SECTION III

BACKGROUND INFORMATION

3-1. BACKGROUND INFORMATION. This section is intended to acquaint the new operator with adequate background information to understand the operation of the system.

3-2. REFERENCE STATION SITE SELECTION

3-3. The first step in planning a survey or positioning operation is to examine the work area and select appropriate points to be used as reference station sites. The criteria to be used in selecting these sites includes:

(1) Line-of-Sight to the Work Area

The MRS-III range measuring system operates at microwave frequencies and requires that line-of-sight be maintained between the reference stations and the receiver /transmitter units. Light foliage may generally be tolerated. However, significant obstructions such as land masses or buildings will interfere with the operation of the system.

(2) Accessibility

A crew member must be able to get to the site in order to set up the station. The small, lightweight MRS-III reference stations minimize this problem.

(3) Power Availability

The MRS-III reference stations are designed to operate from 24 to 30 VDC. They may be powered by a 24-volt battery, a 24-volt DC power supply, or a pair of 12-volt batteries connected in series. The most common power source is a pair of 12-volt automobile or motorcycle batteries connected in series. An ordinary pair of automobile batteries will provide continuous power for up to seven days of operation depending upon battery capacity and reference station duty cycle.

(4) Acceptable Geometry over the Work Area

The MRDP determines the position of the system by a process called trilateration. This is a standard survey technique to determine a position when all three sides of a triangle are known. As with all survey techniques, the positional accuracy of the computation is dependent upon the angle of intersection of the range lines. Good surveying practice requires that the angle of intersection of the range lines be maintained between 30° and 150°.

(5) Known Position

It is important that the position of the site be known or be determined in the coordinate system to be used. These known points may be available from charts or in the form of lighthouses, range lights, or other navigation aids for which survey control is known. If such local control is not available, it may be desirable to establish control through normal land survey techniques or to use the MRS-III itself to set up a local coordinate system.

3-4. COORDINATE SYSTEMS

3-5. The MRDP positioning system will accept many of the different coordinate systems currently in use either directly or with slight conversion. The restrictions placed on the coordinate system are:

(1) It must be rectilinear - that is, it must be made up of a square grid system with equal measurement units in both axes and 90° intersections between the axes. The coordinates on the X axis should increase from left to right and on the Y axis increase from bottom to top when the chart is viewed normally.

(2) It is assumed to be planar - over the distances normally encountered, correction for curvature is not required. Curvature corrections, if required, may be supplied as a system option.

(3) Coordinate data may be up to 7 decimal digits.

(4) Data must be entered in the same units as the MRS-III range measurement.

3-6. Most grid coordinate systems may be used with the MRDP positioning system. It may be necessary to convert coordinates in yards or feet to meters, or conversely, meters to yards or feet. Optional programs are available to work in other coordinate systems. If no local coordinate system exists in the area to be surveyed, it is possible to establish a local coordinate system using the reference stations as the basis. Figure 3-1 illustrates how this may be done. If the reference station site at point A is selected as the origin, it is assigned the coordinates X = 0, Y = 0. The line between point A and the reference station site at point B becomes the X axis, and the distance between A and B may be measured using the MRS-III or other techniques. The coordinates for point B then becomes X = distance A to B, Y = 0. With this data as the starting point, the system may be used to establish coordinates for other reference sites as may be required. If this process is to be continued through more than one extension, good surveying practice should be followed to close the loop and tie in the additional sites from more than one point.

3-7. PLANNING THE LINE

3-8. The survey or positioning operation should be planned by establishing the coordinate data for the start and end points of the basic line through the work area. Data for up to ten basic lines may be entered in the system and for up to 16 reference station sites.

3-9. Figure 3-1 illustrates how a work area may be covered by a basic survey line and parallel offset lines. Offset information may be entered at the time survey is run to allow the helmsman to steer the offset lines. In effect, a grid may be established over a work area using one basic survey line and the desired offset spacing. When planning offsets, keep in mind that when the basic line is viewed from the start toward the end, positive offsets are to the left and negative offsets to the right. Offsets may be selected in coordinate unit increments (meters, yards, feet) up to as many as seven digits positive or negative.

3-10. PRE-PLANNING DATA ENTRY

In order to speed the operational set-up and reduce the probability of error, it is suggested that after the above planning steps have been performed that some decisions about the operating conditions be made and the pertinent data recorded on a suitable format to be followed when the survey is being run. The parameters to be recorded include:

(1) Coordinates of sites and codes of stations to be placed on the sites.

(2) Coordinates of basic survey lines with sites to be used.

(3) Offsets to be run.

(4) Sample rates to be used.

(5) Plotter scales to be used.

(6) Depth corrections and other factors to be entered.

3-11. When the operation is begun, the previously prepared charts and data sheets may be used to quickly set up the system for the line to be run and enter the correct parameter data with a minimum chance for error.

3-12. CHART PRE-PLOTTING AND PLOTTER REFERENCE REQUIREMENTS

3-13. Standard track plotter operations with the MRDP system assume that the basic survey line is always oriented down the center of the chart paper. This orientation places length of the line in the long dimension of the plotter paper, allowing the system to use scale factors which would be impossible with a fixed bed plotter. The plotter position thus represents the position of the survey vehicle with respect to the survey line. This technique, however, results in the orientation of the plot and the user coordinate grid being a variable factor. It is important that the operator keep this fact in mind when planning, operating, and interpreting the system. It may be desirable to pre-plot the intended course on the chart paper using the planned plotter scales to mark the start and end points on the chart. This may be done manually or through the optional automatic pre-plot feature, if so equipped. It may be helpful to note any significant physical features such as buoys or shoals.

3-14. When the pre-plotted chart is placed in the plotter, the chart should be oriented so that the start point of the line is on the left and the end point to the right. Obviously, since the MRDP cannot know what the relationship is between the chart and the pen after the paper has been arbitrarily placed in the plotter, some means must be provided of initially synchronizing the plotter and the MRDP. This process is called "Origining the plotter." The operator may select a "Plotter origin" operation at two points during the operation of the system: During Operate Set-Up and from the Pause mode. This process does not involve physical action by the system, but rather by the operator. When a plot origin operation is requested, the system assumes that the plotter pen has been moved to rest upon the start point of the survey line and resets its internal position registers to agree with that position. It is the operator's responsibility to place the pen at that point using the manual plotter controls. If no pre-plots are used, the pen may be placed at any convenient grid intersection on the chart centerline. If pre-plots are used, the pen must be placed on the start point. Take care in positioning the pen as any error in this initial positioning will be reflected throughout the plot. Be sure to place the plotter controls back to the "track" or "remote" positions after the pen has been placed and press the green ready switch.

3-15. This plotter referencing process is necessary under the following conditions:

(1) After a new line or a new plotter chart has been selected.

(2) After the plotter scale has been changed.

(3) Whenever the plotter controls have been in the manual position while the system was tracking or when the pen has been moved manually while the system was tracking.

3-16. DUAL POSITION PROBLEM

3-17. Whenever two ranges are used to detemine a position from two known points, it is possible for either of two positions to result; one on either side of a line between the two known points (called the baseline). See Figure 3-2.

3-18. To resolve this problem, the MRDP system always assumes one case. This problem is solved by requesting the operator to specify a right and left site. Right and left are determined by the operator assuming that he is at the start point of the desired line looking toward the two reference sites to be used. In Figure 3-2, the right site would be Site 2 if the line were on Side A and Site 1 if the line were on Side B.

3-19. EFFECTS OF GEOMETRY ON POSITIONAL ACCURACY

In paragraph 3.3(4), reference is made to the necessity to maintain adequate geometry in the work area. Figure 3-3 illustrates why such considerations are necessary.

SECTION I

DESCRIPTION AND LEADING PARTICULARS

1-1. PURPOSE AND USE OF EQUIPMENT

1-2. PURPOSE. The purpose of the Mini-Ranger III System (MRS III) shown in figure 1-1 is to accurately determine the position of a mobile unit such as a vessel, aircraft, or land vehicle. This position is determined with respect to Reference Stations located at known, fixed points.

1-3. USE. The MRS III, operating on the basic principle of pulse radar, uses a transmitter (located on the mobile unit) to interrogate the reference stations. The elapsed time between the transmitted interrogation produced by the MRS III transmitter and the reply received from each reference station is used as the basis for determining the range to each reference station. This range information, displayed by the MRS III together with the known location of each reference station, can be trilaterated to provide a position fix of the mobile unit. The standard MRS III operates at line-of-sight ranges up to (approximately 37 kilometers) 20 nautical miles and, with appropriate calibration, the probable range measurement accuracy is better than 3 meters (10 feet). A unique coding system is employed in the MRS III to minimize false range readings caused by radar interference and to provide selective reference station interrogation. The operating frequencies of the MRS III can be set (at the factory) above or below the operating frequencies of on-board radar systems to eliminate possible interference with normal radar operation.

1-4. DESCRIPTION OF EQUIPMENT

1-5. GENERAL. The standard MRS III consists of a Receiver-Transmitter Assembly with Antenna, a Range Console, and two Reference Stations with Antennas. Basic operating principles of these units are described in the following paragraphs.

1-6. RECEIVER-TRANSMITTER DESCRIPTION. The Receiver-Transmitter (figures 1-1 and 1-2) consists of a radar transmitter and receiver. The reference station interrogation signal from the transmitter is passed through a circulator to the antenna. Simultaneously, a signal is developed that serves as the start pulse for the range counters. From the antenna, received reference station signals are routed through the circulator to the receiver. The output of the receiver is decoded to provide a stop pulse to the range counters. The Receiver-Transmitter operates on +28 volt power supplied by the Range Console. The transmitting and receiving functions are contained within a receiver-transmitter subassembly called an R.F. Unit.

1-7. RANGE CONSOLE DESCRIPTION. The Range Console (figure 1-1 and 1-2) consists of a coder, a decoder, a range counter control, a numerical LED readout (range display), and a power supply that provides the necessary dc operating voltages. The power supply also provides +28 volts for operation of the Receiver-Transmitter.

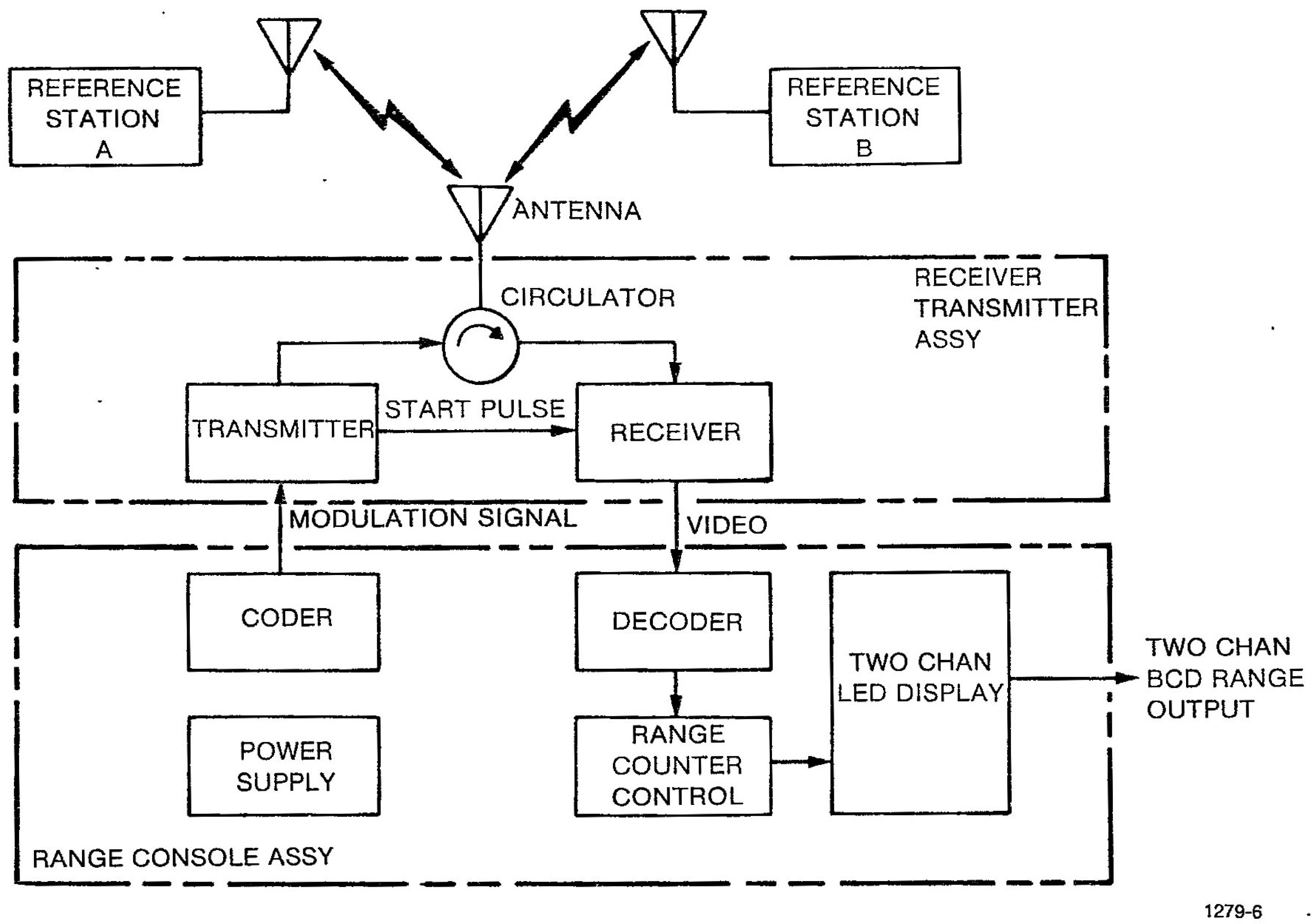


Figure 1-2. MRS III, Overall Block Diagram

1-8. When a start signal from the Receiver-Transmitter is received by the range counter, it begins to count. After five sequential interrogations and the receipt of five replies from a reference station, the count is displayed on the range console front panel as range to the reference station. This range, along with channel and code information, is also available in parallel BCD format at a rear-panel connector for use by peripheral equipment such as printers or computers. Channel A and channel B range data is gathered and displayed within ten milliseconds during each sample period of operation.

1-9. REFERENCE STATION DESCRIPTION. The reference stations are installed at known locations and serve as reference points for the MRS III. The two reference stations receive pulse-coded interrogations from the Receiver Transmitter. The interrogations are decoded by the applicable reference station (depending on the pulse spacings of the interrogation), resulting in a reference station reply. The receiving, transmitting, and decoding functions are contained within a reference station subassembly called a transponder.

SECTION II
INSTALLATION AND OPERATION

2-1. INSTALLATION

2-2. REFERENCE STATION INSTALLATION. Since the Mini-Ranger System III (MRS III) operates at microwave frequencies, the range of the system is limited to line-of-sight. To obtain the maximum usable range, install the reference stations at the highest possible elevation (see figures 2-1 through 2-3). When locating each reference station at the selected site, maintain a minimum separation of 7 feet between the reference station and any magnetic sensing devices such as compasses, and make sure that the reference station is positioned at least 2 inches from any iron, steel, or other magnetic material. Also make sure that adequate ventilation is provided. During reference station operation, the case temperature of the unit must not exceed 71^{o}C (158^{o}F). Install the reference station and its associated antenna vertically, as shown in figure 2-1.

2-3. RECEIVER-TRANSMITTER INSTALLATION. Mount the Receiver-Transmitter and the omnidirectional antenna as a unit. Refer to figure 2-4 for outline dimensions and to paragraph 2-6 for data on the interconnecting cables. Observe the same mounting considerations for the Receiver-Transmitter as listed in paragraph 2-2 for the reference station installation. For best operation the Receiver-Transmitter should be mounted at the highest point of the mobile vehicle where its antenna has no possibility of being shielded by any base station superstructure.

2-4. RANGE CONSOLE INSTALLATION. The following factors must be considered before making a permanent installation: (1) 105- to 115-volt ac, 50- 400-Hz primary power must be available with a one ampere capability (or +24 to +30 Vdc source with a three ampere capability), and (2) the Range Console must be located so that the range readout displayed on the front panel can be read. Refer to figure 2-5 for outline dimensions and to paragraph 2-6 for data on the interconnecting cables.

2-5. OMNIDIRECTIONAL ANTENNA INSTALLATION. The omnidirectional antenna is normally mounted directly to the Receiver-Transmitter. If the antenna is to be mounted separately, make the cable between the antenna and the Receiver-Transmitter as short as possible. The cable used should be of the semi-rigid coaxial type. Consult Motorola for fabrication details. When installing the Receiver-Transmitter and the antenna either as a unit or separately, make sure there are no obstructions in the line-of-sight between the antenna and the reference stations. Also consider the wind velocity, vibration, and the mounting surface when installing the antenna.

2-6. INTERCONNECTING CABLES. The interconnection diagram for the Range Console and the Receiver-Transmitter is shown in figure 2-6. Fabrication details on the interconnecting cables, along with optional cable data, is shown in figure 2-7. Cable reference designations are arbitrarily assigned for purposes of identification only.

2-7. CONTROLS, INDICATORS AND CONNECTORS

2-8. Controls and indicators used in the calibration and operation of the equipment are described in table 2-1 and shown in figures 2-8 through 2-13. The outputs available at BCD OUT connector 1J4 or 1J5 (figure 2-10) can be used with an optional printer. Following is a sample of the printer output format.

Chan A	Chan B
0 2 013657	1 3 000278

2-9. The first digit of either channel's field is the channel identifier. A zero (0) indicates channel A and a one (1) indicates channel B. The next digit indicates the transponder code selected for the given channel. The last six digits indicate the range to that channel's transponder. When the system is operated in the single pulse mode, an output will be present only on channel A and the code identifier will be a digit one (1).

TABLE 2-1. CONTROLS AND INDICATORS

FIG. NO.	CONTROL OR INDICATOR	FUNCTION
	RANGE CONSOLE	
2-8 2-9	VIDEO RCVD A indicator DSI (white)	When illuminated, indicates that five successive replies have been received, processed, and that a display update has occurred.
2-8 2-9	VIDEO RCVD B indicator DS2 (white)	Same as channel A VIDEO RCVD indicator.
2-8 2-9	DISPLAY RATE control R5	Used to adjust rate at which range updates occur. Continuously variable from one update per second to one update every 10 seconds. When in EXT, detented position, system is controlled by an external peripheral.
2-8	XPNDR CALIBRATE 1,2,3, or 4	Used to calibrate code 1,2,3 or 4 circuitry. (Reference Station may be calibrated on either A or B channel).
2-9	REF STATION CAL 1,2,3, or 4	Used to calibrate code 1,2,3 or 4 circuitry. (Reference Station may be calibrated on either A or B channel).

TABLE 2-1. CONTROLS AND INDICATORS (Contd)

FIG. NO.	CONTROL OR INDICATOR	FUNCTION
2-8 2-9	RANGE display DS1 through DS12	Two 6-digit numerical displays of range to transponders being interrogated.
2-8 2-9	RESET switch S5	When pressed momentarily, range counters and control flip-flops are reset, and RANGE display readout is 0 (least significant digit only).
2-9	INTL/EXT Switch A	INTL position allows front panel code selection. EXT position allows remote code selection.
2-9	EXT/INTL Switch B	INTL position allows front panel code selection. EXT position allows remote code selection.
2-8 2-9	HOLD DISPLAY S4	When pressed in, will stop transponder interrogation and freeze last range readings on display. Must be pulled out to resume normal operation.
2-8 2-9	RANGE COMMAND S6	When momentarily depressed, a range update command is generated which updates the range reading.
2-8	XPNDR SELECT A switch S2	Used to select code for channel A interrogate signal. Only that transponder set for same code selected by XPNDR SELECT A switch setting will reply (see table 2-2).
2-9	REF STATION SELECT A switch	Used to select code for channel A interrogate signal. Only that transponder set for same code selected by REF STATION SELECT A switch setting will reply (see table 2-2).

TABLE 2-1. CONTROLS AND INDICATORS (Contd)

FIG NO.	CONTROL OR INDICATOR	FUNCTION
2-8	XPNDR SELECT B switch S3	Used to select code for channel B interrogate signal. Only that transponder set for same code selected by XPNDR SELECT B switch setting will reply (see table 2-2).
2-9	REF STATION SELECT B switch	Used to select code for channel B interrogate signal. Only that transponder set for same code selected by REF STATION SELECT B switch setting will reply (see table 2-2).
2-8 2-9	POWER switch S1	When set to ON, connects primary power to Range Console and R/T. When set to OFF, disconnects power input.
2-10	TEST connector (J6)	Makes second modulation pulse available for triggering test equipment.
2-10	GND connector (J7)	Chassis ground
Internal	Primary fuse F1	Provides system overload protection. (Ac system 2A) (Dc system 3A)
Internal	Antenna fuse F2	Provides overload protection for rotating antenna. (Ac system 1.5A Slo-Blo) (Dc system 2A Slo-Blo)
Internal	R/T fuse F3	Provides overload protection for +28 volt supply line to Receiver-Transmitter. (2A Slo-Blo)
2-10	R/T CABLE connector (J3)	Connects power and received video and transmitter modulation signals between Range Console and Receiver-Transmitter

TABLE 2-1. CONTROLS AND INDICATORS (Contd)

FIG. NO.	CONTROL OR INDICATOR	FUNCTION
2-10	POWER INPUT connector (J1)	Connects primary power input to Range Console. (105 to 125 Vac, 50-400 Hz or 24 to 30 Vdc)
2-10	CHAN A-BCD or CHAN B-BCD (J4 or J5)	Makes 24 lines of BCD range data one channel identifier line, three code identifier lines, freeze display, update flag, and +5 volts available for use with ancillary equipment. See paragraph 2-9 for explanation of channel identifier code and figure 2-7 for pin designations.
2-10	EXT CONTROL connector (J2)	Makes possible a variety of external system control features available. See figure 2-7 for listing of features.
2-10	115/230 Vac Switch (S1)	Provides for either 115 Vac or 230 Vac to power the range console.
	RECEIVER-TRANSMITTER	
2-11	R/T CABLE connector J1	Provides for interconnection of received video and transmitter modulation signals and connection of power from Range Console.
2-11	ANT SIG connector J2	Provides for connection of rf output to antenna.
	REFERENCE STATION	
2-12	POWER Cable connector	Provides for connection of power to the reference station.

TABLE 2-1. CONTROLS AND INDICATORS (Contd)

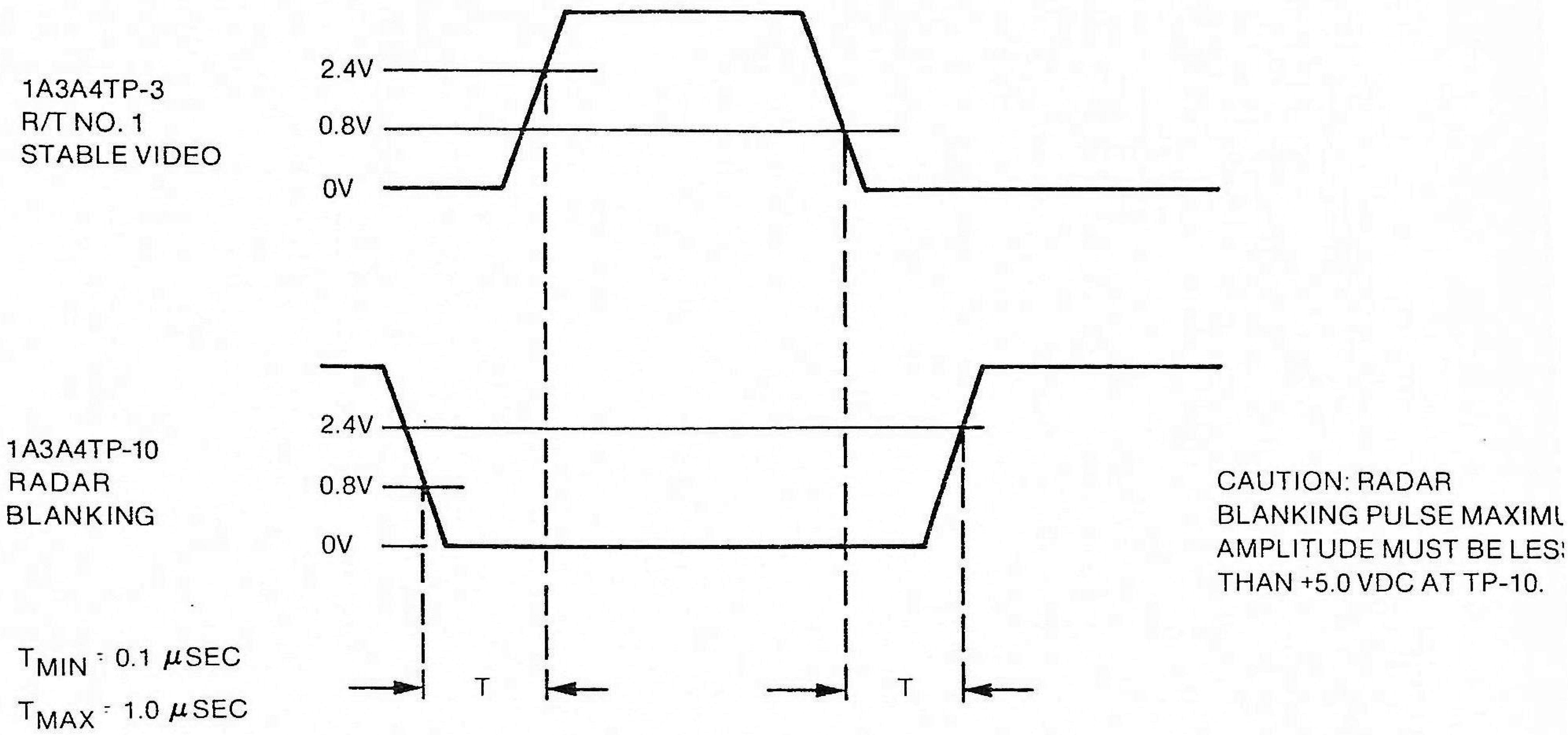
FIG. NO.	CONTROL OR INDICATOR	FUNCTION
RADAR TRANSPONDER AND RF UNIT		
2-13	RF FIL TUN 1 control	Used to tune first cavity of preselector.
2-13	RF FIL TUN 2 control	Used to tune second cavity of preselector.
2-13	RF FIL TUN 3 control	Used to tune third cavity of preselector.
2-13	LO TUN control	Used to tune local oscillator.
2-13	CODE SEL switch	Used to select operating code. Refer to table 2-2 for switch positions.
2-13	PWR & TEST J1 connector	Provides for connection +24 to +30 volt primary power and raw video test output.
2-13	ANT J2 connector	Provides for connection of coaxial cable to antenna.

2-10. RADAR BLANKING

2-11. The MRS III has the capability to blank a received rf pulse. If the transmitter of an on-board radar system causes interference with the MRS III, a pretransmit pulse taken from the radar system can be used to inhibit the range console during the transmit time of the radar system. The blanking pulse should be connected at the RADAR BLANKING line in the EXT CONTROL connector, J2 on the Range Console. The RADAR BLANKING pulse should have the timing characteristic s as shown below, on the specified range console test points. The stable video shown is that due to the interferring on-board radar system, as seen at 1A3A4TP-3.

CAUTION

Any onboard radar producing a +20 dBm or greater rf signal at the receiver-transmitter antenna (at the tuned frequency of the receiver) will damage the MRS III.



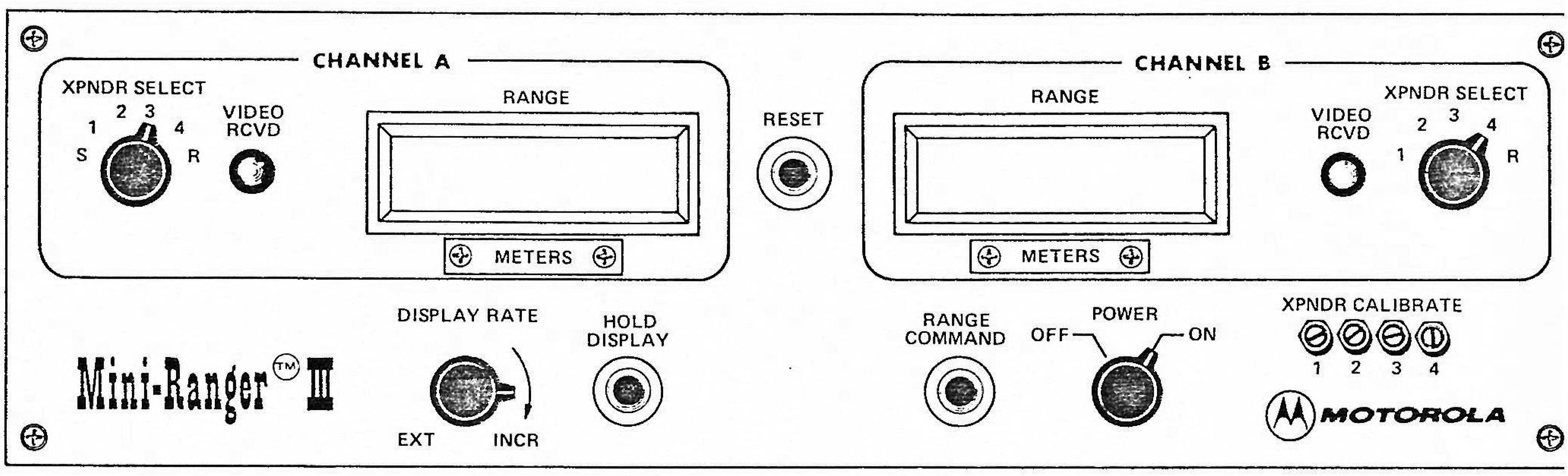


Figure 2-8. Range Console Front Panel, Early Model

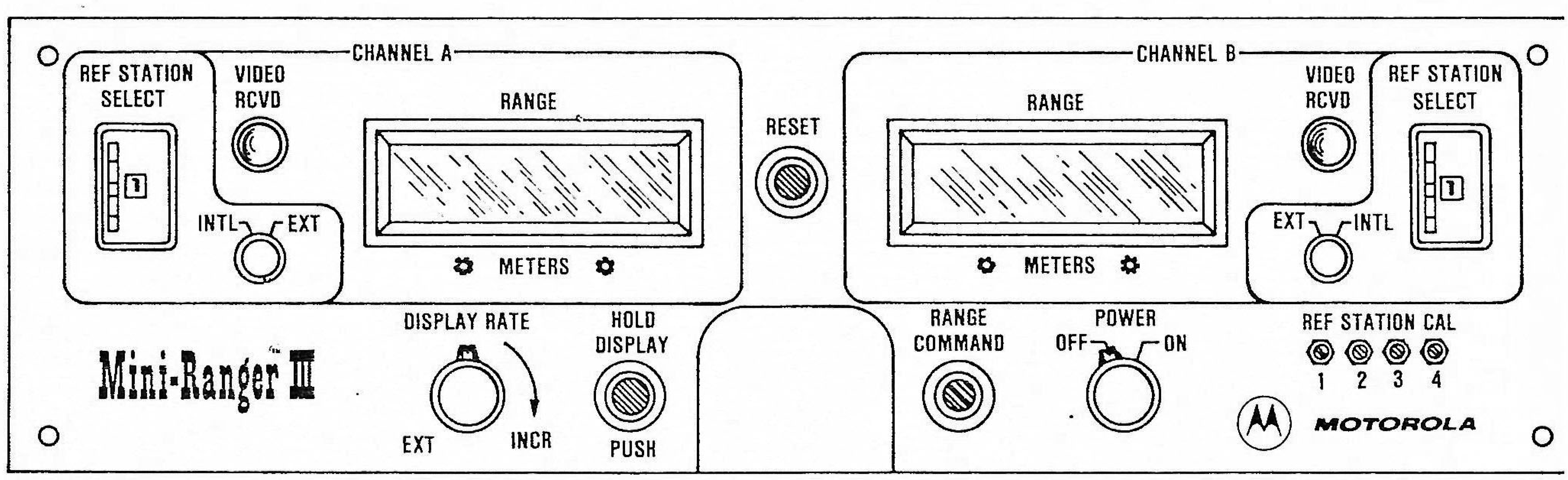


Figure 2-9. Range Console Front Panel, Late Model