INSTRUCTION BOOK

Radiomarine®

Model LR-8803 Direct Reading Loran Receiving Equipment

(AN/SPN-25)

SERVICE MANUAL

RADIO CORPORATION of AMERICA

RADIOMARINE EQUIPMENT DEPARTMENT

CAMDEN, NEW JERSEY

See List of Service Parts on Back Cover

IB-30636-4

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Direct Reading
Loran Receiving Equipment

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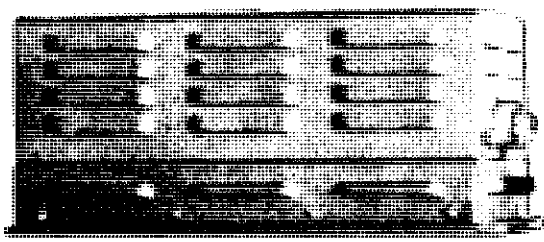

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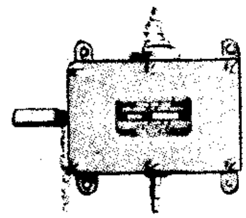

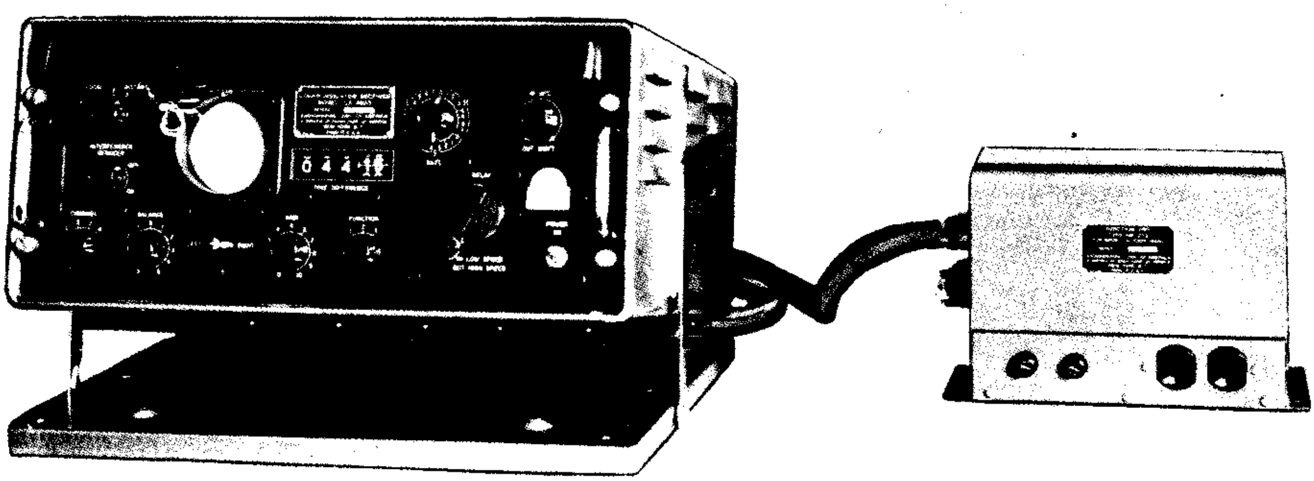

LR-8803 LORAN RECEIVER

RM-219 INTERCONNECTING BOX

LORAN RECEIVING SET AN/SPN-25

CHAPTER I
DESCRIPTION AND DATA

1. SCOPE

This manual contains information on the installation, theory, adjustment, maintenance and repair of Radiomarine model LR-8803 Direct Reading **Loran.**

2. DESCRIPTION OF LR-8803 COMPONENTS

The LR-8803 Loran Receiving Set is a navigational aid used to determine position at sea under all conditions of weather.

The LR-8803 consists of the following major units when used with a 115 volt AC, 50/60 cycle source of power.

TABLE NO. 1 LR-8803 MAJOR COMPONENTS

	Height (inches)	Width (inches)	Depth (inches)	Weight (lbs.)	Outline Dwg.
Indicator-Receiver - LR-8803 MI-555097-A	9-11/16	18-5/16	17-1/8	49	B-31283
Power Supply - RM-218 MI-555098	8-3/8	11-7/16	17-7/17	53½	B-31284
Junction Unit - RM-219 MI-555099	7-7/16	5-11/16	9½	17-3/4	B-31285
Antenna Coupling Unit-RM-220 MI-555100	7-13/16	8-1/16	3-3/8	8-1/8	B-31286

3. POWER REQUIREMENTS

If the ship's primary power supply is direct current, a power converter is required in addition to the four major units described above. This power converter is used to convert the ship's DC power (24, 32, 115 or 220 volts) to 115 volts, 60 cycles, single phase. It uses a heavy duty plug-in vibrator and is designed to provide automatic regulation of its 115 volt, 60 cycle output with variations of plus or minus 15% of the ship's supply voltage. Access to the plug-in vibrator unit is obtained through a hinged door on the front cover of the power converter. Table No. 2 summarizes the currents required and the converter units to be used for the various supply voltages.

Ship's Line Voltage	Ship's Line Current Req'd.	Power Converter Used	Installation Plan	Interconnecting Diagram
AC - 115v 50/60 cps	3 amps	none	Dwg. C-40771	Dwg. D-174
DC - 220v	2 amps	RM-239 (MI-555105)	Dwg. C-40771	Dwg. D-174
DC - 115v	4 amps	RM-238 (MI-555104) or RM-247 (MI-555106) plus RM-251 (MI-555108) Junction Unit	Dwg. C-40771 Dwg. C-40778	Dwg. D-174 Dwg. D-174 and Dwg. C-158
DC - 32v	14 amps	RM-237 (MI-555103) or RM-247A (MI-555107) plus RM-251 (MI-555108) Junction Unit	Dwg. C-40771 Dwg. C-40778	Dwg. D-174 Dwg. D-174 and Dwg. C-158
DC - 24v	19 amps	RM-236 (MI-555102)	Dwg. C-40771	Dwg. D-174

Note: Drawings are located at back of book.

TABLE NO. 2 LR-8803 POWER REQUIREMENTS AND INSTALLATION DATA

CHAPTER II
INSTALLATION

4. GENERAL

Complete installation information is given in the drawings referenced in Table No. 2. The following paragraphs should be studied carefully before attempting to plan an installation.

5. LR-8803 INDICATOR-RECEIVER

This unit should be mounted in a protected place within easy reach of the navigation officers. It may be mounted (a) on the chart table, (b) near the chart table on a suitable mount, (c) from the overhead or (d) on a bulkhead. This unit can be tilted to an angle convenient for viewing.

All these mountings can be accomplished by the same standard mounting base which is furnished with this unit. Normally, the Indicator-Receiver is shipped from the factory assembled for table or shelf mounting. Some simple changes must be made if it is desired to use overhead or bulkhead mounting. These are as follows:

First, loosen the four captive thumbscrews at the front panel and withdraw the unit from the cabinet.

Second, remove the mounting base from the cabinet of the Indicator-Receiver. This is accomplished by (a) removing the six 8-32 screws from the portion of the hinge attached to the cabinet and (b) unscrewing the adjustable "tilting" knobs on each side of the Indicator-Receiver in the direction opposite (counter clockwise) to the normal tightening motion.

Third, remove the two sets of support bars, loading springs and pivots from the base by removing the $\frac{1}{4}$"-20 hex nuts that fasten each bar pivot to the mounting base. These hex nuts are accessible from beneath the mounting base.

Fourth, remove from the cabinet the plate having the notches (which allow the Indicator-Receiver to be adjusted for different viewing angles) by removing two 8-32 bolts and nuts that mount each plate to the cabinet. The sliding adjusting bolts (to which the adjusting knobs are fastened) will also be removed by this operation.

Fifth, re-assemble the mounting base to the cabinet by attaching the hinge to the top rear surface of the mounting base using the row of tapped holes found there. These holes normally contain "filler" screws.

Sixth, re-assemble the notched plate and sliding bolts in such a manner that the notches run opposite to their original direction; i.e., re-mount this plate with the teeth pointing towards the rear of the cabinet instead of towards the front.

Seventh, replace the bars, bar loading springs and bar pivots. Use the two holes closest to the front edge of the mounting base for anchoring the bar loading springs, as this will load the bars in the proper direction for engaging the sliding adjusting bolts to the notches on the plate.

When mounting the Indicator-Receiver, always allow sufficient space in front of the unit for ease of operation and withdrawal of the chassis from the cabinet. In the rear, enough space must be allowed to connect the antenna and power cables and to insure free circulation of air to the blower. When installing the antenna and power cables, be sure to allow at least 30 inches of cable "slack" to permit withdrawal of the indicator from the cabinet.

5. RM-219 JUNCTION UNIT

This unit must be mounted near the Indicator-Receiver Unit in such a manner that the fuses and convenience outlets are available to the operator. It is connected to the Indicator-Receiver by means of a 10 foot length of flexible cable, and this length must be maintained. Never shorten or lengthen this cable between the Indicator-Receiver and Junction Unit.

. RM-218 POWER SUPPLY

Mount this unit on a table, shelf, deck or bulkhead and in such a position that operating personnel may have access to the fuses, and may be able to disengage the six screws which hold the cover. It may be mounted near the Indicator-Receiver Unit, or it may be placed in some remote position. The RM-218 is connected to the RM-219 Junction Unit by means of a special 14 conductor armored cable.

Vessels with DC power supplies must use a power converter as indicated in Table No. 2. Several points should be kept in mind when installing this power converter. During normal operation this unit produces an audible hum which is undesirable in a quiet pilot house or chart room when listening for fog signals. Therefore, it is recommended that the power converter be installed in a space apart from that used for the Loran Indicator-Receiver Unit. The power converter should be mounted on a vertical bulkhead where there is adequate ventilation and protection from the weather.

The two cables which enter the lower section of the power converter should be installed so that, when cleated, the unit may be removed for servicing. The two-conductor cable running from the converter to the switchbox, and the cable from this box to the ship's source of power should be kept as short as possible on 24 and 32 volt installations. Also, use adequate wire size to minimize voltage drop.

8. RM-220 ANTENNA COUPLING UNIT

This unit is mounted only on an external bulkhead. It should be close to the lower end on the antenna in order to keep the lead-in wire from the antenna and the Coupling Unit as short as possible.

9. ANTENNA INSTALLATION

The antenna should be made from regulation 7-#18 AWG stranded phosphor-bronze antenna wire and strung with a strain insulator at the upper and lower ends. The antenna should be as long as possible, up to about 125 feet, and as nearly vertical as possible. The upper end will usually be fastened to a yardarm and the lower end to a bracket near the chart room.

A short lead should run from the lower end of the antenna to the insulator on the Antenna Coupling Unit in such a manner that there is no strain on the "beehive" insulator. Install a length of RG-10/U cable between the Antenna Coupling Unit, RM-220 and the Indicator-Receiver, using the cable fittings provided.

10. GROUND CIRCUIT CONNECTIONS

Always install a good low resistance ground circuit, using ½ inch copper strap or equivalent, between the grounding studs on the RM-219 Junction Unit, the RM-218 Power Supply and the ship's steel hull (or to a ground plate on wooden vessels).

11. INITIAL ADJUSTMENTS AND TESTS

After the equipment has been installed according to the directions given in the preceeding paragraphs, the serviceman should perform all the following tests to be certain that the Loran equipment is functioning properly.

11.1 EQUIPMENT REQUIRED

A. Necessary Test Equipment. Voltohmeter. Simpson model 260 or equivalent meter having at least 20,000 ohms/volt resistance on DC scales.

B. Desirable Test Equipment. (1) Oscilloscope. Tektronix Model 524A or equivalent 'scope with vertical amplifiers at least 5 mc wide. (2) Loran Pulser. Model TS-251/UP.

11.2 GENERAL

Before equipment is turned on, make a visual inspection for any damage caused by shipping, installation, etc. All tubes and crystals should be seated firmly in sockets.

11.3 RM-218 POWER SUPPLY CHECKS. (Refer to drawing D-172).

Step 1. Remove cover from RM-218. Turn Loran equipment ON. With meter set on 250 volt AC scale, check line voltage across terminals 1 and 2 on TB601. The voltage should be between 105 and 125 volts and preferably close to 115 volts.

Step 2. With line voltage near 115 volts AC, check DC voltage from terminal 17 of TB601 to ground (terminal 18 of TB601). Voltage should be +260 volts. If necessary, adjust potentiometer marked "+260V ADJ" on top of RM-218 chassis until this value is obtained.

Step 3. Connect voltmeter between terminal 16 of TB601 and ground. Voltage should be +160 volts. If necessary, adjust potentiometer marked "+160V ADJ" on top of RM-218 chassis until this value is obtained.

Step 4. Check voltage between terminal 15 of TB601 and ground. The voltage should be approximately -105 volts.

Step 5. If an oscilloscope is available, connect the 'scope between terminal 17 of TB601 and ground. Use full vertical gain on 'scope. Adjust potentiometer marked "260V RIPPLE ADJ" on top of RM-218 chassis to minimize any AC ripple seen on the oscilloscope.

Step 6. Repeat procedure of step 5 above with 'scope on terminal 16 of TB601 and adjust potentiometer marked "+160V RIPPLE ADJ".

Step 7. Turn equipment OFF and replace cover on the RM-218 unit.

11.4 INDICATOR-RECEIVER CHECKS

Step 1. Turn equipment ON, and place front panel controls in the following positions:

Control	Position for Check
IN AFC-OUT DRIFT	DRIFT
FUNCTION	1
LOCAL-DISTANT	DISTANT
GAIN	0
BALANCE	0
RATE	HO
INTERFERENCE REDUCER	OFF
DELAY	HIGH SPEED
TIME DIFFERENCE	1000
CHANNEL	1

Step 2. Two horizontal traces should be seen on the screen of the cathode ray tube, with one marker pedestal on each trace. (The position of the pedestal on the upper trace is fixed; the position of the pedestal on the lower trace will depend on the setting of the DELAY crank.)

Step 3. Loosen the four thumbscrews at the corners of the front panel and withdraw the chassis to the stops.

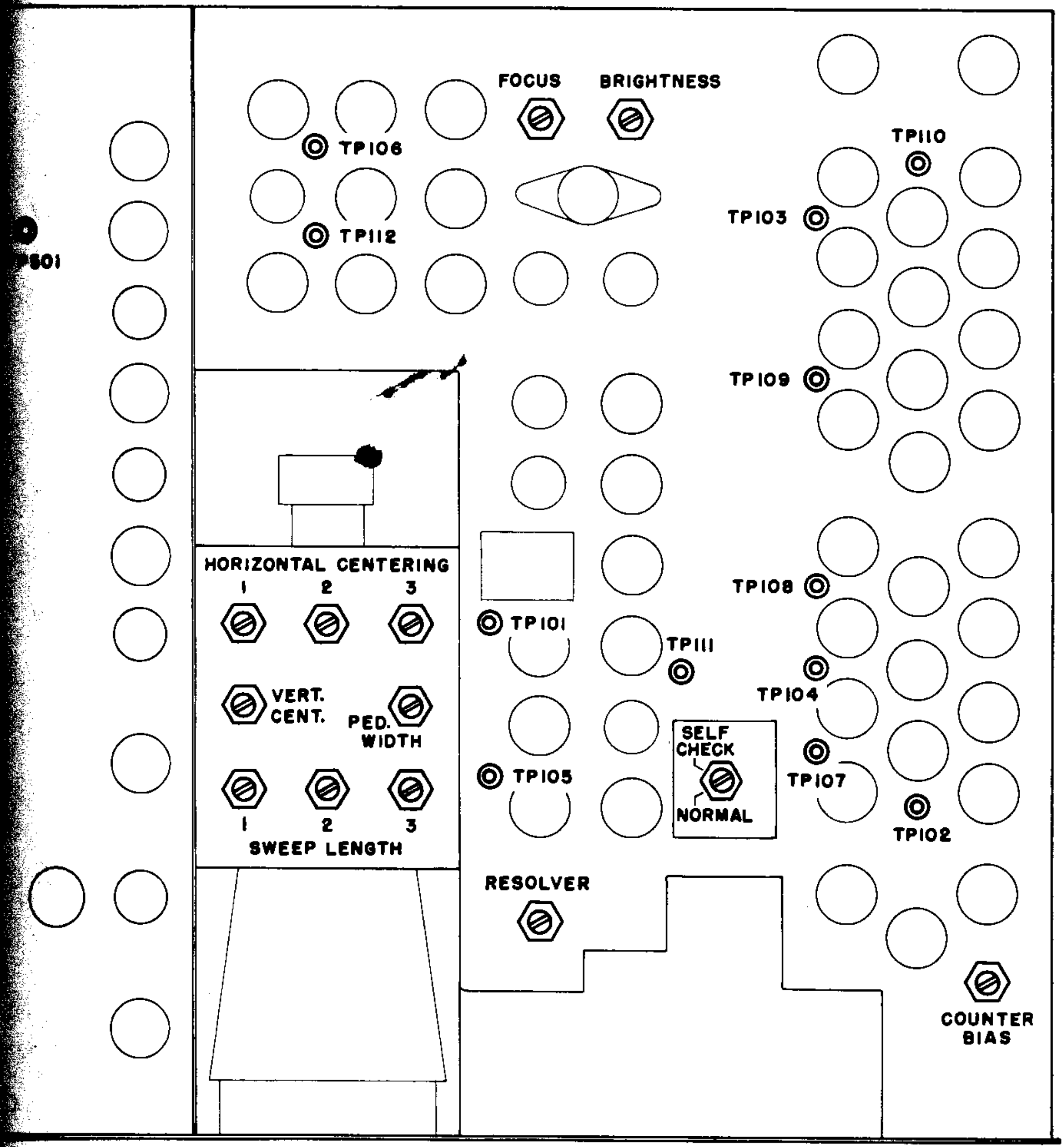

Figure I

INDICATOR ADJUSTMENT AND TEST POINT LOCATIONS

Step 4. Adjust control marked HORIZONTAL CENTERING 1 until the left edge of both traces of FUNCTION 1 is about $\frac{1}{4}$" from the left edge of the cathode ray tube. (See Figure 1 for location of this control.)

Step 5. Adjust control marked VERTICAL CENTERING until both traces are centered around a horizontal line running through the center of the cathode ray tube.

Step 6. Adjust control marked SWEEP LENGTH 1 until the right edge of both traces on FUNCTION 1 is about $\frac{1}{4}$" from the right edge of the cathode ray tube.

Step 7. Adjust control marked PED WIDTH until both pedestals are a convenient width on the cathode ray tube trace. Note: The pedestals are normally wide for "H" rates and narrow for "S" rates.

Step 8. Throw FUNCTION switch to FUNCTION 2. Two traces will now be present on the cathode ray tube, but the pedestals will have disappeared.

Step 9. Adjust control marked HORIZONTAL CENTERING 2 until the left edge of both traces are about $\frac{1}{4}$" from the left edge of the cathode ray tube.

Step 10. Adjust control marked SWEEP LENGTH 2 until the right edge of both traces just disappears off the cathode ray tube face.

Step 11. Throw FUNCTION switch to FUNCTION 3. A single trace will now be present on the cathode ray tube.

Step 12. Adjust control marked HORIZONTAL CENTERING 3 until the left edge of the trace just reaches the left edge of the cathode ray tube.

Step 13. Adjust control marked SWEEP LENGTH 3 until the right edge of the trace just disappears beyond the right face of the cathode ray tube.

Step 14. Adjust the controls at the rear of the chassis marked FOCUS and BRIGHTNESS for a bright, sharp picture for all positions of the FUNCTION switch. Note: The BRIGHTNESS adjustment will be a compromise between the FUNCTION 1 traces and the FUNCTION 3 trace since FUNCTION 1 is the slowest sweep (brightest) and FUNCTION 3 the fastest sweep (least bright).

Step 15. Return FUNCTION switch to POSITION 1. Place the positive probe of a DC voltmeter in the test jack marked TP102 and adjust the control marked COUNTER BIAS throughout the limits, wherein the picture on the cathode ray tube is good, that is, where traces and pedestals are both steady. Then adjust this control to the center of the voltage range, wherein the picture is steady. Example: The range must cover approximately 20 volts, and might be from +38 volts to +58 volts. The control would then be adjusted to +48 volts.

Step 16. Place FUNCTION switch on POSITION 3. With a screwdriver, place the SELF-CHECK NORMAL switch on the top chassis to SELF-CHECK position.

Step 17. Two sets of waves will now appear on the cathode ray tube. This will appear similar to those shown in Figure 2.

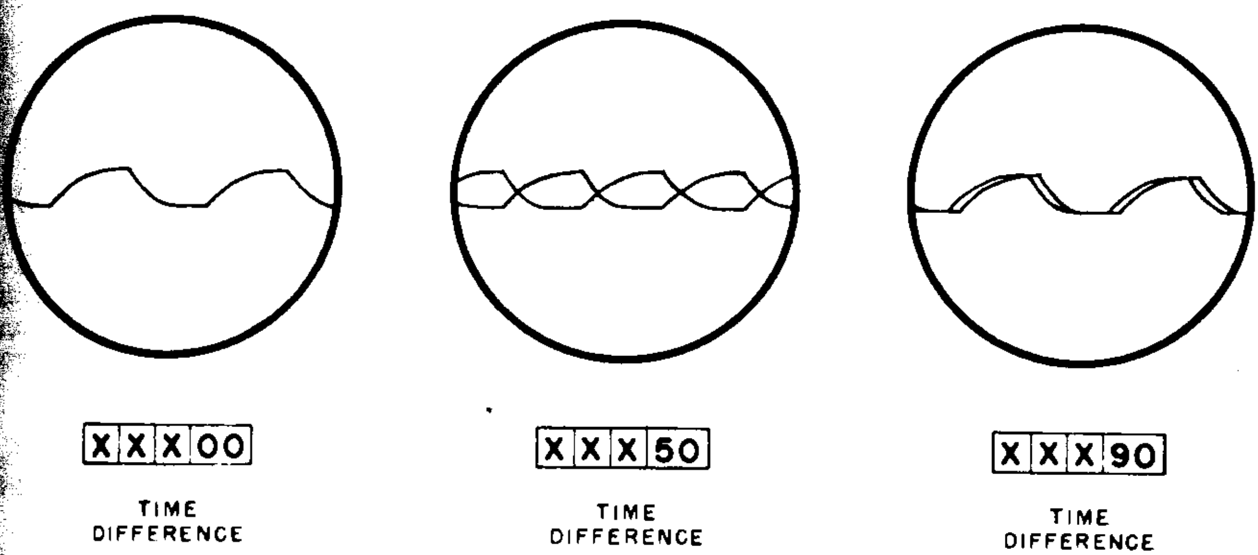

Figure 2
SELF CHECK WAVEFORMS

Step 18. Rotate the DELAY crank in the SLOW SPEED position. One waveform will move across the screen. Each time the TIME DIFFERENCE dial passes through a reading ending in 00 (for example, 01000, 01100, 01200, 12400, etc.) the two sets of waves should be superimposed and appear as one. This indicates that the equipment accuracy is correct. Rotate the DELAY knob through its complete travel and note the time difference reading where the two waves superimpose as one. An error of plus or minus 1 digit is acceptable. That is, if superimposition occurs at 01201 or 01199 (instead of 01200), the Loran equipment is within its allowable error.

Step 19. Place SELF-CHECK switch to NORMAL position.

.5 RM-220 ANTENNA COUPLING UNIT CHECKS

Step 1. This unit houses a tapped antenna loading coil which is slug tuned. This loading coil should resonate with the capacitive reactance of the antenna. It is possible to tune the loading coil to resonance at only one of the Loran RF channels. Determine which channel will be the one most frequently used by the ship as determined by its ports of call. This will usually be CHANNEL 1.

Step 2. Remove the cap from the adjusting screw of the tuning coil (inside of unit), loosen the locknut and set the adjusting screw at approximately mid-point (about 1 inch out).

Step 3. Remove the cover from the Antenna Coupling Unit, exposing the tapped coil. Note that the wire from the large insulator is connected to tap #1 of the coil.

Step 4. Remove from the coil the wire leading to the stuffing tube, (i.e., to the Indicator-Receiver).

Step 5. With the CHANNEL switch on POSITION 1 (or the CHANNEL to be tuned) and with the GAIN control adjusted to give about ½" of noise (grass) on the cathode ray screen when FUNCTION 1 sweeps are viewed, move the lead which was disconnected in step 4 to terminals #2, #3, #4, etc. until a maximum amount of noise appears on the cathode ray screen. Choose the tap which gives maximum noise and attach the lead to this tap. (If a Loran signal can be received in your locality, set the RATE switch to stop the signal and proceed as above to maximize the signal.)

Step 6. When a terminal has been selected which maximizes noise (or signal), adjust the core inside the coil by means of the adjusting screw (see step 2) to give a peak on noise or signals. If noise or signal amplitude increases as the end of the slug adjustment is reached, try the next coil tap and move the slug to the opposite end of travel and then maximize signals.

Step 7. Tighten the locknut and replace the cap on the adjusting screw. Replace the cover carefully with the gasket in place for a weathertight fit.

11.6 OVER-ALL CHECK OF THE LR-8803 LORAN USING THE TS-251/UP LORAN TEST SET

Step 1. The TS-251 Test Set is a convenient device for checking the over-all performance of a Loran set, especially when there are no Loran signals available in a particular locality. It is possible with this Test Set to check (a) receiver performance, (b) timing circuits, (c) delay circuits (Time Difference). Using a short piece of coaxial cable, connect the jack marked ANTENNA on the TS-251/UP set to the antenna input on back of the Indicator-Receiver.

Step 2. Put the TS-251 switch marked CHANNEL to CHANNEL 1 (or channel to be checked). Be sure the LR-8803 CHANNEL switch agrees with the TS-251 reading.

Step 3. Put the TS-251 switch marked PULSE-CW to PULSE, and the switch marked OUTPUT to 15 UV.

Step 4. Set the Indicator-Receiver RATE switch to the H-3 position. A total of 9 pulses will now be seen on the sweeps of FUNCTION 1.

Step 5. With the Indicator-Receiver GAIN control adjusted for approximately ¼" of noise, these signals should be several times greater than noise. (Since the output of the TS-251/UP Test Set is constant, the size of these pulses is an indication of the receiver sensitivity of the LR-8803 Loran.)

Step 6. Place the AFC-DRIFT control on the LR-8803 Indicator-Receiver to DRIFT. Adjust the DRIFT control until the signals are stationary. It should be possible to cause the signals to drift slowly to the right or left as the DRIFT control is turned either way from the stationary position. The fact that signals from the Test Set can be stopped (made stationary) is proof that the LR-8803 sweep circuits are accurate for the H-3 rate.

Step 7. Now position one of the pulses on the top trace at the left edge of the master pedestal. (Note: Review the operating procedures in CHAPTER III for a description of the front panel controls and detailed instructions for taking Loran readings.) Lock this pulse in by putting switch on AFC position.

Step 8. Turn the TIME DELAY crank and move the slave pedestal until the first signal on the bottom trace to the right of the master pedestal is placed on top the slave pedestal. Then note the TIME DIFFERENCE reading after the two signals have been superimposed according to the instructions in the next section. The DELAY reading should be 1650 microseconds.

Step 9. Move the slave pedestal to the next signal to the right of the one measured in step 8, and note the TIME DIFFERENCE. This should be 4950.

Step 10. The TIME DIFFERENCE for the next pulse should be 8250. For the following pulse, it should be 11,550.

Step 11. Repeat the procedures described in steps 4 thru 10 with the RATE switch set to L-4. The number of pulses and the delay readings are found on a chart on the front of the TS-251/UP Test Set.

Step 12. Repeat the procedures in steps 4 thru 10 with the RATE switch on position S-5.

CHAPTER III
OPERATION

12. GENERAL

After the LR-8803 equipment has been installed and checked according t the instructions given in CHAPTER II, the set is ready for use. Detailed i structions on operation and the interpretation and application of readings presented in another publication, THE OPERATOR'S MANUAL, which should be ca fully studied by all navigators and users of this equipment. However, for the convenience of the serviceman, a listing of the operating controls, and a review of the method of taking a reading is presented in this chapter.

13. FRONT PANEL CONTROLS AND THEIR FUNCTIONS

The LR-8803 Loran Indicator-Receiver is equipped with the following front panel controls for use by the operator.

POWER ON - This switch applies power to the LR-8803.

CHANNEL - This switch enables the operator to select any one of the four radio frequencies used for transmission of Loran signals. For example, if a Loran chart indicates the code of a usable station in a particular area is 1HO, place the CHANNEL switch in POSITION 1; if 2HO is a usable station, place the CHANNEL switch in POSITION 2, etc.

RATE - In order to economize on radio frequency channels, a number of pairs of Loran stations are operated on the same radio frequency channel, but each pair operates at a different pulse recurrence rate. Signals from all Loran stations on the same channel appear on the 'scope screen, (provided the ship is within range of the stations) but these signals drift across the screen at varying speeds. By means of the RATE switch, the operator can select a particular pair of stations which makes the sweep recurrence rate of the indicator the same as the pulse recurrence rate of the desired pair. These signals will then be stationary, while signals from other pairs drift across the screen and can be ignored.

FUNCTION - This three-position switch allows the operator to choose different amounts of sweep magnification in determining the delay between a pair of Loran signals. In FUNCTION 1, the complete Loran cycle is displayed; i.e., two horizontal sweeps each with one pedestal are displayed on the tube. In FUNCTION 2, the sweeps are magnified and the amount of sweep displayed is that determined by the widths of the pedestals in FUNCTION 1. In FUNCTION 3, the sweep is further magnified, and the separation of the top and bottom traces has been eliminated.

DELAY - This control allows the operator to move the pedestal on the bottom trace (in FUNCTION 1) to position the Loran pulse on the pedestal. When the DELAY knob is pulled OUT, the pedestal is moved rapidly across the tube. However, for accurate adjustments in matching Loran pulses, the knob is pushed IN.

TIME DIFFERENCE - This reading, in microseconds, is the difference in time between the arrival of Loran pulses from a pair of stations.

LEFT-RIGHT - This control allows the operator to move the pulses to be measured across the screen quickly either to the right or left.

GAIN - This control varies the sensitivity or amplification of the Loran receiver and it performs the same function as the volume control does on an ordinary receiver. The GAIN control should be adjusted so that approximately $\frac{1}{4}$ inch of noise or "grass" is present on the sweeps in FUNCTION 1 position.

BALANCE - This control enables the operator to balance the amplitudes of different signals so that they can be matched more easily. The BALANCE control varies the gain of the upper trace with respect to the lower, thus allowing the operator to vary the amplitude of a signal on the upper trace with respect to the amplitude of a signal on the lower trace.

AFC-DRIFT - When this knob is pushed IN, the timing oscillator in the Loran set is automatically "locked in" to the frequency of the selected received signals when they are properly positioned on the pedestals. When the knob is pulled OUT, the signals can be made to move slowly to the right or left or stopped on the trace by adjustment of this control.

INTERFERENCE REDUCER - When this switch is turned to the ON position, much of the undesired signal interference created by radar sets, motor sparking, radio transmissions, etc. picked up by the Loran antenna will be reduced.

LOCAL-DISTANT - When operating very close to a Loran transmitter, received signals may be so strong that they overload the Loran receiver. In such cases, the LOCAL-DISTANT switch may be turned to LOCAL POSITION 1 or POSITION 2, in which case a red panel lamp is lighted. In normal operation, the switch must always be left on the DISTANT position. POSITION 1 inserts 10 to 1 signal attenuation (20 db) and POSITION 2 inserts 100 to 1 (40 db) attenuation.

TAILED INSTRUCTIONS FOR TAKING LORAN READINGS

To obtain a Loran fix, the following procedure should be used.

Step 1. Turn POWER switch to the ON position. The TIME DIFFERENCE ial and all panel control identifications will be illuminated and a pattern ill soon appear on the cathode ray tube.

Step 2. Put the FUNCTION switch on POSITION 1, and adjust the GAIN and BALANCE controls until a small amount of "noise" or "grass" is visible on both traces. Loran pulses (appearing as upward projecting vertical line) should now be seen. These pulses will drift slowly across the screen. The position of other controls should be as follows:

AFC-DRIFT - DRIFT POSITION
INTERFERENCE REDUCER - OFF
LOCAL-DISTANT - DISTANT

Step 3. Consult the Loran Tables or Charts to see what pairs of stations may be expected in your locality. Note that each Loran station is given a three-character identification symbol. The first character is the CHANNEL, and the second and third represent the pulse recurrence RATE. For example, 1H4 means the CHANNEL switch should be set on 1 and the RATE switch to H4.

Step 4. Set up CHANNEL and RATE switches to the desired pair of stations. Now, one pair of pulses should be almost stationary on the screen.

Step 5. Operate the LEFT-RIGHT switch in either direction until one of the pulses (master) is visible on the upper trace and the other pulse (slave) is on the lower trace, in such a manner that the master pulse on the top trace is always to the left of the slave pulse on the bottom trace. If both pulses appear on the same trace, use the LEFT-RIGHT switch to drift them into the order described above.

Step 6. Position the master pulse on the top pedestal near the left edge by rotating the DRIFT control. After the master pulse has been moved to this position, adjust the DRIFT control to keep the pulse stationary.

Step 7. Push the AFC knob IN. Now the AFC action should be locked in and hold the master pulse steady on the pedestal.

Step 8. In general, for any station pair being measured, the slave pulse (bottom trace) will not fall on top its pedestal when the master pulse has been positioned according to step 6. Therefore, pull the DELAY crank out (HIGH SPEED) and rotate it in the direction to position the slave pedestal so that the slave signal is on top the pedestal near the left edge.

Step 9. Place the FUNCTION switch in POSITION 2. The two pulses will now be seen near the left side of the medium sweep, approximately one above the other.

Step 10. Readjust the BALANCE and GAIN controls until the pulses are approximately equal and about one inch in height.

Step 11. Push the DELAY crank to the IN position (LOW SPEED) and rotate the crank until the two signals are directly above and below each other.

Step 12. Throw the FUNCTION switch to POSITION 3. Both pulses now ear on the same sweep and by careful manipulation of the DELAY knob W SPEED), the pulses can be made to coincide. Whenever any slight ferences occur in superimposition, carefully match the LEFT or leading es of the pulses rather than the right edge. Adjust the BALANCE con- l to equalize the height of the two signals. For best gain setting, ust the GAIN control until slight flattening of the tops of the pulses noted-- then reduce the gain to just below this point.

Step 13. After the pulses have been carefully superimposed as des- bed in the proceding step, the reading on the TIME DIFFERENCE dial, to- her with the CHANNEL and RATE information, describes a line of position the Loran Charts.

Step 14. Repeat the operations described in steps 1 thru 13 using ther pair of Loran stations to obtain a second line of position. The ersection of two or more lines of position constitutes a "fix".

e 1: When ground wave signals (within 500 to 700 miles in the daytime) being received, use the AFC-DRIFT knob in the AFC or knob IN position. n so adjusted, the Loran equipment will automatically "lock in" with signals. Rotation of the knob in the clockwise direction will then po- ion the "locked in" signals toward the right of the cathode-ray tube on CTION 3, and counter clockwise rotation will move signals toward the left. best positioning of the signals and best operation of AFC the knob should near its mid-position.

ever, when operating at night on sky waves, pull this knob OUT to the FT position. Rotation of this knob now provides a manual control of the nals and is adjusted to stop the desired signals on the pedestals. Slight uching of this control is acquired from time to time when making a read- in this manner.

e 2: If it is noted that unwanted signals, such as radar pulses appear the cathode ray tube display and are strong enough to disturb the taking a reading, throw the INTERFERENCE REDUCER switch to the ON position. This l reduce the unwanted signals without materially affecting the station r and a match can more easily be taken.

e 3: In certain cases where vessels are operating off-shore and are in se proximity to a station or pair of stations, the received signals may too strong for the GAIN control to be fully effective. In such a case, or both signals will have a characteristic "flat top" indicating too ong a signal.

ce the LOCAL-DISTANT switch in POSITION 2. This will reduce the size of h signals. If the stronger one still cannot be properly adjusted by the N and BALANCE controls, place the LOCAL-DISTANT switch in POSITION 3.

This will further reduce the signals on the display and GAIN and BALANCE will be fully effective in making "match". To warn the operator that the receiver is operating with reduced receiver sensitivity, a red light is illuminated. Whenever possible, always keep the LOCAL-DISTANT switch in DISTANT position (red light out) and use the LOCAL position only when required.

CHAPTER IV
DETAILED THEORY OF OPERATION

ERAL

Loran is a system of position finding at sea by reception of radio sig-
ls from transmitting stations of known position. Loran is entirely differ-
t from the ordinary direction finding system, for it measures difference
time of arrival of radio waves rather than direction of arrival.

The operation of the Loran system can be summarized in the following
ve steps:

(1) Radio signals consisting of short pulses are broadcast from a pair of special shore-based transmitting stations.

(2) These signals are received aboard ship on a specifically designed radio receiver.

(3) The difference in time of arrival of the signals from the two stations is measured on a Loran indicator.

(4) This measured time difference is utilized to determine directly from special tables or charts a line of position of the earth's surface.

(5) Two or more lines of position, determined from two or more pairs of transmitting stations, are crossed to obtain a Loran fix.

The Loran indicator is the instrument on which the navigator measures
e difference in times of arrival of the pulsed Loran signals. The equip-
nt includes a radio receiver especially designed for Loran use which feeds
e pulsed signals into the "display tube" or cathode ray oscilloscope of
e indicator. Pulses appear on the screen of the 'scope as vertical lines
t on top of the "pedestals" on two horizontal traces. Controls on the
ont panel are set to the proper frequency channel, basic recurrence rate
d the specific station rate of the desired Loran station pair. The pulses
om this pair will then appear practically stationary on the 'scope. Pulses
om other stations having different recurrence rates will drift across the
reen and should be neglected.

The conventional sound method of identifying stations by call letters
nnot be used to identify a given pair of Loran transmitting stations.
erefore, identification is accomplished by using four different trans-
tting frequencies known as channels, and each channel is used by twenty-
ur different pair of Loran transmitting stations. Each pair of trans-
tting stations have different pulse-repetition rates. (Pulse-repetition

rate is the number of Loran pulses transmitted per second.) The pulse-repetition rates are divided into three basic groups known as H, L and S. Each basic group of pulse-repetition rates contain eight, specific station rates designated numerically from 0 thru 7. Thus, a particular Loran pair is identified if (a) the channel, (b) the basic repetition rate and (c) the station rate are known. For example, a station identified as 1H4 means CHANNEL 1 basic rate H and station rate 4. On the LR-8803 Indicator, the switch marked CHANNEL is turned to #1 and the RATE switch is turned to H4. The time interval between successive pulses transmitted from a given station for the different pulse repetition rates is given in the table below.

TABLE NO. 3

Basic Pulse Repetition Rate Group	Station Repetition Rate Designation	Pulse Repetition Rate or Frequency (cycles/sec)	Recurrence Interval Between Pulses (microseconds)
H	0	33-3/9	30,000
H	1	33-4/9	29,900
H	2	33-5/9	29,800
H	3	33-6/9	29,700
H	4	33-7/9	29,600
H	5	33-8/9	29,500
H	6	34	29,400
H	7	34-1/9	29,300
L	0	25-1/16	40,000
L	1	25-2/16	39,900
L	2	25-3/16	39,800
L	3	25-4/16	39,700
L	4	25-5/16	39,600
L	5	25-6/16	39,500
L	6	25-7/16	39,400
L	7	25-8/16	39,300
S	0	20	50,000
S	1	20-1/25	49,900
S	2	20-2/25	49,800
S	3	20-3/25	49,700
S	4	20-4/25	49,600
S	5	20-5/25	49,500
S	6	20-6/25	49,400
S	7	20-7/25	49,300

The Loran receiving equipment must, therefore, have circuits to accomplish the following:

a) Receive the pulses transmitted by Loran stations.

b) Identify the various Loran pairs.

c) Measure the time difference of arrival between the two pulses of a Loran pair (master and slave pulse).

. RECEIVER CIRCUITS

The receiver circuits are shown in detail on drawing D-171. Since pulse signals, approximately 40 microseconds long are being received, the receiver has a relatively broadband response (38 kc). The four RF channels assigned to the Loran system are as follows:

CHANNEL 1	1950 kc
CHANNEL 2	1850 kc
CHANNEL 3	1900 kc
CHANNEL 4	1750 kc

Therefore, a four channel, crystal controlled superheterodyne type circuit is used. It consists of 1 stage of RF amplification (V501), a pentagrid converter (V502), 2 stages of IF amplification at 1100 kc (V503, V504), a detector (CR501) and 3 stages of video amplification (V505A, V505B and V131B). In addition, the receiver includes an input attenuator for strong signals, and an interference reducer.

.1 ANTENNA AND INPUT CIRCUITS

Incoming signals are picked up by the Loran antenna and fed to the Antenna Coupling Unit, RM-220. The antenna should be as nearly vertical as possible, and may be 30 to 125 feet in length. The inductance in the RM-220 Coupling Unit neutralizes the capacitive component of the antenna at a given frequency, thus insuring maximum signal transfer to the receiver input.

From the Antenna Coupling Unit the signals are conducted to the antenna input connector on the rear of the Indicator-Receiver Unit by means of coaxial cable. Before signals are applied to the first RF stage of the receiver, they are fed to the LOCAL-DISTANT switch, S502. This switch has three positions:- LOCAL 1, LOCAL 2 and DISTANT. With the switch in the DISTANT position, signals are fed directly to the RF amplifier input transformer, T501. In position LOCAL 1, a resistance network of 20 db attenuation is inserted. In position LOCAL 2, the attenuation is 40 db. These networks are PI-type pads which are used to attenuate strong signals before they are applied to the first stage of the receiver. This prevents overload of the receiver circuits, thus preventing large errors in the TIME DIFFERENCE reading. The attenuator circuits should be used only when the ship is very close to a Loran transmitting station.

.2 RADIO FREQUENCY AMPLIFIER

There is one stage of RF amplification, tube V501. The inductance of the input transformer, T501 is adjusted to resonate the fixed capacitors, T501A (56 uuf) and C504 when the CHANNEL switch is in POSITION 1. For

CHANNEL 2, a variable capacitor, C503 is switched across the coil and fixed capacitor of T501, and this capacitor only is adjusted to resonate the tuned circuit to the RF frequency of CHANNEL 2. To resonate the circuit for CHANNEL 3, capacitor C502 is switched in and adjusted; and capacitor C501 is switched and adjusted for CHANNEL 4. Note that the inductance of T501 is adjusted only for CHANNEL 1.

The output of the RF amplifier, V501 is coupled to the converter tube, V502 by means of transformer, T502 which has a tuned primary and a tuned secondary. The method of tuning is the same as that described for the input transformer. That is, the primary inductance of T502 is adjusted to resonance for CHANNEL 1 with the fixed capacitors, T502A and C508. For CHANNEL 2, C507 is switched (by S501B) across T502 primary winding and adjusted. For CHANNEL 3, C506 is switched (by S501B) across T502 primary winding and adjusted. For CHANNEL 4, C505 is switched (by S501B) across T502 primary winding and adjusted. The secondary winding is tuned in the same manner, and the secondary inductance resonates with capacitors, T502B and C517 for CHANNEL 1 and with C516, C515 and C513 respectively, when the CHANNEL switch is placed on CHANNELS 2, 3 and 4.

Inductance, L501 in the cathode of V501 is part of a tuned circuit resonant at 1100 kc. This circuit is tuned to the IF frequency, thus trapping out any signals at 1100 kc which might get through the RF stage. Thus, IF rejection is improved.

16.3 CONVERTER

Tube V502 is a pentagrid converter. The RF signal is applied to pin 7 of this tube, and the circuits associated with pin 1 make up the Colpitts type oscillator. Crystals are switched into the circuit by switch S501C. On CHANNEL 1, crystal Y504 (3050 kc) is used. CHANNEL 2 uses a crystal at 2950 kc (Y502). The crystal for CHANNEL 3 is Y503 at 3000 kc and the CHANNEL 4 crystal is Y501 at 2850 kc. In every case the value of the crystal is such that an intermediate frequency of 1100 kc is produced in the plate circuit of the converter due to the beating between the signal and oscillator frequency.

16.4 IF AMPLIFIERS

V503 and V504 are IF amplifiers and are similar in operation. These circuits are tuned by transformers T504 and T505. Both the primary and secondary windings of these transformers are tuned to 1100 kc by means of powered iron cores which project through the top and bottom of the transformer can.

The gain of the receiver is controlled by applying an adjustable negative bias to the RF and IF amplifiers. In addition to this normal GAIN control, an additional waveform is supplied to these grids on the GAIN line. This is the AMPLITUDE BALANCE circuit and its operation is discussed fully in the Indicator section. This circuit allows the operator to vary the gain of either master or slave pulse without varying the gain of the other.

CTOR, VIDEO AMPLIFIER AND INTERFERENCE REDUCER

IF signals are rectified by a germanium crystal diode, (CR501) type 9, and positive signals appear at the detector output test point TP501. e positive video signals are coupled to the grid of the first video lifier, V505A which is operating as a cathode follower. Therefore, tive signals also appear at the cathode of V505A.

The INTERFERENCE REDUCER which is fed by the cathode follower, V505A witched in or out of the circuit by switch S503. Capacitor, C530 and act as a differentiating circuit which is effective in reducing the ects of certain kinds of interference, such as that produced by CW smitters. Due to this differentiation, a sharp positive pulse fol-d by a negative pulse appears across R534. Since only the positive se is used in displaying the Loran signals, the negative pulse is inated by a crystal diode, CR502 across resistor R534. This diode as a very low resistance to the negative part of the waveform, thus, assing it to ground. When the INTERFERENCE REDUCER is in the OFF po-ion, positive pulses from the cathode of V505A are coupled without tortion to the grid of the second video amplifier, V505B. This ampli-r inverts the pulse, producing negative pulses at the plate. These ative output pulses are coupled to the Indicator chassis through J502.

ICATOR CIRCUITS

The indicator performs two very important functions. (1) it enables operator to select and identify a particular pair of stations and (2) accurately measures the time difference between the master and slave se of a Loran pair, and indicates this time difference on a direct read- dial.

Since each pair of Loran stations has a different pulse repetition e, a station can be identified by exactly synchronizing the deflection cuits in the indicator with the incoming Loran signal pulses. In other rds, the sweep repetition rate of the indicator is made to equal the pulse etition rate of the signal. When this occurs, signals from the station question will be stationary on the screen and a time difference reading then be taken. Received signals on the same RF channel, but with a e different from the desired station, will drift across the screen and be ignored. Therefore, the indicator must be able to produce any one 24 different sweep rates, varying from 20 cycles per second to 34-1/9 les per second. The circuits which produce these accurately timed eps are called the Pulse Repetition Rate (or P.R.R.) circuits.

In addition to the PRR circuits which accurately control the 'scope eeps, a continuously variable delay system must be provided. This must capable of measuring delays directly on a counter with an accuracy within microsecond for any value between zero and 10,000 microseconds or more. th the PRR circuits and the Delay circuits use as a basic timing source 80 kc oscillator and various waveforms derived from it by means of fre-uency divider circuits.

17.1 P.R.R. CIRCUITS

Although the PRR circuits have to produce 24 different sweep outputs, as an example, this section will discuss in detail the operation of the PRR circuit for the H-0 rate. From Table No. 3, the pulse repetition rate is found to be 33-1/3 cycles per second. This corresponds to an interval between pulses of 30,000 microseconds. However, since FUNCTION 1 consists of two sweeps, each 15,000 microseconds long, the period of these sweeps, which are equal to one half the pulse recurrence interval is considered as the primary reference interval. Thus, the output of the frequency dividers is always twice the pulse recurrence frequency of the station in question, and the output sweep generator in FUNCTION 1 is triggered at this rate. This results in two sweeps which have a total length equal to the full recurrence interval. In addition, the output of the frequency dividers triggers a square wave generator which provides triggers at the pulse recurrence rate (33-1/3 cycles for H-0).

17.2 CRYSTAL OSCILLATOR

The basic timing source for the equipment is an 80 kc oscillator, V102A which produces sine waves at this frequency. Slight changes in frequency can be produced by means of the reactance tube, V101 which is shunted across the crystal. This circuit will be discussed later with reference to the AFC-DRIFT operation, but as far as timer operation is concerned, this frequency is assumed to be exactly 80 kc. This circuit is a tuned plate, tuned grid oscillator using a quartz crystal as the tuned grid circuit. Fixed capacitor, C111 and the variable inductance, L102 form the tuned plate circuit. For oscillation, the plate circuit is tuned to a frequency higher than that of the crystal so that the plate circuit will present an inductive reactance to the crystal frequency. Feedback between plate and grid is obtained by C110. The oscillator output can be observed at TP101.

Output from the crystal oscillator is coupled to the grid of the ringer tube, V102B. The coupling network, C113 and R108 form a long time constant which develops a grid leak bias to keep the ringer cut-off except for the positive peaks of the input sine wave. In the plate circuit of V102B, an inductance, L103, together with the stray capacity associated with this circuit forms a resonant circuit at some high frequency. When this tube conducts due to the positive peak of the sine wave on the grid, a transient waveform or "ringing" take place in the plate circuit due to the resonant circuit just described, and a very sharp positive and negative pulse occurs for each cycle of the 80 kc sine wave. The output from the ringer is coupled to the grid of V103A, the 80 kc clipper circuit. Again the grid circuit coupling constants are chosen so that a large grid leak bias is developed. Therefore, only the large positive pulses developed by the ringer produce an output from the clipper tube. This output consists of negative pulses which are used as input triggers to the counter chain. One trigger is developed for each cycle of the 80 kc oscillator. The period for each cycle of the oscillator is 12.5 microseconds, and the time between each negative trigger is also 12.5 microseconds. (Period = 1/frequency, therefore, period = 1/80 kc and period = 12.5×10^{-6} sec.).

...RY COUNTERS

...From the preceding paragraph, it is evident that the basic time unit ...12.5 microseconds. To establish the timing period for the H-O rate ... example), we must get two triggers whose period is exactly 15,000 ...roseconds. Now if 15,000 is divided by 12.5 we find that exactly 1200 ...these basic time units give us the period we require, (that is, 1200 x ...5 usec = 15,000 usec). The PRR problem then resolves itself into one ...being able to count these basic time units, and being able to cause ... special mark to occur when the proper number has been reached. As ... as this happens, the circuit must start counting over again.

Now a binary counter divides by 2. That is, for every two bits of ...ormation fed into it, only 1 bit comes out. In the binary counter case, ... negative-going triggers are fed in, and the output is a wave with only ... negative-going portion.

Figure 3 shows a simplified circuit of a binary counter, and an ex...nation of its operation follows:

A binary counter is a type of multivibrator circuit which, as long as ...is not triggered, conducts continuously in one or the other section ...il something is introduced to alter that condition.

Assume that plate voltage has been applied to this circuit, but that ...re are no input triggers. Due to some slight unbalance in the circuit, ...e A is conducting. The plate current drawn by this tube develops a ...hode bias across the cathode resistor which is common to both tubes, ... this cathode voltage is sufficient to cut tube B off. Tube B is easily ... off because its grid voltage is low. This is true because the grid ...tage is developed from the plate voltage of tube A (through R4, R7 and ...) and this plate voltage is low since tube A is conducting heavily. ...es A and B will remain in this state (A conducting, B cut off) until ...ative triggers are introduced.

Now suppose positive triggers are introduced through capacitor C4 ... the junction of the two germanium diodes, CR1 and CR2. These positive ...iggers will not pass through either diode because of the high diode back ...sistance and, therefore, the state of tubes A and B remains unchanged.

On the other hand, suppose a negative trigger is introduced through ...4. Crystal, CR1, does not readily pass the negative trigger since its ...ate is connected to the plate of tube A, which makes the plate of the ...ystal have a lower voltage than the cathode. Crystal CR2, however, ...sses the negative trigger readily since the plate of this diode is at ...60 volts (the plate supply voltage of non-conducting tube B). The ...igger tends to drop the plate voltage of section B, and this drop is ...upled through C2 and R5 to the grid of tube A. C2, a speed-up capacitor, ...llows the sharp negative trigger pulse to pass immediately to the grid ...f section A from the plate of section B.

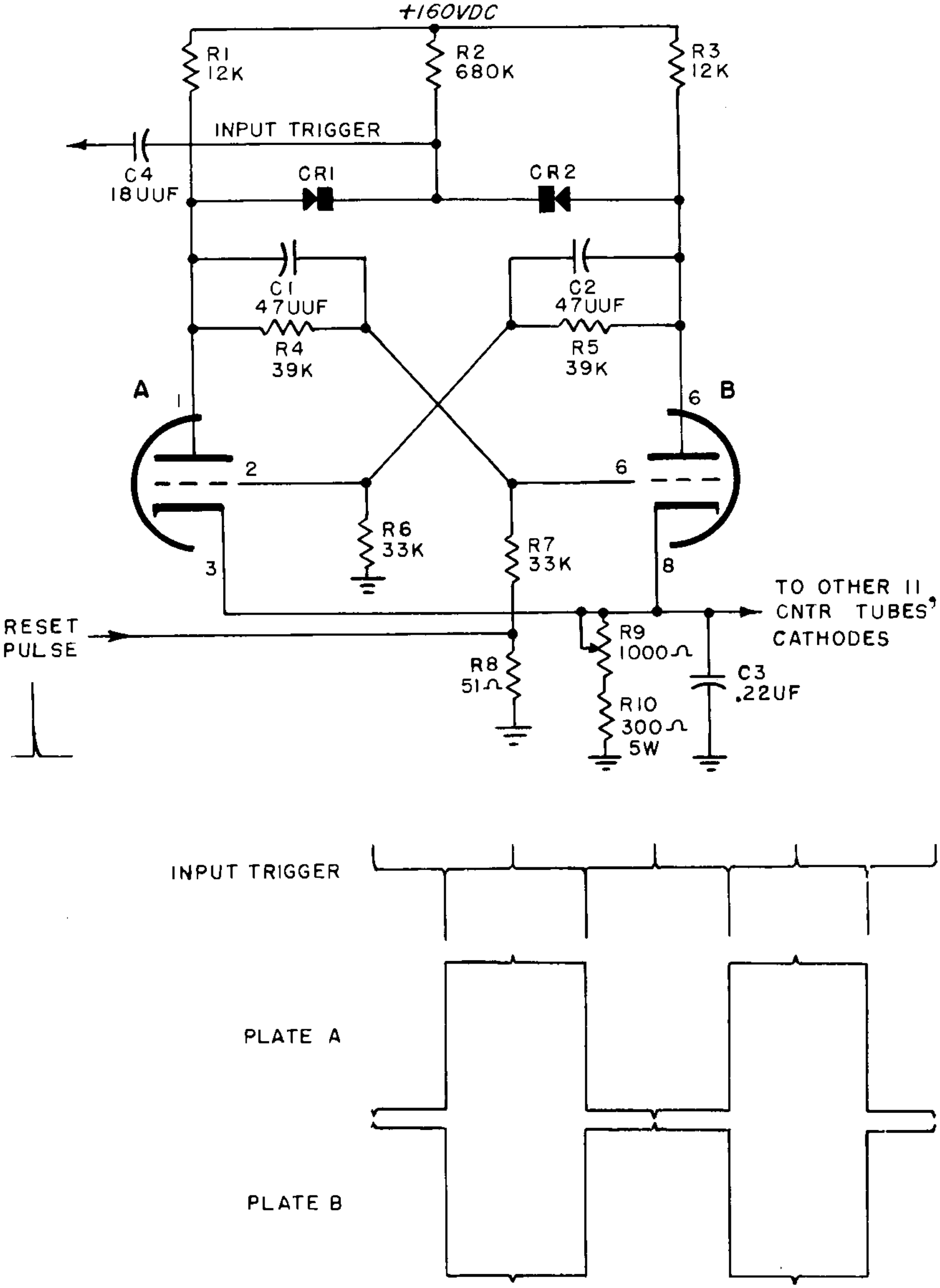

Figure 3

SIMPLIFIED BINARY COUNTER CIRCUIT & WAVEFORMS

Originally, the grid of section A had been drawing a slight amount of current and hence, its grid bias (voltage with respect to cathode) was roximately zero. However, the negative trigger from plate of tube B pled to the grid of tube A tends to cut-off tube A, thus reduce the plate rent in section A, which in turn causes the plate of section A to rise. rise is coupled through C1 and R4 to the grid of section B, thus causing tion B to conduct more heavily. This cycle thus becomes cumulative and section B is conducting heavily and section A is cut off.

When the next negative trigger is introduced, tube A will again conduct section B will cut off, and the plate voltages of tubes A and B will flip k and forth with the introduction of each negative trigger.

Figure 3 shows the plate waveforms of section A and B of the binary nter together with the input triggers. Note that both waveforms are ilar except that they are 180 degrees out of phase. Also note that the roduction of positive triggers does nothing to change the counter wave- m except to add a slight "pip" at the time the trigger is introduced.

Figure 4 indicates the waveforms that are obtained when four counters cascaded. In this case, the output of each counter is coupled to the t counter through a small 18 micromicrofarad capacitor which differentiates square wave output of each counter stage to form positive and negative iggers.

Line A shows the output of the 80 kc crystal oscillator which has a riod of 12.5 microseconds.

Line B shows the negative triggers which have been formed as described preceding paragraphs.

Line C shows the output of the left plate (section A) of the first counter 104), and Line D shows the output of the right plate of the first counter.

Line E shows the triggers produced when the square wave of Line D is dif- rentiated by the coupling capacitor (18 mmf) which couples the output of the rst counter to the input of the second counter, V105.

Note that the number of negative triggers out of the first counter is actly one-half of the number of input triggers fed in. This is what is ant by saying a binary counter divides by 2. Since the input triggers to e first counter are 12.5 usecs apart, the input triggers to the second unter are 25 usecs apart, to the third counter 50 usecs, etc. From this t can be seen that a great number of counters can be used to get PRR sweep riggers for, perhaps, one of the rates, but it would not be possible to form ll 24 rates by this simple process

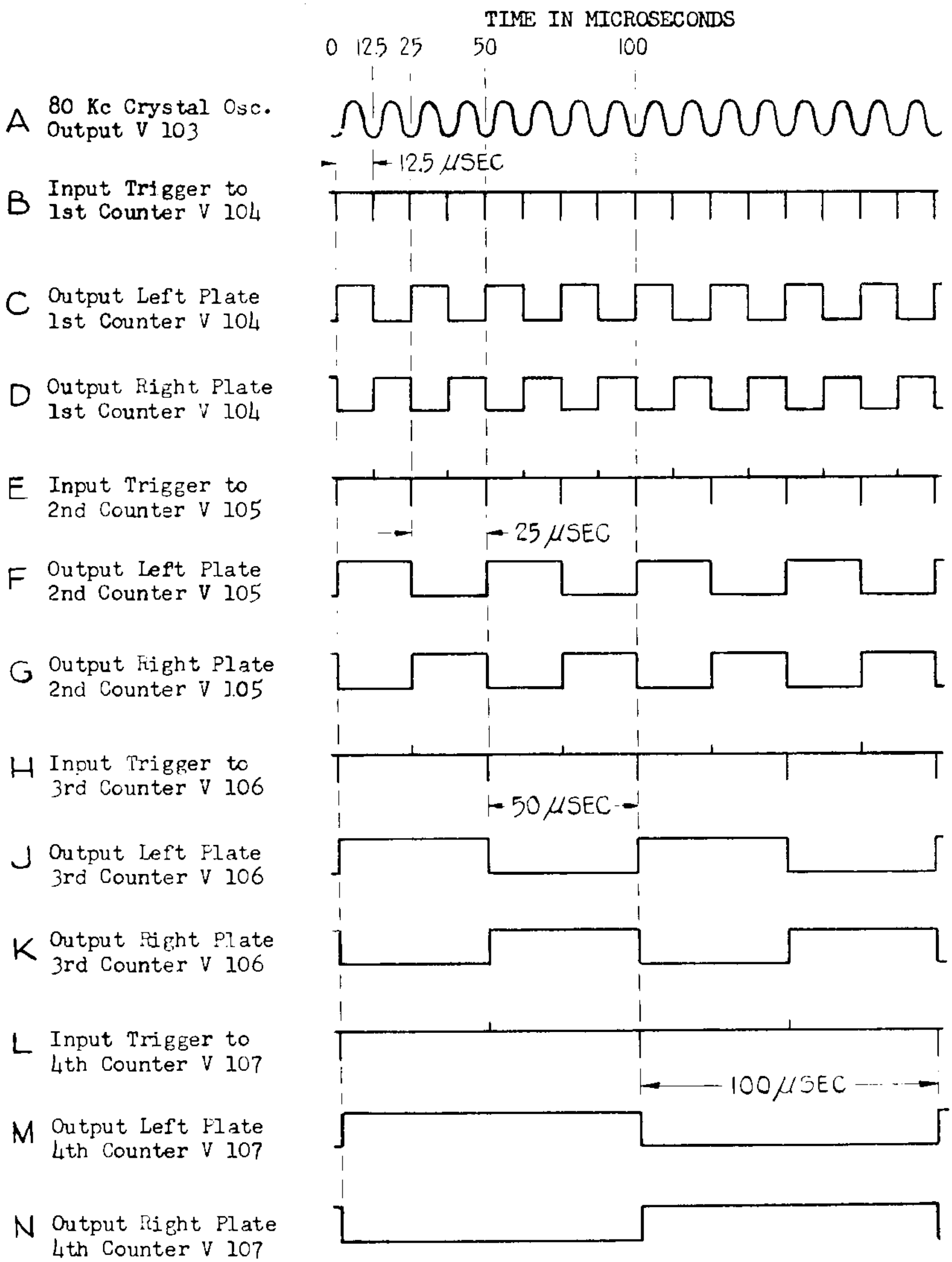

Figure 4

TIME RELATIONSHIP OF FIRST FOUR BINARY COUNTERS ggers, 15,000 microseconds apart, cannot be obtained by of counters, we must consider a more sophisticated mind our original example for the H-O rate, we must exactly 15,000 microseconds. Now the output of 11 ded gives us many waveforms which can be combined in o produce a resultant waveform of the desired charac- wave output of the first counter has a period of 25 ans the waveform is positive for 12.5 microseconds and .5 microseconds. The outputs of all the various counters

TABLE NO. 4

Period	½ Period Time Positive	½ Period Time Negative
25 usec	12.5 usec	12.5 usec
50 "	25.0 "	25.0 "
100 "	50 "	50 "
200 "	100 "	100 "
400 "	200 "	200 "
800 "	400 "	400 "
1600 "	800 "	800 "
200 "	1600 "	1600 "
400 "	3200 "	3200 "
800 "	6400 "	6400 "
600 "	12800 "	12800 "

he waveforms which are obtained from the various counter have assumed our zero time to be the time at which the unters are going positive. (This is a valid assumption shown how and why this is done.) Thus, the output of the rd counter is going positive at time zero, and it stays seconds. At the end of 50 microseconds, it reverses and 50 microseconds. This cycle repeats as long as triggers d counter.

counter has only one-half as many triggers fed to it (due " of the third counter), its left plate starts out positive 0 microseconds and then it reverses for 100 microseconds. he fifth counter has a positive ½ period of 200 microse- ½ period of 200 microseconds. The sixth, seventh, eighth, nth likewise have equal positive and negative ½ periods es shown in Table No. 4.

that the eleventh counter remains positive for 12,800 this long time, it is not possible to draw the various nd therefore, sections of waveforms between 600 and ust be omitted. This omission is represented by the ertically through the waveforms.

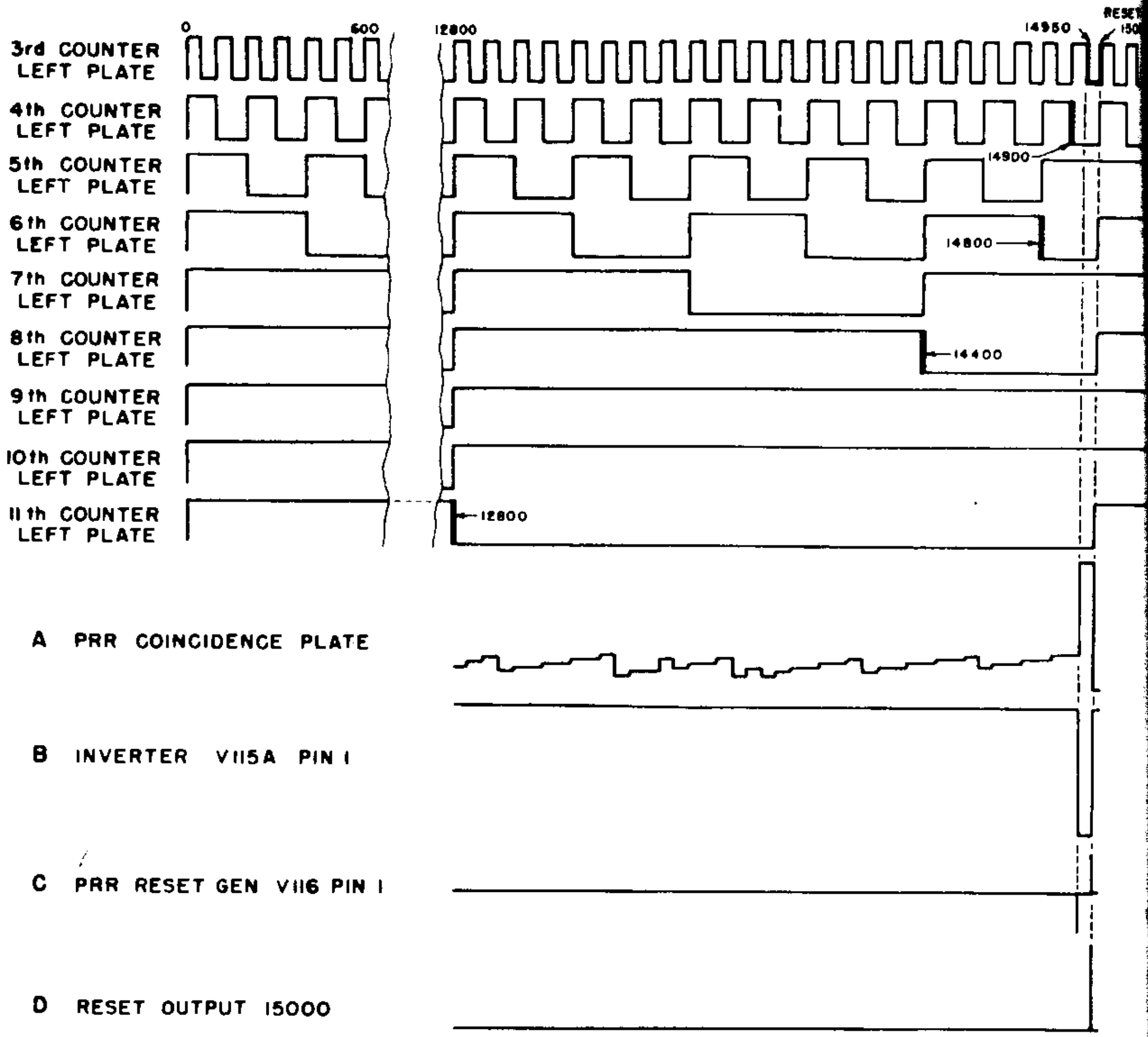

Figure 5
PRR CIRCUIT WAVEFORMS

Remembering that our problem is to determine a time 15,000 microseconds from the zero point, and again referring to Figure 5, we see that the left plate of the 11th counter has remained in a positive state for 12,800 microseconds. At the end of this time the plate becomes negative. All other counters are making a change at this time also. Thus, we now have a point in time which is near our goal, and if we start at this point and add the duration of some of the other counter outputs to this time it will add up to our desired 15,000 microseconds.

Therefore, to the output of 12,800 microseconds, we can add a time of 1600 microseconds available from counter 8. This gives us a total of 14,400 microseconds and we are not too far away from our goal of 15,000 microseconds We see from Table No. 4 (and we can measure on Figure 5) that the 6th counter has a half period of 400 microseconds, so this is added to the total of 14,40 microseconds to give 14,800 microseconds. The output of the 4th counter can add an additional 100 microseconds making the total now 14,900. Since the 3rd counter has a half period of 50 microseconds, this too, is added to give 14,950 microseconds.

From Figure 5, and the previous discussion, we see how waveforms from the 11th, 8th, 6th, 4th and 3rd counters can be used to pick a certain point on the 3rd counter plate which is exactly 14,950 - 15,000 microseconds from a fixed beginning (zero time). Having just shown that there is a point on the 3rd counter output which is exactly equal to the desired recurrence interval, it must now be demonstrated that this point can always be selected with certainty. This is accomplished in the following manner. In Figure 5, note that the 3rd counter goes negative at 14,950 microseconds and remains so until 15,000 microseconds. Also note that the 4th counter is negative during this time. So is the 6th, 8th and 11th counters. But the important thing to remember is that only between 14,950 and 15,000 microseconds are all the outputs of the 3rd, 4th, 6th, 8th and 11th counters negative at the same time. At any other point in time there is always at least one of the counters in question which has a positive value. This is the unique feature which allows us to select a certain recurrence interval from among all the various counter waveforms, and this function is performed by the coincidence tubes.

PRR COINCIDENCE CIRCUIT

Figure 6 shows a simplified schematic of the PRR coincidence circuit. The coincidence amplifiers are V121, V122, V123, V124 and V115B. The outputs of the 3rd, 4th, 6th, 8th and 11th counters are connected to the grids of the coincidence amplifiers as indicated. In addition, negative waveforms from the 5th, 7th, 9th and 10th counters are also connected to the grids of the coincidence amplifiers. (Note: These waveforms are not required to produce the desired pulse recurrence interval, but outputs are taken from the unused counters in order that all the binary counters have a constant load attached to their output plates at all times.) The nine plates of the coincidence tubes are all tied together through a common plate load resistor. The nine cathodes are likewise tied together to a heavily by-passed cathode resistor, resulting in a cathode voltage of approximately 90 volts.

The coincidence circuit functions in such a manner that if any one of the nine triode sections is conducting, sufficient drop in voltage is established across the plate load resistor to keep the plate voltage at a low value. However, if all nine grids go negative at the same time then all the tube sections are cut off and the plate voltage rises to +B. This is shown on Figure 6 as the plate waveform of the coincidence amplifiers. The width of the output pulse so obtained is 50 microseconds and the trailing edge of this pulse is exactly 15,000 microseconds from zero, or starting time.

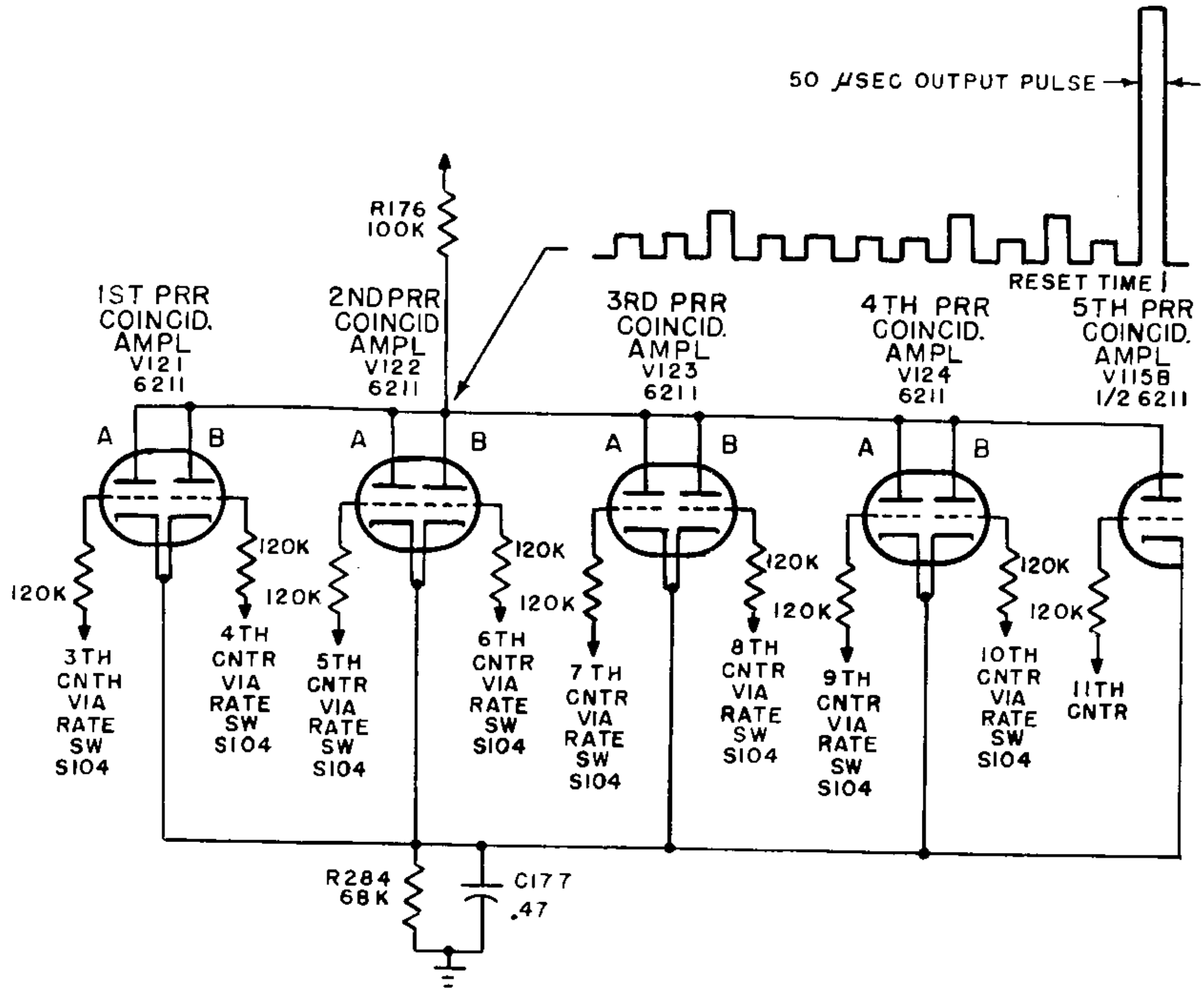

Figure 6

SIMPLIFIED PRR COINCIDENCE CIRCUIT

PRR RESET GENERATOR

The 50 microsecond positive pulse obtained from the plates of the coincidence amplifiers is fed to the grid of tube V115A (see Figure 7). This tube inverts the pulse, producing a negative pulse similar to that shown in Line B of Figure 7. This negative pulse is differentiated by C134 and R181 to give a negative spike when the pulse is going in a negative direction and a positive spike when the pulse starts toward zero. The two spikes produced are shown in Line C.

The two spikes, or triggers, thus formed are now fed to a tube called the PRR reset generator, V116. The reset generator is a thyratron tube normally biased to cut off. However, when the positive trigger of Line C is applied to its grid, the tube fires and a large positive pulse appears on the cathode of V116. This is called the reset pulse and is represented on Line D of Figure 7. The reset pulse is fed back to each of the 11 counter tubes in such a manner as to force the right hand section of each counter into conduction (which, in turn, forces the left hand section "off"). Therefore, at the time of the reset pulse, there is always a known condition established, and every timing cycle begins the same way. In other words, the reset pulse forces the binary counters to begin over again each time the pulse recurrence period has been reached. Thus, the PRR reset pulse is the basic time reference point for all timing sequences in the LR-8803 Loran.

Normally, once a thyratron has fired it will continue to conduct. However, the large reset pulse developed on the cathode (made possible because C136 discharges through the tube) reduces the plate to cathode voltage of the thyratron to such a low value that the thyratron is extinguished. The plate voltage then rises to its normal value as C136 recharges. The plate waveform of the thyratron is shown on Line E of Figure 7.

The question may now be asked as to how the reset pulse which is positive can trigger (or force) each of the eleven counters into a known state of operation when previous discussion of the binary counters stated that only negative pulses are used as triggers. The positive reset pulse can perform this function because (a) it is fed directly (through a 33k resistor) to the grid of the right hand tube of the binary counter and (b) since it is approximately 100 volts in amplitude, it just "overpowers" each counter and forces the right plate "on" (in other words, to conduct heavily). Of course, if the right hand section of the tube happens to be conducting at reset time, its state is not affected by the reset pulse.

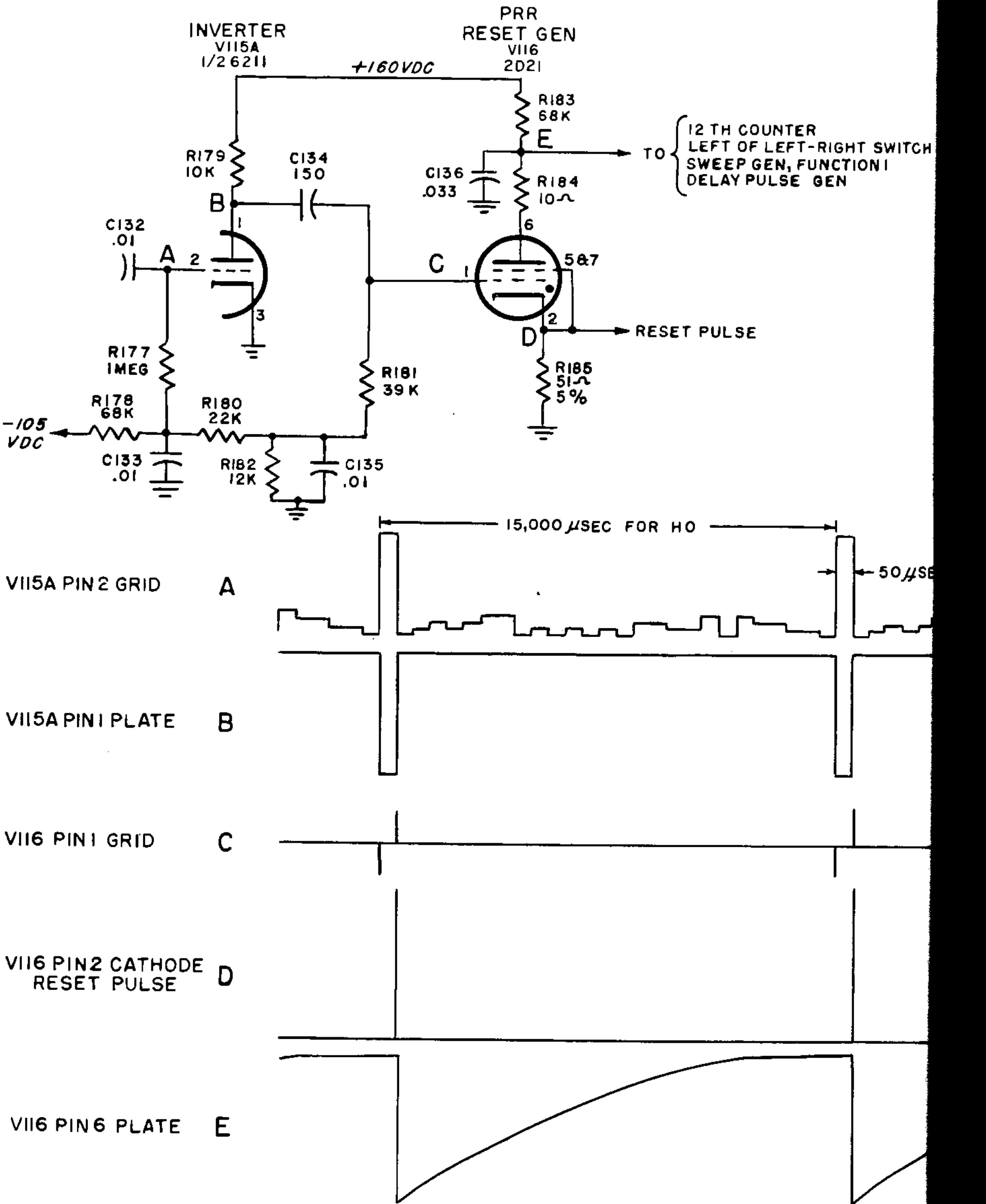

Figure 7
SIMPLIFIED RESET GENERATOR

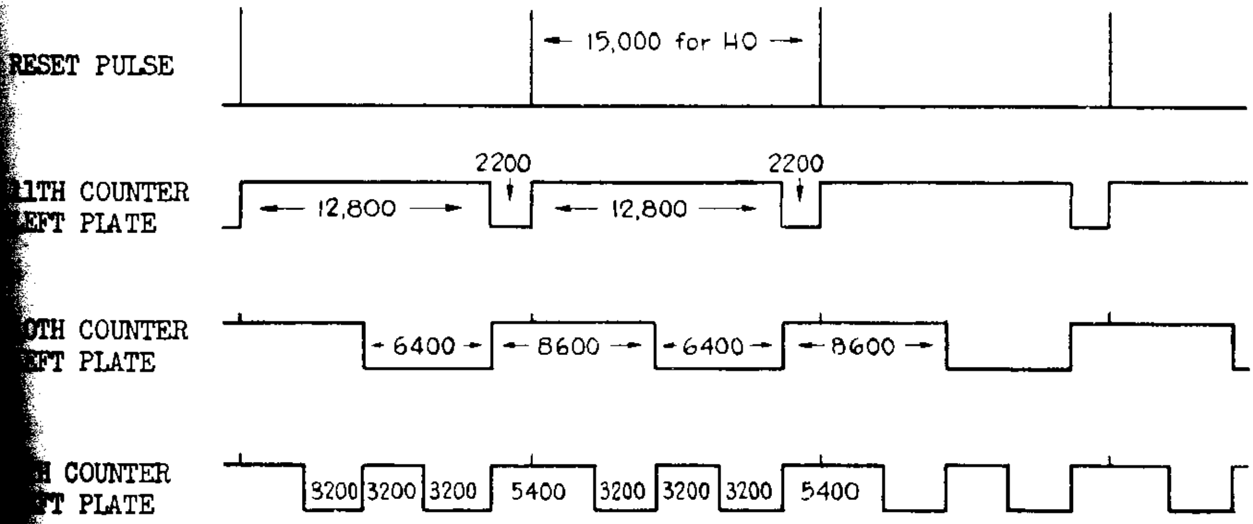

Figure 8

EFFECT OF RESET ON BINARY COUNTER WAVEFORM SYMMETRY

igure 8 shows the effect of the PRR reset pulse on the appearance of the counter waveforms. If there were no reset pulse, the waveforms from all rs would be symmetrical (have equal positive and negative portions). of Figure 8 shows the output of the 11th counter as positive for 12,800 conds after reset, and then negative for only 2200 microseconds. The for the relatively short negative portion of the wave is obvious:- 2200 microseconds of negative wave, the total elapsed time from the re- lse is 15,000 microseconds. This is the required recurrence interval HO rate, and therefore, the PRR thyratron, V116, fires, thus resetting nters so that all left counter plates are positive. If an oscilloscope ed to view the output of the 11th counter, the waveform would have the nce shown in Line B for a LR-8803 Loran working properly (in HO rate).

tice in Line C of Figure 8 that the 10th counter waveform is also non- rical, but the unbalance between positive and negative portions is not iceable.

e output of the 9th counter, shown in Line D, has three symmetrical and then a non-symmetrical one. It is obvious that the lower the counter 8th, 7th, 6th), the greater the number of symmetrical waves before re- urs. For example, the output of the 6th counter will consist of 37 ical cycles before disturbance by the reset pulse occurs.

17.6 GENERATION OF OTHER PULSE REPETITION RATES

Previously, we have seen how the HO rate could be developed by choos ing various waveforms from the binary counters and feeding such waveforms into the coincidence circuit to develop a 50 microsecond pulse which in turn produced a reset pulse having the wanted recurrence interval.

In a similar manner all the recurrence rates, HO thru H7, LO thru L7 and SO thru S7 can be developed. In each case, certain waveforms are tak from the counters and fed to the coincidence tubes by means of the RATE switch, S104.

Table No. 5 indicates which output of each counter must be used to d velop a given rate. For example, to produce the L4 rate, the A-plate out puts of the 3rd, 4th, 6th, 10th and 11th counters are fed to the coincide tube grids, as well as the B-plate outputs of the 5th, 7th, 8th and 9th counters.

TABLE NO. 5 PRR COUNTER CONNECTIONS

A = Plate A B = Plate B

					COUNTER			
RATE	3rd	4th	5th	6th	7th	8th	9th	10th
HO	A	A	B	A	B	A	B	B
H1	B	A	B	A	B	A	B	B
H2	A	B	B	A	B	A	B	B
H3	B	B	B	A	B	A	B	B
H4	A	A	A	B	B	A	B	B
H5	B	A	A	B	B	A	B	B
H6	A	B	A	B	B	A	B	B
H7	B	B	A	B	B	A	B	B
LO	A	A	A	A	B	B	B	A
L1	B	A	A	A	B	B	B	A
L2	A	B	A	A	B	B	B	A
L3	B	B	A	A	B	B	B	A
L4	A	A	B	A	B	B	B	A
L5	B	A	B	A	B	B	B	A
L6	A	B	B	A	B	B	B	A
L7	B	B	B	A	B	B	B	A
SO	A	A	B	B	A	A	A	A
S1	B	A	B	B	A	A	A	A
S2	A	B	B	B	A	A	A	A
S3	B	B	B	B	A	A	A	A
S4	A	A	A	A	B	A	A	A
S5	B	A	A	A	B	A	A	A
S6	A	B	A	A	B	A	A	A
S7	B	B	A	A	B	A	A	A

17.7 BASIC DISPLAY WAVEFORMS

The output of the PRR generator is the basic time reference for all timing sequences in the LR-8803 Loran. This output is shown in Line A of Figure 9. Figure 9 shows the time relationship between the PRR reset generator output and the sweeps and pedestals used for the cathode ray tube presentation.

In FUNCTION 1 position, the full Loran timing cycle is displayed; that is, 30,000 microseconds for the HO rate. The resulting 'scope picture consists of two lines, one above the other, each of 15,000 microseconds duration. The PRR reset generator output is used to start the FUNCTION 1 sweeps and each output of this tube is fed to the sweep generator, V145, which develops the sweep waveform shown in Line B of Figure 9. This waveform is used to deflect the spot from left to right across the cathode ray tube in a linear manner each time a reset pulse occurs.

In order that two horizontal lines can be separated for the FUNCTION 1 sweeps, a square wave (Line C of Figure 9), is developed by the 12th counter, V117. This square wave, when applied to the vertical plates of the cathode ray tube, will displace one sweep from the next, thus developing the two traces.

To complete the picture on FUNCTION 1, two pedestals are developed, one on the top trace a fixed distance from the start of the sweep, and one on the bottom trace which can be varied in position along this trace as the <u>DELAY</u> crank is rotated.

Both top and bottom pedestals, master and slave, are developed by the same pedestal generator, V143. However, the triggers which time these pedestals are generated by separate circuits; the master pedestal being developed from the PRR generator, while the slave pedestal is developed from the delay generators. Line D shows the master pedestal trigger, and the slave pedestal trigger is shown on Line E.

Both triggers are fed to the pedestal generator which forms the pedestals shown on Line F. These pedestals are fed to the vertical deflection plates of the cathode ray tube.

In the FUNCTION 2 position, the cathode ray tube presentation consists of two horizontal traces which have a time duration equal to the width of the pedestals. Therefore, the pedestal generator is used to trigger the sweep generator so that a horizontal sweep occurs only during the time the pedestal generator is in operation. Since the time duration of the pedestal is only a fraction of the full sweep of FUNCTION 1, the horizontal sweep in FUNCTION 2 is much faster than that of FUNCTION 1. The FUNCTION 2 sweep waveform is shown on Line G.

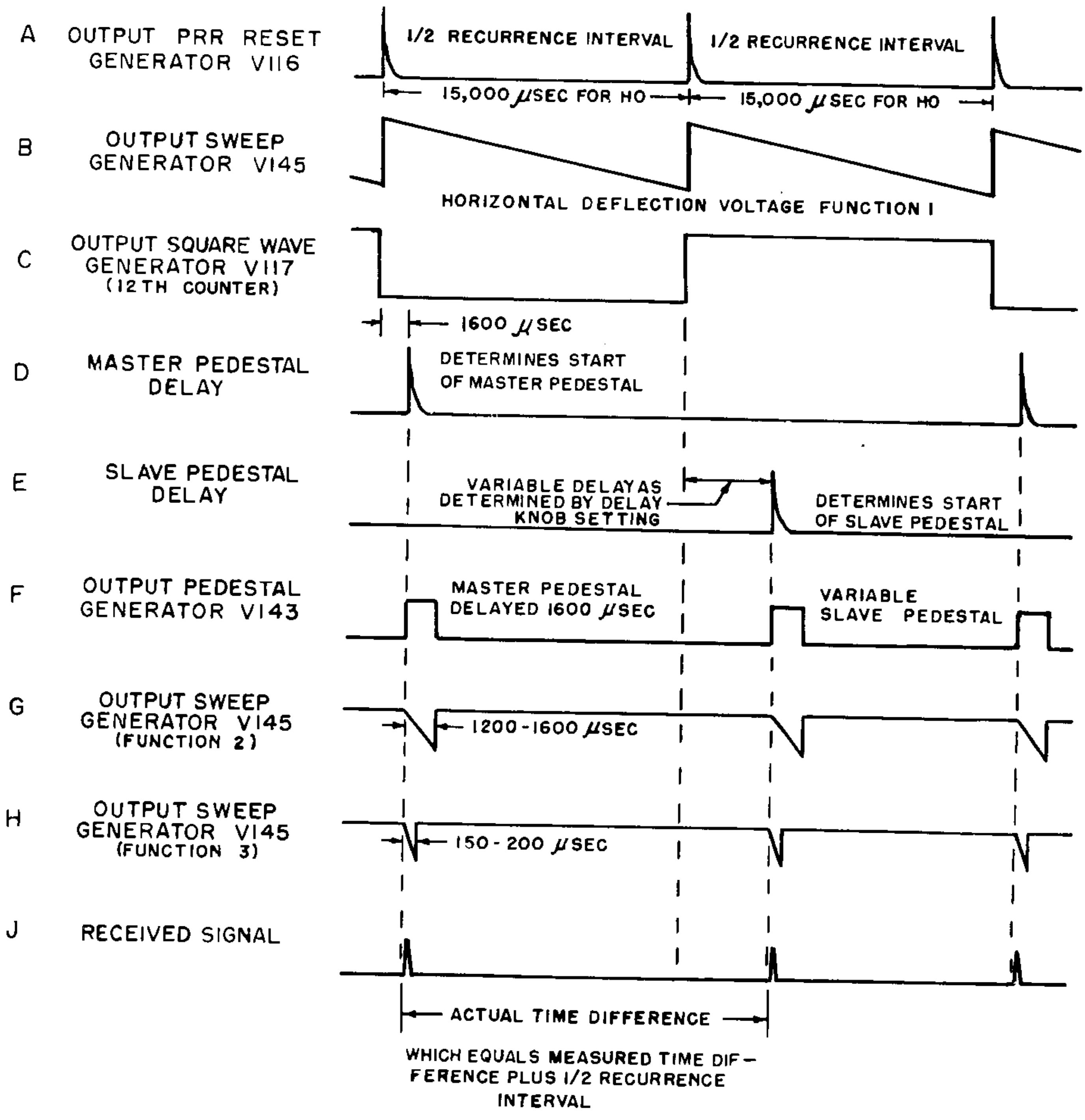

Figure 9
BASIC TIMING WAVEFORMS

The FUNCTION 3 sweep is similar in operation to those of FUNCTION 2, except that the two horizontal lines have now been superimposed (no separation of the two traces) and the horizontal sweep speed is faster. The sweep waveform is shown in Line H. Superimposition of the two traces is accomplished by removing the square wave (Line C) from the vertical plates of the cathode ray tube.

HORIZONTAL SWEEP CIRCUITS

For FUNCTION 1, the sweep generator, V145 is triggered by the plate output of the reset generator. This is shown as Line E of Figure 7 and again as Line A of Figure 10. Referring to Figure 7, it can be seen that when the thyratron fires, capacitor C136 will discharge quickly through the tube. This current flow develops the reset pulse (Line D of Figure 7) on the cathode. This discharge of C136 lowers the plate voltage rapidly and the plate voltage soon reaches such a low value that the tube is extinguished. When this occurs, C136 recharges slowly through R183, thus developing the waveform shown in Line E. The steep negative drop in this waveform corresponds in time, of course, with the reset pulse.

Now this negative waveform from the plate of the reset generator is shaped by C206, R369 and R370 to form the negative pulse shown in Line B of Figure 10. This negative trigger is coupled through FUNCTION switch S102B contacts 10 and 11 by means of capacitor C207 to the suppressor grid of the sweep generator tube. The sweep clamper tube, V144A is not used in FUNCTION 1. However, it is connected to the suppressor in such a way as to allow the negative pulses to be applied to the suppressor unchanged.

Before the negative trigger is applied to the suppressor, tube V145 is conducting; hence, the plate voltage is relatively low. Application of the negative trigger, however, cuts off the flow of plate current (although the screen is still drawing heavy current). The plate then rises rapidly as C208 charges through the combined resistance of R382 and the grid resistance of the tube.

When the negative trigger is removed, plate current begins to flow and the plate voltage drops a few volts. This drop is coupled through C208, thus causing the grid to drop to a voltage such as to maintain a slight amount of plate current. The grid voltage tries to rise to the value of positive voltage established by the bleeder network R175 and R377. However, as the grid tries to rise, due to the charging of C208 through R379 and R383, the resultant drop in plate voltage is coupled back to the grid through C208 to prevent the rise. However, the grid does rise slowly and the plate falls in the linear manner shown in Line C of Figure 10. By varying the potential applied to the grid, the sweep length may be adjusted to fill the cathode ray tube screen.

Since the time interval between triggers is different for the various rates (15,000 microseconds for HO, 20,000 microseconds for LO, and 25,000 microseconds for SO), the amplitude of the various sweeps would vary since the amplitude is proportional to the time C208 is recharging. To prevent this, compensation is added by making the grid return voltage slightly different for all three basic rates, this voltage being highest for the H rates

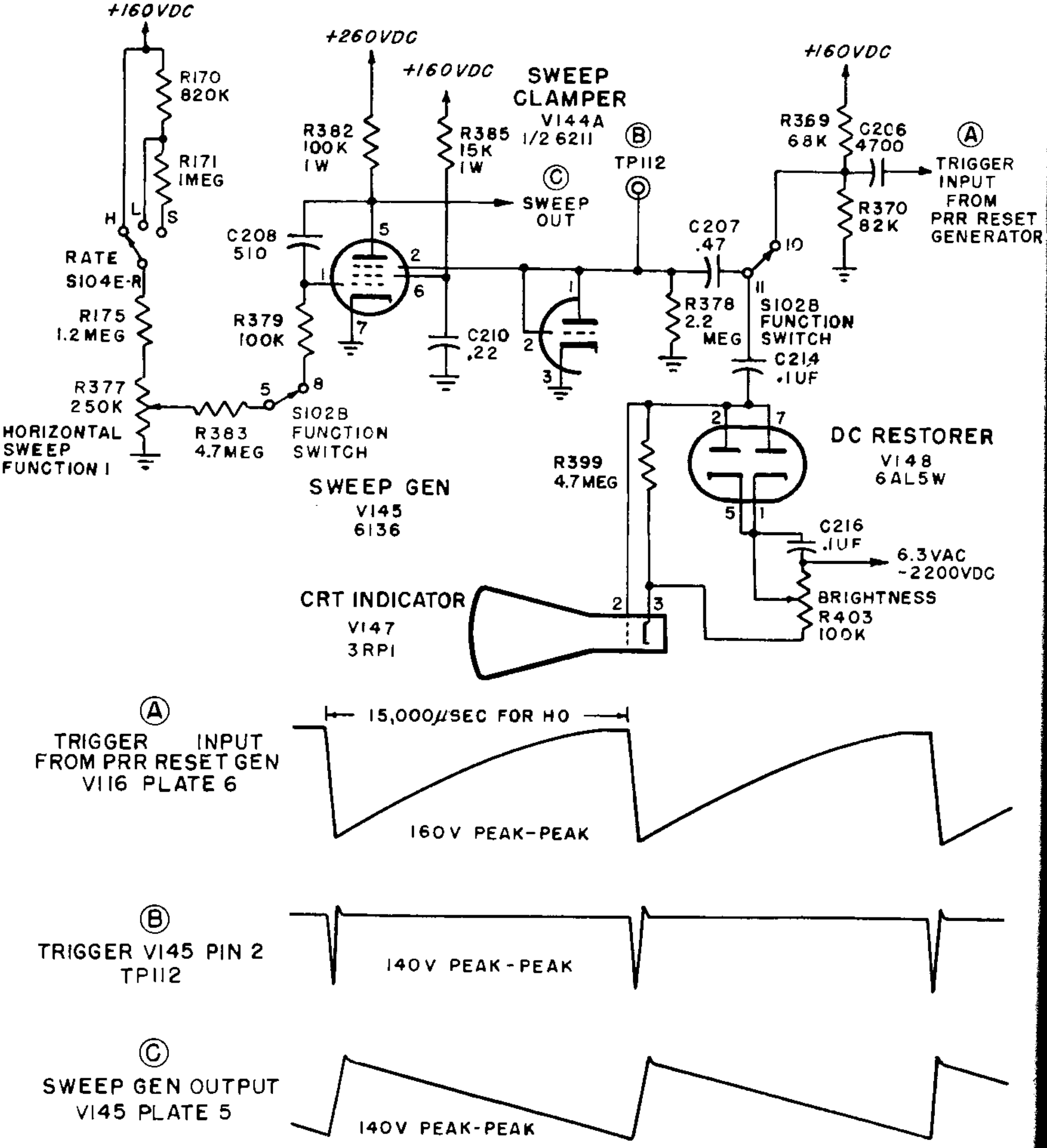

Figure 10

SIMPLIFIED HORIZONTAL SWEEP CIRCUIT (FUNCTION 1) and lowest for the S rates. This is accomplished by switching R170 in series with the bleeder when the L rates are being used and by switching R170 and R171 in series with the bleeder for the S rates. Because of this compensation, the horizontal sweep length potentiometer, R377, can be adjusted to establish approximately the same amplitude FUNCTION 1 sweep (which determines width on the screen) for all three rates.

In the FUNCTION 2 position, the operation of the sweep circuit is somewhat different and Figure 11 shows a simplified schematic for this case. The FUNCTION 3 sweeps are entirely similar, (except shorter time constants are used) and they will not be analyzed.

The FUNCTION 2 sweep has a duration equal to the pedestal width. Therefore, the positive pedestal from the pedestal generator, V143 is used to gate the sweep generator V145.

At all times, other than the time the pedestal is present, the suppressor must be held at a large negative value in order to keep the sweep generator from producing sweep output. This is accomplished as follows:- when the positive pedestal appears, it charges up capacitor C207. Since the plate of the sweep clamper diode, V144A, is connected to the suppressor side of this capacitor, the positive pulse appearing on the plate will casue the diode to conduct, thus causing the suppressor voltage to approach zero (or ground), since there is only a small drop across the sweep clamper tube. Capacitor C207 has, meanwhile, been charged to the peak value of the pedestal voltage, and when the pedestal is no longer present, this capacitor must discharge through R378, a large resistor (2.2 meg.). Due to the charge on C207, there is a large negative voltage on the suppressor side of this capacitor which will remain until C207 is discharged through R378. It is apparent that the sweep clamper diode will not help to discharge C207 because the plate is negative. Since R378 is so large, the capacitor, C207, will hold its charge almost from one pedestal to the next.

When the next pedestal arrives, however, the suppressor voltage is returned to zero. This is shown on Line B of Figure 11. During the time between pedestals, the negative voltage on the suppressor cuts the sweep generator off, and the plate voltage is high. When a pedestal is generated, however, the sweep tube, V145, will begin to conduct due to the change of suppressor voltage, and the plate voltage will fall as shown in Line C of Figure 11. This drop is coupled to the grid through C208 and a linear sweep is produced under the same circumstances as has been described under FUNCTION 1. Since V145 can only conduct during the time a pedestal is present, the resultant sweep will have a time duration equal to the pedestal width.

SWEEP INVERTER

The output of the sweep generator, V145 is fed to one of the horizontal plates of the cathode ray tube. Since push-pull deflection is required, an inverted sweep must be applied to the opposite horizontal plate. Therefore, the sweep output of V145 is also fed to the grid of the sweep inverter tube, V145B through resistor, R393. A sweep of equal amplitude, but of opposite polarity appears on the plate of V144B and this is fed to the other horizontal

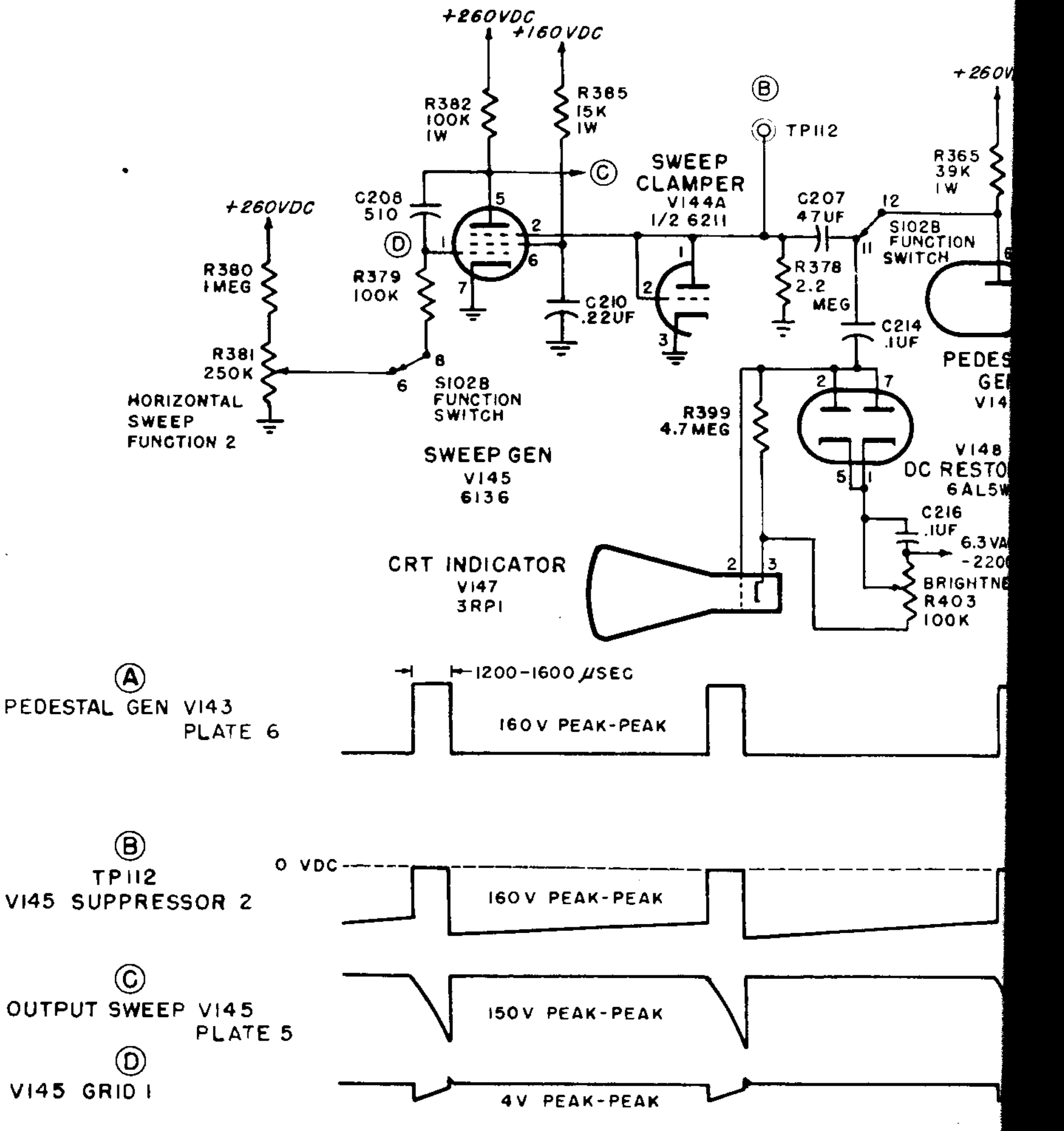

Figure 11

SIMPLIFIED HORIZONTAL SWEEP CIRCUIT (FUNCTION 2) plate of the cathode ray tube. Note that a part of the output of the sweep inverter tube is fed back to the grid of this tube through R395. This negative feedback results in good linearity of the inverted sweep, and tends to keep the amplitude of the inverted sweep equal to the sweep output of the sweep generator.

C.R.T. BLANKING

In FUNCTION 1 position (see Figure 10), the negative pulse used to trigger the sweep generator (Line B) is also coupled through C214 to the grid of the cathode ray tube. Since the plates of the DC restorer, V148, are connected to the grid of the CRT, the applied negative pulses will not be affected by the DC restorer and they cut off the CRT electron steam during this period. Since this interval represents the time in which the sweep is returning from the right side of the CRT screen to the left (retrace time), and since the CRT is cut off during this time, the tube is thereby blanked, and the retrace is not visible.

In FUNCTIONS 2 and 3 the action of the blanking circuit is similar to the suppressor grid gating (blanking) of the sweep generator by the positive pedestal. In Figure 11, note that the positive pedestal which gates the suppressor of V145 is also fed through C214 to the plates of the DC restorer (V148) which is connected between the grid and cathode of the CRT.

The positive pedestal on the plates of the DC restorer causes it to conduct, thereby resulting in zero bias between grid and cathode of the CRT during the sweep interval. Therefore, a trace will be visible and the CRT is unbalanced during the sweep interval. When the pedestal disappears, however, a negative charge has been left on capacitor C214 which is connected to the DC restorer plates and the CRT grid. This charge must leak off through R399, a large resistor, and therefore, the grid of the CRT is biased below cutoff (blanked) until the next pedestal appears. Thus, the voltage on the grid of the CRT has a form similar to that of Line B in Figure 11.

TWELFTH COUNTER AND TWELFTH COUNTER CATHODE FOLLOWER

As described under the PRR circuits, the first eleven counters are used to generate an output which has a pulse recurrence interval equal to 1/2 that of the desired Loran station interval. This output causes the PRR reset generator to fire resulting in a plate output of V116 equal to that shown on Line A of Figure 12. This negative output is differentiated by capacitor, C138 and resistor, R188 to produce the negative triggers shown in Line B of Figure 12, which is used to trigger the twelfth counter. Notice that this counter, V117, is exactly the same as the first eleven counters except there is no connection to the reset line. This is not necessary since the repetition period has already been established by the first eleven counters (15,000 microseconds for HO rate). The twelfth counter divides the 15,000 microsecond input triggers by 2, producing a square wave whose period is 30,000 microseconds. Line C shows this result. In Line C we have a positive wave of 15,000 microseconds, followed by a negative wave of 15,000 microseconds. Of course, the second plate of the twelfth binary counter will produce an output of 180 degrees out of phase with the output of the first plate, and this is shown in Line D.

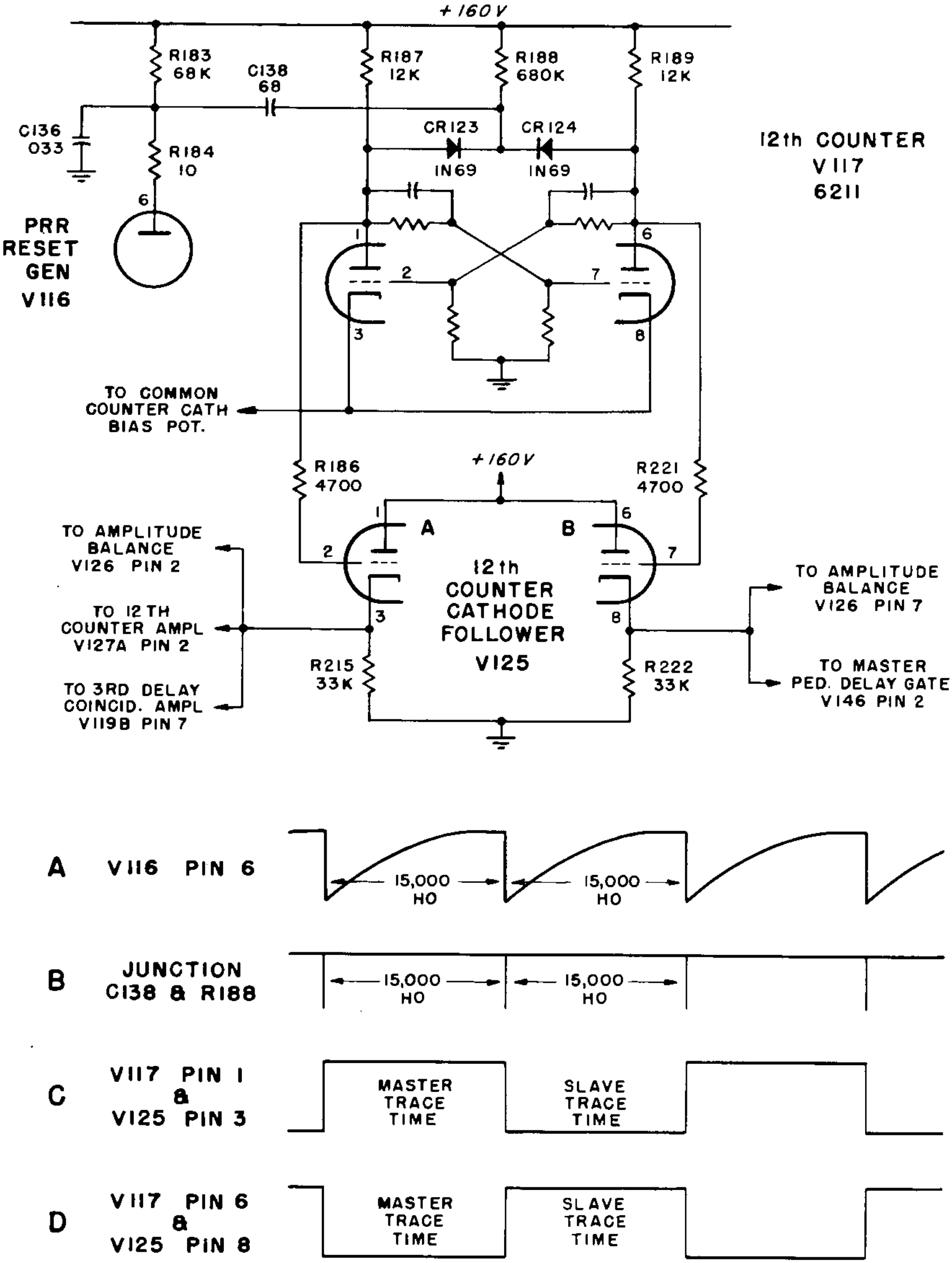

Figure 12
SIMPLIFIED 12th COUNTER & 12th COUNTER CATHODE FOLLOWER