INSTALLATION • OPERATION • MAINTENANCE

INSTRUCTIONS

TYPE TA-2.2 FREQUENCY-SHIFT AUDIO TONES

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

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

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

APPLICATION

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

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

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

SECURITY MEASURES

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

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

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

PILOT WIRE DESIGN

In applying a tone system for protection, the user and the cooperating telephone company should recognize the peculiar requirements of a tone protection channel. Preconceived notions and practices based on experience with tones for other uses must be re-examined in light of the following facts. The period of usefulness during the lifetime of any given installation will be very small. Yet this infinitesimal period (compared to years) is precisely the time when noise levels can be adnormally high and 60-Hertz disturbing voltages will appear on the pilot wire. The recommendations summarized in Figs. 1 and 2 have been formulated with the above facts in mind.

For a recommended installation:

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

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

c. Do not use open pilot wires.

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

e. Use surge protection across tone connection.

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

Fig. 1 shows the recommended practices for privately owned cable installations. The best approach is to make the cable self-protecting. The incremental cost (installed) of better cable insulation is relatively small. Good electromagnetic shielding by the shield and by the messenger will keep induced potential to reasonable levels. The shield should provide a shielding factor of 50% or less (actual induced voltage of 50% of calculated value ignoring shielding effect).

CONSTRUCTION

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

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

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

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

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

2. Voltage Regulator HB25210 (See Fig. 4 for Internal Schematic)

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

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

B. TRANSMITTER MODULES

1. Transmitter Module –HB-24335-26 (Fig. 6)

   The transmitter module consists of a transistor keying circuit, an oscillator, an output amplifier and an output band-pass filter. The band-pass filter and oscillator are the frequency determining components and are contained in a separate plug-in enclosure on the transmitter module.

2. Beat Frequency Oscillator And Demodulator Module – HB.25640 (Fig. 7)

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

C. RECEIVER MODULES

1. Receiver Filter Module – HB58700

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

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

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

D. NOISE SUPERVISORY MODULE

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

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

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

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

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

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

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

(Some systems use 595 Hz)

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

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

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

G. LOGIC INTERFACE (Fig. 19)

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

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

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

OPERATION

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

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

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

Converter (Fig. 3)

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

Regulator (Fig. 4)

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

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

B. FS TRANSMITTER – HB-24335-26

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

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

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

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

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

BF Oscillator and Demodulator – HB-25640

Three functions are provided in this module.

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

BF Oscillator

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

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

Line Amplifier and Demodulator

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

C. RECEIVER MODULES

1. Receiver Input Filter HB58700

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

2. FS Receiver – HB-19915-27

Limiter Amplifier

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

Discriminator

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

Low Signal Squelch Circuit

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

Carrier Detector

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

Output D-C Amplifier

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

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

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

Across the output of the FS Receiver filter is this AM Receiver's sensitivity control R1 (see Figure 9). This control provides the means by which the receiver sensitivity is adjusted. Two RC coupled stages of amplification using Q1 and Q2 as the active elements follow this control. R3 and R2 set the DC biasing for the base of Q1 while R5 and R6 provide emitter self-biasing. C3 acts as a bypass for R6. R5 is not bypassed and introduces degeneration into the stage for greater stability of the circuit under varying conditions. R4 is the collector load for the stage. The operation of the second stage involving Q2 is the same. R12 and C4 act as a decoupling network to prevent self-oscillation in the high-gain receiver.

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

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

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

1. Line Level & Noise Supervisory Module HB25150.

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

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

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

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

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

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

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

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

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

CHARACTERISTICS

General

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

D-C TO D-C CONVERTER AND VOLTAGE REGULATOR

Converter HB25190 and HB25200, Regulator HB25210

Power Output:

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

Power Input:

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

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

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

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

Regulation:

+18 and –18 v.d.c. within 0.1 volt.

Regulation Indicator:

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

Ripple:

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

Converter Frequency:

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

Overloads:

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

Isolation:

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

FS Transmitter – HB-24335-26

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

FS Receiver – HB-19915-27

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

B.F. Oscillator & Demodulator

Carrier Input

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

Demodulator Output

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

BF Oscillator:

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

LINE LEVEL AND NOISE SUPERVISORY HB25150 AND FILTERS HB55283 AND HB55187

Output:

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

Noise Filters HB55187 and HB55283

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

Noise Filter Amplifier:

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

Line Level Amplifier:

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

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

Output Level:

600 ohms nominal, isolated and balanced.

Output Stability:

±1.5 dB from −30°C to +70°C.

Frequency Stability:

HB21050-12 ±.25% from −30°C to +70°C.

Keying Inputs:

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

AM RECEIVER 24030-3

Sensitivity: Adjustable from 0dBm to −35dBm.

Input Impedance: 600 ohms nominal.

LOGIC INTERFACE

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

Output Voltage: +18V D.C.

INSTALLATION

(Outline and Drilling Plan, Figure 14)

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

SETTINGS

Transmitters HB24335-26

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

The audio output level of the transmitter is measured by connecting a 600-ohm resistor or load across the signal output terminals. No other signal should be present on the line if it is used. The level can be measured at the output terminals using an a-c vacuum-tube voltmeter. The level control is then adjusted for the desired output. After all the transmitters are adjusted properly and multiplexed, a VTVM reading should be taken at the "OUT" pin jack on the front panel and recorded for maintenance and check-out purposes. This avoids the necessity of disconnecting the transmitter from the line when levels are to be checked or readjusted. The 425-Hz transmitter should be set the same as any other transmitter.

Demodulator – Level Control

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

FS Receiver HB19915-27

Plug a d-c voltmeter (at least 20 volt range) into TP norm. and TP comm. of receiver. (The tone transmitters must be previously set to their desired output levels.) Connect a VTVM across the tone receiver input terminals (TP Lo and TP Hi) and note the normal received voltage (preferably in db). Now connect a calibrated attenuator (such as the Hewlett-Packard Model 350B Attenuator) between the telephone line and the terminal equipment. Set the attenuator for 6 db attenuation. This value can be checked on the VTVM. If such an attenuator is not available, connect a variable resistor, 500 ohms maximum is adequate, across the incoming line and reduce the resistance until the incoming signal level drops 6 db.

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

Line Level and Noise Supervisory Module

(Refer to Fig. 18 for Levels)

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

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

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

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

Carrier Level Monitor (When Used)

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

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

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

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

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

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

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

ACCEPTANCE CHECK

D-C to D-C Converter HB25190 or HB25200

Non-Regulated Voltages:

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

Voltage Regulator

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

Transmitter

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

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

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

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

Output Level:	at least +2 dBm

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

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

F.S. Receiver

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

Line Level and Noise Supervisory

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

Carrier Level Monitor – AM Receiver HB24030-3

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

Logic Interface

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

ADJUSTMENTS

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

POWER SUPPLY

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

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

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

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

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

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

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

3. **Demodulator – level control**

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

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

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

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

LINE LEVEL & NOISE SUPERVISORY MODULES

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

MAINTENANCE

The modules in this equipment use transistors and other components which are conservatively rated for reliability and long life. In normal operation, the monitoring function provides a continuous check on the performance of the equipment.

As long as the channel is operating satisfactorily, no maintenance work is necessary other than seeing that the equipment is free of dust or dirt. However, a scheduled routine check will prevent down-time loss, since it may indicate deterioration in the performance of one of the units. A channel failure occurs because of the terminal equipment, a trouble-shooting procedure should be used similar to that employed for any electronic equipment. First determine where the failure has taken place (transmitter or receiver); then determine the portion of the circuit at fault. Refer to Table I for typical transistor voltages.

Test Equipment

For routine maintenance, the following equipment will be adequate:

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

For troubleshooting, the following additional test equipment is desirable:

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

GENERAL INFORMATION

Connection Drawings

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

RENEWAL PARTS

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

Replaceable parts are shown in the Parts List.

TABLE I

TYPICAL VOLTAGE MEASUREMENTS (REFERRED TO "COMMON")

200 mA LOAD ±22.5V INPUT

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

NO LOAD ±34.2V INPUT

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

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

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

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

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

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

ELECTRICAL PARTS LIST

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

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

ELECTRICAL PARTS LIST

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

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

ELECTRICAL PARTS LIST

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

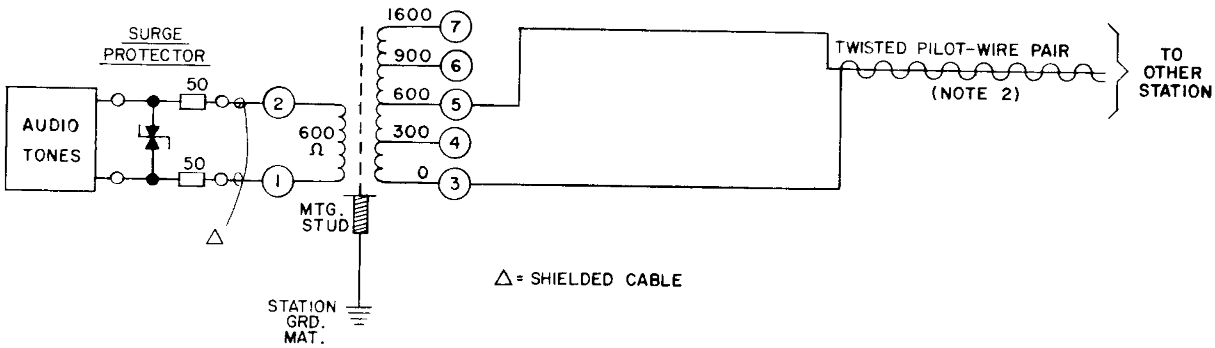
	HB-25150 LINE LEVEL – NOISE SUPERVISORY MODULE	
R1, R2, R4-R8, R11-R16, R18. R21-R42	±5%, ¼ watt, unless otherwise specified.	
R9, R10	RESISTOR, wirewound, 600 ±5%, 1½ watt. Ohmite 995-1A.	H-1100-442
R43	RESISTOR, wirewound, 2.5K ±5%, 1½ watt. Ohmite 995-1A.	H-1100-423
R19	RESISTOR, metal film, 121 ±1%,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

ELECTRICAL PARTS LIST

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

ELECTRICAL PARTS LIST

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



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

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

292B017

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

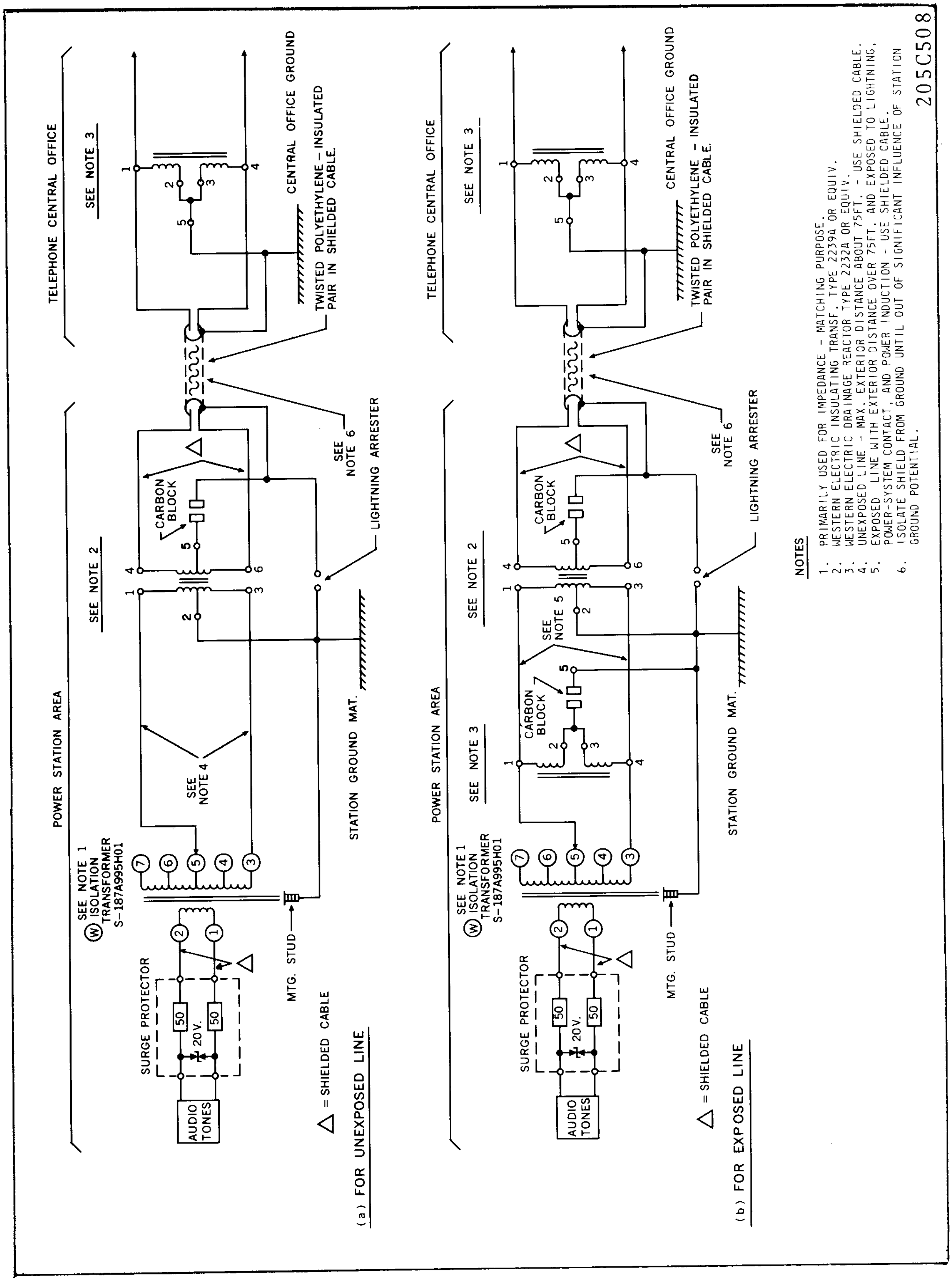
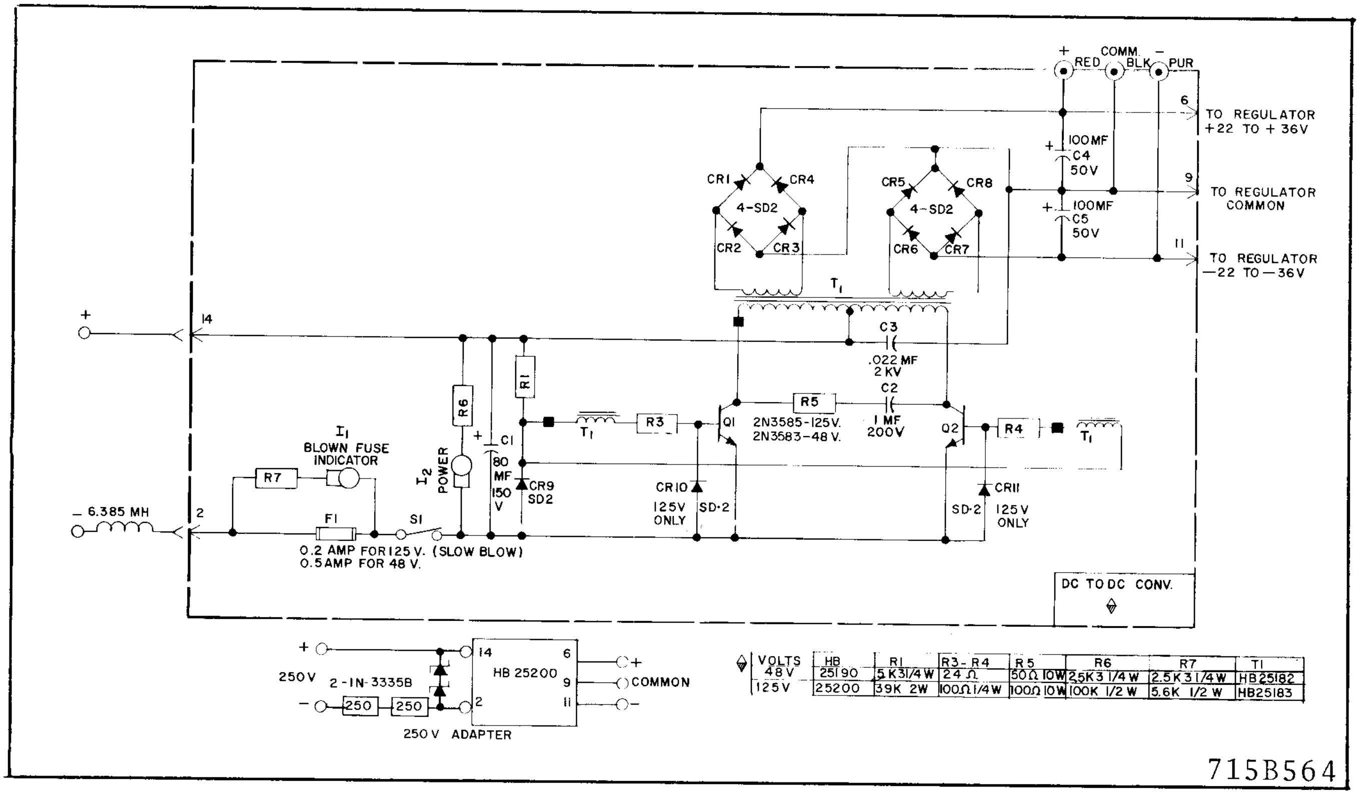


Fig. 2 Recommended Connections and Protective Arrangements for Two-Terminal Lines



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

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

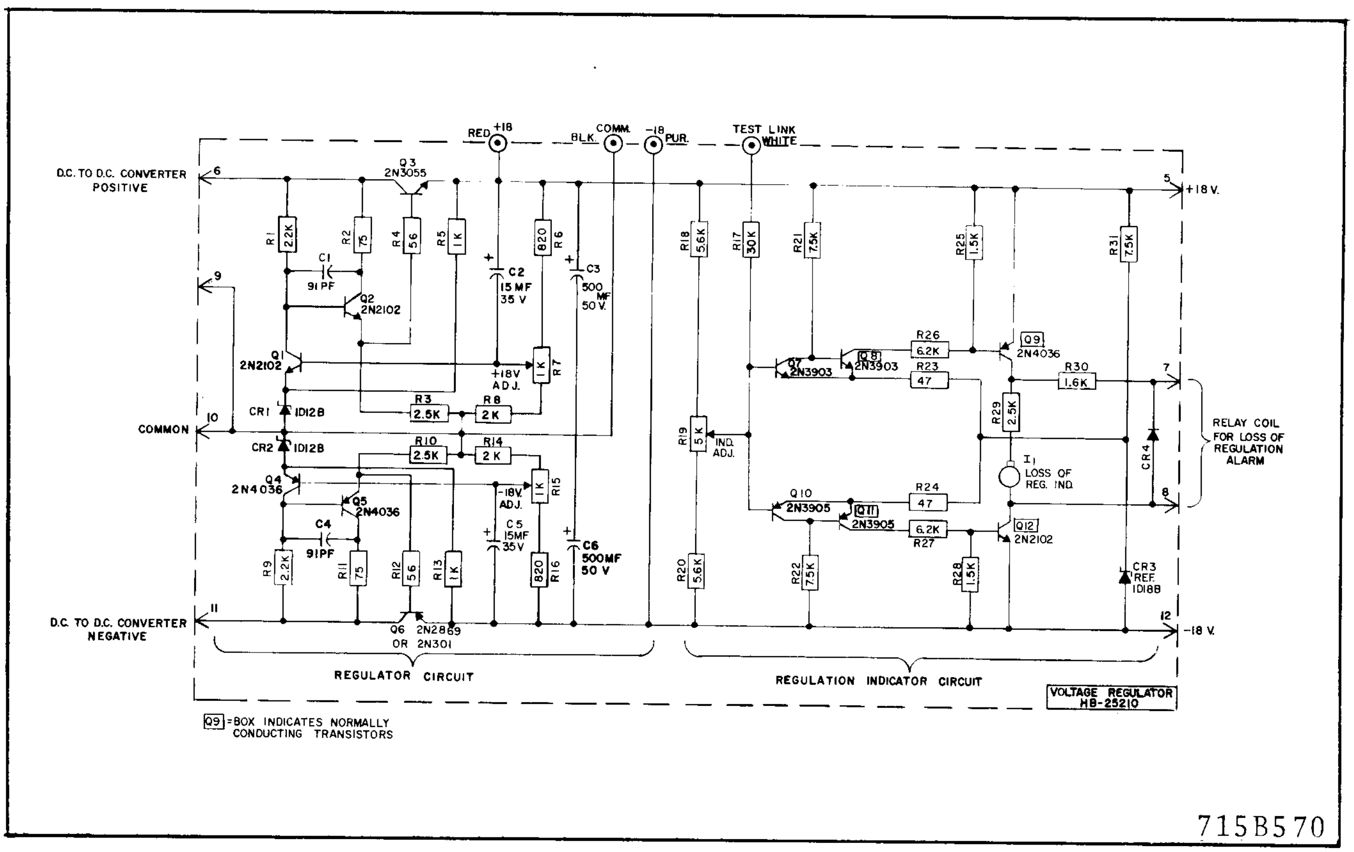


Fig. 4 Voltage Regulator HB-25210.

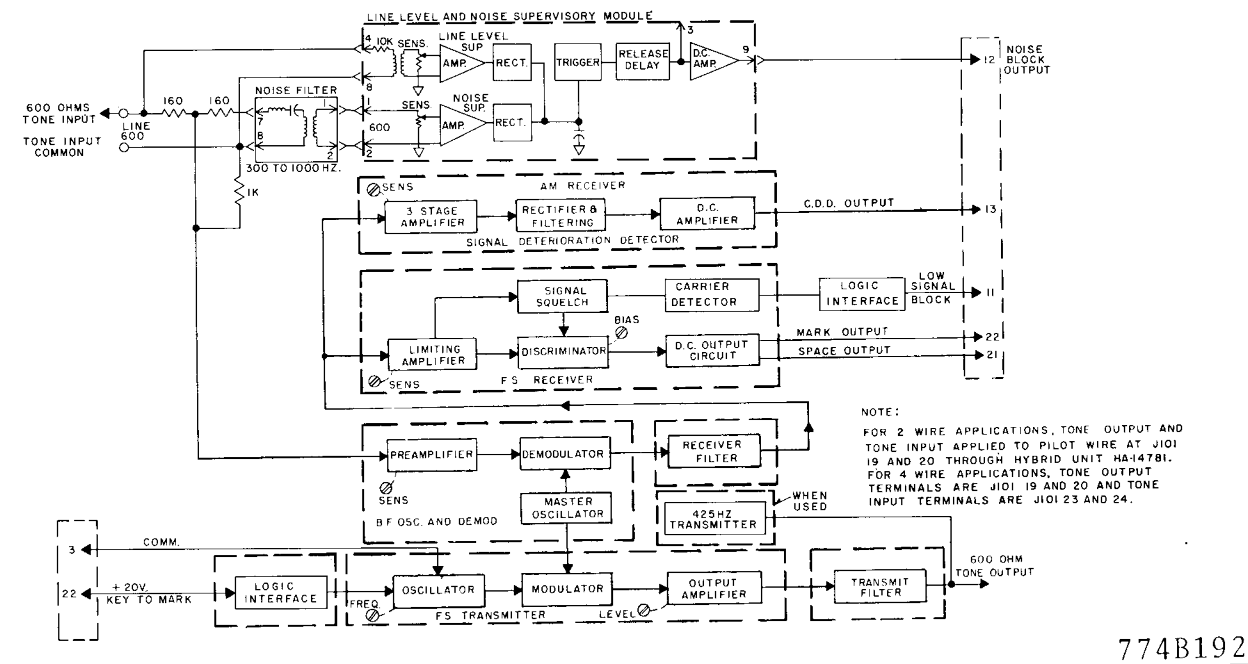
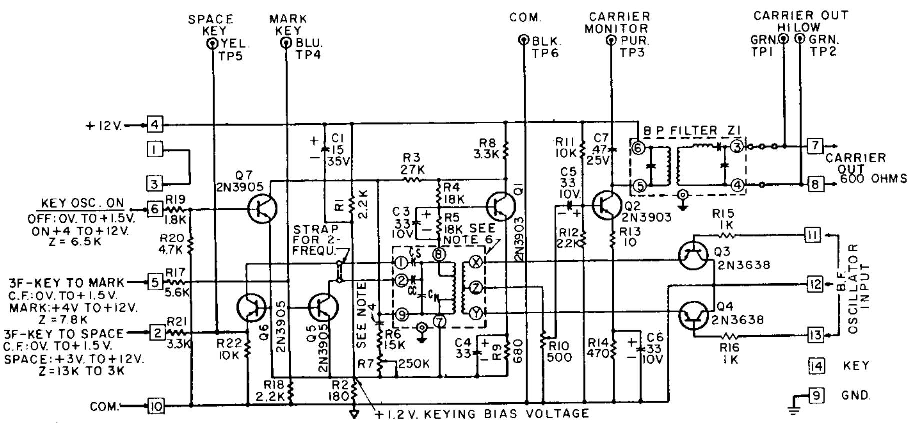


Fig. 5 Block Diagram of TA-2.2 Tone Assembly



DC VOLTAGE LEVELS (NOTE 1,2 & 3)	Q1	Q2
COLLECTOR	+ 6.0V.	+ 11.7 V.
BASE	+ 1.25 V.	+ 2.25V.
EMITTER	+ .70 V.	+ 1.70 V.

AC VOLTAGE LEVELS (NOTES 1,2 & 3)	Q1	Q2
COLLECTOR	8VP-P	6VRMS MAX.
BASE	.06 VRMS	.06 VRMS MAX.
EMITTER	0 V	.03 VRMS MAX.

NOTES:

1. VOLTAGES SHOWN ARE SAMPLE VALUES AND ARE TO BE USED FOR DETERMINING RELATIVE MAGNITUDES ONLY.
2. VOLTAGES MEASURED AT Q1 ARE WITH REFERENCE TO THE + 1.2V. KEYING BIAS VOLTAGE.
3. VOLTAGES MEASURED AT Q2 AND THE KEYING VOLTAGES ARE WITH REFERENCE TO THE CIRCUIT COMMON.
4. THE VALUE OF C2 WILL VARY WITH SOME CHANNEL FREQUENCIES AND BANDWIDTHS.
5. FIXED RESISTORS ARE 10% VALUES, 1/4 WATT, UNLESS OTHERWISE SPECIFIED.
6. SIGNAL OSCILLATOR P/O FILTER ASS'Y. Z1

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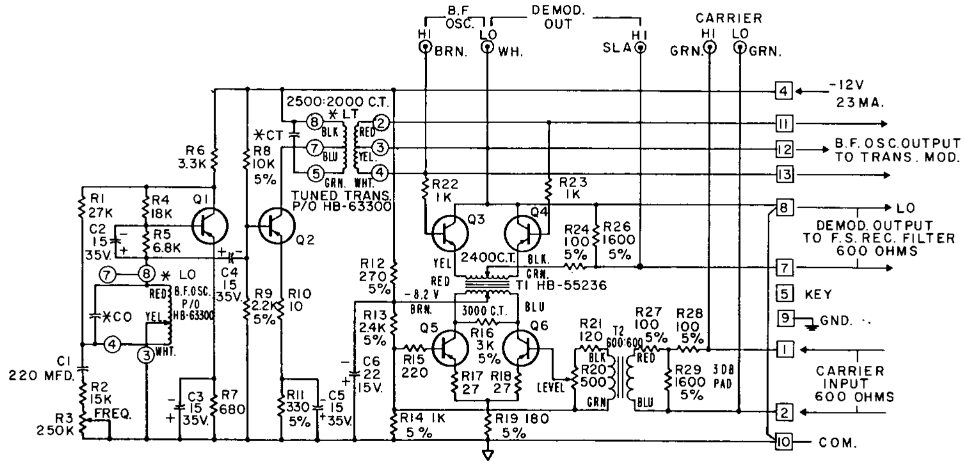
Fig. 6 Transmitter Module HB-24335-26



NOTES:

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

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

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

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

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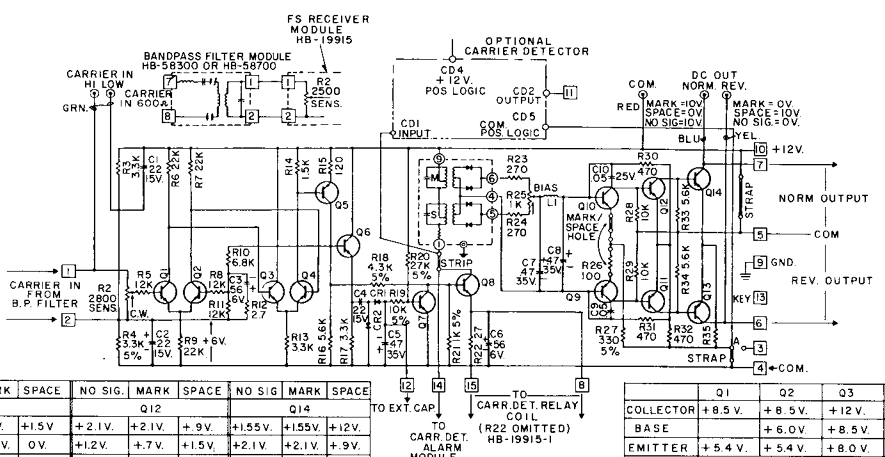
Fig. 7 Beat Frequency Oscillator and Demodulator HB-25640



	NO SIG.	MARK	SPACE	NO SIG.	MARK	SPACE	NO SIG	MARK	SPACE
	Q10			Q12			Q14		
COLLECTOR	+.8V.	+.7V.	+1.5V	+2.1V.	+2.1V.	+.9V.	+1.55V.	+1.55V.	+12V.
BASE	+1.0V.	+1.32V.	0V.	+1.2V.	+.7V.	+1.5V.	+2.1V.	+2.1V.	+.9V.
EMITTER	+0.5V.	+.7V.	+.7V.	+1.1V.	+.85V.	+.95V.	+1.55V.	+1.55V.	+1.45V.
	Q9			Q11			Q13		
COLLECTOR	+1.7V.	+1.5V.	+.8V.	+1.1V.	+.8V.	+2.0V.	+12V.	+12V.	+1.5V.
BASE	+1.0V.	0V.	+1.51V.	+1.7V.	+1.5V.	+.8V.	+1.1V.	+.8V.	+2.0V.
EMITTER	+.55V.	+.7V.	+.9V.	+1.1V.	+.85V.	+.95V.	+1.55V.	+1.55V.	+1.45V.

Q5 IS 2N3905 ALL OTHER TRANSISTORS ARE 2N3903

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

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

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Fig. 8 Frequency Shift Receiver HB19915-27

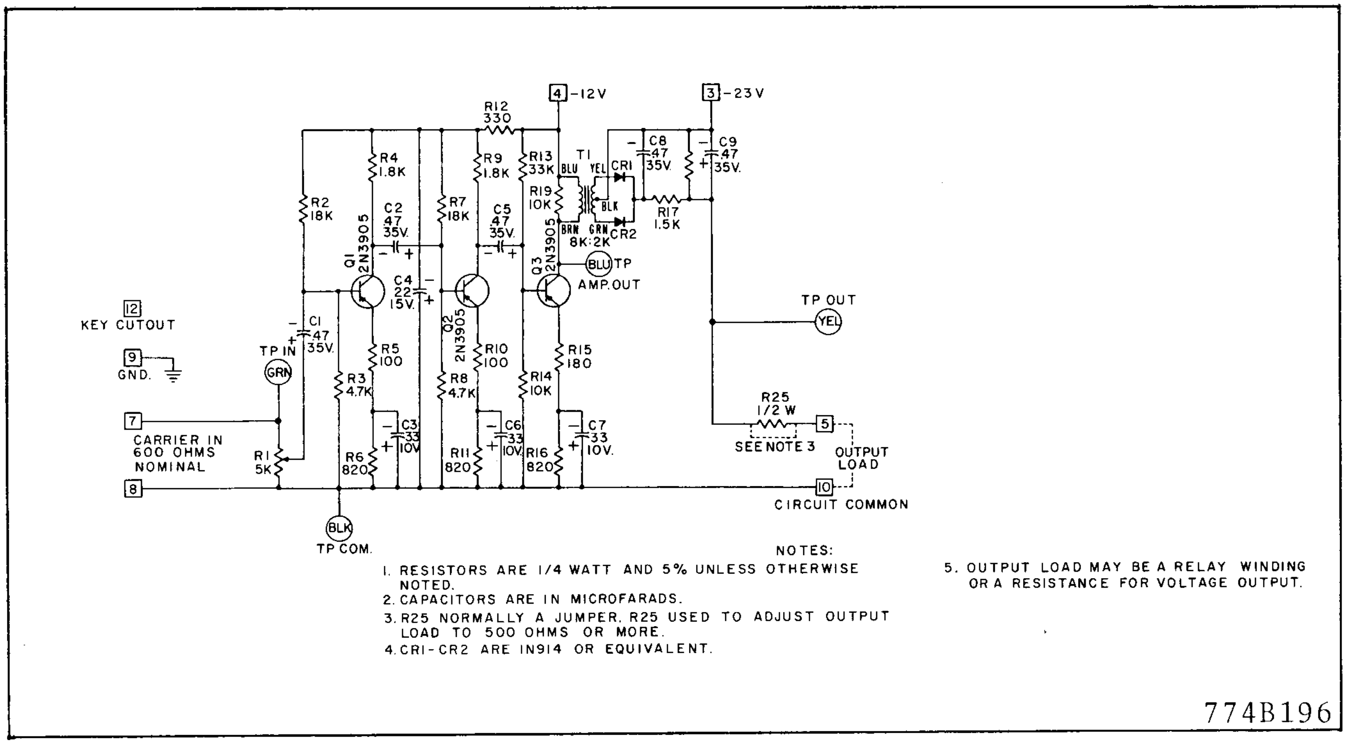

Fig. 9 Carrier Deteriation Detector HB-24030-3

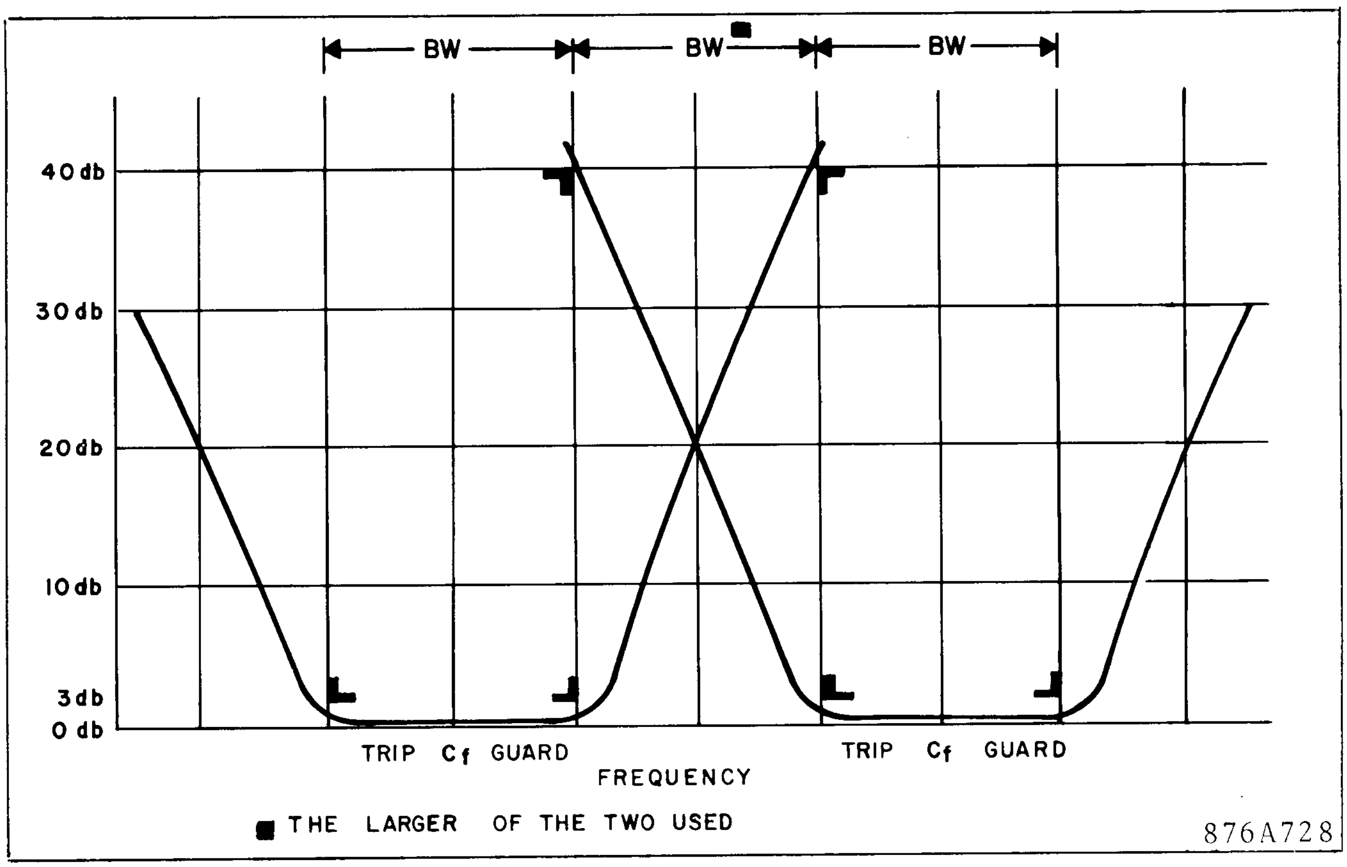

Fig. 10 Tone Receiver Filter Characteristics HB-63100.

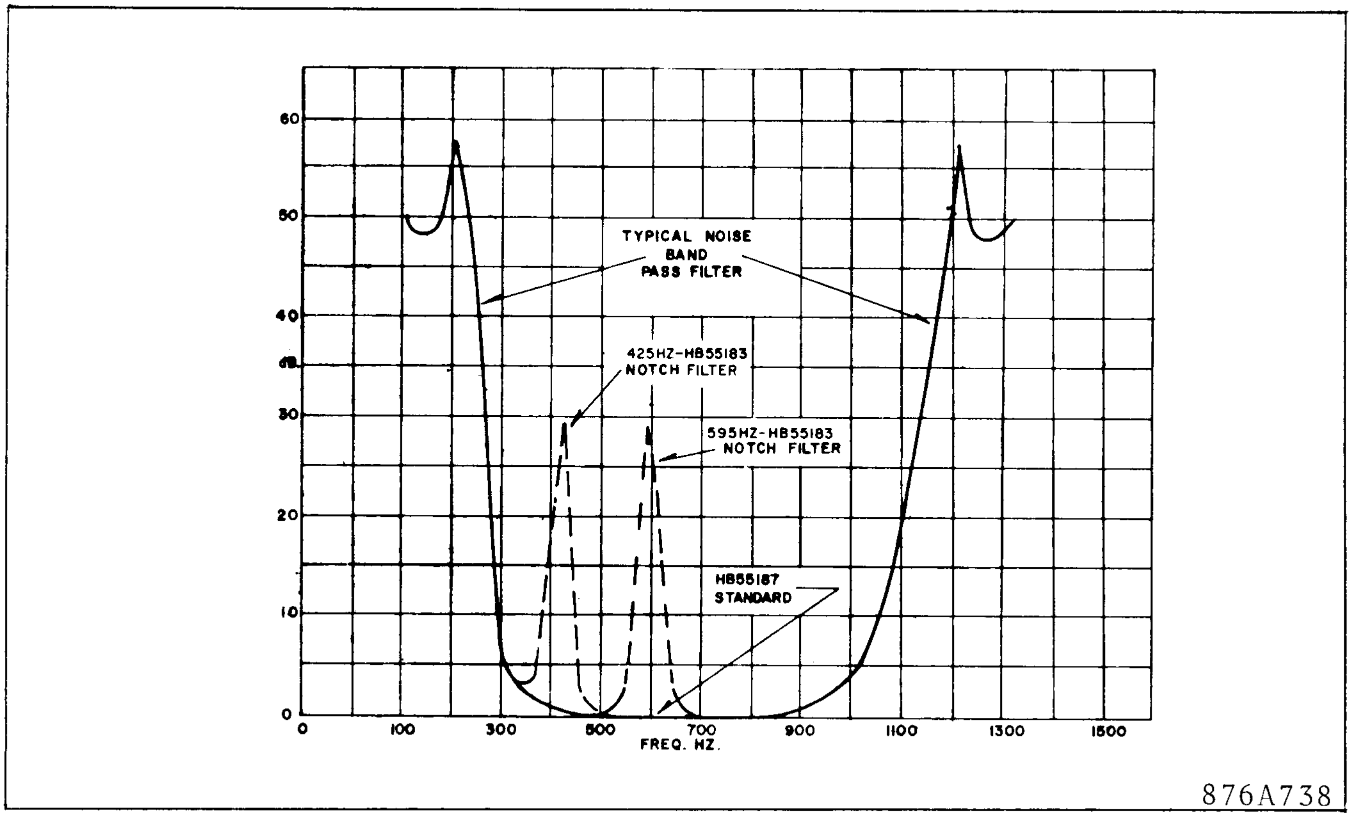

Fig. 11 Typical Noise Bandpass Filter.

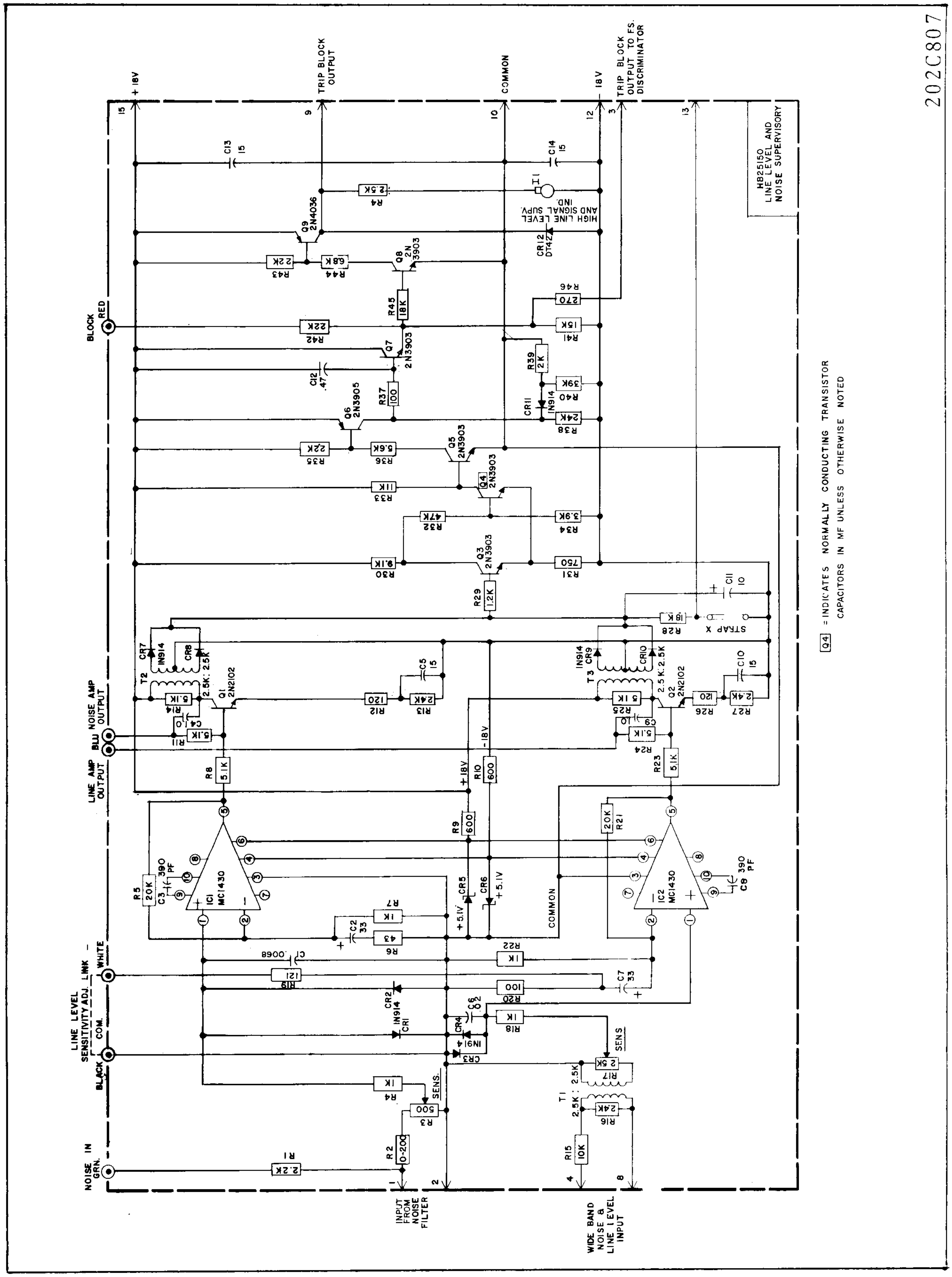

Fig. 12 Receiver Line Level and Noise Supervisory Module HB-25150.

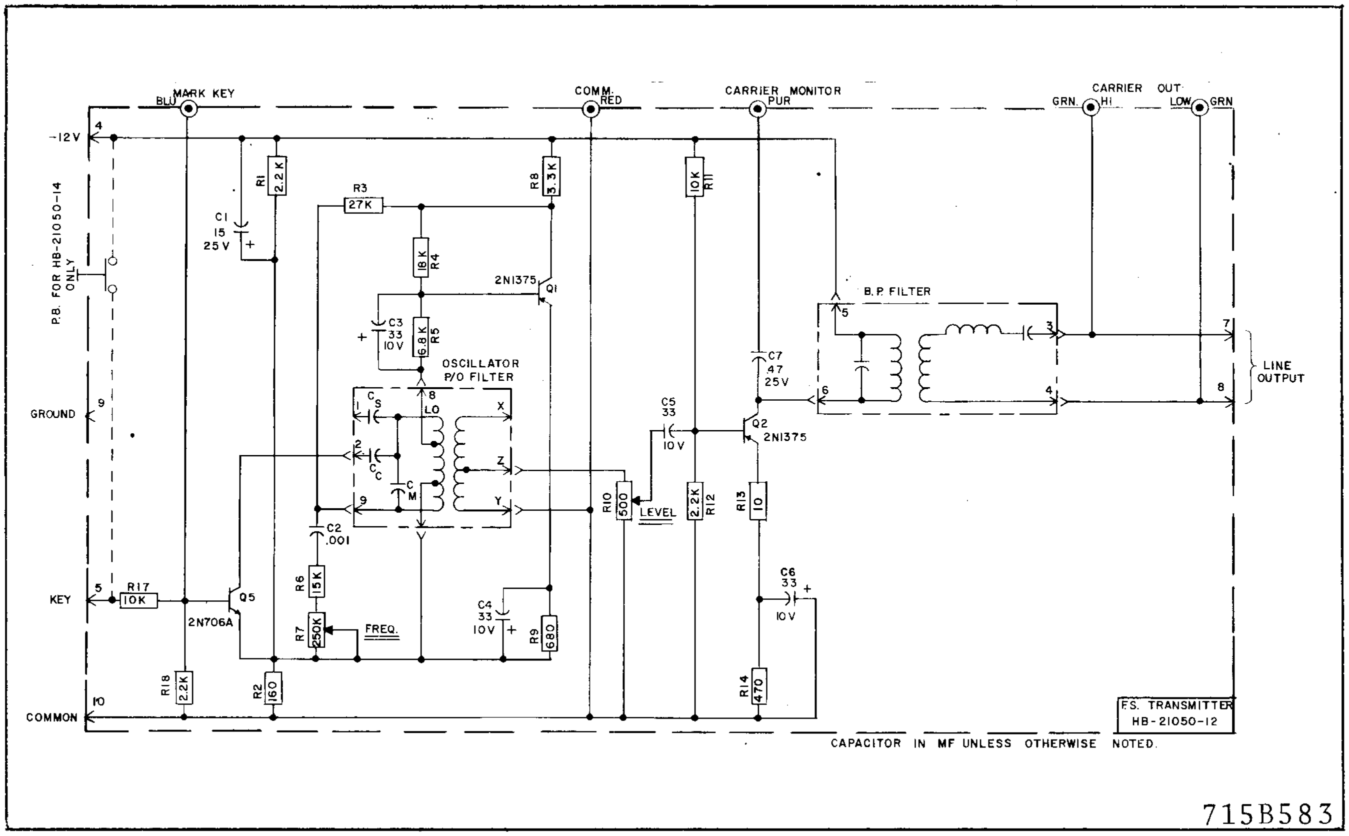

Fig. 13 425-Hz Transmitter HB-21050-2.

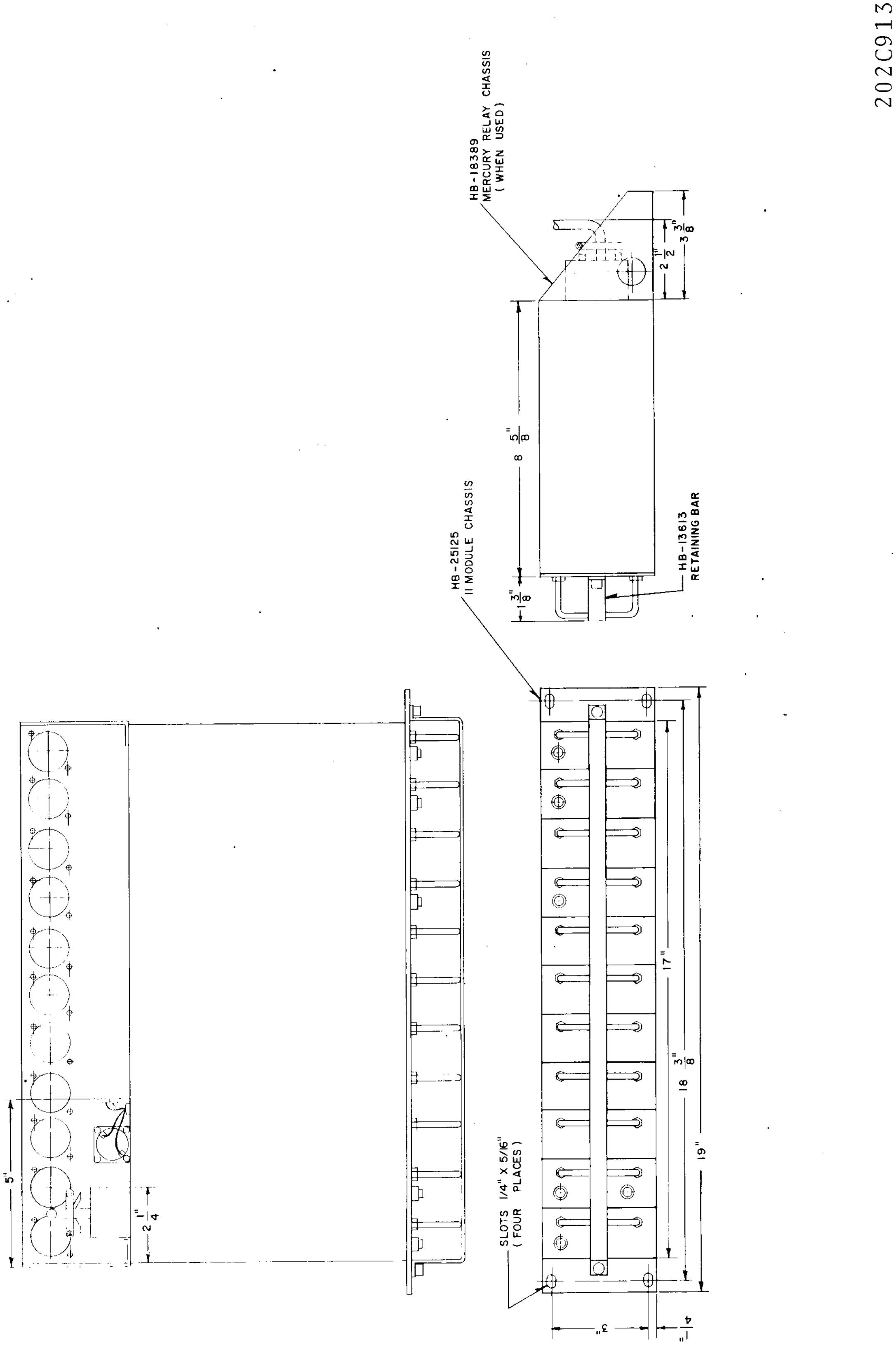

Fig. 14 Outline and Drilling Plan.

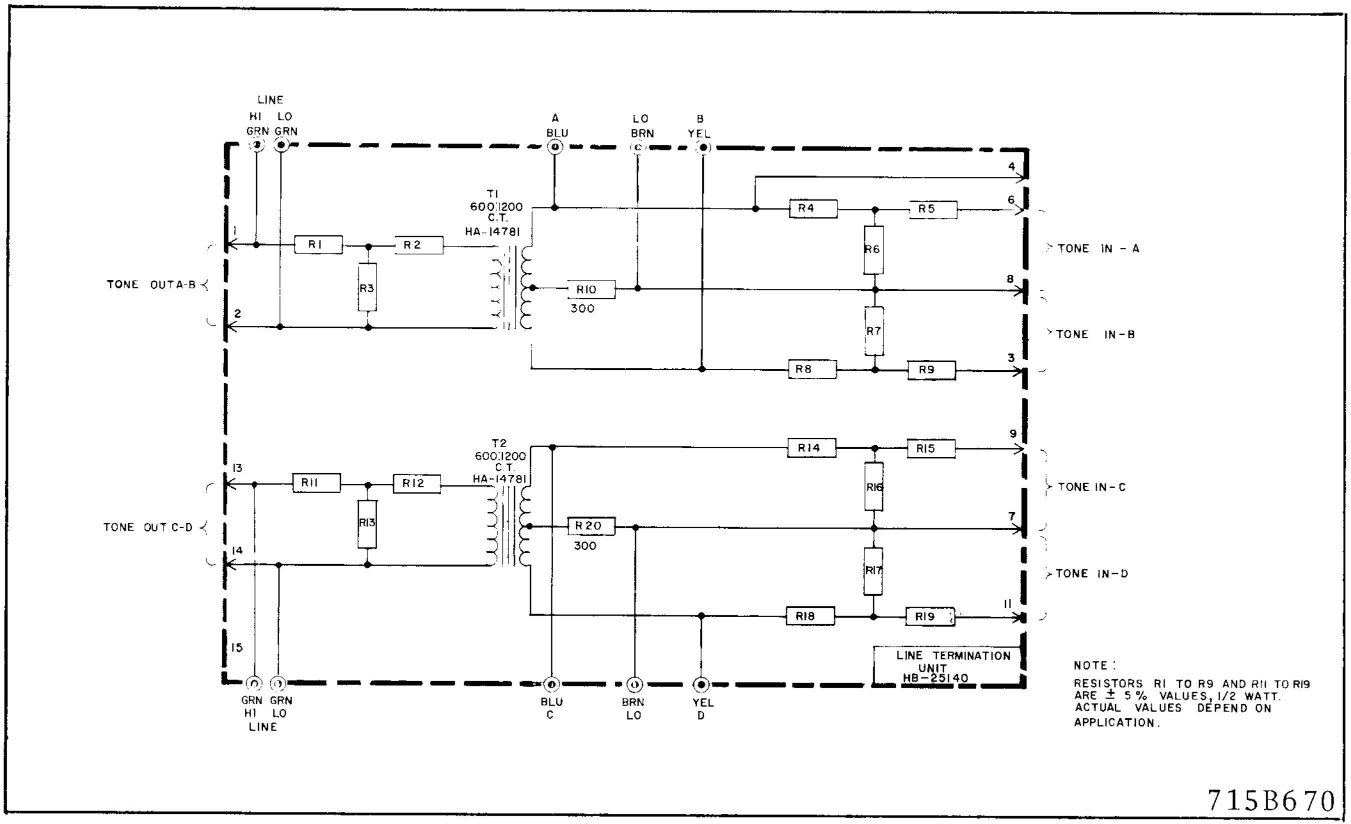

Fig. 15 Line Termination Module HB-25140.

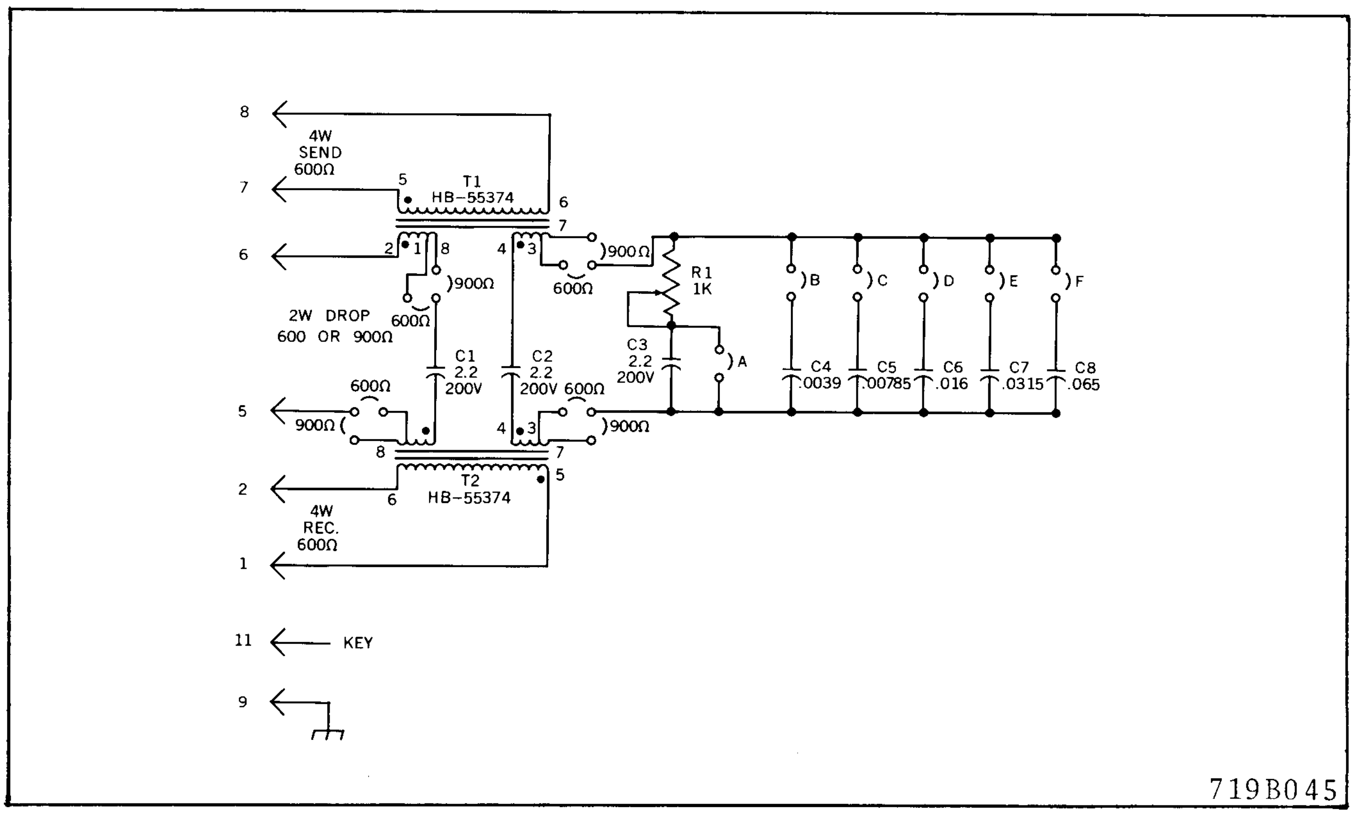

Fig. 16 Hybrid for Two Wire Termination HB-35315.

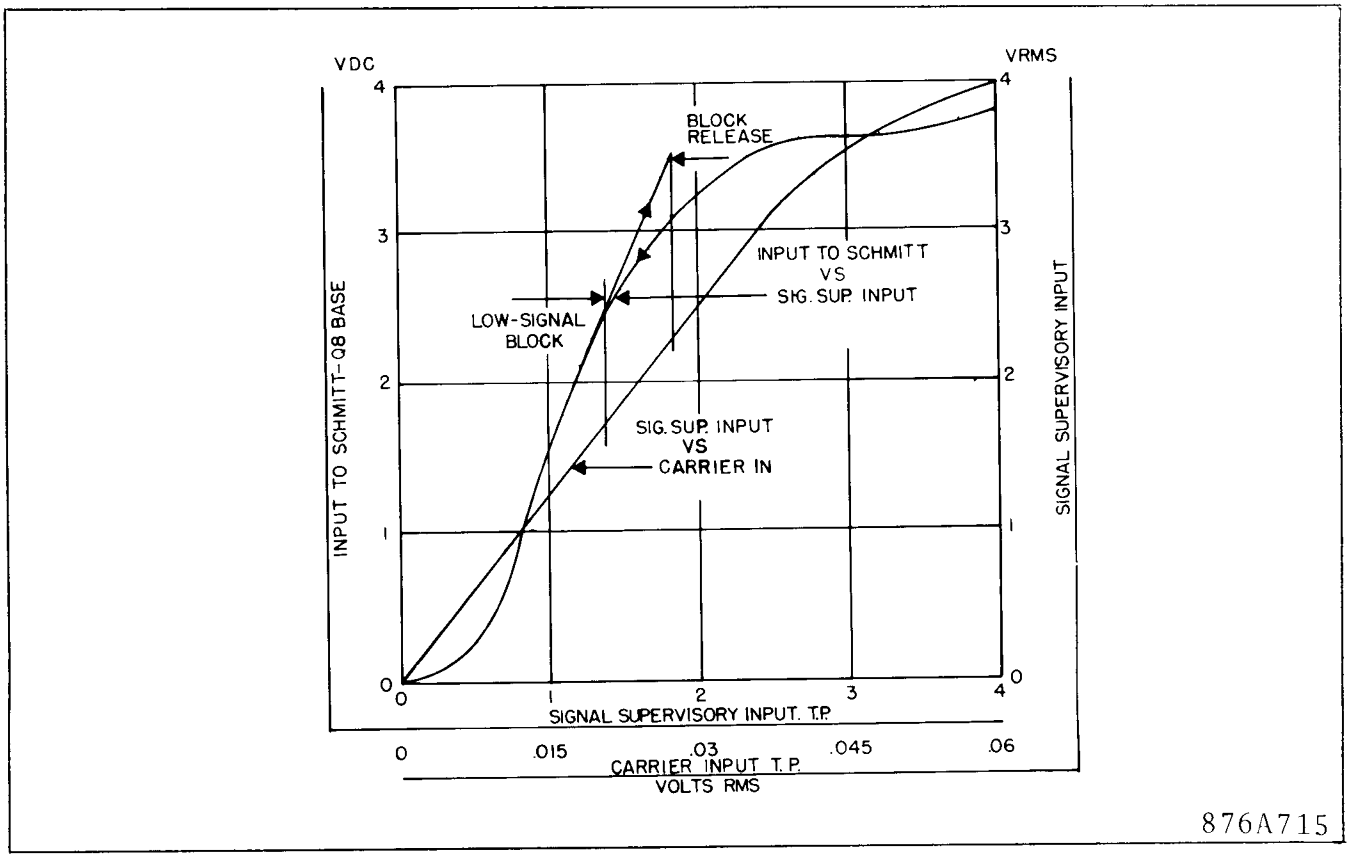

Fig. 17 Signal Supervisory Circuit Characteristics.

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RECEIVER DYNAMIC OPERATING RANGE

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

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

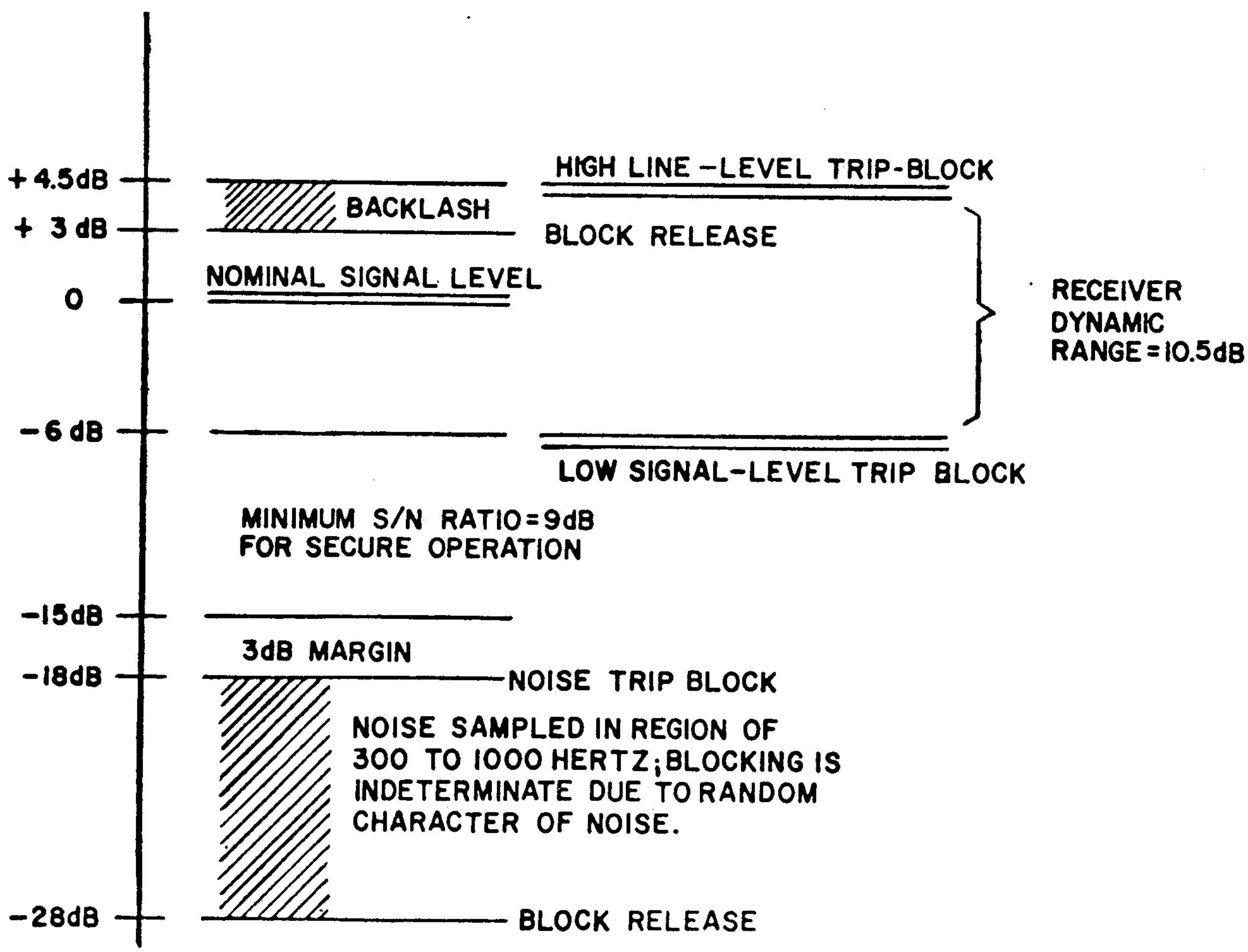

Fig. 18 Receiver Dynamic Operating Range.

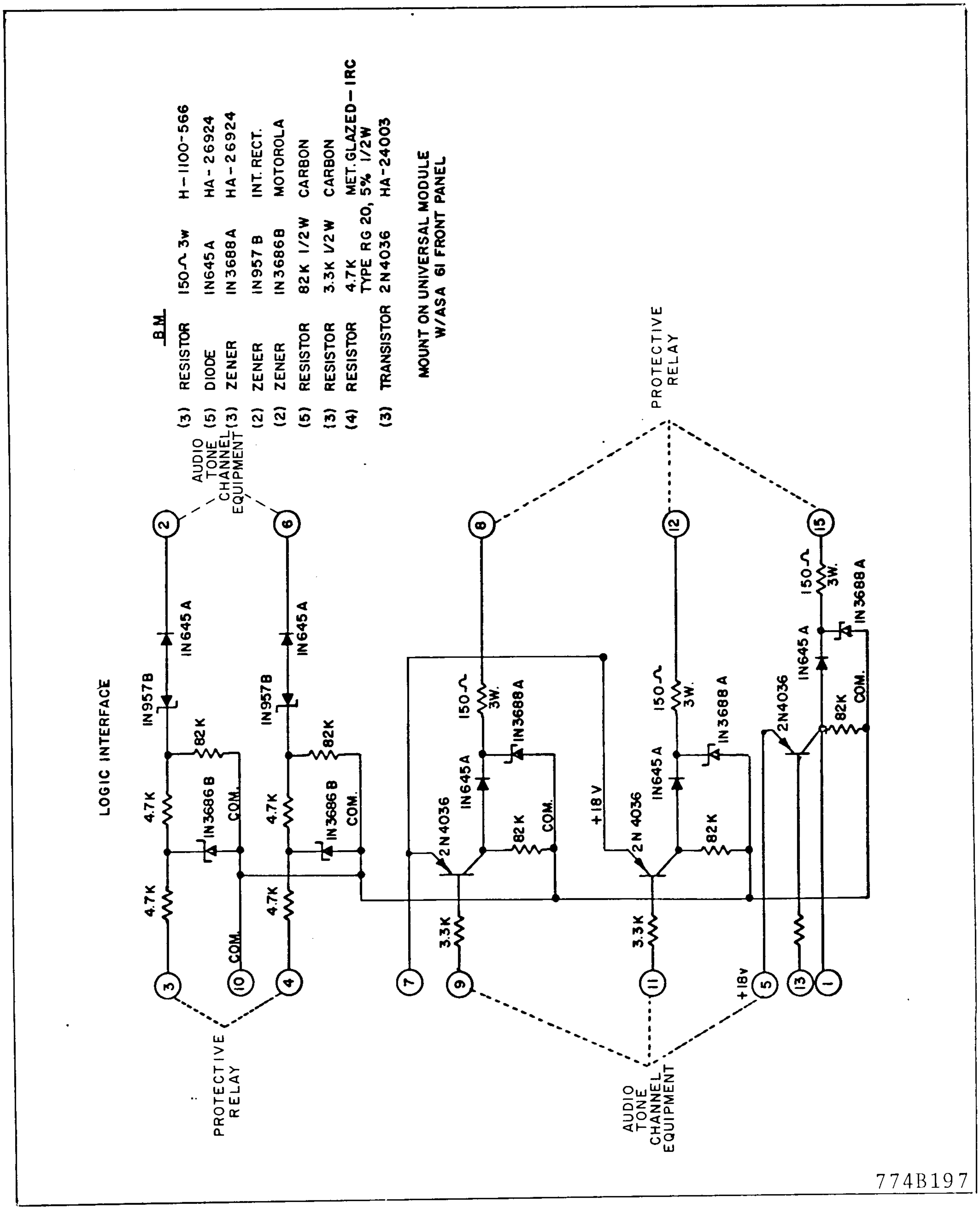

Fig. 19 Logic Interface Module

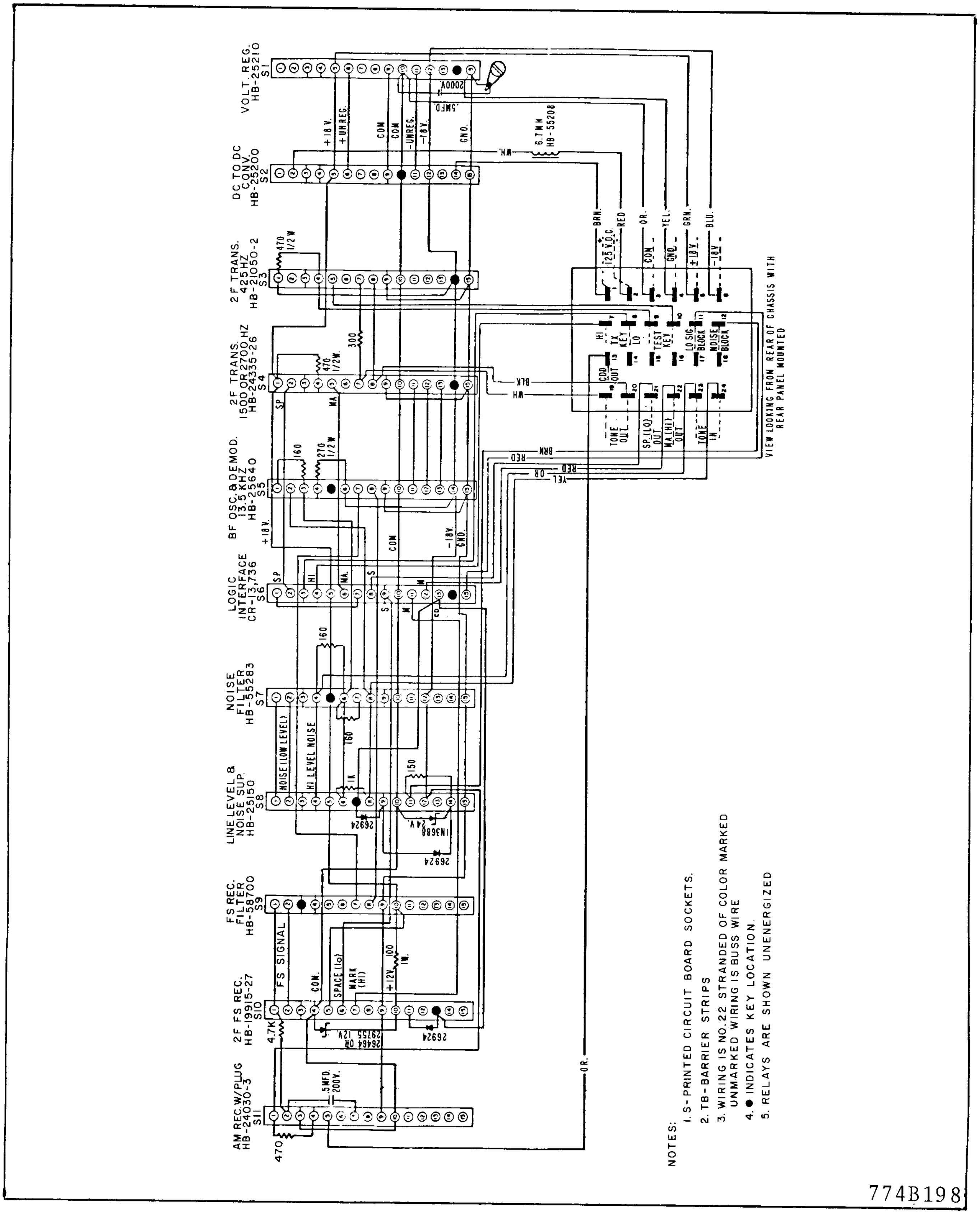

Fig. 20 Typical Terminal Block Wiring

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RELAY-INSTRUMENT DIVISION
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Printed in U.S.A.