INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TA-2.2 FREQUENCY-SHIFT AUDIO TONES

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

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

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

APPLICATION

The type TA-2.2 tones are of the high speed frequency shift type that are used in conjunction with a permissive relaying system. They are applied in the dual-phase comparison system for the protection of a transmission line.

The TA-2.2 tone channel is available in two band-widths (340 Hz and 600 Hz). In order to provide a high speed tripping system the 600 Hz band-width tone should be used with dual phase comparison. The only application where the 600 Hz tone can not be used is when a three terminal power line is being protected using a two wire audio channel. In this case, the 340 Hz band-width tone must be used in order to provide the needed frequencies.

The TA-2.2 equipment may be used directly over a pilot wire pair or may be multiplexed on a microwave or other carrier channel. When using the 600 Hz band-width tones, the maximum channel delay (exclusive of TA-2.2 delay) that can be tolerated is 3.5 ms. For the 340 Hz band-width tones this maximum delay is 2 ms.

SECURITY MEASURES

The TA-2.2 tone system has been designed to obtain maximum security against noise. The TA-2-2 takes advantage of the inherent noise rejection characteristics of a frequency-shift receiver so that the relaying can be depended upon to trip when needed. The tone receiver is expected to operate with a minimum in-band signal-to-noise ratio of 9 db. Since an increased noise level on the pilot wire may often be concurrent with a trip request, the noise clamps are adjusted at a level based on the above minimum signal-to-noise ratio to avoid unnecessary clamping of the receiver.

The system provides a 300-1000 Hz band-pass filter and receiver to sample the random noise level of the pilot channel. This receiver will protect against false tripping due to random noise. In conjunction with the band-pass filter there is a line level monitoring system which samples the total frequency spectrum of the channel, and is set to operate for an overall increase of energy on the pilot channel. This monitoring feature will protect against false trips due to impúlse noise which may have energy concentrated about frequencies not seen by the 300-1000 Hz noise filter. When noise has caused the blocking of a receiver, the drop-out of the blocking is delayed by 10 msec. to override the receiver response time.

Also available as an option is a frequency translation protection circuit. This is applied to protect against tone frequency variations caused by a pilot carrier frequency shift.

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 light of the following facts. The period of usefulness during the lifetime of any given installation will be very small. Yet this infinitesimal period (compared to years) is precisely the time when noise levels can be adnormally high and 60-Hertz disturbing voltages will appear on the pilot wire. The recommendations summarized in Figs. 1 and 2 have been formulated with the above facts in mind.

For a recommended installation:

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

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

c. Do not use open pilot wires.

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

e. Use surge protection across tone connection.

To protect personnel, use an isolating transformer (S#187A995H01 serves the dual purpose of impedance matching and isolation.) Mount it with the drainage and neutralizing devices in an enclosure marked "High Voltage".

Fig. 1 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

Type TA-2.2 tone equipment has been designed for protective relaying applications. Modular design is used, and a system is assembled using plug-in modules to meet the requirements of a specific application. Figure 3 shows a typical system.

In a typical relaying application, the tone system consists of the following modules. (The basic module construction is shown in Figure 4).

A. POWER SUPPLY MODULES (See Figure 3 for Internal Schematic)

1. <u>**DC to D-C Converter**</u> HB25190 (48V d-c), HB25200 (125V d-c)

   The converter contains a saturable core inverter with two separate output windings rectifiers to deliver positive and negative output voltages to the regulator. This module is supplied for either 48 or 125V d-c, and there is a 125V d-c external zener regulator for use in conjunction with the 125V d-c converter when a 250V d-c supply is used. There is a blown fuse indicator light and also a power-on light on the modules.

2. <u>**Voltage Regulator**</u> HB25210 (See Fig. 4 for Internal Schematic)

   The regulator module consist of two regulator transistors with the necessary associated circuitry. In addition, there is a loss-of regulator indicator on the front panel and an output amplifier to operate an optional relay for power supply loss-of-regulation indication.

   In order to provide the proper heat dissipation, the Voltage Regulator Module is mounted on the extreme left of the chassis. This will provide the module with vent holes which are beneficial for cooling of the regulator transistors by natural convection. An additional regulator may be mounted on extreme right of the chassis.

B. TRANSMITTER MODULES

1. <u>**Transmitter Module**</u> –HB-24335-26 (Fig. 6)

   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 are the frequency determining components and are contained in a separate plug-in enclosure on the transmitter module.

2. <u>**Beat Frequency Oscillator And Demodulator Module**</u> – HB.25640 (Fig. 7)

   The beat frequency oscillator and demodulator module consists of an oscillator, a mixing circuit, and an amplifier. The tuned circuits for the beat frequency oscillator are contained in a sealed plug-in assembly. The front panel provides controls for adjustment of the output level frequency, and includes test jacks for monitoring these adjustments.

C. RECEIVER MODULES

1. <u>**Receiver Filter Module**</u> – HB58700

   This module is a band-pass filter which connects the demodulator to the receiver. The sum frequencies of the demodulator and the audio frequency carrier are selected to be passed by the filter.

2. **Frequency Shift Receiver Module-** HB19915-27

The receiver module consists of a limiting amplifier,a specially tuned discriminator, rectifying and filter circuitry and two d-c amplifiers. A low signal squelch circuit is also included in this module. In addition, a carrier detector circuit is included for driving an external relay on low signal for alarm purposes.

D. NOISE SUPERVISORY MODULE

NOTE: One set is needed for every telephone line used.

1. **Noise Filter Module** HB55187 or HB55283

(Fig. 11) (Notched for 425 Hz Transmitter) (Some systems use 595 Hz Transmitter) This module contains a filter (see Fig. 18) that samples noise in the 300 to 1000 Hz region. There are two different types of filters. Filter module HB55283 has a rejection notch at 425 Hz and is used in conjunction with a 425 Hz transmitter located at the remote terminal for detection of carrier drifts. This system is used on four-wire telephone channels where there is a possibility of carrier shifting the telephone band, which affects the F.S. receiver intelligence by conditions existing outside of the transmitters and receivers.

2. **Receiver Line Level and Noise Supervisory Module** HB25150 (Fig. 12)

This module consists of two receivers (see Figure 19). One of them uses the output from the noise filter module for the Noise Supervisory function. The line level receiver uses the entire tone band to supervise the total in-band level of noise (this includes the frequencies usedfor protective line relaying).

An abnormal signal of sufficient strength on either of the receivers will cause an output on the line level and noise supervisory modules which will clamp both mark and space outputs on the tone receiver to 0V D.C. and gives an indication on the front panel.

E. 425-HZ TRANSMITTER HB21050-12 (Fig. 13)

(Some systems use 595 Hz)

NOTE: One of these units is needed for each telephone pair when used. This transmitter is to be used in conjunction with HB55283 notch filter. Its function is to block the end through the noise supervisory module when there is frequency deterioration between the transmitter and the receivers in a telephone line. It consists of a 425-Hz frequency-shift transmitter with an output filter.

F. CARRIER DETERIORATION DETECTOR – HB24030-3 (Fig. 9)

This is an AM receiver available as an option. The output is used to drive a microammeter to determine the signal level received from the remote transmitter. It is connected to the output of the wide-band filter of the FS receiver.

G. LOGIC INTERFACE (Fig. 19)

The logic interface consists of zener diodes, diodes, and resistors on the inputs to the tones as insurance against random noise and high voltage inputs to the tones causing misoperation. In addition it contains transistors, diodes, and resistors on the output of the tones to provide proper output levels for interfacing with solid state relays as well as protection against misoperation due to random noise or high voltage pickup.

H. HYBRID FOR TWO WIRE TERMINATION HB35315 (Fig. 16)

This module is used for applications requiring just two wire termination for both transmitter and receivers. It is used to isolate the local transmitter from the receiver when a single line pair is used. It contains plug in jumpers for selecting capacitor values for matching telephone line characteristics along with adjustable resistor R1. It also contains plug in jumpers for selecting termination impedance of either 600 ohms or 900 ohms.

OPERATION

As shown in Figure 5, the output of a high frequency oscillator in the TA-2 tone set is beat with the output of a lower frequency oscillator. The difference frequency or the translated frequency is applied through a band-pass filter to the pilot channel. By keying the transmitter with a voltage, the frequency is shifted from one frequency to a second frequency. At the receiving end of the channel, the incoming audio tone frequency is translated to the higher frequency of the transmitter and is applied to the FS receiver through a band-pass filter. The receiver converts the frequency to a d-c voltage which is applied to the relaying scheme.

In a dual phase comparison relaying system, the phase relationship of square wave pulses are compared to determine if a fault is internal or external to the protective transmission line – a pulse derived from the 60 Hertz current at one line terminal is compared in phase relationship to a pulse received from a remote line terminal. The transmitter is shifted in frequency at a rate equal to the power system frequency. On alternate half cycles, either a mark or space frequency is applied to the pilot channel and is received at the remote terminal. The receiver converts the mark and space frequencies to two d-c pulses which are applied to the dual phase comparison relay for comparing to local pulses at the remote terminal.

A. POWER SUPPLY MODULES (See Figures 3 and 4 for Internal Schematics)

Converter (Fig. 3)

The d-c to d-c converter contains a saturable core type multi-vibrator with Q1 and Q2 acting as switching transistors for transformer T1 in series with the applied battery voltage. Starting current is applied through R1 and oscillations are maintained at a nominal 500 Hz by the drive from the feedback windings in the base circuit. Capacitor C1 provides the high-surge current which occurs during the switching interval as the magnetic field of T1 reverses and Q1 and Q2 change their conducting states. Capacitor C1 and the 6.38-mHy choke provide a low-pass filter section to reduce high-voltage transients on the battery bus for protection of transistors Q1 and Q2. Oscillator switching transients are attenuated by R5 and C2. Two secondary windings on T1 feed the bridge rectifier circuits, C41 through CR8, to develop separate positive and negative output voltages.

Regulator (Fig. 4)

Polar output voltages from the d-c to d-c converter are applied to the Voltage Regulator HB25210. Transistor Q3 is the series regulating element for the positive voltage input. Resistors R6, R7, and R8 comprise a voltage divider across the emitter-follower output. A portion of this output voltage is fed back to the base of Q1 and compared with a reference voltage across the zener diode CR1 in the emitter circuit. The difference voltage across the base-emitter junction of Q1 controls the collector current through load resistor R1. The voltage drop across R1 is coupled by emitter follower Q2 to the base of Q3. Any change in the output voltage at the emitter of Q3 is opposed by a change in base voltage as a result of the controlling current flow in R1. The feedback voltage from the voltage divider circuit is made variable by resistor R7 to permit accurate setting of the output voltage level. Transistors Q4, Q5 and Q6 provide a similar regulator circuit for the negative voltage output.

The regulation indicator circuit is essentially a bridge connected across the positive and negative output terminals of the polar power supply, a span of 36 volts. One leg of the bridge is the 18-volt zener diode CR3. The output leg of the bridge is between the zener diode and the center arm of potentiometer R19. R19 is adjusted for a zero-volt output, or balance, at a total power-supply output of 36 volts. A change in power supply level after balance adjustment will produce a ± voltage change at the bridge output. This is detected by a complementary Schmitt trigger circuit consisting of Q7, Q8, Q10, and Q11. At balance, Q7 and Q10 are both cut off, and transistors Q9 and Q12 are two closed switches in series to energize the indicating lamp plus a remote relay. An increase in one or both of the supply output voltages will cause Q7 to conduct, and a decrease in one or both voltages will cause Q10 to conduct. Conduction of either Q7 or Q10 will open the associated series switching transistor, and the lamp and relay will be de-energized.

B. FS TRANSMITTER – HB-24335-26

The oscillator shown schematically in Figure 6 is tuned to a high frequency relative to the audio tone channel frequency. The output of the oscillator is applied to a balanced modulator circuit which is driven by a beat frequency to produce a difference frequency equal to that of the audio tone channel. Both sidebands thus generated are applied to an amplifier having a band-pass filter in the output circuit. The filter rejects the upper sideband and passes the lower sideband to the line. A shift in the frequency of the oscillator when keyed will produce the same amount of shift in cycles of the audio tone output.

The oscillator stage includes transistor Q1 and associated circuit components. The tuned circuit consists of inductance L_O and the Capacitor C_M. C_S and C_C are the frequency shifting capacitors.

Oscillations from the tuned circuit are coupled to the base of Q1 by capacitor C3. Feedback to the tuned circuit from the collector of Q1 is through resistor R3. The network consisting of C2, R6 and variable resistor R7 allows frequency adjustment by variation of the effective capacity of C2 across a portion of the tuned circuit.

The secondary winding on L_O is center-tapped and serves as a part of the balanced modulator which includes switching transistors Q3 and Q4. The bases of Q3 and Q4 are driven with the beat frequency voltage from a center-tapped winding on the BF Oscillator module. Both sidebands appear across the LEVEL control R10 from which they are coupled to the base of the output amplifier Q2. The band-pass filter in the collector circuit of Q2 rejects the upper sideband and passes the lower sideband to the line.

Capacitors C_C and C_S are strapped in parallel on the circuit board and clamped by Q5, forward biased at the emitter, across L_O to generate a Space frequency. A negative voltage applied to the base of Q5 through divider R17 and R18 will increase the collector-emitter impedance to effectively remove C_S and C_C from L_O. This will leave C_M only across L_O and the carrier frequency will shift to Mark.

BF Oscillator and Demodulator – HB-25640

Three functions are provided in this module.

1. A beat frequency voltage is generated.
2. The received audio tone signal is mixed with the output of the beat frequency oscillator in a balanced modulation circuit for frequency translation.
3. The received audio tone signal is amplified before translation to compensate for losses in the modulator circuit and impedance improving pads.

BF Oscillator

The BF oscillator stage includes transistor Q1 and a tuned LC circuit. Oscillations from the tuned circuit are coupled to the base of Q1 by capacitor C2. Feedback from the collector of Q1 to the tuned circuit is through resistor R1. An RC network consisting of C1, R2, and R3 is connected across a portion of the tuned circuit for frequency trimming purposes; R3 is variable and controls the effective capacity of C1.

Voltage from the tuned circuit is also coupled by capacitor C4 to the base of Q2 which operates as a Class A output amplifier. The tuned transformer in the collector circuit has a center-tapped secondary for applying the switching voltage to the bases of the modulator transistors Q3 and Q4.

Line Amplifier and Demodulator

The audio tone line amplifier consists of transformers T2 and T1, transistors Q5 and Q6 with associated components, a LEVEL control R20, and impedance improving pads R24 through R29. The audio tone signal to the amplifier is applied through a 3-db pad and line isolating transformer T2. The secondary winding of T2 is terminated with R21 and the LEVEL control which applies a base-to-base input signal to Q5 and Q6. Q5 and Q6 are biased to Class A operation. Q5 and Q6 are an emitter-coupled pair with a push-pull output transformer T1 in the collector circuit. The secondary winding of T1 is center-tapped to serve as part of the balanced demodulator circuit which includes switching transistors Q3 and Q4. The load on the secondary winding is a 3-db pad and the receiver band-pass filter. This load is in effect switched across each half of the secondary winding by alternate half cycles of the beat frequency voltage. Thus the amplified audio tone signal T1 will appear across the load in modulated form as two sideband frequencies; the beat frequency oscillator frequency minus the audio tone frequency, the beat frequency being suppressed to a low value by balanced modulator action. The lower sideband will be rejected by the receiver band-pass filter, and the upper sideband will be passed to the receiver.

C. RECEIVER MODULES

1. **Receiver Input Filter HB58700**

This filter is provided so that only the specified channel frequency comes into each receiver.

2. FS Receiver – HB-19915-27

Limiter Amplifier

In the schematic diagram of Figure 8, the limiting amplifier consists of three direct coupled stages. The first stage is an emitter coupled pair of transistors, Q1 and Q2, as a differential amplifier which provides a push-pull signal to the second stage. The second stage includes an emitter-coupled pair, Q3 and Q4, to provide a single-ended output to the third stage Q5. A feedback network from the collector of Q5 to the inverting input of the first stage yields d-c and a-c stability to the amplifier. The signal from the band-pass filter and sensitivity control in parallel is applied to the non-inverting input which has a high impedance characteristic.

Discriminator

The output signal from Q5 is coupled to the base of Q8 by resistors R18 and R21 which also serve to provide a d-c bias voltage to Q8. With full limiting, Q8 is switched on and off at the translated frequency rate, allowing 40 MA peak pulses to energize the tuned discriminator in the collector circuit. The discriminator consists of two parallel tuned circuits resonant at Mark and Space respectively. A secondary winding on each tuned circuit yields a d-c output by means of full wave rectifier diodes. The d-c outputs are connected in series aiding and applied across series resistors R23, R25 and R24, the combination in effect being a bridge circuit. Output from the bridge is taken between the center arm of the BIAS control R25 and the center connections of the secondary windings. As the discriminator is energized with alternate Mark and Space signals, the output will be approximately ±1.5 volts, and zero volts in the absence of the translated tone signal. C7, L1 and C8 filter the translated tone component from the discriminator output which is applied to the output d-c amplifier.

Low Signal Squelch Circuit

A squelch circuit on the discriminator is provided by Q6, C7 and associated components. In the absence of a carrier signal, Q7 is clamped by a forward base bias through R20; this shunts the base of Q8 the discriminator driver. When the limiter amplifier is coupled to the rectifier diodes CR1 and CR2 by the emitter follower Q6 a reverse bias voltage is applied through R19 to the base of Q7, causing Q7 to unclamp. The carrier output from Q5 can then drive Q8 to energize the discriminator. The circuit is designed so that the carrier must reach a level high enough to yield a receiver output with very little distortion before Q7 unclamps and permits the discriminator to drive the output d-c amplifier. Hence when the receiver carrier falls below this level, the discriminator is squelched and receiver output signals cease. This threshold level is determined by the setting of the SENSITIVITY control R2. The value of capacitor C5 determines the speed of operation of the squelching action. Charging is less rapid than discharge in this circuit. As C5 becomes larger, the unclamping action of Q7 is delayed while the clamping time is not increased appreciably. Thus the turn-on time of the receiver can be delayed to make the circuit less vulnerable to noise when the carrier falls below a predetermined level setting of the SENSITIVITY control. The band-width, carrier frequency and level of a channel are also determining factors in the speed of operation of the squelch circuit.

Carrier Detector

A carrier detector feature is derived as follows. The voltage appearing at the collector of Q8 the discriminator driver is 17 volts peak to peak. A lead from this point to the module edge connector permits this signal to be coupled to the HB-27330 carrier detector alarm card where it is rectified and amplified to produce an output voltage which can operate an indicating light or relay. The presence or absence of this signal is controlled by the operation of the squelch circuit on the discriminator. Carrier detector HB-27330 is mounted directly on the HB-19915 board and strapped to the collector of Q8 (HB-19915-27), as shown.

Output D-C Amplifier

In the d-c amplifier the output transistors Q14 and Q13 provide push-pull output. They are driven by a two-stage push-pull regenerative circuit consisting of Q10, Q9, Q12 and Q11. The regenerative circuit is monostable due to the unequal resistances in the emitter circuits of

Q10 and Q9; Q10 on- Q12 off, and Q9 off-Q11 on. Thus in absence of discriminator output Q14 is saturated and Q13 is cut off. A Mark signal from the discriminator will maintain the above condition. A Space signal from the discriminator will reverse the conducting states, and Q12 will be saturated while Q14 is cut off. The trigger type of switching action due to regeneration yields fast rise and fall time to the output pulses.

3. Carrier Deterioration Detector – HB24030-3 (When Supplied)

Across the output of the FS Receiver filter is this AM Receiver's sensitivity control R1 (see Figure 9). 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.

Voltage output may be obtained for end equipment if the load is a resistance. The rectifier circuit produces a positive voltage output. C8, C9 and R17 form a low pass RC filter to remove the carrier components. This filter is capable of passing 10 cycles per second but cuts off somewhat above this frequency.

D. NOISE SUPERVISORY MODULES (Internal Schematic Fig. 12)

1. Line Level & Noise Supervisory Module HB25150.

The output of Noise Filter HB55187 or HB55283 is amplified by an operational amplifier IC1 with a gain determined by resistors R5 and R6. Resistor R1 at the NOISE IN test point is a voltage divider for applying the test signal when adjusting the trip block threshold for a specific signal-to-noise ratio as described in the settings section. The input to the line level amplifier is amplified by IC2 with a gain determined by R21 and R20. Resistor R19 is shunted across R20 to increase the gain for trip block threshold adjustment.

The outputs of IC1 and IC2 are amplified by Q1 and Q2 respectively. Full-wave rectification for each of these noise circuits is employed with diodes CR7 through CR10, across a common load resistor R28 and capacitor C11. The resultant voltage is applied to a Schmitt trigger circuit, Q3 and Q4, which in turn operates a trip blocking circuit. Figure 18 shows the operating region for this circuit. The block and block release points are at a relatively low value of the maximum possible voltage due to rectified noise. Thus, C11 will delay block release for a longer period of time after high-level noise bursts.

During normal communication circuit operation, Q4 is conducting, Q5 and Q6 are cut off, and capacitor C12 is charged to a negative voltage. Emitter follower Q7 delivers this negative voltage to a clamping transistor in each of the trip output circuits of the system, effectively removing the clamp. Rectified noise applied to the base of Q3 will reverse the conducting states of these transistors instantly. Capacitor C12 discharges to a positive potential through Q6, and emitter follower Q7 delivers a positive clamping voltage to all receiver trip output circuits.

After a block, the block release is delayed by C12 which must charge to a negative potential through R38. The delay time is approximately 10 milliseconds.

2. 425-HZ Transmitter HB21050-12 (Fig. 13) (Some Systems use 595 Hz)

With reference to the schematic diagram of Figure 20, an LC oscillator is employed to generate the carrier frequency. (Keying circuits are provided to shift the carrier to a lower frequency for checking the operation of the clamp.) The output of the oscillator is amplified and coupled to the line through a bandpass filter which provides d-c isolation and minimizes adjacent channel loading. The tuned circuits for the oscillator and filter are contained in one plug-in hermetically-sealed assembly.

The oscillator stage includes transistor Q1 and associated circuit components. The tuned circuit consists of inductance L_O and capacitor CM; C_S and C_C are the frequency shifting capacitors. Oscillations from the tuned circuit are coupled to the base of Q1 by capacitor C3. Feedback to the tuned circuit from the collector of Q1 is through resistor R3. The network consisting of C2, R6 and variable resistor R7 allows frequency adjustment by variation of the effective capacitance of C2 across a portion of the tuned circuit. Note that the oscillator circuit voltages are referenced to a keying bias voltage level of approximately −1.2 volts d-c with respect to the circuit common which is developed across R2.

A secondary winding on L_O couples the output of the oscillator to the LEVEL control R10. This winding provides d-c isolation between the oscillator circuit and the output amplifier Q2 which operates from the full −12V d-c. supply. Transistor Q2 is a Class A common-emitter stage with the base input signal coupled from the LEVEL control by d-c blocking capacitor C5. The carrier bandpass filter is the collector load.

This transmitter, together with HB55283 filter at the remote end is used to prevent adverse effects from frequency translation. When a telephone line is multiplexed with other telephone lines, sometimes there is a drift in band frequencies due to the receivers and transmitters used in multiplexing. These conditions, although lying beyond the control of the tone channels, are detected at the receiving end by applying the 425-cycle transmitted frequency to the noise filter. The noise filter HB55283 together with the noise supervisory module do not tolerate a frequency translation (due to line multiplexing) of more than ±40 Hz without blocking the receivers.

CHARACTERISTICS

General

Audio Tone Center Frequencies (Hz):	600 Hz Band-width – 1500, 2700 340 Hz Band-width – 1500, 2180, and 2860.
Shift in Frequency:	±300 Hz (600 Hz Band-width) or ±170 Hz (340 Hz Band-width)
Frequency BF Oscillator:	13.5 kHz
Transmitter Center Frequencies:	15 kHz For 1500 Hz Tone Channel 15.68 kHz For 2180 Hz Tone Channel 16.2 kHz For 2700 Hz Tone Channel 16.36 kHz For 2860 Hz Tone Channel
Operating Temperature:	-10° to +60°C
Storage Temperature:	-60°C to +75°C
Operating Time:	Two terminal line 2 to 2.5 MS Three terminal line 3.5 to 4 MS
Energy Requirements:	110 milliamperes at 12 volts d-c
Approximate Weight:	14 lb.

D-C TO D-C CONVERTER AND VOLTAGE REGULATOR

Converter HB25190 and HB25200, Regulator HB25210

Power Output:

Model HB25210 Voltage Regulator with one of the D-C to D-C Converter Modules, HB25190 or HB25200- 7.5 watts maximum; +18 volts at 200 ma. and −18 volts at 200 ma.

Power Input:

Approximately 15 to 23 watts for above output power over the following converter input voltage ranges;

HB25190 – 42 to 56 V d-c, 48 v.d.c. nominal.

HB25200 – 105 to 144 V d-c, 125 v.d.c. nominal.

See Figure 3 for 250V d-c battery input.

Regulation:

+18 and −18 v.d.c. within 0.1 volt.

Regulation Indicator:

Indicates changes greater than 2 volts in ± 18 V d-c output; module panel lamp extinguishes and remote relay is de-energized. Recommended alarm relay is HA18574; two Form-C 5-ampere contacts, 2000-ohm coil.

Ripple:

1 mv RMS maximum on +18 v.d.c. and −18 v.d.c. outputs.

Converter Frequency:

Nominal 500 Hz; 380 Hz to 600 Hz over rated input and output ranges.

Overloads:

No overload protective circuitry. Input to converter is fused; effective only for short-circuit loads. Operation above maximum rated levels should be avoided to prevent damage due to excessive heat generation.

Isolation:

Output circuits are d-c isolated from ground and the converter input battery supply. A transient voltage filtering capacitor, C3, in the converter module is connected between the output COMMON and the positive battery input and has a 2000WV d-c rating. (See schematic diagram, Figure 3.)

FS Transmitter – HB-24335-26

Output Level:	Adjustable from -30 dbm to +2 dbm
Output Impedances:	600 ohms nominal, isolated and balanced
Output Stability:	± 1.5 db from -10°C to +60°C
Frequency Stability:	± .25%

FS Receiver – HB-19915-27

Sensitivity:	Adjustable from −45 dbm to +6 dbm
Input Impedance:	Band-pass filter, 600 ohms nominal
Squelch Circuit:	D-C output assumes a 0 VDC on both mark and space outputs, when level falls to the sensitivity setting of receiver.
Carrier Detector:	Contained on module 12V output
D-C Output:	Push-pull, -10 volt pulses at 5 to 40 Ma. Rise and fall times each less than 5 microseconds.

B.F. Oscillator & Demodulator

Carrier Input

Input impedance 600 ohms, isolated. Input levels in the range of −45dBm to +6dBm, adjustable with LEVEL control for proper demodulation operation.

Demodulator Output

Output impedance 600 ohms. Zero loss from carrier input to demodulator output (one sideband) for single channel operation at a maximum carrier level of 0dBm. For multiplexed channels see Operation Section.

BF Oscillator:

Frequency stability ±0.25% from -30°C to +70°C.

LINE LEVEL AND NOISE SUPERVISORY HB25150 AND FILTERS HB55283 AND HB55187

Output:

Clamping voltage for block circuits in up to 3 F.S. Receiver modules. +13V to +17V at 2 to 3 mA block, −3.4V at 0 mA block release. Block release delay time is 10 milliseconds. D-C amplifier capable of delivering up to 100 mA at 36V to an indicating device, or voltage pulses to logic circuitry. Amplifier is conducting for a block, collector at +18V; non-conducting for block release, collector at −18V.

Noise Filters HB55187 and HB55283

300 to 1000 Hz passband, 600-ohm input impedance in passband, out-of-band rising impedance characteristic. 600-ohm output impedance. Noise filter HB55283 is the same as HB55187 except for a 25-db rejection notch at 425 Hz.

Noise Filter Amplifier:

600-ohm input impedance. Sensitivity adjustable: Maximum sensitivity for a trip block is −52 dBm, +0.5 dB −1 dB.

Line Level Amplifier:

11.2K input impedance. Sensitivity adjustable; maximum sensitivity for a trip block is −27 dBm; +0.5 dB −1 dB.

425-HZ TRANSMITTER HB21050-12 (Some Systems Use 595 Hz)

Output Level:

600 ohms nominal, isolated and balanced.

Output Stability:

± 1.5 dB from −30°C to +70°C.

Frequency Stability:

HB21050-12 ±.25% from −30°C to +70°C.

Keying Inputs:

Neutral voltage pulses, −10V nominal. Input resistance approx. 5K to 15K.

AM RECEIVER 24030-3

Sensitivity: Adjustable from 0dBm to −35dBm.

Input Impedance: 600 ohms nominal.

LOGIC INTERFACE

Input Keying: +10V Min. to +20V Max.

Output Voltage: +18V D.C.

INSTALLATION

(Outline and Drilling Plan, Figure 14)

The tone assemblies should be mounted on relay racks or in suitable cabinets when the eleven-module chassis is used. The mounting location should be free from dirt, moisture, excessive vibration, or heat. All electrical connections are made through a 24-terminal connector on the rear of the chassis per CR drawing which applies to the particular order and appears on the nameplate.

SETTINGS

Transmitters HB24335-26

Only one setting is required on the tone transmitter and that is the output level. This setting is made by using the screwdriver type adjuster marked "gain" on the 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 protective 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 allowable 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 consulated as to the allowable transmitting level.

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 a-c 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. The 425-Hz transmitter should be set the same as any other transmitter.

Demodulator – Level Control

After the remote transmitter has been adjusted, pull out the local transmitter. Check the received signal at top two terminals of the beat frequency oscillator and demodulator module (H1, Lo). Pull out the local F/S receiver filter and connect a 600-ohm load across demodulator out and Lo (white) terminals. Connect a VTVM across the 600-ohm, load and adjust the level control for 3-dbm above the received signal.

FS Receiver HB19915-27

Plug a d-c voltmeter (at least 20 volt range) into TP norm. and TP comm. of receiver. (The tone transmitters must be previously set to their desired output levels.) Connect a VTVM across the tone receiver input terminals (TP Lo and TP Hi) 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 6 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 6 db.

With the level of the incoming tone now set 6 db below normal, advance the sensitivity control of the tone receiver by adjusting sensitivity control on the receiver module until the receiver output increases suddenly to zero from approximately –10 volts, at this point the squelch has operated to clamp the receiver in a zero state. When the attenuator is removed from the circuit, the tone receiver will have a normal operating point 6 db above the pickup signal level.

Line Level and Noise Supervisory Module

(Refer to Fig. 18 for Levels)

NOTE: If a HB55283 notch filter is used, the calibrating procedure should not be altered.

The sensitivity of both noise detecting circuits is adjustable with all channel signals present on the line at their nominal levels for the system. Adjust the noise-filter amplifier sensitivity as follows: first turn the NOISE SENSITIVITY control to its extreme counterclockwise position (if the line level sensitivity has not been adjusted, turn this screw to its extreme counterclockwise position also). Remove the noise filter from the chassis. Connect the CARRIER IN test point of any convenient HB19916-27 Receiver module to the NOISE IN test point on the HB25150 Noise Supervisory Module. Slowly turn the NOISE SENSITIVITY control from its extreme counterclockwise position until the BLOCK light is energized. Remove the test point connections and replace the noise filter in the chassis; the light should turn off. With this adjustment, a trip block will be initiated for an in-band signal-to-noise ratio of 12 dB or less. A minimum of 9 dB is required for security against false tripping in type TA-2 Protective Relaying Channel.

The wide-band noise or line amplifier sensitivity can be adjusted in this manner: Connect the LINE LEVEL SENS. ADJ. test point to the COMMON test point. This will increase the gain of the amplifier by 4.5 dB. Turn the LINE LEVEL SENS. control slowly clockwise until the BLOCK light is energized, then remove the test point connections. When the combined level of signals plus noise increases by 4.5 dB, a trip block will be generated.

A hysteresis of approximately 1.5 dB exists in the trigger-type blocking circuit for a block release. The 4.5 dB high-level block setting and a low signal-level block adjustment of 6 dB in the FS Receiver Module HB19915-27 will give a dynamic operating range of 10.5 dB for the protective relaying receiver.

Carrier Level Monitor (When Used)

The following procedure is to be used when an AM receiver is utilized in conjunction with a 240 Micro-Amp Suppressed Zero meter to detect a partial deterioration of the tone signal. Since the meter is also calibrated with the AM receiver, these instructions only apply when the meter is used. The meter used is Westinghouse Type GX322 S#691B408A09.

a. On AM receiver, set bias control fully counterclockwise position.

b. Set potentiometer in series with meter to fully counter-clockwise position. (zero resistance)

c. Pull AM receiver module from circuit and adjust zero of meter.

d. Push in AM receiver and adjust sensitivity control such that meter is at full-scale deflection with normal received signal.

e. Lower incoming signal by 10 db, and adjust potentiometer control of AM receiver such that the meter is zeroed. The meter is now calibrated for a 10 db deterioration of signal.

f. For deterioration levels greater than 10 db, lower the incoming signal to the desired value and adjust the series potentiometer until the meter is at full zero.

ACCEPTANCE CHECK

D-C to D-C Converter HB25190 or HB25200

Non-Regulated Voltages:

+V d-c to common	+22 to +34 V d-c
–V d-c to common	–22 to –34 V d-c

Voltage Regulator

+18 V to common	+18 V d-c
–18 V to common	–18 V d-c

Transmitter

Key transmitter to mark frequency by applying the correct keying voltage at the terminals indicated on the connection drawing.

All transmitter frequencies and output levels should be checked with a 600-ohm load connected at the output.

Mark Frequency:	within 6 Hz of the frequency specified in the Characteristics section.
Space Frequency:	within 6 Hz of the frequency specified in the Characteristics section.

NOTE: Allow 4 Hz for 340-Hz bandwidth tones.

Output Level:	at least +2 dBm

425-HZ Transmitter (Some Systems use 595-Hz)

Frequency:	425 Hz within 1 Hz
Output:	at least +1 dBm
Keying:	should shift at least 40 Hz to block Noise Supervisory module.

F.S. Receiver

With a transmitter input set at –20 dBm, see that the space and mark outputs operate correctly.

Line Level and Noise Supervisory

Should operate upon receipt of a 700-Hz tone at –37 dBm, or any transmitter tone frequency at –15 dBm. Factory calibration is at a –20 dBm nominal input signal.

Carrier Level Monitor – AM Receiver HB24030-3

Sensitivity:	Adjustable from 0 dBm to –35 dBm from –20°C to +60°C.
Output:	With 240 microamp meter, current should be adjusted with external series potentiometer to 240 microamps.

Logic Interface

Inputs:	+10 V to 20 V
Outputs:	+18 V

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").

POWER SUPPLY

The d-c to d-c converter has no adjustments. The voltage regulator module HB25210 has adjustable reference voltages. In order to adjust the reference voltages, a card extender (HB14583) is needed because the adjusting resistors are not accessible from the front of the panel. Connect a d-c voltmeter to common and +18 volts (front of the panel), and adjust R7 for +18 volts. Repeat this operation by connecting the voltmeter between common and –18 volts and adjusting R15. The regulation indicator is set by adjusting R19 for zero volts between the reference zener diode CR3 and the white test point on the front panel. The regulation indicator will detect any changes over 2 volts by the lamp being extinguished and the optional relay being de-energized.

(In service procedure to be used in conjunction with SKBU Relay)

1. **Beat Frequency Oscillator – frequency control**

   Check the frequency at bottom two terminals of the BF Oscillator and demodulator module (H1, Lo.) Readjust frequency if required to nameplate marking.

2. **Transmitter – level and frequency control**

   a. Check output of transmitter at terminals of channel equipment. Adjust level control for the desired output.

   b. Check mark and space frequencies at green terminals of F/S transmitter (Hi, Lo). (To key transmitter to mark jumper keying lead on J101 to -12 vdc; See Fig. 3). Readjust transmitter frequency if required so that the space and mark frequencies are approximately correct.

3. **Demodulator – level control**

   After remote transmitter has been adjusted, pull out local transmitter. Check the received signal at top two terminals (Hi, Lo). Pull out the local F/S receiver filter and connect a 600-ohm load across the demodulator out and Lo (white) terminals. With a VTVM across the 600-ohm load, adjust the level control for 3-dbm received signal.

4. **Frequency Shift Receiver – sensitivity and bias control**

   a. Reduce incoming space signal by 12-dbm and adjust sensitivity control until the receiver is clamped in a mark state. (-12 vdc between "Comm." T.P. and "Norm." T.P. on the receiver module, with mark and space outputs connected to the relaying system.)

b. Apply sufficient a-c current by using remote terminal functional test panel to pickup the remote fault detector of the SKBU-2 or SKBU-21. With oscilloscope across "Comm." T.P. and "Norm." T.P. on the receiver module, adjust bias control of tone set for pulses of approximately 8 milliseconds.

LINE LEVEL & NOISE SUPERVISORY MODULES

These modules require no adjustments except for the settings covered before.

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.

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. 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. Refer to Table I for typical transistor voltages.

Test Equipment

For routine maintenance, the following equipment will be adequate:

1. A-C Vacuum-Tube Voltmeter, at least 15 kHz, 1 mv sensitivity.
2. Calibrated Attenuator, 600 ohm.

For troubleshooting, the following additional test equipment is desirable:

1. Electronic Frequency Counter, 15 kHz minimum.
2. D-C Vacuum-Tube Volt-Ohmmeter.
3. Cathode-Ray Oscilloscope.
4. Oscillator, 200 to 15,000 Hz.

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 Parts List.

TABLE I

TYPICAL VOLTAGE MEASUREMENTS (REFERRED TO "COMMON")

200 mA LOAD ±22.5V INPUT

			Q1	Q2	Q3	Q4	Q5	Q6
HB25210 Voltage Regulator	Vdc	C	+19.4	+22.0	+22.5	−19.4	−22.0	−22.5
		B	+12.1	+19.4	+18.7	−12.1	−19.4	−18.7
		E	+11.4	+18.7	+18.0	−11.4	−18.7	−18.0

NO LOAD ±34.2V INPUT

			Q1	Q2	Q3	Q4	Q5	Q6
HB25210 Voltage Regulator	Vdc	C	+19.2	+33.5	+34.2	−19.2	−33.5	−34.2
		B	+12.1	+19.2	+18.8	−12.1	−19.2	−18.8
		E	+11.4	+18.8	+18.1	−11.4	−18.8	−18.1

			Q1	Q2
Transmitter Module HB24335-26	Vdc	C	+6.0	+11.7
		B	+1.25	+2.25
		E	+0.7	+1.7
	Vac Rms	C	8.0 pp	6.0
		B	0.06	.06
		E	0	.03

			Q1	Q2	Q5	Q6
B.F. Osc. & Demodulator HB25640	Vdc	C	6	12	7.5	7.5
		B	1.15	2.1	2.3	2.3
		E	1.0	2	2.2	2.2
	Vac Rms	C	8 pp	6.0		
		B	.07	.07		
		E	0	.038		

			Q1	Q2	Q3	Q4	Q5
FS Receiver HB19915-27	Vdc	C	+8.5V	+8.5V	+12V	+11.1	+6.2V
		B			+ 8.5	+ 8.5	+11.1V
		E	+5.4V	+5.4V	+ 8.0	+ 8.0	+11.7V

			Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
FS Receiver HB19915-27	W/O Sig.	C	+12	+0.1	+12	+1.7	+ .8	+1.1	+2.1	+12	+1.55
		B	+ 6.2	+0.6	+ 0.1	+1.0	+1.9	+1.7	+1.2	+1.1	+2.1
		E	+ 5.7	0	0	+ .55	+ 0.5	+1.1	+1.1	+1.55	+1.55
	W/Sig. Vdc	C	+12	+0.8	+8	+1.5 / +0.8	+.7 / +1.5	+0.8 / +2.0	+2.1 / +0.9	+12 / +1.5	+1.5 / +12
		B	+ 6.2	−0.9	+0.8	0 / +1.5	+1.3 / 0	+1.5 / +0.8	+.7V / +1.5	+.8 / +2.0	+2.1 / +.9
		E	+ 6.8	0	+0.6	+0.7 / +0.9	+0.7 / +0.7	+.85 / +0.95	+0.85 / +0.95	+1.55 / +1.45	+1.5 / +1.45

			Q3	Q4	Q5	Q6	Q7	Q8	Q9
HB25150 Line Level and Noise Supv.	Block Vdc	C	< −15	+0.8	− 0.1	+17.9	+18	+0.1	+17.9
		B	< −16	> 16.8	− 0.7	+17.2	+17.9	+0.7	+17.2
		E	< −16.4	< 16.4	0	+18	+17.2	0	+18
	Release Vdc	C	−15	3	+ 18	− 2.6	+18	+18	−18
		B	< 16.3	−15.8	− 2.8	+18	− 2.55	− 2.75	+18
		E	16.4	−16.4	0	+18	− 3.3	0	+18

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB24335-26 TRANSMITTER MODULE	
R1-R22	RESISTOR, fixed comp.: See Note 5, Figure 1	
R7	RESISTOR, variable: 250K, 0.1 W. BD taper	HA-14594
R10	RESISTOR, variable: 500 ohms, 0.125 W, DB taper	HA-13573
C1	CAPACITOR, tantalum: 15μF ±20%, 35V	H-1007-654
C3-C6	CAPACITOR, tantalum: 33μF ±20%, 10V	H-1007-653
C2	CAPACITOR, mica: See Note 4, Figure 1	
C7	CAPACITOR, ceramic: 0.47μF +80% -20%, 50V	H-1007-939
Q3, Q4	TRANSISTOR, silicon: PNP 2N3638	HA-24598
Q5	TRANSISTOR, silicon: NPN, 2N3905	HA-21564
Q1, Q2	TRANSISTOR, silicon: NPN, 2N3903	HA-21562
	BF FILTER and OSC. ASSY. for HB-24335 FS Transmitter & Mod.	HB-61400
	FILTER CABLE CONNECTOR: 3-terminal socket	HA-21091

	HB25640 B.F. OSC. AND DEMODULATOR	
R1 thru R29	RESISTOR, fixed comp. ±5%, ¼ Watt unless otherwise specified	
R3	RESISTOR, variable, 250K, 0.1 watt, BD taper. CTS Corp., Type PE200.	HA-14594
R20	RESISTOR, variable, 500 ohms, +20%, .125 watt, BD taper, CTS Corp. Type PE200.	HA-13573
C1	CAPACITOR, mica. See Note 5, Figure 2.	H-1080-#
C2,C3,C4,C5	CAPACITOR, tantalum, 15μF ±20%, 25V. Mallory, TAM156M025P5C.	H-1007-439
C6	CAPACITOR, tantalum, 22μF ±20%, 15V. Mallory, TAM226M015P5C.	H-1007-494
T1	TRANSFORMER, Demodulation.	HB-55236
T2	TRANSFORMER, input, 600/600. Microtran, MT1FB.	HA-14791
Q1 thru Q6	TRANSISTOR, germanium, PNP. Texas Inst., 2N1375.	HA-17117
	BF OSCILLATOR and tuned Transformer assembly.	HB-63300
	TEST JACKS, Sealectro Corp. SKT10.	

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB-21050 425 Hz FS TRANSMITTER (Also Applies To 595Hz)	
R1-R6, R8, R9 R11-R18	RESISTOR, fixed comp., ±5%, ¼ watt unless otherwise specified.	
R7	RESISTOR, variable, 250K, 0.1 watt, BD taper, CTS Corp., type PE200.	HA-14594
R10	RESISTOR, variable 500 ohms, 0.125 watt, BD taper, CTS Corp., type PE200.	HA-13573
C1	CAPACITOR, tantalum, 15μf ±20%, 25V, Mallory TAM156N025P5C.	H-1007-439
C3, C4, C5, C6	CAPACITOR, tantalum, 33μf ±20%, 10V, Mallory TAM3336M010P5C.	H-1007-438
C2	CAPACITOR, mica, Elmenco Type DM20.	H-1080-X
C7	CAPACITOR, ceramic, 0.47μf +80% –20%, 25V, Sprague 5C11A.	HA-13579
Q1, Q2, Q3, Q4	TRANSISTOR, germanium, PNP, Texas Inst. 2N1375	HA-17117
Q5	TRANSISTOR, silicon, NPN, Texas Inst., 2N706A.	HA-19928
	BF Filter and Osc. Assy. for HB-21055 and HB-21050 FS Transmitter.	HB-58500 or HB-58900
	BP Filter and Osc. Assy. for HB-21040 and HB-19925 FS Trans. & Mod.	HB-58200
	Test Jacks, Sealectro Corp., SKT-10.	
	Filter cable connector, 3-terminal socket, Eby Sales Co.	HA-21091

	HB19915-27 FS RECEIVER	
R1-R35	RESISTOR, fixed comp. See Note 7, Figure 2.	
R2	RESISTOR, variable, 2.8K ±20%, 0.12 watt, AC taper CTS Corp., type PE200	HA-23742
R25	RESISTOR, variable, 1K ±20%, 0.25 watt, linear taper CTS Corp., type PE200	HA-14593
C1, C2, C4	CAPACITOR, tantalum, 22μF ±20%, 15V	H-1007-656
C3, C6	CAPACITOR, tantalum, 56μF ±20%, 6V	H-1007-658
C5, C7, C8	CAPACITOR, tantalum, 0.47μF ±10%, 35V	H-1007-511
C9, C10	CAPACITOR, ceramic, 0.05μF, 25V	H-1007-647
L1	CHOKE, See Note 6, Figure 2	HA-17731
CR1, CR2	DIODE, silicon, 200 PIV, 250 mA	HA-30769
Q1-Q4, Q6-Q14	TRANSISTOR, silicon, NPN, 2N3903 Motorola	HA-21562
Q5	TRANSISTOR, silicon, PNP 2N3905 Motorola	HA-21564
	DISCRIMINATOR ASSEMBLY, plug-in Channels below 4000 Hz	HB-58400
	Channels above 4000 Hz	HB-58800
	BAND-PASS FILTER module Channels below 4000 Hz	HB-58300
	Channels above 4000 Hz	HB-58700
	TEST JACKS, Sealectro Corp., SKT-10	

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB-24030-3 CARRIER DETERIATION DETECTOR RECEIVER	
R1	RESISTOR, variable: comp. 5K .25 watt "A" tapr CTS PE200	HA-13572
R2-R19	RESISTOR, fixed comp.: ±5% ¼ watt, values as shown in Figure 2.	H-1009-X
C1, C2, C5, C8, C9	CAPACITOR, tantalum: 47μF ±10% 35V Texas Inst. SCM474FPO35D2	H-1007-511
C4	CAPACITOR, tantalum: 22μF ±20% 15V Texas Inst. SCM226BPO15D4	H-1007-656
C3, C6, C7	CAPACITOR, tantalum: 33μF ±20% 10V Texas Inst. SCM336BPO10D4	H-1007-653
CR1-CR2	DIODE, silicon: 1N914 250mW Texas Inst. or G.E.	HA-24325
Q1-Q3	TRANSISTOR, silicon: PNP BVCEO 40V 2N3905-18 Motorola	HA-24087
T1	TRANSFORMER, CT8K: 2K CT	HA-3175
	TEST JACKS, Sealectro Corp., SKT-10	
	BAND PASS FILTER (State frequency required)	HB-56500-X

	HB-25150 LINE LEVEL – NOISE SUPERVISORY MODULE	
R1, R2, R4-R8, R11-R16, R18. R21-R42	±5%, ¼ watt, unless otherwise specified.	
R9, R10	RESISTOR, wirewound, 600 ±5%, 1½ watt. Ohmite 995-1A.	H-1100-442
R43	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-423
R19	RESISTOR, metal film, 121 ±1%, 1/8 watt. I.R.C. Type CEA T-O	H-1510-777
R20	RESISTOR, metal film, 100 ±1%, 1/8 watt. I.R.C. Type CEA T-O	H-1510-714
R3	RESISTOR, variable, 500 ±20%, 0.125 watts, BD taper, C.T.S. Type-200	HA-25253
R17	RESISTOR, variable, 2.5K ±20%, 0.125 watts, A taper. C.T.S. Type PE-200	HA-19919
C1	CAPACITOR, poly., 0.0068μF ±2%, 400VDC, Wesco 32P.	H-5115-127
C6	CAPACITOR, poly., 0.02μF ±2%, 100VDC Balco PTWP.	H-5115-49
C3, C8	CAPACITOR, mica, 390pF ±2%, 500WVDC Elemenco DM-19-391-G.	HA-16628
C2, C7	CAPACITOR, tantalum, 33μF ±20%, 10VDC. Texas Inst. SCM336BP010D4.	H-1007-653
C4, C9, C11	CAPACITOR, tantalum, 1.0uF ±20%, 35VDC. Texas Inst. SCM105FP035D4.	H-1007-496
C5, C10, C13, C14	CAPACITOR, tantalum, 15μF ±20%, 35VDC, Texas Inst. SCM156GP035D4.	H-1007-654
C12	CAPACITOR, tantalum, 0.47μF ±10%, 35VDC, Texas Inst. SCM474FP035D2.	H-1007-511
CR1 thru CR4 CR7 thru CR11	DIODE, silicon, 250 mw. Texas Inst., or G.E. type 1N924.	HA-24325
CR12	DIODE, silicon, 200PIV, Diodes Inc., DI-42.	HA-17197
CR5, CR6	DIODE, zener, 5.1V ±5%, 1N4733A. Motorola IM5. 1ZS5.	HA-24328
IC1, IC2	Operational amplifier, TP-5 case. Motorola MC-1430.	HA-25158
Q3, Q4, Q5, Q7, Q8	TRANSISTOR, silicon, NPN, V_{CEO} 40V, TO-92, Motorola 2N3902.	HA-21562
Q6	TRANSISTOR, silicon, PNP, V_{CEO} 40V, TO-92, Motorola 2N3905.	HA-21564
Q1, Q2	TRANSISTOR, silicon, NPN, V_{CEO} 65V, TO-5, RCA 2N2102.	HA-22678
Q9	TRANSISTOR, silicon, PNP, V_{CEO} 65V, TO-5, RCA 2N4036.	HA-24003
T1, T2, T3	TRANSFORMER, 2.5K: 2.5K C.T. Microtran MMT- 19-FB.	HA-25157
I1	Data Lamp, red cartridge, Dialco 507-3910-1431-600.	HA-25156
	Lamp Holder, Dialco 508-7538-504.	HA-17504
	Test jacks, Sealectro Corp., S KT-10	

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB25190 48 VDC, D.C. TO D.C. CONVERTER	
R3, R4	RESISTOR, fixed comp., 24 ±5%, ¼ watt.	H-1009-827
R6, R7	RESISTOR, wirewound, 2.5K ±5%, 3¼ watt. Ohmite 995-3A.	H-1100-329
R1	RESISTOR, wirewound, 5K ±5%, 3¼ watt. Ohmite 995-3A.	H-1100-460
R5	RESISTOR, wirewound, 50 ±3%, 10 watt. Dale Electronics RH-10.	HA-23709
C1	CAPACITOR, elect., 80μF, 150VDC. Cornell Dubilier BR80-150.	H-1007-395
C2	CAPACITOR, met. paper, 0.047μF, 200W VDC. Cornel Dubilier MPY-2S47.	H-1007-674
C3	CAPACITOR, paper, 0.022μF ±10%, 1000VDC. Aerovox V161-615.	H-1007-696
C4, C5	CAPACITOR, ELECT., 100μF, 50VDC. Cornell Dubilier BR-100-50.	H-1007-209
CR1 thru CR9	DIODE, silicon, 200 PIV, 1 Amp. Diodes Inc. SD-2.	HA-17995
Q1, Q2	TRANSISTOR, silicon NPN, V_{CEO} 175V, TO-66. RCA 2N3583.	HA-21847
T1	TRANSFORMER, saturable core.	HB-25182
I1	LAMP, cartridge, red, 10VDC, 0.014A. Dialco 507-3910-1431-600.	HA-25156
I2	LAMP, cartridge, amber, 10VDC, 0.014A. Dialco 507-3910-1433-600.	HA-25784
	LAMPHOLDER. Dialco 508-7538-504.	HA-17504
S1	SWITCH, push button. Leviton #579.	HA-13554
F1	FUSE, 3AG. 0.5 AMP.	HA-9348
	SOCKET, TO-66 transistor mt'g. UID Electronics PTS-4.	HA-21848
	INSULATOR, mica, TO-66 transistor mt'g. Reliance Mica Co. DF-31-A.	HA-23658
	TEST JACKS, Sealectro Corp., SKT-10.	
	HB25200 125 VDC, D.C. TO D.C. CONVERTER	
R3, R4	RESISTOR, fixed comp., 100 ±5%, ¼ watt.	H-1009-758
R6	RESISTOR, fixed comp., 100K ±5%, ½ watt.	H-1009-348
R7	RESISTOR, fixed comp., 56K ±5%, ½ watt.	H-1009-815
R5	RESISTOR, wirewound, 100 ±3%, 10 watt.	HA-23650
R1	RESISTOR, fixed comp., 39K ±5%, 2 watt.	H-1009-885
C1	CAPACITOR, elect., 80μF, 150VDC. Cornell Dubilier BR80-150.	H-1007-395
C2	CAPACITOR, met. paper, 0.022μF, 400 W VDC. Cornell Dubilier MPY-4S22.	H-1007-637
C3	CAPACITOR, paper, 0.022μF ± 10%, 1000VDC. Aerovox V161-615.	H-1007-696
C4, C5	CAPACITOR, elect., 100μF, 50 W VDC. Cornell Dubilier BR-100-50.	H-1007-209
CR1 thru CR11	DIODE, silicon, 200 PIV, 1 Amp. Diodes Inc., SD-2.	HA-17995
Q1, Q2	TRANSISTOR, silicon NPN, V_{CEO} 300V, TO-66. RCA 2N3585.	HA-22593
T1	TRANSFORMER, saturable core.	HB-25183
I1	LAMP, cartridge, red, neon, 105/125VDC. Dialco 507-3835-0931-600.	HA-25203
I2	LAMP, cartridge, amber, neon, 105/125VDC. Dialco 507-3835-0933-600.	HA-25204
	LAMPHOLDER. Dialco 508-7538-504.	HA-17504
S1	SWITCH, push button. Leviton #579	HA-13554
F1	FUSE, 3AG, 0.2A., Slo-Blo.	HA-14691
	SOCKET, TO-66 transistor mt'g. UID Electronics PTS-4.	HA-21848
	INSULATOR, mica, transistor mt'g. Reliance Mica Co. DF-31-A.	HA-23658
	TEST JACKS, Sealectro Corp., SKT-10.	

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB-25210 VOLTAGE REGULATOR	
R17,R21-R28,R31	±5%, ¼ watt, unless otherwise specified.	
R1, R9	RESISTOR, wirewound, 2.2K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-448
R3, R10, R29	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-423
R5, R13	RESISTOR, wirewound, 1K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-429
R6, R16	RESISTOR, wirewound, 820 ±5%, 1½ watt.	H-1100-443
R8, R14	RESISTOR, wirewound, 2K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-422
R30	RESISTOR, wirewound, 1.6K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-543
R2, R11	RESISTOR, wirewound, 75 ±5%, 3 watt. Ohmite 995-3A.	HA-13863
R4, R12	RESISTOR, wirewound, 56 ±5%, 3 watt. Ohmite 995-3A.	H-1100-541
R18, R20	RESISTOR, wirewound, 5.6K ±5%, 3 watt. Ohmite 995-3A.	H-1100-542
R7, R15	RESISTOR, variable wirewound, 1000 ohms. Muter Co. 50-2200 Series	HA-12578
R19	RESISTOR, variable wirewound, 5000 ohms. Muter Co. 50-2200 Series	HA-20924
C1, C4	CAPACITOR, mica, 91pF ±5%, 500V. Elemenco DM-15-910J.	HA-16521
C2, C5	CAPACITOR, tantalum, 15μF, ±20%, 35VDC. Texas Inst., SCM156GP035D4.	H-1007-654
C3, C6	CAPACITOR, elect., 500μF, 50VDC. Sprague TVA-1315.	HA-13569
CR1, CR2	DIODE, zener, 12V ±5%. Diodes Inc. 1D12B.	HA-12920
CR3	DIODE, zener, 18V ±5%. Diodes Inc. 1D18B.	HA-25217
CR4	DIODE, silicon, 200 PIV. Diodes Inc. DI-42,	HA-17197
Q7, Q8	TRANSISTOR, silicon NPN, V_{CEO} 40V, TO-92. Motorola 2N3903.	HA-21562
Q10, Q11	TRANSISTOR, silicon PNP, V_{CEO} 40V, TO-92. Motorola 2N3905.	HA-21564
Q1, Q2, Q12	TRANSISTOR, silicon NPN, V_{CEO} 65V, TO-5. RCA 2N2102.	HA-22678
Q4, Q5, Q9	TRANSISTOR, silicon PNP, V_{CEO} 65V, TO-5. RCA 2N4036.	HA-24003
Q3	TRANSISTOR, silicon NPN, V_{CEO} 60V, TO-3. Motorola 2N3055.	HA-24327
Q6	TRANSISTOR, germanium PNP, V_{CEO} 50V, TO-3. RCA 2N2869/2N301.	HA-17992
	TRANSISTOR socket, TO-3. Augat Bros. 8043-1G3.	HA-18538
	INSULATOR, mica, TO-3 transistor mt'g. Reliance Mica Co. 732	HA-11964
I1	LAMP, cartridge, amber, 10VDC., 0.014A. Dialco 507-3910-1433-600.	HA-25784
	LAMPHOLDER, Dialco 508-7538-504.	HA-17504
	TEST JACKS, Sealectro Corp. SKT-10.	

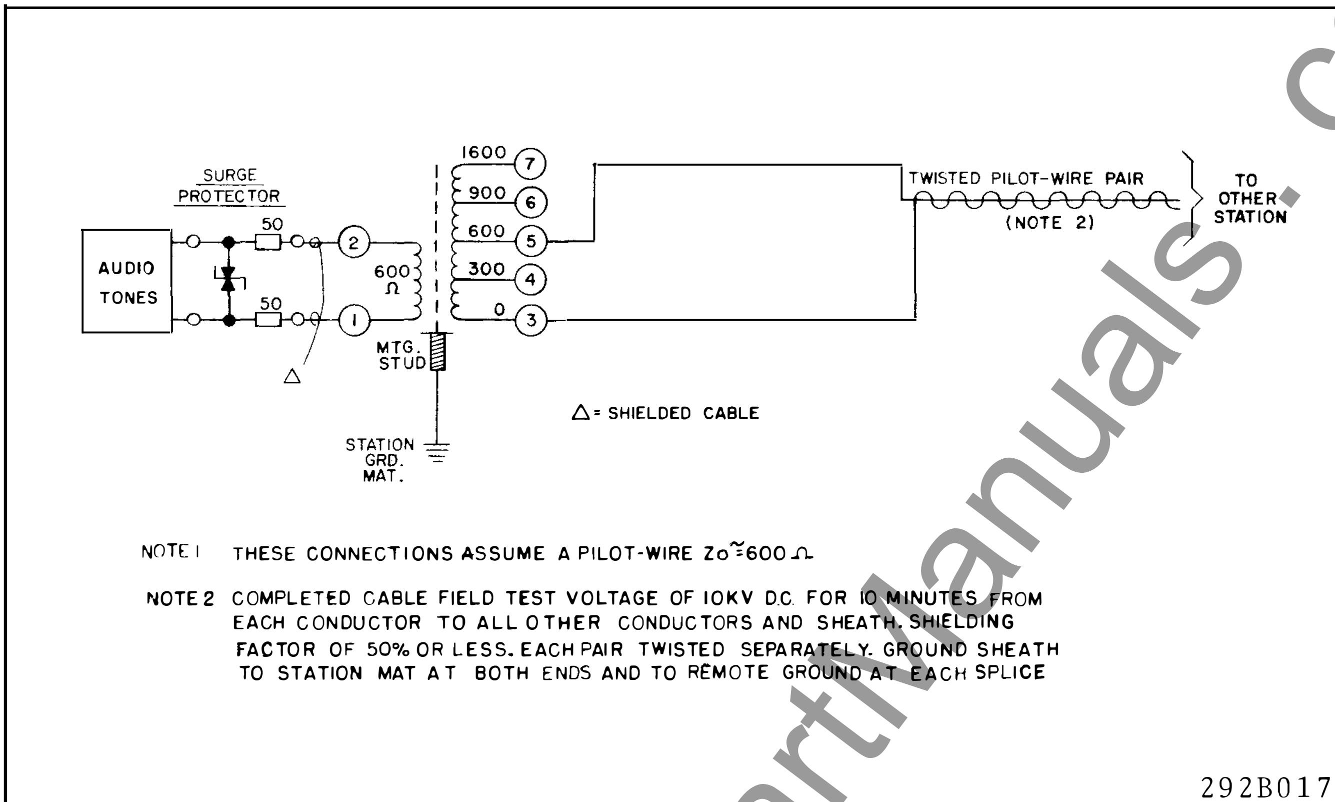
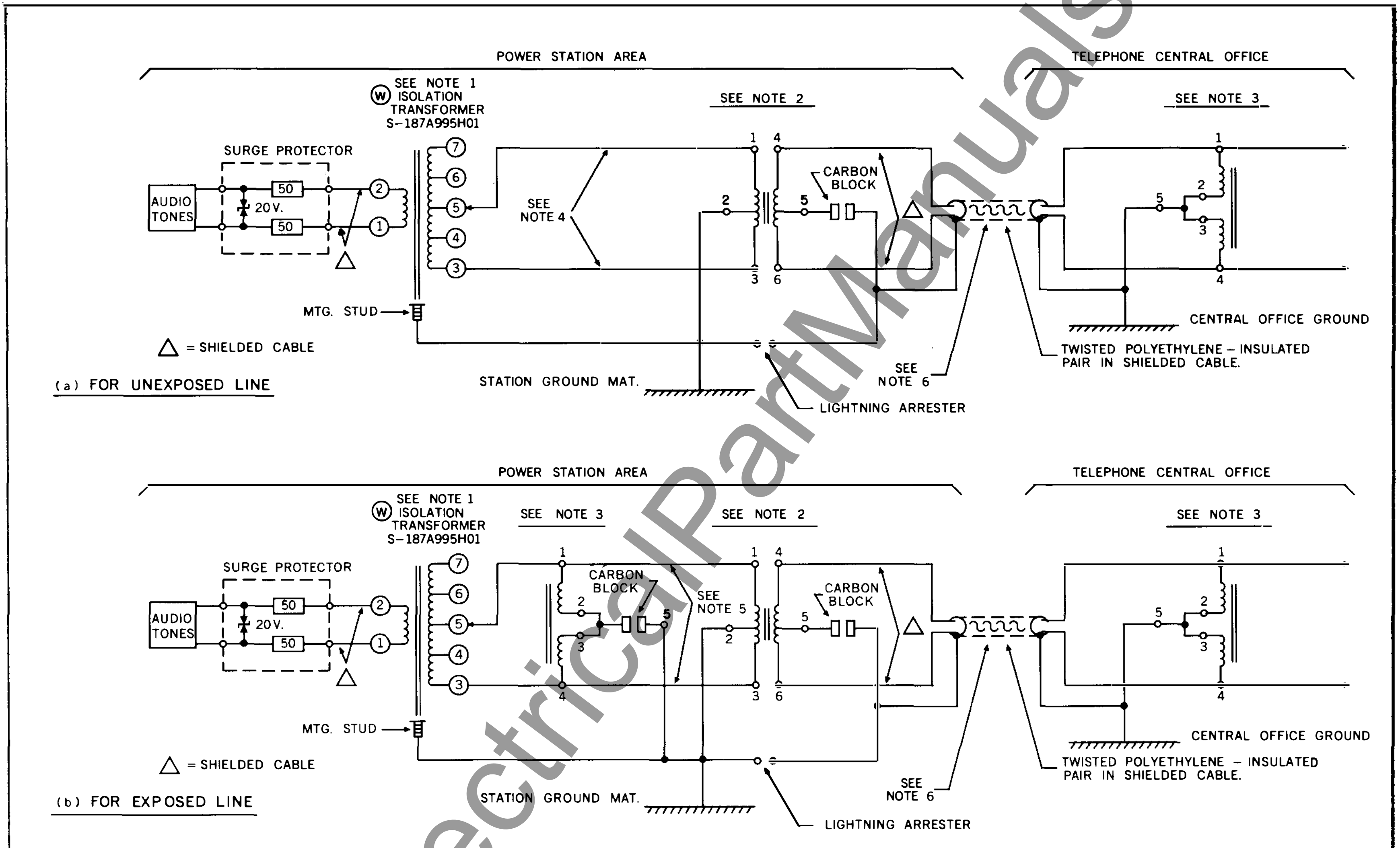


Fig. 1 Recommended Connections and Pilot Wire Design for Privately Owned Two-Terminal Lines.

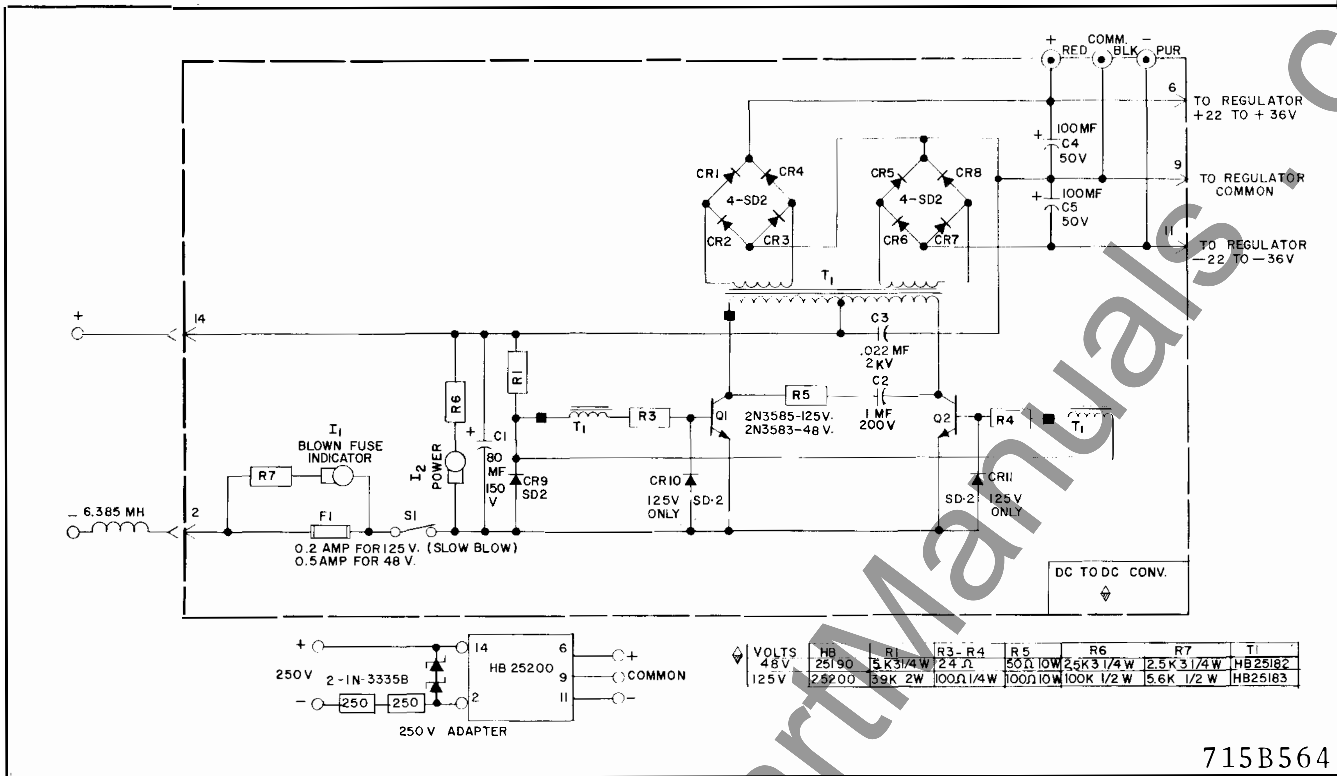


NOTES

1. PRIMARILY USED FOR IMPEDANCE - MATCHING PURPOSE.
2. WESTERN ELECTRIC INSULATING TRANSF. TYPE 2239A OR EQUIV.
3. WESTERN ELECTRIC DRAINAGE REACTOR TYPE 2232A OR EQUIV.
4. UNEXPOSED LINE - MAX. EXTERIOR DISTANCE ABOUT 75FT. - USE SHIELDED CABLE.
5. EXPOSED LINE WITH EXTERIOR DISTANCE OVER 75FT. AND EXPOSED TO LIGHTNING, POWER-SYSTEM CONTACT, AND POWER INDUCTION - USE SHIELDED CABLE.
6. ISOLATE SHIELD FROM GROUND UNTIL OUT OF SIGNIFICANT INFLUENCE OF STATION GROUND POTENTIAL.

205C508

Fig. 2 Recommended Connections and Protective Arrangements for Two-Terminal Lines



VOLTS	HB	R1	R3-R4	R5	R6	R7	T1
48V	25190	5K 3 1/4W	24 Ω	50Ω 10W	2.5K 3 1/4W	2.5K 3 1/4W	HB25182
125V	25200	39K 2W	100Ω 1/4W	100Ω 10W	100K 1/2W	5.6K 1/2W	HB25183

Fig. 3 Power Supply HB-25190 and HB-25200.

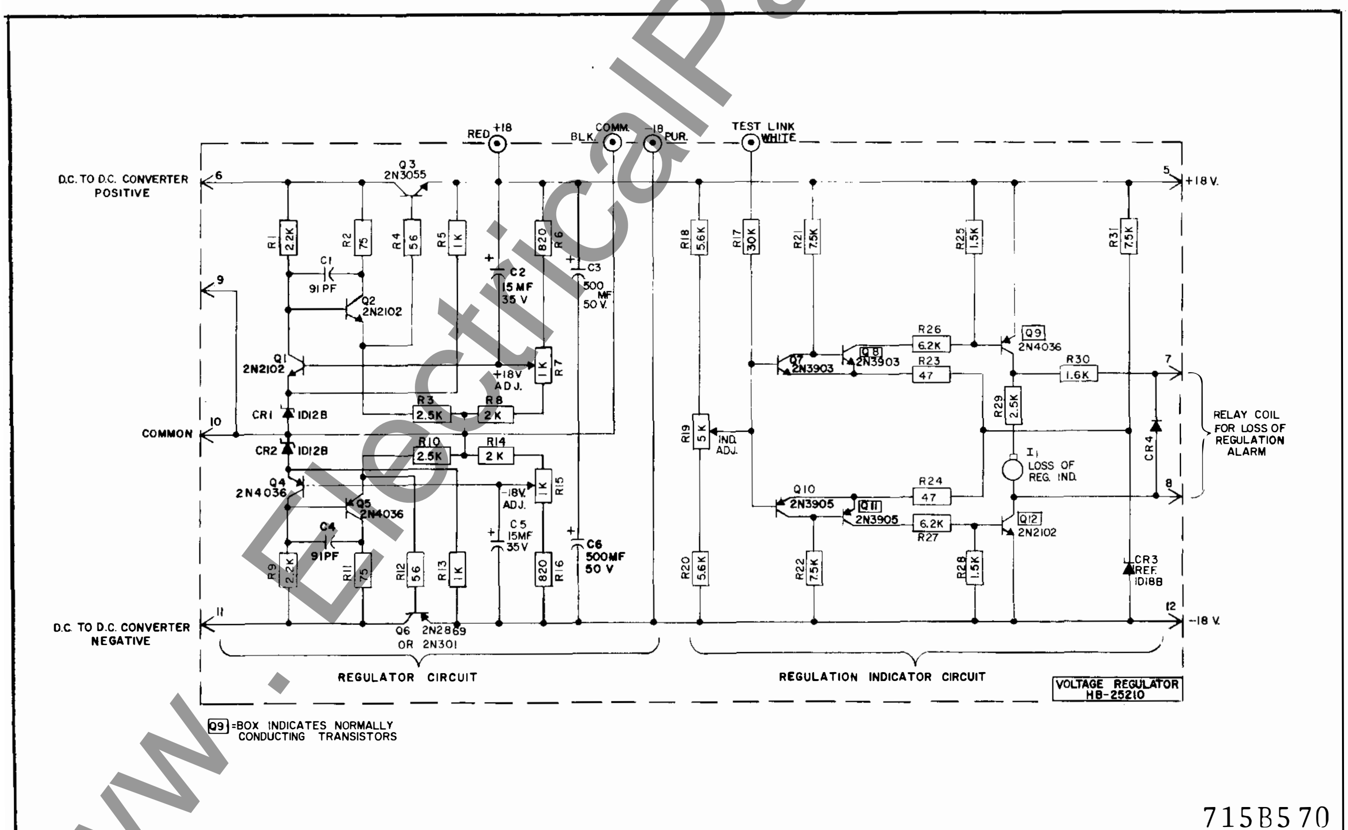


Fig. 4 Voltage Regulator HB-25210.

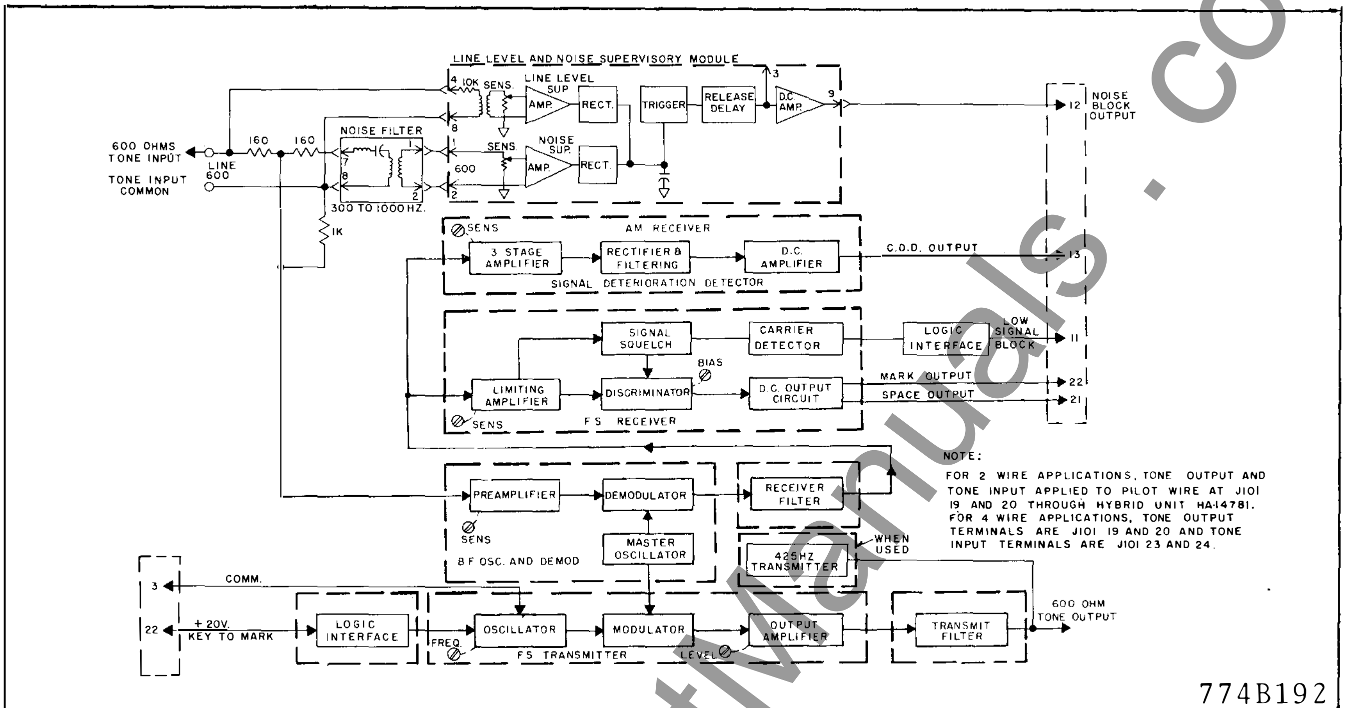
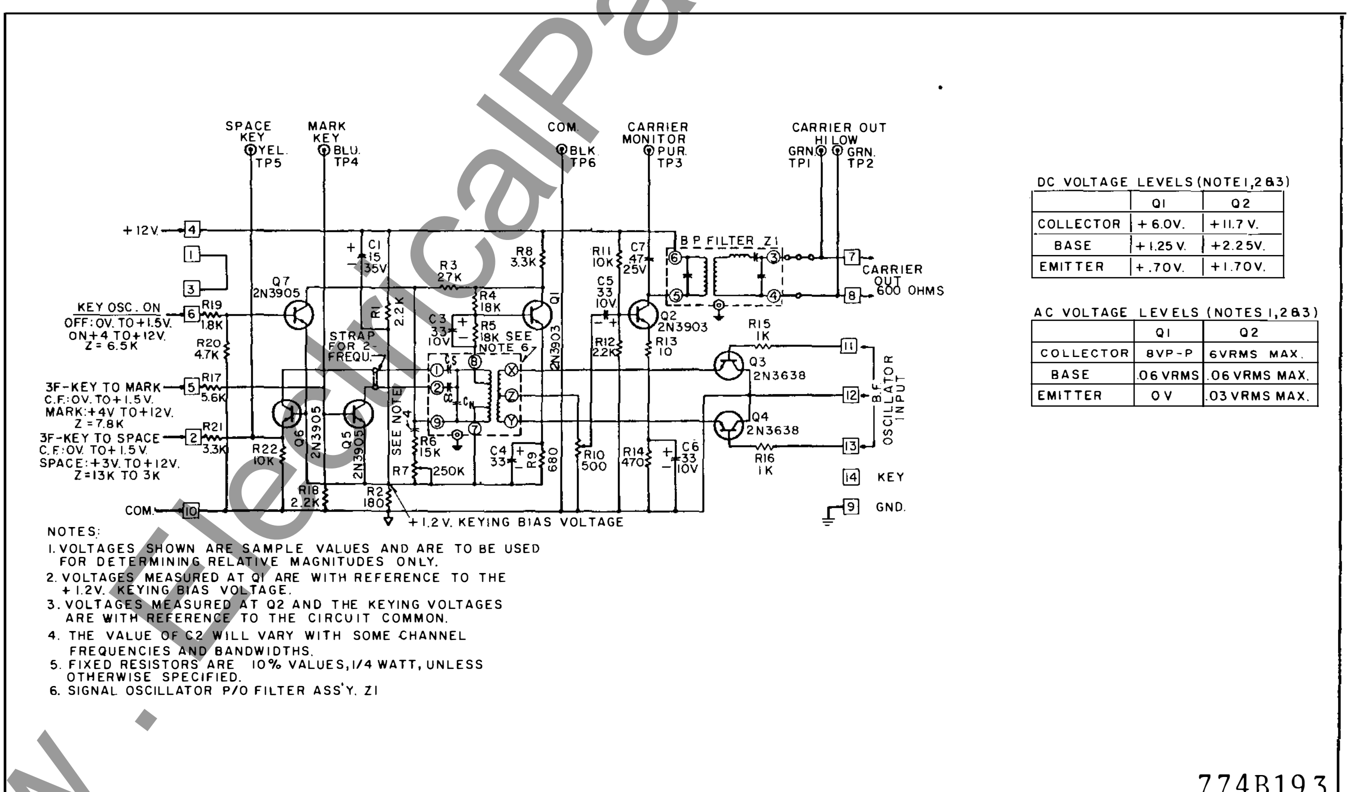


Fig. 5 Block Diagram of TA-2.2 Tone Assembly



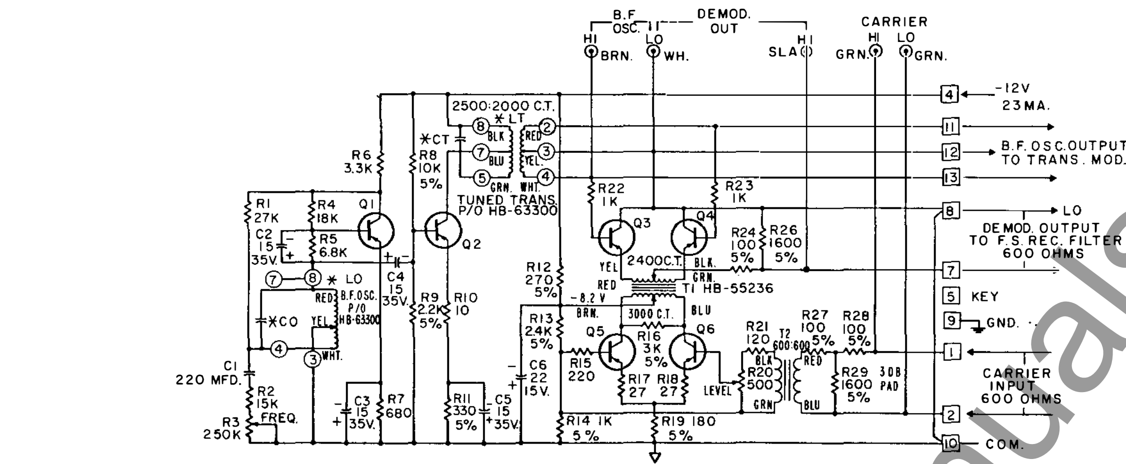
DC VOLTAGE LEVELS (NOTE 1,2&3)

	Q1	Q2
COLLECTOR	+ 6.0V.	+ 11.7 V.
BASE	+ 1.25 V.	+ 2.25V.
EMITTER	+ .70V.	+ 1.70V.

AC VOLTAGE LEVELS (NOTES 1,2&3)

	Q1	Q2
COLLECTOR	8VP-P	6VRMS MAX.
BASE	.06 VRMS	.06 VRMS MAX.
EMITTER	0 V	.03 VRMS MAX.

Fig. 6 Transmitter Module HB-24335-26



NOTES:

1. VOLTAGES SHOWN ARE SAMPLE VALES AND ARE TO BE USED FOR DETERMINING RELATIVE MAGNITUDES ONLY.
2. THE BF OSC. OUTPUT IS 2.7VRMS. WHEN THIS CIRCUIT IS LOADED WITH ONE FS TRANMITTER & MODULATOR MODULE HB-19925 OR HB-21040 IN A DUPLEX SYSTEM.
3. MAXIMUN GAIN FROM CARRIER INPUT TO DEMOD. OUTPUT IS 5DB (ONE SIDEBAND).
4. MAXIMUN DEMOD. OUTPUT CAPABILITY IS 0 DBM (ONE SIDEBAND).
5. THE VALUE OF C1 WILL VARY FOR SOME FREQUENCIES.
6. FIXED RESISTORS ARE 10% VALUES, 1/4 WATT, UNLESS OTHERWISE SPECIFIED.
7. ASTERIST (*) INDECATES FACTORY VALUE.
8. TRANSISTORS Q1 TO Q6 ARE 2N1375

VOLTAGE LEVELS REF. COM (POSITIVE BATTERY TERMINAL). SEE NOTE 1.

	Q1		Q2	
COLLECTOR	-6 V	8V P-P	-12 V	6V RMS
BASE	-1.15V	.07V RMS	-2.1V	.07 VRMS
EMITTER	-1 V	0VRMS	-2 V	.038VRMS

	Q5	Q6
COLLECTOR	-7.5 V	-7.5 V
BASE	-2.3 V	-2.3 V
EMITTER	-2.2V	-2.2 V

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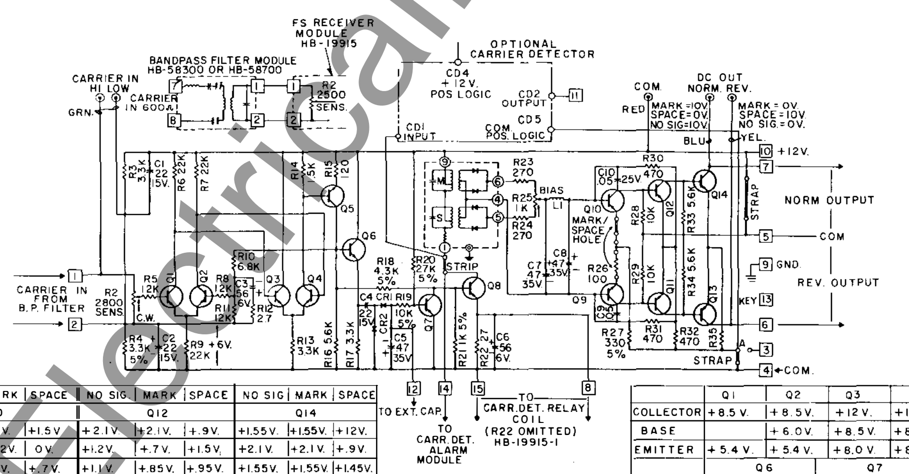
Fig. 7 Beat Frequency Oscillator and Demodulator HB-25640



	NO SIG.	MARK	SPACE	NO SIG.	MARK	SPACE	NO SIG	MARK	SPACE
	Q10			Q12			Q14		
COLLECTOR	+.8V.	+.7V.	+1.5V	+2.1V.	+2.1V.	+.9V.	+1.55V.	+1.55V.	+12V.
BASE	+1.0V.	+1.32V.	0V.	+1.2V.	+.7V.	+1.5V.	+2.1V.	+2.1V.	+.9V.
EMITTER	+0.5V.	+.7V.	+.7V.	+1.1V.	+.85V.	+.95V.	+1.55V.	+1.55V.	+1.45V.
	Q9			Q11			Q13		
COLLECTOR	+1.7V.	+1.5V.	+.8V.	+1.1V.	+.8V.	+2.0V.	+12V.	+12V.	+1.5V.
BASE	+1.0V.	0V.	+1.5IV.	+1.7V.	+1.5V.	+.8V.	+1.1V.	+.8V.	+2.0V.
EMITTER	+.55V.	+.7V.	+.9V.	+1.1V.	+.85V.	+.95V.	+1.55V.	+1.55V.	+1.45V.

Q5 IS 2N3905 ALL OTHER TRANSISTORS ARE 2N3903

	Q1	Q2	Q3	Q4	Q5
COLLECTOR	+8.5 V.	+8.5V.	+12 V.	+11.1 V.	+6.2 V.
BASE		+6.0V.	+8.5V.	+8.5V.	+11.1V.
EMITTER	+5.4 V.	+5.4 V.	+8.0 V.	+8.0 V.	+11.7 V.

	Q6		Q7		Q8	
	W/O SIG.	W/SIG.	W/O SIG.	W/SIG.	W/O SIG.	W/SIG.
COLLECTOR	+12 V.	+12V.	+0.1V	+0.8V.	+12V.	+8 V.
BASE	+6.2V.	+6.2V.	+0.6V	-0.9V.	+0.1V.	+0.8V.
EMITTER	+5.7V.	+6.8V.	0V.	0V.	0V.	+0.6V.

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Fig. 8 Frequency Shift Receiver HB19915-27

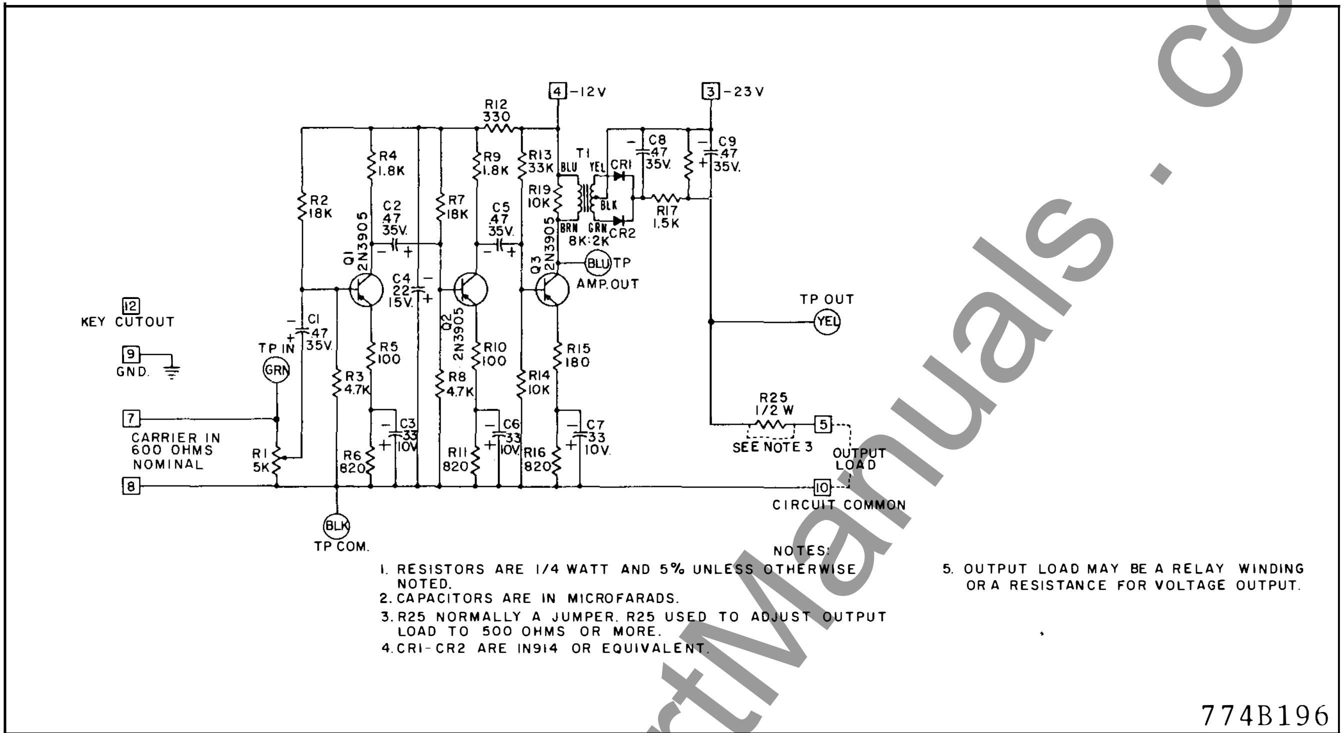

Fig. 9 Carrier Deteriation Detector HB-24030-3

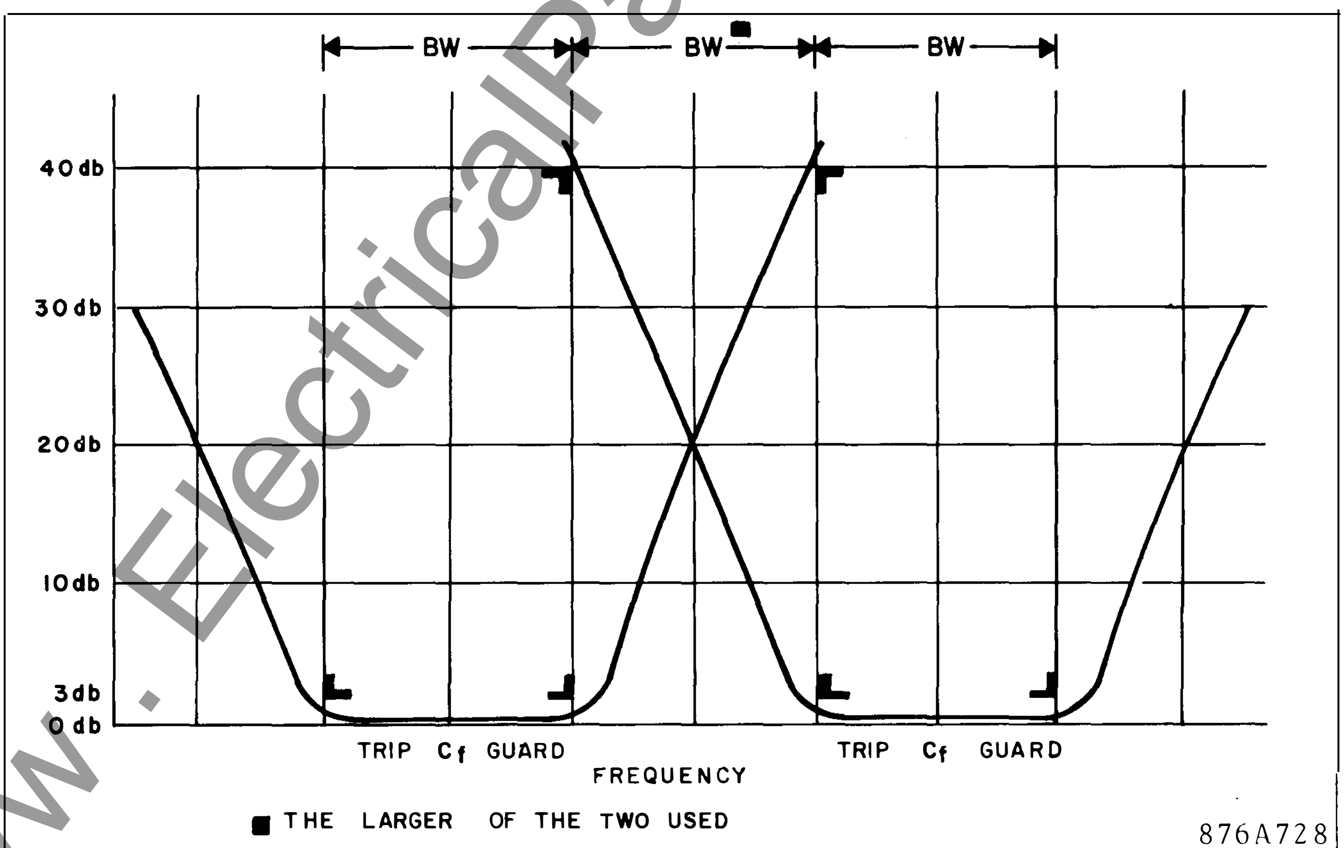

Fig. 10 Tone Receiver Filter Characteristics HB-63100.

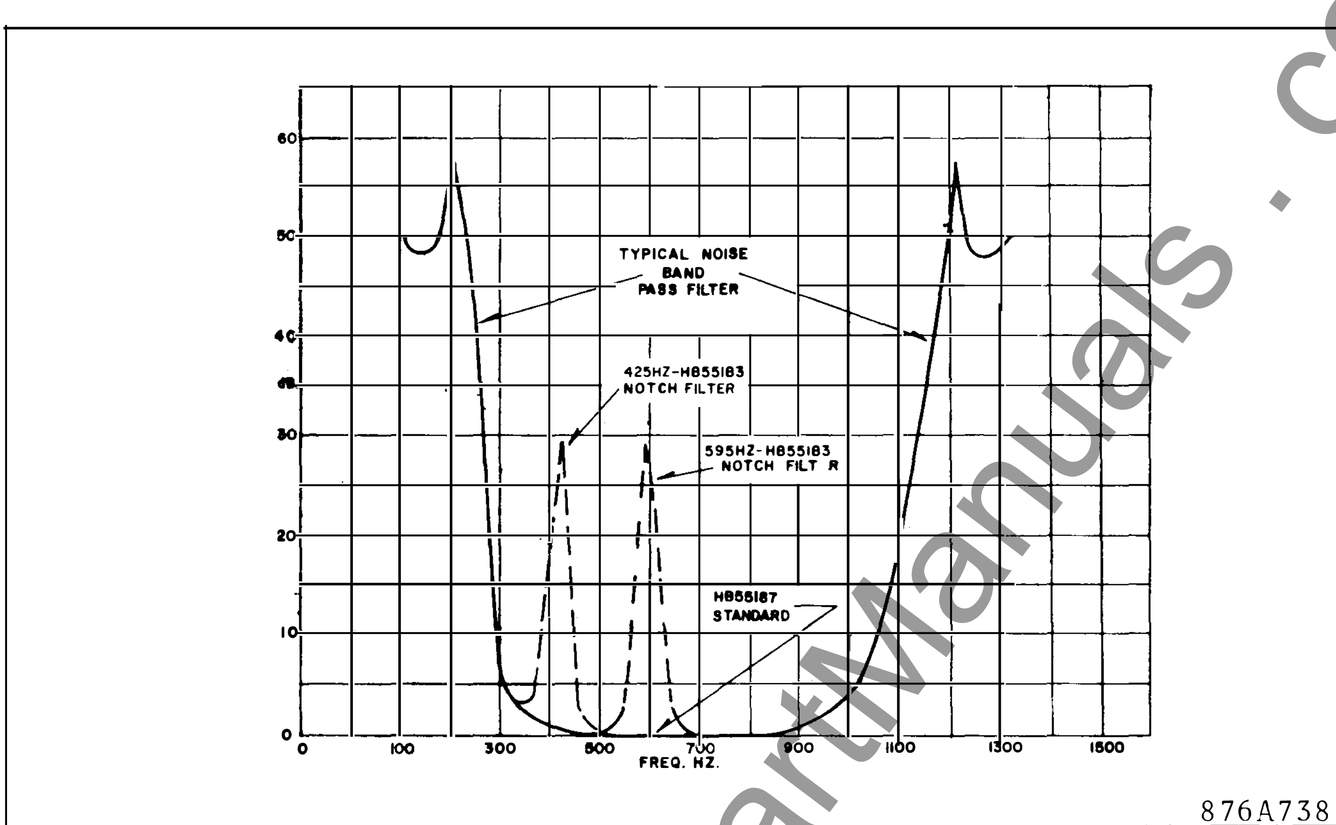

Fig. 11 Typical Noise Bandpass Filter.

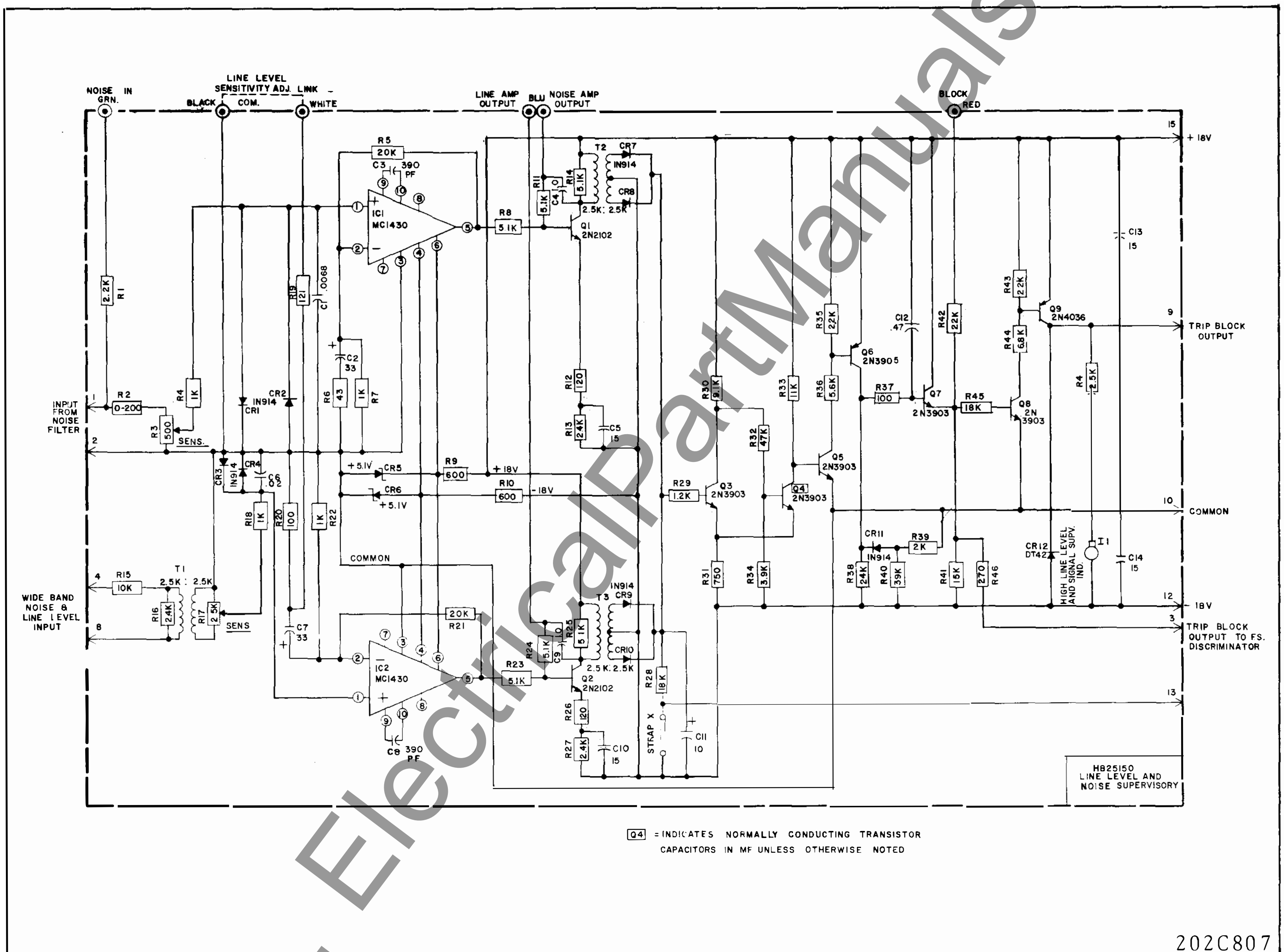

Fig. 12 Receiver Line Level and Noise Supervisory Module HB-25150.

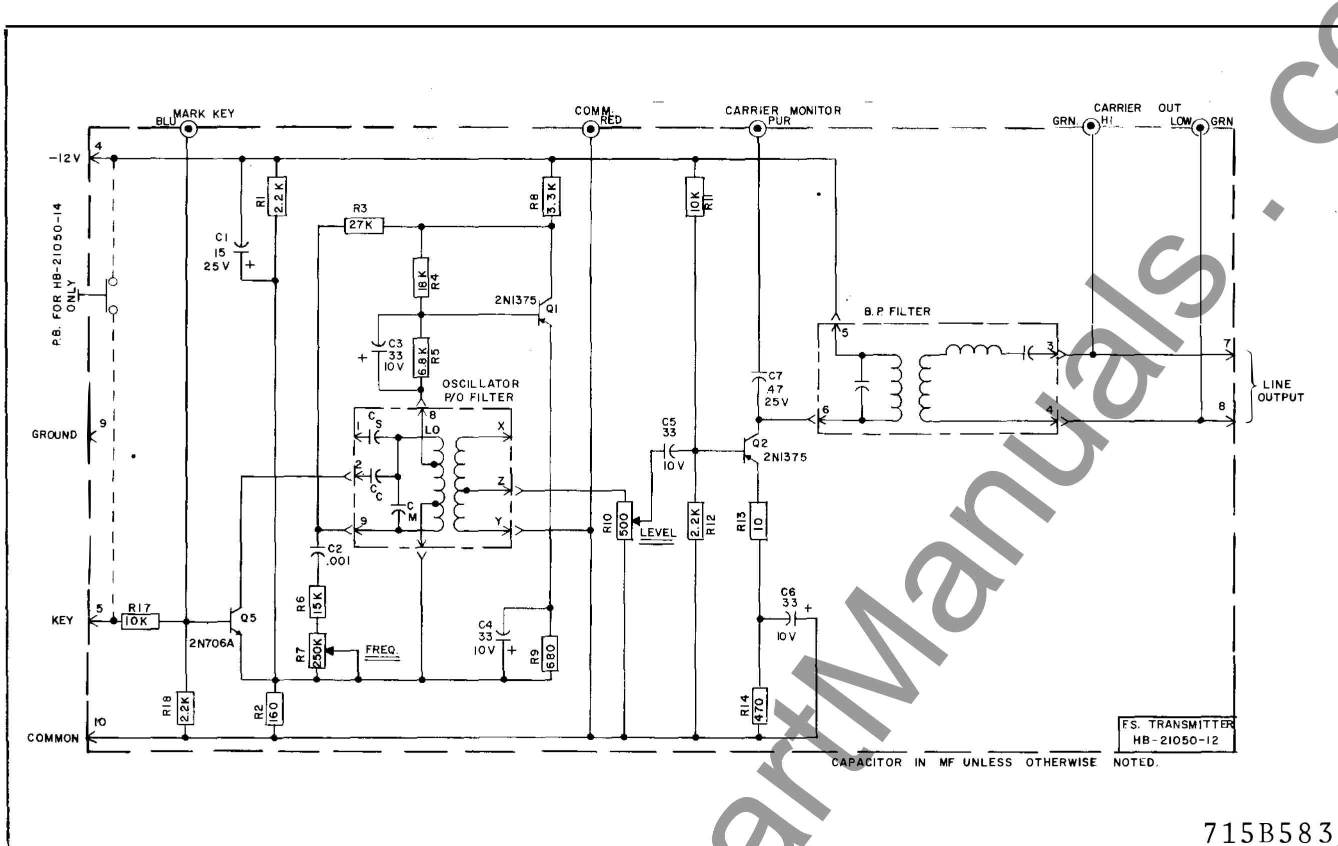

Fig. 13 425-Hz Transmitter HB-21050-2.

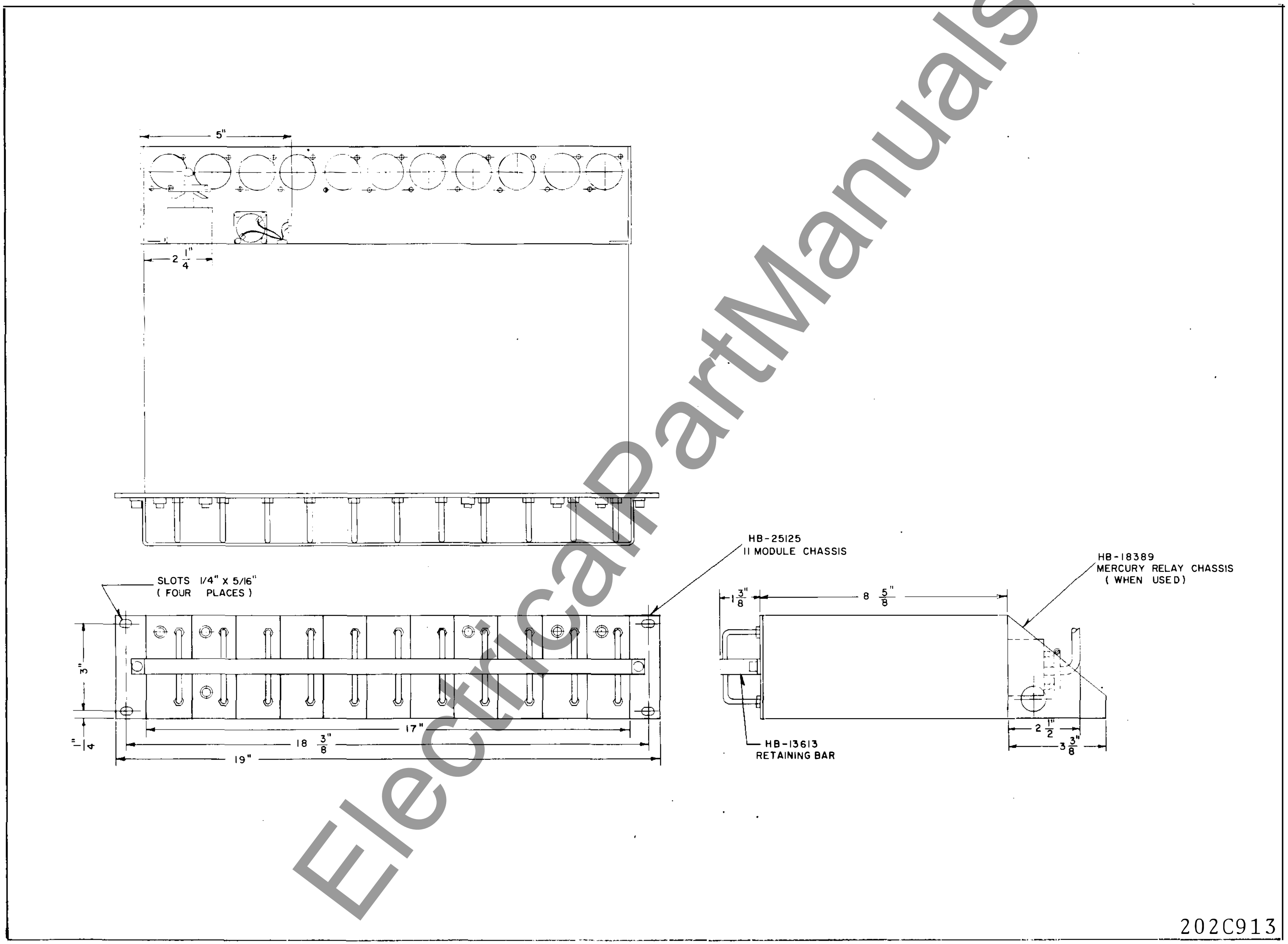

Fig. 14 Outline and Drilling Plan.

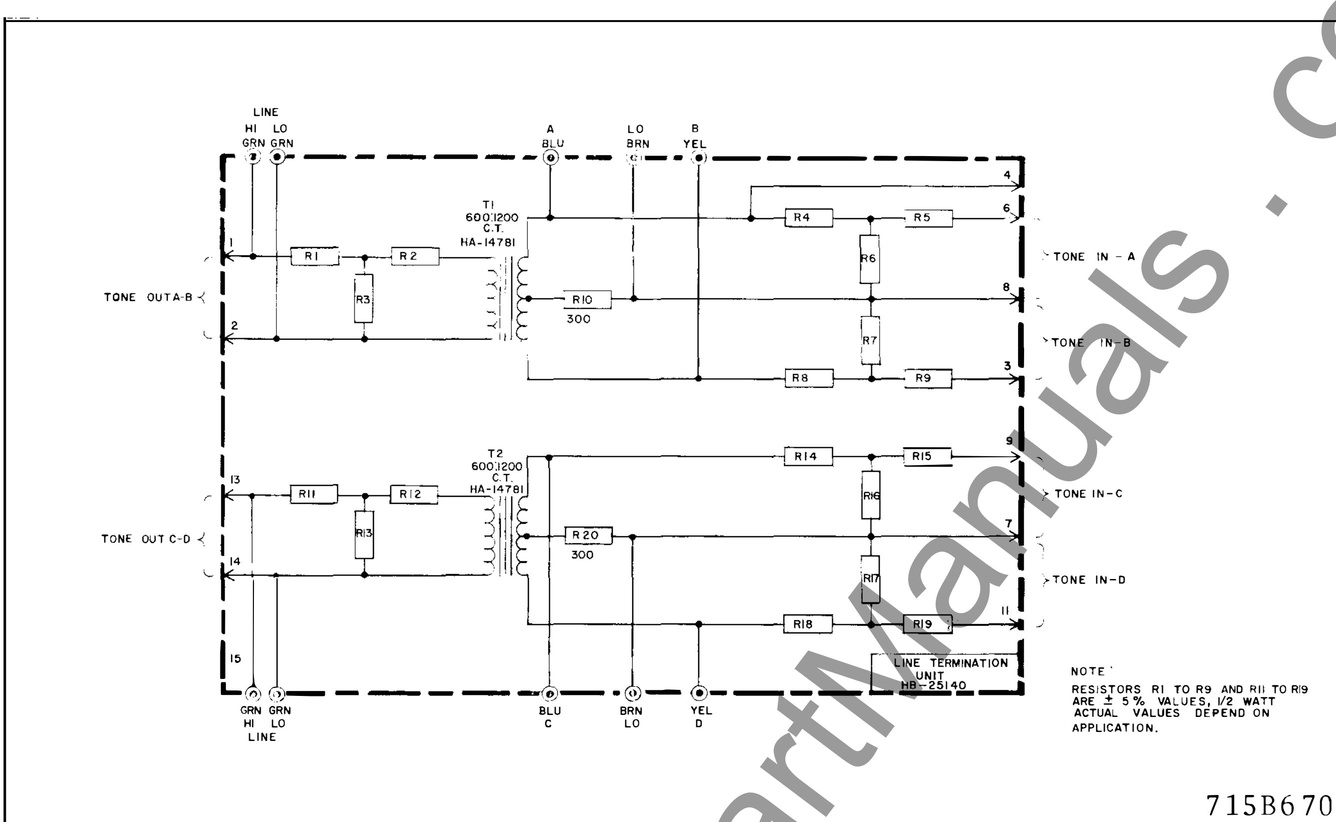

Fig. 15 Line Termination Module HB-25140.

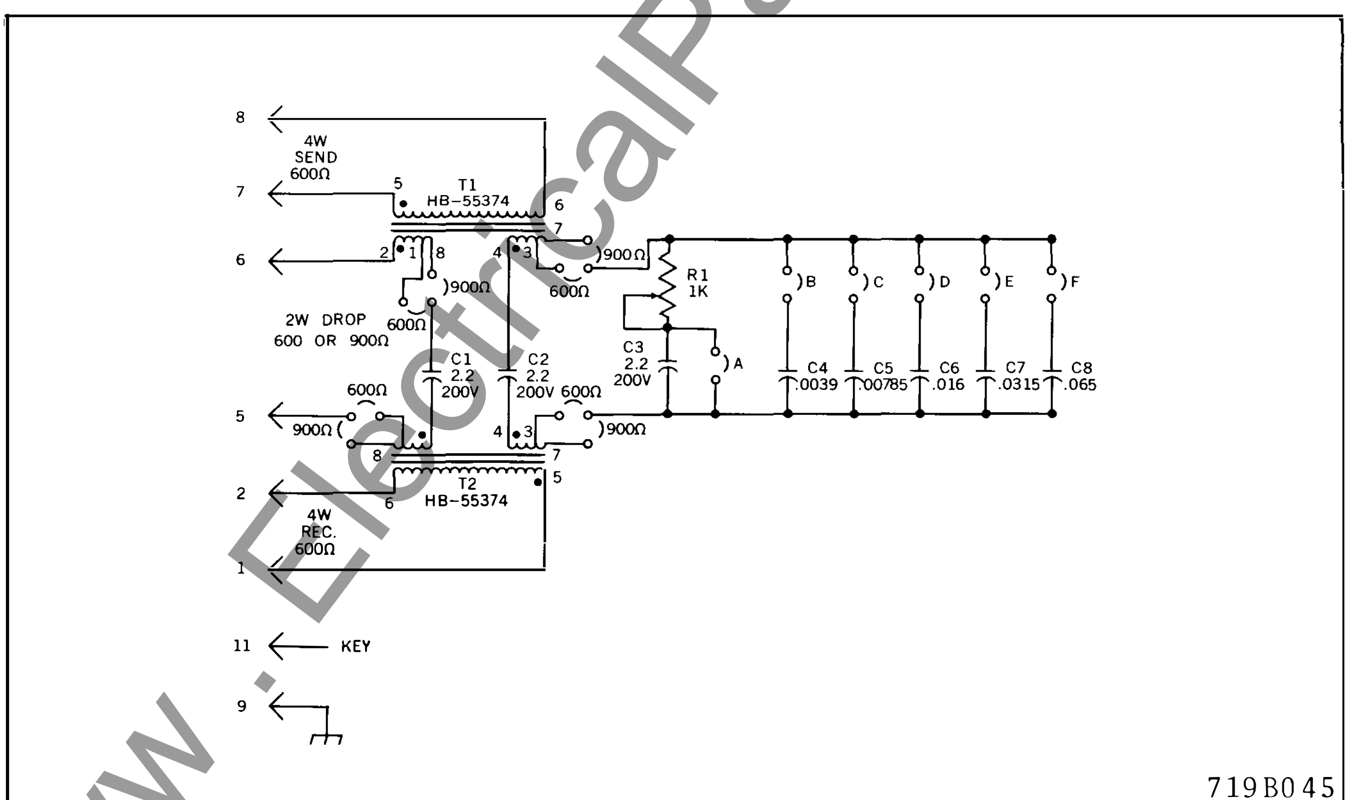

Fig. 16 Hybrid for Two Wire Termination HB-35315.

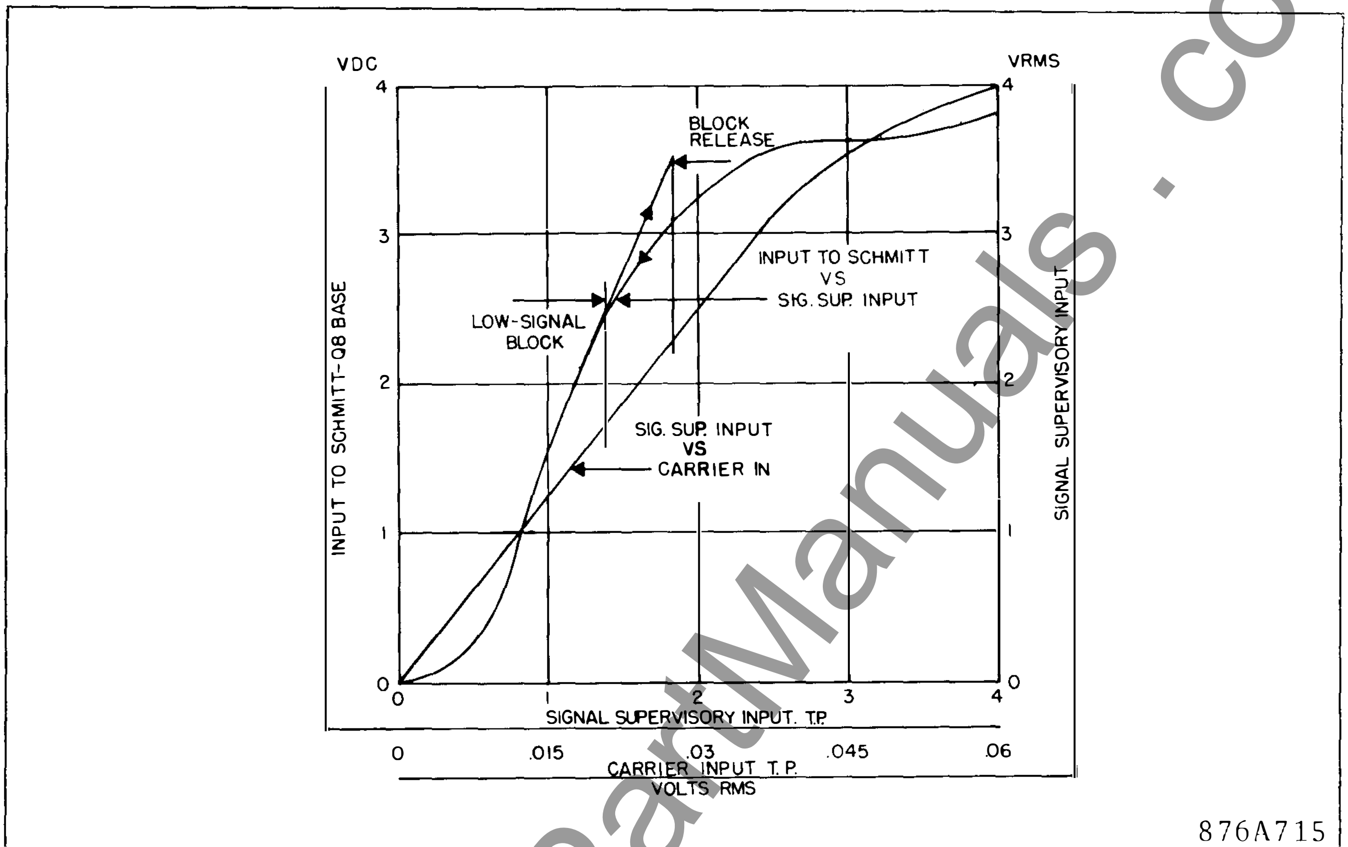

Fig. 17 Signal Supervisory Circuit Characteristics.

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RECEIVER DYNAMIC OPERATING RANGE

MAXIMUM LEVEL OF A SINGLE OUT-OF-BAND TONE (ABOVE 1000 HZ) TO CAUSE A HIGH LINE TRIP BLOCK.

NUMBER OF CHANNELS	OUT-OF-BAND TONE LEVEL ABOVE NORMAL CHANNEL
1.	3.5dB
2.	8.6dB
3.	10.5dB

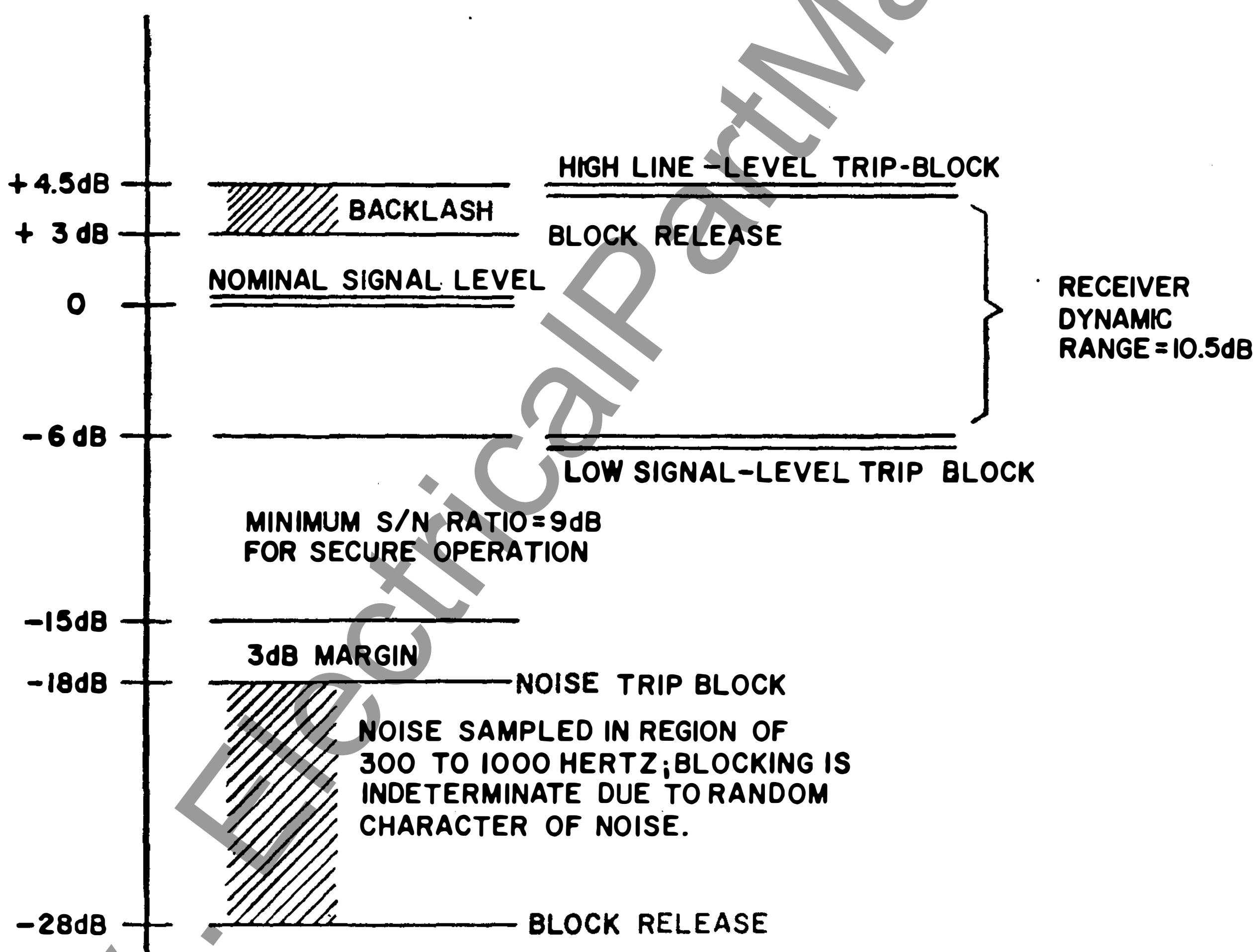
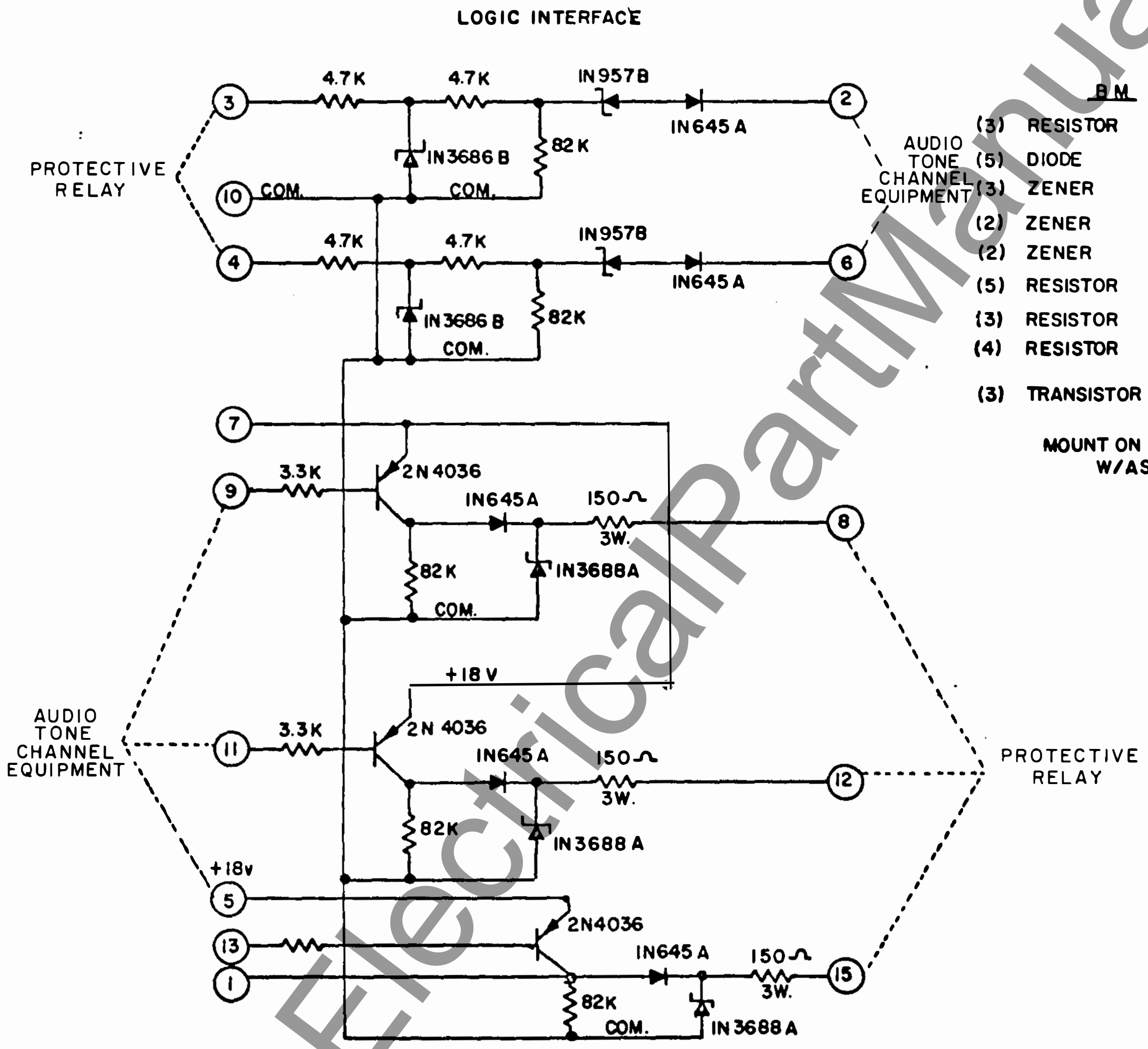


Fig. 18 Receiver Dynamic Operating Range.



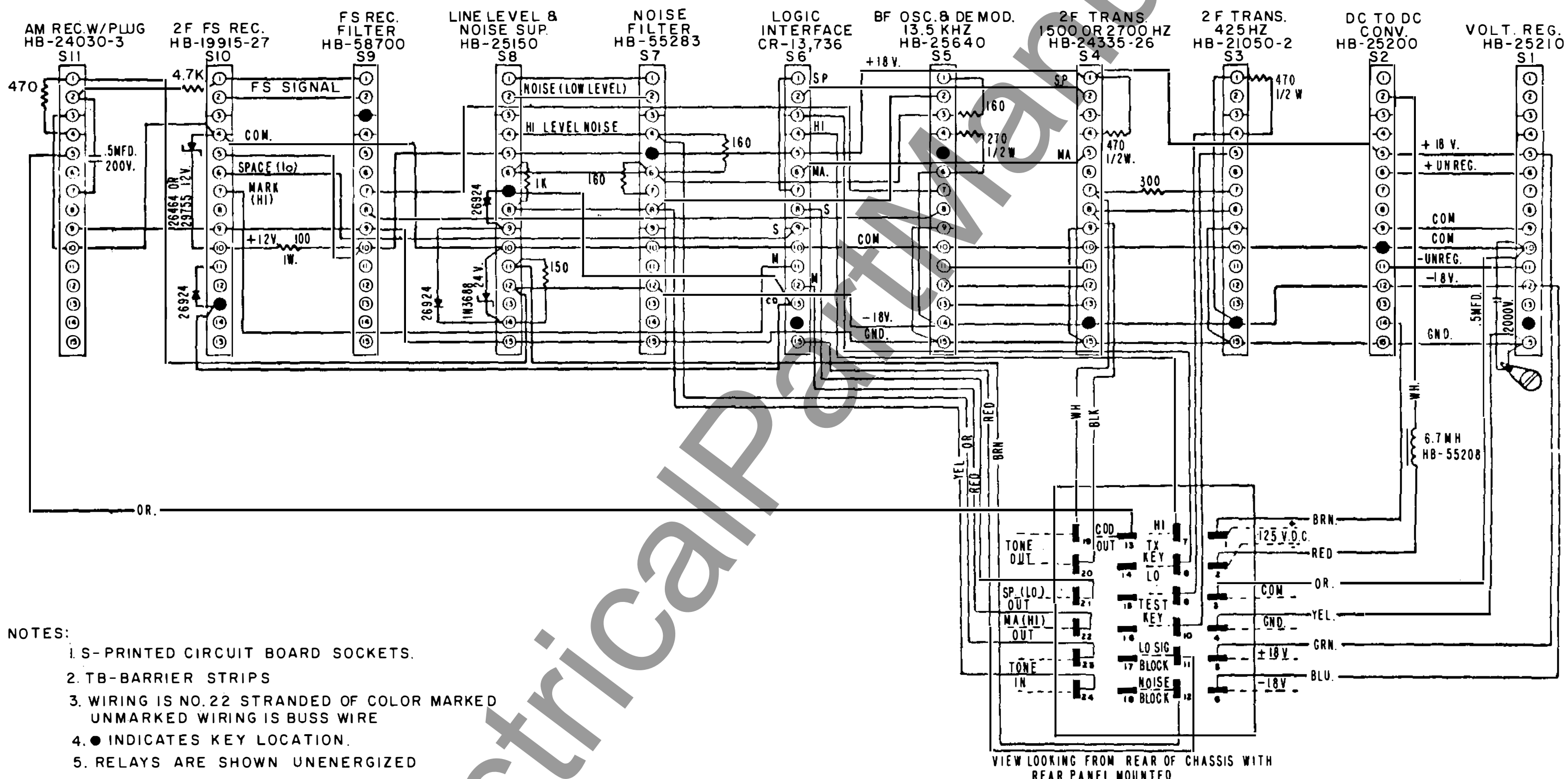
BM

(3)	RESISTOR	150Ω 3w	H-1100-566
(5)	DIODE	IN645A	HA-26924
(3)	ZENER	IN3688A	HA-26924
(2)	ZENER	IN957 B	INT. RECT.
(2)	ZENER	IN3686B	MOTOROLA
(5)	RESISTOR	82K 1/2W	CARBON
(3)	RESISTOR	3.3K 1/2W	CARBON
(4)	RESISTOR	4.7K TYPE RG 20, 5% 1/2W	MET. GLAZED – IRC
(3)	TRANSISTOR	2N4036	HA-24003

MOUNT ON UNIVERSAL MODULE
W/ASA 61 FRONT PANEL

774B197

Fig. 19 Logic Interface Module



NOTES:

1. S-PRINTED CIRCUIT BOARD SOCKETS.
2. TB-BARRIER STRIPS
3. WIRING IS NO. 22 STRANDED OF COLOR MARKED UNMARKED WIRING IS BUSS WIRE
4. ● INDICATES KEY LOCATION.
5. RELAYS ARE SHOWN UNENERGIZED

774B198

Fig. 20 Typical Terminal Block Wiring

WESTINGHOUSE ELECTRIC CORPORATION

RELAY-INSTRUMENT DIVISION

NEWARK, N. J.

Printed in U.S.A.

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.

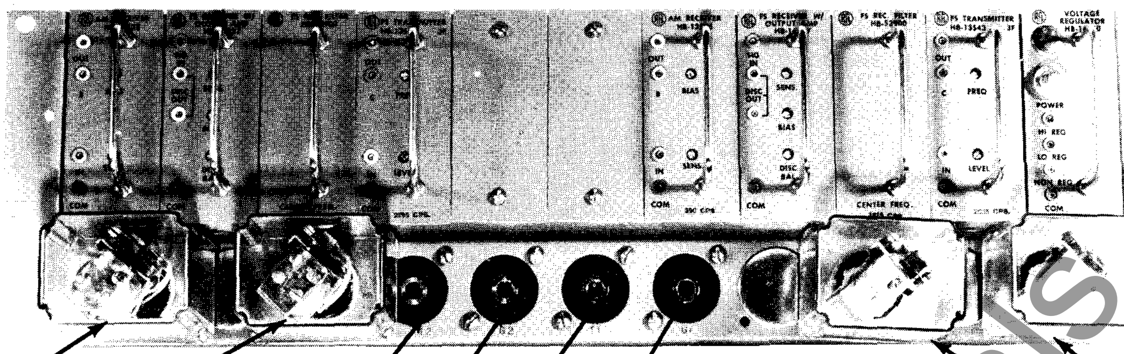


Fig. 1 – Front View of Full Chassis: 1–Telephone Type output relays (when used); 2–Current monitoring jacks (when used).

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 dualpurpose 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.

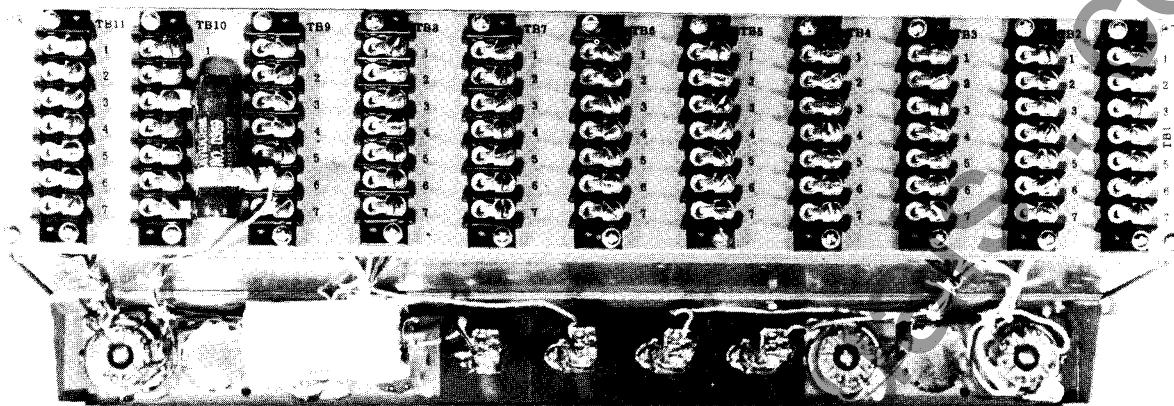


Fig. 2 – Rear View of Full Chassis

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.

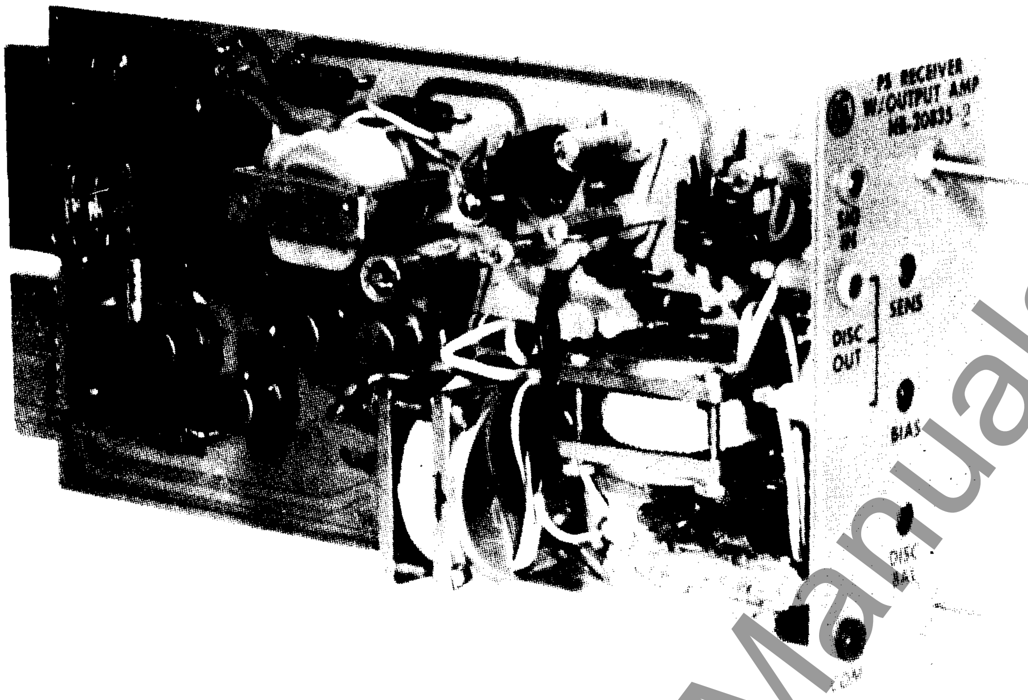


Fig. 3 – Typical Module

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 opperates 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.

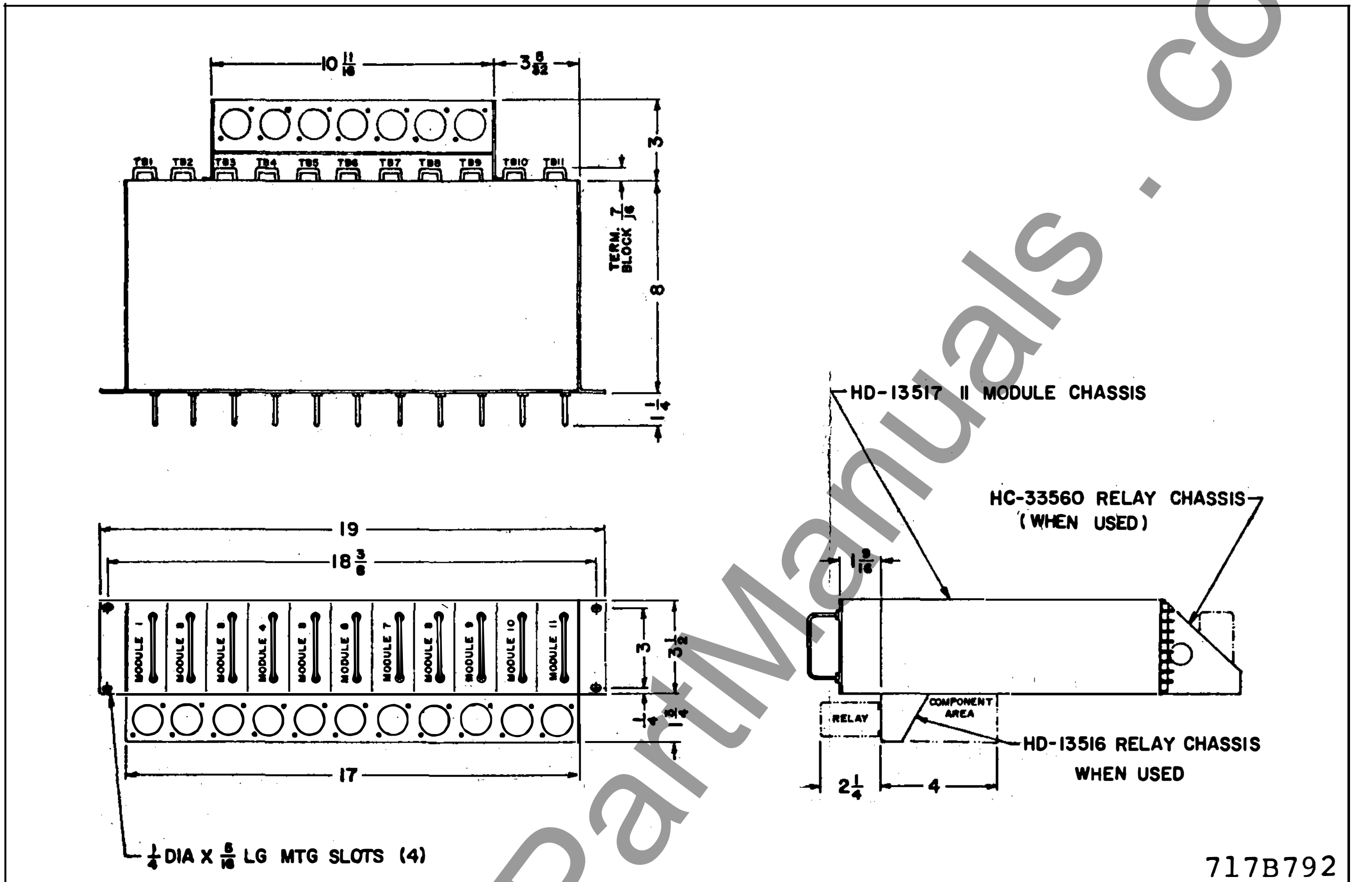


Fig. 4 – Outline and Drilling Plan of 11 Module Chassis

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

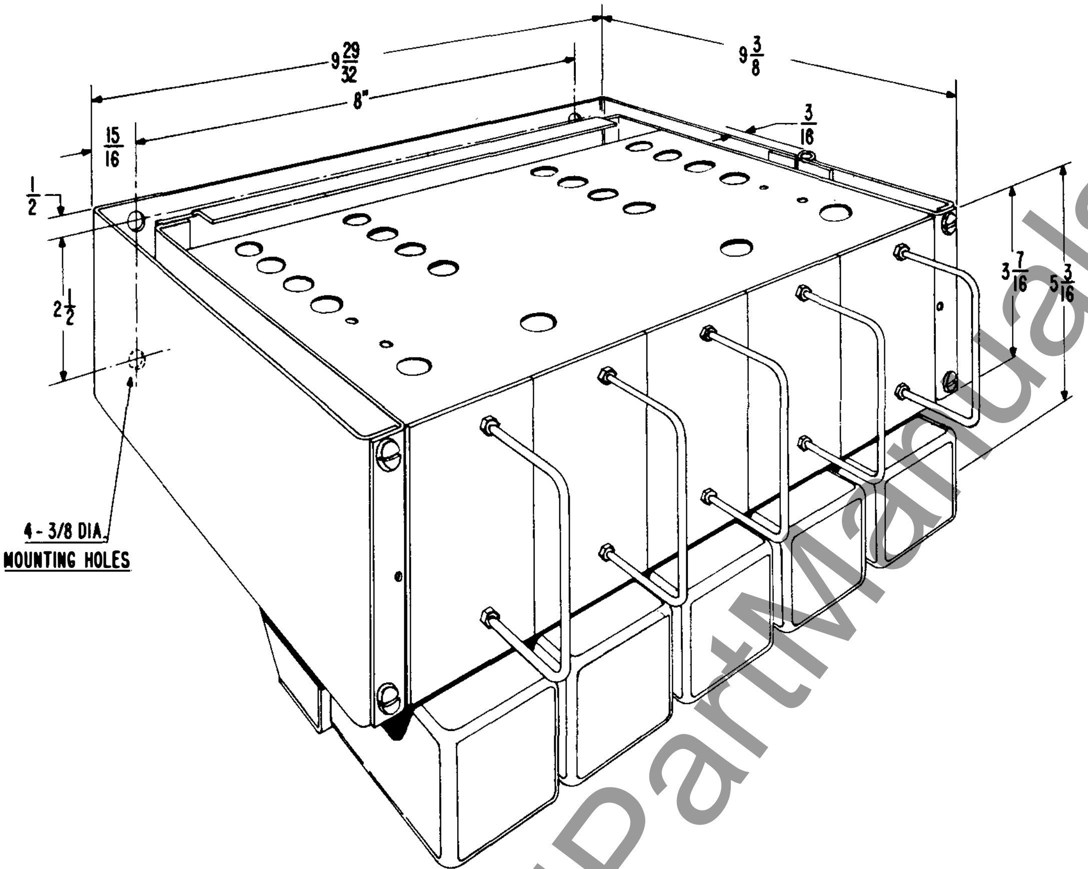


Fig. 5 — Outline and Drilling Plan of 5 Module Chassis

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.

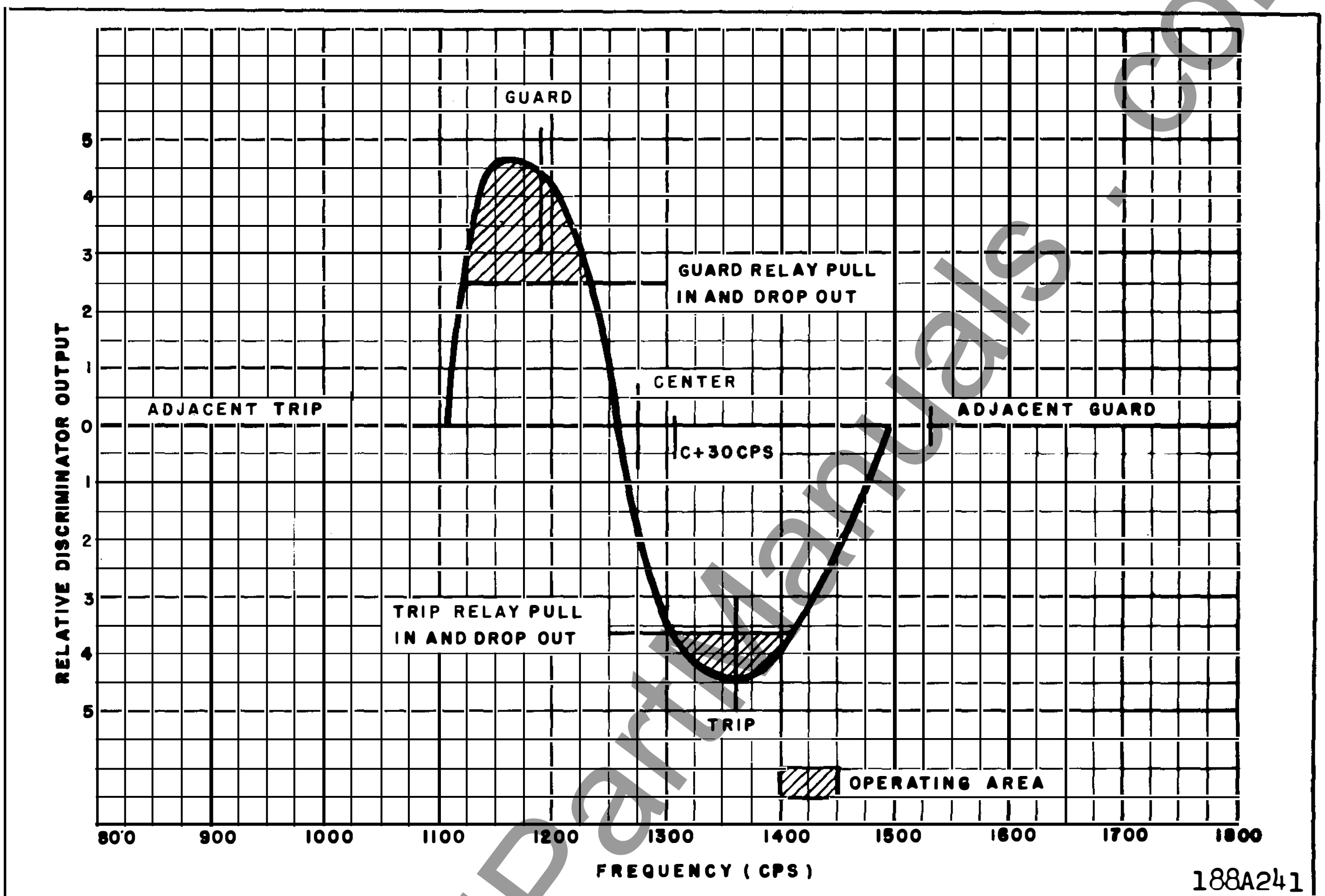


Fig. 6 – Typical discriminator output curve showing relative noise power output affecting trip relay.

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

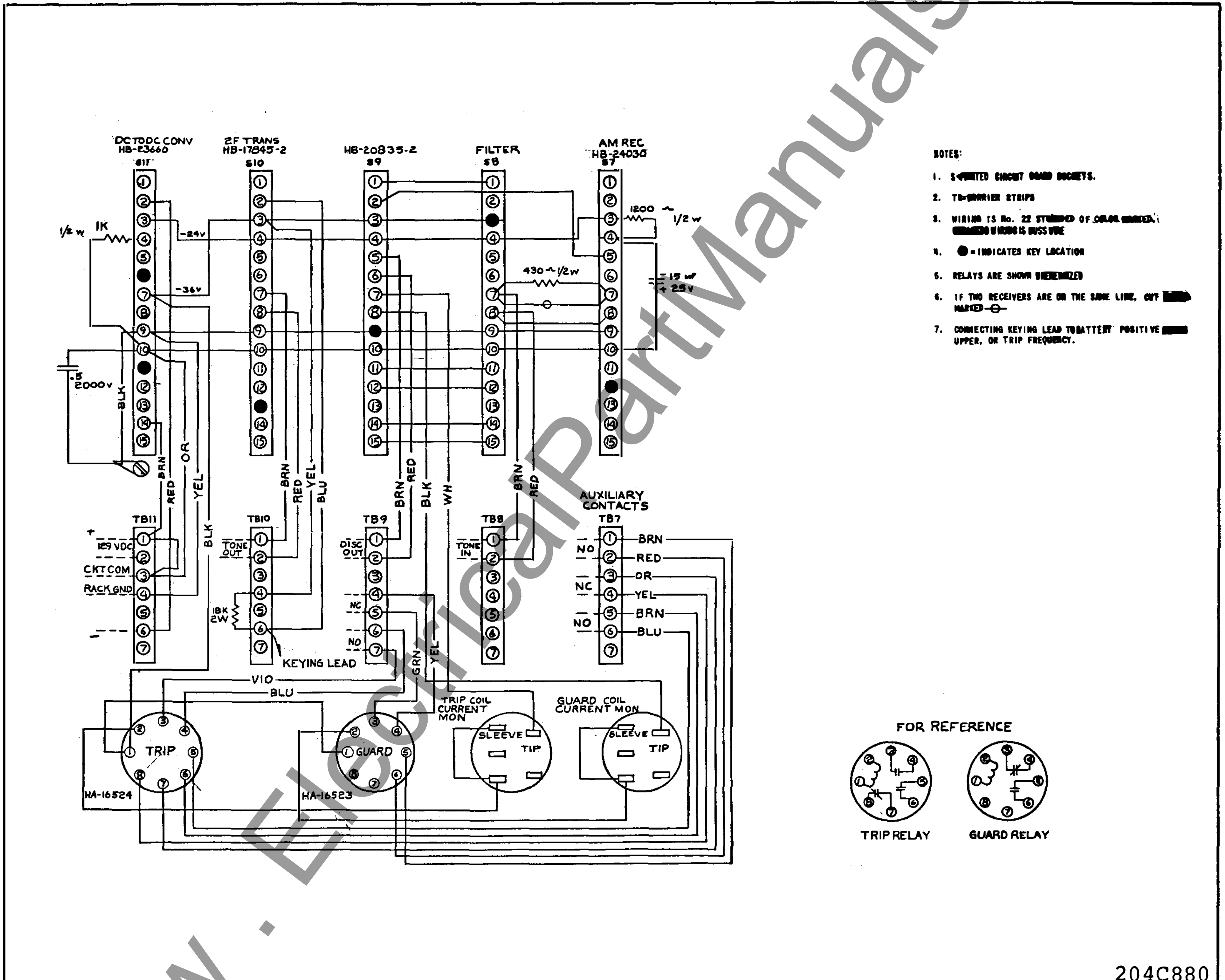


Fig. 7 Typical Terminal Block Drawing of Type TA-1 Assembly. (CR Dwg.)

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, shouldbe 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

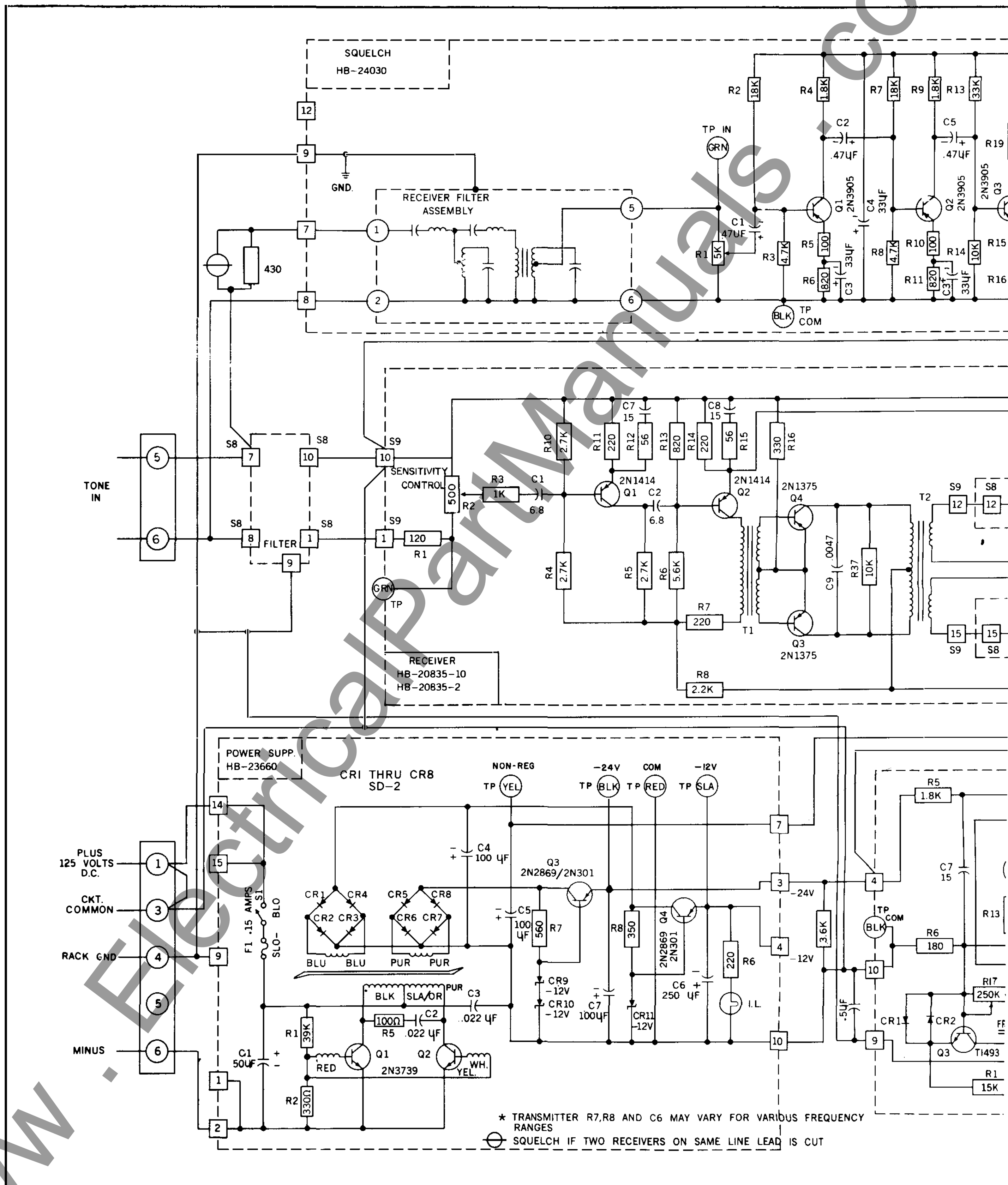
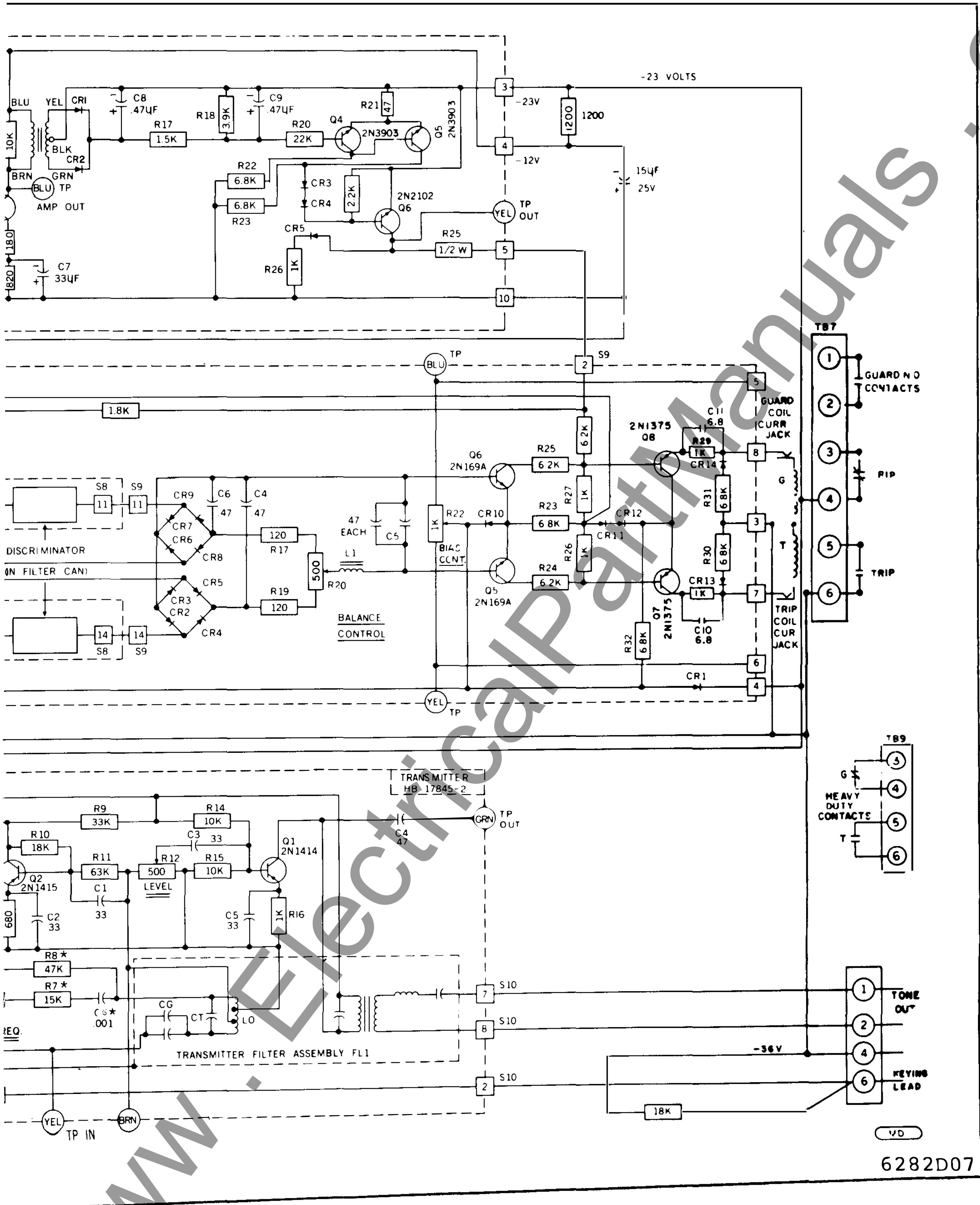


Fig. 8 Typical Schematic Diagram of Type TA-1 As



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.

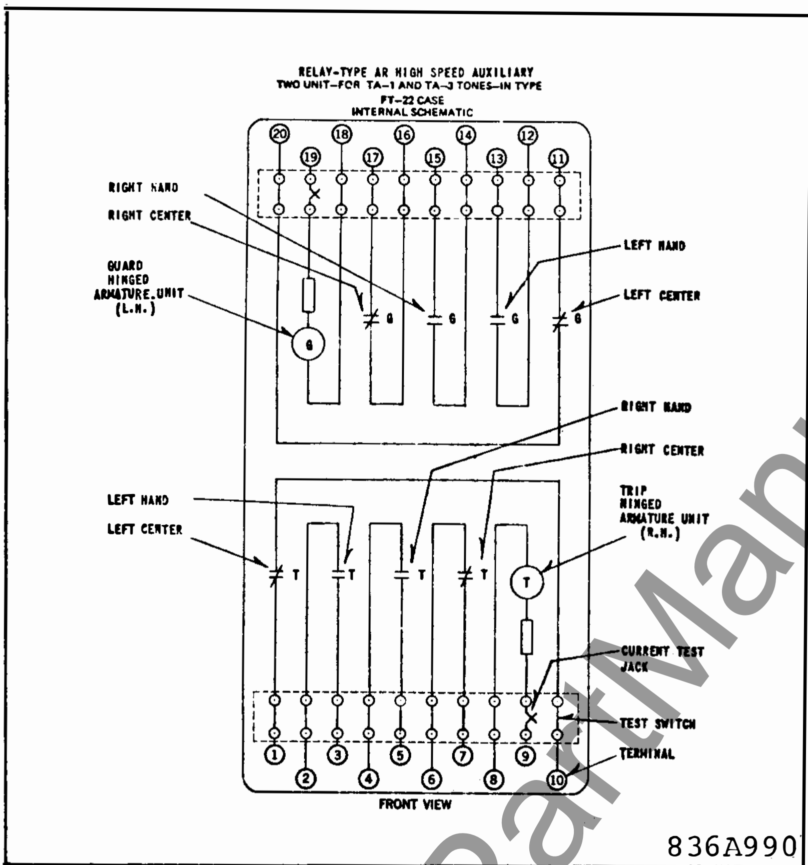


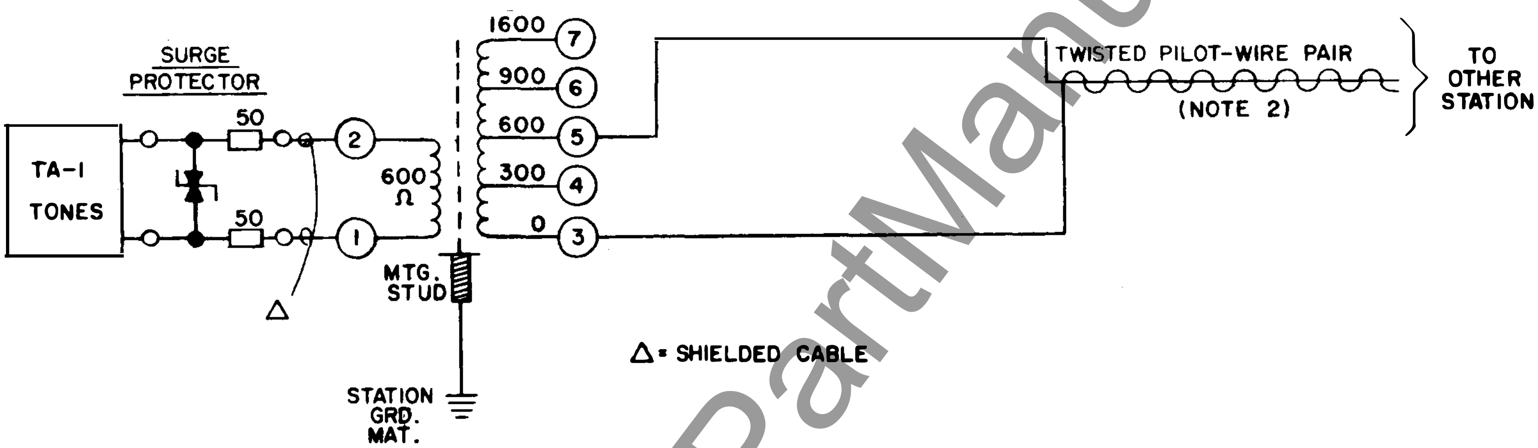
Fig. 10 Internal schematic of the type AR relay for use with TA-1 tones. (For Reference Only)

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	E	0	0	0	0	–	24	–	12									Hi Reg	24VDC
and Voltage Regulator (125V)	B	2.3	1.6	2.3	1.5	–	24	–	12									Lo Reg	12VDC
HB-23360	C	125	–	125	–	–	34	–	19.3									Non Reg	34VDC
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	22	2mv	1.5	2mv	1.5	IN	.039VAC
HB-20835-2	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	
HB-20835-10	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	E	2mv	2.15	.016	2.15	.13	2.45		23		23		23					In	.01VAC
HB-24030	B	2mv	2.3	.018	2.3	.15	2.65		23		13.5		23					OUT	1.2VDC
(Adjusted to Squelch with –40 dbm 400 cps tone input.)	C	.019	7.4	.16	7.4	5	2.45		13.5		22.5		0					V	5.0VAC
DC to DC Converter	E	0	0	0	0	–	24		12									Hi Reg	24VDC
and Voltage Regulator (48V)	B	2.2	1.4	2.2	1.4	–	24		12									Lo Reg	12VDC
HB-23705	C	48	–	48	–	–	34		19.3									Non Reg	34VDC

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



NOTE 1 THESE CONNECTIONS ASSUME A PILOT-WIRE Zo ≃ 600 Ω

NOTE 2 COMPLETED CABLE FIELD TEST VOLTAGE OF 10KV D.C. FOR 10 MINUTES FROM EACH CONDUCTOR TO ALL OTHER CONDUCTORS AND SHEATH. SHIELDING FACTOR OF 50% OR LESS. EACH PAIR TWISTED SEPARATELY. GROUND SHEATH TO STATION MAT AT BOTH ENDS AND TO REMOTE GROUND AT EACH SPLICE

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Fig. 11 – Recommended Connections and Pilot Wire Design for Privately owned Cable for Two Terminal Lines.

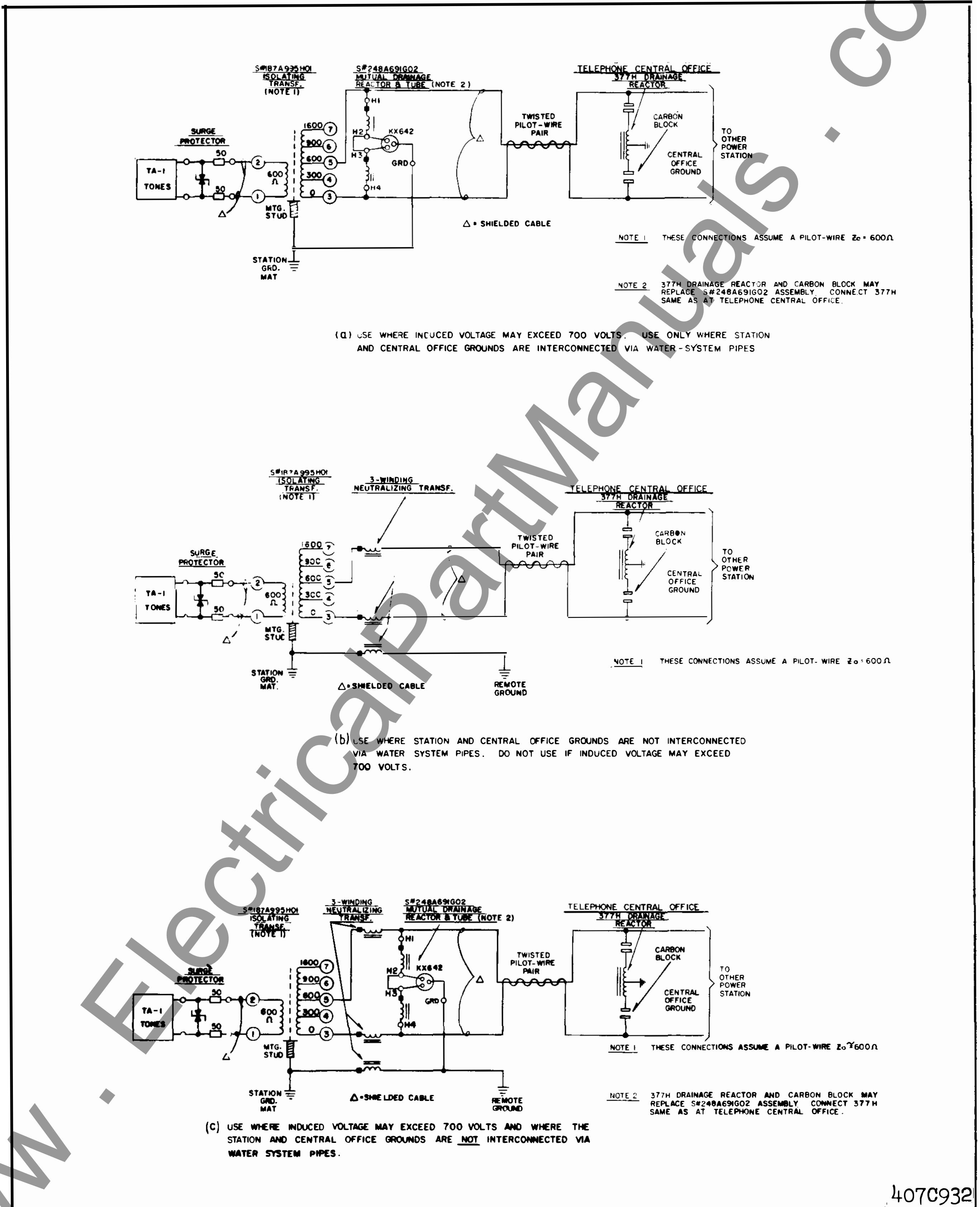


Fig. 12 — Recommended Connections and Protective Arrangements for leased Cable for Two Terminal Lines.

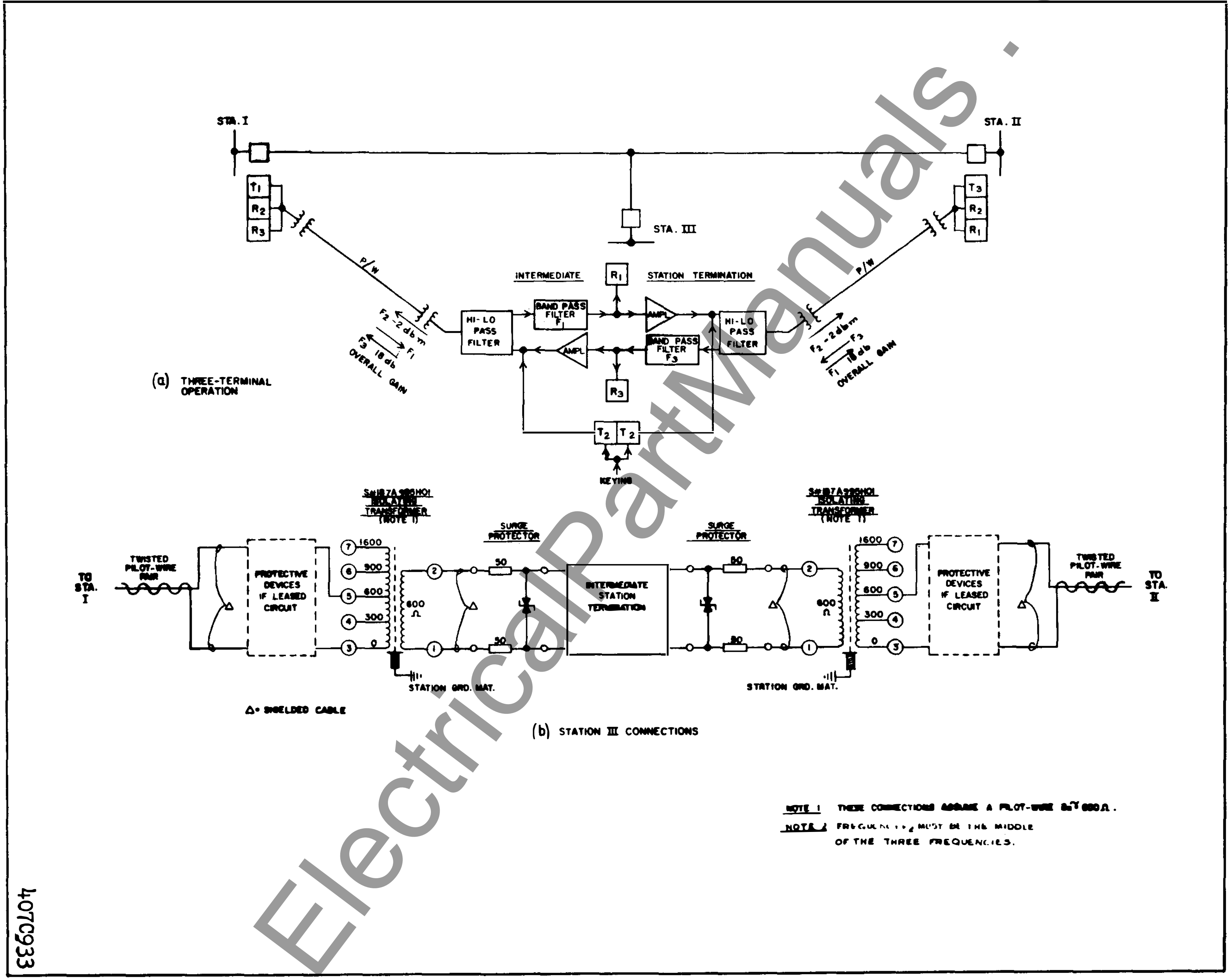


Fig. 13 — Recommended Channel Arrangements for Three Terminal Line Protection.

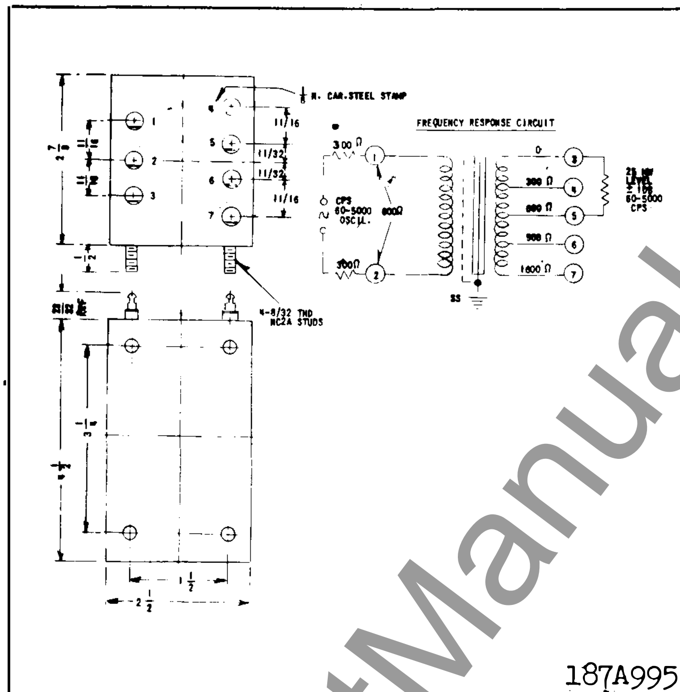


Fig. 14 Isolating Transformer 187A995H01.

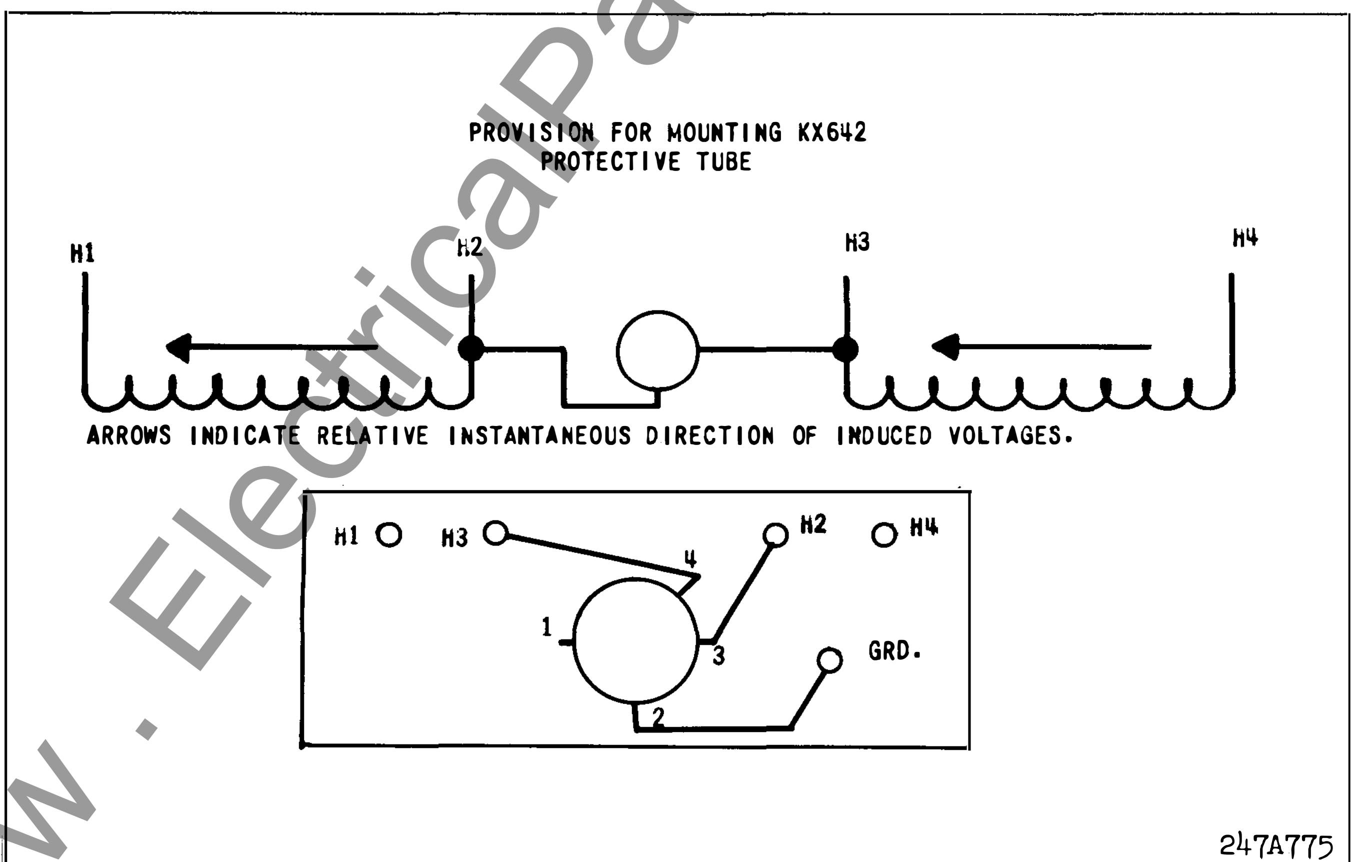


Fig. 15 Drainage Reactor Connections.

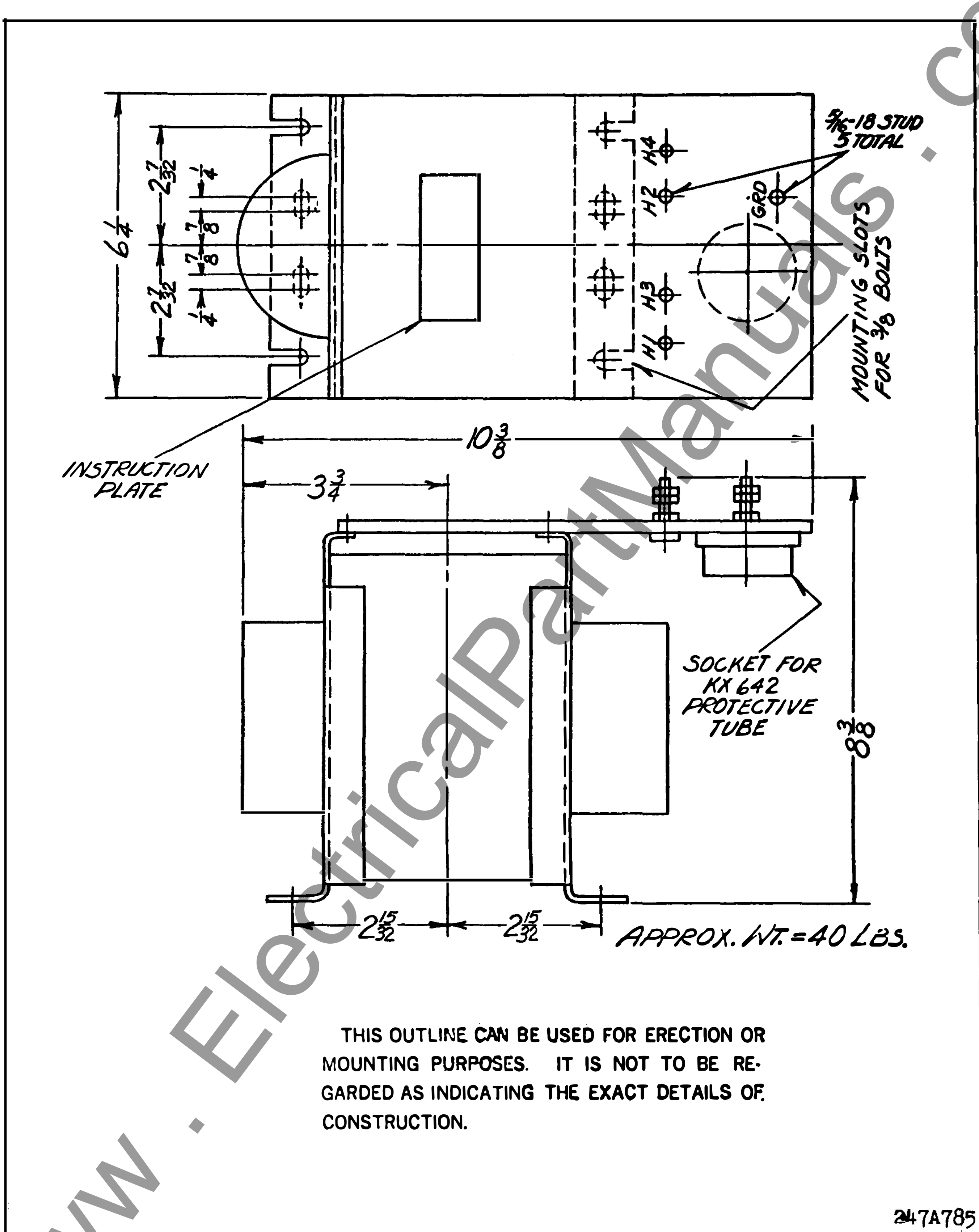


Fig. 16 Drainage Reactor Outline.

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 VDC +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: 22µF ±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 mW 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: 12V ±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.	

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TA-3 FREQUENCY-SHIFT AUDIO TONES

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

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

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

APPLICATION

The Type TA-3 tones are of the high-speed frequency-shift type and are available in two bandwidths: 170 Hz and 340 Hz. These tones have been designed for use with transfer-trip relaying systems, either solid-state or electromechanical. The TA-3 tones are suitable for use on a pilot-wire pair, or they may be multiplexed on a microwave or single-side-band carrier channel.

Transfer-trip relaying system applications are classified as direct or permissive transfer trip. A system which allows the tone receiver to trip directly, either with an output relay or through a solid-state auxiliary such as the STU-92, is considered a direct trip system. Direct trip systems are usually applied to transformer protection and shunt reactor protection, where no high side breaker exists and a remote breaker must be tripped to clear a fault. Another common application of direct trip systems on EHV circuits has been transfer trip for breaker failure protection. The direct trip systems can use either bandwidth TA-3 tone. The permissive type relaying systems are applied for line protection. In these systems the tones may trip a circuit breaker only if a local fault detecting relay has operated. For protection of EHV lines with high-speed breakers, the 340-Hz bandwidth TA-3 should be applied.

A receiver with a guard and trip output should * be used to drive two HG relays which drive two AR relays for use with electromechanical relaying systems, and the receiver with only the trip output should be used with solid-state relaying systems.

SECURITY MEASURES

The TA-3 tone system has been specially designed to obtain maximum security against noise. The TA-3 takes advantage of the inherent noise rejection characteristics of a frequency-shift receiver so that the relaying can be depended upon to trip when needed. The tone receiver is expected to operate with a minimum in-band signal-to-noise ratio of 9 db. Since an increased noise level on the pilot wire may often be concurrent with a trip request, the noise clamps are adjusted at a level based on the above minimum signal-to-noise ratio to avoid unnecessary clamping of the receiver.

The system provides a 300-1000 Hz band-pass filter and receiver to sample the random noise level of the pilot channel. This receiver will protect against false tripping due to random noise. In conjunction with the band-pass filter there is a line level monitoring system which samples the total frequency spectrum of the channel, and is set to operate for an overall increase of energy on the pilot channel. This monitoring feature will protect against false trips due to impulse noise which may have energy concentrated about frequencies not seen by the 300-1000 Hz noise filter. When noise has caused the blocking of a receiver, the drop-out of the blocking is delayed by 10 msec. to override the receiver response time.

Also available as an option is a frequency translation protection circuit. This is applied to protect against tone frequency variations caused by a pilot carrier frequency shift.

PILOT WIRE DESIGN

In applying a tone system for protection, the user and the cooperating telephone company should

SUPERSEDES I.L. 41-963.2A
*Denotes change from superseded issue.

EFFECTIVE MARCH 1972

2. Receiver Line Level and Noise Supervisory Module HB25150 (Fig. 19)

This module consists of two receivers (see Figure 19). One of them uses the output from the noise filter module for the Noise Supervisory function. The line level receiver uses the entire tone band to supervise the total in-band level of noise (this includes the frequencies used for protective line relaying).

An abnormal signal of sufficient strength on either of the receivers will cause an output on the line level and noise supervisory modules which will block the receiver trip output on the tone receiver and give an indication on the front panel.

E. 425-Hz TRANSMITTER HB21050-2 (Fig. 20) (Some systems use 595 Hz)

NOTE: One of these units is needed for each telephone pair when used. This transmitter is to be used in conjunction with HB55183 notch filter. Its function is to block the end through the noise supervisory module when there is frequency deterioration between the transmitter and the receivers in a telephone line. It consists of a 425-Hz frequency-shift transmitter with an output filter.

F. OUTPUT RELAYS

Mercury relays or type AR relays may be used for the outputs of this equipment. Except for the AR, these relays are mounted on the back of the chassis in the position shown on Figure 21. The AR relay is described in separate instructions.

G. LINE TERMINATION MODULE HB25140 (Figure 22)

This module is to be used when the application of the equipment calls for transmitters without any output filters. This module consists of two hybrid transformers and associated resistors used for multiplexing tone channels on a single telephone line or pilot pair.

H. HYBIRD FOR TWO WIRE TERMINATION HB35315 (Figure 23)

This module is used for applications requiring just two wire termination for both transmitter and receivers. It is used to isolate the local transmitter from the receiver when a single line pair is used. It contains plug in jumpers for selecting capacitor values for matching telephone line characteristics along with adjustable resistor R1. It also contains plug in jumpers for selecting termination impedance of either 600 ohms or 900 ohms.

OPERATION

Under normal conditions, the tone transmitter is set to operate at the specified frequency for guard. This frequency is above the channel center frequency. During fault conditions, the transmitter may be keyed to a specified frequency below the center frequency. This causes a trip output from the receiver terminal.

A. POWER SUPPLY MODULES (See Figures 5 and 6 for Internal Schematics)

Converter (Fig. 5)

The d-c to d-c converter contains a saturable core type multi-vibrator with Q1 and Q2 acting as switching transistors for transformer T1 in series with the applied battery voltage. Starting current is applied through R1 and oscillations are maintained at a nominal 500 Hz by the drive from the feedback windings in the base circuit. Capacitor C1 provides the high-surge current which occurs during the switching interval as the magnetic field of T1 reverses and Q1 and Q2 change their conducting states. Capacitor C1 and the 6.38-mHy choke provide a low-pass filter section to reduce high-voltage transients on the battery bus for protection of transistors Q1 and Q2. Oscillator switching transients are attenuated by R5 and C2. Two secondary windings on T1 feed the bridge rectifier circuits, CR1 through CR8, to develop separate positive and negative output voltages.

Regulator (Fig. 6)

Polar output voltages from the d-c to d-c converter are applied to the Voltage Regulator HB25210. Transistor Q3 is the series regulating element for the positive voltage input. Resistors R6, R7, and R8 comprise a voltage divider across the emitter-follower output. A portion of this output voltage is fed back to the base of Q1 and compared with a reference voltage across the zener diode CR1 in the emitter circuit. The difference voltage across the base-emitter junction of Q1 controls the collector current through load resistor R1. The voltage drop across

R1 is coupled by emitter follower Q2 to the base of Q3. Any change in the output voltage at the emitter of Q3 is opposed by a change in base voltage as a result of the controlling current flow in R1. The feedback voltage from the voltage divider circuit is made variable by resistor R7 to permit accurate setting of the output voltage level. Transistors Q4, Q5 and Q6 provide a similar regulator circuit for the negative voltage output.

The regulation indicator circuit is essentially a bridge connected across the positive and negative output terminals of the polar power supply, a span of 36 volts. One leg of the bridge is the 18-volt zener diode CR3. The output leg of the bridge is between the zener diode and the center arm of potentiometer R19. R19 is adjusted for a zero-volt output, or balance, at a total power-supply output of 36 volts. A change in power supply level after balance adjustment will produce a ± voltage change at the bridge output. This is detected by a complementary Schmitt trigger circuit consisting of Q7, Q8, Q10, and Q11. At balance, Q7 and Q10 are both cut off, and transistors Q9 and Q12 are two closed switches in series to energize the indicating lamp plus a remote relay. An increase in one or both of the supply output voltages will cause Q7 to conduct, and a decrease in one or both voltages will cause Q10 to conduct. Conduction of either Q7 or Q10 will open the associated series switching transistor, and the lamp and relay will be de-energized.

B. FREQUENCY SHIFT TRANSMITTER

1. F.S. Oscillator and Keyer HB25110 (For 170 Hz Bandwidth) (Block Diagram Fig. 7)

   With reference to the schematic diagram in Fig. 8, the oscillator is a multivibrator type consisting of Q1 and Q2 with an LC circuit collector to collector, tuned to the guard frequency. The frequency shifting capacitor, CT, is connected across a coupling winding on the tank circuit by switching transistors Q5 and Q6. For keying voltages below the trip level, Q5 and Q6 will present high collector impedances in series with CT effectively removing it from the circuit, and a guard frequency will be generated. When the keying voltage exceeds the trip level, Q5 and Q6 will saturate and connect CT across the oscillator causing a shift to the trip frequency. The oscillator output is taken from the level control R24 across a winding on the oscillator coil.

   In the keying circuit, Q3 and Q4 comprise a Schmitt trigger. The trigger circuit is energized by the voltage across R2 when keying current flows. The input to the base of Q3 is through zener diode CR2. For voltages below the zener voltage, Q3 is cut off and Q4 conducts; current cannot flow through coupling diodes CR3 and CR4 to the bases of switching transistors Q5 and Q6, and CT is not connected across the oscillator. When the zener voltage is exceeded, the Schmitt trigger action causes Q4 to be cut off, and current flows through CR3 and CR4 to clamp the switching transistors and generate a trip frequency. Keying circuit characteristics are shown in Figure 24.

2. Transmitter Amplifier HB25220 (Fig. 10) (For 170 Hz Bandwidth)

   With reference to the schematic diagram of Figure 10, amplifiers Q2 and Q3 are an emitter-coupled pair with push-pull collector output. Load coupling to the collectors is through the optional plug-in assemblies, multiplexing filter HB62600 or transformer HB55207. Signals from the HB25110 F-S oscillator are amplified by Q1 and applied to the base of Q2, the input to the push-pull amplifier. The GAIN control R2 can be set to maximum, and the channel level adjustments can be obtained using the LEVEL control on the oscillator module.

*3. F.S. Oscillator and Keyer HB25110-3 (For 340 Hz Bandwidth) (See Fig. 9)

   This is similar to the F.S. Oscillator and Keyer HB25110 above except for the addition of modulator transistors Q8 and Q9 for mixing the frequency of the B.F.O. with the frequency of the frequency shift oscillator. The frequency from the beat frequency oscillator is 10 KHz and is used to amplitude modulate the frequency of the frequency shift oscillator which in this case is 10 KHz plus the tone frequency (guard or trip). This amplitude modulation produces both the sum and difference frequencies of the two frequencies which are fed to the transmitter amplifier HB33375.

4. Transmitter Amplifier HB33375 (For 340 Hz Bandwidth) (See Fig. 11)

This is similar to the Transmitter Amplifier HB25220 above except for the addition of the beat frequency oscillator composed of transistors Q4 and Q5, inductor LO, tuned transformer LT, capacitors C6, C7, C8, C9, C10, C11, and C12 and resistors R12, R13, R14, R15, R16, R17, R18, R19, R20, R21, and R22. The oscillator stage includes transistor Q4 and a tuned LC tank circuit. Oscillations from the tuned circuit are coupled to the base of Q4 by capacitor C8. Feedback from the collector of Q4 to the tuned circuit is through resistor R12.

Voltage from the tank circuit is also coupled to the base of Q5 which operates as a class A output amplifier. The tuned transformer LT in the collector circuit has a center-tapped output winding for applying the switching voltages to the base of the modulating transistors Q8 and Q9 of the FS Oscillator module. The frequency of the BF Oscillator in this case is 10 KHz.

The sum and difference frequencies of the BFQ and the FSO created in the FS Oscillator module HB25110-3 by the modulator transistors Q8 and Q9 are fed back to this transmitter amplifier and amplified. The transmitter filter HB62600 must be used for coupling to the line so that the sum frequency will be rejected and only the difference frequency will be put on the line.

C. RECEIVER MODULES
(Block Diagram Figure 12)

1. Receiver Input Filter HB63100 (Fig. 13)

This filter is provided so that only the specified channel frequency comes into each receiver.

2. Receiver Limiter and Signal Supervisory HB25160-1

Referring to Figure 14 for the signal supervisory circuit, IC1 is an operational amplifier with a-c gain determined essentially by the resistor network R4, R6, and R7. The amplified carrier signal from IC1 is coupled by emitter follower Q7 to a voltage doubler rectifier. Output from the rectifier actuates a trigger-type block function as follows.

At normal channel level, Q8 is conducting and Q9 is cut off. Q10 is likewise nonconducting, and capacitor C9 is charged to a negative potential. This negative voltage is coupled by emitter follower Q11 to a trip blocking transistor in the discriminator module and effectively removes the block. When the signal level and rectifier output decreases, Q8, Q9, and Q10 reverse their conducting states instantly, and C9 is discharged through the low collector resistance of Q10. Emitter follower Q11 then applies a positive voltage to the trip blocking clamp in the discriminator module to disable the trip output circuit. In order to release the clamp, the carrier level must increase until Q8 conducts. Capacitor C9 then charges to the negative voltage through R34, resulting in a delay of clamp release. Transistors Q12 and Q13 are used for output indication.

Figure 25 shows the region of operation for the signal supervisory circuit. The block-release operating points occur in the linear region of amplification from carrier input to the signal supervisory circuit input.

For additional amplification and limiting, the output of IC1 is applied to a differential amplifier, Q1 and Q2. The output from Q1 drives a complementary circuit consisting of Q3, Q4, Q5, and Q6. This provides a complementary emitter follower output which with resistor R24 presents a 600-ohm driving source for the discriminator module.

3. Discriminator and D-C Amplifier Modules HB25130-2 and HB25170 (Figs. 15 and 16)

NOTE: Either module contains the discriminator tuned circuits in the HB62700 unit. (Fig. 17)

The discriminator consists of two separate parallel resonant circuits, tuned above and below the channel center frequency and connected in series with the carrier limiter output signal. Rectified outputs from the tuned circuits are added algebraically across R1 with respect to the circuit common. The resultant polar voltages are passed through a low-pass filter to a Schmitt trigger circuit: Q1 and Q2 in module HB-25170; Q2, Q3, Q7 and Q8 in module HB25130. Transistors Q1 and Q4 are the low-signal level and noise clamps respectively, operated by polar voltages from signal and noise supervisory circuits. Q9 and Q5 are direct-coupled drivers for the output amplifiers which are connected across the ± 18 volt polar supply.

The upper trip point for the Schmitt trigger is approximately 1 volt. This yields a degree of security against discriminator output voltages which are a function of noise. Figure 17 shows a typical curve for the discriminator output voltage versus frequency for a complete channel receiver including the bandpass filter, with sensitivity adjusted for a block at a 6-db decrease of carrier below nominal level. The curve was obtained with a variable frequency oscillator at the nominal level. The discontinuities occur as the frequency departs from the filter pass band, and the low-level blocking circuit loads the discriminator. The 3-db hysteresis in clamp release is indicated by the dotted lines as the frequency enters the filter passband.

D. NOISE SUPERVISORY MODULES
(Block Diagram Fig. 12, Internal Schematic Fig. 19)

1. Line Level & Noise Supervisory Module HB25150.

The output of Noise Filter HB55187 or HB55183 is amplified by an operational amplifier IC1 with a gain determined by resistors R5 and R6. Resistor R1 at the NOISE IN test point is a voltage divider for applying the test signal when adjusting the trip block threshold for a specific signal-to-noise ratio as described in the settings section. The input to the line level amplifier is amplified by IC2 with a gain determined by R21 and R20. Resistor R19 is shunted across R20 to increase the gain for trip block threshold adjustment.

The outputs of IC1 and IC2 are amplified by Q1 and Q2 respectively. Full-wave rectification for each of these noise circuits is employed with diodes CR7 through CR10, across a common load resistor R28 and capacitor C11. The resultant voltage is applied to a Schmitt trigger circuit, Q3 and Q4, which in turn operates a trip blocking circuit. Figure 26 shows the operating region for this circuit. The block and block release points are at a relatively low value of the maximum possible voltage due to rectified noise. Thus, C11 will delay block release for a longer period of time after high-level noise bursts.

During normal communication circuit operation, Q4 is conducting, Q5 and Q6 are cut off, and capacitor C12 is charged to a negative voltage. Emitter follower Q7 delivers this negative voltage to a clamping transistor in each of the trip output circuits of the system, effectively removing the clamp. Rectified noise applied to the base of Q3 will reverse the conducting states of these transistors instantly. Capacitor C12 discharges to a positive potential through Q6, and emitter follower Q7 delivers a positive clamping voltage to all receiver trip output circuits.

After a block, the block release is delayed by C12 which must charge to a negative potential through R38. The delay time is approximately 10 milliseconds.

2. <u>425-Hz Transmitter</u> HB21050-2 (Fig. 20) (Some systems use 595 Hz)

With referance to the schematic diagram of Figure 20, an LC oscillator is employed to generate the carrier frequency. (Keying circuits are provided to shift the carrier to a lower frequency for checking the operation of the clamp.) The output of the oscillator is amplified and coupled to the line through a bandpass filter which provides d-c isolation and minimizes adjacent channel loading. The tuned circuits for the oscillator and filter are contained in one plug-in hermetically-sealed assembly.

The oscillator stage includes transistor Q1 and associated circuit components. The tuned circuit consists of inductance $L_\bullet$ and capacitor CM; C_S and C_C are the frequency shifting capacitors. Oscillations from the tuned circuit are coupled to the base of Q1 by capacitor C3. Feedback to the tuned circuit from the collector of Q1 is through resistor R3. The network consisting of C2, R6, and variable resistor R7 allows frequency adjustment by variation of the effective capacitance of C2 across a portion of the tuned circuit. Note that the oscillator circuit voltages are referenced to a keying bias voltage level of approximately −1.2 volts d-c with respect to the circuit common which is developed across R2.

A secondary winding on L_O couples the output of the oscillator to the LEVEL control R10. This winding provides d-c isolation between the oscillator circuit and the output amplifier Q2 which operates from the full –12V d-c. supply. Transistor Q2 is a Class A common-emitter stage with the base input signal coupled from the LEVEL control by d-c blocking capacitor C5. The carrier band-pass filter is the collector load.

This transmitter, together with HB55183 filter at the remote end is used to prevent adverse effects from frequency translation. When a telephone line is multiplexed with other telephone lines, sometimes there is a drift in band frequencies due to the receivers and transmitters used in multiplexing. These conditions, although lying beyond the control of the tone channels, are detected at * the receiving end by applying the 425-cycle transmitted frequency to the noise filter. The noise filter HB55183 together with the noise supervisory module do not tolerate a frequency translation (due to line multiplexing) of more than ±40 Hz without blocking the receivers.

D-C TO D-C CONVERTER AND VOLTAGE REGULATOR

Converter HB25190 and HB25200, Regulator HB25210

Power Output:

Model HB25210 Voltage Regulator with one of the D-C to D-C Converter Modules, HB25190 or HB25200 – 7.5 watts maximum; +18 volts at 200 ma. and –18 volts at 200 ma.

Power Input:

Approximately 15 to 23 watts for above output power over the following converter input voltage ranges;

HB25190 – 42 to 56 V d-c, 48 v.d.c. nominal.

HB25200 – 105 to 144 V d-c, 125 v.d.c. nominal.

See Figure 5 for 250V d-c battery input.

Regulation:

+18 and –18 v.d.c. within 0.1 volt.

Regulation Indicator:

Indicates changes greater than 2 volts in ±18 V d-c output; module panel lamp extinguishes and remote relay is de-energized. Recommended alarm relay is HA18574; two Form-C 5-ampere contacts, 2000-ohm coil.

Ripple:

1 mv RMS maximum on +18 v.d.c. and –18 v.d.c. outputs.

Converter Frequency:

Nominal 500 Hz; 380 Hz to 600 Hz over rated input and output ranges.

Overloads:

No overload protective circuitry. Input to con-

CHARACTERISTICS

CHANNELS		TRIP FREQUENCY		GUARD FREQUENCY	
170-Hz b.w.	340-Hz b.w.	170-Hz b.w.	340-Hz b.w.	170-Hz b.w.	340-Hz b.w.
1275 1615	1360	1190 1530	1190	1360 1700	1530
1955 2295	2040	1870 2210	1870	2040 2380	2210
2635 2975	2720	2550 2890	2550	2720 3060	2890

When 170-Hz and 340-Hz bandwidth (b.w.) channels are used in conjunction, the 340-Hz channel takes the space of the two 170-Hz adjacent channels. It is recommended that the lower frequencies be used for wide bands (340-Hz b.w.).

CHANNEL DELAY TIME

	170 Bw. W/TRANSF.	170 Bw. W/FILTER	340 Bw. W/FILTER
Channel Time (excluding telephone line)	7.5 ms.	9.0 ms.	5.0 ms.
* Relay Time			
2 Amp Mercury Wetted Relay or Mercury Wetted Relay and 10W AR	3.0 ms.	3.0 ms.	3.0 ms.
Total	10.5 ms.	12.0 ms.	8.0 ms.

Ambient Operating Temperature: .... –20° to +55°C.

Storage Temperature: .... –60° to +75°C.

Approximate Weight: .... 14 lb.

verter is fused; effective only for short-circuit loads. Operation above maximum rated levels should be avoided to prevent damage due to excessive heat generation.

Isolation:

Output circuits are d-c isolated from ground and the converter input battery supply. A transient voltage filtering capacitor, C3, in the converter module is connected between the output COMMON and the positive battery input and has a 2000WV d-c rating. (See schematic diagram, Figure 5.)

* F.S. OSCILLATOR AND KEYER HB25110 and HB25110-3

Output Level:

0.11 Vrms maximum –17 dBm, unbalanced, ±0.75 dB. Less than 0.25-dB difference between steady-state guard and trip frequencies.

Keying Circuit:

Requires 16 mA ±10% to shift from guard to trip. Return to guard at 4 mA less than maximum trip current. No intermediate frequencies or stopping of oscillation for any keying voltage. Nominal keying voltages are 24V, 48V and 125V d.c. with series resistance values per Fig. 8. Shift from guard to trip is at approximately 50% of keying voltage. Input resistance approximately 1000 ohms. See Figure 24.

* Frequency: (HB25110 Only)

Guard is above channel center frequency. Trip is below channel center frequency. Frequency stability 0.2% of channel frequency.

* Frequency: (HB25110-3 Only) (340 Hz Bandwidth Only)

The guard frequency is equal to the chanel center frequency plus 170 Hz plus 10 KHz for normal applications. The trip frequency is the channel center frequency minus 170 Hz plus 10 KHz for normal applications.

(In dual channel systems, one of the channels utilizes a shift up in frequency for trip. In this case, the guard frequency for this particular channel would be 10 KHz minus the channel center frequency and minus 170 Hz. [$f_g = 10{,}000 - f_c - 170$]. The trip frequency would then be 10 KHz minus the channel center frequency and plus 170 Hz. [$f_t = 10{,}000 - f_c + 170$]).

* TRANSMITTER AMPLIFIER HB25220 and HB33375

Gain:

30 dB with transformer HB55207, 28 dB with filter HB62600, –1 + 0.5 dB from setting.

Output Level:

+8 dBm maximum in 600 ohms with filter. +10 dBm max. in 600 ohms with transformer.

Harmonic Distortion:

Total distortion with HB25110 f-s. oscillator input is 1.5% with transformer output, less than 0.2% with filter output, at maximum rated output level.

Transient Response:

With HB25110 f-s. oscillator input and filter output, trip signal and transients are within –3dB to +3dB of guard signal level.

* Beat Frequency Oscillator: (HB33375 Only) (340 Hz Bandwidth Only) 10 KHz ± 0.25%.

RECEIVER LIMITER AND SIGNAL SUPERVISORY HB25160-1, RECEIVER FILTER HB63100

Sensitivity:

Maximum sensitivity of the HB25160-1 receiver module for block release after a signal-loss block is –44 dBm, measured at CARRIER IN test point. Maximum sensitivity referred to channel level on communication circuit is determined by the loss in the channel filter and coupling network. See Figure 23 for recommended nominal levels and Figure 12 for coupling scheme. This arrangement, when used with the HB25150 noise supervisory module, will permit a minimum nominal line level per channel of –28 dBm. Sensitivity is constant within +1 dB.

Outputs:

Limited carrier signal, ±17 volts for driving discriminator module, 600-ohm driving impedance. Clamping voltage for trip block circuit in discriminator module.

Input Impedance:

HB63100 filter input 600 ohms in passband, out-of-band rising impedance characteristic.

F.S. DISCRIMINATOR AND D-C AMPLIFIER HB25170 and HB25130 (Dual Output)

Discriminator Input:

9V rms carrier signal derived from ±17 volt limited signal from limiter section in HB25160 module.

Low Signal Block Input:

Block – 3 mA, +0.8V. Block release – -3.4V, 0 mA. From signal supervisory section in HB25160 module.

Noise Block Input:

Block– 2 to 3 mA, +14 to +17V. Block release– –3.4V, 0 mA. From noise supervisory module HB25150.

HB25130-2 Outputs:

Trip amplifier, 100 mA capability. Nonconducting for a guard signal, collector at –18 volts. Conducting for a trip signal, collector at +18 volts. Guard amplifier, 100 mA capability. Nonconducting for a trip signal, collector at +18 volts. Conducting for a guard signal, collector at –18 volts.

HB25170 Output:

Trip amplifier, 100 mA capability. Nonconducting for a guard signal, collector at –18 volts. Conducting for a trip signal, collector at +18 volts.

LINE LEVEL AND NOISE SUPERVISORY HB25150 AND FILTERS HB55183 AND HB55187

Output:

Clamping voltage for trip block circuits in up to six F.S. Discriminator and D-C Amplifier modules (HB25170 or HB25130); +13V to +17V at 2 to 3 mA block, –3.4V at 0 mA block release. Block release delay time is 10 milliseconds. D-C amplifier capable of delivering up to 100 mA at 36V to an indicating device, or voltage pulses to logic circuitry. Amplifier is conducting for a block, collector at +18V; nonconducting for block release, collector at –18V.

Noise Filters HB55187 and HB55183

300 to 1000 Hz passband, 600-ohm input impedance in passband, out-of-band rising impedance characteristic. 600-ohm output impedance. Noise filter HB55183 is the same as HB55187 except for a
* 25-db rejection notch at 425 Hz.

Noise Filter Amplifier:

600-ohm input impedance. Sensitivity adjustable: Maximum sensitivity for a trip block is –52 dBm, +0.5 dB –1 dB.

Line Level Amplifier:

11.2K input impedance. Sensitivity adjustable; maximum sensitivity for a trip block is –27 dBm; +0.5 dB –1 dB.

* 425-HZ TRANSMITTER HB21050-2 (Some Systems Use 595 Hz)

Output Level:

600 ohms nominal, isolated and balanced.

Output Stability:

±1.5 dB from –30°C to +70°C.

Frequency Stability:

HB21050-2 ±.25% from –30°C to +70°C.

Keying Inputs:

Neutral voltage pulses, −10V nominal. Input resistance approx. 5K to 15K.

INSTALLATION

(Outline and Drilling Plan, Figure 19)

The tone assemblies should be mounted on relay racks or in suitable cabinets when the eleven-module chassis is used. The mounting location should be free from dirt, moisture, excessive vibration, or heat. All electrical connections are made through a 24-terminal connector on the rear of the chassis per CR drawing which applies to the particular order and appears on the nameplate.

Use of current monitoring jacks: Standard telephone-type current jacks can be supplied on special order to monitor the guard, trip or alarm, output relay coil currents when such are mounted on the bottom of the TA-3 tone assembly. This assembly will be three rack units high.

The type AR relays, when used, should be mounted near the TA-3 tone chassis in a location free from dirt, moisture, excessive vibration, or heat.

SETTINGS

Transmitters

Only one setting is required on the tone transmitter and that is the output level. This setting is made by using the screwdriver type adjuster marked * "gain" on the transmitter amplifier 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 protective 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 allowable 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 a-c 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 level are to be checked or readjusted. The 425-Hz * transmitter should be set the same as any other transmitter.

F.S. Receiver

(Refer to Fig. 26 for Relative Levels)

The sensitivity is adjusted with a carrier signal present at the input of the channel filter at the nominal level for the particular installation. Short circuit the two test points designated sens. adj. link on the panel of the Receiver Limiter and Signal Supervisory module. This will decrease the sensitivity of the receiver by 6 dB. Turn the SENSITIVITY control slowly from its extreme clockwise position until the BLOCK light is energized, then remove the short from the test points. With this setting, a 6-dB decrease in channel level will generate a trip block function; a 3-dB recovery is required to release the block.

Line Level and Noise Supervisory Module

(Refer to Fig. 26 for Levels)

NOTE: If a HB55183 notch filter is used, the calibrating procedure should not be altered.

The sensitivity of both noise detecting circuits is adjustable with all channel signals present on the line at their nominal levels for the system. Adjust the noise-filter amplifier sensitivity as follows: first turn the NOISE SENSITIVITY control to its extreme counterclockwise position (if the line level sensitivity has not been adjusted, turn this screw to its extreme counterclockwise position also). Remove the noise filter from the chassis. Connect the CARRIER IN test point of any convenient HB25160 Receiver module to the NOISE IN test point on the HB25150 Noise Supervisory Module. Slowly turn the NOISE SENSITIVITY control from its extreme counterclockwise position until the BLOCK light is energized. Remove the test point connections and replace the noise filter in the chassis; the light should turn off. With this adjustment, a trip block will be initiated for an in-band signal-to-noise ratio of 12 dB or less. A minimum of 9 dB is required for security against false tripping in type TA-3 Protective Relaying Channel.

The wide-band noise or line level amplifier sensitivity can be adjusted in this manner: Connect the LINE LEVEL SENS. ADJ. test point to the COMMON test point. This will increase the gain of the amplifier by 4.5 dB. Turn the LINE LEVEL SENS. control slowly clockwise until the BLOCK light is energized, then remove the test point connections. When the combined level of signals plus noise increases by 4.5 dB, a trip block will be generated.

* A hysteresis of approximately 1.5 dB exists in the trigger-type blocking circuit for a block release. The 4.5-dB high-level block setting and a low signal-level block adjustment of 6 dB in the Limiter and Signal Supervisory Module HB25160 will give a dynamic operating range of 10.5 dB for the protective relaying receiver.

F.S. Discriminator and D.C. Amplifier

(See Fig. 17, Typical Discriminator Output)

With a −5, 0, +5 v.d.c. voltmeter of at least 20,000 ohms-per-volt resistance connected between common and "Disc. out" T.P., check for equal outputs at Guard and trip frequencies and adjust the discriminator bias on the front panel to correct this if necessary.

ACCEPTANCE CHECK

D-C to D-C Converter HB25190 or HB25200

Non-Regulated Voltages:

+V d-c to common	+22 to +34 V d-c
−V d-c to common	−22 to −34 V d-c

Voltage Regulator

+18 V to common	+18 V d-c
−18 V to common	−18 V d-c

Transmitter

(Consists of an oscillator and keyer, and a transmitter amplifier.)

Key transmitter to trip frequency by applying the correct keying voltage at the terminals indicated on the connection drawing.

All transmitter frequencies and output levels should be checked with a 600-ohm load connected at the output.

Guard Frequency: within 2 Hz of the frequency specified in the Characteristics section.

Trip Frequency: within 2 Hz of the frequency specified in the Characteristics section.

NOTE: Allow 4 Hz for 340-Hz bandwidth tones.

Output Level:

at least +8 dBm when supplied with filter output.

at least +10 dBm when supplied with transformer output.

* **425-Hz Transmitter (Some Systems use 595-Hz)**

Frequency: 425 Hz within 1 Hz

Output: at least + 1 dBm

Keying: should shift at least 40 Hz to block Noise Supervisory module.

F.S. Receiver

With a transmitter input set at −20 dBm, see that the guard and trip outputs operate correctly.

Line Level and Noise Supervisory

Should operate upon receipt of a 700-Hz tone at −37 dBm, or any transmitter tone frequency at −15 dBm. Factory calibration is at a −20 dBm nominal input signal.

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").

POWER SUPPLY

The d-c to d-c converter has no adjustments. The voltage regulator module HB25210 has adjustable reference voltages. In order to adjust the reference voltages, a card extender (HB14583) is needed because the adjusting resistors are not accessible from the front of the panel. Connect a d-c voltmeter to common and +18 volts (front of the panel), and adjust R7 for +18 volts. Repeat this operation by connecting the voltmeter between common and −18 volts and adjusting R15. The regulation indicator is set by adjusting R19 for zero volts between the reference zener diode CR3 and the white test point on the front panel. The regulation indicator will detect any changes over 2 volts by the lamp being extinguished and the optional relay being de-energized.

TRANSMITTER MODULES

F.S. Oscillator Keyer

Oscillator frequency is determined by the plug-in tuned circuit assembly. A FREQUENCY ADJUSTMENT control on the module panel enables a slight frequency trimming in the event that the channel tuned circuit assembly is changed. This adjustment affects the trip and guard frequencies simultaneously and in the same direction. The LEVEL control permits setting the oscillator output level to the system requirement. Both adjustments can be monitored at test points on the panel.

Transmitter Amplifier

The output level of the transmitter amplifier was discussed in the SETTINGS section.

RECEIVER MODULES

The only adjustment needed in the receiver modules (level adjustment was covered in the SETTINGS section) is the adjustment of the Discriminator Balance Control.

Adjustment of the DISCRIMINATOR BALANCE control is made with alternate trip and guard frequencies applied to the discriminator. With equal output, as measured at the DISC. OUT test point, a slight guard preference in operation will be derived. This can be seen with reference to Fig. 15.

LINE LEVEL AND NOISE SUPERVISORY MODULES

These modules require no adjustments except for the settings covered before.

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. The acceptance check procedure will provide a more thorough test.

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 type AR 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. Refer to Table I for typical transistor voltages.

Test Equipment

For routine maintenance, the following equipment will be adequate:

* 1. A-C Vacuum-Tube Voltmeter, at least 15 kHz, 1 mv sensitivity.

2. Calibrated Attenuator, 600 ohm.

For troubleshooting, the following additional test equipment is desirable:

* 1. Electronic Frequency Counter, 15 kHz minimum.

2. D-C Vacuum-Tube Volt-Ohmmeter.

3. Cathode-Ray Oscilloscope.

* 4. Oscillator, 200 to 15,000 Hz.

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 Parts List.

TABLE I

TYPICAL VOLTAGE MEASUREMENTS (REFERRED TO "COMMON")

200 mA LOAD ±22.5V INPUT

			Q1	Q2	Q3	Q4	Q5	Q6
HB25210 Voltage Regulator	Vdc.	C	+19.4	+22.0	+22.5	−19.4	−22.0	−22.5
		B	+12.1	+19.4	+18.7	−12.1	−19.4	−18.7
		E	+11.4	+18.7	+18.0	−11.4	−18.7	−18.0

NO LOAD ±34.2V INPUT

			Q1	Q2	Q3	Q4	Q5	Q6
HB25210 Voltage Regulator	Vdc	C	+19.2	+33.5	+34.2	−19.2	−33.5	−34.2
		B	+12.1	+19.2	+18.8	−12.1	−19.2	−18.8
		E	+11.4	+18.8	+18.1	−11.4	−18.8	−18.1

			Q1	Q2			Q1	Q2
HB25110 F.S. OSC And Keyer (Fig. 8)	Vdc	C	+18	+18	AC Signals Vp – p.	C	34	34
		B	+ 7	+ 7		B	10	10
		E	+ 6.5	+ 6.5		E	5	5

			Q1	Q2	Q3	Q4	Q5	Q6	Q8	Q9
F.S.OSC & Keyer HB25110 & HB25110-3 Fig. 8 & Fig. 9 (Where applicable	VDC	C	+18		See Fig. 24		–		0	
		B	+ 7				–		–	
		E	+ 6.5				0		–	
	Vac p-p	C	34		–		34		–	
		B	10		–		–		2.2	
		E	5		–		–		–	

			Q1	Q2	Q3
HB25220 Transmitter Amplifier	Vdc	C	7	15	15
		B	0	−0.3	−0.3
		E	−0.7	−0.9	−0.9

TABLE I (Continued)

TYPICAL VOLTAGE MEASUREMENTS (REFERRED TO "COMMON")

			Q1	Q2	Q3	Q4	Q5
Trans. Ampl. & B.F. Osc. HB33375 Fig. 11	Vdc	C	7	15	15	-5.8	-12
		B	0	-0.3	-0.3	-1.1	-2.2
		E	-0.7	-0.9	-0.9	- .95	-2.
	Vac p-p	C				15	2.7
		B				.08	.08
		E				0	—

			Q1	Q2	Q3	Q4	Q5	Q6	
HB25160-1 Rec. Lim. And Sig. Supv.	Vdc	C	+16.6	+18	+ .9	+ .4	18	- 18	
		B	0	0	+16.6	-15V	.9	- .4	
		E	- .7	- .7	+17.2	-16	—	—	
			Q7	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**
	W/O Sig. Vdc	C	+18	+ 7	+17.2	+17.9	+18	0	-18
		B	0	-18	-14.4	+17.2	+17.9	+17.5	+18
		E	- 0.7	-14.9	-14.9	+18	+17.2	+18	+18
	W/Sig. Vdc	C	-14.7	+18	-2.7	+18	0	+17.9	
		B	-14.5	-15.1	+18	- 2.7	- 2.8	+17	
		E	-15.2	-15.2	+18	- 3.4	+ .05	+18	

			Q2	Q3	Q5	Q6	Q7	Q8	Q9	Q10
HB25130-2 HB25170 F.S. Disc. and D-C Amp.	Guard Vdc	C	+7.5	+6.1	+18.0	-18.0	-0.45	-7.6	-6.9	-17.9
		B	-0.6	+1.2	+ 4.0	+18.0	-1.1	-0.1	-7.6	-17.2
		E	+0.55	+0.55	+ 6.8	+18.0	-0.43	-0.43	-6.8	+18
	Trip Vdc	C	+0.45	+7.4	+ 6.9	+ 7.9	+7.5	-3.7	-18	+18
		B	+1.1	+0.1	+ 7.4	+17.2	+1.1	-1.22	-3.65	-18
		E	+0.42	+0.42	+ 6.8	+18.0	+0.56	-0.56	-6.8	-18

			Q3	Q4	Q5	Q6	Q7	Q8	Q9
HB25150 Line Level and Noise Supv.	Block Vdc	C	<-15	+ 0.8	- 0.1	+17.9	+18	+ 0.1	+17.9
		B	<-16	>16.8	- 0.7	+17.2	+17.9	+ 0.7	+17.2
		E	<-16.4	< 16.4	0	+18	+17.2	0	+18
	Release Vdc	C	-15	3	+ 18	- 2.6	+18	+18	-18
		B	< 16.3	-15.8	- 2.8	+18	-2.55	- 2.75	+18
		E	16.4	-16.4	0	+ 18	-3.3	0	+18

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB25110 AND HB25110-3 F.S. OSCILLATOR AND KEYER	
* R3 thru R20, R22, R23	RESISTOR, fixed comp., ±5%, ¼ watt, unless otherwise specified	
R2	RESISTOR, fixed WW: 1.5K ±5%, 1½ watt, Ohmite type 995-1A.	H-1100-421
* R1	RESISTOR, fixed WW: 600 ±5%, 3 watt, Ohmite type 995-3A.	HA-1220-22
R21	RESISTOR, variable: 250K ±30%, 0.1 watt, BD taper, C.T.S. PE200	HA-14594
R24	RESISTOR, variable: 500 ±20%, 0.125 watt, BD taper. C.T.S. PE200	HA-25253
C1	CAPACITOR, mylar, 0.1 μF ±10%, 100V, Cornell Dubilier WMF1P1.	H-1007-624
C3	CAPACITOR, mica, 1200pF ±2%, Elmenco DM19D122G0500WV4CR.	H-1080-333
C4	CAPACITOR, tantalum, 1 μF ±20%, 35V, Texas Inst. SCM105FP035D4.	H-1007-496
CR1	DIODE, zener, 6.8V ±5%, Motorola 1N4736A	HA-21504
CR2	DIODE, zener, 5.1V ±5%, Motorola 1N4733A.	HA-24328
CR3, CR4	DIODE, silicon, 200 PIV, 500mA, Diodes Inc., DI-42.	HA-17197
Q1 thru Q6	TRANSISTOR, silicon NPN, VECO 40V, TO-92 case, Motorola 2N3903.	HA-21562
* Q8, Q9	TRANSISTOR, Germanium, PNP, Texas Instr. 2N1375	HA-17117
	Tuned oscillator ckt., sealed plug-in assembly.	HB-62800
	Test jacks, Sealectro Corp., SKT-10.	
	HB25220 TRANSMITTER AMPLIFIER	
* R3, R4, R6, R7, R8, R10	RESISTOR, fixed comp., ±5%, ¼ watt unless otherwise specified.	
R1	RESISTOR, fixed WW., 200 ±5%, 1½ watt, Ohmite type 995-1A.	H-1100-427
R9	RESISTOR, fixed WW., 1300 ±5%, 1½ watt, Ohmite type 995-1A.	H-1100-529
R2	RESISTOR, variable, 5K ±30%, 0.25 watt. log taper, C.T.S. PE200.	HA-13572
R5	RESISTOR, fixed comp., 10K ±5%, ½ watt.	H-1009-416
* C1, C2	CAPACITOR, tantalum, 15 μf ±10%, 35V. Texas Inst. SCM156GP035D4.	H-1007-654
* C4: C5	CAPACITOR, tantalum, 1.0 μf ±20%, 35V. Texas Inst. SCM105FP035D4.	H-1007-496
C3	CAPACITOR, mica 470pf ±2%, Emeco DM-19.	HA-16632
Q2, Q3	TRANSISTOR, silicon NPN V_{CEO} 65V TP-5 case. 2N2102	HA-22678
Q1	TRANSISTOR, silicon NPN V_{CEO} 40V, TO-92 case. 2N3903	HA-21562
	TRANSFORMER, Plug-in assembly.	HB-55207
	Multiplexing filter, plug-in assembly.	HB-62600
	Test jacks, Sealectro Corp. SKT-10.	

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	*** HB33375 TRANSMITTER AMPLIFIER & B.F. OSC.**	
R3, R4, R6, R7, R8 R10,R11,R12,R13 R14,R15,R16,R17 R18,R19,R20,R21	RESISTOR, fixed comp., ±5%, ¼ watt unless otherwise specified	
R1	RESISTOR, fixed WW., 200 ±5%, 1½ watt, Ohmite Type 995-1A	H-1100-427
R9	RESISTOR, fixed WW., 1300 ±5%, 1½ watt, Ohmite Type 995-1A	H-1100-529
R2	RESISTOR, Variable, 5K ±30%, ¼ watt Log Taper, C.T.S. PE 200	HA-13572
R5	RESISTOR, fixed comp. 10K ±5%, ½ watt	H-1009-416
C1, C2	CAPACITOR, tantalum, 15 μf ±10%, 35V, T.I. SCM156GP03504	H-1007-654
C4, C5	CAPACITOR, tantalum, 1.0 μf ±20%, 35V, T.I. SCM105FP035D4	H-1007-496
C3	CAPACITOR, Mica 470pf ±2%, Emenco DM-19	HA-16632
C7, C8, C9, C10 C11	CAPACITOR, 15 μf ±20%, 25V Mallory, TAM156M025P5C	H-1007-439
Q1	TRANSISTOR, Silicon NPN, 2N3903	HA-21562
Q2, Q3	TRANSISTOR, Silicon NPN, 2N2102	HA-22678
Q4, Q5	TRANSISTOR, Silicon PNP, 2N3905	HA-21564
	Transmitter Filter, Plug-in Assembly	HB-62600
	Tuned Transformer & B.F. Oscillator Assy.	HB-63300
	*** HB-21050 425 Hz FS TRANSMITTER (Also Applies To 595Hz)**	
* R1-R6, R8, R9, R11-R18	RESISTOR, fixed comp., ±5%, ¼ watt unless otherwise specified.	
R7	RESISTOR, variable, 250K, 0.1 watt, BD taper. CTS Corp., type PE200.	HA-14594
R10	RESISTOR, variable 500 ohms, 0.125 watt, BD taper, CTS Corp., type PE200.	HA-13573
C1	CAPACITOR, tantalum, 15 μf ±20%, 25V, Mallory TAM156N025P5C.	H-1007-439
C3, C4, C5, C6	CAPACITOR, tantalum, 33 μf ±20%, 10V, Mallory TAM336M010P5C.	H-1007-438
C2	CAPACITOR, mica, Elmenco Type DM20.	H-1080-X
C7	CAPACITOR, ceramic, 0.47 μf +80% −20%, 25V, Sprague 5C11A.	HA-13579
Q1, Q2, Q3, Q4	TRANSISTOR, germanium, PNP, Texas Inst. 2N1375.	HA-17117
Q5	TRANSISTOR, silicon, NPN, Texas Inst., 2N706A.	HA-19928
	BP Filter and Osc. Assy. for HB-21055 and HB-21050 FS Transmitter.	HB-58500 or HB-58900
	BP Filter and Osc. Assy. for HB-21040 and HB-19925 FS Trans.& Mod.	HB58200
	Test Jacks, Sealectro Corp., SKT-10.	
	Filter cable connector, 3-terminal socket, Eby Sales Co.	HA-21091

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
HB-25160-1 RECEIVER LIMITER AND SIGNAL SUPERVISORY		
* R1, R3-R5, R8-R42	5%, ¼-watt, unless otherwise specified.	
R6	RESISTOR, metal film, 13K ±1%, 1/8 watt, I.R.C. Type CEA-T-O.	H-1510-778
R7	RESISTOR, metal film, 10K ±1%, 1/8 watt. I.R.C. Type CEA-T-O.	H-1510-775
R43	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite Type 995-1A	H-1100-423
R2	RESISTOR, variable, 500 ±20%, 0.125 watts, BD taper. C.T.S. PE-200	HA-25253
C1	CAPACITOR, poly., 0.0068 μF, 2% 400V. Wesco 32P.	H-5115-127
C3	CAPACITOR, mica, 320pF ±2% 500VDCW. Elmenco DM-19-391G.	HA-16628
C2	CAPACITOR, tantalum, 33μF, ±20%, 10V. Texas Inst., SCM336BP010D4.	H-1007-653
C4, C7, C8	CAPACITOR, tantalum, 1.0μF, ±20%, 35V. Texas Inst., SCM105FP035D4.	H-1007-496
C5, C6	CAPACITOR, tantalum, 15 μF, ±20%, 35V. Texas Inst., SCM156GP035D4.	H-1007-654
C9	CAPACITOR, tantalum, 0.47 μF, ±10%, 35V. Texas Inst., SCM474FP935D2.	H-1007-511
CR1, CR2, CR5 thru CR10	DIODE, silicon, 250mw Texas Inst., 1N914.	HA-24325
CR11	DIODE, silicon, 200 PIV. Diodes Inc. DI-42.	HA-17197
CR3, CR4	DIODE, zener, 5.1V ±5%, 1N4733A. Motorola IM5. Q 1ZS5.	HA-24328
Q1, Q2, Q4, Q5 Q7, Q8, Q9, Q11	TRANSISTOR, silicon, NPN, V_{CEO} 40V, TO-92 case, Motorola, 2N3903.	HA-21562
Q3, Q6, Q10, Q12	TRANSISTOR, silicon, PNP, V_{CEO} 40V, TO-92 case, Motorola, 2N3905.	HA-21564
Q13	TRANSISTOR, silicon, PNP, V_{CEO} 65V, TO-5 case. RCA 2N4036.	HA-24003
IC1	Integrated circuit, operational amplifier, Motorola MC1430, TO-5 case.	HA-25158
I1	Data lamp, red, 10VDC, 0.014A. Dialco No. 507-3910-1431-600.	HA-25156
	Lamp holder, Dialco No. 508-7538-504.	HA-17504
	Test jacks, Sealectro Corp. SKT-10.	
HB25170 AND HB25130-2 F.S. DISCRIMINATOR AND D.C. AMPLIFIER		
* R2 thru R15, R17	±5%, ¼ watt, unless otherwise specified.	
R16	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite type 995-1A.	H-1100-423
R1	RESISTOR, variable, 5K ±30%, ¼ watt, linear C.T.S. PE-200.	HA-14655
C1	CAPACITOR, poly., 0.082 μF 2%, 100V. Wesco 32P.	H-5115-79
C2	CAPACITOR, mylar. 0.255 μF 2%, 100V. Wesco 32M.	H-1007-572
CR2	DIODE, zener, 6.8V ±5%, 1N14736-A, Motorola 1M6, 8ZS5.	HA-21504
CR1, CR3, CR4	DIODE, silicon, 200 PIV. Diodes Inc. DI-42.	HA-17197
Q1, Q2, Q3, Q4, Q5	TRANSISTOR, silicon NPN, V_{CEO} 40V., TO-92 case, Motorola 2N3903.	HA-21562
Q6	TRANSISTOR, silicon PNP, V_{CEO} 65V., TO-5 case, RCA 2N4036.	HA-24003
L1	Choke, 0.892 Hy.	HB-55201
I1	Datalamp, red cartridge, 0.014A, 10VDC. Dialco 507-3910-1431-600.	HA-25156
	Lampholder, Dialco 508-7538-504.	HA-17504
	Test jacks, Sealectro Corp., SKT-10.	
	Discriminator plug-in assembly.	HB-62700

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
HB25130-2 THESE PARTS ARE IN ADDITION TO PARTS LISTED ON PRECEDING PAGE		
R18 thru R27	±5%, ¼ watt unless otherwise specified	
R28	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite type 995-1A.	H-1100-423
CR5	DIODE, zener, 6.8V ±5%, 1N14736-A, Motorola 1M6, 8ZS5.	HA-21504
CR6	DIODE, silicon, 200 PIV, Diodes, Inc. DI-42.	HA-17197
Q7, Q8, Q9	TRANSISTOR, silicon PNP, V_{CEO} 40V., TO-92 case. Motorola 2N3905.	HA-21564
Q10	TRANSISTOR, silicon NPN, V_{CEO} 65V., TO-5 case. RCA 2N2102.	HA-22678
I2	Datalamp, amber cartridge, 0.014A, 10VDC. Dialco 507-3910-1433-600.	HA-25784
	Lampholder, Dialco 508-7538-504.	HA-17504
HB-25150 LINE LEVEL – NOISE SUPERVISORY MODULE		
* R1, R2, R4-R8, R11-R16, R18, R21-R42	±5%, ¼ watt, unless otherwise specified.	
R9, R10	RESISTOR, wirewound, 600 ±5%, 1½ watt. Ohmite 995-1A.	H-1100-442
R43	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-423
R19	RESISTOR, metal film, 121 ±1%, 1/8 watt. I.R.C. Type CEA T-O	H-1510-777
R20	RESISTOR, metal film, 100 ±1%, 1/8 watt. I.R.C. Type CEA T-O	H-1510-714
R3	RESISTOR, variable, 500 ±20%, 0.125 watts, BD taper. C.T.S. Type-200	HA-25253
R17	RESISTOR, variable, 2.5K ±20%, 0.125 watts, A taper. C.T.S. Type PE-200	HA-19919
C1	CAPACITOR, poly., 0.0068 μF ±2%, 400VDC, Wesco 32P.	H-5115-127
C6	CAPACITOR, poly., 0.02 μF ±2%, 100VDC Balco PTWP.	H-5115-49
C3, C8	CAPACITOR, mica, 390pF ±2%, 500WVDC Elemenco DM-19-391-G.	HA-16628
C2, C7	CAPACITOR, tantalum, 33μF ±20%, 10VDC. Texas Inst. SCM336BP010D4.	H-1007-653
C4, C9, C11	CAPACITOR, tantalum, 1.0 μF ±20%, 35VDC. Texas Inst. SCM105FP035D4.	H-1007-496
C5, C10, C13, C14	CAPACITOR, tantalum, 15μF ±20%, 35VDC, Texas Inst. SCM156GP035D4.	H-1007-654
C12	CAPACITOR, tantalum, 0.47μF ±10%, 35VDC, Texas Inst. SCM474FP035D2.	H-1007-511
CR1 thru CR4 CR7 thru CR11	DIODE, silicon, 250 mw. Texas Inst., or G.E. Type 1N924.	HA-24325
CR12	DIODE, silicon, 200PIV, Diodes Inc., DI-42.	HA-17197
CR5, CR6	DIODE, zener, 5.1V ±5%, 1N4733A. Motorola IM5. 1ZS5.	HA-24328
IC1, IC2	Operational amplifier, TO-5 case. Motorola MC-1430.	HA-25158
Q3, Q4, Q5, Q7, Q8	TRANSISTOR, silicon, NPN, V_{CEO} 40V, TO-92, Motorola 2N3903.	HA-21562
Q6	TRANSISTOR, silicon, PNP, V_{CEO} 40V, TO-92, Motorola 2N3905.	HA-21564
Q1, Q2	TRANSISTOR, silicon, NPN, V_{CEO} 65V, TO-5, RCA 2N2102.	HA-22678
Q9	TRANSISTOR, silicon, PNP, V_{CEO} 65V, TO-5, RCA 2N4036.	HA-24003
T1, T2, T3	TRANSFORMER, 2.5K: 2.5K C.T. Microtran MMT 19-FB.	HA-25157
I1	Data Lamp, red cartridge. Dialco 507-3910-1431-600.	HA-25156
	Lamp holder, Dialco 508-7538-504.	HA-17504
	Test jacks, Sealectro Corp., SKT-10	

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB25190 48 VDC, D.C. TO D.C. CONVERTER	
R3, R4	RESISTOR, fixed comp., 24 ±5%, ¼ watt.	H-1009-827
R6, R7	RESISTOR, wirewound, 2.5K ±5%, 3¼ watt. Ohmite 995-3A.	H-1100-329
R1	RESISTOR, wirewound, 5K ±5%, 3¼ watt. Ohmite 995-3A.	H-1100-460
R5	RESISTOR, wirewound, 50 ±3%, 10 watt. Dale Electronics RH-10.	HA-23709
C1	CAPACITOR, elect., 80μF, 150VDC. Cornell Dubilier BR80-150.	H-1007-395
C2	CAPACITOR, met. paper, 0.047μF, 200W VDC. Cornel Dubilier MPY-2S47.	H-1007-674
C3	CAPACITOR, paper, 0.022μF ±10%, 1000VDC. Aerovox V161-615.	H-1007-696
C4, C5	CAPACITOR, ELECT., 100μF, 50VDC. Cornell Dubilier BR-100-50.	H-1007-209
CR1 thru CR9	DIODE, silicon, 200 PIV, 1 Amp. Diodes Inc. SD-2.	HA-17995
Q1, Q2	TRANSISTOR, silicon NPN, V_{CEO} 175V, TO-66. RCA 2N3583.	HA-21847
T1	TRANSFORMER, saturable core.	HB-25182
I1	LAMP, cartridge, red, 10VDC, 0.014A. Dialco 507-3910-1431-600.	HA-25156
I2	LAMP, cartridge, amber, 10VDC, 0.014A. Dialco 507-3910-1433-600.	HA-25784
	LAMPHOLDER. Dialco 508-7538-504.	HA-17504
S1	SWITCH, push button. Leviton #579.	HA-13554
F1	FUSE, 3AG. 0.5 AMP.	HA-9348
	SOCKET, TO-66 transistor mt'g. UID Electronics PTS-4.	HA-21848
	INSULATOR, mica, TO-66 transistor mt'g. Reliance Mica Co. DF-31-A.	HA-23658
	TEST JACKS, Sealectro Corp., SKT-10.	
	HB25200 125 VDC, D.C. TO D.C. CONVERTER	
R3, R4	RESISTOR, fixed comp., 100 ±5%, ¼ watt.	H-1009-758
R6	RESISTOR, fixed comp., 100K ±5%, ½ watt.	H-1009-348
R7	RESISTOR, fixed comp., 56K ±5%, ½ watt.	H-1009-815
R5	RESISTOR, wirewound, 100 ±3%, 10 watt.	HA-23650
R1	RESISTOR, fixed comp., 39K ±5%, 2 watt.	H-1009-885
C1	CAPACITOR, elect., 80μF, 150VDC. Cornell Dubilier BR80-150.	H-1007-395
C2	CAPACITOR, met. paper, 0.022μF, 400 W VDC. Cornell Dubilier MPY-4S22.	H-1007-637
C3	CAPACITOR, paper, 0.022μF ± 10%, 1000VDC. Aerovox V161-615.	H-1007-696
C4, C5	CAPACITOR, elect., 100μF, 50 W VDC. Cornell Dubilier BR-100-50.	H-1007-209
CR1 thru CR11	DIODE, silicon, 200 PIV, 1 Amp. Diodes Inc., SD-2.	HA-17995
Q1, Q2	TRANSISTOR, silicon NPN, V_{CEO} 300V, TO-66. RCA 2N3585.	HA-22593
T1	TRANSFORMER, saturable core.	HB-25183
I1	LAMP, cartridge, red, neon, 105/125VDC. Dialco 507-3835-0931-600.	HA-25203
I2	LAMP, cartridge, amber, neon, 105/125VDC. Dialco 507-3835-0933-600.	HA-25204
	LAMPHOLDER. Dialco 508-7538-504.	HA-17504
S1	SWITCH, push button. Leviton #579	HA-13554
F1	FUSE, 3AG, 0.2A., Slo-Blo.	HA-14691
	SOCKET, TO-66 transistor mt'g. UID Electronics PTS-4.	HA-21848
	INSULATOR, mica, transistor mt'g. Reliance Mica Co. DF-31-A.	HA-23658
	TEST JACKS, Sealectro Corp., SKT-10.	

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB-25210 VOLTAGE REGULATOR	
* R17,R21-R28,R31	±5%, ¼ watt, unless otherwise specified.	
R1, R9	RESISTOR, wirewound, 2.2K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-448
R3, R10, R29	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-423
R5, R13	RESISTOR, wirewound, 1K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-429
R6, R16	RESISTOR, wirewound, 820 ±5%, 1½ watt.	H-1100-443
R8, R14	RESISTOR, wirewound, 2K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-422
R30	RESISTOR, wirewound, 1.6K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-543
R2, R11	RESISTOR, wirewound, 75 ±5%, 3 watt. Ohmite 995-3A.	HA-13863
R4, R12	RESISTOR, wirewound, 56 ±5%, 3 watt. Ohmite 995-3A.	H-1100-541
R18, R20	RESISTOR, wirewound, 5.6K ±5%, 3 watt. Ohmite 995-3A.	H-1100-542
R7, R15	RESISTOR, variable wirewound, 1000 ohms. Muter Co. 50-2200 Series	HA-12578
R19	RESISTOR, variable wirewound, 5000 ohms. Muter Co. 50-2200 Series	HA-20924
C1, C4	CAPACITOR, mica, 91pF ±5%, 500V. Elemenco DM-15-910J.	HA-16521
C2, C5	CAPACITOR, tantalum, 15μF, ±20%, 35VDC. Texas Inst., SCM156GP035D4.	H-1007-654
C3, C6	CAPACITOR, elect., 500μF, 50VDC. Sprague TVA-1315.	HA-13569
CR1, CR2	DIODE, zener, 12V ±5%. Diodes Inc. 1D12B.	HA-12920
CR3	DIODE, zener, 18V ±5%. Diodes Inc. 1D18B.	HA-25217
CR4	DIODE, silicon, 200 PIV. Diodes Inc. DI-42,	HA-17197
Q7, Q8	TRANSISTOR, silicon NPN, V_{CEO} 40V, TO-92. Motorola 2N3903.	HA-21562
Q10, Q11	TRANSISTOR, silicon PNP, V_{CEO} 40V, TO-92. Motorola 2N3905.	HA-21564
Q1, Q2, Q12	TRANSISTOR, silicon NPN, V_{CEO} 65V, TO-5. RCA 2N2102.	HA-22678
Q4, Q5, Q9	TRANSISTOR, silicon PNP, V_{CEO} 65V, TO-5. RCA 2N4036.	HA-24003
Q3	TRANSISTOR, silicon NPN, V_{CEO} 60V, TO-3. Motorola 2N3055.	HA-24327
Q6	TRANSISTOR, germanium PNP, V_{CEO} 50V, TO-3. RCA 2N2869/2N301.	HA-17992
	TRANSISTOR socket, TO-3. Augat Bros. 8043-1G3.	HA-18538
	INSULATOR, mica, TO-3 transistor mt'g. Reliance Mica Co. 732	HA-11964
I1	LAMP, cartridge, amber, 10VDC., 0.014A. Dialco 507-3910-1433-600.	HA-25784
	LAMPHOLDER, Dialco 508-7538-504.	HA-17504
	TEST JACKS, Sealectro Corp. SKT-10.	

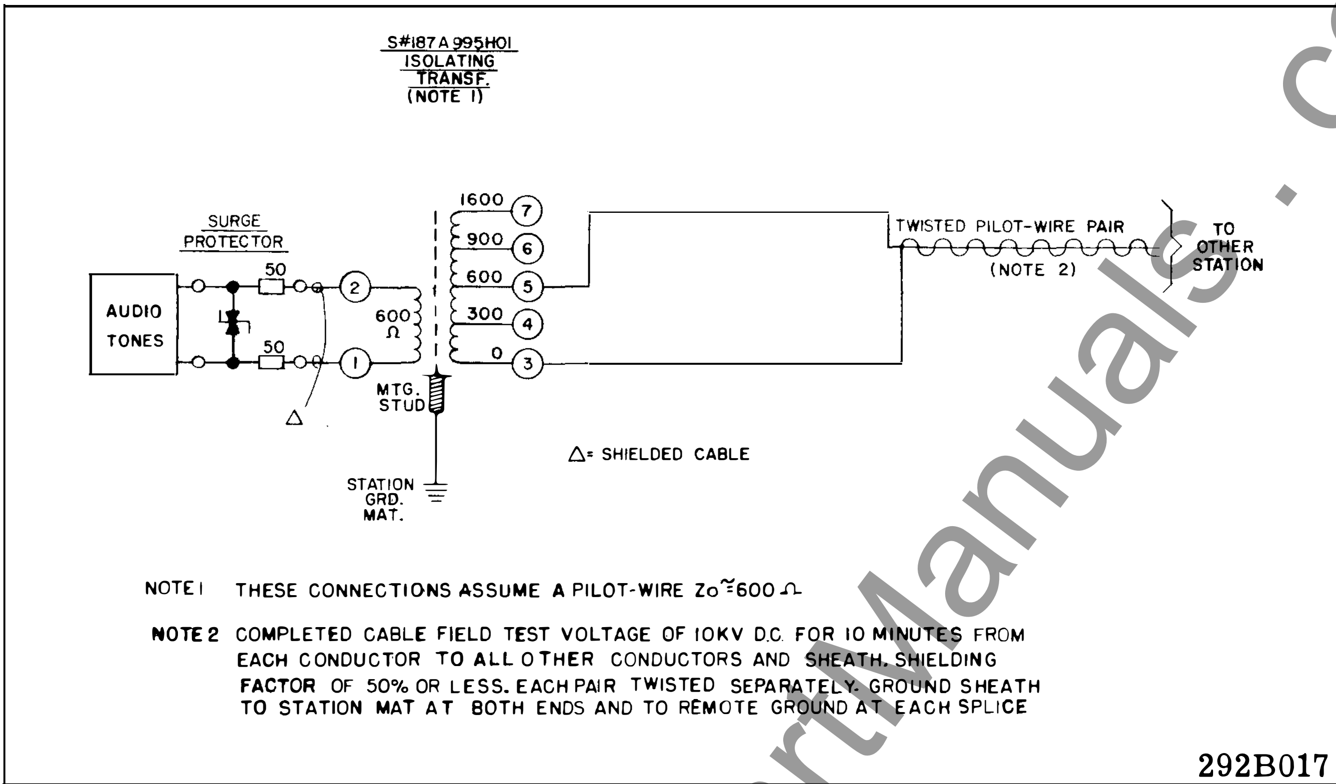
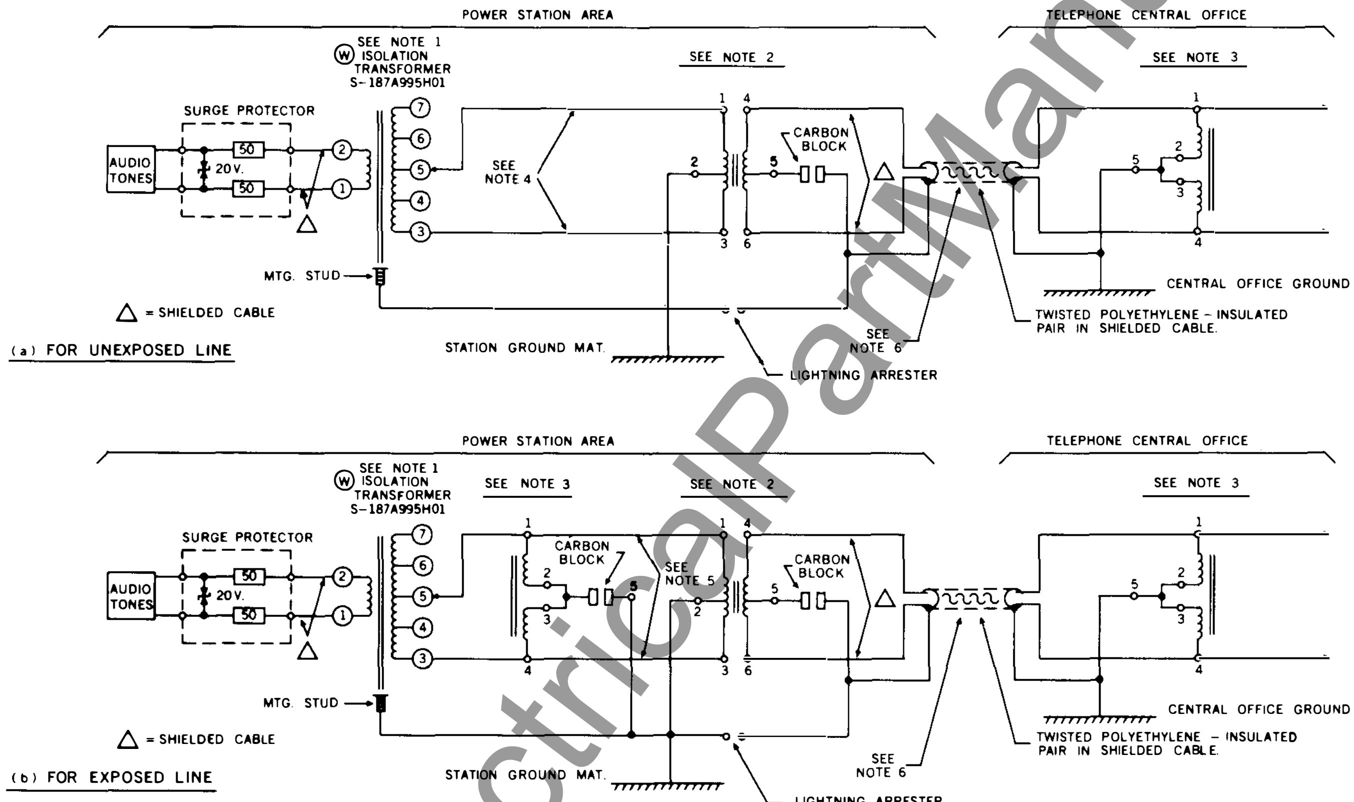


Fig. 1. Recommended Connections and Pilot Wire Design for Privately Owned Two-Terminal Lines.



NOTES

1. PRIMARILY USED FOR IMPEDANCE - MATCHING PURPOSE.
2. WESTERN ELECTRIC INSULATING TRANSF. TYPE 2239A OR EQUIV.
3. WESTERN ELECTRIC DRAINAGE REACTOR TYPE 2232A OR EQUIV.
4. UNEXPOSED LINE – MAX. EXTERIOR DISTANCE ABOUT 75FT. – USE SHIELDED CABLE.
5. EXPOSED LINE WITH EXTERIOR DISTANCE OVER 75FT. AND EXPOSED TO LIGHTNING, POWER-SYSTEM CONTACT, AND POWER INDUCTION – USE SHIELDED CABLE.
6. ISOLATE SHIELD FROM GROUND UNTIL OUT OF SIGNIFICANT INFLUENCE OF STATION GROUND POTENTIAL.

205C508

*Fig. 2. Recommended Connections and Protective Arrangements for Two-Terminal Lines

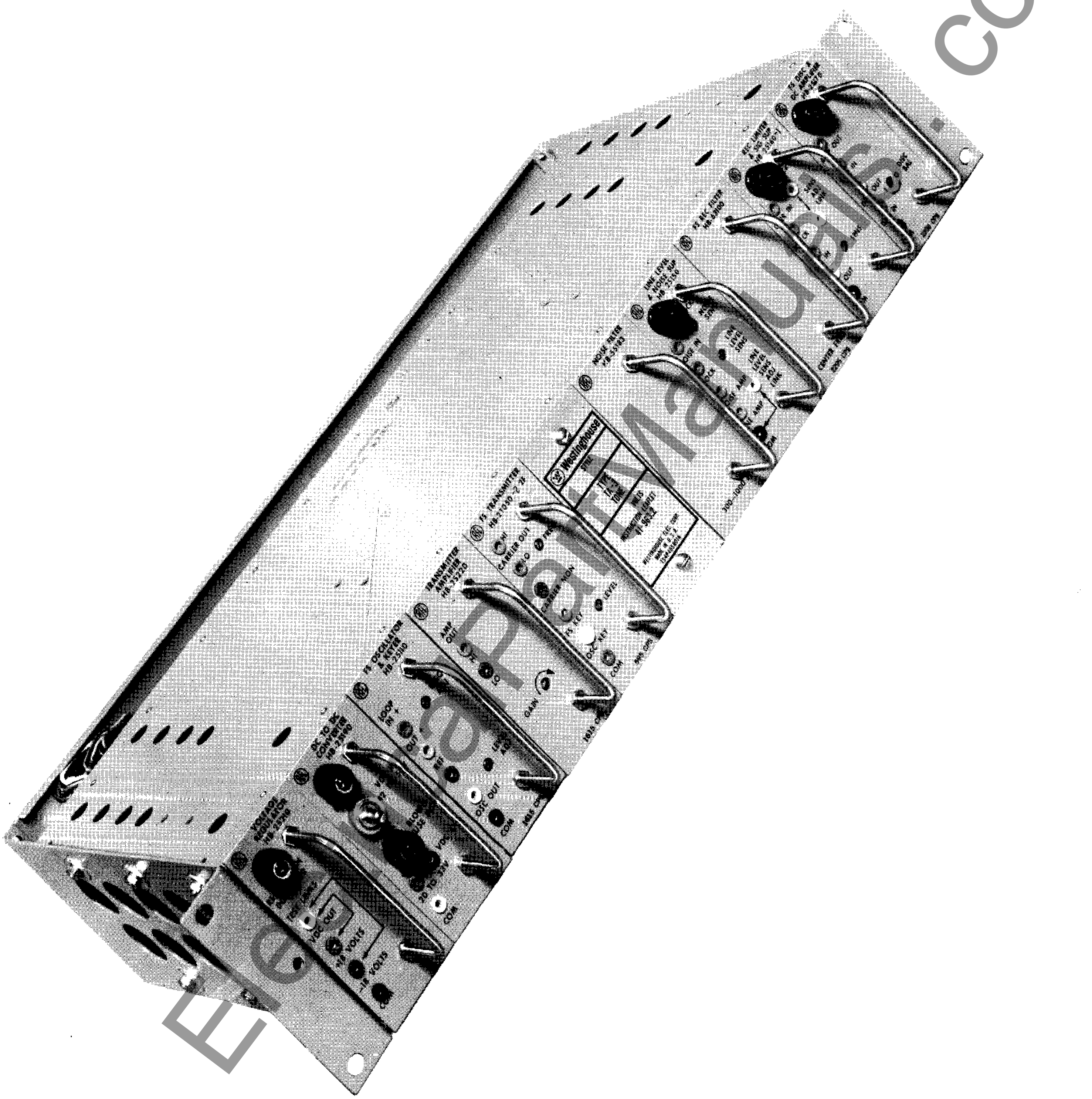


Fig. 3. Front View of Full Chassis.

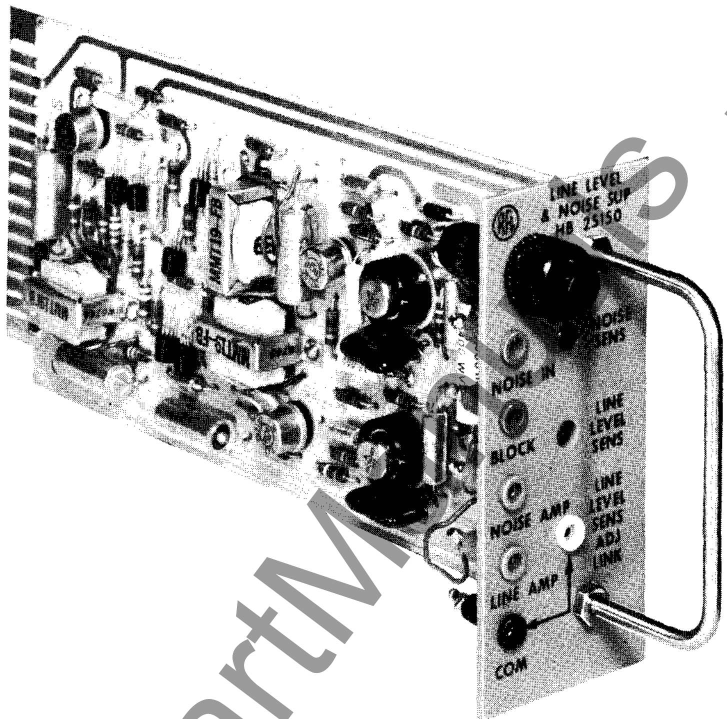


Fig. 4. Typical Module.

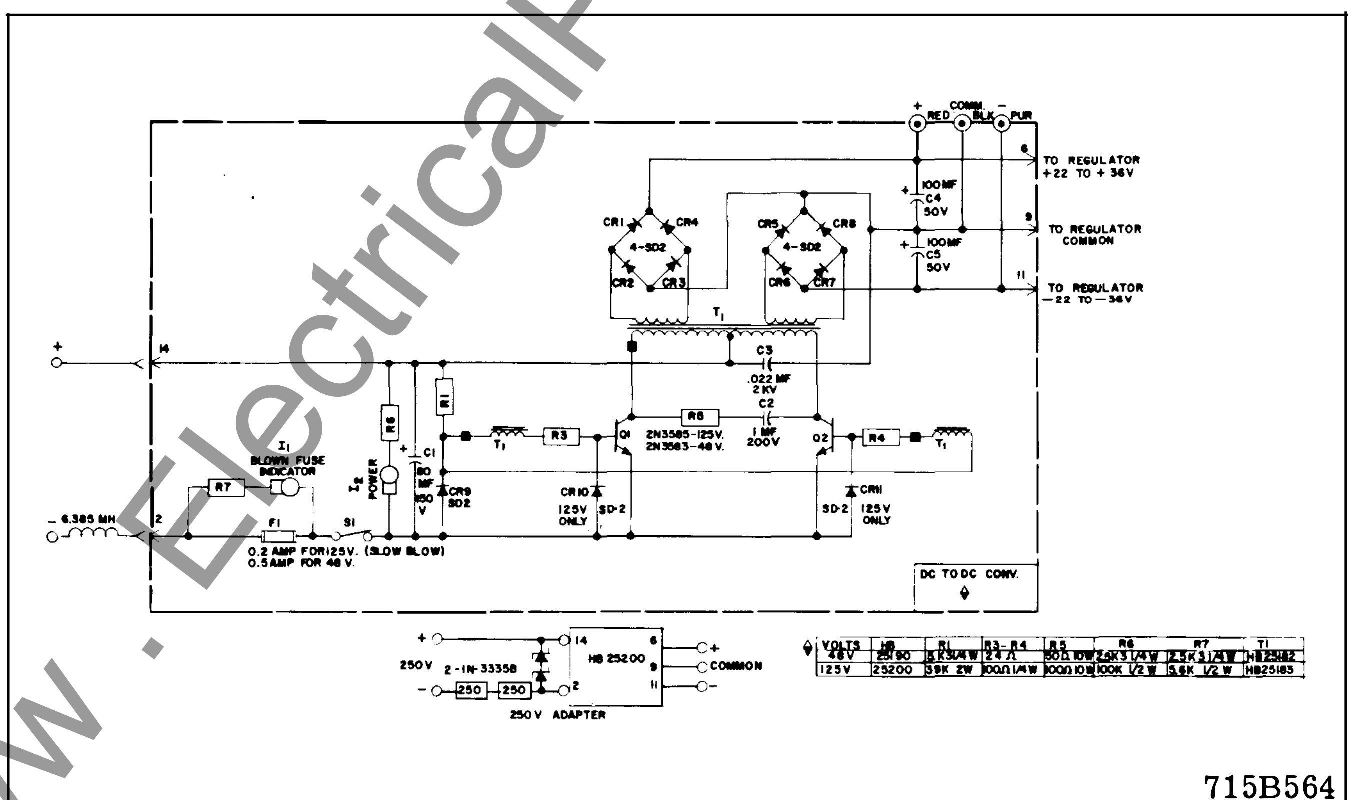
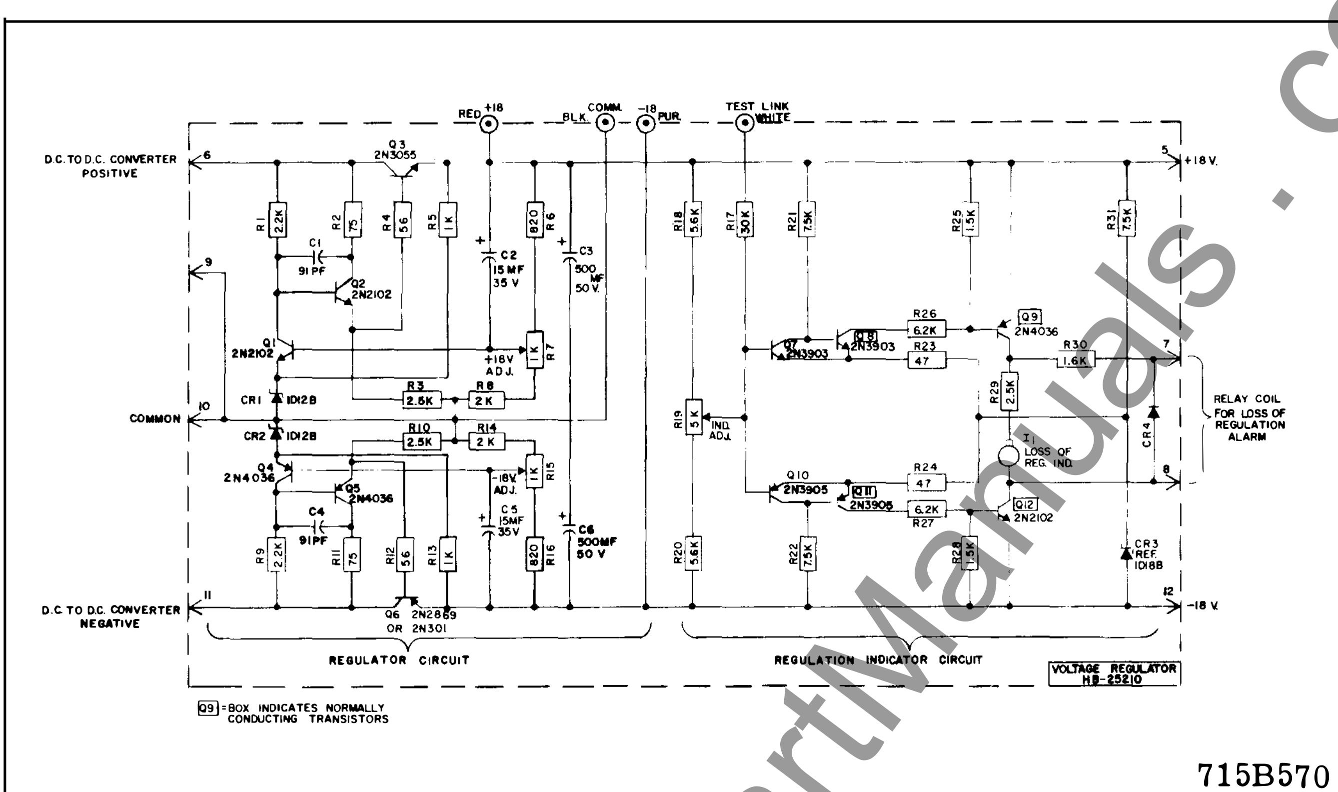
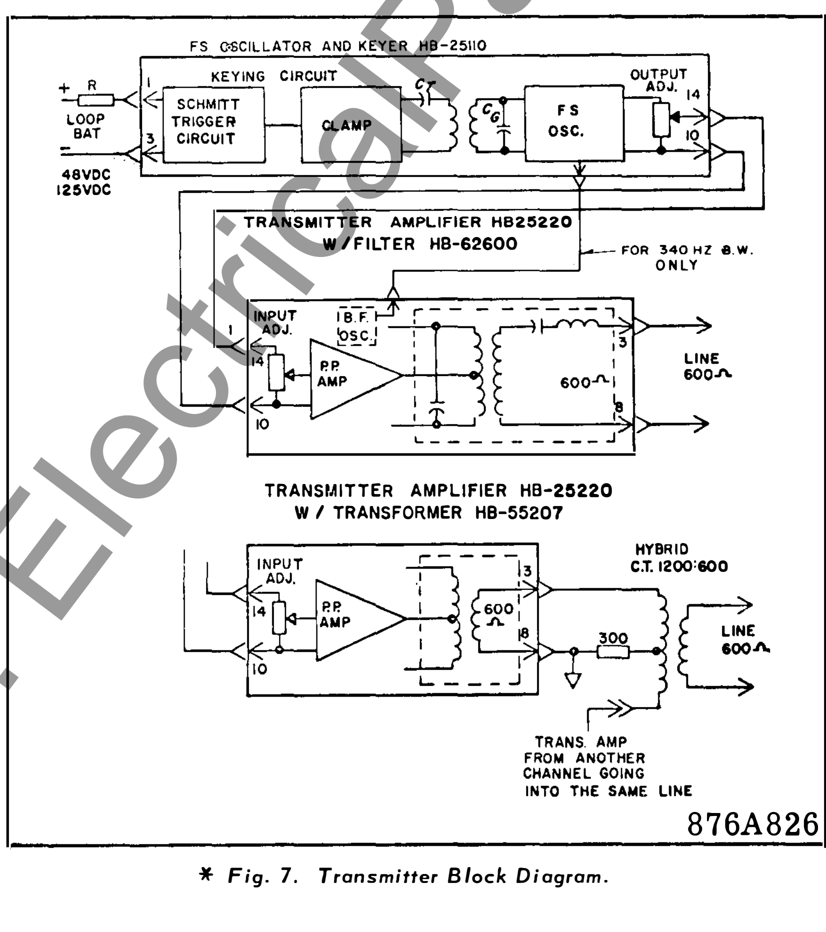


Fig. 5. Power Supply HB-25190 and HB-25200.



* *Fig. 6. Voltage Regulator HB-25210.*



* *Fig. 7. Transmitter Block Diagram.*

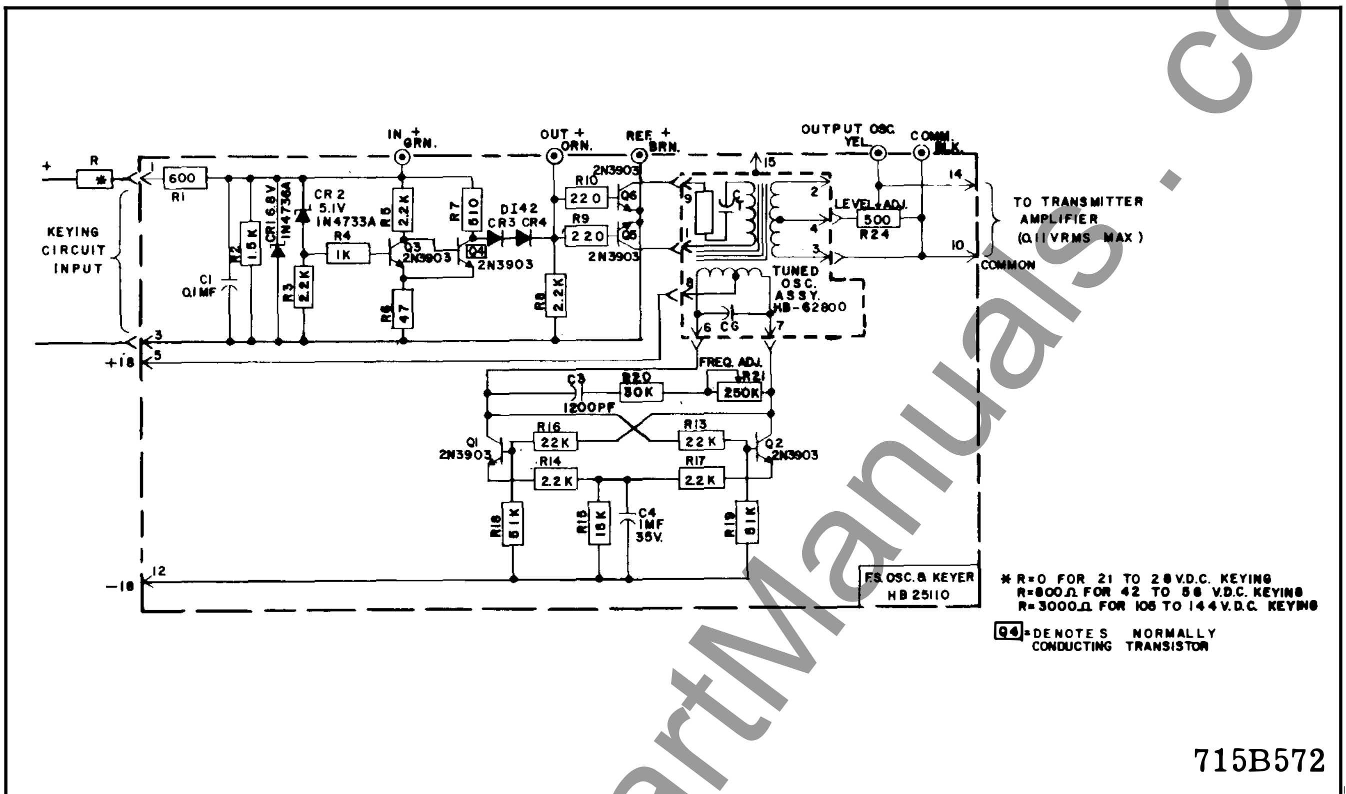
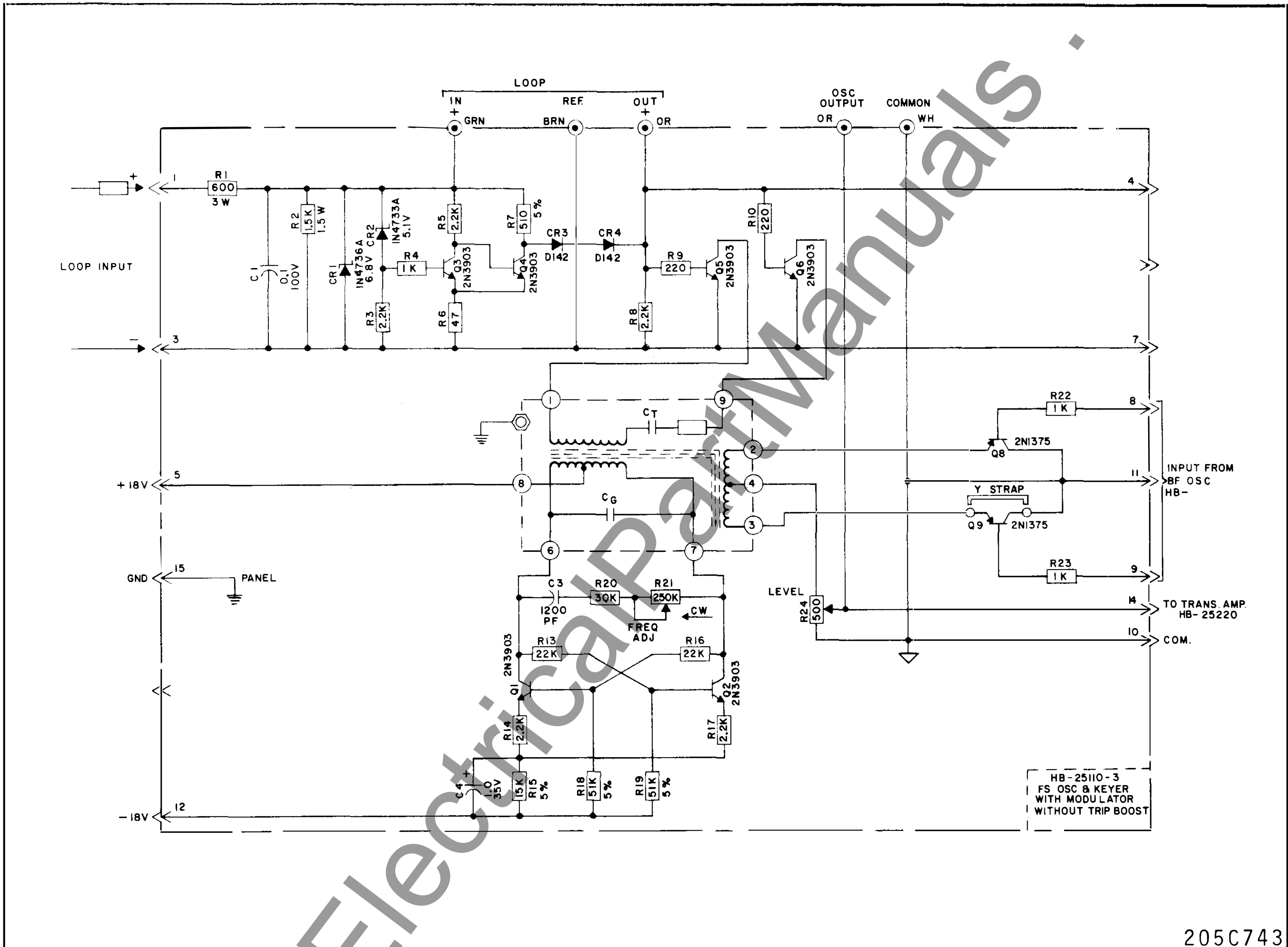
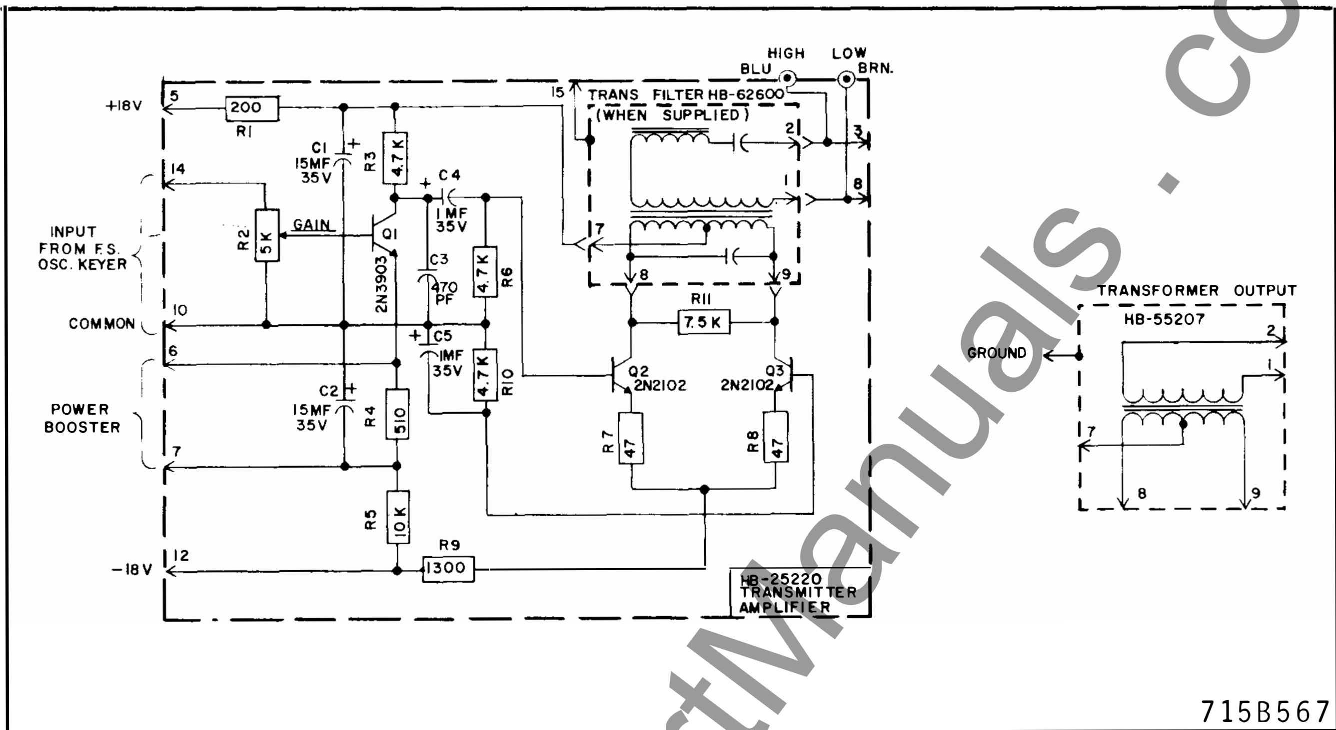


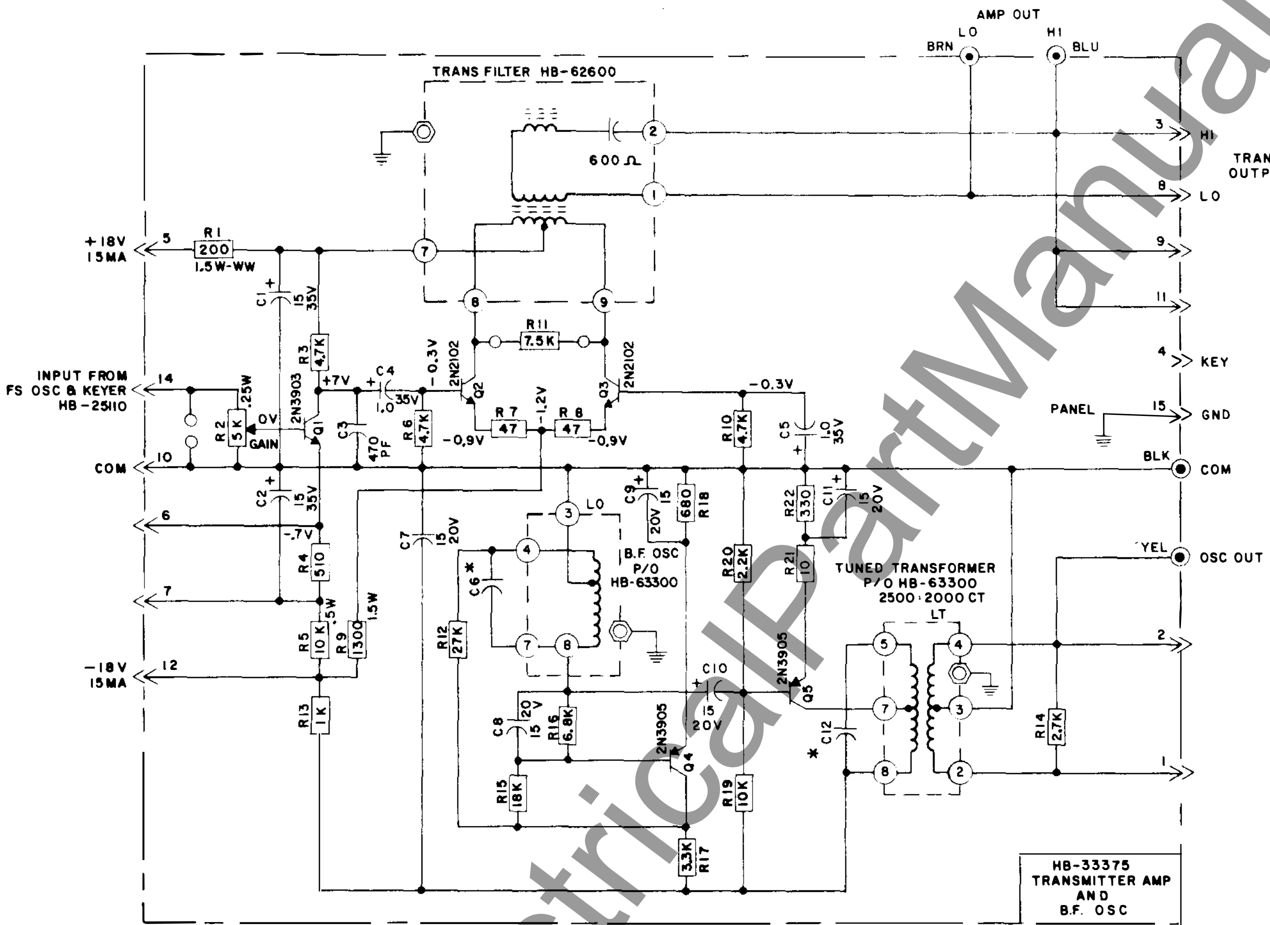
Fig. 8. F.S. Oscillator and Keyer HB-25610.



∗ Fig. 9. F.S. Oscillator and Keyer HB25110-3.



* *Fig. 10. Transmitter Amplifier HB-25220.*



NOTES:

1 - VOLTAGE SHOWN ARE SAMPLE VALUES TO BE USED FOR DETERMINING RELATIVE MAGNITUDES.

2 - FIXED RESISTORS ARE 1/4 WATT ±5% VALUES UNLESS OTHERWISE SPECIFIED

3 - ASTERISK (*) INDICATES FACTORY VAULE

4 - HB-33375 TO BE USED ONLY WITH HB-25110-2 AND/OR HB-25110-3 FS OSC & KEYER.

205C742

*Fig. 11. Transmitter Amplifier HB-33375.

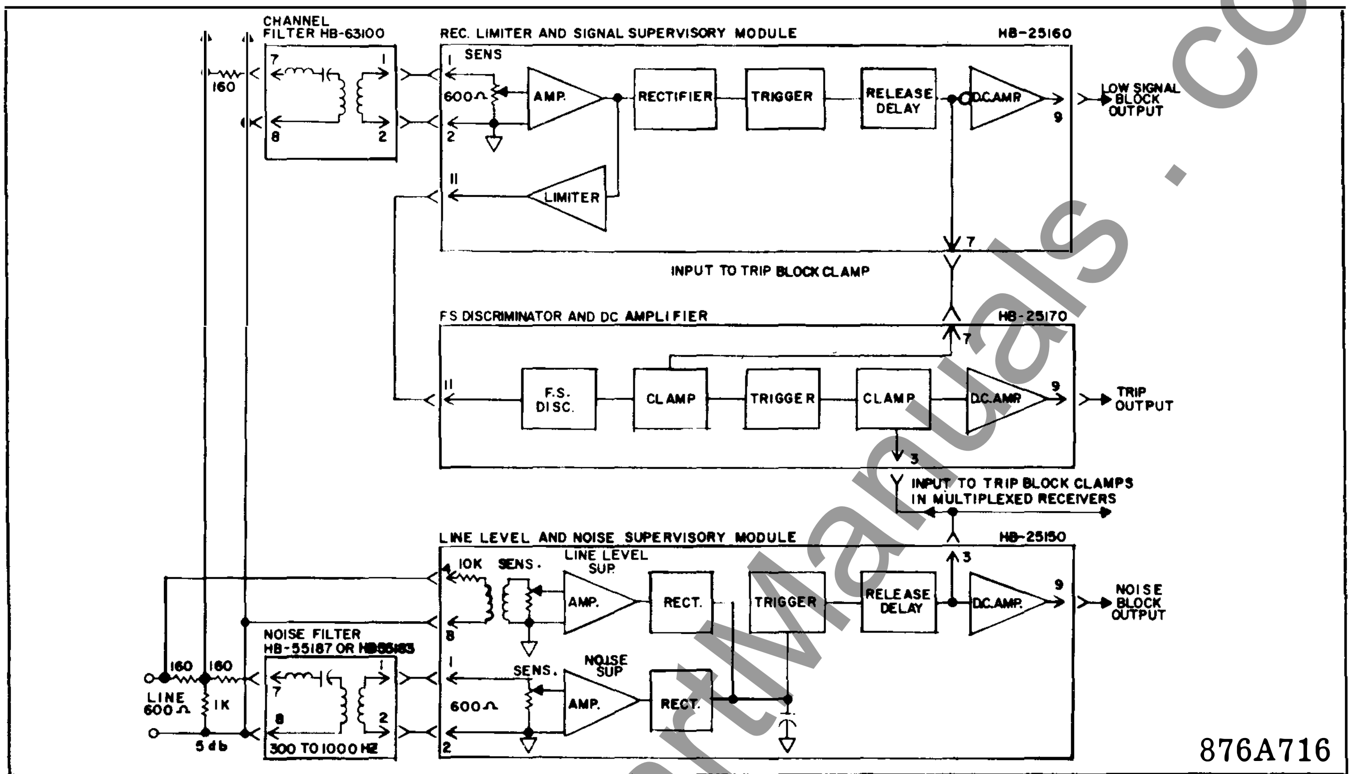


Fig. 12. Receiver Block Diagram HB-63100.

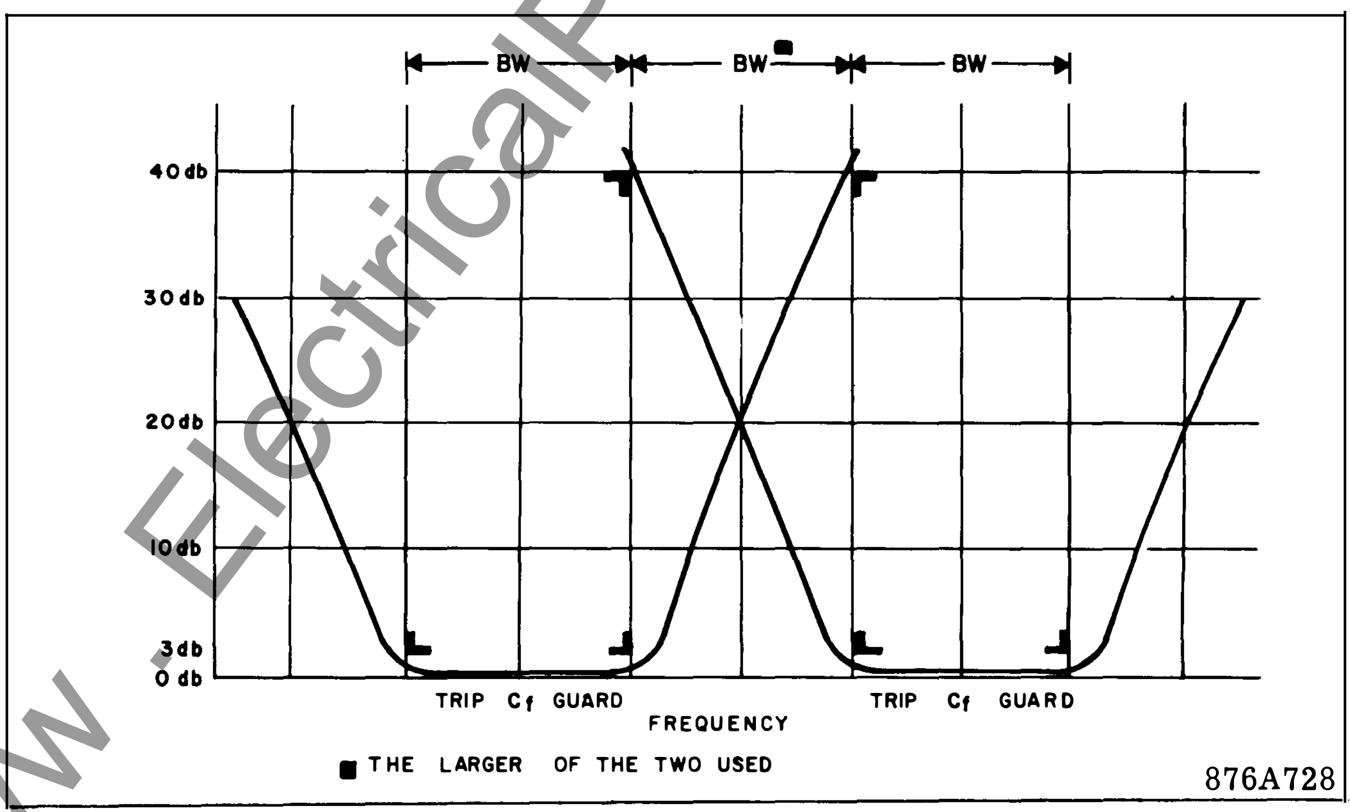


Fig. 13. Tone Receiver Filter Characteristics HB-63100.

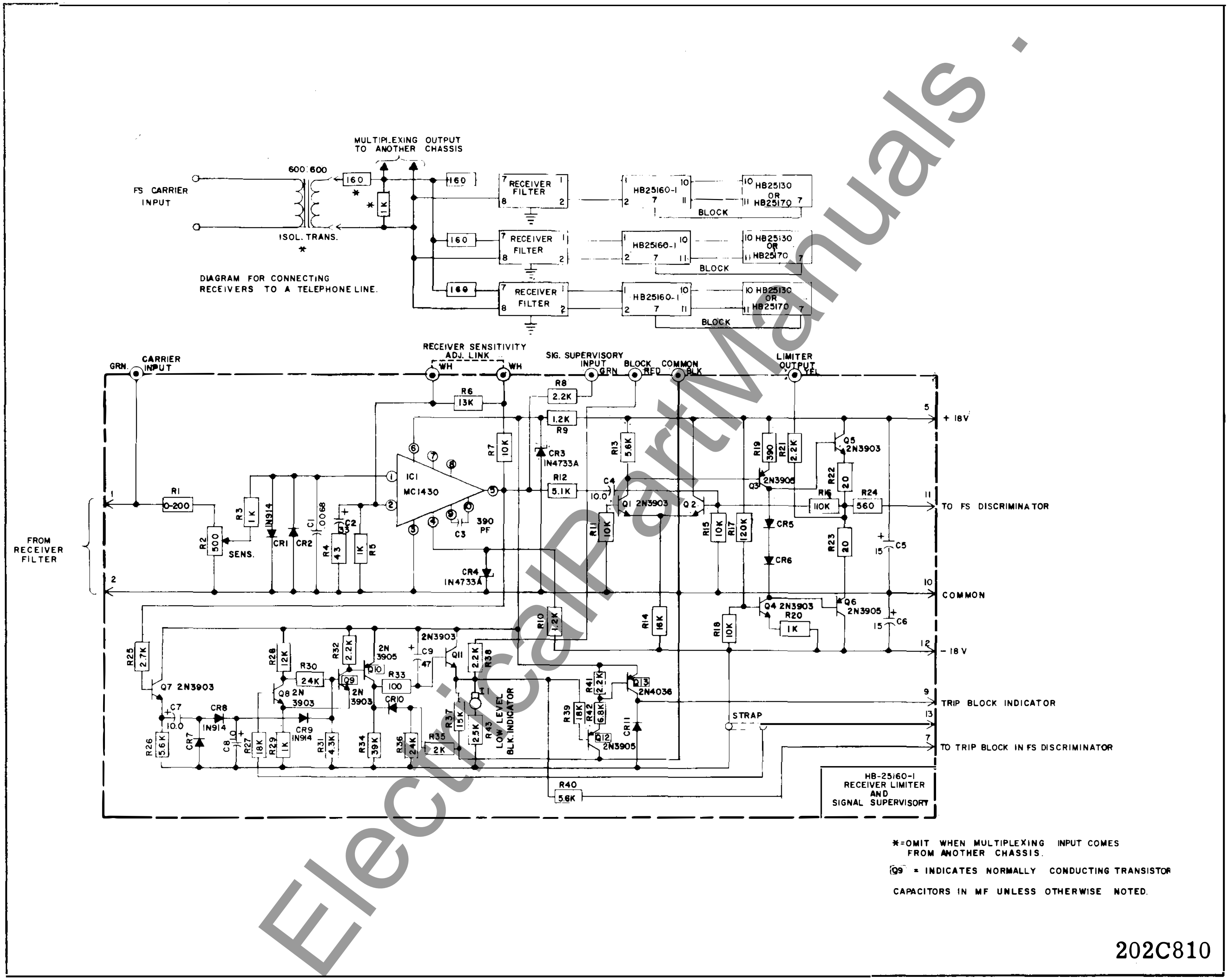
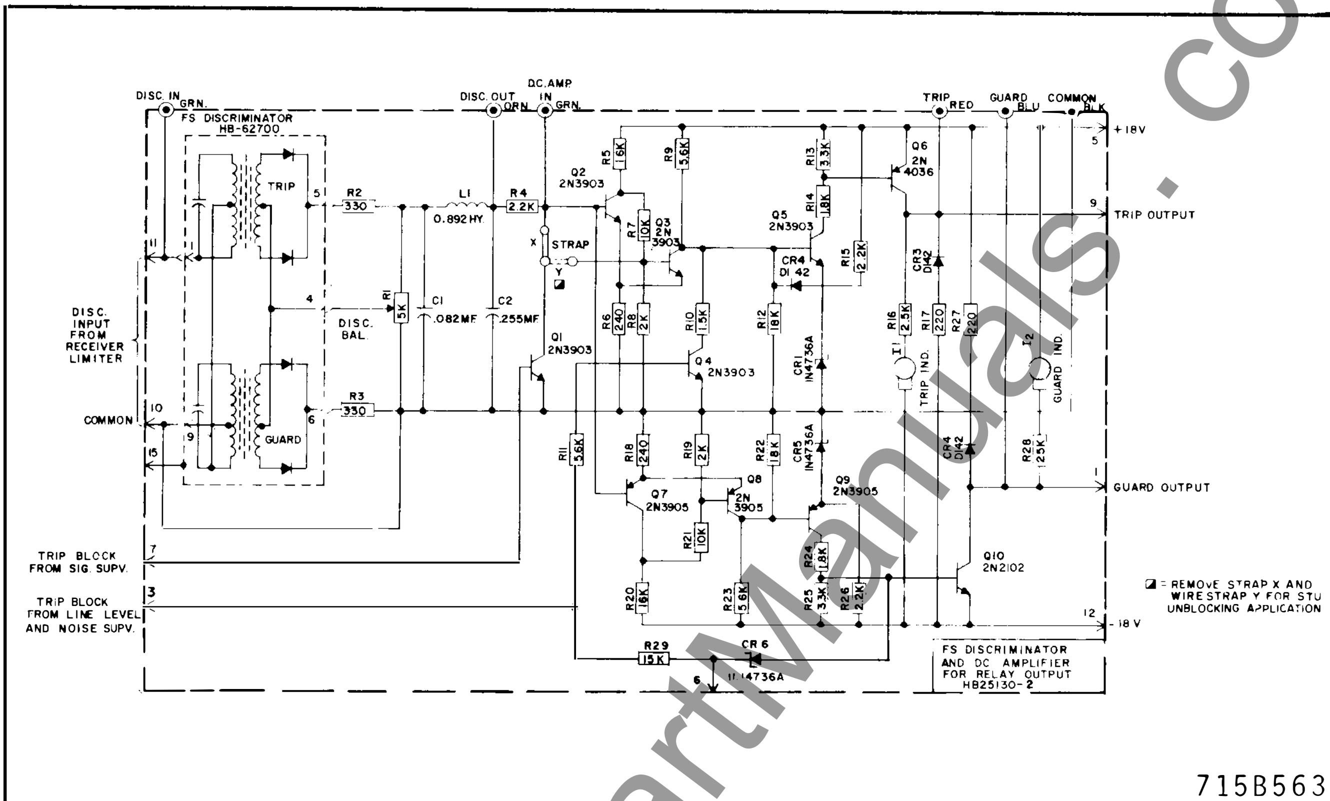


Fig. 14. Receiver Limiter and Signal Supervisory HB-25160-1.



* *Fig. 15. F.S. Discriminator and D-C Amplifier for Relay Output HB-25130-2.*

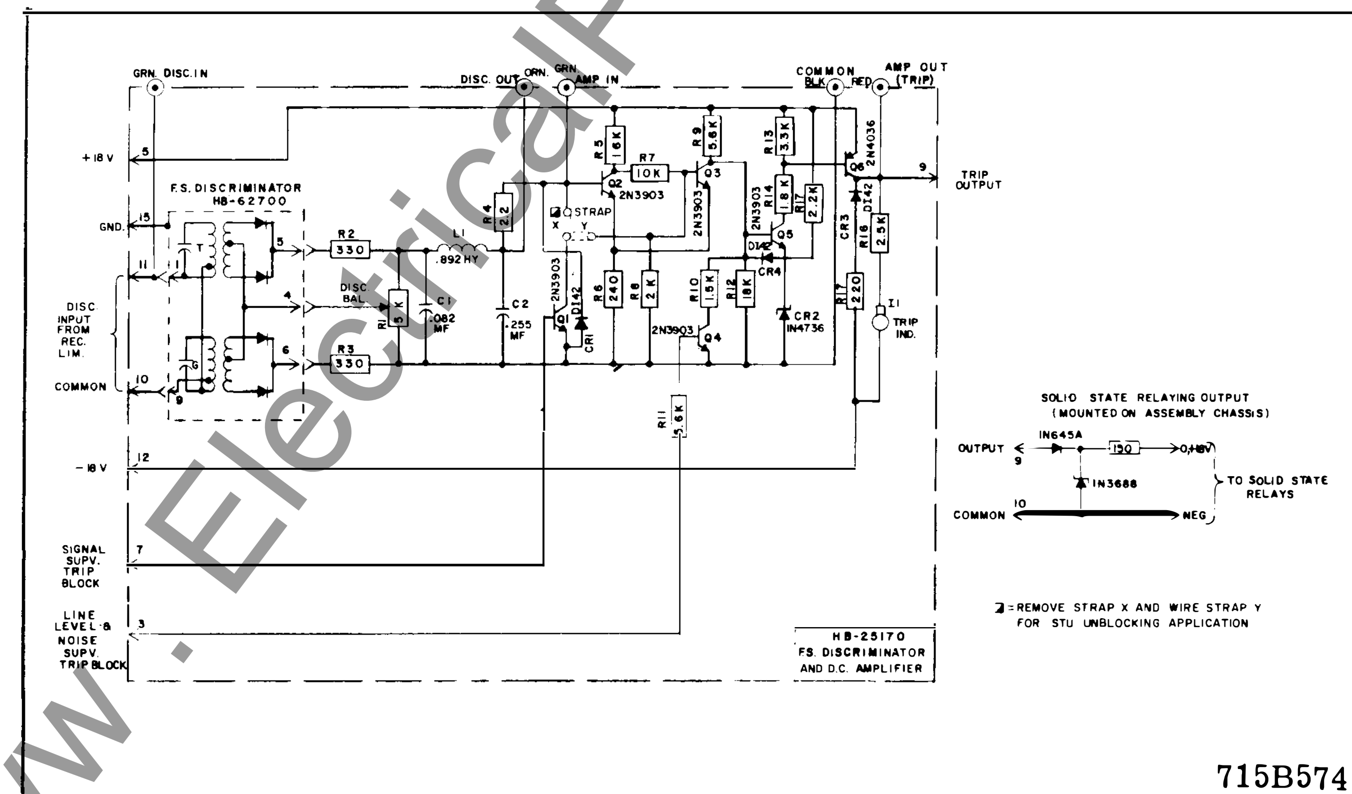


Fig. 16. F.S. Discriminator and D-C Amplifier for Solid-State Relaying HB-25170.

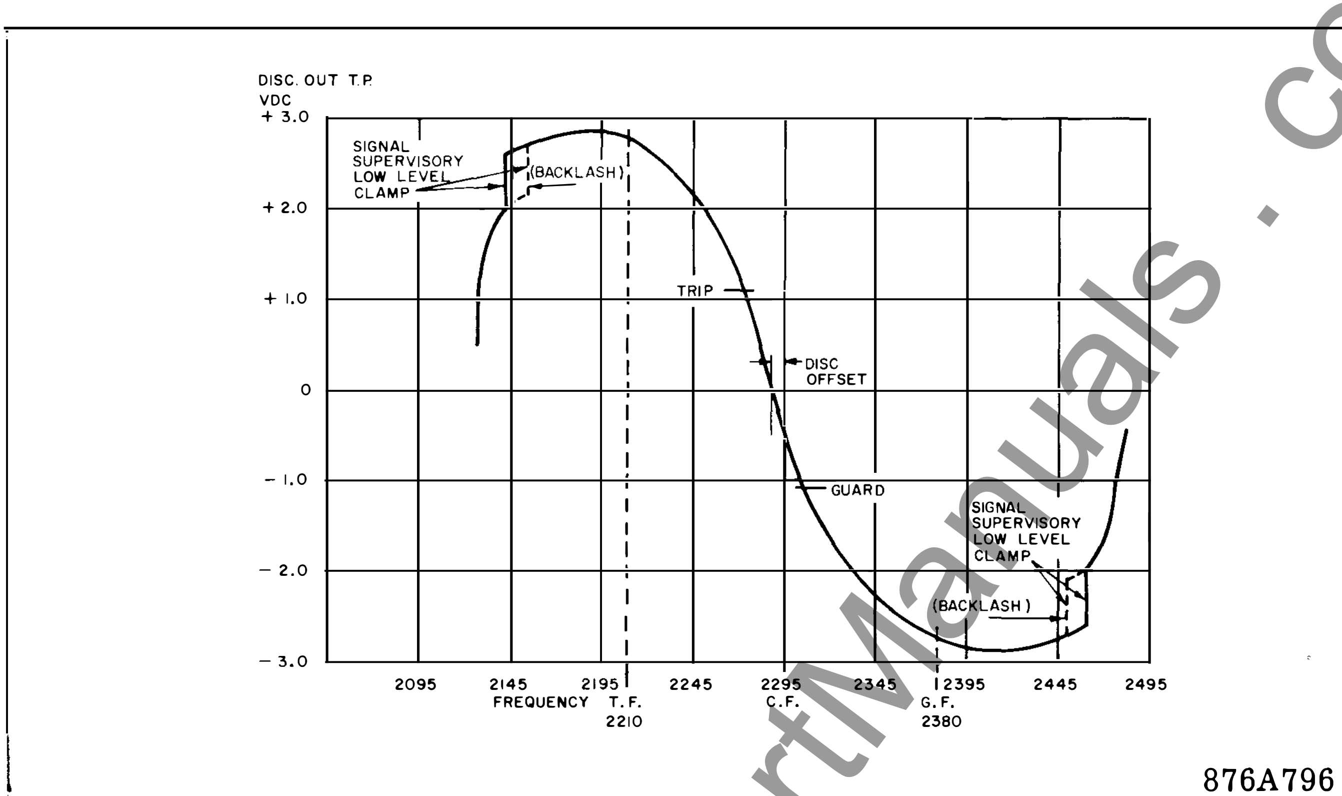
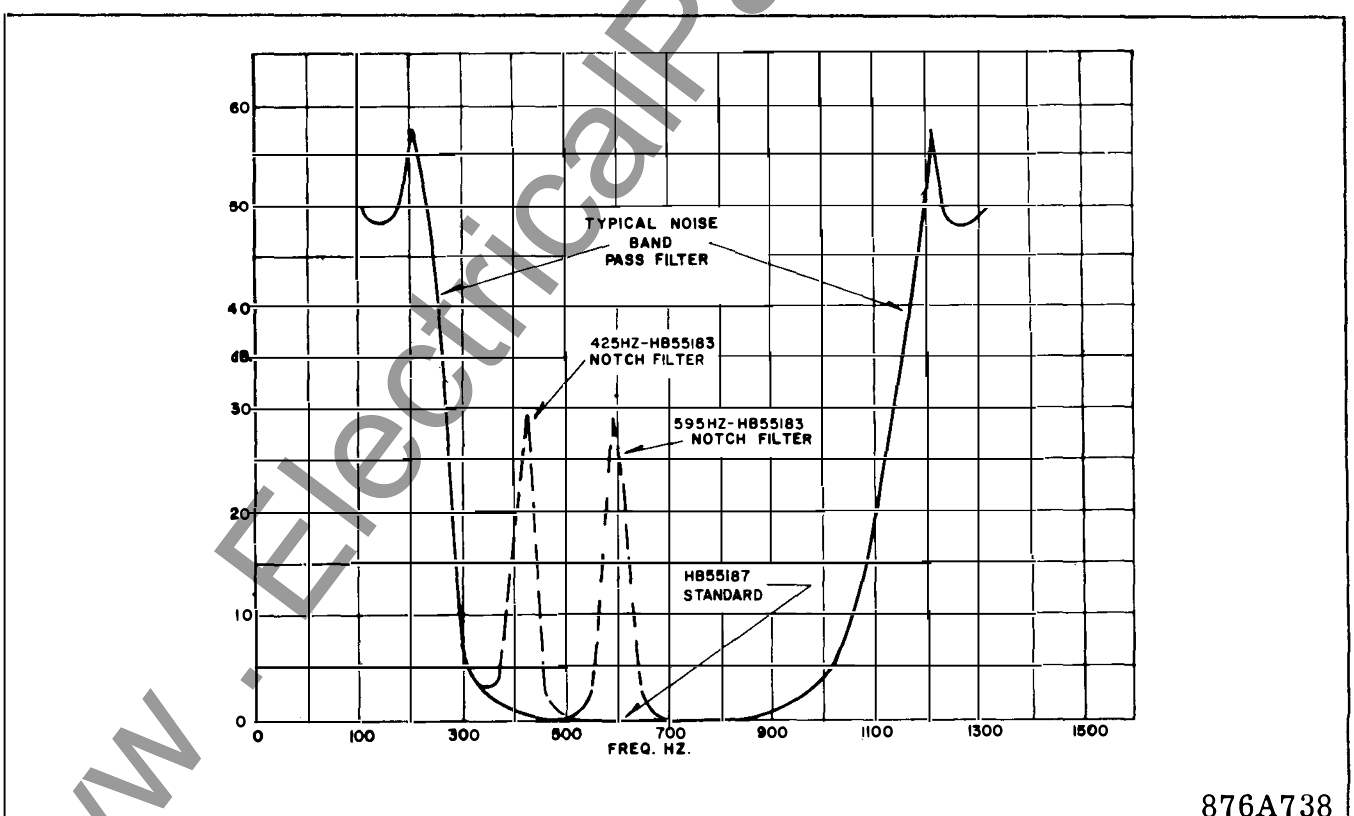
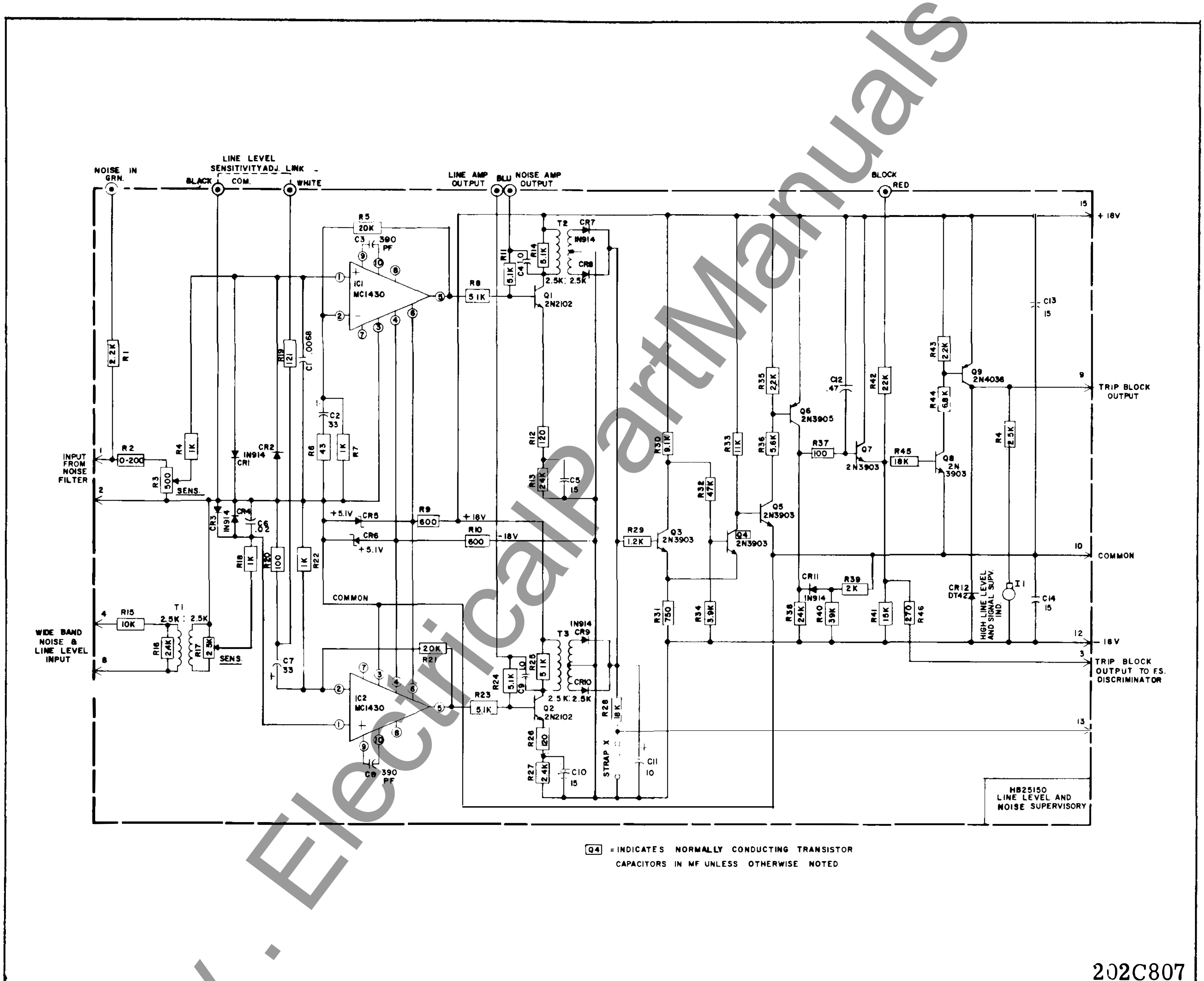


Fig. 17. Typical Discriminator Output.



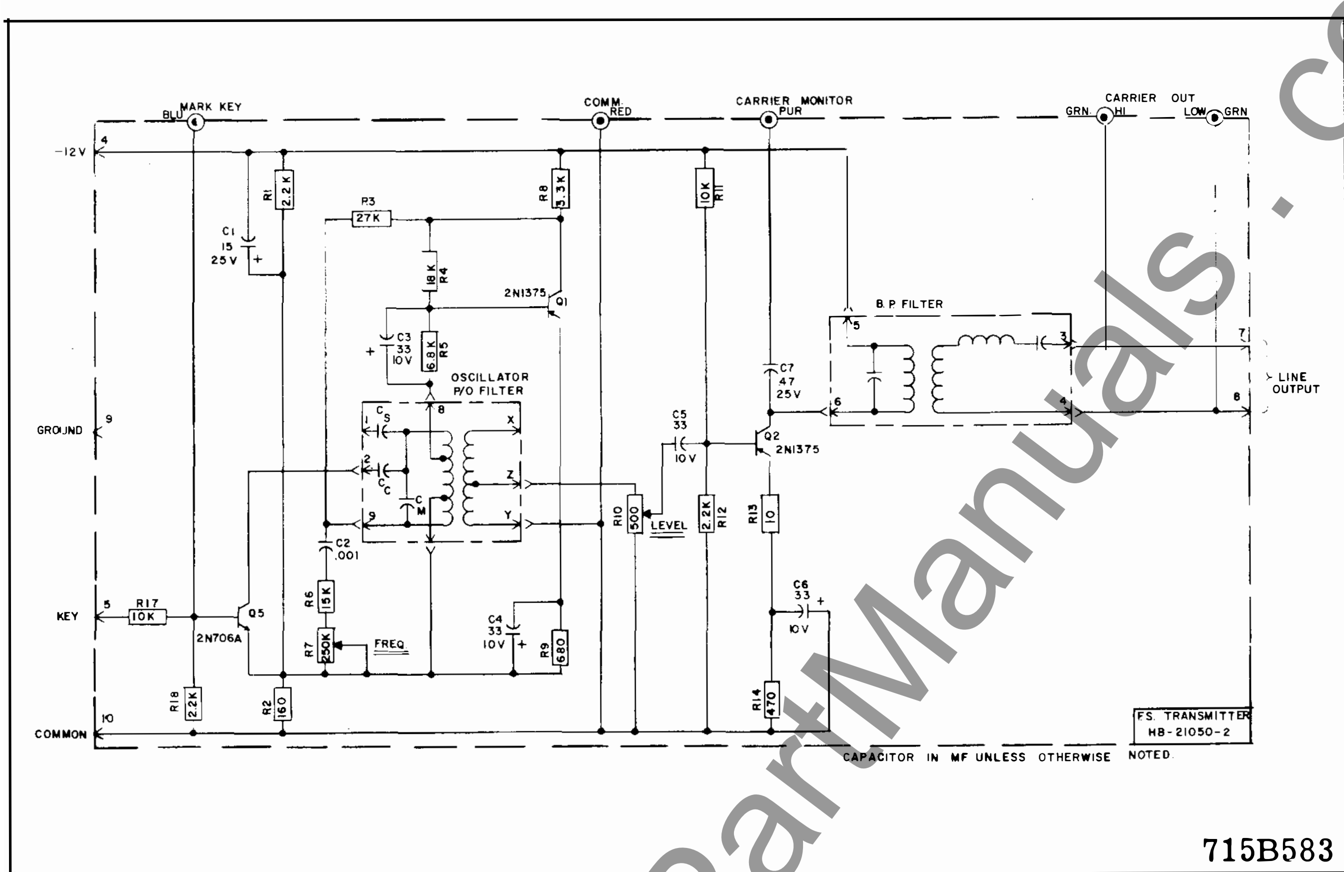
* *Fig. 18. Typical Noise Bandpass Filter.*



Q4 = INDICATES NORMALLY CONDUCTING TRANSISTOR

CAPACITORS IN MF UNLESS OTHERWISE NOTED

Fig. 19. Receiver Line Level and Noise Supervisory Module HB-25150.



* *Fig. 20. 425-Hz Transmitter HB-21050-2.*

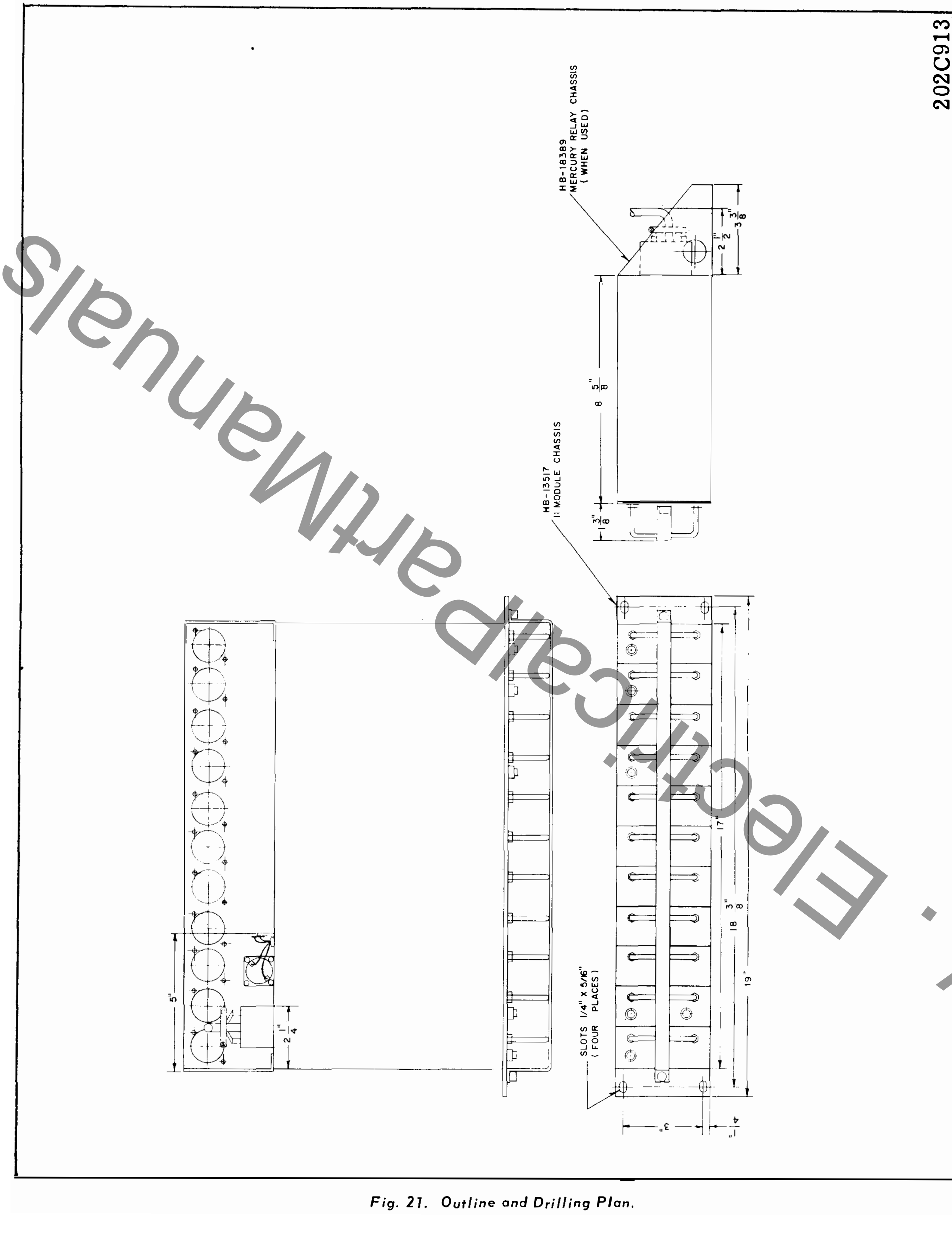


Fig. 21. Outline and Drilling Plan.

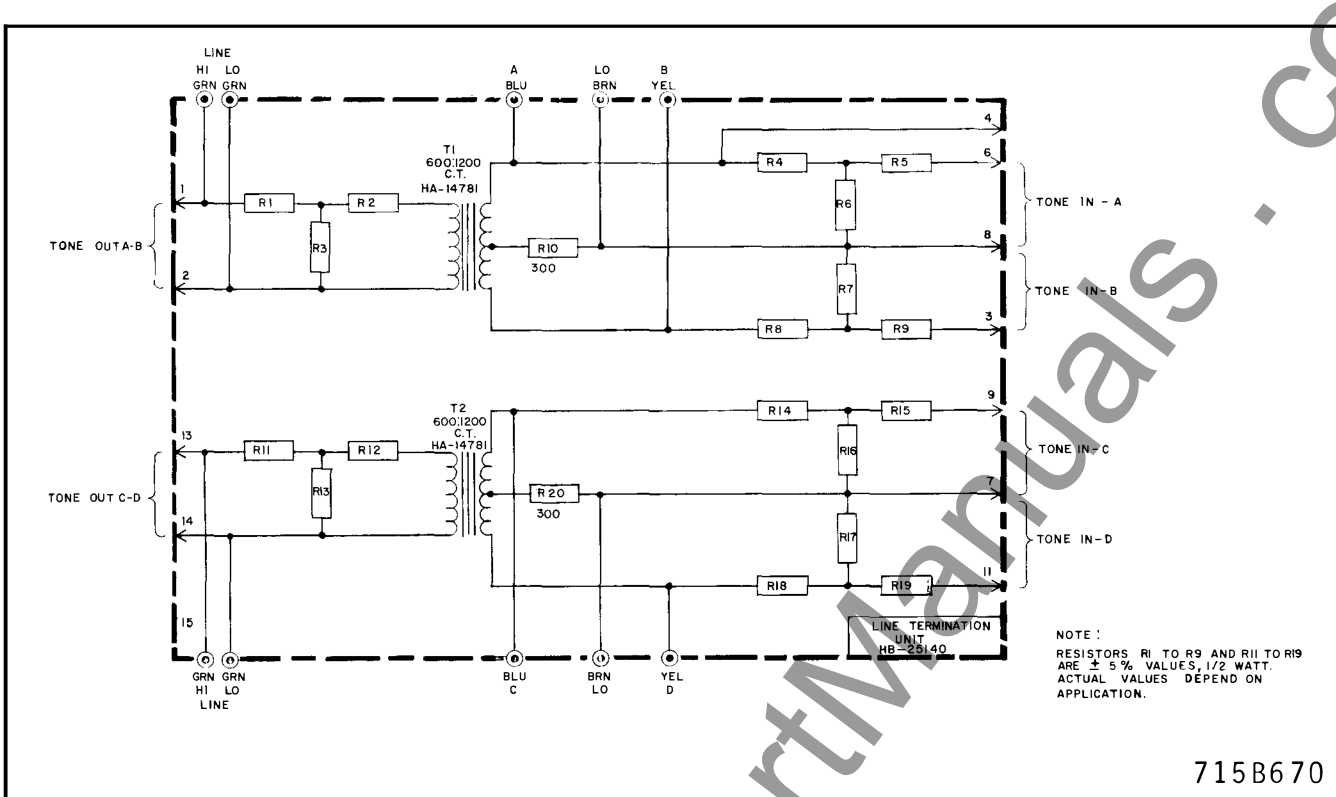
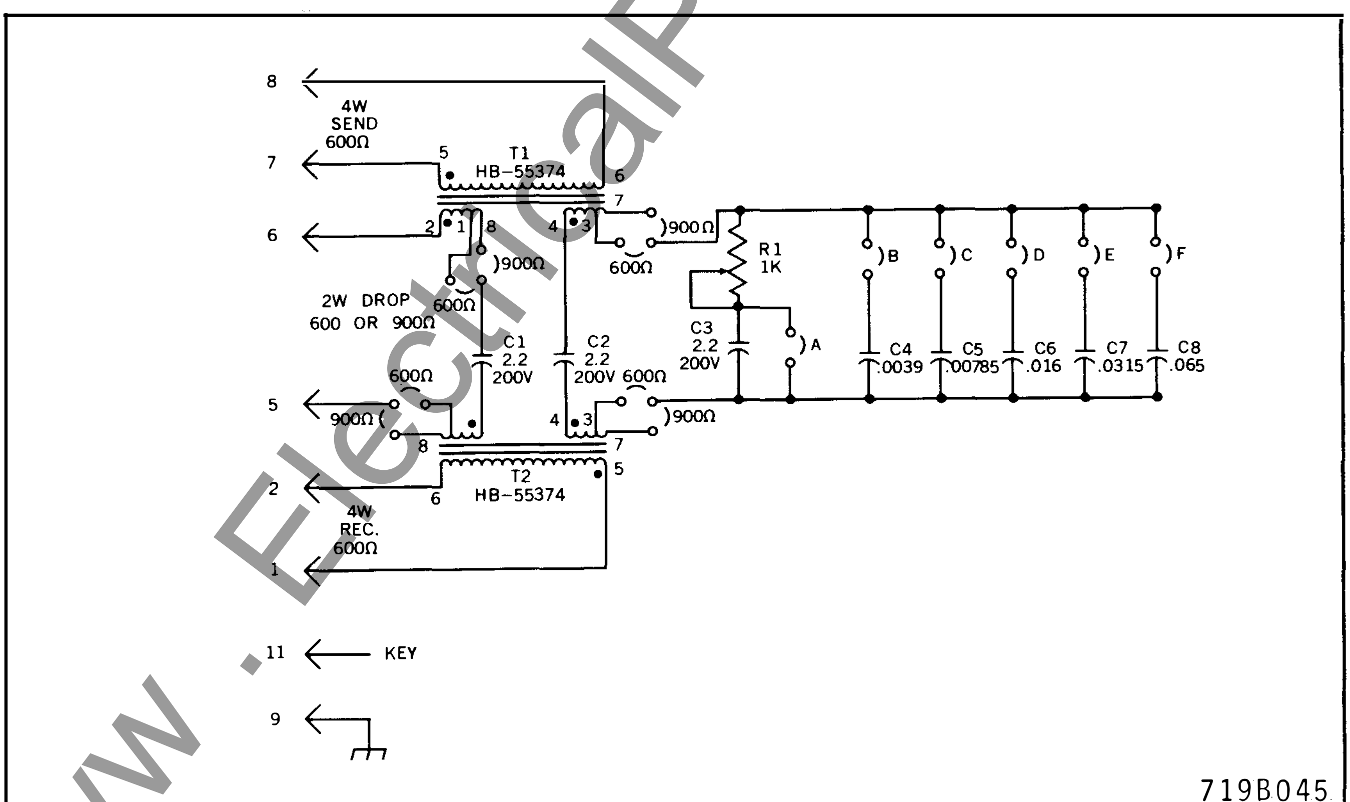


Fig. 22. Line Termination Module HB-25140.



** Fig. 23. Hybrid for Two Wire Termination HB-35315.*

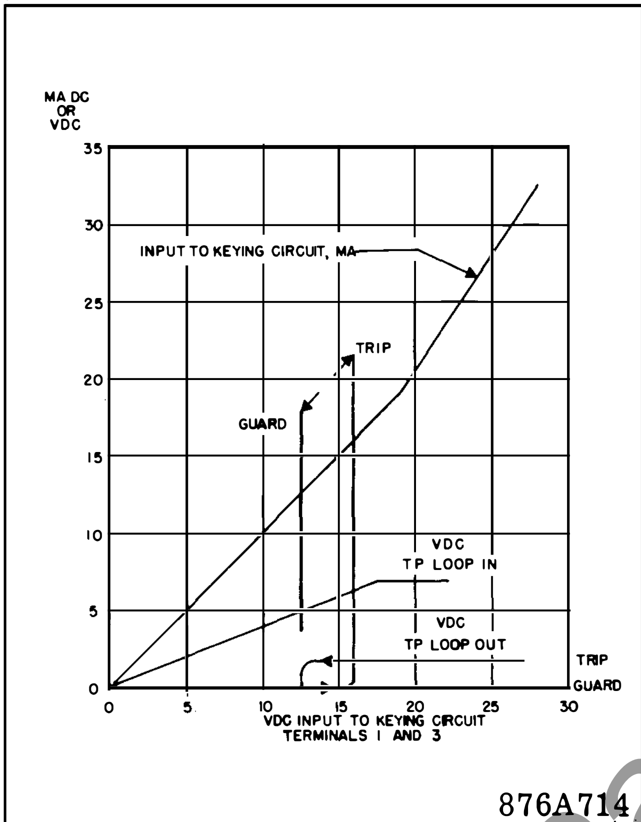


Fig. 24. Transmitter Keying Circuit Characteristics.

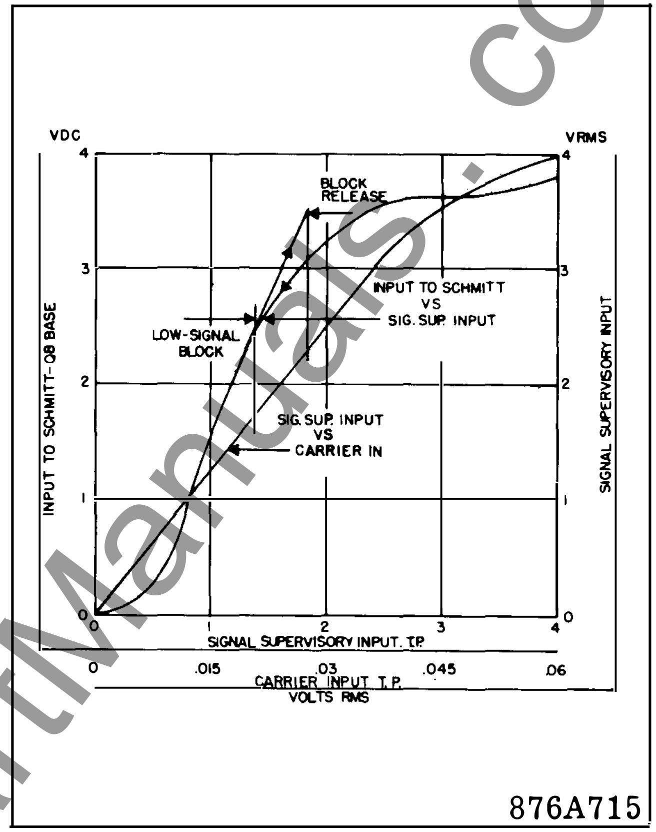
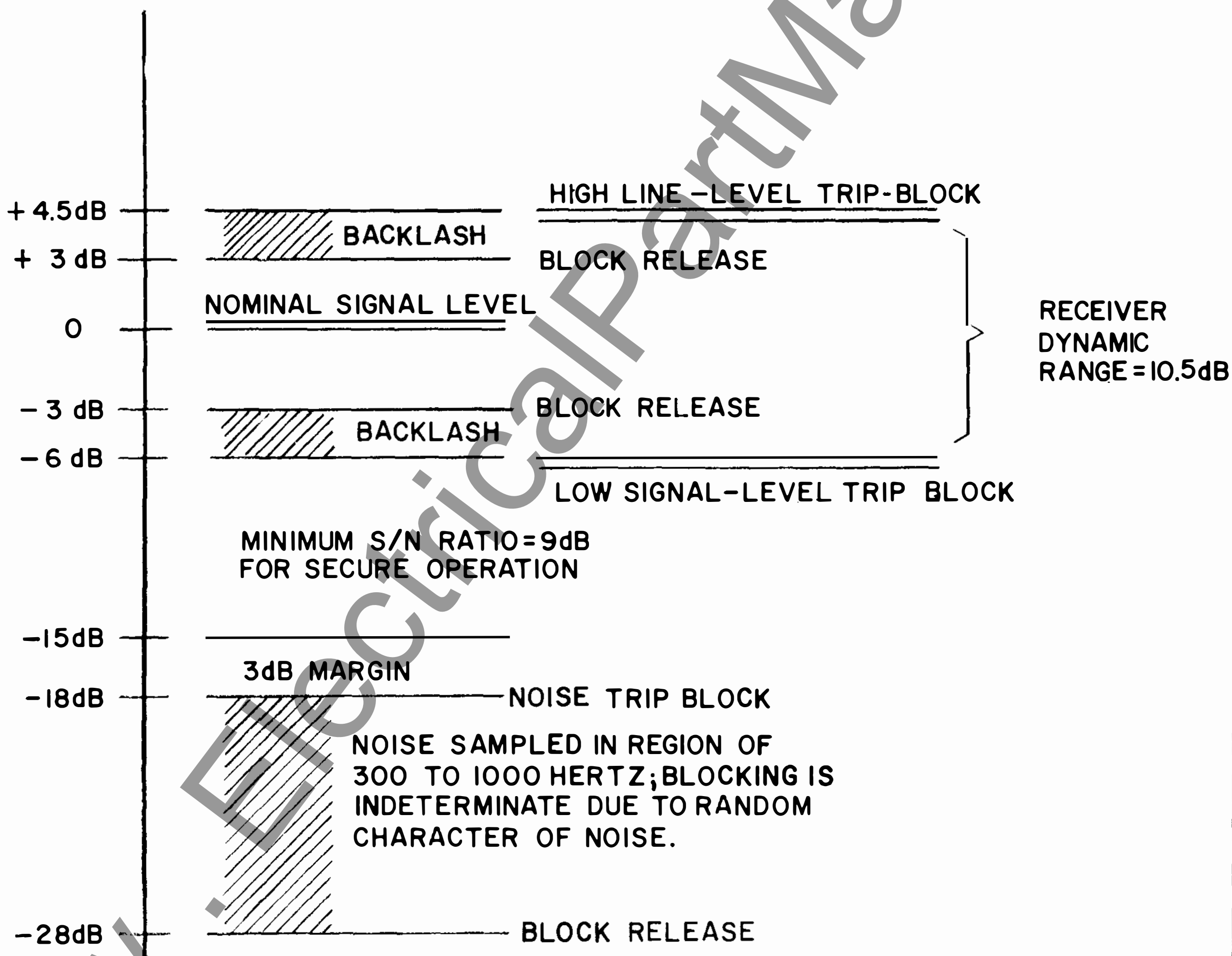


Fig. 25. Signal Supervisory Circuit Characteristics.

RECEIVER DYNAMIC OPERATING RANGE

MAXIMUM LEVEL OF A SINGLE OUT-OF-BAND TONE (ABOVE 1000 HZ) TO CAUSE A HIGH LINE TRIP BLOCK.

NUMBER OF CHANNELS	OUT-OF-BAND TONE LEVEL ABOVE NORMAL CHANNEL
1.	3.5 dB
2.	8.6 dB
3.	10.5 dB
4.	11.8 dB
5.	12.4 dB
6.	12.9 dB



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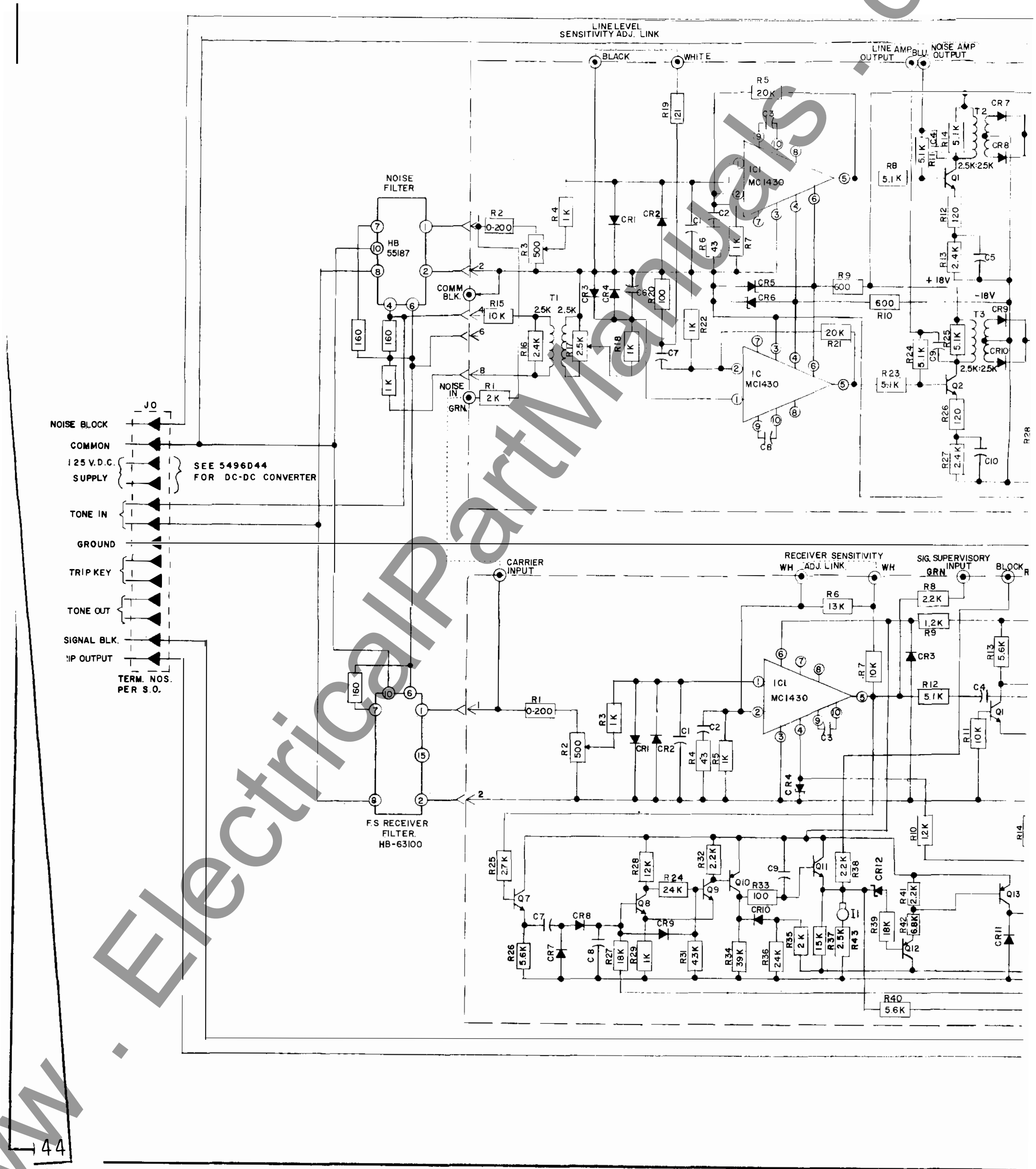
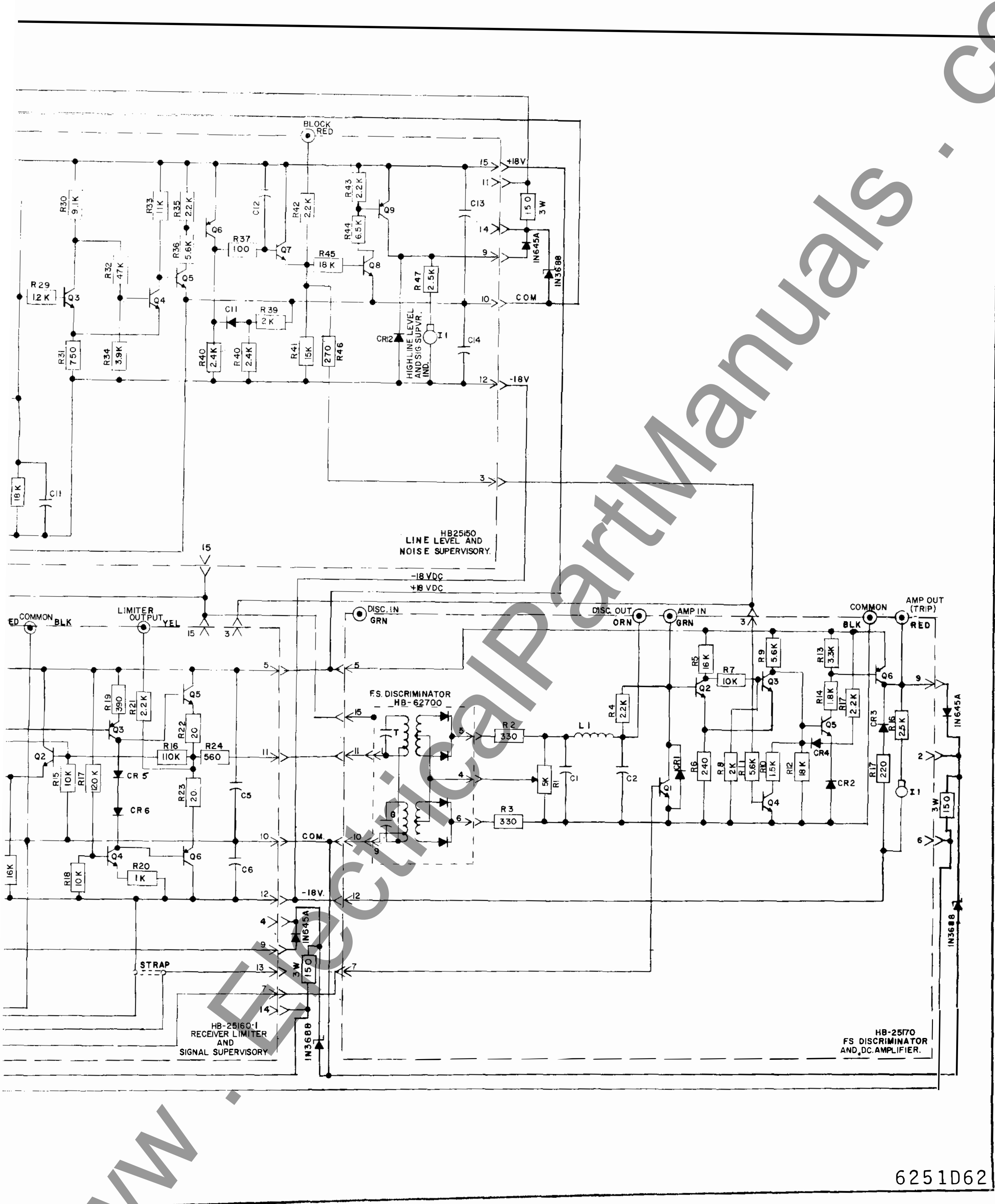
* *Fig. 26. Receiver Dynamic Operating Range.*



* *Fig. 28. TA-3 F.S. Receiver, Li*



ıe Level and Noise Supervisory-S.S. Output.

WESTINGHOUSE ELECTRIC CORPORATION

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

Printed in U.S.A.

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TA-2 FREQUENCY-SHIFT AUDIO TONES

CAUTION: It is recommended that the user of this equipment become acquainted with the information in this instruction leaflet before connecting the equipment in a relaying system. If the set is mounted in a cabinet, the cabinet must be bolted down to the floor or otherwise secured before swinging out the equipment rack to prevent its tripping over.

APPLICATION

The type TA-2 tones are of the high speed frequency shift type that are used in conjunction with a permissive relaying system. They are applied in the dual-phase comparison system for the protection of a transmission line.

The TA-2 tone channel is available in two bandwidths (340 Hz and 600 Hz). In order to provide a high speed tripping system the 600 Hz band-width tone should be used with dual phase comparison. The only application where the 600 Hz tone can not be used is when a three terminal power line is being protected using a two wire audio channel. In this case, the 340 Hz band-width tone must be used in order to provide the needed frequencies.

The TA-2 equipment may be used directly over a pilot wire pair or may be multiplexed on a microwave or other carrier channel. When using the 600 Hz band-width tones, the maximum channel delay (exclusive of TA-2 delay) that can be tolerated is 3.5 ms. For the 340 Hz band-width tones this maximum delay is 2 ms.

CONSTRUCTION

The type TA-2 tone system used plug-in modules to meet the requirements of a permissive relaying system.

In a typical relaying application, the tone system consists of a transmitter module, a beat frequency oscillator and demodulator module, two receiver modules, (a band pass filter and a frequency shift receiver), an optional AM receiver module for tone deterioration detection, and two noise modules (a band pass filter and an AM receiver module).

Basic construction is shown in Figure 1.

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 are the frequency determinimg components and are contained in a separate plug-in enclosure on the transmitter module.

Beat Frequency Oscillator And Demodulator Module

The beat frequency oscillator and demodulator module consists of an oscillator, a mixing circuit, and an amplifier. The tuned circuits for the beat frequency oscillator are contained in a sealed plug-in assembly The front panel provides controls for adjustment of the output level frequency, and includes test jacks for monitoring these adjustments.

Receiver Filter Module

This module is a band-pass filter which connects the demodulator to the receiver. The sum frequencies of the demodulator and the audio frequency carrier are selected to be passed by the filter.

Frequency Shift Receiver Module

The receiver module consists of a limiting amplifier, a specially tuned discriminator, rectifying and filter circuitry and two d-c amplifiers. A low signal squelch circuit is also included in this module.

AM Receiver Noise Squelch

This module consists of a three-stage amplifier, rectifying and filtering circuitry and an output d-c amplifier. This module is connected to a separate input filter module which is normally tuned for a pass band of 650 to 1050 Hertz.

SUPERSEDES I.L. 41-963.1
*Denotes change from superseded issue.

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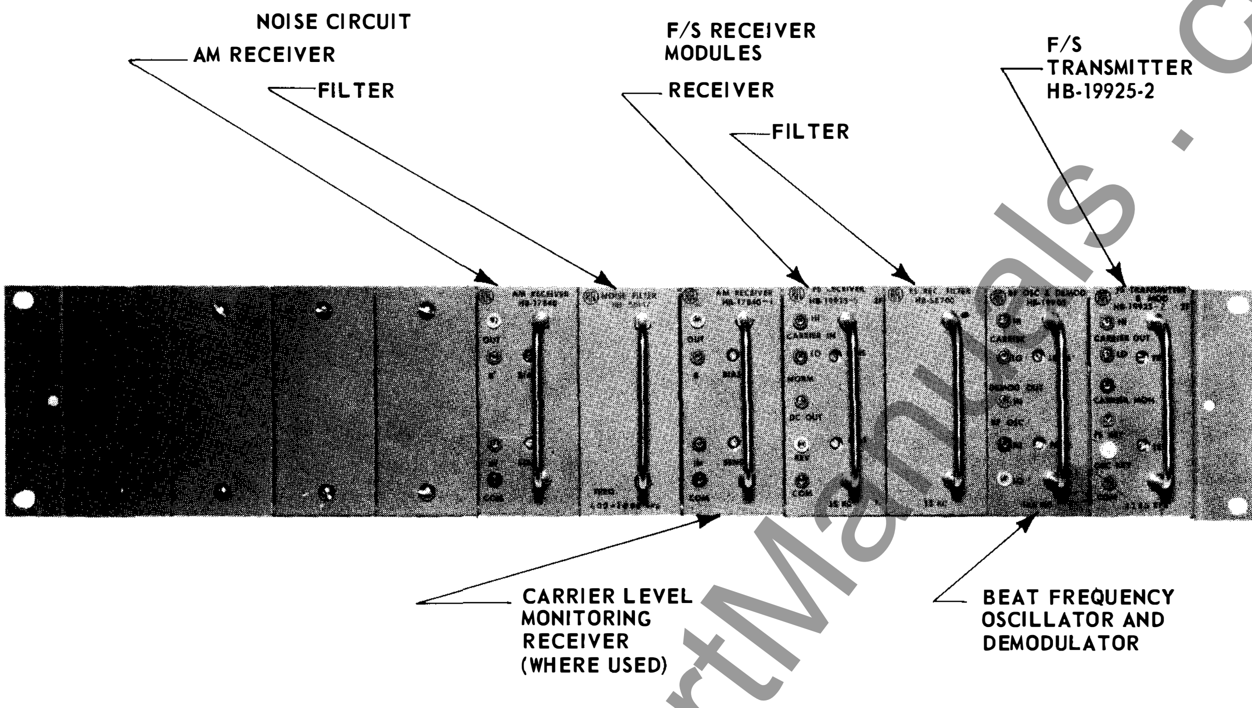


Fig. 1. Front View of Full Chassis.

OPERATION

As shown in Figure 2, the output of a high frequency oscillator in the TA-2 tone set is beat with the output of a lower frequency oscillator. The difference frequency or the translated frequency is applied through a band-pass filter to the pilot channel. By keying the transmitter with a voltage, the frequency is shifted from one frequency to a second frequency. At the receiving end of the channel, the incoming audio tone frequency is translated to the higher frequency of the transmitter and is applied to the FS receiver through a band-pass filter. The receiver converts the frequency to a d-c voltage which is applied to the relaying scheme.

In a dual phase comparison relaying system, the phase relationship of square wave pulses are compared to determine if a fault is internal or external to the protective transmission line — a pulse derived from the 60 Hertz current at one line terminal is compared in phase relationship to a pulse received from a remote line terminal. The transmitter is shifted in frequency at a rate equal to the power system frequency. On alternate half cycles, either a mark or space frequency is applied to the pilot channel and is received at the remote terminal. The receiver converts the mark and space frequencies to two d-c pulses which are applied to the dual phase comparison relay for comparing to local pulses at the remote terminal.

FS Transmitter – HB-19925-2

The oscillator shown schematically in Figure 3 is tuned to a high frequency relative to the audio tone channel frequency. The output of the oscillator is applied to a balanced modulator circuit which is driven by a beat-frequency oscillator tuned below this oscillator frequency to produce a difference frequency equal to that of the audio tone channel. Both sidebands thus generated are applied to an amplifier having a band-pass filter in the output circuit. The filter rejects the upper sideband and passes the lower sideband to the line. A shift in the frequency of the oscillator when keyed will produce the same amount of shift in cycles of the audio tone output.

The oscillator stage includes transistor Q1 and associated circuit components. The tuned circuit consists of inductance L_O and the Capacitor C_M, C_S and C_C are the frequency shifting capacitors.

Oscillations from the tuned circuit are coupled to the base of Q1 by capacitor C3. Feedback to the tuned circuit from the collector of Q1 is through resistor R3. The network consisting of C2, R6 and variable resistor R7 allows frequency adjustment by variation of the effective capacity of C2 across a portion of the tuned circuit.

The secondary winding on L_O is center-tapped and serves as a part of the balanced modulator which includes switching transistors Q3 and Q4. The bases of Q3 and Q4 are driven with the beat frequency voltage from a center-tapped winding on the BF Oscillator module. Both sidebands appear across the LEVEL control R10 from which they are coupled to the base of the output amplifier Q2. The band-pass filter in the collector circuit of Q2 rejects the upper sideband and passes the lower sideband to the line.

Capacitors C_C and C_S are strapped in parallel on the circuit board and clamped by Q5, forward biased at the emitter, across L_O to generate a Space frequency. A negative voltage applied to the base of Q5 through divider R17 and R18 will increase the collector-emitter impedance to effectively remove C_S and C_C from L_O. This will leave C_M only across L_O and the carrier frequency will shift to Mark.

BF Oscillator And Demodulator - HB-19905

Three functions are provided in this module.

1. A beat frequency voltage is generated.
2. The received audio tone signal is mixed with the output of the beat frequency oscillator in a balanced modulation circuit for frequency translation.
3. The received audio tone signal is amplified before translation to compensate for losses in the modulator circuit and impedance improving pads.

BF Oscillator

The BF oscillator stage includes transistor Q1 and a tuned LC circuit. Oscillations from the tuned circuit are coupled to the base of Q1 by capacitor C2. Feedback from the collector of Q1 to the tuned circuit is through resistor R1. An RC network consisting of C1, R2, and R3 is connected across a portion of the tuned circuit for frequency trimming purposes; R3 is variable and controls the effective capacity of C1.

Voltage from the tuned circuit is also coupled by capacitor C4 to the base of Q2 which operates as a Class A output amplifier. The tuned transformer in the collector circuit has a center-tapped secondary for applying the switching voltage to the bases of the modulator transistors Q3 and Q4.

Line Amplifier and Demodulator

The audio tone line amplifier consists of transformers T2 and T1, transistors Q5 and Q6 with associated components, a LEVEL control R20, and impedance improving pads R24 through R29. The audio tone signal to the amplifier is applied through a 3-db pad and line isolating transformer T2. The secondary winding of T2 is terminated with R21 and the LEVEL control which applies a base-to-base input signal to Q5 and Q6. Q5 and Q6 are biased to Class A operation. Q5 and Q6 are an emitter-coupled pair with a push-pull output transformer T1 in the collector circuit. The secondary winding of T1 is center-tapped to serve as part of the balanced demodulator circuit which includes switching transistors Q3 and Q4. The load on the secondary winding is a 3-db pad and the receiver band-pass filter. This load is in effect switched across each half of the secondary winding by alternate half cycles of the beat frequency voltage. Thus the amplified audio tone signal from T1 will appear across the load in modulated form as two sideband frequencies; the beat frequency oscillator frequency plus the audio tone frequency, and the beat frequency oscillator frequency minus the audio tone frequency, the beat frequency being suppressed to a low value by balanced modulator action. The lower sideband will be rejected by the receiver band-pass filter, and the upper sideband will be passed to the receiver.

FS Receiver – HB-19915-5

Limiter Amplifier

In the schematic diagram of Figure 3, the limiting amplifier consists of three direct coupled stages. The first stage is an emitter coupled pair of transistors, Q1 and Q2, as a differential amplifier which provides a push-pull signal to the second stage. The second stage includes an emitter-coupled pair, Q3 and Q4, to provide a single-ended output to the third stage Q5. A feedback network from the collector of Q5 to the inverting input of the first stage yields d-c and a-c stability to the amplifier. The signal from the band-pass filter and sensitivity control in parallel is applied to the non-inverting input which has a high impedance characteristic.

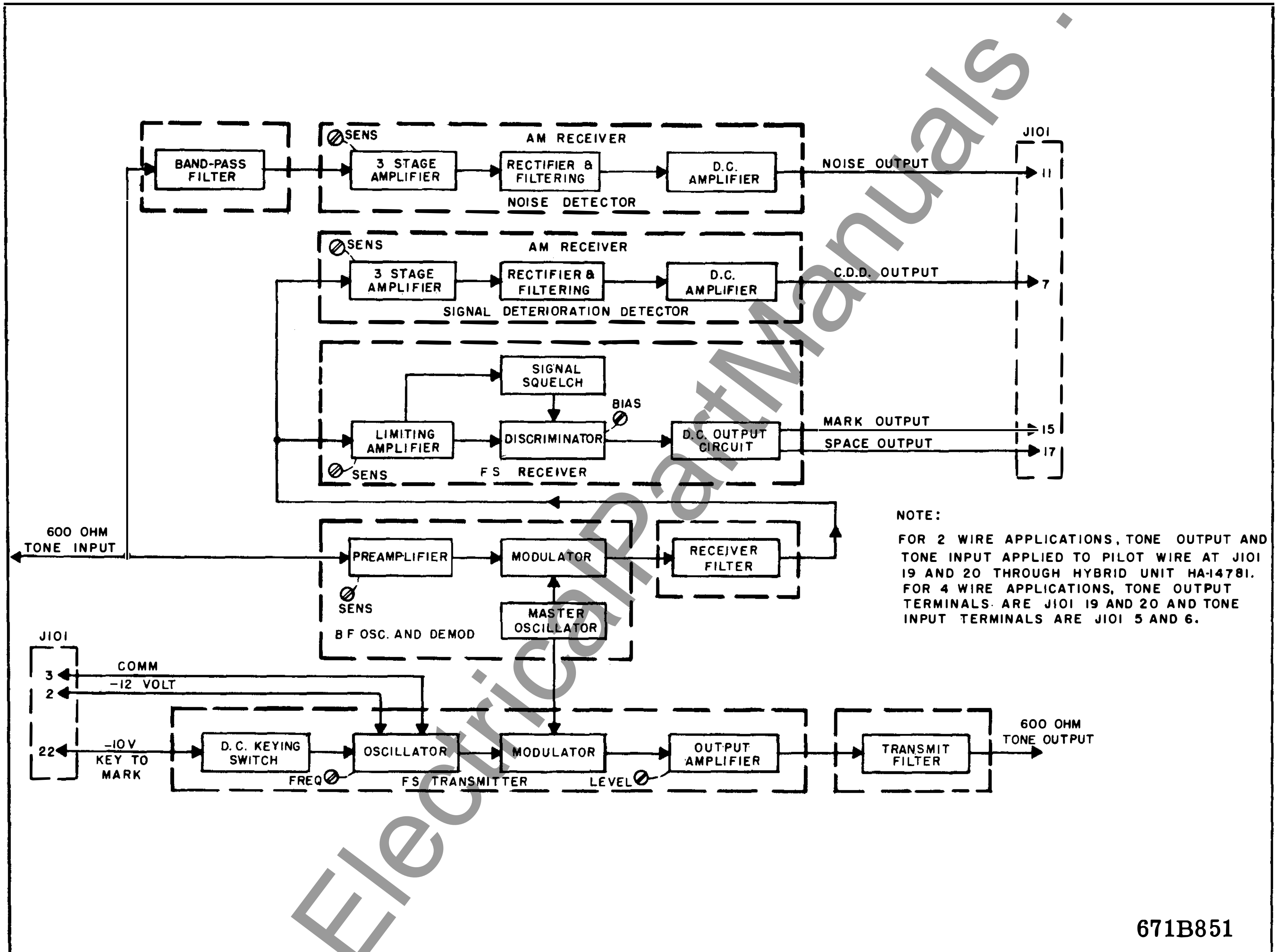


Fig. 2. Block Diagram of Type TA-2 Tone Assembly.

Discriminator

The output signal from Q5 is coupled to the base of Q8 by resistors R18 and R21 which also serve to provide a d-c bais voltage to Q8. With full limiting, Q8 is switched on and off at the translated frequency rate, allowing 40 MA peak pluses to energize the tuned discriminator in the collector circuit. The discriminator consists of two parallel tuned circuits resonant at Mark and Space respectively. A secondary winding on each tuned circuit yields a d-c output by means of full wave rectifier diodes. The d-c outputs are connected in series aiding and applied across series resistors R23, R25 and R24, the combination in effect being a bridge circuit. Output from the bridge is taken between the center arm of the BIAS control R25 and the center connections of the secondary windings. As the discriminator is energized with alternate Mark and Space signals, the output will be approximately ± 1.5 volts, and zero volts in the absence of the translated tone signal. C7, L1 and C8 filter the translated tone component from the discriminator output which is applied to the output d-c amplifier.

Low Signal Squelch Circuit

A squelch circuit on the discriminator is provided by Q6, C7 and associated components. In the absence of a carrier signal, Q7 is clamped by a forward base bias through R20; this shunts the base of Q8 the discriminator driver. When the signal from the limiter amplifier is coupled to the rectifier diodes CR1 and CR2 by the emitter follower Q6 a reverse bias voltage is applied through R19 to the base of Q7, causing Q7 to unclamp. The carrier output from Q5 can then drive Q8 to energize the discriminator. The circuit is designed so that the carrier must reach a level high enough to yield a receiver output with very little distortion before Q7 unclamps the permits the discriminator to drive the output d-c amplifier. Hence when the receiver carrier falls below this level, the discriminator is squelched and receiver output signals cease. This threshold level is determined by the settine of the SENSITIVITY control R2. The value of capacitor C5 determines the speed of operation of the squelching action. Charging is less rapid than discharge in this circuit. As C5 becomes larger, the unclamping action of Q7 is delayed while the clamping time is not increased appreciably. Thus the turn-on time of the receiver can be delayed to make the circuit less vulnerable to noise when the carrier falls below a predetermined level setting of the SENSITIVITY control. The band-width, carrier frequency and level of a channel are also determining factors in the speed of operation of the squelch circuit.

Output D-C Amplifier

In the d-c amplifier the output transistors Q14 and Q13 provide push-pull output. They are driven by a two-stage push-pull regenerative circuit consisting of Q10, Q9, Q12 and Q11. The regenerative circuit is monostable due to the unequal resistances in the emitter circuits of Q10 and Q9; Q10 on- Q12 off, and Q9 off-Q11 on. Thus in the absence of discriminator output Q14 is saturated and Q13 is cut off. A Mark signal from the discriminator will maintain the above condition. A Space signal from the discriminator will reverse the conducting states, and Q13 will be saturated while Q14 is cut off. The trigger type of switching action due to regeneration yields fast rise and fall time to the output pulses.

AM Noise Receiver – HB-17840-1

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

The receiver sensitivity control R1 (see Figure 3) is connected across the output of the filter. 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 d-c 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 acts 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 input Q4 is biased to cut-off by means of the voltage divider R19 and R22 and no collector current flows. 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.

Carrier Deterioration Detector – HB-17840-10

This is an AM receiver similar to the AM Noise Receiver with the exception of the output circuit. Q4 is removed and the output of the receiver is across two diodes. The output is used to drive a microammeter to determine the signal level of the remote transmitter. It is connected to the output of the wide-band filter of the FS receiver.

CHARACTERISTICS

General

Audio Tone Center Frequencies (Hz):	340 Hz Band-width – 1500, 2700 170 Hz Band-width – 1500, 2180, and 2860
Shift in Frequency:	±300 Hz (600 Hz Band-width) or ±170 Hz (340 Hz Band-width)
Frequency BF Oscillator:	13.5 kHz
Transmitter Center Frequencies:	15 kHz For 1500 Hz Tone Channel 15.68 kHz For 2180 Hz Tone Channel 16.2 kHz For 2700 Hz Tone Channel 16.36 kHz For 2860 Hz Tone Channel
Operating Temperature:	-10° to +60°C
Storage Temperature:	-60°C to +75°C
Operating Time:	Two terminal line 2 to 2.5 MS Three terminal line 3.5 to 4 MS
Energy Requirements:	110 milliamperes at 12 volts d-c

FS Transmitter – HB-19925-2

Output Level:	Adjustable from -30 dbm to +2 dbm
Output Impedances:	600 ohms nominal, isolated and balanced
Output Stability:	±1.5 db from -10°C to +60°C
Frequency Stability:	±.25% to +1.5%
Keying Input:	-10 volts

FS Receiver – HB-19915-2

Sensitivity:	Adjustable from -40 dbm to +6 dbm
Input Impedance:	Band-pass filter, 600 ohms nominal
Squelch Circuit:	D-C output assumes a mark-hold condition when level falls to the sensitivity setting of receiver.
D-C Output:	Push-pull, -10 volt pulses at 5 to 40 MA. Rise and fall times each less than 5 microseconds.

INSTALLATION

The tone assemblies should be mounted on relay racks or in suitable cabinets. The mounting location should be free from dirt, moisture, excessive vibration as well as heat. All electrical connections are made to a connector terminal on the rear of the chassis.

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.

If zero dbm is the maximum allowance level, a single tone transmitter will be set to that level (0.775 volt into 600 ohms).

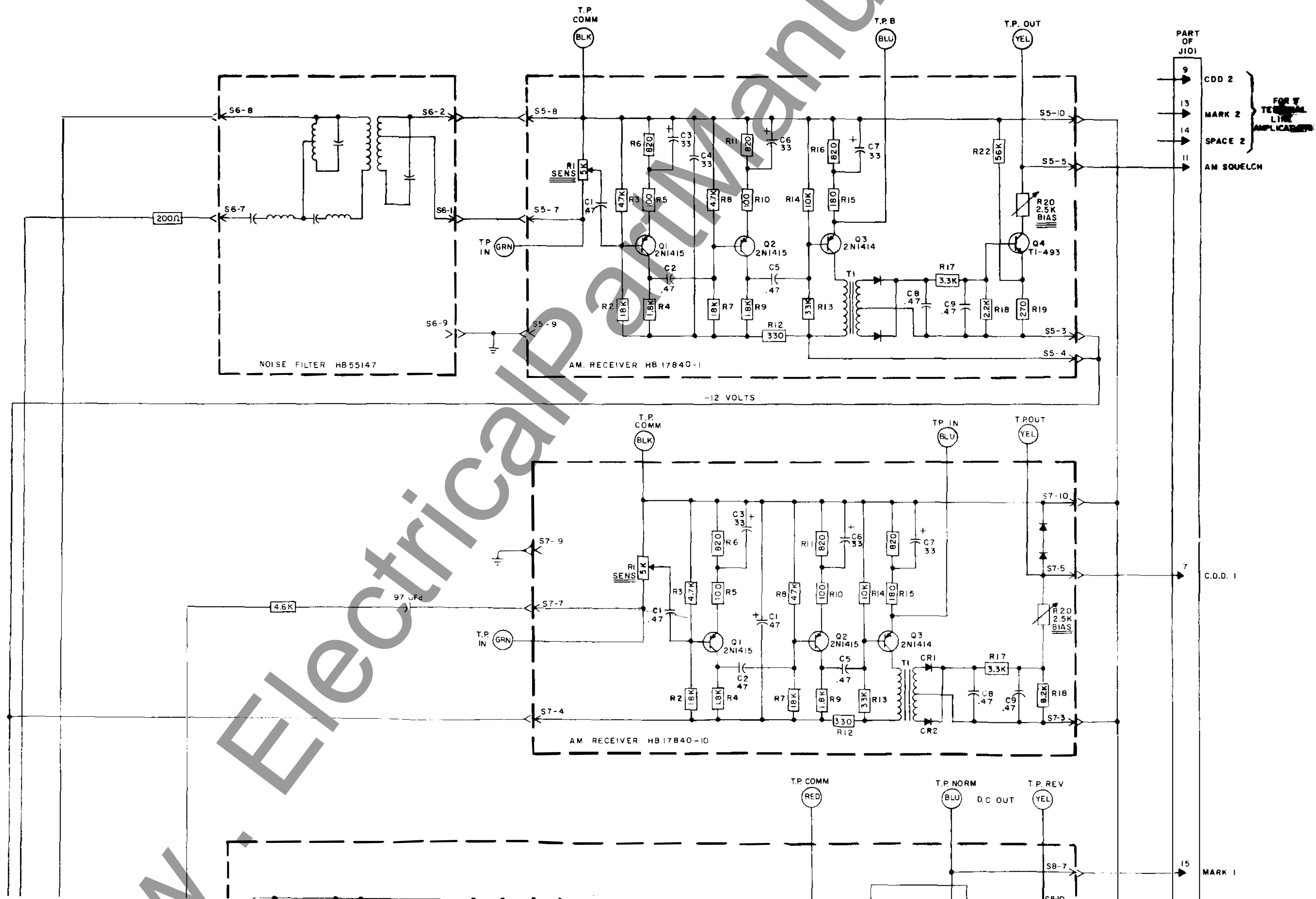
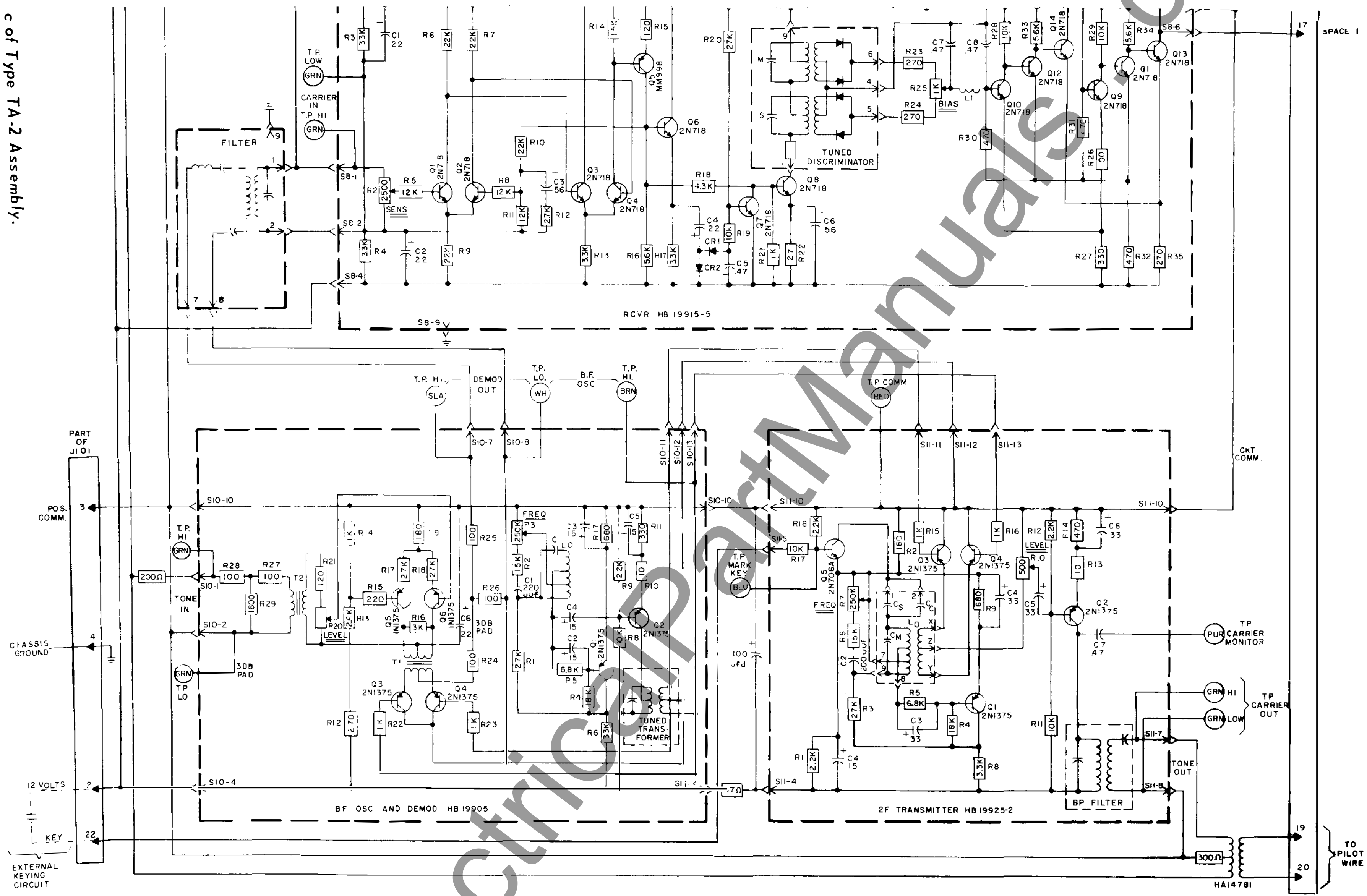


Fig. 3. Internal Schemati

c of Type TA-2 Assembly.



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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 a-c vacuum-tube voltmeter. The level control is then adjusted for the desired output. After the transmitter is adjusted properly, 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.

Demodulator – Level Control

After the remote transmitter has been adjusted, pull out the local transmitter. Check the received signal at top two terminals of the beat frequency oscillator and demodulator module (H1, Lo). Pull out the local F/S receiver filter and connect a 600-ohm load across demodulator out and Lo (white) terminals. Connect a VTVM across the 600-ohm load, and adjust the level control for 3-dbm above the received signal.

FS Receiver

Plug a d-c voltmeter (at least 20 volt range) into TP norm. and TP comm. of receiver. (The tone transmitters must be previously set to their desired output levels.) Connect a VTVM across the tone receiver input terminals (TP Lo and TP Hi) 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 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 increases suddenly from zero to approximately -12 volts, at this point the squelch has operated to clamp the receiver in a mark state. When the attenuator is removed from the circuit, the tone receiver will have a normal operating point 12 db above the pickup signal level.

AM Receiver Noise Squelch (Where Used)

The AM squelch receiver is set in the factory such that an output is obtained across TP out and TP comm. when the noise measured in the 650–1050 band exceeds the FS receiver setting by 5 db (e.g. if frequency shift receiver sensitivity at -32 dbm, AM receiver sensitivity at -27 dbm).

Carrier Level Monitor (When Used)

The following procedure is to be used when an AM receiver is utilized in conjunction with a Weston Model 1092 meter relay to detect a partial deterioration of the tone signal. Since the meter is also calibrated with the AM receiver, these instructions only apply when the meter is used.

a. On AM receiver, set bias control fully counter-clockwise position.

b. Set potentiometer in series with meter to fully counter-clockwise position. (zero resistance)

c. Pull AM receiver module from circuit and adjust zero of meter such that the contacts just close.

d. Push in AM receiver and adjust sensitivity control such that meter is at full-scale deflection with normal received signal. Adjust zero adjustment of meter such that the contacts just close with the normal received signal.

e. Lower incoming signal by 10 db, and adjust sensitivity control of AM receiver such that the meter contacts just make. The meter is now calibrated for a 10 db deterioration of signal.

f. For deterioration levels greater than 10 db, lower the incoming signal to the desired value and adjust the series potentiometer until the meter contacts just make.

ADJUSTMENTS AND MAINTENANCE

(In service procedure to be used in conjunction with SKBU Relay)

1. Beat Frequency Oscillator – frequency control

Check the frequency at bottom two terminals of the BF oscillator and demodulator module (H1, Lo.) Readjust frequency if required to nameplate marking.

2. Transmitter – level and frequency control

a. Check output of transmitter at terminals of channel equipment. Adjust level control for the desired output.

b. Check mark and space frequencies at green terminals of F/S transmitter (Hi, Lo). (To key transmitter to mark jumper keying lead on J101 to -12 vdc; See Fig. 3.) Readjust transmitter frequency if required so that the space and mark frequencies are approximately correct.

3. Demodulator – level control

After remote transmitter has been adjusted, pull out local transmitter. Check the received signal at top two terminals (Hi, Lo). Pull out the local F/S receiver filter and connect a 600-ohm load across the demodulator out and Lo (white) terminals. With a VTVM across the 600-ohm load, adjust the level control for 3-dbm above received signal.

4. Frequency Shift Receiver – sensitivity and bias control

a. Reduce incoming space signal by 12-dbm and adjust sensitivity control until the receiver is clamped in a mark state. (-12 vdc between "Comm." T.P. and "Norm." T.P. on the receiver module, with mark and space outputs connected to the relaying system.)

b. Apply sufficient a-c current by using remote terminal functional test panel to pickup the remote fault detector of the SKBU–2 or SKBU –21. With oscilloscope across "Comm." T.P. and "Norm." T.P. on the receiver module, adjust bias control of tone set for pulses of approximately 8 milliseconds.

5. Carrier Level Monitor Circuit

a. On AM receiver, set bias control fully counter-clockwise position.

b. Set potentiometer in series with meter to full counter-clockwise position. (zero resistance)

c. Pull AM reciever module from circuit and adjust zero of meter such that the contacts just close.

d. Push in AM receiver and adjust sensitivity control such that meter is at full-scale deflection with normal received signal. Adjust zero adjustment of meter such that the contacts just close with the normal received signal.

e. Lower incoming signal by 10 db, and adjust sensitivity control of AM receiver such that the meter contacts just make. The meter is now calibrated for a 10 db deterioration of signal.

f. For deterioration levels greater than 10 db, lower the incoming signal to the desired value and adjust the series potentiometer until the meter contacts just make.

6. AM Noise Circuit – sensitivity control

a. Set bias control fully counter-clockwise.

b. Pull local and remote transmitters.

c. Apply a 800-cycle signal to channel from external oscillator, and connect d-c voltmeter across "Comm. and T.P. "Out" on A.M. Noise Receiver.

d. Adjust sensitivity control of AM receiver until the d-c voltmeter reads about -10 volts when the 800-cycle signal is set at the desired level.

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. 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.

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.

TABLE OF REPLACEABLE PARTS

DIAGRAM SYMBOL	DESCRIPTION	PART NUMBER
	FS TRANSMITTER HB-19925-2	
R1-R22	RESISTOR, fixed comp., see Note 5, Fig. 1 and 2.	
R7	RESISTOR, variable, 250K, 0.1 watt, BD taper. CTS Corp., type PE 200.	HA-14594
R10	RESISTOR, variable, 500 ohms, 0.125 watt, DB taper. CTS Corp., type PE2000.	HA-13573
C1	CAPACITOR, tantalum, 15 uf ± 20%, 25V, Mallory TAM156M025P5C	H-1007-439
C3,C4,C5,C6	CAPACITOR, tantalum, 33 uf ± 20%, 10V, Mallory TAM336M010P5C.	H-1007-438
C2	CAPACITOR, mica, see Note 4, Fig. 1 and 2 Elmenco Type DM20.	H-1080-X
C7	CAPACITOR, ceramic, 0.47 uf + 80%, -20%, 25V, Sprague 5C11A.	HA-13579
Q1,Q2,Q3,Q4	TRANSISTOR, germanium, PNP, Texas Inst. 2N1375	HA-17117
Q5,Q6,Q7	TRANSISTOR, silicon, NPN, Texas Inst., 2N706A.	HA-19928
	BP Filter and Osc. Assy. HB-19925 FS Transmitter and Mod.	HB-58200
	Test Jacks, Sealectro Corp., SKT-10.	
	Filter Cable connector, 3-terminal socket, Eby Sales Co.	HA-21091
	BF OSCILLATOR AND DEMODULATOR HA-19905	
R1-R29	RESISTOR, fixed comp. See Note 6, Fig. 1	
R3	RESISTOR, variable, 250K, 0.1 watt, BD taper. CTS Corp., type PE200.	HA-14594
R20	RESISTOR, variable, 500 ohms ± 20%, 125 watt, BD taper. CTS Corp., type PE200.	HA-13573
C1	CAPACITOR, mica, see Note 5, Fig. 1.	H-1080-*
C2,C3,C4,C5	CAPACITOR, tantalum, 15 uf ± 20%, 25V. Mallory, TAM156M025P5C.	H-1007-439
C6	CAPACITOR, tantalum, 22 uf ± 20%, 15V. Mallory, TAM226M015P5C	H-1007-494
T1	TRANSFORMER, modulation, 4000 C.T./2400 C.T.	HB-18936
T2	TRANSFORMER, input, 600/600. Microtran, MT1FB.	HA-14791
Q1-Q6	TRANSFORMER, germanium, PNP. Texas Inst., 2N1375.	HA-17117
	BF Oscillator and unted Transformer assembly, plug in	HA-58600
	Test Jacks, Sealectro Corp., SKT10.	

TABLE OF REPLACEABLE PARTS (Cont.)

DIAGRAM SYMBOL	DESCRIPTION	PART NUMBER
	FS RECEIVER	
R1-R35	RESISTOR, fixed comp. See Note 7, Fig. 1	
R2	RESISTOR, variable, 2.8K ± 20%, 0.12 watt, AC taper. CTS Corp., type PE200.	HA-23742
R25	RESISTOR, variable, 1K ± 20%, 0.25 watt, linear taper. CTS Corp., type PE200.	HA-14593
C1,C2,C4	CAPACITOR, tantalum, 22 uf ± 20%, 15V. Mallory, TAM226M015P5C.	H-1007-494
C3, C6	CAPACITOR, tantalum, 56 uf ± 20%, 6V. Mallory, TAM566M006P5C	H-1007-495
C5,C7,C8	CAPACITOR, tantalum, 0.47 uf ± 10%, 35V. Texas Inst,. SCM474FP035D2. See Note 6, Fig. 1	H-1007-511
L1	CHOKE, See Note 6, Fig. 1.	HA-23703
CR1,CR2	DIODE, silicon, 200 PIV., 250 MA. Diode, Inc., DI42.	HA-17197
Q1–Q4, Q6–Q14	TRANSISTOR, silicon, NPN. Texas Inst., 2N118	HA-19938
Q5	TRANSISTOR, silicon, PNP. Motorola, MM998.	HA-19751
	DISCRIMINATOR ASSEMBLY, plug-in	HB-58400
	BAND-PASS FILTER module, Channels below 4000 cps.	HB-58300
	TEST JACKS, Sealectro Corp., SKT-10.	
	AM RECEIVER	
R2-R19, R22	RESISTOR, fixed comp.: All ± 10%, ½ watt, values as shown in Fig.2 Int. Res. Corp. #GBT-½	H-1009-X
R1	RESISTOR, variable: comp., 5K, .25W, "AC" Taper CTS #PE200.	HA-13572
R20	RESISTOR, variable: comp., 2.5K, .25W, "D" Taper CTS #PE200.	HA-13588
C1,C2,C5, C8,C9	CAPACITOR, tantalum: .47 uf, ± 20%, 35V, Tex. Instr. #SCM474FP035A4.	H-1007-433
C3, C6,C7	CAPACITOR, tantalum: 33 uf,± 20%, 10V., Mallory #TAM336M010P5C.	H-1107-438
C4	CAPACITOR, tantalum: 22 uf, ± 20%, 15V., Mallory #TAM226M015P5C.	H-1107-494
Q1,Q2	TRANSISTOR, PNP: 2N415. G.E. #1415.	HA-21519
Q3	TRANSISTOR, PNP: 2N1414. G.E. #1414.	HA-21514
Q4	TRANSISTOR, NPN: T1493. . Tex. Instr. #T1493	HA-17113
	Jack, Pin: various colors. Sealectro #SKT-10.	
T1	TRANSFORMER: 2000 CT/8000 CT, 150 MW. Berkshire #BTC 5080.	HA-3175
CR1,CR2	DIODE silicon: 200 PIV, 250 MA. Diodes, Inc., #DI42.	HA-17197

WESTINGHOUSE ELECTRIC CORPORATION

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

Printed in U.S.A.

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

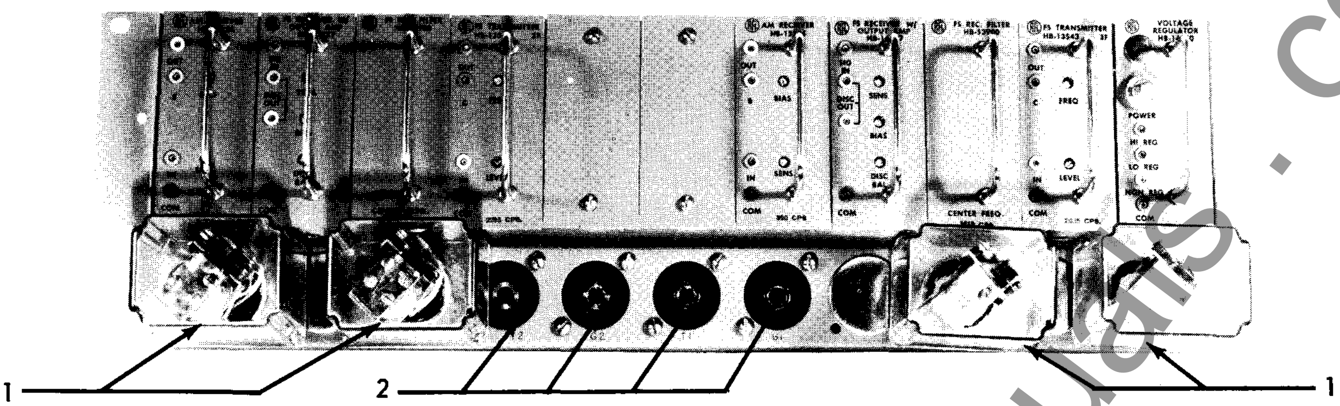


Fig. 1 – Front View of Full Chassis: 1–Telephone Type output relays (when used); 2–Current monitoring jacks (when used).

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 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

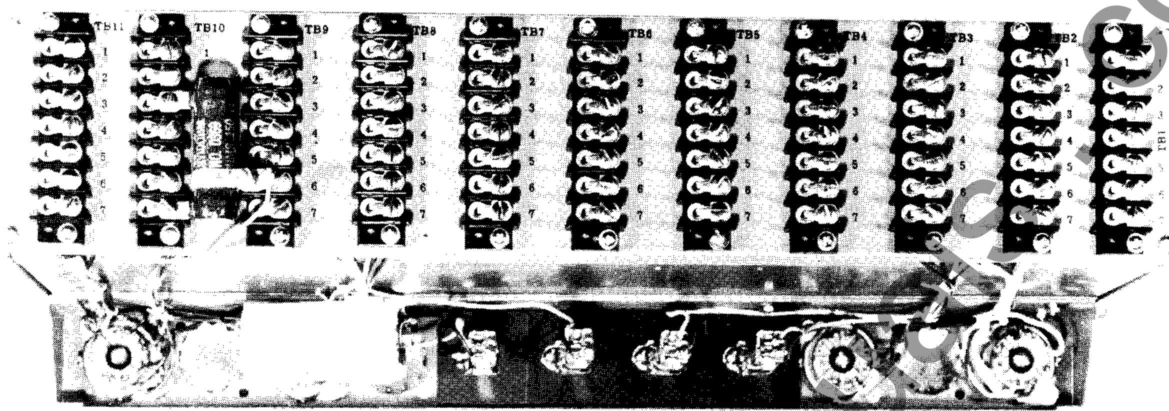


Fig. 2 — Rear View of Full Chassis

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.

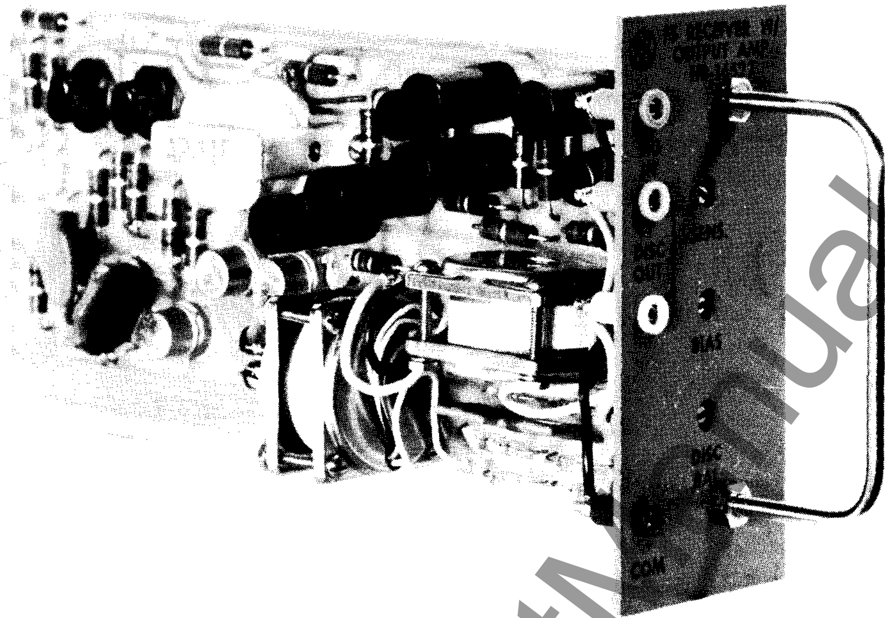


Fig. 3 — Typical Module

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 opperates 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)

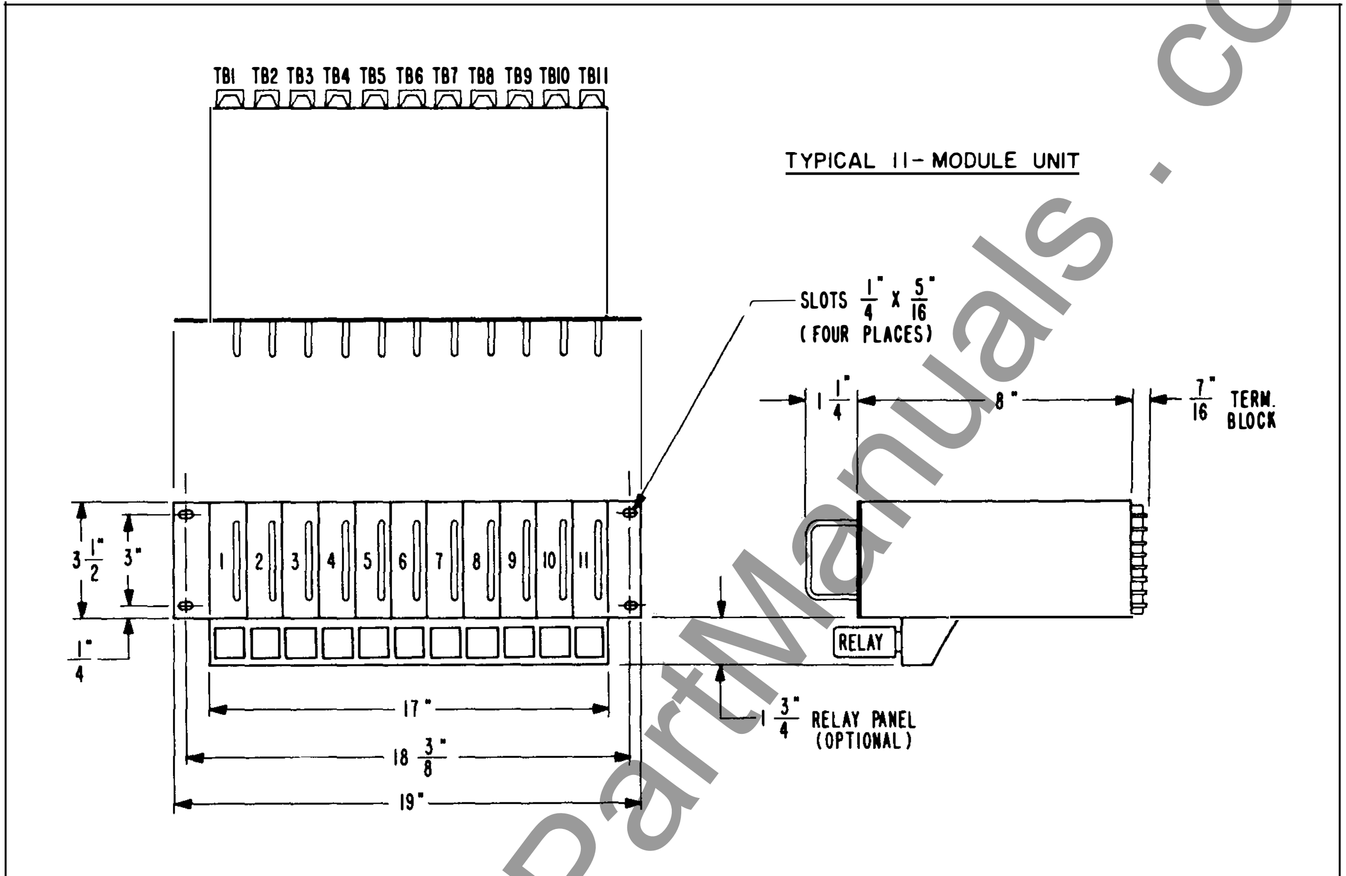


Fig. 4 — Outline and Drilling Plan of 11 Module Chassis

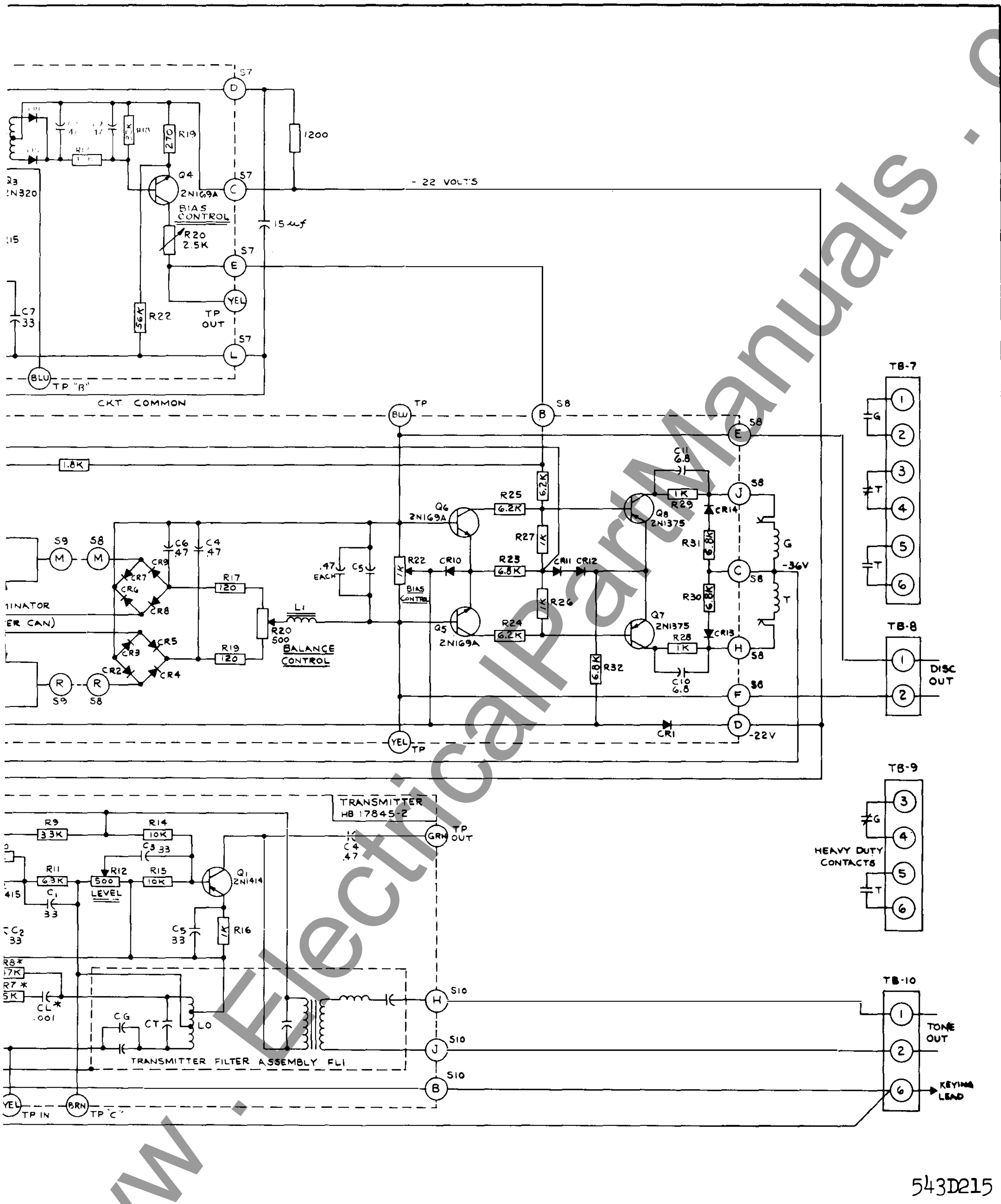
The input of the receiver is designed to reject adjacent channel tones by at least 40 db. The sharply sloping skirts of the filter also aid in preventing noise frequencies, just above the trip frequency, from causing false trip relay operation.

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.



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 super-
* impose 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.

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.

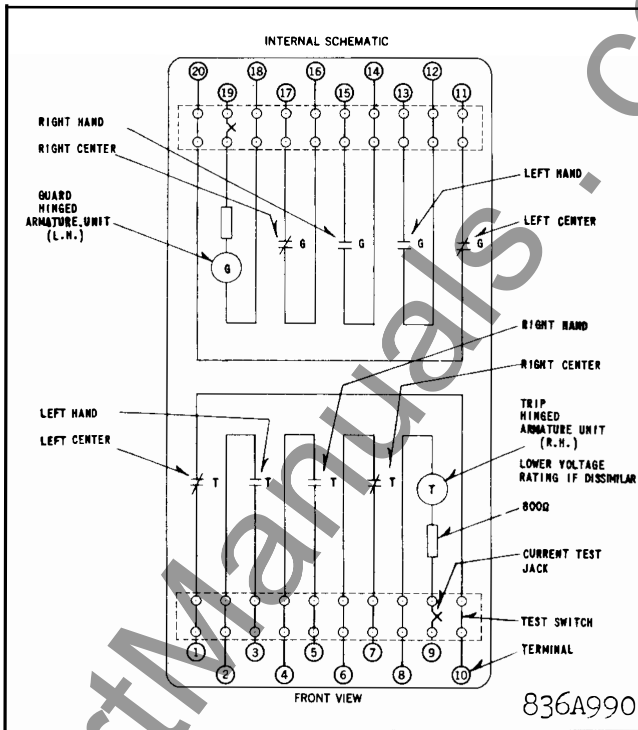


Fig. 10 Internal schematic of the type AR relay for use with TA-1 tones.

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.

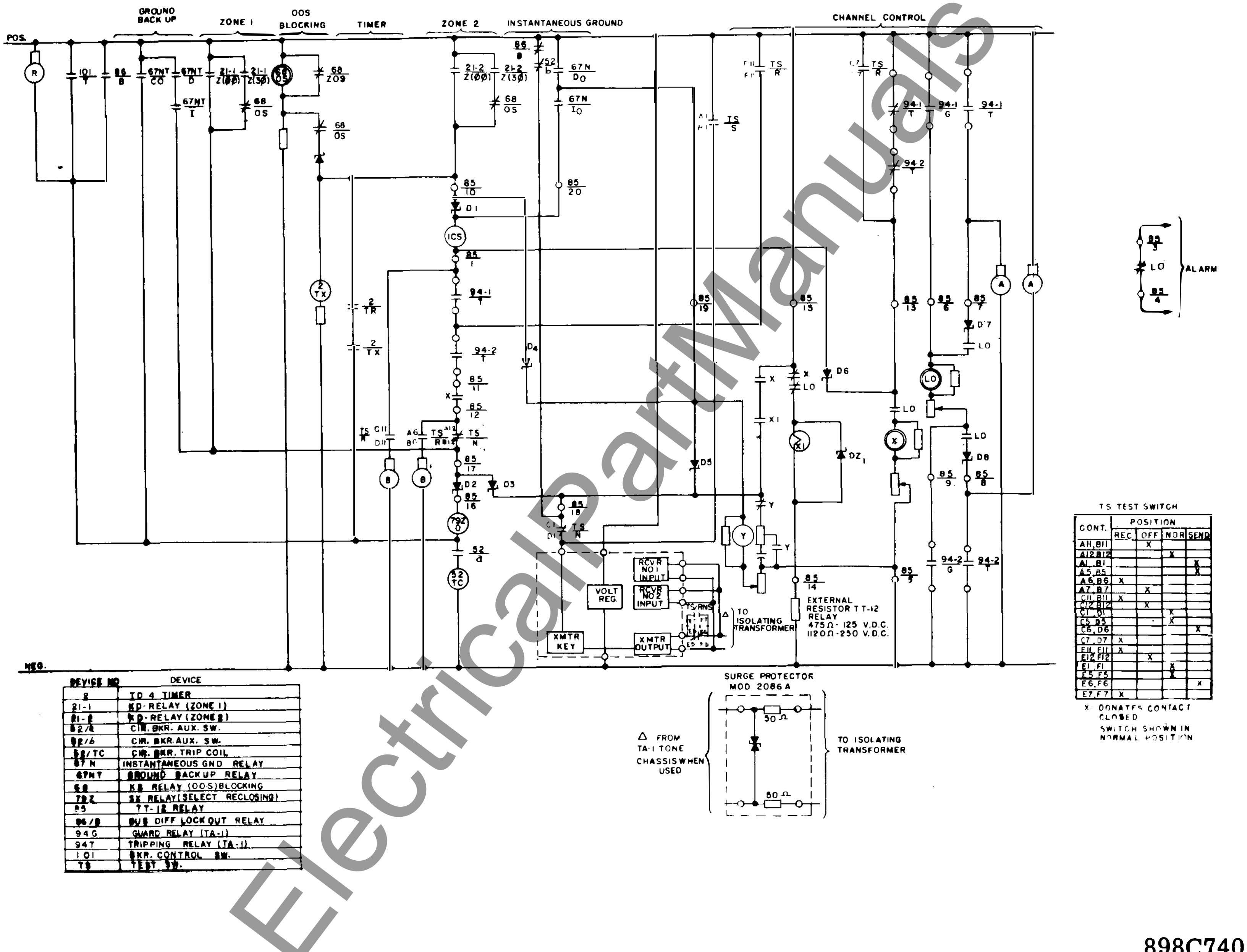
Replaceable parts are shown in Table 2.

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 AC	Q1 VOLTS DC	Q2 VOLTS AC	Q2 VOLTS DC	Q3 VOLTS AC	Q3 VOLTS DC	Q4 VOLTS AC	Q4 VOLTS DC	Q5 VOLTS AC	Q5 VOLTS DC	Q6 VOLTS AC	Q6 VOLTS DC	Q7 VOLTS AC	Q7 VOLTS DC	Q8 VOLTS AC	Q8 VOLTS DC	TEST POINTS	
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.



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 COIL
67 N	INSTANTANEOUS GND RELAY
67NT	GROUND BACKUP RELAY
68	KS RELAY (OOS) BLOCKING
79Z	SX RELAY (SELECT RECLOSING)
85	TT-12 RELAY
86/B	BUS DIFF LOCKOUT RELAY
94G	GUARD RELAY (TA-1)
94T	TRIPPING RELAY (TA-1)
101	BKR. CONTROL SW.
TS	TEST SW.

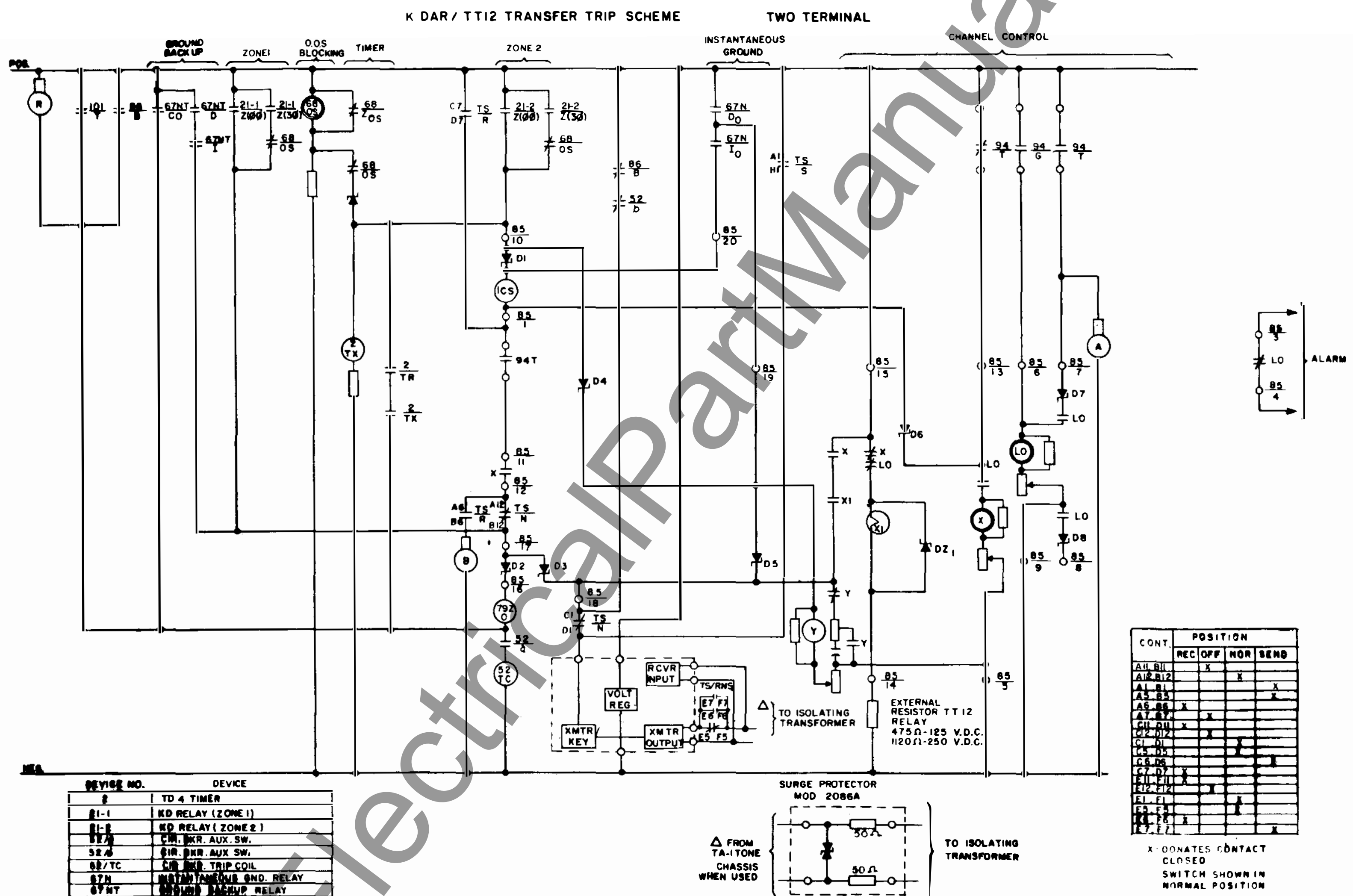
TS TEST SWITCH

CONT.	POSITION			
	REC.	OFF	NOR	SEND
A11, B11		X		
A12, B12			X	
A1, B1				X
A5, B5				X
A6, B6	X			
A7, B7		X		
C11, B11	X			
C12, B12		X		
C1, D1			X	
C5, D5			X	
C6, D6				X
C7, D7	X			
E11, F11	X			
E12, F12		X		
E1, F1			X	
E5, F5			X	
E6, F6				X
E7, F7	X			

X: DONATES CONTACT CLOSED

SWITCH SHOWN IN NORMAL POSITION

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



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 COIL
67N	INSTANTANEOUS GND. RELAY
67NT	GROUND BACKUP RELAY
68	RS RELAY (O.O.S.) BLOCKING
79Z	SX RELAY (SELECT RECLOSING)
85	TT-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

CONT.	POSITION			
	REC	OFF	NOR	SEND
A11 B11		X		
A12 B12			X	
A1 B1				X
A5 B5				X
A6 B6	X			
A7 B7		X		
C11 D11	X			
C12 D12		X		
C1 D1			X	
C5 D5			X	
C6 D6				X
C7 D7	X			
E11 F11	X			
E12 F12		X		
E1 F1			X	
E5 F5			X	
E6 F6	X			
E7 F7				X

X - DONATES CONTACT CLOSED
SWITCH SHOWN IN NORMAL POSITION

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

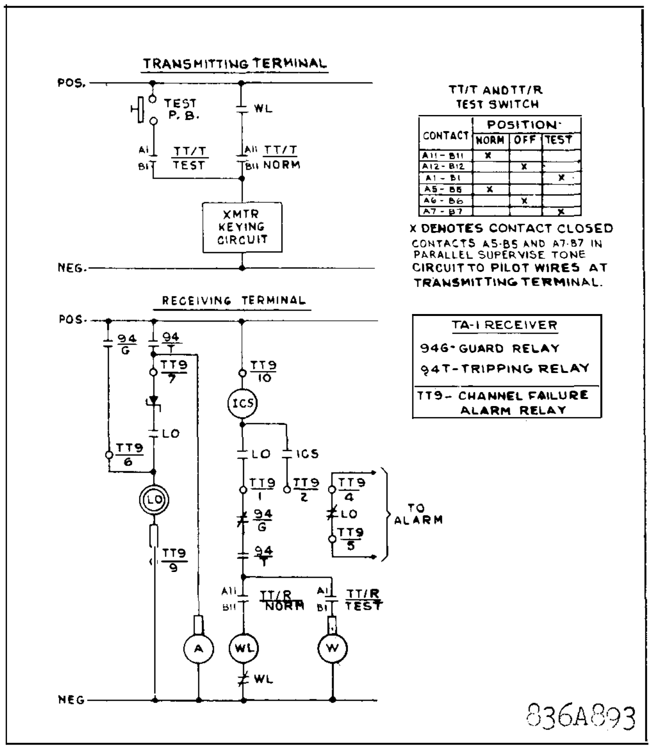


Fig. 13 Transformer Protection – Single Channel Transfer Trip.

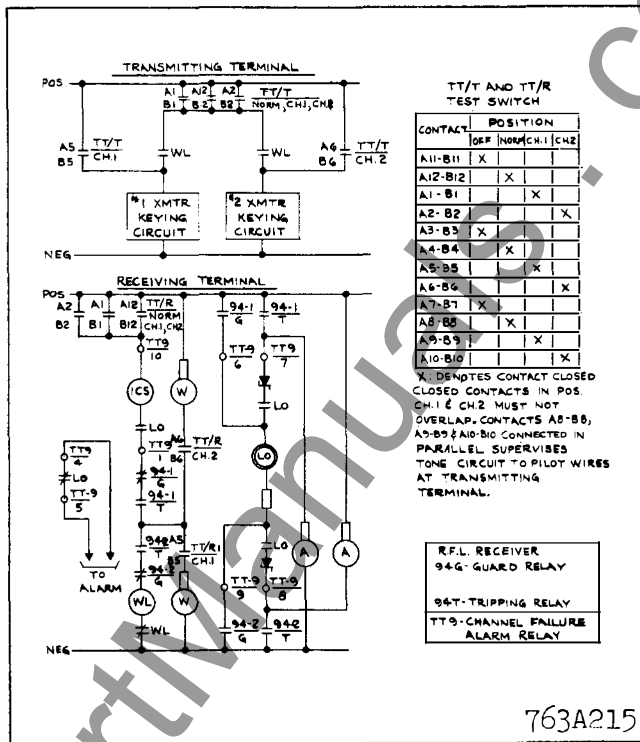
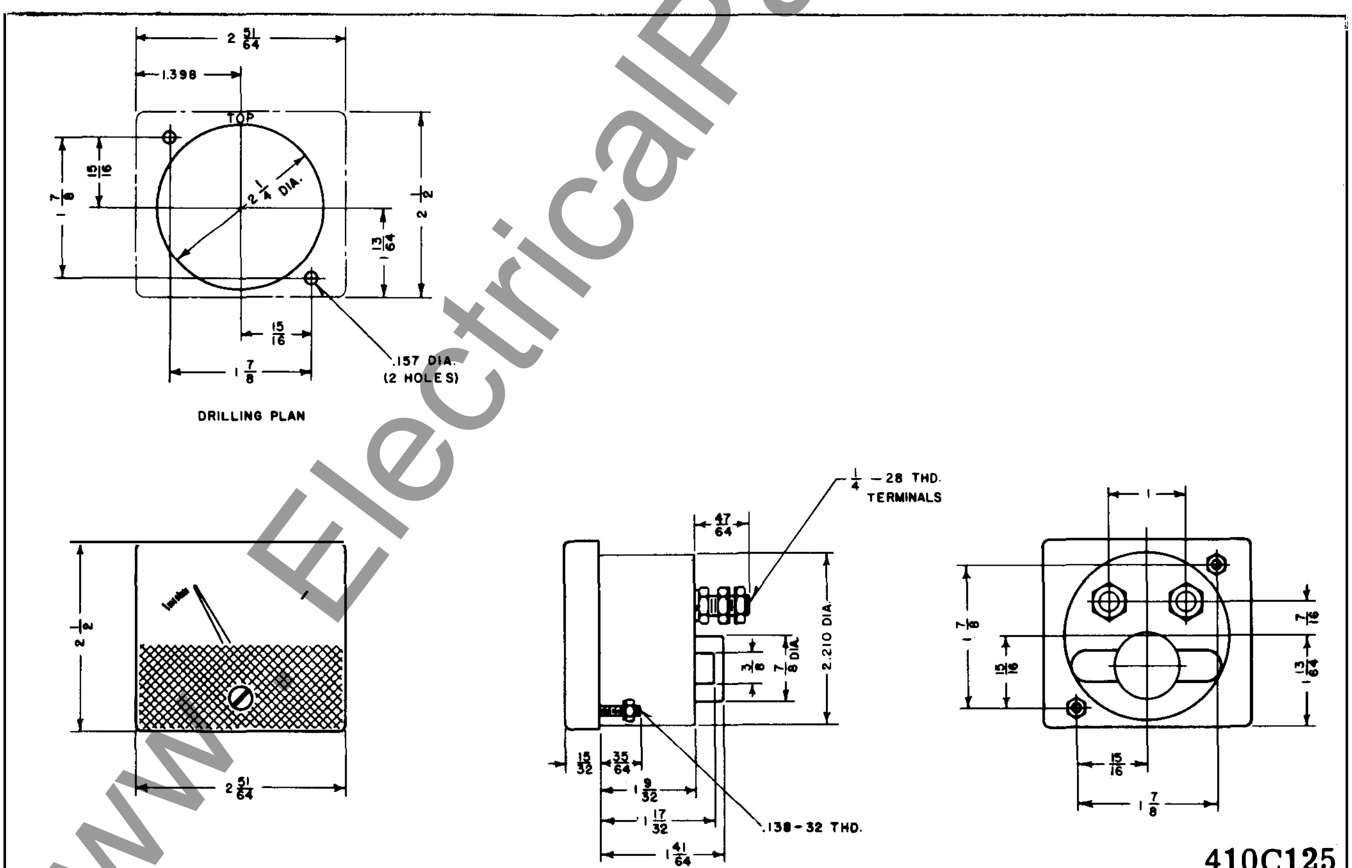
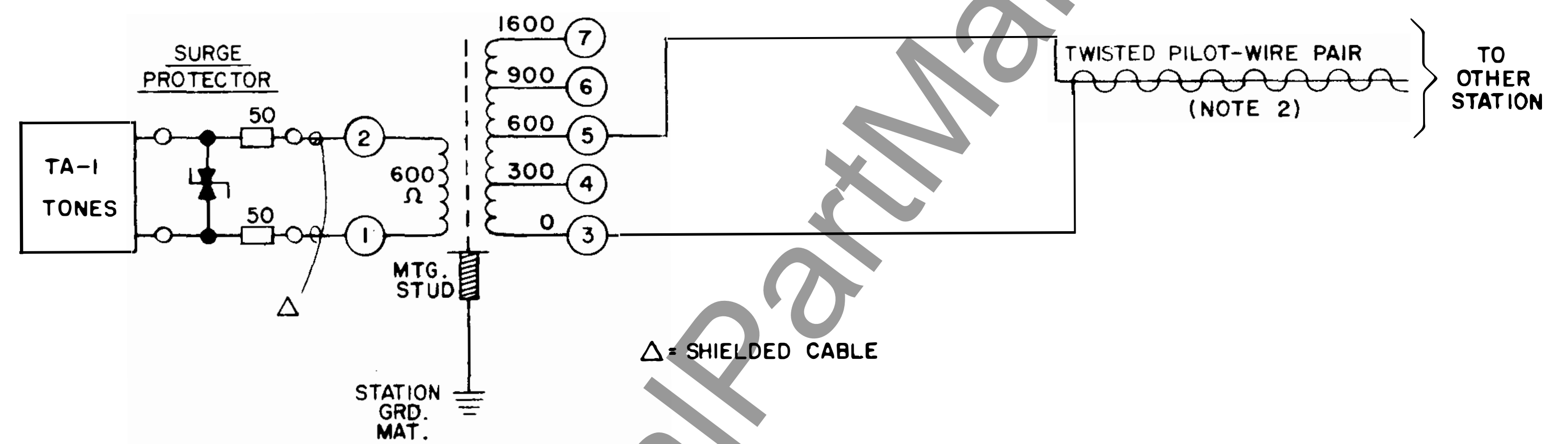


*Fig. 14 Transformer Protection – Dual Channel Transfer Trip.



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



NOTE 1 THESE CONNECTIONS ASSUME A PILOT-WIRE Zo ≈ 600 Ω

NOTE 2 COMPLETED CABLE FIELD TEST VOLTAGE OF 10KV D.C. FOR 10 MINUTES FROM EACH CONDUCTOR TO ALL OTHER CONDUCTORS AND SHEATH. SHIELDING FACTOR OF 50% OR LESS. EACH PAIR TWISTED SEPARATELY. GROUND SHEATH TO STATION MAT AT BOTH ENDS AND TO REMOTE GROUND AT EACH SPLICE

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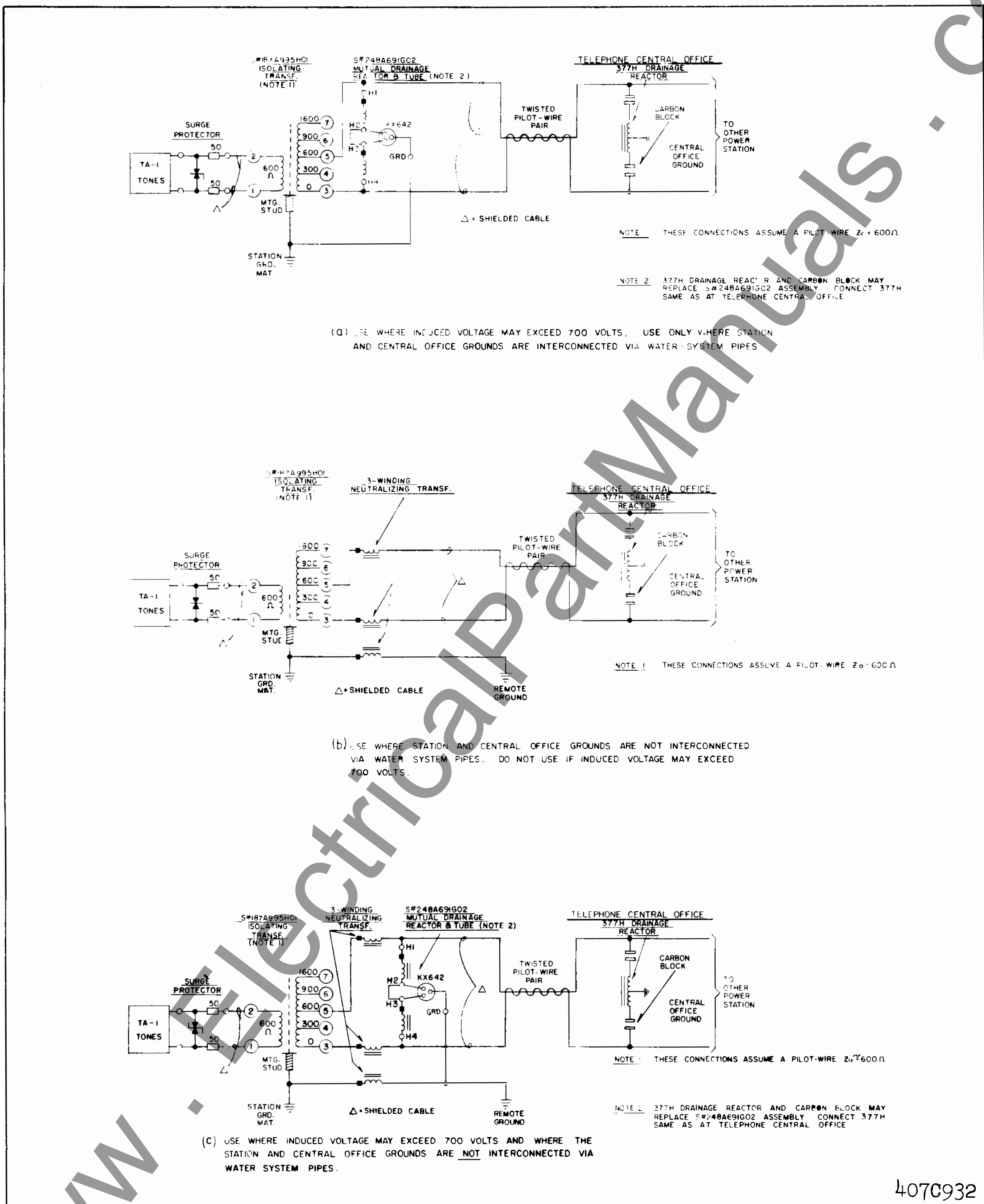
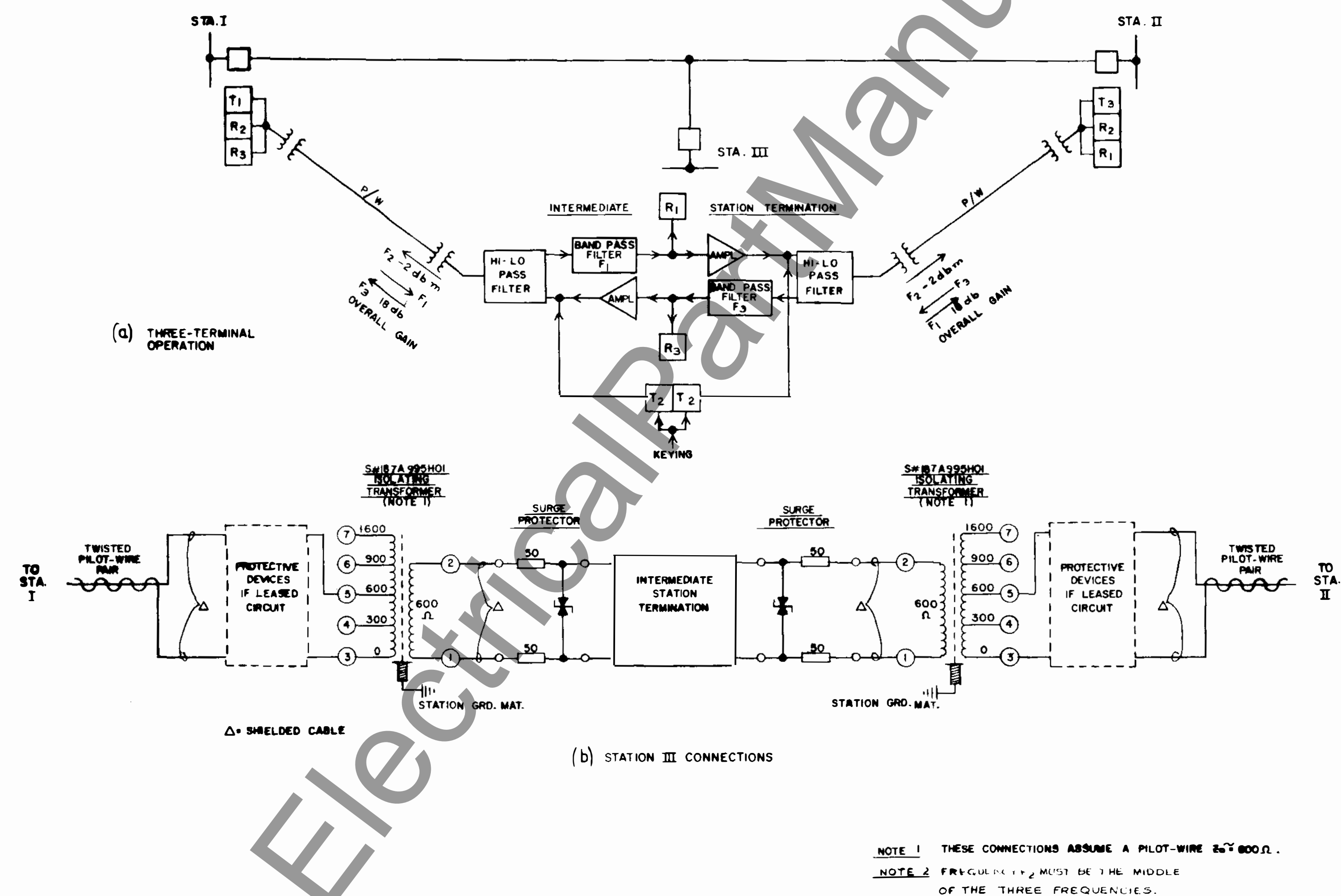
* *Fig. 16– Recommended Connections and Pilot Wire Design for Privately owned Cable for Two Terminal Lines.*



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



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

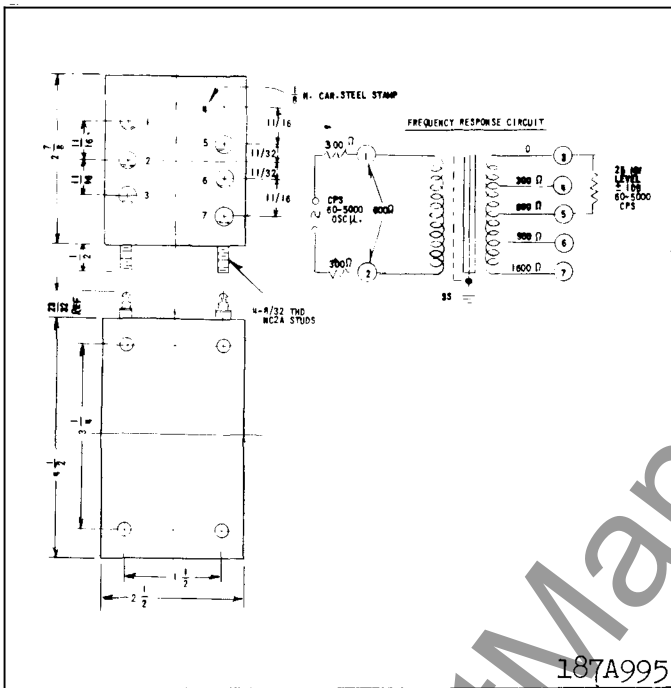


Fig. 19 Isolating Transformer 187A995H01.

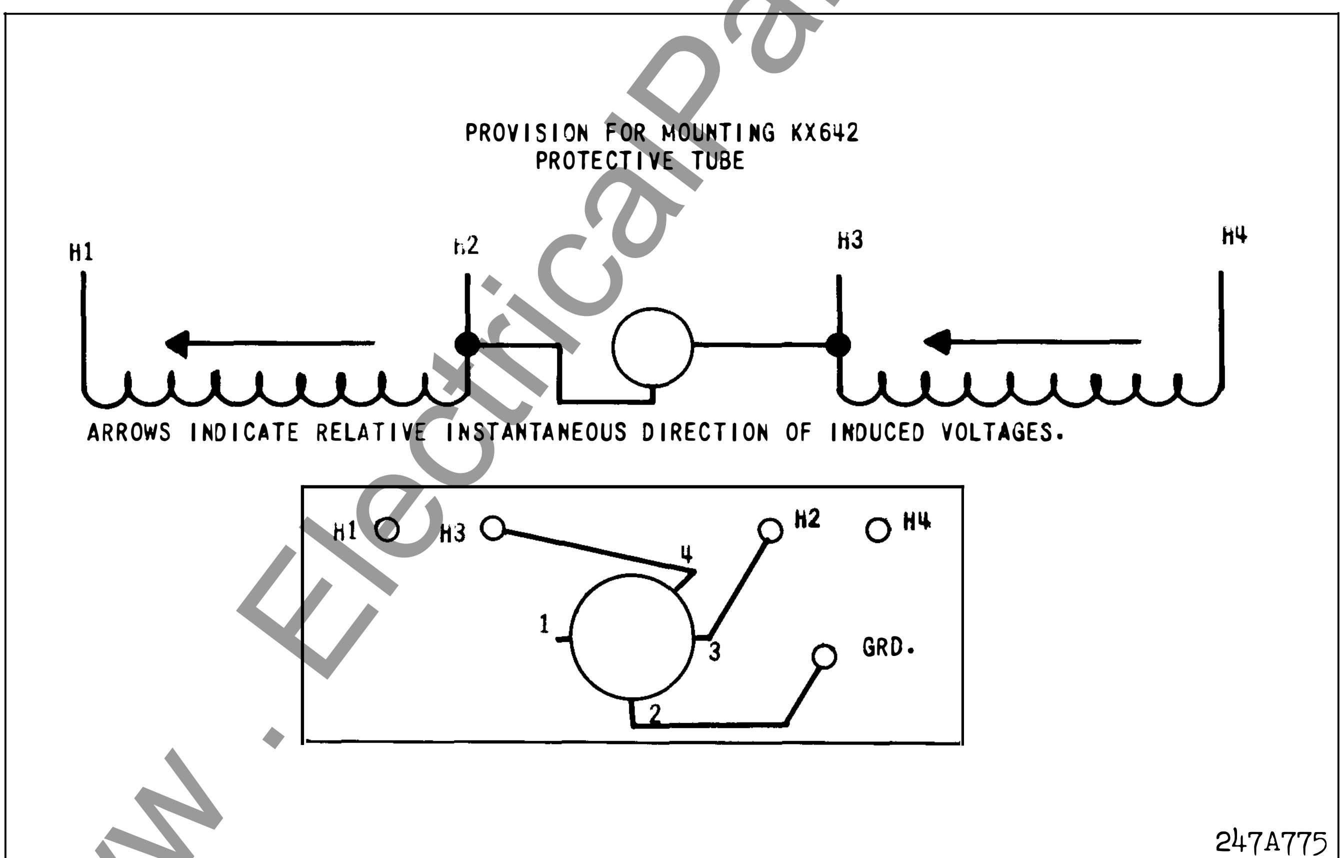


Fig. 20 Drainage Reactor Connections.

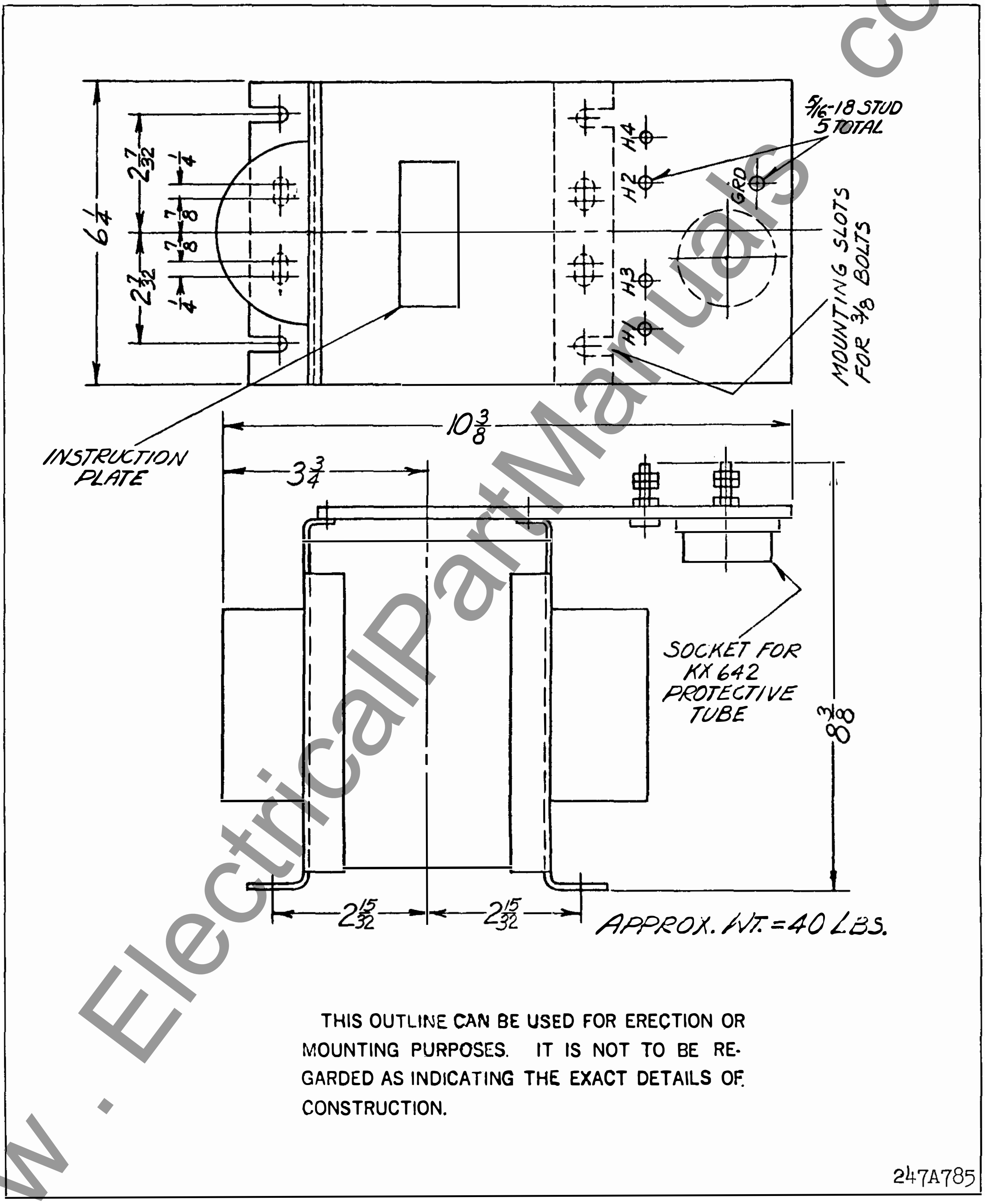


Fig. 21 Drainage Reactor Outline

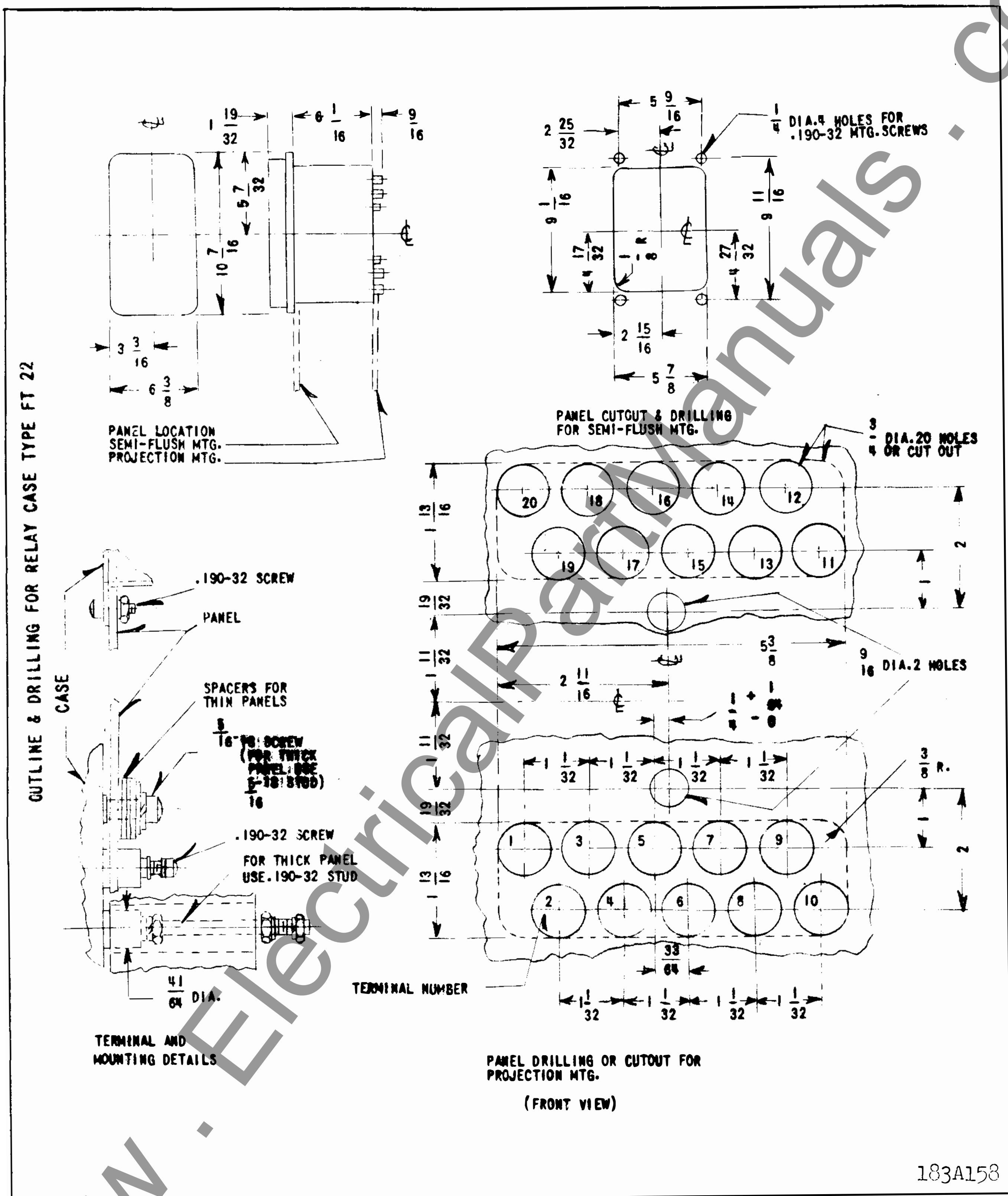


Fig. 22 Outline and Drilling plan for the type AR relay in the FT-22 case.

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, 10 V.	C1, 2, 3, & 5
H-1007-439	CAPACITOR, tantalum: 15 μF, 25 V.	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, .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, 25V.	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 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, 10V.	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: 4.7 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: 33K, ±10%, ½ W.	R13
H-1009-391	RESISTOR, fixed, comp: 10K ±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: 8.2K, ±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, std. 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 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: 500µF, 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; 3.3K, ±10%, 1W.	R1
H-1100-375	RESISTOR, fixed: comp; 300 ohms, ±5%, 20 W.	R2
H-1009-481	RESISTOR, fixed: WW; 4.7K, ±10%, 2W.	R3
H-1009-314	RESISTOR, fixed: 2.2K, ±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.	

INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TA-3 FREQUENCY-SHIFT AUDIO TONES

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

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

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

APPLICATION

The Type TA-3 tones are of the high-speed frequency-shift type and are available in two bandwidths: 170 Hz and 340 Hz. These tones have been designed for use with transfer-trip relaying systems, either solid-state or electromechanical. The TA-3 tones are suitable for use on a pilot-wire pair, or they may be multiplexed on a microwave or single-side-band carrier channel.

Transfer-trip relaying system applications are classified as direct or permissive transfer trip. A system which allows the tone receiver to trip directly, either with an output relay or through a solid-state auxiliary such as the STU-92, is considered a direct trip system. Direct trip systems are usually applied to transformer protection and shunt reactor protection, where no high side breaker exists and a remote breaker must be tripped to clear a fault. Another common application of direct trip systems on EHV circuits has been transfer trip for breaker failure protection. The direct trip systems can use either bandwidth TA-3 tone. The permissive type relaying systems are applied for line protection. In these systems the tones may trip a circuit breaker only if a local fault detecting relay has operated. For protection of EHV lines with high-speed breakers, the 340-Hz bandwidth TA-3 should be applied.

A receiver with a guard and trip output should * be used to drive two HG relays which drive two AR relays for use with electromechanical relaying systems, and the receiver with only the trip output should be used with solid-state relaying systems.

SECURITY MEASURES

The TA-3 tone system has been specially designed to obtain maximum security against noise. The TA-3 takes advantage of the inherent noise rejection characteristics of a frequency-shift receiver so that the relaying can be depended upon to trip when needed. The tone receiver is expected to operate with a minimum in-band signal-to-noise ratio of 9 db. Since an increased noise level on the pilot wire may often be concurrent with a trip request, the noise clamps are adjusted at a level based on the above minimum signal-to-noise ratio to avoid unnecessary clamping of the receiver.

The system provides a 300-1000 Hz band-pass filter and receiver to sample the random noise level of the pilot channel. This receiver will protect against false tripping due to random noise. In conjunction with the band-pass filter there is a line level monitoring system which samples the total frequency spectrum of the channel, and is set to operate for an overall increase of energy on the pilot channel. This monitoring feature will protect against false trips due to impulse noise which may have energy concentrated about frequencies not seen by the 300-1000 Hz noise filter. When noise has caused the blocking of a receiver, the drop-out of the blocking is delayed by 10 msec. to override the receiver response time.

Also available as an option is a frequency translation protection circuit. This is applied to protect against tone frequency variations caused by a pilot carrier frequency shift.

PILOT WIRE DESIGN

In applying a tone system for protection, the user and the cooperating telephone company should

SUPERSEDES I.L. 41-963.2A
*Denotes change from superseded issue.

EFFECTIVE MARCH 1972

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 light of the following facts. The period of usefulness during the lifetime of any given installation will be very small. Yet this infinitesimal period (compared to years) is precisely the time when noise levels can be abnormally high and 60-Hertz disturbing voltages will appear on the pilot wire. The recommendations summarized in Figs. 1 and 2 have been formulated with the above facts in mind.

For a recommended installation:

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

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

c. Do not use open pilot wires.

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

e. 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. 1 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

Type TA-3 tone equipment has been designed for protective relaying applications. Modular design is used, and a system is assembled using plug-in modules to meet the requirements of a specific application. Figure 3 shows a typical system.

In a typical relaying application, the tone system consists of the following modules. (The basic module construction is shown in Figure 4).

A. POWER SUPPLY MODULES
(See Figure 5 for Internal Schematic)

1. D-C to D-C Converter HB25190 (48V d-c), HB25200 (125V d-c)

   The converter contains a saturable core inverter with two separate output windings and rectifiers to deliver positive and negative output voltages to the regulator. This module is supplied for either 48 or 125V d-c, and there is a 125V d-c external zener regulator for use in conjunction with the 125V d-c converter when a 250V d-c supply is used. There is a blown fuse indicator light and also a power-on light on the modules.

2. Voltage Regulator HB25210 (See Fig. 6 for Internal Schematic)

   The regulator module consist of two regulator transistors with the necessary associated circuitry. In addition, there is a loss-of-regulation indicator on the front panel and an output amplifier to operate an optional relay for power supply loss-of-regulation indication.

   In order to provide the proper heat dissipation, the Voltage Regulator Module is mounted on the extreme left of the chassis. This will provide the module with vent holes which are beneficial for cooling of the regulator transistors by natural convection. An additional regulator may be mounted on the extreme right of the chassis.

B. FREQUENCY SHIFT TRANSMITTER
(Block Diagram Figure 7)

1. Frequency Shift Oscillator and Keyer HB25110 (See Fig. 8 for Internal Schematic)

   The function of this module is to generate the tone frequency with which the intelligence of the protective relay channel is communicated. It consists of a tuned oscillator with an isolated impedance circuit coupled to the tuned oscillator which shifts the transmitter to a lower frequency when operated. Figure 8 shows the internal schematic of the transmitter. The frequency of the oscillator is determined by plug-in unit HB-62800.

2. Transmitter Amplifier HB-25220 (See Fig. 10)

This module is designed to amplify the oscillator output of HB-25110. One of these modules is required for each oscillator module since it provides matching for the output of the transmitter. There are two different matching output units used. The band-pass filter HB62600 provides a 600-ohm output impedance in the center of the channel pass-band with a high out-of-band impedance characteristic to prevent adjacent channel loading. This filter adds 1.5-millisecond channel delay time. There is also a transformer output HB55207 for applications where a band-pass filter is not necessary. These units are mounted on HB-25220 module.

3. Transmitter Amplifier HB-33375 (See Fig. 11)

   This module is used instead of Transmitter Amplifier HB-25220 on 340 HZ bandwidth tones. This module is the same as the HB-25220 except for the addition of the beat frequency oscillator circuit and its associate filter (HB-63300-4) and the necessity of the transmitter output filter HB-62600.

4. Frequency Shift Oscillator and Keyer HB25110-3 (See Figure 9)

   This module is used instead of Frequency Shift Oscillator and Keyer HB25110 on 340 HZ bandwidth tones. It is essentially the same as the HB25110 except for the addition of the modulator circuit which mixes the frequencies of the beat frequency oscillator and the frequency shift oscillator.

C. RECEIVER MODULES (Block Diagram Fig. 12)

1. Receiver Input Filter HB63100 (See Fig. 13)

   A filter is provided to pass only the desired incoming signal to the receivers. One is needed for each receiver. Typical receiver filter characteristics are shown in Figure 13.

2. Receiver Limiter and Signal Supervisory Module HB25160-1 (Fig. 14)

   One module is required for each channel of the system. This module together with the input filter module provides a suitable input for use with the discriminator module. It also supervises the signal coming into the receiver, giving an absence-of-output indication when the signal falls below a predetermined level and also clamping the output d-c amplifier. A low signal condition is indicated by a light on the front panel.

3. F.S. Discriminator and D-C Amplifier Module HB25130-2 and HB25170 (Figs. 15 and 16)

   This module provides the receiver with the information sent by the transmitter at the remote location. The discriminator consists of two tuned circuits which respond to each of the two transmitter frequencies. The tuned circuits are contained in unit HB-62700 A typical discriminator output is shown in Fig. 17.

   Either the HB25130 or the HB25170 module is used to amplify the output of the discriminator so that either electromechanical relays or solid-state relays may be used.

   Both modules are the same with the exception that HB25170 (Internal Schematic in Figure 16) has only one output which occurs on receipt of trip signal. On either module, the trip output is blocked by the noise supervisory module. However, the low-level clamp from the signal supervisory module may be used for either blocking the output(s) (Strap X) or biasing the trip amplifier into a trip condition (Strap Y) without interfering with the guard output. The latter system is used for unblock applications. On either module, the output(s) are indicated by lights on the front panel.

D. NOISE SUPERVISORY MODULE (Block Diagram Fig. 12)

NOTE: One set is needed for every telephone line used.

1. Noise Filter Module HB55187 or HB55183 (Fig. 18) (Notched for 425 Hz Transmitter) (Some systems use 595 Hz Transmitter) This module contains a filter (see Fig. 18) that samples noise in the 300 to 1000 Hz region. There are two different types of filters. Filter module HB55183 has a rejection notch at 425 Hz and is used in conjunction with a 425 Hz transmitter located at the remote terminal for detection of carrier drifts. This system is used on four-wire telephone channels where there is a possibility of carrier shifting the telephone band, which affects the F.S. receiver intelligence by conditions existing outside of the transmitters and receivers.

2. Receiver Line Level and Noise Supervisory Module HB25150 (Fig. 19)

This module consists of two receivers (see Figure 19). One of them uses the output from the noise filter module for the Noise Supervisory function. The line level receiver uses the entire tone band to supervise the total in-band level of noise (this includes the frequencies used for protective line relaying).

An abnormal signal of sufficient strength on either of the receivers will cause an output on the line level and noise supervisory modules which will block the receiver trip output on the tone receiver and give an indication on the front panel.

E. 425-Hz TRANSMITTER HB21050-2 (Fig. 20) (Some systems use 595 Hz)

NOTE: One of these units is needed for each telephone pair when used. This transmitter is to be used in conjunction with HB55183 notch filter. Its function is to block the end through the noise supervisory module when there is frequency deterioration between the transmitter and the receivers in a telephone line. It consists of a 425-Hz frequency-shift transmitter with an output filter.

F. OUTPUT RELAYS

Mercury relays or type AR relays may be used for the outputs of this equipment. Except for the AR, these relays are mounted on the back of the chassis in the position shown on Figure 21. The AR relay is described in separate instructions.

G. LINE TERMINATION MODULE HB25140 (Figure 22)

This module is to be used when the application of the equipment calls for transmitters without any output filters. This module consists of two hybrid transformers and associated resistors used for multiplexing tone channels on a single telephone line or pilot pair.

H. HYBRID FOR TWO WIRE TERMINATION HB35315 (Figure 23)

This module is used for applications requiring just two wire termination for both transmitter and receivers. It is used to isolate the local transmitter from the receiver when a single line pair is used. It contains plug in jumpers for selecting capacitor values for matching telephone line characteristics along with adjustable resistor R1. It also contains plug in jumpers for selecting termination impedance of either 600 ohms or 900 ohms.

OPERATION

Under normal conditions, the tone transmitter is set to operate at the specified frequency for guard. This frequency is above the channel center frequency. During fault conditions, the transmitter may be keyed to a specified frequency below the center frequency. This causes a trip output from the receiver terminal.

A. POWER SUPPLY MODULES (See Figures 5 and 6 for Internal Schematics)

Converter (Fig. 5)

The d-c to d-c converter contains a saturable core type multi-vibrator with Q1 and Q2 acting as switching transistors for transformer T1 in series with the applied battery voltage. Starting current is applied through R1 and oscillations are maintained at a nominal 500 Hz by the drive from the feedback windings in the base circuit. Capacitor C1 provides the high-surge current which occurs during the switching interval as the magnetic field of T1 reverses and Q1 and Q2 change their conducting states. Capacitor C1 and the 6.38-mHy choke provide a low-pass filter section to reduce high-voltage transients on the battery bus for protection of transistors Q1 and Q2. Oscillator switching transients are attenuated by R5 and C2. Two secondary windings on T1 feed the bridge rectifier circuits, CR1 through CR8, to develop separate positive and negative output voltages.

Regulator (Fig. 6)

Polar output voltages from the d-c to d-c converter are applied to the Voltage Regulator HB25210. Transistor Q3 is the series regulating element for the positive voltage input. Resistors R6, R7, and R8 comprise a voltage divider across the emitter-follower output. A portion of this output voltage is fed back to the base of Q1 and compared with a reference voltage across the zener diode CR1 in the emitter circuit. The difference voltage across the base-emitter junction of Q1 controls the collector current through load resistor R1. The voltage drop across

R1 is coupled by emitter follower Q2 to the base of Q3. Any change in the output voltage at the emitter of Q3 is opposed by a change in base voltage as a result of the controlling current flow in R1. The feedback voltage from the voltage divider circuit is made variable by resistor R7 to permit accurate setting of the output voltage level. Transistors Q4, Q5 and Q6 provide a similar regulator circuit for the negative voltage output.

The regulation indicator circuit is essentially a bridge connected across the positive and negative output terminals of the polar power supply, a span of 36 volts. One leg of the bridge is the 18-volt zener diode CR3. The output leg of the bridge is between the zener diode and the center arm of potentiometer R19. R19 is adjusted for a zero-volt output, or balance, at a total power-supply output of 36 volts. A change in power supply level after balance adjustment will produce a ± voltage change at the bridge output. This is detected by a complementary Schmitt trigger circuit consisting of Q7, Q8, Q10, and Q11. At balance, Q7 and Q10 are both cut off, and transistors Q9 and Q12 are two closed switches in series to energize the indicating lamp plus a remote relay. An increase in one or both of the supply output voltages will cause Q7 to conduct, and a decrease in one or both voltages will cause Q10 to conduct. Conduction of either Q7 or Q10 will open the associated series switching transistor, and the lamp and relay will be de-energized.

B. FREQUENCY SHIFT TRANSMITTER

1. F.S. Oscillator and Keyer HB25110 (For 170 Hz Bandwidth) (Block Diagram Fig. 7)

   With reference to the schematic diagram in Fig. 8, the oscillator is a multivibrator type consisting of Q1 and Q2 with an LC circuit collector to collector, tuned to the guard frequency. The frequency shifting capacitor, CT, is connected across a coupling winding on the tank circuit by switching transistors Q5 and Q6. For keying voltages below the trip level, Q5 and Q6 will present high collector impedances in series with CT effectively removing it from the circuit, and a guard frequency will be generated. When the keying voltage exceeds the trip level, Q5 and Q6 will saturate and connect CT across the oscillator causing a shift to the trip frequency. The oscillator output is taken from the level control R24 across a winding on the oscillator coil.

   In the keying circuit, Q3 and Q4 comprise a Schmitt trigger. The trigger circuit is energized by the voltage across R2 when keying current flows. The input to the base of Q3 is through zener diode CR2. For voltages below the zener voltage, Q3 is cut off and Q4 conducts; current cannot flow through coupling diodes CR3 and CR4 to the bases of switching transistors Q5 and Q6, and CT is not connected across the oscillator. When the zener voltage is exceeded, the Schmitt trigger action causes Q4 to be cut off, and current flows through CR3 and CR4 to clamp the switching transistors and generate a trip frequency. Keying circuit characteristics are shown in Figure 24.

2. Transmitter Amplifier HB25220 (Fig. 10) (For 170 Hz Bandwidth)

   With reference to the schematic diagram of Figure 10, amplifiers Q2 and Q3 are an emitter-coupled pair with push-pull collector output. Load coupling to the collectors is through the optional plug-in assemblies, multiplexing filter HB62600 or transformer HB55207. Signals from the HB25110 F-S oscillator are amplified by Q1 and applied to the base of Q2, the input to the push-pull amplifier. The GAIN control R2 can be set to maximum, and the channel level adjustments can be obtained using the LEVEL control on the oscillator module.

*3. F.S. Oscillator and Keyer HB25110-3 (For 340 Hz Bandwidth) (See Fig. 9)

   This is similar to the F.S. Oscillator and Keyer HB25110 above except for the addition of modulator transistors Q8 and Q9 for mixing the frequency of the B.F.O. with the frequency of the frequency shift oscillator. The frequency from the beat frequency oscillator is 10 KHz and is used to amplitude modulate the frequency of the frequency shift oscillator which in this case is 10 KHz plus the tone frequency (guard or trip). This amplitude modulation produces both the sum and difference frequencies of the two frequencies which are fed to the transmitter amplifier HB33375.

A secondary winding on L_O couples the output of the oscillator to the LEVEL control R10. This winding provides d-c isolation between the oscillator circuit and the output amplifier Q2 which operates from the full −12V d-c. supply. Transistor Q2 is a Class A common-emitter stage with the base input signal coupled from the LEVEL control by d-c blocking capacitor C5. The carrier band-pass filter is the collector load.

This transmitter, together with HB55183 filter at the remote end is used to prevent adverse effects from frequency translation. When a telephone line is multiplexed with other telephone lines, sometimes there is a drift in band frequencies due to the receivers and transmitters used in multiplexing. These conditions, although lying beyond the control of the tone channels, are detected at * the receiving end by applying the 425-cycle transmitted frequency to the noise filter. The noise filter HB55183 together with the noise supervisory module do not tolerate a frequency translation (due to line multiplexing) of more than ±40 Hz without blocking the receivers.

D-C TO D-C CONVERTER AND VOLTAGE REGULATOR

Converter HB25190 and HB25200, Regulator HB25210

Power Output:

Model HB25210 Voltage Regulator with one of the D-C to D-C Converter Modules, HB25190 or HB25200 — 7.5 watts maximum; +18 volts at 200 ma. and −18 volts at 200 ma.

Power Input:

Approximately 15 to 23 watts for above output power over the following converter input voltage ranges;

HB25190 – 42 to 56 V d-c, 48 v.d.c. nominal.

HB25200 – 105 to 144 V d-c, 125 v.d.c. nominal.

See Figure 5 for 250V d-c battery input.

Regulation:

+18 and −18 v.d.c. within 0.1 volt.

Regulation Indicator:

Indicates changes greater than 2 volts in ±18 V d-c output; module panel lamp extinguishes and remote relay is de-energized. Recommended alarm relay is HA18574; two Form-C 5-ampere contacts, 2000-ohm coil.

Ripple:

1 mv RMS maximum on +18 v.d.c. and −18 v.d.c. outputs.

Converter Frequency:

Nominal 500 Hz; 380 Hz to 600 Hz over rated input and output ranges.

Overloads:

No overload protective circuitry. Input to con-

CHARACTERISTICS

CHANNELS		TRIP FREQUENCY		GUARD FREQUENCY	
170-Hz b.w.	340-Hz b.w.	170-Hz b.w.	340-Hz b.w.	170-Hz b.w.	340-Hz b.w.
1275 1615	1360	1190 1530	1190	1360 1700	1530
1955 2295	2040	1870 2210	1870	2040 2380	2210
2635 2975	2720	2550 2890	2550	2720 3060	2890

When 170-Hz and 340-Hz bandwidth (b.w.) channels are used in conjunction, the 340-Hz channel takes the space of the two 170-Hz adjacent channels. It is recommended that the lower frequencies be used for wide bands (340-Hz b.w.).

CHANNEL DELAY TIME

	170 Bw. W/TRANSF.	170 Bw. W/FILTER	340 Bw. W/FILTER
Channel Time (excluding telephone line)	7.5 ms.	9.0 ms.	5.0 ms.
* Relay Time			
2 Amp Mercury Wetted Relay or Mercury Wetted Relay and 10W AR	3.0 ms.	3.0 ms.	3.0 ms.
Total	10.5 ms.	12.0 ms.	8.0 ms.

Ambient Operating Temperature: .... −20° to +55°C.

Storage Temperature: .... −60° to +75°C.

Approximate Weight: .... 14 lb.

verter is fused; effective only for short-circuit loads. Operation above maximum rated levels should be avoided to prevent damage due to excessive heat generation.

Isolation:

Output circuits are d-c isolated from ground and the converter input battery supply. A transient voltage filtering capacitor, C3, in the converter module is connected between the output COMMON and the positive battery input and has a 2000WV d-c rating. (See schematic diagram, Figure 5.)

* F.S. OSCILLATOR AND KEYER HB25110 and HB25110-3

Output Level:

0.11 Vrms maximum −17 dBm, unbalanced, ±0.75 dB. Less than 0.25-dB difference between steady-state guard and trip frequencies.

Keying Circuit:

Requires 16 mA ±10% to shift from guard to trip. Return to guard at 4 mA less than maximum trip current. No intermediate frequencies or stopping of oscillation for any keying voltage. Nominal keying voltages are 24V, 48V and 125V d.c. with series resistance values per Fig. 8. Shift from guard to trip is at approximately 50% of keying voltage. Input resistance approximately 1000 ohms. See Figure 24.

* Frequency: (HB25110 Only)

Guard is above channel center frequency. Trip is below channel center frequency. Frequency stability 0.2% of channel frequency.

* Frequency: (HB25110-3 Only) (340 Hz Bandwidth Only)

The guard frequency is equal to the chanel center frequency plus 170 Hz plus 10 KHz for normal applications. The trip frequency is the channel center frequency minus 170 Hz plus 10 KHz for normal applications.

(In dual channel systems, one of the channels utilizes a shift up in frequency for trip. In this case, the guard frequency for this particular channel would be 10 KHz minus the channel center frequency and minus 170 Hz. [$f_g = 10{,}000 - f_c - 170$]. The trip frequency would then be 10 KHz minus the channel center frequency and plus 170 Hz. [$f_t = 10{,}000 - f_c + 170$]).

* TRANSMITTER AMPLIFIER HB25220 and HB33375

Gain:

30 dB with transformer HB55207, 28 dB with filter HB62600, −1 + 0.5 dB from setting.

Output Level:

+8 dBm maximum in 600 ohms with filter. +10 dBm max. in 600 ohms with transformer.

Harmonic Distortion:

Total distortion with HB25110 f-s. oscillator input is 1.5% with transformer output, less than 0.2% with filter output, at maximum rated output level.

Transient Response:

With HB25110 f-s. oscillator input and filter output, trip signal and transients are within −3dB to +3dB of guard signal level.

* Beat Frequency Oscillator: (HB33375 Only) (340 Hz Bandwidth Only) 10 KHz ± 0.25%.

RECEIVER LIMITER AND SIGNAL SUPERVISORY HB25160-1, RECEIVER FILTER HB63100

Sensitivity:

Maximum sensitivity of the HB25160-1 receiver module for block release after a signal-loss block is −44 dBm, measured at CARRIER IN test point. Maximum sensitivity referred to channel level on communication circuit is determined by the loss in the channel filter and coupling network. See Figure 23 for recommended nominal levels and Figure 12 for coupling scheme. This arrangement, when used with the HB25150 noise supervisory module, will permit a minimum nominal line level per channel of −28 dBm. Sensitivity is constant within +1 dB.

Outputs:

Limited carrier signal, ±17 volts for driving discriminator module, 600-ohm driving impedance. Clamping voltage for trip block circuit in discriminator module.

Input Impedance:

HB63100 filter input 600 ohms in passband, out-of-band rising impedance characteristic.

F.S. DISCRIMINATOR AND D-C AMPLIFIER HB25170 and HB25130 (Dual Output)

Discriminator Input:

9V rms carrier signal derived from ±17 volt limited signal from limiter section in HB25160 module.

Low Signal Block Input:

Block – 3 mA, +0.8V. Block release – -3.4V, 0 mA. From signal supervisory section in HB25160 module.

Noise Block Input:

Block – 2 to 3 mA, +14 to +17V. Block release – −3.4V, 0 mA. From noise supervisory module HB25150.

HB25130-2 Outputs:

Trip amplifier, 100 mA capability. Nonconducting for a guard signal, collector at −18 volts. Conducting for a trip signal, collector at +18 volts. Guard amplifier, 100 mA capability. Nonconducting for a trip signal, collector at +18 volts. Conducting for a guard signal, collector at −18 volts.

HB25170 Output:

Trip amplifier, 100 mA capability. Nonconducting for a guard signal, collector at −18 volts. Conducting for a trip signal, collector at +18 volts.

LINE LEVEL AND NOISE SUPERVISORY HB25150 AND FILTERS HB55183 AND HB55187

Output:

Clamping voltage for trip block circuits in up to six F.S. Discriminator and D-C Amplifier modules (HB25170 or HB25130); +13V to +17V at 2 to 3 mA block, −3.4V at 0 mA block release. Block release delay time is 10 milliseconds. D-C amplifier capable of delivering up to 100 mA at 36V to an indicating device, or voltage pulses to logic circuitry. Amplifier is conducting for a block, collector at +18V; nonconducting for block release, collector at −18V.

Noise Filters HB55187 and HB55183

300 to 1000 Hz passband, 600-ohm input impedance in passband, out-of-band rising impedance characteristic. 600-ohm output impedance. Noise filter HB55183 is the same as HB55187 except for a
* 25-db rejection notch at 425 Hz.

Noise Filter Amplifier:

600-ohm input impedance. Sensitivity adjustable: Maximum sensitivity for a trip block is −52 dBm, +0.5 dB −1 dB.

Line Level Amplifier:

11.2K input impedance. Sensitivity adjustable; maximum sensitivity for a trip block is −27 dBm; +0.5 dB −1 dB.

* **425-HZ TRANSMITTER HB21050-2 (Some Systems Use 595 Hz)**

Output Level:

600 ohms nominal, isolated and balanced.

Output Stability:

±1.5 dB from −30°C to +70°C.

Frequency Stability:

HB21050-2 ±.25% from −30°C to +70°C.

Keying Inputs:

Neutral voltage pulses, −10V nominal. Input resistance approx. 5K to 15K.

INSTALLATION

(Outline and Drilling Plan, Figure 19)

The tone assemblies should be mounted on relay racks or in suitable cabinets when the eleven-module chassis is used. The mounting location should be free from dirt, moisture, excessive vibration, or heat. All electrical connections are made through a 24-terminal connector on the rear of the chassis per CR drawing which applies to the particular order and appears on the nameplate.

Use of current monitoring jacks: Standard telephone-type current jacks can be supplied on special order to monitor the guard, trip or alarm, output relay coil currents when such are mounted on the bottom of the TA-3 tone assembly. This assembly will be three rack units high.

The type AR relays, when used, should be mounted near the TA-3 tone chassis in a location free from dirt, moisture, excessive vibration, or heat.

SETTINGS

Transmitters

Only one setting is required on the tone transmitter and that is the output level. This setting is made by using the screwdriver type adjuster marked * "gain" on the transmitter amplifier 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 protective 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 allowable 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 a-c 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 level are to be checked or readjusted. The 425-Hz * transmitter should be set the same as any other transmitter.

F.S. Receiver

(Refer to Fig. 26 for Relative Levels)

The sensitivity is adjusted with a carrier signal present at the input of the channel filter at the nominal level for the particular installation. Short circuit the two test points designated sens. adj. link on the panel of the Receiver Limiter and Signal Supervisory module. This will decrease the sensitivity of the receiver by 6 dB. Turn the SENSITIVITY control slowly from its extreme clockwise position until the BLOCK light is energized, then remove the short from the test points. With this setting, a 6-dB decrease in channel level will generate a trip block function; a 3-dB recovery is required to release the block.

Line Level and Noise Supervisory Module

(Refer to Fig. 26 for Levels)

NOTE: If a HB55183 notch filter is used, the calibrating procedure should not be altered.

The sensitivity of both noise detecting circuits is adjustable with all channel signals present on the line at their nominal levels for the system. Adjust the noise-filter amplifier sensitivity as follows: first turn the NOISE SENSITIVITY control to its extreme counterclockwise position (if the line level sensitivity has not been adjusted, turn this screw to its extreme counterclockwise position also). Remove the noise filter from the chassis. Connect the CARRIER IN test point of any convenient HB25160 Receiver module to the NOISE IN test point on the HB25150 Noise Supervisory Module. Slowly turn the NOISE SENSITIVITY control from its extreme counterclockwise position until the BLOCK light is energized. Remove the test point connections and replace the noise filter in the chassis; the light should turn off. With this adjustment, a trip block will be initiated for an in-band signal-to-noise ratio of 12 dB or less. A minimum of 9 dB is required for security against false tripping in type TA-3 Protective Relaying Channel.

The wide-band noise or line level amplifier sensitivity can be adjusted in this manner: Connect the LINE LEVEL SENS. ADJ. test point to the COMMON test point. This will increase the gain of the amplifier by 4.5 dB. Turn the LINE LEVEL SENS. control slowly clockwise until the BLOCK light is energized, then remove the test point connections. When the combined level of signals plus noise increases by 4.5 dB, a trip block will be generated.

* A hysteresis of approximately 1.5 dB exists in the trigger-type blocking circuit for a block release. The 4.5-dB high-level block setting and a low signal-level block adjustment of 6 dB in the Limiter and Signal Supervisory Module HB25160 will give a dynamic operating range of 10.5 dB for the protective relaying receiver.

F.S. Discriminator and D.C. Amplifier

(See Fig. 17, Typical Discriminator Output)

With a –5, 0, +5 v.d.c. voltmeter of at least 20,000 ohms-per-volt resistance connected between common and "Disc. out" T.P., check for equal outputs at Guard and trip frequencies and adjust the discriminator bias on the front panel to correct this if necessary.

ACCEPTANCE CHECK

D-C to D-C Converter HB25190 or HB25200

Non-Regulated Voltages:

.+V d-c to common	+22 to +34 V d-c
–V d-c to common	–22 to –34 V d-c

Voltage Regulator

+18 V to common	+18 V d-c
–18 V to common	–18 V d-c

Transmitter

(Consists of an oscillator and keyer, and a transmitter amplifier.)

Key transmitter to trip frequency by applying the correct keying voltage at the terminals indicated on the connection drawing.

All transmitter frequencies and output levels should be checked with a 600-ohm load connected at the output.

Guard Frequency: within 2 Hz of the frequency specified in the Characteristics section.

Trip Frequency: within 2 Hz of the frequency specified in the Characteristics section.

NOTE: Allow 4 Hz for 340-Hz bandwidth tones.

Output Level:

at least +8 dBm when supplied with filter output.

at least +10 dBm when supplied with transformer output.

* 425-Hz Transmitter (Some Systems use 595-Hz)

Frequency: 425 Hz within 1 Hz

Output: at least + 1 dBm

Keying: should shift at least 40 Hz to block Noise Supervisory module.

F.S. Receiver

With a transmitter input set at –20 dBm, see that the guard and trip outputs operate correctly.

Line Level and Noise Supervisory

Should operate upon receipt of a 700-Hz tone at –37 dBm, or any transmitter tone frequency at –15 dBm. Factory calibration is at a –20 dBm nominal input signal.

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").

POWER SUPPLY

The d-c to d-c converter has no adjustments. The voltage regulator module HB25210 has adjustable reference voltages. In order to adjust the reference voltages, a card extender (HB14583) is needed because the adjusting resistors are not accessible from the front of the panel. Connect a d-c voltmeter to common and +18 volts (front of the panel), and adjust R7 for +18 volts. Repeat this operation by connecting the voltmeter between common and –18 volts and adjusting R15. The regulation indicator is set by adjusting R19 for zero volts between the reference zener diode CR3 and the white test point on the front panel. The regulation indicator will detect any changes over 2 volts by the lamp being extinguished and the optional relay being de-energized.

TRANSMITTER MODULES

F.S. Oscillator Keyer

Oscillator frequency is determined by the plug-in tuned circuit assembly. A FREQUENCY ADJUSTMENT control on the module panel enables a slight frequency trimming in the event that the channel tuned circuit assembly is changed. This adjustment affects the trip and guard frequencies simultaneously and in the same direction. The LEVEL control permits setting the oscillator output level to the system requirement. Both adjustments can be monitored at test points on the panel.

Transmitter Amplifier

The output level of the transmitter amplifier was discussed in the SETTINGS section.

RECEIVER MODULES

The only adjustment needed in the receiver modules (level adjustment was covered in the SETTINGS section) is the adjustment of the Discriminator Balance Control.

Adjustment of the DISCRIMINATOR BALANCE control is made with alternate trip and guard frequencies applied to the discriminator. With equal output, as measured at the DISC. OUT test point, a slight guard preference in operation will be derived. This can be seen with reference to Fig. 15.

LINE LEVEL AND NOISE SUPERVISORY MODULES

These modules require no adjustments except for the settings covered before.

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. The acceptance check procedure will provide a more thorough test.

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 type AR 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. Refer to Table I for typical transistor voltages.

Test Equipment

For routine maintenance, the following equipment will be adequate:

* 1. A-C Vacuum-Tube Voltmeter, at least 15 kHz, 1 mv sensitivity.

2. Calibrated Attenuator, 600 ohm.

For troubleshooting, the following additional test equipment is desirable:

* 1. Electronic Frequency Counter, 15 kHz minimum.

2. D-C Vacuum-Tube Volt-Ohmmeter.

3. Cathode-Ray Oscilloscope.

* 4. Oscillator, 200 to 15,000 Hz.

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 Parts List.

TABLE I

TYPICAL VOLTAGE MEASUREMENTS (REFERRED TO "COMMON")

200 mA LOAD ±22.5V INPUT

			Q1	Q2	Q3	Q4	Q5	Q6
HB25210 Voltage Regulator	Vdc.	C	+19.4	+22.0	+22.5	–19.4	–22.0	–22.5
		B	+12.1	+19.4	+18.7	–12.1	–19.4	–18.7
		E	+11.4	+18.7	+18.0	–11.4	–18.7	–18.0

NO LOAD ±34.2V INPUT

			Q1	Q2	Q3	Q4	Q5	Q6
HB25210 Voltage Regulator	Vdc	C	+19.2	+33.5	+34.2	–19.2	–33.5	–34:2
		B	+12.1	+19.2	+18.8	–12.1	–19.2	–18.8
		E	+11.4	+18.8	+18.1	–11.4	–18.8	–18.1

			Q1	Q2			Q1	Q2
HB25110 F.S. OSC And Keyer (Fig. 8)	Vdc	C	+18	+18	AC Signals Vp – p.	C	34	34
		B	+ 7	+ 7		B	10	10
		E	+ 6.5	+ 6.5		E	5	5

			Q1	Q2	Q3	Q4	Q5	Q6	Q8	Q9
F.S.OSC & Keyer HB25110 & HB25110-3 Fig. 8 & Fig. 9 (Where applicable	VDC	C	+18		See Fig. 24		–		0	
		B	+ 7				–		–	
		E	+ 6.5				0		–	
	Vac p-p	C	34		–		34		–	
		B	10		–		–		2.2	
		E	5		–		–		–	

			Q1	Q2	Q3
HB25220 Transmitter Amplifier	Vdc	C	7	15	15
		B	0	–0.3	–0.3
		E	–0.7	–0.9	–0.9

TABLE I (Continued)

TYPICAL VOLTAGE MEASUREMENTS (REFERRED TO "COMMON")

Circuit	Measurement	Element	Q1	Q2	Q3	Q4	Q5
Trans. Ampl. & B.F. Osc. HB33375 Fig. 11	Vdc	C	7	15	15	−5.8	−12
		B	0	−0.3	−0.3	−1.1	−2.2
		E	−0.7	−0.9	−0.9	− .95	−2.
	Vac p-p	C				15	2.7
		B				.08	.08
		E				0	−

Circuit	Measurement	Element	Q1	Q2	Q3	Q4	Q5	Q6
HB25160-1 Rec. Lim. And Sig. Supv.	Vdc	C	+16.6	+18	+ .9	+ .4	18	−18
		B	0	0	+16.6	−15V	.9	− .4
		E	− .7	− .7	+17.2	−16	−	−

Circuit	Measurement	Element	Q7	Q8	Q9	Q10	Q11	Q12	Q13
HB25160-1 Rec. Lim. And Sig. Supv.	W/O Sig. Vdc	C	+18	+ 7	+17.2	+17.9	+18	0	−18
		B	0	−18	−14.4	+17.2	+17.9	+17.5	+18
		E	− 0.7	−14.9	−14.9	+18	+17.2	+18	+18
	W/Sig. Vdc	C	−14.7	+18	−2.7	+18	0	+17.9	
		B	−14.5	−15.1	+18	− 2.7	− 2.8	+17	
		E	−15.2	−15.2	+18	− 3.4	+ .05	+18	

Circuit	Measurement	Element	Q2	Q3	Q5	Q6	Q7	Q8	Q9	Q10
HB25130-2 HB25170 F.S. Disc. and D-C Amp.	Guard Vdc	C	+7.5	+6.1	+18.0	−18.0	−0.45	−7.6	−6.9	−17.9
		B	−0.6	+1.2	+ 4.0	+18.0	−1.1	−0.1	−7.6	−17.2
		E	+0.55	+0.55	+ 6.8	+18.0	−0.43	−0.43	−6.8	+18
	Trip Vdc	C	+0.45	+7.4	+ 6.9	+ 7.9	+7.5	−3.7	−18	+18
		B	+1.1	+0.1	+ 7.4	+17.2	+1.1	−1.22	−3.65	−18
		E	+0.42	+0.42	+ 6.8	+18.0	+0.56	−0.56	−6.8	−18

Circuit	Measurement	Element	Q3	Q4	Q5	Q6	Q7	Q8	Q9
HB25150 Line Level and Noise Supv.	Block Vdc	C	<−15	+ 0.8	− 0.1	+17.9	+18	+ 0.1	+17.9
		B	<−16	>16.8	− 0.7	+17.2	+17.9	+ 0.7	+17.2
		E	<−16.4	<16.4	0	+18	+17.2	0	+18
	Release Vdc	C	−15	3	+18	− 2.6	+18	+18	−18
		B	< 16.3	−15.8	− 2.8	+18	−2.55	− 2.75	+18
		E	16.4	−16.4	0	+18	−3.3	0	+18

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB25110 AND HB25110-3 F.S. OSCILLATOR AND KEYER	
* R3 thru R20, R22, R23	RESISTOR, fixed comp., ±5%, ¼ watt, unless otherwise specified	
R2	RESISTOR, fixed WW: 1.5K ±5%, 1½ watt, Ohmite type 995-1A.	H-1100-421
* R1	RESISTOR, fixed WW: 600 ±5%, 3 watt, Ohmite type 995-3A.	HA-1220-22
R21	RESISTOR, variable: 250K ±30%, 0.1 watt, BD taper, C.T.S. PE200	HA-14594
R24	RESISTOR, variable: 500 ±20%, 0.125 watt, BD taper. C.T.S. PE200	HA-25253
C1	CAPACITOR, mylar, 0.1 μF ±10%, 100V, Cornell Dubilier WMF1P1.	H-1007-624
C3	CAPACITOR, mica, 1200pF ±2%, Elmenco DM19D122G0500WV4CR.	H-1080-333
C4	CAPACITOR, tantalum, 1 μF ±20%, 35V, Texas Inst. SCM105FP035D4.	H-1007-496
CR1	DIODE, zener, 6.8V ±5%, Motorola 1N4736A	HA-21504
CR2	DIODE, zener, 5.1V ±5%, Motorola 1N4733A.	HA-24328
CR3, CR4	DIODE, silicon, 200 PIV, 500mA, Diodes Inc., DI-42.	HA-17197
Q1 thru Q6	TRANSISTOR, silicon NPN, VECO 40V, TO-92 case, Motorola 2N3903.	HA-21562
* Q8, Q9	TRANSISTOR, Germanium, PNP, Texas Instr. 2N1375	HA-17117
	Tuned oscillator ckt., sealed plug-in assembly.	HB-62800
	Test jacks, Sealectro Corp., SKT-10.	
	HB25220 TRANSMITTER AMPLIFIER	
* R3, R4, R6, R7, R8, R10	RESISTOR, fixed comp., ±5%, ¼ watt unless otherwise specified.	
R1	RESISTOR, fixed WW., 200 ±5%, 1½ watt, Ohmite type 995-1A.	H-1100-427
R9	RESISTOR, fixed WW., 1300 ±5%, 1½ watt, Ohmite type 995-1A.	H-1100-529
R2	RESISTOR, variable, 5K ±30%, 0.25 watt. log taper, C.T.S. PE200.	HA-13572
R5	RESISTOR, fixed comp., 10K ±5%, ½ watt.	H-1009-416
* C1, C2	CAPACITOR, tantalum, 15 μf ±10%, 35V. Texas Inst. SCM156GP035D4.	H-1007-654
* C4. C5	CAPACITOR, tantalum, 1.0 μf ±20%, 35V. Texas Inst. SCM105FP035D4.	H-1007-496
C3	CAPACITOR, mica 470pf ±2%, Emeco DM-19.	HA-16632
Q2, Q3	TRANSISTOR, silicon NPN V_{CEO} 65V TP-5 case. 2N2102	HA-22678
Q1	TRANSISTOR, silicon NPN V_{CEO} 40V, TO-92 case. 2N3903	HA-21562
	TRANSFORMER, Plug-in assembly.	HB-55207
	Multiplexing filter, plug-in assembly.	HB-62600
	Test jacks, Sealectro Corp. SKT-10.	

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	*** HB33375 TRANSMITTER AMPLIFIER & B.F. OSC.**	
R3, R4, R6, R7, R8 R10, R11, R12, R13 R14, R15, R16, R17 R18, R19, R20, R21	RESISTOR, fixed comp., ±5%, ¼ watt unless otherwise specified	
R1	RESISTOR, fixed WW., 200 ±5%, 1½ watt, Ohmite Type 995-1A	H-1100-427
R9	RESISTOR, fixed WW., 1300 ±5%, 1½ watt, Ohmite Type 995-1A	H-1100-529
R2	RESISTOR, Variable, 5K ±30%, ¼ watt Log Taper, C.T.S. PE 200	HA-13572
R5	RESISTOR, fixed comp. 10K ±5%, ½ watt	H-1009-416
C1, C2	CAPACITOR, tantalum, 15μf ±10%, 35V, T.I. SCM156GP03504	H-1007-654
C4, C5	CAPACITOR, tantalum, 1.0 μf ±20%, 35V, T.I. SCM105FP035D4	H-1007-496
C3	CAPACITOR, Mica 470pf ±2%, Emenco DM-19	HA-16632
C7, C8, C9, C10 C11	CAPACITOR, 15 μf ±20%, 25V Mallory, TAM156M025P5C	H-1007-439
Q1	TRANSISTOR, Silicon NPN, 2N3903	HA-21562
Q2, Q3	TRANSISTOR, Silicon NPN, 2N2102	HA-22678
Q4, Q5	TRANSISTOR, Silicon PNP, 2N3905	HA-21564
	Transmitter Filter, Plug-in Assembly	HB-62600
	Tuned Transformer & B.F. Oscillator Assy.	HB-63300
	*** HB-21050 425 Hz FS TRANSMITTER (Also Applies To 595Hz)**	
* R1-R6, R8, R9, R11-R18	RESISTOR, fixed comp., ±5%, ¼ watt unless otherwise specified.	
R7	RESISTOR, variable, 250K, 0.1 watt, BD taper. CTS Corp., type PE200.	HA-14594
R10	RESISTOR, variable 500 ohms, 0.125 watt, BD taper, CTS Corp., type PE200.	HA-13573
C1	CAPACITOR, tantalum, 15μf ±20%, 25V, Mallory TAM156N025P5C.	H-1007-439
C3, C4, C5, C6	CAPACITOR, tantalum, 33μf ±20%, 10V, Mallory TAM336M010P5C.	H-1007-438
C2	CAPACITOR, mica, Elmenco Type DM20.	H-1080-X
C7	CAPACITOR, ceramic, 0.47μf +80% –20%, 25V, Sprague 5C11A.	HA-13579
Q1, Q2, Q3, Q4	TRANSISTOR, germanium, PNP, Texas Inst. 2N1375.	HA-17117
Q5	TRANSISTOR, silicon, NPN, Texas Inst., 2N706A.	HA-19928
	BP Filter and Osc. Assy. for HB-21055 and HB-21050 FS Transmitter.	HB-58500 or HB-58900
	BP Filter and Osc. Assy. for HB-21040 and HB-19925 FS Trans.& Mod.	HB58200
	Test Jacks, Sealectro Corp., SKT-10.	
	Filter cable connector, 3-terminal socket, Eby Sales Co.	HA-21091

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB-25160-1 RECEIVER LIMITER AND SIGNAL SUPERVISORY	
* R1, R3-R5, R8-R42	5%, ¼-watt, unless otherwise specified.	
R6	RESISTOR, metal film, 13K ±1%, 1/8 watt, I.R.C. Type CEA-T-O.	H-1510-778
R7	RESISTOR, metal film, 10K ±1%, 1/8 watt. I.R.C. Type CEA-T-O.	H-1510-775
R43	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite Type 995-1A	H-1100-423
R2	RESISTOR, variable, 500 ±20%, 0.125 watts, BD taper. C.T.S. PE-200	HA-25253
C1	CAPACITOR, poly., 0.0068 μF, 2% 400V. Wesco 32P.	H-5115-127
C3	CAPACITOR, mica, 320pF ±2% 500VDCW. Elmenco DM-19-391G.	HA-16628
C2	CAPACITOR, tantalum, 33μF, ±20%, 10V. Texas Inst., SCM336BP010D4.	H-1007-653
C4, C7, C8	CAPACITOR, tantalum, 1.0μF, ±20%, 35V. Texas Inst., SCM105FP035D4.	H-1007-496
C5, C6	CAPACITOR, tantalum, 15 μF, ±20%, 35V. Texas Inst., SCM156GP035D4.	H-1007-654
C9	CAPACITOR, tantalum, 0.47 μF, ±10%, 35V. Texas Inst., SCM474FP935D2.	H-1007-511
CR1, CR2, CR5 thru CR10	DIODE, silicon, 250mw Texas Inst., 1N914.	HA-24325
CR11	DIODE, silicon, 200 PIV. Diodes Inc. DI-42.	HA-17197
CR3, CR4	DIODE, zener, 5.1V ±5%, 1N4733A. Motorola IM5. Q 1ZS5.	HA-24328
Q1, Q2, Q4, Q5 Q7, Q8, Q9, Q11	TRANSISTOR, silicon, NPN, V_{CEO} 40V, TO-92 case, Motorola, 2N3903.	HA-21562
Q3, Q6, Q10, Q12	TRANSISTOR, silicon, PNP, V_{CEO} 40V, TO-92 case, Motorola, 2N3905.	HA-21564
Q13	TRANSISTOR, silicon, PNP, V_{CEO} 65V, TO-5 case. RCA 2N4036.	HA-24003
IC1	Integrated circuit, operational amplifier, Motorola MC1430, TO-5 case.	HA-25158
I1	Data lamp, red, 10VDC, 0.014A. Dialco No. 507-3910-1431-600.	HA-25156
	Lamp holder, Dialco No. 508-7538-504.	HA-17504
	Test jacks, Sealectro Corp. SKT-10.	
	HB25170 AND HB25130-2 F.S. DISCRIMINATOR AND D.C. AMPLIFIER	
* R2 thru R15, R17	±5%, ¼ watt, unless otherwise specified.	
R16	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite type 995-1A.	H-1100-423
R1	RESISTOR, variable, 5K ±30%, ¼ watt, linear C.T.S. PE-200.	HA-14655
C1	CAPACITOR, poly., 0.082 μF 2%, 100V. Wesco 32P.	H-5115-79
C2	CAPACITOR, mylar. 0.255 μF 2%, 100V. Wesco 32M.	H-1007-572
CR2	DIODE, zener, 6.8V ±5%, 1N14736-A, Motorola 1M6, 8ZS5.	HA-21504
CR1, CR3, CR4	DIODE, silicon, 200 PIV. Diodes Inc. DI-42.	HA-17197
Q1, Q2, Q3, Q4; Q5	TRANSISTOR, silicon NPN, V_{CEO} 40V., TO-92 case, Motorola 2N3903.	HA-21562
Q6	TRANSISTOR, silicon PNP, V_{CEO} 65V., TO-5 case, RCA 2N4036.	HA-24003
L1	Choke, 0.892 Hy.	HB-55201
I1	Datalamp, red cartridge, 0.014A, 10VDC. Dialco 507-3910-1431-600.	HA-25156
	Lampholder, Dialco 508-7538-504.	HA-17504
	Test jacks, Sealectro Corp., SKT-10.	
	Discriminator plug-in assembly.	HB-62700

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB25130-2 THESE PARTS ARE IN ADDITION TO PARTS LISTED ON PRECEDING PAGE	
R18 thru R27	±5%, ¼ watt unless otherwise specified	
R28	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite type 995-1A.	H-1100-423
CR5	DIODE, zener, 6.8V ±5%, 1N14736-A, Motorola 1M6, 8ZS5.	HA-21504
CR6	DIODE, silicon, 200 PIV, Diodes, Inc. DI-42.	HA-17197
Q7, Q8, Q9	TRANSISTOR, silicon PNP, V_{CEO} 40V., TO-92 case. Motorola 2N3905.	HA-21564
Q10	TRANSISTOR, silicon NPN, V_{CEO} 65V., TO-5 case. RCA 2N2102.	HA-22678
I2	Datalamp, amber cartridge, 0.014A, 10VDC. Dialco 507-3910-1433-600. Lampholder, Dialco 508-7538-504.	HA-25784 HA-17504
	HB-25150 LINE LEVEL – NOISE SUPERVISORY MODULE	
* R1, R2, R4-R8, R11-R16, R18, R21-R42	±5%, ¼ watt, unless otherwise specified.	
R9, R10	RESISTOR, wirewound, 600 ±5%, 1½ watt. Ohmite 995-1A.	H-1100-442
R43	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-423
R19	RESISTOR, metal film, 121 ±1%, 1/8 watt. I.R.C. Type CEA T-O	H-1510-777
R20	RESISTOR, metal film, 100 ±1%, 1/8 watt. I.R.C. Type CEA T-O	H-1510-714
R3	RESISTOR, variable, 500 ±20%, 0.125 watts, BD taper. C.T.S. Type-200	HA-25253
R17	RESISTOR, variable, 2.5K ±20%, 0.125 watts, A taper. C.T.S. Type PE-200	HA-19919
C1	CAPACITOR, poly., 0.0068 μF ±2%, 400VDC, Wesco 32P.	H-5115-127
C6	CAPACITOR, poly., 0.02 μF ±2%, 100VDC Balco PTWP.	H-5115-49
C3, C8	CAPACITOR, mica, 390pF ±2%, 500WVDC Elemenco DM-19-391-G.	HA-16628
C2, C7	CAPACITOR, tantalum, 33μF ±20%, 10VDC. Texas Inst. SCM336BP010D4.	H-1007-653
C4, C9, C11	CAPACITOR, tantalum, 1.0μF ±20%, 35VDC. Texas Inst. SCM105FP035D4.	H-1007-496
C5, C10, C13, C14	CAPACITOR, tantalum, 15μF ±20%, 35VDC, Texas Inst. SCM156GP035D4.	H-1007-654
C12	CAPACITOR, tantalum, 0.47μF ±10%, 35VDC, Texas Inst. SCM474FP035D2.	H-1007-511
CR1 thru CR4 CR7 thru CR11	DIODE, silicon, 250 mw. Texas Inst., or G.E. Type 1N924.	HA-24325
CR12	DIODE, silicon, 200PIV, Diodes Inc., DI-42.	HA-17197
CR5, CR6	DIODE, zener, 5.1V ±5%, 1N4733A. Motorola IM5. 1ZS5.	HA-24328
IC1, IC2	Operational amplifier, TO-5 case. Motorola MC-1430.	HA-25158
Q3, Q4, Q5, Q7, Q8	TRANSISTOR, silicon, NPN, V_{CEO} 40V, TO-92, Motorola 2N3903.	HA-21562
Q6	TRANSISTOR, silicon, PNP, V_{CEO} 40V, TO-92, Motorola 2N3905.	HA-21564
Q1, Q2	TRANSISTOR, silicon, NPN, V_{CEO} 65V, TO-5, RCA 2N2102.	HA-22678
Q9	TRANSISTOR, silicon, PNP, V_{CEO} 65V, TO-5, RCA 2N4036.	HA-24003
T1, T2, T3	TRANSFORMER, 2.5K: 2.5K C.T. Microtran MMT 19-FB.	HA-25157
I1	Data Lamp, red cartridge. Dialco 507-3910-1431-600. Lamp holder, Dialco 508-7538-504. Test jacks, Sealectro Corp., SKT-10	HA-25156 HA-17504

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB25190 48 VDC, D.C. TO D.C. CONVERTER	
R3, R4	RESISTOR, fixed comp., 24 ±5%, ¼ watt.	H-1009-827
R6, R7	RESISTOR, wirewound, 2.5K ±5%, 3¼ watt. Ohmite 995-3A.	H-1100-329
R1	RESISTOR, wirewound, 5K ±5%, 3¼ watt. Ohmite 995-3A.	H-1100-460
R5	RESISTOR, wirewound, 50 ±3%, 10 watt. Dale Electronics RH-10.	HA-23709
C1	CAPACITOR, elect., 80μF, 150VDC. Cornell Dubilier BR80-150.	H-1007-395
C2	CAPACITOR, met. paper, 0.047μF, 200W VDC. Cornel Dubilier MPY-2S47.	H-1007-674
C3	CAPACITOR, paper, 0.022μF ±10%, 1000VDC. Aerovox V161-615.	H-1007-696
C4, C5	CAPACITOR, ELECT., 100μF, 50VDC. Cornell Dubilier BR-100-50.	H-1007-209
CR1 thru CR9	DIODE, silicon, 200 PIV, 1 Amp. Diodes Inc. SD-2.	HA-17995
Q1, Q2	TRANSISTOR, silicon NPN, V_{CEO} 175V, TO-66. RCA 2N3583.	HA-21847
T1	TRANSFORMER, saturable core.	HB-25182
I1	LAMP, cartridge, red, 10VDC, 0.014A. Dialco 507-3910-1431-600.	HA-25156
I2	LAMP, cartridge, amber, 10VDC, 0.014A. Dialco 507-3910-1433-600.	HA-25784
	LAMPHOLDER. Dialco 508-7538-504.	HA-17504
S1	SWITCH, push button. Leviton #579.	HA-13554
F1	FUSE, 3AG. 0.5 AMP.	HA-9348
	SOCKET, TO-66 transistor mt'g. UID Electronics PTS-4.	HA-21848
	INSULATOR, mica, TO-66 transistor mt'g. Reliance Mica Co. DF-31-A.	HA-23658
	TEST JACKS, Sealectro Corp., SKT-10.	
	HB25200 125 VDC, D.C. TO D.C. CONVERTER	
R3, R4	RESISTOR, fixed comp., 100 ±5%, ¼ watt.	H-1009-758
R6	RESISTOR, fixed comp., 100K ±5%, ½ watt.	H-1009-348
R7	RESISTOR, fixed comp., 56K ±5%, ½ watt.	H-1009-815
R5	RESISTOR, wirewound, 100 ±3%, 10 watt.	HA-23650
R1	RESISTOR, fixed comp., 39K ±5%, 2 watt.	H-1009-885
C1	CAPACITOR, elect., 80μF, 150VDC. Cornell Dubilier BR80-150.	H-1007-395
C2	CAPACITOR, met. paper, 0.022μF, 400 W VDC. Cornell Dubilier MPY-4S22.	H-1007-637
C3	CAPACITOR, paper, 0.022μF ± 10%, 1000VDC. Aerovox V161-615.	H-1007-696
C4, C5	CAPACITOR, elect., 100μF, 50 W VDC. Cornell Dubilier BR-100-50.	H-1007-209
CR1 thru CR11	DIODE, silicon, 200 PIV, 1 Amp. Diodes Inc., SD-2.	HA-17995
Q1, Q2	TRANSISTOR, silicon NPN, V_{CEO} 300V, TO-66. RCA 2N3585.	HA-22593
T1	TRANSFORMER, saturable core.	HB-25183
I1	LAMP, cartridge, red, neon, 105/125VDC. Dialco 507-3835-0931-600.	HA-25203
I2	LAMP, cartridge, amber, neon, 105/125VDC. Dialco 507-3835-0933-600.	HA-25204
	LAMPHOLDER. Dialco 508-7538-504.	HA-17504
S1	SWITCH, push button. Leviton #579	HA-13554
F1	FUSE, 3AG, 0.2A., Slo-Blo.	HA-14691
	SOCKET, TO-66 transistor mt'g. UID Electronics PTS-4.	HA-21848
	INSULATOR, mica, transistor mt'g. Reliance Mica Co. DF-31-A.	HA-23658
	TEST JACKS, Sealectro Corp., SKT-10.	

ELECTRICAL PARTS LIST

DIAGRAM SYMBOL	NAME OF PART AND DESCRIPTION	PART NO.
	HB-25210 VOLTAGE REGULATOR	
* R17,R21-R28,R31	±5%, ¼ watt, unless otherwise specified.	
R1, R9	RESISTOR, wirewound, 2.2K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-448
R3, R10, R29	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-423
R5, R13	RESISTOR, wirewound, 1K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-429
R6, R16	RESISTOR, wirewound, 820 ±5%, 1½ watt.	H-1100-443
R8, R14	RESISTOR, wirewound, 2K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-422
R30	RESISTOR, wirewound, 1.6K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-543
R2, R11	RESISTOR, wirewound, 75 ±5%, 3 watt. Ohmite 995-3A.	HA-13863
R4, R12	RESISTOR, wirewound, 56 ±5%, 3 watt. Ohmite 995-3A.	H-1100-541
R18, R20	RESISTOR, wirewound, 5.6K ±5%, 3 watt. Ohmite 995-3A.	H-1100-542
R7, R15	RESISTOR, variable wirewound, 1000 ohms. Muter Co. 50-2200 Series	HA-12578
R19	RESISTOR, variable wirewound, 5000 ohms. Muter Co. 50-2200 Series	HA-20924
C1, C4	CAPACITOR, mica, 91pF ±5%, 500V. Elemenco DM-15-910J.	HA-16521
C2, C5	CAPACITOR, tantalum, 15μF, ±20%, 35VDC. Texas Inst., SCM156GP035D4.	H-1007-654
C3, C6	CAPACITOR, elect., 500μF, 50VDC. Sprague TVA-1315.	HA-13569
CR1, CR2	DIODE, zener, 12V ±5%. Diodes Inc. 1D12B.	HA-12920
CR3	DIODE, zener, 18V ±5%. Diodes Inc. 1D18B.	HA-25217
CR4	DIODE, silicon, 200 PIV. Diodes Inc. DI-42,	HA-17197
Q7, Q8	TRANSISTOR, silicon NPN, V_{CEO} 40V, TO-92. Motorola 2N3903.	HA-21562
Q10, Q11	TRANSISTOR, silicon PNP, V_{CEO} 40V, TO-92. Motorola 2N3905.	HA-21564
Q1, Q2, Q12	TRANSISTOR, silicon NPN, V_{CEO} 65V, TO-5. RCA 2N2102.	HA-22678
Q4, Q5, Q9	TRANSISTOR, silicon PNP, V_{CEO} 65V, TO-5. RCA 2N4036.	HA-24003
Q3	TRANSISTOR, silicon NPN, V_{CEO} 60V, TO-3. Motorola 2N3055.	HA-24327
Q6	TRANSISTOR, germanium PNP, V_{CEO} 50V, TO-3. RCA 2N2869/2N301.	HA-17992
	TRANSISTOR socket, TO-3. Augat Bros. 8043-1G3.	HA-18538
	INSULATOR, mica, TO-3 transistor mt'g. Reliance Mica Co. 732	HA-11964
I1	LAMP, cartridge, amber, 10VDC., 0.014A. Dialco 507-3910-1433-600.	HA-25784
	LAMPHOLDER, Dialco 508-7538-504.	HA-17504
	TEST JACKS, Sealectro Corp. SKT-10.	

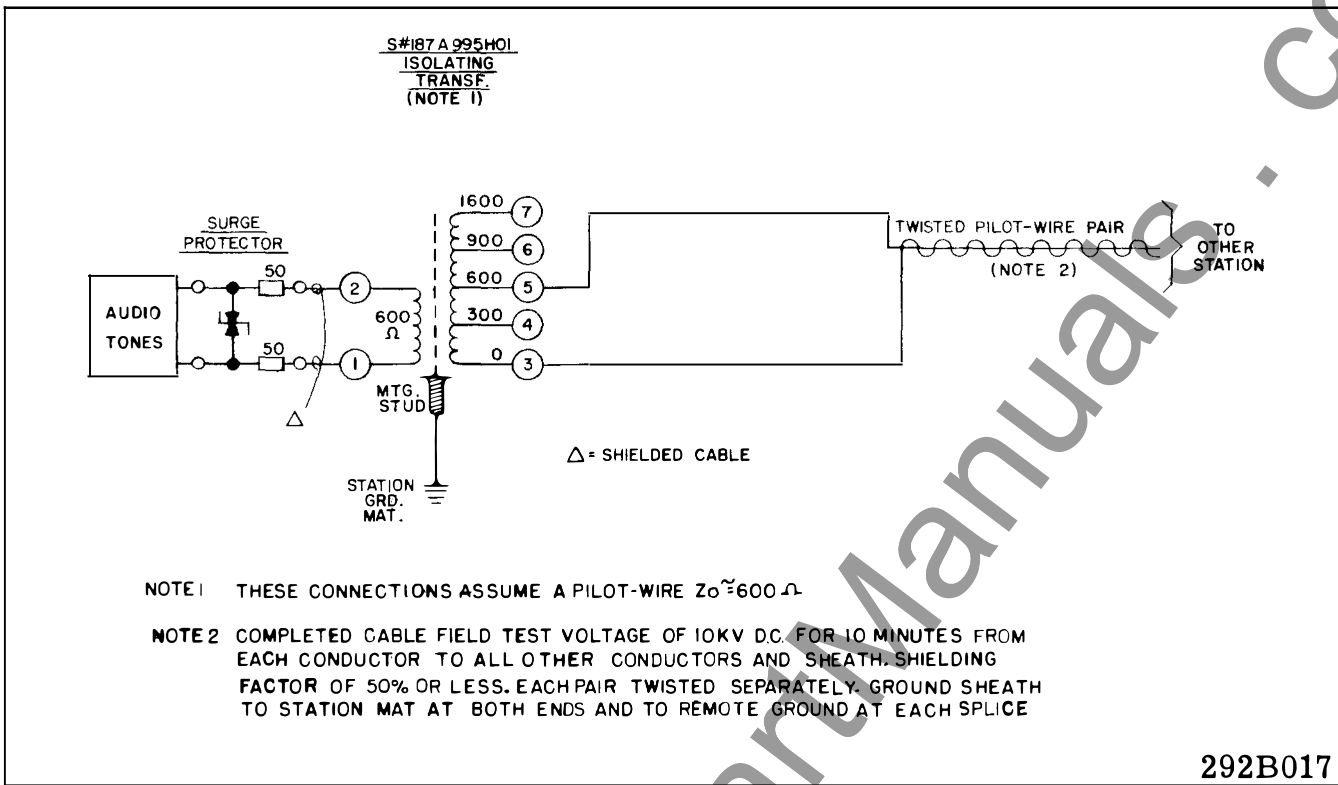
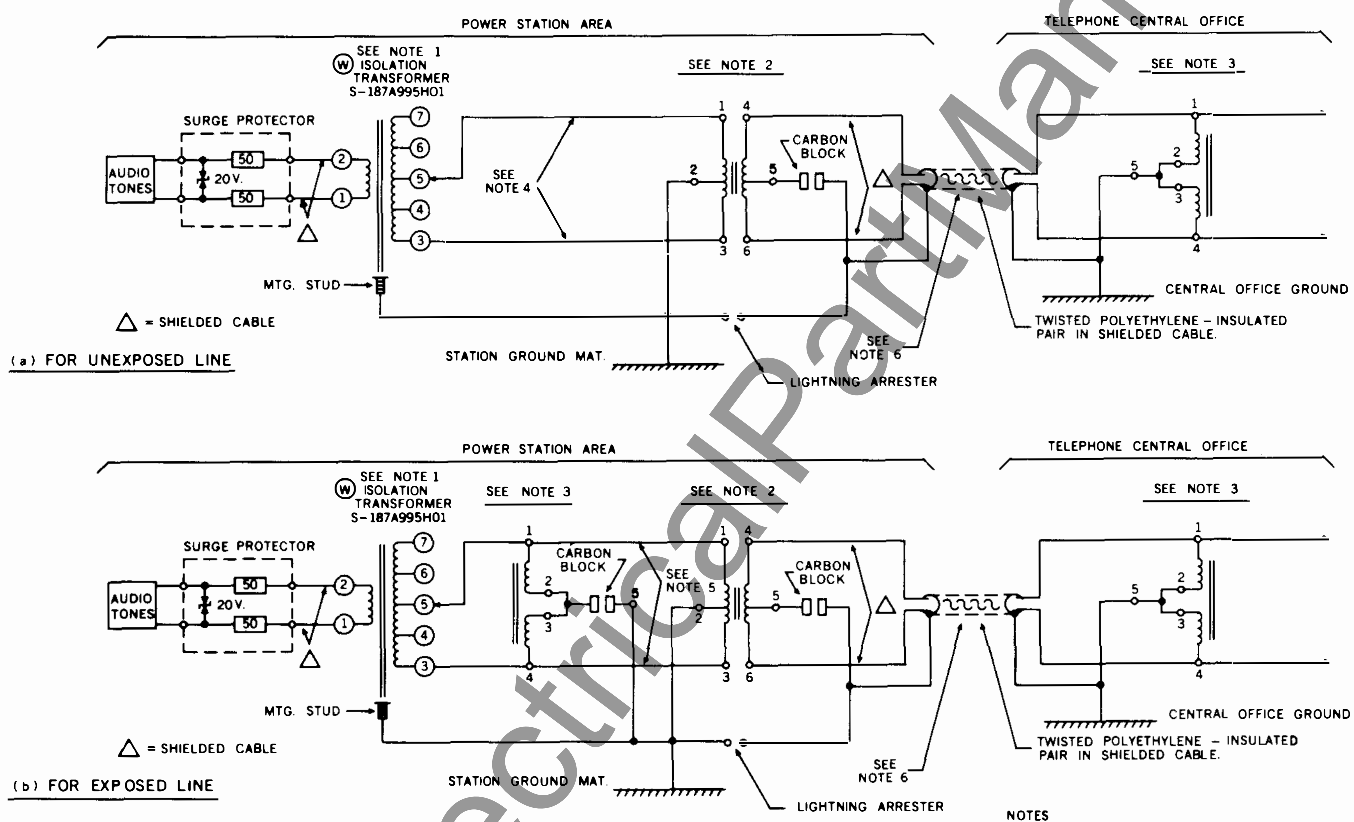


Fig. 1. Recommended Connections and Pilot Wire Design for Privately Owned Two-Terminal Lines.



NOTES

1. PRIMARILY USED FOR IMPEDANCE - MATCHING PURPOSE.
2. WESTERN ELECTRIC INSULATING TRANSF. TYPE 2239A OR EQUIV.
3. WESTERN ELECTRIC DRAINAGE REACTOR TYPE 2232A OR EQUIV.
4. UNEXPOSED LINE - MAX. EXTERIOR DISTANCE ABOUT 75FT. - USE SHIELDED CABLE.
5. EXPOSED LINE WITH EXTERIOR DISTANCE OVER 75FT. AND EXPOSED TO LIGHTNING, POWER-SYSTEM CONTACT, AND POWER INDUCTION - USE SHIELDED CABLE.
6. ISOLATE SHIELD FROM GROUND UNTIL OUT OF SIGNIFICANT INFLUENCE OF STATION GROUND POTENTIAL.

205C508

* *Fig. 2. Recommended Connections and Protective Arrangements for Two-Terminal Lines*

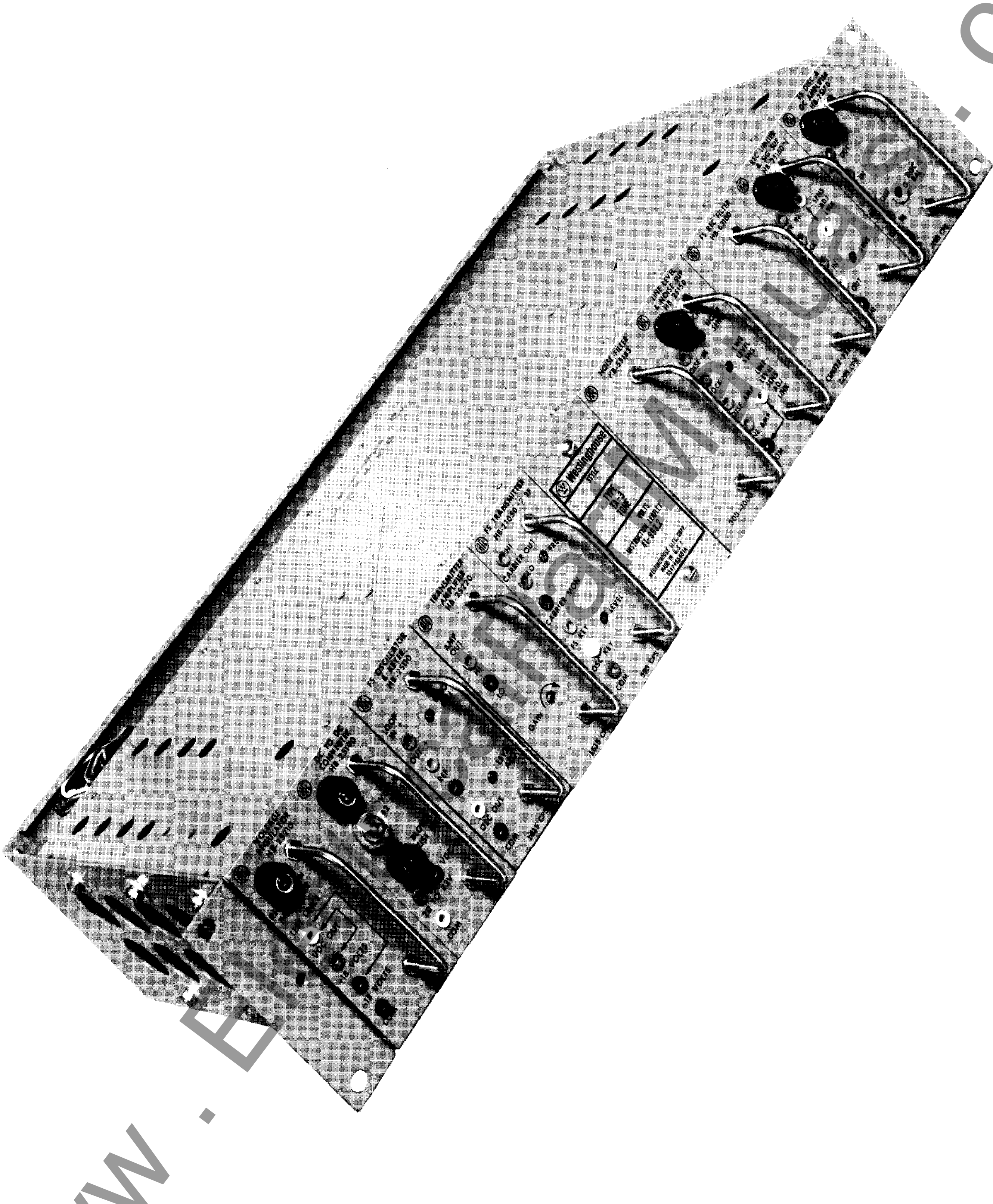


Fig. 3. Front View of Full Chassis.

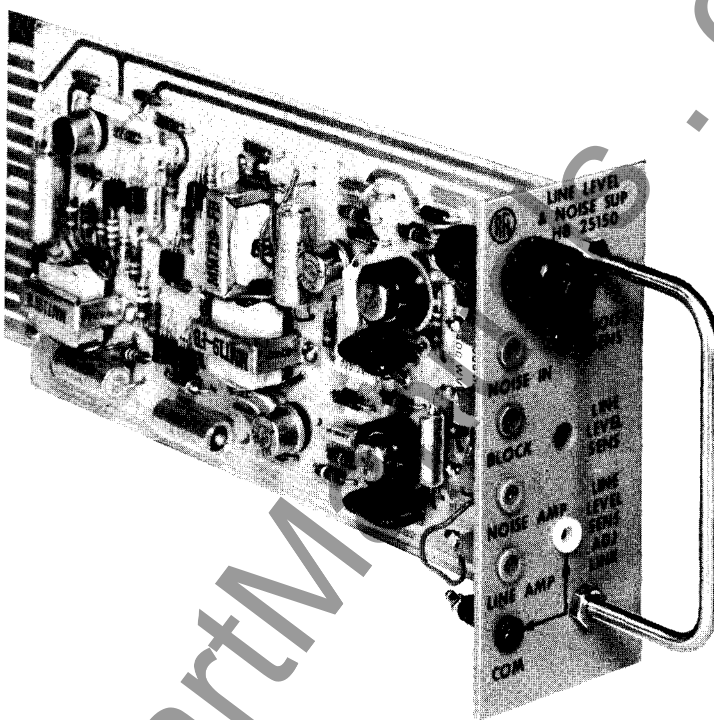
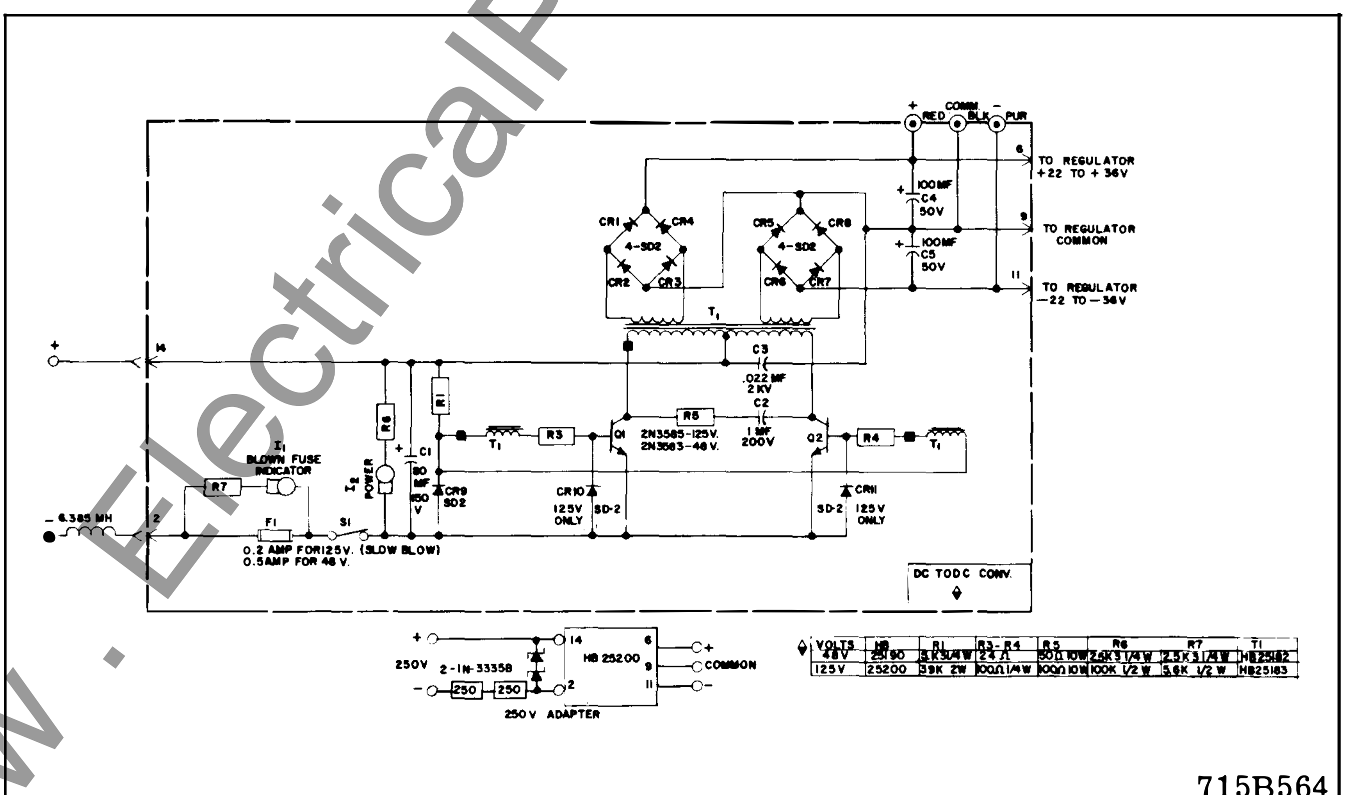
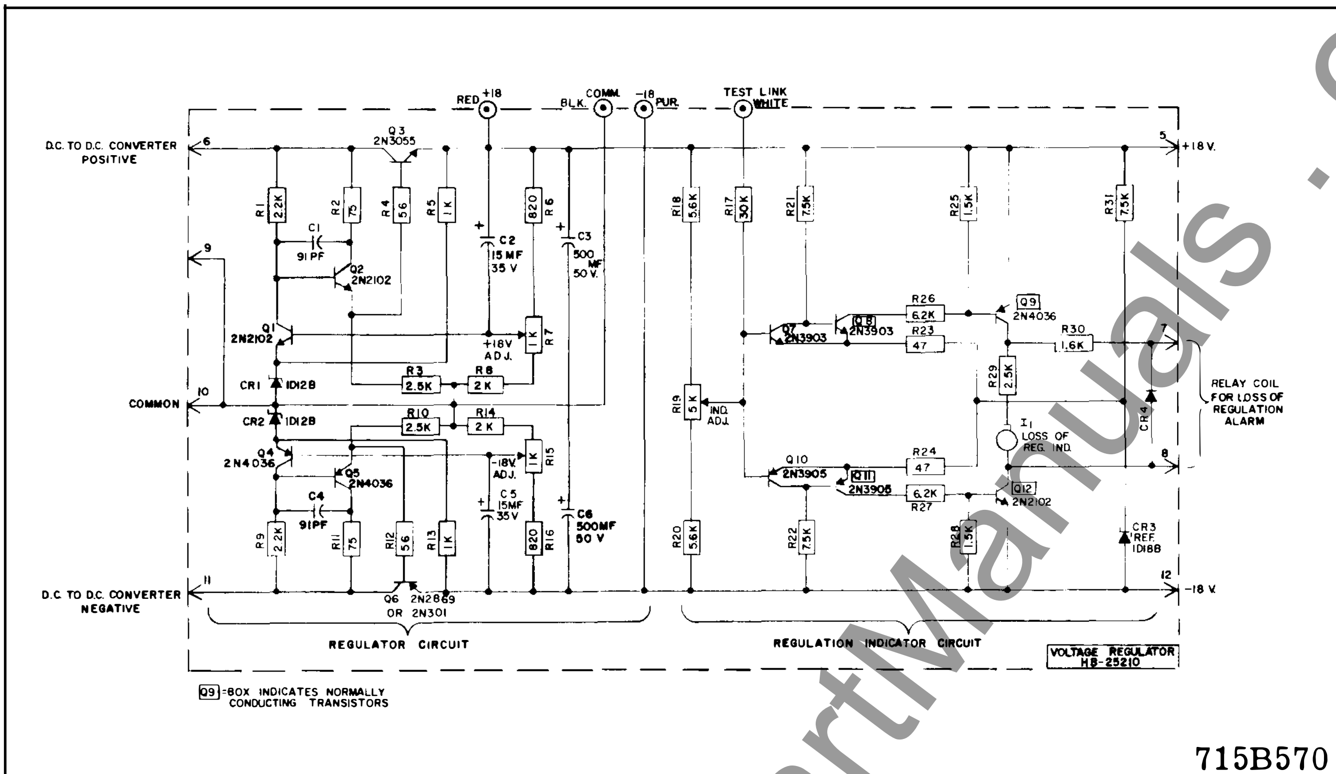


Fig. 4. Typical Module.

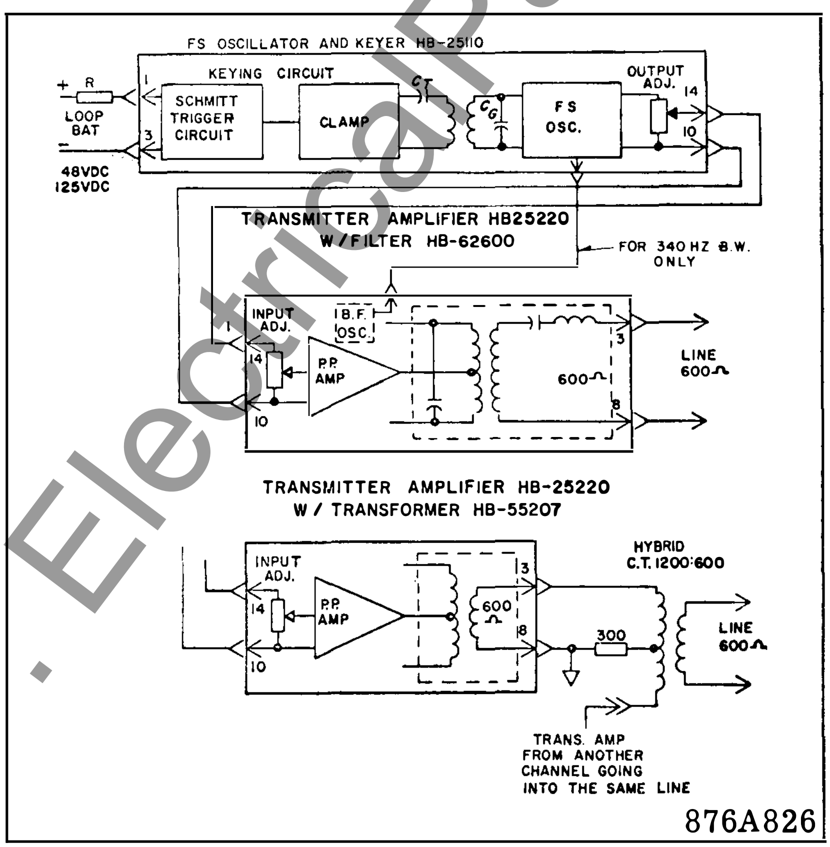


VOLTS	HB	R1	R3-R4	R5	R6	R7	T1
48V	25190	5.1K 3/4 W	24 Ω	50Ω 10W	2.5K 3 1/4 W	2.5K 3 1/4 W	HB25182
125V	25200	39K 2W	100Ω 1/4W	100Ω 10W	100K 1/2 W	5.6K 1/2 W	HB25183

Fig. 5. Power Supply HB-25190 and HB-25200.



* *Fig. 6. Voltage Regulator HB-25210.*



* *Fig. 7. Transmitter Block Diagram.*

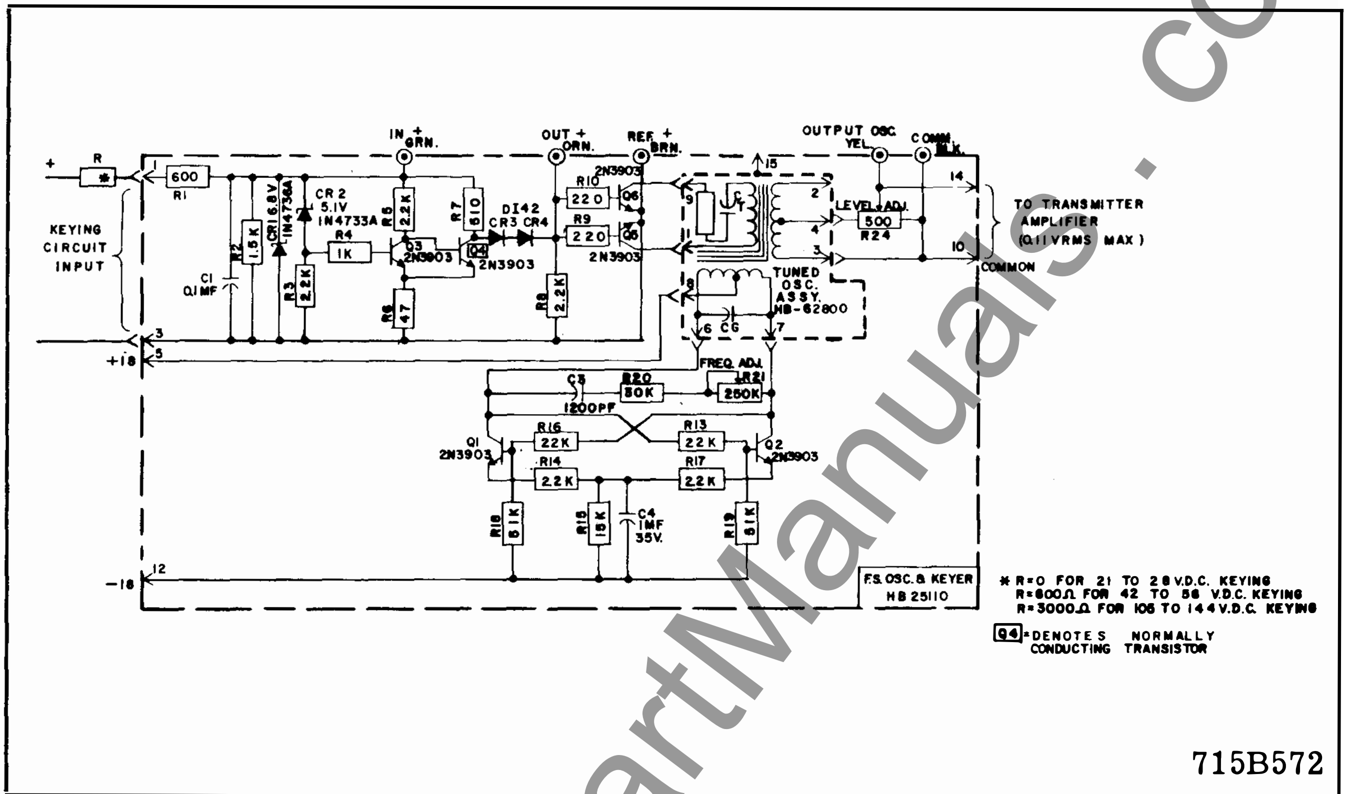
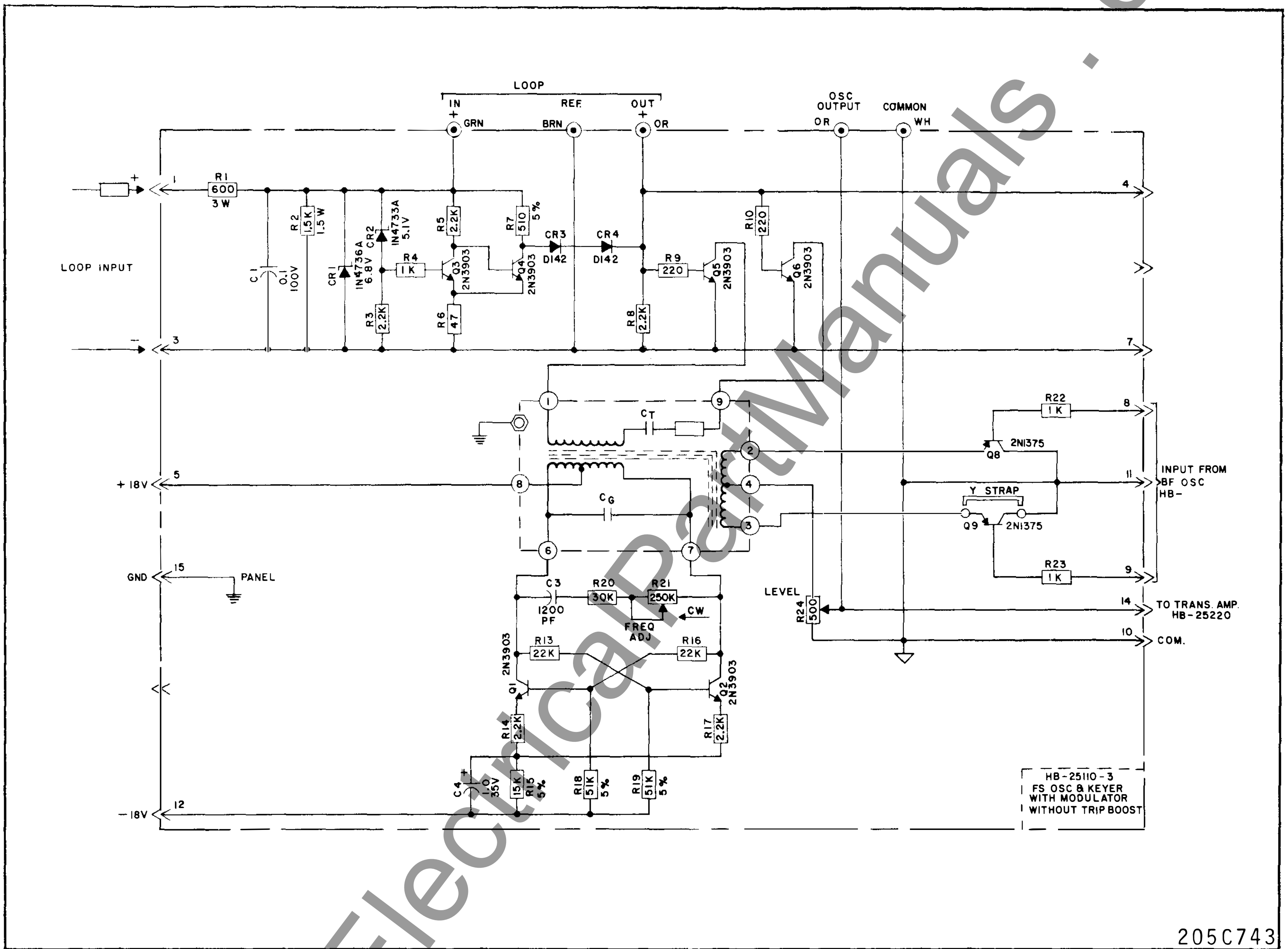
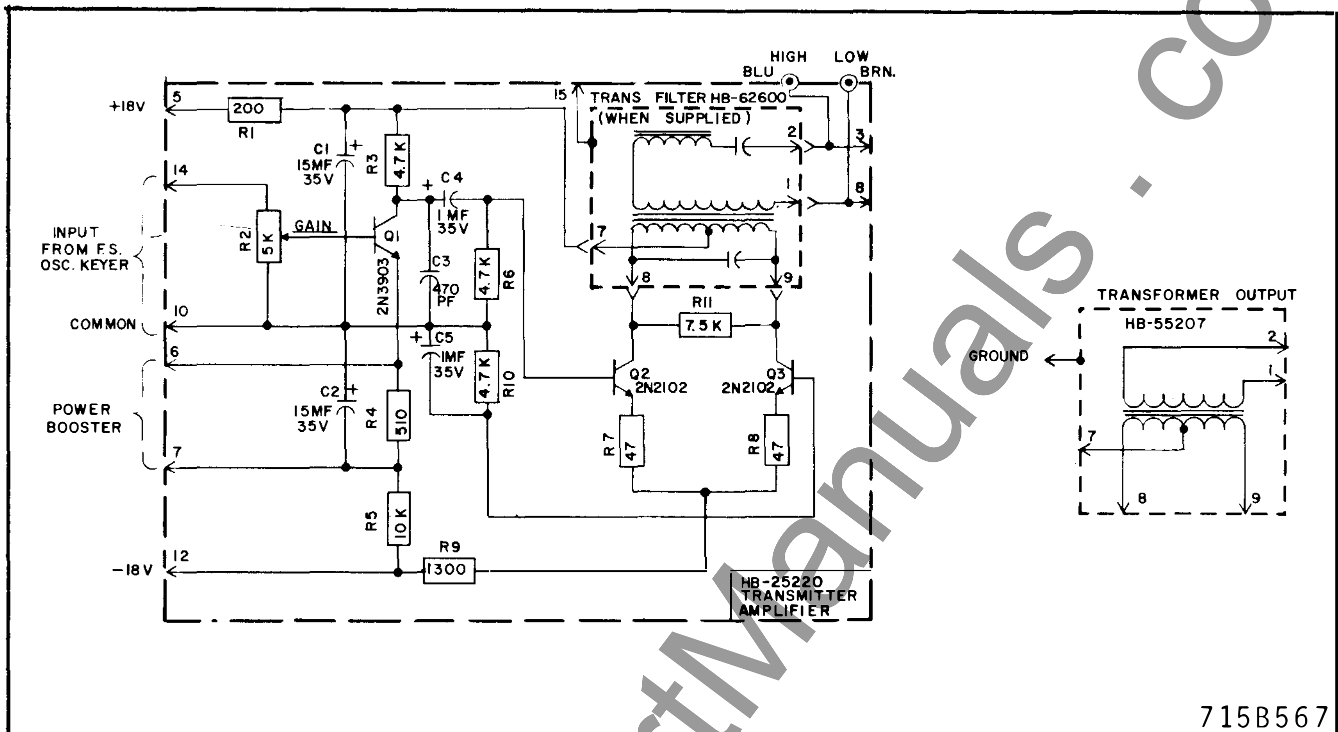


Fig. 8. F.S. Oscillator and Keyer HB-25610.



✱ Fig. 9. F.S. Oscillator and Keyer HB25110-3.



* *Fig. 10. Transmitter Amplifier HB-25220.*

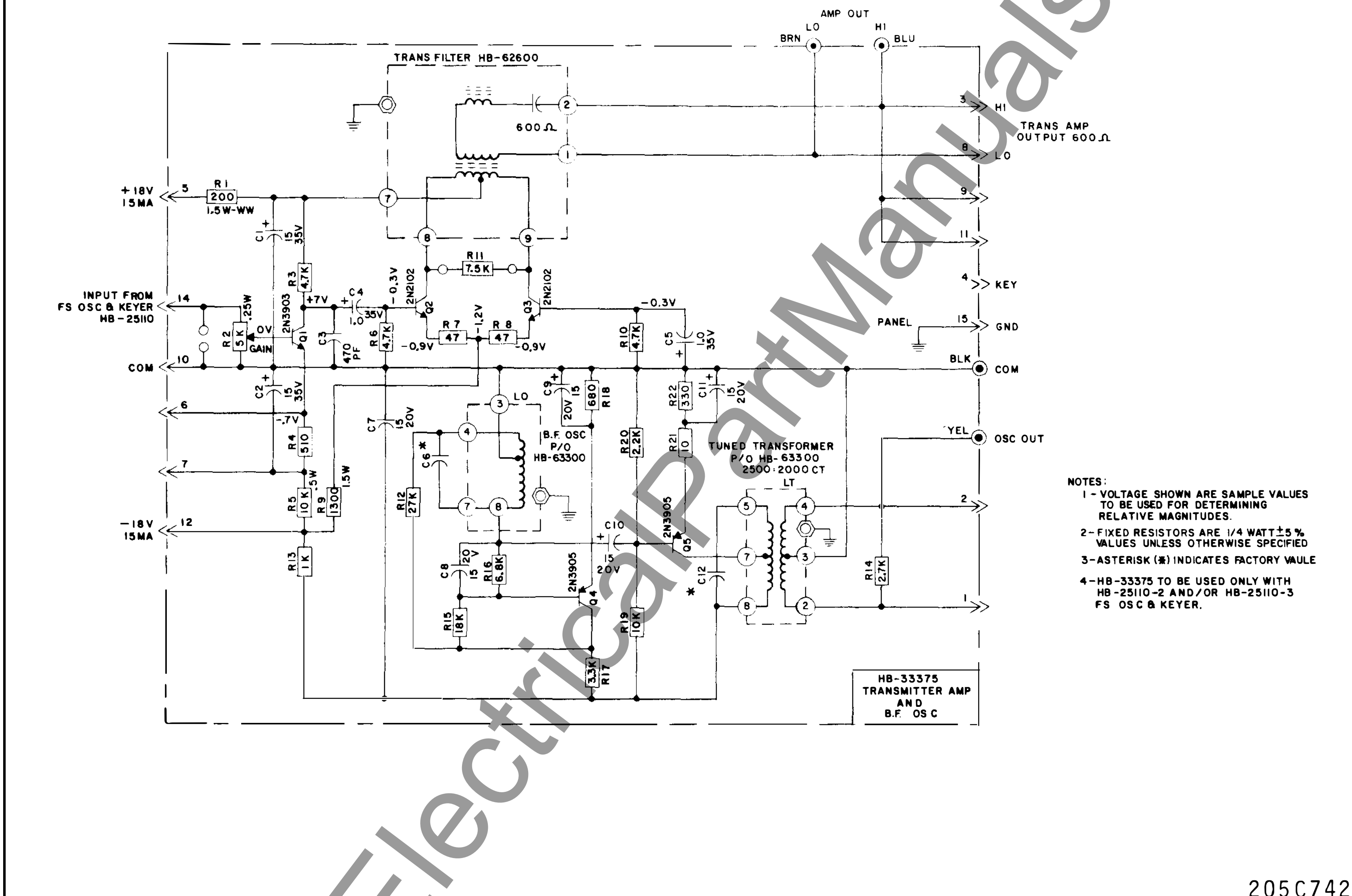


*Fig. 11. Transmitter Amplifier HB-33375.

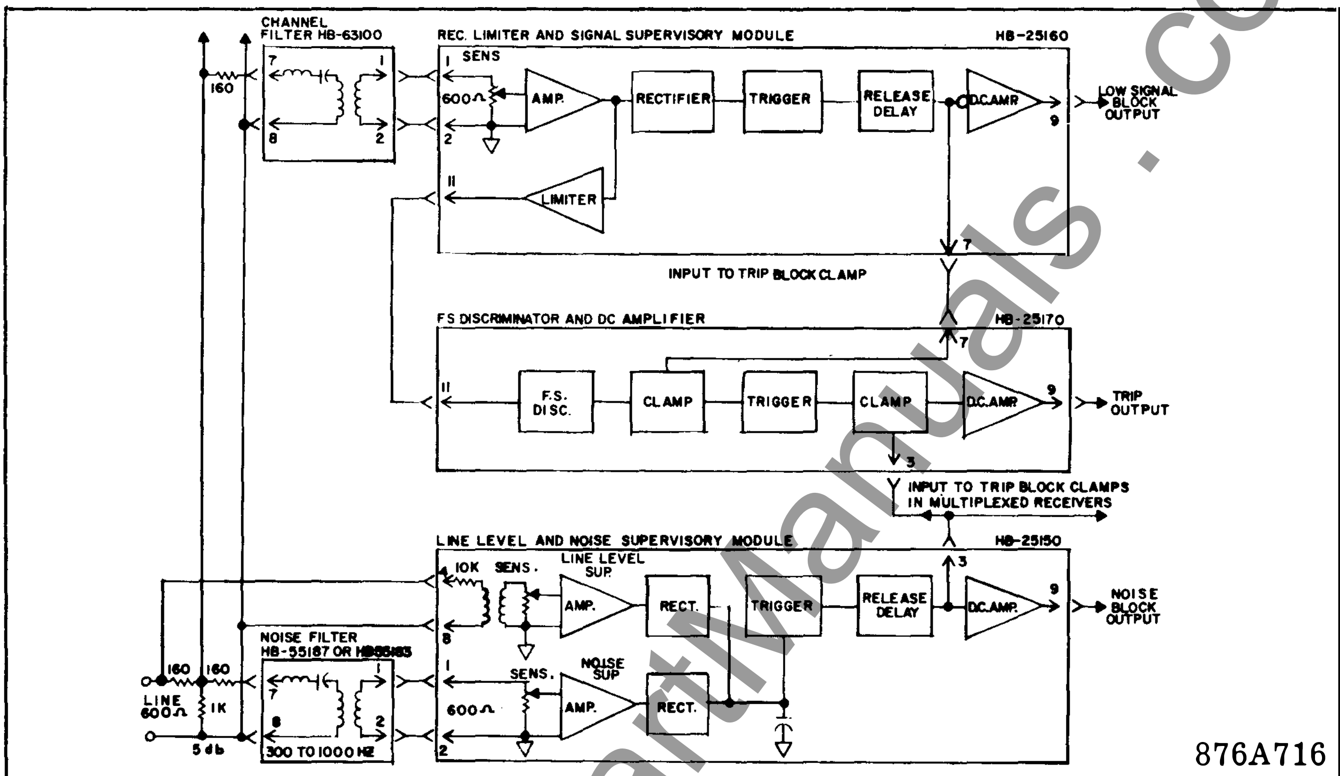


Fig. 12. Receiver Block Diagram HB-63100.

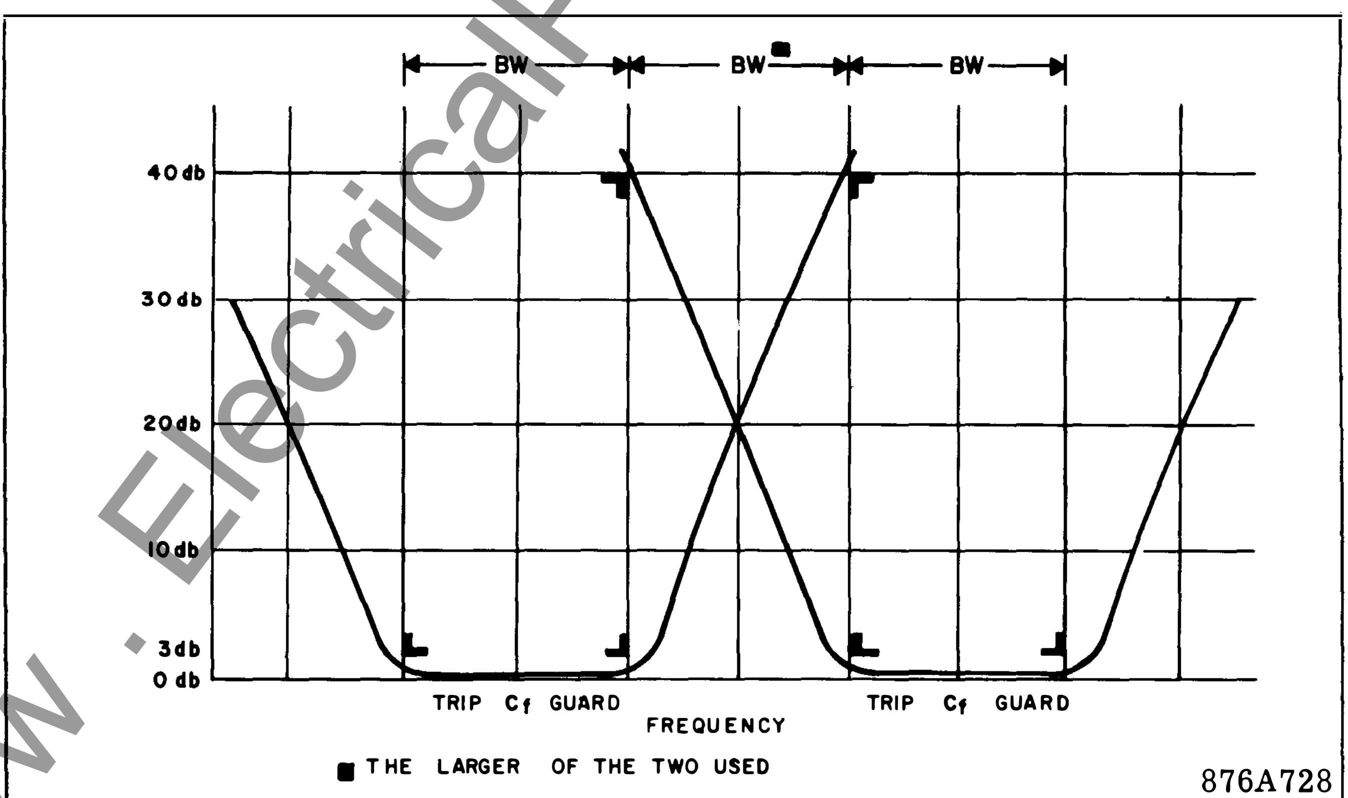


Fig. 13. Tone Receiver Filter Characteristics HB-63100.

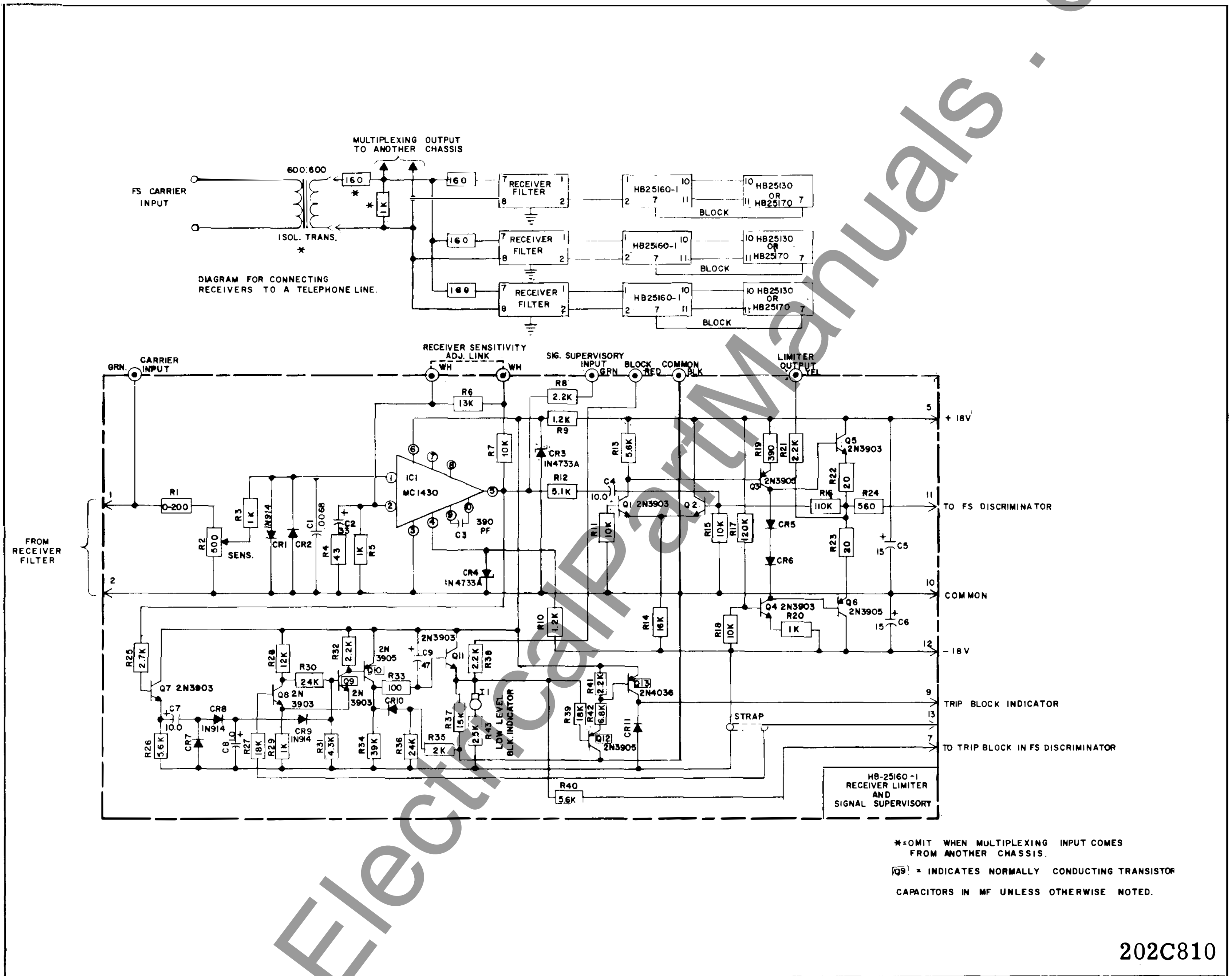
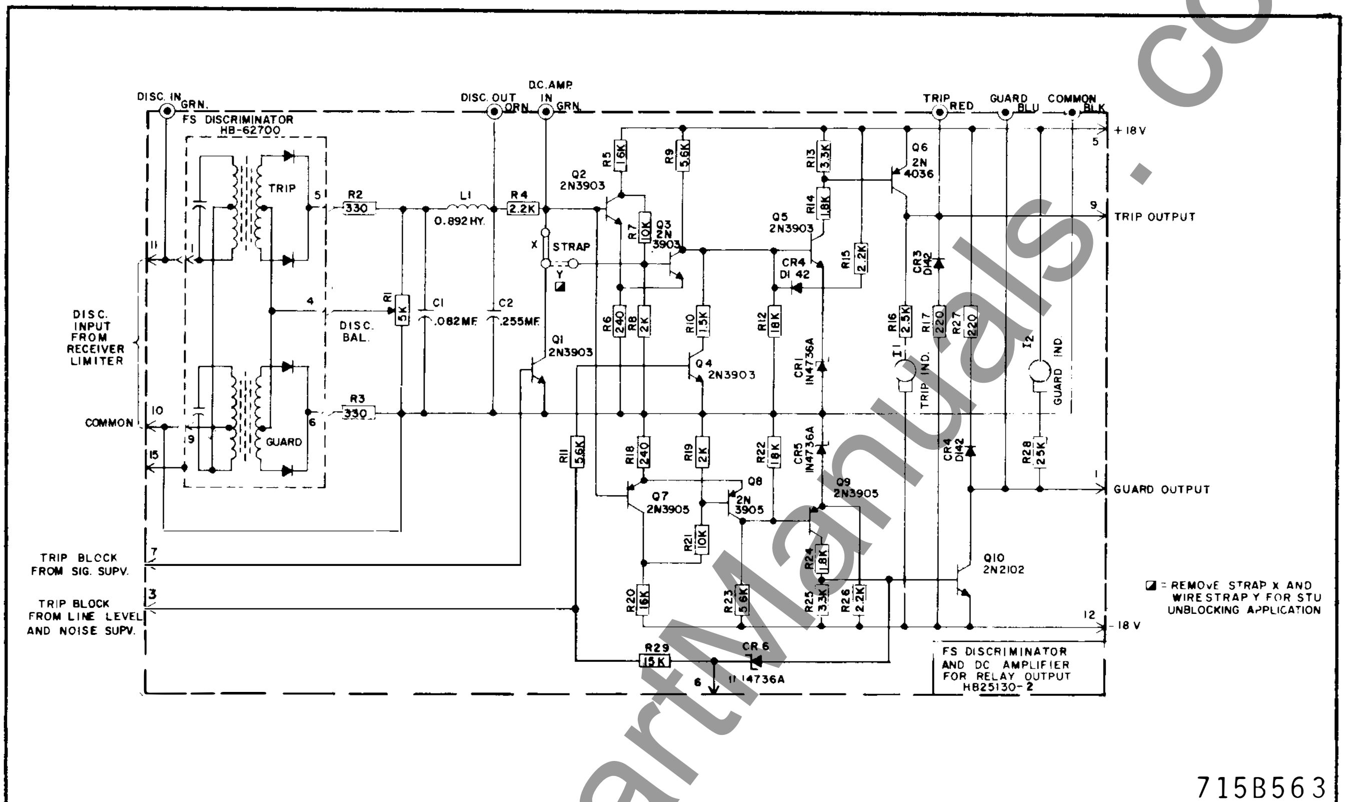


Fig. 14. Receiver Limiter and Signal Supervisory HB-25160-1.



* *Fig. 15. F.S. Discriminator and D-C Amplifier for Relay Output HB-25130-2.*

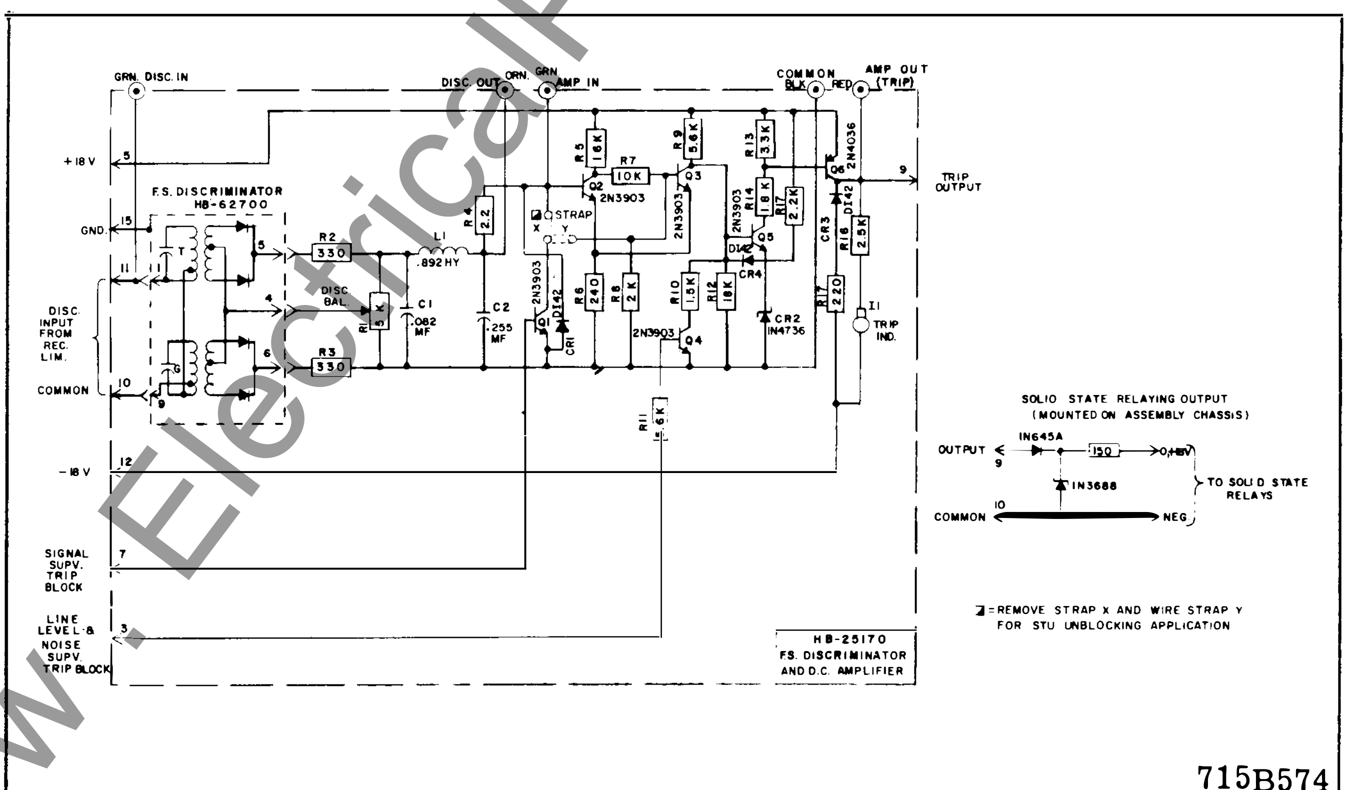


Fig. 16. F.S. Discriminator and D-C Amplifier for Solid-State Relaying HB-25170.

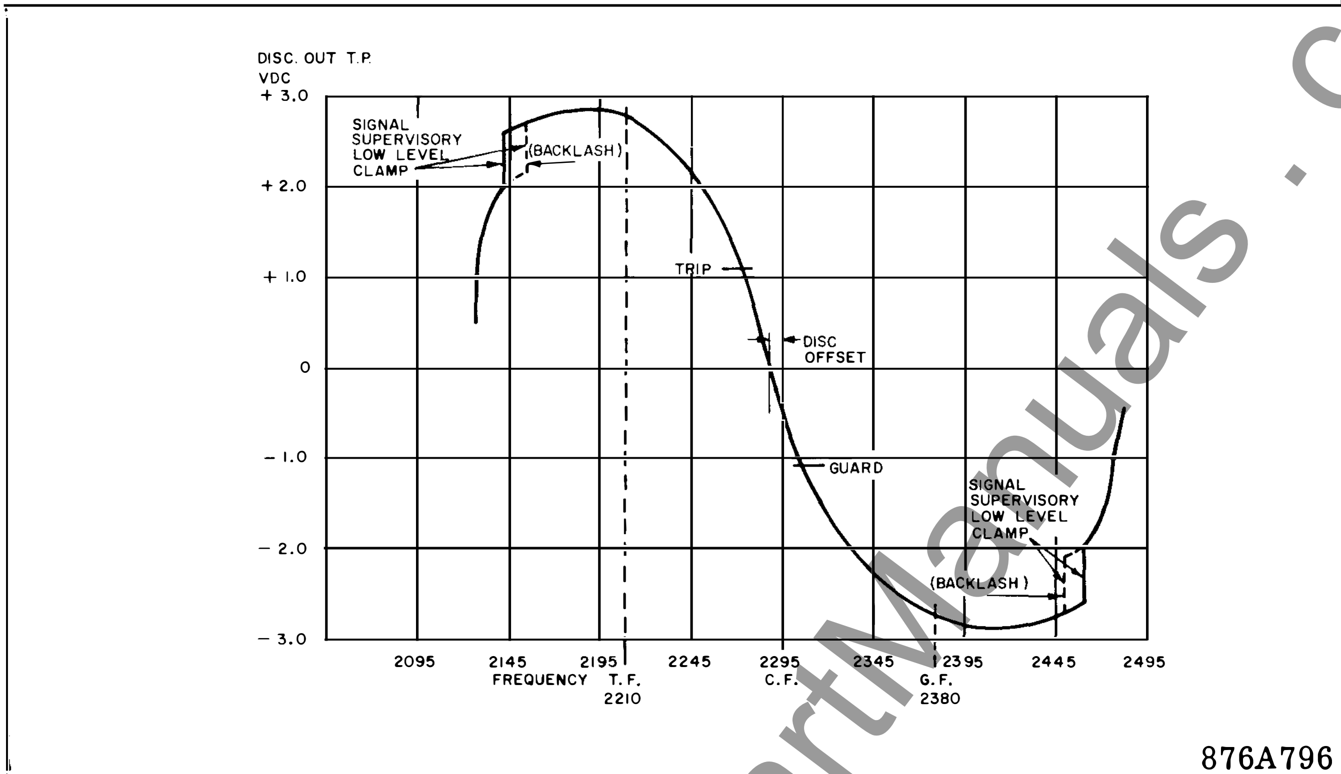
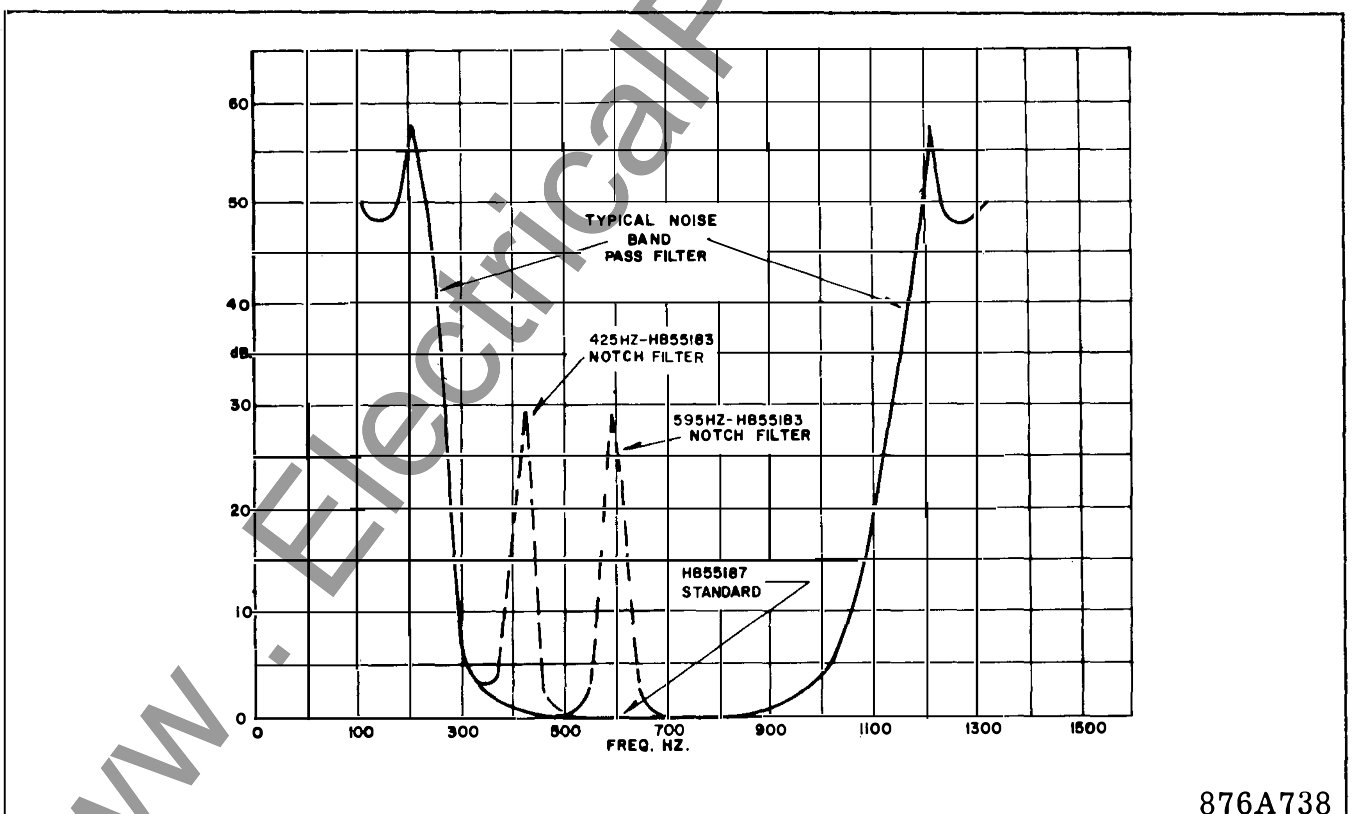


Fig. 17. Typical Discriminator Output.



* *Fig. 18. Typical Noise Bandpass Filter.*

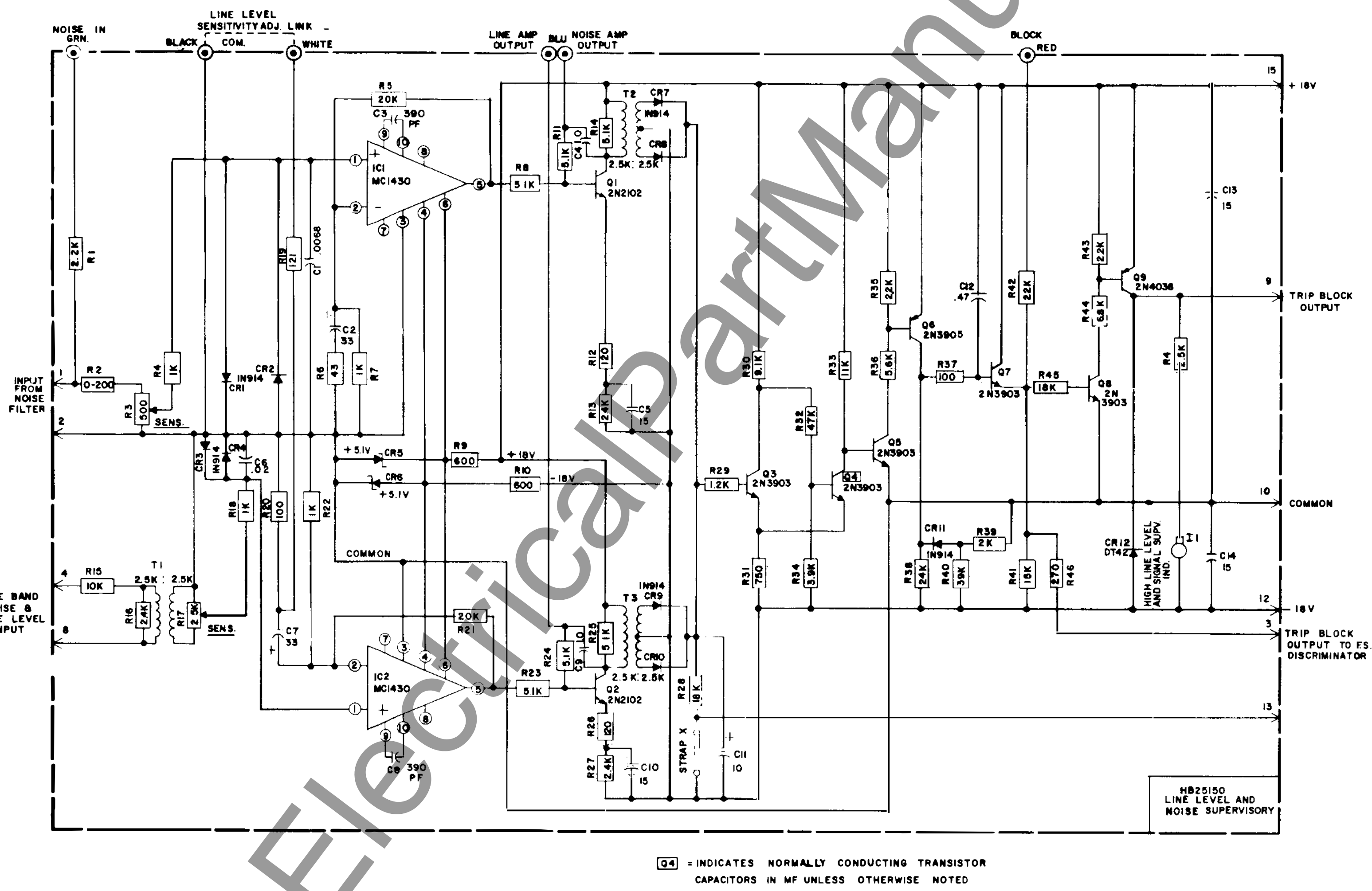
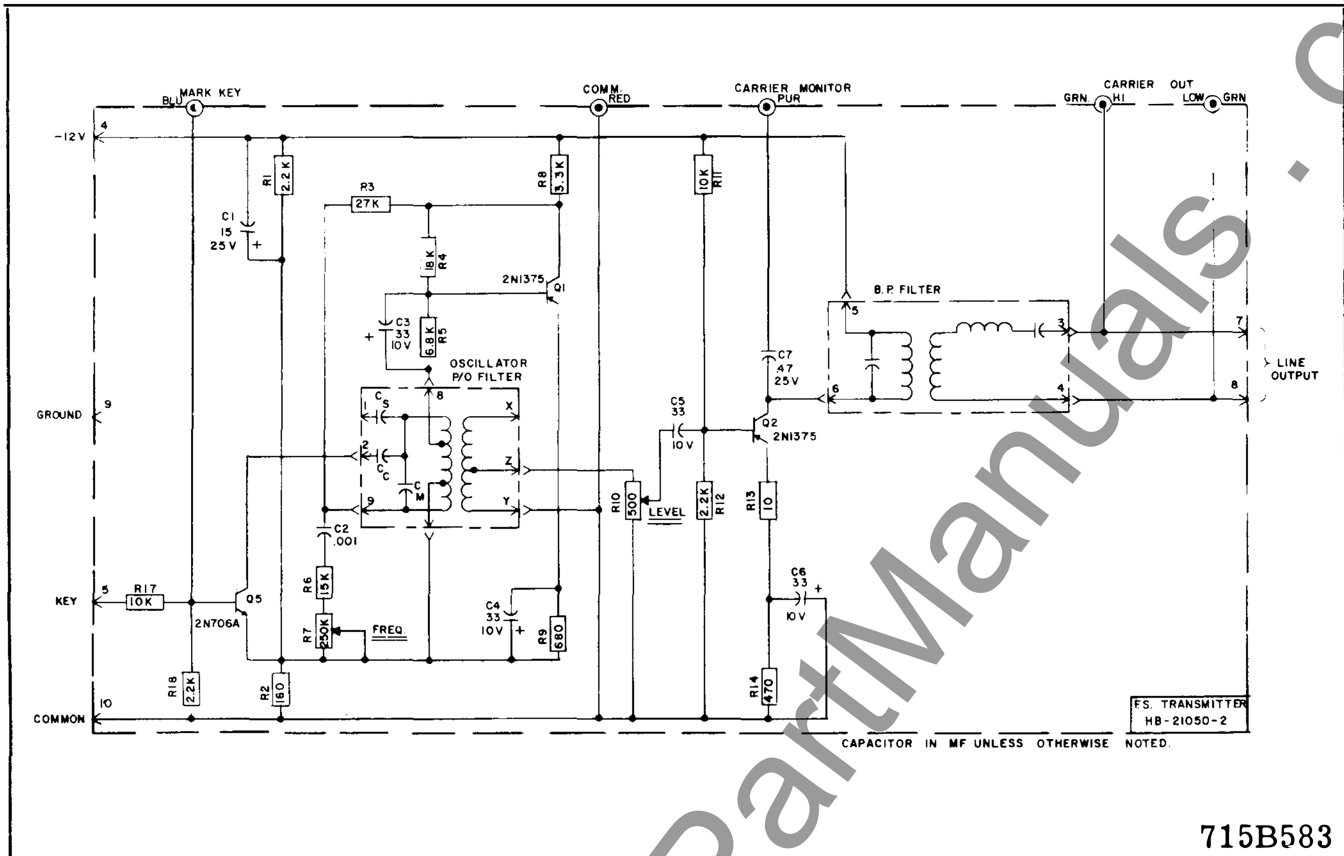


Fig. 19. Receiver Line Level and Noise Supervisory Module HB-25150.



* *Fig. 20. 425-Hz Transmitter HB-21050-2.*

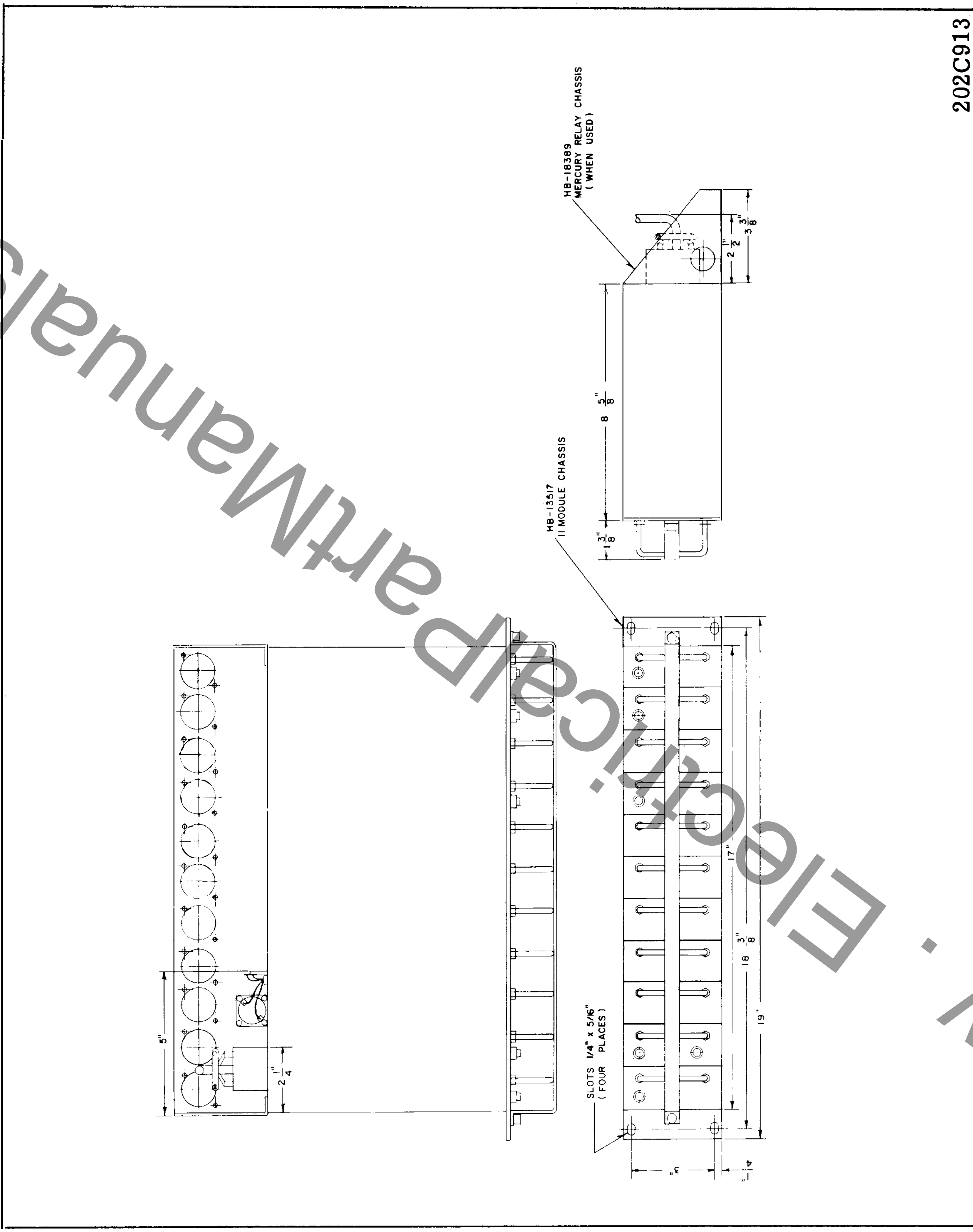


Fig. 21. Outline and Drilling Plan.

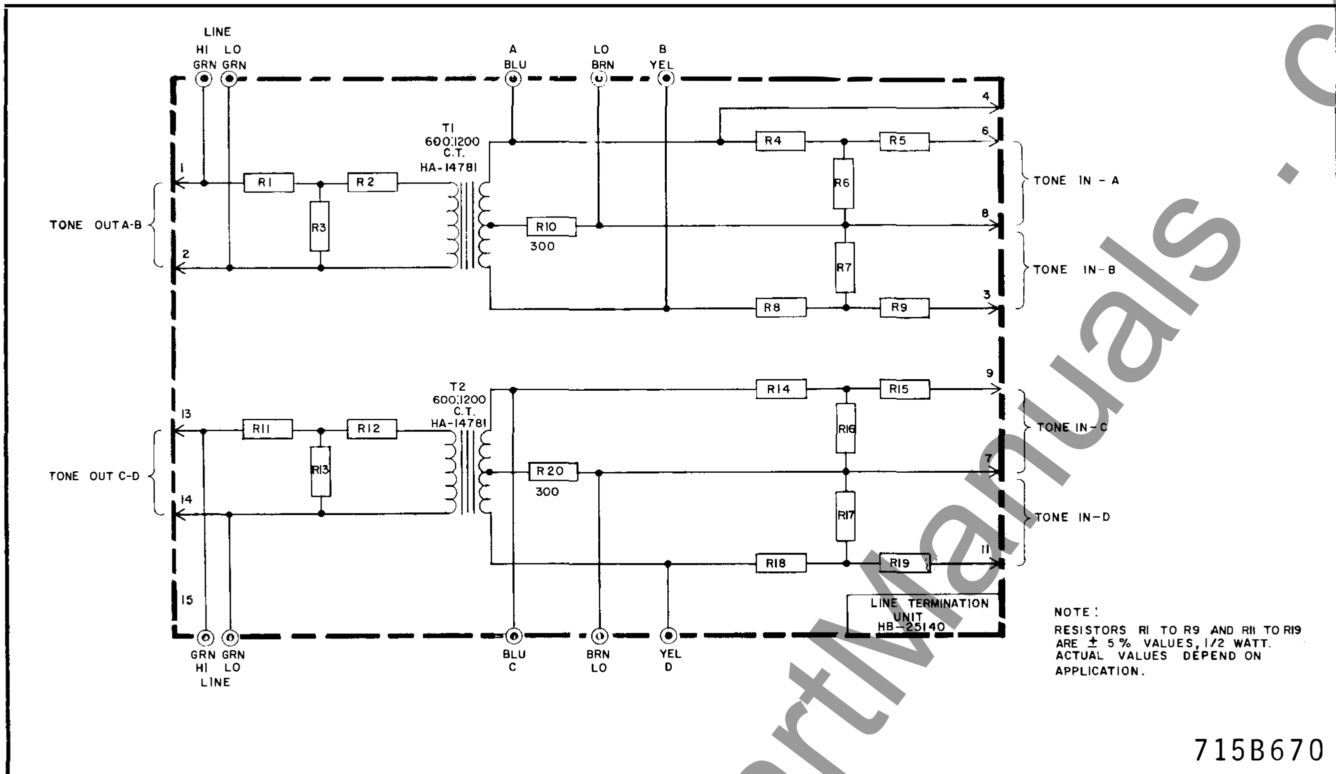
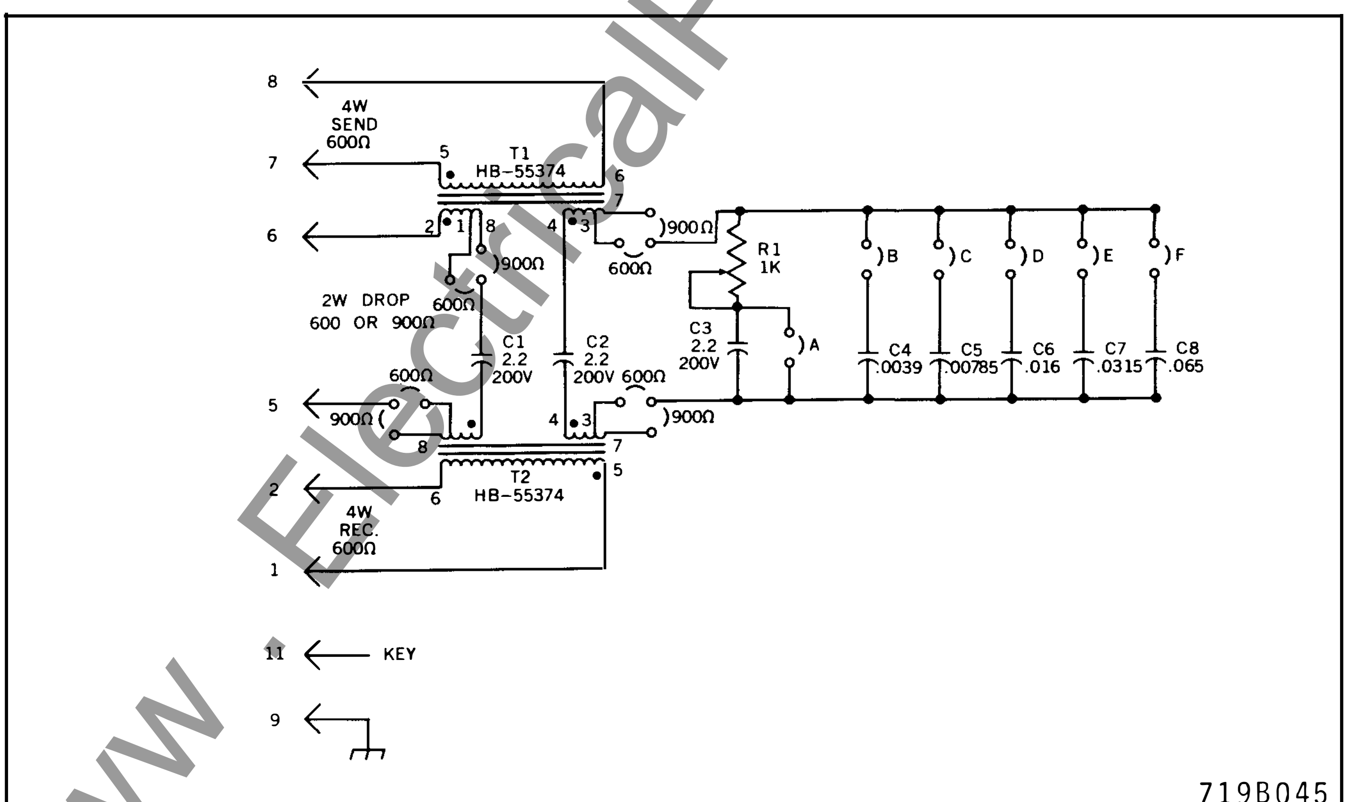


Fig. 22. Line Termination Module HB-25140.



* *Fig. 23. Hybrid for Two Wire Termination HB-35315.*

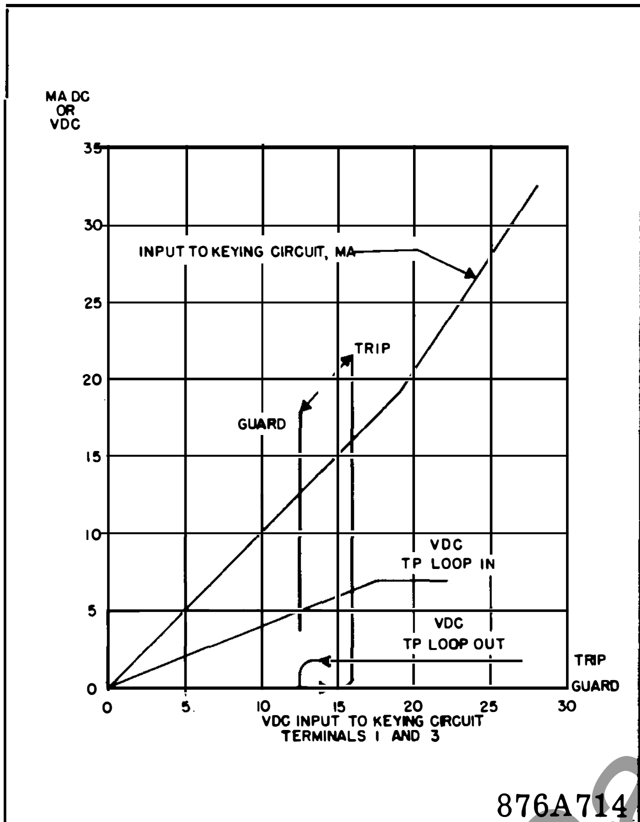


Fig. 24. Transmitter Keying Circuit Characteristics.

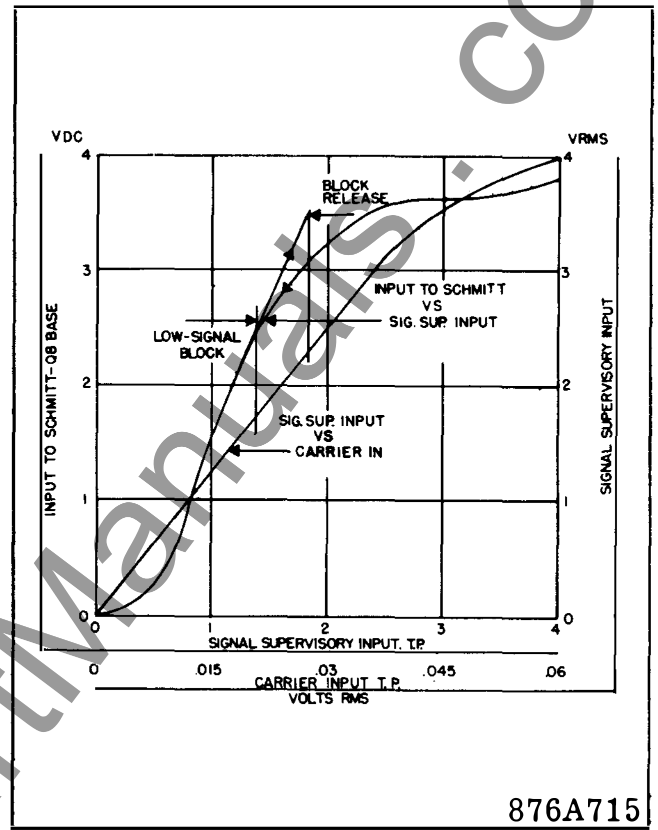
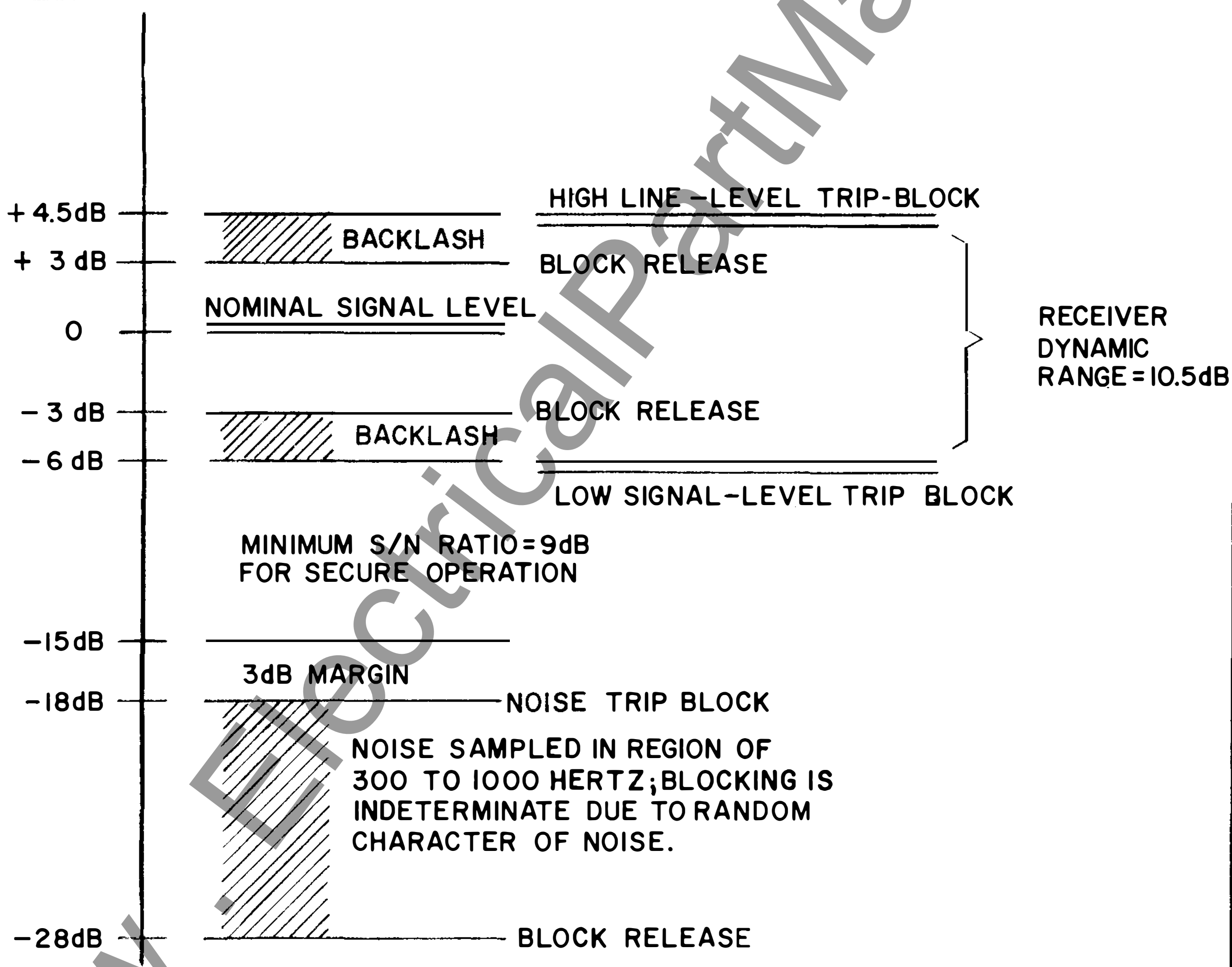


Fig. 25. Signal Supervisory Circuit Characteristics.

RECEIVER DYNAMIC OPERATING RANGE

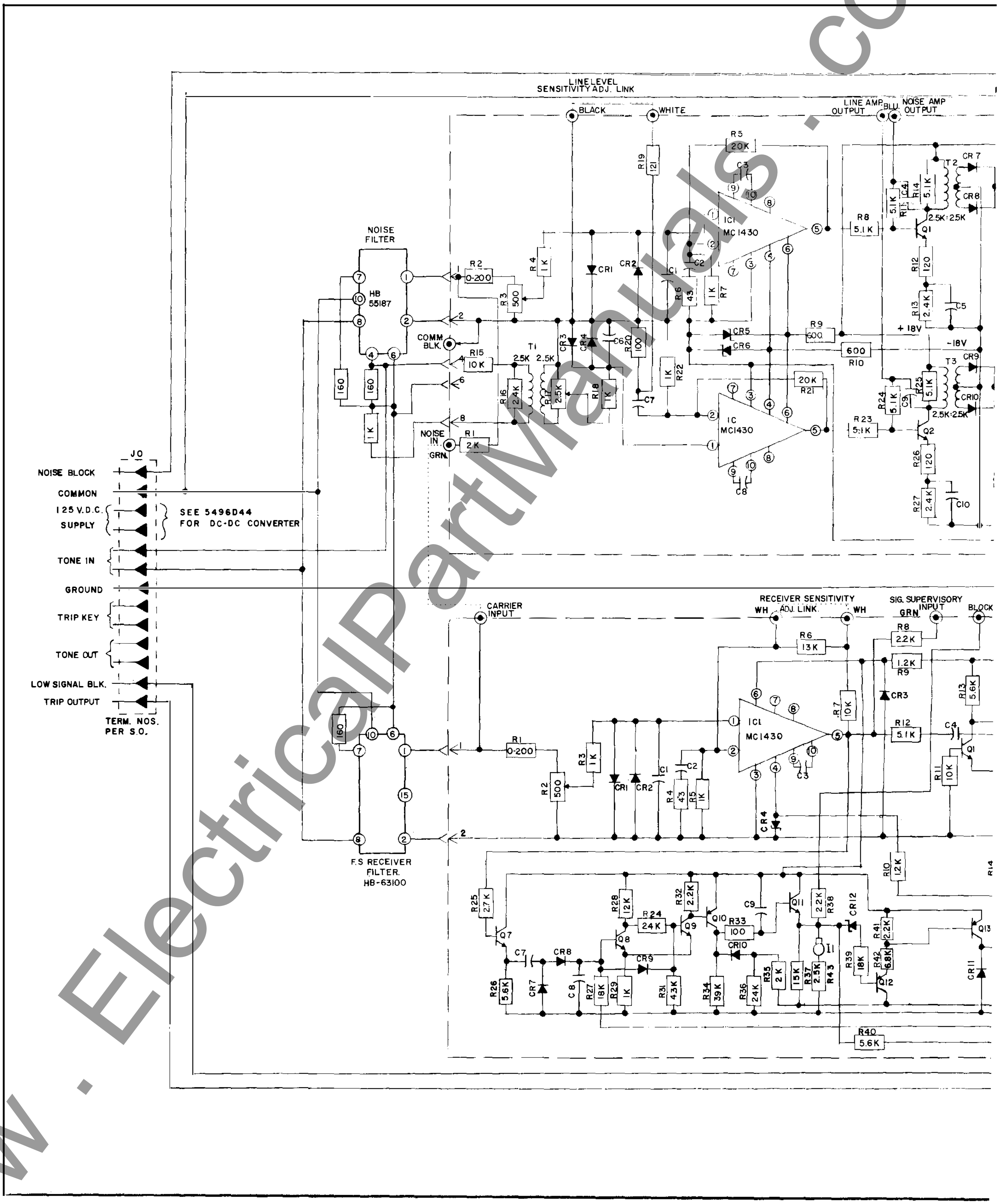
MAXIMUM LEVEL OF A SINGLE OUT-OF-BAND TONE (ABOVE 1000 HZ) TO CAUSE A HIGH LINE TRIP BLOCK.

NUMBER OF CHANNELS	OUT-OF-BAND TONE LEVEL ABOVE NORMAL CHANNEL
1.	3.5dB
2.	8.6dB
3.	10.5dB
4.	11.8 dB
5.	12.4dB
6.	12.9dB

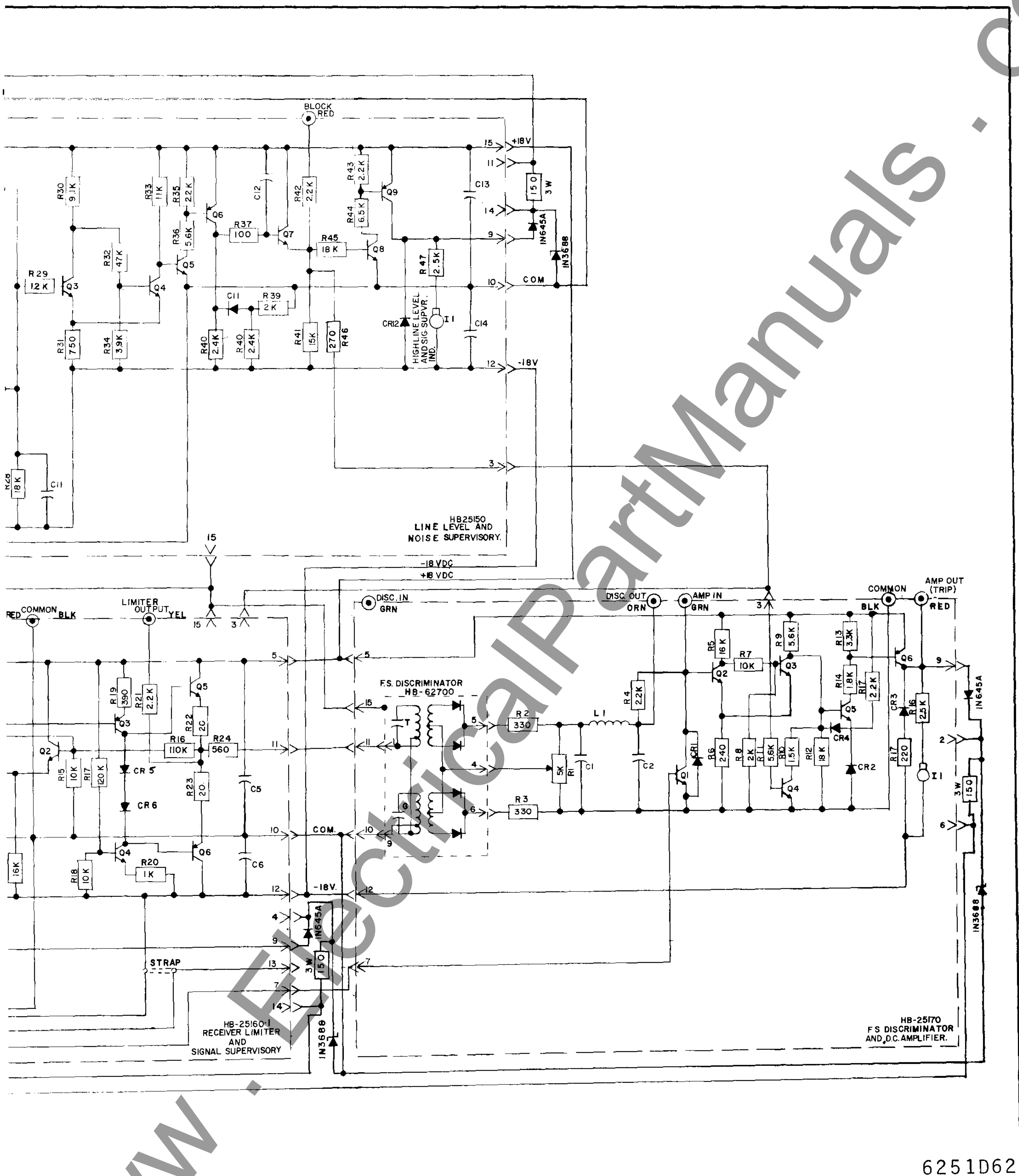


876A827

* *Fig. 26. Receiver Dynamic Operating Range.*



* *Fig. 28. TA-3 F.S. Receiver, Li*



…e Level and Noise Supervisory-S.S. Output.