J68386G AND H TRANSMITTER-RECEIVER BAYS

DESCRIPTION

TD-3 MICROWAVE RADIO

1. GENERAL

SCOPE

1.01 This section describes the J68386G repeater station and J68386H main station transmitter-receiver (T-R) bays of the TD-3A Microwave Radio System (Fig. 1). An overall functional and physical description of the T-R bays is given in Part 1. Parts 2 through 22 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 23 of this section.

1.02 This section is reissued to add a caution (paragraph 6.05) regarding use of the IF driver amplifier—transmitter modulator BIAS control, to add a warning in Part 6 regarding equipment damage which will result if J68387U and J68387U-2 IF units are interchanged, and to add information on the solid-state, 5-watt 660( ) IC RF power amplifier used as an option to the traveling-wave tube amplifier. Since this is a major revision, change arrows ordinarily used have been omitted.

BRIEF DESCRIPTION OF TD-3A MICROWAVE RADIO SYSTEM

1.03 The TD-3A Microwave Radio System is intended primarily for high capacity, long-haul routes carrying multichannel telephone, television, carrier telegraph, high-speed data, or other broadband signals. The system operates in the common-carrier frequency band between 3700 and 4200 MHz.

1433 TYPE
CHANNEL NETWORK

1432 TYPE
CHANNEL NETWORK

40-MHZ OSC AND
SHIFT MODULATOR

ALARM PANEL

27A INTEGRATED CKT

28A INTEGRATED CKT

IF DRIVER AMPLIFIER AND
TRANSMITTER MODULATOR

METER PANEL

IF LIMITER
CARRIER RESUPPLY

29A INTEGRATED CKT

30A INTEGRATED CKT

TWT AMPLIFIER

TWT POWER SUPPLY

MICROWAVE GENERATOR(S)

-19V REGULATOR

19A ISOLATOR

1348 FILTER

RECEIVE MOD
IF PREAMP

IF MAIN AMPL

1431 TYPE
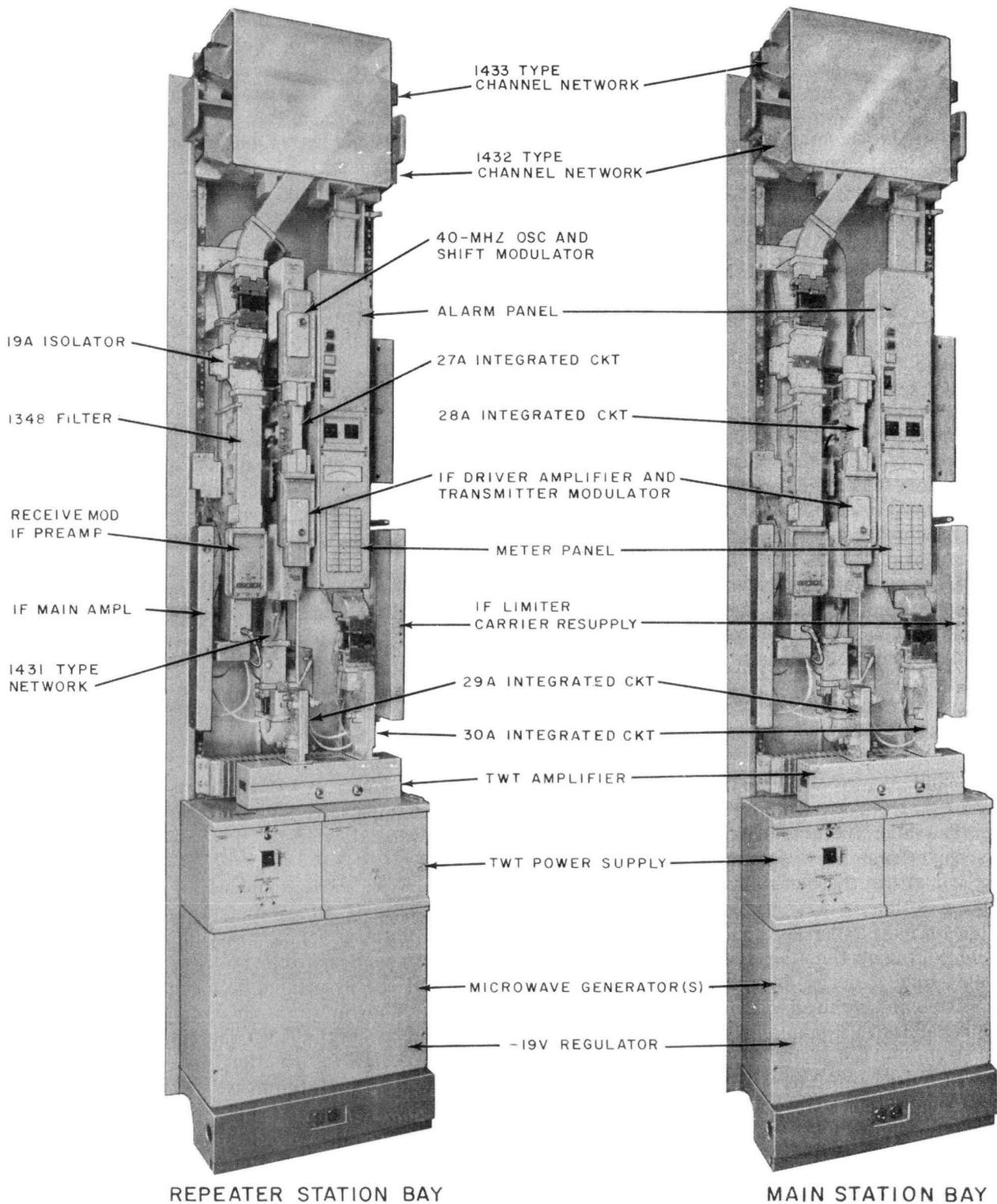NETWORK

REPEATER STATION BAY

MAIN STATION BAY

Fig. 1—J68386G and H Transmitter—Receiver Bays

Radio stations are spaced typically 20 to 30 miles apart, and they are placed at locations and elevations suitable for line-of-sight transmission. At a loading of 1200 or 1800 message circuits per radio channel, the system meets the current Bell System noise objective of 41 dBrnc0 worst circuit noise for a 4000-mile system during nonfading conditions. With 1500 circuit loading, the noise performance is about 2 dB higher.

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 and one standby, frequency diversity, protection channel. Half of these channels are vertically polarized and the other half are horizontally polarized in an arrangement described by the TD-3 frequency plan. The current maximum capacity of each channel is 1800 message circuits or one monochrome or 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 FM terminal equipment at main stations. For 1- or 2-channel routes, where frequency diversity switching cannot be used or for special applications, the radio system can be arranged in a hot standby/space diversity or hot-standby-only configuration.

OVERALL DESCRIPTION OF TRANSMITTER-RECEIVER (T-R) BAYS

A. 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 IF frequency. The transmitted and received microwave frequencies differ by 40 MHz.

1.06 In a repeater station bay, 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—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—shift modulator in a main station receiver. In almost all other respects, the main station bay is identical to the repeater station bay.

1.08 Two RF power amplifiers are available for TD-3 main station and repeater bays. The original equipment transmit RF power amplifier is a traveling-wave tube amplifier. The availability of a 5-watt version of the solid-state 660( ) IC RF amplifier will make it possible to fully equip the bays with semiconductor devices. 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 type 731A coaxial cable.

1.09 With the development of the 713( ) integrated circuit (RF combiner), T-R bays used in regular or data service may be equipped for space diversity in a single hop or in multiple hops using the 713( ) IC and the associated 95A control unit which are mounted at the top of the receiver bay. Section 422-500-501 covers the 713( ), the 95A, and provides waveguide DADE information. When the T-R bays are required to operate in the hot standby/space diversity (HS/SD) or hot standby (HS) only configuration, main station and repeater station bays are arranged in pairs and are designated *regular* and *standby*. The receiver in the regular bay is fed from the main antenna while the receiver in the standby bay is fed either from a second space diversity antenna in an HS/SD configuration or from a directional coupler in the waveguide run from the main antenna in an HS

only configuration. In the HS/SD arrangement, an IF switch in the standby bay selects the appropriate receiver with higher IF output on the basis of AGC voltage monitoring. The switch is revertive and normally selects the output of the regular receiver. A drop in received signal strength causes a switch to the standby receiver, which will remain in effect as long as the received signal level at the regular receiver is depressed. Restoration of this signal to normal level causes the IF switch to revert to the regular receiver.

1.10 The output of either the regular or standby transmitter is selected by an RF switch in the regular bay and fed to a single antenna via the channel combining network in the regular bay. The standby transmitter is connected to the RF switch by a microwave coaxial cable run between the bays. The standby transmitter is selected if the transmitter output of the regular bay fails or in the case of a main station, there is a drop in the level of a baseband pilot that is monitored at the transmitter output. Restoration of this output causes the switch to revert to the regular transmitter.

1.11 The objective of the HS/SD switching arrangement is to protect service against transmitter and receiver equipment failure and outages due to fading. The HS only arrangement only provides protection against equipment failure.

1.12 Certain component circuits are common to all bays. These include dc regulators, microwave generators, frequency multipliers, alarm circuit, meter circuit, and with certain minor differences depending on the bay, a carrier distribution network.

1.13 The descriptions in the various parts of this section apply to a fully equipped repeater bay as used in a frequency diversity, HS/SD, or HS only switching application. In this manner, all of the component units which might be found in a T-R bay will be explained. All of these may not be present in some field applications, but the operation of the bay is basically the same in any standard combination.

B. Functional Description

1.14 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.

1.15 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 1.06 are mentioned again where appropriate.

Microwave Receiver

1.16 The microwave receiver accepts an input signal from one of the twenty-four 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 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 is passed through a bandpass filter, which is part of the channel network. This filter, which is tuned to the frequency of the selected channel, provides additional receiver discrimination (selectivity) against out-of-band signals. The overall channel network is self-equalized over its passband, from the RF input port to the output of the bandpass filter.

1.17 The output of the channel network is passed through an isolator to the band-rejection segment of a directional filter. (See Fig. 2.) This level is typically −26 dBm, but will be about 10 dB higher if the 652A RF preamplifier is used. One function of the isolator is to provide a good return loss over a wide bandwidth at the output of the channel network to prevent undesirable interaction between the network and the directional filter. The local oscillator signal from the 40-MHz oscillator—shift modulator is applied to the bandpass segment of the directional filter. (The local oscillator signal in a main station

BLOCK DIAGRAM

EQUIPMENT DIAGRAM
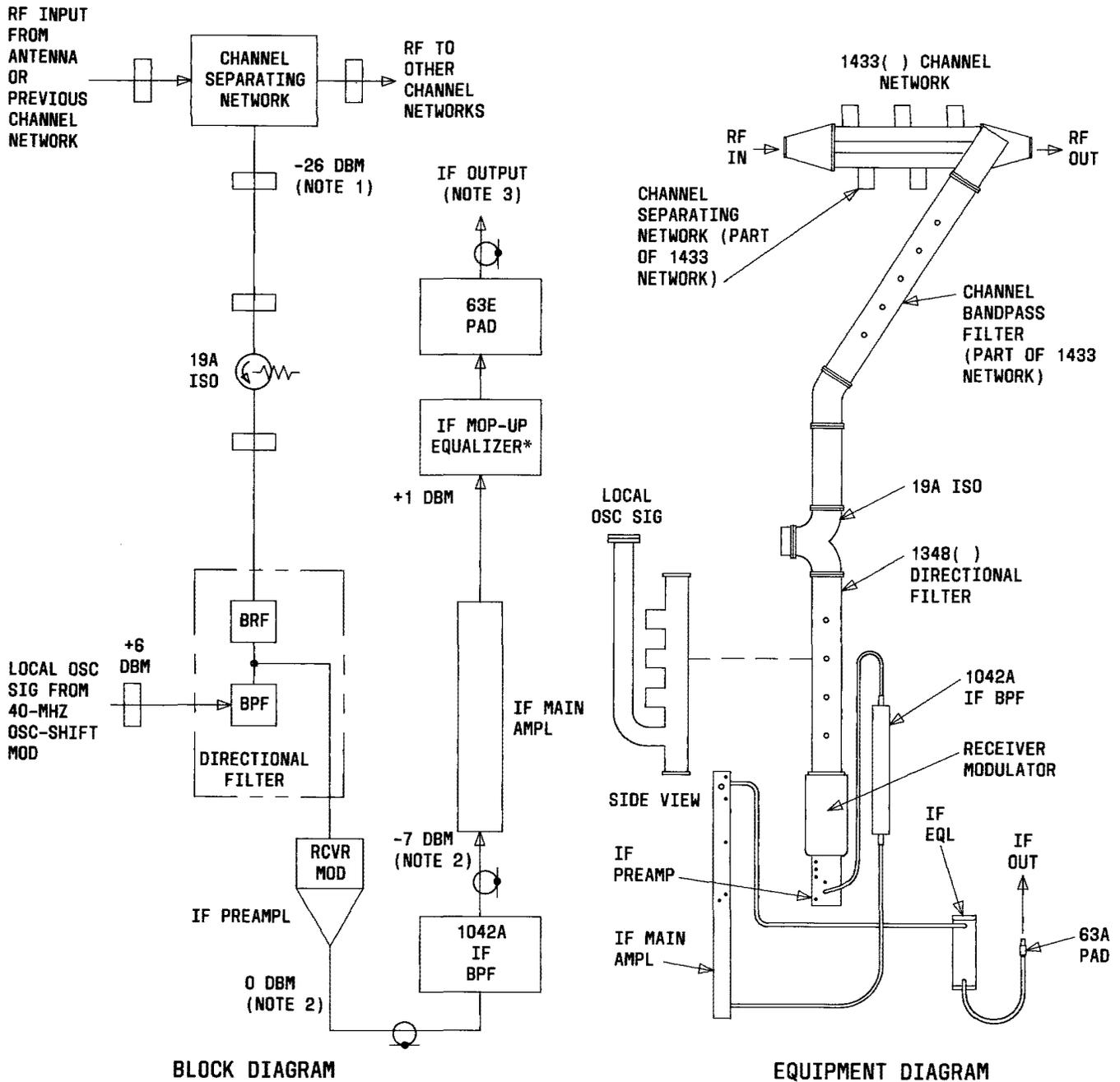
NOTES:
1. 10 DB HIGHER WHEN EQUIPPED WITH 652A RF PREAMPLIFIER.
2. 3 DB HIGHER WHEN EQUIPPED WITH 652A RF PREAMPLIFIER.
3. REFER TO PAR. 1.23 FOR ADDITIONAL ITEMS WHICH MAY BE INSTALLED AT THIS POINT.
* OPTIONAL

Fig. 2—Microwave Receiver—Functional and Equipment Diagrams

receiver comes directly from a microwave generator instead of the 40-MHz oscillator—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.

1.18 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 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 about 0 dBm at its output under nonfading conditions. This level is approximately 3 dB higher when the 652A RF preamplifier is used.

1.19 The output from the preamplifier is applied to the IF main amplifier through an IF bandpass 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 region 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. The filter also 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.

1.20 The level of the signal applied to the IF main amplifier under nonfading conditions is about −7 dBm (−4 dBm if the 652A RF amplifier is used). The IF main amplifier has an automatic gain control

(AGC) circuit to maintain an output level of +1 dBm. Thus, when the input signal is at its nominal value of −7 dBm, the gain of the IF main amplifier is 8 dB. If the input signal fades, the operation of the AGC can cause the IF main amplifier to provide additional gain of up to 40 dB and still maintain the +1 dBm output. Any further reduction of the input signal level results in a corresponding reduction of the IF main amplifier output signal level. If the 652A RF preamplifier is used, the gain of the IF main amplifier is reduced to 5 dB. The AGC range is then extended to 43 dB.

1.21 No IF basic equalizer is required in the T-R bay because each of the passive networks and filters, in both the receiver and transmitter, are self-equalized, and all of the active circuits have very broad passbands. However, there are some residual distortions that can accumulate in an IF switching section and require mop-up type equalization to compensate. For this reason, an optional IF delay slope or parabolic delay shape mop-up equalizer is shown in Fig. 2 at the output of the IF main amplifier. The amount and type of mop-up equalization needed is determined by envelope delay distortion measurements on the overall IF-to-IF switching section. Sufficient mop-up equalizers then are distributed among the receivers in the section to provide the total equalization needed.

1.22 The output from the equalizer is applied to a 63E pad which attenuates the IF signal to approximately −7 dBm.

1.23 Prior to 1974, provision was made for installing a DADE (differential absolute delay equalization) cable at the output of the 63E pad. (DADE cable was 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 was then delivered either to the radio transmitter in a repeater station bay or to the IF switching equipment at main stations. DADE equalization has been suspended mainly because of the administrative difficulties that have arisen in switching sections composed of more than one type of T-R bay.

Microwave Transmitter

1.24 The input to the transmitter [Fig. 3 for bays equipped with the 461A TWT or Fig. 4 for bays equipped with the 660( ) amplifier] 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. The IF limiter circuit 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 a cross-modulation type noise by the succeeding circuits of the transmitter. The carrier resupply circuit 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 inserts high loss in the signal path and substitutes for the regular signal a 70-MHz IF carrier modulated

by 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 and which in turn, could cause excessive noise spillover into the adjacent channels. The pilot modulation on the carrier prevents the IF protection switching system from switching service to the channel while the carrier resupply is operating. Normal output power is −7 dBm.

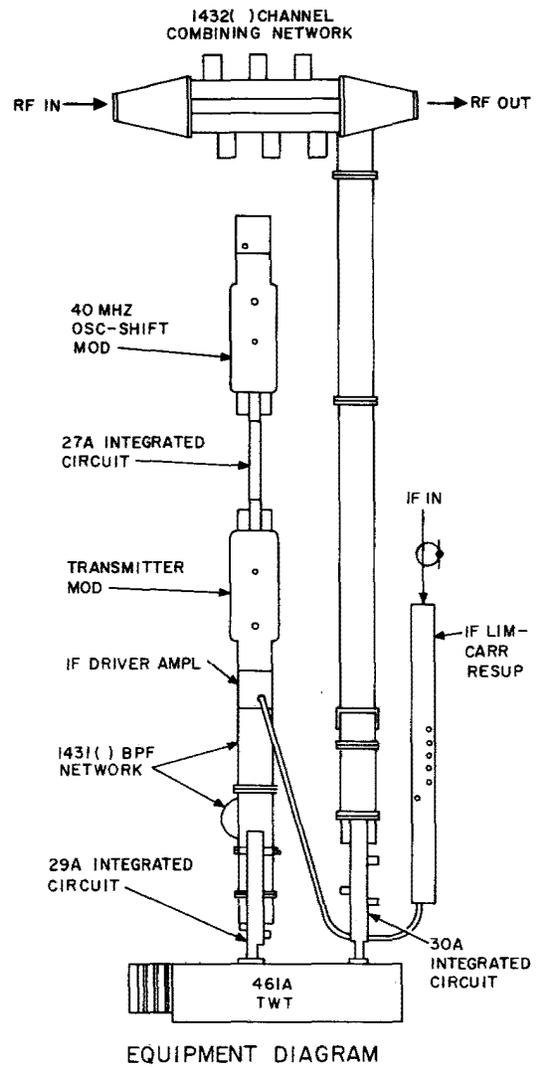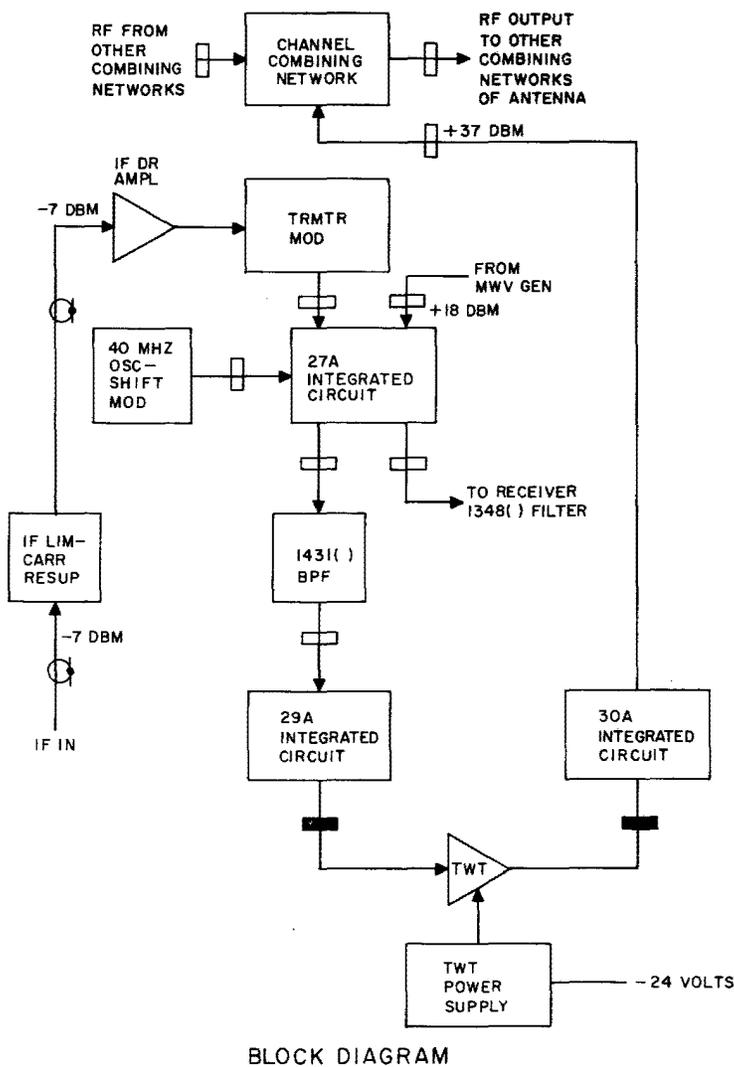1.25 The IF output from the IF limiter—carrier resupply (either the regular signal or the rein-

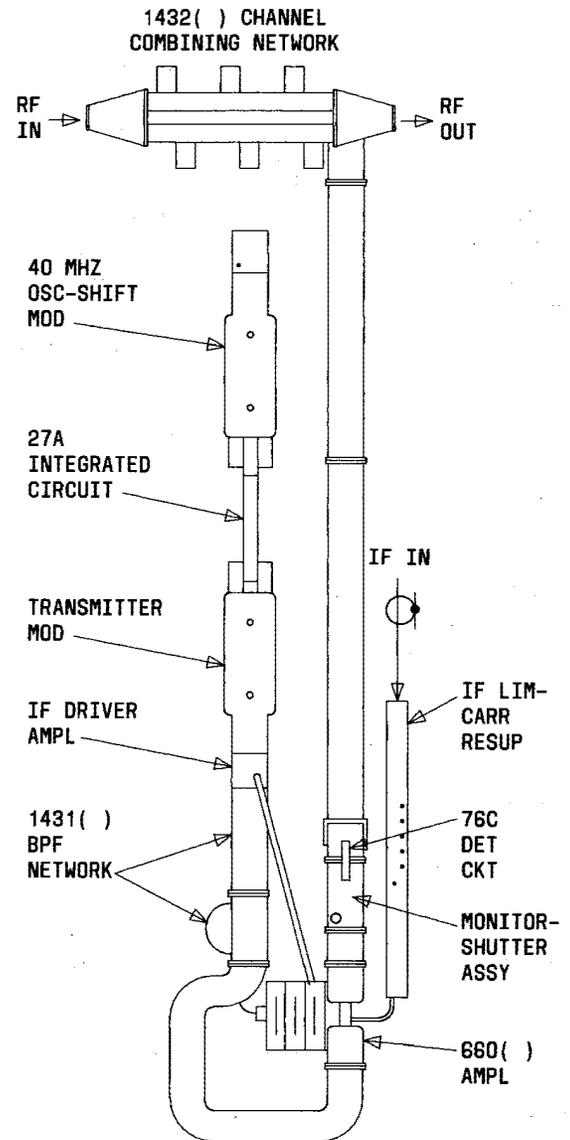Fig. 3—Transmitter Bay Equipped With 461A TWT—Functional Diagram

BLOCK DIAGRAM

RF FROM OTHER COMBINING NETWORKS

CHANNEL COMBINING NETWORK

RF OUTPUT TO OTHER COMBINING NETWORKS OF ANTENNA

+37 DBM

IF DR AMPL

-7 DBM

TRMTR MOD

FROM MWV GEN

+18 DBM

40 MHZ OSC-SHIFT MOD

27A INTEGRATED CIRCUIT

TO RECEIVER 1348( ) FILTER

NETWORK) IF LIM-CARR RESUP

-7 DBM

1431( ) BPF

76C DET CKT

MONITOR-SHUTTER ASSY

+8 DBM

IF IN

660( ) AMPL

EQUIPMENT DIAGRAM

1432( ) CHANNEL COMBINING NETWORK

RF IN

RF OUT

40 MHZ OSC-SHIFT MOD

27A INTEGRATED CIRCUIT

TRANSMITTER MOD

IF DRIVER AMPL

1431( ) BPF NETWORK

IF IN

IF LIM-CARR RESUP

76C DET CKT

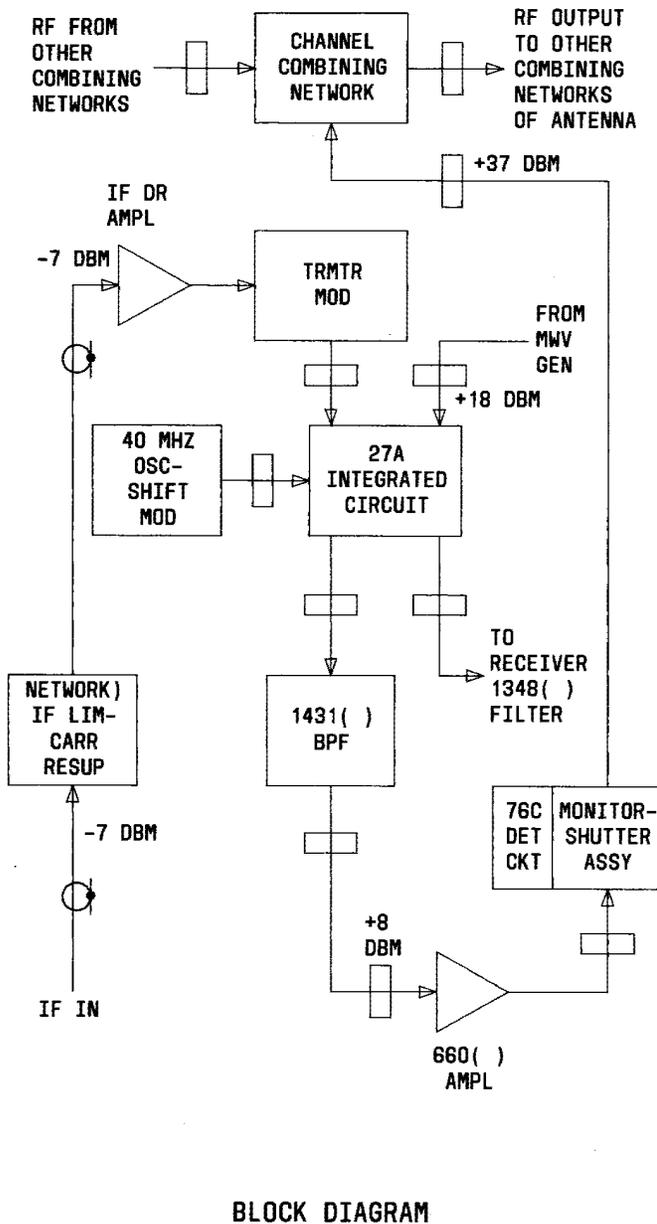MONITOR-SHUTTER ASSY

660( ) AMPL

Fig. 4—Transmitter Bay Equipped With 660( ) Amplifier—Functional Diagram

serted signal) is applied to the amplifier section of the IF driver amplifier—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 the transmitter modulator.

1.26 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 microwave generator provides a signal to the 27A integrated circuit which is split in two directions. One of

the signals is fed to the 40-MHz oscillator—shift modulator and is shifted by 40 MHz. The modulator output is then fed to the directional filter on the receive side of the repeater. The other portion of the microwave generator signal is applied to the transmitter modulator where it is mixed (modulated) with the IF signal. 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. These outputs are returned through the 27A to a bandpass filter. The bandpass filter, [coded 1431( )] which is equalized across its passband by an associated cavity equalizer, passes the desired frequency and rejects all others.

1.27 Two equipment options are available at this point in the transmit bay. Development of the 5-watt version of the solid-state 660( ) RF amplifier has made it possible to replace the 29A IC, the 30A IC, the TWT, and the TWT power supply with a 660( ) amplifier. When the TWT is used, the output of the 1431( ) filter is connected to the 29A integrated circuit which provides test access and monitoring for the signal from the transmitter modulator, and RF drive and input impedance matching adjustments for the TWT amplifier. The 29A output is applied to the TWT amplifier, which provides the power amplification. The output of the TWT amplifier is connected to the 30A integrated circuit which contains a low-pass filter, an output power monitoring circuit, and tuning adjustments to optimize the transmission response of the TWT amplifier. The signal is next applied to a channel combining network that passes only the 20-MHz band of frequencies to be transmitted. The output from the transmitter is adjusted to +37 dBm (5 watts) at the input to the channel combining network.

1.28 When the 660( ) IC RF power amplifier is used, the output of the 1431( ) filter is connected to the 660( ) amplifier which provides an output of +37 dBm. The output of the amplifier is connected to an ED-52277 monitor shutter assembly and a 17C detector which is designated MON 1 and provides for checking the output power level. The monitor shutter is connected to the transmit channel combining network.

1.29 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 voltage required by the TWT.

1.30 For hot standby/space diversity or hot-standby-only switching, the waveguide connections between the transmitter and the antenna differ from those used in the frequency diversity configuration. The regular bay at a main station contains an electromechanical coaxial RF switch which connects the regular or standby transmitter to the transmitting antenna via the channel combining network in the *regular* bay. The switch also connects a termination to the unused transmitter output. Coaxial cable and waveguide-to-coaxial transducers are used to make the connections to the RF switch.

1.31 In a HS/SD application, the standby bay contains a solid-state IF switch which selects the receiver output from either the regular or standby bay. The IF signal from the switch output is then applied to a hybrid transformer (located in the standby bay) which double feeds the regular and standby transmitters at a repeater station or FM receivers at a main station.

C. Equipment Description

1.32 The transmitter and receiver components (Fig. 1) are mounted on a single 9-foot high, 19-inch unequal flange, duct-type framework about 22 inches wide and 15 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.

1.33 In a repeater station bay, the lower compartment of the base of the bay houses one microwave generator and one −19 volt regulator. The upper compartment of the base is not equipped when the solid-state 660( ) amplifier is used. When the TWT is used, the upper compartment contains the TWT power supply. The power supply consists of two units: the oscillator unit on the left and the converter output unit on the right side. An internal cable from the converter output 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 upright. 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 microwave integrated circuits that match the regular-height waveguide to the reduced-height waveguide required by the TWT.

1.34 The meter panel and alarm panel are mounted on the front right side of the bay. Access to the units for visual inspection or for maintenance purposes can be accomplished by removing the four screws on the front of each panel.

1.35 The channel 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.

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 run of the TD-type microwave radio system (Fig. 5). When used, the preamplifier is common to all received channels in a 6-bay lineup. It has a typical gain of 10 dB when powered and a maximum insertion loss of 13 dB when unpowered.

2.02 The 652A preamplifier is used to improve the thermal noise and fade margin of a radio hop. Two 652A units 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 preamplifier is required 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-3A repeater to about 3 dB. For 1200 and 1500 circuit loadings, the 652A RF preamplifier is not required. For 1800 circuit loading, the 652A 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-3A transmitters are operating at 5 watts output.) The 652A should not be used if the normal received carrier power is greater than −24 dBm. At inputs above −24 dBm, third-order intermodulation noise largely offsets the thermal noise improvement and thus negates the benefit of using the 652A unit. This noise is generated within the 652A by the cross-products of multiple signals in the common receiving waveguide run. The 652A RF 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 re-
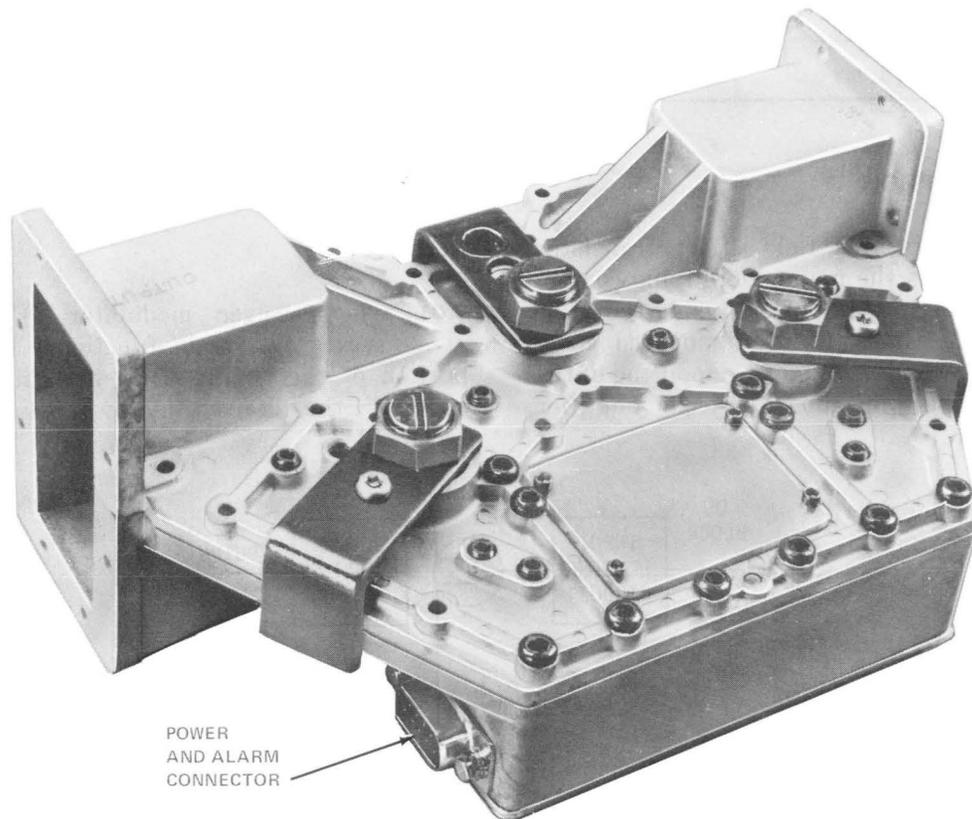

POWER AND ALARM CONNECTOR

Fig. 5—652A RF Preamplifier

mote alarm. When the 652A unit 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 13 dB (typically 5 to 8 dB). Table A lists typical performance of the preamplifier.

TABLE A

652A RF PREAMPLIFIER TYPICAL PERFORMANCE VALUES

	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

FUNCTIONAL DESCRIPTION

2.04 A gallium arsenide field effect transistor (GaAs FET) is the major amplifying component in the 652A RF preamplifier. Inside the 652A unit (Fig. 6) 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.

2.05 The 652A RF preamplifier contains three circulators assembled in air dielectric stripline. One circulator is used at the input and another is used 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 input and output circulators to form the passive bypass path for failsafe operation.

EQUIPMENT DESCRIPTION

2.06 The 652A RF 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 plug is located as shown in Fig. 5. Refer to Section 420-802-100 for further description and installation procedures of the preamplifier.

3. J68387P RECEIVER MODULATOR—IF PREAMPLIFIER

GENERAL

3.01 The receiver modulator—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-
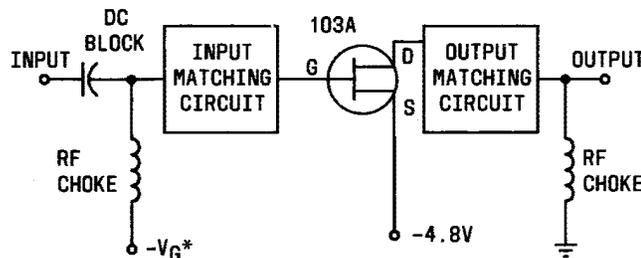
* V_G AUTOMATICALLY ADJUSTED FOR I_{DS}= 15mA

Fig. 6—652A RF Preamplifier—Amplifier Modular Diagram

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 The J68387P receiver modulator—IF preamplifier uses an unbalanced (single diode) modulator section. The noise figure is typically 7 dB and the normal (nonfaded) IF output power is set to 0 dBm if a 652A RF preamplifier is not used (+3 dBm if a 652A is used). The unit is designed to work with a normal received carrier power as high as −14 dBm. The local oscillator input power required is +6 dBm.

FUNCTIONAL DESCRIPTION

3.03 Figure 7 is a block diagram of the overall downconverter circuit consisting of a 1348-type waveguide directional filter and the J68387P receiver modulator—IF preamplifier. The received signal and local oscillator signal are combined in the

waveguide directional filter. Refer to Part 22D for a description of the filter. The combined signal output of the filter is fed through a step transducer and waffle-iron type low-pass filter to the diode modulator where mixing of the two signals takes place. The IF output signal from the diode (i.e., 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.

3.04 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
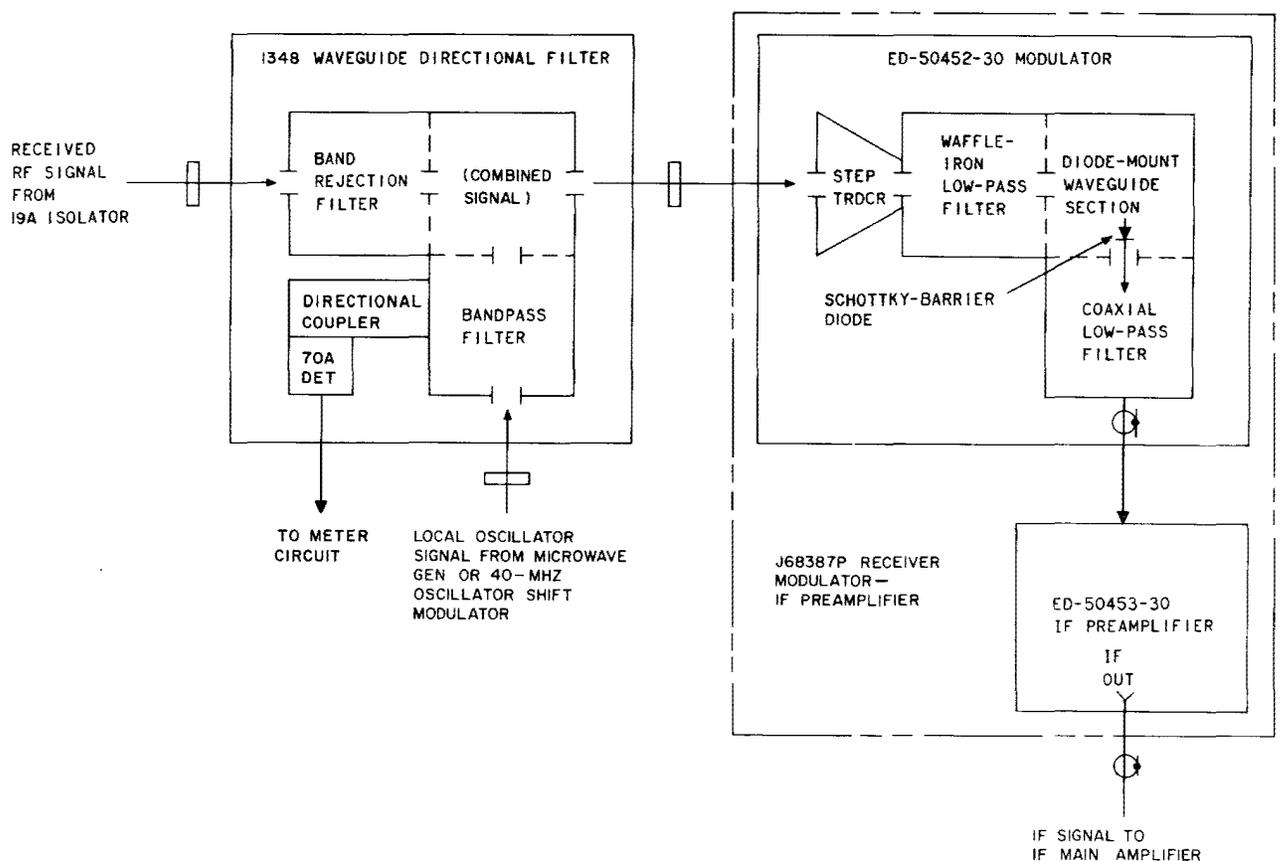
Fig. 7—Receiver Downconverter—Preamplifier—Block Diagram

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.

3.05 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, therefore, is used ahead of the diode to attenuate these harmonics before they leave the modulator input. This filter has a cutoff 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.

3.06 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.

3.07 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.

3.08 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 3.04. 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.

EQUIPMENT DESCRIPTION

3.09 The receiver downconverter—preamplifier assembly consists of two units, the 1348-type waveguide directional filter and the J68387P receiver modulator—IF preamplifier. A description of the directional filter is given in Part 22D.

3.10 The receiver modulator (Fig. 8) contains four main components: a die-cast housing, a collet assembly, the diode, and the coaxial low-pass filter. Figure 9 is a simplified mechanical diagram of how the modulator components fit together.

3.11 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. 8) 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 the photograph. The transducer is a conventional 3-step design.

3.12 The collet 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.

3.13 The coaxial low-pass filter is shown in Fig. 10. 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.

3.14 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.

4.   J68387S IF MAIN AMPLIFIER

GENERAL

4.01 The IF main amplifier is comprised of three major sections: the IF amplifier, the AGC
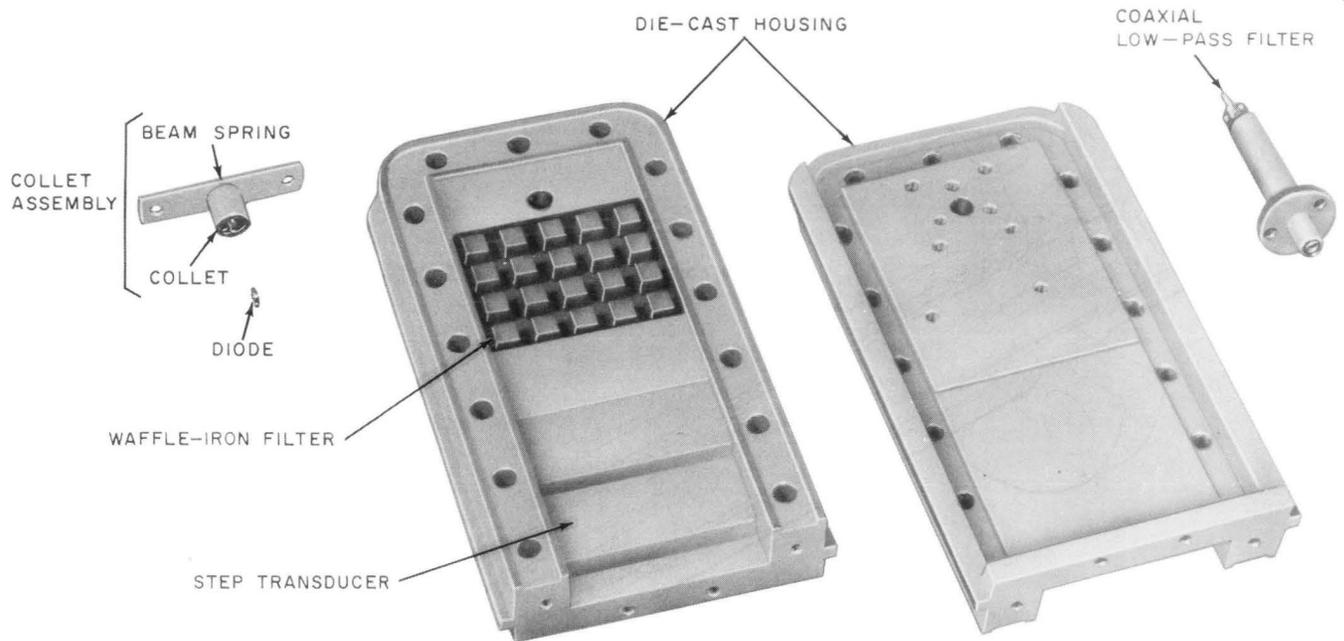
Fig. 8—Receiver Modulator Components
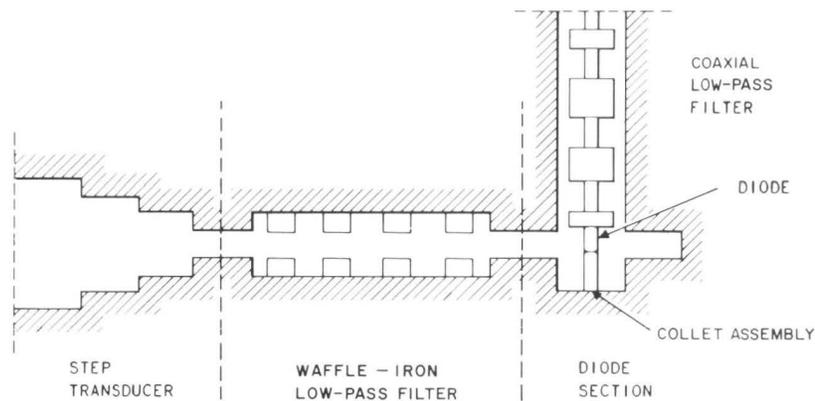
Fig. 9—Cross-Section of Receiver Modulator

amplifier, and the power filter and meter network. The IF amplifier has two fixed gain stages and three variable gain stages. The AGC amplifier contains one IF gain stage, an IF detector, a differential amplifier, and a 2-stage dc amplifier. The IF main amplifier and AGC amplifier operate together to maintain the receiver IF output power constant with input signal down-fades as deep as 40 dB and "up-fades" as high as 6 dB.

4.02 The IF main amplifier is shown in the block diagram, Fig. 11. The output of the IF main amplifier is maintained constant by the action of the three variable gain (or variolosser) stages which are under the control of the AGC amplifier. With a normal signal (−7 dBm) at the input to the IF main amplifier, the overall gain of the amplifier is 8 dB and its output power is +1 dBm. When the signal level at the input to the amplifier decreases, the AGC ampli-

DIODE
PLUGS
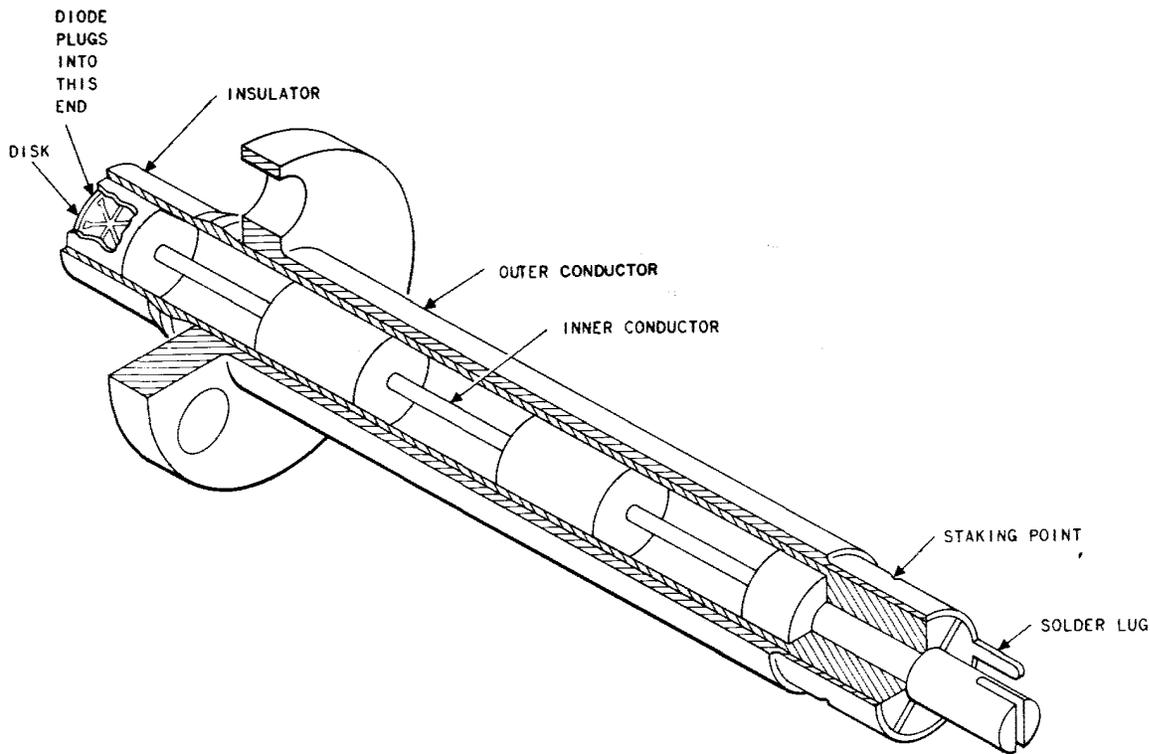INTO
THIS
END

INSULATOR

DISK

OUTER CONDUCTOR

INNER CONDUCTOR

STAKING POINT

SOLDER LUG

Fig. 10—Coaxial Low-Pass Filter

fier 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 Amplifier

4.03 The IF main amplifier has three gain-variolosser stages connected in series. Each of these stages can be varied in gain from approximately −4 dB to +13 dB by a control current from the AGC amplifier. The three stages together give the amplifier a variable gain range of about 46 dB.

4.04 Each variolosser stage is a 2-transistor feedback amplifier (doublet), dc coupled to minimize the use of coupling capacitors and bias resistors. The feedback, and therefore gain, of each stage is varied by varying the current through a pair of PIN diodes in the feedback path. The last variolosser

stage contains the SLOPE 1 and SLOPE 2 controls. These controls are used to flatten the amplitude response of the IF main amplifier over the 60- to 80-MHz IF band.

4.05 Preceding the first variolosser stage is a doublet amplifier stage that provides input impedance matching and 8 dB of gain. This stage contains return-loss control RL1 used to adjust the input return loss of the amplifier.

4.06 Following the last variolosser stage is a doublet stage having 4 dB of gain. The RL2 control associated with this stage is provided for adjustment of the amplifier output return loss. A monitor circuit in the output of the Q9 amplifier stage provides an IF input signal for the AGC circuit.

B. AGC Amplifier

4.07 The AGC amplifier consists of an IF gain stage, an IF detector, a differential amplifier, and a 2-stage dc amplifier. The IF gain stage provides isolation between the IF detector and IF amplifier
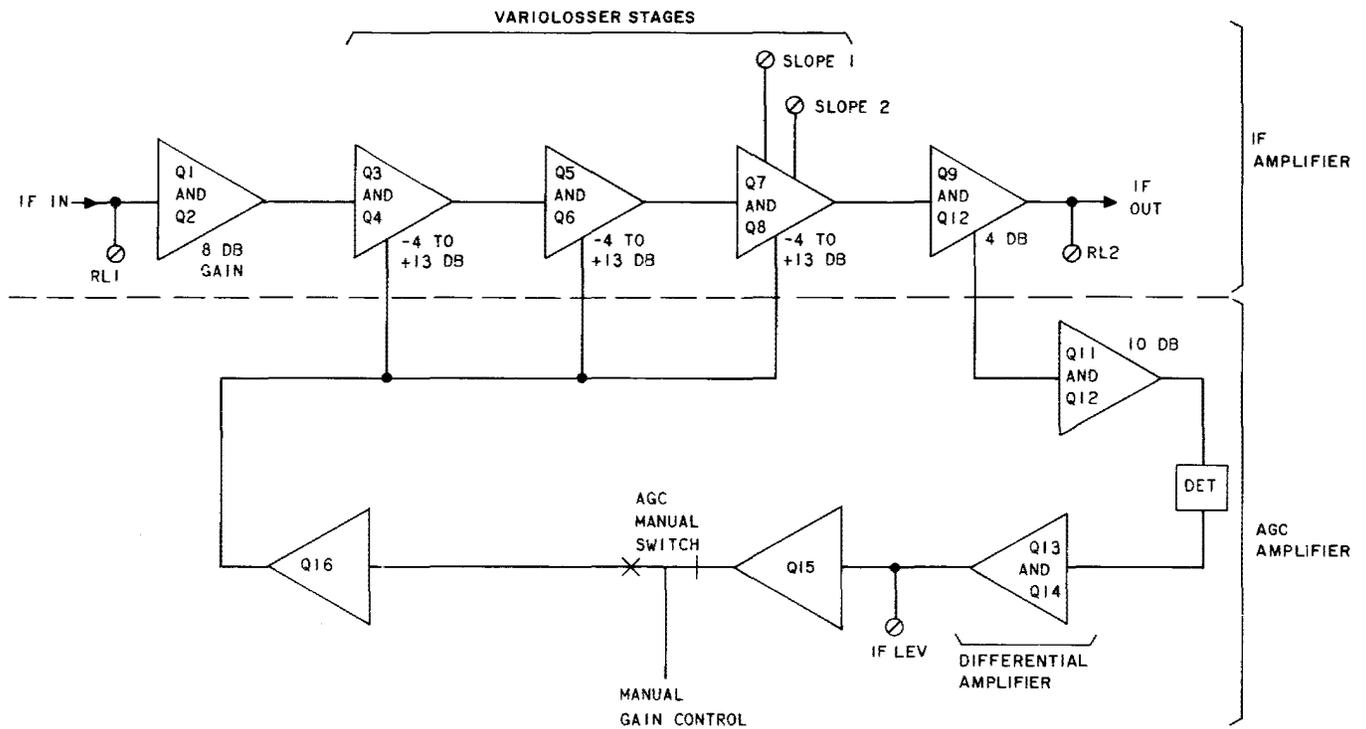
VARIOLOSSER STAGES

⊘ SLOPE 1

⊘ SLOPE 2

IF IN→

⊘
RL1

Q1
AND
Q2
8 DB
GAIN

Q3
AND
Q4
-4 TO
+13 DB

Q5
AND
Q6
-4 TO
+13 DB

Q7
AND
Q8
-4 TO
+13 DB

Q9
AND
Q12
4 DB

IF
OUT

⊘RL2

IF
AMPLIFIER

Q11
AND
Q12
10 DB

DET

AGC
MANUAL
SWITCH

Q16

Q15

Q13
AND
Q14

⊘
IF LEV

AGC
AMPLIFIER

DIFFERENTIAL
AMPLIFIER

MANUAL
GAIN CONTROL

Fig. 11—J68387S IF Main Amplifier—Block Diagram

and amplifies the signal by 10 dB to provide a level sufficient to feed the detector.

4.08 The dc output from the detector is applied to a differential amplifier. This stage amplifies the signal and delivers an output that is proportional to the difference between the input signal and a reference voltage. The IF LEV adjustment determines the signal level at the output of the IF main amplifier and is adjusted for a +1 dBm indication.

4.09 The output of the differential amplifier goes through two additional dc amplifier stages. The first stage (Q15) further amplifies the dc voltage and provides an output from which the control current for the PIN diodes in the variolosser stages is obtained. The second stage (Q16) provides a high source impedance for driving the variolosser diodes.

C. Power Filter and Meter Network

4.10 This circuit serves as an interface between the IF main amplifier, AGC amplifier, and the external meter and dc power connections in the T-R bay. Included in the circuit is the MAN-AGC switch,

used for operating the amplifier either under manual or automatic gain control. Also provided are a linearizing circuit and a MTR SENS control that are used in conjunction with the T-R bay meter to give a linear indication of the received carrier power over the full fade range. Decoupling circuits for the external meter and the dc input power leads also are provided.

EQUIPMENT DESCRIPTION

4.11 The assembly consists of three printed wiring boards: the IF amplifier, the AGC amplifier, and the power filter and meter network. These are mounted inside an aluminum housing fitted with covers. The return-loss and other adjustments are accessible through guides in the front of the frame. The 567A coaxial IF input and output jacks are located in the rear, and a multicontact connector for dc power and metering is located at the top.

5. J68387T IF LIMITER—CARRIER RESUPPLY

GENERAL

5.01 The J68387T IF limiter—carrier resupply monitors the signal power at its input. When this signal is above the threshold level, the unit operates as a limiter to remove undesired amplitude modulation (AM) present on the desired FM signal. If the signal fades below the threshold level, the normal transmission through the limiter is blocked, and a tone-modulated FM signal is provided at the output. The presence of this signal prevents subsequent repeaters in the transmission path from going to full gain if the channel fails. The 9-MHz tone modulation of this signal is provided to simulate noise at the frequency of the noise detector slot in the automatic protection switching system. By this means, the system recognizes that the channel is not suited for service.

5.02 The IF limiter—carrier resupply is an IF-to-IF 0-dB gain unit comprised of several sections: a monitor, an oscillator gate control, a carrier resupply operation alarm, an oscillator and deviator, a deviator control and oscillator blocking gate, a 9-MHz oscillator monitor for an external meter and alarm, a signal blocking gate, and a signal limiter and low-pass filter. The unit is designed to operate over the 60- to 80-MHz frequency range when connected between 75-ohm impedances. Normal input and output power is −7 dBm.

5.03 The threshold level for insertion of the tone-modulated, resupplied carrier is adjustable over the range −13.5 to −22 dBm at the input. The normal threshold setting is −16 dBm. An alarm ground is provided to external circuits delayed nominally 50 seconds after the carrier resupply has operated. If the channel failure is corrected during this interval, the alarm is automatically reset. An alarm ground is also provided in the event of failure of the 9-MHz tone oscillator.

FUNCTIONAL DESCRIPTION

5.04 The IF limiter—carrier resupply block diagram (Fig. 12), is comprised of several circuits; a monitor, an oscillator gate control, a carrier resupply operation alarm, an oscillator and deviator, a deviator control and oscillator blocking gate, a 9-MHz oscillator monitor for an external meter and alarm, a signal blocking gate, and a signal limiter and low-pass filter.

5.05 The input signal is applied through an impedance matching network with controls IN RL1 and IN RL2 which are used to adjust the input return loss. Approximately one-fifth of the input current is diverted into the monitor circuit by the resistive splitting network. A 2-transistor (doublet stage) variable-gain amplifier provides gain for the monitor circuit input signal and allows adjustment of the TRIP control for the proper threshold or trip point.

5.06 Following the variable gain amplifier is a single-stage amplifier which provides gain, impedance transformation, and partial isolation for the detector circuit. The bandpass filter circuit at the output of this amplifier narrows the bandwidth of the monitor circuit. The passband of the monitor circuit must be narrow enough to attenuate interferring signals that could affect the operating point of the oscillator gate circuit. It must be wide enough, however, to permit making swept envelope delay distortion measurements on the system without causing the carrier resupply to operate. The DBPF (detector bandpass filter) control is used to adjust the bandpass filter to meet the above requirements. The filter network 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.

5.07 The diode detector converts the amplified narrowband IF input signal to a dc voltage whose level is proportional to the level of the IF input signal. This dc voltage is applied through a dc amplifier to the gate control circuit.

5.08 In the gate control circuit, a Schmitt trigger controlled by the dc voltage from the monitor circuit functions as a level-sensitive switch that controls the state of the IF limiter—carrier resupply circuit. The Schmitt trigger is bi-stable, remaining in the state in which it happens to be operating until the dc voltage level at its input changes sufficiently. Several transistors connected to the output of the Schmitt trigger act as electronic switches which control the state of the gate circuits and initiate the timing circuit in the alarm delay circuit.

5.09 When the dc level at the input to the Schmitt trigger circuit decreases to the point set by the TRIP control, the Schmitt trigger circuit changes its operating state. This, in turn, causes the diode gates to be operated so as to insert the substitute IF signal into the normal IF signal path.

5.10 The circuit remains in this state until the normal received IF signal level increases approxi-
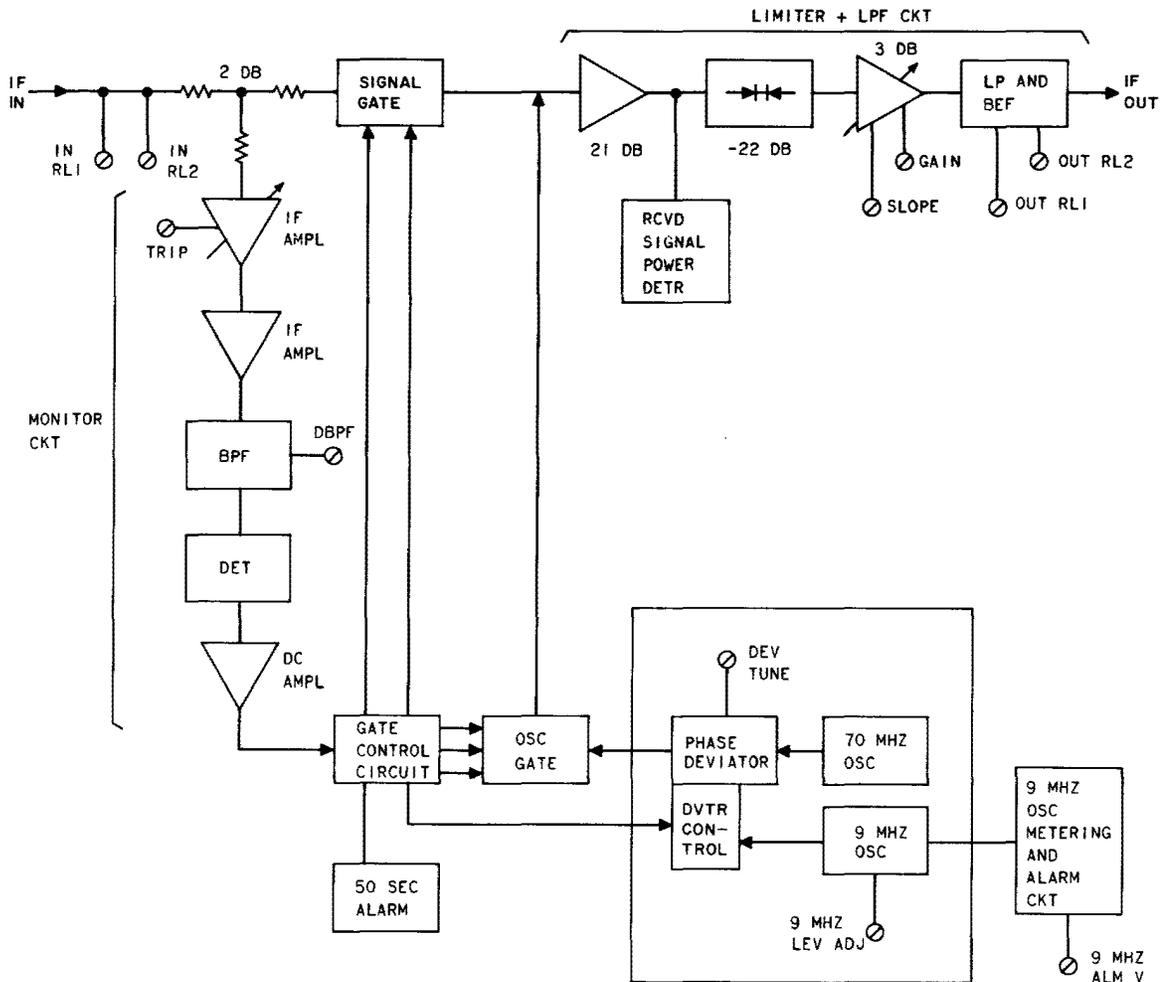
Fig. 12—J68387T IF Limiter—Carrier Resupply—Block Diagram

mately 2.5 dB above the value set by the TRIP control. At this point, the Schmitt trigger circuit flips back to its normal state. This hysteresis ensures stable operation, preventing the carrier resupply from "chattering" or rapidly switching back and forth from one operating condition to the other.

5.11 The alarm circuit operates when the input signal level drops below the threshold or trip set point. The alarm provides a 50-second delay when initiated (to avoid unnecessary alarms on normal fades) and will reset automatically when the input signal is restored to normal.

5.12 The oscillator and deviator circuits provide a substitute frequency-modulated, 70-MHz signal. A 70-MHz crystal-controlled oscillator furnishes

a highly stable carrier input to the phase deviator. A second crystal-controlled oscillator, operating at 9 MHz, provides the modulating signal input to the deviator. The 9-MHz LEV ADJ control is provided in the circuit to adjust the 9-MHz signal level and thereby set the modulation index. The 9-MHz ALM V control provides the desired output voltage for the metering and alarming circuit. In the deviator circuit, the DEV TUNE control is used to peak the 70-MHz signal.

5.13 The substitute carrier is continuously applied to the phase deviator 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 is applied through the signal blocking gate

circuit to the IF limiter circuit. The deviator control circuit and the oscillator gate circuit, which are operated by voltages from the gate control circuit, together present at least 75-dB loss to the substitute signal, thereby effectively blocking it from the channel. For normal signal transmission, the deviator control is switched on, which causes the deviator to be detuned and the 9-MHz signal to be bypassed to ground. The oscillator gate is opened, the deviator control is switched off, and the substitute signal is inserted, when needed, into the normal IF signal path via the signal blocking gate.

5.14 The 9-MHz oscillator metering and alarm circuit supplies outputs to permit the 9-MHz carrier to be monitored in the T-R bay alarm panel and the meter circuit. The monitored point for the 9-MHz oscillator is taken from the deviator diode in the phase deviator.

5.15 The signal blocking gate is designed to pass an input signal as low as −22 dBm before the monitor circuit trip point is reached. Once the trip point is reached, the gate circuit will pass the modulated 70-MHz carrier resupply signal through the IF limiter circuit to the IF OUT jack. When the signal blocking gate circuit is passing the carrier resupply signal, it inserts attenuation in the normal signal path to suppress any incoming channel noise. This attenuation also ensures that the carrier resupply signal does not leak back into the monitor circuit to cause the unit to be unstable and chatter.

5.16 The input stage to the IF limiter circuit is a 2-transistor, feedback amplifier (doublet) having very stable bias and gain characteristics.

5.17 The limiter circuit 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.

5.18 The IF signal from the limiter diodes is applied to a doublet amplifier. This stage provides a −7 dBm output power for an overall 0-dB gain of the IF limiter—carrier resupply unit. The SLOPE control in this stage is used to adjust the overall amplitude response of the limiter for minimum slope across the IF band. The GAIN control is used to set the nominal output of the limiter to −7 dBm at the IF OUT jack.

5.19 A low-pass filter is located between the output amplifier stage and the IF OUT jack. This filter attenuates harmonics produced in the limiter stage, particularly the third harmonic of the IF carrier frequency. The filter includes an impedance matching network containing controls OUT RL1 and OUT RL2, used to adjust the output return loss of the limiter.

EQUIPMENT DESCRIPTION

5.20 The assembly consists of three printed wiring boards: the IF limiter and control, the 9- and 70-MHz oscillators, and the oscillator gate. These boards are mounted, together with dc power and metering filters, inside an aluminum frame fitted with covers. Test points and the trip control are accessible at the front of the unit. The other adjustments, input and output return loss, gain, slope, filter tuning, and 9-MHz alarm and level, are all accessible at the right side of the unit. IF input and output 567A coaxial jacks, mounting holes, and a multicontact connector for power and metering leads are located at the rear.

6. J68387U IF DRIVER AMPLIFIER—TRANSMITTER MODULATOR

> *Warning: The J68387U driver amplifier—transmitter modulator used in the J68386G and H T-R bays and the J68387U-2 driver amplifier—transmitter modulator used in TD-2 bays are identical in appearance but are NOT interchangeable. The J68387U uses −19 volts; the J68387U-2 uses −24 volts, and neither unit will operate properly if supplied the other voltage. (The J68387U unit may be damaged if supplied −24 volts rather than the normal −19 volts.)*

GENERAL

6.01 The J68387U driver amplifier—transmitter modulator (Fig. 13) converts an input 70-MHz IF signal to a 4-GHz output signal with a 16-dB gain. The driver amplifier accepts a −7 dBm input signal in the 60- to 80-MHz band and delivers a nominal out-

put of +16 dBm to the transmitter modulator. Input return loss, slope, gain, and diode bias controls are provided to optimize transmission level and flatness. The amplifier is coupled to the modulator through a coaxial low-pass filter. In the modulator, the IF signal combines with a local oscillator signal in the 4-GHz band and produces two sidebands at ±70 MHz from the local oscillator frequency. One of the sidebands is desired; the other is removed by a subsequent filter. The transmitter modulator consists of six basic parts: a step waveguide transducer, a waffle-iron low-pass filter, a diode, a diode mount, a coaxial low-pass filter, and a harmonic termination to absorb harmonics of the 4-GHz signals generated in the modulator diode. The modulator has a single waveguide port which serves as both input for the local oscillator signal and output for the modulated sideband signals. The nominal local oscillator input power is +18 dBm. The nominal RF output power is +9 dBm.
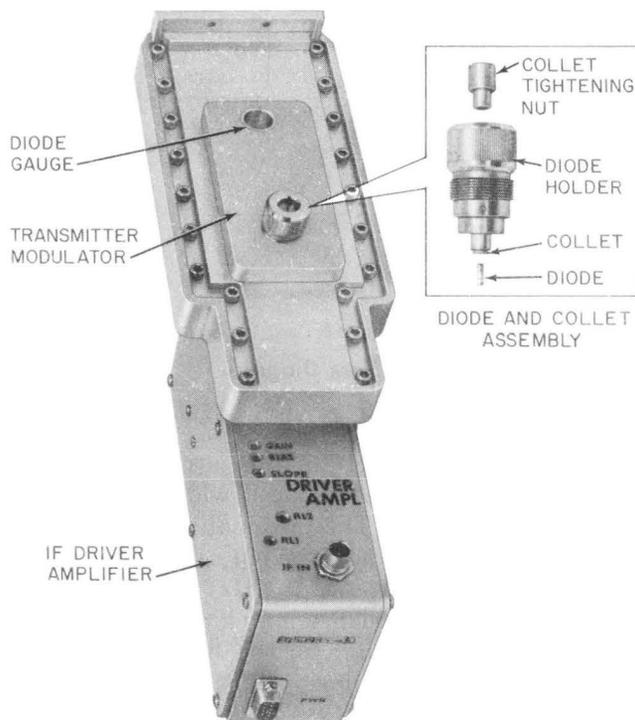

Fig. 13—J68387U IF Driver Amplifier—Transmitter Modulator

FUNCTIONAL DESCRIPTION

6.02 The IF driver amplifier is shown in block diagram (Fig. 14). The first stage is essentially an impedance matching, unity gain stage. The RL1 and RL2 controls associated with this stage are used to adjust the input return loss of the driver amplifier.

6.03 The second stage contains the SLOPE control for adjustment of the amplitude response of the overall IF driver amplifier and transmitter modulator. The variation of the SLOPE control is about 2 dB. The gain of the second stage is approximately 8 dB.

6.04 The third stage comprises a 2-transistor feedback amplifier. A GAIN control in the feedback path provides a variable range of 8 dB.

6.05 The last stage delivers a nominal output of +16 dBm at a 50-ohm impedance to drive the transmitter modulator. A portion of the output signal is rectified by a diode and applied to the T-R bay meter circuit to be monitored. The BIAS control at the output of the last stage sets the self-bias developed by the modulator diode and is adjusted to maximize the power output of the modulator.

Caution: Previous issues of this and other sections have authorized adjustment of the BIAS control as a trimmer for transmission slope: field experience has shown that the BIAS control must be adjusted to maximize the output power of the modulator and not used for any other purpose.

6.06 The transmitter modulator consists of six basic parts: a stepped waveguide transformer, a waffle-iron low-pass filter, a diode, a diode holder, a coaxial low-pass filter, and a harmonic termination.

6.07 The stepped transformer provides an impedance transformation from the standard height waveguide input-output port (1.145 inch) to a reduced height waveguide structure (0.100 inch).

6.08 The waffle-iron low-pass filter passes frequencies from 3700 to 4200 MHz with negligible loss but provides at least 50-dB loss to frequencies of 7 GHz and above. This prevents harmonics of the 4-GHz signals generated in the diode from entering
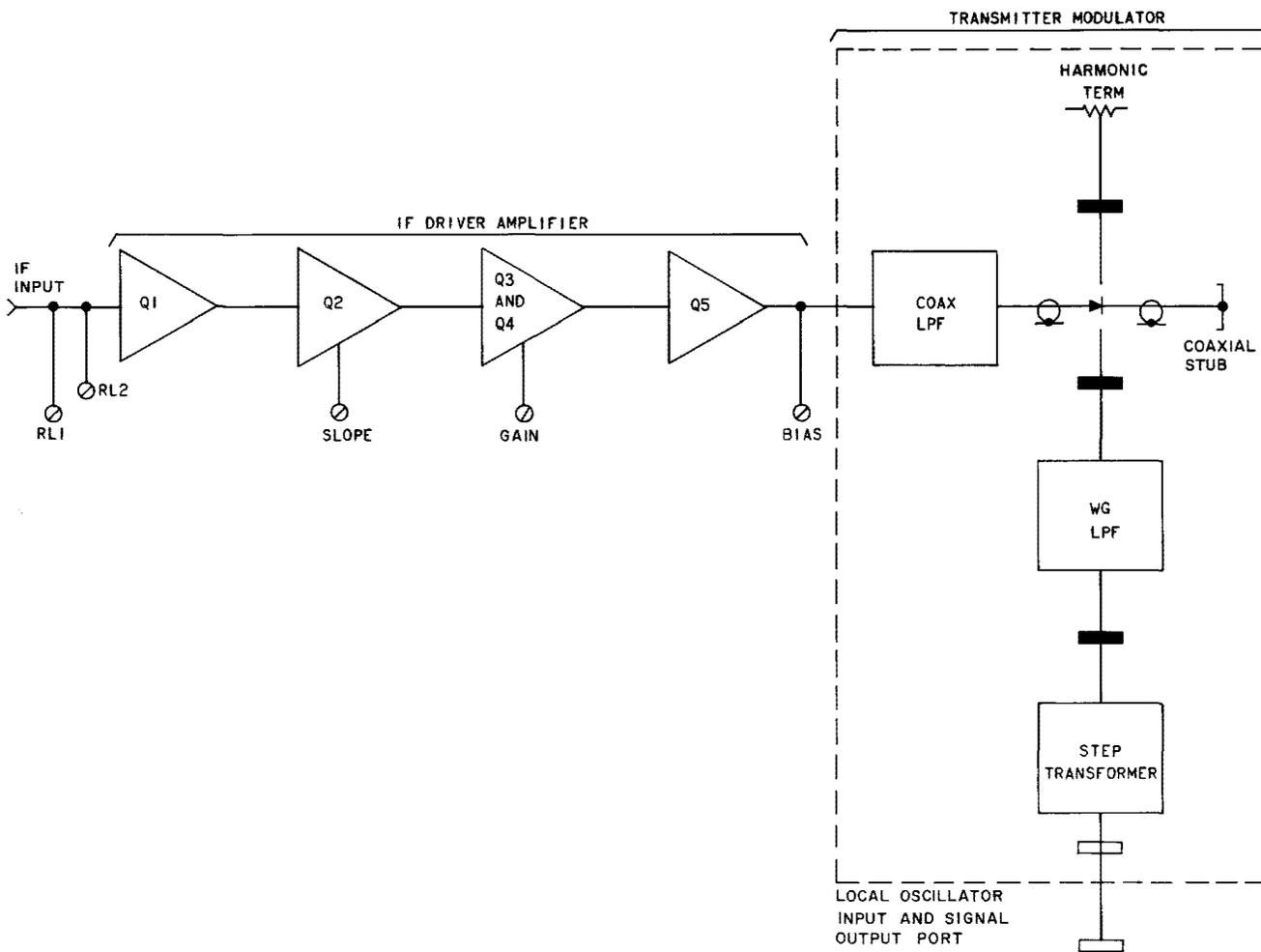
Fig. 14—J68387U IF Driver Amplifier—Transmitter Modulator—Block Diagram

succeeding circuits in the transmitter and causing undesired intermodulation and transmission distortion effects.

6.09 The diode is a Schottky-type device mounted in a diode holder located on the front of the modulator unit. The diode is connected in series with the coaxial low-pass filter and an impedance matching stub formed by the diode holder and composed of a short length of coaxial line terminated in a short circuit. The low-pass filter offers very high insertion loss to frequencies above 3 GHz and negligible loss at IF frequencies. The filter prevents the 4-GHz signals in the modulator from entering the output stage of the driver amplifier where they could cause undesirable overload and intermodulation effects.

6.10 The harmonic termination is a reduced height (0.100 inch) and reduced width (1.245 inch) waveguide structure. The termination absorbs harmonics generated in the diode but reflects the 4-GHz signals. This reflective (at 4 GHz) termination, together with the impedance matching stub, provides a fixed, broadband match for the diode in the modulator unit. No diode tuning adjustments are necessary.

EQUIPMENT DESCRIPTION

6.11 The assembly consists of two physically associated, nonfield separable units. The IF driver amplifier consists of a cast aluminum housing which connects to the modulator and is fitted with covers. The amplifier printed wiring board and RF

decoupling networks for the external meter and dc power connections are mounted inside this frame. Adjustments are accessible through guides in the front of the unit. A 567A coaxial jack in the front provides for the IF input signal. A multicontact connector for dc power and metering is located at the bottom of the frame. The transmitter modulator consists of a 2-piece aluminum housing which forms the step transducer from full to reduced height waveguide, the waffle-iron low-pass filter, and the reduced width waveguide section into which fits the harmonic termination. The construction is similar to that of the receiver modulator (Fig. 8). A diode holder screws into the front of the housing and the IF coaxial low-pass filter fastens to the rear. A hole gauge is provided at the front to set the position of the diode in its holder.

7. RF POWER AMPLIFIER

GENERAL

7.01 Two RF power amplifiers are available for use in TD-3 bays. Original equipment is the 461A traveling-wave tube amplifier. The solid-state 660E or F IC RF power amplifier has been developed in a 5-watt version for use in TD-3 radio systems. The RF

input to either type power amplifier is adjusted to obtain +37 dBm at the input to the transmitter channel combining network.

A. 461A Traveling-Wave Tube Amplifier

Functional Description

7.02 The TWT amplifier consists of a traveling-wave tube mounted in a magnetic focusing structure (Fig. 15). Amplification is provided by energy transfer between the RF signal and an electron stream. The RF input signal to the tube is obtained from the transmitter modulator through the 29A integrated circuit which includes a variable attenuator and tuner. 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.

7.03 The input of the TWT amplifier is shown in Fig. 16. 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

Fig. 15—461A Traveling-Wave Tube Amplifier

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.
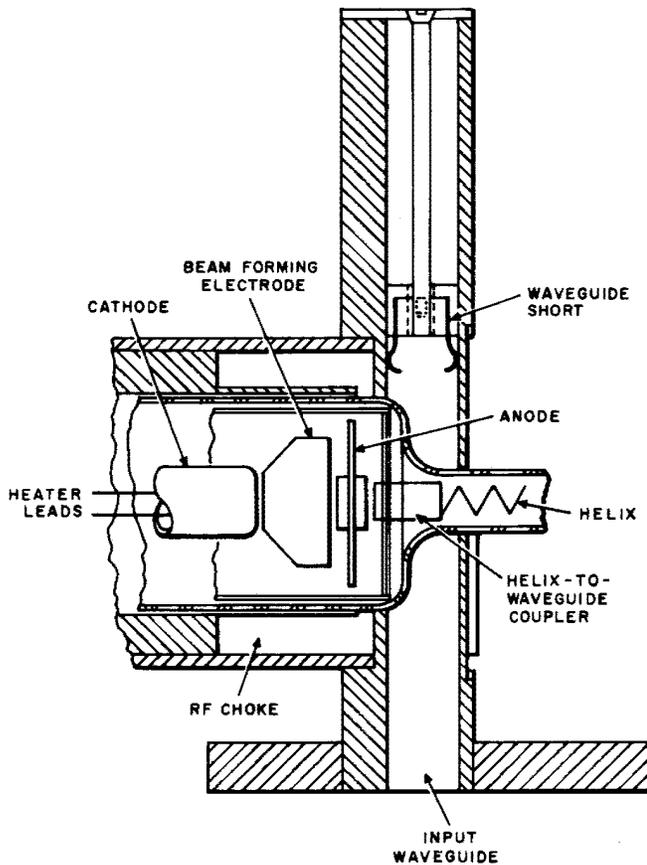

Fig. 16—Electron Gun and Input Waveguide Region of TWT Amplifier

7.04 The electron gun (Fig. 16) 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.

7.05 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. The RF signal travels along the spiral path of the helix winding of the traveling-wave tube. The electron stream is confined to the longitudinal axis of the helix winding. Maximum amplifier gain is obtained when the velocity of the electron stream is approximately equal to the forward velocity component of the RF signal. The electron stream velocity 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).

7.06 A permanent magnet focusing structure (Fig. 17) 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.

7.07 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 tuner in an external microwave integrated circuit (30A) is used to optimize the output impedance match of the amplifier.

7.08 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.
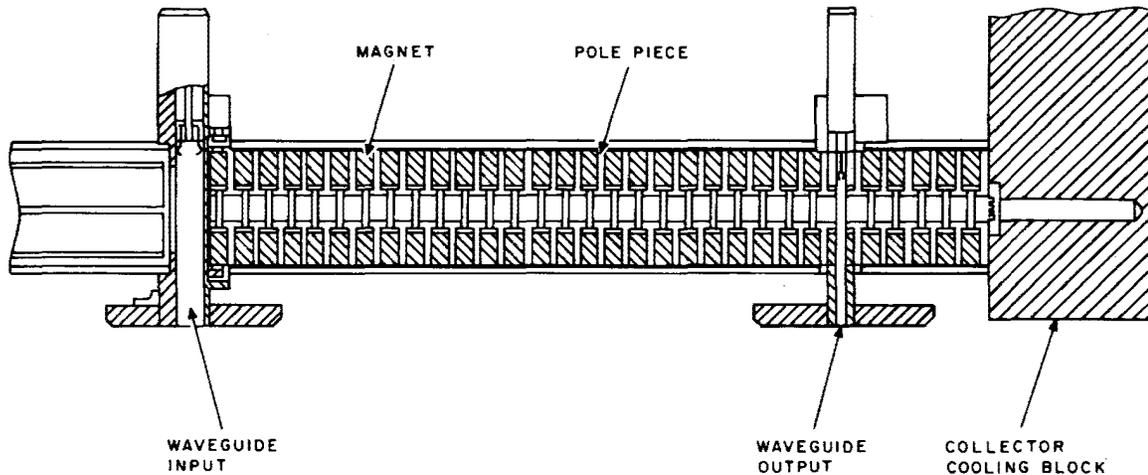
Fig. 17—Cross-Section of Periodic Permanent Magnet Focusing Structure

Equipment Description

7.09 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 tube is not replaced in the field; instead, the entire structure is returned to the factory where a new tube is inserted and optimally focused in the reusable magnetic structure.

7.10 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 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 10).

B. Solid-State 660( ) Intergrated Circuit Amplifier

General

7.11 This part describes the solid-state 660( ) IC amplifier which may be used in place of the traveling-wave tube power amplifier in TD-3 bays. (See Fig. 18.)

7.12 The 660( ) 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 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

7.13 The amplifier has four gain stages. Each employs a single gallium arsenide field-effect transistor (GaAs FET) mounted in a microstrip-type circuit that includes the necessary input and output impedance matching networks for the stage. The first two stages basically form a preamplifier which provides a net gain of about 17 dB to drive the power output stage. A circulator, also constructed in microstrip, isolates the preamplifier from the output stage and permits the second stage to be optimized for power handling capacity and linearity.

7.14 The input and output isolators, which provide a good input and output return loss for the

PWR ADJ ADJUSTMENT

NOTE:
   THE APPEARANCE OF THE 660A AND B (2 WATT)
   AND THE 660C AND D (5 WATT) AMPLIFIER IS THE
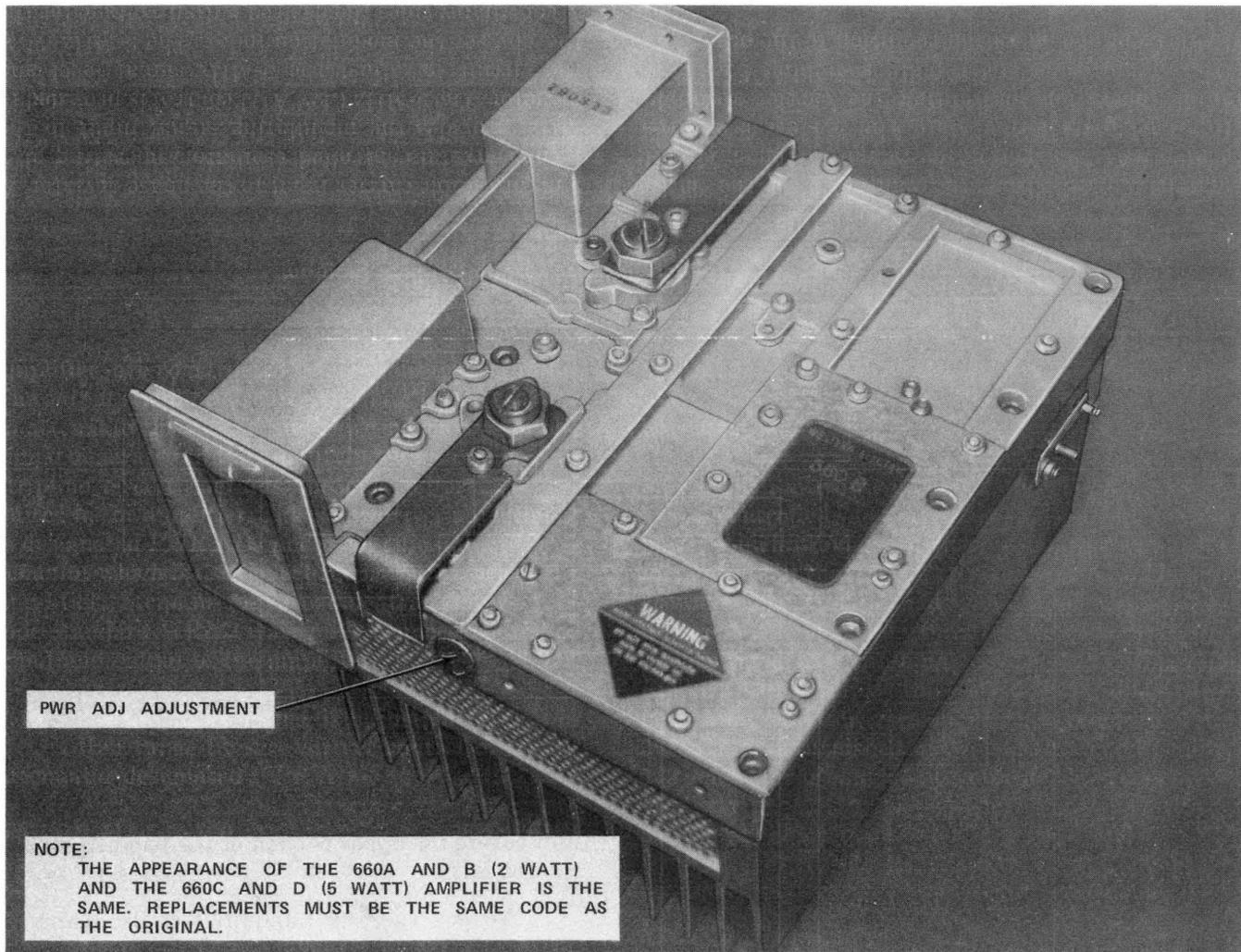   SAME. REPLACEMENTS MUST BE THE SAME CODE AS
   THE ORIGINAL.

Fig. 18—660( ) Type RF Power Amplifier

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 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 is 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.

7.15 The amplifier output is adjustable over a 5-dBm range by screwdriver control of an RF attenuator designated PWR ADJ.

8. J68387R( ) MICROWAVE GENERATOR

GENERAL

8.01 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 of +25 dBm. Figure 19 illustrates the J68387R-1 microwave generator. A later version of this generator, the J68387R-2, is furnished in two models. The List 132, 133 generator is equivalent to the J68387R-1 genera-

tor in frequency and power. The List 134, 135 generator is a low powered version for application in receivers of main station bays. In the low-power version, the 1-GHz and 4-GHz multipliers, as in the J68387R-1 and the R-2 L132, 133 generators, are not used and the output of the 500-MHz generator feeds a ×8 nonlinear diode multiplier to the 4-GHz range at +9 dBm output. The J68387R-2, L132, 133 is electrically similar to the J68387R-1 generator and the following circuit description of the J68387R-1 generator is applicable to both. The new generators were introduced into TD-3 bays manufactured in 1973.

8.02 In the generator, 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 three frequency doublers and a quadrupler to the desired output frequency.

FUNCTIONAL DESCRIPTION

8.03 The J68387R-1 microwave generator (Fig. 20) consists of a crystal-controlled oscillator, a buffer amplifier, three transistor frequency doublers, and a diode quadrupler.

8.04 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 crystal 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).

8.05 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 meter circuit of the transmitter-receiver bay.

8.06 In the following paragraphs, 125-, 250-, 500-, 1000-, and 4000-MHz values are used as nomi-
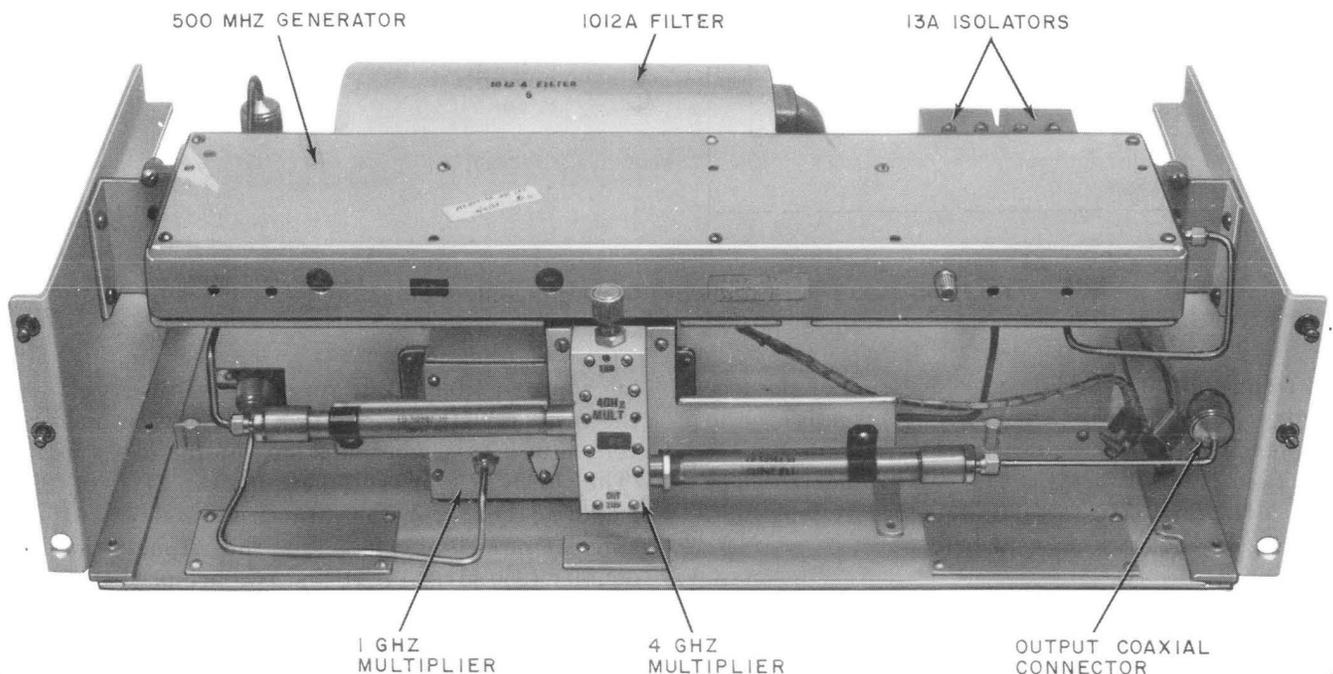

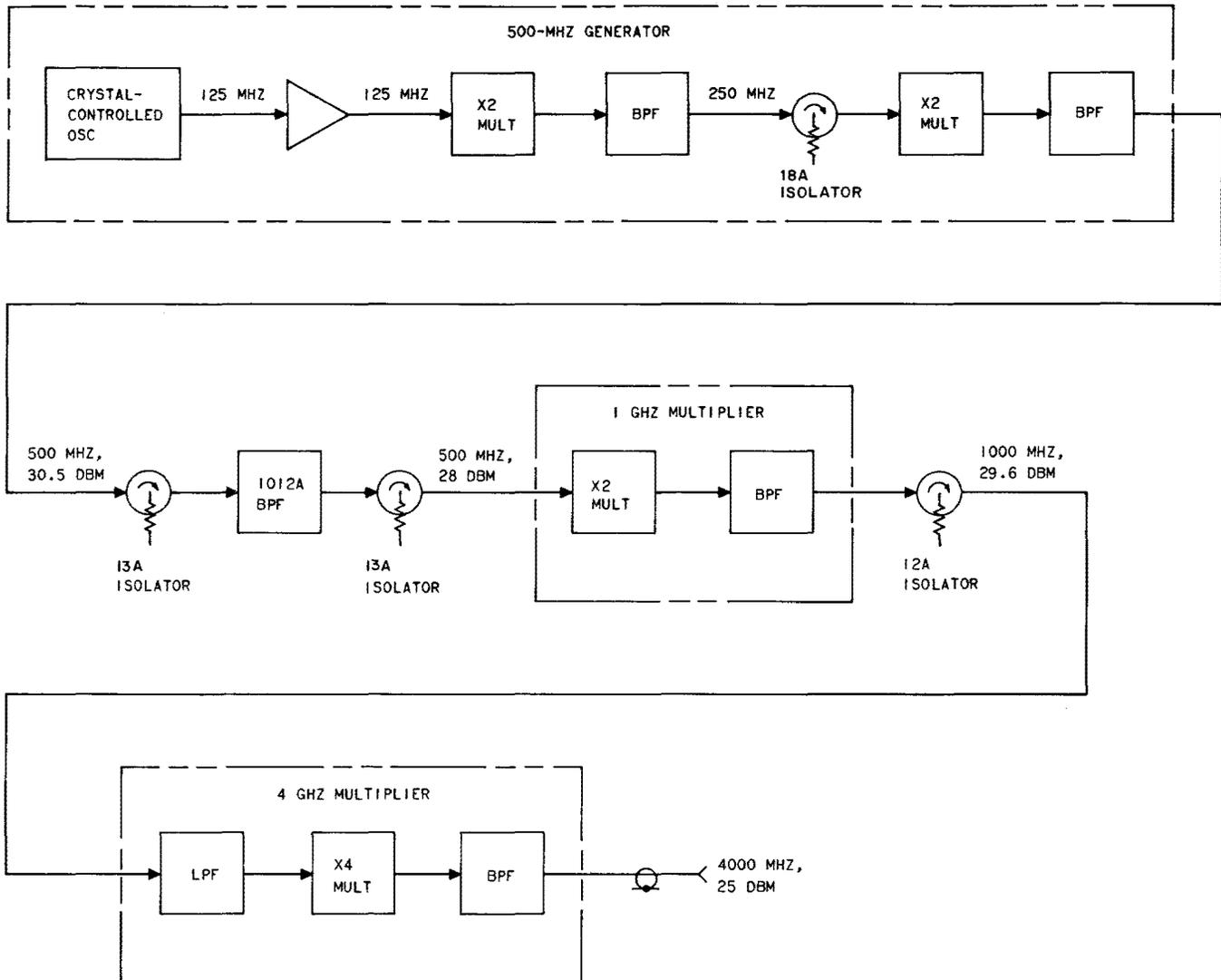Fig. 19—J68387R-1 Microwave Generator

Fig. 20—J68387R-1 Microwave Generator—Block Diagram

nal 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.

8.07 The 125- to 250-MHz and the 250- to 500-MHz double 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. An 18A isolator hav-

ing approximately 20-dB reverse loss is used between the two doubler stages to provide isolation and prevent interaction when making tuning adjustments. (The J68387R-2 uses either a 20A, 21A, or 22A isolator.) 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 meter circuit of the transmitter-receiver bay.

8.08 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.

8.09 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 monitored by the meter circuit 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.

8.10 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.

EQUIPMENT DESCRIPTION

8.11 The J68387R-1 microwave generator mounts into the lower portion of the transmitter-receiver bay framework. 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. The J68387R-2, L132, 133 generator is similar physically to the J68387R-1 generator. There has been a redesign of the 500-MHz TUN control and a change in output bandpass filter design and location. The J68387R-2, L134, 135 generator is recognizable by the absence of the 1- and 4-GHz multipliers and the substitution of the ×8 multiplier.

9. J68387W 40-MHz OSCILLATOR—SHIFT MODULATOR

GENERAL

9.01 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.

9.02 The modulator combines the input signal from the microwave generator with a 40-MHz signal from the oscillator unit to produce two output signals 40 MHz above and below the microwave generator output frequency. The desired signal is selected and the other removed by a subsequent bandpass filter. The 40-MHz oscillator unit consists of a crystal-controlled transistor oscillator stage followed by two transistor amplifier stages. The unit generates a 40-MHz signal at a level adjustable over the range +12 to +21 dBm. Frequency adjustment is provided. The signal is coupled through a 50-ohm coaxial low-pass filter to the modulator. The modulator unit includes a step waveguide transducer, a waveguide low-pass filter, diode, diode holder, and a waveguide termination. The modulator has a single port which serves as both input for the generator signal and output for the shifted-frequency signals. The nominal input from the microwave generator is +18 dBm and the shifted output is +9 dBm.

FUNCTIONAL DESCRIPTION

9.03 The 40-MHz oscillator—shift modulator (Fig. 21) consists of a 40-MHz oscillator and a 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.

9.04 The 40-MHz oscillator consists of a crystal-controlled oscillator stage followed by a buffer amplifier and a power amplifier. The oscillator stage
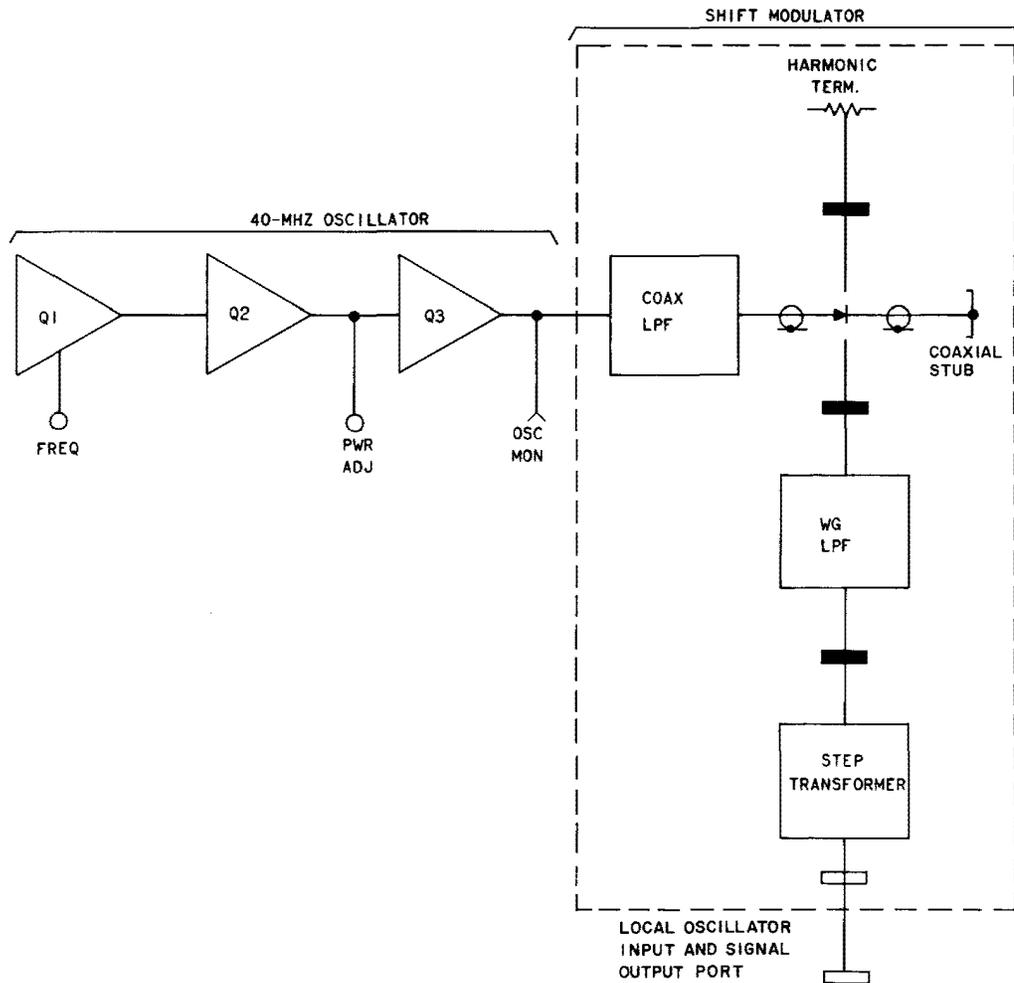
Fig. 21—J68387W 40-MHz Oscillator—Shift Modulator—Block Diagram

uses a third overtone crystal to produce the 40-MHz signal. Fine adjustment of the oscillator frequency is provided by the FREQ control. The PWR ADJ control is used to set the power output of the last stage, typically to +16 dBm. 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 T-R bay meter circuit. The main output from the power amplifier is fed through the 50-ohm coaxial low-pass filter to the modulator circuit.

9.05 The shift modulator consists of six basic parts: a stepped waveguide transformer, a waffle-iron low-pass filter, a diode, a diode holder, a coaxial low-pass filter, and a harmonic termination.

9.06 The stepped transformer provides an impedance transformation from the standard height waveguide input port (1.145 inch) to a reduced height waveguide structure (0.100 inch).

9.07 The waffle-iron low-pass filter passes frequencies from 3700 to 4200 MHz with negligible loss but provides at least 50-dB loss to frequencies of 7 GHz and above. This prevents harmonics of the 4-GHz signals generated in the diode from entering succeeding circuits in the receiver. Without this, there would be undesired intermodulation and transmission distortion effects.

9.08 The diode is a Schottky-type device mounted in a diode holder located on the front of the

modulator unit. The diode is connected in series with the coaxial low-pass filter and an impedance matching stub formed by the diode holder and composed of a short length of coaxial line terminated in a short circuit. The low-pass filter offers very high insertion loss to frequencies above 3 GHz and a negligible loss at 40 MHz. The filter prevents harmonics of the 4-GHz signals in the modulator from entering the output stage of the oscillator where they could cause undesirable overload effects.

9.09 The harmonic termination is a reduced height (0.100 inch) and reduced width (1.245 inch) waveguide structure. The termination absorbs harmonics generated in the diode but reflects the 4-GHz signals. This reflective (at 4 GHz) termination, together with the impedance matching stub, provides a fixed, broadband match for the diode in the modulator unit. No diode tuning adjustments are necessary.

EQUIPMENT DESCRIPTION

9.10 The 40-MHz oscillator—shift modulator (Fig. 22) consists of two physically associated, nonfield separable units. The 40-MHz oscillator, assembled on a printed wiring board, and RF decoupling networks for the internal meter and dc power connections, are mounted inside a cast aluminum frame. The frame is fitted with covers and connects to the modulator. Adjustments are accessible through guides in the front of the unit. A coaxial jack in the front provides for monitoring the frequency of the oscillator. A multicontact connector for dc power and metering is located in the top of the frame. The shift modulator consists of a 2-piece aluminum housing which forms the step transducer from full to reduced height waveguide, the waffle-iron low-pass filter, and the reduced width waveguide section into which fits the harmonic termination. The construction is similar to that of the receiver modulator (Fig. 8). The diode holder screws into the front of the housing, and the coaxial low-pass filter fastens to the rear. A hole gauge is provided at the front to set the position of the diode in its holder. The assembled unit measures approximately 3-1/2 by 6 by 12-1/2 inches and weighs 4-3/4 pounds.

10. J86890A TWT POWER SUPPLY

GENERAL

10.01 The J86890A TWT power supply is a solid-state, dc-to-dc converter that operates from
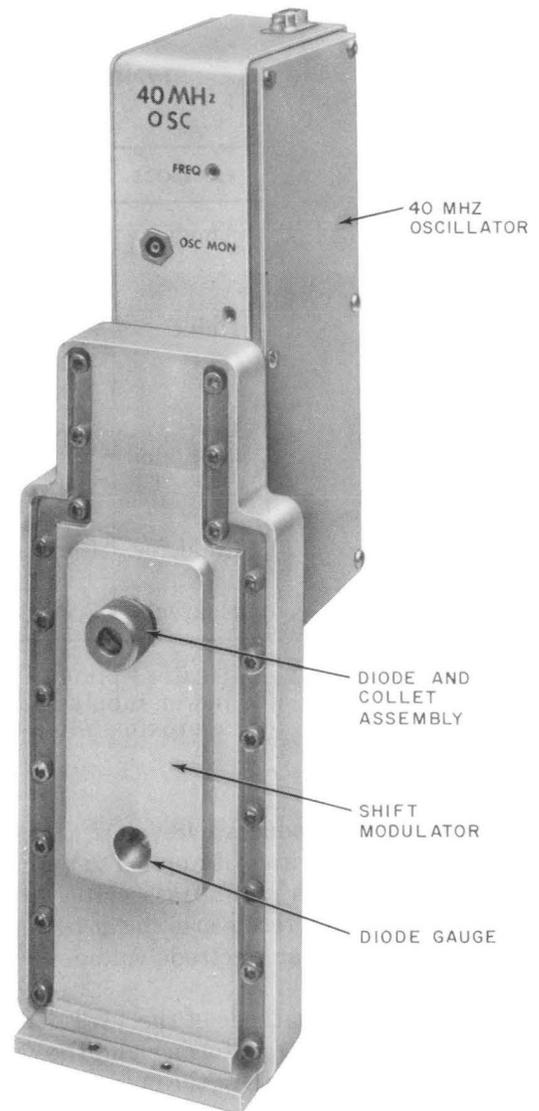

Fig. 22—J68387W 40-MHz Oscillator—Shift Modulator

the station −24 volt battery plant. It provides the relatively high dc voltages required by the traveling-wave tube (TWT) electrodes. The range of electrode voltages and currents provided is shown in Table B. The nominal dc current input to the power supply is 5.5 amperes.

FUNCTIONAL DESCRIPTION

10.02 A block diagram of the TWT power supply is shown in Fig. 23. The 24-volt battery power is applied through a circuit breaker and input filter

TABLE B

**TYPICAL VOLTAGE AND CURRENT RANGES OF
TWT POWER SUPPLY**

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	40-45 mA
Collector	Connected to ground	40 mA
Heater*	7.5V below the cathode	0.8-0.95A

*Heater voltage is 9.1V upon initial turnon of the
power supply and automatically drops to 7.5V after
approximately 3 minutes.

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.

10.03 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 monitor circuit in the collector lead permits monitoring the collector current with the T-R bay meter circuit.

10.04 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.

10.05 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

10.06 The TWT power supply consists of two plug-in units mounted side by side in a metal housing. The oscillator unit on the left-hand side and the converter output unit on the right-hand side are electrically joined by connectors at the rear of the housing. A cable and connector assembly from the converter output unit connect to the TWT amplifier,
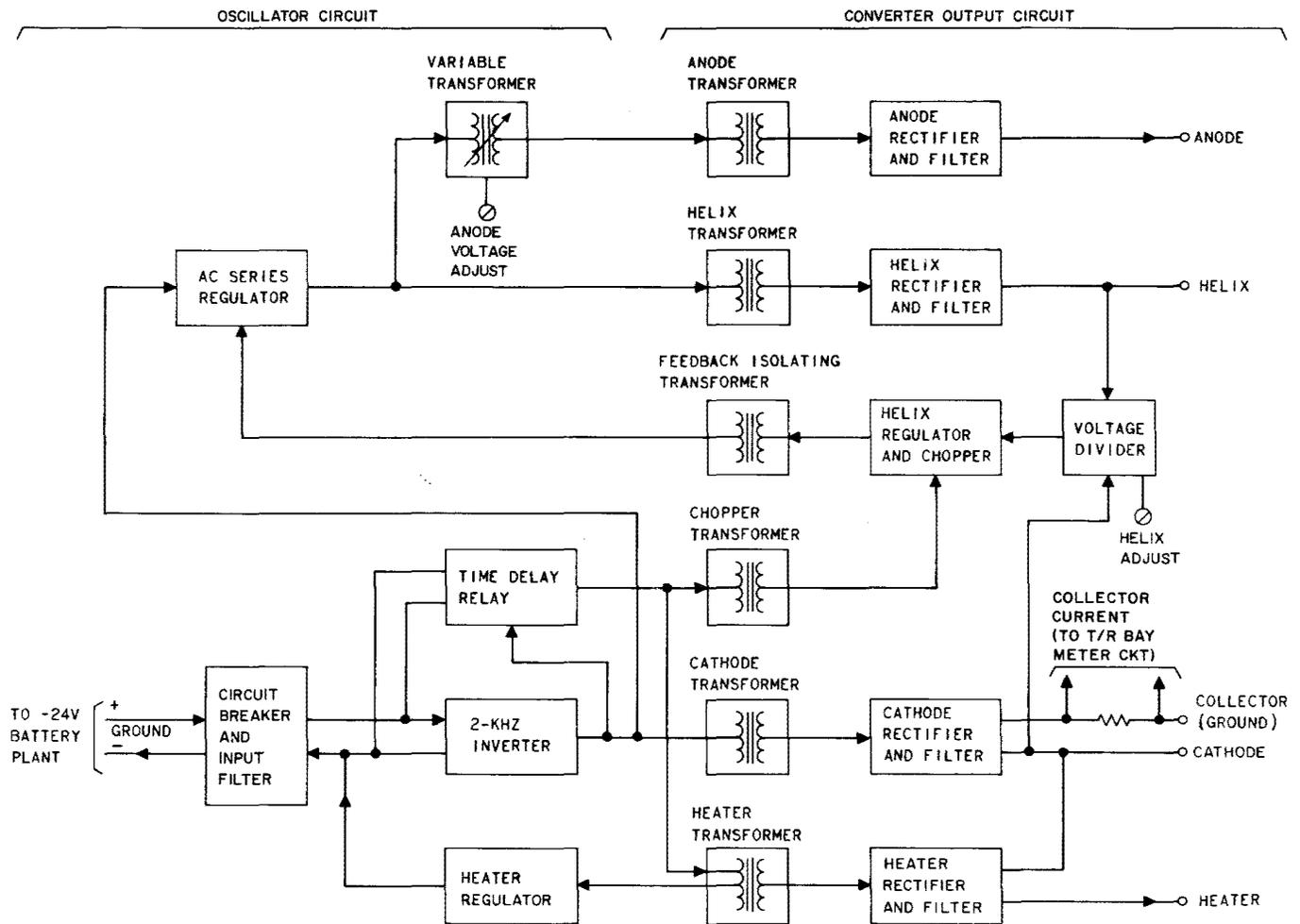
OSCILLATOR CIRCUIT   CONVERTER OUTPUT CIRCUIT

Fig. 23—J86890A TWT Power Supply—Block Diagram

which is shown mounted in its normal position above the power supply.

10.07 Removing the oscillator unit opens an electrical interlock circuit and disables the circuits of the converter output 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, mechanical interlocking also is provided. This is accomplished by having a lip on the front panel of the converter output unit extend behind the front panel of the oscillator unit. Thus, any attempt to remove the former unit will automatically eject the latter unit.

10.08 The oscillator unit is constructed of three castings (including the front panel) on which components are mounted. Two of the castings, as shown in the illustration, have fins for dissipating the heat from transistors and diodes mounted on them.

10.09 The converter output unit 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.

11. J87279A AND 92A/92B −19 VOLT REGULATORS

11.01 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 circuits and the microwave generator in the transmitter-receiver bay. Two −19 volt regulators, one for the receiver and one for the transmitter, are used in a main-station T-R bay; one regulator is used in a repeater-station bay.

11.02 The J87279A −19 volt regulator has the following characteristics:

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

(2) 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.

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

(4) For a 120-Hz input ripple voltage of 300 millivolts RMS, the output ripple voltage is less than 1 millivolt RMS.

(5) 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. The 92A/92B −19 volt regulator is a cost reduced, lower current capacity version of the J87279A regulator. It is a solid-state, feedback series voltage regulator providing a −19 volt output (±1 percent) from a −24 volt input for any input supply voltage between −21 and −29 volts and a load current between 0.2 and 2.0 amperes. The 92A and 92B units are interchangeable, the only difference being in circuit changes in the 92B made necessary by lightning protection circuitry addition to the bay −24 volt supply. When these changes were made, the 92A was rated Manufacture Discontinued. Since the 92A and 92B are compatible, 92As in low lightning activity areas may continue in use without modification to 92B unless the radio bay −24 volt lightning protection is installed.

11.03 A simplified block diagram of the J87279A −19 volt regulator is shown in Fig. 24. Output

voltage regulation is accomplished by a loop composed of a voltage divider network, an error voltage amplifier, a dc 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 the zener diode is amplified 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.

11.04 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.

11.05 The J87279A −19 volt regulator 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 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.

12. J68387Y-1 METER CIRCUIT

12.01 The J68387Y-1 meter circuit provides for metering various components of the radio bay. Metering connections are established through three 10-position pushbutton keys to a 50-microampere meter. Each button is marked to identify the function being measured. Operation of a button connects the appropriate function to the meter and lights the button depressed. Mechanical release
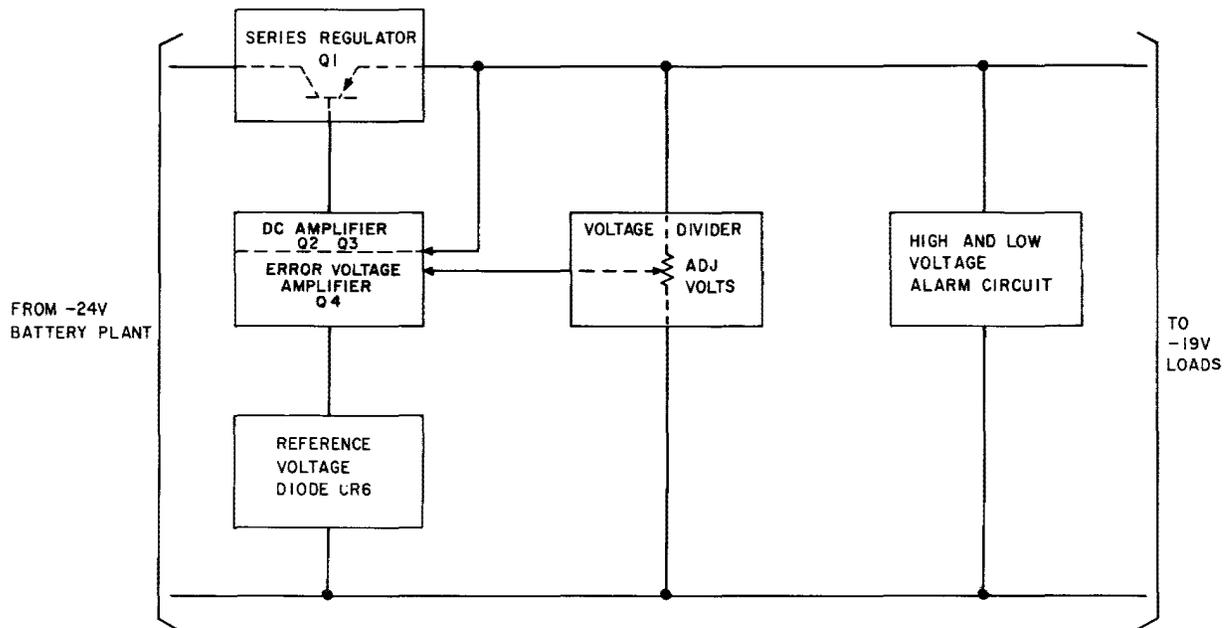
Fig. 24—J87279A 19-Volt Regulator—Block Diagram

of previously operated buttons is provided, and electrical interlocking prevents simultaneous connection of different functions.

12.02 The panel consists of an aluminum front plate which contains mounting holes and supports the meter and pushbuttons. Each pushbutton contains a designation insert, and half the outer surface is frosted to provide a surface for penciled notation of measured values. A rear bracket supports two multicontact connectors for dc power and metering leads. Panels for a repeater or a main station bay differ only in the designation inserts provided for the pushbutton keys.

13. J68387Y-2 METER CIRCUIT

13.01 The J68387Y-2 meter circuit, introduced into production during 1972, provides an electrically and mechanically simplified and lower cost means for metering various components of the radio bay. Metering connections are established through a 24-position, 3-wafer rotary switch to a 50-microampere meter. Each rotary position is marked to identify the function being measured.

13.02 The panel consists of an aluminum front plate which contains mounting holes and supports the meter and the rotary switch. Each rotary position contains a designated stamping and a position beside each function to record penciled notations of measured values. A rear bracket supports two multicontact connectors for metering leads. Panels for a repeater or a main station bay differ only in the designations labeled for each rotary position.

14. J68387AA ALARM CIRCUIT

14.01 The J68387AA alarm circuit receives alarm signals from various components of the radio bay and converts them to contact closures which can be used to operate external audible and visual alarms. The panel provides visual indication of trouble conditions in the bay, external identification of particular failures, and cut-off of external audible alarms.

14.02 Two power monitoring circuits are included in the alarm circuit for converting a predetermined drop in output power from an external circuit into an alarm contact closure. Each circuit comprises a 2-stage dc amplifier, a Schmitt trigger, and a relay driver circuit. One monitor circuit is used in conjunction with a diode detector in the 30A integrated circuit at the output of the TWT amplifier. This circuit is set to trigger the alarm relays when

the transmitter output power drops 3 dB. The other circuit is fed from a diode detector in the IF limiter-carrier resupply and is adjusted to trigger an alarm for a 6-dB drop in level of the 9-MHz modulating signal. In both cases, the alarm condition is indicated by switching on the output stage in the relay driver, which effectively provides a ground input to the alarm relay circuit.

14.03 The alarm relay portion of the circuit consists of a pair of relays in an alarm panel for a repeater station T-R bay, or two pairs of relays, one for the receiver and one for the transmitter in the alarm panel for a main station bay. An alarm condition (ground) from any of the alarmed circuits turns on the first of the pair of relays. This relay provides contact closures which activate the station audible and visual alarms, operate the alarm panel visual alarm indications, and provide indications of the alarm condition to a remote alarm center via the C1 or E-type system. Operation of the alarm cutoff (ACO) switch on the panel transfers to the second relay of the pair all alarm contact closures except the station audible alarm, which is thereby turned off. These relays obtain their power from the station −24 volt alarm battery supply (ABS) through an ABS circuit breaker on the alarm panel. An additional pair of relays, powered by the −24 volt signal battery supply, provides a backup for the alarm circuit in the event that a failure trips the ABS circuit breaker.

14.04 In addition to indicating a drop in transmitter output power or 9-MHz modulating signal, alarms also are provided if: the IF carrier resupply is operated for more than 50 seconds (see paragraph 5.11); the output voltage from the −19 volt regulator is outside the range −18 to −20 volts; the MAN-AGC switch in the IF main amplifier is in the MAN position; there is a failure of a 652A RF preamplifier; or a space diversity combiner has failed. Identification (ID) leads are provided for all but the MAN-AGC switch alarm so that the remote alarm center can determine the nature of the alarm condition.

14.05 The alarm circuit consists of an aluminum front plate which contains mounting holes and supports the alarm lamps, ABS lamp, ACO switch, and circuit breaker. The relays are mounted in pairs on printed wiring boards which are supported by brackets on the rear of the panel. Another printed wiring board contains a carrier resupply alarm relay and status indicating assembly. The

panel also supports a mounting assembly for the power detection circuit printed wiring boards. A bracket at the rear supports two multicontact connectors for power, ACO, and alarm input and output connections.

15. 27A INTEGRATED CIRCUIT

15.01 The 27A integrated circuit (Fig. 25) is a distribution network for the microwave generator output signal in a repeater station T-R bay. The input signal from the microwave generator is split in two directions by the integrated circuit, one portion going to the 40-MHz shift modulator and the other to the transmitter modulator. The 27A provides connecting ports for these modulators, a means of passing the desired output signals from the modulators onto the succeeding circuits, and the necessary isolation between the modulators. Also included is a monitoring diode that permits checking the power from the microwave generator on the T-R bay meter circuit.

15.02 A schematic of the 27A integrated circuit is shown in Fig. 26. The output from the microwave generator is connected to the circuit at port 1 via a coaxial-to-50-ohm stripline transducer. The signal passes through circulator F, in the direction indicated, to a power splitter formed by an adjustable reactive mismatch. This mismatch is factory adjusted to split the power approximately equally, one half of it going past the power splitter and the other half being reflected back towards circulator F.

15.03 The portion of the signal passing through the power splitter is delivered to port 2 of the circuit via circulators E and D and a 50-ohm stripline-to-waveguide transducer. Circulator E acts as an isolator. The T-R bay transmitter modulator is connected directly to port 2. The sideband outputs (microwave generator frequency ±70 MHz) from the transmitter modulator are returned to port 2 and, after passing through circulators D and C, are delivered to port 3 by another stripline-to-waveguide transducer. The desired sideband output is selected by an external filter (1431-type) connected to port 3. Unwanted outputs from the modulator are reflected by the filter and absorbed in the termination on circulator C.

15.04 The portion of the microwave generator signal that is reflected from the power splitter is delivered to port 4 of the circuit via circulators F,
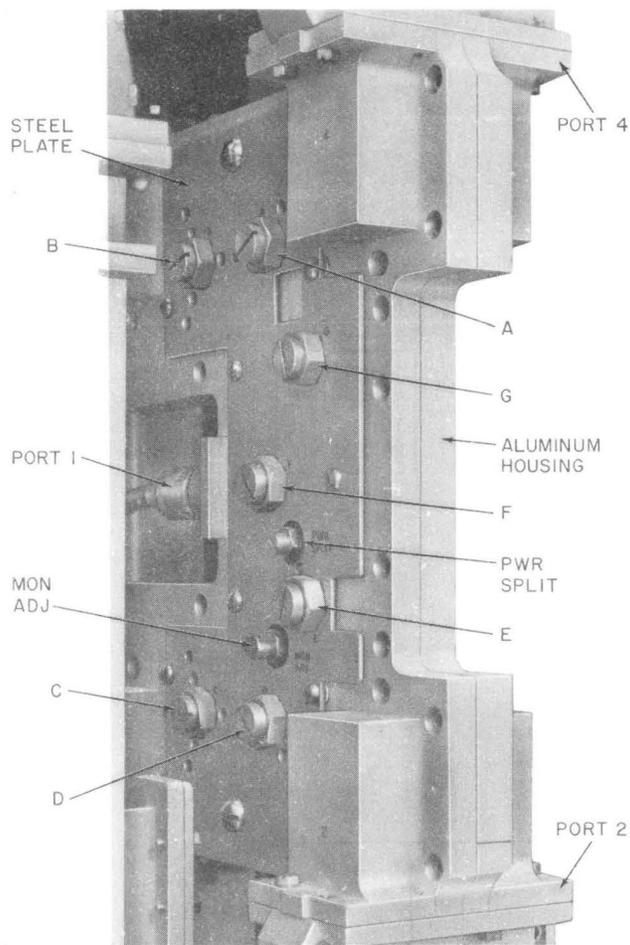
Fig. 25—27A Integrated Circuit

G, and A and a 50-ohm stripline-to-waveguide transducer. Circulator G serves as an isolator. The 40-MHz shift modulator in the T-R bay is connected directly to port 4. The sideband outputs (microwave generator frequency ±40 MHz) are returned to port 4 and are delivered to port 5 via circulators A and B and a stripline-to-waveguide transducer. An external filter (1348-type) connected to port 5 selects the desired sideband output. The unwanted outputs from the modulator are reflected back to port 5 by the filter, where they are absorbed in the termination on circulator B.

15.05 A diode detector circuit capacitively coupled to the main transmission line between circulator D and E provides a means of monitoring, on the T-R bay meter circuit, the microwave generator power delivered to the transmitter modulator. The

MON ADJ control is used to adjust the meter indication to a specific value for the normal power condition. A varistor across the meter connection protects the diode from damage that could result if transient voltage spikes were to couple onto the meter circuit leads.

15.06 The 27A integrated circuit is assembled in a 2-piece aluminum housing. The transmission paths through the circuit are 50-ohm stripline formed by conductor strips plated onto thin alumina ceramic substrates. The circulators are composed of ferrite disks bonded to opposite sides of the substrate. Each circulator is magnetically biased by a permanent magnet attached to a steel screw (Fig. 25) which is factory-adjusted to obtain the required circulator performance. Return paths for the magnetic field are provided by interconnected steel plates attached to both sides of the aluminum housing and by steel plugs below each circulator.

16. 28A INTEGRATED CIRCUIT

16.01 The 28A integrated circuit (Fig. 27) furnishes the connecting circuits needed between the transmitter microwave generator and the transmitter modulator, and between the receiver microwave generator and the receiver modulator, in a main station T-R bay. Separate paths are provided for this purpose. Each path provides isolation between the generator and the connecting circuits, and each includes a level setting attenuator to adjust the generator power delivered to the modulator. The transmitter path also contains a monitoring diode that permits checking the power from the transmitter microwave generator on the T-R bay meter circuit.

16.02 A schematic of the 28A integrated circuit is shown in Fig. 28. The output of the transmitter microwave generator is connected to the circuit via a coaxial-to-50-ohm stripline transducer at port 1. The signal is passed through circulator E to an adjustable reactive mismatch, ATT 1. This mismatch serves as a variable attenuator, reflecting a portion of the incident power and passing the remainder onto the termination. The power reflected from ATT 1 returns through circulator E and is delivered to port 2 via circulator D and a stripline-to-waveguide transducer. The T-R bay transmitter modulator is connected directly to port 2. The setting of ATT 1 determines the amount of microwave generator power that is delivered to the transmitter modulator.
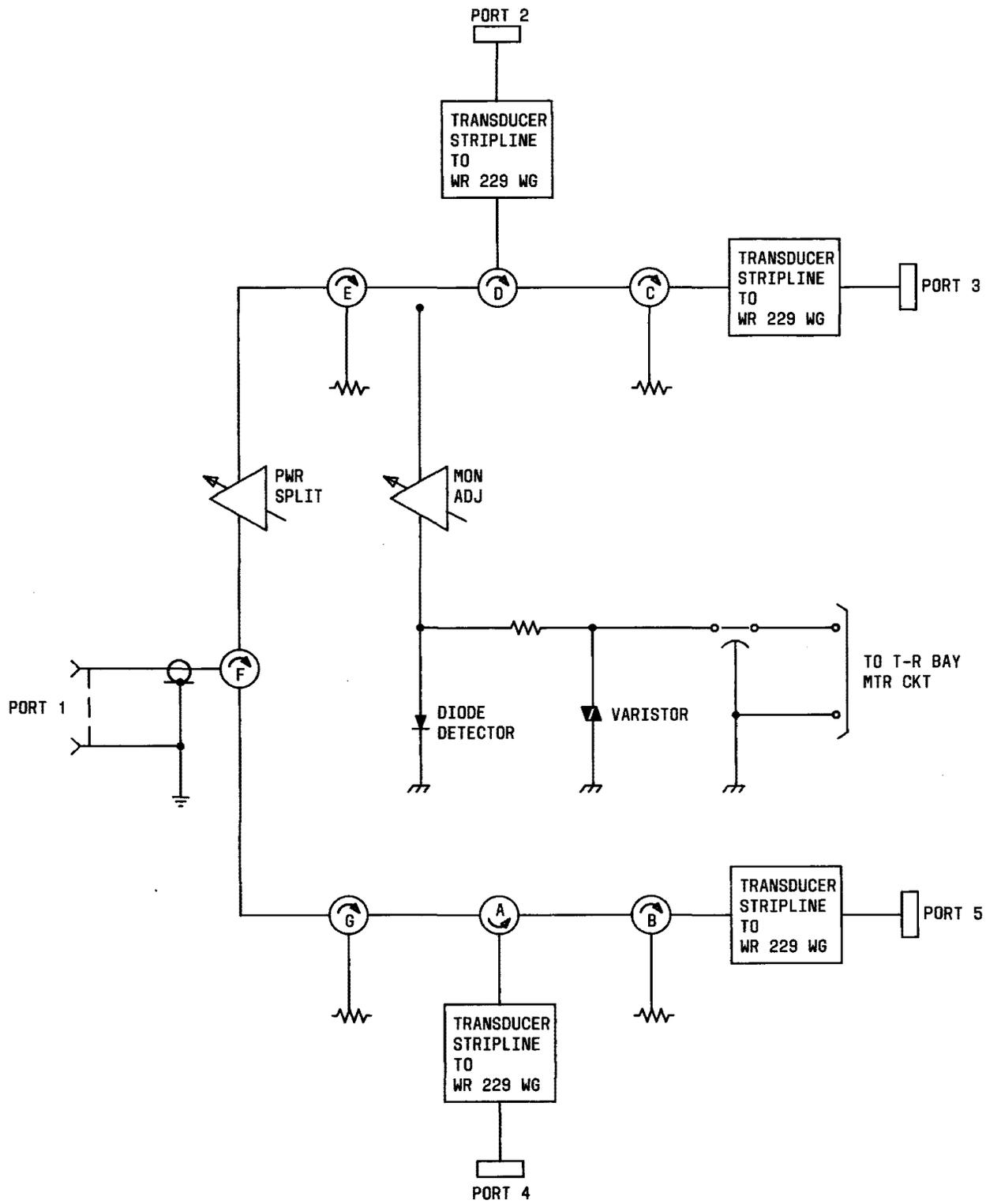
PORT 2

TRANSDUCER
STRIPLINE
TO
WR 229 WG

TRANSDUCER
STRIPLINE
TO
WR 229 WG

PORT 3

E   D   C

PWR
SPLIT

MON
ADJ

TO T-R BAY
MTR CKT

PORT 1

F

DIODE
DETECTOR

VARISTOR

G   A   B

TRANSDUCER
STRIPLINE
TO
WR 229 WG

PORT 5

TRANSDUCER
STRIPLINE
TO
WR 229 WG

PORT 4

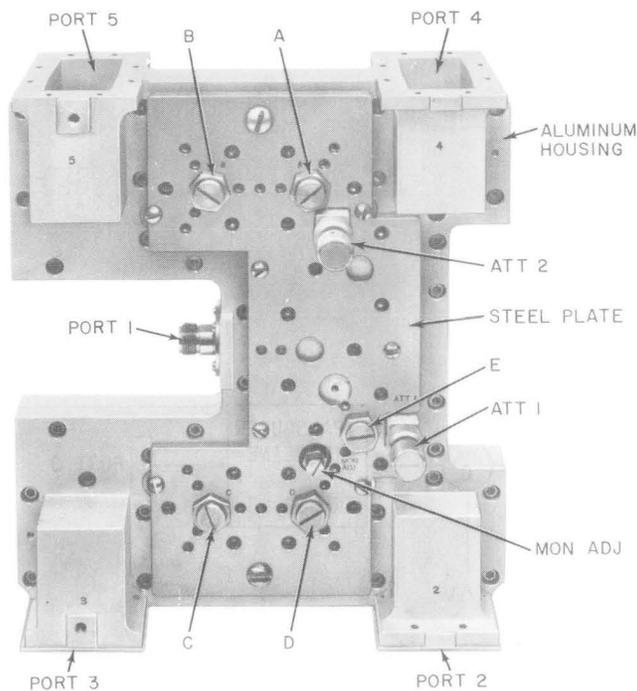**Fig. 26—27A Integrated Circuit—Schematic Diagram**

Fig. 27 — 28A Integrated Circuit

The sideband outputs (microwave generator frequency ±70 MHz) from the transmitter modulator are returned to port 2 and, after passing through circulators D and C are delivered to port 3 via another stripline-to-waveguide transducer. The desired sideband output is selected by an external filter (1431-type) connected to port 3. Unwanted outputs from the modulator are reflected by the filter and absorbed in the termination on circulator C.

16.03 A diode detector circuit identical to that in the 27A integrated circuit (paragraph 15.05) provides a means of monitoring on the T-R bay meter circuit the transmitter microwave generator power delivered to the transmitter modulator.

16.04 The output of the receiver microwave generator is connected to port 4 of the circuit. The signal is passed through a waveguide-to-stripline transducer and circulator A to an adjustable reactive mismatch, ATT 2. The power reflected from ATT 2 is returned to circulator A and is delivered to port 5 via circulator B and a stripline-to-waveguide transducer. The power that is not reflected is absorbed in the termination beyond ATT 2. Thus, the setting of ATT 2 determines the amount of microwave generator

power that is delivered to port 5. The output signal from port 5 is passed through an external filter (1348-type) to the T-R bay receiver modulator. Circulator B serves as an isolator.

16.05 The construction of the 28A integrated circuit is essentially identical to that of the 27A integrated circuit (paragraph 15.06).

17.   29A INTEGRATED CIRCUIT

17.01 The 29A integrated circuit (Fig. 29) provides the tuning and monitoring circuits required at the input to the traveling-wave tube amplifier. The circuit includes a variable attenuator for adjusting the input power to the TWT, a test access port for checking the input signal, tuners for adjusting the input return loss of the TWT, and a monitoring diode to permit checking the input power on the T-R bay meter circuit.

17.02 A schematic of the 29A integrated circuit is shown on Fig. 30. The input signal, supplied from the transmitter modulator through the 1431-type network in the T-R bay, is applied to port 1. The signal is passed through a waveguide-to-50-ohm stripline transducer and circulators A and B to an adjustable reactive mismatch, ATT. This mismatch reflects a portion of the incident power and passes the remainder onto the TEST port. This port, which is normally terminated, provides a means of checking the input signal from the transmitter modulator. Circulator A serves as an isolator to provide a good termination for the external 1431-type network.

17.03 The portion of the incident power that is reflected from ATT is delivered to port 2 via circulator B, a stripline-to-reduced-height waveguide transducer, and a pair of tuning adjustments, IN TUN 1 and IN TUN 2. Thus, the setting of ATT determines the power delivered to port 2. This port is connected directly to the input of the TWT amplifier. The tuning adjustments are used to obtain a good impedance match looking into the TWT.

17.04 A diode detector circuit coupled to the main transmission line through a stripline directional coupler provides a means of monitoring, on the T-R bay meter circuit, the power being delivered to the input of the TWT amplifier. The MON ADJ control is used to set the meter reading to a specific value for a +9 dBm input power. This control is normally adjusted only in the factory. A varistor across the
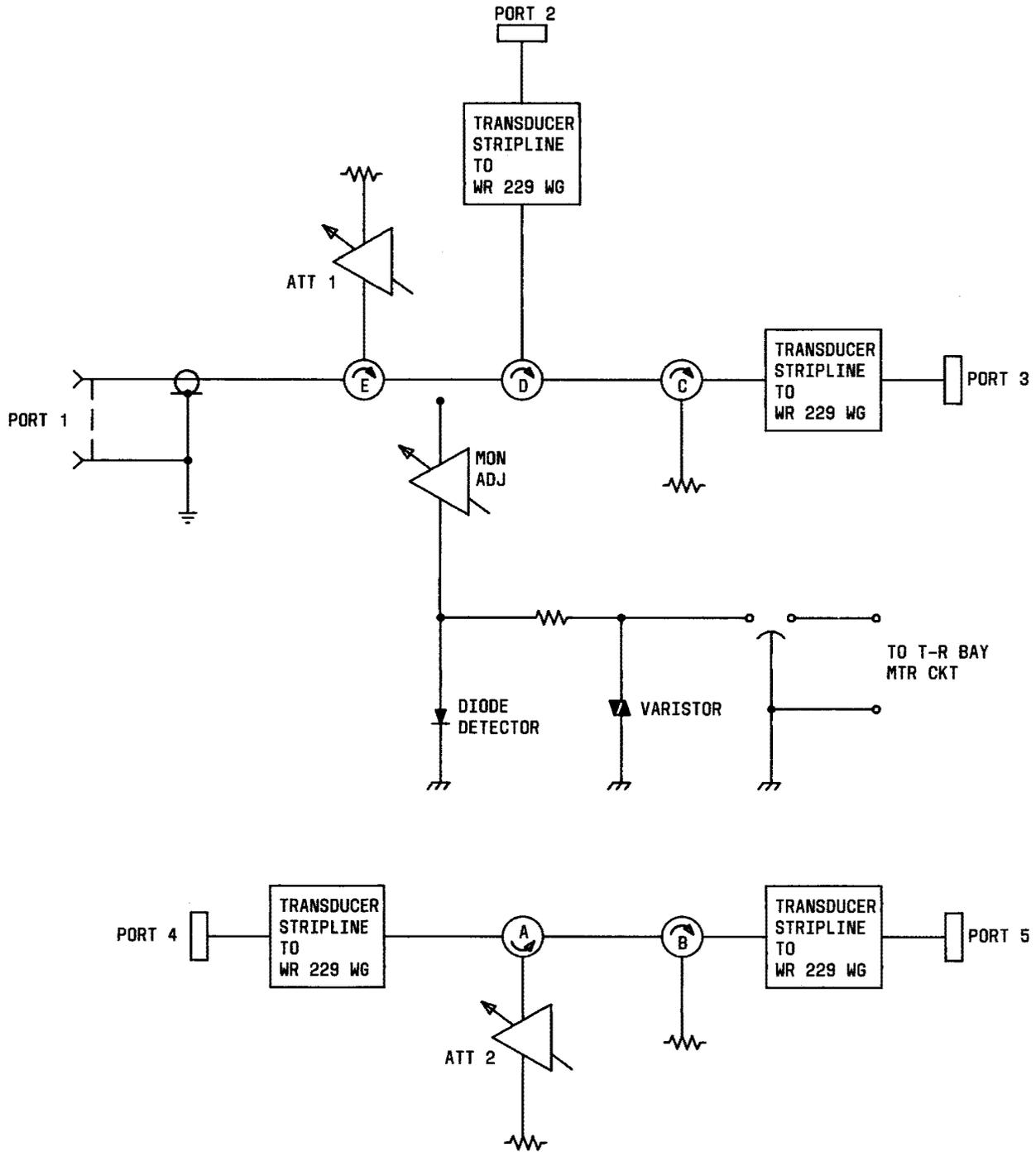
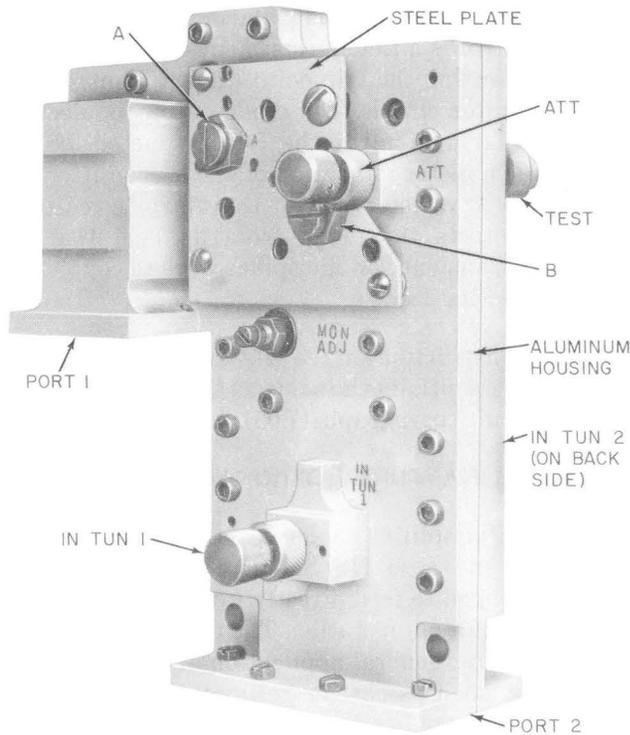**Fig. 28—28A Integrated Circuit—Schematic Diagram**

Fig. 29—29A Integrated Circuit

meter connection protects the diode from damage that could result if transient voltage spikes were to couple onto the meter circuit leads.

17.05 The 29A integrated circuit is assembled in a 2-piece aluminum housing. The 50-ohm stripline paths in the circuit are formed by conductor strips plated onto thin alumina ceramic substrates. Each circulator is composed of a pair of ferrite disks bonded to opposite sides of the substrate. The magnetic field bias required by each circulator is supplied by a permanent magnet attached to a steel screw located above the ferrite disk assembly. The steel screw is factory adjusted to obtain the required circulator performance. Return paths for the magnetic field are provided by interconnected steel plates attached to both sides of the aluminum housing and by steel plugs below each circulator.

18. 30A INTEGRATED CIRCUIT

18.01 The 30A integrated circuit (Fig. 31) provides the tuning, monitoring and harmonic filtering circuits required at the output of the traveling-wave tube amplifier. The circuit includes a low-pass filter, tuners for adjusting the output flatness of the TWT, a diode detector to feed the TWT power monitor in the T-R bay alarm circuit, and an output isolator.

18.02 A schematic of the 30A integrated circuit is shown in Fig. 32. The circuit is connected directly to the output of the TWT amplifier at port 1. The signal from the TWT is passed through a waffle-
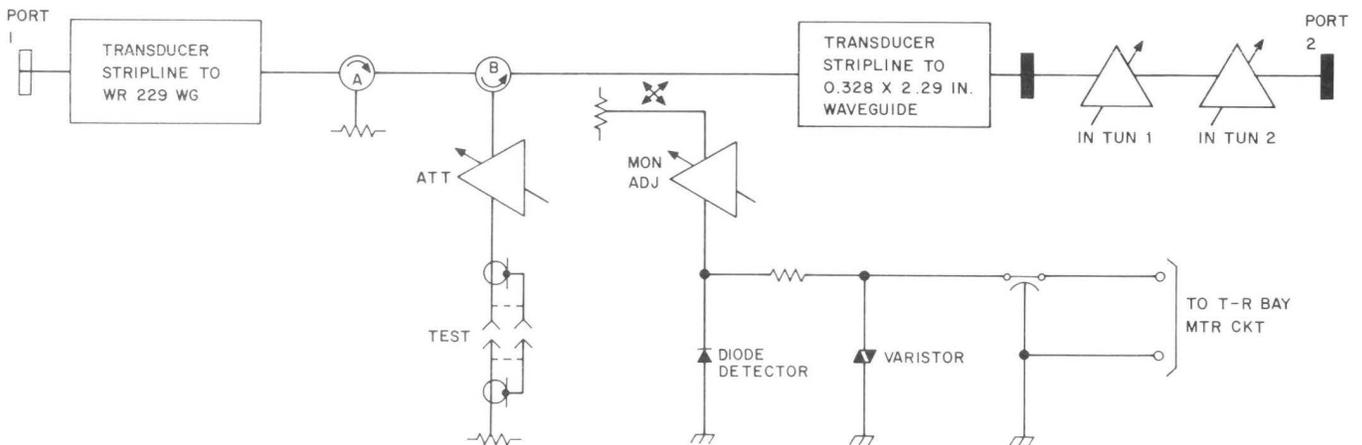

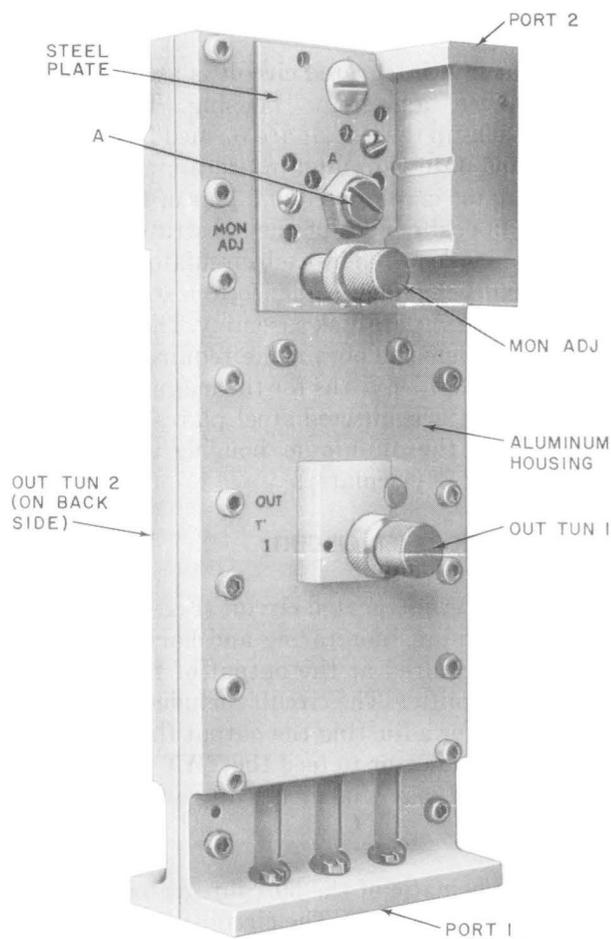Fig. 30—29A Integrated Circuit—Schematic Diagram

Fig. 31—30A Integrated Circuit

iron type low-pass filter which provides at least 50 dB of rejection to the second and third harmonics of the 4-GHz signal. Following the low-pass filter is a pair of tuners, OUT TUN 1 and OUT TUN 2, used to flatten the amplitude response of the TWT over the channel bandwidth. The signal is then passed through a reduced height waveguide-to-stripline transducer, circulator A, and a stripline-to-full-height waveguide transducer to port 2. Port 2 is connected via a waveguide run in the T-R bay to the 1432-type channel network. Circulator A serves as an isolator to provide a good return loss looking back into port 2.

18.03   A diode detector circuit capacitively coupled to the stripline circuit provides an input to a

power monitor in the T-R bay alarm circuit. The MON ADJ control is a field adjustment used in conjunction with setting the trip point (alarm point) of the power monitor circuit. The diode output is also fed from the alarm circuit to the T-R bay meter circuit to provide a meter indication of the transmitter output power. A varistor across the alarm circuit connection protects the diode from damage that could occur if transient voltage spikes were to couple onto the connecting leads.

18.04   The construction of the 30A integrated circuit is essentially the same as that of the 29A integrated circuit (paragraph 17.05).

19.   J68387AB IF AMPLIFIER (OPTIONAL)

19.01   This IF amplifier replaces the J68387S amplifier in those HS/SD or HS only bays which are arranged to feed directly into an IF patch and access bay at a main station. The unit was originally developed for general application and contains some features, such as carrier resupply, which are not used in this application. The nominal output power of the amplifier can be changed, by optional wiring, for either +1 dBm or +10 dBm level. For this application, it is used at +10 dBm in order to provide standard levels at the IF patch and access bay. The unit also contains an AGC monitor which will signal the hot standby/space diversity switch control unit when a radio path fade requires a switch.

19.02   The amplifier is a solid-state device powered by a −19 volt regulated source and consists of the following ten major sections:

(a) IF amplifier

(b) detector

(c) AGC amplifier

(d) CRS control circuit

(e) squelch gate

(f) meter circuit

(g) hot standby/space diversity control circuit

(h) SW/ALM driver circuit

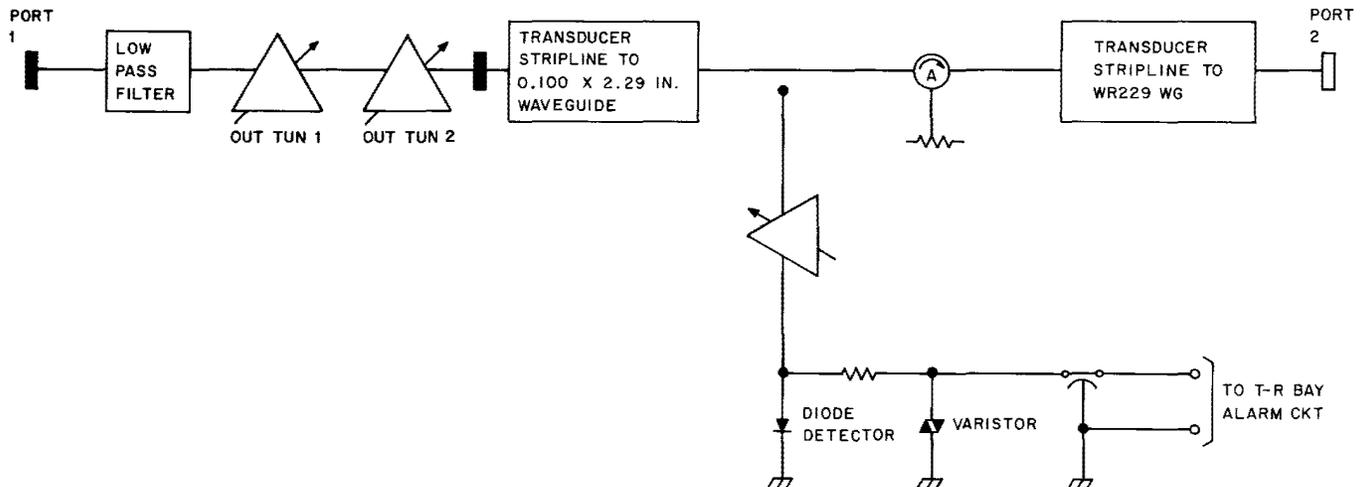(i) delayed alarm circuit

(j) carrier resupply and generator circuit.

Fig. 32—30A Integrated Circuit—Schematic Diagram

19.03 The major working limits are as follows:

(a) Input power −8 dBm

(b) Output power +10 dBm (W option) or +1 dBm (X option)

(c) AGC range is from −48 dBm to −2 dBm, a total of 46 dB

(d) Transmission slope is controlled to within ±0.1 dB and deviation from a linear slope to within 0.03 dB between 60 and 80 MHz

(e) Input and output return losses can be adjusted to better than 30 dB between 60 and 80 MHz

(f) The noise figure at 70 MHz is approximately 12 dB at normal gain and improves to approximately 9 dB at maximum gain

(g) The squelch gate provides better than 70-dB loss to the IF output signal in the gate off condition

(h) The carrier resupply generator provides a 70-MHz FM signal at the IF OUT jack at the rated amplifier output power.

19.04 Functional designations are as follows:

DESIGNATION	MEANING
RL IN	Input return-loss adjustment
RL OUT	Output return-loss adjustment
OUTPUT POWER	Output power adjustment
CRS TRIP	Carrier resupply operate point control
HS/SD TRIP	Hot standby/space diversity operate point control
CRS DEV TUNE	70-MHz oscillator tuning adjustment
CRS PILOT FREQ	Sideband frequency adjustment
CRS PILOT PWR	Sideband power adjustment.

19.05 Detailed circuit information may be obtained from the SD listed in Part 23 of this section and its accompanying CD.

20. IF SWITCH (OPTIONAL)

20.01 The hot standby/space diversity configuration includes an IF switch located in the *standby* bay. This switch selects the receiver output from either bay and applies it to the input of a hybrid transformer which double feeds the transmitters at

a repeater station or individual FM receivers at a main station. Normally the IF switch connects the hybrid input to the receiver output of the *regular* bay. A specified drop in received signal level causes a switch to the *standby* bay which remains in force until the received signal level at the *regular* bay returns to its normal level. At this point, the switch reverts to the *regular* bay. The switch also connects a 75N termination to the unused receiver.

20.02 The IF switch (295A) is mounted in the *standby* bay together with the 2671A hybrid transformer. The switch is a diode-type switch initially designed for the 400A Protection Switching System. Input and output connections are provided on the front and rear of the unit, respectively.

21. RF SWITCH (OPTIONAL)

21.01 The RF switch is used in hot standby/space diversity or hot-standby-only switching configurations. This switch connects the regular or standby transmitter to the transmitting antenna. It also connects a termination to the unused transmitter output. This switch receives a command from the J68434A control panel (which is mounted external to the T-R bay) and switches to either the regular or standby transmitter.

21.02 The RF switch and its associated 337A relay and coaxial termination share a common mounting bracket. This bracket is fastened to the back plate of the *regular* bay. Two of its four coaxial ports are connected to the waveguide output of the *regular* and *standby* transmitters, respectively, by semirigid coaxial cables and coaxial-to-waveguide transducers. A third port connects to the channel combining network in the regular bay by a similar coaxial cable and transducer. A coaxial termination connects directly to the fourth port of the switch and absorbs the power output of the unused transmitter. The 337A relay, operated by the switch control unit outside the bay, provides the large current pulse required to operate the RF switch.

## 22. PASSIVE COMPONENTS

A. 1433-Type Channel Network

22.01 The 1433-type channel network is a self-equalized microwave network that separates a particular channel from the composite signal applied to it, delivers this channel via an associated

bandpass filter to the receiver, and passes all the other channels on to the other receivers.

22.02 The channel separating portion of the network consists of a 4C- and a 5C-waveguide hybrid junction and two waveguide band-rejection filters. In the network, the band-rejection filters are tuned to reject the frequency of the channel being dropped. The 4C and 5C junctions are electrically identical; they differ mechanically in that the 5C junction has a termination permanently connected to the H arm (arm 2, Fig. 33A), whereas the 4C junction provides a waveguide output on that arm.

22.03 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. 33A), 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 4C hybrid and all the energy is split between arms 3 and 4 into two components of equal amplitude and phase. Virtually no energy is directly coupled through to arm 2. The filters attached to arms 3 and 4 of the hybrid pass the F2 and F3 signals on to the 5C junction but reflect the F1 signal. The F2 and F3 signals combine in phase in the 5C junction and are sent out arm 1 to the next channel network in the bay lineup. Arm 2 of the 5C 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.

22.04 The effective electrical input to one band-rejection filter (BRF) is located one-quarter wavelength further from the 4C 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 4C 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 4C junction equal in amplitude but 180 degrees out of phase. As the two components of the F1 signal pass through the 4C hybrid, they are shifted out of phase by another 180 degrees. Therefore, the components combine in phase in arm 2 of the junction, and the resultant signal is applied to the input of the
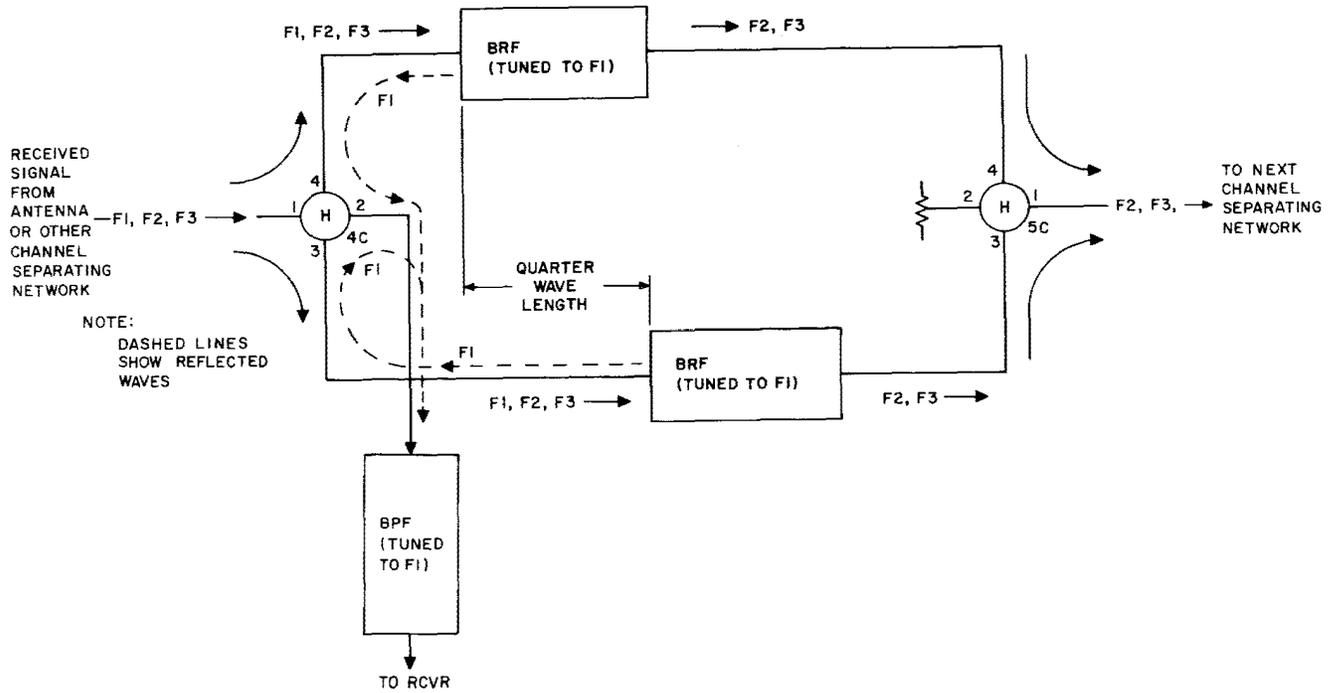
(A) 1433-CHANNEL SEPARATING NETWORK
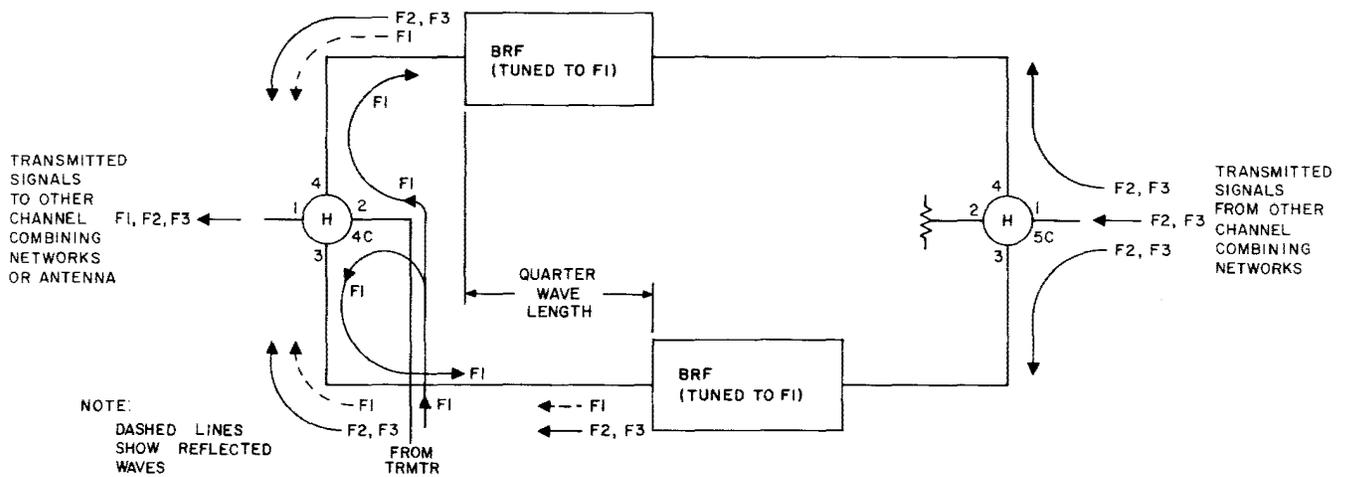
(B) 1432-CHANNEL COMBINING NETWORK

Fig. 33—Channel Networks

bandpass filter (BPF). Virtually none of the F1 signal reflected from the filters appears at arm 1.

22.05 The bandpass filter is used to obtain additional RF selectivity. The filter consists of five resonant cavities built into a length of waveguide. The three middle cavities are of the "triple-post" design, being bounded on each end by three equal diameter, uniformly spaced, cylindrical posts. The two end cavities are "single-post" design, being bounded on each end by only one cylindrical post.

22.06 The channel network has an approximately flat envelope delay distortion characteristic across the passband of the separated channel. This "self-equalization" is obtained by the design and tuning of the band-rejection filters. Each cavity is factory adjusted for resonance at the channel frequency by means of two tuning screws. These screws are locked in place and are not adjusted in the field. By suitably choosing the bandwidth of each of the cavities and trimming the bandwidth with the tuning adjustments, the envelope delay distortion of the overall channel network from the input to the 4C junction to the output of the bandpass filter can be held to within 0.2 nanoseconds peak to peak over a 16-MHz band centered at the channel center frequency. This design provides a high degree of amplitude equalization as well, controlling the amplitude response to within 0.03 dB peak to peak over the same band.

22.07 In addition to its channel separating function, the channel network provides the RF selectivity needed ahead of the receiver modulator in the microwave receiver. Typical out-of-band losses, from the input to the 4C junction to the output of the bandpass filter, are 11 dB at ±40 MHz, greater than 50 dB at ±80 MHz, and greater than 80 dB at ±140 MHz from the channel center frequency. The insertion losses of the network are about 0.6 dB for the separated channel and less than 0.07 dB for the through or nonseparated channels.

22.08 The bandpass and band-rejection filters are fabriated from standard WR229 copper waveguide tubing. Each of the 24 BPF and BRF filter codes has a distinct dimensioning of elements to give the overall channel network uniformity of performance from channel to channel. Since the relative humidity affects the dielectric constant of the air and hence the resonant frequency of a tuned cavity, all of the networks in a bay lineup are supplied with dry air

from the station dry air supply. This minimizes the detuning effect on the filter cavities that otherwise would result from the normal day-by-day humidity changes in the station. Further stabilization of the transmission characteristics of the network is obtained by restricting the normal temperature range of the station to 75° ±20°F.

22.09 The channel separating network is mounted on an aluminum casting at the top of the bay. A 2-inch section of flexible waveguide is used to connect the network to adjacent bays (Fig. 34).

B. 1432-Type Channel Network

22.10 The 1432-type channel network is a self-equalized microwave network that combines the output signal from the transmitter with the outputs from other transmitters to form a composite signal for application to the transmitting antenna.

22.11 The network consists of a 4C and a 5C waveguide hybrid junction and two waveguide band-rejection filters. In the network the band-rejection filters are tuned to the frequency of the transmitter signal being added to the line. The 4C and 5C junctions are electrically identical; they differ mechanically in that the 5C junction has a termination permanently connected to the H arm (arm 2, Fig. 33B), whereas the 4C junction provides a waveguide output on that arm.

22.12 Operation of the channel combining network is similar to that of the separating network. Signals F2 and F3 (Fig. 33B) from previous combining networks are applied to arm 1 of the 5C junction. They split evenly and are applied in phase through the band-rejection filters to arms 3 and 4 of the 4C junction. The F1 output from the transmitter is applied to arm 2 of the 4C juntion. 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 4C 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 4C junction in phase. They combine with the F2 and F3 energy in arm 1 of the junction, and the combined signal is applied to the next channel combining network or to the antenna waveguide run.
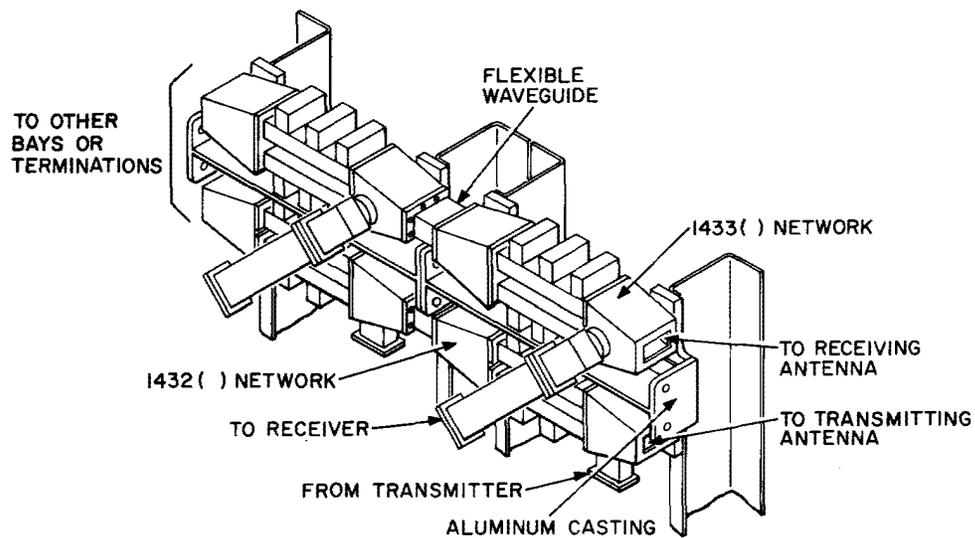
Fig. 34—Channel Combining and Separating Network Arrangement for Adjacent Bays

22.13 The envelope delay distortion of the channel combining network, from the transmitter port (port 2) to the main arm port (port 1) of the 4C junction, is flat to within 0.2 nanoseconds peak to peak over a 16-MHz band centered at the channel center frequency. This "self-equalization" is achieved in the same manner as described for the 1433-type channel network (paragraph 22.06). Between these same ports, the amplitude response is flat to within 0.03 dB peak to peak over the same band.

22.14 In addition to its channel combining function, the network provides additional out-of-band selectivity needed in the transmitter, principally to suppress unwanted products generated in the transmitter modulator. Typical out-of-band losses are 23 dB at ±70 MHz and 25 dB at ±140 MHz from the channel center frequency. The insertion losses are about 0.4 dB for the combined channel and 0.05 dB for the through channels.

22.15 The band-rejection filters are fabricated from standard WR229 copper waveguide tubing. Each of the 24 filter codes has a distinct dimensioning of elements to give the channel network uniformity of performance from channel to channel. The networks are supplied with dry air from the station dry air supply to minimize the effect of humidity changes (see paragraph 22.08).

22.16 The channel combining network is mounted on an aluminum casting at the top of the bay.

A 2-inch section of flexible waveguide is used to connect the network to adjacent bays.

C. 1431-Type Network

22.17 The 1431-type network is an equalized microwave bandpass filter located at the transmitter modulator output between the 27A (or 28A) and 29A integrated circuits. The network passes the desired sideband output of the transmitter modulator and attenuates the microwave generator (local oscillator) signal and unwanted sideband outputs.

22.18 The bandpass filter portion of the network has six resonant cavities tuned to the center of the desired pass band. The cavities are assembled in an 18-inch length of standard WR229 copper waveguide tubing. Each of the 24 filter codes has a distinct dimensioning of elements to obtain uniformity of performance from channel to channel.

22.19 The equalizer portion of the network is composed of a circular cavity iris-coupled to a section of rectangular waveguide. Five factory-adjusted tuning screws are used to flatten the delay distortion of the overall network to within 0.2 nanoseconds peak to peak over a 16-MHz band centered at the channel center frequency. The amplitude response over this same band is flat to within 0.05 dB peak to peak.

22.20 The 1431-type network supplies an appreciable portion of the selectivity needed in the

transmitter, principally to suppress unwanted products from the transmitter modulator. Typical out-of-band losses are 50 dB at ±70 MHz and greater than 80 dB at ±140 MHz from the channel center frequency. The midband insertion loss is typically less than 0.6 dB.

D. 1348-Type Directional Filter

22.21 The 1348-type directional filter 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.

22.22 The directional filter consists of two resonant filters that are tuned to the local oscillator frequency. The filter in the port 2 arm passes the local oscillator signal but reflects the received signal, effectively preventing the received signal from entering the local oscillator arm. The out-of-band loss of this filter, which is needed to suppress unwanted products from the 40-MHz shift modulator, is typically greater than 80 dB at ±40 MHz and greater than 120 dB at ±80 MHz from the center frequency. The filter in the port 3 arm 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.

22.23 The band-rejection filter section uses resonant cavities with coupling irises of the type described in paragraph 22.06. The cavities of the filter are factory-adjusted for resonance at the proper frequency and are not adjusted in the field.

22.24 The 70A detector associated with the directional filter provides a means of monitoring the local oscillator power delivered to the receiver modulator. The detector circuit includes a diode which supplies a dc current to the meter circuit in the T-R bay. The coupler has a built-in termination on its unused arm.

E. 1042A IF Bandpass Filter

22.25 The 1042A IF bandpass filter is used at the output of the IF preamplifier to provide additional receiver selectivity. The filter has loss peaks greater than 40 dB at 50 and 90 MHz to provide atten-

uation at the frequencies of the adjacent channel carriers. In addition, the filter has at least 30-dB loss at the second harmonic and 15-dB loss at the third harmonic of the 70-MHz carrier. Loss at the harmonic frequencies is necessary to prevent an echo-type of cross-modulation noise that can result when these harmonics, generated in the IF preamplifier, recombine with the fundamental in a nonlinear stage of the IF main amplifier. The amplitude and delay distortion of the filter are equalized to within 0.06 dB and 0.6 nanoseconds peak to peak, respectively, over the band from 62 to 78 MHz.

22.26 The circuit components of the filter are mounted on two printed circuit boards enclosed in a metal can.

F. Mop-up Delay Equalization

22.27 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 411-100-501. Each type of equalizer is shown in Fig. 35.

22.28 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.

G. 19A Isolator

22.29 The 19A isolator is a magnetically-biased ferrite device which propagates a microwave

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

signal with very low attenuation in one direction (termed the forward direction) but which provides high attenuation to signals propagating in the reverse direction. Over the 3700- to 4200-MHz frequency range, the isolator has typically 0.25-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. The isolator is used between the channel network and directional filter in the receiver to absorb unwanted products generated in the receiver modulator.

23. REFERENCE DRAWING LIST

NUMBER	TITLE
SD-50583-01	Application Schematic—TD-3A Radio Transmitter-Receiver Bay
SD-50558-01	Receiver Modulator—IF Preamplifier
SD-50569-01	IF Main Amplifier (J68387S)
SD-50584-01	IF Limiter—IF Carrier Resupply
SD-50585-01	IF Driver Amplifier—Transmitter Modulator
SD-50574-01	Microwave Generator (J68387R-1)
SD-50574-02	Microwave Generator (J68387R-2)
SD-50586-01	40-MHz Oscillator—Shift Modulator
SD-82004-01	TWT Power Supply Circuit
SD-81783-01	J87279A —19 Volt Regulator
SD-82133-01	92A/92B —19 Volt Regulator
SD-50589-01	J68387Y-1 Meter Circuit
SD-50589-02	J68387Y-2 Meter Circuit
SD-50588-01	Alarm Circuit
SD-50405-01	Application Schematic—Main Station Interconnecting Circuits
SD-51463	Application Schematic for 4-GHz Systems Using Hot Standby/Space Diversity Switching

Fig. 35—Mop-up Equalizers

NUMBER	TITLE
SD-81767-01	DC Distribution Circuit for TD Radio Relay System
SD-50575-01	Radio Bay Arrangement and Indoor Waveguide Circuit
SD-51548-01	IF Main Amplifier—Carrier Resupply Circuit (J68387AB)