INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TA–1
FREQUENCY – SHIFT AUDIO TONES

CAUTION: Check polarity of battery supply connections before applying power to the equipment.

APPLICATION

The type TA-1 tones are high-speed frequency-shift audio-frequency tones. They are designed for use in transferred-tripping systems for transformer and line protection. They may be used directly over a pilot wire pair, or may be impressed on a microwave channel.

Applications are classified as either permissive or non-permissive. The non-permissive system allows the receiver relay to trip directly, as opposed to a permissive system where a fault detecting relay supervises receiver relay tripping. The overreaching scheme is usually a permissive system since the phase and ground fault detecting relays are inherently present. Examples of this type of system are shown in figs. 11 and 12. These fault detectors are not present in an underreaching scheme or a transformer protection channel; therefore, these are classified as non-permissive. Examples of non-permissive systems are shown in figs. 13 and 14.

The presence or lack of trip-circuit supervision greatly influences the security and reliability considerations. As with all protection systems, one must strike a compromise between the conflicting requirements of security and reliability – security against undesired tripping and reliability in tripping when required. With non-permissive schemes the burden for security rests entirely with the tones themselves; whereas, the fault-detecting relays in the permissive scheme share the burden with tones for security. Thus, we can ease up on the security requirements of the tones proper when used in a permissive scheme. This is desirable not just for economy, but also to eliminate components which tend to detract from reliability.

Security Measures

The TA-1 frequency-shift receiver has been specially designed for security against noise. Audio frequency random noise must be at least 50 db peak over the guard signal to cause trip relay operation. With the recommended –32 dbm maximum receiver sensitivity, this means that the a-f random noise must be about +18 dbm to cause undesired trip relay operation. This compares with quiescent noise levels on the order of –50 dbm.

This leaves impulse noise to be considered. Not only are these of higher energy level, but they also cannot be classed as random in the sense that the energy is uniformly distributed across the audio spectrum. Inadvertently applied voice signals and power-system arcs and disturbing voltages are prime sources of impulse noise. To guard against the possibility that this impulse noise might fall in the trip band, a noise squelch is recommended. This squelch receiver disables the frequency shift receiver whenever the noise measured in the 300-480 cycle band exceeds the dbm setting of the squelch.

The receiver guard relay also contributes to security. In non-permissive applications a break contact of this relay supervises the trip circuit. It must be dropped out at the same instant that the trip relay is picked up, in order to trip. This feature helps when the receiver sees high-energy impulse noise which intermittently tends to concentrate at the trip frequency.

A high signal level, along with an insensitive receiver, also helps the channel to ignore noise. A receiver sensitivity no higher than –32 dbm and a received signal level of at least –20 dbm is a good objective. This means that the channel attenuation should be no higher than –15 db on leased circuits to allow for the required reduced transmitter output where transmitters are paralleled. This reduction to 5dbm keeps the combined audio energy down to tolerable levels from a voice interference standpoint.

Pilot-Wire Design

In applying a tone system for protection, the

SUPERSEDES I.L. 41-963A
*Denotes change from superseded issue.

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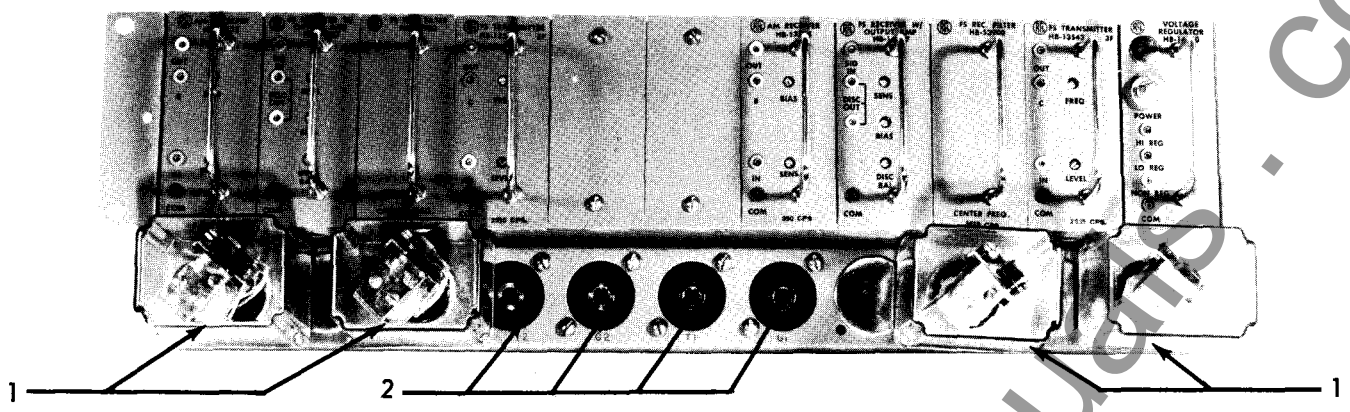


Fig. 1 – Front View of Full Chassis: 1–Telephone Type output relays (when used); 2–Current monitoring jacks (when used).

user and the cooperating telephone company should recognize the peculiar requirements of a tone protection channel. Preconceived notions and practices based on experience with tones for other uses must be re-examined in the light of the following facts. The period of usefulness during the lifetime of any given installation will range from 0-10 seconds. Yet this infinitesimal period (compared to years) is precisely the time when noise levels can be abnormally high and 60 cycle disturbing voltages will appear on the pilot wire. The recommendations summarized in Figs. 17, 18, and 19 have been formulated with the above facts in mind.

For a recommended installation:

a) Use a drainage reactor in all paths to ground.

* b) If KX642 gas tubes are installed, connect them only to ground as shown in Fig. 16. Do not connect the tube without shorting H2 to H3. This is especially important where the squelch receiver is used, as a failure to follow these recommendations will result in the squelch disabling the channel whenever the tube flashes.

c) The pilot-wire pair must be twisted separately from any other wires in the cable.

d) Do not use open pilot wires.

e) Shield any substantial length of wire between pilot wire and tone equipment.

f) Use surge protection across tone connection.

To protect personnel, use isolating transformer (S#185A495H01 serves the dual purpose of impedance matching). Mount it with the drainage and neutralizing devices in an enclosure marked "High Voltage."

Fig. 17 shows the recommended practices for privately owned cable installations. The best approach is to make the cable self-protecting. The incremental cost (installed) of better cable insulation is relatively small. Good electromagnetic shielding by the shield and by the messenger will keep induced potential to reasonable levels. The shield should provide a shielding factor of 50% or less (actual induced voltage of 50% of calculated value ignoring shielding effect).

CONSTRUCTION

The type TA-1 tone equipment has been specifically designed for protective relaying applications. Modular design is used, and a system is assembled using plug-in modules to meet the requirement of a specific application.

In a typical relaying application, the tone system consists of a power supply module, a transmitter module, two receiver modules, an optional squelch module, and two output relays. These components are mounted on separate chassis.

Basic construction is shown in Figs. 1 through 3.

A. Transmitter Module

The transmitter module consists of a transistor

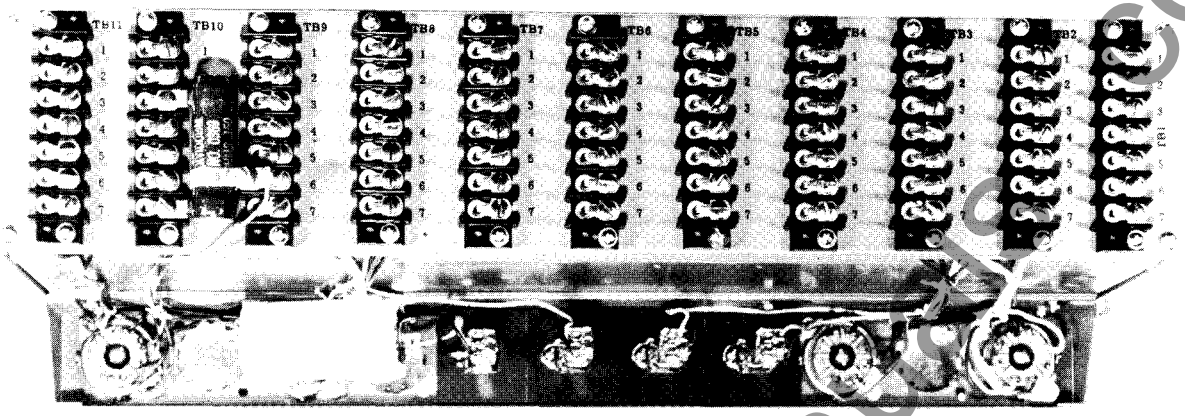


Fig. 2 – Rear View of Full Chassis

keying circuit, an oscillator, an output amplifier and an output band-pass filter. The band-pass filter and oscillator frequency determining components are contained in a separate plug-in enclosure to simplify changes in frequency assignments and stocking of spares.

B. Receiver Module

The receiver module consists of an input band-pass filter, a limiting amplifier, a specially tuned discriminator, rectifying and filtering circuitry and a two-stage d-c amplifier. The band-pass filter and discriminator, which determines the operating frequency of the receiver, are mounted on a separate plug-in card. The discriminator output is brought out to separate screw terminals at the rear of the chassis to facilitate connection of a channel monitoring meter.

C. Voltage Regulator Module

The voltage regulator consists of a power-on switch, power-on light, fuse and two transistor-Zener diode circuits. The regulator is capable of supplying regulated 36 and 22 vdc to two complete transmitter-receiver assemblies with squelch circuits.

D. AM Receiver Noise Squelch (when used)

This module consists of an input filter, normally tuned for a pass band of 300 to 480 cps, a three-stage amplifier, rectifying and filtering circuitry and an output d-c amplifier.

E. Output Relays

The output relays are either telephone type relays or high speed type AR relays. On systems with telephone type relays, the relays are mounted on the same chassis as the modules and current jacks are used to monitor the relay coil current. In the type AR relay systems, the output relay is mounted in an FT-22 case separate from the tone chassis and must be connected to the output of the receiver module. Current test jacks on the FT case are used to monitor the AR coil current.

The AR output relay is a small high-speed attracted-armature type of unit. An insulated member, fastened to the free end of the armature, draws down four moving-contact springs to close the trip-circuit contacts when the relay coil is energized.

A typical tone assembly using telephone type output relays is shown in figure 8.

The tone assembly for an AR type system is shown in figure 9, and the schematic of the type AR output relay is shown in figure 10.

F. Physical Features

The modules are the same size, and plug into either of two basic chassis.

a) An eleven module chassis with a nominal overall size of 5¼'' h x 19'' w x 9¾'' d, which mounts in standard relay rack. Outline and drilling dimensions are shown in Figure 4.

b) A five module wall mount chassis with a nominal overall size of 5¼'' h x 9 15/16'' w x 10 5/8'' d. Module shelf swings out 180° for easy access to rear terminals. Outline and drilling dimensions are shown in Figure 5.

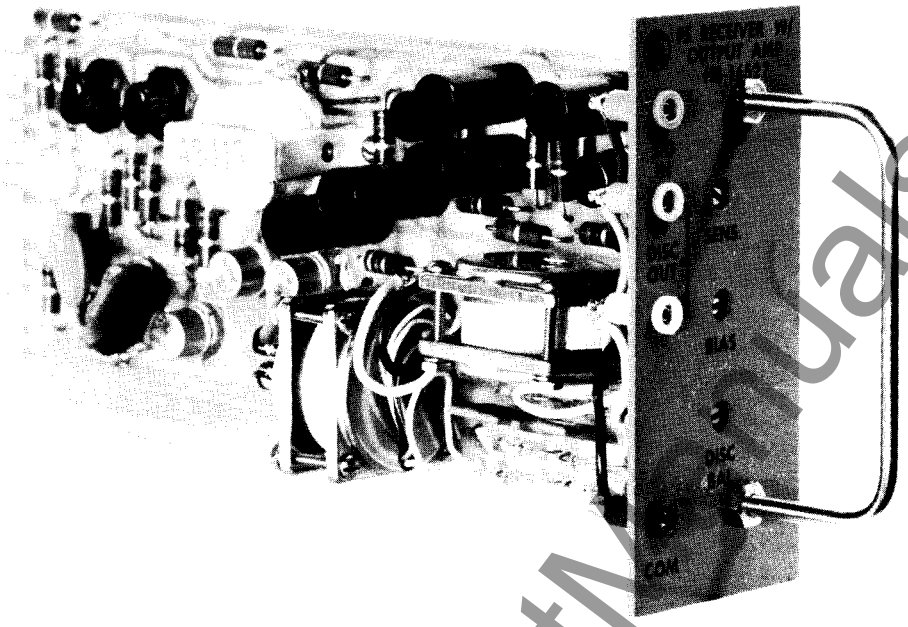


Fig. 3 – Typical Module

THEORY OF OPERATION

Under normal line conditions, the tone transmitter operates at its guard frequency which is 85 cps below the nominal or center frequency marked on the unit. At the receiving terminal, the reception of the guard frequency develops an output from the receiver discriminator which operates the guard relay.

When a tripping function is called for, operation of the protective relay shifts the tone transmitter to its trip frequency which is 85 cps above the nominal or center frequency of the tone. At the receiving terminal, the reception of the trip frequency develops an output from the receiver discriminator which operates the trip relay. Since the guard discriminator output is no longer present, the guard relay drops out.

A. FS Transmitter (HB-17845-2)

For guard frequency transmission, the transistor, Q3, is biased into conduction by application of a negative voltage on the emitter. This in effect inserts the guard frequency capacitors in the oscillator tuned circuit. The guard capacitors are removed when the forward bias is removed from the emitter and the oscillator shifts to the trip frequency. This is usually accomplished by a contact closure from terminal 6 on the connector block to battery positive.

An oscillator, using the frequency determining L_O, C_G and C_T, generates the guard and trip frequencies. The voltage tap of R_{12}, the output level control, is used to drive transistor Q_1, an output buffer amplifier. The filter, FL-1 is the collector load of the amplifier and also serves to d-c isolate the oscillator from the line and to match a line impedance of 600 ohms.

The filter and the oscillator are the only frequency sensitive components in the transmitter and are packaged together in a hermetically sealed plug-in can.

Frequency adjustment is obtained through the use of capacitor C_6, resistor R_7 and R_{17}. The effective capacitance introduced into the tuned circuit is varied with resistor R_{17}. When resistor R_{17} is adjusted to maximum resistance, the capacitor C_6 is isolated from the tuned circuit. Resistor R_7 is used to prevent the entire value of capacitance from becoming effective in the tuned circuit.

B. FS Receiver (HB-16527-2, HB-20835-2, and HB-20835-10)

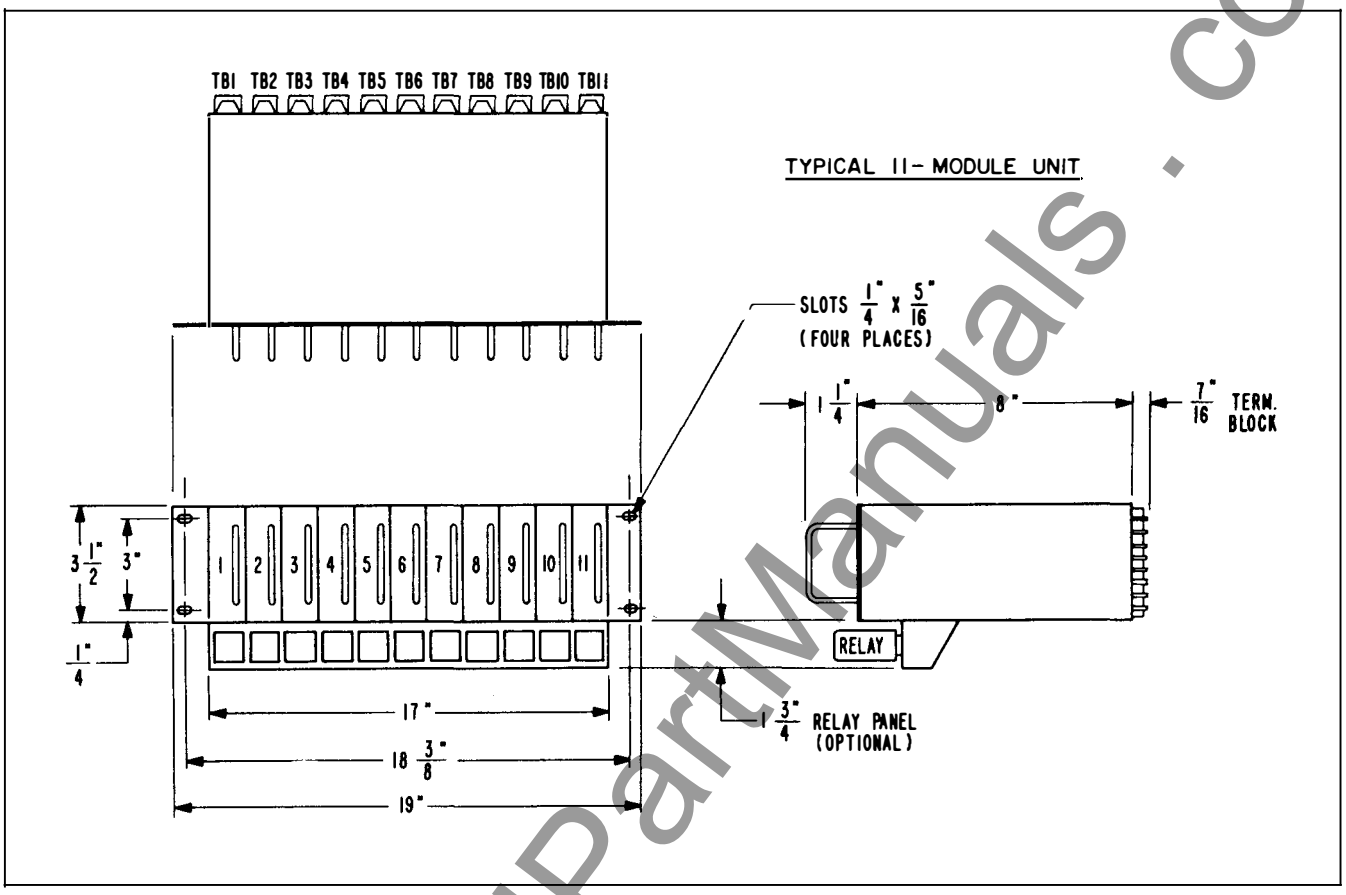


Fig. 4 – Outline and Drilling Plan of 11 Module Chassis

The input of the receiver is designed to reject adjacent channel tones by at least 40 db. The sharply sloping skirts of the filter also aid in preventing noise frequencies, just above the trip frequency, from causing false trip relay operation.

Transistors Q_1 Q_2, Q_3 and Q_4 comprise a three stage limiter amplifier and will provide full limiting of the discriminator input signal to approximately −40 dbm.

The discriminator consists of two tuned circuits, one tuned to peak at the trip frequency and the other tuned to peak below the guard frequency. The effect of this tuning is shown on the discriminator output curve Figure 6. This tuning, combined with a bias adjustment, greatly reduces the receiver sensitivity to random noise. The in-band noise power delivered to the d-c amplifiers is much lower over the band of frequencies affecting the trip condition than it is in the remainder of the band.

Resistor R_{20}, the balance control, is essentially a trimmer for the discriminator, allowing precise adjustment of the output at the guard and trip frequencies. The discriminator output also appears across resistor R_{22}, the relay bias control. If resistor R_{22}, is adjusted such that a greater portion of discriminator output is delivered to transistor Q_6 rather than transistor Q_5, it follows that more power must be delivered to transistor Q_5 to cause conduction. Resistor R_{23} and diode CR_{10} form a bias network preventing operation of either transistor Q_5 or Q_6 during the no signal condition. Resistor R_{32}, diodes CR_{11} and CR_{12} perform the same function on transistors Q_7 and Q_8.

Resistor-capacitor combinations, R_{28}, C_{10} and R_{29}, C_{11}, form accelerating networks for the output relays. When transistor Q_7 is switched on by transistor Q_5, capacitor C_{10}, momentarily shunts resistor R_{28}, causing a large inrush current to energize the output relay. A low holding current limited by resistor R_{28}, is required to keep the relay energized after capacitor C_{10}, is fully charged.

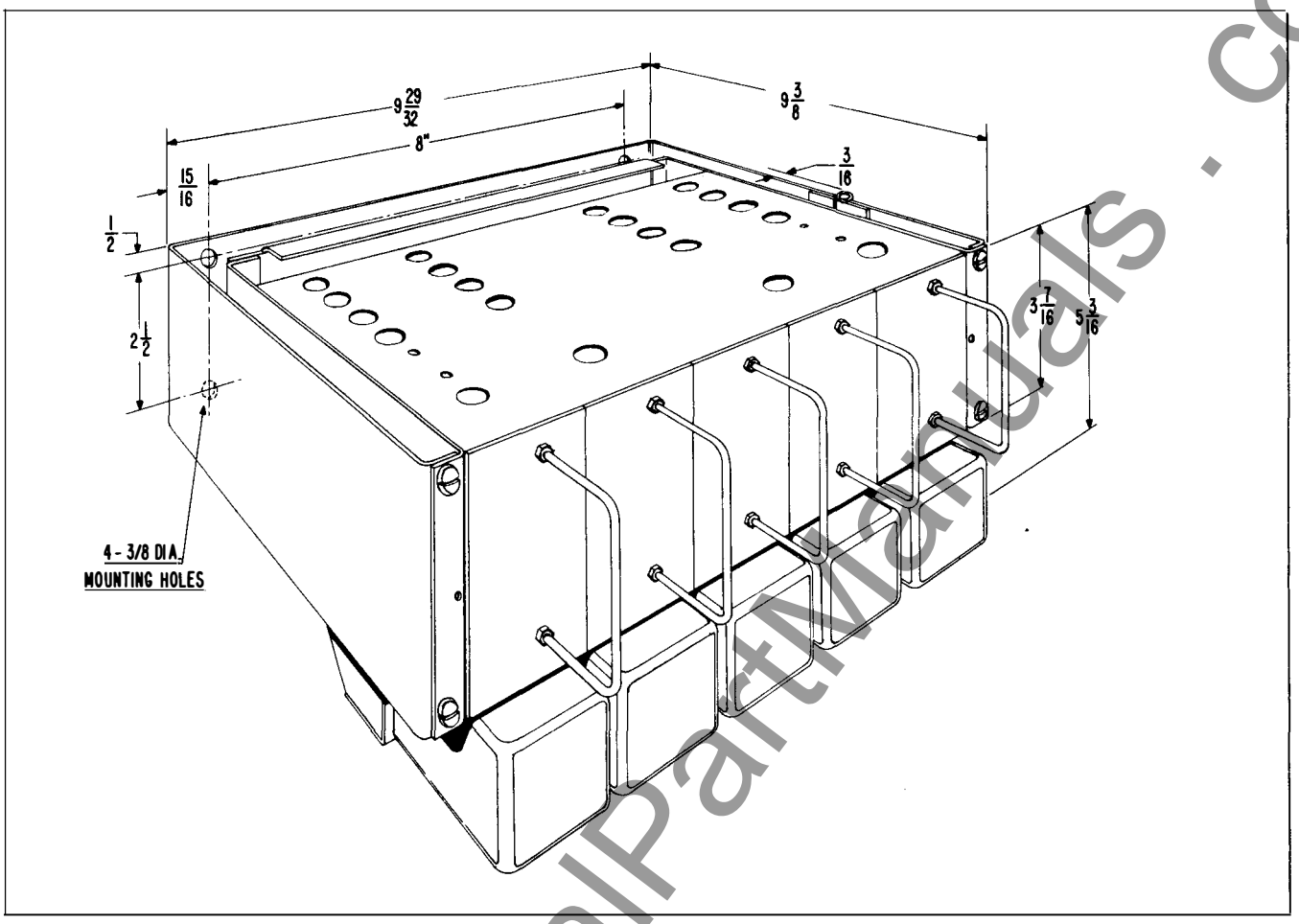


Fig. 5 – Outline and Drilling Plan of 5 Module Chassis

C. AM Receiver Noise Squelch (When used - HB-17840)

As shown in Figure 8, transistors Q_1, Q_2 and Q_3 form a three stage linear amplifier which drives rectifiers CR_1 and CR_2. During a low signal or low noise condition, the voltage divider, resistor R_{19} and R_{22}, biases the output transistor Q_4 into a non-conducting state. If the positive voltage from the rectifiers is large enough to overcome the bias, transistor Q_4 conducts. Terminal E is connected to the emitter of transistor Q_2 and the base of Q_8 on the FS Receiver. A negative voltage is applied to Q_2 and Q_8 when noise signals of sufficient amplitude cause transistor Q_4 of the squelch circuit to conduct. Reverse biasing of transistor Q_2 completely disables the FS Receiver and leaves the receiver in a no signal condition. The negative voltage on Q_8, allows Q_8 to conduct and keep the guard relay picked up.

CHARACTERISTICS

General

Channel Frequencies: cps	935 1955 1275 1615 2295 2635 (For special applications, additional frequencies can be supplied).
Shift in Frequency:	± 85 cycles
Operating Temperature:	-10°C to 60°C
Storage Temperature:	-60°C to +75°C
Operating Time: (Includes guard relay drop-out time and trip relay pickup time)	17-20 ms with telephone type output relays. 11-15 ms - with type AR output relays.

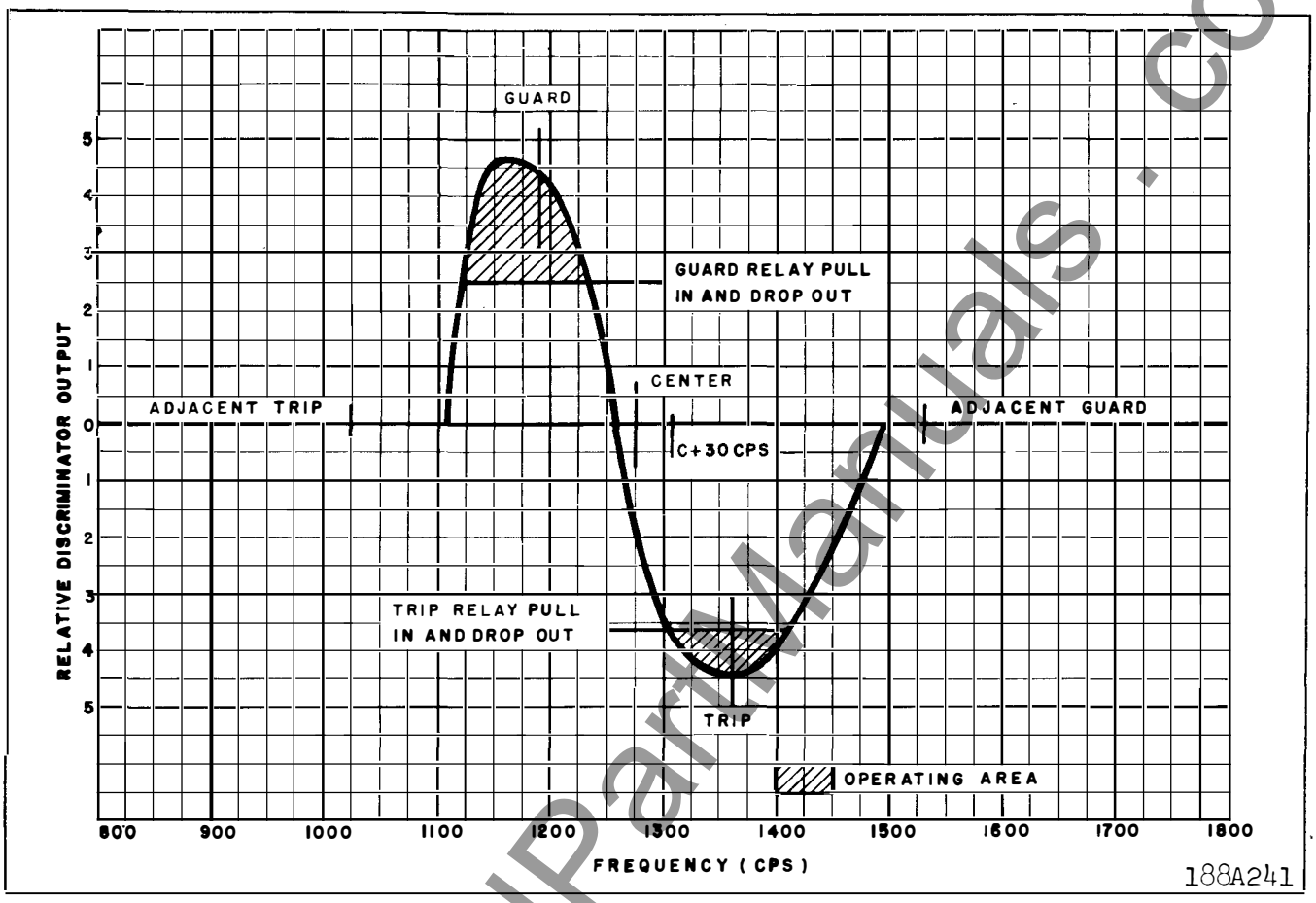


Fig. 6 – Typical discriminator output curve showing relative noise power output effecting trip relay.

DC supply voltage: 48, 125, or 250 volts dc, external dropping resistors are used on 125 and 250 v dc.

Energy Requirements: 0.15 amperes dc @ rated dc voltage per chassis, including one or two transmitter or receivers, or one each, plus power supply.

FS Transmitter

Output Level: +1 dbm to −30 dbm continuously adjustable.

Frequency Stability: 0.1% ± 2 cps

Output Impedance: 600 ohms in the pass-band: high impedance outside of pass-band ungrounded and unbalanced.

FS Receiver

Sensitivity: 0 dbm to −40 dbm for full limiting.

Input Impedance: 600 ohms in the pass-band; high impedance outside of pass-band, unbalanced, must be ac grounded.

(A 0.5 mfd, 2,000 volt capacitor is provided in each assembly to provide the ac grounding).

Adjacent Channel Rejection: At least 40 db.

Noise rejection without squelch circuit: Audio frequency random noise must be at least 50 db over the guard signal to cause false trip relay operation.

AM Receiver Noise Squelch (when used)

Sensitivity:	-40 dbm adjustable
Input Impedance:	600 ohms with rising characteristics out of band.

INSTALLATION

The tone assemblies should be mounted on relay racks or in suitable cabinets when the eleven module chassis is used. The five module chassis can be wall mounted. The mounting location should be free from dirt, moisture, excessive vibration or heat. All electrical connections are made to the terminal blocks on the rear of the chassis, per CR drawing (See Fig. 7) which applies to the particular order.

Use of current monitoring jacks: Standard telephone-type current jacks are shown on the connection diagrams. They are used to monitor the guard and trip output relay coil current.

The type AR relay should be mounted near the TA-1 tone chassis in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting, or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel-panel mounting or to the terminal studs furnished with the relay for thick-panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

SETTINGS

Transmitter:

Only one setting is required on the tone transmitter and that is the output level. This setting is made by using the screwdriver type adjustor marked "level" on transmitter module. In general, the tone transmitters are set to the maximum level allowed by the telephone company on the pilot wire or telephone pair. For example, in relaying applications, generally only one or two tone transmitters will be connected to the pilot channel at any one terminal. If zero dbm is the maximum allowance level, a single tone transmitter will be set to that level (0.775 volt). If more than one transmitter is used at one terminal, the telephone company should be consulted as to the allowable transmitting levels.

The audio output level of the transmitter is measured by connecting a 600-ohm resistor or load across the signal output terminals. No other signal should be present on the line if it is used. The level can be measured at the output terminals using an AC vacuum-tube voltmeter. The level control is then adjusted for the desired output. After all the transmitters are adjusted properly and multiplexed a VTVM reading should be taken at the "OUT" pin jack on the front panel and recorded for maintenance and check-out purposes. This avoids the necessity of disconnecting the transmitter from the line when levels are to be checked or readjusted.

FS Receiver

Plug a d-c milliammeter of at least 50 ma. range into receiver trip relay jack. Close the keying circuit of the associated tone transmitter to shift its frequency from Guard to Trip. (The tone transmitters must be previously set to their desired output levels). Connect a vtvm across the tone receiver input terminals and note the normal received voltage (preferably in db). Now connect a calibrated attenuator (such as the Hewlett-Packard Model 350B Attenuator) between the telephone line and the terminal equipment. Set the attenuator for 12 db attenuation. This value can be checked on the vtvm. If such an attenuator is not available, connect a variable resistor, 500 ohms maximum is adequate, across the incoming line and reduce the resistance until the incoming signal level drops 12 db.

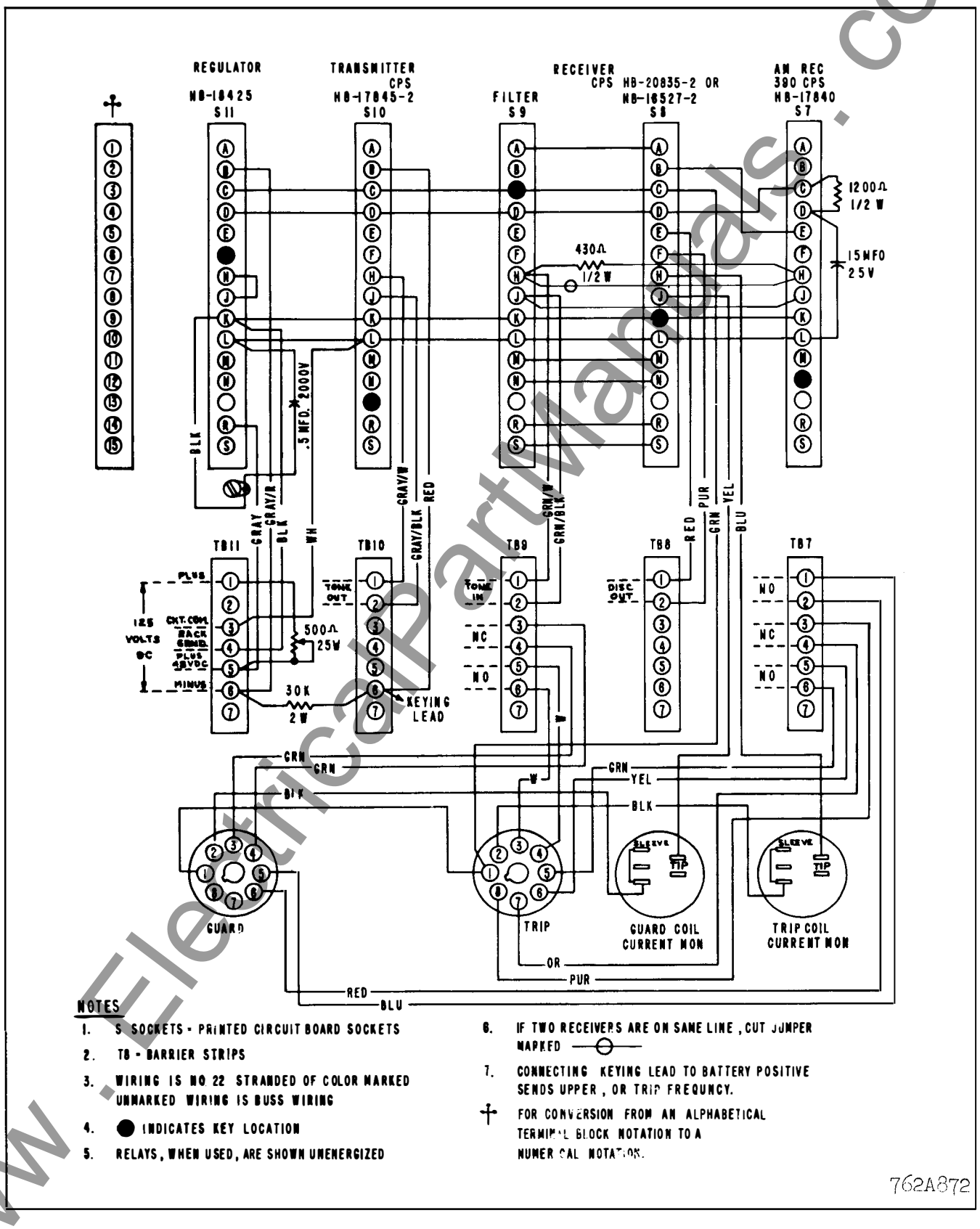
With the level of the incoming "trip" tone set 12 db below normal, advance the gain control of the tone receiver by adjusting level control on the receiver module, until the receiver output current increases suddenly from zero to approximately 25 ma for telephone type output relays and 32 ma for type AR output relays, at this point the trip relay has operated. When the attenuator is removed from the circuit, the tone receiver will have a normal operating point 12db above the pickup signal level.

Voltage Regulator

No setting required.

AM Receiver Noise Squelch (when used)

The AM squelch receiver is set in the factory



NOTES

1. S SOCKETS - PRINTED CIRCUIT BOARD SOCKETS
2. TB - BARRIER STRIPS
3. WIRING IS NO 22 STRANDED OF COLOR MARKED UNMARKED WIRING IS BUSS WIRING
4. ● INDICATES KEY LOCATION
5. RELAYS, WHEN USED, ARE SHOWN UNENERGIZED
6. IF TWO RECEIVERS ARE ON SAME LINE, CUT JUMPER MARKED —⊖—
7. CONNECTING KEYING LEAD TO BATTERY POSITIVE SENDS UPPER, OR TRIP FREQUENCY.

† FOR CONVERSION FROM AN ALPHABETICAL TERMINAL BLOCK NOTATION TO A NUMERICAL NOTATION.

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Fig. 7 Typical Terminal Block Drawing of Type TA-1 Assembly. (CR Dwg.)

such that the receiver is disabled whenever the noise measured in the 300-480 cycle band exceeds -40 dbm. The following adjustment procedure is recommended: With the transmitter set at -20 dbm output and AM receiver bias control fully counter clockwise superimpose a 400 cycle, -10 dbm tone on existing guard signal to FS receiver, and adjust sensitivity of AM receiver for zero output on microammeter across "Disc Out" test points.

ADJUSTMENT AND MAINTENANCE

The proper adjustments to insure correct operation of the tones have been made at the factory. Upon receipt of the tones, no customer adjustments other than those covered under "Settings", should be required.

Acceptance Check

Voltage Regulator

Non regulated voltage = 45 to 38 vdc

Hi regulated voltage = 36 vdc

Lo regulated voltage = 22 vdc

Voltages measured between common test point and the other specific test points.

Transmitter

Key transmitter to trip frequency by shorting between terminals indicated on connection drawing, which is supplied for each order.

All transmitter frequencies and output levels to be checked with a 600 ohm load.

Guard frequencies -Normal or center frequency minus 85 cycles.

Trip frequencies -Normal or center frequency plus 85 cycles.

Output -at least +1 dbm

FS Receiver

With transmitter output set at -20 dbm, see that guard and trip output relays function properly when respective guard and trip signals are applied.

AM Receiver (Squelch when used)

With a 400 cps -10 to -15 dbm external tone superimposed on existing guard signal, see that there is a zero output across discriminator output test points. This indicates that the receiver has been biased off. This output may be checked by plugging a 500-0-500 microammeter with a 5100 ohm resistor in series into the test points marked "Disc Out".

Type AR Output Relay (when used)

1. Contact gaps
   a. Normally open contacts should have a gap of .018 to .023 inch.
   b. Normally closed contact gap should be .013 minimum.

2. Contact pressure
   On two normally open and two normally closed relays, the normally closed contacts should have approximately 8 grams contact pressure in the de-energized position. Each normally open contact spring should have approximately 8 grams pressure against the card.

3. Armature gap
   The armature gap should be approximately .009 inches measured at the narrowest part of the armature gap.

Adjustments

Use the following procedure for adjusting the tones, if the tone adjustments have been disturbed. This procedure should not be used unless it is apparent that the tones are not in proper working order (See "Acceptance Check").

Transmitter

The frequency of the transmitter is adjusted at the factory before shipment and does not normally have to be readjusted. The adjustment, however, should be checked if the filter-oscillator assembly is changed. To make the adjustment the transmitter output should be properly loaded and a counter or other device capable of measuring frequency within 2 cycles attached to the output. The test point "OUT" (on the transmitter side of the filter) can also be used. Readings should be made in both guard and trip condition and the frequency should be adjusted until an equal guard and trip shift from center is effected.

Note voltage levels per table 1.

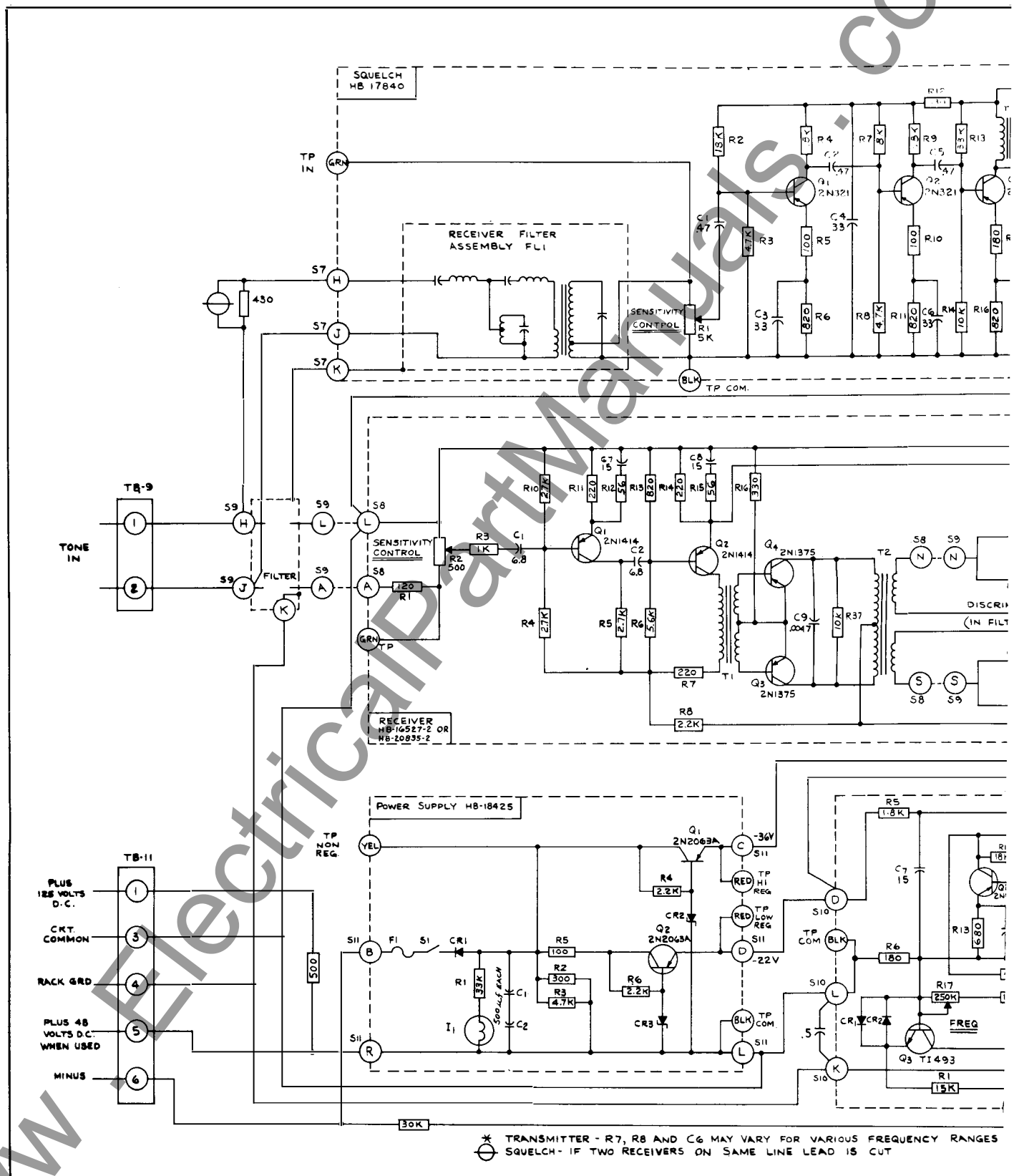
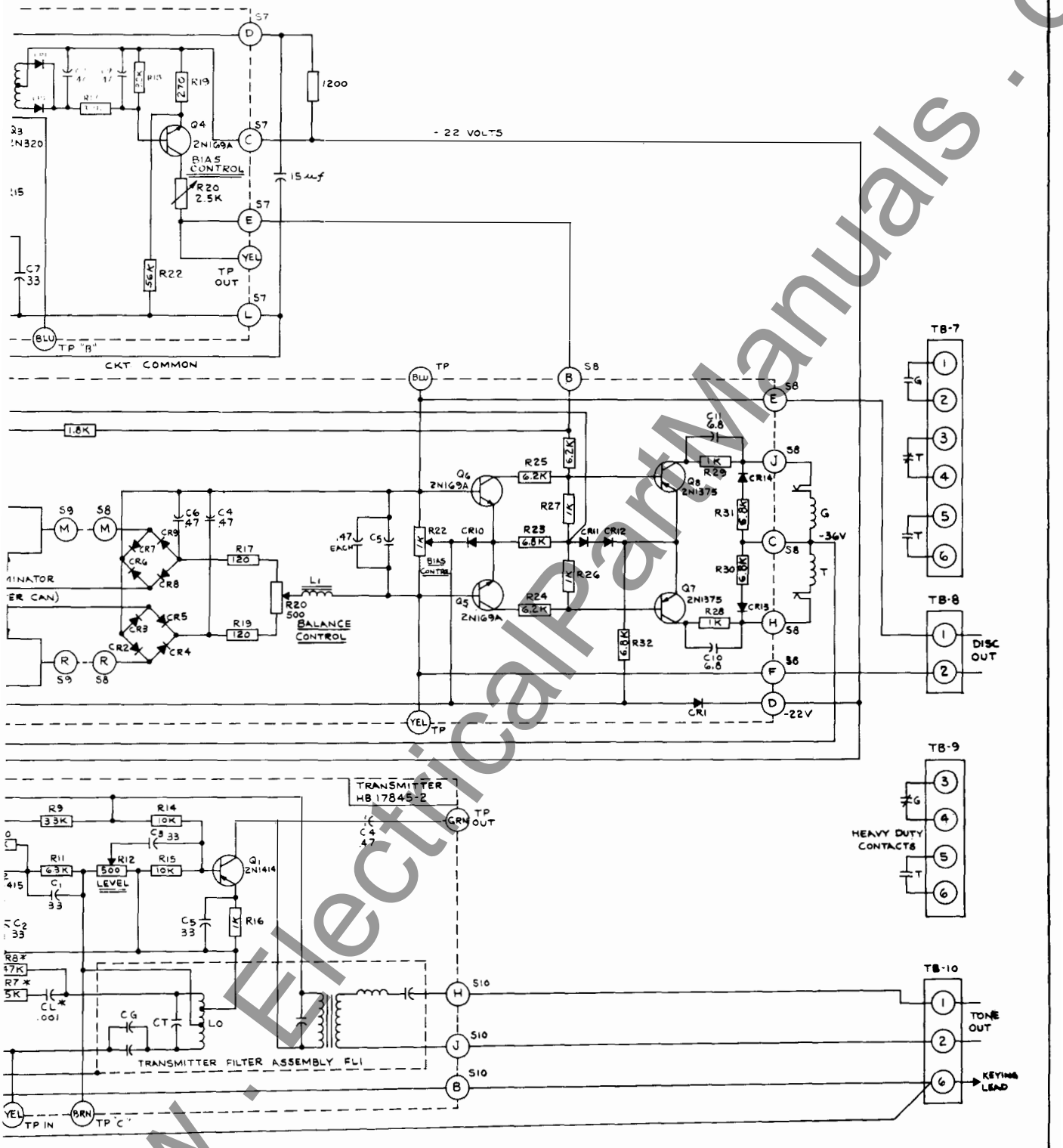


Fig. 8 Typical Schematic Diagram of Ty



pe TA-1 Assembly (with Telephone Relay Output).

FS Receiver

There are three receiver adjustments – an input sensitivity control, a bias control and a discriminator output balance control.

The bias control and discriminator output balance control are factory adjusted for optimum operation. Except for special applications these controls should not be readjusted.

Prior to setting the receiver bias, the discriminator output should be balanced for both the guard and trip frequencies. Plug the connections of a 500-0-500 microammeter (zero center scale) with a 5100 ohm resistor in series with the meter terminal into the test points marked "Disc Out". With the receiver sensitivity control at its maximum setting (fully clockwise) and the receiver bias control at its mechanical center adjust discriminator balance control for equal outputs at guard and trip frequencies.

In order to make the proper bias adjustment an external variable frequency source (oscillator) is required. With the output of the oscillator set at –20 dbm, adjust bias control for trip relay pickup of 30 cycles above center frequency of receiver. A recheck of the discriminator output may show a deviation of approximately 10% from previously balanced condition and a readjustment is not necessary.

Note voltage levels per Table 1.

AM Receiver Noise Squelch (when used)

With transmitter set at -20 dbm output and AM receiver bias control fully counter clockwise superimpose a 400 cycle -25 dbm tone on existing guard signal to FS receiver, and adjust sensitivity of AM receiver for zero output on microammeter across "Disc Out" test points. Receiver bias control should remain in counter clockwise position.

Voltage Regulator

No adjustments. – Note voltage levels per Table 1.

When the TA-1 tones with an AR output relay is used, the series resistor of the power supply has been set for 55 volts across the unregulated test point with the following conditions:

1. D.C. supply of 140 volts d.c.
2. AR relay removed from its chassis. This is to protect the electronic components against excessive voltages. With the AR unit in its chassis, the non-regulated voltage will be lower than the 55 volt.

Calibration of Type AR Output Relay

The type AR output relay unit has been properly adjusted at the factory to insure correct operation, and under normal field conditions should not require readjustment. If, however, the adjustments are disturbed in error, or it becomes necessary to replace some part, use the following adjustment procedure. This procedure should not be used until it is apparent that the relay is not in proper working order, and then only if suitable tools are available for checking the adjustments.

a. Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.
b. Adjust each contact spring to obtain 4 grams pressure at the very end of the spring. This is measured when the spring moves away from the edge of the insulated crosspiece.
c. Adjust each stationary contact screw to obtain a contact gap of 0.020-inch. This will give 15-30 grams contact pressure. This completes the adjustment procedure for the AR tripping relay unit.

Maintenance

The modules in this equipment use transistors and other components which are conservatively rated for reliability and long life. In normal operation, the monitoring function provides a continuous check on the performance of the equipment. At periodic intervals, it may be desired to check the tripping function. For such a check, the channel may have to be taken out of service to prevent unnecessary breaker operation. The keying circuit may then be closed to check the operation of the tripping relay.

As long as the channel is operating satisfactorily, no maintenance work is necessary other than seeing that the equipment is free of dust or dirt. However, a scheduled routine check will prevent down-time loss, since it may indicate deterioration in the performance of one of the units. The output relay contacts may be burnished on the same schedule as that for the associated protective relays. If a channel failure occurs because of the terminal equipment, a trouble-shooting procedure should be used similar to that employed for any electronic equipment. First determine where the failure has taken

place (transmitter or receiver); then determine the portion of the circuit at fault.

Follow the tables of voltage levels which apply to these circuits.

Test Equipment – For routine maintenance, the following equipment will be adequate:

1. A-C vacuum-tube voltmeter, H-P Model 400D or equivalent.

2. Calibrated attenuator, H-P Model 350B or equivalent.

As an alternative, a 500-ohm variable resistor can be used.

For trouble shooting, the following additional test equipment is desirable:

1. Electronic frequency counter, H-P Model 523 C or equivalent.

2. D-C vacuum-tube volt-ohmmeter, RCA Senior Voltohmyst or equivalent.

3. Cathode-ray oscilloscope.

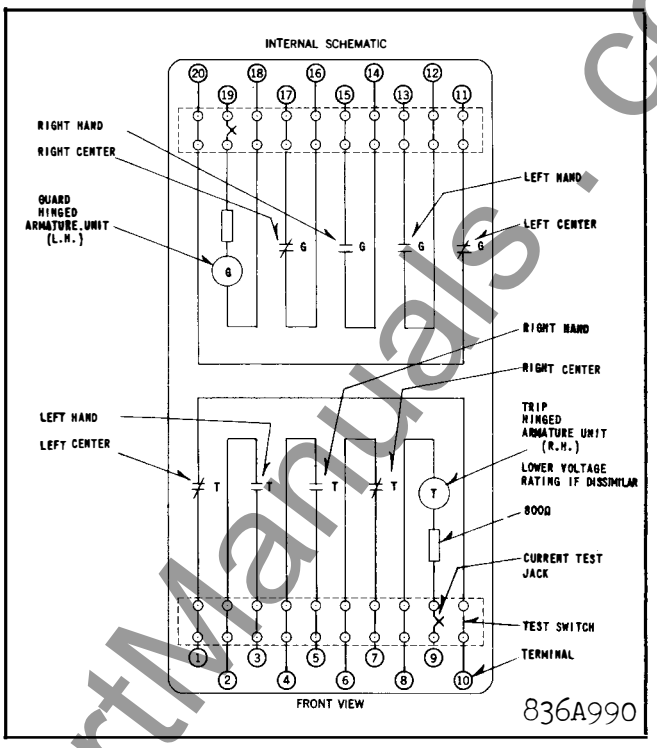


Fig. 10 Internal schematic of the type AR relay for use with TA-1 tones.

GENERAL INFORMATION

Connection Drawings

The drawings applicable to the specific order will be supplied. The applicable "CR" drawing information is included as part of the nameplate data.

Tone Applications

Figures 11 thru 14 show typical relaying applications which make use of the tone characteristics.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to users who are equipped for doing repair work. When ordering parts, always give the assembly style number and voltage rating, plus the component identification and module in which it is located.

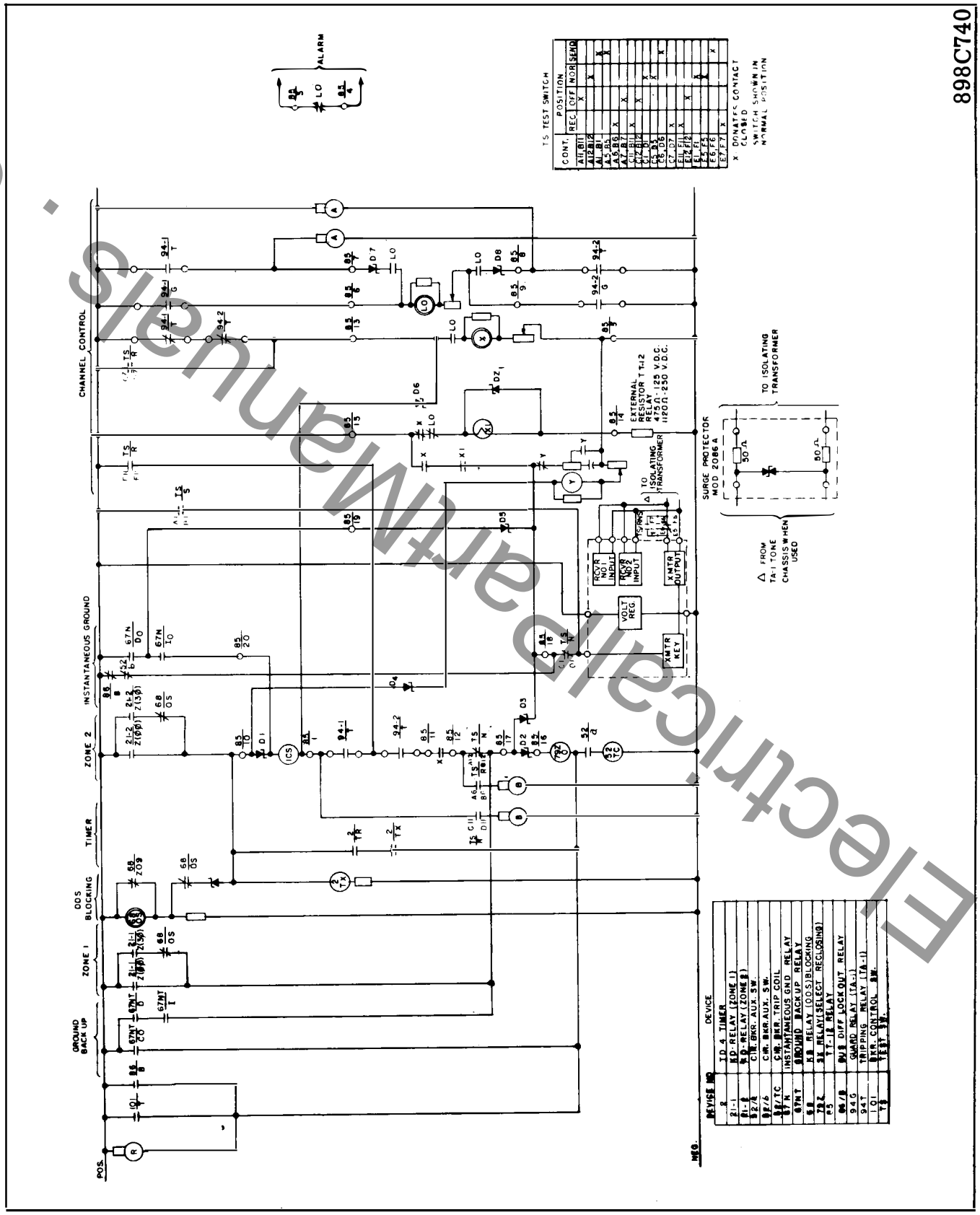
Replaceable parts are shown in Table 2.

TABLE I – VOLTAGE LEVELS

Measurements taken with respect to circuit common; –20 dbm guard signal transmitted and received.
E = Emitter; B = Base; C = Collector.

MODULE		Q1 VOLTS		Q2 VOLTS		Q3 VOLTS		Q4 VOLTS		Q5 VOLTS		Q6 VOLTS		Q7 VOLTS		Q8 VOLTS		TEST POINTS	
		AC	DC	AC	DC	AC	DC	AC	DC	AC	DC	AC	DC	AC	DC	AC	DC		
Voltage	E		36		22													Hi Reg	36VDC
Regulator	B		36.2		22.2													Lo Reg	22VDC
HB-18425	C		43		29													Non Reg	43VDC
FS Transmitter	E	7mv	4.35	4.2mv	.8	1mv	.67											Out	.12VAC
HB-17845-2	B	2mv	4.5	.045	.9	<1mv	0											C	.046VAC
	C	.12	9.6	3.0	4.8	1mv	.67												
FS Receiver	E	.5mv	.45	3mv	.75	2.1	2.7	2.1	3.7	.033	22	.033	21	2mv	1.5	2mv	1.5	IN	.039VAC
HB-16527-2	B	.8mv	.6	5mv	.9	2.4	3.8	2.6	3.8	.03	24	.033	21.8	3mv	0	3mv	1.2	Disc. Out-Equal and opposite VDC at guard and trip.	
HB-20835-2 HB-20835-10	C	5mv	1.7	1.1	4.8	12	22	12	22	4mv	0	.033	22	4mv	36 43 †	<.1m	1.6		
AM Receiver	E	2mv	2.15	.016	2.15	.13	2.45	.027	20									In	.01VAC
HB-17840	B	2mv	2.3	.018	2.3	.15	2.65	.03	22									OUT	1.2VDC
(Adjusted to Squelch with –40 dbm 400 cps tone input.)	C	.019	7.4	.16	7.4	.5	2.45	.25	7.5									V	5.0VAC

† Collector of Q7 only for the HB-20835-10 module.



* *Fig. 11 Line Protection – KDAR/TT12 Transfer Trip Schematic (3 Terminal). (125-250 VDC)*

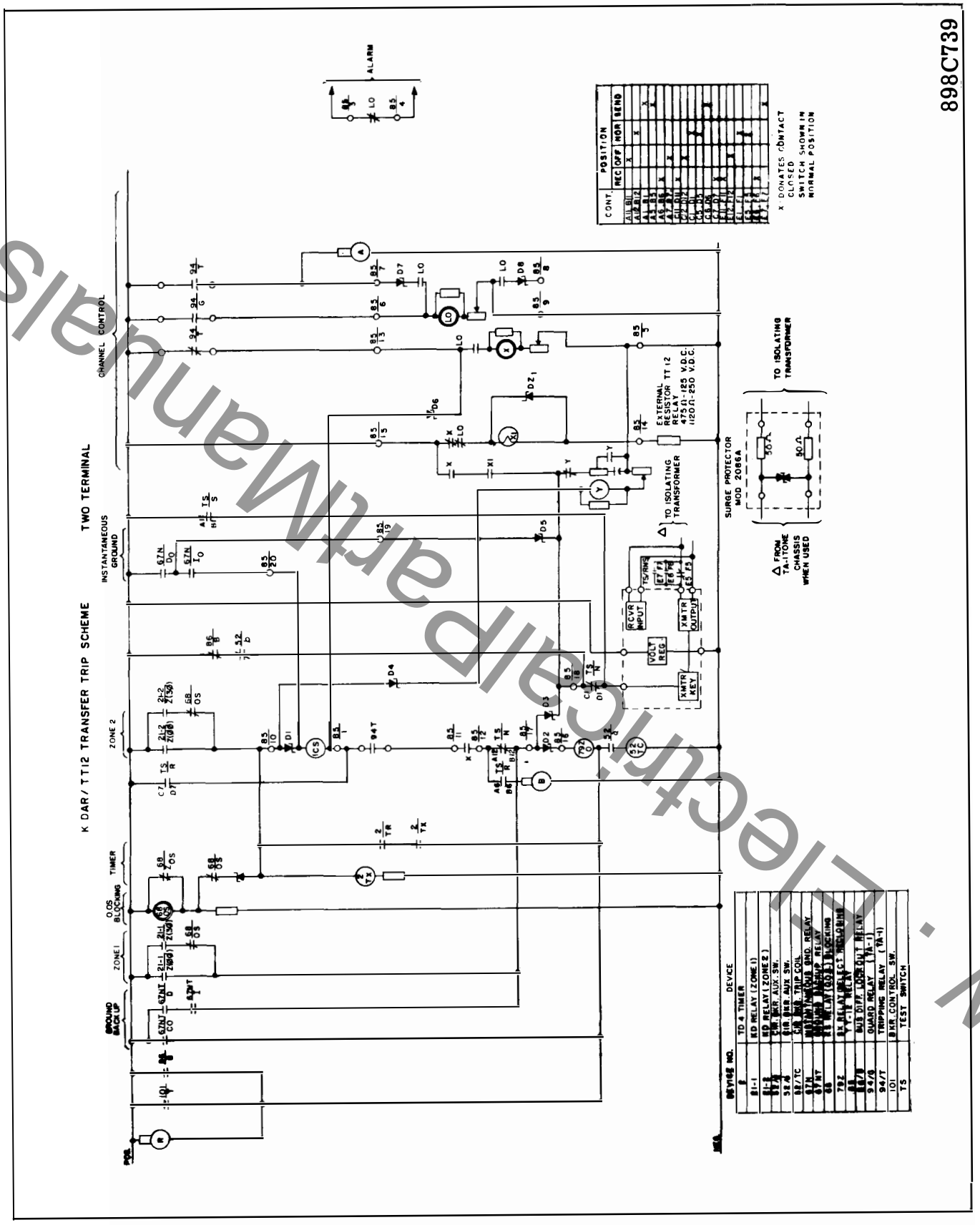


Fig. 12 Line Protection – KDAR/TT12 Transfer Trip Schematic (2 Terminal). (125 & 250 VDC)

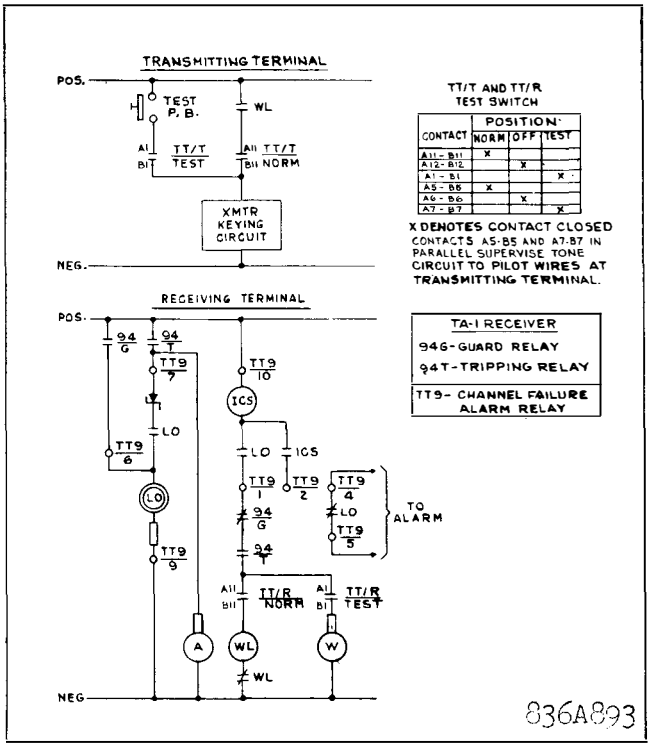


Fig. 13 Transformer Protection – Single Channel Transfer Trip.

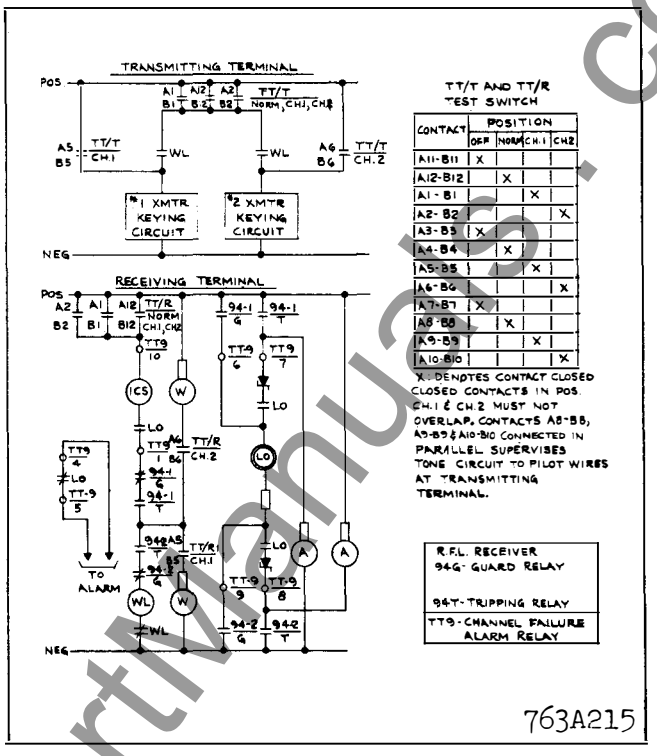
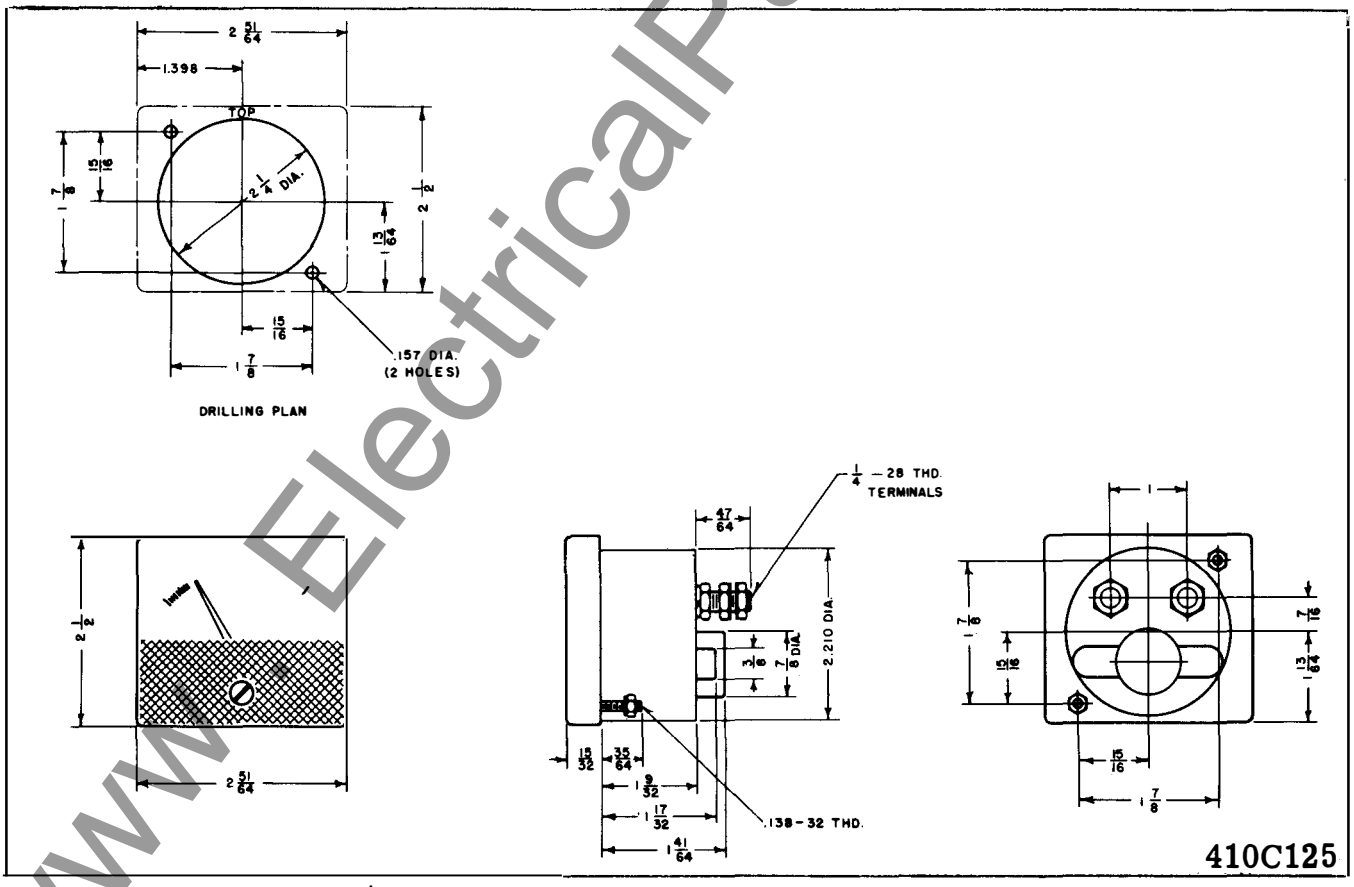
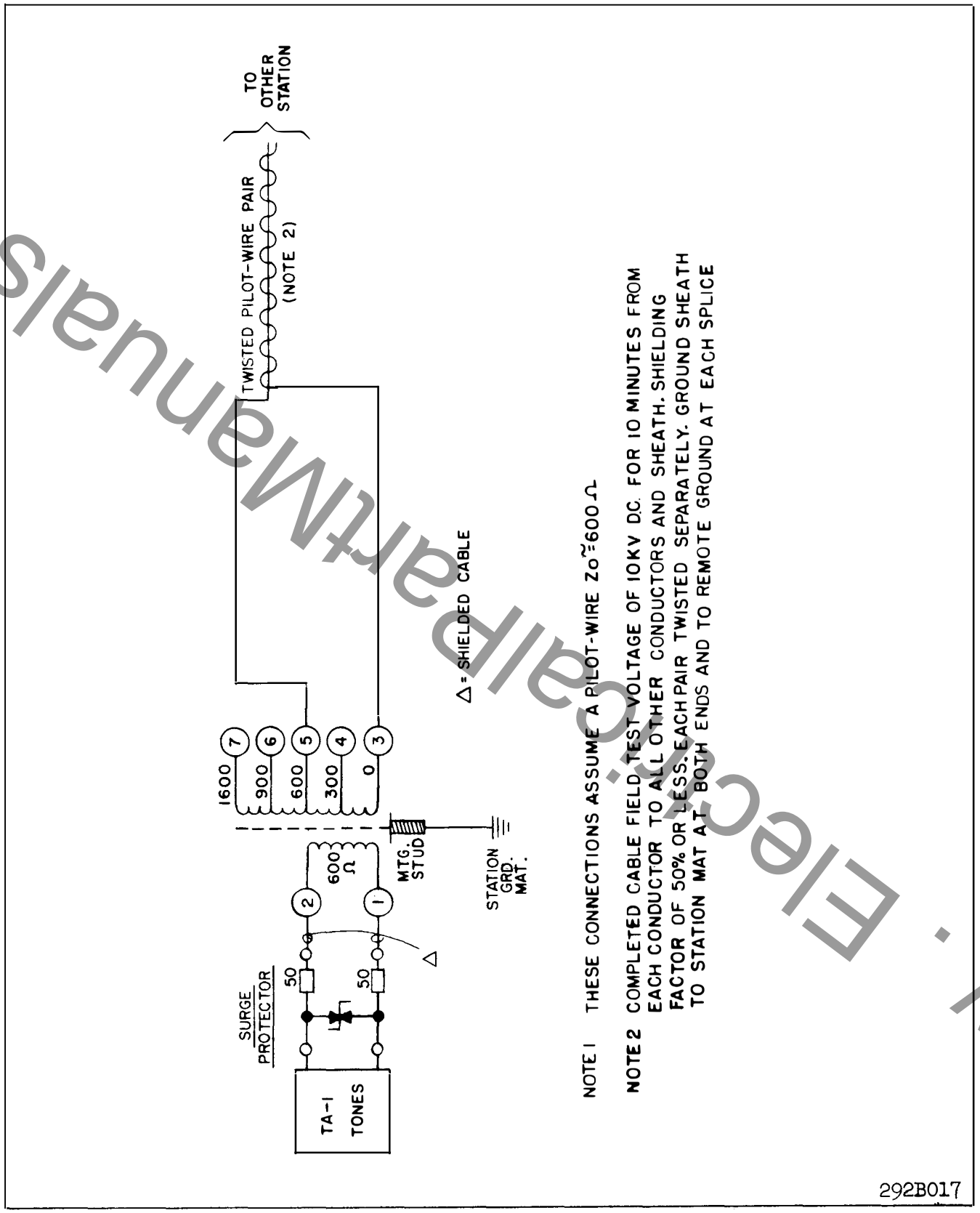


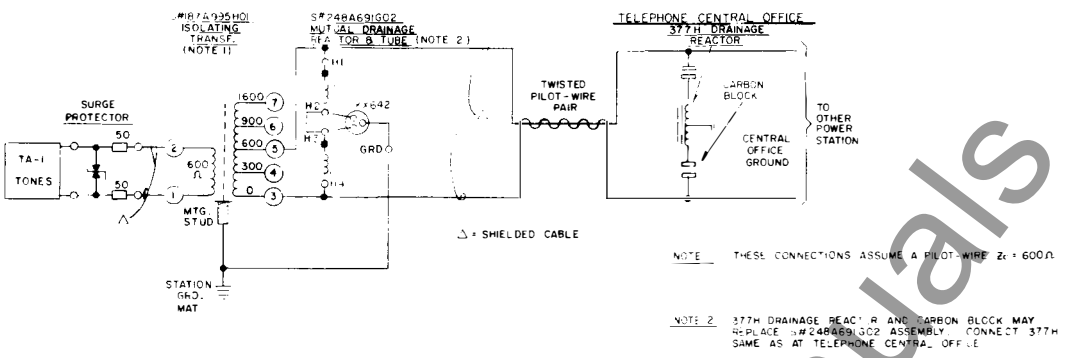
**Fig. 14 Transformer Protection – Dual Channel Transfer Trip.*



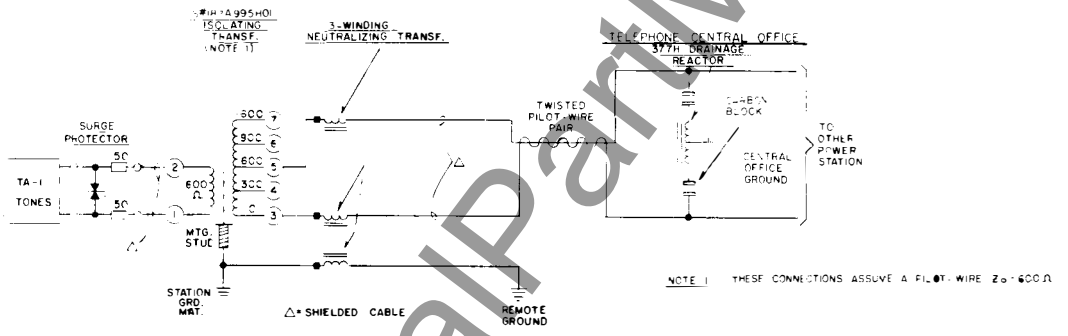
* *Fig. 15 Outline and Drilling Plan For Carrier Level Meter.*



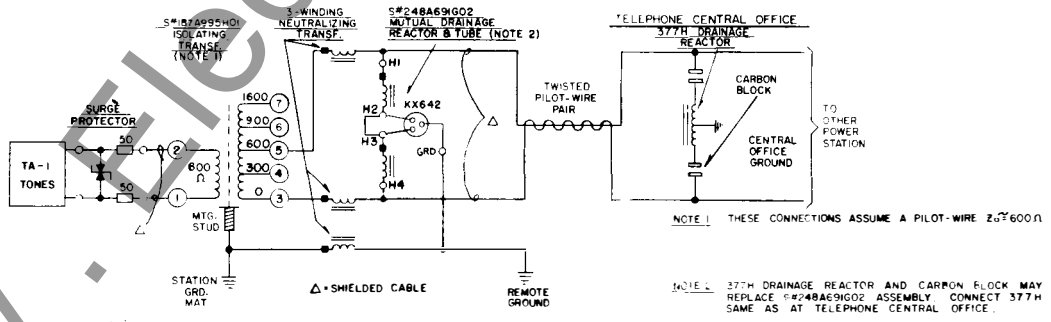
* *Fig. 16– Recommended Connections and Pilot Wire Design for Privately owned Cable for Two Terminal Lines.*



(a) USE WHERE INDUCED VOLTAGE MAY EXCEED 700 VOLTS. USE ONLY WHERE STATION AND CENTRAL OFFICE GROUNDS ARE INTERCONNECTED VIA WATER SYSTEM PIPES.



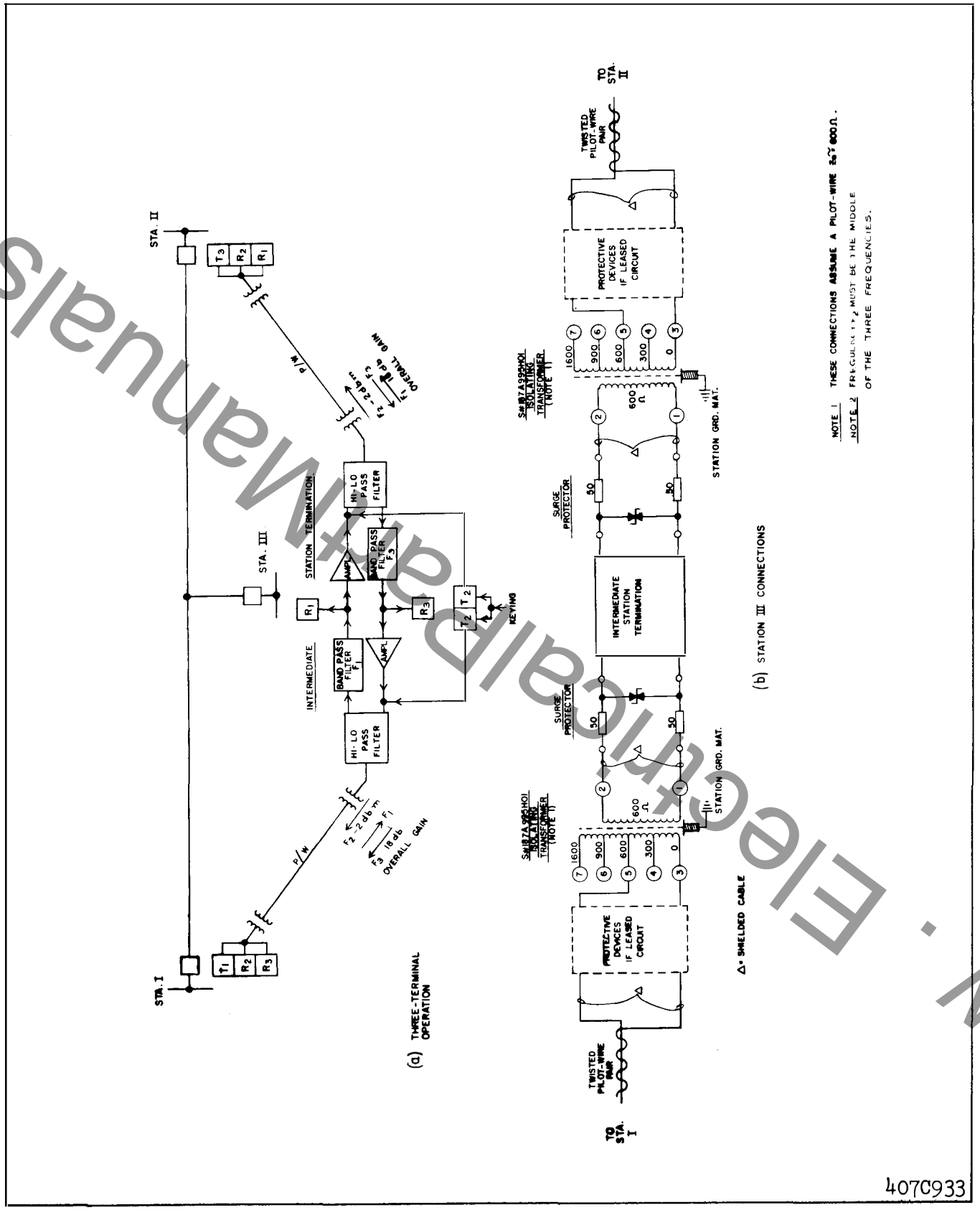
(b) USE WHERE STATION AND CENTRAL OFFICE GROUNDS ARE NOT INTERCONNECTED VIA WATER SYSTEM PIPES. DO NOT USE IF INDUCED VOLTAGE MAY EXCEED 700 VOLTS.



(c) USE WHERE INDUCED VOLTAGE MAY EXCEED 700 VOLTS AND WHERE THE STATION AND CENTRAL OFFICE GROUNDS ARE NOT INTERCONNECTED VIA WATER SYSTEM PIPES.

4070932

** Fig. 17 – Recommended Connections and Protective Arrangements for leased Cable for Two Terminal Lines.*



* *Fig. 18 – Recommended Channel Arrangements for Three Terminal Line Protection.*

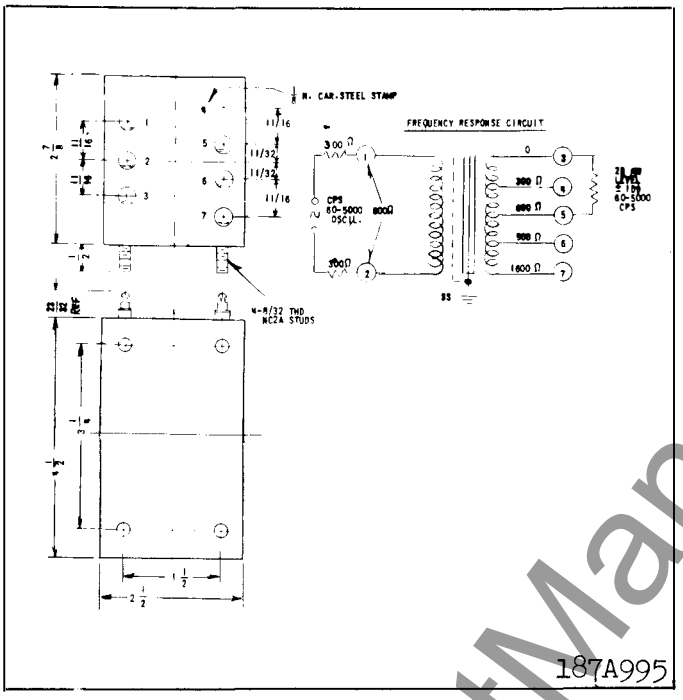


Fig. 19 Isolating Transformer 187A995H01.

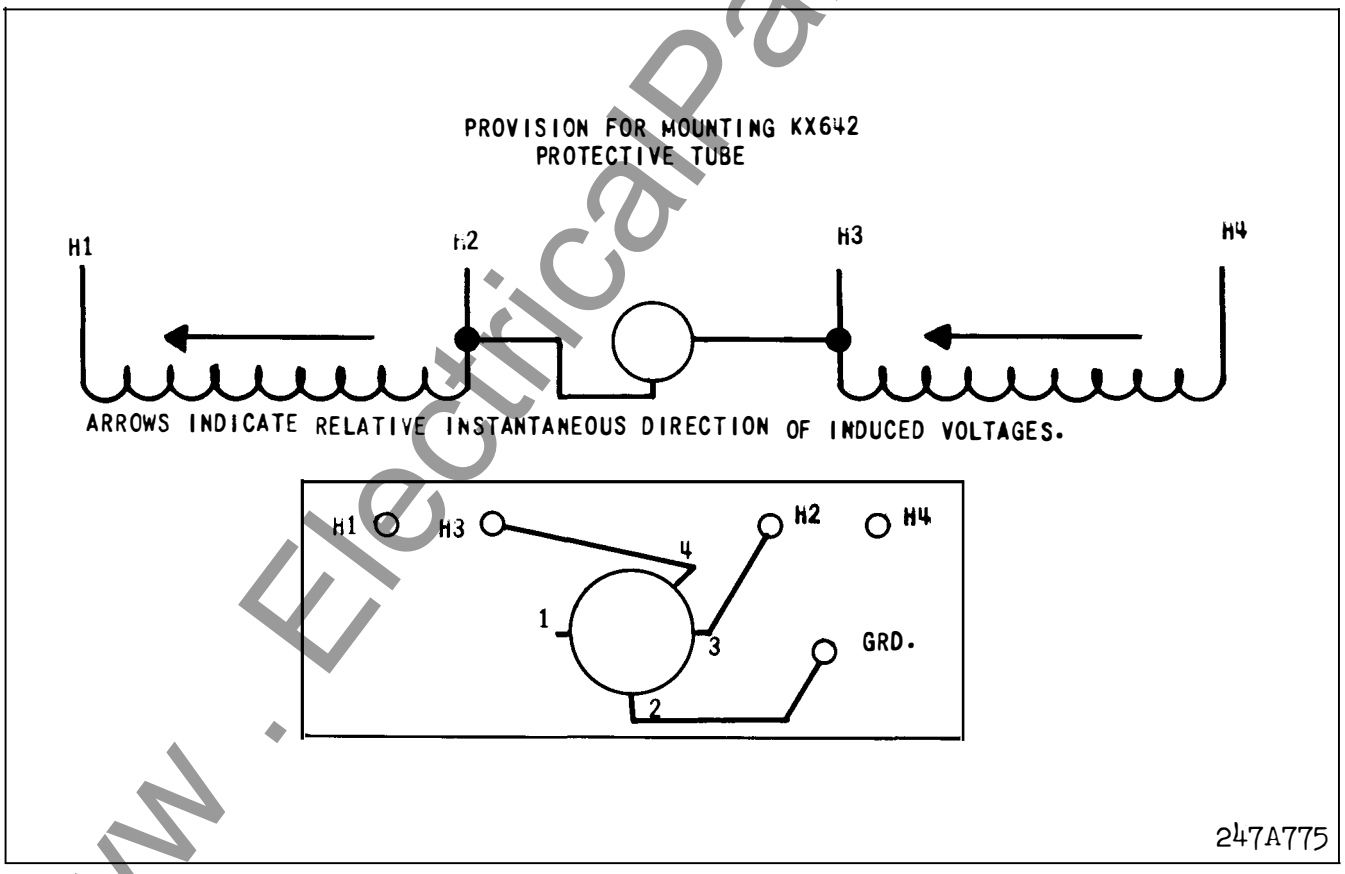
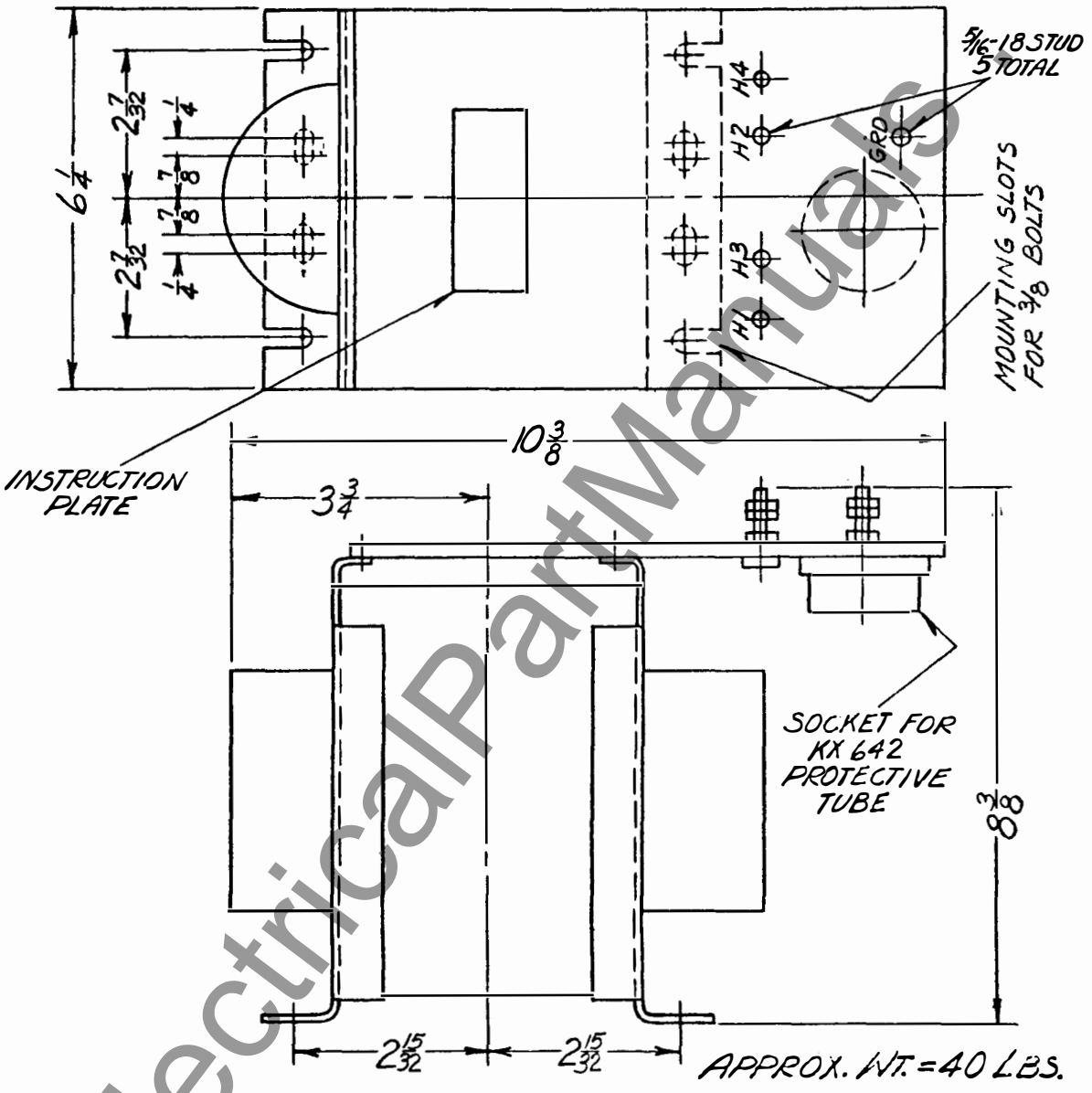


Fig. 20 Drainage Reactor Connections.



THIS OUTLINE CAN BE USED FOR ERECTION OR MOUNTING PURPOSES. IT IS NOT TO BE REGARDED AS INDICATING THE EXACT DETAILS OF CONSTRUCTION.

247A785

Fig. 21 Drainage Reactor Outline

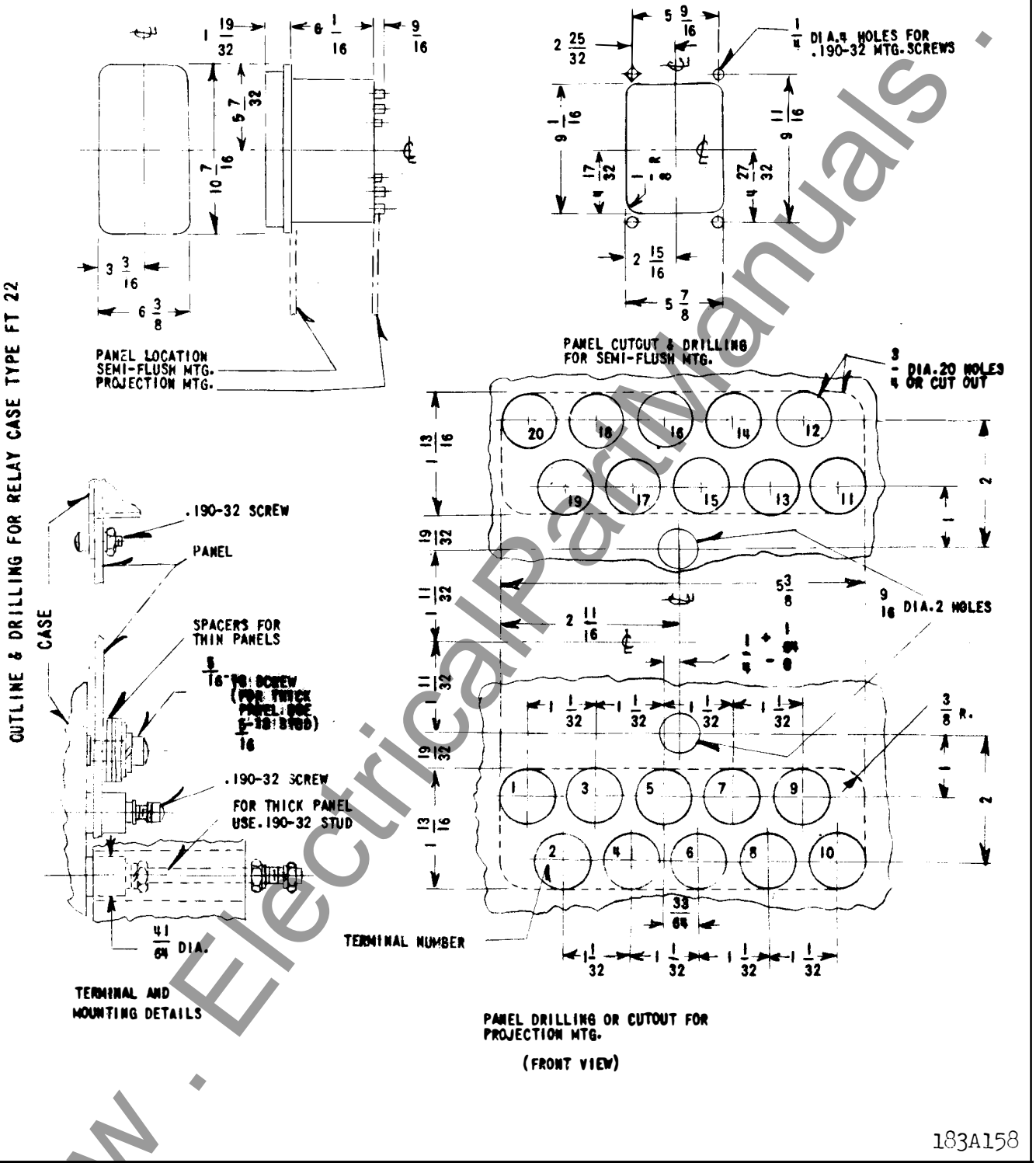


Fig. 22 Outline and Drilling plan for the type AR relay in the FT-22 case.

Table of Electrical Parts

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
	HB-17845-2 FS TRANSMITTER	
HB-57100	TRANSMITTER FILTER & TUNED CIRCUIT, 170 cps bandwidth, 340 cps spacing.	
H-1007-439	CAPACITOR, tantalum: 33 μF, 10V.	C1, 2, 3, & 5
H-1007-439	CAPACITOR, tantalum: 15 μF, 25V.	C7
HA-13579	CAPACITOR, ceramic: 0.47 μF, 25 V DC +80%, -20%.	C4
H-1080-245	CAPACITOR, silver mica: .001 μF ± 5%.	C6
H-1009-620	RESISTOR, fixed comp; 15K, ±10%, ½ W.	R1
H-1009-429	RESISTOR, fixed: comp; 1K, ±10%, ½ W.	R16
H-1009-442	RESISTOR, fixed: comp; 47 K, ±10%, ½ W.	R3
H-1009-530	RESISTOR, fixed: comp; 5.6 K, ±10%, ½ W.	R4
H-1009-446	RESISTOR, fixed: comp; 1.8 K, ±10%, ½ W.	R5
H-1009-607	RESISTOR, fixed: comp; 180 ohms ±10%, ½ W.	R6
H-1009-408	RESISTOR, fixed: comp; 15K ±10%, ½ W.	R7
H-1009-442	RESISTOR, fixed: comp; 57 K, ±10%, ½ W.	R8
H-1009-419	RESISTOR, fixed comp; 3.3 K, ±10%, ½ W.	R9
H-1009-639	RESISTOR, fixed: comp; 18 K, ±10%, ½ W.	R10
H-1009-640	RESISTOR, fixed: comp; 6.8 K, ±10%, ½ W.	R11
HA-13573	RESISTOR, variable: 500 ohms, .125 V; linear taper, std. length shaft 1/8" beyond mtg. surface; ear mounted; screwdriver adj; printed circuit board.	R12
H-1009-473	RESISTOR, fixed: comp; 680 ohms, ±10%, ½ W.	R13
H-1009-391	RESISTOR, fixed: comp; 10 K, ±10%, ½ W.	R14, 15
HA-14594	RESISTOR, variable: 250 K ohms, 0.2 W bd. taper; 1/8" screw-driver shaft; printed circuit; ear mounted.	R17
HA-3167	TRANSISTOR: type PNP; 2N1414.	Q1
HA-3166	TRANSISTOR: type PNP; 2N1415	Q2
HA-17113	TRANSISTOR: type NPN, silicon; TI493.	Q3, Q4
HA-3165	DIODE, silicon: SG22 (Stabistor).	CR1, CR2

Table of Electrical Parts

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
	HB-16527 FS RECEIVER	
HB-53900	BAND-PASS FILTER & DISCRIMINATOR.	
HA-13579	CAPACITOR, ceramic: 0.47 μF, 25 V DC +80%, -20 %.	C5, C6, C4
H-1007-479	CAPACITOR, tantalum: 6.8 μF, 25 V.	C1, C2
H-1007-439	CAPACITOR, tantalum: 15 μF, 25V.	C3, C7, C8
H-1007-92	CAPACITOR, ceramic disc: .0047 μF, 600 V.	C9
H-1007-403	CAPACITOR, solid electrolytic tantalex: 6.8 μF, ±20%, 35 WVDC.	C10, C11
HA-13576	CHOKE: 1 H.	L1
HA-10271	DIODE, silicon.	CR11, CR12
HA-13242	DIODE, germanium.	CR1, 2, 3, 4, 5, CR6, 7, 8, 9, 10, CR13, 14
H-1009-391	RESISTOR, fixed: comp; 10 K ±10%, ½ W.	R37
H-1009-429	RESISTOR, fixed: comp; 1 K ±10%, ½ W.	R26, 27 & 3
H-1009-434	RESISTOR, fixed: comp; 2.2 K ±10%, ½ W.	R8
H-1009-497	RESISTOR, fixed: comp; 330 ohms, ±10%, ½ W.	R16
H-1009-530	RESISTOR, fixed: comp; 5.6 K, ±10%, ½ W.	R6
H-1009-541	RESISTOR, fixed: comp; 2.7 K, ±10%, ½ W.	R10, R5
H-1009-544	RESISTOR, fixed: comp; 220 ohms, ±10%, ½ W.	R11, 7, 14
H-1009-598	RESISTOR, fixed: comp; 27 K, ±10%, ½ W.	R4
H-1009-608	RESISTOR, fixed: comp; 820 ohms, ±10%, ½ W.	R13
H-1009-640	RESISTOR, fixed: comp; 6.8 K, ±10%, ½ W.	R23, 30, 31, 32
H-1009-697	RESISTOR, fixed: comp; 6.2 K, ±5%, ½ W.	R24, 25
H-1009-665	RESISTOR, fixed: comp; 120 ohms, ±10%, ½ W.	R1, R9, R17
H-1009-249	RESISTOR, fixed: comp; 56 ohms, ±10%, ½ W.	R12, R15
HA-13573	RESISTOR, variable: 500 ohms, 0.125 W; standard length shaft 1/8" beyond mounting surface; screwdriver adj. for PC board; taper bd; terminals are to be at right angles to shaft.	R2
HA-14593	RESISTOR, variable: 1000 ohms, 0.25 W; linear taper; standard length shaft 1/8" beyond mounting surface; screwdriver adj. for PC board; terminals are to be at right angles to shaft.	R22

Table of Electrical Parts

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
HA-14643	RESISTOR, variable: 500 ohms, 0.25 W; linear taper; standard length shaft 1/8" beyond mtg. surface; screwdriver adj. for PC board; terminals are to be at right angles to shaft.	R20
HA-3175	TRANSFORMER: primary impedance ohms 2000 CT; secondary impedance ohms 8000 CT; 150 MW O/A.	T1
HA-13575	TRANSFORMER.	T2
HA-13806	TRANSISTOR: NPN, germanium 2N169A.	Q5, Q6
HA-3167	TRANSISTOR: PNP, germanium 2N1414.	Q1, Q2
HA-17117	TRANSISTOR: PNP, germanium; 2N1375.	Q4, 7, 8 & 3
HA-16523	Guard Relay.	
HA-16524	Trip Relay.	
	HB-17840 RECEIVER MODULE W/O FILTER	
HB-56500	RECEIVER BAND-PASS FILTER.	
HA-13579	CAPACITOR, ceramic: 0.47 μF, 25 V DC +80%, -20% (5 req.).	C1, 2, 5, C8 & 9
H-1007-438	CAPACITOR, tantalum: 33 μF, 10 V.	C3, 6, 7 & 4
HA-17197	DIODE, silicon.	CR1, 2
HA-13572	RESISTOR, variable: 5K, 0.25W, log taper; std. length shaft 1/8" beyond mtg. surface; screwdriver adj.	R1
H-1009-639	RESISTOR, fixed, comp: 18K, ±10%, ½ W (2 req.).	R2, R7
H-1009-485	RESISTOR, fixed, comp: 4.7K, ±10%, ½W (2 req.).	R3, R8
H-1009-446	RESISTOR, fixed, comp: 1.8K, ±10%, ½W (2 req.).	R4, R9
H-1009-435	RESISTOR, fixed, comp: 100 ohms, ±10%, ½W (2 req.).	R5, R10
H-1009-608	RESISTOR, fixed, comp: 820 ohms ±10%, ½W (3 req.).	R6, R11 R16
H-1009-497	RESISTOR, fixed, comp: 330 ohms, ±10%, ½W.	R12
H-1009-423	RESISTOR, fixed, comp: 33K, ±10%, ½W.	R13
H-1009-391	RESISTOR, fixed, comp: 10K ±10%, ½W.	R14
H-1009-607	RESISTOR, fixed, comp: 180 ohms, ±10%, ½W.	R15
H-1009-419	RESISTOR, fixed, comp: 3.3K, ±10%, ½W.	R17

Table of Electrical Parts

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
HA-13913	RESISTOR, fixed, comp: 8.2 K, ±10%, ½ W.	R18
H-1009-431	RESISTOR, fixed, comp: 270 ohms, ±10%, ½ W.	R19
HA-13588	RESISTOR, variable: 2.5 K, 0.25 W, std. length shaft 1/8" beyond mtg. surface; linear taper; screwdriver adjust.	R20
H-1009-530	RESISTOR, fixed, comp: 5.6 K, ±10%, ½ W.	R22
HA-3175	TRANSFORMER: primary impedance ohms 2000 CT; sec. impedance ohms 800 CT; 150 mv O/A 1 x 3/4 x 3/4.	T1
HA-3166	TRANSISTOR: type PNP (2 req.) 2N1415.	Q1, Q2
HA-3167	TRANSISTOR: type PNP 2N1414.	Q3
HA-13806	TRANSISTOR: NPN 2N169A.	Q4
	HB-18425 VOLTAGE REGULATOR	
HA-13569	CAPACITOR, electrolytic: 500 μF, 50 V.	C1, C2
HA-17994	DIODE, zener: 22 V, 1 W, ±5%.	
HA-17506	DIODE, zener: 36 V, 1 W, ±5%.	
HA-9348	FUSE: 0.5 amp; 250 V, 3 AG.	F1
H-1009-730	RESISTOR, fixed: comp; 3.3 K, ±10%, 1 W.	R1
H-1100-375	RESISTOR, fixed: comp; 300 ohms, ±5%, 20 W.	R2
H-1009-481	RESISTOR, fixed: WW; 4.7 K, ±10%, 2 W.	R3
H-1009-314	RESISTOR, fixed: 2.2 K, ±10%, 1 W.	R4, R6
H-1220-33	RESISTOR, fixed: WW; 100 ohms, ±5%, 3 W.	R5
HA-13554	SWITCH, pushbutton.	S1
HA-13273	TRANSISTOR, power: germanium; 2N2063A.	Q1, Q2
	MISCELLANEOUS	
HA-17159	CAPACITOR; plastic, 0.5 mfd., 2000 WVD, used on chassis.	

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TA-1
FREQUENCY — SHIFT AUDIO TONES

CAUTION: Check polarity of battery supply connections before applying power to the equipment.

* APPLICATION

The type TA-1 tones are high-speed frequency-shift audio-frequency tones. They are designed for use in transferred-tripping systems for transformer and line protection. They may be used directly over a pilot wire pair, or may be impressed on a microwave channel.

Applications are classified as either permissive or non-permissive. The non-permissive system allows the receiver relay to trip directly, as opposed to a permissive system where a fault detecting relay supervises receiver relay tripping. The overreaching scheme is usually a permissive system since the phase and ground fault detecting relays are inherently present. Examples of this type of system are shown in figs. 11 and 12. These fault detectors are not present in an underreaching scheme or a transformer protection channel; therefore, these are classified as non-permissive. Examples of non-permissive systems are shown in figs. 13 and 14.

The presence or lack of trip-circuit supervision greatly influences the security and reliability considerations. As with all protection systems, one must strike a compromise between the conflicting requirements of security and reliability — security against undesired tripping and reliability in tripping when required. With non-permissive schemes the burden for security rests entirely with the tones themselves; whereas, the fault-detecting relays in the permissive scheme share the burden with tones for security. Thus, we can ease up on the security requirements of the tones proper when used in a permissive scheme. This is desirable not just for economy, but also to eliminate components which tend to detract from reliability.

Security Measures

The TA-1 frequency-shift receiver has been specially designed for security against noise. Audio frequency random noise must be at least 50 db peak over the guard signal to cause trip relay operation. With the recommended −32 dbm maximum receiver sensitivity, this means that the a-f random noise must be about +18 dbm to cause undesired trip relay operation. This compares with quiescent noise levels on the order of −50 dbm.

This leaves impulse noise to be considered. Not only are these of higher energy level, but they also cannot be classed as random in the sense that the energy is uniformly distributed across the audio spectrum. Inadvertently applied voice signals and power-system arcs and disturbing voltages are prime sources of impulse noise. To guard against the possibility that this impulse noise might fall in the trip
* band, a noise squelch is recommended. This squelch receiver disables the frequency shift receiver whenever the noise measured in the 300-480 cycle band exceeds the dbm setting of the squelch.

The receiver guard relay also contributes to security. In non-permissive applications a break contact of this relay supervises the trip circuit. It must be dropped out at the same instant that the trip relay is picked up, in order to trip. This feature helps when the receiver sees high-energy impulse noise which intermittently tends to concentrate at the trip frequency.

A high signal level, along with an insensitive receiver, also helps the channel to ignore noise. A receiver sensitivity no higher than −32 dbm and a received signal level of at least −20 dbm is a good objective. This means that the channel attenuation should be no higher than −15 db on leased circuits to allow for the required reduced transmitter output where transmitters are paralleled. This reduction to 5dbm keeps the combined audio energy down to tolerable levels from a voice interference standpoint.

Pilot-Wire Design

In applying a tone system for protection, the

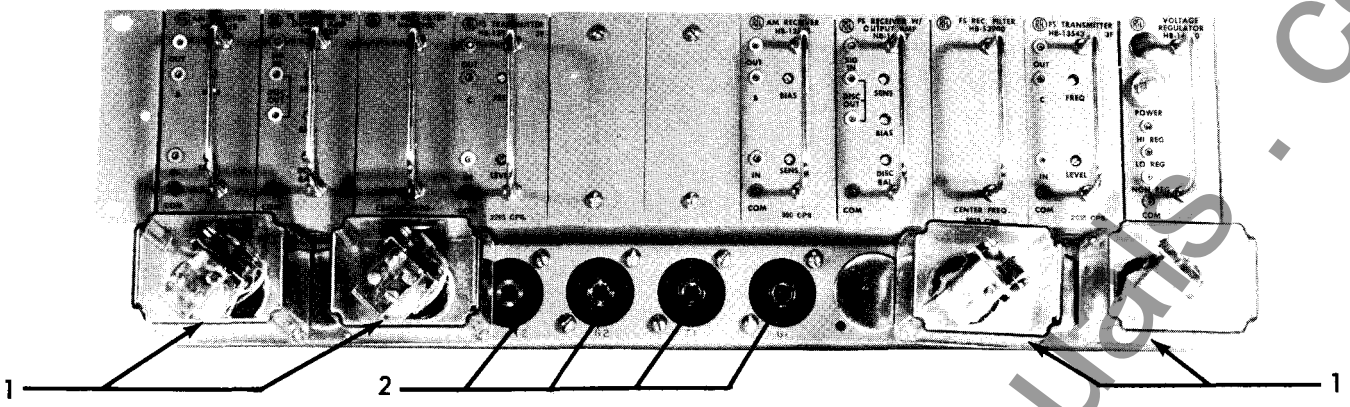


**Fig. 1 – Front View of Full Chassis: 1–Telephone Type output relays (when used); 2–Current monitoring jacks (when used).*

user and the cooperating telephone company should recognize the peculiar requirements of a tone protection channel. Preconceived notions and practices based on experience with tones for other uses must be re-examined in the light of the following facts. The period of usefulness during the lifetime of any given installation will range from 0-10 seconds. Yet this infinitesimal period (compared to years) is precisely the time when noise levels can be abnormally high and 60 cycle disturbing voltages will appear on the pilot wire. The recommendations summarized in Figs. 17, 18, and 19 have been formulated with the above facts in mind.

For a recommended installation:

a) Use a drainage reactor in all paths to ground.

b) If gaps (gas tubes or carbon blocks) are installed, connect them only to ground. Do not connect gaps in series with the separate windings of the drainage reactors. This is especially important where the squelch receiver is used, as a failure to follow these recommendations will result in the squelch disabling the channel whenever the gaps flash. Note that gaps may be completely bypassed; however, this will interfere with the detection of accidental cable grounds.

c) The pilot-wire pair must be twisted separately from any other wires in the cable.

d) Do not use open pilot wires.

e) Shield any substantial length of wire between pilot wire and tone equipment.

f) Use surge protection across tone connection.

To protect personnel, use isolating transformer (S#185A495H01 serves the dual purpose of impedance matching). Mount it with the drainage and neutralizing devices in an enclosure marked "High Voltage."

Fig. 17 shows the recommended practices for privately owned cable installations. The best approach is to make the cable self-protecting. The incremental cost (installed) of better cable insulation is relatively small. Good electromagnetic shielding by the shield and by the messenger will keep induced potential to reasonable levels. The shield should provide a shielding factor of 50% or less (actual induced voltage of 50% of calculated value ignoring shielding effect).

CONSTRUCTION

The type TA-1 tone equipment has been specifically designed for protective relaying applications. Modular design is used, and a system is assembled using plug-in modules to meet the requirement of a specific application.

* In a typical relaying application, the tone system consists of a power supply module, a transmitter module, two receiver modules, an optional squelch module, and two output relays. These components are mounted on separate chassis.

Basic construction is shown in Figs. 1 through 3.

* A. Transmitter Module

The transmitter module consists of a transistor

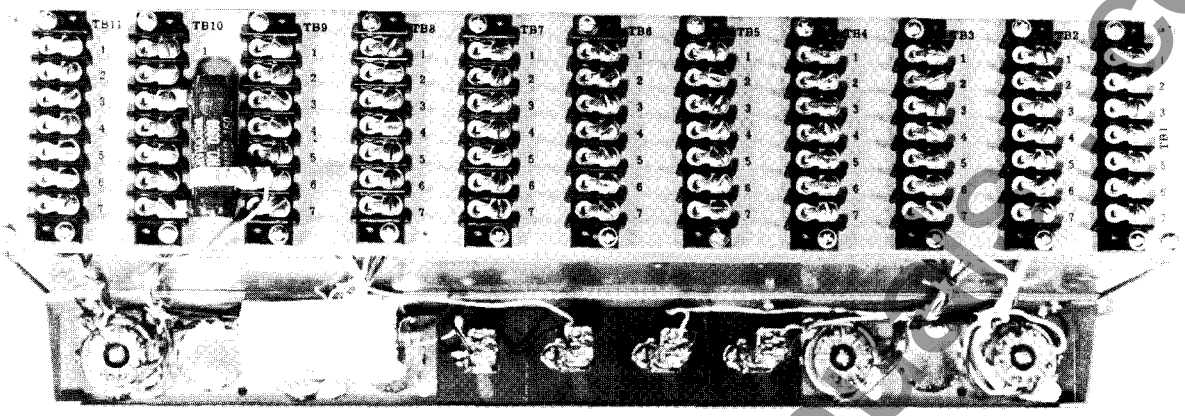


Fig. 2 – Rear View of Full Chassis

keying circuit, an oscillator, an output amplifier and an output band-pass filter. The band-pass filter and oscillator frequency determining components are contained in a separate plug-in enclosure to simplify changes in frequency assignments and stocking of spares.

* B. Receiver Module

The receiver module consists of an input band-pass filter, a limiting amplifier, a specially tuned discriminator, rectifying and filtering circuitry and a two-stage d-c amplifier. The band-pass filter and discriminator, which determines the operating frequency of the receiver, are mounted on a separate plug-in card. The discriminator output is brought out to separate screw terminals at the rear of the chassis to facilitate connection of a channel monitoring meter.

* C. Voltage Regulator Module

The voltage regulator consists of a power-on switch, power-on light, fuse and two transistor-Zener diode circuits. The regulator is capable of supplying regulated 36 and 22 vdc to two complete transmitter-receiver assemblies with squelch circuits.

* D. AM Receiver Noise Squelch (when used)

This module consists of an input filter, normally tuned for a pass band of 300 to 480 cps, a three-stage amplifier, rectifying and filtering circuitry and an output d-c amplifier.

* E. Output Relays

The output relays are either telephone type relays or high speed type AR relays. On systems with telephone type relays, the relays are mounted on the same chassis as the modules and current jacks are used to monitor the relay coil current. In the type AR relay systems, the output relay is mounted in an FT-22 case separate from the tone chassis and must be connected to the output of the receiver module. Current test jacks on the FT case are used to monitor the AR coil current.

The AR output relay is a small high-speed attracted-armature type of unit. An insulated member, fastened to the free end of the armature, draws down four moving-contact springs to close the trip-circuit contacts when the relay coil is energized.

A typical tone assembly using telephone type output relays is shown in figure 8.

The tone assembly for an AR type system is shown in figure 9, and the schematic of the type AR output relay is shown in figure 10.

* F. Physical Features

The modules are the same size, and plug into either of two basic chassis.

a) An eleven module chassis with a nominal overall size of 5¼'' h x 19'' w x 9¾'' d, which mounts in standard relay rack. Outline and drilling dimensions are shown in Figure 4.

b) A five module wall mount chassis with a nominal overall size of 5¼'' h x 9 15/16'' w x 10 5/8'' d. Module shelf swings out 180° for easy access to rear terminals. Outline and drilling dimensions are shown in Figure 5.

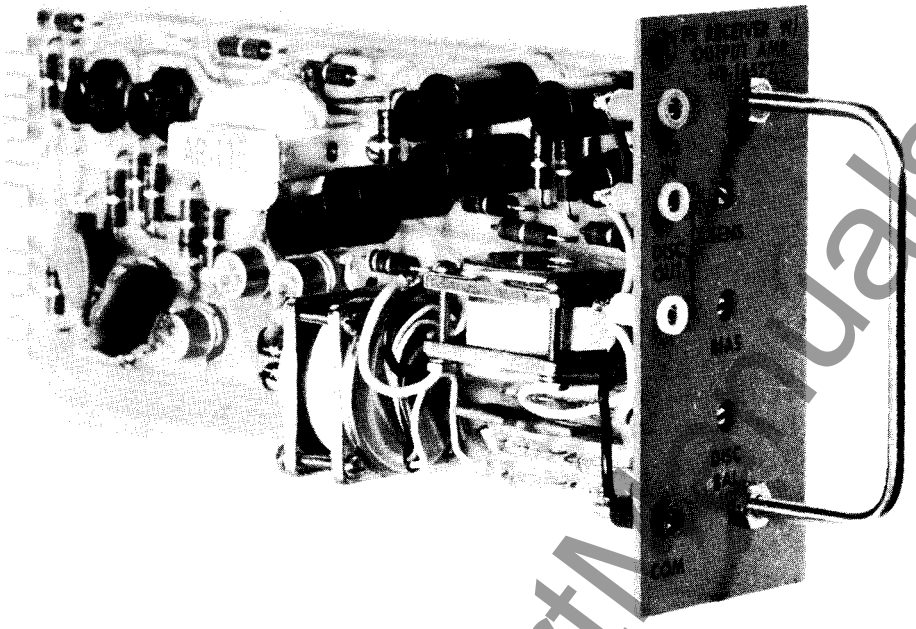


Fig. 3 – Typical Module

THEORY OF OPERATION

Under normal line conditions, the tone transmitter operates at its guard frequency which is 85 cps below the nominal or center frequency marked on the unit. At the receiving terminal, the reception of the guard frequency develops an output from the receiver discriminator which operates the guard relay.

When a tripping function is called for, operation of the protective relay shifts the tone transmitter to its trip frequency which is 85 cps above the nominal or center frequency of the tone. At the receiving terminal, the reception of the trip frequency develops an output from the receiver discriminator which operates the trip relay. Since the guard discriminator output is no longer present, the guard relay drops out.

A. FS Transmitter (HB-17845-2)

* For guard frequency transmission, the transistor, Q3, is biased into conduction by application of a negative voltage on the emitter. This in effect inserts the guard frequency capacitors in the oscillator tuned circuit. The guard capacitors are removed when the forward bias is removed from the emitter and the oscillator shifts to the trip frequency. This is usually accomplished by a contact closure from terminal 6 on the connector block to battery positive.

An oscillator, using the frequency determining L_O, C_G and C_T, generates the guard and trip frequencies. The voltage tap of R_{12}, the output level control, is used to drive transistor Q_1, an output buffer amplifier. The filter, FL-1 is the collector load of the amplifier and also serves to d-c isolate the oscillator from the line and to match a line impedance of 600 ohms.

The filter and the oscillator are the only frequency sensitive components in the transmitter and are packaged together in a hermetically sealed plug-in can.

Frequency adjustment is obtained through the use of capacitor C_6, resistor R_7 and R_{17}. The effective capacitance introduced into the tuned circuit is varied with resistor R_{17}. When resistor R_{17} is adjusted to maximum resistance, the capacitor C_6 is isolated from the tuned circuit. Resistor R_7 is used to prevent the entire value of capacitance from becoming effective in the tuned circuit.

* B. FS Receiver (HB-16527-2, HB-20835-2, and HB-20835-10)

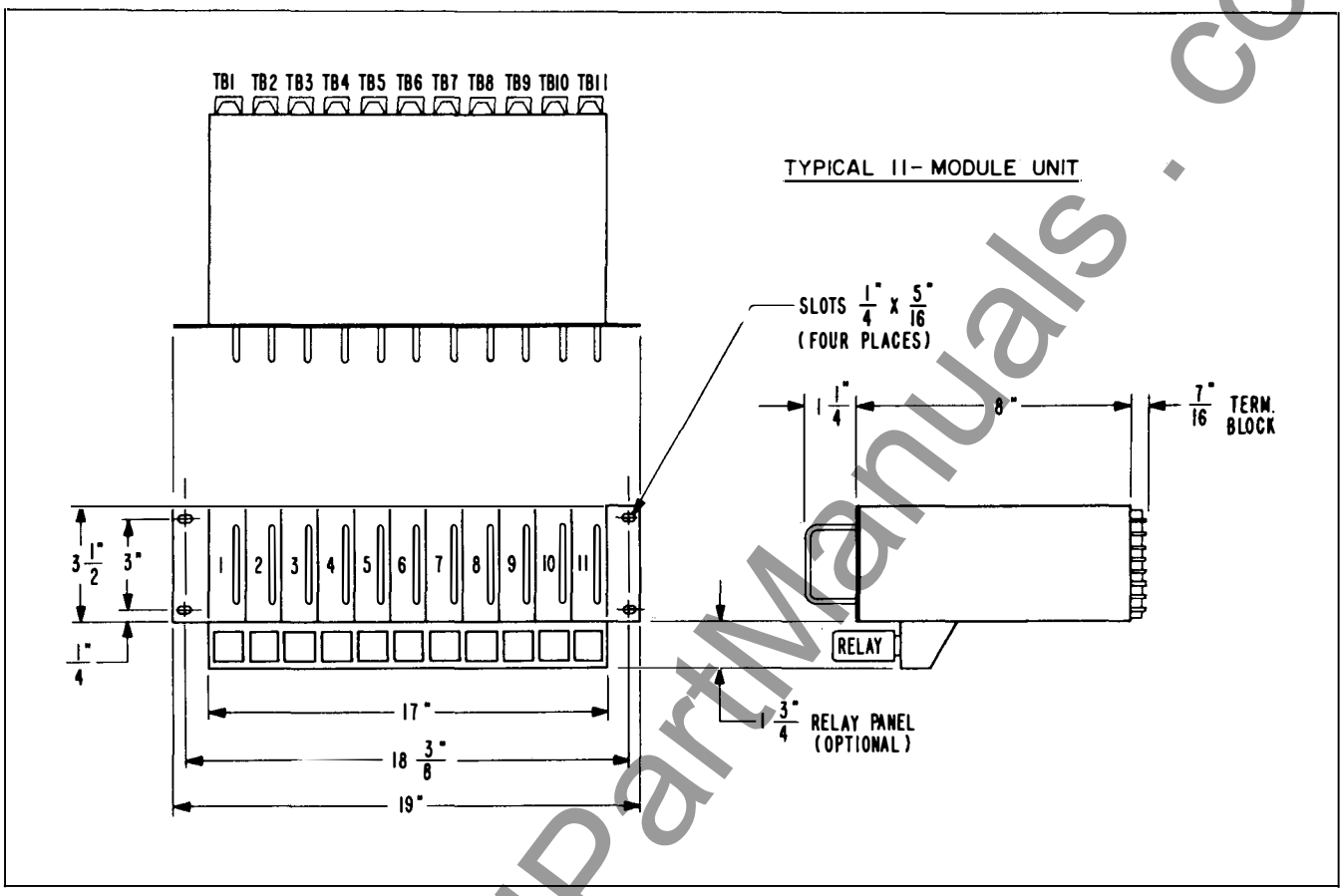


Fig. 4 – Outline and Drilling Plan of 11 Module Chassis

The input of the receiver is designed to reject adjacent channel tones by at least 40 db. The sharply sloping skirts of the filter also aid in preventing noise frequencies, just above the trip frequency, from causing false trip relay operation.

Transistors Q_1 Q_2, Q_3 and Q_4 comprise a three stage limiter amplifier and will provide full limiting of the discriminator input signal to approximately
* -40 dbm.

The discriminator consists of two tuned circuits, one tuned to peak at the trip frequency and the other tuned to peak below the guard frequency. The effect of this tuning is shown on the discriminator output curve Figure 6. This tuning, combined with a bias adjustment, greatly reduces the receiver sensitivity to random noise. The in-band noise power delivered to the d-c amplifiers is much lower over the band of frequencies affecting the trip condition than it is in the remainder of the band.

Resistor R_{20}, the balance control, is essentially a trimmer for the discriminator, allowing precise adjustment of the output at the guard and trip frequencies. The discriminator output also appears across resistor R_{22}, the relay bias control. If resistor R_{22}, is adjusted such that a greater portion of discriminator output is delivered to transistor Q_6 rather than transistor Q_5, it follows that more power must be delivered to transistor Q_5 to cause conduction. Resistor R_{23} and diode CR_{10} form a bias network preventing operation of either transistor Q_5 or Q_6 during the no signal condition. Resistor R_{32}, diodes CR_{11} and CR_{12} perform the same function on transistors Q_7 and Q_8.

Resistor-capacitor combinations, R_{28}, C_{10} and R_{29}, C_{11}, form accelerating networks for the output relays. When transistor Q_7 is switched on by transistor Q_5, capacitor C_{10}, momentarily shunts resistor R_{28}, causing a large inrush current to energize the output relay. A low holding current limited by resistor R_{28}, is required to keep the relay energized after capacitor C_{10}, is fully charged.

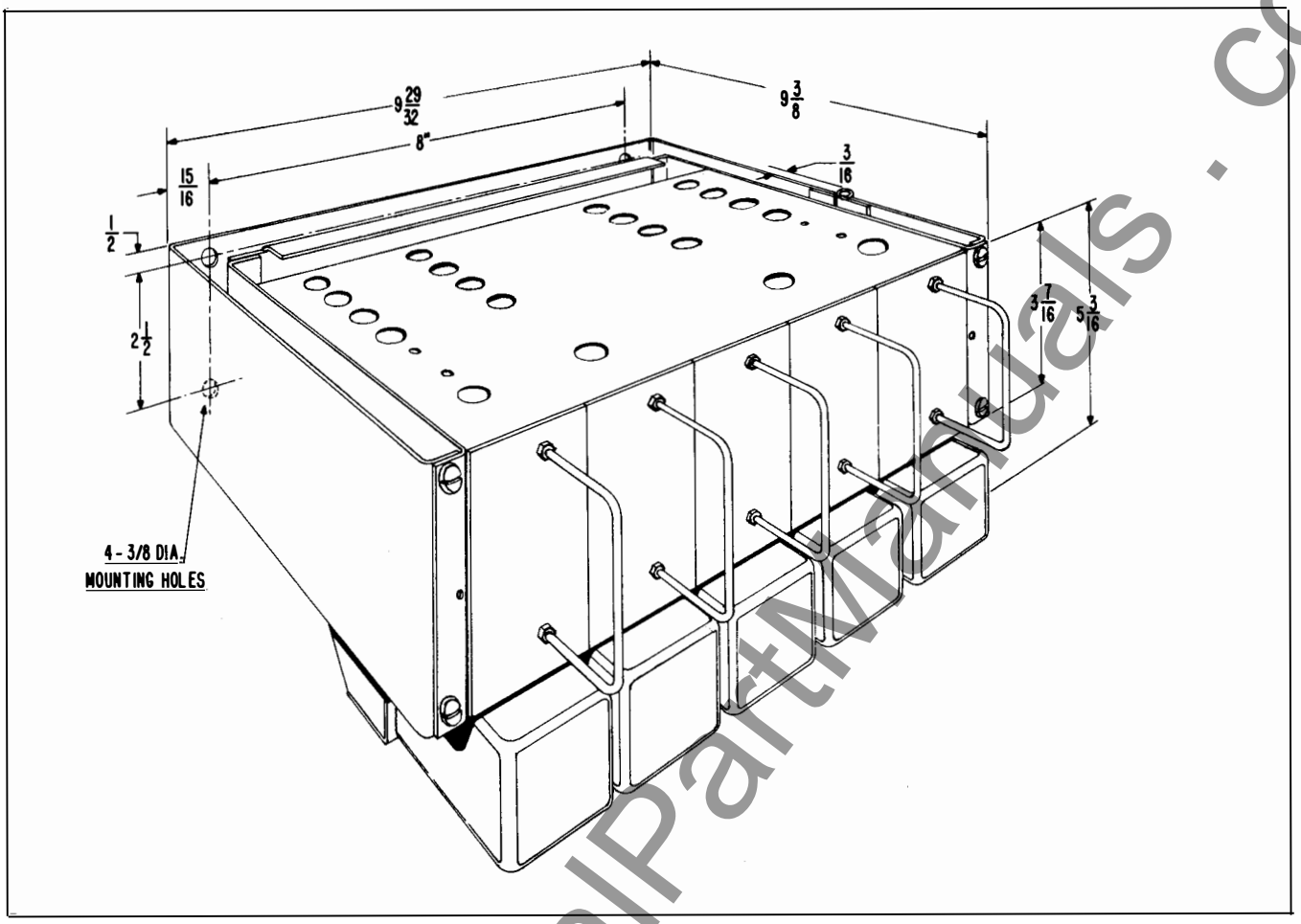


Fig. 5 – Outline and Drilling Plan of 5 Module Chassis

C. AM Receiver Noise Squelch (When used - HB-17840)

As shown in Figure 8, transistors Q_1, Q_2 and Q_3 form a three stage linear amplifier which drives rectifiers CR_1 and CR_2. During a low signal or low noise condition, the voltage divider, resistor R_{19} and R_{22}, biases the output transistor Q_4 into a non-conducting state. If the positive voltage from the rectifiers is large enough to overcome the bias, transistor Q_4 conducts. Terminal E is connected to the emitter of transistor Q_2 and the base of Q_8 on the FS Receiver. A negative voltage is applied to Q_2 and Q_8 when noise signals of sufficient amplitude cause transistor Q_4 of the squelch circuit to conduct. Reverse biasing of transistor Q_2 completely disables the FS Receiver and leaves the receiver in a no signal condition. The negative voltage on Q_8, allows Q_8 to conduct and keep the guard relay picked up.

CHARACTERISTICS

General

Channel Frequencies: cps	935 1955 1275 1615 2295 2635 (For special applications, additional frequencies can be supplied).
Shift in Frequency:	± 85 cycles
Operating Temperature:	-10°C to 60°C
Storage Temperature:	-60°C to +75°C
* Operating Time: (Includes guard relay drop-out time and trip relay pickup time)	17-20 ms with telephone type output relays. 11-15 ms - with type AR output relays.

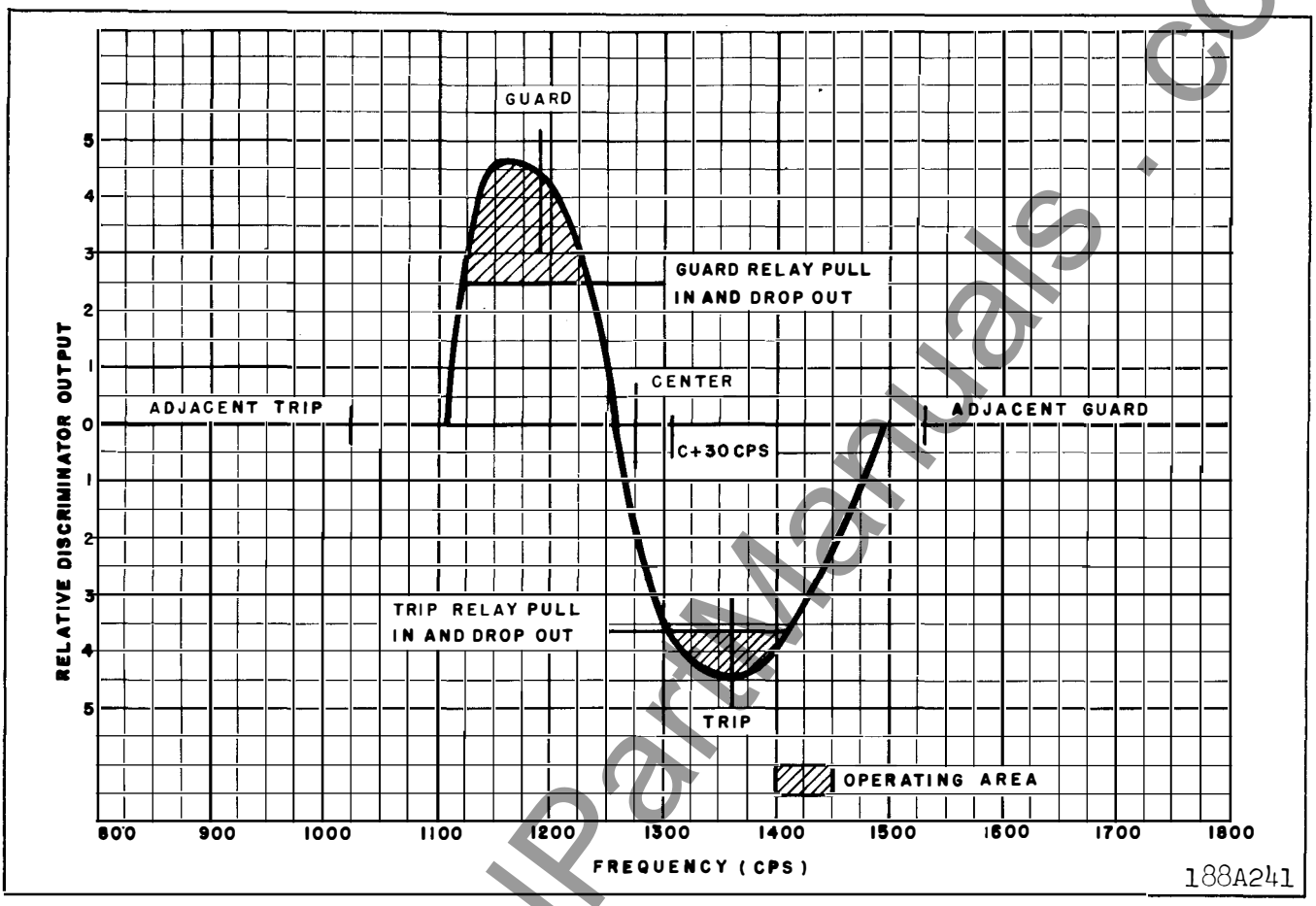


*Fig. 6 – Typical discriminator output curve showing relative noise power output effecting trip relay.

DC supply voltage: 48, 125, or 250 volts dc, external dropping resistors are used on 125 and 250 v dc.

Energy Requirements: 0.15 amperes dc @ rated dc voltage per chassis, including one or two transmitter or receivers, or one each, plus power supply.

FS Transmitter

Output Level: +1 dbm to −30 dbm continuously adjustable.

Frequency Stability: 0.1% ± 2 cps

Output Impedance: 600 ohms in the pass-band: high impedance outside of pass-band ungrounded and unbalanced.

FS Receiver

Sensitivity: 0 dbm to −40 dbm for full limiting.

Input Impedance: 600 ohms in the pass-band; high impedance outside of pass-band, unbalanced, must be ac grounded.

(A 0.5 mfd, 2,000 volt capacitor is provided in each assembly to provide the ac grounding).

Adjacent Channel Rejection: At least 40 db.

Noise rejection without squelch circuit: Audio frequency random noise must be at least 50 db over the guard signal to cause false trip relay operation.

AM Receiver Noise Squelch (when used)

Sensitivity:	-40 dbm adjustable
Input Impedance:	600 ohms with rising characteristics out of band.

* INSTALLATION

The tone assemblies should be mounted on relay racks or in suitable cabinets when the eleven module chassis is used. The five module chassis can be wall mounted. The mounting location should be free from dirt, moisture, excessive vibration or heat. All electrical connections are made to the terminal blocks on the rear of the chassis, per CR drawing (See Fig. 7) which applies to the particular order.

Use of current monitoring jacks: Standard telephone-type current jacks are shown on the connection diagrams. They are used to monitor the guard and trip output relay coil current.

The type AR relay should be mounted near the TA-1 tone chassis in a location free from dirt, moisture, excessive vibration, and heat. Mount the relay vertically by means of the four mounting holes on the flange for semi-flush mounting, or by means of the rear mounting stud or studs for projection mounting. Either a mounting stud or the mounting screws may be utilized for grounding the relay. The electrical connections may be made directly to the terminals by means of screws for steel-panel mounting or to the terminal studs furnished with the relay for thick-panel mounting. The terminal studs may be easily removed or inserted by locking two nuts on the stud and then turning the proper nut with a wrench.

For detailed FT case information, refer to I.L. 41-076.

SETTINGS

Transmitter:

Only one setting is required on the tone transmitter and that is the output level. This setting is made by using the screwdriver type adjustor marked "level" on transmitter module. In general, the tone transmitters are set to the maximum level allowed by the telephone company on the pilot wire or telephone pair. For example, in relaying applications, generally only one or two tone transmitters will be connected to the pilot channel at any one terminal. If zero dbm is the maximum allowance level, a single tone transmitter will be set to that level (0.775 volt). If more than one transmitter is used at one terminal, the telephone company should be consulted as to the allowable transmitting levels.

The audio output level of the transmitter is measured by connecting a 600-ohm resistor or load across the signal output terminals. No other signal should be present on the line if it is used. The level can be measured at the output terminals using an AC vacuum-tube voltmeter. The level control is then adjusted for the desired output. After all the transmitters are adjusted properly and multiplexed a VTVM reading should be taken at the "OUT" pin jack on the front panel and recorded for maintenance and check-out purposes. This avoids the necessity of disconnecting the transmitter from the line when levels are to be checked or readjusted.

FS Receiver

Plug a d-c milliammeter of at least 50 ma. range into receiver trip relay jack. Close the keying circuit of the associated tone transmitter to shift its frequency from Guard to Trip. (The tone transmitters must be previously set to their desired output levels). Connect a vtvm across the tone receiver input terminals and note the normal received voltage (preferably in db). Now connect a calibrated attenuator (such as the Hewlett-Packard Model 350B Attenuator) between the telephone line and the terminal equipment. Set the attenuator for 12 db attenuation. This value can be checked on the vtvm. If such an attenuator is not available, connect a variable resistor, 500 ohms maximum is adequate, across the incoming line and reduce the resistance until the incoming signal level drops 12 db.

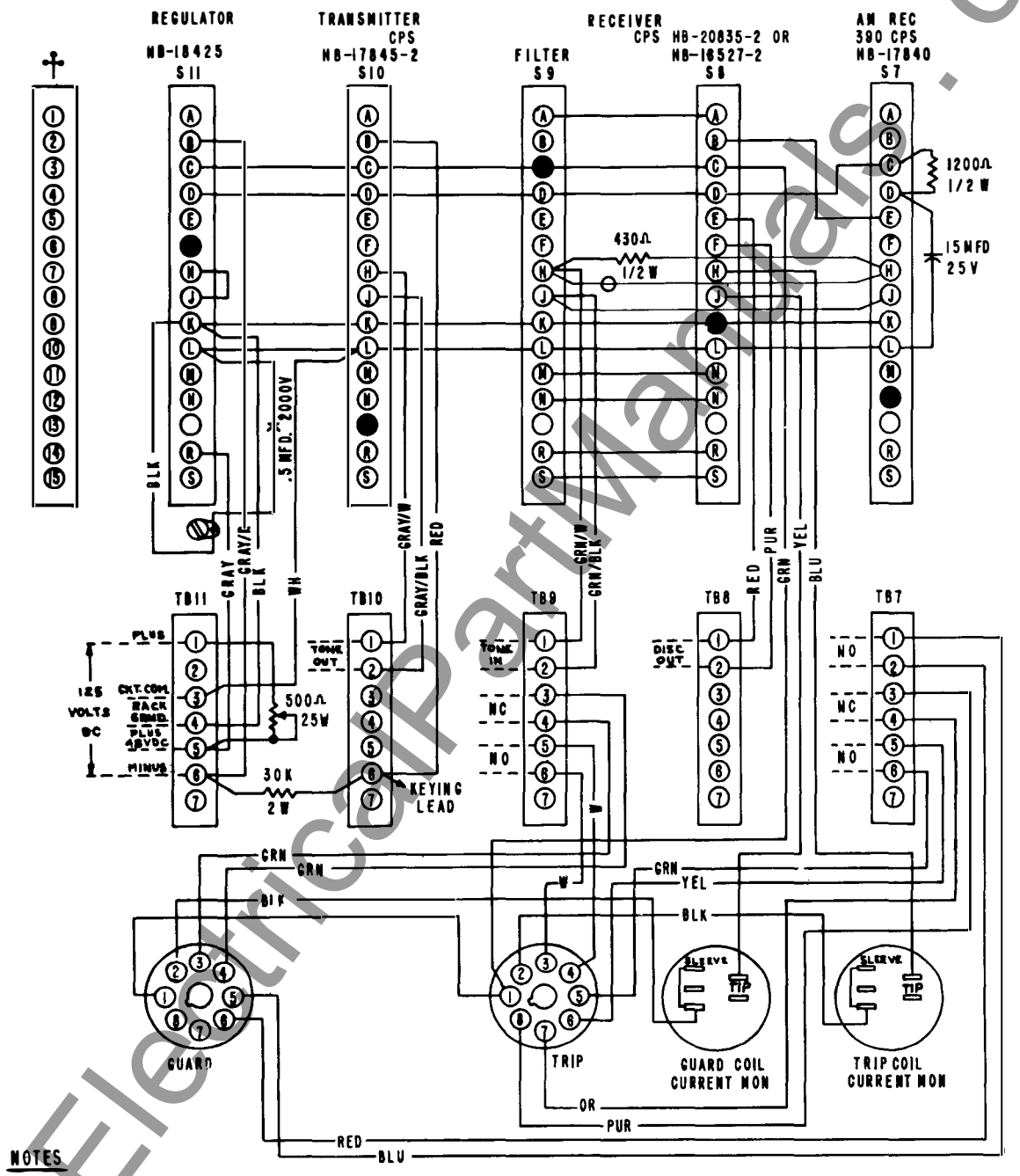
With the level of the incoming "trip" tone set 12 db below normal, advance the gain control of the tone receiver by adjusting level control on the receiver module, until the receiver output current increases suddenly from zero to approximately 25 ma for telephone type output relays and 32 ma for type AR output relays, at this point the trip relay has operated. When the attenuator is removed from the circuit, the tone receiver will have a normal operating point 12db above the pickup signal level.

Voltage Regulator

No setting required.

*** AM Receiver Noise Squelch (when used)**

The AM squelch receiver is set in the factory



NOTES

1. S SOCKETS - PRINTED CIRCUIT BOARD SOCKETS
2. TB - BARRIER STRIPS
3. WIRING IS NO 22 STRANDED OF COLOR MARKED UNMARKED WIRING IS BUSS WIRING
4. ● INDICATES KEY LOCATION
5. RELAYS, WHEN USED, ARE SHOWN UNENERGIZED
6. IF TWO RECEIVERS ARE ON SAME LINE, CUT JUMPER MARKED —⊖—
7. CONNECTING KEYING LEAD TO BATTERY POSITIVE SENDS UPPER, OR TRIP FREQUNCY.

† FOR CONVERSION FROM AN ALPHABETICAL TERMINAL BLOCK NOTATION TO A NUMERICAL NOTATION.

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*Fig. 7 Typical Terminal Block Drawing of Type TA-1 Assembly. (CR Dwg.)

such that the receiver is disabled whenever the noise measured in the 300-480 cycle band exceeds -10 dbm. The squelch can be adjusted for other sensitivities by the method shown under "Adjustments". The -10 dbm to -15 dbm setting is recommended in order to take advantage of the noise rejection capabilities of the FS receiver.

ADJUSTMENT AND MAINTENANCE

The proper adjustments to insure correct operation of the tones have been made at the factory. Upon receipt of the tones, no customer adjustments other than those covered under "Settings", should be required.

Acceptance Check

* Voltage Regulator

Non regulated voltage = 45 to 38 vdc

Hi regulated voltage = 36 vdc

Lo regulated voltage = 22 vdc

Voltages measured between common test point and the other specific test points.

Transmitter

Key transmitter to trip frequency by shorting between terminals indicated on connection drawing, which is supplied for each order.

All transmitter frequencies and output levels to be checked with a 600 ohm load.

Guard frequencies -Normal or center frequency minus 85 cycles.

Trip frequencies -Normal or center frequency plus 85 cycles.

Output -at least + 1 dbm

FS Receiver

With transmitter output set at -20 dbm, see that guard and trip output relays function properly when respective guard and trip signals are applied.

* AM Receiver (Squelch when used)

With a 400 cps -10 to -15 dbm external tone superimposed on existing guard signal, see that there is a zero output across discriminator output test points. This indicates that the receiver has been biased off. This output may be checked by plugging a 500-0-500 microammeter with a 5100 ohm resistor in series into the test points marked "Disc Out".

* Type AR Output Relay (when used)

1. Contact gaps
   a. Normally open contacts should have a gap of .018 to .023 inch.
   b. Normally closed contact gap should be .013 minimum.

2. Contact pressure

   On two normally open and two normally closed relays, the normally closed contacts should have approximately 8 grams contact pressure in the de-energized position. Each normally open contact spring should have approximately 8 grams pressure against the card.

3. Armature gap
   The armature gap should be approximately .009 inches measured at the narrowest part of the armature gap.

Adjustments

Use the following procedure for adjusting the tones, if the tone adjustments have been disturbed. This procedure should not be used unless it is apparent that the tones are not in proper working order (See "Acceptance Check").

Transmitter

The frequency of the transmitter is adjusted at the factory before shipment and does not normally have to be readjusted. The adjustment, however, should be checked if the filter-oscillator assembly is changed. To make the adjustment the transmitter output should be properly loaded and a counter or other device capable of measuring frequency within 2 cycles attached to the output. The test point "OUT" (on the transmitter side of the filter) can also be used. Readings should be made in both guard and trip condition and the frequency should be adjusted until an equal guard and trip shift from center is effected.

Note voltage levels per table 1.

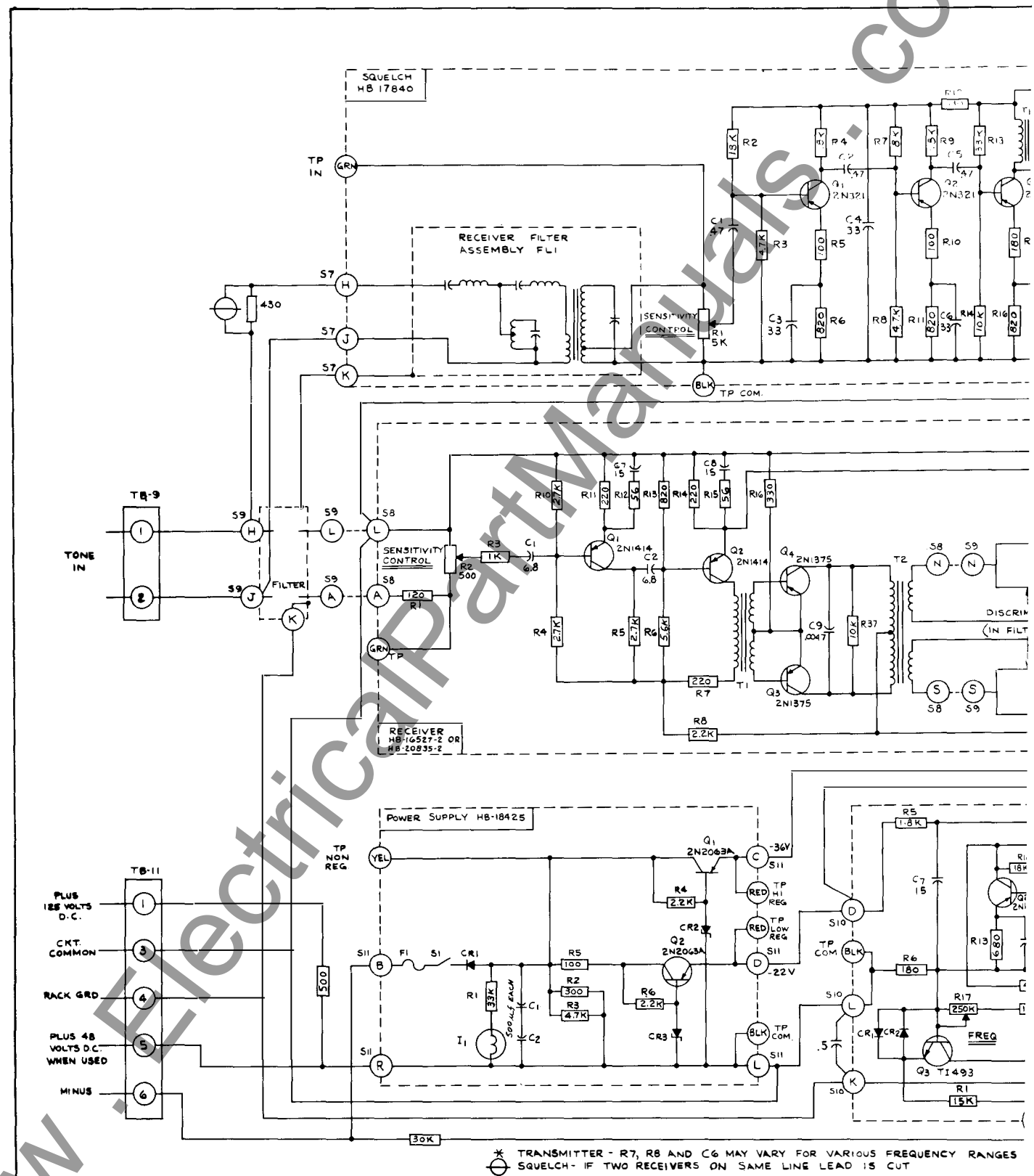
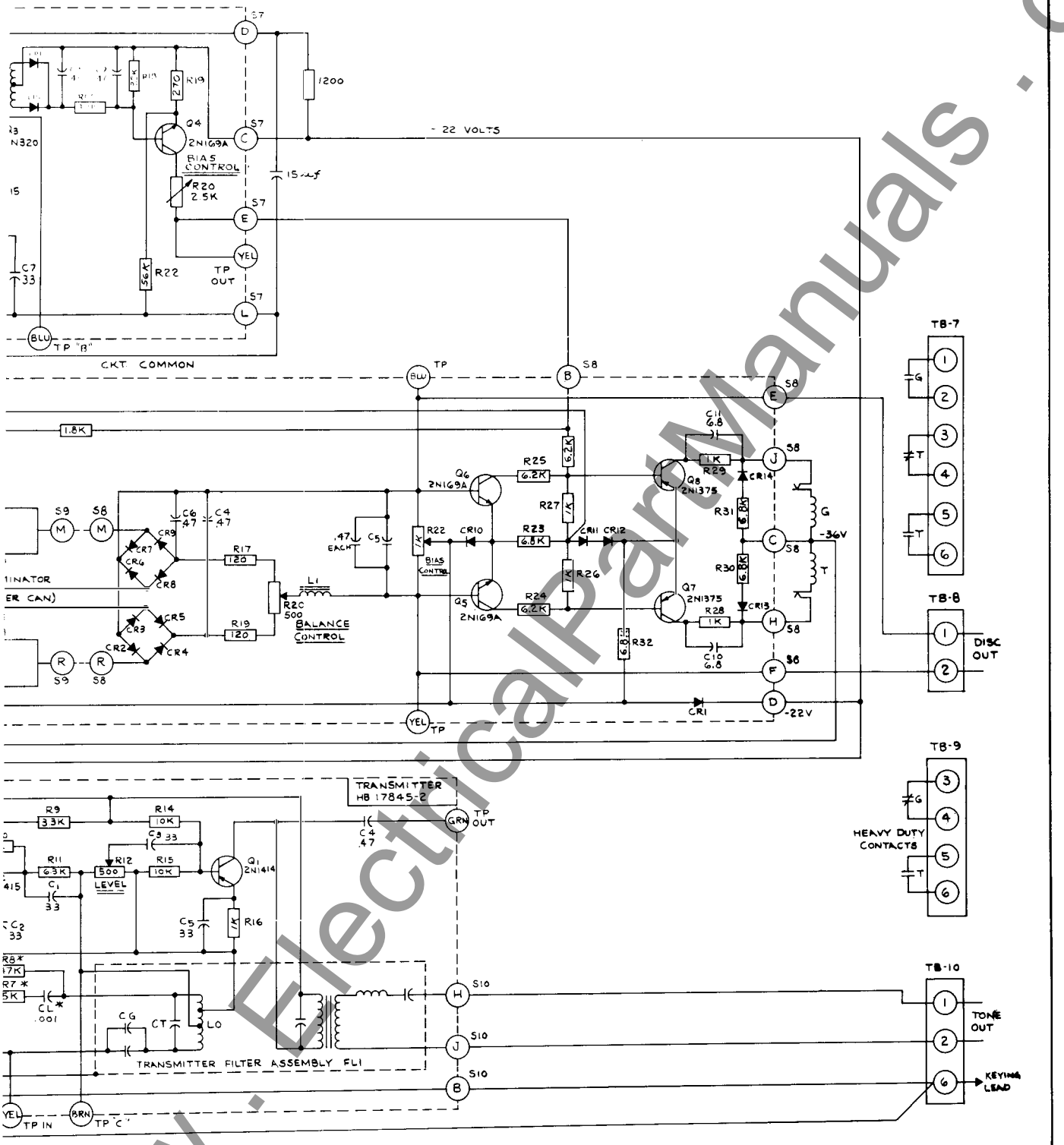


*Fig. 8 Typical Schematic Diagram of Ty



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pe TA-1 Assembly (with Telephone Relay Output).

FS Receiver

There are three receiver adjustments – an input sensitivity control, a bias control and a discriminator output balance control.

The bias control and discriminator output balance control are factory adjusted for optimum operation. Except for special applications these controls should not be readjusted.

Prior to setting the receiver bias, the discriminator output should be balanced for both the guard and trip frequencies. Plug the connections of a 500-0-500 microammeter (zero center scale) with a 5100 ohm resistor in series with the meter terminal into the test points marked "Disc Out". With the receiver sensitivity control at its maximum setting (fully clockwise) and the receiver bias control at its mechanical center adjust discriminator balance control for equal outputs at guard and trip frequencies.

In order to make the proper bias adjustment an external variable frequency source (oscillator) is required. With the output of the oscillator set at –20 dbm, adjust bias control for trip relay pickup of 30 cycles above center frequency of receiver. A recheck of the discriminator output may show a deviation of approximately 10% from previously balanced condition and a readjustment is not necessary.

Note voltage levels per Table 1.

AM Receiver Noise Squelch (when used)

With transmitter set at –20 dbm output and AM * receiver bias control fully counter clockwise superimpose a 400 cycle, –10 dbm tone on existing guard signal to FS receiver, and adjust sensitivity of AM receiver for zero output on microammeter across "Disc Out" test points.

* Voltage Regulator

No adjustments. – Note voltage levels per Table 1.

When the TA-1 tones with an AR output relay is used, the series resistor of the power supply has been set for 55 volts across the unregulated test point with the following conditions:

1. D.C. supply of 140 volts d.c.
2. AR relay removed from its chassis. This is to protect the electronic components against excessive voltages. With the AR unit in its chassis, the non-regulated voltage will be lower than the 55 volt.

* Calibration of Type AR Output Relay

The type AR output relay unit has been properly adjusted at the factory to insure correct operation, and under normal field conditions should not require readjustment. If, however, the adjustments are disturbed in error, or it becomes necessary to replace some part, use the following adjustment procedure. This procedure should not be used until it is apparent that the relay is not in proper working order, and then only if suitable tools are available for checking the adjustments.

a. Adjust the set screw at the rear of the top of the frame to obtain a 0.009-inch gap at the rear end of the armature air gap.
b. Adjust each contact spring to obtain 4 grams pressure at the very end of the spring. This is measured when the spring moves away from the edge of the insulated crosspiece.
c. Adjust each stationary contact screw to obtain a contact gap of 0.020-inch. This will give 15-30 grams contact pressure. This completes the adjustment procedure for the AR tripping relay unit.

Maintenance

The modules in this equipment use transistors and other components which are conservatively rated for reliability and long life. In normal operation, the monitoring function provides a continuous check on the performance of the equipment. At periodic intervals, it may be desired to check the tripping function. For such a check, the channel may have to be taken out of service to prevent unnecessary breaker operation. The keying circuit may then be closed to check the operation of the tripping relay.

As long as the channel is operating satisfactorily, no maintenance work is necessary other than seeing that the equipment is free of dust or dirt. * However, a scheduled routine check will prevent down-time loss, since it may indicate deterioration in the performance of one of the units. The output relay contacts may be burnished on the same schedule as that for the associated protective relays. If a channel failure occurs because of the terminal equipment, a trouble-shooting procedure should be used similar to that employed for any electronic equipment. First determine where the failure has taken

place (transmitter or receiver); then determine the portion of the circuit at fault.

Follow the tables of voltage levels which apply to these circuits.

Test Equipment – For routine maintenance, the following equipment will be adequate:

1. A-C vacuum-tube voltmeter, H-P Model 400D or equivalent.

2. Calibrated attenuator, H-P Model 350B or equivalent.

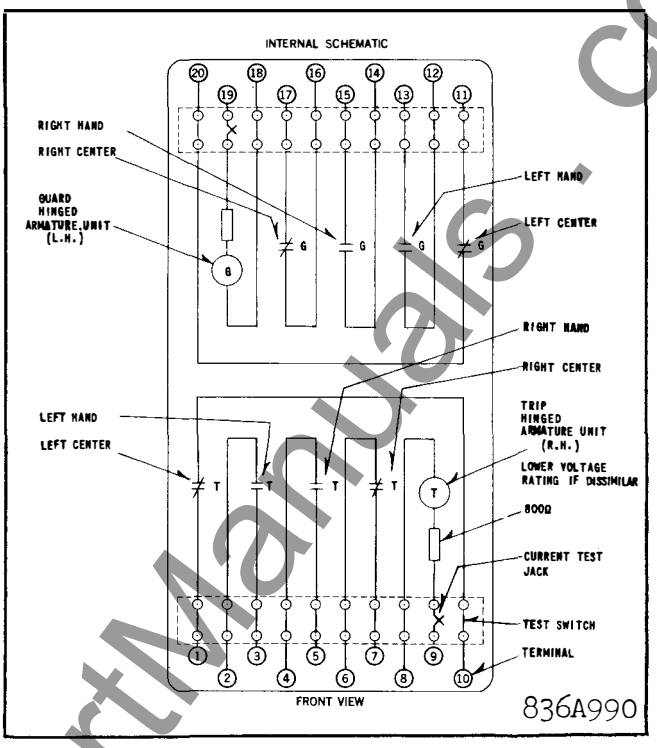
As an alternative, a 500-ohm variable resistor can be used.

For trouble shooting, the following additional test equipment is desirable:

1. Electronic frequency counter, H-P Model 523 C or equivalent.

2. D-C vacuum-tube volt-ohmmeter, RCA Senior Voltohmyst or equivalent.

3. Cathode-ray oscilloscope.



* *Fig. 10 Internal schematic of the type AR relay for use with TA-1 tones.*

GENERAL INFORMATION

Connection Drawings

The drawings applicable to the specific order will be supplied. The applicable "CR" drawing information is included as part of the nameplate data.

Tone Applications

Figures 11 thru 14 show typical relaying applications which make use of the tone characteristics.

RENEWAL PARTS

Repair work can be done most satisfactorily at the factory. However, interchangeable parts can be furnished to users who are equipped for doing repair work. When ordering parts, always give the assembly style number and voltage rating, plus the component identification and module in which it is located.

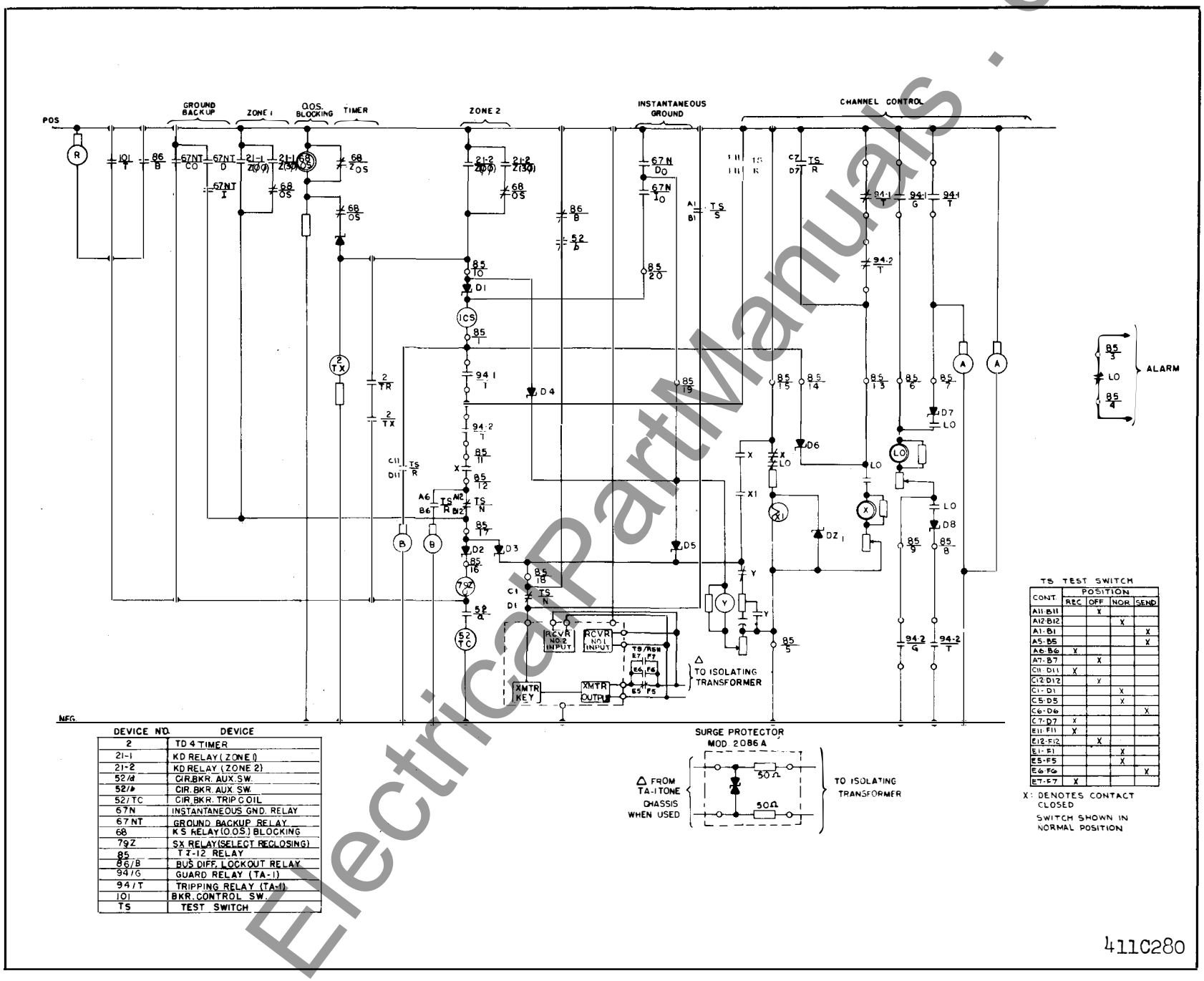
Replaceable parts are shown in Table 2.

* TABLE I – VOLTAGE LEVELS

Measurements taken with respect to circuit common; –20 dbm guard signal transmitted and received.
E = Emitter; B = Base; C = Collector.

MODULE		Q1 VOLTS		Q2 VOLTS		Q3 VOLTS		Q4 VOLTS		Q5 VOLTS		Q6 VOLTS		Q7 VOLTS		Q8 VOLTS		TEST POINTS	
		AC	DC	AC	DC	AC	DC	AC	DC	AC	DC	AC	DC	AC	DC	AC	DC		
Voltage	E		36		22													Hi Reg	36VDC
Regulator	B		36.2		22.2													Lo Reg	22VDC
HB-18425	C		43		29													Non Reg	43VDC
FS Transmitter	E	7mv	4.35	4.2mv	.8	1mv	.67											Out	.12VAC
HB-17845-2	B	2mv	4.5	.045	.9	<1mv	0											C	.046VAC
	C	.12	9.6	3.0	4.8	1mv	.67												
FS Receiver	E	.5mv	.45	3mv	.75	2.1	2.7	2.1	3.7	.033	22	.033	21	2mv	1.5	2mv	1.5	IN	.039VAC
HB-16527-2	B	.8mv	.6	5mv	.9	2.4	3.8	2.6	3.8	.03	24	.033	21.8	3mv	0	3mv	1.2	Disc. Out-Equal	
HB-20835-2 HB-20835-10	C	5mv	1.7	1.1	4.8	12	22	12	22	4mv	0	.033	22	4mv	36 43 †	<.1m	1.6	and opposite VDC at guard and trip.	
AM Receiver	E	2mv	2.15	.016	2.15	.13	2.45	.027	20									In	.01VAC
HB-17840	B	2mv	2.3	.018	2.3	.15	2.65	.03	22									OUT	1.2VDC
(Adjusted to Squelch with –40 dbm 400 cps tone input.)	C	.019	7.4	.16	7.4	5	2.45	.25	7.5									V	5.0VAC

† Collector of Q7 only for the HB-20835-10 module.



DEVICE NO.	DEVICE
2	TD 4 TIMER
21-1	KD RELAY (ZONE 1)
21-2	KD RELAY (ZONE 2)
52/a	CIR.BKR. AUX. SW.
52/b	CIR. BKR. AUX. SW.
52/TC	CIR. BKR. TRIP C. OIL
67N	INSTANTANEOUS GND. RELAY
67NT	GROUND BACKUP RELAY
68	KS RELAY (O.O.S.) BLOCKING
79Z	SX RELAY (SELECT RECLOSING)
85	TZ-12 RELAY
86/B	BUS DIFF. LOCKOUT RELAY
94/G	GUARD RELAY (TA-1)
94/T	TRIPPING RELAY (TA-1)
101	BKR. CONTROL SW.
TS	TEST SWITCH

Fig. 11 Line Protection – KDAR/TT12 Transfer Trip Schematic (3 Terminal).

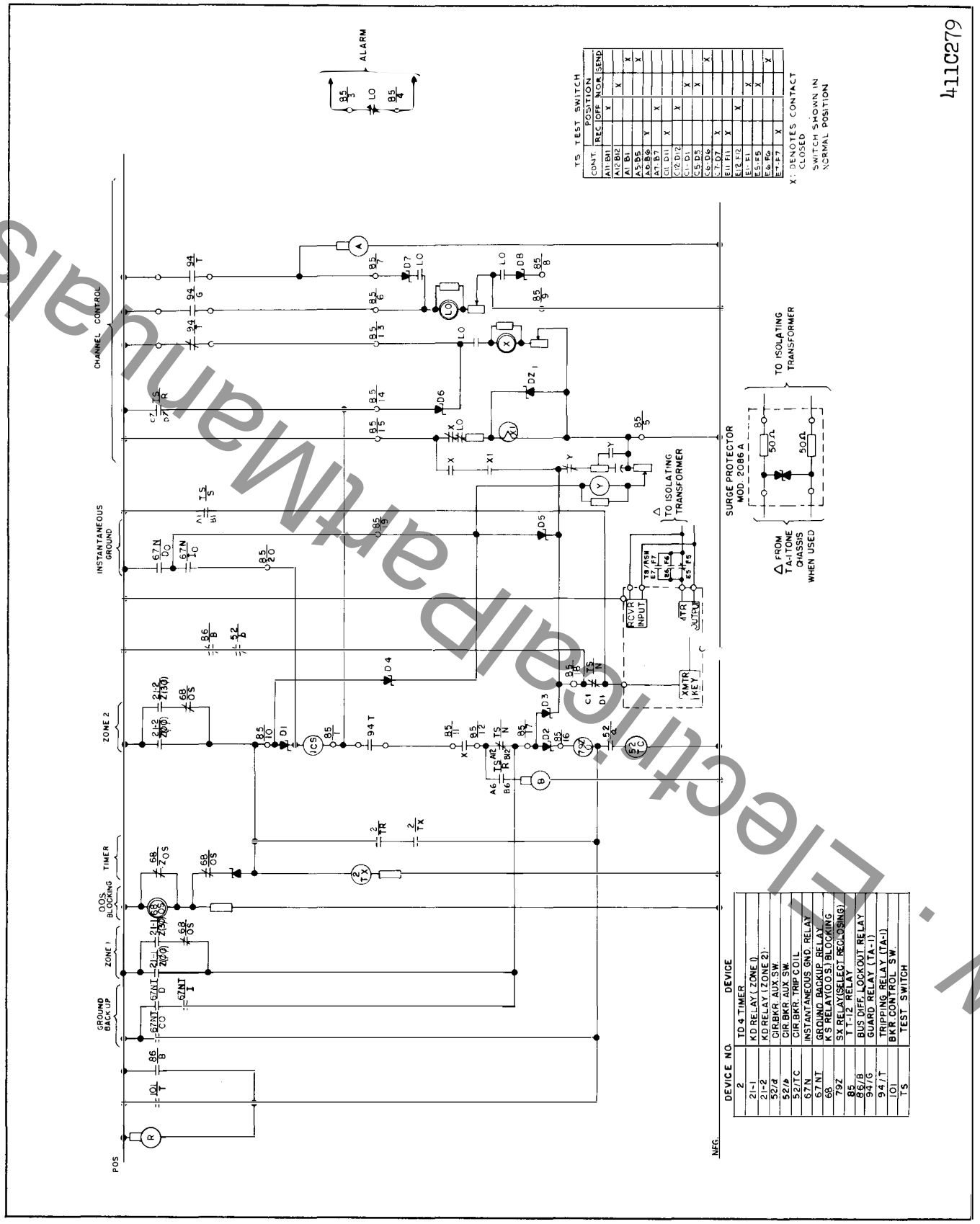


*Fig. 12 Line Protection – KDAR/TT12 Transfer Trip Schematic (2 Terminal).

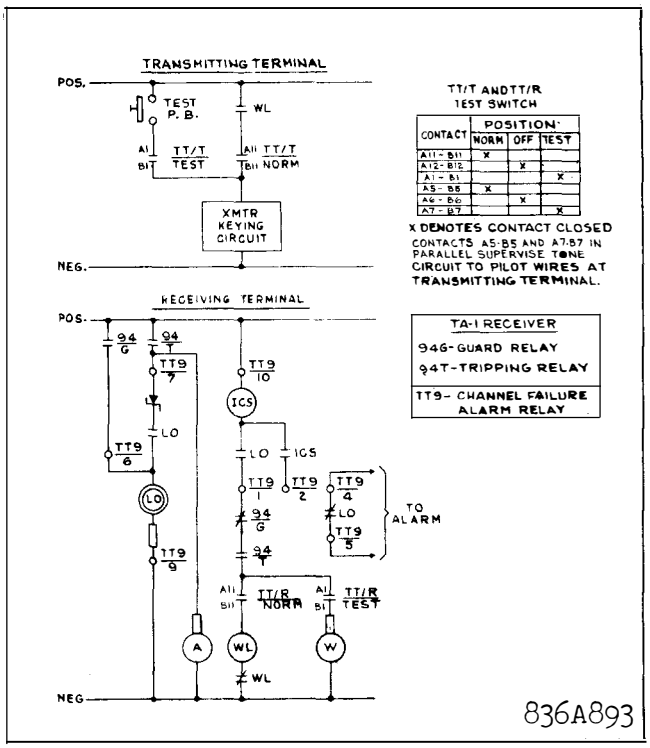


*Fig. 13 Transformer Protection — Single Channel Transfer Trip.

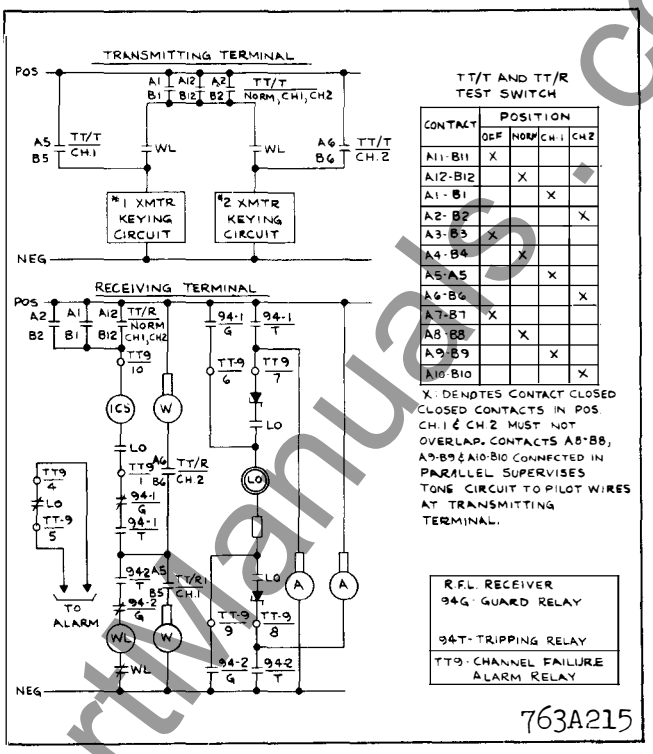
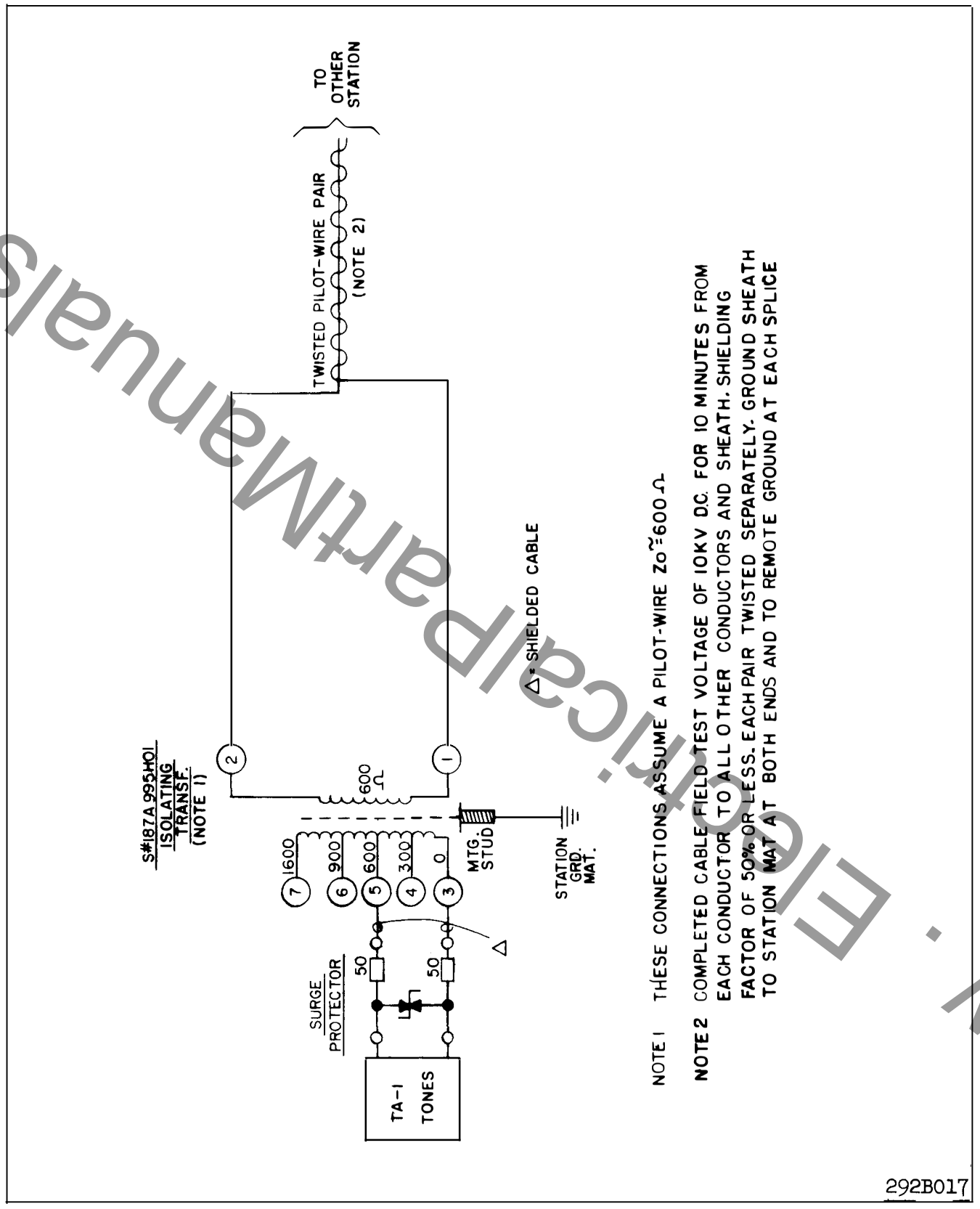
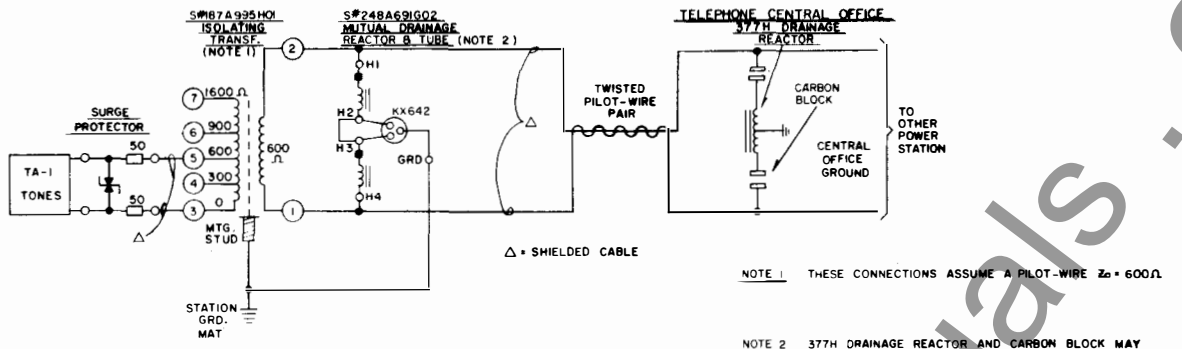


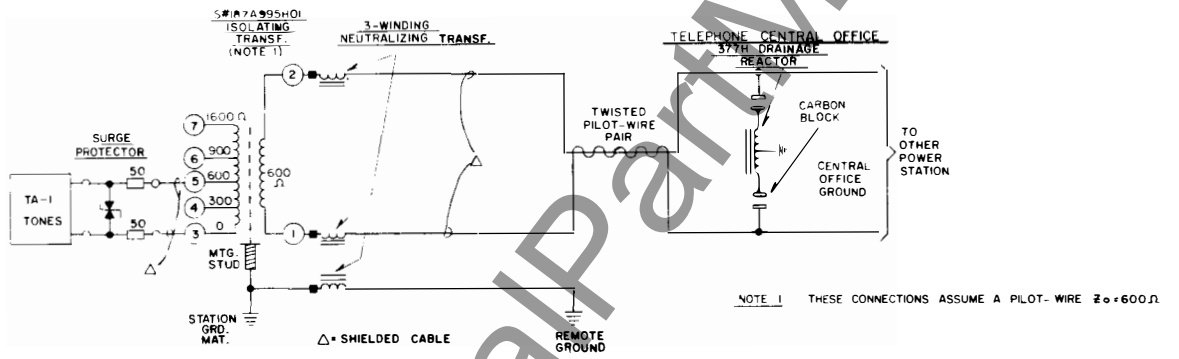
*Fig. 14 Transformer Protection — Dual Channel Transfer Trip.



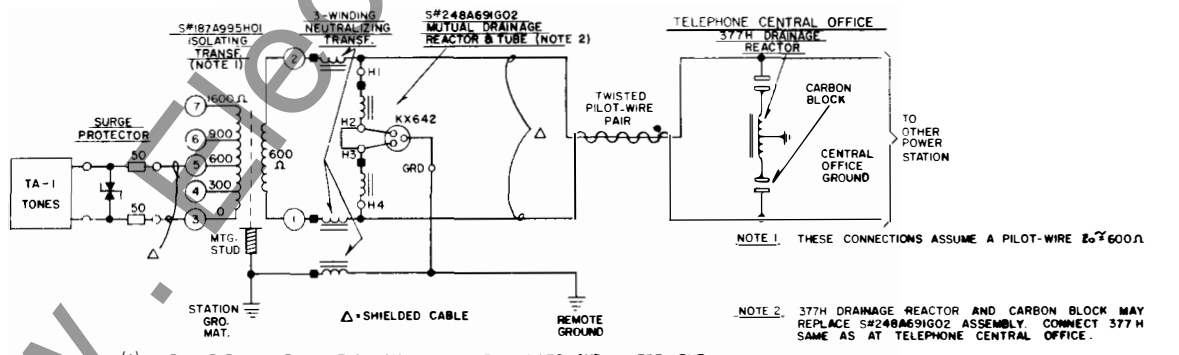
** Fig. 15 – Recommended Connections and Pilot Wire Design for Privately owned Cable for Two Terminal Lines.*



(a) USE WHERE INDUCED VOLTAGE MAY EXCEED 700 VOLTS. USE ONLY WHERE STATION AND CENTRAL OFFICE GROUNDS ARE INTERCONNECTED VIA WATER-SYSTEM PIPES.



(b) USE WHERE STATION AND CENTRAL OFFICE GROUNDS ARE NOT INTERCONNECTED VIA WATER SYSTEM PIPES. DO NOT USE IF INDUCED VOLTAGE MAY EXCEED 700 VOLTS.



(c) USE WHERE INDUCED VOLTAGE MAY EXCEED 700 VOLTS AND WHERE THE STATION AND CENTRAL OFFICE GROUNDS ARE NOT INTERCONNECTED VIA WATER SYSTEM PIPES.

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** Fig. 16 – Recommended Connections and Protective Arrangements for leased Cable for Two Terminal Lines.*

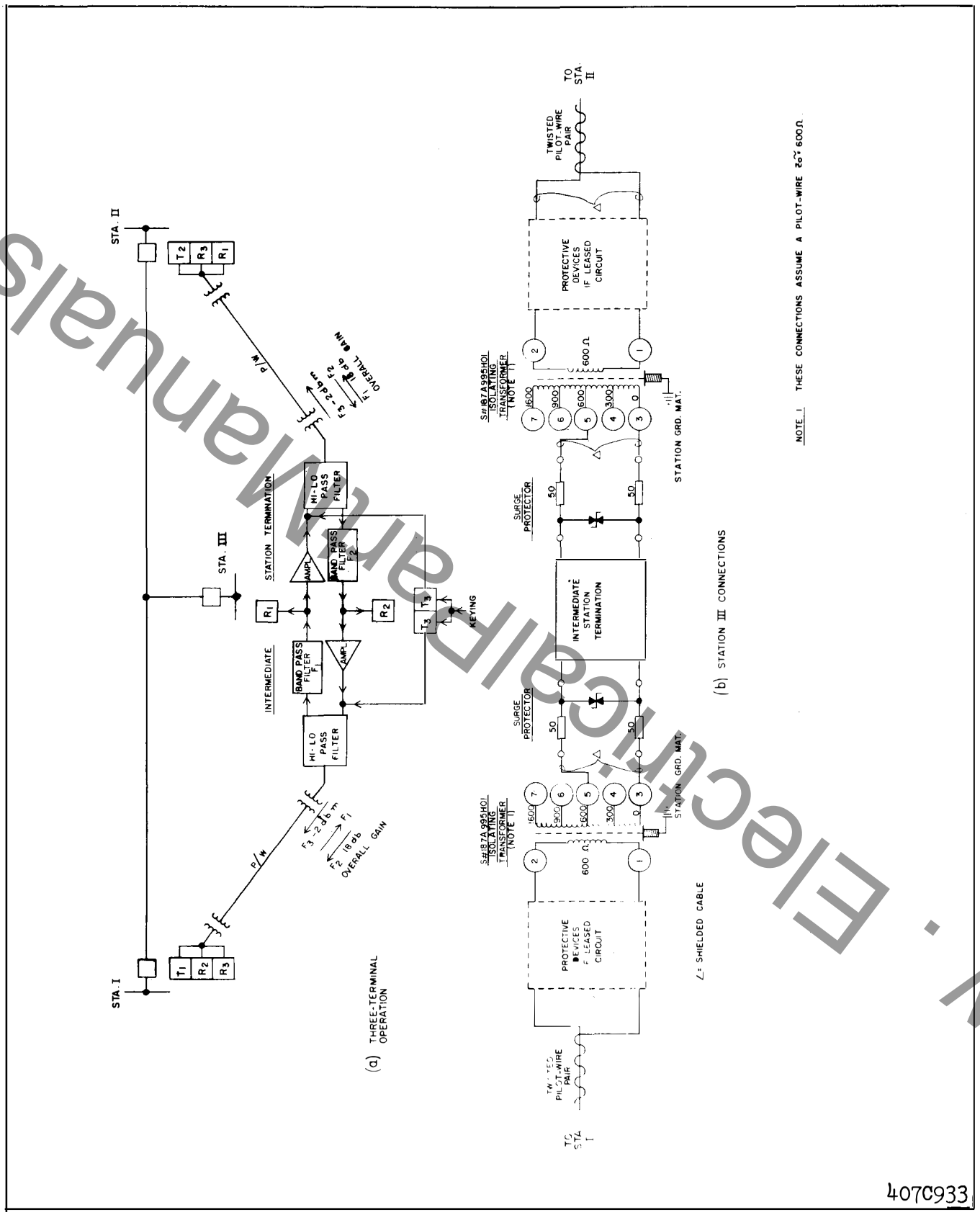
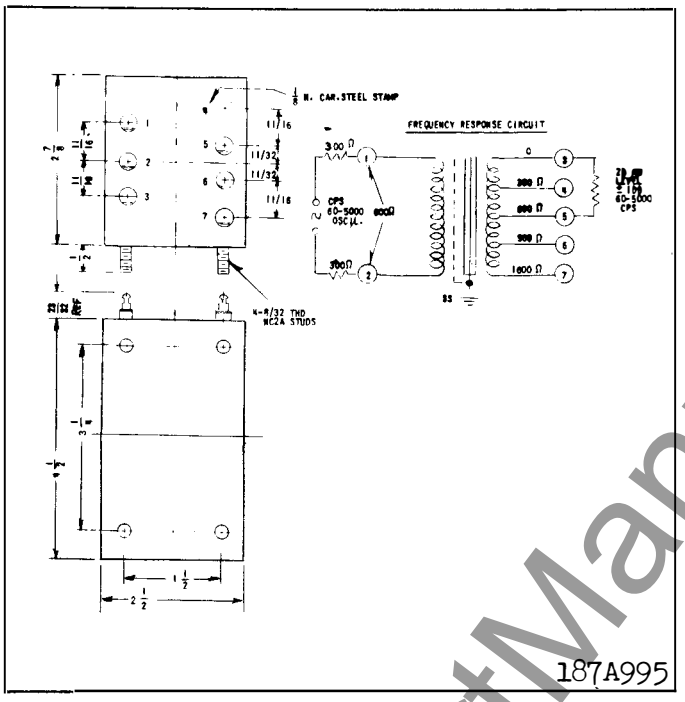


*Fig. 17 – Recommended Channel Arrangements for Three Terminal Line Protection.



** Fig. 18 Isolating Transformer 187A995H01.*

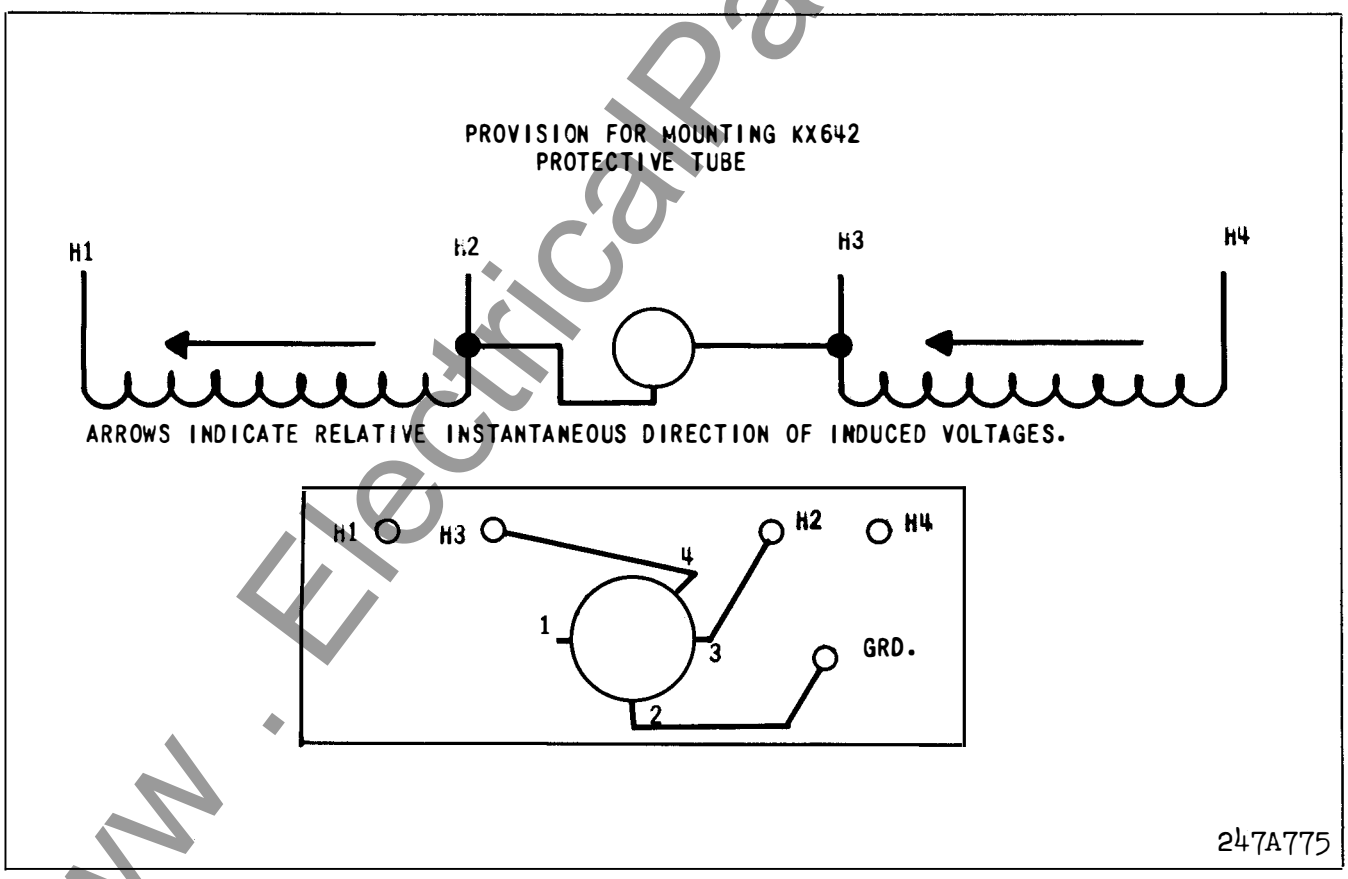
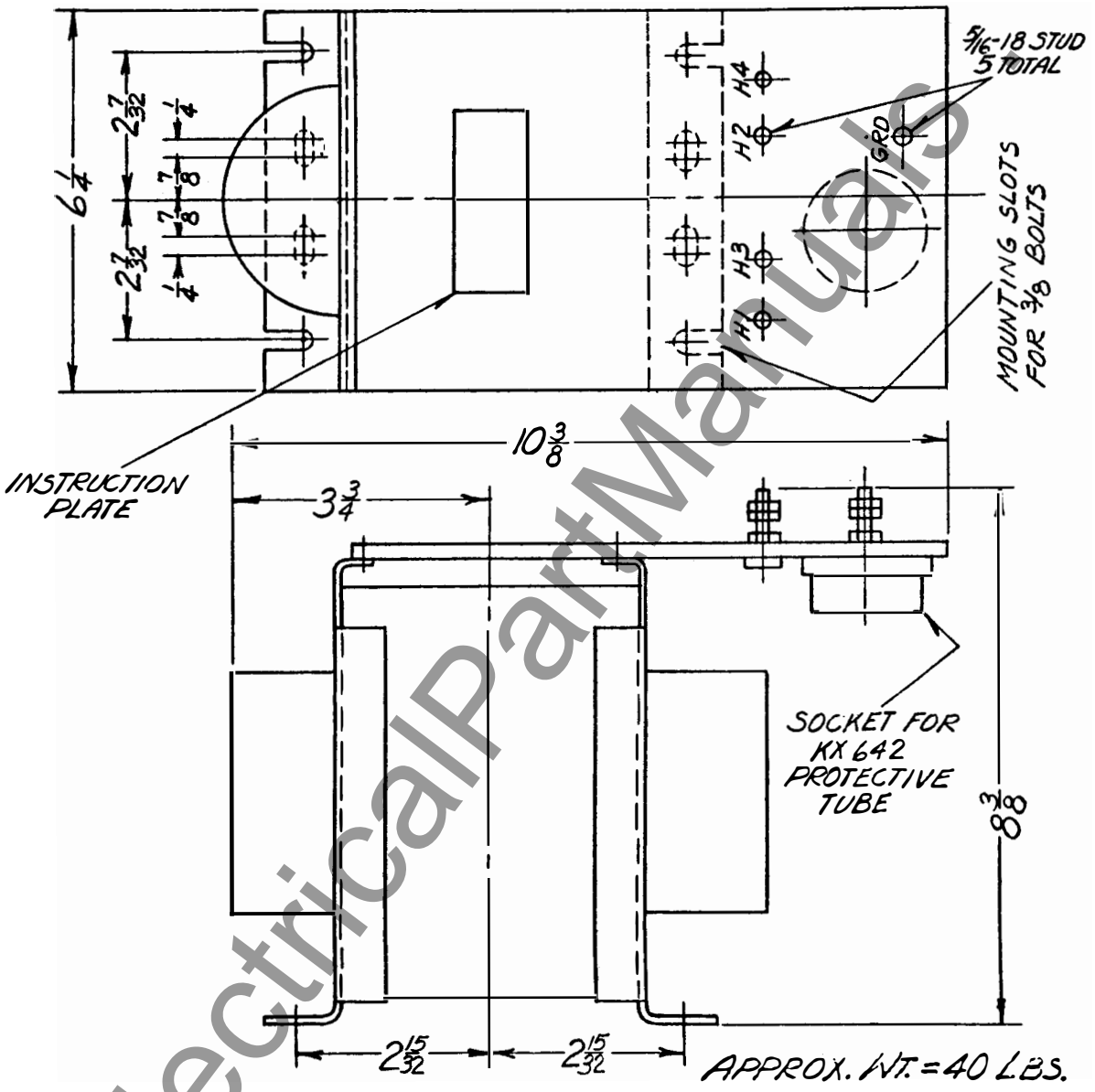


**Fig. 19 Drainage Reactor Connections.*



THIS OUTLINE CAN BE USED FOR ERECTION OR MOUNTING PURPOSES. IT IS NOT TO BE REGARDED AS INDICATING THE EXACT DETAILS OF CONSTRUCTION.

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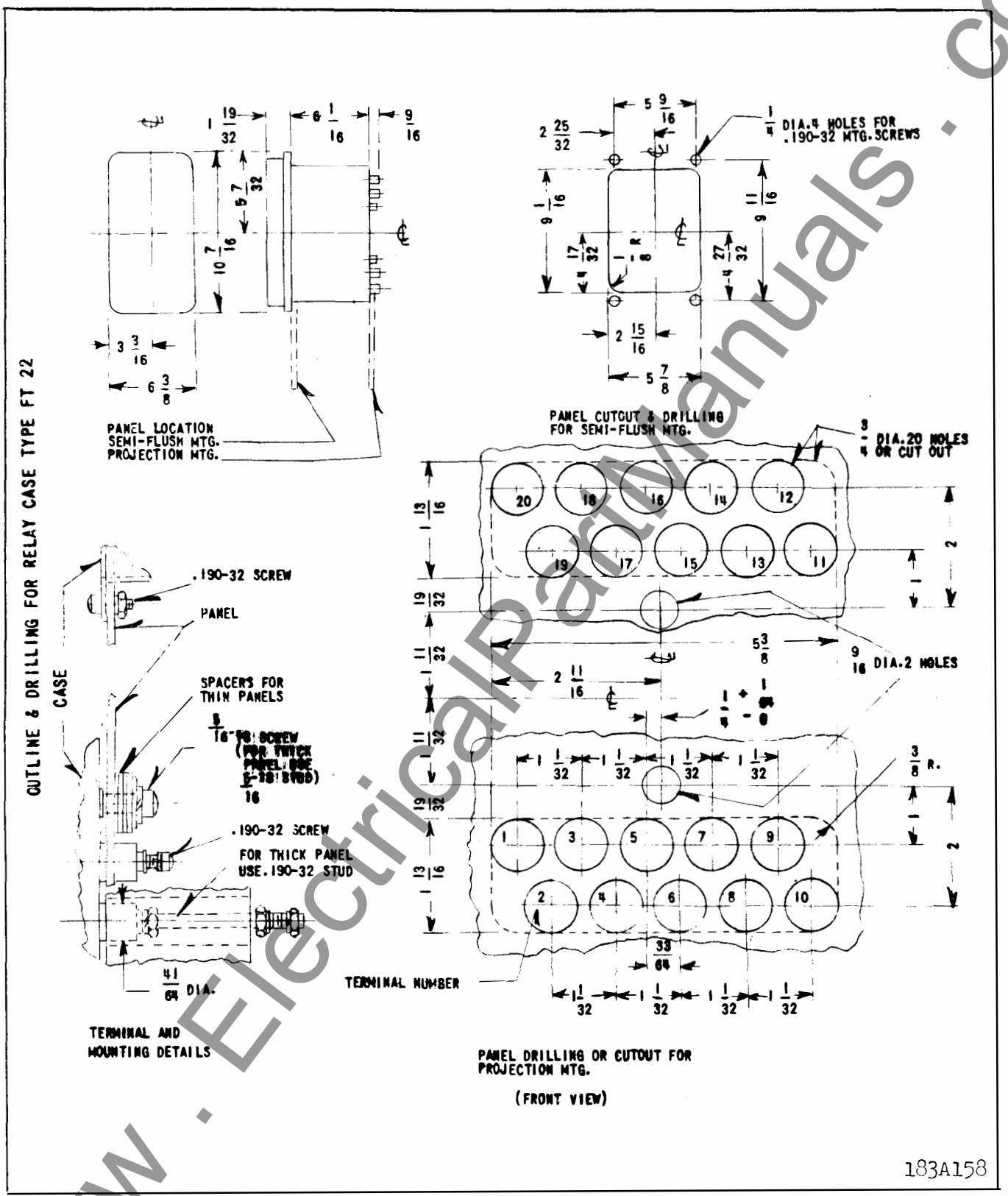
*Fig. 20 Drainage Reactor Outline



** Fig. 21 Outline and Drilling plan for the type AR relay in the FT-22 case.*

Table of Electrical Parts

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
	HB-17845-2 FS TRANSMITTER	
HB-57100	TRANSMITTER FILTER & TUNED CIRCUIT, 170 cps bandwidth, 340 cps spacing.	
H-1007-439	CAPACITOR, tantalum: 33 μF, 10V.	C1, 2, 3, & 5
H-1007-439	CAPACITOR, tantalum: 15 μF, 25V.	C7
HA-13579	CAPACITOR, ceramic: 0.47 μF, 25 V DC +80%, -20%.	C4
H-1080-245	CAPACITOR, silver mica: .001 μF ±5%.	C6
H-1009-620	RESISTOR, fixed comp; 15 K, ±10%, ½ W.	R1
H-1009-429	RESISTOR, fixed: comp; 1K, ±10%, ½ W.	R16
H-1009-442	RESISTOR, fixed: comp; 47 K, ±10%, ½ W.	R3
H-1009-530	RESISTOR, fixed: comp; 5.6 K, ±10%, ½ W.	R4
H-1009-446	RESISTOR, fixed: comp; 1.8 K, ±10%, ½ W.	R5
H-1009-607	RESISTOR, fixed: comp; 180 ohms ±10%, ½ W.	R6
H-1009-408	RESISTOR, fixed: comp; 15 K ±10%, ½ W.	R7
H-1009-442	RESISTOR, fixed: comp; 57 K, ±10%, ½ W.	R8
H-1009-419	RESISTOR, fixed comp; 3.3 K, ±10%, ½ W.	R9
H-1009-639	RESISTOR, fixed: comp; 18 K, ±10%, ½ W.	R10
H-1009-640	RESISTOR, fixed: comp; 6.8 K, ±10%, ½ W.	R11
HA-13573	RESISTOR, variable: 500 ohms, .125V; linear taper, std. length shaft 1/8" beyond mtg. surface; ear mounted; screwdriver adj; printed circuit board.	R12
H-1009-473	RESISTOR, fixed: comp; 680 ohms, ±10%, ½ W.	R13
H-1009-391	RESISTOR, fixed: comp; 10 K, ±10%, ½ W.	R14, 15
HA-14594	RESISTOR, variable: 250 K ohms, 0.2 W bd. taper; 1/8" screwdriver shaft; printed circuit; ear mounted.	R17
HA-3167	TRANSISTOR: type PNP; 2N1414.	Q1
HA-3166	TRANSISTOR: type PNP; 2N1415	Q2
HA-17113	TRANSISTOR: type NPN, silicon; TI493.	Q3, Q4
HA-3165	DIODE, silicon: SG22 (Stabistor).	CR1, CR2

Table of Electrical Parts

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
	HB-16527 FS RECEIVER	
HB-53900	BAND-PASS FILTER & DISCRIMINATOR.	
HA-13579	CAPACITOR, ceramic: 0.47 μF, 25 V DC +80%, -20%.	C5, C6, C4
H-1007-479	CAPACITOR, tantalum: 6.8 μF, 25 V.	C1, C2
H-1007-439	CAPACITOR, tantalum: 15 μF, 25 V.	C3, C7, C8
H-1007-92	CAPACITOR, ceramic disc: .0047 μF, 600 V.	C9
H-1007-403	CAPACITOR, solid electrolytic tantalex: 6.8 μF, ±20%, 35 W VDC.	C10, C11
HA-13576	CHOKE: 1 H.	L1
HA-10271	DIODE, silicon.	CR11, CR12
HA-13242	DIODE, germanium.	CR1, 2, 3, 4, 5, CR6, 7, 8, 9, 10, CR13, 14
H-1009-391	RESISTOR, fixed: comp; 10 K ±10%, ½ W.	R37
H-1009-429	RESISTOR, fixed: comp; 1 K ±10%, ½ W.	R26, 27 & 3
H-1009-434	RESISTOR, fixed: comp; 2.2 K ±10%, ½ W.	R8
H-1009-497	RESISTOR, fixed: comp; 330 ohms, ±10%, ½ W.	R16
H-1009-530	RESISTOR, fixed: comp; 5.6 K, ±10%, ½ W.	R6
H-1009-541	RESISTOR, fixed: comp; 2.7 K, ±10%, ½ W.	R10, R5
H-1009-544	RESISTOR, fixed: comp; 220 ohms, ±10%, ½ W.	R11, 7, 14
H-1009-598	RESISTOR, fixed: comp; 27 K, ±10%, ½ W.	R4
H-1009-608	RESISTOR, fixed: comp; 820 ohms, ±10%, ½ W.	R13
H-1009-640	RESISTOR, fixed: comp; 6.8 K, ±10%, ½ W.	R23, 30, 31, 32
H-1009-697	RESISTOR, fixed: comp; 6.2 K, ±5%, ½ W.	R24, 25
H-1009-665	RESISTOR, fixed: comp; 120 ohms, ±10%, ½ W.	R1, R9, R17
H-1009-249	RESISTOR, fixed: comp; 56 ohms, ±10%, ½ W.	R12, R15
HA-13573	RESISTOR, variable: 500 ohms, 0.125 W; standard length shaft 1/8" beyond mounting surface; screwdriver adj. for PC board; taper bd; terminals are to be at right angles to shaft.	R2
HA-14593	RESISTOR, variable: 1000 ohms, 0.25 W; linear taper; standard length shaft 1/8" beyond mounting surface; screwdriver adj. for PC board; terminals are to be at right angles to shaft.	R22

Table of Electrical Parts

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
HA-14643	RESISTOR, variable: 500 ohms, 0.25 W; linear taper; standard length shaft 1/8" beyond mtg. surface; screwdriver adj. for PC board; terminals are to be at right angles to shaft.	R20
HA-3175	TRANSFORMER: primary impedance ohms 2000 CT; secondary impedance ohms 8000 CT; 150 MW O/A.	T1
HA-13575	TRANSFORMER.	T2
HA-13806	TRANSISTOR: NPN, germanium 2N169A.	Q5, Q6
HA-3167	TRANSISTOR: PNP, germanium 2N1414.	Q1, Q2
HA-17117	TRANSISTOR: PNP, germanium; 2N1375.	Q4, 7, 8 & 3
HA-16523	Guard Relay.	
HA-16524	Trip Relay.	
	HB-17840 RECEIVER MODULE W/O FILTER	
HB-56500	RECEIVER BAND-PASS FILTER.	
HA-13579	CAPACITOR, ceramic: 0.47 μF, 25 V DC +80%, -20% (5 req.).	C1, 2, 5, C8 & 9
H-1007-438	CAPACITOR, tantalum: 33 μF, 10 V.	C3, 6, 7 & 4
HA-17197	DIODE, silicon.	CR1, 2
HA-13572	RESISTOR, variable: 5 K, 0.25 W, log taper; std. length shaft 1/8" beyond mtg. surface; screwdriver adj.	R1
H-1009-639	RESISTOR, fixed, comp: 18 K, ±10%, ½ W (2 req.).	R2, R7
H-1009-485	RESISTOR, fixed, comp: 4.7 K, ±10%, ½ W (2 req.).	R3, R8
H-1009-446	RESISTOR, fixed, comp: 1.8 K, ±10%, ½ W (2 req.).	R4, R9
H-1009-435	RESISTOR, fixed, comp: 100 ohms, ±10%, ½ W (2 req.).	R5, R10
H-1009-608	RESISTOR, fixed, comp: 820 ohms ±10%, ½ W (3 req.).	R6, R11 R16
H-1009-497	RESISTOR, fixed, comp: 330 ohms, ±10%, ½ W.	R12
H-1009-423	RESISTOR, fixed, comp: 33 K, ±10%, ½ W.	R13
H-1009-391	RESISTOR, fixed, comp: 10 K ±10%, ½ W.	R14
H-1009-607	RESISTOR, fixed, comp: 180 ohms, ±10%, ½ W.	R15
H-1009-419	RESISTOR, fixed, comp: 3.3 K, ±10%, ½ W.	R17

Table of Electrical Parts

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
HA-13913	RESISTOR, fixed, comp: 8.2 K, ±10%, ½ W.	R18
H-1009-431	RESISTOR, fixed, comp: 270 ohms, ±10%, ½ W.	R19
HA-13588	RESISTOR, variable: 2.5 K, 0.25 W, std. length shaft 1/8" beyond mtg. surface; linear taper; screwdriver adjust.	R20
H-1009-530	RESISTOR, fixed, comp: 5.6 K, ±10%, ½ W.	R22
HA-3175	TRANSFORMER: primary impedance ohms 2000 CT; sec. impedance ohms 800 CT; 150 mv O/A 1 x 3/4 x 3/4.	T1
HA-3166	TRANSISTOR: type PNP (2 req.) 2N1415.	Q1, Q2
HA-3167	TRANSISTOR: type PNP 2N1414.	Q3
HA-13806	TRANSISTOR: NPN 2N169A.	Q4
	HB-18425 VOLTAGE REGULATOR	
HA-13569	CAPACITOR, electrolytic: 500 μF, 50V.	C1, C2
HA-17994	DIODE, zener: 22V, 1W, ±5%.	
HA-17506	DIODE, zener: 36V, 1W, ±5%.	
HA-9348	FUSE: 0.5 amp; 250V, 3AG.	F1
H-1009-730	RESISTOR, fixed: comp; 3.3 K, ±10%, 1W.	R1
H-1100-375	RESISTOR, fixed: comp; 300 ohms, ±5%, 20 W.	R2
H-1009-481	RESISTOR, fixed: WW; 4.7 K, ±10%, 2W.	R3
H-1009-314	RESISTOR, fixed: 2.2 K, ±10%, 1W.	R4, R6
H-1220-33	RESISTOR, fixed: WW; 100 ohms, ±5%, 3W.	R5
HA-13554	SWITCH, pushbutton.	S1
HA-13273	TRANSISTOR, power: germanium; 2N2063A.	Q1, Q2
	MISCELLANEOUS	
HA-17159	CAPACITOR; plastic, 0.5 mfd., 2000 WVD, used on chassis.	