TECHNICAL MANUAL

for

DUAL DIVERSITY RECEIVER
MODEL DDR-5L

SYSTEM

THE TECHNICAL MATERIEL CORPORATION
MAMARONECK, N.Y. OTTAWA, CANADA

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THE TECHNICAL MATERIEL CORPORATION
COMMUNICATIONS ENGINEERS
700 FENIMORE ROAD MAMARONECK, N. Y.

Warranty

The Technical Materiel Corporation, hereinafter referred to as TMC, warrants the equipment (except electron tubes,* fuses, lamps, batteries and articles made of glass or other fragile or other expendable materials) purchased hereunder to be free from defect in materials and workmanship under normal use and service, when used for the purposes for which the same is designed, for a period of one year from the date of delivery F.O.B. factory. TMC further warrants that the equipment will perform in a manner equal to or better than published technical specifications as amended by any additions or corrections thereto accompanying the formal equipment offer.

TMC will replace or repair any such defective items, F.O.B. factory, which may fail within the stated warranty period, PROVIDED:

1. That any claim of defect under this warranty is made within sixty (60) days after discovery thereof and that inspection by TMC, if required, indicates the validity of such claim to TMC's satisfaction.
2. That the defect is not the result of damage incurred in shipment from or to the factory.
3. That the equipment has not been altered in any way either as to design or use whether by replacement parts not supplied or approved by TMC, or otherwise.
4. That any equipment or accessories furnished but not manufactured by TMC, or not of TMC design shall be subject only to such adjustments as TMC may obtain from the supplier thereof.

Electron tubes*furnished by TMC, but manufactured by others, bear only the warranty given by such other manufacturers. Electron tube warranty claims should be made directly to the manufacturer of such tubes.

TMC's obligation under this warranty is limited to the repair or replacement of defective parts with the exceptions noted above.

At TMC's option any defective part or equipment which fails within the warranty period shall be returned to TMC's factory for inspection, properly packed with shipping charges prepaid. No parts or equipment shall be returned to TMC, unless a return authorization is issued by TMC.

No warranties, express or implied, other than those specifically set forth herein shall be applicable to any equipment manufactured or furnished by TMC and the foregoing warranty shall constitute the Buyers sole right and remedy. In no event does TMC assume any liability for consequential damages, or for loss, damage or expense directly or indirectly arising from the use of TMC Products, or any inability to use them either separately or in combination with other equipment or materials or from any other cause.

*Electron tubes also include semi-conductor devices.

PROCEDURE FOR RETURN OF MATERIAL OR EQUIPMENT

Should it be necessary to return equipment or material for repair or replacement, whether within warranty or otherwise, a return authorization must be obtained from TMC prior to shipment. The request for return authorization should include the following information:

1. Model Number of Equipment.
2. Serial Number of Equipment.
3. TMC Part Number.
4. Nature of defect or cause of failure.
5. The contract or purchase order under which equipment was delivered.

PROCEDURE FOR ORDERING REPLACEMENT PARTS

When ordering replacement parts, the following information must be included in the order as applicable:

1. Quantity Required.
2. TMC Part Number.
3. Equipment in which used by TMC or Military Model Number.
4. Brief Description of the Item.
5. The *Crystal Frequency* if the order includes crystals.

PROCEDURE IN THE EVENT OF DAMAGE INCURRED IN SHIPMENT

TMC's Warranty specifically excludes damage incurred in shipment to or from the factory. In the event equipment is received in damaged condition, the carrier should be notified immediately. Claims for such damage should be filed with the carrier involved and not with TMC.

All correspondence pertaining to Warranty Claims, return, repair, or replacement and all material or equipment returned for repair or replacement, within Warranty or otherwise, should be addressed as follows:

THE TECHNICAL MATERIEL CORPORATION
Engineering Services Department
700 Fenimore Road
Mamaroneck, New York

RECORD OF CORRECTIONS MADE

Change No.	Date of Change	Date Entered	Entered By

NOTE

This manual revision (5/20/65) covers DDR-5L Receivers, serial # 23127 and up.

FOREWORD

TMC's Dual Diversity Receiver, Model DDR-5L consists of 13 major components.

QTY	COMPONENT
2	HFR-1A Continuous RF Tuner
1	HFS-1 Control Synthesizer and Standard
2	MSA-1 Multiple Sideband Adapter
2	MCG-1 Mux Carrier Generator
2	AFC-3 Automatic Frequency Control Unit
1	BSP-6B Bridging Speaker Panel
2	HFP-1 Power Supply
1	HPP-1 Utility Panel

These 13 basic units are also included in various TMC receiver systems as well as in the DDR-5L. To satisfy this condition most practically, individual manuals on each unit are written, then combined, as required to cover any receiver system. The DDR-5L manual is made up of a system manual and modular-unit manuals* as follows.

Technical Manual for Dual Diversity Receiver, Model DDR-5L -- system

Technical Manual for Continuous RF Tuner, Model HFR-1A

Technical Manual for Control Synthesizer and Standard, Model HFS-1

Technical Manual for Multiple Sideband Adapter, Model MSA-1

Technical Manual for Mux Carrier Generator, Model MCG-1

Technical Manual for Automatic Frequency Control Unit, Model AFC-2A and AFC-3

Technical Manual for Loudspeaker Assembly, Model BSP-6 B

Technical Manual for Power Supply, Model HFP-1

Appendix for Dual Diversity Receiver, Model DDR-5L

*HPP-1 Utility Panel is described in DDR-5L Appendix.

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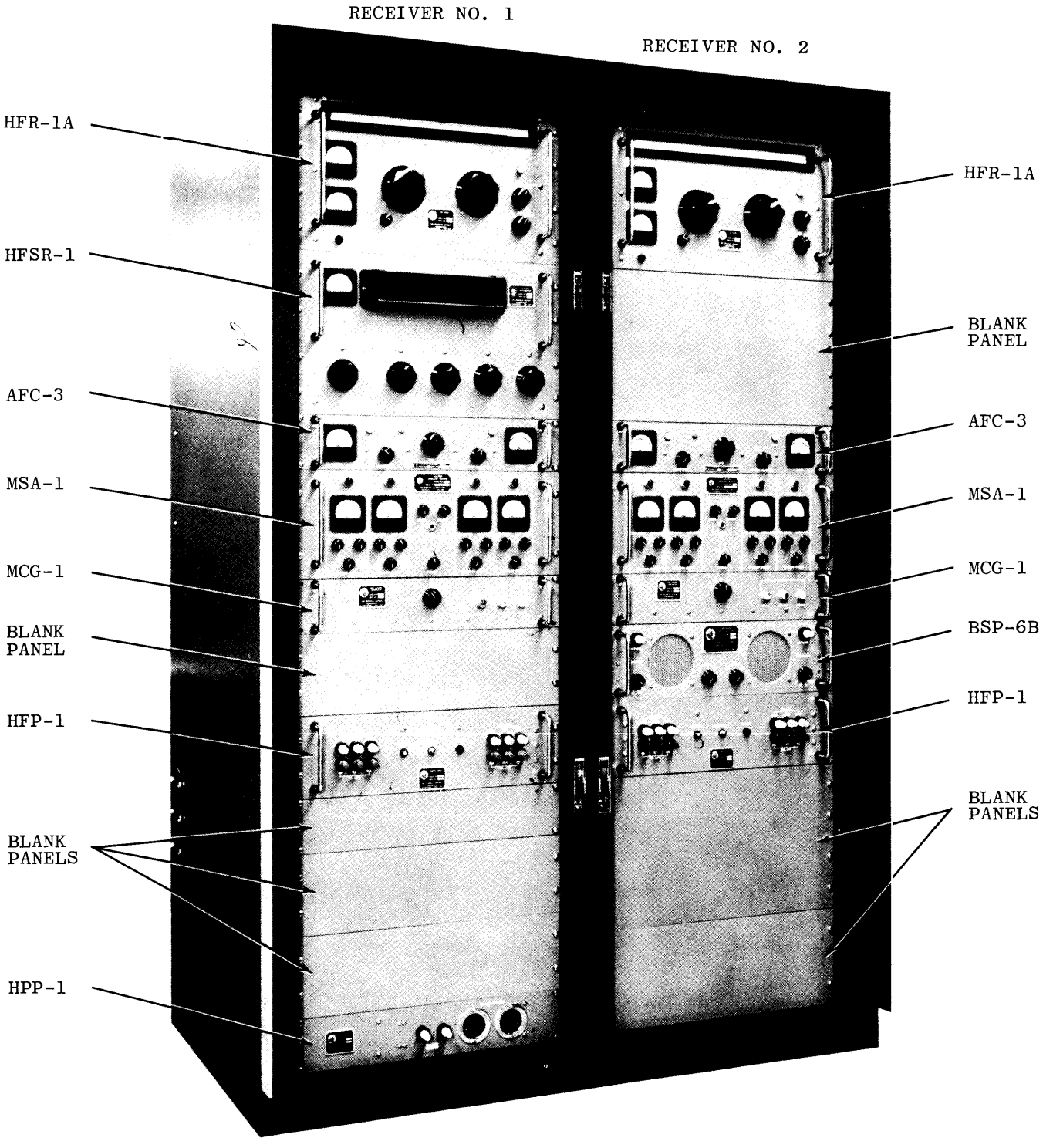


Figure 1-1. Dual Diversity Receiver, Model DDR-5L

SECTION 1
GENERAL INFORMATION

1-1. GENERAL DESCRIPTION.

Dual Diversity Receiver, Model DDR-5L, (figure 1-1) is a dual diversity 4-channel receiving system covering the frequency range of 2 to 32 mc for the reception of SSB, ISB, AM, MCW, FSK, and FAX signals. In ISB reception, 4 discrete 3-kc width voice channels may be received by each of the 2 receiver systems (Receiver No. 1 and No. 2). Each channel may contain voice, voice frequency telegraph signals, FSK, FAX, data transmission or any type of information that can be contained within the 250 cps to 3000 cps range. Each of the 4 channels has an individually adjustable AGC and squelch feature to suit the particular type of signal. The two receiver systems may be operated in space diversity or they may be operated independently and simultaneously to bring in a total of 8 discrete channels on two carriers.

The 2 to 32 mc range covered by the DDR-5L is divided into eight r-f bands. The tuning coverage for each band is in 100 cps steps for diversity operation, or it can be continuous coverage for single receiver non-synthesized operation. For sideband signals with a fully suppressed carrier, a synthesizer, referenced to an internal 1-mc frequency standard, produces receiver frequency stability within 1 part in 1×10^8 per 24-hour period, tunable in 100 cps steps. For sideband signals with a reduced carrier (30 db below PEP* maximum), an automatic frequency control compensates for combined transmitter/receiver drift to produce audio accurate to within 1 cps.

Other additional features include r-f tuning dial calibration signals (referenced to the 1-mc frequency standard), an r-f noise silencer circuit, carrier drift/level monitoring and isolated dynamic speaker monitoring for the 8 audio channel outputs.

Symmetrical Dutch doors, the upper halves with windows, allow the 1-inch high lighted digital display of the tuned carrier frequency to be readable at a distance and afford protection of the equipment against tampering and dust.

All major components are mounted on tilt-lock type drawer slides. Each rack has its own forced-air cooling system using squirrel cage blowers and washable air filters in the rack intake and exhaust.

The DDR-5L receiver configuration is designed for field conversion to a TMC remote-operated TechniMatic** receiver system.

*PEP = peak envelope power.

**Trademark applied for. See TMC sales brochures on TechniMatic tuning.

1-2. DESCRIPTION OF UNITS.

a. GENERAL. - Paragraphs b through i, below, give a brief description of the modular units used in one receiver system. For more detailed information pertaining to these units, refer to the individual modular-unit manuals.

b. CONTINUOUS RF TUNER, MODEL HFR 1A Continuous RF Tuner HFR provides coverage from 2 to 32 mc in eight bands and displays the tuned frequency on a 14-inch slide-rule dial. It converts the r-f signal to a first i-f of 1.75 mc. Using Control Synthesizer and Standard HFS with the HFR stabilizes the high frequency oscillator to a frequency stability of one part in 10^8 per day.

c. CONTROL SYNTHESIZER AND STANDARD, MODEL HFS-1. - Control Synthesizer and Standard HFS, monitors the HFO contained in the Continuous RF tuner HFR and provides the d-c correction voltages to maintain the free-running oscillator to a stability of one part in 10^8 per day. Tuning of the HFS is accomplished by bringing the carrier frequency up on the 1-inch high lighted numeral display by means of detented rotary switches. In diversity operation, the one HFS is used to control the high frequency oscillator of both receivers, providing synchronization of frequencies. In addition, the HFS furnishes highly stable 2-mc and 250-kc injection frequencies for Multiple Sideband Adapter MSA to be used in receiving a sideband signal with no carrier.

d. AUTOMATIC FREQUENCY CONTROL UNIT, MODEL AFC-3. - Automatic Frequency Control AFC is used in reception of reduced carrier signals. It effectively locks onto the carrier component of the signal and provides an altered i-f translating signal to Multiple Sideband Adapter MSA and an altered carrier injection signal to Mux Carrier Generator MCG and to Multiple Sideband Adapter MSA to compensate for frequency drift. By keeping the sideband-to-synthetic carrier frequency relationship true, the audio output of the receiver is maintained correct to within 1 cycle of the original transmitted tone. A memory circuit provides for momentary carrier fades.

e. MULTIPLE SIDEBAND ADAPTER, MODEL MSA-1. - Multiple Sideband Adapter MSA receives the carrier and sidebands from Continuous RF Tuner HFR in the 1.75 mc IF stage, separates the 4 channels and extracts the audio intelligence from each channel in product detector circuits. Injection frequencies for the four product detectors are obtained from Mux Carrier Generator MCG. Each channel has an adjustable AGC DECAY time and SQUELCH adjustment and a LINE LEVEL control. A non-loading channel monitoring circuit is also provided.

f. MUX CARRIER GENERATOR, MODEL MCG-1. - Mux Carrier Generator MCG provides the four injection frequencies for the product detectors of Multiple Sideband Adapter MSA. Two frequencies are for the direct channels (A1 and B1) in a 4-channel or 2-channel communication system. The other two frequencies are for the translated channels (A2 and B2). A front panel selector switch enables the operator to use the stabilized injection frequencies (2 mc and 250 kc) from the HFS unit (for reception of suppressed carrier signals) or to use the drift compensated injection frequencies from Automatic Frequency Control AFC (for reception of reduced carrier signals).

g. BRIDGING SPEAKER PANEL, MODEL BSP-6B. - Bridging Speaker Panel BSP has a dynamic speaker for each receiver system. Two 4-position rotary switches selects the output of each of the 8 channels for monitoring purposes.

h. POWER SUPPLY, MODEL HFP-1. - Power Supply HFP converts line voltage into regulated plate, regulated bias and filament voltages for one receiver system. It also supplies crystal ovens throughout the system with heater element voltages. The STANDBY position of the rear chassis switch is used to place the receiver system in standby condition when not being used. This condition provides crystal oven heater and high frequency oscillator filament voltages only, for maintained frequency stabilization.

i. UTILITY PANEL, MODEL HPP-1. - Utility Panel HPP, receives line voltage from the line voltage input. It contains two extension UTILITY sockets, in the front panel, for connecting the line voltage to auxiliary equipment used with the DDR-5L.

1-3. REFERENCE DATA.

Table 1-1 lists the reference data that is pertinent to the DDR-5L for one receiver system. For reference data concerning the modular units used in the DDR-5L, refer to the individual modular-unit manuals.

TABLE 1—1. DDR-5L, TECHNICAL SPECIFICATIONS

a. Frequency Range:	2 to 32 mc
b. Tuning:	In eight r-f bands as listed below: BAND 1 - 2-3 mc BAND 2 - 3-4 mc BAND 3 - 4-6 mc BAND 4 - 6-8 mc BAND 5 - 8-12 mc BAND 6 - 12-16 mc BAND 7 - 16-24 mc BAND 8 - 24-32 mc For synthesized operation, tuning is in 100 cps steps. For non-synthesized operation, with or without AFC, tuning is continuous.
c. Modes of Operation:	SSB, 2-channel or 4-channel ISB*, AM, MCW, FSK and FAX. Space diversity or single receiver.
d. Stability:	For synthesized operation, receiver frequency stability is 1 part in 10^8 for 24 hours for a change in ambient temperature within the limits of 0 to 50° C. For reception of reduced carrier signals (-30 db maximum), receiver stability is as described above with the addition of a transmitted carrier drift compensator (AFC) reducing the error in the audio output to within 1 cps. AFC will function at a maximum carrier drift rate of 10 cps per second and a total deviation of $\pm$750 cps. Memory circuit for signal fades

* All the other modes may be received simultaneously and in any combination on 4-channel ISB.
**With a 5-microvolt input signal at the antenna.

TABLE 1-1. DDR-5L TECHNICAL SPECIFICATIONS (CONT)

e. Audio Channel Widths:	3 kc, nominal, per channel.
f. Maximum r-f Bandwidth:	15 kc, symmetrical around carrier.
g. Noise Figure and Sensitivity:	6 db or better over the band, i.e., with a 1 uv signal and a 7.5-kc bandwidth, the output signal-to-noise ratio is 15 db or better.
h. Antenna Input Impedance:	Nominal 50 ohms, unbalanced.
i. Audio Outputs:	Four 3-kc wide channels for 600-ohm loads; 0-10 mw per channel.
j. Audio Response: (per channel)	Flat within ±1.5 db from 250 cps to 3-kc.
k. Multiplexed Channel Translation:	Displaced by 6.29 kc.
l. Intermodulation: (1 or 2-channel reception)	Intermodulation products are down 60 db from the maximum tone in the desired sideband as a result of two signals in the unwanted sideband.
m. Image Ratio:	80 db referenced to 1 uv input signal.
n. Spurious Response: (as defined by CCIR)	For synthesized operation, no greater than .01 uv when referred to the antenna.
o. IF Rejection:	Better than 80 db average.
p. AGC:	Four separate AGC systems, one for each channel, with an adjustable 1-10 second decay time for each channel. Output remains within ±1.5 db for a 60 db change in input within input range of 1 uv to 0.1 volt.
q. Audio Frequency Distortion:	Intermodulation products are better than 50 db below full output through the audio channel.
r. Hum Level:	Minus 50 db at full audio output.
s. Power Supply Requirements: (for both receivers)	1500 watts, average consumption. 115 VAC or 230 VAC, 50/60 cps, single phase.***
t. Ambient Temperature and Humidity:	0 to 50°C and up to 90% relative humidity.
u. Overall Dimensions:	69 inches high x 47 inches wide x 30 inches deep.

***Supplied wired for 115 VAC unless specified as otherwise on order.

TABLE 1—2. MILITARY NOMENCLATURE DDR-5L, COMPONENTS

TMC DESIGNATION		MILITARY NOMENCLATURE	
MODEL	NAME	NUMBER	NAME
HFR-1A	Continuous RF Tuner	TN-376A/UR	Tuner, Radio Frequency
HFS-1	Control Synthesizer and Standard	0-941/UR	Generator, Reference Signal
MSA-1	Multiple Sideband Adapter	CV-1865/FRR	Converter, Single Sideband
MCG-1	Mux Carrier Generator	0-1257/FRR	Generator, Reference Signal
AFC-3	Automatic Frequency Control	C-4099/FRR-60(V)	Control, Receiver
BSP-6B	Bridging Speaker Panel	LS-521/FRR-72	Loudspeaker Assembly
HPP-1	Utility Panel	SB-1866/FR	Panel, Power Distribution
HFP-1	Power Supply	PP-3341/FRR-60(V)	Power Supply
DDR-5L	Dual Diversity Receiver		

SECTION 2
INSTALLATION

2—1. UNPACKING AND HANDLING.

Inspect the DDR-5L packing cases for possible damage when it arrives at the operating site. With respect to equipment damage for which the carrier is liable, The Technical Materiel Corporation will assist in describing methods of repair and the furnishing of replacement parts. Inspect the packing material for parts that may have been shipped as loose items. Most of the cable assemblies used in the DDR-5L are mounted in the rack and taped in place.

2—2. RACK INSTALLATION.

Figure 2-1 shows overall dimensions, clearances and other installation data pertinent to locating the DDR-5L rack. The room or van in which the receiver is placed should have adequate ventilation.

2-3. POWER REQUIREMENTS.

The DDR-5L leaves the factory wired for 115 vac, 50/60 cps operation, unless otherwise specified on order. The receiver is also available for 230 volt, 50/60 cps operation on special order.

Average power consumption of the complete DDR-5L is approximately 1500 watts; 3-conductor shielded power cabling of sufficient size to provide 20 amperes at 115 VAC is adequate. Connect the power cable to the input of AF-103 Line Filter in the rear RECEIVER No. 1 rack. The connection points for the 3 conductors are No. 10 screw terminals.

2—4. ASSEMBLY OF RECEIVER.

a. INSTALLATION OF MODULAR UNITS. - Refer to figure 1-1 for information regarding location of all modular units. All major units are slide-mounted on tilt-lock drawer slides. To install any slide-mounted unit in its compartment, refer to figure 2-3 and proceed as follows:

(1) Untape or unstrap cable assemblies and all other components fastened to the rack frame for shipment.

CAUTION

Start by installing bottom units first per steps 2 through 6 in order to avoid rack tipping over from extended center of gravity.

(2) Pull center section of associated compartment track out until it locks in an extended position.

(3) Position slide mechanisms of modular unit in tracks, and ease modular unit forward into rack until release buttons engage holes in track.

(4) Make the necessary cable and electrical connections as described in paragraph 2-4b. To prevent the cables extending from the modular units from snagging, utilize the cable retractors located inside the rack in the rear (see figure 2-2).

(5) Depress release buttons and slide modular unit completely into compartment.

(6) Secure front panel of modular unit to rack with screws.

b. INTERCONNECTING CABLING. - Connect cabling as shown in the Interconnect Cabling Diagram in the appendix.

2—5. CONNECTION OF EXTERNAL EQUIPMENT.

a. ANTENNA. - Two antennas are required for space diversity operation. Each receiver in the DDR-5L is normally used with a sloping V, rhombic, or log-periodic antenna. The antenna input to the receiver is for a 50 ohms, unbalanced transmission line. Make both antenna connections at the vertical panel located inside RECEIVER No. 2 rack rear door on left. Connect RECEIVER No. 2 antenna to J8501 jack and RECEIVER No. 1 antenna to J8502 jack. Two TMC PL-156 type QDS plugs are supplied in shipment. (Use RG58/U cable or equivalent. UG-88/U type BNC

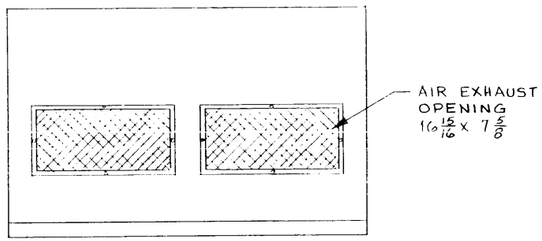
b. AUDIO LINES. - Connect audio output lines for channels A1, A2, B1 and B2 at the filter box inside RECEIVER No. 2 rear rack door as shown in figure 2-4.

2—6. INITIAL ADJUSTMENTS.

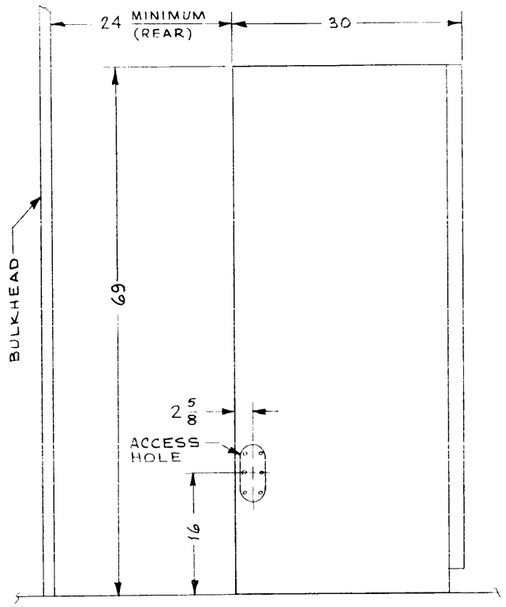
The DDR-5L has been factory tested and aligned as a complete system before disassembly for shipment. No initial adjustments of chassis-mounted variable components are necessary before operation.

2—7. DIVERSITY AGC CONNECTION.

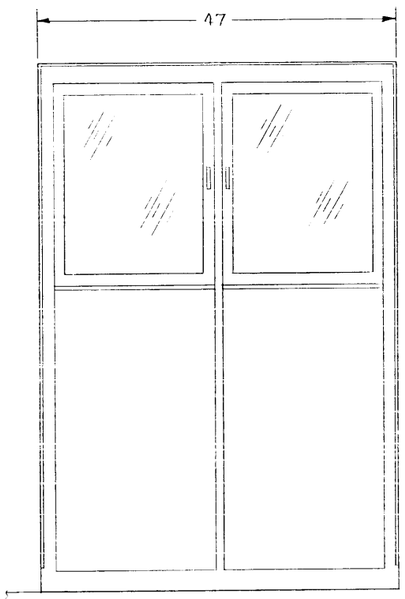
The two receivers of the DDR-5L are designed to work together in space diversity reception, sharing a common HFS unit, with or without AGC feedback outputs tied together. If the audio output arrangement is such that the interaction of AGC is desired, however, the tie-in is effected by the installation of a jumper wire between terminals 1 and 3 of terminal block TB8501 on the audio filter box located on the rear outer wall of RECEIVER No. 2 rack (see figure 2-4). Terminal 2 is for shield ground, if required.



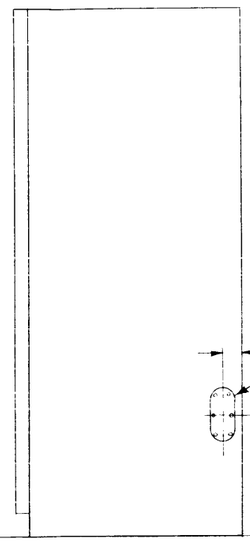
TOP VIEW



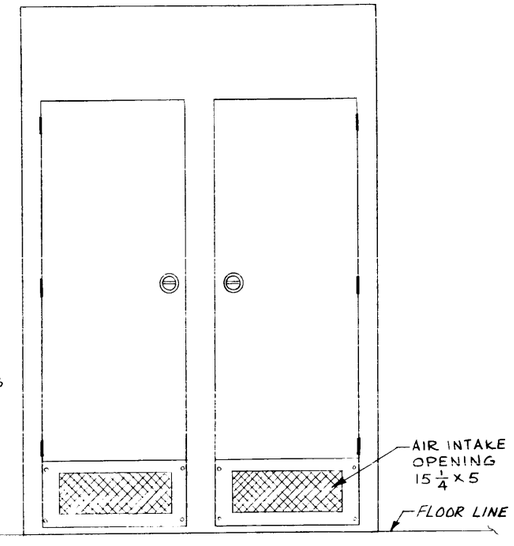
LEFT SIDE VIEW



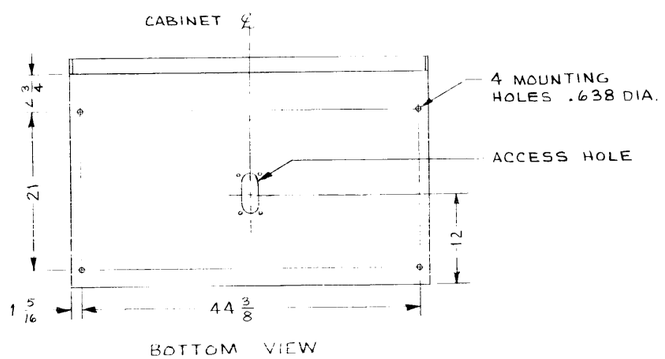
FRONT VIEW



RIGHT SIDE VIEW

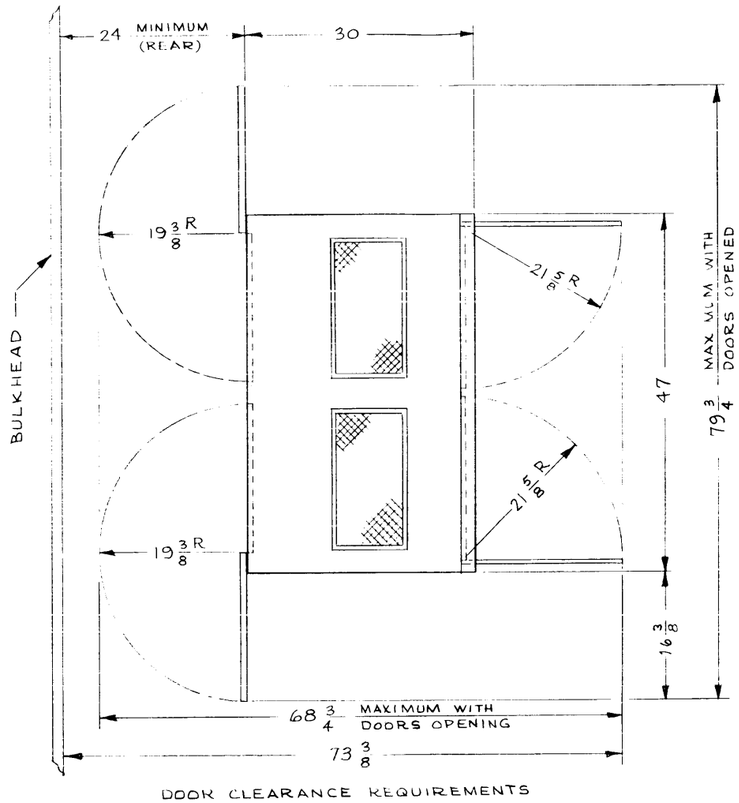


REAR VIEW

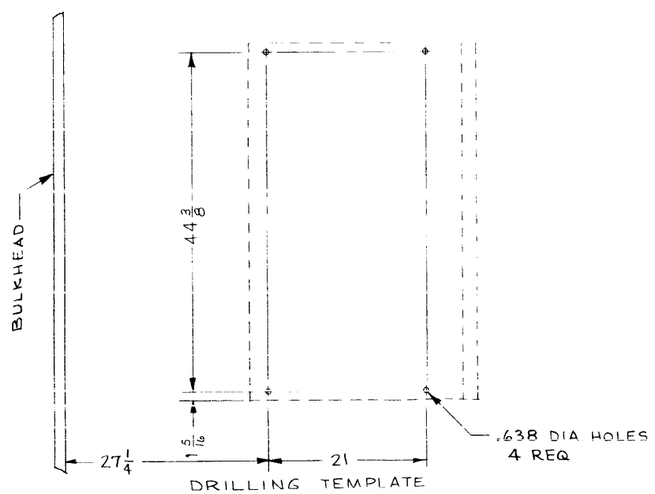


BOTTOM VIEW

Figure 2-1. Installation Dimensions, DDR-5L
(Sheet 1 of 2)



DOOR CLEARANCE REQUIREMENTS
TOP VIEW



DRILLING TEMPLATE

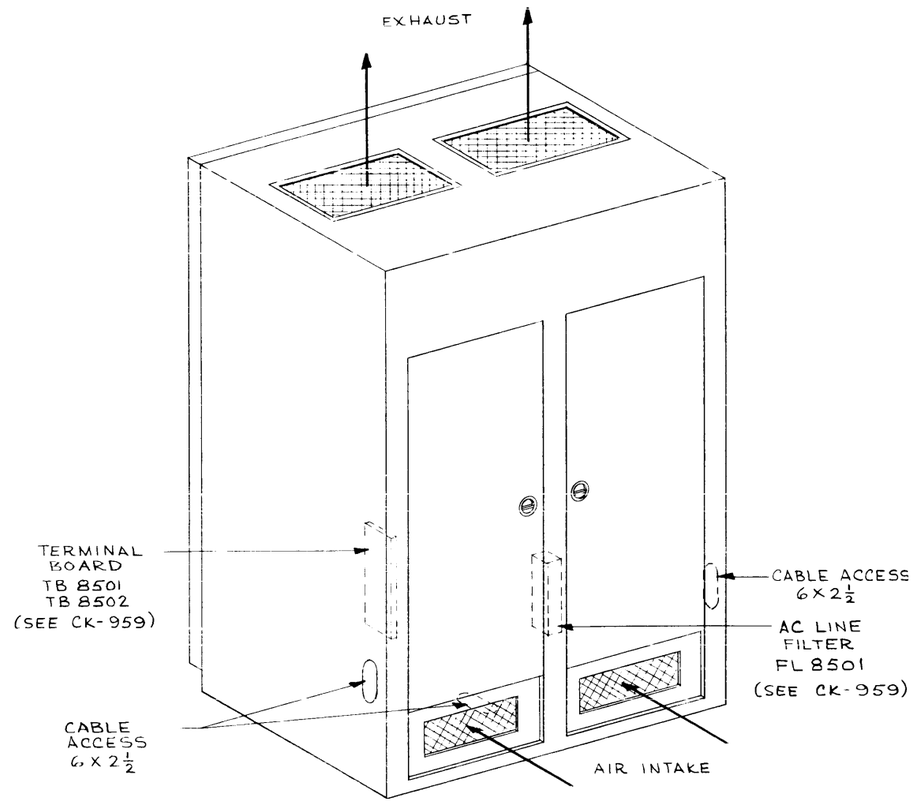


Figure 2-1. Installation Dimensions, DDR-5L
(Sheet 2 of 2)

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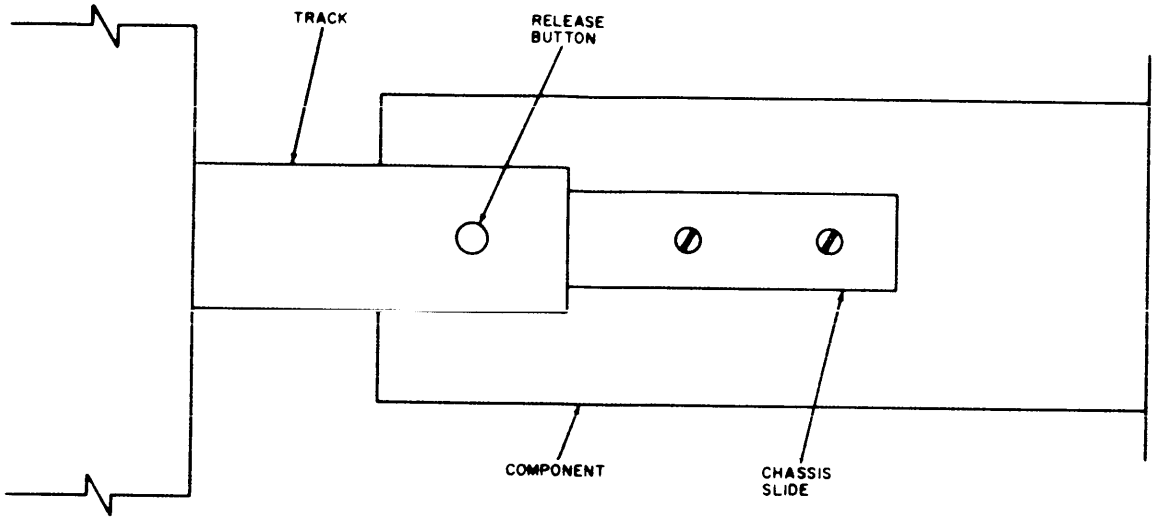
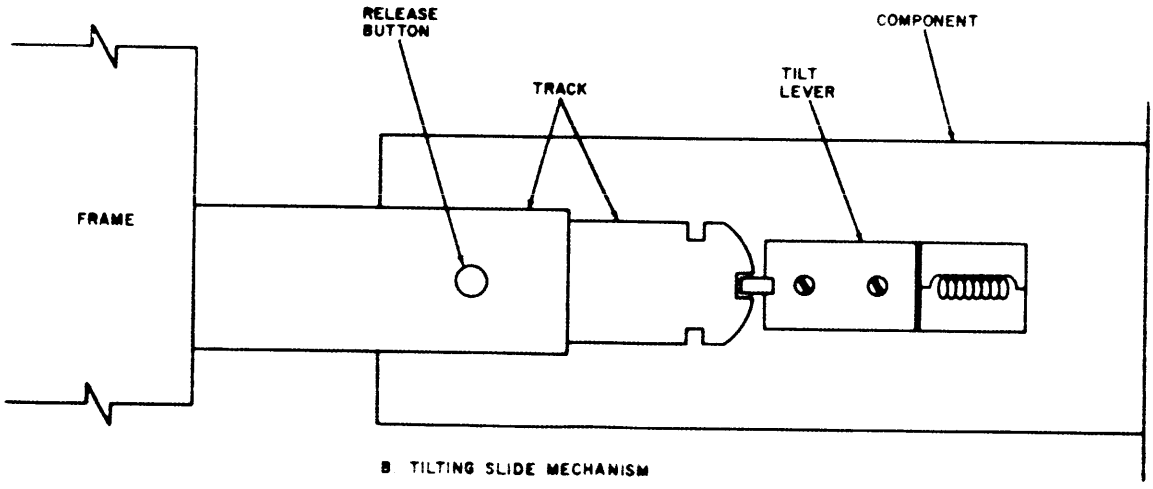


A. NON-TILTING SLIDE MECHANISM



B TILTING SLIDE MECHANISM

Figure 2-2. Slide-Mounting Details

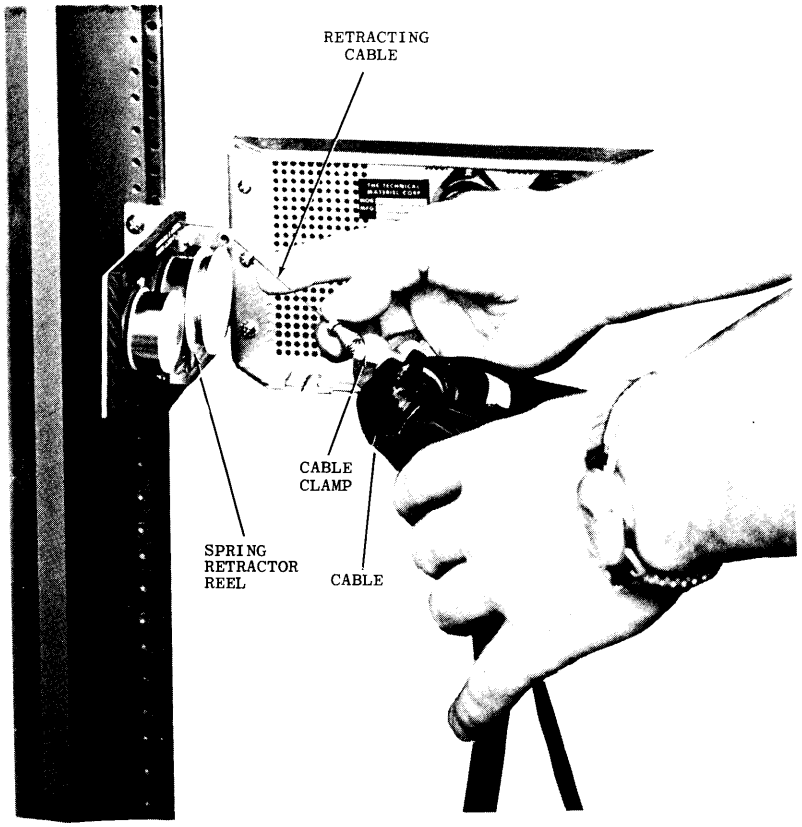


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Figure 2-3. Attaching Cable Retractor

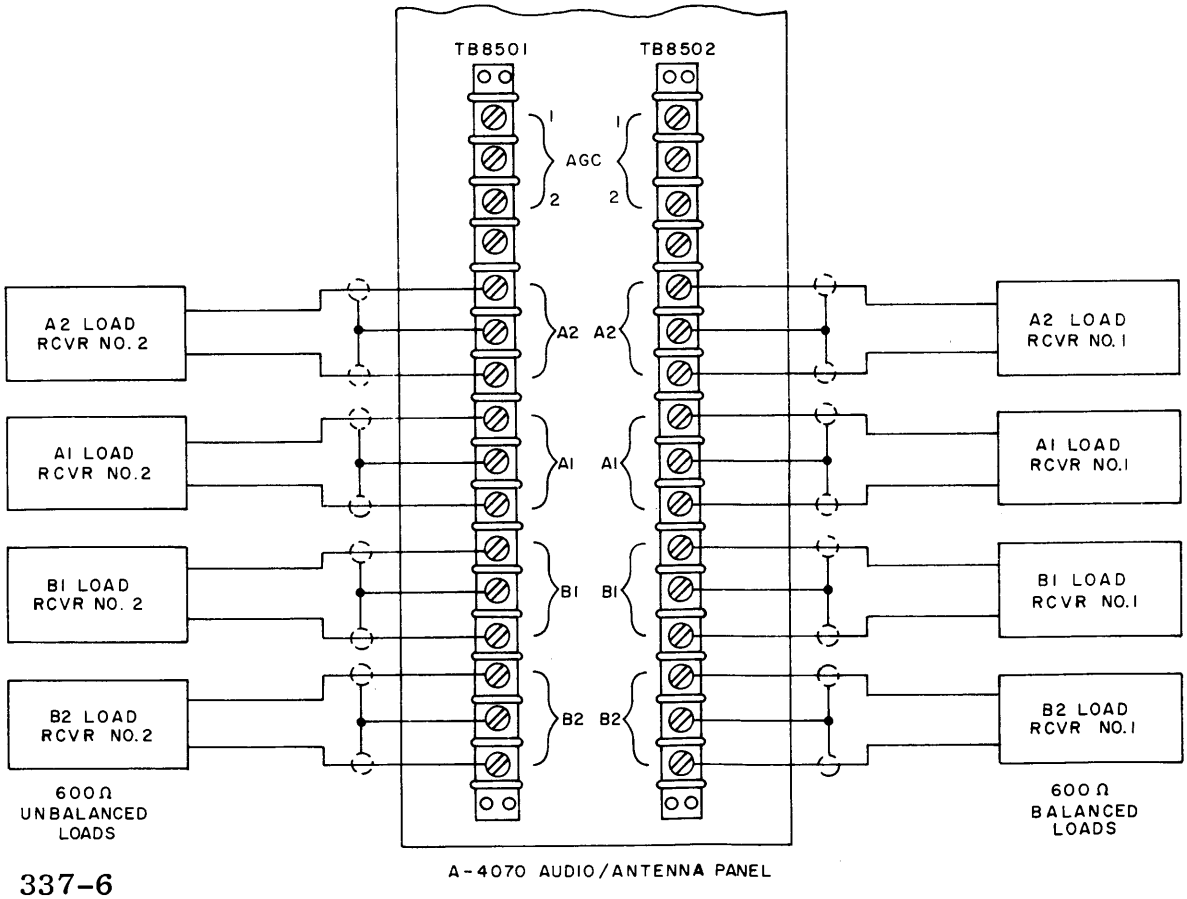

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Figure 2-4. Connection Diagram, Audio Loads

SECTION 3
OPERATOR'S SECTION

3—1. TUNING CAPABILITIES OF DDR-5L.

A review of paragraph 4-2 and figure 4-1, Simplified Functional Block Diagram will familiarize the operator with the functioning of modular components and resulting capabilities of the DDR-5L.

Operation of the DDR-5L falls into two main classifications: space diversity and single receiver.

In space diversity operation the receiver is capable of receiving up to 4 discrete voice channels symmetrical about one carrier and contained in the two sidebands of an ISB transmission. Each channel may contain any form of audio intelligence: voice, code, teletype, etc. In two-channel ISB transmission, the intelligence will appear at the direct channel outputs, A1 and B1. In four-channel multiplexed ISB, in additional to A1 and B1, the translated channels will appear at A2 and B2 outputs. A single AM or MCW transmission signal may be received by using the output of A1 or A2, whichever sideband gives the best reception. A SSB transmission will result in an A1 output, for an upper sideband transmission, or a B1 output for a lower sideband transmission. A single FSK or FAX transmission, (without a carrier component) requires that the receiver be tuned either higher or lower than the r-f center frequency in order to have audio mark and space frequencies emerge at A1 or B1 output, respectively. One or more AFSK or AFAX signals transmitted as SSB or ISB will appear at the channel output similar to its channel origin at the transmitter. One or more MCW codes sent as keyed tones appearing in the sidebands of an SSB or ISB transmission will appear as keyed audio tones in the channel or channels as originated at the transmitter end. In all SSB and ISB transmissions with a reduced carrier (no more than 30 db below PEP) and in all AM or MCW transmissions, the carrier component in the signal may be used in Automatic Frequency Control to compensate for signal drift. In SSB and ISB transmissions with no carrier component present, the AFC cannot be used; the same is true for FSK or FAX signal transmissions since there is no carrier component to lock onto. In most cases, if the transmitter is synthesized (with a correction loop for its oscillator similar to that of the HFS) the incoming signal remains stable enough that (using the HFS) AFC is not required. In all diversity operations, the one HFS Control Synthesizer and Standard is used to furnish required synchronization of the high frequency oscillators contained in the two HFR units. Therefore, tuning coverage is in 100 cps steps since this is the synchronizing adjustment points of the HFS.

In single-receiver operation, each receiver may be tuned to a different carrier, either simultaneously or separately. The capabilities of the single receiver are the same as those for the diversity operation, except that Control Synthesizer and Standard HFS can be used with Receiver No. 1 only. In RECEIVER No. 1, the HFS may be used or not, as transmitting stability conditions require. When the HFS is not used, the HFR has continuous tuning coverage.

In summation, the DDR-5L can simultaneously receive 4 channels of an assortment of intelligence, in diversity, from one ISB transmission. The economy of this communication system is the large saving in transmitter power over separate transmissions. In addition, the DDR-5L is capable of receiving other types of transmission, as previously outlined. For simplicity, the following operating instructions in Table 3-1 are in terms of receiving a 4-channel multiplexed ISB signal, in diversity, with and without the AFC. Following the table are notes on tuning-in other types of signals.

3—2. OPERATING PROCEDURE.

a. INITIAL WARM-UP OF OVENS. - Before operating the DDR-5L for the first time, the receivers (RECEIVER No. 1 and RECEIVER No. 2) require an initial warm-up period in order to stabilize the oscillator oven temperatures. To do this, set all modular unit power switches at OFF or STANDBY, then set MAIN POWER OFF/STANDBY switches on the rear of each HFP Power Supply chassis at STANDBY. HFP STANDBY lamps will light. Leave the DDR-5L in standby condition for 24 hours before operating it.

b. TUNING FOR 4-CHANNEL ISB IN DIVERSITY. - Table 3-1 is the procedure for tuning the DDR-5L for receiving a 4-channel multiplexed ISB transmission in diversity operation. Locations of RCVR No. 1 and No. 2 modular units are shown in figure 1-1.

c. TUNING FOR 2-CHANNEL ISB IN DIVERSITY. - Follow the same procedure as that in Table 3-1. Outputs will appear on channels A1 (for the upper sideband) and B1 (for the lower sideband) instead of A1, A2, B1 and B2.

d. TUNING FOR AM OR MCW IN DIVERSITY. - Follow the same procedure as that in Table 3-1. Automatic frequency control may be used if desired. The intelligence will appear both at channel A1 and channel B1 outputs. Select the output that gives the clearest reception for each receiver.

e. TUNING FOR SSB IN DIVERSITY. Follow the same procedure as that in Table 3-1. Upper sideband intelligence will appear at channel A1 output; lower sideband intelligence will appear at channel B1.

TABLE 3—1. TUNING FOR 4-CHANNEL ISB, DIVERSITY OPERATION, DDR-5L

STEP	OPERATION
1 (BOTH RCVRS)	With the DDR-5L initial oven warm-up completed, set both MSA POWER switches at ON. HFP STANDBY lamp will go out and HFP TIME DELAY lamp will light. After 60 seconds, the TIME DELAY lamp will go out and the HFP OPERATE lamp will light. Then proceed to step 2.
2 (BOTH RCVRS)	Set HFR NOISE SILENCER/OFF/ALIGNMENT SIGNAL switch to OFF, AFC TUNING/KCS knob at 0, AFC CARRIER SELECTOR switch at OSC, AFC SENSITIVITY knob fully ccw, MCG SYN/AFC/INT switch at SYN, MSA A1, A2, B1 and B2 AGC DECAY knobs fully cw, SQUELCH ADJUST knobs fully ccw and LINE LEVEL knobs fully cw, and BSP RECEIVER 1 INCR knob to mid-position.
3 (RCVR#1)	Set MC, 100KC, 10KC, 1KC and .1KC switches on HFS so that desired carrier frequency is displayed on HFS nixie indicators.
4	Set RECEIVER switch on BSP at A1. Set TUNE/SYNC/OPERATE switch on HFR at SYNC. Set BAND switch on HFR so that band that includes desired frequency appears in MEGACYCLES window. Turn TUNE control on HFR to obtain zero beat; pointer on MEGACYCLE dial should indicate desired frequency.
5	Set TUNE/SYNC/OPERATE switch of HFR at OPERATE, and adjust TUNE control to obtain center-scale indication on SYNCHRONIZE meter.
6	Adjust LINE LEVEL and AGC DECAY ADJUST controls on MSA for desired output level (0 VU indication on output meter is recommended) and agc decay periods.
7 (RCVR#2)	Set TUNE/SYNC/OPERATE switch on HFR at TUNE. Set BAND switch as outlined in step 4 above. Rotate control TUNE control so that MEGACYCLES dial indication is identical to that on RECEIVER No. 1.
8	Set controls on MSA as in step 6 above. With BSP RECEIVER switches, check that audio outputs of the two receivers are the same. If necessary, adjust TUNE control of HFR (Receiver No. 2) so that audio outputs of Receiver No. 2 are identical with corresponding audio outputs of Receiver No. 1.
9 (BOTH RCVRS)	Monitor all 4 channels with the BSP RECEIVER switches. If noise of the impulse type is encountered in any of the channels, try the HFR NOISE SILENCER/OFF/ALIGNMENT switch in the NOISE SILENCER position to eliminate it.
10 (BOTH RCVRS)	On each channel, during periods of no incoming signal, adjust MSA SQUELCH ADJUST for point just before the MSA CHANNEL light goes out.
	NOTE If a carrier component is present in the signal with an amplitude over 30 db below PEP, the AFC unit may be used to compensate for transmitter instability. Using the AFC reduces the error in the audio output to within 1 cps. If using the AFC, proceed to step 11; if not using the AFC, the tuning procedure is completed.
11 (BOTH RCVRS)	Set MCG SYN/AFC/INT switch at AFC. With TUNING/KCS knob set at 0 and CARRIER SELECTOR switch at OSC, turn SENSITIVITY knob fully clockwise. Observing CARRIER LEVEL meter, hold down RESET button and adjust TUNING/KCS knob to obtain peak on CARRIER LEVEL meter. Release RESET button. Monitor all signals in all 4 channels, with the BSP containing changing frequencies (i.e.: voice, FSK, etc.)

TABLE 3—1. TUNING FOR 4-CHANNEL ISB, DIVERSITY OPERATION, DDR-5L (CONT)

STEP	OPERATION
11 (BOTH RCVRS) (cont)	while observing the AFC DRIFT meter. Needle will remain steady through tone frequency variations if the AFC is locked onto the carrier. If the needle varies with the tone changes, the AFC is locked onto one of the sidebands and the process should be repeated. If one of the channels contains a keyed (intermittent) tone, monitor this tone with the BSP and observe the AFC CARRIER LEVEL meter. If the needle varies with the keying, the AFC is locked onto the keyed tone and the process should be repeated. **NOTE** If there is a steady tone telegraph signal in one of the channels and if step 3 was not executed properly, it is possible to lock the AFC onto the tone instead of the carrier. If this has happened, it will show up as an unsteady indication on CARRIER LEVEL meter when the tone becomes keyed. In this case, repeat process from step 3.

f. TUNING FOR SINGLE FSK OR FAX IN DIVERSITY. - Connect channel A1 or B1 outputs to teletype or FAX audio-to-pulse converter (see paragraph 3-1). Follow the same procedure as that in Table 3-1, tuning either slightly higher or lower than the transmitter center frequency. Do not use the AFC unit.

g. TUNING FOR ALL MODES, SINGLE RECEIVER. - Follow the procedure as outlined in Steps 1 through 6 in Table 3-1 and paragraphs 3-2c through 3-2h, using RECEIVER No. 1 for synthesized reception (using the HFS). For non-synthesized reception (without the HFS), either RECEIVER No. 1 or No. 2 may be used. For non-synthesized reception, set TUNE SYNC OPERATE switch on the HFR at TUNE. TUNE HFR until upper sideband of desired signal appears in channel A1 or lower sideband of desired signal appears is channel B1. Automatic frequency control may be employed as outlined in step 11 of Table 3-1.

h. PLACING RECEIVER IN STANDBY. - After operating the DDR-5L, either one or both receivers may be set in standby condition. For each receiver, set the MSA POWER switch and HFP MAIN POWER switch both to their STANDBY positions. In this condition, the receiver draws line voltage current for its oscillator oven heating elements and HFO filament only, thus stabilizing the HFR, AFC and MCG oscillator frequencies.

SECTION 4
PRINCIPLES OF OPERATION

4-1. INTRODUCTION.

This section describes the major functions of the modular components in the DDR-5L system. For a more detailed analysis of each module, refer to the individual modular-unit manual.

4—2. SIMPLIFIED FUNCTIONAL ANALYSIS.

(See figure 4-1.)

A 2- to 32 mc signal, including partial or suppressed carrier and sidebands (shown here for 4-channel ISB), enters the HFR r-f tuner section and proceeds to the mixer. An adjustable high frequency oscillator (HFO) injects a 3.75 to 33.75 mc frequency into the mixer. The TUNE control which tunes the r-f amplifier stages is ganged to the HFO adjustment in such a way as to produce an i-f signal centered at 1.75 mc at the output of the mixer. The sidebands at the output of the mixer are inverted in the frequency spectrum; this situation is corrected in the second mixer (in the MSA) where the 1.75 mc i-f is mixed with a 2-mc injection frequency to produce a second i-f signal centered at 250-kc. The second mixer stage reinverts the i-f signal, placing the sidebands in their original positions in the spectrum. At this point, the translated channel B2, in the lower sideband, runs from approximately 243 kc to 246 kc, direct channel B1 from 246.5 kc to 249.5 kc, direct channel A1 in the upper sideband from 250.5 kc to 253.5 kc and translated channel A2 from 254 kc to 257 kc. The entire spectrum is introduced to four tuned i-f amplifier stages which also contain bandpass filters. The effect of the filters is to pass the four channels on to individual product detector circuits, at the same time blocking the carrier frequency component. Signals of the direct channels, A1 and B1, get mixed with 250 kc (from the MCG unit) in product detectors to produce the nominal .5 kc to 3 kc difference audio outputs. Channel A2, the upper sideband translated channel is mixed with a 256.29 kc injection frequency to produce the original .5 kc to 3 kc audio input into the transmitter. Channel B2, the lower sideband translated channel, is mixed with a 243.71 kc injection frequency to produce the .5 kc to 3 kc. A selector switch connects a speaker to each one of the channel outputs through an amplifier to provide isolated monitoring while tuning.

The MCG supplies the four injection frequencies to the MSA product detectors. The SYN/AFC/INT switch affords a selection of 3 sources for the basic 2 mc and 250-kc injection signals. In SYN position, these two signals are taken from the HFS, referenced to the highly stable 1 mc frequency standard. If the AFC feature is required, due to shifting transmitter frequencies or other signal drifting conditions, the switch is set at AFC and the two signals originate in the AFC unit with suitable deviations to compensate for the drift. The AFC works from an input of the reduced 250-kc carrier. The INT position of the switch, in which the MCG crystal oscillators may be used, should only be used in case of failure in the HFS. The 250 kc signal, regardless of its source, is fed into a mixer in the MCG where it is heterodyned with a 6.29-kc oscillator output to produce a sum frequency of 256.29-kc and a difference frequency of 243.71 kc. Narrow band-pass filters in the mixer output separate and direct the two signals to the proper product detectors.

The HFS also uses its stabilized 1-mc frequency standard to provide a correction loop for stabilizing the high frequency oscillator (HFO) in the HFR. A sample of the 3.75- to 33.75-mc HFO output is used by the HFS to indicte any frequency deviation from the correct HFO output. A d-c correction is then produced from a phase detector to bring the HFO back to its correct frequency. The HFS also produces an audio sync tone to aid the operator in tuning the HFR into the "capture range" of the phase detector. The sync tone comes out at the MSA A1 MONITOR headset jack output.

The combined AGC of each channel is fed back to the r-f input to prevent intermodulation between channels that sometimes occurs from strong signals in 4-channel ISB.

In diversity operation, the HFO output of RECEIVER #1 HFR unit (called the "master" unit) is used for its own mixer injection frequency and the injection frequency of the "slave" HFR mixer in RECEIVER #2, as well. This synchronizes the 1.75 mc from both receivers to the MSA mixers. A further synchronization is had from the common 2-mc and 250-kc injection frequencies from the HFS through the MCG switches in their SYN positions. This ensures that their is no deviation in frequency between the two receiver audio outputs. Setting the MCG switches at AFC also ensures similar audio outputs since both AFC units correct as a result of a common transmitted signal drift.

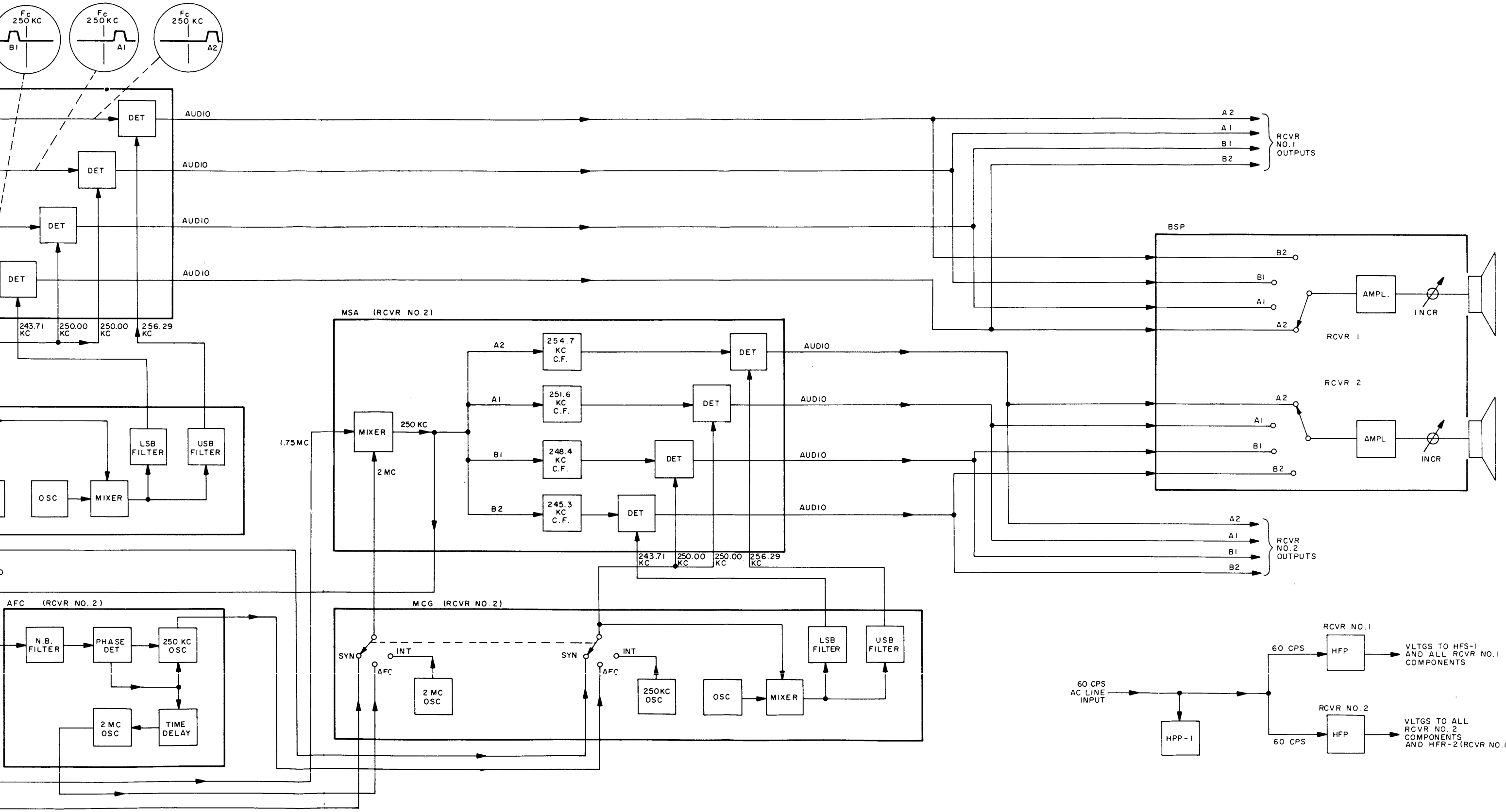
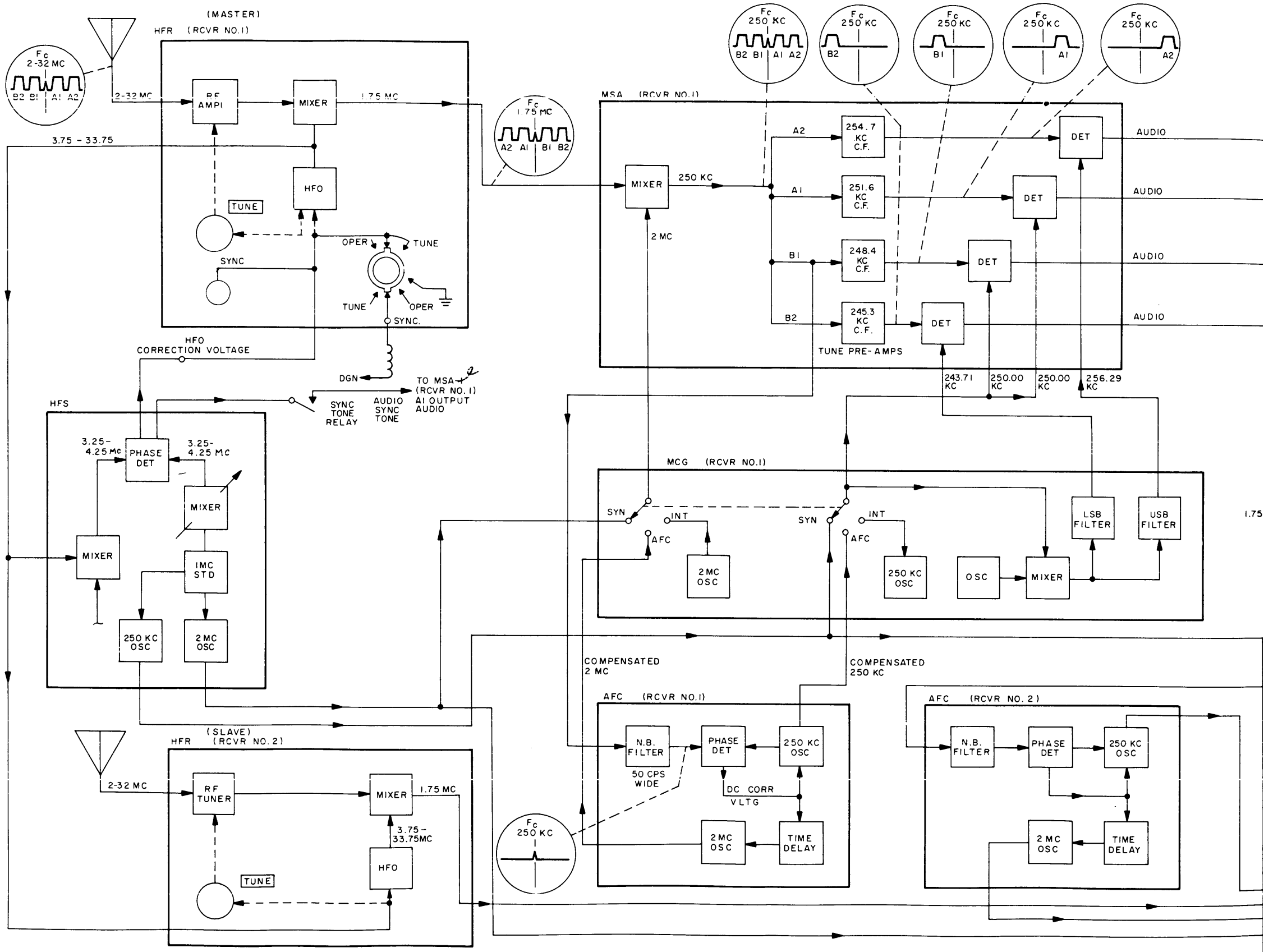


Figure 4-1. Simplified Functional Block Diagram, Model DDR-5L



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SECTION 5
MAINTENANCE

5-1. GENERAL.

This section includes preventive maintenance, troubleshooting and alignment procedures for the DDR-5L system as a whole. Preventive maintenance, troubleshooting and alignment procedures for the individual modular units are found in the modular unit manuals.

5—2. SPECIAL TOOLS AND TEST EQUIPMENT.

Special tools required for DDR-5L maintenance are described in the Appendix to this manual. Table 5-1, in this section, lists the standard laboratory test equipment required for DDR-5L alignment and maintenance.

TABLE 5-1. TEST EQUIPMENT, DDR-5L

ITEM	MANUFACTURER
Frequency Counter	Hewlett Packard, Model 524C, or equivalent
Signal Generator	Measurements, Model 82, or equivalent
Vacuum Tube Voltmeter	Hewlett Packard, Model 410B, or equivalent
R-f Voltmeter*	Ballantine Laboratories, Model 314, or equivalent

*If an r-f voltmeter is not available, use the VTVM listed above, with an r-f probe.

5-3. PREVENTIVE MAINTENANCE.

a. GENERAL. - The DDR-5L has been designed to provide long-term, trouble-free operation under continuous duty conditions. However, similar to any other piece of equipment that contains assemblies of many electrical and mechanical parts optimum performance and service life of the DDR-5L are dependent upon an adequate preventive maintenance schedule that is strictly adhered to.

b. CLEANING AND INSPECTION. - At periodic intervals (at least every six months) each modular unit should be removed from the cabinet for cleaning and inspection. All accessible covers should be removed and the wiring and all components inspected for dirt, corrosion, charring, discoloring, or grease; in particular, the tube sockets should be carefully inspected for deterioration. Dust may be removed with a soft brush or a vacuum cleaner if one is available. Remove dirt or grease from electrical parts with trichloroethylene. Remove dirt or grease from other parts with any good dry cleaning fluid.

WARNING

When using trichloroethylene, make certain that adequate ventilation exists. Avoid prolonged contact with skin.

Carefully inspect equipment for loose solder connections or screws, especially those on solder lugs. Tighten and resolder connections as required.

c. REPLACEMENT OF ELECTRON TUBES. - While the modular units are out of the cabinet for periodic inspection, all electron tubes should be checked and replaced as required. Particular attention should be paid to the following:

(1) When withdrawing miniature tubes from their sockets, pull them straight out; do not rock or turn them. If pins of miniature tubes are bent, straighten them with a proper pin straightener before replacing the tube.

(2) Some circuits, for example oscillator circuits, may function better with one tube than with another even though both tubes are new or both tubes measure the same when checked on a tube tester.

(3) Tubes should not be replaced or discarded merely because they have been used for some time. Satisfactory operation in a circuit is the final proof of tube quality; the tube in use may work better than a new tube.

d. GEAR LUBRICATION. - Examine all gears and gear assemblies contained in the modular units. If any of the gears show signs of becoming dry, coat them heavily with a molybdenum disulphide compound such as Molykote Type G made by the Alpha Corporation of Greenwich, Conn.

5-4. TROUBLESHOOTING.

Troubleshooting the DDR-5L consists of two phases: the first is to locate the faulty modular unit, the second is to locate the faulty component within the modular unit. Procedures for the first phase are outlined in this section. The second phase is covered in the individual modular-unit manuals.

Block diagram figure 4-1 and the tuning procedure outlined in Table 3-1 will serve as an aid in localizing troubles. Any indicator that fails to respond in the Table 3-1 procedure will usually reveal the faulty

unit. Additional troubleshooting hints are given in Table 5-2. In the case of a repeatedly blown fuse, refer to Figure 5-1 and Table 5-3 for fuse vs. circuit.

For tracing wiring, refer to rack inter-module wiring in the Appendix and Technical Manuals for the modules.

TABLE 5—2. FAULTY UNIT LOCATION, DDR-5L

TROUBLE	UNIT
No power in entire system	AF-103 Line Filter
No power in one receiver system	HFP-1 for receiver system
Fuse cap lit in HFP (indicates blown fuse)	See Table 5-3 for fuse vs. unit
No audio sync tone available	MSA A1 audio, SYNC TONE relay or HFS phase detector
No sync indication on HFR SYNC IND light or SYNCHRONIZE meter	HFS or HFO in HFR (RCVR#1)
Not possible to lock AFC onto carrier	HFS or AFC
No audio output	MSA or AFC
No audio output in channels A2 and B2	MCG

TABLE 5—3. FUSE FUNCTIONS, DDR-5L

FUSE LOCATION IN FIGURE 5-1	RATING	HFP-1 SCHEMATIC WIRING SYMBOL	CIRCUIT PROTECTED
1	4A/115V 2A/230V	F8003	Line voltage for oscillator ovens in HFR, MCG, HFS and AFC, RCVR#1
2	4A/115V 2A/230V	F8004	Line voltage for oscillator ovens in HFR, MCG, HFS and AFC, RCVR#1
3	3/4A	F8007	Input to "A" B+ regulator circuit in HFP, RCVR#1
4	2A/115V 1A/230V	F8005	Utility line to J8004 in HFP, RCVR#1
5	3/4A	F8008	Input to "B" B+ regulator circuit in HFP, RCVR#1
6	1/10A	F8006	Input to bias supply circuit in HFP, RCVR#1
7	15A/115V 7.5A/230V	F8001	Main line voltage input to HFP & MSA Blower, RCVR#1
8	15A/115V 7.5A/230V	F8002	Main line voltage input to HFP & MSA Blower, RCVR#1
9	.5A*	F8019	"A" B+ to MSA and Audio Sync Tone Relay, RCVR#1
10	.375A	F8012	"A" B+ to HFS, RCVR#1
11	.125A	F8010	"B" B+ (No Connection)
12	4A	F8009	Filament supply (No Connection)

*Changed from .375A rating in standard HFP-1.

TABLE 5—3. FUSE FUNCTIONS, DDR-5L (CONT)

FUSE LOCATION IN FIGURE 5-1	RATING	HFP-1 SCHEMATIC WIRING SYMBOL	CIRCUIT PROTECTED
13	5A	F8015	Filament supply to AFC, RCVR#1
14	15A	F8011	Filament supply to HFS, RCVR#1
15	.250A	F8016	"B" B+ to MCG, RCVR#1
16	.125A	F8014	"B" B+ (No Connection)
17	.250A	F8018	"B" B+ (No Connection)
18	10A	F8020	Filament supply to MSA, RCVR#1
19	10A	F8013	Filament supply to MCG, RCVR#1
20	8A	F8017	Filament supply HFR , RCVR#2
21	4A/115A 2A/230V	F8003	Line voltage to oscillator ovens in HFR, MCG, HFS and AFC, RCVR#2
22	4A/115V 2A/230V	F8004	Line voltage to oscillator ovens in HFR, MCG, HFS and AFC , RCVR#2
23	3/4A	F8007	Input to "A" B+ regulator circuit in HFP
24	2A/115V 1A/230V	F8005	Utility line to J8004 in HFP, RCVR#2
25	3/4A	F8008	Input to "B" B+ regulator circuit in HFP, RCVR#2
26	1/10A	F8006	Input to bias supply circuit in HFP, RCVR#2
27	15A/115V 7.5A/230V	F8001	Main line voltage input to HFP & MSA blower, RCVR#2
28	15A/115V 7.5A/230V	F8002	Main line voltage input to HFP & MSA blower, RCVR#2
29	3/8A	(BSP) (F101)	Left speaker (RCVR#1)
30	3/8A	(BSP) (F102)	Right speaker (RCVR#2)
31	.5A*	F8019	"A" B+ to MSA, RCVR#2
32	.375A	F8012	"A" B+ to HFR, RCVR#1
33	.125A	F8010	"B" B+ (No Connection)
34	4A	F8009	Filament supply (No Connection)
35	5A	F8015	Filament supply to AFC, RCVR#2
36	15A	F8011	Filament supply to HFR, RCVR#1
37	.250A	F8016	"B" B+ to MCG, RCVR#2
38	.125A	F8014	"B" B+ (No Connection)

*Changed from .375A rating in standard HFP-1.

TABLE 5—3. FUSE FUNCTIONS, DDR-5L (CONT)

FUSE LOCATION IN FIGURE 5-1	RATING	HFP-1 SCHEMATIC WIRING SYMBOL	CIRCUIT PROTECTED
39	.250A	F8018	"B" B+ (No Connection)
40	10A	F8020	Filament supply to MSA, RCVR#2
41	10A	F8013	Filament supply to MCG, RCVR#2
42	8A	F8017	Filament supply to HFR, RCVR#2
43	10A/115V 5A/230V	(HPP) F9401	HPP UTILITY OUTLETS
44	10A/115V 5A/230V	(HPP) F9402	HPP UTILITY OUTLETS

5—5. REPAIR.

Repair procedures and replaceable electrical parts lists for the HFR, HFS-1, AFC-3, MSA-1, MCG-1, and HFP-1 may be found in the modular Technical Manuals for these units. Repair of the rack interconnecting cabling wiring, audio/antenna panel, audio sync tone relay and HPP-1 consists of replacing electrical parts or repairing wiring. Parts lists and wiring schematics for these areas are included in the Appendix to this manual.

5—6. ALIGNMENT AND ADJUSTMENT. The alignment and adjustment procedures for Continuous RF Tuner HFR given in this section utilize the Control Synthesizer and Standard HFS and the audio sync tone generated by the HFS and issuing at Receiver 1 channel A1 output. With the exception of the procedures given in paragraphs (a), (b), and (c) below, all alignment and adjustment is accomplished on an individual modular unit basis. Refer to the appropriate modular-unit manual for the necessary alignment or adjustment procedures.

a. ALIGNMENT OF HFO CIRCUITS OF CONTINUOUS RF TUNERS HFR NO. 1 and HFR NO. 2. Proceed as follows:

NOTE

For the sake of brevity and clarity in this procedure, the modular units contained in receiver 1 are designated HFR No. 1, MSA No. 1, etc. The modular units contained in receiver 2 are designated HFR No. 2, MSA No. 2, etc.

(1) Set DDR-5L controls as listed in step (1) of paragraph 3-2b.

(2) Set Control Synthesizer and Standard HFS nixie selectors for 2.0 mc.

(3) Carefully tune HFR No. 1 for zero beat at 2.0 mc. If zero beat is obtained with dial pointer of HFR No. 1 exactly at 2.0 mc, no adjustment is necessary. If zero beat is not obtained with dial pointer exactly at 2.0 mc, insert alignment tool TP-115 in rear orifice on top of HFO oven of HFR No. 1, and adjust oscillator trimmer until zero beat obtained.

(4) Set NOISE SILENCER/OFF/ALIGNMENT SIGNAL switch of HFR No. 2 at ALIGNMENT SIGNAL.

(5) Carefully tune HFR No. 2 for a null at 2.0 mc. If null is obtained with dial pointer of HFR No. 2 exactly at 2.0 mc, no adjustment is necessary. If null is not obtained with dial pointer exactly at 2.0 mc, insert alignment tool in rear orifice on top of HFO oven of HFR No. 2, and adjust oscillator trimmer until null is obtained.

(6) Set NOISE SILENCER/OFF/ALIGNMENT SIGNAL switch HFR No. 2 at OFF, and set HFS nixie selectors for 3.0 mc.

(7) Carefully tune HFR No. 1 for zero beat at 3.0 mc. If zero beat is not obtained with dial pointer exactly at 3.0 mc, insert alignment tool TP-114 in front orifice on top of HFO oven of HFR No. 1, and adjust HFO trimmer until zero beat is obtained.

(8) Set NOISE SILENCER/OFF/ALIGNMENT SIGNAL switch of HFR No. 2 at ALIGNMENT SIGNAL.

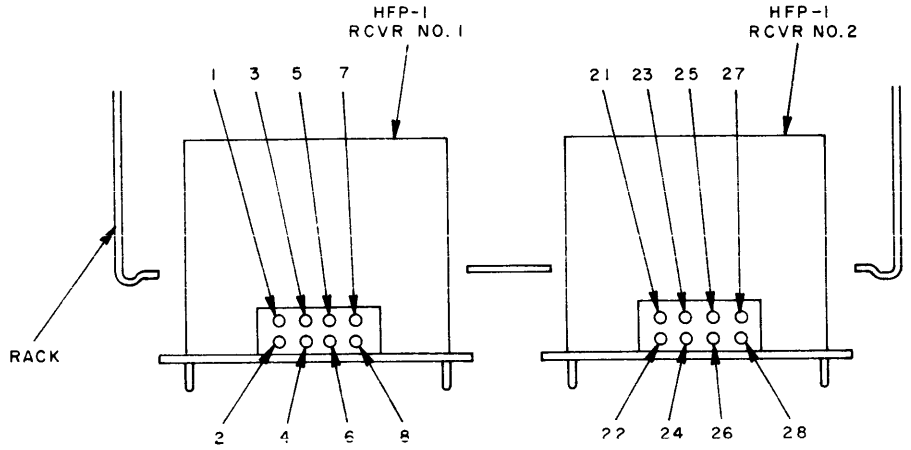
(9) Carefully tune HFR No. 2 for a null at 3.0 mc. If null is not obtained with dial pointer exactly at 3.0 mc, insert alignment tool TP-114 in front orifice on top of HFO oven of HFR No. 2, and adjust HFO trimmer until null is obtained.

(10) Repeat steps (2) through (9) above until no further adjustment is necessary.

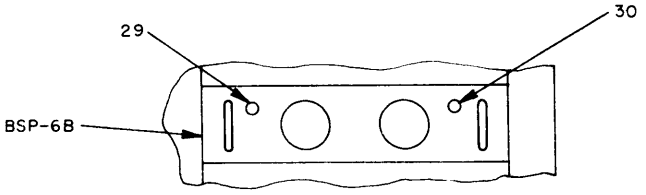
CAUTION

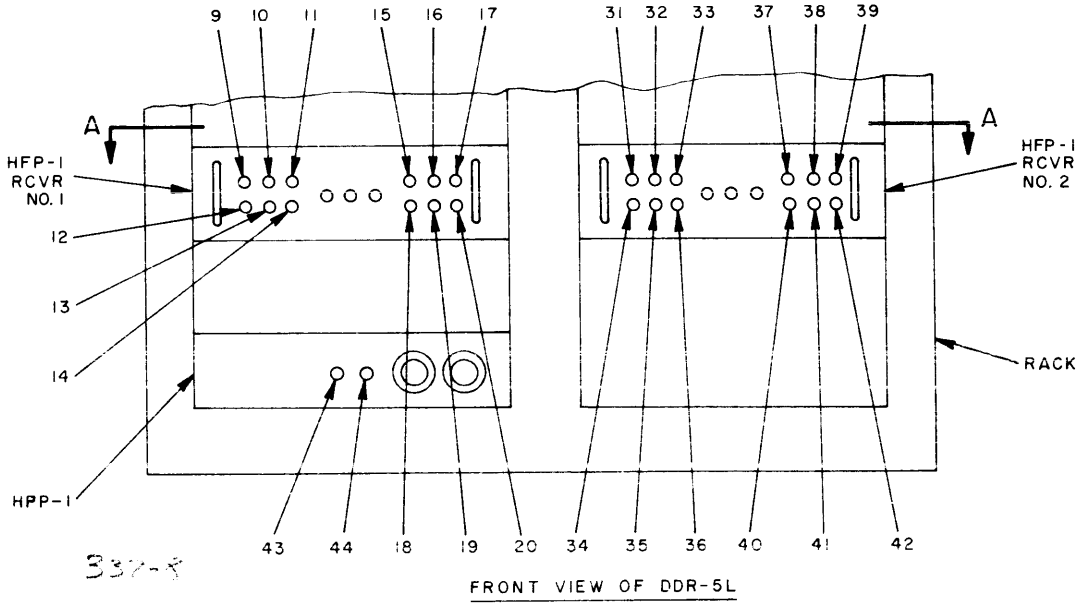
When performing step (11) below, be sure to remove alignment tools before attempting to rotate BAND controls of HFR units.

(11) Using procedures outlined in steps (2) through (10) above, align HFO circuits of both HFR units at high and low frequencies of each band.



SECTION A-A





FRONT VIEW OF DDR-5L

NOTE: SEE TABLE 5-3 FOR FUSE FUNCTIONS.

Figure 5-1. Fuse Location Diagram, DDR-5L

b. ALIGNMENT OF R-F CIRCUITS OF CONTINUOUS RF TUNERS HFR NO. 1 AND HFR NO. 2. Proceed as follows:

NOTE

For the sake of brevity and clarity in this procedure, the modular units contained in receiver 1 are designated HFR No. 1, MSA No. 1, etc. The modular units contained in receiver 2 are designated HFR No. 2, MSA No. 2, etc.

(1) On both HFR units, remove top cover of r-f turret to expose "L" and "C" adjustments of r-f tuner strips.

(2) Set DDR-5L controls as listed in step (1) of paragraph 3-2b.

(3) Set HFS nixie selectors for 2.0 mc, and tune both HFR units to 2.0 mc exactly.

(4) Set NOISE SILENCER/OFF/ALIGNMENT SIGNAL switch of both HFR units at ALIGNMENT SIGNAL.

(5) Using alignment tool TP-115 (see figure 5-1) adjust inductors L1001, L1005, L1007, and L1009 of HFR No. 1 for maximum indication on associated RF LEVEL meter. Adjustment of L1001 will be very broad.

(6) Repeat step (5) for HFR No. 2.

(7) Set HFS nixie selectors for 3.0 mc, and tune both HFR units to 3.0 exactly.

(8) Ensure that NOISE SILENCER/OFF/ALIGNMENT SIGNAL switches of both HFR units are set at ALIGNMENT SIGNAL.

(9) Using alignment tool TP-114 adjust capacitors C1009, C1015, C1023, and C1031 of HFR No. 1 for maximum indication on associated RF LEVEL meter.

(10) Repeat step (9) for HFR No. 2.

(11) Repeat steps (3) through (10) above until no further peaking can be obtained.

(12) Repeat procedure outlined in steps (3) through (11) above for high and low frequencies of each band. Adjust inductors at low end of band and capacitors at high end of band; in all cases, adjustment of input inductor will be very broad.

c. ADJUSTMENT OF SYNCHRONIZE METER CIRCUIT OF CONTINUOUS RF TUNERS HFR NO. 1 AND HFR NO. 2. - To adjust the SYNCHRONIZE meter circuit of either HFR unit set the TUNE/SYNC/OPERATE switch at TUNE or SYNC, and adjust R1320 for zero center scale on the SYNCHRONIZE meter.