ELECTROMAGNETIC LOG VOLTAGE SIMULATOR WITH SOUND-POWERED PHONES

Henry K. Whitesel, et al

Naval Ship Research and Development Center
Annapolis, Maryland

September 1973

NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
Bethesda, Md. 20034

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by

H. K. Whitesel, H. A. Palmer,
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PROPULSION AND AUXILIARY SYSTEMS DEPARTMENT
Annapolis

RESEARCH AND DEVELOPMENT REPORT

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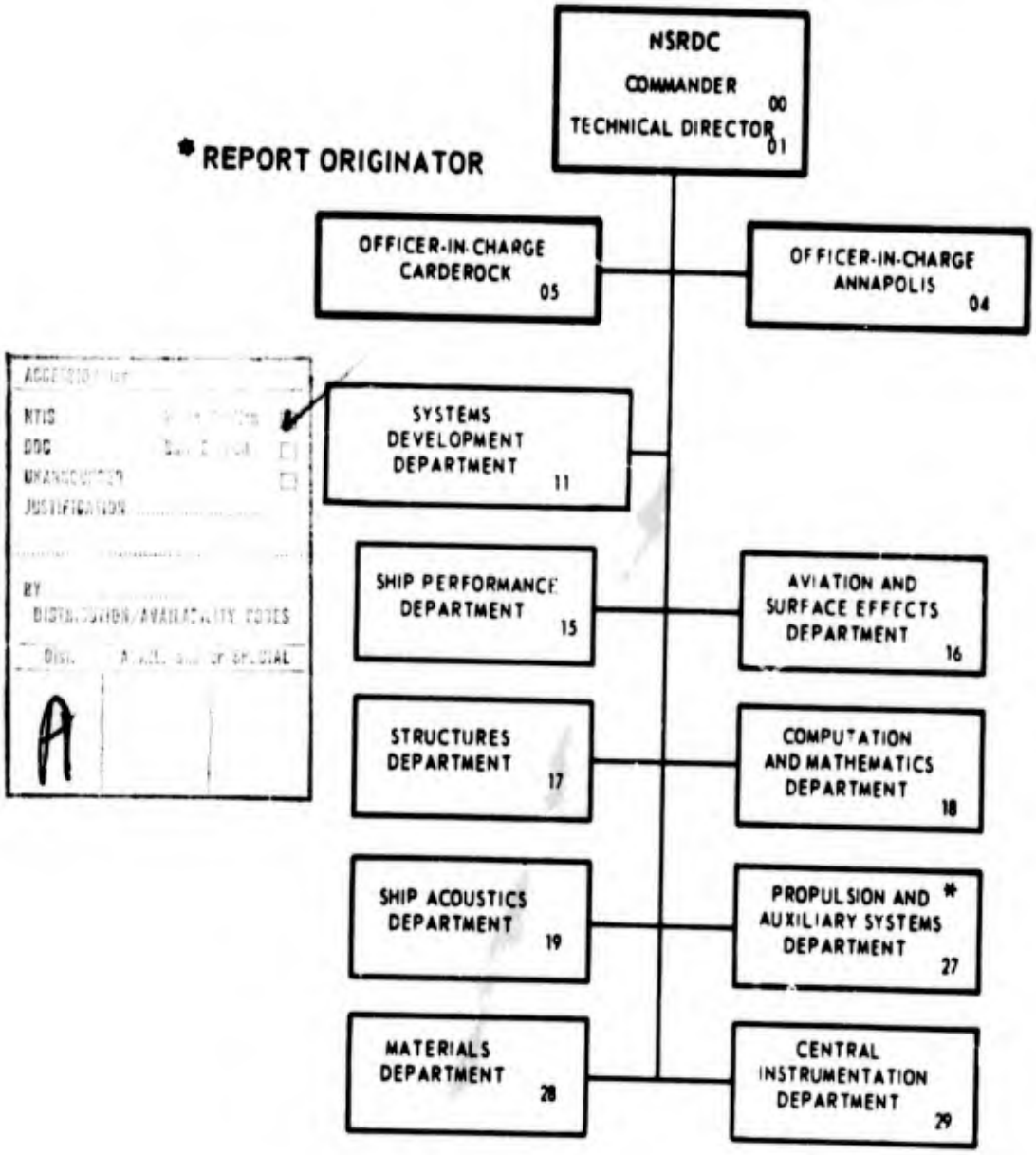

DEPARTMENT OF THE NAVY

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13. ABSTRACT

This is an instruction manual for the Electromagnetic Log Voltage Simulator. The Electromagnetic Log Voltage Simulator is designed to assist in the adjustment, calibration, and troubleshooting of the underwater electromagnetic log system by providing a calibrated voltage which can be directly connected to the indicator/transmitter. The Electromagnetic Log Voltage Simulator can be substituted for the rodmeter on all shipboard installations of the electromagnetic log system regardless of type or manufacture. This manual contains complete operating instructions and connection diagrams required for shipboard use.

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Voltage simulator						
Calibration						
Troubleshooting						
Rodmeter						
Diagrams						
Instructions						
Sound-powered phone						

FOREWORD

This is an instruction manual for the Electromagnetic Log Voltage Simulator. The Electromagnetic Log Voltage Simulator is designed to assist in the adjustment, calibration, and troubleshooting of the underwater electromagnetic log system by providing a calibrated voltage which can be directly connected to the indicator/transmitter. The Electromagnetic Log Voltage Simulator can be substituted for the rodmeter on all shipboard installations of the electromagnetic log system regardless of type or manufacture. This manual contains complete operating instructions and connection diagrams required for shipboard use.

ADMINISTRATIVE INFORMATION

This is a technical manual for an electromagnetic log system calibration device, the Electromagnetic Log Voltage Simulator, designed by this laboratory and funded by NAVSHIPS under the NAVSHIPS OMN assignment PO 0-0192.

TABLE OF CONTENTS

1.0 INTRODUCTION

The Electromagnetic Log Voltage Simulator (ELVS) is intended for use by Navy personnel involved with the calibration, operation, or maintenance of electromagnetic (EM) log systems used to measure a ship's speed and distance traveled relative to water. The purpose of this technical manual is to instruct Fleet and shipyard personnel in the method of operation of ELVS and its potential uses in adjusting and troubleshooting the EM log system.

The EM log system used on surface ships and submarines is a system which senses ship's speed through the water by electromagnetic induction and displays and transmits signals representing speed and distance traveled relative to water. Accurate operation of the EM log system requires that the complete shipboard system be calibrated to correct for variations in individual sensors and the ship's hull. Ships must repeat this calibration periodically to ensure continued system accuracy.

Although the ELVS cannot take the place of a measured range calibration, it can perform many functions essential to maintaining the accuracy of a calibrated system. For example, the accuracy of a system is sometimes degraded when some of its electronics components become degraded or when they are replaced by new ones. The simulator can be used as a comparison standard to determine whether any changes in the log system electronics have degraded its accuracy. The ELVS may also be used in adjusting and troubleshooting the EM log system after the basic calibration has been obtained on a measured range. By properly using the ELVS, the accuracy of the log system can be maintained through many maintenance operations that might otherwise render it suspect.

The ELVS provides a simulated speed signal to the input of the indicator/transmitter (I/T) and may be connected directly to the input of the I/T, to the junction box, or to any of the cables at the junction box or rodmeter. To accommodate all log system models, the ELVS has been equipped with nine different adapter connectors and a main connector which permits it to be connected to any I/T or associated rodmeter cable which has been installed prior to 1973.

The ELVS provides for a communication link between the I/T and any of the ELVS locations by providing a set of sound-powered phones and the necessary adapters for its use. The sound-powered phones will prove most useful when the ELVS is connected at the rodmeter site to the log system cables.

2.0 IDENTIFICATION OF EQUIPMENT

2.1 ELVS Description

The ELVS system comprises 12 separable units, the voltage simulator, 9 cable adapters, and 2 sound-powered phones (handsets). Figure 1 shows the voltage simulator with the adapters and phones in the stowed position with technical manual and calibration data in the cover of the aluminum carrying case. One electrical component (a dummy coil) is mounted on the inside wall of the carrying case opposite the panel. This dummy coil is enclosed in a potting compound which will have a temperature rise when the equipment is in operation and must have free circulation of the surrounding air.

The face of the voltage simulator, figure 2, consists of a FULL-SCALE ADJUSTMENT dial, a sense light, a sound-powered phone jack, a four-position selector switch, and a SPEED SETTING (KNOTS) dial.

Figure 1
ELVS with Adapters in Stowed Position

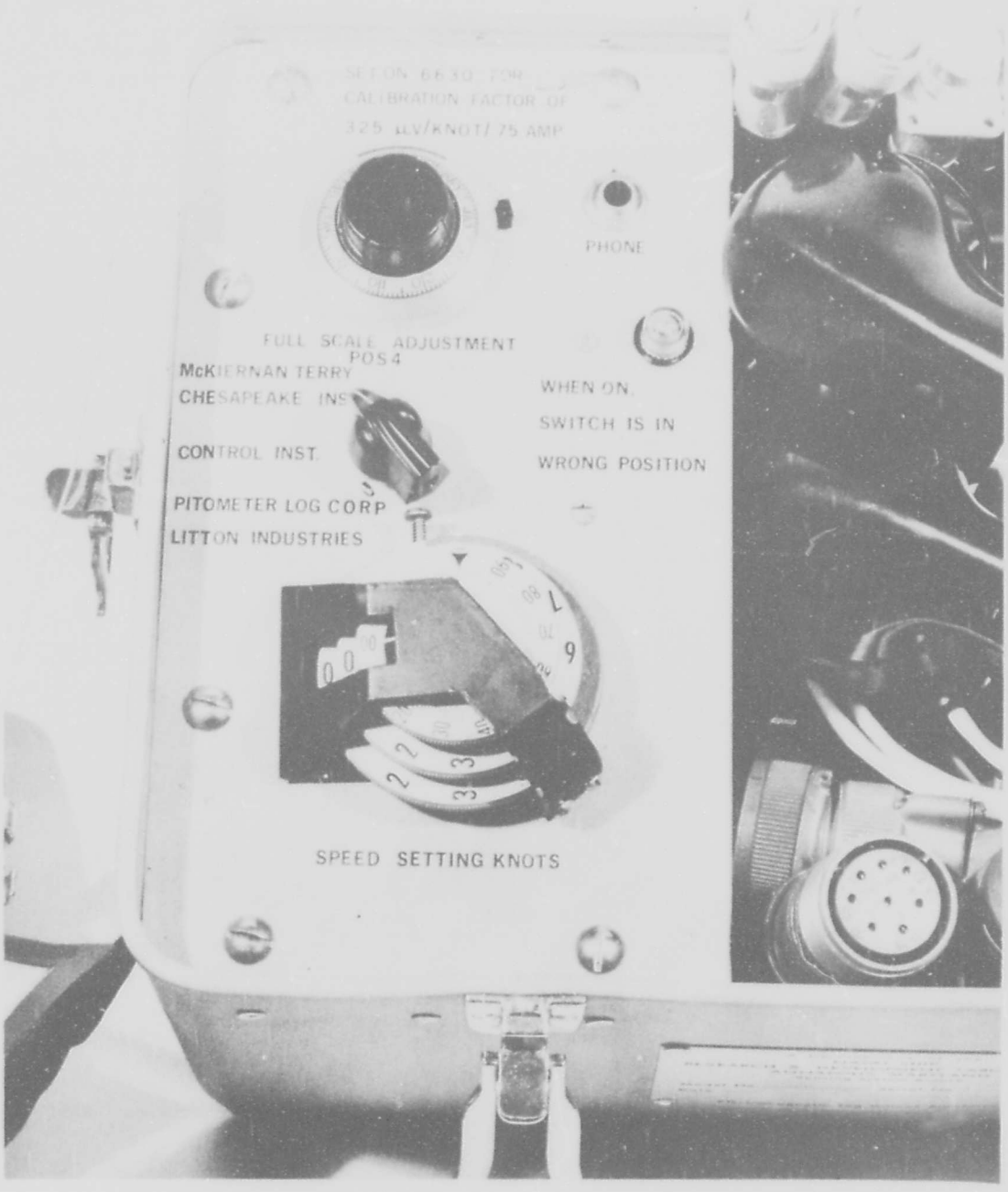


Figure 2

Top View of Panel in ELVS

The FULL-SCALE ADJUSTMENT dial has two coaxial dials; the innermost dial readings are in tenths and hundredths; the outermost dial or window readings are in units.

The sense light is a 28-volt, No. 327 miniature lamp, FSN 6240-155-7836, with an amber lens. When this lamp is on, the selector switch is in the wrong position.

The selector switch is a four-position switch which is used to select the proper connection for log systems made by different manufacturers. When improperly set, it turns on the sense light.

The sound-powered phone jack is used with the sound-powered phone handset provided with the ELVS. These phones are used to maintain communication between the I/T and wherever the ELVS is located, such as at the rodmeter or junction box.

The SPEED SETTING (KNOTS) dial has three coaxial dials. The numbers on the dials are viewed through a guard window which ensures proper setting and guards against accidental movement of the dial. The innermost dial settings are in tenths and hundredths of a knot, the middle dial settings are at 1-knot intervals, and the outermost dial settings are at 10-knot intervals. The outermost dial, the tens of knots, is stopped and color coded red to prevent accidental settings in excess of 40 knots.

The nine cable connection adapters each have a label attached which indicates the number assigned. The adapters, when not in use, are stowed in the aluminum case. Figure 3 is a photograph of adapters 1 through 9 and the two sound-powered handsets. To find the proper adapter needed to connect the ELVS to your underwater log system, see the section in this text labeled "Operating Instructions."

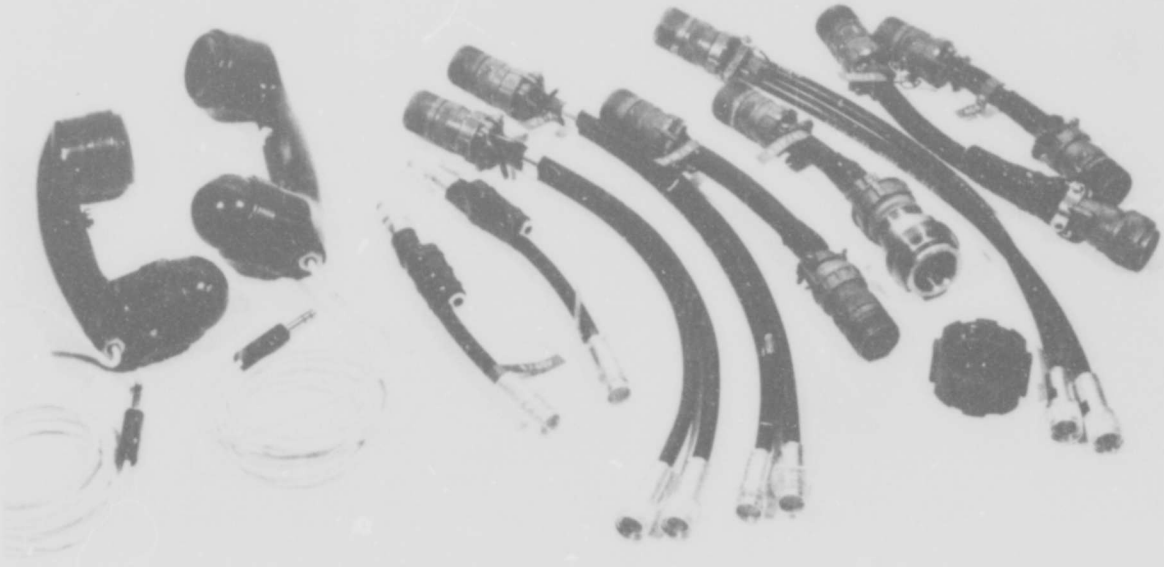


Figure 3
Adapters

To ensure proper calibration of this unit, it should not be operated in the vicinity of strong magnetic fields. For example, keep ELVS out of the general area of large electric motors or transformers when it is in operation.

2.2 ELVS Specifications

- Electrical
  - Power: no external power is required.
  - Accuracy of dialed-in speed setting: 0.01 knot.
  - Accuracy of speed signal output: ±0.03 knot.
  - Operating temperature range: 19 -29° C, 66 -84° F.*
- Mechanical
  - Principal components: voltage simulator, nine cable connection adapters, and two sound-powered phone handsets.
  - Enclosure: dripproof aluminum case.
  - Outside dimensions: 9 x 9 x 13 inches.
  - Weight: 20 pounds.

3.0 INSTALLATION AND STORAGE INSTRUCTIONS

Since the ELVS is used for calibration and troubleshooting purposes, it is not intended for permanent mounting on the ship. There should be a regular location selected by ship's technical personnel for storing the ELVS when it is not in use. When selecting the storage facility, one should note the following: The temperature may vary from 40° to 149° F. When the cover of the ELVS is locked in place, the case is dripproof. Since the ELVS was not designed to be fully shock and vibration resistant, it should not be stored in a high vibration environment such as the engine room; the normal electronic equipment storage facilities should be adequate.

4.0 CALIBRATION INSTRUCTIONS

The ELVS must be calibrated by the manufacturer or a Navy laboratory. It is impossible for shipboard personnel to calibrate the simulator without very specialized equipment. If any components are changed in the simulator, it must not be used as a calibrated source for the I/T of the log system; however, it still may be used to provide a simulated speed signal for the I/T for troubleshooting purposes.

*Abbreviations used in this text are from the GPO Style Manual, 1973, unless otherwise noted.

During normal operation, the ELVS generates a simulated speed signal of 325 μV/kn/0.75 ampere of coil current when the FULL-SCALE ADJUSTMENT potentiometer setting is set as per instructions on the inside panel of the simulator box. Consult figure 2 for a view of the inside of the simulator box. Changing the setting of the FULL-SCALE ADJUSTMENT will cause the ELVS to generate a signal different from 325 μV/kn/0.75 ampere. This procedure is explained in detail in Section 5.0 of this manual.

5.0 OPERATING INSTRUCTIONS

In operation, the ELVS will be used in place of the rodmeter in the EM log system. The ELVS generates a simulated speed signal for use in checking the cabling between the rodmeter and the I/T and for calibrating, adjusting, and troubleshooting the I/T. This section explains the connection details and operating procedures required.

The operator must be aware of three cautions while using the ELVS.

- The ELVS must not be operated in the vicinity of strong 60-Hz magnetic fields as this will cause induced voltage on the wiring and components and thus introduce an error in the simulated speed signal.

- The ELVS should not be operated continuously for several days because the dummy coil (located on the right side of ELVS in the adapter stowage space) will eventually overheat and fail. The operator should periodically (every hour) check the temperature rise of the dummy coil by touching the aluminum enclosure. If he cannot hold his hand on the enclosure, it is too hot and the ELVS should be disconnected until the dummy coil cools.

- The ELVS should be electrically insulated from the ship deck when readings are being taken.

5.1 Connection and Adjustment of Voltage Simulator

The first step is to select the point in the EM log system where the ELVS is to be connected. The ELVS may be connected to any of four locations: (1) directly to the I/T, (2) at the junction box to the ship's cable between the junction box and the I/T, (3) to the junction box on the rodmeter side, and (4) at the rodmeter to the ship's cable between the rodmeter and the junction box. Some log systems may not have a junction box between the I/T and the rodmeter; in this case, the ELVS may be connected only at positions (1) and (4) (at the I/T and the rodmeter).

Since the ELVS was designed to substitute for the rodmeter at several points in the log system, and may be used with any log system in the Navy, the main cable will not always fit. In this case, one of the adapters, stowed in the ELVS, must be attached to the main cable.

5.1.1 Adapter Selection

To select the proper adapter (if one is required), the manufacturer of the I/T and the type of rodmeter used must be known. To determine if an adapter is required, and to select the particular one required, consult the tabulation below to find the figure outlining the connection diagram for the particular log system in use.

INDEX TO CONNECTION DIAGRAMS

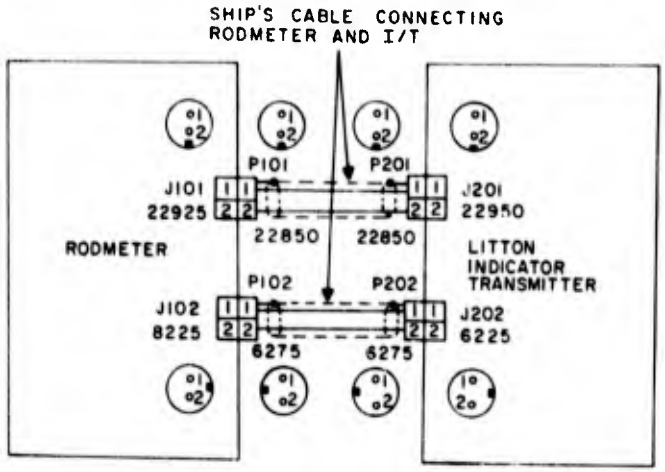
Manufacturers	Rodmeter Type	Figure No.
Litton Industries	Retractable two-connector (twin-coaxial) rodmeter	4
Control Instrument	Retractable two-connector (twin-coaxial) rodmeter	5
McKiernan-Terry	Retractable two-connector (twin-coaxial) rodmeter	6
	Single-connector rodmeter, retractable or low-pressure, fixed type	7
	Fixed rodmeter, high-pressure, single connector	8
Chesapeake Instrument Corporation	Retractable two-connector (twin-coaxial) rodmeter	6
	Single-connector rodmeter, retractable or low-pressure, fixed type	7
	Fixed rodmeter, high-pressure, single connector	8
Pitometer Log Corporation	Retractable two-connector (twin-coaxial) rodmeter	6
	Single-connector rodmeter, retractable or low-pressure, fixed type	7
	Fixed rodmeter, high-pressure, single connector	8

The figure specified shows each log system as normally connected and the ELVS connected to each of the possible points, with or without the sound-powered phone connected. The operator must select the adapter specified in the figures and connect it to the ELVS main cable and the log system as shown. The adapter number is written on a tab attached to the cable of each adapter. If this adapter label is missing, figure 16 (see page 45) of this text can be used to identify the adapter.

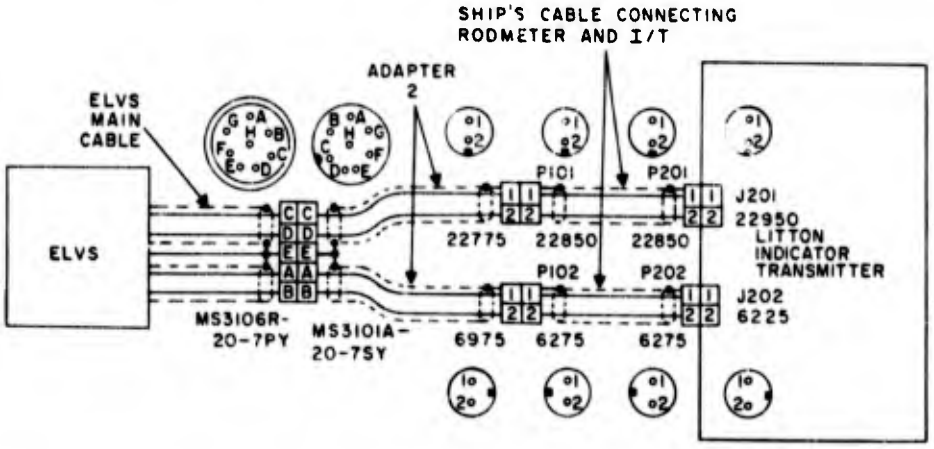
The connection diagrams, figures 4 through 8, include complete wiring diagrams of each adapter shown connected in the system. The connection diagram of each adapter is also shown separately in Section 6.0 of this manual.

On many ships, the junction box and the cables connecting the I/T, junction box, and the rodmeter are installed by the shipbuilder. Thus, the adapters connected at the junction box may not always fit because the ship builder may not choose the recommended connectors. In this event, the technician will have to make his own adapter if he wants to connect the ELVS at the junction box. The wires connecting the I/T and the ELVS must have the same continuity shown in the connection diagrams, figures 4 through 8. A tenth adapter may be formed by connecting adapters 1 and 2 together as shown in figure 9. This may be useful in connecting the ELVS at the junction box.

Item (a) - Litton Log System Connected Normally



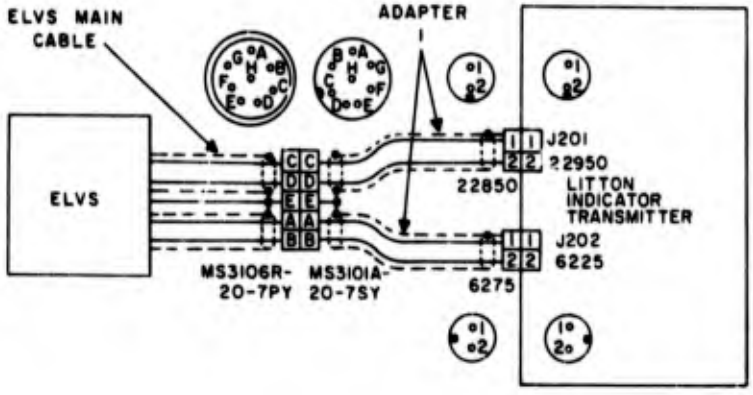
Item (b) - ELVS Connected at Rodmeter to Ship's Cable Between Rodmeter and the I/T



Note: On some ships, the I/T is connected through a junction box to a rodmeter with a single connector. In this case, the ELVS may be connected to the cable on the I/T side of the junction box as shown in item (b). To connect to the junction box on the rodmeter side and to the cable at the rodmeter, consult figure 7 and 8.

Figure 4
Connection Diagram for Litton Industries Indicator/Transmitter

Item (c) - ELVS Connected Directly to I/T



Item (d) - ELVS Connected at Rodmeter to Ship's Cable Between Rodmeter and the I/T Showing Sound-Powered Phone

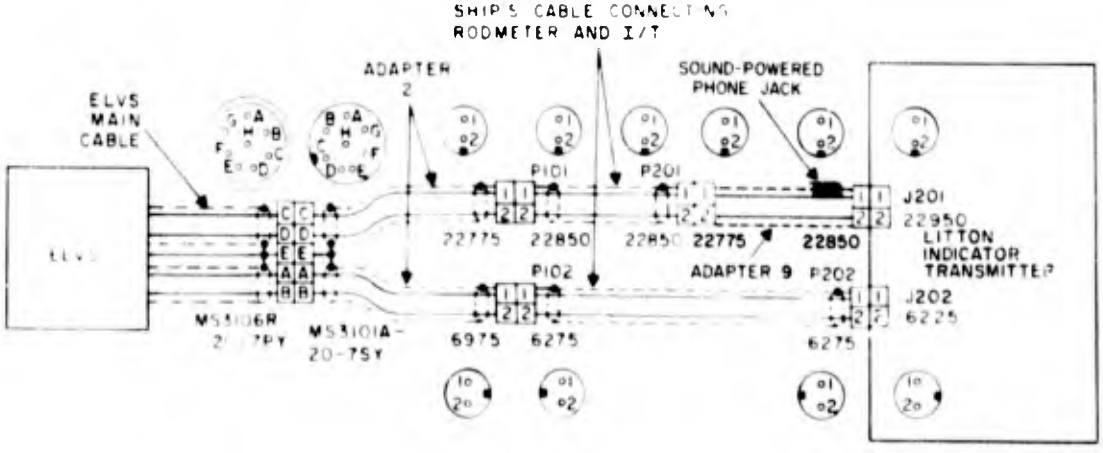
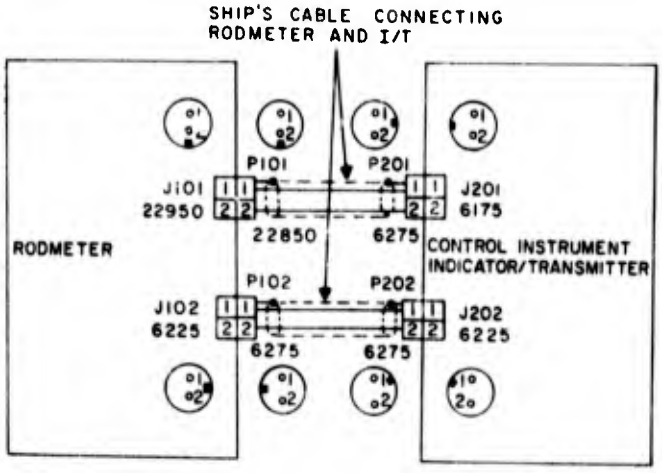
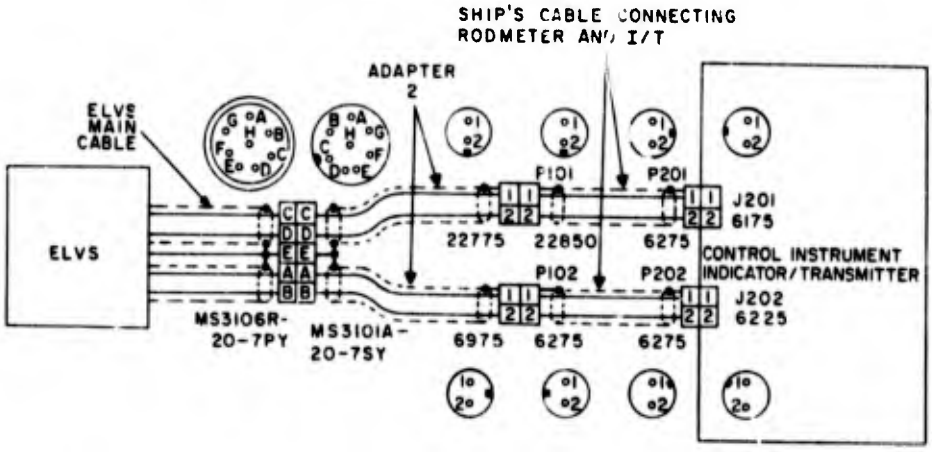


Figure 4 (Cont)

Item (a) Control Instrument Log System, Connected Normally



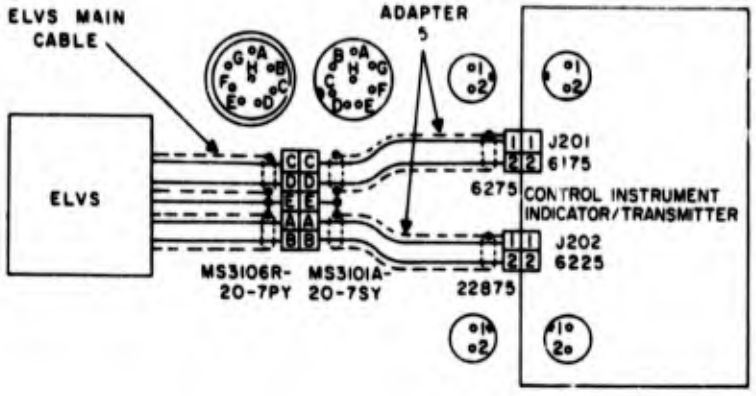
Item (b) - ELVS Connected at Rodmeter to Ship's Cable Between Rodmeter and I/T



Note: On some ships the I/T is connected through a junction box to a rodmeter with a single connector. In this case, the ELVS may be connected to the cable on the I/T side of the junction box as shown in item (b). To connect to the junction box on the rodmeter side and to the cable at the rodmeter, consult figures 7 and 8.

Figure 5
Connection Diagram for Control Instrument Indicator/Transmitter

Item (c) - ELVS Connected Directly to I/T



Item (d) - ELVS Connected at Rodmeter to Ship's Cable Between Rodmeter and I/T Showing Sound-Powered Phone Adapter Location

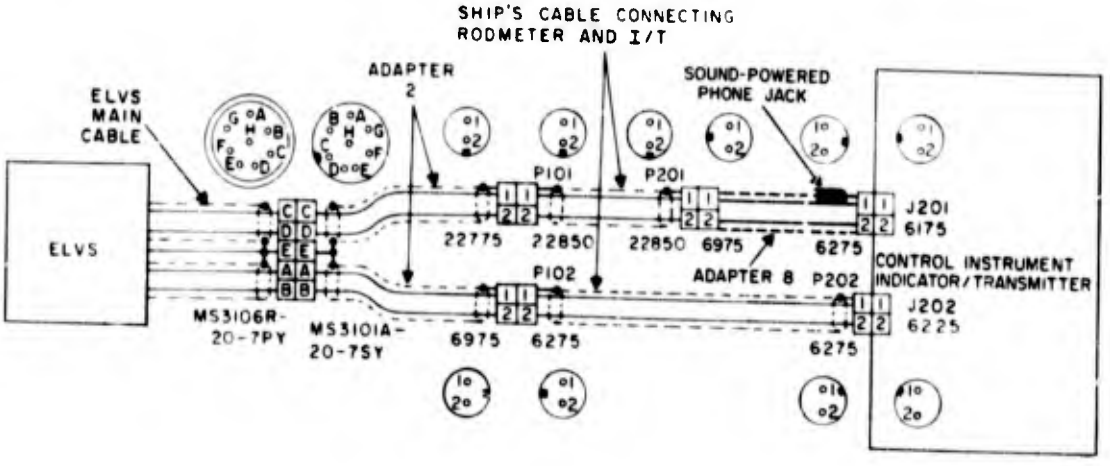
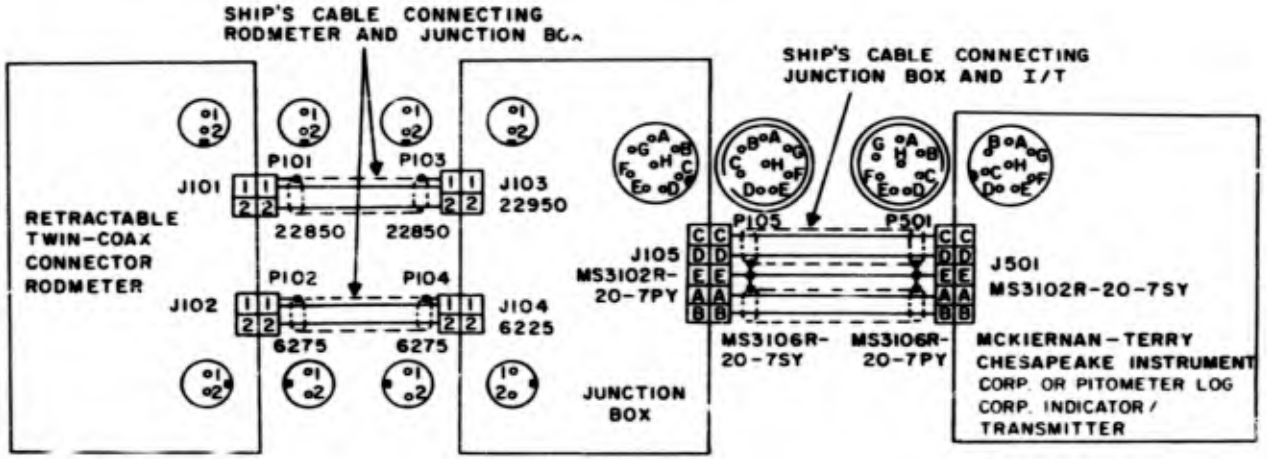


Figure 5 (Cont)

Item (a) – Log System Connected Normally



Item (b) – ELVS Connected at Rodmeter to Ship's Cable Between Rodmeter and Junction Box

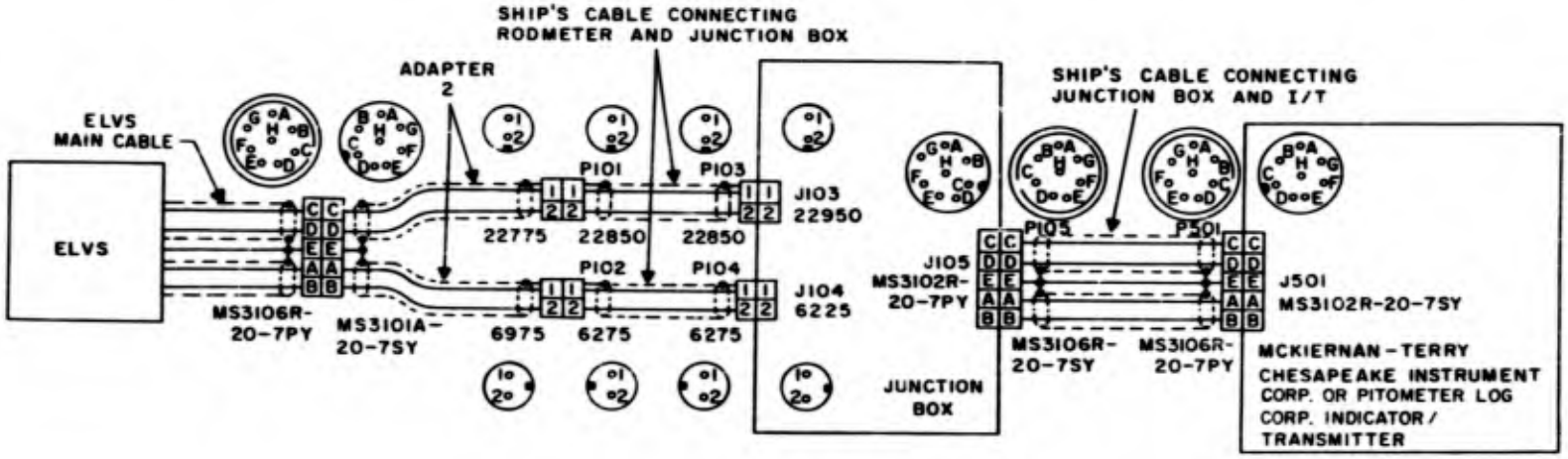
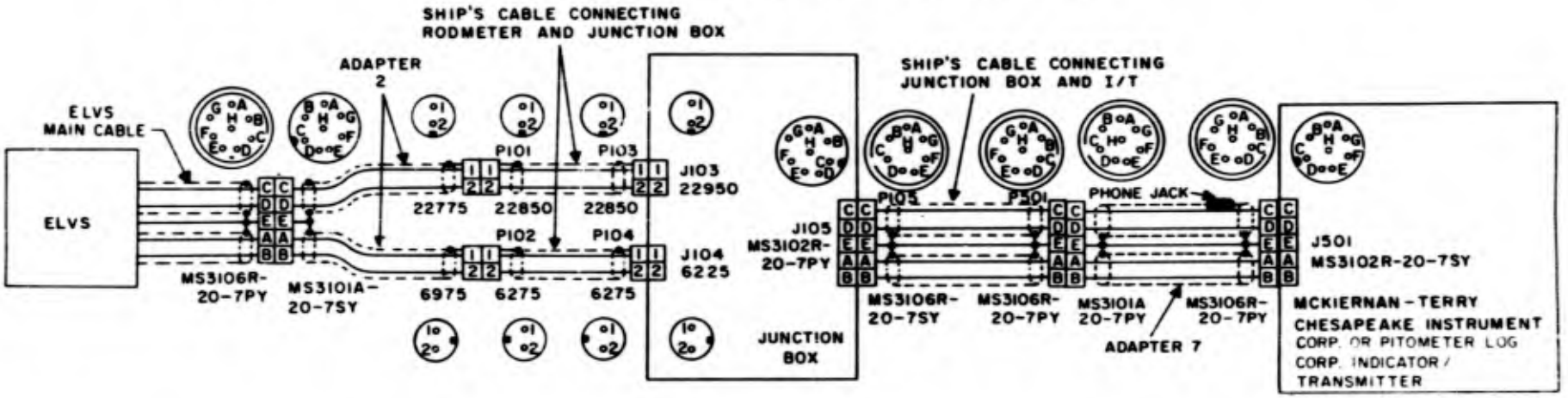
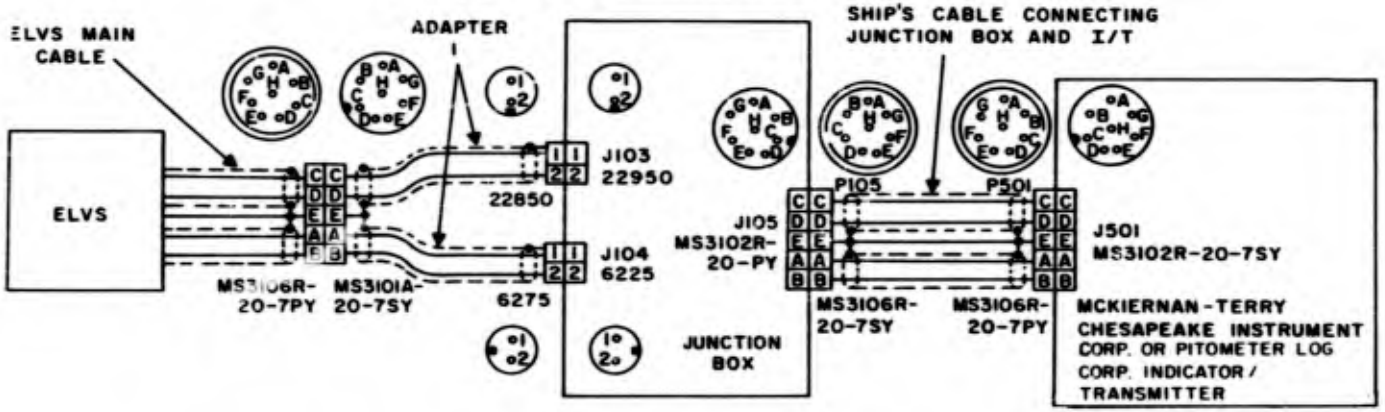


Figure 6
Connection Diagram for Indicator/Transmitters Made by McKiernan-Terry, Chesapeake Instrument Corporation, and Pitometer Log Corporation Used With a Retractable Twin-Coaxial Connector Rodmeter

Item (c) - ELVS Connected at Rodmeter to Ship's Cable Between Rodmeter and Junction Box Showing Sound-Powered Phone Adapter Location

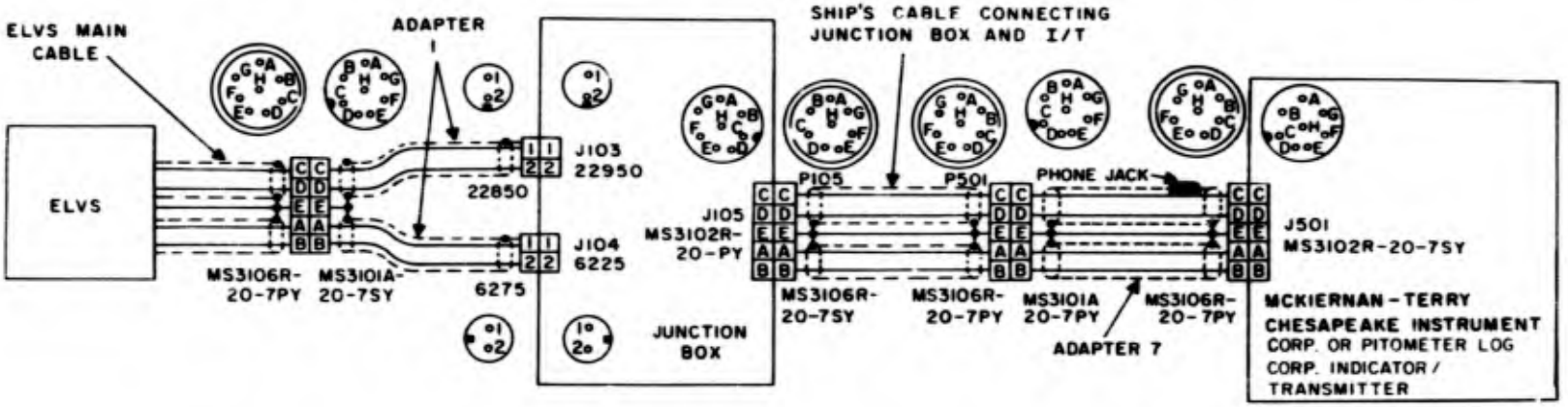


Item (d) - ELVS Connected to Junction Box

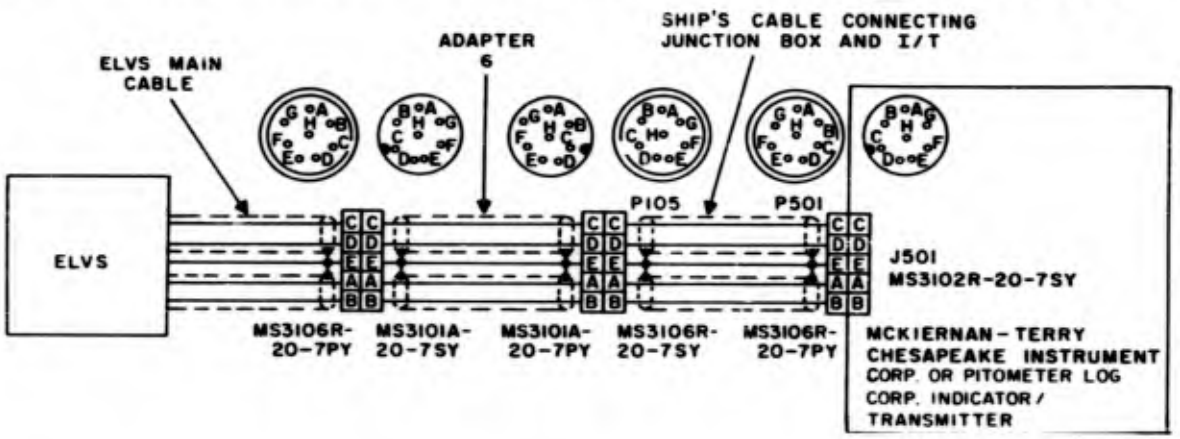


Page 2, Figure 6

Item (e) - ELVS Connected to Junction Box and Showing Sound-Powered Phone Adapter Location

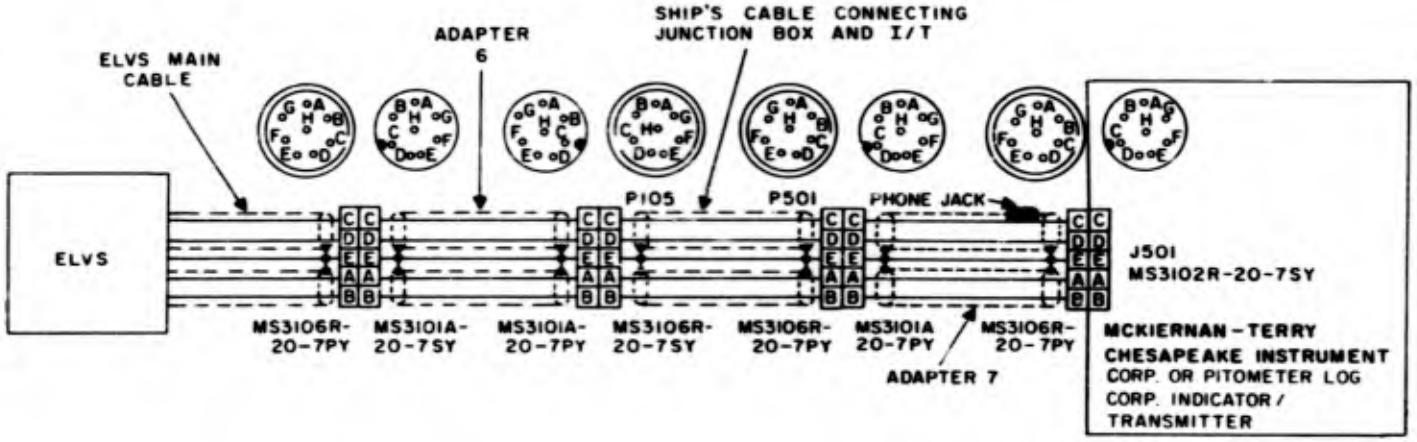


Item (f) - ELVS Connected at Junction Box to Ship's Cable Between Junction Box and I/T

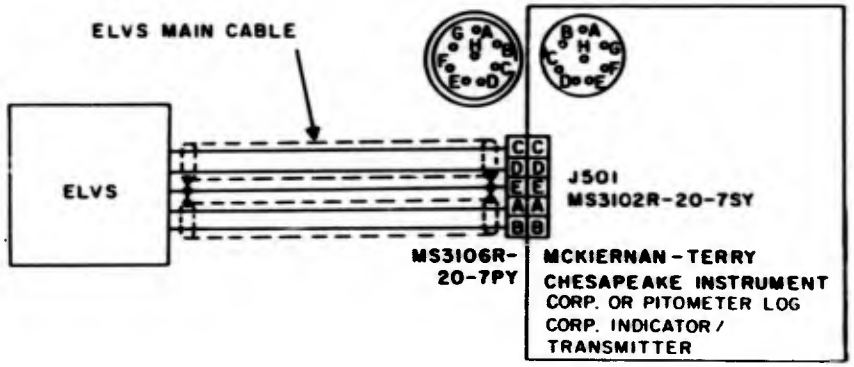


Page 3, Figure 6

Item (g) - ELVS Connected at Junction Box to Ship's Cable Between Junction Box and Showing Sound-Powered Phone Adapter Location

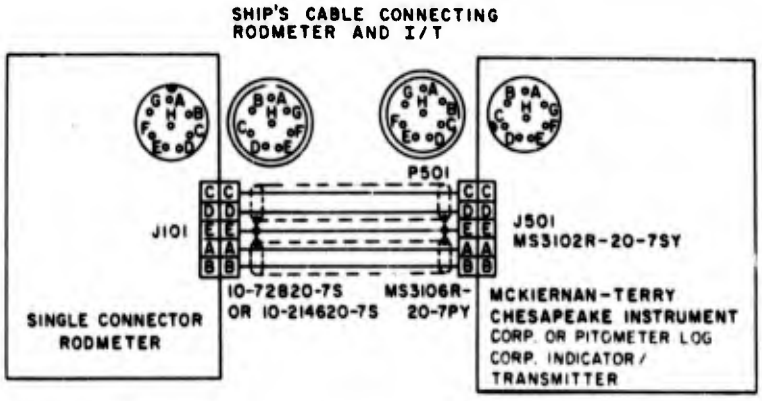


Item (h) - ELVS Connected Directly to I/T

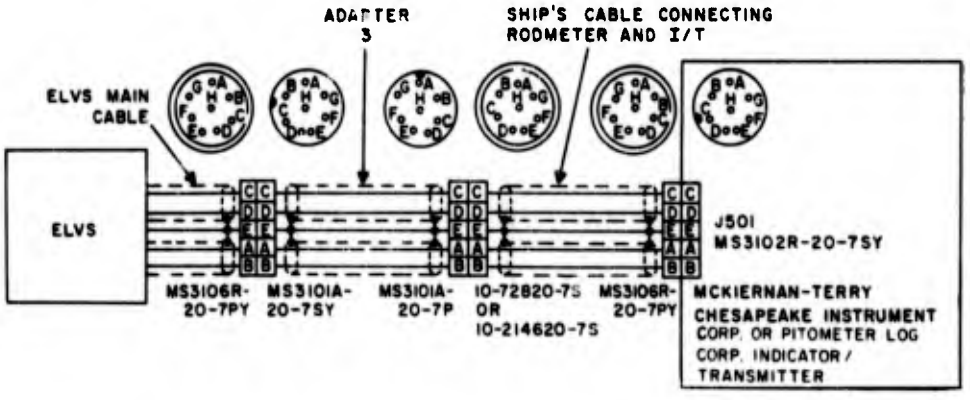


Page 4, Figure 6

Item (a) - Log System Connected Normally



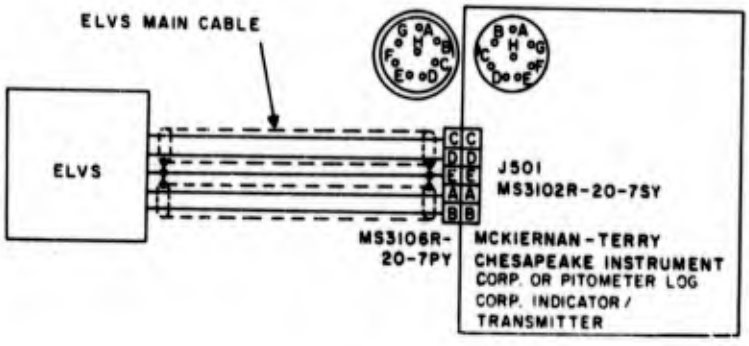
Item (b) - ELVS Connected at Rodmeter to Ship's Cable Between Rodmeter and I/T



Note: If there is a junction between the rodmeter and the I/T, the ELVS may be connected there, as shown in item (d) of figure 6, item (c) of figure 8, and/or item (d) of figure 8.

Figure 7
Connection Diagram for Indicator/Transmitters Made by McKiernan-Terry, Chesapeake Instrument Corporation, and Pitometer Log Corporation Used With a Single-Connector Rodmeter of Either the Retractable or Low-Pressure Fixed Type

Item (c) - ELVS Connected Directly to I/T



Item (d) - ELVS Connected at Rodmeter to Ship's Cable Between Rodmeter and I/T Showing Sound-Powered Phone Adapter Location

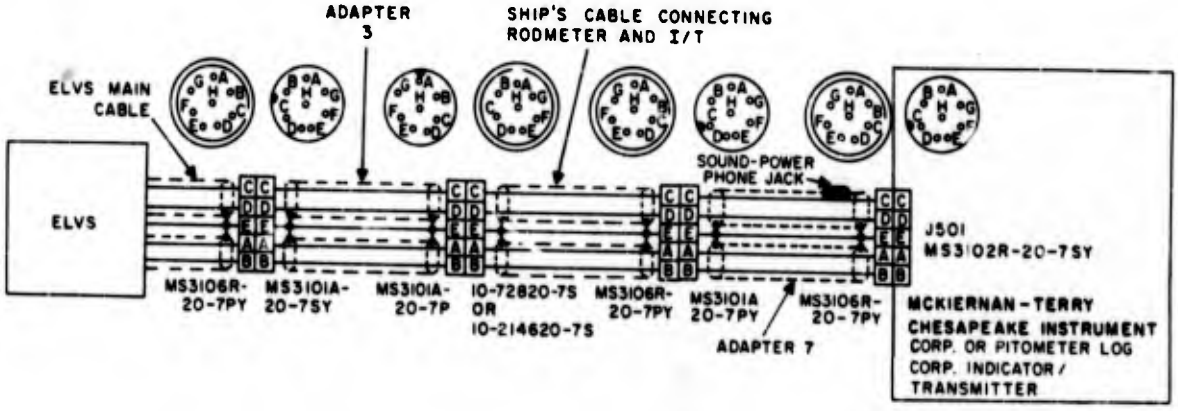
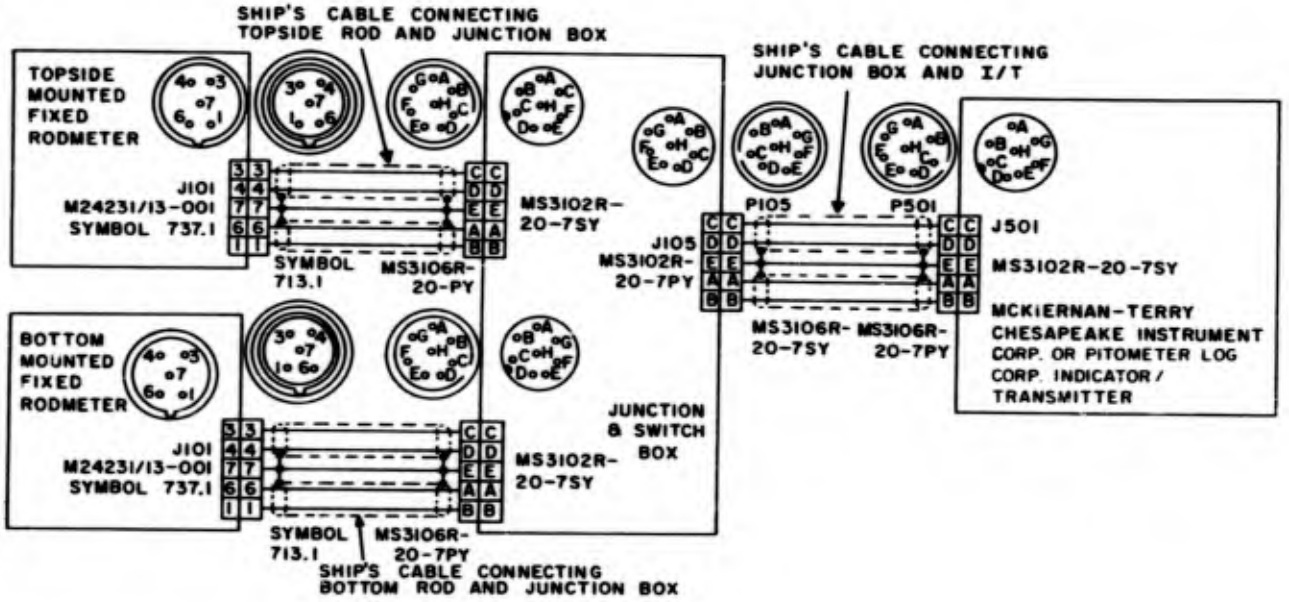


Figure 7 (Cont)

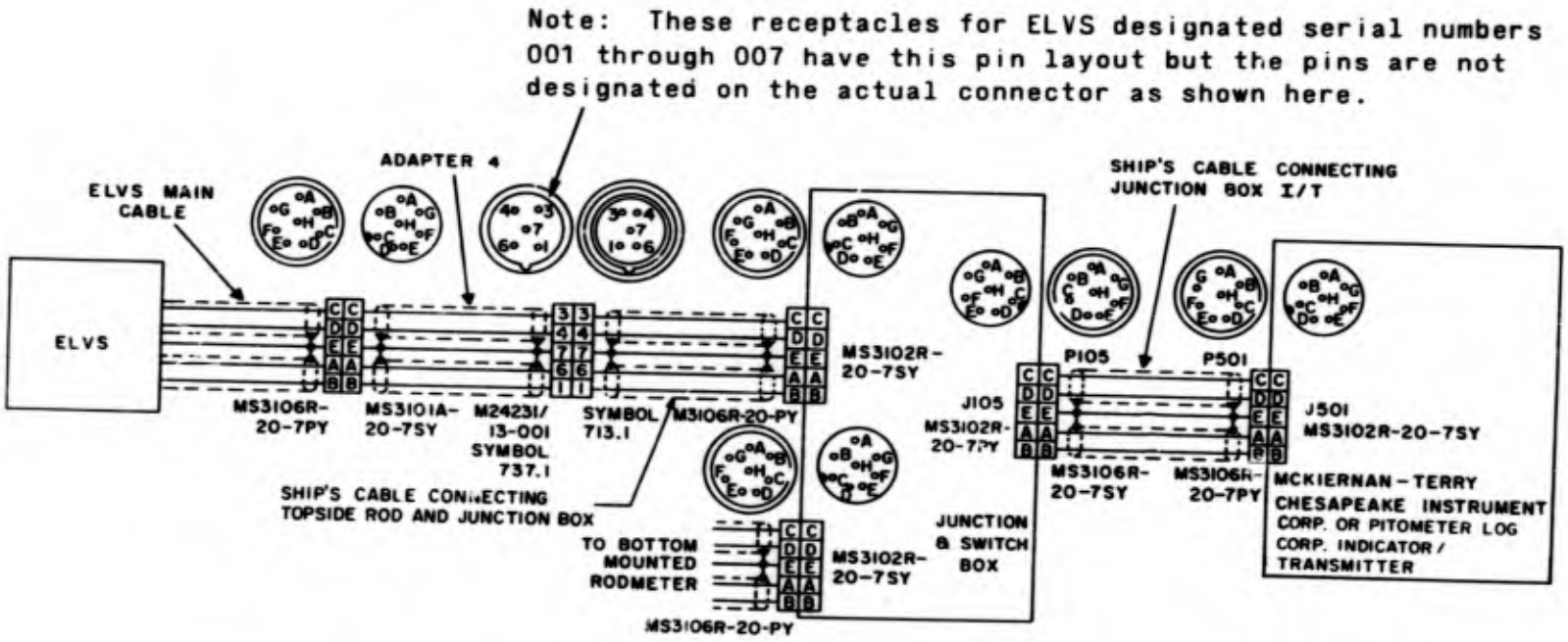
Item (a) - Log System Connected Normally



Note: On some ships the I/T will be either the Litton Industries or the Control Instrument type and thus require twin coaxial cables and connectors between the junction box and the I/T. In this case, the ELVS may be connected at the junction box to the ship's cable according to item (b), figure 4 or 5, and may be connected directly to the I/T as shown in item (c), figure 4 or 5.

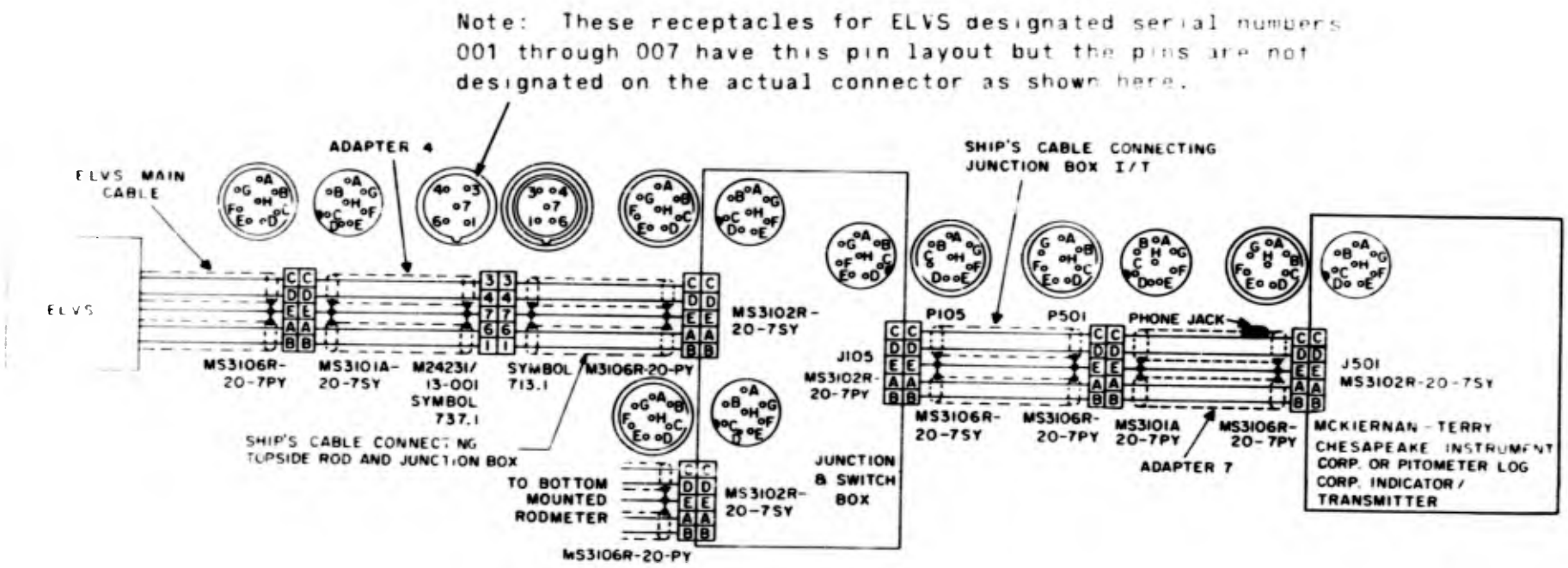
Page 1, Figure 8
Connection Diagram for Indicator/Transmitter Made by McKiernan-Terry, Chesapeake Instrument Corporation, and Pitometer Log Corporation Used With a High-Pressure Fixed Rodmeter

Item (b) - ELVS Connected at Topside Rodmeter to Ship's Cable Between Topside Rodmeter and Junction Box



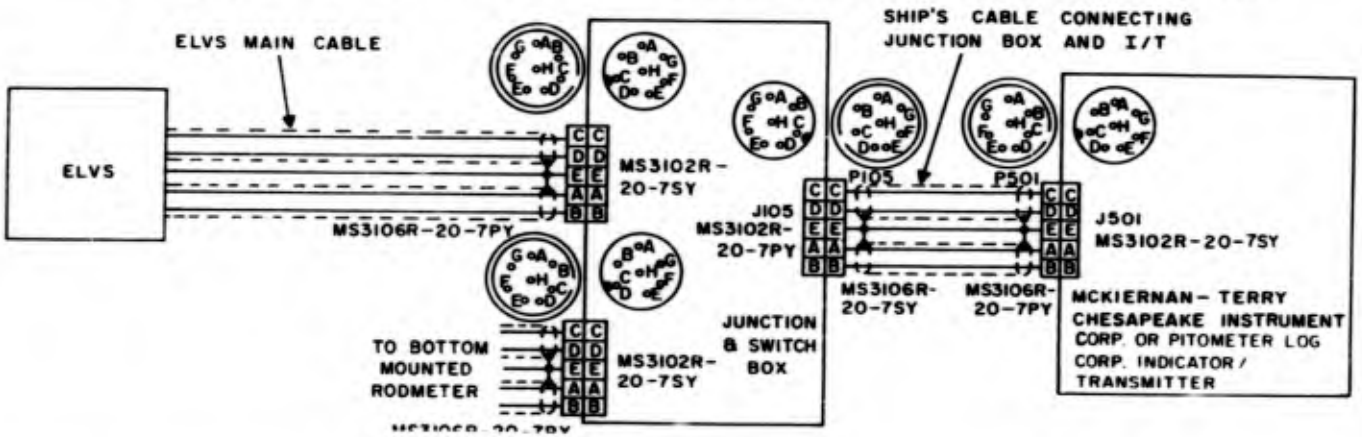
Note: The ELVS may be connected at the bottom-mounted rodmeter exactly as shown for the topside rodmeter.

Item (c) - ELVS Connected at Topside Rodmeter to Ship's Cable Between Topside Rodmeter and Junction Box Showing Sound-Powered Phone Adapter Location.



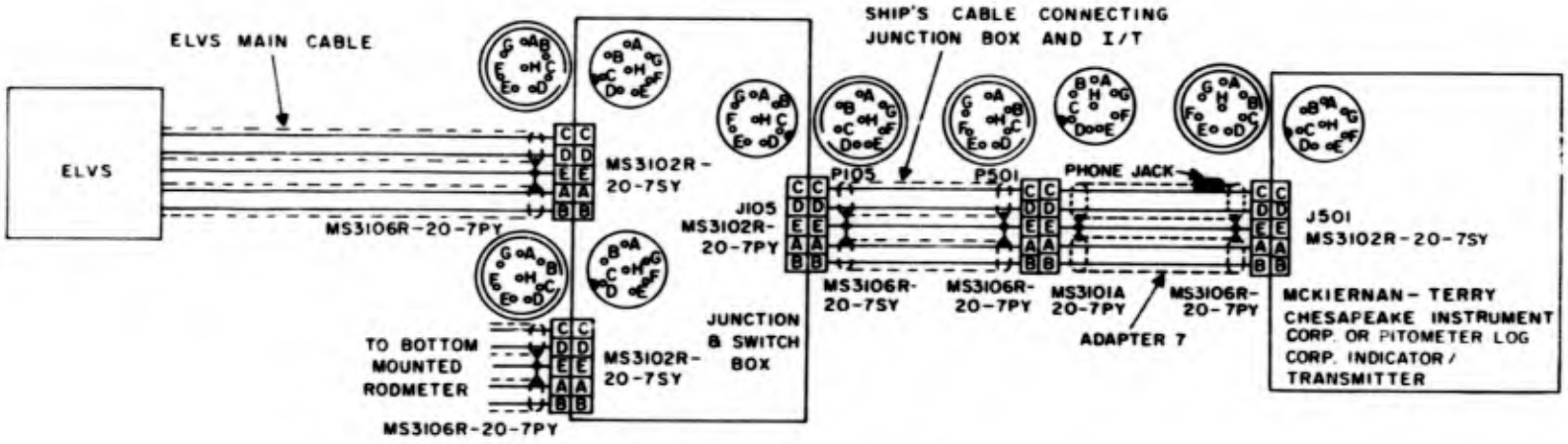
Note: The ELVS may be connected at the bottom-mounted rodmeter exactly as shown for the topside rodmeter.

Item (d) - ELVS Connected to Junction Box at Topside Rodmeter Receptacle



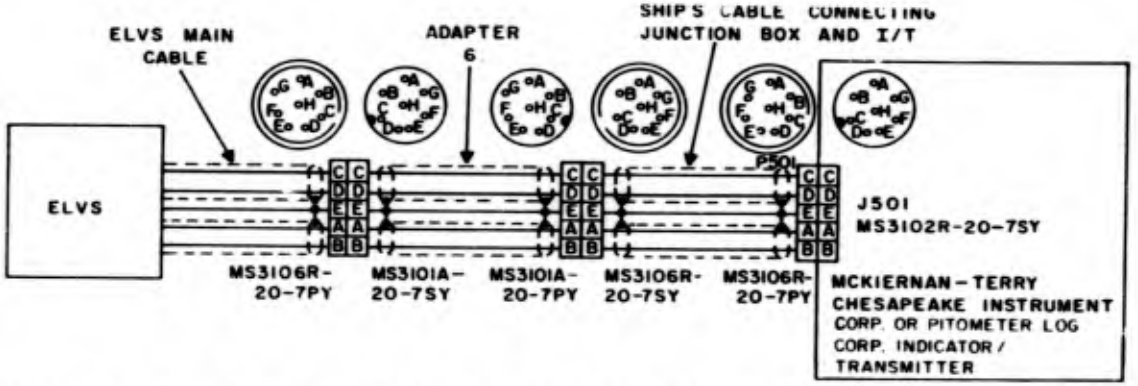
Note: The ELVS may be connected to the bottom rodmeter receptacle exactly as shown for the topside rodmeter receptacle.

Item (e) - ELVS Connected to Junction Box at Topside Rodmeter Receptacle Showing Sound-Powered Phone Adapter Location



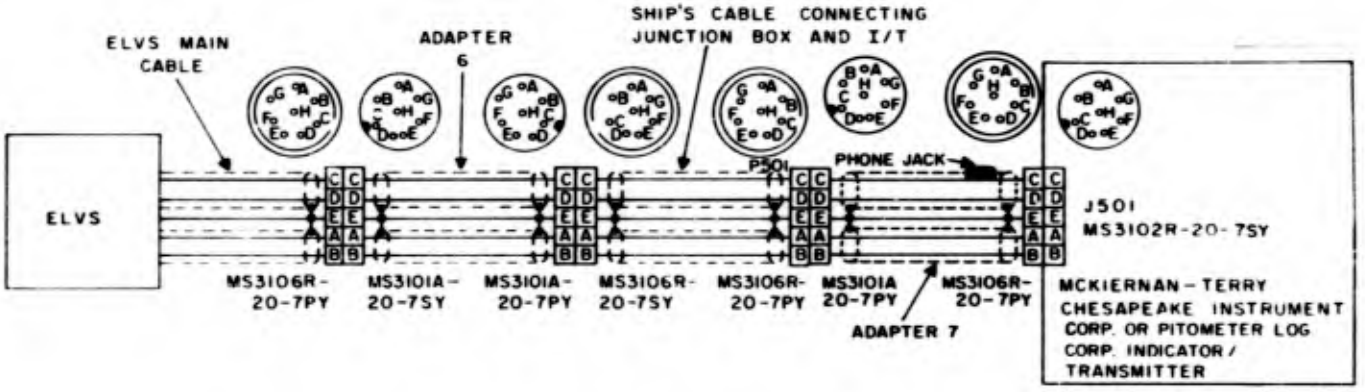
Page 4, Figure 8

Item (f) - ELVS Connected at Junction Box to Ship's Cable Between Junction Box and I/T.



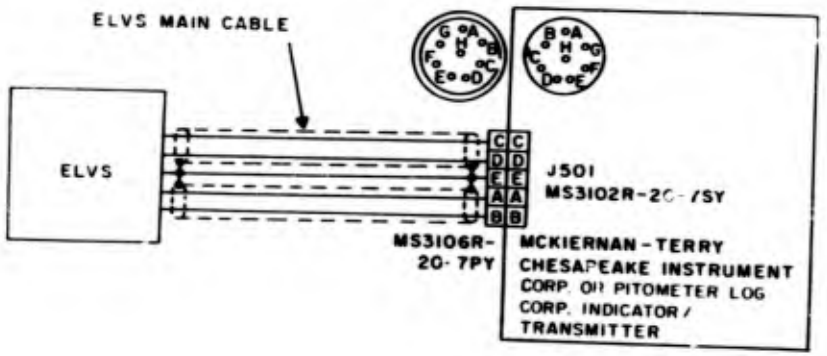
Note: The ELVS may be connected to the bottom rodmeter receptacle exactly as shown for the topside rodmeter receptacle.

Item (g) - ELVS Connected at Junction Box to Ship's Cable Between Junction Box and I/T Showing Sound-Powered Phone Adapter Location.



Page 5, Figure 8

Item (h) - ELVS Connected Directly to I/T



Page 6, Figure 8

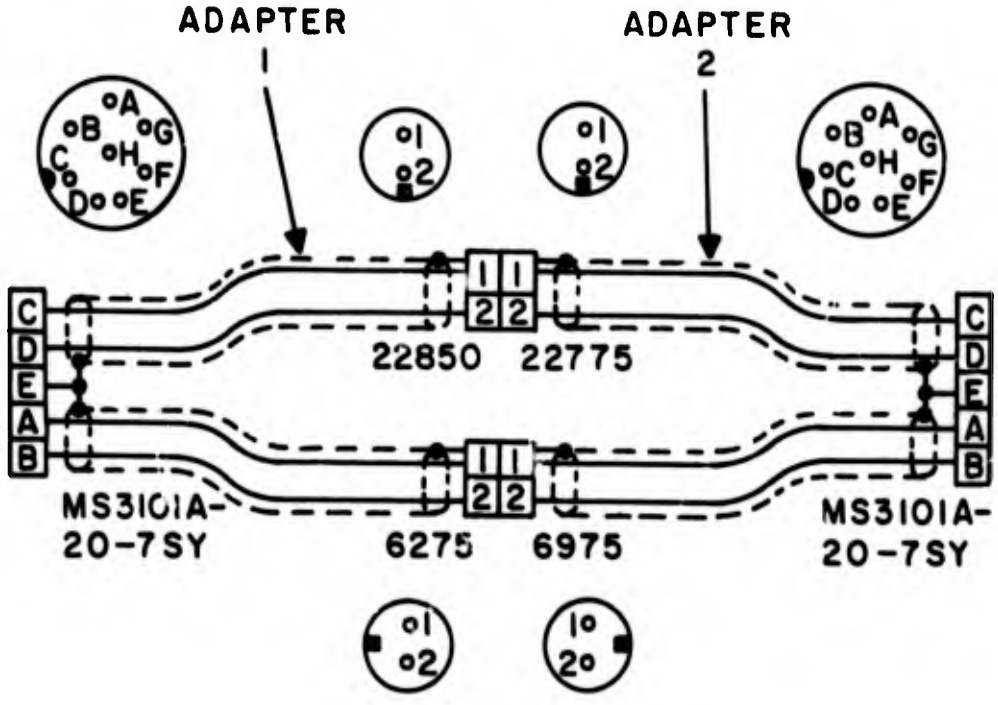


Figure 9
Wiring Diagram of a Seventh Adapter Using Adapters 1 and 2

5.1.2 Use of ELVS with Sound-Powered Phone Handset

The ELVS is equipped with sound-powered phones to maintain communication between the I/T and the ELVS when separated either by distance or bulkheads. The ELVS sound-powered phone system requires no additional cable runs for its operation. The system uses the existing cable runs (between the I/T and the rodmeter) and three special adapters with integral phone jacks which are supplied with the ELVS and designed to connect into the cabling at the I/T.

To connect and operate the sound-powered phones, first locate and then connect into the log systems cabling at the I/T a sound-powered phone adapter (one of three) which was designed for your log system. To identify the correct adapter for your log system, refer to Section 5.1.1 and figures 4, 5, 6, 7, or 8. One of the sound-powered phones supplied with the ELVS is plugged into the jack on the adapter at the I/T and the other phone is plugged into the jack located on the face of the ELVS. It is important to note that the button on the sound-powered phone handset must be depressed both to hear and talk and should not be pushed when final adjustments to the I/T are being attempted. Some forethought should be given to the means by which each talker (I/T

talker and ELVS box talker) is going to be able to maintain a communication link with the other talker, because the button on the handset must be depressed to communicate and because of the impracticality of a ringing device being supplied with each ELVS. It is recommended that before the talkers locate themselves at the I/T and the ELVS, they agree upon a time to pick up the phone and begin to communicate. Each time thereafter that they cut off communication, they agree upon a time for the next communication.

5.1.3 Selector Switch Setting and Warning Light

As shown in figure 2, the selector switch has four positions labeled: Litton Industries and Pitometer Log Corp., Control Instrument, Chesapeake Instrument and McKiernan-Terry, and position 4. (The circuit schematic shows the selector switch positions as Nos. 1, 2, 3, and 4, respectively, corresponding to positions labeled: Litton Industries and Pitometer Log Corp., Control Instrument, Chesapeake Instrument and McKiernan-Terry, and Position 4.)

To determine the proper position for the selector switch, the manufacturer of the I/T must be known. This information is found on the I/T nameplate.

Initially the selector switch must be set on the position corresponding to the name of the manufacturer of the I/T. Due to differences in individual ship's wiring, there may be occasions when the selector switch is set on the named position and the warning light is on and/or the speed dial of the I/T is driven backwards. It is therefore important that the SPEED SETTING KNOTS dial be set on a value no greater than 1 knot. If the I/T is driven backwards, the selector switch must be reset to a position where the warning light is out and the I/T is being driven forward, regardless of the manufacturer. (To determine if the speed dial of the I/T is driven forwards or backwards, the speed setting must be set at a nonzero value.)

5.1.4 FULL-SCALE ADJUSTMENT Setting

The FULL-SCALE ADJUSTMENT setting for an output of 325 μV/kn/0.75 ampere is printed on the panel of the ELVS box. The operator should check this setting and correct it if necessary prior to adjustment of the I/T or troubleshooting of the log system.

Each ELVS has a plastic envelope which contains a graph showing the FULL-SCALE ADJUSTMENT settings to vary the calibration factor from 292.5 to 357.5 μV/kn/0.75 ampere. Figure 10 is a typical graph.

> WARNING: Each graph is accurate only for the ELVS unit for which it was drawn. The graph of figure 10 will not give accurate results for all units and should not be used for precision adjustment purposes.

The FULL-SCALE ADJUSTMENT should be set to three significant figures.

5.2 Adjustment and Calibration of the Indicator/Transmitter

The ELVS may be used to calibrate and adjust the I/T of the EM log system as the need arises. On most Navy ships, the EM log system will be calibrated periodically (about every 2 years) on a measured mile course, a tracking range, or with readings from the Submarine Inertial Navigation System (SINS). Immediately after

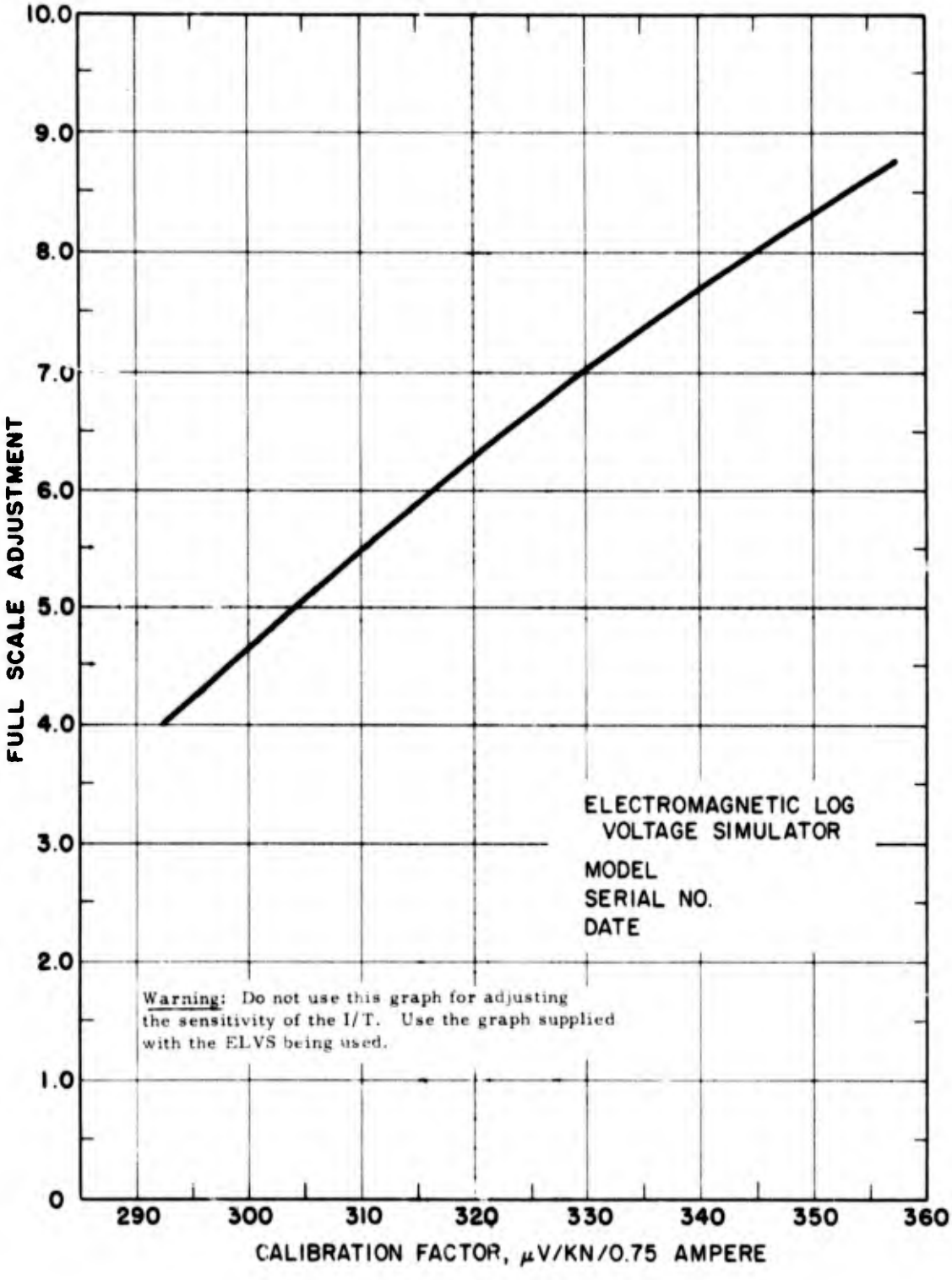


Figure 10
Typical Graph of the FULL-SCALE ADJUSTMENT Setting
Versus The Simulator Output

this calibration, the I/T response should be checked with the ELVS at 4-knot intervals of 0, 4, 8, 12, 16, 20, 24, 28, 32, 36, and 40 knots. Data should be recorded on a calibration record table showing the I/T speed indication and the ELVS speed setting. After a failure and repair of the I/T, the calibration network potentiometers (in the I/T) may be set to match the original calibrated response to the ELVS. In this way, the calibration of the EM log system may be maintained through an I/T repair cycle. Likewise, after changing rodmeters, the calibration of the EM log system may be maintained by using the calibration record table and the sensitivities of the rodmeters.

Other uses of the ELVS include:

- Setting the sensitivity of the I/T at any point over the range 292.5 to 375.5 μV/kn/0.75 ampere (usually done for test purposes).
- Checking the accuracy of the EM log system integrator.
- Setting the zero offset of the shipboard EM log system.

5.2.1 Calibration Record Table

The calibration record table must be completed immediately after a measured mile, a SINS, or a tracking range calibration is completed. The table should be kept with the I/T (glued to the inside of the I/T cover) for future use. If this record is kept, the log system can be returned to its original calibration after repair.

The following procedures should be used to complete the calibration record table:

- Connect the ELVS directly to the I/T as instructed in Section 5.1.
- Set the FULL-SCALE ADJUSTMENT dial on the ELVS to the value written on the panel that sets the calibration factor of the ELVS to 325 μV/kn/0.75 ampere.
- Let the I/T warm up for 30 minutes with the ELVS connected.
- Set the ELVS SPEED SETTING dial to 0.00, 4.00, 8.00, 12.00, 16.00, 20.00, 24.00, 28.00, 32.00 36.00, and 40.00 knots, and record the speed indicated by the speed indicator dial of the I/T on the calibration record table. The speed dial of the I/T may drive against the zero stop at the 0.00 setting. If this happens, use 1.00 knot as the ELVS SPEED SETTING value. A sample of a calibration record table is shown in figure 11 for reference purposes.

5.2.2 Checking the I/T Speed Indication

After the log system has been calibrated and its response to the ELVS setting has been recorded in the calibration record table and the error curve plotted, the ELVS may be used to check and adjust the I/T at any time that its performance becomes suspect. It is suggested that a regular check schedule (perhaps, once per month) be established and that special checks be performed whenever maintenance and repair of the I/T is suspected of changing the log system calibration. (Nearly all repairs on the log system will affect the calibration factor in some way. Examples are overhaul of the I/T and potentiometer changes in the feedback circuitry.) The following procedures should be used to check the calibration of the I/T.

Item (a) - Example

Column A	Column B	Column C	Column D
ELVS SPEED SETTING Dial knots	I/T Speed Indication knots	I/T Potentiometers	
		Potentiometer No*	Setting knots
0.00	0.68	ZERO ADJUST	+0.88
4.00	4.91	R201	-0.02
8.00	9.05	R202	-0.29
12.00	13.50	R203	+0.30
16.00	17.60	R204	+0.30
20.00	21.48	R205	-0.28
24.00	25.44	R206	+0.09
28.00	29.30	R207	-0.13
32.00	33.11	R208	-0.11
36.00	37.00	R209	-0.09
40.00	39.80	R210	-0.25
		Full Scale	+0.32

*The potentiometer numbers shown apply to a Litton Industries I/T. Other manufacturers equipment will have a different potentiometer number.

DATE 11/1/72

ELVS SERIAL NO. 009

ELVS FULL-SCALE ADJUSTMENT 6.665 ELVS CALIBRATION FACTOR 325 μV/kn

RODMETER MANUFACTURER Chesapeake Instrument Corp.

RODMETER SERIAL NO. 290 RODMETER SENSITIVITY 314 μV/kn

I/T MANUFACTURER Pitometer Log Corp.

I/T SERIAL NO. 74

Figure 11
Calibration Record Table

Item (b) - Form

Column A	Column B	Column C	Column D
ELVS SPEED SETTING Dial knots	I/T Speed Indication knots	I/T Potentiometers	
		Potentiometer No.	Setting knots
0.00			
4.00			
8.00			
12.00			
16.00			
20.00			
24.00			
28.00			
32.00			
36.00			
40.00			

DATE_____

ELVS SERIAL NO._____

ELVS FULL-SCALE ADJUSTMENT_____ ELVS CALIBRATION FACTOR_____μV/kn

RODMETER MANUFACTURER_____

RODMETER SERIAL NO._____ RODMETER SENSITIVITY_____μV/kn

I/T MANUFACTURER_____

Figure 11 (Cont)

WARNING: While performing this check, if the indications of the I/T are unstable or are found to differ by more than 0.1 knot from those obtained following calibration of the log system, a need for maintenance of the I/T is indicated. No adjustment of the I/T should be attempted until this problem is corrected.

- Connect the ELVS directly to the I/T as instructed in Section 5.1.

- Set the FULL-SCALE ADJUSTMENT dial on the ELVS to the value written on the panel that sets the calibration factor of the ELVS to 325 μV/kn/0.75 ampere.

- Let the I/T warm up for 30 minutes after the ELVS is connected.

- Set the ELVS SPEED SETTING dial to 0.00, 4.00, 8.00, 12.00, 16.00, 20.00, 24.00, 28.00, 32.00, 36.00, and 40.00 knots, and record the speed indicated by the speed indicator dial of the I/T.

- Compare the speed indicator dial reading of the I/T with those shown on the calibration record table. If the readings differ by more than 0.1 knot, the potentiometers of the calibration network in the I/T should be reset by following the steps detailed in Section 5.2.3. If the readings do not differ by more than 0.1 knot, the I/T is within calibration an . the calibration network potentiometers should not be changed.

5.2.3 Recalibration of the I/T

When the I/T response to the ELVS does not match the recorded values in the calibration record table (as discussed in Section 5.2.2), the following procedures should be used to recalibrate the I/T. Briefly, the procedure is to set the zero offset of the I/T to the previous value recorded in the calibration record table, draw a new error curve from the calibration record table and new ELVS data, and set the calibration network potentiometers of the I/T according to procedures discussed in your technical manual for the underwater log equipment. In detail, the steps to be completed are:

- Connect the ELVS directly to the I/T as instructed in Section 5.1.

- Set the FULL-SCALE ADJUSTMENT dial on the ELVS to the value written on the panel that sets the calibration factor of the ELVS to 325 μV/kn/0.75 ampere.

- Let the I/T warm up for 30 minutes after the ELVS is connected.

- Set the ELVS SPEED SETTING dial to 0.00 and adjust the ZERO-ADJUST dial on the I/T so that the speed indicator dial of the I/T shows the same reading as recorded in the calibration record table. (If the ELVS SPEED SETTING dial was set at 1.00 on the calibration record table, a setting of 1.00 should be used for this step also.)

- Set the ELVS SPEED SETTING dial on 0.00, 4.00, 8.00, 12.00, 16.00, 20.00, 24.00, 28.00, 32.00, 36.00, and 40.00 knots, and record the speed indicated by the speed indicator dial of the I/T in column B of the calibration work table as shown in figure 12. (The values shown in figure 12 are typical values for

Item (a) - Example

Column A	Column B	Column C	Column D
ELVS SPEED SETTING Dial knots	I/T Speed Indication knots	I/T Speed Indication From Column B of the Calibration Record Table, knots	I/T Speed Indication Difference knots
0.00	0.68	0.68	0.00
4.00	4.89	4.91	-0.02
8.00	9.00	9.05	-0.05
12.00	13.55	13.50	+0.05
16.00	17.80	17.60	+0.20
20.00	21.70	21.48	+0.22
24.00	25.60	25.44	+0.16
28.00	29.55	29.30	+0.25
32.00	33.43	33.11	+0.32
36.00	37.13	37.00	+0.13
40.00	39.90	39.80	+0.10

DATE 11/1/72

ELVS SERIAL NO. 009 ELVS FULL-SCALE ADJUSTMENT 6.665

ELVS CALIBRATION FACTOR 325 μV/kn

RODMETER MANUFACTURER Chesapeake Instrument Corp.

RODMETER SERIAL NO. 290 RODMETER SENSITIVITY 314 μV/kn

I/T MANUFACTURER Pitometer Log Corp.

I/T SERIAL NO. 74

Figure 12
Calibration Work Table Used in Recalibrating the I/T with the ELVS

Item (b) - Form

Column A	Column B	Column C	Column D = B - C
ELVS SPEED SETTING Dial knots	I/T Speed Indication knots	I/T Speed Indication From Column B of the Calibration Record Table, knots	I/T Speed Indication Difference knots
0.00			
4.00			
8.00			
12.00			
16.00			
20.00			
24.00			
28.00			
32.00			
36.00			
40.00			

DATE_____

ELVS SERIAL NO. _____ ELVS FULL-SCALE ADJUSTMENT_____

ELVS CALIBRATION FACTOR_____μV/kn

RODMETER MANUFACTURER_____

RODMETER SERIAL NO. _____ RODMETER SENSITIVITY_____μV/kn

I/T MANUFACTURER_____

I/T SERIAL NO. _____

Figure 12 (Cont)

illustrative purposes; they are not to be used in the actual calibration.) The data taken in Section 5.2.2 cannot be used because it contains a zero offset.

- Transfer column B of the calibration record table to column C of the calibration work table.

- Calculate column D of the calibration work table by subtracting column C from column B. When column B is higher than column C, the difference is positive, and when column B is lower than column C, the difference is negative.

- Plot an error curve by plotting column D of the calibration work table versus the ELVS SPEED SETTING, column A, as illustrated in figure 13.

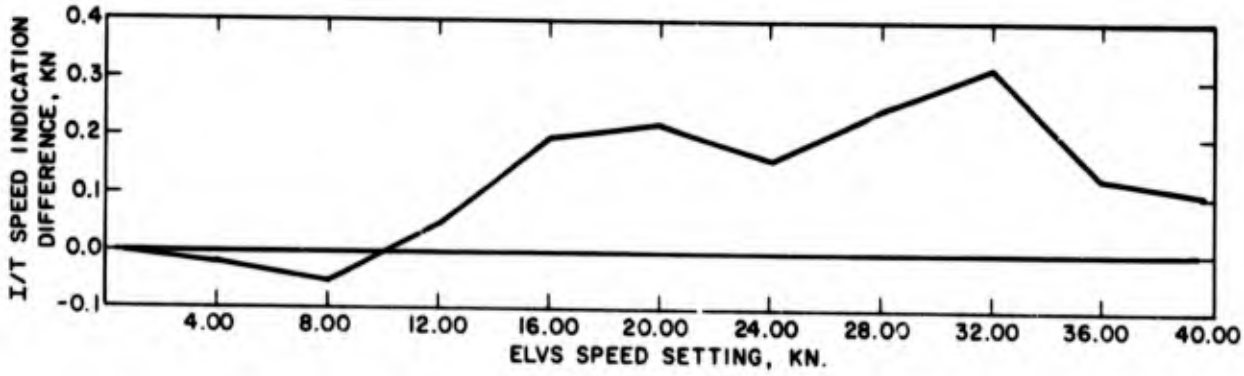


Figure 13
Example of an Error Curve Used in Recalibration of the I/T Using ELVS

- Determine the calibration network potentiometer settings of the I/T by following the procedure outlined in the technical manual that applies for your particular underwater log system. The error curve plotted in the above step is used in place of the error curve mentioned in the technical manual of the underwater log system. (The exact details of the procedure to determine the calibration network potentiometer settings for the I/T is not given in this manual because it is slightly different for each different manufacturer.)

- Set the calibration network potentiometers of the I/T according to the values calculated above.

- Check the response of the I/T to an input from the ELVS by following the procedure outlined in Section 5.2.2. If the speed indicator dial readings of the I/T differ from the values shown in the calibration record table by more than 0.1 knot, the I/T should be recalibrated again according to the procedures outlined above.

5.2.4 Recalibrating the EM Log System After Replacing the Rodmeter

In the event that the rodmeter fails or is replaced for any other reason, the continued accuracy of the log system may be assured by adjusting it for the difference in sensitivity of the two rodmeters. Actually, the accuracy of the log system may be degraded to 1% because of the method used in measuring the sensitivity stamped on the rodmeters and due to nonlinearities of the rodmeter which cannot be accounted for. The log system can be recalibrated after replacing the rodmeter by using the following procedure (an example is shown in figure 14 for illustrative purposes):

(a) Sensitivity of replacement rodmeter 313 μV/kn
(b) Sensitivity of old rodmeter 325 μV/kn
(c) Sensitivity difference (line (a) minus line (b)) -12 μV/kn
(d) ELVS FULL-SCALE ADJUSTMENT for I/T indication of 39.95 knots 7.00
(e) Log system calibration factor for old rodmeter (from ELVS graph) 330 μV/kn
(f) Log system calibration factor for the replacement rodmeter
(g) ELVS FULL-SCALE ADJUSTMENT for replacement rodmeter 6.15

Figure 14
Example of Calculations Required to Recalibrate the
EM Log System After Replacing Rodmeters

- Record the sensitivity stamped on the old rodmeter. On retractable rodmeters, the sensitivity is stamped on the nameplate. On fixed rodmeters, the sensitivity is either stamped on the nameplate or the flange lip of the connector.

- Record the sensitivity stamped on the replacement rodmeter.

- Calculate the sensitivity difference (replacement minus the old).

- Connect the ELVS directly to the I/T as instructed in Section 5.1.

- Let the I/T warm up for 30 minutes after the ELVS is connected.

- Turn the ELVS FULL-SCALE ADJUSTMENT to zero.

- Set the ELVS SPEED SETTING dial to 39.95 knots.

- Adjust the ELVS FULL-SCALE ADJUSTMENT until the I/T indicates a speed of 39.95 knots. Record the value of the ELVS FULL-SCALE ADJUSTMENT.

- Use this ELVS FULL-SCALE ADJUSTMENT setting with the calibration graph (like the graph in figure 10) provided with the ELVS to find the corresponding calibration factor. Record this value as the log system calibration factor for the old rodmeter.

- Algebraically add the sensitivity difference to the log system calibration factor for the old rodmeter. Record this value as the log system calibration factor for the replacement rodmeter.

- Use the calibration graph provided with the ELVS to find the corresponding ELVS FULL-SCALE ADJUSTMENT. Record this value as the ELVS FULL-SCALE ADJUSTMENT for the replacement rodmeter.

- Set the ELVS FULL-SCALE ADJUSTMENT to the new value.

- Adjust the I/T full-scale potentiometer until the I/T indicates a speed of 39.95 knots.

- A new calibration record table should now be made according to the procedures outlined in Section 5.2.1.

5.2.5 Zero Adjustment of the EM Log System

One of the current problems with the underwater EM Log System is the lack of an easy method of setting the zero after installation onboard ship. Present methods discussed in the technical manuals recommend building a water dam around the rodmeter or setting the ZERO ADJUST with the rodmeter extended at ebb tide. For various reasons, these methods have proved inadequate. The ELVS can be used to set the ZERO ADJUST of the I/T with greater precision than the other methods and is much easier to use.

The ELVS may be used for setting the zero offset of the EM log system by using the following procedure:

- Connect the ELVS to the ship's cabling at the rodmeter, as instructed in Section 5.1. If it is impossible to get to the rodmeter, the ELVS should be connected as close to the rodmeter as possible. The idea is to transmit a signal through all the cabling connecting the rodmeter and the I/T, because the electrical pickup on the cabling will then be compensated.

- Let the I/T warm up for 30 minutes with the ELVS connected.

- Set the ELVS SPEED SETTING dial on 0.00.

- Set the ZERO ADJUST on the I/T so that the indicated speed is 0.00.

5.2.6 Adjustment of the I/T for a Rodmeter Sensitivity of 325 μV/Kn/0.75 Ampere

When the operator desires to calibrate an I/T for a sensitivity of 325 μV/kn/0.75 ampere the following steps should be performed:

Connect the ELVS directly to the I/T as instructed in Section 5.1.

- Check the setting of the FULL-SCALE ADJUSTMENT on the ELVS and set, if required.

- Set the speed setting of the ELVS at zero and the zero potentiometer of the I/T to indicate 00.01 knots on the speed dial.

- Set the ELVS speed dial to 39.99 and adjust the full-scale potentiometer of the I/T until the I/T speed dial indicates 39.99 knots.

- The linearity of the I/T may be checked by dialing in any number between 00.00 and 40.00 on the speed setting and recording the speed dial indication of the I/T.

This mode of adjustment should be performed prior to calibrating the log system on a measured range as a check for proper performance of the system. After a measured range calibration (performed as specified in the log system manual), all

settings of the calibration dial on the I/T should be recorded. The foregoing procedure should then be repeated without changing the position of any calibration dials on the I/T but merely recording the I/T indications for each 4-knot interval setting of the ELVS from 0 to 40 knots. This record together with the dial settings of the calibrated log system, the date of calibration, the serial number of the ELVS, and the setting of the ELVS full-scale potentiometer should be kept with the I/T at all times (preferably taped under plastic to the outside of the I/T cover).

5.2.7 Adjusting the I/T for Other Sensitivities

If the operator desires to adjust an I/T for any sensitivity from 292.5 to 357.5 μV/kn/0.75 ampere, the FULL-SCALE ADJUSTMENT should be set as described in Section 5.1.3 and the test procedure of 5.2.6 followed.

5.2.8 Checking the Accuracy of the Log System-Integrator

The ELVS may be used to provide a dummy signal input to the EM log system for the purpose of calibrating the log system distance integrator prior to performing system calibrations on a measured course. Before using the distance output of the log system during this calibration, it is prudent to check that the distance output of the log system is functioning accurately. This may be accomplished by using the ELVS to generate a dummy speed signal at each speed to be used for the calibration.

Example: If the log is to be calibrated at 4, 8, 12, 16, and 20 knots, set the ELVS to produce a 4.00-knot reading on the log system and perform a calibration of using the distance counter output as explained in the Log System Technical Manual. Repeat this procedure for 8, 12, 16, and 20 knots. The differences between the set speeds and those calculated from the distance counter output may be assumed as the integrator error and applied as correction calibration error data.

5.3 Troubleshooting of a Log System

The ELVS may be used to isolate faulty components when troubleshooting log systems. There are three possible problem conditions with any inoperative log system:

A. Malfunctioning rodmeter.

B. Short- or open-circuited connecting cable between the rodmeter and the I/T.

C. Malfunctioning I/T.

Condition A is present if the I/T operates correctly when the ELVS is connected to the cables in place of the rodmeter but does not operate correctly when normally connected to the rodmeter.

Condition B is present if the I/T operates correctly when the ELVS is connected directly to the I/T and does not operate correctly when the ELVS is connected to the cable/cables at the rodmeter.

Condition C is present if the I/T does not operate correctly when the ELVS is connected directly to it. In this case, the ELVS can be used to provide a dummy speed input signal to the I/T for assistance in tracing the speed signal through the I/T components.

In addition to isolating log system problems to the rodmeter, ship's cabling, or I/T, the ELVS will prove invaluable when troubleshooting a defective I/T. The signal from the ELVS can be traced through the I/T electronics until the defective stage is located.

6.0 THEORY OF OPERATION

This section is intended to acquaint the shipboard technician with the operating principle of the ELVS and thus lead to understanding its operating limitations. Additionally, it will be shown that only a few components may be changed in the event of failure.

The ELVS was designed to replace the EM rodmeter in the log system by connecting directly to the I/T. The purpose of the ELVS is to generate an accurate dummy speed signal for use in adjusting and troubleshooting the I/T and to determine when an EM rodmeter has failed. The design goal was to make the ratio of the output signal to the coil current linear and accurate to within 0.04 knot.

The circuit diagrams of the ELVS and associated adapters are shown in figures 15, 16, and 17. All the following symbols used in explaining the circuit operation refer to figure 15.

The coil current, i_c (intended for the EM rodmeter), is connected through terminals A and B to inductor L_1, which replaces the coil of the EM rodmeter in the regular log system circuitry. Resistor R_1 is connected in series with L_1 and generates a reference voltage proportional to the coil current i_c. Potentiometers R_2 and R_3 divide this reference voltage to a value approximately 35 times the normal speed signal generated in an EM rodmeter. The transformer, T_1, then reduces the amplitude of this simulated speed signal by a factor of 35 to 1. The secondary of T_1 is center-tapped to ground to provide a balanced input to the I/T. The secondary voltage appears between terminals C and D and is the simulated speed signal, e_s.

The simulated speed signal, e_s, is given by

$$e_s = \frac{K_3 R_3 A R_1 i_c}{K_2 R_2 + R_3}$$

where

i_c = coil current, amperes

R_1 = current sensing resistor, ohms

R_2 = FULL-SCALE ADJUSTMENT potentiometer, ohms

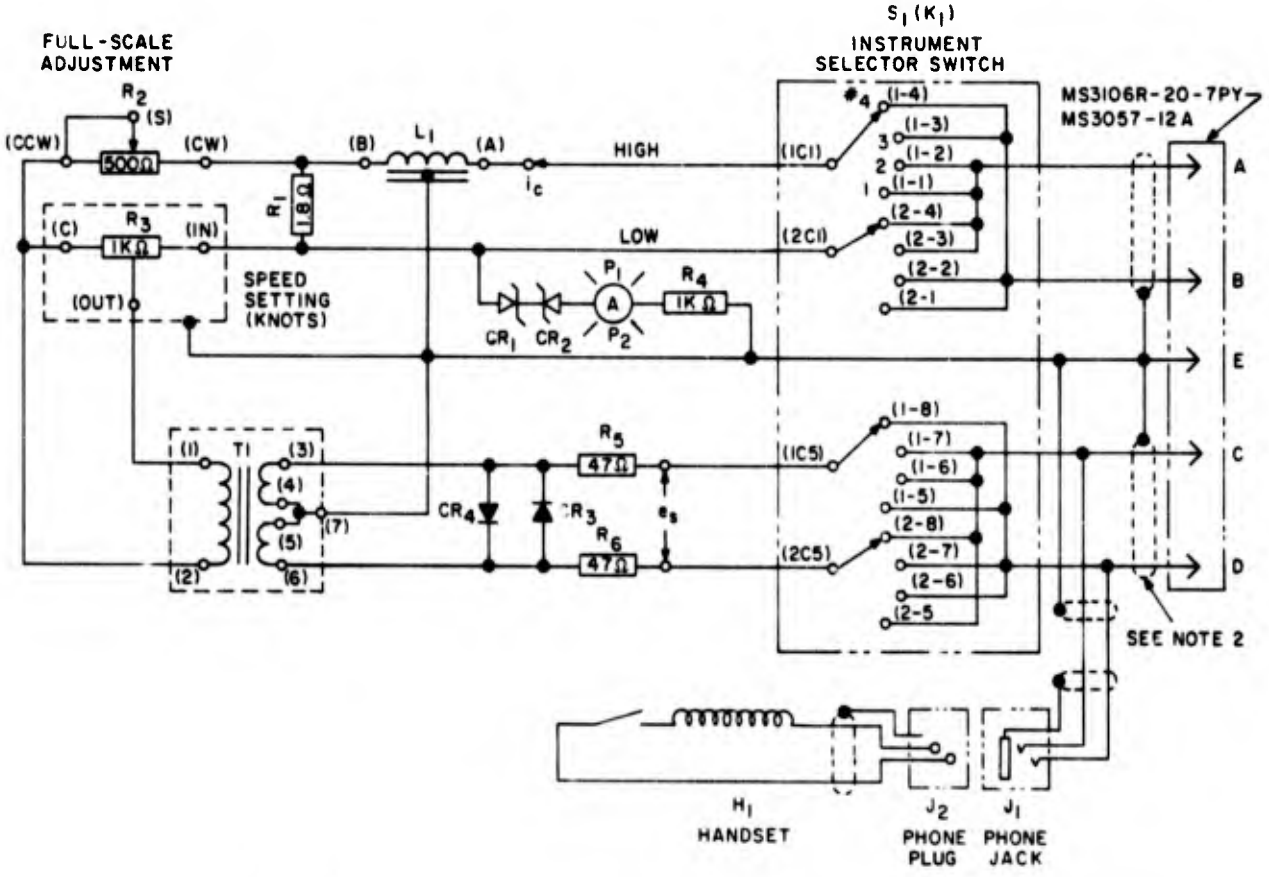
K_2 = setting of R_2, 0 to 1.000

R_3 = speed setting potentiometer, ohms

K_3 = setting of R_3, 0 to 0.4000

A = forward turns ratio of transformer T_1, 1/35.

The values of the components were chosen to generate a simulated speed signal of 325 μV/kn/0.75 ampere.



TWISTED PAIRS

$R_5 - S_1$ (1C5) TWISTED WITH $R_6 - S_1$ (2C5)

L_1 (A) - S_1 (1C1) TWISTED WITH R_1 (LOW) - S_1 (2C1)

R_3 (OUT) - T_1 (1) TWISTED WITH R_3 (C) - T_1 (2)

S_1 POSITION ASSIGNMENTS

#1 LITTON INDUSTRIES PITOMETER LOG CORP

#2 CONTROL INST.

#3 CHESAPEAKE INST. McKIERNAN TERRY

#4 NOT ASSIGNED

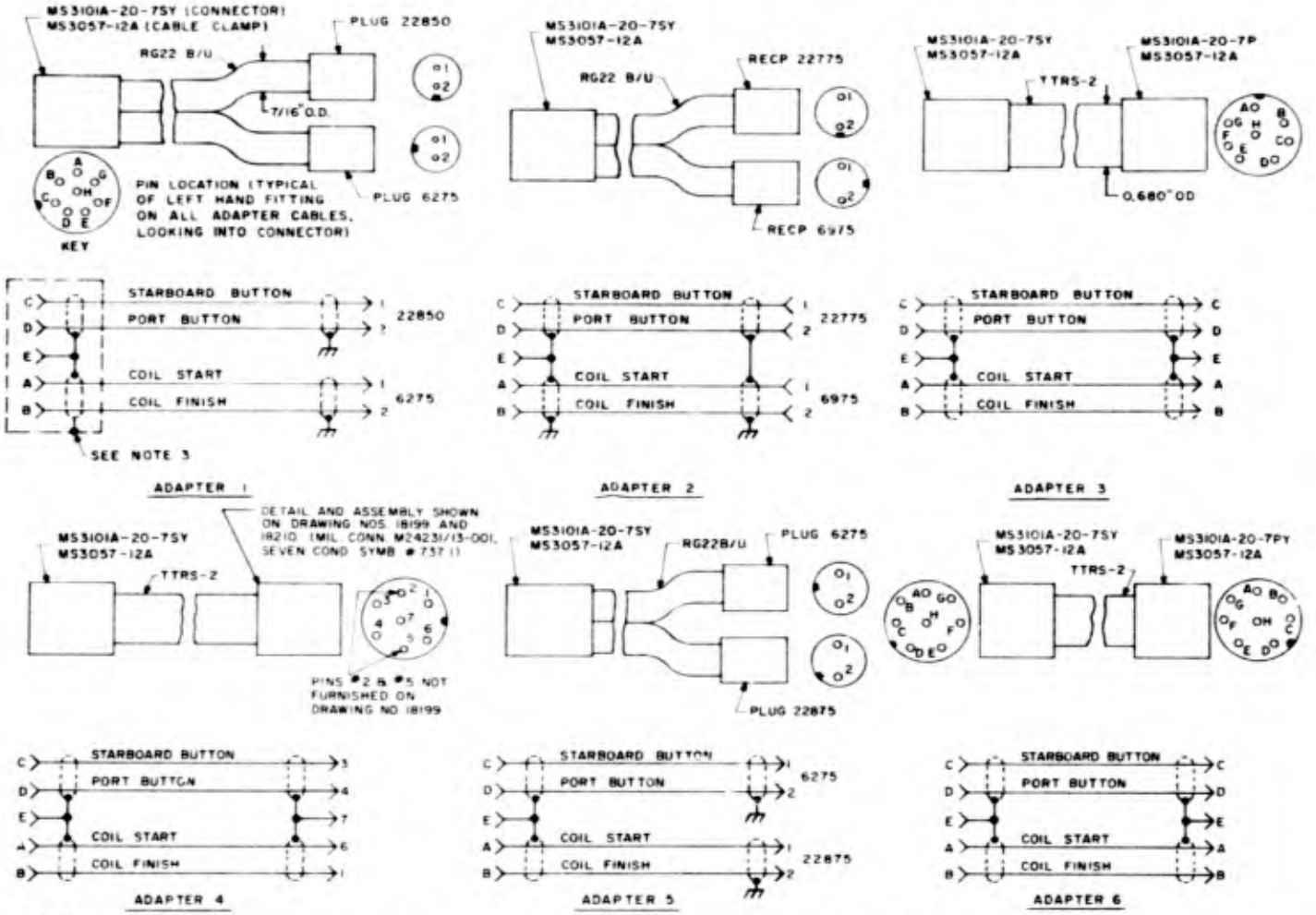
NOTES:

1. ALL CONNECTING WIRES SHALL BE #20 AWG. OR LARGER.
2. SHIELDING SHALL BE STRIPPED BACK FROM SWITCH TERMINALS NO MORE THAN 1 INCH.
3. RESISTORS R_5 AND R_6 SHOULD BE CONNECTED TO T_1 (3) AND T_1 (6) WITH WIRE LEADS NO LONGER THAN 1/2 INCH.
4. THE WIRE CONNECTING R_5 AND R_6 WITH S_1 (1C5) AND S_1 (2C5), J_1 WITH SWITCH, AND THE WIRE BETWEEN H_1 AND J_2 SHOULD BE OF THE SHIELDED TYPE TWISTED PAIR #20 AWG.

Figure 15
ELVS Schematic Diagram

PARTS LIST				
ITEM NO.	DESCRIPTION	REQ'D	MAT'L	REMARKS
L_1	Coil, as follows: resistance, 14.25 Ω ±1.25 ; inductance, 0.170 - 0.180 henries at 55V - 60 Hz;minimum insulation resistance shall be 10 megohms at 500 vdc, winding to ground; operation, minimum 25 hrs. continuously in air.	1	COMM'L	Chesapeake Instr. Co. #D3036, Rev. D (Shall be potted in Stycast #2850FT)
R_1	Resistor, 1.8 Ω ±1%, W.W., 20 W., AL. Die-cast housing	1	"	Dale Electronics, Inc. #RH-25
R_2	Potentiometer, 500 Ω±5%, 10 turn, linearity ±0.15%, T.C. ±20 P/M/°C, resolution 0.02%	1	"	Beckman Instr. Inc. Mod. #7601 R.5KL.15
R_3	Potentiometer, 1000 Ω ±0.01%, T.C. 2 P/M/°C, resolution 0.003%, long term linearity ±(20 P/M +0.5 Dial Division), two decade dial with interpolation	1	"	Electo Scientific Ind. Mod. #DP1211-1K
R_4	Resistor, Carbon, 1K Ω ±10%, 2W	1	"	
P_1	Lamp, Incand, Type 327, 28V	1	"	FSN 6240-155-7836
P_2	Socket, Incandescent, Solder term., amber lens	1	"	Dialco #162-8430-0933-502
S_1	Switch, Rotary, 4 position, 2 decks, 2 commons per deck	1	"	Grayhill Inc. #44A45-02-2-4N
T_1	Transformer	1	"	FSN 5950-830-4843 (U.T.C. #W6727B)
CR_1 CR_2	Diode, Zenier, V = 3.6, 1 Watt	2	"	IN4729
J_1	Jack, Phone, 3 Cond.	1	"	Switchcraft Inc. Type 12B
K_1	Knob, Pointer, Black, for $\frac{1}{4}$" Shaft	1	"	Allied Electronics #8380037
H_1	Handset, Sound-powered	2	"	FSN 5965-840-8849
J_2	Plug, Phone, 3 Cond	1	"	Switchcraft Inc. Type 190
R_5 R_6	Resistor, Carbon, 47 Ω +10%, $\frac{1}{2}$W.	2	"	
CR_3 CR_4	Diode	2	"	IN4005

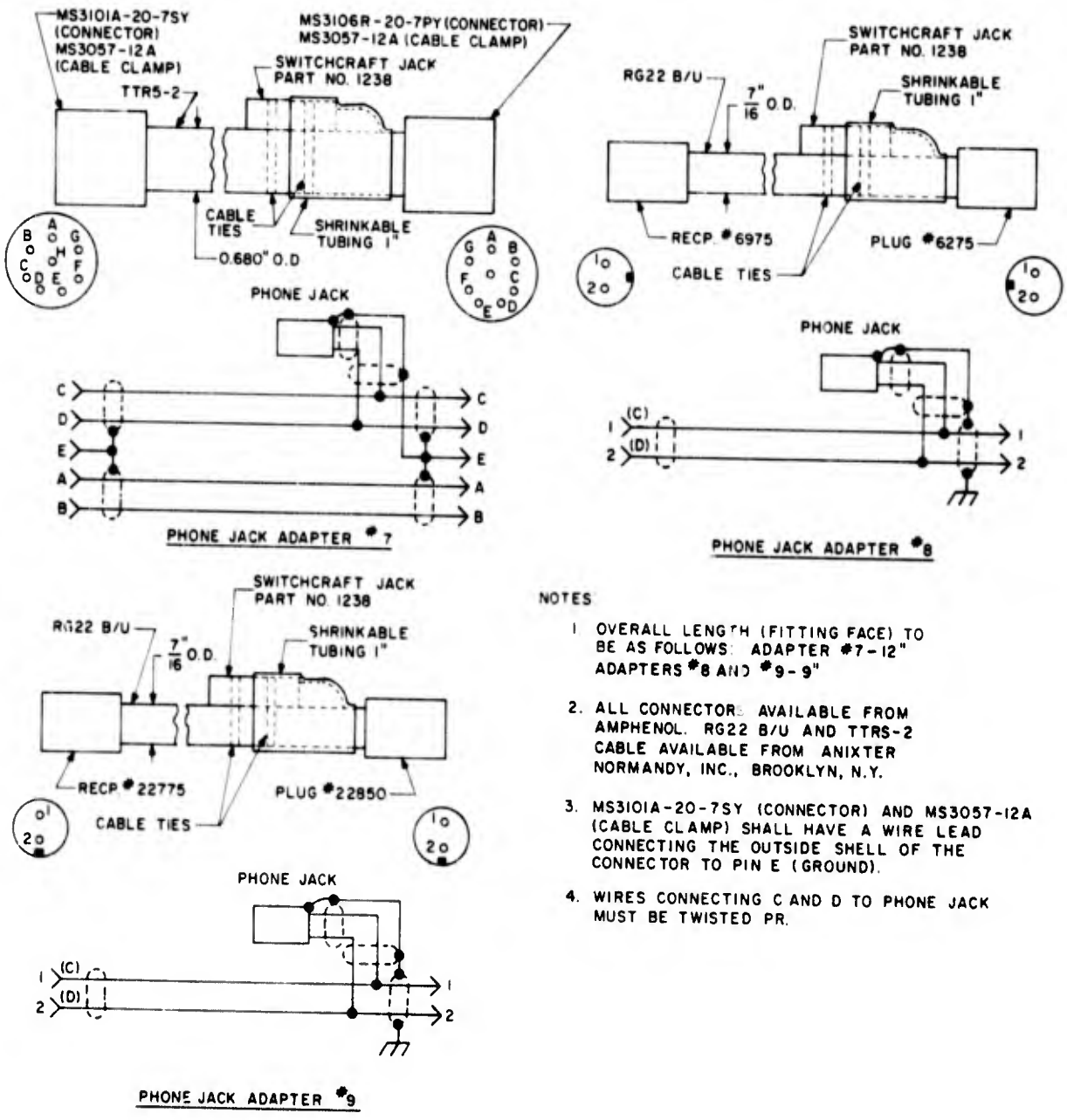
Figure 15 (Cont)



NOTES:

1. OVERALL LENGTH (FITTING FACE TO FITTING FACE) OF ADAPTERS #1, #2, & #5 TO BE 18", AND ADAPTERS #3, #4, & #6 TO BE 9"
2. ALL ADAPTERS ARE ATTACHABLE TO THE MAIN CABLE THROUGH CONNECTOR MS 3101A-20-7SY
3. ALL CONNECTORS EXCEPT M24231/13-001 AVAILABLE FROM AMPHENOL. M24231/13-001 AVAILABLE FROM L.L. ROWE CO. RG22 B/U AND TTRS-2 CABLE AVAILABLE FROM ANIXTER NORMANDY, INC., BROOKLYN, N.Y.
4. ALL MS3101A-20-7SY (CONNECTORS) AND MS3057-12A (CABLE CLAMPS) SHALL HAVE A WIRE LEAD CONNECTING THE OUTSIDE SHELL OF THE CONNECTOR TO PIN E (GROUND)

Figure 16
ELVS Adapter Cables



NOTES

1. OVERALL LENGTH (FITTING FACE) TO BE AS FOLLOWS: ADAPTER #7 - 12" ADAPTERS #8 AND #9 - 9"
2. ALL CONNECTORS AVAILABLE FROM AMPHENOL. RG22 B/U AND TTRS-2 CABLE AVAILABLE FROM ANIXTER NORMANDY, INC., BROOKLYN, N.Y.
3. MS3101A-20-7SY (CONNECTOR) AND MS3057-12A (CABLE CLAMP) SHALL HAVE A WIRE LEAD CONNECTING THE OUTSIDE SHELL OF THE CONNECTOR TO PIN E (GROUND).
4. WIRES CONNECTING C AND D TO PHONE JACK MUST BE TWISTED PR.

Figure 17
ELVS Phone Jack Adapter Cables

R_2 is a linear 10-turn potentiometer which is used to adjust the full-scale ratio of e_s/i_c. The range of adjustment is sufficient to compensate for worst-case component variation and additionally to adjust for a ±10% variation from the normal EM rodmeter sensitivity of 325 μV/kn/0.75 ampere. The full-scale potentiometer setting corresponding to an e_s/i_c ratio of 325 μV/kn/0.75 ampere is stamped on the panel of each ELVS. Additionally, each ELVS has been calibrated over a ±10% variation giving full-scale potentiometer settings for e_s/i_c ratios extending from 292.5 to 357.5 μV/kn/0.75 ampere.

R_3 is a linear 40-position switching potentiometer (Kelvin-Varley circuit) which is used for setting the simulated speed signal at any value between 00.00 and 40.00 knots. The total worst-case linearity error of R_3 will be ±0.0175% of full scale where full scale is 400 ohms. (Actually R_3 is a 1000 ohm pot with the top six positions blocked off.) The loading of R_3 by the transformer T_1 causes the linearity error of the entire ELVS to increase to ±0.05% of full scale. This figure accounts for variations due to phase shift, loading effects, and frequency variations.

The selector switch, S_1, is used to reverse the connections between the ELVS circuitry and the main connector pins C and D and A and B. Diodes CR_3 and CR_4 suppress any transient due to this switching. This reversal of connections is required for two reasons:

- Some of the log systems require a different phase relation between the coil current, i_c, through pins P and B and the speed signal, e_s, out of pins C and D to drive the speed indication forward. This phase relationship is always the same for log systems manufactured by the same company.

- Some of the log systems, depending on the manufacturer, have the low side of the coil power supply connected to pin A and others to pin B. It is necessary to always have the low side of the coil power supply connected to the side labeled low in figure 11. This prevents the circuitry from being offset by 55 volts and generating a high common-mode signal through capacitive coupling in the cable. A warning light, A, has been provided to warn the operator that switch S_1 is on the wrong setting. The operator should never perform an adjustment of an I/T with the warning light on because the common-mode signal will cause a significant error.

Each ELVS has been calibrated by the manufacturer to an accuracy of 0.025% of full scale or ±0.01 knot. The calibration was originally performed with a Control Instrument Company log system as a transfer standard. This transfer standard was calibrated by a standard voltage simulator maintained by this laboratory. Accuracy of this standard voltage simulator is ±0.01%. The other +0.015% error accounts for errors contributed by the log system used as a transfer standard.