

C-O-N-F-I-D-E-N-T-I-A-L

MEMORANDUM FOR: *SE/P/C*


15 January 1963

FROM: Chief, MS/COM


SUBJECT: Cuban Telephone Equipment Specifications

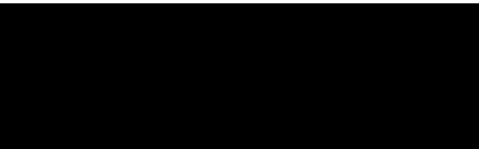
Attached for your retention are copies of RCA catalogs of equipment currently in use on the ROCMI 24 telephone-channel microwave network in Cuba and catalogs of equipment required to increase the capacity of this network to 120 telephone channels.

25X1A

This material is an unclassified enclosure 

25X1A

 Additional copies can be obtained from the CIA library upon request.



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C-O-N-F-I-D-E-N-T-I-A-L

GROUP 1  
Excluded from automatic  
downgrading and  
declassification

# MICROWAVE COMMUNICATION EQUIPMENT

~~TOP SECRET~~

T. O. 31R5-4-14-21

INSTRUCTIONS

## Microwave Relay Equipment

BASIC STATIONS



RADIO CORPORATION OF AMERICA  
COMMUNICATION PRODUCTS DEPARTMENT, CAMDEN, NEW JERSEY

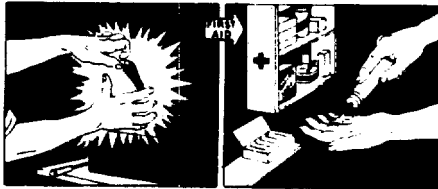
# FIRST AID

## WARNING!

Operation of electronic equipment involves the use of high voltages which are dangerous to life. Operating personnel must at all times observe all safety regulations. Do not change tubes or make adjustments inside the equipment with voltage supply on. Under certain conditions dangerous potentials may exist in circuits with power controls in the off position due to charges retained by capacitors, etc. To avoid casualties, ALWAYS DISCHARGE AND GROUND CIRCUITS PRIOR TO TOUCHING THEM.

## ABOUT FIRST AID

Personnel engaged in the installation, operation and maintenance of this equipment or similar equipment are urged to become familiar with the following rules both in theory and in the practical application thereof. It is the duty of every radioman to be prepared to give adequate First Aid and thereby prevent avoidable loss of life.



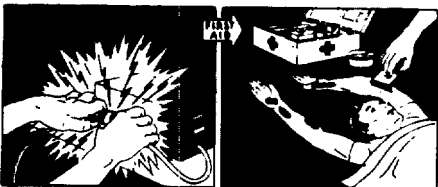
### FIRST DEGREE BURN

SKIN REDDENED. Temporary treatment—Apply baking soda or Unguentine.



### SECOND DEGREE BURN

SKIN BLISTERED. Temporary treatment—Apply baking soda, wet compress, white petroleum jelly, foille jelly, olive oil, or tea.



### THIRD DEGREE BURN

FLESH CHARRED. Temporary treatment—Apply baking soda, wet compress, white petroleum jelly, or foille spray. Treat for severe shock.

## BACK PRESSURE—ARM LIFT METHOD OF ARTIFICIAL RESPIRATION (Courtesy of the American Red Cross)

1. Position of the subject (See Fig. 1)  
Place the subject in the face down, prone position. Bend his elbows and place the hands one upon the other. Turn his face to one side, placing the cheek upon his hands.

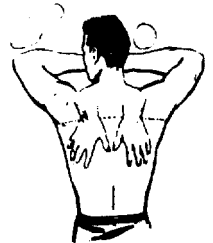


FIGURE 1

2. Position of the operator (See Fig. 2)  
Kneel on either the right or left knee at the head of the subject facing him. Place the knee at the side of the subject's head close to the forearm. Place the opposite foot near the elbow. If it is more comfortable, kneel on both knees, one on either side of the subject's head. Place your hands upon the flat of the subject's back in such a way that the heels lie just below a line running between the armpits. With the tips of the thumbs just touching, spread the fingers downward and outward.



FIGURE 2

3. Compression phase (See Fig. 3)  
Rock forward until the arms are approximately vertical and allow the weight of the upper part of your body to exert slow, steady, even pressure downward upon the hands. This forces air out of the lungs. Your elbows should be kept straight and the pressure exerted almost directly downward on the back.



FIGURE 3

4. Position for expansion phase (See Fig. 4)  
Release the pressure, avoiding a final thrust, and commence to rock slowly backward. Place your hands upon the subject's arms just above his elbows.



FIGURE 4

5. Expansion phase (See Fig. 5)  
Draw his arms upward and toward you. Apply just enough lift to feel resistance and tension at the subject's shoulders. Do not bend your elbows, and as you rock backward the subject's arms will be drawn toward you. Then lower the arms to the ground. This completes the full cycle. The arm lift expands the chest by pulling on the chest muscles, arching the back, and relieving the weight on the chest.



FIGURE 5

THE CYCLE SHOULD BE REPEATED 12 TIMES PER MINUTE AT A STEADY, UNIFORM RATE. THE COMPRESSION AND EXPANSION PHASES SHOULD OCCUPY ABOUT EQUAL TIME; THE RELEASE PERIODS BEING OF MINIMUM DURATION.

### Additional related directions:

It is all important that artificial respiration, when needed, be started quickly. There should be a slight inclination of the body in such a way that fluid drains better from the respiratory passage. The head of the subject should be extended, not flexed forward, and the chin should not sag lest obstruction of the respiratory passages occur. A check should be made to ascertain that the tongue or foreign objects are not obstructing the passages. These aspects can be cared for when placing the subject into position or shortly thereafter, between cycles. A smooth rhythm in performing artificial respiration is desirable, but split-second timing is not essential. Shock should receive adequate attention, and the subject should remain recumbent after resuscitation until seen by a physician or until recovery seems assured.

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**EQUIPMENT LOST OR DAMAGED IN TRANSIT**

When delivering the equipment to you, the truck driver or carrier's agent will present a receipt for your signature. Do not sign it until you have (a) inspected the containers for visible signs of damage and (b) counted the containers and compared with the amount shown on the shipping papers. If a shortage or if evidence of damage is noted, insist that notation to that effect be made on the shipping papers before you sign them.

Further, after receiving the equipment, unpack it and inspect thoroughly for concealed damage. This should be done within 15 days, if possible. If concealed damage is discovered immediately notify the carrier, confirmed in writing and insist upon an inspection and report.

In addition to the above, the shortages or damages should also be reported to RCA, but do not return any damaged equipment unless we have furnished complete return shipping instructions.

Transportation companies are required to adjust for damage resulting from their negligence and RCA will assist you, if necessary, in obtaining settlement. Accordingly, you should save all shipping papers, letters or invoices concerning the shipment until it is certain that the equipment was delivered in good condition or until any damage has been adjusted.

**REPLACEMENT PARTS**

When ordering replacement parts, please give symbol, description, and stock number of each item ordered.

The part which will be supplied against an order for a replacement item may not be an exact duplicate of the original part. However, it will be a satisfactory replacement differing only in minor mechanical or electrical characteristics. Such differences will in no way impair the operation of the equipment.

The following tabulations list service parts and electron tube ordering instructions according to your geographical location.

**SERVICE PARTS**

LOCATION	ORDER SERVICE PARTS FROM:
Continental United States, Alaska and Hawaii	Service Parts Order Service, Bldg. 60, 19th & Federal Sts., Camden 5, New Jersey or through your nearest RCA Regional Office. Emergency orders may be telephoned, telegraphed, or teletyped to RCA Emergency Service, Bldg. 60, Camden, N. J. (Telephone: WO 3-8000).
Dominion of Canada	RCA Victor Company Limited, 1001 Lenoir Street, Montreal, Quebec or through your local Sales Representative or his office.
Outside of Continental United States, Alaska, Hawaii and the Dominion of Canada	RCA International Division, Clark, N. J., U.S.A. or through your local Sales Representative.

**ELECTRON TUBES**

LOCATION	ORDER ELECTRON TUBES FROM:
Continental United States, Alaska and Hawaii	Local Tube Distributor.
Dominion of Canada	RCA Victor Company Limited, 1001 Lenoir Street, Montreal, Quebec or through your local Sales Representative or his office.
Outside of Continental United States, Alaska, Hawaii and the Dominion of Canada	Local Tube Distributor or from: Tube Department RCA International Division 30 Rockefeller Plaza New York 20, New York, U.S.A.

If for any reason, it is desired to return tubes, please return them to the place of purchase.

**PLEASE DO NOT RETURN TUBES DIRECTLY TO RCA WITHOUT AUTHORIZATION AND SHIPPING INSTRUCTIONS.**

It is important that complete information regarding each tube (including type, serial number, hours of service and reason for its return) be given.

When tubes are returned, they should be shipped to the address specified on the Return Authorization form. A copy of the Return Authorization and also a Service Report for each tube should be packed with the tubes.

**LIST OF RCA REGIONAL OFFICES**

- |  |   |   |   |
|--|---|---|---|
| <i>Atlanta 3, Georgia</i><br>522 Forsyth Bldg.<br>Jackson 4-7703         | <i>Boston 16, Mass.</i><br>Room 2301, John Hancock Bldg.<br>200 Berkley St.<br>Hubbard 2-1700 | <i>Chicago 54, Ill.</i><br>1186 Merchandise Mart Plaza<br>DElaware 7-0700 | <i>Cleveland 15, Ohio</i><br>1600 Keith Bldg.<br>CHerry 1-3450  |
| <i>Dallas 35, Texas</i><br>7901 Freeway #183<br>FLeetwood 2-3911         | <i>Hollywood 28, Calif.</i><br>RCA Bldg., 1560 N. Vine St.<br>HOLLYwood 9-2154                | <i>Kansas City 6, Missouri</i><br>340 Dierks Bldg.<br>HARRison 1-6480     | <i>New York 20, New York</i><br>36 W. 49th St.<br>JUDson 6-3800 |
| <i>Branch—San Francisco 2, Calif.</i><br>420 Taylor St.<br>ORdway 3-8027 |   |   |   |



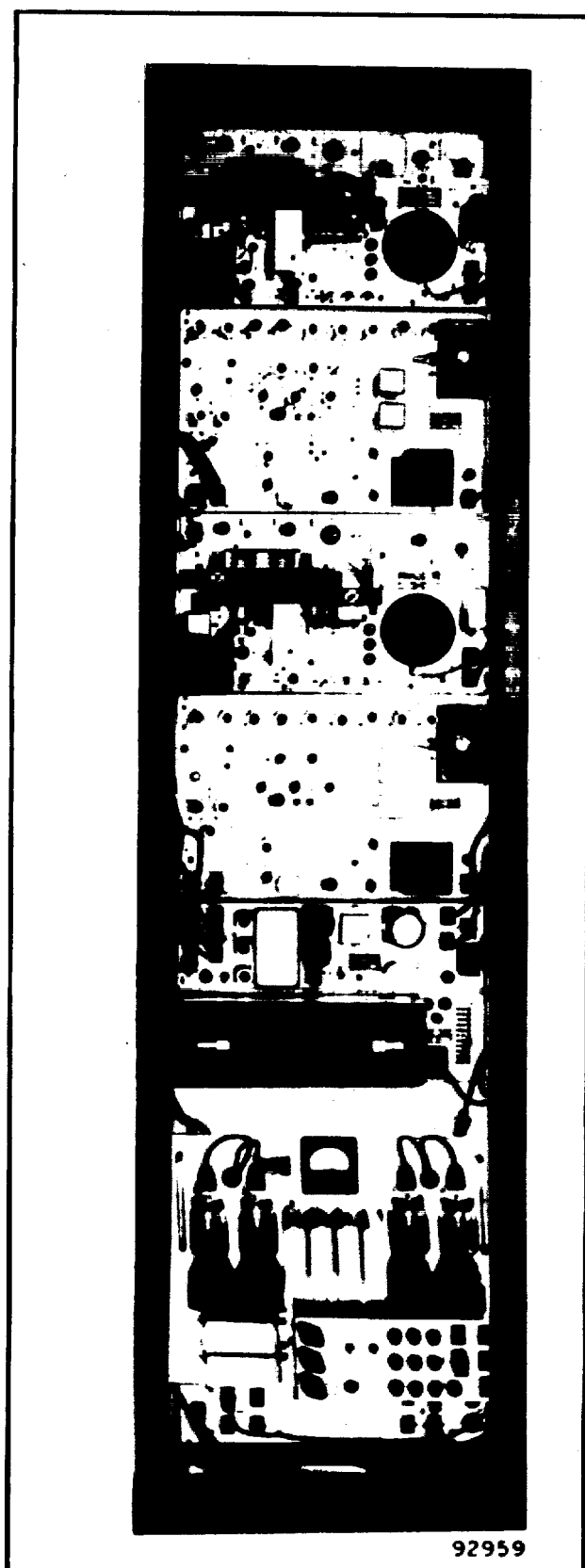
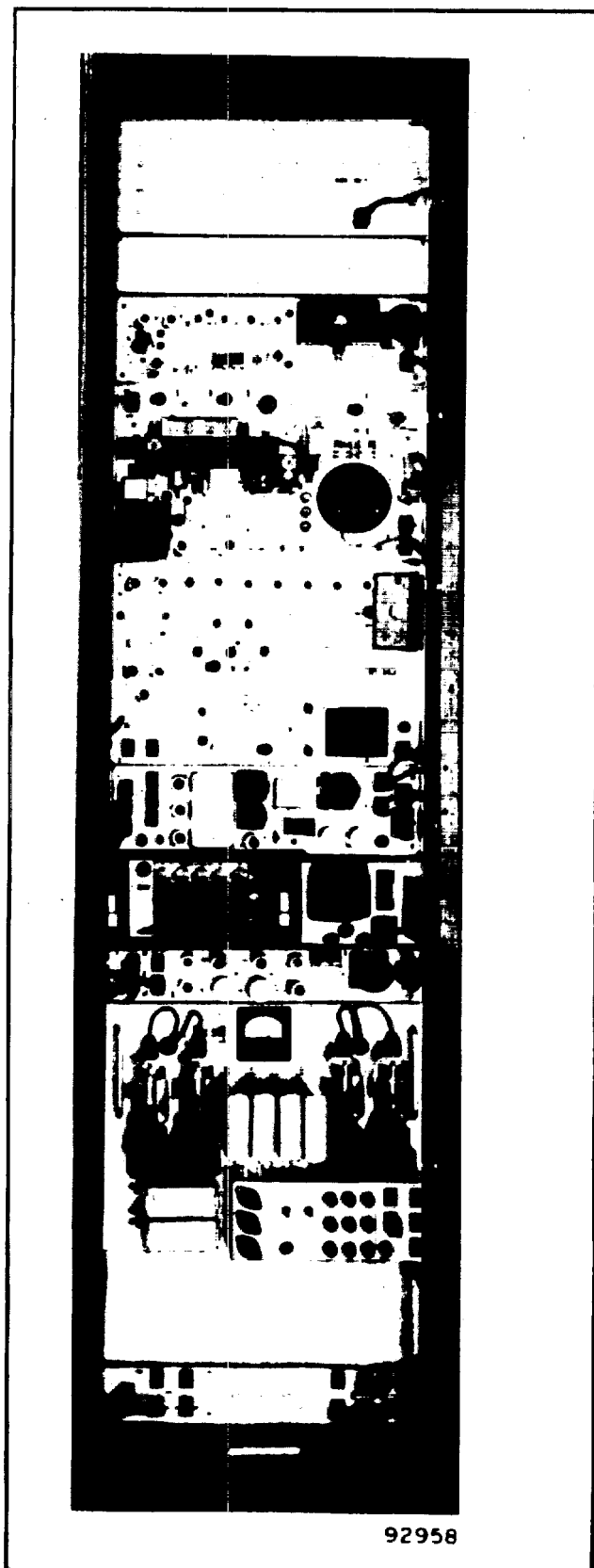
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**Figure S-1—Typical Terminal Rack**

**Figure S-2—Typical Drop Repeater Rack**

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**TECHNICAL DATA FOR SYSTEM**

**GENERAL CHARACTERISTICS**

<p><b>Frequency Range</b> 1700-1990 mc (CW-20A/AW) 2450-2700 mc (MM-26A/AW)</p> <p><b>Type of Modulation</b> Frequency Modulation</p> <p><b>Type of Multiplex</b> Frequency division</p> <p><b>Total Peak Deviation</b> ± 1.5 mc</p> <p><b>Type of Repeater</b> Heterodyne</p> <p><b>Transmitter Power Output</b> 3.0 watt (CW-20A/AW) 1.0 watt (MM-26A/AW)</p> <p><b>Frequency Stability</b> ± .02%</p> <p><b>Modulation Frequency Range</b> 3 kc to 160 kc 3 kc to 600 kc (wideband system)</p> <p><b>Service Channel Frequency Range</b> 300 cycles to 3 kc</p> <p><b>Receiver Bandwidth</b> 6 mc</p> <p><b>Type of Frequency Control</b> Quartz crystal reference AFC</p>	<p><b>Number of Channels</b> 30 120 (wideband system)</p> <p><b>Nominal Transmitting Modulation Sensitivity per Channel</b> -26 dbm</p> <p><b>Nominal Receiving Output Level Per Channel</b> -10 dbm -20 (wideband system)</p> <p><b>Receiver Noise Figure</b> 8 db (CW-20A/AW) 9 db (MM-26A/AW)</p> <p><b>A-c Power Source</b> 115 v, ± 5%</p> <p><b>A-c Power Required (Repeater Station)</b> 800 watts (approx.) (CW20A/AW) 960 watts (approx.) (MM26A/AW)</p> <p><b>A-c Power Required (Terminal Station)</b> 550 watts (approx.) (CW20A/AW) 650 watts (approx.) (MM26A/AW)</p> <p><b>Frequency Spacing at Repeater</b> 40 mc</p> <p><b>Tower Rigidity (For a 6 ft. Reflector)</b> ± 2½ degrees</p> <p><b>Temperature Range</b> -20°C to +50°C</p>
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**WEIGHTS AND DIMENSIONS**

	Weight			Height Incl. Filters		Width	Depth	
	Term	Thru Rep.	Drop Rep.	Term.	Rep.		Incl. Doors & Handles	Incl. Pwr. Supply
Cabinet Rack . . . . .	541 lbs.	572 lbs.	580 lbs.	88½"	93"	22"	25"	
Frame Rack . . . . .	436 lbs.	470 lbs.	478 lbs.	88"	92½"	21"		18"

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## DESCRIPTION

The RCA Type CW-20A (MM-20A) and MM-26A Microwave Relay Equipments are frequency modulated radio relay systems designed specifically for two way point to point communication by telephone, telegraph, teletype, facsimile, etc., all carried on simultaneously over a single radio circuit without interaction or interference between the services. They are intended for use by companies requiring an efficient system of supervisory control, telemetering, teleprinting, etc., such as electric power, pipe line and trucking companies; government agencies and many others. The equipment is designed for reliable unattended operation and so may be installed at remote locations not easily accessible. Weather, atmospheric and electrical interference have negligible effect on the operation of the system.

There are three basic types of microwave relay station equipments, the terminal station, thru repeater station and drop repeater station. The stations of a relay system are located within line-of-sight of each other at fixed points along the route which the system is to service. A basic relay system consists of two terminal stations and one or more repeater stations. A terminal station originates the signals and the repeater station receives the microwave signal and retransmits it to the next repeater or terminal. The same thing occurs, in the opposite direction, to a signal emanating from the other terminal station. There are two types of repeater stations; the thru repeater station which picks up and relays on to the next station the original microwave transmission, and the drop repeater station which in addition to relaying the microwave signal has the facilities to insert multiplex signals into and tap off multiplex signals from the relay channels. A thru repeater station can be made a drop repeater station by the simple addition of a baseband unit. See figure S-3 for a block diagram showing a system consisting of a thru repeater, a drop repeater and two terminal stations.

There are a number of operational options possible by the use of various combinations of available equipment units. The equipment required for the 12 basic system combinations is shown in Table S-1.

The microwave relay equipment is extremely flexible in its application and lends itself to many variations from the basic systems. There are combinations using drop repeaters, terminal repeater stations, repeater stations bridged by direct wire instead of microwave, etc. Information concerning its adaptation to a particular application can be obtained by consulta-

tion with Microwave Communication Section, RCA Commercial Electronic Products, Camden, N. J.

This equipment is intended for use with frequency division, single side band multiplex equipment. Any or all of the channels can be multiplexed to carry up to 16 supervisory control or telemetering functions. High or low speed telegraph or teleprinting tones can be transmitted. Also sections of the modulation band can be used for broadband systems such as high speed facsimile. Signalling channels can be inserted directly without use of voice-band multiplexing equipment, thereby simplifying the insertion or dropping of signalling channels and improving the reliability.

Each station equipment consists of separate units mounted in an 84" open rack or standard cabinet. The units are the panel mounting type and all the power and other inter-unit connections are made by means of Jones plug terminating cabling thereby facilitating quick and easy unit changing. R.F. connections between units are made by coaxial cabling. Service channel voice communication and fault locating facilities are included as an integral part of the equipment. The faulty repeater station and the type of trouble can be quickly identified at the fault identifying station and the service rapidly restored in the event of a station failure. Frequency control networks are provided in all station equipment insuring constant on-frequency operation.

The basic system uses heterodyne repeaters with a frequency shift of 40 mc (either up or down). Only two r-f channels are required under normal conditions with the transmitting frequencies alternating at successive stations. Transmission is by frequency modulation.

Typical system transmitting frequencies will be found in Tables S-2 and S-3. Other allocations can be arranged within the 1700 to 1990 mc and 2450 to 2700 mc frequency band.

Power supply requirements call for 115 volts 50/60 cycles. Voltage regulation of  $\pm 5\%$  is recommended.

### Terminal Station

For the following terminal station description refer to the terminal station portion of the block diagram of figure S-3. Input channel frequencies from the multiplex equipment are fed into the baseband unit. In the baseband unit this signal is amplified and combined with the service channel communication

TABLE S-1

LIST OF EQUIPMENT FOR BASIC STATION OPTIONS													
Equipment Unit	MI	Options*											
		1	2	3	4	5	6	7	8	9	10	11	12
Transmitter	31132-1	x	x	x	x	x	x						
Transmitter	31132-2							x	x	x	x	x	x
Receiver/Modulator	25969	x	x	x									
Receiver/Modulator	25969				x	x	x						
Receiver/Modulator	31174							x	x	x			
Receiver/Modulator	31174										x	x	x
Terminal AFC Unit	31492	x	x	x	x	x	x	x	x	x	x	x	x
Baseband Unit	31910	x	x	x				x	x	x			
Baseband Unit	31910				x	x	x				x	x	x
Power Supply	31494	x	x	x	x	x	x	x	x	x	x	x	x
Repeater Service Unit	31495	x			x			x			x		
Terminal Service Unit	31496	x			x			x			x		
Service Channel Unit	31140		x	x		x	x		x	x		x	x
Indicon Coder and Decoder Units	31138												
	31139			x			x			x			x

BASIC SYSTEM CHARACTERISTICS FOR THE BASIC STATION OPTIONS													
Characteristics	Options*												
	1	2	3	4	5	6	7	8	9	10	11	12	
Frequency Range (1700 mc to 1990 mc)	x	x	x	x	x	x							
Frequency Range (2450 mc to 2700 mc)							x	x	x	x	x	x	x
Modulation Frequency Range (3 kc to 160 kc)	x	x	x				x	x	x				
Modulation Frequency Range (3 kc to 600 kc)				x	x	x				x	x	x	
Voice Channels (up to 30)	x	x	x				x	x	x				
Voice Channels (up to 120)				x	x	x				x	x	x	
Remote Indications (6)	x			x			x			x			
Remote Indications (10)			x			x			x				x

\*Each of the system options listed in this table are also available with standby equipment at either terminal, thru repeater or drop repeater stations.

and fault signals (300 cycles to 3 kc) from the service unit. The baseband unit feeds the signal at the proper voltage level into the modulator section of the receiver/modulator unit.

In the modulator unit the amplitude modulated signals from the baseband are applied to a 40 mc f-m oscillator for a peak deviation of  $\pm 1.5$  mc.

This 40 mc frequency modulated output is combined with a 110 mc signal in the modulator i-f mixer stage. This 110 mc signal is obtained from the terminal AFC unit. The resulting difference frequency of 70 mc is amplified and then coupled thru a coaxial cable to a 70 mc amplifier in the transmitter unit.

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**TYPICAL SYSTEM FREQUENCIES**

**TABLE S-2**

**CW-20A (MM-20A) SYSTEM**

<i>Frequency Designation</i> <i>Mc</i>	<i>Transmitted Frequency</i> <i>Mc</i>	<i>Received Frequency</i> <i>Mc</i>	<i>Trans./Rec. L.O. Freq.</i> <i>Mc</i>	<i>AFC L.O. Freq.</i> <i>Mc</i>	<i>Divide By</i>	<i>AFC Crystal MI</i>	<i>AFC Crystal Freq.</i>
A1	1855	1895	1925	1875	48	31687-T1	39.0625
A2	1895	1855	1825	1875	48	31687-T2	39.0625
A3	1865	1905	1935	1885	48	31687-T3	39.2708
A4	1905	1865	1835	1885	48	31687-T4	39.2708
A5	1875	1915	1945	1895	48	31687-T5	39.4792
A6	1915	1875	1845	1895	48	31687-T6	39.4792
A7	1965	1925	1895	1945	48	31687-T7	40.5208
A8	1925	1965	1995	1945	48	31687-T8	40.5208
A9	1975	1935	1905	1955	48	31687-T9	40.7292
A10	1935	1975	2005	1955	48	31687-T10	40.7292
A11	1985	1945	1915	1965	48	31687-T11	40.9375
A12	1945	1985	2015	1965	48	31687-T12	40.9375
A13	1710	1750	1780	1730	44	31687-T13	39.3182
A14	1750	1710	1680	1730	44	31687-T14	39.3182
A15	1720	1760	1790	1740	44	31687-T15	39.5455
A16	1760	1720	1690	1740	44	31687-T16	39.5455
A17	1730	1770	1800	1750	44	31687-T17	39.7727
A18	1770	1730	1700	1750	44	31687-T18	39.7727
A19	1820	1780	1750	1800	44	31687-T19	40.9091
A20	1780	1820	1850	1800	44	31687-T20	40.9091
A21	1830	1790	1760	1810	44	31687-T21	41.1364
A22	1790	1830	1860	1810	44	31687-T22	41.1364
A23	1840	1800	1770	1820	44	31687-T23	41.3636
A24	1800	1840	1870	1820	44	31687-T24	41.3636

**TABLE S-3**  
**MM-26A SYSTEM**

<i>Frequency Designation</i>	<i>Transmitted Frequency</i> <i>Mc</i>	<i>Received Frequency</i> <i>Mc</i>	<i>Trans./Rec. L.O. Freq.</i> <i>Mc</i>	<i>AFC L.O. Freq.</i> <i>Mc</i>	<i>Divide By</i>	<i>AFC Crystal MI</i>	<i>AFC Crystal Freq.</i> <i>Mc</i>
A65	2455	2495	2525	2475	64	31687-T65	38.6719
A66	2495	2455	2425	2475	64	31687-T66	38.6719
A67	2505	2545	2575	2525	64	31687-T67	39.4531
A68	2545	2505	2475	2525	64	31687-T68	39.4531
A69	2515	2555	2585	2535	64	31687-T69	39.6094
A70	2555	2515	2485	2535	64	31687-T70	39.6094
A71	2525	2565	2595	2545	64	31687-T71	39.7656
A72	2565	2525	2495	2545	64	31687-T72	39.7656
A73	2535	2575	2605	2555	64	31687-T73	39.9219
A74	2575	2535	2505	2555	64	31687-T74	39.9219
A75	2585	2625	2655	2605	64	31687-T75	40.7031
A76	2625	2585	2555	2605	64	31687-T76	40.7031
A77	2595	2635	2665	2615	64	31687-T77	40.8594
A78	2635	2595	2565	2615	64	31687-T78	40.8594
A79	2605	2645	2675	2625	64	31687-T79	41.0156
A80	2645	2605	2575	2625	64	31687-T80	41.0156
A81	2615	2655	2685	2635	64	31687-T81	41.1719
A82	2655	2615	2585	2635	64	31687-T82	41.1719

The transmitter local oscillator generates the basic microwave signal which is heterodyned in the transmitter mixer stage with the 70 mc signal from the modulator section of the receiver/modulator unit. The output of this mixer may be either the sum or difference frequency of the two applied components. The system plan determines whether the upper or lower side band mixer output will be used. The mixer output is coupled to the r-f amplifier. The r-f carrier output from this final stage is passed through a filter network to a dipole or waveguide radiator and parabolic reflector which serves as antenna for both receiver and transmitter. The transmitter filter unit is sufficiently selective to prevent spurious transmitter emissions. Each terminal station contains a terminal AFC loop which functions in the following manner. The transmitted frequency is compared to a multiple of a reference quartz crystal oscillator and the resultant difference frequency is applied to a reactance tube which controls the frequency of the 110 mc signal feeding the modulator i-f mixer. The change in the 110 mc frequency in response to an error signal keeps the transmitted frequency correct if either the transmitter oscillator, 40 mc modulated oscillator or the 110 mc signal tend to drift in frequency. This keeps the terminal station exactly on frequency and by the nature of the heterodyne type of relay system, controls the frequency of the entire repeater station chain.

The received frequency modulated signal is passed thru a filter network and then to the receiver input. This filter prevents the transmitter signal from entering the receiver. The received microwave signal is combined with a portion of the transmitter local oscillator output in a mixer cavity using a silicon crystal detector. The frequency of the transmitter local oscillator determines the receiver i-f frequency. If this changes from the nominal value of 30 mc, a dc voltage is produced in the receiver discriminator output. This dc, through the action of the transmitter AFC circuit corrects the transmitter local oscillator to keep the heterodyne signal obtained from the receiver r-f mixer always centered on the pass band of the i-f stage. The 30 mc i-f signal thus produced is amplified thru six stages of amplification and two limiting stages before being applied to the 30 mc discriminator. The discriminator circuit demodulates the 30 mc i-f signal to extract the composite multiplex and service signals from the 30 mc carrier. At an option 1, 4, 7 or 10 station these signals are amplified and separated into service channel and multiplex channel frequencies. The multiplex signals are then amplified in the baseband unit to the proper level for the multi-

plex equipment. The service channel and fault signal frequencies after separation from the composite signal are amplified in the receiver/modulator and supplied directly to the terminal service unit.

At an option 2, 3, 5, 6, 8, 9, 11 or 12 station the composite signal is supplied to the baseband unit which separates and distributes the multiplex signals to the multiplex equipment and the service channel and fault signals to the service unit.

#### Thru Repeater Station

A thru repeater station receives the microwave signals from a terminal or a repeater station and retransmits them to the next repeater or terminal station. It contains no facilities for dropping or inserting multiplex signals.

A thru repeater station contains no terminal AFC unit or baseband unit. The frequency of the repeater station is controlled by the terminal station so a terminal AFC unit is unnecessary. A baseband unit is only needed when multiplex signals are dropped or inserted.

The receiver/modulator and transmitter units function differently in a repeater station than in a terminal station as follows: (refer to the thru repeater station portion of the block diagram of figure S-3). The 70 mc output of the modulator i-f mixer is the sum frequency of the 30 mc i-f receiver signal and the 40 mc oscillator output. The 110 mc oscillator/fault relay combination in addition to its function of reporting a receiver failure to the service unit also serves as an i-f mixer heterodyne oscillator to keep a transmitter signal on the air if the received signal fails. Since the signal radiated from the transmitter would be very noisy if the incoming signal fails, it is necessary that provision be made for effectively replacing the noise being fed to the i-f mixer by the 30 mc i-f, with a quiet carrier. In case the received signal fails, the absence of a signal will be indicated by zero d-c output from the 6th i-f grid rectifier since the 30-mc intermediate frequency will no longer be present. The dc output from the 6th i-f is normally utilized to bias off the 110 mc oscillator. When the dc from the 6th i-f stage disappears, the oscillator will become active and provide a 110 mc signal to the mixer which in combination with the signal from the 40 mc oscillator will provide the necessary 70-mc output for the transmitter.

The 110 MC oscillator also operates a noise suppression relay which disables the receiver limiter stages thereby preventing the noise voltages from

S-10

reaching the i-f mixer or the multiplex equipment. At a terminal station the 110 mc oscillator becomes a dc amplifier for operating the fault and noise suppression relays only.

At standby stations a transmitter or receiver equipment failure will cause the standby radio equipment to be switched into operation. A lockout circuit in the receiver/modulator unit differentiates between a loss-of-signal condition and an actual equipment failure.

The modulation band is passed through the repeater station with a minimum of distortion since it is not demodulated. The instability in transmitted frequency which can be introduced at a repeater station is negligible.

#### **Drop Repeater Station**

A drop repeater station is simply a thru repeater station with a baseband unit added. (Refer to the drop repeater station portion of the block diagram of figure S-3.) This permits the insertion or dropping of multiplex channels. The thru channel repeater service will not be interrupted in any way.

#### **Terminal Repeater Station**

A terminal repeater station consists of two terminal equipment racks connected back-to-back. For long systems it is advisable to install a terminal repeater after approximately the 15th repeater station. Systems which cover great distances should have a terminal repeater station inserted every 400 miles or less so that maintenance centers will not be so widely separated. A terminal repeater station can originate, stop, transfer or shift in carrier frequency any channel or combination of channels if appropriate channelling equipment is used. The maintenance service channel and fault locating system are also broken at these points to avoid the difficulty of having too many repeaters reporting faults to one operating unit.

#### **SERVICE CHANNEL AND FAULT LOCATING EQUIPMENT**

Each terminal and repeater has voice communication facilities for full party line operation between all stations. An audio tone is utilized as the ringing signal for party line calling between stations. Fault locating facilities are provided as part of the system. The failure of the radio equipment or the occurrence of some other fault causes a coded signal to be generated at any unattended station. This tone is transmitted along with the multiplex signal on the microwave carrier. This signal when received at an

attended station is separated from the multiplex signal and passed to the indicating equipment where a combination of lights show up on a lamp indicator panel. Using the code for the particular system, the station operator can use the lamp panel to identify which unattended station is having trouble and the type of failure. These indications will be repeated at frequent intervals. A number of remote-indications can be displayed consecutively on the lamp panel. A lockout circuit in each unattended station allows only one fault transmission at a time to be transmitted down the circuit, thus preventing intermingling of several transmissions which would result in an incorrectly recorded lamp display.

The system provides for the reporting to an attended station a number of remote-indications from the unattended stations. Some of these are: failure of the radio equipment units, failure of the emergency power supply and others, including those specified by the customer.

In systems using service channel and indicon equipment, the lockout circuit of the receiver/modulator unit performs the function of initiating the transmission and the identification of a loss-of-signal condition.

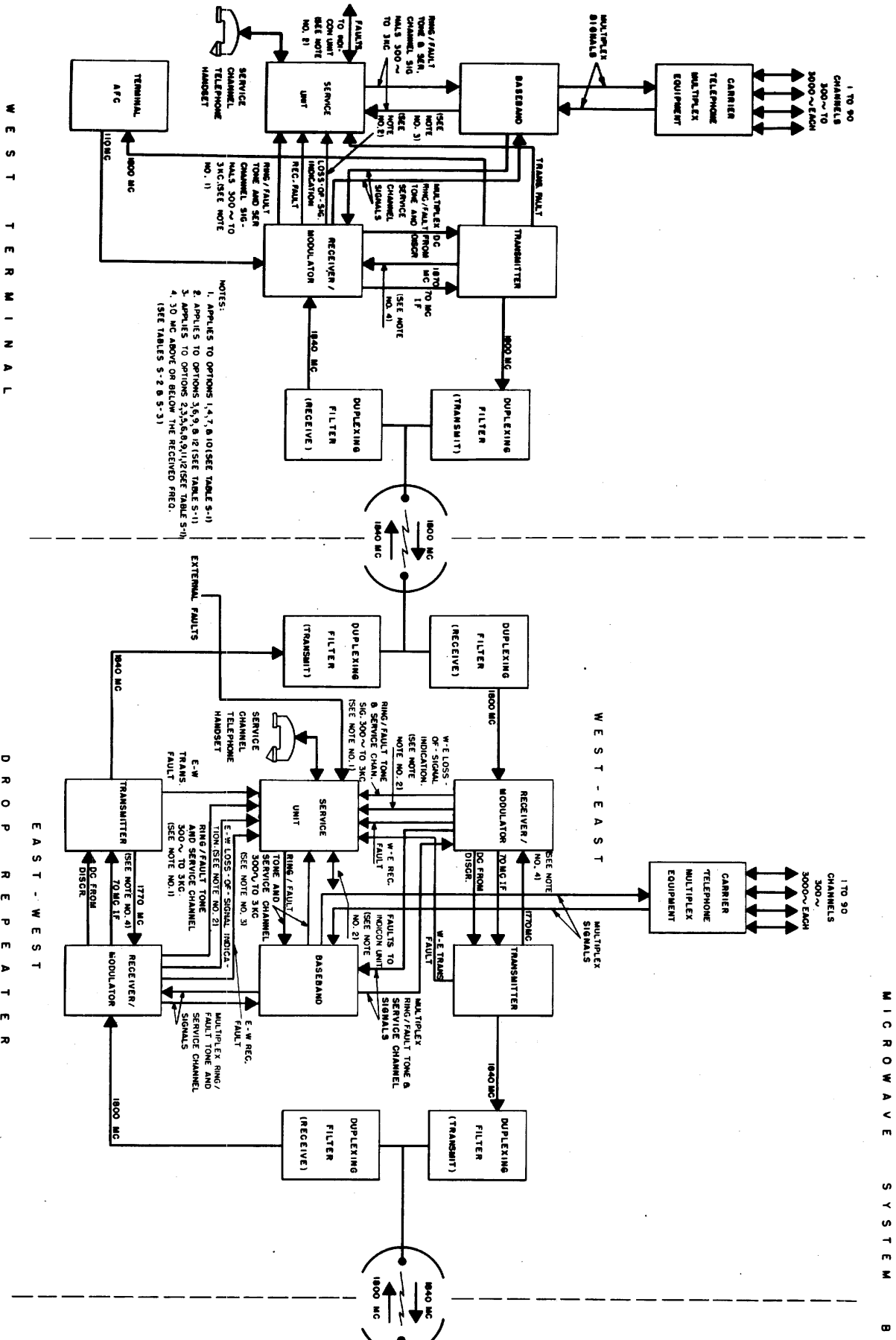
#### **EQUIPMENT RACKS MI-31025-H84, MI-30922-A84 and MI-31130**

The installations at all stations are made using either of three styles of racks. MI-31025-H84 is an 84" high, 19" wide channel, open frame type rack. MI-30922-A84 is an 84" high, 19" wide channel, cabinet rack with doors both front and back. Doors have handles with built in locks to keep unauthorized personnel from tampering with the equipment. Side panels MI-30544-H84 are required to complete the cabinet assembly. Stylized Rack MI-31130 is an 84" high, 19" wide channel open frame type rack. Side panels and a front door are available if desired. The back is left open for easy accessibility to the equipment units.

#### **CABLES**

For interunit rack cabling information for terminal, through repeater and drop repeater stations consult the cabling diagrams of figure S-8. Each type cable is made in several lengths with the suffix number of the MI designation denoting the cable lengths. There are several general types of antenna cabling installations. The requirements of each antenna installation is different so that the type of coaxial cabling and associated components required can only be ascer-





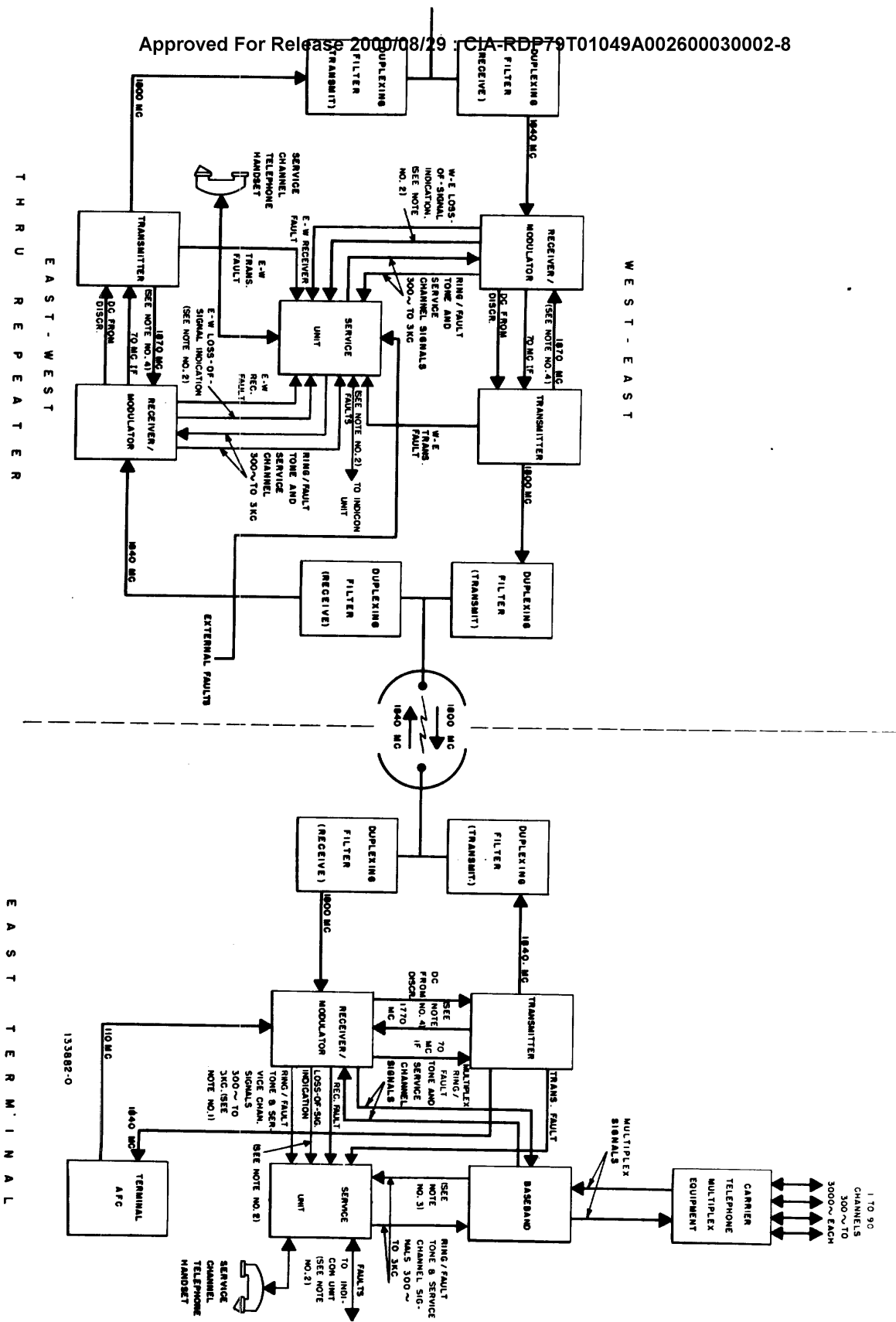


Figure S-3—Microwave Relay System, Basic Stations—Block Diagram (Sample System)

tained after each location is inspected (for height of tower and other such pertinent information) by the Microwave Communication Section, RCA Commercial Electronic Products, Camden, N. J.

### ANTENNA SYSTEM

The antenna system consists of the transmission line, from the rack to the antenna, the antenna and reflector and its mounting bracket. A terminal station needs one antenna for transmission and reception in one direction only whereas a through or drop repeater station requires two antenna installations,

one for each of the two directions of transmission and reception.

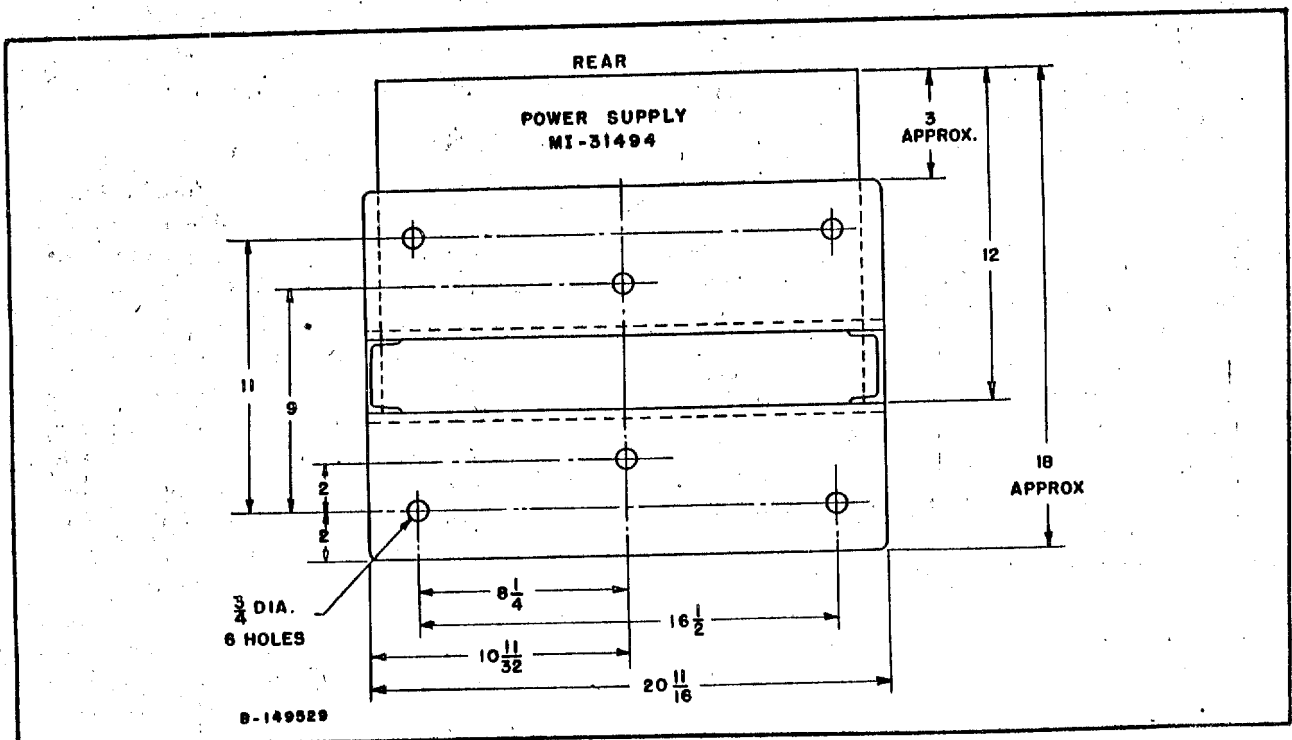
The radiating element of the antenna is a dipole or waveguide feed mounted in the center of a parabolic reflector. The reflector has the necessary studs for fastening to the mounting bracket which has devices for tilting the antenna assembly both vertically and horizontally so that it may be made to face directly toward the next station. The transmission line is either a gas filled rigid or flexible coaxial cable. Additional information on the various types of antenna system equipment available will be found in the installation section.

### INSTALLATION

#### 1. General

The first factor to consider in the installation of a microwave relay system is the geographic location of the stations. Clear line-of-sight between stations is necessary for satisfactory operation of the system. A careful survey of the terrain is required in order that the stations may be installed at locations with unobstructed paths between stations. It is possible to locate stations up to fifty or more miles apart depending on the tolerable signal loss due to obstructions in a portion of the microwave signal beam path.

For information and assistance in choosing station sites, for advice on installation and for the selection of auxiliary equipment for installations that vary from the basic system described in this book, RCA maintains a systems engineering group for the convenience of the customer. To obtain this service, write to the Microwave Communication Section, RCA Commercial Electronic Products, Camden, New Jersey. This group can provide complete system design including site selection using aerial and map surveys.



**Figure S-4—Base Mounting—Open Frame Rack**

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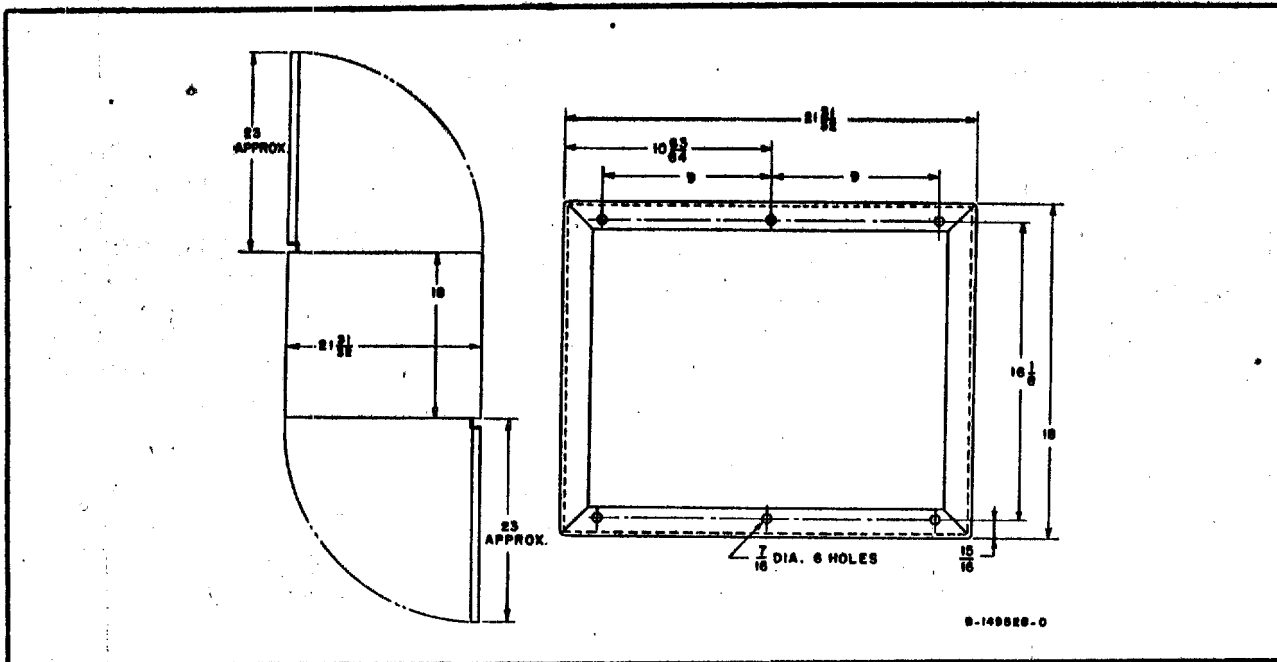


Figure S-5—Base Mounting—Cabinet Rack

a. Terminal Station

The terminal station is usually located in a metropolitan area where a tall building can be utilized for making the installation and where the required facilities such as power etc., are readily available. The equipment rack may be located on one of the upper floors and the antenna installed on the roof.

b. Repeater Station

The repeater station, the location of which is governed by the nature of the terrain, is in some cases not easily accessible. This and other factors requires additional installation considerations and the use of auxiliary equipment. A tower is generally used to place the antennas at a height sufficient to provide an unobstructed propagation path.

2. Equipment House

A small building located at the base of the tower is generally required at repeater stations for housing the rack installation and associated equipment. It is also used to house a gasoline driven generator should it be desired as a standby source of 115 v ac power.

The equipment house is normally built as close to the base of the tower as possible. In localities where ice is likely to form on the tower, the equipment house should either be built sturdily enough to withstand the weight of the falling ice or placed far

enough away from the tower to avoid the falling ice. A distance of at least 5 or 6 feet from the base of the tower will permit the transmission line to expand and contract and prevent ice from hitting the roof of the building.

Repeater stations, except for periodic maintenance checks, are operated unattended, therefore, safeguards should be taken to prevent intrusion.

3. Rack Installation

The rack equipment should be installed indoors as close to the antenna as possible to reduce the length of transmission line to the antenna. At terminal stations the location should be easily accessible to the personnel at all hours. The equipment is shipped with all the rack units and the inter-unit connecting cable in place except the power supply and the duplex filters. These units are shipped in separate containers. Mount the power supply in the proper place in the rack and the duplex filters on top of the rack with the hardware supplied with the units. Also packed with the filter units are the coaxial cables for connecting the filters to the receivers and transmitters. Allow sufficient clearance about all equipment to provide adequate ventilation, ease of service and replacement of units within the rack. Fasten the base of the racks to the floor by means of bolts set into the floor prior to installation. Refer to figures S-4, S-5 and S-6 for the diagrams showing

the dimensions for locating these bolts. Bolt racks MI-31025-H84 and MI-31130 directly to the floor. For cabinet rack MI-30922-A84 remove the base and bolt to the floor and then bolt the rack to the base. All external connections to the rack except the antenna lines are made to the Line Termination Panel MI-31056-A or MI-31156.

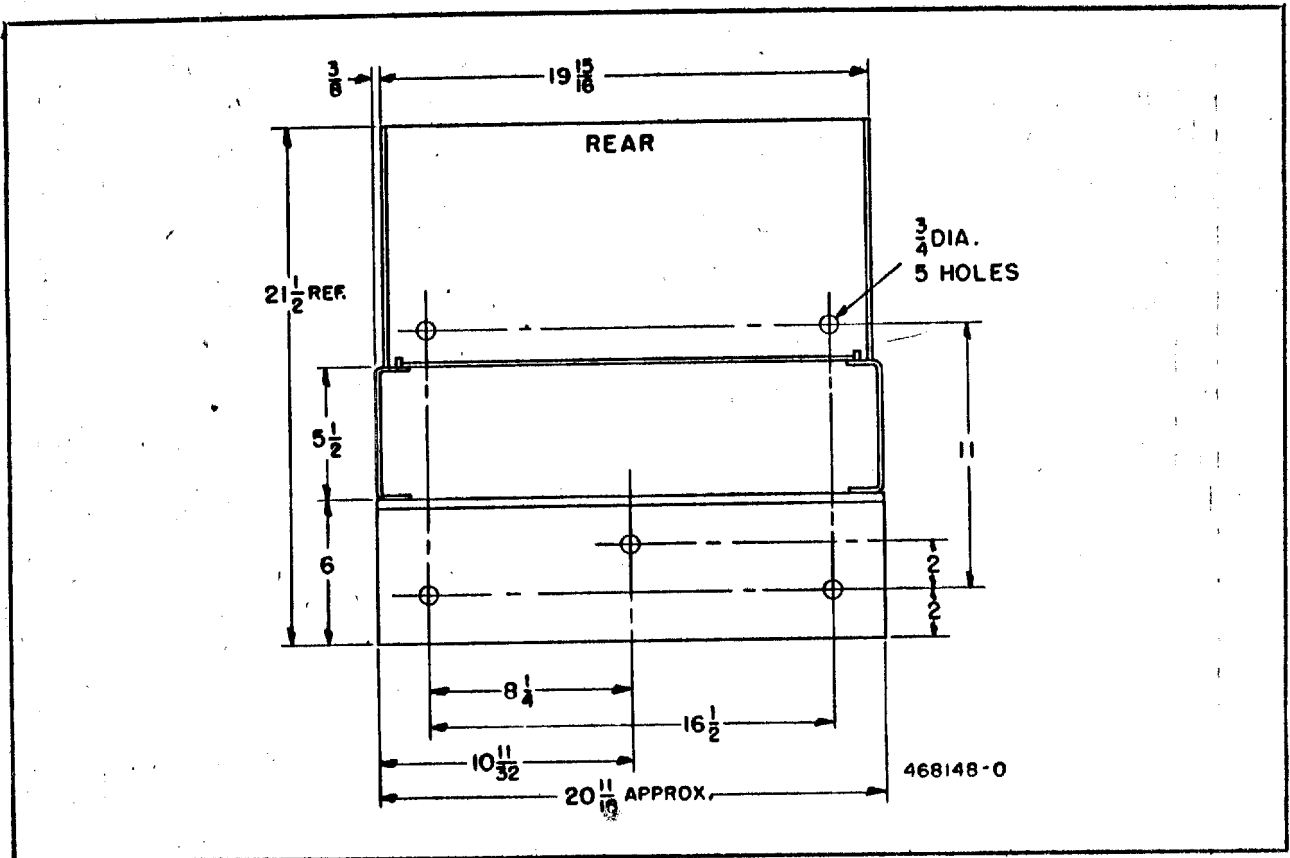
**CAUTION:** When making the 115 v ac power connections be sure that the grounded side of the line is connected to terminal 1 of 8TB1 of the line termination panel.

Other external connections to the termination panel are as follows: (a) Faults "C", "D" and "6" terminals (13, 14 and 18 of 8TB1) for external faults such as tower light failure, etc. (b) For indicating transmitter and/or receiver faults at a location remote from the rack, connect the indicating device between terminals 17 and 15 of 8TB1 for a W-E transmitter fault and between terminals 17 and 16 for an E-W transmitter fault. (c) For drop repeater or terminal stations, terminals 32 and 33 of 8TB2 are for connecting the multiplexing equip-

ment signal output to the rack, and terminals 35 and 36 are for connecting the baseband signal output to the multiplex equipment. For these and other connections refer to figures S-10 and S-11.

The transmitter output to the antenna and the receiver input from the antenna are made through their respective filters to a common coaxial terminal to which the coaxial transmission line to the antenna is connected.

The power switches, fuse boxes, 115 v ac outlets should be conveniently located and mounted to suit the particular installation. For installations at points where the commercial power may vary more than  $\pm 5\%$ , it is recommended that a Sola constant voltage transformer of sufficient capacity be provided. If used, this transformer should not be placed close to any radio or channelling equipment since it has a powerful induction field. At locations where the supply voltage may exceed the Sola range of 95 to 125 volts, a motor driven tap changing regulator can be furnished to keep the voltage supplied to the microwave equipment within an acceptable range.



**Figure S-6—Base Mounting—Stylized Rack, MI-31130**

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**4. Antenna Installation**

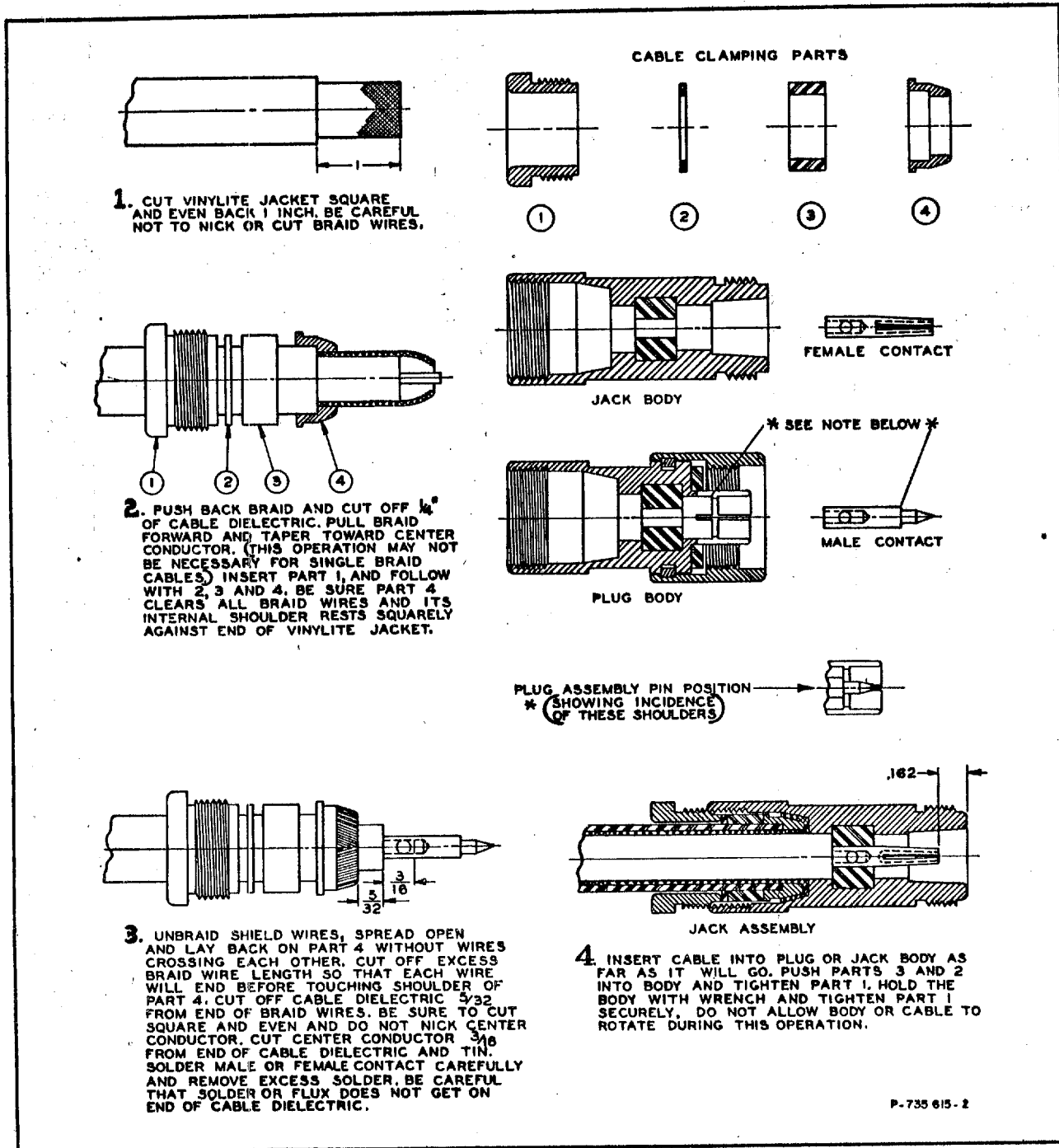
**a. Towers**

The selection of the antenna system for a microwave installation involves several factors of great importance, of which tower rigidity is paramount. Microwave towers are of two types, guyed and self-supporting. The use of anchors for guy wires necessitates a large ground area for the guyed tower. The self-supporting tower is used where

ground space is limited, within city limits for example, and on roof tops.

The tower on which the antenna is mounted must be tall enough so that there is an unobstructed path from the antenna mounted at the top of the structure, to the antenna of the next station.

Because of the narrow beam widths associated with high gain antennas used in microwave systems, tower rigidity is most essential. The degree of rigidity



**Figure S-7—Coaxial Plug Assembly**

required varies according to the size of the reflector employed. As an example, a tower rigidity of  $\pm 2.5$  degrees is sufficient when using a 6 ft. reflector. A larger reflector requires a greater degree of rigidity. A deflection of one degree of the tower will cause a deviation of the beam center of approximately one-half mile at a distance of thirty miles.

The method of grounding microwave towers consists of bonding a copper wire to the tower leg and running the wire underground to the guy anchor where it is bonded to the guy cable near the anchor position. This is done with each anchor and tower leg. Ground rods are driven at intervals along the wire as well as at the base of the tower and are attached to the copper ground wire by means of clamps.

The towers must be lighted and painted in accordance with the CAA specifications.

#### b. Antennas

The antenna reflectors and feeds, except for the horn, are stocked without mountings. The antennas can be obtained in various equivalent sizes—2 ft., 4 ft., 6 ft. and 10 ft. The antenna feed is equipped with a  $\frac{7}{8}$ " flange for interconnection with  $\frac{7}{8}$ " air line. The feed also includes a pressure release valve.

The antenna and reflector assembly may be mounted on the side of the tower or building by means of a wall mounting bracket or it may be fastened to a 4" diameter pole with a pipe mounting bracket. Position the antenna stub so that the dipole is in the horizontal plane or the vertical plane depending on the system plan. De-icing kits are not provided for the antennas. Experience has shown that when the antennas are mounted vertically ice and snow which may collect or pack into the antenna do not materially affect the operation of the system. It should be remembered that cold or stormy weather conditions result in excellent propagation. Therefore, the normal fading margin far exceeds the loss which may be caused by any ice or snow collecting on the radiating surfaces.

#### c. Brackets

Two types of mounting brackets are available, wall mounting and pipe mounting. Both types are designed to fit on the pads provided on the 4 ft. and 6 ft. reflectors. MI-31041-P provides two brackets which mount on the four pads on the back side to a 4" diameter extra-strength pipe. Approximately  $2\frac{1}{2}$  ft. of mounting space on the pipe should be provided for each antenna.

MI-31041-W is a wall mounting bracket designed to fit the four pads on the back side of the reflector. This wall mounting bracket can be bolted to a flat wall such as a brick penthouse wall or can be bolted directly to a pair of steel channels attached to the face of a tower.

#### d. Transmission Line

Basically there are two types of transmission line assemblies, solid dielectric transmission line for short runs and pressurized air dielectric transmission line for runs of greater length, such as tall power installations.

The type of cable to be used will usually depend on the length of transmission line required for a particular installation.

#### Solid Dielectric Transmission Line

##### 1. RG-8/U Transmission Line.

RG-8/U Cable can only be used in installations where a short transmission line is required. This is sometimes possible in office buildings or mountain tops where the antenna is mounted on the outside wall of the equipment room.

This antenna installation is not pressurized, therefore, it is recommended that the release valve be opened downward or a  $\frac{1}{8}$  inch hole drilled in the bottom of the antenna cover so that the antenna can breathe with temperature changes. A pin hole can cause serious trouble for water will collect over the small hole and will be sucked into the antenna when a cold rain occurs and the pressure in the antenna feed drops. It is better to have a hole large enough to permit the antenna feed to breathe without sucking water into the line.

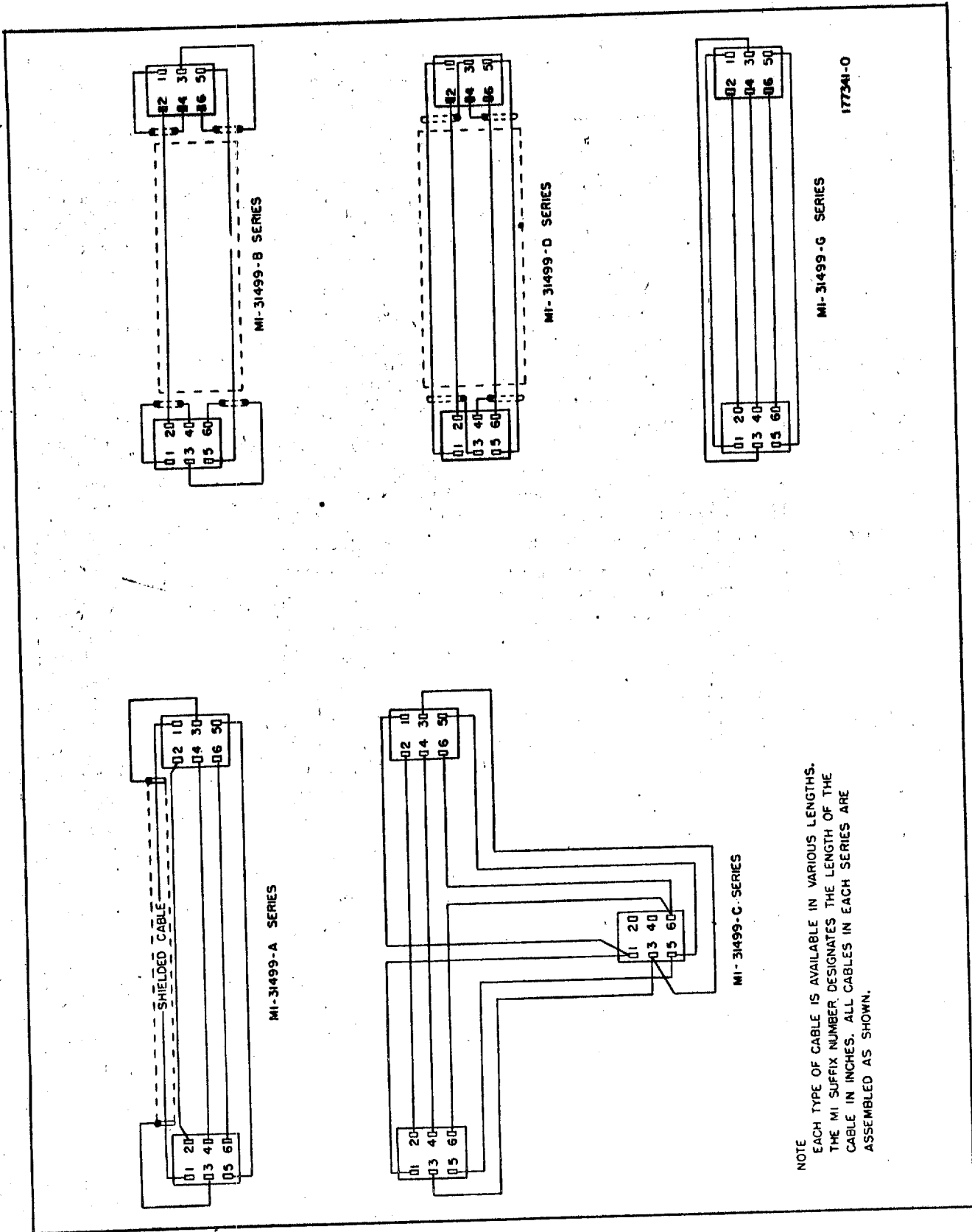
##### 2. RG-17/U Transmission Line

An RG-17/U Transmission Line installation requires the following components:

1. Adaptors MI-31038-5,  $\frac{7}{8}$ " to RG-8/U
2. Plug MI-31657-2, UG-167/U
3. Cable MI-47, RG-17/U
4. Straight Adaptor UG-30/U, Amphenol 82-66 (substitutes UG-29A/U or UG-29B/U)
5. RG-8/U Jumper MI-31031-20
6. Antenna

Adaptor, MI-31038-5, fits a  $\frac{7}{8}$ " air line flange on one side and a UG-167/U plug on the other side. Plug UG-167/U (MI-31657-2) is designed for installation on RG-17/U cable and does not introduce line discontinuities at the frequencies involved. It

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**Figure S-8—Cables—Connection Diagrams**



should be noted that plug UG-167/U for the lower end of the RG-17/U transmission line run, interconnects the RG-17/U cable with a UG-30/U Adaptor. A 60" RG-8/U cable is included to interconnect the adaptor with the Type N male fitting on the radio equipment. This type of antenna also requires that the antenna be permitted to breathe with temperature changes.

### Pressurized Air Dielectric Transmission Line

At installations where long runs of transmission lines are required, such as stations that have very high antenna towers, the use of  $\frac{7}{8}$ " and  $1\frac{1}{8}$ " pressurized air dielectric coaxial cable of the rigid or styroflex type is necessary. As each installation is different it is not within the scope of this book to go into the requirements of all possible installations. RCA carries in stock a complete line of coaxial transmission line and fittings necessary for installation including line hangers, line guides, elbows, flanges and pressurizing equipment. For details of the complete line, for information on its use, methods of installation and assistance in planning installations consult with your nearest RCA representative or write to the Microwave Communications Section, RCA Commercial Electronic Products, Camden, N. J.

#### e. Line Pressurizing

The common method of pressurizing the transmission line is to provide a manual pump, motor driven pump or a tank of nitrogen gas. A manual pump is a rather cumbersome way of pressurizing a line and does not insure a dry line in the event a small leak develops. The motor driven pump is a rather expensive unit and is not ordinarily used for unattended microwave installations. A tank of nitrogen gas will serve very well if large leaks do not develop but precautions must be taken to insure that the tanks are replaced at proper intervals.

The use of air pressure available from the tube ventilating air chamber of the transmitter units in conjunction with the MA-20 Dehydrator MI-31043 is an ideal solution to the coaxial line pressurizing problem. This method of pressurizing does not involve any additional motors or moving parts and it will prevent moisture entering the line even if small leaks develop in the transmission line. There will always be sufficient pressure from the transmitter air chamber to keep the transmission line properly pressurized.

The MA-20 unit is designed for mounting on the top of the cabinet or rack near the filters. This

permits links of copper tubing to be installed between the transmitter air chamber, the pressurizing unit, and the transmission line pressurizing inlets.

**CAUTION:** Remove the scotch tape covering the breather port.

The MA-20 Dehydrator unit consists of two chambers, the upper one, which is a lucite chamber, containing a drying agent such as silica-gel. The

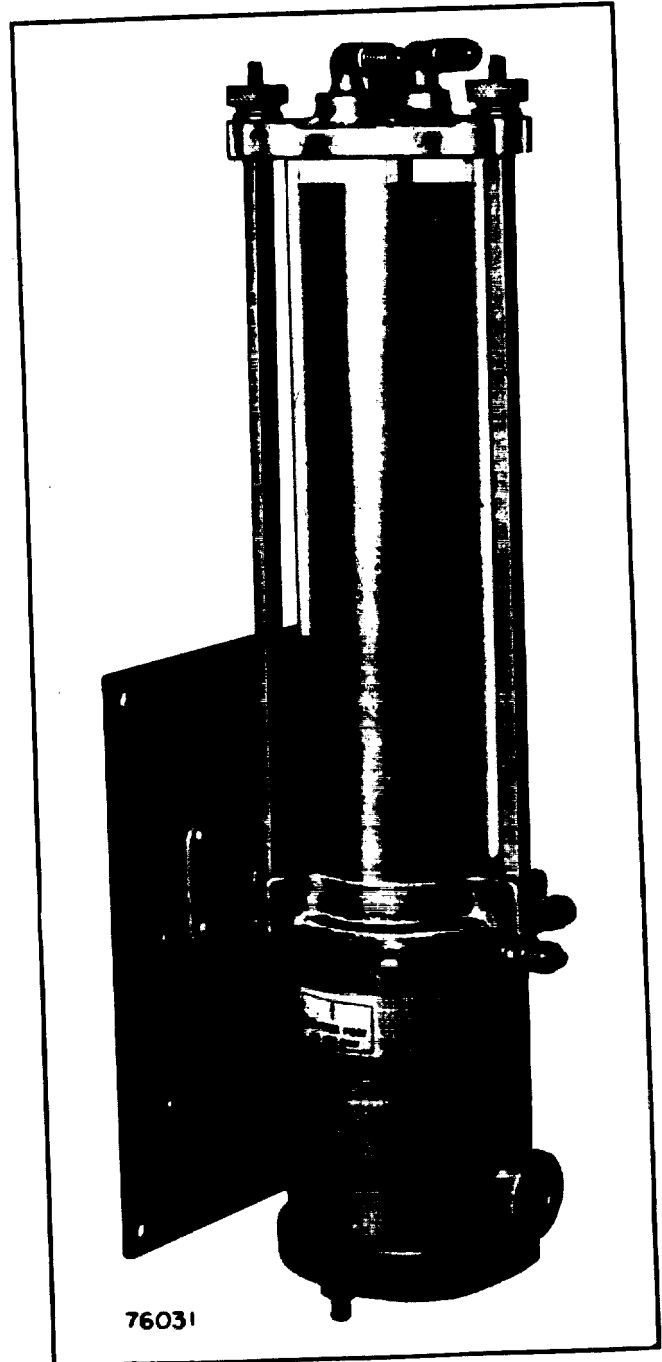


Figure S-9—MA-20 Dehydrator, MI-31043

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lower chamber contains a special arrangement of reservoirs and a pool of special oil. There are three inlets to the lower chamber and two outlets from the upper chamber. The three inlets to the lower chamber are used for connections to the air chamber of the transmitter. This air chamber on the transmitter has an air pressure outlet provided for this purpose. 1, 2, or 3 of the pressure inlets can be used as required. A terminal station would use one inlet and a repeater station would use two inlets. It is not necessary to seal off the inlets which are not used as this is accomplished by the oil seal within the unit. The upper two outlets are connected by copper lines to the pressurizing connection on the end seal of the transmission line. The gauge normally supplied with the pressurizing connection is not used where the MA-20 Dehydrator is installed. At a terminal station one of the outlets is capped. At a repeater station the two outlets can be used to pressurize lines to both antennas. Whichever transmitter is in operation will feed air through the lower chamber thence through the dehydrating chamber to the transmission line. If a small leak develops in the transmission line, the air passing from the blowers is dried by the upper chamber and dry air passes into the transmission line unit and out through the leak preventing moisture from collecting within the line.

The lower chamber of the unit permits the air in the transmission lines to expand and contract with temperature changes without breaking the seal in the lower chamber. A special reservoir is incorporated to permit the oil level to fluctuate

to counteract for pressure changes in the transmission line. The breather port of the lower chamber allows the release of excessive pressure in the line caused by the thermal expansion of the air on a hot day. The fluid reservoir permits the air pressure to be released through the breather port preventing excessive back pressure from forcing the fluid into the blower feed lines.

The silica-gel can be observed through the plastic container and can be easily replaced or dried out as required.

#### f. Orientation

Connect a plumb bob line to the top of the reflector and by means of the vertical adjustment of the mounting bracket, tilt the reflector until the rim of the reflector is exactly vertical. Tighten and secure the vertical adjustment screw.

By using a compass and a surveyor's transit adjust the antenna reflector azimuth angle to a fixed number of degrees from true north so that it faces toward the next station. The azimuth setting of each antenna is determined from maps showing geographical location of the station sites.

After the system is put into operation the azimuth angle of the antennas should be checked by moving them slightly to either side of the normal setting and noting the variations of the received signal on the appropriate receiver. The antennas should be left in the position which results in the maximum received signal.

## INITIAL ADJUSTMENTS

In putting a relay system into operation all of the stations of the system should be installed before attempting to put any of the stations into operation so that the tuning may proceed in an orderly fashion from one end of the system to the other. In general, the tuning should start at one terminal station and proceed toward the other. Only those units operating in the same direction (E-W or W-E) as the original terminal station should be tuned since those operating in the opposite direction will not be receiving an on-frequency signal. A return journey down the system, tuning the remaining equipment, can be made after the second terminal station has been reached and tuned. The units of the equipment are tested and adjusted for proper performance before shipment. If trouble should be encountered in tuning any of the units refer to the instruction book of the unit concerned.

For correct operation of the AFC motor 1B1 observe the following wiring instructions (See the schematic and wiring diagrams of the transmitter instructions).

1. For upper side band operation, wire the front (nearest the panel) motor winding connection to pin 6 of 1TB8 and the back motor winding connection to pin 2 of 1TB8. Retain the common winding connections on pin 1 of 1TB8.

2. For lower side band operation, wire the front motor winding connection to pin 2 of 1TB8 and the back motor winding connection to pin 6 of 1TB8. Retain the common winding connections on pin 1 of 1TB8.

#### Terminal Station Tuning

Perform the following operations in the order in which they are listed.

1. All cables and tubes should be in place and the blower shipping screws removed. Check the receiver/modulator unit for the correct internal connections for use at terminal stations and check the service channel equipment for correct strapping. Refer to the schematic diagrams in the instructions pertaining to the specific equipment used.

2. Move the AFC MOTOR disabling switch 1S3 to the "OFF" position.

3. Turn on the power supply switch marked LINE and allow the tubes to warm up for 1 minute.

4. Set the transmitter meter switch at MIX. The meter should read at least 35 ma when the tubes have reached operating temperature and the reading obtained on 1M1 when 1J9 is connected to 1J7 shall be at least 35  $\mu$ a.

5. *Oscillator Tuning (CW-20A)*. Tune the oscillator stage according to the following procedure when adjusting a CW-20A transmitter unit. For an MM-26A transmitter use the succeeding "Oscillator Tuning (MM-26A)" procedure.

Set the meter switch at OSC and turn on the TRANS TUNE switch on the power supply. Turn the oscillator cathode tuning screw (lower left). The cathode current should change and the tuning screw should be set for a maximum current.

*CAUTION: If the cathode current exceeds 100 ma during the maximizing adjustment it must be reduced by means of the potentiometer marked OSC. After the current has been maximized, the OSC potentiometer should be adjusted for a current of 70 ma.*

If the cathode current doesn't change when turning the cathode tuning screw, the tube is not oscillating. In this case, the cathode current should be adjusted by means of the potentiometer marked OSC to a value of 30 ma and the cathode tuning slug turned through its full range until an increase in cathode current is observed, and then maximized as described above.

*Oscillator Tuning (MM-26A)*. The following procedure is to be used only when tuning the oscillator stage of an MM-26A transmitter. For a CW-20A transmitter use the above "Oscillator Tuning (CW-20A)" procedure.

Set the 2N339 BIAS ADJ. control (1R43) one quarter turn from its full counter-clockwise position. Place the meter switch (1S1) on the "+" position and connect one end of the test lead to meter pin jack 1J7 and the other to pin jack 1J10. Turn "on" the 500 V switch of the power supply and after warmup, turn the oscillator tuning plug (lower left) for maximum meter tuning indication. This meter indication is not a measurement of the current flow in the cathode circuit (oscillator activity) but is used strictly as a tuning indication.

If the cathode current does not change when turning the cathode tuning screw, the tube is not oscillating. If this should happen, turn potentiometer 1R43 another quarter of a turn clockwise and adjust the cathode tuning slug until an increase in the meter reading is observed.

Turn the oscillator tuning plug (lower left) for maximum meter tuning indication.

Turn the meter selector to the OSC position and adjust the 2N339 BIAS ADJ. control for a meter reading of 70 ma. The reading obtained in this measurement is the actual cathode current of the oscillator stage.

6. Set the transmitter oscillator frequency, by means of Wavemeter MI-31028, to the proper value according to the system frequency plan. The oscillator frequency may be determined from the given system frequencies as follows: (1) If the transmitted frequency is greater than the received frequency, the oscillator frequency should be 30 mc less than the received frequency. (2) If the transmitted frequency is less than the received frequency, the oscillator frequency should be 30 mc greater than the received frequency. Normally the equipment will be factory tuned before shipment but the procedure outlined here should be followed and minor adjustments made when found necessary.

a. Attach a ground lead from the black pinjack of the frequency meter to the transmitter chassis.

b. Attach test lead from the red pinjack to the METER pinjack on the transmitter.

c. Connect the transmitter local oscillator L.O. terminal to the meter input BNC connector (use an RG-58/U coaxial cable, terminated with two UG-88/U plugs).

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d. Set the rheostat knob to maximum sensitivity (fully clockwise).

e. Set METER switch to the "—" position.

f. Turn the frequency meter dial for maximum reading on transmitter meter 1M1. The frequency meter dial is adjusted to the frequency of the transmitter local oscillator when meter 1M1 reads maximum. If the transmitter local oscillator is off frequency as indicated by the frequency meter dial reading, adjust the top left tuning screw of the local oscillator cavity in the proper direction to correct the frequency (out for an increase in frequency), and repeat the oscillator tuning.

g. Keep rechecking and retuning the transmitter local oscillator until it is adjusted to its assigned frequency.

**NOTE:** It will be found that the top left tuning screw of the oscillator cavity adjusts primarily the frequency of the oscillations while the bottom left tuning screw (the cathode cavity) adjusts primarily the amplitude of the oscillations. The bottom left screw has enough effect upon the frequency, however, so that a frequency measurement should be taken only when this adjustment is completed.

After the frequency is adjusted, recheck the oscillator tuning and retune if necessary, using the applicable procedure of step #5.

7. Tune the mixer and amplifier stages. First disconnect one end of the 70 mc cable running from the receiver/modulator unit to the transmitter unit. With the meter switch on AMPL position, tune the top right tuning screw for a maximum current on meter 1M1.

**CAUTION:** If the current exceeds 125 ma it should be reduced by turning the potentiometer control marked AMPL counter-clockwise.

Tune the bottom right tuning screw for a maximum R.F. MONITOR current. If this meter tends to go off scale reduce its reading by turning the potentiometer control, marked MONITOR ADJUST, counter-clockwise.

The r-f amplifier is now tuned to the oscillator frequency. This procedure merely establishes a preliminary reference tuning adjustment. Next con-

sult the system frequency plan to determine if the mixer and r-f amplifier should be tuned above or below the oscillator frequency. If it is above, reconnect the 70 mc cable to the receiver/modulator unit and screw the mixer tuning screw (top right) out until the next maximum is reached on the cathode current of the r-f amplifier. Turn the amplifier tuning screw (bottom right) out for a maximum monitor current. Recheck the oscillator cathode current and set it at 70 ma. Check the amplifier current and set the potentiometer marked AMPL for 100 ma. When making the AMPL current adjustment watch the r-f output current reading of the R.F. MONITOR, meter 1M2. If the reading of this meter increases very slowly as the plate current is increased the r-f output of the tube is approaching or has reached saturation and any further plate current increase will effect no appreciable increase in r-f output. In this case, it is advisable to operate the amplifier at less than 100 ma since a proportionate increase in r-f output is not obtained as the current is increased. Longer tube life will be obtained with a current of 80 ma.

If the system frequency plan requires the mixer and amplifier to be tuned below the oscillator frequency, the mixer and amplifier tuning screws should be turned "in" instead of "out" as described above.

8. With an accurate ac voltmeter, read the ac regulated output voltage of the power supply. If the reading is not within  $\pm 5$  volts of 115 volts, change the connection of the jumper in 5P1 from 6-1 to 6-2, 6-3 or 6-4, whichever gives the closest approximation to 115 volts in the ac regulated output.

With power applied to all units, read the output of the 250 volt supply with an accurate dc voltmeter. Connect the wire from the 115 volt tap of transformer 5T2 to the tap on terminal board 5TB1 which gives the closest approximation to 250 volts at the power supply output.

With all 2C39B tubes drawing their specified currents, measure the output voltage of the 500 v supply. For CW20A/AW systems if the reading is not between 500 volts and 600 volts, connect the wire from terminal 1 of switch 5S2 to the tap on terminal board 5TB1 which gives an output voltage in this range. For MM26A/AW systems this voltage shall be between 775 and 875 volts.

NOTE: Although these measurements should be made with all power on, the adjustments should be made only with all power off.

Repeat steps 6 and 7.

9. Tune the terminal AFC unit. Connect the tuning meter to the jack marked OSC GRID and tune the XTAL OSC control for a sharp peak in grid current. The current should be at least 70  $\mu$ a.

Connect the tuning meter to the jack marked MIXER XTAL. Tune the MULT 3L21 and 3L17 controls for a maximum current. The reading should be 30  $\mu$ a or more. (To obtain a peak indication when tuning this circuit it may be necessary to remove the r-f cable connecting the transmitter output to the crystal cavity on the terminal AFC unit. The cable should be replaced immediately after peaking the circuit.)

Connect the tuning meter to the LIMITER jack. The current should read 25  $\mu$ a or more. The transmitter must be on and tuned up for this test. Adjust the tuning of the crystal mixer for a maximum limiter current.

Connect the tuning meter to the jack marked DISC and note the reading. This reading should be zero. If it is not zero, adjust the transmitter oscillator frequency slightly until a zero reading is obtained. It is good practice to check and see if the meter reading can be made either positive or negative by slightly tuning the transmitter oscillator. (If the oscillator is considerably off the correct frequency a zero will also be obtained but in this case a very low reading will be obtained with the meter connected to the limiter jack.) Recheck the transmitter oscillator cathode tuning for a peak current.

10. The terminal station adjustments are now complete except for the transmitter AFC adjustment and receiver cavity tuning adjustment which must be made after the first repeater station is placed in operation.

NOTE: To complete the tuning of the terminal station a signal from the first repeater station is required. Proceed to the first repeater station and perform tunings steps 1 through 22 of the Repeater Station Tuning section. Move toward the next terminal station and tune each of the repeater stations for operation in both directions before returning to the first terminal station. Complete the tuning of the first terminal station, performing the following tuning steps 11 through 20.

11. Tune the terminal station receiver mixer cavity. The first repeater station must now be transmitting back toward the terminal. This cavity should

be tuned for a maximum signal with the test meter 1M1 connected to the jack on the receiver marked "SIG." If the signal is very strong this meter may show two peaks or a broad maximum as the cavity is tuned. If so, a 20 db coaxial attenuator should be placed in the antenna lead to the receiver and the cavity peaked. If an attenuator is not available, a temporary adjustment can be made by tuning the cavity to the dip between the two peaks, which will be the maximum signal input to the receiver.

12. Check the crystal mixer current. Connect the test meter to the jack on the receiver marked XTAL CUR. The reading should be adjusted to 40 to 60  $\mu$ a. To make this adjustment, loosen the locking screw on the oscillator input bushing and rotate the probe until the proper reading is obtained.

13. Connect the test meter 1M1 to the receiver discriminator jack. Set the AFC loop indicator to the zero position. If the discriminator reading is not zero, turn the oscillator frequency slug slowly until a zero reading is obtained. Repeak the oscillator cathode tuning slug. Recheck to see if the discriminator is still zero.

14. Move the AFC motor disabling switch 1S3 to the ON position. If the AFC motor runs, as indicated by one of the two lights on transmitter panel, adjust the DC AMPL BIAS control until the motor stops when the discriminator reading on the test meter is zero.

15. Set the pointer on the "O" position of the AFC LOOP INDICATOR scale. Recheck the oscillator cathode tuning (left, bottom of cavity) for a maximum oscillator tuning current.

16. Adjust the 110 mc/fault relay circuit in the receiver/modulator unit. The adjustment is made by means of the potentiometer marked REL/OSC CONTROL. To adjust the control, first disconnect the antenna from the receiver, plug the meter lead into the "SIG" jack and note the noise reading on the test meter. Reconnect the antenna to the receiver through the 20 db coaxial attenuator and detune the receiver cavity until a SIG reading of 20  $\mu$ a above the noise reading is obtained. Then turn the REL/OSC CONTROL fully clockwise and then carefully counter-clockwise, stopping when the relay clicks.

After the adjustment is made, be sure to retune the receiver cavity for a maximum signal and then remove the attenuator.

17. Check the terminal AFC unit discriminator reading. Connect the test meter to the jack on this unit marked DISCR. If the reading is not zero,

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adjust the 55 MC OSC tuning control very slowly until the meter reads zero. The AFC motor may run when the 55 mc oscillator frequency is changed slightly. Therefore, after a slight change in the frequency of the 55 mc oscillator is made, wait for the AFC tuning motor indicator light to go out before continuing the adjustment.

18. Make the following preliminary service channel level adjustments:

a. At stations using a Terminal Service Unit, set the INPUT CONTROL at about half the total clockwise rotation. Adjust the OSC OUTPUT and MIKE OUTPUT at about half rotation but not so high that the calling tone or voice will cause the transmitter output to drop. Adjust the HANDSET VOLUME to the desired listening level.

b. At stations using a Service Channel Unit, adjust the 2.0 KC LEV and MIC GAIN controls at about half rotation but not so high that the calling tone or voice will cause the transmitter output to drop. Adjust the VOLUME control to the desired listening level.

19. After the complete circuit has been operating for at least 24 hours the following steps should be taken.

a. Repeat step 17 above.

b. Check the frequency of the 40 mc osc. as described in Repeater Station Tuning step 22(a).

c. Set the pointer on the "O" position of the AFC LOOP INDICATOR scale.

d. Tune the transmitter cathode (lower left tuning screw) for a maximum oscillator current.

e. Maximize the R.F. monitor current by tuning the mixer and amplifier (upper right and lower right tuning screws).

20. Perform the service channel level adjustments as follows:

a. At stations using a Terminal Service Unit:

(1) Connect an audio voltmeter (Ballantine Model 300 or equivalent) to pin 2J12-2 and ground of the receiver/modulator unit.

(2) Press the CALLING button and adjust the OSC OUTPUT control of the terminal service unit for a reading of 0.048 volt at 2J12-2.

(3) With conditions the same as in (1) above, adjust the MIKE OUTPUT control of the terminal service unit for a meter reading of from 0.03 to 0.04 volt at 2J12-2 on voice peaks.

(4) Adjust the INPUT CONTROL to its maximum clockwise position.

(5) Adjust the HANDSET VOLUME control to the desired listening level.

b. At stations using a Service Channel Unit:

(1) Check to see that the connections to the pads in the input of 23V1-A and in the output of 23V1-B of the Service Channel Unit are correct for use at a terminal station. Refer to the schematic diagram of the Service Channel Unit instructions.

(2) Connect an audio voltmeter (Ballantine Model 300 or equivalent) to pin 2J12-2 and ground of the receiver/modulator unit.

(3) Activate the CALL switch and adjust the 2.0 KC LEV control for reading of 0.048 volt at 2J12-2.

(4) Adjust the MIC GAIN control for a meter reading of 0.03 to 0.04 volt at 2J12-2 on voice peaks.

(5) Adjust the VOLUME control to the desired listening level.

#### Repeater Station Tuning

Perform the following operations in the order in which they are listed below: Follow this same tuning procedure for both the E-W and W-E sections of the station.

1. All cables and tubes should be in place and the blower shipping screws removed. Check the receiver/modulator unit for the correct internal connections for use at repeater stations and check the service channel equipment for correct strapping. Refer to the schematic diagrams in the instructions pertaining to the specific equipment used.

2. Move the AFC MOTOR disabling switch 1S3 to the "OFF" position.

3. Turn on the power supply switch marked LINE and allow the tubes to warm up for 1 minute.

4. Set the transmitter meter switch to MIX. The meter should read at least 35 ma when the tubes have reached operating temperature and the reading obtained on 1M1 when 1J9 is connected to 1J7 shall be at least 35  $\mu$ a.

5. *Oscillator Tuning (CW-20A)*. Tune the oscillator stage according to the following procedure when adjusting a CW-20A transmitter unit. For an MM-26A transmitter use the succeeding "Oscillator Tuning (MM-26A)" procedure.

Set the meter switch at OSC and turn on the TRANS. TUNE switch on the power supply. Turn the oscillator cathode tuning screw (lower left). The cathode current should change and the tuning screw should be set for a maximum current.

*CAUTION: If the cathode current exceeds 100 ma during the maximizing adjustment it must be reduced by means of the potentiometer marked OSC. After the current has been maximized, the OSC potentiometer should be adjusted for a current of 70 ma.*

If the cathode current doesn't change when turning the cathode tuning screw, the tube is not oscillating. In this case, the cathode current should be adjusted by means of the potentiometer marked OSC to a value of 30 ma and the cathode tuning slug turned through its full range until an increase in cathode current is observed, and then maximized as described above.

*Oscillator Tuning (MM-26A).* The following procedure is to be used only when tuning the oscillator stage of an MM-26A transmitter. For a CW-20A transmitter use the above "Oscillator Tuning (CW-20A)" procedure.

Set the 2N339 BIAS ADJ. control (1R43) one quarter turn from its full counter-clockwise position. Place the meter switch (1S1) on the "+" position and connect one end of the test lead to meter pin jack 1J7 and the other to pin jack 1J10. Turn "on" the 500 V switch of the power supply and after warmup, turn the oscillator tuning plug (lower left) for maximum meter tuning indication. This meter indication is not a measurement of the current flow in the cathode circuit (oscillator activity) but is used strictly as a tuning indication.

If the cathode current does not change when turning the cathode tuning screw, the tube is not oscillating. If this should happen, turn potentiometer 1R43 another quarter of a turn clockwise and adjust the cathode tuning slug until an increase in the meter reading is observed.

Turn the oscillator tuning plug (lower left) for maximum meter tuning indication.

Turn the meter selector to the OSC position and adjust the 2N35 BIAS ADJ. control for a meter reading of 70 ma. The reading obtained in this measurement is the actual cathode current of the oscillator stage.

6. Set the transmitter oscillator frequency by means of Wavemeter MI-31028 to the proper value according to the system frequency plan. Normally the

equipment will be factory tuned before shipment but the procedure outlined here should be followed and minor adjustments made when found necessary.

a. Attach a ground lead from the black pinjack of the frequency meter to the transmitter chassis.

b. Attach a test lead from the red pinjack to the METER pinjack on the transmitter.

c. Connect the transmitter local oscillator L.O. terminal to the meter input BNC connector (use an RG-58/U coaxial cable, terminated with two UG-88/U plugs).

d. Set the rheostat knob to maximum sensitivity (fully clockwise).

e. Set METER switch to the "-" position.

f. Turn the frequency meter dial for maximum reading on transmitter meter 1M1. The frequency meter dial is adjusted to the frequency of the transmitter local oscillator when meter 1M1 reads maximum. If the transmitter local oscillator is off frequency as indicated by the frequency meter dial reading, adjust the top left tuning screw of the local oscillator cavity in the proper direction to correct the frequency (out for an increase in frequency), and repeat the oscillator tuning.

g. Keep rechecking and retuning the transmitter local oscillator until it is adjusted to its assigned frequency.

NOTE: It will be found that the top left tuning screw of the oscillator cavity adjusts primarily the frequency of the oscillator while the bottom left tuning screw (the cathode cavity) adjusts primarily the amplitude of the oscillations. The bottom left screw has enough effect upon the frequency, however, so that a frequency measurement should be made only when this adjustment is completed.

After the frequency is adjusted, recheck the oscillator tuning and retune if necessary, using the applicable procedure of step #5.

7. Tune the mixer and amplifier stages. First disconnect one end of the 70 mc cable running from the receiver/modulator unit to the transmitter unit with the meter switch on the AMPL position. Tune the top right tuning screw for a maximum current on meter 1M1.

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**CAUTION:** If the current exceeds 125 ma it should be reduced by turning the potentiometer control marked *AMPL* counter-clockwise.

Tune the bottom right tuning screw for a maximum R.F. Monitor current. If this meter tends to go off scale reduce its reading by turning the potentiometer control, marked *MONITOR ADJUST*, counter-clockwise.

8. The r-f amplifier is now tuned to the oscillator frequency. This procedure merely establishes a preliminary reference tuning adjustment. Next consult the system frequency plan to determine if the mixer and r-f amplifier should be tuned above or below the oscillator frequency. If it is above, reconnect the 70 mc cable to the receiver/modulator unit and screw the mixer tuning screw (top right) out until the next maximum is reached on the cathode current of the r-f amplifier. Turn the amplifier tuning screw (bottom right) out for a maximum monitor current. Recheck the oscillator cathode current and set it at 70 ma. Check the amplifier current and set the potentiometer marked *AMPL* for 100 ma. When making the *AMPL* current adjustment watch the r-f output current reading of the *RF MONITOR*, meter 1M2. If the reading of this meter increases very slowly as the plate current is increased the r-f output of the tube is approaching or has reached saturation and any further plate current increase will effect no appreciable increase in r-f output. Therefore, it is advisable to operate the amplifier at less than 100 ma since a proportionate increase in r-f output is not obtained as the current is increased.

(If the system frequency plan requires the mixer and amplifier to be tuned below the oscillator frequency, the mixer and amplifier tuning screws should be turned "in" instead of "out" as described above.)

9. With an accurate ac voltmeter, read the ac regulated output voltage of the power supply. If the reading is not within  $\pm 5$  volts of 115 volts, change the connection of the jumper in 5P1 from 6-1 to 6-2, 6-3 or 6-4, whichever gives the closest approximation to 115 volts in the ac regulated output.

With power applied to all units, read the output of the 250 volt supply with an accurate dc voltmeter. Connect the wire that goes from transformer 5T2 to terminal board 5TB1, to the terminal of 5TB1

which gives the closest approximation to 250 volts at the power supply output.

For CW20A/AW systems with all 2C39B tubes drawing their specified currents, measure the output voltage of the 500 v supply. If the reading is not between 500 volts and 600 volts, connect the wire that goes from switch 5S2 to terminal board 5TB1, to the terminal of 5TB1 which gives an output voltage in this range. For MM26A/AW systems this voltage shall be between 775 and 875 volts.

**NOTE:** Although these measurements should be made with all power on, the adjustments should be made only with all power off.

Repeat steps 6 and 7.

10. Adjust the receiver mixer cavity tuning screw for a maximum indication with the test meter connected to the jack on the receiver marked *SIG*. If the signal is very strong this meter may show two peaks or a broad maximum as the cavity is tuned. If so, a 20 db coaxial attenuator should be placed in the antenna lead to the receiver and the cavity tuning peaked. If an attenuator is not available, a temporary adjustment can be made by tuning the cavity to the dip between the two peaks, which will be the maximum signal input to the receiver. This adjustment as well as the following steps can be made only if a signal is being transmitted to the repeater station.

11. Check the receiver discriminator current. Connect the test meter to the receiver jack marked *DISC*. The reading should be adjusted to approximately zero by very slowly tuning the transmitter oscillator frequency adjustment. (Top, left on transmitter.) A zero reading may also be obtained if the transmitter oscillator is tuned too far off the correct frequency. A good rule to follow is to see that a zero discriminator reading coincides with a maximum signal indication with the meter connected to the *SIG* jack.

12. Check the receiver mixer crystal current. Adjust the probe of connector 2J2 for a current reading of 40 to 60  $\mu$ a on the test meter.

13. Connect the test meter 1M1 to the receiver discriminator jack. Set the AFC loop indicator to the zero position. If the discriminator reading is not zero, turn the oscillator frequency slug slowly until zero reading is obtained. Repeat the oscillator cathode tuning slug. Recheck to see if the discriminator is still zero.



14. Move the AFC motor disabling switch 1S3 to the ON position. If the AFC motor runs, as indicated by one of two lights on the transmitter panel, adjust the DC AMPL BIAS control until the motor stops when the discriminator reading on the test meter is zero.

15. Set the pointer on the "O" position of the AFC LOOP INDICATOR scale. Recheck the oscillator cathode tuning (left, bottom of cavity), for a maximum oscillator tuning current.

16. Adjust the receiver fault oscillator relay control. This adjustment is made by means of the potentiometer on the receiver/modulator unit marked REL OSC CONTROL. To adjust the control, first disconnect the antenna from the receiver, plug the meter lead into the SIG jack and note the noise reading on the meter. Reconnect the antenna to the receiver through the 20 db coaxial attenuator and detune the receiver cavity until a SIG reading of 20  $\mu$ a above the noise reading is obtained. Then turn the REL OSC CONTROL fully clockwise and then carefully counter-clockwise stopping when the relay clicks.

After the adjustment is made, be sure to retune the receiver cavity for a maximum signal and then remove the attenuator.

17. Set the frequency of the 110 mc oscillator in the receiver/modulator as follows:

Have a person at any other station in the direction being served by the receiver/modulator being adjusted, observe his "DISCR" reading with the system operating normally. Then remove the antenna connection to the receiver/modulator thus activating the 110 mc oscillator. Adjust the core (found on the rear of the receiver/modulator unit and labeled 110 mc OSC) of the 110 mc oscillator until the observer at the remote station has a discriminator reading the same as the original value.

18. Check the 70 mc drive to the transmitter. Disconnect the 70 mc cable at the transmitter end and connect it to the 70 mc dummy load (test equip. item 27(f)). The dc output of the 70 mc dummy load should be 1.0 volt or greater for two conditions. The first is with the receiver/modulator receiving its normal signal and the second is with the receiver input disconnected (and the 110 mc oscillator operating).

19. Recheck the tuning of the transmitter mixer and rf amplifier; tuning for a maximum output meter reading.

20. Normally, tuning adjustments will progress from one terminal to the other, through successive repeater stations. Therefore, only one receiver at a repeater will have a signal. However, the receiver/modulator and transmitter in the return circuit can be adjusted by reversing the antenna cable connections to the filters. Adjustment steps No. 3 through No. 19 can now be performed on the return circuit receiver/modulator and transmitter. Finally, reconnect the antenna cables to their proper filters.

21. Make the following preliminary service channel level adjustments:

a. At stations using a Repeater Service Unit, set the E-W INPUT and W-E INPUT controls at about half the total clockwise rotation. Adjust the OSC OUTPUT and MIKE OUTPUT controls at about half rotation but not so high that the calling tone or voice will cause the transmitter output to drop. Adjust the HANDSET VOLUME control to the desired listening level.

b. At stations using a Service Channel Unit, adjust the 2.0 KC LEV and MIC GAIN controls at about half rotation but not so high that the calling tone or voice will cause the transmitter output to drop. Adjust the volume control to the desired listening level.

Although the preceding adjustments can be made over the complete circuit without communicating with the other stations, a communication channel is at least a convenience and may save time as the adjustment proceeds from station to station.

22. After the complete circuit has been operating for at least 24 hours, the following steps should be taken:

a. Check the 40 mc oscillator frequency in the receiver/modulator units with a crystal-calibrated heterodyne frequency meter and set to the correct frequencies in accordance with the following instruction: (Use a Lampkin Frequency Meter, Type 105-B.)

(1) Connect a test lead from the RF jack of the meter to the 40 MC OSC FREQ jack of the receiver/modulator unit. Do not use the test lead plug for direct connection to the FREQ jack. Remove the plug and insert the loose wire end into the jack opening for capacitive pickup only.

(2) Vary the meter tuning dial for a zero beat with the loudest harmonic using a headset plugged into the meter. Read the dial to see if the 40 mc oscillator is on frequency. Remove the test lead from the FREQ jack, while a beat note is being heard, as a check to see if the signal actually is from the 40 mc oscillator.

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(3) If the 40 mc oscillator is off frequency, set the meter dial to the 40 mc frequency position. Remove the dust cover from the receiver/modulator and adjust the screw labeled 40 MC OSC for a zero beat. For precise information on the operation of the Lampkin frequency meter consult the instructions furnished with the unit.

NOTE: In case the receiver/modulator being adjusted is receiving a signal with service channel noise or modulation on it, it may be helpful to temporarily remove 2J12 while measuring the 40 mc oscillator frequency.

b. Set the pointer on the "O" position of the AFC LOOP INDICATOR scale.

c. Tune the transmitter cathode (lower left tuning screw) for a maximum oscillator current.

d. Maximize the r-f monitor current by tuning the mixer and amplifier (upper right and lower right tuning screws).

23. Perform the service unit level adjustments as follows:

a. At drop repeater stations using a repeater service unit:

(1) At a drop repeater station be sure that the lead to 6J12-2 is connected to the junction of resistors 6R62 and 6R63.

(2) Connect an audio voltmeter (Ballantine Model 300 or equivalent) to pin 2J12-2 and ground of either of the receiver/modulator units.

(3) Press the CALLING button and adjust the OSC OUTPUT control of the repeater service unit for a meter reading of 0.048 volt.

(4) With conditions the same as in (1) and (2) above, speak into the handset microphone and adjust the MIKE OUTPUT control of the repeater service unit for a meter reading of from 0.03 to 0.04 volt on voice peaks.

(5) Adjust the E-W INPUT and W-E INPUT controls to their maximum clockwise position.

(6) Adjust the HANDSET VOLUME control to the desired listening level.

b. At thru repeater stations using a repeater service unit:

(1) Check to see that the lead to 6J12-2 is connected to the junction of resistors 6R59 and 6R62.

(2) Connect an audio voltmeter (Ballantine Model 300 or equivalent) to pin 2J12-2 and ground of either of the receiver/modulator units.

(3) Press the CALLING button and adjust the OSC OUTPUT control of the repeater service unit for a meter reading of 0.048 volt.

(4) With the conditions the same as in a.(1) and (2) above, adjust the MIKE OUTPUT control of the repeater service unit for a meter reading of from 0.03 to 0.04 volt on voice peaks.

(5) Adjust the E-W INPUT and W-E INPUT controls to their maximum clockwise position.

(6) Adjust the HANDSET VOLUME control to the desired listening level.

c. At drop or thru repeater stations using a service channel unit:

(1) Check to see that the connections to the pads in the input to 23V1-A and in the output of 23V1-B of the service channel unit are correct for use at a drop or thru repeater station. Refer to the schematic diagram in the service channel unit instructions.

(2) Connect an audio voltmeter (Ballantine model 300 or equivalent) to pin 2J12-2 and ground of the receiver/modulator unit.

(3) Activate the CALL switch and adjust the 2.0 KC LEV control for a reading of 0.048 volt at 2J12-2.

(4) Adjust the MIC GAIN control for a meter reading of 0.03 to 0.04 volt at 2J12-2 on voice peaks.

(5) Adjust the VOLUME control to the desired listening level.

**General Systems Tuning**

After the system is set up and operating and before starting traffic thru the system, make the following system check.

a. Check the excess signal present at every receiver. This can be done by inserting the 10 db and 20 db pads (test item 9) between the receiving r-f filter and the receiver/modulator 2J1 input. With the pads inserted the service channel can be monitored to see if it is well quieted. Thus the path propagation can be checked roughly.

b. The match presented by the transmission line-antenna assemblies should be checked at every station. This should be done after the antenna and transmission line installation is complete and after the MA-20 Dehydrators have been in operation for at least a week if such are used.

The field directional coupler (test item 8) is used by inserting it between the tower base end of the transmission line and the T junction between the two RF filters. The values of V.S.W.R. measured will vary from station to station. In general values of 1.1 are

very good, 1.4 are fair, and values over 2.0 should be investigated for trouble.

**Channel Equipment Level Adjustments**

**General**

The output signal level of each voice channel from the multiplex equipment to the baseband unit and the input signal level of each voice channel from the baseband unit to the multiplex equipment should be the same at each terminal or drop repeater. The gain of the multiplex channel unit is usually set for -4 dbm or -6 dbm output with a 0 dbm tone at the multiplex voice input of the terminal or drop repeater station. All of the voice channelling equipment can be adjusted to the proper levels and the hybrid transformer balanced before it is connected to the microwave equipment. The proper loads must be placed on both the input and the output of the channelling equipment when adjusting levels. The instruction book on the channelling equipment should be followed in making the hybrid balance adjustment. Briefly this procedure is to apply a signal from an oscillator to the input of the channel unit receiver at the standard level, and with an electric voltmeter connected to the sideband output of the channel unit transmitter, adjust the hybrid balance resistor for a minimum output voltage. Remove the handset of the multiplex channel from the "hook" while making this adjustment.

Signal level adjustments in the baseband unit must be made so the correct frequency deviation is obtained on each channel signal and that the deviation is the same at drop repeaters and terminals. In installations where standby equipment is used, the deviation in both directions on a system must be the same so the standby transmitter and receiver can be used in either direction without causing a change in channel levels.

Two means of setting levels are described below. The first (Standardized Unit Level Setting) presumes the use of receiver/modulator units which have standardized input and output levels for the baseband signals. Receiver/modulator units are aligned in the factory test by setting the potentiometers 2R107 and 2R109 to these levels. The second (System Level Setting) describes a method in which deviation and levels may be set in the field.

**Level Settings (30 Channel Capacity System)**

**Standardized Unit Level Setting**

The signal levels which are considered as optimum values in the multiplex voice channel circuits are -26 dbm for the output level (with 0 dbm tone input

on the 2 wire termination) to the baseband unit and -10 dbm for the multiplex input level from the baseband unit.

Receiver/modulator units are adjusted in the factory test so that a 0.95 volt 5 kc tone at 2J12-2 will produce a deviation of the 40 mc modulated oscillator of  $\pm 1.5$  mc. The same deviation in the receiver/modulator i-f will produce an output at 2J12-5 of 0.38 volt. Assuming the above alignment, the transmit and receive levels at each station can be set without the cooperation of any other station.

The following table lists the levels for a typical example at different points in the circuit.

**TABLE S-4  
 BASEBAND LEVEL SUMMARY  
 (30 CHANNEL)**

Transmitting		
Item	Voice Channels	Tone Channels
A Input to baseband (600 ohms)	-26 dbm	-36 dbm
B 2J12-2 voltage	0.071 v	0.023 v
C Metered dbm at 2J12-2 with 1 db Sierra loading factor	-21.7 dbm	-31.7 dbm
D Deviation	112 kc	36 kc
Receiving		
Item	Voice Channels	Tone Channels
E Deviation	112 kc	36 kc
F 2J12-5 voltage	0.028 v	0.0089 v
G Metered dbm at 2J12-5 with 1.5 db Sierra loading factor	-29.7 dbm	-39.7 dbm
H Output from baseband into resistive 600 ohms	-10 dbm	-20 dbm

NOTE: The procedure for using the Baseband Level Summary table (Table S-4) is as follows:

**Transmitting Levels**

1. Apply a 5 kc tone to the baseband unit input termination panel (terminals 32 and 33) at a level of -26 dbm.
2. Measure the voltage at 2J12-2 with an electronic voltmeter.
3. Adjust the baseband transmitting amplifier attenuator (4AT1) connections to the terminals most nearly giving 0.071 volt at 2J12-2.

**Receiving Levels**

1. Remove tube 2V15 from the receiver/modulator to remove existing signals from the receiver output,

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2. Attach an audio oscillator between 2J12-5 and ground. Adjust it to supply .028 volt at 5 kc.

3. Replace whatever load is on the baseband output (termination panel terminals 35 and 36) with a 600 ohm resistor and measure the voltage across this resistor.

4. Adjust the baseband receiving amplifier attenuator (4AT2) connections to the terminals most nearly giving a baseband output of -10 dbm to the channelling equipment.

If the other channels are active and cannot be removed at the time a particular level is being set, a Sierra or other tuned voltmeter can be used. In this case the individual channel level can be measured at the baseband input, or output or at 2J12. If a Sierra voltmeter with a 10,000 ohms input impedance is used, some loading of the circuits at 2J12 will be experienced when the readings are taken at 2J12. A reading at 2J12-2 of -21.7 dbm (item C of table 4) on the Sierra voltmeter indicates that the correct voltage level (.071 v) is present at the input to the modulator section of the receiver/modulator unit. This reading (-21.7 dbm) takes into account the 1 db loading present when a Sierra voltmeter is used. Likewise a Sierra voltmeter reading at 2J12-5 of -29.7 dbm (item G of table 4) indicates that the correct voltage (.028 v) is present at the input to the receiving amplifier of the baseband unit. The -29.7 dbm reading takes into account the 1 db loading of the meter.

**System Level Setting**

If the system levels do not appear to be uniform, the following adjustments can be made either at one station or throughout the system.

Adjust each multiplex voice channel gain so the output is -26 dbm with a 2 wire input of 0 dbm. Connect an audio oscillator through a 5,000 to 10,000 ohm series resistor to a 600 ohm load on the 2 wire voice channel input. Connect an electronic voltmeter such as a Ballantine model 300 or Hewlett Packard 4000 to the 2 wire voice channel input and adjust the audio oscillator for 1000 cycles and 0 dbm. Move the voltmeter to the channel output and adjust the channel modulator gain for -26 dbm. The channel output must be loaded with 600 ohms.

The channel output can be loaded either by connection to the baseband input or it can be removed from the circuit and loaded with a 600 ohm resistor. After the hybrid balance has been adjusted, the channel levels should be rechecked as just described.

NOTE: If group modulators and demodulators are used in the multiplex equipment, gain adjustments should be as low as possible in the demodulators and as high as possible in the group modulators and the individual channel gains correspondingly adjusted in order to maintain the proper levels of 0 dbm tone input for -26 dbm sideband output and -10 dbm sideband input with -4 to -6 dbm tone output. Otherwise, excessive intermodulation may occur in the channelling equipment.

The above adjustments to the multiplex equipment should be made at each terminal and drop repeater station when performing the signal level adjustment procedure described below: It is preferable to use two men when performing this procedure. To simplify the description the two men are designated as "A" and "B."

1. A is at the east terminal and B is at the first repeater.

2. A sets the 40 mc modulated oscillator to 1.5 mc deviation by adjusting 2R109 with a 0.95 v, 5 kc tone at 2J12-2 using a modulation test set (test item 11) or a TV calibrator.

3. B adjusts 2R109 of the E-W, W-E and standby receiver/modulator units the same as in step 2 above.

4. A applies a 0.95 v, 5 kc tone at 2J12-2 and B adjusts 2R107 of the E-W receiver/modulator to read 0.38 v at 2J12-5.

5. B reverses the antenna connections and adjusts 2R107 of the W-E receiver/modulator to read 0.38 v at 2J12-5 on a signal from A.

6. B returns the antennas to their normal connections, switches to standby and adjusts 2R107 of the standby receiver/modulator to read 0.38 v at 2J12-5 on a signal from A.

7. B applies a 0.95 v, 5 kc tone at 2J12-2 of the W-E receiver/modulator and A adjusts 2R107 to read 0.38 at 2J12-5.

8. B reverses antennas and applies a 0.95 v, 5 kc tone at 2J12-2 of the E-W receiver/modulator. A should read 0.38 v at 2J12-5.

9. B switches to standby and applies a 0.95 v, 5 kc tone at 2J12-2 of the standby receiver/modulator. A should read 0.38 v at 2J12-5.

10. A remains at the east terminal while B proceeds to the next repeater and adjusts R109 of the W-E receiver/modulator while applying a 0.95 v, 5 kc tone at 2J12-2 until A reads 0.38 at 2J12-5.

11. B then adjusts 2R107 of the E-W receiver/modulator for 0.38 v at 2J12-5 on a signal from A.

12. B switches to standby and adjusts 2R107 of the standby receiver/modulator for 0.38 at 2J12-5 on a signal from A.

13. B reverses antennas and adjusts 2R107 in the W-E receiver/modulator for 0.38 v at 2J12-5 on a signal from A.

14. B adjusts 2R109 of the E-W receiver/modulator while applying a 0.95 v, 5 kc tone at 2J12-2 until A reads 0.38 v at 2J12-5.

15. B switches to standby and adjusts 2R109 of the E-W receiver/modulator while applying a 0.95 v, 5 kc tone at 2J12-2 until A reads 0.38 v at 2J12-5. B returns the antennas to their normal connections.

16. B proceeds to each of the remaining repeater stations in the system and repeats steps 10 through 15 at each station.

17. When B reaches the west terminal all systems levels have been set to the same standard and only one trip is required. Local baseband and service channel levels can be set by B while at each station.

**Level Settings (120 Channel Capacity System)**

The signal levels which are considered as optimum values in the multiplex voice channel circuits are -26 dbm for the output level (with 0 dbm tone input on the 2 wire termination) to the baseband unit and -20 dbm for the multiplex input level from the baseband unit.

Receiver/modulator units are adjusted in the factory test so that a 0.95 volts 5 kc tone at 2J12-2 will produce a deviation of the 40 mc modulated oscillator of  $\pm 1.5$  mc. The same deviation in the receiver/modulator i-f will produce an output at 2J12-5 of 0.38 volt. Assuming the above alignment, the transmit and receive levels at each station can be set without the cooperation of any other station.

The following table lists the levels for a typical example at different points in the circuit.

**TABLE S-5  
 BASEBAND LEVEL SUMMARY  
 (120 CHANNEL)**

Transmitting		
Item	Voice Channels	Tone Channels
A Input to baseband (135 ohms)	-26 dbm	-36 dbm
B 2J12-2 voltage	0.071 v	0.023 v
C Metered dbm at 2J12-2 with 1 db Sierra loading factor	-21.7 dbm	-31.7 dbm
D Deviation	112 kc	36 kc

Receiving		
Item	Voice Channels	Tone Channels
E Deviation	112 kc	36 kc
F 2J12-5 voltage	0.028 v	0.0089 v
G Metered dbm at 2J12-5 with 1 db Sierra loading factor	-29.7 dbm	-39.7 dbm
H Output from baseband into resistive 135 ohms	-20 dbm	-30 dbm
I Metered dbm at baseband output using Sierra calibrated for 600 ohms	-26.5	-36.5

NOTE: The procedure for using the Baseband Level Summary table (Table S-5) is as follows:

**Transmitting Levels**

1. Apply a 5 kc tone to the baseband unit input termination panel (terminals 32 and 33) at a level of -26 dbm.

2. Measure the voltage at 2J12-2 with an electronic voltmeter.

3. Adjust the baseband transmitting amplifier attenuator (4AT1) connections to the terminals most nearly giving 0.071 volt at 2J12-2.

**Receiving Levels**

1. Remove tube 2V15 from the receiver/modulator to remove existing signals from the receiver output.

2. Attach an audio oscillator between 2J12-5 and ground. Adjust it to supply 0.028 volt at 5 kc.

3. Replace whatever load is on the baseband output (termination panel terminals 35 and 36) with a 135 ohm resistor and measure the voltage across this resistor.

4. Adjust the baseband receiving amplifier attenuator (4AT2) connections to the terminals most nearly giving a baseband output of -20 dbm to the channelling equipment.

If the other channels are active and cannot be removed at the time a particular level is being set, a Sierra or other tuned voltmeter can be used. In this case the individual channel level can be measured to the baseband input, or output or at 2J12. If a Sierra voltmeter with a 10,000 ohms input impedance is used, some loading of the circuits at 2J12 will be experienced when the readings are taken at 2J12. A reading at 2J12-2 of -21.7 dbm (item C of table 5) on the Sierra voltmeter indicates that the correct voltage level (.071 v) is present at the input to the modulator section of the receiver/modulator unit. This reading

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(-21.7 dbm) takes into account the 1 db loading present when a Sierra voltmeter is used. Likewise a Sierra voltmeter reading at 2J12-5 of -29.7 dbm (item G of table 5) indicates that the correct voltage (.028 v) is present at the input to the receiving amplifier of the baseband unit for adjusting attenuator 4AT2. The -29.7 dbm reading takes into account the 1 db loading of the meter.

### System Level Setting

If the system levels do not appear to be uniform, the following adjustments can be made either at one station or throughout the system.

Adjust each multiplex voice channel gain so the output is -26 dbm with a 2 wire input of 0 dbm. Connect an audio oscillator through a 5,000 to 10,000 ohm series resistor to a 600 ohm load on the 2 wire voice channel input. Connect an electronic voltmeter such as a Ballantine model 300 or Hewlett Packard 400C to the 2 wire voice channel input and adjust the audio oscillator for 1000 cycles and 0 dbm. Move the voltmeter to the channel output and adjust the channel modulator gain for -26 dbm. The channel output must be loaded with 135 ohms.

The channel output can be loaded either by connection to the baseband input or it can be removed from the circuit and loaded with a 135 ohm resistor. After the hybrid balance has been adjusted, the channel levels should be rechecked as just described.

NOTE: If group modulators and demodulators are used in the multiplex equipment, gain adjustments should be as low as possible in the demodulators and as high as possible in the group modulators and the individual channel gains correspondingly adjusted in order to maintain the proper levels of 0 dbm tone input for -26 dbm sideband output and -10 dbm sideband input with -4 to -6 dbm tone output. Otherwise, excessive intermodulation may occur in the channelling equipment.

The above adjustments to the multiplex equipment should be made at each terminal and drop repeater station when performing the signal level adjustment procedure described below: It is preferable to use two men when performing this procedure. To simplify the description the two men are to be designated as "A" and "B".

1. A is at the east terminal and B is at the first repeater.

2. A sets the 40 mc modulated oscillator to 1.5 mc deviation by adjusting 2R109 with a 0.95 v, 5 kc tone at 2J12-2 using a modulation test set (test item 11) or a TV calibrator.

3. B adjusts 2R109 of the E-W, W-E and standby receiver/modulator units the same as in step 2 above.

4. A applies a 0.95 v, 5 kc tone at 2J12-2 and B adjusts 2R107 of the E-W receiver/modulator to read 0.38 v, at 2J12-5.

5. B reverses the antenna connections and adjusts 2R107 of the W-E receiver/modulator to read -0.38 v at 2J12-5 on a signal from A.

6. B returns the antennas to their normal connections, switches to standby and adjusts 2R107 of the standby receiver/modulator to read 0.38 v at 2J12-5 on a signal from A.

7. B applies a 0.95 v, 5 kc tone at 2J12-2 of the W-E receiver/modulator and A adjusts 2R107 to read 0.38 v at 2J12-5.

8. B reverses antennas and applies a 0.95 v, 5 kc tone at 2J12-2 of the E-W receiver/modulator. A should read 0.38 v at 2J12-5.

9. B switches to standby and applies a 0.95 v, 5 kc tone at 2J12-2 of the standby receiver/modulator. A should read 0.38 v at 2J12-5.

10. A remains at the east terminal while B proceeds to the next repeater and adjusts 2R109 of the W-E receiver/modulator while applying a 0.95 v, 5 kc tone at 2J12-2 until A reads 0.38 v at 2J12-5.

11. B then adjusts 2R107 of the E-W receiver/modulator for 0.38 v at 2J12-5 on a signal from A.

12. B switches to standby and adjusts 2R107 of the standby receiver/modulator for 0.38 at 2J12-5 on a signal from A.

13. B reverses antennas and adjusts 2R107 in the W-E receiver/modulator for 0.38 v at 2J12-5 on a signal from A.

14. B adjusts 2R109 of the E-W receiver/modulator while applying a 0.95 v, 5 kc tone at 2J12-2 until A reads 0.38 v at 2J12-5.

15. B switches to standby and adjusts 2R109 of the E-W receiver/modulator while applying a 0.95 v, 5 kc tone at 2J12-2 until A reads 0.38 v at 2J12-5. B returns the antennas to their normal connections.

16. B proceeds to each of the remaining repeater stations in the system and repeats steps 10 through 15 at each station.

17. When B reaches the west terminal all systems levels have been set to the same standard and only one trip is required. Local baseband and service channel levels can be set by B while at each station.

### OPERATIONAL CHECKS

After all the stations have been put into operation a check of the operation of the entire system should be made.

1. Check the service channel operation by voice communicating from a terminal station with each of the other stations of the system. Pressing the CALL button will sound a buzzer to alert each station. Voice communication from the terminal to each repeater will prove that the system is operating satisfactorily.

2. Check the system for correct operation of the fault equipment. Cause a fault at a repeater station (disconnect the receiver signal input cable, for example) and check for the correct indication on the lamp panel at the terminal station. This should be done at each repeater station in the system. This checks the fault sending equipment at the repeaters as well as the terminals fault receiving and indicating apparatus. A check of each of the other faults may be done in the same manner.

3. Orient the antennas at each station for maximum pickup at the next station. Move the reflector in the horizontal plane only. Establish communication from the rack to the man at the antenna and direct the antenna movement while contacting via the service channel the person observing the metered signal strength at the receiver of the next station.

With all the above steps completed the relay system is in condition to handle traffic. With the frequency division multiplex channelling equipment connected to the termination panel of the microwave equipment rack at the terminal and drop repeater stations, the complete microwave system is ready for operation.

After the complete relay system has been fully adjusted and giving normal operating service, check each station of the system and record the meter readings at every position of each switch and at all test jacks of all the units. Enter the meter readings on a permanent record for reference when making routine checks. This will provide up to date operating data on the equipment to speed servicing in the event of a possible breakdown. It is advisable to have an instruction book of the equipment assigned permanently to each station and containing all the individual information and data on that particular station.

Once in operation the microwave relay system remains in 24-hour-a-day operation. Periodic operational maintenance checks of the terminal station equipment and operational tests of the entire relay system from the terminal station should be made daily. Regularly scheduled inspections should also be made at repeater stations in addition to the test from the terminal stations.

### OPERATION

After the Initial Adjustments have been completed the stations are ready for operation on a 24-hour-a-day schedule and are prepared to handle the communication channels of the microwave system. After being put into service the transmission of the microwave signal is continuous and the stations perform their function without attention from the operator except for occasional operational checks as described in the maintenance section.

To put the stations into operation, the only requirement is to apply power to the equipment units. Move the power switch of the power supply to the LINE position. The red jewel will glow indicating that the power is on. After one minute turn on the 500 V switch of the power supply. This completes

the application of power to the microwave equipment and the station is ready for full-time operation. After the equipment has warmed up, check the transmitter output and the meter readings at all the check points to see that the apparatus is functioning properly.

With the multiplex equipment connected at terminal and drop repeater stations the relaying of the signal channels will be accomplished throughout the microwave system automatically on an around-the-clock schedule.

Service channel voice communication can be performed by pressing the CALLING pushbutton to alert the attendants of the other stations and then talking with them, using the telephone handset.

**MAINTENANCE**

**SYSTEM MAINTENANCE**

Operating personnel are generally present at terminal stations a large part of each day so that the system may be checked several times a day to insure top performance by detecting possible troubles before they occur. Repeater stations should be visited periodically for maintenance checks. Any variance from normal operation should be watched to prevent deterioration of, or complete loss of, signal anywhere in the system.

**Maintenance Notes**

- a. Call and talk to another station to check the operation of the service channel system.
- b. To test the fault indicating circuit of a terminal station, press the LIGHT TEST button and note if all the neon lamps on the indicator panel light up.
- c. To check the fault circuit of a repeater station, press the TEST button and call the terminal station to see if the correct indicator lamps light.
- d. It is recommended that periodically the 40 mc oscillators in the receiver/modulator units of the entire system be checked and set on frequency if necessary.

e. To insure the most reliable operation of the transmitter units, a test can be performed on each unit as a service man makes a periodic station check. It consists of monitoring the 2C39B oscillator cathode current while slightly detuning the oscillator anode cavity (the top left cavity). The top left tuning screw can be grasped and alternately pushed down and pulled up. During the excursion the cathode current should vary symmetrically about the maximum value which should occur at the normal undeformed position. During the test turn the AFC disabling switch 1S3 "OFF" to prevent the transmitter AFC circuit from operating.

In addition to the above, the position of the AFC loop in the oscillator anode cavity should be checked and maintained at 45° by setting the pointer on the "O" position of the AFC LOOP INDICATOR scale.

f. It is recommended that a technical log be prepared at each station for recording actual operating values and data observed under normal operating conditions. This log should include entries for all meter readings which can be taken with the transmitter test meter 1M1, using the test meter lead. Also record all other pertinent data. Use table S-6 as a guide in preparing the station technical log.

**TABLE S-6  
 TEST MEASUREMENTS**

<b>TERMINAL STATION</b>		
<b>Transmitter</b>		
<i>Circuit</i>	<i>Test Equipment</i>	<i>Data</i>
B+ (250 v dc) . . . . .	Meter sw. & Meter 1M1	µa
B+ (500 v dc) . . . . .	Meter sw. & Meter 1M1	µa
Oscillator current . . . . .	Meter sw. & Meter 1M1	ma
Mixer current . . . . .	Meter sw. & Meter 1M1	ma
Amplifier current . . . . .	Meter sw. & Meter 1M1	ma
70 MC Input Signal (1J9) . . . . .	Meter sw. & Meter 1M1	µa
AFC loop position . . . . .		degrees
RF Monitor . . . . .		µa
<b>Receiver/Modulator</b>		
<i>Circuit</i>	<i>Test Equipment</i>	<i>Data</i>
Xtal current . . . . .	Meter 1M1 . . . . .	µa
Signal reading on signal . . . . .	Meter 1M1 . . . . .	µa
Signal reading on noise Discriminator . . . . .	Meter 1M1 . . . . .	µa
40 MC Osc. Cathode current (2J14) . . . . .	Meter 1M1 . . . . .	µa
40 MC Osc. frequency	Test Item 13 . . . . .	mc
110 MC Osc. frequency	Test Item 13 . . . . .	mc
Lockout current . . . . .	Meter 1M1 . . . . .	µa
70 MC dummy load voltage . . . . .	Test Items 1 & 27 (f)	volts
Fault relay operating point . . . . .	"SIG"	µa
<b>Terminal AFC Unit</b>		
<i>Circuit</i>	<i>Test Equipment</i>	<i>Data</i>
Oscillator Grid current	Meter 1M1 . . . . .	ma
Mixer Crystal current	Meter 1M1 . . . . .	ma
Limiter current . . . . .	Meter 1M1 . . . . .	ma
Discriminator current	Meter 1M1 . . . . .	ma
55 MC Osc. Grid current . . . . .	Meter 1M1 . . . . .	ma
<b>REPEATER STATION</b>		
<b>Transmitter (E-W and W-E)</b>		
<i>Circuit</i>	<i>Test Equipment</i>	<i>Data</i>
B+ (250 v dc) . . . . .	Meter sw. & Meter 1M1	µa
B+ (500 v dc) . . . . .	Meter sw. & Meter 1M1	µa
Oscillator current . . . . .	Meter sw. & Meter 1M1	ma
Mixer current . . . . .	Meter sw. & Meter 1M1	ma
Amplifier current . . . . .	Meter sw. & Meter 1M1	ma
70 MC Input Signal (1J9) . . . . .	Meter sw. & Meter 1M1	µa
AFC loop position . . . . .		degrees
RF Monitor . . . . .		µa



Receiver/Modulator (E-W and W-E)		
Circuit	Test Equipment	Data
Xtal current .....	Meter 1M1 .....	$\mu$ a
Signal reading on signal .....	Meter 1M1 .....	$\mu$ a
Signal reading on noise .....	Meter 1M1 .....	$\mu$ a
Discriminator .....	Meter 1M1 .....	$\mu$ a
40 MC Osc. Cathode current (2J14) ....	Meter 1M1 .....	$\mu$ a
40 MC Osc. frequency .....	Test Item 13 .....	mc
110 MC Osc. frequency .....	Test Item 13 .....	mc
Lockout current .....	Meter 1M1 .....	$\mu$ a
70 MC dummy load voltage .....	Test Items 1 & 27 (f)	volts
Fault relay operating point .....	"SIG"	$\mu$ a

The station's technical log will aid in determining when tubes need changing. In general no tube should be replaced unless there is strong evidence of cumulative deterioration as indicated by a change of grid current, cathode current, received signal current or other measured quantity.

### SYSTEM TROUBLE SHOOTING

The microwave relay equipment is designed for continuous operation. Systematic trouble shooting will aid in maintaining continuous service. By means of the fault locating equipment at all terminal stations, the station at fault and the type of trouble can be determined immediately after the trouble occurs. The station in trouble and the type of trouble is read directly from the fault indicating light panel on the service unit, with the aid of the system fault code.

The service personnel can be quickly dispatched to the station at fault and the traffic promptly restored by replacing the faulty unit with a spare unit which has been pre-tested and held in reserve for immediate use. The faulty unit can then be repaired and kept in readiness for future use.

### STATION MAINTENANCE

The station equipment requires little servicing to maintain it in proper working order. However to avoid interruption of service and keep it at peak performance a regular schedule of inspection at all terminal and repeater stations should be established. Routine checks should cover the following items:

a. *Cleanliness* — Keep equipment clean and free of all dust and dirt by the use of a brush or dry air blast, especially around terminal boards and relay terminals.

b. *Tightness* — Check against all looseness, that all terminal connections are tight, that tubes and crystal units are firmly seated in their sockets and that cable connectors are firmly in place.

c. *Relays* — Keep the relay contacts clean to assure good connections during operation. Clean when necessary by applying carbon tetrachloride to the contact surfaces with a soft brush. Pitted or burned contacts should be polished with crocus cloth or burnished with a burnishing tool or, if too badly damaged, replaced.

d. *Fuses* — The line fuse should be checked if the pilot light fails to light. Fuses should not be replaced until circuits have been checked. When replacing a fuse, always use one with the same current rating as that of the original.

### STATION TROUBLE SHOOTING

a. When a station fails to function causing an interruption in service, the chief consideration is to restore the station to service with the least amount of delay. It is desirable to have pre-tested duplicate units available for exchange with a faulty unit. The faulty unit may be repaired at a service shop later. The service man at a terminal station knows which station is the faulty one and the nature of the trouble from the lights displayed on the fault indicator panel. Upon arrival at the faulty station the trouble can be localized to a specific unit and the unit replaced with another. However, before replacing any unit that may not really need repair, the following checks should be made.

1. *Tube operation* — Check the tube filaments for glow or warmth. Check metering indications for normal tube operation.

2. *Interconnection cables* — Check for obvious faults such as poor connections, damaged wires and plugs.

3. *Frequency and Tuning Adjustments* — Check frequencies, tuning adjustments and metering indications.

4. Check voltages at pinjacks on the front panel.

5. Check for defective crystals.

6. Check antenna and its connecting cables.

b. If the failure of the entire station equipment is sudden and complete it is usually due to a blown fuse in the power supply. Replace it with one of the same value after first ascertaining that there is no trouble present which will cause the fuse to keep blowing repeatedly.

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TABLE S-7  
FIELD TEST EQUIPMENT

1. Voltohmyst (RCA Model WV-97A)	5. TV Calibrator (RCA WR-89A)
2. Audio Oscillator (Hewlett-Packard 200C or 200CD)	6. Wavemeter (RCA MI-31028)
3. Electronic Voltmeter (Ballantine Model 300 or equivalent)	7. AC Voltmeter rms reading (Weston 433)
4. Oscilloscope of minimum vertical sensitivity, 11 rms microvolts per inch deflection (RCA WO-56A)	8. RCA Field Directional Coupler
	9. 10 db and 20 db 50 ohm coaxial pads (RCA MI-31037-A, -B)
	10. Voltohmmeter (Simpson 260)

TABLE S-8  
MAINTENANCE CENTER TEST EQUIPMENT

11. Distortion Modulation Test Unit (RCA MI-31023-A)	21. Ferris Microvolter (Model 18C)
12. Megacycle meter (Measurements Corp. Model 59)	22. Hewlett-Packard R.F. Voltmeter Model 410B (not more than 3 mmf input)
13. Lampkin Frequency Monitor (Model 105B)	23. Spare Terminal AFC with crystal
14. 200 $\mu$ a-660 ohm meter	24. Spare Receiver/Modulator
15. Headphones	25. Spare Transmitter
16. Signal Generator 20-80 mc (Measurements Corp. Model 80)	26. Spare Baseband
17. Signal Generator 1700-2700 mc (Hewlett-Packard 616A)	27. Receiver/Modulator Test Kit consisting of:
18. IF Sweep Generator as follows: center frequencies: 20 mc, 30 mc and 70 mc; marker frequencies 25.6 mc, 30 mc, 34.4 mc, 64 mc and 76 mc; sweep range: 15 mc or greater; output: 15 v or greater; suggested unit—Kay Electric Rada-sweep modified as above	a. 10 mf., 350 v electrolytic capacitor with 3" leads with clips
19. Power Supply to deliver +250 v dc at 300 ma max. with less than .030 v rms ripple	b. Resistor network made of 1/2 watt Allen Bradley resistors (see figure RM-8)
20. Power Supply (Douglas Laboratories Model AM-1 300 ma, 500 v)	c. IF Alignment Jig (see figure RM-6)
	d. 10 microhenry r-f choke with 1" leads
	e. 1500 mmf ceramic disk capacitor mounted on the end of an insulated stick support. The leads shall be no more than 3/8" long.
	f. 70 mc dummy load (see figure RM-7)
	28. MI-31019-B Handset

If trouble persists after checking the fuse, the next step is to check the tubes. Do this by the substitution method, putting in a known good tube to detect the weak or bad tube.

c. If the preceding tests do not identify and correct the trouble, one or more of the circuit components may need to be replaced. Routine procedure used in servicing and locating faulty components in equipment of this type in general may be applied in making repairs on these units. The values of the various components are shown on the schematic diagrams of each of the units.

NOTE: When performing maintenance work on the separate units you will find that certain tuning cores in the receiver/modulator, transmitter and terminal AFC units will be sealed with a rubber like material. These are not to be retuned for any reason. They are parts of factory aligned broadband circuits. If one of these coils should open up or become damaged, installing a replacement unit with its core turned in approximately the same amount as in the original coil will be preferable to realigning the whole circuit. However, if complete realignment of any of the units is necessary do not undertake it without complete familiarity with the equipment and the complete set of recommended test equipment.

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**TEST EQUIPMENT**

Tables S-7 and S-8 list the test equipment required for servicing the CW-20A (MM-20A) and MM-26A microwave radio equipment. (It does not include test equipment necessary for maintenance of multiplex or other equipment.)

Table S-7 is a list of the test items essential for field maintenance only.

Tables S-7 and S-8 lists the test items necessary for maintenance work at major repair centers where complete alignment of the units will be done.

**ANTENNA ASSEMBLY****General Notes**

a. The entire antenna assembly should be inspected at reasonable intervals so see that all cable connections are tight and that the mounting hardware is firmly fastened. Be sure that there is no water leakage at any joint or that there are no air leaks in pressurized installations.

b. At pressurized installations the air pressure should be checked on all possible occasions and brought up to 5 lbs. at installations using a manually operated pump.

c. At pressurized installations utilizing the transmitter blower and containing a Type MA-20 Dehydrator, the following checks should be made several times a year:

**1. Check for Silica Gel Activation**

When the color of  $\frac{3}{4}$  of the silica gel has turned from blue to red it should be replaced or reactivated. Silica gel may be reactivated by heating in an oven until the blue color returns.

**2. Fluid Check**

Loosen the top thumb screws and lift the top casting to relieve excess transmission line pressure. This will allow any fluid in the reservoir to drain. If the level of the fluid in the window is below the center of the black dot more than  $\frac{1}{16}$ " while the top cap is loose, add fluid to raise the level to the dot. If the level is above the center of the dot while the top cap is loose, drain the excess fluid by means of the bottom drain valve until the surface of the fluid is level with the center of the dot.

3. The fluid should be completely drained and replaced every two to five years.

d. If the parabolic reflector is mechanically damaged, the circuit operating conditions can be checked to determine if electrical damage has been done. The average signal for the path can be noted. The standing wave ratio into the antenna can be measured using the Field Directional Coupler.

e. Periodically, perhaps once a year, the standing wave ratio of the transmission line-antenna assembly should be checked using the Field Directional Coupler.

**REPLACEMENT PARTS LIST FOR ACCESSORIES**

	Description	Drawing No.	Stock No.
<b>TELEPHONE HANDSET MI-31019-B</b>			
	Cable, 3 conductor, coiled type, rubber covered, less connector		50471
	Cap, earcap		207561
	Connector, male, phone type		32171
	Contacts, telephone handset transmitter set of 2		209559
	Mouthpiece		209560
	Receiver, telephone handset receiver mechanism only		209557
	Switch, push, s.p.s.t. momentary, normally closed		209558
	Transmitter, telephone handset transmitter mechanism only		209556
<b>CABINETS — MI-30922-A SERIES</b>			
	Connector, female, 2 contact A.C., chassis mounting	8843737-1	95591
<b>AIR FILTER KIT MI-31027-A</b>			
	Boot, canvas blower boot, 6-5/16 dia. x 2" lg., wool gabardine	8832079-2	206490
	Screw, thumb, #10-32 x 1/2" lg., with 7/16" dia. knurled head	99017-4	30680

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	<i>Description</i>	<i>Drawing No.</i>	<i>Stock No.</i>
<b>RF CABLES MI-31031 SERIES</b>			
	Connector, male, coaxial type "N" cable mounting	146978-502	96579
<b>INTERCONNECTING CABLES MI-31499-A, -B, -C, -D, -E, -G, -J, -K, -L SERIES</b>			
	Clamp, cable, molded white nylon, for $\frac{3}{8}$ " dia. cable (for MI-31499-L-45 only)	8811154-5	210391
	Connector, female, 6 contacts, cable mounting type, complete with cable clamps (for MI-31499-A, B, C, D, E, G and L only)	449614-7	95555
	Connector, male, 6 contact, cable mounting type (for MI-31499-A, B, C, D, E, G and L only)	181494-2	28454
	Connector, male, 33 contact, cable mounting (for MI-31499-J only)	474200-8	205747
	Connector, female, 33 contact, cable mounting (for MI-31499-K only)	474200-9	205873
	Connector, female, 21 contact, cable mounting (for MI-31499-L-45 only)	449653-9	207192
	Connector, male, 12 contact, cable mounting (for MI-31499-L-33 only)	449614-3	59744

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**DUPLEX FILTER MI-31497, MI-31113****DESCRIPTION**

The duplex filters MI-31497 and MI-31113 consist of one transmitter and one receiver filter, an antenna tee connector, and the transmission line to connect the tee to the filters. They are mounted atop the equipment rack at the time of installation and are installed at all stations. Terminal stations require one duplex filter and repeater stations two, one for E-W and one for W-E operation. The MI number has suffix letter-number designations which are allotted to the prescribed system frequencies. The complete MI number required for any installation depends on the set of frequencies assigned to the system. The frequency designation column of the TYPICAL SYSTEM FREQUENCIES chart shows the letter-number suffix combinations for certain sets of frequencies used by CW-20A (MM-20A) and MM-26A microwave systems.

The purpose of the filters is to allow the use of one antenna for both receiving and transmitting. The transmitter filter is sufficiently selective to accept only the transmitted frequencies and prevents the incoming microwave signal, which is separated from the transmitted frequency by 40 mc, from entering the transmitter output circuit. The receiver filter prevents the transmitter signal from entering the receiver input.

The filters are adjusted in the factory and are labeled with the frequency to which they are tuned. The units are symmetrical so that either terminal may be connected to the antenna. The alignment of these filters can be seriously disturbed if the units are bent or stressed, consequently the following note of caution attached to each unit must be strictly observed.

**WARNING**

This filter is a precision instrument. It must not be dropped. Avoid any bending or compression of the filter.

The alignment of the r-f filters is a job requiring test equipment and techniques not usually available in the field. Consequently, the filters should be handled carefully so as to avoid deformation. *The filter tuning slugs are not to be adjusted for any reason.*

Note that the length of the coaxial sections connecting each filter to the antenna "T" must be of the proper length for the operating frequencies.

If either the filters or the coaxial sections are damaged, they must be returned to the factory for retuning. The transmitting and receiving frequencies must be specified.

**REPLACEMENT PARTS LIST**

	Description	Drawing No.	Stock No.
<b>DUPLEX FILTER MI-31497-D, F, H, K</b>			
	Connector, female, tee, coaxial type, cable mounting	8845691-1	95396
	Connector, male, coaxial, chassis mounting type, including 0.511" lg. probe, silver plated (receiver and transmitter probe)	474728-506	207806
	Core, brass tuning core, 3/8-24 thread, 1 3/8" lg.	8831031-3	206315
	Gasket, silicone rubber, 3/8" O.D. x 5/16" I.D. x 0.062 thk.	895807-15	207805
	Nut, hex, brass 3/8-24 thread for tuning core and connector probe assembly	874927-6	95395
	Washer, spring, for tuning core and probe assembly	8903734-1	207380
<b>DUPLEX FILTER MI-31113-A, B, C, D, E</b>			
	Filter (Receiver)	474719-501	
	Filter (Transmitter)	474715-501	
	(Not stocked complete — Following parts only stocked)		
	Connector, male, coaxial, chassis mtg. type, including 0.402 lg. probe (receiver probe)	474728-503	206316
	Connector, male, coaxial, chassis mtg. type, including 0.280 lg. probe (transmitter probe)	474728-504	206317
	Core, brass tuning core, 3/8-24 thread x 1-1/16" lg.	8831031-1	95393

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	<i>Description</i>	<i>Drawing No.</i>	<i>Stock No.</i>
	Nut, hex, brass 5/8-24 thread (for tuning core and connector probe assembly)	874927-6	95395
	Washer, spring, beryllium copper, for tuning core and probe assembly	8831068-2	95394
	<i>Miscellaneous:</i> Connector, female, tee, coaxial cable mounting	8845691-1	95396

## LINE TERMINATION PANEL MI-31056-A, MI-31156

### DESCRIPTION

A Line Termination Panel is used at all microwave stations and is located in the bottom position of the equipment rack. It is used for making the connections from the microwave equipment to equipment external to the rack and for the 115 v ac power input connections. Connections from the rack units to the line termination panel are made to Jones plugs 8J1 through 8J7 via cables supplied with the station equipment. Internally the Jones plugs are connected to terminal boards 8TB1 and 8TB2. The external connections are made to terminal board 8TB1 and 8TB2. Figures S-10 and S-11 show the external power supply, service unit and baseband unit connections to terminal

boards 8TB1 and 8TB2. These connections are completed to the equipment units through Jones plugs 8J1, 8J2 and 8J3. The connections to Jones plugs 8J4 to 8J7 and the external connections to their 8TB1 and 8TB2 terminations will vary depending on the system in which the panel is used. MI-31156 may also be equipped to provide for the additional connections required when information from the indicon units is extended. See the notes of figure S-11 for a description of these connections.

**CAUTION:** When making the 115 v ac power connections to the line termination panel be sure that the grounded side of the line is connected to terminal 1 of 8TB1.

### REPLACEMENT PARTS LIST

Symbol No.	Description	Drawing No.	Stock No.
<b>LINE TERMINATION PANEL MI-31056-A</b>			
8J1, 8J2	Connector, male, 6 contact, chassis mounting type	181494-3	28507
8J3	Connector, female, 6 contact, chassis mounting type	181494-4	18534
8J4 to 8J6	Not used.		
8J7	Connector, female, 6 contact, chassis mounting type. Same as 8J3	181494-4	18534
8TB1, 8TB2	Board, terminal, black bakelite moulded, 18 terminal	441608-17	
	Clamp, cable, rubber covered, 1/2" I.D.	8835327-1	98716
	Clamp, cable, rubber covered, 7/8" I.D.	8835327-2	98717
	Clamp, cable, rubber covered, 1-3/16" I.D.	8835327-3	98718
<b>LINE TERMINATION PANEL MI-31156</b>			
8J1, 8J2	Connector, male, 6 contact, chassis mounting	181494-3	28507
8J3	Connector, female, 6 contact, chassis mounting	181494-4	18534
8J4	Connector, male, 6 contact, chassis mounting. Same as 8J1	181494-3	28507
8J5	Connector, female, 6 contact, chassis mounting. Same as 8J3	181494-4	18534
8J6	Connector, male, 6 contact, chassis mounting. Same as 8J1	181494-3	28507
8J7, 8J8	Connector, female, 6 contact, chassis mounting. Same as 8J3	181494-4	18534
8J9	Connector, male, 6 contact, chassis mounting. Same as 8J1	181494-3	28507
8TB1	Board, 4 terminal, 3 1/4" lg. x 2" wide x 1 1/4" thick, molded black textolite	449691-	
8TB2	Board, 50 terminal, 3-3/16" lg. x 2-15/16" wide x 2 5/8" high, laminated phenolic	475996-501	
	Clamp, cable, white molded nylon, for 5/16" dia. cable	8811154-4	209861

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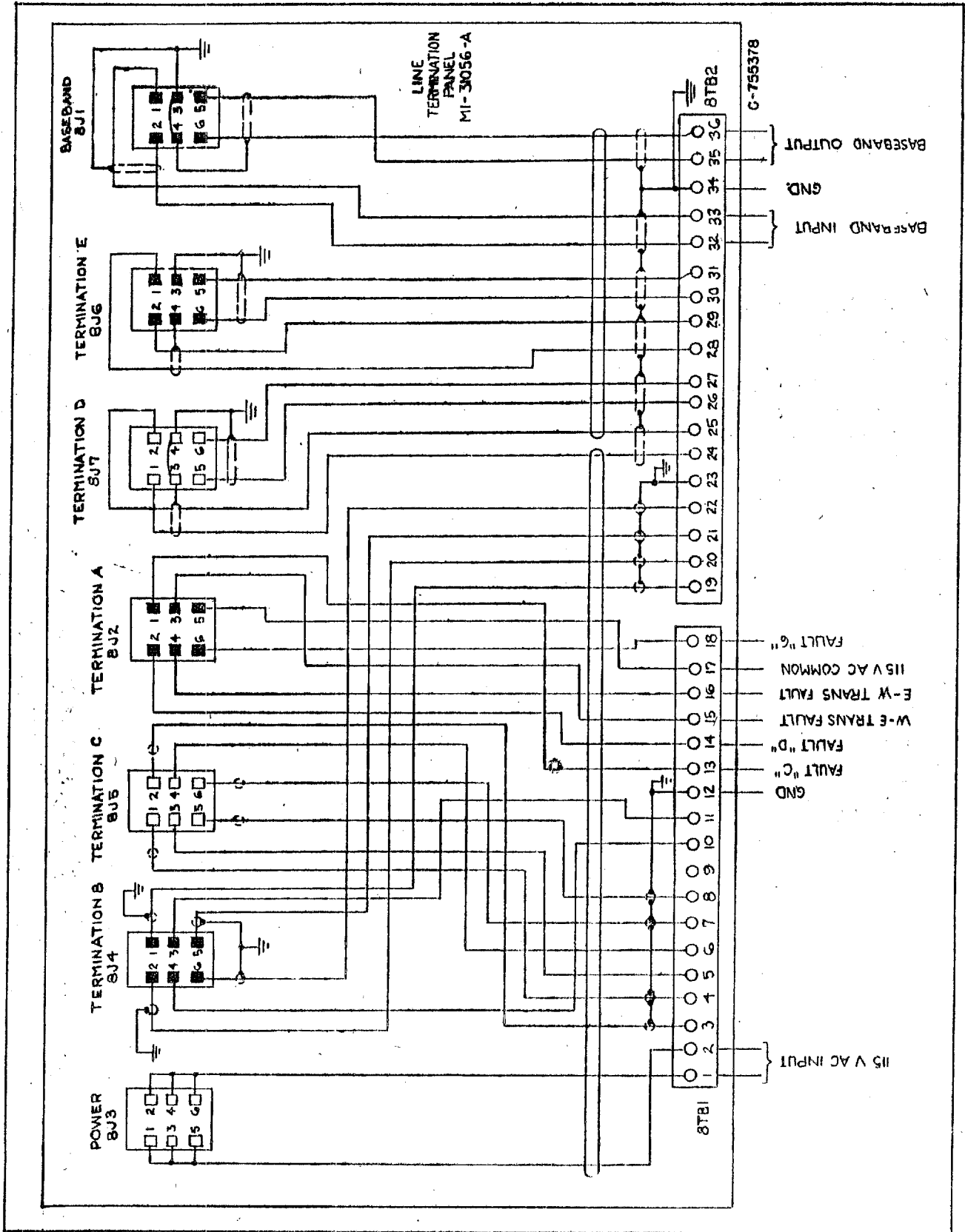
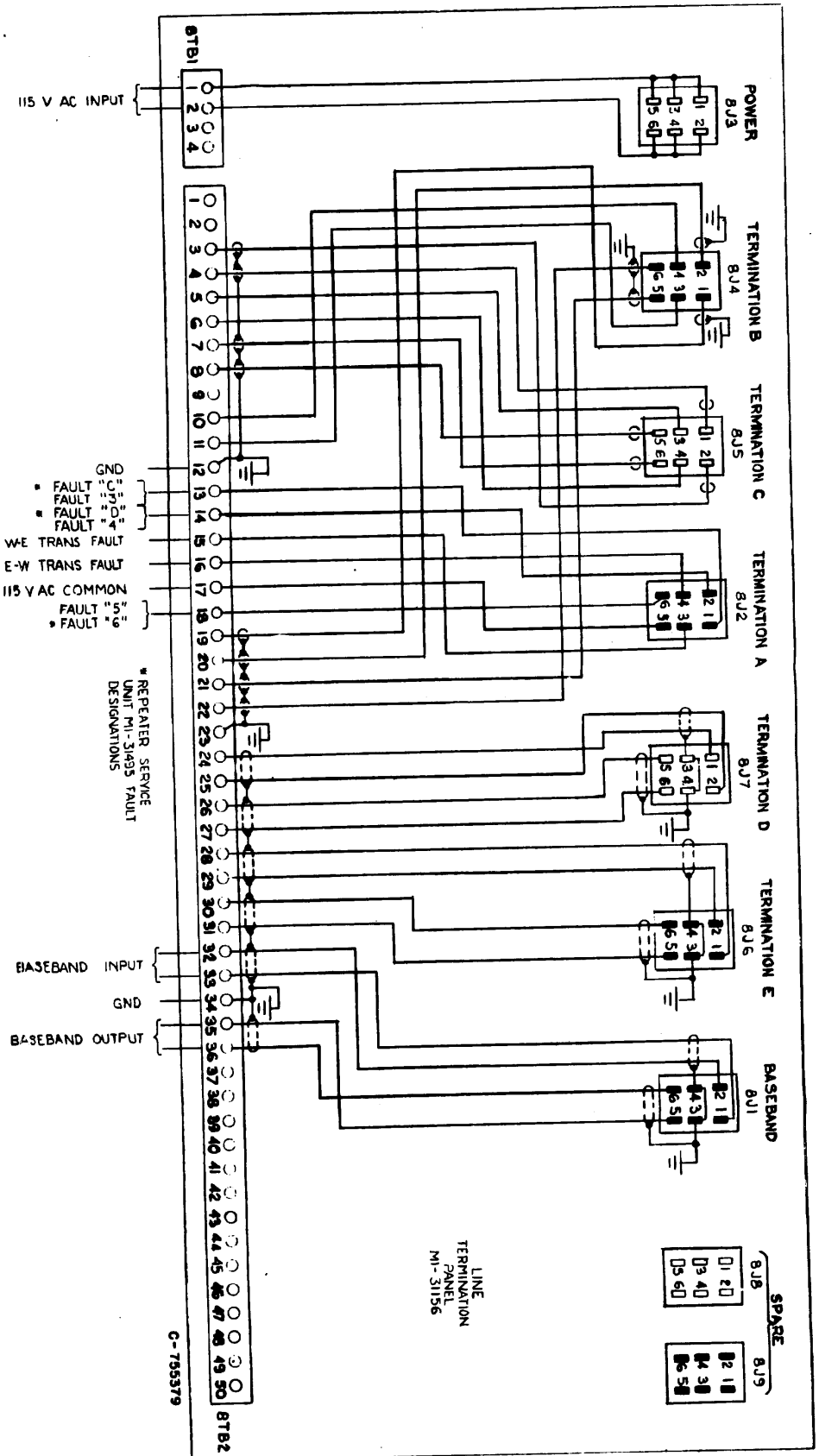


Figure S-10—Line Termination Panel MI-31056-A—Connection Diagram



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NOTES 1- WHEN EXTENDING 33 TERMINAL 6J2 OF THE INDICON CODER, MI-31499-J45 IS USED, THE 33 CONDUCTOR CABLE OF THIS MI IS WIRED TO TERMINAL BLOCK PROVIDED WITH IT, CONNECTING 1 TO 1, 2 TO 2, --- 33 TO 33.

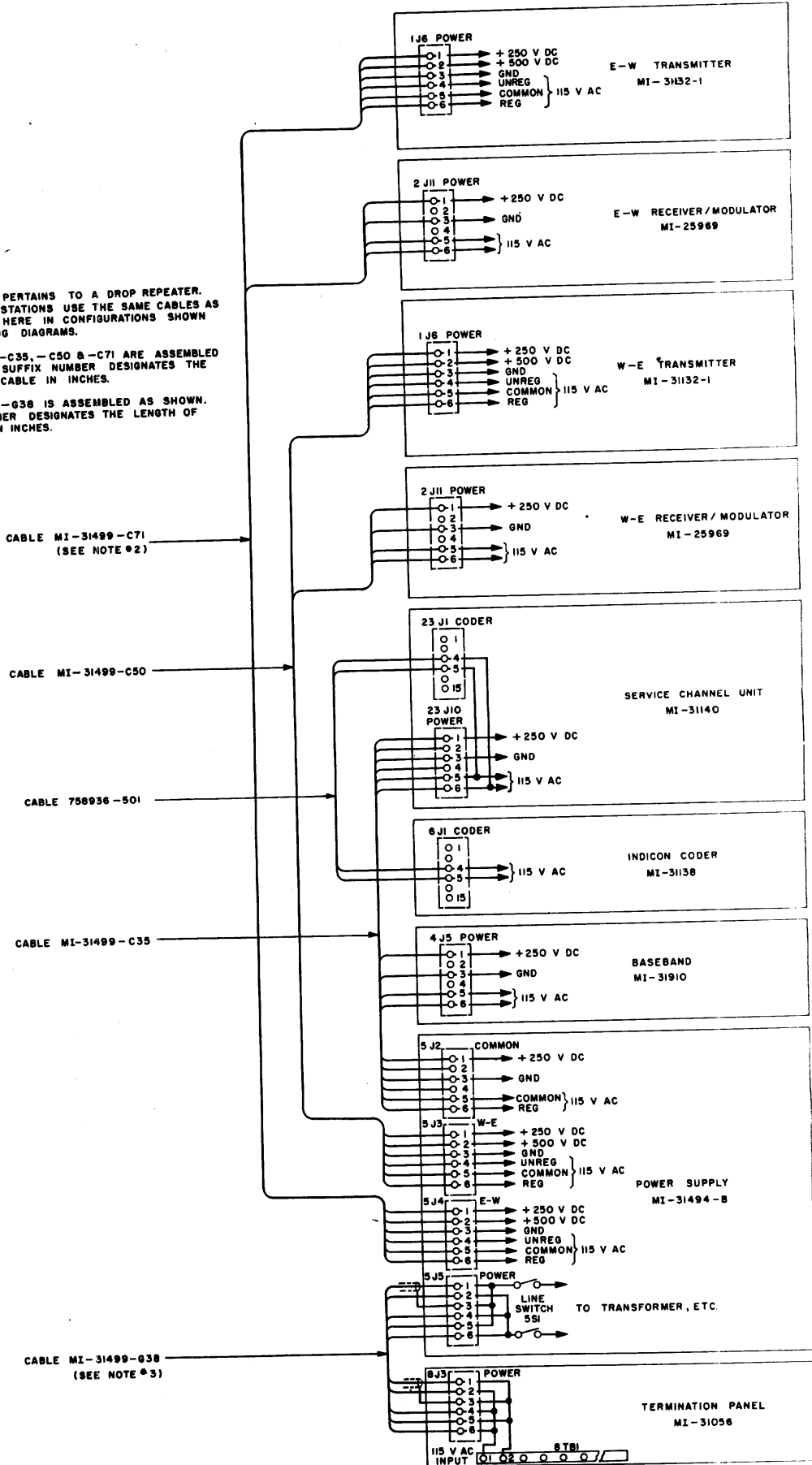
2- WHEN EXTENDING 33 TERMINAL 7J2 & 21 TERMINAL 7J3 OF THE INDICON DECODER, MI-31499-K45 & MI-31499-L45 ARE USED, THE CABLE OF MI-31499-K45 IS WIRED TO THE TERMINAL BLOCK PROVIDED WITH IT, CONNECTING 1 TO 1, 2 TO 2, --- 33 TO 33. TERMINALS 1 THRU 17 OF 7J3 (MI-31499-L45) ARE CONNECTED TO 34 THRU 50, RESPECTIVELY, OF TERMINAL BLOCK PROVIDED WITH MI-31499-K45. TERMINALS 18 THRU 21 ARE CONNECTED TO TERMINALS 47 THRU 50, RESPECTIVELY OF 6T82.

Figure S-11—Line Termination Panel MI-31156—Connection Diagram

NOTE #1: THIS SCHEMATIC PERTAINS TO A DROP REPEATER. OTHER TYPES OF STATIONS USE THE SAME CABLES AS ARE ILLUSTRATED HERE IN CONFIGURATIONS SHOWN IN STATION CABLING DIAGRAMS.

NOTE #2: CABLES MI-31499-C35, -C50 & -C71 ARE ASSEMBLED AS SHOWN. THE SUFFIX NUMBER DESIGNATES THE LENGTH OF THE CABLE IN INCHES.

NOTE #3: CABLES MI-31499-G36 IS ASSEMBLED AS SHOWN. THE SUFFIX NUMBER DESIGNATES THE LENGTH OF OF THE CABLE IN INCHES.



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Figure 12.—Power Wiring—Connection Diagram.



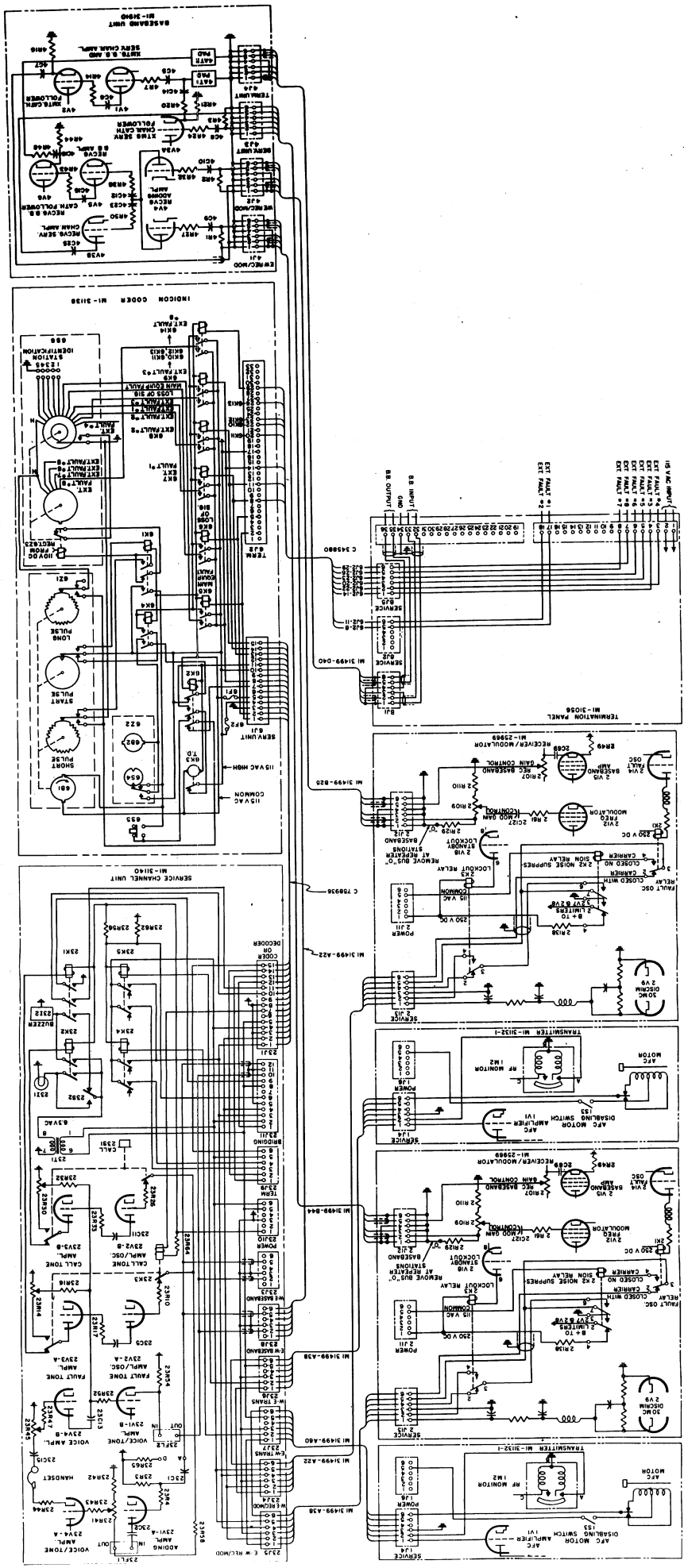


Figure 14 - Drop Repeater - Connection Diagram.

T.O. 31R5-4-21

S-49 S-50

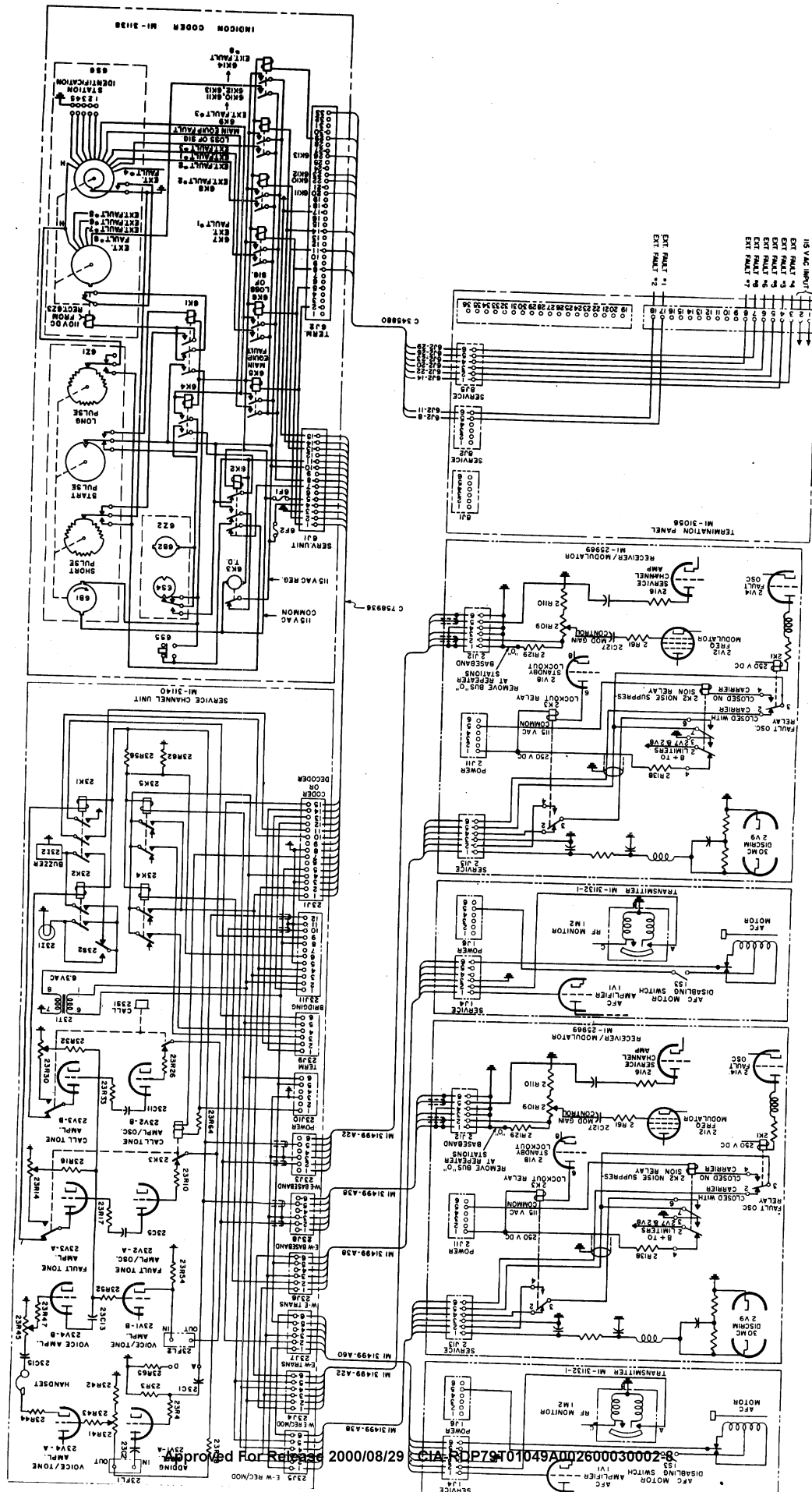
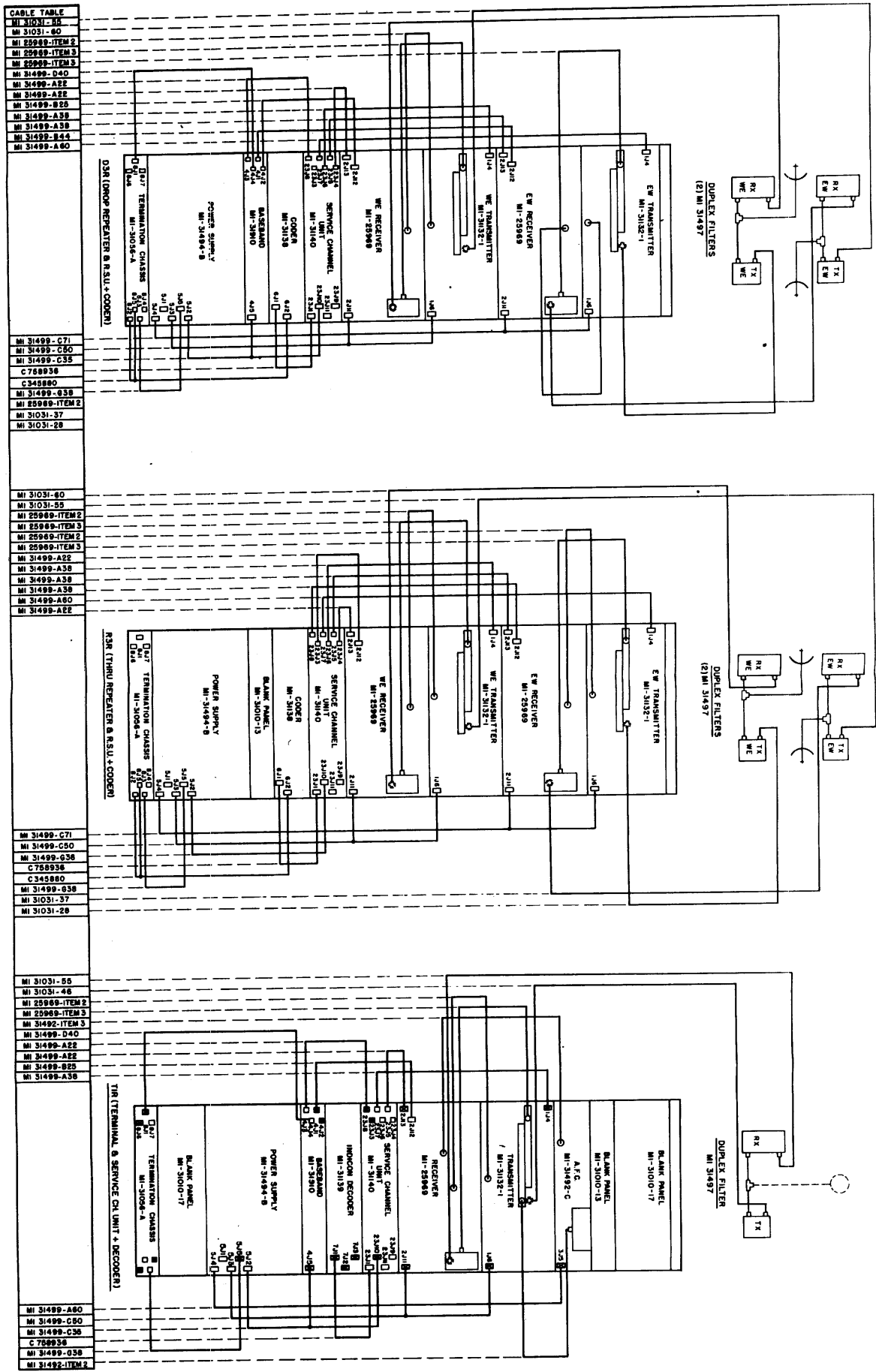


Figure 15.—Twy Reporters—Connection Diagram.

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T.O. 31R5-4A-21

S-53 S-54

Figure 16. CW 30AW Basic Terminal, Thru Repeater and Drop Repeater Station Equipment.

# MICROWAVE COMMUNICATION EQUIPMENT

T.O. 31R5-4-A-21

## Transmitter MI-31132-1C

- TECHNICAL DATA
- DESCRIPTION
- MAINTENANCE
- REPLACEMENT PARTS



RADIO CORPORATION OF AMERICA  
COMMUNICATION PRODUCTS DEPARTMENT, CAMDEN, NEW JERSEY

**T.O. 31R5-4-A-21**

T-1

**TECHNICAL DATA**

<b>Power Input:</b>		<b>Tube Complement</b>		
a.	Fil. Heaters and Blower. 95 watts at 115 volts— 50/60 cycle A.C.	<i>Symbol</i>	<i>Type</i>	<i>Function</i>
b.	Plate Supply: 65 milliamps at 250 v dc 300 milliamps at 500 v dc	1V1	12AT7	DC Amplifier
		1V2	2C39A	Local Oscillator
		1V3	2C39A	Transmitter Mixer
		1V4	2C39A	RF Amplifier
		1V5	6CL6	70 mc i-f Amplifier
		1V6	2E26	70 mc i-f Amplifier
		1V7	35C5	Osc. Cathode Current Regu- lator
<b>Frequency Range</b> 1700-1990 megacycles				
<b>Modulated Signal Input</b> 70 megacycle FM Signal from the receiver/modulator unit				
<b>R-F Bandwidth</b> 8 mc				
<b>Peak Carrier Deviation</b> ±1.5 megacycles				
<b>Transmitter Power Output</b> 3 watts				
<b>Crystal</b>		<b>Weight and Dimensions</b>		
<i>Symbol</i>	<i>Type</i>	<i>Function</i>	Weight—25 lbs.	
1CR1	1N21B	RF Rectifier	Height—10½"	
1CR2	1N48	RF Rectifier	Depth back of panel: (6" plus 1" allowance for air passage. 11" with air filter)	
			Depth front of panel: 4"	
			Width: 19" Rack Mounting	

**DESCRIPTION**

This Transmitter Unit is designed for installation in either a standard 19" open rack or cabinet and is used in both terminal and repeater stations. It provides a frequency modulated r-f output in the frequency range of 1700 to 1990 mc.

The transmitter unit contains the equipment to generate and amplify the microwave carrier. The oscillator frequency is determined by tuning resonant cavity 1Z1A by means of the top left tuning screw. (This and the three other cavity tuning screws are located on the cavity assembly mounted on the front panel.) This frequency is coupled directly to the mixer cathode resonant cavity 1Z1B which is tuned by the lower left tuning screw. The oscillator frequency is mixed with the 70 mc carrier from the modulator section of the receiver/modulator unit. This 70 mc frequency modulated signal is injected into the cathode circuit of mixer tube 1V3. The resultant frequency, the sum or difference in accordance with the system plan, is fed thru mixer anode tuning cavity 1Z1C to the r-f amplifier 1V4. 1Z1C is tuned to the output frequency of the mixer stage by the upper right cavity tuning screw. The r-f amplifier stage is tuned to the same frequency as the mixer output. This

tuning is done in resonant cavity 1Z1D by the lower right cavity tuning screw. (All cavity tuning screws are turned out for an increase in frequency).

The plate tuning cavity 1Z1D of the r-f amplifier contains three pickup devices. The one connected to jack 1J2 absorbs a comparison sample for the terminal AFC unit. A loop transfers to 1J3 the r-f energy for the antenna. A slot is used to obtain energy to operate r-f monitor 1M2, the combination output meter and fault relay.

Seventy mc amplifier stages 1V5 and 1V6 amplify the 70 mc signal from the receiver/modulator to raise it to the proper amplitude before injection into the transmitter mixer circuit.

R-f monitor 1M2 is an r-f output indicating meter which also acts as the transmitter fault indicating device. The r-f energy for operating 1M2 is rectified by crystal 1N21B in cavity 1Z1D. MONITOR ADJUST 1R14 controls the amount of current flowing through 1M2 to keep the meter pointer on scale. When the output of r-f amplifier 1V4 drops to a certain predetermined value a circuit is closed inside 1M2 which energizes a transmitter fault reporting relay in the service unit. The value at which the 1M2 relay reports a fault is in-



I-2

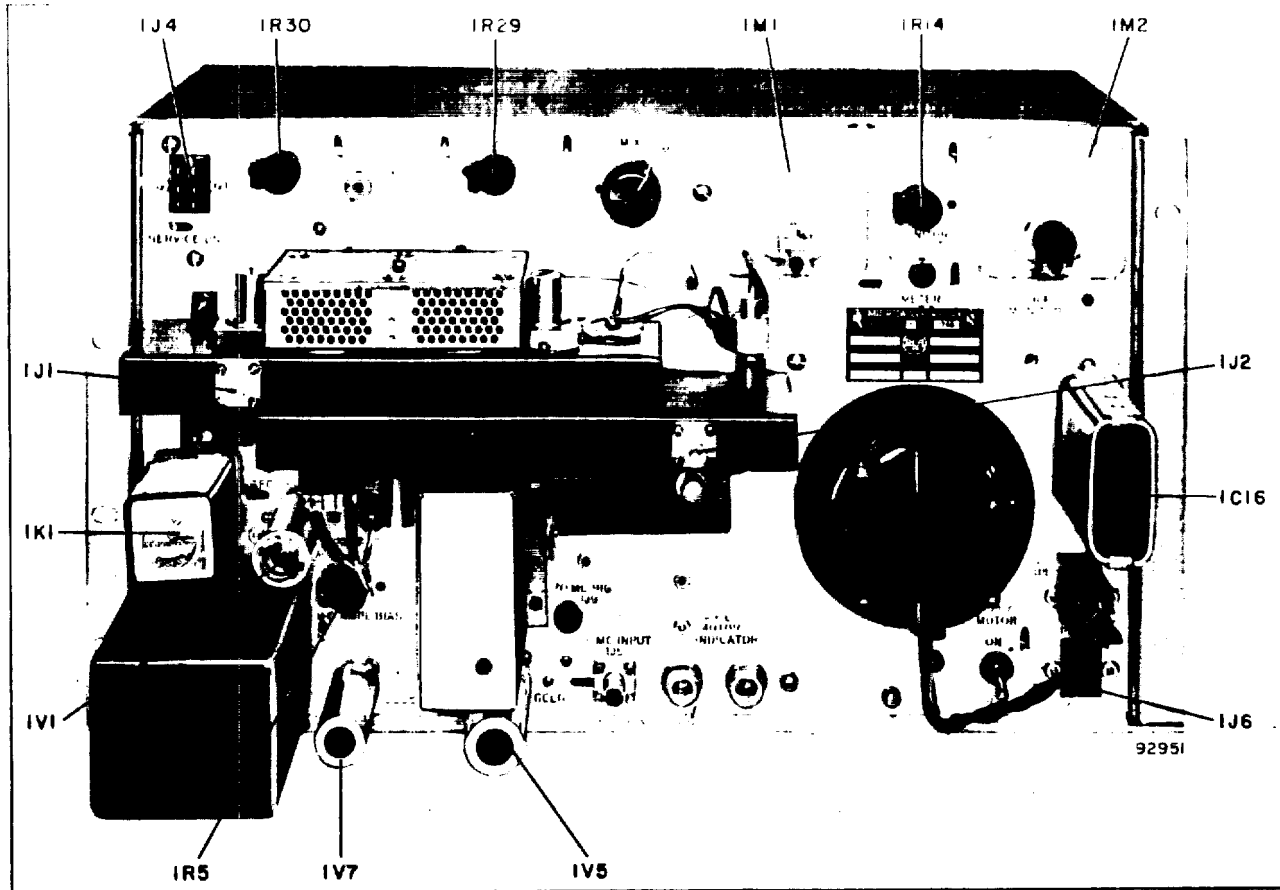


Figure T-1—Transmitter—Front View

indicated by the red pointer which can be set manually by a control knob on the front of 1M2.

DC amplifier 1V1, relay 1K1 and AFC motor 1B1 and associated circuits constitute the transmitter oscillator frequency control section. The following is the sequence of events that cause this equipment to function: A portion of the transmitter local oscillator output is coupled by a cable, attached to jack 1J1, to the receiver r-f mixer in the receiver/modulator unit. The transmitter oscillator frequency and the received microwave frequency determines the receiver 30 mc i-f. If the transmitter local oscillator drifts the resultant change in the receiver i-f causes a dc component to appear in the receiver 30 mc discriminator output. This dc is carried through the service unit to the transmitter jack 1J4 of the transmitter. From terminal 1 of jack 1J4 it is applied to the control grid of the 1-2-3 section of dc amplifier 12AT7 (1V1).

When the transmitter operates on the sideband above the L.O. (local oscillator) frequency, the connections to motor 1B1 are as shown in figures T-3 and T-4. (Motor 1B1 is actually two motors mounted on a single shaft. The F and B terminals

shown on the schematic are the power connections to the "front" (F) and "back" (B) motors of 1B1. The "front" motor refers to the one nearest the panel.) Contact 7 of relay 1K1 is connected to the F terminal of 1B1 and contact 4 of 1K1 is connected to the B terminal of 1B1. If the receiver i-f increases for any reason, a positive dc voltage at 1V1-2 from the receiver discriminator will cause relay 1K1 to function so that 1B1 runs in a counterclockwise direction as indicated by the lighting of the + (112) lamp. This will turn the tuning loop in cavity 1Z1A to increase the L.O. frequency so that the receiver i-f is again 30 mc. A decrease of receiver i-f causes a negative dc voltage at 1V1-2 which will move the tuning loop in a clockwise direction, as indicated by the lighting of the - (111) lamp, and decrease the L.O. frequency so that the receiver i-f is again 30 mc.

For lower sideband transmitter operation the connections to 1B1 are: contact 7 of relay 1K1 is connected to the B terminal of 1B1 and contact 4 of 1K1 is connected to the F terminal of 1B1. When 1B1 is connected in this manner a positive dc voltage at 1V1-2, caused by a receiver i-f increase, will

**T.O. 31R5-4-A-21**

T-3

cause the 1Z1A tuning loop to turn in a clockwise direction and light the + (1I2) lamp. This will decrease the L.O. frequency until the receiver i-f is again 30 mc. A negative voltage at 1V1-2 caused by a receiver i-f decrease will cause the 1Z1A tuning loop to turn in a counterclockwise direction and light the - (1I1) lamp. This will increase the L.O. frequency until the receiver i-f is again 30 mc. The dc amplifier bias control 1R5 is adjusted so that when the receiver discriminator dc output is at zero voltage the AFC motor 1B1 stops running.

In order to prevent the AFC motor 1B1 from moving the tuning loop out of position during initial installation or when servicing the station equipment, an AFC motor disabling switch has been provided. With the AFC Motor switch 1S3 open (OFF) the 115 v ac to 1B1 is disconnected.

Meter Switch 1S1A in conjunction with test meter 1M1 supplies a means of making the following measurements: On the 250 and 500 positions of 1S1A, meter 1M1 registers the two B+ voltages from the power supply. On the OSC, MIX and AMPL positions of 1S1A, 1M1 measures the cathode current of the oscillator 1V2, mixer 1V3, and RF amplifier 1V4 respectively. The + and - positions of 1S1A are used when positive and negative external voltage readings are made in this and other units by means of a test lead.

The transmitter oscillator, mixer and r-f amplifier tubes are cooled by blower 1B2 and if for any reason the blower should stop, the air operated switch 1S2 breaks the ac power to their filament transformer to prevent these tubes from overheating.

The cathode current of the oscillator 1V2 contains a 35C5 ballast tube. This is a current regulating device which prevents the cathode current of 1V2 from varying greatly from the value set by 1R30. If the cathode current of 1V2 tends to increase or decrease appreciably the resistance of the filament of 1V7 will increase and decrease accordingly to maintain the current through it at a nearly constant value.

**CONTROLS**

a. The Local Oscillator Tuning Screw (Upper left) of cavity 1Z1A varies the resonant frequency of the plate circuit cavity and so determines the frequency of the oscillator. (Turning the screw

out increases the resonant frequency of the cavity. This applies to all four of the transmitter cavity tuning screws.)

b. The Local Oscillator Cathode Tuning Screw (Lower left) of cavity 1Z1B varies the resonant frequency of the cathode cavity of the local oscillator and mixer cathode circuits. This tuning control has only a negligible effect on the oscillator frequency.

c. The Mixer Plate Turning Screw (Upper right) of cavity 1Z1C varies the resonant frequency of the mixer tuning cavity. It is tuned either to the local oscillator frequency plus the 70 mc i-f carrier or to the local oscillator frequency minus the 70 mc i-f carrier in accordance with the system plan.

d. The RF Amplifier Tuning Screw (Lower right) of the cavity 1Z1D varies the resonant frequency of the plate tuning cavity. It is tuned to the mixer output frequency.

e. The OSC control (1R30) is a screwdriver adjusted potentiometer which controls the cathode current of the oscillator tube 1V2 by varying its cathode bias.

f. The AMPL control (1R29) is a screwdriver adjusted potentiometer which controls the cathode current of the r-f amplifier tube 1V4 by varying its cathode bias.

g. The MONITOR ADJUST control (1R14) is a screwdriver adjusted potentiometer that controls the amount of rectified r-f output from the r-f amplifier plate cavity which flows thru RF MONITOR 1M2. It is set so that the indicator of 1M2 remains on scale. This control is adjusted in conjunction with the setting of the red pointer on RF MONITOR 1M2.

h. The METER SW (1S1) allows various current and voltage readings of the transmitter and associated units to be observed on test meter 1M1.

Position 250 measures 250 v dc B+ from the power supply. (1000 volts full scale)

Position 500 measures 500 v dc B+ from the power supply. (1000 volts full scale)

Position OSC measures the cathode current of r-f oscillator 1V2. (200 milliamps full scale)

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T-4

Position MIX measures the cathode current of mixer 1V3. (200 milliamps full scale)

Position AMPL measures the cathode current of r-f amplifier 1V4. (200 milliamps full scale)

\*Position + measures positive voltages. (200 microamps full scale)

\*Position - measures negative voltages. (200 microamps full scale)

\* From test points in this and other units by means of a test lead connected to the METER jack.

i. The DC AMPL BIAS control (1R5) varies the cathode bias of the 6-7-8 section of dc amplifier 1V1, the AFC relay control tube.

j. The Test Meter (1M1) (to the right of the meter switch) is used in conjunction with meter switch 1S1 to measure various circuit values in the transmitter unit and, by means of a plug-in test lead, to make current measurements in the other units.

k. METER pinjack (1J7) is the test lead connection when test meter 1M1 is used to measure voltage and current values in associated units.

l. The RF MONITOR r-f meter and relay (1M2), a combination r-f output meter and fault relay, gives a relative indication of r-f carrier output and functions as a fault reporting relay when the r-f output reaches a predetermined low value.

m. The L.O. (local oscillator) coaxial cable terminal (1J1) is used for supplying a portion of

the local oscillator energy to the receiver r-f mixer stage.

n. The A.F.C. coaxial cable terminal (1J2) is used for transferring a portion of the transmitter output signal to the AFC mixer in the terminal AFC unit. Only used for terminal stations.

o. The 70 MC INPUT coaxial cable terminal (1J5) is the input connection for the coaxial cable carrying the 70 mc i-f signal from the receiver/modulator.

p. The A.F.C. MOTOR INDICATOR (lamps 1I1 and 1I2) show when the AFC motor is running and in which direction. When the motor is correcting the local oscillator frequency, one of the lamps is lit and when the frequency correction is complete the lamp is extinguished.

q. The A.F.C. MOTOR SWITCH 1S3 is used for opening the 115 v ac line to AFC motor 1B1 to disable it during installation or servicing.

r. The 70 MC INPUT signal jack 1J9 is used for checking the 70 mc signal input level from the receiver/modulator.

s. The AFC LOOP INDICATOR shows the position of the AFC tuning loop in the local oscillator cavity. The pointer, when moved, changes the angle of the loop in the cavity. When the pointer is at the 0 position, the loop is at approximately 45° from the vertical, the correct position of the loop in the cavity.

**MAINTENANCE****General Notes**

If the transmitter power output is decreasing the following notes may facilitate isolating the difficulty:

a. First, check the 70 mc drive to the transmitter mixer by turning off the 500 volts supply. The "MIX" reading should be greater than 35 ma. (The 40 ma figure listed in the INITIAL ADJUSTMENT section of the system instructions is the expected minimum for new tubes.) The reading obtained on 1M1 when 1J9 is connected to 1J7 should be at least 30 $\mu$ a.

If the "MIX" reading is below 35 ma check the 70 mc signal voltage input from the receiver/modulator. The 30  $\mu$ a reading at 1J9 is equivalent to 1 volt at 1V5-3. If this value is less than 1 volt the

receiver/modulator is not delivering enough drive to the transmitter and the correction will have to be made in the receiver/modulator unit. If the input to 1V5 is sufficient, check both 1V5 and 1V6 tubes and replace if necessary.

b. Second, check the quality of the oscillator tube by noting how much its cathode current increases as the tube changes from a non-oscillating to an oscillating condition. (The bottom oscillator slug can be detuned to stop oscillation.) The current should increase by approximately 3:1 for a good tube. If the increase is less than 1.5:1 the tube should be replaced.

c. If the oscillator is supplying adequate drive to the mixer the mixer tube cathode current (meter

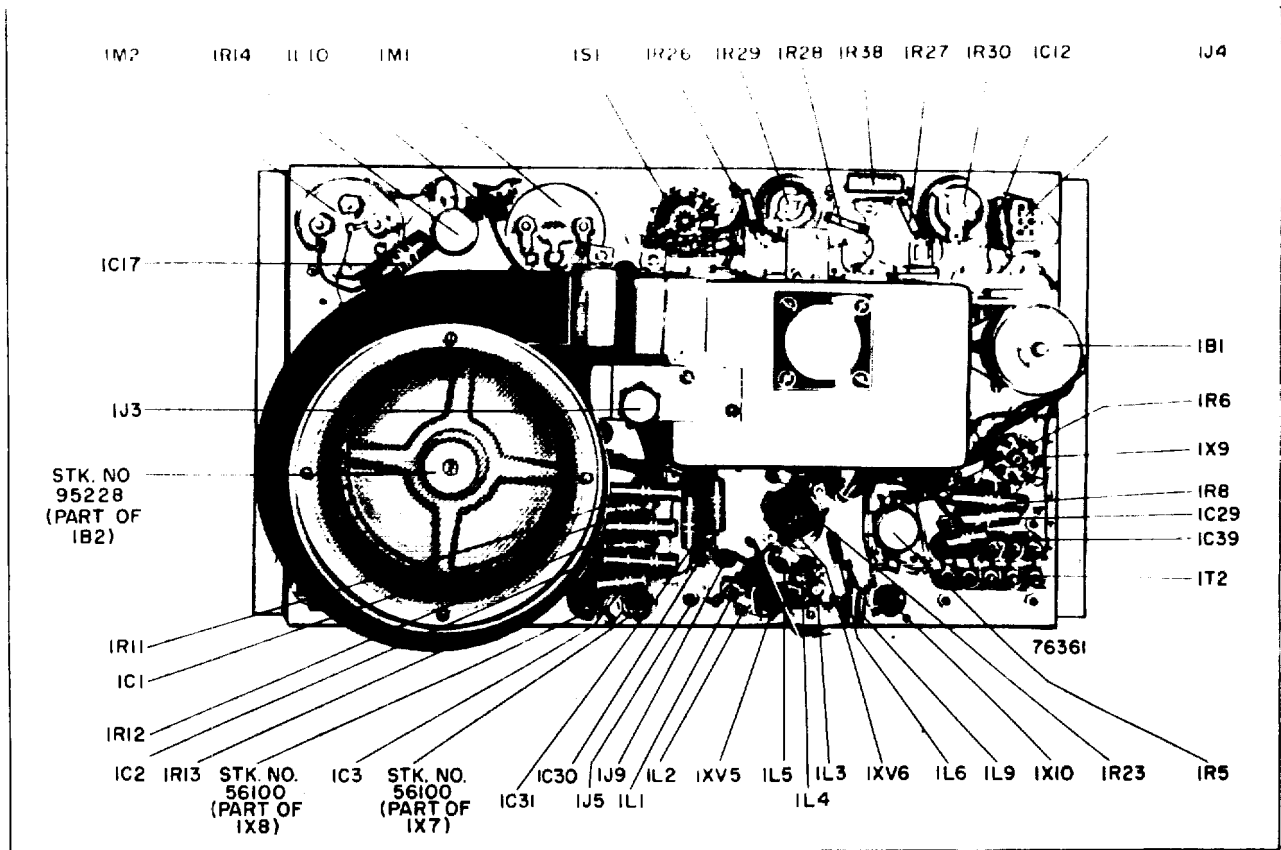


Figure T-2—Transmitter—Rear View

switch at MIX) should drop to roughly 50% of the normal value when the 70 mc cable is removed. If this decrease is of the order of only 10%, a point of marginal operation has been reached. The mixer cathode current is determined in part by the oscillator drive. If the mixer cathode current exceeds 125 ma, the oscillator cathode current should be reduced.

d. A poor 2C39A amplifier is frequently revealed by an inability to get adequate cathode current, with sufficient drive from the mixer, as the cathode variable resistor (1R29) is decreased. When less than 75 ma of "AMPL" cathode current is obtained with 1R29 set at minimum the amplifier tube should probably be replaced.

e. If the transmitter fails completely it may be caused by a defective 2C39A electron tube or the breakdown of capacitors 1C19, 1C23 or 1C26. If one of these capacitors is shorted due to dust and moisture or if certain elements of tubes 1V2, 1V3

or 1V4 become shorted, then the 500 v B+ power is short circuited and fuse 5F16 in the power supply will be blown.

f. Variable resistor 1R14 "MONITOR ADJUST" is used to adjust the operating point of meter relay 1M2. A suggested setting of 1R14 is that which will give a 1M2 reading of 150  $\mu$ a. Set the red hand of 1M2 at the meter reading below which the transmitter output should not fall. Meter/Relay 1M2 will report a transmitter fault to the service unit when the transmitter output falls to this value.

g. Both the transmitter AFC motor and the blower motor have lifetime lubricated bearings. The grease sealed bearings of the blower section of the blower-motor should be inspected periodically and replaced with new bearings when necessary. The normal life of the bearings is between three and four years.

h. If the blower motor runs but the tube filaments do not burn, check the operation of the air operated switch 1S2.

## T.O. 31R5-4-A-21

T-6

### Transmitter AFC Circuit

As d-c amplifier tube 1V1 ages, D.C. AMPL. BIAS potentiometer 1R5 must be readjusted to keep the i-f frequency of the receiver/modulator centered at 30 mc. When the range of adjustment provided by 1R5 is no longer adequate to center the i-f, 1V1 must be replaced.

### Transmitter AFC Circuit Test

If the transmitter AFC circuit fails to respond to the dc correction signals from the discriminator of the receiver/modulator, the d-c amplifier may be the cause.

Check the sensitivity of the d-c amplifier 1V1 as follows (with the AFC motor 1B1 connected for upper side band operation as shown in Figure T-3):

1. Apply + .15 volts to pin 1 of jack 1J4 and ground. This voltage should cause the AFC motor indicator light, marked +, to light.
2. Apply - .15 volts to pin 1 of jack 1J4 and ground. This voltage should cause the AFC motor indicator light, marked -, to light.
3. Check the action of the clutch by moving the loop indicator by hand.

### 70 MC Circuit Alignment

NOTE: The test items specified in this alignment procedure refer to the test equipment items listed in the test equipment tables of the system instructions.

- a. Apply the output of the 70 mc sweep generator (test item 18), with markers, to 1V6-5. (Tube shields of 2E26 and 6CL6 and the shields of transformer 1T1 must be in place.)
- b. Connect the CRO (test item 4) to the cathode of 1V3 (2C39A mixer tube).
- c. Turn on the 115 volt a-c and 250 volt d-c supplies.
- d. Adjust 1T1 and 1C33 for correct alignment. The response is that of an over-coupled double-tuned circuit with peaks approximately 12 megacycles apart.

NOTE: Should it be impossible to align this stage the reason is, most likely, that either of the two circuits is not tuned to 70 mc  $\pm 1$  mc. The resonant frequencies of the two circuits are easily checked with test item 12.

### TYPICAL TRANSMITTER VOLTAGES AND METER READINGS

The following are approximate voltages existing between the indicated tube pins and ground as measured with a voltohmmyst with 100,000 ohms in series with the measuring probe. All voltages are dc unless otherwise noted.

Tube	Type	Function	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
1V1	12AT7	DC ampl.	90	0	1.8	0	0	250	90	92	6.3 ac
1V5	6CL6	70 mc. ampl.	2.3	0	117	0	6.3 ac	228	2.3	117	—
1V6	2E26	70 mc. ampl.	15	0	185	15	0	15	6.3 ac	—	Plate cap 250

The following are typical readings of test meter 1M1 for the various positions of "METER SW" 1S1:

250v— 50 $\mu$ a	} Meter connected as a voltmeter of roughly 1000 volt full scale reading
500v—100 $\mu$ a	
OSC—70 ma	
MIX.—100 ma max., 60 ma min.	
AMPL.—100 ma max.	
+ }	} In these positions the meter is connected to an external probe for use in testing other unit quantities
- }	

**T.O. 31R5-4-A-21**

e. Connect the CRO to 1V6-3, connect the sweep generator to 1V5-2, and adjust 1L3, 1L4, and 1L5 for the correct response. The response curve is nearly flat with 3 db points 10 mc apart.

f. Connect the CRO to 1V5-8, connect the sweep generator to Pin No. 1 of the 70 mc amplifier 2V11 and connect the 70 MC OUTPUT jack 2J9 to the 70 MC INPUT jack 1J5 of the transmitter and adjust 1L1 and 1L2 for the correct response.

g. Connect the CRO to the cathode of 1V3 to check the overall response.

**IMPORTANT**

If the repair of cavity 1Z1 is required and if the removal of the mounting assemblies of electron tubes 1V2, 1V3 and 1V4 is necessary it is important that these parts be very carefully positioned upon reassembly. If the opening in the plates of these assemblies are not in line the tubes are likely to be

broken when inserted. For proper installation of these tube mounting assemblies use the following instructions:

1. Install the ring assembly in the holes of the partition between the two cavity sections and tighten the screws.

2. Install the assembly that holds the cathode and filament terminals (small end) of the tubes but leave the mounting screws very loose.

3. Install the assembly that holds the plate (large end) terminal of the tubes but leave the mounting screws loose.

4. Insert a 2C39A tube allowing all parts to center about the tube. Tighten all screws with the tube in place. Remove the tube.

The installation of tubes 1V2, 1V3 and 1V4 may now be done without danger of damage to the tubes.

**REPLACEMENT PARTS LIST**

Symbol No.	Stock No.	Drawing No.	Description
1B1	94203	8832092-1	Motor: timing motor and gear unit, (AFC Drive) 110 v. 60 cy. Blower: 115/230 v. 50/60 cy., 3300 RPM Motor: for blower 1B2, 115/230 v. 50/60 cy. 3300 RPM, pt. of 1B2 Bearing: ball, for blower motor, pt. of 1B2
1B2	216921	741276-4	
	94204	741276-2	
	95228	8830675-2	
1C1 to 1C3		735715-363	<b>CAPACITORS</b> Paper:, 0.01 $\mu$ f, +10%, 1000 v Mica: 1000 $\mu$ f, $\pm$ 10%, 500 v. Ceramic, 820 $\mu$ f, +100 -0%, 500 v. Ceramic, 220 $\mu$ f $\pm$ 20%, 500 v. Ceramic, 820 $\mu$ f +100 -0%, 500 v Paper, 0.1 $\mu$ f $\pm$ 20%, 200 v Ceramic, feed thru type, 1000 $\mu$ f +80 -20%, 500 v. Paper, 4 $\mu$ f $\pm$ 10%, 330 v. ac., for blower motor Not Used Part of 1Z1 Ceramic, 820 +100 -0%, 500 v. Paper, 0.1 $\mu$ f $\pm$ 10%, 400 v Paper, 0.033 $\mu$ f $\pm$ 20%, 400 v Ceramic, 22 $\mu$ f +5%, 500 v Variable, ceramic trimmer, 4.5/28 $\mu$ f Ceramic, 220 $\mu$ f $\pm$ 20%, 500 v Not Used Electrolytic, 100 $\mu$ f, 50 v. Silver mica, button type, 25 $\mu$ f $\pm$ 10%, (part of 1Z1) Rectifier: germanium diode 1N21B Rectifier: germanium diode 1N48 Lamp: neon, starting volts 65 v. ac, 90 v. dc, min bay base Connector: female, coaxial, chassis mounted (part of 1Z1) less 1/4" lg. cavity loop Connector: female, coaxial, chassis mounted with 13/32" lg. loop and teflon beads Connector: male, 6 contact, chassis mounted Connector: female, coaxial, chassis mounted Connector: male, 6 contact, chassis mounted Connector: pin jack, for 0.080 dia., pin Connector: female, 6 contact, chassis mounted Connector: pin jack, for 0.080 dia. pin Relay: differential polarized, SP., 3 pos. null seeking coils
1C4	94189	984002-121	
1C5 to 1C8	94190	449696-1	
1C9	95319	735717-633	
1C10, 1C11	94190	449696-1	
1C12		735715-25	
1C13 to 1C15	203760	8828585-3	
1C16	208503	990195-2	
1C17			
1C18 to 1C27			
1C28	94190	449696-1	
1C29		735715-175	
1C30, 1C31		735715-119	
1C32	93716	984015-218	
1C33	203761	8819214-1	
1C34	95319	735717-633	
1C35			
1C36	214667	442901-154	
1C37, 1C38	215957	984002-661	
1CR1	67876	1N21B	
1CR2	203954	1N48	
1I1, 1I2	101857	872291-9	
1J1, 1J2	94205	456989-501	
1J3	98557	460231-501	
1J4	28507	181494-3	
1J5	94205	8845666-1	
1J6	28507	181494-3	
1J7	93678	742565-1	
1J8	18534	181494-4	
1J9, 1J10	93678	742565-1	
1K1	94206	8834407-1	

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T-8

Symbol No.	Stock No.	Drawing No.	Description
IL1	94207	629132-522	Coil: adj. iron core, 3 turns of 0.0126 dia. wire on form 0.920 lg.
IL2	94208	629132-524	Coil: adj. iron core, 5 turns of 0.0126 dia. wire on form 0.920 lg.
IL3	94245	629132-517	Coil: adj. iron core, 11 turns of 0.0126 dia. wire on form 0.920
IL4	94239	629132-527	Coil: adj. iron core, 15 turns of 0.0126 dia. wire on form 0.920 lg.
IL5	94211	629132-520	Coil: adj. iron core, 6 turns of 0.0126 dia. wire on form 0.920 lg.
IL6	94040	8834424-501	Reactor: iron core 2.5 microhenry
IL7	217800	941524-245	Reactor: RF choke, 6.8 microhenry
IL8			Part of 1Z1
IL9	217800	941524-245	Reactor: RF choke, 6.8 microhenry
IL10	98426	8886161-6	Reactor: RF choke, 2.5 mh, 50 ma
IL11	57239	8898641-2	Reactor: RF choke, 0.84 microhenry, 1000 ma
	208637	8832091-2	Core: tuning, iron, threaded type, 1/4-28 x 3/8" lg. with fibre nut and spring washer. (for 1L1, 1L2, 1L3, 1L4, 1L5)
IM1	94213	456986-1	Meter: dc, 0.200 ma
IM2	94214	8834409-1	Meter: dc, special, 0-200 ma, with switch and contact locking winding, single contact low limit adj.
IP1	28454	181494-2	Connector: male, 6 contact, cable mounting type
			<b>RESISTORS:</b> <i>Fixed, Composition, Unless Otherwise Specified</i>
IR1		82283-35	4.7 meg. $\pm 20\%$ , $\frac{1}{2}$ w
IR2			Not Used
IR3		82283-139	150 ohm $\pm 5\%$ , $\frac{1}{2}$ w
IR4		82283-89	180,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w
IR5	94039	737829-30	Variable, comp., 5000 ohm $\pm 10\%$ , 2 w
IR6		99126-72	6800 ohm $\pm 10\%$ , 2 w
IR7, IR8		99126-194	30,000 ohm $\pm 5\%$ , 2 w
IR9		99126-209	120,000 ohm $\pm 5\%$ , 2 w
IR10			Not Used
IR11 to IR13	59282	8825410-54	Wire wound, 50, ohm $\pm 10\%$ , 10 w
IR14	203068	737829-32	Variable, comp. 50,000 ohm $\pm 10\%$ , 2 w
IR15		82283-193	27,000 ohm $\pm 5\%$ , $\frac{1}{2}$ w
IR16		82283-64	1500 ohm $\pm 10\%$ , $\frac{1}{2}$ w
IR17		82283-50	100 ohm $\pm 10\%$ , $\frac{1}{2}$ w
IR18		82283-68	3300 ohm $\pm 10\%$ , $\frac{1}{2}$ w
IR19		90496-79	27,000 ohm $\pm 10\%$ , 1 w
IR20		82283-13	1000 ohm $\pm 20\%$ , $\frac{1}{2}$ w
IR21		82283-64	1500 ohm $\pm 10\%$ , $\frac{1}{2}$ w
IR22		82283-58	470 ohm $\pm 10\%$ , $\frac{1}{2}$ w
IR23		90496-82	47,000 ohm $\pm 10\%$ , 1 w
IR24		82283-50	100 ohm $\pm 10\%$ , $\frac{1}{2}$ w
IR25		82283-74	10,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w
IR26 to IR28	56327	8871557-11	Wire wound, 0.66 ohm $\pm 1\%$ , 1 w, meter shunt
IR29, IR30	95312	180639-8	Variable, wire wound, 500 ohm $\pm 10\%$ , 25 w
IR31			Not Used
IR32		82283-249	5.6 meg. $\pm 5\%$ , $\frac{1}{2}$ w
IR33		82283-50	100 ohm $\pm 10\%$ , $\frac{1}{2}$ w
IR34		82283-249	5.6 meg. $\pm 5\%$ , $\frac{1}{2}$ w
IR35, IR36		82283-91	270,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w
IR37		82283-74	10,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w
IR38	94377	458572-26	Wire wound, 100 ohm $\pm 5\%$ , 5 w
IR39			Not Used
IS1	94193	458908-1	Switch: rotary, wafer, single section, single circuit 7 pos., non-shorting
IS2	59479	449277-1	Switch: rotary, snap action, SPST, normally open contacts, 125 v. ac, (air interlock)
IS3	48791	187454-2	Switch: toggle, SPST, 3 app, 250 v. ac or dc
IT1	203762	8819222-501	Transformer: RF, adj. core, 70 mc
IT2	207287	469743-1	Transformer: filament
IX1	94880	984055-2	Socket: tube, 9 pin min.

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Symbol No.	Stock No.	Drawing No.	Description
1X2 to 1X4	94880	984055-2	Part of 1Z1
1X5	68590	99391-1	Socket: tube, 9 pin, min.
1X6		8834425-1	Socket: tube, std. octal, natural phenolic
1X7, 1X8	94121		Pilot Light Assembly
	56100		Jewel: pilot light clear jewel only less socket and lamp (pt. of 1X7 and 1X8)
	68590	99100-3	Socket: pilot light socket only less jewel and lamp (pt. of 1X7 and 1X8)
1X9	94879	737867-18	Socket: tube, std. octal, black phenolic
1X10	213898-A	647661-501	Socket: tube, 7 pin min.
1Z1	94270	8831010-1	Cavity Assembly: transmitter, tuning range, 1700-1990 mc (The following parts also stocked)
	94205	456989-501	Bushing: Textolite 0.499 O.D. x 0.470 I.D. x 0.1601 g., mixer capacitor insulating
	207374	8903740-501	Connector: Female, coaxial, chassis mtg. less 1/2 lg. cavity loop
	207375	8903740-502	Contact: Beryllium copper, grid contact ring, less Osc. loop, for 2C39 A tubes
	207376	8903749-501	Contact: Beryllium copper, grid contact ring, with Osc. loop, for 2C39A tubes
	207378	8832042-2	Contact: Beryllium copper, cathode contact ring, for 2C39A tube
	216922	750302-503	Contact: Beryllium copper, filament contact stud, for 2C39A tubes
	216922	750302-504	Contact: Beryllium copper, plate contact ring, for 1V 4 (2C39 A tubes) with insulating ring
	207377	8903730-1	Contact: Beryllium copper plate contact ring, for 1V2, 1V3, (2C39 A tubes) less insulating ring
	207379	8831012-2	Core: Brass, #5/8" - 24 threaded type 1-7/8" lg. overall, cavity tuning
	94269	8831011-1	Insulator: Laminated phenolic, 7/8" O.D. x 0.116 I.D. x 1/16" thick, with 3/16" dia. off set hole, filament contact insulating for 2C39-A Tubes
	95395	874927-6	Nut: Brass, knurled, 1" - 32 inside thread, 3/4" I.D. opposite side 1-1/16" O.D. x 5/32 for mixer capacitor
	203766	892950-3	Nut: Brass, #5/8 - 24 Hex, tuning core locking
	207380	8903734-1	Washer: Mica, 1/2" O.D. x 0.484 I.D. x .006 thick filament contact insulating for 2C39-A tubes
	94385	8832079-1	Washer: Spring, Beryllium copper, 21/32" I.D. x 25/32 O.D. x 0.15 thick tuning core locking
	211661	8813040-501	<i>Miscellaneous</i>
	93856	185290-1	Boot: Blower, wool gabardine, 2-31/32" dia. x 2" lg.
	207701	888550-1	Coil: A.F.C. Loop & Shaft assembly
	213900	8819241-1	Connector: Male, pin jack, cable mtg.
	94784	8833025-4	Connector: Tube cap, for 1V6
	94382	8834421-1	Contact: 2C39 tube radictor plate, less lead
	30075	712336-507	Cushion: AFC drive assy. mtg. rubber 7/8" lg. x 1/4 x 3/16", with 1/16" wide x 1/8 deep channel, supplied in bulk piece 19" lg.
	94383	8832071-501	Insulator: Textolite bead, 9/32" lg. x 0.447 O.D. x 0.254 I.D. (1CRL & 1C4 mtg.)
	94381	8831054-1	Knob: round bakelite, pointer type, for 1S1
	56359	8858642-3	Lever: 1S2 switch activating lever and plate assembly
	94387	8834442-501	Screw: Thumb, #6-32 x 15/16" lg. overall, with 13/32" dia. x 3/8" lg. knurled hd. cover plate retaining.
	94386	8832080-1	Shield: tube, 9 pin min. l. 15/16" lg.
	210897	99369-3	Spring: Helical, mtd. on plate 1-5/16" sq. Blower shock mtg. 3 req'd.
			Strap: Steel, 0.0179 thick x 11-1/8" lg. x 1/2" wide blower bootclamping, 2 req'd.
			Shield: tube, 7 pin min., 2-1/4" lg.



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T-11, T-12

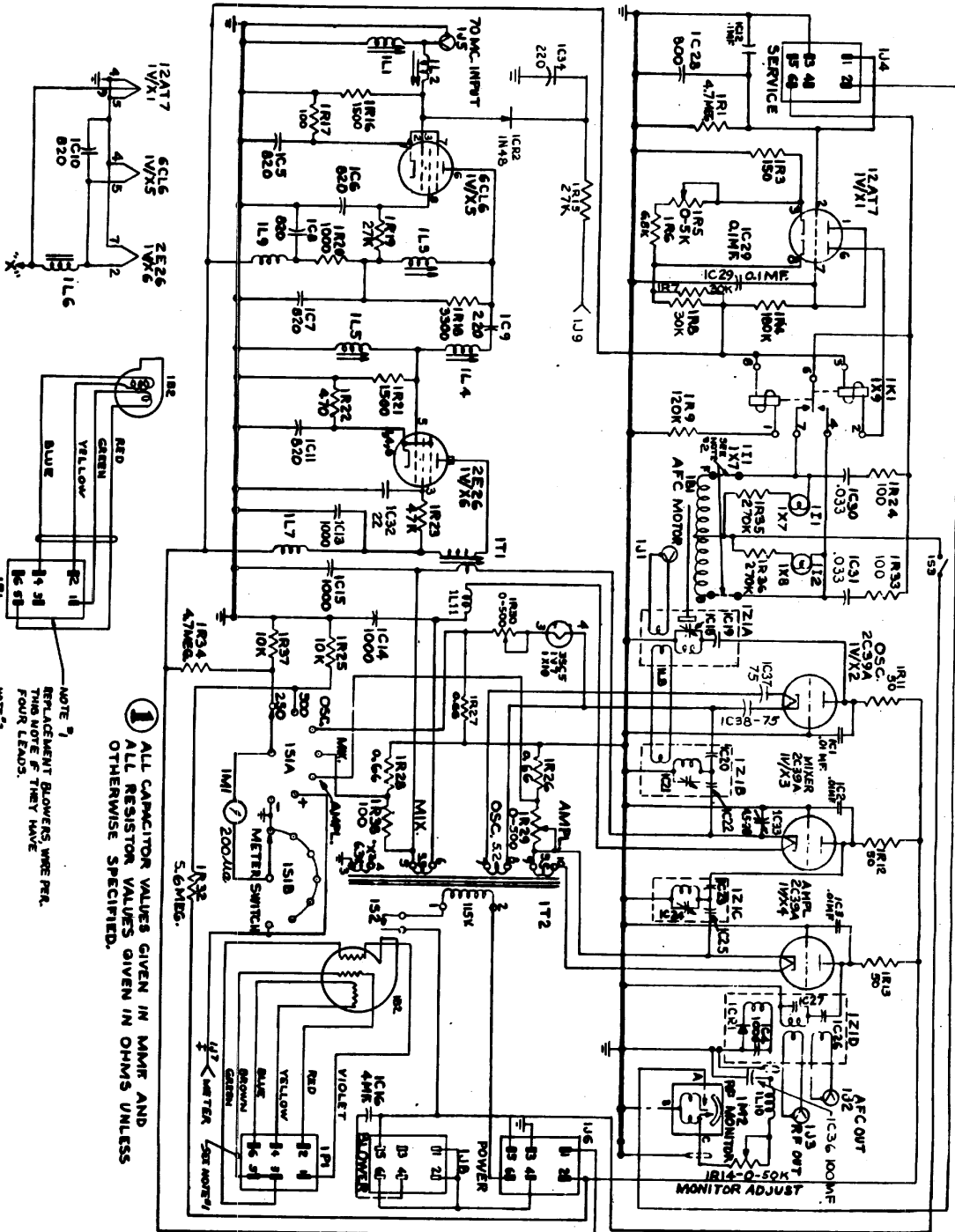


Figure T-3—Transmitter—Schematic Diagram



# **MICROWAVE COMMUNICATION EQUIPMENT**

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## **Receiver / Modulator**

**MI-25969 Wide-Band (For CW-20 Systems)**

**MI-31174 Wide-Band (For MM-26 Systems)**

**MI-25969-1 Narrow-Band (For CW-20 Systems)**

**MI-31174-1 Narrow-Band (For MM-26 Systems)**

- TECHNICAL DATA
- DESCRIPTION
- MAINTENANCE
- REPLACEMENT PARTS



**RADIO CORPORATION OF AMERICA**  
**COMMUNICATION PRODUCTS DEPARTMENT, CAMDEN, NEW JERSEY**

### TECHNICAL DATA

<b>Power Input:</b>		<b>Crystals</b>		
a. Filament Heaters: 46 watts at 115 v, 50/60 cycle ac		<b>Symbol</b>	<b>Type</b>	<b>Function</b>
b. Plate Supply: 140 milliamps at 250 v dc		2CR1	1N21D MI-25969	RF Mixer
<b>Frequency Range</b>			1N23E MI-31174	
1700-1990 megacycles (MI-25969)		2CR2	CK705	RF Rectifier
2450-2700 megacycles (MI-31174)		2CR3	CK705	First Limiter
<b>Receiver Band Width</b>		2CR4	CK705	First Limiter
6 megacycles		2CR5	CK705	Second Limiter
<b>Receiver Noise Figure</b>		2CR6	CK705	Second Limiter
9 db (MI-25969)		2CR7	CK705	RF Rectifier
8 db (MI-31174)		2CR8	CK705	Third Limiter
<b>I.F. Frequency</b>		2CR9	CK705	Third Limiter
30 mc		<b>Tube Complement</b>		
<b>R.F. Input Impedance</b>		<b>Symbol</b>	<b>Type</b>	<b>Function</b>
50 ohms		2V1	6CB6	First i-f Amplifier
<b>Carrier Operated Relay Sensitivity</b>		2V2	6CB6	Second i-f Amplifier
C/N = 12 db max.		2V3	6CB6	Third i-f Amplifier
<b>Baseband Output for ± 1.5 mc Peak Deviation</b>		2V4	6CB6	Fourth i-f Amplifier
1.2 v rms		2V5	6CB6	Fifth i-f Amplifier
<b>Baseband Output Frequency Range</b>		2V6	6CB6	Sixth i-f Amplifier
3 kc to 540 kc		2V7	6CB6	First Limiter
<b>Service Channel Output for ± 75 kc Peak Deviation</b>		2V8	6CB6	Second Limiter
0.61 v rms		2V9	OA2	Voltage Regulator
<b>Service Channel Frequency Response</b>		2V10	6AS6	Modulator Mixer
300 cps to 3 kc ± 2 db		2V11	6CB6	70 MC Amplifier
<b>Service Channel Signal-to-Noise Ratio</b>		2V12	6AH6	FM Modulator
(below ± 75 kc peak deviation)		2V13	12AT7	40 MC Oscillator
35 db		2V14	12AT7	Fault Oscillator
<b>Modulator Input for ± 1.5 mc Peak Deviation</b>		2V15	6CB6	Baseband Amplifier
0.95 v		2V16	12AX7	Service Channel Amplifier
<b>Relays</b>		* 2V17	12AX7	Lockout Amplifier
<b>Symbol</b>	<b>Function</b>	* 2V18	12AT7	Lockout Amplifier
2K1	Receiver Fault	2V19	6AH6	Driver
2K2	Noise Suppression	2V20	6AH6	Driver
* 2K3	Standby Lockout	2V21	6AL5	Discriminator
		<b>Weight and Dimensions</b>		
		Weight - 15 lbs.		
		Height - 12 1/4"		
		Depth back of panel: 2-7/8"		
		Depth front of panel: 4"		
		Width: 19" Rack Mounting		

\* Required when receiver is operated with standby equipment.  
 Supplied with Terminal or Repeater Switching Unit.  
 Not included with Receiver/Modulators MI-25969 and MI-31174.

### DESCRIPTION

The Receiver/Modulator is designed for mounting in either a standard 19" open rack or cabinet and is used in both terminal and repeater stations. The unit has two main functions. The receiver section amplifies and demodulates the incoming f-m signal from a terminal or repeater station and delivers the .3 to 600 kc information to the baseband and/or service units. The modulator section provides the transmitter with a 70 mc f-m carrier, modulated with the .3 to 600 kc multiplex and service channel signals. In a receiver at a repeater station the modulation on this 70 mc carrier also

includes the incoming modulation on the 30 mc i-f signal.

#### Receiver

In the receiving section the incoming microwave signal is first converted to a 30 mc i-f. This is accomplished by mixing the microwave signal with a sample of the transmitter local oscillator frequency. These two frequencies are always 30 mc apart in accordance with the system plan. Refer to the system instructions for Typical Systems Frequencies. This mixing is done in mixer cavity 2Z1 which receives

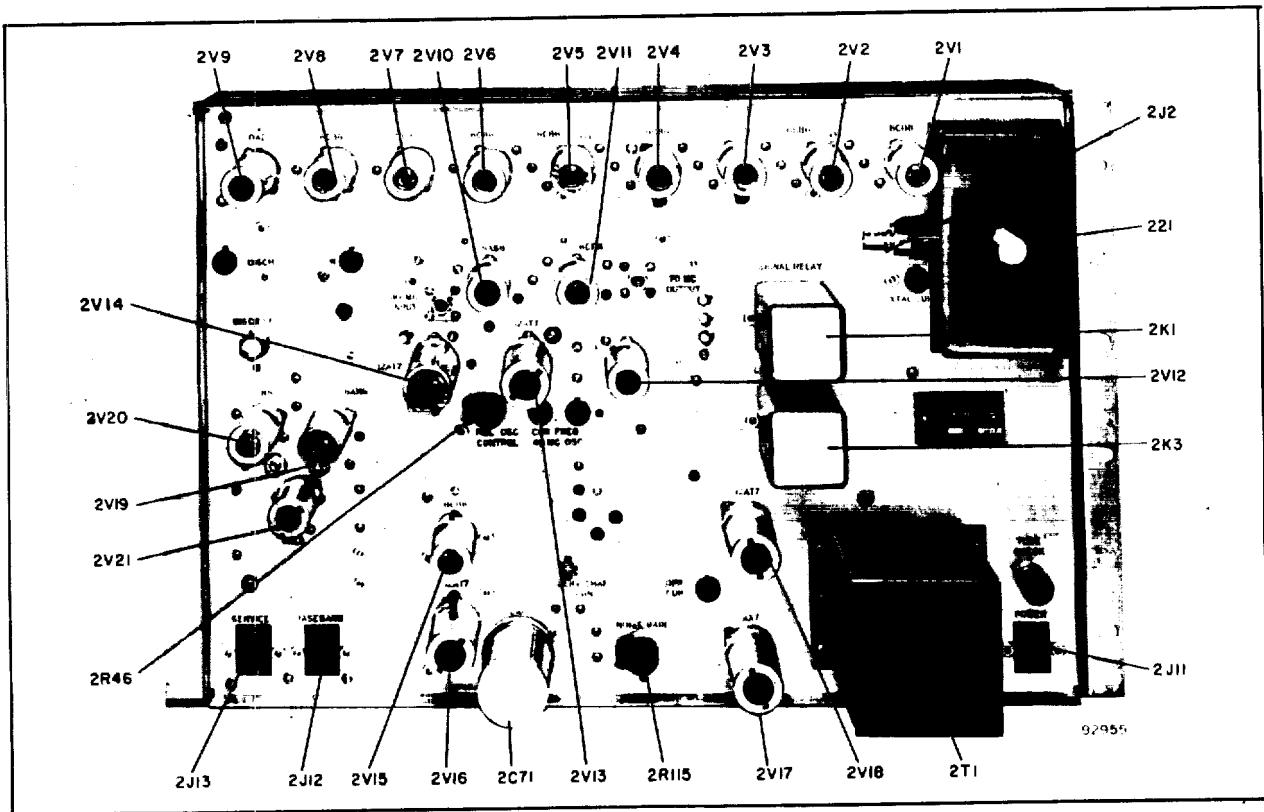


Figure RM-1—Receiver/Modulator—Front View

the microwave signal through a coaxial cable from the receiving filter unit. This cable is connected to cavity terminal 2J1 on the back of the chassis. A sample of the transmitter local oscillator frequency is fed by means of a coaxial cable from terminal 1J1 of the transmitter to terminal 2J2, labeled LOCAL OSC., of the mixer cavity 2Z1. The difference frequency is generated by the mixer cavity crystal 2CR1 and delivered to the grid of the first 30 mc i-f stage. The screwdriver adjusting control on the front of 2Z1 resonates the cavity to the correct frequency. Coupling loop 2J2 couples the local oscillator energy into the mixer cavity. The 30 mc output of cavity 2Z1 is amplified by 6 stages (2V1 thru 2V6) of i-f amplifiers to a sufficiently high level so that proper limiting action can take place in the two limiting stages 2V7 and 2V8. Each of the two limiting stages contain dual limiting circuits. Besides the limiting that occurs in the electron tubes, additional limiting action is performed in the circuits containing crystals 2CR3 and 2CR4 of the 1st limiter stage and crystals

2CR5 and 2CR6 of the 2nd limiter stage and crystals 2CR8 and 2CR9. The 30 mc output of the 2nd limiter stage is fed to the two parallel drivers 2V19 and 2V20. Voltage regulator 2V9 provide a regulated 150 volts dc for the screens of the two driver stages, 2V19 and 2V20. The outputs of the driver are fed to discriminator 2V21, driver 2V19 feeds the low tuned section of the discriminator, driver 2V20 feeds the high tuned section. The fm signal is demodulated and the 300 cycles to 600 kc component is delivered to the baseband amplifier, 2V15. The output of 2V15 is connected to plug 2J12 for delivery to the baseband unit at terminal and drop repeater stations. At thru repeater stations the 300 cycle to 3 kc portion of the band is amplified by the service channel amplifier. 2V16 and its output is connected to plug 2J12 for delivery to the service channel unit. A connection to terminal 1 of jack 2J13 from the discriminator output provides the dc amplifier of the transmitter AFC circuit with

the dc correction voltage when the transmitter local oscillator drifts off frequency.

### Modulator

In the modulator section, mixer 2V10 produces the 70 mc i-f signal which modulates the transmitter microwave carrier. Amplifier 2V11 amplifies the 70 mc i-f output of the modulator i-f mixer which is then coupled by coaxial cable to the transmitter by means of 70 MC OUTPUT jack 2J9. The source of the two signals that supply modulator i-f mixer 2V10 with its heterodyning frequencies differ for each type of station as follows:

a. At a terminal station the 70 mc subcarrier output of the modulator i-f mixer 2V10 is the difference frequency of a 110 mc and a 40 mc signal. The 40 mc signal is the output of oscillator 2V13 and contains the multiplex and service channel signals from the baseband unit. The 110 mc frequency is received from the terminal AFC and is coupled through a coaxial cable to the 110 MC INPUT jack 2J8 of the receiver/modulator. At terminal stations only, internal bus connection "P" must be made to jack 2J8, connection "O" made at jack 2J12, coil 2L47 shorted, and connection "L" omitted. (The letters "P", "O" and "L" refer to connections found on the receiver/modulator schematic of figure RM-8.) Adding connection "P" feeds the 110 mc frequency from the terminal AFC unit to the modulator i-f mixer 2V10. Removing connection "L" disconnects the receiver 30 mc signal from 2V10. Shorting 2L47 prevents 2V14 from operating as a 110 mc oscillator. Adding connection "O" maintains the proper baseband output load impedance when only one receiver/modulator unit is used as at a terminal station. The amount of baseband signal applied to 2V12 is determined by the setting of MODULATOR GAIN control 2R109 which is adjusted at the factory so that the modulation sensitivity of all receiver/modulator units will be the same.

b. At drop repeater stations the 70 mc subcarrier output of the modulator i-f mixer 2V10 is the sum frequency of a 30 mc and a 40 mc signal. The signal from the 40 mc oscillator 2V13 and frequency modulator 2V12 contains the 300 cycle to 600 kc multiplex and service channel frequencies added 600 at this station. The 30 mc signal comes from the receiver 1st limiter stage output and contains the intelligence modulated on the received microwave signal.

c. The modulator section of a thru repeater station

is the same as that of a drop repeater station except the 40 mc oscillator signal to the modulator-mixer stage 2V10 contain only 300 cycles to 3 kc service channel information (voice communication and fault tone pulses) from the repeater service unit.

In repeater stations the 30 mc frequency to the modulator mixer stage 2V10 comes from the 1st limiter (2V7) output circuit. Be certain that internal connection L is made when the receiver/modulator is used in either a drop repeater or a thru repeater station and removed when used at a terminal station.

### Fault Circuit

The fault circuit consists of fault oscillator 2V14 and relays 2K1 and 2K2. This circuit performs its functions when the i-f amplifier fails or when the microwave signal from the previous transmitter is absent. When either of the above conditions exists a lowering of the normal positive dc voltage from crystal 2CR2 of the six receiver i-f stage to the control grid #2 of fault oscillator 2V14 causes the following action to occur:

a. At a drop or thru repeater station the 110 mc fault oscillator 2V14 normally is inoperative, but when the receiver signal fails the blocking bias is removed and 2V14 starts oscillating to supply one of the heterodyne frequencies to mixer 2V10. This frequency in combination with the 40 mc oscillator output (110 mc — 40 mc) provides the necessary 70 mc output to keep the transmitter radiating a quieted microwave carrier. In addition relay 2K1 is operated.

b. At a terminal station the 110 mc output of fault oscillator 2V14 is not required, so 2V14 is changed to a dc amplifier by shorting out plate coil 2L47. If the incoming signal stops or the i-f amplifier fails, amplifier 2V14 will cause 2K1 to operate.

### Relay 2K1 Operation

1. Contact 2-3 opens. This breaks the 115 v ac supply to the AFC motor in the transmitter, disabling it for the duration of the fault. This is done because, if the absence of an incoming signal is the reason 2K1 is energized, amplified noise from the i-f amplifier may produce a dc voltage at the discriminator output which would cause the AFC motor to run although no transmitter frequency correction is necessary.

2. Contact 3-4 closes, operating relay 2K2.

RM-4

**Relay 2K2 Operation**

1. Contact 2-4 opens. This breaks the B+ circuit to limiters 2V7 and 2V8, keeping noise from being fed to the discriminator 2V21 and mixer 2V10 at a repeater station or to 2V21 only at a terminal station. The noise voltage is thus prevented from reaching the multiplex equipment and service units and from being transmitted.

2. Contact 6-7 closes.

(a) At a non-standby station, contact 6-7 connects the 115 V AC through the closed contacts of relay 2K3, to either the main equipment failure relay or the loss of signal relay in the indicon coder or decoder unit depending on whether relay 2K3 is operated or not operated.

(b) At a standby station, contact 6-7 also connects 110 V AC to the receiver fault switchover relay of the standby switching unit (relay 9K8 of the repeater switching unit or relay 10K7 of the terminal switching unit) *providing contact 2-3 of relay 2K3 is closed*, initiating the radio equipment standby switchover operation.

**Relay 2K3 Operation—Standby Lockout Circuit**

If the receiver I.F. amplifier fails, contact 2-3 of 2K3 is closed (2K3 released) by the action of the standby lockout circuit causing standby switchover and transmission of a fault signal. The standby lockout circuit will not allow relay 2K3 to release on failure of the incoming signal only. Contacts 2-3 of relay 2K3 will remain open and standby switchover will not occur.

For complete description of the functioning of the standby lockout circuit consult the Standby Switchover Instructions.

**Tube Check**

When the TUBE CHECK pushbutton 2S1 is pressed a 75 ohm resistor is connected in series with the primary of filament transformer 2T1. This reduces the filament voltage of the tubes by approximately 25%. By checking the meter reading at the various circuit test points and by other test checks the marginal tubes will be revealed.

**CONTROLS**

a. The Cavity Tuning control (2Z1) is used to tune the mixer cavity to the frequency of the incoming signal from the antenna.

b. The REL. OSC. control (2R46) adjusts the grid bias of the dc amplifier section of 2V14 thereby controlling the condition under which the 110 mc oscillator will commence operation and 2K1 will operate.

c. The DISC pin jack (2J5) is used to connect test meter 1M1 to the output of the discriminator to determine if the i-f frequency is centered at 30 mc.

d. The SIG. pin jack (2J4) is used to connect the test meter 1M1 to measure the signal voltage of the i-f section when tuning the receiver.

e. The CUR. (2J14) pin jack is used to connect the test meter 1M1 when tuning the 40 mc f-m osc. of the modulator section.

f. The FREQ. (2J7) pin jack is used to connect the distortion and modulation test unit to the modulator while aligning the receiver.

g. The XTAL. CUR pin jack (2J3) is used to connect the test meter 1M1 when adjusting 2J2 of the mixer cavity for proper crystal excitation.

h. The 110 MC INPUT (2J8) coaxial terminal is used to connect the 110 mc output of the terminal AFC unit to the receiver r-f mixer grid. It is used only at terminal stations.

i. The 70 MC OUTPUT coaxial terminal (2J9) is used to connect the 70 mc output of the modulator section to the transmitter 70 mc input.

j. The LOCAL OSC coaxial terminal (2J2) is the input terminal for connecting a portion of the output of the transmitter local oscillator to the mixer cavity.

k. The Receiver Baseband Gain control 2R107 is a screw driver adjusting potentiometer for regulating the signal voltage level from amplifier stage 2V15 to the baseband unit and to the signal channel amplifier stage 2V16. This control, located in the rear of the unit, is adjusted and sealed at the factory.

l. The Modulator Gain control 2R109 is a screw-driver adjusting potentiometer for controlling the amount of signal voltage from the baseband unit applied to the 40 mc modulator stage 2V12. This control, located in the rear of the unit, is adjusted and sealed at the factory and normally requires no adjustment in the field.

m. The NOISE GAIN potentiometer 2R115 is a control for regulating the amount of noise signal to amplifier 2V17 (6-7-8).

n. The "OPR CUR" jack 2J15 is for monitoring the operating current of the dc amplifier 2V18 (6-7-8) when adjusting the noise gain control.

o. The TUBE CHECK pushbuttons 2S1 is used to reduce the filament voltage of the tubes for the purpose of checking their operating condition.

p. The SERV CHAN GAIN control 2R140 is used to adjust the input to the service channel amplifier 2V16.

## MAINTENANCE

### General Notes

The majority of tubes in the receiver/modulator can be checked while the unit is in operation by use of TUBE CHECK pushbutton 2S1. With the unit operating normally connect SIG jack 2J4 to test meter 1M1 and note the current reading. If this reading drops more than 50% when 2S1 is depressed there is a near-failure tube probable in one of the first five 30 mc i-f sockets (2V1 thru 2V5). If the current read at the 40 mc OSC CUR jack drops more than 20% with 2S1 depressed it is probable that either 2V12 or 2V13 are near failure. If this check is satisfactory, a check of 2V10 and 2V11 is possible by observing the rf monitor meter 1M2 reading. If its reading drops more than 60% a near-failure tube is probable in sockets 2V10 or 2V11. A check of 2V6 thru 2V9 and 2V15 is possible by monitoring a received multiplex signal. If the level of this signal varies more than  $\pm 2$  db a probable near-failure tube exists in one of these sockets.

Regarding changing tubes in the receiver/modulator it should be cautioned that certain tubes should be replaced only if absolutely necessary. 2V8 (2nd Lim.), 2V19 (Driver), 2V20 (Driver), 2V21 (Discr.), 2V12 (Mod.), and 2V13 (Osc.) have effects upon the modulation and demodulation linearity of the system. As a consequence these should not be changed unless complete tube failure makes it necessary.

The changing of these tubes may affect the linearity of these stages. Do not attempt a linearity realignment unless the cross talk between channels is noticed to increase intolerably. See the CIRCUIT ALIGNMENT section following, if linearity alignment is required.

If either 2V12 or 2V13 are changed, the frequency of the 2V13 oscillator should be adjusted to 40 mc by varying 2L57 "40 MC OSC" only. When measuring the frequency of the 40 mc oscillator there must be no modulation on it. To make sure there is no hum input pull out the baseband plug feeding the receiver/modulator during the measurement. If 2V14 is changed the frequency and operating point of the 110 mc oscillator will need to be reset.

The information required for checking and adjusting the frequency of the 40 mc and 110 mc oscillators will be found in the INITIAL ADJUSTMENT procedure of the system instructions and the CIRCUIT ALIGNMENT section following.

When replacing Crystal 2CR1, caution must be exercised to prevent damaging the crystal by static discharge. To prevent this, one hand should be grounded to the chassis before the crystal is allowed to touch any part of the equipment. A soldering iron should never be used on circuits connected to the 2CR1 crystal without unplugging the iron for the period of use. AC leakage current may otherwise burn out the crystal. The 2CR1 crystal current should never be allowed to exceed a meter reading at 2J3 of 200  $\mu$ a.

If a tuning coil in the 30 mc i-f or 70 mc i-f circuits should open or become damaged, install a replacement coil with its core turned in the same amount as in the faulty coil. When thus repaired these circuits will be adequately well aligned.

Tuning coils of the frequency modulator stages 2V12 or 2V13 and discriminator stage 2V21 cannot be replaced without alignment of those circuits.

The plug-in electrolytic capacitor 2C71 should be replaced after being in use continuously for one year.

The schematic of figure RM-8 shows the dc voltage values at all pertinent circuit check points. Certain of these points contain double voltage readings. Wherever these readings occur, except for standby lockout circuit 2V18, the value above the line is the voltage with no signal at the receiver input and the value below the line is present with a saturating signal. For 2V18 the upper value is for little or no signal and the lower value is with tube 2V1 removed.

### CIRCUIT ALIGNMENT

The following instructions describe the process for complete realignment of a receiver/modulator unit. It is strongly cautioned that before such a realignment be attempted full familiarity with the unit be obtained and all of the recommended test equipment listed in the test equipment tables of the system instructions be assembled.

The test items specified in the following alignment procedures refer to the test equipment items listed in the test equipment tables of the system instructions.

#### Limiters Alignment

a. Remove 2CR1. Attach the sweep generator output to the junction of 2C42 and 2C45; attach the scope lead to the junction of 2L75 and 2C58; attach test equipment item 27 (a) between ground and 2C139. Set the sweep generator output low enough



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so that the stage has not started to limit and the scope response is sharp. Peak 2L35 at 30.0 mc.

NOTE: In this and other applications, use a 10 microhenry r-f choke with leads approximately one inch long (test item 27(d)) in series with the scope lead.

b. Turn 2C164 all the way in, and 2C165 all the way out. Repeat (a), peaking 2L64 and 2L65 with the sweep generator attached to the same place and the scope attached to 2V19-5 (or 2V20-5).

c. Repeat (a), peaking 2L31 with the sweep generator attached to the high side of 2L27 and the scope attached to 2V7-6. Remove test equipment item 27 (a).

### 30 MC I-F Alignment

a. Remove the rubber base cement used to prevent the cores of the i-f transformers from moving. Use a sharp instrument to loosen the edge of the seal and then peel off the cement.

b. Apply the output of the 30 mc sweep generator to the bottom end of 2L22, ground pin 1 of 2V4 to the center pin of the socket with a test prod, and attach the scope to the junction of 2C37 and 2R21. Adjust the output of the sweep generator for approximately +0.2 v dc at 2R21 with the "sweep" knob in the "narrow" position. Turn on the sweep generator markers at 25.6 mc and 34.4 mc. With the "sweep" knob in the "wide" position, align the stage for symmetrical response, (stages will vary from critical coupled to somewhat less than critical coupled) and for band-width such that the two markers fall on the 50% response point. It will be found that 2L25 and 2L27 act much the same as the primary and secondary respectively of a double-tuned circuit. 2L26 controls the primary-to-secondary coupling and consequently the stage bandwidth.

NOTE: Solder a 100 K ohm isolation resistor in series with the Voltohmyst test probe.

c. Connect the sweep generator to 2L17, ground 2V3-1, connect test equipment item 27(c) (see Figure RM-3) to the bottom end of 2C27, and attach the scope to the alignment jig. With the scope gain on maximum, adjust the sweep generator output for the minimum value providing an adequate picture. Align 2L20, 21 and 22 as above except place the 25.6 mc marker at the 60% response point and the 34.4 mc marker at the 40% response point as shown in figure RM-2.

This is done so that when the slight capacity added by the alignment jig is removed, the stage will be properly centered around 30 mc.

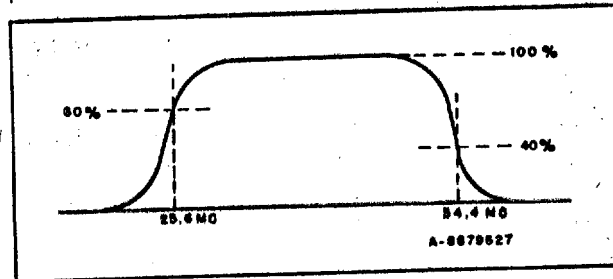


Figure RM-2—30 mc IF Response Curve

d. Apply the sweep generator to 2L12, ground 2V2-1, attach the alignment jig to the bottom of 2C21, and apply capacitor test equipment item 27(e), to 2V5-5 so as to ground this point to r-f only. Align 2L15, 16 and 17 as in (c).

e. Align 2L10, 11 and 12 as in (d) by moving all test equipment items forward one stage.

f. Attach the 680-ohm - 47 ohm resistor combination, test equipment item 27 (b) (see Figure RM-5), between the screw directly above 2L3 and the standoff insulator connection to 2L1.

Align 2L5, 6 and 7 as in (d) by moving all test equipment items forward one stage except apply sweep generator through a 1500 mmf ceramic capacitor to 2V1-1.

g. Attach the sweep generator to the high side of the 47 ohm resistor, the scope to the junction of 2L3 and 2R86 and r-f ground 2V2-5. Align 2L1, 2 and 3 for a flat-topped response regardless of the stage bandwidth unless this bandwidth is less than 8.8 mc. In this latter case align for 8.8 mc bandwidth.

Since the alignment jig is not used in this case the stage is to be aligned symmetrically about 30 mc as in (b) with the two markers at the same percentage response.

Remove test equipment item 27(b).

h. To insure that the limiter interstages are acting as limiters, connect the sweep generator to 2L22, the scope to the junction of 2C153 and 2R155, and test equipment item 27 (a) to 2C139. Starting with a low enough sweep generator output so that the picture viewed is a sharply peaked response, increase the output and observe that the response broadens out and reaches a limiting value. Repeat with the scope on 2V8-6 and 2V7-6.

NOTES: 1. To minimize spurious interstage coupling, the ground return connection of the sweep generator should always be kept to the left of the point at which the sweep generator is being applied (as viewed from the rear of the chassis).

2. The sweep generator output cable is to be terminated in 68 ohms at the cable end. The

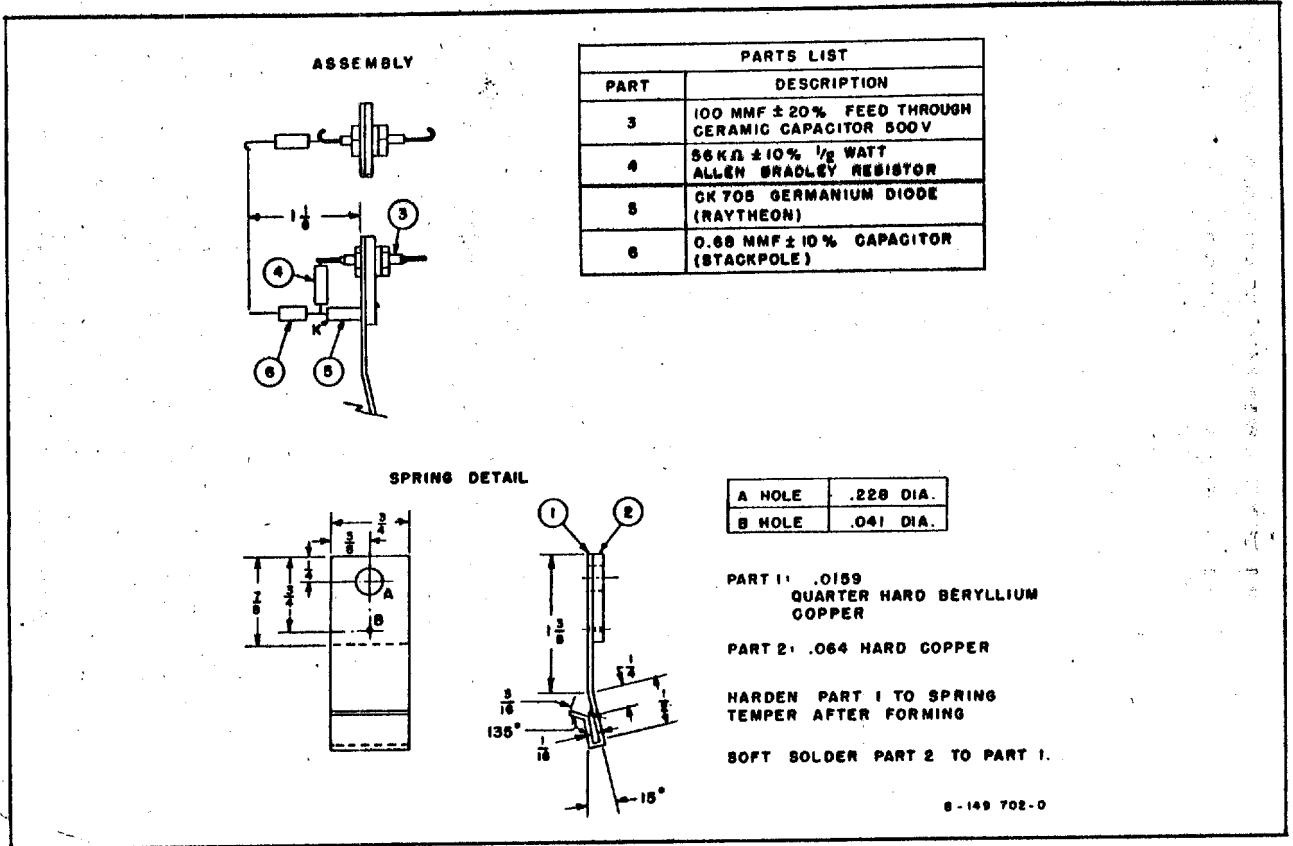


Figure RM-3—30 mc IF Alignment Jig

leads from the end of the cable to the point of use should be kept as short as possible—certainly under 2".

3. To obtain an i-f response centered around 30 mc, it may be necessary to slightly favor either band edge marker at the expense of the other. Depending upon how well the results of test (b) (I-F Response Check) indicate i-f symmetry, a touch method for tuning the i-f's a bit high or low may need to be used.

**R-F Test and I-F Gain Check**

Insert 2CR1.

*CAUTION: Ground the body to the receiver chassis before inserting the crystal to prevent static discharge from damaging the crystal.*

a. Apply the transmitter local oscillator frequency to 2J2. Adjust the position of 2J2 for 2J31 = 50  $\mu$ a. With no input signal to the i-f or r-f note the value of 2J4E due to amplified noise. If this reading is below 0.1 volt, the i-f has insufficient gain and the quality of the i-f tubes should be investigated. The 0.1 volt reading is equivalent to a reading of 5  $\mu$ a using the 200  $\mu$ a test meter.

b. Maintaining the local oscillator feed at 2J31 = 50  $\mu$ a attach test equipment item 16, the r-f signal generator. Note the reading of 2J4E on noise with

the signal generator off. Turn on the signal generator and adjust its frequency to that normally received. Fine tuning is accomplished by tuning for zero discriminator current (2J5). Increase the 2J4E reading by the noise figure factor listed below (depending upon the original noise reading).

2J4E on Noise	Noise Figure Factor
.05 v to 0.1 v	1.6 x
0.1 v to 0.4 v	1.5 x
0.4 v to 0.8 v	1.4 x

Note the signal generator reading in microvolts. It should be equal to or less than 2.7  $\mu$ v. This figure corresponds to a noise figure of 8.0 db.

NOTE: For all of these tests a short, low loss r-f cable must be used to connect the r-f test equipment to the receiver.

**I-F Response Check**

a. Calibrate the discriminator (with the i-f cover on) by applying high level, saturating signals to the i-f at 28, 30 and 32 mc, recording the discriminator voltage for these frequencies.

Connect the r-f signal generator to 2J1 and apply a signal at the frequency of the assigned received

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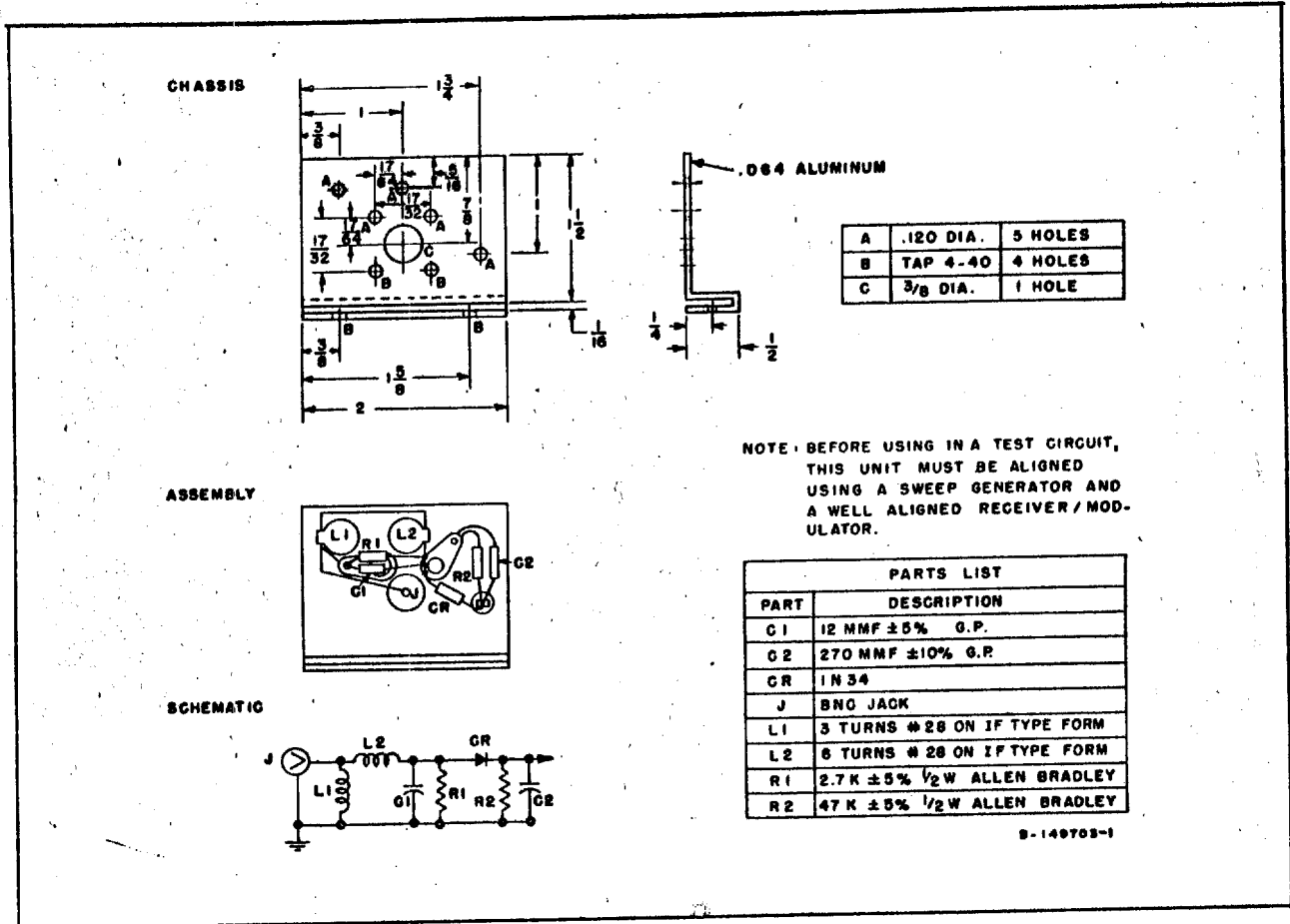


Figure RM-4—70 mc Dummy Load

signal. Adjust its exact frequency so that the i-f frequency is 30.0 (0 current at 2J5 mc and adjust the level for 2J4 = 1.0 v. Adjust the slug of 2Z1 for a peak reading. Vary the signal generator frequency (keeping its output constant) and note 2J4E for i-f signals of 28.0 mc and 32.0 mc. The i-f response in db, defined as

$$20 \log_{10} \frac{E(28 \text{ mc or } 32 \text{ mc})}{E(30 \text{ mc})}$$

should not vary from the 30 mc value by more than ±1.5 db.

NOTE: In this case and others when a saturating 30 mc i-f signal is desired, the maximum output of the i-f signal generator will suffice. It should be fed into the i-f strip through the hole in the cover just above the hole for the tuning slug of 2L2.

**70 mc I-F Alignment**

a. Connect the "70 MC OUTPUT" of the receiver/modulator to the 70 mc jack of test equipment item 27(f) (see Figure RM-4) using the 70 mc coaxial cable that is normally connected to the Transmitter "70 MC INPUT." (No other cable should

be used.) Attach the scope to the "d-c" pin of test item 27(f) (70 mc dummy load) and the sweep generator, with 70 mc sweep at full output, to 2V11-1. Align the output network, by tuning 2L55 and 2L56 so that the response is symmetrical and the 64 mc and 76 mc pips fall at the 70% response point.

b. Connect the sweep generator to the hot end of 2L50. With the scope still on "d-c", reduce the output of the sweep generator until the observed scope picture height is roughly the same as it was in (a). Connect the scope to 2V11-6. Align 2L52, 53 and 54 as above for symmetrical response and for pips at the 70% response points.

**Mixer Circuit Alignment**

Using the megacycle meter (test equipment item 12) adjust the 40 mc oscillator (2V13) so that its frequency is 40.0 mc. Make sure that 2J14I (as measured with the 200 μa meter, test item 14) is reading a reasonable value—between +65 μa and +80 μa. Apply a 30.0 mc saturating signal to the 30 mc i-f. Metering the voltage at the "d-c" terminal of 70 mc dummy load, peak 2L49 and 2L50. This must be done very carefully since the maxima are

quite broad. The rectifier dummy load dc voltage should be 1.5 volts or greater. *Wire "L" must be connected for this test.*

#### Fault Oscillator/Relay Adjustment

a. Turn 2R46 maximum clockwise to insure strong oscillation of 2V14. Using the megacycle meter (test item 12) set the oscillator frequency to 110 mc. The rectified dummy load dc voltage should be 1.5 volts or greater.

b. To adjust the REL/OSC CONTROL 2R46 connect the r-f signal generator (test item 16) to 2J1. With the signal generator at zero output, plug the 1M1 meter lead into the SIG jack and note the noise reading on the test meter. Turn up the signal generator output until a reading of 20  $\mu$ a plus the noise reading is obtained. Then turn the REL/OSC CONTROL fully clockwise and then carefully counter-clockwise, stopping when the relay clicks. The relay should now operate and the 110 mc oscillator become operative and inoperative as the signal is removed and reapplied.

#### Discriminator Alignment

a. Remote wire "L". Turn controls 2R107 and 2R109 on the receiver/modulator unit to maximum. Adjust the frequency of the signal generator, test equipment item 16 by the T.V. calibrator, test equipment item 5 for 30 mc. Insert the 30 mc probe near the grid of the first i-f stage and adjust 2R151 for zero discriminator d-c output (2J5). Remove the probe.

Attach the distortion and modulation test unit, test equipment item 11 to the receiver modulator, putting only the 30 mc probe and the 40 mc probe in place. With the "40 mc Var" oscillator and the "40 mc Xtal" oscillator on, locate the beat between the two with the "40 mc Var" control. With the "40 mc Xtal" oscillator off, adjust the 35 mc oscillator of the test set for zero discriminator d-c output (2J5). Turn the "40 mc Var" oscillator off, and adjust 2L57 for zero discriminator d-c output".

NOTE: For all of this test the covers for both the 30 mc i-f and the oscillator-mixer section must be kept on.

b. Plug in the baseband connection.

Each distortion and modulation test unit is factory adjusted so that its meter (M1) will read 100 for  $\pm 750$  kc deviation when the meter is on the "35 mc Osc" position at which time it reads the tone level being supplied to the 35 mc modulator/oscillator. For an average modulator section (in the receiver/modulator unit) a reading of 30 will result in a  $\pm 750$  kc deviation, with the meter switch on the "Rec-Mod" position.

Put the operation switch in the "Discr" position.

With meter on "35 mc Osc." adjust Osc. B on 50 kc for a reading of 100. With the meter on "Rec. Mod." adjust Osc. A on 70 kc for a reading of 30. With the meter on 0 db and Osc. B changed to 30 kc, adjust "30 kc Gain" for full scale (0 db) reading. With Osc. A on the 70 kc and 80 kc positions, and Osc. B on 50 kc read the intermodulation products at 30 kc with the meter. In the 70 kc and 80 kc positions the unit is measuring the products due to third and second order intermodulation respectively. Adjust the discriminator so that both 70 kc and 80 kc products are minimum. It should be possible to align the units so these products are below  $-43$  db, however a value of  $-40$  db will provide satisfactory service.

In aligning the discriminator it will be found that 2L71 and 2C165 primarily adjust the high frequency peak and 2L70 and 2C164 primarily adjust the low frequency peak. The 70 kc product is determined by the separation of these two peaks and the 80 kc product is determined primarily by the 2R151 setting.

In tuning the discriminator the condition shall be maintained that: *the discriminator d-c output (2J5) for a saturating CW signal of 30.0 mc must be zero volts  $\pm 0.01$  v.*

c. Test the discriminator linearity at half deviation using essentially the same procedure as above, except use readings of  $1/2$  the above for the oscillator levels. (Readjust the "30 kc Gain" for full scale reading in this revised condition.) It should be possible to align the units so that in this case the products will be below  $-51$  db, however, a value of  $-45$  db will provide satisfactory service.

#### Modulator Alignment

a. Continuing with the test unit, change to the "overall" test position. With the meter on "Rec Mod", "Osc. A" off and "Osc. B" on 50 kc adjust the output of "Osc. B" to 60. With "Osc. B" off and "Osc. A" on 70 kc adjust its output to 60. With both oscillators on and Osc. B on 30 kc, adjust

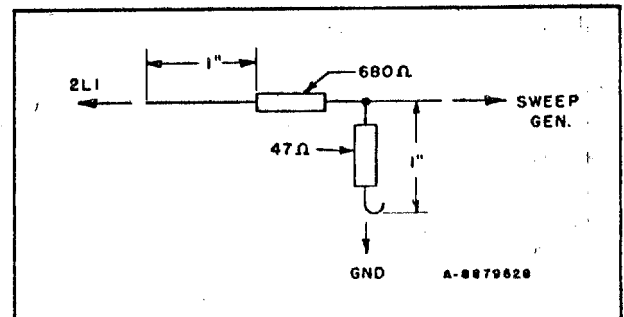


Figure RM-5—30 mc Alignment Resistor Network

RM-10

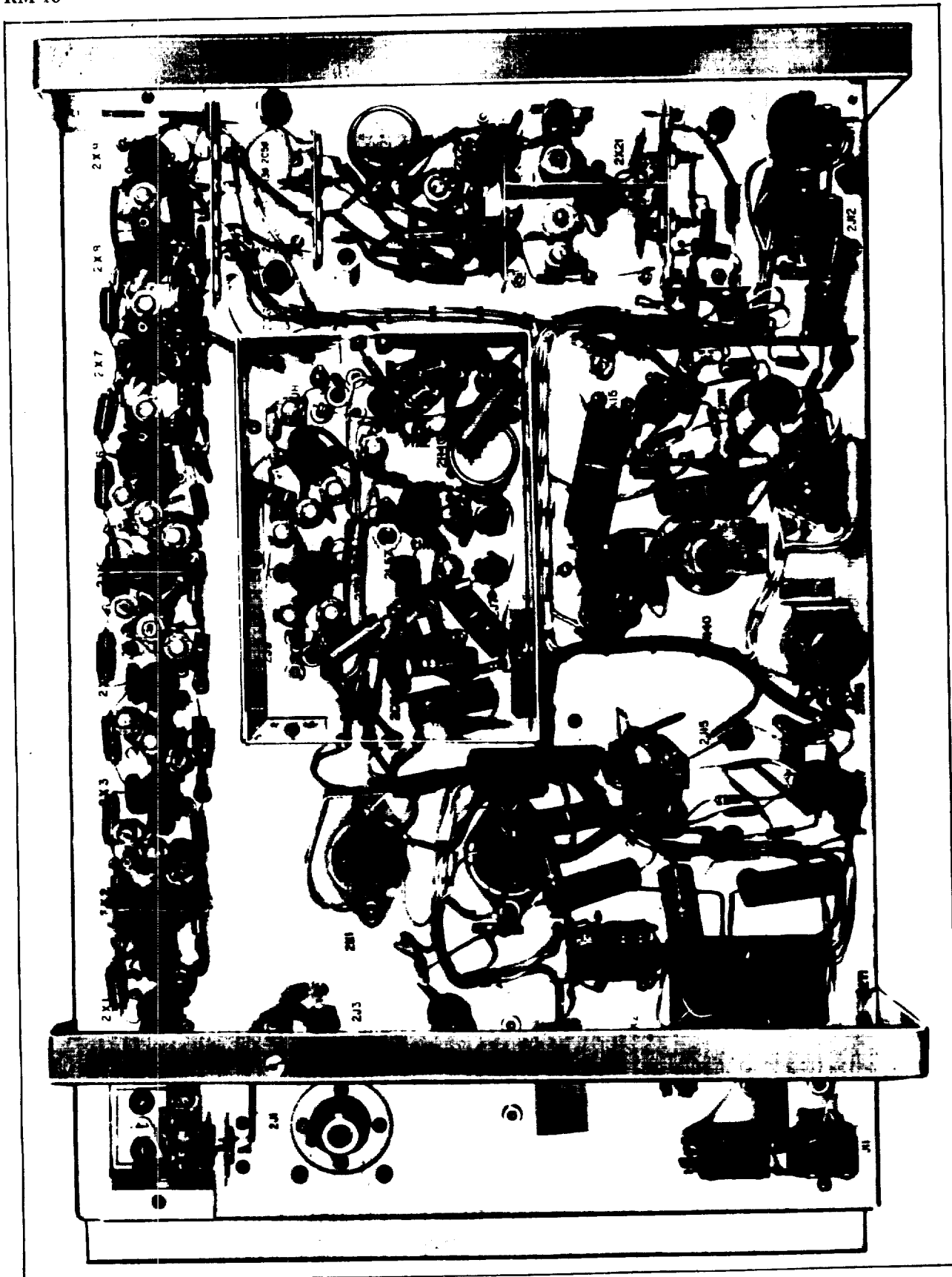


Figure RM-6—Receiver/Modulator—Rear View, Dust Cover and Shield Covers Removed

"30 kc Gain" for full scale on meter "O db". With "Osc. A" on 80 kc, tune 2L58 for minimum meter reading. Check the meter reading with oscillator A on 70 kc. It should be possible to align the units so that these products are below -43 db, however a value of -40 db will provide satisfactory service.

b. Test the overall operation at half deviation using essentially the same procedure as above except using a meter reading of 30. (Readjust "30 kc Gain" for full scale.) It should be possible to align the units so that in this case the products will be below -51 db, however a value of -45 db will provide satisfactory service.

NOTES: 1. Since an average reading of 30 is used for the receiver 40 mc modulator, occasionally difficulty may arise due to over-deviating an unusually sensitive modulator. If there is doubt, calibrate the individual modulator as is generally described in (c) below.

2. In all discriminator and modulator alignment tests the 200  $\mu$ a test meter must *not* be connected to 2J5.

c. Connect the electronic voltmeter test equipment item 3 between 2J12-2 and ground on the receive/modulator. Using the test unit "40 mc Var" oscillator as a deviation meter, set the test switch to the OVER-

**TYPICAL RECEIVER/MODULATOR VOLTAGE AND METER READINGS**

The following are approximate voltages existing between individual tube pins and ground as measured with the Voltohmyst with a 100k resistor in series with the probe. In the case of signal-dependent voltages the left-hand value is for no signal and the right-hand value for high signal. All voltages are dc unless otherwise noted.

Tube	Type	Function	Pin #1	Pin #2	Pin #3	Pin #4	Pin #5	Pin #6	Pin #7	Pin #8	Pin #9
2V1	6CB6	I.F.	-.20	0	6.1 ac	0	60	60	0	—	—
2V2	6CB6	I.F.	0	1.0	6.1 ac	0	80	80	0	—	—
2V3	6CB6	I.F.	0	1.0	6.1 ac	0	80	80	0	—	—
2V4	6CB6	I.F.	0	1.0	6.2 ac	0	80	80	0	—	—
2V5	6CB6	I.F.	0, -1.6	1.2, 1.3	6.2 ac	0	80, 70	80, 70	0	—	—
2V6	6CB6	I.F.	0, -2.0	1.2, 1.3	6.2 ac	0	80, 65	80, 65	0	—	—
2V7	6CB6	I.F.	0	3.0	6.3 ac	0	100	100	0	—	—
2V8	6CB6	I.F.	0	2.5	6.3 ac	0	100	107	0	—	—
2V9	OA2	Voltage Reg.	145	0	0	0	145	0	0	—	—
2V9	6AL5	Disc.	0	-3.4	0	6.3 ac	var.	0	-3.4	—	—
2V10	6AS6	Mixer	-1.8, -.03	.85, .55	6.3 ac	0	33, 64	33, 64	0	—	—
2V11	6CB6	Amp.	0	1.4	6.3 ac	0	100	100	1.4	—	—
2V12	6AH6	Mod.	3.5	7.0	6.3 ac	0	160	135	7.0	—	—
2V13	12AT7	Osc.	160	2.7	4.4	0	0	160	+2.7	4.4	6.3 ac
2V14	12AT7	Osc/Relay	26, 12	0.1, 2.7	2.5	0	0	215, 250	26, 12	32, 24	6.3 ac
2V15	6CB6	B.B.Amp.	78.0	80.0	6.3 ac	0	250	195	80	—	—
2V16	12AX7	S.Ch.Amp.	75	0	1.5	0	0	165	0	1.8	6.3 ac
2V17	12AX7	Lockout Amp.	125	0	1.5	0	0	125	0	1.5	6.3 ac
2V18	12AT7	Lockout Amp.	90	-3.0, 0	2.0	0	0	200, 250	33.0	35, 15	6.3 ac
2V19	6AH6	Driver	13	16	6.3 ac	0	235	150	16	—	—
2V20	6AH6	Driver	13	16	6.3 ac	0	235	150	16	—	—
2V21	6AL5	Discriminator	Var +3	Var -3	0	6.3 ac	0	0	0	—	—

Voltages are positive unless noted. Var.—variable with received frequency.

The following are typical readings obtained using the 200 microamperes test meter (1M1) in the transmitter unit.

Xtal Cur.	(2J3):	-50 $\mu$ a
Sig.	(2J4):	+5 $\mu$ a no signal; +140 $\mu$ a high signal
Disc.	(2J5):	zero for 30.0 mc I. F. signal; up to $\pm$ 150 $\mu$ a for off freq. signal. A typical value is $\pm$ 30 $\mu$ a for carrier frequencies different from 30 mc by $\pm$ 1 mc.
Grid. Cur.	(2J14):	+70 $\mu$ a
Lookout Cur.	(2J15):	110 $\mu$ a with no signal or low signal 55 $\mu$ a with 2V1 removed from the socket.

RM-12

ALL position, turn Osc A off, Osc B on 30 kc and adjust the 30 kc level until the peak deviation is exactly  $\pm 750$  kc. Measure the required modulator input. Limits 0.24 v to 0.37 v rms. Note the test unit meter current reading and use this value in place of the average value of 30.

**Baseband Amplifier Check**

a. Maintaining the conditions above, meter the 30 kc voltage on 2J12-5. Limits 0.5 v to 1.0 v.

NOTE: The components affecting this output include 2V8, 2V19, 2V20 and 2V21. If it is necessary to change any of these tubes in order to pass the above test, (b) and (c) of Discriminator Alignment must be redone. As an aid to isolating low baseband output difficulties, it may be desirable to note the discriminator deviation sensitivity. This has been found to average around 0.4 v rms for a peak deviation of  $\pm 0.75$  mc. This voltage is measured at 2C61 with the electronic voltmeter. A 10 microhenry choke must be used in series with the hot lead of the electronic voltmeter.

**Baseband Gain Control and Modulator Gain Control Adjustments**

a. Maintain the distortion and modulation test unit set up as above, except remove the lead feeding the baseband output (2J12-5) to the test unit. Place a 2,200 ohm resistor between 2J12-5 and ground to properly terminate the baseband output.

b. Using the distortion and modulation test unit 35 mc modulated oscillator or some other source of standard deviation, calibrate the discriminator determining what ac voltage it delivers when the i-f signal is deviated  $\pm 1.5$  mc.

c. Apply a 5 kc tone at a level of 0.95 volts to 2J12-2. Adjust the modulator gain control 2R109 until the discriminator voltage is the value measured in (b) above.

d. Measure the voltage between 2J12-5 and ground and adjust the baseband gain control 2R107 for 0.38 volts output.

**Service Channel Amplifier Check**

Disconnect wires and connect wire Q to 2J12-5. Apply a voltage at 1 kc from test equipment item 2 to 2J12-2 at a level of 0.0475 v rms. This will deviate the oscillator by  $\pm 75$  kc. The service channel output from 2J12-5 into 100k ohms should then be greater than .61 volts with 2R140 at its maximum clockwise position. Adjust 2R140 for a .61 volt output. Remove the resistors placed between 2J12-5 and ground. If receiver/modulator is to be used at a drop repeater or terminal station, remove wire Q and reconnect wire S. If receiver modulator is used at a thru repeater station, leave connected as above.

For additional information on the use of the Distortion and Modulation Test Unit MI-31023-A (test item 11) consult the instructions supplied with the unit.

If the receiver/modulator unit is to be used in a terminal station remove wire "L". Retain this connection if the unit is to be used in a repeater station. Apply core sealing material to the tops of all tuning coils except 2L47 and 2L57. Also seal 2R107 and 2R109.

**Standby Lockout Circuit**

The standby lockout circuit is used only at standby stations. The adjustment of this circuit is described in the Standby Switchover Instruction Book.

**NARROW BAND RECEIVER/MODULATORS MI-25969-1 and MI-31174-1**

These Receiver/Modulators are used in systems employing a modulation frequency of 300 C.P.S. to 160 KC. They differ from MI-25969 and MI-31174 in two respects. The baseband amplifier stage 2V15, and the modulator gain control circuit are connected as shown in the lower right-hand corner of Figure RM-7, and

the upper right-hand corner of Figure RM-8.

The adjustment, test and performance of Receiver/Modulators MI-25969-1 and MI-31174-1 is the same as for MI-25969 and MI-31174, except for the baseband frequency range of 300 C.P.S. to 160 KC, and the socket voltages of stage 2V15, given below.

Tube	Type	Function	Pins								
			1	2	2	4	5	6	7	8	9
2V15	6CB6	Baseband Amplifier	3.2	4.1	6.3 ac	0	210	65	4.1		

LIST OF REPLACEMENT PARTS  
WIDE BAND RECEIVERS MI-25969 AND MI-31174 (Dwg. 349736-501)

Symbol No.	Stock No.	Drawing No.	Description
2C1			<b>CAPACITOR</b>
2C2	73748	449696-3	Part of 2Z1
2C3	94189	984002-121	Ceramic, 1500 $\mu\text{mf}$ , +100%, 0%, 500 v
2C4	102015	735717-33	Mica, 1,000 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C5			Ceramic, 220 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C6, 2C7	73748	449696-3	Not Used
2C8			Ceramic, 1500 $\mu\text{mf}$ , +100%, -0%, 500 v
2C9	102015	737717-33	Not Used
2C10	93602	735717-427	Ceramic, 220 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C11, 2C12			Ceramic, 68 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C13	73748	449696-3	Not Used
2C14			Ceramic, 1500 $\mu\text{mf}$ , +100%, -0%, 500 v
2C15	102015	735717-33	Not Used
2C16	93602	735717-427	Ceramic, 220 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C17			Ceramic, 68 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C18	73748	449696-3	Not Used
2C19, 2C20			Ceramic, 1500 $\mu\text{mf}$ , +100%, -0%, 500 v
2C21	102015	735717-33	Not Used
2C22	93602	735717-427	Ceramic, 220 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C23			Ceramic, 68 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C24	73748	449696-3	Not Used
2C25, 2C26			Ceramic, 1500 $\mu\text{mf}$ , +100%, -0%, 500 v
2C27	102015	735717-33	Not Used
2C28	93602	735717-427	Ceramic, 220 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C29, 2C30			Ceramic, 68 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C31	73748	449696-3	Not Used
2C32			Ceramic, 1500 $\mu\text{mf}$ , +100%, -0%, 500 v
2C33	102015	735717-33	Not Used
2C34	93602	735717-427	Ceramic, 220 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C35	73748	449696-3	Ceramic, 68 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C36	204866	8864187-2	Ceramic, 1500 $\mu\text{mf}$ , +100%, -0%, 500 v
2C37	94222	984002-181	Ceramic, 1500 $\mu\text{mf}$ , $\pm 20\%$ , 500 v
2C38			Mica, button, silver mica, 220 $\mu\text{mf}$ $\pm 10\%$ , 500 v
2C39	73748	449696-3	Not Used
2C40, 2C41			Ceramic, 1500 $\mu\text{mf}$ , +100%, 0%, 500 v
2C42	102015	735717-33	Not Used
2C43	105776	735717-37	Ceramic, 220 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C44			Ceramic, 470 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C45	93602	735717-427	Not Used
2C46	73748	449696-3	Ceramic, 68 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C47, 2C48			Ceramic, 1500 $\mu\text{mf}$ , +100%, -0%, 500 v
2C49	102015	735717-33	Not Used
2C50	105289	99327-6	Ceramic, 220 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C51	105776	735717-37	Headed lead, 4.7 $\mu\text{mf}$ , $\pm 20\%$ , 500 v
2C52			Ceramic, 470 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C53	93602	735717-427	Not Used
2C54	94189	984002-121	Ceramic, 68 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C55	73748	449696-3	Mica, 1000 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C56, 2C57			Ceramic, 1500 $\mu\text{mf}$ , +100%, -0%, 500 v
2C58	101940	735717-21	Not used
2C59, 2C60	94189	984002-121	Ceramic, 22 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C61			Mica, 1000 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C62		735715-163	Not Used
2C63 to 2C65	102015	735717-33	Paper, 0.01 $\mu\text{f}$ , $\pm 10\%$ , 400 v
2C66	204866	8864187-2	Ceramic, 220 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
2C67			Ceramic, 1500 $\mu\text{mf}$ , $\pm 20\%$ , 500 v
2C68		735715-171	Not Used
2C69		1215671-3	Paper, .047 $\mu\text{f}$ $\pm 10\%$ , 400 v
2C70	78276	735717-431	Paper, 1.0 $\mu\text{f}$ $\pm 10\%$ , 400 v (Cornell Dubilier MP4W1)
2C71-A, B, C	96566	449618-1	Ceramic, 150 $\mu\text{mf}$ , $\pm 10\%$ , 500 v
			Electrolytic, 10/10/10 $\mu\text{f}$ , 400 v



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Symbol No.	Stock No.	Drawing No.	Description
2C72			Not Used
2C73	93602	735717-427	Ceramic, 68 $\mu$ f, $\pm$ 10%, 500 v
2C74	75610	735717-443	Ceramic, 1500 $\mu$ f, $\pm$ 10%, 500 v
2C75		735715-175	Paper, 0.1 $\mu$ f, $\pm$ 10%, 400 v
2C76	106943	8914319-340	Mica, 470 $\mu$ f, $\pm$ 5%, 300 v
2C77	217799	8972995-1	Porcelain, 6.8 $\mu$ f, $\pm$ 5%, 500 v
2C78	102084	449696-1	Ceramic, 820 $\mu$ f, +100%, -0%, 500 v
2C79		735715-171	Paper, 0.047 $\mu$ f, $\pm$ 10%, 400 v
2C80	215197	8914319-320	Mica, 68 $\mu$ f, $\pm$ 5%, 500 v
2C81	217803	8914319-324	Mica, 100 $\mu$ f, $\pm$ 5%, 500 v
2C82	71504	99327-11	Headed lead, 0.68 $\mu$ f, $\pm$ 10%, 500 v
2C83			Not Used
2C84	73748	449696-3	Ceramic, 1500 $\mu$ f, +100%, -0%, 500 v
2C85	102084	449696-1	Ceramic, 820 $\mu$ f, +100%, -0%, 500 v
2C86	204866	8864187-2	Ceramic, 1500 $\mu$ f, $\pm$ 20%, 500 v
2C87	102084	449696-1	Ceramic, 820 $\mu$ f, +100%, -0%, 500 v
2C88	102015	735717-33	Ceramic, 220 $\mu$ f, $\pm$ 10%, 500 v
2C89	102084	449696-1	Ceramic, 820 $\mu$ f, +100%, -0%, 500 v
2C90	71500	99327-13	Headed lead, 1.5 $\mu$ f, $\pm$ 10%, 500 v
2C91	102084	449696-1	Ceramic, 820 $\mu$ f, +100%, -0%, 500 v
2C92	105776	735717-37	Ceramic, 470 $\mu$ f, $\pm$ 10%, 500 v
2C93, 2C94	204866	8864187-2	Ceramic, 1500 $\mu$ f, $\pm$ 20%, 500 v
2C95, 2C96			Not Used
2C97		735715-169	Paper, 0.033 $\mu$ f, $\pm$ 10%, 400 v
2C98			Not Used
2C99	93602	735717-427	Ceramic, 68 $\mu$ f, $\pm$ 10%, 500 v
2C100	75641	735717-436	Ceramic, 390 $\mu$ f, $\pm$ 10%, 500 v
2C101 to 2C103	73748	449696-3	Ceramic, 1500 $\mu$ f, +100%, -0%, 500 v
2C104	204866	8864187-2	Ceramic, 1500 $\mu$ f, $\pm$ 20%, 500 v
2C105, 2C106	73748	449696-3	Ceramic, 1500 $\mu$ f, +100%, -0%, 500 v
2C107	204866	8864187-2	Ceramic, 1500 $\mu$ f, $\pm$ 20%, 500 v
2C108, 2C109	73748	449696-3	Ceramic, 1500 $\mu$ f, +100%, -0%, 500 v
2C110	77690	99327-12	Headed lead, 1.0 $\mu$ f, $\pm$ 10%, 500 v
2C111			Not Used
2C112, 2C113	73748	449696-3	Ceramic, 1500 $\mu$ f, +100%, -0%, 500 v
2C114		735715-80	Paper, 0.27 $\mu$ f, $\pm$ 10%, 200 v
2C115, 2C116	73960	449696-55	Ceramic, 10,000 $\mu$ f, +100%, -0%, 450 v
2C117		735715-175	Paper, 0.1 $\mu$ f, $\pm$ 10%, 400 v
2C118	102015	735715-33	Ceramic, 220 $\mu$ f, $\pm$ 10%, 500 v
2C119	73960	449696-55	Ceramic, 10,000 $\mu$ f, +100%, -0%, 450 v
2C120		735715-175	Paper, 0.1 $\mu$ f, $\pm$ 10%, 400 v
2C121, 2C122	73960	449696-55	Ceramic, 10,000 $\mu$ f, +100%, -0%, 450 v
2C123		735715-175	Paper, 0.1 $\mu$ f, $\pm$ 10%, 400 v
2C124	73960	449696-55	Ceramic, 10,000 $\mu$ f, +100%, -0%, 450 v
2C125		735715-71	Paper, 1.0 $\mu$ f, $\pm$ 20%, 100 v
2C126			Not Used
2C127		735715-171	Paper, 0.047 $\mu$ f, $\pm$ 10%, 400 v
2C128	102721	735717-439	Ceramic, 680 $\mu$ f, $\pm$ 10%, 500 v
2C129	73748	449696-3	Ceramic, 1500 $\mu$ f, +100%, -0%, 500 v
2C130	77625	990167-109	Ceramic, 220 $\mu$ f, $\pm$ 20%, 500 v
2C131	73748	449696-3	Ceramic, 1500 $\mu$ f, +100%, -0%, 500 v
2C132, 2C133	77252	449696-2	Ceramic, 1000 $\mu$ f, +100%, -20%, 500 v
2C134	73748	449696-3	Ceramic: 1500 $\mu$ f +100 -0%, 500 v
2C135, 2C136	77252	449690-2	Ceramic: 1000 $\mu$ f +100 -20%, 500 v
2C137	73748	449696-3	Ceramic, 1500 $\mu$ f, +100%, -0%, 500 v
2C138	77252	449696-2	Ceramic, 1000 $\mu$ f, +100%, -20%, 500 v
2C139	94189	984002-121	Mica, 1000 $\mu$ f, $\pm$ 10%, 500 v
2C140 to 2C143	99177	8825449-1	Ceramic, 1000 $\mu$ f, $\pm$ 20%, 500 v
2C144, 2C145	105289	99327-6	Headed lead, 4.7 $\mu$ f, $\pm$ 20%, 500 v
2C146	102230	990167-111	Ceramic, 470 $\mu$ f, $\pm$ 20%, 500 v
2C147	94189	984002-121	Mica, 1000 $\mu$ f, $\pm$ 10%, 500 v
2C148	102230	990167-111	Ceramic, 470 $\mu$ f, $\pm$ 20%, 500 v
2C149, 2C150	77625	990167-109	Ceramic, 220 $\mu$ f, $\pm$ 20%, 500 v

Symbol No.	Stock No.	Drawing No.	Description
2C151, 2C152	94189	984002-121	Mica, 1000 $\mu\text{f}$ , $\pm 10\%$ , 500 v
2C153	77625	990167-109	Ceramic, 220 $\mu\text{f}$ $\pm 20\%$ , 500 v
2C154	102234-A	990167-113	Ceramic, 1000 $\mu\text{f}$ $\pm 20\%$ , 500 v
2C155, 2C156	73473	8811182-4	Ceramic, 4700 $\mu\text{f}$ $\pm 20\%$ , 500 v
2C157	102234-A	990167-113	Ceramic, 1000 $\mu\text{f}$ $\pm 20\%$ , 500 v
2C158	77625	990167-109	Ceramic, 220 $\mu\text{f}$ $\pm 20\%$ , 500 v
2C159, 2C160	94189	984002-121	Mica, 1000 $\mu\text{f}$ $\pm 10\%$ , 500 v
2C161 to 2C163	102234-A	990167-113	Ceramic, 1000 $\mu\text{f}$ $\pm 20\%$ , 500 v
2C164, 2C165	217084	1040180-1	Variable air trimmer, 4.5-28 $\mu\text{f}$
2C166, 2C167	93602	735717-227	Ceramic, 68 $\mu\text{f}$ $\pm 20\%$ , 500 v
2C168	94189	984002-121	Mica, 1000 $\mu\text{f}$ $\pm 10\%$ , 500 v
2C169	102230	990167-111	Ceramic, 470 $\mu\text{f}$ $\pm 20\%$ , 500 v
2C170			(See note 6 on Schematic)
2C171	77625	990167-109	Ceramic, 220 $\mu\text{f}$ $\pm 100 -0\%$ , 500 v
2C172			
2CR1(MI-25969)	216735		Rectifier: crystal diode 1N21D
2CR1(MI-31174)			Rectifier: Crystal diode (Sylvania Type 1N23E)
2CR2 to 2CR9	94229		Rectifier: Crystal diode 1N66
2E1, 2E2	211486	339202-1	Terminal: feed-thru. 5/8" lg.
2E3, 2E4		8834451-1	Terminal: stand-off 5/8" lg. overall
2E5 to 2E26	211646	8886187-1	Terminal: Stand-off, melamine. Body, 27/32" lg. with #4-40 mtg. hole
		8834451-1	Terminal: stand-off 5/8" lg. overall
2E27, 2E28		339202-1	Terminal: feed-thru 5/8" lg.
2E29, 2E30	211486	456961-501	Connector: female, coaxial, chassis mtg., including 0.511 lg. probe
2J1	95392		
2J2	94231	8834436-501	Coupling loop: comprising 1 each, female coaxial chassis mtg. connector, sleeve and 33 ohm $\frac{1}{2}$ w. resistor
2J3 to 2J5	93678	742565-1	Connector: pin jack
2J6			Not Used
2J7	93678	742565-1	Connector: pin jack
2J8, 2J9	94205	8845666-1	Connector: female, coaxial, chassis mtg.
2J10			Not Used
2J11	28507	181494-3	Connector: male, 6 contact, chassis mtg.
2J12	18534	181494-4	Connector: female, 6 contact, chassis mtg.
2J13	28507	181494-3	Connector: male, 6 contact, chassis mtg.
2J14, 2J15	93678	742565-1	Connector: pin jack
2K1	56316	8888583-1	Relay: 8000 ohm, contacts S.P.D.T.
2K2	95350-A	8708717-3	Relay: 115 v., 50/60 cy., contacts D.P.D.T.
2L1	94233	629132-511	Coil: adj. core, 18 turns
2L2	94234	629132-506	Coil: adj. core, 32 turns
2L3	94235	629132-509	Coil: adj. core, 22 turns
2L4	217800	941524-245	Reactor: RF choke, 6.8 microhenry 1600 MA
2L5	94236	629132-505	Coil: adj. core, 33 turns
2L6	94237	629132-503	Coil: adj. core, 40 turns
2L7	94238	629132-510	Coil: adj. core, 19 turns
2L8	94040	8834424-501	Reactor: R.F. choke, 2.4 microhenry
2L9			Not Used
2L10	94236	629132-505	Coil: adj. core, 33 turns
2L11	94237	629132-503	Coil: adj. core, 40 turns
2L12	94238	629132-510	Coil: adj. core, 19 turns
2L13	94040	8834424-501	Reactor: R.F. choke, 2.4 microhenry
2L14	217800	941524-245	Reactor: R.F. choke, 6.8 microhenry 1600 MA
2L15	94236	629132-505	Coil: adj. core, 33 turns
2L16	94237	629132-503	Coil: adj. core, 40 turns
2L17	94238	629132-510	Coil: adj. core, 19 turns
2L18	94040	8834424-501	Reactor: R.F. choke, 2.4 microhenry
2L19	217800	941524-245	Reactor: R.F. choke, 6.8 microhenry 1600 MA
2L20	94236	629132-505	Coil: adj. core, 33 turns
2L21	94237	629132-503	Coil: adj. core, 40 turns
2L22	94238	629132-510	Coil: adj. core, 19 turns

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Symbol No.	Stock No.	Drawing No.	Description
2L23	94040	8834424-501	Reactor: R.F. choke, 2.4 microhenry
2L24	217800	941524-245	Reactor: R.F. choke, 6.8 microhenry 1600 MA
2L25	94236	629132-505	Coil: adj. core, 33 turns
2L26	94237	629132-503	Coil: adj. core, 40 turns
2L27	94238	629132-510	Coil: adj. core, 19 turns
2L28	94040	8834424-501	Reactor: R.F. choke, 2.4 microhenry
2L29, 2L30	217800	941524-245	Reactor: R.F. choke, 6.8 microhenry, 1600 MA
2L31	94210	629132-526	Coil: adj. core, 15 turns
2L32	94040	8834424-501	Reactor: R.F. choke, 2.4 microhenry
2L33, 2L34	217800	941524-245	Reactor: R.F. choke, 6.8 microhenry, 1600 MA
2L35	94239	629132-527	Coil: adj. core, 14 turns
2L36	94040	8834424-501	Reactor: R.F. choke, 2.4 microhenry
2L37 to 2L39	217800	941524-245	Reactor: R.F. choke, 6.8 microhenry, 1600 MA
2L40 to 2L43			Not Used
2L44	94040	8834424-501	Reactor: R.F. choke, 2.4 microhenry
2L45			Not Used
2L46	217800	941524-245	Reactor: R.F. choke, 6.8 microhenry, 1600 MA
2L47	94211	629132-520	Coil: adj. core, 6 turns
2L48			Not Used
2L49, 2L50	94241	629132-513	Coil: adj. core, 16 turns
2L51	217800	941524-245	Reactor: R.F. choke, 6.8 microhenry, 1600 MA
2L52	94244	629132-514	Coil: adj. core, 13 turns
2L53	94235	629132-509	Coil: adj. core, 22 turns
2L54	94245	629132-517	Coil: adj. core, 8 turns
2L55	94246	629132-516	Coil: adj. core, 10 turns
2L56	94208	629132-524	Coil: adj. core, 4 turns
2L57	205051	629132-535	Coil: adj. core, 11 turns
2L58	94239	629132-527	Coil: adj. core, 14 turns
2L59	94040	8834424-501	Reactor: R.F. choke, 2.4 microhenry
2L60	217800	941524-245	Reactor: R.F. choke, 6.8 microhenry 1600 MA
2L61	57259	8834437-503	Reactor: R.F. choke, 7 microhenry, 1000 MA
2L62	95885	8834423-502	Reactor: R.F. Inductor
2L63	98387	8834423-503	Reactor: R.F. Inductor
2L64	217085	344067-508	Coil: R.F.
2L65	94209	629132-525	Coil: R.F.
2L66 to 2L69	217800	941524-245	Reactor: R.F. choke, 6.8 microhenry, 1600 MA
2L70	94239	629132-527	Coil: adj. core, 14 turns
2L71	205051	629132-535	Coil: adj. iron core, 11 turns
2L72	217800	941524-245	Reactor: R.F. choke, 6.8 microhenry, 1600 MA
2L73, 2L74	94040	8834424-501	Reactor: R.F. choke, 2.4 microhenry
2L75	217800	941524-245	Reactor: R.F. choke, 6.8 microhenry, 1600 MA
2L76	217801	941524-251	Reactor: R.F. choke, 12 microhenry 1000 MA
	208637	8832091-2	Core: Tuning, iron, threaded type with fiber nut and spring washer, for (2L1, 2, 3, 5, 6, 7, 10, 11, 12, 15, 16, 17, 20, 21, 22, 25, 26, 27, 31 and 35)
2R1			<b>RESISTORS:</b>
2R2			<i>Fixed composition, unless otherwise specified</i>
2R3 to 2R5			Not Used
2R6		82283-175	4700 ohm $\pm 5\%$ , $\frac{1}{2}$ w
2R7			Not Used
2R8		82283-44	33 ohm $\pm 10\%$ , $\frac{1}{2}$ w (Part of 2J2)
2R9, 2R10			Not Used
2R11		82283-175	4700 ohm $\pm 5\%$ , $\frac{1}{2}$ w
2R12			Not Used
2R13		82283-175	4700 ohm $\pm 5\%$ , $\frac{1}{2}$ w
2R14, 2R15			Not Used
2R16		82283-52	150 ohm $\pm 10\%$ , $\frac{1}{2}$ w
2R17			Not Used
2R18		82283-175	4700 ohm $\pm 5\%$ , $\frac{1}{2}$ w

Symbol No.	Stock No.	Drawing No.	Description
2R19, 2R20		82283-193	Not Used
2R21			27,000 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R22			Not Used
2R23		82283-175	4700 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R24			Not Used
2R25		82283-58	470 ohm $\pm 10\%$ . $\frac{1}{2}$ w
2R26		82283-50	100 ohm $\pm 10\%$ . $\frac{1}{2}$ w
2R27		82283-62	1000 ohm $\pm 10\%$ . $\frac{1}{2}$ w
2R28			Not used
2R29, 2R30		82283-57	390 ohm $\pm 10\%$ . $\frac{1}{2}$ w
2R31		82283-173	3900 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R32		90496-75	12,000 ohm $\pm 10\%$ . 1 w
2R33, 2R34		82283-57	390 ohm $\pm 10\%$ . $\frac{1}{2}$ w
2R35		82283-173	3900 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R36		90496-75	12,000 ohm $\pm 10\%$ . 1 w
2R37 to 2R39			Not Used
2R40		82283-193	27,000 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R41	59175	82283-94	470,000 ohm $\pm 10\%$ . $\frac{1}{2}$ w
2R42		458572-90	wire wound, 22,000 ohm $\pm 5\%$ . 5 w
2R43, 2R44		82283-98	1.0 meg. $\pm 10\%$ . $\frac{1}{2}$ w
2R45	94192	82283-95	560,000 ohm $\pm 10\%$ . $\frac{1}{2}$ w
2R46		737829-31	Variable, comp. 25,000 ohm $\pm 10\%$ . 2 w
2R47		90496-66	2200 ohm $\pm 10\%$ . 1 w
2R48		82283-98	1.0 meg. $\pm 10\%$ . $\frac{1}{2}$ w
2R49		82283-145	270 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R50		82283-74	10,000 ohm $\pm 10\%$ . $\frac{1}{2}$ w
2R51, 2R52			Not Used
2R53		82283-159	1000 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R54		82283-215	220,000 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R55		82283-223	470,000 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R56		82283-217	270,000 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R57		82283-211	150,000 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R58		82283-213	180,000 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R59		82283-155	680 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R60		99126-77	18,000 ohm $\pm 10\%$ . 2 w
2R61			Not Used
2R62		82283-207	100,000 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R63		90496-207	100,000 ohm $\pm 5\%$ . 1 w
2R64			Not Used
2R65		99126-199	47,000 ohm $\pm 5\%$ . 2 w
2R66			Not Used
2R67		82283-191	22,000 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R68		82283-163	1500 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R69		82283-137	120 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R70		82283-159	1000 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R71	211398	458572-66	Wire wound, 4800 ohm $\pm 5\%$ . 5 w
2R72		99126-81	39,000 ohm $\pm 10\%$ . 2 w
2R73		82283-175	4700 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R74		82283-169	2700 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R75		82283-143	220 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R76		99126-78	22,000 ohm $\pm 10\%$ . 2 w
2R77		82283-177	5600 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R78 to 2R81			Not Used
2R82		82283-169	2700 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R83		82283-215	220,000 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R84			Not Used
2R85		99126-77	18,000 ohm $\pm 10\%$ . 2 w
2R86		82283-86	100,000 ohm $\pm 10\%$ . $\frac{1}{2}$ w
2R87		90496-74	10,000 ohm $\pm 10\%$ . 1 w
2R88		82283-167	2200 ohm $\pm 5\%$ . $\frac{1}{2}$ w
2R89		82283-52	150 ohm $\pm 10\%$ . $\frac{1}{2}$ w

RM-18

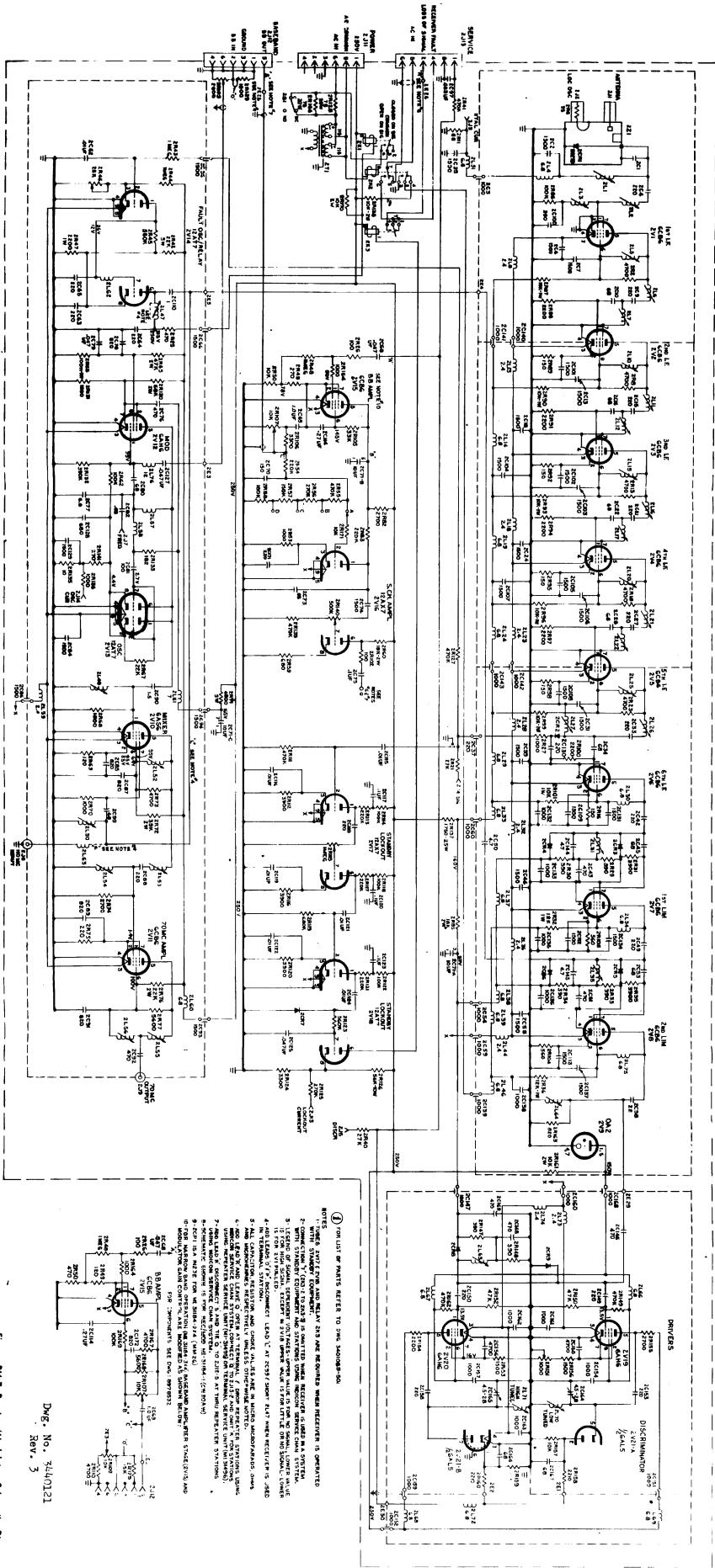
Symbol No.	Stock No.	Drawing No.	Description
2R90		90496-74	10,000 ohm ±10%. 1 w
2R91		82283-167	2200 ohm ±5%. ½ w
2R92		82283-52	150 ohm ±10%. ¼ w
2R93		90496-74	10,000 ohm ±10%. 1 w
2R94		82283-167	2200 ohm ±5%. ½ w
2R95		82283-52	150 ohm ±10%. ¼ w
2R96		90496-74	10,000 ohm ±10%. 1 w
2R97		82283-167	2200 ohm ±5%. ½ w
2R98		82283-52	150 ohm ±10%. ¼ w
2R99		90496-74	10,000 ohm ±10%. 1 w
2R100		82283-167	2200 ohm ±5%. ½ w
2R101		82283-52	150 ohm ±10%. ¼ w
2R102		90496-74	10,000 ohm ±10%. 1 w
2R103, 2R104		82283-50	100 ohm ±10%. ¼ w
2R105		82283-59	560 ohm ±10%. ¼ w
2R106		82283-80	33,000 ohm ±10%. ¼ w
2R107	93175	82283-68	3300 ohm ±10%. ½ w
2R108		337834-10	Var. comp. 10,000 ohm ±10%. 2 w
2R109	51925		Not Used
2R110		737829-29	Var. comp., 2000 ohm ±10%. 2 w
2R111			Not Used
2R112		82283-94	470,000 ohm ±10%. ½ w
2R113		82283-173	3900 ohm ±5%. ½ w
2R114	98077	82283-215	220,000 ohm ±5%. ½ w
2R115		82283-86	100,000 ohm ±10%. ½ w
2R116		746053-22	Var. comp., 1 meg. ±20%. 2 w
2R117		82283-173	3900 ohm ±5%. ½ w
2R118		82283-215	220,000 ohm ±5%. ½ w
2R119		82283-86	100,000 ohm ±10%. ½ w
2R120		82283-96	680,000 ohm ±10%. ½ w
2R121		82283-173	3900 ohm ±5%. ½ w
2R122		82283-215	220,000 ohm ±5%. ½ w
2R123		82283-86	100,000 ohm ±10%. ½ w
2R124		82283-95	560,000 ohm ±10%. ½ w
2R125	53702	82283-171	3300 ohm ±5%. ½ w
2R126		82283-217	270,000 ohm ±5%. ½ w
2R127	16239	458574-90	wire wound, 56,000 ohm ±5%. 10 w
2R128		82283-94	470,000 ohm ±10%. ½ w
2R129		8811127-1	wire wound, 75 ohm ±10%. 20 w
2R130		82283-165	Comp., 1800 ohm ±5%. ½ w
2R131	215169	99126-203	68,000 ohm ±5%. 2 w
2R132		990185-301	carbon film, 1000 ohm ±1%. ½ w
2R133	207833	82283-221	390,000 ohm ±5%. ½ w
2R134		990185-226	Carbon film, 182 ohm ±1%. ½ w
2R135			Not Used
2R136	206726	82283-111	10 ohm ±5%. ½ w
2R137		82283-159	1000 ohm ±5%. ½ w
2R138		8817665-21	Wire wound, 1750 ohm ±10%. 25 w
2R139	206494	99126-74	10,000 ohm ±10%. 2 w
2R140		82283-94	470,000 ohm ±10%. ½ w
2R141		737887-12	Var. comp., 500,000 ohm ±20%. 2 w
2R142 to 2R146		735730-145	270 ohm ±5%. ½ w
2R147, 2R148			Not Used
2R149	98956	82283-57	390 ohm ±10%. ½ w
2R150		82283-94	470,000 ohm ±10%. ½ w
2R151		82283-82	47,000 ohm ±10%. ½ w
2R152		737830-20	Var. comp., 1000 ohm ±10%. 2 w
2R153		82283-82	47,000 ohm ±10%. ½ w
2R154		82283-64	1500 ohm ±10%. ½ w
2R155		82283-64	2200 ohm ±10%. ½ w
2R156		82283-67	2700 ohm ±10%. ½ w
		82283-64	1500 ohm ±10%. ½ w

Symbol No.	Stock No.	Drawing No.	Description
2R157		82283-183	10,000 ohm $\pm 5\%$ , $\frac{1}{2}$ w
2R158	218766	990185-334	film, 2210 ohm $\pm 1\%$ , $\frac{1}{2}$ w
2R159		82283-183	10,000 ohm $\pm 5\%$ , $\frac{1}{2}$ w
2R160	218766	990185-334	film, 2210 ohm $\pm 1\%$ , $\frac{1}{2}$ w
2R161		99126-74	10,000 ohm $\pm 10\%$ , 2 w
2R162		82283-94	470,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w
2R163		82283-61	820 ohm $\pm 10\%$ , $\frac{1}{2}$ w
2R164		82283-62	1000 ohm $\pm 10\%$ , $\frac{1}{2}$ w
2R165			Not Used
2R166	16239	8811127-1	wire wound, 75 ohm $\pm 10\%$ , 20 w
2R167 to 2R169		82283-74	Not Used
2R170		99126-74	10,000 ohm $\pm 10\%$ , 2 w
2R171		82283-183	10,000 ohm $\pm 5\%$ , $\frac{1}{2}$ w
2S1	95572	8835332-2	Switch: push type, S.P.D.T., black button
2T1	218137	8874796-2	Transformer: filament, pri., 115/220 v. 50/60 cy.
2TB1 to 2TB15			Terminal board: (Not stocked)
2XC71	207594	99100-7	Socket: Capacitor, octal tube type for (2C71)
2XK1	43639	849224-1	Socket: relay, 5 pin (for 2K1)
2XK3	43639	849224-1	Socket: relay, 5 pin (for 2K3)
2XV1 to 2XV12	94879	737867-18	Socket: tube, 7 pin min.
2XV13, 2XV14	94880	984055-2	Socket: tube, 9 pin min.
2XV15	98479	737867-18	Socket: tube, 7 pin min.
2XV16 to 2XV18	94880	984055-2	Socket: tube, 9 pin min.
2XV19 to 2XV21	94879	737867-18	Socket: tube, 7 pin min.
2Z1	216210	458907-502	Cavity Assembly: 1700-2000 MC
	95394	8831068-2	Washer: Spring, $\frac{7}{8}$ " O.D. x $\frac{21}{32}$ " I.D. x 0.025 thick beryllium copper, tuning core tension (for 2Z1)
	95395	874927-6	Nut: Hex, brass #5/8-24 thread, tuning core locking for (2Z1)
	94389	8834415-1	Insulator: teflon coated glass fabric 1-3/16 x 13/16 x 0.010 thick, crystal bypass 4 req'd. for (2Z1)
	94390	8834416-1	Contact: Beryllium copper, crystal bypass for (2Z1)
	95393	8831031-1	Core: Brass, tuning, 5/8-24 thread, 1-1/16" lg. for (2Z1 tuning)
	215719	458918-501	<b>Miscellaneous</b> Cable: coaxial, 11-3/4" lg., with 2 male connectors
	215720	458918-502	Cable: coaxial, 20" lg., with 2 male connectors
	54392	8898625-501	Connector: male, coaxial, cable mtg.
	52266	57421-30	Grommet: Rubber, 0.19 I.D. x 0.50 O.D. to fit 0.31 dia. chassis hole
	217095	8924133-6	Insert: for jan tube shield, 7 pin min. 1-3/8" high (for 2V10, 2V21)
	217094	8924133-5	Insert: for jan tube shield 7 pin min. 1-3/4" high (for 2V1 to 2V8, 2V11, 2V12, 2V15, 2V19, 2V20)
	217093	8924133-4	Insert: for jan tube shield, 7 pin min. 2-1/4" high (for 2V9)
	217092	8924133 2	Insert: for jan tube shield, 9 pin min. 1-15/16" high (for 2V13, 2V14, 2V16, 2V17, 2V18)
	94391	8886111-2	Screw: thumb #10-32 x 1" lg. back cover holding
	53016	99369-1	Shield: tube, 7 pin min. 1-3/8" high (for 2V10, 2V21)
	54521	99369-2	Shield: tube, 7 pin min. 1-3/4" high for 2V1 to 2V8, 2V11, 2V12, 2V15, 2V19, 2V20
	210897	99369-3	Shield: tube, 7 pin min. 2-1/4" high (for 2V9)
	56359	8858642-3	Shield: tube, 9 pin min. 1-15/16" lg. for (2V13, 2V14, 2V16, 2V17, 2V18)

RM-20

The following parts (available in kit form) are used in narrow band receivers only. All items not shown are the same as those used in wide-band receivers.

Symbol No.	Stock No.	Drawing No.	Description
<b>RECEIVER/MODULATOR, NARROW-BAND MODIFICATION KIT, MI-31180</b>			
2C172	206880	727868-245	Capacitor: mica, 820 $\mu\mu\text{f}$ $\pm 5\%$ , char "D"
2R49		82283-137	Resistor: fixed, comp., 120 ohm $\pm 5\%$ , $\frac{1}{4}$ w
2R50		82283-151	Resistor: fixed, comp., 470 ohm $\pm 5\%$ , $\frac{1}{4}$ w
2R109		737801-44	Resistor: variable, comp., 10,000 ohm $\pm 10\%$ , 2 w
2R110		82283-175	Resistor: fixed, comp., 4700 ohm $\pm 5\%$ , $\frac{1}{4}$ w
2R129		82283-187	Resistor: fixed, comp., 15,000 ohm $\pm 5\%$ , $\frac{1}{4}$ w
2R167		82283-175	Resistor: fixed, comp., 4700 ohm $\pm 5\%$ , $\frac{1}{4}$ w
2R168		82283-177	Resistor: fixed, comp., 5600 ohm $\pm 5\%$ , $\frac{1}{4}$ w
2R169		82283-207	Resistor: fixed, comp., 100,000 ohm $\pm 5\%$ , $\frac{1}{4}$ w



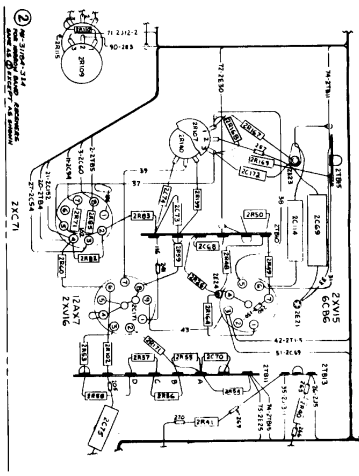
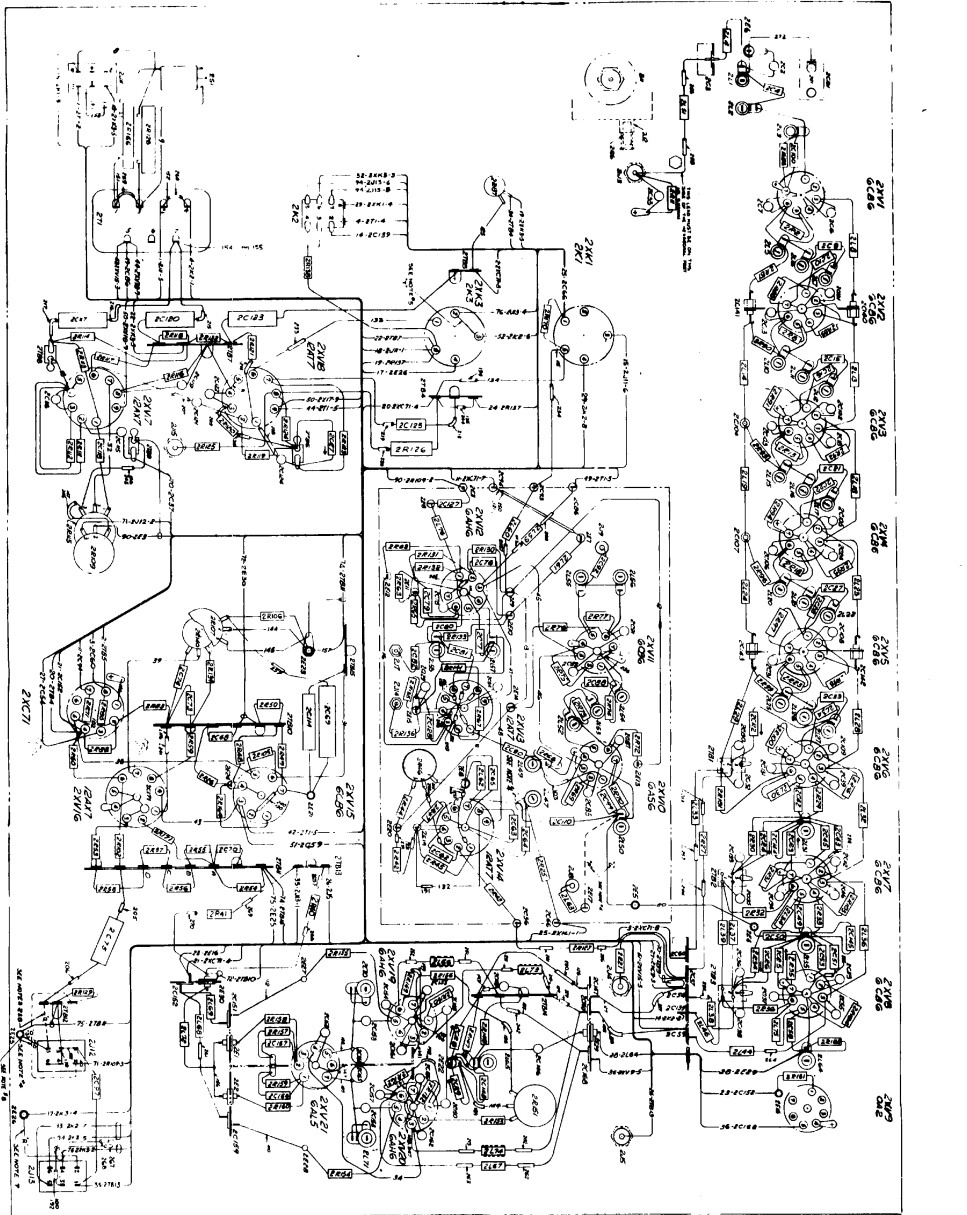
① LIST OF PARTS REFER TO THE ASSEMBLY

1. CHECK ALL PARTS AND MAKE SURE THEY ARE RECEIVED WHEN RECEIVED IS OPERATED
2. CHECK ALL PARTS AND MAKE SURE THEY ARE RECEIVED WHEN RECEIVED IS OPERATED
3. CHECK ALL PARTS AND MAKE SURE THEY ARE RECEIVED WHEN RECEIVED IS OPERATED
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9. CHECK ALL PARTS AND MAKE SURE THEY ARE RECEIVED WHEN RECEIVED IS OPERATED
10. CHECK ALL PARTS AND MAKE SURE THEY ARE RECEIVED WHEN RECEIVED IS OPERATED

Rev. 3

RM 21, RM 22





Part No.	Part Name	Quantity	Notes
2X101	...	...	...
2X102	...	...	...
2X103	...	...	...
2X104	...	...	...
2X105	...	...	...
2X106	...	...	...
2X107	...	...	...
2X108	...	...	...
2X109	...	...	...
2X110	...	...	...
2X111	...	...	...
2X112	...	...	...
2X113	...	...	...
2X114	...	...	...
2X115	...	...	...
2X116	...	...	...
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2X118	...	...	...
2X119	...	...	...
2X120	...	...	...
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2X198	...	...	...
2X199	...	...	...
2X200	...	...	...

1. 2X101-122, 2X103-122, 2X104-122, 2X105-122, 2X106-122, 2X107-122, 2X108-122, 2X109-122, 2X110-122, 2X111-122, 2X112-122, 2X113-122, 2X114-122, 2X115-122, 2X116-122, 2X117-122, 2X118-122, 2X119-122, 2X120-122, 2X121-122, 2X122-122, 2X123-122, 2X124-122, 2X125-122, 2X126-122, 2X127-122, 2X128-122, 2X129-122, 2X130-122, 2X131-122, 2X132-122, 2X133-122, 2X134-122, 2X135-122, 2X136-122, 2X137-122, 2X138-122, 2X139-122, 2X140-122, 2X141-122, 2X142-122, 2X143-122, 2X144-122, 2X145-122, 2X146-122, 2X147-122, 2X148-122, 2X149-122, 2X150-122, 2X151-122, 2X152-122, 2X153-122, 2X154-122, 2X155-122, 2X156-122, 2X157-122, 2X158-122, 2X159-122, 2X160-122, 2X161-122, 2X162-122, 2X163-122, 2X164-122, 2X165-122, 2X166-122, 2X167-122, 2X168-122, 2X169-122, 2X170-122, 2X171-122, 2X172-122, 2X173-122, 2X174-122, 2X175-122, 2X176-122, 2X177-122, 2X178-122, 2X179-122, 2X180-122, 2X181-122, 2X182-122, 2X183-122, 2X184-122, 2X185-122, 2X186-122, 2X187-122, 2X188-122, 2X189-122, 2X190-122, 2X191-122, 2X192-122, 2X193-122, 2X194-122, 2X195-122, 2X196-122, 2X197-122, 2X198-122, 2X199-122, 2X200-122.

2. 2X101-122, 2X103-122, 2X104-122, 2X105-122, 2X106-122, 2X107-122, 2X108-122, 2X109-122, 2X110-122, 2X111-122, 2X112-122, 2X113-122, 2X114-122, 2X115-122, 2X116-122, 2X117-122, 2X118-122, 2X119-122, 2X120-122, 2X121-122, 2X122-122, 2X123-122, 2X124-122, 2X125-122, 2X126-122, 2X127-122, 2X128-122, 2X129-122, 2X130-122, 2X131-122, 2X132-122, 2X133-122, 2X134-122, 2X135-122, 2X136-122, 2X137-122, 2X138-122, 2X139-122, 2X140-122, 2X141-122, 2X142-122, 2X143-122, 2X144-122, 2X145-122, 2X146-122, 2X147-122, 2X148-122, 2X149-122, 2X150-122, 2X151-122, 2X152-122, 2X153-122, 2X154-122, 2X155-122, 2X156-122, 2X157-122, 2X158-122, 2X159-122, 2X160-122, 2X161-122, 2X162-122, 2X163-122, 2X164-122, 2X165-122, 2X166-122, 2X167-122, 2X168-122, 2X169-122, 2X170-122, 2X171-122, 2X172-122, 2X173-122, 2X174-122, 2X175-122, 2X176-122, 2X177-122, 2X178-122, 2X179-122, 2X180-122, 2X181-122, 2X182-122, 2X183-122, 2X184-122, 2X185-122, 2X186-122, 2X187-122, 2X188-122, 2X189-122, 2X190-122, 2X191-122, 2X192-122, 2X193-122, 2X194-122, 2X195-122, 2X196-122, 2X197-122, 2X198-122, 2X199-122, 2X200-122.

Dwg. No. 3440128  
Rev. 3

Figure RM-2 Receiver/Modulator-Connection Diagram

RM-23, RM-24

# MICROWAVE COMMUNICATION EQUIPMENT

T.O. 31R5-4-A-21

## Terminal AFC Unit MI-31492-C

- TECHNICAL DATA
- DESCRIPTION
- MAINTENANCE
- REPLACEMENT PARTS



RADIO CORPORATION OF AMERICA  
COMMUNICATION PRODUCTS DEPARTMENT, CAMDEN, NEW JERSEY

# T.O. 31R5-4-A-21

AFC-1

## TECHNICAL DATA

Power Input		Crystals		
		Symbol	Type	Function
a. Filament Heaters:	19 watts at 115 v, 50/60 cycles ac	3CR1	1N21B	AFC Mixer
b. Plate Supply:	95 milliamps at 250 v dc	3Y1	MI-31687-*	Beating Oscillator (See Note)
I-F Frequency		Tube Complement		
	20 mc	Symbol	Type	Function
Bandwidth				
	2 mc	3V1	6CB6	First i-f Amplifier
		3V2	6CB6	Second i-f Amplifier
		3V3	6CB6	Third i-f Amplifier
Required R-F Input				
	1 mw	3V4	6CB6	Fourth i-f Amplifier
		3V5	6AL5	Discriminator
		3V6	12AT7	Oscillator/Multiplier
110 MC Output				
	2 volt	3V7	6U8	55 MC Amplifier and Multiplier
		3V8	6CB6	55 MC Oscillator
		3V9	6AH6	Reactance Control
Weight and Dimensions				
Weight—7 lbs.				
Height—5 $\frac{1}{4}$ "				
Depth Back of Panel: 2 $\frac{7}{8}$ "				
Depth Front of Panel: 2 $\frac{1}{2}$ "				
Width—19" Rack Mounting				

NOTE: The letter-number suffix (\*) of the MI-31687 crystal series is determined by the system frequency assignment. Consult the system instructions for Typical System Frequencies.

## DESCRIPTION

The Terminal AFC Unit (MI-31492-C) is designed for mounting in either a standard 19" open rack or cabinet. It is mounted adjacent to the transmitter unit and is used in terminal stations only. This unit keeps the terminal transmitter stabilized at its assigned frequency. This is extremely important because the frequency of the whole relay chain is controlled by the terminal station transmitter frequency.

The transmitter frequency is compared with a reference frequency from a quartz crystal controlled oscillator. The error voltage is used to change the frequency of a 55 mc oscillator, the frequency of which is doubled in the multiplier stage. The multiplier output changes the receiver/modulator I-F mixer frequency which corrects the transmitter carrier frequency.

AFC-2

1. The basic control frequency of the Terminal AFC Unit MI-31492-C is generated by the crystal controlled oscillator/multiplier 3V6. The frequency of the quartz crystal 3Y1 of the crystal oscillator 3V6 is calculated from the following equation:

$$F_r = \frac{F_t + F_r}{2X}$$

where:  $F_t$  is the frequency of the quartz crystal 3Y1 of the crystal oscillator  
 $F_t$  is the transmitted frequency  
 $F_r$  is the received frequency  
 $X$  is the multiple of the crystal frequency and is found in the following table:

Range of $\frac{F_t + F_r}{2}$	Value of X
1720 mc to 1840 mc	44
1841 mc to 2000 mc	48
2001 mc to 2160 mc	52
2161 mc to 2320 mc	56
2321 mc to 2470 mc	60
2471 mc to 2640 mc	64
2641 mc to 2680 mc	68

Refer to the systems book for Typical System Frequencies.

2. The oscillator/multiplier 3V6 generates the heterodyning frequency required in the 3Z1 mixer cavity. The plate circuit of the oscillator section of 3V6 is tuned to the frequency of the crystal (3Y1). The plate circuit of the multiplier section of 3V6 is tuned to the 4th harmonic of the crystal. The output of this stage is fed to the 1N21B crystal in the resonant mixer cavity 3Z1. The other mixer frequency is a sample of the microwave transmitter output which is fed by coaxial cable to the R.F. CARRIER INPUT terminal 3J1 of mixer cavity 3Z1. The transmitter frequency is heterodyned with a high order harmonic of the crystal multiplier to produce a difference frequency of 20 mc. The actual harmonic used may be from the 11th to the 17th depending on the

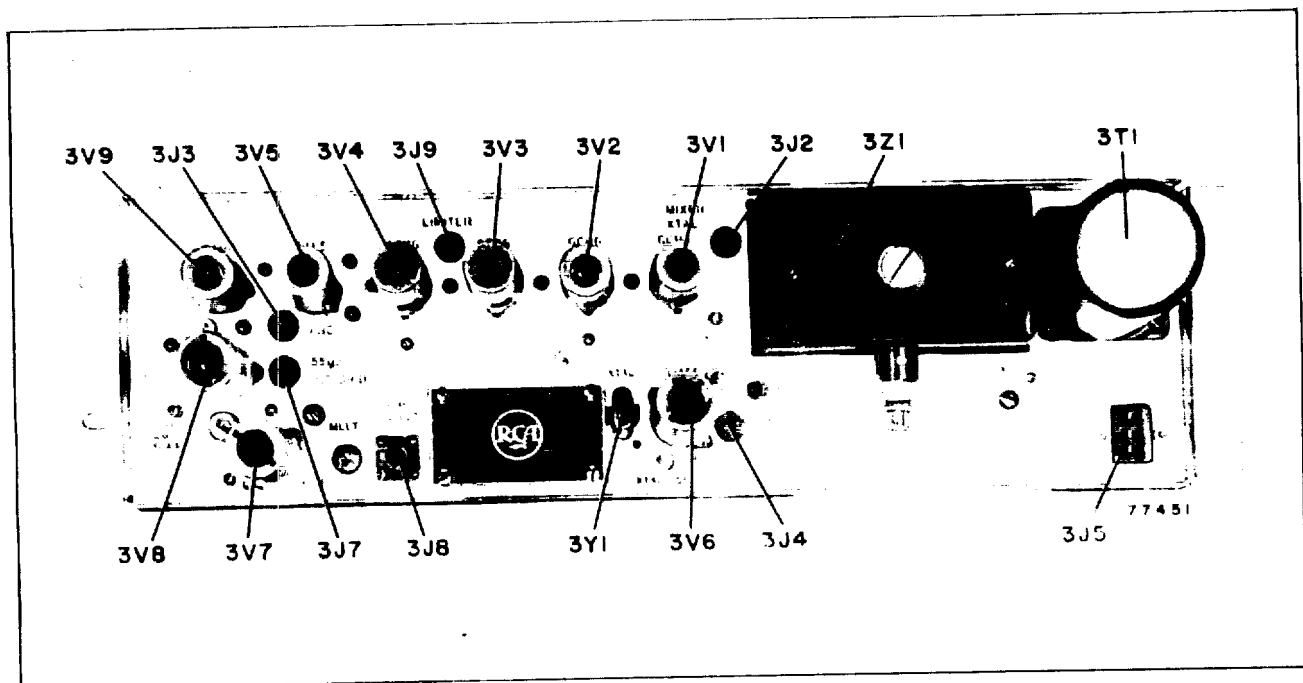


Figure AFC-1—Terminal AFC Unit, MI-31492-B and MI-31492-C—Front View

**T.O. 31R5-4-A-21**

AFC-3

frequency of the transmitter. The harmonic used is found by dividing the value of X in the equation, by four. The adjustable screw in the cavity tunes it to the frequency of the signal from the transmitter and the adjustable loop inside terminal 3J1 controls the amount of the signal input.

With the transmitter operating on its specified frequency the i-f output of 3Z1 is 20 mc. The mixer output is amplified through four i-f stages and then applied to discriminator 3V5 which is tuned to 20 mc. A 20 mc signal will cause a 0 discriminator output. Any variation of the transmitter frequency will change the frequency of the i-f input to 3V5 with a resultant dc discriminator output voltage. The dc voltage from 3V5 is applied to the reactance circuit of 3V9 which changes the frequency of the 55 mc oscillator (3V8) relative to the amount of dc applied to 3V9 from the discriminator. The 55 mc output of 3V8 is doubled in the amplifier/multiplier stage 3V7. A change in the 110 mc output of 3V7 occurs only if the transmitter output frequency tends to drift. The 110 mc output of 3V7 is fed to mixer 2V10 in the receiver/modulator unit.

In the receiver/modulator unit the 110 mc output of the AFC unit heterodynes with the 40 mc f-m signal in mixer stage 2V10 to produce the 70 mc subcarrier which modulates the microwave carrier. Any variation in the 110 mc output frequency of the AFC unit will cause 2V10 to either increase or decrease the frequency of the 70 mc signal carrier. Any fluctuation (increase or decrease) in the transmitter local oscillator (1V2) frequency will be compensated for in the transmitter mixer stage (1V3) by a corresponding decrease or increase in the 70 mc carrier frequency, thereby correcting the transmitted microwave carrier frequency. (Refer to the terminal station block diagram of the system book for the automatic frequency control circuit.)

**CONTROLS**

a. The XTAL OSC tuning screw is for adjusting the plate peaking coil 3L22 of the crystal oscillator (the 1-2-3 section of 3V6) to the crystal frequency.

b. The OSC GRID pin jack 3J4 is used to connect meter 1M1 to indicate when the crystal oscillator (1-2-3 of 3V6) is tuned (by the XTAL OSC screw) to the frequency of the crystal 3Y1.

c. The MULT tuning screws of coils 3L21 and 3L17 are for adjusting the multiplier stage (the

6-7-8 section of 3V6) to the 4th harmonic of the crystal oscillator.

d. The MIXER XTAL pin jack 3J2 is used to connect meter 1M1 to indicate when the multiplier stage (6-7-8 of 3V6) is tuned to the 4th harmonic of the crystal oscillator.

e. The crystal mixer cavity R.F. CARRIER INPUT terminal 3J1 is the receptacle for connecting the cable which supplies a sample of the output frequency from the transmitter.

f. The tuning screw of the crystal mixer cavity is for resonating the cavity to the frequency of the transmitter.

g. The LIMITER pin jack 3J9 is for connecting meter 1M1 to show when the crystal mixer cavity is tuned to resonance at the transmitter frequency.

h. The DISC pin jack 3J3 is used to connect meter 1M1 when checking the discriminator dc voltage output when tuning the AFC and transmitter.

i. The 55 MC OSC tuning screw of coil 3L24 is for adjusting the frequency of the 55 mc oscillator 3V8.

j. The 55 MC OSC GRID pin jack 3J7 is used to connect meter 1M1 to check the grid current when adjusting 3V8 to 55 mc with the 55 MC OSC tuning screw.

k. The 55 MC AMP tuning screw of coil 3L23 is for adjusting the frequency of the 55 mc amplifier stage (the pentode section, elements 7-2-3-6, of 3V7).

l. The MULT 3T3 tuning screw of transformer 3T3 is for adjusting the frequency of the 110 mc amplifier stage (the triode section, elements 8-9-1, of 3V7).

m. The 110 MC OUTPUT jack 3J8 is used to connect the output of the 110 mc multiplier stage (3V7-8-9-1) to the 110 MC INPUT jack of the receiver.

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AFC-4

**MAINTENANCE****General Notes**

a. To check the operation of the AFC unit connect the test meter, 1M1, test lead to the "DISC" jack. 1M1 should read zero. When the transmitter oscillator cavity is squeezed, the 1M1 reading should increase to approximately 50  $\mu$ a if the AFC unit is working properly.

b. If the transmitter r-f output fails completely one of the possible causes could be the failure of the terminal AFC unit to deliver a 110 mc signal to the modulator i-f mixer of the receiver/modulator. There is no 70 mc drive to the transmitter during the absence of the 110 mc frequency from the terminal AFC unit.

c. If the terminal AFC unit is the cause of the transmitter failure, check the tubes and replace the ones that are bad. The four i-f tubes and discriminator tube (3V1 thru 3V5) can be changed without retuning any of the circuits. If the oscillator/multiplier tube 3V6 is changed, tuning coils 3L21, 3L22, 3L17, 3L16, 3L15 and 3C39 should be peaked as follows:

1. Connect the transmitter test meter 1M1 to the OSC GRID 3J4 and tune the XTAL OSC control 3L22 for maximum grid current. A reading of at least 70  $\mu$ a should be obtained.

2. Connect meter 1M1 to the MIXER XTAL jack 3J2 and tune the MULT controls 3L21 and 3L17 for maximum current. Since this is a double tuned circuit it is advisable to keep the cores at about the same depth, when tuning over any great range, in order to get an initial reading to maximize. The meter reading should be 25  $\mu$ a or more. (To obtain a peak indication when tuning this circuit it may be necessary to remove the r-f cable connecting the transmitter output to the crystal cavity on the terminal AFC unit. The cable should be replaced immediately after peaking the circuit.)

d. If either the 55 mc oscillator, 110 mc multiplier or reactance tube (3V8, 3V7, 3V9) is changed, the tuned circuits of these stages should be retuned as described in the CIRCUIT ALIGNMENT section, and the operation of the AFC system checked as follows:

Check the terminal AFC unit discriminator reading by connecting the test meter 1M1 to the jack marked "DISCR". If the meter reading is not zero, adjust the 55 MC OSC control 3L24 very slowly until the meter reads zero. The transmitter AFC motor may run when the 55 mc oscillator frequency is changed slightly. After a slight change in the frequency of the 55 mc oscillator is made, wait for the AFC tuning motor indicator light to go out before continuing adjustment. Keep adjusting 3L24 in this manner until the DISC reading is zero. If this adjustment is considerably off the correct point, a zero discriminator current will also be observed, but in this case of improper adjustment, there will be a very small reading of limiter current on this unit instead of the normal value of 25  $\mu$ a or more. After the zero reading is reached tune the 55 MC AMP and MULT 3T3 controls for maximum output at 3J8 as described in item (b) of the 55 MC Oscillator/Multiplier Circuit test in the following CIRCUIT ALIGNMENT section.

**CIRCUIT ALIGNMENT**

The following headings contain detailed alignment and test procedure for all the circuits of the terminal AFC unit. These tests and alignments should be made with the unit on a test bench. The test items specified in the following procedures refer to the test equipment items listed in the test equipment tables of the system instructions. Use test item 19 to supply power to operate the terminal AFC unit.

**Crystal Oscillator Circuit Test**

Connect the microammeter to 3J4 (OSC GRID) and adjust the XTAL OSC control 3L22 for maximum grid current as indicated on the meter. A current reading of 80  $\mu$ a or more indicates satisfactory operation.

**Multiplier Circuit Tuning Adjustment**

Connect the microammeter to 3J2 (MIXER CRYSTAL) and tune the MULT controls 3L21 and 3L17 for maximum current. A reading of 50  $\mu$ a is adequate. Be sure the current can be maximized by tuning either coil.

**55 Mc Oscillator/Multiplier Circuit Test**

a. Connect the microammeter to 3J7. Ground the junction of 3R35 and 3R37. With the core of 3L25 in the mid-position adjust the 55 MC OSC

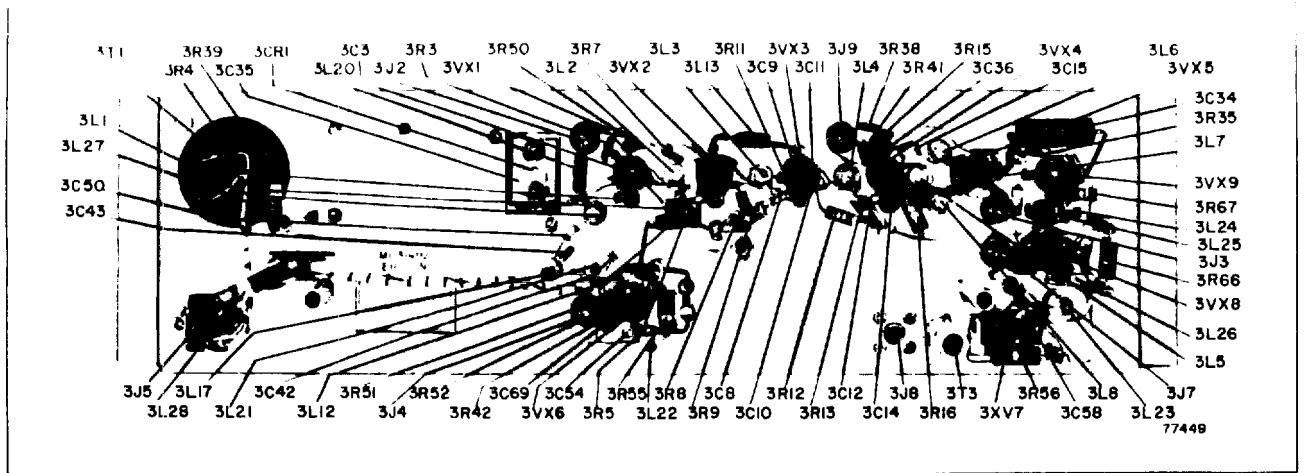


Figure AFC-2—Terminal AFC Unit, MI-31492-C—Rear View, Dust Cover Removed

control 3L24 for a frequency of 55 mc. (Use test item 13). Adjust 3L25 for a reading of  $55 \mu\text{a}$ . Re-adjust the frequency, if necessary, to  $55 \text{ mc} \pm 0.1 \text{ mc}$ .

b. Connect the r-f voltmeter (test item 22) to the 110 MC OUTPUT jack 3J8 and adjust the 55 MC AMP Control 3L23 and the MULT 3T3 control for maximum output. A reading of at least 2 volts must be obtained.

#### Discriminator and I-F Alignment

- a. Connect the CRO to 3V5-5.
- b. Connect the 20 mc sweep generator (test item 18) output to 3V4-1.
- c. Adjust 3L5, 3L6, and 3L8 for the correct discriminator response. No great amount of time should be spent in obtaining exact linearity. It is essential that the alignment be such that the discriminator peaks are 3 mc apart and that crossover is located at 20 mc. Remove the sweep generator and oscilloscope.
- d. Connect the microammeter to the LIMITER jack 3J9.
- e. Connect the signal generator (test item 16) to 3V3-1 and set it for exactly 20 mc.
- f. Tune 3L4 for a maximum meter reading. Reduce the signal generator output for a meter reading of approximately  $50 \mu\text{a}$ .
- g. Move the signal generator to 3V2-1 and tune 3L3 for a maximum reading at 3J9. Adjust the signal generator for a meter reading at 3J9 of approximately  $50 \mu\text{a}$ .

h. Move the signal generator to 3V1-1 and tune 3L2 for a maximum reading at 3J9. Adjust the signal generator for a meter reading at 3J9 of approximately  $50 \mu\text{a}$ .

i. Connect the Voltomyst probe to 3V5-1. Use the most sensitive scale. While maintaining the signal generator output to produce limiter saturation, tune 3L6, 3L7 and 3L8 so the crossover voltage is exactly at 20 mc and the two peaks are at  $18.5$  and  $21.5 \text{ mc} \pm 0.2 \text{ mc}$  and of approximately equal amplitude. Coil 3L7 controls the amplitude, 3L6 the high frequency peak and 3L8 the low frequency peak. Remove the signal generator, microammeter and Voltomyst.

#### I.F. Gain Measurement

- a. Connect the microammeter to 3J9 (LIMITER).
- b. Remove the 1N21B from its socket.
- c. Connect the 20 mc signal generator to the low end of 3L1.
- d. With sufficient output to get a small reading on the microammeter tune 3L1 for a maximum response at 20 mc.
- e. It should now require not more than  $2000 \mu\text{v}$  to obtain a reading of  $100 \mu\text{a}$  at 3J9 (LIMITER).

#### Reactance Tube Sensitivity Test

- a. Connect the Voltomyst to the DISC jack 3J3 with the signal generator connected as in (c) of the I-F Gain Measurement test.
- b. Tune the signal generator to 20 mc for a zero reading at 3J3.

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### AFC-6

c. With the conditions as above, tune the 55 MC OSC control 3L24 for a 55 mc  $\pm 0.1$  mc frequency reading. Measure the frequency at the 110 MC OUTPUT jack 3J8 using test item 13.

d. Change the frequency of the 20 mc signal generator until the Voltohmyst reads 1 volt and again measure the frequency at 3J8. The difference between this measurement and that at (c) should not be less than  $\pm 1$  mc.

#### R-F Mixer Circuit Test

a. Replace the 1N21B.

b. Orient the plane of the loop on 3J1 (R-F CARRIER INPUT) perpendicular to the long axis of 3Z1.

c. With the unit operating normally, connect the 2700 mc signal generator (test item 17) to R-F CARRIER INPUT 3J1.

d. Connect the microammeter to 3J9 (LIMITER).

e. With the signal generator set for approximately 1 milliwatt output, tuning the signal generator to the correct frequency should give a response in the i-f amplifier as indicated on the microammeter.

NOTE: There are several frequencies that will give a response. For a given crystal frequency, signal generator frequencies at which a response will be obtained are equal to the crystal frequency, in megacycles, multiplied by 44, 48, 52, 56, 60, 64 or 68 with 20 mc added or subtracted from the product.

f. 3Z1 should be tuned for a maximum i-f response. The reading at 3J9 must be at least 40 ma.

g. Retune 3L1 for maximum response.

### TYPICAL TERMINAL AFC VOLTAGE AND METER READINGS

The following are approximate voltages existing between the indicated tube pins and ground as measured with a Voltohmyst with 100,000 ohms in series with the measuring probe. All voltages are dc unless otherwise noted:

Tube	Type	Function	Pin #1	Pin #2	Pin #3	Pin #4	Pin #5	Pin #6	Pin #7	Pin #8	Pin #9
3V1	6CB6	I-F Ampl.	0	2	6.3 ac	0	210	140	0	—	—
3V2	6CB6	I-F Ampl.	0	2	6.3 ac	0	210	140	0	—	—
3V3	6CB6	I-F Ampl.	0	2	6.3 ac	0	210	140	0	—	—
3V4	6CB6	Limitter	0	1.2	6.3 ac	0	60	80	0	—	—
3V5	6AL5	Detector	0	var*	6.3 ac	0	var*	0	var.*	—	—
3V6	12AT7	Crystal Osc./Mult.	180	0	2.7 ac	0	0	220	0	9.6	6.3 ac
3V7	6U8	55 mc Amp./110 mc Mult.	130	0	110	0	6.3 ac	200	1.6	2.5	0
3V8	12AT7	55 mc Osc.	160	0	0	0	0	160	0	0	6.3 ac
3V9	6AH6	React.	var*	3.3	6.3 ac	0	160	140	3.3	—	—

var\*—variable with signal level and frequency.

The following are typical meter readings obtained using the 200 microampere test meter (1M1) in the transmitter unit.

Mixer Xtal. (3J2)	— -15 to -75 $\mu$ a
Disc. (3J3)	— zero for on-frequency operation; up to off scale plus or minus for off-frequency operation
Osc. Grid (3J4)	— -110 $\mu$ a
55 mc Os. Grid (3J7)	— -45 $\mu$ a
Limitter (3J9)	— -25 $\mu$ a



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AFC-7

## REPLACEMENT PARTS LIST

TERMINAL AFC UNIT—MI-31492-C			
Symbol No.	Description	Drawing No.	Stock No.
3C1, 3C2, 3C3	Capacitor, fixed ceramic, 1500 mmf, +100 -0%, 500 v. ....	449696-3	73748
3C4	Capacitor, fixed ceramic, 220 mmf, ±20%, 500 v. ....	735717-133	102015
3C5, 3C6, 3C7	Capacitor, fixed ceramic, 1500 mmf, +100 -0%, 500 v. Same as 3C1	449696-3	73748
3C8	Capacitor, fixed ceramic, 220 mmf, ±20%, 500 v. Same as 3C4	735717-133	102015
3C9, 3C10, 3C11	Capacitor, fixed ceramic, 1500 mmf, +100 -0%, 500 v. Same as 3C1	449696-3	73748
3C12	Capacitor, fixed ceramic, 220 mmf, ±20%, 500 v. Same as 3C4	735717-133	102015
3C13, 3C14	Capacitor, fixed ceramic, 1500 mmf, +100 -0%, 500 v. Same as 3C1	449696-3	73748
3C15	Capacitor, fixed ceramic, 15 mmf, ±20%, 500 v. ....	735717-119	94195
3C16	Capacitor, fixed ceramic, 4700 mmf, ±100 -0%, 500 v. ....	990119-11	73473
3C17 to 3C27	Not used.		
3C28	Capacitor, fixed ceramic, 1500 mmf, +100 -0%, 500 v. Same as 3C1	449696-3	73748
3C29	Not used.		
3C30	Capacitor, fixed ceramic, 1500 mmf, +100 -0%, 500 v. Same as 3C1	449696-3	73748
3C31, 3C32, 3C33	Not used.		
3C34	Capacitor, fixed paper, 0.1 mf, ±10%, 400 v. ....	735715-175	73551
3C35	Part of 3Z1.		
3C36	Capacitor, fixed ceramic, 1500 mmf, +100 -0%, 500 v. Same as 3C1	449696-3	73748
3C37 to 3C41	Not used.		
3C42	Capacitor, fixed mica, 8 mmf, ±5%, 300 v. ....	748252-308	205068
3C43	Capacitor, fixed mica, 10 mmf, ±5%, 300 v. ....	748252-310	59905
3C44 to 3C49	Not used.		
3C50	Capacitor, fixed ceramic, 1.5 mmf, ±0.25 mmf, 500 v. ....	722401-54	78928
3C51, 3C52, 3C53	Capacitor, fixed ceramic, 820 mmf, +100 -0%, 500 v. ....	449696-1	94190
3C54	Capacitor, fixed ceramic, 27 mmf, ±5%, 500 v. ....	90575-219	79488
3C55	Capacitor, fixed ceramic, 820 mmf, +100 -0%, 500 v. Same as 3C51	449696-1	94190
3C56	Capacitor, fixed ceramic, 8 mmf, ±0.5 mmf, 500 v. ....	90575-207	99600
3C57	Capacitor, fixed ceramic, 820 mmf, +100 -0%, 500 v. Same as 3C51	449696-1	94190
3C58	Capacitor, fixed ceramic, 100 mmf, ±20%, 500 v. ....	735717-129	101853
3C59, 3C60	Capacitor, fixed ceramic, 820 mmf, +100 -0%, 500 v. Same as 3C51	449696-1	94190
3C61	Capacitor, fixed ceramic, 470 mmf, ±20%, 500 v. ....	735717-637	75198
3C62, 3C63	Capacitor, fixed ceramic, 820 mmf, +100 -0%, 500 v. Same as 3C51	449696-1	94190
3C64	Capacitor, fixed ceramic, 100 mmf, ±20%, 500 v. Same as 3C58	735717-129	101853
3C65	Capacitor, fixed ceramic, 820 mmf, +100 -0%, 500 v. Same as 3C51	449696-1	94190
3C66	Capacitor, fixed ceramic, 100 mmf, ±20%, 500 v. Same as 3C58	735717-129	101853
3C67	Capacitor, fixed ceramic, 470 mmf, ±20%, 500 v. Same as 3C61	735717-637	75198
3C68	Capacitor, fixed ceramic, 820 mmf, +100 -0%, 500 v. Same as 3C51	449696-1	94190
3C69	Capacitor, fixed ceramic, 10 mmf, ±0.5 mmf, 500 v. ....	90575-209	98225
3CR1	Rectifier, germanium diode	1N21B	67876
3J1	Connector, female, coaxial, coupling loop assembly, chassis mtg. ....	8834436-501	94231
3J2, 3J3, 3J4	Connector, female, pin jack	742565-1	93678
3J5	Connector, male, 6 contact, chassis mtg. ....	181494-3	28507
3J6	Not used.		
3J7	Connector, female, pin jack. Same as 3J2	742565-1	93678
3J8	Connector, female, coaxial, chassis mtg. ....	8845666-1	94205
3J9	Connector, female, pin jack. Same as 3J2	742565-1	93678

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AFC-8

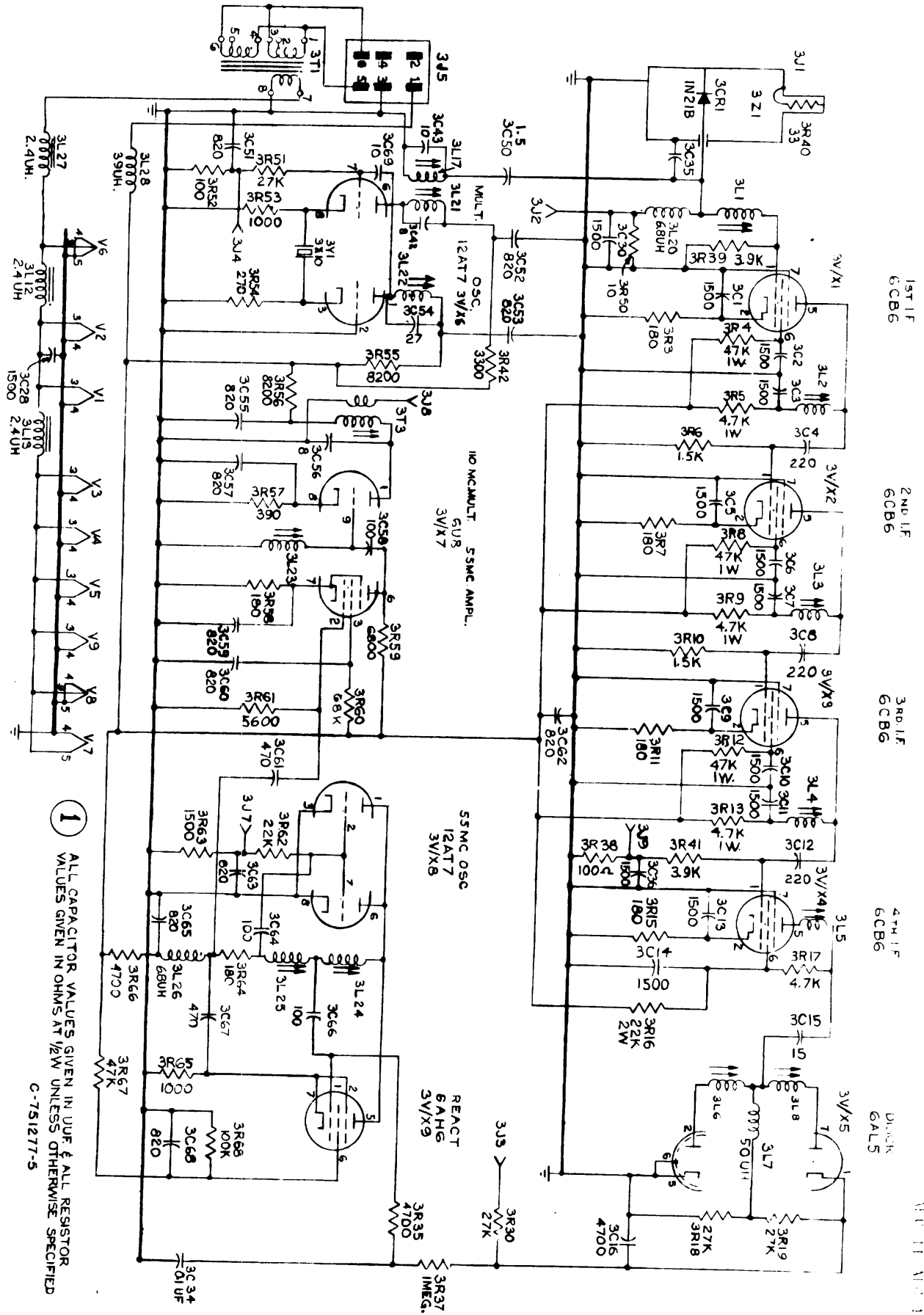
<i>Symbol No.</i>	<i>Description</i>	<i>Drawing No.</i>	<i>Stock No.</i>
3L1	Coil, adj. iron core .....	629132-507	94240
3L2, 3L3, 3L4	Coil, adj. iron core .....	629132-508	94250
3L5	Coil, adj. iron core .....	629132-501	94251
3L6	Coil, adj. iron core .....	629132-505	94236
3L7	Reactor, r-f choke, 50 microhenrys .....	8834437-502	94242
3L8	Coil, adj. iron core. Same as 3L5 .....	629132-501	94251
3L9, 3L10, 3L11	Not used.		
3L12	Reactor, r-f choke, 2.4 microhenrys .....	8834424-501	94040
3L13	Reactor, r-f choke, 2.4 microhenrys. Same as 3L12 .....	8834424-501	94040
3L14 to 3L16	Not used.		
3L17	Coil, adj. core, mult. plate tuning, 160 mc. ....	8864102-4	204735
3L18, 3L19	Not used.		
3L20	Reactor, r-f choke, 6.8 microhenrys .....	941524-245	217800
3L21	Coil, adj. core, mult. plate tuning, 160 mc. Same as 3L17 .....	8864102-4	204735
3L22	Coil, adj. core, osc. plate tuning, 40 mc. ....	8864102-2	204736
3L23	Coil, adj. core, 55 mc. plate output tuning .....	8864101-1	204737
3L24	Coil, adj. core, osc. plate tuning, 55 mc. ....	8864102-3	204738
3L25	Coil, adj. core, osc. grid tuning, 55 mc. ....	629132-517	94245
3L26	Reactor, r-f choke, 6.8 microhenrys. Same as 3L20 .....	941524-245	217800
3L27	Reactor, r-f choke, 2.4 microhenrys. Same as 3L12 .....	8834424-501	94040
3L28	Reactor, r-f choke, 39 microhenrys .....	473909-39	205859
3R1, 3R2	Not used.		
3R3	Resistor, fixed composition, 180 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-53	
3R4	Resistor, fixed composition, 47,000 ohm, $\pm 10\%$ , 1 w. ....	90496-82	
3R5	Resistor, fixed composition, 4700 ohm, $\pm 20\%$ , 1 w. ....	90496-17	
3R6	Resistor, fixed composition, 1500 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-64	
3R7	Resistor, fixed composition, 180 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. Same as 3R3 .....	82283-53	
3R8	Resistor, fixed composition, 47,000 ohm, $\pm 10\%$ , 1 w. Same as 3R4 .....	90496-82	
3R9	Resistor, fixed composition, 4700 ohm, $\pm 20\%$ , 1 w. Same as 3R5 .....	90496-17	
3R10	Resistor, fixed composition, 1500 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. Same as 3R6 .....	82283-64	
3R11	Resistor, fixed composition, 180 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. Same as 3R3 .....	82283-53	
3R12	Resistor, fixed composition, 47,000 ohm, $\pm 10\%$ , 1 w. Same as 3R4 .....	90496-82	
3R13	Resistor, fixed composition, 4700 ohm, $\pm 20\%$ , 1 w. Same as 3R5 .....	90496-17	
3R14	Not used.		
3R15	Resistor, fixed composition, 180 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. Same as 3R3 .....	82283-53	
3R16	Resistor, fixed composition, 22,000 ohm, $\pm 20\%$ , 2 w. ....	99126-21	
3R17	Resistor, fixed composition, 4700 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-70	
3R18, 3R19	Resistor, fixed composition, 27,000 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-79	
3R20 to 3R29	Not used.		
3R30	Resistor, fixed composition, 27,000 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. Same as 3R18 .....	82283-79	
3R31 to 3R34	Not used.		
3R35	Resistor, fixed composition, 4700 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. Same as 3R17 .....	82283-70	
3R36	Not used.		
3R37	Resistor, fixed composition, 1 meg. $\pm 20\%$ , $\frac{1}{2}$ w. ....	82283-31	
3R38	Resistor, fixed composition, 100 ohm, $\pm 5\%$ , $\frac{1}{2}$ w. ....	82283-135	
3R39	Resistor, fixed composition, 3900 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-69	
3R40	Resistor, fixed composition, 33 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. (part of 3J1 assy) .....	82283-44	
3R41	Resistor, fixed composition, 3900 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. Same as 3R39 .....	82283-69	
3R42	Resistor, fixed composition, 3300 ohm, $\pm 10\%$ , 1 w. ....	90496-68	
3R43, to 3R49	Not used.		

**T.O. 31R5-4-A-21**

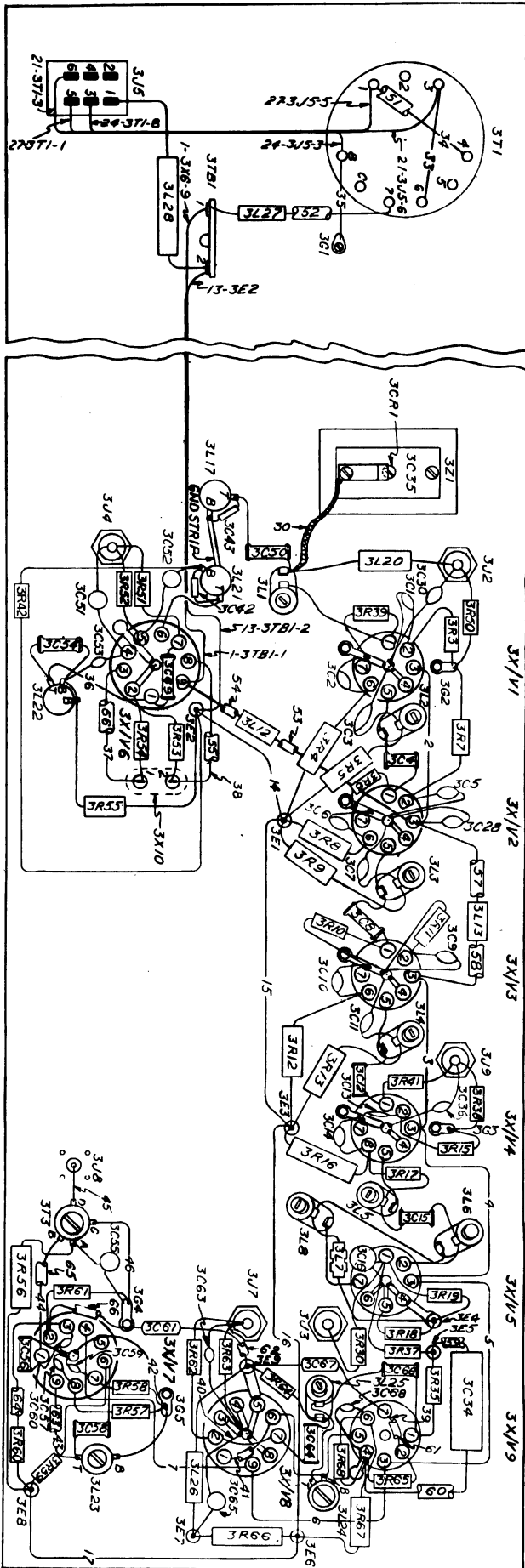
AFC-9

Symbol No.	Description	Drawing No.	Stock No.
3R50	Resistor, fixed composition, 10 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-38	
3R51	Resistor, fixed composition, 27,000 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. Same as 3R18	82283-79	
3R52	Resistor, fixed composition, 100 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-50	
3R53	Resistor, fixed composition, 1000 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-62	
3R54	Resistor, fixed composition, 270 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-55	
3R55, 3R56	Resistor, fixed composition, 8200 ohm, $\pm 10\%$ , 2 w. ....	99126-73	
3R57	Resistor, fixed composition, 390 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-57	
3R58	Resistor, fixed composition, 180 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. Same as 3R3 ...	82283-53	
3R59	Resistor, fixed composition, 6800 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-72	
3R60	Resistor, fixed composition, 68,000 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-84	
3R61	Resistor, fixed composition, 5600 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-71	
3R62	Resistor, fixed composition, 22,000 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-78	
3R63	Resistor, fixed composition, 1500 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. Same as 3R6 ...	82283-64	
3R64	Resistor, fixed composition, 180 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. Same as 3R3 ...	82283-53	
3R65	Resistor, fixed composition, 1000 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. Same as 3R53 ...	82283-62	
3R66	Resistor, fixed composition, 4700 ohm, $\pm 10\%$ , 2 w. ....	99126-70	
3R67	Resistor, fixed composition, 47,000 ohm, $\pm 10\%$ , 1 w. Same as 3R4	90496-82	
3R68	Resistor, fixed composition, 100,000 ohm, $\pm 10\%$ , $\frac{1}{2}$ w. ....	82283-86	
3T1	Transformer, filament	949385-1	94196
3T2	Not used.		
3T3	Transformer, adj. core, multiplier output, 110 mc. ....	8864100-1	204739
3X1 to 3X5	Socket, 7 pin min. ....	737867-18	94879
3X6, 3X7, 3X8	Socket, 9 pin min. ....	984055-2	94880
3X9	Socket, 7 pin min. Same as 3X1	737867-18	94879
3X10	Socket, crystal, 2 contact, steatite	8885952-1	79970
3Z1	Cavity Assembly (associated parts below)	458907-501	
	Core, brass tuning core, $\frac{3}{8}$ -24 thread, $1\frac{1}{16}$ " lg., 1Z1 tuning	8831031-1	95393
	Contact: beryllium copper, for 1Z1	8834416-1	94390
	Insulator: teflon coated glass fabric, $1\frac{3}{16}$ " x $1\frac{1}{16}$ " x .010" thick	8834415-1	94389
Pt. of 3C35	Washer, spring, $\frac{7}{8}$ " OD x $2\frac{1}{32}$ " ID x 0.025" thick beryllium copper, tuning core tension	8831068-2	95394
	Nut, hex, brass $\frac{3}{8}$ -24 thread, tuning core locking	874927-6	95395
	<i>Miscellaneous</i>		
	Connector, male, coaxial, cable mtg. ....	8898625-501	54392
	Screw, thumb #10-32 thread, back panel holding	8886111-2	94391
	Shield, tube, 7 pin min., $1\frac{3}{8}$ " lg.	99369-1	53016
	Shield, tube, 7 pin min., $1\frac{1}{4}$ " lg.	99369-2	54521
	Shield, tube, 9 pin min., $1\frac{1}{10}$ " lg.	8858642-3	56359

T.O. 31R5-4A-21



- NOTES:
1. NUMBERS IN WIRES ARE WIRE NUMBERS (SEE TABLE)
  2. WIRES IN CABLES HAVE WIRE NUMBERS AND DESTINATIONS AT EACH END.
  3. WHERE A THINNED COPPER WIRE PASSES THRU A SOLDER LUG A HEAVY DOT INDICATES THAT IT SHOULD BE SOLDERED TO THE LUG.
  4. SOLDER ALL ELECTRICAL CONNECTIONS USING PT 50.
  5. SOLDER LUGS ON COILS ARE DELINEATED FOR CONVENIENCE IN SHOWING CONNECTIONS



T.O. 31R5-4-A-21

AFC-13, AFC-14

WIRE NO	DESCRIPTION	PS NUMBER	PARS LIST	WIRE NOS (EXCLUSIVE)
1 TO 7	WHT-BRN	10/010	PS-B05-B	57
13 TO 16	WHT-RED	10/010	PS-B05-B	58
21	WHT-RED	7/010	PS-B05-B	61
24	WHT-YEL/BLK	7/010	PS-B05-6	60
27	WHT	7/010	PS-B05-6	59
30	BRND CABLE	72-577-723	PS-439-53	55
33 TO 46	THINNED COPPER WIRE	0820	PS-105	57
37 TO 66	BLCK INS. TUBING	0820	PS-B	56

Figure AFC-6—Terminal AFC-Unit, MI-31492-C—Connection Diagram

# MICROWAVE COMMUNICATION EQUIPMENT

T.O. 31R5-4-A-21

## Baseband Unit MI-31910

- TECHNICAL DATA
- DESCRIPTION
- MAINTENANCE
- REPLACEMENT PARTS



RADIO CORPORATION OF AMERICA  
COMMUNICATION PRODUCTS DEPARTMENT, CAMDEN, NEW JERSEY

## T.O. 31R5-4-A-21

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## TECHNICAL DATA

<b>Power Input</b>	<b>Transmitting Amplifier</b>
<b>Filament Heaters</b>	Less than 100 ohms (To the frequency modulator of the receiver/modulator unit)
20 watts at 115 v., 50/60 cycles ac	
<b>Plate Supply</b>	<b>Output Level</b>
80 ma at 250 v. dc, ripple less than 0.030 volt	<b>Receiving Amplifier</b>
	Multiplex: —20 dbm per channel (0.037 volt)
<b>Input Impedance</b>	Service Channel: 0.61 volt
<b>Receiving Amplifier</b>	<b>Transmitting Amplifier</b>
2200 ohms (From the baseband amplifier of the receiver/modulator unit)	Multiplex: 0.071 volt per low frequency channel
<b>Transmitting Amplifier</b>	Service Channel: 0.048 volt
Multiplex: 135 ohms unbalanced (From the channelling equipment)	<b>Tube Complement</b>
Service Channel: 100,000 ohms (From the service unit)	
<b>Input Level</b>	<b>Symbol</b> <b>Type</b> <b>Function</b>
<b>Receiving Amplifier</b>	4V1    6CB6    Transmitting Baseband and Service Channel Amplifier
Multiplex: 0.028 volt per channel	4V2    6CL6    Transmitting Cathode Follower Output Stage
Service Channel: 0.019 volt	4V3    6AW8    Transmitting Service Channel Cathode Follower/Receiving Service Channel Amplifier
<b>Transmitting Amplifier</b>	4V4    5965    Receiving Adding Amplifier
Multiplex: —26 dbm per channel (0.0184 volt)	4V5    6CB6    Receiving Baseband Amplifier
Service Channel: 0.258 volt	4V6    6CL6    Receiving Cathode Follower Output Stage
<b>Output Impedance</b>	<b>Weight and Dimensions</b>
<b>Receiving Amplifier</b>	Weight: 8 lbs.
Multiplex: 135 ohms unbalanced (To the channelling equipment)	Height: 3½ inches
Service Channel: 22,000 ohms (To the service unit)	Depth front of panel: 2½ inches
	Depth back of panel: 4 inches
	Width: 19 inches

## DESCRIPTION

The baseband unit is designed for amplifying the signals passing to and from the channelling equipment (frequencies between 3 kc and 600 kc) and to and from the service unit (frequencies between 300 cps to 3 kc) at terminal and drop repeater stations.

The baseband unit amplifies the multiplex and service channel signals from the channelling equipment and service unit to the proper level and transfers them to the receiver/modulator units. It also amplifies the received signals (300 cps to 600 kc) from the receiver/modulator to the correct level before they are sent to the channelling equipment and service unit.

The baseband unit consists of two independent amplifier circuits. The transmitting amplifier (4V1, 4V2 and 4V3A) feeds the multiplex and service channel signals to the receiver/modulator units. It has two inputs, one for the multiplex signals and the other for the service channel signals and two

outputs, one for each receiver/modulator unit. The receiving amplifier (4V3B, 4V4, 4V5 and 4V6) accepts the received signals and feeds them to the channelling equipment and the service unit. It has two inputs, one for each of the two possible receiver/modulator units and two outputs, one for the multiplex signals and the other for service channel signals.

There are two separate signal paths in the baseband unit. One path is from the multiplex signal input terminal 4J4-1 and the service channel input signal terminal 4J3-2, through the transmitting amplifier and cathode follower to output terminals 4J1-2 and 4J2-2. The transmitting amplifier consists of amplifier stage 4V1 and cathode follower output stage 4V2. The service channel signals are fed to amplifier 4V1 through cathode follower stage 4V3-A. The 3 kc to 600 kc signals from the channelling equipment are connected to the input circuit of 4V1 through 4AT1. 4AT1 is a 1 to 15

B-2

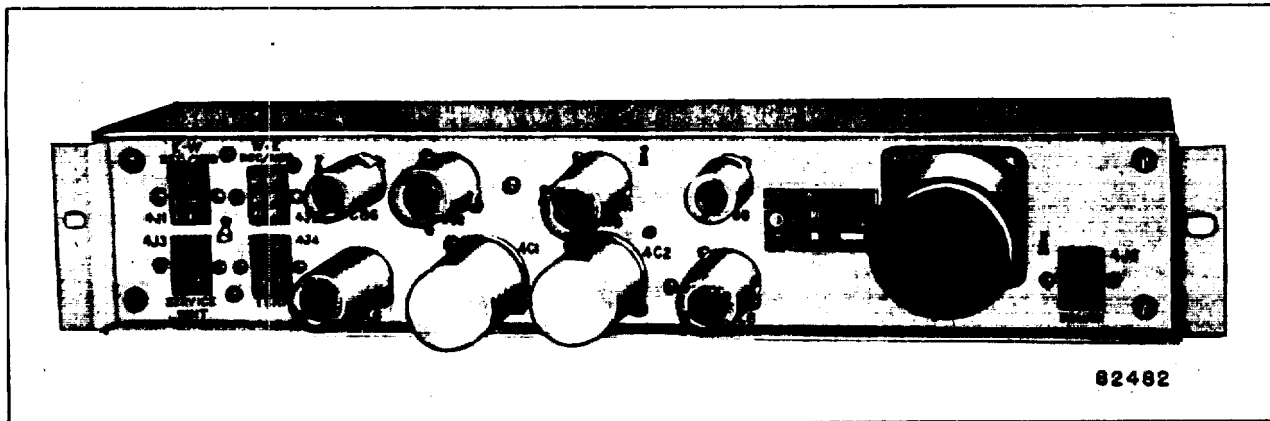


Figure B-1—Baseband Unit—Front View

db attenuator provided to set the signal level to amplifier 4V1 in order to obtain the correct output voltage at 4J1-2 and 4J2-2 to the receiver/modulator units. It contains individual pads of 1, 2, 4 and 8 db loss which can be connected in cascade to give the desired attenuation. The service channel signals (300 cps to 3 kc) from the service unit are applied to cathode follower 4V3-A the output of which is fed to amplifier 4V1. The output of 4V1 which contains both multiplex and service channel signals is applied to 4V2. The output of cathode follower 4V2 is fed to the frequency modulator of the receiver/modulator units.

A second signal path is from 4J1-5 and 4J2-5, the input terminals for the received multiplex and service channel signals from the receiver/modulator units, through the receiving amplifier to the multiplex signal output terminal 4J4-5 and service channel output terminal 4J3-5. The receiving amplifier is composed of 4V3B, 4V4, 4V5 and 4V6. It utilizes a separate output amplifier and cathode follower (4V5 and 4V6) for the multiplex signals and another output amplifier (4V3B) for the service channel signals. The input stage is a 5965 dual triode tube (4V4) which serves as an adding amplifier for the signal from the E-W and W-E receiver/modulators at a repeater station. From 4V4 the signals are applied to separate amplifiers 4V3B and 4V5. The service channel signals (300 cps to 3 kc) in the output of 4V3B are fed to the

service unit. The multiplex and service channel signals (300 cps to 600 kc) are amplified by 4V5 and delivered to the multiplex equipment. A 1 to 15 db attenuator provides a means of setting the output of amplifier 4V6 to obtain the proper signal level of -20 db to the channelling equipment. The attenuator contains individual pads of 1, 2, 4 and 8 db loss which can be connected in cascade to give the desired attenuation. Connections to the associated units including the power supply are made through interconnecting cables to Jones plugs on the front of the unit.

#### Attenuators 4AT1 and 4AT2

Connections to 4AT1 and 4AT2 are made at the factory and need not be changed thereafter. The individual pads are connected in cascade to obtain the required attenuation. Attenuator 4AT1 is connected between terminals 4J4-1 and 4XZ1-F. The required pads are connected together so that with an input of -26 dbm the output of the transmitting amplifier (at 4J1-2 and 4J2-2) is 0.071 volt to the frequency modulators of the receiver/modulator units for a low frequency channel. Attenuator 4AT2 is connected between terminals 4XZ6-E and 4J4-5. The pads of this attenuator are connected so that the output of receiving amplifier 4V6 (at 4J4-5) to the channelling equipment is -20 dbm per channel.

## MAINTENANCE

### General Notes

1. Replace electrolytic capacitors 4C1 and 4C2 once a year.
2. The tubes seldom need replacing. The circuits employed allow the tubes to deteriorate appreciably

before a change in gain is noticeable. However the gain of the unit should be checked as described under *Voltage Gain Check* at yearly intervals and also if, after changing tubes, the gain of the amplifiers is still outside the stated tolerance.



# T.O. 31R5-4-A-21

B-3

3. Excessive intermodulation distortion can usually be remedied by replacing tubes. If this fails to reduce the distortion, socket voltages and resistor values should be checked.

### Voltage Gain Check

To check the voltage gain of the baseband unit use the following procedure. Before performing the check disconnect the cables from plugs 4J1, 4J2, 4J3, and 4J4. This removes the signal sources from the unit and allows the system to remain in operation while the measurements are being made. Make sure that there is no system traffic through the baseband unit before removing the plugs. Make all audio voltage measurements with a Ballantine Model 310A voltmeter (or equivalent) and use a Hewlett Packard Type 200CD audio oscillator (or equivalent) to generate the test tones.

### Transmitting Amplifier

#### Baseband Input

1. Connect the audio voltmeter to 4J2-2. (Load with 1000 ohms.)
2. Apply a 0.0184 volt, 100 kc tone to 4J4-1.
3. The meter reading at 4J2-2 should be 0.071 volt  $\pm 1.0$  db.
4. Connect the audio voltmeter to 4J1-2 and repeat step 2.

5. The meter reading at 4J1-2 should be 0.071 volt  $\pm 1.0$  db.

#### Service Channel Input

1. Apply a 0.258 volt, 1000 cycle tone to 4J3-2. Load 4J4-1 with 135 ohms.
2. The meter reading at 4J2-2 should be 0.048 volt  $\pm 0.5$  db.

### Receiving Amplifier

#### Baseband Output

1. Connect the audio voltmeter to 4J4-5. (Load with 600 ohms.)
2. Apply a 0.028 volt, 100 kc tone alternately to 4J1-5 and 4J2-5.
3. The meter reading at 4J4-5 should be 0.037 volt  $\pm 1.0$  db with the tone applied at either 4J1-5 or 4J2-5.

NOTE: This figure applies for the standard level setting (4C12 connected to the junction of 4R34 and 4R35). In systems in which 4C12 is connected to the plates of 4V4 a meter reading of 0.074 volt  $\pm 1.0$  db should be obtained.

#### Service Channel Output

1. Connect the audio voltmeter to 4J3-5 and load with 22,000 ohms.

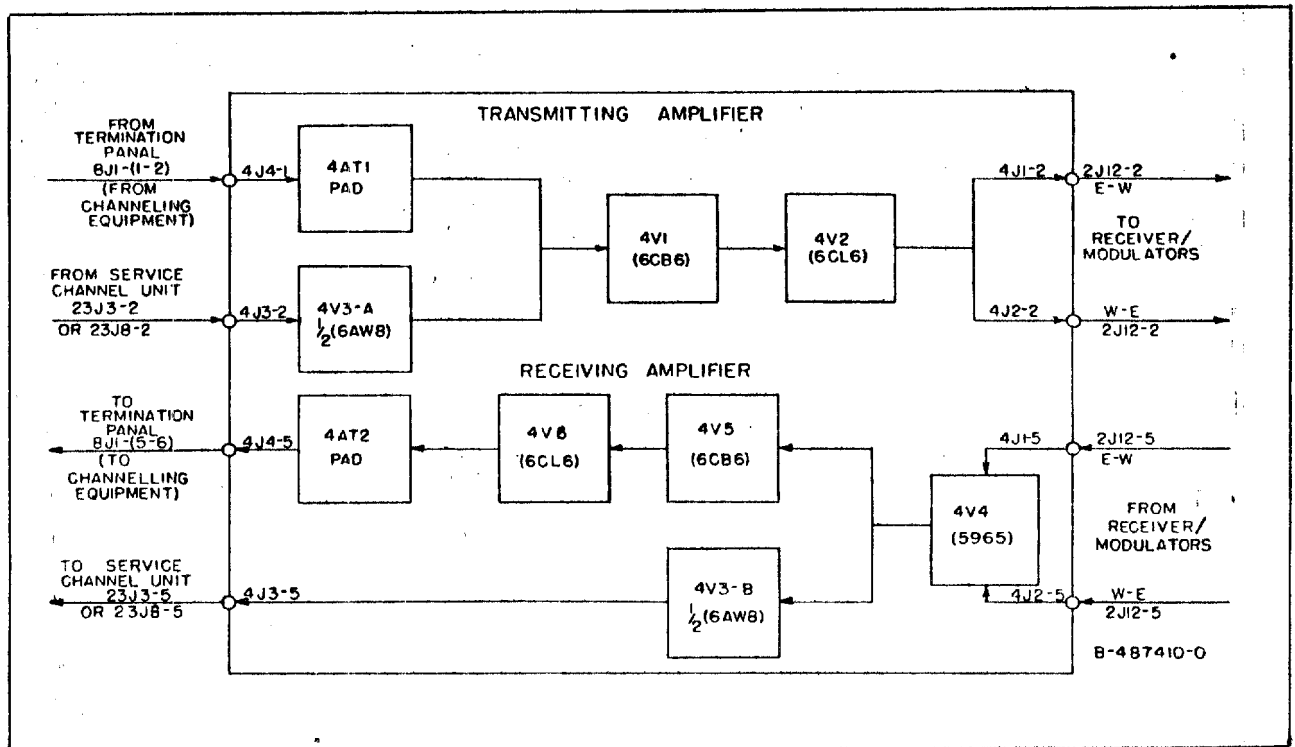


Figure B-2—Baseband Unit—Block Diagram

P.O. 31R5-4A-21

B-4

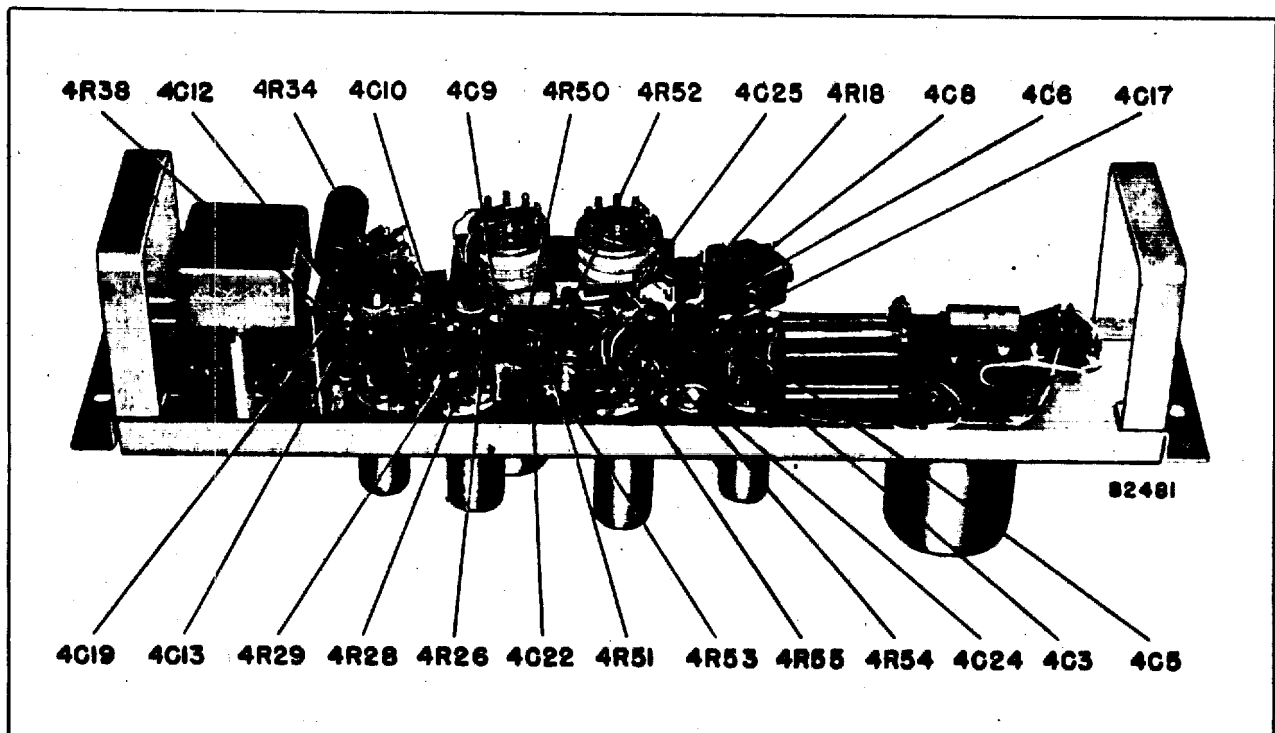


Figure B-3—Baseband Unit—Rear View, Dust Cover Removed

2. Apply a 0.019 volt, 1000 cycle tone alternately to 4J1-5 and 4J2-5.

3. The meter reading at 4J3-5 should be 0.61 volt  $\pm 1.0$  db with the tone applied at either 4J1-5 or 4J2-5.

After completing the check remove the test equipment and terminating resistors, and reconnect the cables to plugs 4J1, 4J2, 4J3 and 4J4.

**Frequency Response Check**

To check the frequency response of the baseband unit, follow the procedure described below. Before performing the check make sure there is no system traffic through the baseband unit. Disconnect the cables from plugs 4J1, 4J2, 4J3, and 4J4. This removes the signal sources from the unit and allows the system to remain in operation while the measurements are being made. Make all audio voltage measurements with a Ballantine Model 310A audio voltmeter (or equivalent) and use a Hewlett Packard Type 200 CD audio oscillator (or equivalent) as the test tone source.

**Transmitting Amplifier**

*Baseband Input*

1. Connect the audio voltmeter to 4J2-2. (Load with 1000 ohms.)

2. Apply the test frequencies listed in step  $\#3$  below to 4J4-1 through a 135 ohms series resistor. Keep the oscillator output constant at 0.2 volt measured at the oscillator terminals.

3. Measure the output at the test frequencies at 4J2-2. With the 100 kc output as a 0 db reference the readings must be within the following limits:

Frequency (kc)	Nominal (db)	Tolerance (db)
0.1	-6.0	
0.3	-1.0	$\pm 0.2$
1.0	-0.0	$\pm 0.3$
3.0	-0.1	$\pm 0.5$
5.0	-0.1	$\pm 0.3$
10	0.0	$\pm 0.2$
20	0.0	$\pm 0.2$
50	0.0	$\pm 0.2$
100	0.0	$\pm 0.0$
200	0.0	$\pm 0.2$
300	0.0	
500	-0.2	$\pm 0.5$
600	-0.4	$\pm 0.5$

*Service Channel Input*

1. Connect the audio voltmeter to 4J2-2. (Load with 1000 ohms.)
2. Apply the frequencies listed in step #3 below to 4J3-2. Keep the oscillator output constant at 0.30 volt.
3. With the 1000 cycles input as 0 db reference the readings must be within the following limits:

Frequency (cycles)	Nominal (db)	Tolerance (db)
300	-1.2	± 0.3
1000	0.0	± 0.0
3000	-0.5	± 0.2

**Receiving Amplifier**

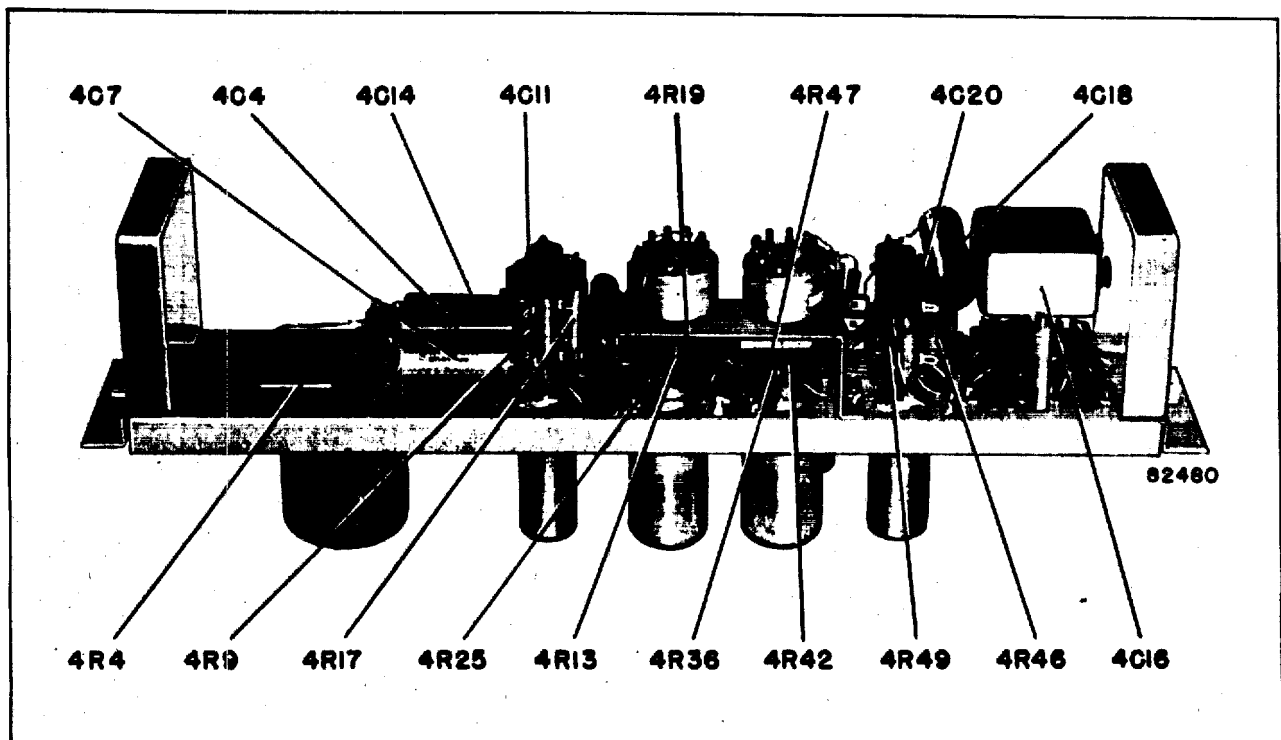
*Baseband Output*

1. Connect the audio voltmeter to 4J4-5. (Load with 135 ohms.)
2. Apply the set of test frequencies listed below first to 4J1-5 and then to 4J2-5 and measure the output at 4J4-5. Keep the oscillator output constant at 0.20 volt at all frequencies. Make a separate check for each test input (4J1-5 and 4J2-5). With the 100 kc output as a 0 db reference the readings must be within the following limits:

Frequency (kc)	Nominal (db)	Tolerance (db)
0.1	-4.5	± 1.0
0.3	0.3	± 0.5
1.0	0.4	± 0.5
3.0	0.2	± 0.5
5.0	0.0	± 0.3
10	0.0	± 0.2
20	0.0	± 0.2
50	0.0	± 0.2
100	0.0	± 0.0
200	0.0	± 0.2
300	0.0	± 0.2
500	-0.2	± 0.5
600	-0.5	± 0.5

*Service Channel Output*

1. Connect the audio voltmeter to 4J3-5. (Load with 22,000 ohms.)
2. Apply the test frequencies listed in step #3 below to 4J1-5: Keep the oscillator output constant at 0.016 volt for all frequencies.
3. Measure the output at the above frequencies at 4J3-5. With the 1000 cycle output as a 0 db reference the readings must be within the following limits:



**Figure B-4—Baseband Unit—Rear View, Dust Cover Removed**

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Frequency (kc)	Nominal (db)	Tolerance (db)
0.1	-9.0	±1.0
0.3	-1.3	±0.3
0.5	-0.3	±0.3
1.0	0.0	±0.0
2.0	-1.1	±0.3
3.0	-2.5	±0.3

5.0	-5.5	±0.6
10	-11.5	±1.0
20	-20.0	±2.0
40	-30.0	±5.0

After completing the check remove the test equipment and terminating resistors and reconnect the cables to plugs 4J1, 4J2, 4J3 and 4J4.

#### TYPICAL BASEBAND UNIT VOLTAGES

The following are typical voltages existing between individual tube pins and ground as measured with an RCA Voltohmyst WV97A. All readings are dc unless otherwise specified.

Tube	Type	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
4V1	6CB6	-0.55	0	6.0 ac	0	125	32	0	—	—
4V2	6CL6	85	57	210	0	6.0 ac	210	210	210	57
4V3	6AW8	65	35	210	0	6.0 ac	1.1	0	42	170
4V4	5965	150	12	14.5	0	0	150	12	145	6.0 ac
4V5	6CB6	-0.55	0	6.0 ac	0	110	34	0	—	—
4V6	6CL6	70	52	180	0	6.0 ac	180	180	180	52

#### REPLACEMENT PARTS LIST

Symbol No.	Description	Drawing No.	Stock No.
4AT1, 4AT2	Resistor, attenuator, fixed, 0-15 db, in 1, 2, 4, and 8 db steps	8914324-1	211642
4C1-A, B, C	Capacitor, dry electrolytic, 10/10/10 mf, 450/450/450 v.	449618-1	56304
4C2-A, B, C			
4C3	Capacitor, fixed, mica, 150 mmf ±2%, 500 v.	737837-435	211643
4C4	Capacitor, fixed, paper, 0.47 mf ±10%, 200 v.	984611-137	
4C5, 4C6	Capacitor, fixed, paper, 0.015 mf ±10%, 400 v.	735715-165	73797
4C7	Capacitor, fixed, paper, 1.0 mf ±10%, 200 v.	984611-139	211741
4C8 to 4C10	Capacitor, fixed, paper, 0.01 mf ±10%, 400 v.	735715-163	73561
4C11	Capacitor, fixed, mica, 1200 mmf ±5%, 500 v.	727868-249	39654
4C12	Capacitor, fixed, paper, 0.015 mf ±10%, 400 v. Same as 4C5	735715-165	73797
4C13	Capacitor, fixed, mica, 120 mmf ±2%, 500 v.	737837-433	205529
4C14	Capacitor, fixed, paper, 0.47 mf ±10%, 200 v. Same as 4C4	984611-137	
4C15	Capacitor, fixed, paper, 0.015 mf ±10%, 400 v. Same as 4C5	735715-165	73797
4C16	Capacitor, fixed, paper, 4.0 mf ±10%, 100 v.	8887706-3	211740
4C17	Capacitor, fixed, paper, 0.1 mf ±10%, 400 v.	735715-175	73551
4C18	Capacitor, fixed, paper, 1.0 mf ±10%, 200 v. Same as 4C7	984611-139	211741
4C19	Capacitor, fixed, mica, 1200 mmf ±5%, 500 v. Same as 4C11	727868-249	39654
4C20	Capacitor, fixed, mica, 470 mmf ±5%, 500 v.	737837-347	208960
4C21, 4C22	Capacitor, fixed, mica, 47 mmf ±5%, 500 v.	748252-323	95320
4C23	Capacitor, fixed, paper, 0.01 mf ±10%, 400 v. Same as 4C8	735715-163	73561
4C24	Capacitor, dry electrolytic, 10 mf, 50 v.	442901-51	52534
4C25	Capacitor, fixed, paper, 0.022 mf ±10%, 400 v.	735715-167	73562
4J1, 4J2	Connector, male, 6 contact chassis mtg.	181494-3	28507
4J3, 4J4	Connector, female, 6 contact, chassis mtg.	181494-4	18534
4J5	Connector, male, 6 contact chassis mtg. Same as 4J1	181494-3	28507
4R1, 4R2	Resistor, fixed, composition, 2200 ohm ±5%, ½ w.	735730-167	502222
4R3	Resistor, fixed, composition, 100,000 ohm ±5%, ½ w.	735730-207	502410
4R4	Resistor, fixed, wire wound, 50 ohm ±5%, 5 w.	458572-15	210969
4R5, 4R6	Resistor, fixed, composition, 270 ohm ±5%, ½ w.	735730-145	502127
4R7	Resistor, fixed, composition, 4700 ohm ±5%, ½ w.	735730-175	502247
4R8	Resistor, fixed, composition, 1000 ohm ±10%, ½ w.	735730-62	502210
4R9	Resistor, fixed, composition, 56,000 ohm ±5%, ½ w.	735730-201	502356

## T.O. 31R5-4-A-21

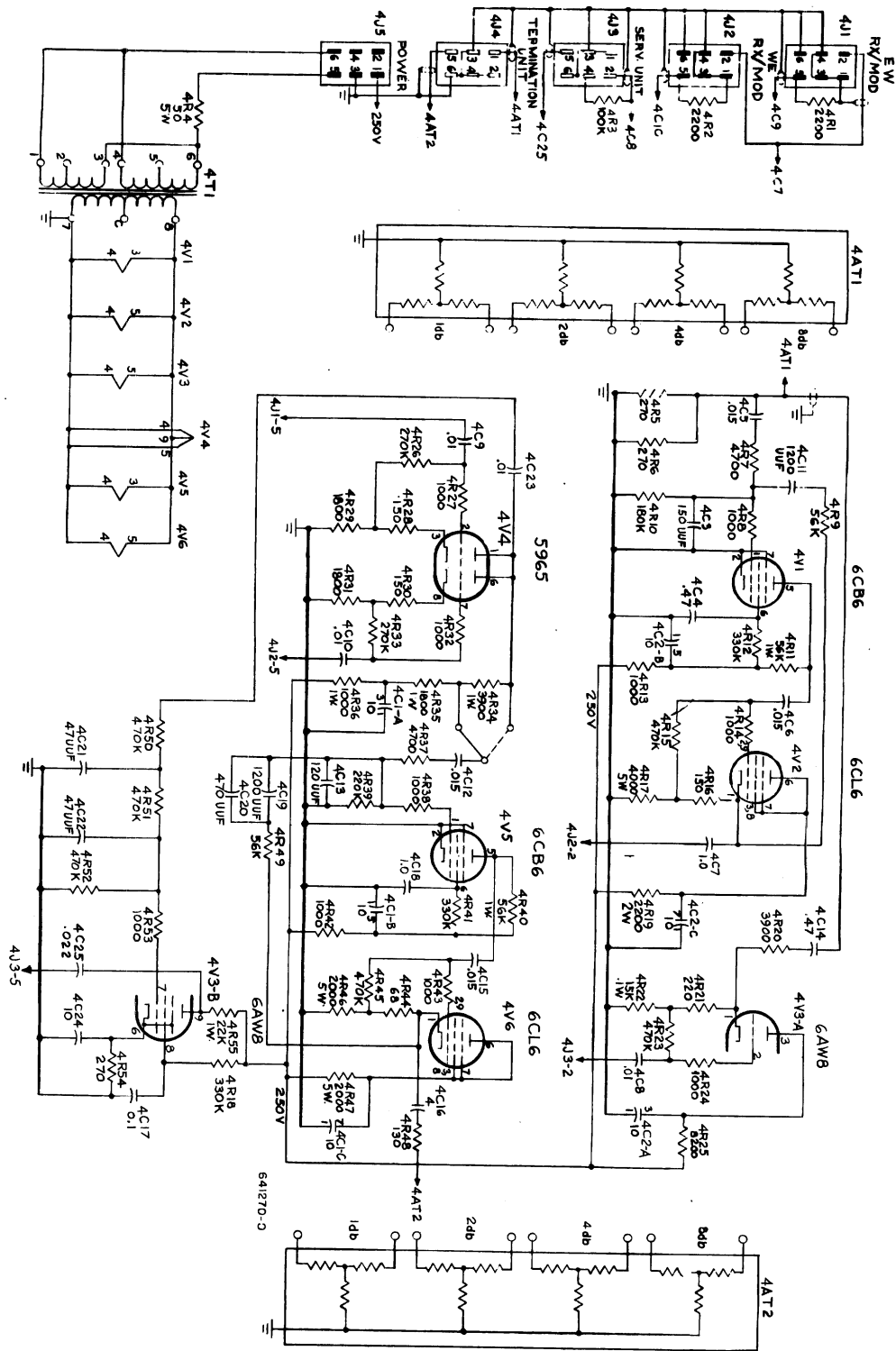
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Symbol No.	Description	Drawing No.	Stock No.
4R10	Resistor, fixed, composition, 180,000 ohm $\pm 10\%$ , 1/2 w. ....	735730-89	502418
4R11	Resistor, fixed, composition, 56,000 ohm $\pm 10\%$ , 1 w. ....	90496-83	512356
4R12	Resistor, fixed, composition, 330,000 ohm $\pm 10\%$ , 1/2 w. ....	735730-92	502433
4R13, 4R14	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , 1/2 w. Same as 4R8 ..	735730-62	502210
4R15	Resistor, fixed, composition, 470,000 ohm $\pm 10\%$ , 1/2 w. ....	735730-94	502447
4R16	Resistor, fixed, composition, 150 ohm $\pm 5\%$ , 1/2 w. ....	735730-139	502115
4R17	Resistor, fixed, wire wound, 4000 ohm $\pm 5\%$ , 5 w. ....	458572-64	98600
4R18	Resistor, fixed, composition, 330,000 ohm $\pm 10\%$ , 1/2 w. Same as 4R12	735730-92	502433
4R19	Resistor, fixed, composition, 2200 ohm $\pm 10\%$ , 2 w. ....	99126-66	522222
4R20	Resistor, fixed, composition, 3900 ohm $\pm 5\%$ , 1/2 w. ....	735730-173	502239
4R21	Resistor, fixed, composition, 220 ohm $\pm 5\%$ , 1/2 w. ....	735730-143	502122
4R22	Resistor, fixed, composition, 15,000 ohm $\pm 5\%$ , 1 w. ....	90496-187	512315
4R23	Resistor, fixed, composition, 470,000 ohm $\pm 10\%$ , 1/2 w. Same as 4R15	735730-94	502447
4R24	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , 1/2 w. Same as 4R8 ..	735730-62	502210
4R25	Resistor, fixed, composition, 8200 ohm $\pm 10\%$ , 1 w. ....	90496-73	512282
4R26	Resistor, fixed, composition, 270,000 ohm $\pm 10\%$ , 1/2 w. ....	735730-91	502427
4R27	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , 1/2 w. Same as 4R8 ..	735730-62	502210
4R28	Resistor, fixed, composition, 150 ohm $\pm 5\%$ , 1/2 w. Same as 4R16 ...	735730-139	502115
4R29	Resistor, fixed, composition, 1800 ohm $\pm 5\%$ , 1/2 w. ....	735730-165	502218
4R30	Resistor, fixed, composition, 150 ohm $\pm 5\%$ , 1/2 w. Same as 4R16 ...	735730-139	502115
4R31	Resistor, fixed, composition, 1800 ohm $\pm 5\%$ , 1/2 w. Same as 4R29 ..	735730-165	502218
4R32	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , 1/2 w. Same as 4R8 ..	735730-62	502210
4R33	Resistor, fixed, composition, 270,000 ohm $\pm 10\%$ , 1/2 w. Same as 4R26	735730-91	502427
4R34	Resistor, fixed, composition, 3900 ohm $\pm 5\%$ , 1 w. ....	90496-173	512239
4R35	Resistor, fixed, composition, 1800 ohm $\pm 5\%$ , 1 w. ....	90496-165	512218
4R36	Resistor, fixed, composition, 1000 ohm $\pm 5\%$ , 1 w. ....	90496-159	512210
4R37	Resistor, fixed, composition, 4700 ohm $\pm 5\%$ , 1/2 w. Same as 4R7 ...	735730-175	502247
4R38	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , 1/2 w. Same as 4R8 ..	735730-62	502210
4R39	Resistor, fixed, composition, 220,000 ohm $\pm 10\%$ , 1/2 w. ....	735730-90	502422
4R40	Resistor, fixed, composition, 56,000 ohm $\pm 10\%$ , 1w. Same as 4R11 ..	90496-83	512356
4R41	Resistor, fixed, composition, 330,000 ohm $\pm 10\%$ , 1/2 w. Same as 4R12	735730-92	502433
4R42, 4R43	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , 1/2 w. Same as 4R8 ..	735730-62	502210
4R44	Resistor, fixed, composition, 68 ohm $\pm 5\%$ , 1/2 w. ....	735730-131	502068
4R45	Resistor, fixed, composition, 470,000 ohm $\pm 10\%$ , 1/2 w. Same as 4R15	735730-94	502447
4R46, 4R47	Resistor, fixed, wire wound, 2000 ohm $\pm 5\%$ , 5 w. ....	458572-58	48344
4R48	Resistor, fixed, composition, 130 ohm $\pm 5\%$ , 1/2 w. ....	735730-138	502113
4R49	Resistor, fixed, composition, 56,000 ohm $\pm 5\%$ , 1/2 w. Same as 4R9 ..	735730-201	502356
4R50 to 4R52	Resistor, fixed, composition, 470,000 ohm $\pm 10\%$ , 1/2 w. Same as 4R15	735730-94	502447
4R53	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , 1/2 w. Same as 4R8 ..	735730-62	502210
4R54	Resistor, fixed, composition, 270 ohm $\pm 5\%$ , 1/2 w. Same as 4R5 ...	735730-145	502127
4R55	Resistor, fixed, composition, 22,000 ohm $\pm 5\%$ , 1 w. ....	90496-191	512322
4T1	Transformer, filament .....	949385-1	94196
4X1	Socket, tube, 7 pin min, turret type .....	746949-9	211644
4X2, 4X3	Socket, tube, noval, turret type .....	746949-4	205034
4X4	Socket, tube, noval, turret type .....	746949-10	211645
4X5	Socket, tube, 7 pin min, turret type. Same as 4X1 .....	746949-9	211644
4X6	Socket, tube, noval, turret type. Same as 4X2 .....	746949-4	205034
4X7, 4X8	Socket, capacitor, octal .....	746008-34	209011
4XZ1	Socket Assembly, not stocked complete, the following parts only stocked, 4C3, 4C5, 4R5, 4R6, 4R7, 4R8, 4R10, 4R11, 4R12, 4X1 .....	641266-501	
4XZ2	Socket Assembly, not stocked complete, the following parts only stocked, 4C6, 4R9, 4R14, 4R15, 4R16, 4R17, 4X2 .....	641266-502	
4XZ3	Socket Assembly, not stocked complete, the following parts only stocked, 4C8, 4C25, 4R18, 4R20, 4R21, 4R22, 4R23, 4R24, 4R54, 4R55, 4X3 .....	641266-503	
4XZ4	Socket Assembly, not stocked complete, the following parts only stocked, 4C9, 4C10, 4C23, 4R26, 4R27, 4R28, 4R29, 4R30, 4R31, 4R32, 4R33, 4X4 .....	641266-504	
4XZ5	Socket Assembly, not stocked complete, the following parts only stocked, 4C12, 4C13, 4C19, 4C20, 4R37, 4R38, 4R39, 4R40, 4R41, 4X5 .....	641266-505	
4XZ6	Socket Assembly, not stocked complete, the following parts only stocked, 4C15, 4R43, 4R44, 4R45, 4R46, 4R48, 4R49, 4X6 .....	641266-506	

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	<i>Description</i>	<i>Drawing No.</i>	<i>Stock No.</i>
	<i>Miscellaneous</i>		
	Base, tube shield (For 4V1, 4V5) .....	746949-1	98907
	Base, tube shield (For 4V2, 4V3, 4V4, 4V6) .....	746949-3	205036
	Shield, tube, 7 pin min (For 4V1, 4V5) .....	99147-2	54521
	Shield, tube, noval (For 4V4) .....	8888549-2	56359
	Shield, tube, noval (For 4V2, 4V3, 4V6) .....	8888549-3	205035
	Terminal, stand-off, melamine body, 27/32" lg., with #4-40 tapped hole mtg. ....	8886187-1	211646

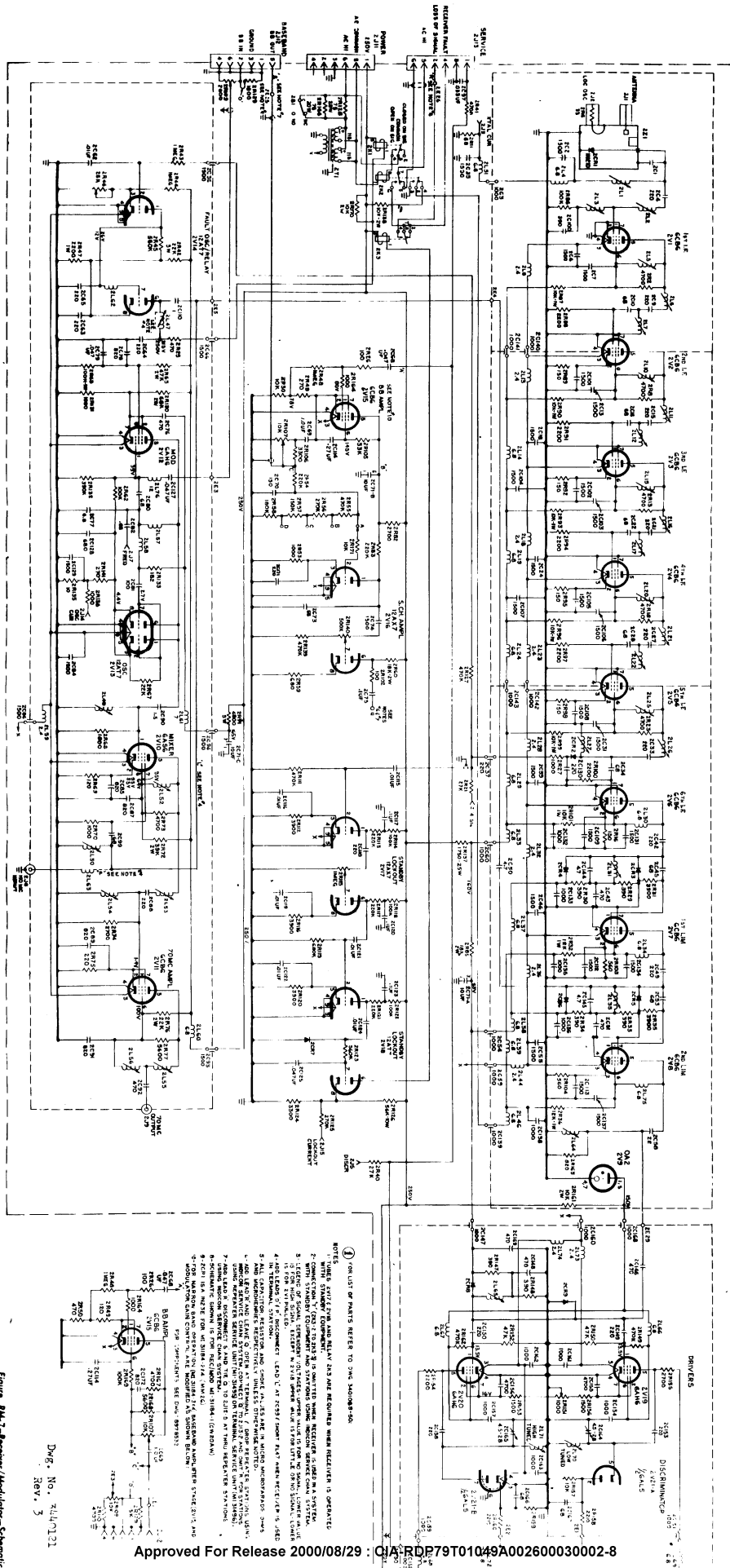


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B-9, B-10

① ALL RESISTOR VALUES GIVEN IN OHMS AND ALL CAPACITOR VALUES GIVEN IN UF UNLESS OTHERWISE SPECIFIED.

Figure B-5—Baseband Unit—Schematic Diagram



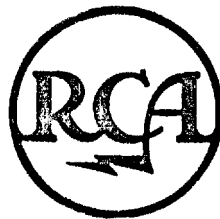


# MICROWAVE COMMUNICATION EQUIPMENT

T.O. 31R5-4-A-21

## Power Supply MI-31494-B

- TECHNICAL DATA
- DESCRIPTION
- MAINTENANCE
- REPLACEMENT PARTS



RADIO CORPORATION OF AMERICA  
COMMUNICATION PRODUCTS DEPARTMENT, CAMDEN, NEW JERSEY

PRINTED IN U.S.A.  
DU 539

18-33230-2

## T.O. 31R5-4-A-21

PS-1

## TECHNICAL DATA

<b>Power Input:</b>	<b>Tube Complement</b>		
95 to 125 volts rms 50/60 cycles, 1000 watts	<i>Symbol</i>	<i>Type</i>	<i>Function</i>
	5V1	3B28	H.V. Rectifier
	5V2	3B28	H.V. Rectifier
	5V3	3B28	L.V. Rectifier
	5V4	3B28	L.V. Rectifier
<b>Power Outputs:</b>	<b>Fuses:</b>		
500 volts dc at full load of 600 ma ripple: 1.0 volts rms max.	<i>Symbol</i>	<i>Rating</i>	<i>Circuit</i>
250 volts dc at full load of 500 ma ripple: 0.030 volts rms max.	5F6	*	ac common
115 v ac 50/60 cycles 300 w Local Supply Voltage	5F7	*	ac for 250 v supply
115 v ac 50/60 cycles $\pm 5\%$ , 250 w, controlled by auto-transformer taps.	5F8	*	ac for 500 v supply
	5F9	.2 amp.	250 v dc
	5F10	*	ac regulated
	5F11	.2 amp.	250 v dc.
	5F12	.3 amp.	500 v dc
	5F13	.8 amp.	ac regulated
	5F14	.8 amp.	ac unregulated
	5F15	*	250 v dc.
	5F16	*	500 v dc
	5F17	*	ac regulated
	5F18	*	ac unregulated
<b>Weight and Dimensions:</b>	* Refer to the Replacement Part List.		
Weight: 275 lbs. packed 225 lbs. net			
Height: 14"			
Depth Back of Panel: 12"			
Depth Front of Panel: 5"			
Width: Standard 19" Rack Mounting			

## DESCRIPTION

The Power Supply MI-31494-B is built for installation in either a standard 19" open rack or cabinet and is used in both terminal and repeater stations. It operates from a 115 v ac, 50-60 cycle source and supplies 250 v and 500 v dc and 115 v ac to the other rack units.

Power Supply MI-31494-B has two separate rectifying sections each employing two 3B28 rectifier tubes in a full wave rectifier circuit. Separate high voltage transformers, 5T3 and 5T2, are provided for each rectifier section. Rectifier filament voltage is supplied by a third transformer 5T1, the primary of which is tapped to permit adjustment of the regulated ac to 115 volts for several different line voltages. These primary taps also permit adjustment of the voltage supplied to the primary of each high voltage transformer, so that each rectifier output voltage can be adjusted to near its nominal value for various values of line voltage and load current. Each section employs double choke filtering assuring a dc voltage with extremely low ripple content. The ac input circuit and all the ac and dc output circuits are protected by fuses.

Time delay relay 5K3 is provided to prevent application of plate voltage to the rectifier tubes before the filaments are emitting properly. The

if the filaments are not warmed up before the high voltage is applied. When line switch 5S1 is closed, relay 5K3 operates after a time delay of from 20 to 40 seconds. This allows sufficient time for the filaments to warm up before high voltage is applied to the plates.

5K3 will not release until from 2 to 3 seconds has elapsed after opening line switch 5S1. This prevents sharp drops in line voltage from releasing 5K3 which would cause 20 to 40 second periods during which the station is not operating.

The voltages available for the other rack units are 250 and 500 volts dc and 115 volts ac. Plug 5P1 provides the means for making the input connection to the primary tap of filament transformer 5T1 which best accommodates the actual ac input voltage. This will also adjust the 115 v ac at terminals 5 and 6 of jacks 5J2, 5J3 and 5J4. 5TB1 provides a means of changing the ac input to the +250 v and +500 v rectifying sections. This permits these supplies to be adjusted to deliver near their nominal output voltages for different values of output current.

If the line voltage is not subject to rapid transients, and if its variation is not greater than  $\pm 5\%$  from nominal, this supply can be connected

PS-2

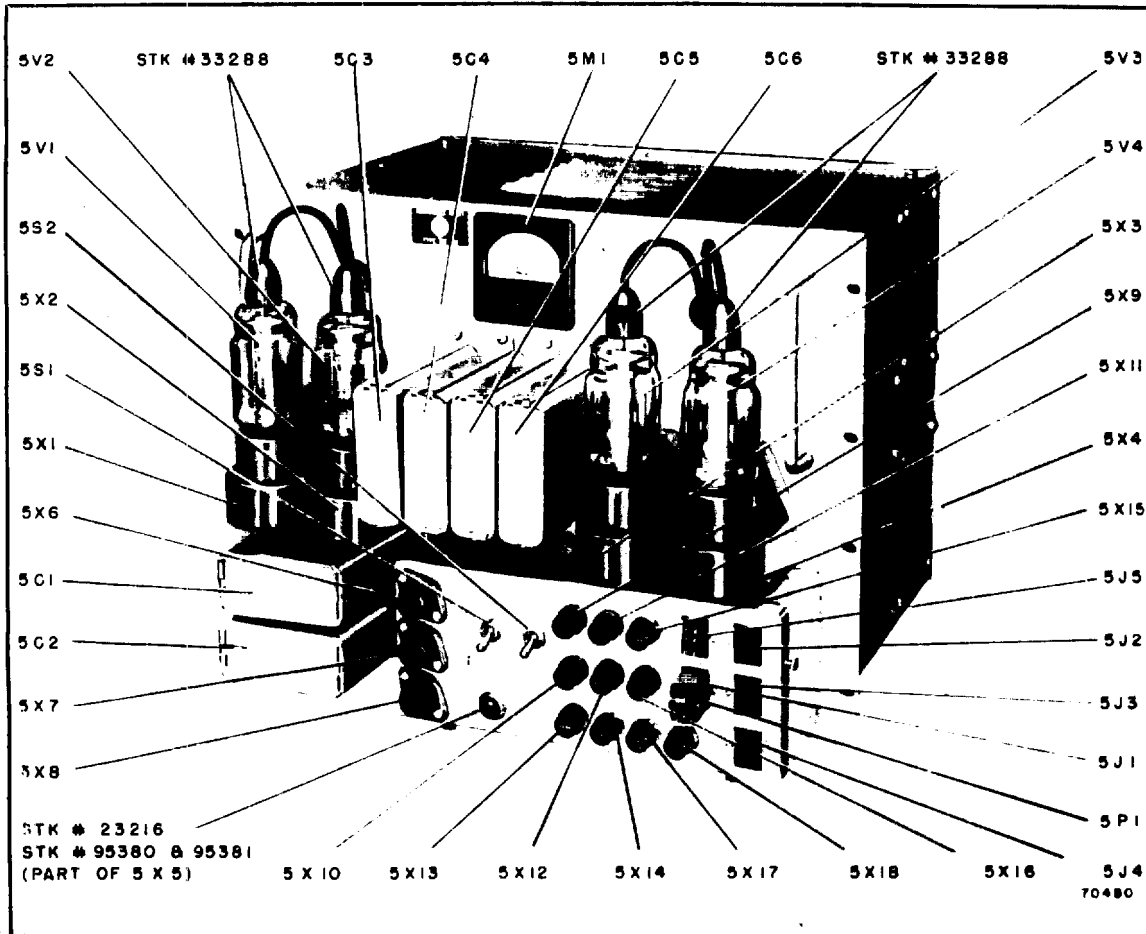


Figure PS-1—Power Supply, MI-31494-B—Front View

directly to the line. If these conditions are not adhered to, however, an ac regulating transformer should be used between the line and the power supply input.

### CONTROLS

a. The LINE switch 5S1 is a double pole single throw switch which connects and disconnects all input power.

b. The TRANS TUNE switch 5S2 closes and opens the 115 v ac supply to the primary of transformer 5T3 of the 500 volt rectifier section.

c. Lamp 5I1 illuminates the red jewel on the fuse panel indicating that the power supply unit is receiving 115 v ac from its power source, and that line switch 5S1 is "ON."

d. Hour meter 5M1 registers the total time that the unit has been in operation.

### MAINTENANCE

#### General Notes

a. Measure the voltage at terminal 5-6 of jacks 5J2, 5J3 or 5J4 periodically to see that the correct connection in plug 5P1 is being used. Also check the dc output voltages to see that the proper connections to 5T1 are being used.

b. If an objectional 120 cycle hum develops in the equipment, check the ripple voltage in both the 500 v and 250 v dc outputs. If the ripple voltage is greater than 1 volt for the 500 v dc supply or

more than 0.030 volt for the 250 v dc supply the condition of the filter capacitors 5C1 thru 5C6 should be checked and the faulty capacitor or capacitors replaced.

c. Check the rectifier filament voltages to see that they are approximately 2.5 volts.

d. The recommended fuse type for 5F6, 7 and 8 is the Bussman Fusetron Type FNM and for 5F9 thru 5F18 is either Bussman Fusetron Type MDM or LittleFuse 4AG Slo-Blo.

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### Typical Power Supply Voltage and Current Readings

The following are dc voltages measured between the listed points and ground. The input line voltage for these measurements is 115 v, and the jumper in 5P1 is connected from Pin 6 to Pin 1. For the full load condition the 5T2 input is connected to the 115 v tap, on terminal board 5TB1. For the minimum load condition the 5T2 input is connected to the 105 v tap on 5TB1. 5T3 input is connected through switch 5S2 to the 115 volt tap on 5TB1 under other load conditions.

#### D. C. Voltages

Point	Full Load Voltage	Min. Load Voltage
Pin 4, 5V1-5V2	564	564
High Side, 5C1	533	557
Pin 2, 5J4	500	550
Pin 2, 5J3	500	550
Pin 4, 5V3, 5V4	300	283
High Side, 5C3	275	270
Pin 1, 5J4	250	250
		with proper 5TB1 connections
Pin 1, 5J3	250	250
		with proper 5TB1 connections

The following are the rms ac voltages and currents measured between various points in the power supply. These readings were taken with the same conditions existing as described for the dc voltage measurements.

#### A.C. R.M.S. Voltages

Voltmeter Position	Full Load Voltage	Min. Load Voltage
Across primary 5T3	115	115
Plate 5V1 to ground	645	650
Plate 5V2 to ground	645	650
Across primary 5T2	115	115
Plate 5V3 to ground	370	330
Plate 5V4 to ground	370	330
Pin 3 to Pin 5, 5J1	95	95
Pin 4 to Pin 5, 5J1	105	105
Pin 1 to Pin 5, 5J1	115	115
Pin 2 to Pin 5, 5J1	125	125
Pin 5 to Pin 6, 5J2-3-4	115	115
Pin 5 to Pin 4, 5J3-4	115	115

#### A.C. R.M.S. Currents

Ammeter Position	Full Load Current	Min. Load Current
Across Fuse Holder 5X8 (5F8 removed)	3.7 amps.	1.1 amps.
Across Fuse Holder 5X7 (5F7 removed)	1.8 amps.	.92 amps.
Across Fuse Holder 5X6 (5F6 removed)	8.2 amps.	—

### REPLACEMENT PARTS LIST

Symbol No.	Description	Drawing No.	Stock No.
5C1, 5C2	Capacitor, fixed, paper, 10 mf., $\pm 20\%$ , 1000 v.	984619-117	18118
5C3 to 5C6	Capacitor, fixed, paper, 10 mf., $\pm 20\%$ , 600 v.	984619-108	18501
5F1 to 5F5	Not used.		
5F6	Fuse, cartridge, 8 amp., 250 v. (for use at all non-standby terminal or repeater stations and junction terminal or repeater stations, not utilizing baseband bridge MI-31151)	8835339-3	95105
5F6	Fuse, cartridge, 10 amp., 250 v. (for use at all standby stations and non-standby junction stations utilizing the baseband bridge MI-31151)	8835339-6	96162
5F7	Fuse, cartridge, 2 amp., 250 v. (for terminal or repeater station only)	8835339-1	95107
5F7	Fuse, cartridge 2.5 amp., 250 v. (for terminal or repeater station with standby only)	8835339-4	96160
5F8	Fuse, cartridge, 4 amp., 250 v. (for terminal or repeater station only)	8835339-2	95106
5F8	Fuse, cartridge, 5 amp., 250 v. (for terminal or repeater station with standby only)	8835339-5	96161
5F9	Fuse, cartridge, 0.2 amp., 250 v. (for terminal or repeater station only)	8835338-2	95103
5F10	Fuse, cartridge, 0.5 amp., 250 v. (for terminal stations with terminal service unit, junction terminal or repeater stations with filter and relay panels, or service channel bridge)	8835338-8	56069

**T.O. 31R5-4-A-21**

PS-4

Symbol No.	Description	Drawing No.	Stock No.
5F10	Fuse, cartridge, 1.25 amp., 125 v. (for terminal stations with service channel unit and indicon decoder, repeater stations with service channel unit and indicon coder or decoder) .....	8835338-12	215880
5F10	Fuse, cartridge, 0.8 amp., 250 v. (for repeater station with repeater service unit) .....	8835338-4	95111
5F10	Fuse, cartridge, 2.5 amp., 125 v. (for junction terminal or repeater stations with baseband bridge MI-31151 and relay panel or service channel bridge) .....	8835338-11	97446
5F11	Fuse, cartridge, 0.2 amp., 250 v. (for terminal or repeater station only) Same as 5F9 .....	8835338-2	95109
5F12	Fuse, cartridge, 0.3 amp., 250 v. (for terminal or repeater station only) ..	8835338-3	95110
5F13, 5F14	Fuse, cartridge, 0.8 amp., 250 v. (for terminal or repeater station only) ..	8835338-4	95111
5F15	Fuse, cartridge, 0.2 amp., 250 v. (for terminal or repeater station only) Same as 5F9 .....	8835338-2	95109
5F15	Fuse, cartridge, 0.8 amp., 250 v. (for terminal or repeater station with standby only) Same as 5F13 .....	8835338-4	95111
5F16	Fuse, cartridge, 0.3 amp., 250 v. (for repeater station only) Same as 5F12 ..	8835338-3	95110
5F16	Fuse, cartridge, 0.8 amp., 250 v. (for repeater station with standby only) Same as 5F13 .....	8835338-4	95111
5F17	Fuse, cartridge, 0.3 amp., 250 v. (for terminal station only) Same as 5F12 ..	8835338-3	95110
5F17	Fuse, cartridge, 0.8 amp., 250 v. (for repeater station only) Same as 5F13 ..	8835338-4	95111
5F17	Fuse, cartridge, 2.5 amp., 125 v. (for terminal or repeater station with standby only) .....	8835338-11	97446
5F18	Fuse, cartridge, 0.8 amp., 250 v. (for repeater station only) Same as 5F13 ..	8835338-4	95111
5F18	Fuse, cartridge, 2.0 amp., 125 v. (for terminal or repeater station with standby only) .....	8835338-5	95557
5I1	Lamp, pilot light, 120 v., 0.05 amps., 6 w. clear candleabra screw base. ....	61114-9	23216
5J1 to 5J4	Connector, female, 6 contact, chassis mtg. ....	181494-4	18534
5J5	Connector, male, 6 contact, chassis mtg. ....	181494-3	28507
5K3	Relay, ac, time delay, coil 115 v., 50/60 cy., 3.5 to 5 watts. ....	470877-1	204348
5L1, 5L2	Reactor, iron core, 5 henry .....	949378-1	95372
5L3, 5L4	Reactor, iron core, 10 henry .....	949379-1	95373
5M1	Meter, elapsed time, 0-99,999 hours .....	8833317-1	95389
5P1	Connector, male, 6 contact, cable mtg. ....	181494-2	28454
5R1	Resistor, fixed, wire wound, 500 ohms, $\pm 5\%$ , 10 w. ....	8817663-14	96267
5R2	Resistor, variable, wire wound, 500 ohms, $\pm 10\%$ , 25 w. ....	108406-5	95374
5R3	Resistor, fixed, wire wound, 50,000 ohms, $\pm 10\%$ , 100 w. ....	449695-18	98116
5R4	Resistor, fixed, wire wound, 25,000 ohms, $\pm 10\%$ , 50 w. ....	182120-12	98117
5S1, 5S2	Switch, toggle, DPST, 15 amps., 125 v., 10 amps., 250 v. ....	449663-109	56882
5T1	Transformer, filament .....	949375-1	95376
5T2	Transformer, plate, pri. 115/124 v., sec. 355-0-355 v. ....	949376-1	95377
5T3	Transformer, plate, pri. 124 v., sec. 645-0-645 v. ....	949377-1	95378
5X1 to 5X4	Socket, tube, for UX-4 pin tubes, with underwriters shield, brkt. type and upright panel mtg. (special) .....	8843563-1	93654
5X5	Pilot light assy. (red) .....	458948-1	
5X6 to 5X8	Holder, fuse, panel mtg., for $1\frac{1}{2}$ " lg. x $13/32$ " dia. fuse .....	8871827-1	95379
5X9 to 5X18	Fuse, holder, cartridge, panel mtg. for $1\frac{1}{4}$ " x $9/32$ " dia. fuses .....	99088-1	58933
	Socket, pilot light socket only less lamp and jewel (pt. of 5X5) .....	458948-1	95380
	Jewel, pilot light red jewel only, less socket and lamp (pt. of 5X5) .....	458948-1	95381
<i>Miscellaneous</i>			
	Connector, tube cap, with 36" cable .....	896952-502	33288

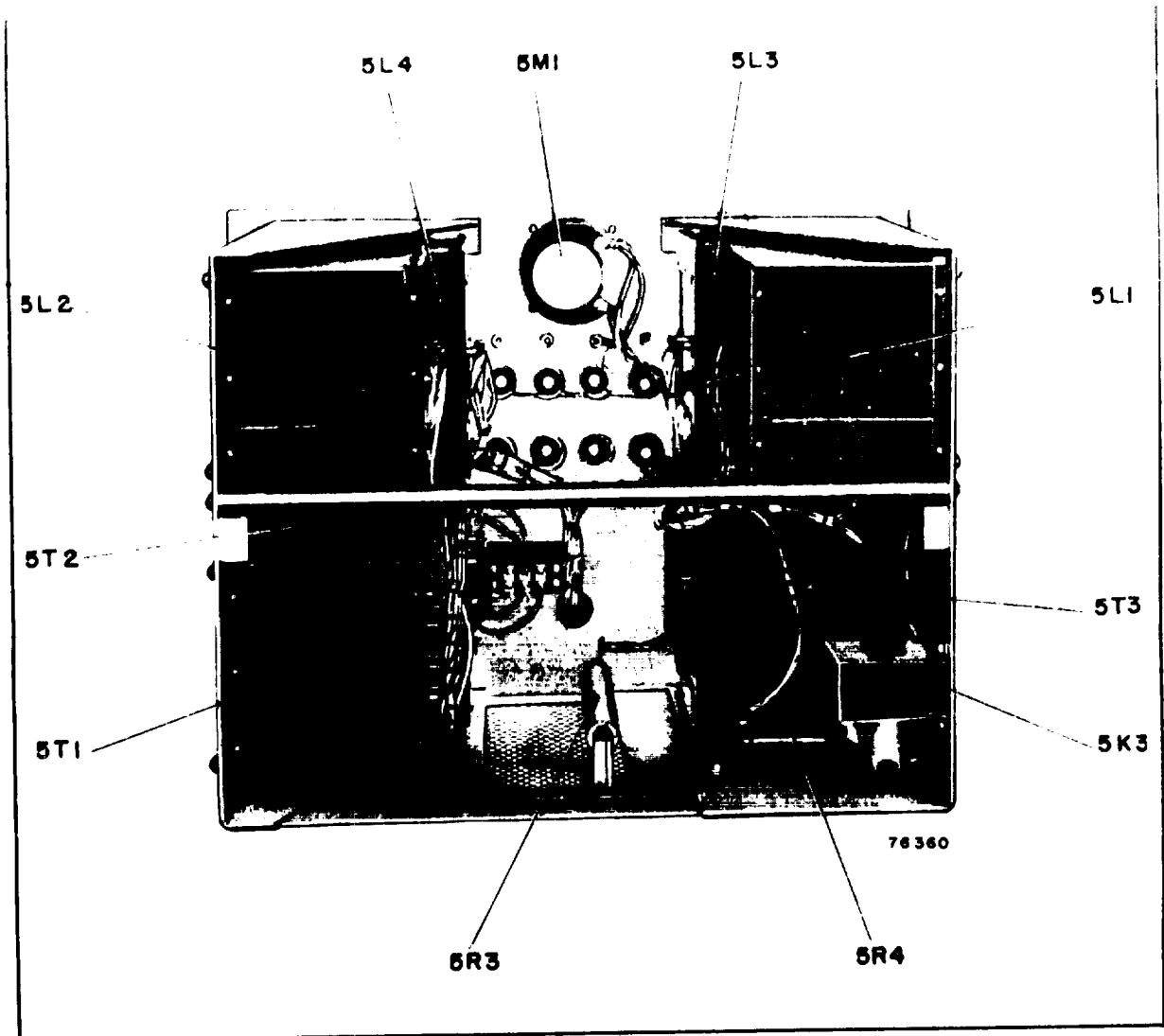
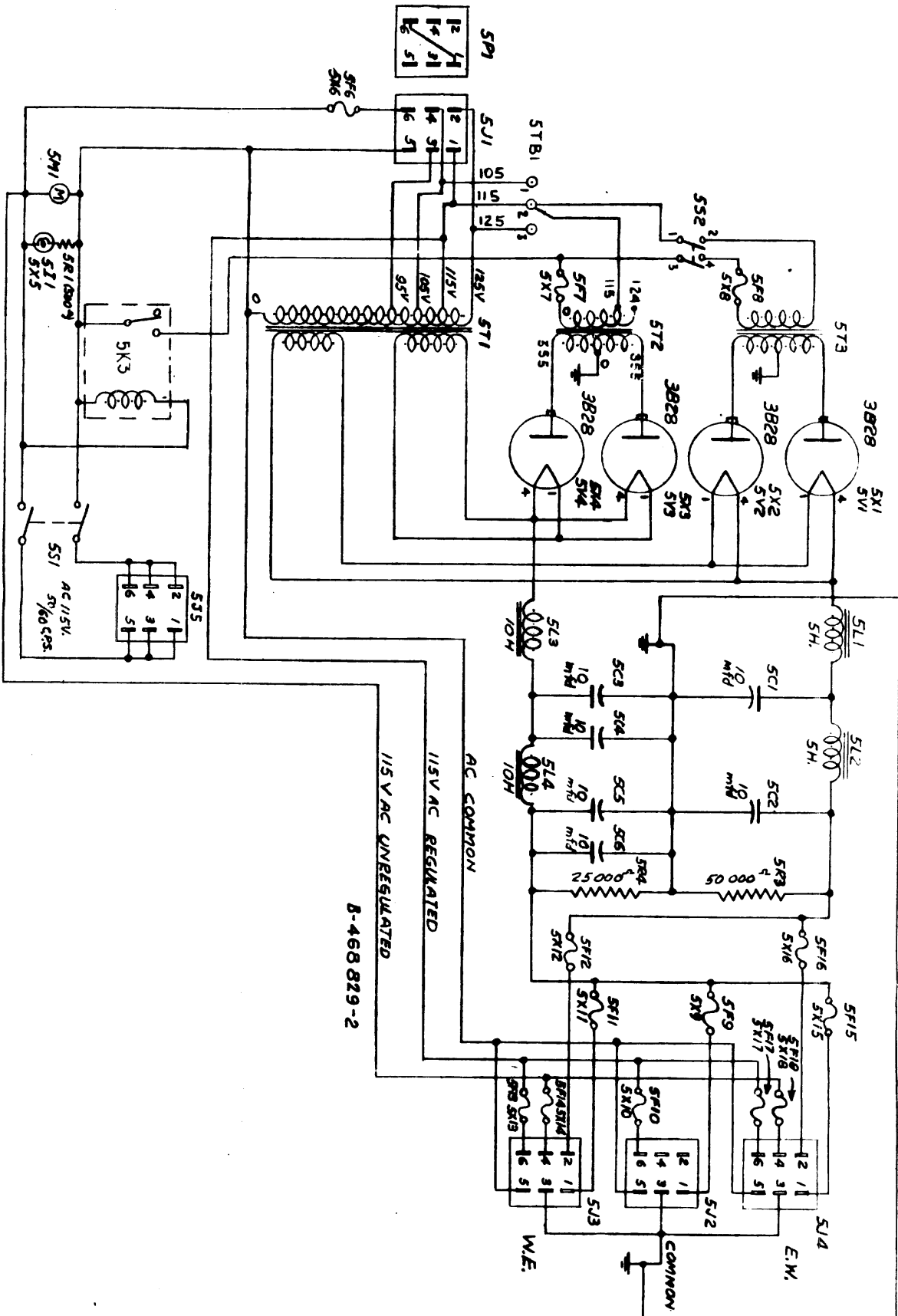


Figure PS-2—Power Supply, MI-31494-B—Rear View, Dust Cover Removed



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FIG. 1 (REV.)

B-468 829-2

Figure PS-3—Power Supply, MI-31894-B—Schematic Diagram



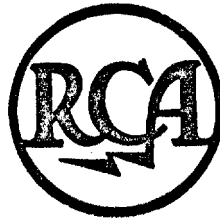


# MICROWAVE COMMUNICATION EQUIPMENT

T.O. 31R5-4-A-21

## Service Channel Unit - MI-31140

- TECHNICAL DATA
- DESCRIPTION
- MAINTENANCE
- REPLACEMENT PARTS



RADIO CORPORATION OF AMERICA  
COMMUNICATION PRODUCTS DEPARTMENT, CAMDEN, NEW JERSEY

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IB-33303-2

DU 539

## T.O. 31R5-4-A-21

SC-1

## TECHNICAL DATA

<b>Power Input</b>		<b>Symbol</b>	<b>Function</b>
115 v ac, 50/60 cycle, 15 watts		23K3	Remote-Indication Oscillator Keying
250 v dc, 80 ma, ripple less than 0.030 volt		23K4	E-W Transmitter Remote-Indication
		23K5	W-B Transmitter Remote-Indication
<b>Impedance</b>		<b>Tube Complement</b>	
Input: } These vary depending on the input and		<b>Symbol</b>	<b>Type</b>
Output: } output strapping connections as shown		23V1	5965
		23V2	12AX7
			<b>Function</b>
		23V3	5965
		23V4	5965
<b>Levels</b>			Input/Output Amplifier
Transmitting Amplifier			½ Remote-Indication Tone Oscillator/Amplifier and ½ Calling Tone Oscillator/Amplifier
Output: 0.258 v rms			½ Remote-Indication Tone Oscillator/Amplifier and ½ Calling Tone Oscillator/Amplifier
Receiving Amplifier			Handset Amplifier
Input: 0.61 v rms			
<b>Calling Frequency</b>			
2000 cycles			
<b>Remote-Indication Signal Frequency</b>		<b>Dimensions</b>	
2500 cycles		Height:	5¼ inches
		Width:	19 inches
		Depth:	6 inches (overall)
<b>Relays</b>		<b>Weight</b>	
<b>Symbol</b>	<b>Function</b>		
23K1	Indicon Decoder Keying/Lockout		
23K2	Calling Buzzer Keying		

## DESCRIPTION

The Service Channel Unit when used in microwave relay stations provides the facilities for party line calling and communication, for generating the tone frequency for the Indicon Coder Unit and for amplifying the received tones for pulsing the Decoder Unit.

An indicon coder unit can be used with the service channel unit at stations where remote-indication reporting facilities are desired. The remote-indication signal tone is generated in the service channel unit and is coded by the indicon coder unit. The received remote-indication tones are converted to pulses by the service channel unit for keying the indicon decoder unit which identifies the remote-indication and the station sending the tones. The service channel unit may be used without either indicon unit where only service channel communication is desired. Normally a decoder unit is located only at attended stations and a coder unit at unattended stations, but it is possible to have both a coder and/or a decoder at any station.

## FUNCTIONAL ANALYSIS

The service channel unit consists of two fundamental circuits, the transmitting and the receiving circuits. It also contains the circuits for reporting

the condition of the local equipment. Note that portions of the unit perform a dual role by functioning as part of both the receiving and transmitting circuits. Tubes 23V2-A/23V3-A serve both as a remote-indication tone generator (transmitting) and as a remote-indication tone amplifier (receiving). Tubes 23V2-B/23V3-B serve both as a calling tone generator (transmitting) and as a calling tone amplifier (receiving). Refer to the block diagram of figure SC-2 and the schematic diagram of figure SC-4 in following the circuit description.

## Receiving Section

Service channel signals (remote-indication tone, calling tone and voice signals—300 to 3000 cycles) are transmitted along with the multiplex signals and when received at a microwave station are separated from the multiplex signals and fed to the service channel unit. These service channel signals are first amplified by 23V1-A and passed through 23FL1 which serves to eliminate any frequency above 3000 cycles which may be present due to multiplex transmission through the system. The signals from 23FL1 are fed to 3 separate circuits.

One circuit consisting of 23V2-A and 23V3-A is an amplifier selective to 2500 cycles, the remote-

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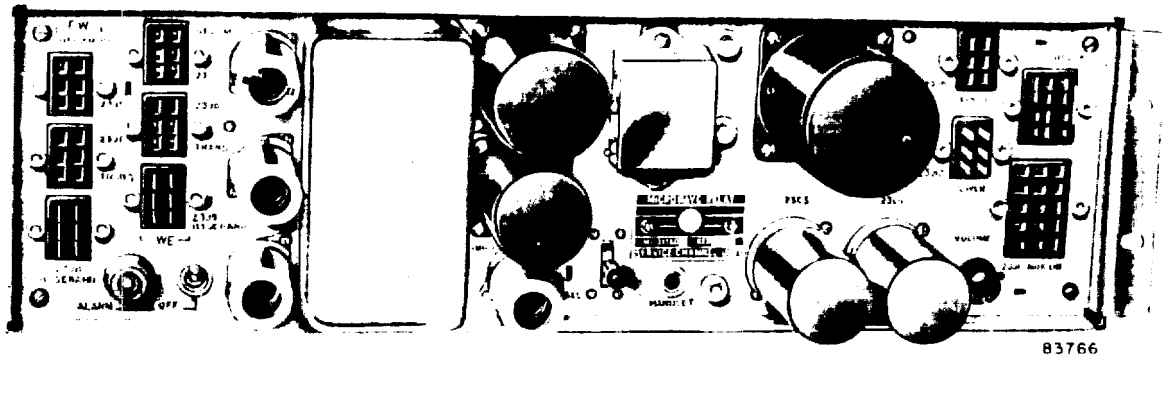


Figure SC-1—Service Channel Unit—Front View

indication tone frequency. The selective circuit consisting of 23L1, 23C4 and 23C19 develops a voltage when a remote-indication tone is received, which is applied to 23V3-A. The resultant plate current flow causes relay 23K1, in the plate circuit of 23V3-A, to operate. The reception of a remote-indication tone train will cause relay 23K1 to operate for each of 15 tone pulses. Contact 23K1-(3-4) closes, shorting terminals 10 & 11 of jack 23J1. When the service channel unit is operated in conjunction with a decoder, terminals 7J1-(10-11) are shorted each time a remote-indication tone pulse is received. Each long tone pulse lights an indicator lamp in the decoder unit. The resultant lamp display identifies the station sending the tone signal and the condition of the equipment at that station. The closing of contact 23K1-(5-6) when 23K1 operates, will sound buzzer 23I2, if the ALARM-OFF switch is on the ALARM position. This alerts the attendant to an arriving remote-indication signal and enables him, if he desires, to aurally read the signal. The signal may also be decoded by listening to the received 2500 cps remote-indication tone on the handset.

Since a large number of stations may be cascaded in a section of a system, it is possible that two or more stations may attempt to transmit remote-indication signals at the same time. When a station starts a remote-indication tone transmission, it is necessary to lock out all other coders of the system for the duration of the transmission to prevent the confusion that would arise in the event of simultaneous transmissions. When a remote-indication tone reaches a station equipped with a coder, relay contact 23K1-(3-4) shorts terminals 6J1-(10-11) in the coder unit. This activates a lockout circuit which

disables the pulsing circuit of the coder unit for a short time interval.

At a station using both a coder and a decoder unit, contact 7-8 of relay 23K1 is used to key the decoder unit instead of contact 3-4 which in this case initiates the lockout operation of the coder unit.

A second branch of the receiving section is an amplifier (23V2-B/23V3-B) selective to 2000 cycles, the calling tone frequency. The selective circuit consisting of 23L2, 23C9 and 23C18 develops a voltage when a calling tone is received, which is applied to 23V3-B. The resultant current flow causes relay 23K2, in the plate circuit of 23V3-B to operate. When 23K2 operates, contact 4-5 will close and sound buzzer 23I2.

The third circuit of the receiving branch is a cathode follower stage 23V4-(1-2-3) which amplifies the voice frequencies to handset jack 23J2 for the telephone handset receiver. The handset signal level is set by VOLUME control 23R41.

#### Transmitting Section

The function of one branch of the transmitting section is to generate tone signals whenever a remote-indication initiates a sequence of action in the coder unit which results in a series of 15 pulses, each of which operates relay 23K3 in the service channel unit. Each time 23K3 operates, 23V2-A/23V3-A becomes a 2500 cycle tone oscillator and a tone is transmitted for each of the 15 (long and short) pulses. Each operation of 23K3 results in the following action in the 23V2-A/23V3-A circuit:

1. Contact 3-4 opens, disconnecting the input circuit from 23FL1.

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2. Contacts 4-5 and 7-8 close, connecting the feed back circuit from 23V3-A to 23V2-A.
3. Contact 6-7 opens, disconnecting the output of 23V3-A from relay 23K1.
4. The opening of contacts 3-4, 6-7, 9-10, 12-13 and 15-16 and the closing of contacts 4-5, 7-8, 10-11, 13-14 and 16-17 makes the necessary circuit changes to convert 23V2-A/23V3-A from a remote-indication tone amplifier circuit to a 2500 cycle oscillator.

The function of a second branch of the transmitting section is to generate a calling tone for the communication channel. When the CALL switch is activated the 23V2-B/23V3-B circuit becomes a 2000 cycle tone generator and a calling tone is transmitted which will sound buzzers at the other stations of the system. This is accomplished in the following manner:

1. Contact 1-2 opens and disconnects the input circuit from 23FL1.
2. Contacts 2-3 and 5-6 close, connecting the feedback circuit from 23V3-B to 23V2-B.
3. Contact 4-5 opens and disconnects the buzzer relay from the output of 23V3-B.
4. The opening of contacts 7-8, 10-11 and 13-14 and the closing of contacts 8-9, 11-12 and 14-15 makes the necessary circuit changes to convert 23V2-B/23V3-B from a calling tone amplifier to a calling tone oscillator.

The third branch of the transmitter section is the voice communication circuit. The output of the handset microphone is amplified by 23V4 (6-7-8). From the output of amplifier 23V4 (6-7-8) the voice signals are passed through a limiter stage consisting of crystal diodes 23CR1, 23CR2 and resistors 23R66, 23R67, 23R68 and 23R69. The voice signals, remote-indication tones, and calling tones are all applied to output amplifier 23V1-B (6-7-8) and passed through filter 23FL2 (where all frequencies above 3000 cycles are suppressed) to the modulator of the relay station.

#### Remote-Indication Circuits

Six remote-indication connections from the associated units to the decoder unit are made through the service channel unit. They are; receiver equipment, receiver loss-of-signal, transmitter equipment and three external inputs. All of these connections with the exception of the transmitter remote-indication signals are 115 v ac lines. The two receiver and three external remote-indication circuits when activated energize a relay in the coder unit initiating a tone transmission. The transmitter remote-indication inputs are connections to relays 23K4 and 23K5. These relays are operated by the 250 v dc supply of the service channel unit when a trans-

mitter remote-indication completes the relay energizing circuit. When these relays are operated contact 4-5 completes a 115 v ac connection to the coder unit for a tone transmission. Contacts 7-8 are the connections to the standby switchover equipment.

#### Jack Connections

Connections to and from the service channel unit are made through Jones connectors 23J1, 23J3 through 23J11 and handset jack 23J2. The following is a description of the connections to and from the service channel and associated units. (Refer to the block diagram of figure SC-2 and the schematic diagram of figure SC-4.)

**INDICON Jack 23J1:** All external connections from this jack terminate in the coder (jack 6J1) or decoder (jack 7J1). Terminal 1 is the combined receiver/transmitter equipment remote-indication connection, terminal 2 is the receiver loss-of-signal connection and terminals 4 and 5 are the 115 v ac power connections to the coder or decoder units. Terminal 7 is the tone pulse keying connection from the coder unit. Terminals 10 and 11 are the lockout circuit connections to the coder unit and when using a decoder unit they are the coded pulse signal connections that key the decoder. Terminal 12 is used only a junction station and connects to the station identification code terminal 6TB1-5 (pulse #5) of the coder unit to identify the rack not containing the service channel unit. Terminals 13, 14 and 15 are the external remote-indication connections to the coder unit. At a decoder station terminal 13 carries the 48 v dc from the decoder unit to the LOCAL jack and then to the termination panel where it is available for limited external use.

**HANDSET jack 23J2:** The telephone handset plugs into jack 23J2.

**E-W BASEBAND and W-E BASEBAND Jacks 23J8 and 23J3:** Terminals 2 and 3 are connections from the service channel signal output amplifier 23V1-B to the baseband unit or receiver/modulator unit and terminals 3 and 5 are the baseband unit or receiver/modulator unit output connections to the receiver circuit amplifier 23V1-A. At a drop repeater and terminal station the connections are made to the baseband units and at a thru repeater station the service channel signal connections are made directly to the receiver/modulator unit. Both jacks are required at a thru or drop repeater station whereas a terminal station uses only the E-W BASEBAND jack.

**E-W REC/MOD and W-E REC/MOD jacks 23J5 and 23J4:** Terminals 2 and 4 are the loss-of-signal and receiver equipment remote-indication connec-

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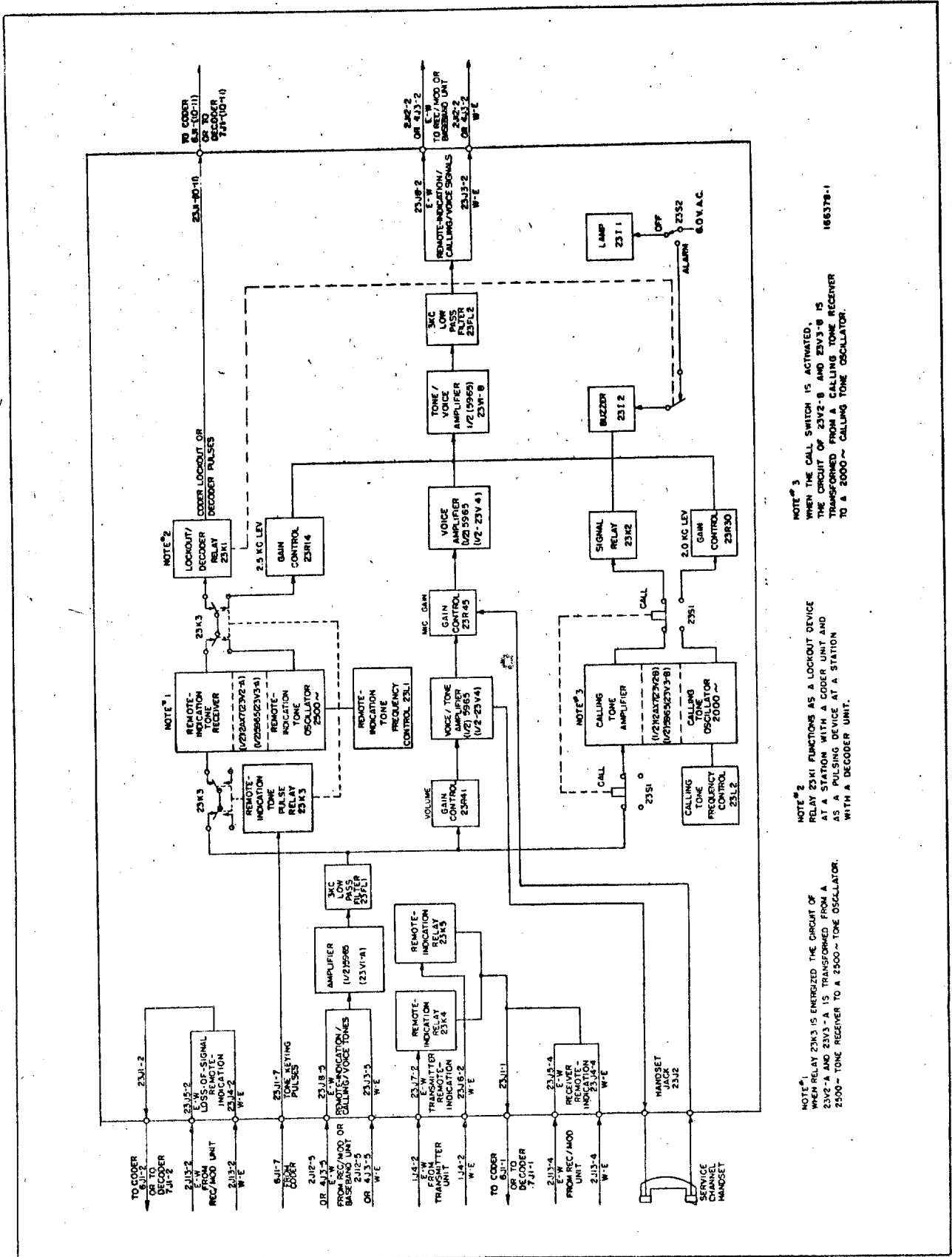


Figure SC-2—Service Channel Unit—Block Diagram

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tions from the receiver/modulator units to the indicon units. They connect to terminals 1 and 2 of the INDICON jack 23J1. Terminal 5 is the 115 v ac line high connection to the receiver/modulator unit for the remote-indication circuit.

E-W XMTR and W-E XMTR jacks 23J7 and 23J6: Terminal 2 connects the transmitter remote-indication line from the transmitter to relays 23K4 and 23K5. When these relays are energized by a transmitter remote-indication a 115 v ac line is completed to the coder unit and to the switchover unit at a standby station. Both jacks are required at a thru or drop repeater station but only the E-W XMTR jack 23J7 is used at a terminal station.

LOCAL jack 23J9: All connections to this jack are from outside the rack through the termination unit. Terminals 1, 2 and 6 are external connections to the coder unit. At a rack with a decoder unit, terminal 1 carries the 48 v dc which may be used in applications external to the rack. It is received from the 48 volt relay power supply of the decoder unit through 23J1-13. Terminals 3 and 4 are the transmitter remote-indication connections to the switchover unit at standby stations.

BRIDGE jack 23J11: This jack is used at junction stations and all connections are to and from units of the branch rack through the termination units of both racks. Terminal 1 is the connection for the identifying code used at junction stations to tell which of the two racks initiated the code transmission. Terminals 2 and 8 are the 115 v ac remote-indication power connections to the branch rack. Terminals 3 and 4 are the transmitter/receiver equipment and receiver loss-of-signal remote-indication connections respectively, from the branch rack to the indicon coder or decoder unit. Terminal 6 is the operating power connection to the remote-indication relays in the branch circuit. Terminal 9 is not used in junction station applications.

Terminals 10 and 11 are the service channel transmit signal connections to the baseband unit of the branch rack and terminals 11 and 12 are the service channel receive connections from the branch baseband unit. Jack 23J11 may also be used at installations incorporating both the coder and decoder; in this case the coder is connected to 23J1, the decoder to 23J11.

**CONTROLS**

The 2.5 KC LEV control 23R14 is used to adjust the output level of the 2500 cycle tone oscillator.

The Remote-Indication Tone Frequency Control 23L1 is used to adjust the frequency of the remote-indication tone oscillator to 2500 cycles.

The 2.0 KC LEV control 23R30 is used to adjust the output level of the 2000 cycle calling tone oscillator.

The Calling Tone Frequency Control 23L2 is used to adjust the frequency of the calling tone oscillator to 2000 cycles.

The CALL switch 23S1 when activated changes the calling tone amplifier to a 2000 cycle calling tone oscillator.

The VOLUME control 23R41 varies the amount of received voice signal voltage applied to handset receiver amplifier 23V4 (1-2-3).

The MIC GAIN control 23R45 is used to adjust the microphone amplifier output level.

The HANDSET jack 23J2 is for connecting the service channel telephone handset.

The ALARM-OFF switch 23S2 when placed on the ALARM position permits buzzer 23I2 to sound when relay 23K1 is operated by a received remote-indication tone signal.

The ALARM-OFF lamp 23I1 is lit when 23S2 is in the OFF position indicating that buzzer 23I1 will not be operated by a received remote-indication tone signal.

**MAINTENANCE**

The following are test and adjustment procedures for various circuits of the unit. They are to be made with the unit in the rack with the power supply turned on and all of the connections to the service channel unit removed except the power plug. These procedures may be performed at regular maintenance periods or when there are indications of erratic performance in any of the circuits. All signals are to be applied and all voltage and frequencies are to be measured between the designated terminals and chassis ground. The required test units are items 2, 3 and 4 of the equipment list in the system book.

**Input Circuit**

1. *Receive Remote-Indication Circuit*
  - a. Connect the signal generator to terminal 23J8-5.
  - b. Place the ALARM-OFF switch 23S2 on the ALARM position. (ALARM-OFF lamp 23I1 not lit)
  - c. Adjust the signal generator frequency to 2500 cps. Starting at 0.10 volt slowly increase the output until the buzzer sounds. This should happen when the signal output is between 0.20 and 0.45 volt.

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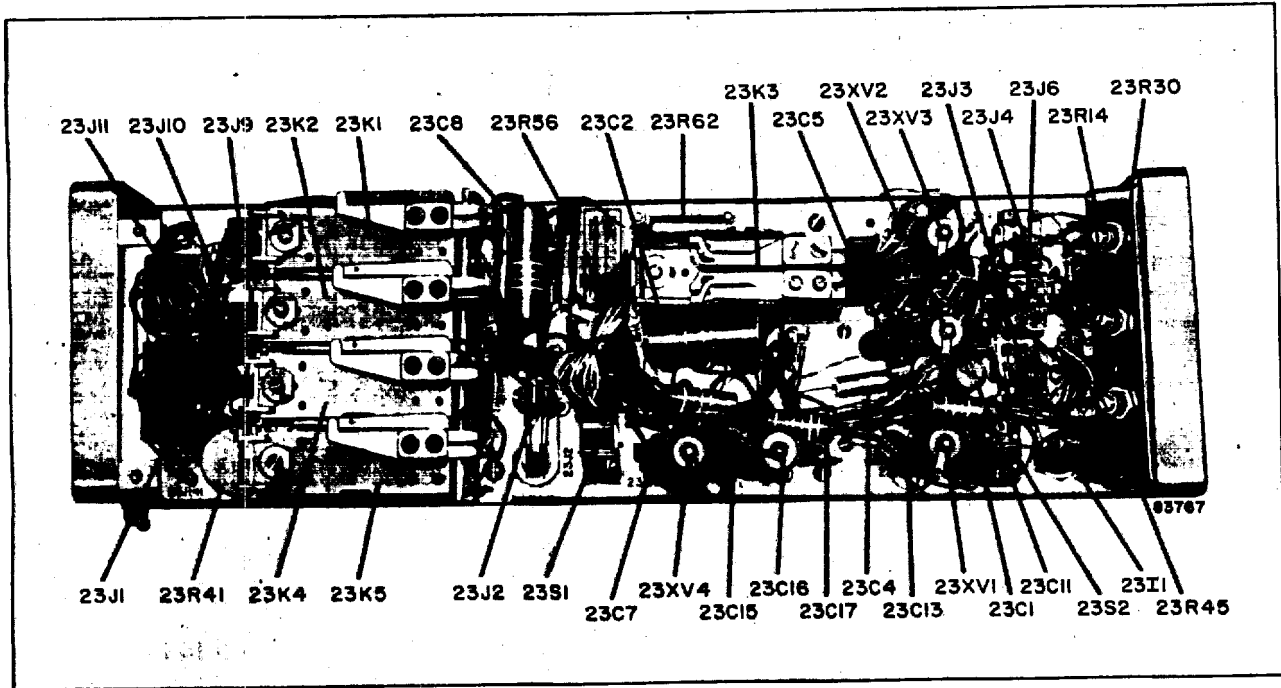


Figure SC-3—Service Channel Unit—Rear View, Cover Removed

**2. Calling Tone Circuit**

a. With the conditions the same as in procedure (1) above reduce the signal generator voltage to 0.10 volt and change the frequency to 2000 cps.

b. Increase the output of the signal generator until the buzzer sounds. This should occur when the signal output is between 0.20 and 0.45 volt.

**3. Voice Circuit**

a. Adjust the signal generator, connected as in procedures (1) and (2) above, to a frequency of 1000 cps at 0.61 volt.

b. Plug the handset into HANDSET jack 23J2.

c. Listen to the handset earpiece and adjust VOLUME control 23R41 for a comfortable listening level.

**Output Circuit**

**1. Remote-Indication Tone Circuit**

a. Check the frequency at 23J8-2 using the scope and a calibrated signal generator. (Connect 23J8-2 to the horizontal sweep and the calibrated signal generator output at 2500 cps to the vertical sweep.)

b. Manually operate 23K3 and adjust the remote-indication tone frequency control 23L1 for the configuration on the scope signifying a 2500 cps tone at 23J8-2.

c. Remove the scope and signal generator and connect the audio voltmeter at 23J8-2.

d. Adjust the remote-indication tone output control 23R14 for a meter reading of 0.258 volt at 23J8-2.

**2. Calling Tone Circuit**

a. Check the frequency at 23J8-2 using the scope and a calibrated signal generator. Connect 23J8-2 to the horizontal sweep and the calibrated signal generator output at 2000 cps to the vertical sweep.)

b. Activate the CALL switch and adjust the calling tone frequency control 23L2 for the configuration on the scope signifying a 2000 cps tone at 23J8-2.

c. Remove the scope and signal generator and connect the audio voltmeter at 23J8-2.

d. Adjust the calling tone output control 23R30 for a reading of 0.258 at 23J8-2.

e. Replace the dust cover over 23L1 and 23L2.

**3. Voice Channel**

a. Plug the handset into HANDSET jack 23J2.

b. Connect the audio voltmeter at 23J8-2.

c. Adjust the microphone gain control 23R45 for a reading of 0.08 to 0.10 volt at 23J8-2 while speaking into the handset microphone at a nominal voice level.

**Limiter Circuit**

The limiter circuit can be checked by making the measurements shown in the table below and if any

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of the measured values are not within the prescribed limits, crystals 23CR1 and/or 23CR2 should be replaced.

### LIMITER TEST MEASUREMENT

Measure the dc voltage from the indicated test points to ground using an RCA voltohmyst WV.97A or equivalent.

Test Point	DC Voltages (Limits)
a. Junction of 23R67 and 23R68	3.0 ±0.5 v.
b. Junction of 23R68 and 23R69	½ the reading of (a) ±0.2 v.
c. Junction of 23CR1 and 23CR2	½ the reading of (a) ±0.4 v

### TYPICAL SERVICE CHANNEL UNIT VOLTAGES

The following are approximate voltages existing between the indicated tube pins and ground as measured with an RCA Volttohmyst WV97A or equivalent. All readings are dc unless otherwise specified.

Tube	Type	Function	Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9
23V1	5965	Input/Output Amplifier	188	0	3.1	0	0	248	0	4.2	6.0 ac
*23V2	12AX7	½ Remote-Indication Tone Osc Amp. & ½ Calling Tone Osc./Amp.	248	0	1.8	0	0	248	0	1.8	6.0 ac
**23V2	12AX7		250	-3.5	1.0	0	0	248	-3.5	1.0	6.0 ac
*23V3	5965	½ Remote-Indication Tone Osc Amp. & ½ Calling Tone Osc./Amp.	248	18.0	26.0	0	0	248	18.0	26.0	6.0 ac
**23V3	5965		185	0	2.9	0	0	185	0	2.9	6.0 ac
23V4	5965	Handset Amp.	248	0	4.5	0	0	100	0	0.9	6.0 ac

\* Relay 23K3 not operated, "CALL" switch 23S1 not depressed.  
 \*\* Relay 23K3 operated, "CALL" switch 23S1 depressed.

### REPLACEMENT PARTS LIST

Symbol No.	Description	Drawing No.	Stock No.
23C1	Capacitor, fixed, paper, 0.022 mf ±10%, 400 v.....	735715-167	73562
23C2	Capacitor, fixed, paper, 0.015 mf ±10%, 400 v.....	735715-177	73793
23C3-A, B, C	Capacitor, dry electrolytic, 10/10/10 mf, 450/450/450 v.....	449618-1	56304
23C4	Capacitor, fixed, mica, 0.01 mf ±2%, 300 v.....	722033-562	90007
23C5	Capacitor, fixed, paper, 0.1 mf ±10%, 400 v.....	735715-175	73551
23C6	Capacitor, fixed, paper, 0.0047 mf ±10%, 600 v.....	735715-259	73920
23C7	Capacitor, fixed, paper, 0.015 mf ±10%, 400 v.....	735715-165	73797
23C8	Capacitor, fixed, paper, 0.47 mf ±10%, 200 v.....	735715-83	73787
23C9	Capacitor, fixed, mica, 9100 mmf ±2%, 300 v.....	722033-562	95383
23C10-A, B, C	Capacitor, dry electrolytic, 10/10/10 mf, 450/450/450 v. Same as 23C3-A, B, C .....	449618-1	56304
23C11	Capacitor, fixed, paper, 0.1 mf ±10%, 400 v. Same as 23C5.....	735715-175	73551
23C12	Capacitor, fixed, paper, 0.0047 mf ±10%, 600 v. Same as 23C6 .....	735715-259	73920
23C13	Capacitor, fixed, paper, 0.047 mf ±10%, 400 v.....	735715-171	73553
23C14	Capacitor, fixed, paper, 0.47 mf ±10%, 200 v. Same as 23C8 .....	735715-83	73787
23C15	Capacitor, fixed, paper, 0.1 mf ±10%, 400 v. Same as 23C5.....	735715-175	73551
23C16	Capacitor, dry electrolytic, 10 mf +100 -10%, 50 v.....	442901-151	212092
23C17	Capacitor, fixed, paper, 0.047 mf ±10%, 400 v. Same as 23C13 .....	735715-171	73553
23C18	Not used.....		
23C19	Capacitor, fixed, mica, 6200 mmf ±2%, 300 v.....	722033-558	211494
23CR1, 23CR2	Rectifier, crystal diode .....		94229



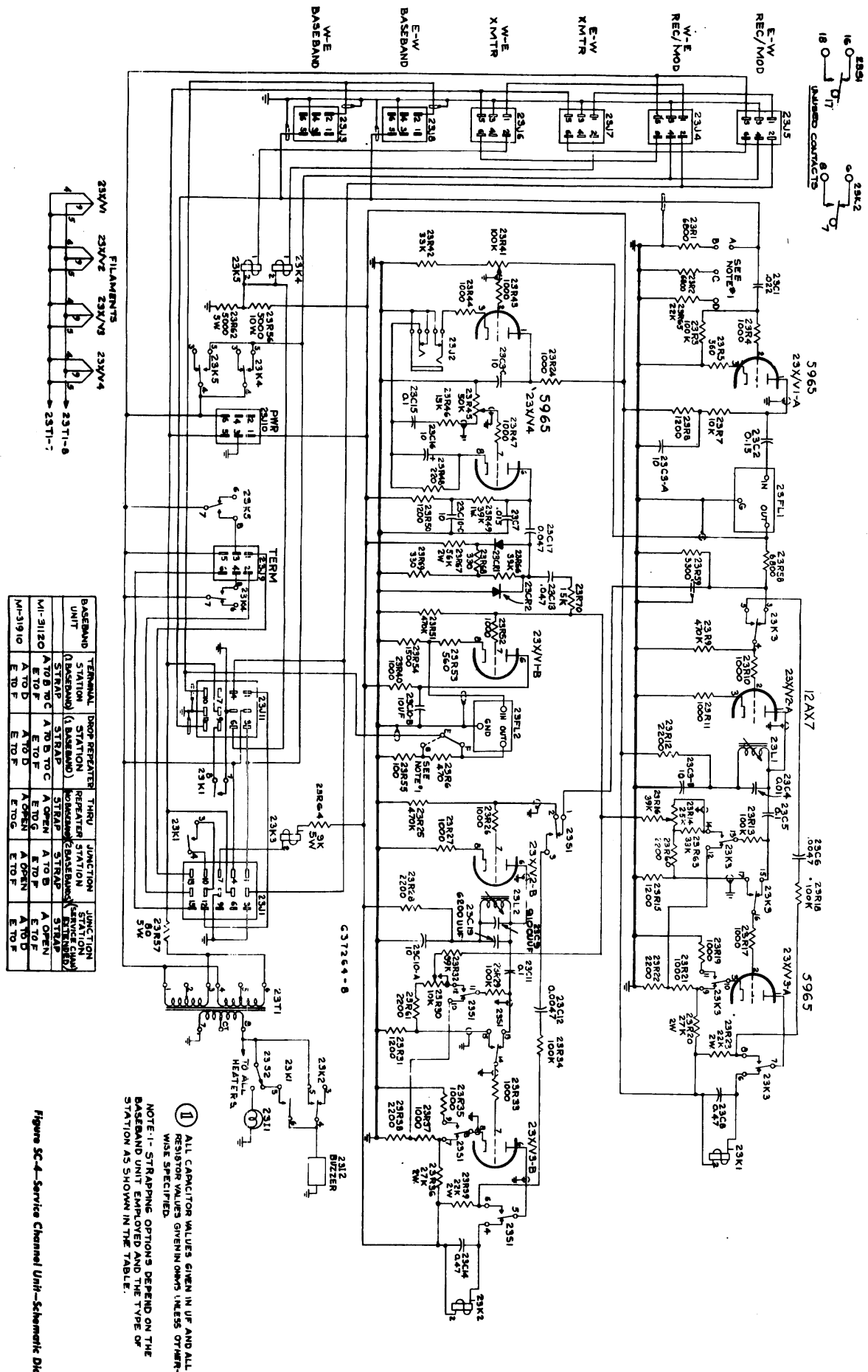
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Symbol No.	Description	Drawing No.	Stock No.
23FL1	Filter, audio, input impedance, 10,000 ohm, output impedance, 10,000 ohm	8903720-1	211441
23FL2	Filter, audio, input impedance, 500 ohm, output impedance, 500 ohm	8903719-1	211442
23I1	Lamp, pilot light, min. bay, 6.3 v., 0.15 amp., clear	990158-12	31480
23I2	Buzzer, door bell type, 5-7 v., 60 cy.	8848315-2	211557
23J1	Connector, female, 15 contact, chassis mtg.	449613-4	95561
23J2	Jack, telephone type double break contacts	8845648-1	94232
23J3	Connector, male, 6 contact, chassis mtg.	181494-3	28507
23J4 to 23J7	Connector, female, 6 contact, chassis mtg.	181494-4	18534
23J8	Connector, male, 6 contact, chassis mtg. Same as 23J3	181494-3	28507
23J9	Connector, female, 6 contact, chassis mtg. Same as 23J4	181494-4	18534
23J10	Connector, male, 6 contact, chassis mtg. Same as 23J3	181494-3	28507
23J11	Connector, male, 12 contact, chassis mtg.	449613-1	56078
23K1	Relay, coil, 68 v.d.c, 3.0 ma, 11,300 ohm, 3 form "A" make contacts	174913-22	95348
23K2	Relay, coil, 72 v.d.c, 3.2 ma, 2 form "C" break make contacts	174913-21	95351
23K3	Relay, coil, 120 v.d.c, contacts, 5 form "C" break make contacts	757640-1	211615
23K4, 23K5	Relay, coil, 72 v.d.c, 3.2 MA, 11,300 ohm, 2 form "C" break make contacts. Same as 23K2	174913-21	95351
23L1, 23L2	Reactor, adjustable, nominal inductance, 350 millihenry	8910549-1	211443
23R1, 23R2	Resistor, fixed, composition, 6800 ohm $\pm 5\%$ , $\frac{1}{2}$ w.	735730-179	
23R3	Resistor, fixed, composition, 100,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w.	735730-86	
23R4	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , $\frac{1}{2}$ w.	735730-62	
23R5	Resistor, fixed, composition, 560 ohm $\pm 5\%$ , $\frac{1}{2}$ w.	735730-153	
23R6	Resistor, fixed, composition, 470 ohm $\pm 5\%$ , $\frac{1}{2}$ w.	735730-151	
23R7	Resistor, fixed, composition, 10,000 ohm $\pm 5\%$ , $\frac{1}{2}$ w.	735730-183	
23R8	Resistor, fixed, composition, 1200 ohm $\pm 10\%$ , $\frac{1}{2}$ w.	735730-63	
23R9	Resistor, fixed, composition, 470,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R4	735730-94	
23R10	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R4	735730-62	
23R11	Resistor, fixed, composition, 1000 ohm $\pm 5\%$ , $\frac{1}{2}$ w.	735730-159	
23R12	Resistor, fixed, composition, 2200 ohm $\pm 10\%$ , $\frac{1}{2}$ w.	735730-66	
23R13	Resistor, fixed, composition, 100,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R3	735730-86	
23R14	Resistor, variable, composition, 25,000 ohm $\pm 10\%$ , 2 w.	737829-31	94192
23R15	Resistor, fixed, composition, 1200 ohm $\pm 5\%$ , $\frac{1}{2}$ w.	735730-161	
23R16	Resistor, fixed, composition, 39,000 ohm $\pm 5\%$ , $\frac{1}{2}$ w.	735730-197	
23R17	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R4	735730-62	
23R18	Resistor, fixed, composition, 100,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R3	735730-86	
23R19	Resistor, fixed, composition, 1000 ohm $\pm 5\%$ , $\frac{1}{2}$ w. Same as 23R11	735730-159	
23R20	Resistor, fixed, composition, 27,000 ohm $\pm 5\%$ , 2 w.	99126-193	
23R21	Resistor, fixed, composition, 1000 ohm $\pm 5\%$ , $\frac{1}{2}$ w. Same as 23R11	735730-159	
23R22	Resistor, fixed, composition, 2200 ohm $\pm 5\%$ , $\frac{1}{2}$ w.	735730-167	
23R23	Resistor, fixed, composition, 22,000 ohm $\pm 5\%$ , 2 w.	99126-191	
23R24	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R4	735730-62	
23R25	Resistor, fixed, composition, 470,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R9	735730-94	
23R26	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R4	735730-62	
23R27	Resistor, fixed, composition, 1000 ohm $\pm 5\%$ , $\frac{1}{2}$ w. Same as 23R11	735730-159	
23R28	Resistor, fixed, composition, 2200 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R12	735730-66	
23R29	Resistor, fixed, composition, 100,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R3	735730-86	
23R30	Resistor, variable, composition, 10,000 ohm $\pm 10\%$ , 2 w.	737801-44	206880
23R31	Resistor, fixed, composition, 1200 ohm $\pm 5\%$ , $\frac{1}{2}$ w. Same as 23R15	735730-161	
23R32	Resistor, fixed, composition, 39,000 ohm $\pm 5\%$ , $\frac{1}{2}$ w. Same as 23R16	735730-197	
23R33	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R4	735730-62	
23R34	Resistor, fixed, composition, 100,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R3	735730-86	
23R35	Resistor, fixed, composition, 1000 ohm $\pm 5\%$ , $\frac{1}{2}$ w. Same as 23R11	735730-159	
23R36	Resistor, fixed, composition, 28,000 ohm $\pm 5\%$ , 5 w.	993007-110	
23R37	Resistor, fixed, composition, 1000 ohm $\pm 5\%$ , $\frac{1}{2}$ w. Same as 23R11	735730-159	
23R38	Resistor, fixed, composition, 2200 ohm $\pm 5\%$ , $\frac{1}{2}$ w. Same as 23R22	735730-167	
23R39	Resistor, fixed, composition, 22,000 ohm $\pm 5\%$ , 2 w. Same as 23R23	99126-191	
23R40	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , 1 w.	90496-62	
23R41	Resistor, variable, composition, 100,000 ohm $\pm 10\%$ , 2 w.	737885-29	95243
23R42	Resistor, fixed, composition, 33,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w.	735730-80	
23R43	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R4	735730-62	

**T.O. 31R5-4-A-21**

Symbol No.	Description	Drawing No.	Stock No.
23R44	Resistor, fixed, composition, 1000 ohm $\pm 5\%$ , $\frac{1}{2}$ w. Same as 23R11 .	735730-159	
23R45	Resistor, variable, composition, 50,000 ohm $\pm 10\%$ , 2 w. ....	737829-32	
23R46	Resistor, fixed, composition, 15,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. ....	735730-76	
23R47	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R4 .	735730-62	
23R48	Resistor, fixed, composition, 220 ohm $\pm 10\%$ , $\frac{1}{2}$ w. ....	735730-54	
23R49	Resistor, fixed, composition, 39,000 ohm $\pm 10\%$ , 1 w. ....	90496-81	
23R50	Resistor, fixed, composition, 1200 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R8 .	735730-63	
23R51	Resistor, fixed, composition, 470,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R9	735730-94	
23R52	Resistor, fixed, composition, 1000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R4 .	735730-62	
23R53	Resistor, fixed, composition, 560 ohm $\pm 5\%$ , $\frac{1}{2}$ w. Same as 23R5 ...	735730-153	
23R54	Resistor, fixed, composition, 1500 ohm $\pm 5\%$ , $\frac{1}{2}$ w. ....	735730-163	
23R55	Resistor, fixed, composition, 100 ohm $\pm 5\%$ , $\frac{1}{2}$ w. ....	735730-135	
23R56	Resistor, fixed, wire wound, 5000 ohm $\pm 10\%$ , 10 w. ....	8817663-21	50854
23R57	Resistor, fixed, wire wound, 80 ohm $\pm 5\%$ , 5 w. ....	458572-22	207048
23R58	Resistor, fixed, composition, 6800 ohm $\pm 5\%$ , $\frac{1}{2}$ w. Same as 23R1 ..	735730-179	
23R59	Resistor, fixed, composition, 3300 ohm $\pm 5\%$ , $\frac{1}{2}$ w. ....	735730-171	
23R60,			
23R61	Resistor, fixed, composition, 2200 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R12	735730-66	
23R62	Resistor, fixed, wire wound, 5000 ohm $\pm 5\%$ , 5 w. ....	458572-67	53368
23R63	Resistor, fixed, composition, 33,000 ohm $\pm 10\%$ , $\frac{1}{2}$ w. Same as 23R42	735730-80	
23R64	Resistor, fixed, wire wound, 9000 ohm $\pm 5\%$ , 5 w. ....	458572-76	
23R65	Resistor, fixed, composition, 22,000 ohm $\pm 5\%$ , $\frac{1}{2}$ w. ....	735730-191	
23R66	Resistor, fixed, composition, 39,000 ohm $\pm 5\%$ , $\frac{1}{2}$ w. Same as 23R16	735730-197	
23R67	Resistor, fixed, composition, 56,000 ohm $\pm 5\%$ , 2 w. ....	99126-201	
23R68,			
23R69	Resistor, fixed, composition, 330 ohm $\pm 5\%$ , $\frac{1}{2}$ w. ....	735730-147	
23R70	Resistor, fixed, composition, 15,000 ohm $\pm 5\%$ , $\frac{1}{2}$ w. ....	735730-187	
23S1	Switch, key lever, telephone type, 6 type "C" contacts, one way non-locking	8910533-1	211444
23S2	Switch, toggle, s.p.d.t. ....	449663-103	97009
23T1	Transformer, filament	949385-1	94196
23X5, 23X6	Socket, capacitor, octal tube type	99100-7	207594
23XI1	Socket, pilot light socket only less red jewel and lamp	480313-2	56100
	Jewel, pilot light red jewel only less socket and lamp (Pt. of 23XI1)	480313-31	208457
23XV1 to 23XV4	Socket, tube, 9 pin miniature	742413-8	210918
	<i>Miscellaneous</i>		
	Base, tube shield base only, for 9 pin min. tube	8911149-5	210919
	Knob, round, black bakelite, for 23R41	69916-3	4323
	Nut, knurled, #3/8-32 thread, (For 23J2)	60514-103	100779
	Shield, tube, for 9 pin min. tube	8858642-3	56359



T.O. 31R54-A-21 SC-11, SC-12

BASEBAND UNIT	TERMINAL STATION (BASEBAND)	DIOP REPEATER STATION (BASEBAND)	THRU REPEATER STATION (BASEBAND)	JUNCTION STATION (SERVICE CHN)	JUNCTION STATION (SERVICE CHN)
M-31120	A TO F	A TO F	A TO F	A TO F	A TO F
M-31910	E TO F	E TO F	E TO F	E TO F	E TO F

NOTE: 1- STRAPPING OPTIONS DEPEND ON THE BASEBAND UNIT EMPLOYED AND THE TYPE OF STATION AS SHOWN IN THE TABLE.

Figure SC-4 Service Channel Unit - Schematic Diagram

# MICROWAVE COMMUNICATION EQUIPMENT

T.O. 31R5-4-A-21

## **Indicon Coder Unit MI-31138 and Indicon Decoder Unit MI-31139**

- TECHNICAL DATA
- DESCRIPTION
- MAINTENANCE
- REPLACEMENT PARTS

RADIO CORPORATION OF AMERICA  
COMMUNICATION PRODUCTS DEPARTMENT, CAMDEN, NEW JERSEY

PRINTED IN U.S.A.  
GO 539

1B-33304-1

**T.O. 31R5-4-A-21**

IU-1

**TECHNICAL DATA**

**INDICON CODER UNIT MI-31138**

**Power Requirements**

115 v ac, 100 watts maximum

**Relays**

Symbol	Function
6K1	Coder and Stepping Switch Control
6K2	Lockout
6K3	Lockout Timer
6K4	Coder and Timer Initiating
6K5	Radio Equipment Remote-Indication
6K6	Loss-of-Signal Remote-Indication
6K7 through 6K14	External Remote-Indications
6Z1	
6Z2	Timer Assembly

**Fuses**

Symbol	Rating	Circuit
6F1	1.0 amp	115 v ac
6F2	1.0 amp	115 v ac

**Dimensions**

Height: 5 1/4 inches  
 Width: 19 inches  
 Depth: 8 3/8 inches (overall)

**Weight**

19 1/4 pounds

**INDICON DECODER UNIT MI-31139**

**Power Requirements**

115 v ac, 75 watts maximum

**Relays**

Symbol	Function
7K1	Pulse Identifying
7K2	7K8 Contact Transfer
7K3	7K8 Reset (10th pulse)
7K4	7K8 Reset (15th pulse)
7K5	Timer Control
7K6	Lamp Control
7K7	Pulse Repeating
7K8	Impulse Counter
7K9	Lockout Timer
7K10	Lamp 7I1 Control
7K11	Lamp 7I2 Control
7K12	Lamp 7I3 Control
7K13	Lamp 7I4 Control
7K14	Lamp 7I5 Control
7K15	Lamp 7I6 Control
7K16	Lamp 7I7 Control
7K17	Lamp 7I8 Control
7K18	Lamp 7I9 Control
7K19	Lamp 7I10 Control

**Symbol Function**

7K20	Lamp 7I11 Control
7K21	Lamp 7I12 Control
7K22	Lamp 7I13 Control
7K23	Lamp 7I14 Control
7K24	Lamp 7I15 Control
7K25	Lamp 7I16 Control
7K26	Lamp 7I17 Control

**Fuses**

Symbol	Rating	Circuit
7F1	1.0 amp	115 v ac
7F2	1.0 amp	115 v ac
7F3	0.3 amp	48 v dc

**Dimensions**

Height: 5 1/4 inches  
 Width: 19 inches  
 Depth: 9 3/8 inches (overall)

**Weight**

25 1/2 pounds

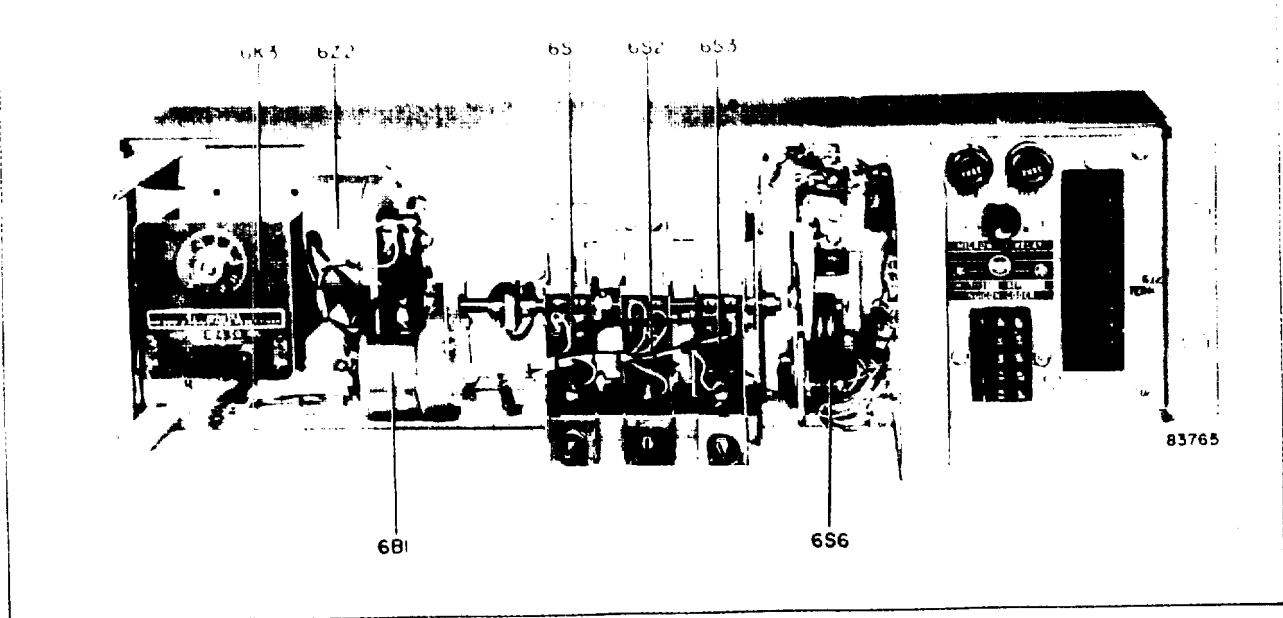
**DESCRIPTION**

**General**

The Indicon Coder and Decoder Units provide for automatic reporting of remote-indications and station identification when used in conjunction with Service Channel Unit MI-31140 in CW20A (MM20A) and MM26A microwave relay stations. The coder causes a pulse train to be transmitted automatically from the station in which it is located when any of up to ten

conditions occur. The pulse train containing fifteen binary counts is coded to report the identification of the originating station and the condition which caused the transmission. The decoder deciphers the pulse train and displays the decoded information on a lamp panel for visual observation. One indicon system is capable of reporting ten separate conditions from thirty-one stations. An auxiliary tone channel is required for use of the coder and decoder when used

IU 2



**Figure IU-1—Indicon Coder Unit—Front View, Dust Cover Removed**

in other applications; normally this function is provided by Service Channel Unit MI-31140.

Either of the indicon units can be used at a terminal, drop repeater, thru repeater, standby or

junction station. Generally a coder is installed at unattended stations and a decoder at attended stations. Both units can be used at installations where both indicating and reporting are desired.

### INDICON CODER UNIT MI-31138

The Indicon Coder Unit is designed to provide coded pulses that key the 2500 cycle tone oscillator in the service channel unit whenever a local failure occurs. The unit is supplied with five remote-indication relays, but as many as five additional relays can be included, if desired. With the full complement of relays the unit can report ten remote-indications from as many as thirty-one stations and if the station code information is eliminated, 15 remote-indications can be handled. The unit contains a circuit which locks out local coded transmissions for 20 seconds after the reception of the first of a train of pulses from any other coder in the system thereby preventing overlap of remote-indication signals.

The coder unit contains eight relays; 6K1, 6K2 and 6K4 through 6K9 with the option of adding five extra relays 6K11 through 6K14. It also contains lock-out timer 6K3, timer assembly 6Z2, code pulse assembly 6Z1, step switch 6S6, dc relay power supply 6Z3 and fuses 6F1 and 6F2. All the connections to the unit are made through Jones plugs 6J1 and 6J2. Lock-out timer 6K3 is the mechanism of the lockout circuit

that delays the transmission of a local remote-indication signal, when another remote-indication signal is already on the system. Timer assembly 6Z2 provides the control for the repetition of the coded tone signal transmission at 10 minute intervals as long as the failure exists. Code pulse assembly 6Z1 creates the pulse intervals for keying the tone oscillator in the service unit. Stepping switch 6S6 provides the proper connections for keying the station and remote-indication code pulses. The dc power for operating the step coil of stepping switch 6S6 is supplied by dc rectifier 6Z3.

A card is included with each unit which may be used to show the code which identifies the stations of a particular system.

#### Relays

Relay 6K1 controls the pulse producing assembly 6Z1 and stepping switch 6S6. Relay 6K2 along with timer 6K3 constitutes the lockout circuit. The action of the pulse formation sequence is initiated through the operation of relay 6K4 which is energized by one

of the remote-indication relays, 6K5 through 6K14. Relay 6K5 is the radio equipment (receiver/transmitter) fault relay, and 6K6 the loss-of-signal relay. Relays 6K7 through 6K14 can be used for external remote-indications such as tower light operation, emergency power operation etc.

### FUNCTIONAL ANALYSIS

The following is a detailed description of the functioning of the code pulse generating mechanism when a remote-indication occurs. Refer to the block diagrams of figures IU-2 and IU-3 and the schematic of figure IU-9.

#### Code Pulse Sequence

The coder unit will generate a coded pulse train when any of the designated station equipment failures (remote-indications) listed below occur.

##### *Radio Equipment Remote-Indication*

A marked decrease or complete loss of transmitter output or failure of the receiver/modulator i-f amplifier will cause the radio equipment remote-indication relay 6K5 in the coder unit to operate.

##### *Loss-of-Signal Remote-Indication*

A loss-of-incoming-signal condition in the receiver/modulator unit will cause the loss-of-signal remote-indication relay 6K6 in the coder unit to operate.

##### *Other Remote-Indications*

In addition to relays 6K5 and 6K6 there are 8 other remote-indication relays, 6K7 through 6K14 in the coder unit. These may be used to initiate a remote-indication tone transmission by an equipment failure external to the microwave equipment rack. These extra circuits may be used for whatever failure the customer may desire to have transmitted.

##### *Operation of Remote-Indication Relays 6K5 through 6K14*

When any of the relays, 6K5 through 6K14, become energized, the keying pulse sequence of the coder unit is initiated. The description of the action that follows when one of these relays operates will be described in terms of relay 6K5. The operation of relays 6K6 through 6K14 is identical to that of relay 6K5.

1. Contact 1-4 closes, operating 6K4.
2. Contact 2-6 closes, connecting one side of the 115 v ac line to terminal 3 of 6J2. For the other remote-indication relays this line voltage is connected to other terminals of 6J2. The voltage may be used to operate an external indicating device or for any other purpose desired by the customer provided

the current drain is kept within the rating of fuses 6F1 and 6F2.

3. Contact 3-5 closes. This grounds the radio equipment remote-indication identifying step contact (terminal 6) of stepping switch 6S6. For the other remote-indication relays, contacts ground the 6S6 contact terminal identified with the particular relay.

##### *Relay 6K4 Operation*

When relay 6K4 is operated by a remote-indication relay the following action occurs:

1. Contact 1-4 closes. This connection locks in relay 6K4 while the start pulse switch 6S2 of 6Z1 is "home."
2. Contact 2-6 closes and connects motor 6B1 across the ac line through contact 1-7 of 6K2 (if 6K2 is not operated in the lockout function) and the normally closed 2-3 contact of 6S4. Contact 2-6 also starts motor 6B2 of the timer assembly 6Z2.
3. Contact 3-5 is not used.

#### Fault Coding System

Motor 6B1 rotates a shaft containing a start pulse cam, a short pulse cam and a long pulse cam. The start pulse cam has one notch and the short and long pulse cams each contain fifteen notches. These cams operate switches 6S2, 6S1 and 6S3 respectively. Motor 6B1 turns one cycle (12 seconds) each 10 minute period for the duration of the remote-indication. The recurring 10 minute interval cycling periods are controlled by timer assembly 6Z2. At each of the fifteen notches of the short pulse cam, the oscillator keying circuit, 6J1 terminal 7, is closed for 90 milliseconds. The long pulse cam likewise will simultaneously fall into fifteen notches. However, a long 360 ms pulse will be keyed, masking the corresponding short pulse, only when the associated segment of stepping switch 6S6 is grounded. The first five pulses are normally used for station identification. Station identification grounds are to be permanently connected at terminal board 6TB1 when the stations are installed. In the example which follows it is assumed that terminals 1, 2 and 4 of 6TB1 have been connected to ground. By using all the combinations of five, except the one with all terminals of 6TB1 off ground, up to thirty-one stations may be identified. Segments six thru fifteen of stepping switch 6S6 are grounded by contact 3-5 of relays 6K5 through 6K14 respectively when these relays are operated. In the example which follows it is assumed relay 6K5 (radio equipment failure) has operated, grounding segment six of 6S6.

#### IU-4

The short and long pulse cams are arranged mechanically to send pulses in groups of five at the rate of two per second with a one second interval between each group of five. The example chosen will cause the following pulse train to be transmitted:

long	long	short	long	short
long	short	short	short	short
short	short	short	short	short

At stations equipped with the decoder, the indicator lamps corresponding to the long pulses will light. The pulse train can likewise be readily decoded aurally.

The following describes a complete revolution of 6B1.

#### 6Z1 Keying Operation

In the description of the operation of the short pulse and long pulse cams, refer to the schematic of figure IU-9 and note that the armature of switches 6S1 and 6S3 are, as used in this application, making contact with the "normally open" (NO) contact when the 6Z1 assembly is in the quiescent or non-operating condition.

##### *Start Pulse Cam*

1. Cam 6S2 comes out of the (H) "home" notch and the "normally closed" (NC) contact of 6S2 opens, breaking the ac connection to the lock-in contact 1-4 of relay 6K4 until the "home" position is again reached. When 6S2 reaches "home" twelve seconds later the "normally closed" (NC) contact, which was open throughout the cycle, again closes, locking-in relay 6K4 through its 1-4 contact for at least another cycle of 6B1 if the fault has not been cleared. If the fault has been cleared relay 6K4 is released opening the ac circuit to motors 6B1 and 6B2.

2. When cam 6S2 leaves the (H) "home" notch, the "normally open" (NO) contact closes and operates relay 6K1 for one revolution of motor 6B1.

##### *Relay 6K1 Operation*

1. Contact 8-6 closes and locks in motor 6B1.
2. Contact 9-2 opens, breaking the homing circuit of 6S6.
3. Contact 7-4 closes and completes a circuit that energizes the step coil of 6S6. This cocks the step mechanism for the first of a series of 15 steps.

##### *Short Pulse Cam*

As motor 6B1 turns the short pulse cam, the armature of switch 6S1 falls into 15 notches each cycle. At each notch the following occurs:

1. As the armature of switch 6S1 falls into the first notch the "normally closed" (NC) contact (which is actually open at the beginning of the cycle and between each notch) closes grounding the tone keying lead to the service channel unit (6J1-7). When the armature leaves the notch 90 ms later the (NC) contact opens removing the ground from the tone keying lead. This occurs at each of the 15 notches, thus 15 short pulses of 90 ms duration are formed to key the 2500 cycle tone oscillator in the service channel unit.

2. The step coil of 6S6 is energized through contact 7-4 of relay 6K1 and the closed (NO) contact of 6S1 before the short pulse cam reaches its first notch. When the armature of switch 6S1 falls into the first notch the "normally open" (NO) contact (which is actually closed at the beginning of the cycle) opens and the step coil of 6S6 is deenergized, moving the stepping switch to the 1st step position. Between each of the succeeding 14 notches the armature of 6S1 contacts the (NO) contact energizing the step coil of 6S6, cocking it for the next step. At each of the succeeding notches the armature of 6S1 breaks the (NO) contact deenergizing the step coil of 6S6, stepping 6S6 to the next step. Switch 6S6 steps one position each time the armature of 6S1 falls into a notch and as the armature leaves the notch, 6S6 is cocked (the step coil energized) for the next step. Thus 6S6 steps along in synchronism with the notches in the short pulse cam.

##### *Long Pulse Cam*

As the armature of switch 6S3 falls into each notch, the "normally closed" (NC) contact (which is actually open at the beginning of the cycle and between notches) closes for a period of 340 ms. This connects the keying circuit to the stepping switch and when the stepping switch reaches a grounded segment (which in this example is at steps 1, 2, 4 and 6) the keying circuit is completed to the service channel unit through 6J1-7, transmitting a long pulse. Because the notches of the short pulse cam and the notches of the long pulse cam move along in synchronism, with the short pulse starting 20 ms before the long pulse, each grounded long (340 ms) pulse masks a portion of the corresponding short (90 ms) pulse to produce a long combined pulse of 360 ms.

##### **Homing**

As 6B1 completes its revolution, the start pulse cam reaches the home position releasing switch 6S2. The contacts of 6S2 in turn release relay 6K1 and lock in 6K4 if the fault persists. When 6K1 releases the fol-



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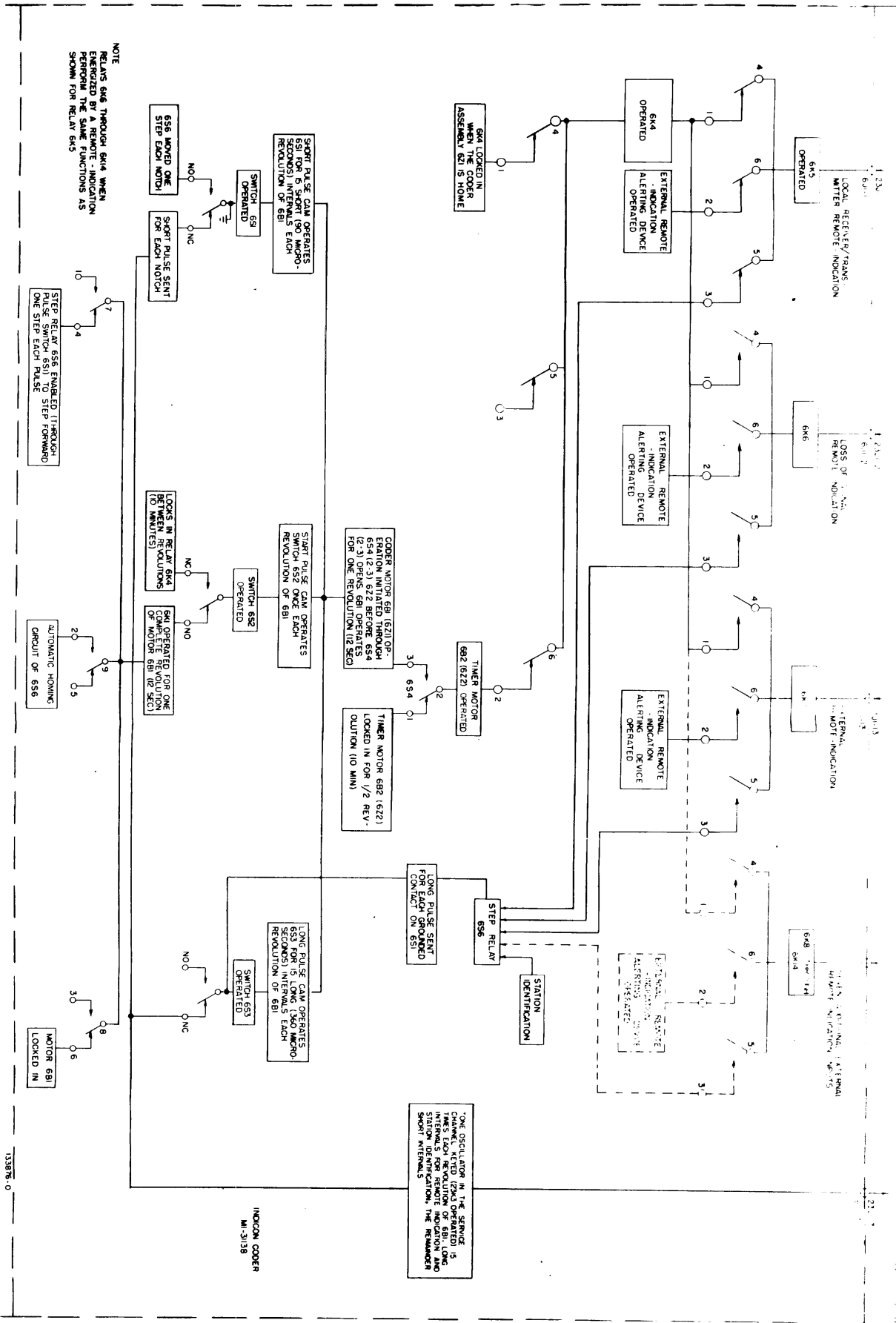


Figure 1U-2—Indicon Coder Unit Code Pulse Sequence—Block Diagram

**T.O. 31R5-4-A-21**

IU-7

lowing occurs: contact 6-8 opens stopping 6B1 (switch 6S4 of timer assembly 6Z2 has operated during the revolution of 6B1 as described in Timer 6Z2 Operation below), contact 4-7 opens the energizing circuit of 6S6 and contact 2-9 closes completing the homing circuit of 6S6 via its interrupter and off-normal springs. The interrupter spring contacts open the energizing circuit whenever the coil of 6S6 is energized and close each time it is de-energized. Thus the switch operates and releases in rapid succession stepping until the H segment is reached. At this point the homing circuit is opened by the off-normal springs, and the switch is ready for the next pulse train.

**Timer 6Z2 Operation**

When relay 6K4 operated its 2-6 contact closed applying ac power to motors 6B1 and 6B2. Motor 6B1 will complete one revolution in 12 seconds, motor 6B2 one revolution in 20 minutes. The notches of the cam of timer assembly 6Z2 are designed so that switch 6S4 will operate before 6B1 completes its revolution. When 6S4 operates it locks in motor 6B2 and opens the starting circuit to motor 6B1, however 6B1 will continue to complete its revolution since 6K1 has previously locked it in for one revolution.

Thus, after completing one transmission, coder assembly 6Z1, will remain in a quiescent condition until switch 6S4 falls into the second notch of the cam of assembly 6Z2. At this time it starts 6B1 for one revolution, repeating the fault transmission. The fault transmission is thus repeated automatically at 10 minute intervals. If the fault has been cleared since the last transmission, one additional transmission will be initiated since 6K4 remains locked in through its 1-4 contact and the NC contact of switch 6S2. This transmission will send only station identification and as it is completed 6K4 will be released when switch 6S2 is operated by the start pulse cam. Motor 6B2 will continue to run for 10 minutes. It will release when 6S4 falls into the next notch.

The timer cam of 6Z2 has an adjustable segment, containing one of the notches, which can be moved to reposition the notch. There are two screws which can be loosened to allow the segment to be moved. This adjustment is provided so that in the event of simultaneous failures at two or more stations the repeat transmissions will be staggered.

**Lockout Sequence**

When a station begins a coded tone transmission, it is necessary to lock out all other coders of the

system for the duration of the transmission to prevent the confusion that would rise in the event of simultaneous coded tone transmissions. The lockout circuit consists of relay 6K2 and timer 6K3 and functions to prevent the coder unit from forming keying pulses if a local failure should occur while a remote-indication transmission is being made from another station. The lockout interval is determined by 6K3, an adjustable timer set to 20 seconds at the factory. When the first pulse of a remote-indication transmission is received from another station, relay 23K1 in the service channel unit operates, closing contact 4-5 which connects together pins 10 and 11 of 6J1. Relay 6K2 operates immediately and 6K3 begins its timing cycle.

**Relay 6K2 Operation**

1. Contact 1-7 opens, breaking the triggering circuit to coder assembly 6Z1.
2. Contact 2-9 opens, disabling test switch 6S5.
3. Contact 5-9 closes, locking in relay 6K2 and timer 6K3 through contact 6K3 (4-5).
4. Contact 8-3 opens and disconnects the keying circuit from 6Z1 so that no keying pulses will result even if remote and local failures have occurred simultaneously.

The condition resulting from the operation of relay 6K2 will prevail until timer 6K3 completes its delay cycle at which time contact 4-5 opens breaking the locking circuit of 6K2 and 6K3. The relay and timer both release, restoring the circuit to normal. The coder lockout circuit functions each time a coded tone train is received.

**Connections**

Jones plugs 6J1 and 6J2 provide accommodations for all the connections to the coder unit; 6J1 is the coder terminal for the cable from the service channel unit and 6J2 is the terminal for connections to the coder unit from outside the equipment rack (normally made via the termination panel).

**SERV CHAN Jack 6J1**

All the connections to this jack are from the service unit. Terminal 1 is the radio equipment failure connection and terminal 2 the loss-of-signal connection. Terminals 4 and 5 are the 115 v ac power input connections. The keying connection is to terminal 7, and terminal 8 is the keying line common ground. Terminals 10 and 11 are the lockout circuit connections. When they are shorted by the operation of relay 23K1 in the service unit the lockout circuit is energized. Terminal 12 is used at junction stations for

IU-8

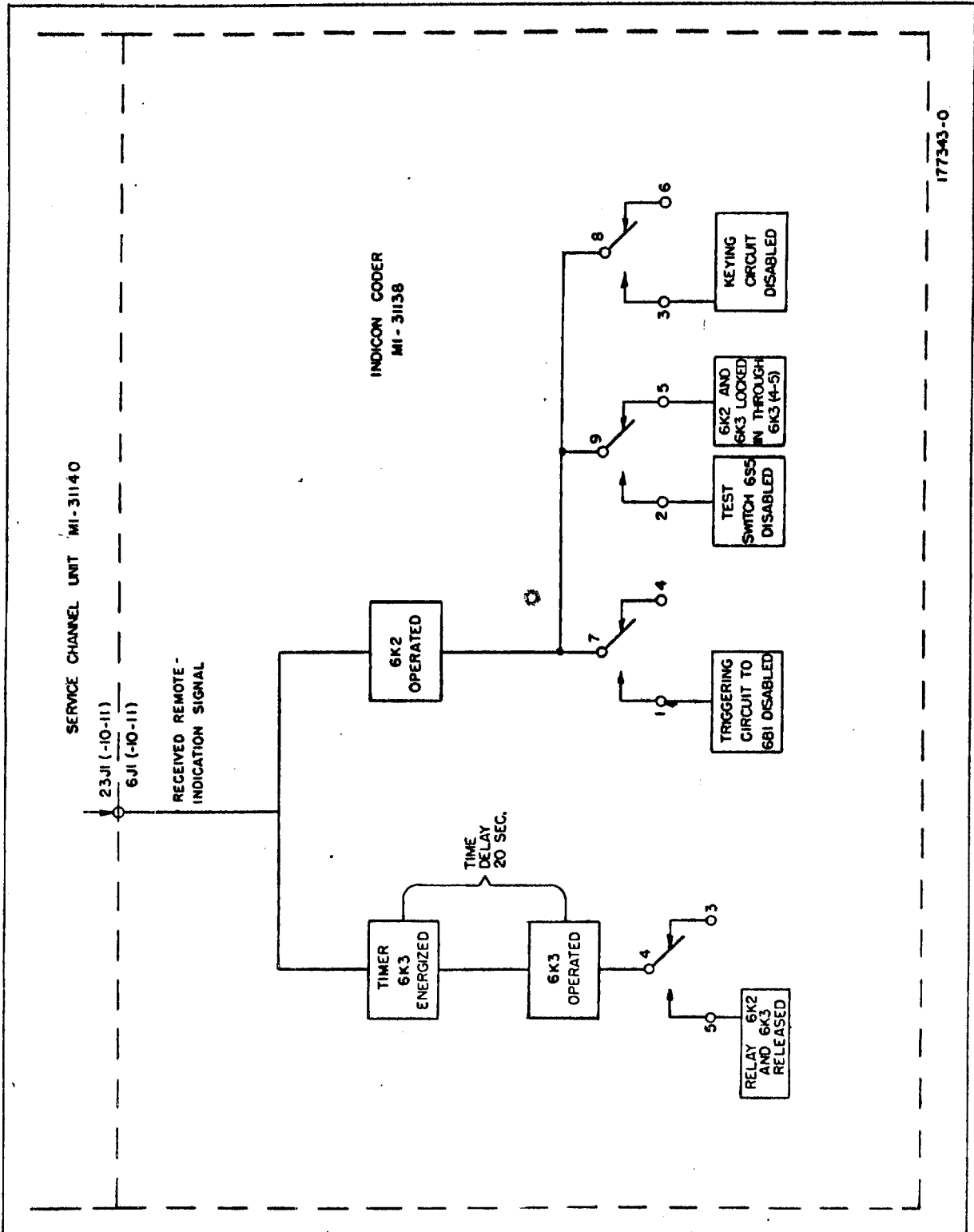


Figure IU-3—Indicon Coder Unit Lockout Sequence—Block Diagram

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indicating which station assembly has failed. When used for this purpose terminal 12 is connected to ground by a remote-indication that occurs in the rack that does not contain the indicon unit. This causes a "5" to be transmitted along with the prewired station code. When a "5" is used for this purpose it cannot be used in the station code for that particular station. Terminals 13, 14 and 15 are external equipment remote-indication connections. These circuits function when the occurrence of an external failure completes the circuit externally to pin 4 of 6J1.

**TERM jack 6J2**

All connections to this unit from equipment external to the microwave equipment rack are made through socket 6J2. In supervisory control applications only input power, lockout and keying connections are made through 6J1; all other connections are made through 6J2.

Both sides of a fused ac line are brought out to 6J2 at terminals 1 and 4. The operating leads to each of the ten remote-indication relays are brought out at terminals 2, 5, 8, 11, 14, 20, 22, 23, 26 and 29. The station code connections to the code pulse assembly 6Z1 via terminal board 6TB1 are made to terminals 7, 10, 13, 16 and 19. The station code thus can be

wired at 6TB1, at socket 6J2 or remotely. It is possible to have five additional remote-indications transmitted by connecting external relays to terminals 7, 10, 13, 16 and 19 and not send station identification information. Terminals 3, 6, 9, 12, 15, 18, 21, 24, 27 and 30 can be used for making ac power connections to indicating devices with terminal 4 as the common return connection. Terminals 25 and 28 are connections for triggering the unit when using it for supervisory control.

NOTE: Any external indicators connected to 6J2 should be of sufficiently low current drain to insure that the fuse protection is not overloaded.

**TEST Push Button 6S5**

Test switch 6S5 provides a means of manually starting the pulse generating mechanism. When pressed, this switch supplies starting voltage to assembly 6Z1 which locks itself in through relay 6K1 for one cycle. One complete pulse train is transmitted. This will send station identification plus any remote-indications present at the time. If no remote-indications are present when 6S5 is activated station identification only will be transmitted and the last ten pulses will all be short pulses.

**INDICON DECODER UNIT MI-31139**

The Indicon Decoder Unit is designed to decode, identify and record on a lamp display panel the received remote-indication signals from other stations in the system. It can also record a local radio equipment (receiver/transmitter) failure and loss-of-incoming-signal condition. It is usually located at an attended station and requires the use of an auxiliary tone receiver. This function is normally performed by a service channel unit. The lamp display panel identifies the station sending the signals and the nature of the remote-indication. Up to 31 stations and as many as ten remote-indications can be identified with one system. Additional capacity can be achieved by installing additional indicon units and using another tone channel.

In addition to display lamps 7I1 through 7I10, 7I16 and 7I17 the decoder unit contains 19 relays; 7K1 through 7K7, 7K10 through 7K19, 7K25 and 7K26 with the option of adding five extra lamp relays 7K20 through 7K24 and lamps 7I11 through 7I15. It also contains impulse counter 7K8, lockout timer 7K9, dc relay power supply (7CR1, 7T1 and 7C1), LAMP RELEASE switch 7S1, LAMP TEST switch 7S2 and fuses 7F1, 7F2 and 7F3. All connections to

the unit are made through Jones plugs 7J1, 7J2 and 7J3.

**Remote-Indication Lamp Display Panel**

As shown in figure IU-4 there are two rows of indicating lights on the display panel. These lights become illuminated in accordance with the pulse signals sent from a coder. The top row of lights (REMOTE STATION) (opal) identify the station sending the coded signals and the second row of lights (REMOTE INDICATIONS) (red) reveal the remote-indications which have caused the pulse signals to be transmitted. A complete pulse train consists of 15 pulses sent in three groups of five. The first five pulses are for station identification and those that follow are remote-indication tones. The sixth pulse is for a radio equipment (receiver/transmitter) failure, the seventh for a loss-of-incoming signal and the balance are for remote-indications external to the equipment rack. The remote-indication display may be increased to ten by installing a third row of lamps and their associated relays.

The pulsed signals are supplied by the service channel unit to the decoder unit. For every long pulse a

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lamp corresponding to its position in the pulse train will be illuminated. Using as an example a pulse train consisting of long pulses at positions number 1, 2, 4 and 6 (11010-10000-00000), the number 1, 2 and 4 lamps (opal) of the top row and the number 1 lamp (red) of the second row will be illuminated. Using the binary system for the first five pulses only (top row) the station sending the tone signal is number 26 and the remote-indication is a radio equipment failure. A card is included with each unit which may be used to show the code which identifies the stations of a particular system.

The unit has two other indicating lamps (red) for reporting local station conditions. the EQUIPMENT lamp indicates a local radio equipment failure and the SIGNAL lamp indicates a local loss-of-incoming-signal condition.

**Relays**

Relay 7K1 is a slow release relay that releases on long pulses to activate the lamp relays, but does not release on short pulses. Relay 7K2 connects lamp relays 7K20 through 7K24 to the first five steps of the impulse counter 7K8, for the last five pulses of the pulse train. Relay 7K4 resets the unit in readiness for the next pulse train by releasing 7K9 for another cycle and resetting impulse counter 7K8 to the "home" position. Relay 7K5 controls the operation of timer 7K9. Relay 7K6 controls 7K5 and extinguishes all the indicating lamps for the new pulse train. Relay 7K7 initiates the decoding cycle upon the arrival of the pulse train. Relays 7K10 through 7K24, light the indicating lamp when actuated by a long pulse.

The impulse counter 7K8 moves one step for each pulse of the pulse train applying ac on long pulses only to the lamp relays which light the display lamps. Timer 7K9 allows sufficient time for the pulse train to be concluded and then restores the counting circuits to the "ready" condition if a pulse train with an incorrect number of pulses is received. The dc power for operating relays 7K1 through 7K7 and impulse counter 7K8 is supplied by the dc rectifier composed of 7CR1, 7T2 and 7C1.

**FUNCTIONAL ANALYSIS**

The following is a detailed description of the functioning of the decoding mechanism when a pulse train is received from the service channel unit. Refer to the block diagram of figure IU-5 and the schematic diagram of figure IU-10.

**Pulse Decoding Sequence**

There is one lamp relay and one lamp for each of the 15 pulses of the received pulse train. The function of the decoding mechanism when a pulse train is received is to first extinguish any lamp illuminated by a previous pulse train and then light the lamps corresponding to each long (360 ms) pulse but not light the lamps corresponding to the short (90 ms) pulses. A pulse train having a long pulse at pulse numbers 1, 2, 4 and 6 will be used in this description. Relay 7K7 is operated by each pulse of the pulse train arriving from the service channel unit.

**Relay 7K7 Operation**

When the pulse train is received, relay 7K7 operates for the duration of each pulse (360 ms for a long pulse and 90 ms for a short pulse).

1. Contact 3-4 opens breaking the circuit to relay 7K1 for the duration of the pulse. 7K1 is a slow release relay which will only release on a long pulse. When 7K1 releases it applied ac to the common contact bus of impulse counter 7K8 which (using our sample pulse train) is on pulses 1, 2, 4 and 6.

2. Contact 5-6 closes for the duration of the pulse, enabling relay 7K3 to operate on the 10th pulse (through contact 10-13 of counter 7K8) and relay 7K4 to operate on the 15th pulse (through position 5 of counter 7K8).

3. Contact 7-8 closes for the duration of the pulse energizing the coil of impulse counter 7K8, stepping the counter forward one position for each pulse. On the first pulse, the counter steps to position 1 (1st armature pulled down) on the second pulse to position 2 etc.

4. Contact 9-10 closes energizing relay 7K6 on the first pulse only for the duration of the pulse.

**Relay 7K6 Operation**

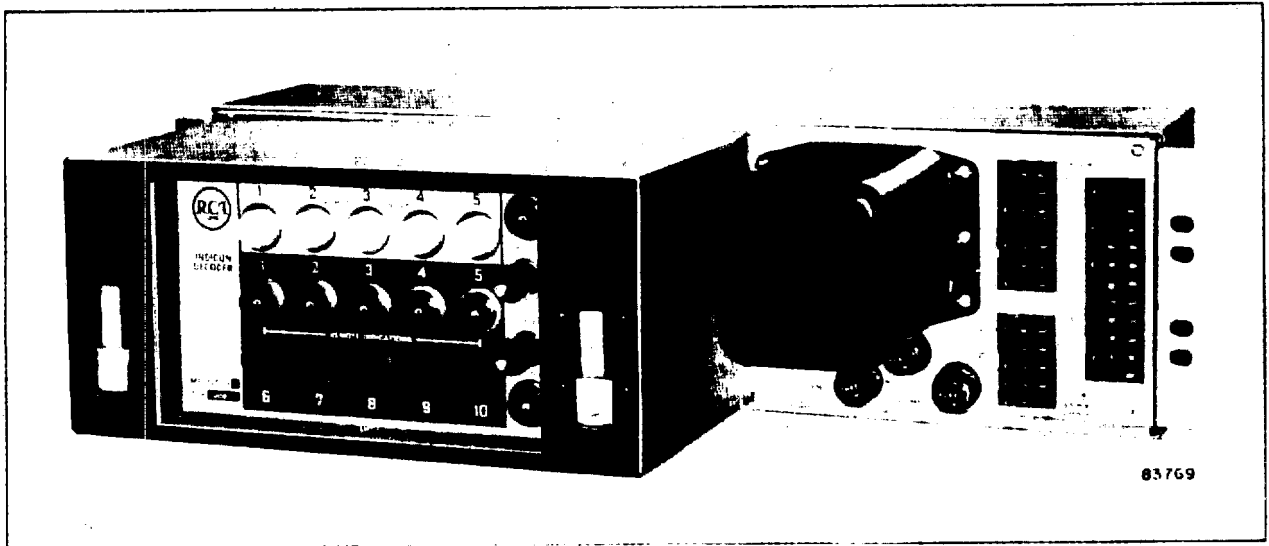
1. Contact 3-4 opens breaking the ac line to all lamp relays causing any previously operated relays to release, extinguishing all lamps.

2. Contact 5-6 closes, operating relay 7K5.

Relay 7K6 operates only on the first pulse of each pulse train. It is locked out for all succeeding pulses by the operation of 7K5.

**Relay 7K5 Operation**

1. Contact 7-5 closes and contact 6-7 opens an instant later. Contact 5-6-7 is a make-before-break contact which locks-in relay 7K5 when the 5-7 contact is made and releases 7K6 when contact 6-7 opens. Thus relay 7K6 does not operate again until the



**Figure IU-4—Indicon Decoder Unit—Front View**

first pulse of the next pulse train and 7K5 remains operated until released by relay 7K4 (contact 9-10 opens) on the 15th pulse or by timer 7K9 if an incorrect number of pulses are received. When relay 7K6 releases, contact 3-4 is closed reestablishing the indicator lamp circuit. The action between the initial pulse operating 7K7 and the reestablishing of the lamp circuit is quick enough to permit lamp 7I1 to be illuminated if the first pulse is a long one.

2. Contact 3-4 closes, energizing timer 7K9 which does not operate until approximately 20 seconds later.

#### *Impulse Counter 7K8*

Each time relay 7K7 operates, which is on each pulse of the pulse train, contact 7K7 (7-8) energizes the stepping coil of impulse counter 7K8. This closes contact 1 with the common bus contact (the 1st armature pulled down). The next pulse closes contact 2 with the common bus contact (the 2nd armature pulled down) and releases contact 1, breaking its connection to the common contact bus. This continues for 10 pulses and on the 10th pulse after the 10th armature is pulled down, relay 7K3 energizes the knockdown coil which resets the counter to the home position (all armatures up) ready for the 11th pulse. The 11th pulse closes contact 1 with the common bus contact (the 1st armature pulled down), the 12th pulse closes contact 2 with the common bus contact (the 2nd armature pulled down) and releases contact 1, breaking its connection to the common contact bus. This continues through the 15th pulse. Thus 7K7 (7-8) steps the impulse counter one step for each pulse of the pulse train. When a long pulse arrives relay 7K1 is released long enough for

ac to be applied to the contact bus of 7K8. This energizes the lamp relay associated with that step contact. In our example the 1st pulse is long, so relay 7K10 is operated. Each succeeding long pulse will operate a corresponding lamp relay. Since each lamp relay, 7K10 through 7K24, when operated perform identical functions, only the action of relay 7K10 will be described.

#### *Relay 7K10 Operation*

1. Contact 7-4 closes, locking in relay 7K10 until released by the LAMP RELEASE pushbutton or by the next pulse train.

2. Contact 9-5 closes, illuminating lamp 7I1 (lamp 7I2 through 7I15 for relays 7K11 through 7K24).

3. Contact 3-8 opens and 8-6 closes releasing or operating external indicating devices, if used.

On the 2nd pulse, relay 7K6 does not operate, since the open 5-6 contact of 7K5 keeps 7K6 locked out. Contact 7-8 of 7K7 steps counter 7K8 to position 2, and since in our example the 2nd pulse is long, contact 3-4 opens and remains open long enough to permit 7K1 to release. This operates 7K11, which in turn lights 7I2.

The 3rd pulse next arrives, and the counter is stepped to position 3. Since the 3rd pulse in this example is short, contact 3-4 of 7K7 closes again before 7K1 can release; therefore the common contact bus of 7K8 is not energized, relay 7K12 is not operated, and lamp 7I3 is not illuminated.

The action on the 4th pulse (a long one) is similar to that described for the 2nd pulse, with the counter

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stepping to position 4, relay 7K13 operating and lamp 7I4 becoming illuminated. The 5th pulse (a short one) results in the counter stepping to position 5 and lamp 7I5 remaining dark. The 6th pulse, being long, operates relay 7K15 and lights lamp 7I6. All subsequent pulses in this example are short, so no additional lamps will be illuminated.

The action at the 7th, 8th or 9th pulses is the same as for the 5th pulse (relays 7K16, 7K17 and 7K18 not operated), but on the 10th pulse, action is taken to reset the counter for the last five pulses. When the counter steps into position 10, it applies ground to relay 7K3, which operates as follows:

*Relay 7K3 Operation*

1. Contact 3-4 closes, locking-in relay 7K3 through contact 7K7 (5-6) for the duration of the 10th pulse.
2. Contact 5-6 closes energizing the knockdown winding of the impulse counter which immediately resets to the "home" position ready for pulses 11 through 15.
3. Contact 7-8 closes but the 10th pulse being a short one, relay 7K19 is not operated. If the 10th pulse had been a long one relay 7K19 would be operated through contacts 7K1 (3-4) and 7K3 (7-8). Relay 7K19 when operated, will lock itself in, light lamp 7I10 and operate an external indicating device, if used.

4. Contact 9-10 closes operating relay 7K2.

*Relay 7K2 Operation*

1. Contacts 3-4-5, 6-7-8, 9-10-11, 14-15-16 and 17-18-19 transfer the first five contacts of 7K8 from the coil circuits of 7K10 through 7K14 to the coil circuits of relays 7K20 to 7K24.
2. Contact 12-13 closes, locking in relay 7K2 through contact 7K4 (9-10).

3. Contact 20-21 opens and contact 21-22 closes, transferring the number 5 back contact of the impulse counter from the common contact bus to ground.

At the conclusion of the 10th pulse, the opening of contact 5-6 of 7K7 releases relay 7K3. The 11th, 12th, 13th, and 14th pulses, being short, merely step the counter past relays 7K20, 7K21, 7K22 and 7K23 to position 4. However, if, for example, the 12th pulse is long, relay 7K21 will be operated and lamp 7I12 illuminated.

On the 15th pulse (position 5) the impulse counter and all the relays (except the lamp relays) must be reset to the "home" position in preparation for the next pulse train and lamp 7I15 must be illuminated

if the pulse is a long one. As the impulse counter steps into position 5 for the second time, ground is applied to the coil of relay 7K4, through contact 7K2(21-22). Relay 7K4 operates and the following occurs:

*7K4 Operation*

1. Contact 3-4 closes, locking in relay 7K4 through contact 7K7 (5-6) for the duration of the 15th pulse.
2. Contact 5-6 opens, preventing relay 7K14 from operating on the 15th pulse (if the 15th pulse is a long one) after 7K2 is released but before 7K8 moves off the 5th contact to "home."
3. Contact 7-8 closes connecting the common contact bus of the counter to the coil of relay 7K24 so that if the 15th pulse is a long one (the common contact bus becoming energized) relay 7K24 will operate, illuminating lamp 7I15. However, since the 15th pulse is a short one in this example, relay 7K24 is not operated.
4. Contact 9-10 opens, releasing 7K2 and 7K5.
5. Contact 11-12 closes, energizing the knockdown winding of impulse counter 7K8 resetting it to its "home" position.

When relay 7K5 is released by 7K4(9-10), contact 5-6 of relay 7K5 opens releasing timer 7K9, which recycles rapidly and sets up the circuit for the operation of 7K6, the lamp extinguishing relay on the first pulse of the next pulse train. At the end of the 15th pulse contact 7K7(5-6) releases 7K4, and the entire circuit, with the exception of the lamp relays and lamps, is back to its normal waiting condition. A complete pulse train requires 12 seconds.

*Timer 7K9 Operation*

Within approximately 20 seconds after relay 7K5 energizes it, timer 7K9 operates if a pulse train containing an incorrect number of pulses has been received. If a correct pulse train has been received, timer 7K9 is released by 7K5 as described above. Timer 7K9 restores the coder to its normal waiting condition whenever a pulse train containing other than 15 pulses is received. The following happens when 7K9 operates:

1. Contact 4-5 opens and releases relays 7K2 and 7K5. Relay 7K5 in turn releases relay 7K9 as described above.
2. Contact 3-4 closes energizing the knockdown winding of impulse counter 7K8 which resets immediately to its zero or "home" position ready for the next pulse train.

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IU-13, IU-14

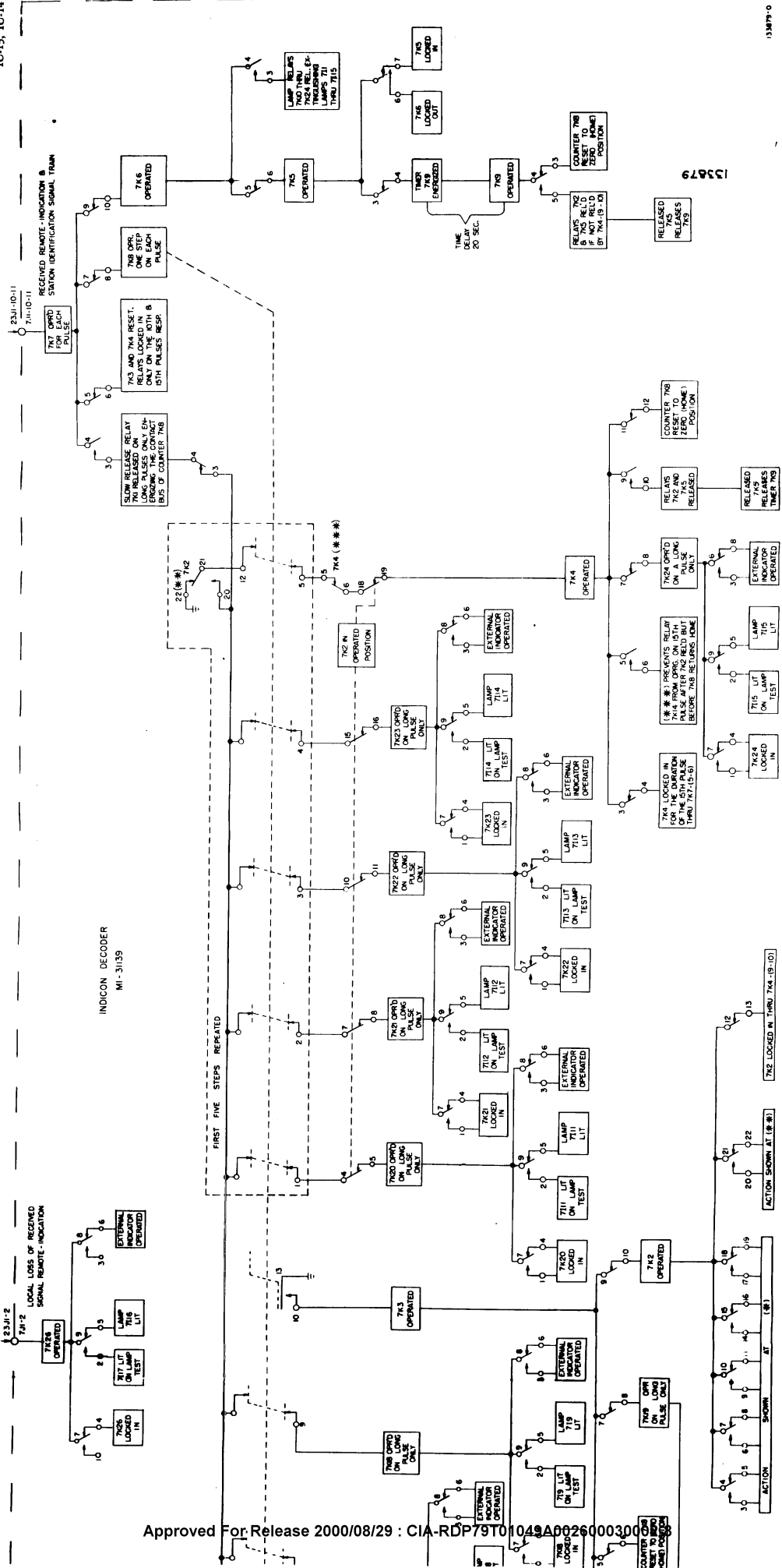
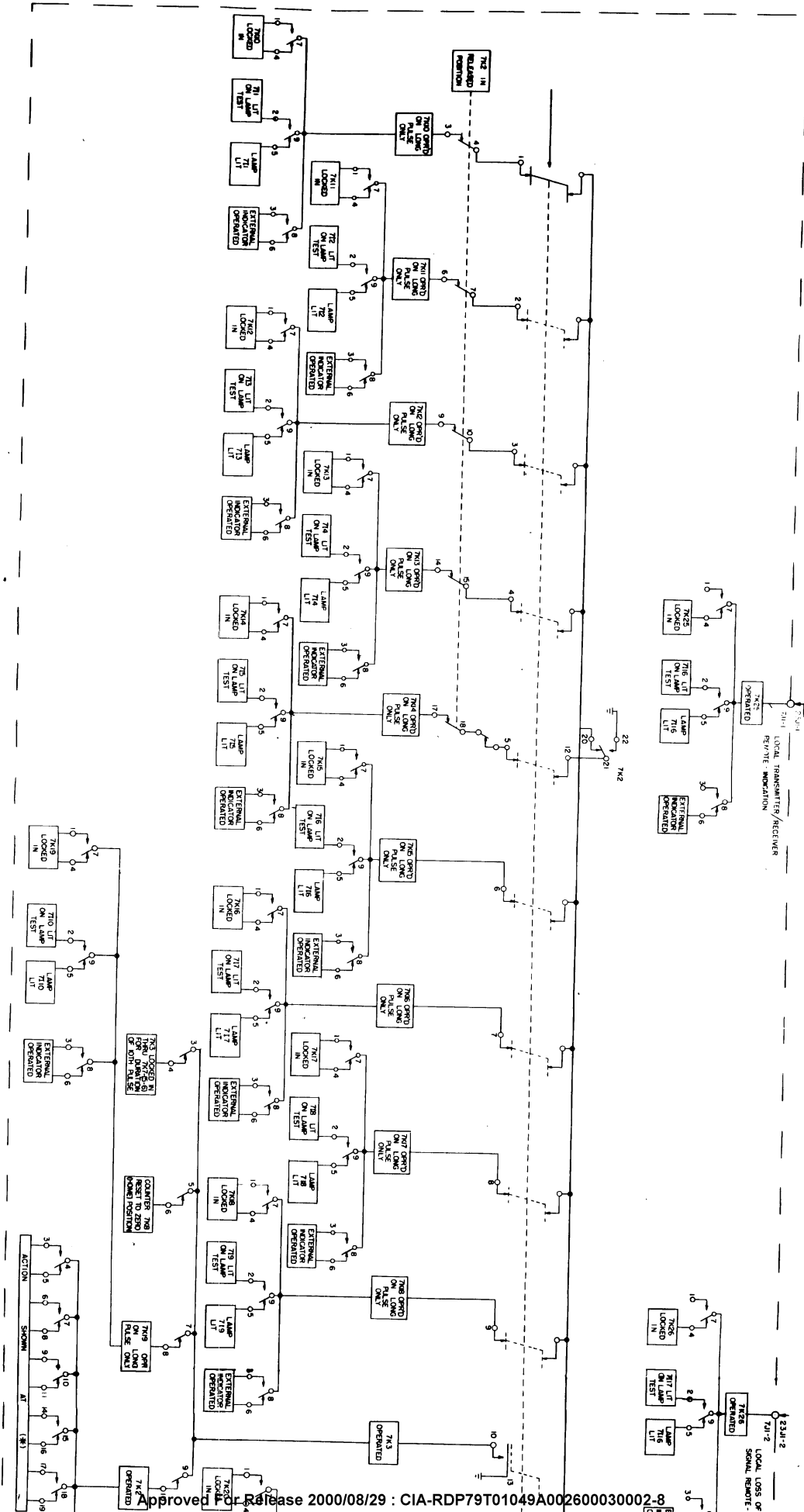


Figure 10-5—Indicon Decoder Unit Pulse Decoding Sequence—Block Diagram





### Local Indications

The local indication of equipment or signal failure is provided for by relays 7K25 and 7K26 and lamps 7I16 and 7I17. If a local radio equipment (receiver/transmitter) failure should occur pins 1 and 4 of 7J1 are connected externally. This applies ac to relay 7K25 which operates, locking itself in and lighting lamp 7I16. In the event of a local loss-of-incoming signal, pins 2 and 4 of 7J1 are connected externally. Relay 7K26 operates, locking itself in and lighting 7I17.

### Connections

All the connections to and from the unit are made through Jones plugs 7J1, 7J2 and 7J3. 7J1 is the decoder terminal for the cable from the service channel unit and 7J2 and 7J3 are provided for making connections to the coder unit from outside the equipment rack.

#### *SERV CHAN jack 7J1*

All connections to this jack are from the service channel unit. Terminal 1 is the local radio equipment failure connection and terminal 2 is the local loss-of-signal connection. Terminal 3 is the ground connection. Terminals 4 and 5 are the 115 v ac power input connections. The received remote-indication pulse train input connections are terminals 10 and 11. The output of the decoder 48 v dc supply is connected via terminal 13 to the service unit and then to the termination panel. This voltage is made available for

limited external use. The external current drain should not exceed 300 ma.

#### *TERM jacks 7J2 and 7J3*

All connections to these two jacks are from the 3, 6 and 8 contacts of lamp relays 7K10 through 7K24. Each of these contacts are connected to a terminal on either 7J2 or 7J3. For example, terminals 1, 2 and 3 of 7J2 are connected to 7K10 relay contacts 6, 8 and 3 respectively. Each time a lamp relay is operated by a remote-indication pulse the circuit to a pair of 7J2 or 7J3 terminals is opened and the circuit to another pair of terminals is closed. This arrangement may be used for any external application desired.

NOTE: Any external indicators connected to 7J2 or 7J3 should be of sufficiently low current drain, to insure that the fuse protection is not overloaded.

### LAMP TEST pushbutton 7S2

This switch is for checking the condition of the indicating lamps 7I1 through 7I17. When this switch is operated, power is applied to all lamps and when the switch is released any lamp already illuminated by a pulse train will remain illuminated and the other lamp will be extinguished. This test will reveal any faulty lamps in the lamp display panel.

### LAMP RELEASE pushbutton 7S1

When operated, this switch opens the power circuit to the indicating lamp relays and is used to manually clear the lamp display.

## MAINTENANCE

The indicon coder and decoder units require occasional maintenance checks to insure that the relays and other electro-mechanical devices are in good operating condition. At routine maintenance periods the units should be manually operated. This will wipe the relay and switch contacts clean before film or corrosion can accumulate and also provides a check on the operating condition of the unit. Procedures for effecting these routine checks are outlined in paragraphs entitled *Operational Check* in the maintenance notes for each of the units.

### Maintenance Notes

#### *Care and Servicing of Relays*

1. Trouble free relay operation depends upon maintaining contacts clean and free of dust, lint, grease, paint, oil or other similar material. These are common sources of arcing, pitting and burning of the contact surfaces.

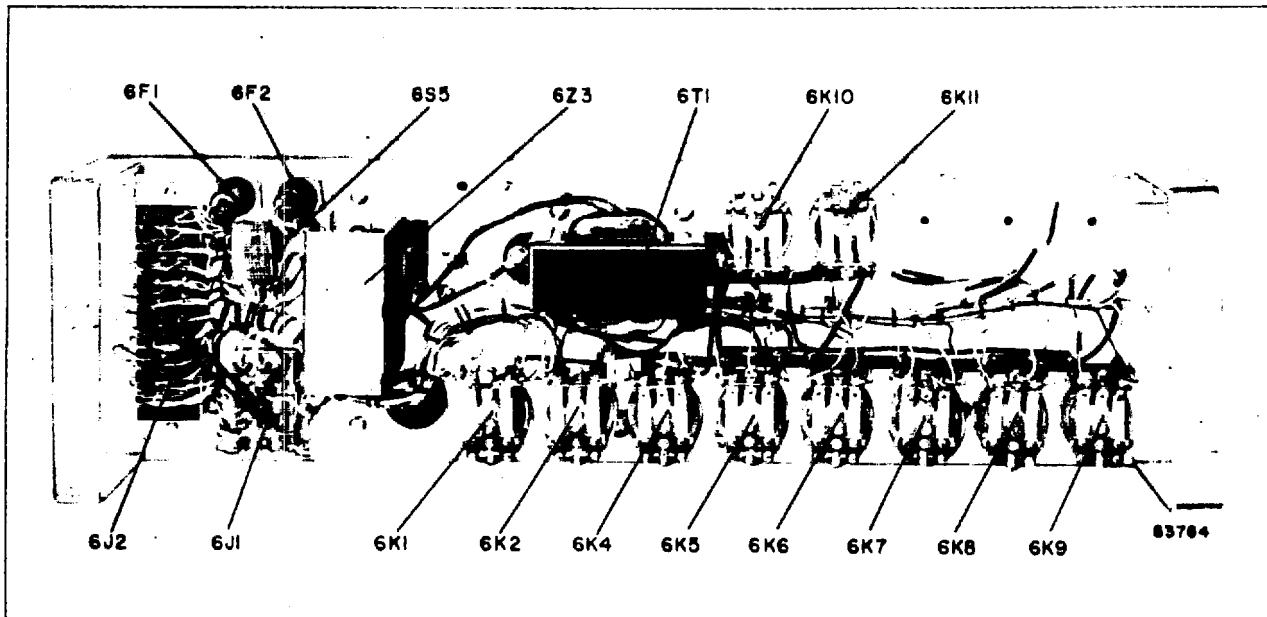
Contacts should be cleaned with carbon tetrachloride only. Burnishing tools used to touch the relay contacts should first be wiped clean with a cloth dampened in carbon tetrachloride.

2. Clean contacts once every three months burnishing all contacts lightly with a contact cleaning tool, usually about four strokes of the burnisher across the contact suffices. Never use a file or other rough tool or materials. Clean burnisher blade with carbon tetrachloride before using.

Normally-closed contacts will exert enough pressure if the burnisher is worked between them but normally-open contacts should be pressed together against the burnisher blade by operating the relay armature either manually or electrically.

If burnishing does not clear operational trouble in a set of contacts, they should be cleaned with carbon tetrachloride. Use one drop on the flat end of a

IU-16



**Figure IU-6—Indicon Coder Unit—Rear View, Dust Cover Removed**

tooth-pick. Separate the contacts enough to permit spreading the fluid across the contact surfaces. Then, with a second drop of cleaning fluid, flush the contact surfaces and the side of the contacts as well. Do not let the fluid touch any bushings, spoolheads, or insulators.

When the contacts have dried thoroughly, burnish them as described above. Even badly pitted contacts can be made serviceable with this routine and it is usually unnecessary to remove the pits or built up surfaces. However, when contacts are so badly burned as to indicate the likelihood of relay failure, they should be replaced and the cause of the burning discovered and corrected.

3. The following is a list of conditions to watch for when making routine maintenance checks. Some of these conditions apply only to the "Z" type relays.

- a. Improperly adjusted residual screws.
- b. Arcing contacts caused by defective spark suppressors.
- c. Spring and contact assemblies which show evidence of tampering.
- d. Contacts out of alignment more than 1/3 of their diameter at the base of the contact points.
- e. Loose screws and nuts.
- f. Insecurely mounted coils, contacts and other parts.

g. Mutilated or defective screws, nuts or other parts.

h. Sharp bends or kinks in springs. The free length of relay-spring can have only a gradual bow.

i. Bushings not in the approximate center of the springs they strike.

#### **Coder Unit**

##### *Operational Check*

The code pulsing sequence can be checked by simulating one or any combination of the remote-indications or by activating test switch 6S5. Test switch 6S5 when operated supplies starting voltage to the code pulsing assembly 6Z1 which locks itself in through relay 6K1 for one revolution. The stepping switch will contact 15 positions and then step "home." A code train will be transmitted consisting of the station identification (long and short) pulses in the first group of five and then ten short pulses if no fault is present. Remote-indications can be activated by shorting terminal 6J2-1 to terminals 6J2 (-2, -5, -8, -11, -14, -20, -22, -23, -26, and -29) in any combination desired or by creating a condition which is to be reported. The performance of the coder unit can be ascertained by having an attended station check the resultant lamp displays on the decoder unit.

The lockout circuit can be checked by simulating the arrival of a code tone train. Short terminals 10 and 11 of jack 6J1 momentarily. Relay 6K2 operates and timer 6K3 is energized. The action of relay 6K2

prevents the coder assembly from starting. After 20 seconds the circuit is returned to its normal condition by the operation of timer 6K3.

For a detailed account of the correct operation of the code pulsing sequence and the lockout circuit, refer to the Functional Analysis section.

#### Code Pulsing Assembly 6Z1 Adjustment

The code pulsing assembly 6Z1 is adjusted at the factory and under ordinary circumstances will not require readjusting. If however, a change in the timing and/or the duration of the pulses should occur the switch levers can be adjusted to correct the malfunctioning. Switch 6S2 is the start switch, 6S1 is the short pulse switch and 6S3 is the long pulse switch. If the duration of the pulse of the cams is incorrect, the operating levers of 6S1, 6S2 and 6S3 can be adjusted by turning the spring loaded screws in the direction to correct the fault. By turning the screws in, the pawl is moved farther into the notch. This decreases the

duration of the pulse. Turning the screws out moves the pawl so as to increase the duration of the pulse. One revolution of the adjusting screw results in a change in the pulse length of 20 ms. When making these adjustments be careful not to cause the damage that will result to the switches if the operating lever is forced against its operating cam.

The armatures of switches 6S1 and 6S3 must be positioned so that switch 6S1, the short pulse switch, actuates slightly before 6S3, the long pulse switch. This adjustment may be accomplished by loosening the mounting screws of switch 6S3 and sliding this switch backward or forward as required. The movement of switch 6S3 toward its spring loaded adjusting screw decreases the differential and vice versa. When making this adjustment move the switch in small increments and maintain its vertical position throughout the adjustment.

If an audio oscillator (Hewlett Packard 200CD or equivalent) and a counter (Berkeley Model 5500

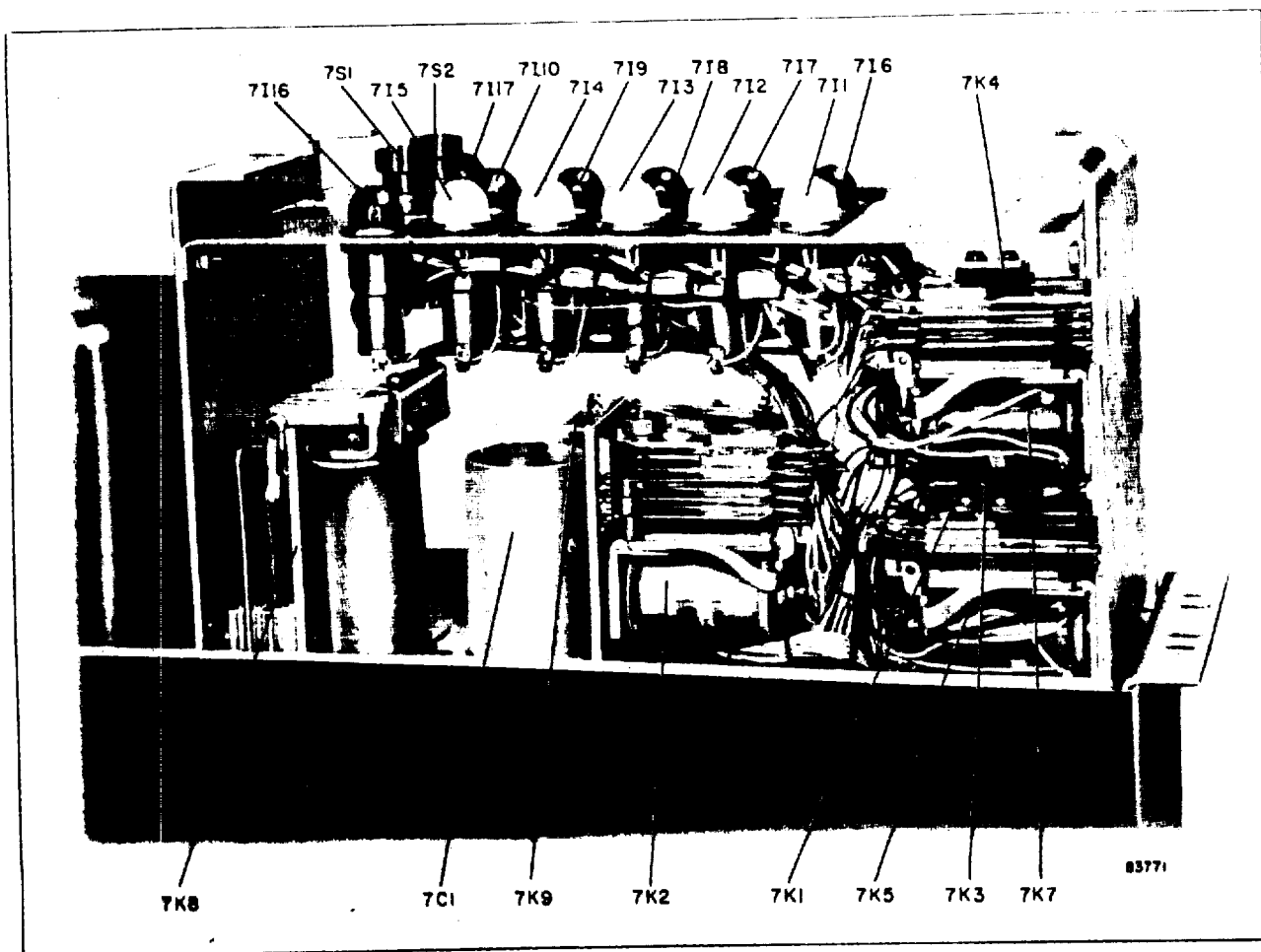
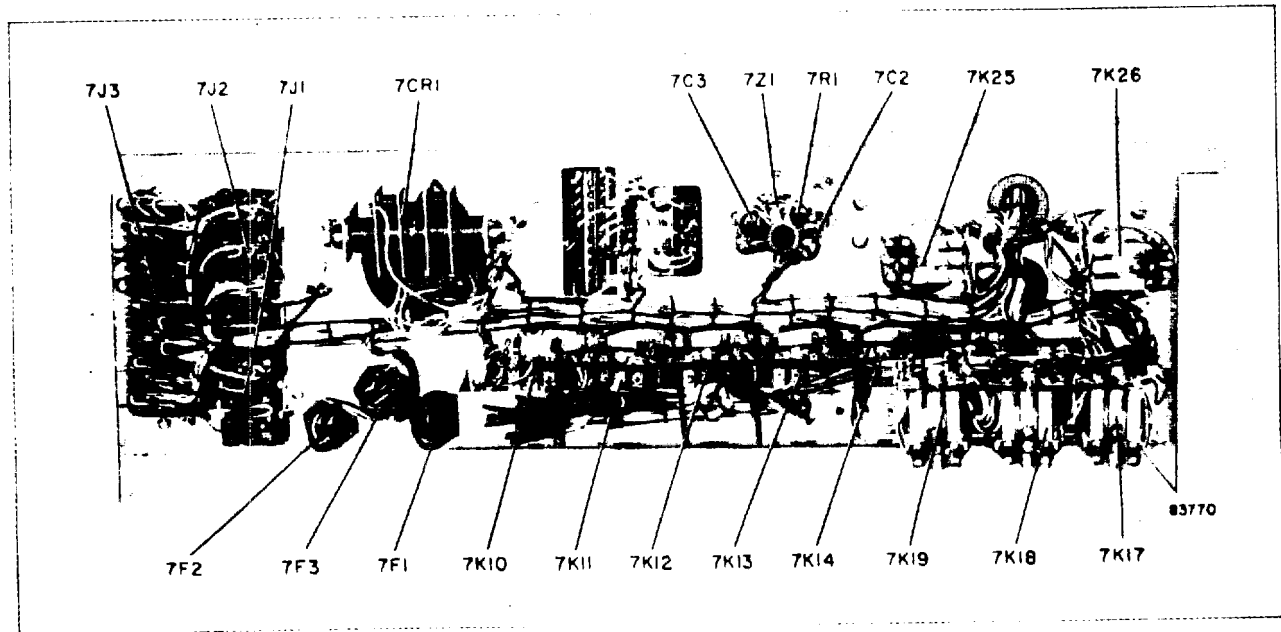


Figure IU-7—Indicon Decoder Unit—Side View, Front Dust Cover Removed

IU-18



**Figure IU-8—Indicon Decoder Unit—Rear View, Dust Cover Removed**

Eput or equivalent) are available a more precise adjustment can be made.

#### **Preliminary Adjustment of the Test Instruments**

Connect the output of the oscillator to the input of the counter. Adjust the oscillator to  $1000 \pm 1$  cps and set the counter to read 1000 cps. It is now possible to take a time measurement of the notch widths (pulses) in milliseconds (ms).

##### *Adjustment of the Start Pulse*

Connect the output of the audio oscillator to the operating lever of switch 6S2 and the input of the counter to the NC contact of 6S2. Adjust the spring loaded screw on the 6S2 mounting bracket for a start pulse of  $250 \pm 20$  ms duration.

NOTE: One revolution of the adjusting screw changes the pulse length approximately 20 ms.

##### *Adjustment of the Short Pulse*

Connect the output of the audio oscillator to the operating lever of switch 6S1 and the input of the counter to the NC contact of switch 6S1. Adjust each pulse for 80 ms or more. The time of each group of 5 pulses should be  $450 \pm 50$  ms.

##### *Adjustment of the Long Pulse*

Connect the output of the oscillator to the operating lever of switch 6S3 and the input of the counter to the NC contact of switch 6S3. Adjust each group of 5 pulses for  $1700 \pm 50, \pm 100$  ms.

##### *Adjustment of the Combined Pulse*

Connect the output of the oscillator to the operating lever of switches 6S1 and 6S3 and connect the input of the counter to the NC contact of switches 6S1 and 6S3. When correctly adjusted the duration of the long (combined) pulse is 360 ms with the short pulse beginning 20 ms before the long pulse has been initiated. Make the adjustments necessary to achieve this.

#### **Decoder Unit**

##### *Operational Check*

The operation of the decoder unit can be checked by having a simulated code train transmitted from another station and observing if the correct indicating lamps on the display panel are illuminated. The lamp display should correctly identify the station sending the code train and the remote-indication being simulated. The operation of the unit can also be checked by pulsing relay 7K7. This can be done manually or by shorting terminals 10 and 11 of 7J1.

Check the operation of LAMP RELEASE switch 7S1 and LAMP TEST switch 7S2 occasionally. All lamps on the display panel should be extinguished when switch 7S1 is depressed. LAMP TEST switch 7S2 is used to check the display lamps. All the lamps on the display panel should be illuminated when this switch is depressed.

Timer 7K9 should be set to operate .33 minute (20 seconds) after it is energized. To check its

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operation energize relay 7K7 by shorting terminals 10 and 11 of 7J1 momentarily. This simulates an incomplete transmission and timer 7K9 will complete its cycle and should reset the decoder to its normal waiting condition within 20 seconds after 7K7 was operated.

**TROUBLE SHOOTING**

If the coder should fail to function in sending a correctly coded pulse train, remove the dust covers and observe the equipment while simulating a fault. This can be done by manually or electrically operating any of relays 6K5 through 6K10. Relay 6K5 for example can be operated by shorting out terminals 1 and 4 of 6J1 or terminals 2 and 1 of 6J2.

If a decoder should fail to correctly display received pulse trains, remove the dust covers and observe the equipment while a pulse train is being received. This requires the cooperation of a coder station which will transmit the coded signals. These can be sent by simulating a fault as described above for the coder unit. If this is not feasible the decoder can be checked

by manually or electrically pulsing relay 7K7. This is done electrically by shorting terminals 10 and 11 of 7J1.

Thus by simulating faults and using the block diagrams of figures IU-2, IU-3, or IU-5, the schematic diagrams of figures IU-9 or IU-10, and by visual observation of the relay action with the power on and continuity measurements with the power off, the trouble can be diagnosed. If the trouble is corroded contacts, attempt to clear it by repeated operation of the relay, either electrically or manually. If that does not correct the trouble refer to the maintenance notes on the care and servicing of relays. Should the trouble be due to contacts being out of adjustment, they should be carefully adjusted with a standard relay spring bender. This should only be done when necessary for proper operation. The initial factory adjustment is superior to field adjustment and should not be disturbed except when necessary.

If the unit fails completely, check the fuses in the unit and if blown, locate and remedy the trouble before replacing the fuses.

**REPLACEMENT PARTS LIST**

Symbol No.	Description	Drawing No.	Stock No.
<b>INDICON CODER MI-31138</b>			
6B1	Motor, 115 v., 60 cy., 5 rpm (part of 6Z1) .....	8924174-1	211868
6B2	Motor, 115 v., 60 cy., 1/20 rpm (part of 6Z2) .....	8924174-2	211869
6C1	Capacitor, electrolytic, 40 mf, 150 v. (part of 6Z3) .....	442901-60	59417
6C2	Capacitor, fixed, paper, 0.027 mf, ±10%, 400 v. (part of 6Z3) .....	735715-168	73554
6CR1	Rectifier, selenium, rms input, 130 v., output, 200 ma, dc (part of 6Z3)		206312
6F1, 6F2	Fuse, cartridge 1.0 amp., 32 v. ....	8835338-9	94877
6J1	Connector, male, 15 contact, chassis mtg. ....	449613-6	95562
6J2	Connector, female, 33 contact, chassis mtg. ....	470698-12	211867
6K1, 6K2	Relay, 115 v., 50/60 cy., contacts 3 P.D.T. ....	8708717-6	211866-A
6K3	Timer, fault lockout, time range 0-57 sec., 115 v., 60 cy. ....	8835342-1	95563
6K4 to 6K14	Relay, 115 v., 50/60 cy., contacts 3 P.S.T. (N.O.) .....	8708717-4	95349-A
6R1	Resistor, fixed, composition, 22 ohm ±10%, 2 w. (part of 6Z3) .....	99126-119	
6R2	Resistor, fixed, composition, 510 ohm ±5%, 1 w. (part of 6Z3) .....	90496-152	
6S1 to 6S3	Switch, micro, S.P.D.T. (part of 6Z1) .....	8924172-1	211870
6S4	Switch, micro, S.P.D.T. same as 6S1 (part of 6Z2) .....	8924172-1	211870
6S5	Switch, push, S.P.D.T., 1 amp. 250 v., black button .....	8835332-2	95572
6S6	Relay, rotary stepping, coil, 110 v. dc, 22 point contacts, non-shorting ..	480431-1	211865
	Mounting, shock (1 pair per stk. no.) for mtg. 6S6 .....	8953703-1	215785
6T1	Transformer, isolation .....	949761-1	204118
6XF1, 6XF2	Holder, fuse, panel mtg., for 6F1, 6F2 .....	8811145-1	99218
6Z1	Coder Assembly, not stocked complete .....	641289-501	
	The following parts only available		
	Bearing, oilite bronze, for cam shaft .....	90492-14	212177
	Cam, coder switch actuating cam #1, for 6S1 .....	480433-501	212174
	Cam, coder switch actuating cam #2, for 6S2 .....	480433-502	212175
	Cam, coder switch actuating cam #3, for 6S3 .....	480433-503	212176
	Coupling, flexible, ¼ dia. shaft holes, 13/16" lg. overall .....	8847533-2	212179
	Motor, (see 6B1)		

**T.O. 31R5-4-A-21**

IU-20

Symbol No.	Description	Drawing No.	Stock No.
6Z2	Pin, steel, spring roll type, for cams #1, 2 and 3 .....	990333-51	212173
	Ring, steel, retaining, external type, cam shaft bearing retaining .....	474846-157	212178
	Screw, set #4-40 x 1/8" lg. allen hd. ....	8888539-101	50993
	Spring, helical compression .....	477833-6	212180
	Switch, (see 6S1, 6S2, 6S3) .....		
	Motor Assembly, not stocked complete .....	480422-501	
	See parts below		
	Cam, coder switch actuating cam #5, for 6S4 .....	8924196-1	212181
	Cam, coder switch actuating cam #4, for 6S4 .....	480422-502	212182
	Motor, (see 6B2)		
6Z3	Screw, set, #4-40 x 5/16" lg. allen hd. ....	8888539-104	212183
	Switch, (see 6S4)		
	Rectifier, selenium power pack complete, 115 v. ac, input, 110 v. dc, 200 ma, output, including 6C1, 6C2, 6CR1, 6R1 and 6R2 .....	8925025-1	211864
	<i>Miscellaneous</i>		
	Connector, female, 15 contact, cable mtg. for cable assembly .....	449653-2	44177
	Connector, male, 15 contact, cable mtg. for cable assembly .....	449653-1	57597
<b>INDICON DECODER MI-31139</b>			
7C1	Capacitor, electrolytic, 80 mf, 100 v. ....	449618-8	211871
7C2, 7C3	Capacitor, fixed, paper, 0.1 mf ±20%, 200 v. (part of 7XZ1) .....	735715-25	73784
7CR1	Rectifier, selenium .....	8908824-7	211872
7F1, 7F2	Fuse, cartridge, 1.0 amp., 32 v. ....	8835338-9	94877
7F3	Fuse, cartridge, 0.3 amp., 250 v. ....	8835338-3	95110
7I1 to 7I17	Lamp, neon, min. bay., 65 v. ac, 90 v. dc .....	872291-9	101857
7J1	Connector, male, 15 contact, chassis mtg. ....	449613-6	95562
7J2	Connector, male, 33 contact, chassis mtg. ....	470698-11	212521
7J3	Connector, male, 21 contact, chassis mtg. ....	470698-10	207191
7K1	Relay, coil, 48 v. dc, 1100 ohm, contacts, 1 form "B", break .....	746911-1	211874
7K2	Relay, coil, 48 v. dc, 1300 ohm, contacts, 6 form "C", break-make, 1 form "A" make .....	746911-2	211875
7K3	Relay, coil, 48 v. dc, 1100 ohm, contacts, 3 form "A", make, 1 form "A" preliminary make .....	746911-3	211876
7K4	Relay, coil, 48 v. dc, 1100 ohm, contacts, 2 form "A" make, 2 form "B" break, 1 form "A" preliminary make .....	746911-4	211877
7K5	Relay, coil, 48 v. dc, 2300 ohm, contacts, 1 form "A" make, 1 form "D" make before break .....	746911-5	211878
7K6	Relay, coil, 48 v. dc, 1100 ohm, contacts, 1 form "A" make, 1 form "B" break .....	746911-6	211879
7K7	Relay, coil, 48 v. dc, 2300 ohm, contacts, 3 form "A" make, 1 form "B" break .....	746911-7	211880
7K8	Relay, impulse counter, coil, 48 v. dc, contacts, 10 successive break make .....	746910-1	211881
7K9	Timer, fault lockout, time range 0-57 sec., 115 v., 60 cycle .....	8835342-1	95563
7K10 to 7K26	Relay, coil, 115 v. ac, contacts, 3 form "C" break-make .....	8708717-6	211866
7R1, 7R2	Resistor, fixed, composition, 1200 ohm ±10%, 1 w. (part of 4XZ1) ..	90496-63	512212-A
7R3	Resistor, fixed, composition, 27 ohm ±10%, 1/2 w. (part of 4XZ1) ..	735730-43	
7R4	Resistor, fixed, composition, 27 ohm ±10%, 1/2 w. Same as 7R3 .....	735730-43	
7S1, 7S2	Switch, push button, S.P.D.T., momentary contacts .....	8835332-2	
7T1	Transformer, filament .....	949894-1	211882
7XC1	Socket, vector turret type, octal, socket only less electrical parts (part of 7XZ1) .....	746048-5	210645
7XF1	Holder, fuse, panel mtg., for 7F1 .....	8811145-1	99218
7XF2	Holder, fuse, panel mtg., for 7F2, same as 7XF1 .....	8811145-1	99218
7XF3	Holder, fuse, panel mtg., for 7F3, same as 7XF1 .....	8811145-1	99218
7XI1 to 7XI5	Light, pilot light assembly, opal jewel less lamp .....	8856279-22	
7XI6 to 7XI17	Light, pilot light assembly, red jewel, less lamp .....	8856279-28	
	Jewel, pilot light "opal" jewel only less socket and lamp .....	Pt. of 8856279-22	56611

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IU-21

Symbol No.	Description	Drawing No.	Stock No.
7XZ1	Jewel, pilot light "red" jewel only less socket and lamp .....	Pt. of 8856279-28	56612
	Socket, pilot light socket only less jewel and lamp, for 7X11 to 7X117 incl. ....	Pt. of 8856279-22 or 28	56610
	Socket, vector socket assembly (not stocked complete) (for parts see 7R1, 7R2, 7R3, 7R4, 7C2, 7C3, 7XC1) .....	480421-501	
	<i>Miscellaneous</i>		
	Connector, female, 15 contact, cable mtg., for cable assembly .....	449653-2	44177
Connector, male, 15 contact, cable mtg., for cable assembly .....	449653-1	57597	



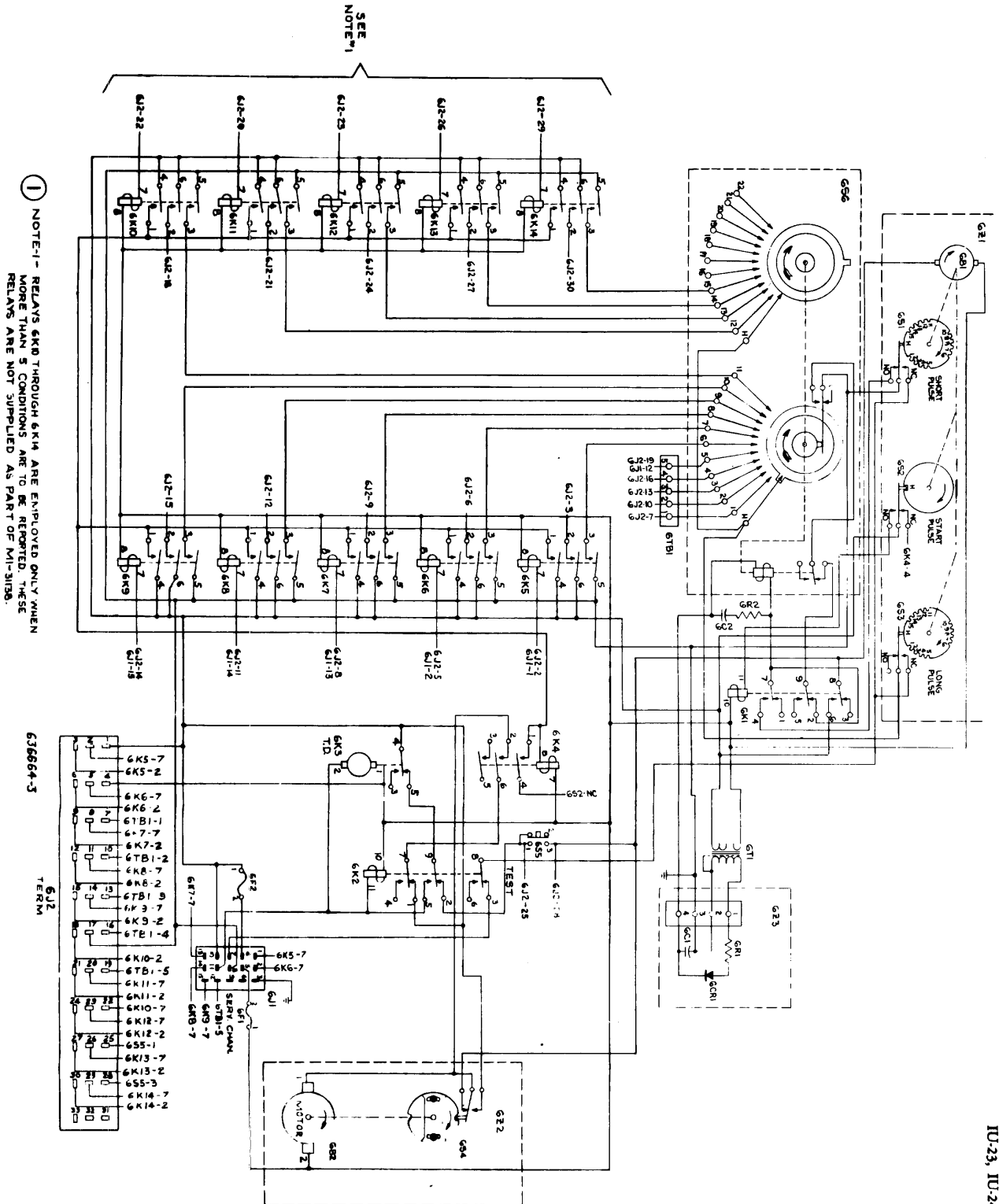
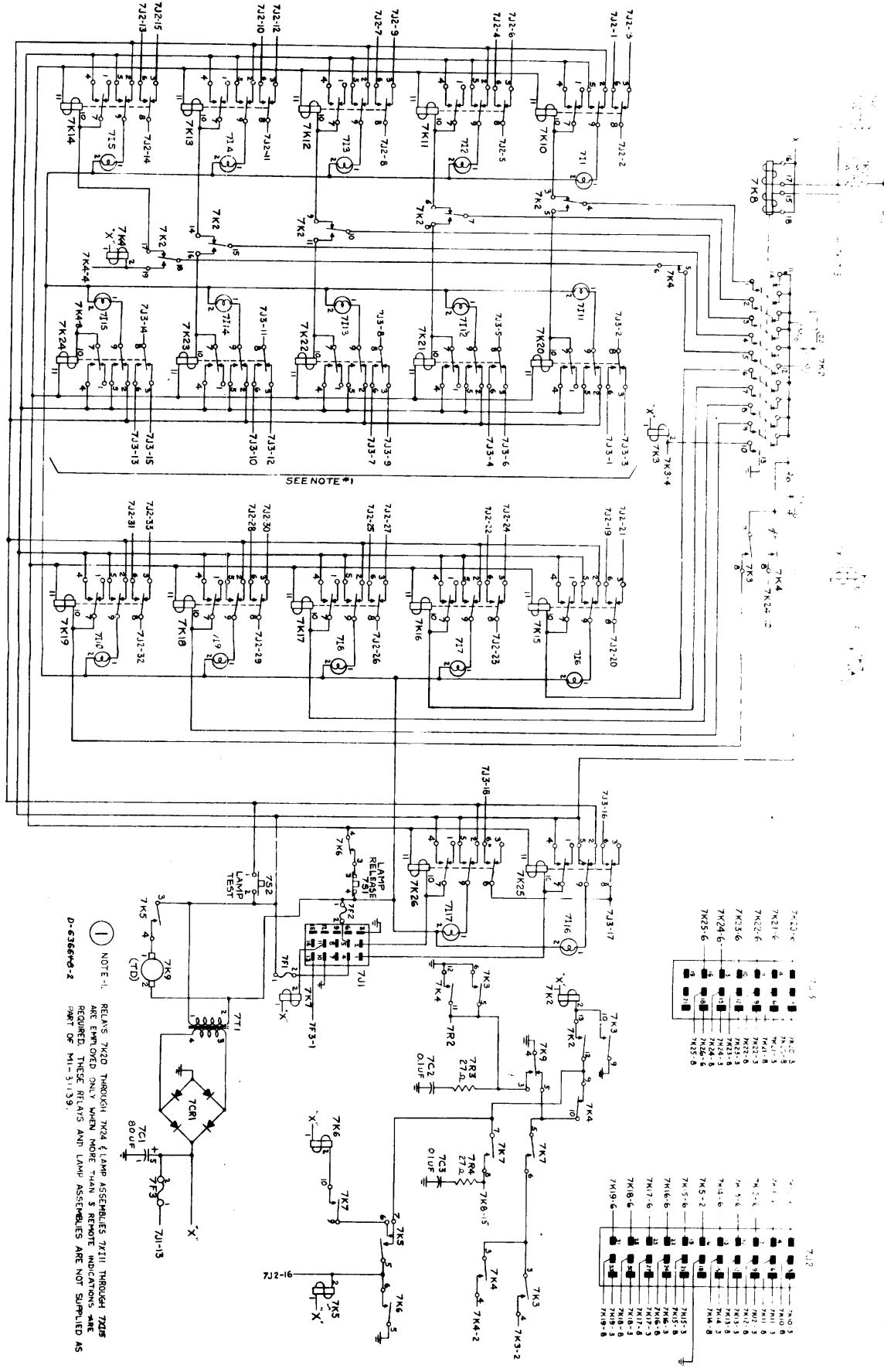


Figure IU-9-Jadicon Codar Unit—Schematic Diagram



SEE NOTE #1

NOTE-1: RELAYS 7K20 THROUGH 7K24 & LAMP ASSEMBLIES 7T11 THROUGH 7T15 ARE EMPLOYED ONLY WHEN MORE THAN ONE LAMP IS REQUIRED. THESE RELAYS AND LAMP ASSEMBLIES ARE NOT SUPPLIED AS PART OF MI-31139.

Figure 1U-10-Indian Decoder Unit—Schematic Diagram

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II 25, II 36