J68386A AND B TRANSMITTER-RECEIVER BAYS

DESCRIPTION

TD-3 MICROWAVE RADIO

1. GENERAL

A. Scope

1.01 This section describes the J68386A repeater station and J68386B main station transmitter-receiver (T-R) bays of the TD-3 Microwave Radio

System. An overall functional and physical description of the T-R bays is given in Part 1. Parts 2 through 17 describe each of the major units of the bays. The functional description portions are limited in scope to block diagram type descriptions. For more detailed information, refer to the applicable circuit description (CD) and schematic drawing (SD) listed in Part 18 of this section. For detailed coverage of engineering-type information pertaining to the T-R bays, refer to Section 940-382-102.

1.02 This section is reissued to add information on the 660( ) integrated circuit amplifier and the 713( ) radio frequency combiner and 95A control unit used in space diversity TD-3 systems. Revision arrows are used to emphasize the more significant changes.

B. Brief Description of TD-3 Microwave Radio System

1.03 The TD-3 Microwave Radio System is intended primarily for high capacity, long-haul routes carrying multichannel telephony, television, carrier telegraph, high-speed data, or other broadband signals. The system operates in the common-carrier frequency band between 3700 and 4200 MHz. Radio stations are spaced typically 20 to 30 miles apart, and they are placed at locations and elevations suitable for line-of-sight transmission. The system is designed to meet the current Bell System noise objective of 41 dBrnc0 worst-circuit noise for a 4000-mile system during nonfading conditions.

1.04 On a fully equipped route, twelve broadband radio channels are provided in each direction of transmission, which may be used as eleven working channels and one standby protection channel. The capacity of each channel is 1800 message circuits or one monochrome or National Television System Committee (NTSC) color television channel. Thus, a fully equipped route handling only telephone traffic can carry 19,800 message circuits. Provision is made for dropping or adding baseband signals through frequency modulation (FM) terminal equipment at main stations. For a more detailed description of the overall TD-3 Microwave Radio System, refer to Section 411-100-100.

C. Overall Description of Transmitter-Receiver (T-R) Bays

General

1.05 The microwave transmitter, microwave receiver, microwave generator, and −19 volt regulator constitute the basic building blocks for both the main station and repeater station type T-R bays. The transmitter and receiver are of the heterodyne type, operating on the microwave frequencies of the radio channel and the 70-MHz intermediate frequency (IF). The transmitted and received microwave frequencies differ by 40 MHz.

1.06 In a repeater station bay (Fig. 1), the microwave receiver and transmitter serve one direction of transmission only. The IF output of the receiver is connected directly to the IF input of the associated transmitter. A single microwave generator and a single −19 volt regulator serve both the receiver and transmitter. The microwave generator provides the local oscillator frequency required for the transmitter. A 40-MHz oscillator and shift modulator circuit is used in the receiver to shift by 40 MHz a portion of the generator output to obtain the local oscillator frequency required for the receiver.

1.07 In a main station bay, the microwave receiver and transmitter serve opposite directions of transmission. The IF output from the receiver and the IF input to the transmitter are connected to IF switching, patching, and distribution circuits in the station. The bay uses one microwave generator and one regulator for the receiver and a second generator and regulator for the transmitter to provide independent operation for the two directions of transmission. This arrangement improves overall system reliability and facilitates main station bay maintenance. Since separate generators are used, the 40-MHz difference required between the receiver and transmitter local oscillator frequencies is obtained by using generators which differ in output frequency by 40 MHz. This eliminates the need for a 40-MHz oscillator and shift modulator in a main station receiver. (As noted in Part 10, the early manufactured main station bays are equipped with a 40-MHz oscillator and shift modulator. In these bays, the two generators have the same output frequency.) In almost all other respects, the main station bay is identical to the repeater station bay.

PLASTIC COVER

RECEIVING CHANNEL SEPARATING NETWORK

IF DRIVER AMPLIFIER TRANSMITTER MODULATOR

TRANSMITTING CHANNEL COMBINING NETWORK

WAVEGUIDE CLAMP

IF MAIN AMPLIFIER

TERMINAL STRIP

IF CARRIER RESUPPLY

CHANNEL FILTER

IF LIMITER

40 MHZ OSCILLATOR SHIFT MODULATOR

AGC AMPLIFIER

RF DETECTOR

RECEIVER CONTROL UNIT

TRANSMITTER CONTROL UNIT

COMMON ALARM PANEL

RECEIVER MODULATOR IF PREAMPLIFIER

TWT AMPLIFIER

HEAT SINK

MICROWAVE GENERATOR (BEHIND COVER)

TWT POWER SUPPLY

BLANK SPACES-RESERVED FOR GENERATOR AND -19 VOLT REGULATOR ON A MAIN STATION BAY (BEHIND COVER)
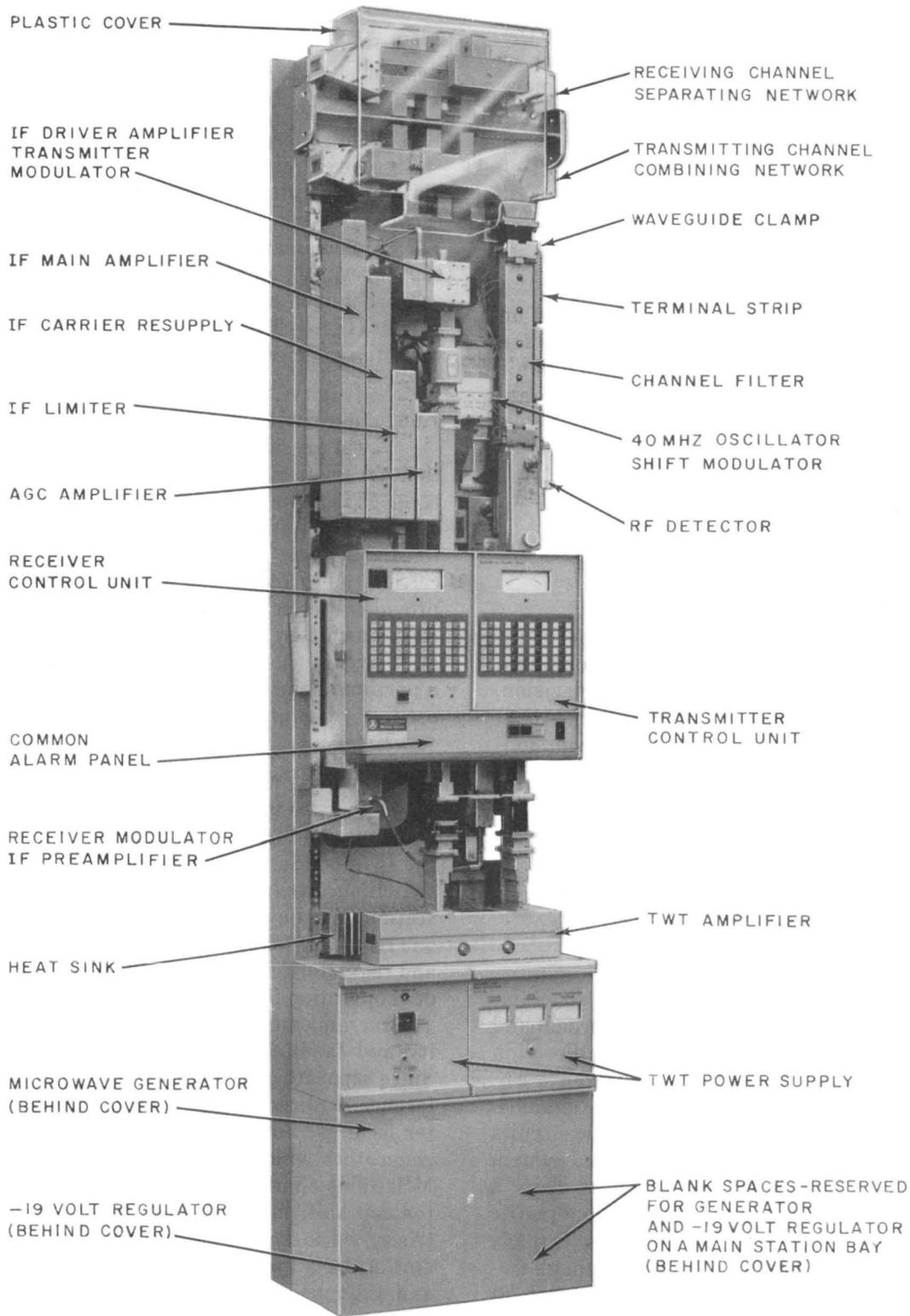
-19 VOLT REGULATOR (BEHIND COVER)

Fig. 1—TD-3 Repeater Station Transmitter-Receiver Bay

1.08 ♦Two equipment complements are available for use at both main and repeater stations. Original equipment includes a 461A traveling-wave tube (TWT) amplifier, plus the power supply, waveguide, and filters to serve this design. A later design provides for use of the solid-state 660(E/F) integrated circuit amplifier [660( ) IC] 5-watt output power amplifier, plus the waveguide and filters unique to this equipment array.♦ Unless otherwise indicated, all waveguide portions of the T-R bays use WR229 size waveguide. All IF circuits are 75-ohm input and output impedance and are interconnected with 728A coaxial cable.

Functional Description

1.09 The following descriptions of the microwave receiver, microwave transmitter, and microwave generator output power distribution circuit are concerned primarily with the functional operation of the equipment. In the illustrations associated with the descriptions, however, the functional block diagram is placed alongside an equipment layout diagram with corresponding elements of both diagrams oriented the same way. This is done to pictorially correlate the signal flow with the equipment arrangement of the various components in the bay.

1.10 Because of the similarity of the signal paths in the repeater station and main station bays, only the repeater station bay is described in the paragraphs that follow. However, some of the differences between the two types of bays that were noted in paragraph 1.07 are mentioned again where appropriate. The receiver that is described is assumed to be equipped with a J68387P receiver modulator and IF preamplifier. This unit is used in all but the earliest manufactured equipment (see paragraph 3.02).
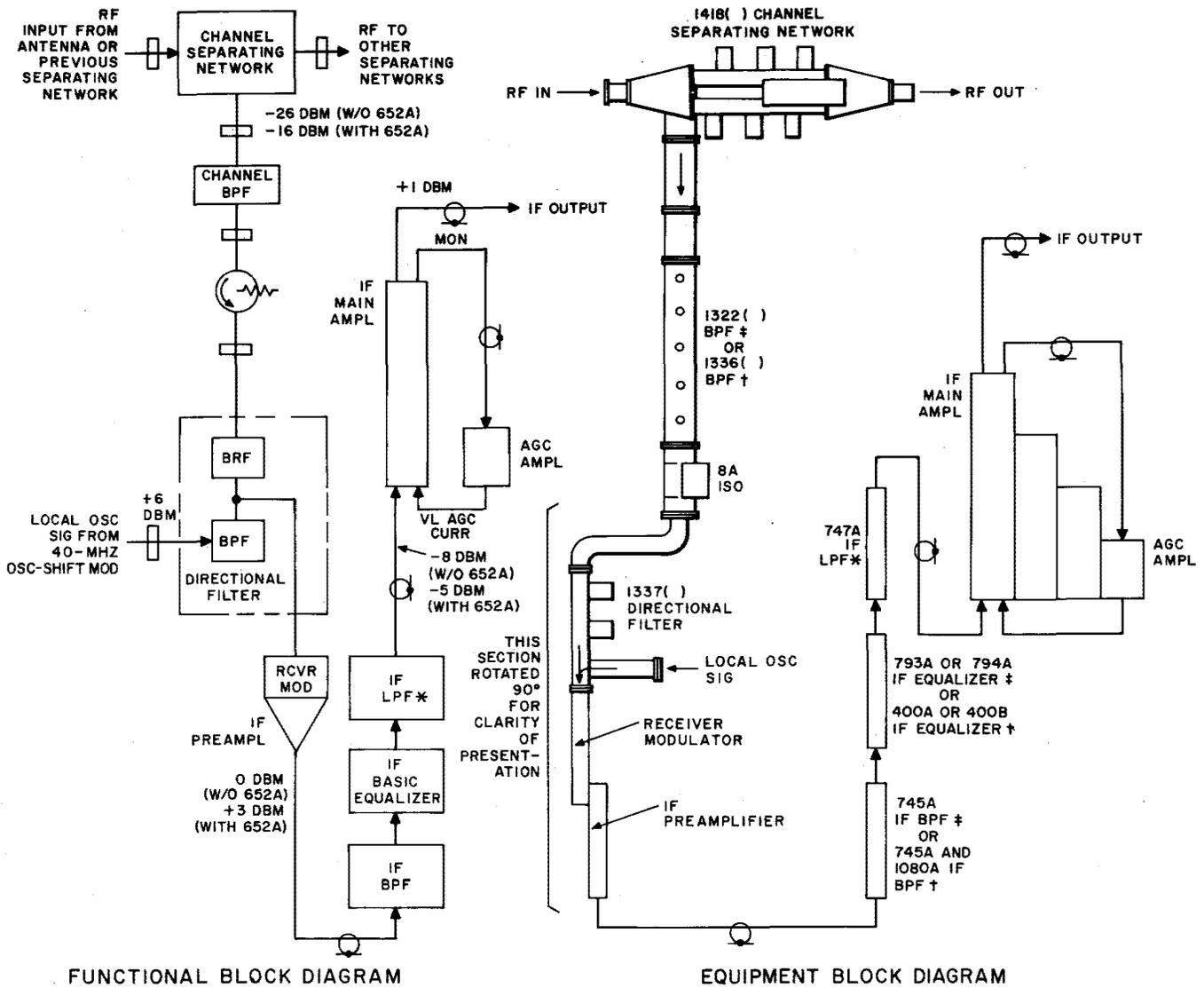
Microwave Receiver

1.11 The microwave receiver accepts an input signal from one of the 24 radio channels in the 3700- to 4200-MHz frequency range. At each station, the receiving antenna for each direction of transmission receives up to six horizontally polarized and six vertically polarized channels. The channels are separated in the antenna system by polarization and are applied through rectangular waveguide to separate T-R bay lineups, one for each polarization. Thus, each bay lineup may contain up to six T-R bays, one for each received channel of the particular polarization. The channel separating network (Fig. 2) in each T-R

bay selects a specific channel for application to the associated receiver and passes on to the succeeding T-R bays any remaining received channels outside the selected band. The received signal, shown in Fig. 2 at a typical level of −26 dBm (without 652A IC radio frequency (RF) preamplifier) or −16 dBm (with 652A IC RF preamplifier), is passed to a channel bandpass filter. This filter, which is tuned to the frequency of the selected channel, provides additional receiver discrimination (selectivity) against out-of-band signals. The channel bandpass filter (1322-type) originally used in the bay for 1200 circuit loading was found to contribute excessive delay distortion and cross-modulation noise for 1500 and 1800 circuit loadings. For these higher loadings, a wider bandpass unit (1336-type) is used.

1.12 The output of the channel filter is passed through an isolator to the band-rejection segment of a directional filter. One function of the isolator is to provide a good return loss over a wide bandwidth at the output of the channel filter to prevent undesirable impedance interactions between the channel filter and the directional filter. The local oscillator signal from the 40-MHz oscillator and shift modulator is applied to the bandpass segment of the directional filter. (The local oscillator signal in a main station receiver comes directly from a microwave generator instead of the 40-MHz oscillator and shift modulator.) The received and local oscillator signals differ in frequency by 70 MHz. Both the band-rejection filter and the bandpass filter segments of the directional filter are tuned to the local oscillator signal frequency. The band-rejection filter directs virtually all of the local oscillator signal toward the receiver modulator; the filter loss, together with the reverse loss of the isolator, provides high attenuation to that component of the local oscillator signal directed toward the antenna to prevent it from causing interference in other channels. The bandpass filter portion of the directional filter serves to direct virtually all of the received signal toward the receiver modulator and prevents all but a negligible portion of the signal from entering the local oscillator path.

1.13 The combined local oscillator and received signal output from the directional filter is applied to the input of the receiver modulator. The receiver modulator is an unbalanced-type downconverter which uses a single Schottky-barrier diode as the mixing element. The two RF input signals are mixed (or modulated) together in the diode, and the 70-MHz difference frequency product which

FUNCTIONAL BLOCK DIAGRAM   EQUIPMENT BLOCK DIAGRAM

* RELOCATED TO IF MAIN AMPLIFIER OUTPUT
  FOR 1500 AND 1800 CIRCUIT LOADING
† FOR 1500 AND 1800 CIRCUIT LOADING
‡ FOR 1200 CIRCUIT LOADING

Fig. 2—Microwave Receiver—Functional and Equipment Diagrams

is generated forms the desired IF output signal. This IF output signal is applied directly to the IF preamplifier. The preamplifier gain normally is adjusted to provide an IF signal level of either 0 dBm (without 652A IC RF preamplifier) or +3 dBm (with 652A IC RF preamplifier) at its output under nonfading conditions.

1.14   The output from the preamplifier is applied to the IF main amplifier through an IF bandpass filter, an equalizer, and a low-pass filter. The IF bandpass filter passes the IF band of frequencies between about 60 and 80 MHz with very little transmission distortion but provides high attenuation to the regions of 50 and 90 MHz. These out-of-band loss peaks further increase the overall selectivity of the receiver to protect it and the succeeding transmitter from the effects of adjacent channel carriers.

1.15   The IF basic equalizer compensates for both the amplitude and delay distortion introduced into each radio hop by the channel separating network and channel bandpass filter used in the receiver, and the channel combining network and channel bandpass filter used at the output of the preceding transmitter. These four microwave networks and filters introduce almost all of the inband transmission distortion in each radio hop. One of two codes of equalizers is used, depending on the frequency relationship between the received signal and the local oscillator signal. One code is used when the local oscillator frequency is above the received signal frequency; the other is used when the local oscillator frequency is below the received signal frequency.

1.16   The IF low-pass filter passes the IF band of frequencies between 60 and 80 MHz but attenuates the second- and third-order harmonics of the IF signal generated in the IF preamplifier. If not suppressed, these harmonics would generate excessive cross-modulation noise in the IF main amplifier.

1.17   The level of the signal applied to the IF main amplifier under nonfading conditions is either −8 or −5 dBm, depending on the IF preamplifier output power. The IF main amplifier works in conjunction with the automatic gain control (AGC) amplifier to maintain an output level of +1 dBm. Thus, when the input signal is at its nominal value of −8 or −5 dBm the gain of the IF main amplifier is 6 or 9 dB, respectively. The input to the AGC amplifier is an IF signal from the monitor output stage of the IF main amplifier. The AGC amplifier rectifies this signal

and applies the resulting dc signal as a control current to variolosser stages in the IF main amplifier. If the input signal fades, the operation of these circuits can cause the IF main amplifier to provide additional gain of up to 35 dB and still maintain the +1 dBm output power level. Any further reduction of the input signal level results in a corresponding reduction of the IF main amplifier output signal level.

1.18   Provision is made for installing a differential absolute delay equalization (DADE) cable and a delay distortion mop-up equalizer at the output of the IF main amplifier. (The DADE cable is used to build out all channels at a station to the same electrical length to avoid hits when switching between the working and protection channels.) The output signal is then padded down to approximately −7 dBm and delivered either to the radio transmitter in a repeater station bay or to the IF switching equipment at main stations.

Microwave Transmitter

1.19   The input to the transmitter ◆[Fig. 3 for bays equipped with the 461A TWT or Fig. 4 fór bays equipped with the 660( ) IC]◆ is an IF signal originating from the FM terminal equipment or from a previous receiver. The IF signal, at a nominal level of −7 dBm, is applied to an IF limiter-carrier resupply unit that removes any residual amplitude modulation that might be present on the input signal. This is done primarily to prevent the amplitude modulation from being converted to cross-modulation type noise by the succeeding circuits of the transmitter. The output of the IF limiter, also at −7 dBm since the limiter provides no net gain, is applied to the IF carrier resupply (CRS). With 1500 and 1800 circuit loadings, a noise figure improvement modification in the limiter resulted in an overall gain of ◆4.5 dB.◆ A ◆4.5-dB◆ pad is added between the limiter and CRS unit to maintain the −7 dBm input to the CRS unit.

1.20   The IF carrier resupply monitors the IF signal level at a point ahead of the limiting stage in the IF limiter. If the level drops below a predetermined value, the IF carrier resupply causes the IF limiter to introduce high loss in the signal path and substitutes for the regular signal a 70-MHz IF carrier modulated by either a 7- or a 9-MHz pilot. The substitute signal serves a dual purpose. The reinserted carrier prevents the subsequent receivers on the route from going to full gain with only a noise input, which otherwise would occur in the absence of the carrier

RF OUTPUT TO OTHER COMBINING NETWORKS OF ANTENNA ← CHANNEL COMBINING NETWORK ← RF FROM OTHER COMBINING NETWORKS

61A DETR → TO CONTROL PANEL

+37 DBM

IF DR AMPL

-7 DBM

TRMTR MOD ← +20 DBM FROM MWV GEN

BPF

DIR CPLR 28 DB

8A ISO

BPF

MON

ATTEN 0-13 DB

IF CARR RESUP

IF LIM

-7 DBM

LPF

8A ISO +5 DBM

8A ISO

-7 DBM*

TUN

TUN

IF IN

-26 DBM†

5 DB PAD

TWT

TWT POWER SUPPLY -24 VOLTS

1418( ) CHANNEL COMBINING NETWORK

RF OUT ← ← RF IN

IF DR AMPL

MON

TRMTR MOD

8A ISO

FROM MWV GEN

1322( ) BPF* OR 1336( ) BPF†

IF CARR RESUP

IF LIM

1336( ) BPF

TO CONTROL PANEL

61A DET

24B DIR CPLR

†19 DB PAD

IF INPUT

1326A LPF

* 1200 CIRCUIT LOADING

† 1500 AND 1800 CIRCUIT LOADING

31A ATTEN

8A ISO

8A ISO

400 AY TUNER

400 AY TUNER

32A TRDCR

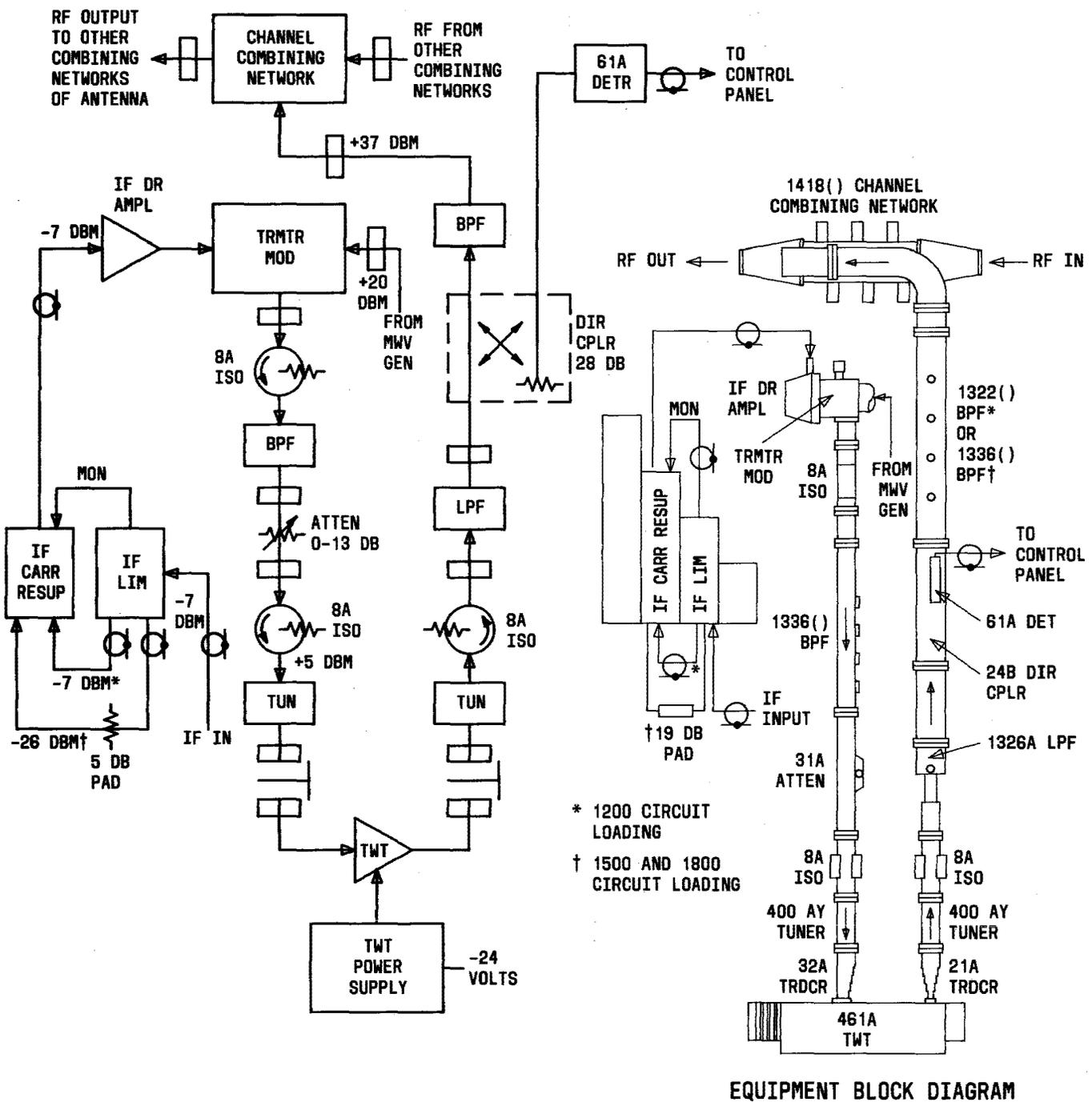21A TRDCR

461A TWT

EQUIPMENT BLOCK DIAGRAM

Fig. 3—Microwave Transmitter Equipped With TWT—Functional and Equipment Diagrams

and which, in turn, could cause excessive noise spillover into the adjacent channels. The pilot modulation on the carrier (9 MHz on working channels and either 7 MHz or 9 MHz on protection channels) prevents the 100A Protection Switching System from switching service to the channel while the carrier resupply is operating. (See Part 6 for additional information on the pilot frequency for the protection channels.)

1.21 The IF output from the carrier resupply (either the regular signal or the reinserted signal) is applied to the amplifier section of the IF driver amplifier and transmitter modulator. The purpose of this circuit is to shift (or "up-convert") the IF signal to the transmitter channel frequency. The driver amplifier raises the level of the IF signal and applies it to each of the two varacter diodes used in the balanced-type transmitter modulator. The local oscillator signal for the transmitter modulator, at a frequency either 70 MHz above or below the transmitter channel frequency, is obtained from a microwave generator. The IF and local oscillator signals are mixed (modulated) together in the diodes. The output products of the modulator include signals centered at the local oscillator frequency plus 70 MHz and the local oscillator frequency minus 70 MHz. A bandpass filter, tuned to the transmitter channel frequency, passes one of these products and rejects all others.

1.22 ♦Two equipment options are available at this point in the transmit bay. Development of the 5-watt version of the solid-state 660( ) IC has made it possible to replace the 400AY tuners, 21A transducer, 32A transducer and the TWT, and the TWT power supply with a 660( ) amplifier. In bays equipped with a TWT,♦ the output from the filter is connected through a variable attenuator, an isolator, and a tuner to the TWT amplifier. The attenuator is used to adjust the drive to the amplifier to obtain the required transmitter output power. The isolators preceding and following the bandpass filters are used to absorb unwanted products from the modulator and to prevent undesirable impedance interaction between the connected circuits. The tuner is used as an impedance matching device to permit delivering maximum power to the TWT amplifier.

1.23 The output of the TWT amplifier is connected through a tuner and an isolator to a low-pass filter. The tuner is used to optimize the transmission flatness through the TWT amplifier, and the isolator

serves to provide a good return loss looking toward the amplifier from the transmitting antenna. The low-pass filter passes the output signal in the 4-GHz band but provides high attenuation to the second and third harmonics of the signal generated in the TWT amplifier.

1.24 The output of the low-pass filter is passed through a directional coupler on the sidearm of which is connected an RF detector. The detector monitors the RF signal for transmitter output power alarm purposes. The signal is next applied to a channel bandpass filter that passes only the 20-MHz band of frequencies to be transmitted. This filter provides additional attenuation to unwanted products from the transmitter modulator to prevent them from causing interference into other channels. As in the receiver, the original filter (1322-type) was found to contribute excessive delay distortion and cross-modulation noise for the increased circuit loadings. Thus, for 1500 and 1800 circuits, a 1336-type filter is used. The output from the filter is applied to the channel combining network where it is added to other signals from other transmitters and sent via a common waveguide run to the transmitting antenna. The output from the transmitter is approximately +37 dBm (5 watts) at the input to the channel combining network. The TWT electrode voltages are supplied by the TWT power supply. This supply is a solid-state dc-to-dc converter which converts the −24 volt input voltage from the station battery supply to the various voltages required by the TWT.

1.25 ♦In bays equipped with the solid-state 600( ) IC (Fig. 4), the output of the 8A isolator is connected to the 660( ) IC which provides an output of + 37 dBm. The output of the amplifier is connected to the 8A isolator and then to the low-pass filter. The output from the low-pass filter passes through a 24B directional coupler and passive waveguide units to the channel combining network.

Microwave Generator Signal Distribution in a Repeater Station Bay

1.26 Figure 5 is a block diagram and equipment layout showing the distribution of the microwave generator output signal in a repeater station bay. The coaxial cable output from the microwave generator is coupled to the waveguide line through a coaxial-to-waveguide transducer. The signal is fed through an isolator and variable attenuator to a directional coupler. Here the signal splits, a portion
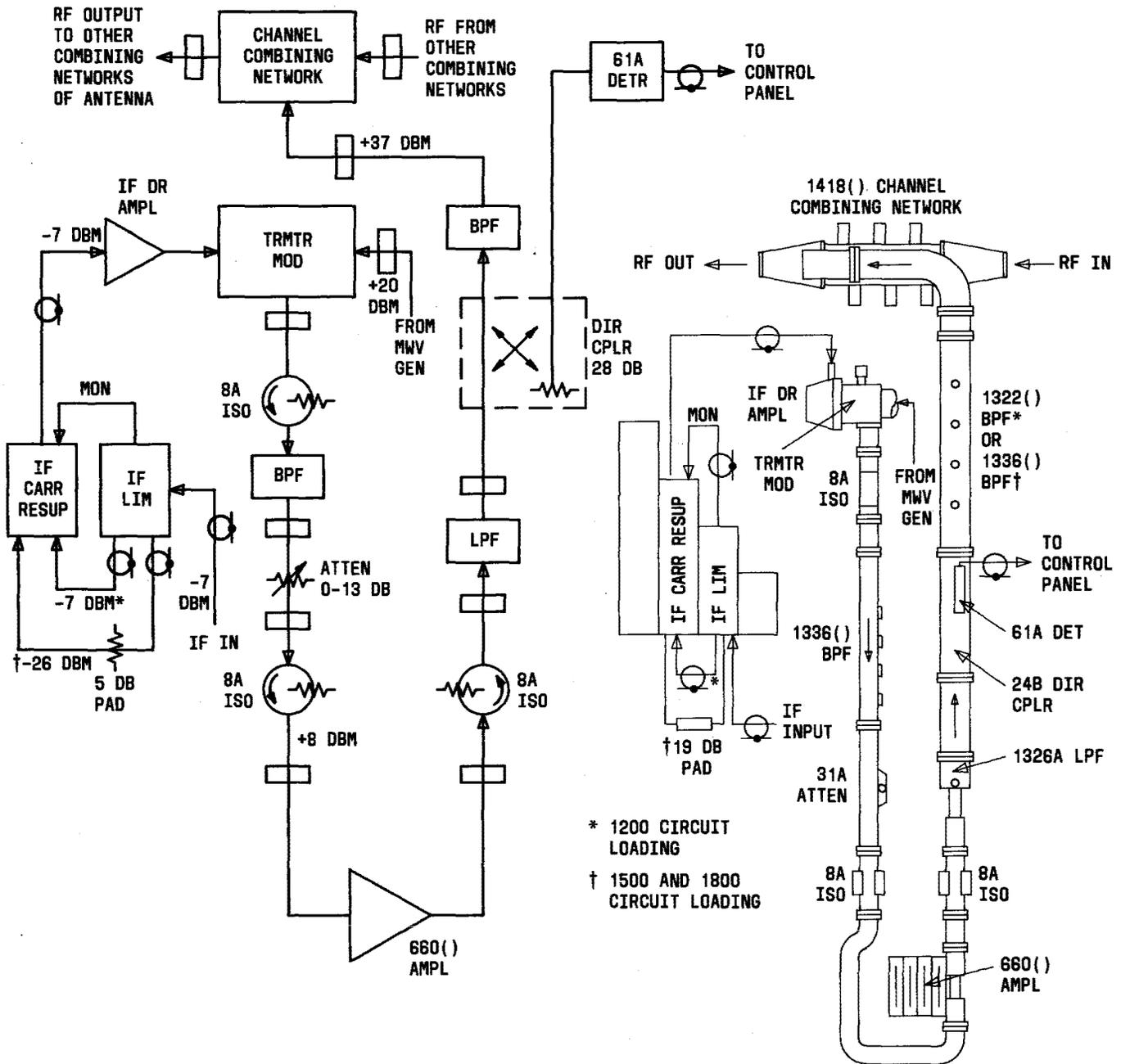
Fig. 4—◆Microwave Transmitter Equipped With 660( ) Amplifier—Functional and
Equipment Diagrams◀

going to the transmitter circuit and a portion going to the receiver circuit. The variable attenuator is used to set the power of the generator output signal applied to the transmitter and receiver circuits. The isolator serves to provide a good return loss looking back toward the generator from the rest of the distribution circuits.◀

1.27 The transmitter portion of the signal is applied through a directional coupler to the local oscillator input arm of the transmitter modulator. An RF detector connected to the sidearm of the directional coupler is used to monitor the microwave generator signal for output power alarm purposes. The reverse loss of the isolator serves to attenuate unwanted products generated in the transmitter modulator and directed back toward the generator.

1.28 The receiver portion of the microwave generator signal is applied through an isolator to the 40-MHz oscillator and shift modulator. The reverse loss of the isolator absorbs unwanted products generated in the shift modulator and directed back toward the generator. The output of the shift modulator includes two signals, one 40 MHz above and one 40 MHz below the microwave generator frequency. The bandpass filter rejects the undesired output and passes the selected signal through an isolator, variable attenuator, and a directional coupler to the receiver directional filter. The variable attenuator is used to set the power of the signal applied to the receiver directional filter. The cap on the directional coupler is removable for test purposes to permit measuring this power. The isolator is used to prevent impedance interaction between the bandpass filter and the directional filter.

Equipment Description

1.29 The transmitter and receiver components (Fig. 1) are mounted on a single 9-foot high, 19-inch unequal flange, duct-type framework about 22-1/2 inches wide and 15-1/2 inches deep. The bays can be positioned either back to back or against a wall. All equipment is accessible and removable from the front of the bay.

1.30 In a repeater station bay, the lower compartment of the base of the bay houses one microwave generator and one −19 volt regulator. The compartment is provided with sufficient space to house the second microwave generator and −19 volt regulator which are required in a main station bay.

These units are located behind a front cover as shown in Fig. 1. ◆The upper compartment of the base is not used when the bay is equipped with the solid-state 660( ) IC. When the TWT power amplifier is used,◀ the upper compartment of the base contains the TWT power supply. The power supply consists of two units: the inverter and heater regulator unit on the left and the rectifier and helix regulator unit on the right side. An internal cable from the rectifier and helix regulator unit supplies the operating voltages to the TWT amplifier, which is mounted directly above the power supply. The tube is completely enclosed in the TWT amplifier package which, in turn, is bolted to a cooling block mounted on the bay uprights. The collector of the TWT is thermally coupled to the cooling block. This conduction cooling arrangement keeps the TWT operating temperature at approximately 150°F. The RF input and output connections to the TWT amplifier are made through transducers that match the regular-height waveguide to the reduced-height waveguide required by the TWT.

1.31 The transmitter control unit, receiver control unit, and common alarm panel are housed in a door-like frame near the middle of the bay. The receiver control unit is on the left, the transmitter control unit is on the right, and the common alarm panel is across the bottom. The frame is hinged on the right-hand side and swings open to provide access to the apparatus located behind the frame and to the meter-type alarm relays that are visible through openings on the rear of the frame.

1.32 The IF main amplifier, the IF carrier resupply, the IF limiter, and the AGC amplifier are mounted on a door-like framework above the control unit assembly on the left side of the bay. The framework assembly is hinged on the left side and swings open to expose the connectors at the rear of the IF units and the waveguide apparatus behind the door.

1.33 The channel combining and channel separating networks are attached to an aluminum casting at the top of the bay. The dropping and combining arms are connected through waveguide to the apparatus of the receiving and transmitting circuits, respectively. The plastic cover placed over the network is intended to protect the networks from falling tools or other objects during installation activity.

1.34 The IF driver amplifier and transmitter modulator is centrally located below the channel

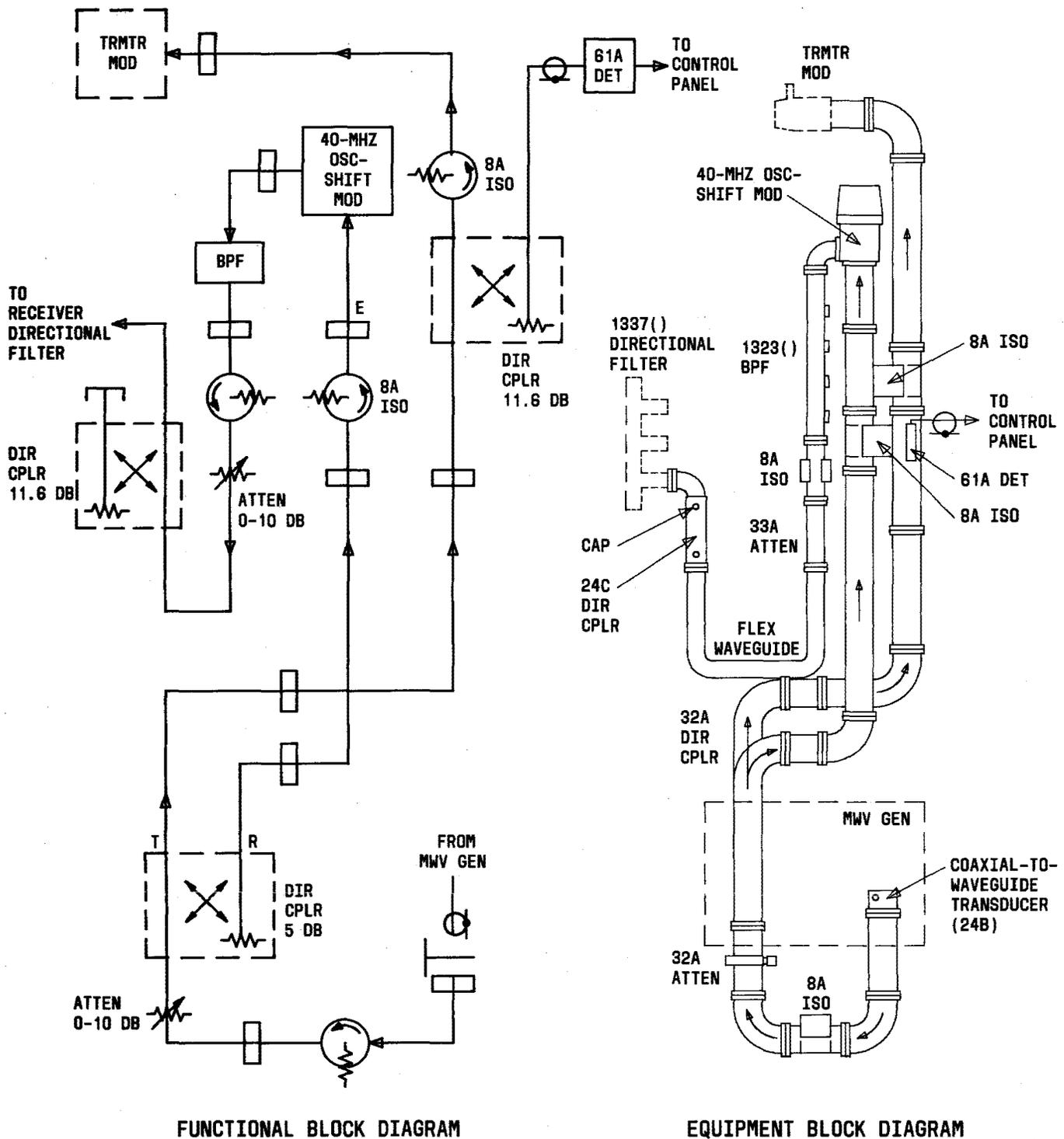FUNCTIONAL BLOCK DIAGRAM   EQUIPMENT BLOCK DIAGRAM

Fig. 5—Repeater Bay Microwave Generator Signal Distribution—Functional and Equipment Diagrams

networks. The 40-MHz oscillator and shift modulator is below and to the right rear of the transmitter modulator. The receiver modulator and IF preamplifier is mounted below the common alarm panel.

D. ▶RF Combiner and Control Unit

1.35 The TD-3 bays may be equipped for space diversity operation by adding the 713( ) radio frequency (RF) combiner and associated 95A control unit at the top of the bay as shown in Fig. 1. The RF combiner is covered in Section 410-410-100, and the waveguide DADEing procedures required where the RF combiner is used are covered in Section 422-500-501.◀

2. 652A RF PREAMPLIFIER

GENERAL

2.01 The 652A RF preamplifier is a solid-state fixed gain, factory aligned, broadband amplifier designed for use in the common receiving waveguide runs of the TD-type microwave radio systems (Fig. 6). The preamplifier is common to all received channels in a 6-bay lineup and has a typical insertion gain of 10 dB when powered, and a maximum insertion loss of 13 dB when unpowered.

2.02 The 652A RF preamplifier is required on 1800 circuit channels for thermal noise and fade margin improvement on any hop having a normal received carrier power less than −24 dBm, as measured or calculated at the first equipped bay facing the regular antenna. Two 652A RF preamplifier units
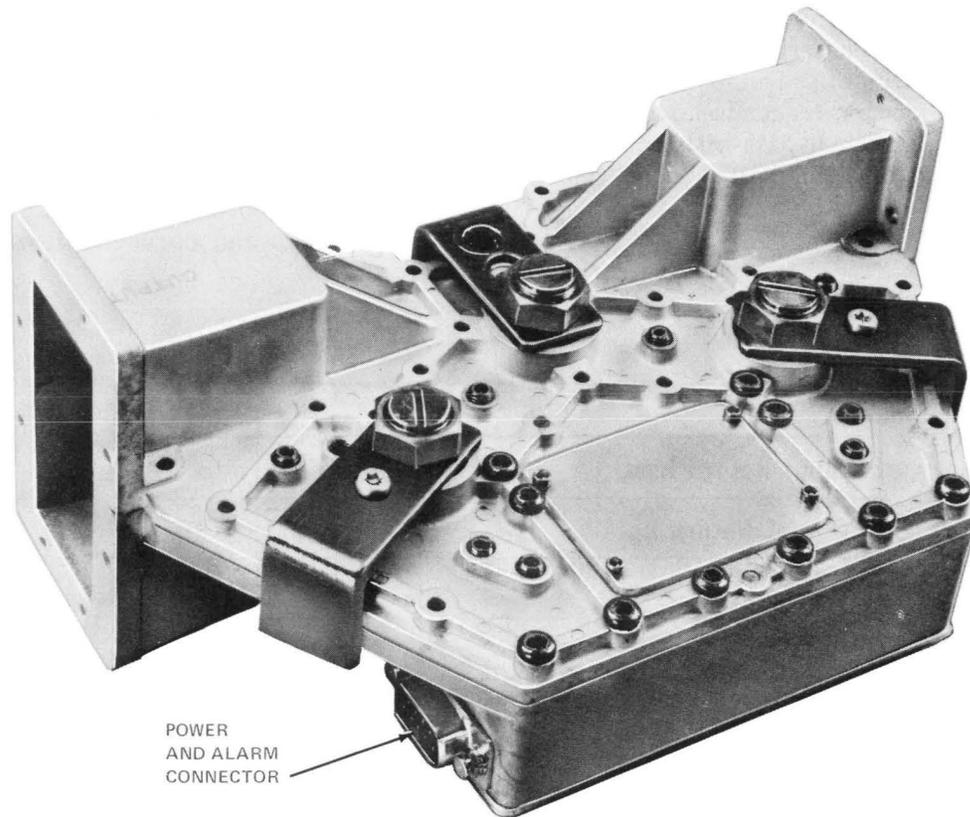

POWER
AND ALARM
CONNECTOR

Fig. 6—652A RF Preamplifier

are required per bay lineup in stations where a space diversity antenna is provided. One preamplifier is required for the regular common waveguide run and another for the diversity common waveguide run.

2.03 The low noise figure (typically 1.8 dB) and moderate gain (typically 10 dB) of the 652A RF preamplifier combine to reduce the overall noise figure of the TD-3 repeater by about +3 dB. For 1800 circuit loading, the 652A IC should be used on hops having received carrier powers up to −24 dBm to meet noise and fade margin objectives. (This upper limit assumes that all of the TD-3 transmitters are operating at a 5-watt output). The 652A IC should not be used if the normal received carrier power is greater than −23 dBm. At inputs above −23 dBm, third-order intermodulation noise generated within the 652A IC, involving cross-products of the up-to-six received signals in the common receiving waveguide run, largely offsets the thermal noise improvement and thus negates the benefit of using the 652A IC.

2.04 The preamplifier operates from a −24 Vdc power supply at 45 milliamperes. In case of dc power supply or internal circuit failure, a contact to ground is provided which energizes a remote alarm. When the 652A RF preamplifier is unpowered or internal circuit failure occurs, transmission is maintained by means of a passive bypass within the unit that yields a maximum insertion loss of 10 dB (typically 5 to 8 dB). Table A lists typical performance of the preamplifier.

FUNCTIONAL DESCRIPTION

2.05 A gallium arsenide field effect transistor (GaAs FET) is the major amplifying component in the 652A RF preamplifier. Inside the 652A unit (Fig. 7), the GaAs FET is mounted in a microstrip circuit which allows easy mounting of the transistor and dc-blocking capacitors. The amplifier module has no field adjustments. Tuning screws near the input and output of the module and in the circulator arms are used to factory adjust the preamplifier for optimum noise figure and gain flatness. This feature compensates for variations in transistor parameters as well as for manufacturing tolerances of the piece parts.

2.06 The 652A RF preamplifier contains three circulators assembled in an air dielectric stripline. One circulator is used at the input and another at the output to provide a good return loss (greater than 25 dB) over the 4-GHz band. The third circulator is connected between the other two to form the passive bypass path for fail-safe operation.

EQUIPMENT DESCRIPTION

2.07 The 652A preamplifier circuit is assembled in a 2-piece, die-cast aluminum housing. The aluminum housing and major piece parts are die-replicated so as to fit together with minimal assembly effort. On the bottom side of the lower housing is a power regulator and alarm circuit where the cable

TABLE A

	MAX	MIN	UNITS
Input Return Loss	—	25	dB
Output Return Loss	—	25	dB
Noise Figure	2.0	—	dB
Gain	11.0	8.0	dB
Gain Flatness	±0.5	—	dB
Intermodulation (2A-B Intercept)	—	23	dBm
Unpowered Insertion Loss	13	—	dB
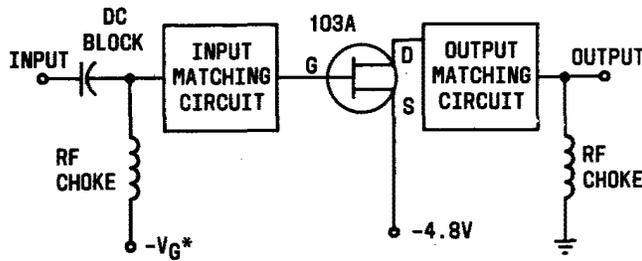
* V_G AUTOMATICALLY ADJUSTED FOR I_{DS} = 15mA

Fig. 7—652A RF Preamplifier—Amplifier Module

plug is located, as shown in Fig. 6. Refer to Section 420-802-100 for further description and installation procedures of the preamplifier.

3. RECEIVER MODULATOR AND IF PREAMPLIFIER

GENERAL

3.01 The receiver modulator and IF preamplifier serves two main functions. The modulator portion of the circuit is used to shift (or "down-convert") the received microwave signal to the 70-MHz IF band. The IF preamplifier provides gain to make up for the loss of the modulator and raise the level of the signal sufficiently for delivery to the succeeding circuits of the receiver.

3.02 One of two types of receiver modulator and IF preamplifiers is used in the receiver. The J68387C model, which has a balanced-type (2-diode) modulator section, is the older of the two and was furnished with the first 265 transmitter-receiver bays that were manufactured. The J68387P model, which has an unbalanced (single diode) modulator section, has been used in all subsequent production.

3.03 The two models of receiver modulator and IF preamplifier have similar performance characteristics except for noise figure and nominal output power. The J68387P model has a lower noise figure, typically about 7 dB as compared to 10.5 dB for the J68387C model. If no waveguide RF preamplifier is used, the normal output power of the J68387P model is 0 dBm as compared to −7 dBm for the J68387C model. Both units are designed to work with normal received carrier power inputs up to approximately −17 dBm and still provide the 0 and −7 dBm power

output. If a waveguide RF preamplifier is used, the input power to the modulator can go as high as −14 dBm, but the output of the IF preamplifier is set to +3 dBm to reduce distortion generated in the units. Local oscillator input power required for the J68387P unit is typically +6 dBm, and for the J68387C unit about +3 dBm.

J68387P RECEIVER MODULATOR AND IF PREAMPLIFIER

A. Functional Description

3.04 Figure 8 is a block diagram of the overall downconverter circuit consisting of a 1337-type waveguide directional filter and the J68387P receiver modulator and IF preamplifier. The received signal and local oscillator signal are combined in the waveguide directional filter. Refer to Part 17F for a description of the filter. The combined signal output of the filter is fed through a step transducer and waffle-iron low-pass filter to the diode modulator where mixing of the two signals takes place. The IF output signal from the diode (that is, the 70-MHz difference frequency between the received signal and the local oscillator) is fed through a coaxial low-pass filter to the IF preamplifier.

3.05 The semiconductor device used for RF-to-IF downconversion in the modulator is a gallium arsenide Schottky-barrier diode. This diode has a low-noise figure and is an efficient, low conversion loss, microwave mixer. The conversion loss, and therefore noise figure, of the modulator is dependent on the dc bias applied to the diode. The diode bias is obtained from the −19 volts available in the IF preamplifier through a potentiometer control (DIODE BIAS). The optimum bias for each unit for operation at 4010 MHz (channel 4B) is determined at the factory and stamped on the modulator block. The appropriate maintenance practice gives the correction factors to apply to the stamped bias value when using the modulator on other frequencies.

3.06 Second and third harmonics of the local oscillator signal are generated in the modulator diode. These harmonics, if allowed to reach the receiving common waveguide run, can cause interference in other receivers, particularly those in the same bay lineup. The harmonics are too high in frequency to be effectively attenuated by the isolator or filters in the external circuit preceding the modulator. A waffle-iron type low-pass filter is used ahead of the diode, therefore, to attenuate these harmonics before
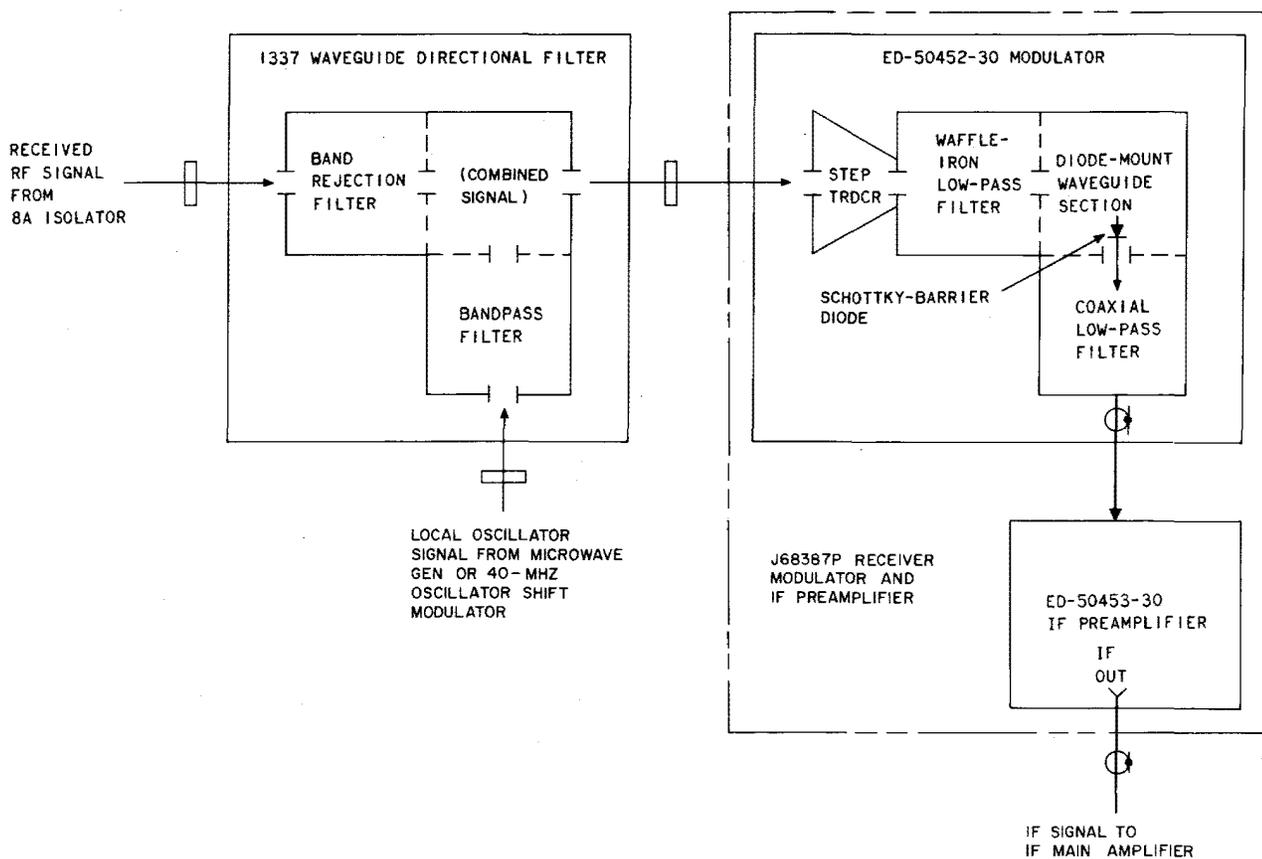
Fig. 8—Receiver Downconverter—Preamplifier—Block Diagram

they leave the modulator input. This filter has a cut-off frequency of about 6 GHz and provides typically more than 50 dB loss to the second and third harmonics. The loss introduced across the 4-GHz band is negligible.

3.07 The coaxial low-pass filter which follows the diode has a cutoff frequency of 2460 MHz. This filter passes the IF signal to the preamplifier with virtually no loss but introduces more than 40-dB attenuation between 3.7 and 8.4 GHz. The filter is necessary to prevent the input signals as well as the many RF products that are generated in the diode from causing interference and overloading effects in the IF preamplifier.

3.08 The IF preamplifier is a transistorized, 5-stage amplifier. Because the signal level is lowest at the input to the IF preamplifier, the noise figure of the entire receiver is affected significantly by the noise figure of the IF preamplifier. The noise figure of the preamplifier, in turn, is dependent mainly on the first stage. This stage uses a transistor having a noise figure of 2.5 dB or less and provides a gain of approximately 17 dB at 70 MHz to mask the noise contribution of the following stages. The overall noise figure of the preamplifier is typically about 2.5 to 3.0 dB.

3.09 There are four controls on the preamplifier: DIODE BIAS, SHAPE, SLOPE, and LEVEL. The DIODE BIAS control is used to set the bias on the receiver modulator diode as described in paragraph 3.05. The SHAPE and SLOPE controls are adjusted to obtain a flat amplitude response from the receiver modulator input to the preamplifier output. The LEVEL control is used to set the power output of the preamplifier.

B.   Equipment Description

3.10   The receiver downconverter—preamplifier assembly (Fig. 9) consists of two units, the 1337-type waveguide directional filter and the J68387P receiver modulator and IF preamplifier. A description of the directional filter is given in Part 17F.

3.11   The receiver modulator (Fig. 10) contains four main components: a die-cast housing, a collet assembly, the diode, and the coaxial low-pass filter. Figure 10 is a simplified mechanical schematic of how the modulator components fit together.

3.12   The receiver modulator diode section and waffle-iron filter require reduced height waveguide to obtain the desired performance. Thus, a waveguide transducer is needed at the receiver modulator input to transduce from full-height waveguide (1.145 inches) to the reduced height (0.090 inches) used in the filter and diode sections. The transducer, waffle-iron filter, and diode section are formed in a die-cast housing (Fig. 10) consisting of two cast aluminum halves fastened together with machine screws. Features of the transducer and the waffle-iron low-pass filter are apparent in Fig. 10. The transducer is a conventional 3-step design.

3.13   The collect assembly consists of a beam spring and collet. The collet tightly holds one end of the diode. The other end of the diode plugs into a holder on the flange end of the coaxial low-pass filter. The collet assembly enables the diode to be replaced easily without any further dismantling of the modulator.

3.14   The coaxial low-pass filter is shown in Fig. 12. One end of the inner conductor serves as a receptacle for one end of the modulator diode. The other end is soldered to the input circuit of the IF preamplifier.

3.15   The IF preamplifier uses conventional printed wiring construction and is assembled in a die-cast aluminum housing. The housing, in turn, is attached to the die-cast modulator housing with machine screws. The modulator and IF preamplifier are not designed to be separated in the field but instead are kept together as a complete assembly. The overall assembly measures approximately 11 by 4 by 5 inches and weighs about 3-1/2 pounds.
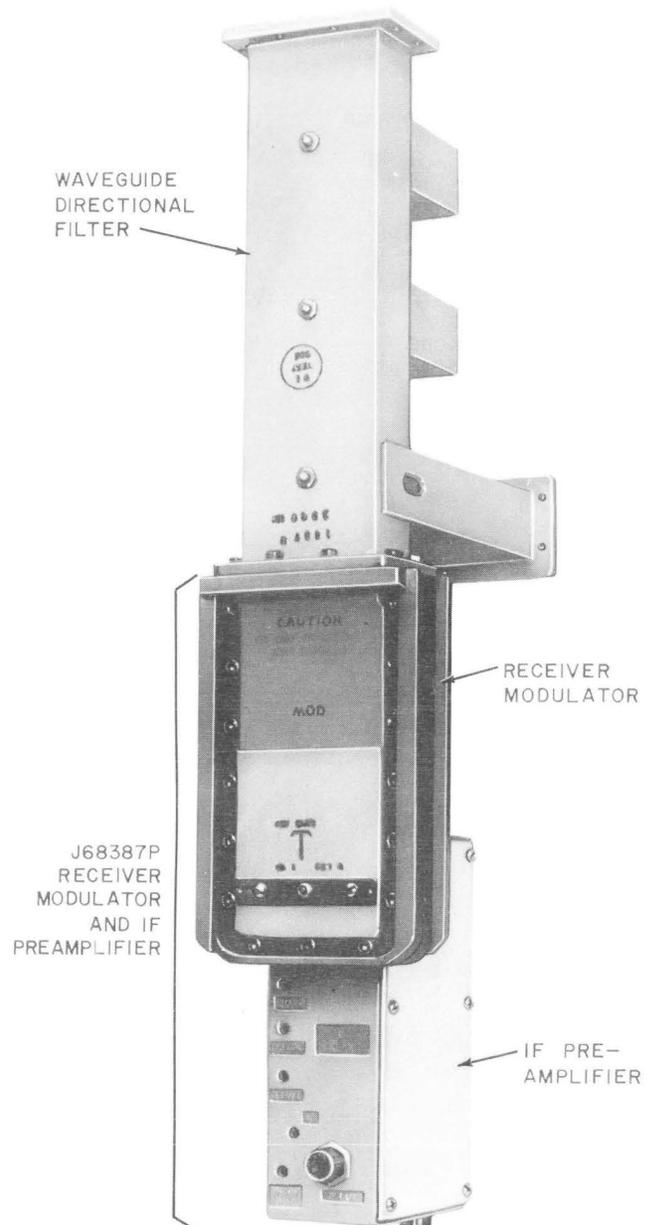

Fig. 9—Receiver Downconverter—Preamplifier Assembly

J68387C RECEIVER MODULATOR AND IF PREAMPLIFIER

A.   Functional Description

3.16   In the J68387C unit (Fig. 13), the received signal and local oscillator signal are combined in a waveguide magic-T hybrid junction. The
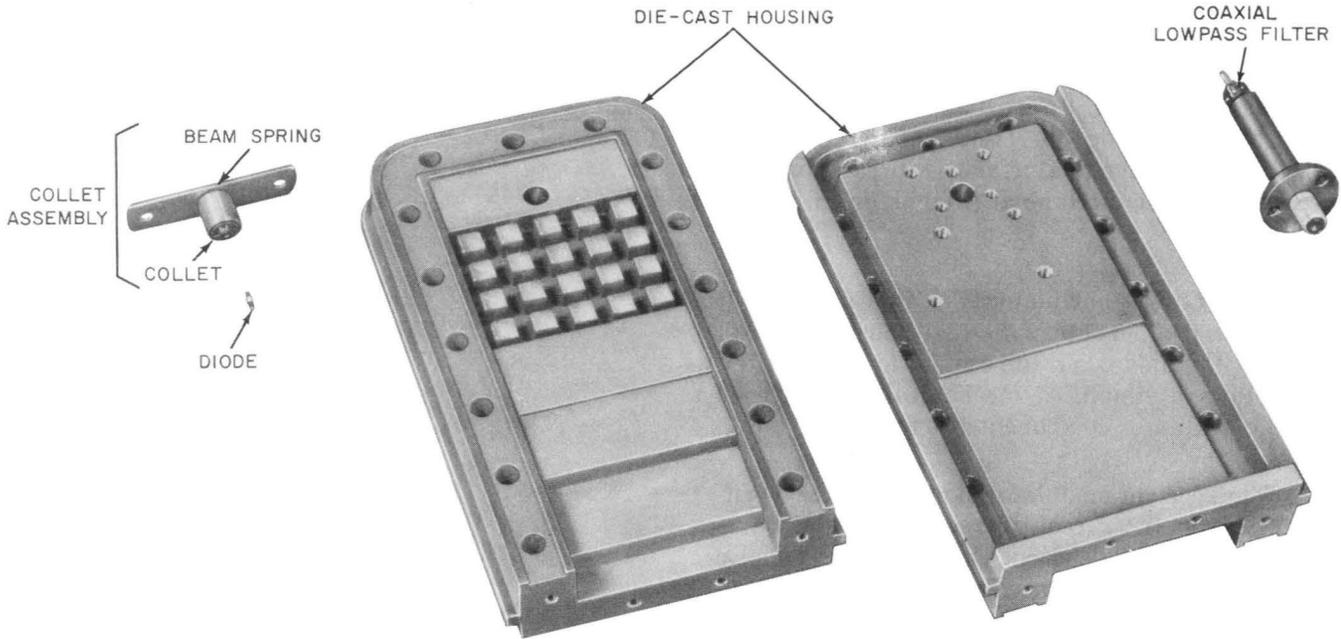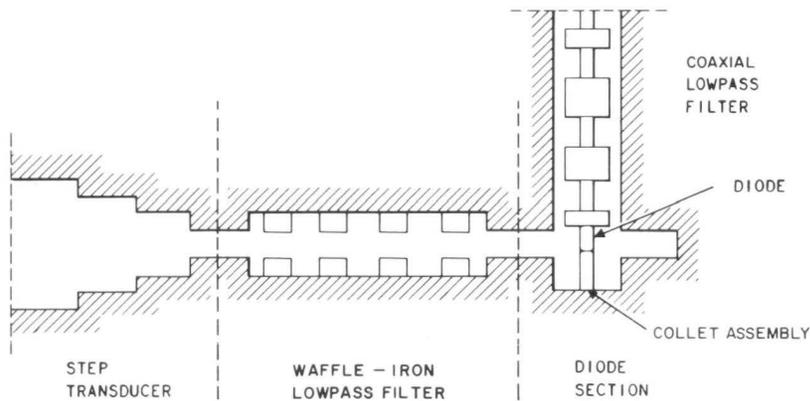
Fig. 10—Receiver Modulator Components

Fig. 11—Cross-Section of Receiver Modulator

downconversion from RF to IF takes place in a balanced modulator circuit using two matched diodes. The resulting IF output signals from the diodes are combined and amplified by the IF preamplifier.

3.17 In a magic-T hybrid junction having equal impedances connected to the sidearms (arms 1 and 2, Fig. 13), energy applied to either the E arm or H arm divides equally between the sidearms; and virtually no energy emerges from the opposite arm. The received signal from the 8A isolator is applied to the H arm of the hybrid; the local oscillator signal at a frequency 70 MHz away from the received signal is applied to the E arm. The received signal is split by the hybrid into two in-phase signals. Each of these signals is then applied through a waveguide-to-coaxial transducer to a coaxial-T structure containing one of the modulator diodes. The local oscillator
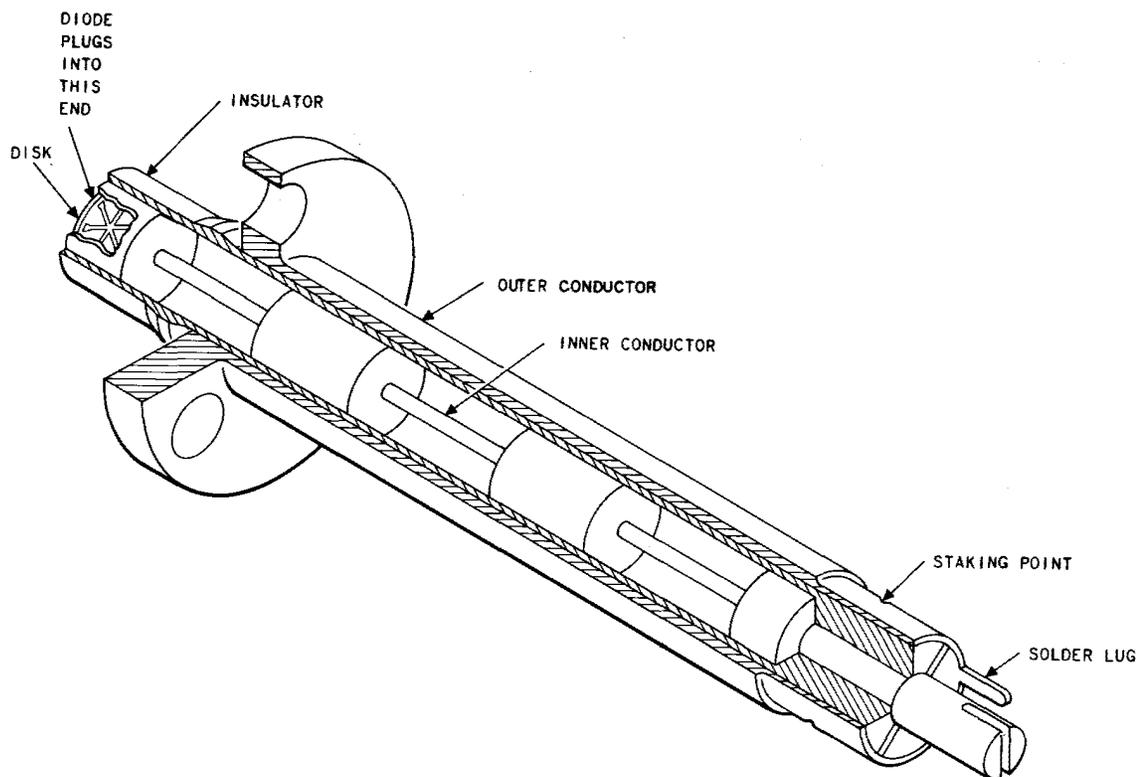
DIODE
PLUGS
INTO
THIS
END

DISK

INSULATOR

OUTER CONDUCTOR

INNER CONDUCTOR

STAKING POINT

SOLDER LUG

Fig. 12—Coaxial Low-Pass Filter

signal is similarly split and applied to the coaxial-T structures; however, in this case, the split signals have opposite phase. By using matched diodes and identical circuit elements on the two sidearms, good isolation is obtained between the E and H arms and an equal split of each of the input signals into the sidearms is assured.

3.18 The RF-to-IF downconversion takes place at the diodes in the coaxial-T structures. A matched pair of silicon point-contact diodes are used. Since the local oscillator signal from the magic-T hybrid arrives at one diode 180 degrees out of phase with respect to that arriving at the other diode, the diodes must be mounted in opposite directions in the diode holders to obtain the same phase of output signal. The in-phase 70-MHz IF outputs from the diodes are passed through filters and combined in the IF preamplifier.

3.19 The diodes are self-biased, and the dc path for each is completed through a resistor (R3 or R4, Fig. 13). The voltage drop across each of these

resistors can be read on the receiver control unit meter to check that the modulator is operating, that the diodes are balanced, and that the local oscillator power is correct.

3.20 Harmonics of the local oscillator signal generated in the diodes are prevented from leaving the modulator unit by coaxial low-pass filters FLT 1 and FLT 2. These filters have a cutoff frequency of about 6 GHz and provide more than 50-dB loss to the second and third harmonics of the local oscillator. Suppression of these harmonics before they reach the common receiving waveguide run is necessary to prevent their causing interference in other receivers, particularly those in the same bay lineup.

3.21 The local oscillator signal, the received signal, and the many RF products that are generated in the modulator diodes are prevented from entering the IF output portion of the modulator by dual-cavity, radial-line type chokes FLT 3 and FLT 4. These chokes attenuate 4-GHz frequencies by at least 45 dB, but the 70-MHz IF signal passes through them
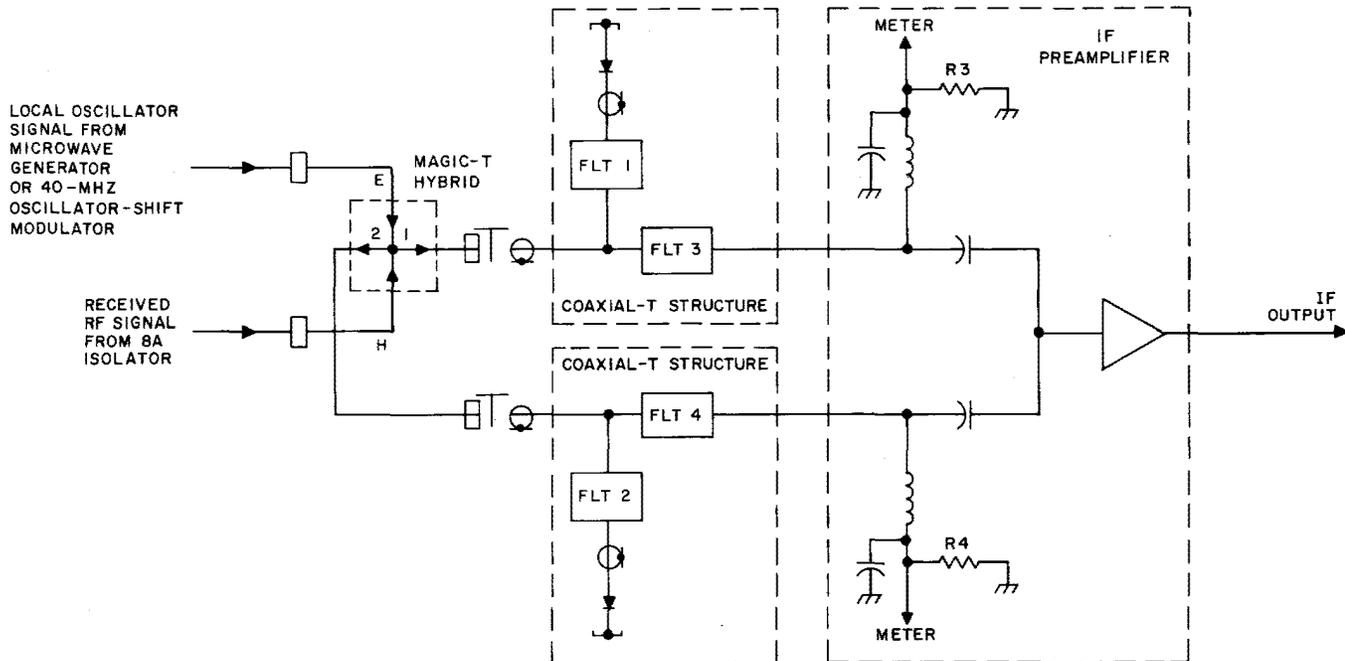
Fig. 13—J68387C Receiver Modulator and IF Preamplifier—Block Diagram

without attenuation. Suppression of the microwave signals is necessary to prevent them from causing interference and overload effects in the IF preamplifier.

3.22 The IF preamplifier is a 5-stage amplifier similar to that used in the J68387P receiver modulator and IF preamplifier. The nominal output is lower, −7 dBm instead of 0 dBm. The preamplifiers of the two units have approximately the same noise figure. However, primarily because of the higher conversion loss of the point contact diodes, compared to the Schottky-barrier diode, the overall noise figure of the J68387C receiver modulator and IF preamplifier is higher, typically 10.5 dB compared to about 7 dB for the J68387P unit.

3.23 Three controls, GAIN, LOW SLOPE, and HIGH SLOPE are provided for adjustment of the overall amplitude response of the receiver modulator and IF preamplifier. A fourth control, LEVEL, provides for adjustment of output power.

B. Equipment Description

3.24 The J68387C receiver modulator and IF preamplifier (Fig. 14) consists of two physically

associated units, the modulator and the preamplifier. The combined assembly measures approximately 6 by 6 by 4 inches and weighs 7-3/4 pounds. The magic-T hybrid, which forms the main body of the modulator, is machined from an aluminum block. Assembled to this block are the waveguide-to-coaxial transducers, low-pass filters, RF chokes, and diode holders. The diode holders are removable to permit easy replacement of the diodes in the field. The IF preamplifier printed circuit board and several IF decoupling components are mounted inside a cast aluminum box that fits over and connects to one side of the modulator block. The preamplifier box assembly can be detached easily from the modulator block for repair and replacement. Figure 14 shows the locations of the preamplifier controls, the IF output connector, and other features. Not visible are the E and H arm waveguide ports of the magic-T hybrid which are located on the top and back sides, respectively, of the modulator block.

4. J68387F IF MAIN AMPLIFIER AND J68387G AGC AMPLIFIER

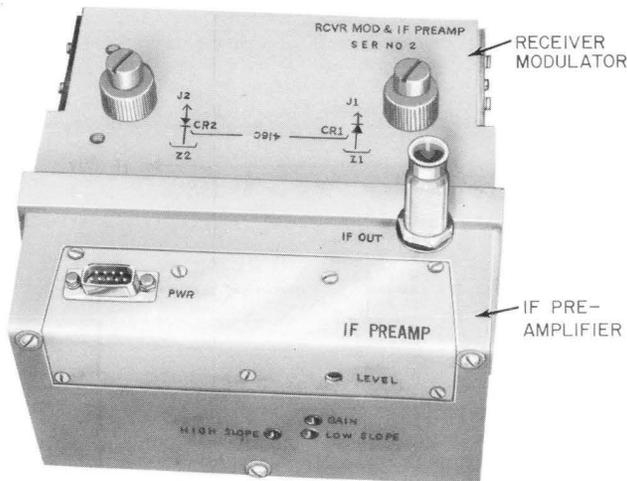**GENERAL**

4.01 The IF main amplifier and AGC amplifier

Fig. 14—J68387C Receiver Modulator and IF Preamplifier

operate together to maintain the receiver IF output power constant with input signal down-fades as deep as 28 dB in a receiver equipped with a balanced diode modulator (J68387C) and as deep as 35 dB in a receiver with a Schottky-barrier diode modulator (J68387P). The IF output also remains constant with input signal "up-fades" of 13 dB for a receiver equipped with the balanced modulator and 6 dB for a receiver with the Schottky modulator. The 7-dB difference in the nominal AGC range for up-fades and down-fades for the two types of receivers is the result of the J68387C unit having a normal output power 7 dB lower than that of the J68387P unit.

4.02 The AGC loop is shown in the block diagram, Fig. 15. The output of the IF main amplifier is maintained constant by the action of variable loss (variolosser) stages associated with gain stages. A gain stage-variolosser stage combination is called a gain-variolosser block. The gain of each block can be varied under the control of the AGC amplifier. With a normal signal at the input to the IF main amplifier, the total gain of the amplifier is such that it has an output of +1 dBm. When the signal level at the input to the amplifier decreases, the AGC amplifier detects the change and automatically increases the overall gain of the IF main amplifier enough to maintain the output at +1 dBm. Conversely, if the signal level increases, as in an up-fade, the overall gain of the IF main amplifier decreases, maintaining the output at +1 dBm.

FUNCTIONAL DESCRIPTION

A. IF Main Amplifier

4.03 The IF main amplifier (Fig. 16) has seven gain-variolosser blocks connected in series. Each of these blocks can be varied in gain from approximately −1 dB to +5 dB by a control current from the AGC amplifier. The seven blocks together give the amplifier a variable gain range of about 41 dB. The IF levels shown on the block diagram indicate the signal level in dBm at significant points throughout the amplifier. The middle line of figures is for normal gain, the top line is for maximum gain (corresponding to 35-dB down-fade), and the bottom line is for minimum gain (corresponding to 6-dB up-fade). The normal input level shown (−8 dBm) is the normal level at the input to the IF main amplifier in a receiver equipped with a J68387P receiver modulator and IF preamplifier. Under this condition, it can be seen that normal gain of the amplifier is 9 dB; and each of the seven gain-variolosser blocks is operating at 0-dB gain.

4.04 Each gain-variolosser block comprises a transistor gain stage followed by a transistor-coupled variolosser network containing a PIN diode. The network functions as a variable attenuator whose loss is controlled by the dc current from the AGC amplifier. Two of the gain-variolosser blocks, the second and fifth from the input stage, contain SLOPE 1 and SLOPE 2 controls, respectively. These controls are used to flatten the amplitude response of the IF main amplifier.

4.05 Preceding the first gain-variolosser block is an amplifier stage that provides input impedance matching and 5 dB of gain. This stage contains return-loss controls IN RL1 and IN RL2 used to adjust the input return loss of the amplifier.

4.06 Following the last variolosser stage is a 2-transistor, fixed-gain stage having 4 dB of gain. The OUT RL control associated with this stage is provided for adjustment of the amplifier output return loss. A single transistor stage, having a net loss of 1 dB, is connected across the amplifier output. This stage serves to monitor the level of the IF output signal and provide, at the MON OUT jack, a suitably isolated or decoupled IF input signal for the AGC amplifier. The monitor output stage has one control associated with it, the MON RL control used for adjusting the return loss at the MON OUT jack.
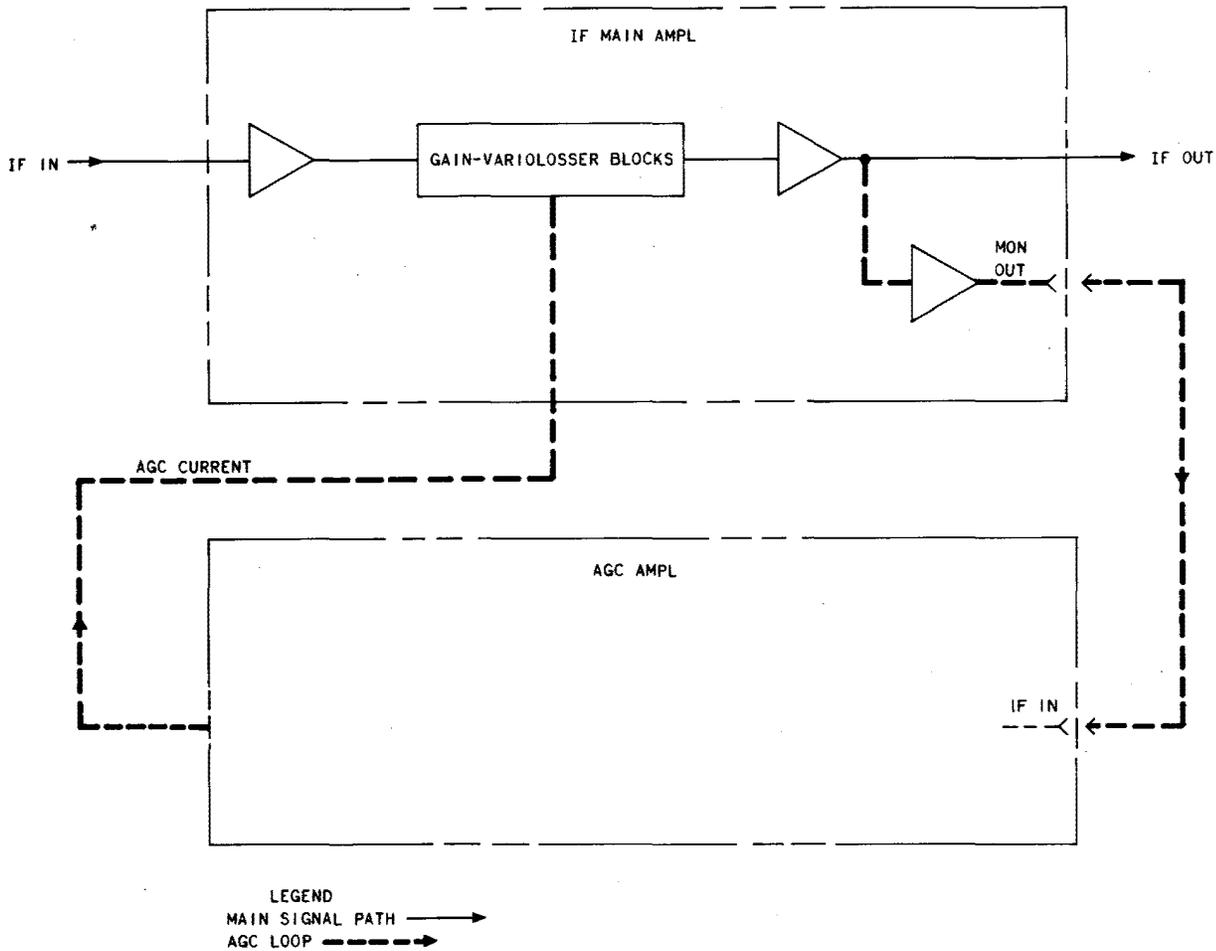
IF IN →

IF MAIN AMPL

GAIN-VARIOLOSSER BLOCKS

MON OUT

IF OUT

AGC CURRENT

AGC AMPL

IF IN

LEGEND
MAIN SIGNAL PATH ──────▶
AGC LOOP ━━━━▶

Fig. 15—AGC Loop—Simplified Block Diagram

B. AGC Amplifier

4.07 The AGC amplifier (Fig. 17) consists of an isolation amplifier, a bandpass filter, an IF amplifier stage, an IF detector, and a dc amplifier. The circuit amplifies and rectifies the IF signal and compares the rectified signal voltage with a reference voltage. Any difference or error voltage is applied as a control current to the variolosser stages of the IF main amplifier to change the gain of the amplifier in a direction to minimize the error voltage.

4.08 The IF isolation amplifier is a single-stage amplifier that provides isolation between the monitor output stage of the IF main amplifier and the AGC circuit bandpass filter. Isolation is necessary to prevent the reactive impedance of the filter

from affecting the transmission characteristic of the IF main amplifier.

4.09 Any spurious signal generated within the radio system and falling in the IF band would be combined in the detector with the regular 70-MHz signal. Since the detector is not selective, a false indication of the IF signal level could result. This condition can become especially serious during a deep fade if the level of the spurious signal becomes greater than that of the IF signal. In effect, the AGC action can be "held up" or prevented from following the fading signal. The bandpass filter reduces this type of interference by limiting the band of frequencies passed to the IF detector to 70 ±9 MHz at the 3-dB points.
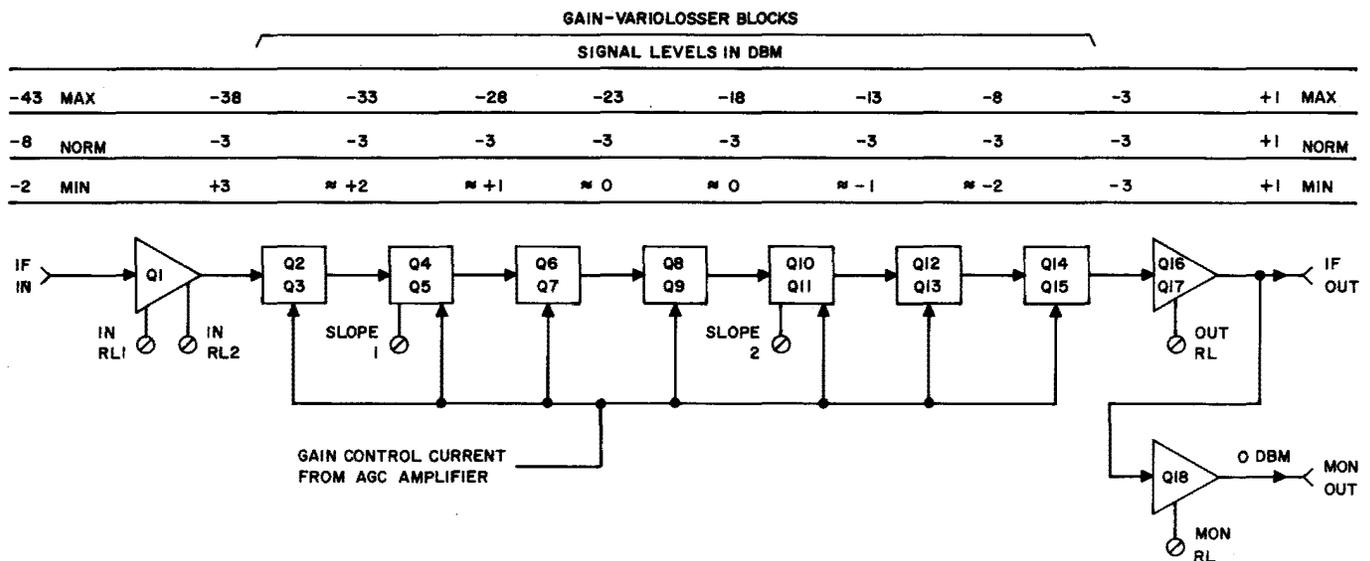
GAIN-VARIOLOSSER BLOCKS

SIGNAL LEVELS IN DBM

		-38	-33	-28	-23	-18	-13	-8	-3	+1	
-43	MAX	-38	-33	-28	-23	-18	-13	-8	-3	+1	MAX
-8	NORM	-3	-3	-3	-3	-3	-3	-3	-3	+1	NORM
-2	MIN	+3	≈ +2	≈ +1	≈ 0	≈ 0	≈ -1	≈ -2	-3	+1	MIN

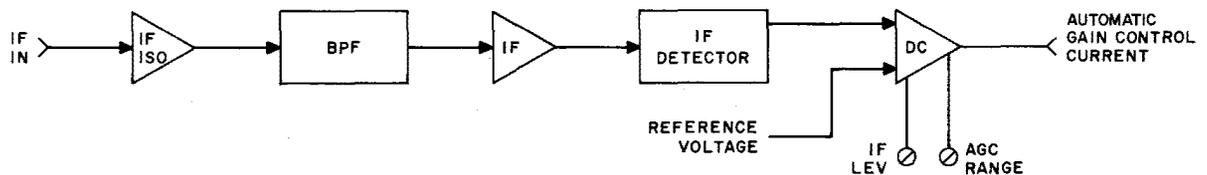Fig. 16—IF Main Amplifier—Block and Level Diagram

Fig. 17—AGC Amplifier—Block Diagram

4.10 A single-stage amplifier circuit follows the bandpass filter to raise the level of the IF signal before applying it to a peak-type detector. The detector rectifies the IF signal, and the resulting dc voltage is applied to a dc amplifier.

4.11 The dc amplifier is a differential amplifier that compares the detected signal input, which is proportional to the IF signal level, to a reference voltage. The level of the reference voltage, which is adjusted by the IF LEV control, sets the operating point of the differential amplifier. This, in turn, determines the amount of current applied to the variolosser stages and, consequently, the overall gain of the IF main amplifier. The AGC RANGE control is used to set the lower limit of the AGC range of the IF main amplifier.

4.12 The dc current applied to the variolosser stages can be monitored by the meter in the receiver control unit (RCVD SIG LEV position). A network in the AGC amplifier linearizes the current through the control panel meter, and the resulting meter indication serves as a convenient calibrated monitor of the actual received carrier power.

EQUIPMENT DESCRIPTION

4.13 The IF main amplifier and AGC amplifier are shown with their covers removed in Fig. 18. The IF main amplifier assembly consists of two printed circuit boards and several IF decoupling components mounted in a cast aluminum frame. Both sides are covered by aluminum plates to which are cemented IF shielding gaskets. Adjustments are accessible through the front of the frame. Located at the rear of the frame are the IF input, IF output, and

monitor output coaxial connectors and a multicontact connector for dc power and variolosser control voltage connections. The IF main amplifier measures 23-3/4 by 2 by 3-3/4 inches and weighs 5-1/4 pounds.

4.14 The AGC amplifier assembly consists of two printed circuit boards mounted in a cast aluminum frame. Both sides of the frame are covered by gasketed aluminum plates. Adjustments and test points are accessible through the front of the frame. Located at the rear of the frame are a coaxial connector for the IF input and a multicontact connector for dc power, variolosser control voltage output, and metering connections. The AGC amplifier assembly measures 8-3/4 by 2 by 3-3/4 inches and weighs 2 pounds.

5. J68387H IF LIMITER

GENERAL

5.01 The IF limiter receives the input signal to the radio transmitter supplied typically by either a preceding radio receiver or an FM terminal transmitter. Its primary output is appled via the IF carrier

resupply unit to the IF driver amplifier. The purpose of the IF limiter is to remove any amplitude modulation from the frequency modulated IF signal applied to the transmitter. This is done to reduce the cross-modulation noise generated by the mechanism of amplitude modulation to phase modulation (AM-to-PM) conversion in the succeeding circuits of the transmitter.

5.02 The original IF limiter has 0-dB gain; its input and signal path output levels are normally −7 dBm. For 1500 and 1800 circuit loadings, a noise figure improvement modification results in a 5-dB gain; thus the power output is −2 dBm. For the latter case, a 5-dB pad is used at the limiter output to reduce the level back to the "standard" −7 dBm. In either case, a second output, which is at a level of 0 dBm, provides a monitor signal used by the carrier resupply unit.

FUNCTIONAL DESCRIPTION

5.03 The IF limiter (Fig. 19) is functionally composed of four circuits: an input amplifier, a monitor stage, a limiter stage, and an output amplifier.
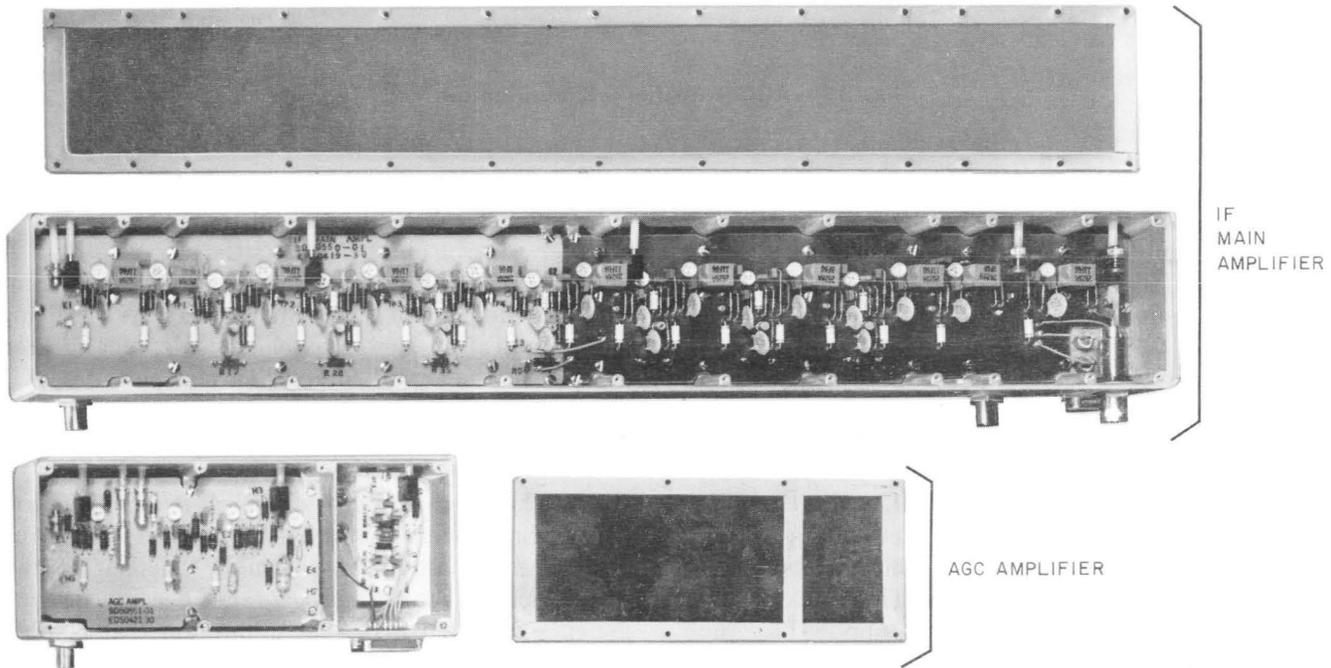

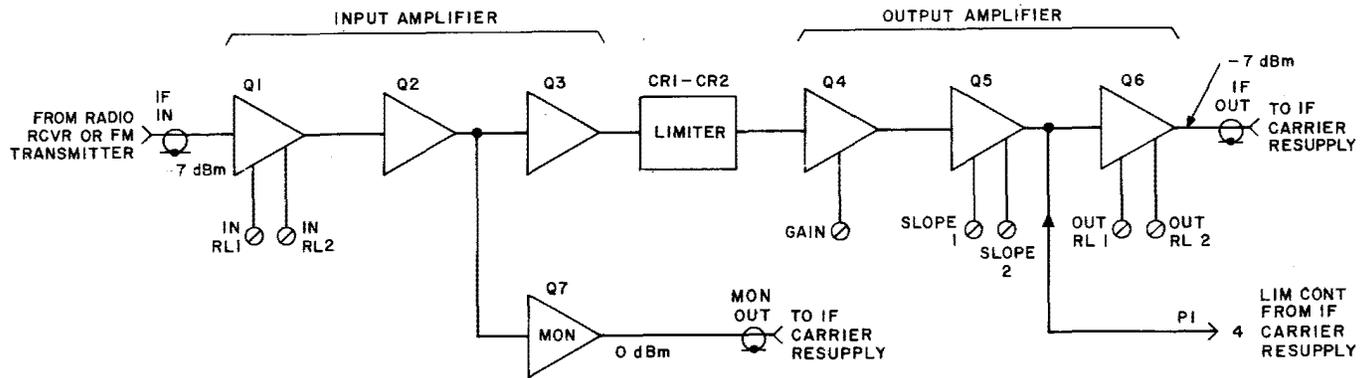Fig. 18—J68387F IF Main Amplifier and J68387G AGC Amplifier Assemblies

Fig. 19—IF Limiter—Block Diagram

5.04 The input signal is applied through the IF IN connector to a 3-stage amplifier which has a gain of approximately 15 dB. The first stage of the amplifier includes an impedance matching network with controls IN RL1 and IN RL2 which are used to adjust the input return loss of the limiter.

5.05 A monitor stage is connected at the output of the second gain stage of the input amplifier. This stage serves principally as an impedance transforming stage and delivers approximately 0 dBm at the MON OUT jack.

5.06 The limiter stage uses a pair of forward-biased, series diodes. The limiting or clipping level is determined by the bias voltage. When the IF signal voltage, either on the positive or negative portion of the cycle, exceeds the bias voltage, one or the other of the diodes becomes back biased and stops conducting. This limits the output amplitude of the applied signal to the level set by the diode bias. Normally, the limiter is driven hard enough to clip the signal to the point that it approximates a square wave at the limiter output. The limiting action, which causes the output power to remain constant as the input power varies, is effective for up to about a 9-dB decrease in input power. In effect, then, the limiter extends the AGC range of a repeater by about 9 dB, as viewed at the output of the limiter.

5.07 The IF signal from the limiter stage is applied to a 3-stage output amplifier. The amplifier includes a bandpass filter located between the first and second stages. This filter attenuates harmonics produced in the limiter stage, particularly the third

harmonic of the IF carrier frequency. The amplitude response through the filter is adjusted by the SLOPE 1 control. The SLOPE 2 control is used to adjust the overall amplitude response of the limiter for minimum slope across the IF band. A GAIN control, associated with the input circuit to the amplifier, is used to set the nominal output level of the limiter to −7 dBm at the IF OUT jack. This GAIN control is removed in limiters used in 1500 and 1800 circuit bays and results in a power output of −2 dBm at the IF OUT jack.

5.08 The last stage of the output amplifier is cut off by a ground from the carrier resupply circuit during an IF signal failure or a very deep fade. This causes the limiter to introduce at least 20 dB of loss in the IF signal path. The purpose of this is to prevent noise or spurious tones originating in circuits ahead of the limiter from causing interference into adjacent channels during the time the channel is failed and the carrier resupply is operating. The ground is applied to the limiter control (LIM CONT) lead.

5.09 The output stage includes an impedance matching network containing controls OUT RL1 and OUT RL2. These are used to adjust the output return loss of the limiter.

EQUIPMENT DESCRIPTION

5.10 The IF limiter assembly (Fig. 20) consists of a printed circuit board and several IF decoupling components mounted in a cast aluminum frame. Both sides are covered by aluminum plates to which are cemented IF shielding gaskets. Adjust-

ments are accessible through the front of the frame. Located at the rear of the frame are the IF input, IF output, and monitor output coaxial connectors and a multicontact connecter for dc power and the limiter control voltage connections. The IF limiter assembly measures 12 by 2 by 3-3/4 inches and weighs 3 pounds.

6. J68387J IF CARRIER RESUPPLY

GENERAL

6.01   The J68387J IF carrier resupply receives the output from the IF limiter and, under normal conditions, supplies the signal, unmodified, to the IF driver amplifier and transmitter modulator.

6.02   If the IF signal input to a radio transmitter were interrupted for any reason, all the subsequent repeaters for that channel along the route would operate at maximum gain, producing high-level noise. This noise could spill over into adjacent channels, increasing the noise and reducing the fade margin of the affected channels.

6.03   The IF carrier resupply substitutes a frequency-modulated, 70-MHz carrier to the IF driver amplifier and transmitter modulator if the regular IF signal is interrupted prior to its reaching the carrier resupply. The substitute carrier causes the succeeding repeaters along the route to operate at

normal gain, thereby preventing the noise spillover problem.

6.04   The substitute carrier is modulated so that the 100A Protection Switching System can recognize that a channel has failed and that a substitute carrier has taken its place. The 70-MHz carrier is modulated by a 9-MHz pilot for working channels and by either a 7-MHz or 9-MHz pilot for protection channels. The 100A Protection Switching System interprets the presence of the 9-MHz pilot as an indication of an unusable channel. Originally, the 9-MHz pilot was used only on the working channels, and a 7-MHz pilot served the protection channels. The presence of the 7-MHz pilot on the protection channel prevents the 100A system from completing a switch to the channel by making it appear that the head-end bridge cannot be completed. However, a disadvantage of using the 7-MHz pilot frequency is that when the protection channel is idle, the 100A system cannot tell whether the pilot is the normal 7-MHz pilot coming from the 100A transmitting switch bay or is a carrier resupply pilot, indicative of a failed channel. Therefore, in 1970 an option was made available in the 100A system to permit 9-MHz pilot operation of the carrier resupplies on the protection channels. This improvement was introduced to permit the 100A system to recognize the failure of an idle protection channel and provide an immediate alarm indication.

6.05   When there is a deep fade or a failure of the regular IF signal, the carrier resupply places
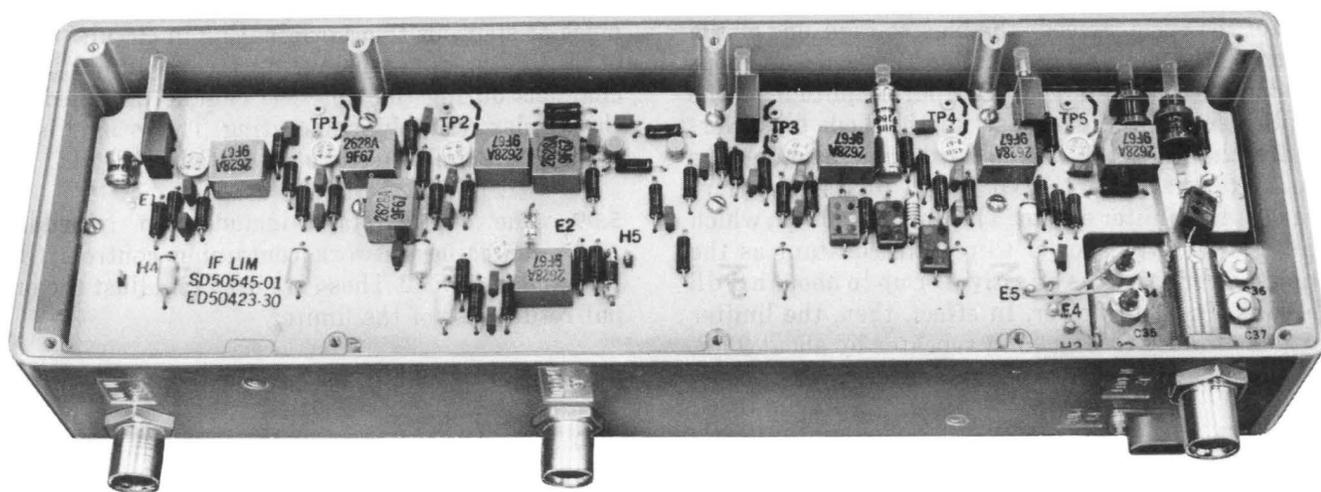

Fig. 20—J68387H IF Limiter

the pilot-modulated substitute carrier on the channel in less than 100 microseconds. In addition, it blocks the path of the failed IF signal by disabling the output amplifier of the J68387H IF limiter (paragraph 5.08), and energizes a 45-second delay alarm circuit.

6.06 The carrier resupply is normally adjusted to operate when the level of the received IF signal drops about 50 dB. Since such deep fades occur relatively infrequently and are of short duration, the carrier resupply is operated mainly during the performance of normal maintenance routines on the channel.

FUNCTIONAL DESCRIPTION

6.07 The IF carrier resupply consists of six functionally related circuits. These are the monitor amplifier, logic circuit, oscillator and power amplifier circuit, limiter circuit, gate circuit, and alarm delay circuit. The block diagram of the IF carrier resupply is shown in Fig. 21.

6.08 The substitute, frequency-modulated, 70-MHz carrier is generated by the oscillator and power amplifier circuit. This circuit consists of two crystal-controlled oscillators and three power amplifier stages. One oscillator operates at 70 MHz and the other at either 61 or 63 MHz. The frequency stability maintained by both oscillators is ± 4 kHz. Both oscillators have temperature compensation to maintain a constant output over a temperature range of 30° to 140°F.

6.09 The 70-MHz oscillator is followed by two stages of amplification. Since the 61- or 63-MHz oscillator is used to produce the modulating pilot, not as much output power is required at these frequencies as compared to 70 MHz. Therefore, only one stage of amplification follows the 61- or 63-MHz oscillator. A portion of the output from the 61- or 63-MHz oscillator is rectified for metering purposes.

6.10 When the IF carrier resupply is used in a working channel application, the 61- or 63-MHz oscillator is set to generate a 61-MHz signal; in a protection channel application, the oscillator is set for either 61 or 63 MHz, as explained in paragraph 6.04. For the rest of this description, it is assumed that the oscillator is set for 61 MHz.

6.11 The two amplified oscillator signals are combined and applied to a limiter circuit. The combined signal is equivalent to a 70-MHz carrier which is both frequency-modulated and amplitude-modulated by a 9-MHz signal, the difference frequency between the 70-MHz and 61-MHz signals. The limiter removes the amplitude modulation, leaving only the frequency modulation on the carrier.

6.12 The level of the 61-MHz signal, which determines the amount of deviation of the FM signal, is controlled by the 61-63 MC LEV control. The power of the composite signal, which because of the low index of modulation used is principally the power in the 70-MHz carrier, is adjusted with the 70 MC LEV control. A portion of the 70-MHz output of the limiter is rectified for metering purposes.

6.13 The substitute carrier with its 9-MHz sidebands is continuously applied to the diode gate circuit. By operating the oscillators continuously, the substitute IF signal is ready for immediate (within 100 microseconds) application when needed. During normal operation, the IF signal from the IF limiter is applied through a T-network in the carrier resupply gate circuit to the IF driver amplifier and transmitter modulator. The diode gate circuit, which is kept closed by voltages from the logic circuit, presents at least 95-dB loss to the substitute signal, thereby effectively blocking it from the channel. The gate is opened and the substitute signal is applied, when needed, to the shunt arm of the T-network for transmission over the normal IF signal path.

6.14 The monitor amplifier circuit of the carrier resupply receives as its input the IF monitor signal from the J68387H IF limiter. The monitor amplifier contains two stages of amplification, a bandpass filter and a diode rectifier. Associated with the 2-stage amplifier is a gain control designated TRIP. Adjusting the TRIP control sets the dc level applied to the trigger stage of the logic circuit, setting the operating point of the logic circuit. The operating point is always set with the carrier resupply connected to the IF limiter. Thus, any variations in the carrier power available from the limiter circuit will be accounted for.

6.15 The bandpass filter narrows the bandwidth of the monitor amplifier. The passband of the monitor amplifier must be narrow enough to attenuate interfering signals that could affect the operating point of the logic circuit. It must be wide enough, however, to permit making sweep envelope delay distortion measurements on the system without causing
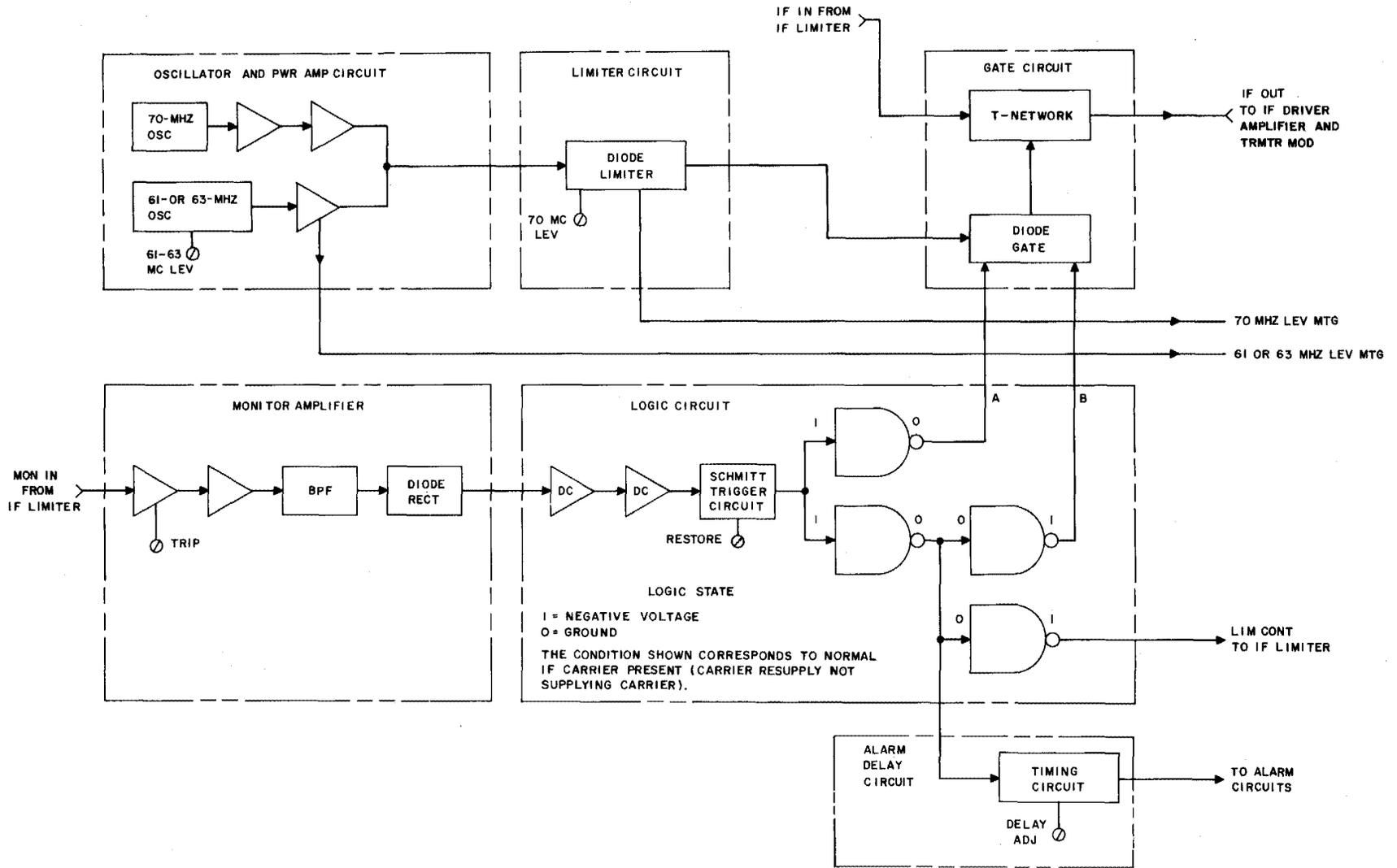
OSCILLATOR AND PWR AMP CIRCUIT

70-MHZ OSC

61-OR 63-MHZ OSC

61-63 MC LEV

LIMITER CIRCUIT

DIODE LIMITER

70 MC LEV

IF IN FROM IF LIMITER

GATE CIRCUIT

T-NETWORK

DIODE GATE

IF OUT TO IF DRIVER AMPLIFIER AND TRMTR MOD

70 MHZ LEV MTG

61 OR 63 MHZ LEV MTG

MONITOR AMPLIFIER

MON IN FROM IF LIMITER

TRIP

BPF

DIODE RECT

LOGIC CIRCUIT

DC

DC

SCHMITT TRIGGER CIRCUIT

RESTORE

A

B

LOGIC STATE

I = NEGATIVE VOLTAGE
O = GROUND

THE CONDITION SHOWN CORRESPONDS TO NORMAL IF CARRIER PRESENT (CARRIER RESUPPLY NOT SUPPLYING CARRIER).

LIM CONT TO IF LIMITER

ALARM DELAY CIRCUIT

TIMING CIRCUIT

DELAY ADJ

TO ALARM CIRCUITS

Fig. 21—IF Carrier Resupply—Block Diagram

the carrier resupply to operate. The filter provides about 13 dB of loss at 60 and 80 MHz, which is normally sufficient to prevent interference from the tones expected in the system at these frequencies.

6.16   The diode rectifier converts the amplified and band-narrowed IF input signal to a dc voltage whose level is proportional to the level of the IF input signal. This dc voltage is applied to the logic circuit.

6.17   The logic circuit consists of a 2-stage dc amplifier, a Schmitt trigger circuit, and four logic gates. The dc amplifier provides amplification of the dc voltage from the monitor amplifier and provides isolation between the monitor and the trigger circuit. The Schmitt trigger circuit functions as a level-sensitive switch that controls the state of the logic gates. The Schmitt trigger circuit is bistable, remaining in the state in which it happens to be operating until the dc voltage level at its input changes substantially. The logic gates are electronic switches which control the state of the diode gate circuit, provide the limiter control voltage which determines the operating condition of the IF limiter, and initiate the timing circuit in the alarm delay circuit.

6.18   When the dc level at the input to the logic circuit decreases, the trigger circuit recognizes this as a decrease in the IF signal level. When the level decreases to the point set by the TRIP control, the Schmitt trigger circuit changes its operating state which, in turn, operates the logic gates. The A and B outputs from the logic gates reverse and open the diode gate, allowing the substitute IF signal to be inserted into the normal IF signal path. Operation of the logic gates also provides an output which disables the IF limiter, and another output which initiates the alarm delay circuit. The logic circuit remains in this state until the normal received IF signal level increases to the value set by the RESTORE control in the Schmitt trigger circuit. This control is used to set the point at which the Schmitt trigger circuit flips back to its normal state. This point is normally set 2 dB higher than the trip point. This ensures stable operation preventing the carrier resupply from "chattering" or rapidly switching back and forth from one operating condition to the other.

6.19   When the Schmitt trigger circuit and logic gates flip back to their normal states, the carrier resupply reverses its functions: the diode gate is closed, blocking the substitute IF signal; the inhibit voltage is removed from the IF limiter, allowing the

regular IF signal to be passed through that unit; and the alarm delay circuit is cleared, making it ready to start timing again.

6.20   The carrier resupply must be operated for about 45 seconds before the alarm circuits are activated to provide a channel failure alarm indication to the operating personnel. This 45-second delay is provided by the alarm delay circuit. If the regular IF signal is restored within 45 seconds, the alarm delay circuit is rapidly restored to its normal state so it will be ready to time for a full 45 seconds on a subsequent fade or failure. The timing interval is adjusted by the DELAY ADJ control. The alarm delay feature prevents unnecessary alarms from being brought into the alarm center during periods of deep but short duration fading.

EQUIPMENT DESCRIPTION

6.21   The carrier resupply unit (Fig. 22) consists of six printed circuit boards, the IF diode gate section, and several IF decoupling components mounted inside a cast aluminum frame having eight compartments. Both sides of the frame are covered by aluminum plates to which are cemented IF shielding gaskets. An indicator is provided in the front of the frame so that a visual check can be made of whether the 61-MHz or the 63-MHz option has been made in the oscillator and power amplifier circuit. Located on the rear of the frame are the IF input, IF output, and monitor IF input connectors and a multicontact connector for dc power, metering, limiter control, and alarm function connections. The assembly measures 19-1/4 by 2 by 4-1/2 inches and weighs 6-1/4 pounds.

6.22   In the gate circuit compartment, the components are housed in three subcompartments. The diodes are mounted in holes in the partitions so that the two ends of each diode are in different subcompartments. This reduces unwanted coupling paths by interposing ground planes between circuit points. This is to ensure that the transmission path for the input to the output of the diode gate is very nearly through the diodes only. Coupling paths from the output of the gate to all other parts of the carrier resupply also must be carefully connected. This is accomplished with the gasketed covers. The gasketing material contains tiny particles of silver which compress and form a tight shield against IF leakage when the covers are in place and all screws tightened.
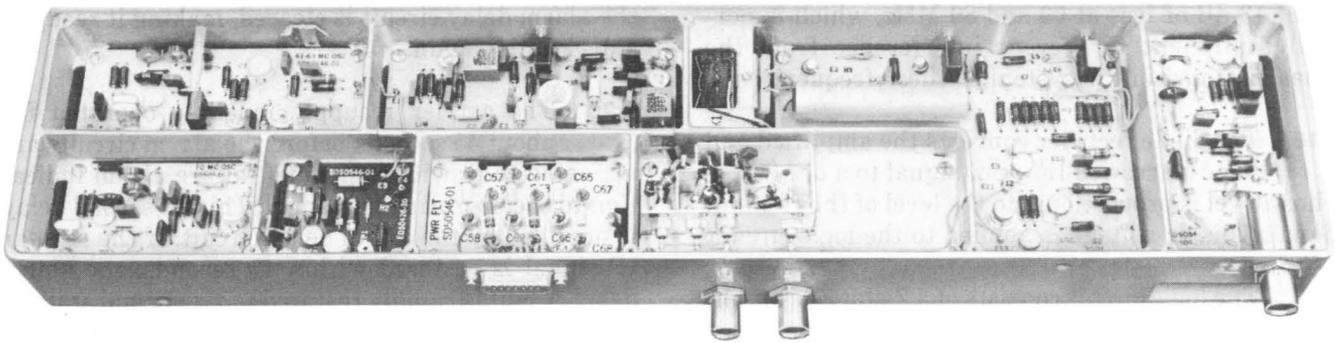
Fig. 22—J68387J IF Carrier Resupply

7. J68387E IF DRIVER AMPLIFIER—TRANSMITTER MODULATOR

7.01   The J68387E IF driver amplifier and transmitter modulator takes the output signal from the IF carrier resupply and, by combining it with a local oscillator signal, translates (or "up-converts") the IF signal to the RF channel frequency of the microwave transmitter. The driver amplifier provides approximately 7-dB gain and converts the unbalanced IF input signal to a balanced output signal for application to the modulator diodes. The modulator uses a pair of varactor diodes in a balanced-type up-converter circuit that provides additional signal gain. The nominal IF input power to the driver amplifier is −7 dBm, and the modulator output power is +8.5 dBm minimum. The local oscillator input power to the modulator is approximately +20 dBm.

FUNCTIONAL DESCRIPTION

7.02   The IF driver amplifier (Fig. 23) is a 5-stage amplifier. The first stage is essentially an impedance matching stage. The RL1 and RL2 controls associated with this stage are used to adjust the input return loss of the driver amplifier.

7.03   Virtually all of the approximately 7-dB gain of the IF driver amplifier is provided by the second amplifier stage. This stage contains three controls for adjustment of the amplitude response of the overall IF driver amplifier and transmitter modulator. Although the controls are somewhat interacting, the HIGH SLOPE control affects predominantly the high-frequency end of the response, the LOW SLOPE

affects predominantly the low-frequency end, and the GAIN control affects mainly the overall gain.

7.04   The output from the third amplifier stage is split through a transformer to feed a pair of isolation stages. These stages deliver the IF signal to the modulator diodes while at the same time isolating the rest of the driver amplifier circuit from the loading effect of the diodes.

7.05   The transmitter modulator uses the same type of magic-T hybrid structure as the balanced-type receiver modulator described in Part 3. The IF-to-RF modulation, or "up-conversion," takes place in a matched pair of varactor diodes which provide about 9-dB gain along with frequency conversion. The overall IF-to-RF gain of the driver amplifier and transmitter modulator is approximately 16 dB.

7.06   The IF signal is applied through frequency selective attenuators AT1 and AT2 and filters FLT 3 and FLT 4 to the varactor diodes. The input from the microwave generator is applied to the E arm of the magic-T hybrid junction. Provided that equal impedances are connected to the sidearms (arms 1 and 2), energy applied to either the E arm or the H arm divides equally between the sidearms and almost no energy emerges from the opposite arm. Thus, the microwave generator signal is split by the hybrid into two equal and, in this case, opposite phase signals. Each of these signals passes through a waveguide-to-coaxial transducer to a coaxial-T structure containing one of the modulator diodes. Filters FLT 3 and FLT 4 are dual-cavity, radial-line type chokes that prevent signals in the 4-GHz band from entering the IF driver amplifier. Attenuators
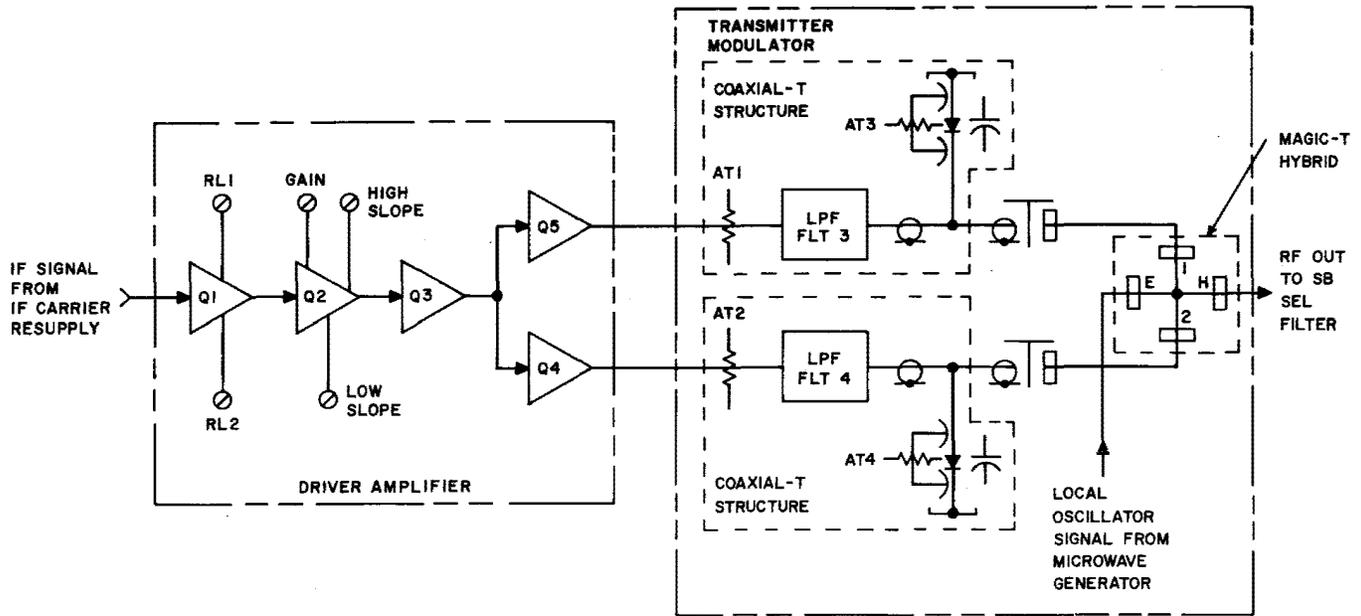
Fig. 23—J68387E IF Driver Amplifier and Transmitter Modulator—Block Diagram

AT1 and AT2 are of composition material and act as lossy terminations on the chokes to protect the driver amplifier from RF signals generated in the diodes and falling outside the 4-GHz band. These attenuators provide at least 50-dB suppression to signals which fall above the 4-GHz band but have only about 0.1-dB loss at IF.

7.07 The IF signals applied to the diodes are in phase. However, the microwave generator signals are out of phase. Therefore, the diodes are mounted in their holders in opposite directions so that in-phase sidebands will be generated in the diodes. At the hybrid, the in-phase sidebands combine and leave the modulator through the H arm. An external 1336-type filter selects the desired sideband output (either the upper sideband at a frequency equal to the microwave generator frequency plus 70 MHz, or the lower sideband at a frequency equal to the microwave generator frequency minus 70 MHz). The unwanted sideband, as well as all other 4-GHz band products generated in the diodes and appearing at the modulator output, are reflected from the filter and absorbed by an isolator that precedes the filter in the external circuit.

7.08 Any microwave generator signals reflected from the diodes back to the hybrid appear at the modulator output 180 degrees out of phase and, if equal in amplitude, cancel each other. Tuning screws on the diode holders are used both to maximize the output power of the desired sideband and to balance, or suppress, the microwave generator output. Typically, the microwave generator power appearing at the modulator output can be adjusted to be at least 25 dB below the power at the E arm input.

7.09 Attenuators AT3 and AT4 are thin-wall cyclindrical sleeves that fit around the diodes. Varactor diodes, particularly when operated to provide conversion gain, have a tendency to be unstable. The sleeves are made of a composition-type lossy material which is effective at microwave frequencies in preventing instability oscillations. These oscillations, if not eliminated, could cause excessive cross-modulation noise to be introduced in the radio channel.

EQUIPMENT DESCRIPTION

7.10 The J68387E IF driver amplifier and transmitter modulator (Fig. 24) consists of two units: the modulator unit and the IF driver amplifier unit. The magic-T hybrid, which forms the main body of the modulator, is machined from an aluminum block. Assembled to this block are the coaxial filters,

attenuators, waveguide-to-coaxial transducers, and diode holders. The diode holders are removable to permit easy replacement of the diodes in the field. The IF driver amplifier printed circuit board and several IF decoupling components are mounted inside a cast aluminum box that fits over and connects to one side of the modulator block. The driver amplifier box assembly can be detached easily from the modulator block for repair or replacement. Figure 24 shows the locations of the driver amplifier controls, the input connector, the diode holders, and other features. Not visible are the E and H arm waveguide ports of the magic-T hybrid, which are located on the top and back side, respectively, of the modulator block. The assembly of both units measures 6 by 6 by 4 inches and weighs 7-3/4 pounds.
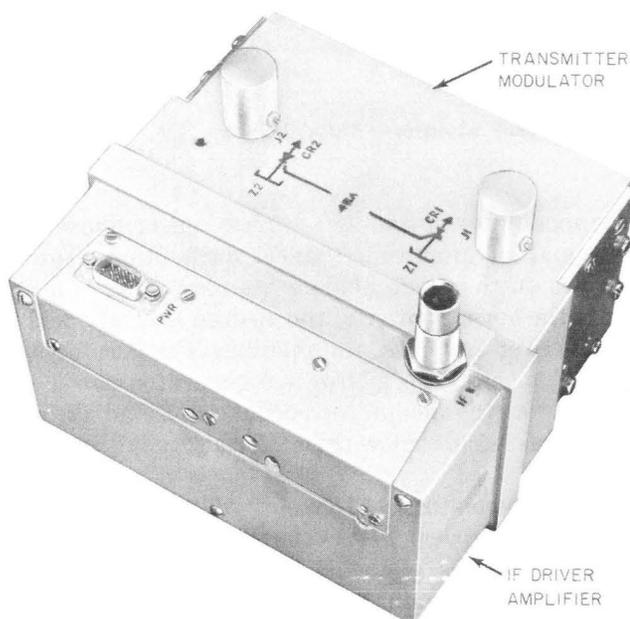
Fig. 24—J68387E IF Driver Amplifier and Transmitter Modulator

8. RF POWER AMPLIFIERS

A. 461A Traveling-Wave Tube Amplifier

8.01 The 461A traveling-wave tube (TWT) amplifier is used as a power amplifier stage in the output circuit of the microwave transmitter. At its normal operating voltage, the amplifier provides from 32 to 38 dB of gain and increases the level of the RF signal delivered to it from the transmitter modulator to approximately +37 dBm at the input to the transmitter channel combining network.

Functional Description

8.02 The TWT amplifier consists of a traveling-wave tube mounted in a magnetic focusing structure (Fig. 25). Amplification is provided by an interaction involving energy transfer between the RF signal, which travels along the helix of the traveling-wave tube, and an electron stream that is confined along the axis of the helix winding. The RF input signal to the tube is obtained from the transmitter modulator through an external circuit that includes a variable attenuator, tuner, and waveguide transducer. The variable attenuator is used to adjust the RF input power to the tube to obtain the required output power. The tuner provides input impedance matching, and the transducer converts from standard WR229 waveguide to the reduced height size waveguide used at the amplifier input.

8.03 The input of the TWT amplifier is shown in Fig. 26. The input signal, appearing in the reduced height waveguide, is coupled onto the helix through a helix-to-waveguide coupler. This coupler, which consists essentially of a cylindrical, hollow post, couples the signal to the helix in much the same manner that the probe in a waveguide-to-coaxial transducer couples a signal onto a coaxial line. The helix is a spiral, spring-like winding that traverses the length of the tube to the output waveguide.

8.04 The electron gun (Fig. 26) consists of a heater, cathode, beam forming electrode, and anode. This structure forms an electron stream that is passed through a hole in the center of the anode to the helix portion of the tube. The anode-to-cathode voltage determines the magnitude of the current of this electron stream. Typically, about +2900 volts is required on the anode, relative to the cathode, to obtain the normal cathode current of 40 milliamperes. The beam forming electrode, which helps form the electron beam, operates at cathode potential.

8.05 The helix consists of a 30-turns-per-inch spiral winding of 0.01-inch diameter wire. It is supported within the glass stem of the tube by three symmetrically spaced ceramic rods. The inside diameter of the helix is approximately 0.1 inch, and its length is about 7 inches. Maximum amplifier gain is obtained when the velocity of the electron stream

Fig. 25—461A Traveling-Wave Tube Amplifier

flowing along the longitudinal axis of the helix is approximately equal to the forward-directed component of velocity of the RF wave traveling along the spiral path of the helix winding. The electron stream velocity, in turn, is determined in the helix region of the tube by the helix-to-cathode voltage. This voltage is adjusted to obtain maximum amplifier gain and typically is about +2700 volts (helix relative to cathode).

8.06 A permanent magnet focusing structure (Fig. 27) is used to confine the electron stream within the 0.1-inch inside diameter of the helix winding. The focusing structure consists of 28 ring-shaped Alnico 8 magnets separated by soft iron pole pieces. The magnets are assembled with opposing polarities. As a result, along the axis of the helix the magnetic field direction reverses and the field intensity passes through zero at each pole piece. In between pole pieces, the field intensity reaches a maximum amplitude of about 1000 gauss. The overall structure forming this sinusoidally varying focusing field is commonly referred to as a periodic-type permanent magnet focusing structure. The use of reduced height waveguides at the input and output of the amplifier is necessary to minimize, as much as possible, the disruption created in the periodic magnetic focusing field by the introduction of the waveguide.

8.07 The amplified signal appearing at the output end of the helix is coupled to the output waveguide through a hollow, cylindrical helix-to-waveguide coupler similar to that used at the input. A transducer and tuner in the external circuit are used to transduce the signal back to WR229 size waveguide and to optimize the output impedance match of the amplifier, respectively.

8.08 The electron stream passes through the output helix-to-waveguide coupler to the collector electrode. The collector operates typically about +1400 volts with respect to the cathode. As a result, for an electron stream of 40 milliamperes, 56 watts of power must be dissipated at the collector. This heat is conducted away from the tube through a cooling block which, in turn, is thermally coupled to a finned cooling block mounted on the transmitter-receiver bay. This arrangement holds the collector temperature below about 150°F.
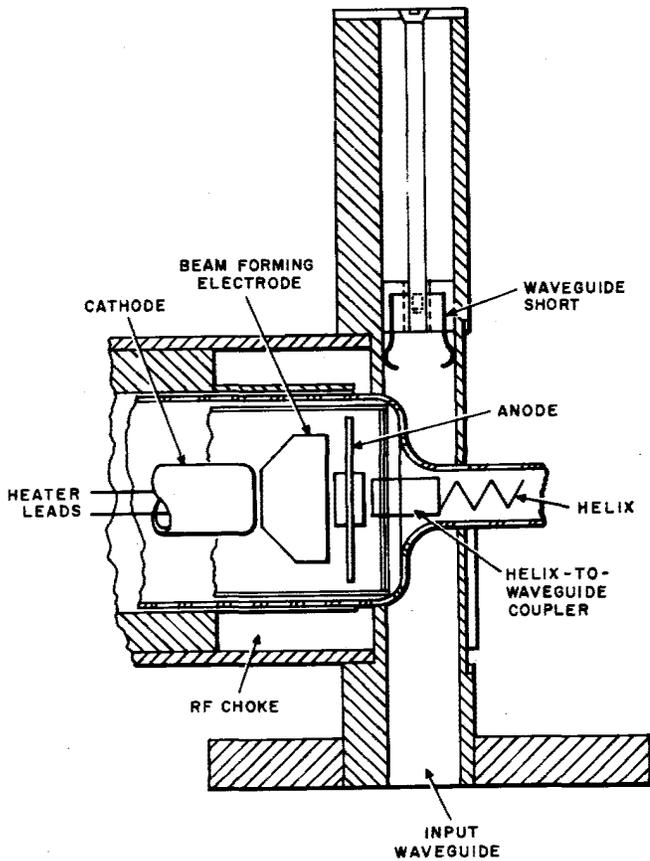
Fig. 26—Electron Gun and Input Waveguide Region of TWT Amplifier

Equipment Description

8.09 The TWT amplifier is furnished as a complete factory-assembled package consisting of the tube mounted in its associated focusing structure. The overall assembly is enclosed in a sheet steel container that provides both mechanical strength and electrical protection for operating personnel. The amplifier measures 3-1/4 by 4 by 16 inches and weighs 16 pounds. The tube is not replaced in the field; instead, the entire structure is returned to the factory where a new tube is inserted and optimumly focused in the reusable magnetic structure.

8.10 The amplifier is attached to the bay-mounted cooling block by means of two threaded studs which extend from the cooling block through the center portion of the amplifier package. Thermal connection between the amplifier cooling block and the bay-mounted cooling block is provided by a layer of silicon grease that fills the very small air gap between the two blocks. Electrical safety is ensured by operating the collector and the associated cooling block at ground potential (or, in other words, with the cathode at −1400 volts with respect to ground) and by a mounting arrangement that completely encloses the interlocked high-voltage connector between the amplifier and the TWT power supply (see Part 11).
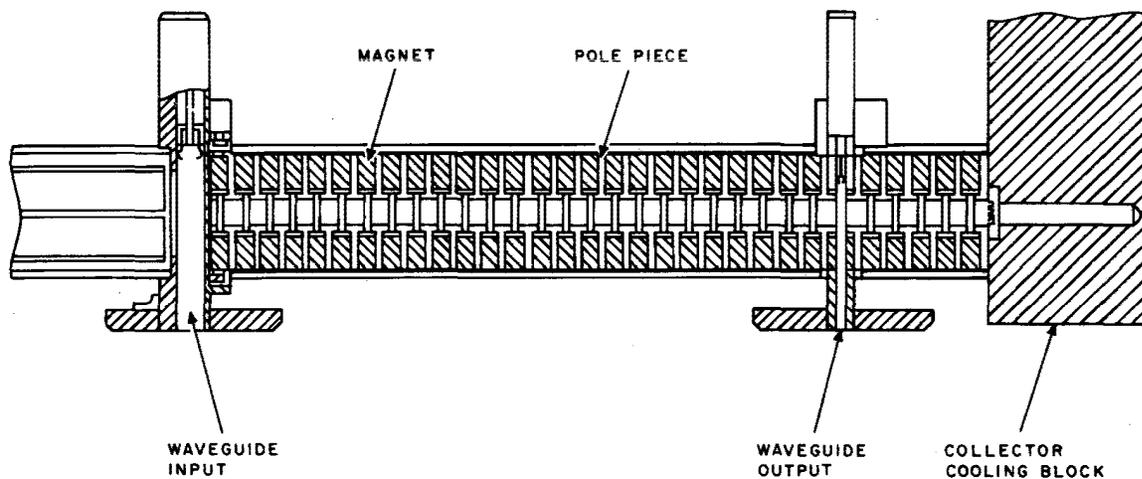

Fig. 27—Cross-Section of Periodic Permanent Magnet Focusing Structure

B. ▶Solid-State 660( ) Integrated Circuit Amplifier◀

General

8.11 This part describes the solid-state 660( ) IC which may be used in place of the traveling-wave tube amplifier in TD-3 bays. See Fig. 28.

8.12 The 660( ) IC is a broadband microwave amplifier capable of delivering 5 watts (+37 dBm) RF output power in the 4-GHz band. The amplifier is produced in two codes to provide the required frequency response characteristic. The 660E unit covers the low-frequency range of 3700 to 3940 MHz; the 660F unit covers the upper portion of the band from 3940 to 4200 MHz.

> *Note:* The 660 amplifier is also manufactured in a 2-watt model coded 660A and 660B and a 5-watt model coded 660C and 660D for use in TD-2 and other systems. All units are identical in appearance so replacements must be carefully identified.

Circuit Description

8.13 The amplifier has four gain stages. Each of the first three stages employs a single gallium arsenide field-effect transistor (GaAs FET) mounted
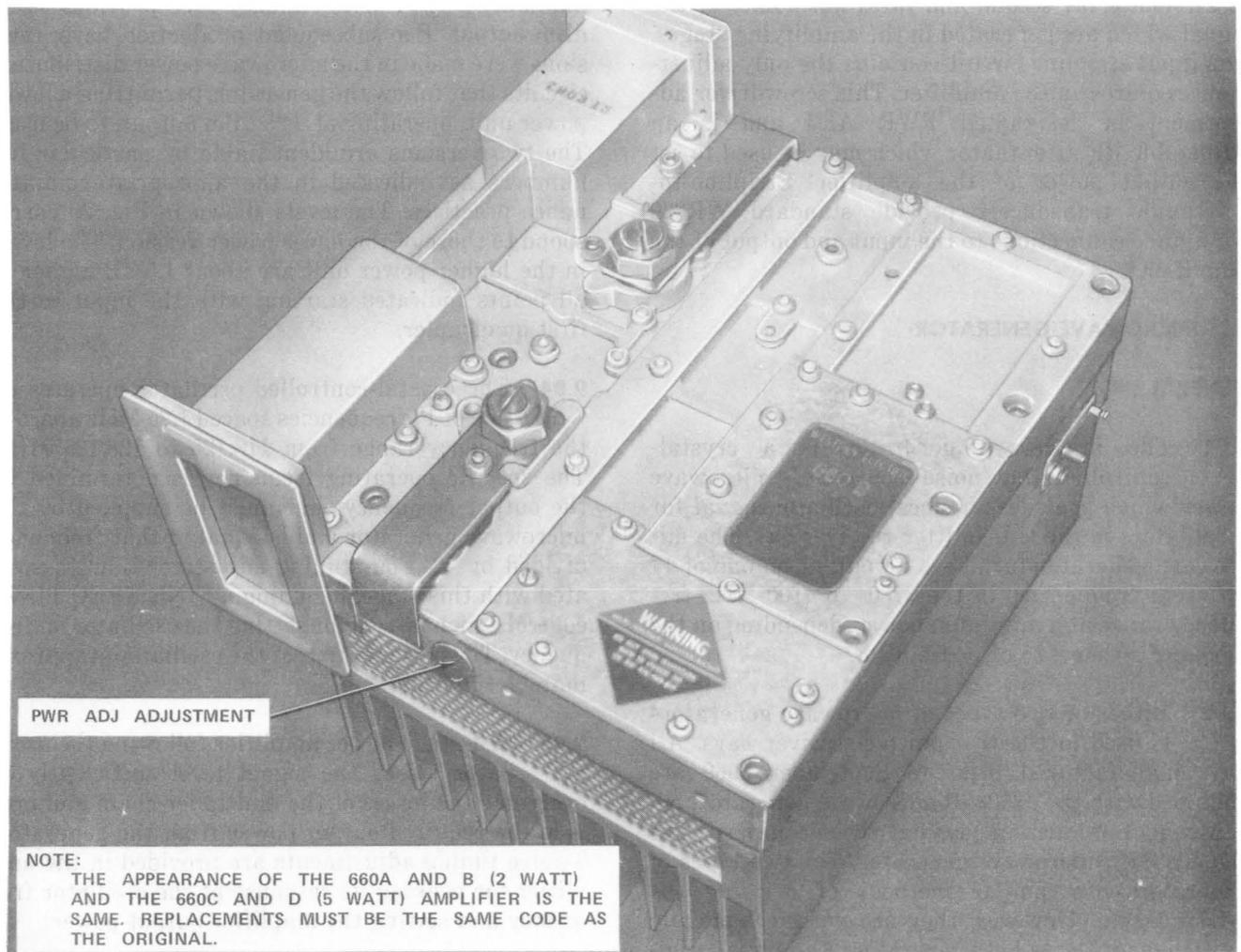

Fig. 28—▶660( ) IC RF Power Amplifier◀

in a microstrip-type circuit that includes the necessary input and output impedance matching networks for the stage. The fourth stage consists of two GaAs FETs mounted in parallel to provide the 5-watt power capability. The first two stages basically form a preamplifier which provides a net gain of about 20 dB to drive the power output stage. A circulator, also constructed in microstrip, isolates the preamplifier from the third stage and permits the second stage to be optimized for power handling capacity and linearity. A second microstrip circulator is used between the third and fourth stages for similar reasons.

8.14 The input and output isolators, which provide a good input and output return loss for the amplifier, are constructed in air-dielectric stripline. The output stripline circuit contains a low-pass filter to attenuate the second and third harmonics of the signal which are generated in the amplifying stages. The input stripline circuit contains the only adjustment required in the amplifier. This screwdriver adjustment is designated PWR ADJ and is an adjustable RF attenuator which may be used to set the output power of the amplifier. Stripline-to-waveguide transducers provide standard WR229 waveguide connections to the input and output of the amplifier.◀

9. MICROWAVE GENERATOR

GENERAL

9.01 The microwave generator is a crystal-controlled, low-noise source of microwave power which provides the local oscillator signal for modulators in the transmitter-receiver bay. The microwave generator furnishes an output on one of 17 different frequencies in the 3780- to 4100-MHz frequency range at a minimum power, depending on the model of either +25 or +26.5 dBm.

9.02 Either of two types of microwave generators is used in the transmitter-receiver bays. All bays manufactured prior to September 1969 are equipped with the J68387B microwave generator. All subsequent production bays have been equipped with the J68387R microwave generator. The two types of generators use similar methods of deriving the 4-GHz signal. However, they are not mechanically interchangeable. In both generators, the signal originates in a crystal-controlled oscillator operating in the 118.125- to 128.125-MHz frequency range. This frequency is then multiplied by frequency doublers

and quadruplers to the desired output frequency. The J68387B microwave generator uses a quadrupler, a doubler, and another quadrupler to obtain the required multiplication factor of 32. The J68387R microwave generator accomplishes the same multiplication with three doublers and a quadrupler.

J68387B MICROWAVE GENERATOR

A. Functional Description

9.03 The J68387B microwave generator (Fig. 29) consists of a crystal-controlled oscillator followed by a power amplifier that drives a frequency multiplier chain. There are two versions of this generator that differ in output power by 1.5 dB. The generator furnished with transmitter-receiver bays manufactured prior to January 1968 provides +26.5 dBm output. For subsequent production bays, revisions were made in the microwave power distribution circuits that follow the generator, permitting a lower power unit, operating at +25 dBm output, to be used. The two versions are identifiable by particular list numbers as indicated in the appropriate maintenance practices. The levels shown in Fig. 29 correspond to those of the lower power version. The levels in the higher power unit are about 1.5 dB higher at all points indicated starting with the input to the first quadrupler.

9.04 The crystal-controlled oscillator operates on one of 17 frequencies spaced 1.25 MHz apart in the frequency range from 118.125 to 128.125 MHz. The specific operating frequency is determined by the output frequency that must be supplied by the microwave generator and is equal to that frequency divided by 32. Four tuning adjustments are associated with this stage, including a FINE FREQ TUNE control which is used for setting the oscillator on frequency. The power output of the oscillator is approximately +10 dBm.

9.05 A 4-stage power amplifier following the oscillator raises the signal level sufficiently to overcome the losses of the multiplier chain and provide the required output power from the generator. Twelve tuning adjustments are provided in the amplifier for peaking its response at the oscillator frequency and setting the amplifier output power.

9.06 In the following paragraphs, 125-, 500-, 1000-, and 4000-MHz values are used as nominal frequencies to describe the operation of the frequency
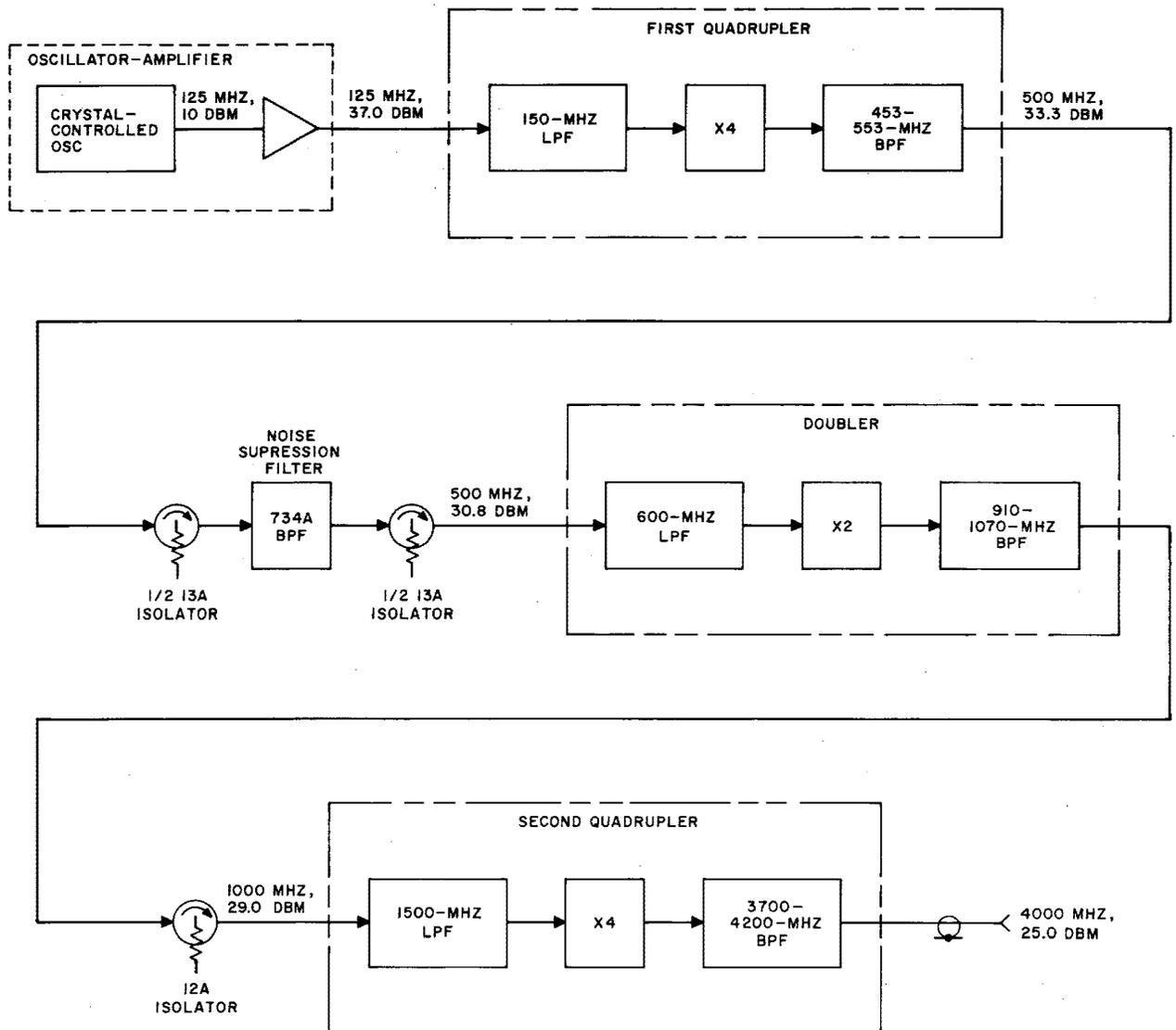
Fig. 29—J68387B Microwave Generator—Block Diagram

multiplying circuits. Actually, the frequencies could be values from 118.125 to 128.125 MHz, 472.5 to 512.5 MHz, 945 to 1025 MHz, and 3780 to 4100 MHz, respectively.

9.07 The first quadrupler uses a varactor diode in a lumped-element multiplier circuit to generate the fourth harmonic of the crystal oscillator frequency. A low-pass filter having a cutoff frequency of 150 MHz is used ahead of the multiplier circuit. This filter passes the 125-MHz output of the power amplifier but rejects all harmonics of 125 MHz gener-

ated in the multiplier stage. Similarly, a 453- to 533-MHz bandpass filter and the output passes the 500-MHz harmonic and rejects all others. The multiplier stage has three tuning adjustments used for maximizing the 500-MHz output.

9.08 The output of the first quadrupler is applied to a 734A bandpass filter. This is a tunable, high-Q cavity filter used to improve the overall signal-to-noise ratio of the microwave generator. The filter bandwidth is approximately 300 kHz at the 3-dB points. Isolators having about 20-dB reverse loss

are located before and after the 500-MHz bandpass filter to isolate the filter from the first quadrupler and the doubler. The two isolators are packaged as a single assembly coded the 13A isolator.

9.09 The doubler uses a varactor diode in a lumped-element circuit to multiply the 500-MHz input signal to 1000 MHz. A low-pass filter, which has a cutoff frequency of 600 MHz, is located at the input to the multiplier stage. It passes the 500-MHz input signal and rejects all harmonics of 500 MHz generated in the multiplier stage. A 910- to 1070-MHz bandpass filter at the output of the multiplier passes only the 1000-MHz harmonic, rejecting all others. Two tuning adjustments in the multiplier stage provide means of maximizing the 1000-MHz output power. A 12A isolator which provides approximately 20-dB reverse loss is used at the output of the doubler to isolate the doubler from the second quadrupler.

9.10 The second quadrupler uses a varactor diode in a distributed-element circuit to multiply the 1000-MHz input signal to 4000 MHz. A 1500-MHz low-pass filter at the input to the multiplier stage passes the 1000-MHz input signal and rejects all higher frequencies generated in that stage. The 3700- to 4200-MHz bandpass filter at the output of the mul-

tiplier stage passes only the 4000-MHz harmonic. The multiplier stage has three tuning adjustments used for maximizing the 4000-MHz output.

B. Mechanical Description

9.11 The J68387B microwave generator (Fig. 30) measures approximately 21 inches wide by 11 inches deep by 7 inches high and weighs 40-3/4 pounds. The generator is assembled on a die-cast aluminum chassis that mounts into the lower portion of the transmitter-receiver bay framework. The chassis fastens to the sides of the framework with 1/4-turn fasteners. Handles are provided at each side for lifting. All adjustments are accessible from the front of the unit. Mounted at the rear is a multicontact connector which provides dc power and metering connections. At the front upper right of the assembly is a type-N coaxial connector from which the microwave output from the unit is taken.

J68387R MICROWAVE GENERATOR

A. Functional Description

9.12 The J68387R microwave generator (Fig. 31) consists of a crystal-controlled oscillator, a
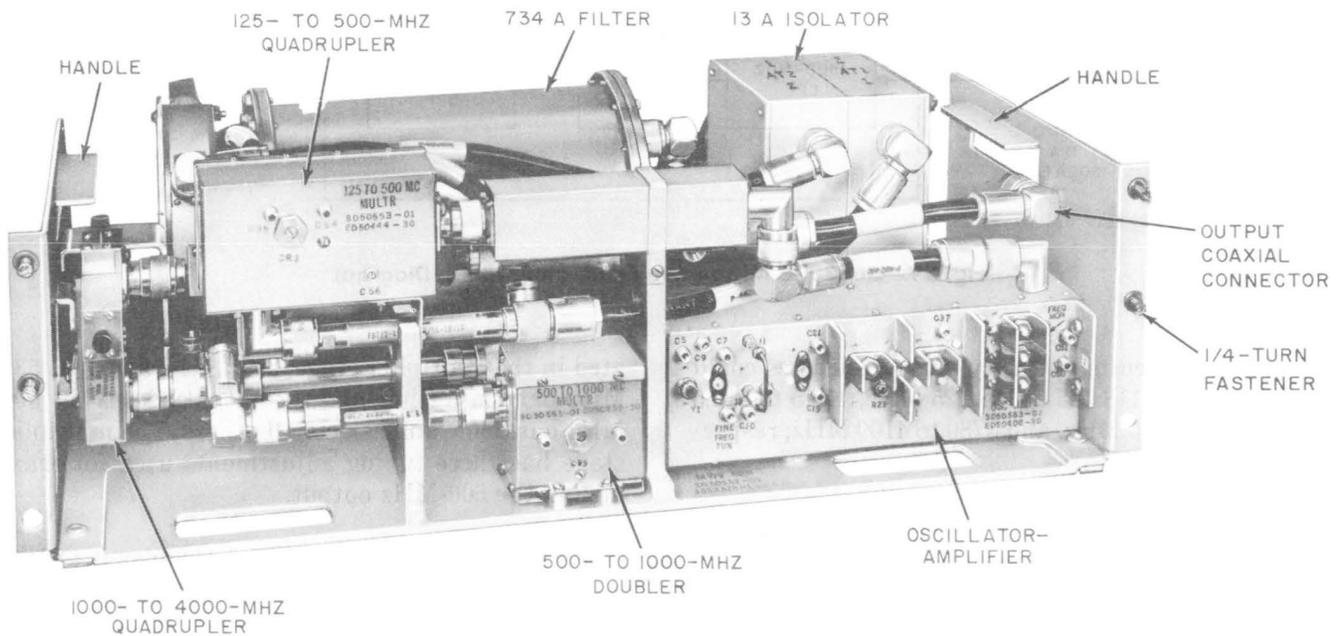

Fig. 30—J68387B Microwave Generator

buffer amplifier, three transistor frequency doublers, and a diode quadrupler. The nominal output power of the generator is +25 dBm.

9.13 The oscillator, amplifier, and first two doublers are contained in one package called the 500-MHz generator. The crystal-controlled oscillator operates on one of 17 frequencies spaced 1.25 MHz apart in the frequency range from 118.125 to 128.125 MHz. The specific operating frequency is determined by the output frequency that must be supplied by the microwave generator and is equal to that frequency divided by 32. Two tuning adjustments are associated with the oscillator stage, one to set the

oscillator on frequency (FREQ ADJ) and one to maximize the oscillator output power (125 MHz TUN).

9.14 The buffer amplifier following the oscillator is a single fixed-tuned amplifier which provides approximately 10-dB gain to the oscillator signal. This stage raises the signal level and also serves to isolate the oscillator from the first doubler stage, thereby preventing oscillator instability due to circuit interactions. A monitoring diode is connected to the output of this stage to provide an indication of the oscillator-amplifier output level on the appropriate control panel meter of the transmitter-receiver bay.
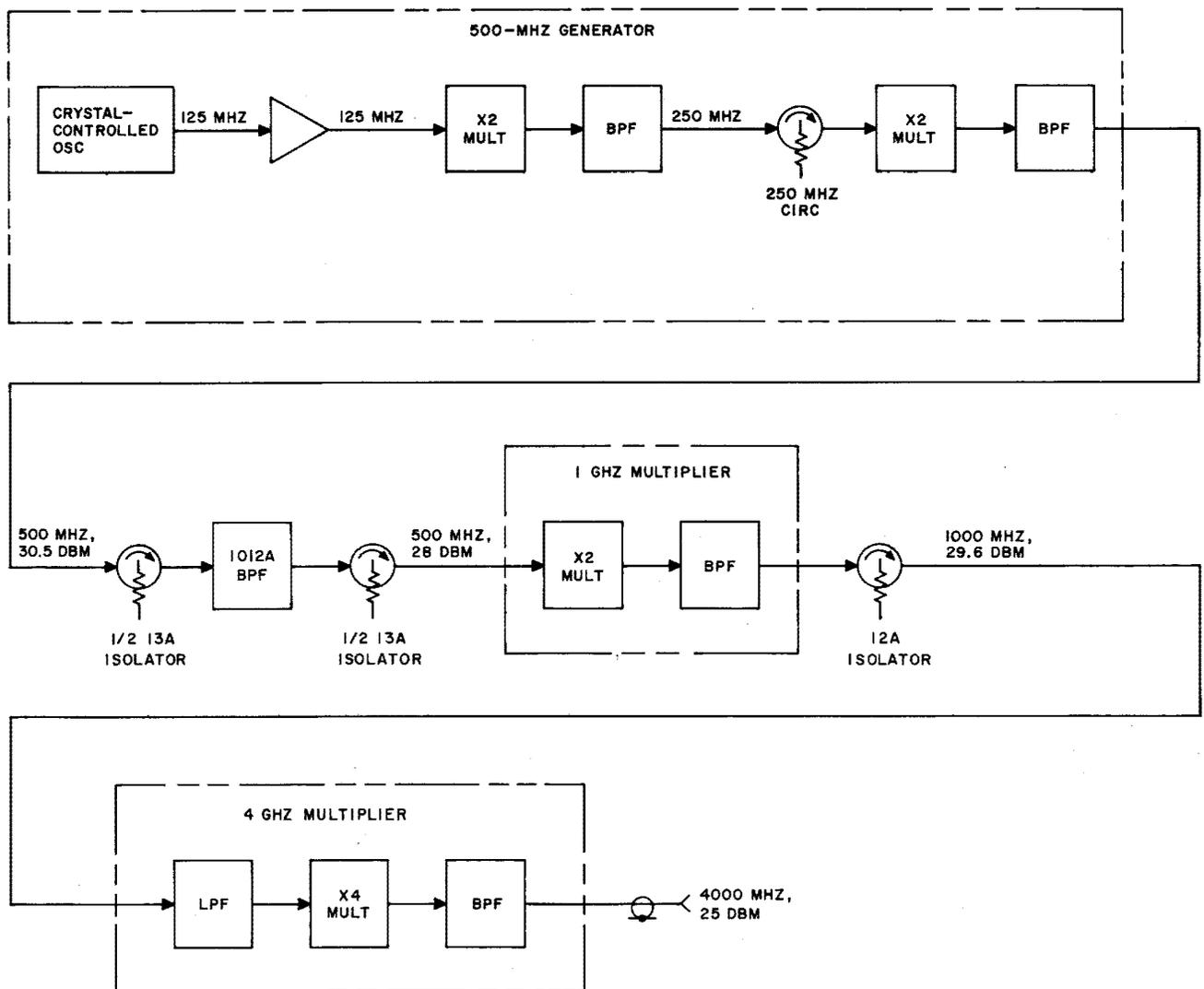

Fig. 31—J68387R Microwave Generator—Block Diagram

9.15 In the following paragraphs, 125-, 250-, 500-,
1000-, and 4000-MHz values are used as nominal frequencies to describe the operation of the frequency multiplying circuits. Actually, the frequencies could be values from 118.125 to 128.125 MHz, 236.25 to 256.25 MHz, 472.5 to 512.5 MHz, 945 to 1025 MHz, and 3780 to 4100 MHz, respectively, depending on the crystal frequency.

9.16 The 125- to 250- and the 250- to 500-MHz doubler stages each use an overlay type transistor to simultaneously obtain frequency doubling and conversion gain. A bandpass filter at the output of each doubler circuit passes the desired harmonic frequency and rejects all others. A 250-MHz circulator having approximately 20-dB reverse loss is used between the two doubler stages to provide isolation and prevent interaction when making tuning adjustments. Four controls are associated with these stages. One is used to maximize the output of the first doubler (250 MHz TUN), and two are used to maximize the output of the second doubler (500 MHz TUN 1 and TUN 2). The fourth control, LEV ADJ, is a common gain control for both doublers and is used to set the 500-MHz output level. A portion of the output of each doubler stage is rectified by a monitoring diode to provide an indication of output level on the appropriate control panel meter of the transmitter-receiver bay.

9.17 The output of the 500-MHz generator is applied to a 1012A bandpass filter. This is a tunable, high-Q cavity filter used to improve the signal-to-noise ratio of the microwave generator. The filter has a bandwidth of approximately 300 kHz at the 3-dB points. Isolators having about 20-dB reverse loss are used at the input and output of the filter to prevent interaction between the filter and the adjoining doubler stages. The two isolators are packaged as an assembly and coded the 13A isolator.

9.18 The 1-GHz multiplier circuit uses a transistor amplifier-doubler stage to multiply the 500-MHz input signal to 1000 MHz. A filter at the output passes the 1000-MHz signal and rejects the other harmonics generated in the multiplier. Four tuning adjustments are used for setting the 1000-MHz output. A measure of this output is provided by the transistor collector current which can be read on the meter of the appropriate control panel in the transmitter-receiver bay. A 12A isolator, having about 20-dB reverse loss, is used at the output of the 1-GHz

multiplier to prevent interaction with the 4-GHz multiplier.

9.19 Frequency multiplication in the 4-GHz multiplier is obtained using a varactor diode mounted in a distributed-element circuit. The multiplier stage is preceded by a low-pass filter which passes the 1000-MHz input signal and rejects all harmonics of 1000 MHz generated in the multiplier. The bandpass filter at the output of the multiplier passes only the 4000-MHz harmonic, rejecting all other harmonics. The multiplier stage has two tuning adjustments used for maximizing the 4000-MHz output.

B. Equipment Description

9.20 The J68387R microwave generator (Fig. 32) measures 21 inches wide by 11 inches deep by 7 inches high and weighs 40-3/4 pounds. The generator is assembled on a die-cast aluminum chassis that mounts into the lower portion of the transmitter-receiver bay framework. The chassis fastens to the sides of the framework with 1/4-turn fasteners. Handles are provided at each side for lifting. All adjustments are accessible from the front of the unit. Two cables with multicontact connectors are used to connect to a pair of bay-mounted connectors, appearing near the front right hand side of the generator to provide dc power and metering connections. Also located at this same point is a type-N coaxial connector from which the microwave output from the unit is taken.

10. J68387D 40-MHz OSCILLATOR AND SHIFT MODULATOR

10.01 In a standard transmitter-receiver bay, the transmitted and received frequencies differ by 40 MHz. The common microwave generator furnished in a repeater station bay operates at the local oscillator frequency required by the transmitter modulator. The function of the 40-MHz oscillator and shift modulator is to shift a portion of the output of the microwave generator by 40 MHz to provide the local oscillator frequency required by the receiver modulator.

10.02 The 40-MHz oscillator and shift modulator is used also in all standard main station bays manufactured prior to 1968. In these early bays, both the receiver and transmitter microwave generators operate at the transmitter modulator local oscillator frequency. The 40-MHz oscillator and shift modulator is used, therefore, to shift the output of the re-
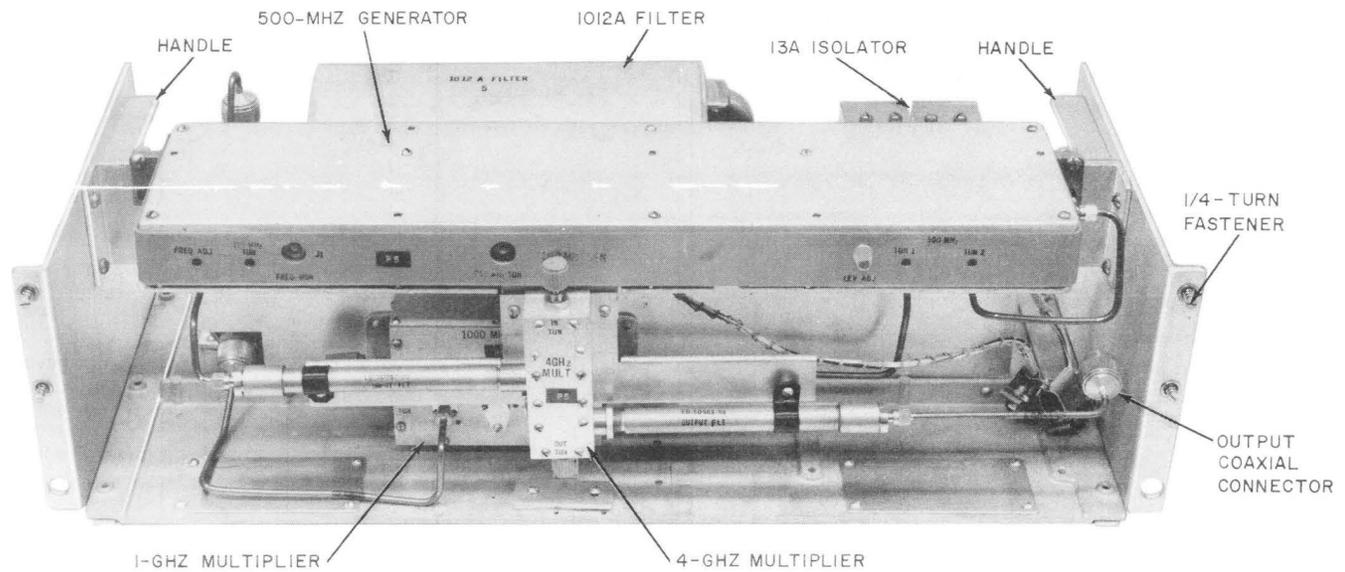
Fig. 32—J68387R Microwave Generator

ceiver microwave generator to obtain the proper local oscillator frequency for the receiver modulator. In all later manufactured main station bays, the receiver microwave generator furnishes directly the local oscillator frequency required by the receiver modulator. Thus, no 40-MHz oscillator and shift modulator is required in these bays.

FUNCTIONAL DESCRIPTION

10.03 The 40-MHz oscillator and shift modulator (Fig. 33) consists of a 40-MHz oscillator and a balanced modulator. An RF signal from the microwave generator is applied to the modulator along with the output from the 40-MHz oscillator. The modulator produces two RF output signals, one 40 MHz higher than the frequency of the microwave generator signal and one 40 MHz lower in frequency. A bandpass filter in the external circuit selects the desired sideband for use as the local oscillator input to the receiver modulator.

10.04 The 40-MHz oscillator consists of a crystal-controlled oscillator stage followed by a buffer amplifier and a power amplifier. The oscillator stage uses a third overtone crystal to produce the 40-MHz signal. Fine adjustment of the oscillator frequency is provided by the FREQ ADJ control. The OSC TUN and AMPL TUN controls are used to tune

the oscillator stage and buffer amplifier, respectively, for maximum power output. The LEV 2 control is used to adjust the input drive to the power amplifier and normally is set to give a +17 dBm output from this stage. A small portion of the power amplifier output is rectified to provide an indication of the oscillator output power that can be read on the receiver control panel meter. The main output from the power amplifier is split into two equal, in-phase signals that are applied through filters to the modulator diodes.

10.05 The modulator circuit uses the same type of magic-T hybrid junction as the balanced-type receiver modulator described in Part 3 and the transmitter modulator described in Part 7. The mixing of the 40-MHz oscillator output signal with the signal from the microwave generator takes place in a matched pair of point contact silicon diodes.

10.06 The signal from the microwave generator is applied to the E arm of the hybrid junction. Provided that equal impedances are connected to the sidearms (arms 1 and 2), energy applied to either the E arm or the H arm divides equally between the sidearms and almost no energy emerges from the opposite arm. Thus, the microwave generator input signal is split by the hybrid into two equal and, in this case, opposite phase signals. Each of these signals passes through a waveguide-to-coaxial transducer
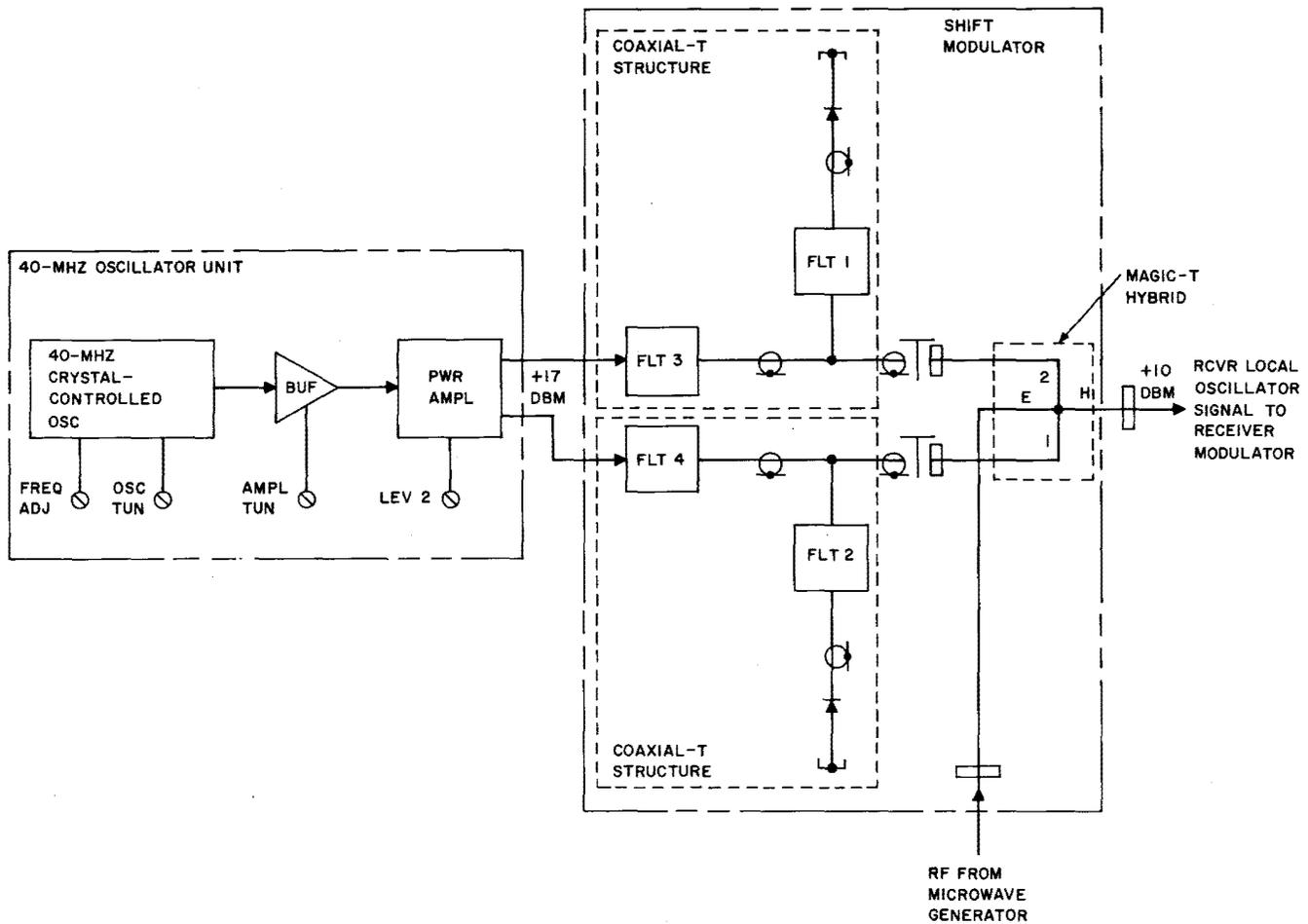
Fig. 33—40-MHz Oscillator and Shift Modulator—Block Diagram

into a coaxial-T structure containing one of the modulator diodes. The diodes combine the microwave generator signal and the 40-MHz signal and generate two new signals, one 40 MHz above the microwave generator signal and one 40 MHz below. The diodes are mounted in their holders in opposite directions so that the sidebands generated in one diode will be in phase with the sidebands generated in the other diode. At the hybrid, the in-phase sidebands combine and leave the modulator through the H arm. The nominal level of each sideband at this point is about +10 dBm. Any microwave generator input signals reflected by the diodes back to the hybrid appear at the H arm 180 degrees out of phase and, if equal in amplitude, cancel each other.

10.07 Filters FLT 3 and FLT 4 are dual-cavity, radial-line type chokes that prevent signals in the 4-GHz band from entering the 40-MHz oscillator. Filters FLT 1 and FLT 2 in the diode legs of the coaxial-T structures are low-pass filters that have a cutoff frequency of about 6 GHz and provide more than 50-dB loss to the second and third harmonics of the microwave generator signal generated in the diodes.

EQUIPMENT DESCRIPTION

10.08 The 40-MHz oscillator and shift modulator (Fig. 34) consists of two units: the modulator unit and the 40-MHz oscillator unit. The magic-T hybrid, which forms the main body of the modulator unit, is machined from an aluminum block. Assembled to this block are the waveguide-to-coaxial transducers, low-pass filters, RF chokes, and diode holders. The diode holders are removable to permit easy replacement of the diodes in the field. The

printed circuit board of the 40-MHz oscillator and several RF decoupling components are mounted inside a cast aluminum box that fits over and connects to one side of the modulator block. The oscillator box assembly can be detached easily from the modulator block for repair or replacement. The assembly of both units measures 6 by 6 by 4 inches and weighs 7-3/4 pounds. Figure 34 shows the locations of the oscillator unit tuning adjustments, the diode holders, and other features. Located on the top of the oscillator unit is the OSC MON coaxial connector which is used when measuring the 40-MHz output power and frequency. This connector is normally terminated by a 368A plug. On the side of the oscillator unit is a multicontact connector for dc power and metering connections. Not visible in Fig. 34 are the E and H arm waveguide ports of the magic-T hybrid, which are located on the top and back side, respectively, of the modulator block.
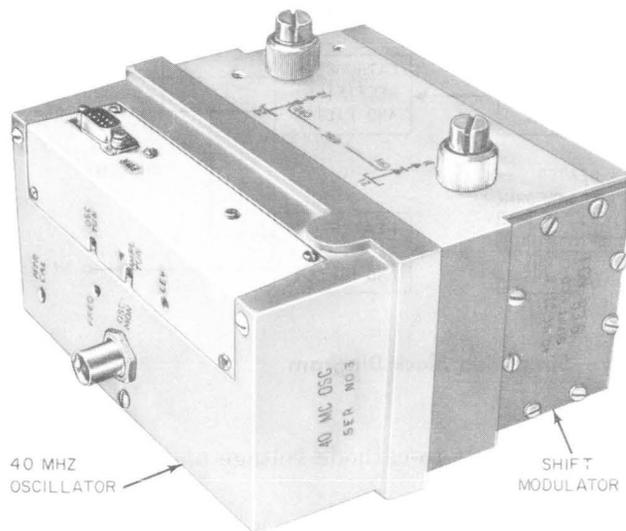
Fig. 34—J68387D 40-MHz Oscillator and Shift Modulator

11. J86835A TWT POWER SUPPLY

11.01 The J86835A TWT power supply is a solid-state, dc-to-dc converter that operates from the station −24 volt battery plant and provides the relatively high dc voltages required by the TWT electrodes. The range of electrode voltages and currents provided is shown in Table B.

TABLE B

ELECTRODE	VOLTAGE	CURRENT
Anode	Adjustable, +60 to +500V with respect to the helix voltage	0-1 mA
Helix	Adjustable, +2500 to +2900V with respect to the cathode voltage	0-4 mA
Cathode	Fixed, −1420V with respect to the collector voltage	35-40 mA
Collector	Connected to ground	—
Heater*	7.5V below the cathode	0.8-0.95A
—	—	5.5A

* Heater voltage is 0.1V upon initial turnon of the power supply and automatically drops to 7.5V after approximately 3 minutes.

FUNCTIONAL DESCRIPTION

11.02 A block diagram of the TWT power supply is shown in Fig. 35. The 24-volt battery power is applied through a circuit breaker and input filter to an inverter which produces a 48-volt, 2-kHz square wave output. This ac voltage is applied to four transformers, each of which has an associated rectifier and filter circuit which reconverts the ac power to dc and supplies a particular electrode voltage.

11.03 Power for the cathode of the TWT is derived by the cathode transformer and the cathode rectifier and filter. One side of the output goes to the TWT collector which is grounded; the other side furnishes the cathode potential. A meter in the cathode lead permits monitoring the cathode current.
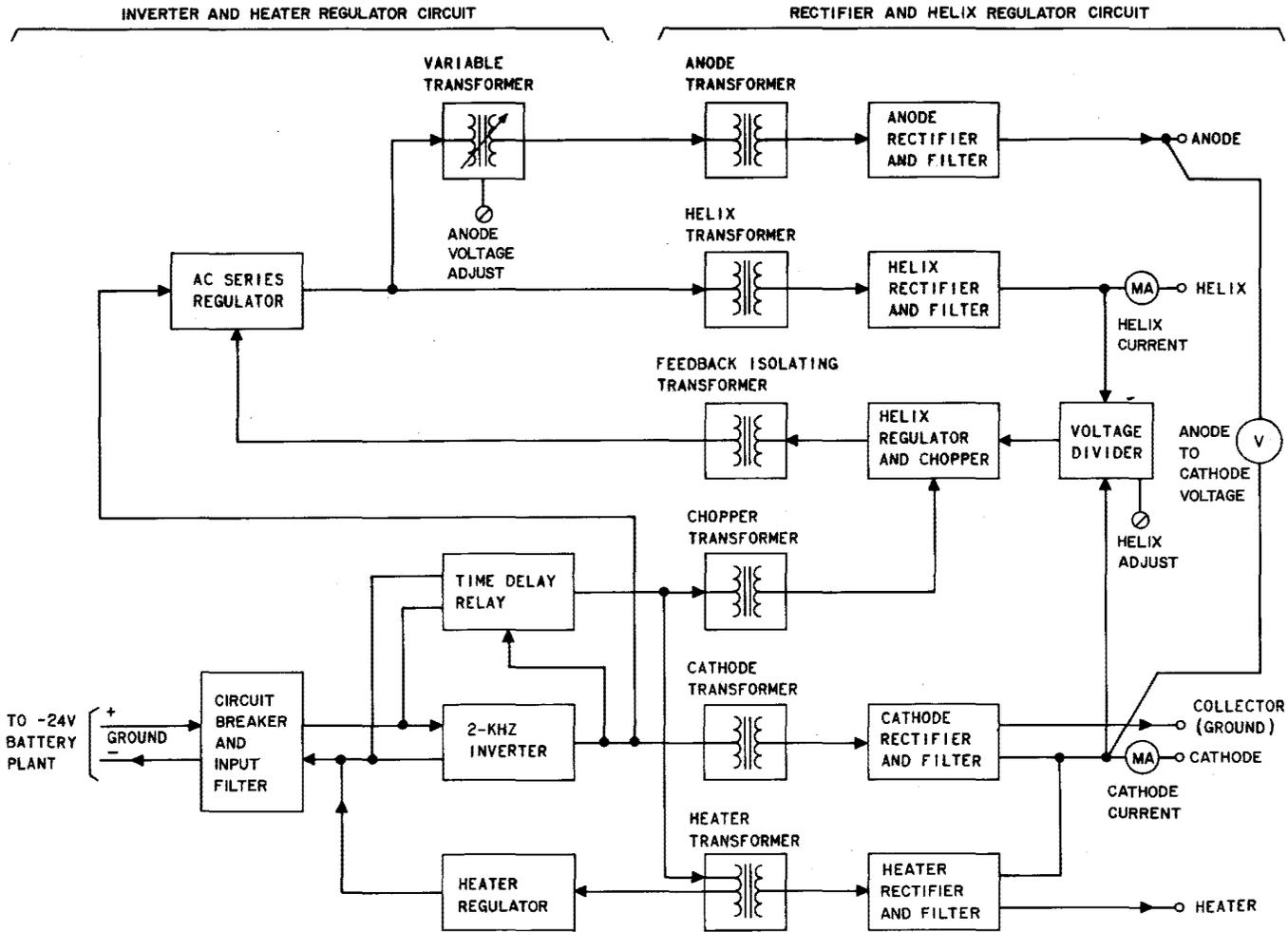
INVERTER AND HEATER REGULATOR CIRCUIT   RECTIFIER AND HELIX REGULATOR CIRCUIT

Fig. 35—J86835A TWT Power Supply—Simplified Block Diagram

11.04 The anode and helix transformers are supplied through a common ac series regulator. The helix and anode potentials relative to the cathode potential are regulated by monitoring the helix-to-cathode voltage through a voltage divider network. The monitored voltage is compared to a reference voltage. Any difference (error) voltage is amplified, chopped at a 2-kHz rate, and passed through a dc isolating transformer to the ac series regulator. Here the voltage is rectified and used as a bias voltage to control the voltage drop across the ac series regulator. This changes the ac voltages applied to the primary windings of the helix and anode transformers in such a direction as to reduce the error voltage. Separate controls are provided for setting the anode and helix voltages, and meters are provided for monitoring the anode-to-cathode voltage and the helix current.

11.05 The input voltage for the TWT heater transformer is supplied through an electronic time delay relay. The relay permits the heater voltage at the tube to be high for a period of approximately 3 minutes when the supply is first turned on. During this initial period, the relay applies the ac input voltage to one pair of taps on the primary of the heater transformer that results in a heater voltage of −9.1 volts. After the delay time has elapsed, the tap connection is switched and the heater voltage is reduced to −7.5 volts. The heater regulator is a series-type circuit that holds the ac voltage applied to the heater transformer to a constant value.

EQUIPMENT DESCRIPTION

11.06 The TWT power supply is shown in Fig. 36. It consists of two plug-in units mounted side by side in a metal housing. The inverter and heater regulator unit on the left-hand side and the rectifier and helix regulator unit on the right-hand side are electrically joined by connectors at the rear of the housing. A cable and connector assembly from the rectifier and helix regulator unit connect to the TWT amplifier which is shown mounted in its normal position above the power supply. The power supply is 22-3/8 inches wide, 10 inches deep, 10-1/2 inches high, and weighs approximately 60 pounds.

11.07 Removing the inverter and heater regulator unit opens an electrical interlock circuit and disables the circuits of the rectifier and helix regulator unit. This prevents high voltages from being present when the power supply is opened. Further electrical interlocking is provided in the TWT amplifier connector which must be connected to the amplifier for the high-voltage circuits to operate. In addition to this electrical interlocking scheme, me-chanical interlocking also is provided. This is accomplished by having a lip on the front panel of the rectifier and helix regulator unit extend behind the front panel of the inverter and heater regulator unit. Thus, any attempt to remove the former unit will automatically eject the latter unit.

11.08 The inverter and heater regulator unit (Fig. 37) is constructed of three castings (including the front panel) on which components are mounted. Two of the castings, as shown in Fig. 37, have fins for dissipating the heat from transistors and diodes mounted on them.

11.09 The rectifier and helix regulator unit (Fig. 38) is constructed of two castings: a panel casting and a chassis casting that holds the transformers, capacitors, and associated high-voltage components. A printed circuit board contains the helix regulator circuit components. The front panel and a plastic panel at the rear are on hinges and can be opened to gain access to the apparatus for troubleshooting and repair. The panel can be opened only when the unit has been removed from the housing.
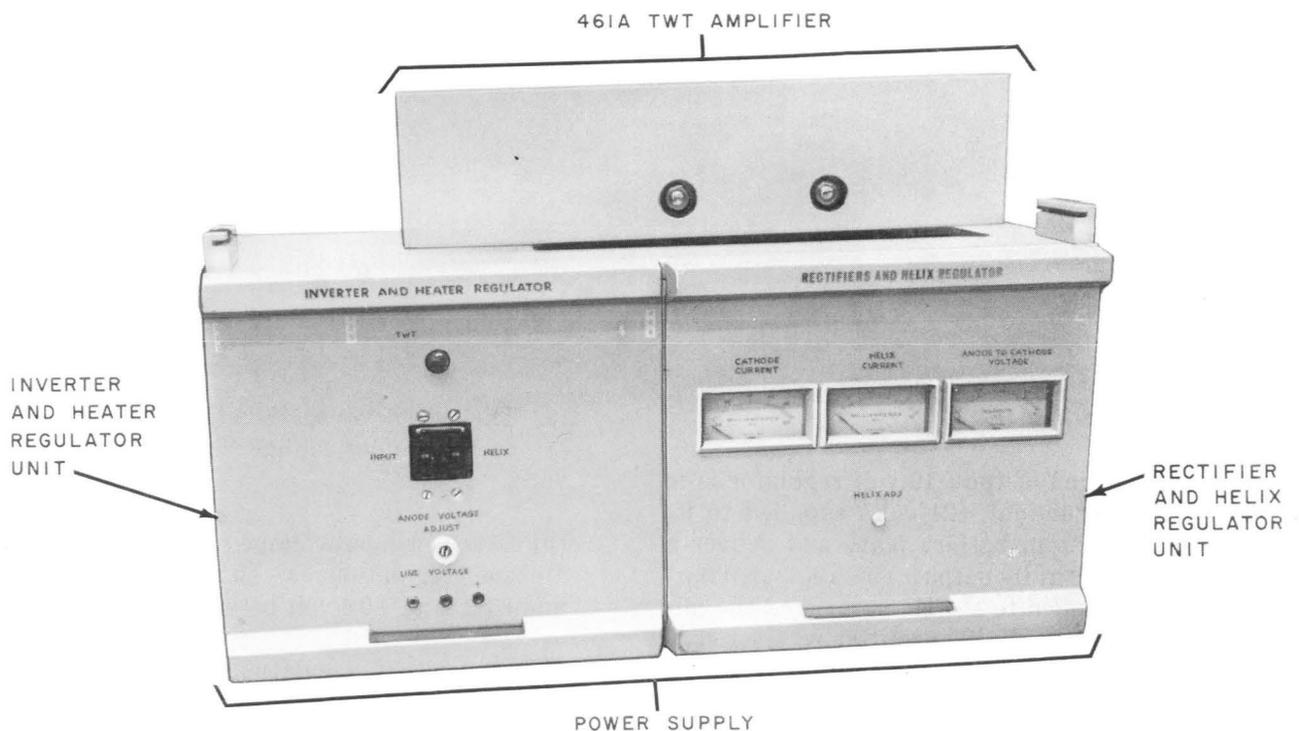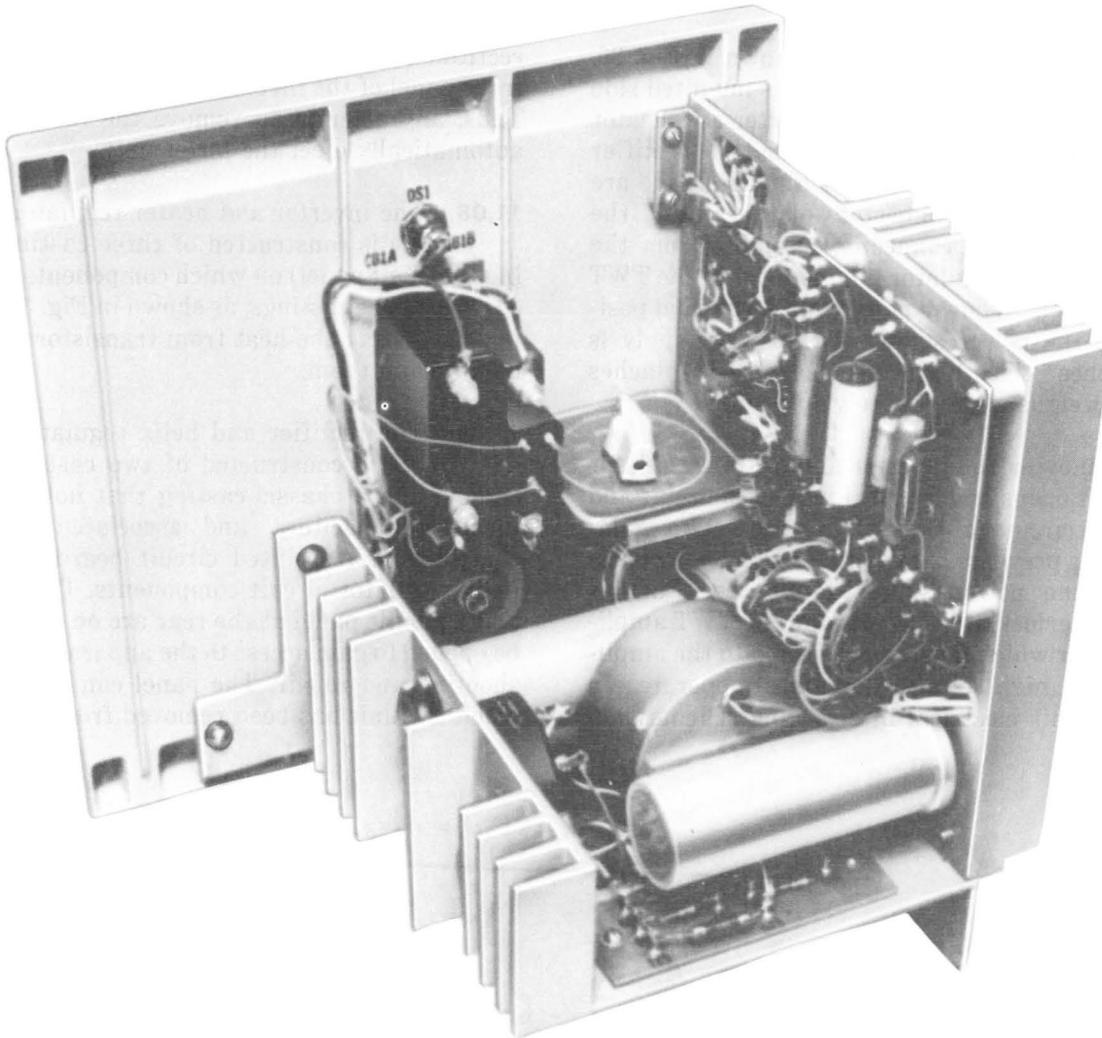

Fig. 36—J86835A TWT Power Supply

Fig. 37—Inverter and Heater Regulator Unit

12. −19 VOLT REGULATOR

12.01 The function of the −19 volt regulator is to take the nominal −24 volts supplied to its input from the station battery plant and deliver a regulated −19 volts at its output. This regulated output voltage is supplied to the IF circuit and the microwave generator in the transmitter-receiver bay. Two −19 volt regulators are used in a main station T-R bay; one regulator is used in a repeater station bay.

12.02 The −19 volt regulator has the following characteristics.

(a) The output voltage is adjustable to −19 volts over the input voltage range from −21 to −27 volts.

(b) Over this input voltage range, the output voltage regulation is ±0.2 volt between 70° and 80°F and ±0.4 volt between 40° and 140°F.

(c) The output regulation is maintained with loads of 0 to 4 amperes.

(d) For a 120-Hz input ripple voltage of 300 millivolts root mean square (RMS), the output ripple voltage is less than 1 millivolt RMS.
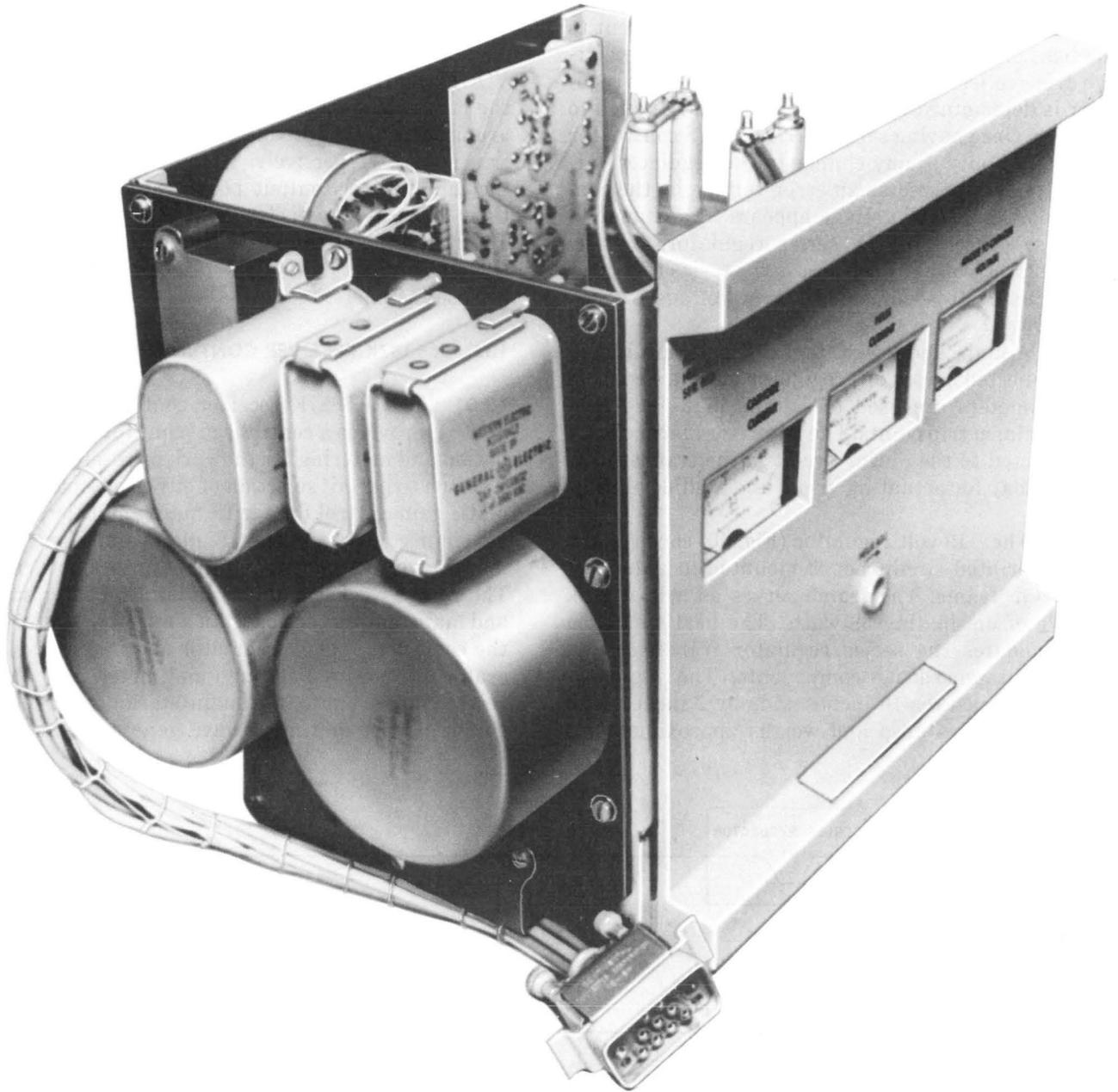
Fig. 38—Rectifier and Helix Regulator Unit

(e) When operating in conjunction with the T-R bay alarm circuit, a regulator high-voltage alarm will occur at −20 volts output and a low-voltage alarm will occur at −18 volts output.

12.03 A simplified block schematic of the −19 volt regulator is shown in Fig. 39. Output voltage regulation is accomplished by a loop composed of a voltage divider network, an error voltage amplifier, and a series regulator. The setting of the ADJ VOLTS control in the voltage divider network establishes an input voltage to the error voltage amplifier which is proportional to the regulator output voltage. The difference between this input voltage and a reference

voltage across a zener diode is amplified by the error voltage amplifier and applied as a control current to the base of the series regulator transistor. The voltage drop (collector-to-emitter) across the series regulator is determined by the control current applied to the base. Once having set the ADJ VOLTS control for the desired output, any change in the regulator output voltage is viewed as an error voltage by the control loop. This error voltage appears as a change in the base current of the series regulator, thereby changing the voltage drop across the series regulator in a direction to minimize the error voltage.

12.04 A high- and low-voltage alarm circuit is connected across the regulator output. Separate potentiometers are used to set the high- and low-voltage alarm trip points. The regulator alarm circuit is connected to the alarm circuit in the transmitter-receiver bay for actuating visual and audible alarms.

12.05 The −19 volt regulator (Fig. 40) consists of a printed circuit board mounted in a die-cast aluminum frame. The frame serves as a heat sink capable of dissipating 38 watts. The heat sink area accommodates the series regulator transistor and other heat-generating components. The regulator assembly measures 10 inches wide by 2 inches high by 13-1/2 inches deep and weighs approximately 5

pounds. The front panel of the regulator contains DC OUTPUT pin jacks for connection of a voltmeter. Also accessible from the front panel are the ADJ VOLTS control for adjusting the output voltage, and the HV ALM ADJ and LV ALM ADJ controls which are used to set high-voltage and low-voltage alarm trip points, respectively. A multicontact connector for input power, output power, and alarm connections to the T-R bay is located at the rear of the unit. The regulator assembly is fastened in place in the bottom compartment of the T-R bay with two quick-release fasteners.

13. J68387K RECEIVER CONTROL UNIT

13.01 The J68387K receiver control unit (Fig. 41) provides a centralized point for power distribution and metering for the various receiver circuits, a switch to permit selection of either manual or automatic gain control for the IF main amplifier, a manual gain control for the IF main amplifier, and a microwave generator low output power alarm circuit. The receiver control unit is in both repeater station and main station type bays. In a repeater station bay, the common −19 volt regulator and microwave generator are powered through and metered by the receiver control unit. In a main station bay, the −19 volt regulator and microwave generator associated
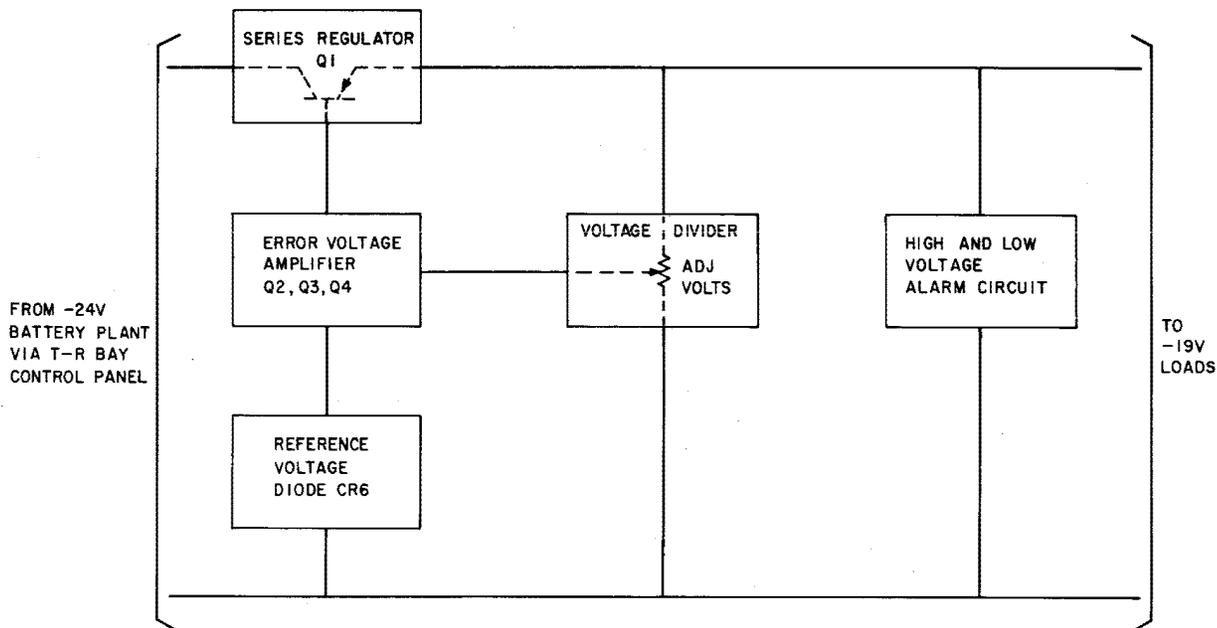

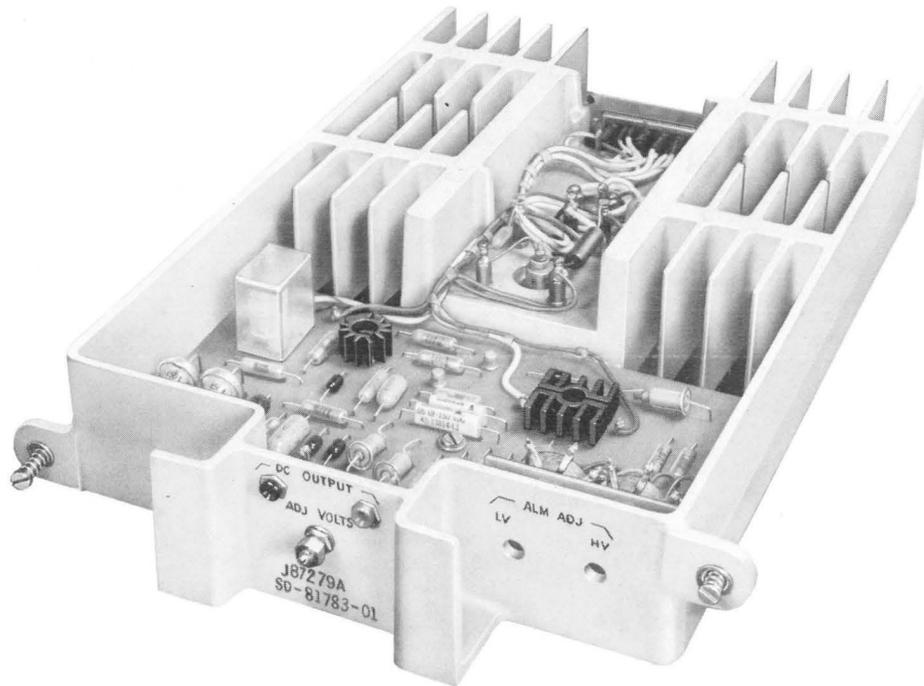**Fig. 39—Simplified Block Diagram of −19 Volt Regulator**

Fig. 40—J87279A −19 Volt Regulator

with the receiver are powered through and monitored by the receiver control unit. The transmitter regulator and generator are associated with a main station bay transmitter control unit, J68387M (see Part 15).

13.02 The POWER circuit breaker provides overload protection for one −19 volt regulator in the transmitter-receiver bay and for the −24 volt circuits in the control panel. The circuit breaker is a 2-section circuit breaker; one section trips at 5 amperes and the other section trips at 2 amperes. The 5-ampere section provides overload protection for the indicator lamps and the microwave generator alarm circuit in the control panel, and for the −19 volt regulator when the station battery voltage is greater than about −22 volts. The 2-ampere section of the breaker provides protection for the −19 volt regulator when the battery voltage is below about −22 volts. An auxiliary switch is a part of the circuit breaker, and it provides ground to external alarm circuits when the circuit breaker is tripped.

13.03 The −19V CHECK switch and either two or four 6-pushbutton switch assemblies are used to switch the control unit meter between the various external circuits to be metered. In receivers equipped with the J68387B microwave generator, four switch assemblies are used. In these receivers, a number of the originally provided pushbutton positions are no longer needed. Therefore, at the time the J68387B microwave generator was replaced in production with the J68387R generator, changes were made in the receiver control unit which reduced the metering circuit to two switch assemblies. The newer of these two versions of the receiver control unit is shown in Fig. 41. Each of the switch assemblies has six self-locking pushbuttons, and the assemblies are mechanically ganged such that when any pushbutton is depressed any previously selected pushbutton is released. Each of the individual switches used is connected to metering leads from a circuit within the receiver. Operation of any selected circuit within the receiver can then be monitored by depressing the applicable pushbutton. Each of the circuit-selecting pushbuttons is illuminated when it is depressed.

13.04 The control unit meter is a 5900-ohm, 20-microampere full scale unit. The meter scale is linear, with calibration marks every two units from 0 to 100 units full scale. The meter has two nega-
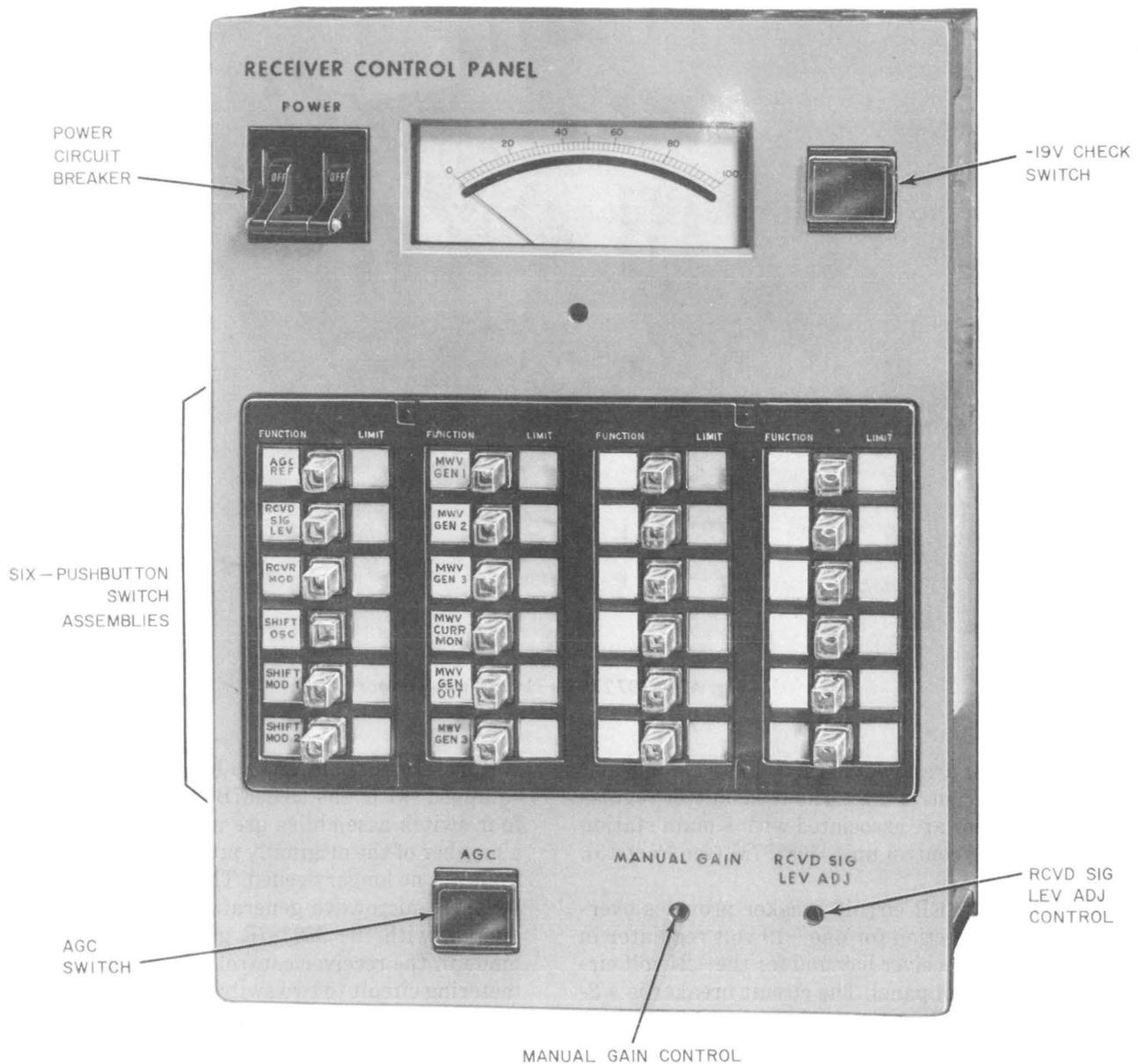
Fig. 41—J68387K Receiver Control Unit

tive terminals and one common positive terminal. Associated with one of the negative terminals is an internal resistor which provides precise calibration of the meter at 70 units (marked with a red line) for use when checking the output of the −19 volt regulator. When the −19V CHECK pushbutton switch is depressed, the meter is disconnected from the other pushbutton switches and its −19 volt calibrated terminals are connected across the output of the regula-

tor. The −19V CHECK switch is spring-loaded so that when the pushbutton is released the switch will return to its nonoperated condition.

13.05 The pushbutton-operated AGC switch is used to change the gain control of the IF main amplifier from automatic to manual. When the IF main amplifier gain is being controlled automatically, the AGC pushbutton is not illuminated and the

MANUAL GAIN control is inoperative. When the AGC pushbutton is depressed, the word "MANUAL" is illuminated on the pushbutton and the MANUAL GAIN control can be operated to control the gain of the amplifier. Depressing the AGC pushbutton again restores the gain operation to automatic and extinguishes the pushbutton lamp.

13.06 With the RCVD SIG LEV pushbutton depressed, the RCVD SIG LL ADJ control can be adjusted to set the meter to a prescribed indication for a particular value of received carrier power. Normally, the meter reading is set to give a convenient meter indication, linear in dB, of the actual received carrier power relative to the calibration value over a dB range equal to the AGC range of the IF main amplifier.

13.07 The microwave generator alarm circuit consists of a meter-type relay and a MWV GEN ALM SET control mounted on the rear of the control unit. A dc current from a monitoring detector located in the microwave generator output power distribution circuit of the transmitter-receiver bay provides a measure of the generator output for the meter-type relay. The circuit can be calibrated so that the relay contacts will close for a specified decrease in generator output power. Contact closure provides a ground which is used by the transmitter-receiver bay alarm circuit to activate audible and visual alarms. Once closed, the contacts are locked together until the generator power is restored and the meter reset circuit in the bay alarm unit is operated.

13.08 Also mounted on the rear of the receiver control unit are two multicontact connectors, one for metering leads from the circuits to be monitored and one for dc power, alarm, and control connections. The rear panel is hinged to provide access to the inside of the control unit for maintenance. The receiver control unit measures 9-1/4 by 12-1/2 by 3 inches and weighs 8-1/4 pounds.

14. J68387L REPEATER STATION BAY TRANSMITTER CONTROL UNIT

14.01 The J68387L repeater station bay transmitter control unit (Fig. 42) provides a centralized point for distributing −19 volts to the IF circuits in the transmitter, a meter circuit for monitoring the operation of certain of the transmitter circuits, and a transmitter low output power alarm circuit. Many of the features of this control unit are identical to

those in the J68387K receiver control unit. One major difference between the two units is that the transmitter control unit has no circuit breaker or −19V CHECK switch; in a repeater station type bay, these functions are provided for both the transmitter and receiver by the receiver control panel.

14.02 One 6-pushbutton switch assembly is used to switch the control unit meter between the various external circuits to be metered. The switch contains six self-locking pushbuttons each of which, when depressed, is illuminated and releases any previously selected pushbutton.

14.03 The transmitter output power alarm circuit consists of a meter-type relay and a TRMTR OUT ALM SET control mounted on the rear of the control panel. A dc current from a monitoring detector located in the output circuit of the transmitter provides a measure of the transmitter output power for the meter-type relay. The associated control permits calibrating the meter so that the relay contacts will close when the transmitter output power decreases, typically by 3 dB. The operation of this alarm circuit in conjunction with the transmitter-receiver bay alarm circuit is identical to that previously described for the microwave generator alarm (paragraph 13.07).

14.04 Also located on the rear of the control unit are two multicontact connectors, one for metering leads and one for dc power, alarm, and control connections. The rear panel is hinged to provide access to the inside of the control unit for maintenance. The assembly measures 9-1/4 by 12-1/2 by 3 inches and weighs 4-1/2 pounds.

15. J68387M MAIN STATION BAY TRANSMITTER CONTROL UNIT

15.01 The J68387M main station bay transmitter control unit (Fig. 43) provides a centralized point for power distribution and metering for various circuits for a main station transmitter. This unit also contains circuits for initiating an alarm in case of low output power from either the transmitter or the transmitter microwave generator.

15.02 Since, in a main station bay, the transmitter and receiver operate completely independently of each other, each with its own −19 volt regulator and microwave generator, the main station bay transmitter control unit must provide the same type
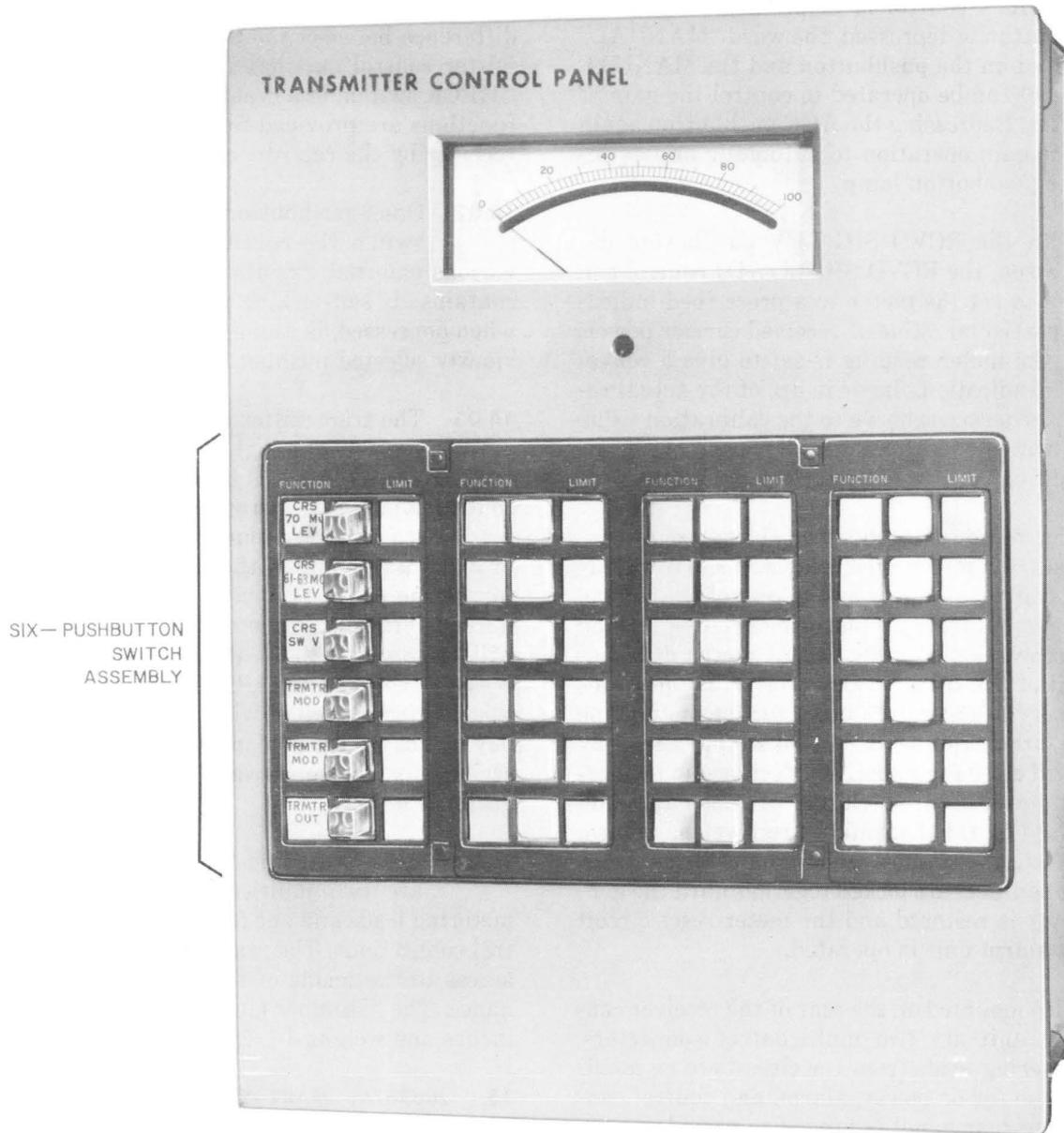
Fig. 42—J68387L Repeater Station Bay Transmitter Control Unit

of operating features as the receiver control panel. Thus, the main station bay transmitter control unit contains a POWER circuit breaker, a −19V CHECK switch, and a microwave generator receiver control unit previously described in Part 12. Also included is a transmitter low output power alarm circuit identical to that in the repeater station bay transmitter control unit (paragraph 14.03).

15.03 Either two or three 6-pushbutton switch assemblies are used to switch the control unit meter between the various external circuits to be metered. In transmitters equipped with the J68387B microwave generator, three switch assemblies are used; transmitters equipped with the J68387R generator require only two switch assemblies. The latter control unit is shown in Fig. 43. The operation of the switch assemblies, in conjunction with the meter cir-
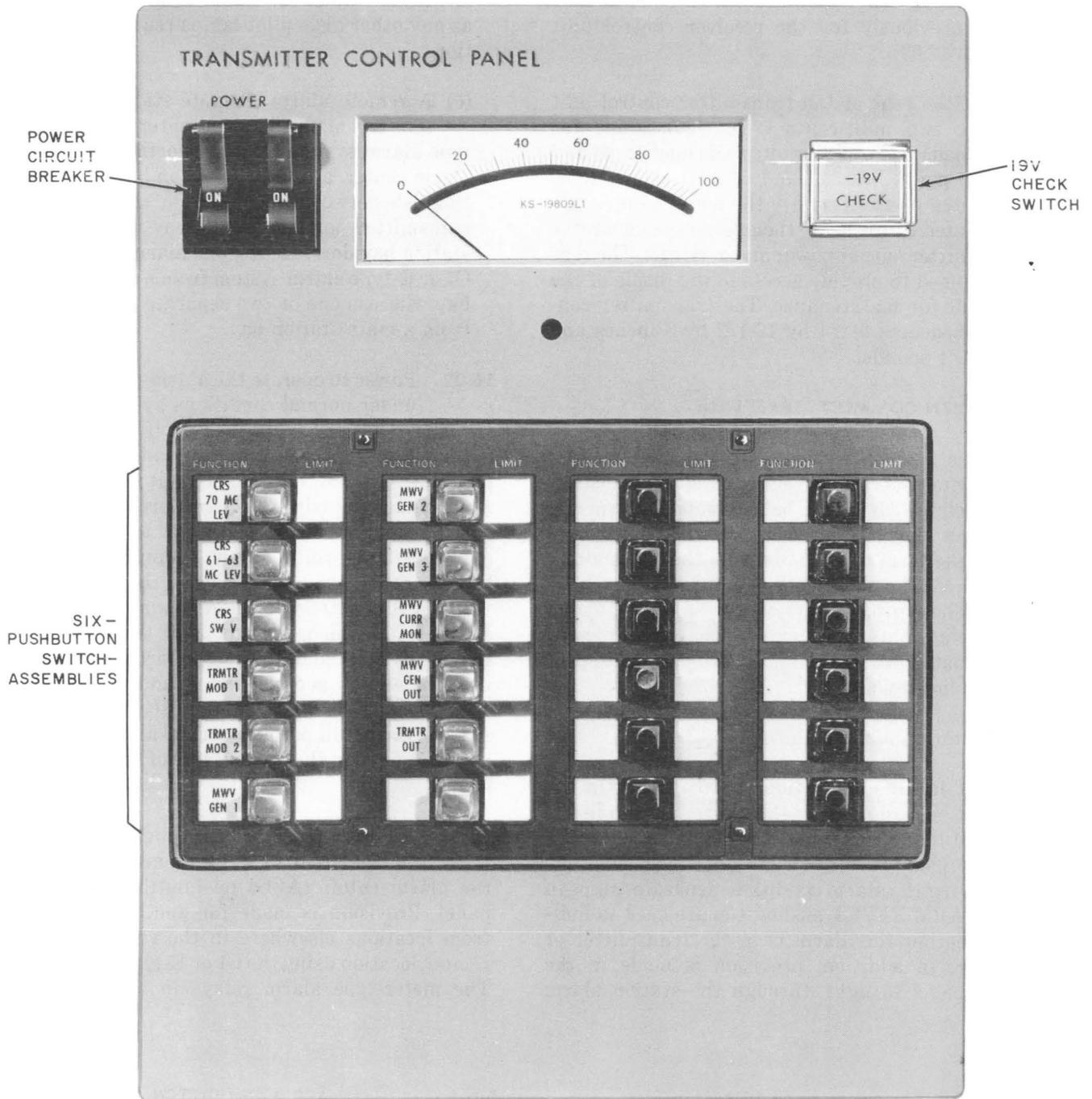
Fig. 43—J68387M Main Station Bay Transmitter Control Unit

cuit and the −19V CHECK switch, is the same as that described previously for the receiver control unit (paragraph 12.03).

15.04 At the rear of the transmitter control unit are two multicontact connectors, one for metering leads from the circuits to be monitored and one for dc power, alarm, and control connections. Also mounted on the rear are the meter-type relays and associated controls for the microwave generator and transmitter output power alarm circuit. The rear panel is hinged to provide access to the inside of the control unit for maintenance. The transmitter control unit measures 9-1/4 by 12-1/2 by 3 inches and weighs 7-1/4 pounds.

16. J68387N COMMON ALARM PANEL

16.01 The J68387N common alarm panel (Fig. 44) contains a receiver alarm circuit, a transmitter alarm circuit, an alarm battery supply alarm circuit, and an alarm reset circuit. The panel receives inputs in the form of grounds from the transmitter or receiver control units when there is a T-R bay malfunction. These grounds are converted by the alarm panel to relay contact closures which, in conjunction with associated external circuits, can be used to provide the following alarms:

(a) A station audible alarm.

(b) A T-R bay and station visual alarm. On the T-R bay originating the alarm, a lamp in the ALARM RESET pushbutton of the alarm panel is lighted. This provides visual identification of the bay having the alarm condition. Separate lamps in the ALARM RESET pushbutton are used to indicate whether the alarm is in the transmitter or receiver. In addition, provision is made in the alarm panel to light, through the station alarm

circuit, a lamp at the end of the bay lineup as well as any other aisle pilot lamps required in the station.

(c) A remote alarm. Remote station alarms are sent to a manned alarm center via the C1 or E-type alarm system. When reporting alarms to an alarm center, a repeater station bay does not distinguish between alarms from the receiver and transmitter portions of the bay whereas a main station bay does. Hence, one alarm is sent via the C1 or E-type alarm system from a repeater station bay whereas one or two separate alarms are sent from a main station bay.

16.02 Power to operate the alarm panel is supplied under normal conditions by the station −24 volt alarm battery supply (ABS). If the alarm panel malfunctions and causes an overload on the ABS supply, the ALARM POWER circuit breaker on the alarm panel will trip. The circuit breaker is equipped with an auxiliary switch connected to the station signal (SIG) −24 volt battery supply. If the circuit breaker trips, the switch closes, thereby supplying −24 volt SIG battery to the ABS alarm relays in the alarm panel which, in turn, light the ABS lamp on the alarm panel and, through external circuits, activate the station audible, visual, and remote alarms. This "backup" provided by the SIG battery and the ABS alarm circuit permits normal alarm functions to be maintained in the event of loss of the −24 volt ABS supply voltage.

16.03 The audible alarm initiated by any of the alarm circuits can be silenced by depressing the alarm cutoff (ACO) pushbutton on the alarm panel. Provision is made for audible alarm cutoff from locations elsewhere in the station or from a remote location using the C1 or E-type alarm system. The meter-type alarm relays in the receiver and
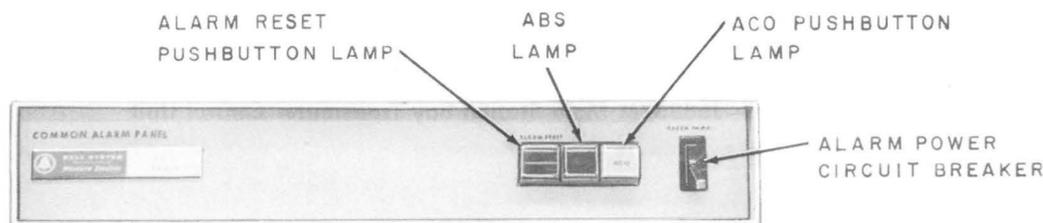

Fig. 44—J68387N Common Alarm Panel

transmitter control units can be reset locally by depressing the ALARM RESET pushbutton on the alarm panel or remotely via the C1 or E-type alarm system.

16.04 The common alarm panel is mounted directly below, and on the same swinging door assembly with, the transmitter and receiver control units. A printed circuit board for the alarm reset circuit is mounted on the rear of the front panel. Six relays are mounted in pairs on three printed circuit boards which, in turn, are mounted between the front and rear panels. The rear panel has three multicontact connectors. One connector is for transmitter alarm inputs, one is for receiver alarm inputs, and one is for dc power and alarm outputs. The common alarm panel assembly measures 18-3/4 by 3 by 3 inches and weighs 3-3/4 pounds.

17. PASSIVE COMPONENTS

A. 1418-Type Channel Networks

17.01 Two channel networks are utilized in each transmitter-receiver bay. One of the networks, commonly referred to as the channel separating network, separates a particular channel from the composite signal applied to it, applying this channel to the receiver and passing all the other channels on to other receivers. The other network, referred to as the channel combining network, combines the output signal from the transmitter with the outputs from other transmitters to form a composite signal for application to the transmitting antenna.

17.02 Each of the networks consists of a 4B and a 5B waveguide hybrid junction and two 1321-type waveguide band-rejection filters. In a channel separation network, the band-rejection filters are tuned to reject the frequency of the channel being dropped. In a channel combining network, the filters are tuned to the frequency of the transmitter signal being added to the line. The 4B and 5B junctions are electrically identical; they differ mechanically in that the 5B junction has a termination permanently connected to the H arm (arm 2, Fig. 45) whereas the 4B junction provides a waveguide output on that arm.

17.03 The signal fed to a repeater bay lineup from the receiving antenna consists of up to six similarly polarized channels having 80-MHz separation between carriers and located in the frequency range of 3710 to 4170 MHz. For this description

[Fig. 45(A)], it is assumed that the signal consists of three channels—F1, F2, and F3—and that F1 is the frequency to be dropped. The combined signal is applied to arm 1 of the 4B hybrid junction and all the energy is split evenly between arms 3 and 4; virtually no energy is directly coupled through to arm 2. The filters attached to arms 3 and 4 of the hybrids pass the F2 and F3 signals on to the 5B junction but reflect the F1 signal. The F2 and F3 signals combine in phase in the 5B junction and are sent out arm 1 to the next channel separating network in the bay lineup. Arm 2 of the 5B junction is terminated so that any energy reaching this arm is absorbed. At the last bay in the line, arm 1 is terminated to close off the end of the waveguide and absorb any remaining signal power.

17.04 The effective electrical input to one band-rejection filter (BRF) is located one-quarter wavelength farther from the 4B junction than the effective input to the other filter. As a result, the F1 signal arriving at one filter is 90 degrees out of phase with respect to the signal arriving at the other filter. The filters reflect the F1 signal back to the 4B junction. Again, because of the one-quarter wavelength difference in the distance of travel, there is another 90-degree phase shift. Therefore, the two reflected components of the F1 signal arrive back at the 4B junction equal in amplitude but 180 degrees out of phase. The components combine in phase in arm 2 of the junction, and the resultant signal is applied to the input of the receiver. Virtually none of the F1 signal reflected from the filters appears at arm 1.

17.05 Operation of the channel combining network is similar to that of the separating network. Signals F2 and F3 [Fig. 45(B)] from previous combining networks are applied to arm 1 of the 5B junction. They split evenly and are applied in phase through the band-rejection filters to arms 3 and 4 of the 4B junction. The F1 output from the transmitter is applied to arm 2 of the 4B junction. This signal splits into two components of equal amplitude but 180 degrees out of phase in arms 3 and 4. Since the path lengths to the band-rejection filters differ by one-quarter wavelength, the phases of the F1 signal components arriving at the filter differ by an additional 90 degrees of phase shift. The filters reflect the F1 signals back to the 4B junction. Again, because of the one-quarter wavelength difference in distance of travel, a second 90-degree phase shift takes place. Therefore, the two F1 components arrive back at the 4B junction in phase. They combine with the F2 and F3 energy in arm 1 of the junction, and the combined
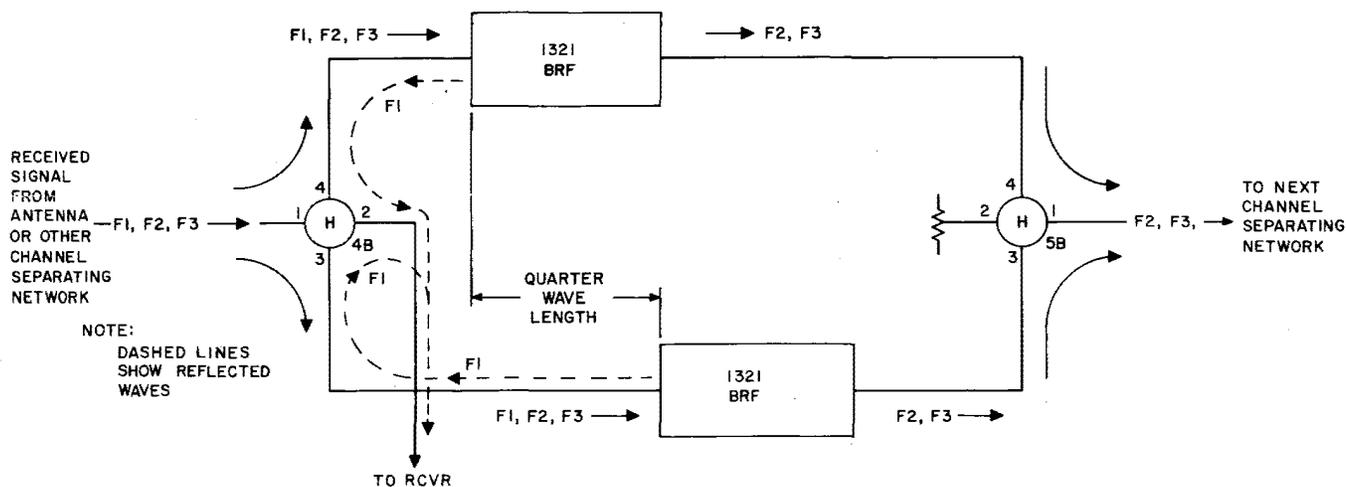
(A) CHANNEL SEPARATING NETWORK
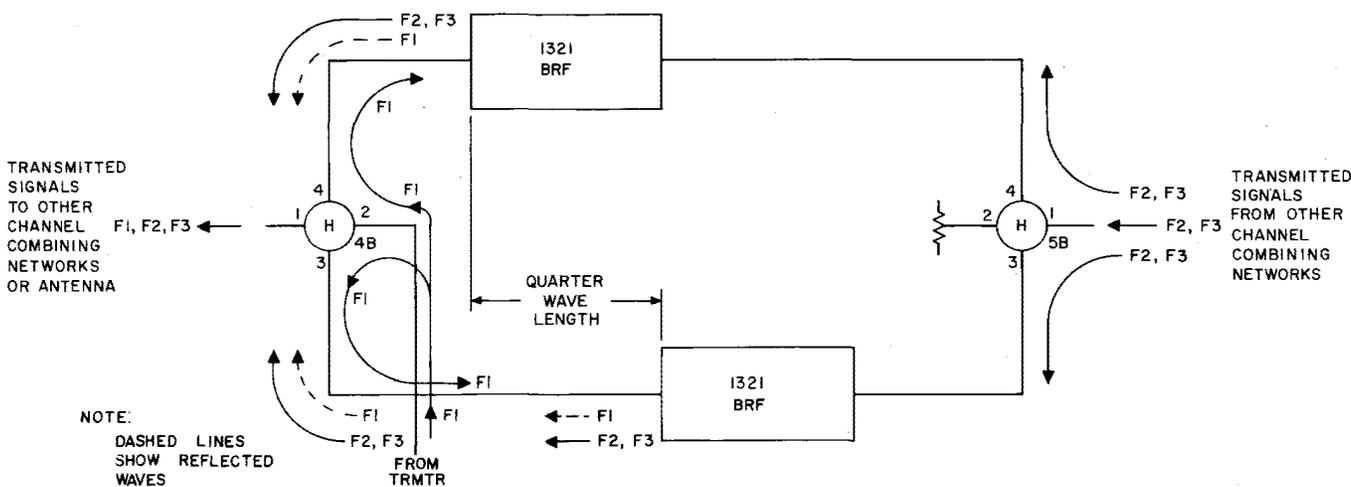
(B) CHANNEL COMBINING NETWORK

Fig. 45—Channel Networks

signal is applied to the next channel combining network or to the antenna waveguide run.

17.06 Each band-rejection filter is composed of three rectangular waveguide cavities (Fig. 46) spaced along the main waveguide at three-quarter wavelength intervals. The cavities are coupled to the waveguide by circular irises. A fixed capacitive tuning stub located opposite each iris compensates for the series inductance of the iris. Each cavity is factory adjusted for resonance at the channel frequency by means of a tuning screw. These screws are locked in place and are not adjusted in the field.

17.07 Each channel network provides a portion of the RF selectivity required in the receiver or transmitter that it serves. For example, at 20 MHz away from the center frequency of the separated (or combined) channel, the arm 1 to arm 2 (of the 4B junction) insertion loss is about 4 dB. This loss increases to approximately 35 dB at frequencies 80
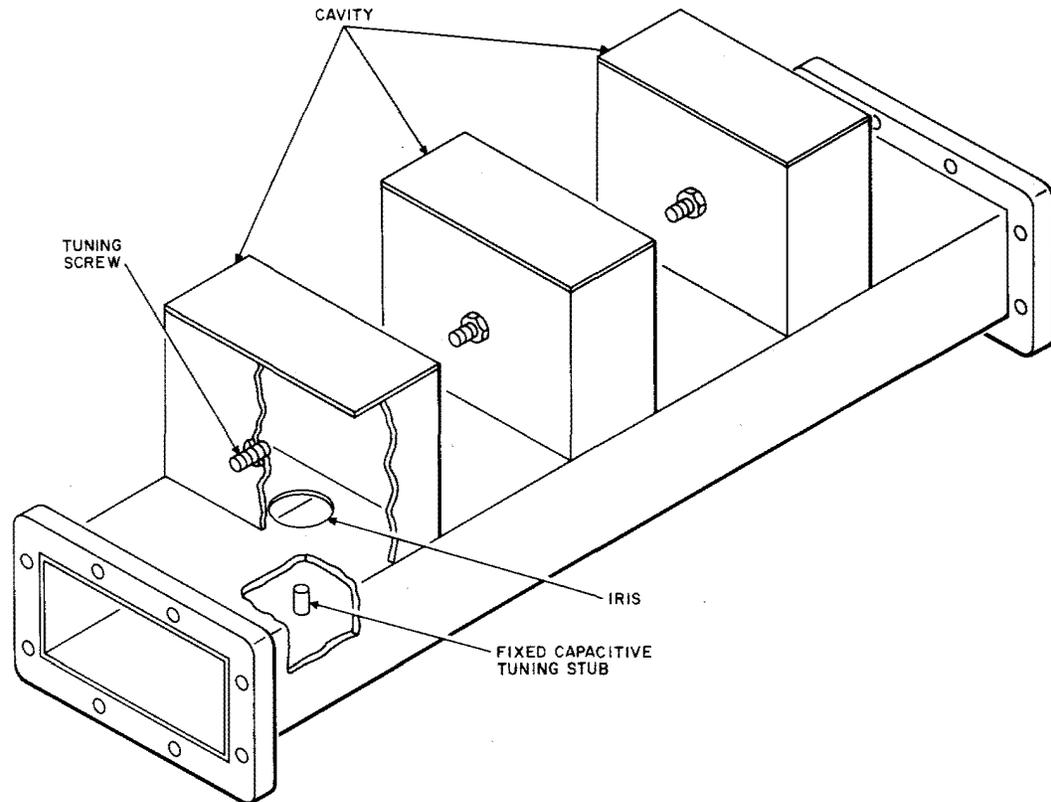
Fig. 46—Band-Reject Filter Used in Channel Combining and Separating Network

MHz or more off center frequency. At center frequency, the loss to the separated (or combined) channel is about 0.5 dB. The loss to through channels is approximately 0.1 dB. There are 24 codes of channel networks, each one optimally designed for one of the 24 radio channels in the 3700- to 4200-MHz band.

17.08 To minimize shifting of the transmission characteristic with changes in temperature, the band-rejection filters are fabricated from WR229 waveguide tubing made of a low temperature coefficient INVAR* nickel alloy. The inside of the tubing is copper-clad to obtain high conductivity (low loss).

17.09 The channel separating and combining networks are mounted in the bay on an aluminum casting. A 2-inch section of flexible waveguide is used to connect the networks of adjacent bays. This is shown in Fig. 47.

*Registered Trademark of the Nickel Alloys Corporation

B. 1322-Type Channel Bandpass Filter

17.10 The 1322-type filter is a waveguide filter used to obtain additional RF selectivity both at the receiver input and at the transmitter output. The filter consists of five resonant cavities (Fig. 48), each one-half wavelength long, built into a length of waveguide. Each cavity is bounded on each end by three equal-diameter, uniformly spaced cylindrical posts. A capacitive tuning screw centrally located between the array of posts is used to tune each cavity to the channel center frequency. One-quarter wavelength spacing is used between cavities. This type cavity is referred to as the "triple-post" type.

17.11 The 1322-type filter is a fairly narrow band filter. Typical losses are 15 dB at 20 MHz off center frequency and 70 dB at 80 MHz off center frequency. Midband loss is approximately 0.5 dB.

17.12 The filter consists of a 16-inch section of WR229 waveguide made of low temperature
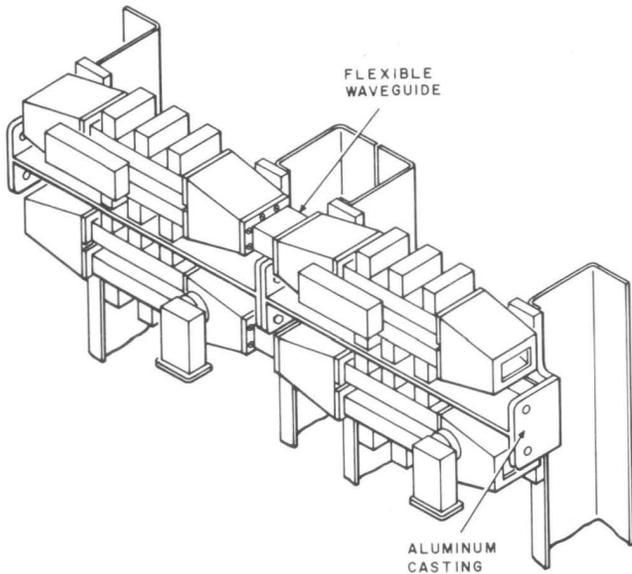
FLEXIBLE
WAVEGUIDE

ALUMINUM
CASTING

**Fig. 47—Channel Combining and Separating Networks
Arrangement for Adjacent Bays**

coefficient INVAR nickel alloy to minimize the effects of temperature changes on the filter transmission characteristics. The inside of the filter is copper-clad to provide high conductivity. The inductive posts are made of copper plated INVAR nickel alloy and are soldered in place. Each of the 24 filter codes has a distinct physical arrangement of elements to give uniformity of performance from channel to channel.
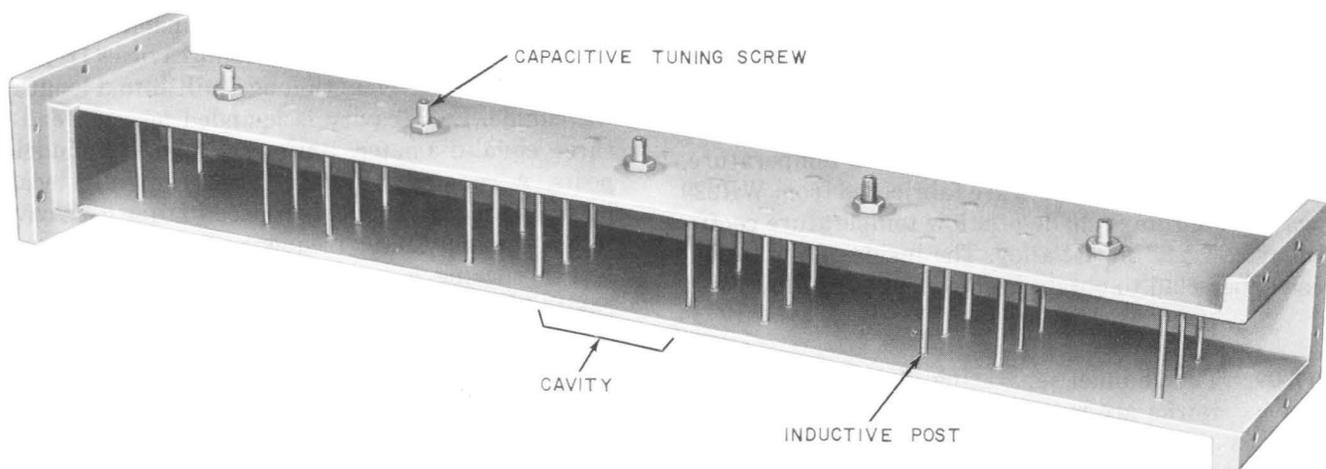
The tuning screws used to resonate the cavities are locked in place and are not adjusted in the field.

C.   1323-Type Bandpass Filter

17.13   The 1323-type bandpass filter is a narrowband filter used at the output of the 40-MHz oscillator and shift modulator. The filter passes the desired local oscillator signal for the receiver modulator and attenuates the microwave generator signal and other unwanted products generated in the shift modulator. The midband insertion loss is about 2 dB; and the losses at 40 and 80 MHz off center frequency are typically 90 and 112 dB, respectively.

17.14   The filter has four resonant cavities tuned to the receiver local oscillator frequency. Each cavity is of the "triple-post" design described for the 1322-type filter in Part 17B. The cavities are assembled in a 15-inch length of standard WR229 copper waveguide tubing.

D.   1326A Low-Pass Filter

17.15   The 1326A low-pass filter is used at the output of the TWT amplifier to attenuate, by at least 50 dB, the second and third harmonics of the transmitted signal which are generated in the TWT. The insertion loss of the filter across the 3700- to 4200-MHz band is approximately 0.2 dB.

CAPACITIVE TUNING SCREW

CAVITY

INDUCTIVE POST

Fig. 48—Cutaway View of Channel Bandpass Filter

17.16 The filter (Fig. 49) is composed of a pair of WR229 waveguide-to-coaxial transducers between which is assembled a 7-section coaxial filter which provides the stop-band loss. The axes of the two waveguide sections are rotated 90 degrees with respect to each other to provide a 90-degree mechanical rotation required in the output waveguide circuit of the transmitter.

E. 1336-Type Bandpass Filter

17.17 The 1336-type bandpass filter is located between the transmitter modulator and the traveling-wave tube amplifier. The filter passes the desired sideband output of the transmitter modulator and attenuates the microwave generator signal and unwanted sideband outputs. The filter provides only a minimal amount of selectivity in order to minimize the inband amplitude and delay distortion appearing ahead of the TWT amplifier. For example, at 70 MHz off center frequency, the loss is typically only 15 dB. Midband insertion loss is less than 0.1 dB. The 1336-type filter is also used in place of a 1322-type filter in the receiver input and transmitter output in the 1500 and 1800 circuit outputs.

17.18 The filter has three resonant cavities tuned to the center of the desired passband. The cavities are of the "triple-post" design described for the 1322-type filter in Part 17B. The cavities are assembled in a 16-inch length of standard WR229 copper waveguide tubing; because of its wide bandwidth, temperature changes cause only negligible changes in the inband transmission characteristics and therefore the use of low temperature coefficient INVAR tubing is not required.

F. 1337-Type Waveguide Directional Filter

17.19 The 1337-type waveguide directional filter (Fig. 50) is used directly ahead of the J68387P receiver modulator and IF preamplifier to combine the received signal and the receiver local oscillator signal. The received signal is applied to port 3, and the local oscillator signal is applied to port 2. The output from the filter, consisting of the combination of the two applied signals, is at port 1.

17.20 The directional filter consists of two resonant filters that are tuned to the local oscillator frequency. The filter in the port 2 arm is a 2-cavity bandpass filter having about 0.3-dB midband
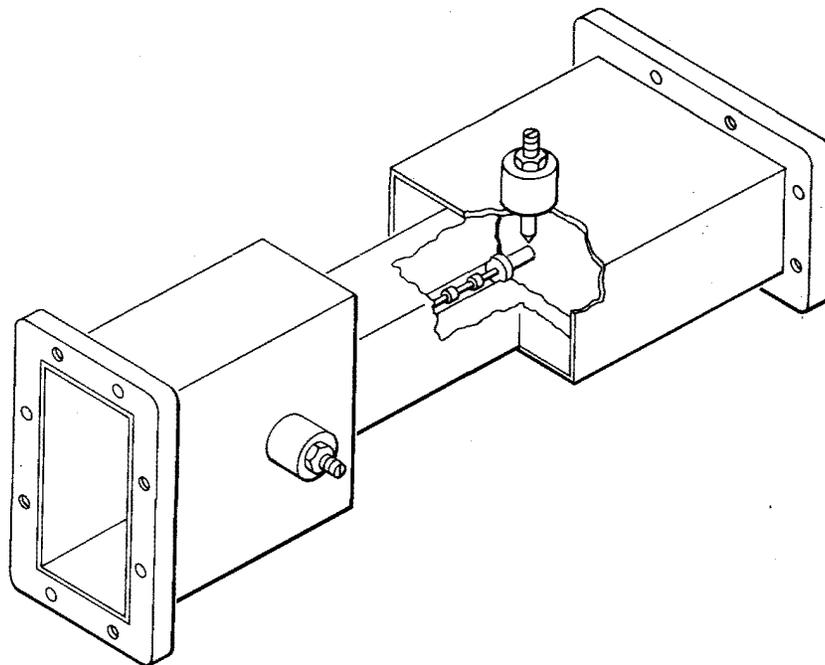

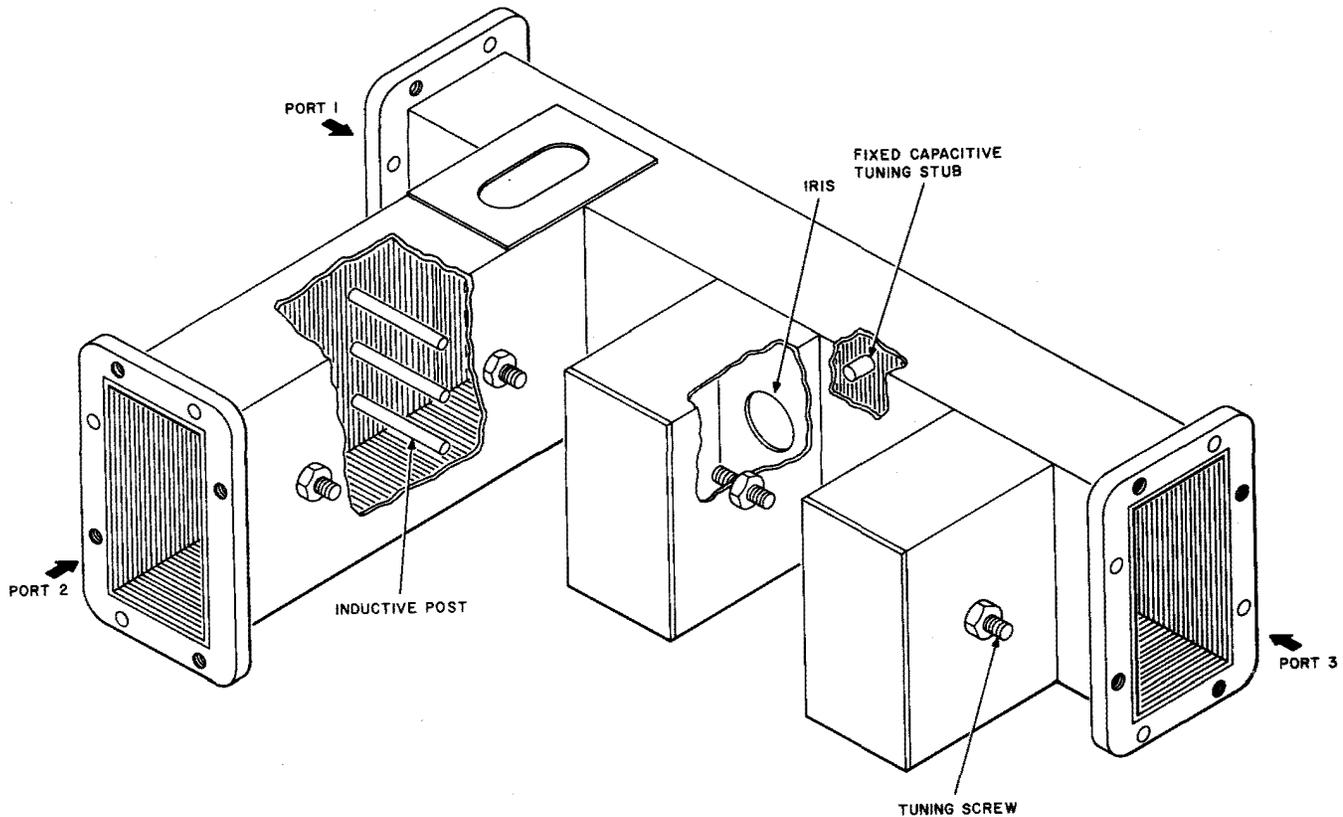**Fig. 49—1326A Low-Pass Filter**

Fig. 50—1337-Type Waveguide Directional Filter

insertion loss that passes the local oscillator signal but provides high attenuation to the received signal, effectively preventing the received signal from entering the local oscillator arm. The filter in the port 3 arm is a 2-cavity band rejection filter. This filter allows the received signal to pass through to the port 1 arm with negligible loss but provides more than 40-dB attenuation to the local oscillator signal.

17.21 The band-rejection filter section uses resonant cavities with coupling irises of the type described in paragraph 17.06. The cavities of the bandpass filter section are of the "triple-post" design described in paragraph 17.10. The filter assembly is constructed from standard WR229 copper waveguide tubing. The cavities of the filter are factory adjusted for resonance at the proper frequency and are not adjusted in the field.

G. 745A IF Bandpass Filter

17.22 The 745A IF bandpass filter (Fig. 51) is used at the output of the IF preamplifier to provide additional receiver selectivity. The filter is amplitude equalized to within ±0.03 dB and delay equalized to within ±0.3 ns over the band from 62 to 78 MHz. The midband insertion loss is typically 2.7 dB. Out of band, the filter has insertion loss peaks, typically of at least 24 dB, in the region of 50 and 90 MHz.

17.23 The circuit components of the filter are mounted on two printed circuit boards which are assembled on a sectionalized, cast aluminum base and enclosed with a sheet aluminum cover. Each inductor is enclosed in an individual compartment of the base to minimize coupling between inductors.
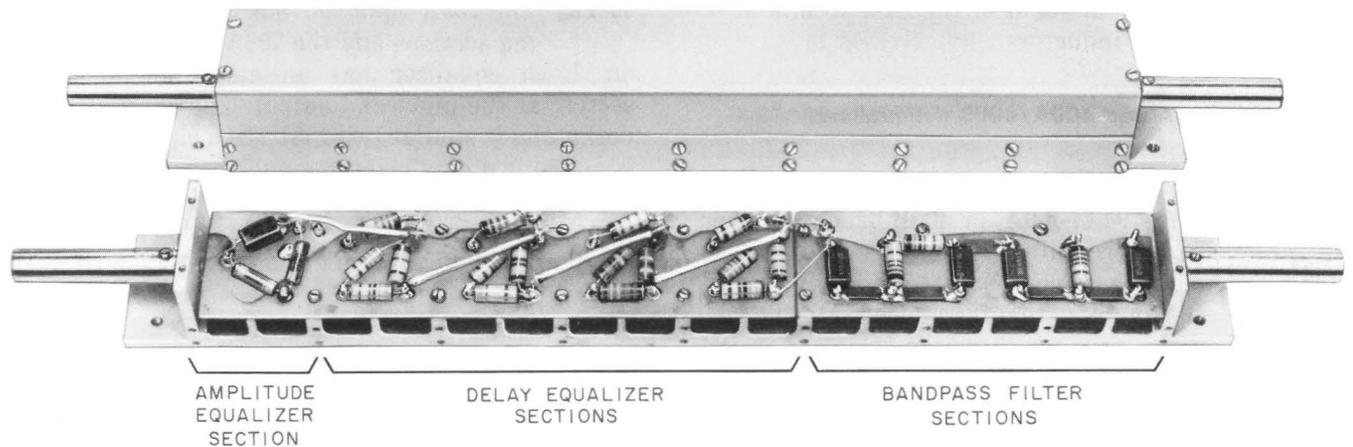
AMPLITUDE
EQUALIZER
SECTION

DELAY EQUALIZER
SECTIONS

BANDPASS FILTER
SECTIONS

Fig. 51—745A IF Bandpass Filter

H. 747A IF Low-Pass Filter

17.24 The 747A IF low-pass filter (Fig. 52) is used ahead of the IF main amplifier in the receiver to attenuate, by at least 20 dB, the second and third harmonics of the IF signal generated in the IF preamplifier. The insertion loss of the filter across the 60- to 80-MHz band is approximately 0.6 dB. Over this IF band, the filter is amplitude equalized to within ±0.05 dB and delay equalized to within ±0.3 ns.

17.25 The 747A filter components are assembled on a printed circuit board which is mounted on an 8-section cast aluminum base and enclosed with a sheet aluminum cover. Each inductor is enclosed in
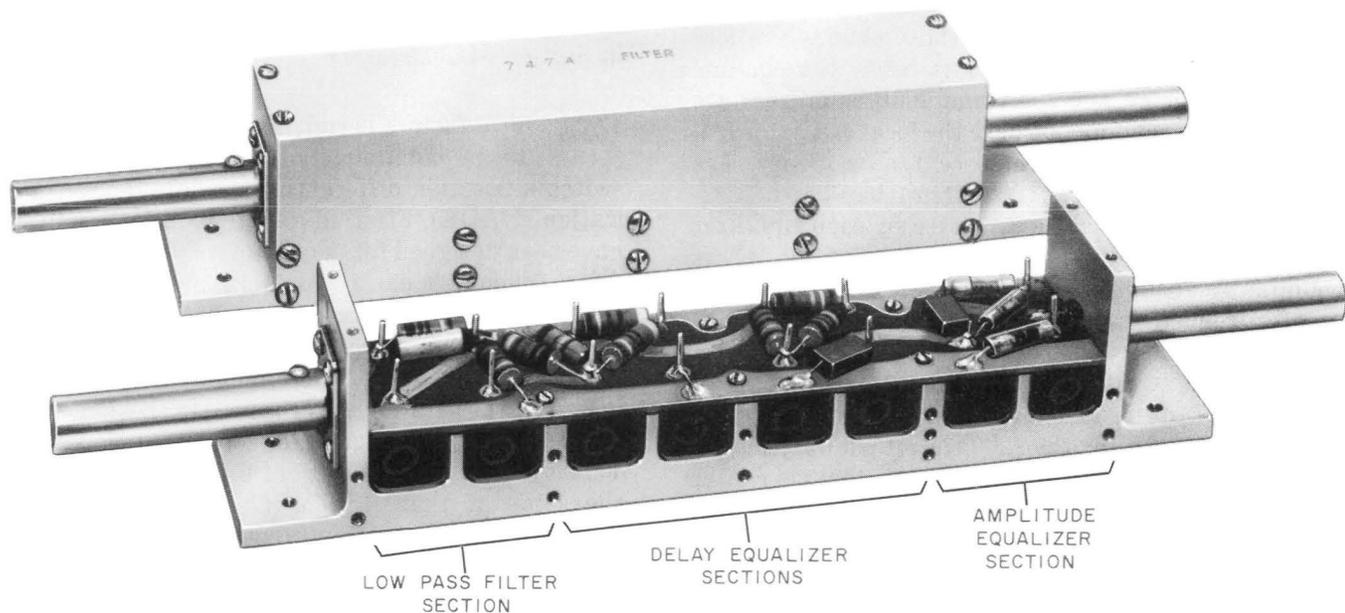

LOW PASS FILTER
SECTION

DELAY EQUALIZER
SECTIONS

AMPLITUDE
EQUALIZER
SECTION

Fig. 52—747A IF Low-Pass Filter

an individual compartment of the base to minimize coupling between inductors.

I. 793A/794A and 400A/400B IF Equalizers

17.26 Every radio receiver is equipped with either a 793A, 794A, 400A, or 400B basic equalizer in the IF circuit preceding the main amplifier. The 793A/794A equalizers compensate for both the amplitude and delay distortion introduced into the signal path by the channel networks (1418-type) and channel bandpass filters (1322-type) of the receiver and the preceding transmitter in the 1200 circuit bays. The 400A/400B equalizers perform a similar function in the 1500 and 1800 circuit bays where the 1322-type filter has been changed to a 1355-type filter. These networks and filters account for almost all of the inband distortion of a radio hop since all of the other microwave networks and filters, as well as the active circuits, are broadband and the IF filters are self-equalized.

17.27 The amplitude and delay distortion of the channel networks and bandpass filters are not symmetrical about the channel center frequency. Since the equalizer that corrects for this distortion is located at IF, two different equalizers are required; the one used in a particular receiver is dependent on the frequency relationship between the microwave signal and the local oscillator signal. The 793A and 400A equalizers are used for those channels where the local oscillator frequency is below the channel center frequency; the 794A and 400B equalizers are used for those channels where the local oscillator frequency is above the channel center frequency. The delay distortion of the 1200 circuit bay (with 1322-type filter) that must be corrected by each equalizer is approximately parabolic in shape and, at RF, is nominally about 23 ns at 8 MHz below the channel center frequency and 14 ns at 8 MHz above the channel center frequency. The nominal distortion is reduced by the equalizer to approximately ±0.3 ns over the 62- to 78-MHz IF band. Similarly, the amplitude distortion, at RF for the 1200 circuit channels, averages about 0.4 dB at 8 MHz below the channel center frequency and 0.25 dB at 8 MHz above the channel center frequency. For 1500 and 1800 circuit channels, the amplitude distortion is about half that for 1200 circuit channels. The equalizers reduce this to about ±0.05 dB over the 62- to 78-MHz band. The 70-MHz insertion loss is about 5 dB for the 793A/794A equalizers and about 2 dB for the 400A/400B equalizers.

17.28 The 739A equalizer has eight delay equalizing sections and the 794A equalizer has seven. Each equalizer has an amplitude equalizing section at the input and output. The construction of both units is similar (Fig. 53). Each equalizer section is assembled on a printed circuit board and inserted in an individual can to reduce coupling between sections. The overall assembly of cans is enclosed by a single cover which gives mechanical strength to the unit.

17.29 The 400A and 400B equalizers consist of component apparatus mounted on a printed wiring board contained in a rectangular metal can equipped with a cover. The size of the can is 4-11/16 by 2-3/4 by 1-3/8 inches excluding the length of input and output IF jacks.

J. Mop-up Delay Equalization

17.30 Residual delay slope and parabolic delay distortion are reduced in each IF protection switching section through the use of mop-up equalizers distributed among the receivers of the section. Provision is made for mounting one mop-up equalizer in each receiver at the output of the IF main amplifier. Six types of mop-up equalizers are available; their characteristics are summarized in Table C. The total number and types of equalizers required for each channel of the switching section are determined from envelope delay distortion measurements as described in Section ▶422-300-500.◀

17.31 Two factors permit the mop-up equalization to be administered independently of the switching section differential absolute delay equalization (DADE). First, all of the mop-up equalizers have been designed for approximately equal absolute delay (about 23 ns) at 70 MHz. Second, the 919B equalizer, which has zero delay slope but the same absolute delay as the other equalizers, has been provided. At each station where mop-up equalization is installed, the 919B equalizer is used in those receivers which require no distortion-correcting equalizers. This is done to keep the absolute delay of all receivers the same at that station. This, in turn, permits changing the type of mop-up equalizer in any receiver at that station without affecting the switching section DADE equalization.

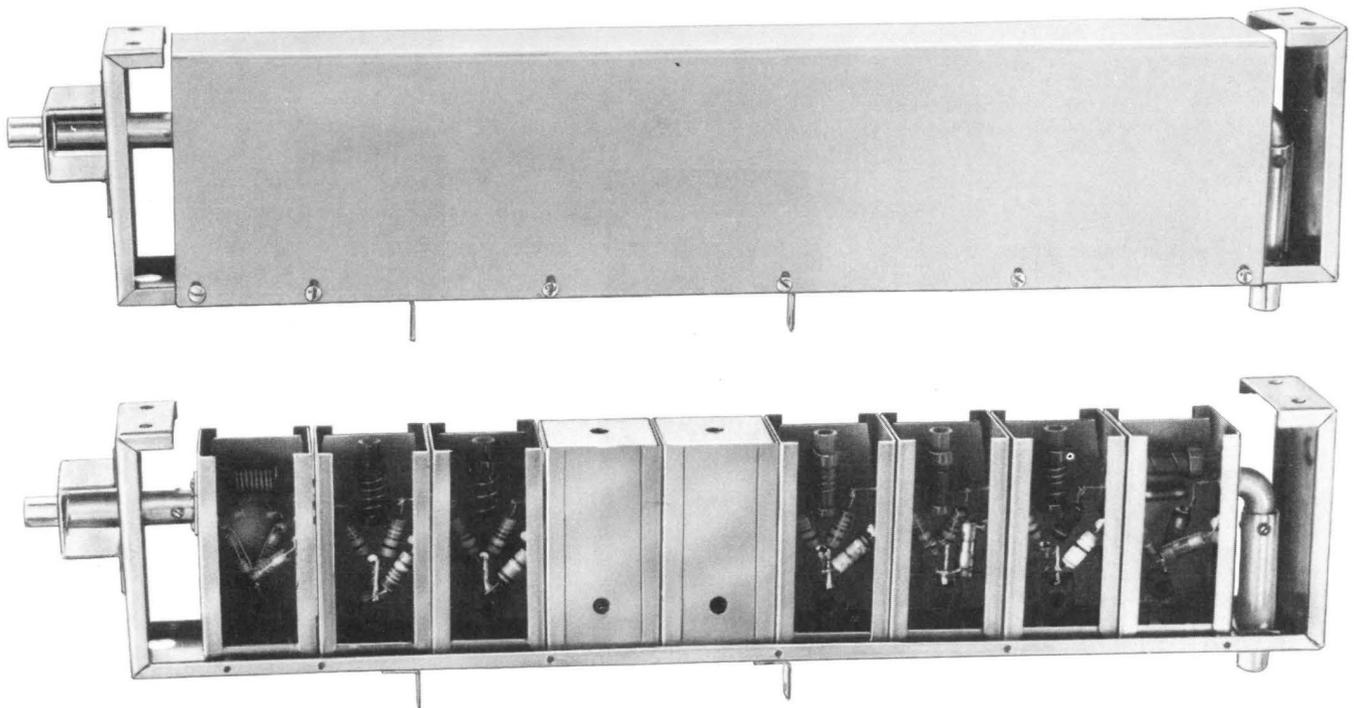**17.32** The mechanical features of the 918-, 919-, and 920-type equalizers are similar to those

Fig. 53—794A IF Equalizer

TABLE C

CODE	SHAPE	DELAY SLOPE (ns per MHz)	MAGNITUDE OF PARABOLIC SHAPE AT 64 AND 76 MHz (ns)	MAXIMUM INSERTION LOSS (dB)
918A	Negative slope	−0.5	—	0.45
918B	Negative slope	−0.25	—	0.45
918C	Negative parabolic	—	−3.4	0.7
919A	Positive slope	+0.25	—	0.7
919B	Flat delay	0	—	0.6
920A	Positive slope	+0.5	—	0.85

of the IF basic equalizers described in Part 17J. Each type of equalizer is shown in Fig. 54.

K. 8A Isolator

17.33 The 8A isolator (Fig. 55) is a nonreciprocal attenuator which propagates a microwave signal in one direction (termed the forward direction) with very little attenuation but provides high attenuation to signals propagating in the reverse direction. Isolators are used both in the signal paths and in the microwave generator distribution circuit of the T-R bay principally for absorbing unwanted products generated in the various modulators and for providing good return loss.

Fig. 54—Mop-Up Equalizers

17.34 The isolator is classified as a resonance type and is composed of a pair of ferrite slabs magnetically biased by the field from a permanent magnet. Nonreciprocal loss is attained by placing the ferrite at a point in the waveguide where the magnetic field component of the applied microwave signal appears to be circularly polarized. If the signal is applied in the so-called forward direction, little interaction occurs between the ferrite and the circularly polarized component of the wave. However, if the signal is applied in the reverse direction, a strong interaction occurs; and almost all of the power of the applied signal is absorbed by the ferrite. Optimum electric and magnetic field distribution of the applied signal in the waveguide, relative to the location of the ferrite slabs, is obtained by center-loading the waveguide with a high dielectric constant alumina bar. Over the 3700- to 4200-MHz frequency range, the isolator has typically 0.15-dB forward loss and at least 30-dB reverse loss. Over the same frequency range, the input and output return losses are greater than 30 dB.

17.35 The isolator is housed in an aluminum waveguide casting. The two end sections are WR229 waveguide, and the center section is half-
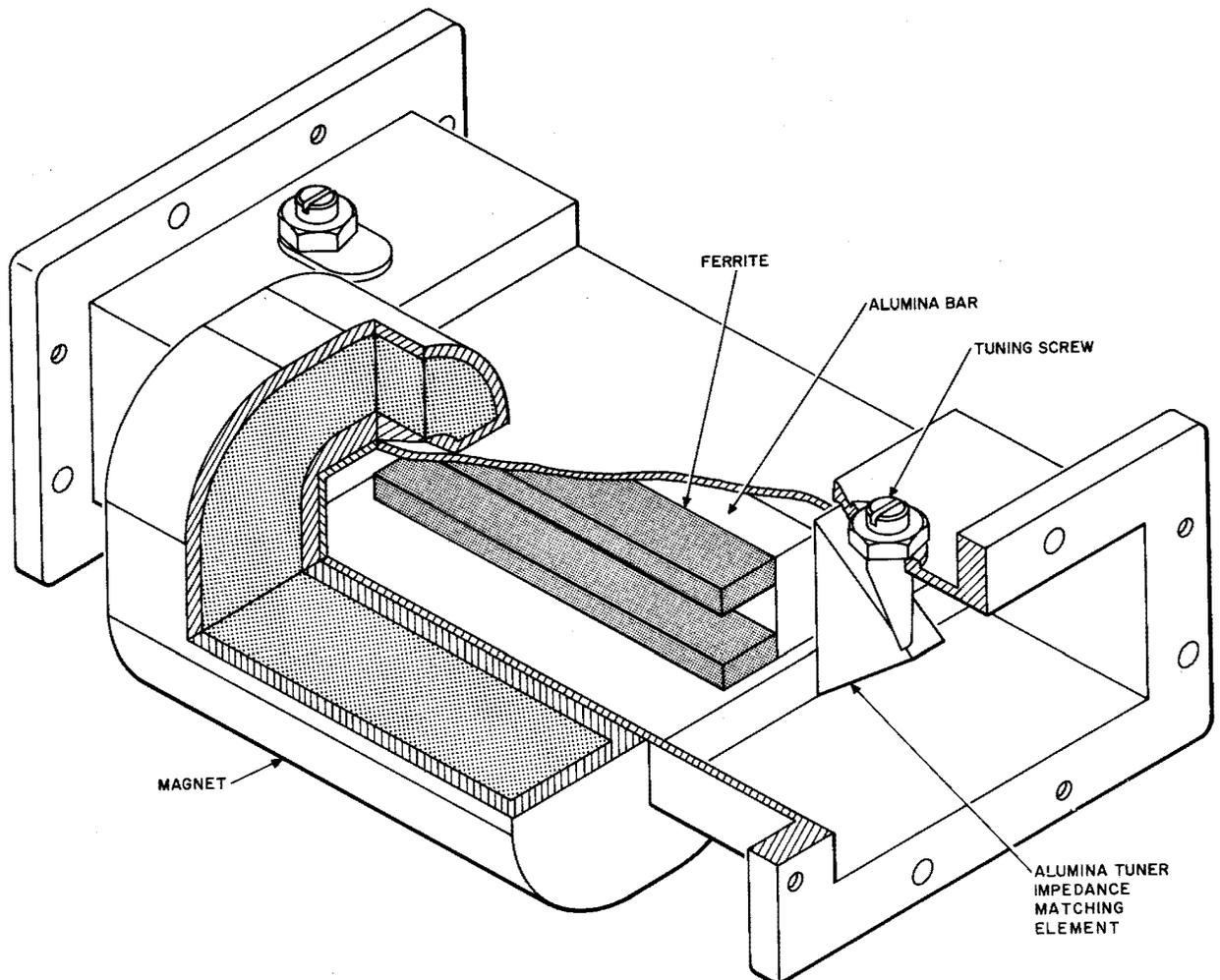
Fig. 55—Cutaway View of 8A Isolator

height waveguide. Each of the WR229 sections contains an alumina dielectric impedance matching element and a factory-adjusted aluminum tuning screw. The two ferrite slabs and the alumina dielectric bar are attached to the broad walls of the half-height section. The ferrite is biased to ferromagnetic resonance by a permanent magnet attached to the half-height waveguide. The isolator is 5.600 inches long by 3.750 inches wide by 2.380 inches high.

L. Directional Couplers

17.36 Directional couplers are used in the T-R bay for power splitting and power monitoring purposes. The number and types of directional couplers used depend on the particular version and type

of bay, and reference should be made to the application schematic SD-50544-01 for detailed information. Fig. 56 illustrates two types which are used.

17.37 Each directional coupler is a 4-port network consisting of two waveguide sections coupled together through a common wall. Port 1 (Fig. 56) is the input port and port 2 is the main output port. Port 3 receives a portion of the signal applied to port 1. The ratio of the power appearing at port 3 to the power applied at port 1 depends on the coupling holes in the common wall. This ratio defines the coupling loss of the directional coupler. Port 4 is terminated; virtually none of the power applied to port 1 appears at port 4.
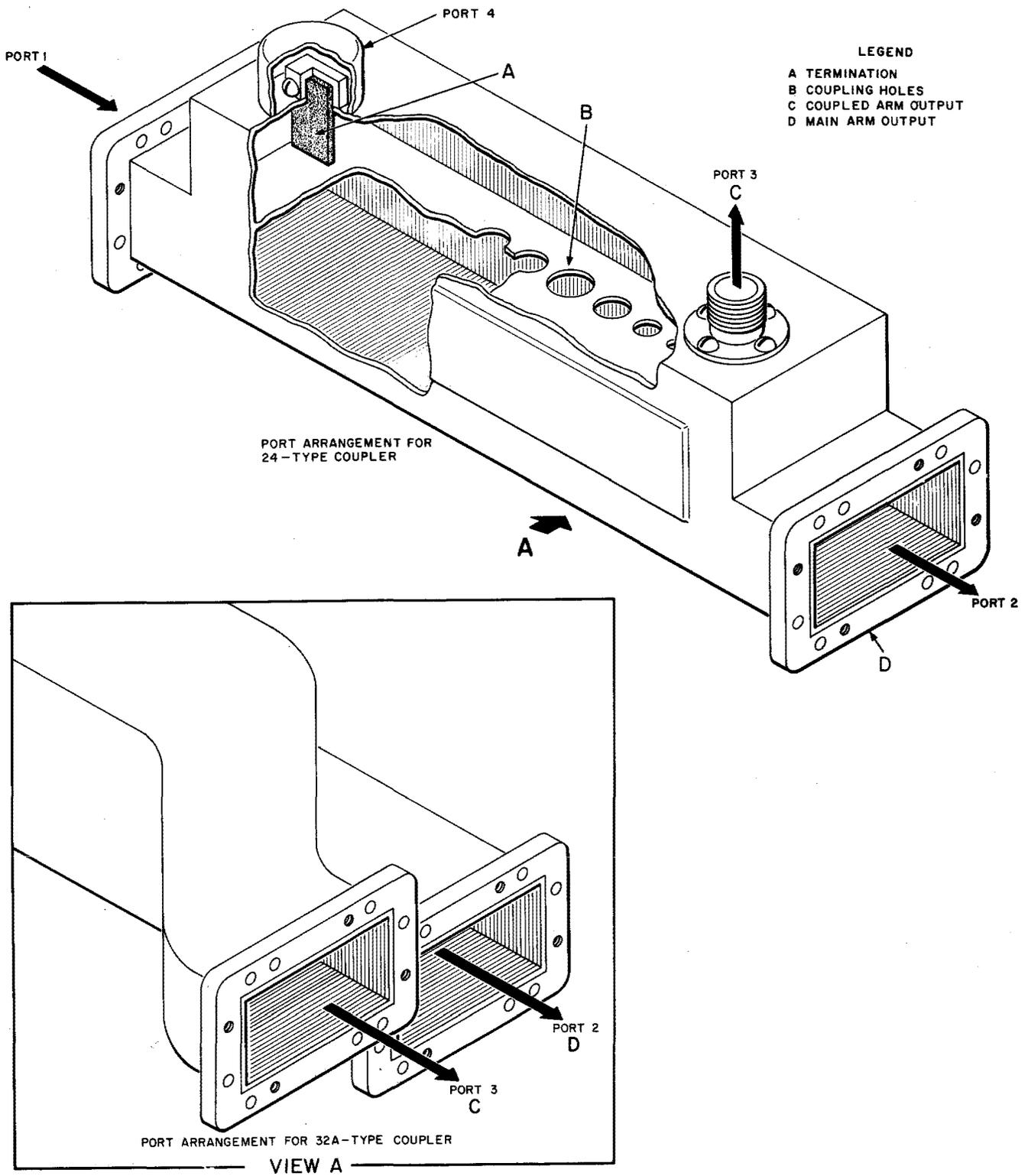
PORT 4

PORT 1

A

B

LEGEND

A TERMINATION
B COUPLING HOLES
C COUPLED ARM OUTPUT
D MAIN ARM OUTPUT

PORT 3

C

PORT ARRANGEMENT FOR
24—TYPE COUPLER

A

PORT 2

D

PORT 2
D

PORT 3
C

PORT ARRANGEMENT FOR 32A—TYPE COUPLER

VIEW A

Fig. 56—Cutaway View of Directional Couplers

17.38 In the couplers used for power monitoring, the output at port 3 is a 50-ohm, type-N connector. Couplers of this type are the 24A and 24C, which have nominally 11.6-dB coupling loss and are used in the microwave generator distribution circuit; and the 24B, which has nominally 28-dB coupling loss and is used in the output circuit of the transmitter. The couplers used for power splitting have a waveguide output at port 3. Couplers of this type, which are used in the microwave generator distribution circuit, are the 23A, which has about 7.2-dB coupling loss, and the 31A and 32A, which have approximately 5-dB coupling loss. Mechanically, the 23A, 31A, and 32A couplers differ in the relative orientations of ports 2 and 3; the particular arrangement used for the 32A is shown in Fig. 56.

M.   61A Detector

17.39 The 61A detector (Fig. 57) is used in conjunction with a power monitoring type directional coupler to rectify a portion of the waveguide signal. The dc output current from the detector is used as an input to either a microwave generator or transmitter output power alarm circuit. The detector operates over the frequency range between 3700 and 4200 MHz. The normal RF input power is approximately +9 dBm; the corresponding dc output current is typically between 200 and 250 microamperes into a load resistance of 1200 ohms. The input return loss is greater than 25 dB. The detector consists of a T-shaped coaxial structure containing a removable point contact silicon diode in one arm. A 50-ohm, type-N stainless steel connector is mounted on the input arm for direct connection to the monitoring coupler. The dc output is taken from the third arm of the structure through a KS-19692, List 1 coaxial connector.

N.   Attenuators

17.40 Waveguide-type, noncalibrated, variable attenuators (Fig. 58) are used in the T-R bay to adjust the microwave power applied to certain of the modulators and to the TWT amplifier. Three types are used: the 31A, which has an attenuation range of 0 to 13 dB; and the 32A and 33A, which have an attenuation range of 0 to 10 dB. All three are mechanically and electrically similar. Each has a vane of power-absorbing material to attenuate the signal. The vane is positioned in the waveguide parallel to the narrow waveguide wall. The amount of loss depends on the distance between the sidewall and the vane, and this
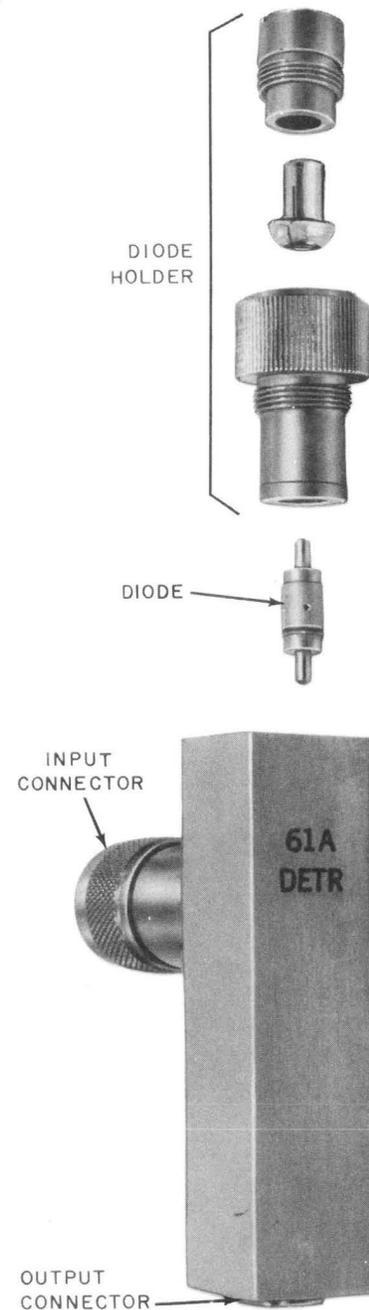

Fig. 57—61A Detector

distance is adjustable by means of a knob-controlled mechanical drive. Increasing loss is obtained by moving the vane towards the center of the waveguide.

O.   400AY Tuner

17.41   Two 400AY tuners (Fig. 59) are used in association with the TWT amplifier circuit. One is connected ahead of the input transducer that feeds the TWT amplifier, and the other is connected after the output transducer. The tuners are used to adjust

the TWT output signal for maximum power and flatness over the bandwidth of the radio channel.

17.42   Each tuner contains two adjustable broadband resonant circuits, which are approximately an eighth of a wavelength apart. Each of the resonant circuits contains an off-center rod, which acts as an inductance, and an adjustable capacitive screw. The net reactance which the tuner introduces into the circuit, which, in turn, determines the impedance match of the TWT amplifier circuit to the
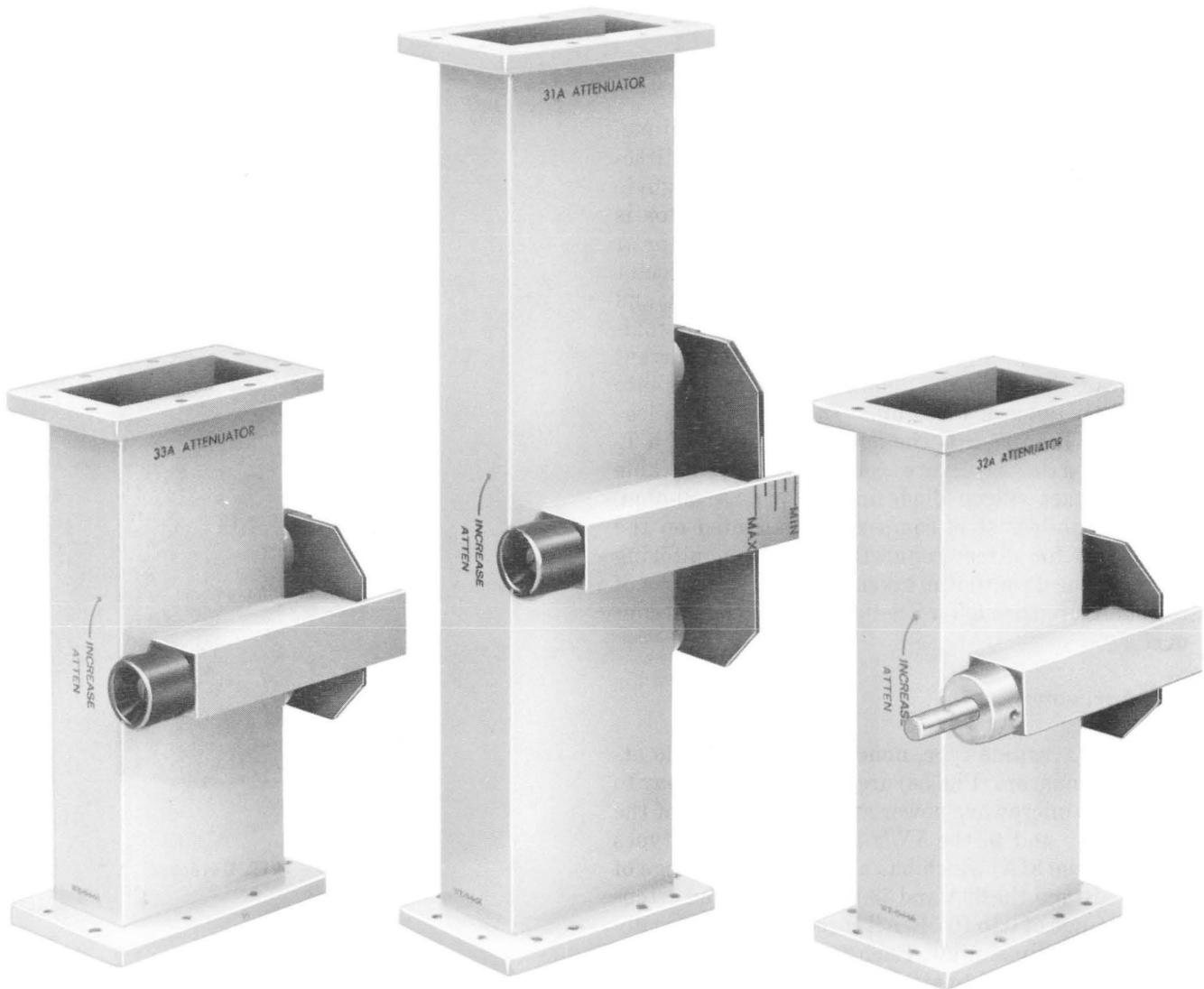

Fig. 58—Variable Attenuators

Fig. 59—400AY Tuner

external circuits, is adjusted by means of the tuning screws.

P. Transducers

17.43 Transducers are used in the transmitter-receiver bay to make transitions between waveguide and coaxial cable and between one size of waveguide and another. Three types of transducers are used. These are the 24B, 21A, and 32A shown in Fig. 60.

17.44 The 24B transducer is used to go between WR229 waveguide and 50-ohm coaxial cable. A stainless steel type-N coaxial connector is mounted on the body of the transducer. A coupling probe, connected to the center conductor of the connector and operating in conjunction with the shorting plate that closes off the end of the waveguide section, forms the waveguide-to-coaxial transition. The return loss of the transducer is greater than 27 dB in the frequency range of 3700 to 4200 MHz.

17.45 The 21A and 32A transducers are 5-step waveguide-to-waveguide transducers used in conjunction with the TWT amplifier. The 21A transducer transforms the 2.290-inch by 0.100-inch output port of the amplifier to WR229 waveguide; the 32A transducer transforms WR229 waveguide to 2.290-inch by 0.328-inch waveguide size used at the amplifier input. The return loss of both transducers is greater than 35 dB between 3700 and 4200 MHz.

18. REFERENCE DRAWING LIST

**18.01** The following drawings provide additional information.

NUMBER	TITLE
SD-50544-01	Application Schematic—TD-3 Radio Transmitter-Receiver Bay
SD-50545-01	IF Limiter
SD-50546-01	IF Carrier Resupply
SD-50547-01	IF Driver Amplifier—Transmitter Modulator
SD-50548-01	Receiver Modulator and IF Preamplifier
SD-50549-01	40-MHz Oscillator and Shift Modulator
SD-50550-01	IF Main Amplifier
SD-50551-01	AGC Amplifier
SD-50553-01	Microwave Generator
SD-50554-01	Receiver Control Unit
SD-50555-01	Repeater Station Transmitter Control Circuit
SD-50556-01	Main Station Transmitter Control Circuit
SD-50557-01	Transmitter-Receiver Common Alarm Circuit
SD-50558-01	Receiver Modulator and IF Preamplifier Circuit
SD-50561-01	Indoor Waveguide Distribution Circuit
SD-50563-01	DADE Cabling for Broadband Radio Channels
SD-50574-01	Microwave Generator
SD-50575-01	Radio Bay Arrangement and Indoor Waveguide Circuit
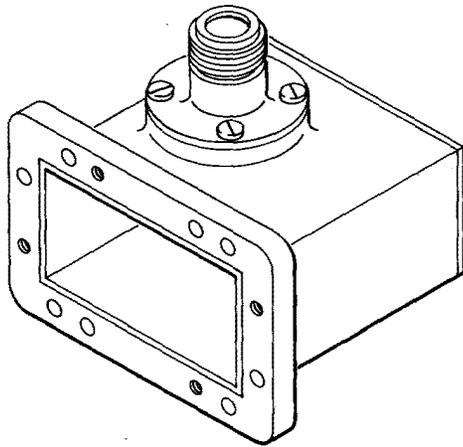
24B
(WAVEGUIDE TO COAXIAL)
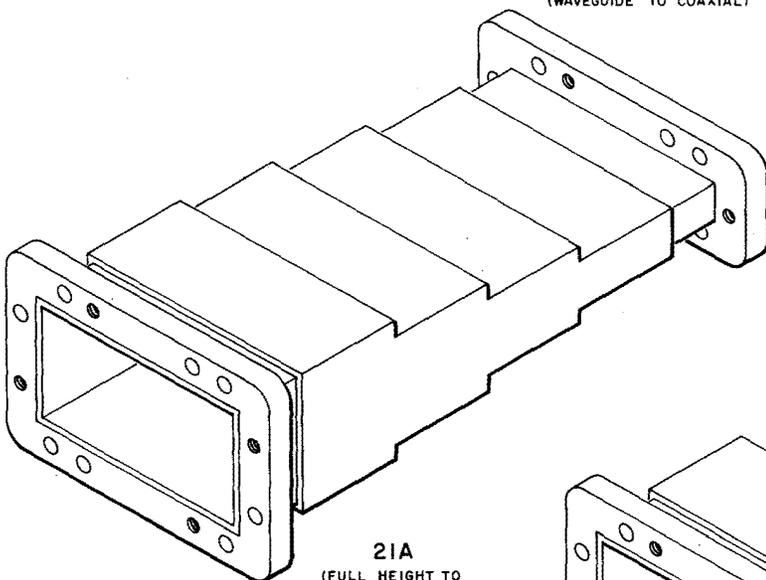
21A
(FULL HEIGHT TO
REDUCED HEIGHT
WAVEGUIDE)
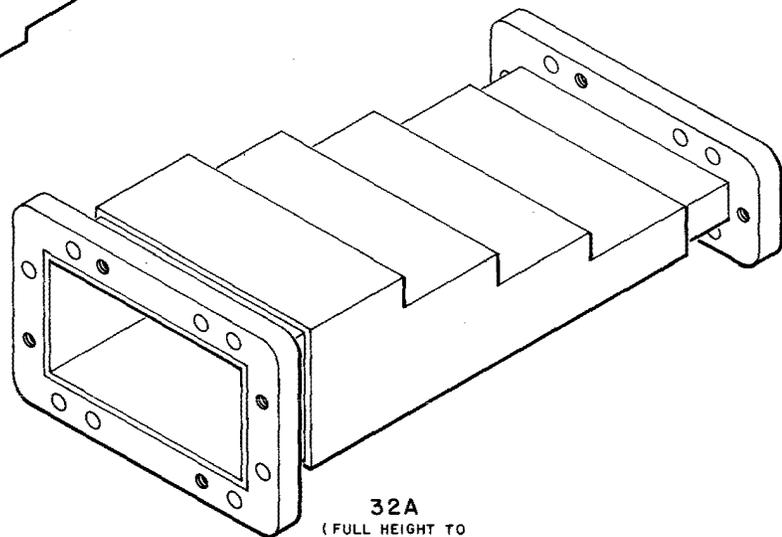
32A
(FULL HEIGHT TO
REDUCED HEIGHT
WAVEGUIDE)

Fig. 60—Transducers

NUMBER	TITLE
SD-81660-01	Power Supply Circuit (TWT)
SD-81767-01	DC Distribution Circuit for TD Radio Relay System
SD-81783-01	−19 Volt Regulator