guard to Trip by closure of a protective relay contact, the discriminator shifts its outputs very rapidly and the interval during which there is no input to Q105 is only 1.5 to 2.0 ms. Most of the charge that builds up in C103 during this interval flows to the base of Q107 and keeps it conducting after the appearance of Trip signal has removed the input through R125. However, this delay has approximately the same duration as the minimum delay obtained from block I and thus does not increase the minimum overall time for tripping following a legitimate Trip signal.

At times when severe random noise is present, such as might be produced by opening a nearby disconnect switch, the noise-produced signal may override the Guard signal and produce a discriminator output that no longer has a constant Guard output but rapidly fluctuates between Guard and Trip (and beyond). There will be relatively long periods when the discriminator has neither Guard nor Trip output. At such times capacitor C103 may approach or reach its maximum voltage, thereby keeping Q107 conducting for 40 to 50 ms. Also, because of the quick reset feature of logic block I, intermittent reappearance of Guard signal during noise will fully reactivate the time delay for which it has been set. If a fault should occur and Trip frequency be transmitted at a time when high level noise frequencies are present, tripping may be somewhat delayed but will be accomplished before the cessation of noise unless conditions are extremely severe. The recommended 10 db. increase of transmitter output level at Trip frequency minimizes such delay.

It may appear that the function of block E in the logic diagram is duplicated by block F and could have been omitted. This is correct when the time constants are as normally supplied, but block E was retained to make the circuit adaptable to possible extreme conditions with minimum change.

In summary, the logic circuit provides the following functions:

1. Energizes alarm in case of loss of signal.
2. Prevents cancellation of an alarm by noise-produced signal.
3. Allows tripping upon reception of legitimate Trip signal.
4. Prevents tripping if channel is not operative immediately prior to reception of Trip signal.
5. Minimizes effect of noise-produced signals by utilizing noise characteristics to introduce additional Trip delay.

## OUTPUT CIRCUITS

The output stage of the receiver contains the alarm relay (AL) and the tripping relay (AR). Either relay is energized from the regulated 45 volt supply when the logic circuit has determined that the existing conditions require such operation. The AL relay is a telephone type relay with a copper slug on the end of the core opposite the armature. It has two sets of Form C contacts, all points of which are connected to terminals of jack J3. The AR relay has two normally-open and two normally-closed contacts. The Four sets of contacts are connected to terminals of jack J3. The AR relay has been designed to provide very high speed operation with negligible contact bounce. While normally it is energized only briefly, it will not be damaged by continuous energization.

## CARRIER LEVEL INDICATOR (WHEN SUPPLIED)

With the logic circuit connections shown on Fig. 1, the AL relay closes contacts to energize an alarm when there is absence of both Guard and Trip signal for a definite time interval. This is satisfactory when the channel fails suddenly and completely. However, the signal may weaken gradually from various causes, and it is desirable to have a means for providing a visual indication of the channel condition as well as for energizing an alarm when the signal has weakened seriously but has not reached the point of complete failure. These functions are provided if a carrier level indicator stage is included in the receiver.

The carrier level indicator is housed in the right-hand compartment of the enclosure that contains the circuit boards. Fig. 2 shows the connections of the components on this circuit board and also the external connections of the board. All other stages of the receiver are identical with those shown on Fig. 1. The same AL relay is used, but it is energized through transistor Q104 of the logic stage when the receiver does not include carrier level indication and through Q154 of the carrier level indicator when the latter is supplied. A TCF-10 receiver in which the carrier level indicator was not included at time of assembly can have this feature added later by installing the required circuit boards and making minor changes in the wiring.

The S/N detection module (carrier level indicator) has one basic function: to measure incoming in-band signal level and provide both an output to a carrier level indicating instrument and to an alarm circuit in the output module for alarming at the desired low level of signal.

This same output is also fed to an alarm circuit on the output module (contact output) for alarming at low signal levels.

The narrow-band signal of 220 hertz bandwidth called the I.F. is fed into the S/N detection board through isolation transformer T32. The amount of signal fed into the board is adjustable by means of potentiometer R111. The circuit composed of operational amplifiers IC7 and IC8 and associated components is an RMS circuit which converts the signals into a dc voltage proportional to the r.m.s. value of the ac signals present in the IF bandwidth.

The output of the IF rms circuit is then fed to the logarithmic circuit composed of IC11A, IC12A, and IC11B which puts out a dc signal level linearly proportional to signal level in dB for feeding a microammeter calibrated with a linear dB scale with 10dB equal to 33 1/3 microamperes, is contained on the output module (contact output).

The input to the carrier level indicator is not affected by frequency variations that are within the pass band of the crystal input filter, but only by the level of the receiver input signal. When the alarm relay is energized through transistor Q104 of the logic stage (in a receiver without carrier level indicator—Fig. 1), the alarm will be activated on complete loss of signal or on loss of Guard signal if Trip signal does not appear within approximately 150 ms. After the alarm relay has dropped out and activated the alarm, the relay will not be picked up by subsequent appearance of Trip signal but only by the reappearance of Guard signal. It is desirable to retain this alarm feature when the carrier level indicator is supplied, and a single alarm relay can be caused to respond to frequency change as well as to signal level by the interconnection between the terminals of the logic and carrier level indicator circuit boards.

When Guard signal is being received, the voltage at the collector of Q103 in the logic circuit is approximately 10 volts, but this voltage is blocked from the base of (Q154) in the carrier level indicator circuit by diode D155. However, if the discriminator Guard output should fail because of a sufficient frequency shift either above or below Guard frequency, Q103 would become conductive and the collector current of (Q153) would be diverted to negative through D155 and Q103 rather than entering the base of (Q154). The latter would become nonconductive and the alarm relay would drop out, closing the alarm circuit even though the signal level is unchanged.

With Guard signal being received, the signal level just below which the discriminator Guard output drops to zero is the minimum operating level of the receiver. The AL relay should energize the alarm at a signal level somewhat above this. For usual operating conditions it should be satisfactory to set the input attenuator (R5) 15 db. above the minimum operating level and set the AL relay (by means of R156) to drop out at a signal 5 db. above the minimum operating level.

## POWER SUPPLY

The regulated 20 V.D.C. and 45 V.D.C. circuits of the receiver are supplied from Zener diodes mounted on a common heat sink on the rear of the panel. Resistors (R2, R3) of suitable value are connected between the station battery supply and the 45 volt Zener to adapt the receiver for use on 48, 125 or 250 V.D.C. battery circuits. The receiver is connected to the external supply through a switch and fuses, and a pilot light indicates whether the D.C. circuits are energized. Capacitors C1 and C2 bypass r.f. or transient voltages to ground. Chokes L1 and L2 isolate the receiver from transient voltages that may appear on the D.C. supply.

## CHARACTERISTICS

| | |
|---|---|
| Frequency range | 30-300 kHz |
| Sensitivity (noise-free channel) | 0.005 volt (65 db below 1 watt for limiting) |
| Input Impedance | 5000 ohms minimum |
| Bandwidth (crystal filter) | down $<$ 3 db at 220 hertz<br>down $>$ 60 db at 1000 hertz |
| Discriminator | Set for 200 cycles shift from Guard to Trip frequency. Offset 25 hertz to favor Guard for all relay-output applications. |
| Operating time | 9 ms. channel (transm. and recvr.)<br>2 ms. min. logic delay<br>+ 3 ms. AR relay<br>14 ms. minimum time<br>+18 ms. max. added logic time (if req'd. by noise conditions)<br>32 ms. maximum time |

| | |
|---|---|
| Frequency spacing | |
| A. For two or more signals over one-way channel | 500 hertz minimum |
| B. For two-way channel | 1000 hertz, minimum between transmitter and adjacent receiver frequencies. |
| Ambient temperature range | −20° C to +55° C temperature around chassis. |
| Battery voltage variations | |
| Rated voltage | Allowable variation |
| 48 V.D.C. | 42 − 56 V.D.C. |
| 125 V.D.C. | 105 − 140 V.D.C. |
| 250 V.D.C. | 210 − 280 V.D.C. |
| Battery drain | 0.20 a. at 48 V.D.C.<br>0.27 a. at 125 or 250 V.D.C. |
| Dimensions | Chasis height − 5 1/4″ or 3 r.u.<br>Chassis width − 19″ |
| Weight | 13 lbs. |

## INSTALLATION

The TCF-10 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 55° C.

## ADJUSTMENTS

All factory adjustments of the TCF-10 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; discriminator offset from center frequency; frequency spacing and magnitude of discriminator output peaks. Adjustments that must be made at time of installation are: setting of input attenuator R5; setting of the logic time delay by R7. The input attenuator and the logic time delay adjustments are made by knobs on the front of the panel.

The receiver should not be set with a greater margin of sensitivity than is needed to assure correct operation with the maximum expected variation in attenuation of the transmitter signal. In the absence of data on this, the receiver may be set to operate on a signal that is 15 db below the expected maximum signal. After installation of the receiver and the corresponding transmitter, and with a normal Guard signal being received, input attenuator R5 should be adjusted to the position at which the alarm relay drops out. R5 then should be readjusted to increase the voltage supplied to the receiver by 15 db. The scale markings for R5 permit an approximate setting to be made but it is preferable to make this setting by means of the db scales of an ac VTVM connected from ground to the sliding contact of R5.

In case the transmitter has a 1 Watt/1 Watt output and diode D56 in the discriminator is not bypassed (see discussion under OPERATION-Discriminator), the transmitter should be keyed to trip, transistor Q103 should be kept non-conducting by connecting a short clip lead across R128, and R5 should be adjusted to the position at which the trip relay just picks up. R5 then should be readjusted for a 15 db increase in receiver input, and the jumper across R128 should be removed. If D56 is bypassed the input levels at which the AL and AR relays just operate will be approximately the same, and the AL relay minimum operating point can be used as reference for arriving at the R5 setting, as described in the preceeding paragraph.

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. (Note: When CL1 instrument is supplied within the chassis, this is factory adjusted.)

1. Set incoming level into receiver at +10dB above normal level.
2. Adjust span adjustment, R147, so that the voltage at TP72 with respect ot TP62 (common) is +3.000 volts.
3. Reduce incoming signal into receiver by 30dB.
4. Adjust full scale adjustment, R153, so that instrument now reads −20dB. (This is approximately 0 microamperes).
5. Increase signal to +10dB level. (This is 100 microamperes).
6. Adjust slope adjustment R155 to read +10dB on instrument.
7. Reduce signal to normal level. Instrument should read OdB. If desired, instrument could be adjusted to read OdB with R155 with sacrifice in reading accuracy for +10dB.

It is recommended that R7 be set for maximum time delay (full clockwise rotation) unless field tests have shown that a shorter delay can be used without danger of false tripping under conditions of severe line noise, such as may be caused by the opening of nearby disconnect switches.

## 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 adustment 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 higher 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. (Note: Input attenuator R5 could be used to produce 5 mv of signal across input test jacks J1 and J2 if desired.)

Adjustment of the discriminator is made by capacitors C63 and C68. In order to offset the discriminator by 25 Hertz in the Trip direction, apply to the receiver input a 5 mv. signal taken from an oscillator set at fc-25 Hertz (R5 at zero.) Connect a 1.5-0-1.5 milliammeter in the circuit at J1 and a VTVM across R80. Adjust C68 for zero current in the milliammeter and C63 for maximum voltage across R80 rechecking the adjustments alternately until no further change is observed. Remove the VTVM from across R80 and observe the milliammeter reading as the oscillator frequency is varied. Postive and negative peaks should occur at fc + 75 Hertz and fc-125 Hertz, with the latter peak being 20% or 15% lower than the former because of diode D56 in the Trip output path.

In case a check is desired of any of the delay times of the reciver (such as channel time or logic delays), this can be done most conveniently by means of an oscilloscope with a calibrated triggered sweep. A two-pole toggle switch, checked to have less than 1 ms. interval between pole closures, can be used to impress the signal and trigger the sweep.

## MAINTENANCE

Periodic checks of the received carrier signal and the receiver sensitivity 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 drop out the alarm relay. 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 or loss of receiver sensitivity.

All adjustable components on the printed circuit boards are accessible when the front cover is removed. However, as described under "CONSTRUCTION", any board may be made entirely accessible while permitting electrical operation by using board extender style no. 1447C86G01. This permits attaching instrument leads to the various test points of terminals when making voltage, oscilloscope or frequency checks. It also contains switches to facilitate trouble shooting.

It is advisable to record voltage values 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 values are given in Table I and II. Voltages should be measured with a VTVM. Some readings may vary as much as ±20%.

## TABLE I
## RECEIVER D-C MEASUREMENTS

**NOTE**: All voltage readings taken with ground of dc VTVM on terminal 9 (neg. d.c.). Receiver adjusted for 15 db operating margin with Guard signal down 50 db from 1 watt and Trip signal down 40 db. Unless otherwise indicated, voltage will not vary appreciably whether signal is Guard, Trip or zero.

| Collector Transistor | Volts (+) | |
|---|---|---|
| Q11 | <13 | |
| Q12 | 15 | (Guard or Trip) |
| Q13 | 15 | (Guard or Trip) |
| Q31 | 2.5 | |
| Q32 | 2.5 | |
| Q51 | 11.5 | |
| Q52 | 12 | |
| Q53 | 15.5 | |
| Q54 | 2.5 | |
| Q55 | < 1 | (No. sig. or Trip) |
| Q55 | 19.5 | (Guard) |
| Q56 | < 1 | (No sig. or Guard) |
| Q56 | 19.5 | (Trip) |
| Q101 | < 1 | (No sig. or Trip) |
| Q101 | 7 | (Guard) |
| Q102 | 21 | (No signal) |
| Q102 | < 1 | (Guard or keyed Trip # ) |
| Q103 | < 1 | (No signal) |
| Q103 | 10 | (Guard or keyed Trip) |
| Q104 | 45 | (No signal) |
| Q104 | < 1 | (Guard or keyed Trip) |
| Q105 | 40 | (No signal) |
| Q105 | < 1 | (Guard or Trip) |
| Q106 | 15 | (No sig. or Guard) |
| Q106 | < 1 | (Trip) |
| Q107 | < 1 | (No sig. or Guard) |
| Q107 | 15 | (Trip) |
| Q108 | 45 | (No sig. or Guard) |
| Q108 | < 1 | (Keyed Trip) |
| Q109 | 10 | (No sig. or Trip) |
| Q109 | < 1 | (Guard) |
| Q110 | < 1 | (No sig. or Trip) |
| Q110 | 15 | (Guard) |
| Q111 | 15 | (No sig. or Trip) |
| Q111 | < 1 | (Guard) |

# - "Keyed Trip" signifies minimum transition time from Guard to Trip.

## TABLE II
## RECEIVER RF MEASUREMENTS

**NOTE**: Voltmeter readings taken between receiver input and Q32 are not meaningful or feasible because of waveform or effect of instrument loading. Receiver adjusted as in Table I. Reference to +20V.

| Collector of Transistor | Volts (1 watt-Guard) | Volts (10 watts-Trip) |
|---|---|---|
| Q32 | .25 | .8 |
| Q51 | .3 | .9 |
| Q52 | .4 | .65 |
| Q53 | 2.1 | 2.2 |
| Q54 | 4.8 | 4.5 |

## RELAY MAINTENANCE AND ADJUSTMENT

The AL and AR relay contacts should

be cleaned periodically. A contact burnisher S # 182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing, particularly in the case of the AR relay.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

## FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only 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 Dwg. 849A109 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 4 shows the −3db and −60db check points for the crystal filters. 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 Fig. 4 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3db maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18 db minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20 db (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 resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10db (2.45 volts) 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 11db 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-10 receiver for operating on a different channel frequency consist of a new crystal filter (FL1), a new local oscillator crystal (Y11) and probably a different feedback capacitor (C12). Because the wide range of channel frequencies precludes maintaining a factory stock of the various crystals, immediate shipment of the filter and the oscillator crystal cannot be made. After the crystals have been procured and the filter has been completed, it is recommended that the receiver be returned to the factory for the conversion and for complete test and adjustment. However, if the time that the receiver can be out of service must be kept to a minimum, the conversion may be made by customers who are equipped for this work.

## RECOMMENDED TEST EQUIPMENT

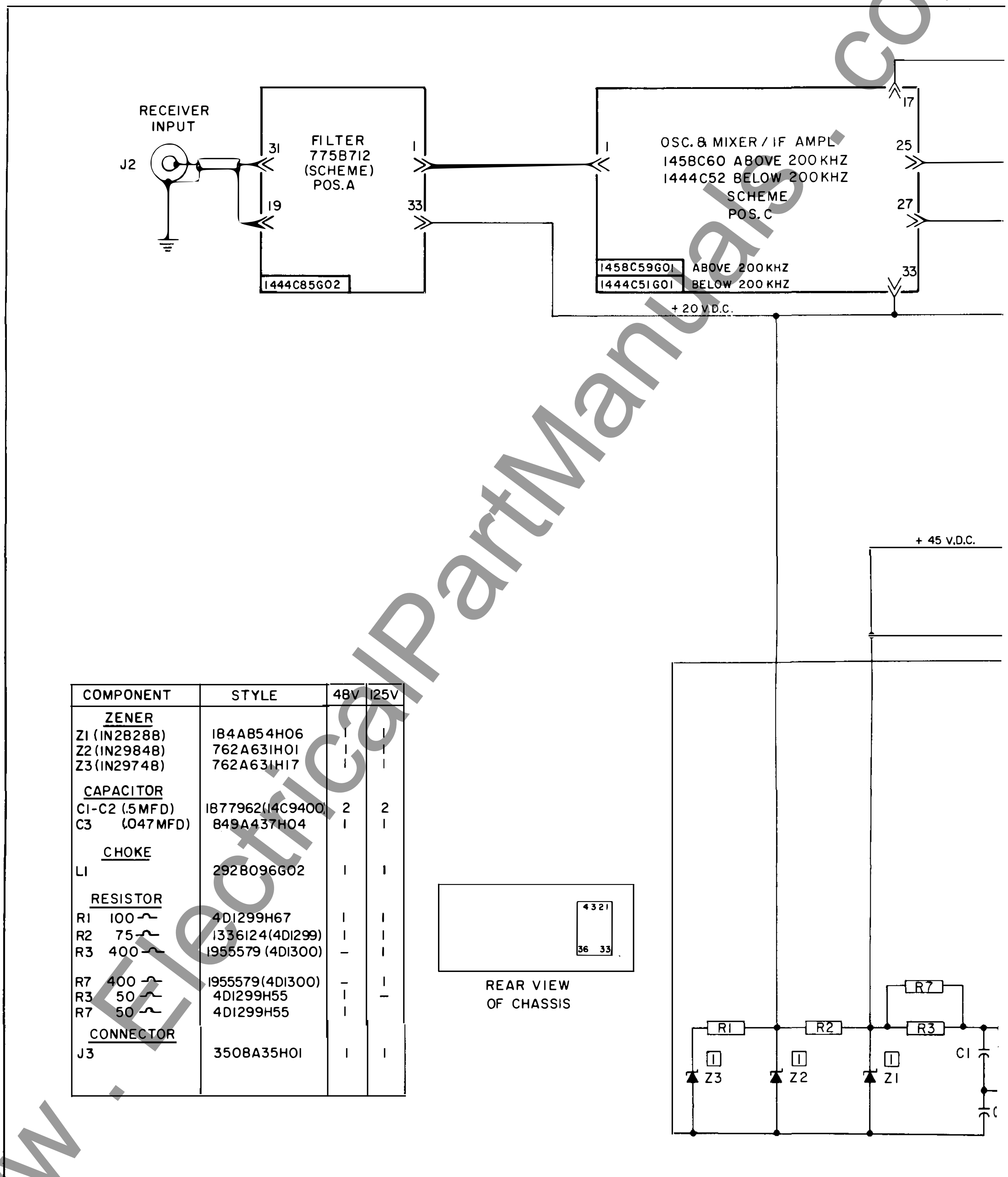
I. Minimum Test Equipment for Installation.
   a. AC vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 Hz to 330 kHz, input impedance 7.5 megohms.
   b. DC Vacuum Tube Voltmeter (VTVM).
      Voltage Range: 1.5 to 300 volts
      Imput Impedance: 7.5 megohms
   c. Milliammeter, 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 330-kHz
   c. Oscilloscope
   d. Frequency counter
   e. Ohmmeter
   f. Capacitor checker
   g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

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.

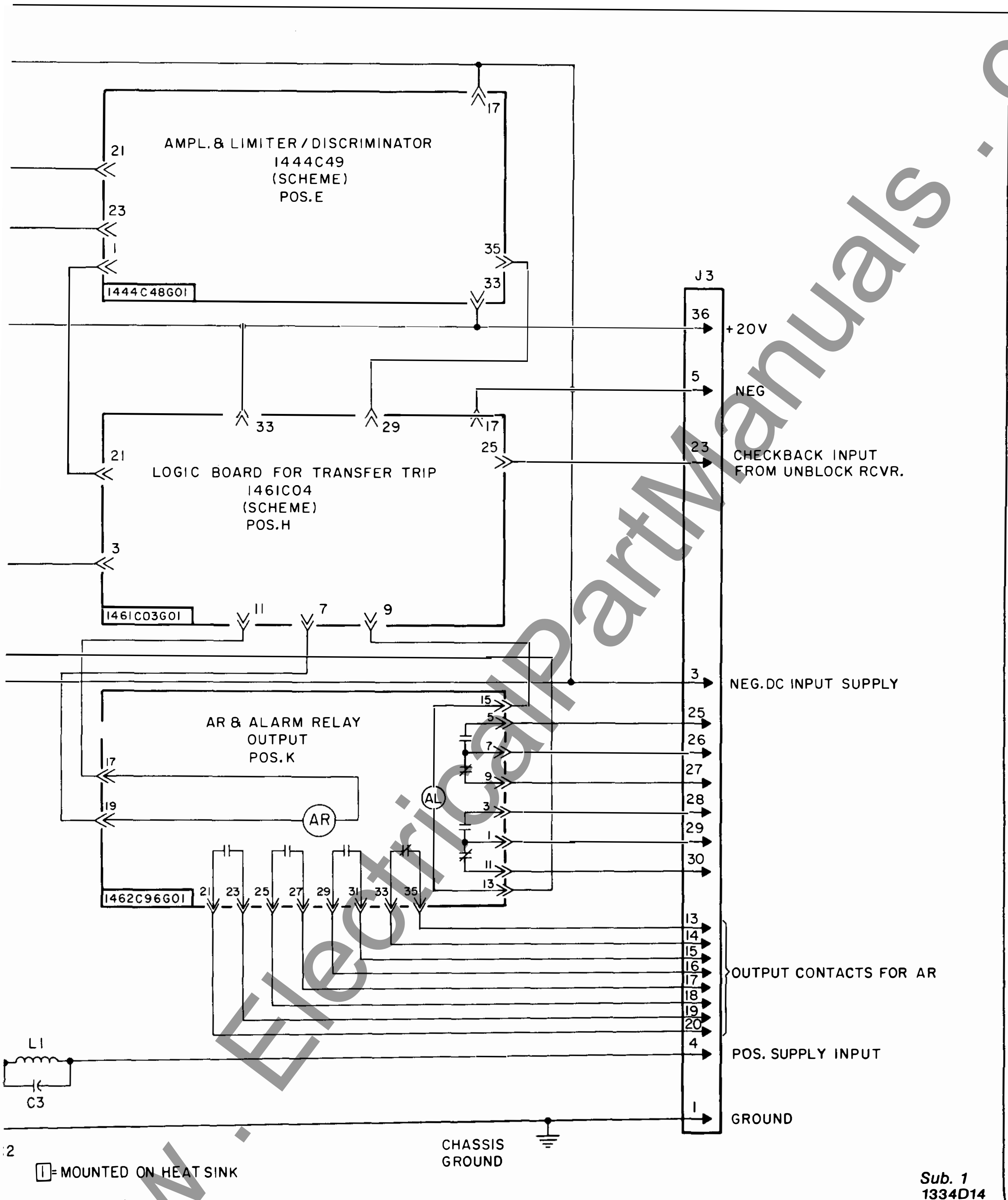
## RENEWAL PARTS

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 (.5 MFD) | 1877962(14C9400) | 2 | 2 |
| C3 (.047 MFD) | 849A437H04 | 1 | 1 |
| **CHOKE** | | | |
| L1 | 292B096G02 | 1 | 1 |
| **RESISTOR** | | | |
| R1 100 Ω | 4D1299H67 | 1 | 1 |
| R2 75 Ω | 1336124(4D1299) | 1 | 1 |
| R3 400 Ω | 1955579 (4D1300) | – | 1 |
| R7 400 Ω | 1955579(4D1300) | – | 1 |
| R3 50 Ω | 4D1299H55 | 1 | – |
| R7 50 Ω | 4D1299H55 | 1 | |
| **CONNECTOR** | | | |
| J3 | 3508A35H01 | 1 | 1 |

*Fig. 1 Internal Schematic of Transfer Trip Receiv*




…er Without Carrier Level Indicator, Pilot Light and Fuses

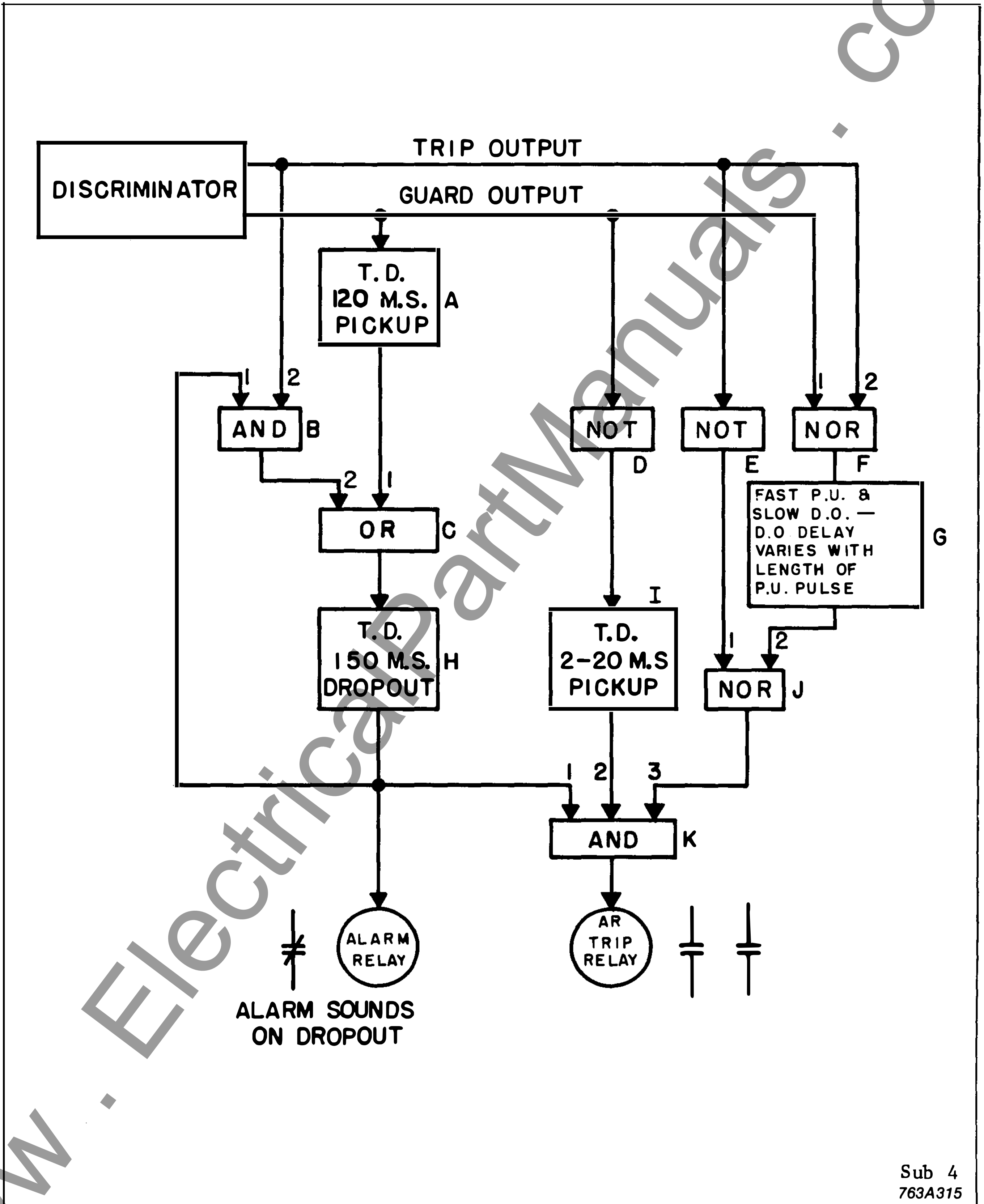



*Fig. 3. Block Diagram of Output Logic Circuit*

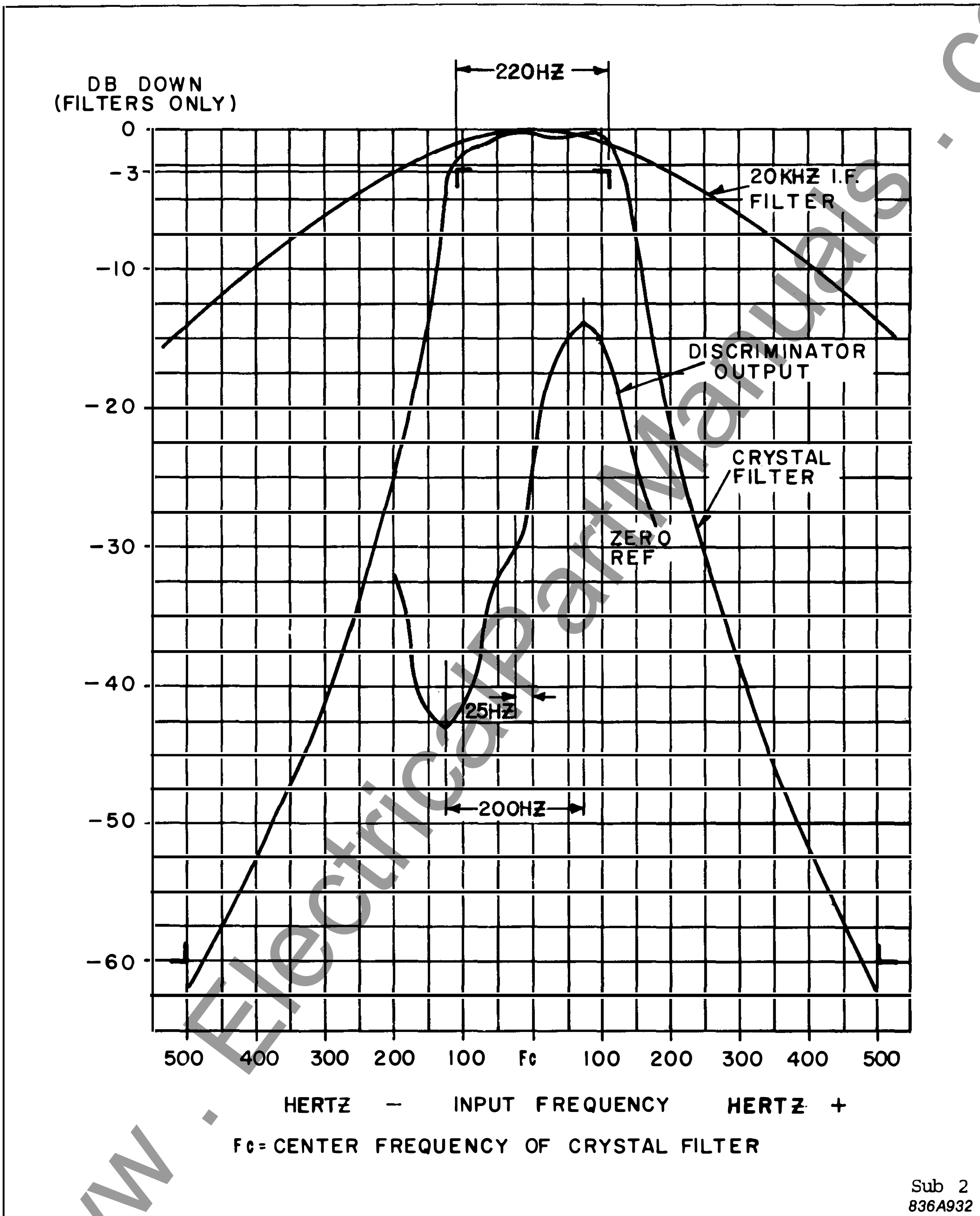



*Fig. 4. Filter and Discriminator Characteristics of the Receiver*

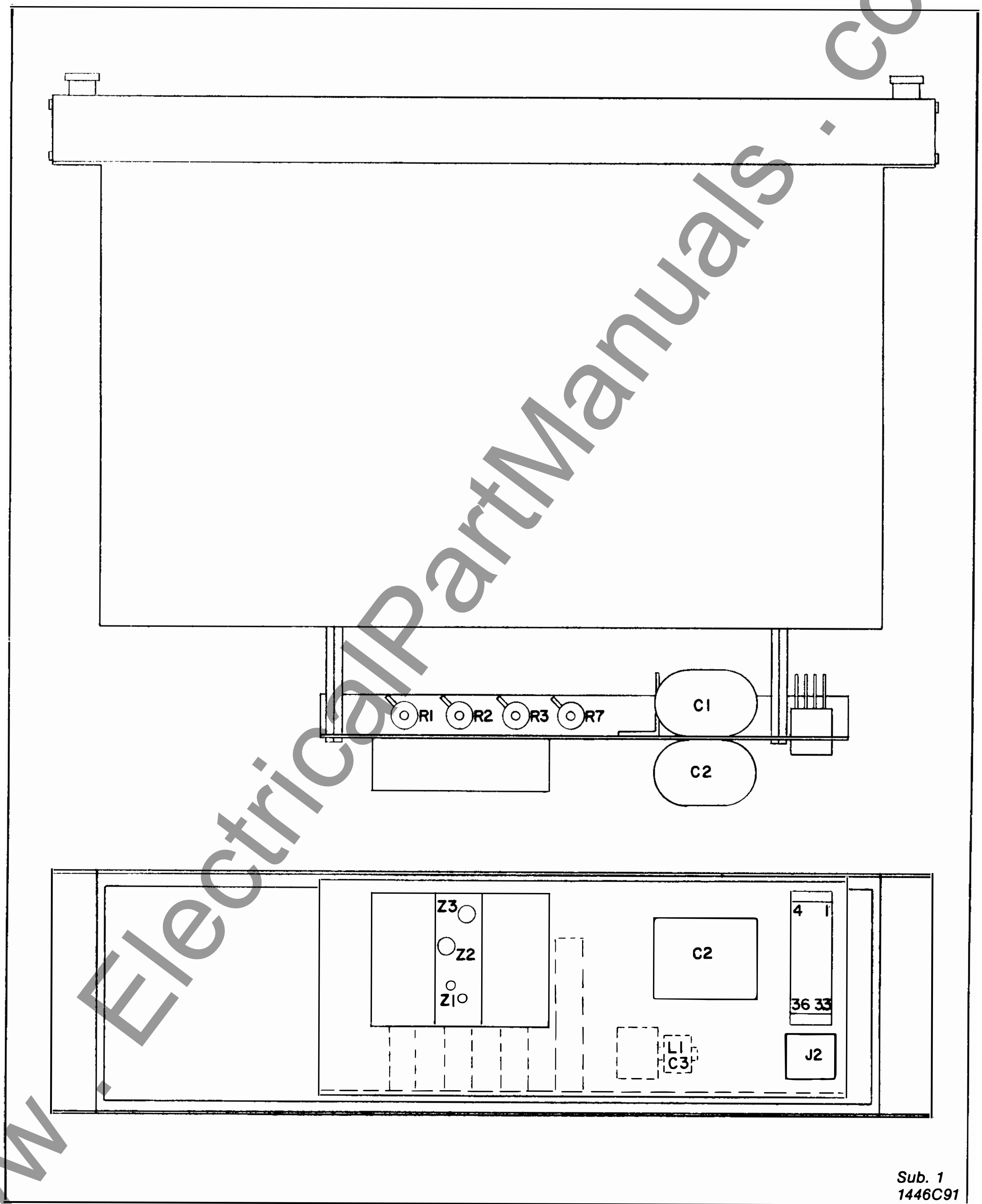



*Fig. 5. Component Location of the Receiver Panel*

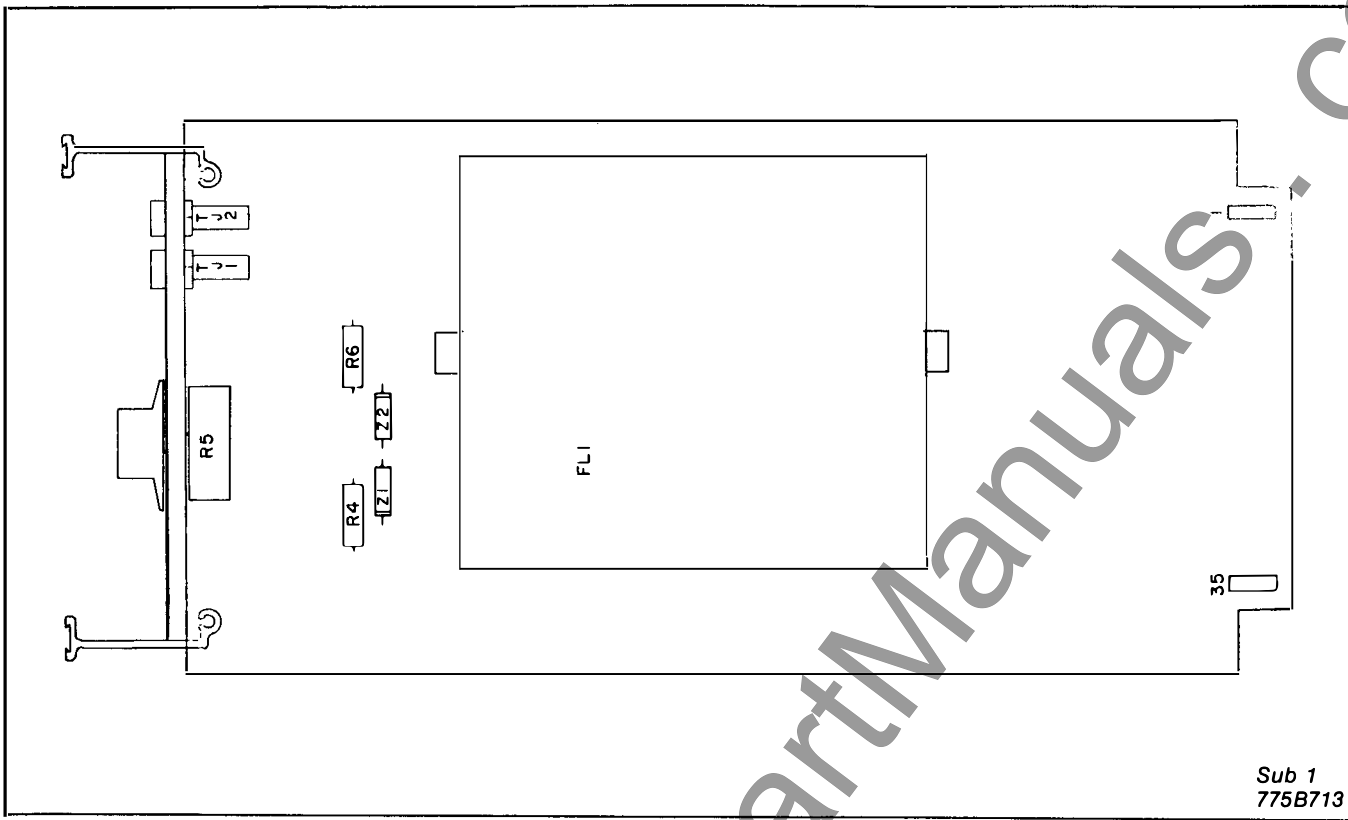



Fig. 6. Component Location of the Input Filter Module

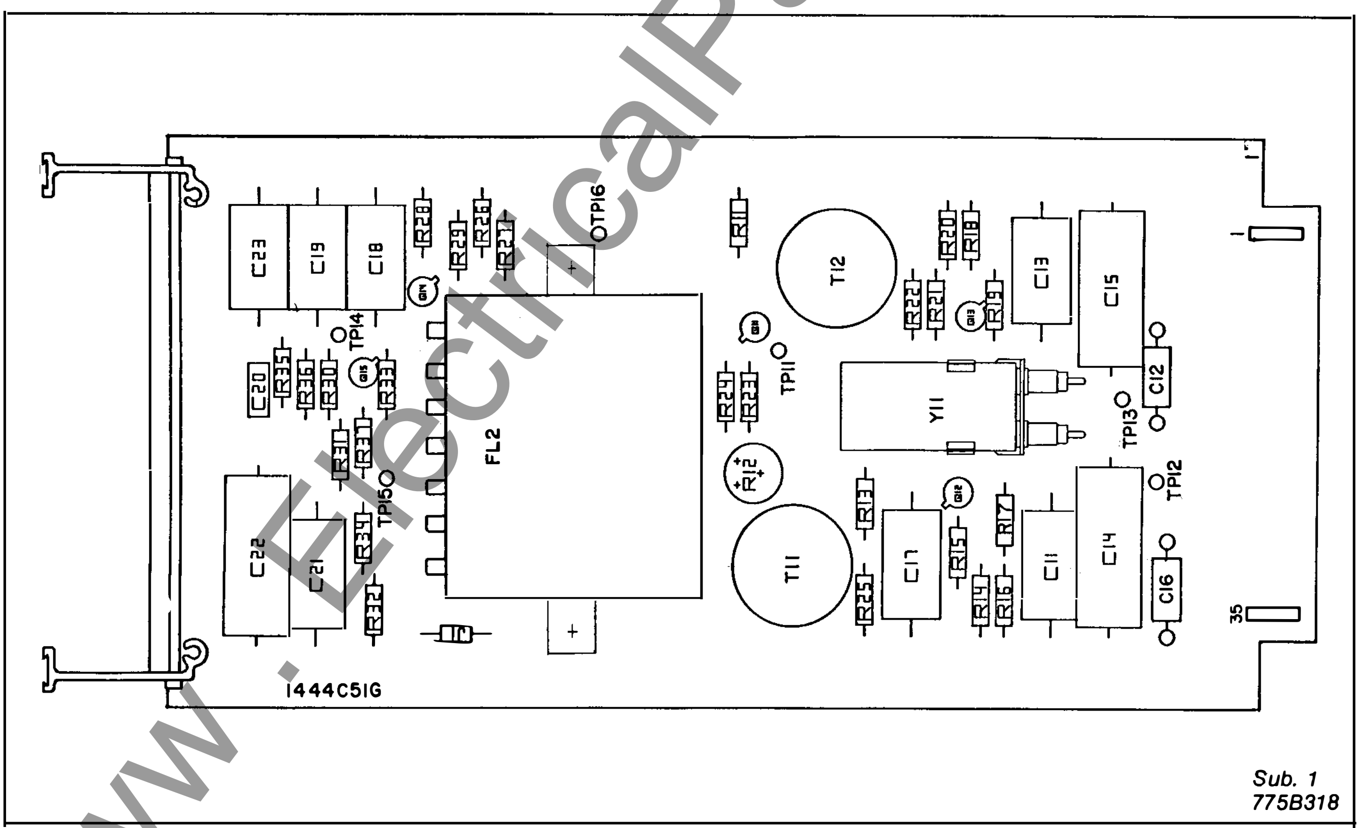
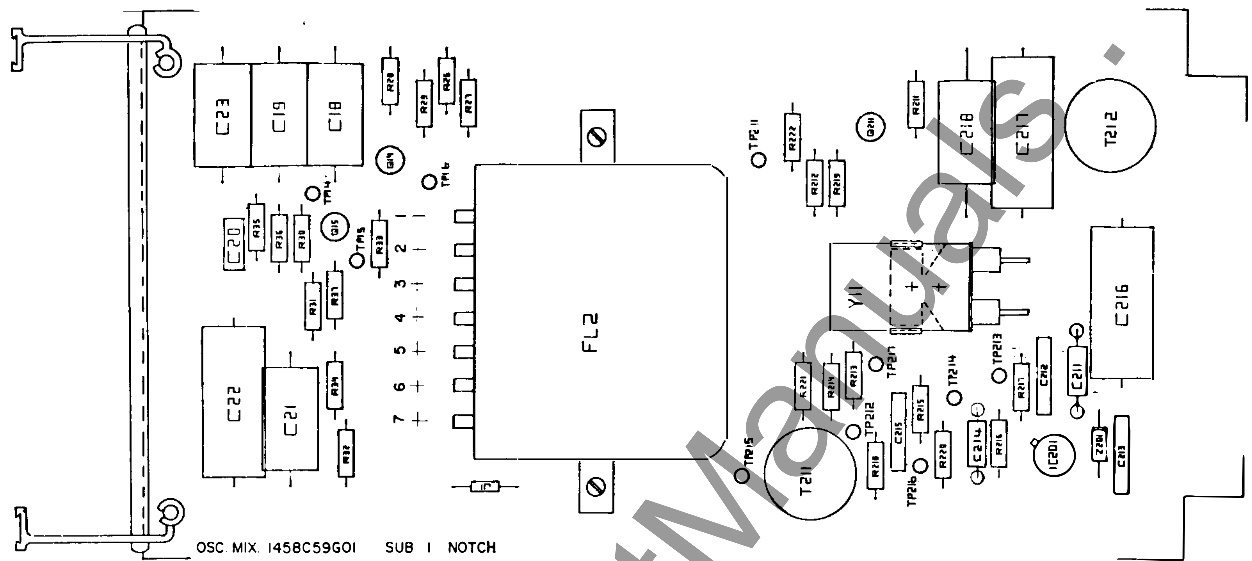
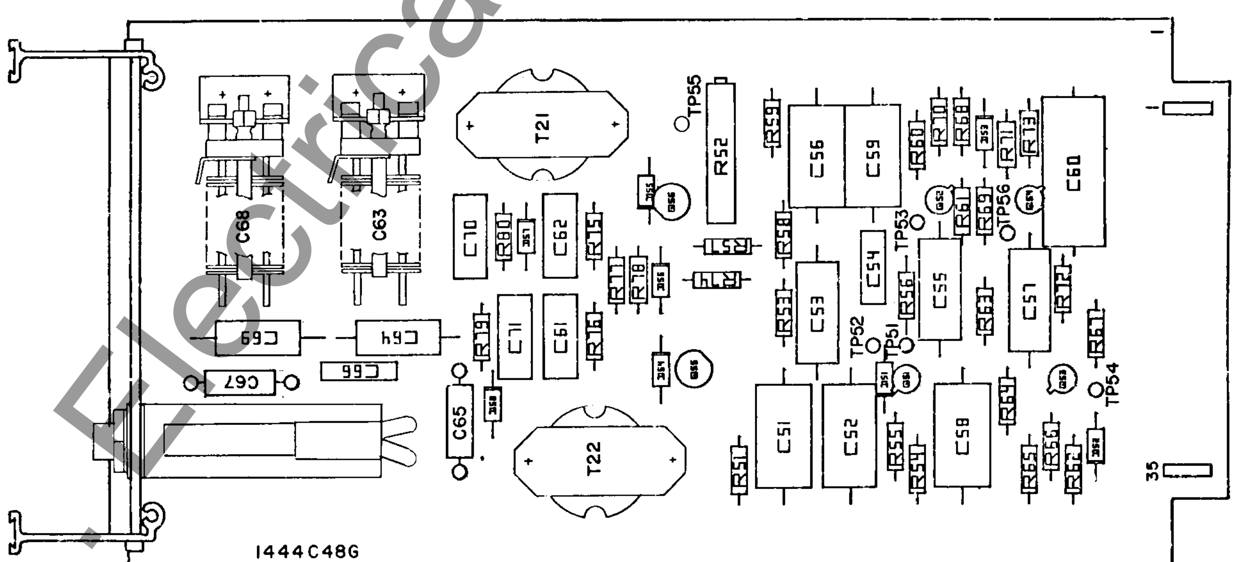



Fig. 7. Component Locations 30-200Hz. Oscillator and Mixer I.F. Amplifier




Sub. 1
775B922

*Fig. 8. Component Locations 200.5-300Hz. Oscillator and Mixer I.F. Amplifier*

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775B317

*Fig. 9. Component Locations Amplifier and Limiter Discriminator Module*

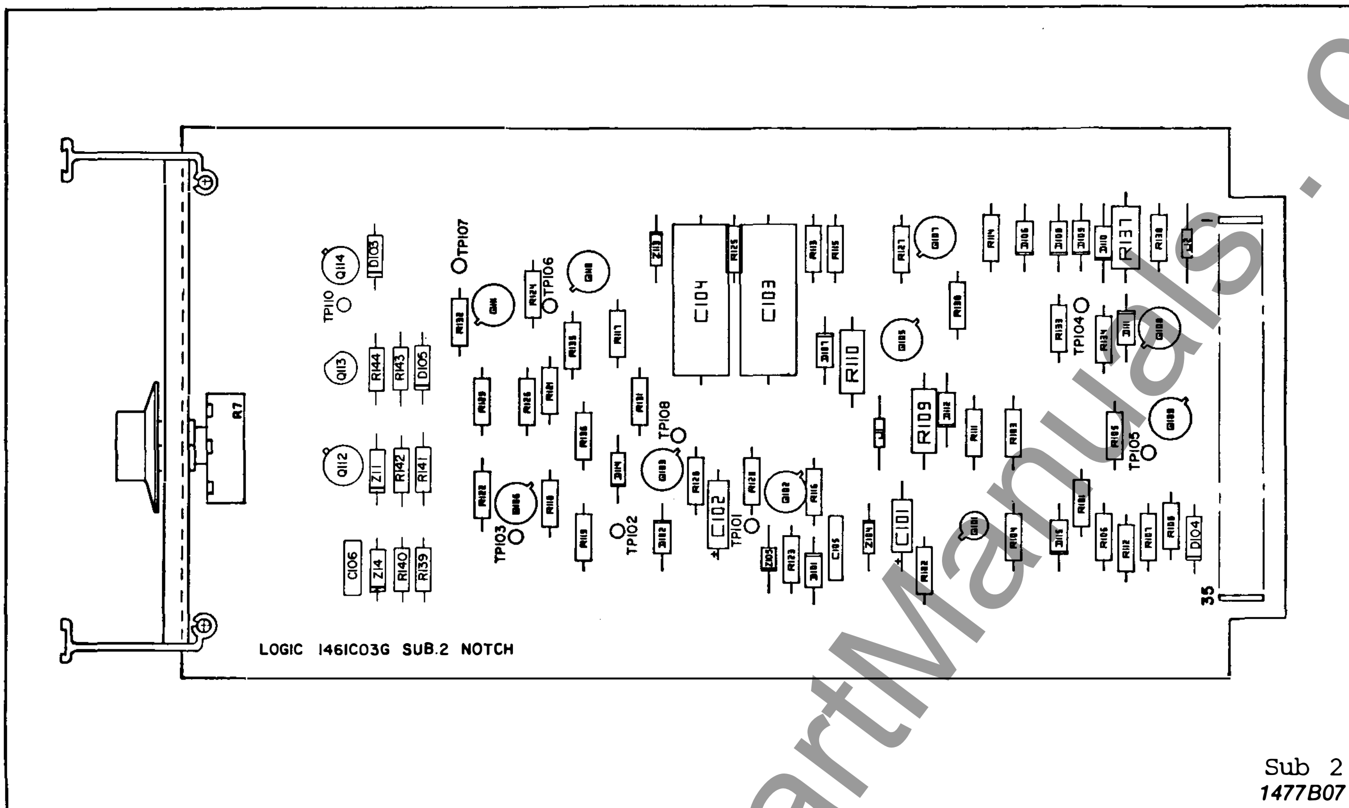



*Fig. 10. Component Locations Logic Board for Transfer Trip*

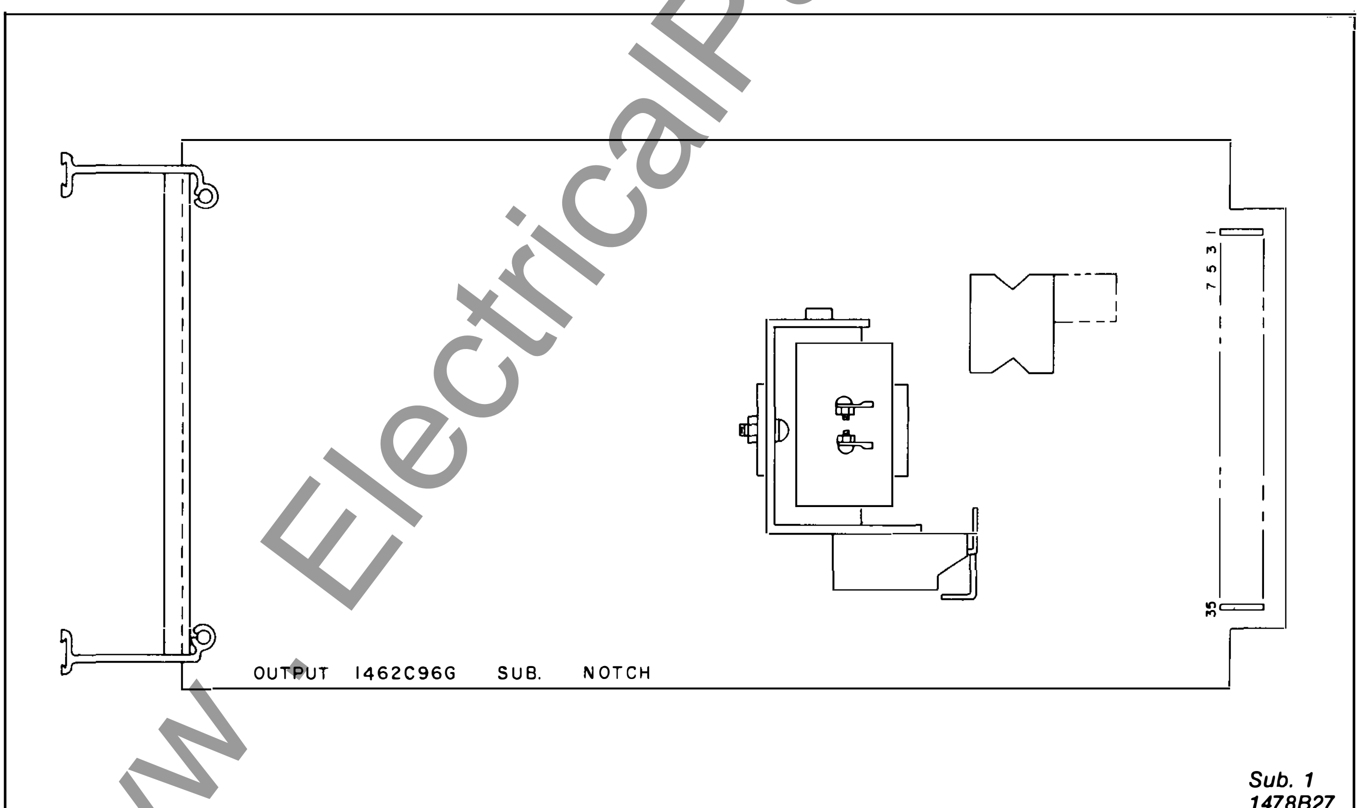



*Fig. 11. Component Locations of the Output Printed Circuit Board*

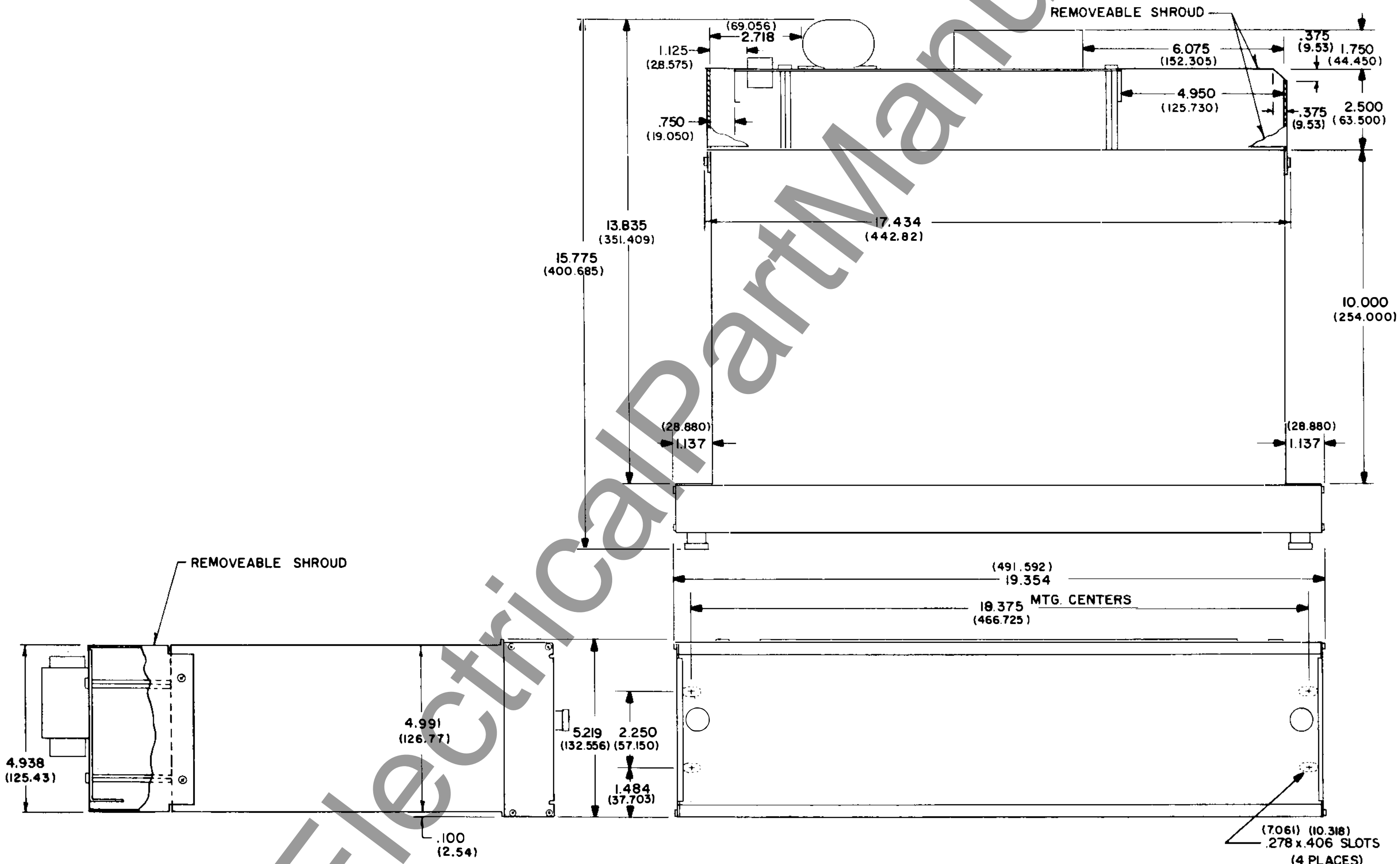



*Fig. 12. Outline and Drilling for Receiver Assembly*

Sub 5
1445C80

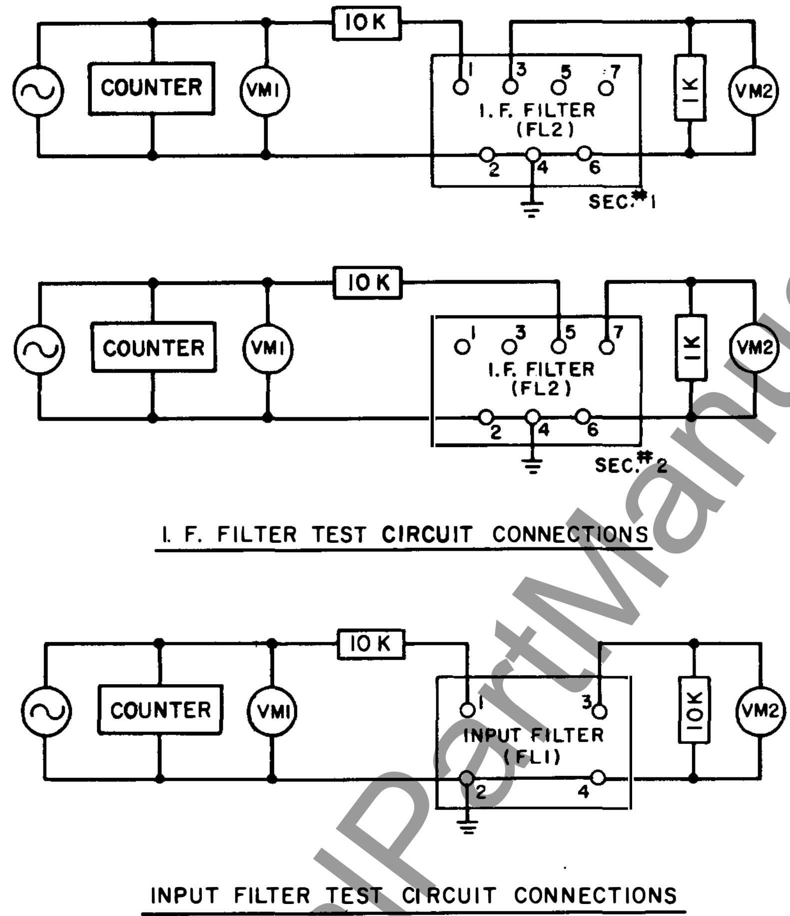
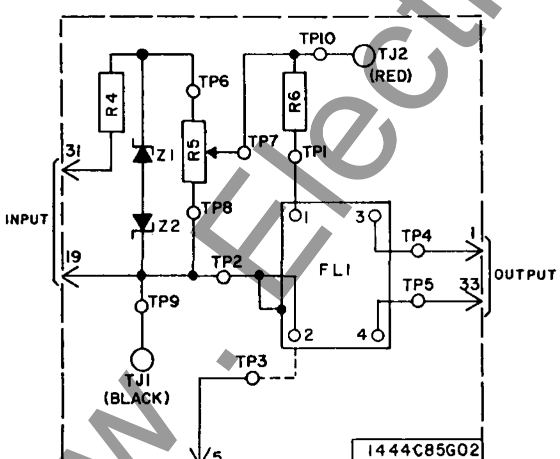



*Fig. 13. Test Currents for Frequency Shift Receiver Filters*

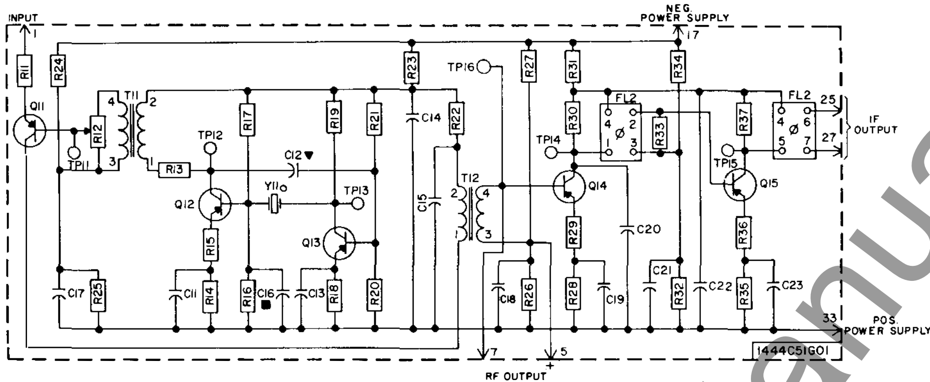



| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| R4 | RESISTOR | 100.0 .50W 5% | 184A763H03 |
| R6 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R5 | POTENTIOMETER | 10.0K 2W | 185A086H10 |
| FL1 | FILTER | | □ |
| TJ1 | TIP JACK | BLACK | 187A332H02 |
| TJ2 | TIP JACK | RED | 187A332H01 |
| Z1 | ZENER | 1N3027B | 188A302H07 |
| Z2 | ZENER | 1N3027B | 188A302H07 |

□ =DETERMINED BY CHANNEL FREQUENCY PER ORDER.

Sub. 1
775B712

*Fig. 13 Test Circuits for Frequency Shift Receiver Filters*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C11 | CAPACITOR | .250UF 200V | 187A624H02 |
| C12 | CAPACITOR | SEE NOTE ▼ | |
| C13 | CAPACITOR | .250UF 200V | 187A624H02 |
| C14 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C15 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C16 | CAPACITOR | SEE NOTE ■ | |
| C17 | CAPACITOR | .250UF 200V | 187A624H02 |
| C18 | CAPACITOR | .250UF 200V | 187A624H02 |
| C19 | CAPACITOR | .250UF 200V | 187A624H02 |
| C20 | CAPACITOR | 100.000PF 500V | 762A757H01 |
| C21 | CAPACITOR | .250UF 200V | 187A624H02 |
| C22 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C23 | CAPACITOR | .250UF 200V | 187A624H02 |
| R11 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R13 | RESISTOR | 4700.0 .50W 5% | 184A763H43 |
| R14 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R15 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| R16 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R17 | RESISTOR | 33.0K .50W 5% | 184A763H63 |
| R18 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R19 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R20 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R21 | RESISTOR | 33.0K .50W 5% | 184A763H63 |
| R22 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| R23 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R24 | RESISTOR | 220.0K .50W 5% | 184A763H83 |
| R25 | RESISTOR | 4700.0 .50W 5% | 184A763H43 |
| R26 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R27 | RESISTOR | 22.0K .50W 5% | 184A763H59 |
| R28 | RESISTOR | 680.0 .50W 5% | 184A763H23 |
| R29 | RESISTOR | 68.0 .50W 5% | 187A290H21 |
| R30 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R31 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| R32 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R33 | RESISTOR | 1000.0 .50W 5% | 184A763H27 |
| R34 | RESISTOR | 22.0K .50W 5% | 184A763H59 |
| R35 | RESISTOR | 680.0 .50W 5% | 184A763H23 |
| R36 | RESISTOR | 68.0 .50W 5% | 187A290H21 |
| R37 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R12 | POT | 1.0K .12W | 629A430H02 |
| J111 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| Q11 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q12 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q13 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q14 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q15 | TRANSISTOR | 2N4249 | 849A441H03 |
| T11 | TRANSFORMER | | 205C043G01 |
| T12 | TRANSFORMER | | 205C043G03 |
| Y11 | CRYSTAL | SEE NOTE ○ | |
| FL2 | FILTER | | 762A613G01 |

▼-C12 RANGE 4 TO 390Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

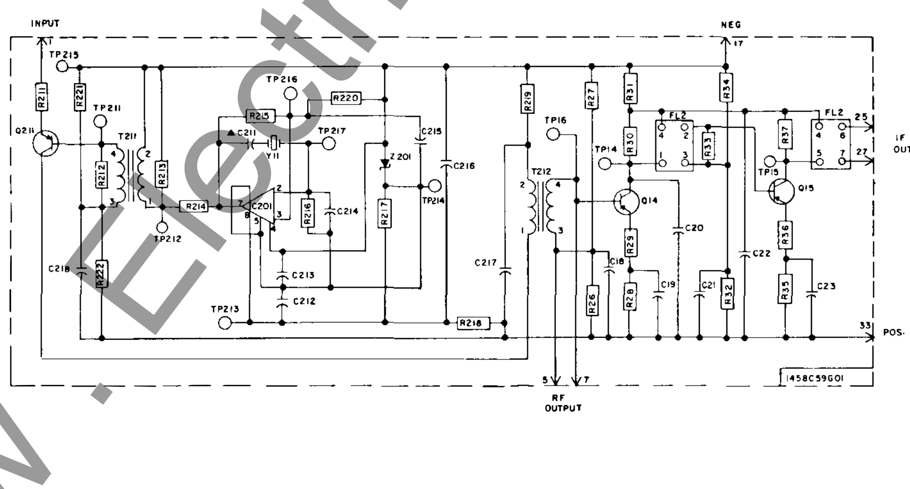
■-C16 RANGE 22 TO 100Pf. AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

○-Y11 RANGE-50 TO 220KHZ.

Ø-COMMON TERMINAL.

Sub 4
1444C52

*Fig. 15. Internal Schematic 30-200Hz. Oscillator and Mixer I.F. Amplifier Module*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C18 | CAPACITOR | .250UF 200V | 187A624H02 |
| C19 | CAPACITOR | .250UF 200V | 187A624H02 |
| C20 | CAPACITOR | 100.000PF 500V | 762A757H01 |
| C21 | CAPACITOR | .250UF 200V | 187A624H02 |
| C22 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C23 | CAPACITOR | .250UF 200V | 187A624H02 |
| ▲ C211 | CAPACITOR | SEE NOTE ▲ | |
| C213 | CAPACITOR | .100UF 50V | 184A663H04 |
| C215 | CAPACITOR | .100UF 50V | 184A663H04 |
| C216 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C217 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C218 | CAPACITOR | .250UF 200V | 187A624H02 |
| O C214 | CAPACITOR | SEE NOTE O | |
| IC201 | INT CKT | MA710 | 201C826H03 |
| J1 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| R26 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R27 | RESISTOR | 22.0K .50W 5% | 184A763H59 |
| R28 | RESISTOR | 680.0 .50W 5% | 184A763H23 |
| R29 | RESISTOR | 68.0 .50W 5% | 187A290H21 |
| R30 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R31 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| R32 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R33 | RESISTOR | 1000.0 .50W 5% | 184A763H27 |
| R34 | RESISTOR | 22.0K .50W 5% | 184A763H59 |
| R35 | RESISTOR | 680.0 .50W 5% | 184A763H23 |
| R36 | RESISTOR | 68.0 .50W 5% | 187A290H21 |
| R37 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R211 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R212 | RESISTOR | 1000.0 .50W 5% | 184A763H27 |
| R213 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R214 | RESISTOR | 2700.0 .50W 5% | 184A763H37 |
| R215 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R216 | RESISTOR | 8200.0 .50W 5% | 184A763H49 |
| R217 | RESISTOR | 2000.0 .50W 5% | 184A763H34 |
| R218 | RESISTOR | 150.0 .50W 5% | 184A763H07 |
| R219 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| R220 | RESISTOR | 47.0K .50W 5% | 184A763H67 |
| R221 | RESISTOR | 220.0K .50W 5% | 184A763H83 |
| R222 | RESISTOR | 4700.0 .50W 5% | 184A763H43 |
| Q14 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q15 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q211 | TRANSISTOR | 2N4249 | 849A441H03 |
| Z201 | ZENER | 1N753A 6.2V | 862A606H01 |
| Y11 | CRYSTAL | SEE NOTE ◘ | |
| T211 | TRANSF | | 714B677G01 |
| T212 | TRANSF | | 205C043G03 |

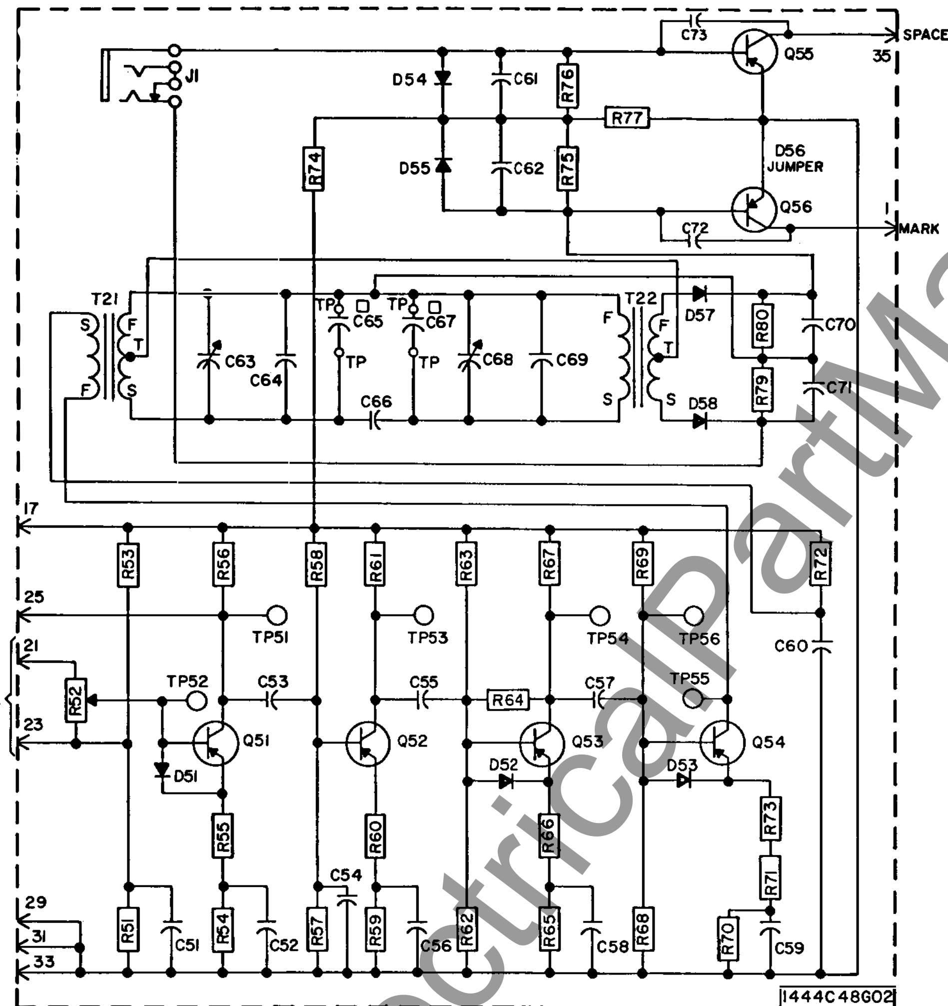
▲ C211 RANGES FROM 100PF TO 1000PF

○ C214 MAY VARY UP TO 100PF 187A695H01 THROUGH H23

◘ Y11 FREQ. EQUALS RCVR (CHANNEL) FREQUENCY PLUS 20KHZ

Sub. 1
1458C60

*Fig. 16. Internal Schematic 200.5-300Hz. Oscillator and Mixer I.F. Amplifier Module*

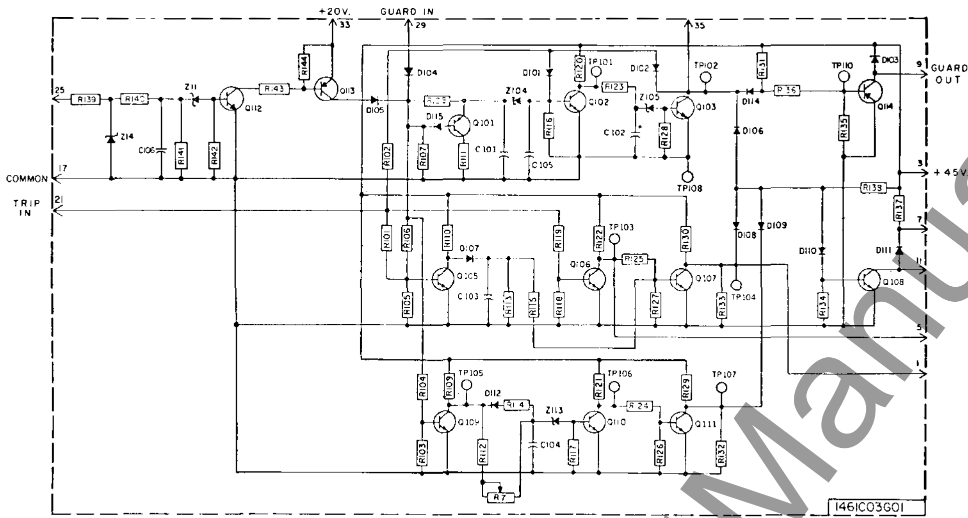



| CØMPØNENT | | DESCRIPTIØN | STYLE NØ. |
|---|---|---|---|
| C51 | CAPACITØR | .250UF 200V | 187A624H02 |
| C52 | CAPACITØR | .250UF 200V | 187A624H02 |
| C53 | CAPACITØR | .100UF 200V | 187A624H01 |
| C54 | CAPACITØR | 1300.000PF 500V | 187A584H15 |
| C55 | CAPACITØR | .100UF 200V | 187A624H01 |
| C56 | CAPACITØR | .250UF 200V | 187A624H02 |
| C57 | CAPACITØR | .100UF 200V | 187A624H01 |
| C58 | CAPACITØR | .250UF 200V | 187A624H02 |
| C59 | CAPACITØR | .250UF 200V | 187A624H02 |
| C60 | CAPACITØR | 1.000UF 200V | 187A624H04 |
| C61 | CAPACITØR | .220UF 50V | 762A703H01 |
| C62 | CAPACITØR | .220UF 50V | 762A703H01 |
| C63 | CAPACITOR | 4.5TO 100PF | 762A736H02 |
| C64 | CAPACITØR | 9100.000PF 200V | 187A624H16 |
| C65 | CAPACITOR | SEE NOTE □ | |
| C66 | CAPACITØR | 100.000PF 500V | 187A684H08 |
| C67 | CAPACITOR | SEE NOTE □ | |
| C68 | CAPACITOR | 4.5TO 100PF | 762A736H02 |
| C69 | CAPACITØR | 9100.000PF 200V | 187A624H16 |
| C70 | CAPACITØR | .220UF 50V | 762A703H01 |
| C71 | CAPACITØR | .220UF 50V | 762A703H01 |
| C72 | CAPACITOR | 330.000PF 200V | 880A397H01 |
| C73 | CAPACITOR | 330.000PF 200V | 880A397H01 |
| D51 | DIØDE | 1N457A | 184A855H07 |
| D52 | DIØDE | 1N457A | 184A855H07 |
| D53 | DIØDE | 1N457A | 184A855H07 |
| D54 | DIØDE | 1N457A | 184A855H07 |
| D55 | DIØDE | 1N457A | 184A855H07 |
| D56 | DIØDE | 1N457A | 184A855H07 |
| D57 | DIØDE | 1N628 | 184A855H12 |
| D58 | DIØDE | 1N628 | 184A855H12 |
| R51 | RESISTØR | 4700.0 .50W 5% | 184A763H43 |
| R53 | RESISTØR | 27.0K .50W 5% | 184A763H61 |
| R54 | RESISTØR | 2200.0 .50W 5% | 184A763H35 |
| R55 | RESISTØR | 27.0 .50W 5% | 187A290H11 |
| R56 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R57 | RESISTØR | 4700.0 .50W 5% | 184A763H43 |
| R58 | RESISTØR | 27.0K .50W 5% | 184A763H61 |
| R59 | RESISTØR | 1500.0 .50W 5% | 184A763H31 |
| R60 | RESISTØR | 180.0 .50W 5% | 184A763H09 |
| R61 | RESISTØR | 4700.0 .50W 5% | 184A763H43 |
| R62 | RESISTØR | 2200.0 .50W 5% | 184A763H35 |
| R63 | RESISTØR | 33.0K .50W 5% | 184A763H63 |
| R64 | RESISTØR | 2700.0 .50W 5% | 184A763H37 |
| R65 | RESISTØR | 680.0 .50W 5% | 184A763H23 |
| R66 | RESISTØR | 68.0 .50W 5% | 187A290H21 |
| R67 | RESISTØR | 4700.0 .50W 5% | 184A763H43 |
| R68 | RESISTØR | 2700.0 .50W 5% | 184A763H37 |
| R69 | RESISTØR | 18.0K .50W 5% | 184A763H57 |
| R70 | RESISTØR | 220.0 .50W 5% | 184A763H11 |
| R71 | RESISTØR | 68.0 .50W 2% | 629A531H04 |
| R72 | RESISTØR | 330.0 .50W 5% | 184A763H15 |
| R73 | RESISTØR | 56.0 .50W 2% | 629A531H02 |
| R74 | RESISTØR | 12.0K .50W 5% | 184A763H53 |
| R75 | RESISTØR | 3000.0 .50W 5% | 184A763H38 |
| R76 | RESISTØR | 3000.0 .50W 5% | 184A763H38 |
| R77 | RESISTØR | 220.0 .50W 5% | 184A763H11 |
| R79 | RESISTØR | 2200.0 .50W 5% | 184A763H35 |
| R80 | RESISTØR | 2200.0 .50W 5% | 184A763H35 |
| R52 | PØT | 1.0K .50W | 629A645H04 |
| Q51 | TRANSISTØR | 2N4249 | 849A441H03 |
| Q52 | TRANSISTØR | 2N4249 | 849A441H03 |
| Q53 | TRANSISTØR | 2N4249 | 849A441H03 |
| Q54 | TRANSISTØR | 2N4249 | 849A441H03 |
| Q55 | TRANSISTØR | 2N3645 | 849A441H01 |
| Q56 | TRANSISTØR | 2N3645 | 849A441H01 |
| T21 | TRANSFORMER | | 6068533G01 |
| T22 | TRANSFORMER | | 6068533G02 |
| J1 | TELEPHONE JACK | | 187A606H01 |

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

Sub 4
1444C49

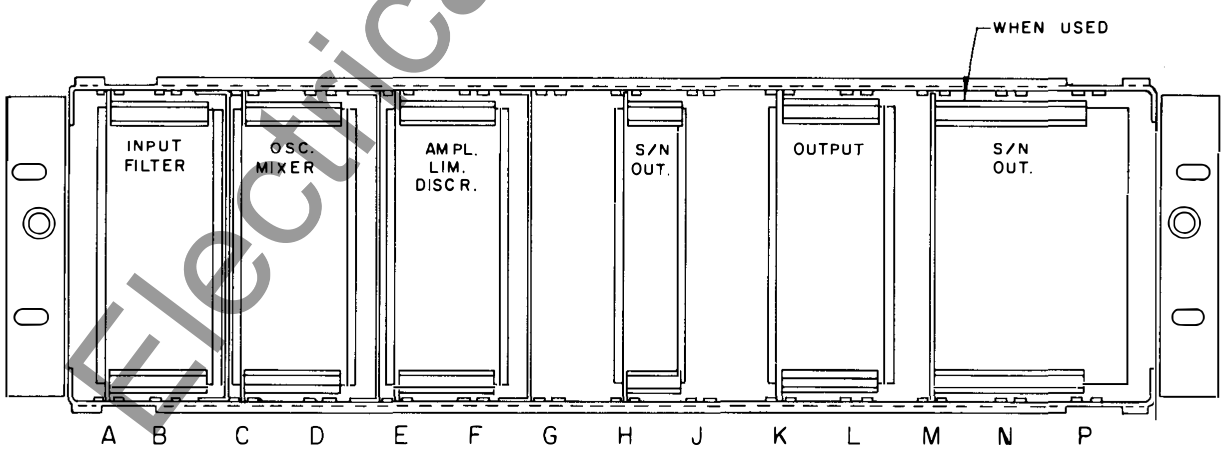
*Fig. 17. Internal Schematic Amplifier and Limiter Discriminator Module*




| COMPONENT | STYLE | REQ | REF |
|---|---|---|---|
| TRANSISTORS | | | |
| Q101 | 849A441H03 | 1 | (2N4249) |
| Q102-105-110-111 | 762A585H01 | 4 | (2N696) |
| Q103 | 184A638H18 | 1 | (2N697) |
| Q107 | 762A585H02 | 1 | (2N698) |
| Q105-108-109-112-114 | 184A638H19 | 5 | (2N699) |
| Q113 | 849A441H02 | 1 | 2N4356 |
| RESISTOR | | | |
| R109 | 187A643H51 | 1 | (10K 1W ±5%) |
| R137 | 184A859H06 | 1 | (800 Ω 3W) |
| R111 | 184A763H19 | 1 | (470 1/2W ±5%) |
| R112-R114-R123 | 184A763H27 | 3 | (1K 1/2W ±5%) |
| R136 | 184A763H39 | 1 | (3.3K 1/2W ±5%) |
| R103-105-116 TO 118-135 138-126-127-128-134 | 184A763H51 | 11 | (10K 1/2W ±5%) |
| R131 | 184A763H53 | 1 | (12K 1/2W ±5%) |
| R107 | 184A763H57 | 1 | (18K 1/2W ±5%) |
| R104 | 184A763H61 | 1 | (27K 1/2W ±5%) |
| R102-124-125-132-133 | 184A763H63 | 5 | (33K 1/2W ±5%) |
| R101-106 | 184A763H65 | 2 | (39K 1/2W ±5%) |
| R108 | 184A763H69 | 1 | (56K 1/2W ±5%) |
| R121-122-129-130 | 184A763H71 | 4 | (68K 1/2W ±5%) |
| R115 | 184A763H73 | 1 | (82K 1/2W ±5%) |
| R119 | 184A763H75 | 1 | (100K 1/2W ±5%) |
| R113 | 184A763H91 | 1 | (470K 1/2W ±5%) |
| R120 | 184A763H65 | 1 | 39K 1/2W ±5% |
| R7 | 185A086H11 | 1 | 250K 1/2W ±5% |
| R110 | 187A643H47 | 1 | 6.8K 1W ±5% |
| R139-R140-R144 | 629A531H48 | 3 | 4.7K 1/2W ±2% |
| R143 | 629A531H58 | 1 | 12K 1/2W ±2% |
| R141 | 629A531H78 | 1 | 82K 1/2W ±2% |
| R142 | 629A531H56 | 1 | 10K 1/2W ±2% |
| CAPACITORS | | | |
| C101 | 184A661H12 | 1 | (4.7MFD 10%) |
| C105 | 184A663H02 | 1 | (.05MFD 50V) |
| C102 | 184A661H25 | 1 | (6.8MFD) |
| C103-104 | 187A624H11 | 2 | (.5MFD ±10%) |
| C106 | 849A437H04 | 1 | .047 MFD 200V |
| | | | |
| DIODES | | | |
| D114 | 182A881H07 | 1 | 1N100A |
| D101 TO 106-107-111 108-109-110-112-115 | 184A855H07 | 13 | (1N457A) |
| DIO-ZENER | | | |
| Z105-Z14 | 185A212H06 | 2 | (1N3686B) |
| Z113-104, Z11 | 186A797H06 | 3 | (1N957B) |

Sub 3
*1461C04*

*Fig. 18. Internal Schematic Logic Board for Transfer Trip Module*




*Sub. 1*
*1463C18*

*Fig. 19. Module Location*

**WESTINGHOUSE ELECTRIC CORPORATION**

**RELAY-INSTRUMENT DIVISION** **CORAL SPRINGS, FL.**

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INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

# TYPE TCF-10 POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT STU-UNBLOCK—WIDE BAND WITH DC/DC CONVERTER POWER SUPPLY

**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 energized. Failure to observe this precaution can result in an undesired tripping output and cause component damage.

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 frequency-shift receiver equipment as adapted for STU-Unblock applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The block signal is transmitted continuously when conditions are normal. Its reception indicates that the channel is operative and that there is no fault in the protected equipment. The block frequency is 100 hertz above the center frequency of the channel. When a fault occurs at the distant end of the power line, protective relays switch the transmitter located there to an unblock frequency, 100 hertz below the center frequency, and also increases the power output of the transmitter (from 1 watt to 10 watts).

## CONSTRUCTION

The TCF receiver unit for STU Unblock applications is mounted on a standard 19-inch wide chassis 5 1/4 inches high (3 rack units) with edge slots for mounting on a standard relay rack. An input attenuator and a jack for metering the discriminator output current, are accessible from the front of the chassis.

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 6. 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 attenuator 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 +12V and −12V supply derived from a self-contained DC to DC converter. The power supply module containing the DC to DC converter has links which enable it to operate from either 48 volts or 125 volts dc.

External connections to the receiver are made through a 36-terminal receptacle, J3. The r-f input connection to the receiver is made through a coaxial cable jack J2. (See Figures 1, 2, or 3).

## OPERATION

### INPUT MODULE

The input module contains the input control and the input filter. The signals to which the TCF-10 receiver responds are fed through a coaxial cable connected to jack J2 at the rear of the chassis to the input module. The input control R5, accessible at the front of the input module, attenuates the signal to a level suitable for the best operating range of the receiver.

A scale on the panel is graduated in dB. While this scale is typical rather than individually calibrated, it is accurate within several dB and is useful in setting approximate levels. Settings should be made more accurately utilizing a suitable ac voltmeter with a dB scale when possible.

### LC FILTER (WIDE BAND RECEIVERS)

From the attenuator, the signal passes through a bandpass LC filter, FL 201. This filter has a passband of approximately 1600Hz which is relatively wide in comparison to the IF filter which has a passband of approximately 500Hz. Still, frequencies several kHz above or below the center frequency ($f_c$) of the channel are greatly attenuated. Figure 5a shows a typical curve for the LC filter as well as a characteristics curve for the IF (intermediate frequency) filter, FL2, and the discriminator output. This apparently wide bandwidth for the input filter in relation to the IF filter is necessary to both achieve high speed data transmission and to achieve proper operation of the noise clamp by sampling noise in the frequency band surrounding the IF band.

This is generally recommended in STU-Unblock applications. However, if the frequency spectrum is too crowded to permit the use of the wide band channel and a slower response time can be tolerated, then the narrowband receiver using a crystal filter is recommended. This operation is described below.

### CRYSTAL FILTER— NARROW BAND RECEIVERS ONLY (SHOWN FOR COMPARISON ONLY)

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred cycles above or below the center frequency ($f_c$) of the channel are greatly attenuated. Figure 5b shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2 and for the discriminator output. The narrow pass band of FL2 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge. This narrow input filter does not permit the use of the same type of noise clamp as the wide band filter.

### OSCILLATOR, MIXER, AND IF AMPLIFIER MODULE

From the input filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20kHz above the channel center frequency, $f_c$. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the latter is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of filter FL1 is impressed on the emitter-collector circuit of Q11. As a result of mixing these two frequencies, the primary of transformer will contain frequencies of 20kHz, $2f_c$ + 20kHz, $f_c$ + 20kHz, and $f_c$.

The output from the secondary of T12 is amplified by Q31 in the intermediate frequency (IF) stage, and is impressed on FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. Since its pass band is narrower than that of the input filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz. The output of this filter is the IF output which is fed to both the amplifier-limiter and the S/N Detection module. The output from the secondary of transformer T11, the RF output, is also fed to the S/N Detection module.

## AMPLIFIER LIMITER AND DISCRIMINATOR MODULE

### AMPLIFIER AND LIMITER

The output from the second section of the IF amplifier stage is fed to potentiometer R52 at the input of the amplifier and limiter stage. Sufficient input is taken from R52 so that with minimum input signal (16 mv.) at J2 and with R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

### DISCRIMINATOR

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at fc-25 hertz. The adjustment for zero output at fc-25 hertz is made by capacitor C68. C63 also is adjusted to obtain a maximum voltage reading across R80 when the current output is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the center frequency. This separation of 200 hertz between the current peaks is affected by the value of C66, (the actual value of which may be changed slightly from its typical value in factory calibration if required).

The purpose of offsetting the zero output frequency of the discriminator by 25 hertz in the unblock direction is to reduce the band of noise-generated trip frequencies (between the discriminator center frequency and the skirt of the FL1 filter), and to similarly increase the band of noise-generated frequencies on the block side of the discriminator center. It should be observed that although block frequency is fc + 100 hertz, after leaving the mixer stage and as seen by the discriminator the block frequency is 20 kHz-100 hertz. Similarly, the unblock frequency is 20 kHz + 100 hertz. The intermediate frequency at which the discriminator has zero output then is 20.025 kHz.

For use with a three frequency transmitter and a second receiver for transfer trip, the discriminator is adjusted opposite in sense to that described above for the standard STU-Unblock. That is, the discriminator is adjusted so that the block output is at 125 hertz below the zero output frequency instead of 125 hertz above while the unblock output is at 75 hertz above the zero output frequency. This is shown in Figure 5c. Since the channel center frequency, fc, is at 100 hertz below the block frequency, the discriminator is thus adjusted for block output at fc + 100 hertz and unblock at fc + 300 hertz with zero output at fc + 225 hertz. Because of this requirement, the STU-Unblock receiver for three frequency operation can only be used with a wide band filter, FL201.

The discriminator output is connected to the bases of transistors Q55 and Q56 in such a manner that transistor Q56 is made conductive when current flows, from the discriminator output, in the forward direction of diode D54, (which occurs with trip output) and Q55 is made conductive when current flows in the forward direction of diode D55 (which occurs with guard output). Consequently, terminal 35 is at a potential of approximately +12 volts at guard (block) frequency and terminal 1 is at +12 volts at trip (unblock) frequency.

## LOGIC CIRCUITS

The block diagram of the logic circuits is shown in Figure 4. Note that the logic involves three modules; the unblock logic module, the S/N output module, and the S/N detection module.

When the discriminator receives block signal, its output terminal 35 supplies positive potential to block AND #2 and 200/0 timer on the logic board. At the same time, if there is good signal level into the receiver, there will be a good signal input into AND #2 from the CL1 on the S/N detection module. This will result in an input to the 120/0 timer on the logic board which consists of R2, C1, and Z1. Capacitor C1 will charge in approximately 120 milliseconds to the breakdown voltage of Z1, and block OR #1 will receive an input #1. OR #1 consists of diodes D2, D3, and Q2. The function of Q1 is not indicated on the block diagram, but it discharges C1 quickly when Guard (block) signal disappears, so that the full 120 milliseconds delay is obtained on closely repetitive appearances of Guard signal. This avoids cancellation of a loss-of-channel alarm by noise-produced Guard signal.

When OR #1 receives input #1 or input #2, Q2 is made conductive and capacitor C3 receives no charge. This capacitor along with Z2 and Q3 represents the 0/150 timer on the block diagram. Note that the absence of an input into the 0/150 timer represents an input #1 into AND #1. However, an input #2 which is a no input from AND #2 is required for AND #1 to put out a trip unblock signal. If guard (block) signal should disappear but be followed promptly by appearance of trip (unblock) signal, the unblock input fed through AND #3 and OR #1, will prevent the 0/150 timer from operating and input #1 will still be presented to AND #1. However, the loss of guard signal will be a no input for input #2 of AND #1, and there will be an immediate trip unblock output out of AND #1. This trip unblock output is fed through a buffer output on the S/N output board to the protective relaying system. However, if guard (block) signal disappears and unblock signal does not appear in approximately 150 milliseconds, then capacitor C3 of the 0/150 millisecond timer will change to the breakdown point of Z2, making Q3 conductive in effect removing input #1 to AND #1. This makes Q5 of AND #1 non-conducting and Q7 of AND #1 conducting thus removing the trip unblock output after 150 milliseconds loss of both guard and trip unblock signals. This bit of logic accounts for the receiver putting out a trip unblock signal for 150 milliseconds upon loss of channel.

The output of 0/150 timer is also fed through OR #2 to AND #3. OR #2 consists of D10, D11, and Q10 while AND #3 consists of D13, D14, D15, D16, and Q9. AND #3 assures that as long as you have good signal, no signal to noise clamp, a trip unblock signal, and have not timed out to 0/150 timer, you will put out a trip unblock signal to the relaying system. However, if the 0/150 timer has timed out because you did not receive a trip signal within 150 milliseconds of losing the guard (unblock) signal, then the system will lock out and not trip for any subsequent trip signal unless it has been preceded by a guard signal for at least 120 milliseconds.

The logic comprising AND #4, 1000/0 timer, 200/0 timer, FLIP-FLOP, and OR #2 is to insure trip unblock on open breaker keying even if the channel is lost for 150 milliseconds after receiving trip. It contains a link which can be removed by the customer if it is desired not to use this feature. Without this logic, if the receiver is receiving trip unblock under open breaker keying of the transmitter and the channel is lost for 150 milliseconds so that the 0/150 timer times out, then the receiver will lock out unless a guard (block) signal is received for 120 milliseconds. This is guard return. However, with this logic in, if the receiver has been receiving trip for over 1000 milliseconds, then if the channel is lost for over 150 milliseconds, the channel will not require a guard return but instead will go to trip immediately upon receipt of trip signal.

With the receipt of trip, input #1 is satisfied into AND #4. Also at this time, if the 0/150 timer has not timed out, (signifying a receipt of trip within 150 milliseconds of lost of guard) input #2 is also satisfied into AND #4. Thus, there will then be an input into the 1000/0 timer. After 1000 milliseconds of continuous receipt of trip, this timer will put out an input into the flip-flop setting the flip-flop. This output is fed back to AND #3 where it is used in place of the trip signal to prevent the 0/150 timer from timing out so that a lost of trip for over 150 milliseconds will not lock out the receiver and necessitate a guard return signal. This flip-flop output through OR #2 is also fed back to AND #4 to lock in the setting of the flip-flop. Now if a guard signal comes in and lasts for over 200 milliseconds, the 200/0 timer will time out and reset the flip-flop so that it again will take 1000 milliseconds of trip signal to set the flip-flop. AND #4 consists of D12, D17, and Q11; 1000/0 timer consists of R40, C4, Z5, and Q12; 200/0 timer consists of D20, Q15, C5, R51, Z6, and Q16; while the flip-flop consists of R46, D18, D19, R47, Q13, Q14 and associated resistors.

The checkback trip output is used for checking channel operation. It signifies a receipt of trip frequency. It is only supervised by the S/N clamp of the detection board. It will put out a checkback trip upon receipt of trip as long as there is no signal to noise clamp. It utilizes AND #5 composed of D77, R171, and Q65 of the S/N output module.

Please note also that it takes a good signal to noise ratio to prevent the 0/150 timer from timing out when receiving trip regardless of the CL1 condition or the flip-flop condition. However, a noise burst at the instant of sending trip will not delay trip unblock as the trip unblock is derived from the loss of guard (block) signal and not the receiving of the trip unblock signal.

It should also be noted that when a trip power boost in the order of 10 dB is used when sending trip, this sudden A.M. increase in power could momentarily activate the S/N clamp as this sudden increase in power level does generate A.M. sidebands which, after all, is noise. However, as noted above, it does neither delay nor effect trip as trip unblock is derived from the loss of guard signal. It manifests itself as only a momentary blip of the S/N noise clamp LED light and should be of no concern.

## S/N DETECTION MODULE

The S/N detection module has three basic functions; first to determine the in-band signal to noise ratio and provide clamping output at the desired level of signal-to-noise ratio, second to measure incoming in band signal level and provide both an output to a carrier level indicating instrument and to a clamping circuit in the output module for clamping at the desired low level of signal, and third to provide a clamping output when the desired signal level exceeds the normal received level by a substantial amount, typically 25dB.

The method of determining signal to noise ratio utilizes the measurement of signal level in two different bandwidths, that of the input filter which is 1600 hertz, and that of the IF filter which is 500 hertz. The total signal plus noise in the 500 hertz bandwidth is subtracted from the signal plus noise in the 1600 hertz bandwidth and this difference is then compared with the signal plus noise in the 500 hertz bandwidth to arrive at a true in-band signal-to-noise ratio using logarithmic circuits. See Figure 29.

If the ratio of signal to noise is less than the value selected, typically 10dB, then there will be a +6V out of IC13 (TP75 and terminal 27). This is a high noise condition and this voltage is used as a clamp to prevent erroneous interpretation of data being received due to high noise conditions. Under normal low noise conditions, typically signal to noise ratio greater than 10dB, the voltage out of IC13 (TP75) is −6V and no clamping is done.

The wide band signal of 1600 hertz bandwidth called the RF signal is fed into the S/N detection board through isolation transformer T31. Operational amplifiers IC1 and IC2 along with their associated components, R82 through R92 and C81 through C90, constitute a 4 pole low pass filter which passes the mixed band of frequencies in the bandwidth of 1600 Hz centered about the 20kHz IF frequency, and blocks all the higher multiples such as in the IF amplifier. Operational amplifier IC3 and associated components amplifies the signal for feeding into the RMS circuit composed of IC4 and IC5 with adjustable potentiometer R94 controlling the amount of amplification. This latter circuit converts the signals into a dc voltage proportional to the RMS value of the ac signals. Operational amplifier IC6A and associated components is used for inversion and isolation of this dc voltage before being fed into the summation amplifier IC6B.

The narrow-band signal of 500 hertz bandwidth called the IF is fed into the S/N detection board through isolation transformer T32. The amount of signal fed into the board is adjustable by means of potentiometer R111. The circuit composed of operational amplifiers IC7 and IC8 and associated components is an RMS circuit which converts the signals into a dc voltage proportional to the RMS value of the ac signals present in the IF bandwidth. The output of this circuit is also then fed into the summation amplifier IC6B.

The summation amplifier takes the difference between the RMS values of the IF signal and the RF signal and feeds it into one half of the logarithmic amplifier composed of IC9 and associated components. At the same time, the RMS value of the IF signal is fed into the other half of this logarithmic amplifier. The logarithmic amplifier takes the logarithmic difference between these two signals (which is equivalent to IF divided by (RF-IF) from the summer). The constants of the circuits are set up so that the output of the logarithmic amplifier is positive when the ratio of the signal to noise ratio in these bandwidths is greater than

10dB, and is negative when the signal to noise ratio is less than 10dB. (Note: The point at which the change in polarity occurs can be altered to other than 10dB signal to noise ratio by altering the adjustments of R94 and R111). In addition, the output of the logarithmic amplifier is also negative when the signal level is approximately 25dB above normal for high level clamping.

The output of the logarithmic amplifier is fed through networks consisting of IC10A and IC13A to the level detector circuit IC13B which has a fast pickup and slow dropout when it receives a signal from the logarithmic amplifier indicating a lower than desired signal to noise ratio (lower than 10dB is initially set when shipped). This will put out a +6 volts out of terminal 27 for this condition. For high signal to noise ratio this output will be −6 volts. This circuit will also put out +6 volts out of terminal 27 for very high signal levels. This is a high signal clamp and occurs for signal levels approximately plus 25dB above normal level.

The output of the IF RMS circuit is also fed to the logarithmic circuit composed of IC11A, IC12A, and IC11B which puts out a dc signal level linearly proportional to signal level in dB for feeding an external microammeter calibrated with a linear dB scale with 10dB equal to 33-1/3 microamperes.

## OUTPUT MODULE

The output module provides four buffered outputs to the relay system. They are block, unblock, S/N level, and not low signal with red indicating light emitting diodes for these outputs and a yellow indicating light emitting diode for normal level (satisfactory signal level). In addition, the output module has logic which will prevent either a +12V block or +12V unblock output whenever the S/N level drops to an unsatisfactory level or the received signal level drops to an unsatisfactory level.

The higher frequency output of plus 12 volts (when present) from the discriminator is fed into the output module through terminal 25 into the "and" gate consisting of diodes D71, D72, D73, and D74, transistors Q62 and Q63, and associated components R163, R164, R165, R166, R167, R168, D88, D75, and Z22. If there is no low level signal or low signal to noise ratio signal to prevent transistor Q62 from becoming conducting, then transistor Q62 becomes conducting, causing Q63 to become conducting and a plus 12 volts signal to appear out of terminal 29 from which it is fed to the outside world. In a similar manner, the lower frequency output of plus 12 volts when present from the discriminator is fed into the output module through terminal 15 into the "and" gate built around transistors Q65 and Q66. Just as in the case of the higher frequency output, the lower frequency output of plus 12 volts will appear out of terminal 27 for feeding to the data acquisition equipment if there is no low level clamp or low signal to noise ratio clamp. If there is a clamp, both of these outputs will be clamped to minus 12 volts output.

The low-signal-level clamp operates off the carrier level signal of the S/N detection module which is basically the same signal level fed to the CL1 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 plus 12 volt signals from appearing on the outputs going to the outside world 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 12 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 +6 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 12 volts out of terminal 13 to the outside world. Transistor Q61 conducting will prevent both transistors Q62 and Q65 from conducting, and thus prevent plus 12 volt signals from appearing at their respective outputs to the outside world. 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.

## OUTPUT MODULE—CONTACT OUTPUT

The output module-contact output performs two functions; alarming on low signal level using a telephone relay with two form C contacts, and indicating signal level with its self-contained CL1 instrument.

The alarm circuit consists of all components associated with IC1, IC2, Q1, Q2, Q3, and relay AL. The signal level from the S/N detection module is fed into a level detector consisting of IC1B and resistors R6, R7, R8, and R9. An adjustable reference for the level detector consisting of IC1A and R1, R2, R17, R3, R4, and R5 is also fed into the level detector. As long as the signal level exceeds the value set by the reference, there will be approximately plus 12 volts out of the level detector into the photo-optical isolator. This causes Q1 to become non-conducting and thus transistors Q2 followed by transistor Q3 to become conducting. As a consequence, the alarm relay AL is picked up on signal levels above the alarm level. When the signal level drops below the alarm level set by the reference, the output of the level detector will be minus 12 volts causing Q1 to become conducting and Q2 and Q3 to become non-conducting and drop out the alarm relay AL. The alarm relay has a delay of approximately 40 milliseconds on dropout to prevent undesirable alarming on short temporary loss of signal. Note that the level of alarm is set by adjusting alarm level R17, accessible from front of module, independent of the low signal level output from the output module (which is set by L.L. ADJ. R178). Also both of these outputs operate on total signal level within the passband of the receiver.

The CL1 instrument operates directly on signal level received from the S/N detection module. It measures signal level in the entire bandwidth of the receiver and thus closely correlates with the low level clamp (L.L. ADJ.) and the low signal alarm AL (alarm level). It thus can be used in setting both of these adjustments.

## POWER SUPPLY

The +12 volt dc, −12 volt dc, and the +45 volt dc supply voltages for the receiver are derived from the power supply module and R3, R7, and Z1 mounted in rear of chassis.

The +12 volt dc supply and the −12 volt dc supply are both derived from the DC to DC converter and are regulated for input voltages to the regulator of from 42 volts to 56 volts. For nominal 48 volt input units, the DC to DC converter has sufficient range so that the preregulator consisting of R3, R7, and Z1 is not necessary and is omitted. In this case, then, the +45 volt supply is derived directly from the input supply voltage and is not regulated.

For nominal 125 volt input units, the pre-regulator consisting of R3, R7, and Z1 is necessary and is supplied. In this case, then, the +45 volt supply is derived from this pre-regulator and is regulated.

The LED's D1 and D2 indicate when the power supply is energized with either 48V or 125V by the proper one glowing. Since this module is always supplied with 48V, the 48V diode will light. A 48V supply can be converted to a 125V supply simply by adding R3, R7, and Z1 jumpers. Similarly, a 125V supply can be converted to a 48V supply by removing R3, R7, and Z1. 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

| | |
|---|---|
| Frequency Range | 30kHz − 300kHz |
| Sensitivity (noise-free channel) | For crystal filter (narrow band)<br>0.005 volt = 65dB below 1 watt for limiting<br>For L-C filter (wide band)<br>0.015 volt = 55dB below 1 watt for limiting |

| | |
|---|---|
| Input Impedance | 5000 ohms minimum |
| Bandwidth | Crystal filter (narrow band)<br>Down <3dB at 220 Hz B.W.<br>Down >60dB at 1000 Hz B.W.<br>L-C filter (wide band)<br>Down <3dB at 600 Hz B.W.<br>Down >40dB at 2000 Hz B.W. |
| Discriminator | Set for 200 Hertz shift from block to unblock frequency. Offset 25 Hertz to favor block. |
| Operating Time | Narrow Band<br>9 ms channel (Transmitter and Receiver)<br>Wide Band<br>4 ms channel (Transmitter and Receiver) |
| Frequency spacing | |
| A. For two or more signals over a one-way channel | Narrow Band<br>500 Hertz minimum<br>Wide Band<br>1000 Hertz minimum |
| B. For two-way channel | Narrow Band<br>1000 Hertz minimum<br>Wide Band<br>2000 Hertz minimum |
| Signal-to-noise ratio clamp setting | 10dB SNR (as shipped) Nominal for wide band receivers |
| Ambient Temperature Range | −20° C to +55° 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 = 5 1/4 inches (3RU)<br>Panel Width = 19 inches |
| Weight | 13 pounds |
| CLI Accuracy | ±2dB between-15dB and 0dB. |

## INSTALLATION

The TCF-10 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 the TCF-10. Heat 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 55° 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 TC-10 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 alarm relay; 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 low signal clamp operates. 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 an unblock nor a low signal 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. (Note: When CL1 instrument is supplied within the chassis, this is factory adjusted).

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. Reducing incoming signal into receiver by 30dB.
4. Adjust full scale adjustment, R153, so that instrument now reads −20dB. (This is approximately 0 microamperes).
5. Increase signal to +10dB level. (This is 100 microamperes).
6. Adjust slope adjustment R155 to read +10dB on instrument.
7. Reduce signal to normal level. Instrument should read 0dB. If desired, instrument could be adjusted to read 0dB with R155 with sacrifice in reading accuracy for +10dB.

## 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 limited 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 unblock 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 IF input with R111 so that signal at TP68 of the S/N detector module is +100 mv dc (with respect to TP62).
3. Adjust RF input with R94 so that signal at TP63 is +145 mv dc (with respect to TP62).
4. Adjust log amplifier balance potentiometer R129 so that S/N clamps operates. This will be +6 volts dc at TP75. This will also appear as +12 volts at TP91 of the output board and the red S/N level indicator will light.
5. Go back and readjust RF input with R94 so that signal level at TP63 is now 74.4 mv dc.

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 145 mv value in step 3.

For S/N of 0dB set TP63 to 297 mv.
5dB set TP63 to 200mv.
15dB set TP63 to 114mv.
20dB set TP63 to 97mv.

**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 unblock frequency signal being received and with an oscilloscope connected across TP56 and terminal 33 of the limited 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 16mv 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 of the output module coming on. There also will be +12 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.

The alarm level is set to alarm at a signal level 5dB above the signal where the receiver just drops out of limiting. This will result in an alarm being given at a point where the signal level has dropped 10dB from the initial nominal setting but the receiver signal level is still 5dB above limiting.

1. With a normal higher frequency signal being received and with an RF voltmeter connected across the input module input test jacks TJ1 and TJ2 (available at front on module), adjust input attenuator R5 to where signal level is 28mv across these test jacks.
2. Adjust the alarm level R17 on the output module—contact output to the point where the alarm relay AL just drops out.
3. Adjust input attenuator R5 to increase signal level into receiver by 10dB. (This is for operation with 15dB margin. For other than 15dB margin, this value should be changed accordingly). This is done by reducing the R5 attenuator setting by 10dB.

## MAINTENANCE

Periodic checks of the received carrier signal level and the receiver sensitivity 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 low level 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.

## RELAY MAINTENANCE AND ADJUSTMENT

The AL relay contacts should be cleaned periodically. A contact burnisher S #182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

## TABLE I
## RECEIVER DC MEASUREMENTS

**NOTE**: All voltage readings taken with the negative 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 lower frequency, higher frequency, or zero.

| Collector of Transistor or Test Point | Voltage (Positive) |
|---|---|
| Q11 | <15 |
| Q12 (TP12) | 17 (Lower or Higher Freq.) |
| Q13(TP13) | 17 (Lower or Higher Freq.) |
| Q14(TP14) | 3 |
| Q15(TP15) | 3 |
| TP11 | 22 |
| TP52 | 19 |
| Q51(TP51) | 14 |
| Q52(TP53) | 14.5 |
| Q53(TP54) | 18 |
| Q54(TP55) | 3 |
| TP56 | 19 |
| Q55 | < 1 (Lower Freq. or No Signal) |
| Q55 | 23 (Higher Freq.) |
| Q56 | 23 (Lower Freq.) |
| Q56 | < 1 (Higher Freq. or No Signal) |

**NOTE**: The following readings are taken with the negative of dc VTVM on terminal 3 (common of dc power supply) of either the S/N detection module or the output module.

| | |
|---|---|
| TP61 | + 4 |
| TP62 | 0 |
| TP63 | + 0.4 |
| TP64 | + 6 |
| TP65 | −12 |
| TP66 | 0 |
| TP67 | + 0.5 |
| TP68 | + 0.5 |
| TP70 | − 6 |
| TP71 | + 6 |
| TP72 | + 1.5 |
| TP73 | + 0.8 |
| TP74 | + 0.3 |
| TP81 | +12 (Higher Frequency) |
| TP81 | −12 (Lower Freq. or No Signal) |
| TP82 | +12 (Lower Frequency) |
| TP82 | −12 (Higher Freq. or No Signal) |
| TP83 | +12 (Higher Frequency) |
| TP83 | −12 (Lower Freq. or No Signal) |
| TP84 | +12 (Lower Frequency) |
| TP84 | −12 (Higher Freq. or No Signal) |
| TP85 | + 0.3 |
| TP86 | +12 (Low Level clamp) |
| TP86 | 0 (No clamp) |
| TP87 | + 6 (Low SNR clamp) |
| TP87 | − 6 (No SNR clamp) |
| TP88 | +12 |
| TP89 | −12 |
| TP90 | +12 (Good Signal Level) |
| TP90 | −12 (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 in 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 |

## LC 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 27 can be used in case there is reason to suspect that either of the filters is not performing correctly.

Figure 5 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 5 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 the IF filter are down 3dB maximum at 19.75 and 20.25 kHz, and for the stop band are down 18dB minimum at 19.00 and 21.00kHz for each section. The signal generator voltage (Figure 27) 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 that 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.

## CRYSTAL FILTER RESPONSE MEASUREMENTS

The input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only 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 23 can be used in case there is reason to suspect that either of the filters has been damaged.

Figure 5 shows the −3dB and −60dB check points for the crystal filters. 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 5 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3dB maximum at 19.75 and 20.25 kHz, and for the stop band are "down 18dB minimum at 19.00 and 21.00 kHz. The signal generator voltage must be held constant throughout the entire check. A value of 20dB (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 resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10dB (2.45 volts) 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 11dB 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-10 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. AC Vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 hertz to 330 kHz, input impedance 7.5 megohms.
   b. DC Vacuum Tube Voltmeter (VTVM).
      Voltage range: 1.5 to 300 volts
      Input impedance: 7.5 megohms
   c. CLI Microammeter, range 0-100$\mu$A, style number 606B592A26, (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: 20kHz to 330kHz
   c. Oscilloscope
   d. Frequency counter
   e. Ohmmeter
   f. Capacitor checker
   g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

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.

*Fig. 1b. Internal Schemat*

Sub. 1
Future

ic STU Unblock Narrow Band

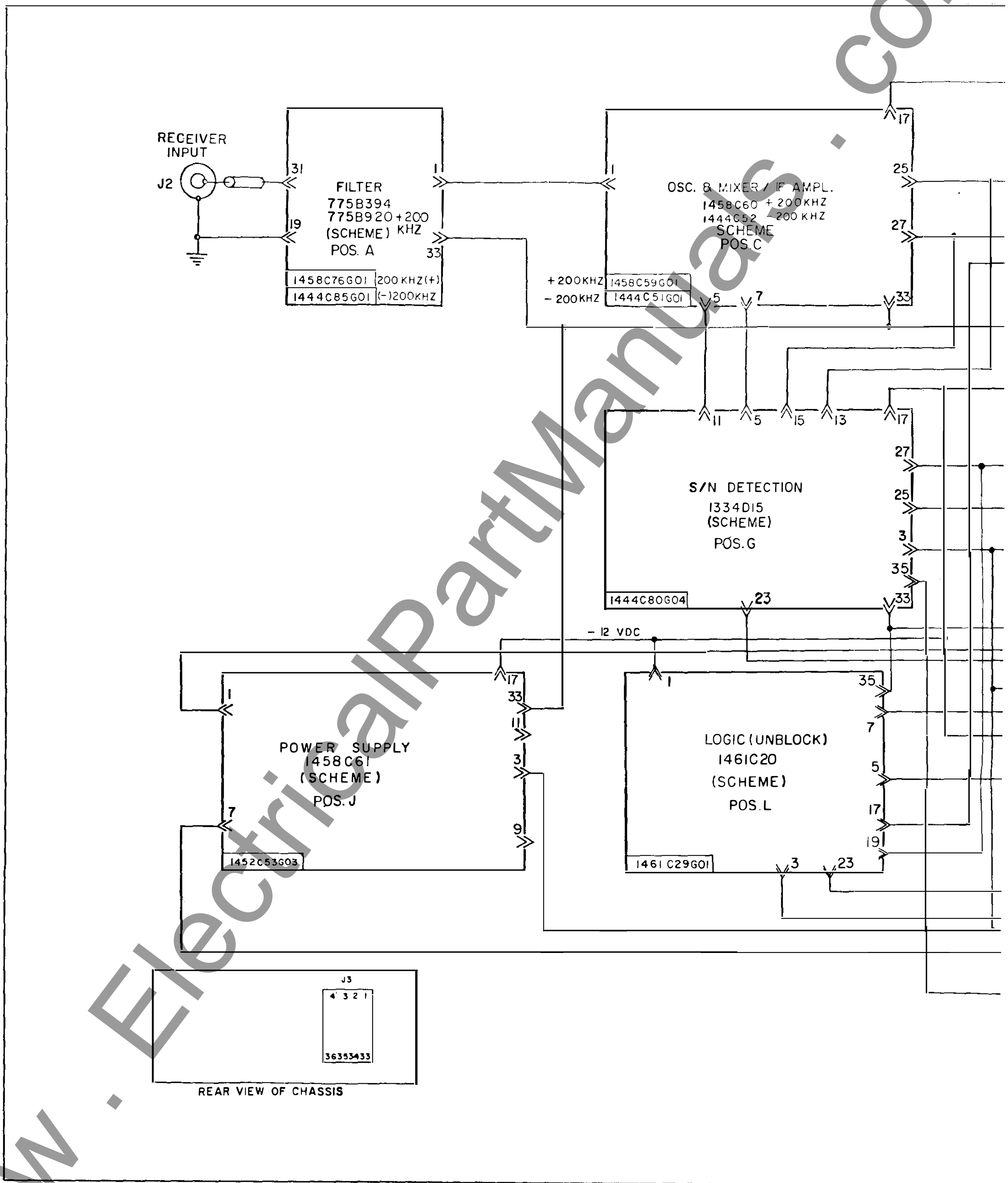
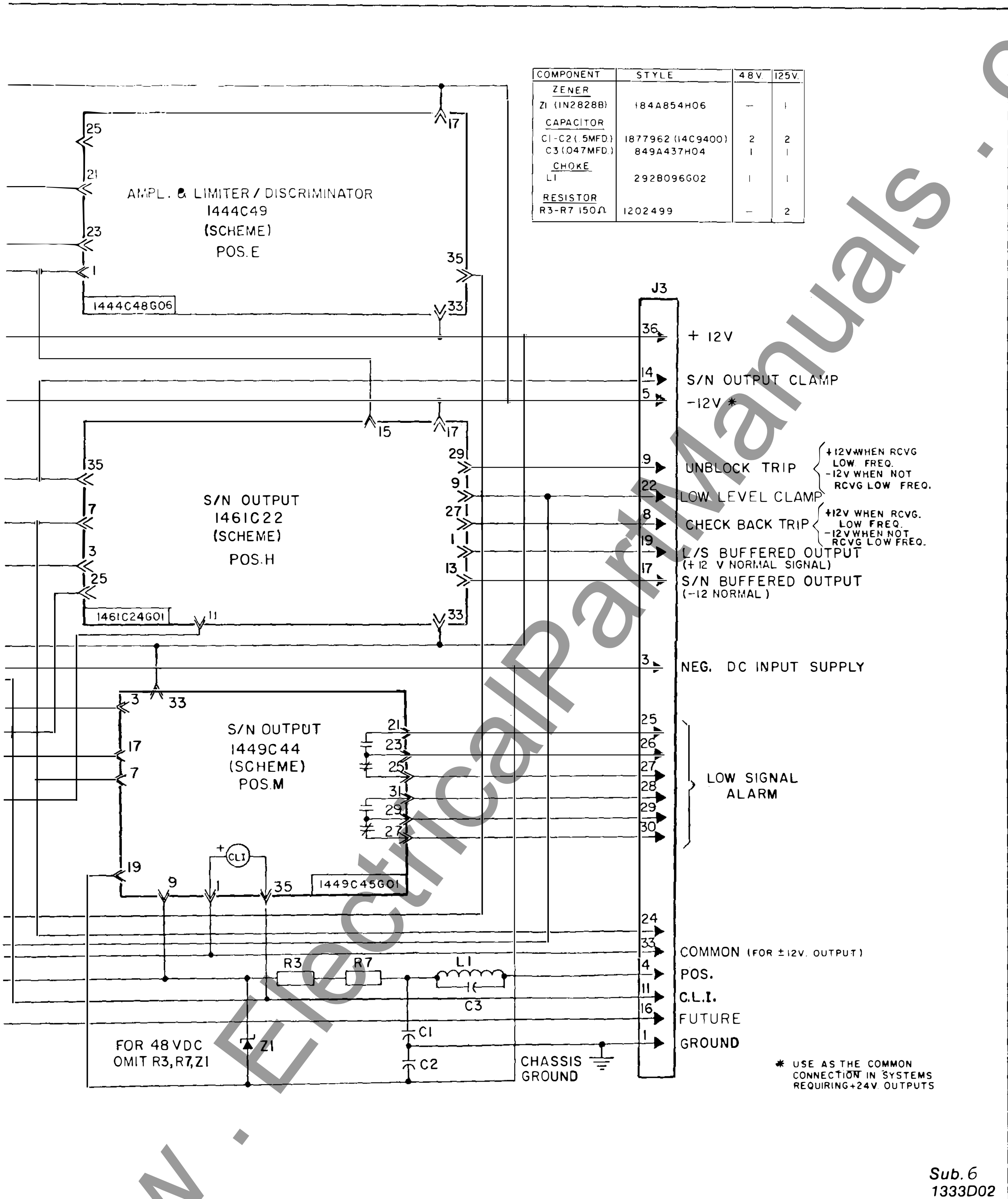
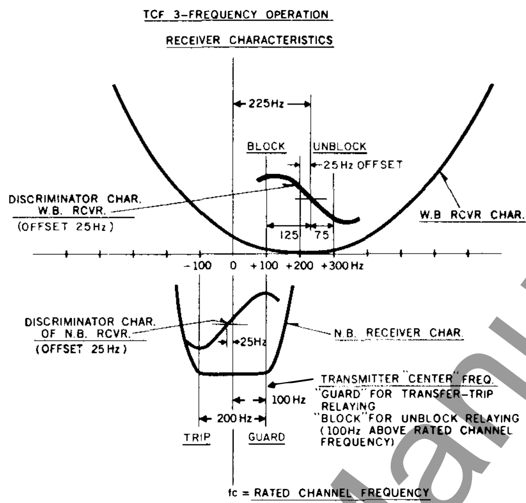



*Fig. 2. Internal Schematic S*

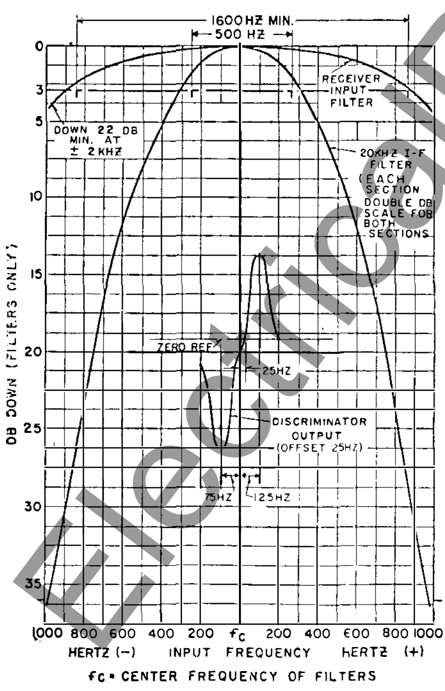
| COMPONENT | STYLE | 48V. | 125V. |
|---|---|---|---|
| ZENER | | | |
| Z1 (IN2828B) | 184A854H06 | — | 1 |
| CAPACITOR | | | |
| C1-C2 (.5MFD) | 1877962 (14C9400) | 2 | 2 |
| C3 (.047MFD) | 849A437H04 | 1 | 1 |
| CHOKE | | | |
| L1 | 292B096G02 | 1 | 1 |
| RESISTOR | | | |
| R3-R7 150Ω | 1202499 | — | 2 |



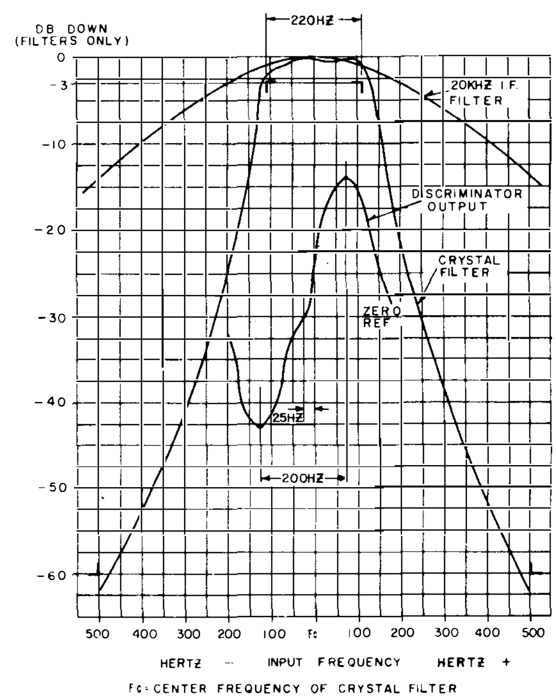

Sub. 6
1333D02




C-3 FREQUENCY RECEIVER 880A986




A-WIDE BAND RECEIVER 3499A90




B-NARROW BAND RECEIVER 836A932

*Fig. 5. Filter and Discriminator Characteristics*

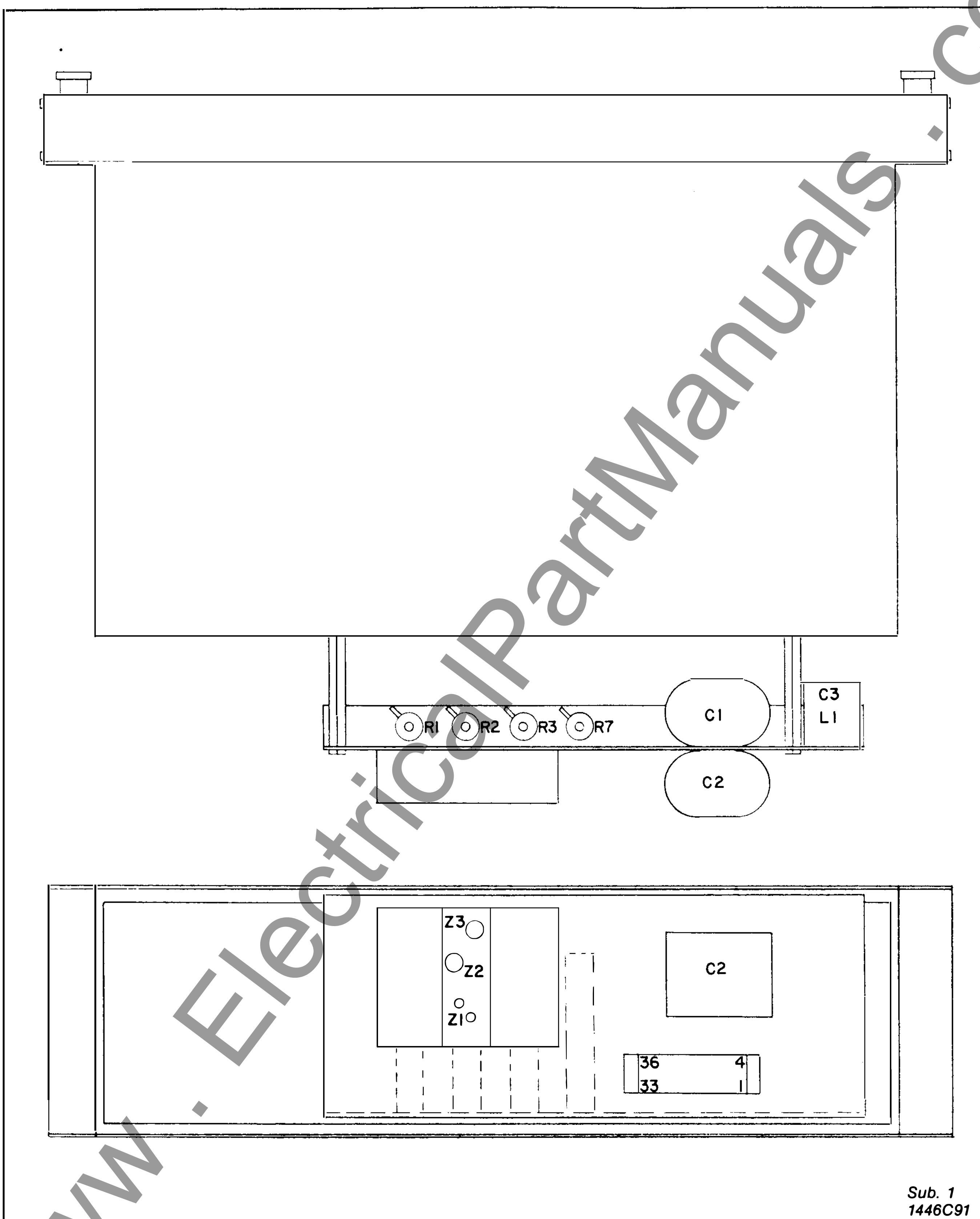
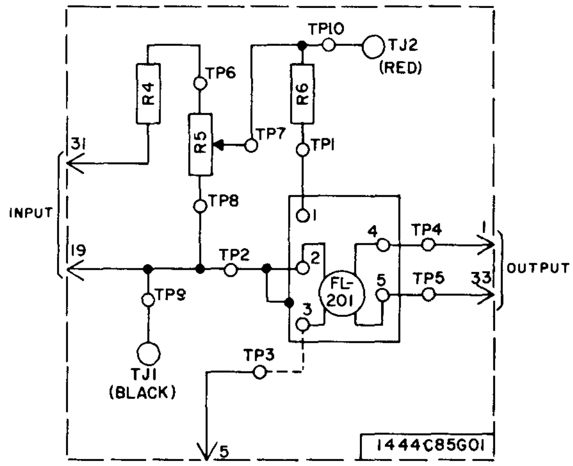



*Fig. 6. Component Location*

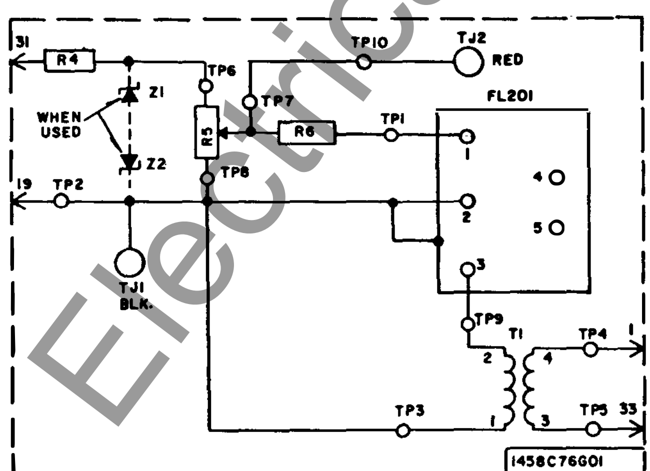



| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| R4 | RESISTOR | 100.0 .50W 5% | 184A763H03 |
| R6 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R5 | POTENTIOMETER | 10.0K 2W | 185A086H10 |
| FL201 | FILTER | | □ |
| TJ1 | TIP JACK | BLACK | 187A332H02 |
| TJ2 | TIP JACK | RED | 187A332H01 |

□ = TO BE DETERMINED.

*Sub. 1*
*775B394*

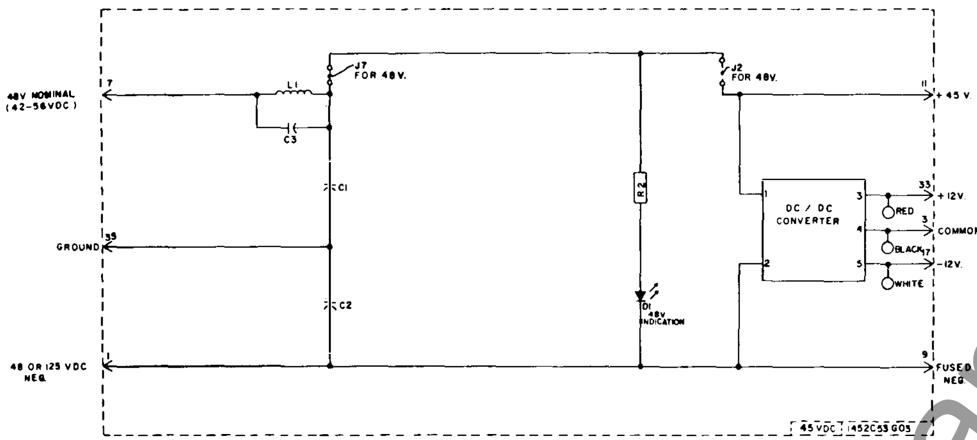
*Fig. 7. Internal Schematic Filter Module 30-200 KHz*




| COMPONENT | | DESCRIPTION | | STYLE NO. |
|---|---|---|---|---|
| R4 | RESISTOR | 100.0 | .50W 5% | 184A763H03 |
| R6 | RESISTOR | 10.0K | .50W 5% | 184A763H51 |
| Z1 | ZENER | 1N3027B | 20.0V | 188A302H07 |
| Z2 | ZENER | 1N3027B | 20.0V | 188A302H07 |
| FL201 | FILTER | D.SPEC | | |
| R5 | POT | 10K | 2W | 185A086H10 |
| T1 | TRANSF | | | 714B677G01 |

*Sub. 2*
*775B920*

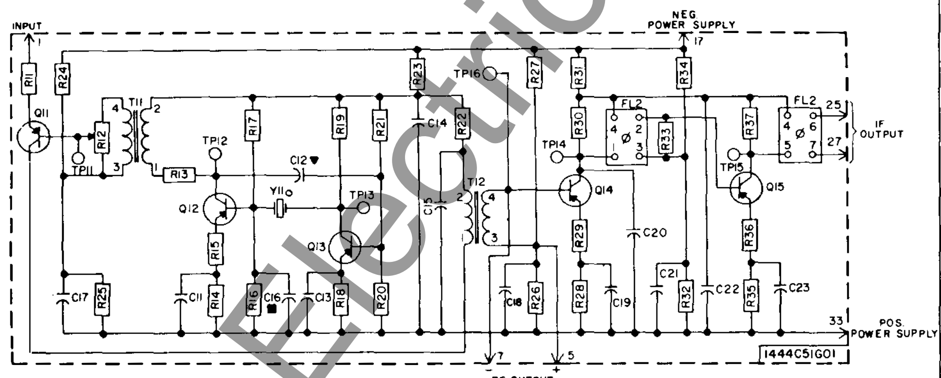
*Fig. 8. Internal Schematic Filter Module 200.5-300 KHz*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C1 | CAPACITOR | .01 MFD. | 3516A36H01 |
| C2 | CAPACITOR | .01 MFD. | 3516A36H01 |
| C3 | CAPACITOR | .047 MFD | 849A437H04 |
| R2 | RESISTOR | 4.7K .50W 2% | 629A531H48 |
| J2 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J7 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| D1 | DIODE | LED | 3508A22H02 |
| L1 | COIL | | 292B096G02 |

*Sub. 1*
*1458C61*

*Fig. 9. Power Supply Module*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C11 | CAPACITOR | .250UF 200V | 187A624H02 |
| C12 | CAPACITOR | SEE NOTE ▼ | |
| C13 | CAPACITOR | .250UF 200V | 187A624H02 |
| C14 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C15 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C16 | CAPACITOR | SEE NOTE ■ | |
| C17 | CAPACITOR | .250UF 200V | 187A624H02 |
| C18 | CAPACITOR | .250UF 200V | 187A624H02 |
| C19 | CAPACITOR | .250UF 200V | 187A624H02 |
| C20 | CAPACITOR | 100.000PF 500V | 762A757H01 |
| C21 | CAPACITOR | .250UF 200V | 187A624H02 |
| C22 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C23 | CAPACITOR | .250UF 200V | 187A624H02 |
| R11 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R13 | RESISTOR | 4700.0 .50W 5% | 184A763H43 |
| R14 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R15 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| R16 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R17 | RESISTOR | 33.0K .50W 5% | 184A763H63 |
| R18 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R19 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R20 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R21 | RESISTOR | 33.0K .50W 5% | 184A763H63 |
| R22 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| R23 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R24 | RESISTOR | 220.0K .50W 5% | 184A763H83 |
| R25 | RESISTOR | 4700.0 .50W 5% | 184A763H43 |
| R26 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R27 | RESISTOR | 22.0K .50W 5% | 184A763H59 |
| R28 | RESISTOR | 680.0 .50W 5% | 184A763H23 |
| R29 | RESISTOR | 68.0 .50W 5% | 187A290H21 |
| R30 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R31 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| R32 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R33 | RESISTOR | 1000.0 .50W 5% | 184A763H27 |
| R34 | RESISTOR | 22.0K .50W 5% | 184A763H59 |
| R35 | RESISTOR | 680.0 .50W 5% | 184A763H23 |
| R36 | RESISTOR | 68.0 .50W 5% | 187A290H21 |
| R37 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R12 | POT | 1.0K .12W | 629A430H02 |
| J111 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| Q11 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q12 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q13 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q14 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q15 | TRANSISTOR | 2N4249 | 849A441H03 |
| T11 | TRANSFORMER | | 205C043G01 |
| T12 | TRANSFORMER | | 205C043G03 |
| Y11 | CRYSTAL | SEE NOTE ○ | |
| FL2 | FILTER | | 762A613G01 |

▼-C12 RANGE 4 TO 390Pf AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

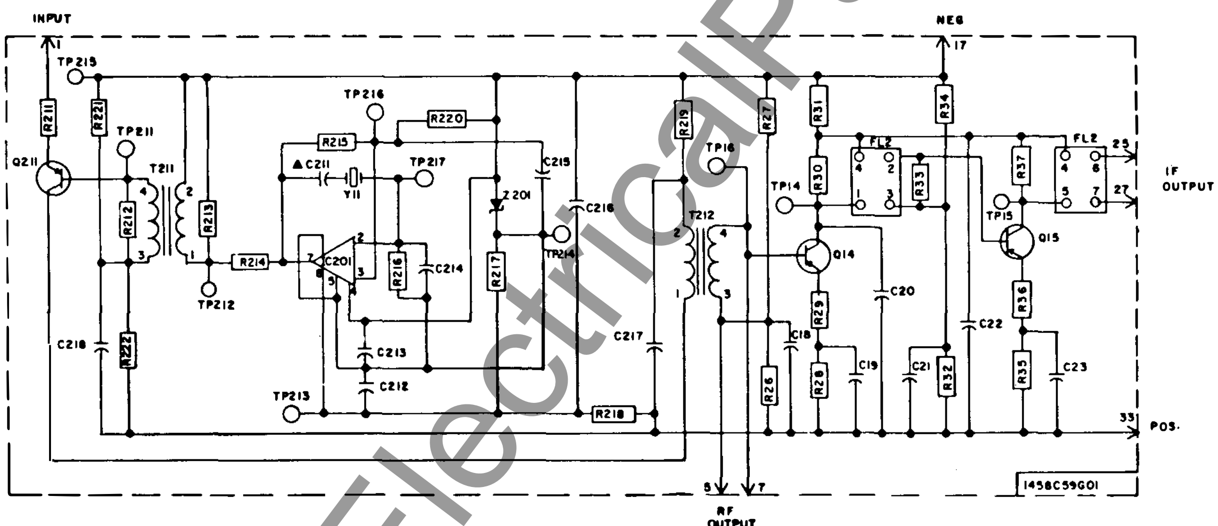
■-C16 RANGE 22 TO 100Pf AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS.

○-Y11 RANGE-50 TO 220KHZ

Ø-COMMON TERMINAL

*Sub. 4*
*1444C52*

*Fig. 10. Internal Schematic 30-200 KHz Oscillator & Mixer*




| | COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|---|
| | C18 | CAPACITOR | .250UF 200V | 187A624H02 |
| | C19 | CAPACITOR | .250UF 200V | 187A624H02 |
| | C20 | CAPACITOR | 100.000PF 500V | 762A757H01 |
| | C21 | CAPACITOR | .250UF 200V | 187A624H02 |
| | C22 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| | C23 | CAPACITOR | .250UF 200V | 187A624H02 |
| ▲ | C211 | CAPACITOR | SEE NOTE ▲ | |
| | C213 | CAPACITOR | .100UF 50V | 184A663H04 |
| | C215 | CAPACITOR | .100UF 50V | 184A663H04 |
| | C216 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| | C217 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| | C218 | CAPACITOR | .250UF 200V | 187A624H02 |
| O | C214 | CAPACITOR | SEE NOTE O | |
| | IC201 | INT CKT | MA710 | 201C826H03 |
| | J1 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| | R26 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| | R27 | RESISTOR | 22.0K .50W 5% | 184A763H59 |
| | R28 | RESISTOR | 680.0 .50W 5% | 184A763H23 |
| | R29 | RESISTOR | 68.0 .50W 5% | 187A290H21 |
| | R30 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| | R31 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| | R32 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| | R33 | RESISTOR | 1000.0 .50W 5% | 184A763H27 |
| | R34 | RESISTOR | 22.0K .50W 5% | 184A763H59 |
| | R35 | RESISTOR | 680.0 .50W 5% | 184A763H23 |
| | R36 | RESISTOR | 68.0 .50W 5% | 187A290H21 |
| | R37 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| | R211 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| | R212 | RESISTOR | 1000.0 .50W 5% | 184A763H27 |
| | R213 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| | R214 | RESISTOR | 2700.0 .50W 5% | 184A763H37 |
| | R215 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| | R216 | RESISTOR | 8200.0 .50W 5% | 184A763H49 |
| | R217 | RESISTOR | 2000.0 .50W 5% | 184A763H34 |
| | R218 | RESISTOR | 150.0 .50W 5% | 184A763H07 |
| | R219 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| | R220 | RESISTOR | 47.0K .50W 5% | 184A763H67 |
| | R221 | RESISTOR | 220.0K .50W 5% | 184A763H83 |
| | R222 | RESISTOR | 4700.0 .50W 5% | 184A763H43 |
| | Q14 | TRANSISTOR | 2N4249 | 849A441H03 |
| | Q15 | TRANSISTOR | 2N4249 | 849A441H03 |
| | Q211 | TRANSISTOR | 2N4249 | 849A441H03 |
| | Z201 | ZENER | 1N753A 6.2V | 862A606H01 |
| | Y11 | CRYSTAL | SEE NOTE □ | |
| | T211 | TRANSF | | 714B677G01 |
| | T212 | TRANSF | | 205C043G03 |

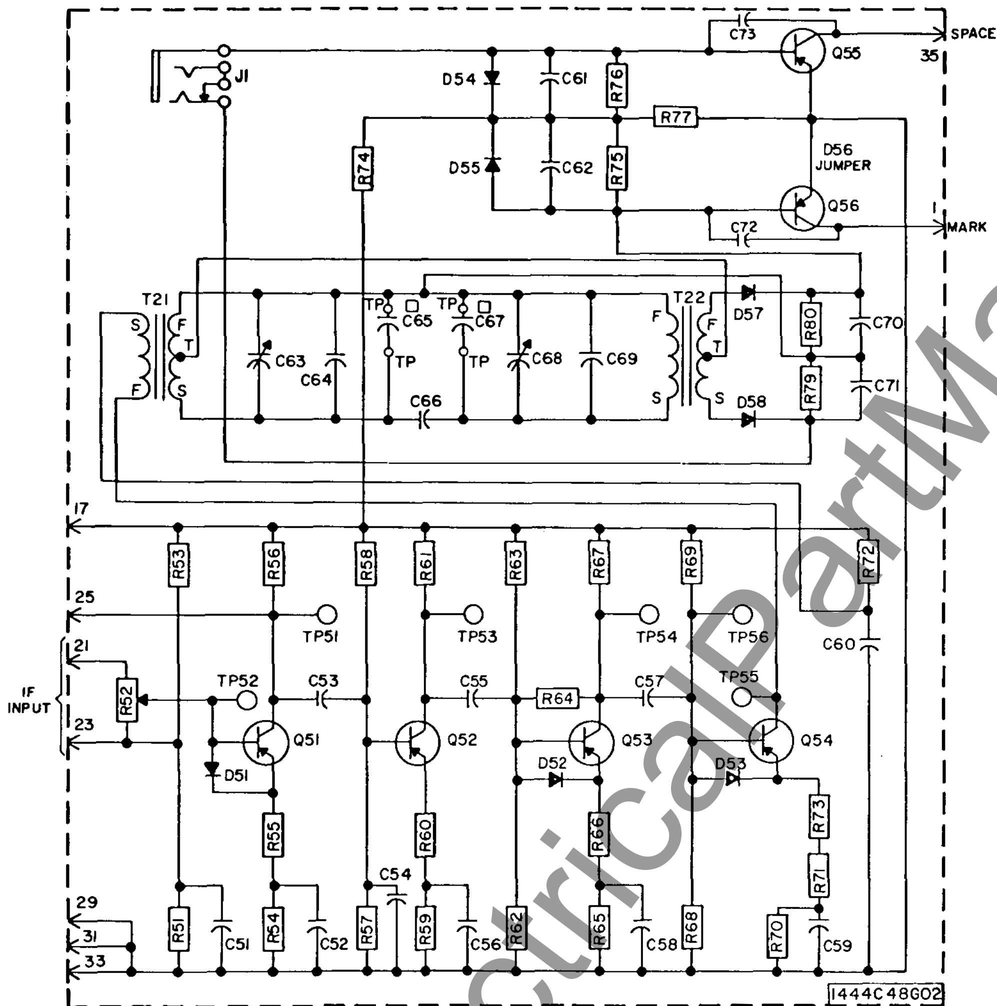
▲ C211 RANGES FROM 100PF TO 1000 PF

O C214 MAY VARY UP TO 100PF 187A695H01 THROUGH H23

□ Y11 FREQ. EQUALS RCVR (CHANNEL) FREQUENCY PLUS 20KHZ

*Sub. 1*
*1458C60*

*Fig. 11. Internal Schematic 200.5-300 KHz Oscillator & Mixer*




| 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 |
| C72 | CAPACITOR | 330.000PF | 200V | 880A397H01 |
| C73 | CAPACITOR | 330.000PF | 200V | 880A397H01 |
| D51 | DIODE | 1N457A | | 184A855H07 |
| D52 | DIODE | 1N457A | | 184A855H07 |
| D53 | DIODE | 1N457A | | 184A855H07 |
| D54 | DIODE | 1N457A | | 184A855H07 |
| D55 | DIODE | 1N457A | | 184A855H07 |
| D56 | DIODE | 1N457A | | 184A855H07 |
| 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.

*Sub. 4*
*1444C49*

*Fig. 12. Internal Schematic Amplifier and Limiter*

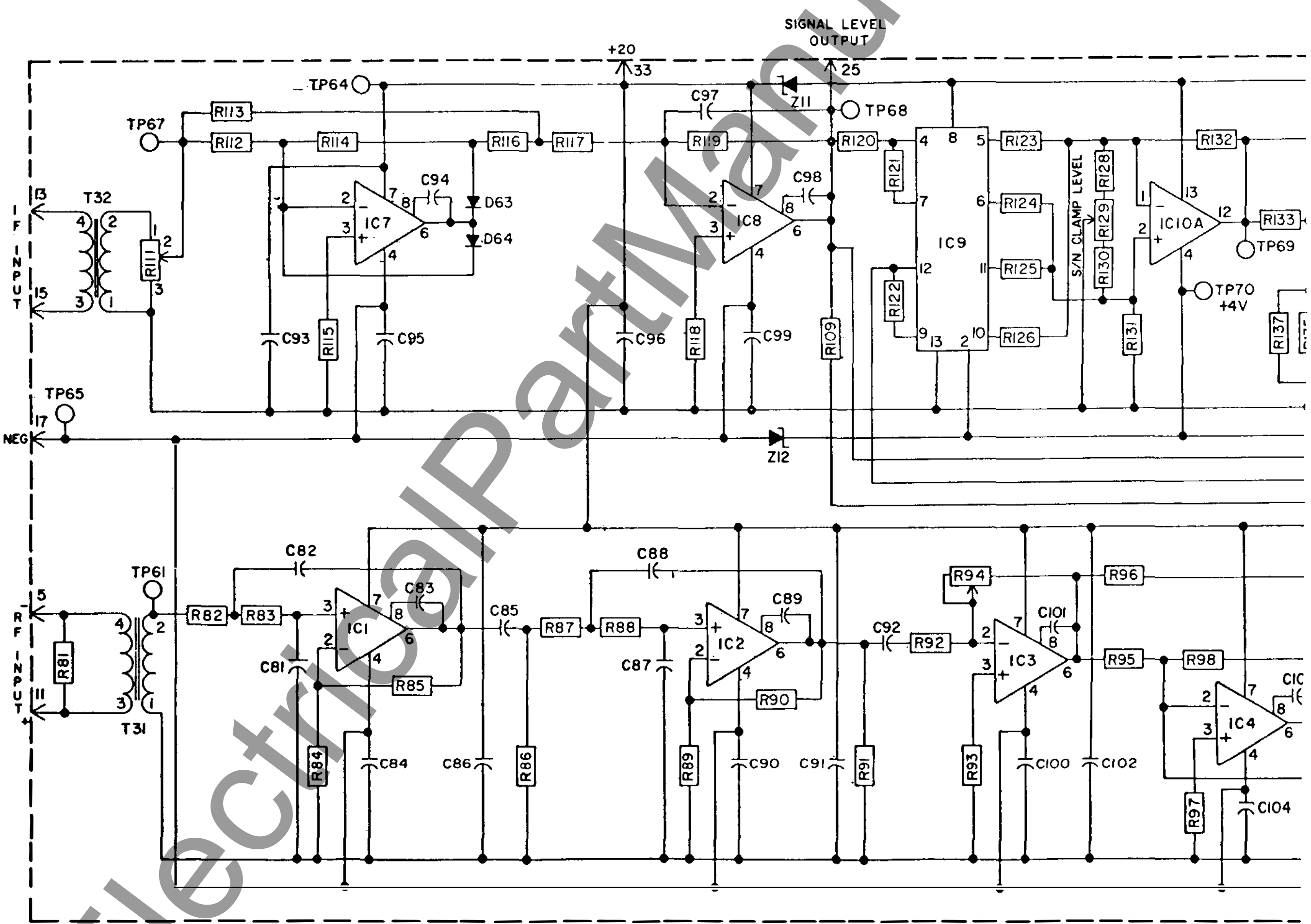
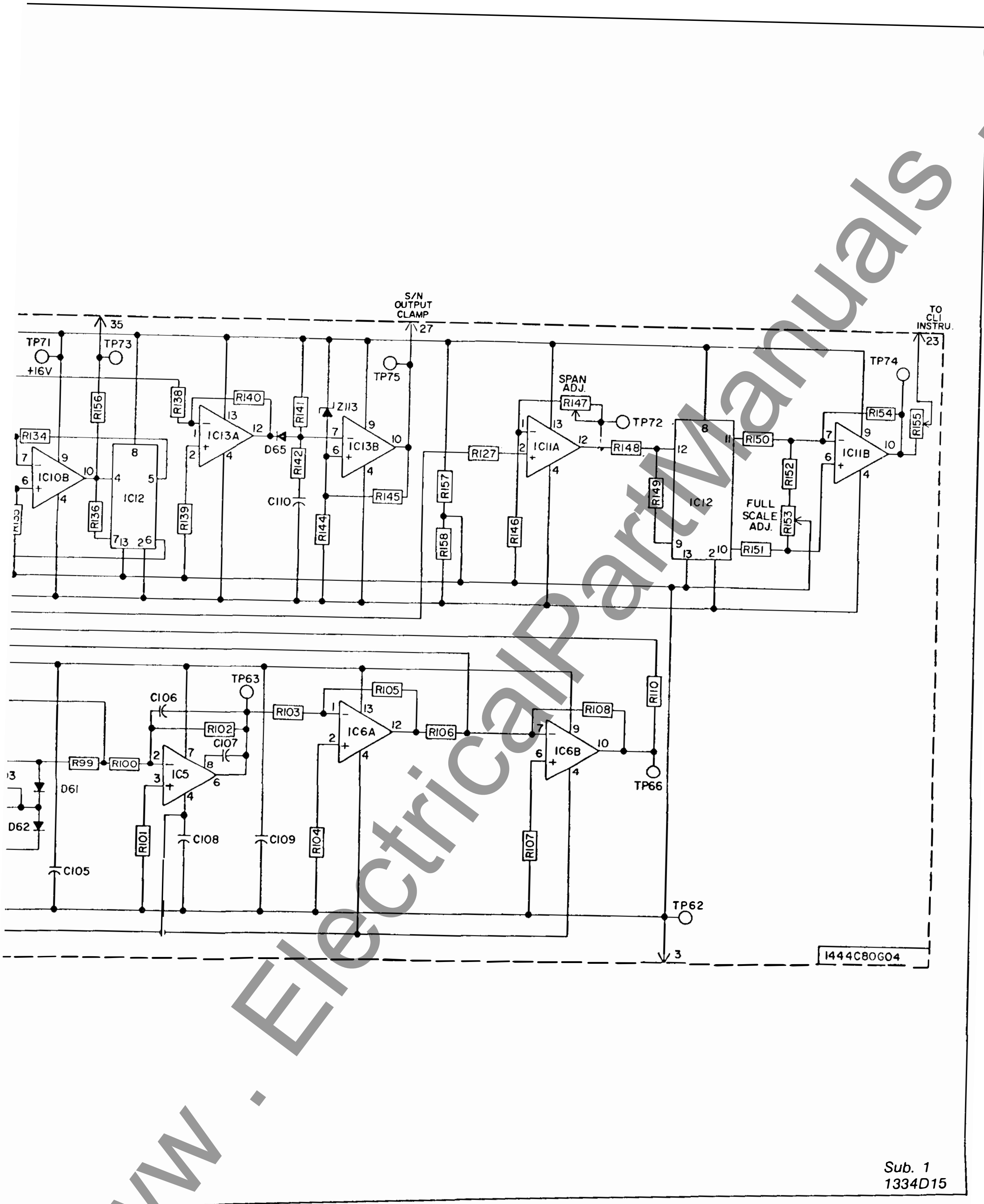
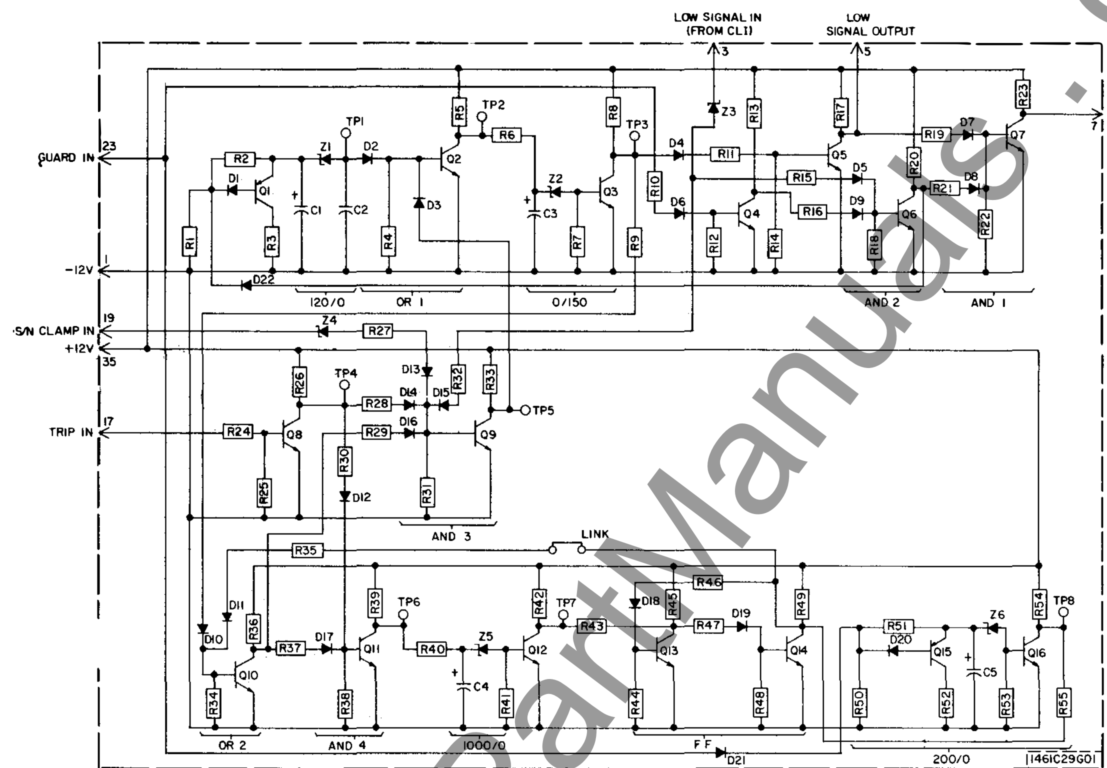



*Fig. 13. Internal Schemat*




ic S/N Detection




1

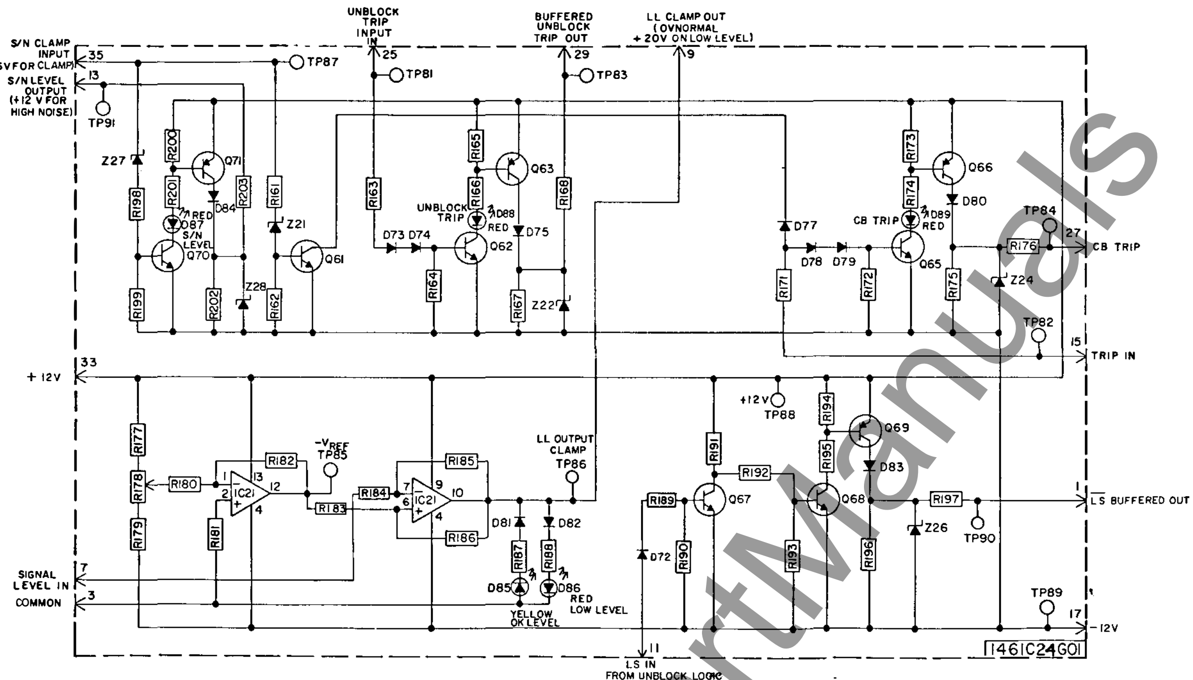
| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C1 | CAPACITØR | 8.000UF 30V | 862A177H07 |
| C2 | CAPACITØR | .050UF 50V | 184A663H02 |
| C3 | CAPACITØR | 22.000UF 15V | 184A661H13 |
| C4 | CAPACITØR | 47.000UF 35V | 187A508H12 |
| C5 | CAPACITØR | 22.000UF 15V | 184A661H13 |
| D1 | DIØDE | 1N457A | 184A855H07 |
| D2 | DIØDE | 1N457A | 184A855H07 |
| D3 | DIØDE | 1N457A | 184A855H07 |
| D4 | DIØDE | 1N457A | 184A855H07 |
| D5 | DIØDE | 1N457A | 184A855H07 |
| D6 | DIØDE | 1N457A | 184A855H07 |
| D7 | DIØDE | 1N457A | 184A855H07 |
| D8 | DIØDE | 1N457A | 184A855H07 |
| D9 | DIØDE | 1N457A | 184A855H07 |
| D10 | DIØDE | 1N457A | 184A855H07 |
| D11 | DIØDE | 1N457A | 184A855H07 |
| D12 | DIØDE | 1N457A | 184A855H07 |
| D13 | DIØDE | 1N457A | 184A855H07 |
| D14 | DIØDE | 1N457A | 184A855H07 |
| D15 | DIØDE | 1N457A | 184A855H07 |
| D16 | DIØDE | 1N457A | 184A855H07 |
| D17 | DIØDE | 1N457A | 184A855H07 |
| D18 | DIØDE | 1N457A | 184A855H07 |
| D19 | DIØDE | 1N457A | 184A855H07 |
| D20 | DIØDE | 1N457A | 184A855H07 |
| D21 | DIØDE | 1N457A | 184A855H07 |
| D22 | DIØDE | 1N457A | 184A855H07 |
| R1 | RESISTØR | 18.0K .50W 5% | 184A763H57 |
| R2 | RESISTØR | 5600.0 .50W 5% | 184A763H45 |
| R3 | RESISTØR | 470.0 .50W 5% | 184A763H19 |
| R4 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R5 | RESISTØR | 22.0K .50W 5% | 184A763H59 |
| R6 | RESISTØR | 1000.0 .50W 5% | 184A763H27 |
| R7 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R8 | RESISTØR | 12.0K1.00W 5% | 187A643H53 |
| R9 | RESISTØR | 5600.0 .50W 5% | 184A763H45 |
| R10 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R11 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R12 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R13 | RESISTØR | 12.0K1.00W 5% | 187A643H53 |
| R14 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R15 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R16 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R17 | RESISTØR | 12.0K1.00W 5% | 187A643H53 |
| R18 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R19 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R20 | RESISTØR | 12.0K1.00W 5% | 187A643H53 |
| R21 | RESISTØR | 33.0K .50W 5% | 184A763H63 |
| R22 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R23 | RESISTØR | 12.0K1.00W 5% | 187A643H53 |
| R24 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R25 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R26 | RESISTØR | 12.0K1.00W 5% | 187A643H53 |
| R27 | RESISTØR | 10.0K .50W 5% | 184A763H51 |

2

| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| R28 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R29 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R30 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R31 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R32 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R33 | RESISTØR | 12.0K1.00W 5% | 187A643H53 |
| R34 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R35 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R36 | RESISTØR | 12.0K1.00W 5% | 187A643H53 |
| R37 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R38 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R39 | RESISTØR | 33.0K .50W 5% | 184A763H63 |
| R40 | RESISTØR | 1000.0 .50W 5% | 184A763H27 |
| R41 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R42 | RESISTØR | 22.0K .50W 5% | 184A763H59 |
| R43 | RESISTØR | 1000.0 .50W 5% | 184A763H27 |
| R44 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R45 | RESISTØR | 12.0K1.00W 5% | 187A643H53 |
| R46 | RESISTØR | 56.0K .50W 5% | 184A763H69 |
| R47 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R48 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R49 | RESISTØR | 12.0K1.00W 5% | 187A643H53 |
| R50 | RESISTØR | 18.0K .50W 5% | 184A763H57 |
| R51 | RESISTØR | 56.0K .50W 5% | 184A763H69 |
| R52 | RESISTØR | 470.0 .50W 5% | 184A763H19 |
| R53 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R54 | RESISTØR | 22.0K .50W 5% | 184A763H59 |
| R55 | RESISTØR | 1000.0 .50W 5% | 184A763H27 |
| Q1 | TRANSISTØR | 2N4249 | 849A441H03 |
| Q2 | TRANSISTØR | 2N696 | 762A585H01 |
| Q3 | TRANSISTØR | 2N697 | 184A638H18 |
| Q4 | TRANSISTØR | 2N696 | 762A585H01 |
| Q5 | TRANSISTØR | 2N696 | 762A585H01 |
| Q6 | TRANSISTØR | 2N696 | 762A585H01 |
| Q7 | TRANSISTØR | 2N696 | 762A585H01 |
| Q8 | TRANSISTØR | 2N696 | 762A585H01 |
| Q9 | TRANSISTØR | 2N696 | 762A585H01 |
| Q10 | TRANSISTØR | 2N696 | 762A585H01 |
| Q11 | TRANSISTØR | 2N696 | 762A585H01 |
| Q12 | TRANSISTØR | 2N697 | 184A638H18 |
| Q13 | TRANSISTØR | 2N696 | 762A585H01 |
| Q14 | TRANSISTØR | 2N696 | 762A585H01 |
| Q15 | TRANSISTØR | 2N4249 | 849A441H03 |
| Q16 | TRANSISTØR | 2N696 | 762A585H01 |
| Z1 | ZENER | 1N957B 6.8V | 186A797H06 |
| Z2 | ZENER | 1N752A 5.6V | 186A797H12 |
| Z3 | ZENER | 1N961B 10.0V | 186A797H07 |
| Z4 | ZENER | 1N961B 10.0V | 186A797H07 |
| Z5 | ZENER | 1N961B 10.0V | 186A797H07 |
| Z6 | ZENER | 1N750A 4.7V | 837A398H03 |

*Sub. 4*
*1461C20*

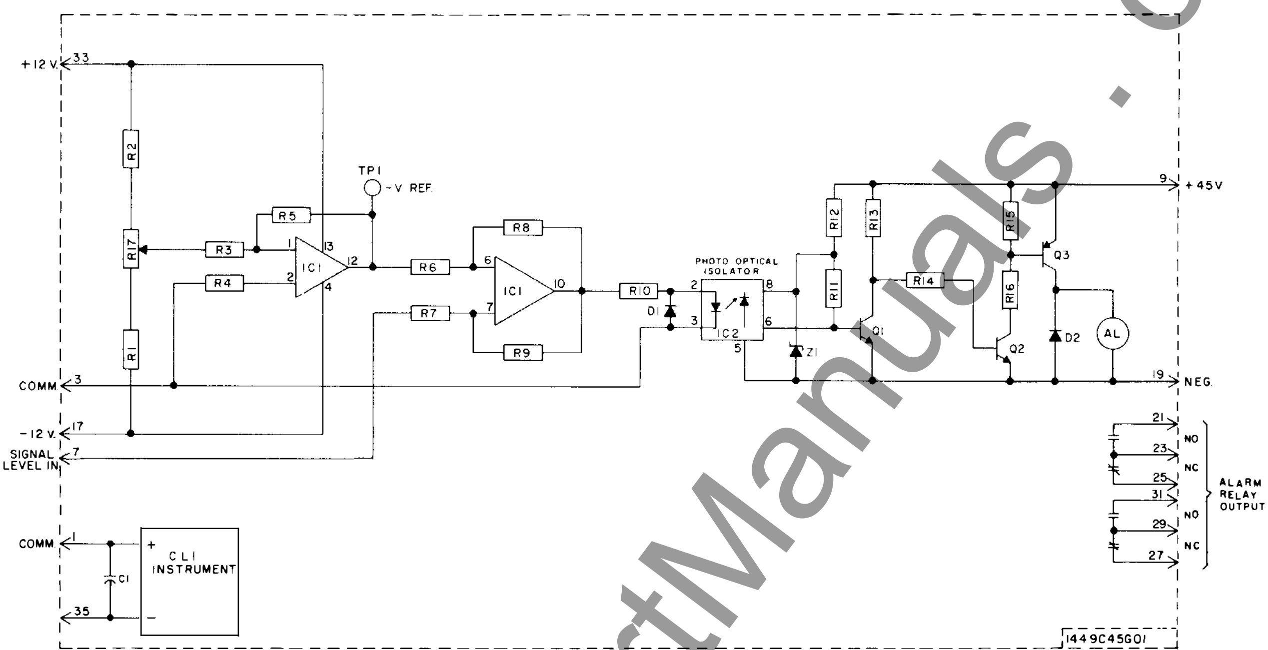
*Fig. 14. Internal Schematic Unblock Module*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| ~~D71~~ | ~~DIØDE~~ | ~~1N645A~~ | ~~837A692H03~~ |
| D72 | DIØDE | 1N645A | 837A692H03 |
| D73 | DIØDE | 1N645A | 837A692H03 |
| D74 | DIØDE | 1N645A | 837A692H03 |
| D75 | DIØDE | 1N645A | 837A692H03 |
| ~~D76~~ | ~~DIØDE~~ | ~~1N645A~~ | ~~837A692H03~~ |
| D77 | DIØDE | 1N645A | 837A692H03 |
| D78 | DIØDE | 1N645A | 837A692H03 |
| D79 | DIØDE | 1N645A | 837A692H03 |
| D80 | DIØDE | 1N645A | 837A692H03 |
| D81 | DIØDE | 1N457A | 184A855H07 |
| D82 | DIØDE | 1N457A | 184A855H07 |
| D83 | DIØDE | 1N645A | 837A692H03 |
| D84 | DIØDE | 1N645A | 837A692H03 |
| D85 | DIØDE | LED | 3508A22H02 |
| D86 | DIØDE | LED | 3508A22H01 |
| D87 | DIØDE | LED | 3508A22H01 |
| D88 | DIØDE | LED | 3508A22H01 |
| D89 | DIØDE | LED | 3508A22H01 |
| IC21 | INT CKT | 747DM | 1443C52H01 |
| J121 | JUMPER | 0 ØHM RESISTØR | 862A478H01 |
| J122 | JUMPER | 0 ØHM RESISTØR | 862A478H01 |
| J123 | JUMPER | 0 ØHM RESISTØR | 862A478H01 |
| ~~J124~~ | ~~JUMPER~~ | ~~0 ØHM RESISTØR~~ | ~~862A478H01~~ |
| R178 | PØT | 2.5K .25W | 629A645H07 |
| R161 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R162 | RESISTØR | 120.0K .50W 5% | 184A763H77 |
| R163 | RESISTØR | 33.0K .50W 5% | 184A763H63 |
| R164 | RESISTØR | 120.0K .50W 5% | 184A763H77 |
| R165 | RESISTØR | 4700.0 .50W 5% | 184A763H43 |
| R166 | RESISTØR | 2400.0 .50W 5% | 184A763H36 |
| R167 | RESISTØR | 82.0K .50W 5% | 184A763H73 |
| R168 | RESISTØR | 150.0 3.00W 5% | 762A679H01 |
| ~~R169~~ | ~~RESISTØR~~ | ~~10.0K .50W 5%~~ | ~~184A763H51~~ |
| ~~R170~~ | ~~RESISTØR~~ | ~~120.0K .50W 5%~~ | ~~184A763H77~~ |
| R171 | RESISTØR | 33.0K .50W 5% | 184A763H63 |
| R172 | RESISTØR | 120.0K .50W 5% | 184A763H77 |
| R173 | RESISTØR | 4700.0 .50W 5% | 184A763H43 |
| R174 | RESISTØR | 2400.0 .50W 5% | 184A763H36 |
| R175 | RESISTØR | 82.0K .50W 5% | 184A763H73 |
| R176 | RESISTØR | 150.0 3.00W 5% | 762A679H01 |
| R177 | RESISTØR | 10.0K .50W 1% | 843A320H45 |
| R179 | RESISTØR | 10.0K .50W 1% | 843A320H45 |
| R180 | RESISTØR | 68.1K .50W 1% | 848A321H26 |
| R181 | RESISTØR | 4990.0 .50W 1% | 843A320H16 |
| R182 | RESISTØR | 6810.0 .50W 1% | 848A320H29 |
| R183 | RESISTØR | 2.0K .50W 1% | 843A319H77 |
| R184 | RESISTØR | 2.0K .50W 1% | 843A319H77 |
| R185 | RESISTØR | 562.0K .50W 1% | 848A322H15 |
| R186 | RESISTØR | 511.0K .50W 1% | 843A322H11 |
| R187 | RESISTØR | 1620.0 .50W 1% | 848A319H68 |
| R188 | RESISTØR | 1620.0 .50W 1% | 848A319H68 |
| R189 | RESISTØR | 33.0K .50W 5% | 184A763H63 |
| R190 | RESISTØR | 68.0K .50W 5% | 184A763H71 |
| R191 | RESISTØR | 68.0K .50W 5% | 184A763H71 |
| R192 | RESISTØR | 33.0K .50W 5% | 184A763H63 |
| R193 | RESISTØR | 120.0K .50W 5% | 184A763H77 |
| R194 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R195 | RESISTØR | 18.0K .50W 5% | 184A763H57 |
| R196 | RESISTØR | 82.0K .50W 5% | 184A763H73 |
| R197 | RESISTØR | 150.0 3.00W 5% | 762A679H01 |
| R198 | RESISTØR | 33.0K .50W 5% | 184A763H63 |
| R199 | RESISTØR | 68.0K .50W 5% | 184A763H71 |
| R200 | RESISTØR | 4700.0 .50W 5% | 184A763H43 |
| R201 | RESISTØR | 2400.0 .50W 5% | 184A763H36 |
| R202 | RESISTØR | 82.0K .50W 5% | 184A763H73 |
| R203 | RESISTØR | 150.0 3.00W 5% | 762A679H01 |
| Q61 | TRANSISTØR | 2N699 | 184A638H19 |
| Q62 | TRANSISTØR | 2N699 | 184A638H19 |
| Q63 | TRANSISTØR | 2N3645 | 849A441H01 |
| ~~Q64~~ | ~~TRANSISTØR~~ | ~~2N699~~ | ~~184A638H19~~ |
| Q65 | TRANSISTØR | 2N699 | 184A638H19 |
| Q66 | TRANSISTØR | 2N3645 | 849A441H01 |
| Q67 | TRANSISTØR | 2N699 | 184A638H19 |
| Q68 | TRANSISTØR | 2N699 | 184A638H19 |
| Q69 | TRANSISTØR | 2N3645 | 849A441H01 |
| Q70 | TRANSISTØR | 2N699 | 184A638H19 |
| Q71 | TRANSISTØR | 2N3645 | 849A441H01 |
| Z21 | ZENER | 1N961B 10.0V | 186A797H07 |
| Z22 | ZENER | 1N3688A 24.0V | 862A288H01 |
| ~~Z23~~ | ~~ZENER~~ | ~~1N961B 10.0V~~ | ~~186A797H07~~ |
| Z24 | ZENER | 1N3688A 24.0V | 862A288H01 |
| ~~Z25~~ | ~~ZENER~~ | ~~1N961B 10.0V~~ | ~~186A797H07~~ |
| Z26 | ZENER | 1N3688A 24.0V | 862A288H01 |
| Z27 | ZENER | 1N961B 10.0V | 186A797H07 |
| Z28 | ZENER | 1N3688A 24.0V | 862A288H01 |

*Sub. 3*
*1461C22*

*Fig. 15. Internal Schematic S/N Output Module*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| R1 | RESISTOR | 10K .50W 5% | 184A763H51 |
| R2 | RESISTOR | 10K .50W 5% | 184A763H51 |
| R3 | RESISTOR | 6.81K .50W 1% | 848A820H29 |
| R4 | RESISTOR | 4.99K .50W 1% | 848A820H16 |
| R5 | RESISTOR | 6.81K .50W 1% | 848A820H29 |
| R6 | RESISTOR | 2.0K .50W 1% | 848A819H77 |
| R7 | RESISTOR | 2.0K .50W 1% | 848A819H77 |
| R8 | RESISTOR | 562.K .25W 1% | 848A822H15 |
| R9 | RESISTOR | 511K .50W 1% | 848A822H11 |
| R10 | RESISTOR | 3.3K .50W 2% | 629A531H44 |
| R11 | RESISTOR | 15K .50W 2% | 629A531H60 |
| R12 | RESISTOR | 120K .50W 2% | 629A531H82 |
| R13 | RESISTOR | 13.3K .50W 1% | 848A820H57 |
| R14 | RESISTOR | 15K .50W 2% | 629A531H60 |
| R15 | RESISTOR | 6.8K .50W 2% | 629A531H52 |
| R16 | RESISTOR | 6.8K .50W 2% | 629A531H52 |
| R17 | POT | 2.5K .25W 10% | 629A645H07 |
| J1 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| D1 | DIODE | 1N645A | 837A692H03 |
| D2 | DIODE | 1N645A | 837A692H03 |
| Z1 | ZENER | 1N957B | 186A797H06 |
| Q1 | TRANSISTOR | 2N3417 | 848A851H02 |
| Q2 | TRANSISTOR | 2N699 | 184A638H19 |
| Q3 | TRANSISTOR | 2N3645 | 849A441H01 |
| IC1 | INT. CKT. | 747DM | 1443C52H01 |
| IC2 | INT. CKT. | 5082-4371 | 7758621H01 |
| C1 | CAPACITOR | .25 MFD. 200VDC | 187A625H02 |
| CL1 | INSTRUMENT | — | 6068592H26 |
| AL | RELAY | — | 408C062H07 |

*Sub. 5*
*1449C44*

*Fig. 16. Internal Schematic S/N Output (Contact) Module*

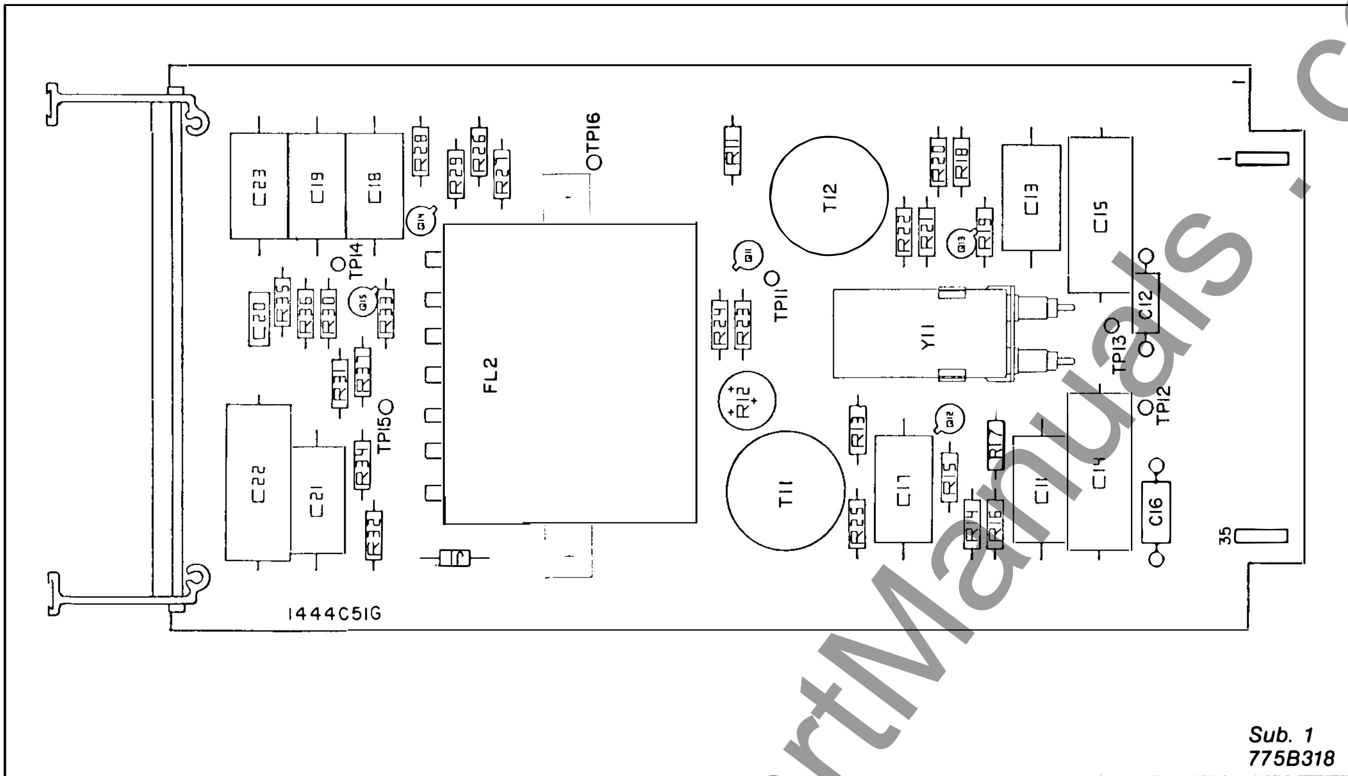



*Fig. 17. Component Location 30-200 KHz Oscillator & Mixer*

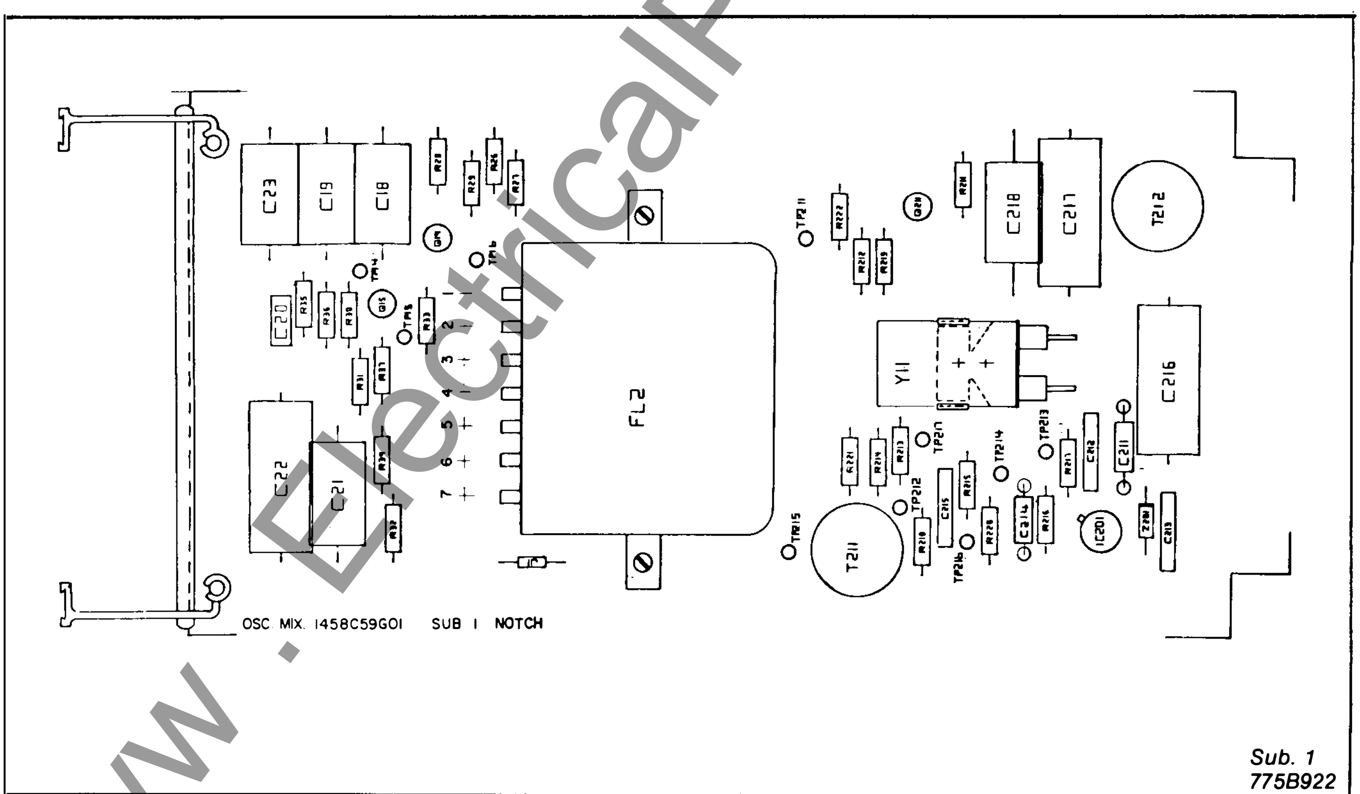



*Fig. 18. Component Location 200.5-300 KHz Oscillator & Mixer*

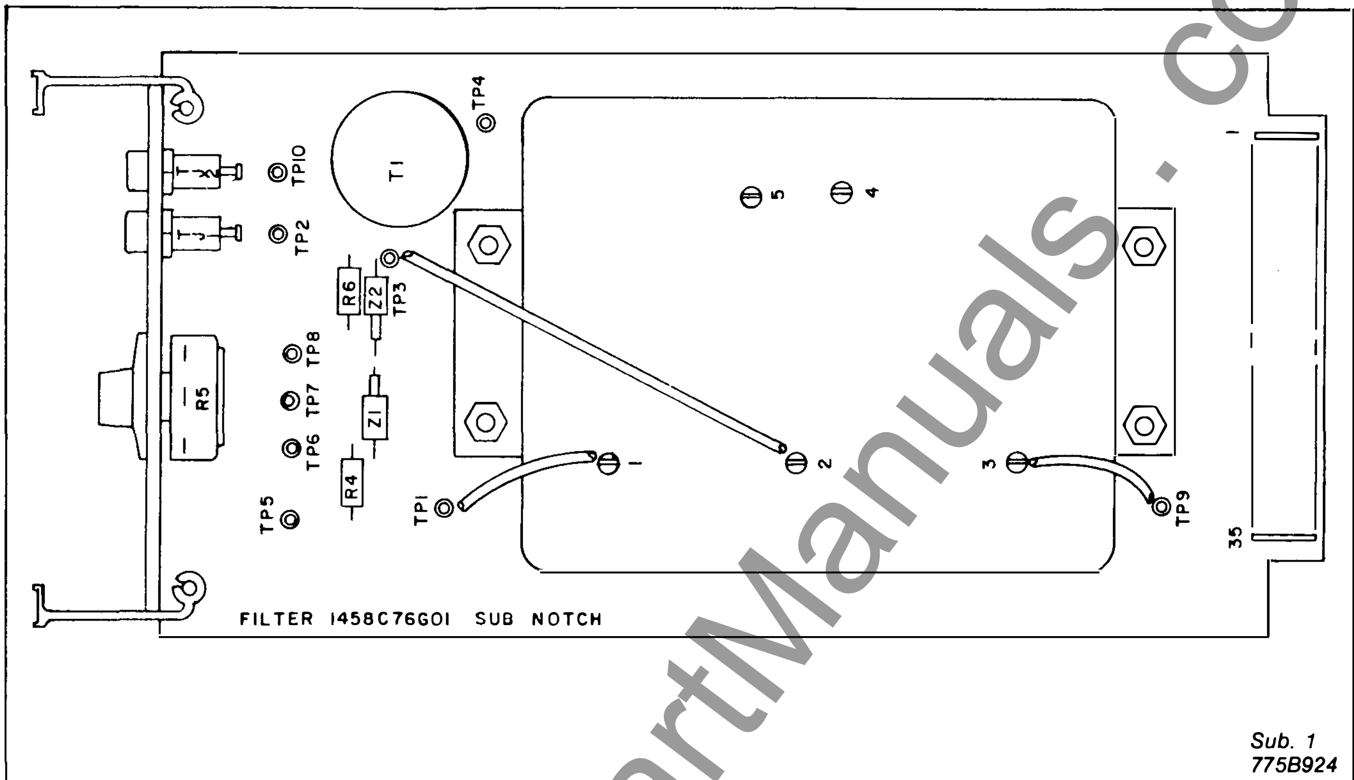



Fig. 19. Component Location Filter Module 200.5-300 KHz

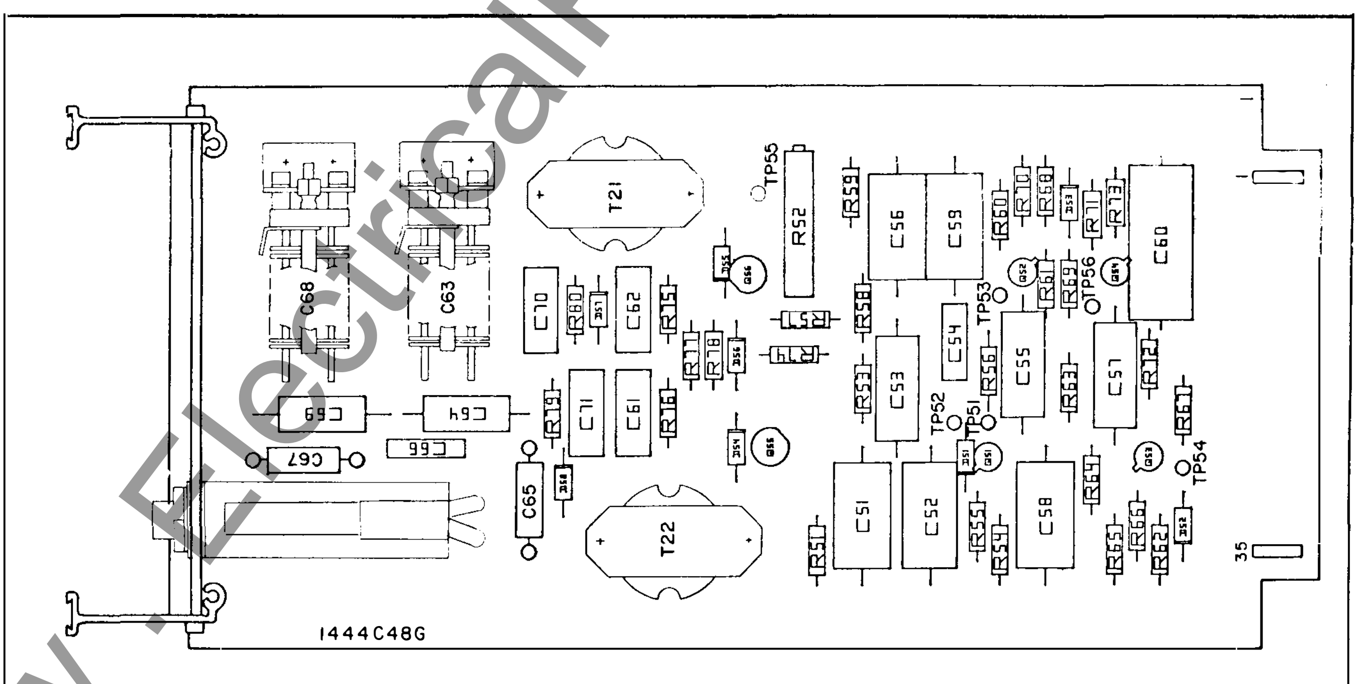



Fig. 20. Component Location Amplifier and Limiter

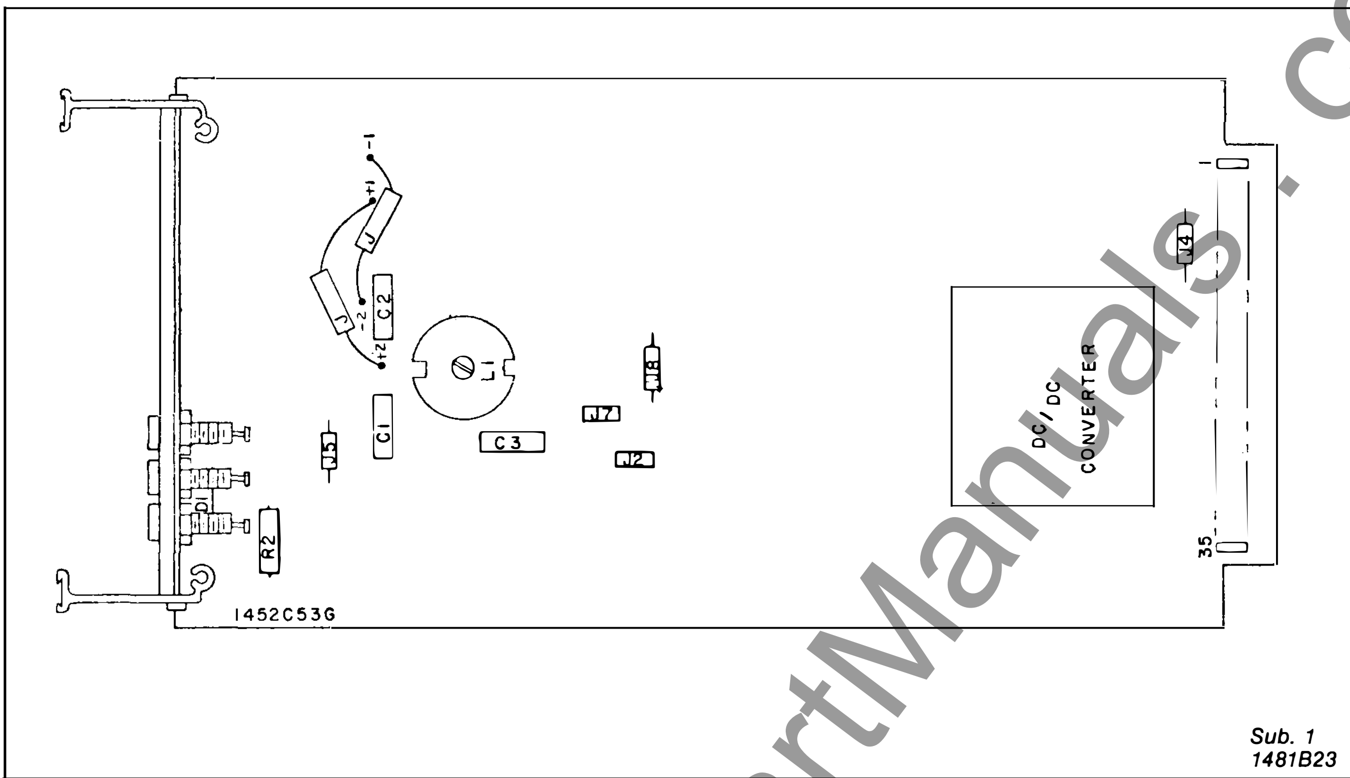



*Fig. 21. Component Location Discriminator—Power Supply Module*

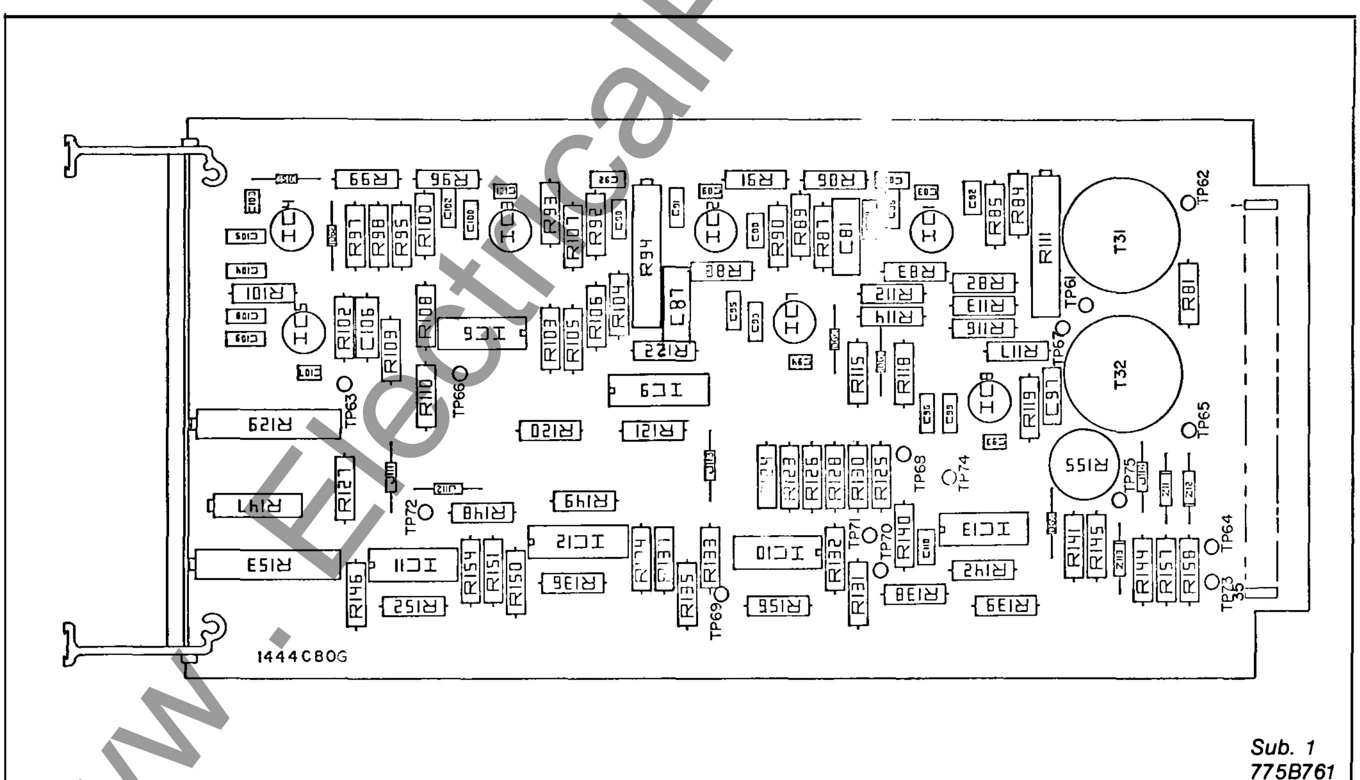



*Fig. 22. Component Location S/N Detection Module*

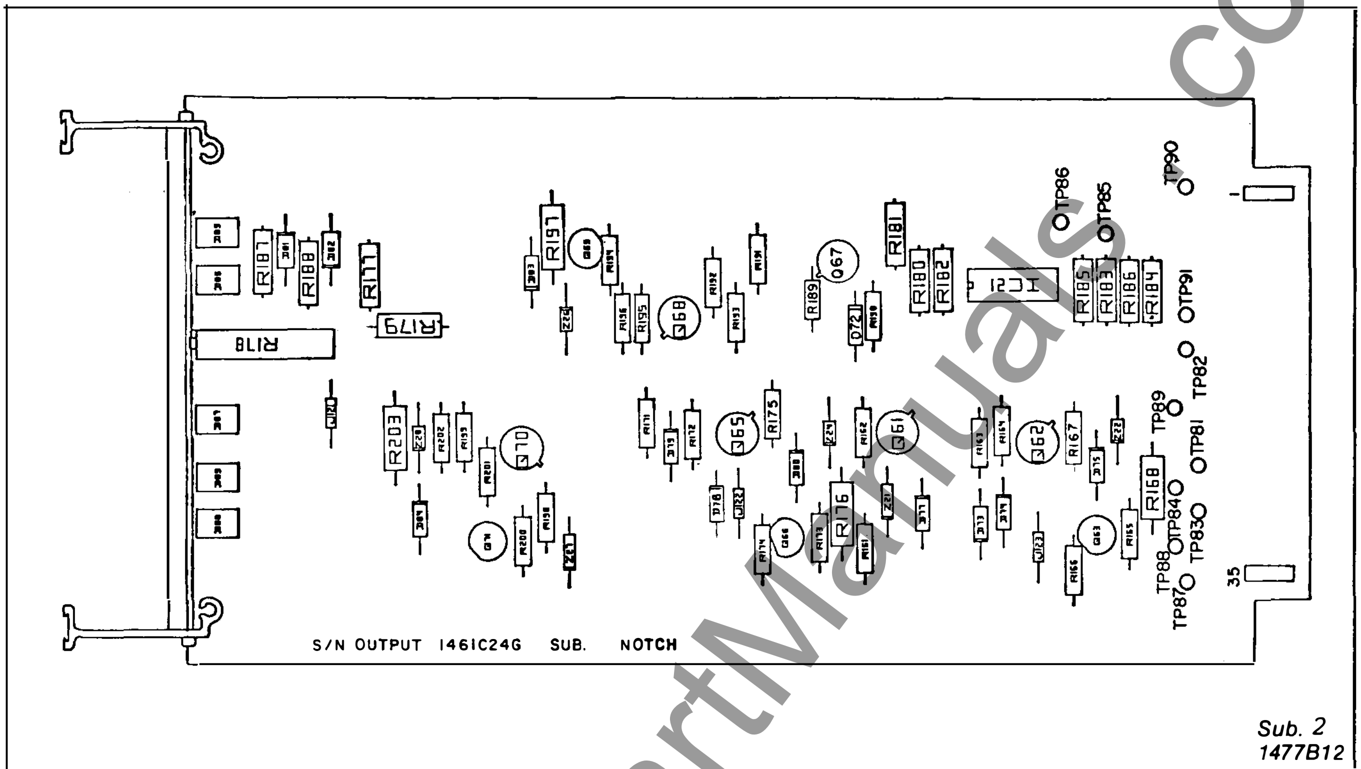



*Fig. 23. Component Location S/N Output Module*

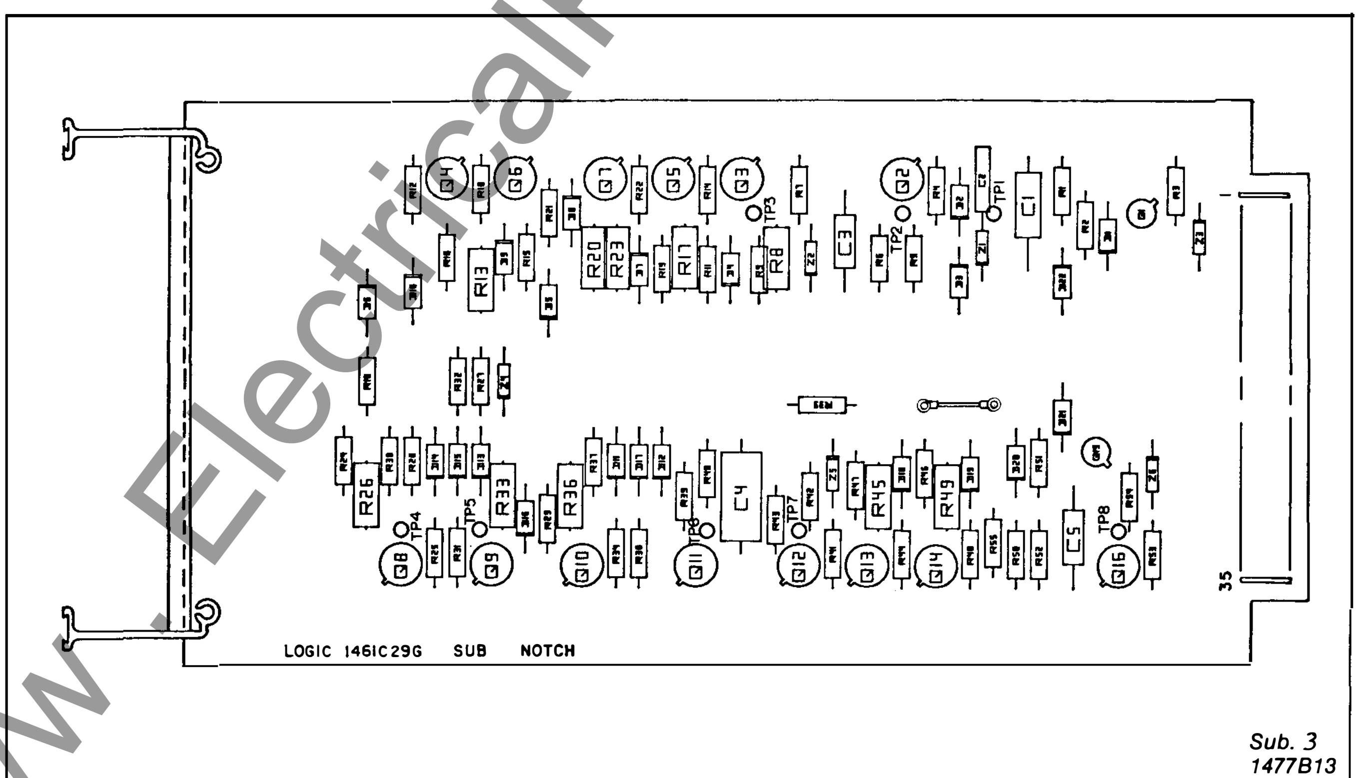



*Fig. 24. Component Location Unblock Logic Module*

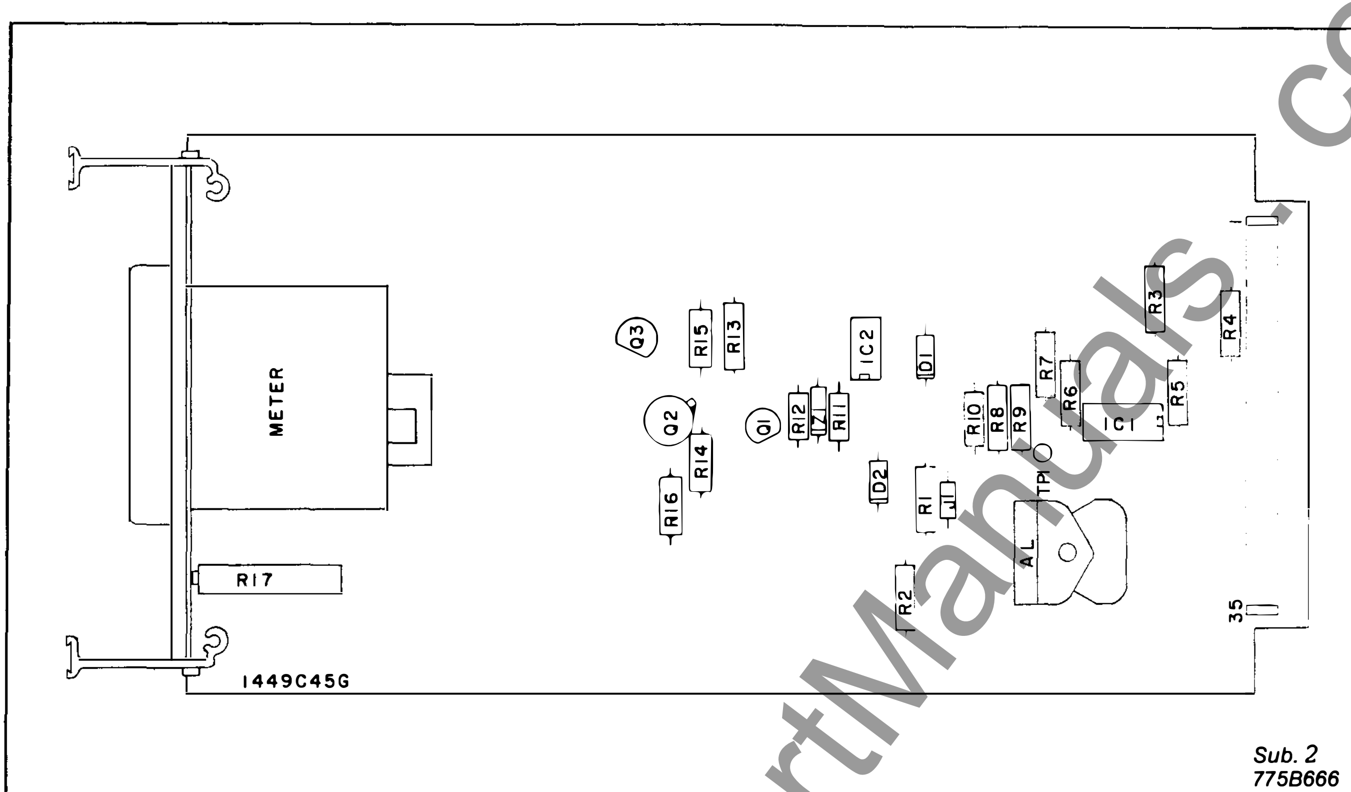



Fig. 25. Component Location S/N Output Contact and Meter Module

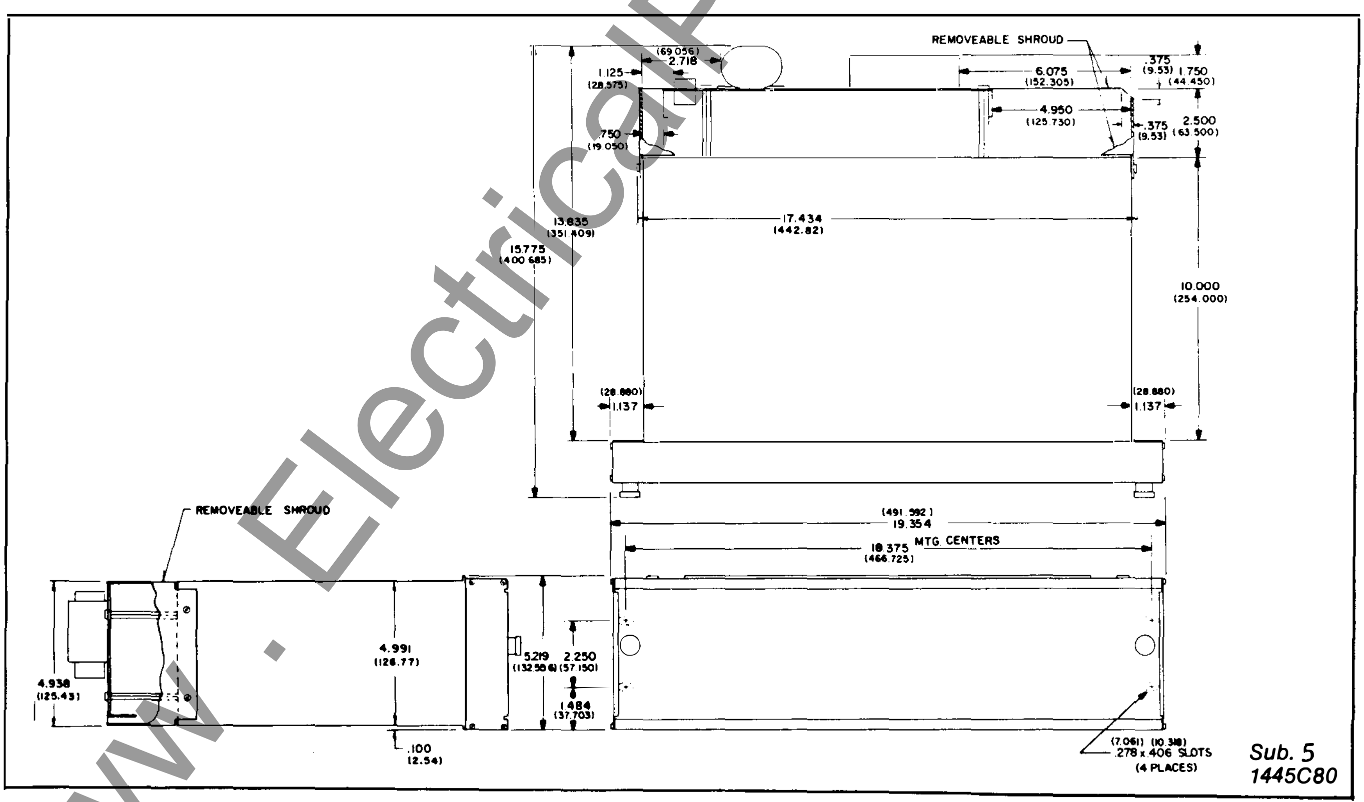
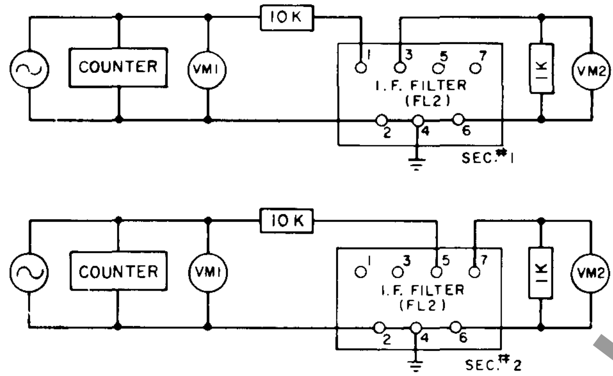
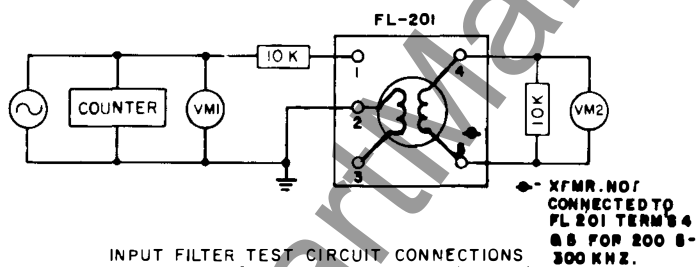



Fig. 26. Outline and Drilling Plan

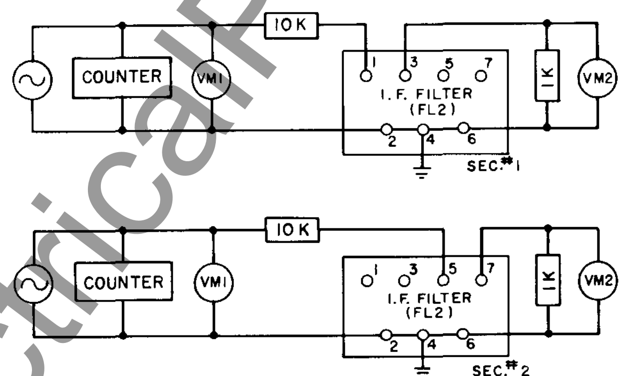



I. F. FILTER TEST CIRCUIT CONNECTIONS

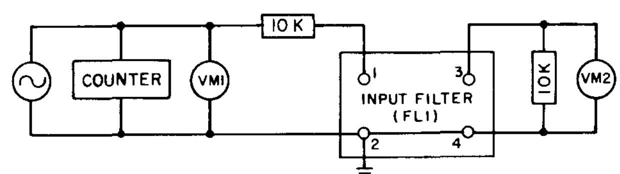



INPUT FILTER TEST CIRCUIT CONNECTIONS

Sub. 2
877A794



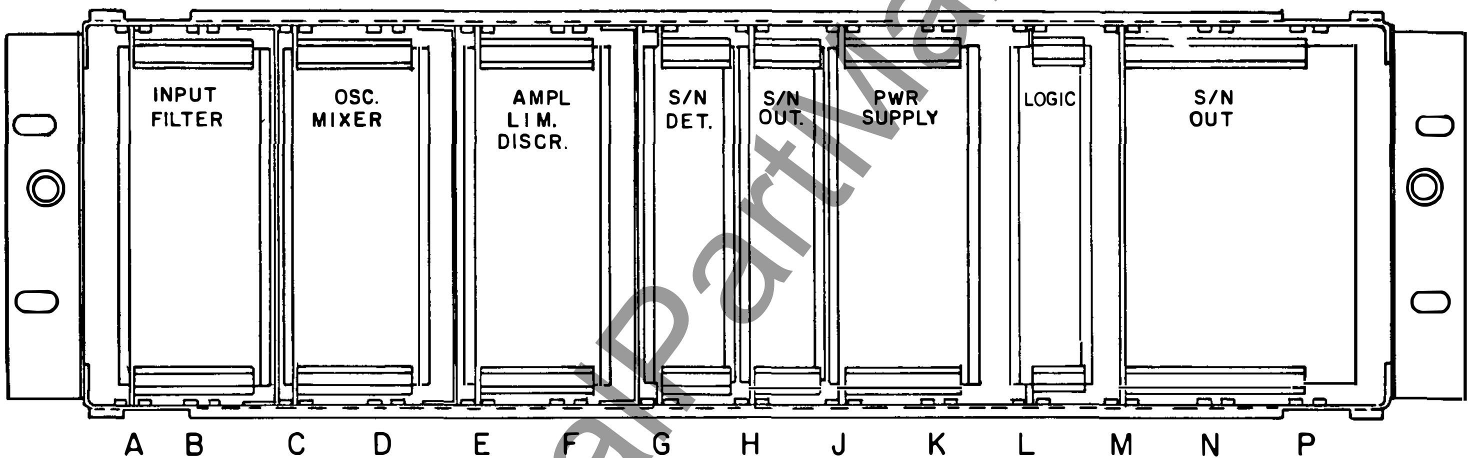

I. F. FILTER TEST CIRCUIT CONNECTIONS




INPUT FILTER TEST CIRCUIT CONNECTIONS

Sub. 1
849A109)

Fig. 27. Test Circuits for TCF-10




Sub. 1
1467C56

Fig. 28. TCF-10 Circuit Board Location

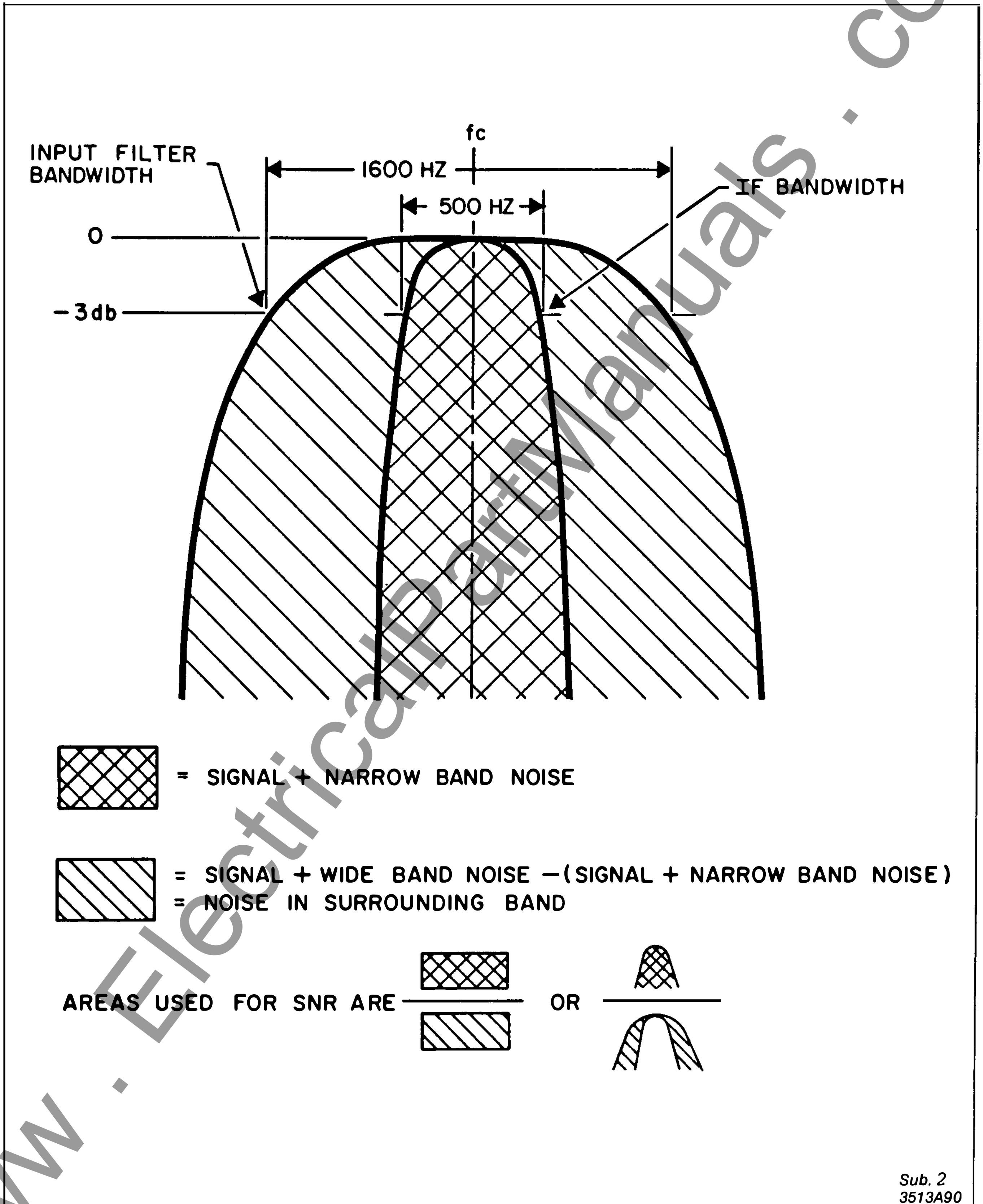



Fig. 29. Signal/Noise Ratio Characteristics

**WESTINGHOUSE ELECTRIC CORPORATION**

**RELAY-INSTRUMENT DIVISION** **CORAL SPRINGS, FL.**

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INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

## TYPE TCF-10 POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT 3 FREQUENCY—10 WATT/1-3.25 WATT/10 WATT—WITH VOICE

**CAUTION**: It is recommended that the user of this equipment become thoroughly familiar 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

A widely used high speed relaying system used for transmission line protection consists of directional-comparison unblock relaying plus a transfer-trip channel for breaker failure protection. Normally these systems of relaying require two frequency-shift channels, wideband for unblocking and narrowband for transfer trip. A saving in channel spectrum can be affected by using a three frequency transmitter for the two relaying functions and two separate receivers, one for each function, as shown in Figures 10 and 11.

### SYSTEM OPERATION

The three frequency TCF-10 carrier transmitter provides for the transmission of any of three closely controlled discrete frequencies, all within the equivalent spacing of a single wideband channel. The center frequency of the channel can vary from 30 kHz to 300 kHz in 0.5 kHz steps. The transmitter normally operates at a frequency that is 100 Hz above the channel center frequency (fc). This frequency serves as the "guard" frequency for the transfer-trip receiver and as the "block" frequency for the unblock receiver. Note that the discriminator characteristic in the unblock receiver in this case is reversed from the normal unblock receiver used with the standard two frequency transmitter. This "guard" "block" frequency is transmitted continuously when conditions are normal. It indicates at the receiving end of the line that the channel is operative and serves to prevent false operation of the receiver by line noise. The lowest frequency, which is 100 Hz less than fc is the "transfer trip" frequency and is transmitted as a signal that an operation (such as tripping a circuit breaker) should be performed at the receiving end of the line. The highest frequency, which is 300 Hz above fc, is the "unblock" frequency and is transmitted as an unblock signal for directional comparison relaying. If a subsequent transfer-trip operation is called for, the transmitter will shift to fc-100 Hz which is the "trip" frequency for the transfer trip (narrow-band receiver.)

Note that when the transmitter shifts to "unblock," the frequency is completely outside the passband of the narrow band transfer-trip receiver. Normally, this would cause a low-signal alarm output from that receiver. In order to prevent a similar alarm output in this case, the checkback output of the unblock receiver is cross-connected to the guard or block input of the transfer trip receiver (through an OR logic circuit). This logic is shown in Figure 10. The checkback output is a receiver output that indicates that a proper signal has been received without going through any time delays or other logic used for the actual relaying output.

With this cross-connected logic, both receivers will function when required, but will not give any incorrect output indications.

The transmitter normally operates at an output level of one watt at the "guard" "blocking" frequency, but increases to ten watts for either "trip" or "unblock" output. An interlock is provided in the transmitter keying circuit to give transfer-trip preference. This means that even while the transmitter is shifted to the "unblock" frequency, if the transfer-trip keying circuit is energized, the transmitter will shift to the "trip" frequency without delay.

The transmitter can also be amplitude modulated at 3.25 watts to provide a voice channel.

## CONSTRUCTION

The 10 watt/1-3.25 watt/10 watt TCF-10 transmitter unit is mounted on a standard 19-inch wide chassis 5 1/4 inches (3 rack units) high with edge slots for mounting on a standard relay rack. See Fig. 8. All of the circuitry that is suitable for printed circuit board mounting is on four such boards, as shown in Fig. 15. The components mounted on each printed circuit board or other sub-assembly are shown enclosed by dotted lines on the internal schematic. Fig. 1. The location of components on the four printed circuit boards are shown on separate illustrations, Fig. 3, 4, 5, & 6.

External connections to the assembly are made through a 36-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2.

## OPERATION

The transmitter is made up of four main stages and two filters. The stages include two crystal oscillators operating at frequencies that differ by the desired channel center frequency, a mixer and buffer amplifier, a driver stage and a power amplifier. The interstage filter is located between the driver and the power amplifier. The output filter removes harmonics that may be generated by distortion in the power amplifier.

A single crystal designed for oscillation in the 30 kHz to 300 kHz range cannot be forced to oscillate away from its natural frequency by as much as ± 100 hz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2 MHz range. The crystals are Y1 and Y2 of Fig. 1. The frequency of Y2 is 2.00 MHz when operated with a specified amount of series capacity, and the frequency of Y1 is 2.00 MHz plus the channel center frequency, or 2.03 MHz for 30 kHz center frequency. Capacitor C55 and crystal Y2 in series are connected between the positive side of the supply voltage and the base of transistor Q51 which operates in the emitter following mode. The emitter is coupled to the base through C57. With Y2 removed the base of Q51 would be held at approximately the midpoint of the supply voltage by R51 and R52. The crystal serves as a series-resonant circuit with very high inductance and low capacitance. The circuit can be made to oscillate at other than the natural frequency of the crystal by varying the series capacitor, C55. Increasing C55 will lower the frequency of oscillations and reducing C55 will raise the frequency.

Capacitor C79 (in parallel with C78) is not effective until D59 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the keying control for unblock is closed which places 45V. dc at terminal 12 of the printed circuit board. With D57 conducting, C79 and C78 are placed in parallel with C55 and C73. The adjustment of C79 will reduce the frequency of the Y2 circuit by 200 hz. Since Y2 is the lower of the two frequencies derived from Y1 and Y2, the difference frequency, which is the frequency transmitted, is now increased by 200 hz. Thus the frequency transmitted is now 200 hz above the guard frequency or 300 hz above the center frequency.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes D51 and D52. By adjustment of C52 this circuit is made to oscillate at 100 hz above its marked frequency. Capacitors C53 and C71 are not effective until D51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the keying control is closed, which places 45 V. dc at terminal 1 of the printed circuit board. With D51 conducting, C53 and C71 are effectively in parallel with C52 and C72. The adjustment of C53 will reduce the frequency by 200 hz.

The crystals taken individually have a greater variation of frequency with temperature than would be acceptable. However, by proper matching of the two crystals, the variation in their difference frequency can be kept within limits that permit holding the frequency stability of the overall transmitter to ± 10 Hz over a temperature range of −20 to +55° C.

The frequencies produced by the two oscillators are coupled to the base of mixer transistor Q53 through C62 and C63. The sum of the two frequencies is so high that a negligible amount appears on the secondary of transformer T51, but the difference frequency is accepted and amplified by Q53 and Q54.

When the keying control is closed, it increases the output power from 1 watt to 10 watts as well as changing the frequency from Guard to Transfer or Unblock Trip. This is effected by reducing the emitter resistance of buffer-amplifier transistor Q54. When the keying control is open, transistor Q55 receives no base current and is non-conducting. Emitter resistor R70 therefore is effectively open-circuited. The level of output power is adjusted to 1 watt by means of R64. When Q55 is made conductive by closing the keying control circuit, R70 is placed in parallel with R68 and the amount of emitter resistance unbypassed by C66 can be adjusted as required to obtain a 10-watt output level.

Note in the keying board logic there is that interlocking logic between the keying for "unblock" and the keying for "transfer trip". This logic permits the "transfer trip" keying to take preference over the "unblock" keying. That is, even if we have "unlock" keying and then get "transfer trip" keying, the "transfer trip" will take immediate preference over the "unblock" keying. This is accomplished by the "transfer trip" keying causing transistor Q1 to conduct which in turn shunts out the keying voltage input to transistor Q3 through diode D9. Thus while Q1 becomes conducting and consequently Q2, effecting "transfer trip" keying, this conduction of Q1 also prevents Q3 from becoming conducting and prevents "unblocking" keying.

As is shown on the Internal Schematic, Fig. 1, the voltage for the keying circuit is obtained from the 45-volt regulated supply in the transmitter.

The driver stage consists of transistors Q56 and Q57 connected in a conventional push-pull circuit with input supplied from the collector of Q54 through transformer T52.

The driver filter, FL101, consists of a series-resonant inductor and capacitor connected between the driver and power amplifier stages by appropriate transformers T1 and T2. This filter greatly improves the waveform of this signal applied to the power amplifier.

The power amplifier uses two series-connected power transistors, Q101 and Q102, operating as a class B push-pull amplifier with single-ended output. Diodes D101 and D103 provide protection for the base-emitter junctions of the power transistors. Zener diodes Z105 and Z106 protect the collector-emitter junctions from surges that might come in from the power line through the coaxial cable.

The output transformer T3 couples the power transistors to the 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 G1 is a small lightning arrester to limit the magnitude of switching surges or other line disturbances reaching the carrier set through the line turner and coaxial cable. Auto-transformer T4 matches the filter impedance to coaxial cable of 50, 60, or 70 ohms.

The series resonant circuit composed of L105, and CE 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, thus providing a reverse impedance that is free of possible "across-the-line" resonances.

The power supply is a series-type transistorized dc voltage regulator which has a very low stand-by current drain when there is no output current demand. The Zener diode Z1 holds a constant base-to-negative voltage on the series-connected power darlington transistor Q1. Depending on the load current, the dc voltage drop through transistor Q1 and resistor R1 and R2 varies to maintain a constant output voltage. The Zener diode Z2 serves to drop the 100v regulated supply to 45v for use with both the keying circuit and the external TCF voice adapter. It is placed in series so that it does not draw current unless called upon by the external voice adapter. Capacitor C3 provides a low carrier-frequency impedance across the dc output voltage. Capacitors C1 and C2 by pass across the dc output voltage. Capacitors C1 and C2 by pass r.f. or transient voltages to ground, thus preventing damage to the transistor circuit.

When keyed for voice by the voice adapter, transistor Q55 is keyed into class A operation so that its conduction can be modulated by the voice input from the voice adapter. Potentiometer R82 is adjusted so that the nominal output of carrier is 3.25 watts (14 volts across 60 ohms). The voice input modulates the carrier through this transistor by varying the amount of conduction of Q55 so that the output power of carrier varies with the voice amplitude following the voice frequency components. Since with Q55 completely nonconducting, R64 has been set to produce a 1 watt output, maximum modulation on the side to shut off Q55 will not result in an output level of less than 1 watt carrier at any time. Also since the output level has been set at 10 watts with Q55 completely conducting by the adjustment of R70, the maximum modulation on the side of turn on of Q55 will not result in a carrier output level of greater than 10 watts at any time. Thus the modulation for voice will not result in the output carrier level dropping below 1 watt and endangering the guard frequency for relaying purposes.

The buffer keying board in addition to providing proper buffering, also contains logic for the proper keying of both frequency and output level in regards to protective relaying operation, voice adapter operation, and 52b contact operation.

It should be remembered that protective relaying operation has first priorty. If the protective relay operates and puts a voltage input into any of the three input points labeled carrier auxiliary keying, the transmitter will both frequency shift to trip frequency and full 10 watts output whether voice is called for or not.

The operation of the 52b contact will remove the 10 watt keying output and permit the voice adapter to key to 3.2 watts output for AM voice modulation. This allows voice modulation on unblock frequency after the 52b contact has operated.

## CHARACTERISTICS

| | |
|---|---|
| Frequency Range Output | 30-300 kHz, 1 watt guard—10 watts trip—(both transfer and unblock)—3.2 watts voice (into 50 to 70 ohm resistive load) at nominal rated input voltage (48 V. or 125 v.d.c.) |
| Frequency Stability | ±10 Hz from −20°C to +55C. |
| Frequency Spacing | Two-way channel,—See Voice Adapter Instruction Leaflet. [41-945.6] |
| Harmonics | Down 55 db (min.) from output level. |
| Input Voltage | 48 or 125 v.d.c. |
| Supply Voltage Variation | 42-56v. for nom. 48v. supply. 105-140v. for nom. 125v. supply. |
| Battery Drain | 0.5 A. guard, 1.15 A. trip } 48 v.d.c.<br>0.2 A. guard, 0.4 A. trip } 125 v.d.c. |
| Keying Circuit Current | 4 mA. |
| Temperature Range | −20 to +55°C. around chassis. |
| Dimensions | Chassis height—5 1/4 or 3 r.u.<br>Chassis width—19″ |
| Weight | 12 lbs. |

## INSTALLATION

TYPE TCF-10 transmitter 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 55° C.

## ADJUSTMENTS

TYPE TCF-10 10W/1-3.2W/10W 3 Frequency transmitter is shipped with the power output controls R64, R82 and R70, set for outputs of 1 watt, 3.2 watts and 10 watts into a 60 ohm load. If it is desired to check the adjustments or if repairs have made readjustment necessary, the coaxial cable should be disconnected from the assembly terminals and replaced with a 50 to 70 ohm non-inductive 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 T4 output lead to the corresponding tap. Connect an ac vacuum tube voltmeter (VTVM) across the load resistor. Turn power output control R64 to minimum (full counter-clockwise). Turn on the power switch on the panel and note the dc voltage across terminals 3 and 7 of J3. If this is in the range of 42 to 46 volts, rotate R64 clockwise to obtain 4 or 5 volts across the load resistor used. 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 used. Then rotate R64 farther clockwise to obtain the correct voltage for 1 watt in the load resistor, as shown in the following table.

Then change to Trip frequency by connecting together terminals 7 and 12 of the transmitter connector J3, and rotate R70 until the voltage across the load resistor is as shown in the following table for a 10 watt output. Recheck the adjustment of L105 for maximum output voltage and readjust R70 for a 10 watt output if necessary. Tighten the locking nut on L105. Open the power switch and remove the jumper used to key the transmitter to the 10 watt level. Key for voice by opening any connection terminal to 10 of J3. Turn the power back on. Adjust R82 for a 3.2 watt output across the load resistor (14V across 60 ohms). Open the power switch, reconnect connection to terminal 10 of J3, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter. Note on frequencies above 200 KHZ, L105 adjustment is a screw-driver adjustment. There is no knurled shaft-locking nut.

## VOLTAGE FOR

| T106 TAP | 1 WATT OUTPUT | 3.2 WATTS OUTPUT | 10 WATTS OUTPUT |
|---|---|---|---|
| 50 | 7.1 | 12.7 | 22.4 |
| 60 | 7.8 | 14 | 24.5 |
| 70 | 8.4 | 15 | 26.5 |

Follow the procedure outlined in the line tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. 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 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.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals, this can be done by turning the matched pair 180° and inserting a crystal in its proper socket with the other crystal unconnected. A sensitive frequency counter with a range of at least 2.3 MHz can be connected from TP51 to TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter and avoids some error from the effect of the counter input capacitance on the oscillator circuit.) While measurement of the oscillator crystals individually is necessary for the initial adjustment of the oscillators, generally any subsequent checks may be made with a lower range counter connected at the transmitter output. If any minor adjustment of the Guard and Trip frequencies should be needed, the Guard adjustment should be made with capacitor C52, the Transfer Trip Adjustment with C53, and the unblock frequency with C79.

## MAINTENANCE

Periodic checks of the transmitter Guard and Trip power outputs will detect 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 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 values are given in the following tables. Voltages should be measured with a VTVM. Readings may vary as much as ±20%.

## TABLE I
## TRANSMITTER DC MEASUREMENTS

Note: All voltages are positive with respect to Neg. (TP51). All voltages read with dc VTVM.

| Test Point | Voltage at 1 Watt Output | | Voltage at 10 Watts Output | | Voltage at 3.2 Watts Output (For voice) | |
|---|---|---|---|---|---|---|
| | 48V units | 125V units | 48V units | 125V units | 48V units | 125V units |
| TP52 | 20 | 20 | 20 | 20 | 20 | 20 |
| TP53 | 5.4 | | 5.4 | | 5.4 | |
| TP54 | 3.4 | | 3.4 | | 3.4 | |
| TP55 | 21 | 20 | 18.5 | 18.5 | — | — |
| TP56 | 21 | 20 | 18.5 | 18.5 | — | — |
| TP57 | <1.0 | | <1.0 | | — | — |
| TP58 | 44.3 | 100 | 44.1 | 100 | — | — |
| TP59 | <1.0 | | <1.0 | | — | — |
| TP101 | 0 | 0 | 0 | 0 | — | — |
| TP103 | 21±2 | 50 | 21±2 | 50 | — | — |
| TP105 | 44.3 | 100 | 44.0 | 100 | — | — |

## TABLE II
## TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages subject to variations, depending upon frequency and transistor characteristics. T51-3 = Terminal 3 of transformer T51. Other transformer terminals identified similarly. All read with a-c VTVM.

| Test Point | Voltage at 1 watt Output | | Voltage at 10 watts Output | | Voltage at 3.2 watts Output (For Voice) |
|---|---|---|---|---|---|
| TP54 to TP51 | 0.015-0.03 | | 0.015-0.03 | | — |
| TP57 to TP51 | 0.05 -0.09 | | 0.3 -1.2 | | — |
| TP59 to TP51 | 0.05 -0.09 | | 0.3 -1.2 | | — |
| | 48V | 125V | 48V | 125V | |
| T1-1 to TP51 | 1.65 | | 5.6 | | — |
| T1-3 to TP51 | 1.45 | | 4.9 | | — |
| T1-4 to Gnd. | .6 | | 2.0 | | — |
| T2-1 to Gnd. | .57 | | 1.85 | | — |
| TP101-TP103 | 5.2 | | 17.0 | | — |
| TP103 to TP105 | 5.2 | | 17.0 | | — |
| T3-4 to Gnd. | 35 | 35 | 112 | 112 | — |
| T4-2 to Gnd. | 31 | 31 | 110 | 110 | — |
| TP109 to Gnd. | 9.8 | 9.8 | 31 | 31 | — |
| J102 to Gnd. | 7.8 | 7.8 | 24.5 | 24.5 | 14 |

## CONVERSION OF TRANSMITTER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a 1W/10W TCF transmitter for operation on a different channel frequency consist of a pair of matched crystals for the new channel frequency, new capacitors C103 and C104 on the power amplifier circuit board if the old and new frequencies are not in the same frequency group (see table on internal schematic drawing) and, in general, new or modified filters FL101 and FL102. Inductors L101, L102 and L103 in these filters are adjustable over a limited range, but forty-two combinations of capacitors and inductors are required to cover the frequency range of 30 to 300 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

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

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

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 T1 and the voltmeter across terminals 1 and 2 of transformer T2. The signal generator should be set at the channel center frequency and at 2 to 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 T3, and a 500 ohm resistor and a VTVM to the terminals of protective gap G1. 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.

After the new pair of matched crystals have been adjusted, as described under "ADJUSTMENTS", the transmitter can be operated with a 50 to 70 ohm load (depending on which tap of T4 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 same section.

If a frequency-sensitive voltmeter is available, the 2nd and 3rd harmonic traps may be adjusted 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 the tuning dial and dB range switch, obtain a maximum on-scale reading of the 2nd 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. Although the transmitter frequency will differ from the channel center frequency by 100 Hz, the effect of this difference on the adjustment of the harmonic traps will be negligible. It should be noted that the true magnitude of the harmonics cannot be measured in this manner because of the preponderance of the fundamental frequency at the voltmeter terminals. Accurate measurement of the harmonics requires use of a filter between TP109 and the voltmeter that provides high rejection of the fundamental. The insertion losses of this filter for the 2nd and 3rd harmonics must be measured and taken into account.

## RECOMMENDED TEST EQUIPMENT

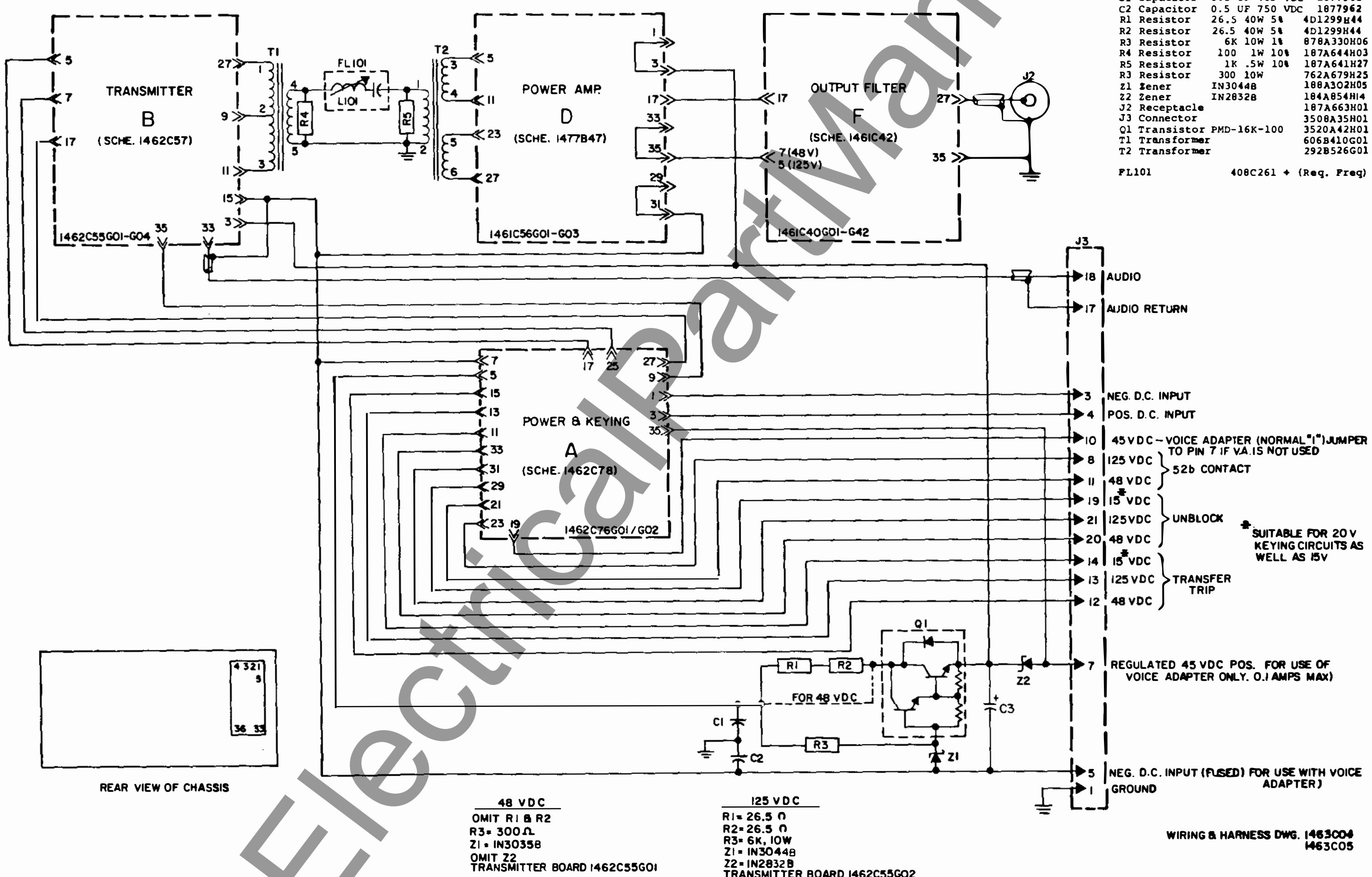
I. Minimum Test Equipment for Installation.
  a. 60-ohm 10-watt non-inductive resistor.
  b. AC Vacuum Tube Voltmeter (VTVM). Voltage range 0.003 to 30 volts, frequency range 60 hz to 330-kHz; input impedance 7.5 megohms.
  c. DC Vacuum Tube Voltmeter (VTVM).
     Voltage Range: 1.5 to 300 volts
     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-kHz to 330-kHz.
  c. Oscilloscope
  d. Frequency counter
  e. Ohmmeter
  f. Capacitor checker.

Some 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 and identify the part by its designation on the Internal Schematic drawing.




| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C3 CAPACITOR | 0.5 UF 200 VDC | 187A624H11 |
| C1 Capacitor | 0.5 UF 705 VDC | 1877962 |
| C2 Capacitor | 0.5 UF 750 VDC | 1877962 |
| R1 Resistor | 26.5 40W 5% | 4D1299H44 |
| R2 Resistor | 26.5 40W 5% | 4D1299H44 |
| R3 Resistor | 6K 10W 1% | 878A330H06 |
| R4 Resistor | 100 1W 10% | 187A644H03 |
| R5 Resistor | 1K .5W 10% | 187A641H27 |
| R3 Resistor | 300 10W | 762A679H25 |
| Z1 Zener | IN3044B | 188A302H05 |
| Z2 Zener | IN2832B | 184A854H14 |
| J2 Receptacle | | 187A663H01 |
| J3 Connector | | 3508A35H01 |
| Q1 Transistor | PMD-16K-100 | 3520A42H01 |
| T1 Transformer | | 606B410G01 |
| T2 Transformer | | 292B526G01 |
| FL101 | | 408C261 + (Req. Freq) |

Sub. 3
1462C85

Fig. 1 Internal Schematic of Transmitter

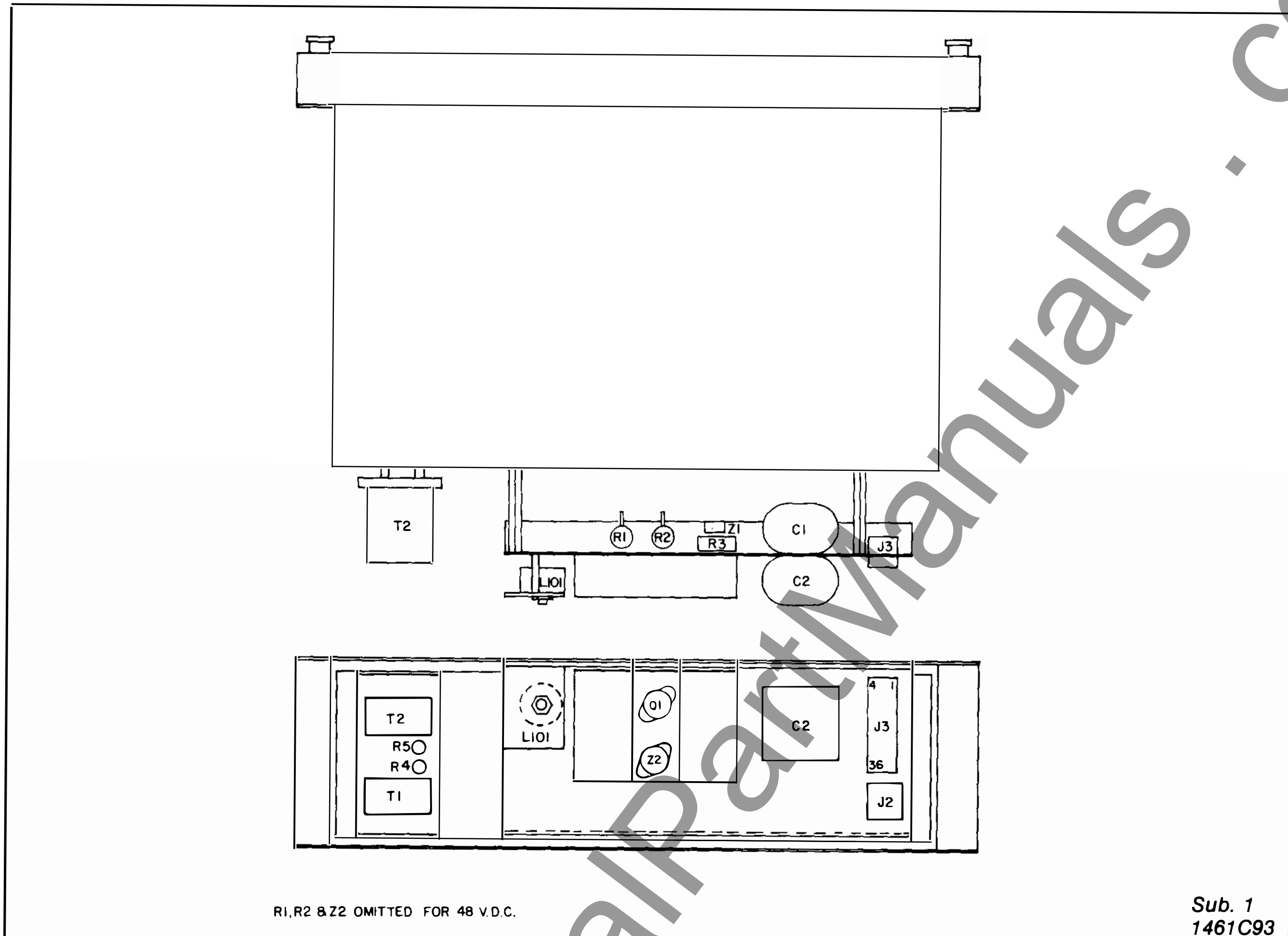



*Fig. 2 Component Location Transmitter Assembly*

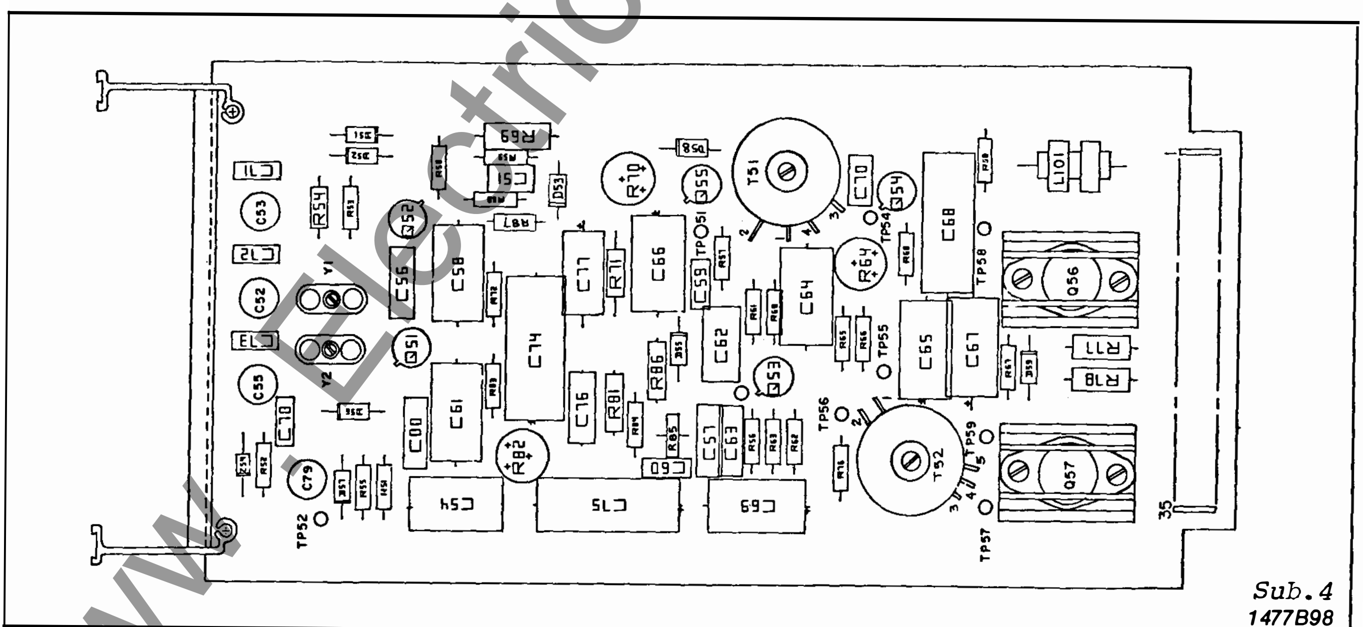



*Fig. 3 Component Location Transmitter Module*

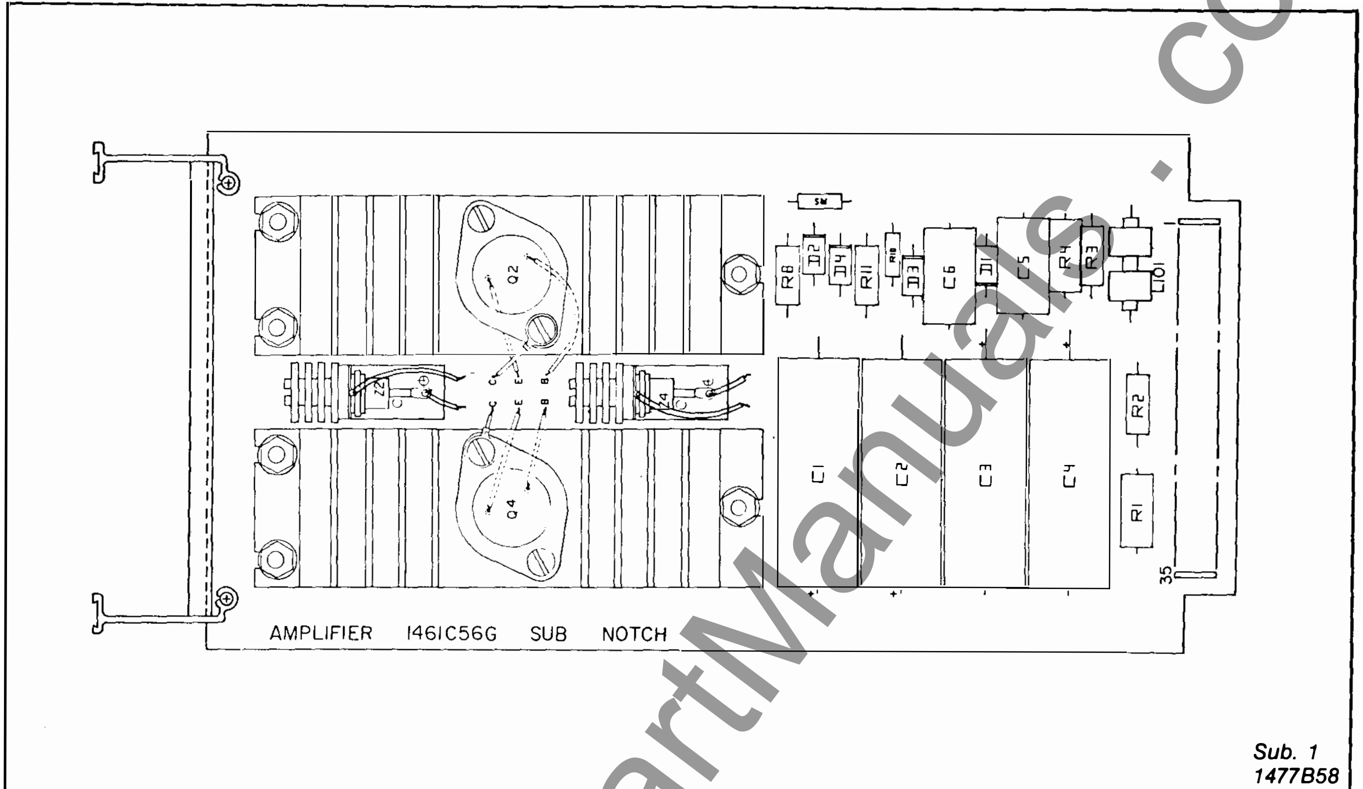



Fig. 4 Component Location Power Amplifier Module

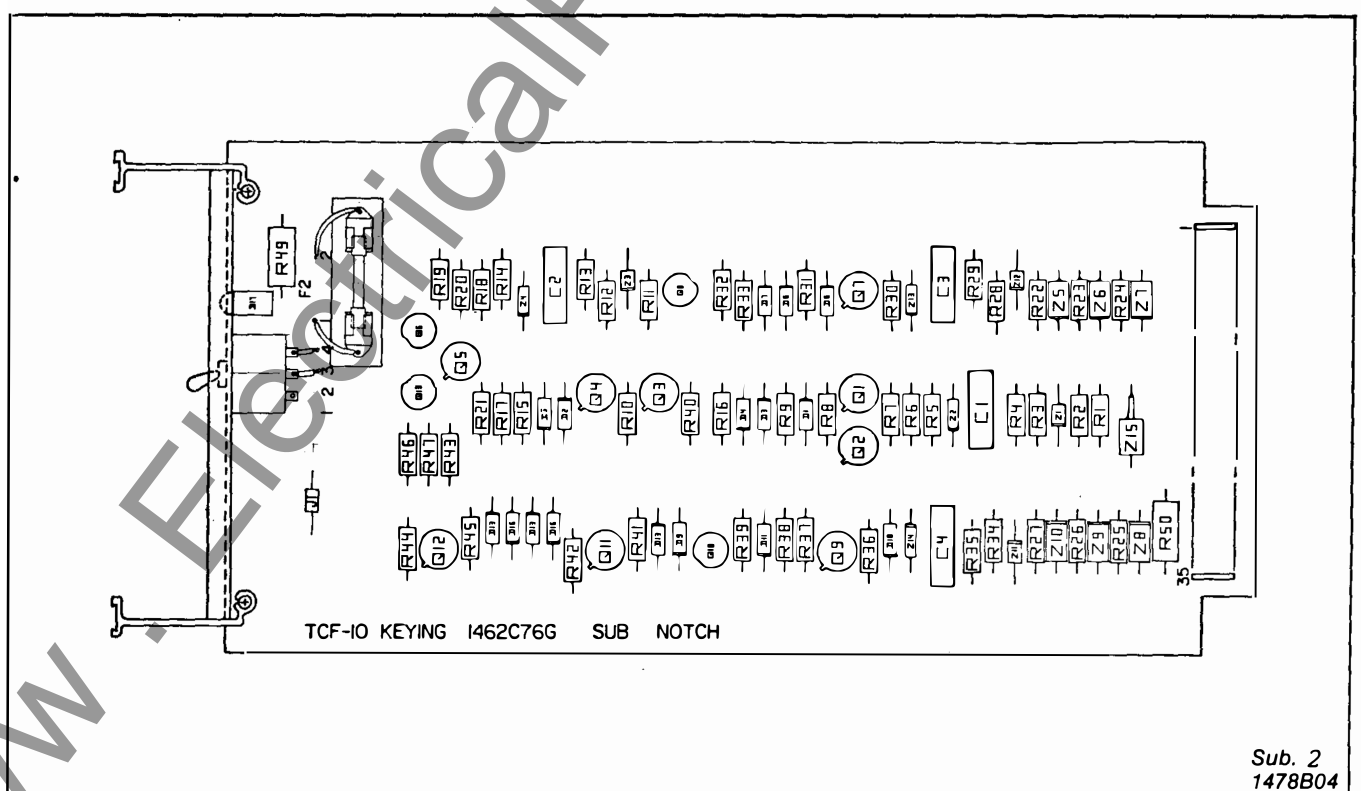
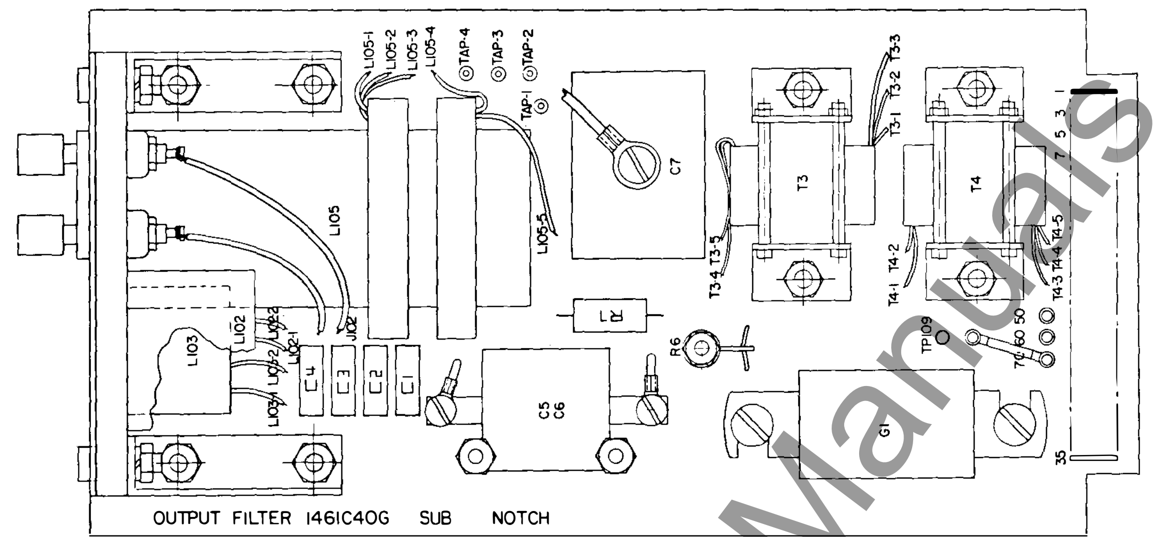
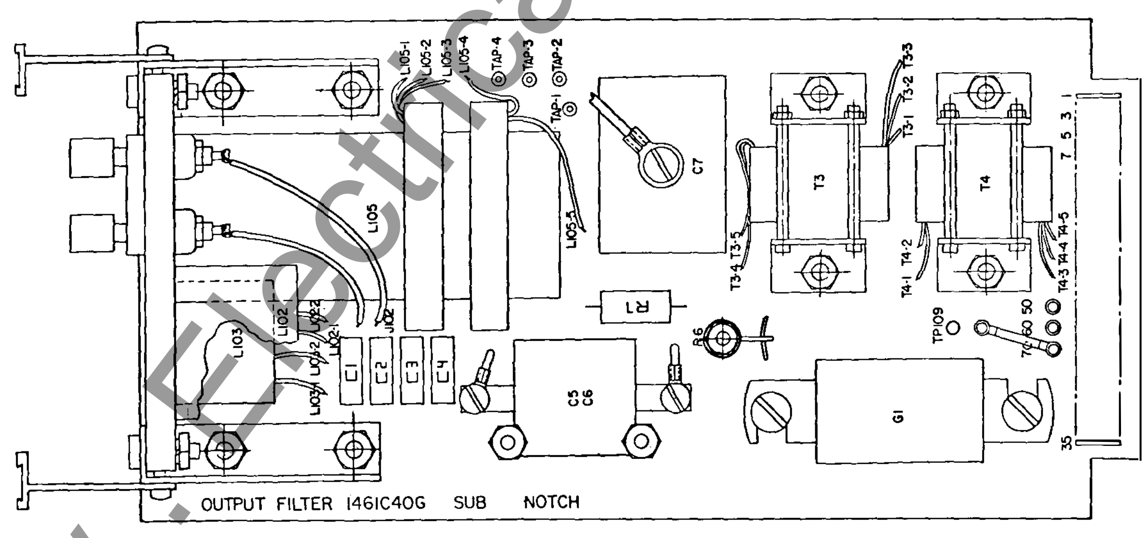



Fig. 5 Component Location Power Amplifier Keying Module




Sub. 3
*1477B28*

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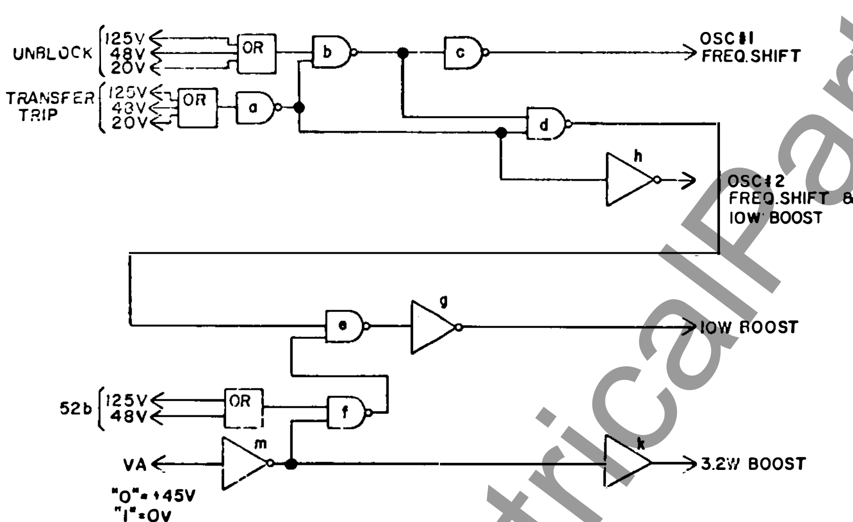
*1479B33*

*Fig. 6 Component Location Output Filter Module*

## LOGIC FOR 3 FREQ. WITH VOICE




## TRUTH TABLE – 3 FREQ. WITH VOICE

| INPUT KEYING | | | | OUTPUTS | | | | |
|---|---|---|---|---|---|---|---|---|
| UN | TT | 52b | VA | TT FREQ. SHIFT | UN FREQ. SHIFT | 3.2W BOOST | 10W BOOST | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | GUARD 1W |
| 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | UNBLK. 10W |
| 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | T.T. 10W |
| 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | UNBLK. 10W |
| 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | UNBLK. 10W |
| 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | TT 10W |
| 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | UNBLK 3.2W |
| 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | TT 10W |
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | TT 10W |
| 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | TT 10W |
| 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | TT 10W |
| 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | TT 10W |
| 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | TT 10W |
| 0 | 0 | 1 * | 0 | 0 * | 1 | 0 | 1 | UNBLK 10W |
| 0 | 0 | 1 * | 1 | 0 * | 1 | 1 | 0 | UNBLK 3.2W |
| 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | GUARD 3.2W |

* = STU RELAY AFTER 180MS OPERATION OF 52b WILL KEY TO UNBLOCK. IN THIS CASE, THE UNBLOCK KEYING IS NOT DONE BY THE LOGIC REPRESENTED BY THESE LOGIC BOARDS.

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1480B82

*Fig. 7 Logic for 3 Frequency With Voice*

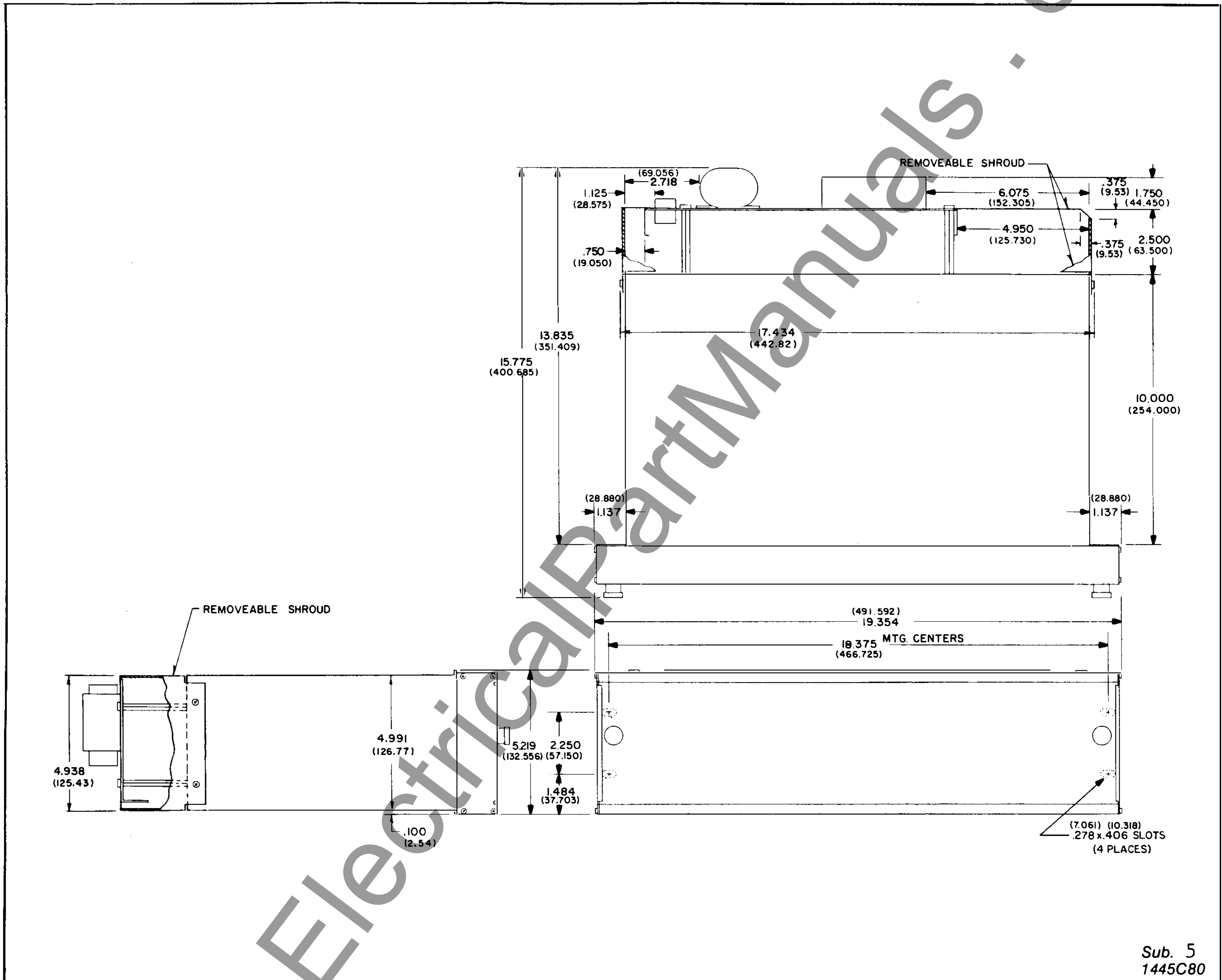



Fig. 8 Outline & Drilling for Transmitter Assembly

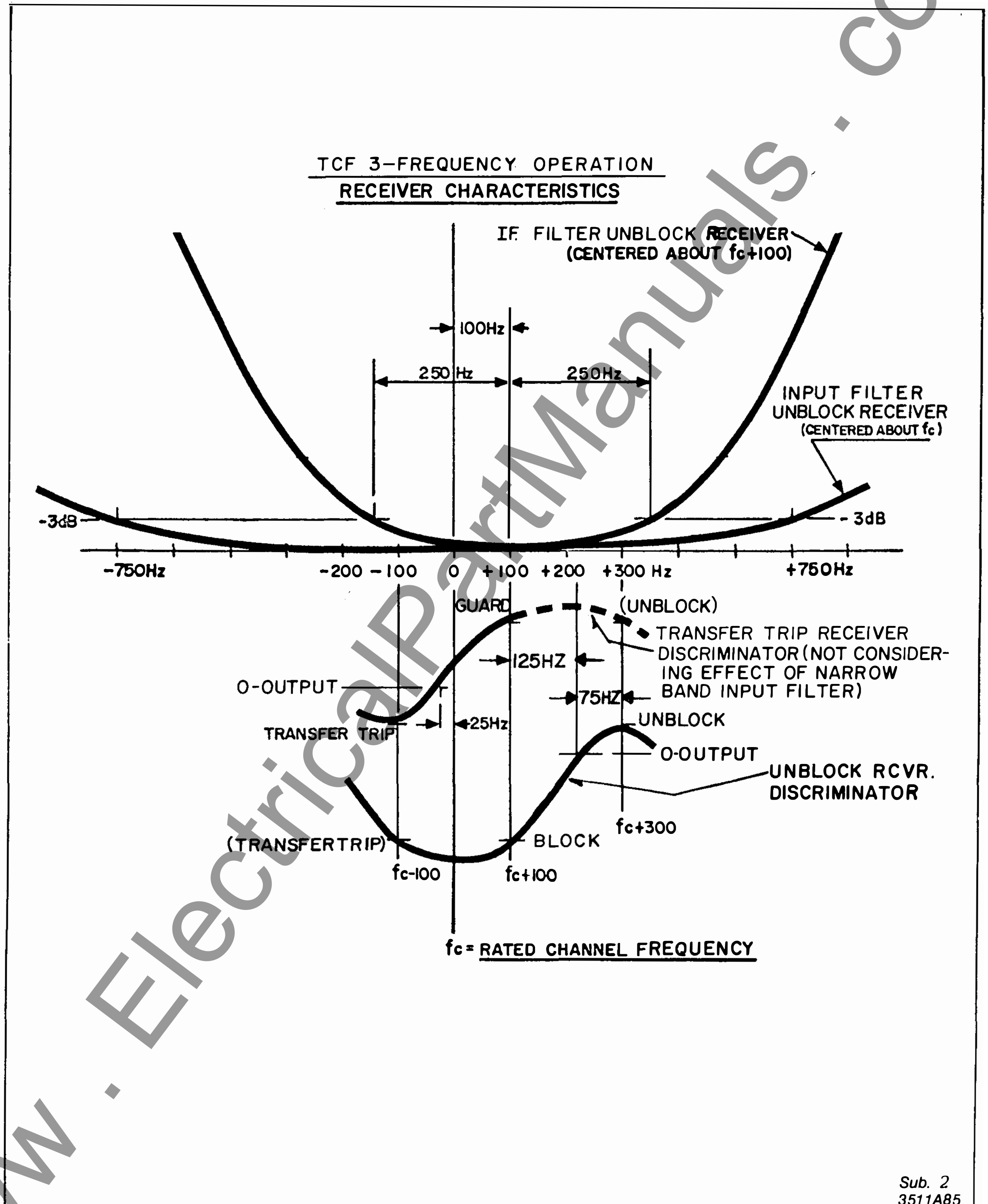



*Fig. 9 Three Frequency Operation—Receiver Characteristics*

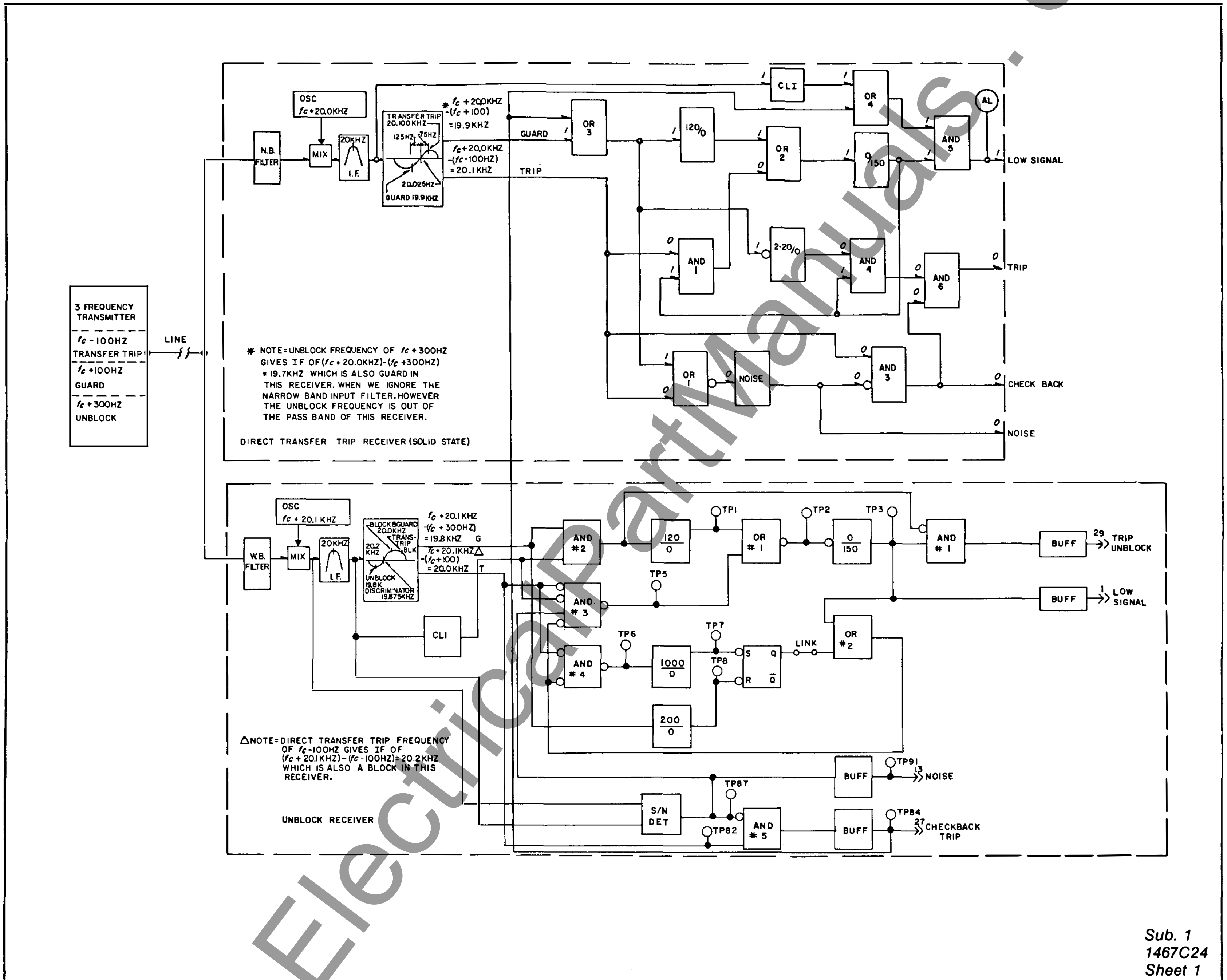



*Fig. 10-1 Receiver Logic Diagram - Solid State Output*

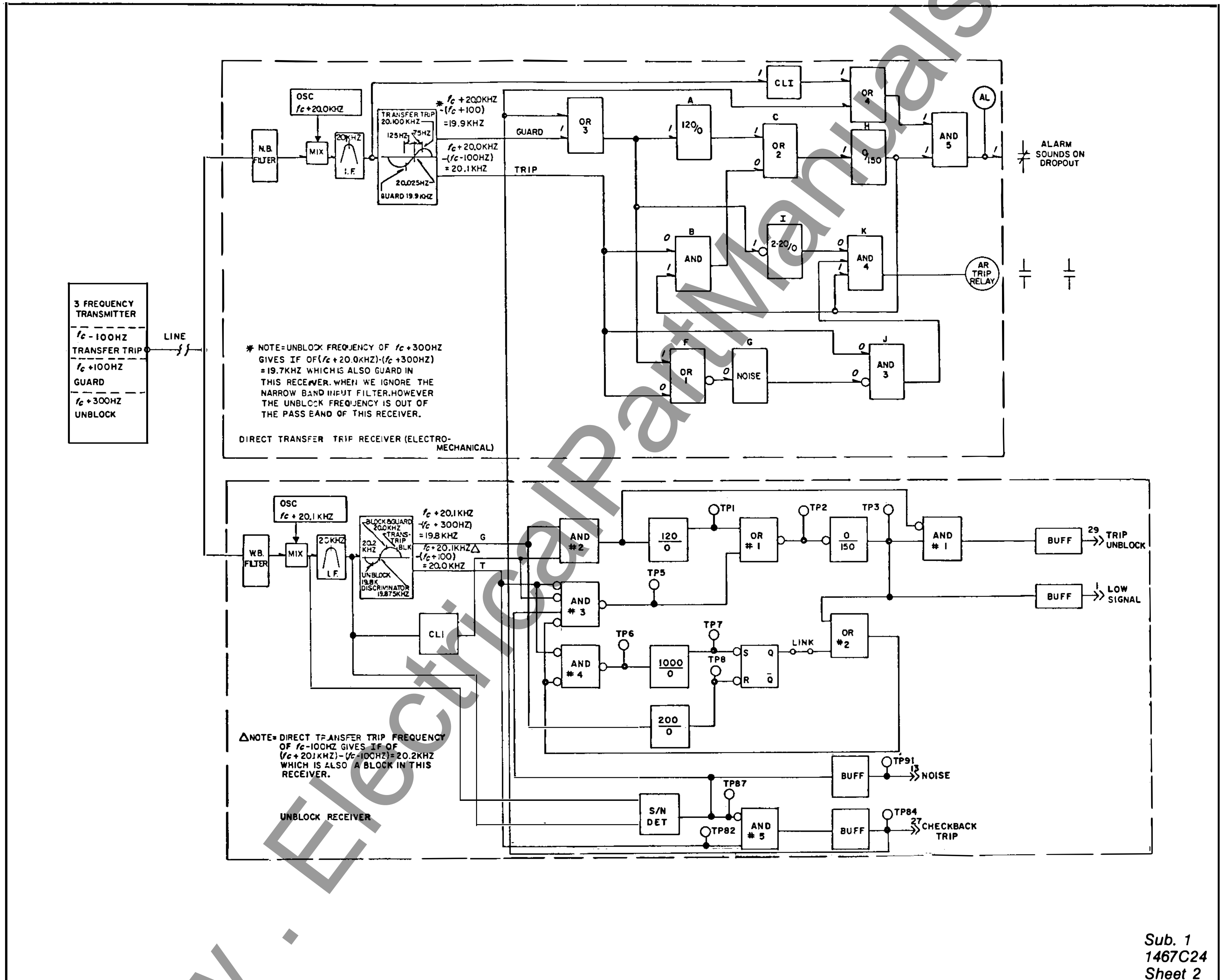



*Fig. 10-2 Receiver Logic Diagram - AR Relay Output*

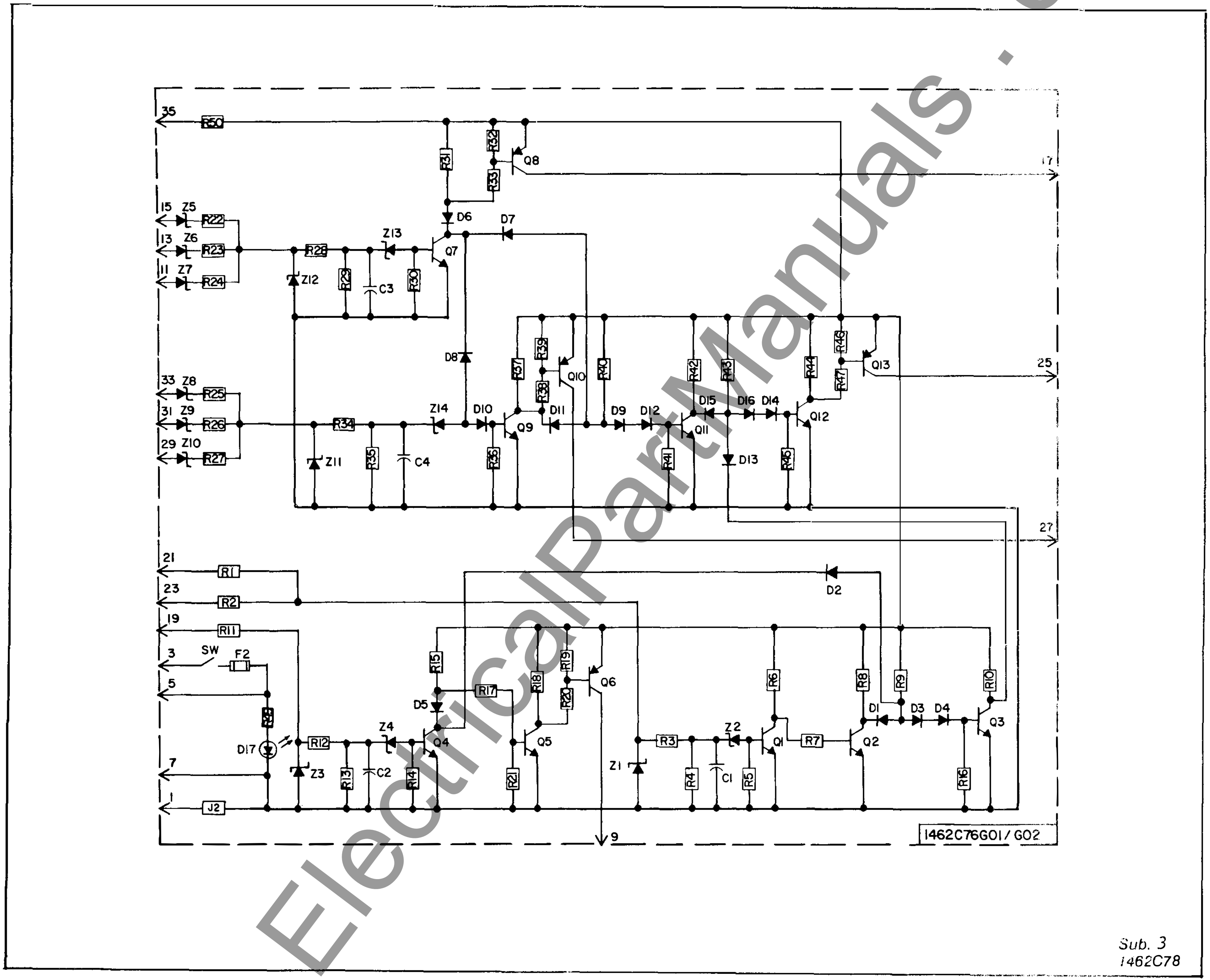
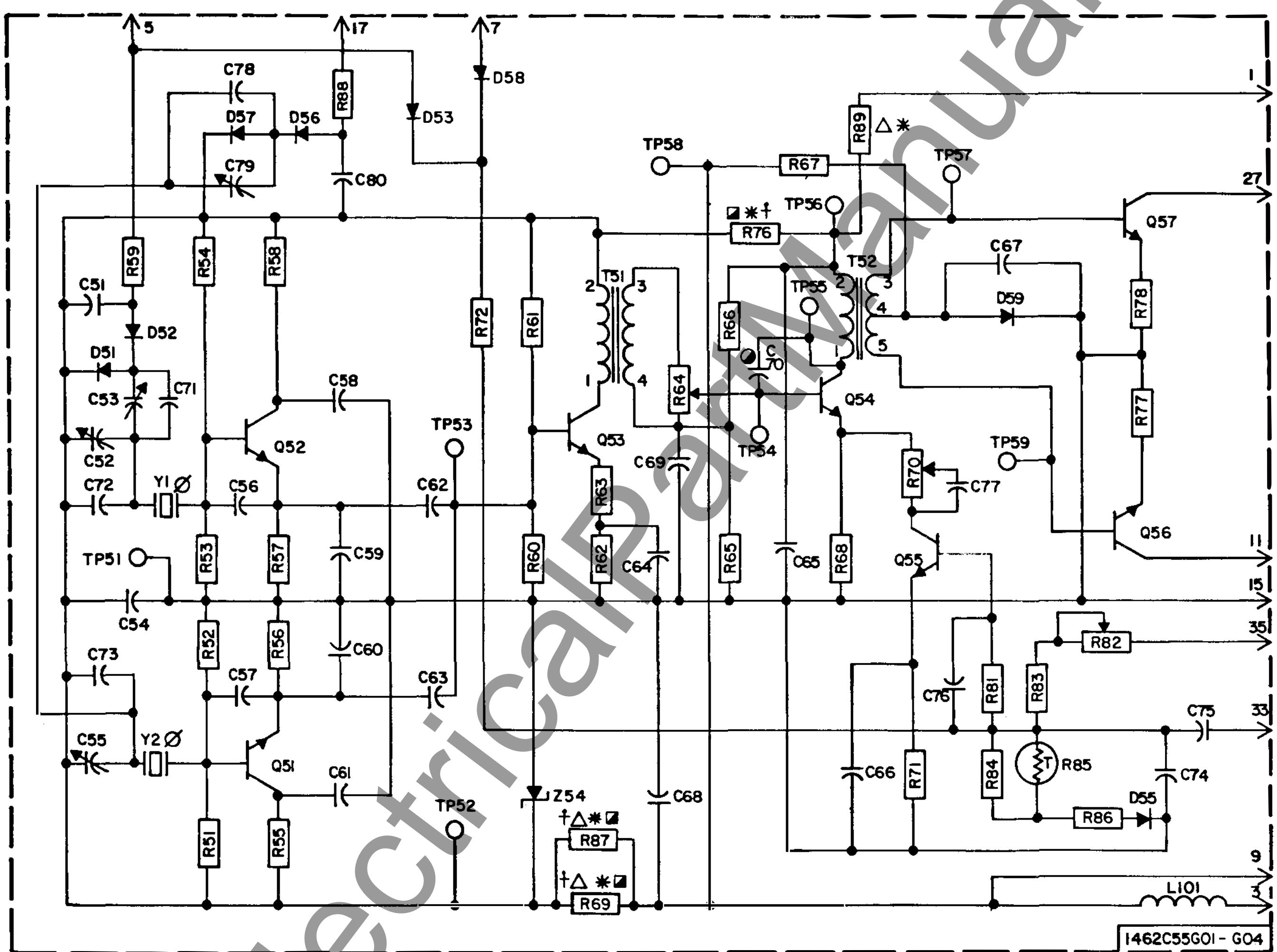



*Fig. 11 Internal Schematic Power & Keying Module*




✱-G01 (48 V.D.C.)USE R69 (OMIT R87 & R89)
△-G02 (125 V.D.C.)USE R69 & R87 (OMIT R89)
(ON-OFF MODE) ◪ -G03 (48V.D.C) USE R69 (OMIT R87 & R76)
(ON-OFF MODE) † - G04 (125V.D.C) USE R69 & R87 (OMIT 76)
◑ - REMOVE FOR VOICE ABOVE 60 KHZ

*Sub.* 5
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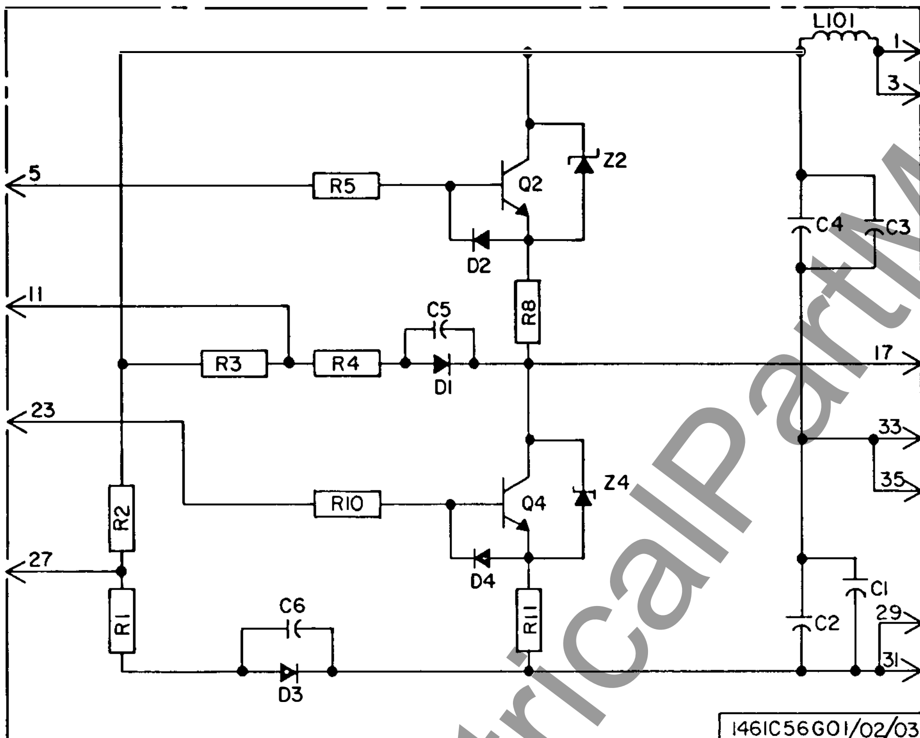
*Fig. 12 Internal Schematic Transmitter Module*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C1 | CAPACITOR | .470UF 400V | 188A293H01 |
| C2 | CAPACITOR | .470UF 400V | 188A293H01 |
| C3 | CAPACITOR | .470UF 400V | 188A293H01 |
| C4 | CAPACITOR | .470UF 400V | 188A293H01 |
| C5 | CAPACITOR | .250UF 200V | 187A624H02 |
| C6 | CAPACITOR | .250UF 200V | 187A624H02 |
| C2 | CAPACITOR | .220UF 400V | 188A293H02 |
| C4 | CAPACITOR | .220UF 400V | 188A293H02 |
| D1 | DIODE | 1N4822 | 188A342H11 |
| D2 | DIODE | 1N4822 | 188A342H11 |
| D3 | DIODE | 1N4822 | 188A342H11 |
| D4 | DIODE | 1N4822 | 188A342H11 |
| Z2 | ZENER | IN2009C | 184A617H14 |
| Z4 | ZENER | IN2009C | 184A617H14 |
| R1 | RESISTOR | 2.7 1W 0% | 629A371H24 |
| R2 | RESISTOR | 100K 1.00W 5% | 187A644H75 |
| R3 | RESISTOR | 51K 1.00W 5% | 187A643H68 |
| R4 | RESISTOR | 2.7 1W 0% | 629A371H24 |
| R5 | RESISTOR | 10.0 .50W 5% | 187A290H01 |
| R8 | RESISTOR | .27 1.00W 10% | 184A636H18 |
| R10 | RESISTOR | 10.0 .50W 5% | 187A290H01 |
| R11 | RESISTOR | .27 1.00W 10% | 184A636H18 |
| Q2, Q4 | TRANSISTOR | 2N6341 (MATCHED) PAIR | 3508A21H04 |

G01 - FOR 30-70 KHZ USE C1, C2, C3, C4 = .47 UF.
G02 - FOR 70-150 KHZ USE C2, C4 = .47 UF OMIT C1 & C3.
G03 - FOR 150 TO 300 KHZ USE C2, C4 = .22 UF OMIT C1 & C3.

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*Fig. 13 Internal Schematic Power Amplifier Module*

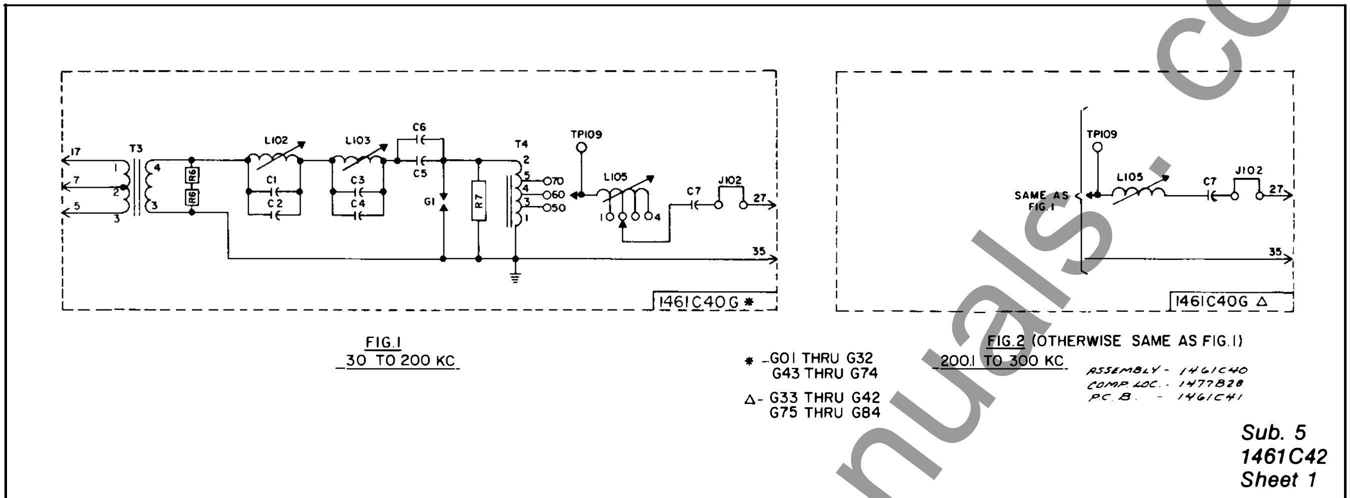



*Fig. 14 Internal Schematic Output Filter*

# PARTS LIST

**1461C40G01,G43**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 2500 MMF 500V | 861A846H20 |
| C2 CAPACITOR | 2700 MMF 500V | 861A846H21 |
| C3 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C4 CAPACITOR | 3300 MMF 500V | 187A584H26 |
| C5 CAPACITOR | 4000 MMF 1200V | 187A705H15 |
| C6 CAPACITOR | 4000 MMF 1200V | 187A705H15 |
| C7 CAPACITOR | 7000 PF 3000V | 203C872H29 |
| L102 POT CORE | | 6708133G04 |
| L103 POT CORE | | 6708133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 2928526G04 |
| T4 TRANSFORMER | | 2928526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G02,G44**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 2500 MMF 500V | 861A846H20 |
| C2 CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 3300 MMF 500V | 187A584H26 |
| C5 CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C6 CAPACITOR | 5000 MMF 1200V | 187A705H16 |
| C7 CAPACITOR | 6000 PF 3000V | 203C872H28 |
| L102 POT CORE | | 6708133G04 |
| L103 POT CORE | | 6708133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 2928526G04 |
| T4 TRANSFORMER | | 2928526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G03,G45**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C2 CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C3 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C4 CAPACITOR | 3300 MMF 500V | 187A584H26 |
| C5 CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C6 CAPACITOR | 4000 MMF 1200V | 187A705H15 |
| C7 CAPACITOR | 5500 PF 3000V | 203C872H27 |
| L102 POT CORE | | 6708133G04 |
| L103 POT CORE | | 6708133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 2928526G04 |
| T4 TRANSFORMER | | 2928526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G04,G46**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C2 CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C4 CAPACITOR | 3300 MMF 500V | 187A584H26 |
| C5 CAPACITOR | 3000 MMF 1200V | 187A705H14 |
| C6 CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C7 CAPACITOR | 5000 PF 3000V | 203C872H26 |
| L102 POT CORE | | 6708133G04 |
| L103 POT CORE | | 6708133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 2928526G04 |
| T4 TRANSFORMER | | 2928526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G05,G47**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 3000 MMF 500V | 187A584H06 |
| C3 CAPACITOR | 820 MMF 500V | 762A757H22 |
| C4 CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C5 CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C6 CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C7 CAPACITOR | 4200 PF 3000V | 203C872H25 |
| L102 POT CORE | | 6708133G04 |
| L103 POT CORE | | 6708133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 2928526G04 |
| T4 TRANSFORMER | | 2928526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G06,G48**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 2500 MMF 500V | 861A846H20 |
| C2 CAPACITOR | 150 MMF 500V | 861A846H25 |
| C3 CAPACITOR | 150 MMF 500V | 861A846H25 |
| C5 CAPACITOR | 200 MMF 1200V | 137A705H04 |
| C6 CAPACITOR | 4000 MMF 1200V | 187A705H15 |
| C7 CAPACITOR | 3500 PF 3000V | 203C872H23 |
| L102 POT CORE | | 6708133G04 |
| L103 POT CORE | | 6708133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 2928526G04 |
| T4 TRANSFORMER | | 2928526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G07,G49**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C2 CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C3 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C4 CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C5 CAPACITOR | 1500 MMF 1200V | 187A705H11 |
| C6 CAPACITOR | 2000 MMF 1200V | 187A705H12 |
| C7 CAPACITOR | 3200 PF 3000V | 203C872H22 |
| L102 POT CORE | | 6708133G04 |
| L103 POT CORE | | 6708133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 2928526G04 |
| T4 TRANSFORMER | | 2928526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G08,G50**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 30 MMF 500V | 763A209H12 |
| C2 CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C3 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C4 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C5 CAPACITOR | 3000 MMF 1200V | 187A705H14 |
| C6 CAPACITOR | 200 MMF 1200V | 187A705H04 |
| C7 CAPACITOR | 2800 PF 3000V | 203C872H20 |
| L102 POT CORE | | 6708133G04 |
| L103 POT CORE | | 6708133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 2928526G04 |
| T4 TRANSFORMER | | 2928526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G09,G51**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C2 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C3 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C4 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C5 CAPACITOR | 2000 MMF 1200V | 187A705H15 |
| C7 CAPACITOR | 2200 PF 3000V | 203C872H17 |
| L102 POT CORE | | 6708133G04 |
| L103 POT CORE | | 6708133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 2928526G04 |
| T4 TRANSFORMER | | 2928526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G10,G52**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 82 MMF 500V | 763A209H23 |
| C2 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C4 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C5 CAPACITOR | 3000 MMF 1200V | 187A705H14 |
| C6 CAPACITOR | 500 MMF 1200V | 187A705H09 |
| C7 CAPACITOR | 3500 PF 3000V | 203C872H23 |
| L102 POT CORE | | 6708133G04 |
| L103 POT CORE | | 6708133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 2928526G04 |
| T4 TRANSFORMER | | 2928526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G11,G53**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C2 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C5 CAPACITOR | 3000 MMF 1200V | 187A7C5H14 |
| C7 CAPACITOR | 3100 PF 3000V | 203C872H21 |
| L102 POT CORE | | 6708133G04 |
| L103 POT CORE | | 6708133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 2928526G04 |
| T4 TRANSFORMER | | 2928526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G12,G54**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C2 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C5 CAPACITOR | 300 MMF 1200V | 187A705H06 |
| C6 CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C7 CAPACITOR | 2800 PF 3000V | 203C872H20 |
| L102 POT CORE | | 6708133G04 |
| L103 POT CORE | | 6708133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 2928526G04 |
| T4 TRANSFORMER | | 2928526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G13,G55

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C2 CAPACITOR | 100 MMF 500V | 762A757H01 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 36 MMF 500V | 763A209H14 |
| C5 CAPACITOR | 2500 MMF1200V | 187A705H13 |
| C7 CAPACITOR | 2500 PF 3000V | 203C872H19 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G14,G56

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 360 MMF 500V | 762A757H14 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 820 MMF 500V | 762A757H22 |
| C4 CAPACITOR | 100 MMF 500V | 762A757H01 |
| C5 CAPACITOR | 200 MMF1200V | 187A705H04 |
| C6 CAPACITOR | 2000 MMF1200V | 187A705H12 |
| C7 CAPACITOR | 2200 PF 3000V | 203C872H17 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G15,G57

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 820 MMF 500V | 762A757H22 |
| C5 CAPACITOR | 1500 MMF 1200V | 187A705H11 |
| C7 CAPACITOR | 2000 PF 3000V | 203C872H15 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G16,G58

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 130 MMF 500V | 762A757H07 |
| C4 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C5 CAPACITOR | 300 MMF1200V | 187A705H06 |
| C6 CAPACITOR | 1500 MMF1200V | 187A705H11 |
| C7 CAPACITOR | 1800 PF 3000V | 203C872H13 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G17,G59

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C3 CAPACITOR | 270 MMF 500V | 762A757H12 |
| C4 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C5 CAPACITOR | 4000 MMF1200V | 187A705H15 |
| C7 CAPACITOR | 2400 PF 3000V | 203C872H18 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G18,G60

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C2 CAPACITOR | 360 MMF 500V | 762A757H14 |
| C3 CAPACITOR | 82 MMF 500V | 763A209H23 |
| C4 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C5 CAPACITOR | 4000 MMF1200V | 187A705H15 |
| C7 CAPACITOR | 2100 PF 3000V | 203C872H16 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 167A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G19,G61

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C2 CAPACITOR | 200 MMF 500V | 762A757H11 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C5 CAPACITOR | 3000 MMF1200V | 187A705H14 |
| C6 CAPACITOR | 500 MMF1200V | 187A705H09 |
| C7 CAPACITOR | 1900 PF 3000V | 203C872H14 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G20,G62

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C2 CAPACITOR | 82 MMF 500V | 763A209H23 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C5 CAPACITOR | 3000 MMF1200V | 187A705H14 |
| C7 CAPACITOR | 1700 PF 3000V | 203C872H12 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G21,G63

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 360 MMF 500V | 762A757H14 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 130 MMF 500V | 762A757H07 |
| C5 CAPACITOR | 2500 MMF1200V | 187A705H13 |
| C7 CAPACITOR | 1500 PF 3000V | 203C872H11 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G22,G64

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C5 CAPACITOR | 2500 MMF1200V | 187A705H13 |
| C7 CAPACITOR | 1300 PF 3000V | 203C872H10 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G23,G65

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 150 MMF 500V | 861A846H25 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 62 MMF 500V | 763A209H20 |
| C4 CAPACITOR | 820 MMF 500V | 762A757H22 |
| C5 CAPACITOR | 200 MMF 1200V | 187A705H04 |
| C6 CAPACITOR | 2000 MMF1200V | 187A705H12 |
| C7 CAPACITOR | 1100 PF 3000V | 203C872H08 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G24,G66

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 56 MMF 500V | 763A209H19 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C4 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C6 CAPACITOR | 2000 MMF 1200V | 187A705H12 |
| C7 CAPACITOR | 1000 PF 3000V | 203C872H07 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G25,G67

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C2 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C3 CAPACITOR | 82 MMF 500V | 763A209H23 |
| C4 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C5 CAPACITOR | 200 MMF 1200V | 187A705H04 |
| C6 CAPACITOR | 1500 MMF1200V | 187A705H11 |
| C7 CAPACITOR | 900 PF 3000V | 203C872H06 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G26,G68

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 270 MMF 500V | 762A757H12 |
| C2 CAPACITOR | 270 MMF 500V | 762A757H12 |
| C4 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C5 CAPACITOR | 1500 MMF 1200V | 187A705H11 |
| C7 CAPACITOR | 800 PF 3000V | 203C872H05 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 11W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G27,G69

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C2 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C3 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C4 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C5 CAPACITOR | 400 MMF 1200V | 187A705H08 |
| C6 CAPACITOR | 1500 MMF 1200V | 187A705H11 |
| C7 CAPACITOR | 1100 PF 3000V | 203C872H08 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G28,G70

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 180 MMF500V | 762A757H10 |
| C2 CAPACITOR | 250 MMF500V | 861A846H11 |
| C3 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C4 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C5 CAPACITOR | 200 MMF 1200V | 187A705H04 |
| C6 CAPACITOR | 1500 MMF1200V | 187A705H11 |
| C7 CAPACITOR | 1000 PF 3000V | 203C872H07 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 166A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G29,G71

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C2 CAPACITOR | 200 MMF 500V | 762A757H11 |
| C3 CAPACITOR | 200 MMF 500V | 762A757H11 |
| C4 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C5 CAPACITOR | 1500 MMF 1200V | 187A705H11 |
| C7 CAPACITOR | 900 PF 3000V | 203C872H06 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 186A317H01 |
| R7 RESISTOR | 15K 10% 2W | 167A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G30,G72

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 82 MMF 500V | 763A209H23 |
| C2 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C3 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C5 CAPACITOR | 400 MMF1200V | 137A705H08 |
| C6 CAPACITOR | 1000 MMF1200V | 137A705H10 |
| C7 CAPACITOR | 750 PF 3000V | 203C872H04 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G31,G73

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C3 CAPACITOR | 150 MMF500V | 861A846H25 |
| C4 CAPACITOR | 200 MMF 500V | 762A757H11 |
| C5 CAPACITOR | 200 MMF 1200V | 187A705H04 |
| C6 CAPACITOR | 1000 MMF 1200V | 187A705H10 |
| C7 CAPACITOR | 650 PF 3000V | 203C872H02 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 186A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 1461C40G32,G74

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 20 MMF 500V | 763A209H07 |
| C2 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C3 CAPACITOR | 130 MMF 500V | 762A757H07 |
| C4 CAPACITOR | 180 MMF500V | 762A757H10 |
| C6 CAPACITOR | 1000 MMF 1200V | 187A705H10 |
| C7 CAPACITOR | 600 PF 3000V | 203C872H02 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G33, G75**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 763A209H19 |
| C2 CAPACITOR | MMF 500V | 762A757H12 |
| C3 CAPACITOR | MMF 500 V | 762A757H11 |
| C4 CAPACITOR | MMF 500V | 763A209H12 |
| C5 CAPACITOR | MMF 1200 V | 187A705H04 |
| C6 CAPACITOR | MMF 1200 V | 187A705H09 |
| C7 CAPACITOR | PF 3000V | 203C872H09 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G34, G76**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C2 CAPACITOR | MMF 500V | 187A584H09 |
| C3 CAPACITOR | MMF 500V | 762A757H11 |
| C4 CAPACITOR | MMF 500V | 763A209H07 |
| C5 CAPACITOR | MMF 1200 V | 187A705H04 |
| C6 CAPACITOR | MMF 1200 V | 187A705H09 |
| C7 CAPACITOR | PF 3000V | 203C872H09 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G35, G77**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 861A846H25 |
| C2 CAPACITOR | MMF 500V | 861A846H25 |
| C3 CAPACITOR | MMF 500 V | 861A846H25 |
| C4 CAPACITOR | MMF 500V | 763A209H19 |
| C5 CAPACITOR | MMF 1200 V | 187A705H08 |
| C6 CAPACITOR | MMF 1200 V | 187A705H04 |
| C7 CAPACITOR | PF 3000V | 203C872H08 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G36, G78**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 763A209H20 |
| C2 CAPACITOR | MMF 500V | 762A757H11 |
| C3 CAPACITOR | MMF 500V | 763A209H20 |
| C4 CAPACITOR | MMF 500V | 762A757H07 |
| C5 CAPACITOR | MMF 1200 V | 187A705H08 |
| C6 CAPACITOR | MMF 1200 V | 187A705H04 |
| C7 CAPACITOR | PF 3000 V | 203C872H08 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G37, G79**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C2 CAPACITOR | MMF 500V | 861A846H11 |
| C3 CAPACITOR | MMF 500V | 861A846H25 |
| C4 CAPACITOR | MMF 500V | 763A209H07 |
| C6 CAPACITOR | MMF 1200 V | 187A705H09 |
| C7 CAPACITOR | PF 3000V | 203C872H07 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G38, G80**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 763A209H12 |
| C2 CAPACITOR | MMF 500V | 762A757H11 |
| C3 CAPACITOR | MMF 500V | 762A757H07 |
| C4 CAPACITOR | MMF 500V | 763A209H12 |
| C6 CAPACITOR | MMF 1200 V | 187A705H09 |
| C7 CAPACITOR | PF 3000V | 203C872H06 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G39, G81**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 763A209H19 |
| C2 CAPACITOR | MMF 500V | 861A846H25 |
| C3 CAPACITOR | MMF 500V | 763A209H20 |
| C4 CAPACITOR | MMF 500V | 763A209H23 |
| C5 CAPACITOR | MMF 1200 V | 187A705H08 |
| C7 CAPACITOR | PF 3000V | 203C872H05 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G40, G82**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 763A209H14 |
| C2 CAPACITOR | MMF 500V | 861A846H25 |
| C3 CAPACITOR | MMF 500 V | 762A757H01 |
| C4 CAPACITOR | MMF 500V | 763A209H12 |
| C5 CAPACITOR | MMF 1200 V | 187A705H08 |
| C7 CAPACITOR | PF 3000V | 203C872H03 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G41, G83**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 763A209H07 |
| C2 CAPACITOR | MMF 500V | 861A846H25 |
| C3 CAPACITOR | MMF 500V | 762A757H01 |
| C4 CAPACITOR | MMF 500V | 763A209H07 |
| C5 CAPACITOR | MMF 1200 V | 187A705H08 |
| C7 CAPACITOR | PF 3000V | 203C872H02 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G42, G84**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C2 CAPACITOR | MMF 500V | 861A846H25 |
| C3 CAPACITOR | MMF 500V | 763A209H23 |
| C4 CAPACITOR | MMF 500V | 763A209H12 |
| C5 CAPACITOR | MMF 1200 V | 187A705H08 |
| C7 CAPACITOR | PF 3000V | 203C872H01 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

Sub. 1
1461C89

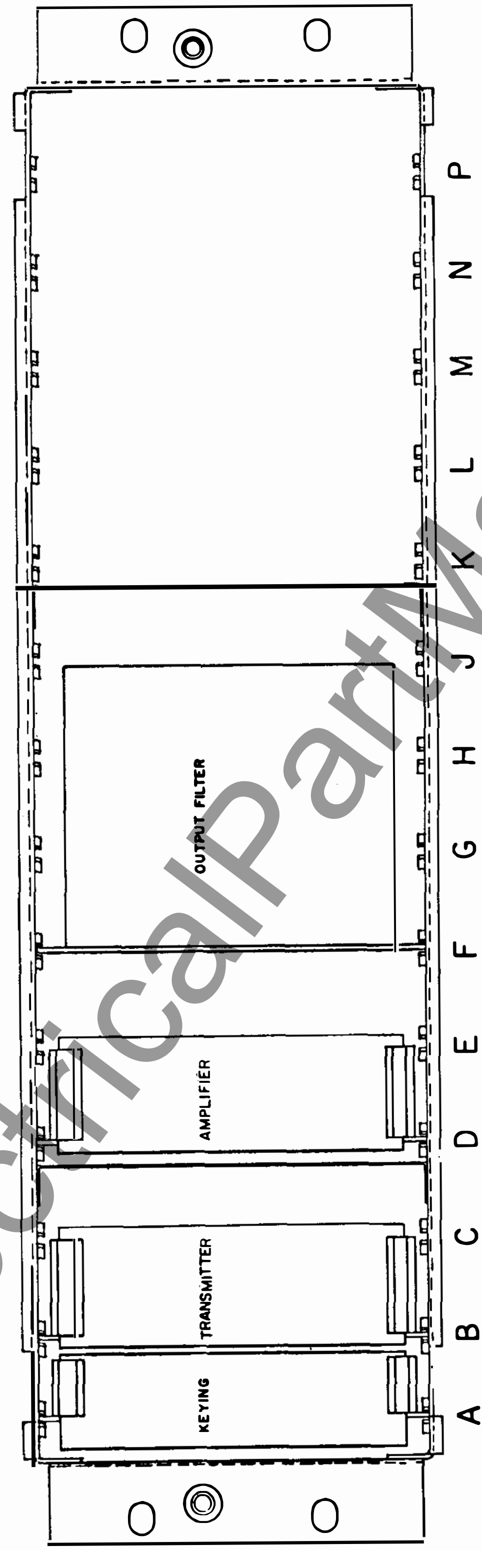



Fig. 15 Module Location

INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

## TYPE TCF-10 POWER LINE CARRIER FREQUENCY-SHIFT TRANSMITTER EQUIPMENT 1 WATT/10 WATT FOR KEYED AND VOICE APPLICATIONS

**CAUTION**: It is recommended that the user of this equipment become thoroughly familiar 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 TCF-10 carrier transmitter equipment provides for the transmission of either of two closely controlled discrete frequencies, both within a narrow-band channel, over high-voltage transmission lines. The center frequency of the channel can vary from 30 to 300 KHz in 0.5 KHz steps. The two frequencies transmitted are separated by 200 Hz, one being at center frequency (fc) plus 100 Hz and the others at center frequency minus 100 Hz. The higher frequency, termed the Guard frequency, is transmitted continuously when conditions are normal. It indicates at the receiving end of the line that the channel is operative and it also serves to prevent false operation of the receiver by line noise. The lower frequency, termed the Trip frequency, is transmitted as a signal that an operation (such as tripping a circuit breaker) should be performed at the receiving end of the line.

When frequency shift carrier is used in protective relaying applications, it is recommended that the trip frequency be transmitted at a higher power level to increase reliability of the system under conditions of abnormally high channel losses or line noise. The frequency is shifted from Guard to Trip by the closing of a protective relay contact, and the same contact also shifts the transmitter from a 1-watt to a 10-watt output level.

When electro-mechanical relays are used for keying from guard to trip frequency, the contact used is connected to the high voltage input of a buffering keying board. This board buffers the input so that random noise does not key the circuits. When solid state relays are used, the 20 V D.C. voltage used for keying is connected to the low voltage input of the buffering keying board.

### CONSTRUCTION

The 1 watt/10 watt TCF-10 transmitter unit is mounted on a standard 19-inch wide chassis 5 1/4 inches (3 rack units) high with edge slots for mounting on a standard relay rack. Fuses, a pilot light, and a power switch are accessible from the front of the panel. See Fig. 6. All of the circuitry that is suitable for printed circuit board mounting is on four such boards, as shown in Fig. 13 The components mounted on each printed circuit board or other sub-assembly are shown enclosed by dotted lines on the internal schematic. Fig. 2. The location of components on the four printed circuit boards are shown on separate illustrations, Fig. 3, 4, 5, & 6.

External connections to the assembly are made through a 36-circuit receptacle, J3. The r.f. output connection to the assembly is made through a coaxial cable jack, J2.



NEW INFORMATION

EFFECTIVE MARCH 1979

A module extender test card, S#1447C86G01 is available to facilitate testing.

## OPERATION

The transmitter is made up of four main stages and two filters. The stages include two crystal oscillators operating at frequencies that differ by the desired channel frequency, a mixer and buffer amplifier, a driver stage and a power amplifier. One filter is located between the driver and the power amplifier and the second filter removes harmonics that may be generated by distortion in the power amplifier.

A single crystal designed for oscillation in the 30 KHz to 300 KHz range cannot be forced to oscillate away from its natural frequency by as much as ± 100 Hz. In order to obtain this desired frequency shift, it is necessary to use crystals in the 2 MHz range. The crystals are Y1 and Y2 of Fig.10 The frequency of Y2 is 2.00 MHz when operated with a specified amount of series capacity, and the frequency of Y1 is 2.00 MHz plus the channel frequency, or 2.03 MHz. Capacitor C55 and crystal Y2 in series are connected between the positive side of the supply voltage and the base of transistor Q51, which operates in the emitter follower mode. The emitter is coupled to the base through C57, and with Y2 removed the base of Q51 would be held at appoximately the midpoint of the supply voltage by R51 and R52. The crystal serves as a series-resonant circuit with very high inductance and low capacitance. The circuit can be made to oscillate at other than the natural frequency of the crystal by varying the series capacitor, C55. Increasing C55 will lower the frequency of oscillations and reducing C55 will raise the frequency.

Crystal Y1 is connected in a circuit that is similar except for the addition of C53 and diodes D51 and D52. By adjustment of C52 this circuit is made to oscillate at 100 Hz above its marked frequency. Capacitor C53 is not effective until D51 is biased in the forward direction and becomes conductive. It is biased in the reverse direction until the relay control contact is closed, which places 45 V.D.C. at terminal 3 of the printed circuit board. With D51 conducting, C53 is effectively in parallel with C52, and adjustment of C53 will reduce the frequency by 200 Hz. The crystals taken individually have a greater variation of frequency with temperature than would be acceptable. However, by proper matching of the two crystals, the variation in their difference frequency can be kept within limits that permit holding the frequency stability of the overall transmitter to ±10 Hz over a temperature range of −20 to ± 60° C.

The frequencies produced by the two oscillators are coupled to the base of mixer transistor Q53 through C62 and C63. The sum of the two frequencies is so high that a negligible amount appears on the secondary of transformer T51, but the difference frequency is accepted and amplified by Q53 and Q54.

When the relay control, or keying, contact is closed, it increases the output power from 1 watt to 10 watts as well as changing the frequency from Guard to Trip. This is effected by reducing the emitter resistance of buffer-amplifier transistor Q54. When the keying contact is open, transistor Q55 receives no base current and is non-conducting. Emitter resistor R70 therefore is effectively open-circuited. The level of output power is adjusted to 1 watt by means of R64. When Q55 is made conductive by closing the keying contact. R70 is placed in parallel with R68 and the amount of emitter resistance not bypassed by C66 can be adjusted as required to obtain a 10-watt output level.

As is shown on the Internal Schematic, Fig. 1, the voltage for the keying circuit is obtained from the 45-volt regulated supply in the transmitter, and opening the single power switch deenergizes both the transmitter and the keying circuit.

The driver stage consists of transistors Q56 and Q57 connected in a conventional push-pull circuit with input supplied from the collector of Q54 through transformer T52.

The driver filter, FL101, consists of a series-resonant inductor and capacitor connected between the driver and power amplifier stages by appropriate transformers T1 and T2. This filter greatly improves the waveform of the signal applied to the power amplifier.

The power amplifier uses two series-connected power transistors, Q2 and Q4 operating as a class B push-pull amplifier with single-ended output. Diodes D2 and D4 provide protection for the base-emitter junctions of the power transistors. Zener diodes Z2 and Z4 protect the collector-emitter junctions from surges that might come in from the power line through the coaxial cable.

The output transformer T3 couples the power transistors to the 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 G1 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 T4 matches the filter impedance to coaxial cables of 50, 60, or 70 ohms.

The series resonant circuit composed of L105 and $C_E$ is tuned to the transmitter frequency, and aids in providing resistive termination for the output stage. Jack J102 is mounted on the front panel of the filter module 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, thus providing a reverse impedance that is free of possible "across-the-line" resonances.

The power supply is a series-type transistorized dc voltage regulator which has a very low stand-by current drain when there is no output current demand. The Zener diode Z1 holds a constant base-to-negative voltage on the series-connected power transistor Q1. Depending on the load current, the dc voltage drop through transistor Q1 and resistors R1 and R2 varies to maintain a constant output voltage. Capacitor C3 provides a low carrier-frequency impedance across the dc output voltage. Capacitors C1 and C2 bypass r.f. or transient voltages to ground, thus preventing damage to the transistor circuits.

When keyed for voice by the voice adapter, transistor Q55 is keyed into class A operation so that its conduction can be modulated by the voice input from the voice adapter. Potentiometer R82 is adjusted so that the nominal output of carrier is 3.25 watts (14 volts across 60 ohms). The voice input modulates the carrier through this transistor by varying the amount of conduction of Q55 so that the output power of carrier varies with the voice amplitude following the voice frequency components. Since with Q55 completely non-conducting, R64 has been set to produce a 1-watt output, maximum modulation on the side to shut off Q55 will not result in an output level of less than 1-watt carrier at any time. Also since the output level has been set at 10 watts with Q55 completely conducting by the adjustment of R70, the maximum modulation on the side of turn on of Q55 will not result in a carrier output level of greater than 10 watts at any time. Thus the modulation for voice will not result in the output carrier level dropping below 1 watt and endangering the guard frequency for relaying purposes.

The buffer keying board in addition to providing proper buffering, also contains logic for the proper keying of both frequency and output level in regards to protective relaying operation, voice adapter operation, and 52b contact operation.

It should be remembered that protective relaying operation has first priority. If the protective relay operates and puts a voltage input into any of the three input points labeled carrier auxiliary keying, the transmitter will both frequency shift to trip frequency and full 10 watts output whether voice is called for or not.

The operation of the 52b contact will remove the 10 watt keying output and permit the voice adapter to key to 3.2 Watts output for AM voice modulation. This allows voice modulation on the trip frequency after the 52b contact has operated.

## CHARACTERISTICS

| | |
|---|---|
| Frequency Range | 30-300 kHz |
| Output | 1 watt guard—10 watts trip—3.2 watts voice (into 50 to 70 ohm resistive load) |
| Frequency Stability | ±10 Hz from −20° C to +55° C. |

| | |
|---|---|
| Frequency Spacing | Two-way channel,—See Voice Adapter Instruction Leaflet. |
| Harmonics | Down 55 db (min.) from output level. |
| Input Voltage | 48 or 125 v.d.c. |
| Supply Voltage Variation | 42-56v. for nom. 48v. supply. 105-140v. for nom. 125v. supply. |
| Battery Drain | 0.5 a. guard 48 v.d.c.<br>1.15a. trip |
| | 0.25 a. guard 125 v.d.c.<br>0.5 a. trip |
| Keying Circuit Current | 4 ma. |
| Temperature Range | −20 to +55° C. around chassis. |
| Dimensions | Panel height—5 1/4″ or 3 r.u.<br>Panel width—19″ |
| Weight | 12 lbs. |

## INSTALLATION

The TCF-10 transmitter 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 55° C.

## ADJUSTMENTS

The TCF-10 1W/10W transmitter is shipped with the power output controls R64, R82 and R70, set for outputs of 1 watt, 3.2 watts and 10 watts into a 60 ohm load. If it is desired to check the adjustments or if repairs have made readjustment necessary, the coaxial cable should be disconnected from the assembly terminals and replaced with a 50 to 70 ohm non-inductive 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 T4 output lead to the corresponding tap. Connect an ac vacuum tube voltmeter (VTVM) across the load resistor. Turn power output control R64 to minimum (full counter-clockwise). Turn on the power switch on the panel and note the dc voltage across terminals 5 and 7 of J3. If this is in the range of 42 to 46 volts, rotate R64 clockwise to obtain 4 or 5 volts across the load resistor used. At this point check the adjustment of the series output tuning coil L105 by loosening the knurled shaft-locking nut and rotating 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 used. Then rotate R64 farther clockwise to obtain the correct voltage for 1 watt in the load resistor, as shown in the following table.

Then change to Trip frequency by connecting together terminals 7 and 12 of J3), and rotate R70 until the voltage across the load resistor is as shown in the following table for a 10 watt output. Recheck the adjustment of L105 for maximum output voltage and readjust R70 for a 10 watt output if necessary. Tighten the locking nut on L105. Open the power switch and remove the jumper used to key the transmitter to the 10 watt level. Key for voice by opening connection between terminals 12 and 7 of J3. This is done by removing handset from telephone hook switch of corresponding voice adapter.

Turn the power back on Adjust R82 for a 3.2 watt output across the load resistor (14V across 60 ohms). Open the power switch, remove the jumper, remove the load resistor, and reconnect the coaxial cable circuit to the transmitter.

| T106 TAP | VOLTAGE FOR 1 WATT OUTPUT | 3.2 WATTS OUTPUT | 10 WATTS OUTPUT |
|---|---|---|---|
| 50 | 7.1 | 12.7 | 22.4 |
| 60 | 7.8 | 14 | 24.5 |
| 70 | 8.4 | 15 | 26.5 |

Follow the procedure outlined in the line tuner instructions for its adjustment.

Normally the output filter (FL102) will require no readjustment except as noted above. 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 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.

The operating frequencies of crystals Y1 and Y2 have been carefully adjusted at the factory and good stability can be expected. If it is desired to check the frequencies of the individual crystals, this can be done by turning the matched pair 180° and inserting a crystal in its proper socket with the other crystal unconnected. A sensitive frequency counter with a range of at least 2.2 MHz can be connected from TP51 to TP54. (Connection to TP54 rather than to TP53 provides a better signal to the counter and avoids some error from the effect of the counter input capacitance on the oscillator circuit.) While measurement of the oscillator crystals individually is necessary for the initial adjustment of the oscillators, generally any subsequent checks may be made with a lower range counter connected at the transmitter output. If any minor adjustment of the Guard and Trip frequencies should be needed, the Guard adjustment should be made with capacitor C52 and the Trip Adjustment with C53.

## MAINTENANCE

Periodic checks of the transmitter Guard and Trip power outputs will detect 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 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 values are given in the following tables. Voltages should be measured with a VTVM. Readings may vary as much as ±20%.

## TABLE I
## TRANSMITTER DC MEASUREMENTS

Note: All voltages are positive with respect to Neg. 45 V. TP51). All voltages read with dc VTVM.

| Test Point | Voltage at 1 Watt Output | | Voltage at 10 Watts Output | | Voltage at 3.2 Watts Output |
|---|---|---|---|---|---|
| | 48V | 125V | 48V | 125V | (For Voice) |
| TP52 | 20 | 20 | 20 | 20 | 20 |
| TP53 | 5.4 | 5.4 | 5.4 | 5.4 | 5.4 |
| TP54 | 3.4 | 3.4 | 3.4 | 3.4 | 3.4 |
| TP55 | 21 | 21 | 18.5 | 18.5 | — |
| TP56 | 21 | 21 | 18.5 | 18.5 | — |
| TP57 | *<1.0 | 1.0 | *<1.0 | 1.0 | — |
| TP58 | 44.3 | 100 | 44.1 | 100 | — |
| TP59 | *<1.0 | 1.0 | *<1.0 | 1.0 | — |
| TERM 1 (POWER | 0 | 0 | 0 | 0 | — |
| TERM 17 AMP | 21 ± 2 | 50V | 21 ± 2 | 50V | — |
| TERM 31 MODULE) | 44.3 | 100 | 44.0 | 100 | — |

## TABLE II
## TRANSMITTER RF MEASUREMENTS

Note: Voltages taken with transmitter set to indicated output across 60 ohms. These voltages subject to variations, depending upon frequency and transistor characteristics. T51 − 3 = Terminal 3 of transformer T51. Other transformer terminals identified similarly. All read with ac VTVM.

| Test Point | | Voltage at 1 watt Output | Voltage at 10 watts Output | Voltage at 3.2 Watts Output (For Voice) |
|---|---|---|---|---|
| TP54 to TP51 | | 0.015 – 0.03 | 0.015 – 0.03 | — |
| TP57 to TP51 | | 0.05 – 0.09 | 0.3 – 1.2 | — |
| TP59 to TP51 | | 0.05 – 0.09 | 0.3 – 1.2 | — |
| T1-1 to TP51 | | 1.65 | 5.6 | — |
| T1-3 to TP51 | | 1.45 | 4.9 | — |
| T1-4 to Gnd. | | .6 | 2.0 | — |
| T2-1 to Gnd. | *POWER* | .57 | 1.85 | — |
| TERM 1 TERM 17 | *AMP* | 5.2 | 17.0 | — |
| TERM 17 TERM 31 | *MODULE* | 5.2 | 17.0 | — |
| T3-4 to Gnd. | | 35 | 112 | — |
| T4-2 to Gnd. | | 31 | 110 | — |
| TP109 to Gnd. | | 9.8 | 31 | — |
| J102 to Gnd. | | 7.8 | 24.5 | 14 |

## CONVERSION OF TRANSMITTER FOR CHANGED CHANNEL FREQUENCY

The parts required for converting a 1W/10W TCF-10 transmitter for operation on a different channel frequency consist of a pair of matched crystals for the new channel frequency, new capacitors C103 and C104 on the power amplifier circuit board if the old and new frequencies are not in the same frequency group (see table on internal schematic drawing) and, in general, new or modified filters FL101 and FL102. Inductors L101, L102 and L103 in these filters are adjustable over a limited range, but forty-two combinations of capacitors and inductors are required to cover the frequency range of 30 to 300 kHz. The widths of the frequency groups vary from 1.5 kHz at the low end of the channel frequency range to 13 kHz at the upper end. A particular assembly can be adjusted over a somewhat wider range than the width of its assigned group since some overlap is necessary to allow for component tolerances. The nominal kHz adjustment ranges of the group are:

| | | | |
|---|---|---|---|
| 30.0-31.5 | 61.0-64.0 | 113.0-119.5 | 207.1-214.0 |
| 32.0-33.5 | 64.5-68.0 | 120.0-127.0 | 214.1-222.0 |
| 34.0-36.0 | 68.5-72.0 | 127.5-135.0 | 222.1-230.0 |
| 36.5-38.5 | 72.5-76.0 | 135.5-143.0 | 230.1-240.0 |
| 39.0-41.0 | 76.5-80.0 | 143.5-151.0 | 240.1-250.0 |
| 41.5-44.0 | 80.5-84.5 | 151.5-159.5 | 250.1-262.0 |
| 44.5-47.0 | 85.0-89.0 | 160.0-169.5 | 262.1-274.0 |
| 47.5-50.0 | 89.5-94.5 | 170.0-180.0 | 284.1-287.0 |
| 50.5-53.5 | 95.0-100.0 | 180.5-191.5 | 287.1-300.0 |
| 54.0-57.0 | 100.5-106.0 | 192.0-200.0 | |
| 57.5-60.5 | 106.5-112.5 | 200.1-207.0 | |

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

A signal generator, a frequency counter and a vacuum tube voltmeter are required for readjustment of FL101. The signal generator and the counter should be connected across terminals 4 and 5 of transformer T1 and the voltmeter across terminals 1 and 2 of transformer T2. The signal generator should be set at the channel center frequency and at 2 to 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 T3, and a 500 ohm resistor and a VTVM to the terminals of protective gap G1. 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.

After the new pair of matched crystals have been adjusted, as described under "ADJUSTMENTS", the transmitter can be operated with a 50 to 70 ohm load (depending on which tap of T4 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 same section.

If a frequency-sensitive voltmeter is available, the 2nd and 3rd harmonic traps may be adjusted 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 the tuning dial and db range switch, obtain a maximum on-scale reading of the 2nd harmonic. Then vary the core position of L102 until a minimum voltmeter reading is obtained. Similarily, tune the voltmeter to the third harmonic and adjust L103 for minimum voltmeter reading. Although the transmitter frequency will differ from the channel center frequency by 100 Hz, the effect of this difference on the adjustment of the harmonic traps will be negligible. It should be noted that the true magnitude of the harmonics cannot be measured in this manner because of the preponderance of the fundamental frequency at the voltmeter terminals. Accurate measurement of the harmonics requires use of a filter between TP109 and the voltmeter that provides high rejection of the fundamental. The insertion looses of this filter for the 2nd and 3rd harmonics must be measured and taken into account.

## RECOMMENDED TEST EQUIPMENT

I. Minimum Test Equipment for Installation.
   a. 60-ohm 10-watt non-inductive resistor.
   b. AC vacuum Tube Voltmeter (VTVM) or equivalent. Voltage range 0.003 to 30 volts, frequency range 60 hz to 330 kHz; impedance 7.5 megohms.
   c. DC Vacuum Tube Voltmeter (VTVM) or equivalent.
   d. Module Extender Test Card S 1447C86G01

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 900 kHz
   c. Oscilloscope
   d. Frequency counter
   e. Ohmmeter
   f. Capacitor checker.

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 and identify the part by its designation on the Internal Schematic drawing.

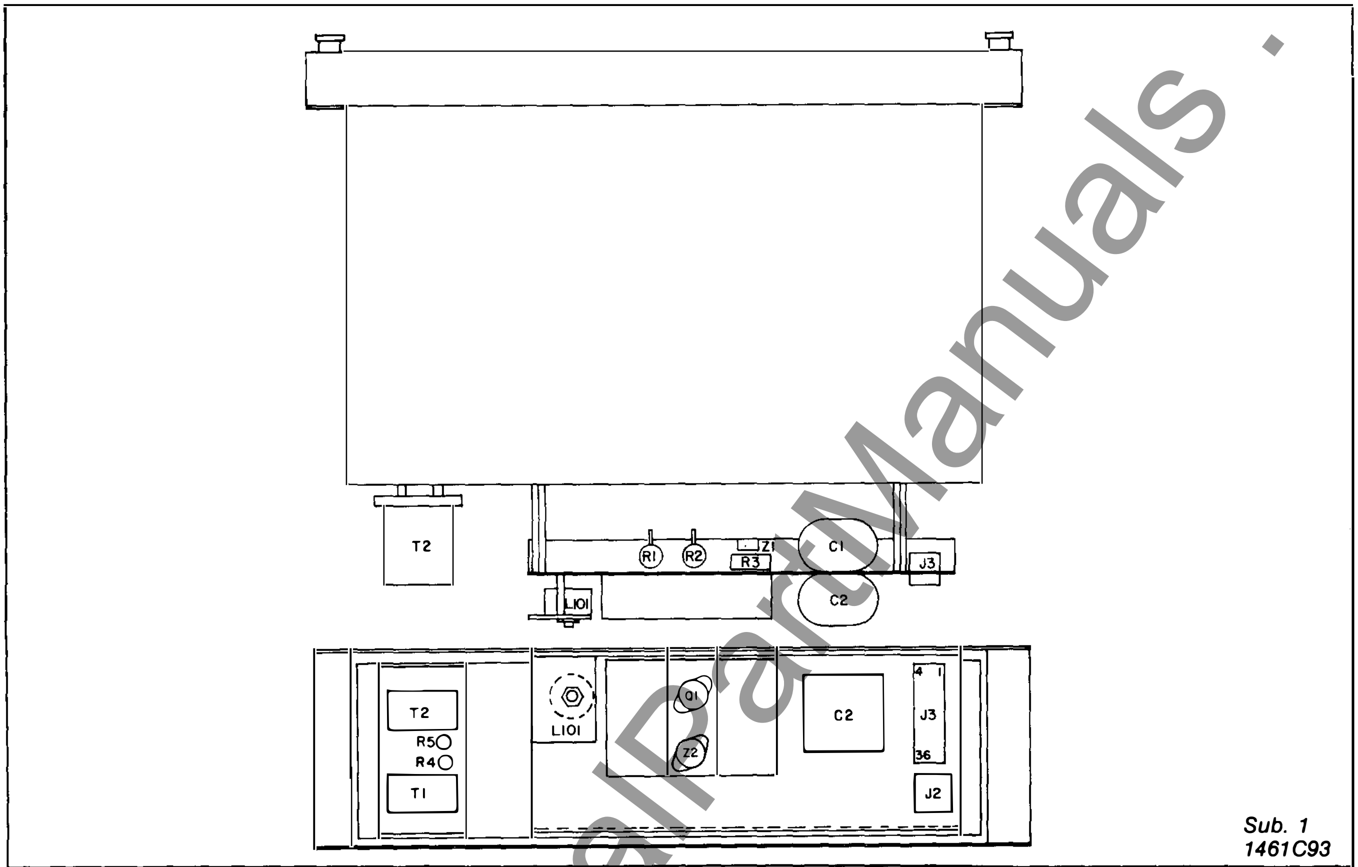
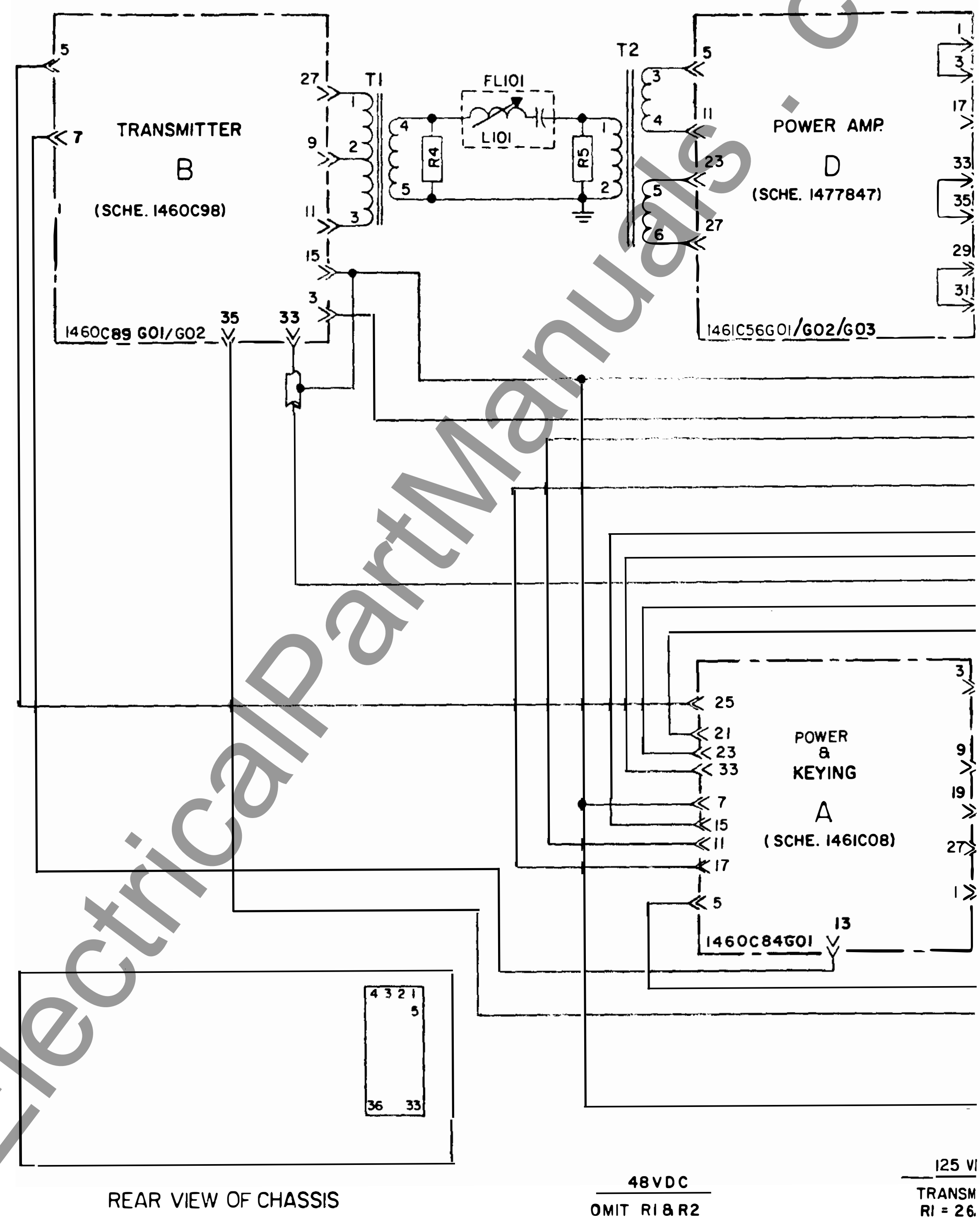



*Fig. 1. Component Location of Assembly*




48VDC

OMIT R1 & R2

R3 = 300 Ω (762A679H25)

Z1 = IN3035B(188A302H08)

OMIT Z2

TRANSMITTER BOARD 1460C89G01

125 V

TRANSM

R1 = 26.

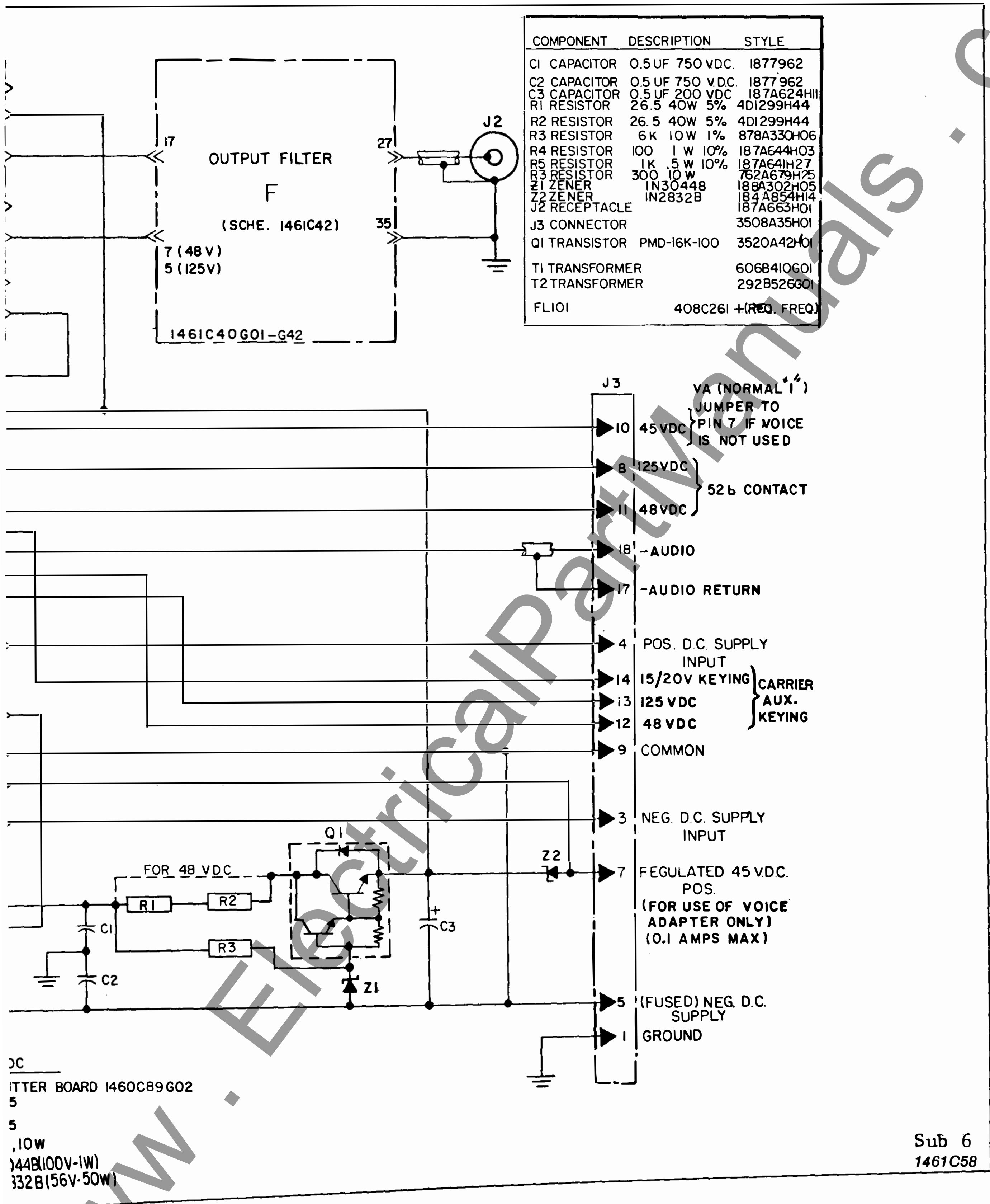
R2 = 26.

R3 = 6K

Z1 = IN30

Z2 = IN2

*Fig. 2. Internal Schematic of Transmitte*




| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 0.5 UF 750 V.D.C. | 1877962 |
| C2 CAPACITOR | 0.5 UF 750 V.D.C. | 1877962 |
| C3 CAPACITOR | 0.5 UF 200 VDC | 187A624H11 |
| R1 RESISTOR | 26.5 40W 5% | 4D1299H44 |
| R2 RESISTOR | 26.5 40W 5% | 4D1299H44 |
| R3 RESISTOR | 6K 10W 1% | 878A330H06 |
| R4 RESISTOR | 100 1 W 10% | 187A644H03 |
| R5 RESISTOR | 1K .5 W 10% | 187A641H27 |
| R3 RESISTOR | 300 10 W | 762A679H25 |
| Z1 ZENER | 1N3044B | 188A302H05 |
| Z2 ZENER | 1N2832B | 184A854H14 |
| J2 RECEPTACLE | | 187A663H01 |
| J3 CONNECTOR | | 3508A35H01 |
| Q1 TRANSISTOR | PMD-16K-100 | 3520A42H01 |
| T1 TRANSFORMER | | 606B410G01 |
| T2 TRANSFORMER | | 292B526G01 |
| FL101 | | 408C261 + (REQ. FREQ.) |

r for Keyed and Voice Applications

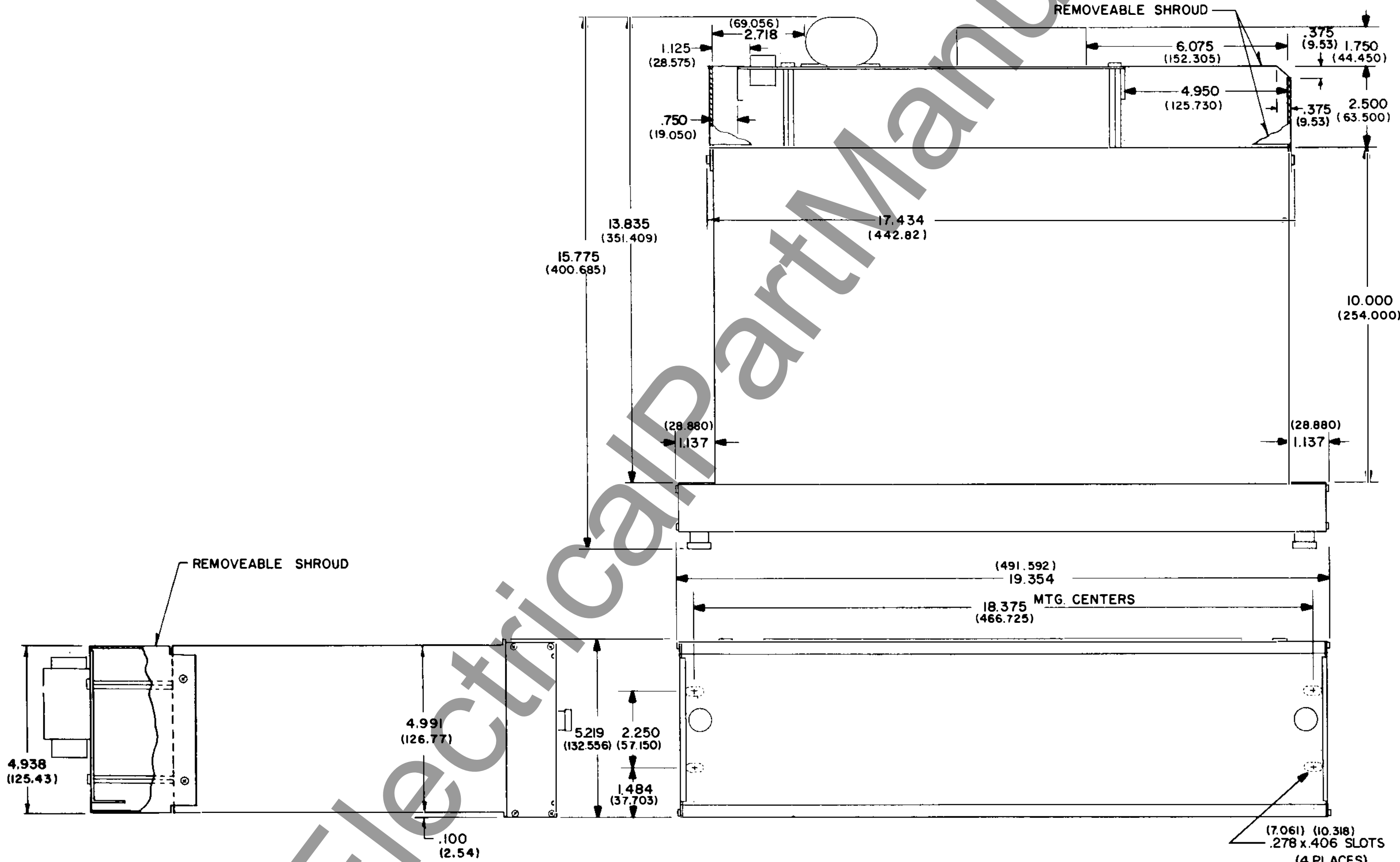



Fig. 7. Outline & Drilling for Transmitter Assembly

Sub 5
1445C80

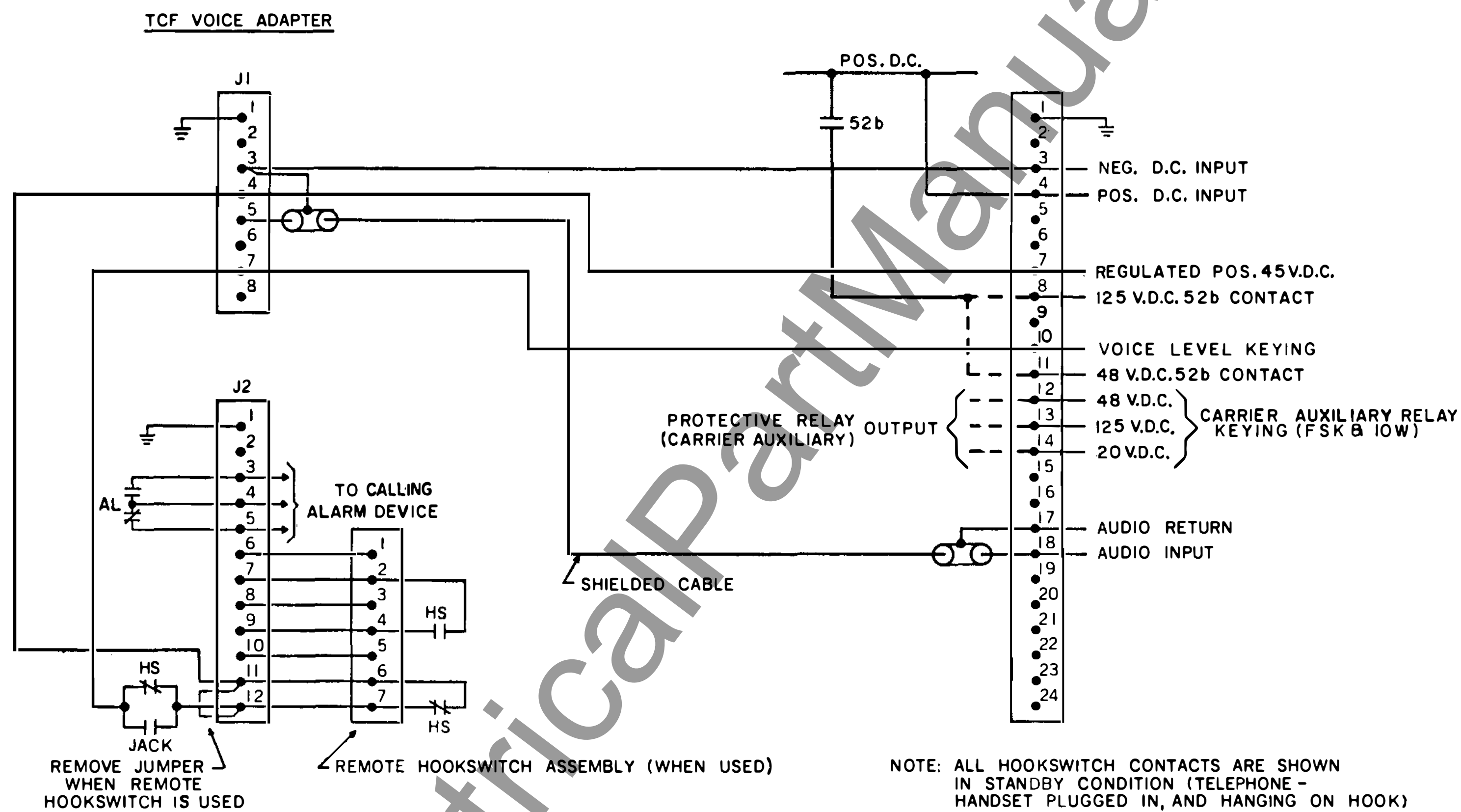
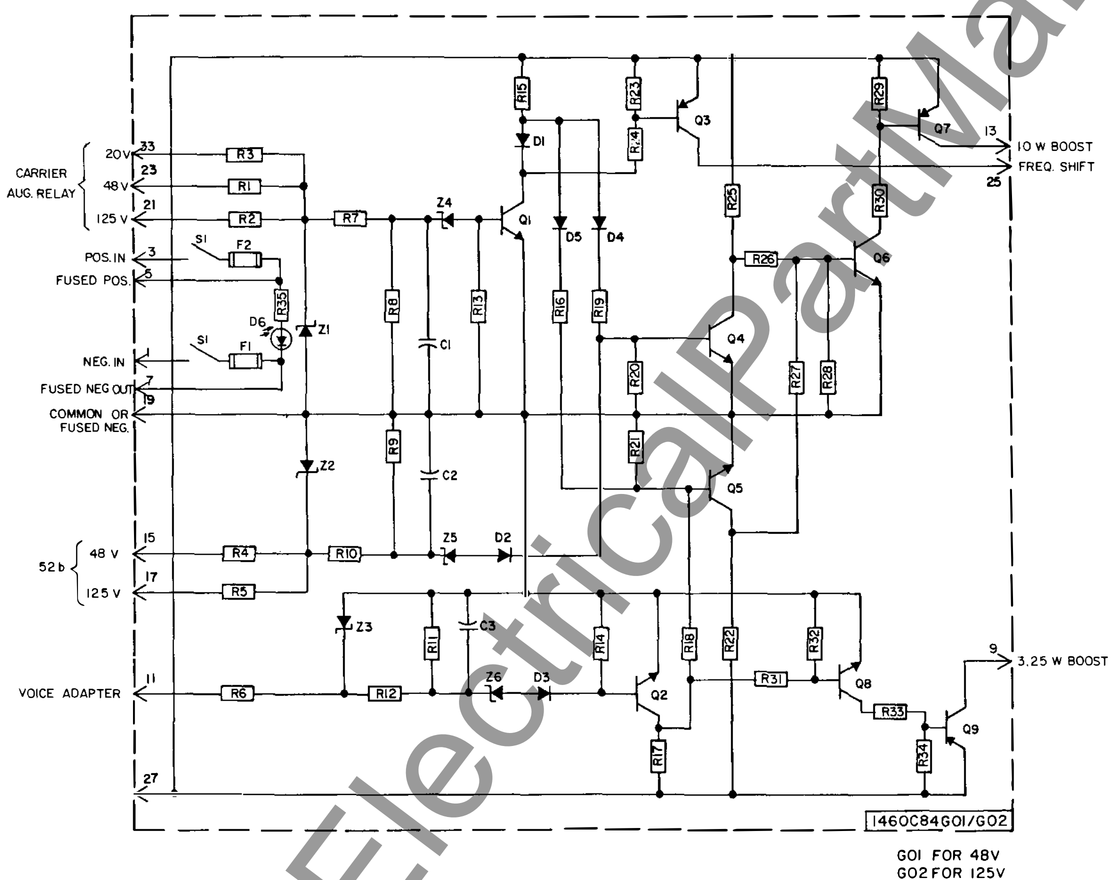



Fig. 8. Voice Adapter, Relaying & Transmitter Interconnections

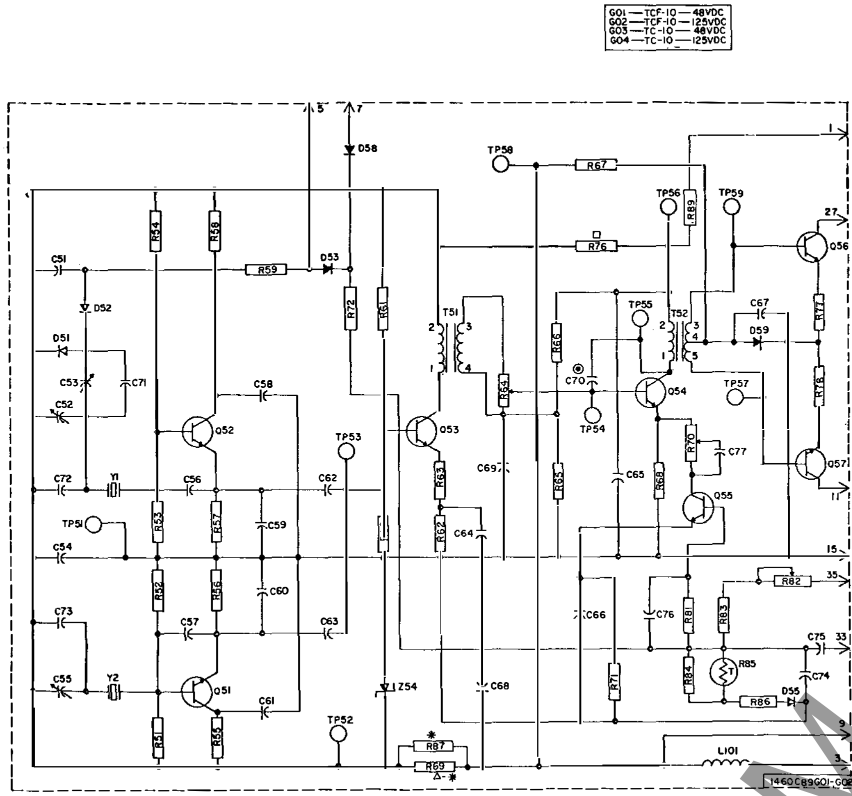
Sub 3
719B386




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C1 | CAPACITOR | .047UF 200V | 849A437H04 |
| C2 | CAPACITOR | .047UF 200V | 849A437H04 |
| C3 | CAPACITOR | .047UF 200V | 849A437H04 |
| D1 | DIODE | 1N457A | 184A855H07 |
| D2 | DIODE | 1N645A | 837A692H03 |
| D3 | DIODE | 1N645A | 837A692H03 |
| D4 | DIODE | 1N457A | 184A855H07 |
| D5 | DIODE | 1N457A | 184A855H07 |
| D6 | DIODE | LED | 3508A22H01 |
| J1 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J2 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| R1 | RESISTOR | 18.0K .50W 2% | 629A531H62 |
| R2 | RESISTOR | 51.0K .50W 2% | 629A531H73 |
| R3 | RESISTOR | 1800.0 .50W 2% | 629A531H38 |
| R4 | RESISTOR | 18.0K .50W 2% | 629A531H62 |
| R5 | RESISTOR | 51.0K .50W 2% | 629A531H73 |
| R6 | RESISTOR | 18.0K .50W 2% | 629A531H62 |
| R7 | RESISTOR | 1500.0 .50W 2% | 629A531H36 |
| R8 | RESISTOR | 6200.0 .50W 2% | 629A531H51 |
| R9 | RESISTOR | 6200.0 .50W 2% | 629A531H51 |
| R10 | RESISTOR | 1500.0 .50W 2% | 629A531H36 |
| R11 | RESISTOR | 6200.0 .50W 2% | 629A531H51 |
| R12 | RESISTOR | 1500.0 .50W 2% | 629A531H36 |
| R13 | RESISTOR | 10.0K .50W 2% | 629A531H56 |
| R14 | RESISTOR | 10.0K .50W 2% | 629A531H56 |
| R15 | RESISTOR | 12.0K .50W 2% | 629A531H58 |
| R16 | RESISTOR | 27.0K .50W 2% | 629A531H66 |
| R17 | RESISTOR | 12.0K .50W 2% | 629A531H58 |
| R18 | RESISTOR | 27.0K .50W 2% | 629A531H66 |
| R19 | RESISTOR | 27.0K .50W 2% | 629A531H66 |
| R20 | RESISTOR | 10.0K .50W 2% | 629A531H56 |
| R21 | RESISTOR | 10.0K .50W 2% | 629A531H56 |
| R22 | RESISTOR | 12.0K .50W 2% | 629A531H58 |
| R23 | RESISTOR | 4.7K .50W 2% | 629A531H48 |
| R24 | RESISTOR | 12.0K .50W 2% | 629A531H58 |
| R25 | RESISTOR | 12.0K .50W 2% | 629A531H58 |
| R26 | RESISTOR | 27.0K .50W 2% | 629A531H66 |
| R27 | RESISTOR | 27.0K .50W 2% | 629A531H66 |
| R28 | RESISTOR | 10.0K .50W 2% | 629A531H56 |
| R29 | RESISTOR | 4.7K .50W 2% | 629A531H48 |
| R30 | RESISTOR | 12.0K .50W 2% | 629A531H58 |
| R31 | RESISTOR | 12.0K .50W 2% | 629A531H58 |
| R32 | RESISTOR | 10.0K .50W 2% | 629A531H56 |
| R33 | RESISTOR | 12.0K .50W 2% | 629A531H58 |
| R34 | RESISTOR | 4.7K .50W 2% | 629A531H48 |
| △ R35 | RESISTOR | 10.0K 3.00W 5% | 763A127H15 |
| Ø R35 | RESISTOR | 27.5K 3.00W 5% | 763A126H60 |
| Q1 | TRANSISTOR | 2N699 | 184A638H19 |
| Q2 | TRANSISTOR | 2N699 | 184A638H19 |
| Q3 | TRANSISTOR | 2N3645 | 849A441H01 |
| Q4 | TRANSISTOR | 2N699 | 184A638H19 |
| Q5 | TRANSISTOR | 2N699 | 184A638H19 |
| Q6 | TRANSISTOR | 2N699 | 184A638H19 |
| Q7 | TRANSISTOR | 2N3645 | 849A441H01 |
| Q8 | TRANSISTOR | 2N699 | 184A638H19 |
| Q9 | TRANSISTOR | 2N3645 | 849A441H01 |
| Z1 | ZENER | 1N3686B 20.0V | 185A212H06 |
| Z2 | ZENER | 1N3686B 20.0V | 185A212H06 |
| Z3 | ZENER | 1N3686B 20.0V | 185A212H06 |
| Z4 | ZENER | 1N957B 6.8V | 186A797H06 |
| Z5 | ZENER | 1N957B 6.8V | 186A797H06 |
| Z6 | ZENER | 1N957B 6.8V | 186A797H06 |
| F1 | FUSE | 1.5 AMP | 183A981H23 |
| F2 | FUSE | 1.5 AMP | 183A981H23 |
| S1 | SWITCH | | 849A249H01 |

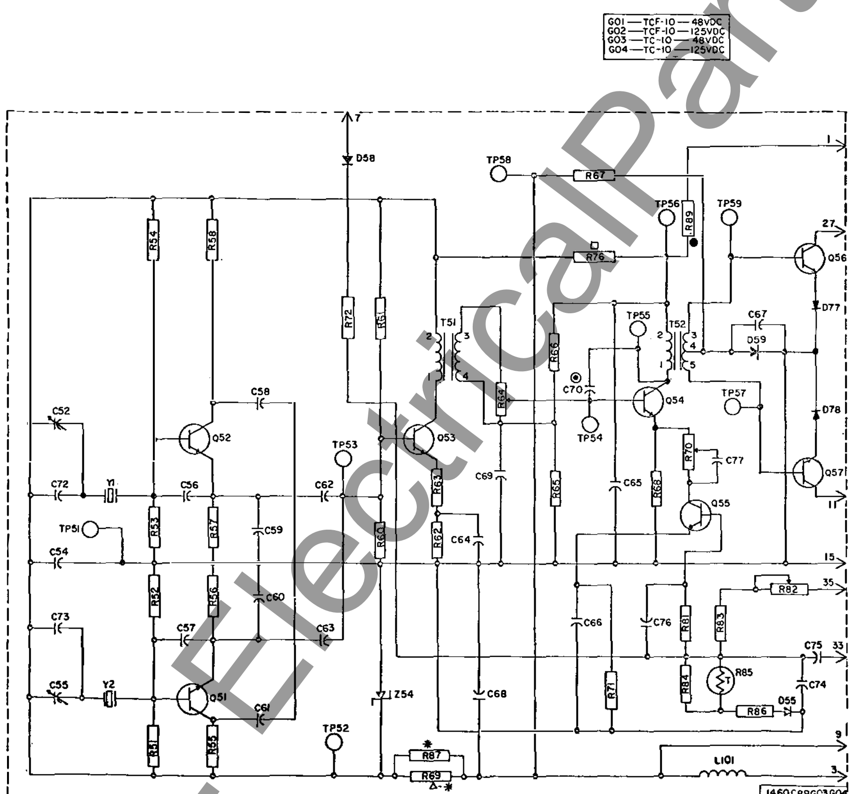
*Fig. 9. Internal Schematic Power & Keying Module*

Sub 2
1461C08




□-FOR GROUPS 1 & 2 ✱-FOR G02 125VDC △-FOR G01 48VDC ⊙-OMIT FOR VOICE ABOVE 60KHZ

| COMPONENT | | DESCRIPTION | STYLE NO. |
| --- | --- | --- | --- |
| C51 | CAPACITOR | 1500.000PF 500V | 762A757H03 |
| C54 | CAPACITOR | .100UF 200V | 187A624H01 |
| C56 | CAPACITOR | 2000.000PF 500V | 187A584H01 |
| C57 | CAPACITOR | 2000.000PF 500V | 187A584H01 |
| C58 | CAPACITOR | .250UF 200V | 187A624H02 |
| C59 | CAPACITOR | 100.000PF 500V | 762A757H01 |
| C60 | CAPACITOR | 100.000PF 500V | 762A757H01 |
| C61 | CAPACITOR | .250UF 200V | 187A624H02 |
| C62 | CAPACITOR | 4700.000PF 500V | 762A757H04 |
| C63 | CAPACITOR | 1000.000PF 500V | 762A757H02 |
| C64 | CAPACITOR | .250UF 200V | 187A624H02 |
| C65 | CAPACITOR | .250UF 200V | 187A624H02 |
| C66 | CAPACITOR | .250UF 200V | 187A624H02 |
| C67 | CAPACITOR | .250UF 200V | 187A624H02 |
| C68 | CAPACITOR | .500UF 200V | 187A624H11 |
| C69 | CAPACITOR | .250UF 200V | 187A624H02 |
| C70 | CAPACITOR | 300.000PF 500V | 187A584H09 |
| C71 | CAPACITOR | 3.000PF 500V | 861A846H03 |
| C72 | CAPACITOR | 3.000PF 500V | 861A846H03 |
| C73 | CAPACITOR | 3.000PF 500V | 861A846H03 |
| C74 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C75 | CAPACITOR | .500UF 200V | 187A624H11 |
| C76 | CAPACITOR | .010UF 600V | 764A278H10 |
| C77 | CAPACITOR | .470UF 200V | 188A669H01 |
| C52 | TRIMMER | 5.5-18PF | 879A834H01 |
| C53 | TRIMMER | 5.5-18PF | 879A834H01 |
| C55 | TRIMMER | 5.5-18PF | 879A834H01 |
| D51 | DIODE | 1N628 | 184A855H12 |
| D52 | DIODE | 1N628 | 184A855H12 |
| D53 | DIODE | 1N628 | 184A855H12 |
| D55 | DIODE | 1N457A | 184A855H07 |
| D58 | DIODE | 1N628 | 184A855H12 |
| D59 | DIODE | 1N4822 | 188A342H11 |
| Y1 | CRYSTAL | MATCHED PAIR | (D-SPEC) |
| Y2 | CRYSTAL | MATCHED PAIR | (D-SPEC) |
| L101 | CHOKE | 50-7 5% | 3500A27H01 |
| -R89 | RESISTOR | 2000.0 .50W 5% | 184A763H34 |
| R64 | POT | 1.0K .12W | 629A430H02 |
| R70 | POT | 1.0K .12W | 629A430H02 |
| R82 | POT | 25.0K | 629A430H09 |
| ✱ R69 | RES | 7K 3W 1% | 763A126H95 |
| ✱ R87 | RES | 7K 3W 1% | 763A126H95 |
| R51 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R52 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R53 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R54 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R55 | RESISTOR | 100.0 .50W 5% | 184A763H03 |
| R56 | RESISTOR | 3600.0 .50W 5% | 184A763H40 |
| R57 | RESISTOR | 3600.0 .50W 5% | 184A763H40 |
| R58 | RESISTOR | 100.0 .50W 5% | 184A763H03 |
| R59 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R60 | RESISTOR | 5600.0 .50W 5% | 184A763H45 |
| R61 | RESISTOR | 15.0K .50W 5% | 184A763H55 |
| R62 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R63 | SENSISTOR | 1.2K .12W 10% | 187A685H03 |
| R65 | RESISTOR | 5600.0 .50W 5% | 184A763H45 |
| R66 | RESISTOR | 15.0K .50W 5% | 184A763H55 |
| □-R67 | RESISTOR | 200K 50W 2% | 629A531H87 |
| R68 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| △-R69 | RESISTOR | 800.0 3.00W 5% | 184A359H36 |
| R71 | RESISTOR | 6.5K .50W 1% | 848A820H27 |
| R72 | RESISTOR | 5600.0 .50W 5% | 184A763H45 |
| R76 | RESISTOR | 2000.0 .50W 5% | 184A763H34 |
| R77 | RESISTOR | 2.7 1.00W 0% | 629A371H24 |
| R78 | RESISTOR | 2.7 1.00W 0% | 629A371H24 |
| R81 | RESISTOR | 1000.0 .50W 1% | 848A819H48 |
| R83 | RESISTOR | 10.0K .50W 1% | 848A820H45 |
| R84 | RESISTOR | 27.0 .50W 5% | 187A290H11 |
| R85 | RESISTOR | 10.0 .00W 10% | 185A211H03 |
| R86 | RESISTOR | 750.0 .50W 1% | 848A819H36 |
| □ T51 | TRANSFORMER | | 606B537G01 |
| □ T52 | TRANSFORMER | | 606B537G03 |
| Q51 | TRANSISTOR | 2N697 | 184A638H18 |
| Q52 | TRANSISTOR | 2N697 | 184A638H18 |
| Q53 | TRANSISTOR | 2N697 | 184A638H18 |
| Q54 | TRANSISTOR | 2N699 | 184A638H19 |
| Q55 | TRANSISTOR | 2N697 | 184A638H18 |
| Q56 | TRANSISTOR | 2N3583 | 849A516H05 |
| Q57 | TRANSISTOR | 2N3583 | 849A516H05 |
| Z54 | ZENER | 1N3686B 20.0V | 185A212H06 |
| T51 | TRANSFORMER | | 606B537G04 |
| T52 | TRANSFORMER | | 606B537G05 |

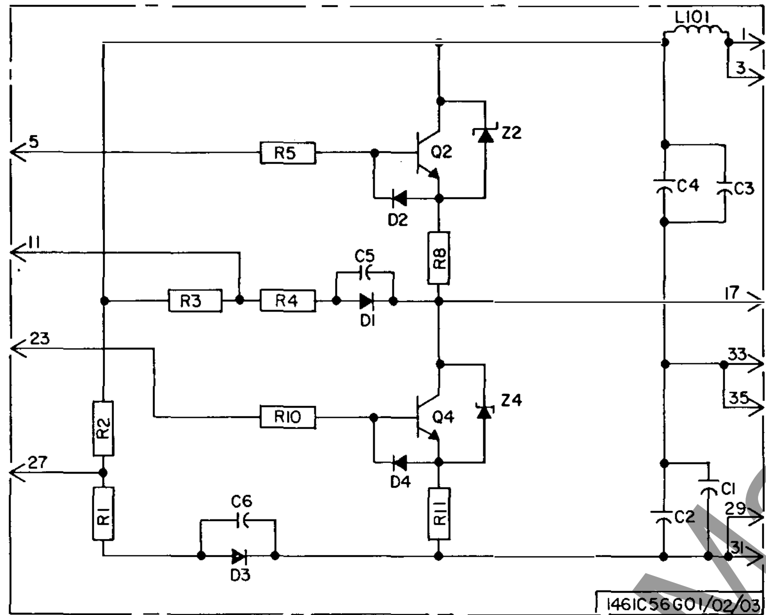



●-FOR GROUPS 3 & 4 (ON-OFF MODE) ✱-FOR G04 (125 V.D.C.) △-FOR G03 (48 V.D.C.) ⊙-OMIT FOR VOICE ABOVE 60KHZ

| COMPONENT | | DESCRIPTION | STYLE NO. |
| --- | --- | --- | --- |
| C54 | CAPACITOR | .100UF 200V | 187A624H01 |
| C56 | CAPACITOR | 2000.000PF 500V | 187A584H01 |
| C57 | CAPACITOR | 2000.000PF 500V | 187A584H01 |
| C58 | CAPACITOR | .250UF 200V | 187A624H02 |
| C59 | CAPACITOR | 100.000PF 500V | 762A757H01 |
| C60 | CAPACITOR | 100.000PF 500V | 762A757H01 |
| C61 | CAPACITOR | .250UF 200V | 187A624H02 |
| C62 | CAPACITOR | 4700.000PF 500V | 762A757H04 |
| C63 | CAPACITOR | 1000.000PF 500V | 762A757H02 |
| C64 | CAPACITOR | .250UF 200V | 187A624H02 |
| C65 | CAPACITOR | .250UF 200V | 187A624H02 |
| C66 | CAPACITOR | .250UF 200V | 187A624H02 |
| C67 | CAPACITOR | .250UF 200V | 187A624H02 |
| C68 | CAPACITOR | .500UF 200V | 187A624H11 |
| C69 | CAPACITOR | .250UF 200V | 187A624H02 |
| C70 | CAPACITOR | 300.000PF 500V | 187A584H09 |
| C72 | CAPACITOR | 3.000PF 500V | 861A846H03 |
| C73 | CAPACITOR | 3.000PF 500V | 861A846H03 |
| C74 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C75 | CAPACITOR | .500UF 200V | 187A624H11 |
| C76 | CAPACITOR | .010UF 600V | 764A278H10 |
| C77 | CAPACITOR | .470UF 200V | 188A669H01 |
| C52 | TRIMMER | 5.5-18PF | 879A834H01 |
| C55 | TRIMMER | 5.5-18PF | 879A834H01 |
| D55 | DIODE | 1N457A | 184A855H07 |
| D58 | DIODE | 1N628 | 184A855H12 |
| D59 | DIODE | 1N4822 | 188A342H11 |
| Y1 | CRYSTAL | MATCHED PAIR | (D-SPEC) |
| Y2 | CRYSTAL | MATCHED PAIR | (D-SPEC) |
| D77 | DIODE | 1N4822 | 188A342H11 |
| D78 | DIODE | 1N4822 | 188A342H11 |
| L101 | CHOKE | 50-7 5% | 3500A27H01 |
| ●-R89 | RESISTOR | 20000 .50W 5% | 184A763H34 |
| R64 | POT | 1.0K .12W | 629A430H02 |
| R70 | POT | 1.0K .12W | 629A430H02 |
| R82 | POT | 25.0K | 629A430H09 |
| ✱ R69 | RES | 7K 3W 1% | 763A126H95 |
| ✱ R87 | RES | 7K 3W 1% | 763A126H95 |
| R51 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R52 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R53 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R54 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R55 | RESISTOR | 100.0 .50W 5% | 184A763H03 |
| R56 | RESISTOR | 3600.0 .50W 5% | 184A763H40 |
| R57 | RESISTOR | 3600.0 .50W 5% | 184A763H40 |
| R58 | RESISTOR | 100.0 .50W 5% | 184A763H03 |
| R60 | RESISTOR | 5600.0 .50W 5% | 184A763H45 |
| R61 | RESISTOR | 15.0K .50W 5% | 184A763H55 |
| R62 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R63 | SENSISTOR | 1.2K .12W 10% | 187A685H03 |
| R65 | RESISTOR | 1.8K .50W 5% | 184A763H33 |
| R66 | RESISTOR | 8.2K .50W 5% | 184A763H49 |
| R67 | RESISTOR | 200K 50W 2% | 629A531H87 |
| R68 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| △-R69 | RESISTOR | 800.0 3.00W 5% | 184A359H36 |
| R71 | RESISTOR | 6.5K .50W 1% | 848A820H27 |
| R72 | RESISTOR | 5600.0 .50W 5% | 184A763H45 |
| R76 | RESISTOR | 2000.0 .50W 5% | 184A763H34 |
| R81 | RESISTOR | 1000.0 .50W 1% | 848A819H48 |
| R83 | RESISTOR | 5K .50W 1% | 848A820H17 |
| R84 | RESISTOR | 27.0 .50W 5% | 187A290H11 |
| R85 | RESISTOR | 10.0 .00W 10% | 185A211H03 |
| R86 | RESISTOR | 750.0 .50W 1% | 848A819H36 |
| T51 | TRANSFORMER | | 606B537G01 |
| T52 | TRANSFORMER | | 606B537G03 |
| Q51 | TRANSISTOR | 2N697 | 184A638H18 |
| Q52 | TRANSISTOR | 2N697 | 184A638H18 |
| Q53 | TRANSISTOR | 2N697 | 184A638H18 |
| Q54 | TRANSISTOR | 2N699 | 184A638H19 |
| Q55 | TRANSISTOR | 2N697 | 184A638H18 |
| Q56 | TRANSISTOR | 2N3583 | 849A516H05 |
| Q57 | TRANSISTOR | 2N3583 | 849A516H05 |
| Z54 | ZENER | 1N3686B 20.0V | 185A212H06 |
| ● T51 | TRANSFORMER | | 606B537G04 |
| ● T52 | TRANSFORMER | | 606B537G05 |

Sub 8
Sheet 1 Sheet 2 1460C98

*Fig. 10. Internal Schematic Transmitter Module*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C1 | CAPACITOR | .470UF 400V | 188A293H01 |
| C2 | CAPACITOR | .470UF 400V | 188A293H01 |
| C3 | CAPACITOR | .470UF 400V | 188A293H01 |
| C4 | CAPACITOR | .470UF 400V | 188A293H01 |
| C5 | CAPACITOR | .250UF 200V | 187A624H02 |
| C6 | CAPACITOR | .250UF 200V | 187A624H02 |
| C2 | CAPACITOR | .220UF 400V | 188A293H02 |
| C4 | CAPACITOR | .220UF 400V | 188A293H02 |
| D1 | DIODE | 1N4822 | 188A342H11 |
| D2 | DIODE | 1N4822 | 188A342H11 |
| D3 | DIODE | 1N4822 | 188A342H11 |
| D4 | DIODE | 1N4822 | 188A342H11 |
| Z2 | ZENER | IN2009C | 184A617H14 |
| Z4 | ZENER | IN2009C | 184A617H14 |
| R1 | RESISTOR | 2.7 1W 0% | 629A371H24 |
| R2 | RESISTOR | 100K 1.00W 5% | 187A644H75 |
| R3 | RESISTOR | 51K 1.00W 5% | 187A643H68 |
| R4 | RESISTOR | 2.7 1W .0% | 629A371H24 |
| R5 | RESISTOR | 10.0 .50W 5% | 187A290H01 |
| R8 | RESISTOR | .27 1.00W 10% | 184A636H18 |
| R10 | RESISTOR | 10.0 .50W 5% | 187A290H01 |
| R11 | RESISTOR | .27 1.00W 10% | 184A636H18 |
| Q2,Q4 | TRANSISTOR | 2N6341 (MATCHED) PAIR | 3508A21H04 |

G01 - FOR 30-70 KHZ USE C1, C2, C3, C4 = .47 UF.
G02- FOR 70-150 KHZ USE C2, C4 = .47 UF OMIT C1 & C3.
G03- FOR 150 TO 300 KHZ USE C2, C4 = .22 UF OMIT C1 & C3.

Sub 6
*1477B47*

*Fig. 11. Internal Schematic Power Amplifier Module*

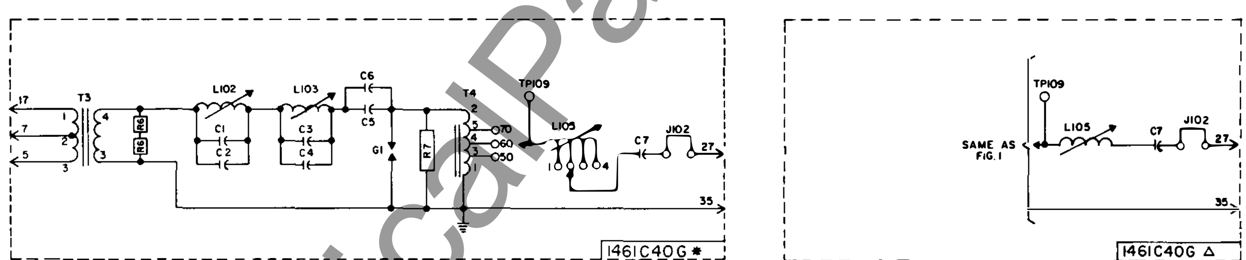



FIG. 1
30 TO 200 KC

* -G01 THRU G32
G43 THRU G74

Δ- G33 THRU G42
G75 THRU G84

FIG. 2 (OTHERWISE SAME AS FIG. 1)
200.1 TO 300 KC.

ASSEMBLY - 1461C40
COMP. LOC. - 1477B28
P.C.B. - 1461C41

Sub 5
*1461C42*

*Fig. 12. Internal Schematic Output Filter Module*

# PARTS LIST

**1461C40G01, G43**

| COMPONENT | | DESCRIPTION | STYLE |
|---|---|---|---|
| C1 | CAPACITOR | 2500 MMF 500V | 861A846H20 |
| C2 | CAPACITOR | 2700 MMF 500V | 861A846H21 |
| C3 | CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C4 | CAPACITOR | 3300 MMF 500V | 187A584H26 |
| C5 | CAPACITOR | 4000 MMF 1200V | 187A705H15 |
| C6 | CAPACITOR | 4000 MMF 1200V | 187A705H15 |
| C7 | CAPACITOR | 7000 PF 3000V | 203C872H29 |
| L102 | POT CORE | | 6708133G04 |
| L103 | POT CORE | | 6708133G06 |
| L105 | COIL | | 292B086G01 |
| T3 | TRANSFORMER | | 292B526G04 |
| T4 | TRANSFORMER | | 292B526G03 |
| R6 | RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 | RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 | LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G02, G44**

| COMPONENT | | DESCRIPTION | STYLE |
|---|---|---|---|
| C1 | CAPACITOR | 2500 MMF 500V | 861A846H20 |
| C2 | CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C3 | CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 | CAPACITOR | 3300 MMF 500V | 187A584H26 |
| C5 | CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C6 | CAPACITOR | 5000 MMF 1200V | 187A705H16 |
| C7 | CAPACITOR | 6000 PF 3000V | 203C872H28 |
| L102 | POT CORE | | 6708133G04 |
| L103 | POT CORE | | 6708133G06 |
| L105 | COIL | | 292B086G01 |
| T3 | TRANSFORMER | | 292B526G04 |
| T4 | TRANSFORMER | | 292B526G03 |
| R6 | RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 | RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 | LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G03, G45**

| COMPONENT | | DESCRIPTION | STYLE |
|---|---|---|---|
| C1 | CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C2 | CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C3 | CAPACITOR | 390 MMF 500V | 762A757H15 |
| C4 | CAPACITOR | 3300 MMF 500V | 187A584H26 |
| C5 | CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C6 | CAPACITOR | 4000 MMF 1200V | 187A705H15 |
| C7 | CAPACITOR | 5500 PF 3000V | 203C872H27 |
| L102 | POT CORE | | 6708133G04 |
| L103 | POT CORE | | 6708133G06 |
| L105 | COIL | | 292B086G01 |
| T3 | TRANSFORMER | | 292B526G04 |
| T4 | TRANSFORMER | | 292B526G03 |
| R6 | RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 | RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 | LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G04, G46**

| COMPONENT | | DESCRIPTION | STYLE |
|---|---|---|---|
| C1 | CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C2 | CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C4 | CAPACITOR | 3300 MMF 500V | 187A584H26 |
| C5 | CAPACITOR | 3000 MMF 1200V | 187A705H14 |
| C6 | CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C7 | CAPACITOR | 5000 PF 3000V | 203C872H26 |
| L102 | POT CORE | | 6708133G04 |
| L103 | POT CORE | | 6708133G06 |
| L105 | COIL | | 292B086G01 |
| T3 | TRANSFORMER | | 292B526G04 |
| T4 | TRANSFORMER | | 292B526G03 |
| R6 | RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 | RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 | LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G05,G47**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 3000 MMF 500V | 187A584H06 |
| C3 CAPACITOR | 820 MMF 500V | 762A757H22 |
| C4 CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C5 CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C6 CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C7 CAPACITOR | 4200 PF 3000V | 203C872H25 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G06,G48**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 2500 MMF 500V | 861A846H20 |
| C2 CAPACITOR | 150 MMF 500V | 861A846H25 |
| C3 CAPACITOR | 150 MMF 500V | 861A846H25 |
| C5 CAPACITOR | 200 MMF 1200V | 137A705H04 |
| C6 CAPACITOR | 4000 MMF 1200V | 187A705H15 |
| C7 CAPACITOR | 3500 PF 3000V | 203C872H23 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G07,G49**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C2 CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C3 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C4 CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C5 CAPACITOR | 1500 MMF 1200V | 187A705H11 |
| C6 CAPACITOR | 2000 MMF 1200V | 187A705H12 |
| C7 CAPACITOR | 3200 PF 3000V | 203C872H22 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G08,G50**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 30 MMF 500V | 763A209H12 |
| C2 CAPACITOR | 2000 MMF 500V | 187A584H01 |
| C3 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C4 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C5 CAPACITOR | 3000 MMF 1200V | 187A705H14 |
| C6 CAPACITOR | 200 MMF 1200V | 187A705H04 |
| C7 CAPACITOR | 2800 PF 3000V | 203C872H20 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G09,G51**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C2 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C3 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C4 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C5 CAPACITOR | 2000 MMF 1200V | 187A705H15 |
| C7 CAPACITOR | 2200 PF 3000V | 203C872H17 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G10,G52**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 82 MMF 500V | 763A209H23 |
| C2 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C4 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C5 CAPACITOR | 3000 MMF 1200V | 187A705H14 |
| C6 CAPACITOR | 500 MMF 1200V | 187A705H09 |
| C7 CAPACITOR | 3500 PF 3000V | 203C872H23 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G11,G53**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C2 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C5 CAPACITOR | 3000 MMF 1200V | 187A705H14 |
| C7 CAPACITOR | 3100 PF 3000V | 203C872H21 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G12,G54**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C2 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C5 CAPACITOR | 300 MMF 1200V | 187A705H06 |
| C6 CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C7 CAPACITOR | 2800 PF 3000V | 203C872H20 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G13,G55**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C2 CAPACITOR | 100 MMF 500V | 762A757H01 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 36 MMF 500V | 763A209H14 |
| C5 CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C7 CAPACITOR | 2500 PF 3000V | 203C872H19 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G14,G56**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 360 MMF 500V | 762A757H14 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 820 MMF 500V | 762A757H22 |
| C4 CAPACITOR | 100 MMF 500V | 762A757H01 |
| C5 CAPACITOR | 200 MMF 1200V | 187A705H04 |
| C6 CAPACITOR | 2000 MMF 1200V | 187A705H12 |
| C7 CAPACITOR | 2200 PF 3000V | 203C872H17 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G15,G57**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 820 MMF 500V | 762A757H22 |
| C5 CAPACITOR | 1500 MMF 1200V | 187A705H11 |
| C7 CAPACITOR | 2000 PF 3000V | 203C872H15 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G16,G58**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 130 MMF 500V | 762A757H07 |
| C4 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C5 CAPACITOR | 300 MMF 1200V | 187A705H06 |
| C6 CAPACITOR | 1500 MMF 1200V | 187A705H11 |
| C7 CAPACITOR | 1800 PF 3000V | 203C872H13 |
| L102 POT CORE | | 670B133G04 |
| L103 POT CORE | | 670B133G06 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 197A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G17,G59**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C3 CAPACITOR | 270 MMF 500V | 762A757H12 |
| C4 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C5 CAPACITOR | 4000 MMF 1200V | 187A705H15 |
| C7 CAPACITOR | 2400 PF 3000V | 203C872H18 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G18,G60**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C2 CAPACITOR | 360 MMF 500V | 762A757H14 |
| C3 CAPACITOR | 82 MMF 500V | 763A209H23 |
| C4 CAPACITOR | 1500 MMF 500V | 762A757H03 |
| C5 CAPACITOR | 4000 MMF 1200V | 187A705H15 |
| C7 CAPACITOR | 2100 PF 3000V | 203C872H16 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 167A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G19,G61**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C2 CAPACITOR | 200 MMF 500V | 762A757H11 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C5 CAPACITOR | 3000 MMF 1200V | 187A705H14 |
| C6 CAPACITOR | 500 MMF 1200V | 187A705H09 |
| C7 CAPACITOR | 1900 PF 3000V | 203C872H14 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G20,G62**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C2 CAPACITOR | 82 MMF 500V | 763A209H23 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C5 CAPACITOR | 3000 MMF 1200V | 187A705H14 |
| C7 CAPACITOR | 1700 PF 3000V | 203C872H12 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 167A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G21,G63**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 360 MMF 500V | 762A757H14 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C4 CAPACITOR | 130 MMF 500V | 762A757H07 |
| C5 CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C7 CAPACITOR | 1500 PF 3000V | 203C872H11 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G22,G64**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 1000 MMF 500V | 762A757H02 |
| C5 CAPACITOR | 2500 MMF 1200V | 187A705H13 |
| C7 CAPACITOR | 1300 PF 3000V | 203C872H10 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G23,G65**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 150 MMF 500V | 861A846H25 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 62 MMF 500V | 763A209H20 |
| C4 CAPACITOR | 820 MMF 500V | 762A757H22 |
| C5 CAPACITOR | 200 MMF 1200V | 187A705H04 |
| C6 CAPACITOR | 2000 MMF 1200V | 187A705H12 |
| C7 CAPACITOR | 1100 PF 3000V | 203C872H08 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G24,G66**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 56 MMF 500V | 763A209H19 |
| C2 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C3 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C4 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C6 CAPACITOR | 2000 MMF 1200V | 187A705H12 |
| C7 CAPACITOR | 1000 PF 3000V | 203C872H07 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G25,G67**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C2 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C3 CAPACITOR | 82 MMF 500V | 763A209H23 |
| C4 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C5 CAPACITOR | 200 MMF 1200V | 187A705H04 |
| C6 CAPACITOR | 1500 MMF 1200V | 187A705H11 |
| C7 CAPACITOR | 900 PF 3000V | 203C872H06 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G26,G68**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 270 MMF 500V | 762A757H12 |
| C2 CAPACITOR | 270 MMF 500V | 762A757H12 |
| C4 CAPACITOR | 620 MMF 500V | 187A584H11 |
| C5 CAPACITOR | 1500 MMF 1200V | 187A705H11 |
| C7 CAPACITOR | 800 PF 3000V | 203C872H05 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G27,G69**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C2 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C3 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C4 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C5 CAPACITOR | 400 MMF 1200V | 187A705H08 |
| C6 CAPACITOR | 1500 MMF 1200V | 187A705H11 |
| C7 CAPACITOR | 1100 PF 3000V | 203C872H08 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

**1461C40G28,G70**

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C2 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C3 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C4 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C5 CAPACITOR | 200 MMF 1200V | 187A705H04 |
| C6 CAPACITOR | 1500 MMF 1200V | 187A705H11 |
| C7 CAPACITOR | 1000 PF 3000V | 203C872H07 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 166A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 146IC40G29,G71

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 180 MMF 500V | 762A757H10 |
| C2 CAPACITOR | 200 MMF 500 V | 762A757H11 |
| C3 CAPACITOR | 200 MMF 500 V | 762A757H11 |
| C4 CAPACITOR | 250 MMF 500 V | 861A846H11 |
| C5 CAPACITOR | 1500 MMF 1200 V | 187A705H11 |
| C7 CAPACITOR | 900 PF 3000V | 203C872H06 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% BW (2 REQ) | 186A317H01 |
| R7 RESISTOR | 15K 10% 2W | 167A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 146IC40G30,G72

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 82 MMF 500V | 763A209H23 |
| C2 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C3 CAPACITOR | 390 MMF 500V | 762A757H15 |
| C5 CAPACITOR | 400 MMF 1200 V | 137A705H08 |
| C6 CAPACITOR | 1000 MMF 1200 V | 137A705H10 |
| C7 CAPACITOR | 750 PF 3000V | 203C872H04 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526GC4 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 146IC40G31,G73

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 300 MMF 500V | 187A584H09 |
| C3 CAPACITOR | 150 MMF 500V | 861A846H 25 |
| C4 CAPACITOR | 200 MMF 500V | 762A757H11 |
| C5 CAPACITOR | 200 MMF 1200 V | 187A705H04 |
| C6 CAPACITOR | 1000 MMF 1200 V | 187A705H10 |
| C7 CAPACITOR | 650 PF 3000V | 203C872H02 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 186A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 146IC40G32,G74

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | 20 MMF 500V | 763A209H07 |
| C2 CAPACITOR | 250 MMF 500V | 861A846H11 |
| C3 CAPACITOR | 130 MMF 500V | 762A757H07 |
| C4 CAPACITOR | 180 MMF 500 V | 762A757H10 |
| C6 CAPACITOR | 1000 MMF 1200 V | 187A705H10 |
| C7 CAPACITOR | 600 PF 3000V | 203C872H02 |
| L102 POT CORE | | 670B133G05 |
| L103 POT CORE | | 670B133G07 |
| L105 COIL | | 292B086G01 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 1W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 146IC40G33,G75

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 763A209H19 |
| C2 CAPACITOR | MMF 500V | 762A757H12 |
| C3 CAPACITOR | MMF 500V | 762A757H11 |
| C4 CAPACITOR | MMF 500V | 763A209H12 |
| C5 CAPACITOR | MMF 1200 V | 187A705H04 |
| C6 CAPACITOR | MMF 1200 V | 187A705H09 |
| C7 CAPACITOR | PF 3000V | 203C872H09 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A115H01 |

### 146IC40G34,G76

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C2 CAPACITOR | MMF 500V | 187A584H09 |
| C3 CAPACITOR | MMF 500V | 762A757H11 |
| C4 CAPACITOR | MMF 500V | 763A209H07 |
| C5 CAPACITOR | MMF 1200V | 187A705H04 |
| C6 CAPACITOR | MMF 1200 V | 187A705H09 |
| C7 CAPACITOR | PF 3000V | 203C872H09 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A115H01 |

### 146IC40G35,G77

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 861A846H25 |
| C2 CAPACITOR | MMF 500V | 861A846H25 |
| C3 CAPACITOR | MMF 500V | 861A846H25 |
| C4 CAPACITOR | MMF 500V | 763A209H19 |
| C5 CAPACITOR | MMF 1200 V | 187A705H08 |
| C6 CAPACITOR | MMF 1200 V | 187A705H04 |
| C7 CAPACITOR | PF 3000V | 203C872H08 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 146IC40G36,G78

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 763A209H20 |
| C2 CAPACITOR | MMF 500V | 762A757H11 |
| C3 CAPACITOR | MMF 500V | 763A209H20 |
| C4 CAPACITOR | MMF 500V | 762A757H07 |
| C5 CAPACITOR | MMF 1200 V | 187A705H08 |
| C6 CAPACITOR | MMF 1200 V | 187A705H04 |
| C7 CAPACITOR | PF 3000V | 203C872H08 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% BW (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A11GH01 |

### 146IC40G37,G79

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C2 CAPACITOR | MMF 500V | 861A846H11 |
| C3 CAPACITOR | MMF 500 V | 861A846H25 |
| C4 CAPACITOR | MMF 500V | 763A209H07 |
| C6 CAPACITOR | MMF1200 V | 187A705H09 |
| C7 CAPACITOR | PF 3000V | 203CB72H07 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% BW (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 146IC40G38,G80

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 763A209H12 |
| C2 CAPACITOR | MMF 500V | 762A757H11 |
| C3 CAPACITOR | MMF 500 V | 762A757H07 |
| C4 CAPACITOR | MMF 500V | 763A209H12 |
| C6 CAPACITOR | MMF1200V | 187A705H09 |
| C7 CAPACITOR | PF 3000V | 203C872H06 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A11GH01 |

### 146IC40G39,G81

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 763A209H19 |
| C2 CAPACITOR | MMF 500V | 861A846H25 |
| C3 CAPACITOR | MMF 500V | 763A209H20 |
| C4 CAPACITOR | MMF 500V | 763A209H23 |
| C5 CAPACITOR | MMF 1200 V | 187A705H08 |
| C7 CAPACITOR | PF 3000V | 203C872H05 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% BW (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 146IC40G40,G82

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 763A209H14 |
| C2 CAPACITOR | MMF 500 V | 861A846H25 |
| C3 CAPACITOR | MMF 500V | 762A757H01 |
| C4 CAPACITOR | MMF 500V | 763A209H12 |
| C5 CAPACITOR | MMF 1200 V | 187A705H08 |
| C7 CAPACITOR | PF 3000V | 203C872H03 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526GC4 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% BW (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 146IC40G41,G83

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C1 CAPACITOR | MMF 500V | 763A209H07 |
| C2 CAPACITOR | MMF 500V | 861A846H25 |
| C3 CAPACITOR | MMF 500 V | 762A757H01 |
| C4 CAPACITOR | MMF 500 V | 763A209H07 |
| C5 CAPACITOR | MMF 1200 V | 187A705H08 |
| C7 CAPACITOR | PF 3000V | 203C872H02 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

### 146IC40G42,G84

| COMPONENT | DESCRIPTION | STYLE |
|---|---|---|
| C2 CAPACITOR | MMF 500V | 861A846H25 |
| C3 CAPACITOR | MMF 500V | 763A209H23 |
| C4 CAPACITOR | MMF 500V | 763A209H12 |
| C5 CAPACITOR | MMF1200 V | 187A705H08 |
| C7 CAPACITOR | PF 3000V | 203C872H01 |
| L102 POT CORE | | 670B133G09 |
| L103 POT CORE | | 670B133G08 |
| L105 POT CORE | | 670B133G09 |
| T3 TRANSFORMER | | 292B526G04 |
| T4 TRANSFORMER | | 292B526G03 |
| R6 RESISTOR | 3K ± 5% 8W (2 REQ) | 188A317H01 |
| R7 RESISTOR | 15K 10% 2W | 187A642H55 |
| G1 LIGHTNING ARRESTER | | 877A116H01 |

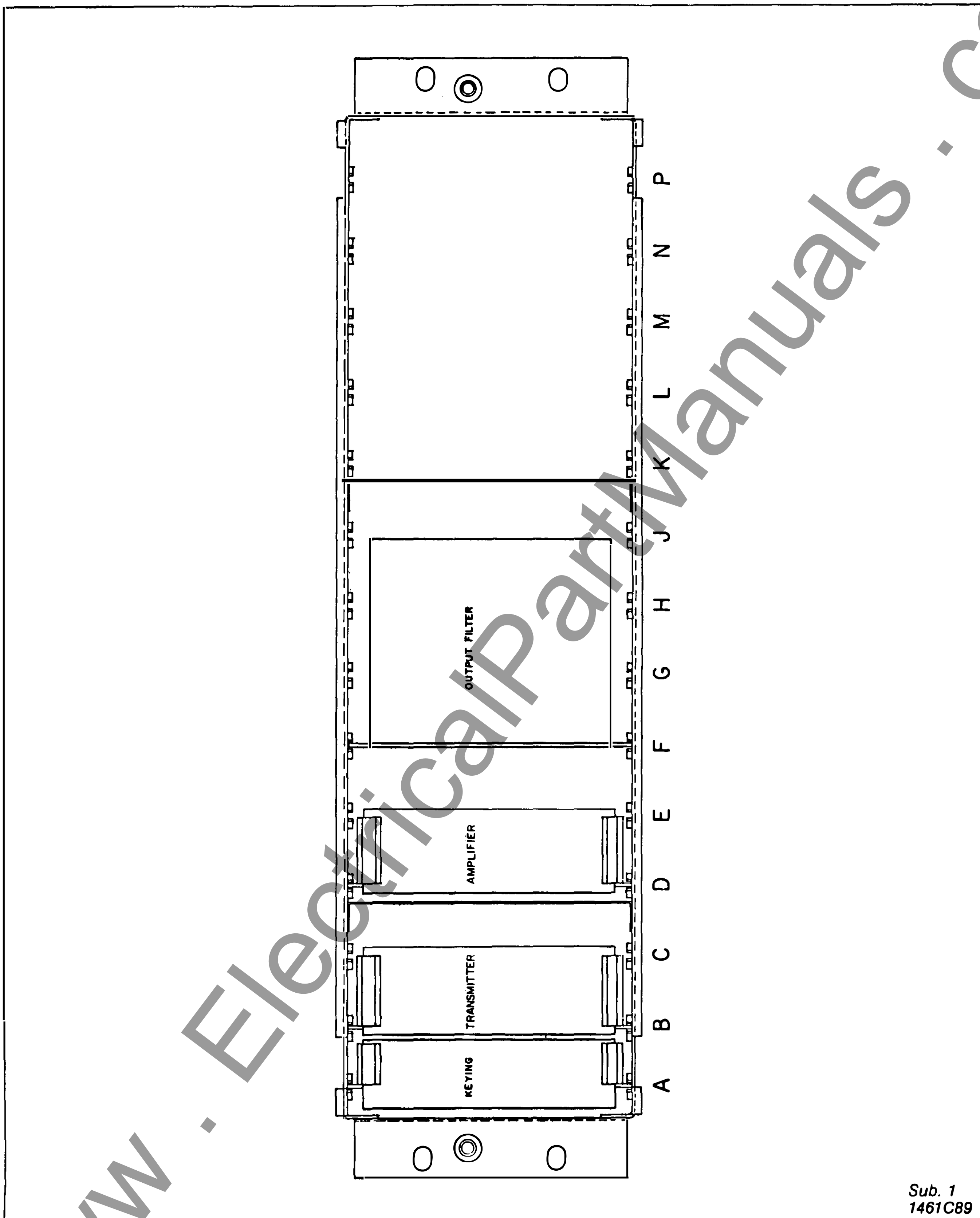



*Fig. 13. Module Location*

**WESTINGHOUSE ELECTRIC CORPORATION**

**RELAY-INSTRUMENT DIVISION** **CORAL SPRINGS, FL.**

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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) WITH DC/DC CONVERTER

## 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. A carrier level indicator instrument, Style No. 606B592A26, with a linear dB scale is also available.

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

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

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 fed through a coaxial cable connected to jack J2 at the rear of the chassis to the input module. The input control R5, accessible at the front of the input module, attentuates the signal to a level suitable for the best operating range of the receiver.

A scale on the panel is graduated in dB. While this scale is typical rather than individually calibrated, it is accurate within several dB and is useful in setting approximate levels. Settings should be made more accurately utilizing a suitable ac voltmeter with a dB scale when possible.

From the attentuator, the signal passes through a band-pass LC filter, FL 201. This filter has a passband of approximately 1600Hz which is relatively wide in comparison to the IF filter which has a passband of approximately 500Hz. Still, frequencies several kHz above or below the center frequency ($f_c$) of the channel are greatly attentuated. Figure 15 shows a typical curve for the LC filter as well as a characteristics curve for the IF (intermediate frequency) filter, FL2, and the discriminator output. This apparently wide bandwidth for the input filter in relation to the IF filter is necessary to both achieve high speed relaying by minimizing channel delay and to achieve proper operation of the noise clamp by sampling noise in the frequency band surrounding the IF band.

### OSCILLATOR, MIXER, AND IF AMPLIFIER MODULE

From the input filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20kHz above the channel center frequency, $f_c$. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the latter is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of filter FL201 is impressed on the emitter-collector circuit of Q11. As a result of mixing these two frequencies, the primary of transformer T12 will contain frequencies of 20kHz, $2f_c$ +20 kHz, $f_c$ +20kHz, and $f_c$.

The output from the secondary of T12 is amplified by Q31 in the intermediate frequency (IF) stage, and is impressed on FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. Since its pass band is narrower than that of the input filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz. The output of this filter is the IF output which is fed to both the amplifier-limiter and the S/N Detection module. The output from the secondary of transformer T12, the RF output, is also fed to the S/N detection module.

### AMPLIFIER LIMITER AND DISCRIMINATOR MODULE

The IF output signal from the IF amplifier is fed into the amplifier limiter through potentiometer R52 at the input of the amplifier limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with input control R5 set for zero attentuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at the channel center frequency, $f_c$. The adjustment for zero output at $f_c$ is made by capacitor C68. In addition, C63 is adjusted for maximum voltage reading across R80 when the output current is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero current output frequency. This separation of 200 hertz between the current peaks is affected by the value of C66 (the actual value of which may be changed slightly from its typical value in factory calibration if required).

It should be observed that although the space frequency is $f_c$ +100 hertz, after leaving the mixer stage, and as seen by the discriminator, the space frequency is 20kHz-100 hertz. Similarly the mark frequency as seen by the discriminator is 20kHz +100 hertz. The intermediate frequency at which the discriminator has zero output then is 20kHz. The discriminator is adjusted so that the mark and space outputs are of equal lengths for equal periods of mark and space signal frequencies.

The discriminator output is connected to the bases of transistors Q55 and Q56 in such a manner that transistor Q56 is made conductive when current flows, from the discriminator output, in the forward direction of diode D54, (which occurs with mark output) and Q55 is made conductive when current flows in the forward direction of diode D55 (which occurs with space output.) Consequently, terminal 35 is at a potential of approximately +20 volts at space frequency and terminal 1 is at +20 volts at mark frequency.

### S/N DETECTION MODULE

The S/N detection module has three basic functions; first to determine the in-band signal-to-noise ratio and provide clamping output at the desired level of signal-to-noise ratio, second to measure incoming in-band signal level and provide both an output to a carrier level indicating instrument and to a clamping circuit in the output module for clamping at the desired low level of signal, and third to provide a clamping output when the desired signal level exceeds the normal received level by a substantial amount, typically 25dB.

The method of determining signal-to-noise ratio utilizes the measurement of signal level in two different bandwidths, that of the input filter which is 1600 hertz, and that of the IF filter which is 500 hertz. The total signal plus noise in the 500 hertz bandwidth is subtracted from the signal plus noise in the 1600 hertz bandwidth and this difference is then compared with the signal plus noise in the 500 hertz bandwidth to arrive at a true in-band signal-to-noise ratio using logarithmic circuits. See Figure 21.

If the ratio of signal to noise is less than the value selected, typically 10, then there will be a +16V out of IC13 (TP75 and terminal 27). This is a high noise condition and this voltage is used as a clamp to prevent erroneous interpretation of data being received due to high noise conditions. Under normal low noise conditions, typically signal-to-noise ratio greater than 10, the voltage out of IC13 (TP75) is +4V and no clamping is done.

The wide band signal of 1600 hertz bandwidth called the RF signal is fed into the S/N detection board through isolation transformer T31. Operational amplifiers IC1 and IC2 along with their associated components, R82 through R92 and C81 through C90, constitute a 4-pole low-pass filter which passes the mixed band of frequencies in the bandwidth of 1600 Hz centered about the 20kHz I.F. frequency, and blocks all the higher multiples such as in the I.F. amplifier. Operational amplifier IC3 and associated components amplifies the signal for feeding into the rms circuit composed of IC4 and IC5 with adjustable potentiometer R94 controlling the amount of amplification. This latter circuit converts the signals into a dc voltage proportional to the rms value of the ac signals. Operational amplifier IC6A and associated components is used for inversion and isolation of this dc voltage before being fed into the summation amplifier IC6B.

The narrow-band signal of 500 hertz bandwidth called the I.F. is fed into the S/N detection board through isolation transformer T32. The amount of signal fed into the board is adjustable by means of potentiometer R111. The circuit composed of operational amplifiers IC7 and IC8 and associated components is an rms circuit which converts the signals into a dc voltage proportional to the rms value of the ac signals present in the IF bandwidth. The output of this circuit is also then fed into the summation amplifier IC6B.

The summation amplifier takes the difference between the rms values of the IF signal and the RF signal and feeds it into one half of the logarithmic amplifier composed of IC9 and associated components. At the same time, the rms value of the IF signal is fed into the other half of this logarithmic amplifier. The logarithmic amplifier takes the logarithmic difference between these two signals (which is equivalent to IF divided by [RF-IF] from the summer). The constants of the circuits are set up so that the output of the logarithmic amplifier is positive when the ratio of the signal to noise ratio in these bandwidths is greater than 10dB, and is negative when the signal to noise ratio is less than 10dB. (Note: The point at which the change in polarity occurs can be altered to other than 10dB signal to noise ratio by altering the adjustments of R94 and R111). In addition, the output of the logarithmic amplifier is also negative when the signal level is approximately 25dB above normal for high-level clamping.

The output of the logarithmic amplifier is fed through networks consisting of IC10A and IC13A to the level detector circuit IC13B which has a fast pickup and slow dropout when it receives a signal from the logarithmic amplifier indicating a lower than desired signal-to-noise ratio (lower than 10dB is initially set when shipped). This will put out a +16 volts out of terminal 27 for this condition. For high signal-to-noise ratio this output will be +4 volts. This circuit will also put out +16 volts out of terminal 27 for very high signal levels. This is a high signal clamp and occurs for signal levels approximately plus 25dB above normal received level.

The output of the IF rms circuit is also fed to the logarithmic circuit composed of IC11A, IC12A, and IC11B which puts out a dc signal level linearly proportional to signal level in dB for feeding an external microammeter calibrated with a linear dB scale with 10dB equal to 33-1/3 microamperes.

## OUTPUT MODULE

The output module provides four buffered outputs to the relaying system. They are mark (or trip positive), space (or trip negative), S/N level. and "not low signal" with red indicating light emitting diodes for these outputs and a yellow indicating light emitting diode for normal level (satisfactory signal level). In addition, the output module has logic which will prevent either a mark or space output whenever the S/N level drops to an unsatisfactory level or the received signal level drops to an unsatisfactory level.

The space output of plus 20 volts (when present) from the discriminator is fed into the output module through terminal 25 into the "and" gate consisting of diodes D71, D72, D73, and D74, transistors Q62 and Q63, and associated comfixed by the crystal used, except that it may be changed a few hertz by the value of capacitor of 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 hertz 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 16 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. (For greater sensitivity when required, the receiver can be set to 5 millivolts for beginning of limiting. However this makes the receiver more susceptible to locally generated noise within the cabinet and should not be used unless absolutely necessary and chassis is located in a noise free area.)

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 (90 mv. for 16 mv normal clipping level; 28mv. for 5 mv maximum sensitivity level).
2. Adjust I.F. input with R111 so that signal at TP68 of the S/N detector module is +100 mv dc (with respect to TP62).
3. Adjust RF input with R94 so that signal at TP63 is +145 mv dc (with respect to TP62).
4. Adjust log amplifier balance potentiometer R129 so that S/N clamps operates. This will be +6 volts dc at TP75 to TP62. This will also appear as +12 volts at TP91 of the output board with respect to board terminal 3, and the red S/N level indicator will light.
5. Go back and readjust RF input with R94 so that signal level at TP63 is now 74.4 mv dc. (with respect to TP62).

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 145 mv value in step 3.

For S/N of 0dB set TP63 to 297mv.
5dB set TP63 to 200mv.
15dB set TP63 to 114mv.
20dB set TP63 to 97mv.

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 16mv with R5 set at zero which is the point at which limiting should begin).
2. Adjust the low-level (LL) adjustment R178 on the output module panel 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 +12 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 where 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 40dB from 1 watt or 50dB 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 | 15 |
| Q12 (TP12) | 17 (Mark or Space) |
| Q13 (TP13) | 17 (Mark or Space) |
| Q14 (TP14) | 3 |
| Q15 (TP15) | 3 |
| TP11 | 22 |
| TP52 | 19 |
| Q51 (TP51) | 14 |
| Q52 (TP53) | 14.5 |
| Q53 (TP54) | 18 |
| Q54 (TP55 | 3 |
| TP56 | 19 |
| Q55 | 1 (Lower Freq. or No Signal) |
| Q55 | 23 (Higher Freq.) |
| Q56 | 23 (Lower Freq.) |
| Q56 | 1 (Higher Freq. or No Signal) |

**NOTE:** The following readings are taken with the negative of dc VTVM on terminal 3 (common of dc power supply) of either the S/N detection module or the output module.

| | |
|---|---|
| TP61 | + 4 |
| TP62 | 0 |
| TP63 | + 0.4 |
| TP64 | + 6 |
| TP65 | − 12 |
| TP66 | 0 |
| TP67 | + 0.5 |
| TP68 | + 0.5 |
| TP70 | − 6 |
| TP71 | + 6 |
| TP72 | + 1.5 |
| TP73 | + 0.8 |
| TP74 | + 0.3 |
| TP81 | + 12 (Higher Frequency) |
| TP81 | − 12 (Lower Freq. or No Signal) |
| TP82 | + 12 (Lower Frequency) |
| TP82 | − 12 (Higher Freq. or No Signal) |
| TP83 | + 12 (Higher Frequency) |
| TP83 | − 12 (Lower Freq. or No Signal) |
| TP84 | + 12 (Lower Frequency) |
| TP84 | − 12 (Higher Freq. or No Signal) |
| TP85 | + 0.3 |
| TP86 | + 12 (Low level clamp) |
| TP86 | 0 (No clamp) |
| TP87 | + 6 (Low SNR clamp) |
| TP87 | − 6 (No SNR clamp) |
| TP88 | + 12 |
| TP89 | − 12 |
| TP90 | + 12 (Good Signal Level) |
| TP90 | − 12 (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. CLI Microammeter, range 0-100$\mu$A, style number 606B592A26, (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: 20kHz 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.

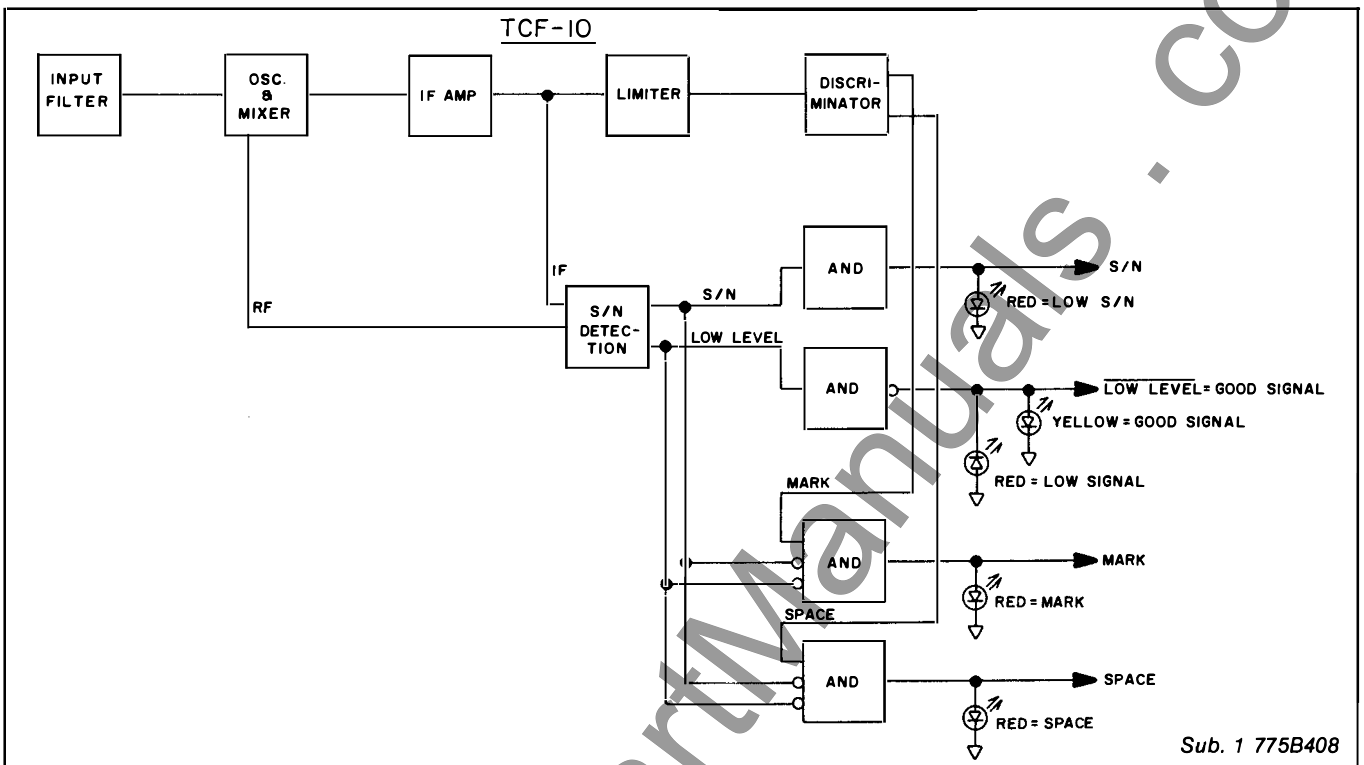



*Fig. 2. Receiver Logic for Dual Phase Comparison.*

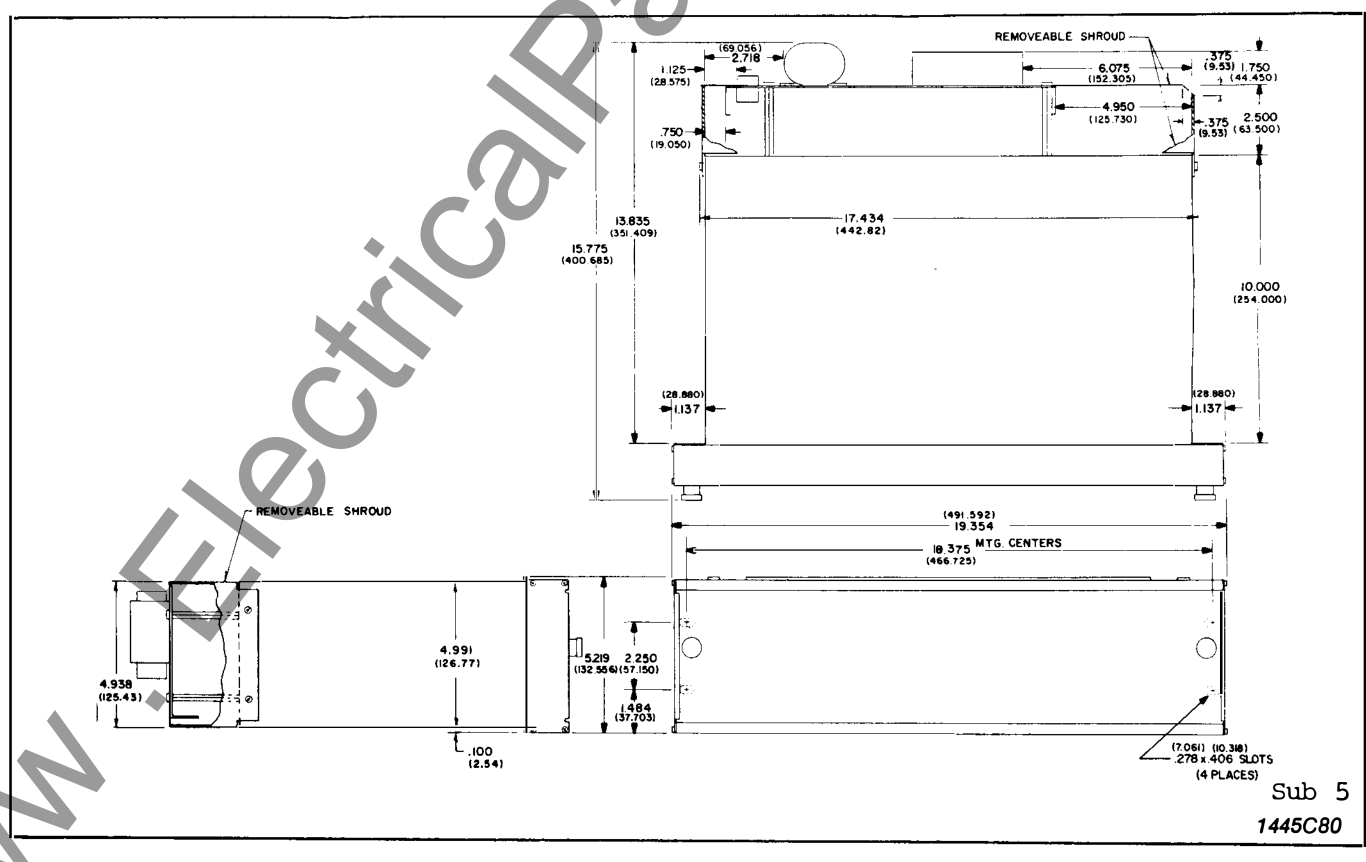
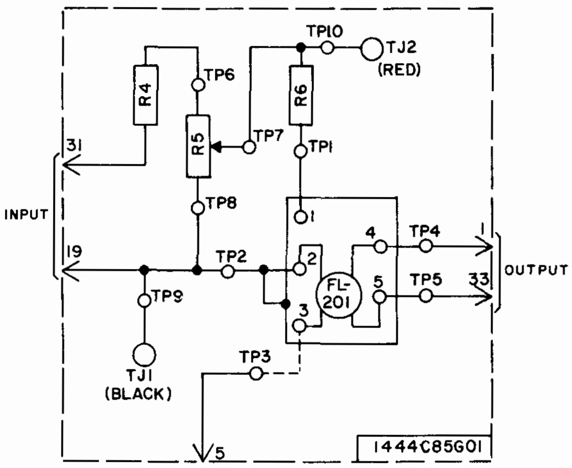



*Fig. 3. Outline TCF-10 Receiver.*

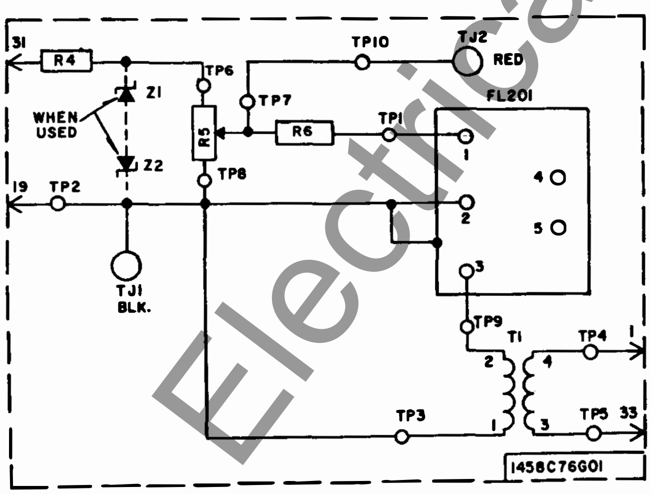



| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| R4 | RESISTOR | 100.0 .50W 5% | 184A763H03 |
| R6 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R5 | POTENTIOMETER | 10.0K 2W | 185A086H10 |
| FL201 | FILTER | | □ |
| TJ1 | TIP JACK | BLACK | 187A332H02 |
| TJ2 | TIP JACK | RED | 187A332H01 |

□ = TO BE DETERMINED.

SUB. 1
775B394

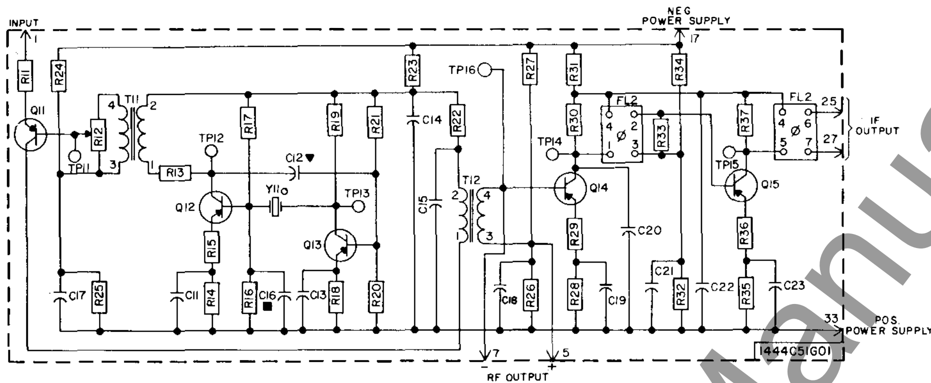
*Fig. 4. Internal Schematic Input Filter Module (Below 200 kHz)*




| CØMPØNENT | | DESCRIPTIØN | STYLE NØ. |
|---|---|---|---|
| R4 | RESISTØR | 100.0 .50W 5% | 184A763H03 |
| R6 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| Z1 | ZENER | 1N3027B 20.0V | 186A302H07 |
| Z2 | ZENER | 1N3027B 20.0V | 186A302H07 |
| FL201 | FILTER | D.SPEC | |
| R5 | POT | 10K 2W | 185A086H10 |
| T1 | TRANSF | | 714B677G01 |

Sub 2
775B920

*Fig. 5. Internal Schematic Input Filter Module (Above 200 kHz)*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C11 | CAPACITOR | .250UF 200V | 187A624H02 |
| C12 | CAPACITOR | SEE NOTE ▼ | |
| C13 | CAPACITOR | .250UF 200V | 187A624H02 |
| C14 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C15 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C16 | CAPACITOR | SEE NOTE ■ | |
| C17 | CAPACITOR | .250UF 200V | 187A624H02 |
| C18 | CAPACITOR | .250UF 200V | 187A624H02 |
| C19 | CAPACITOR | .250UF 200V | 187A624H02 |
| C20 | CAPACITOR | 100.000PF 500V | 762A757H01 |
| C21 | CAPACITOR | .250UF 200V | 187A624H02 |
| C22 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| C23 | CAPACITOR | .250UF 200V | 187A624H02 |
| R11 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R13 | RESISTOR | 4700.0 .50W 5% | 184A763H43 |
| R14 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R15 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| R16 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R17 | RESISTOR | 33.0K .50W 5% | 184A763H63 |
| R18 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R19 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R20 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R21 | RESISTOR | 33.0K .50W 5% | 184A763H63 |
| R22 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| R23 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R24 | RESISTOR | 220.0K .50W 5% | 184A763H83 |
| R25 | RESISTOR | 4700.0 .50W 5% | 184A763H43 |
| R26 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R27 | RESISTOR | 22.0K .50W 5% | 184A763H59 |
| R28 | RESISTOR | 680.0 .50W 5% | 184A763H23 |
| R29 | RESISTOR | 68.0 .50W 5% | 187A290H21 |
| R30 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R31 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| R32 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| R33 | RESISTOR | 1000.0 .50W 5% | 184A763H27 |
| R34 | RESISTOR | 22.0K .50W 5% | 184A763H59 |
| R35 | RESISTOR | 680.0 .50W 5% | 184A763H23 |
| R36 | RESISTOR | 68.0 .50W 5% | 187A290H21 |
| R37 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R12 | POT | 1.0K .12W | 629A430H02 |
| J111 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| Q11 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q12 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q13 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q14 | TRANSISTOR | 2N4249 | 849A441H03 |
| Q15 | TRANSISTOR | 2N4249 | 849A441H03 |
| T11 | TRANSFORMER | | 205C043G01 |
| T12 | TRANSFORMER | | 205C043G03 |
| Y11 | CRYSTAL | SEE NOTE ○ | |
| FL2 | FILTER | | 762A613G01 |

▼=C12 RANGE 4 TO 390Pf AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS

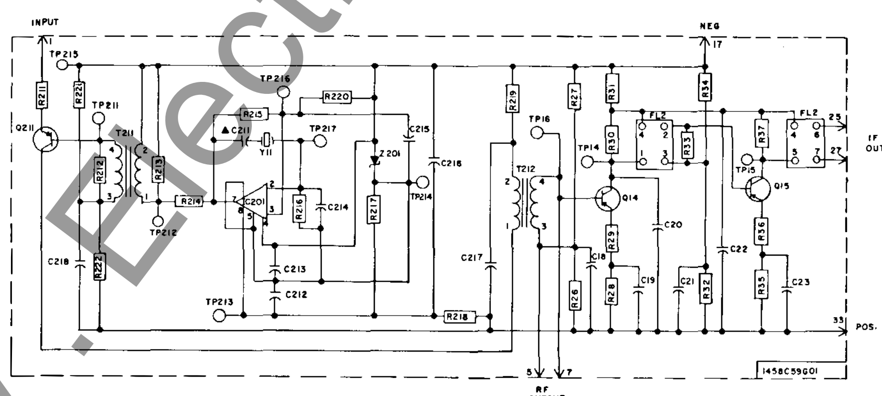
■=C16 RANGE 22 TO 100Pf AS REQUIRED BY FREQUENCY AND CRYSTAL CHARACTERISTICS

○=Y11 RANGE-50 TO 220KHZ

Ø=COMMON TERMINAL

*Sub 4*
*1444C52*

*Fig. 6. Internal Schematic Oscillator-Mixer-IF Amplifier Module (Below 200 kHz)*




| | COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|---|
| | C18 | CAPACITOR | .250UF 200V | 187A624H02 |
| | C19 | CAPACITOR | .250UF 200V | 187A624H02 |
| | C20 | CAPACITOR | 100.000PF 500V | 762A757H01 |
| | C21 | CAPACITOR | .250UF 200V | 187A624H02 |
| | C22 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| | C23 | CAPACITOR | .250UF 200V | 187A624H02 |
| ▲ | C211 | CAPACITOR | SEE NOTE ▲ | |
| | C213 | CAPACITOR | .100UF 50V | 184A663H04 |
| | C215 | CAPACITOR | .100UF 50V | 184A663H04 |
| | C216 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| | C217 | CAPACITOR | 1.000UF 200V | 187A624H04 |
| | C218 | CAPACITOR | .250UF 200V | 187A624H02 |
| O | C214 | CAPACITOR | SEE NOTE O | |
| | IC201 | INT CKT | MA710 | 201C826H03 |
| | J1 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| | R26 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| | R27 | RESISTOR | 22.0K .50W 5% | 184A763H59 |
| | R28 | RESISTOR | 680.0 .50W 5% | 184A763H23 |
| | R29 | RESISTOR | 68.0 .50W 5% | 187A290H21 |
| | R30 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| | R31 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| | R32 | RESISTOR | 3300.0 .50W 5% | 184A763H39 |
| | R33 | RESISTOR | 1000.0 .50W 5% | 184A763H27 |
| | R34 | RESISTOR | 22.0K .50W 5% | 184A763H59 |
| | R35 | RESISTOR | 680.0 .50W 5% | 184A763H23 |
| | R36 | RESISTOR | 68.0 .50W 5% | 187A290H21 |
| | R37 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| | R211 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| | R212 | RESISTOR | 1000.0 .50W 5% | 184A763H27 |
| | R213 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| | R214 | RESISTOR | 2700.0 .50W 5% | 184A763H37 |
| | R215 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| | R216 | RESISTOR | 8200.0 .50W 5% | 184A763H49 |
| | R217 | RESISTOR | 2000.0 .50W 5% | 184A763H34 |
| | R218 | RESISTOR | 150.0 .50W 5% | 184A763H07 |
| | R219 | RESISTOR | 330.0 .50W 5% | 184A763H15 |
| | R220 | RESISTOR | 47.0K .50W 5% | 184A763H67 |
| | R221 | RESISTOR | 220.0K .50W 5% | 184A763H83 |
| | R222 | RESISTOR | 4700.0 .50W 5% | 184A763H43 |
| | Q14 | TRANSISTOR | 2N4249 | 849A441H03 |
| | Q15 | TRANSISTOR | 2N4249 | 849A441H03 |
| | Q211 | TRANSISTOR | 2N4249 | 849A441H03 |
| | Z201 | ZENER | 1N753A 6.2V | 862A606H01 |
| | Y11 | CRYSTAL | SEE NOTE □ | |
| | T211 | TRANSF | | 714B677G01 |
| | T212 | TRANSF | | 205C043G03 |

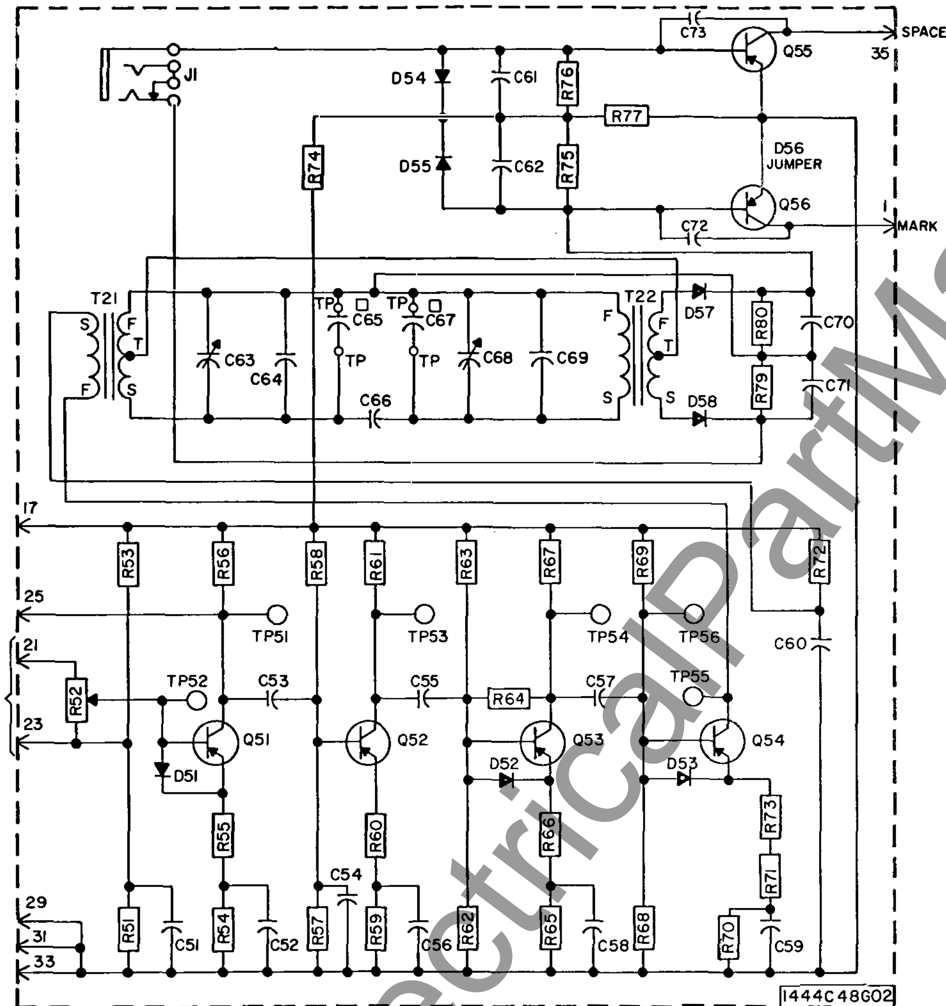
▲ C211 RANGES FROM 100PF TO 1000PF

O C214 MAY VARY UP TO 100PF 187A695H01 THROUGH H23

□ Y11 FREQ. EQUALS RCVR (CHANNEL) FREQUENCY PLUS 20KHZ

Sub 1
*1458C60*

*Fig. 7. Internal Schematic Oscillator-Mixer-IF Amplifier Module (Above 200kHz)*




| 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 |
| C72 | CAPACITOR | 330.000PF | 200V | 880A397H01 |
| C73 | CAPACITOR | 330.000PF | 200V | 880A397H01 |
| D51 | DIODE | 1N457A | | 184A855H07 |
| D52 | DIODE | 1N457A | | 184A855H07 |
| D53 | DIODE | 1N457A | | 184A855H07 |
| D54 | DIODE | 1N457A | | 184A855H07 |
| D55 | DIODE | 1N457A | | 184A855H07 |
| D56 | DIODE | 1N457A | | 184A855H07 |
| 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.

Sub 4
1444C49

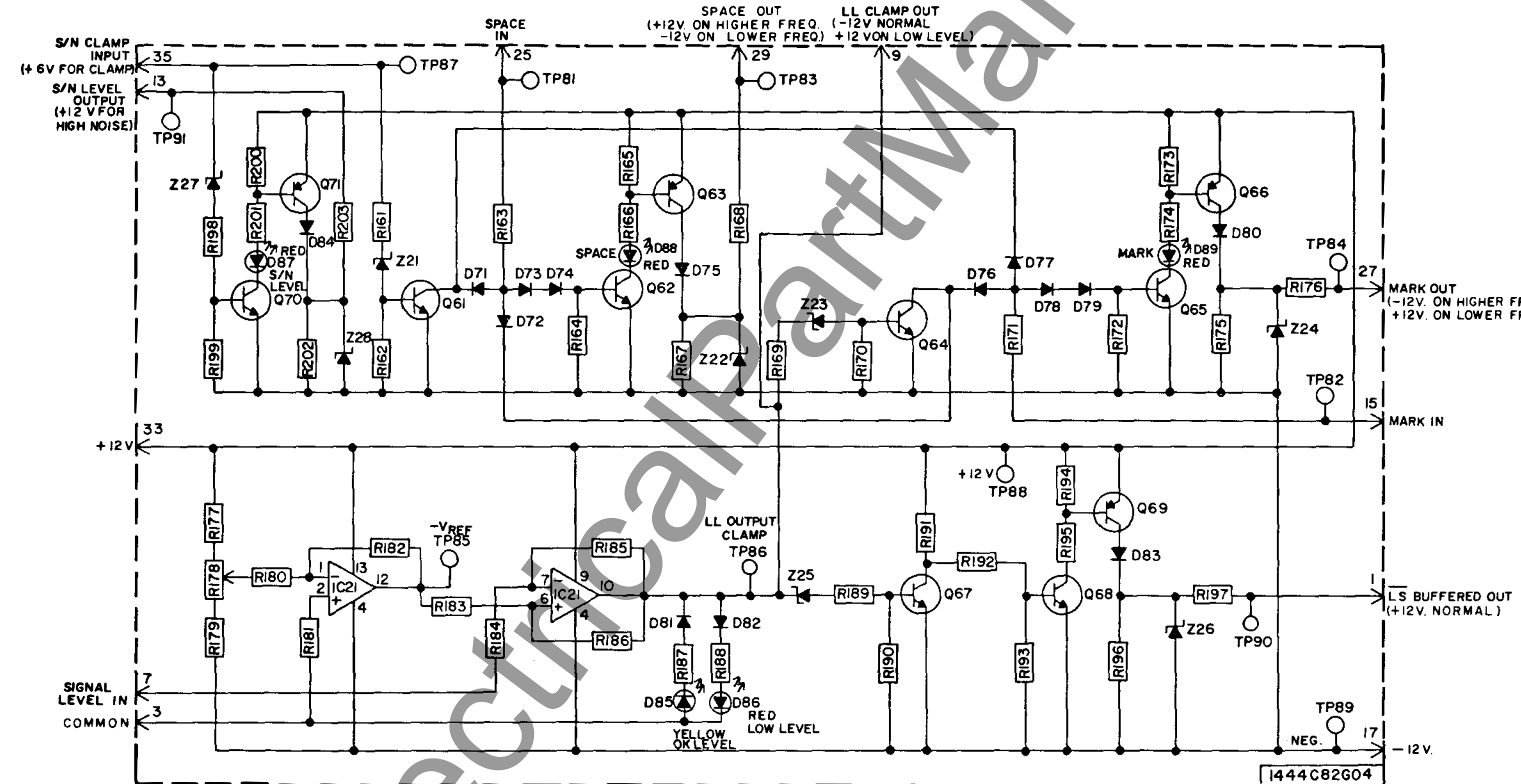
*Fig. 8. Internal Schematic Amplifier Limiter-Discriminator Module*

| 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 | 200.0K | .50W | 1% | 848A821H71 |
| 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 | 1.0K | .50W | 1% | 848A819H48 |
| R155 | RESISTOR | 1.0K | .25W | 20% | 629A430H02 |
| 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 | 629A645H12 |
| 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 | .22.UF 100V | 3512A08H02 |
| 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 | 1N825A 6.2 V | 862A288H06 |
| Z12 | ZENER | 1N825A 6.2 V | 862A288H06 |
| 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 |
| T31 | TRANSFORMER | | 714B677G01 |
| T32 | TRANSFORMER | | 714B677G01 |

Sub 1
1334D15

*List - SNR Detection Module*




Sub 2
1463C13

Fig. 10. Internal Sche

| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| D71 | DIODE | 1N645A | 837A692H03 |
| D72 | DIODE | 1N645A | 837A692H03 |
| D73 | DIODE | 1N645A | 837A692H03 |
| D74 | DIODE | 1N645A | 837A692H03 |
| D75 | DIODE | 1N645A | 837A692H03 |
| D76 | DIODE | 1N645A | 837A692H03 |
| D77 | DIODE | 1N645A | 837A692H03 |
| D78 | DIODE | 1N645A | 837A692H03 |
| D79 | DIODE | 1N645A | 837A692H03 |
| D80 | DIODE | 1N645A | 837A692H03 |
| D81 | DIODE | 1N457A | 184A855H07 |
| D82 | DIODE | 1N457A | 184A855H07 |
| D83 | DIODE | 1N645A | 837A692H03 |
| D84 | DIODE | 1N645A | 837A692H03 |
| D85 | DIODE | LED | 3508A22H02 |
| D86 | DIODE | LED | 3508A22H01 |
| D87 | DIODE | LED | 3508A22H01 |
| R161 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R162 | RESISTOR | 120.0K .50W 5% | 184A763H77 |
| R163 | RESISTOR | 33.0K .50W 5% | 184A763H63 |
| R164 | RESISTOR | 120.0K .50W 5% | 184A763H77 |
| R165 | RESISTOR | 4.7K .50W 5% | 184A763H51 |
| R166 | RESISTOR | 2.4K .50W 5% | 184A763H57 |
| R167 | RESISTOR | 10.0K .50W 1% | 848A820H45 |
| R168 | RESISTOR | 499.0 .50W 1% | 848A819H19 |
| R169 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R170 | RESISTOR | 120.0K .50W 5% | 184A763H77 |
| R171 | RESISTOR | 33.0K .50W 5% | 184A763H63 |
| R172 | RESISTOR | 120.0K .50W 5% | 184A763H77 |
| R173 | RESISTOR | 4.7K .50W 5% | 184A763H51 |
| R174 | RESISTOR | 2.4K .50W 5% | 184A763H57 |
| R175 | RESISTOR | 10.0K .50W 1% | 848A820H45 |
| R176 | RESISTOR | 499.0 .50W 1% | 848A819H19 |
| R177 | RESISTOR | 10.0K .50W 1% | 848A820H45 |
| R179 | RESISTOR | 10.0K .50W 1% | 848A820H45 |
| R180 | RESISTOR | 68.1K .50W 1% | 848A821H26 |
| R181 | RESISTOR | 4990.0 .50W 1% | 848A820H16 |
| R182 | RESISTOR | 6810.0 .50W 1% | 848A820H29 |
| R183 | RESISTOR | 2.0K .50W 1% | 848A819H77 |
| R184 | RESISTOR | 2.0K .50W 1% | 848A819H77 |
| R185 | RESISTOR | 562.0K .25W 1% | 848A822H15 |
| R186 | RESISTOR | 511.0K .50W 1% | 848A822H11 |
| R187 | RESISTOR | 1620.0 .25W 1% | 848A819H68 |
| R188 | RESISTOR | 1620.0 .25W 1% | 848A819H68 |
| R189 | RESISTOR | 33.0K .50W 5% | 184A763H63 |
| R190 | RESISTOR | 68.0K .50W 5% | 184A763H71 |
| R191 | RESISTOR | 68.0K .50W 5% | 184A763H71 |

| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| R192 | RESISTOR | 33.0K .50W 5% | 184A763H63 |
| R193 | RESISTOR | 120.0K .50W 5% | 184A763H77 |
| R194 | RESISTOR | 10.0K .50W 5% | 184A763H51 |
| R195 | RESISTOR | 18.0K .50W 5% | 184A763H57 |
| R196 | RESISTOR | 10.0K .50W 1% | 848A820H45 |
| R197 | RESISTOR | 499.0 .50W 1% | 848A819H19 |
| R198 | RESISTOR | 33.0K .50W 5% | 184A763H63 |
| R199 | RESISTOR | 68.0K .50W 5% | 184A763H71 |
| R200 | RESISTOR | 4700.0 .50W 5% | 184A763H43 |
| R201 | RESISTOR | 2400.0 .50W 5% | 184A763H36 |
| R202 | RESISTOR | 10.0K .50W 1% | 848A820H45 |
| R203 | RESISTOR | 499.0 .50W 1% | 848A819H19 |
| Q61 | TRANSISTOR | 2N699 | 184A638H19 |
| Q62 | TRANSISTOR | 2N699 | 184A638H19 |
| Q63 | TRANSISTOR | 2N3645 | 849A441H01 |
| Q64 | TRANSISTOR | 2N699 | 184A638H19 |
| Q65 | TRANSISTOR | 2N699 | 184A638H19 |
| Q66 | TRANSISTOR | 2N3645 | 849A441H01 |
| Q67 | TRANSISTOR | 2N699 | 184A638H19 |
| Q68 | TRANSISTOR | 2N699 | 184A638H19 |
| Q69 | TRANSISTOR | 2N3645 | 849A441H01 |
| Q70 | TRANSISTOR | 2N699 | 184A638H19 |
| Q71 | TRANSISTOR | 2N3645 | 849A441H01 |
| Z21 | ZENER | 1N961B 10.0V | 186A797H07 |
| Z22 | ZENER | IN4752A 33.0V | 849A515H02 |
| Z23 | ZENER | 1N961B 10.0V | 186A797H07 |
| Z24 | ZENER | IN4752A 33.0V | 849A515H02 |
| Z25 | ZENER | 1N961B 10.0V | 186A797H07 |
| Z26 | ZENER | IN4752 33.0V | 849A515H02 |
| Z27 | ZENER | 1N961B 10.0V | 186A797H07 |
| Z28 | ZENER | IN4752 33.0V | 849A515H02 |
| R178 | POT | 2.5K .25W | 629A645H07 |
| IC21 | INT CKT | 747DM | 1443C52H01 |
| J121 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J122 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J123 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| D88 | DIODE | LED | 3508A22H01 |
| D89 | DIODE | LED | 3508A22H01 |

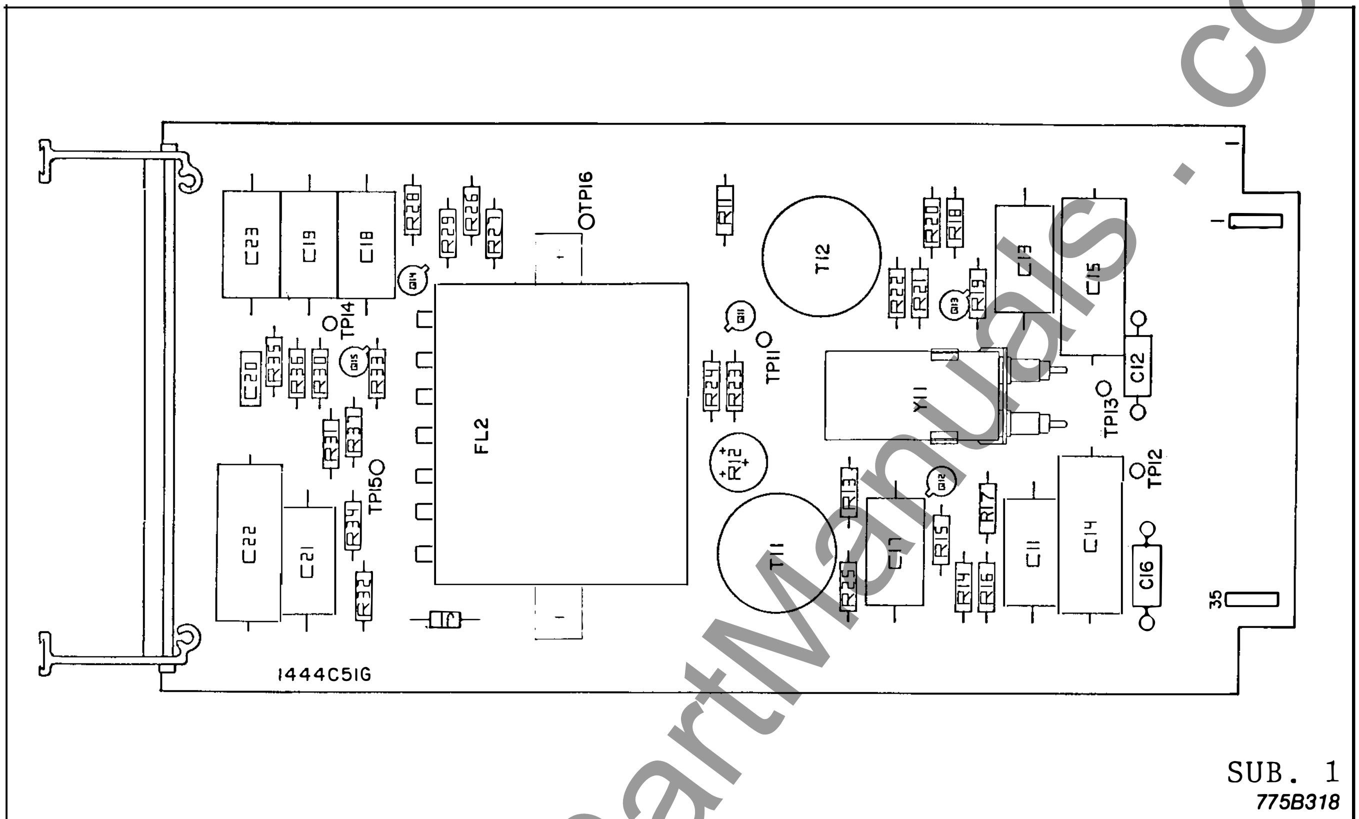



*Fig. 14. Component Location Oscillator Mixer IF Amplifier Module (Below 200kHz)*

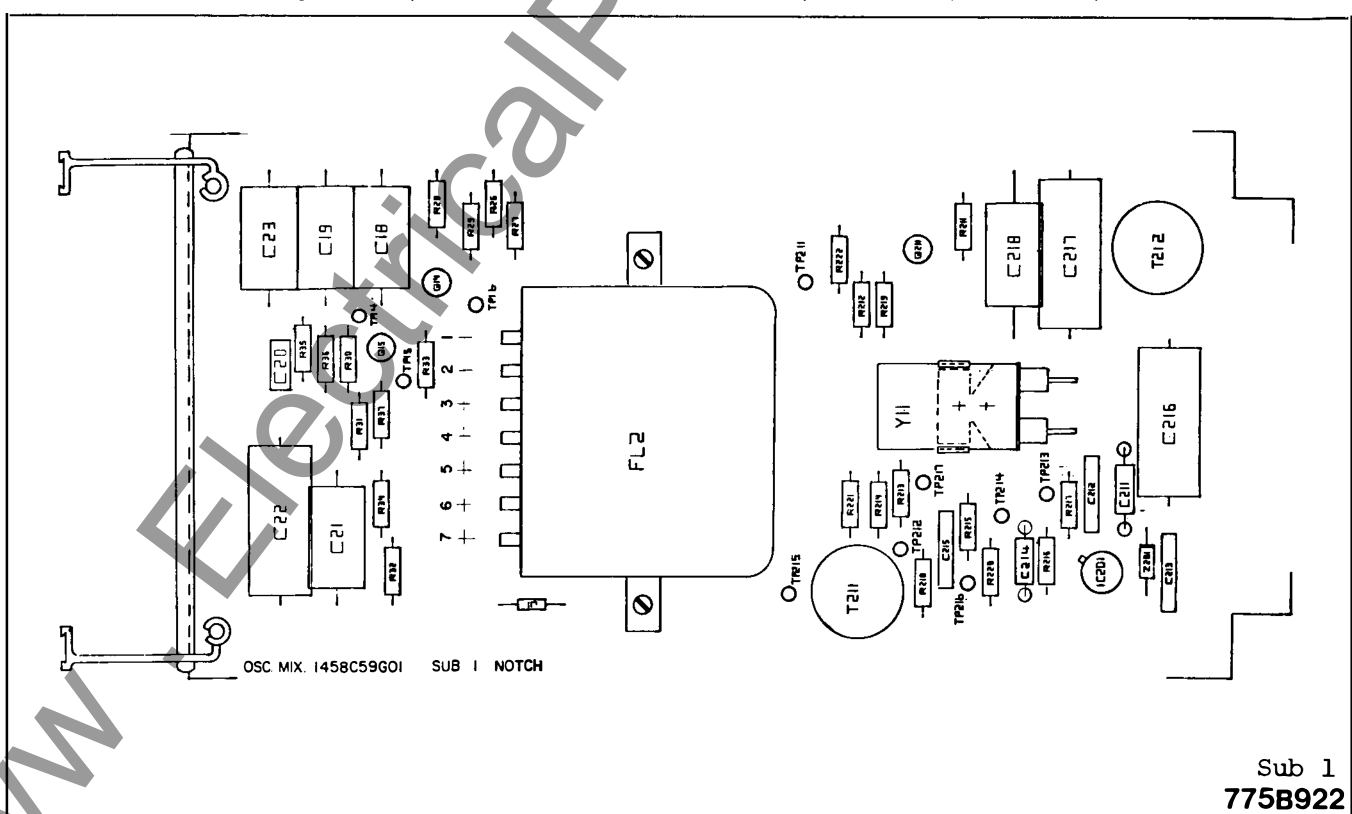



*Fig. 15. Component Location Oscillator-Mixer-IF Amplifier Module (Above 200kHz)*

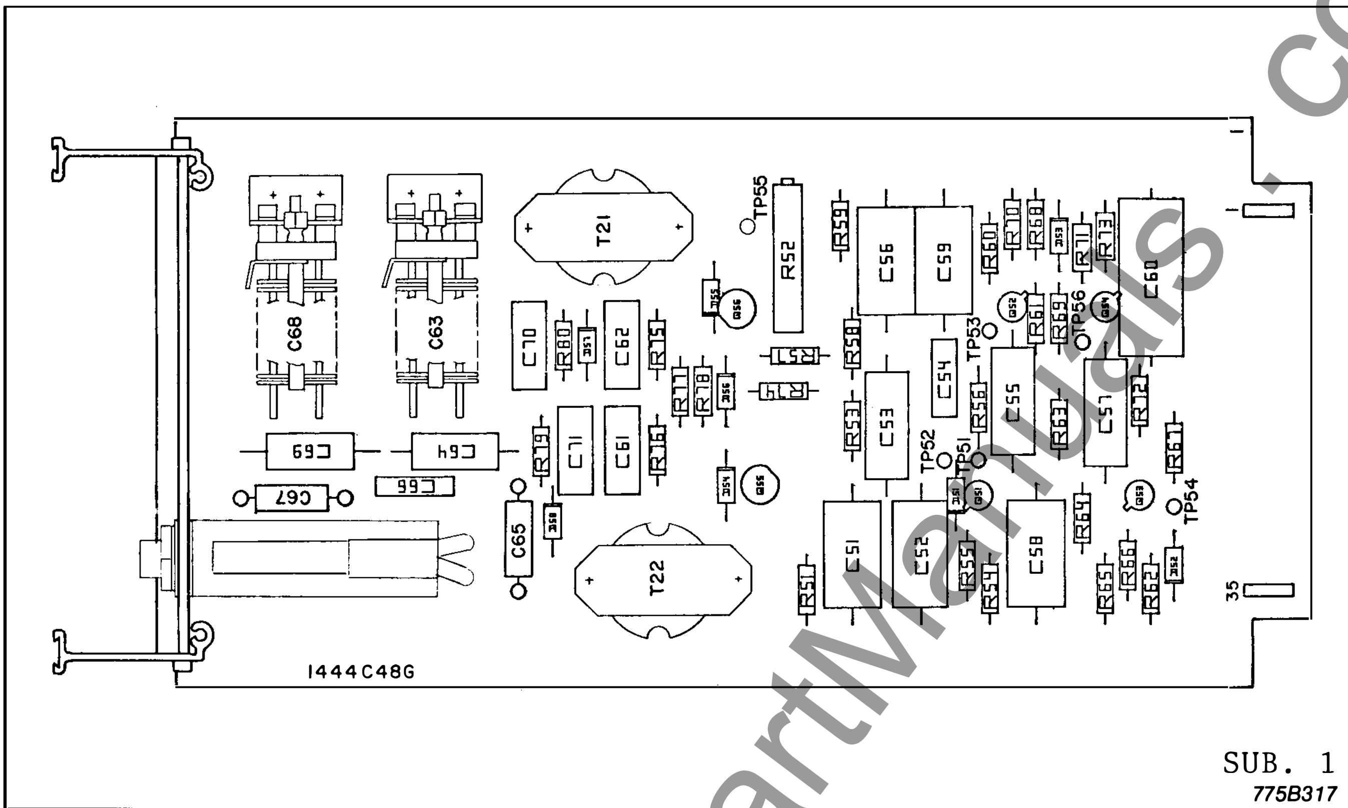



*Fig. 16. Component Location Amplifier Limiter-Discriminator Module.*

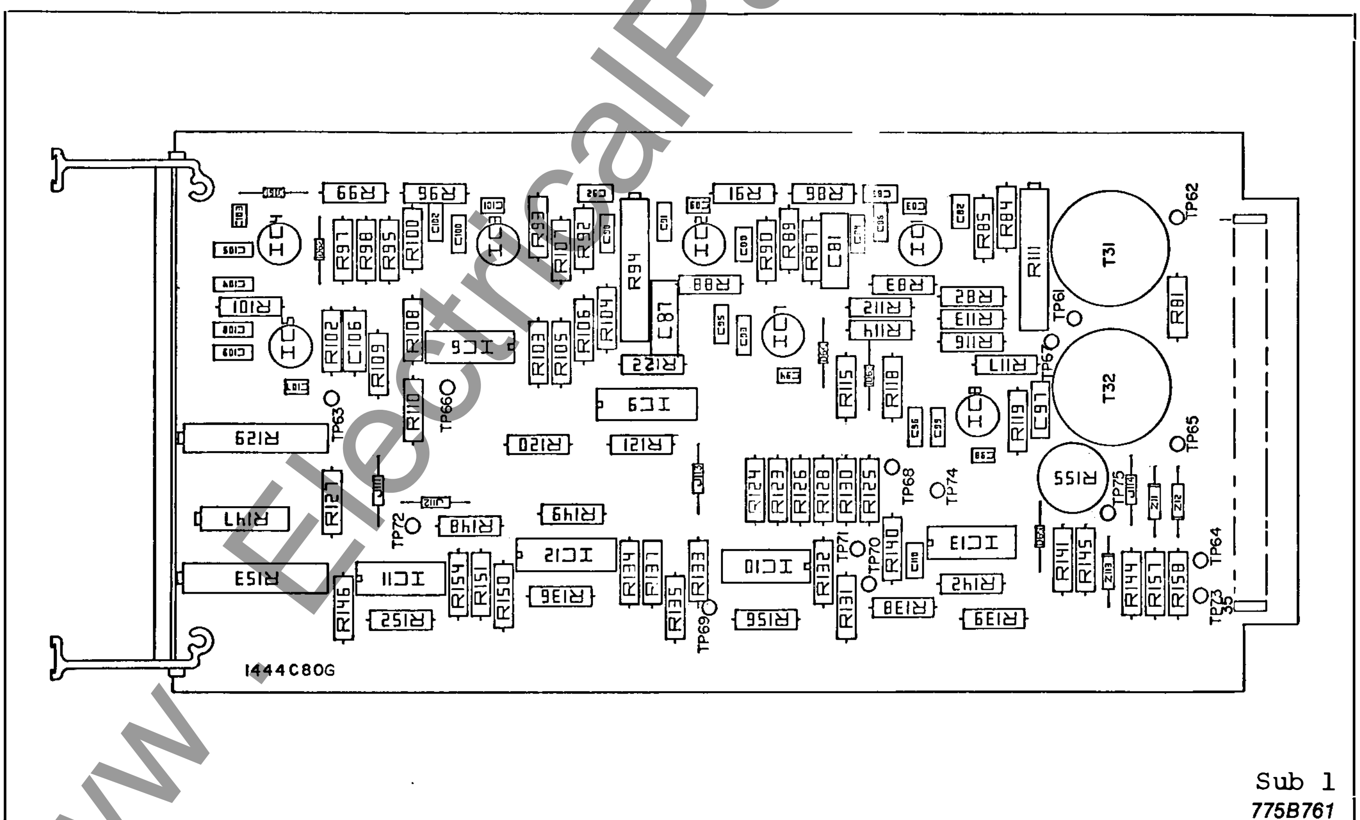



*Fig. 17. Component Location SNR Detection Module.*

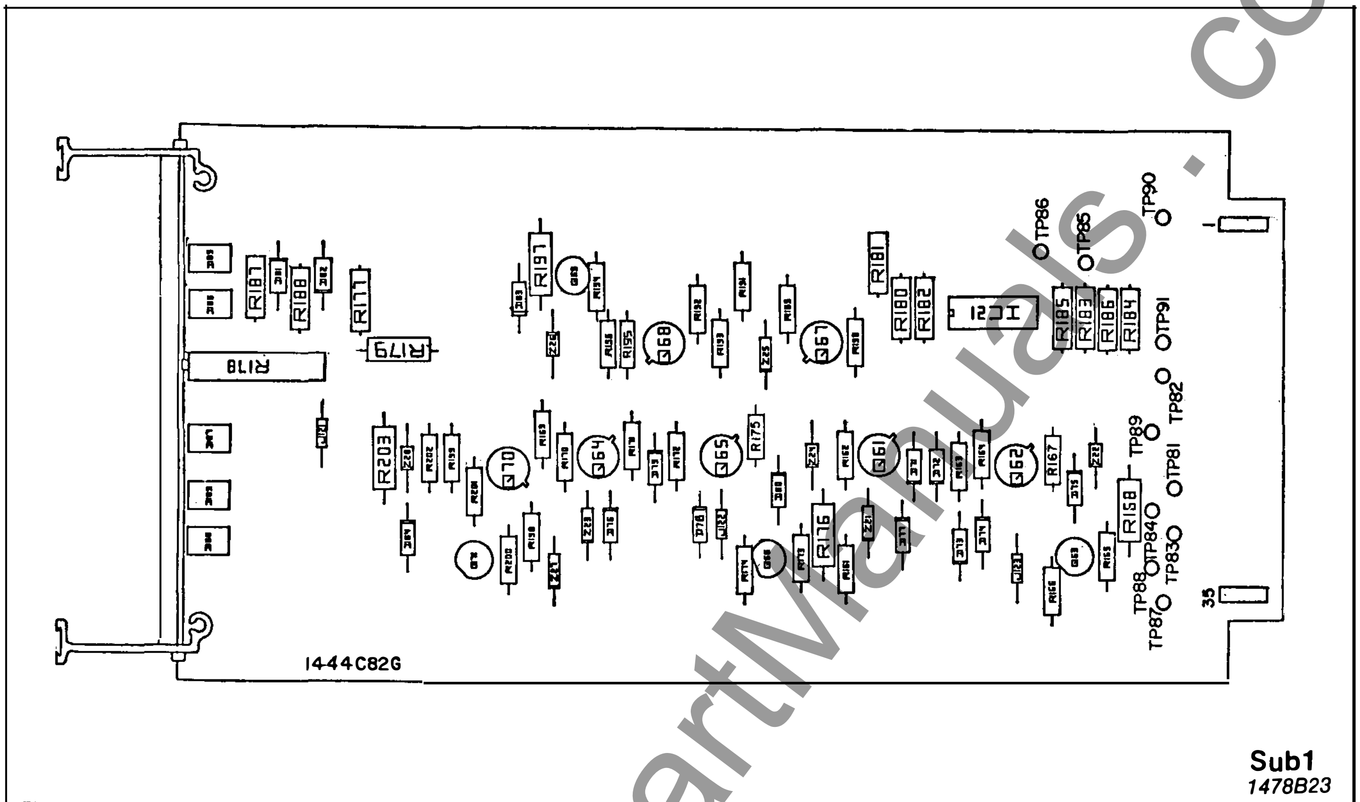



Fig. 18. Component Location Output Module.

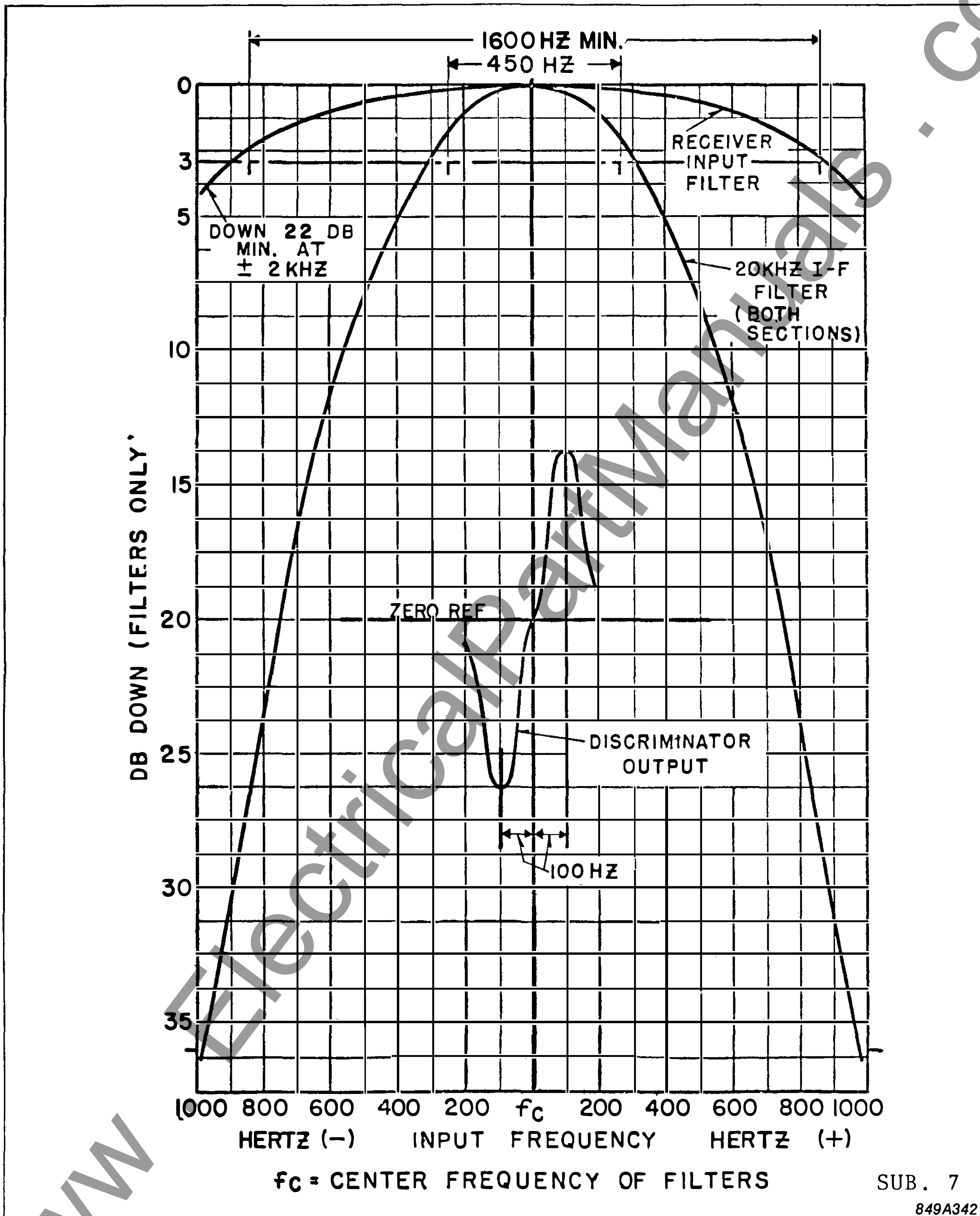



*Fig. 19. Filter and Discriminator Characteristics of the Type TCF-10 Receiver*

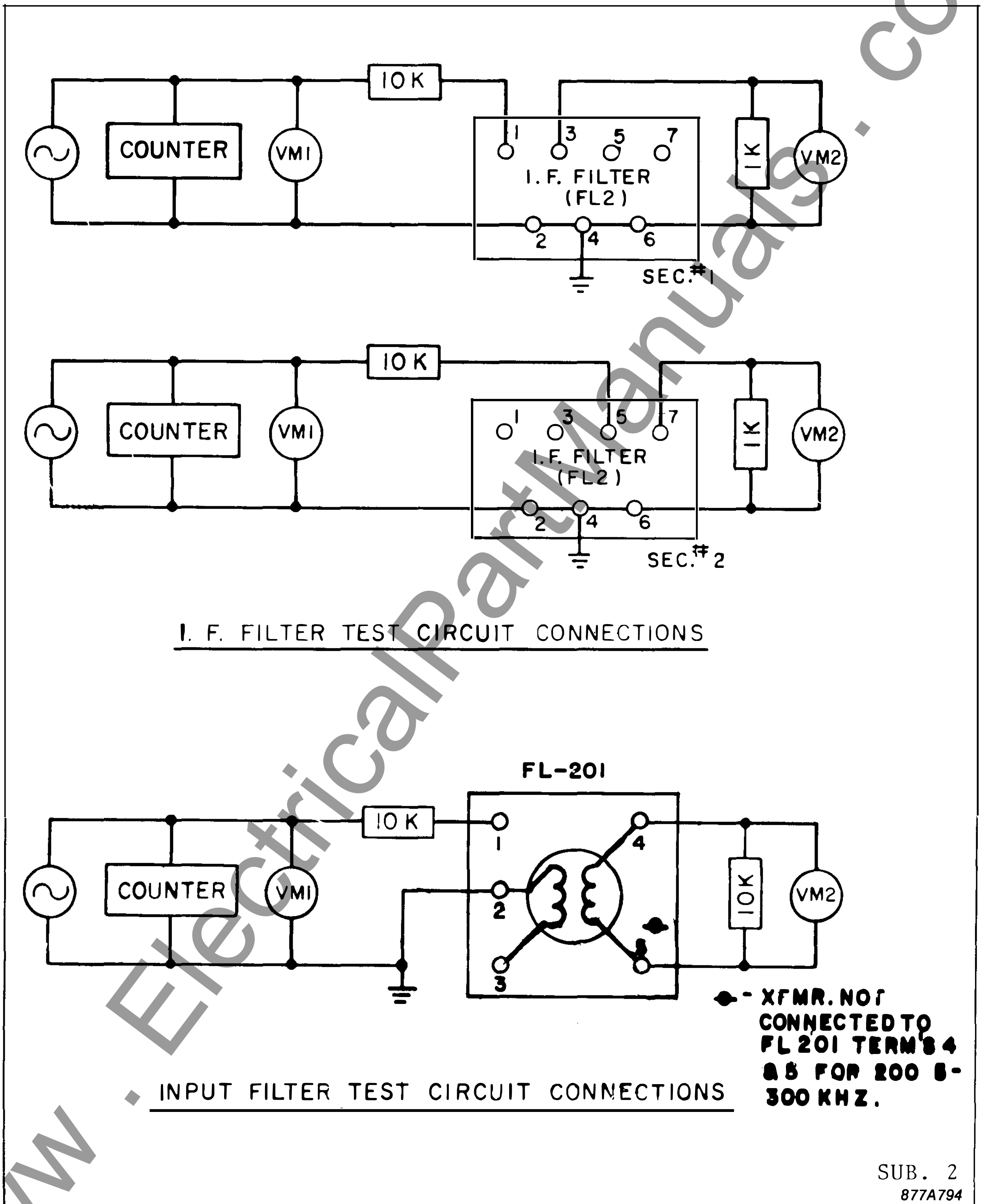



*Fig. 20. Test Circuits for TCF-10 Receiver Filters.*

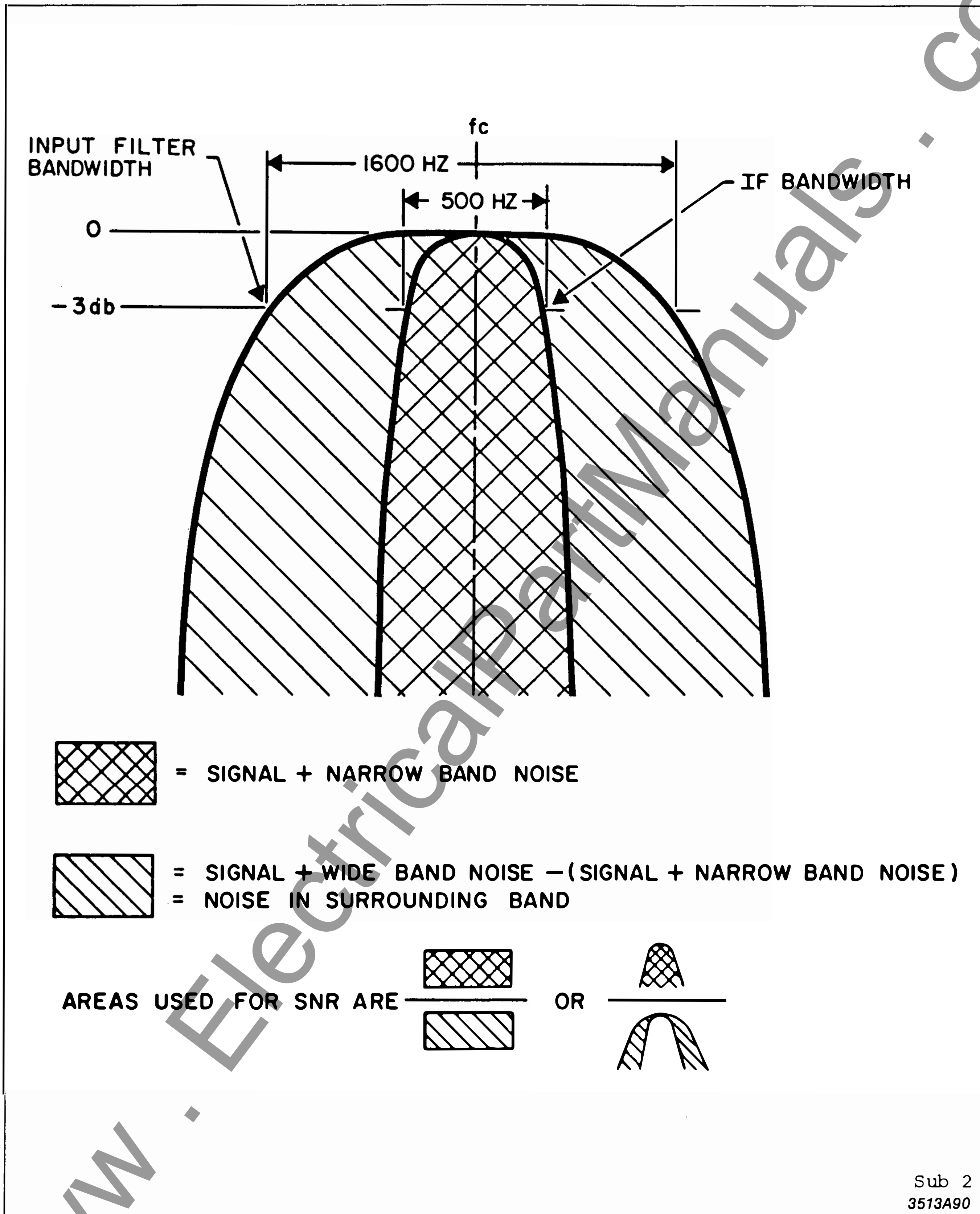
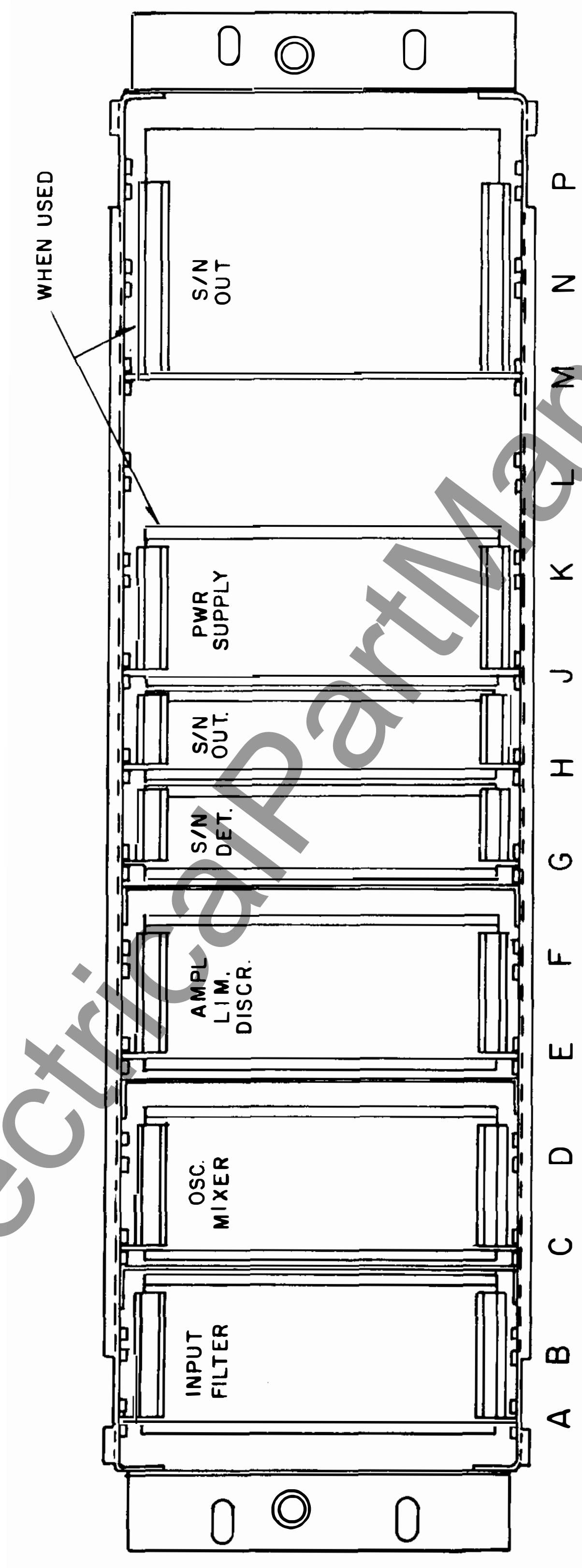
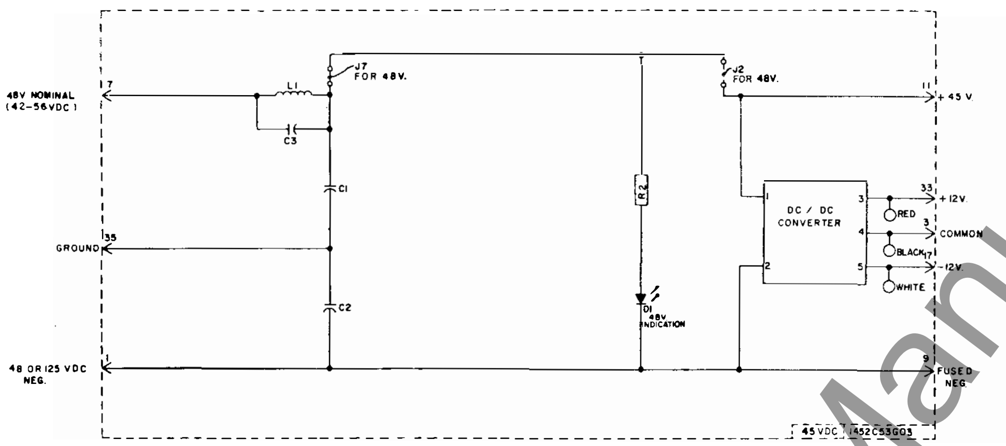



Fig. 21. Signal to Noise Ratio Characteristics.




Sub. 1
1458C95

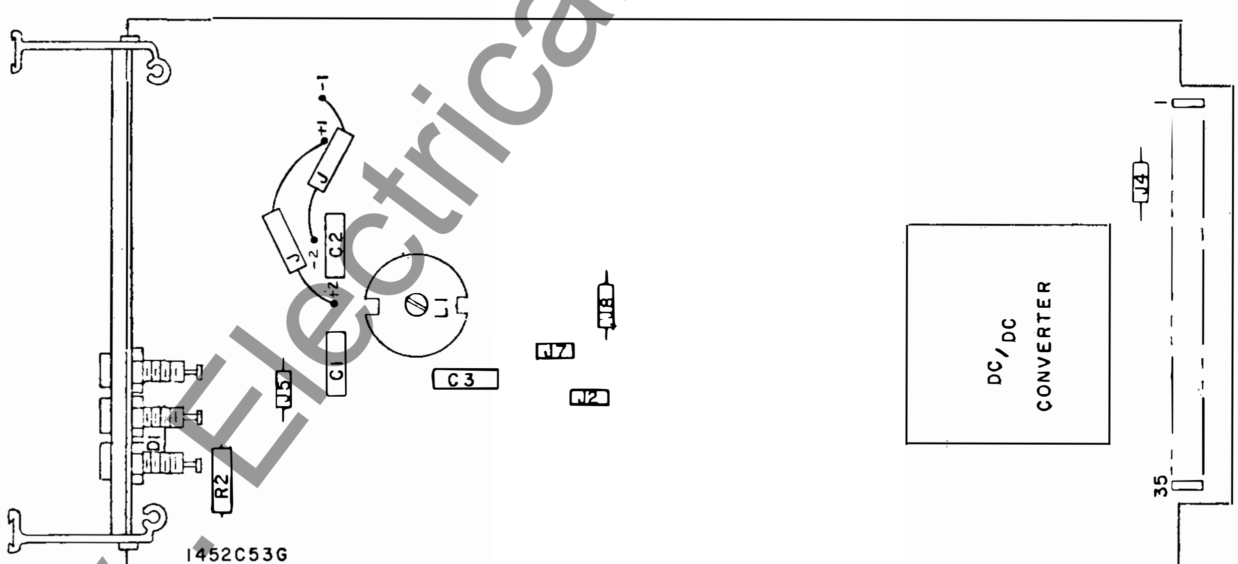
*Fig. 22. Type TCF-10 Receiver, Circuit Board Location.*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C1 | CAPACITOR | .01 MFD | 3516A36H01 |
| C2 | CAPACITOR | .01 MFD. | 3516A36H01 |
| C3 | CAPACITOR | .047 MFD. | 849A437H04 |
| R2 | RESISTOR | 4.7K .50W 2% | 629A531H48 |
| J2 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J7 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| D1 | DIODE | LED | 3508A22H02 |
| L1 | COIL | | 292B096G02 |

(Dwg. 1458C61 Sub 1)

*Fig. 23. Internal Schematic - Power Supply Module*




Sub. 1
(Dwg. 1481B23)

*Fig. 24. Component Location - Power Supply Module*

INSTALLATION • OPERATION • MAINTENANCE

# INSTRUCTIONS

## TYPE TCF-10 POWER LINE CARRIER FREQUENCY-SHIFT RECEIVER EQUIPMENT – WITH RS232C INTERFACE FOR DATA SET APPLICATIONS

### 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 frequency-shift receiver equipment as adapted for data set applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Mark frequency is 100 hertz above the center frequency of the channel (which can be selected within the range of 30kHz to 300kHz), and it is transmitted continuously when conditions are normal and no information is to be conveyed over the channel. Its reception indicates that the channel is operative. The space frequency is 100 hertz below the channel center frequency. When data is to be conveyed over the channel, the transmitter at one end of the channel is switched alternately between mark and space so as to produce at the receiving end a desired number of mark and space outputs. Control of the durations of the intervals of the marks and spaces can be utilized to convey information over the channel.

### CONSTRUCTION

The TCF-10 receiver 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 external connectors are located at the rear of the chassis as shown in Figure 10. 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 attenuator 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

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

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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 +12V and −12V supply derived from a self-contained DC to DC converter. The power supply module containing the DC to DC converter has links which enable it to operate from either 48 volts or 125 volts dc.

External connections to the receiver are made through a 36-terminal receptacle, 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 fed through a coaxial cable connected to jack J2 at the rear of the chassis to the input module. The input control R5, accessible at the front of the input module, attenuates the signal to a level suitable for the best operating range of the receiver.

A scale on the panel is graduated in dB. While this scale is typical rather than individually calibrated, it is accurate within several dB and is useful in setting approximate levels. Settings should be made more accurately utilizing a suitable ac voltmeter with a dB scale when possible.

From the attenuator, the signal passes through a bandpass LC filter, FL 201. This filter has a passband of approximately 1600Hz which is relatively wide in comparison to the IF filter which has a passband of approximately 500Hz. Still, frequencies several kHz above or below the center frequency ($f_c$) of the channel are greatly attenuated. Figure 2 shows a typical curve for the LC filter as well as a characteristics curve for the IF (intermediate frequency) filter, FL2, and the discriminator output. This apparently wide bandwidth for the input filter in relation to the IF filter is necessary to both achieve high speed data transmission and to achieve proper operation of the noise clamp by sampling noise in the frequency band surrounding the IF band.

### OSCILLATOR, MIXER, AND IF AMPLIFIER MODULE

From the input filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20kHz above the channel center frequency, $f_c$. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the latter is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of filter FL1 is impressed on the emitter-collector circuit of Q11. As a result of mixing these two frequencies, the primary of transformer will contain frequencies of 20kHz, $2f_c$ +20kHz, $f_c$ + 20kHz, and $f_c$.

The output from the secondary of T12 is amplified by Q31 in the intermediate frequency (IF) stage, and is impressed on FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. Since its pass band is narrower than that of the input filter, it eliminates the frequencies present at its input that are substantially higher than 20kHz. The output of this filter is the IF output which is fed to both the amplifier-limiter and the S/N Detection module. The output from the secondary of transformer T12, the RF output, is also fed to the S/N Detection module.

### AMPLIFIER LIMITER AND DISCRIMINATOR MODULE

The IF output signal from the IF amplifier is fed into the amplifier limiter through potentiometer R52 at the input of the amplifier limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with input control R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at the channel center frequency, $f_c$. The adjustment for zero output at $f_c$ is made by capacitor C68. In addition, C63 is adjusted for maximum voltage reading across R80 when the output current is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero current output frequency. This separation of 200 hertz between the current peaks is affected by the value of C66 (the actual value of which may be changed slightly from its typical value in factory calibration if required).

It should be observed that although the mark frequency is $f_c$ +100 hertz, after leaving the mixer stage, and as seen by the discriminator, the mark frequency is 20kHz-100 hertz. Similarly the space frequency as seen by the discriminator is 20kHz +100 hertz. The intermediate frequency at which the discriminator has zero output then is 20kHz. The discriminator is adjusted so that the mark and space outputs are of equal lengths for equal periods of mark and space signal frequencies.

The discriminator output is connected to the bases of transistors Q55 and Q56 in such a manner that transistor Q56 is made conductive when current flows, from the discriminator output, in the forward direction of diode D54, (which occurs with space output) and Q55 is made conductive when current flows in the forward direction of diode D55 (which occurs with mark output.) Consequently, terminal 35 is at a potential of approximately +12 volts at mark frequency and terminal 1 is at +12 volts at space frequency.

## S/N DETECTION MODULE

The S/N detection module has three basic functions; first to determine the in-band signal to noise ratio and provide clamping output at the desired level of signal-to-noise ratio, second to measure incoming in band signal level and provide both an output to a carrier level indicating instrument and to a clamping circuit in the output module for clamping at the desired low level of signal, and third to provide a clamping output when the desired signal level exceeds the normal received level by a substantial amount, typically 25dB.

The method of determining signal to noise ratio utilizes the measurement of signal level in two different bandwidths, that of the input filter which is 1600 hertz, and that of the IF filter which is 500 hertz. The total signal plus noise in the 500 hertz bandwidth is subtracted from the signal plus noise in the 1600 hertz bandwidth and this difference is then compared with the signal plus noise in the 500 hertz bandwidth to arrive at a true in-band signal-to-noise ratio using logarithmic circuits. See Figure 21.

If the ratio of signal to noise is less than the value selected, typically 10dB, then there will be a +6V out of IC13 (TP75 and terminal 27). This is a high noise condition and this voltage is used as a clamp to prevent erroneous interpretation of data being received due to high noise conditions. Under normal low noise conditions, typically signal to noise ratio greater than 10dB, the voltage out of IC13 (TP75) is —6V and no clamping is done.

The wide band signal of 1600 hertz bandwidth called the RF signal is fed into the S/N detection board through isolation transformer T31. Operational amplifiers IC1 and IC2 along with their associated components, R82 through R92 and C81 through C90, constitute a 4 pole low pass filter which passes the mixed band of frequencies in the bandwidth of 1600 Hz centered about the 20kHz IF frequency, and blocks all the higher multiples such as in the IF amplifier. Operational amplifier IC3 and associated components amplifies the signal for feeding into the RMS circuit composed of IC4 and IC5 with adjustable potentiometer R94 controlling the amount of amplification. This latter circuit converts the signals into a dc voltage proportional to the RMS value of the ac signals. Operational amplifier IC6A and associated components is used for inversion and isolation of this dc voltage before being fed into the summation amplifier IC6B.

The narrow-band signal of 500 hertz bandwidth called the IF is fed into the S/N detection board through isolation transformer T32. The amount of signal fed into the board is adjustable by means of potentiometer R111. The circuit composed of operational amplifiers IC7 and IC8 and associated components is an RMS circuit which converts the signals into a dc voltage proportional to the RMS value of the ac signals present in the IF bandwidth. The output of this circuit is also then fed into the summation amplifier IC6B.

The summation amplifier takes the difference between the RMS values of the IF signal and the RF signal and feeds it into one half of the logarithmic amplifier composed of IC9 and associated components. At the same time, the RMS value of the IF signal is fed into the other half of this logarithmic amplifier. The logarithmic amplifier takes the logarithmic difference between these two signals (which is equivalent to IF divided by [RF-IF] from the summer). The constants of the circuits are set up so that the output of the logarithmic amplifier is positive when the ratio of the signal to noise ratio in these bandwidths is greater than 10dB, and is negative when the signal to noise ratio is less than 10dB. (Note: The point at which the change in polarity occurs can be altered to other than 10dB signal to noise ratio by altering the adjustments of R94 and R111). In addition, the output of the logarithmic amplifier is also negative when the signal level is approximately 25dB above normal for high level clamping.

The output of the logarithmic amplifier is fed through networks consisting of IC10A and IC13A to the level detector circuit IC13B which has a fast pickup and slow dropout when it receives a signal from the logarithmic amplifier indicating a lower than desired signal to noise ratio (lower than 10dB is initially set when shipped). This will put out a +6 volts out of terminal 27 for this condition. For high signal to noise ratio this output will be −6 volts. This circuit will also put out +6 volts out of terminal 27 for very high signal levels. This is a high signal clamp and occurs for signal levels approximately plus 25dB above normal level.

The output of the IF RMS circuit is also fed to the logarithmic circuit composed of IC11A, IC12A, and IC11B which puts out a dc signal level linearly proportional to signal level in dB for feeding an external microammeter calibrated with a linear dB scale with 10dB equal to 33-1/3 microamperes.

## OUTPUT MODULE

The output module provides four buffered outputs to the data aquisition system. They are mark, space, S/N level, and not low signal with red indicating light emitting diodes for these outputs and a yellow indicating light emitting diode for normal level (satisfactory signal level). In addition, the output module has logic which will prevent either a +12V mark or +12V space output whenever the S/N level drops to an unsatisfactory level or the received signal level drops to an unsatisfactory level.

The higher frequency output of plus 12 volts (when present) from the discriminator is fed into the output module through termical 25 into the "and" gate consisting of diodes D71, D72, D73, and D74, transistors Q62 and Q63, and associated components R163, R164, R165, R166, R167, R168, D88, D75, and Z22. If there is no low level signal or low signal to noise ratio signal to prevent transistor Q62 from becoming conducting, then transistor Q62 becomes conducting, causing Q63 to become conducting and a plus 12 volts signal to appear out of terminal 29 from which it is fed to the outside world. In a similar manner, the lower frequency output of plus 12 volts when present from the discriminator is fed into the output module through terminal 15 into the "and" gate built around transistors Q65 and Q66. Just as in the case of the higher frequency output, the lower frequency output of plus 12 volts will appear out of terminal 27 for feeding to the data acquisition equipment if there is no low level clamp or low signal to noise ratio clamp. If there is a clamp, both of these outputs will be clamped to minus 12 volts output.

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 plus 12 volt signals from appearing on the outputs going to the outside world 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 12 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 +6 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 12 volts out of terminal 13 to the outside world. Transistor Q61 conducting will prevent both transistors Q62 and Q65 from conducting, and thus prevent plus 12 volt signals from appearing at their respective outputs to the outside world. 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.

## OUTPUT MODULE – CONTACT OUTPUT

The output module-contact output performs two functions; alarming on low signal level using a telephone relay with two form C contacts, and indicating signal level with its self-contained CLI instrument.

The alarm circuit consists of all components associated with IC1, IC2, Q1, Q2, Q3, and relay AL. The signal level from the S/N detection module is fed into a level detector consisting of IC1B and resistors R6, R7, R8, and R9. An adjustable reference for the level detector consisting of IC1A and R1, R2, R17, R3, R4, and R5 is also fed into the level detector. As long as the signal level exceeds the value set by the reference, there will be approximately plus 12 volts out of the level detector into the photo-optical isolator. This causes Q1 to become non-conducting and thus transistors Q2 followed by transistor Q3 to become conducting. As a consequence, the alarm relay AL is picked up on signal levels above the alarm level. When the signal level drops below the alarm level set by the reference, the output of the level detector will be minus 12 volts causing Q1 to become conducting and Q2 and Q3 to become non-conducting and drop out the alarm relay AL. The alarm relay has a delay of approximately 40 milliseconds on dropout to prevent undesirable alarming on short temporary loss of signal. Note that the level of alarm is set by adjusting alarm level R17, accessible from front of module, independent of the low signal level output from the output module (which is set by L.L. ADJ. R178). Also both of these outputs operate on total signal level within the passband of the receiver.

The CLI instrument operates directly on signal level received from the S/N detection module. It measures signal level in the entire bandwidth of the receiver and thus closely correlates with the low level clamp (L.L. ADJ.) and the low signal alarm AL (alarm level). It thus can be used in setting both of these adjustments.

## POWER SUPPLY

The +12 volt dc, −12 volt dc, and the +45 volt dc supply voltages for the receiver are derived from the power supply module.

The +12 volt dc supply and the −12 volt dc supply are both derived from the DC to DC converter and are regulated for input voltages to the regulator of from 42 volts to 56 volts. For nominal 48 volt input units, the DC to DC converter has sufficient range so that the preregulator consisting of R1, R4, and Z1 is not necessary and is not connected by omitting jumpers J1 and J3 and supplying J7 and J2. In this case, then, the +45 volt supply is derived directly from the input supply voltage and is not regulated.

For nominal 125 volt input units, the pre-regulator consisting of R1, R4, and Z1 is necessary and is connected by supplying jumpers J1 and J3 and omitting J7 and J2. In this case then, the +45 volt supply is derived from this pre-regulator and is regulated.

The LED's D1 and D2 indicate when the power supply is energized with either 48V or 125V by the proper one glowing. Since all components are supplied in each power supply, a 48V supply can be converted to a 125V supply simply by removing jumpers J7 and J2 and inserting J1 and J3. Similarly, a 125V supply can be converted to a 48V supply by removing jumpers J1 and J3 and inserting J7 and J2. 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 |
| Maximum Sensitivity (Noise free | 0.005 volts (65dB below 1 watt for limiting) |
| Input Impedence | 5000 ohms minimum |
| Bandwidth (Input L C Filter) | Down 3dB at ±800 hertz<br>Down 30dB at ±5000 hertz |
| Overall receiver selectivity | Down 3dB at ±225 hertz<br>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) Nominal |
| Ambient Temperature Range | −20°C to +55°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)<br>Panel Width = 19 inches |
| Weight | 13 pounds |
| CLI Accuracy | ±2dB between −15dB and 0dB. |

## INSTALLATION

The TCF-10 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 the TCF-10. Heat 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 55°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-10 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 alarm relay; 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 nether 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. (Note: When CL1 instrument is supplied within the chassis, this is factory adjusted.)

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 30dB.
4. Adjust full scale adjustment, R153, so that instrument now reads −20dB. (This is approximately 0 microamperes).
5. Increase signal to +10dB level. (This is 100 microamperes).
6. Adjust slope adjustment R155 to read +10dB on instrument.
7. Reduce signal to normal level. Instrument should read 0dB. If desired, instrument could be adjusted to read 0dB with R155 with sacrifice in reading accuracy for +10dB.

## 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 IF input with R111 so that signal at TP68 of the S/N detector module is +100 mv dc (with respect to TP62).
3. Adjust RF input with R94 so that signal at TP63 is +145 mv dc (with respect to TP62).
4. Adjust log amplifier balance potentiometer R129 so that S/N clamps operates. This will be +6 volts dc at TP75. This will also appear as +12 volts at TP91 of the output board and the red S/N level indicator will light.

5. Go back and readjust RF input with R94 so that signal level at TP63 is now 74.4 mv dc.

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 145 mv value in step 3.

For S/N of 0dB set TP63 to 297mv.
5dB set TP63 to 200mv.
15dB set TP63 to 114mv.
20dB set TP63 to 97mv.

**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 limited 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 of the output module coming on. There also will be +12 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.

The alarm level is set to alarm at a signal level 5dB above the signal where the receiver just drops out of limiting. This will result in an alarm be given at a point where the signal level has dropped 10dB from the initial nominal setting but the receiver signal level is still 5dB above limiting.

1. With a normal higher frequency signal being received and with an RF voltmeter connected across the input module input test jacks TJ1 and TJ2 (available at front on module), adjust input attenuator R5 to where signal level is 9mv across these test jacks.

2. Adjust the alarm level R17 on the output module — contact output to the point where the alarm relay AL just drops out.

3. Adjust input attenuator R5 to increase signal level into receiver by 10dB. (This is for operation with 15dB margin. For other than 15dB margin, this value should be changed accordingly.) This is done by reducing the R5 attenuator setting by 10dB.

## MAINTENANCE

Periodic checks of the received carrier signal level and the receiver sensitivity 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 low level 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.

## RELAY MAINTENANCE AND ADJUSTMENT

The AL relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

## TABLE I
## RECEIVER D-C MEASUREMENTS

**NOTE:** All voltage readings taken with the negative 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 lower frequency, higher frequency, or zero.

| Collector of Transistor or Test Point | Voltage (Positive) |
|---|---|
| Q11 | < 15 |
| Q12 (TP12) | 17 (Mark or Space) |
| Q13 (TP13) | 17 (Mark or Space) |
| Q14 (TP14) | 3 |
| Q15 (TP15) | 3 |
| TP11 | 22 |
| TP52 ◆ | 19 |
| Q51 (TP51) | 14 |
| Q52 (TP53) | 14.5 |
| Q53 (TP54) | 18 |
| Q54 (TP55) | 3 |
| TP56 | 19 |
| Q55 | < 1 (Lower Freq. or No Signal) |
| Q55 | 23 (Higher Freq.) |
| Q56 | 23 (Lower Freq.) |
| Q56 | < 1 (Higher Freq. or No Signal) |

**NOTE:** The following readings are taken with the negative of dc VTVM on terminal 3 (common of dc power supply) of either the S/N detection module or the output module.

| | |
|---|---|
| TP61 | + 4 |
| TP62 | 0 |
| TP63 | + 0.4 |
| TP64 | + 6 |
| TP65 | −12 |
| TP66 | 0 |
| TP67 | + 0.5 |
| TP68 | + 0.5 |
| TP70 | − 6 |
| TP71 | + 6 |
| TP72 | + 1.5 |
| TP73 | + 0.8 |
| TP74 | + 0.3 |
| TP81 | +12 (Higher Frequency) |
| TP81 | −12 (Lower Freq. or No Signal) |
| TP82 | +12 (Lower Frequency) |
| TP82 | −12 (Higher Freq. or No Signal) |
| TP83 | +12 (Higher Frequency) |
| TP83 | −12 (Lower Freq. or No Signal) |
| TP84 | +12 (Lower Frequency) |
| TP84 | −12 (Higher Freq. or No Signal) |
| TP85 | + 0.3 |
| TP86 | +12 (Low level clamp) |
| TP86 | 0 (No clamp) |
| TP87 | + 6 (Low SNR clamp) |
| TP87 | − 6 (No SNR clamp) |
| TP88 | +12 |
| TP89 | −12 |
| TP90 | +12 (Good Signal Level) |
| TP90 | −12 (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 in 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 19 can be used in case there is reason to suspect that either of the filters is not performing correctly.

Figure 2 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 2 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 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 19) 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 that 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-10 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 60 hertz to 330 kHz, 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. CLI Microammeter, range 0-100$\mu$A, style number 606B592A26, (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: 20kHz to 330kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

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.

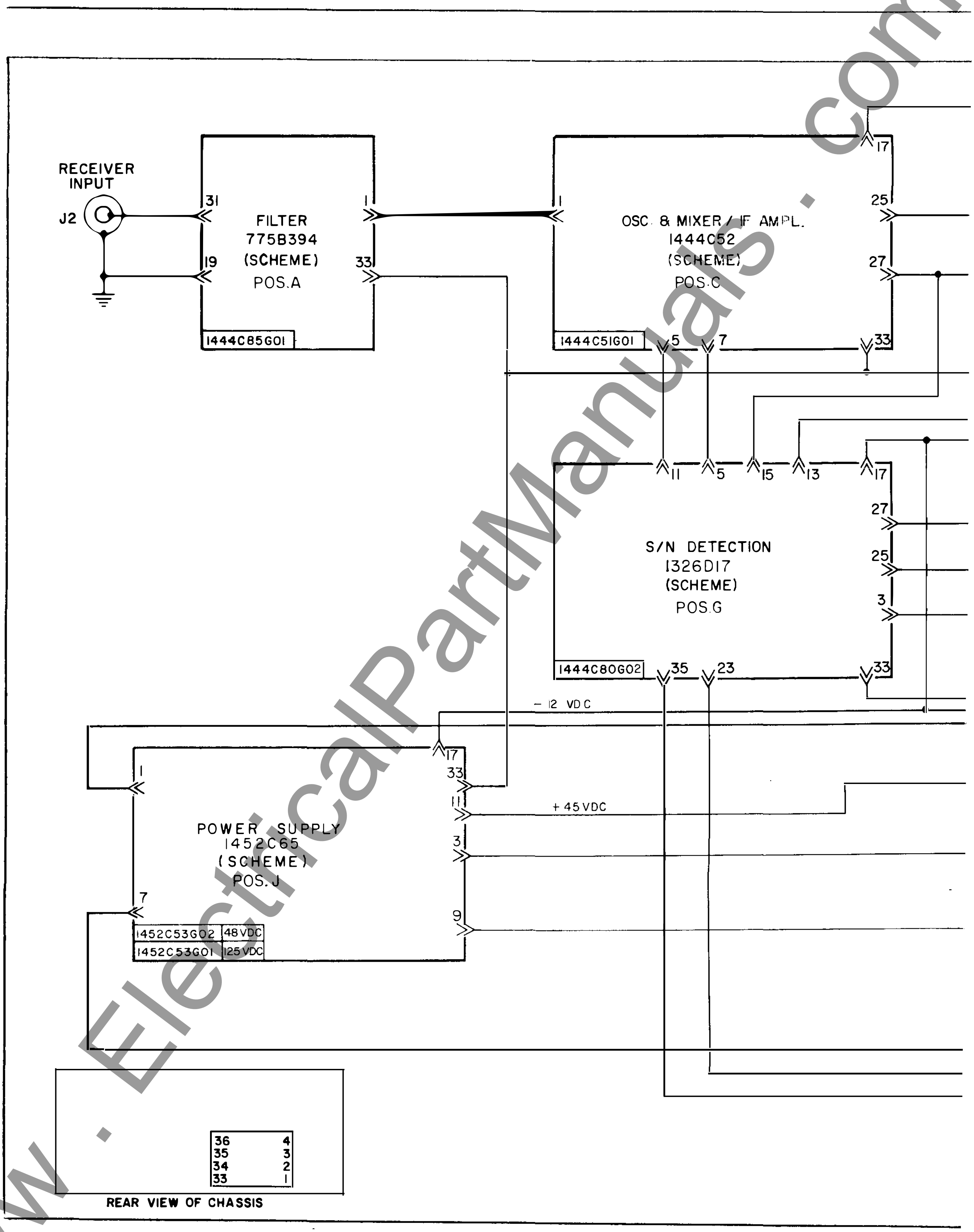
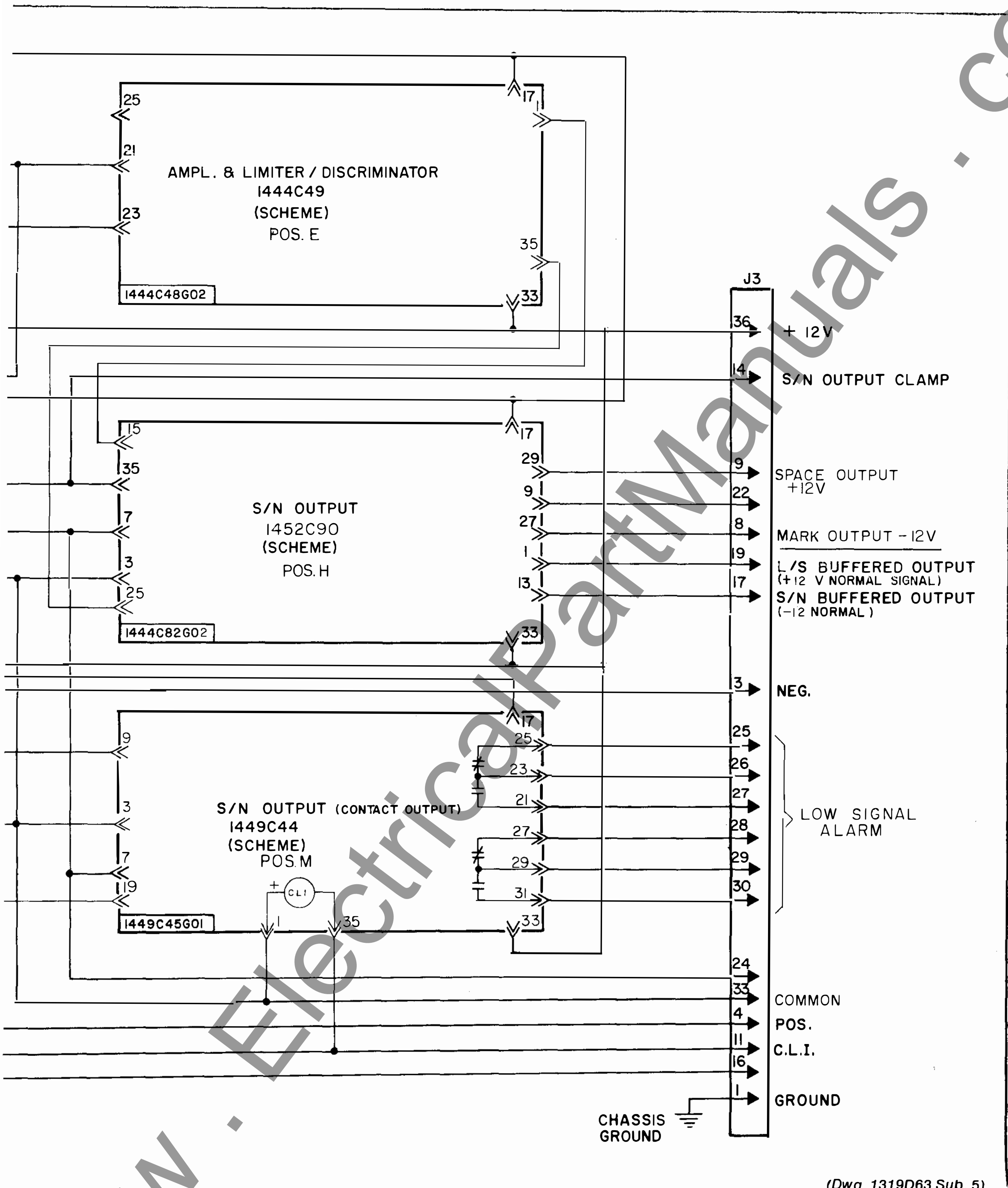
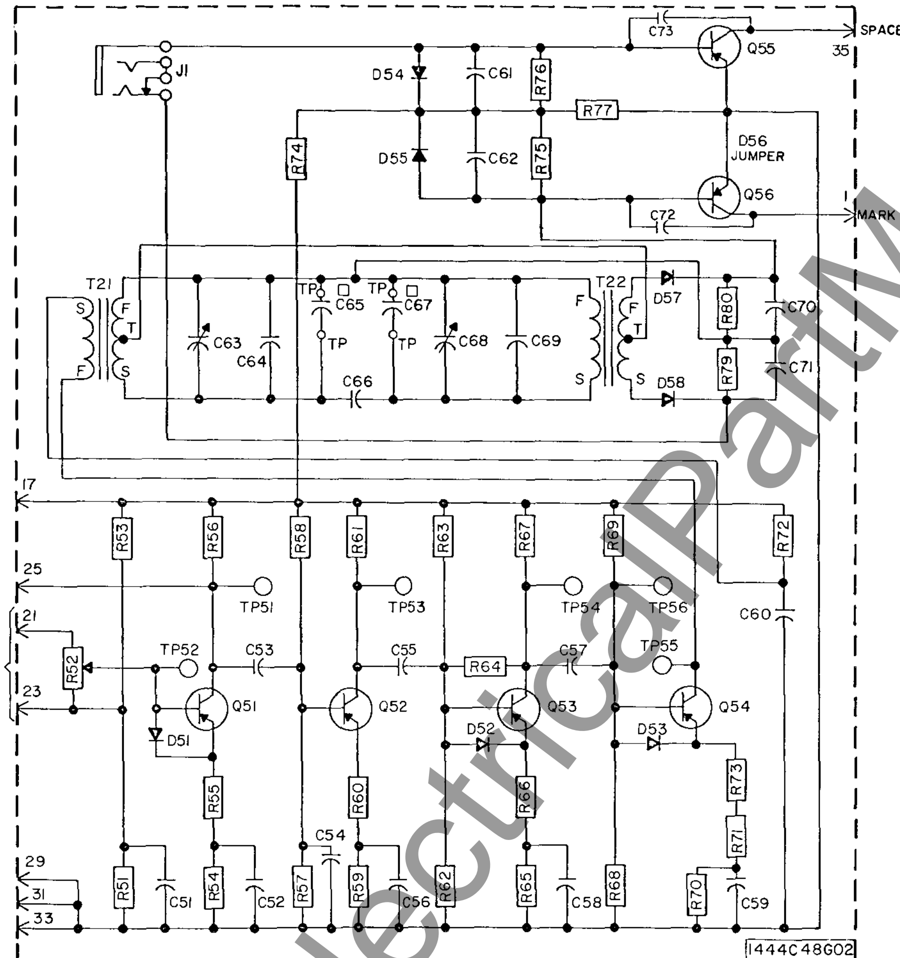



Fig. 1. Overall Schem




*(Dwg. 1319D63 Sub. 5)*

atic of TCF-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 |
| C72 | CAPACITOR | 330.000PF | 200V | 880A397H01 |
| C73 | CAPACITOR | 330.000PF | 200V | 880A397H01 |
| D51 | DIODE | 1N457A | | 184A855H07 |
| D52 | DIODE | 1N457A | | 184A855H07 |
| D53 | DIODE | 1N457A | | 184A855H07 |
| D54 | DIODE | 1N457A | | 184A855H07 |
| D55 | DIODE | 1N457A | | 184A855H07 |
| D56 | DIODE | 1N457A | | 184A855H07 |
| 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 |

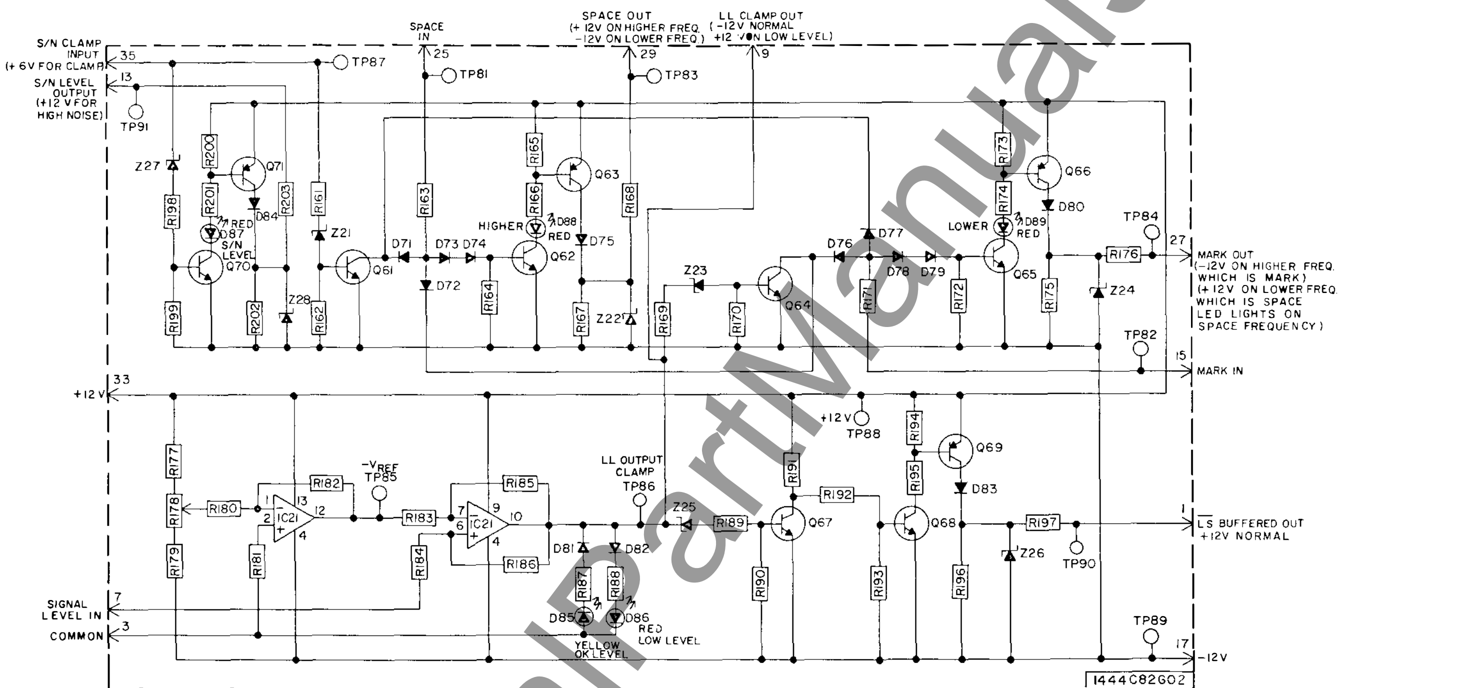
□-ONE OR TWO CAPACITORS USED; VALUES DETERMINED IN TEST.

*(Dwg. 1444C49 Sub. 4)*

✪ *Fig. 5. 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 200.0K .50W 1% | 848A821H71 |
| 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 1.0K .50W 1% | 848A819H48 |
| R155 | RESISTOR 1.0K .25W 20% | 629A430H02 |
| 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 | 629A645H12 |
| 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 .22 UF 100V | 3512A08H02 |
| 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 IN825A 6.2V | 862A288H06 |
| Z12 | ZENER IN825A 6.2V | 862A288H06 |
| Z113 | ZENER IN825A 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 |
| T31 | TRANSFORMER | 714B677G01 |
| T32 | TRANSFORMER | 714B677G01 |

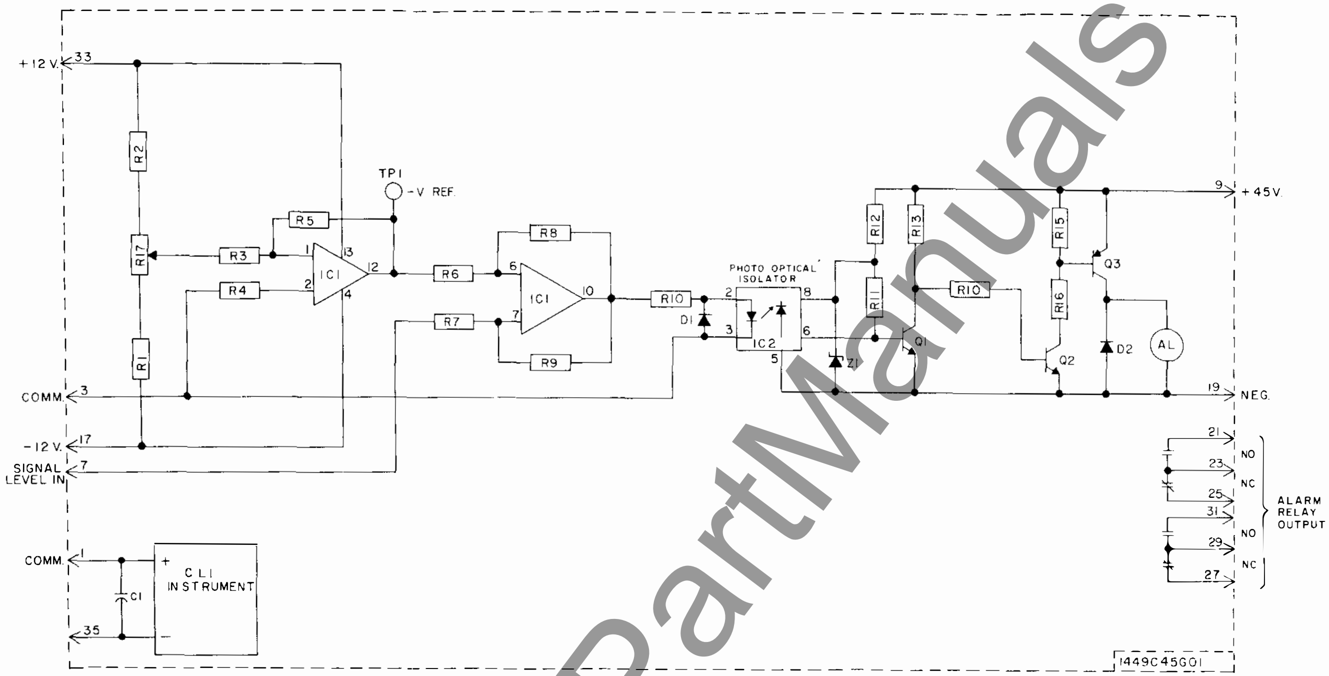



| COMPONENT | | DESCRIPTION | | | STYLE NO. |
|---|---|---|---|---|---|
| D71 | DIODE | 1N645A | | | 837A692H03 |
| D72 | DIODE | 1N645A | | | 837A692H03 |
| D73 | DIODE | 1N645A | | | 837A692H03 |
| D74 | DIODE | 1N645A | | | 837A692H03 |
| D75 | DIODE | 1N645A | | | 837A692H03 |
| D76 | DIODE | 1N645A | | | 837A692H03 |
| D77 | DIODE | 1N645A | | | 837A692H03 |
| D78 | DIODE | 1N645A | | | 837A692H03 |
| D79 | DIODE | 1N645A | | | 837A692H03 |
| D80 | DIODE | 1N645A | | | 837A692H03 |
| D81 | DIODE | 1N457A | | | 184A855H07 |
| D82 | DIODE | 1N457A | | | 184A855H07 |
| D83 | DIODE | 1N645A | | | 837A692H03 |
| D84 | DIODE | 1N645A | | | 837A692H03 |
| D85 | DIODE | LED | | | 3508A22H02 |
| D86 | DIODE | LED | | | 3508A22H01 |
| D87 | DIODE | LED | | | 3508A22H01 |
| R161 | RESISTOR | 10.0K | .50W | 5% | 184A763H51 |
| R162 | RESISTOR | 120.0K | .50W | 5% | 184A763H77 |
| R163 | RESISTOR | 33.0K | .50W | 5% | 184A763H63 |
| R164 | RESISTOR | 120.0K | .50W | 5% | 184A763H77 |
| R165 | RESISTOR | 4.7K | .50W | 5% | 184A763H51 |
| R166 | RESISTOR | 2.4K | .50W | 5% | 184A763H57 |
| R167 | RESISTOR | 1.5K | .50W | 1% | 848A819H65 |
| R168 | RESISTOR | 499.0 | .50W | 1% | 848A819H19 |
| R169 | RESISTOR | 10.0K | .50W | 5% | 184A763H51 |
| R170 | RESISTOR | 120.0K | .50W | 5% | 184A763H77 |
| R171 | RESISTOR | 33.0K | .50W | 5% | 184A763H63 |
| R172 | RESISTOR | 120.0K | .50W | 5% | 184A763H77 |
| R173 | RESISTOR | 4.7K | .50W | 5% | 184A763H51 |
| R174 | RESISTOR | 2.4K | .50W | 5% | 184A763H57 |
| R175 | RESISTOR | 1.5 K | .50W | 1% | 848A819H65 |
| R176 | RESISTOR | 499.0 | .50W | 1% | 848A819H19 |
| R177 | RESISTOR | 10.0K | .50W | 1% | 848A820H45 |
| R179 | RESISTOR | 10.0K | .50W | 1% | 848A820H45 |
| R180 | RESISTOR | 69.1K | .50W | 1% | 848A821H26 |
| R181 | RESISTOR | 4990.0 | .50W | 1% | 848A820H16 |
| R182 | RESISTOR | 6910.0 | .50W | 1% | 848A820H29 |
| R183 | RESISTOR | 2.0K | .50W | 1% | 848A819H77 |
| R184 | RESISTOR | 2.0K | .50W | 1% | 848A819H77 |
| R185 | RESISTOR | 562.0K | .25W | 1% | 848A822H15 |
| R186 | RESISTOR | 511.0K | .50W | 1% | 848A822H11 |
| R187 | RESISTOR | 1620.0 | .25W | 1% | 848A819H48 |
| R188 | RESISTOR | 1620.0 | .25W | 1% | 848A819H45 |
| R189 | RESISTOR | 33.0K | .50W | 5% | 184A763H63 |
| R190 | RESISTOR | 68.0K | .50W | 5% | 184A763H71 |
| R191 | RESISTOR | 68.0K | .50W | 5% | 184A763H71 |

| COMPONENT | | DESCRIPTION | | | STYLE NO. |
|---|---|---|---|---|---|
| R192 | RESISTOR | 33.0K | .50W | 5% | 184A763H63 |
| R193 | RESISTOR | 120.0K | .50W | 5% | 184A763H77 |
| R194 | RESISTOR | 10.0K | .50W | 5% | 184A763H51 |
| R195 | RESISTOR | 18.0K | .50W | 5% | 184A763H57 |
| R196 | RESISTOR | 1.5 K | .50W | 1% | 848A819H65 |
| R197 | RESISTOR | 499.0 | .50W | 1% | 848A819H19 |
| R198 | RESISTOR | 33.0K | .50W | 5% | 184A763H63 |
| R199 | RESISTOR | 68.0K | .50W | 5% | 184A763H71 |
| R200 | RESISTOR | 4700.0 | .50W | 5% | 184A763H43 |
| R201 | RESISTOR | 2400.0 | .50W | 5% | 184A763H36 |
| R202 | RESISTOR | 1.5K | .50W | 1% | 848A819H65 |
| R203 | RESISTOR | 499.0 | .50W | 1% | 848A819H19 |
| Q61 | TRANSISTOR | 2N699 | | | 184A638H19 |
| Q62 | TRANSISTOR | 2N699 | | | 184A638H19 |
| Q63 | TRANSISTOR | 2N3645 | | | 849A441H01 |
| Q64 | TRANSISTOR | 2N699 | | | 184A638H19 |
| Q65 | TRANSISTOR | 2N699 | | | 184A638H19 |
| Q66 | TRANSISTOR | 2N3645 | | | 849A441H01 |
| Q67 | TRANSISTOR | 2N699 | | | 184A638H19 |
| Q68 | TRANSISTOR | 2N699 | | | 184A638H19 |
| Q69 | TRANSISTOR | 2N3645 | | | 849A441H01 |
| Q70 | TRANSISTOR | 2N699 | | | 184A638H19 |
| Q71 | TRANSISTOR | 2N3645 | | | 849A441H01 |
| Z21 | ZENER | 1N961B | 10.0V | | 186A797H07 |
| Z22 | ZENER | IN4752A | 33.0V | | 849A515H02 |
| Z23 | ZENER | 1N961B | 10.0V | | 186A797H07 |
| Z24 | ZENER | IN4752A | 33.0V | | 849A515H02 |
| Z25 | ZENER | 1N961B | 10.0V | | 186A797H07 |
| Z26 | ZENER | IN4752A | 33.0V | | 849A515H02 |
| Z27 | ZENER | 1N961B | 10.0V | | 186A797H07 |
| Z28 | ZENER | IN4752A | 33.0V | | 849A515H02 |
| R178 | POT | 2.5K | .25W | | [illegible] |
| IC21 | INT CKT | 747DM | | | 1443C52H01 |
| J121 | JUMPER | 0 OHM RESISTOR | | | 862A478H01 |
| J122 | JUMPER | 0 OHM RESISTOR | | | 862A478H01 |
| J123 | JUMPER | 0 OHM RESISTOR | | | 862A478H01 |
| D88 | DIODE | LED | | | 3508A22H01 |
| D89 | DIODE | LED | | | 3508A22H01 |

(Dwg. 1452C90 Sub. 4)

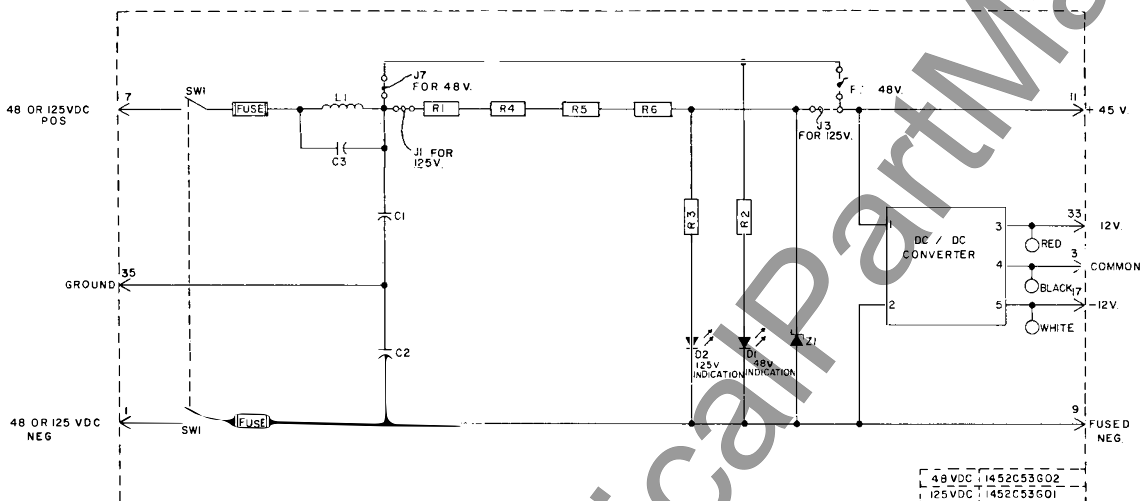
Fig. 7. Internal Schematic Output Module.




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| R1 | RESISTOR | 10K .50W 5% | 184A763H51 |
| R2 | RESISTOR | 10K .50W 5% | 184A763H51 |
| R3 | RESISTOR | 6.81K .50W 1% | 848A820H29 |
| R4 | RESISTOR | 4.99K .50W 1% | 848A820H16 |
| R5 | RESISTOR | 6.81K .50W 1% | 848A820H29 |
| R6 | RESISTOR | 2.0K .50W 1% | 848A819H77 |
| R7 | RESISTOR | 2.0K .50W 1% | 848A819H77 |
| R8 | RESISTOR | 562.K .25W 1% | 848A822H15 |
| R9 | RESISTOR | 511K .50W 1% | 848A822H11 |
| R10 | RESISTOR | 3.3K .50W 2% | 629A531H44 |
| R11 | RESISTOR | 15K .50W 2% | 629A531H60 |
| R12 | RESISTOR | 120K .50W 2% | 629A531H82 |
| R13 | RESISTOR | 13.3K .50W 1% | 848A820H57 |
| R14 | RESISTOR | 15K .50W 2% | 629A531H60 |
| R15 | RESISTOR | 6.8K .50W 2% | 629A531H52 |
| R16 | RESISTOR | 6.8K .50W 2% | 629A531H52 |
| R17 | POT | 2.5K .25W 10% | 629A645H07 |
| J1 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| D1 | DIODE | 1N645A | 837A692H03 |
| D2 | DIODE | 1N645A | 837A692H03 |
| Z1 | ZENER | 1N9578 | 186A797H06 |
| Q1 | TRANSISTOR | 2N3417 | 848A851H02 |
| Q2 | TRANSISTOR | 2N699 | 184A638H19 |
| Q3 | TRANSISTOR | 2N3645 | 849A441H01 |
| IC1 | INT.CKT. | 747DM | 1443C52H01 |
| IC2 | INT.CKT. | 5082-4371 | 775862IH01 |
| C1 | CAPACITOR | .25 MFD.200VDC | 187A625H02 |
| CL1 | INSTRUMENT | — | 6068592H26 |
| AL | RELAY | — | 408C062H07 |

*(Dwg. 1449C44 Sub. 4)*

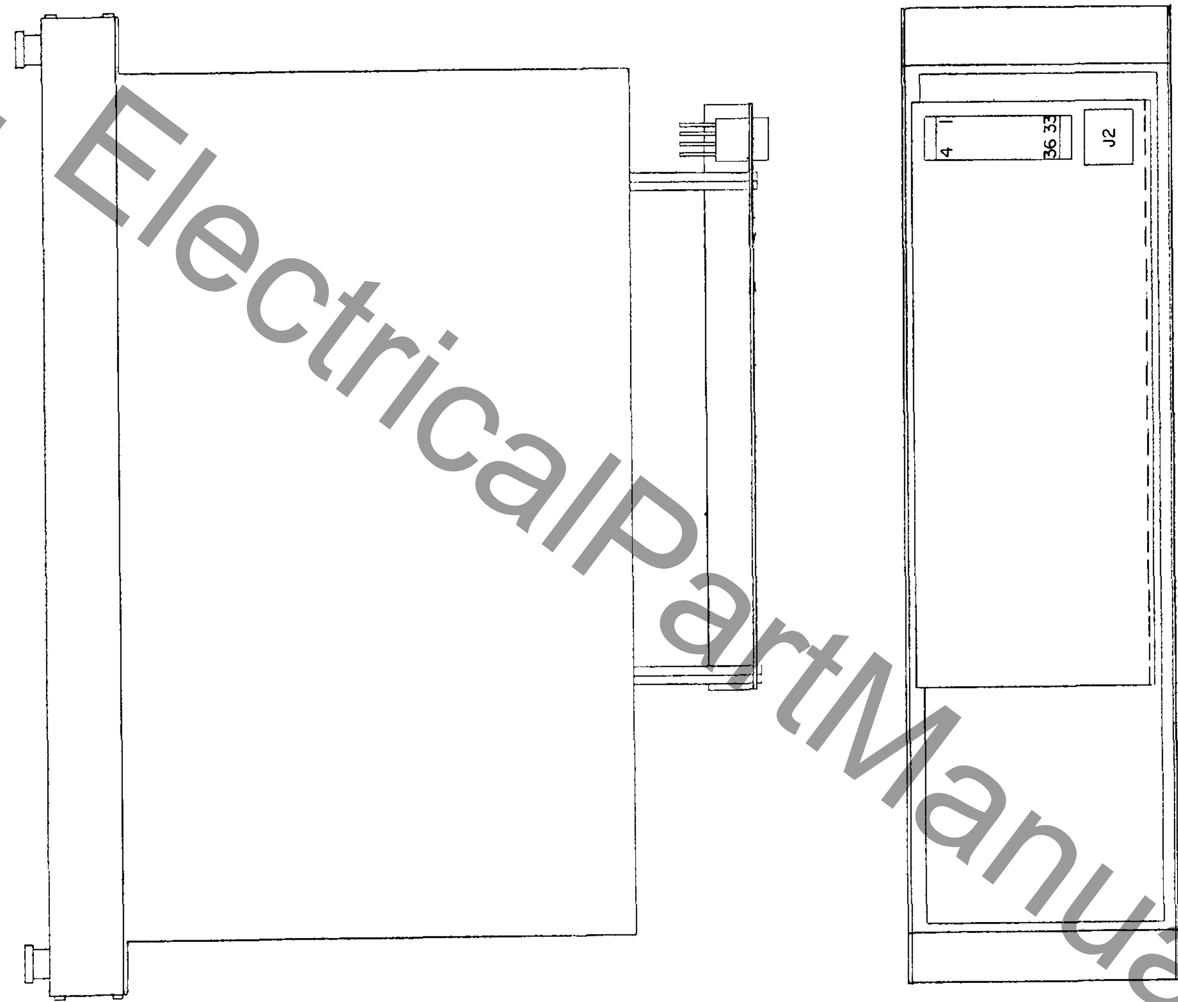
✪ *Fig. 8. Internal Schematic Output Module-Contact Output.*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C1 | CAPACITOR | .01 MFD. | 3516A36H01 |
| C2 | CAPACITOR | .01 MFD. | 3516A36H01 |
| C3 | CAPACITOR | .047 MFD. | 849A437H04 |
| R1,4,5,6 | RESISTOR | 75Ω 25W. | 1267270 |
| R2 | RESISTOR | 4.7K .50W 2% | 629A531H48 |
| R3 | RESISTOR | 4.7K .50W 2% | 629A531H48 |
| Z1 | ZENER | IN28288 | 184A854H06 |
| J1 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J2 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J3 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J7 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| SW1 | SWITCH | DPDT | 849A299H01 |
| D1 | DIODE | LED | 3508A22H02 |
| D2 | DIODE | LED | 3508A22H02 |
| L1 | COIL | | 292B096G02 |

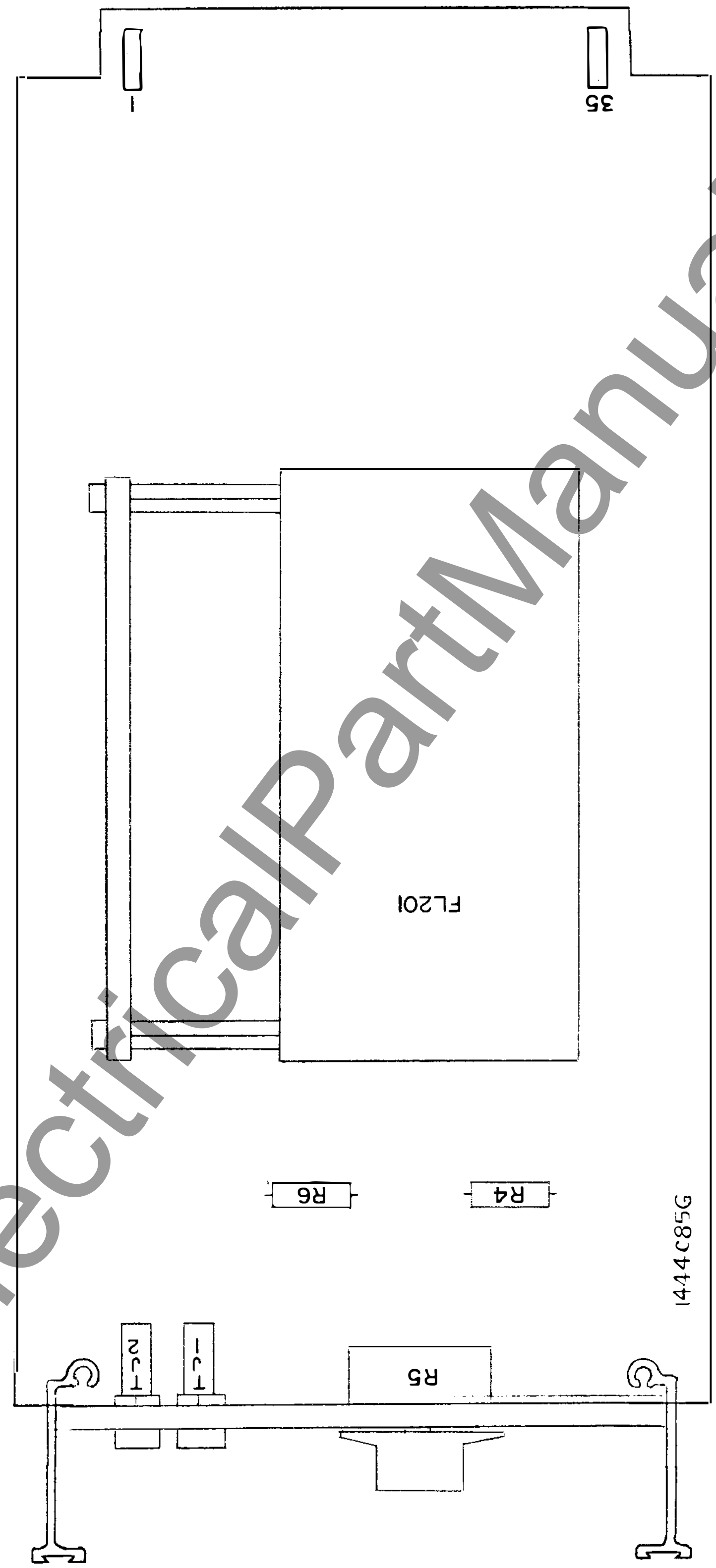
*(Dwg. 1452C65 Sub. 7)*

*Fig. 9. Internal Schematic Power Supply Module.*



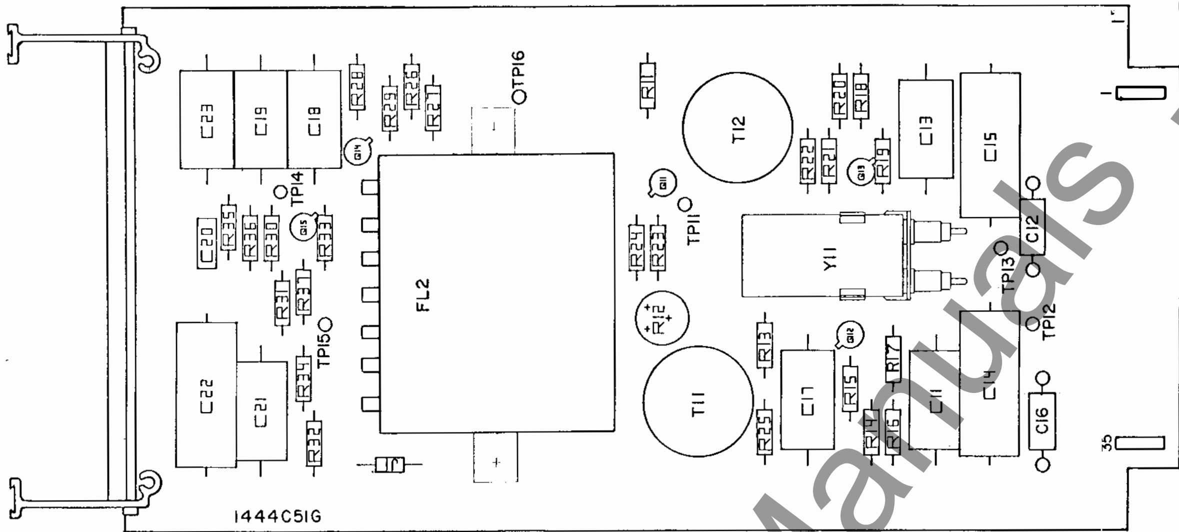

(Dwg. 1453C09 Sub. 2)

Fig. 10. Component Location TCF-10 Receiver.



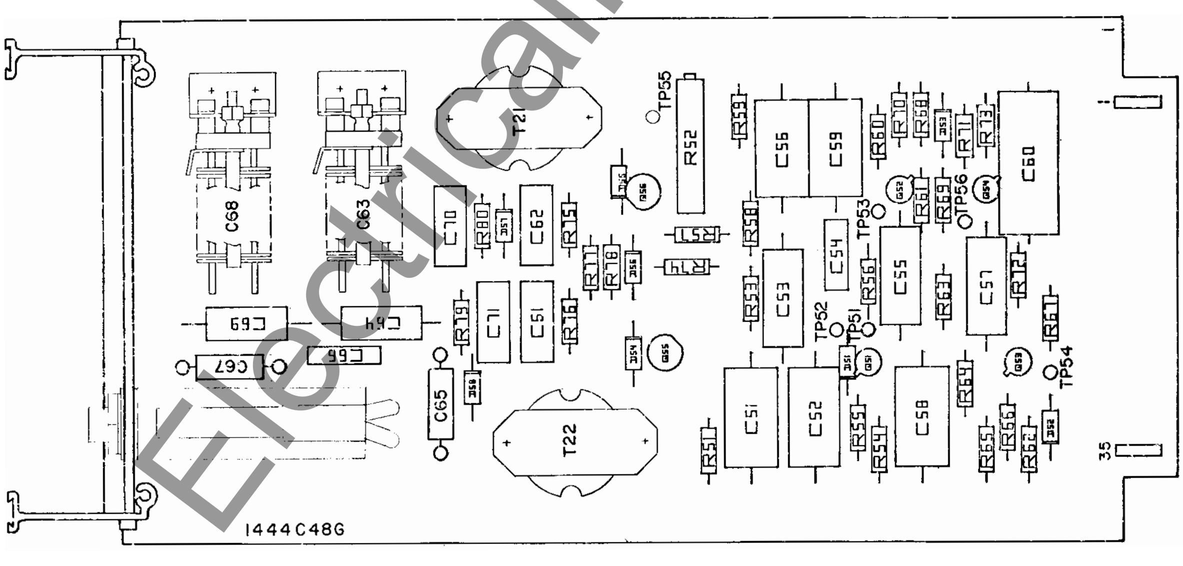

(Dwg. 775B321 Sub. 2)

*Fig. 11. Component Location Input Filter Module*



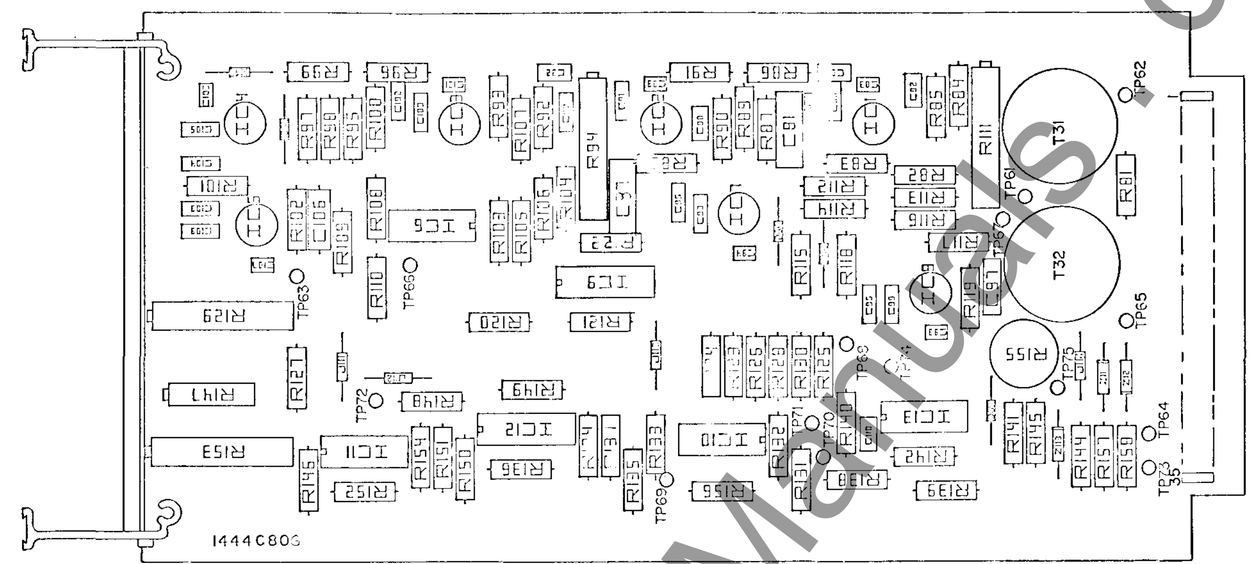

(Dwg. 775B318 Sub. 1)

*Fig. 12. Component Location Oscillator-Mixer-IF Amplifier Module.*



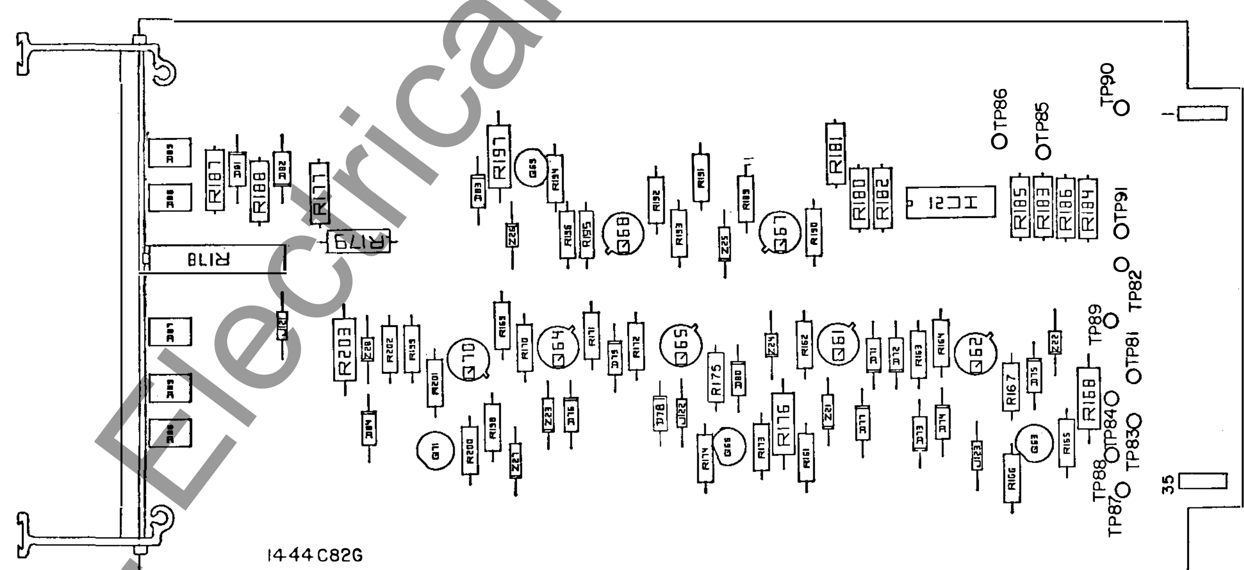

(Dwg. 775B317 Sub. 1)

*Fig. 13. Component Location Amplifier Limiter-Discriminator Module.*



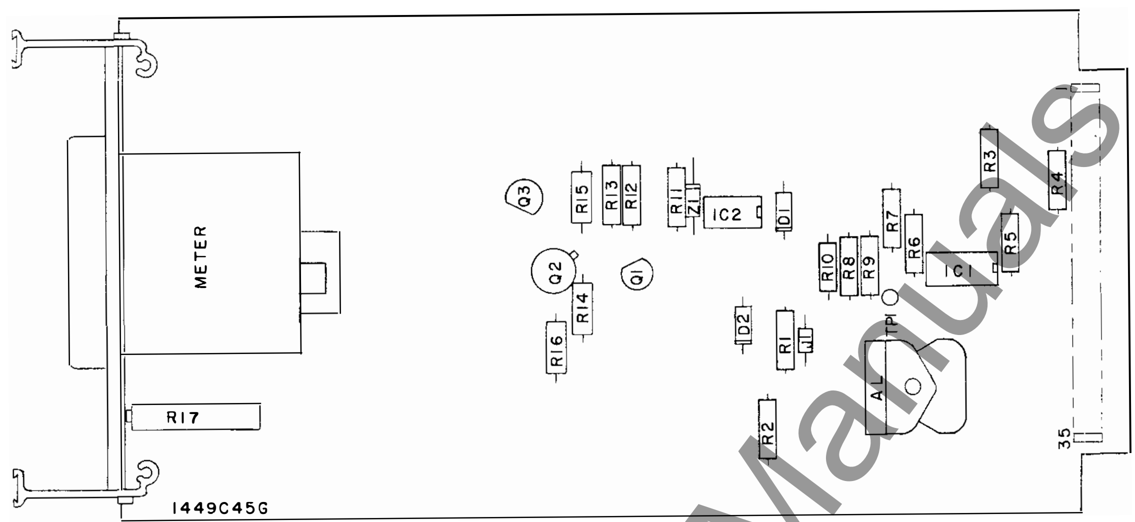

(Dwg. 775B761 Sub. 1)

*Fig. 14. Component Location S/N Detection Module.*



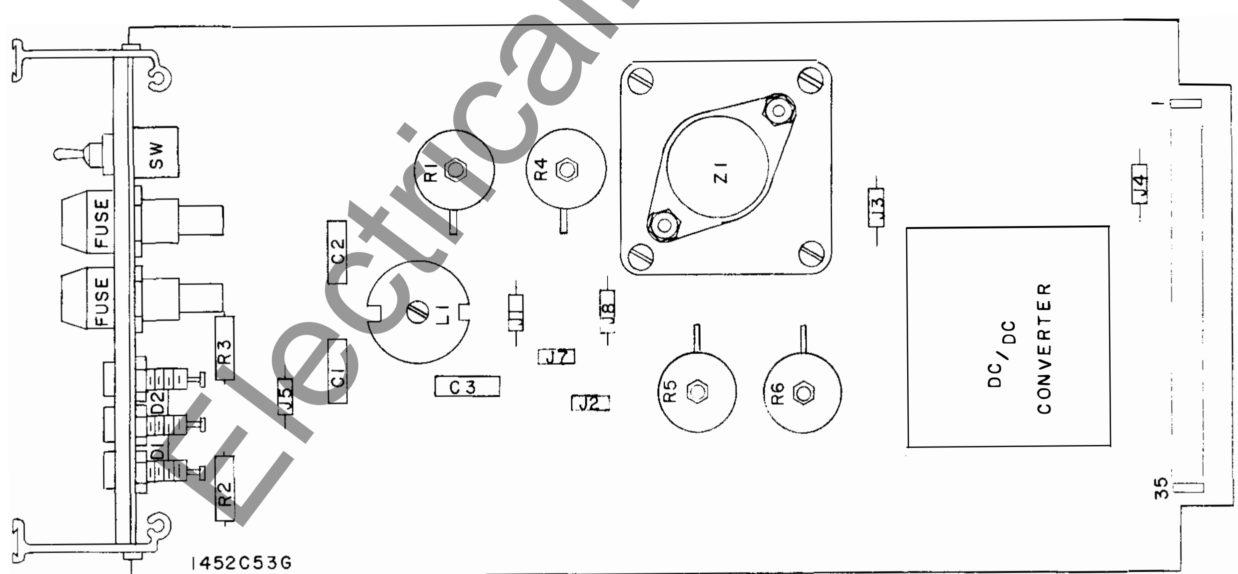

(Dwg. 775B320 Sub. 4)

✪ *Fig. 15. Component Location Output Module.*



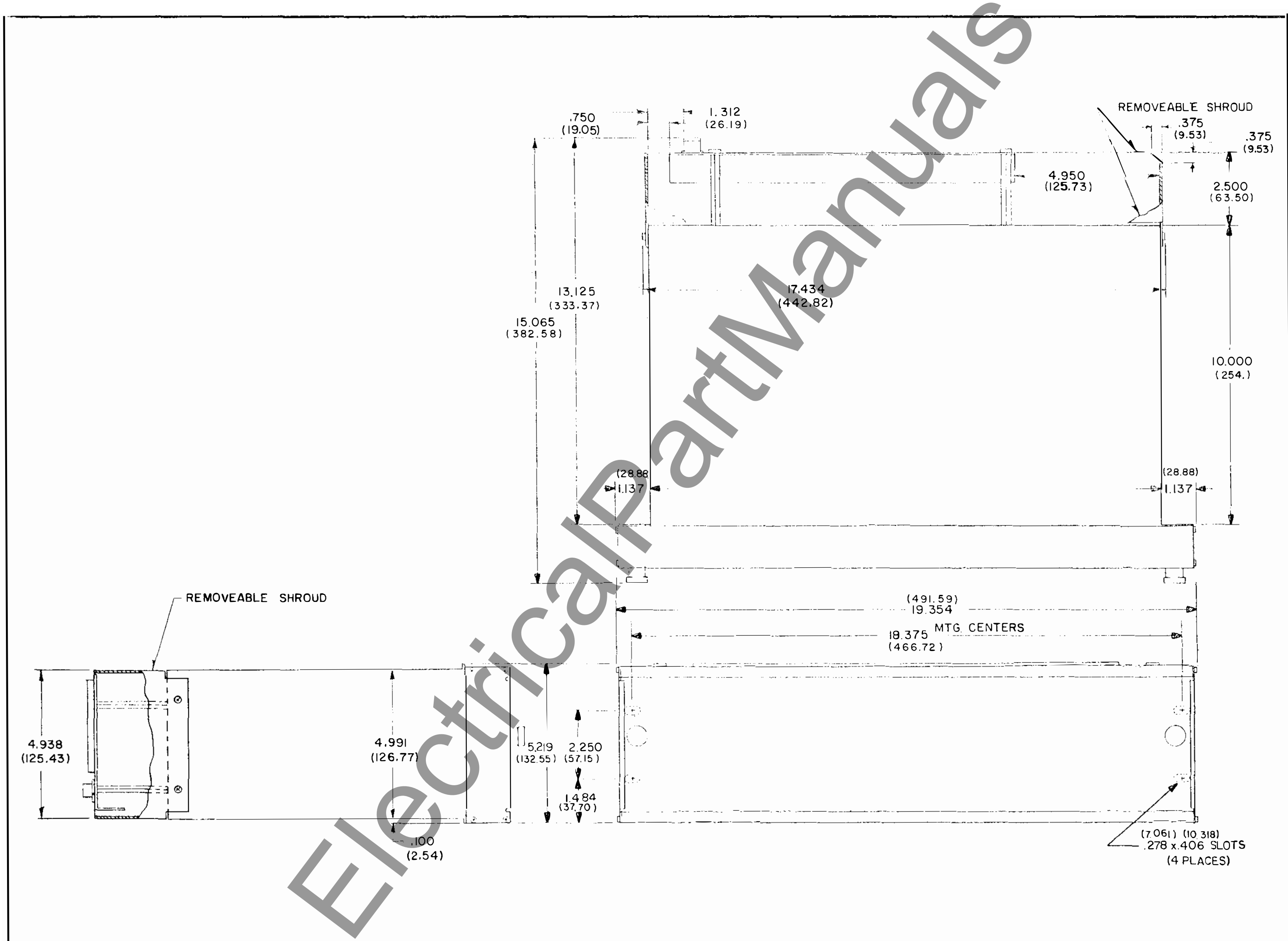

*(Dwg. 775B666 Sub. 1)*

*Fig. 16. Component Location Output Module - Contact Output.*



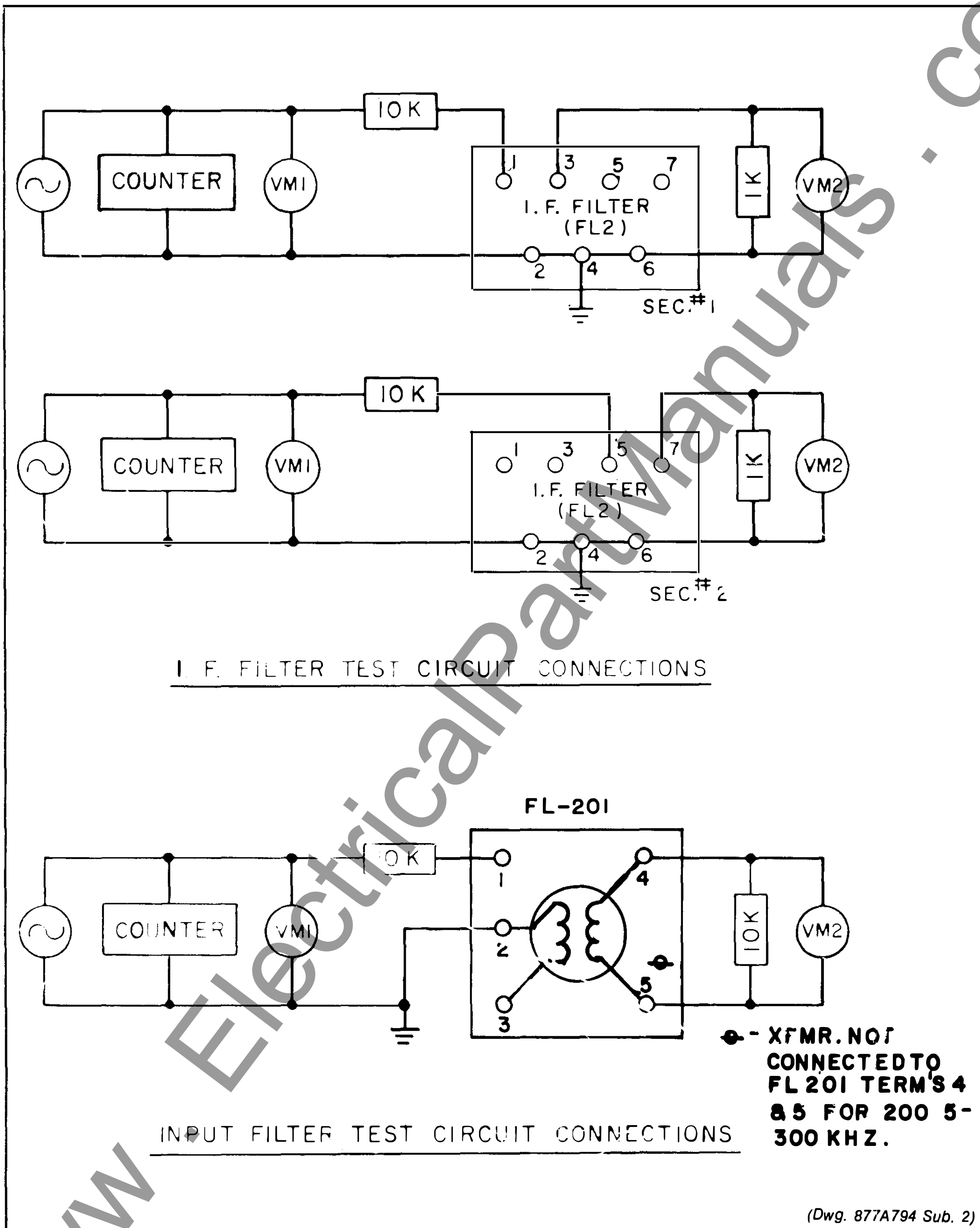

*(Dwg. 775B667 Sub. 3)*

*Fig. 17. Component Location Power Supply Module.*




(Dwg. 1453C10 Sub. 3)

✪ *Fig. 18. Outline TCF-10 Receiver.*




(Dwg. 877A794 Sub. 2)

*Fig. 19. Test Circuits for TCF-10 Receiver Filters.*

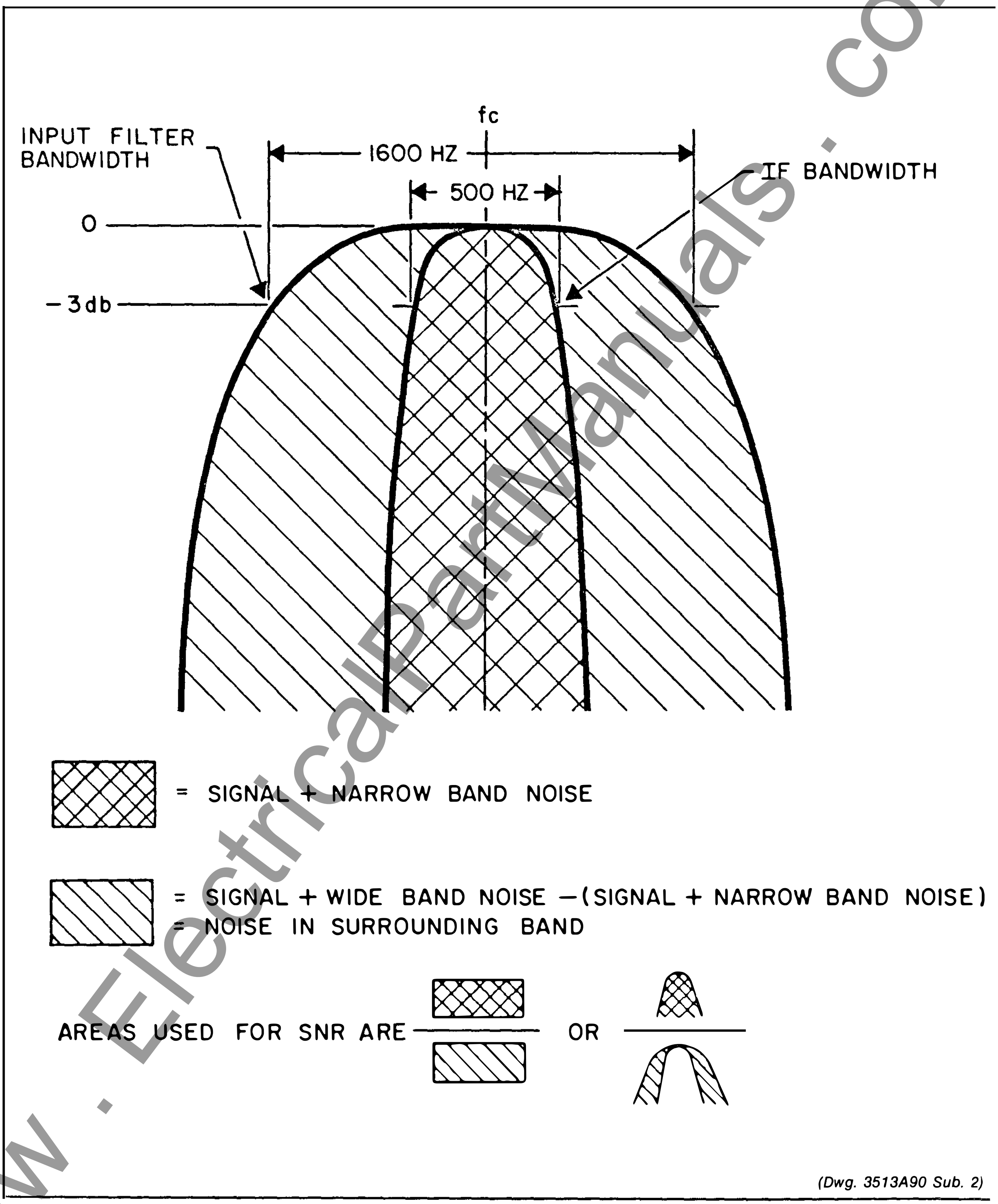



*Fig. 21. Signal to Noise Ratio Characteristics.*

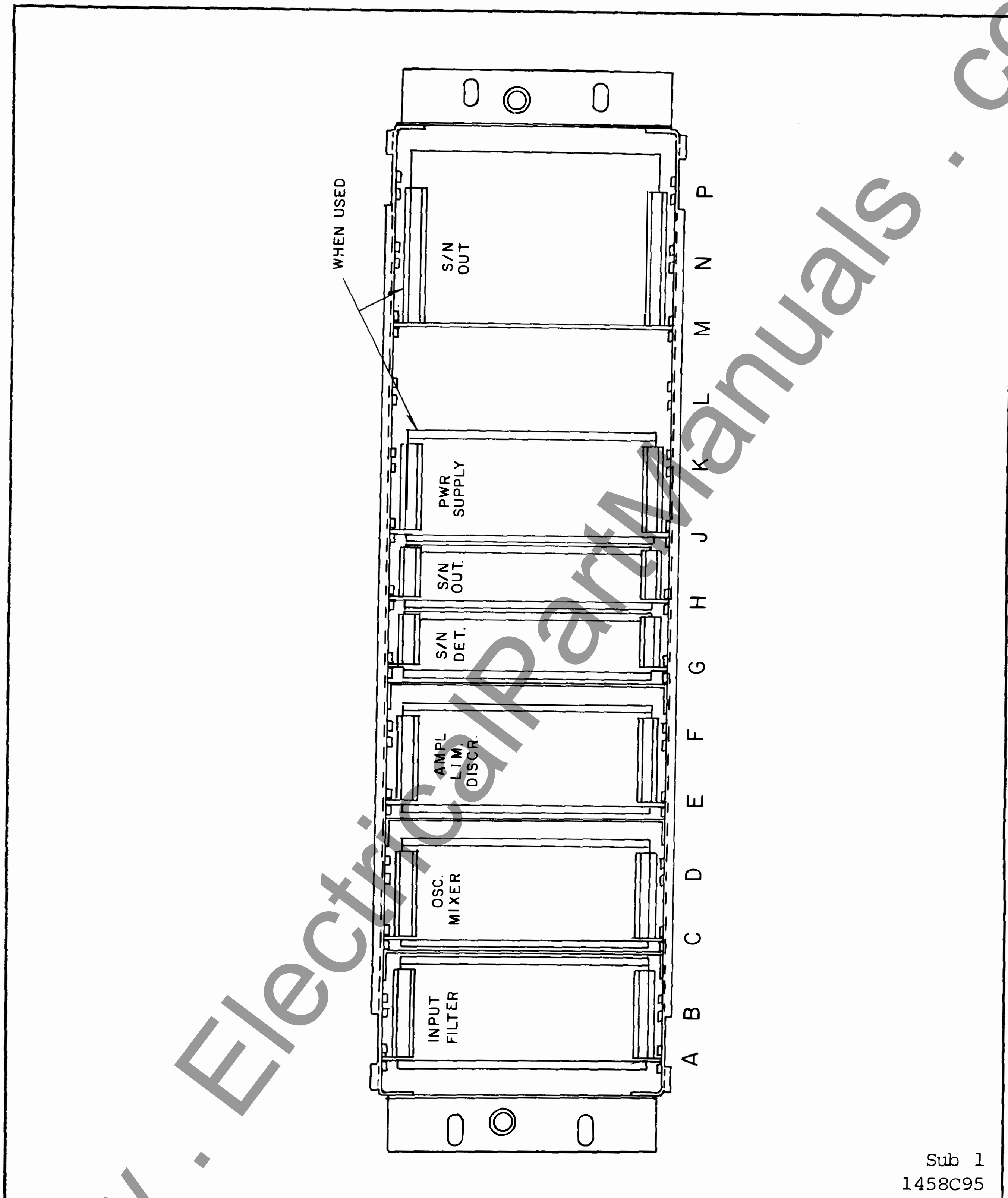



Fig. 22. Type TCF-10 RCVR, Circuit Board Location.

**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 – WITH RELAY OUTPUT FOR SUPERVISORY CONTROL AND TELEMETERING



### 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 frequency-shift receiver equipment as adapted for supervisory control and certain telemetering applications responds to carrier-frequency signals transmitted from the distant end of a power line and carried on the power line conductors. The Mark frequency is 100 hertz above the center frequency of the channel (which can be selected within the range of 30kHz to 300kHz), and it is transmitted continuously when conditions are normal and no information is to be conveyed over the channel. Its reception indicates that the channel is operative. The Space frequency is 100 hertz below the channel center frequency. When supervisory control or telemetering information is to be conveyed over the channel, the transmitter at one end of the channel is switched alternately between Mark and Space so as to produce at the receiving end a desired number of operations of a relay activated by the Space frequency. Control of the durations of the intervals that the relay contacts are open and closed also can be utilized to convey information over the channel.

### CONSTRUCTION

The TCF-10 receiver 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 external connectors are located at the rear of the chassis as shown in Figure 10. 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 attenuator contained on the front of the filter module which is used in adjusting the input receiver signal during initial field installation.

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

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 +12V and −12V supply derived from a self-contained DC to DC converter. The power supply module containing the DC to DC converter has links which enable it to operate from either 48 volts or 125 volts dc.

External connections to the receiver are made through a 36-terminal receptacle, 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 fed through a coaxial cable connected to jack J2 at the rear of the chassis to the input module. The input control R5, accessible at the front of the input module, attenuates the signal to a level suitable for the best operating range of the receiver.

A scale on the panel is graduated in dB. While this scale is typical rather than individually calibrated, it is accurate within several dB and is useful is setting approximate levels. Settings should be made more accurately utilizing a suitable ac voltmeter with a dB scale when possible.

From the attenuator, the signal passes through a crystal filter, FL1. This filter has a narrow pass band, and frequencies several hundred hertz above or below the center frequency (fc) of the channel are greatly attenuated. Figure 2 shows a typical curve for the crystal filter, as well as a characteristic curve for the intermediate frequency filter, FL2, and for the discriminator output. The narrow pass band of FL1 permits close spacing of channel frequencies and reduces the possibility of false operation caused by spurious signals such as may result from arcing disconnects or corona discharge.

### OSCILLATOR, MIXER, AND IF AMPLIFIER MODULE

From the input filter, the signal enters the oscillator and mixer stage of the receiver. Crystal Y11, transistors Q12 and Q13, and their associated resistors and capacitors, comprise a crystal-controlled oscillator that operates at a frequency 20kHz above the channel center frequency, $f_c$. The output from this local oscillator is fed through transformer T11 to potentiometer R12, and the latter is adjusted to feed a suitable input to the base of mixer transistor Q11. The output of filter FL1 is impressed on the emitter-collector circuit of Q11. As a result of mixing these two frequencies, the primary of transformer will contain frequencies of 20kHz, $2f_c$ +20kHz, $f_c$ + 20kHz, and $f_c$.

The output from the secondary of T12 is amplified by Q31 in the intermediate frequency (IF) stage, and is impressed on FL2. This is a two-section filter, with both filters contained in a common case. Its pass band is centered at 20kHz. It eliminates the frequencies present at its input that are substantially higher than 20kHz. The output of this filter is the IF output which is fed to both the amplifier-limiter and the S/N Detection module.

### AMPLIFIER LIMITER AND DISCRIMINATOR MODULE

The IF output signal from the IF amplifier is fed into the amplifier limiter through potentiometer R52 at the input of the amplifier limiter stage. Sufficient input is taken from R52 so that with minimum input signal (5 mv.) at J2 and with input control R5 set for zero attenuation, satisfactory amplitude limiting will be obtained at the output of the limiter stage.

The output of the limiter stage is fed to the discriminator. The discriminator is adjusted at the factory to have zero output (as measured by a milliammeter inserted in the circuit at jack J1) at the channel center frequency, $f_c$. The adjustment for zero output at $f_c$ is made by capacitor C68. In addition, C63 is adjusted for maximum voltage reading across R80 when the output current is zero. Maximum current output, of opposite polarities, will be obtained when the frequency is 100 hertz above or below the zero current output frequency. This separation of 200 hertz between the current peaks is affected by the value of C66 (the actual value of which may be changed slightly from its typical value in factory calibration if required).

It should be observed that although the mark frequency is $f_c$ +100 hertz, after leaving the mixer stage, and as seen by the discriminator, the mark frequency is 20kHz-100 hertz. Similarly the space frequency as seen by the discriminator is 20kHz +100 hertz. The intermediate frequency at which the discriminator has zero output then is 20kHz. The discriminator is adjusted so that the mark and space outputs are of equal lengths for equal periods of mark and space signal frequencies.

The discriminator output is connected to the bases of transistors Q55 and Q56 in such a manner that transistor Q56 is made conductive when current flows, from the discriminator output, in the forward direction of diode D54, (which occurs with space output) and Q55 is made conductive when current flows in the forward direction of diode D55 (which occurs with mark output.) Consequently, terminal 35 is at a potential of approximately +20 volts at mark frequency and terminal 1 is at +20 volts at space frequency.

## S/N DETECTION MODULE

The S/N detection module has one basic function: to measure incoming in-band signal level and provide both an output to a carrier level indicating instrument and to an alarm circuit in the output module for alarming at the desired low level of signal.

The narrow-band signal of 220 hertz bandwidth called the I.F. is fed into the S/N detection board through isolation transformer T32. The amount of signal fed into the board is adjustable by means of potentiometer R111. The circuit composed of operational amplifiers IC7 and IC8 and associated components is an RMS circuit which converts the signals into a dc voltage proportional to the r.m.s. value of the ac signals present in the IF bandwidth.

The output of the IF rms circuit is then fed to the logarithmic circuit composed of IC11A, IC12A, and IC11B which puts out a dc signal level linearly proportional to signal level in dB for feeding a microammeter calibrated with a linear dB scale with 10dB equal to 33-1/3 microamperes, is contained on the output module (contact output).

This same output is also fed to an alarm circuit on the output module (contact output) for alarming at low signal levels.

## OUTPUT MODULE

The output module provides three buffered outputs to the telemetering system. They are mark, space and not low signal with red indicating light emitting diodes for these outputs and a yellow indicating light emitting diode for normal level (satisfactory signal level).

The lower frequency of plus 12 volts (when present) from the discriminator is fed into the output module through terminal 15 into the gate consisting of diodes D78 and D79, transistors Q65 and Q66, and associated components R171, R172, R173, R174, R175, R176, D80, and Z24. Transistor Q65 then becomes conducting, causing Q66 to become conducting and a plus 12 volts to appear at terminal 27 as well as causing LED D89 to glow. This output labeled "Mark" is then fed into the output module – contact output – where it is used to energize the mercury wetted relay for contact outputs. Note that this "Mark" output is plus 12 volts on lower frequency and minus 12 volts on either higher frequency or no signal.

In a similar manner, the higher frequency output of +12 volts when present from the discriminator is fed into the output module through terminal 25 into the gate built about transistors Q62 and Q63. Just as in the case of the "mark" output, the "space" output of plus 12 volts will appear out of terminal 29. This output is wired out to the output connector J3 for external use if desired. Note also that this "space" output is plus 12 volts on higher frequency and minus 12 volts on either lower frequency or no signal.

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, transistor Q67 will become 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 12 volts.

## OUTPUT MODULE – CONTACT OUTPUT

The output module-contact output performs three functions; contact output of mark and spaces using a mercury wetted relay with two form C contacts, alarming on low signal level using a telephone relay with two form C contacts, and indicating signal level with its self-contained CLI instrument.

The mercury wetted relay is energized by the mark output of the output module and picks up on the lower frequency and drops out at the higher frequency.

The alarm circuit consists of all components associated with IC1, IC2, Q1, Q2, Q3, and relay AL. The signal level from the S/N detection module is fed into a level detector consisting of IC1B and resistors R6, R7, R8, and R9. An adjustable reference for the level detector consisting of IC1A and R1, R2, R17, R3, R4, and R5 is also fed into the level detector. As long as the signal level exceeds the value set by the reference, there will be approximately plus 12 volts out of the level detector into the photo-optical isolator. This causes Q1 to become non-conducting and thus transistors Q2 followed by transistor Q3 to become conducting. As a consequence, the alarm relay AL is picked up on signal levels above the alarm level. When the signal level drops below the alarm level set by the reference, the output of the level detector will be minus 12 volts causing Q1 to become conducting and Q2 and Q3 to become non-conducting and drop out the alarm relay AL. The alarm relay has a delay of approximately 40 milliseconds on dropout to prevent undesirable alarming on short temporary loss of signal. Note that the level of alarm is set by adjusting alarm level R17, accessible from front of module, independent of the low signal level output from the output module (which is set by L.L. ADJ. R178). Also both of these outputs operate on total signal level within the passband of the receiver.

The CLI instrument operates directly on signal level received from the S/N detection module. It measures signal level in the entire bandwidth of the receiver and thus closely correlates with the low level clamp (L.L. ADJ.) and the low signal alarm AL (alarm level). It thus can be used in setting both of these adjustments.

## POWER SUPPLY

The +12 volt dc, −12 volt dc, and the +45 volt dc supply voltages for the receiver are derived from the power supply module.

The +12 volt dc supply and the −12 volt dc supply are both derived from the DC to DC converter and are regulated for input voltages to the regulator of from 42 volts to 56 volts. For nominal 48 volt input units, the DC to DC converter has sufficient range so that the preregulator consisting of R1, R4, and Z1 is not necessary and is not connected by omitting jumpers J1 and J3 and supplying J7 and J2. In this case, then, the +45 volt supply is derived directly from the input supply voltage and is not regulated.

For nominal 125 volt input units, the pre-regulator consisting of R1, R4, and Z1 is necessary and is connected by supplying jumpers J1 and J3 and omitting J7 and J2. In this case then, the +45 volt supply is derived from this pre-regulator and is regulated.

The LED's D1 and D2 indicate when the power supply is energized with either 48V or 125V by the proper one glowing. Since all components are supplied in each power supply, a 48V supply can be converted to a 125V supply simply by removing jumpers J7 and J2 and inserting J1 and J3. Similarly, a 125V supply can be converted to a 48V supply by removing jumpers J1 and J3 and inserting J7 and J2. 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

| | |
|---|---|
| Frequency range | 30-300kHz |
| Sensitivity (noise-free channel) | 0.005 volt |
| Input Impedance | 5000 ohms minimum |
| Bandwidth (crystal filter) | down < 3dB at 220 Hz.<br>down > 60dB at 1000 Hz. |
| Discriminator | Set for zero output at channel center frequency and for max. outputs at 100 hertz above and below center frequency. |
| Operating Time | 9 ms. channel (transm. and recvr.)<br><br>2 ms. HG relay operate and release times |
| Frequency spacing | |
| A. For two or more signals over one-way channel | 500 hertz minimum |
| B. For two-way channel | 1000 hertz minimum between transmitter and adjacent receiver frequencies with proper hybrids. |
| Ambient temperature range | −20°C to +55°C temperature around chassis. |
| Battery voltage variations | |
| Rated Voltage | Allowable Variation |
| 48 V dc | 42- 56 V dc |
| 125 V dc | 105-140 V dc |
| Battery drain | .25 a. at 48 V dc or 125 V dc |
| Dimensions | Panel height − 5¼" or 3 r.u.<br>Panel width − 19" |
| Weight | 13 lb. |

## INSTALLATION

The TCF-10 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 the TCF-10. Heat 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 55°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-10 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 alarm relay; 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 low level clamp operates, causing a red LED low level light. 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 output which will produce a −12V output at the low level output, cause the red LED low level light to come on, and cause the yellow LED O.K. level light to go out.

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. (Note: When CL1 instrument is supplied within the chassis, this is factory adjusted.)

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 30dB.

4. Adjust full scale adjustment, R153, so that instrument now reads −20dB. (This is approximately 0 microamperes).

5. Increase signal to +10dB level. (This is 100 microamperes).

6. Adjust slope adjustment R155 to read +10dB on instrument.

7. Reduce signal to normal level. Instrument should read 0dB. If desired, instrument could be adjusted to read 0dB with R155 with sacrifice in reading accuracy for +10dB.

## 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 higher 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. (Note: Input attenuator R5 could be used to produce 5mv of signal across input test jacks J1 and J2 if desired.)

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 higher frequency signal being received and with an RF voltmeter connected across test jacks J1 and J2 of the input module, adjust input attenuator R5 to the point where 5mv of signal appear across these test jacks. (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 L.L. 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 +12 volts at TP86 on the output module. And the yellow O.K. level light will go out.

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. (Note: The low signal clamp as used in this receiver is just used to put out a signal to external equipment for use by the external equipment. It does not clamp any signals within this receiver.)

The alarm level is set to alarm at a signal level 5dB above the signal where the receiver just drops out of limiting. This will result in an alarm be given at a point where the signal level has dropped 10dB from the initial nominal setting but the receiver signal level is still 5dB above limiting.

1. With a normal higher frequency signal being received and with an RF voltmeter connected across the input module input test jacks TJ1 and TJ2 (available at front on module), adjust input attenuator R5 to where signal level is 9mv across these test jacks.

2. Adjust the alarm level R17 on the output module – contact output to the point where the alarm relay AL just drops out.

3. Adjust input attenuator R5 to increase signal level into receiver by 10dB. (This is for operation with 15dB margin. For other than 15dB margin, this value should be changed accordingly.) This is done by reducing the R5 attenuator setting by 10dB.

## MAINTENANCE

Periodic checks of the received carrier signal level and the receiver sensitivity 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 low level 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.

## RELAY MAINTENANCE AND ADJUSTMENT

The AL relay contacts should be cleaned periodically. A contact burnisher S#182A836H01 is recommended for this purpose. The use of abrasive material for cleaning contacts is not recommended, because of the danger of embedding small particles in the face of the soft silver and thus impairing the contact. Care must be taken to avoid distorting the contact springs during burnishing.

These relays have been properly adjusted at the factory to insure correct operation, and under normal field conditions they should not require readjustment. If, however, the adjustments are disturbed in error, or if it becomes necessary to replace some part, the following adjustment procedure should be used.

In the AL relay the armature gap should be approximately 0.004 inch with the armature closed. This adjustment is made with the armature stop screw and locknut. The contact leaf springs should be adjusted to obtain at least 0.015 inch gap on all contacts when fully open. There should be at least 0.010 inch follow on all normally-open contacts and 0.005 inch follow on all normally-closed contacts. The relay should pick up at approximately 35 volts.

## TABLE I
## RECEIVER D-C MEASUREMENTS

**NOTE:** All voltage readings taken with the negative of dc VTVM on terminal 17 (−12V 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 lower frequency, higher frequency, or zero.

| Collector of Transistor or Test Point | Voltage (Positive) |
|---|---|
| Q11 | <15 |
| Q12 (TP12) | 17 (High or Low Freq.) |
| Q13 (TP13) | 17 (High or Low Freq.) |
| Q14 (TP14) | 3 |
| Q15 (TP15) | 3 |
| TP11 | 22 |
| TP52 | 19 |
| Q51 (TP51) | 14 |
| Q52 (TP53) | 14.5 |
| Q53 (TP54) | 18 |
| Q54 (TP55) | 3 |
| TP56 | 19 |
| Q55 | < 1 (Lower Freq. or No Signal) |
| Q55 | 23 (Higher Freq.) |
| Q56 | 23 (Lower Freq.) |
| Q56 | < 1 (Higher Freq. or No Signal) |

**NOTE:** The following readings are taken with the negative of dc VTVM on terminal 3 (common of dc power supply) of either the S/N detection module or the output module.

| Collector of Transistor or Test Point | Voltage (Positive) | |
|---|---|---|
| TP62 | 0 | |
| TP64 | +10 | |
| TP65 | −12V | |
| TP67 | + .5 | |
| TP68 | + .5 | |
| TP70 | − 6 | |
| TP71 | + 6 | |
| TP72 | + 1.5 | |
| TP74 | + .5 | |
| TP81 | +12 | (Higher Frequency) |
| TP81 | −12 | (Lower Freq. or No Signal) |
| TP82 | +12 | (Lower Frequency) |
| TP82 | −12 | (Higher Freq. or No Signal) |
| TP83 | +12 | (Higher Frequency) |
| TP83 | −12 | (Lower Freq. or No Signal) |
| TP84 | +12 | (Lower Frequency) |
| TP84 | −12 | (Higher Freq or No Signal) |
| TP85 | + 0.3 | |
| TP86 | +12 | (Low level clamp) |
| TP86 | −12 | (No clamp) |
| TP88 | +12 | |
| TP89 | −12 | |
| TP90 | +12 | (Good Signal Level) |
| TP90 | −12 | (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 in 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 |
| TP67 | .275 |

## FILTER RESPONSE MEASUREMENTS

The crystal input filter (FL1) and the IF filter (FL2) are in sealed containers and repairs can be made only 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 Fig. 19 can be used in case there is reason to suspect that either of the filters has been damaged.

Fig. 2 shows the −3dB and −60dB check points for the crystal filters. 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 Fig. 2 was chosen to show the crystal filter response, which permitted only a portion of the IF filter curve to be shown. The check points for the pass band of each section of the latter are "down 3dB maximum at 19.75 and 20.25 kHz", and for the stop band are "down 18dB minimum at 19.00 and 21.00 kHz." The signal generator voltage (Fig. 19) must be held constant throughout the entire check. A value of 20dB (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 that the measured difference because of the input resistor and the difference in input and output impedances of the filter.

Because of the extreme frequency sensitivity of the crystal filter, the oscillator used in its test circuit should have very good frequency stability and a close vernier control. The oscillators used for factory testing have special modifications for this use. A value of approximately 10dB (2.45 volts) is suitable for the constant voltage at which to hold VMI 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 11dB 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-10 receiver for operating at a different channel frequency consist of a new crystal input filter FL1, 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, FL1, 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 four 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 60 hertz to 330 kHz, input impedance 7.5 megohms.

b. D-C Vacuum Tube Voltmeter (VTVM).
Voltage range: 1.5 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: 20kHz to 330kHz

c. Oscilloscope

d. Frequency counter

e. Ohmmeter

f. Capacitor checker

g. Milliammeter, 0-1.5 or preferably 1.5-0-1.5 range, for checking discriminator.

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.

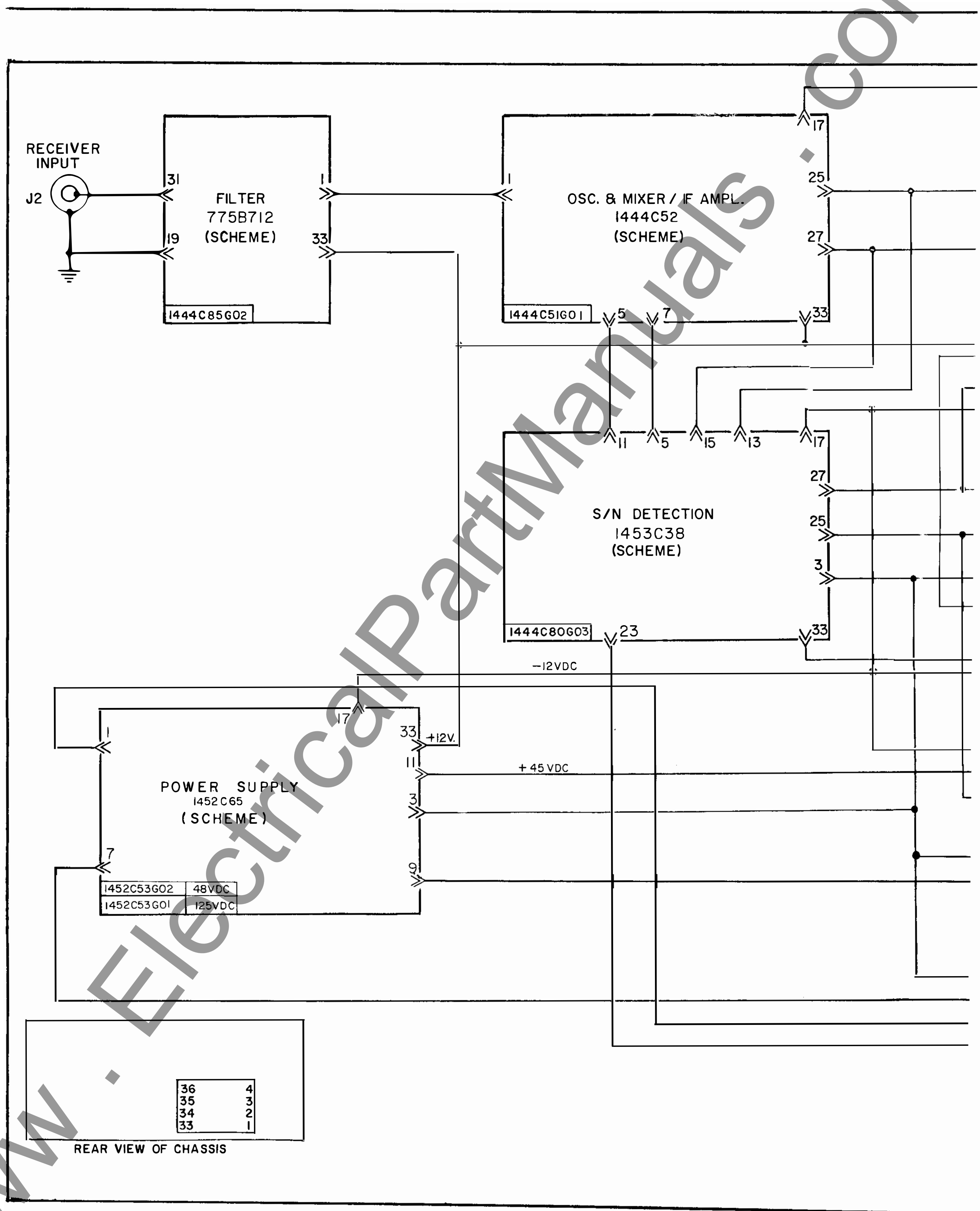
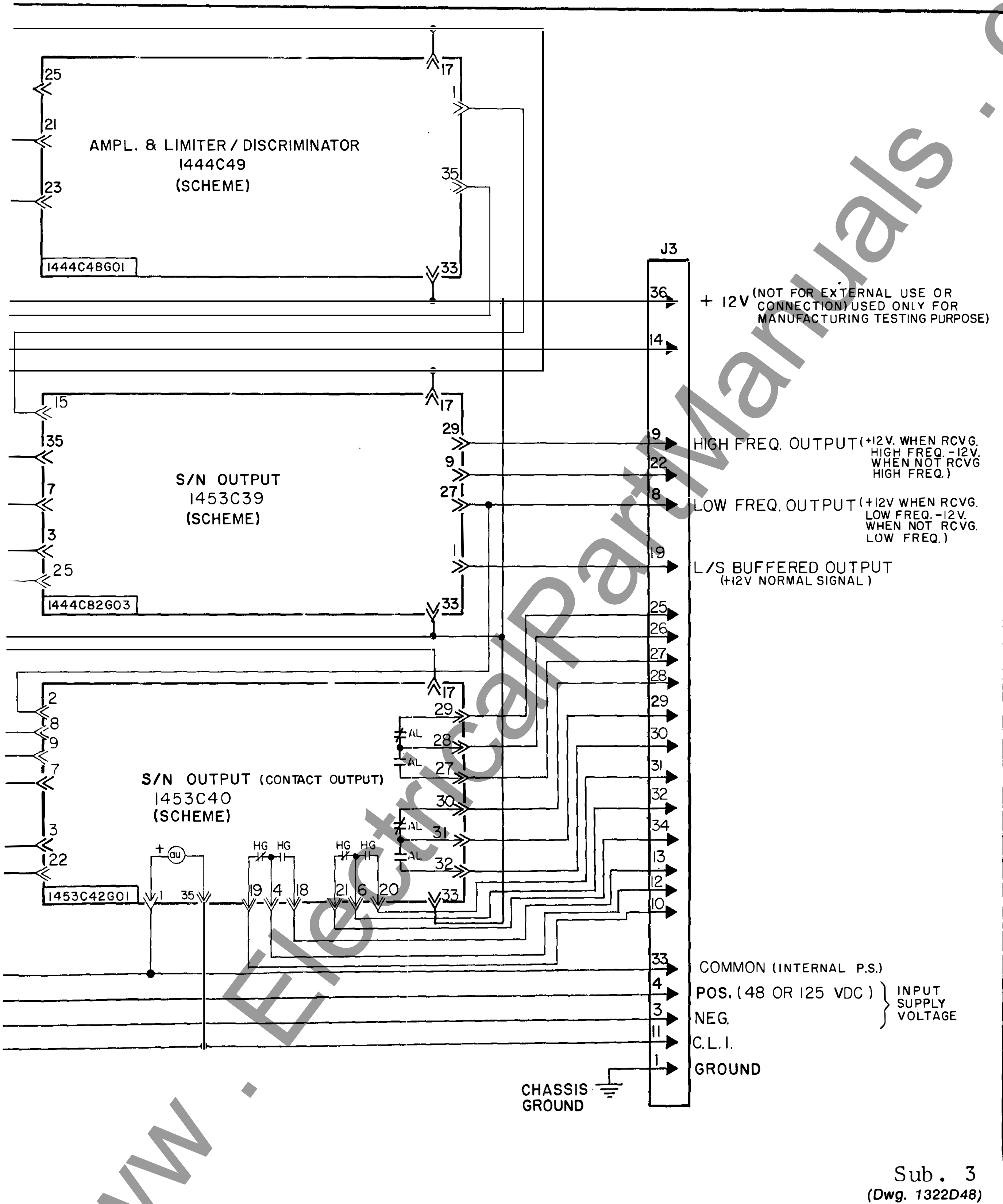
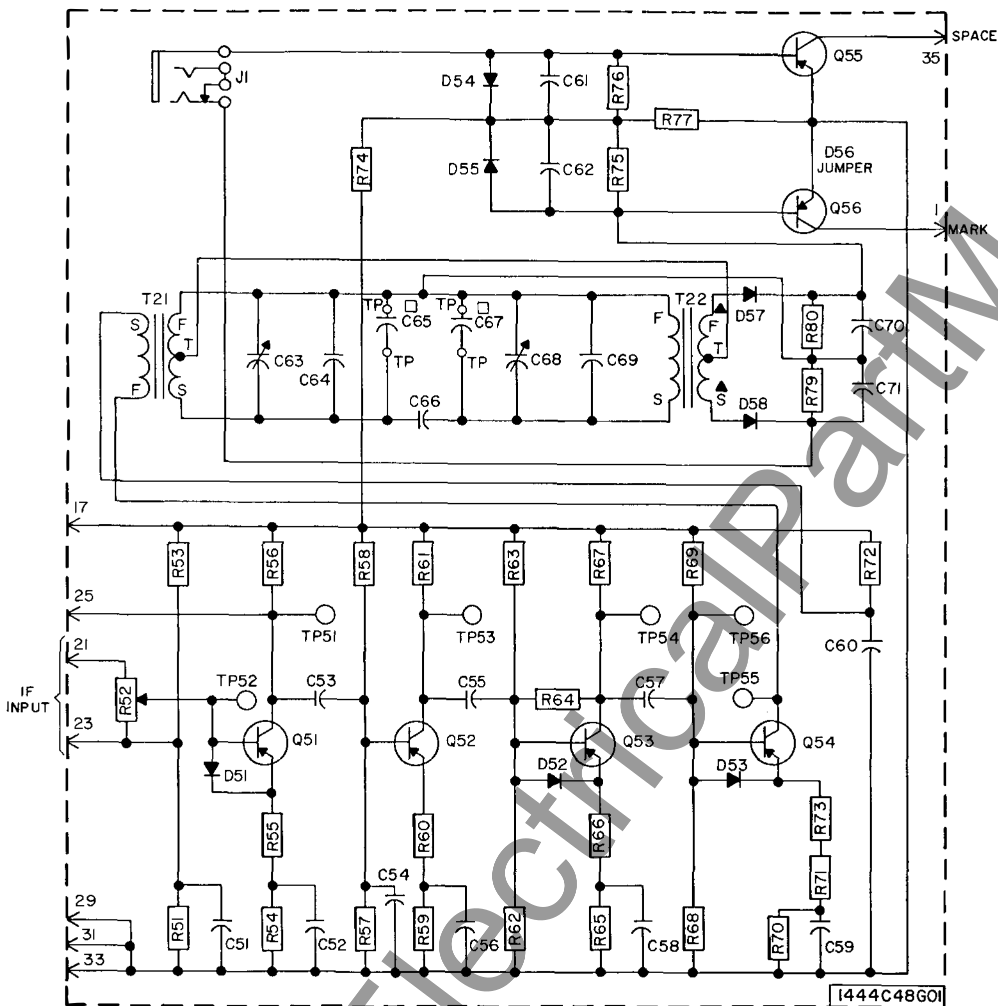



*Fig. 1. Overall Schemati*






; of TCF-10 Receiver.




| CØMPØNENT | DESCRIPTIØN | | STYLE NØ. |
|---|---|---|---|
| C51 | CAPACITØR | .250UF 200V | 187A624H02 |
| C52 | CAPACITØR | .250UF 200V | 187A624H02 |
| C53 | CAPACITØR | .100UF 200V | 187A624H01 |
| C54 | CAPACITØR | 1300.000PF 500V | 187A584H15 |
| C55 | CAPACITØR | .100UF 200V | 187A624H01 |
| C56 | CAPACITØR | .250UF 200V | 187A624H02 |
| C57 | CAPACITØR | .100UF 200V | 187A624H01 |
| C58 | CAPACITØR | .250UF 200V | 187A624H02 |
| C59 | CAPACITØR | .250UF 200V | 187A624H02 |
| C60 | CAPACITØR | 1.000UF 200V | 187A624H04 |
| C61 | CAPACITØR | .220UF 50V | 762A703H01 |
| C62 | CAPACITØR | .220UF 50V | 762A703H01 |
| C63 | CAPACITOR | 4.5TO 100PF | 762A736H02 |
| C64 | CAPACITØR | 9100.000PF 200V | 187A624H16 |
| C65 | CAPACITOR | SEE NOTE □ | |
| C66 | CAPACITØR | 100.000PF 500V | 187A684H08 |
| C67 | CAPACITOR | SEE NOTE □ | |
| C68 | CAPACITOR | 4.5TO 100PF | 762A736H02 |
| C69 | CAPACITØR | 9100.000PF 200V | 187A624H16 |
| C70 | CAPACITØR | .220UF 50V | 762A703H01 |
| C71 | CAPACITØR | .220UF 50V | 762A703H01 |
| D51 | DIØDE | 1N457A | 184A855H07 |
| D52 | DIØDE | 1N457A | 184A855H07 |
| D53 | DIØDE | 1N457A | 184A855H07 |
| D54 | DIØDE | 1N457A | 184A855H07 |
| D55 | DIØDE | 1N457A | 184A855H07 |
| D56 | JUMPER | | 862A478H01 |
| D57 | DIØDE | 1N628 | 184A855H12 |
| D58 | DIØDE | 1N628 | 184A855H12 |
| R51 | RESISTØR | 4700.0 .50W 5% | 184A763H43 |
| R53 | RESISTØR | 27.0K .50W 5% | 184A763H61 |
| R54 | RESISTØR | 2200.0 .50W 5% | 184A763H35 |
| R55 | RESISTØR | 27.0 .50W 5% | 187A290H11 |
| R56 | RESISTØR | 10.0K .50W 5% | 184A763H51 |
| R57 | RESISTØR | 4700.0 .50W 5% | 184A763H43 |
| R58 | RESISTØR | 27.0K .50W 5% | 184A763H61 |
| R59 | RESISTØR | 1500.0 .50W 5% | 184A763H31 |
| R60 | RESISTØR | 180.0 .50W 5% | 184A763H09 |
| R61 | RESISTØR | 4700.0 .50W 5% | 184A763H43 |
| R62 | RESISTØR | 2200.0 .50W 5% | 184A763H35 |
| R63 | RESISTØR | 33.0K .50W 5% | 184A763H63 |
| R64 | RESISTØR | 2700.0 .50W 5% | 184A763H37 |
| R65 | RESISTØR | 680.0 .50W 5% | 184A763H23 |
| R66 | RESISTØR | 68.0 .50W 5% | 187A290H21 |
| R67 | RESISTØR | 4700.0 .50W 5% | 184A763H43 |
| R68 | RESISTØR | 2700.0 .50W 5% | 184A763H37 |
| R69 | RESISTØR | 18.0K .50W 5% | 184A763H57 |
| R70 | RESISTØR | 220.0 .50W 5% | 184A763H11 |
| R71 | RESISTØR | 68.0 .50W 2% | 629A531H04 |
| R72 | RESISTØR | 330.0 .50W 5% | 184A763H15 |
| R73 | RESISTØR | 56.0 .50W 2% | 629A531H02 |
| R74 | RESISTØR | 12.0K .50W 5% | 184A763H53 |
| R75 | RESISTØR | 3000.0 .50W 5% | 184A763H38 |
| R76 | RESISTØR | 3000.0 .50W 5% | 184A763H38 |
| R77 | RESISTØR | 220.0 .50W 5% | 184A763H11 |
| R79 | RESISTØR | 2200.0 .50W 5% | 184A763H35 |
| R80 | RESISTØR | 2200.0 .50W 5% | 184A763H35 |
| R52 | PØT | 1.0K .50W | 629A645H04 |
| Q51 | TRANSISTØR | 2N4249 | 849A441H03 |
| Q52 | TRANSISTØR | 2N4249 | 849A441H03 |
| Q53 | TRANSISTØR | 2N4249 | 849A441H03 |
| Q54 | TRANSISTØR | 2N4249 | 849A441H03 |
| Q55 | TRANSISTØR | 2N3645 | 849A441H01 |
| Q56 | TRANSISTØR | 2N3645 | 849A441H01 |
| T21 | TRANSFORMER | | 606B533G01 |
| T22 | TRANSFORMER | | 606B533G02 |
| J1 | TELEPHONE JACK | | 187A606H01 |

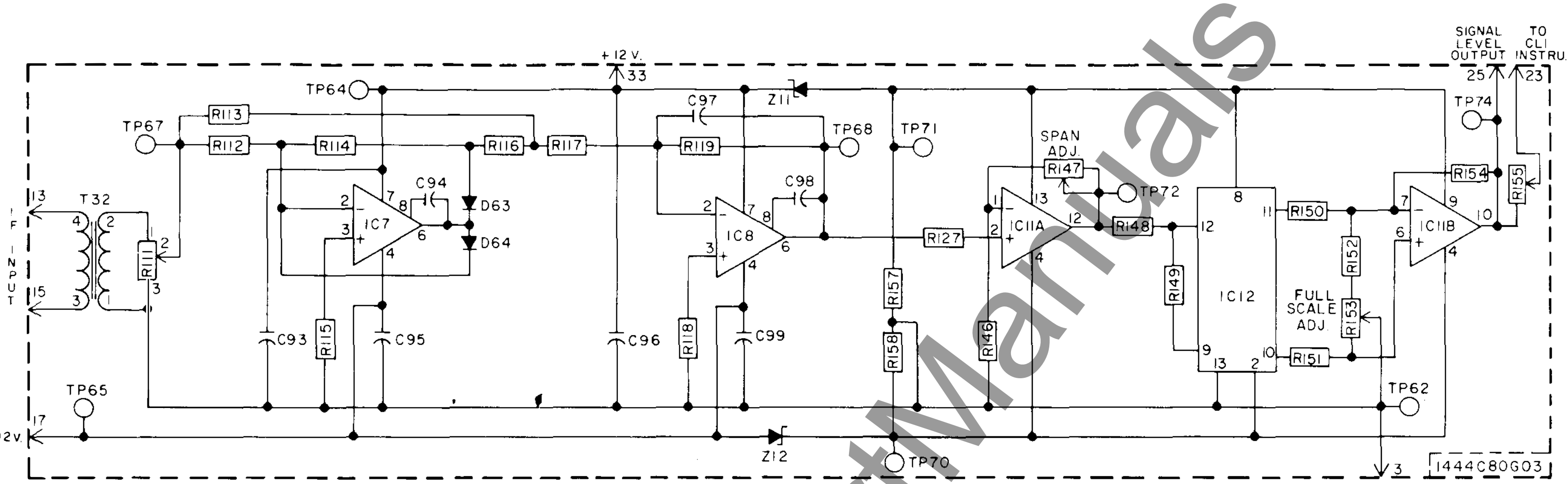
□–ONE OR TWO CAPACITORS USED; VALUES DETERMINED IN TEST.

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

Sub. 2

*(Dwg. 1444C49)*

*Fig. 5. Internal Schematic Amplifier Limiter-Discriminator Module.*



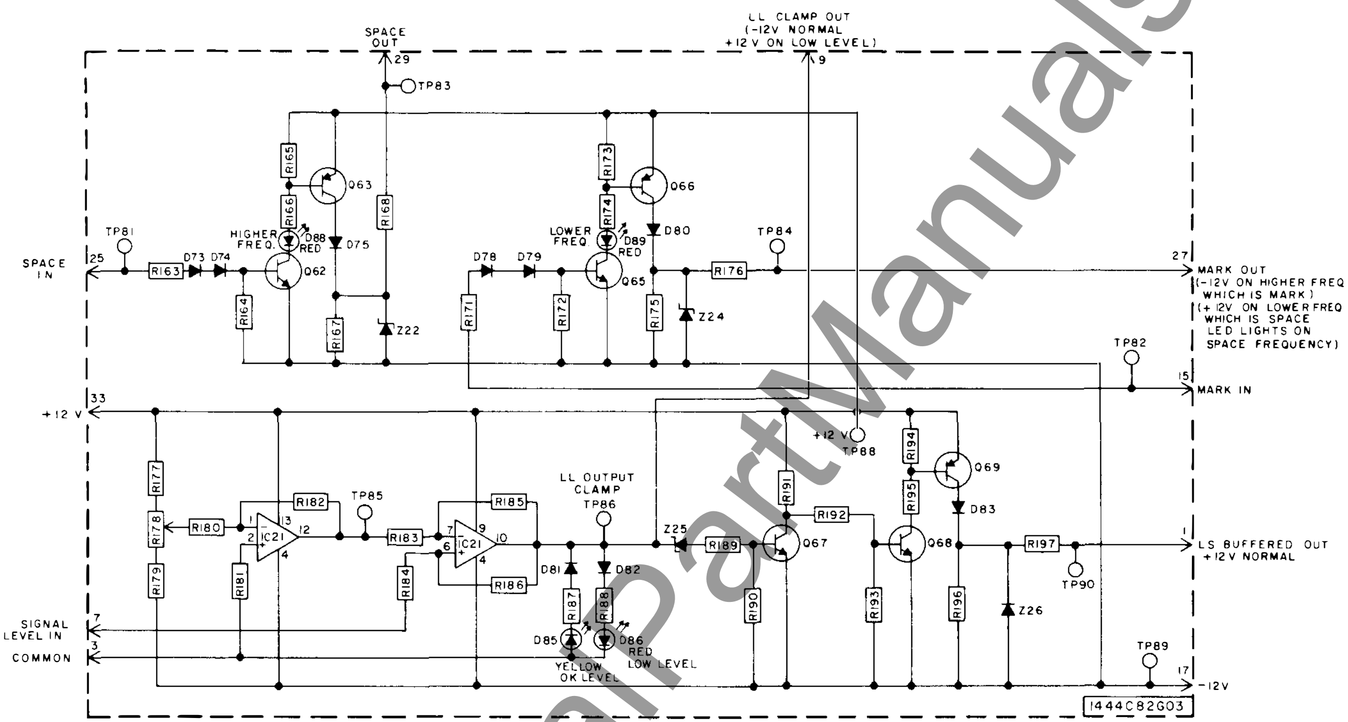

| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C93 | CAPACITOR | .010UF 50V | 184A663H01 |
| C94 | CAPACITOR | 33.000PF 200V | 879A989H07 |
| C95 | CAPACITOR | .010UF 50V | 184A663H01 |
| C96 | CAPACITOR | .010UF 50V | 184A663H01 |
| C97 | CAPACITOR | .470UF 50V | 762A680H04 |
| C98 | CAPACITOR | 33.000PF 200V | 879A989H07 |
| C99 | CAPACITOR | .010UF 50V | 184A663H01 |
| D63 | DIODE | 1N4148 | 836A928H06 |
| D64 | DIODE | 1N4148 | 836A928H06 |
| IC7 | INT CKT | SE5311 | 3512A10H01 |
| IC8 | INT CKT | SE531T | 3512A10H01 |
| IC11 | INT CKT | 747DM | 1443C52H01 |
| IC12 | INT CKT | SN56502 | 3512A09H01 |
| J111 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J112 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J113 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J114 | JUMPER | 0 OHM RESISTOR | 862A478H01 |

| | | | | | |
|---|---|---|---|---|---|
| R111 | POT | 50.0K | .50W | | 629A645H06 |
| R147 | POT | 250.0K | .75W | | 880A826H10 |
| R153 | POT | 2.5K | .25W | | 629A645H07 |
| 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 |
| R127 | RESISTOR | 2.0K | .50W | 1% | 848A819H77 |
| R146 | RESISTOR | 4990.0 | .50W | 1% | 848A820H16 |
| R148 | RESISTOR | 1000.0 | .50W | 1% | 848A819H43 |
| 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 | 1.0K | .25W | 20% | 629A430H02 |
| R156 | RESISTOR | 150.0 | .50W | 1% | 848A818H68 |
| R157 | RESISTOR | 20.0K | .50W | 1% | 848A820H74 |
| R158 | RESISTOR | 20.0K | .50W | 1% | 848A820H74 |
| Z11 | ZENER | IN825A | 6.2V | | 862A288H06 |
| Z12 | ZENER | IN825A | 6.2V | | 862A288H06 |

Sub. 2

(Dwg. 1453C38)

*Fig. 6. Internal Schematic S/N Detection Module.*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| D73 | DIODE | 1N645A | 837A692H03 |
| D74 | DIODE | 1N645A | 837A692H03 |
| D75 | DIODE | 1N645A | 837A692H03 |
| D78 | DIODE | 1N645A | 837A692H03 |
| D79 | DIODE | 1N645A | 837A692H03 |
| D80 | DIODE | 1N645A | 837A692H03 |
| D81 | DIODE | 1N457A | 184A855H07 |
| D82 | DIODE | 1N457A | 184A855H07 |
| D83 | DIODE | 1N645A | 837A692H03 |
| D85 | DIODE | LED | 3508A22H02 |
| D86 | DIODE | LED | 3508A22H01 |
| D88 | DIODE | LED | 3508A22H01 |
| D89 | DIODE | LED | 3508A22H01 |
| IC21 | INT CKT | 747DM | 1443C52H01 |
| J121 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J122 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J123 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| R178 | POT | 2.5K .25W | 629A645H07 |

| | | | | | |
|---|---|---|---|---|---|
| R163 | RESISTOR | 33.0K | .50W | 5% | 184A763H63 |
| R164 | RESISTOR | 120.0K | .50W | 5% | 184A763H77 |
| R165 | RESISTOR | 4700.0 | .50W | 5% | 184A763H43 |
| R166 | RESISTOR | 2400.0 | .50W | 5% | 184A763H36 |
| R167 | RESISTOR | 1.5 K | .50W | 1% | 848A819H65 |
| R168 | RESISTOR | 150.0 | 3.00W | 5% | 762A679H01 |
| R171 | RESISTOR | 33.0K | .50W | 5% | 184A763H63 |
| R172 | RESISTOR | 120.0K | .50W | 5% | 184A763H77 |
| R173 | RESISTOR | 4700.0 | .50W | 5% | 184A763H43 |
| R174 | RESISTOR | 2400.0 | .50W | 5% | 184A763H36 |
| R175 | RESISTOR | 1.5K | .50W | 1% | 848A819H65 |
| R176 | RESISTOR | 150.0 | 3.00W | 5% | 762A679H01 |
| R177 | RESISTOR | 10.0K | .50W | 1% | 848A820H45 |
| R179 | RESISTOR | 10.0K | .50W | 1% | 848A820H45 |
| R180 | RESISTOR | 68.1K | .50W | 1% | 848A821H26 |
| R181 | RESISTOR | 4990.0 | .50W | 1% | 848A820H16 |
| R182 | RESISTOR | 6810.0 | .50W | 1% | 848A820H29 |
| R183 | RESISTOR | 2.0K | .50W | 1% | 848A819H77 |
| R184 | RESISTOR | 2.0K | .50W | 1% | 848A819H77 |
| R185 | RESISTOR | 562.0K | .25W | 1% | 848A822H15 |
| R186 | RESISTOR | 511.0K | .50W | 1% | 848A822H11 |
| R187 | RESISTOR | 1620.0 | .25W | 1% | 848A819H68 |
| R188 | RESISTOR | 1620.0 | .25W | 1% | 848A819H68 |
| R189 | RESISTOR | 33.0K | .50W | 5% | 184A763H63 |
| R190 | RESISTOR | 68.0K | .50W | 5% | 184A763H71 |
| R191 | RESISTOR | 68.0K | .50W | 5% | 184A763H71 |
| R192 | RESISTOR | 33.0K | .50W | 5% | 184A763H63 |
| R193 | RESISTOR | 120.0K | .50W | 5% | 184A763H77 |
| R194 | RESISTOR | 10.0K | .50W | 5% | 184A763H51 |
| R195 | RESISTOR | 18.0K | .50W | 5% | 184A763H57 |
| R196 | RESISTOR | 1.5K | .50W | 1% | 848A819H65 |
| R197 | RESISTOR | 150.0 | 3.00W | 5% | 762A679H01 |

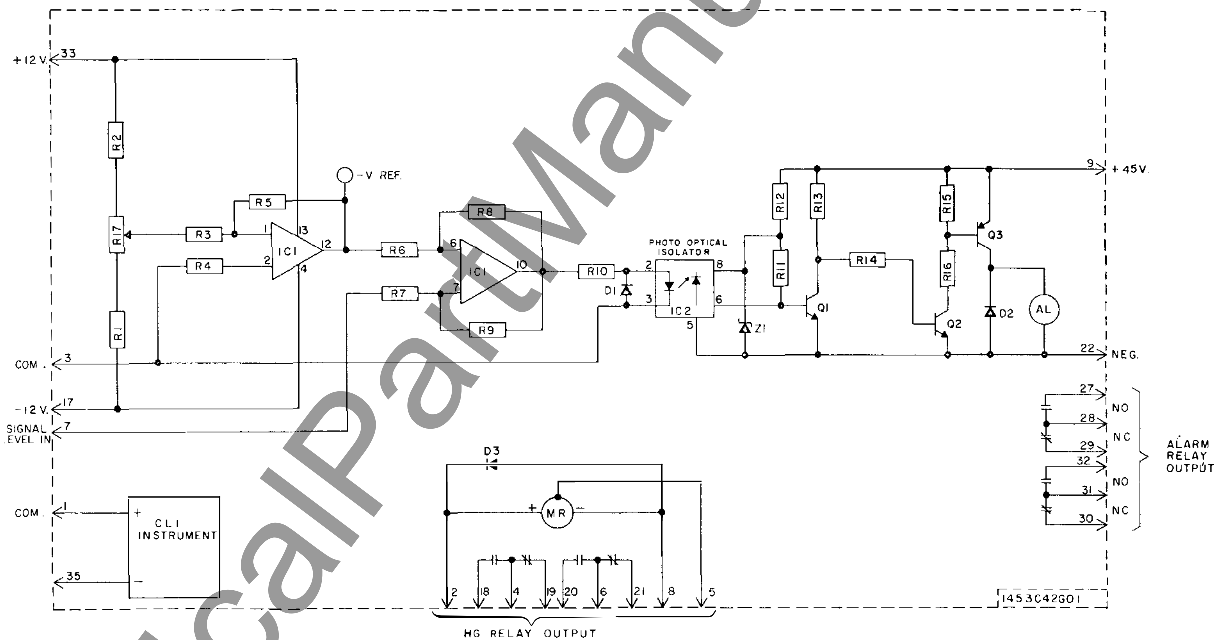
| COMPONENT | | DESCRIPTION | | STYLE NO. |
|---|---|---|---|---|
| Q62 | TRANSISTOR | 2N699 | | 184A638H19 |
| Q63 | TRANSISTOR | 2N3645 | | 849A441H01 |
| Q65 | TRANSISTOR | 2N699 | | 184A638H19 |
| Q66 | TRANSISTOR | 2N3645 | | 849A441H01 |
| Q67 | TRANSISTOR | 2N699 | | 184A638H19 |
| Q68 | TRANSISTOR | 2N699 | | 184A638H19 |
| Q69 | TRANSISTOR | 2N3645 | | 849A441H01 |
| Z22 | ZENER | IN4752A | 33.0V | 849A515H02 |
| Z24 | ZENER | IN4752A | 33.0V | 849A515H02 |
| Z25 | ZENER | IN961B | 10.0V | 186A797H07 |
| Z26 | ZENER | IN4752A | 33.0V | 849A515H02 |

Sub. 3

(Dwg. 1453C39)

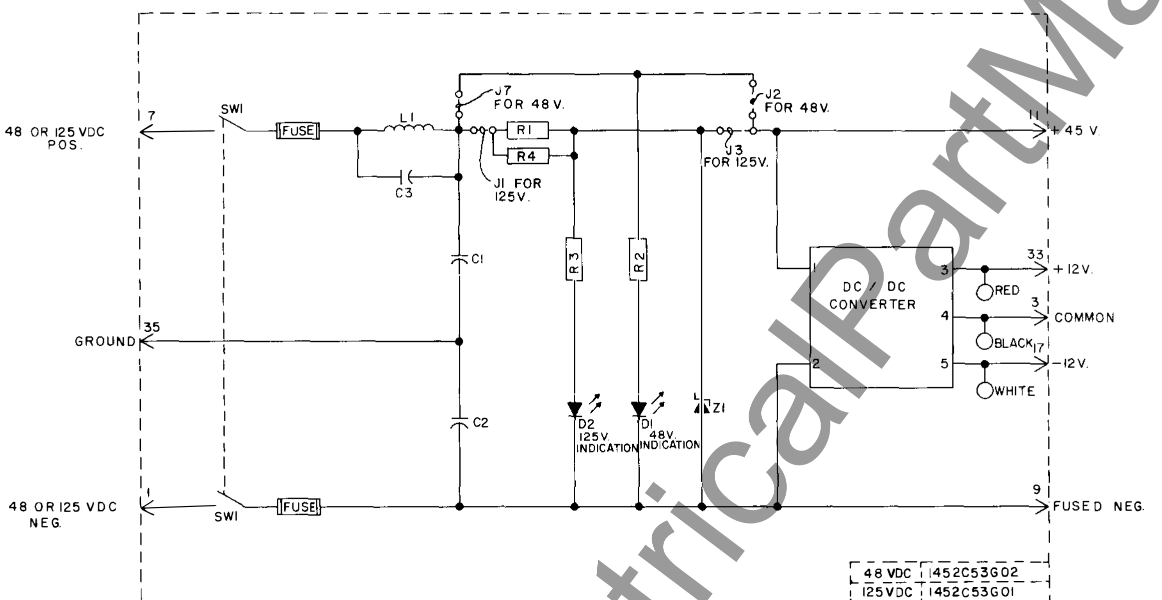
Fig. 7. Internal Schematic Output Module.

| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| R1 | RESISTOR | 10K .50W 5% | 184A763H51 |
| R2 | RESISTOR | 10K .50W 5% | 184A763H51 |
| R3 | RESISTOR | 6.81K .50W 1% | 848A820H29 |
| R4 | RESISTOR | 4.99K .50W 1% | 848A820H16 |
| R5 | RESISTOR | 6.81K .50W 1% | 848A820H29 |
| R6 | RESISTOR | 2.0K .50W 1% | 848A819H77 |
| R7 | RESISTOR | 2.0K .50W 1% | 848A819H77 |
| R8 | RESISTOR | 562.K .25W 1% | 848A822H15 |
| R9 | RESISTOR | 511K .50W 1% | 848A822H11 |
| R10 | RESISTOR | 3.3K .50W 2% | 629A531H44 |
| R11 | RESISTOR | 15K .50W 2% | 629A531H60 |
| R12 | RESISTOR | 120K .50W 2% | 629A531H82 |
| R13 | RESISTOR | 13.3K .50W 1% | 848A820H57 |
| R14 | RESISTOR | 15K .50W 2% | 629A531H60 |
| R15 | RESISTOR | 6.8K .50W 2% | 629A531H52 |
| R16 | RESISTOR | 6.8K .50W 2% | 629A531H52 |
| R17 | POT | 2.5K .25W 10% | 629A645H07 |
| J1 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| D1 | DIODE | IN645A | 837A692H05 |
| D2 | DIODE | IN645A | 837A692H05 |
| D3 | DIODE | IN457A | 184A855H07 |
| Z1 | ZENER | IN9578 | 186A797H06 |
| Q1 | TRANSISTOR | 2N3417 | 848A851H02 |
| Q2 | TRANSISTOR | 2N699 | 184A638H19 |
| Q3 | TRANSISTOR | 2N3645 | 849A441H01 |
| IC1 | INT.CKT. | 747DM | 1443C52H01 |
| IC2 | INT.CKT. | 5082-4371 | 775862IH01 |




Sub. 2
(Dwg. 1453C40)

*Fig. 8. Internal Schematic Output Module-Contact Output.*




| COMPONENT | | DESCRIPTION | STYLE NO. |
|---|---|---|---|
| C1 | CAPACITOR | .01 MFD. | 3516A36H01 |
| C2 | CAPACITOR | .01 MFD. | 3516A36H01 |
| C3 | CAPACITOR | .047 MFD. | 849A437H04 |
| R1 | RESISTOR | 1000 10W. | 644B262H34 |
| R2 | RESISTOR | 4.7K .50W 2% | 629A531H48 |
| R3 | RESISTOR | 4.7K .50W 2% | 629A531H48 |
| R4 | RESISTOR | 1000 10W | 644B262H34 |
| Z1 | ZENER | IN2828B | 184A845H06 |
| J1 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J2 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J3 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| J7 | JUMPER | 0 OHM RESISTOR | 862A478H01 |
| SW1 | SWITCH | DPDT | 849A299H01 |
| O1 | DIODE | LED | 3508A22H02 |
| D2 | DIODE | LED | 3508A22H02 |
| L1 | COIL | | 2928096G02 |

(Dwg. 1452C65)

*Fig. 9. Internal Schematic Power Supply Module.*

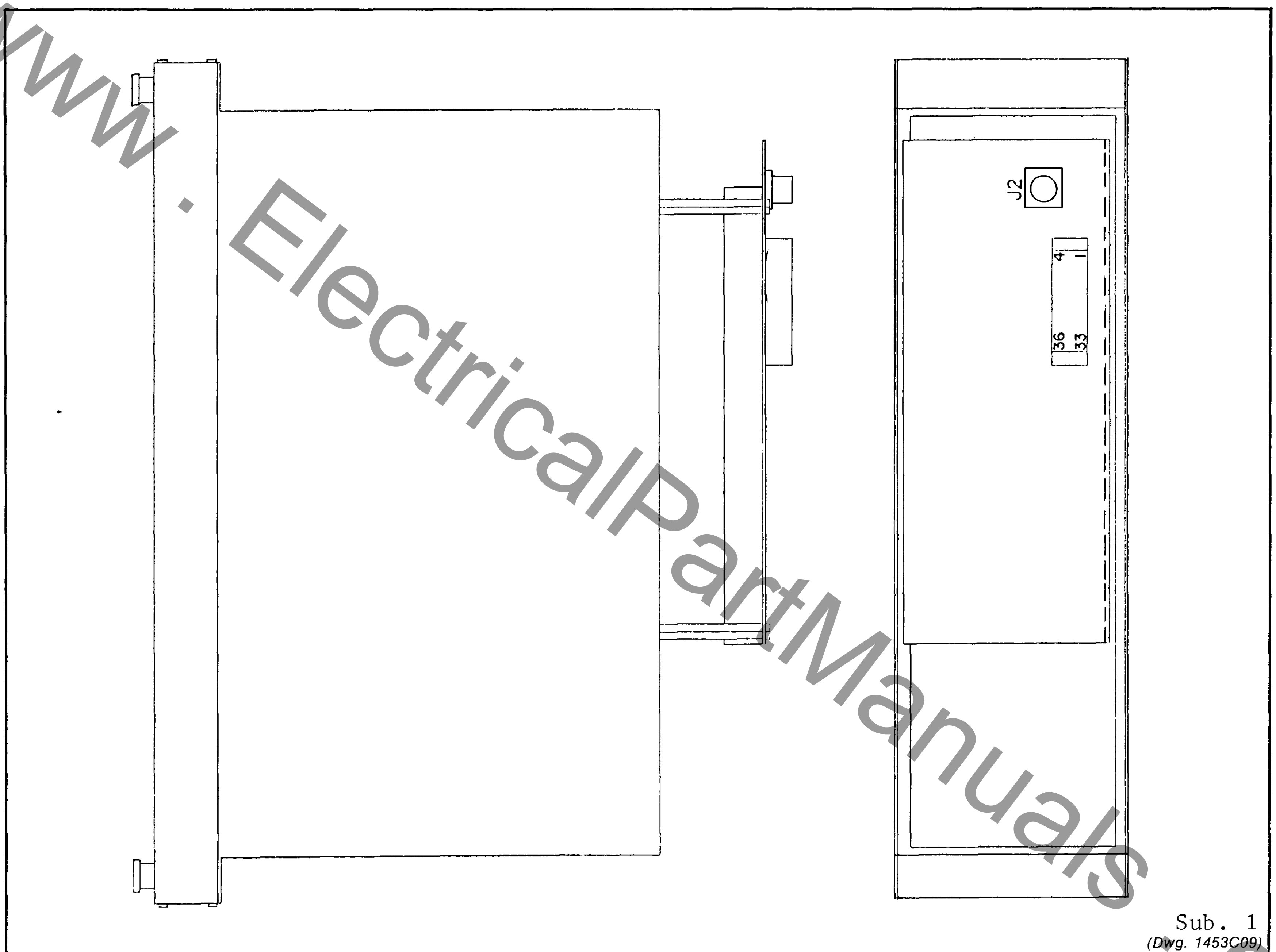



Fig. 10. Component Location TCF-10 Receiver.

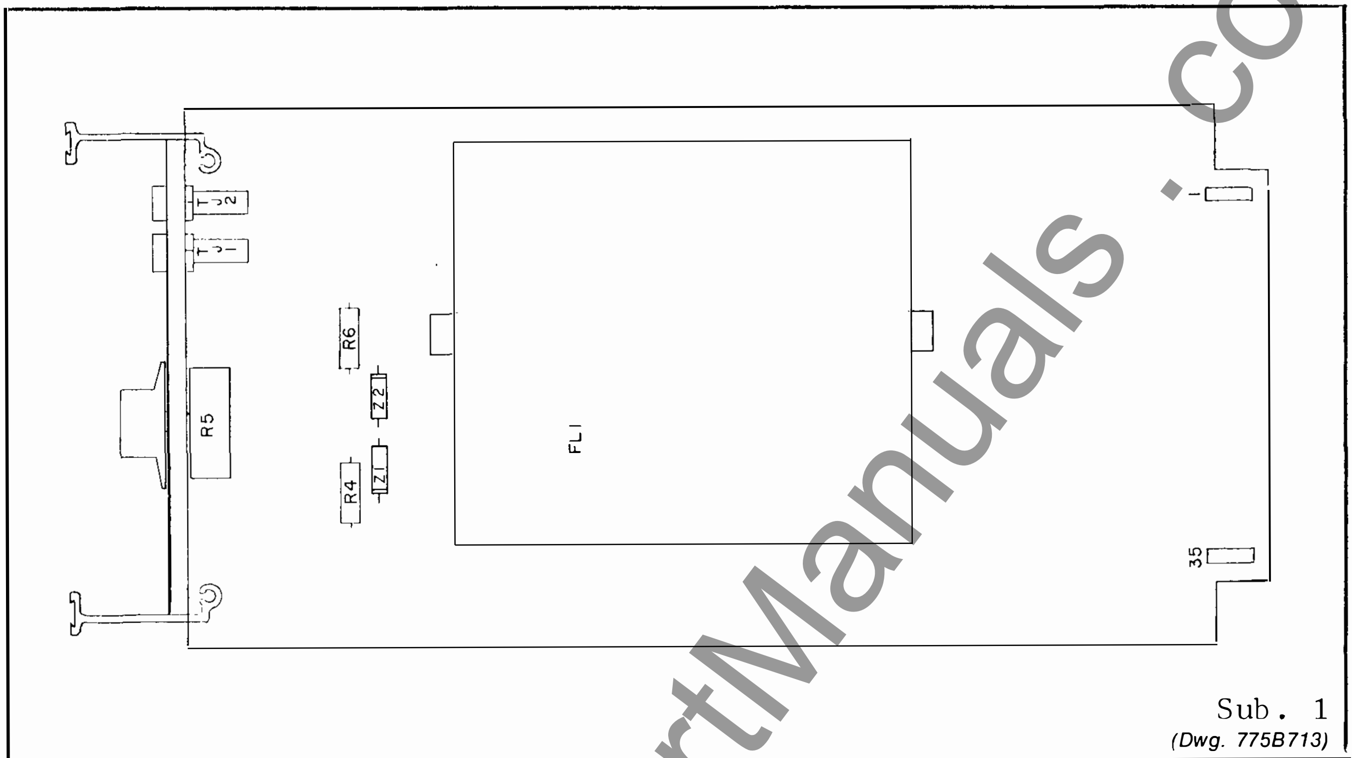



*Fig. 11. Component Location Input Filter Module*

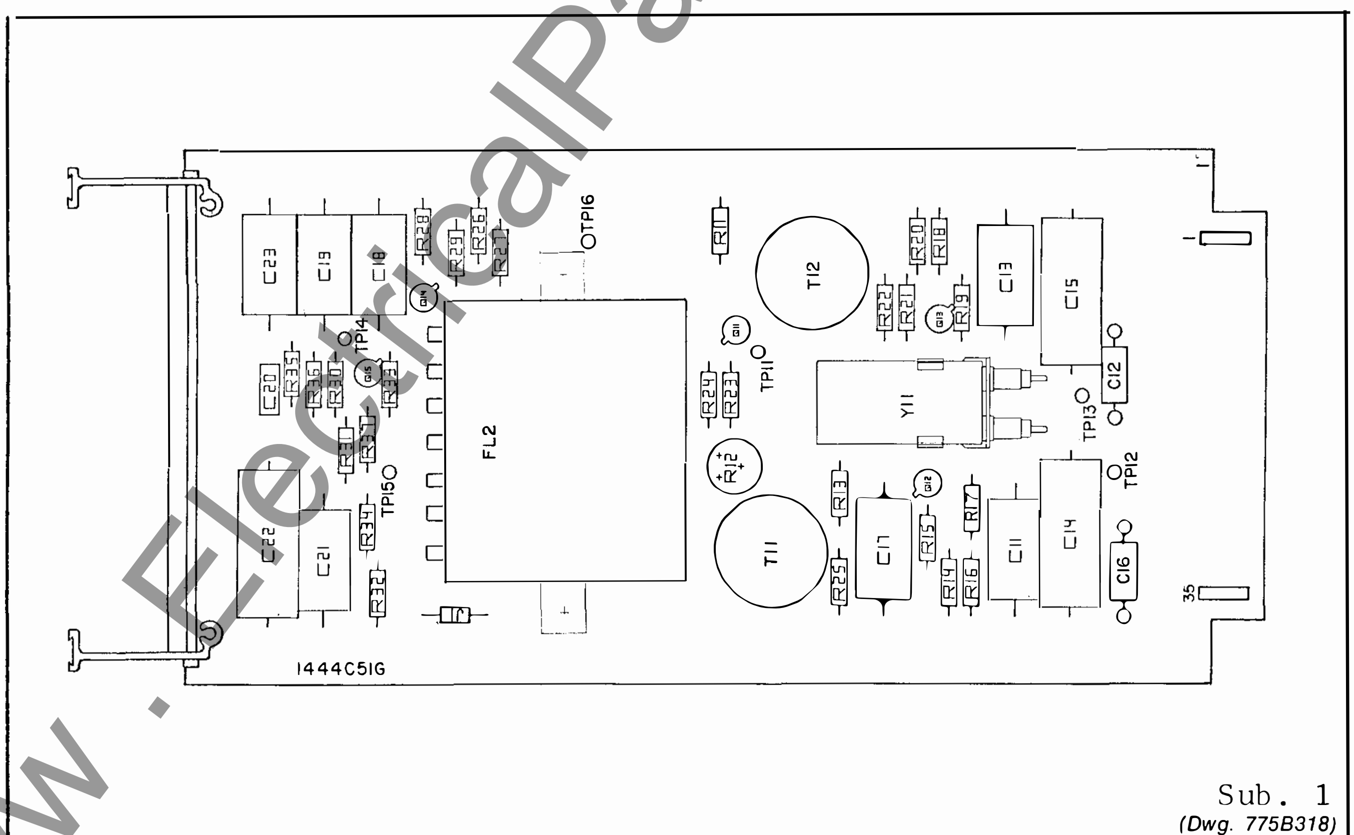
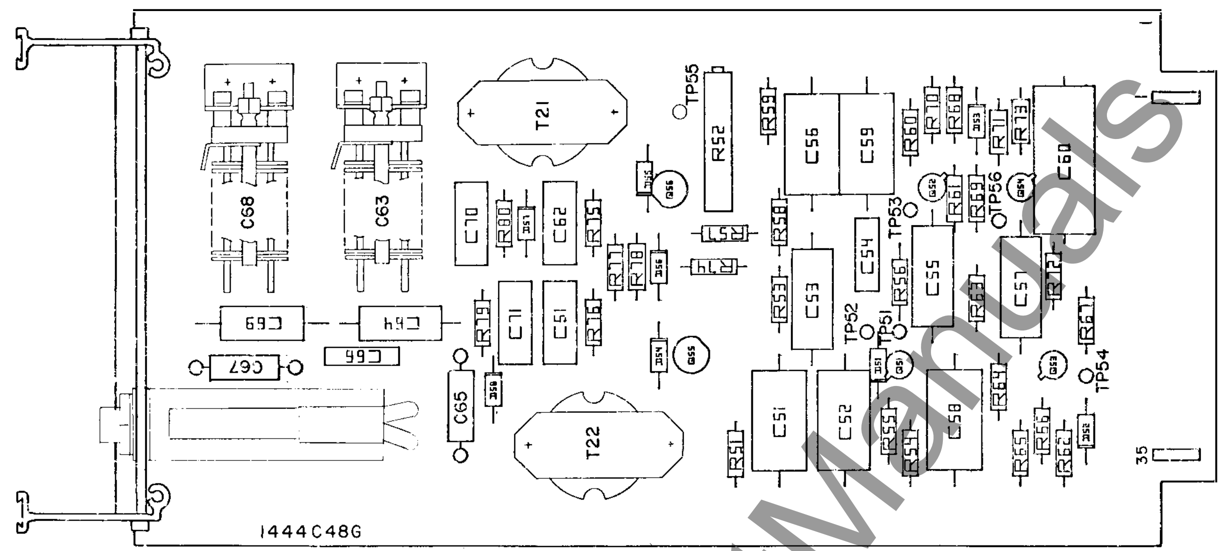
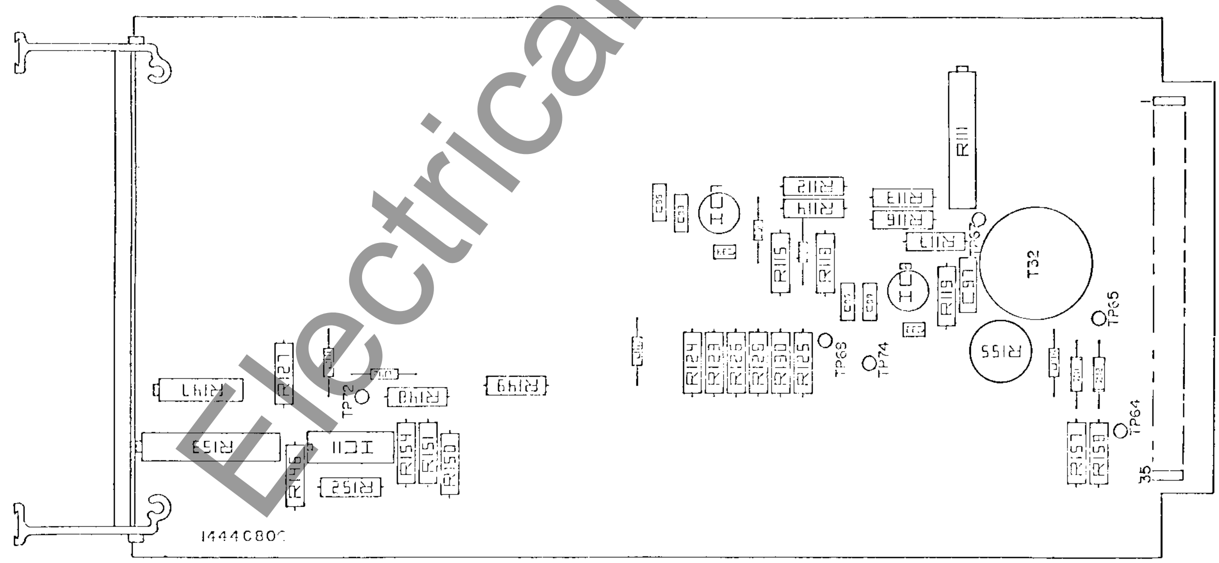



*Fig. 12. Component Location Oscillator-Mixer-IF Amplifier Module.*



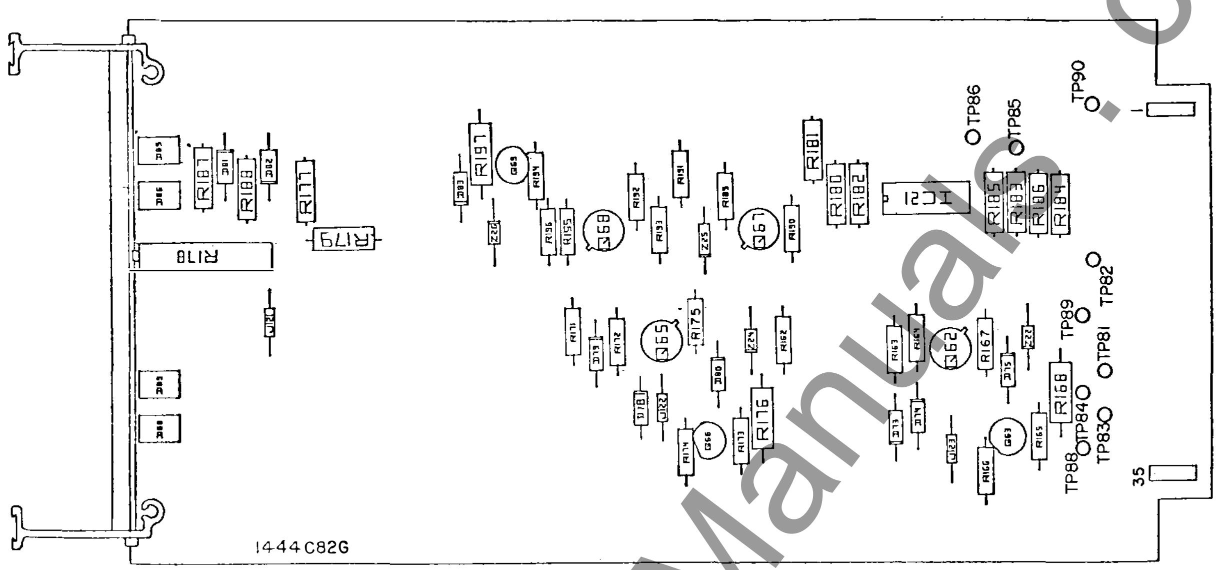

Sub. 1
(Dwg. 775B317)

Fig. 13. Component Location Amplifier Limiter-Discriminator Module.



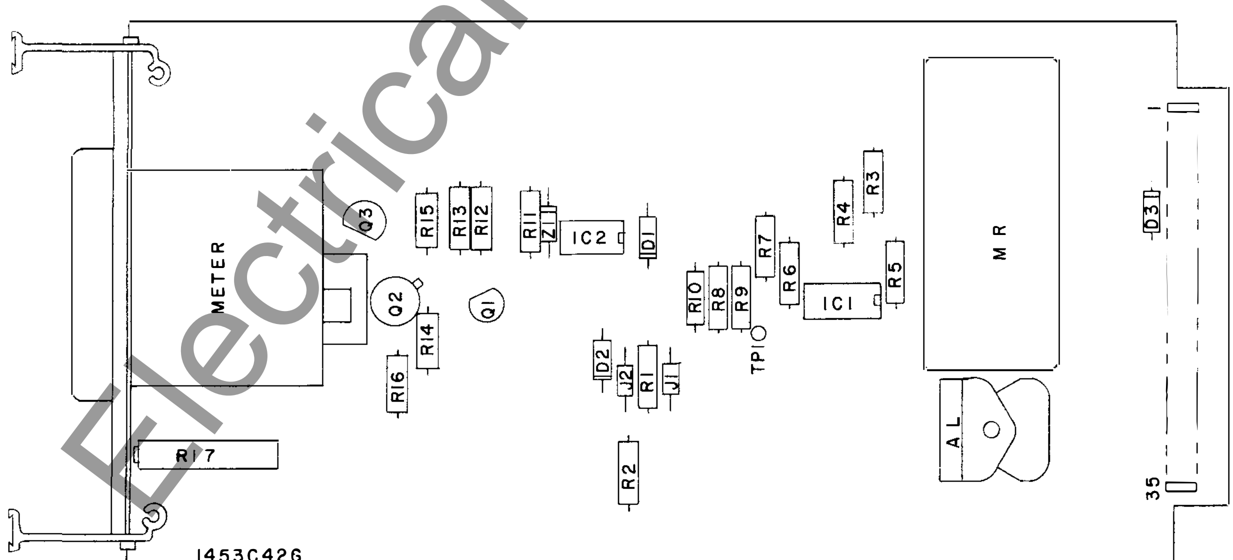

Sub. 2
(Dwg. 775B711)

Fig. 14. Component Location S/N Detection Module.




Sub. 1
(Dwg. 775B714)

Fig. 15. Component Location Output Module.




(Dwg. 775B716)

Fig. 16. Component Location Output Module - Contact Output.

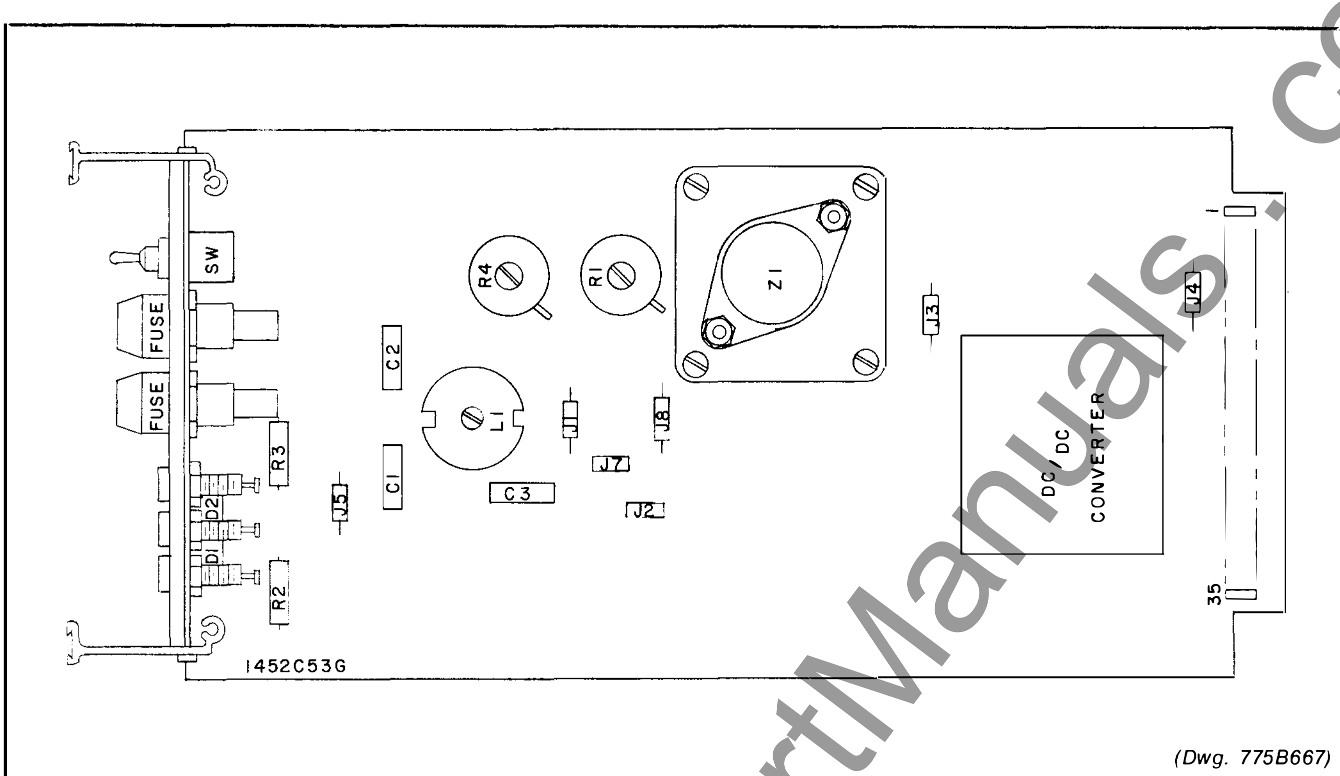



*Fig. 17. Component Location Power Supply Module.*

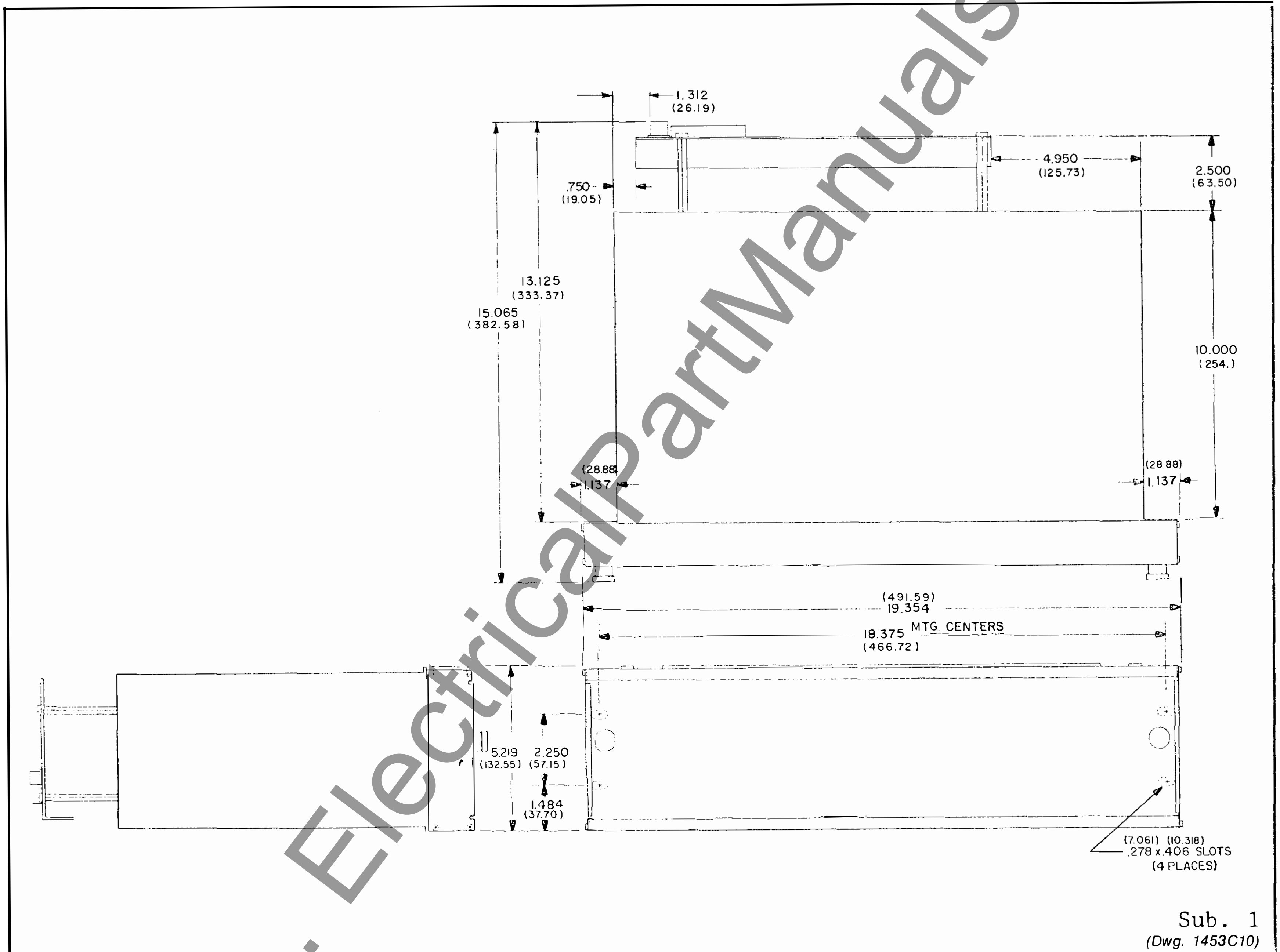



*Fig. 18. Outline TCF-10 Receiver.*

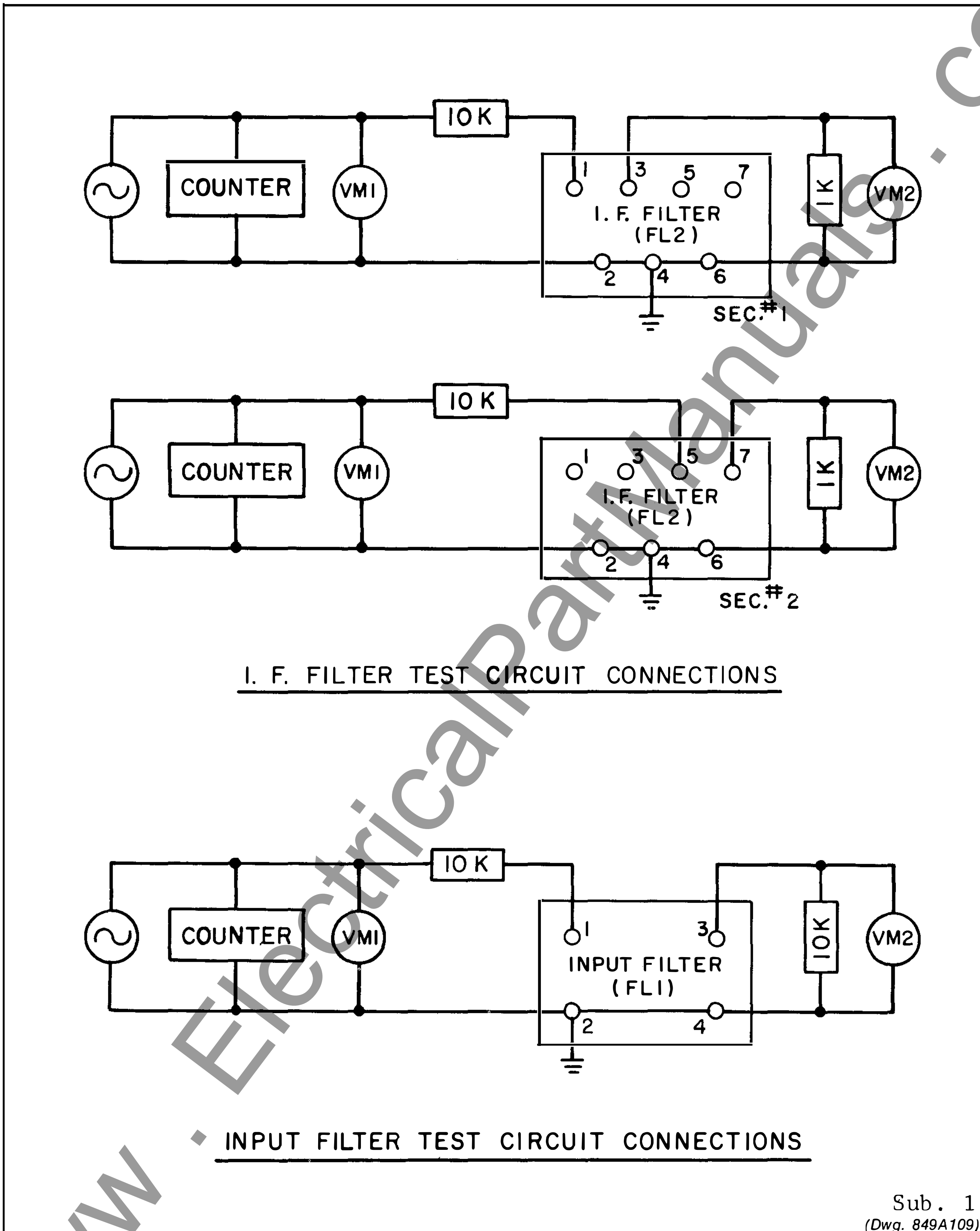



*Fig. 19. Test Circuits for TCF-10 Receiver Filters.*

**WESTINGHOUSE ELECTRIC CORPORATION**

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