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 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

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. If KX642 gas tubes are installed, connect them to ground only as shown in Figure 2. Do not connect the tube without shorting H2 to H3. This is especially important where the noise 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. 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. 9)

   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.

C. RECEIVER MODULES (Block Diagram Fig. 10)

1. Receiver Input Filter HB63100 (See Fig. 11)

   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 11.

2. Receiver Limiter and Signal Supervisory Module HB25160-1 (Fig. 12)

   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 and HB25170 (Figs. 13 and 14)

   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. 15.

   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 14) 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. 10)

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

1. Noise Filter Module HB55187 or HB55183 (Fig. 16) (Notched for 595 Hz Transmitter)

   This module contains a filter (see Fig. 16) that samples noise in the 300 to 1000 Hz region. There are two different types of filters. One of them has a rejection notch at 595 Hz and it is used in conjunction with a 595-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. 17)

   This module consists of two receivers (see Figure 17). 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. 595-Hz TRANSMITTER HB21050-2 (Fig. 18)

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 595-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 19. The AR relay is described in separate instructions.

G. LINE TERMINATION MODULE HB25140 (Figure 20)

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.

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 (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 21.

2. Transmitter Amplifier HB25220 (Fig. 9)

With reference to the schematic diagram of Figure 9, 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.

C. RECEIVER MODULES
(Block Diagram Figure 10)

1. Receiver Input Filter HB63100 (Fig. 11)

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 12 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 22 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 and HB25170 (Figs. 13 and 14)

NOTE: Either module contains the discriminator tuned circuits in the HB62700 unit. (Fig. 15)

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 15 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. 10, Internal Schematic Fig. 17)

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 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 23 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

1. 595-Hz Transmitter HB25010-2 (Fig. 18)

With referance to the schematic diagram of Figure 18, an LC oscillator is employed to generate the carrier frequency. Keying circuits are provided to shift the carrier to a blocking state. 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 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 595-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.

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 3.5-W. 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.

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 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 5.)

F.S. OSCILLATOR AND KEYER HB25110

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 21.

Frequency:

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

TRANSMITTER AMPLIFIER HB25220

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.

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 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 595 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.

595-Hz TRANSMITTER HB21050-2

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 adjustor marked "level" 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 levels are to be checked or readjusted. The 595-Hz transmitter should be set the same as any other transmitter.

F.S. Receiver

(Refer to Fig. 23 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. 23 for Levels)

NOTE: If a 55183 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 1.75 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. 15, 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.

595-Hz Transmitter

Frequency: 595 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 to be made. 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 10 kHz, 1 mv sensitivity.

2. Calibrated Attenuator, 600 ohm.

For troubleshooting, the following additional test equipment is desirable:

1. Electronic Frequency Counter, 10 kHz minimum.

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

3. Cathode-Ray Oscilloscope.

4. Oscillator, 200 to 4000 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 (Q3, Q4-Fig. 12)	Vdc	C	+36	+36	Vp – p.	C	34	34
		B	+25	+25		B	10	10
		E	+24.5	+24.5		E	5	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

			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 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	RFL PART NO.
	HB25110 F.S. OSCILLATOR AND KEYER	
R2 thru R20	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%, 3¼ 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, VCEO 40V, TO-92 case, Motorola 2N3903.	HA-21562
	Tuned oscillator ckt., sealed plug-in assembly.	HB-62800
	Test jacks, Sealectro Corp., SKT-10.	
	HB25220 TRANSMITTER AMPLIFIER	
R3 thru R11	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. PE 200.	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%. Emenco DM-19.	HA-16632
Q2, Q3	TRANSISTOR, silicon NPN V_{CEO} 65V TO-5 case.	HA-22678
Q1	TRANSISTOR, silicon NPN V_{CEO} 40V, TO-92 case.	HA-21562
	TRANSFORMER, Plug-in assembly	HB-55207
	Multiplexing filter, plug-in assembly.	HB-62600
	Test jacks, Sealectro Corp., SKT-10.	
	HB-21050 595 Hz FS TRANSMITTER	
R1-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.	HB-58200
	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	RFL PART NO.
	HB-25160-1 RECEIVER LIMITER AND SIGNAL SUPERVISORY	
R1 thru 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., 0.0068μF, 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, 15μF, ±20%, 35V. Texas Inst. SCM156GP035D4.	H-1007-654
C9	CAPACITOR, tantalum, 0.47μF, ±10%, 35V. Texas Inst., SCM474FP035D2.	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. 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 F.S. DISCRIMINATOR AND D.C. AMPLIFIER	
R2 thru 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., 0.082μ F 2%, 100V. Wesco 32P.	H-5115-79
C2	CAPACITOR, mylar, 0.255μF 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	RFL PART NO.
HB-25130 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 thru R43	±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., 0.02 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 1N914.	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	RFL 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	RFL PART NO.
	HB-25210 VOLTAGE REGULATOR	
R17 thru 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.	

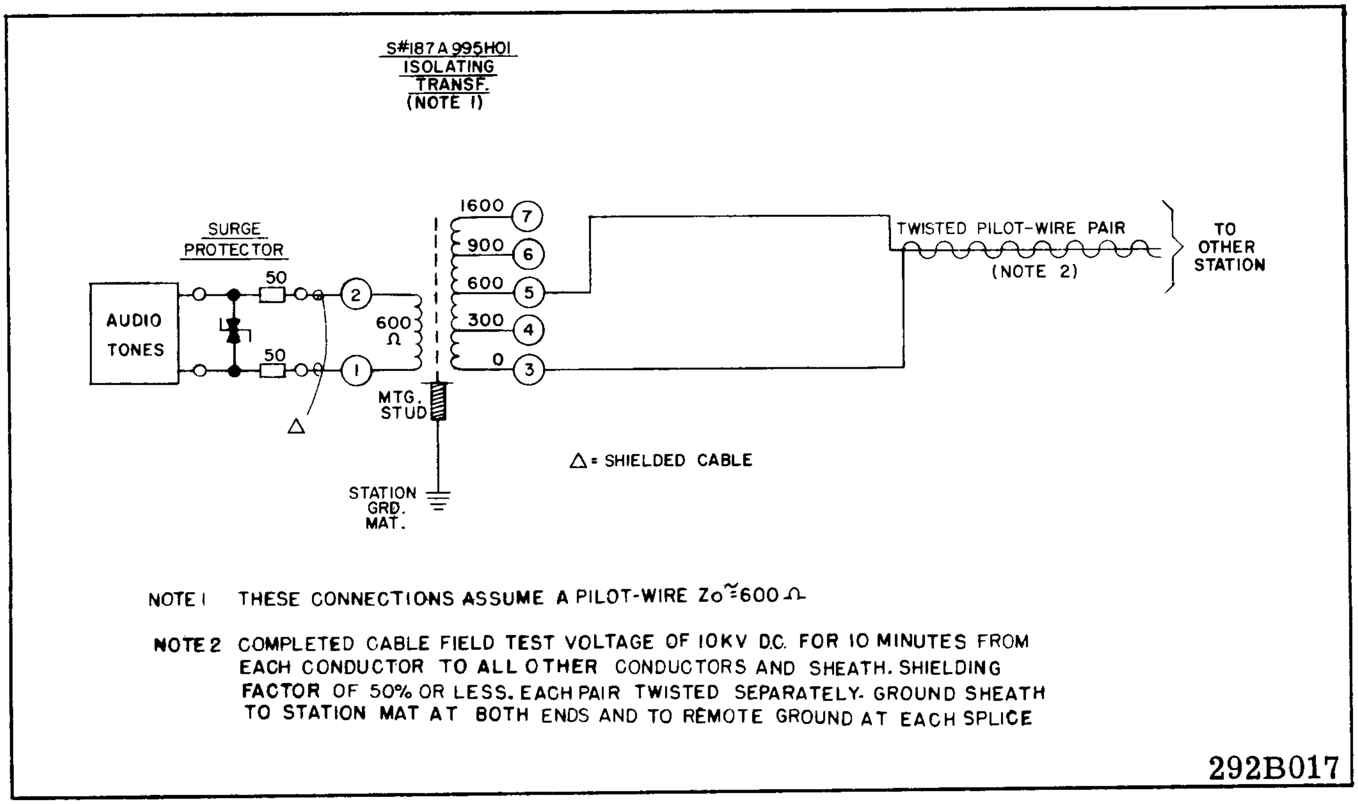


Fig. 1. Recommended Connections and Pilot Wire Design for Privately Owned Two-Terminal Lines.

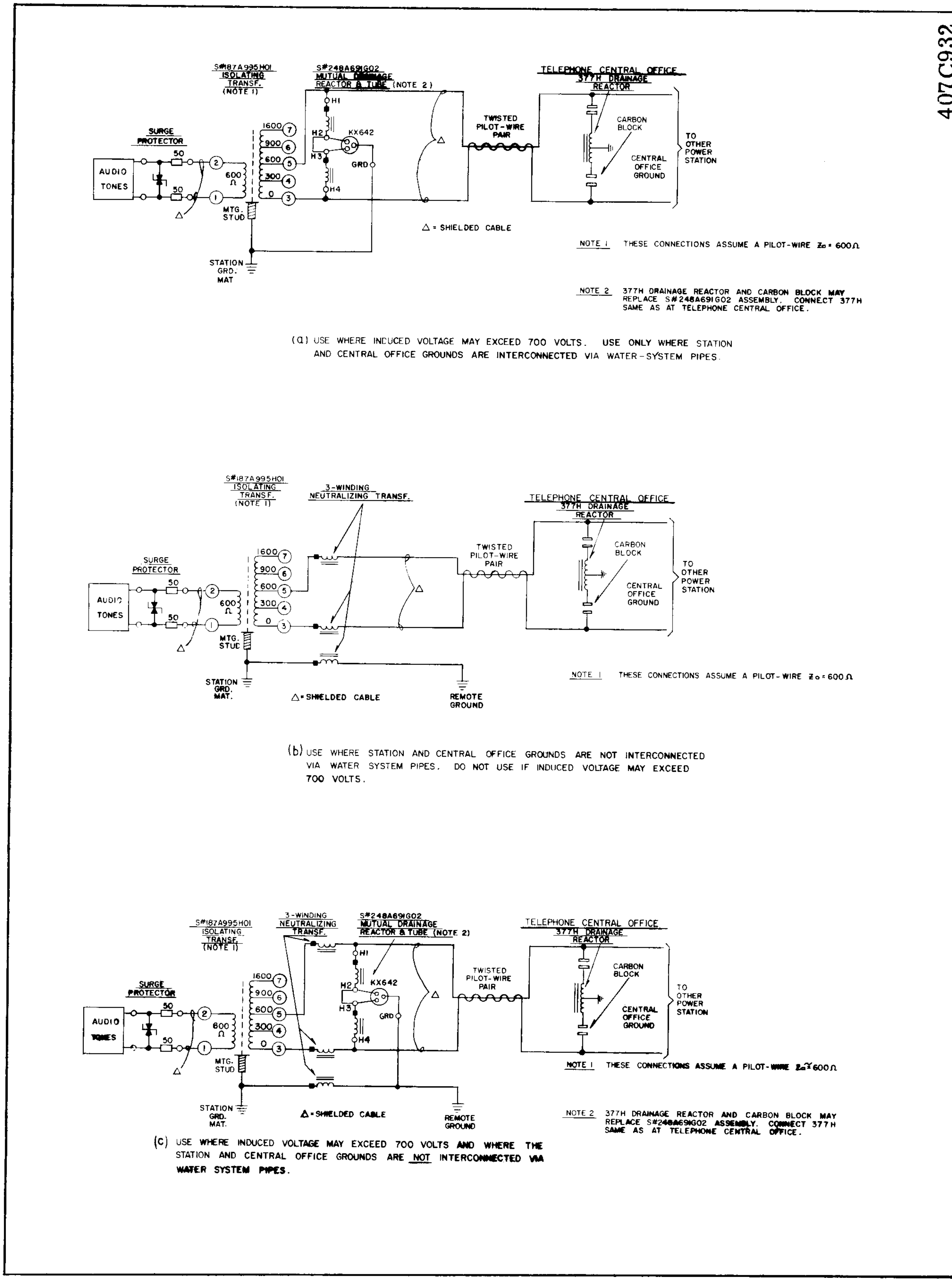


Fig. 2. Recommended Connections and Protective Arrangements for Two-Terminal Lines

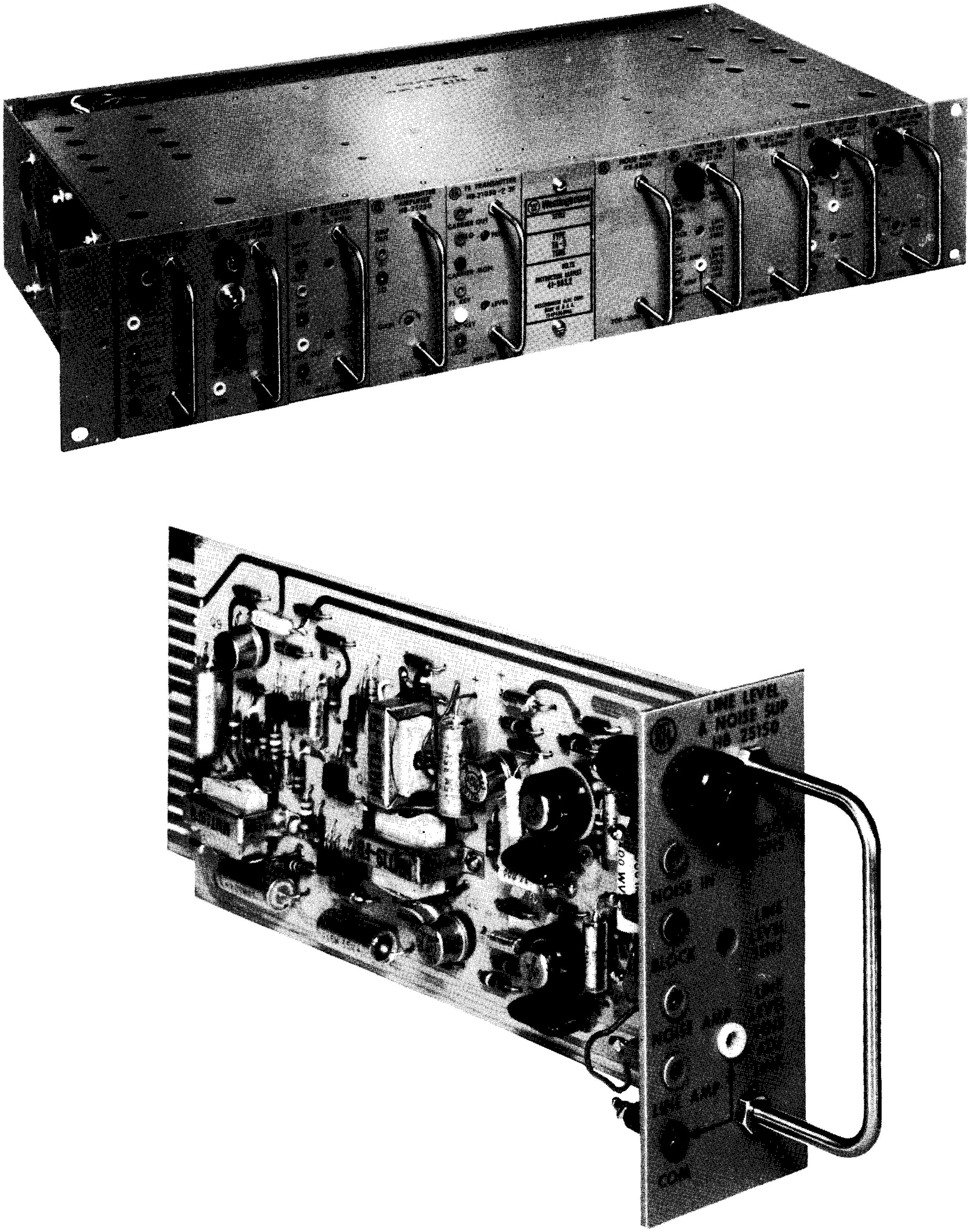
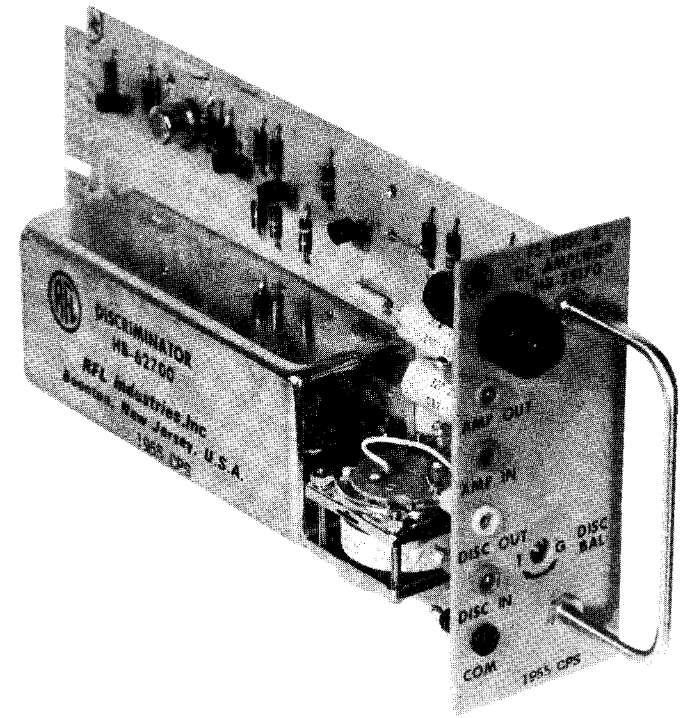
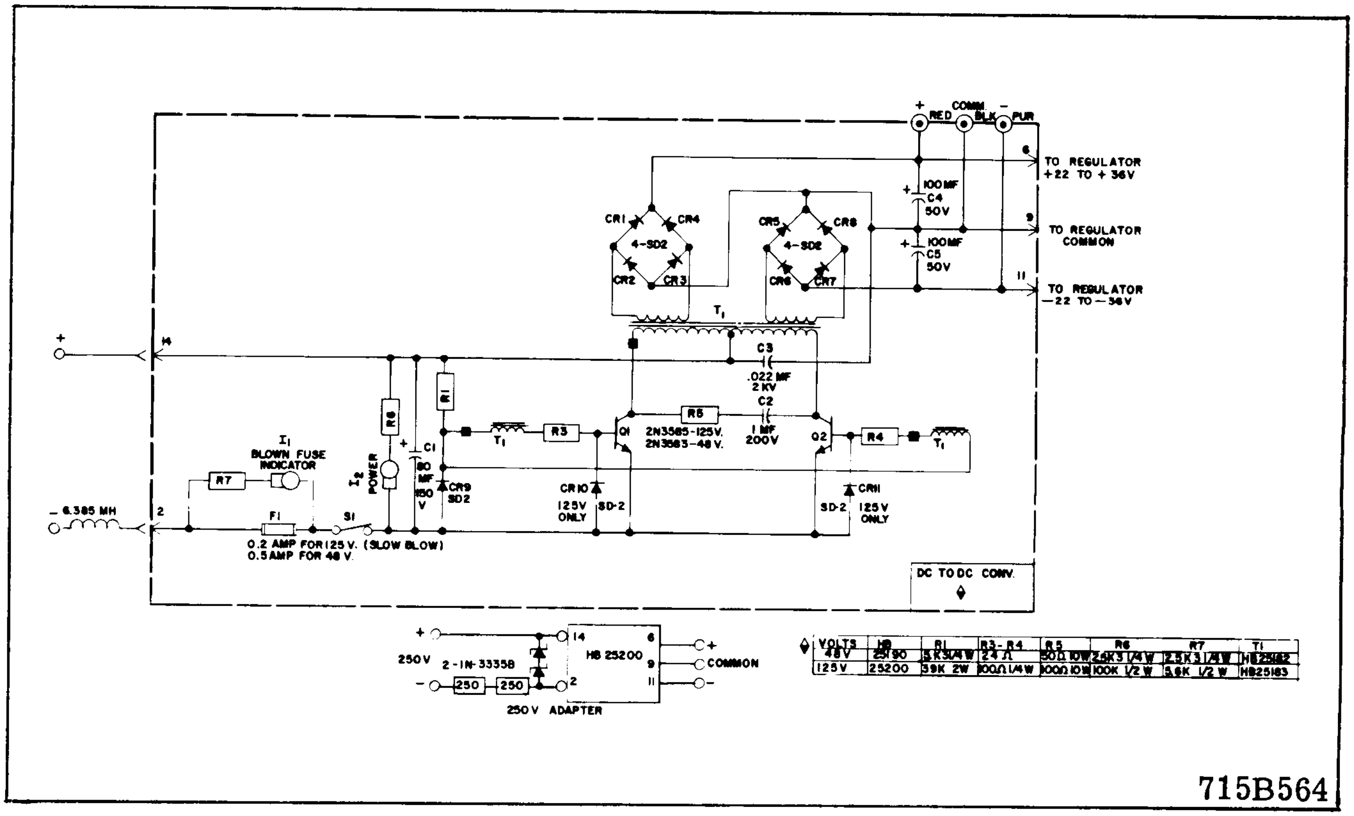


Fig. 3. Front View of Full Chassis. Photo #68-275. #68-276.



N365706

Fig. 4. Typical Module.



VOLTS	HB	R1	R3-R4	R5	R6	R7	T1
48V	25190	5K 3 1/4 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

715B564

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

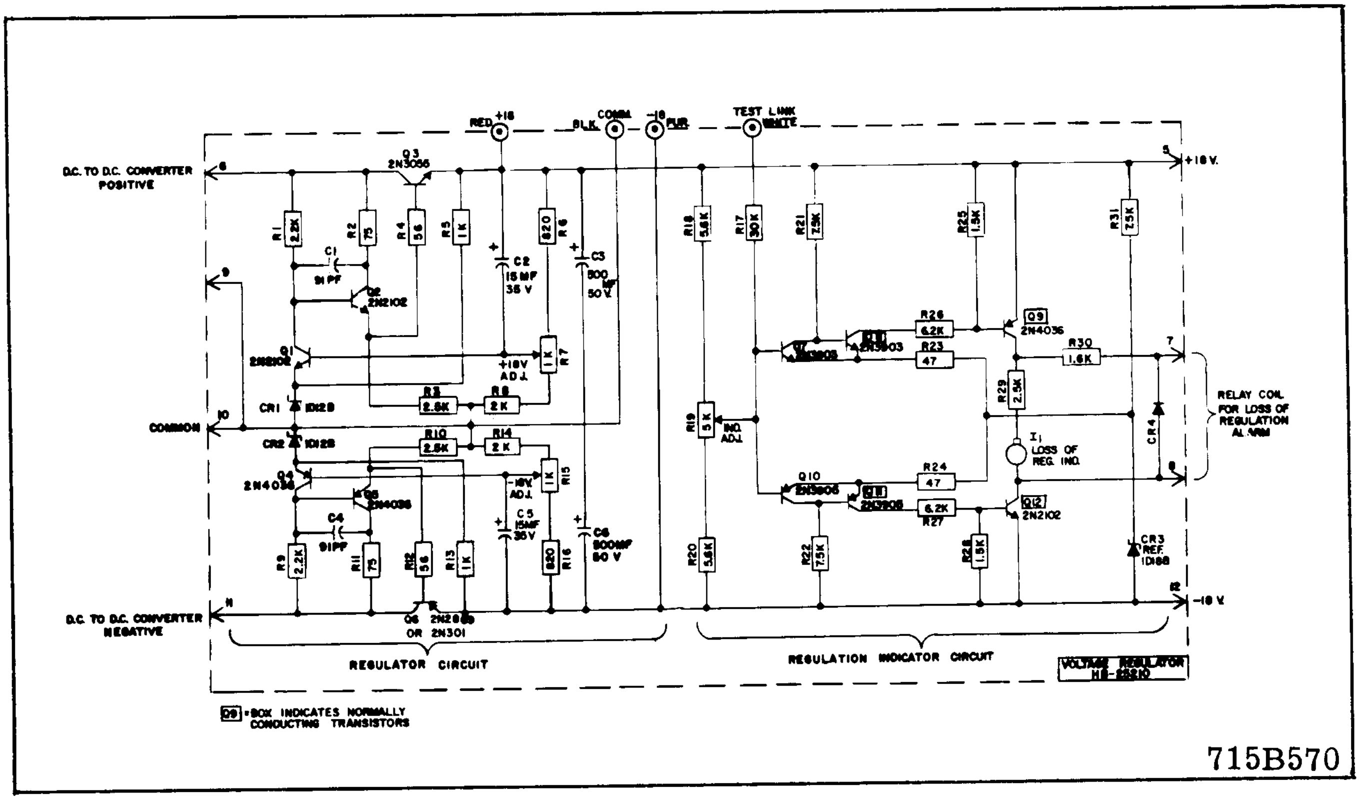


Fig. 6. Voltage Regulator HB-25210.

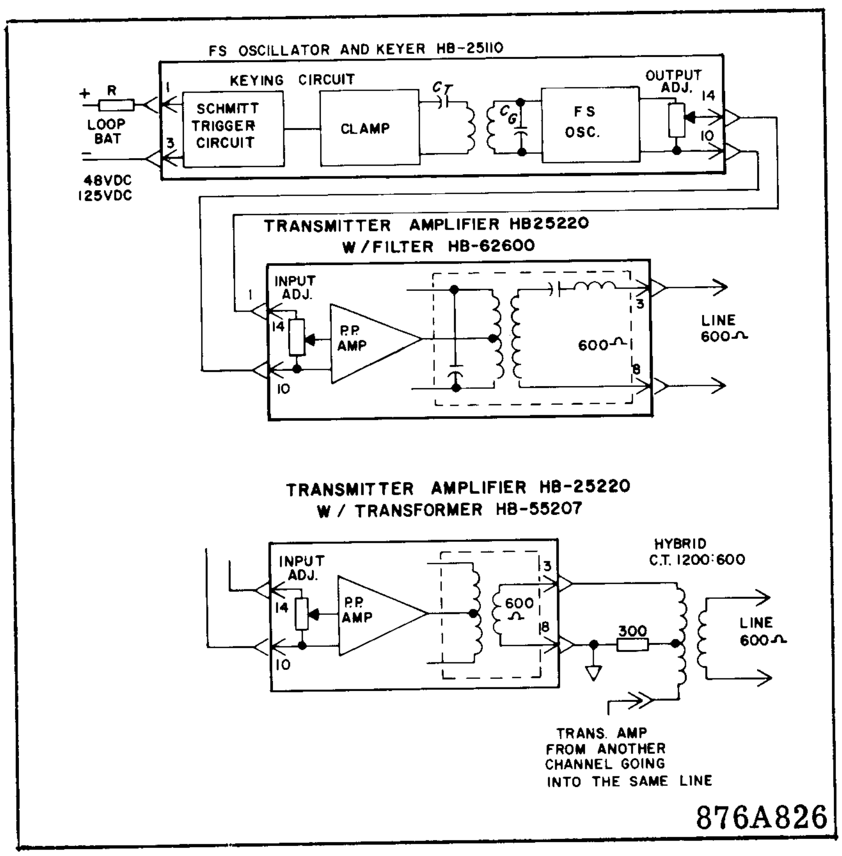


Fig. 7. Transmitter Block Diagram.

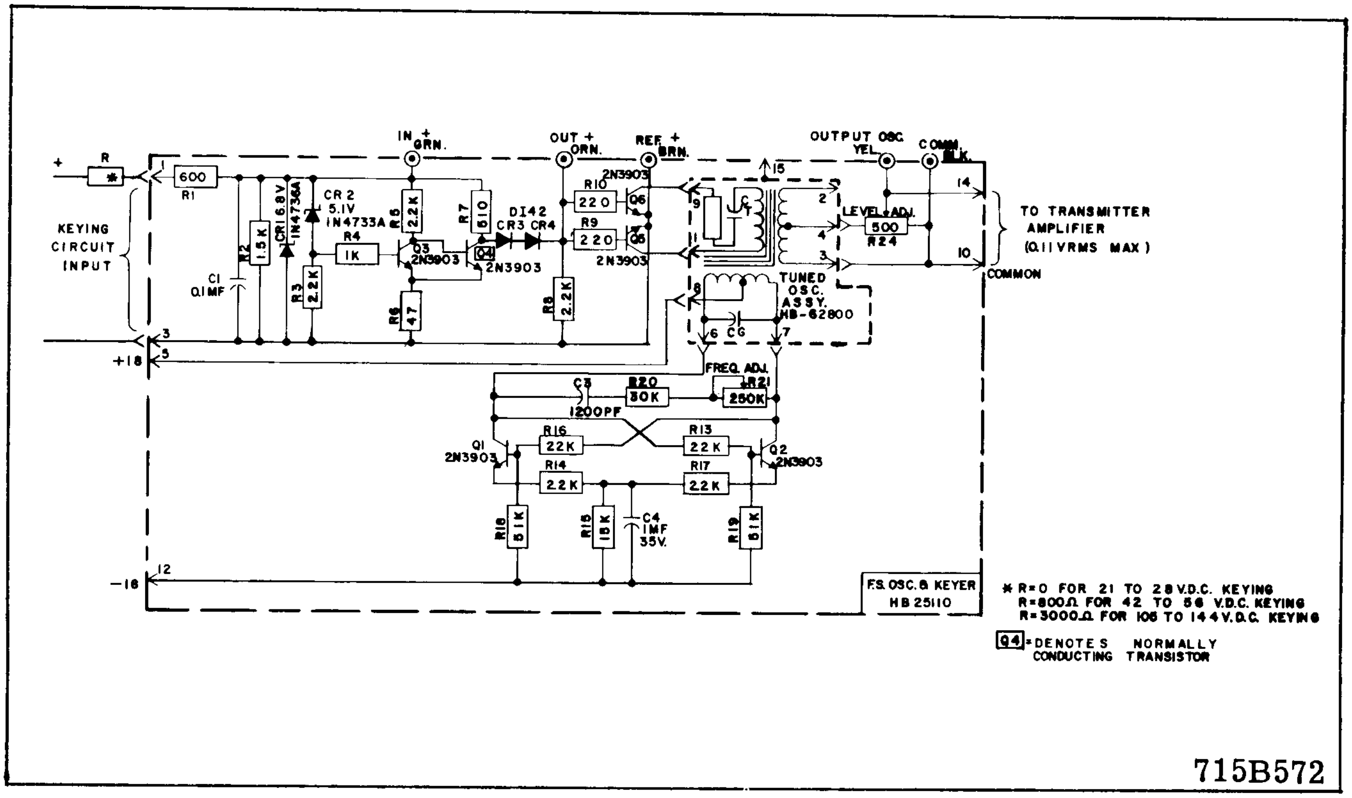


Fig. 8. F.S. Oscillator and Keyer HB-25210.

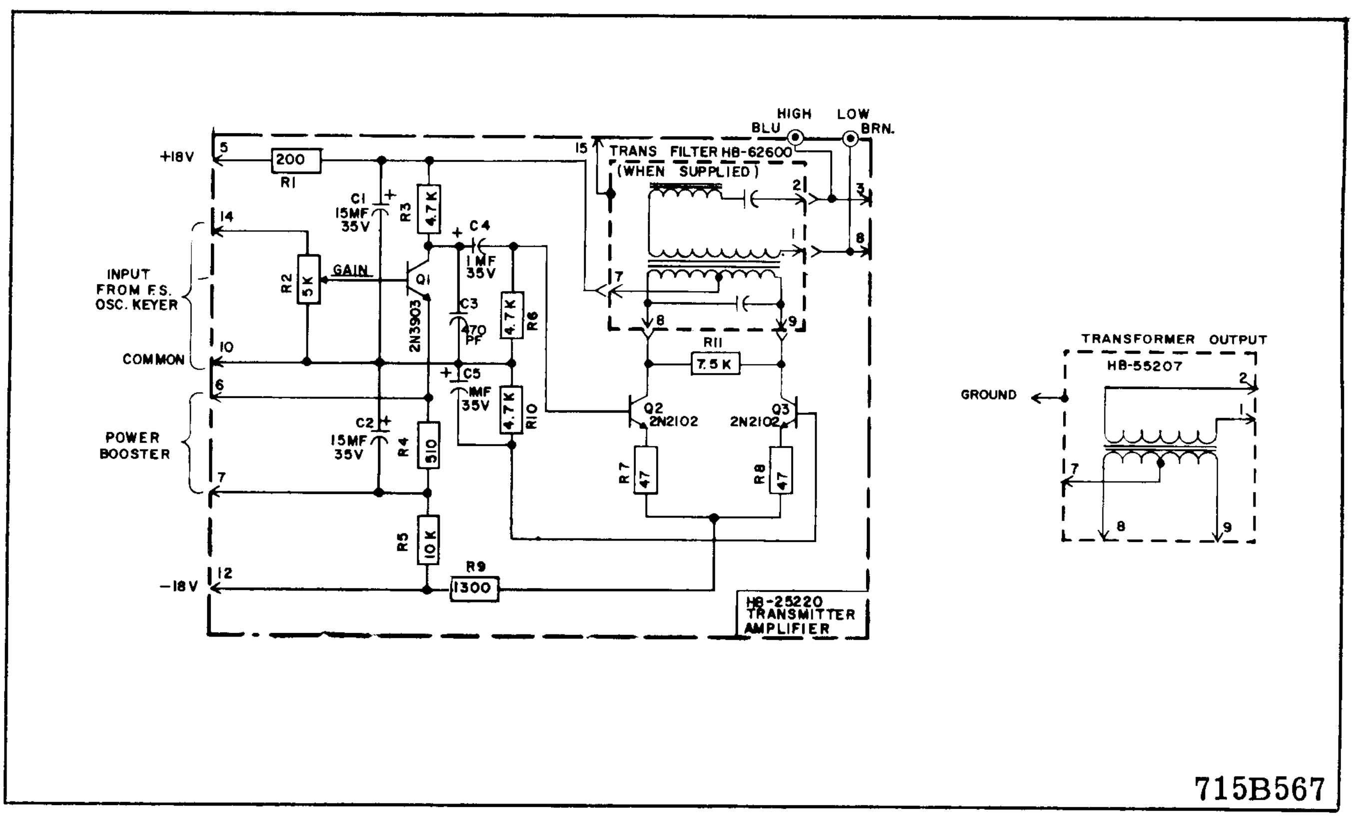


Fig. 9. Transmitter Amplifier HB-25220.

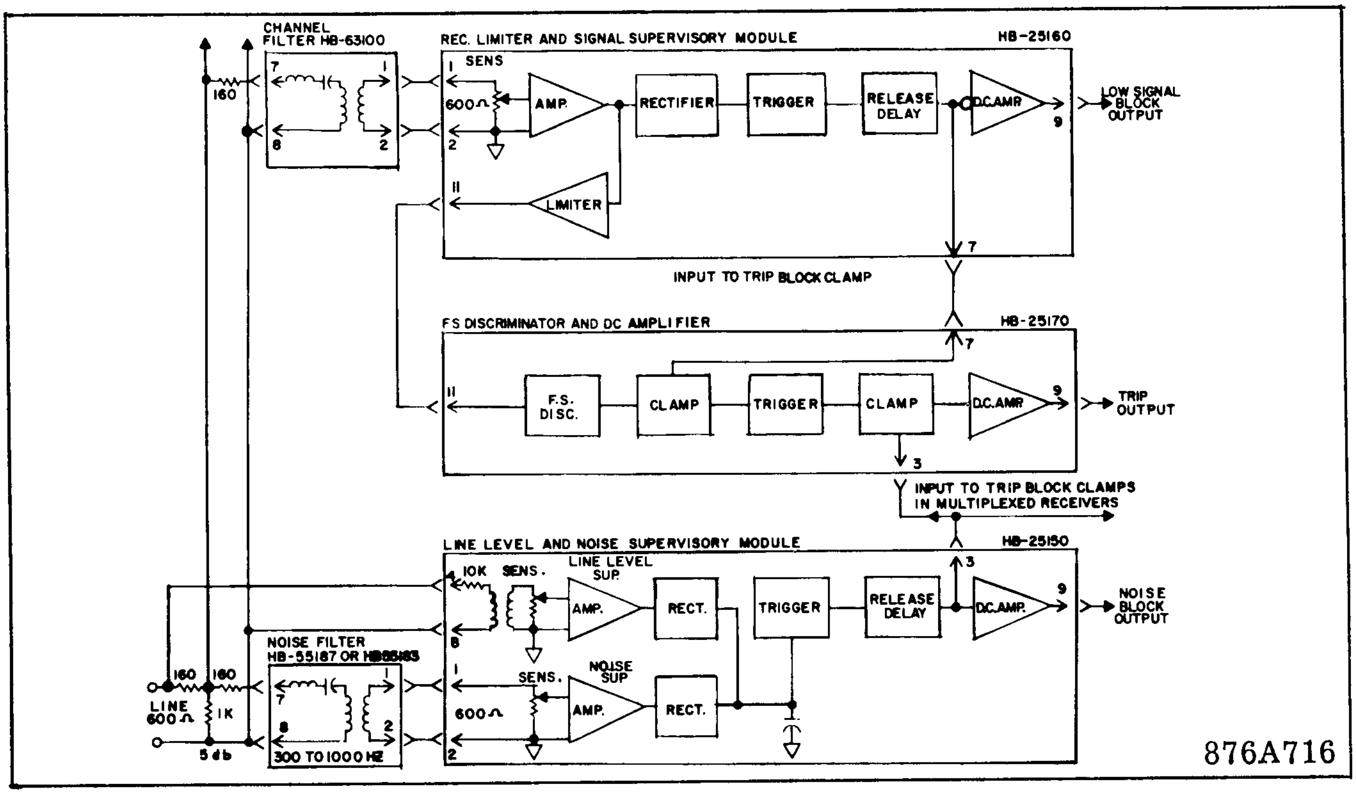


Fig. 10. Receiver Block Diagram HB-63100.

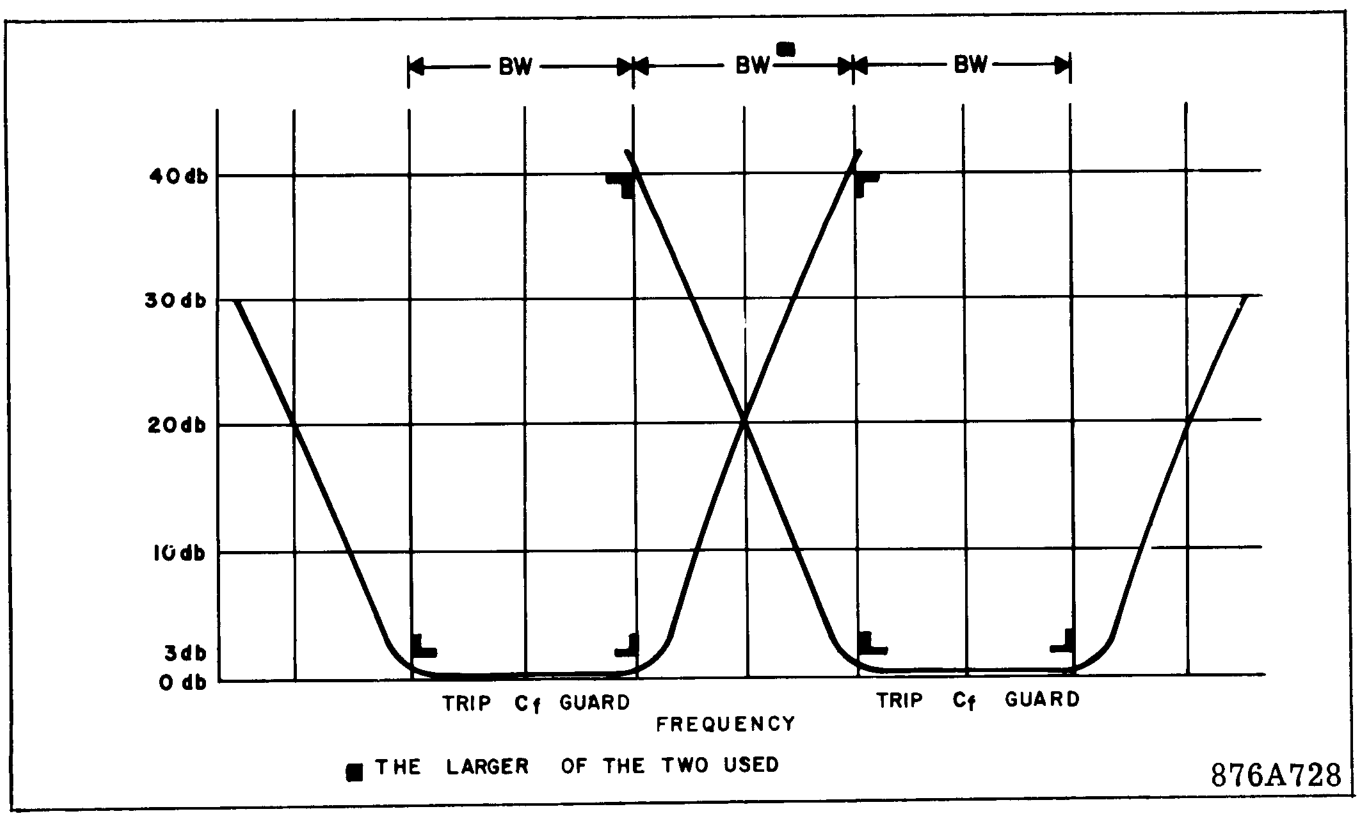


Fig. 11. Tone Receiver Filter Characteristics HB-63100.

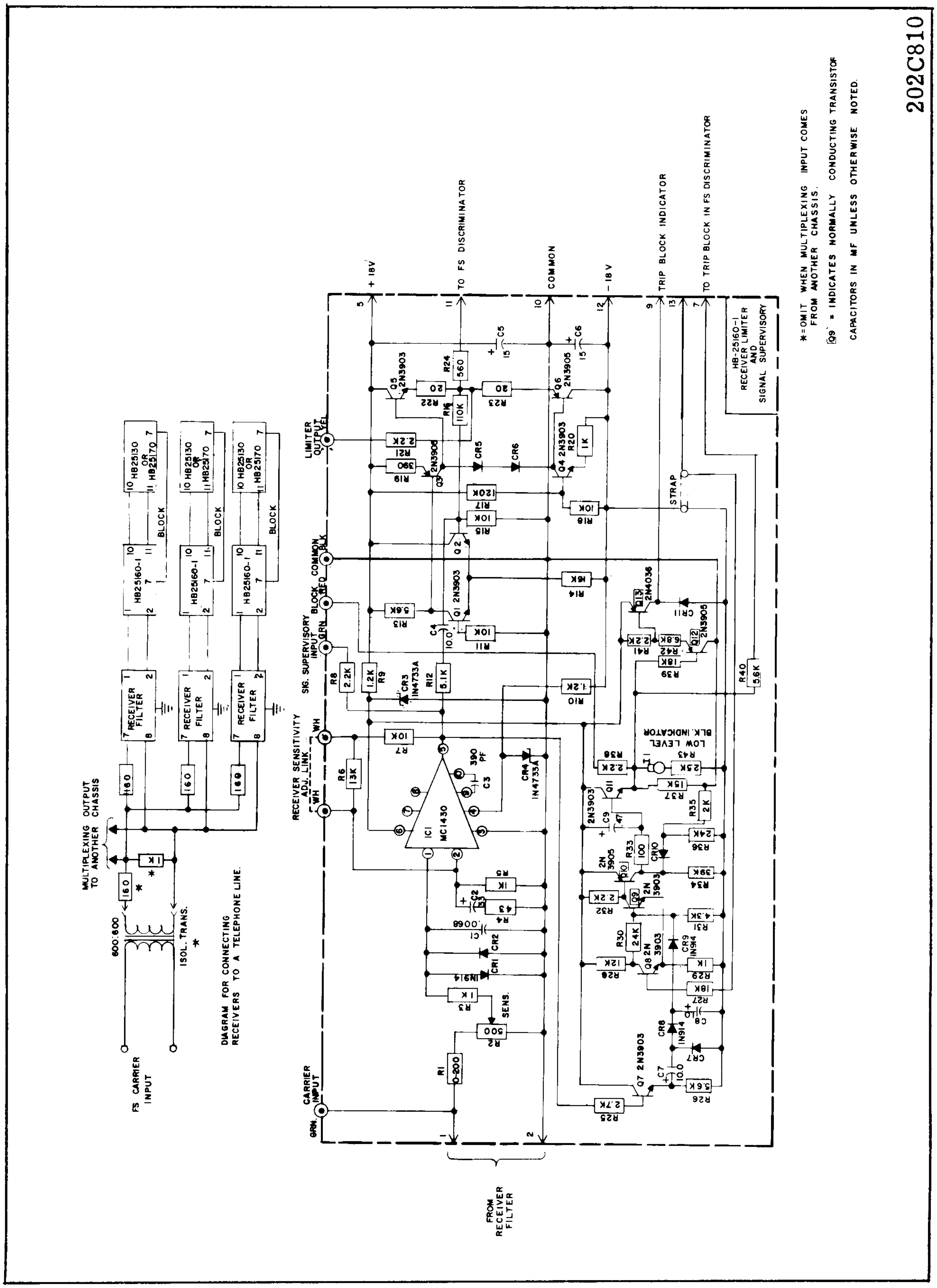


Fig. 12. Receiver Limiter and Signal Supervisory HB-25160-1.

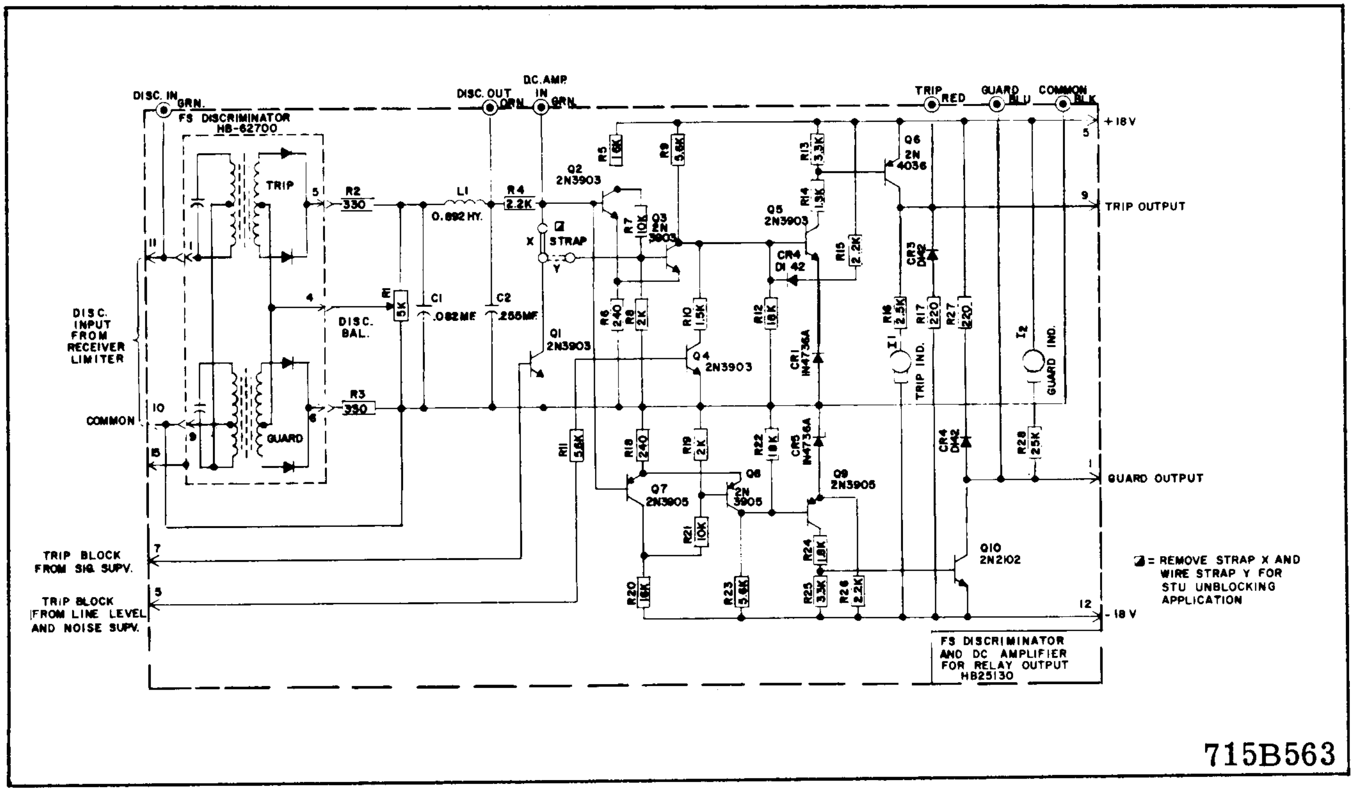


Fig. 13. F.S. Discriminator and D-C Amplifier for Relay Output HB-25130.

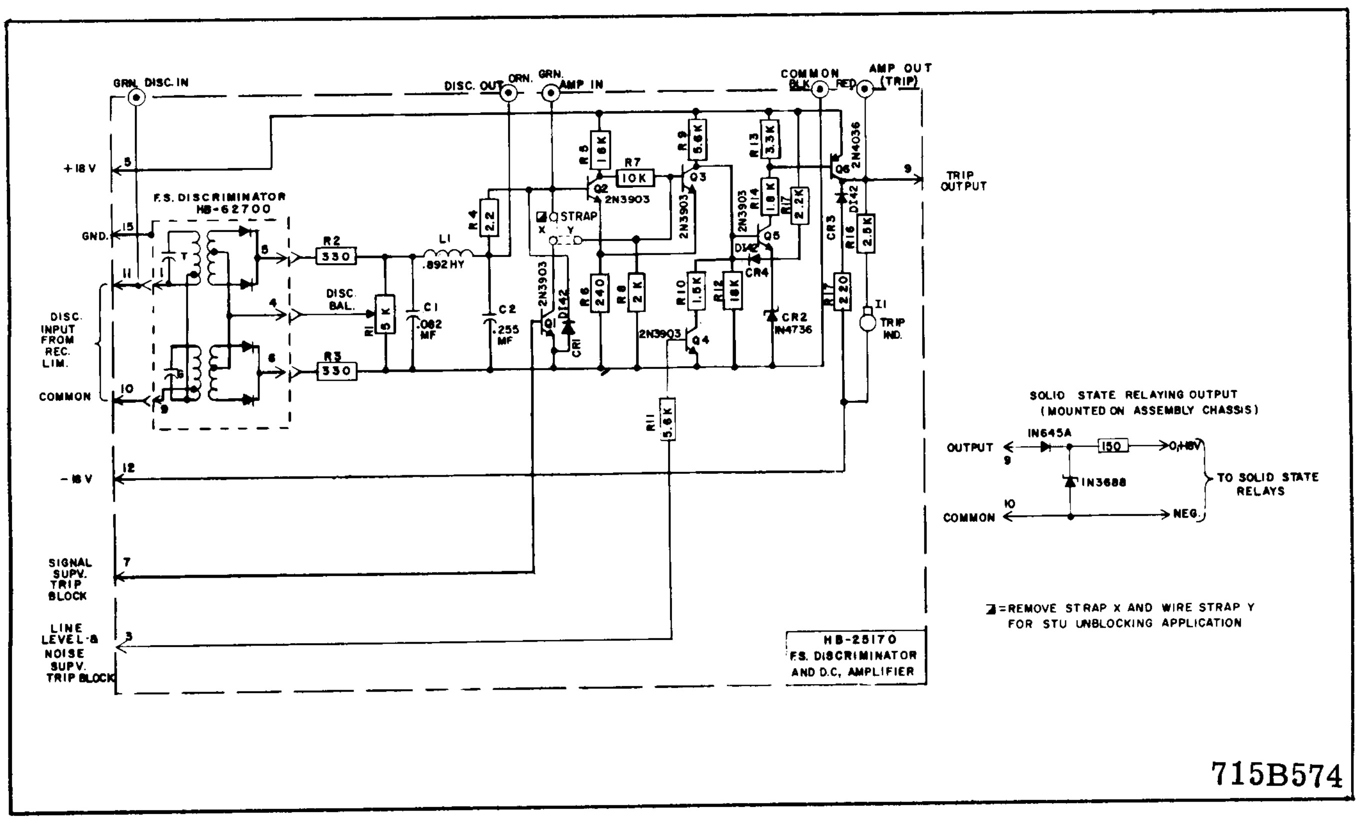


Fig. 14. F.S. Discriminator and D-C Amplifier for Solid-State Relaying HB-25170.

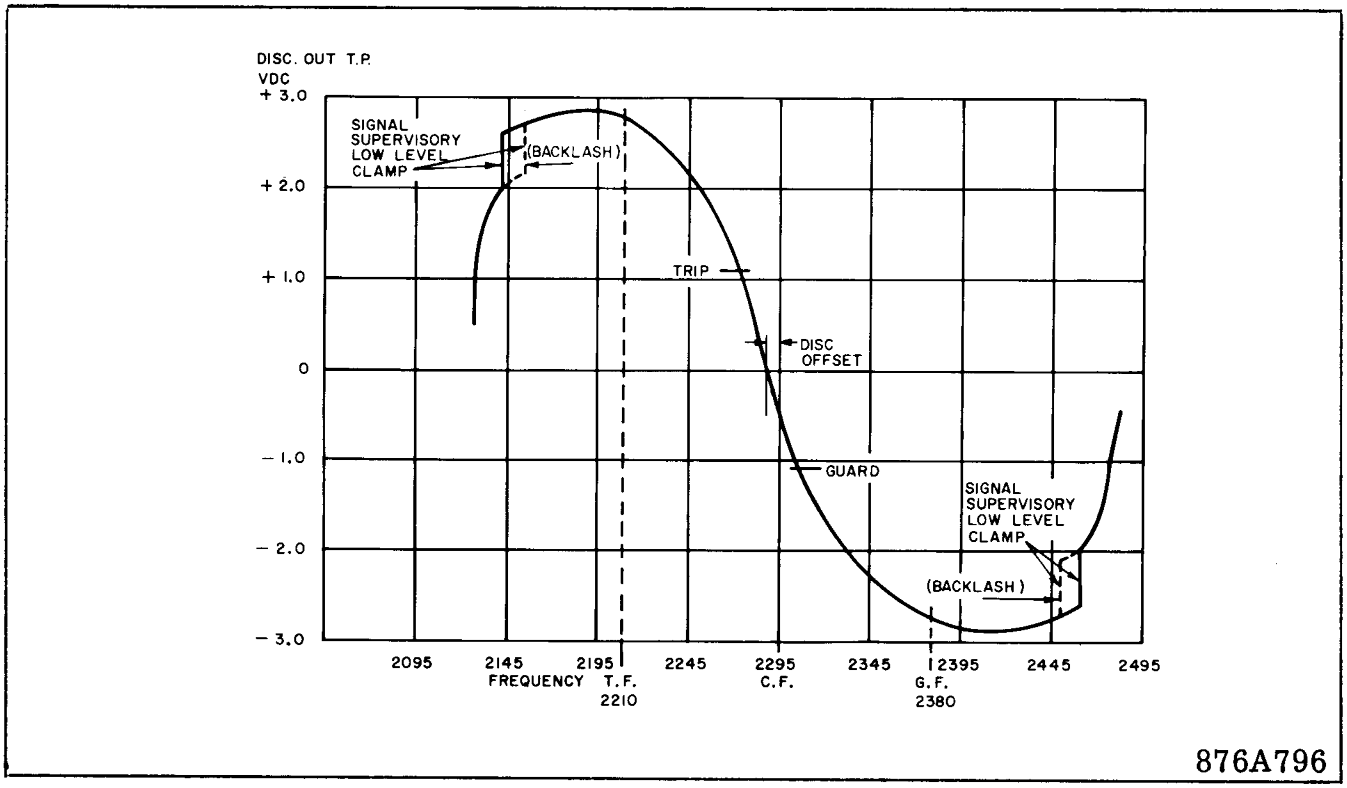


Fig. 15. Typical Discriminator Output.

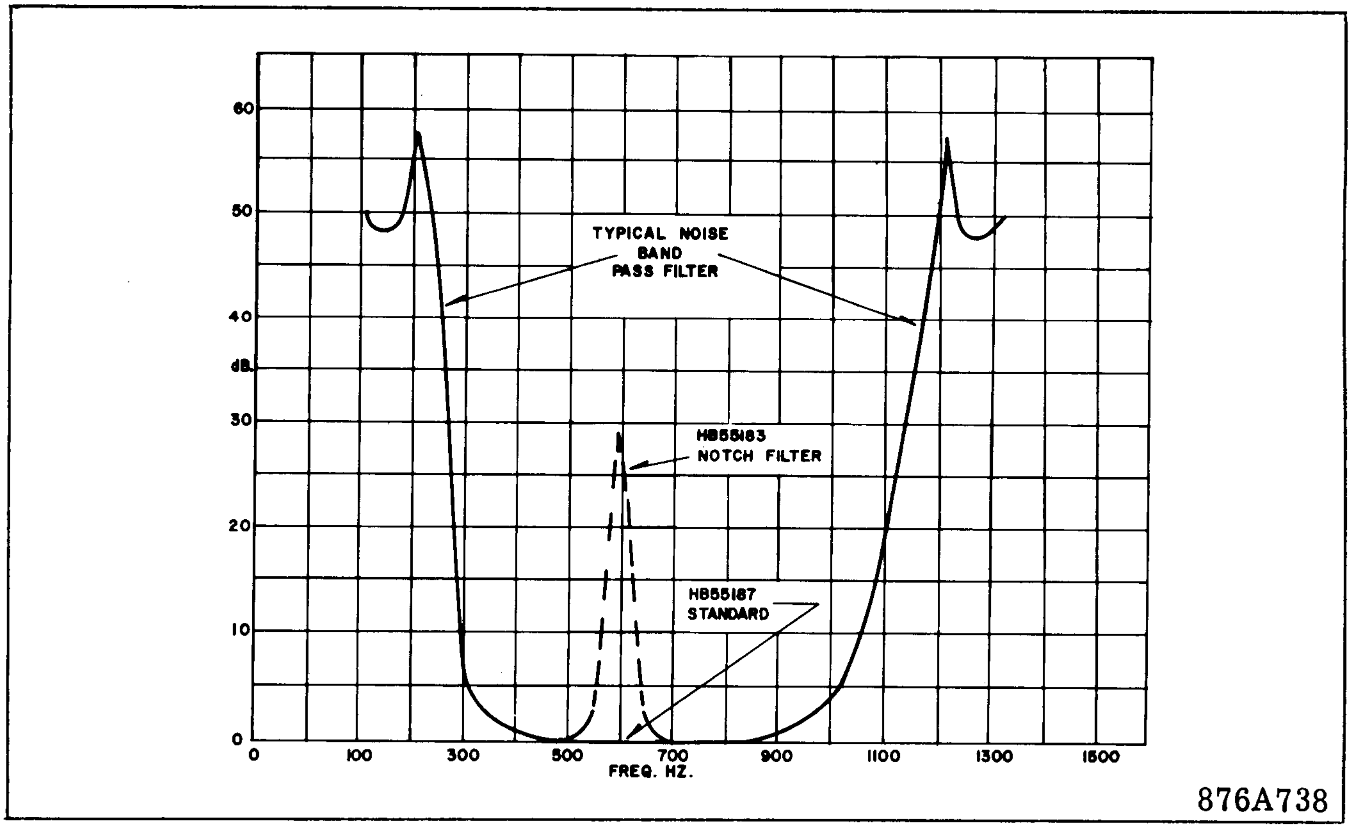


Fig. 16. Typical Noise Bandpass Filter.

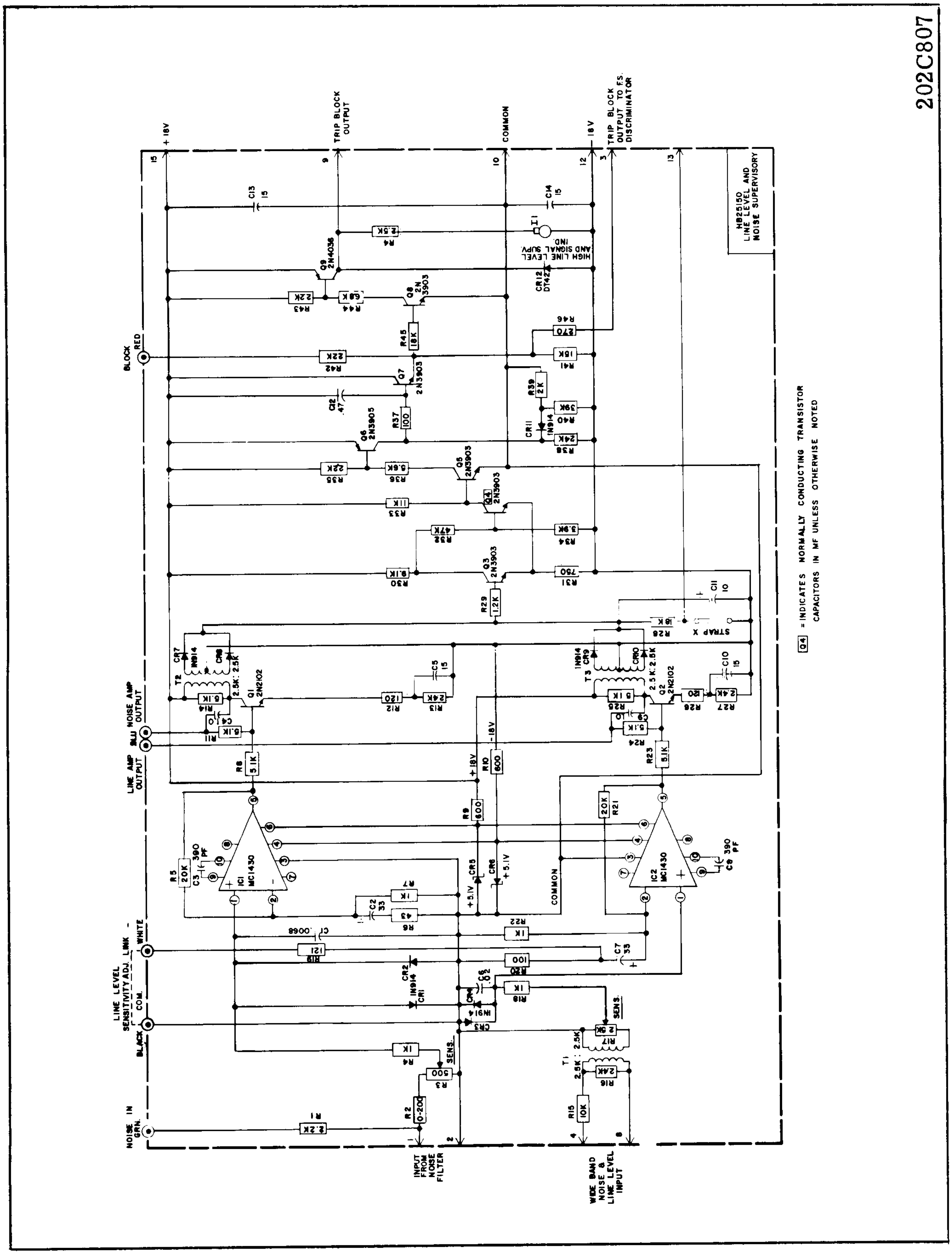


Fig. 17. Receiver Line Level and Noise Supervisory Module HB-25150.

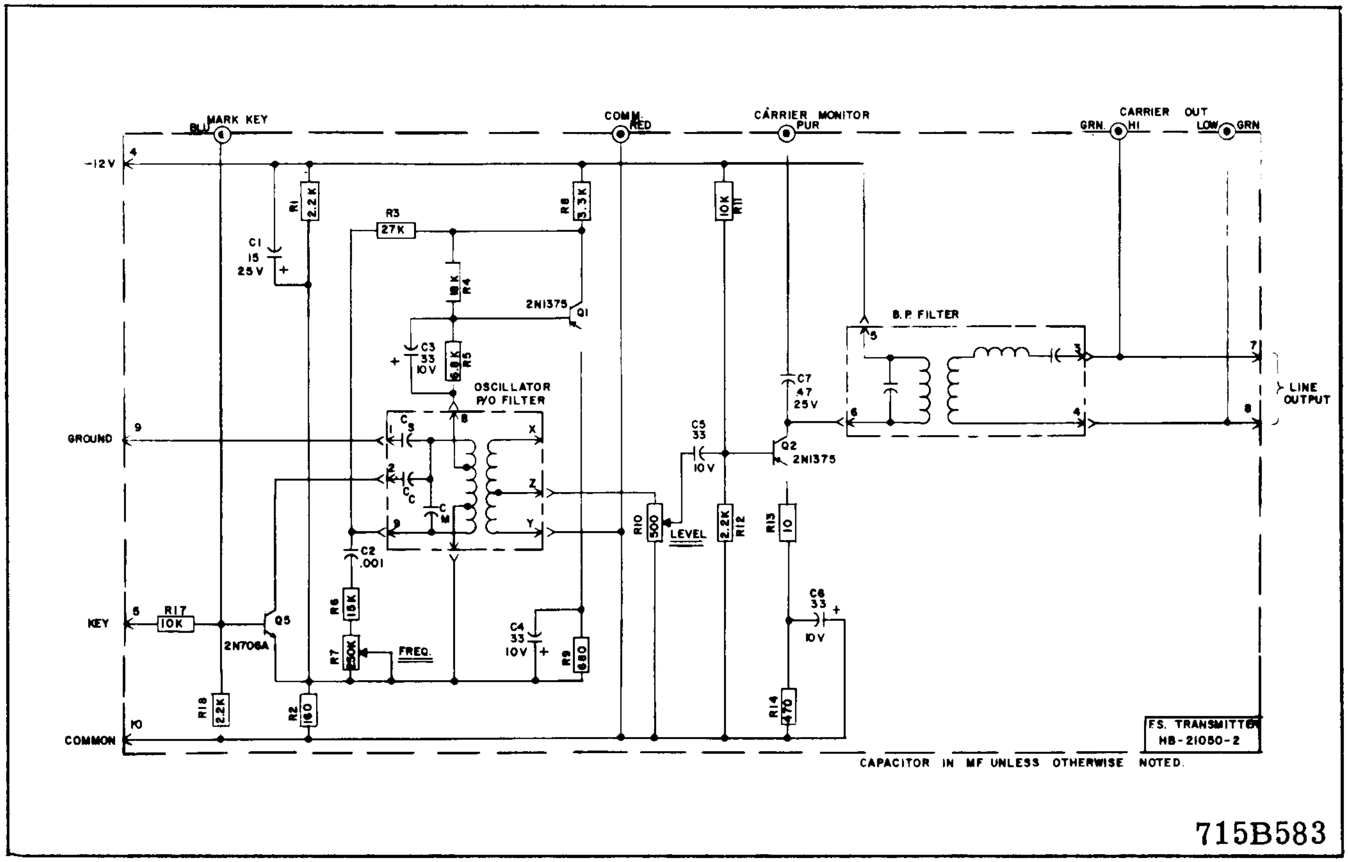


Fig. 18. 595-Hz Transmitter HB-21050-2.

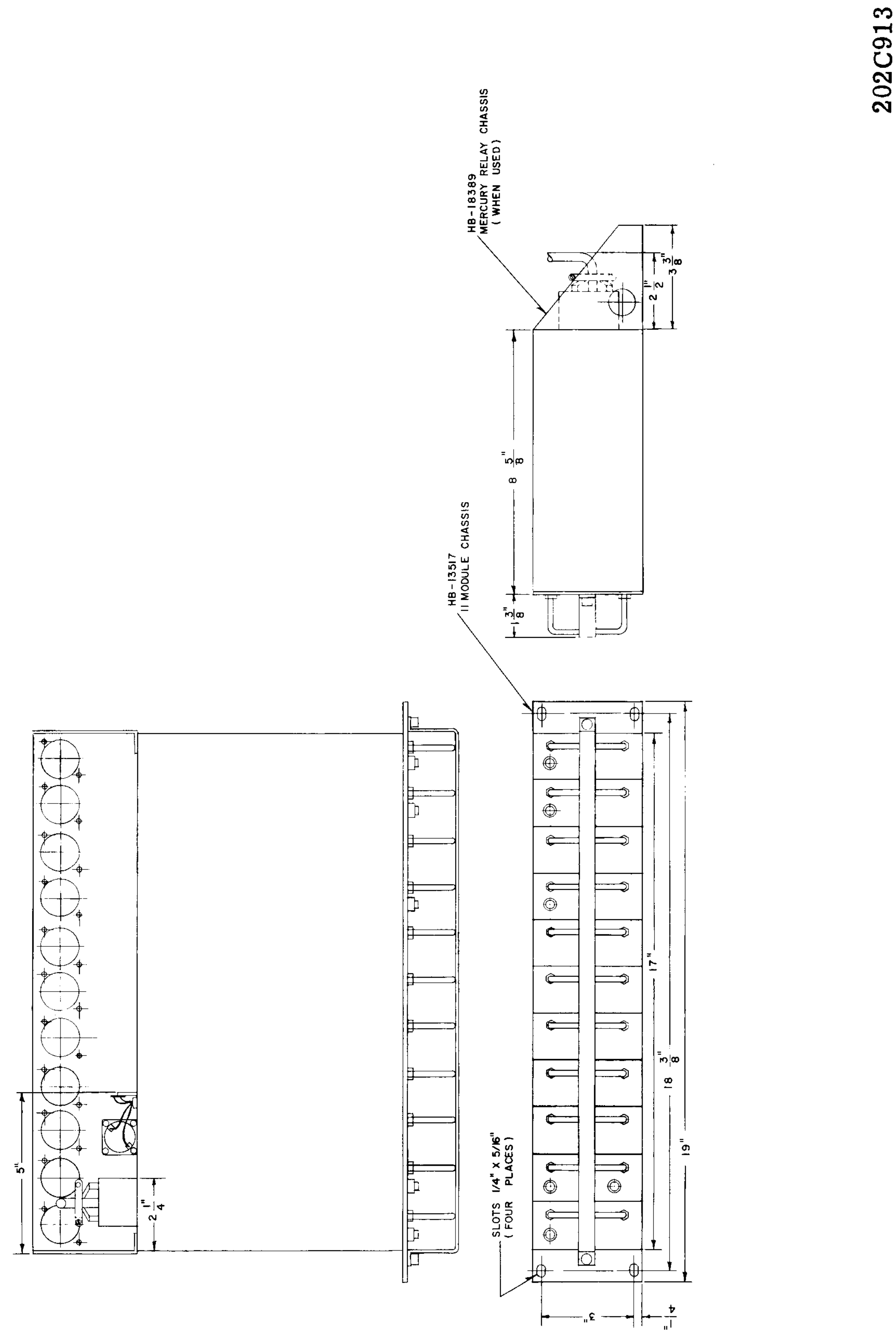


Fig. 19. Outline and Drilling Plan.

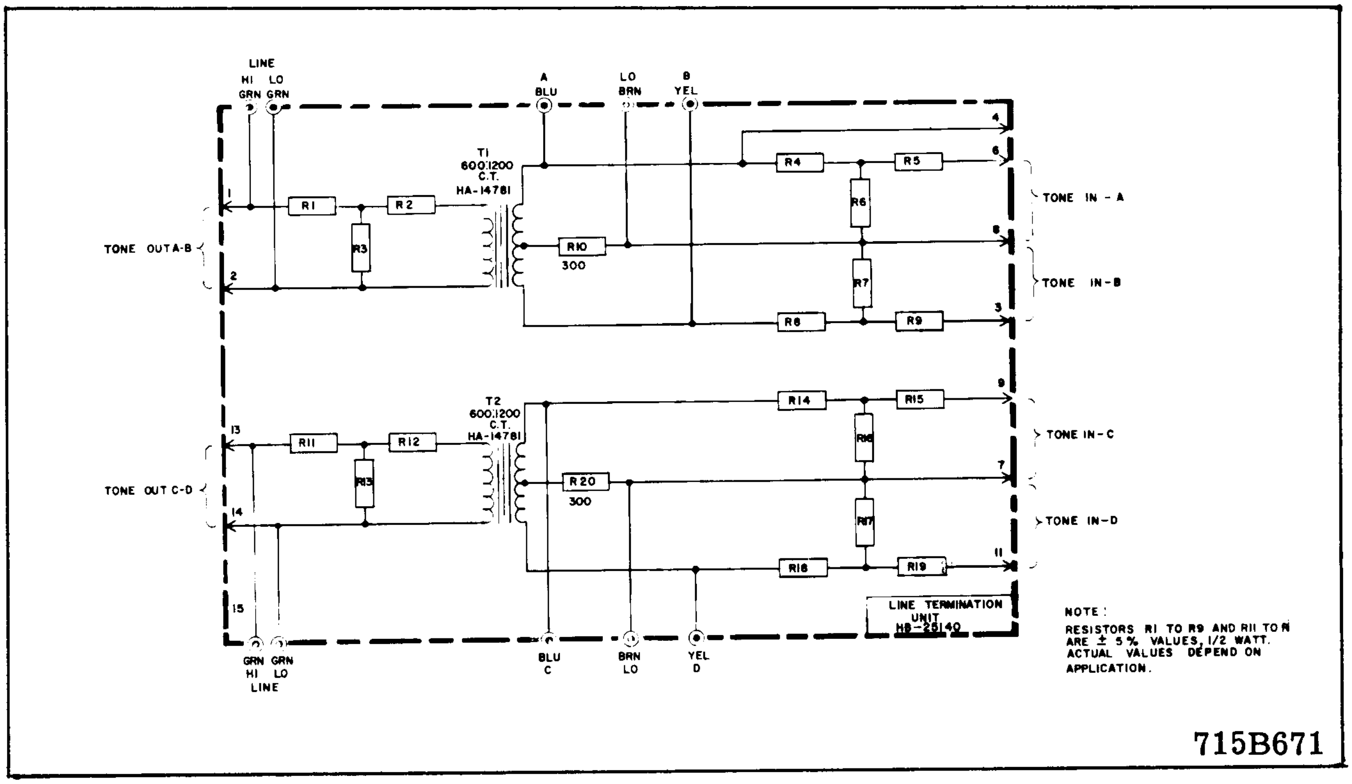


Fig. 20. Line Termination Module HB-25140.

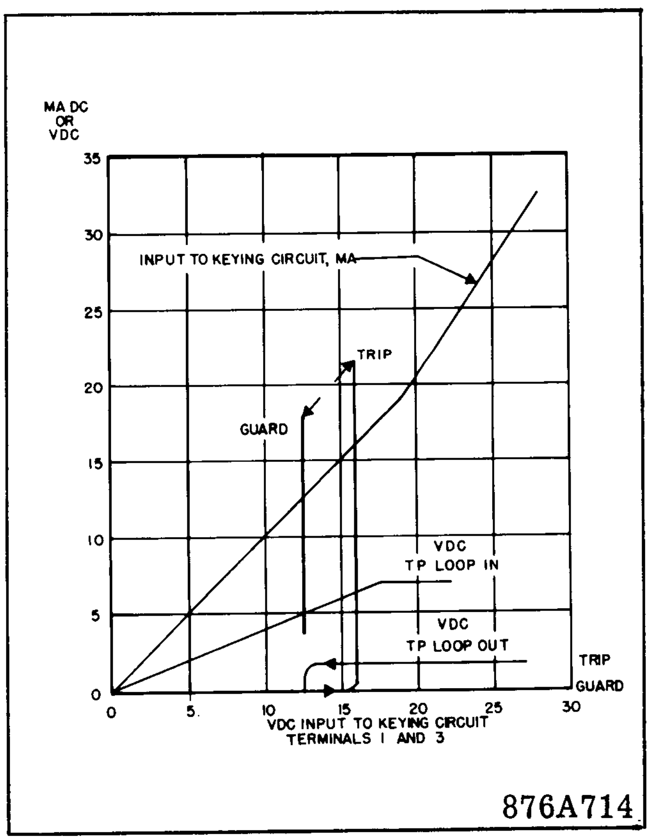


Fig. 21. Transmitter Keying Circuit Characteristics.

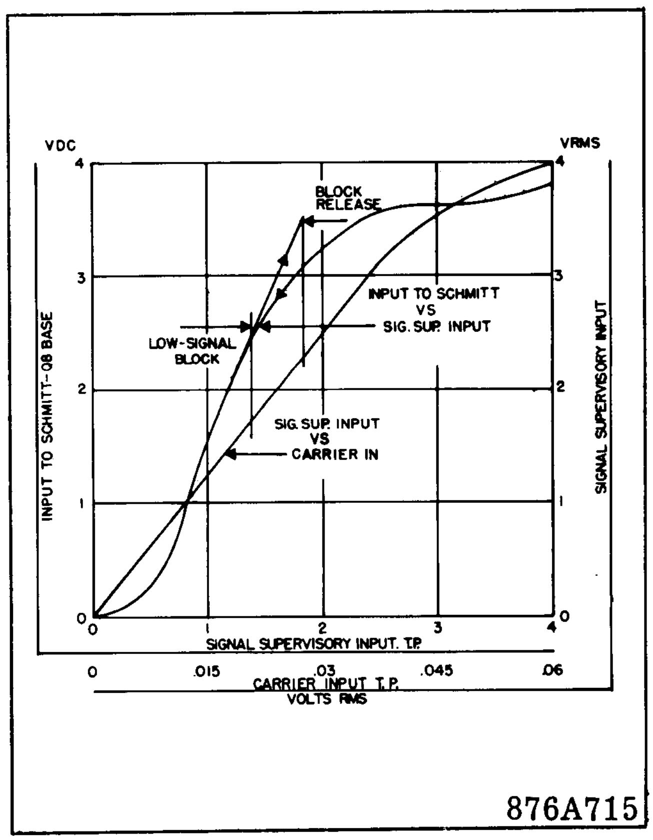


Fig. 22. Signal Supervisory Circuit Characteristics.

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

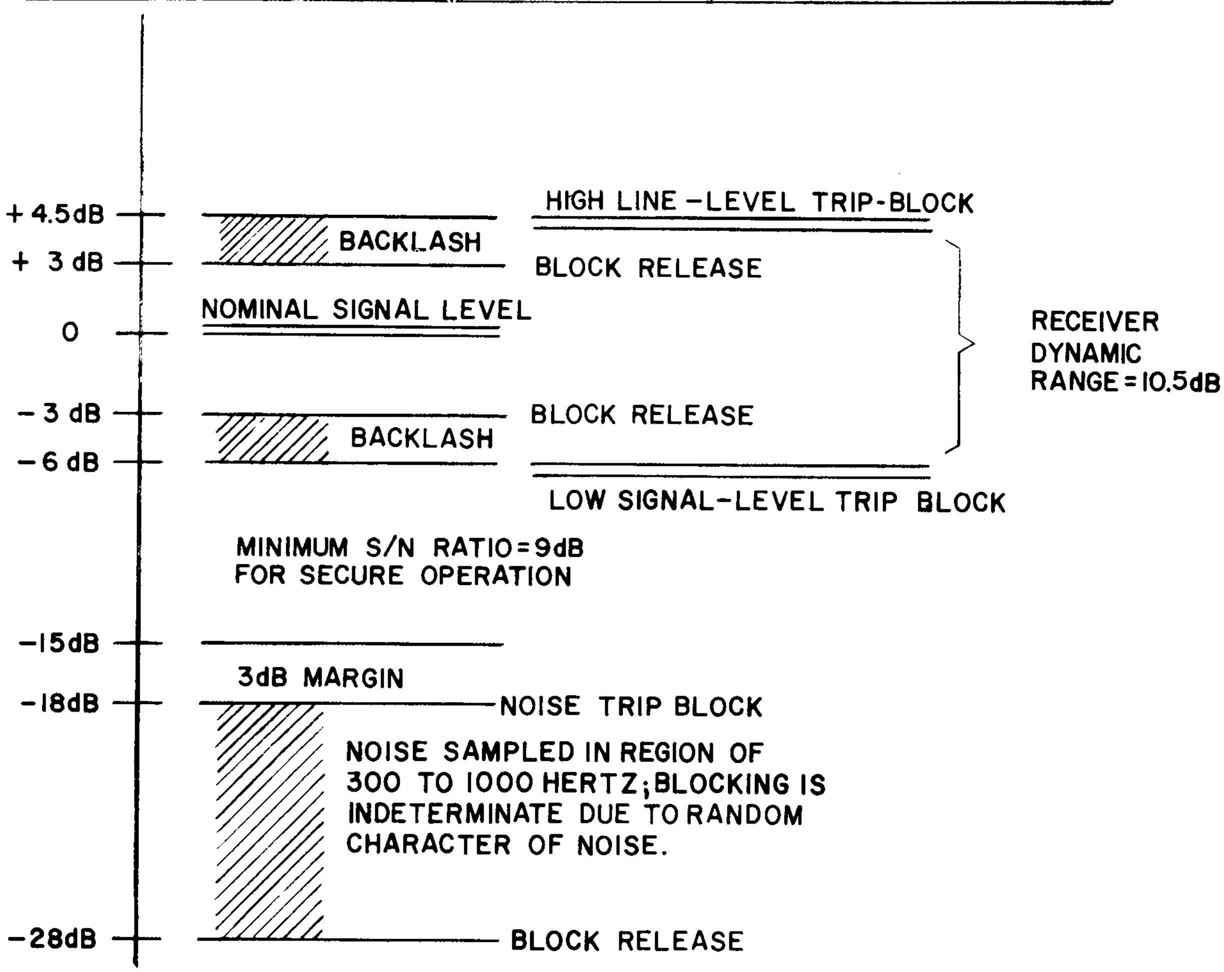


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Fig. 23. Receiver Dynamic Operating Range.

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION
NEWARK, N. J.
Printed in U.S.A.

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 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. 41-963.2
*Denotes change from superseded issue.

EFFECTIVE MAY 1969

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. If KX642 gas tubes are installed, connect them to ground only as shown in Figure 2. Do not connect the tube without shorting H2 to H3. This is especially important where the noise receiver is used, as a failure to follow these recommendations will result in the squelch disabling the channel whenever the tube flashes.

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

d. Do not use open pilot wires.

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

f. Use surge protection across tone connection.

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

Fig. 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. 9)

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.

C. RECEIVER MODULES (Block Diagram Fig. 10)

1. Receiver Input Filter HB63100 (See Fig. 11)

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 11.

2. Receiver Limiter and Signal Supervisory Module HB25160-1 (Fig. 12)

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 and HB25170 (Figs. 13 and 14)

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. 15.

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 14) 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. 10)

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

1. Noise Filter Module HB55187 or HB55183 (Fig. 16) (Notched for 595 Hz Transmitter)

This module contains a filter (see Fig. 16) that samples noise in the 300 to 1000 Hz region. There are two different types of filters. One of them has a rejection notch at 595 Hz and it is used in conjunction with a 595-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. 17)

This module consists of two receivers (see Figure 17). 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. 595-Hz TRANSMITTER HB21050-2 (Fig. 18)

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 595-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 19. The AR relay is described in separate instructions.

G. LINE TERMINATION MODULE HB25140 (Figure 20)

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.

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 (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 21.

2. Transmitter Amplifier HB25220 (Fig. 9)

With reference to the schematic diagram of Figure 9, 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.

C. RECEIVER MODULES
(Block Diagram Figure 10)

1. Receiver Input Filter HB63100 (Fig. 11)

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 12 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 22 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 and HB25170 (Figs. 13 and 14)

NOTE: Either module contains the discriminator tuned circuits in the HB62700 unit. (Fig. 15)

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 15 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. 10, Internal Schematic Fig. 17)

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 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 23 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

1. 595-Hz Transmitter HB25010-2 (Fig. 18)

With referance to the schematic diagram of Figure 18, an LC oscillator is employed to generate the carrier frequency. Keying circuits are provided to shift the carrier to a blocking state. 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 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 595-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.

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 3.5-W. 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.

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 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 5.)

F.S. OSCILLATOR AND KEYER HB25110

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 21.

Frequency:

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

TRANSMITTER AMPLIFIER HB25220

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.

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 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 595 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.

595-Hz TRANSMITTER HB21050-2

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 adjustor marked "level" 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 levels are to be checked or readjusted. The 595-Hz transmitter should be set the same as any other transmitter.

F.S. Receiver

(Refer to Fig. 23 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. 23 for Levels)

NOTE: If a 55183 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 1.75 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. 15, 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.

595-Hz Transmitter

Frequency: 595 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 to be made. 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 10 kHz, 1 mv sensitivity.

2. Calibrated Attenuator, 600 ohm.

For troubleshooting, the following additional test equipment is desirable:

1. Electronic Frequency Counter, 10 kHz minimum.

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

3. Cathode-Ray Oscilloscope.

4. Oscillator, 200 to 4000 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 (Q3, Q4-Fig. 12)	Vdc	C	+36	+36	Vp – p.	C	34	34
		B	+25	+25		B	10	10
		E	+24.5	+24.5		E	5	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

			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 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	RFL PART NO.
	HB25110 F.S. OSCILLATOR AND KEYER	
R2 thru R20	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%, 3¼ 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, VCEO 40V, TO-92 case, Motorola 2N3903.	HA-21562
	Tuned oscillator ckt., sealed plug-in assembly.	HB-62800
	Test jacks, Sealectro Corp., SKT-10.	
	HB25220 TRANSMITTER AMPLIFIER	
R3 thru R11	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. PE 200.	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%. Emenco DM-19.	HA-16632
Q2, Q3	TRANSISTOR, silicon NPN V_{CEO} 65V TO-5 case.	HA-22678
Q1	TRANSISTOR, silicon NPN V_{CEO} 40V, TO-92 case.	HA-21562
	TRANSFORMER, Plug-in assembly	HB-55207
	Multiplexing filter, plug-in assembly.	HB-62600
	Test jacks, Sealectro Corp., SKT-10.	
	HB-21050 595 Hz FS TRANSMITTER	
R1-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, 0.125watt, 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.	HB-58200
	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	RFL PART NO.
	HB-25160-1 RECEIVER LIMITER AND SIGNAL SUPERVISORY	
R1 thru 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., 0.0068µF, 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, 15µF, ±20%, 35V. Texas Inst. SCM156GP035D4.	H-1007-654
C9	CAPACITOR, tantalum, 0.47µF, ±10%, 35V. Texas Inst., SCM474FP035D2.	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. 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 F.S. DISCRIMINATOR AND D.C. AMPLIFIER	
R2 thru 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., 0.082µ F 2%, 100V. Wesco 32P.	H-5115-79
C2	CAPACITOR, mylar, 0.255µF 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	RFL PART NO.
	HB-25130 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 thru R43	±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., 0.02 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 1N914.	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	RFL 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	RFL PART NO.
	HB-25210 VOLTAGE REGULATOR	
R17 thru 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.	

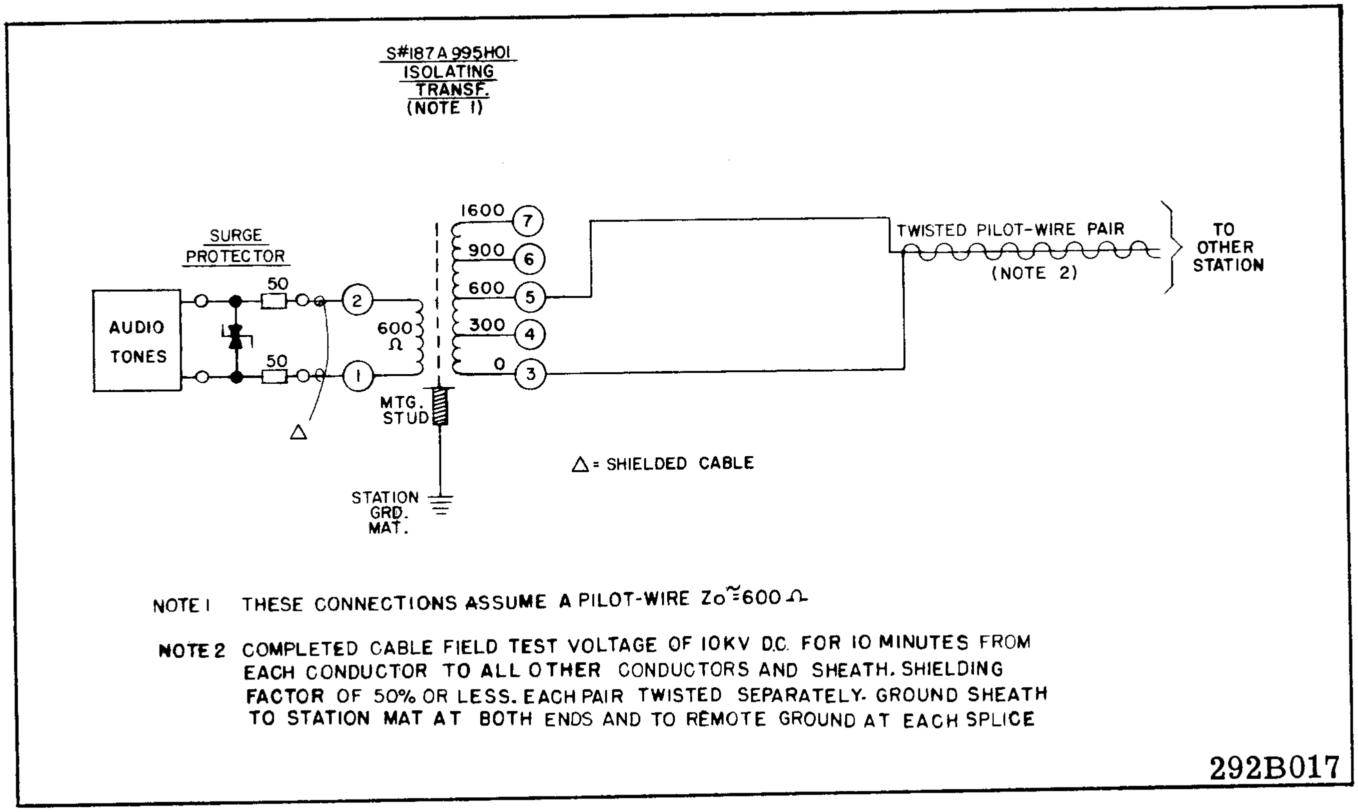
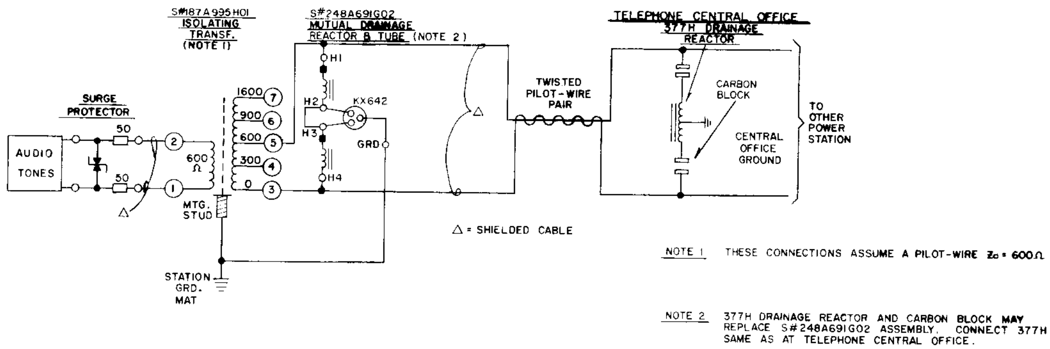
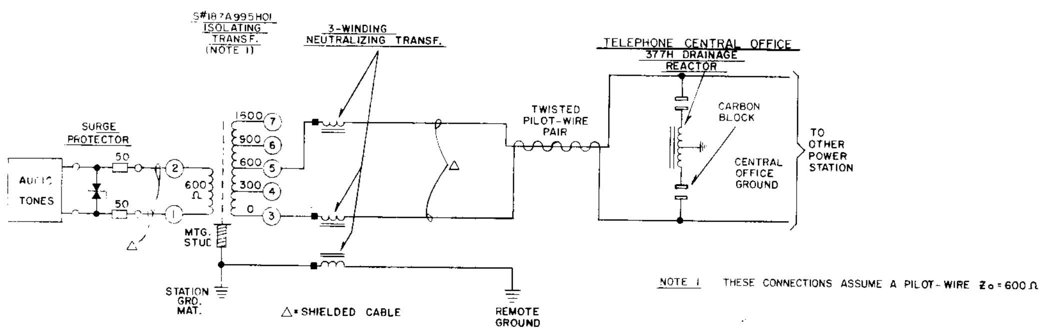


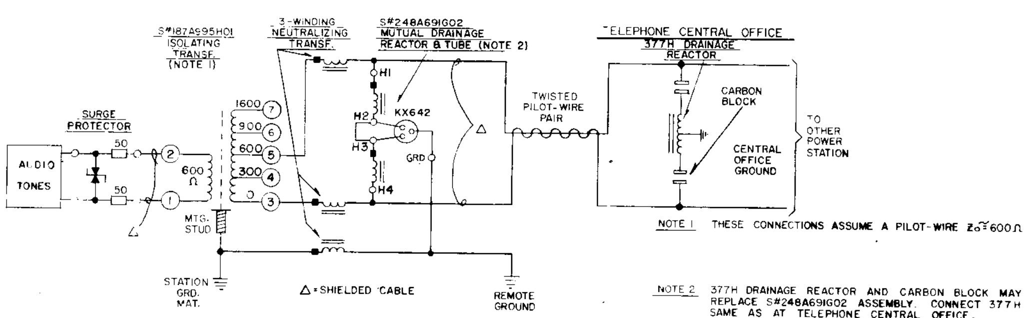
Fig. 1. Recommended Connections and Pilot Wire Design for Privately Owned Two-Terminal Lines.



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



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



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

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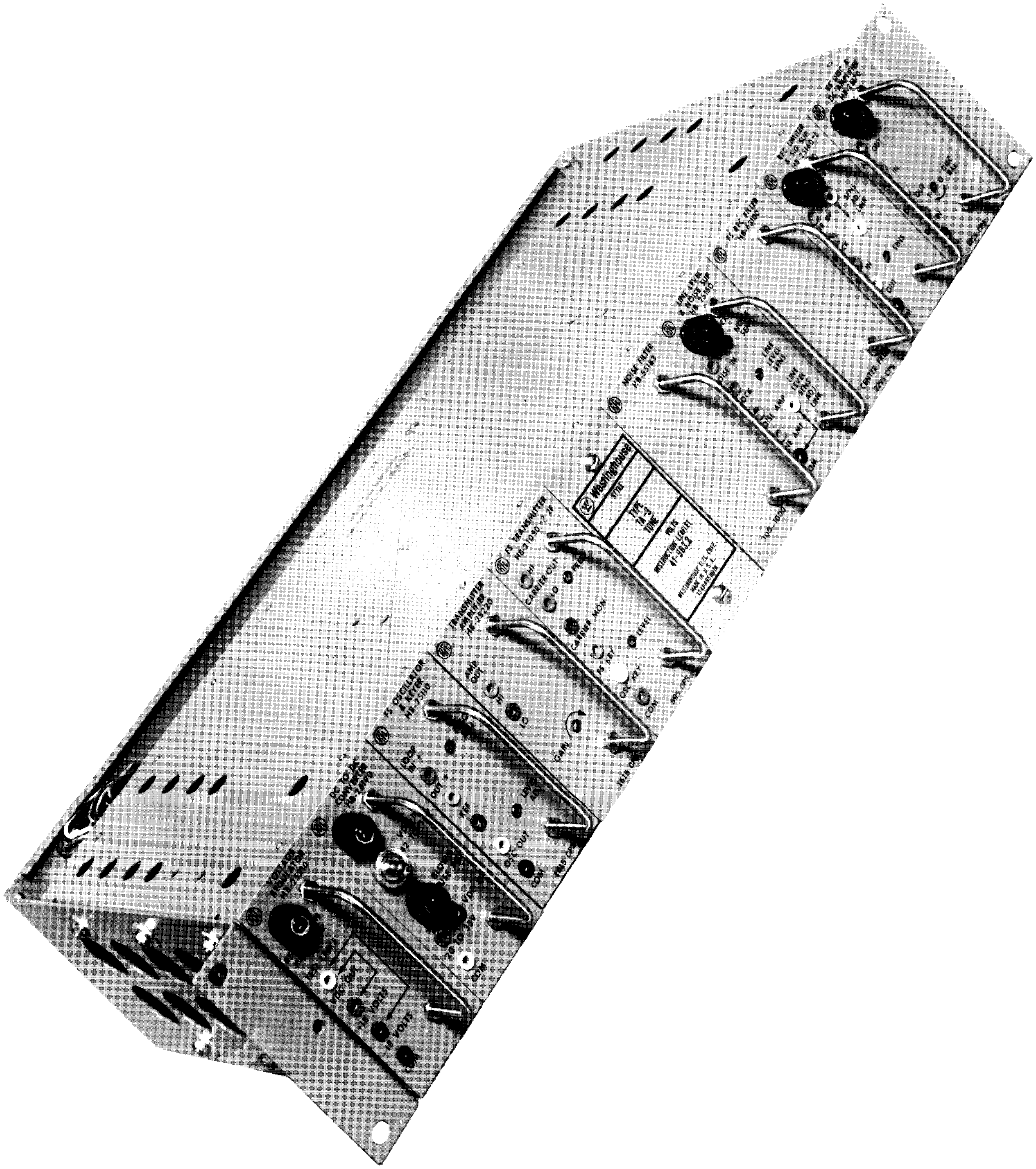
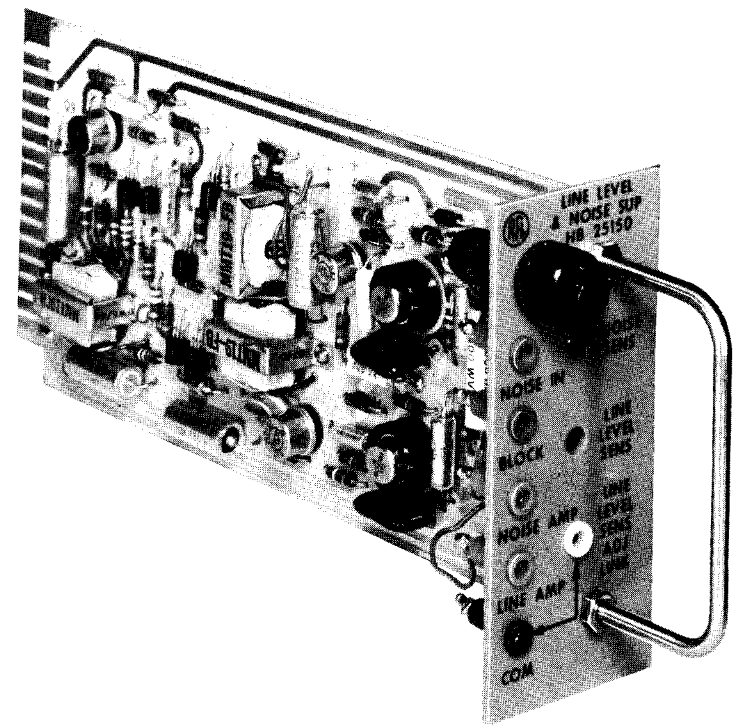
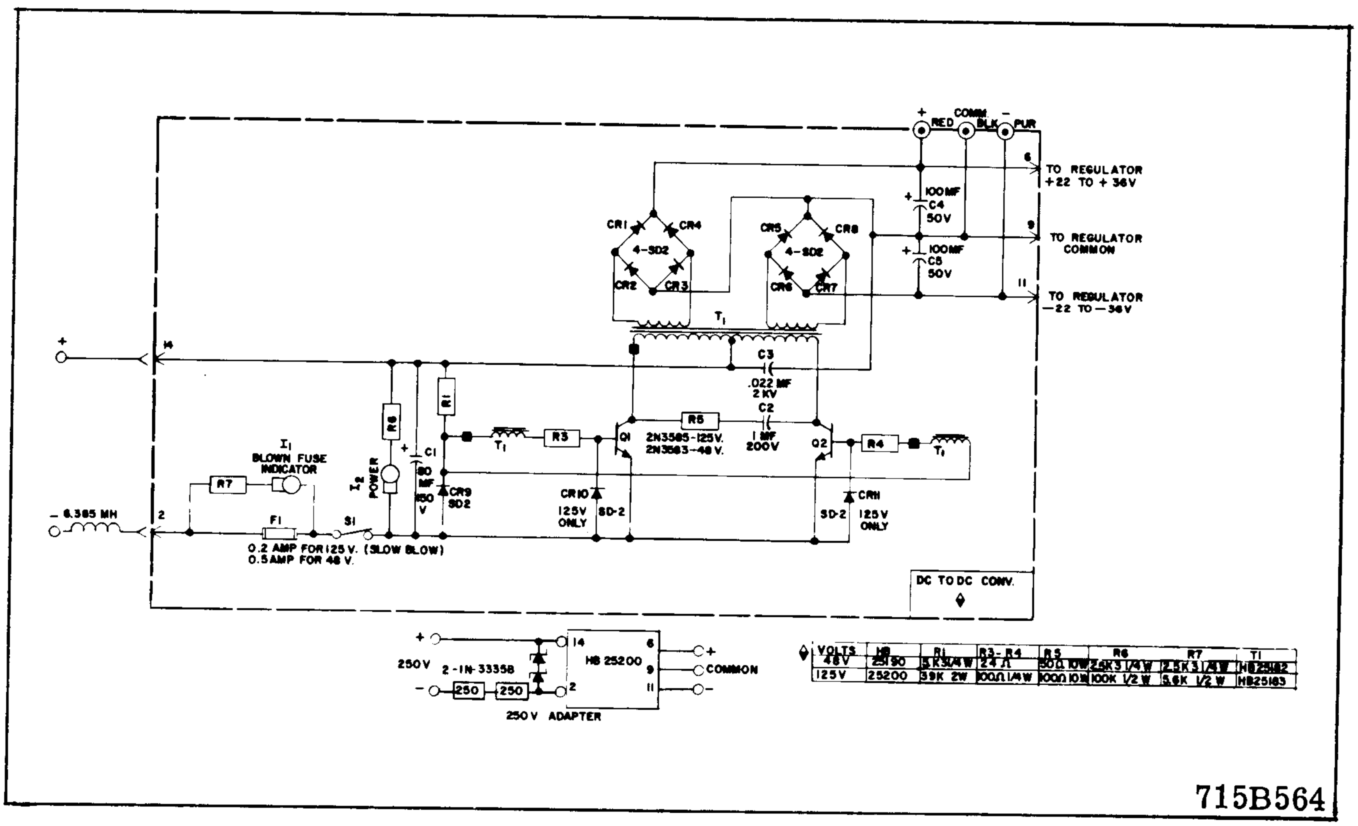
** Fig. 2. Recommended Connections and Protective Arrangements for Two-Terminal Lines*



* *Fig. 3. Front View of Full Chassis. Photo # 68-275.*

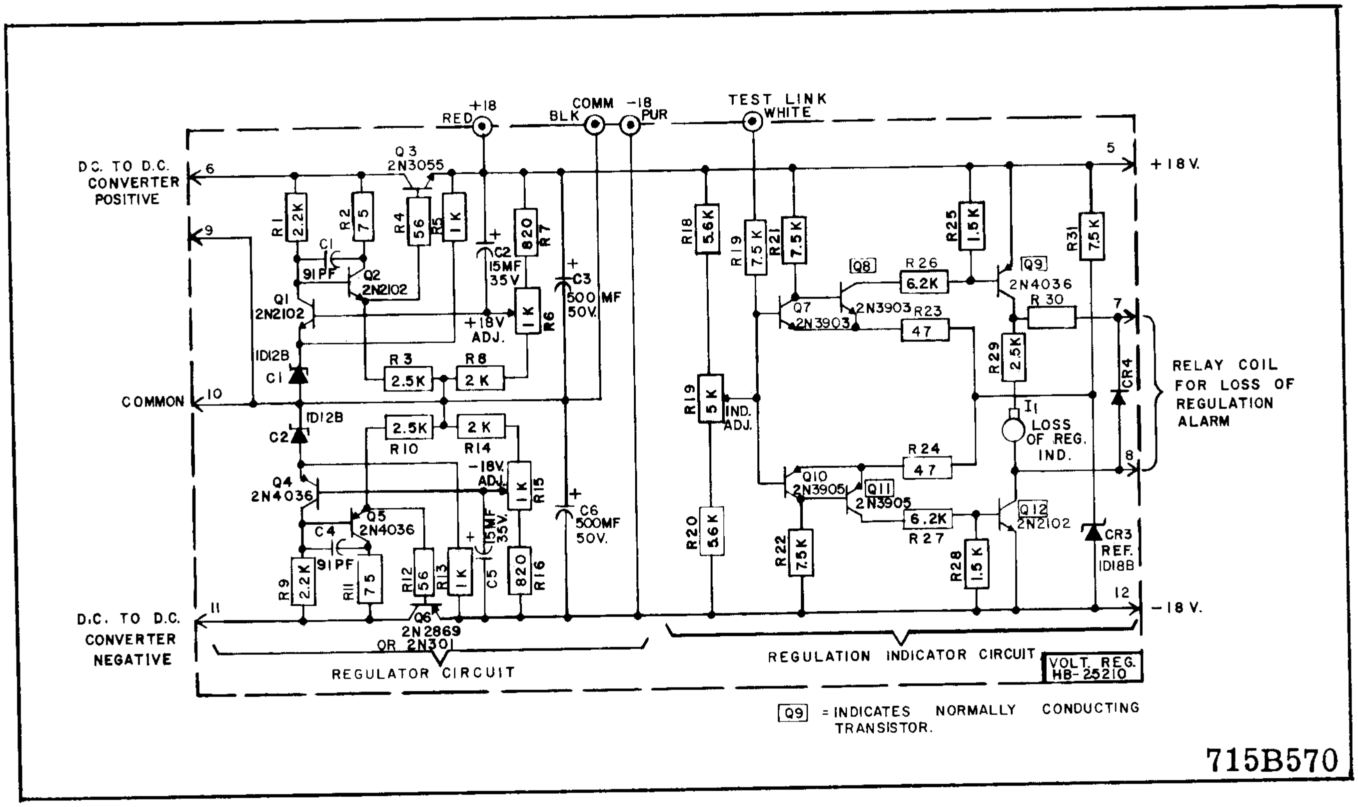


* *Fig. 4. Typical Module. #68-276.*



VOLTS	HB	R1	R3-R4	R5	R6	R7	T1
48V	25190	5K 3/4W	24 Ω	50 Ω 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.*

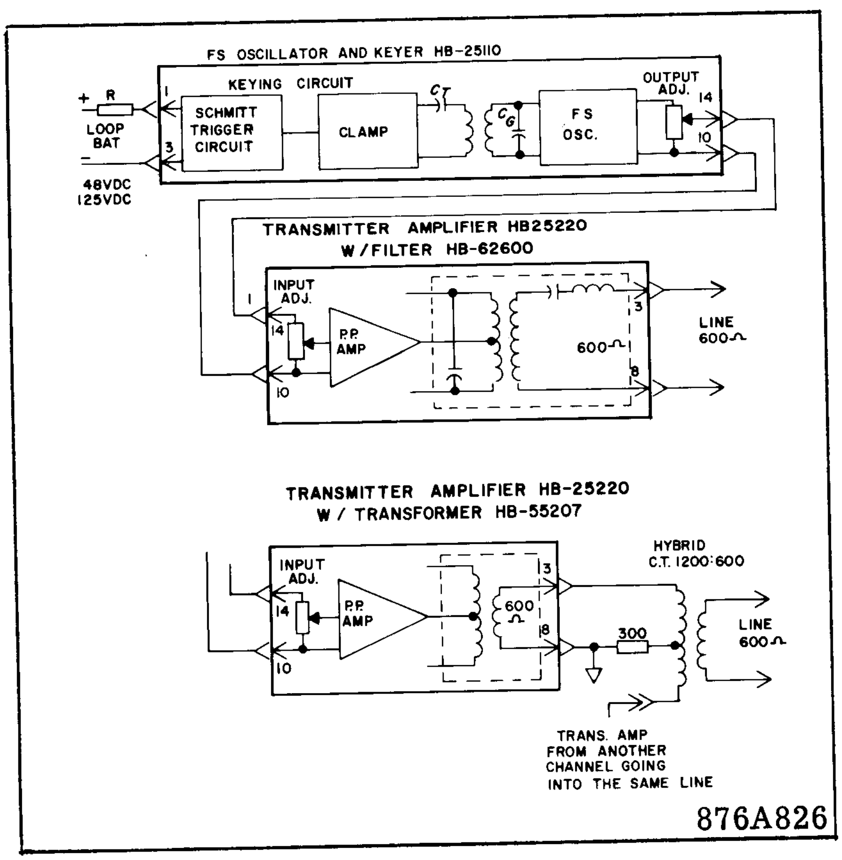


Fig. 7. Transmitter Block Diagram.

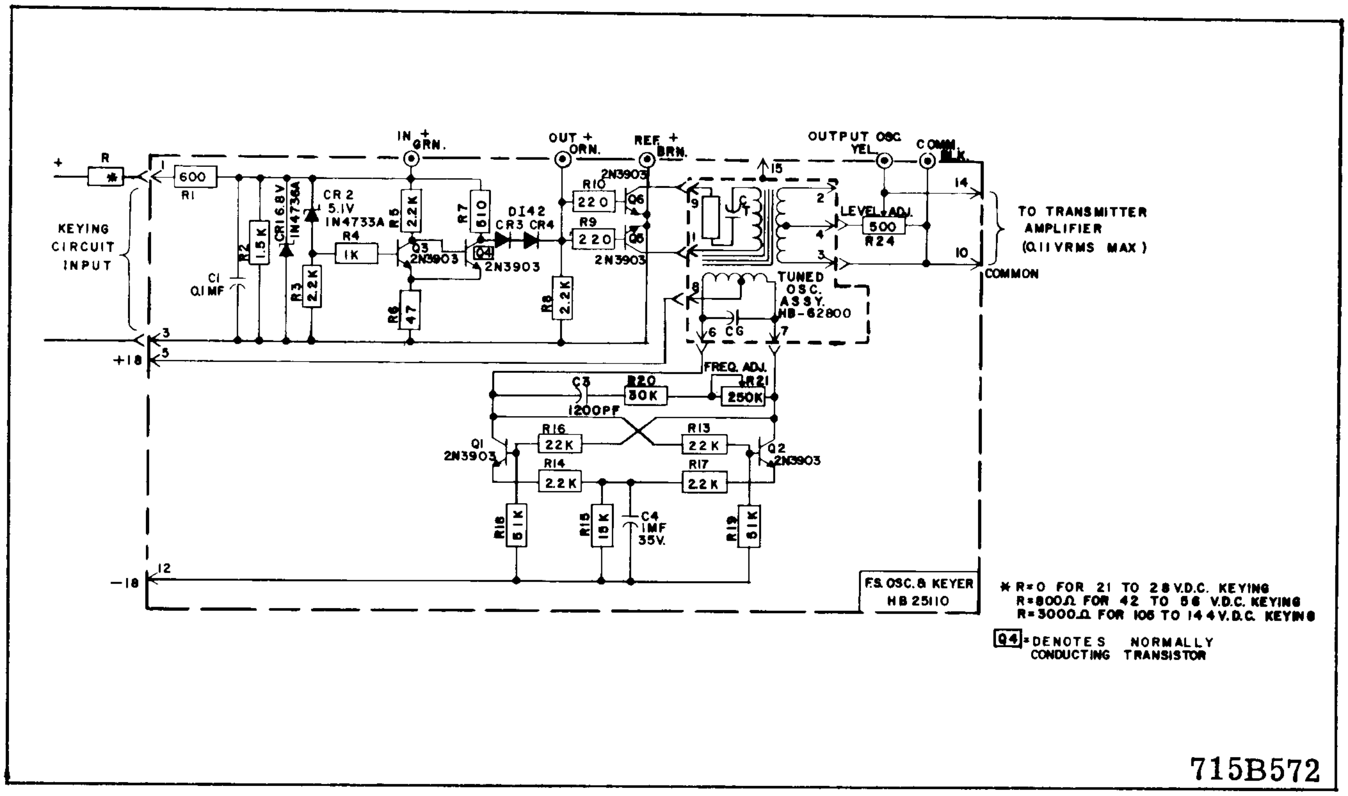


Fig. 8. F.S. Oscillator and Keyer HB-25210.

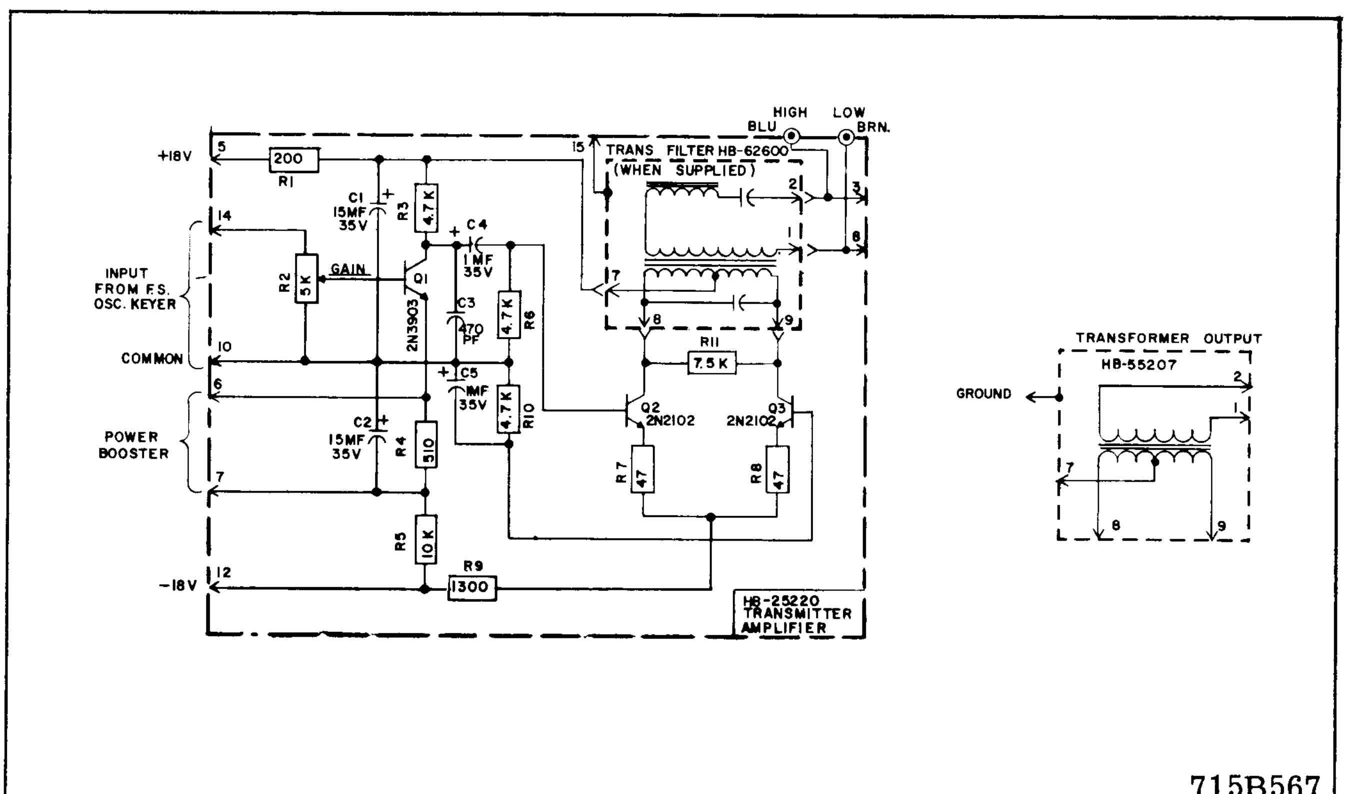


Fig. 9. Transmitter Amplifier HB-25220.

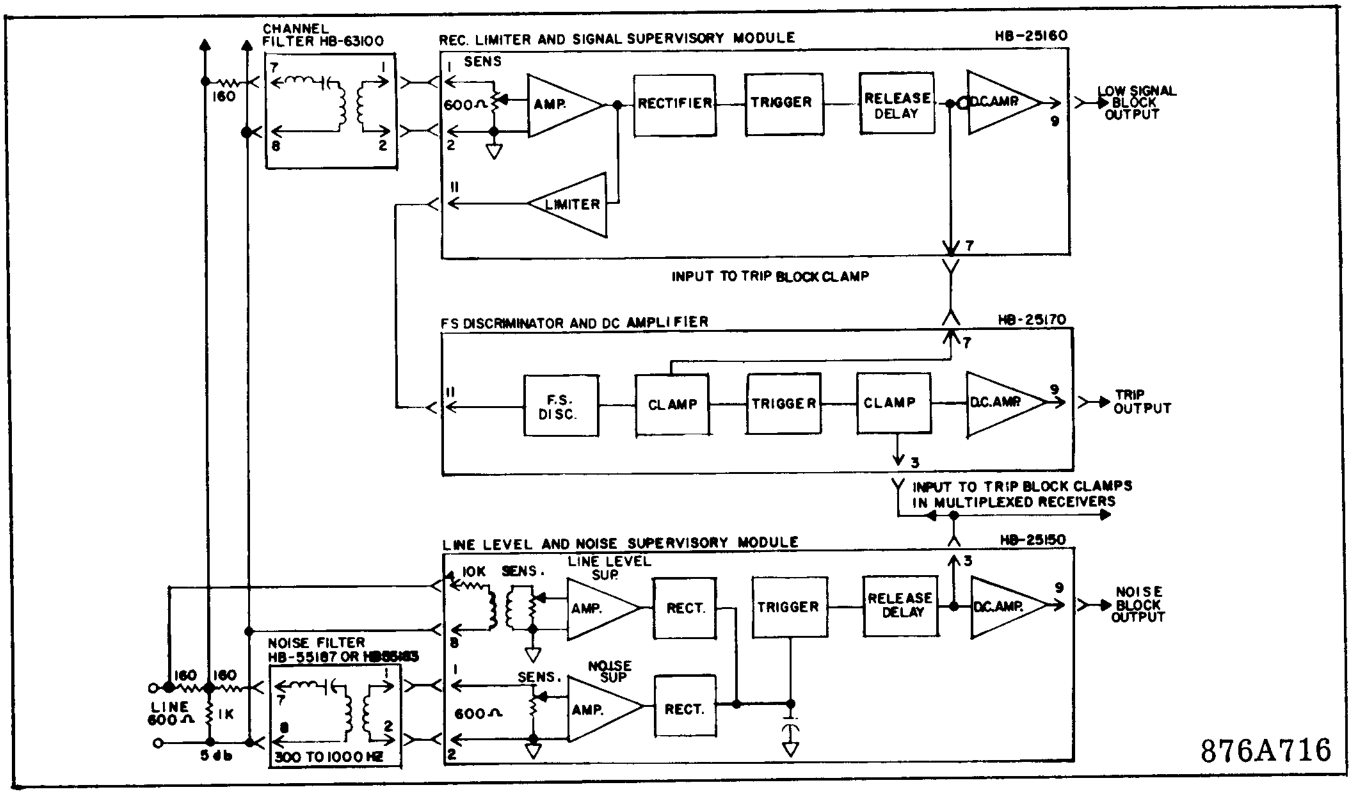


Fig. 10. Receiver Block Diagram HB-63100.

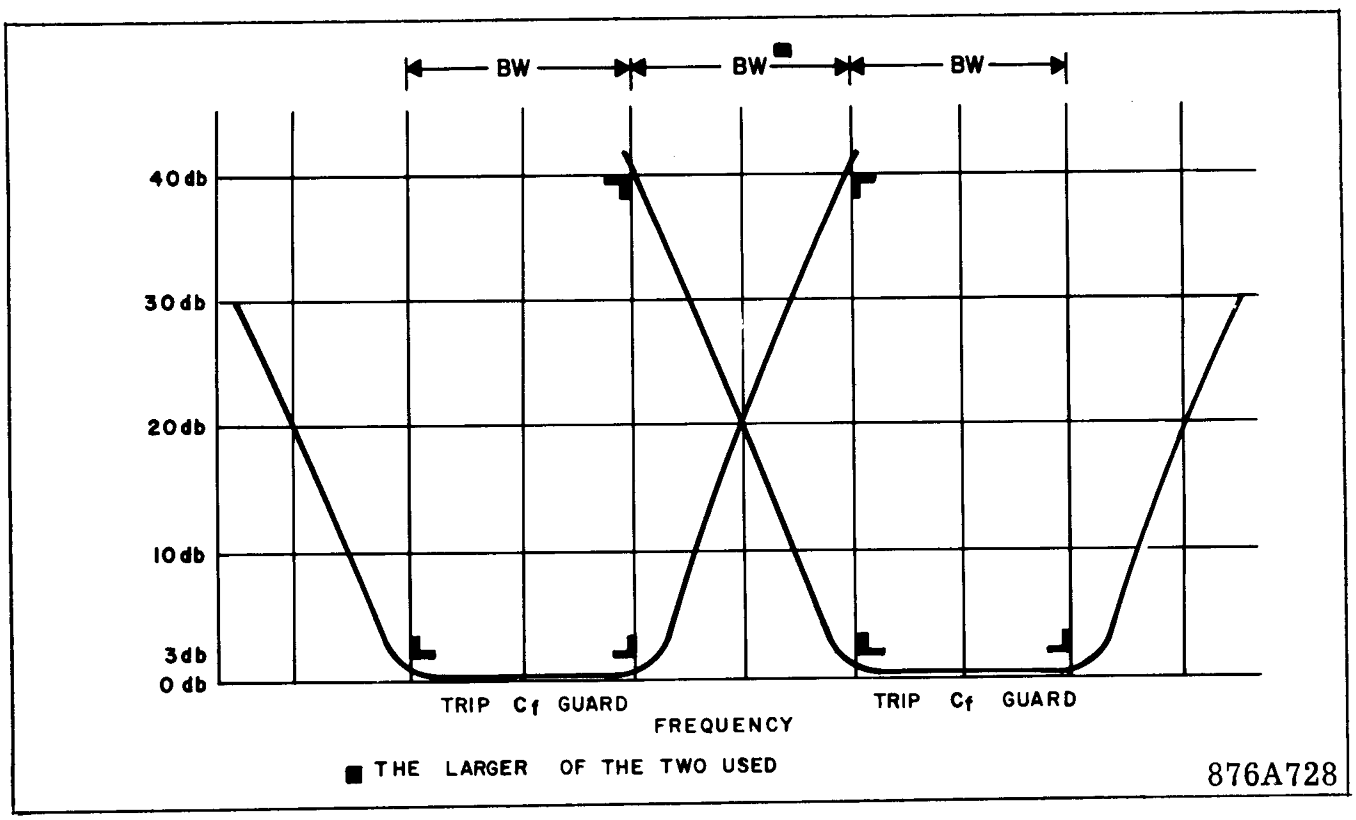
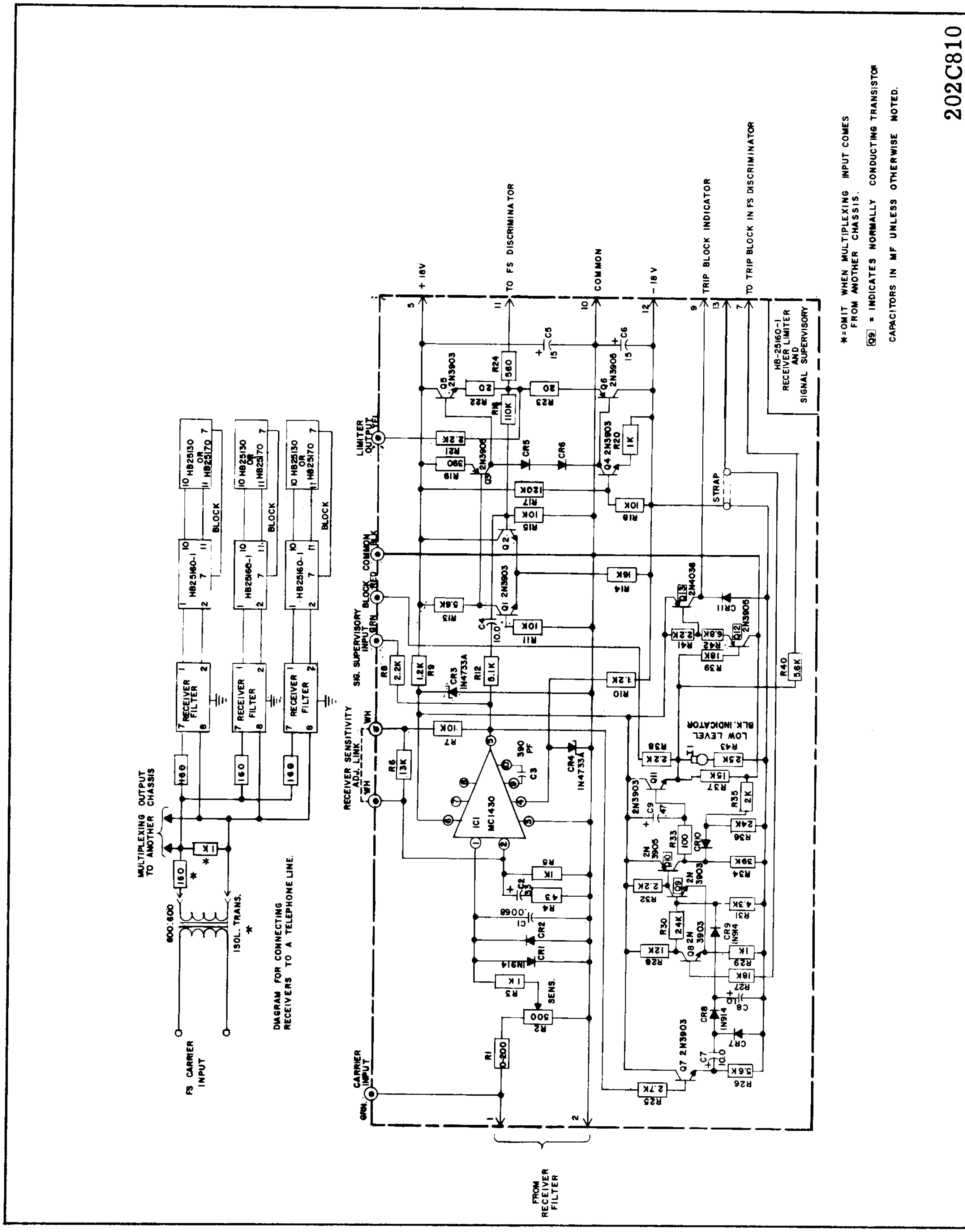


Fig. 11. Tone Receiver Filter Characteristics HB-63100.



* *Fig. 12. Receiver Limiter and Signal Supervisory HB-25160-1.*

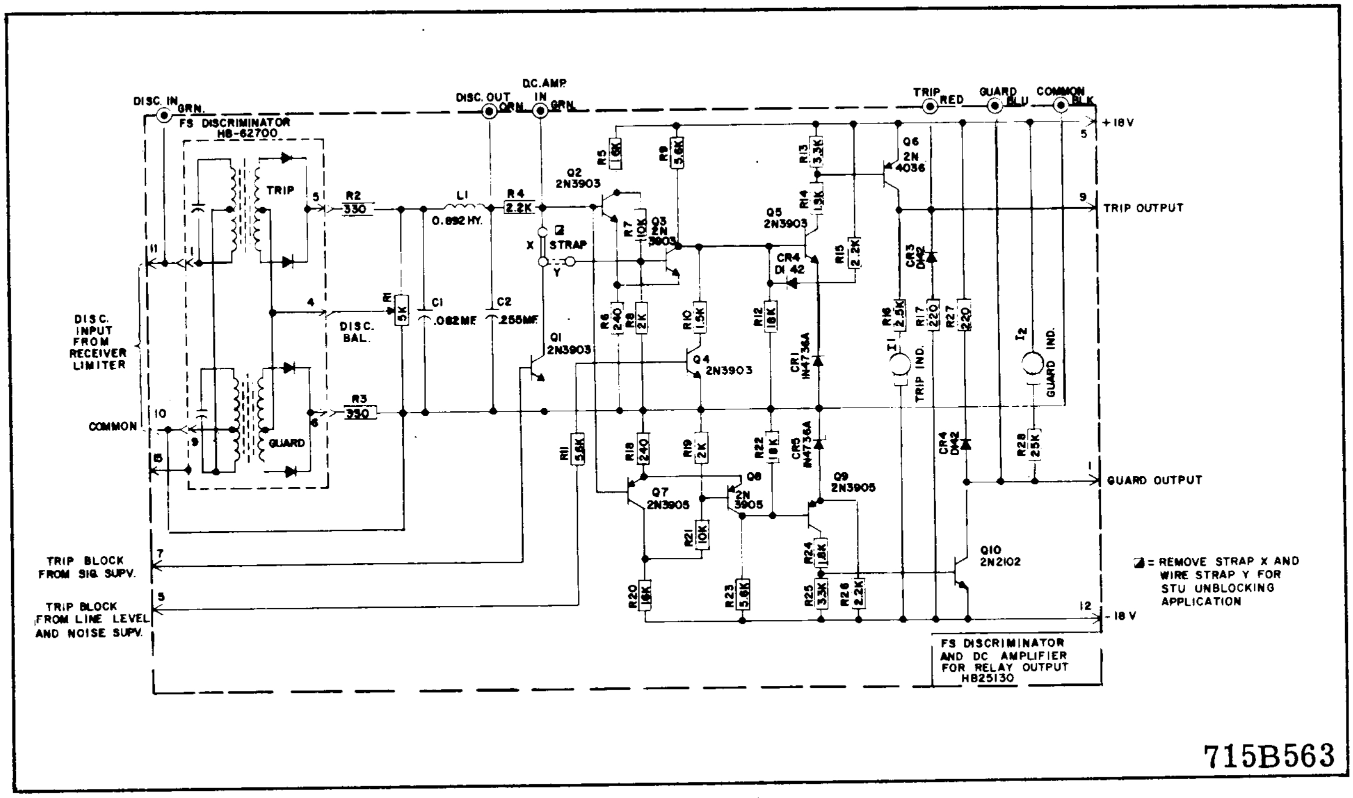


Fig. 13. F.S. Discriminator and D-C Amplifier for Relay Output HB-25130.

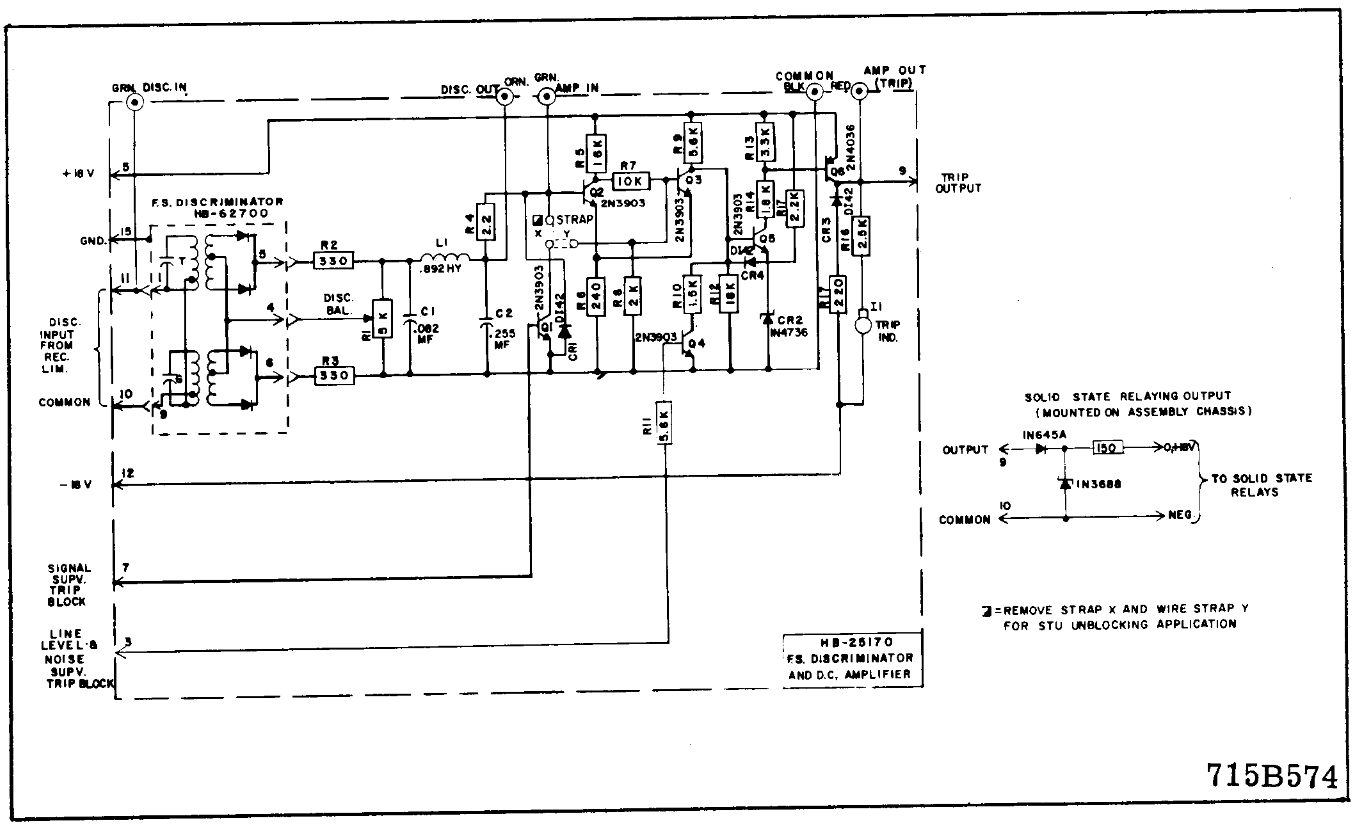


Fig. 14. F.S. Discriminator and D-C Amplifier for Solid-State Relaying HB-25170.

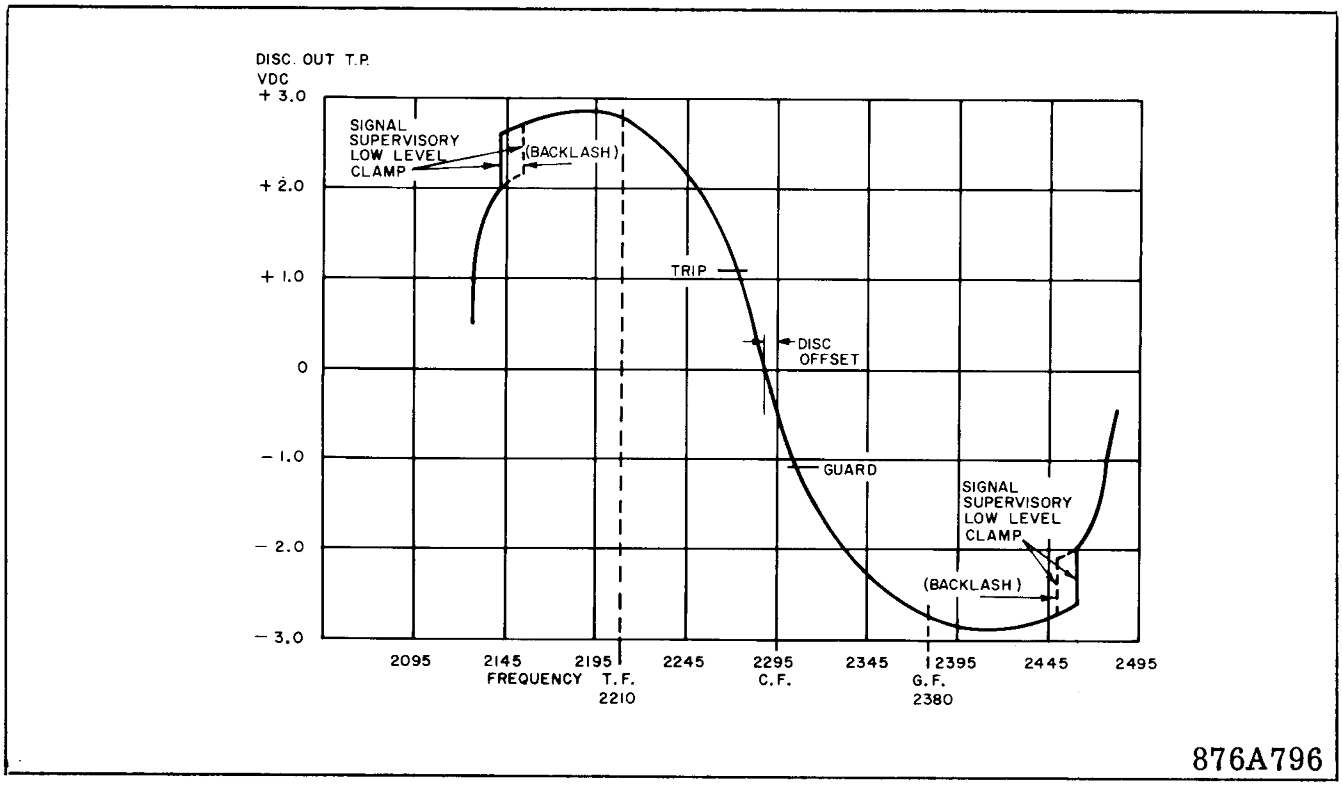


Fig. 15. Typical Discriminator Output.

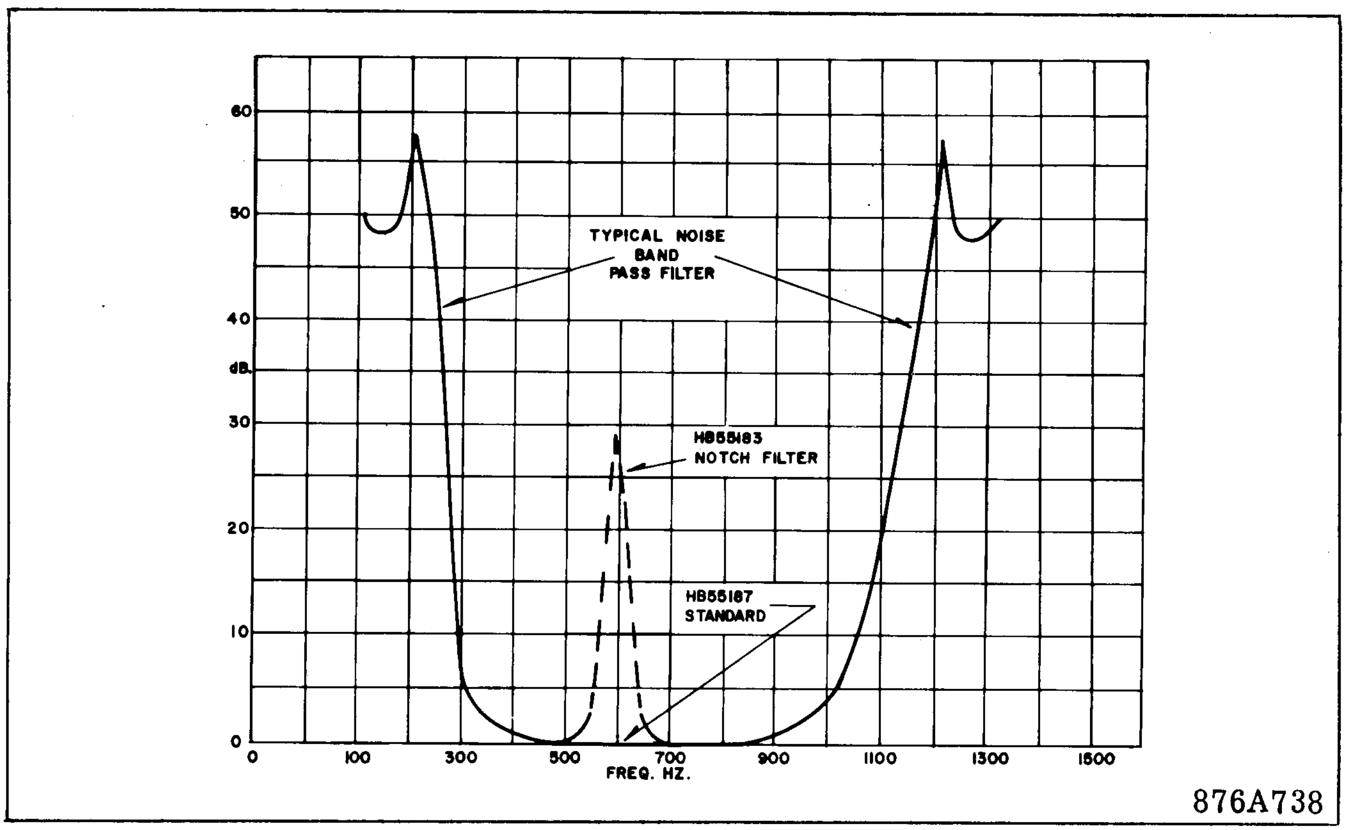
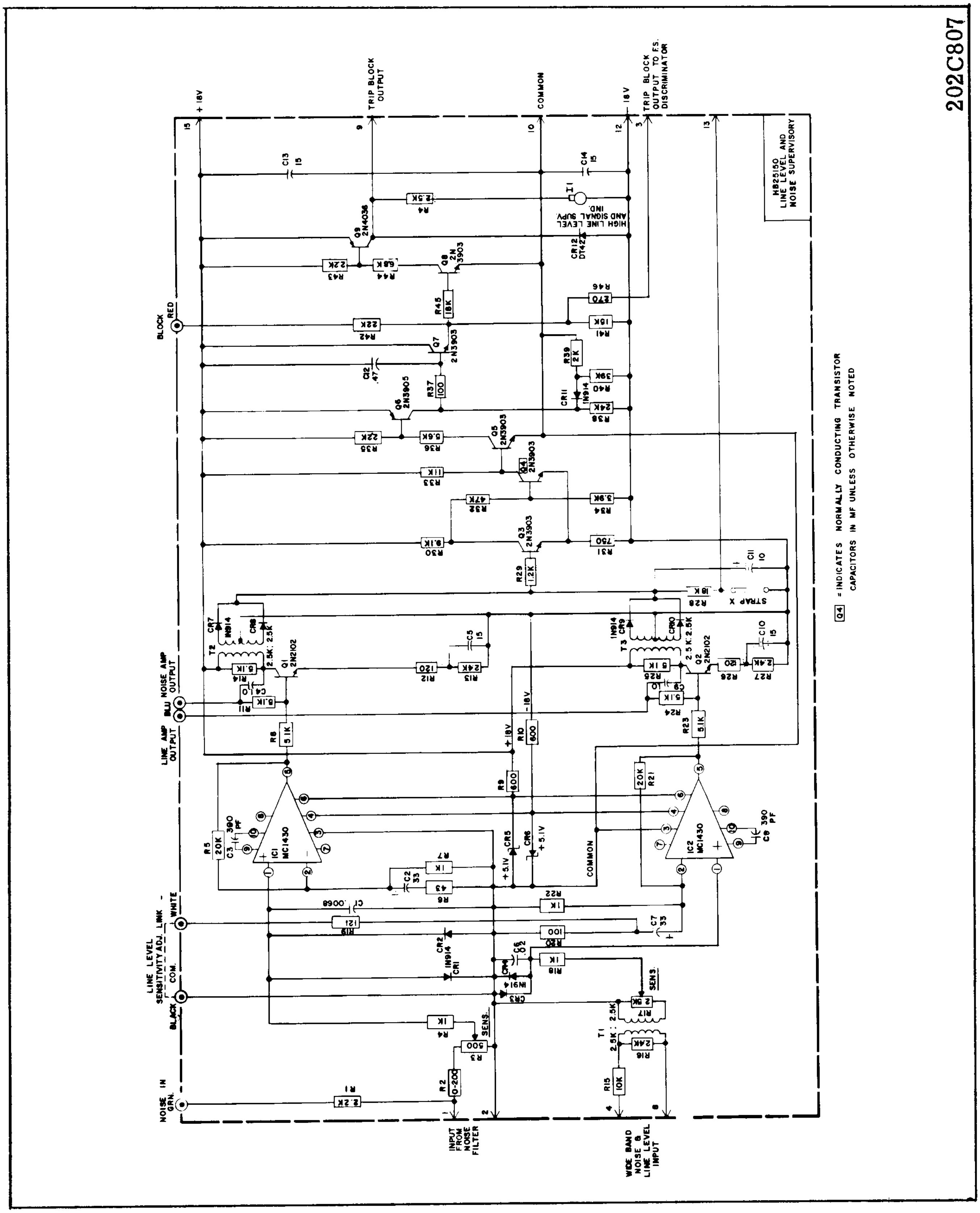


Fig. 16. Typical Noise Bandpass Filter.



* *Fig. 17. Receiver Line Level and Noise Supervisory Module HB-25150.*

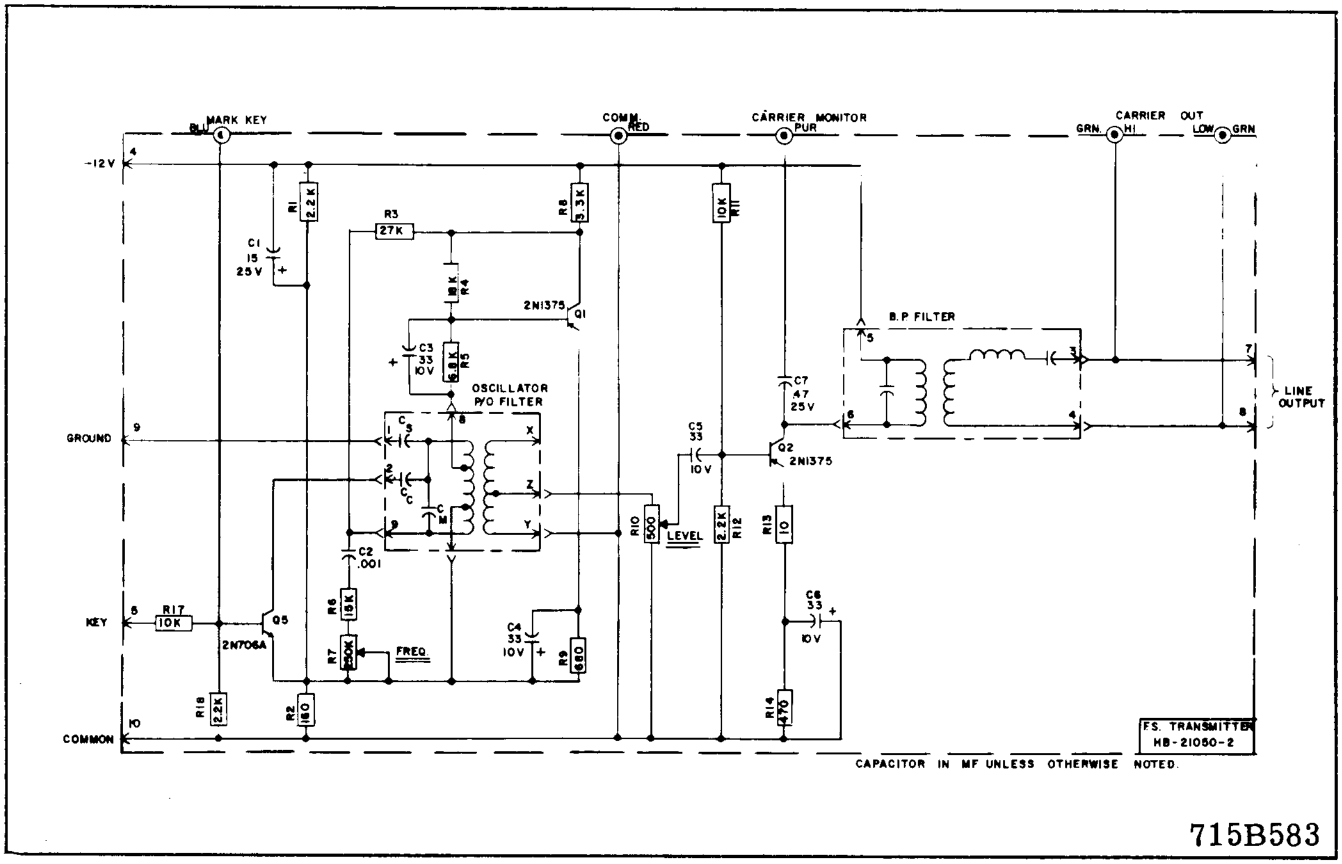
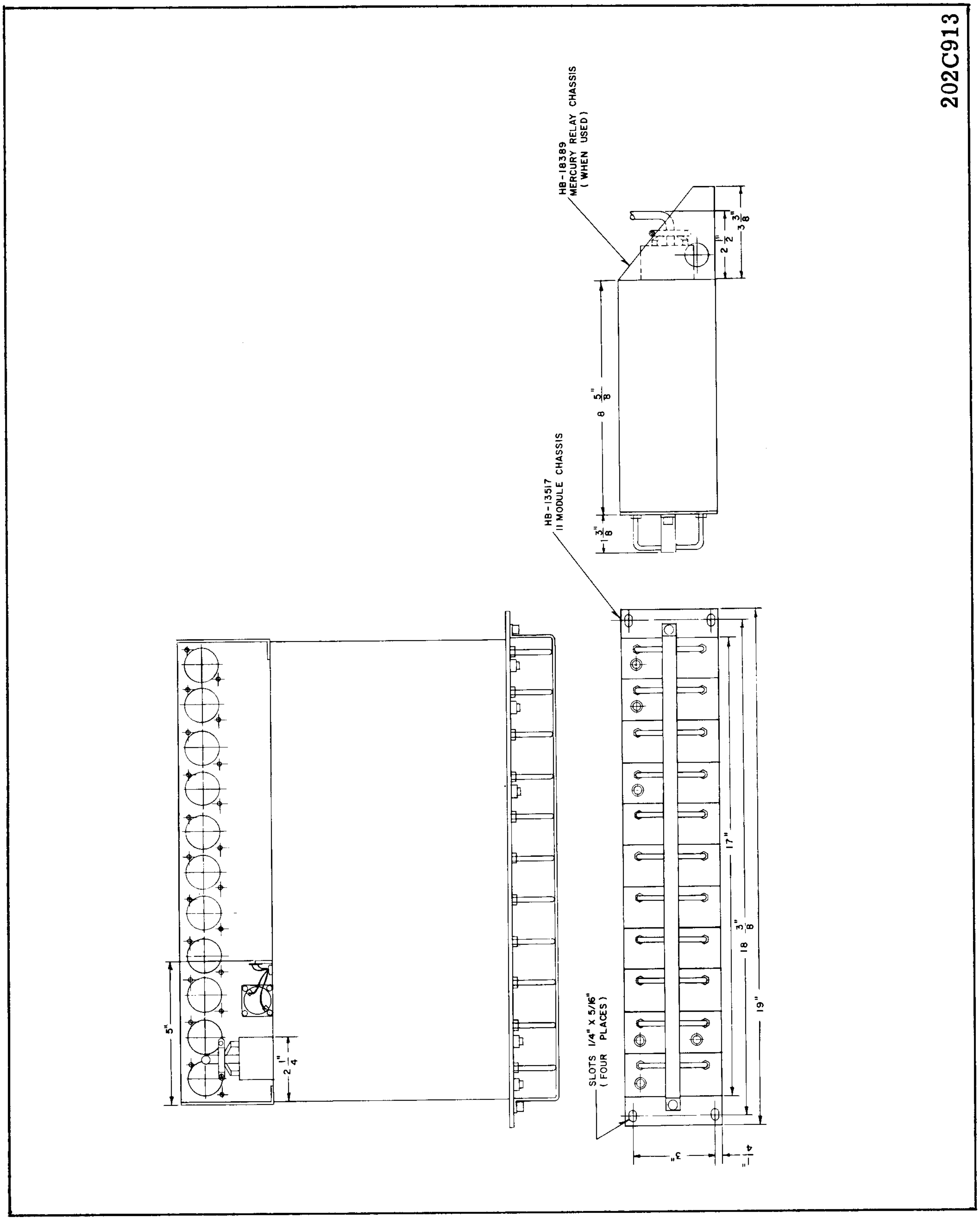
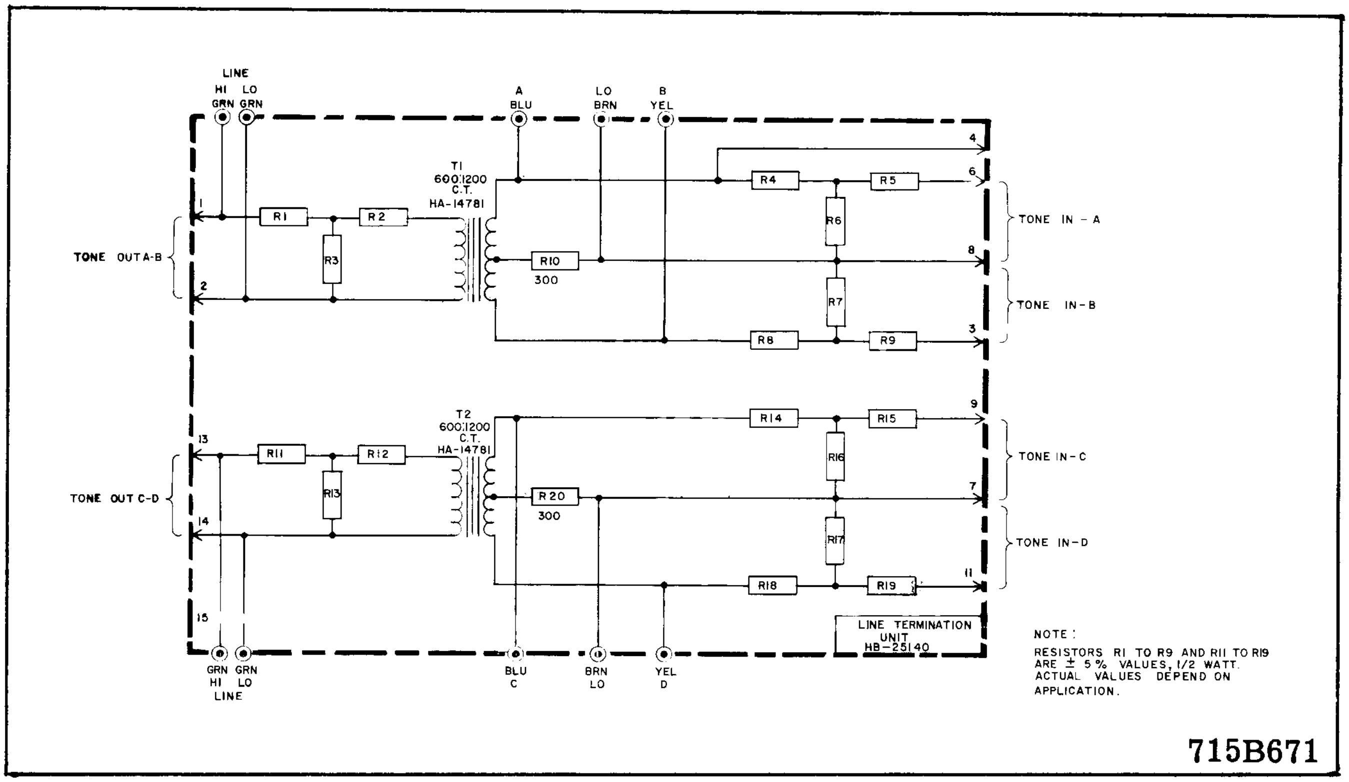


Fig. 18. 595-Hz Transmitter HB-21050-2.



* *Fig. 19. Outline and Drilling Plan.*



✱ *Fig. 20. Line Termination Module HB-25140.*

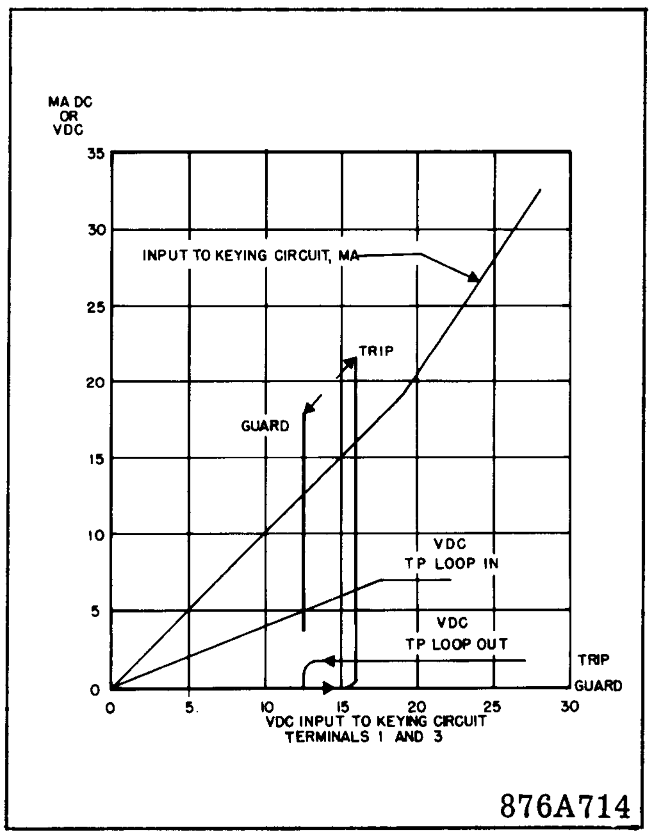


Fig. 21. Transmitter Keying Circuit Characteristics.

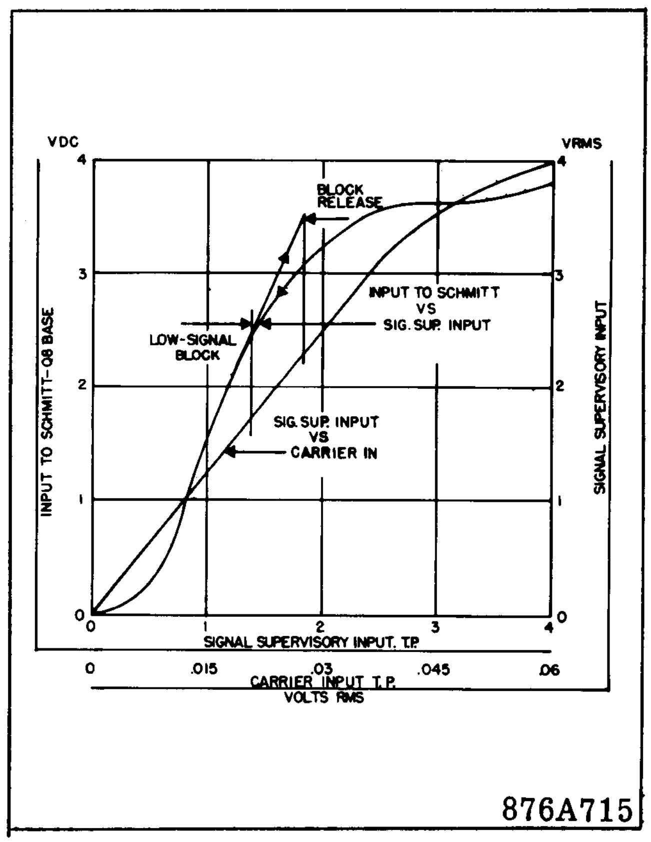
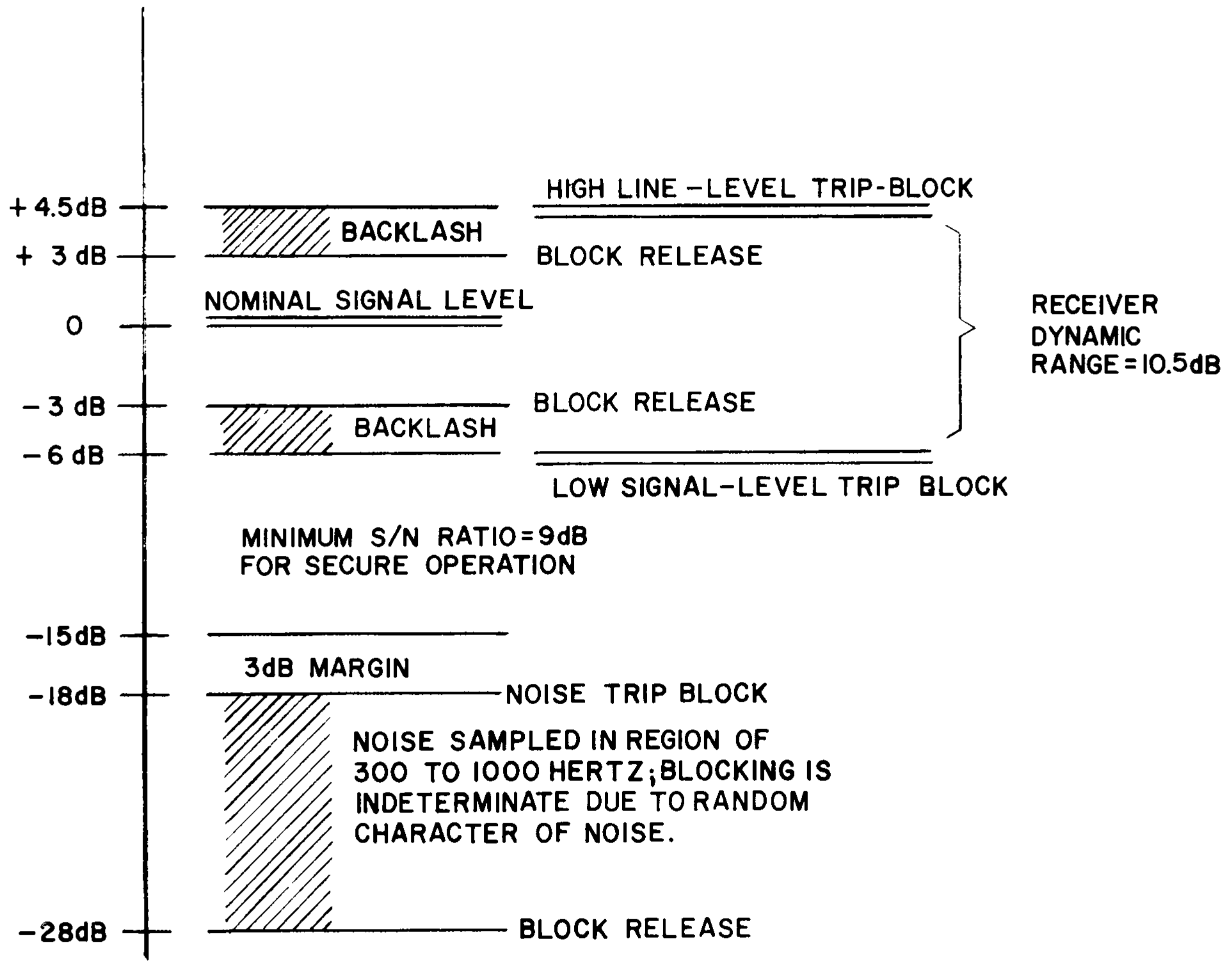


Fig. 22. Signal Supervisory Circuit Characteristics.

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. 23. Receiver Dynamic Operating Range.

WESTINGHOUSE ELECTRIC CORPORATION
RELAY-INSTRUMENT DIVISION **NEWARK, N. J.**
Printed in U.S.A.

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. 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_0 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_0 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. [fg = 10,000 – fc – 170]. The trip frequency would then be 10 KHz minus the channel center frequency and plus 170 Hz. [ft = 10,000 – fc + 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		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		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	

Circuit	Measurement		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		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 μ F ±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.	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, 1.0μF ±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.	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.	

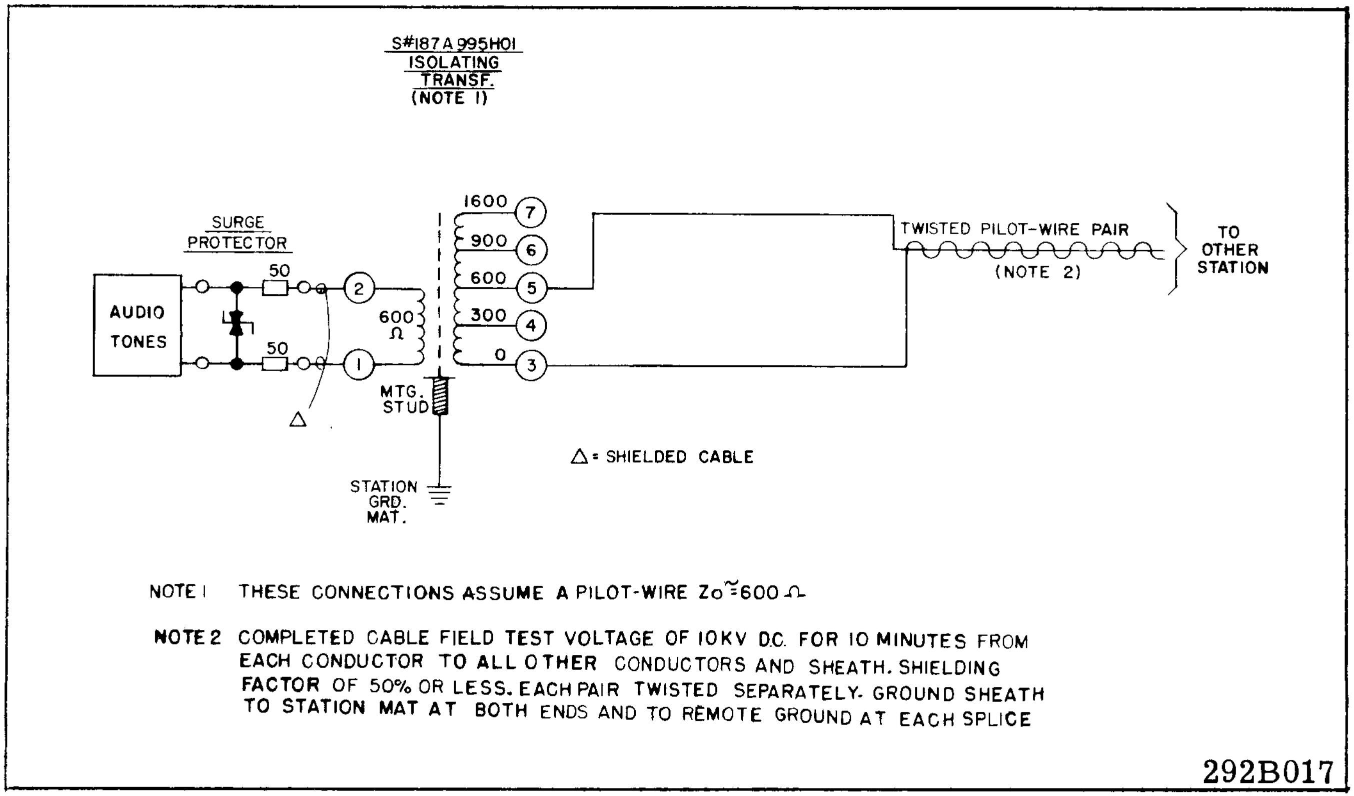
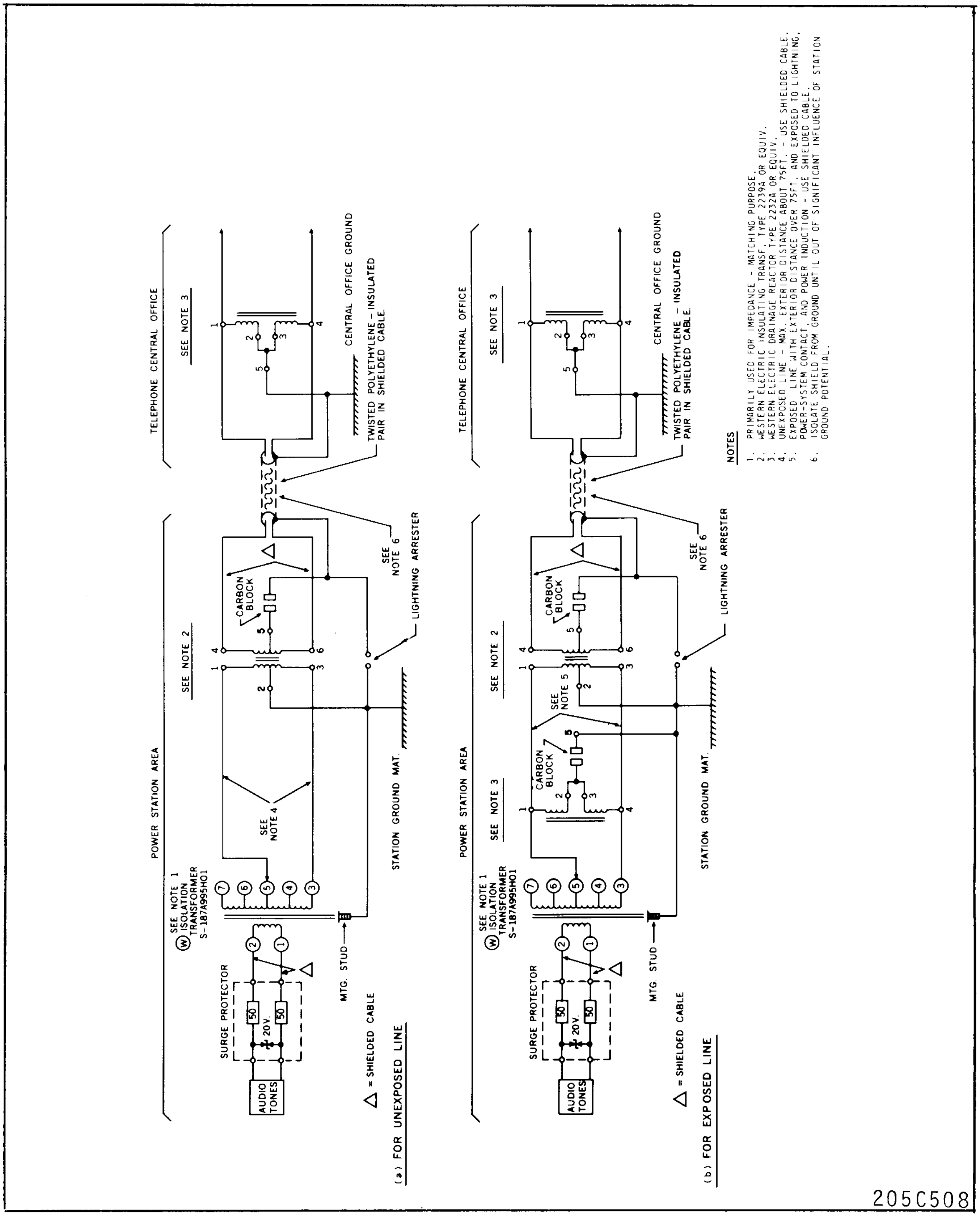


Fig. 1. Recommended Connections and Pilot Wire Design for Privately Owned Two-Terminal Lines.



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

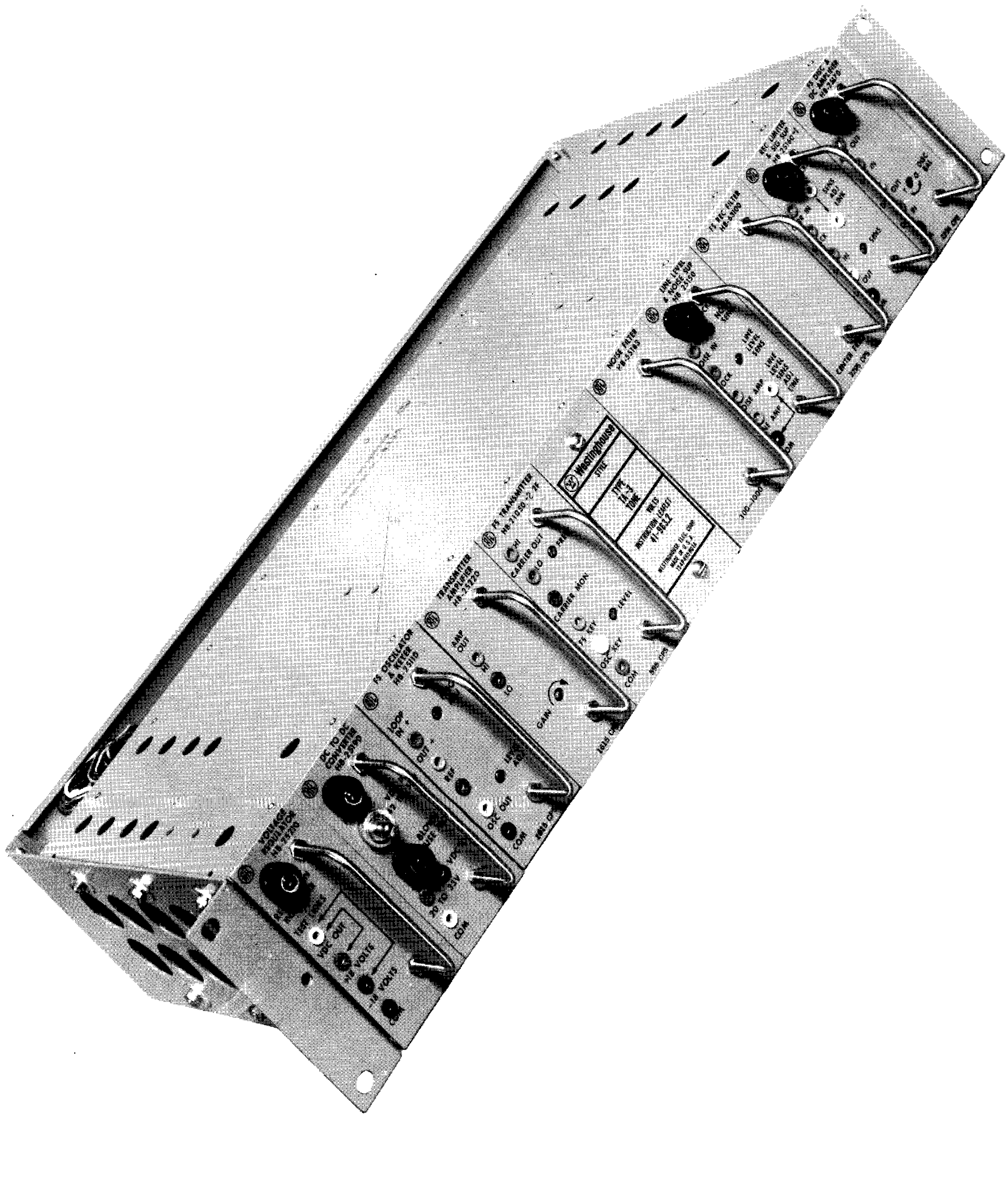


Fig. 3. Front View of Full Chassis.

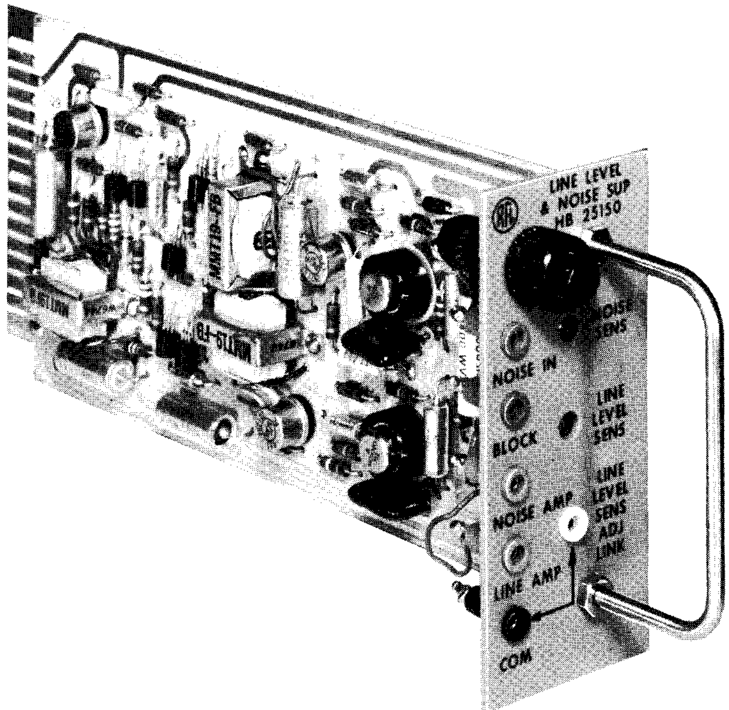
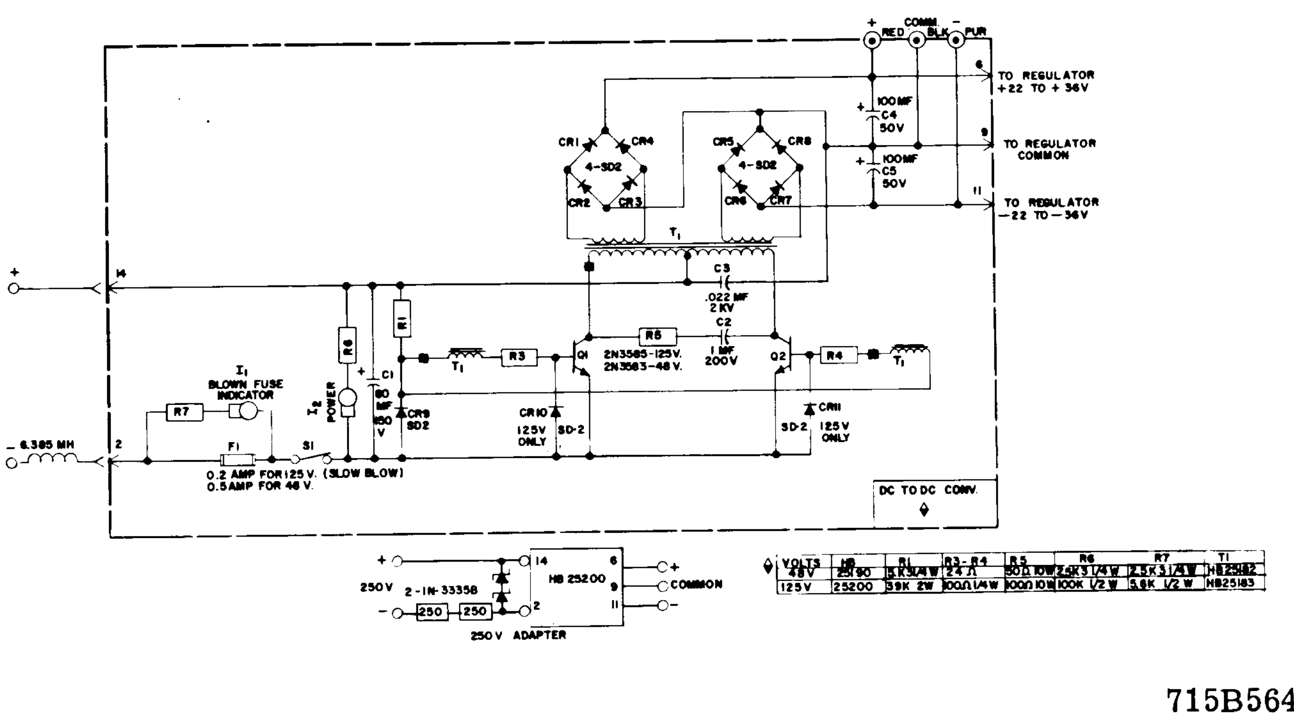
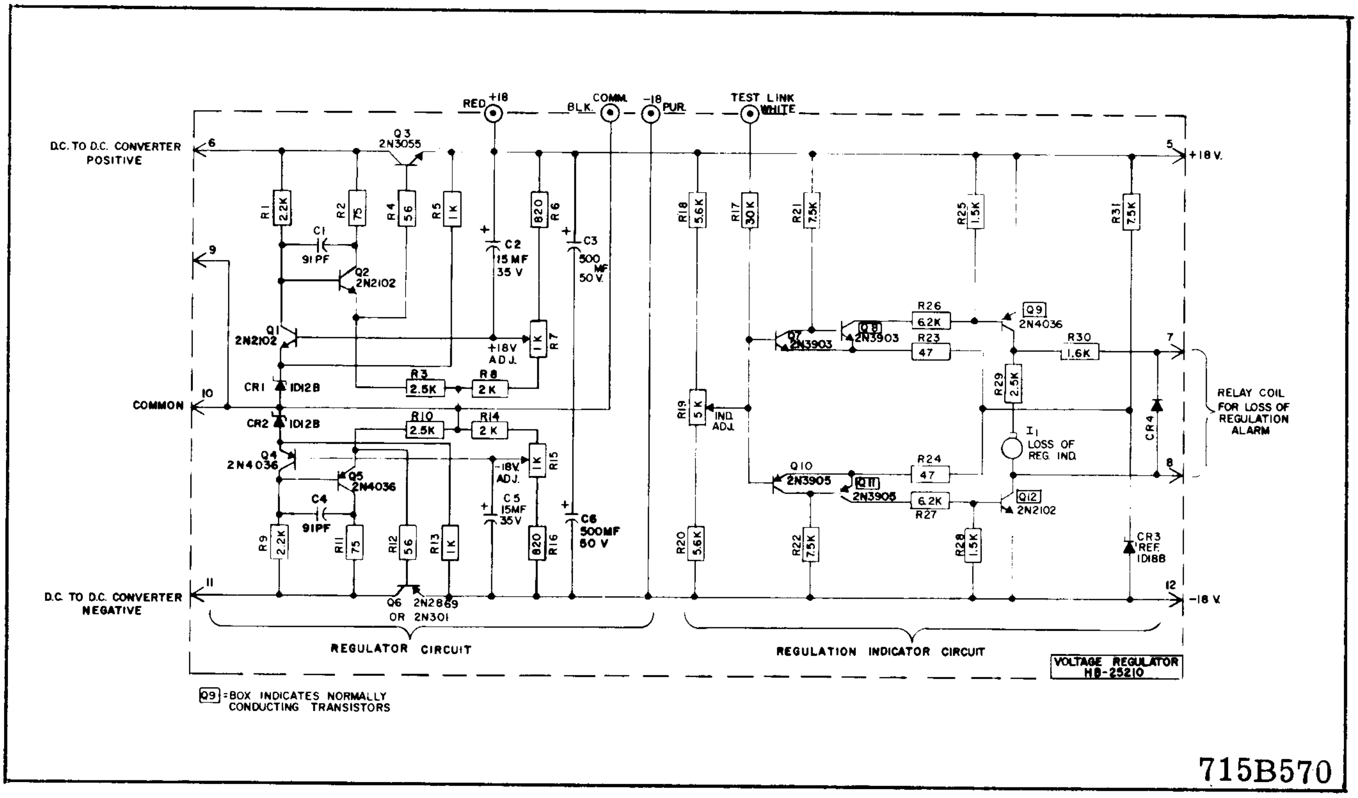


Fig. 4. Typical Module.

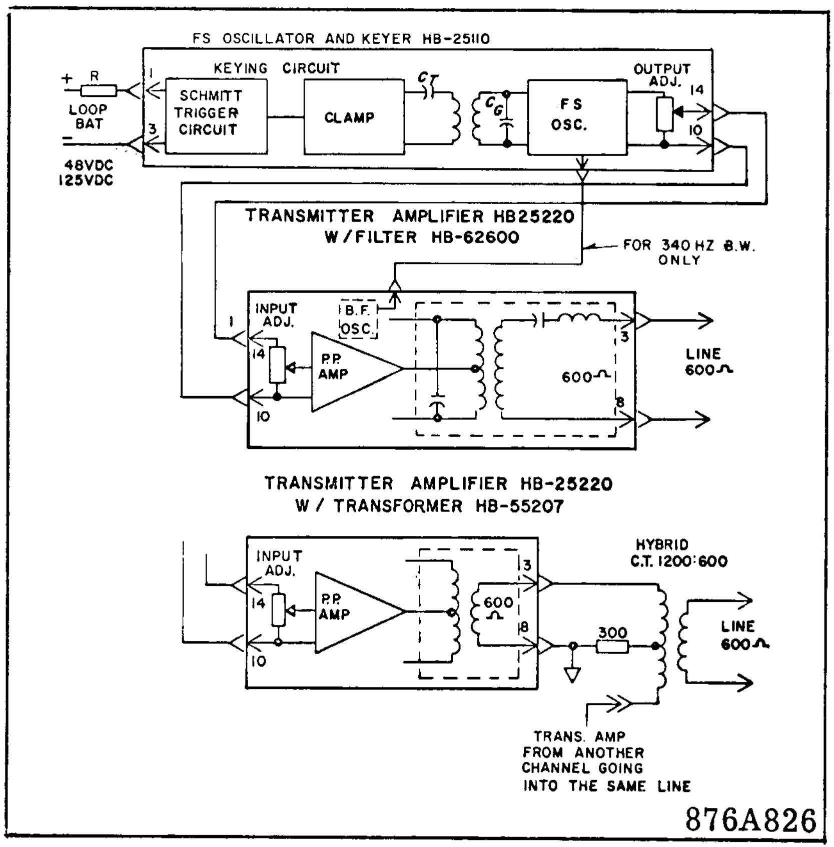


VOLTS	HB	R1	R3 - R4	R5	R6	R7	T1
48V	25190	5K 3 1/4 W	24 Ω	50Ω 10W	2.5K 3 1/4 W	2.5K 3 1/4 W	HB25182
125V	25200	39K 2W	100Ω 1/4 W	100Ω 10W	100K 1/2 W	5.6K 1/2 W	HB25183

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



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



* *Fig. 7. Transmitter Block Diagram.*

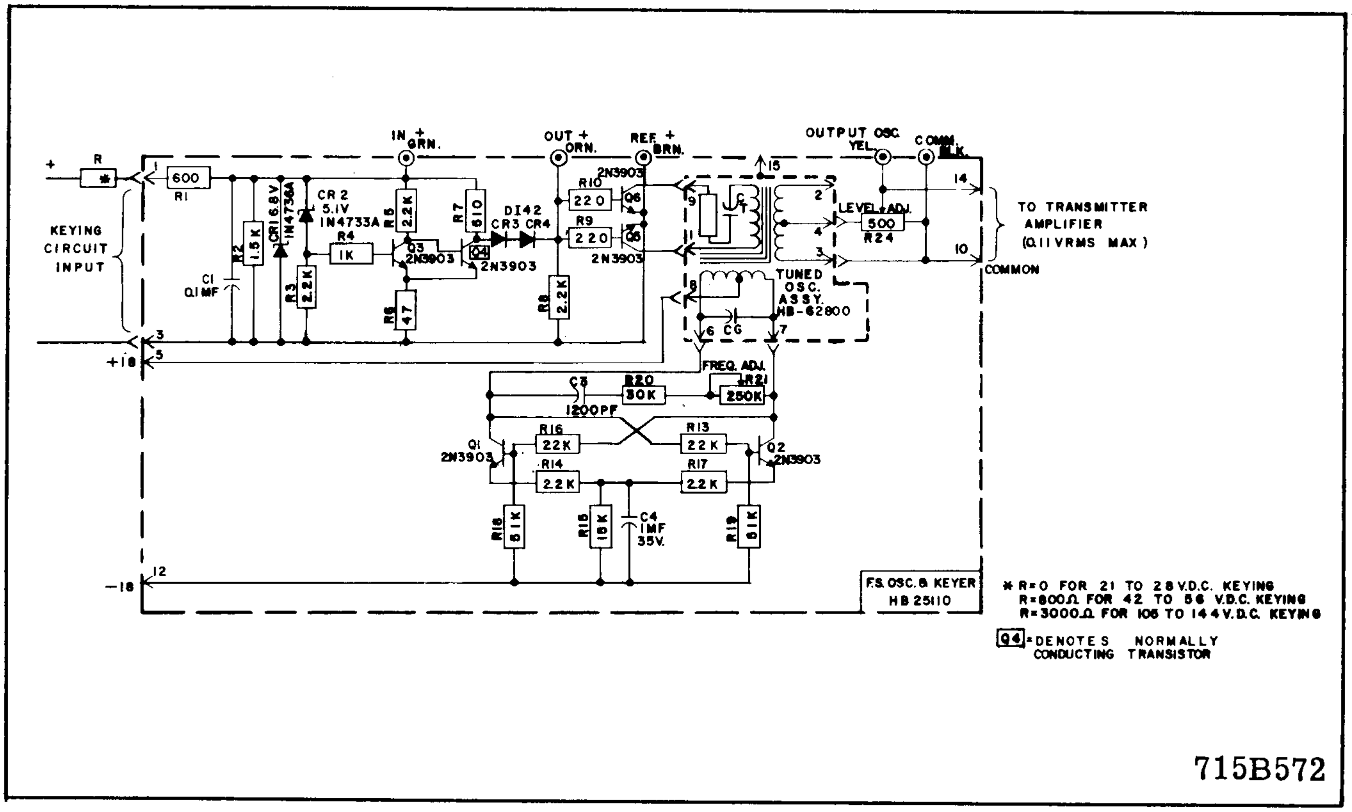
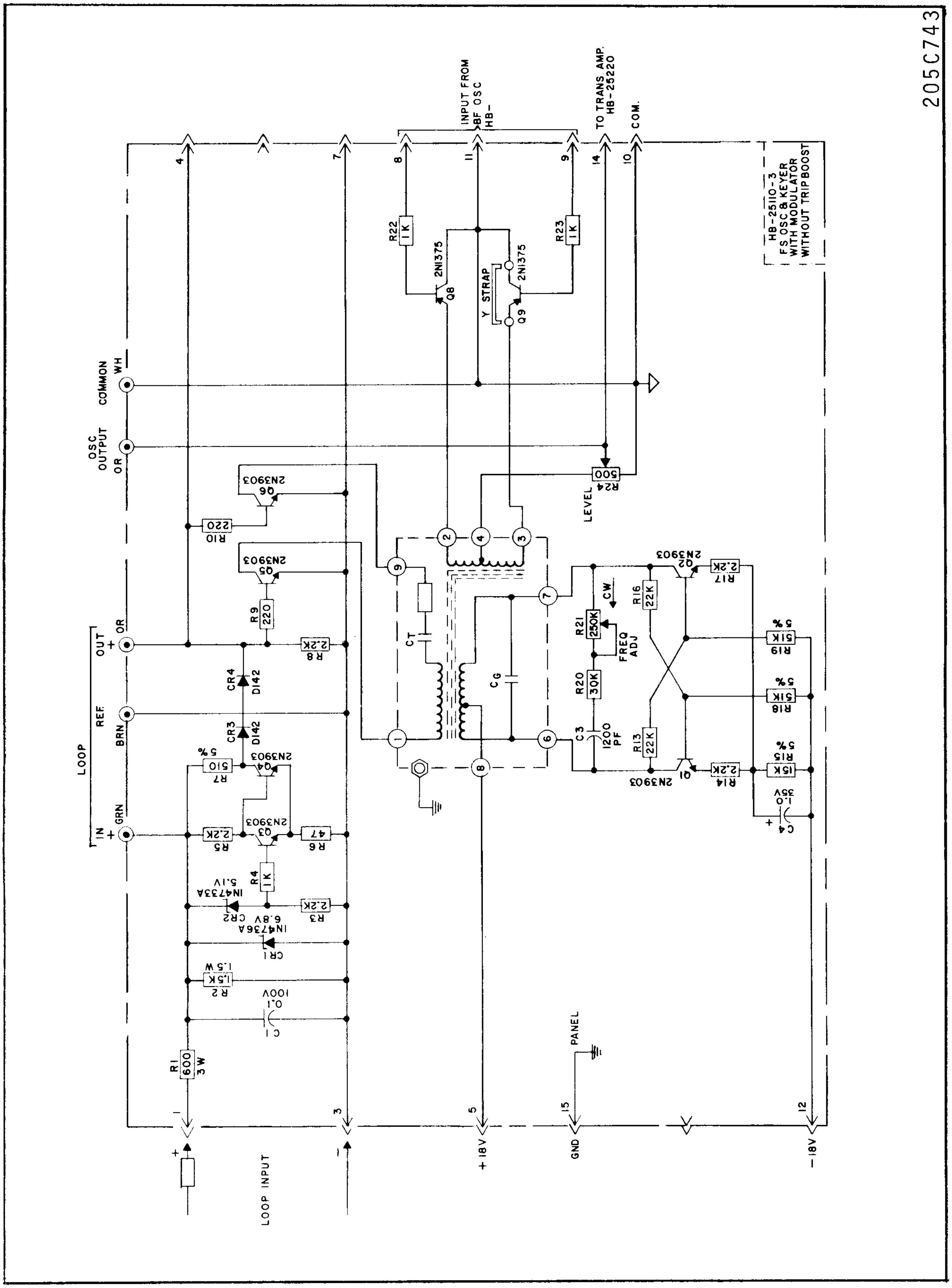
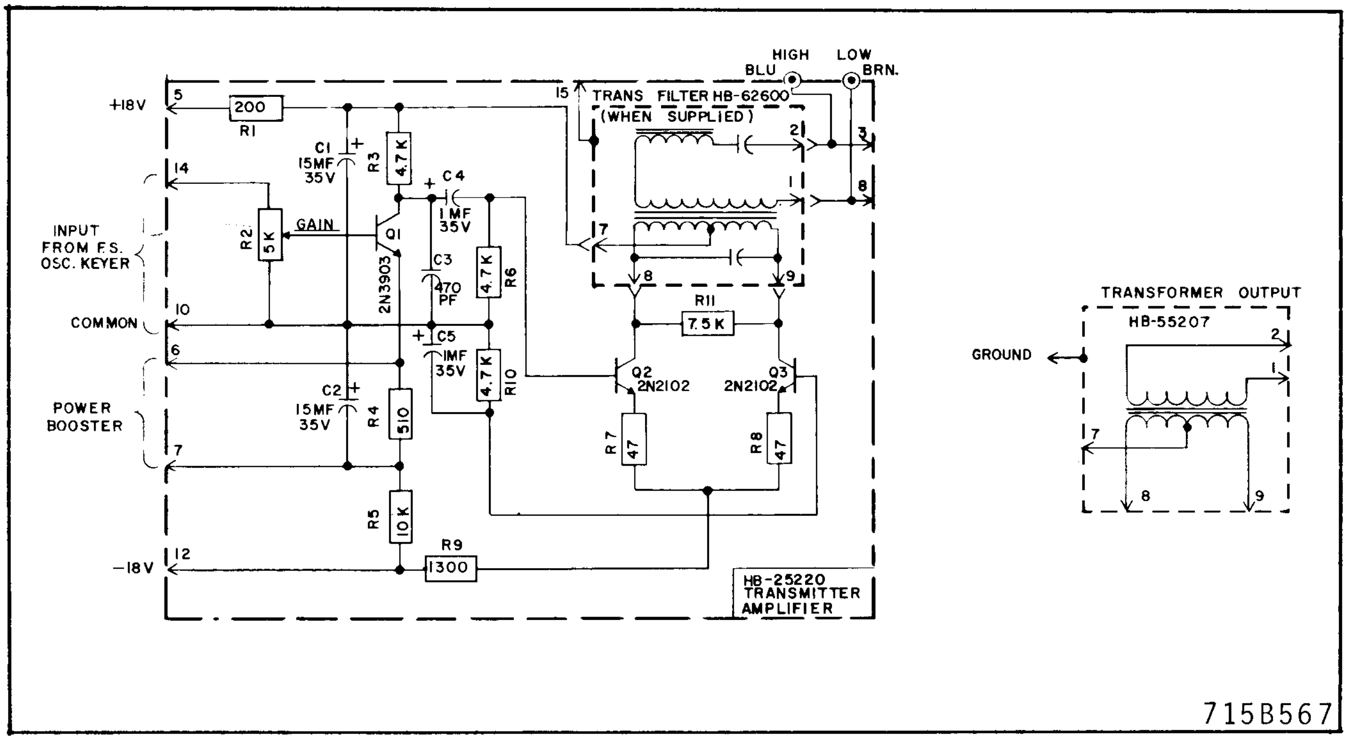


Fig. 8. F.S. Oscillator and Keyer HB-25610.



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



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

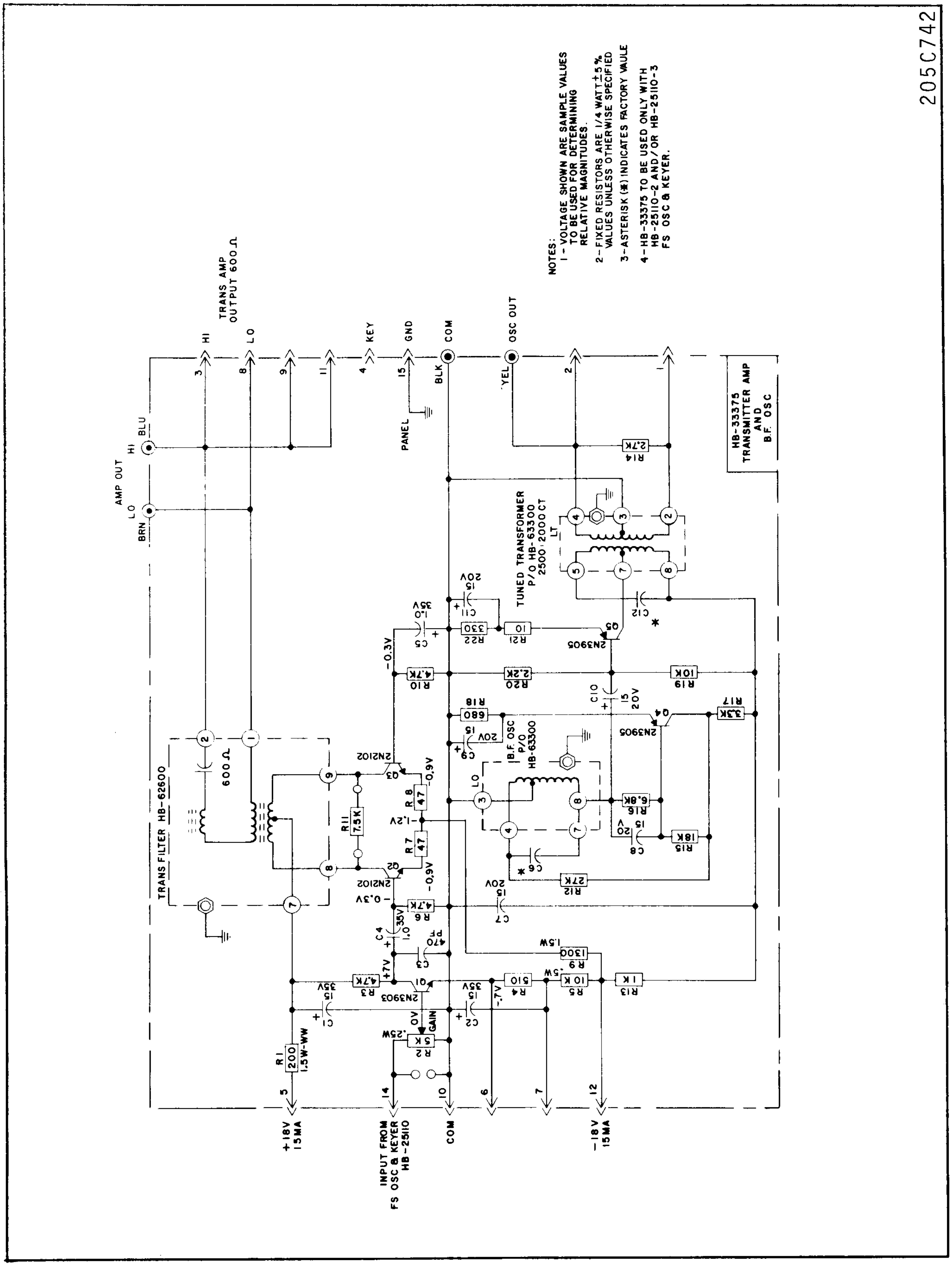


Fig. 11. Transmitter Amplifier HB-33375.

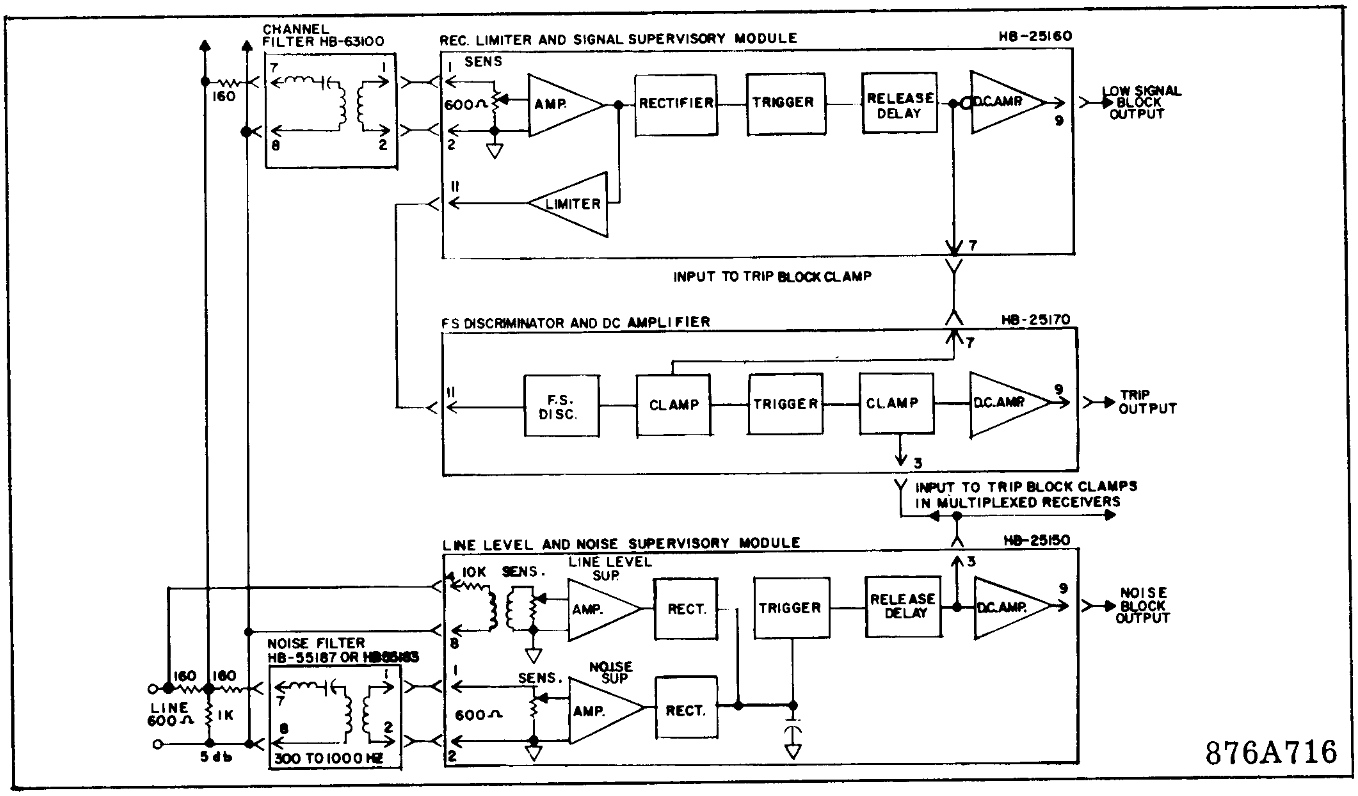


Fig. 12. Receiver Block Diagram HB-63100.

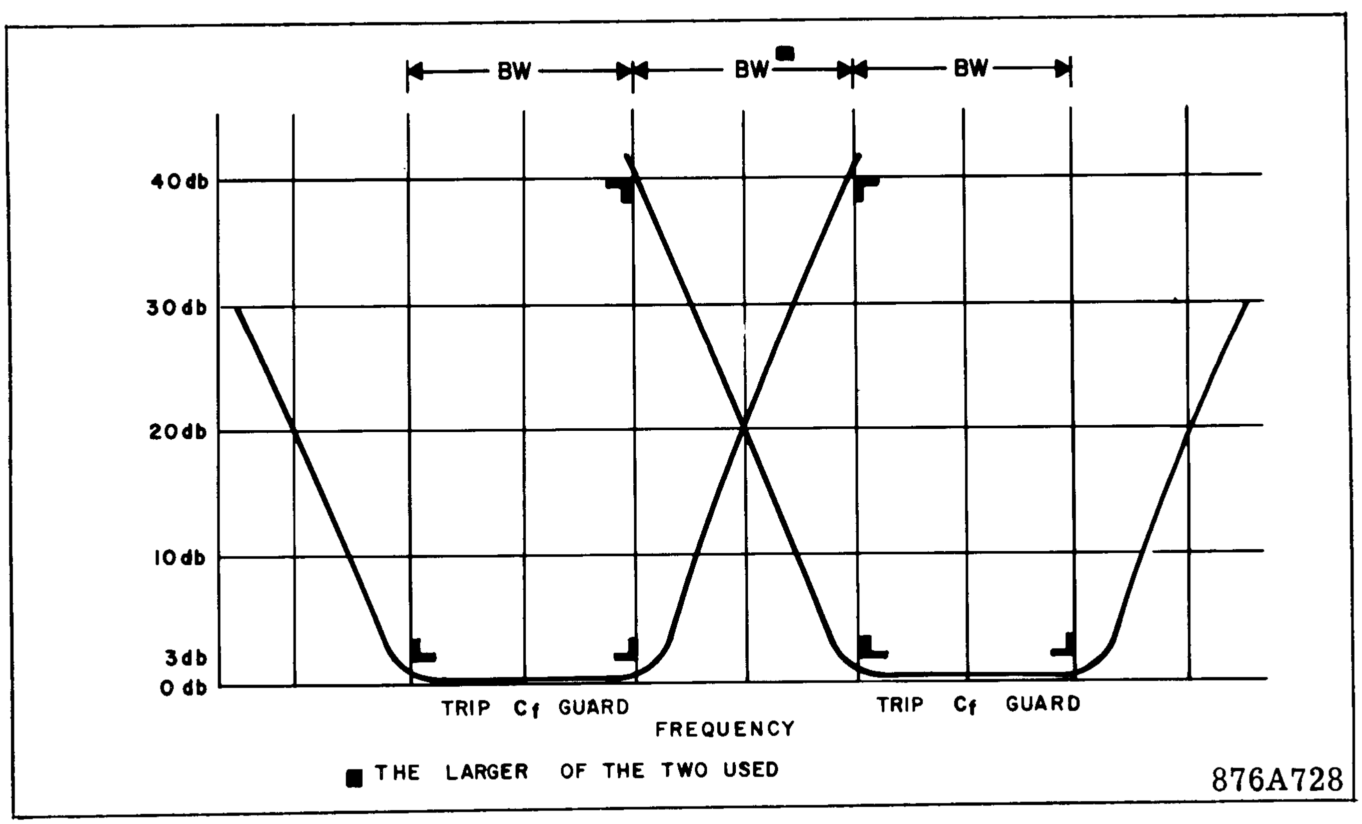


Fig. 13. Tone Receiver Filter Characteristics HB-63100.

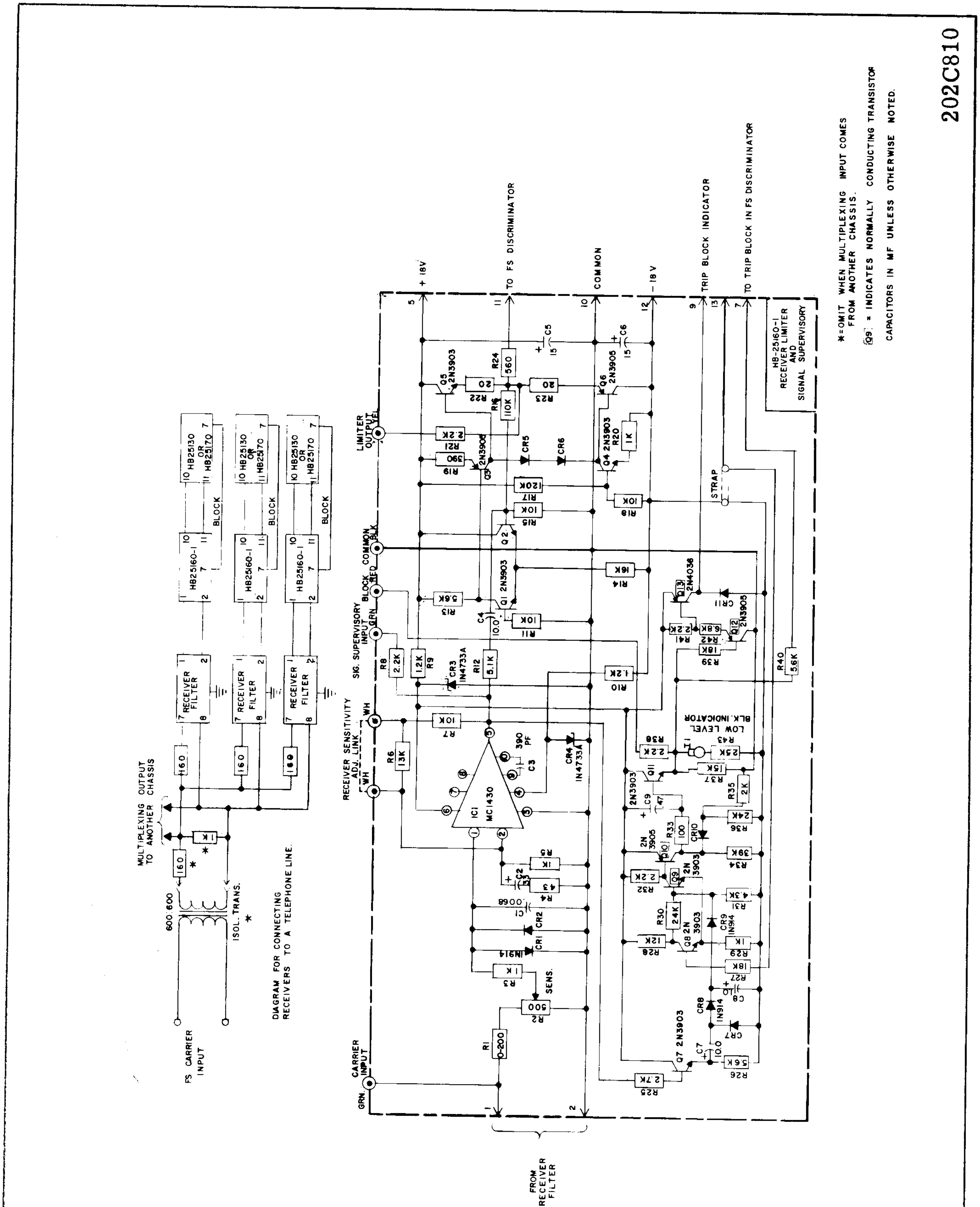
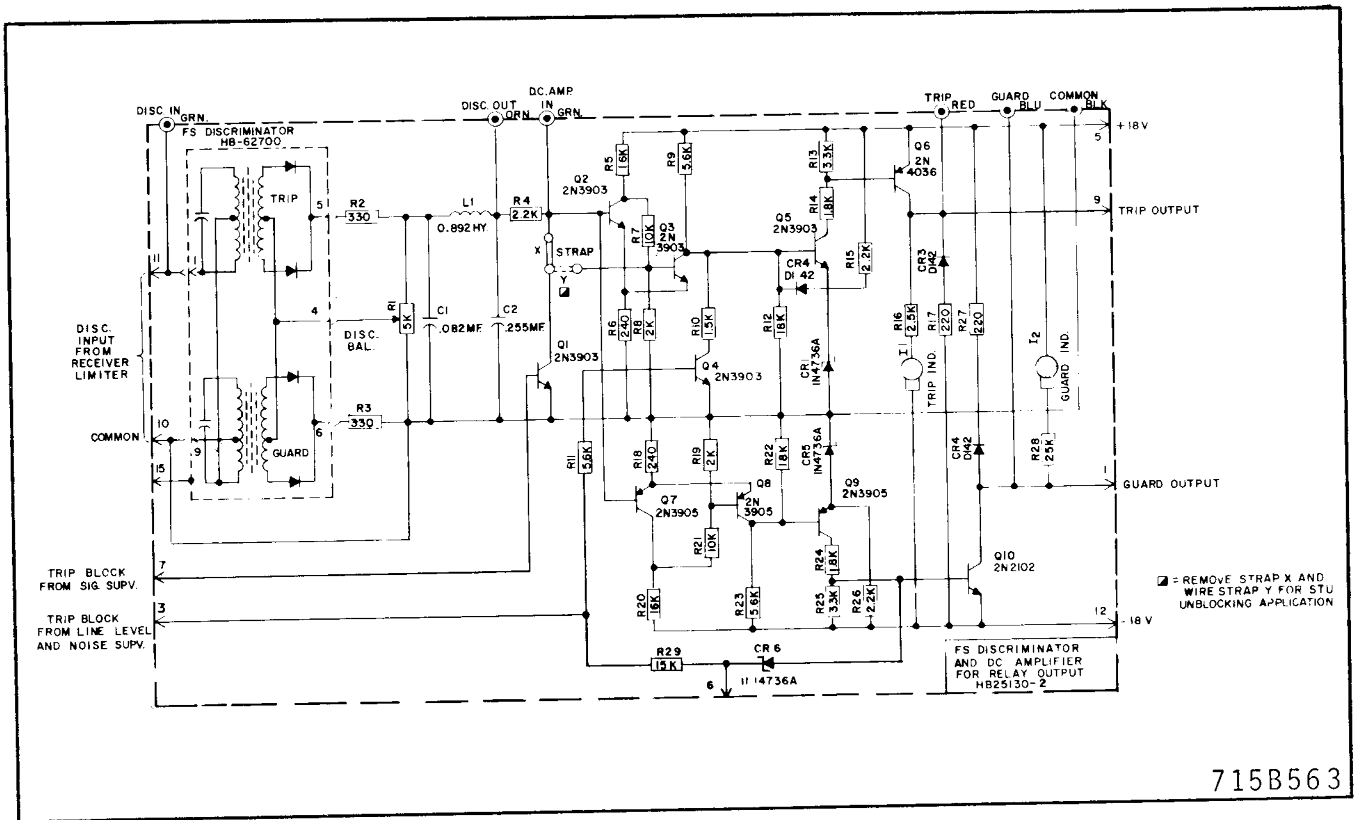


Fig. 14. Receiver Limiter and Signal Supervisory HB-25160-1.



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

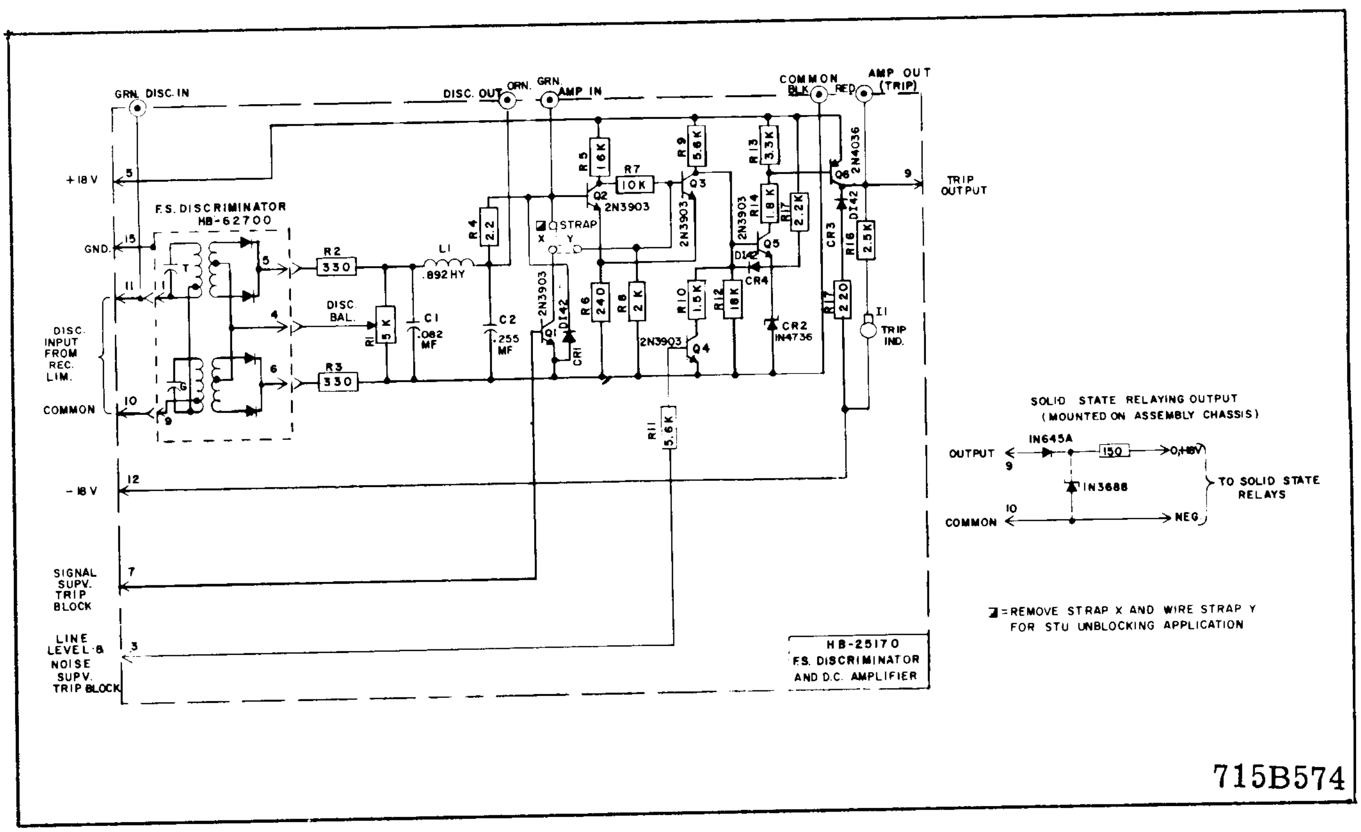


Fig. 16. F.S. Discriminator and D-C Amplifier for Solid-State Relaying HB-25170.

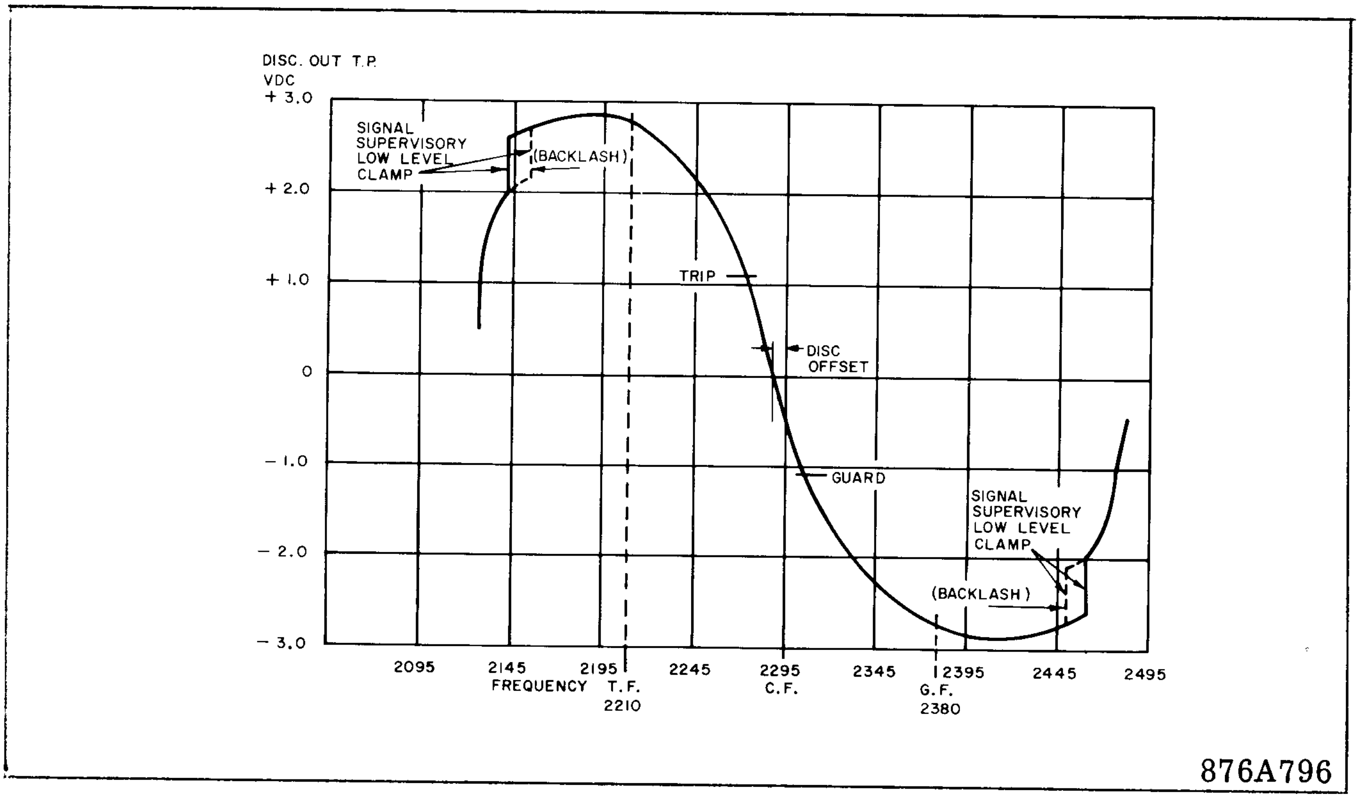
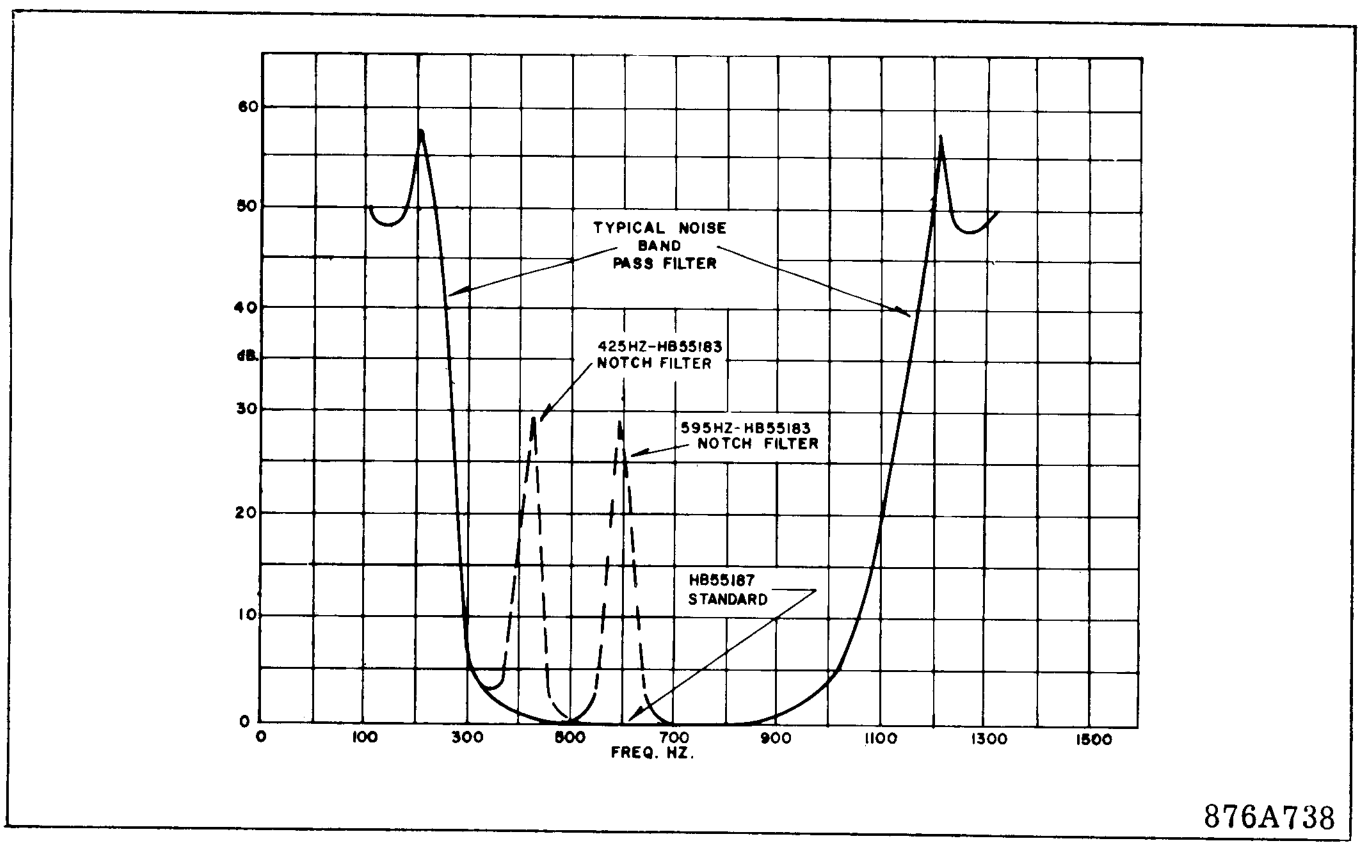


Fig. 17. Typical Discriminator Output.



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

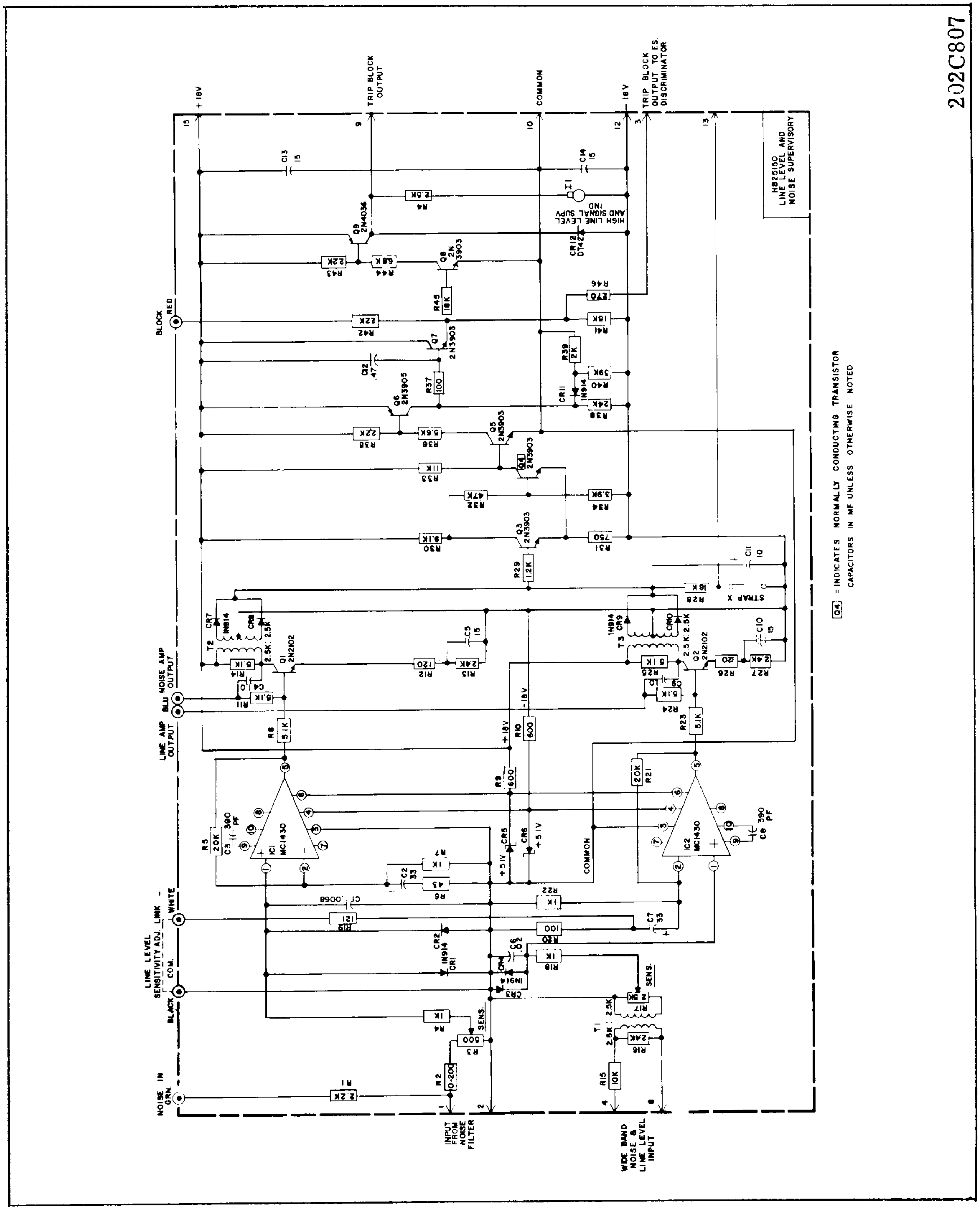
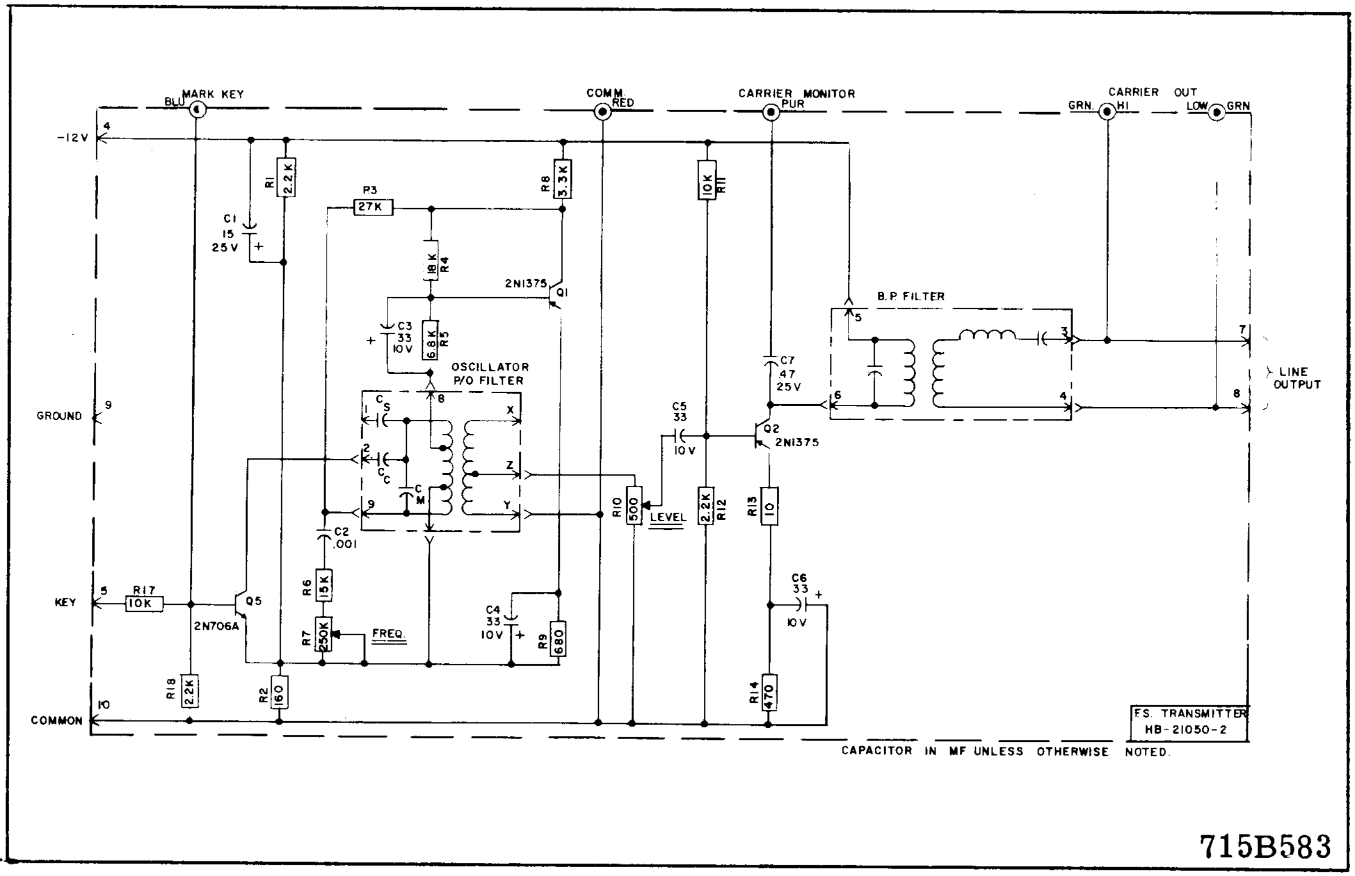


Fig. 19. Receiver Line Level and Noise Supervisory Module HB-25150.



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

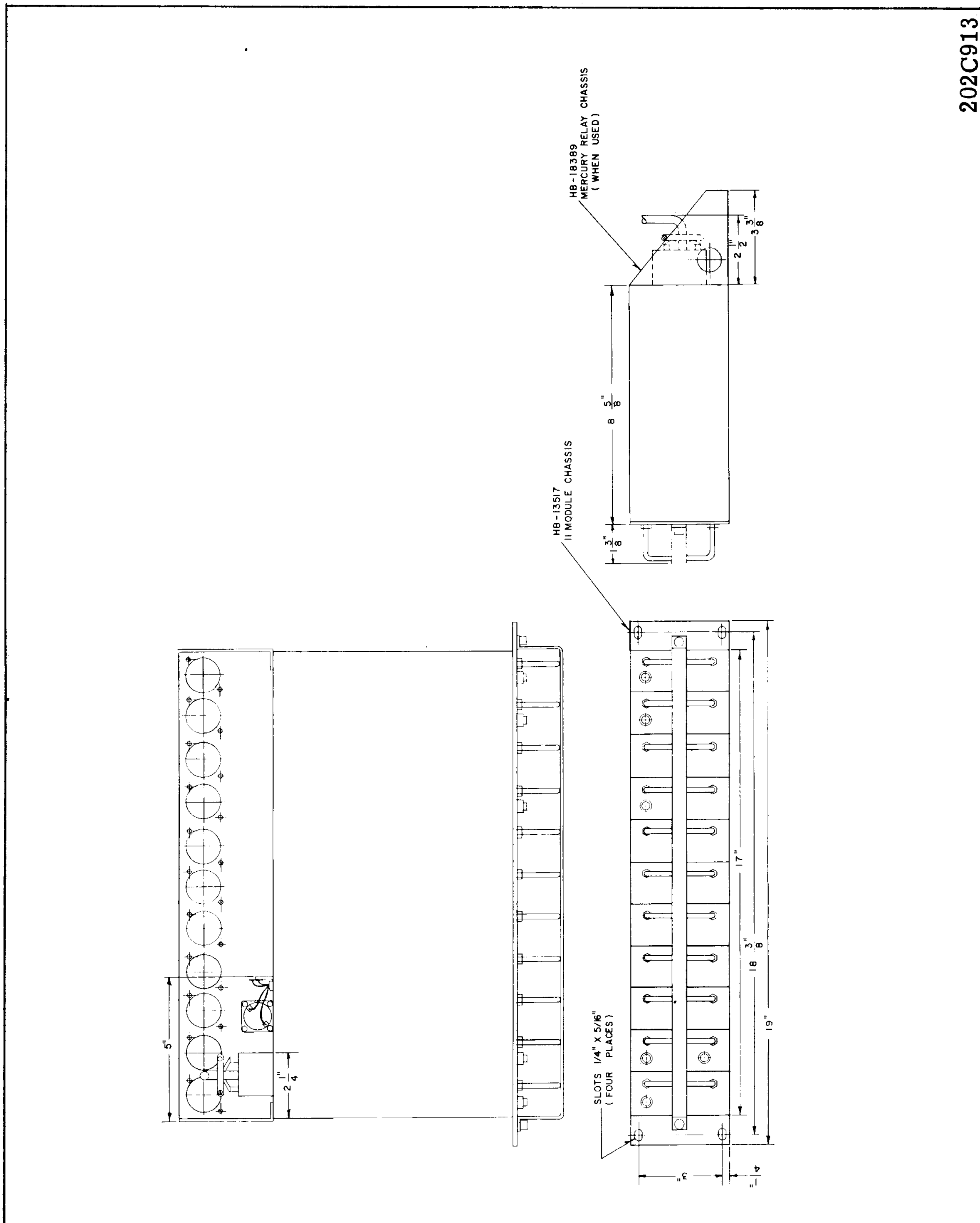


Fig. 21. Outline and Drilling Plan.

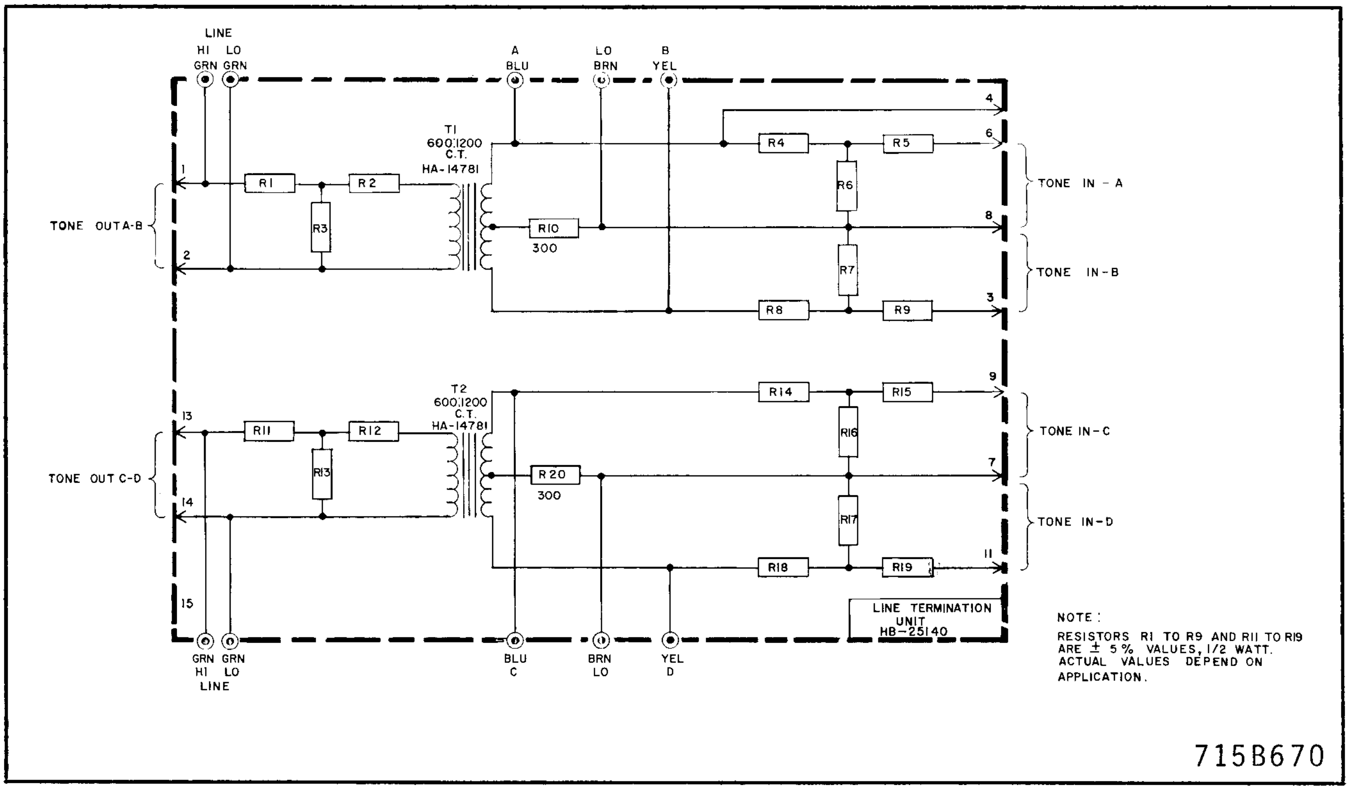
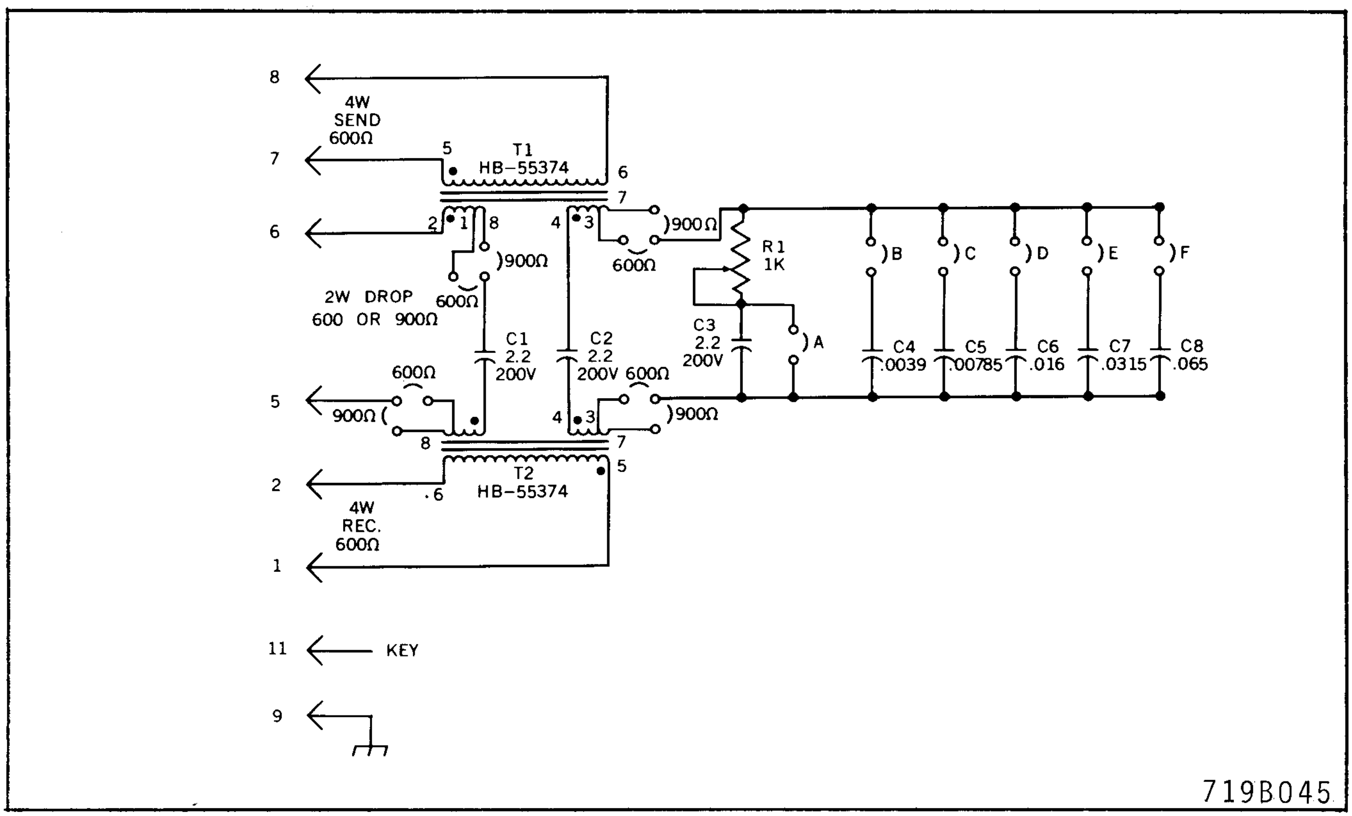


Fig. 22. Line Termination Module HB-25140.



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

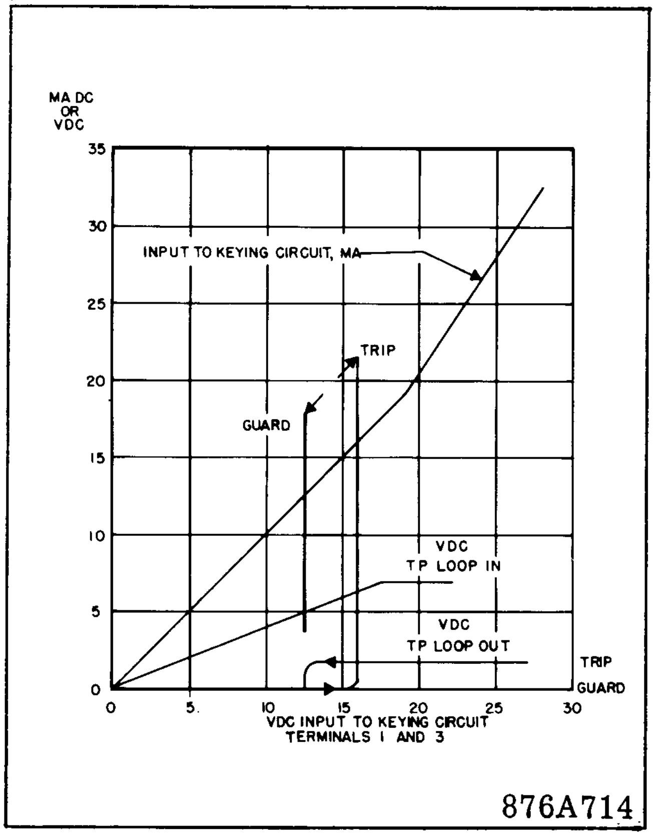


Fig. 24. *Transmitter Keying Circuit Characteristics.*

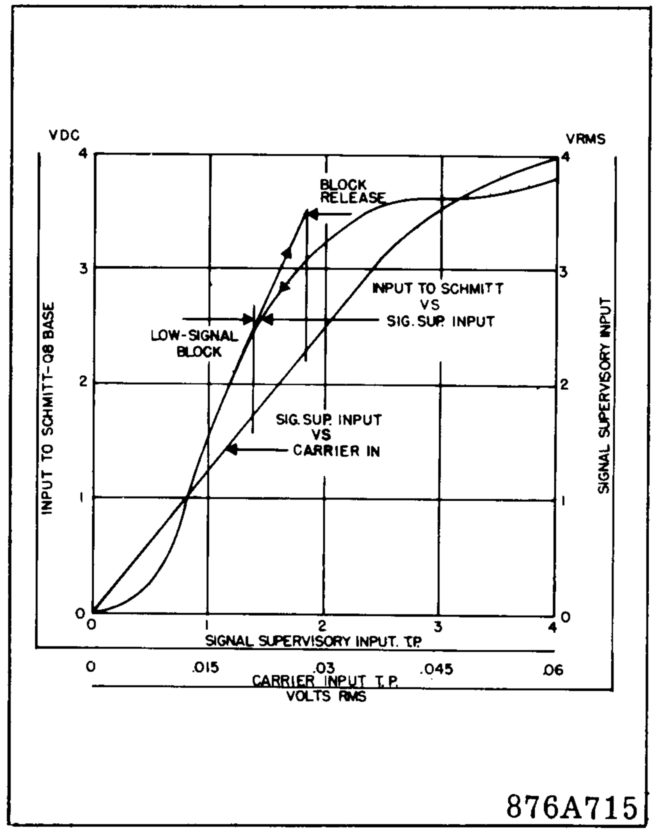
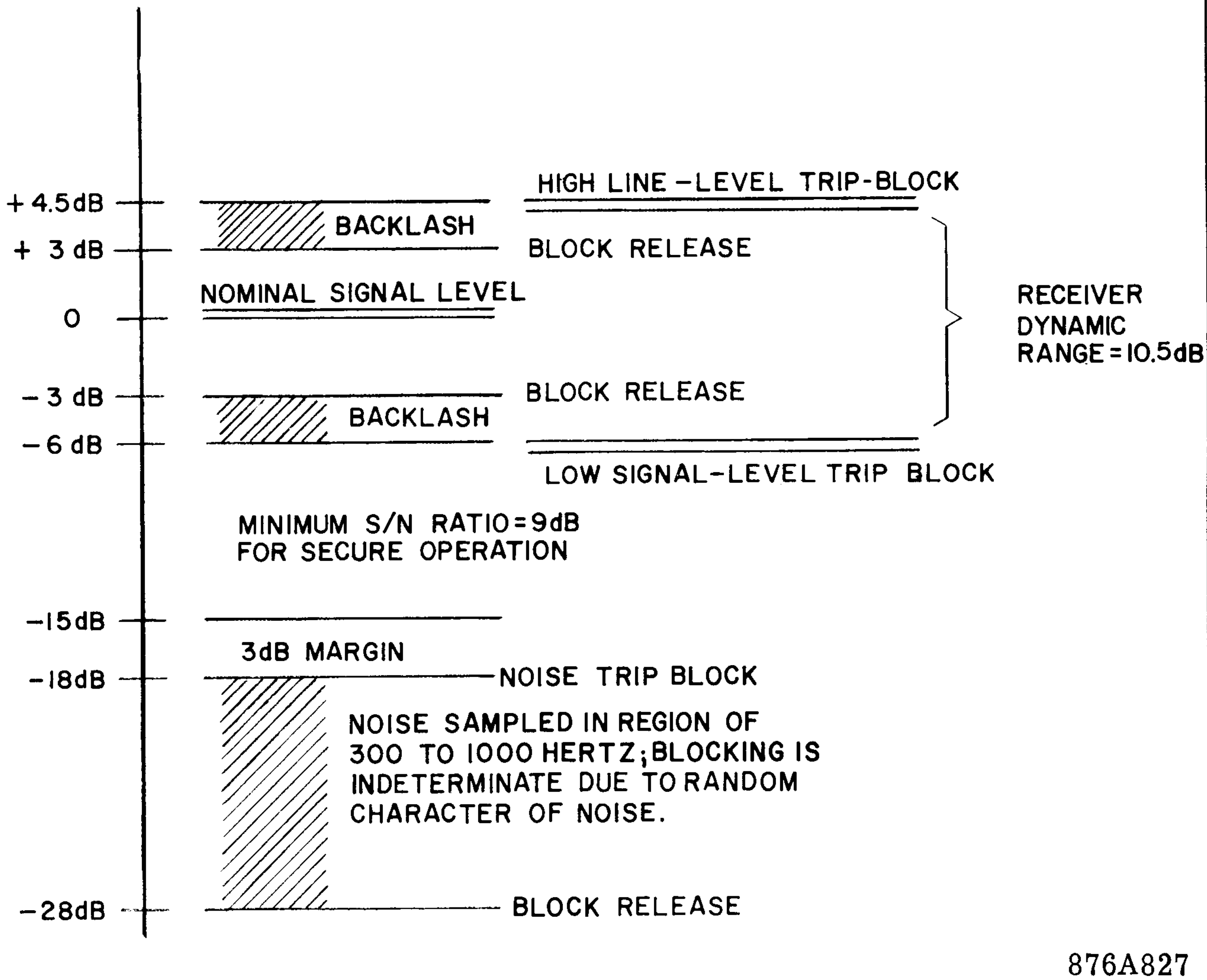


Fig. 25. *Signal Supervisory Circuit Characteristics.*

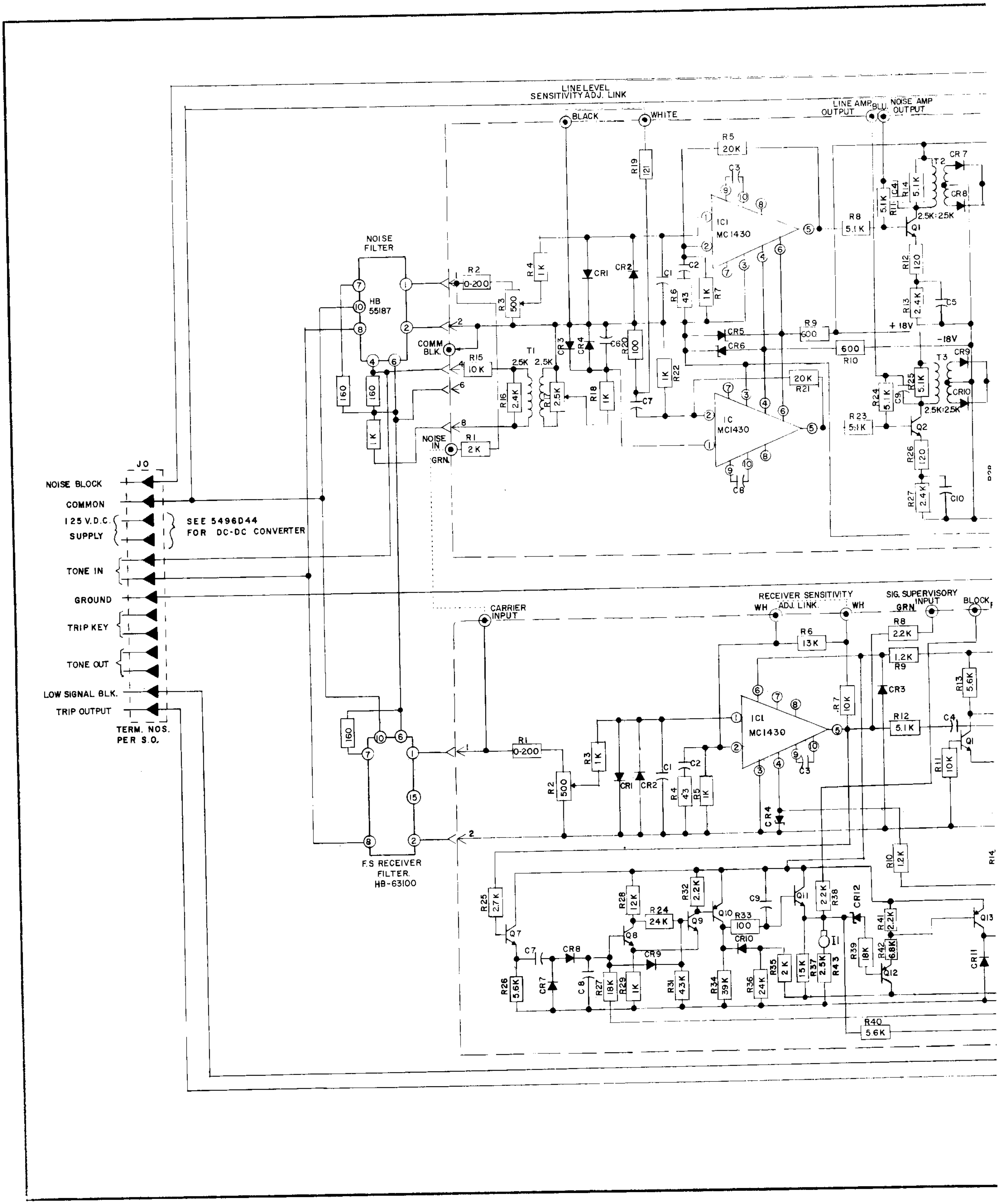
RECEIVER DYNAMIC OPERATING RANGE

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

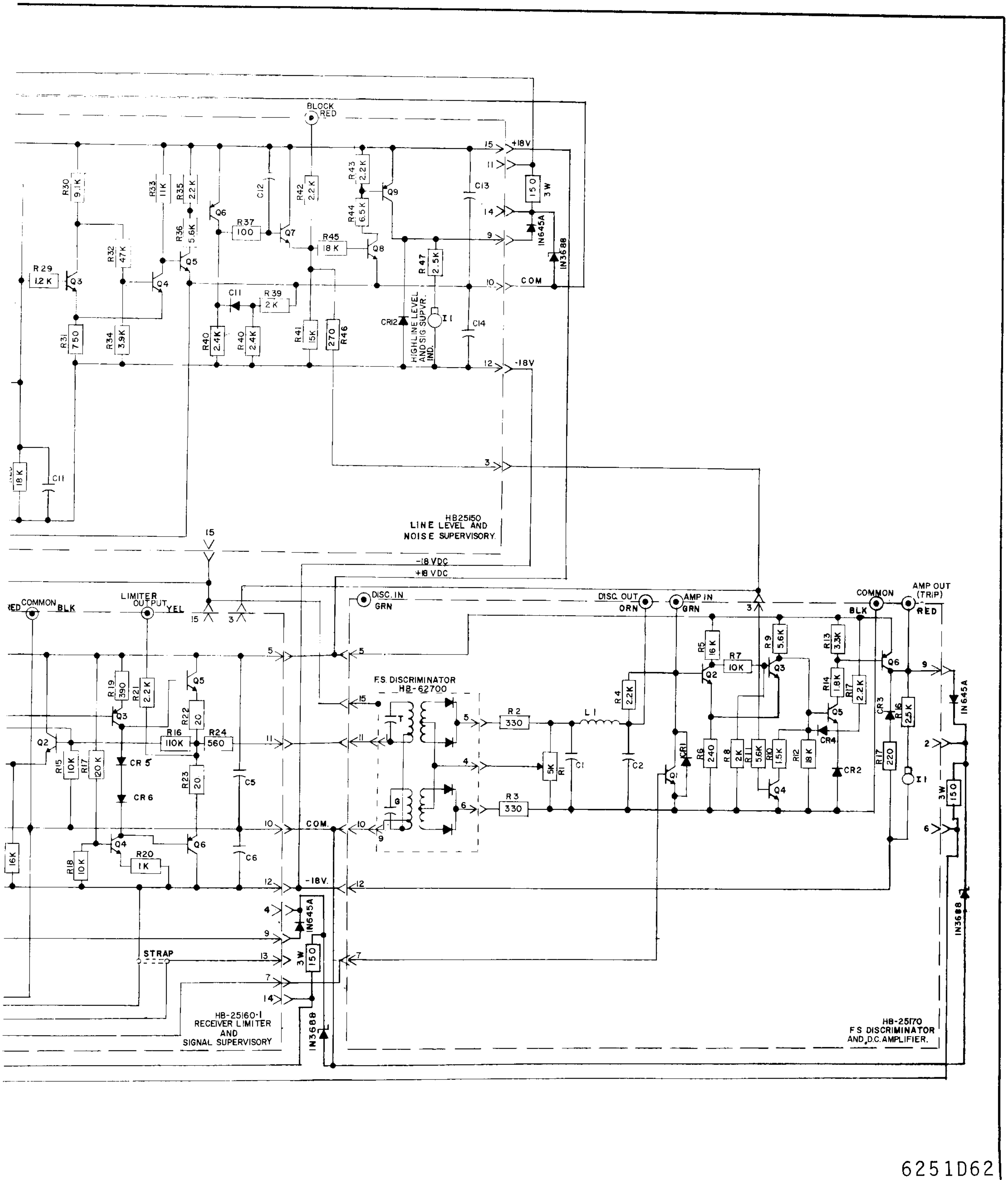
NUMBER OF CHANNELS	OUT-OF-BAND TONE LEVEL ABOVE NORMAL CHANNEL
1.	3.5dB
2.	8.6dB
3.	10.5dB
4.	11.8 dB
5.	12.4dB
6.	12.9dB



* *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-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

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).

* In general it is recommended that the lower frequencies be applied first. The recommended characteristics of the audio line between transmit and receive terminals are as follows:

For 170 HZ bandwidth tones

Channel Center Freq.	
1275 1615 1955	3002 unconditioned † data line or equivalent
2295	3002 - C1 conditioned † data line or equivalent
2635	3002 - C2 conditioned † data line or equivalent
2975	3002 - C4 conditioned data line or equivalent

For 340 HZ bandwidth tones

Channel Center Freq.	
1360 2040	3002 unconditioned † data line or equivalent
2720	3002 - C2 conditioned † data line or equivalent

† The specifications which are directly related to conditioning are covered by Interstate Tariff FCC No. 260 (1/1/69).

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 (715B564G01) (48V d-c), HP25200 (715B564G02) (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 (715B570) (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 (715B572) (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 (715B567) (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 (715B567) module.

* 3. Transmitter Amplifier HB-33375 (205C742)

This module is used instead of Transmitter Amplifier HB-25220 (715B567) 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 (205C743) (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 (202C810) (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 (715B563) and HB25170 (715B574) (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 (715B563) or the HB25170 (715B574) 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 (715B574) (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 (876A738G03) or HB55283 (876A738G01) (Fig. 18) (Notched for 425 Hz Transmitter) (Some systems use 595 Hz Transmitter) (876A738G02)

   This module contains a filter (see Fig. 18) that samples noise in the 300 to 1000Hz region. There are two different types of filters. Filter module HB55283 (876A738G01) 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 (202C807) (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 HB21050-14 (715B583) (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 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. 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 (715B670) (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 (719B045) (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.

* I. TA TONE LEVEL INDICATOR AND ALARM MODULE (Figure 30) HB35505 (6881D97G01) (Single), HB35510 (6681D97G02) (Dual)

The level indicator is an AM receiver available as an option on TA-3 frequency shift audio tones. It is available with either a single unit on a module or a double unit on a module. It operates with an external 100 microampere ammeter for indication of received level and with an external relay for alarming purposes on low signal levels. The microammeter normally supplied with dB scale markings is style number 606B592A25.

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 (715B570). 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 (715B572) (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 (715B567) (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 (205C743) (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 (205C742) (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 BFO 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 (202C810)

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 (715B563) and HB25170 (715B574) (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 (202C807)

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. 425-Hz Transmitter HB21050-14 (715B583) (Fig. 20) (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 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.

* E. TONE LEVEL INDICATOR AND ALARM MODULES (Fig. 30) HB35505 (6681D97G01) and HB35510 (6681D97G02)

The AM receiver is composed primarily of operational amplifiers with just two discrete transistors in each section for driving an external relay. In the single section, operational amplifier IC1A is a pre-amplifier. Half of log amplifier IC2 together with operational IC1B make up an amplifier whose response follows a logarithmic curve so that a current output proportional to a dB scale is achieved. Operational amplifier IC3A and associated components is an AM detector amplifier and IC3B and associated components is a rectifier, filter, amplifier section. Operational amplifier IC4 is the source follower booster amplifier for driving the external indicating microammeter. Operational amplifier IC4B and transistors Q1, and Q2 comprise the final amplifier for driving the external alarm relay. Potentiometer R6 is the level adjustment for adjusting the incoming nominal level while R9 is used to adjust the span (range) of signal to correspond to the microammeter markings with each dB representing 10 micro-amps. Potentiometer R31 is used to set the pickup point of the alarm relay.

It should be pointed out that IC2 is a dual log-amp with half used in each section of the tone level indicator. If a single section tone level indicator is supplied (HB35505), then only half of this log-amp is utilized and all the other components in the second section are omitted.

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.

* D-C TO D-C CONVERTER AND VOLTAGE REGULATOR

Converter HB25190 (715B564G01) and HB25200 (715B564G02), Regulator HB25210 (715B570)

* Power Output:

Model HB25210 (715B570) Voltage Regulator with one of the D-C to D-C Converter Modules, HB25190 (715B564G01) or HB25200 (715B564G02) – 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 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 5.)

* F.S. OSCILLATOR AND KEYER HB25110 (715B572) and HB25110-3 (205C743)

* Power Requirements:

+18V, 2.5 ma; −18V, 2.5 ma.

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) (715B572)

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

* Frequency: (HB25110-3 Only) (205C743) (340Hz 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. [fg = 10,000 − fc − 170]. The trip frequency would then be 10 KHz minus the channel center frequency and plus 170 Hz. [ft = 10,000 − fc + 170]).

* TRANSMITTER AMPLIFIER HB25220 (715B567) and HB33375 (205C742)

* Power Requirements:

HB25220: +18V, 15 ma; −18V, 15 ma.
HB33375: +18V, 21.5 ma; −18V, 21.5 ma.

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 (715B572) 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

* Power Requirements:

+18V, 40 ma; -18V, 37 ma.

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 (715B574) and HB25130 (715B563) (Dual Output)

* Power Requirements:

HB25170: +18V, 25ma; -18V, 12 ma.
HB25130: +18V, 25ma; -18V, 25 ma.

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 (202C807) AND FILTERS HB55283 (876A738G01) AND HB55187 (876A738G03)

* Power Requirements:

+18V, 70 ma; -18V, 55 ma.

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 (876A738G03) and HB55283 (876A738G01)

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 HB21050-14 (715B583) (Some Systems Use 595 Hz)

* Power Requirements:

-18V, 10 ma.

Output Level:

600 ohms nominal, isolated and balanced.

Output Stability:

±1.5 dB from −30°C to +70°C.

Frequency Stability:

* HB21050-14 ±.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. If push button is supplied instead of adjusting link, then just depress push button and hold depressed while making adjustment. 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 HB55283 (876A738G01) 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.

* Tone Level Indicator and Alarm Module

Microammeter meter settings: The settings listed below are for the ammeter set at nominal receive level to provide 90 micro-amps into the microammeter with a scale of 10 micro-amps per dB so that a full scale reading of 100 micro-amps will indicate +1dB from nominal and zero micro-amps will indicate –9dB from nominal. Style number 606B592A25 has scale markings in dB corresponding to –9 dB to +1dB full scale.

a) Measure the incoming nominal receive level
b) Reduce incoming level 9dB below nominal receive level
c) Adjust R6 level adjustment to obtain zero meter reading
d) Increase incoming level 10dB from this level (This is +1dB above nominal level.
e) Adjust R29 span adjustment to obtain full scale reading on the meter
f) Decrease incoming level to the nominal level. The meter should now correspond to the 90 micro-amp reading on the meter. On special supplied meters with scale marked from –9dB to +1dB this will be the 0dB reading.

* Alarm Relay Setting:

Set the alarm relay to drop out with R31 alarm set adjustment at point below nominal received level it is desired to alarm at.

For the TA-3, this should not be lower than 6dB below nominal for a single tone as the single tone will generate a low level trip block when its in-band received signal drops 6dB below nominal. A recommended level for this setting is 3dB below nominal unless experience shows that a setting between 3dB and 6dB below nominal is more desirable.

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.

* Tone Level Indicator and Alarm Module

A. (HB35505) Level Indicator & Alarm Module

1. Strap Options: Strap J2 and J3 (All other straps are open)

2. Test Setup
   a. Connect an audio oscillator across pins 1 & 2 through a 40 db variable attenuator.
   b. Connect a 100 micro amp meter across pins 9 & 8, with the + side on pin 9.
   c. Connect a 2.2 K resistor from pin 11 to –18V
   d. Connect +18 volts to pin 5 and –18V to pin 12. Pin 10 is common.

3. Meter Calibration
   a. Adjust the input signal to –20 DBM at pins 1 and 2 at 1 Khz.
   b. Adjust R6 (level adj) to obtain a zero meter reading. (CW to increase reading)
   c. Increase the input level by 10DB.
   d. Adjust R29 (Span Adj) to obtain a Full Scale reading on the meter.
   e. Vary the attenuator between the two settings. The meter should read linearly within ±0.2DB.

4. Alarm Range Check
   a. Adjust R31 (Alarm Set A) full CW-
   b. Vary the input signal to 0DB, then return it directly to –10DB. From common pin 11 should be approximately +7 volts (Q2 on).
   c. Adjust R31. Full CCW.
   d. Reduce the input signal directly to –20 DBM. Pin 11 should be approximately –18V.

5. Input Range Check
   a. Set the input level to –34 DB. By adjusting R6 (Level Adj.) CW, a 90% FS meter reading should be obtainable.
   b. Set the input level to –6 DB. By adjusting R6 CCW, a 90% FS meter reading should again be obtainable.

6. Frequency Response
   a. Vary the input signal frequency between 400 Hz. and 10Khz. Less than 0.2 DB (2% at FS) variation should be observed with a 2.2K load on the alarm output and a 10K load on the meter output.

B. (HB-35510) Dual Level Indicator and Alarm

(1) Strap option: all straps open.
(2) Repeat steps 2 through 6 at HB35505 Test Procedure.
(3) Repeat steps 2 above, replacing pins 3, 4, 13, 15 and 14 for pins 1, 2, 9, 8 and 11 and resistors R46, 62 and 64 for R6, 29 and 31 respectively.

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	C	34	34
		B	+ 7	+ 7	Vp – p.	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 μ F ±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-21050-14 425 Hz FS TRANSMITTER (Also Applies To 595 Hz)**	
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, 200PIV. 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.	

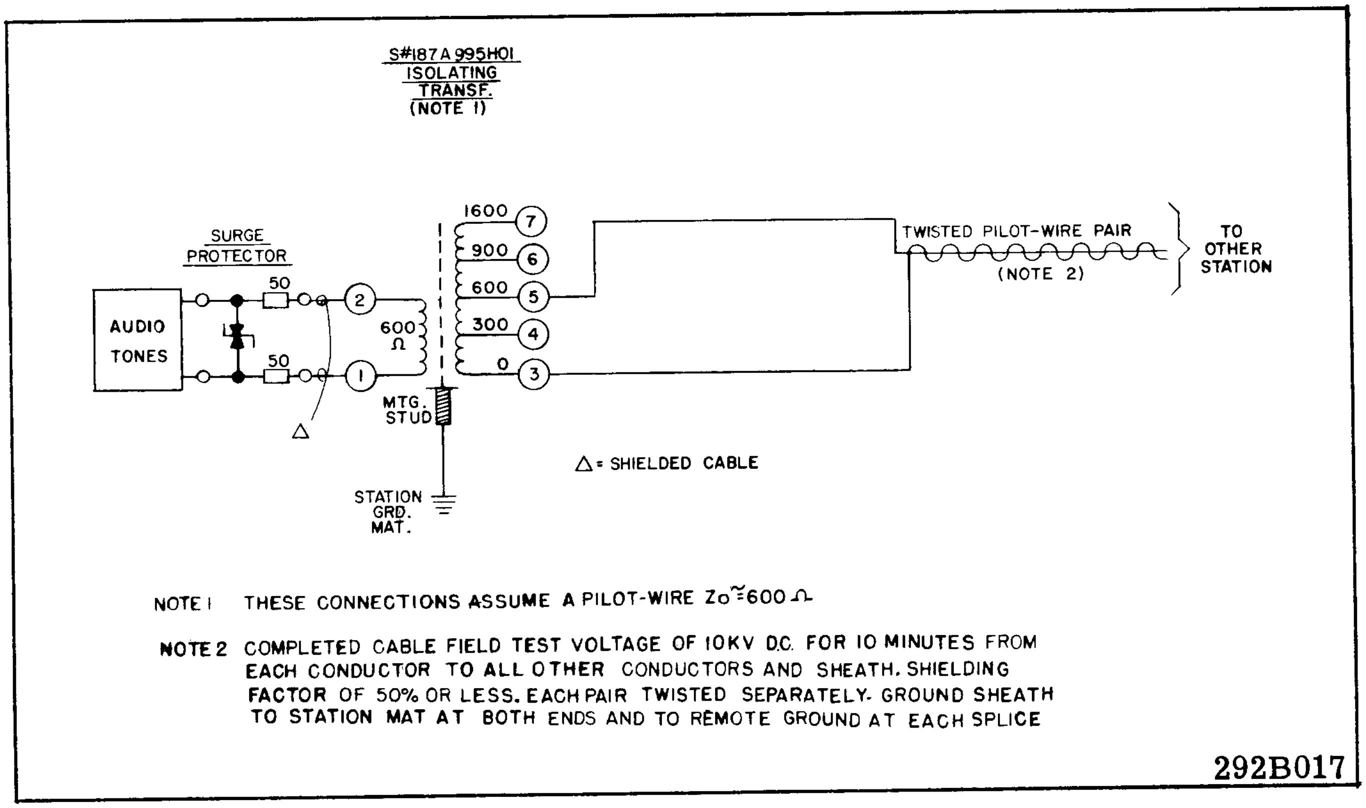


Fig. 1. Recommended Connections and Pilot Wire Design for Privately Owned Two-Terminal Lines.

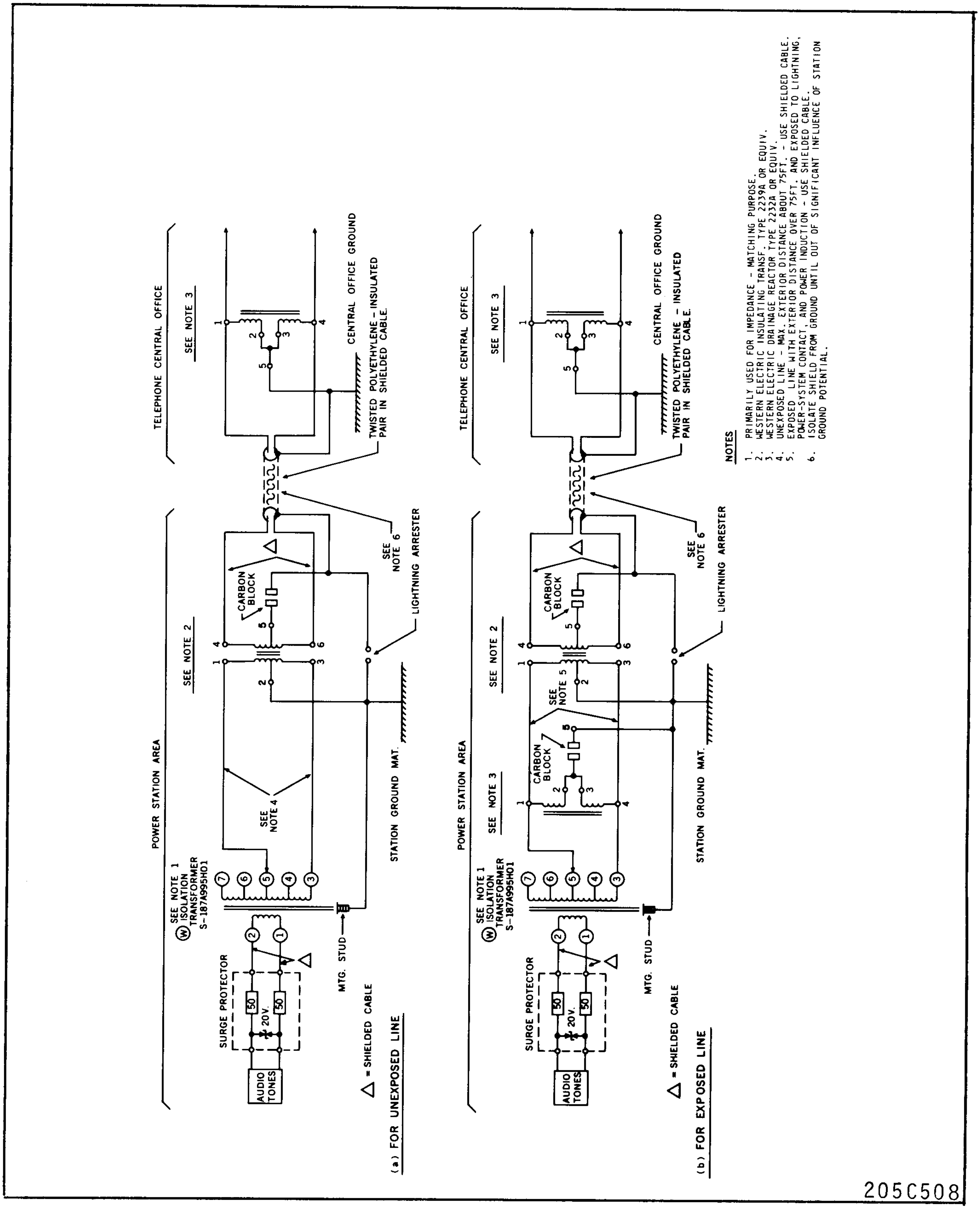
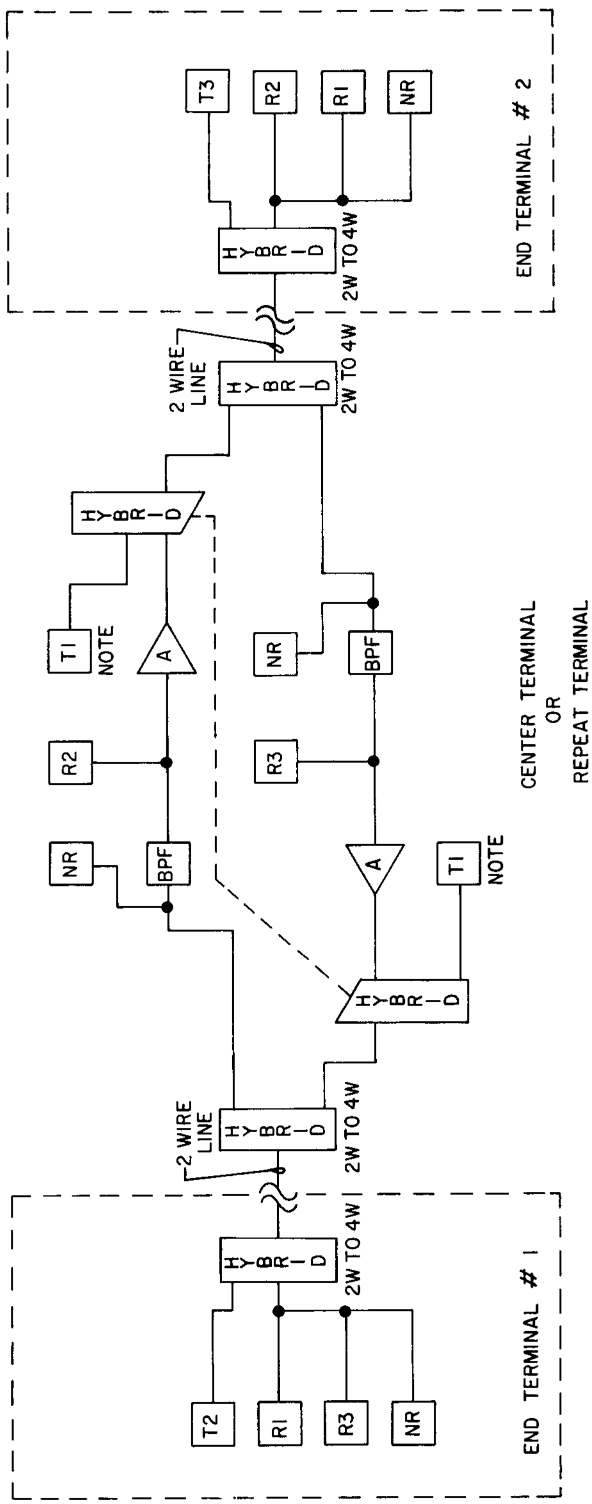


Fig. 2. Recommended Connections and Protective Arrangements for Two-Terminal Lines

265C480



NOTE: TI SHOULD BE THE CENTER FREQUENCY WHICH IS CLOSER TO 1000 HZ.
T = TRANSMITTER
R = RECEIVER
NR = NOISE RECEIVER
BPF = BAND PASS RECEIVER

* *Fig. 3. Two Wire, Three Terminal Application of TA-3 Tones.*

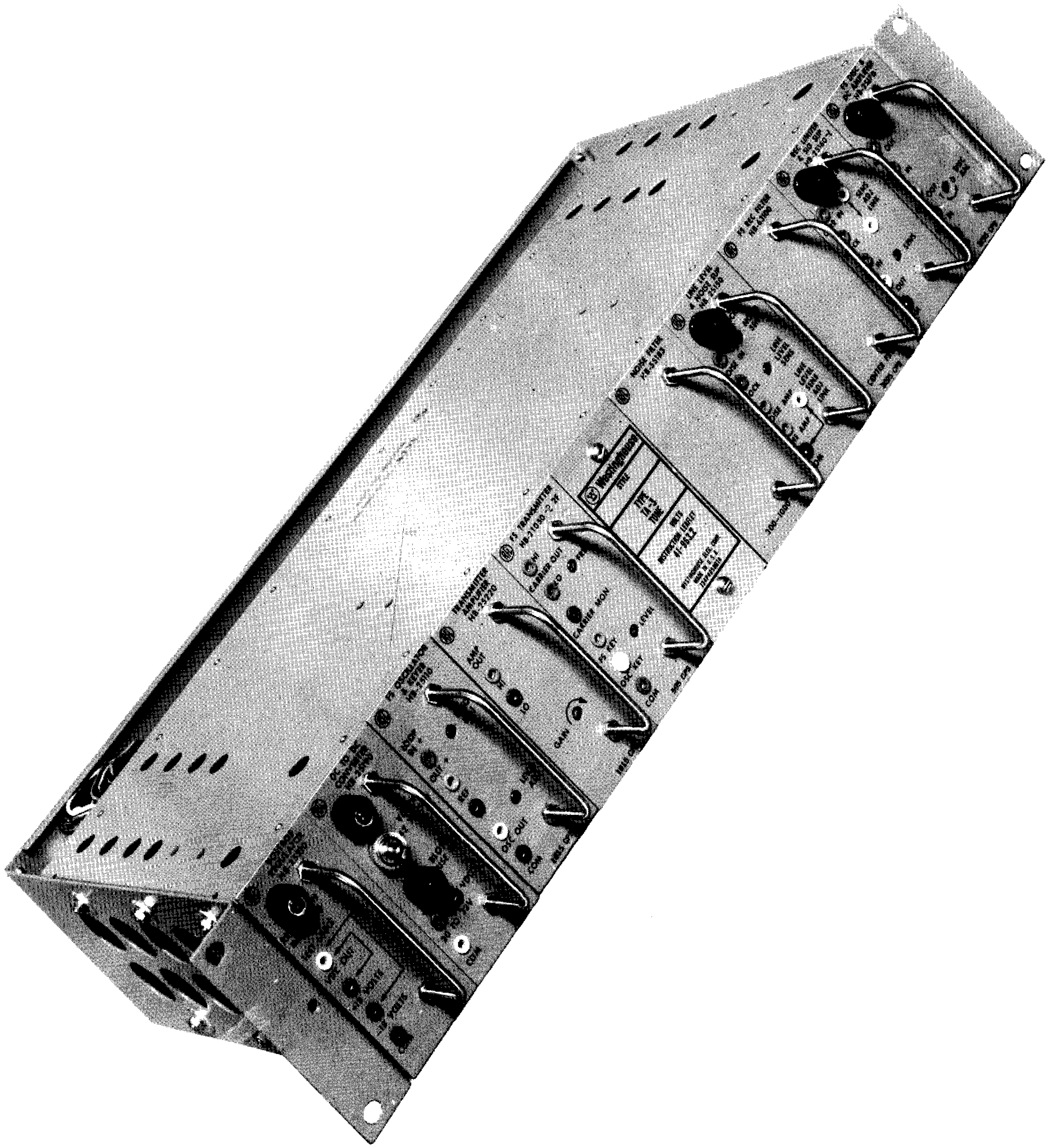
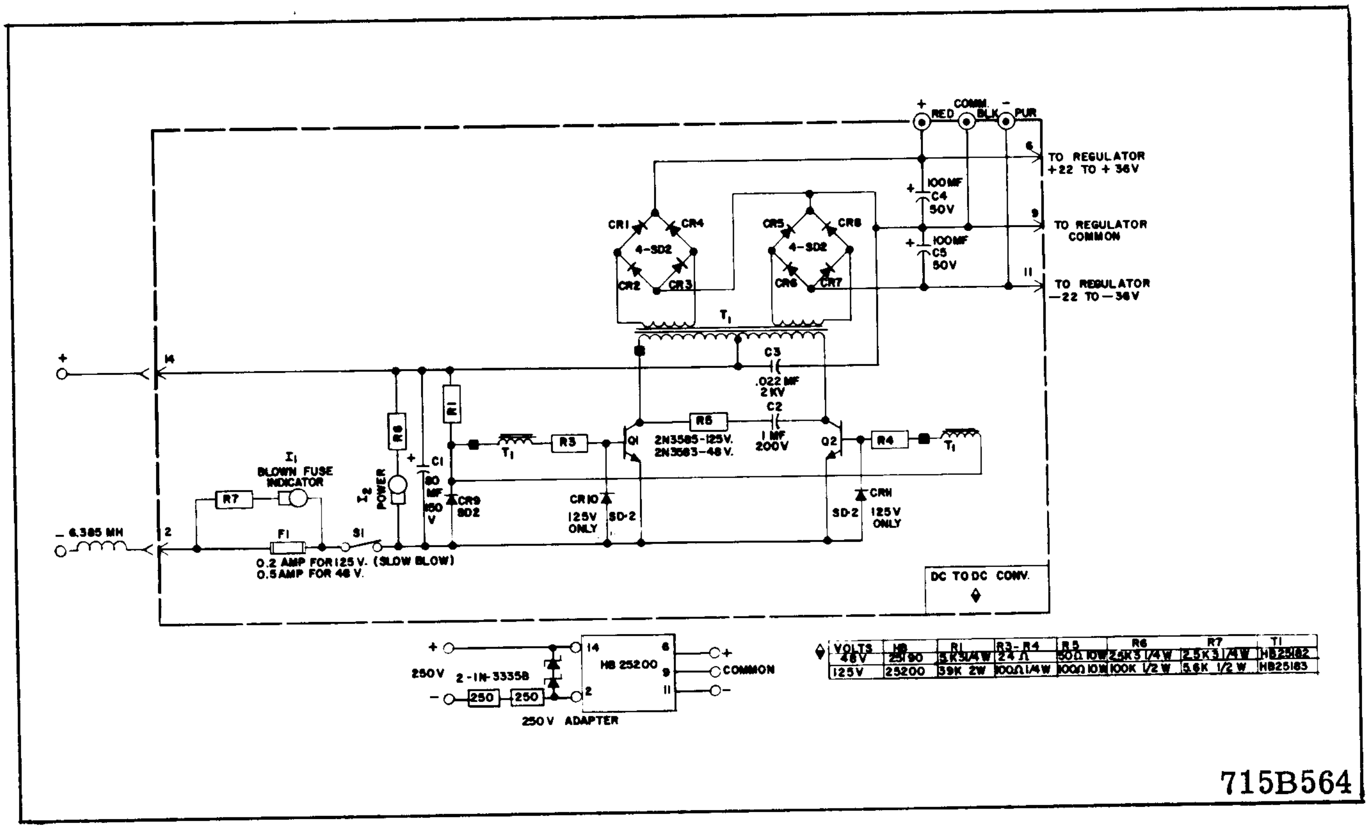


Fig. 4. Front View of Full Chassis.



VOLTS	HB	R1	R3-R4	R5	R6	R7	T1
48V	25190	5K3 1/4 W	24 Ω	50Ω 10W	2.5K3 1/4 W	2.5K3 1/4 W	HB25182
125V	25200	39K 2W	100Ω 1/4 W	100Ω 10W	100K 1/2 W	5.6K 1/2 W	HB25183

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

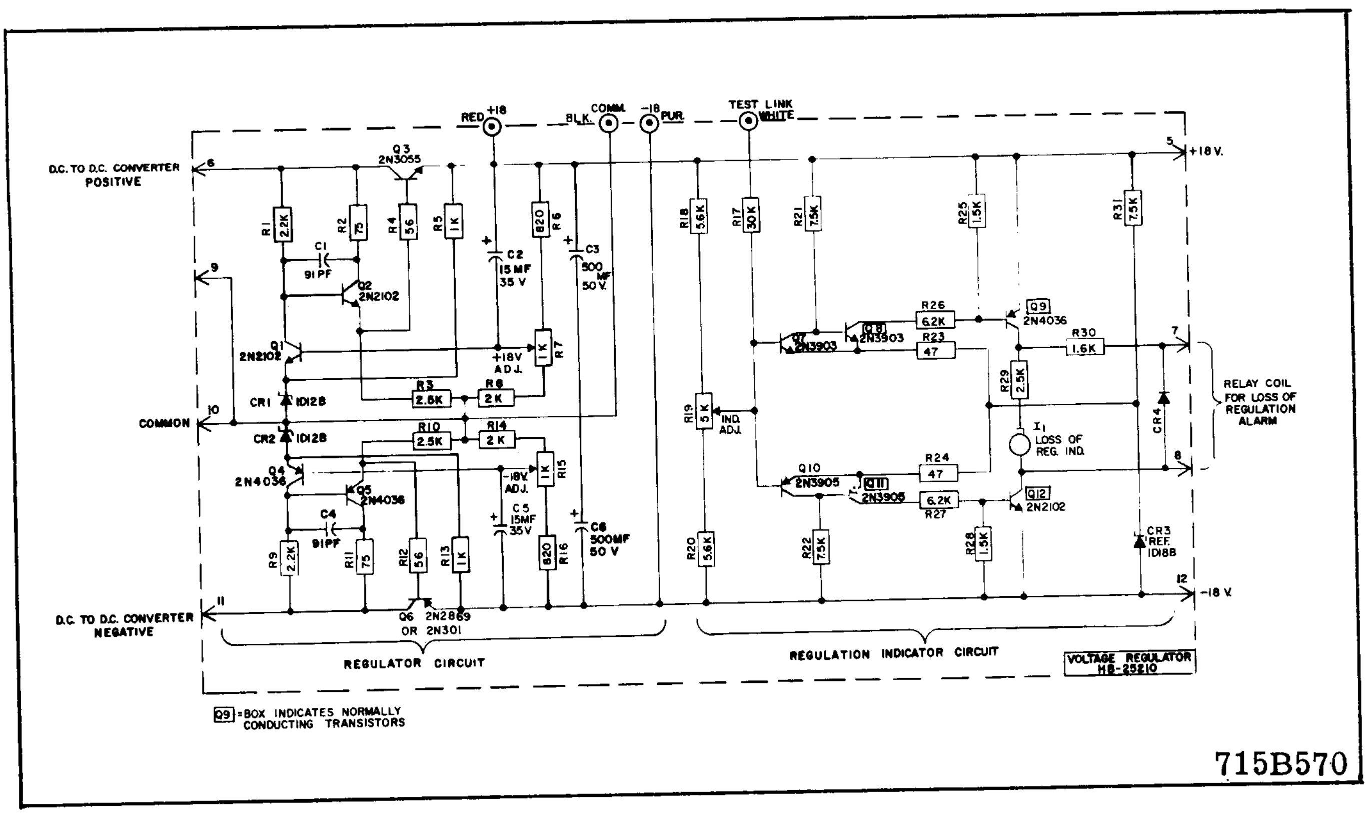


Fig. 6. Voltage Regulator HB-25210.

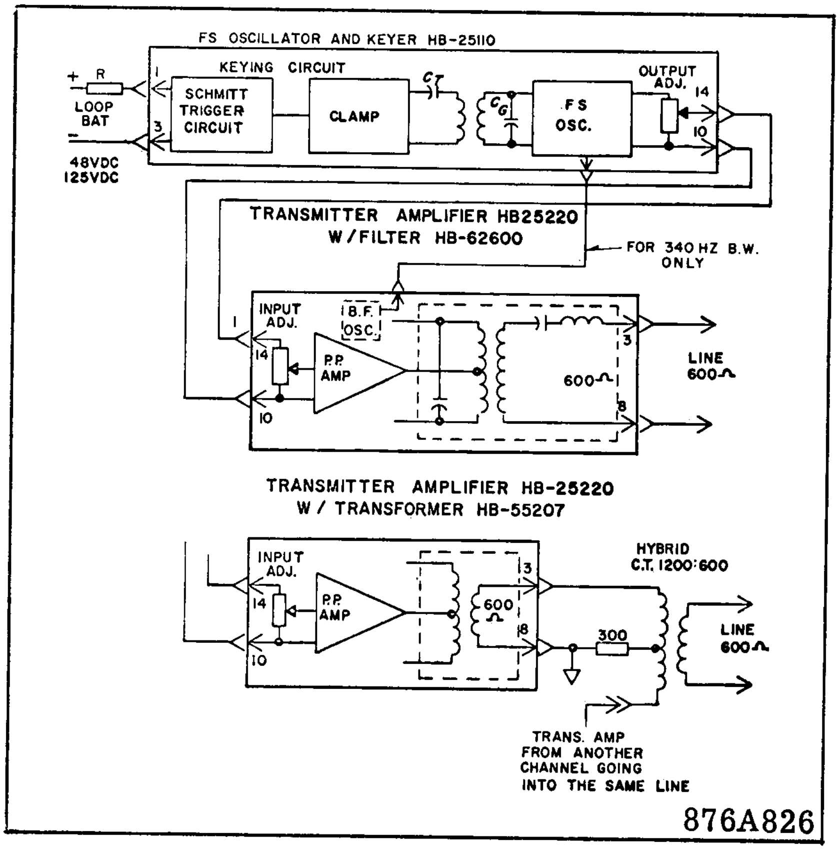


Fig. 7. Transmitter Block Diagram.

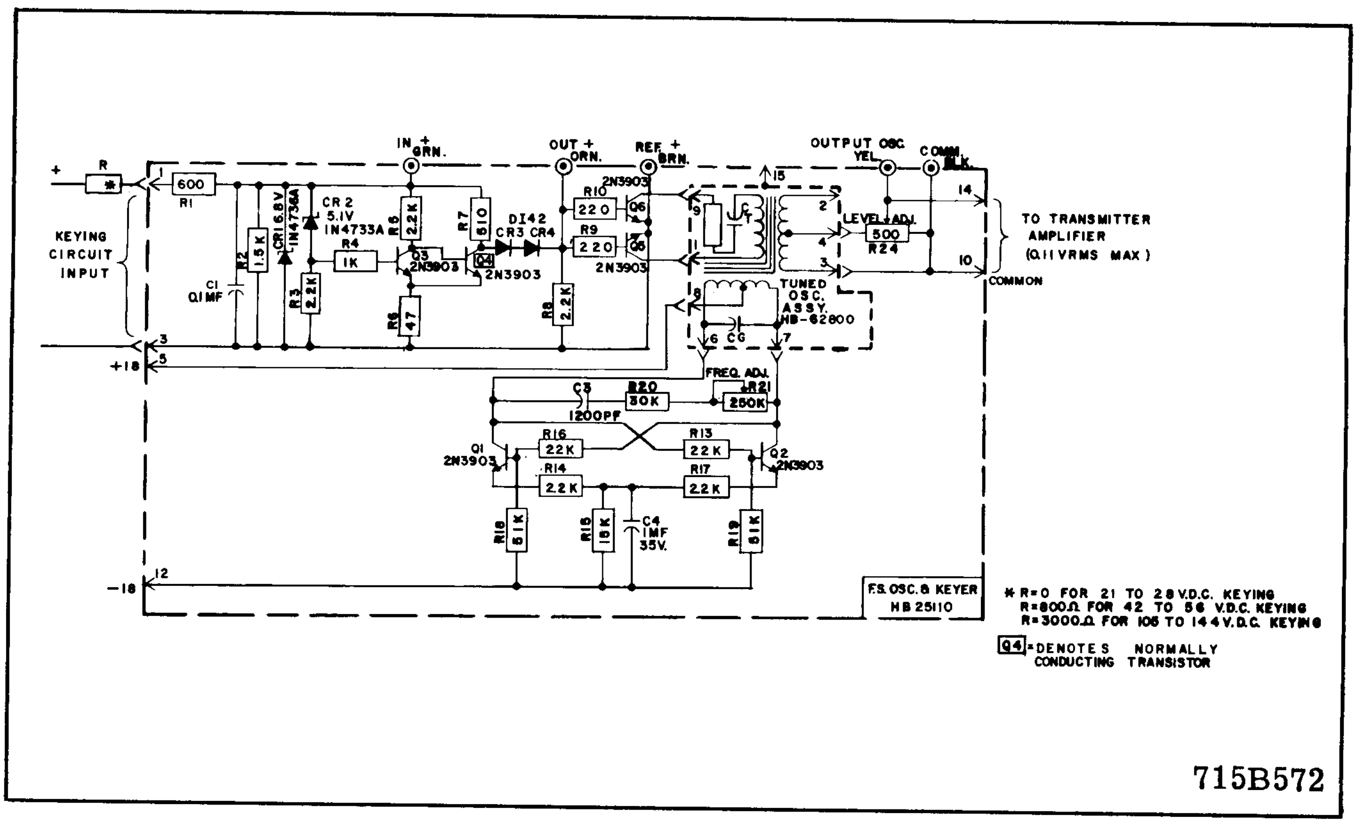


Fig. 8. F.S. Oscillator and Keyer HB-25610.

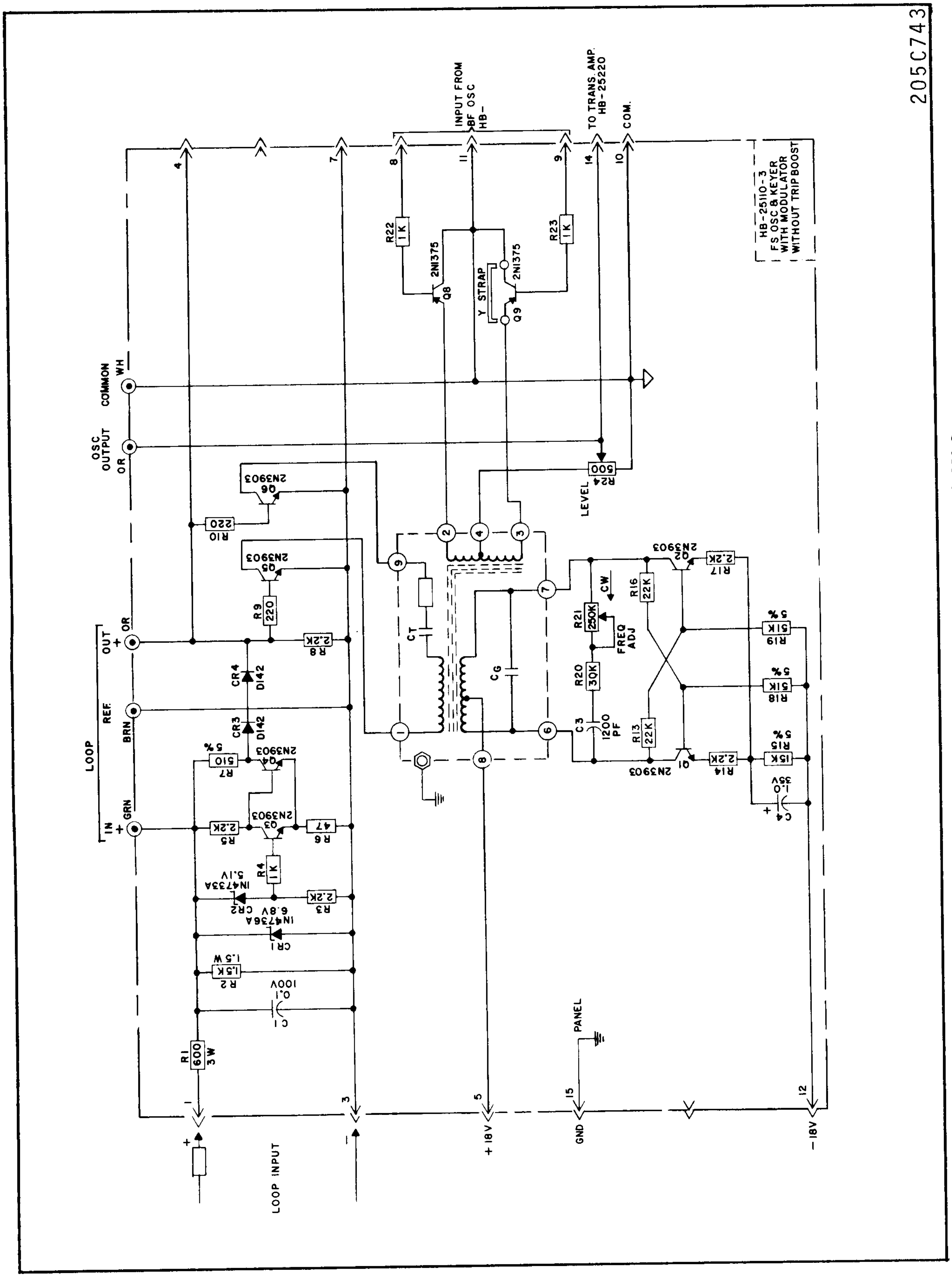


Fig. 9. F.S. Oscillator and Keyer HB25110-3.

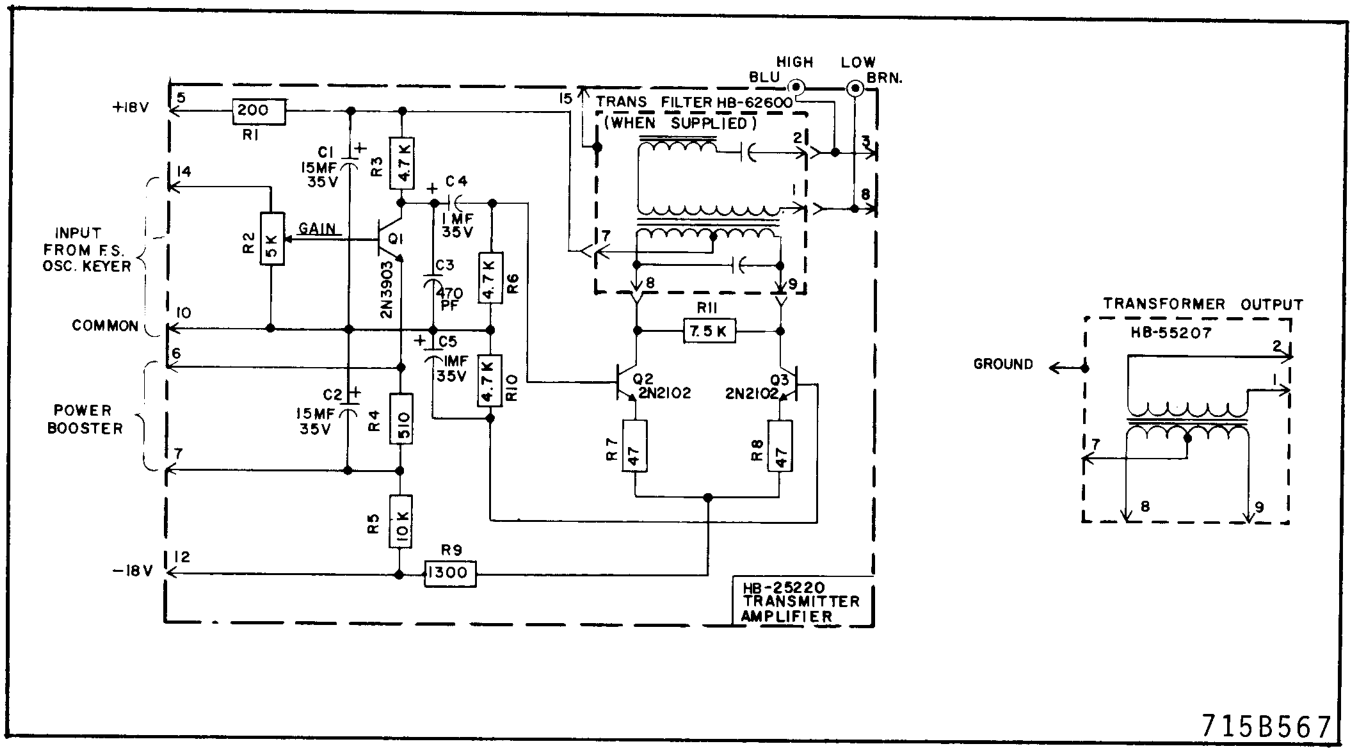


Fig. 10. Transmitter Amplifier HB-25220.

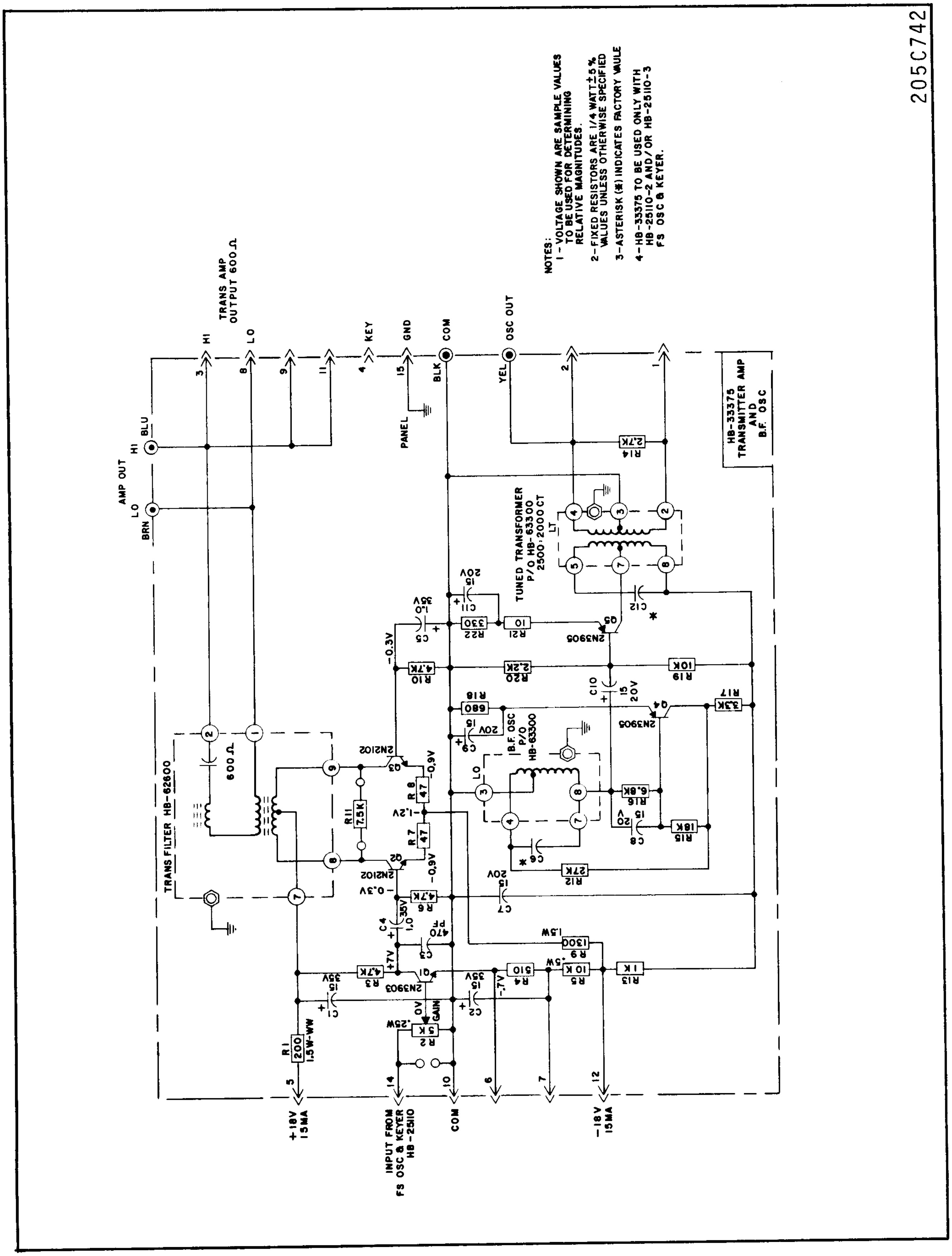


Fig. 11. Transmitter Amplifier HB-33375.

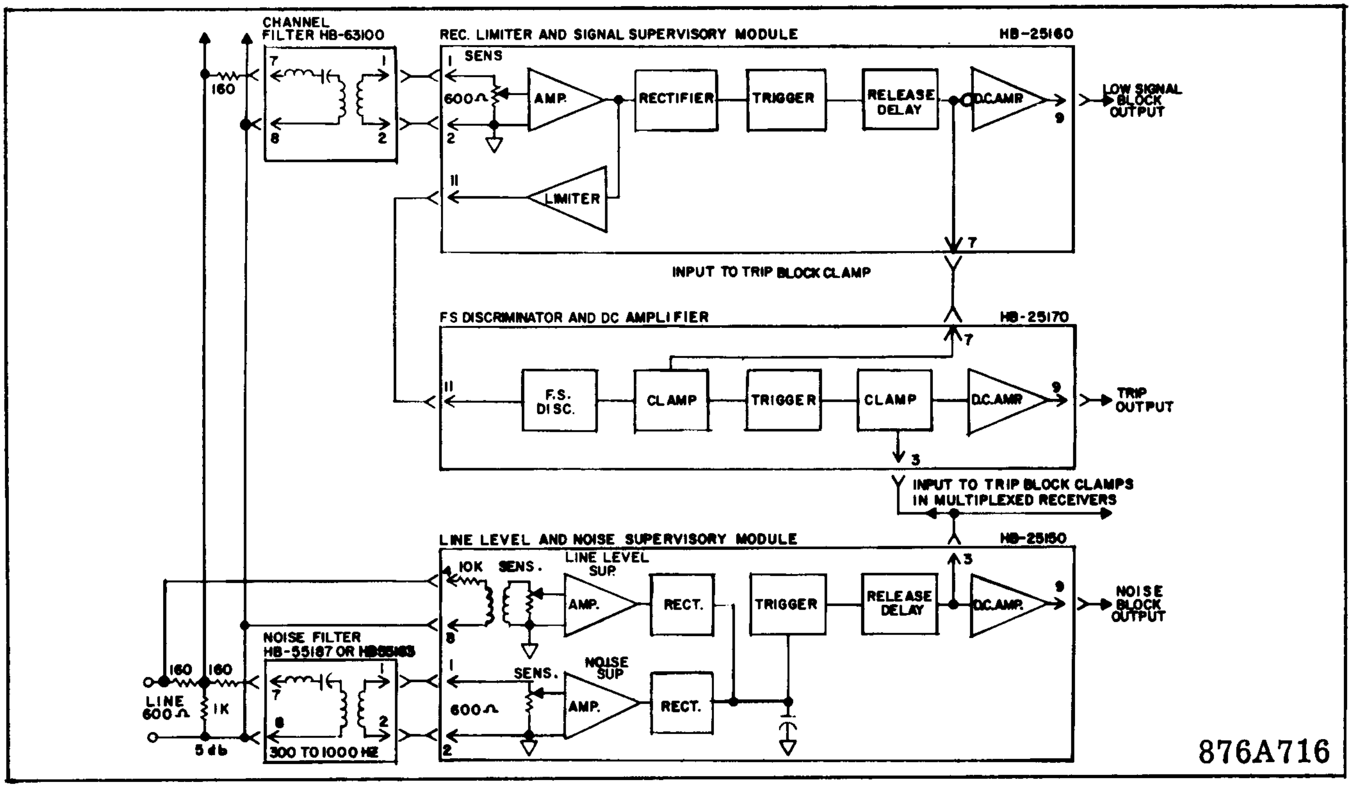


Fig. 12. Receiver Block Diagram HB-63100.

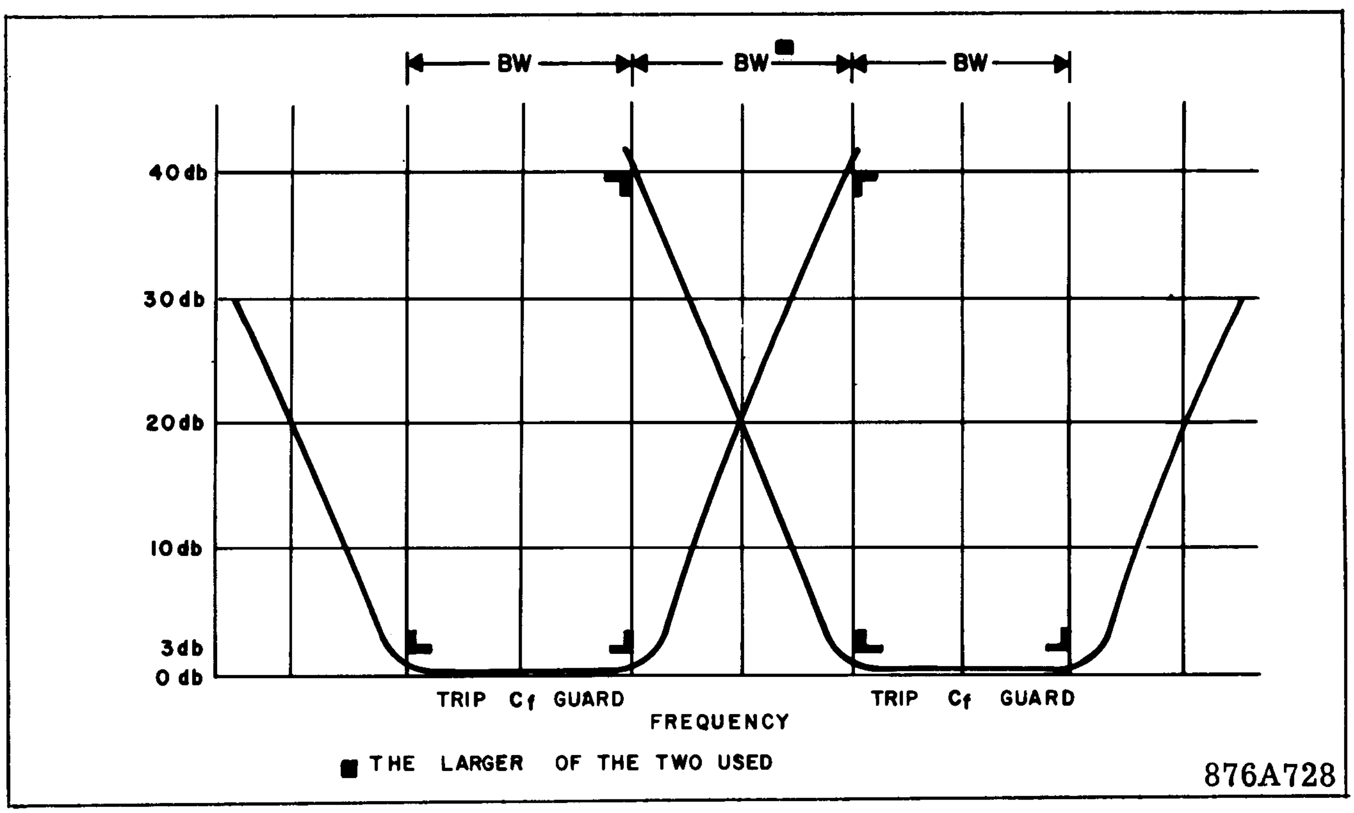
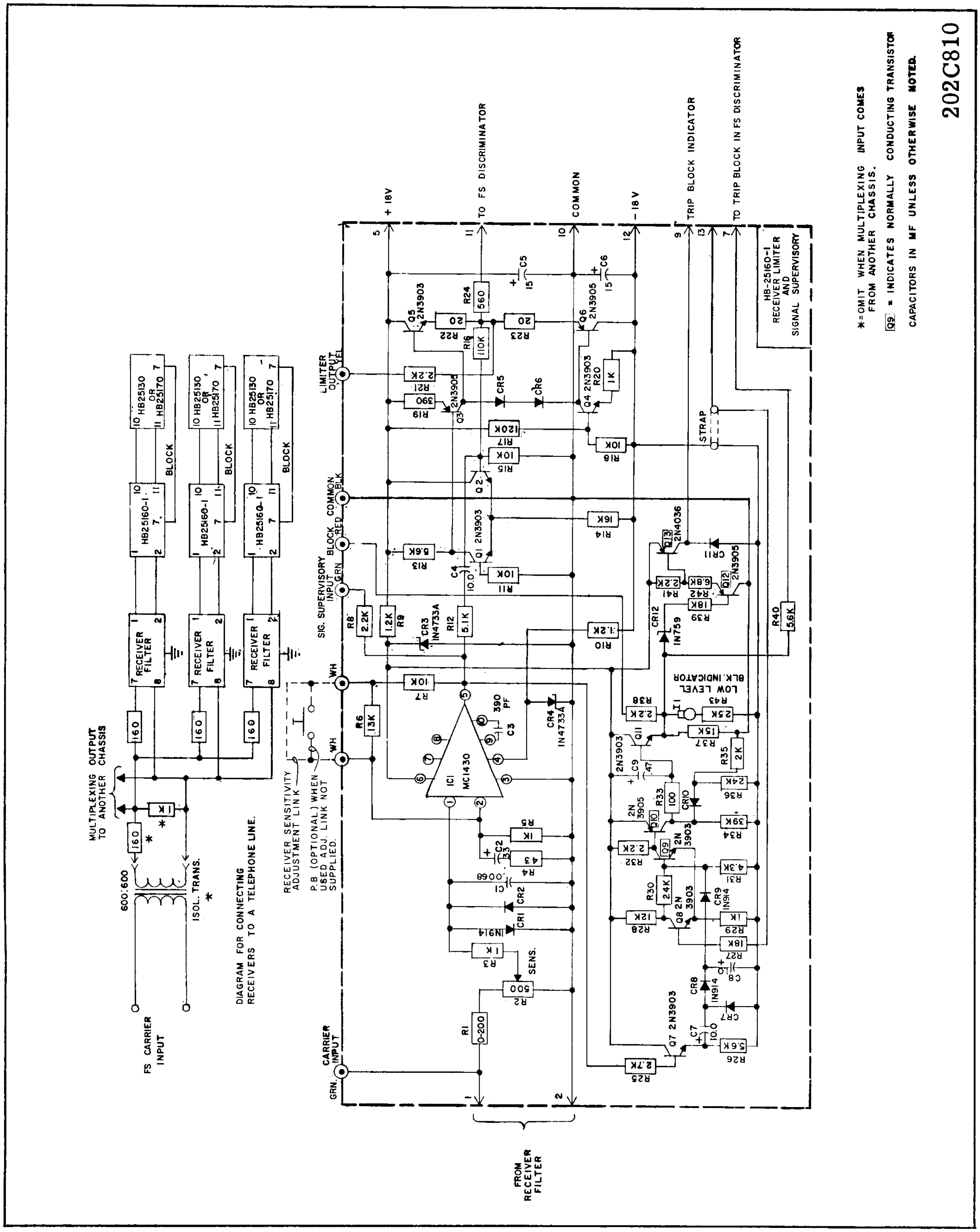


Fig. 13. Tone Receiver Filter Characteristics HB-63100.



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

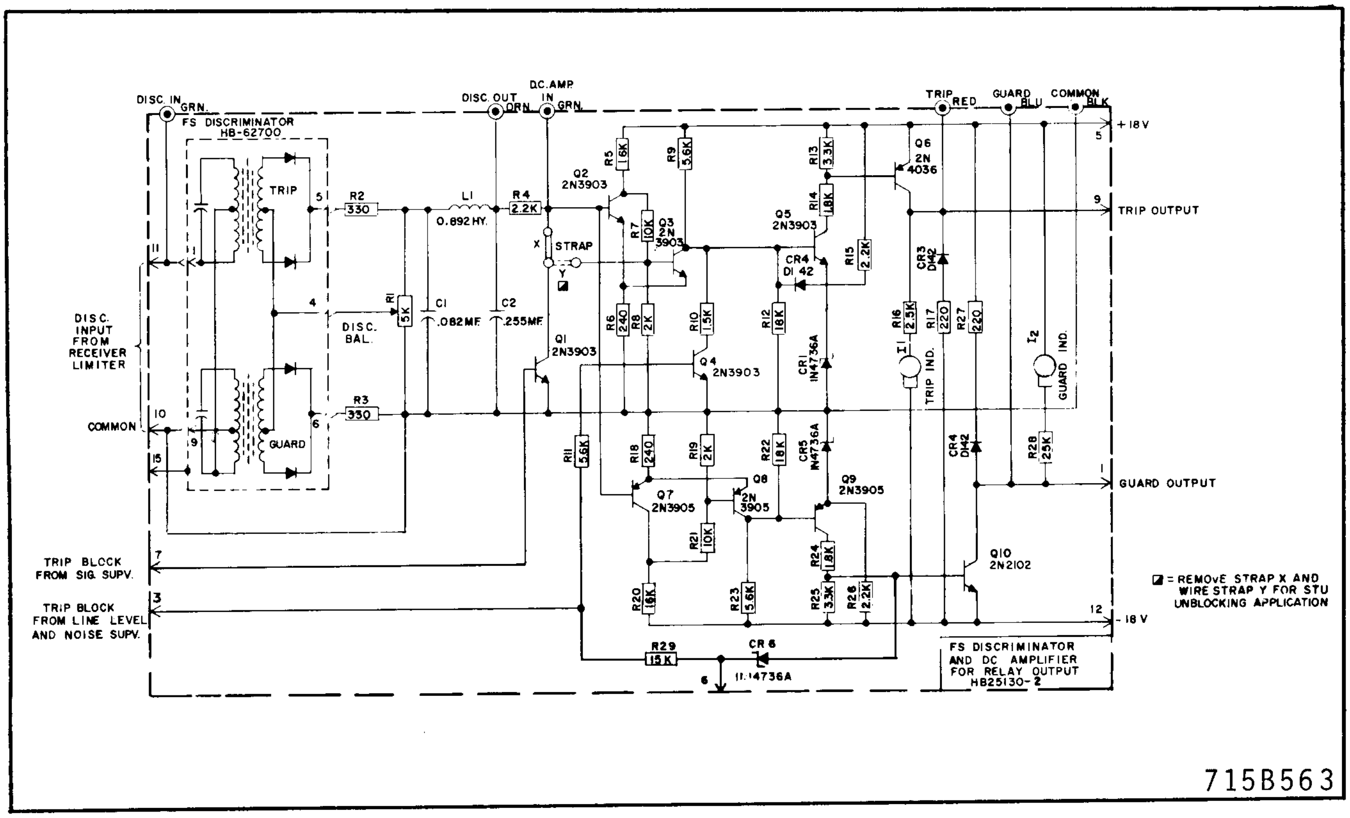


Fig. 15. F.S. Discriminator and D-C Amplifier for Relay Output HB-25130-2.

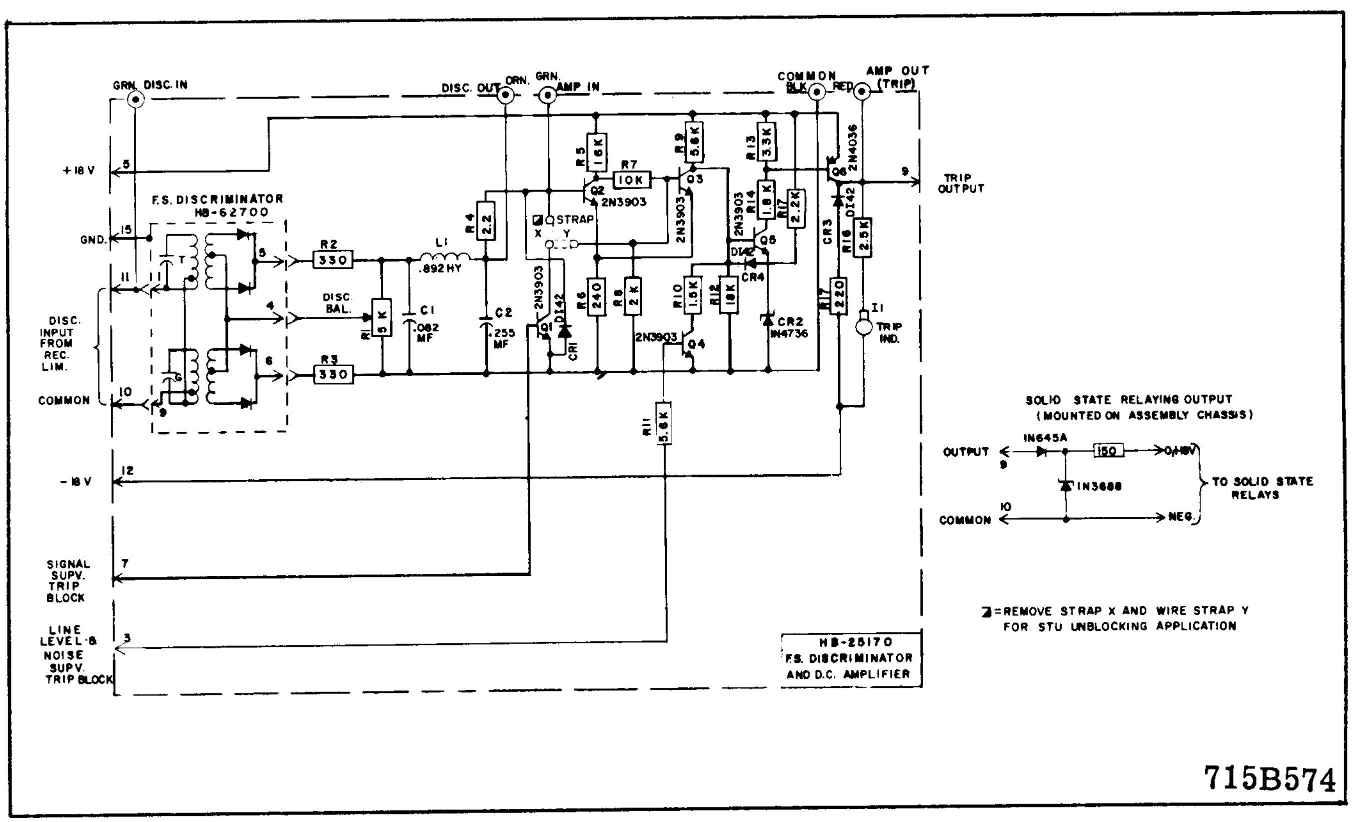


Fig. 16. F.S. Discriminator and D-C Amplifier for Solid-State Relaying HB-25170.

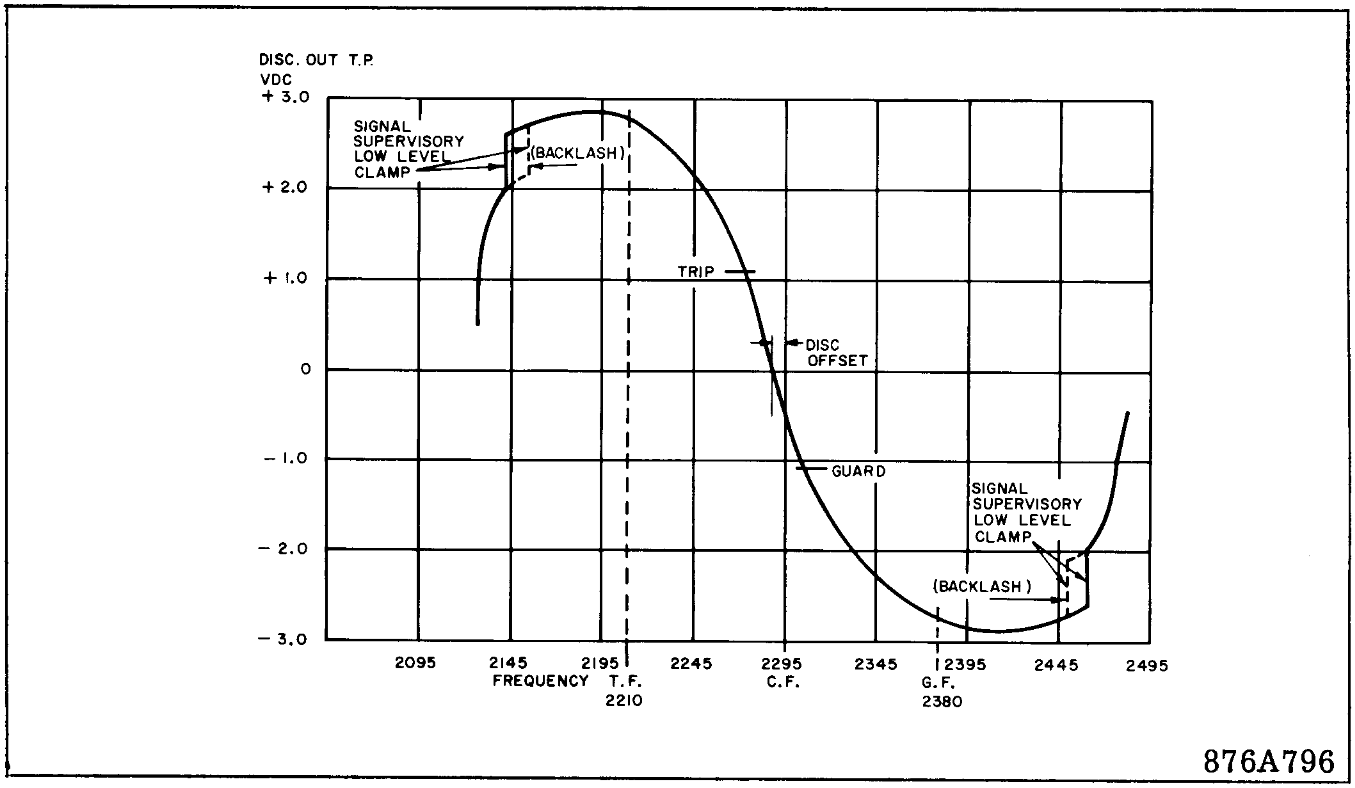


Fig. 17. Typical Discriminator Output.

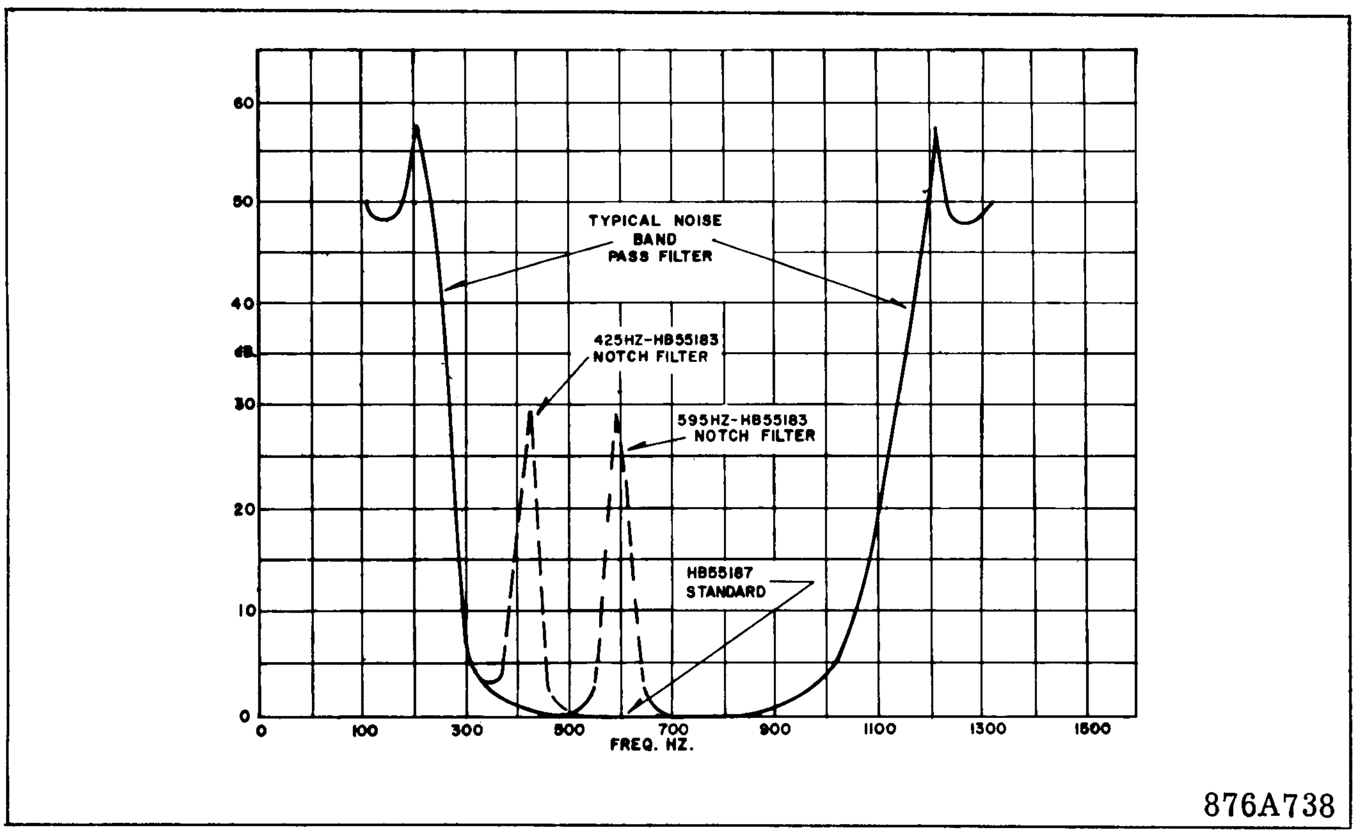


Fig. 18. Typical Noise Bandpass Filter.

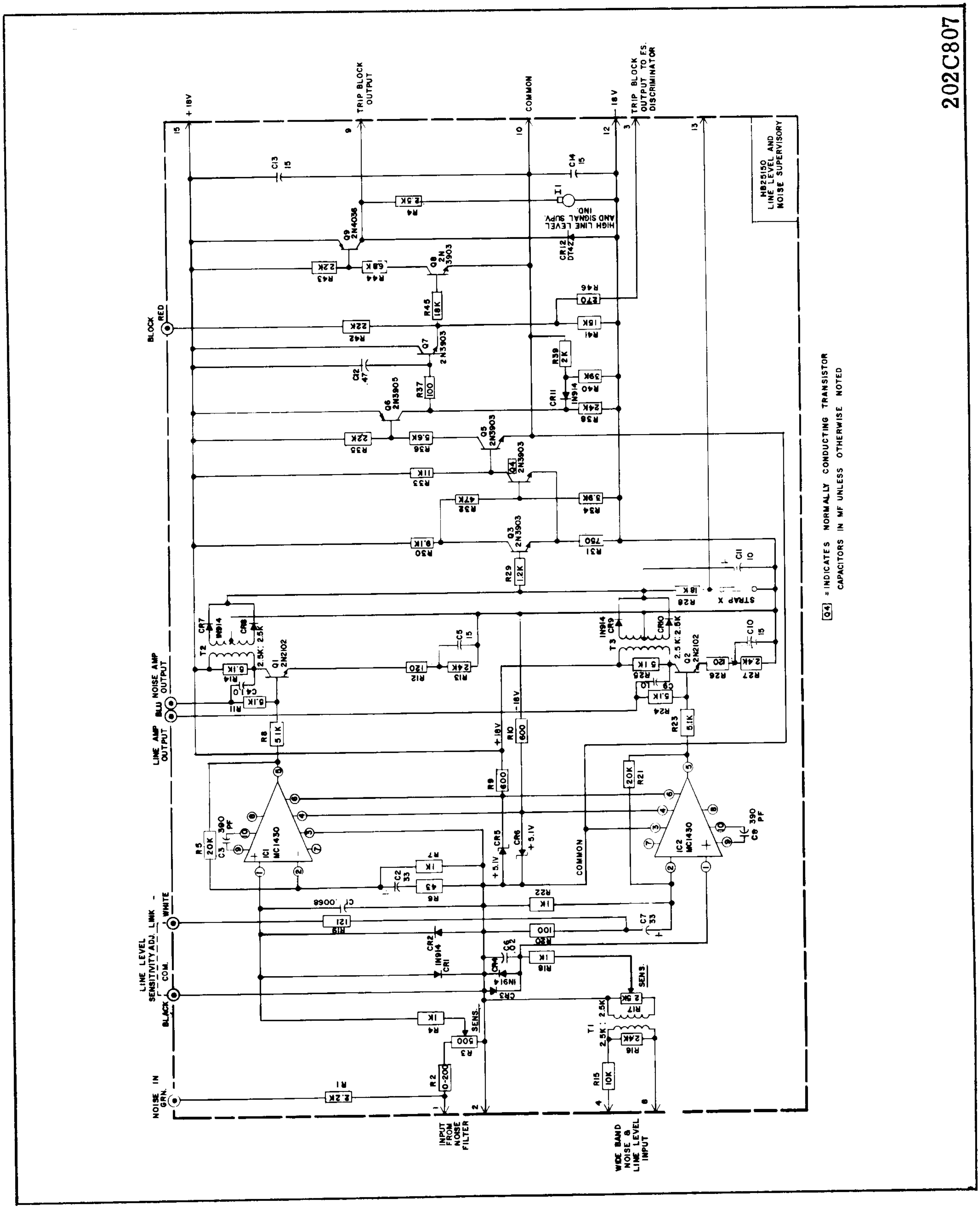
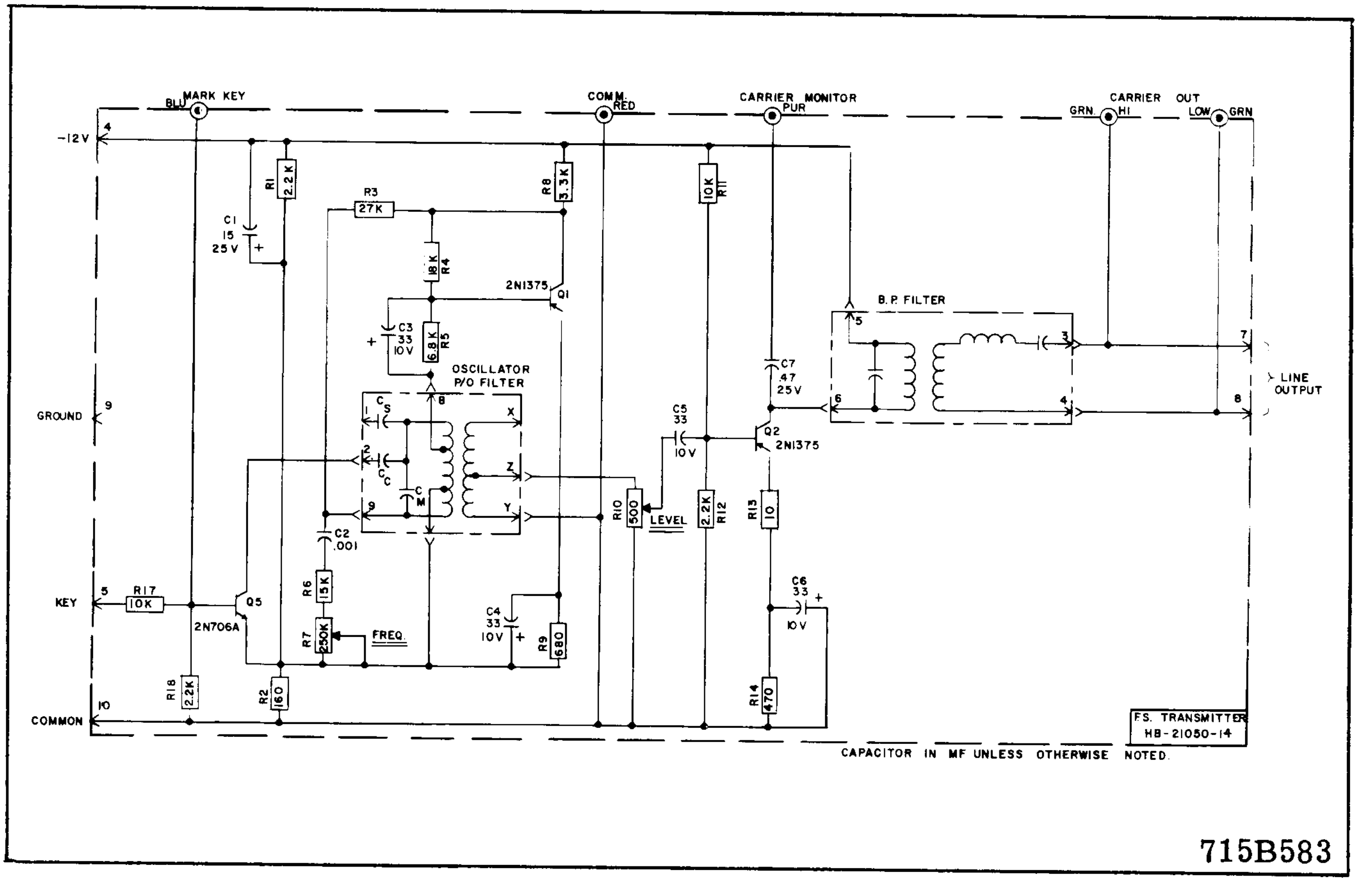


Fig. 19. Receiver Line Level and Noise Supervisory Module HB-25150.



* *Fig. 20. 425-Hz Transmitter HB-21050-14.*

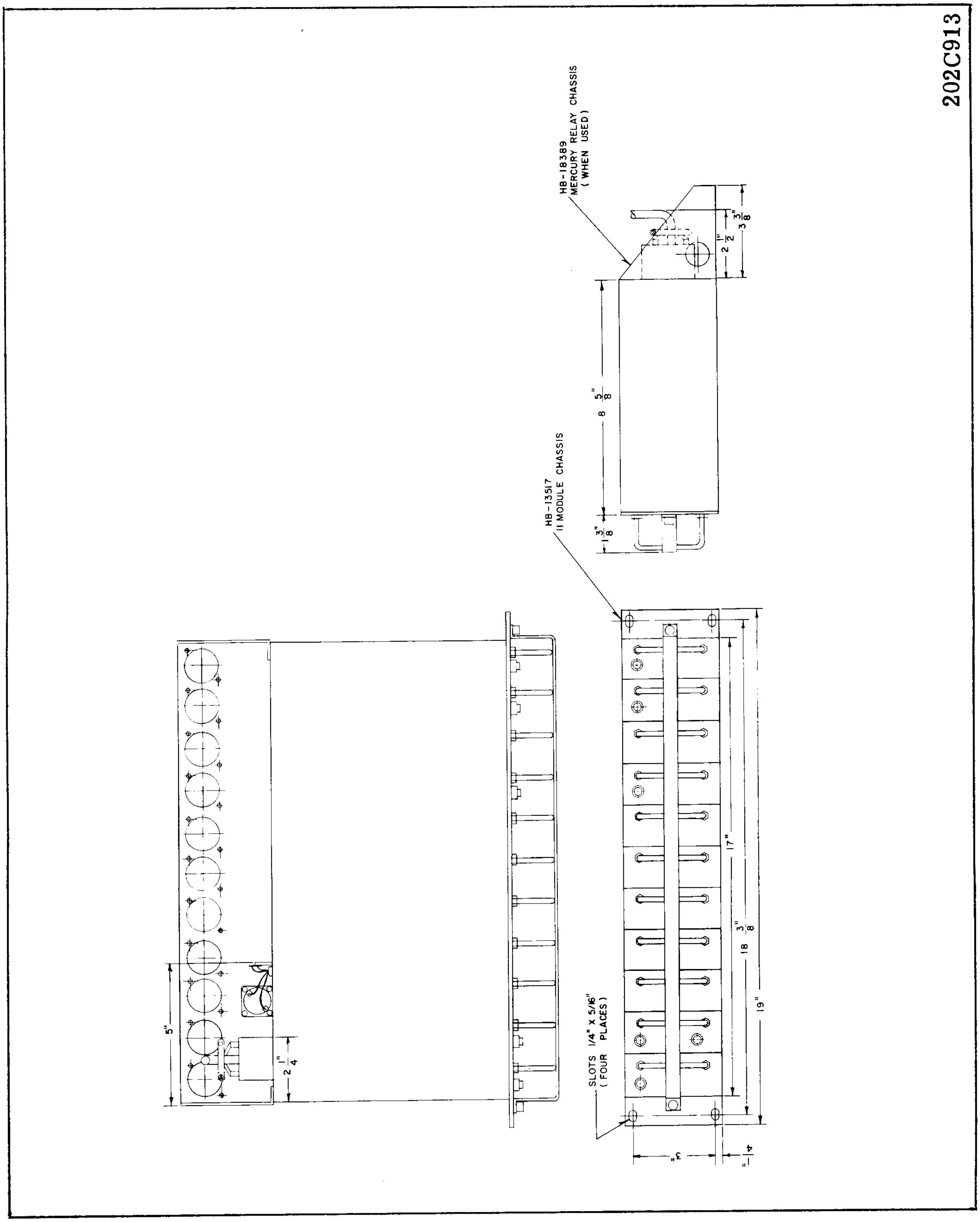


Fig. 21. Outline and Drilling Plan.

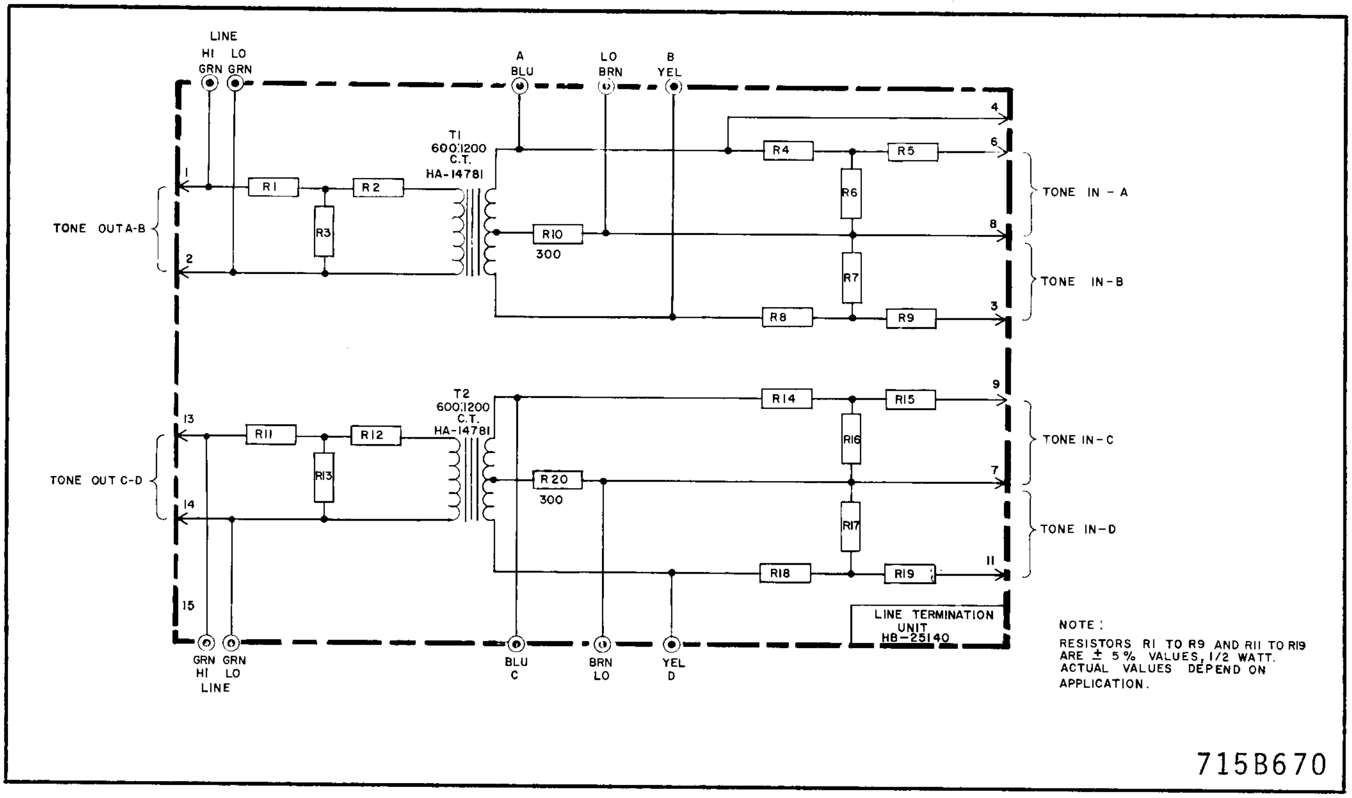


Fig. 22. Line Termination Module HB-25140.

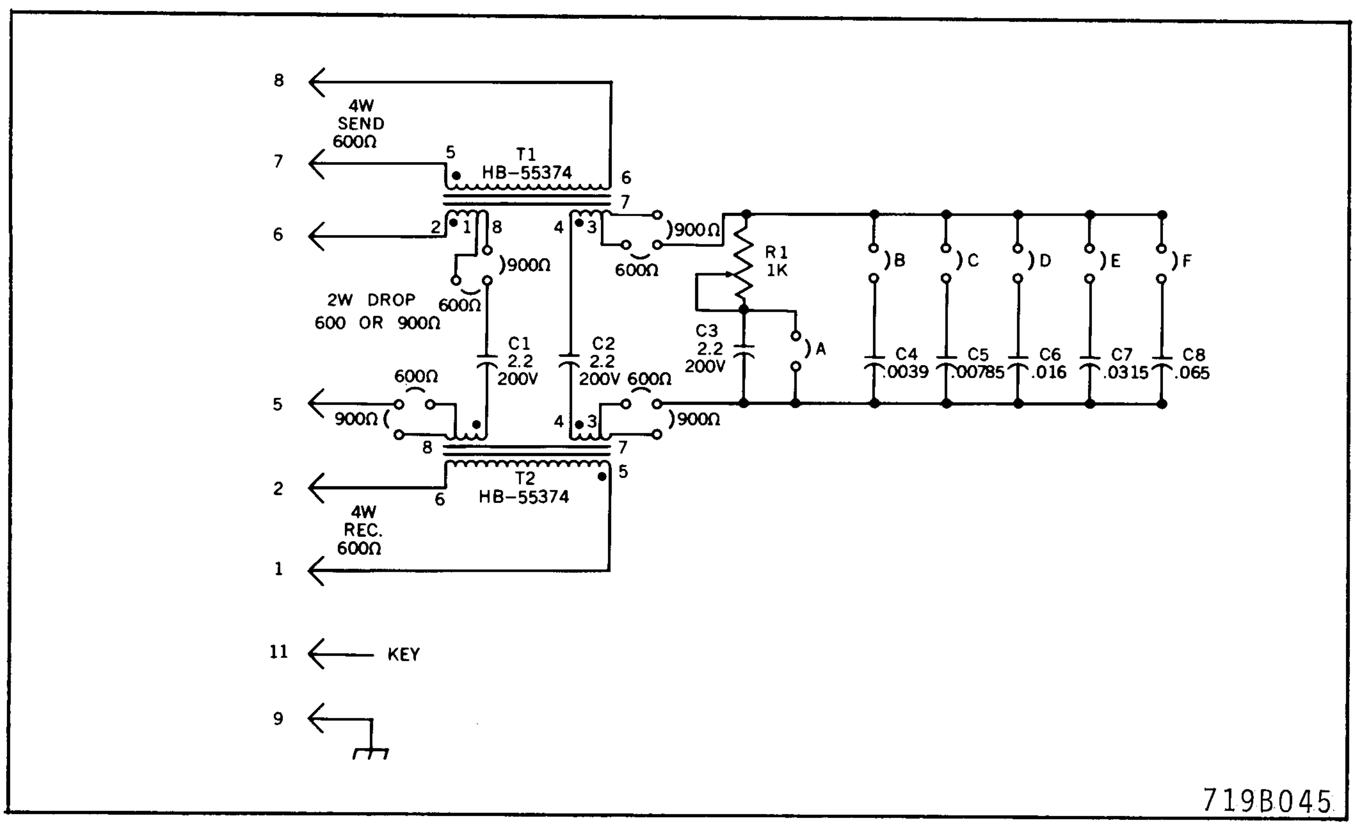


Fig. 23. Hybrid for Two Wire Termination HB-35315.

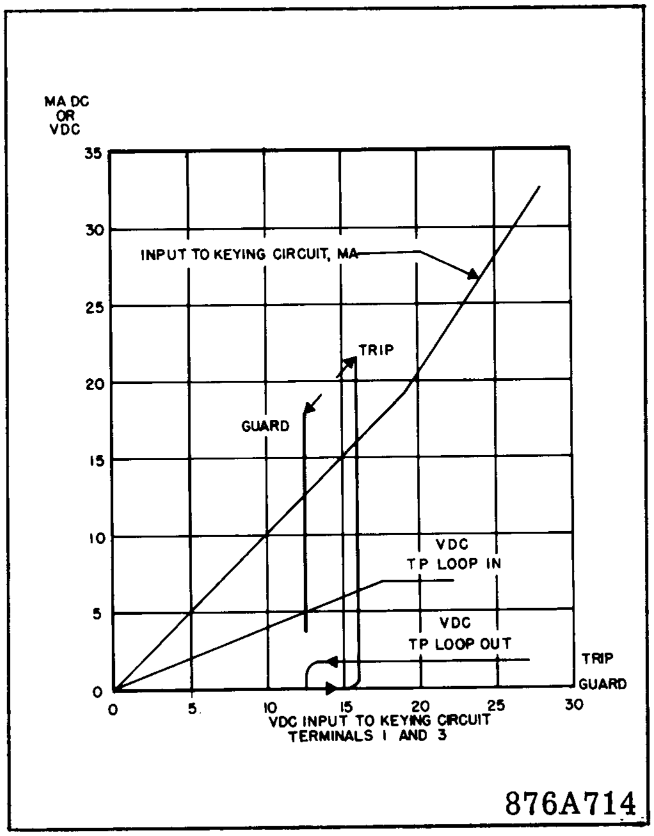


Fig. 24. Transmitter Keying Circuit Characteristics.

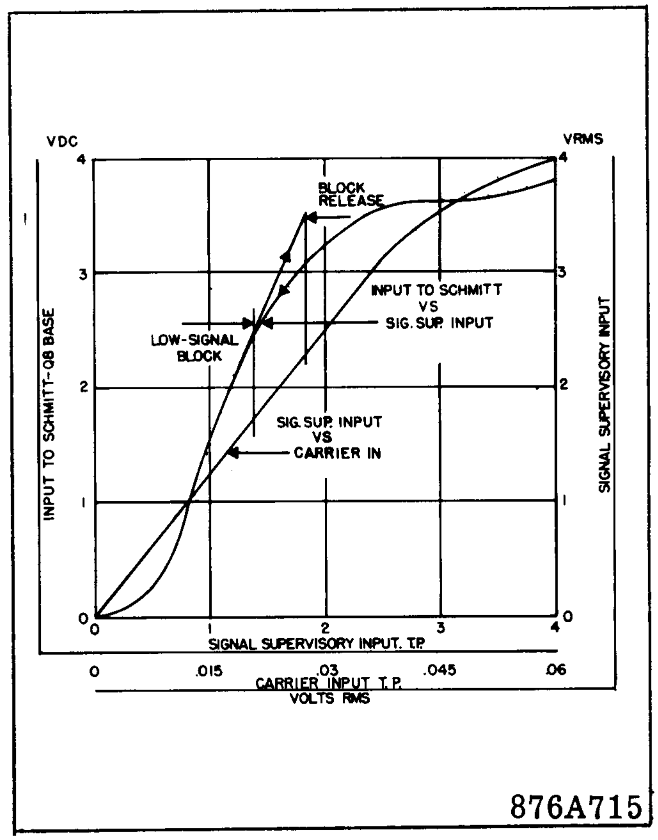


Fig. 25. Signal Supervisory Circuit Characteristics.

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

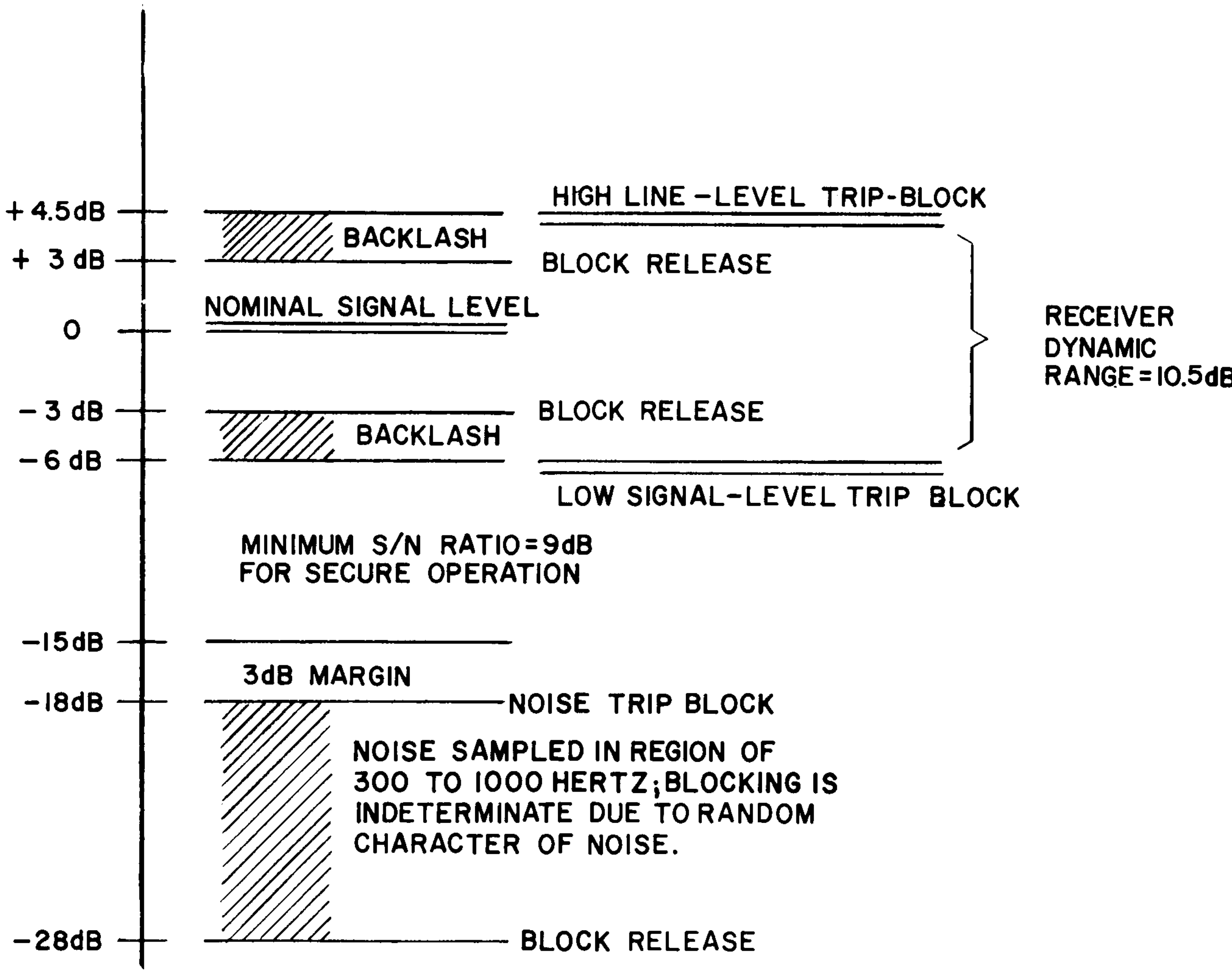


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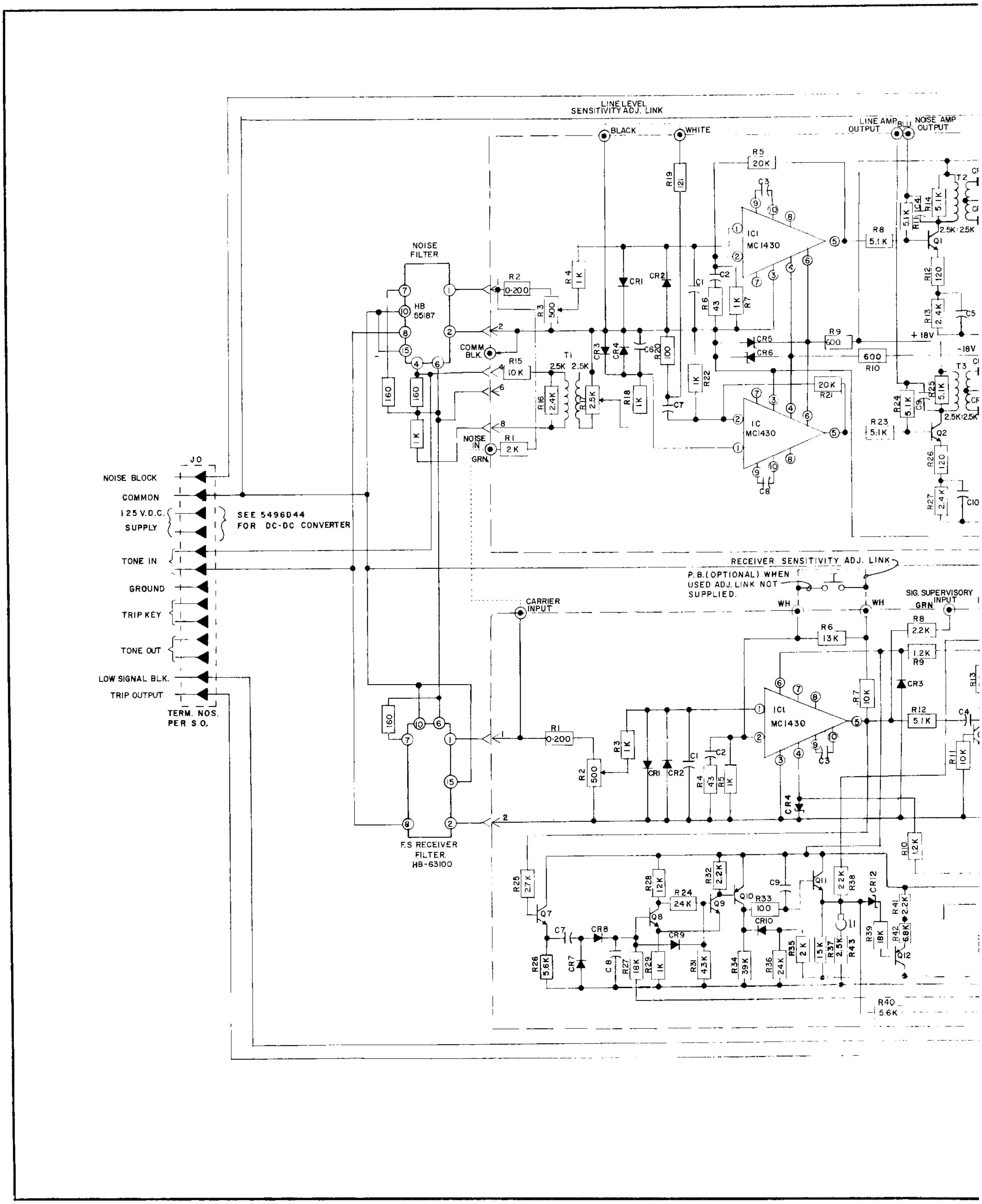
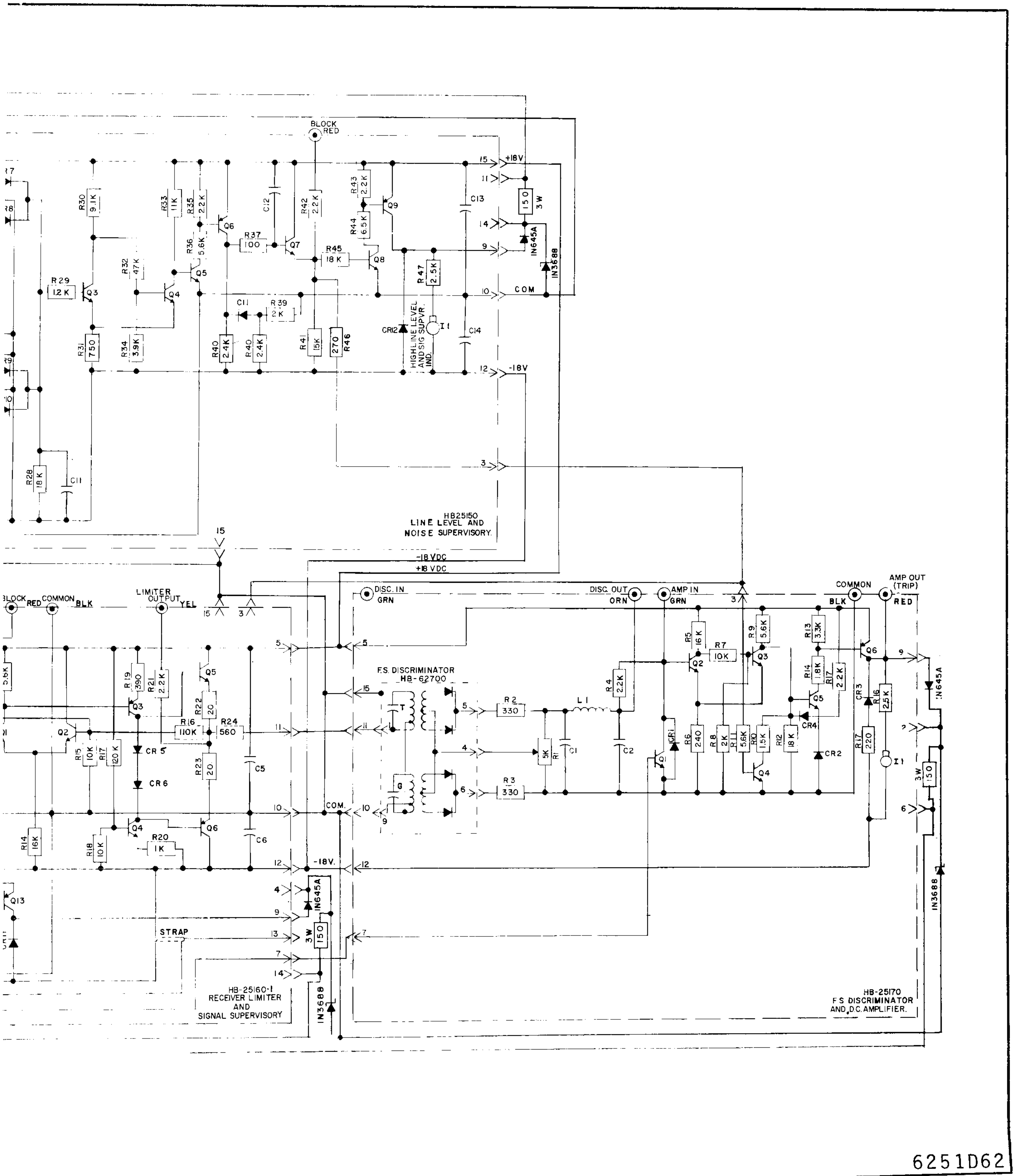
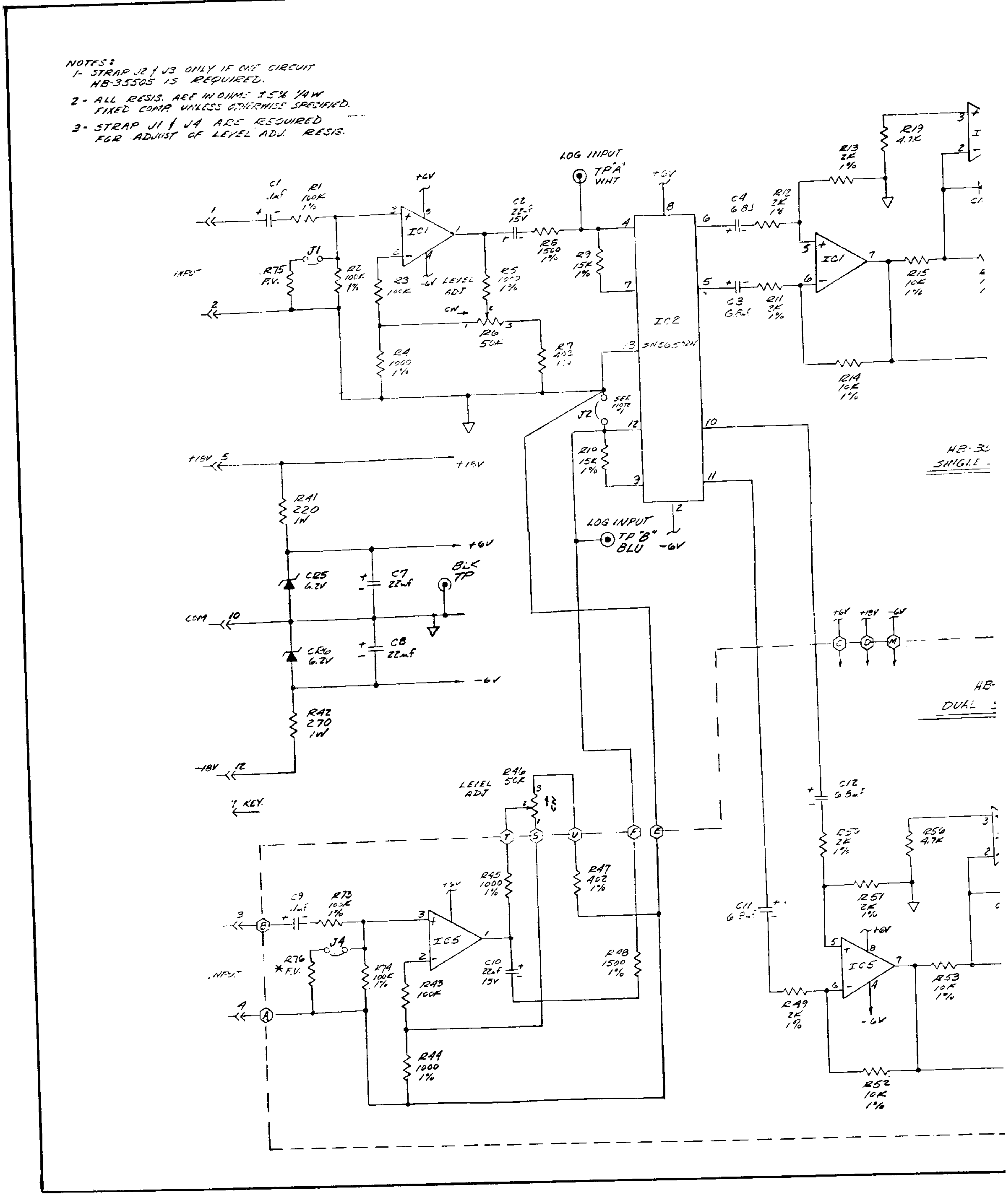
Fig. 26. Receiver Dynamic Operating Range.



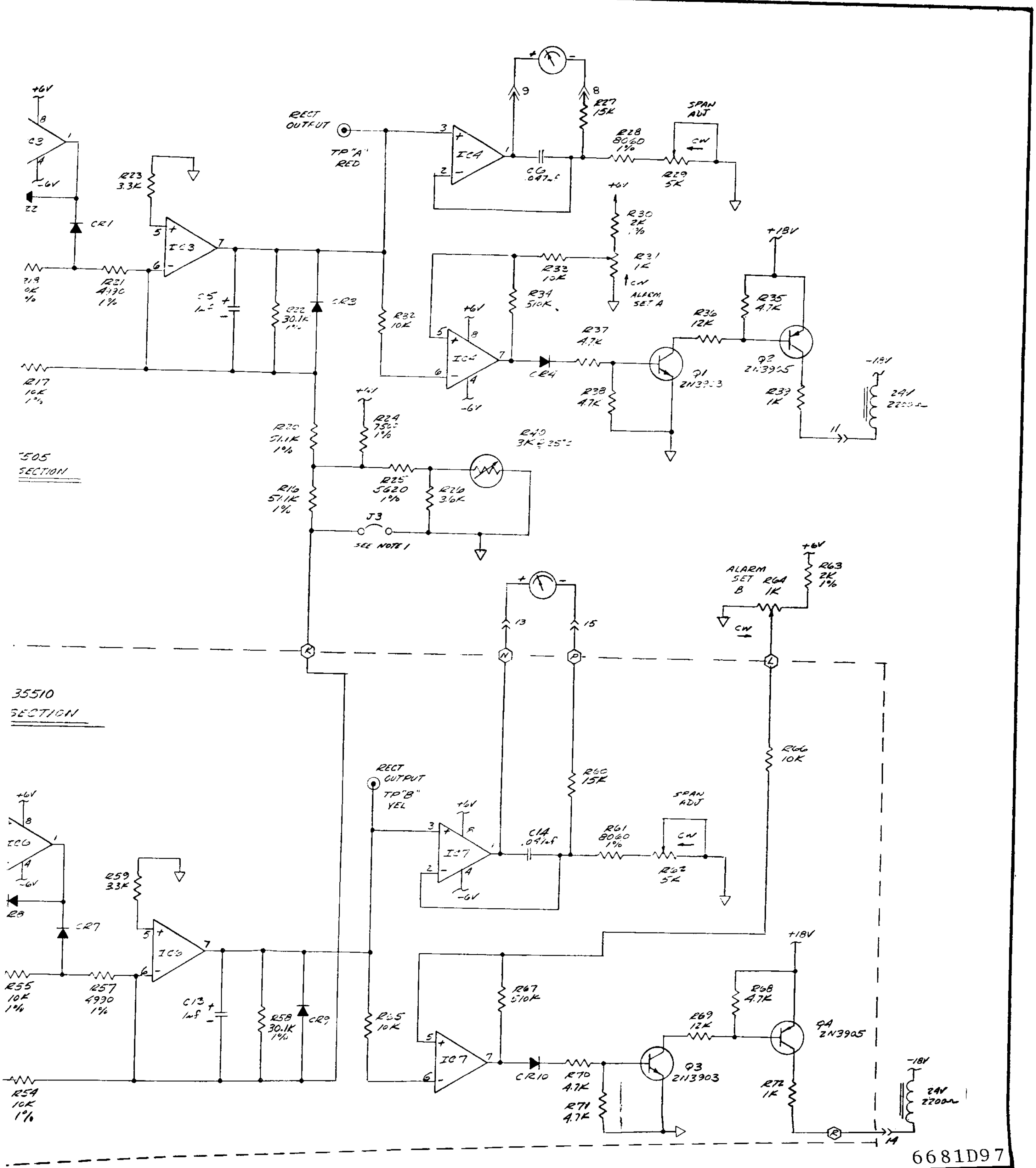
* *Fig. 28. TA-3 F.S. Receiver, L*



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



* Fig. 30. Tone Level Indica



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tor and Alarm Module HB35505 and HB35510

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