

## TL-1 MICROWAVE RADIO RECEIVER DESCRIPTION

CONTENTS	PAGE
1. GENERAL . . . . .	1
2. EQUIPMENT FEATURES . . . . .	2
A. General . . . . .	2
B. Receiver Modulator . . . . .	2
C. Receiver IF and Baseband Circuits . . . . .	3
3. CIRCUIT DESCRIPTION . . . . .	9
A. General . . . . .	9
B. Receivers Equipped With J99262G Receiver IF and Baseband Unit . . . . .	11
C. Receivers Equipped With J99296G-2 IF and Baseband Unit . . . . .	18
D. Receivers Equipped With J99351E-1 IF Amplifier Unit and J99351J-1 FM Receiver Unit . . . . .	18
4. OPERATING CHARACTERISTICS . . . . .	21
5. REFERENCE LIST . . . . .	35

**1. GENERAL**

**1.01** This section contains a description of the electrical and physical characteristics of the radio receiver that is part of the TL-1 Microwave Radio System.

**1.02** This section is reissued to add information for TL-1 receivers that may now be equipped with either of the following:

- (a) The J99296AA-2, List 3 modulator-preamplifier unit with J99296G-2 receiver IF and baseband unit
- (b) The J99296AA-2, List 3 modulator-preamplifier unit with J99351E-1 IF amplifier unit and J99351J-1 FM receiver unit.

Since this is a general revision, the arrows ordinarily used to indicate changes have been omitted.

**1.03** The TL-1 radio receiver accepts frequency-modulated (FM) signals in the 10.7- to 11.7-GHz band and delivers signals at baseband frequencies to a 75-ohm unbalanced line. Associated with the receiver is the 1402-type channel dropping network which, when used, selects the proper portion of the 10.7- to 11.7-GHz band to establish a connection from the antenna to the receiver front end. A receiver modulator combines the incoming signal with the beat oscillator (BO) to produce an intermediate frequency (IF) of 70 MHz.

**1.04** An IF amplifier and baseband circuit provides automatically controlled gain and limiting of the IF signals and recovers the baseband signal in a discriminator circuit. Baseband amplification is provided and the signal is delivered to a 75-ohm unbalanced line. A squelch circuit controls the operation of the baseband amplifier. When the incoming RF signal level drops below a predetermined value, the squelch circuit causes the amplifier to shut off, thereby muting the receiver. This unit also delivers a control voltage to an automatic frequency control (AFC) system that maintains the beat oscillator at the proper frequency.

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**1.05** Metering circuits are provided for measuring the receiver converter crystal currents, klystron cathode current, automatic gain control (AGC) voltage, AFC voltage, and dc supply voltages.

**1.06** The power supply, common to the transmitter and receiver, provides all the voltages required for the receiver.

## 2. EQUIPMENT FEATURES

### A. General

**2.01** The TL-1 receiver is located in the upper part of the transmitter-receiver bay on the left side of the transmitter-receiver panel. The complete receiver is formed through interconnections of a number of equipment assemblies. Two of these, the klystron and boiler assembly and the meter and control panel, are common to the transmitter. Equipment assemblies of the receiver are:

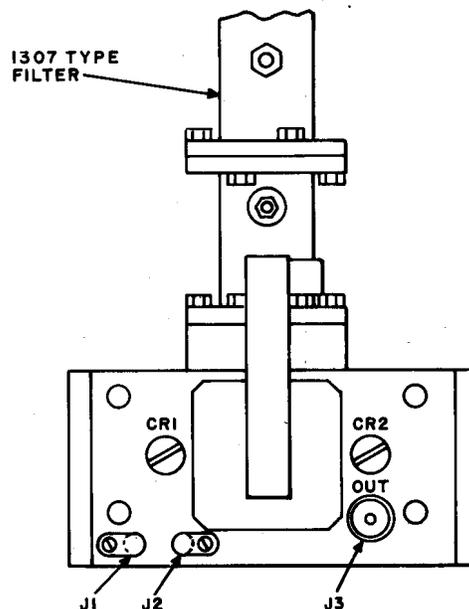
- (a) Receiver modulator and waveguide preselection networks
- (b) Beat oscillator (part of klystron and boiler assembly)
- (c) IF and baseband circuits
- (d) Receiver AFC (part of meter and control panel).

Assemblies (a), (b), and (c) are interconnected through plugs and jacks and are easily removable for maintenance purposes. The portion of the receiver AFC within the meter and control panel is not removable; however, the entire panel assembly is easily replaced. The transmitter-receiver panel is shock mounted to the transmitter-receiver bay to isolate it from external vibration.

### B. Receiver Modulator

**2.02** The receiver is equipped with either the J99262F receiver-modulator channel assembly (Fig. 1) or the J99296AA-2, List 3 modulator-preamplifier (Fig. 2). If the receiver is equipped with the J99262F receiver modulator, refer to 2.03 and 2.05. If the receiver is equipped with the J99296AA-2, L3 modulator-preamplifier, refer to 2.04 and 2.05.

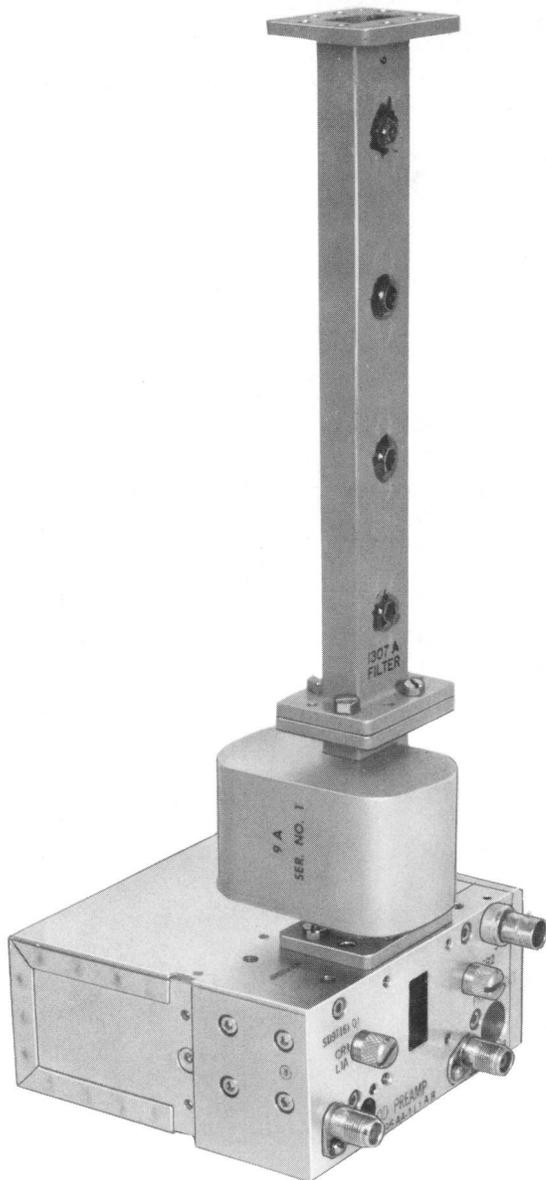
**2.03** The modulator-preamplifier channel assembly (J99262F) consists of an input waveguide section, a balanced crystal detector, and a 1A modulator. The input waveguide section is an assembly of a bandpass filter, waveguide tuner, and frequency-conscious waveguide spacers. The modulator contains a balanced crystal converter. The converter portion consists of a waveguide hybrid which mounts the input waveguide section and a waveguide attenuator through which the BO signal is introduced. The output branches contain matched crystal diodes. A coaxial jack is provided at the output for a connection to the IF and baseband unit. Coaxial jacks are also provided for connections to the receiver control unit to permit reading the modulator crystal currents. The complete receiver-modulator channel assembly is shown in Fig. 1. This assembly is coded as the J99262F modulator channel assembly and must be tested and adjusted as a complete unit.



**Fig. 1—J99262F Receiver-Modulator—Channel Assembly With Modulator**

**2.04** When a receiver is equipped with the redesigned modulator-preamplifier, the channel assembly consists of a bandpass filter, waveguide ferrite isolator, and a J99296AA, List 3 modulator-preamplifier (Fig. 2). The isolator replaces the frequency-sensitive waveguide tuner. The modulator-preamplifier contains a balanced crystal

converter and a transistor preamplifier. A monitor jack has been added providing a bridged input at the interface of the modulator and first IF amplifier stage.



**Fig. 2—J99296AA-2, List 3 Modulator—Preamplifier With Associated 9A Isolator and 1307 Filters**

#### Beat Oscillator

**2.05** The beat oscillator (Fig. 3) comprises a reflex klystron which generates an RF output which

differs from the incoming microwave carrier signal by 70 MHz. The connection to the receiving modulator is made through a 25A variable waveguide attenuator and the 13A transducer. The beat oscillator is located in the klystron and boiler assembly where it is frequency-stabilized with the transmitter klystron by the vapor-phase cooling system. Both klystrons are mounted to the boiler with a U-shaped spring clamp to give good surface-to-surface contact needed for heat conduction from the klystrons to the boiler. This entire assembly is mounted to the RF panel. Heat insulation and safety from high-voltage points are provided by a removable cover which fits over the assembly. Operating voltages are applied to the BO klystron via a plug which connects to the base of the tube. Electrical repeller voltage tuning is provided by a potentiometer on the receiver control unit. Mechanical frequency tuning is by means of a screw on the klystron body which is accessible through a hole in the assembly cover.

#### C. Receiver IF and Baseband Circuits

**2.06** Each receiver is equipped with one of three available IF and baseband units. The three IF and baseband units available in a TL-1 system and described in this section are as follows:

- (a) J99262G receiver IF and baseband unit—refer to paragraph 2.07.
- (b) J99296G-2 IF and baseband unit—refer to paragraph 2.09 and Fig. 4.
- (c) J99351E-1 IF amplifier unit with the J99351J-1 FM receiver unit—refer to paragraph 2.11 and Fig. 5.

#### J99262G Receiver IF and Baseband Unit

**2.07** The J99262G receiver IF and baseband unit is a transistorized component of the RF panel and contains most of the circuits of the receiver. The unit includes:

- (a) Amplifiers that provide gain for the 70-MHz IF signal.
- (b) Two diode variolossers which are part of the AGC circuit that holds the IF output level approximately constant during any change of the input signal level.

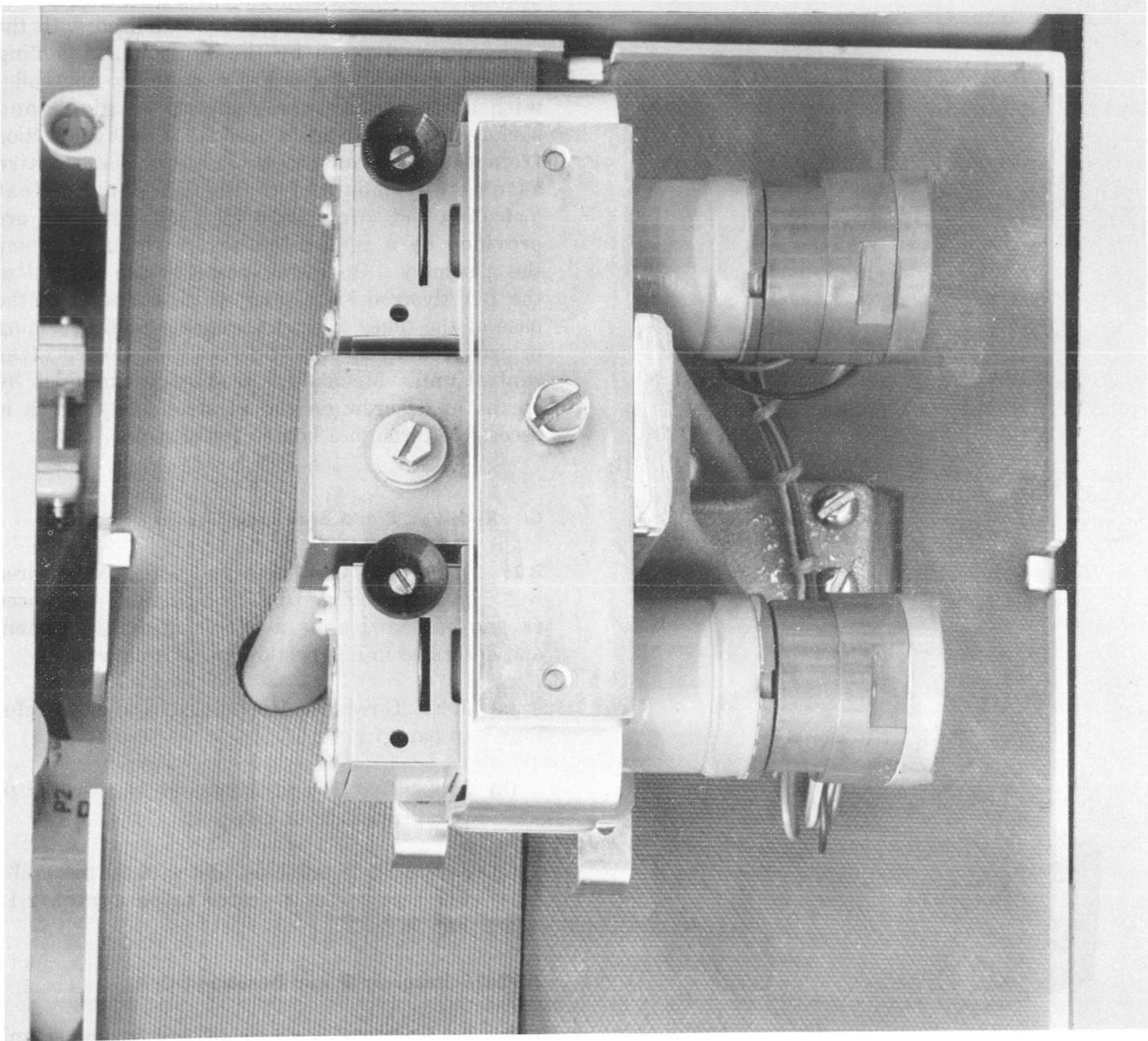


Fig. 3—Beat-Oscillator and Transmitter Klystrons

- (c) An IF bandpass filter to limit the bandwidth to approximately 60 to 80 MHz.
- (d) A limiter to suppress amplitude variation from the frequency-modulated IF signal.
- (e) An AGC detector and amplifier which, in conjunction with the variolossers, hold the input to the limiter approximately constant.
- (f) A discriminator to recover the baseband information from the frequency-modulated IF signal.
- (g) A baseband amplifier to amplify the signal recovered in the discriminator.
- (h) An AFC dc amplifier which transmits the differential output of the discriminator to the AFC magnetic amplifier located on the meter and control panel. The output of the magnetic amplifier is applied to the BO repeller to maintain a constant 70-MHz intermediate frequency.
- (i) A squelch circuit to cut off the baseband amplifier at a specified depth of fade and to prevent excess noise from entering the multiplex equipment. Simultaneously, the AFC loop is opened up so the frequency of the beat oscillator is not affected by noise.

**2.08** The above circuits are mounted on four extruded aluminum forms that are connected together making a rectangular box measuring approximately 19 inches high, 2-1/4 inches wide, and 9-1/4 inches deep. The entire assembly is shielded with two removable side covers that give access to all of the components. All maintenance controls and adjustments are located on the front and top of the unit. Coaxial connections are provided for IF and baseband signal connections and an 8-pin jack-type connector brings out the bias voltage, squelch signal, AGC, AFC, and power leads. The following is a list of the controls and measuring jacks provided on the front panel for maintenance purposes.

- (a) LIM IN jacks give an indirect measurement of limiter input level.
- (b) LIM IN control adjusts the limiter input level.

- (c) AGC ON-OFF switch allows the AGC to be disabled.
- (d) AGC potentiometer adjusts the diversity input.
- (e) AFC jack permits an estimate of incoming signal level.
- (f) RCVR GAIN control adjusts the level of the baseband output signal.
- (g) AFC ZERO control zeros the AFC amplifier output when the IF signal is 70 MHz.
- (h) SQUELCH control sets the receiver muting point.

#### **J99296G-2 IF and Baseband Unit**

**2.09** The J99296G-2 IF and baseband unit (Fig. 4) is a transistorized plug-in component of the RF panel and provides an unbalanced baseband output signal from an unbalanced 70-MHz IF input signal. It includes the following.

- (a) Amplifiers to raise the level of the 70-MHz frequency-modulated IF signal supplied to the unit from the modulator-preamplifier.
- (b) Variolossers which serve as part of the AGC circuit to hold the IF output approximately constant with fading of the input signal.
- (c) An IF bandpass filter to suppress unwanted frequency components outside the 60- to 80-MHz IF band.
- (d) A limiter to remove amplitude modulation from the frequency-modulated IF signal before it is supplied to the discriminator.
- (e) A discriminator to recover the baseband information from the frequency-modulated IF signal.
- (f) A baseband amplifier to raise the signal to the level required for the connecting circuits.
- (g) An AFC dc amplifier to transmit the differential output of the discriminator to the magnetic amplifier located on the receiver control unit. The output of the magnetic amplifier

is applied to the BO repeller to maintain a constant 70-MHz intermediate frequency.

- (h) An AGC detector and amplifier which, in conjunction with the variolossers, hold the limiter input approximately constant.
- (i) A diversity drive circuit which provides a control voltage to operate the diversity switch circuit.
- (j) A squelch circuit under control of the AGC circuit to mute the output of the baseband amplifier at a specified depth of fade. Simultaneously, the automatic frequency control loop is effectively opened to remove control and allow the beat oscillator to return to its correct nominal operating frequency. With the AFC circuit disabled, the beat oscillator is prevented from locking at a new frequency (an adjacent channel carrier or extraneous carrier signal).

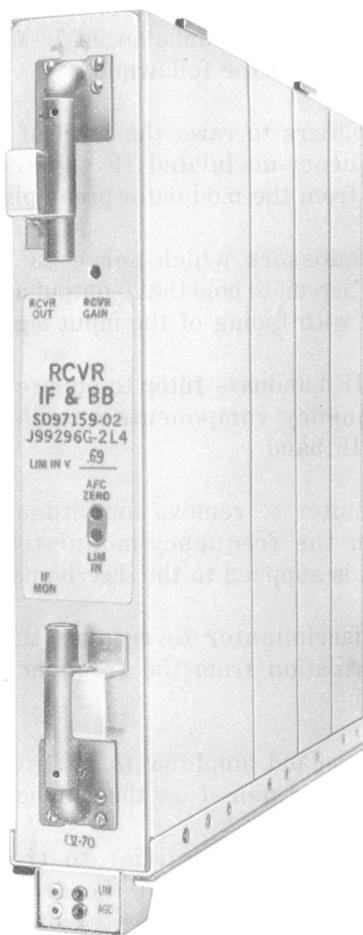


Fig. 4—J99296G-2 IF and Baseband Unit

**2.10** The IF and baseband unit includes panel adjustments and jacks as follows:

- (a) The LIM IN control provides a means for adjusting the limiter input level.
- (b) The AFC ZERO control provides a means for adjusting the differential voltage of the AFC circuit to zero when the IF signal is 70 MHz.
- (c) The RCVR GAIN control is used to adjust the baseband signal output power.
- (d) The IF GAIN control, provided only on the J99296G, L4 and L4A units, provides a means for adjusting the squelch point to correspond with a specific 70-MHz input level. This control is located on the back of the unit and is adjusted at the factory. However, it may be adjusted in the field on an out-of-service basis by removing the unit, making the adjustment, and replacing the unit as required, until the proper squelch point is established.
- (e) The RCVR OUT jack provides the means for connecting the baseband output signal to the connecting circuits.
- (f) The LIM IN (+) and (−) jacks provide a means for indirectly monitoring the limiter input level.
- (g) The AGC (+) and (−) jacks provide a means for monitoring the AGC voltage other than the means provided by the meter AGC position. The voltage of the AGC (−) jack with respect to ground is approximately 6 volts and the difference between the two jacks (+) and (−) ranges from 0 to 1 volt depending on received signal strength.
- (h) The IF IN jack, located on the bottom of the unit, provides the means for supplying the IF signal from the modulator-preamplifier unit to the IF amplifier.
- (i) The RCVR OUT jack, located on the front of the unit near the top, provides the means for supplying the baseband output to the connecting circuits.
- (j) The IF MON jack, located on the front of the unit near the bottom, may be used for test purposes or to drive an IF repeater.

### **J99351E-1 IF Amplifier Unit With J99351J-1 FM Receiver Unit**

**2.11** The IF amplifier and FM receiver arrangement (Fig. 5) is comprised of three individual units consisting of a 1075A filter, IF amplifier (J99351E), and FM receiver (J99351J) packaged together as a plug-in arrangement to replace the receiver IF and baseband unit (J99296G). The 70-MHz FM signal from the modulator-preamplifier unit is supplied through the 1075A filter to the IF amplifier and FM receiver units which, together, recover the baseband information from the IF signal. The baseband signal is amplified and supplied as an unbalanced output to the connecting circuits. The arrangement includes the following:

- (a) Amplifiers which raise the level of the 70-MHz frequency-modulated IF signal supplied through the 1075A filter from the modulator-preamplifier unit.
- (b) Variolossers which hold the IF output level essentially constant with fading of the input signal.
- (c) A limiter which removes amplitude modulation from the IF signal before it is supplied to the discriminator.
- (d) A discriminator which recovers the baseband information from the frequency-modulated IF signal.
- (e) A baseband amplifier which raises the signal to the level required for the connecting circuits.
- (f) An AFC dc amplifier which transmits the differential output voltage derived from the discriminator to the magnetic amplifier located on the receiver control unit. The output of the magnetic amplifier is applied to the BO repeller to maintain a constant 70-MHz intermediate frequency.
- (g) An AGC detector and dc amplifier which hold the limiter input constant.
- (h) A squelch amplifier which monitors the output of the AGC amplifier, compares it with a fixed reference voltage and, when a predetermined level is reached, squelches the baseband amplifier output, and activates the

AFC squelch relay which prevents the beat oscillator from locking on an adjacent channel carrier or extraneous carrier signal.

- (i) A diversity AGC amplifier which converts the polarity and sets the gain of an input from the AGC amplifier to operate a diversity switch.
- (j) The IF filter (1075A) and associated cords which adapt the IF amplifier and FM receiver units to the RF panels.

**2.12** The IF amplifier and FM receiver arrangement includes cords, adjustments, and jacks as follows.

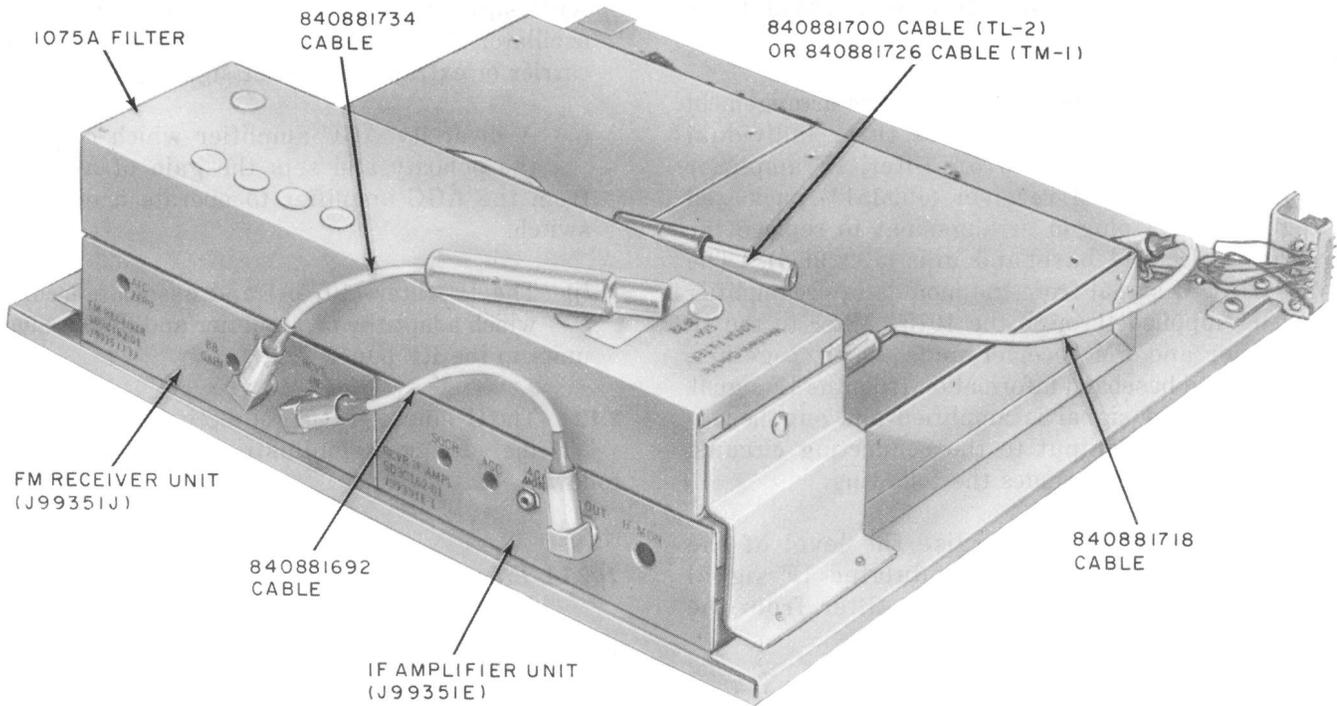
#### **1075A Filter**

- (a) The IF input jack, designated either J1 or J2, provides the coaxial connection from the modulator-preamplifier unit. This jack is located on the rear of the filter enclosure.
- (b) The IF output jack, designated either J1 or J2, provides the coaxial connection from the output of the filter to the input of the IF amplifier unit. This jack is located on the rear of the filter enclosure.

#### **IF Amplifier (J99351E)**

- (c) The IF IN jack provides the means for connecting the output of the 1075A filter to the input circuits of the unit. This jack is located on the rear panel of the unit.
- (d) The IF OUT jack provides a coaxial connection for patching the IF output of the IF amplifier unit to the RCVR IN jack of the FM receiver unit.
- (e) The IF MON jack provides a means for monitoring or measuring the 70-MHz output of the IF amplifier unit. The level at this point is nominally 0 dBm and is normally terminated by a 469A plug (75 ohms).
- (f) The AGC control provides a means for setting the IF output level applied to the limiter to -7 dBm for a prescribed IF input level.

**SECTION 409-300-104**



**Fig. 5—IF Amplifier and FM Receiver Arrangement Consisting of 1075A Filter, J99351E-1 IF Amplifier Unit, J99351J-1 FM Receiver Unit, and Associated Cables**

(g) The SQCH control provides a means for adjusting the squelch point to correspond with a specific 70-MHz IF input signal level.

**Cords**

Coaxial cords with connectors provide the means for interconnecting the filter, IF amplifier, and FM receiver units.

**FM Receiver (J99351J)**

(h) The RCVR IN jack provides a coaxial connection for patching the output of the IF amplifier unit into the input of the receiver unit.

(i) The RCVR OUT jack provides the means for supplying the baseband signal to the connecting circuits.

(j) The BB GAIN control provides a means for setting the level of the baseband signal supplied to the connecting circuits.

(k) The AFC ZERO control provides the means for adjusting the differential voltage of the AFC circuit to zero when the IF signal is 70 MHz.

**Receiver Automatic Frequency Control**

**2.13** The receiver AFC circuit is located within two units, the IF and baseband unit and the meter and control panel. The latter unit mounts the magnetic amplifier and controls required for AFC lineup. The magnetic amplifier is fed an AFC error voltage derived in the IF and baseband circuits, amplifies this voltage, and applies it to the BO repeller. The following front-panel controls are provided for AFC alignment:

(a) AFC ON-OFF switch allows the AFC to be disabled.

(b) FREQ switch and meter M1 allows the AFC error voltage to be monitored on a zero-center meter that functions as a frequency meter since

departures from zero indicate a shift in the IF from 70 MHz.

(c) BO RPLR control adjusts the BO repeller voltage to give correct frequency and maximum power output.

(d) Selector switch position AFC, meter M3, and control R27 provide means for initially adjusting the bias current in the magnetic amplifier and for monitoring its output.

**2.14** Two versions of the meter and control panel may be found in TL-1 bays. Fig. 6 shows the meter and control panel used with J99262G receiver IF and baseband unit. Fig. 7 shows the meter and control panel after modification for use with the J99296G-2 and J99351( ) receiver units.

**2.15** The addition of the printed-wiring board assembly (ED-3C535-30) modifies the TL-1 meter and control panel (Fig. 7) as follows:

- (a) Additional filtering in the BO cathode circuit.
- (b) A network to prevent oscillations in the AFC loop due to the new IF-to-baseband receiver arrangement.
- (c) A reference voltage supply circuit which provides a reference voltage for the AGC metering circuit. This circuit is accessible from the front of the panel by means of a new AGC CAL control.

### Channel Dropping Network

**2.16** This network drops the desired channel and permits the remaining channels to pass through essentially unattenuated for selection in similar networks on the other RF panels on the bay. The network is shown in Fig. 8.

## 3. CIRCUIT DESCRIPTION

### A. General

**3.01** The TL-1 receiver accepts Frequency-Modulated signals in the 10.7- to 11.7-GHz common carrier band and delivers signals at baseband frequencies to a 75-ohm unbalanced line. The equipment uses solid-state components throughout except for the BO klystron.

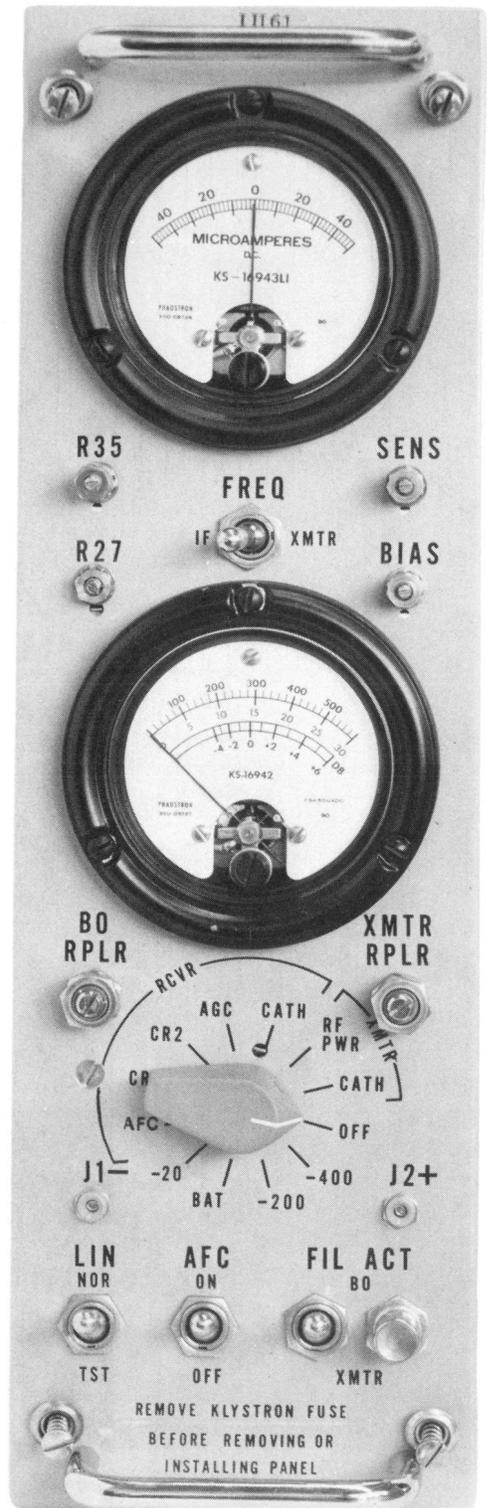


Fig. 6—Meter and Control Panel

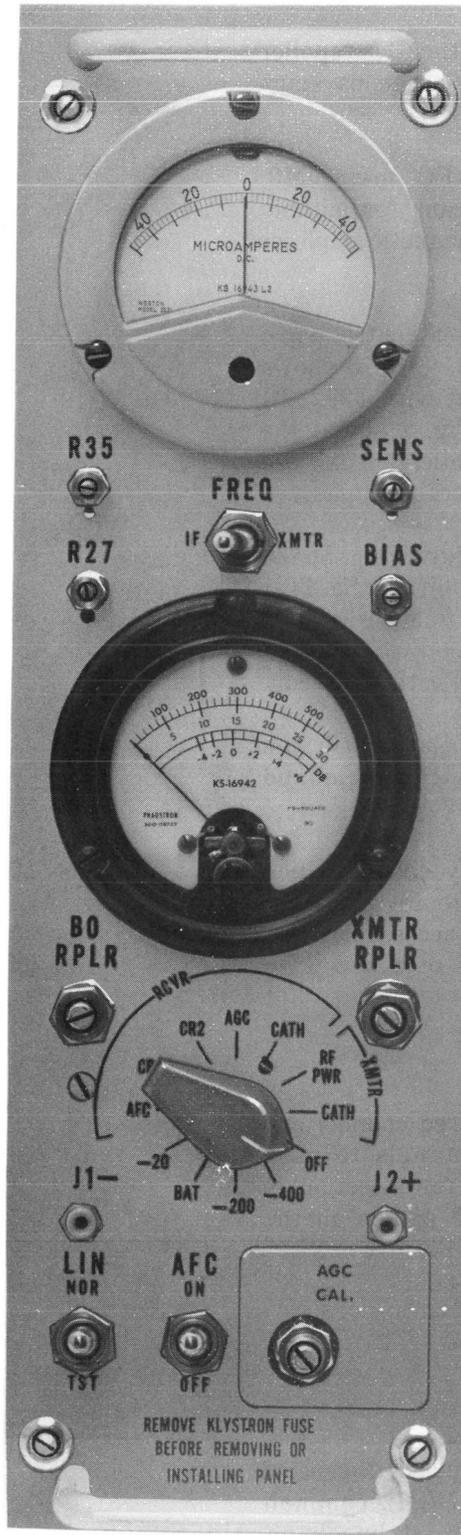


Fig. 7—Meter and Control Panel (With Printed Circuit Board Installed)

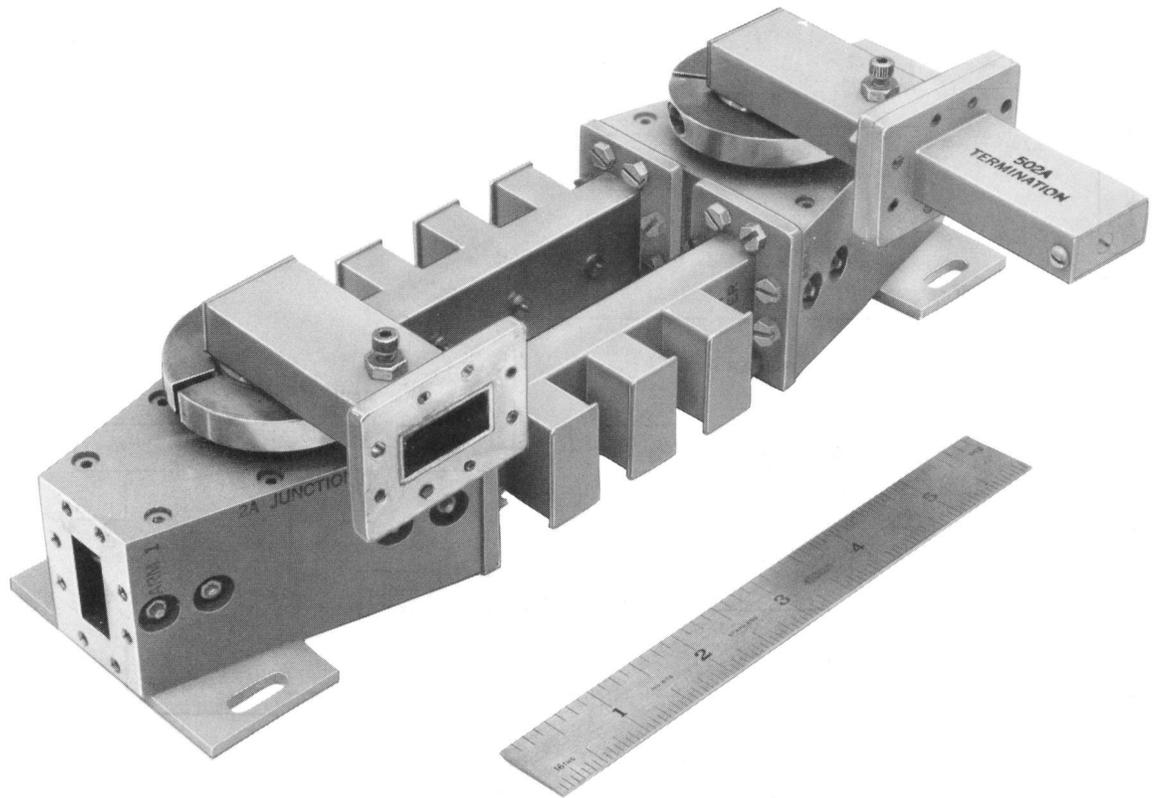


Fig. 8—Channel Dropping Network

**Note:** Three versions of the TL-1 receiver now exist; therefore, the circuit description for the J99262G receiver IF and baseband unit (Part 3, par. B) will contain information concerning equipment unique to the J99262G and information for equipment common to all three configurations of the receiver. Circuit information for exceptions to the TL-1 receiver brought about by the two modifications mentioned in 1.02 will be described in Part 3, par. C and D.

**B. Receivers Equipped With J99262G Receiver IF and Baseband Unit**

**3.02** A block diagram of a TL-1 receiver equipped with the IF and baseband unit (J99262G) is shown in Fig. 9. As shown, a channel dropping network selects its designated RF channel from the other channels and passes it on to the receiver. The remaining RF channels pass through the network. At the end of the waveguide run, selection is not required since only one RF channel is present, the others having been dropped. It is, therefore,

applied directly to the receiver. At the receiver, the signal passes through a 1307-type bandpass filter and a 401A tuner and is then applied to a balanced silicone-diode modulator. In the modulator, the signal is combined with the output of the local oscillator, a reflex klystron, to produce a 70-MHz IF signal which is amplified in a low-noise IF preamplifier equipped with AGC. The signal then passes through a band-restricting IF filter and is applied to an IF main amplifier that amplifies the signal to the level required for limiting. After limiting, the baseband signal is recovered in a frequency discriminator and amplified in a baseband amplifier which provides an unbalanced output of 75 ohms. The discriminator also drives an AFC circuit that establishes an average IF signal frequency of 70 MHz. A receiver squelch circuit mutes the receiver when the received signal drops below a predetermined level.

**Receiver Modulator**

**3.03** A simplified diagram of the receiver modulator is shown in Fig. 10. It is primarily a

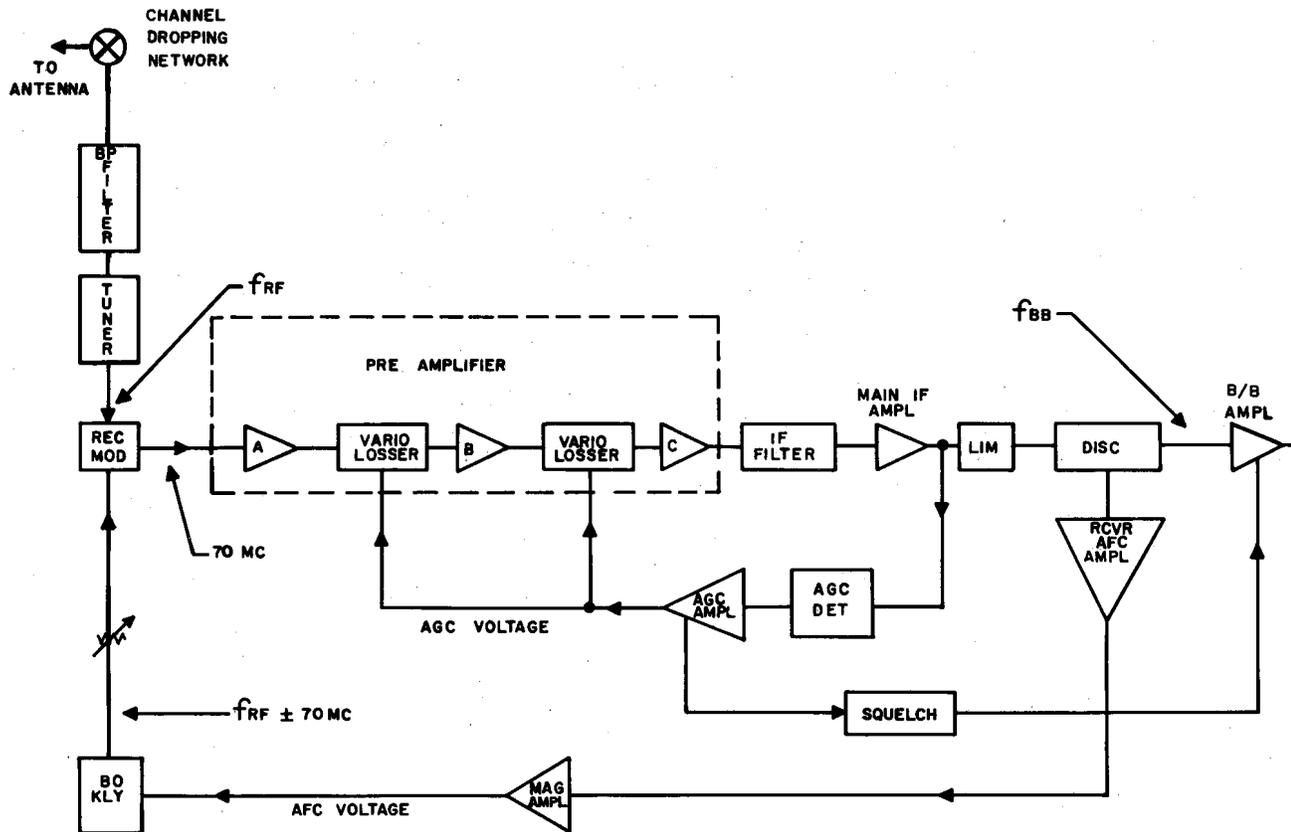


Fig. 9—J99262G Receiver—Block Diagram

balanced crystal converter, or mixer, which combines the incoming signal with a signal from the beat oscillator to produce an intermediate frequency centered at 70 MHz. The beat oscillator is under the control of the AFC circuit and its frequency may be higher or lower than the incoming signal frequency depending upon the channel number. A list of channel numbers, incoming signal, and BO frequencies is shown in Table A. A schematic diagram of the receiver modulator and BO is shown in Fig. 11.

**3.04** The beat-oscillator signal is fed into the E-plane junction at a relatively high level of approximately 0 dBm which is controlled by waveguide attenuator AT1. The signal splits at the junction and is impressed on diodes CR1 and CR2 in opposite phase. Since the diodes are mounted in the waveguide with opposite polarities, they will conduct simultaneously, and a balanced switching action will be produced within the hybrid. Because of the symmetry of the hybrid, none of

the beat-oscillator output will appear at the signal input port of the hybrid, provided the diodes are perfectly matched. The signal at the H-plane junction divides in phase between the two hybrid arms containing CR1 and CR2. These signals are impressed on the diodes which are varying in impedance at the beat-oscillator frequency and, as a result, frequency combinations of beat-oscillator and signal frequencies are produced. Of all the possible combinations, only the difference and the image frequency are of significance. All the other frequency combinations are either at too high a frequency or too low a level to have any affect on the operation of the modulator. The difference frequency is the intermediate frequency of 70 MHz which is obtained by paralleling the outputs of the two diodes as shown in Fig. 10. This signal is then fed to the IF preamplifier through connector J3. The image-frequency signals generated in the diodes are returned to the H-plane junction where they are added in phase to appear at the signal input port. Since this signal is outside the passband

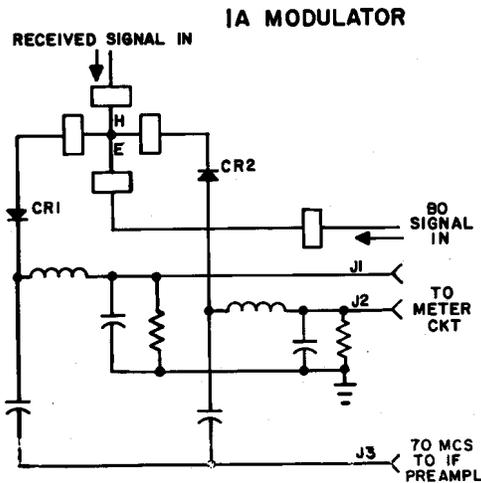
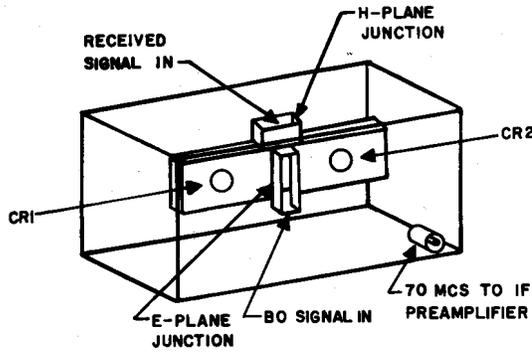


Fig. 10—Receiver Modulator—Simplified Diagram and Schematic Diagram

of the input filter, it is reflected back into the modulator where it recombines with the beat-oscillator signal to produce a 70-MHz difference frequency adding to the IF output. To ensure that the signals add in phase, a waveguide spacer of proper dimensions is located at the signal input port to control the phase of the reflected image signal. In this way, the efficiency of the converter is improved. To adjust the receiver input impedance, a waveguide tuner is provided which corrects for variations in the modulator impedances because of differences in diodes.

**3.05** The overall gain of the modulator-preamplifier is 20 dB from the RF input to the IF output. The average noise figure is 10.5 dB.

**Beat Oscillator**

**3.06** A simplified schematic diagram of the beat oscillator and related circuits is shown in

TABLE A

CHANNEL NUMBER	FREQUENCY	
	SIGNAL	BEAT OSCILLATOR
	GHz	
1A	10.755	10.825
1B	11.405	11.335
2A	10.955	11.025
2B	11.685	11.615
3A	10.995	11.065
3B	11.645	11.575
4A	10.715	10.785
4B	11.445	11.375
5A	11.155	11.085
5B	11.325	11.255
6A	10.875	10.805
6B	11.605	11.535
7A	10.915	10.845
7B	11.565	11.495
8A	11.115	11.045
8B	11.365	11.295
9A	11.075	11.145
9B	11.245	11.315
10A	10.795	10.865
10B	11.525	11.595
11A	10.835	10.905
11B	11.485	11.555
12A	11.035	11.105
12B	11.285	11.355

Fig. 12. Portions of the meter unit, the receiver control unit, and the modulator-preamplifier are included to make clear the dc and signal connections and the nature of the measurements. The RF output of the klystron oscillator is attenuated by the 25A waveguide attenuator to provide approximately 0 dBm of BO power for the modulator. Connections to the klystron repeller and cathode are completed through the receiver control panel while the heater connections are made directly to the power supply. The cathode of the tube is held at -400 volts, and the repeller is operated between -400 and -600 volts under the control of a manual adjustment (BO RPLR) plus a dynamic receiver AFC voltage. Diode CR1 in the receiver control unit is included to prevent the repeller from going positive with

respect to the cathode. The cathode current is determined by measuring the drop across the 2-ohm resistor R5 in series with the cathode.

**3.07** The 25A attenuator is adjusted to achieve proper operation of the demodulator as determined by limits on crystal current. The direct currents flowing in modulator diodes CR1 and CR2 are measured separately as shown in Fig. 12. The receiver control unit components inserted in the measuring path provide additional 70-MHz filtering. Since the modulator is the lowest power level point in the system, all connections to it are heavily filtered in order to achieve optimum receiver noise performance.

#### IF Preamplicifier and Variolossers

**3.08** The IF preamplicifier circuit is shown in Fig. 13. As shown, the initial amplification of the 70-MHz signal in the preamplicifier occurs in a pair of direct-coupled common emitter stages, referred to as a doublet. A simplified diagram of the doublet is shown in Fig. 14. Following this is a cascade of ten wideband common base transformer coupled stages, (Fig. 15). The principal advantage of this amplifier arrangement is that the doublet yields good noise figure and input return loss, while the common base stage exhibits good transistor interchangeability and insensitivity to temperature change. Two diode attenuator networks, known as variolossers (Fig. 16), are placed between common base stages and give automatic gain control of the preamplicifier. They are positioned in the amplifier at points where they have only a slight affect on weak signal receiver noise figure, but still act reasonably linear under strong signal conditions.

#### IF Filter

**3.09** The IF preamplicifier drives bandpass filter FL1 (Fig. 9) which determines the shape of the IF passband. The main functions of the filter are to restrict the IF bandwidth in order to improve the signal-to-noise ratio of the receiver and to equalize the delay of the overall IF amplifier. It also prevents spurious signals generated in the variolossers (and out-of-band interfering signals) from entering the IF main amplifier. The IF filter is designed to work between 75-ohm resistive terminations.

#### IF Main Amplifier

**3.10** The IF main amplifier, Fig. 17, is a cascade of nine common base stages with each developing slightly more than 5 dB of gain, and a parallel common base output stage capable of delivering a maximum power of +13 dBm into the limiter. The nominal power gain of this amplifier is 49 dB, flat to within  $\pm 0.2$  dB over the 64- to 76-MHz IF band.

#### Automatic Gain Control

**3.11** The AGC circuit (Fig. 18) holds the output level of the IF main amplifier nearly constant with changes of RF signal level and temperature. In addition, the AGC circuit prohibits spurious phase modulation by keeping the IF amplifier stages, preceding the output stage, from being overdriven. These conditions are achieved through the use of the AGC circuit consisting of an IF detector, a direct-coupled amplifier (AGC amplifier), and two variolossers. The main IF amplifier output is monitored by the AGC amplifier which feeds back a voltage to control the loss in the variolossers and thereby compensates any tendency for the IF output level to change. The dc amplifier has sufficient gain to multiply the small current drawn from the detector to the magnitude required to drive the variolossers. This circuit holds the limiter input level to +11.5 dBm  $\pm 1$  dB for IF input levels ranging from -83 to -33 dBm over the ambient temperature range. The AGC detector circuit is shown in Fig. 18.

#### Limiter

**3.12** The output signal of the IF main amplifier will be both amplitude modulated (AM) and frequency modulated (FM) by noise and baseband signals. Since the discriminator will respond to AM signals as well as FM signals, a limiter is used to greatly reduce the AM component of the signal entering the discriminator. The operation of the limiter can be understood from a consideration of the theoretical model shown in Fig. 19 and the circuit as shown in Fig. 20.

#### Discriminator

**3.13** A simplified schematic diagram of the discriminator circuit is shown in Fig. 21. As shown, the discriminator is used to recover the baseband information, and to provide an error

NOTES:  
 101. RESISTOR VALUES UNLESS OTHERWISE SPECIFIED, ARE IN OHMS.  
 102. COMPONENT CODES AND VALUES SHOWN MAY NOT AGREE WITH THE LATEST ISSUE OF SD-97038-O1.  
 103. M2 KS-16997 TIMER HAS BEEN MANUFACTURE DISCONTINUED.

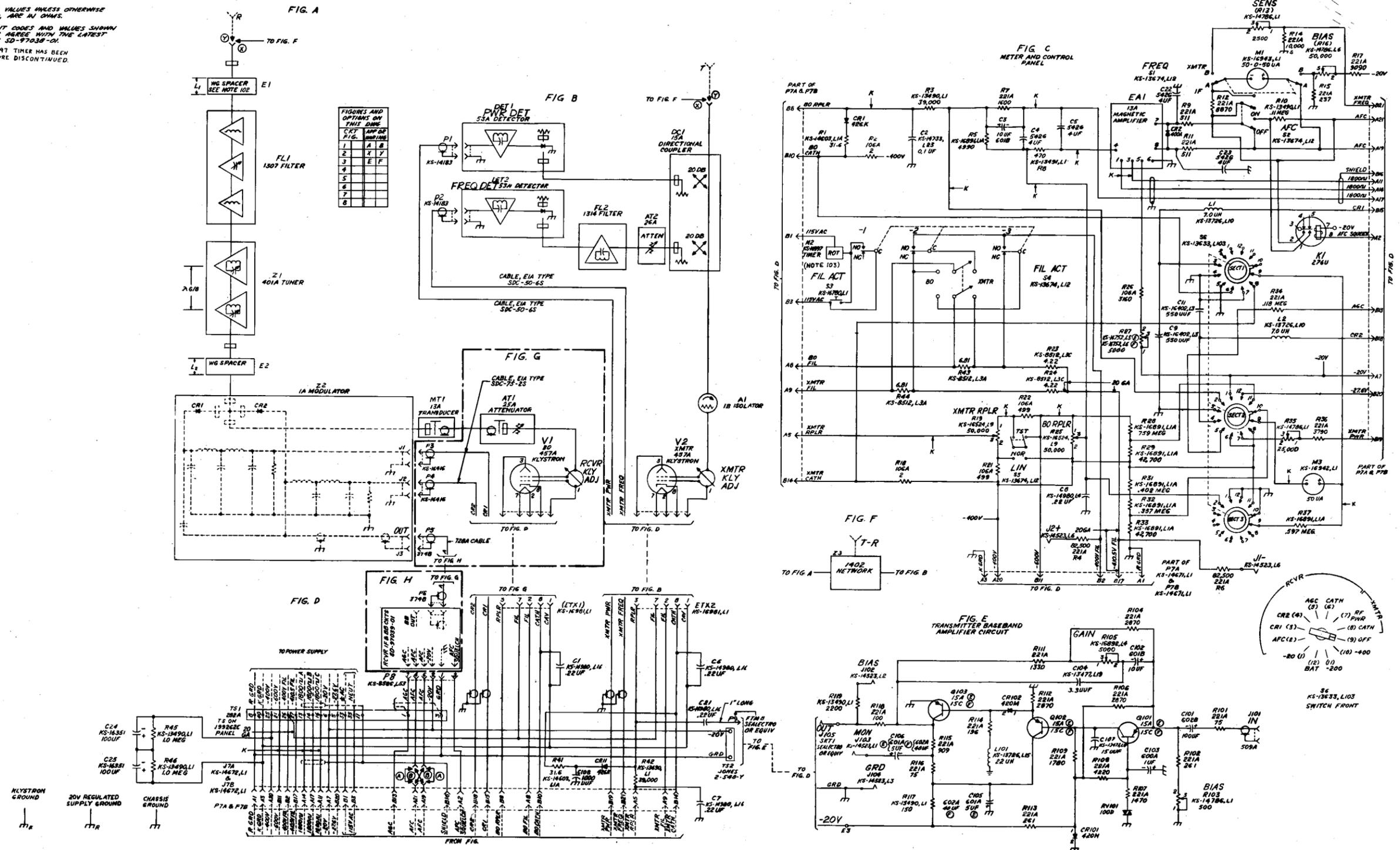


Fig. 11—Typical Transmitter, Receiver, and Control Circuits—Schematic Diagram

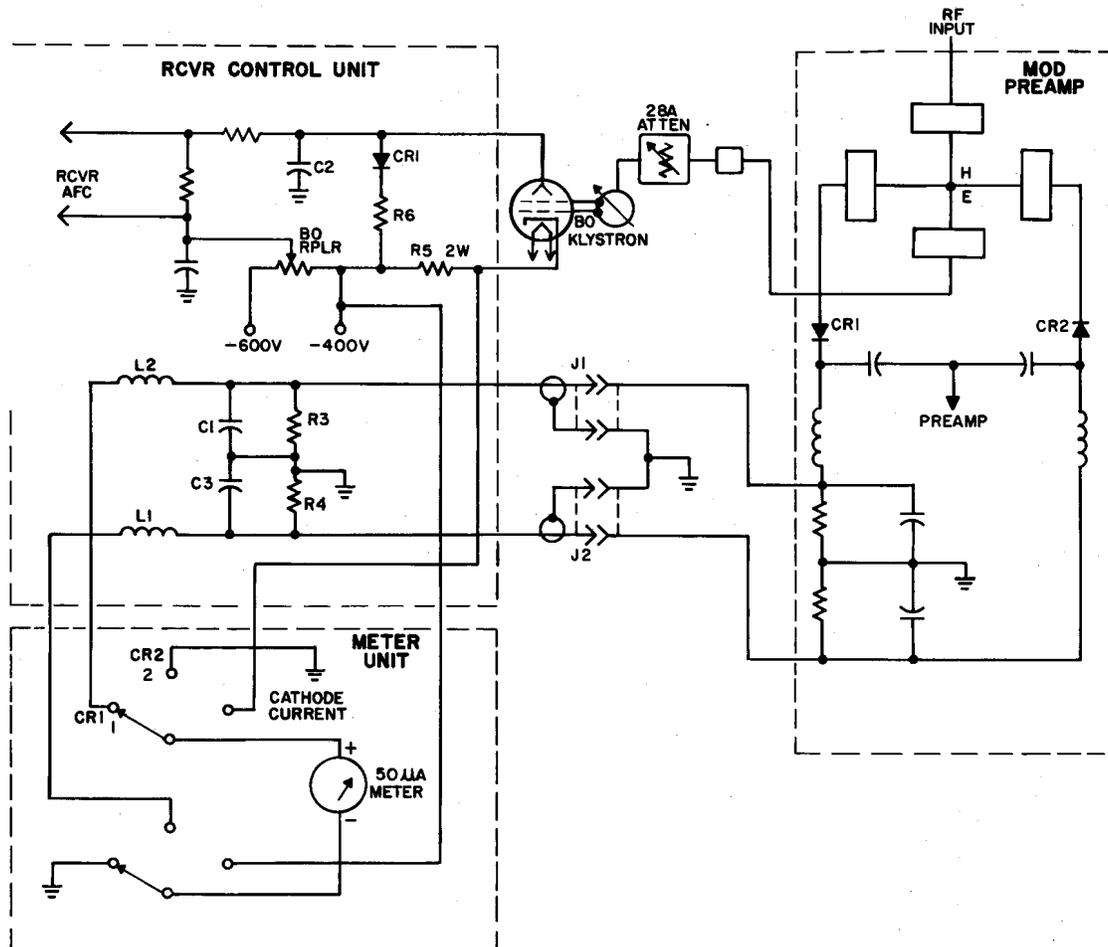


Fig. 12—Beat-Oscillator and Related Circuits—Simplified Schematic Diagram

signal to the AGC amplifier which is used to control the frequency of the beat oscillator to maintain a constant 70-MHz intermediate frequency.

#### Receiver Baseband Amplifier

**3.14** The baseband amplifier is a direct-coupled cascade of three common emitter stages with shunt feedback through a "T" network. This circuit is shown in Fig. 20. After limiting, the IF signal is detected in a wideband frequency discriminator. The recovered baseband signal is then amplified in the baseband amplifier which provides an unbalanced output of 75 ohms. During deep fades, the amplifier is switched off by an input from the squelch circuit sufficient to drive it into saturation.

#### Squelch Circuit

**3.15** The squelch circuit is shown in Fig. 18. This circuit is a Schmitt trigger operating from the variolossers control voltage produced by the AGC amplifier. The trigger is designed to fire in the vicinity of  $-2.8$  volts which corresponds to a carrier level of from  $-80$  to  $-90$  dBm. A graph of voltage versus input power is shown in Fig. 22.

#### Automatic Frequency Control Amplifier

**3.16** A block diagram of the AFC circuit is shown in Fig. 23. As shown, the AFC loop contains two cascaded amplifier circuits, a 2-transistor amplifier followed by a magnetic amplifier. This section describes the transistor AFC amplifier which is a part of the IF and baseband chassis. The

magnetic amplifier is physically located behind the meter and control panel and is described in Section 409-300-102. The primary purpose of the transistor AFC amplifier is to isolate the discriminator and baseband amplifier from the magnetic amplifier, since the latter amplifier produces, at its input terminals, a substantial 1800-Hz signal rich in harmonics which must be attenuated to avoid spurious baseband amplifier output tones.

### Receiver Automatic Frequency Control System

**3.17** Fig. 23 is a block diagram of the receiver AFC system. The dc output of the AFC amplifier is an error signal that indicates the departure of the BO signal from  $RF_{IN} \pm 70$  MHz. This error signal is built up in the magnetic amplifier and applied to the BO repeller which shifts frequency in a direction to minimize the dc error signal when the transmitter or receiver klystron tends to drift in frequency. The AFC system does not give perfect correction, since a small error signal must exist to maintain the required correcting voltage at the BO amplifier repeller. The magnitude of the residual error signal is determined by the loop gain of the system and is made small by making the gain large.

**3.18** Meter M1 is a zero center device provided to measure AFC error voltage for lineup purposes. With **FREQ** switch S1 in the IF position, a zero indication is obtained when the intermediate frequency is its nominal value of 70 MHz. Any departure from this reading indicates a frequency shift. Sensitivity is increased by a factor of 9 when the AFC switch S2 is in the ON position.

### C. Receivers Equipped With J99296G-2 Receiver IF and Baseband Unit

**3.19** A block diagram of a receiver equipped with the J99296G-2 IF and baseband unit is shown in Fig. 24. As shown, in the modulator, the signal is combined with the output of the beat oscillator to produce a 70-MHz IF signal which is amplified in a low-noise IF preamplifier. See Fig 24. In receivers equipped with J99296G-2 IF and baseband unit, the amplified 70-MHz signal is then applied to the IF and baseband unit for additional amplification under the control of the AGC circuit, for band limiting by an IF bandpass filter, and for further amplification by a high-level IF output amplifier which amplifies the signal to the power required for limiting. After limiting, the baseband signal

is recovered in a frequency discriminator and amplified in a baseband amplifier which provides an unbalanced output at an impedance of 75 ohms. The discriminator also provides an error signal which, when amplified and applied to the repeller of the BO klystron, establishes an average IF signal frequency of 70 MHz. A receiver squelch circuit mutes the receiver when the received signal drops below a predetermined level.

**3.20** As shown in Fig. 24, the circuits between the modulator-preamplifier unit and the limiter portion of the IF and baseband unit (J99296G-2) include the input IF amplifier and IF bandpass filter, a factory-adjusted attenuator, and an IF output amplifier. These are known collectively as the IF amplifier. The IF power applied to the limiter is nominally approximately +11.5 dBm. Since the nominal input power of the IF unit is -20 dBm (assuming an RF receiver input of -40 dBm and a modulator-preamplifier gain of 20 dB), the working gain of the IF amplifier is nominally 33.5 dB, while for a 40-dB fade, it is 73.5 dB. Variolossers included in the input amplifier, having a total range of more than 52 dB, act as part of the AGC circuit to hold the signal level applied to the limiter to within 1 dB of the required power over the expected range of receiver input levels. The receiver noise figure is degraded by not more than 0.5 dB between the 40-dB fade and the normal input.

### D. Receivers Equipped With J99351E-1 IF Amplifier Unit and J99351J-1 FM Receiver Unit

**3.21** A block diagram of a receiver equipped with the J99351E IF amplifier and J99351J FM receiver arrangement is shown in Fig. 25. As shown, the 70-MHz signal from the modulator/preamplifier is supplied to the IF amplifier (J99351E) through a 1075A bandpass filter. Plots of insertion loss versus frequency and of delay versus frequency of the filter are shown in Fig. 26 and 27, respectively.

**3.22** The IF amplifier (which consists of three stages) raises the level of the signal prior to limiting in the FM receiver unit. See Fig. 22. An AGC circuit in the IF amplifier unit holds the output of the IF amplifier essentially constant. A squelch amplifier under control of the AGC amplifier mutes the output of the baseband amplifier to prevent noise from being transmitted over the connecting circuits whenever the received signal drops below a specified point during fading conditions.

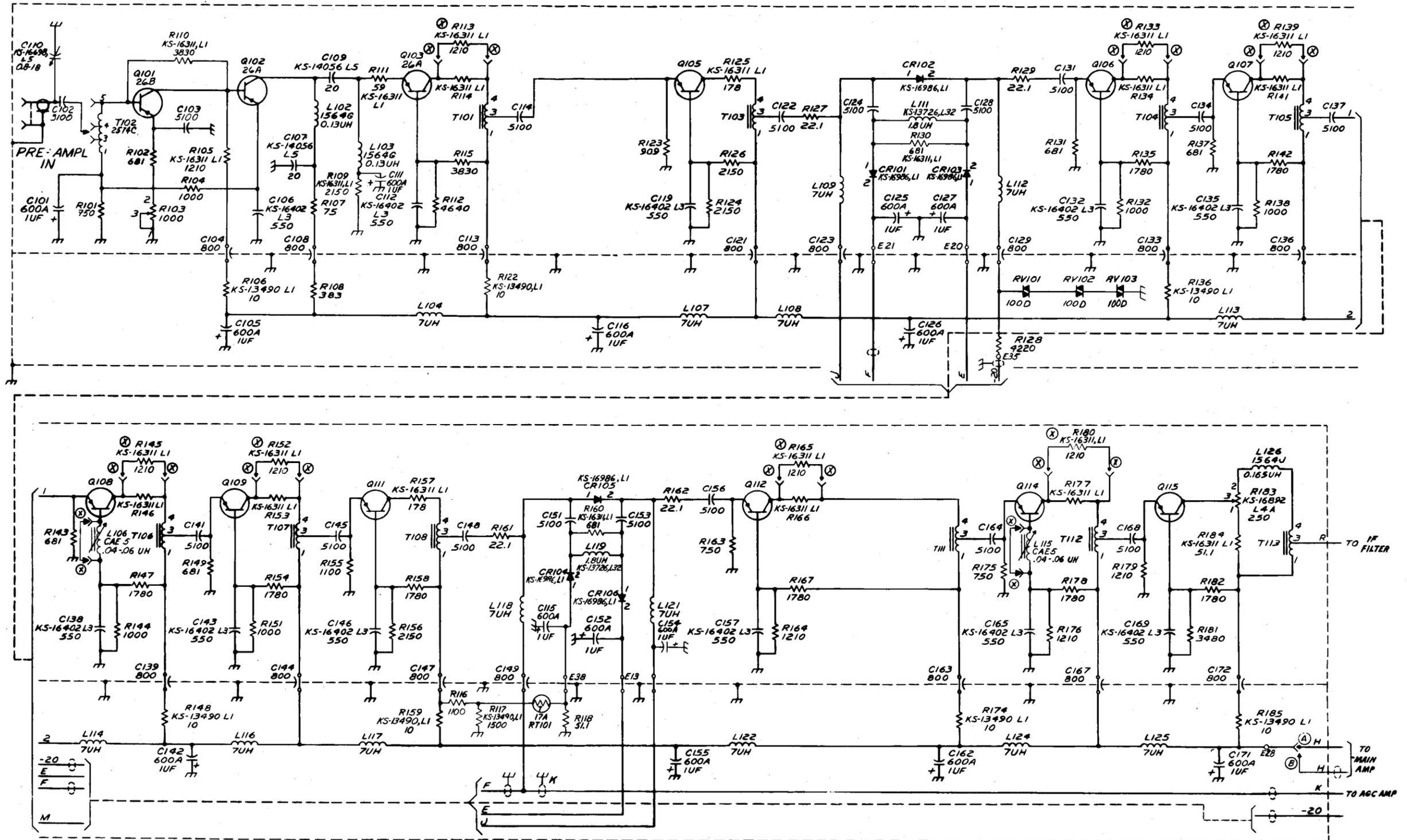


Fig. 13—Typical IF Preamplifier Circuit—Schematic Diagram

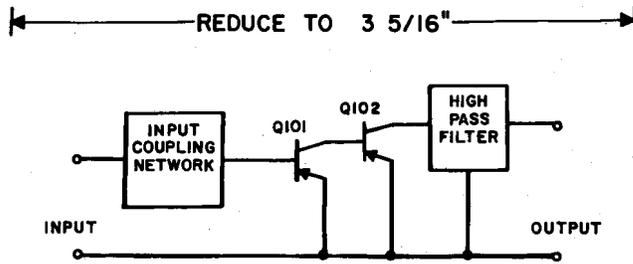


Fig. 14—Doublet Amplifier Circuit—Simplified Schematic Diagram

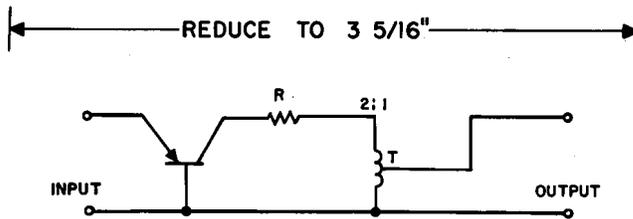


Fig. 15—Common-Base Transistor Amplifier Circuit—Simplified Schematic Diagram

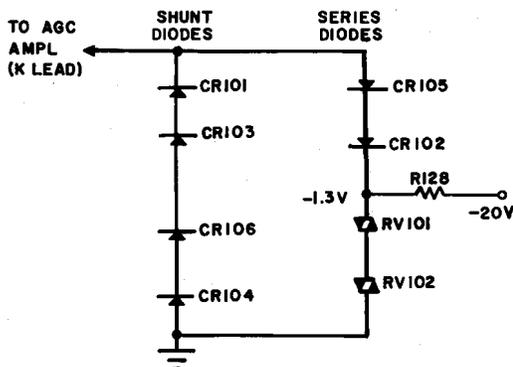
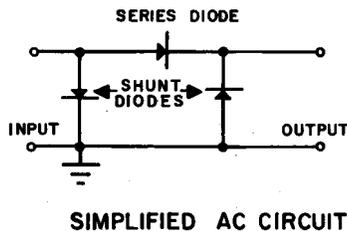


Fig. 16—Variolossor Circuits—Simplified Schematic

The squelch amplifier also functions to remove automatic frequency control from the beat oscillator which allows it to return to its nominal operating frequency instead of locking at a new frequency

under the influence of an adjacent channel carrier or extraneous carrier signal. A diversity AGC circuit, also under control of the AGC amplifier, provides a control voltage which operates a diversity switch whenever the depth of fade reaches a certain point or if loss of received signal occurs.

**3.23** The FM receiver unit provides limiting to reduce amplitude variations of the frequency-modulated IF signal, a discriminator to recover the baseband information, and a baseband amplifier to raise the level of the baseband signal for supplying the connecting circuits. The discriminator also provides an error signal to the AGC amplifier which is used to control the frequency of the beat oscillator to maintain a constant 70-MHz intermediate frequency. The beat oscillator is under the control of the AFC circuit, and its frequency may be higher or lower than the incoming signal frequency depending upon the channel number.

**3.24** The functions of the IF amplifier and AGC circuits in the IF amplifier (J99351E) are essentially the same as those described for the IF and baseband unit (J99296G). The IF amplifier (J99351E), under control of its associated AGC circuit, maintains a nominal -7 dBm IF output level for fades up to 35 dB. The unit provides a maximum gain of approximately 50 dB. The squelch point is adjusted, as required, to cause the squelch circuit to function at a received carrier level of -77 to -82 dBm.

**4. OPERATING CHARACTERISTICS**

**4.01** The operating characteristics of the J99262G receiver IF and baseband unit are as follows:

(a) *IF Preamplifier*

Input impedance	75 ohms unbalanced
Output impedance	75 ohms unbalanced
Normal input power level	-43 dBm
Normal output power level	-36.5 dBm
AGC range	50 dB
Minimum input return loss	20 dB

(b) *IF Filter*

**SECTION 409-300-104**

Transmission band 64 to 76 MHz  
 In-band loss 1 dB

Minimum input and output return loss 20 dB within transmission band  
 (c) **IF Main Amplifier**

Input impedance 75 ohms unbalanced

Output impedance (nominal) 200 ohms

Normal input power level -37.5 dBm

Normal output power level +11.5 dBm

Minimum input return loss 20 dB

(d) **Limiting Discriminator**

Normal limiter input power level +11.5 dBm

Discriminator width between peaks 56 to 88 MHz

(e) **Baseband Amplifier**

Output impedance 75 ohms unbalanced

Gain 16 to 21 dB

Transmission band 300 Hz to 6 MHz

(f) **AFC Amplifier**

Amplifier output level 40 millivolts per MHz

(g) **Squelch Circuit**

RF input level for squelch operation -80 to -90 dBm

**4.02** The operating characteristics of receivers equipped with J99296G-2 IF and baseband unit are as follows:

(a) **IF Amplifier**

Input impedance 75 ohms unbalanced

Output impedance 75 ohms unbalanced

Normal input power level -20 dBm

Nominal working gain 33.5 dB

Minimum input return loss 20 dB

(b) **Modulator Preamplifier**

Input impedance 75 ohms unbalanced

Output impedance 75 ohms unbalanced

**4.03** The operating characteristics of receivers equipped with the J99351E-1 IF amplifier unit and the J99351J-1 FM Receiver unit are as follows:

(a) **IF Amplifier**

Input impedance 75 ohms unbalanced

Output impedance 75 ohms unbalanced

Nominal output level -7 dBm

Nominal insertion loss at carrier frequency 0.5 dB

(b) **FM Receiver Unit**

Input impedance 75 ohms

Frequency range 60 to 80 MHz

Nominal input power -7 dBm

Total gain 20 dB

Average noise figure 10.5 dB

(c) **Baseband Amplifier:**

Output impedance 75 ohms unbalanced

(1) **Input amplifier**

(a) Maximum gain 55 dB

(2) **Output amplifier**

(a) Maximum gain 35 dB

(d) **Squelch Circuit**

RF input level for squelch operation -77 to -82 dBm

Nominal output power at  $\pm 4$  MHz deviation 6.5 dBm

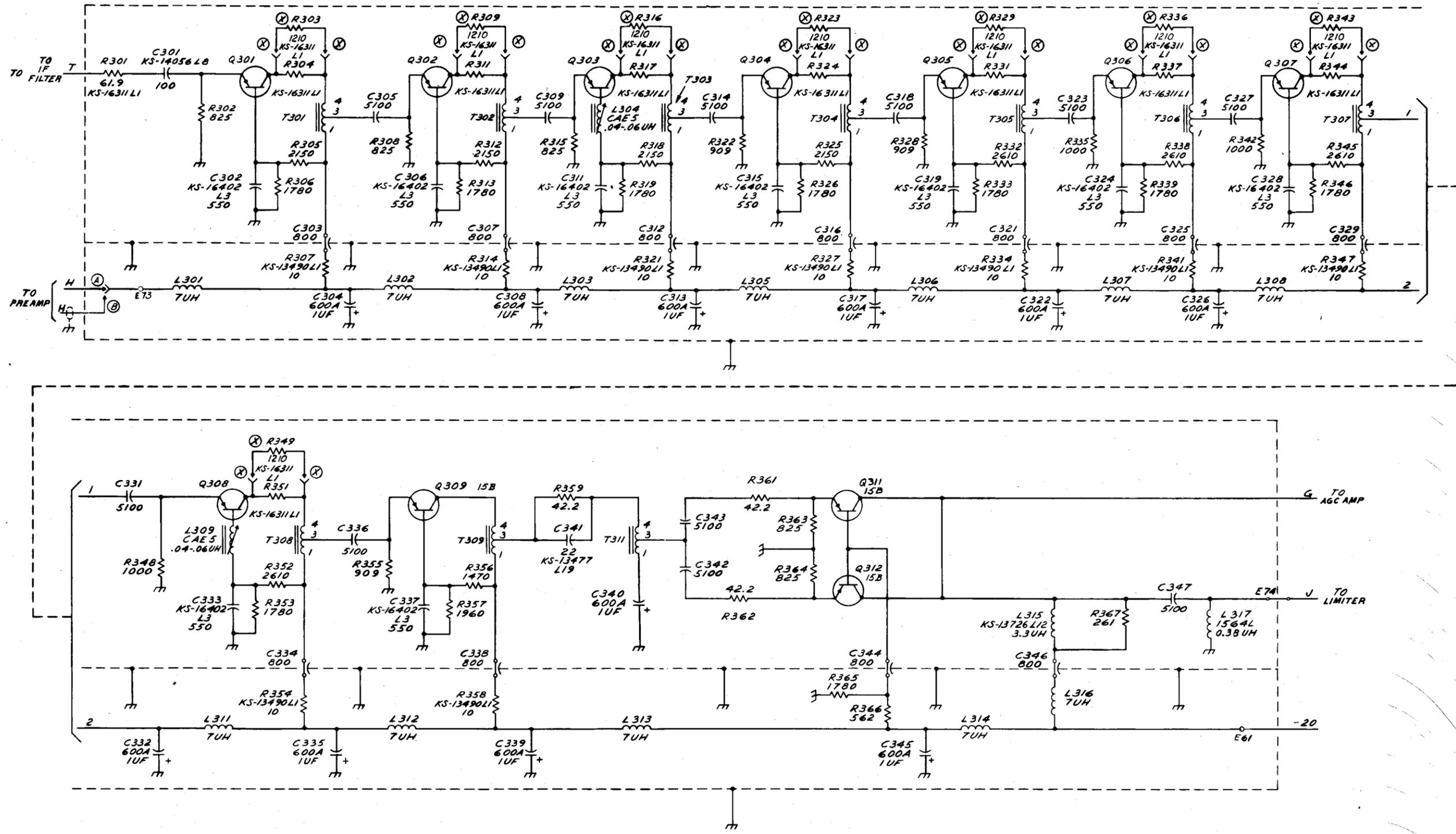


Fig. 17—Typical IF Main Amplifier Circuit—Schematic Diagram

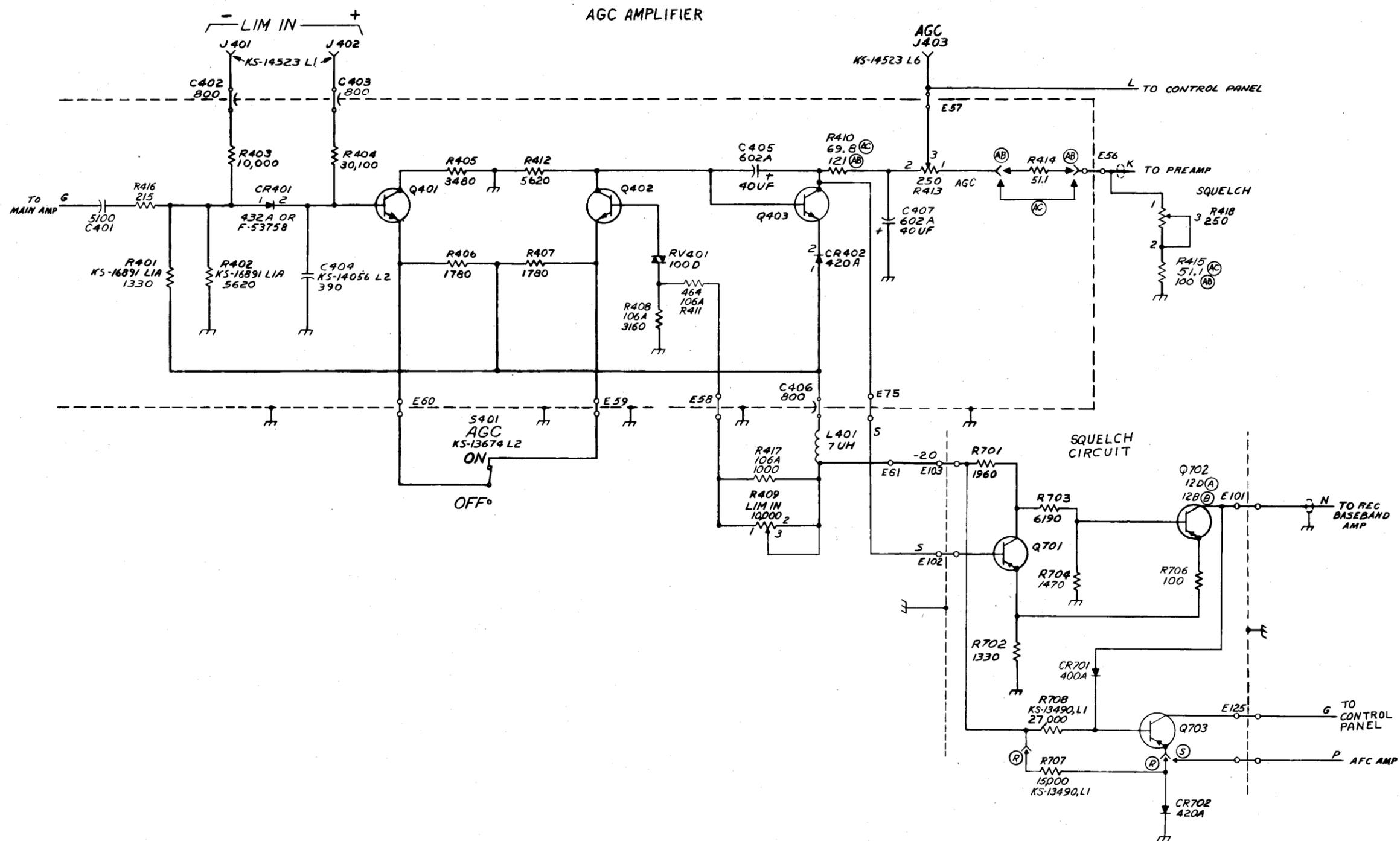


Fig. 18—Typical Automatic Gain Control and Squelch Circuits—Schematic Diagrams

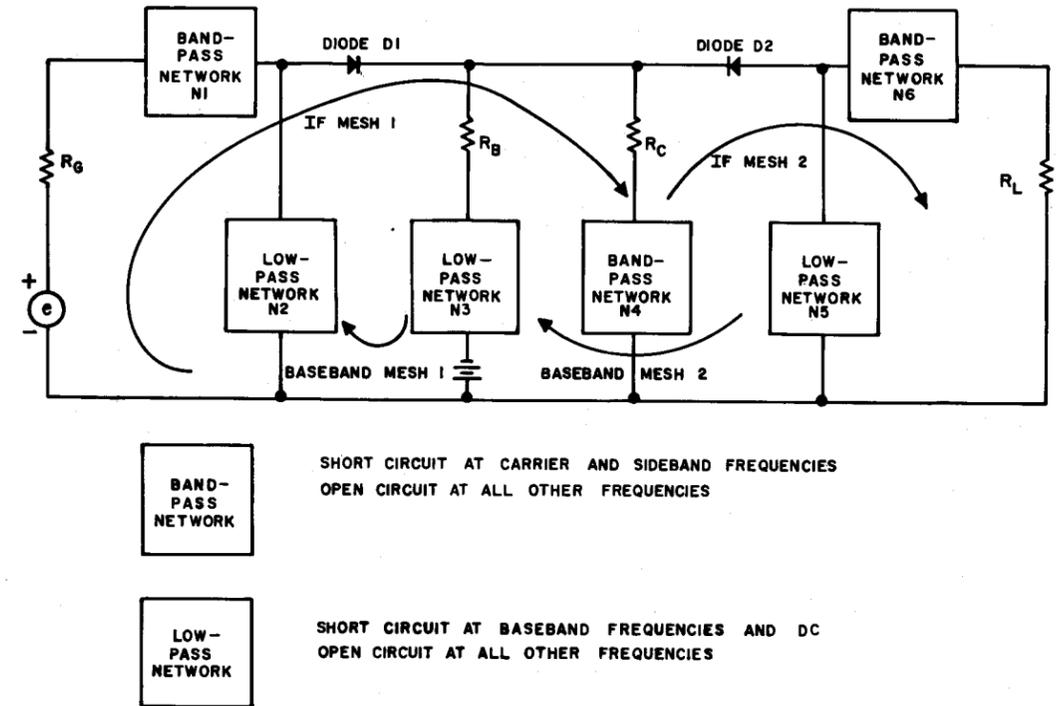


Fig. 19—Theoretical Model of Limiter Circuit—Block Diagram

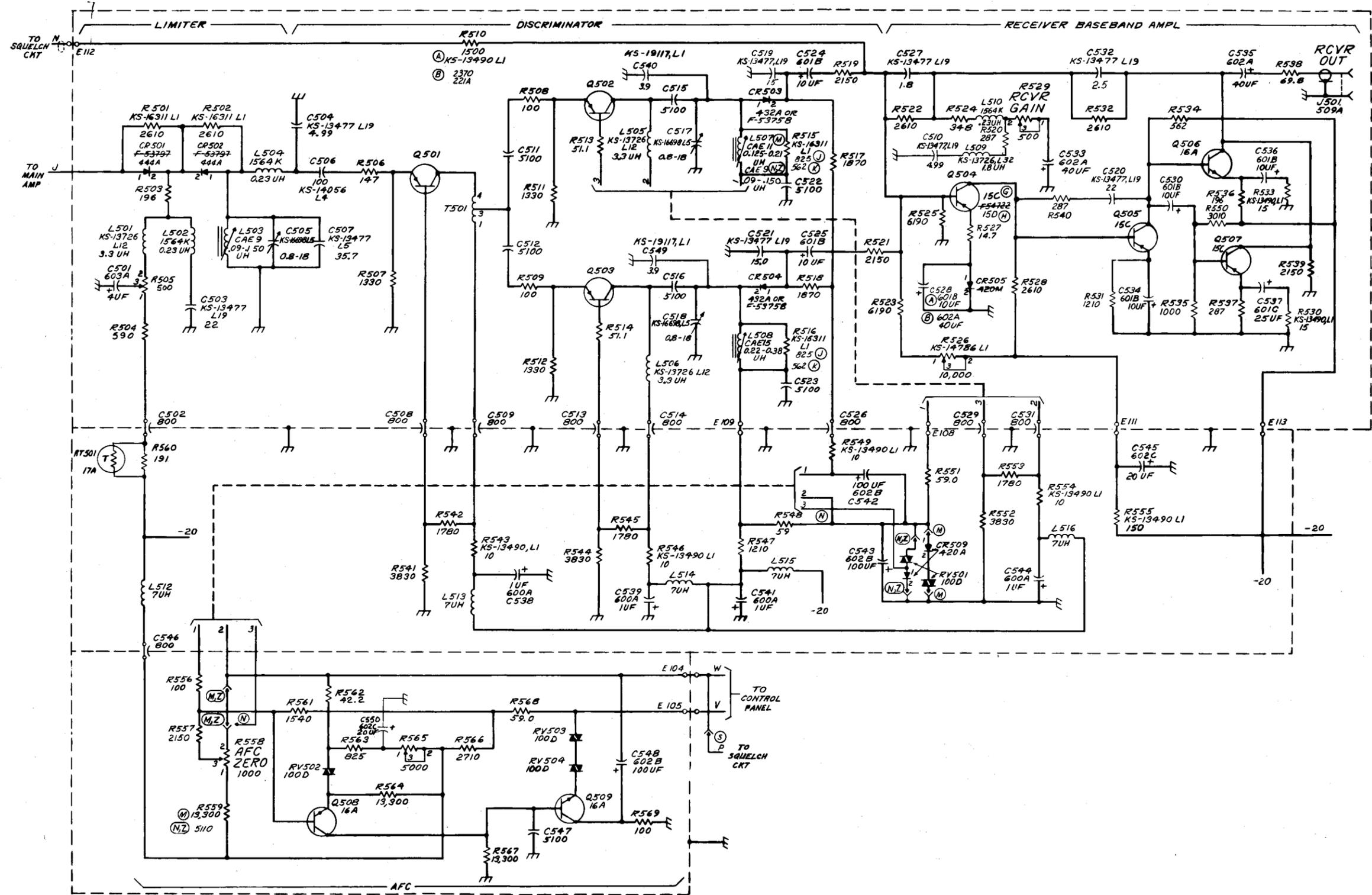


Fig. 20—Typical Limiter, Discriminator, and Receiver Baseband Amplifier Circuits—Schematic Diagram

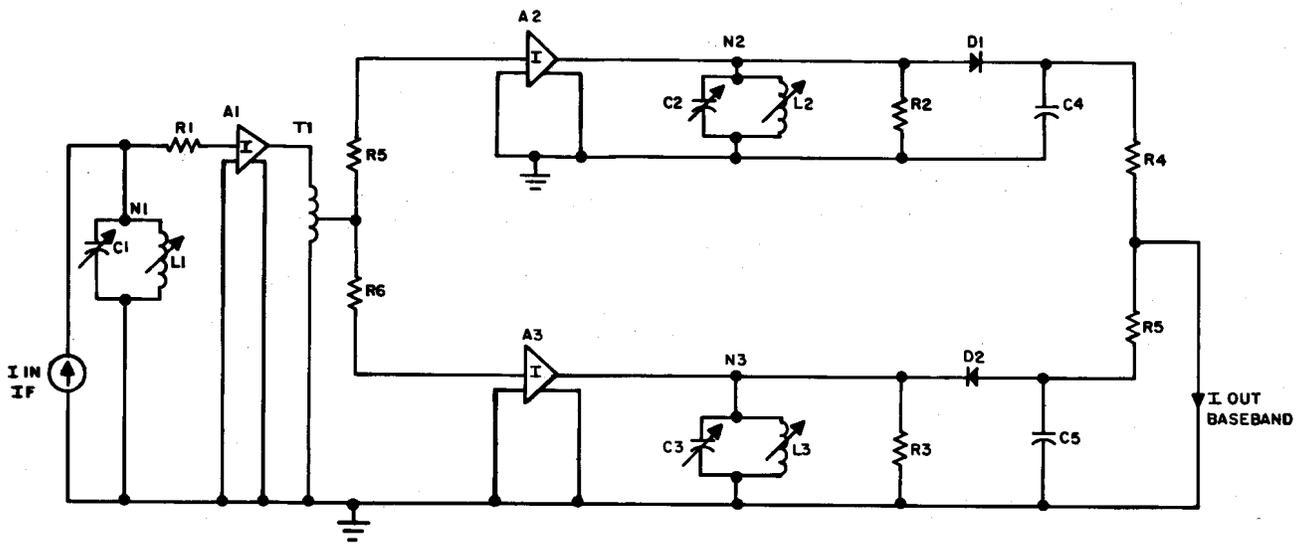


Fig. 21—Discriminator Circuit—Simplified Schematic Diagram

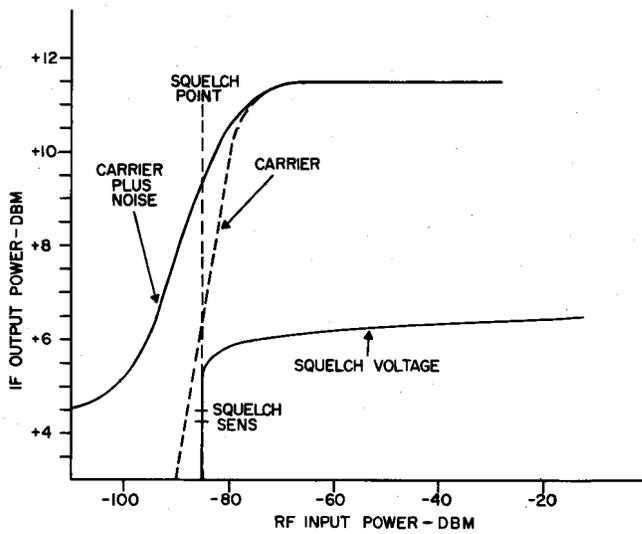


Fig. 22—Squelch Circuit—Voltage Versus Input Power—Graph

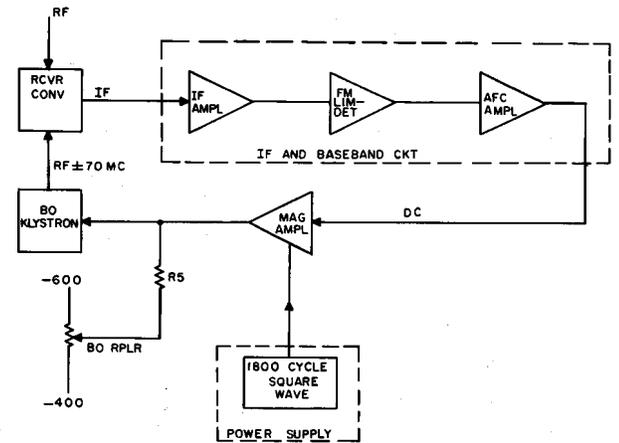


Fig. 23—Receiver Automatic Frequency Control Circuit—Block Diagram

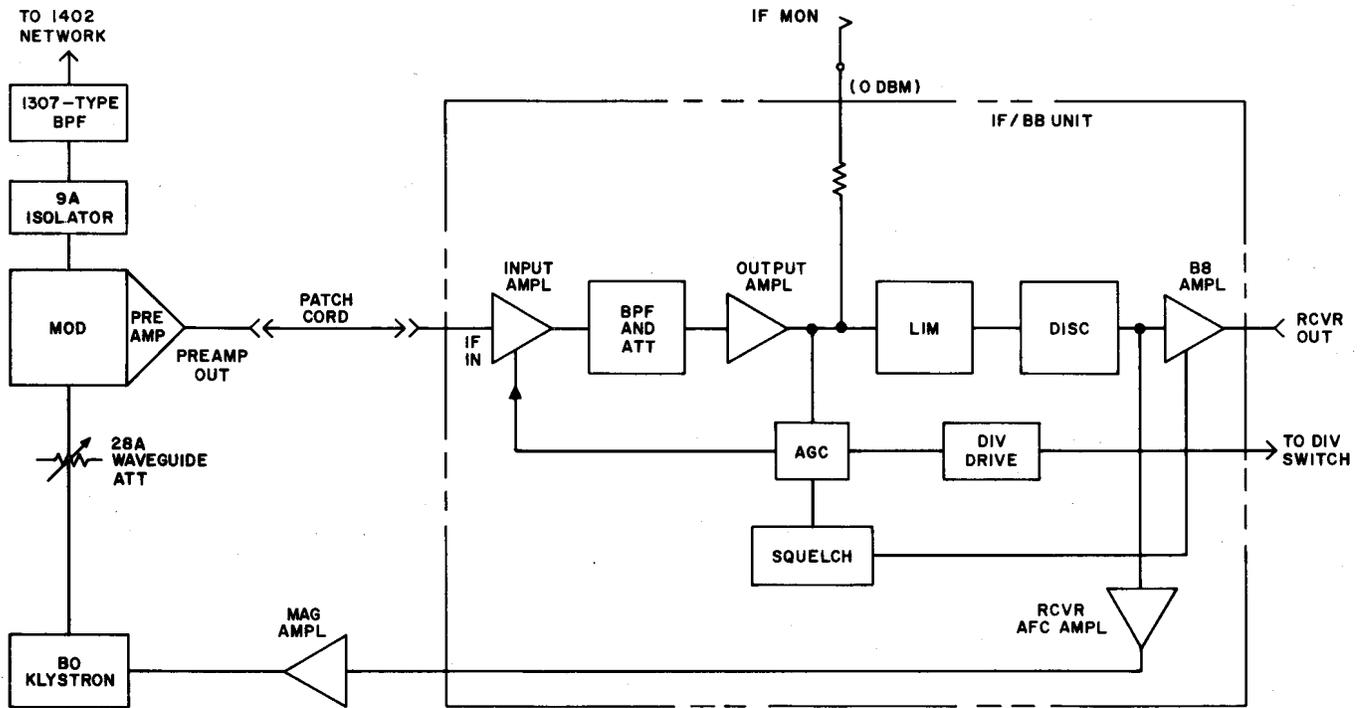


Fig. 24—Receiver Equipped With J99296G IF and Baseband Unit—Block Diagram

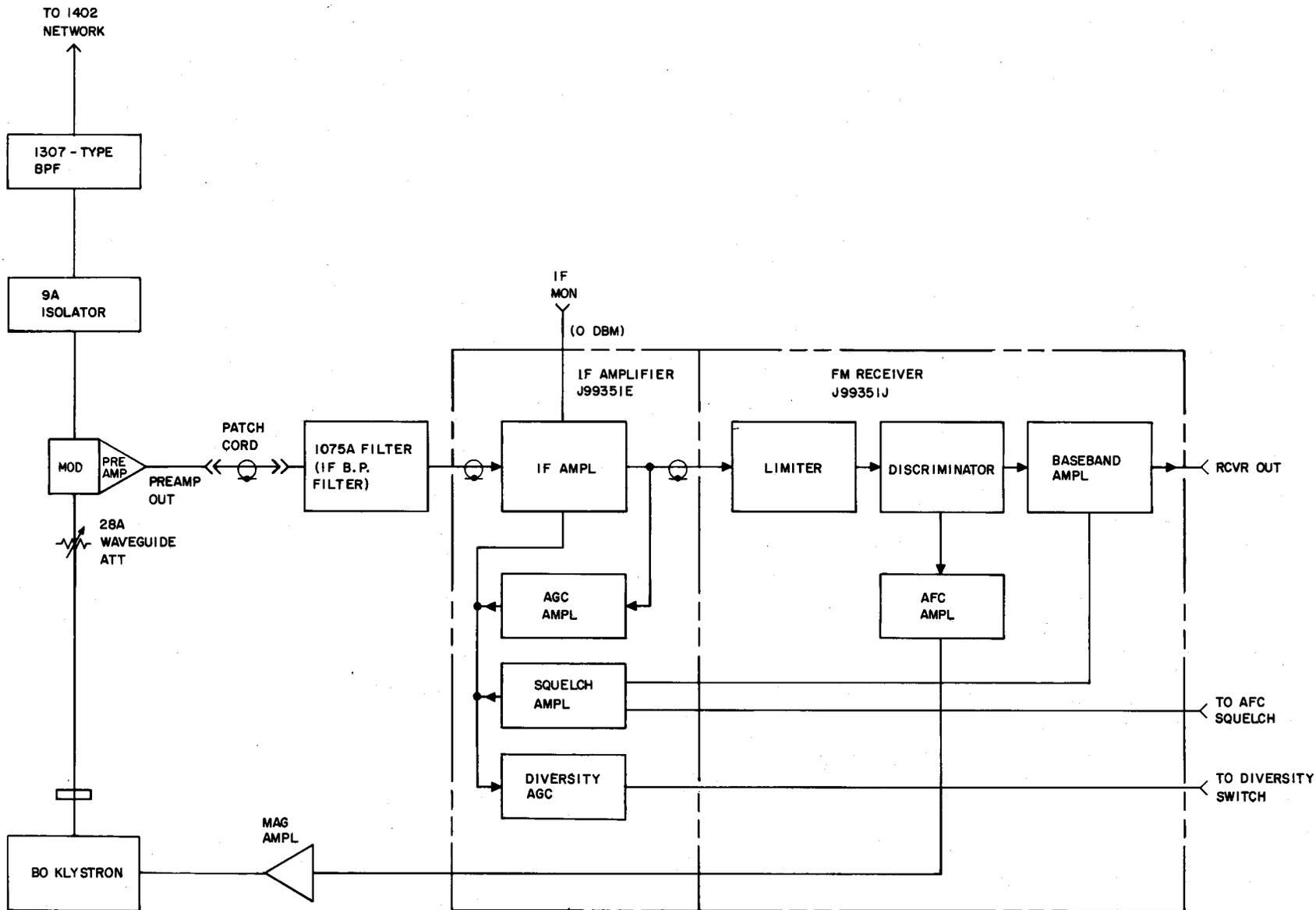


Fig. 25—Receiver Equipped With J99351E IF Amplifier Unit, J99351J FM Unit, and 1075A Filter—Block Diagram

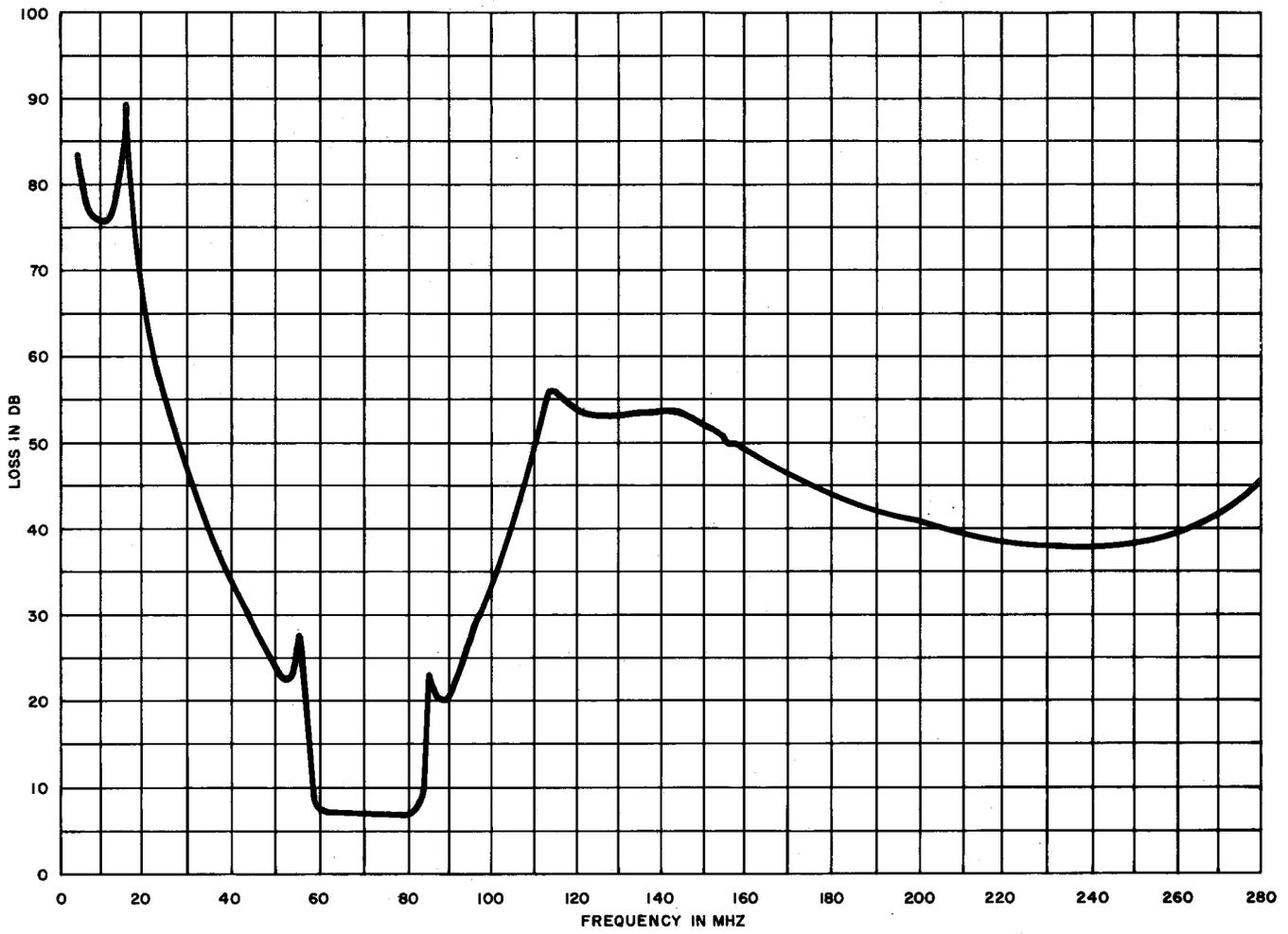


Fig. 26—1075A IF Bandpass Filter Insertion Loss Versus Frequency—Graph

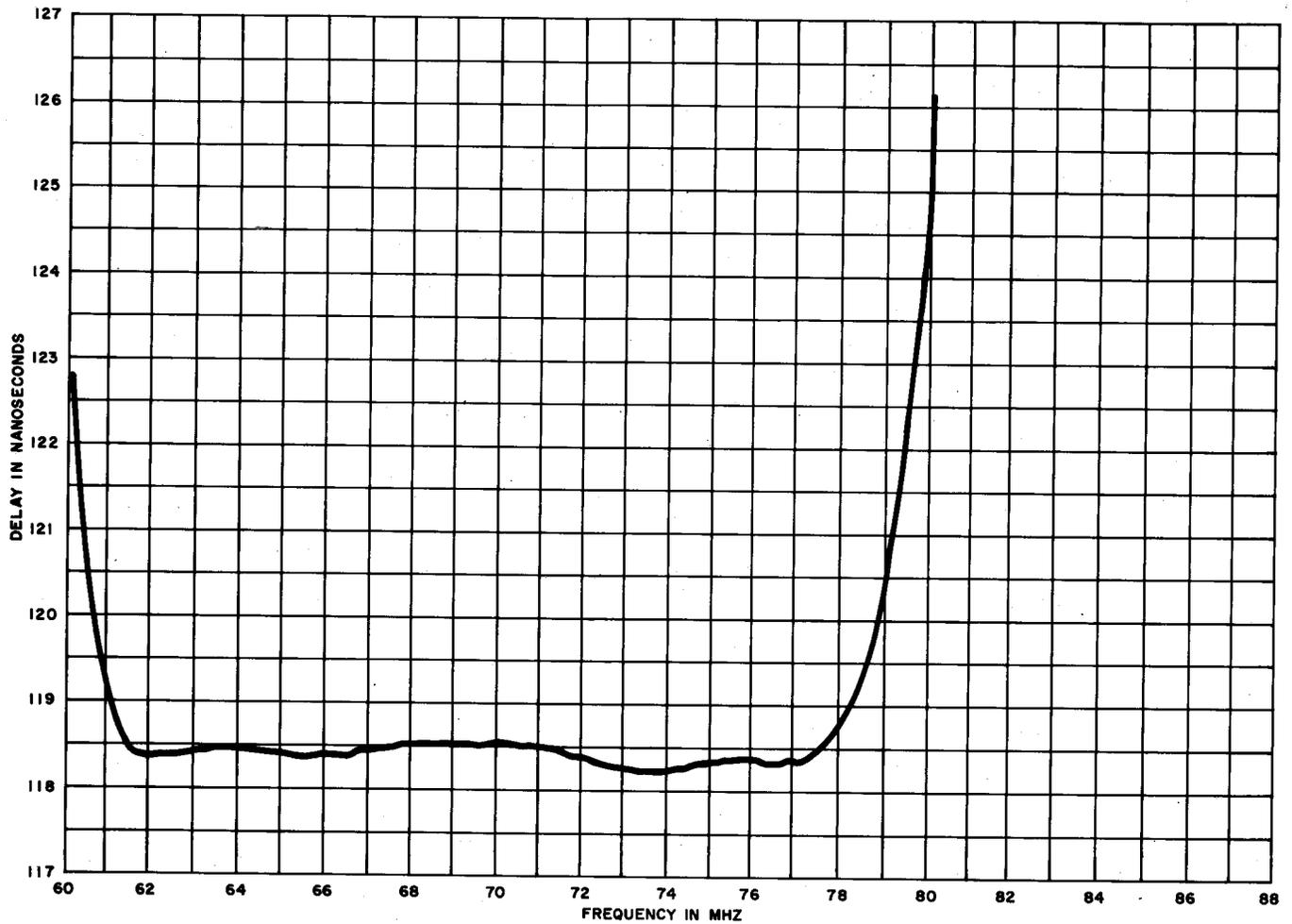


Fig. 27—1075A IF Bandpass Filter—Delay Versus Frequency—Graph

## 5. REFERENCE LIST

SD-97039-01

IF and Baseband Circuits

5.01 Reference is made to the following:

SECTION	TITLE
SD-97038-01	Transmitter-Receiver Panel