INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TA-1 FREQUENCY-SHIFT AUDIO TONES WITH DC-TO-DC CONVERTER

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 direct. The latter 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. These fault detectors are not present in an underreaching scheme or a transformer protection channel therefore, these are classified as direct.

The presence or lack of trip-circuit supervision greatly influences the secuirty 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 direct 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 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 Hz band exceeds the dbm setting of the squelch.

The receiver guard relay also contributes to security. In direct 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 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.

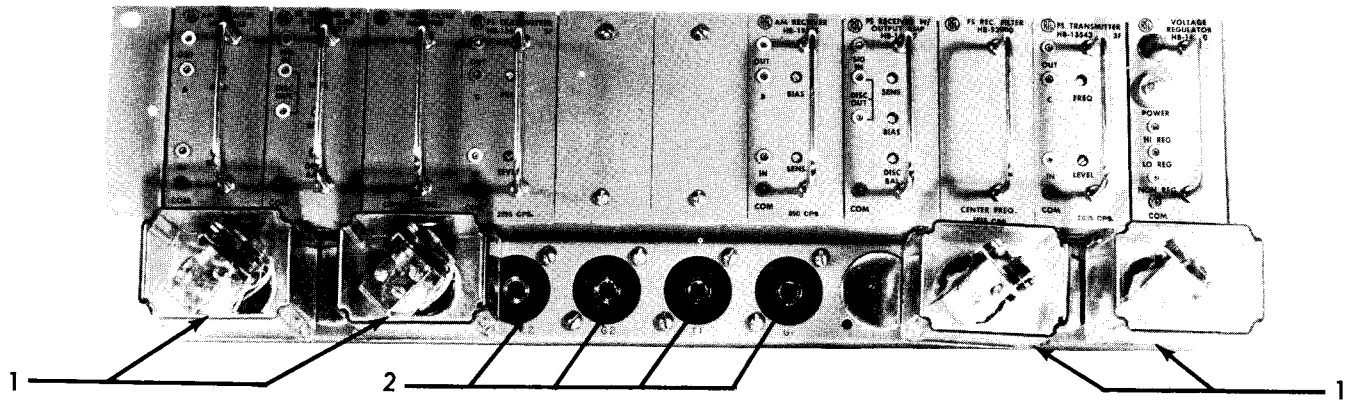


Fig. 1 – Front View of Full Chassis: 1–Telephone Type output relays (when used); 2–Current monitoring jacks (when used).

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 Hz disturbing voltages will appear on the pilot wire. The recommendations summarized in Figs. 11, 12, and 13 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. 12. 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#187A995H01 serves the dual purpose of impedance matching). Mount it with the drainage and neutralizing devices in an enclosure marked "High Voltage."

Fig. 11 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 DC to DC Converter and power supply module, a transmitter module, a receiver module, an optional squelch receiver module, and two output relays.

Basic construction is shown in Figs. 1 through 3.

A. Transmitter Module

The transmitter module consists of a transistor 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.

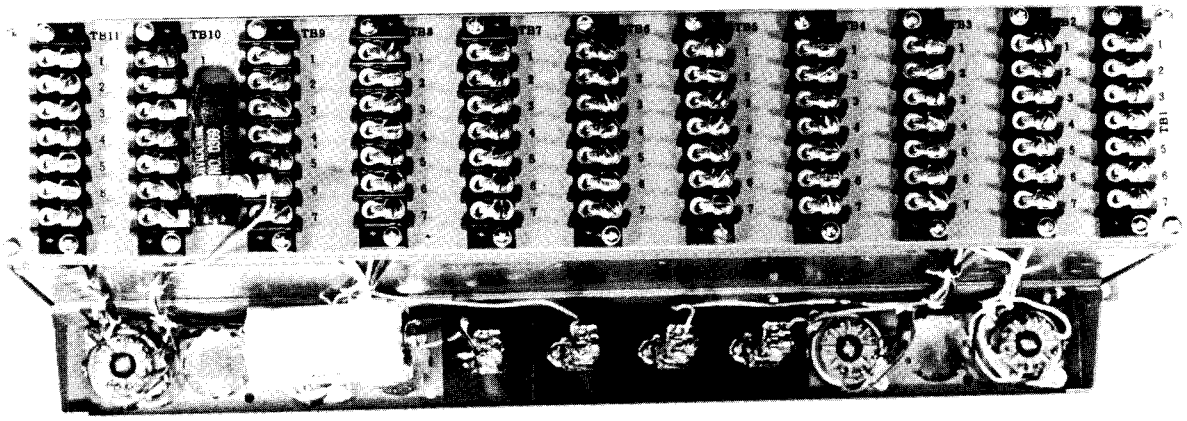


Fig. 2 – Rear View of Full Chassis

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. DC – DC Converter and Regulator

The model HB23705 DC–DC converter is used to provide an isolated regulated power supply from 48V battery to the other modules. The model HB23660 DC–DC converter is similarly used for 125V battery. The model HB23660 is also used in conjunction with external power resistor and zener diode to provide an isolated regulated power supply from 250V battery. A saturating core inverter, rectifiers, and voltage regulating circuits are included in the unit.

Two regulated DC outputs are provided, one at a −24 volt level and one at −12 volts. A non-regulated output of approximately −36 volts is also available for relay operation or for circuits which do not require voltage regulation. Maximum regulated output power is 6 watts at an efficiency of 50% to 35% over the voltage range of 104VDC to 140VDC for the 125V unit and over the voltage range of 42VDC to 56VDC for the 48V unit. For the 250V case, the efficiency is lower due to the external resistor and zener diode used.

D. AM Receiver Noise Squelch (When Used)

The model HB-24030 AM Receiver contains the circuitry to separate the noise signal from the multiplex signals, amplify it, and process the signal into a form that blocks the frequency shift receiver and holds the guard relay picked up. The unit consists of a band pass filter, 3-stage AC amplifier, a rectifier circuit, and a DC amplifier circuit. As in the transmitter, all frequency-determing components are contained in the plug-in filter assembly.

One screwdriver adjustment, the input sensitivity control, is used on the front panel of the receiver. Test points are provided on the front panel for ease of maintenance.

E. Output Relays

The output relays may be either telephone type relays or high speed Mercury-type relays to energize external 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. FDR type AR relay system, the Mercury relays are mounted on a shortened rear bracket. See Fig. 4.

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

The tone assembly for a mercury relay and 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.

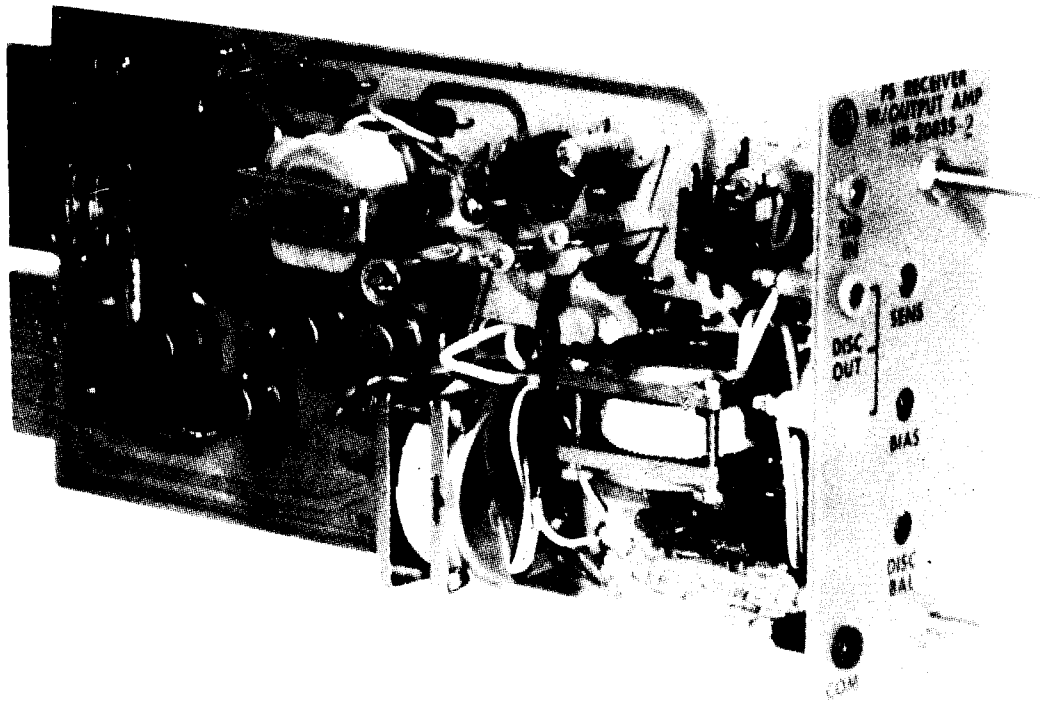


Fig. 3 – Typical Module

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.

THEORY OF OPERATION

Under normal line conditions, the tone transmitter operates at its guard frequency which is 85 Hz 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 Hz 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.

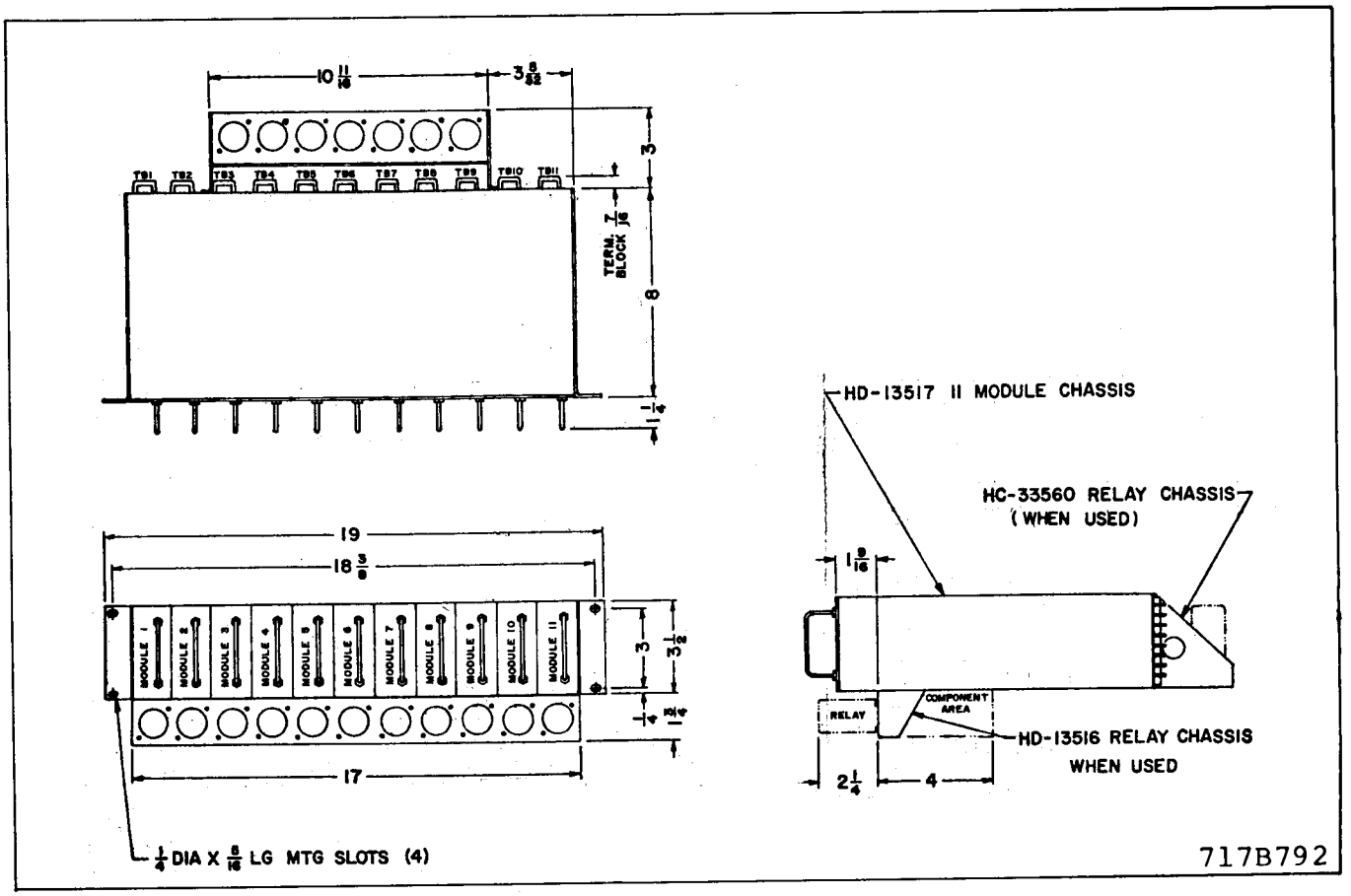


Fig. 4 – Outline and Drilling Plan of 11 Module Chassis

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

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.

C. AM Receiver Noise Squelch (When used-HB 24030)

The filter used at the input of the AM receiver is designed to reject the signals of the adjacent channels, to match the receiver input impedance to the

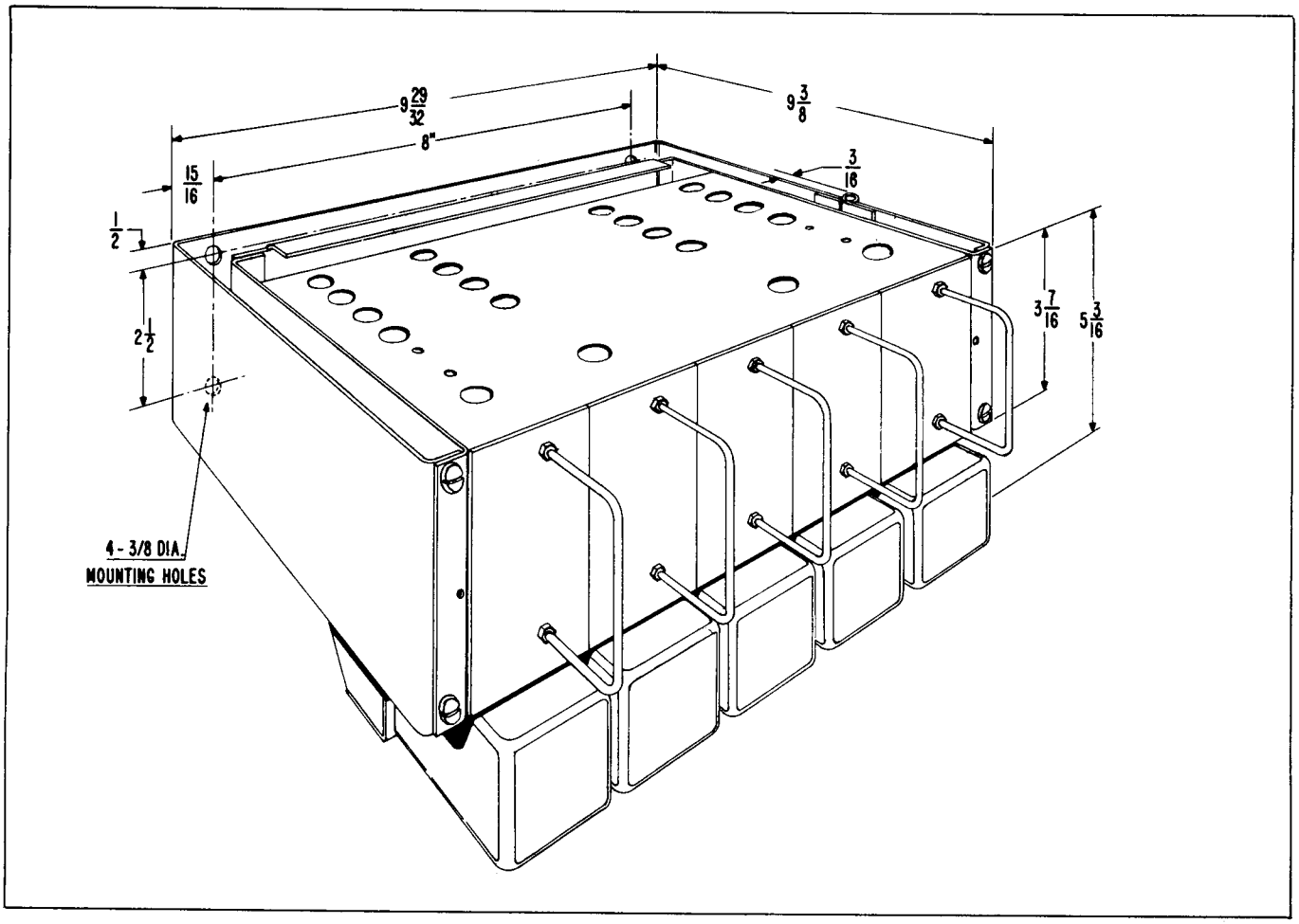


Fig. 5 – Outline and Drilling Plan of 5 Module Chassis

line, and to prevent loading of the adjacent channel signals. The filter has approximately 35dB attenuation to the adjacent channel for the standard channels. This high attenuation provides an extra safety margin for operation in case the channel signal levels at the receiver input become unbalanced.

Across the output of the filter is the receiver sensitivity control R1 (see Figure 8). This control provides the means by which the receiver sensitivity is adjusted. Two RC coupled stages of amplification using Q1 and Q2 as the active elements follow this control. R3 and R2 set the DC biasing for the base of Q1 while R5 and R6 provide emitter self-biasing. C3 acts as a bypass for R6. R5 is not bypassed and introduces degeneration into the stage for greater stability of the circuit under varying conditions. R4 is the collector load for the stage. The operation of the second stage involving Q2 is the same. R12 and C4 act as a decoupling network to prevent self-oscillation in the high-gain receiver.

The third stage acts as an amplifier and driver for the full-wave rectifier stage. T1 is the collector load for Q3 and also matches the impedance of the rectifier circuit to the transistor Q3. The other components of the stage have similar purposes to those described for Q1 or Q2.

With no signal Q4 is biased to cut-off by means of R21 and certain circuits through Q5. R22 is the load resistor for Q4. Direct coupling is used between the collector of Q4 and the base of Q5. The load resistor for Q5 is R23. The output of Q5 is coupled through two diodes in series (CR3 and CR4) to the base of Q6. With no signal Q6 is cut-off. When a "noise" signal arrives the base of Q6 is driven positive with respect to its emitter causing Q6 to conduct through the FS receiver. The rectifier circuit produces a positive voltage output and if sufficient signal is applied this voltage overcomes the reverse bias on Q4 and the transistor conducts. C8, C9 and R17 form a low pass RC filter to remove the carrier components. This filter is capable of passing 10 Hz but cuts off somewhat above this frequency.

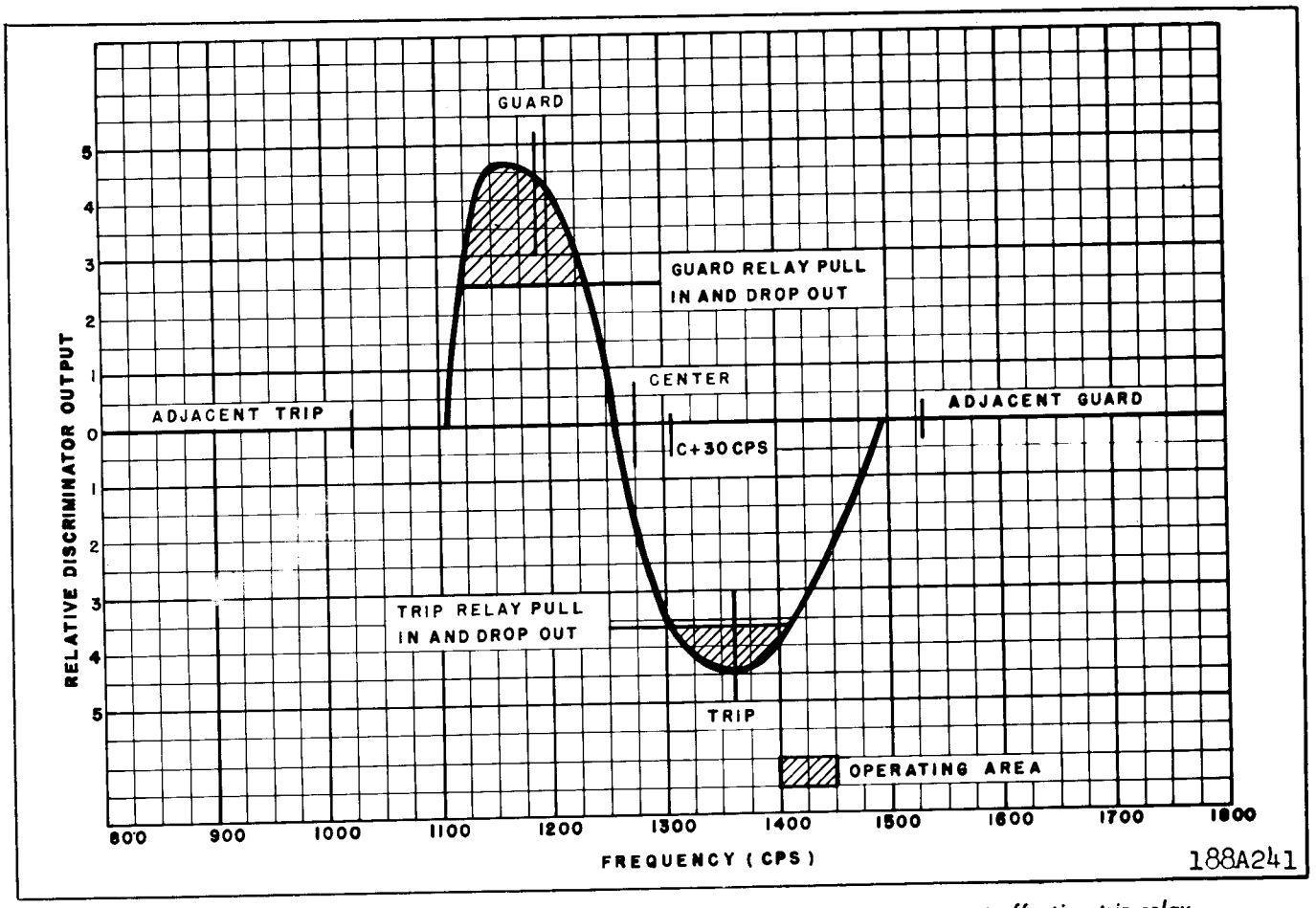


Fig. 6 – Typical discriminator output curve showing relative noise power output affecting trip relay.

CHARACTERISTICS

General

Channel Frequencies: Hz	935 1955 1275 1615 2295 2635 (For special applications, additional frequencies can be supplied).
Shift in Frequency:	± 85 Hz
Operating Temperature:	−20° to 60°C
Operating Time: (Includes guard relay drop-out time and trip relay pickup time)	17-20 ms with telephone type output relays. 13-15 ms - with Mercury relay plus type AR output relays.
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 Hz
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 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 3.7 ma for mercury type 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 such that the receiver is disabled whenever the noise

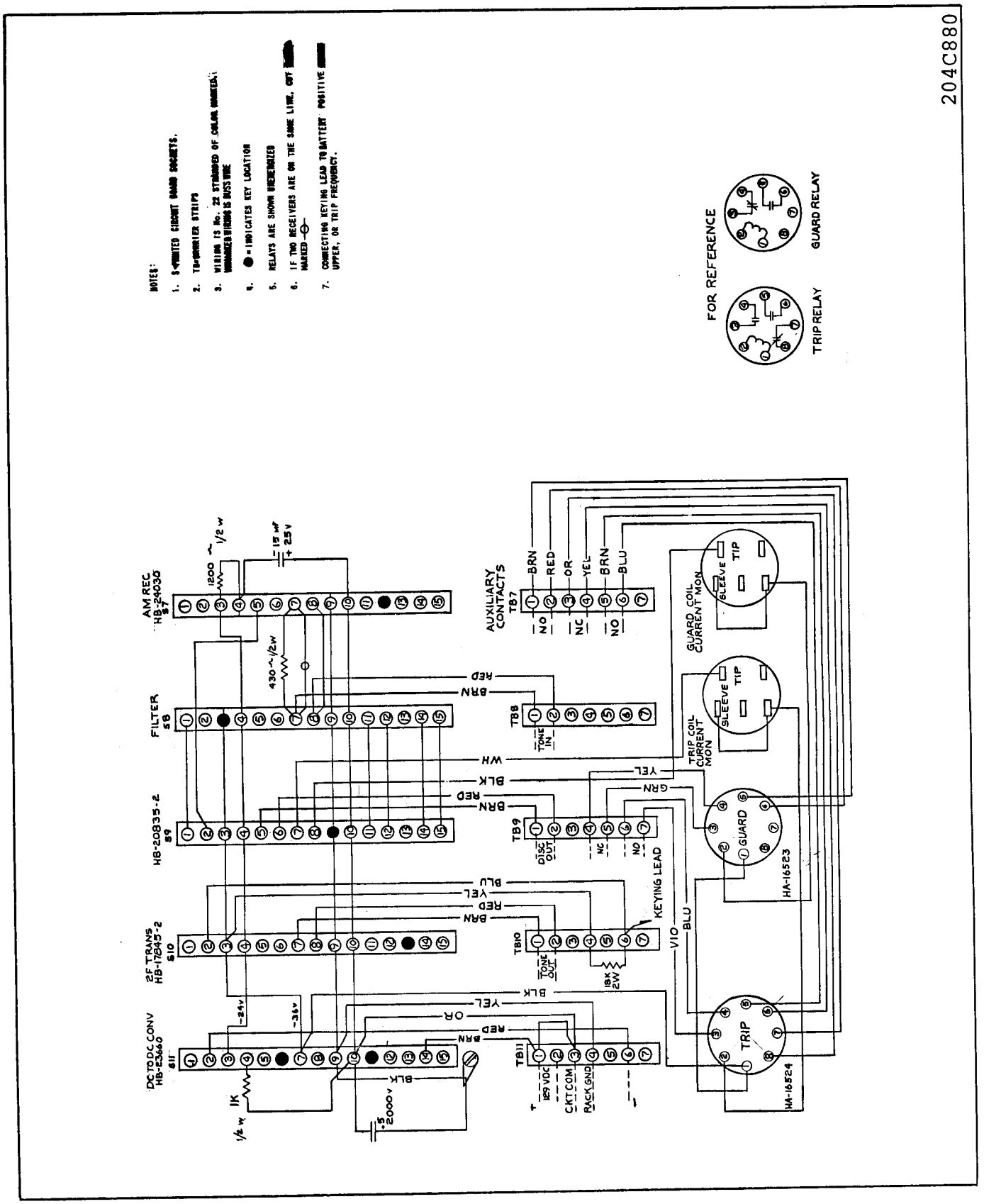


Fig. 7 Typical Terminal Block Drawing of Type TA-1 Assembly. (CR Dwg.)

measured in the 300-480 Hz 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 Hz, -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

DC to DC Converter

Non regulated voltage = 40 to 27 vdc

Hi regulated voltage = 24 vdc

Lo regulated voltage = 12 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 Hz.

Trip frequencies - Normal or center frequency plus 85 Hz.

Output -at least + 1 dbm

FS Receiver

With receiver input 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 Hz −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 0-500 microammeter with a 5100 ohm resistor in series into the test points marked "Disc Out".

Type AR Output Relay (when used)

The AR Auxiliary relay may be used in cases of transfer trip. See appropriate I.L. for charactestics of this relay.

Adjustments (Calibration)

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 Hz 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.

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

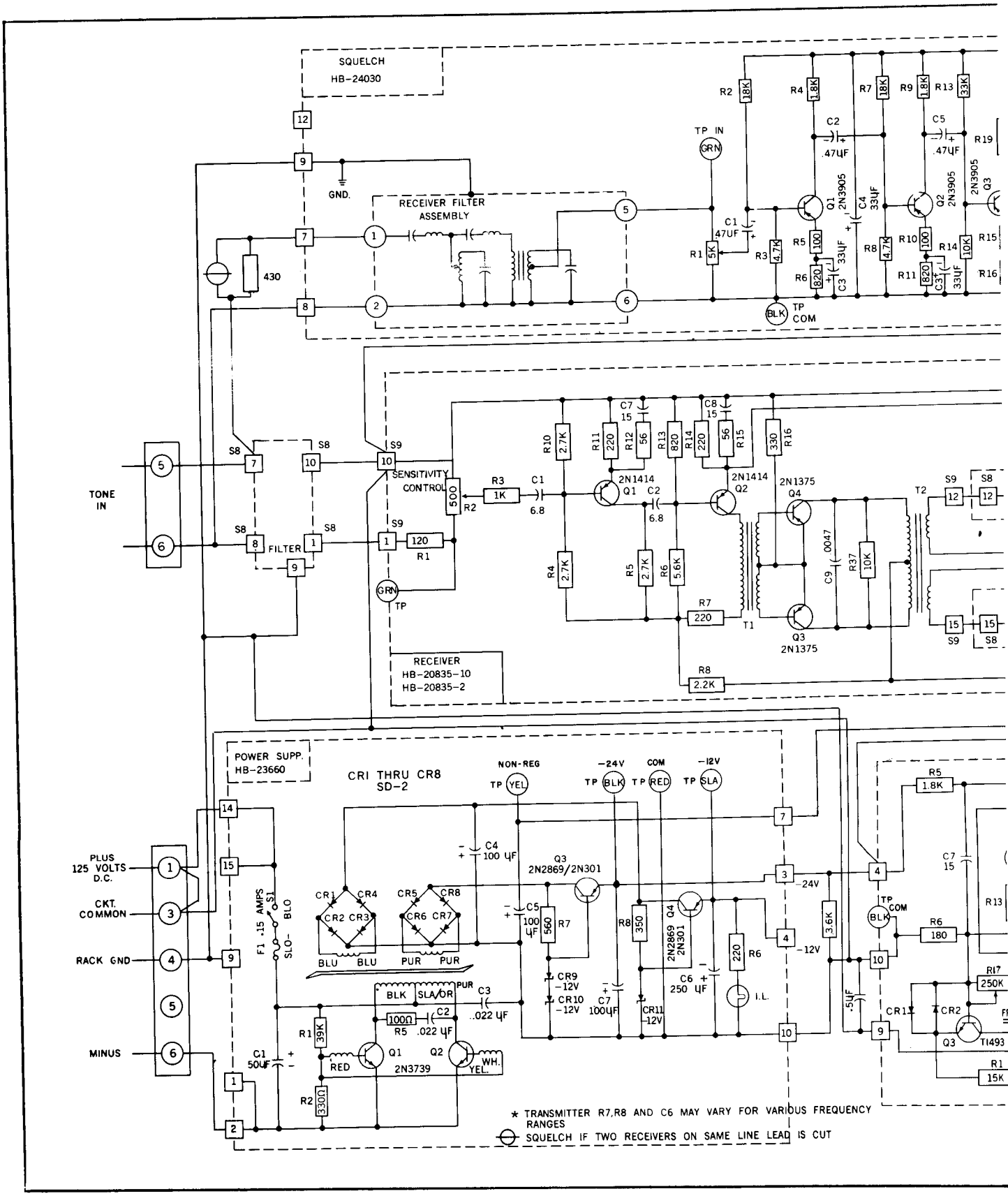
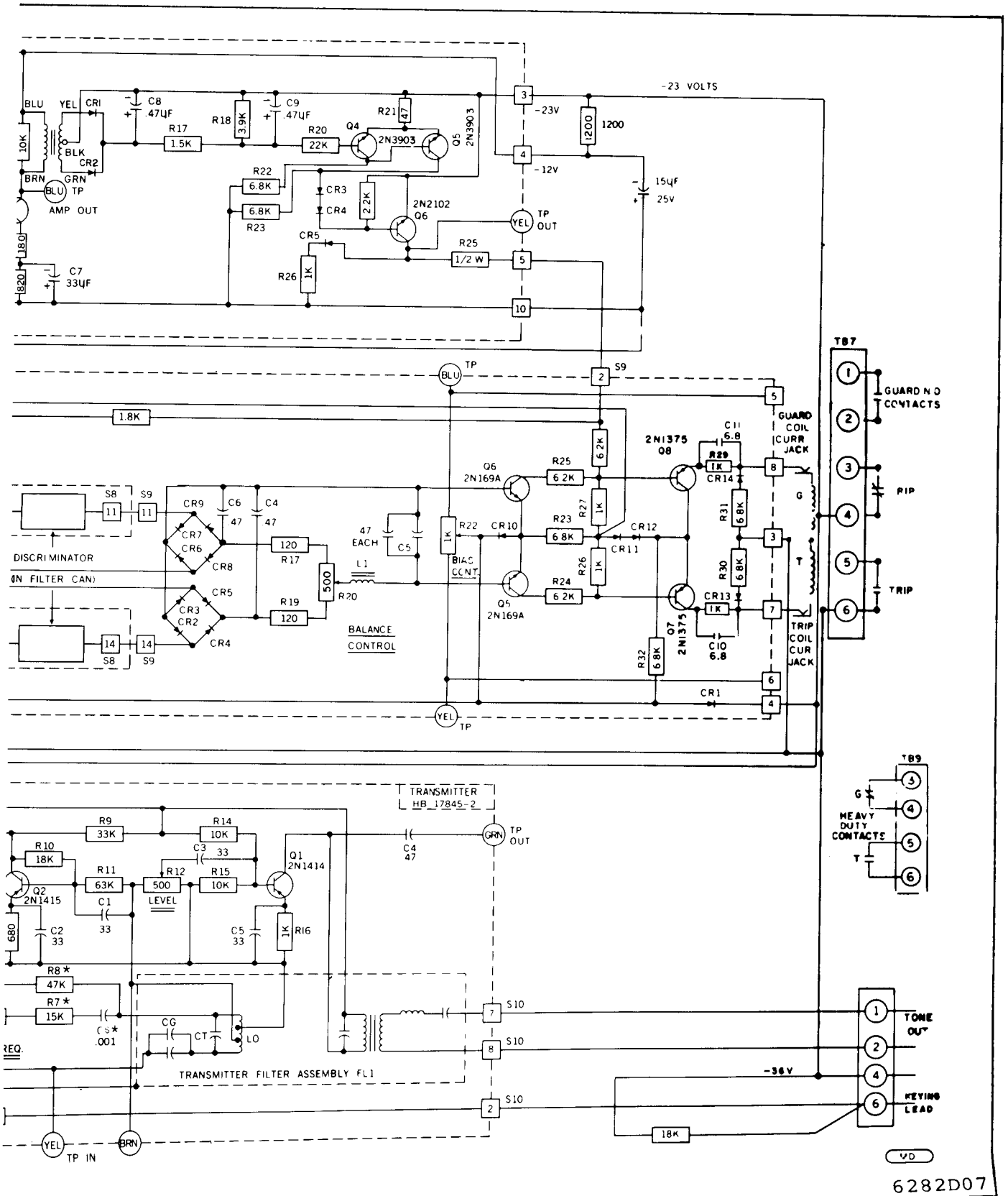


Fig. 8 Typical Schematic Diagram of Type TA-1 A



sembly (with Telephone Relay Output).

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 Hz 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 superimpose a 400 Hz -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.

Voltage Regulator

No adjustments. - Note voltage levels per Table 1.

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.

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.

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 the Table of Electrical Parts.

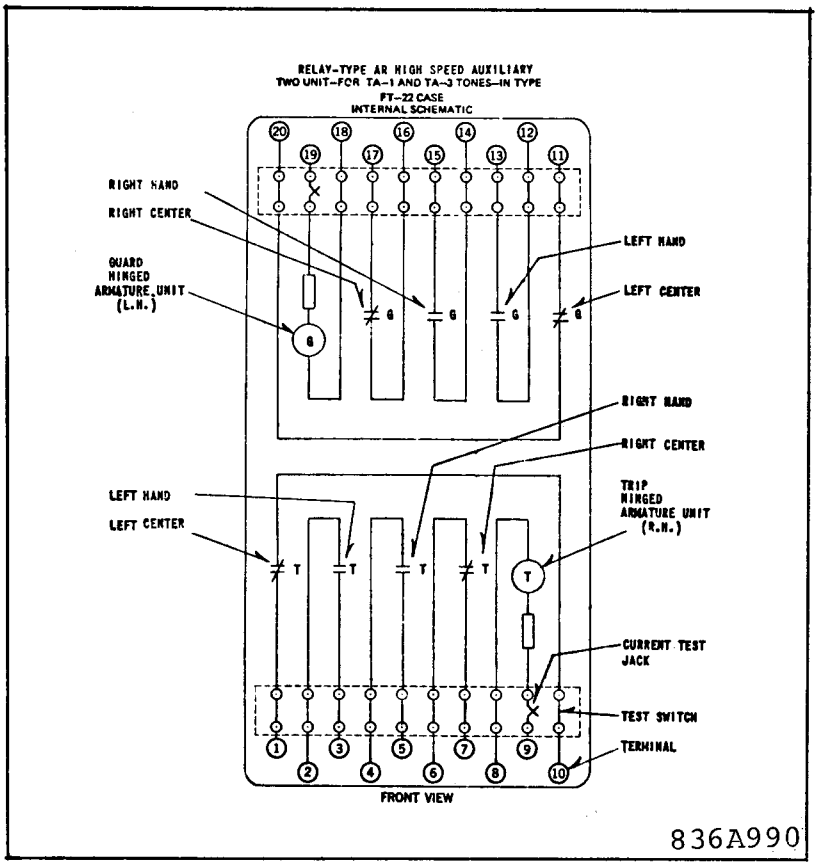


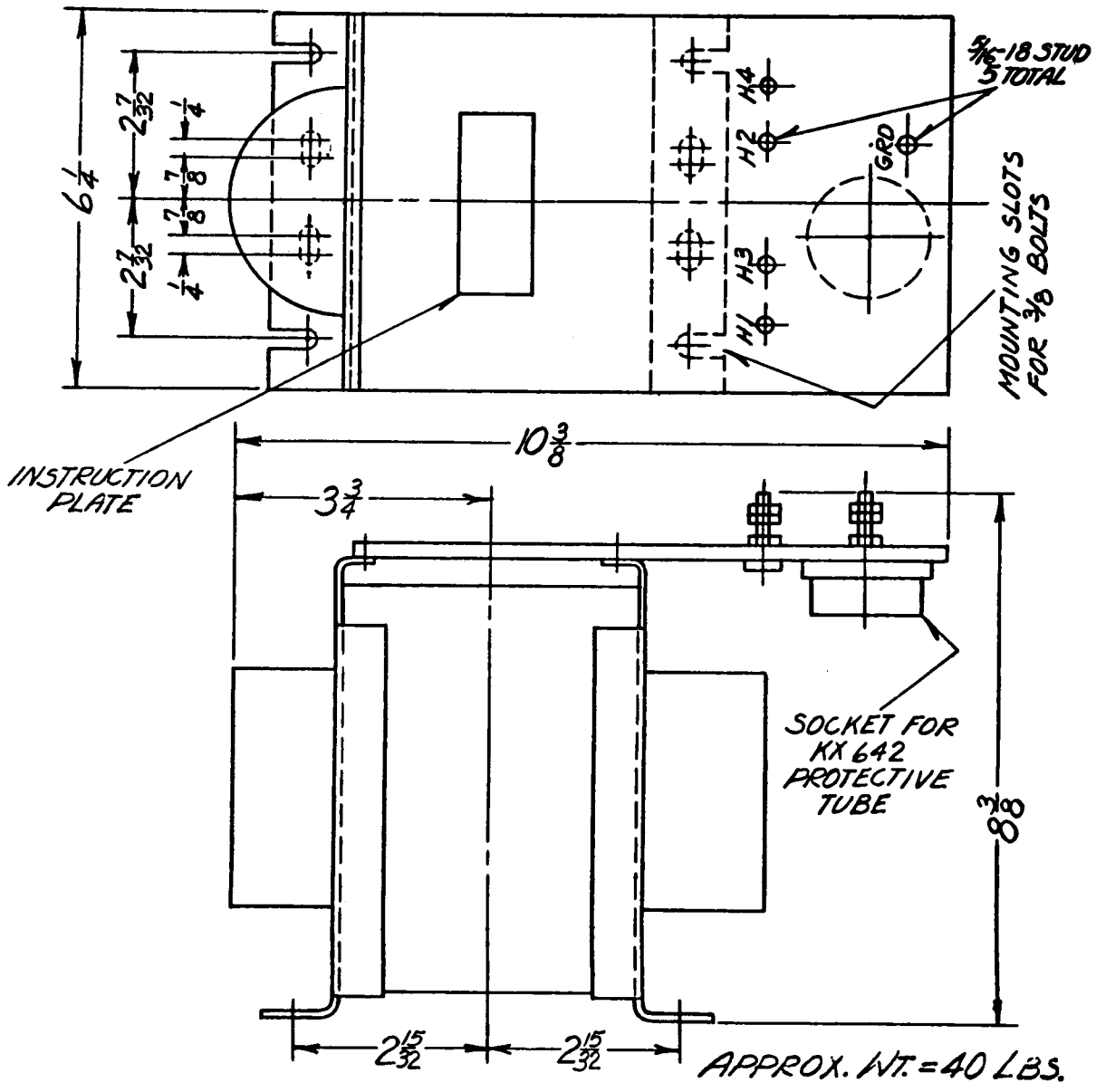
Fig. 10 Internal schematic of the type AR relay for use with TA-1 tones. (For Reference Only)

TABLE I – VOLTAGE LEVELS

Measurements taken with respect to circuit common: –20 dbm guard signal 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 POINT	
		AC	DC	AC	DC	AC	DC	AC	DC	AC	DC	AC	DC	AC	DC	AC	DC		
DC to DC Converter and Voltage Regulator (125V) HB-23360	E	0	0	0	0	–	24	–	12									Hi Reg	24VDC
	B	2.3	1.6	2.3	1.5	–	24	–	12									Lo Reg	12VDC
	C	125	–	125	–	–	34	–	19.3									Non Reg	34VDC
FS Transmitter HB-17845-2	E	7mv	4.35	4.2mv	.8	1mv	.67											Out	.12VAC
	B	2mv	4.5	.045	.9	<1mv	0											C	.046VAC
	C	.12	9.6	3.0	4.8	1mv	.67												
FS Receiver HB-20835-2 HB-20835-10	E	.5mv	.45	3mv	.75	2.1	2.7	2.1	3.7	.033	22	.033	22	2mv	1.5	2mv	1.5	IN	.039VAC
	B	.8mv	.6	5mv	.9	2.4	3.8	2.6	3.8	.03	24	.033	21.8	3 mv	0	3mv	1.2	Disc. Out-Equal and opposite VDC at guard and trip	
	C	5mv	1.7	1.1	4.8	12	22	12	22	4mv	0	.033	22	4 mv	36 43 †	<.1m	1.6		
AM Receiver HB-24030 (Adjusted to Squelch with –40 dbm 400 cps tone input.)	E	2mv	2.15	.016	2.15	.13	2.45		23		23		23					In	.01VAC
	B	2mv	2.3	.018	2.3	.15	2.65		23		13.5		23					OUT	1.2VDC
	C	.019	7.4	.16	7.4	5	2.45		13.5		22.5		0					V	5.0VAC
DC to DC Converter and Voltage Regulator (48V) HB-23705	E	0	0	0	0	–	24		12									Hi Reg	24VDC
	B	2.2	1.4	2.2	1.4	–	24		12									Lo Reg	12VDC
	C	48	–	48	–	–	34		19.3									Non Reg	34VDC

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



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. 16 Drainage Reactor Outline.

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 Hz bandwidth, 340 Hz spacing.	
H-1007-439	CAPACITOR, tantalum: 33 μF, 10V.	C1, 2, 3, & 5
H-1007-439	CAPACITOR, tantalum: 15 μ F, 25V.	C7
HA-13579	CAPACITOR, ceramic: 0.47 μ F, 25 V DC +80%. −20%.	C4
H-1080-245	CAPACITOR, silver mica: .001 μ F ±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; 3.3K, ±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" 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; T1493.	Q3, Q4
HA-3165	DIODE, silicon: SG22 (Stabistor).	CR1, CR2
	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 μ F, 25 V.	C1, C2
H-1007-439	CAPACITOR, tantalum: 15 μ F, 25 V.	C3, C7, C8
H-1007-92	CAPACITOR, ceramic disc: .0047 μ F, 600 V.	C9
H-1007-403	CAPACITOR, solid electrolytic tantalex: 6.8μF, ±20%, 35 W VDC.	C10, C11
HA-13576	CHOKE: 1 H.	L1

TABLE OF ELECTRICAL PARTS

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
	HB-16527 FS RECEIVER (Continued)	
HA-10271	DIODE, silicon.	CR11, CR12
HA-13242	DIODE, germanium.	CR 1,2,3,4,5,6, CR 7,8,9,10,13,14
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: 2.2K ±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; 2.7K, ±10%, ½ w.	R10, R5
H-1009-544	RESISTOR, fixed: comp; 220 ohms, ±10%, ½ w.	R 11, 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
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, Q1
HA-17117	TRANSISTOR: PNP, germanium; 2N1375.	Q4, 7, 8 & 3
HA-16523	Guard Relay	
HA-16524	Trip Relay	

TABLE OF ELECTRICAL PARTS

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
	HB-24030 RECEIVER MODULE W/O FILTER	
HA-13572	RESISTOR, variable: comp. 5K .25 watt "A" taper CTS PE200	R1
H-1009-X	RESISTOR, fixed comp.: ±5% ¼ watt, values as shown in Figure 2.	R2-R21
H-1009-X	RESISTOR, fixed comp.: ±10% ½ watt, values as shown in Figure 2.	R22, R23
H-1009-X	RESISTOR, fixed comp.: ±5% ¼ watt, values as shown in Figure 2.	R24, R26
H-1007-511	CAPACITOR, tantalum: .47μF ±10% 35V Texas Inst. SCM474FPO35D2	C1, C2, C5, C8, C9
H-1007-656	CAPACITOR, tantalum: 22 μF ±20% 15V Texas Inst. SCM226BPO15D4	C4
H-1007-653	CAPACITOR, tantalum: 33μF ±20% 10V Texas Inst. SCM336BPO10D4	C3, C6, C7
HA-24325	DIODE, silicon: 1N914 250 m W Texas Inst. or G.E.	CR1-CR5
HA-24087	TRANSISTOR, silicon: PNP BVCEO 40V 2N3905-18 Motorola	Q1-Q3
HA-25567	TRANSISTOR, silicon: NPN BVCEO 40 V 2N3403-18 Motorola	Q4, Q5
HA-22678	TRANSISTOR, silicon: NPN 2N2102 RCA	Q6
HA-3175	TRANSFORMER, CT8K: 2K CT	T1
	TEST JACKS, Sealectro Corp. SKT-10	
HB-56500-X	BAND PASS FILTER (State frequency required)	
HA-13913	RESISTOR, fixed, comp: 8.2K, ±10%, ½ w.	R18
H-1009-431	RESISTOR, fixed, comp: 270 ohms, ±10%, ½ w.	R19
HA-13588	RESISTOR, variable: 2.5K, 0.25 W, stand. length shaft 1/8" beyond mtg. surface; linear taper; screwdriver adjust.	R20
H-1009-530	RESISTOR, fixed, comp: 5.6K, ±10%, ½ w.	R22
HA-3175	TRANSFORMER: primary impedance ohms 2000 CT; sec. impedance ohms 800 CT; 150 mv O/A 1 x ¾ x ¾.	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-23660 DC TO DC CONVERTER AND VOLTAGE REGULATOR (For 125V)	
H-1009-766	RESISTOR, comp.: 220 ± 10%, ¼ watt.	R6
H-1009-362	RESISTOR, comp.: 330 ± 5%, ½ watt.	R2
H-1009-39	RESISTOR, comp.: 39000 ± 5%, 1 watt.	R1
HA-23650	RESISTOR, WW: 100 ±3%, 10 watt, Dale Elect., RH10.	R5
H-1100-499	RESISTOR, WW: 560 ±5%, 5 watt, Ohmite 995-5B.	R7
H-1100-498	RESISTOR, WW: 350 ±5%, 5 watt, Ohmite 995-5B.	R8
H-1007-635	CAPACITOR, elect.: 50μF, 150WVDC, Cornell Dub. BR50-150.	C1
H-1007-209	CAPACITOR, elect.: 100μF, 50 WVDC, Cornell Dub., BR100-50.	C4, C5, C7
H-1007-636	CAPACITOR, elect.: 250μF, 25 WVDC, Cornell Dub. BR250-25.	C6
H-1007-637	CAPACITOR, met. paper: .022μF, 400 WVDC, Cornell Dub., MPY-4S22.	C2
H-1007-638	CAPACITOR, mylar, .022μF, 600 WVDC, Cornell Dub. PKM-6S22.	C3
HA-17995	DIODE, silicon: 200 PIV, 1 Amp., Diodes Inc., SD-2.	CR1-CR8
HA-12920	DIODE; Zener: 12 V ±5%, Diodes Inc., 1D12B.	CR9, CR10, CR11
H-23663	TRANSISTOR, silicon: NPN, TO-66, Motorola 2N3739.	Q1, Q2
HA-17992	TRANSISTOR, germanium: PNP, TO-3, RCA 2N2869/2N301.	Q3. Q4

TABLE OF ELECTRICAL PARTS

RFL PART NO.	NAME OF PART AND DESCRIPTION	DIAGRAM SYMBOL
HB-23660 DC TO DC CONVERTER AND VOLTAGE REGULATOR (FOR 125V) (Continued)		
HB-23664	Saturable Core transformer.	T1
HA-17505	Light, Indicator: 10 V @ .014A, Dialco #39-10-931.	I1
HA-14392	Fuse, 3 AG, .15 Amp. SLO-BLOW, Fusetron MDL.	F1
HA-13554	Switch, push button, Leviton # 579.	S1
	Sealectro Corp., SKT-10.	Test Jacks
HA-18538	Transistor socket, TO-3, Augat Bros., 8043-1G3.	
HA-21848	Transistor socket, TO-66, U.I.D. Electronics, PTS-4.	
HA-23018	Heat sink, 2 TO-66 Transistors.	
HB-23659	Heat sink, 2 TO-3 Transistors and resistor.	
MISCELLANEOUS		
HA-17159	CAPACITOR: Plastic, 0.5μF, 2000 WVDC, used on chassis	
HB-23705 DC TO DC CONVERTER AND VOLTAGE REGULATOR (For 48V)		
H-1009-766	RESISTOR, comp.: 220 ±10%, ¼ watt.	R6
H-1009-713	RESISTOR, comp.: 24 ±5%, ½ watt.	R3, R4
H-1100-460	RESISTOR, WW: 5000±5%, 3 ¼ watt, Ohmite 995-3A.	R1
HA-23709	RESISTOR, WW: 50 ±3%, 10 watt, Dale Elect., RH10.	R5
H-1100-499	RESISTOR, WW: 560 ±5%, 5 watt, Ohmite 995-5B.	R7
H-1100-498	RESISTOR, WW: 350 ±5%, 5 watt, Ohmite 995-5B.	R8
H-1007-395	CAPACITOR, elect.: 80μF, 150 WVDC, Cornell Dub., BR80-150.	C1
H-1007-209	CAPACITOR, elect.: 100μF, 50 WVDC, Cornell Dub. BR100-50.	C4, C5, C7
H-1007-636	CAPACITOR, elect.: 250μF, 25 WVDC, Cornell Dub. BR250-25.	C6
H-1007-674	CAPACITOR, met. paper: .047μF, 200 WVDC, Cornell Dub. MPY-2S47.	C2
H-1007-638	CAPACITOR, mylar, .022μF, 600 WVDC, Cornell Dub. PKM-6S22.	C3
HA-17995	DIODE, silicon: 200 PIV, 1 Amp., Diodes Inc., SD-2.	CR1; CR8, CR12
HA-12920	DIODE, Zener: 12 V ±5%, Diodes Inc., 1D12B.	CR9, CR10, CR11
HA-21847	TRANSISTOR, silicon: NPN, TO-66, RCA, 2N3583.	Q1, Q2
HA-17992	TRANSISTOR, germanium: PNP, TO-3 RCA 2N2869/2N301.	Q3, Q4
HB-23704	TRANSFORMER, saturable core.	T1
HA-17505	LIGHT, INDICATOR: 10 V @ .014A, Dialco # 39-10-931.	I1
HA-23708	FUSE, 3 AG, .300 Amp. SLO-BLOW, Fusetron MDL.	F1
HA-13554	SWITCH, push button, Leviton # 579.	S1
	Sealectro Corp. SKT-10.	Test Jacks
HA-18538	Transistor socket, TO-3, Augat Bros., 8043-IG3.	
HA-21848	Transistor socket, TO-66, U.I.D. Electronics, PTS-4.	
HA-23018	Heat sink, 2 TO-66 Transistors.	
HB-23659	Heat sink, 2 TO-3 Transistors and resistors.	

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