OP 699 (FIRST REVISION): TORPEDO MARK 27 MOD 4 OPERATION AND MAINTENANCE

UNCLASSIFIED
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with changes 1 & 2

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OP 699[redacted]

(FIRST REVISION)

Chg I, II
Chg III
Complete
3/20/63

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Made
3/20/6

Change made
5/2/63

TORPEDO MARK 27 MOD 4
OPERATION AND MAINTENANCE

UNCLASSIFIED
~~CONFIDENTIAL~~

A BUREAU OF ORDNANCE PUBLICATION

DEPARTMENT OF THE NAVY
NAVAL ORDNANCE SYSTEMS COMMAND
WASHINGTON, D. C. 20360

IN REPLY REFER TO
ORD-054A:GRM
29 June 1970

Dean Paul Ebaugh
College of Engineering
Pennsylvania State University
University Park, Pennsylvania 16802

Dear Paul:

I am forwarding a copy of OP 699 (First Revision) which is the latest manual for the Torpedo MK 27 Mod 4. This manual has been downgraded to UNCLASSIFIED. It is certainly appropriate that you, as project engineer during the development of this torpedo, should have this in your library to remind you of those hectic - and happy, I hope - days at ORL.

Best regards.

Sincerely,

Glenn

Glenn R. Moltrup
Acting Assistant Director
Torpedo Division

Enclosure:
OP 699 (First Revision)

[redacted]

OP 699

(FIRST REVISION)

TORPEDO MARK 27 MOD 4
OPERATION AND MAINTENANCE

[redacted]

28 MARCH 1956

DEPARTMENT OF THE NAVY
BUREAU OF ORDNANCE
WASHINGTON 25, D. C.

28 March 1956

CONFIDENTIAL

ORDNANCE PAMPHLET 699 (FIRST REVISION)

TORPEDO MARK 27 MOD 4—OPERATION AND MAINTENANCE

1. Ordnance Pamphlet 699 (First Revision) describes Torpedo Mark 27 Mod 4 and presents its operational theory. Also this publication includes instructions for testing, adjusting, repairing, handling, and war and exercise firing of the torpedo. It is intended for the use of personnel concerned with operational characteristics and those responsible for maintenance of the torpedo.

2. This publication supersedes ORD 699 (Preliminary) dated March 1952 and should be destroyed by burning.

3. This publication is CONFIDENTIAL and shall be safeguarded in accordance with the security provisions of U. S. Navy Regulations and the provisions of applicable Federal Statutes and Executive Orders summarized in the Department of Defense Industrial Security Manual for Safeguarding Classified Information. As stated in Article 0906.2 of OPNAVINST 5510.1A, dated 2 October 1954, it is forbidden to make extracts from or to copy this classified document without authorization.

F. S. Withington

James H. Ward

James H. Ward
Rear Admiral, U. S. Navy
Acting Deputy and Assistant Chief
Bureau of Ordnance

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Chapter 1

INTRODUCTION

Torpedo Mk 27 Mod 4 is a passive-acoustic electric torpedo intended for use from submarines against other submarines.

General Operating Characteristics

This torpedo is set electrically and fired by Fire Control System Mk 101, Mk 106, or Test Set Mk 183 Mod 1, and can not be used by submarines not equipped with one of these systems. After a target has been located by sonar, radar, or optical instruments, the fire control system is used to set the gyroscope steering control, hydrostatic depth control, and enabler mechanism of the torpedo. These controls guide the torpedo to the general vicinity of the target.

When the torpedo is fired, it runs under gyro and hydrostatic depth control for the distance set into the enabler mechanism. The torpedo then becomes "enabled" and enters a search course. When the acoustic controls of the torpedo are influenced by noise produced by the target, the torpedo enters a pursuit course and homes on the target.

Torpedo Mk 27 Mod 4 runs at a speed of approximately 15.5 knots. Therefore, it will not be effective under all circumstances against target vessels operating at speeds greater than 12 knots. However, this low speed is of advantage because the torpedo operates quietly, thus making detection of the torpedo by the target vessel difficult if not impossible.

The torpedo can be decoyed easily by existing "noise-maker" countermeasures and can not discriminate between noise from the target and distracting noise originating from the launching vessel or other sources. Therefore, the torpedo must be set so that it will enable close to the target and as far as possible outside of the acoustic influence of the launching vessel. ~~As a safety measure for the protection of the launching vessel, the conditions of depth operation of Torpedo Mk 27 Mod 4 may be preset so that the torpedo will attack only targets above a stratum limit of 85 feet or below a stratum limit of 65 feet.~~

References

The following publications contain additional information related to Torpedo Mk 27 Mod 4:

- OP 1105, Ordnance Storage Instructions
- OP 1303, U. S. Navy Synchros
- OP 1999, Exploder Mk 11 Mod 2
- OP 2113, Target (Torpedo) Mk 1 Mod 0
- OP 2114, Sound Measuring Set Mk 1 Mod 0 and Mk 2 Mod 0
- OP 2117, Ordnance Locator Mk 1 (Torpedo) Mods 1 and 2
- *

Change 1

In addition to the above feature, the following safety measures have been added for the protection of the launching vessel: 1. The torpedo cannot be fired if it is in enabled condition; 2. The torpedo cannot be fired if the torpedo test switch is in a test position; ~~3~~.4 The enabler circuit is locked-in following enablement; ~~4~~.5 The exploder plug is not armed until the torpedo enables and will not arm during test procedures; and ~~5~~.6 The conditions of depth operation of the torpedo may be pre-set so that it will attack only targets above a stratum limit of 85 feet or below a stratum limit of 85 feet.* 3 THE TORPEDO CANNOT BE FIRED PRIOR TO WARM-UP.

* OD 10761, Test Set Mk 183 Mod 0 & 1 BUORD LDIS 272840 & 272760

OD 10760, Panel Test Set (attenuator) TG-7244;

OD 10754, audio Oscillator TS 382/U.

Chapter 2

PHYSICAL DESCRIPTION

Torpedo Characteristics

Torpedo Mk 27 Mod 4, figure 1, is approximately 10.5 feet long and has an overall diameter of 21 inches.

In war shot condition, the torpedo weighs approximately 1175 pounds. The displacement in sea water is approximately 1105 pounds, resulting in a negative buoyancy of 70 pounds. In exercise run condition, the torpedo weighs approximately 1075 pounds and has the same displacement as in the war shot condition. Hence, it then has a positive buoyancy of approximately 30 pounds. In both the war shot condition and exercise run condition, the center of gravity is within 0.5 inch of the center of displacement (approximately 55.7 inches from the tip of the head).

The torpedo is driven by a single propeller powered by an electric motor. Power for the motor is furnished by a storage battery (Storage Battery Mk 7 Mod 3 for war shots and Storage Battery Mk 8 Mod 4 for exercise runs). When powered by Storage Battery Mk 7 Mod 3, the motor develops 11.5 horsepower and turns the propeller at approximately 1350 rpm. The torpedo will run at a speed of approximately 15.5 knots for approximately 12 minutes. This allows for a minimum run of 600 yards before enabling followed by 11 minutes of acoustic search and attack, or a maximum run of 3100 yards before enabling followed by 7 minutes of acoustic search and attack.

The torpedo is equipped with rudders for horizontal steering and elevators for vertical steering. The rudders and elevators may be controlled by gyroscopic, hydrostatic, and pendulum controls, or by acoustic circuits. The acoustic circuits employ four hydrophones (two for horizontal steering and two for vertical steering) which detect the noise created by the target vessel and convert this noise into electrical impulses. These impulses are applied as inputs to an electronic control panel which uses them to produce output signals for controlling the positions of the rudders and elevators.

In general, the torpedo run is divided into two distinct phases. In the first phase, called the "gyro run," horizontal steering is under control of a gyroscope which guides the torpedo along a preset course toward the vicinity of the target. Vertical steering is under control of a hydrostatic depth mechanism and a pendulum which keeps the torpedo running level at preset depth (:0 feet or 125 feet). During this portion of

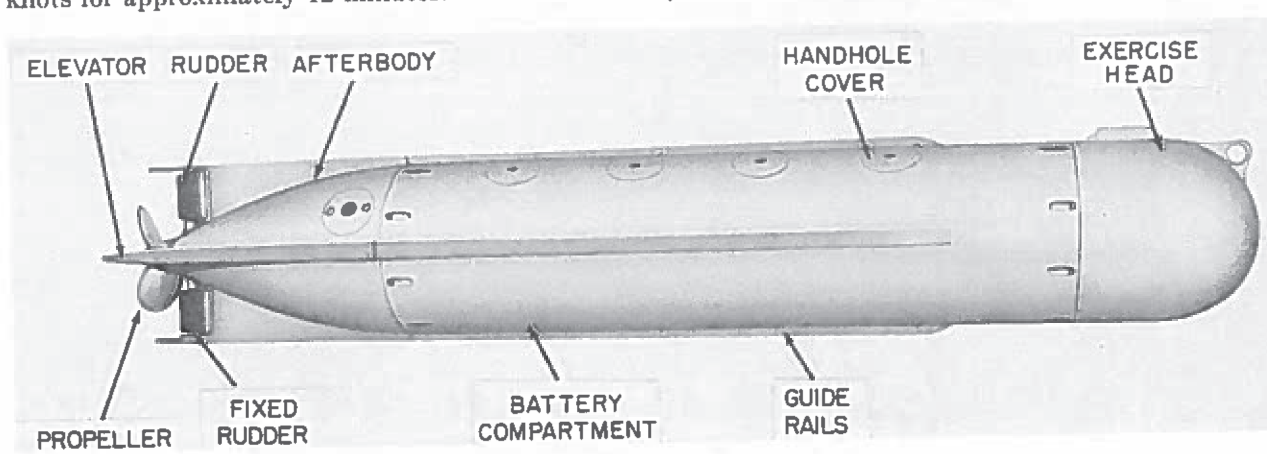

Figure 1—Torpedo Mk 27 Mod 4, Starboard View.

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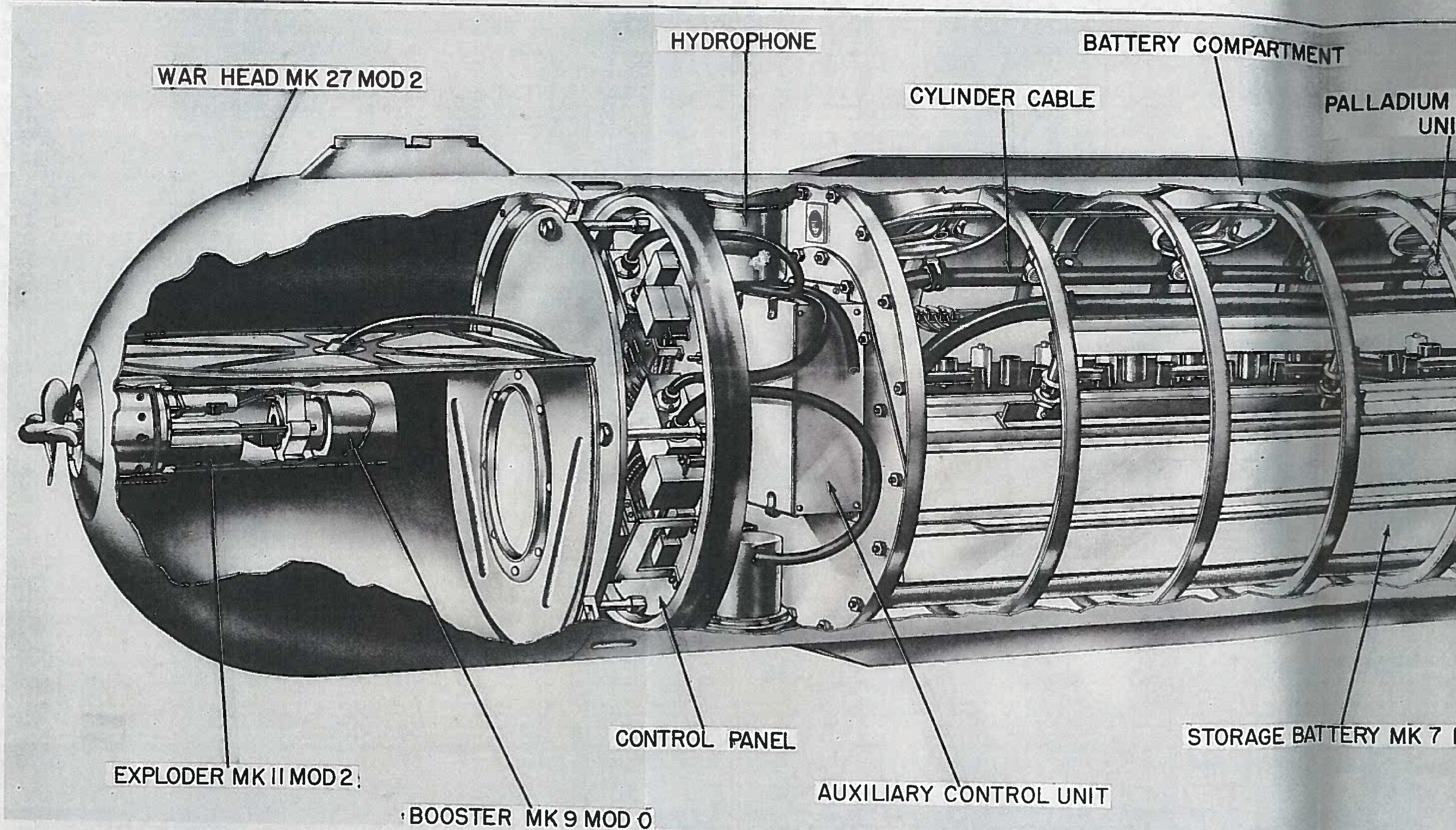

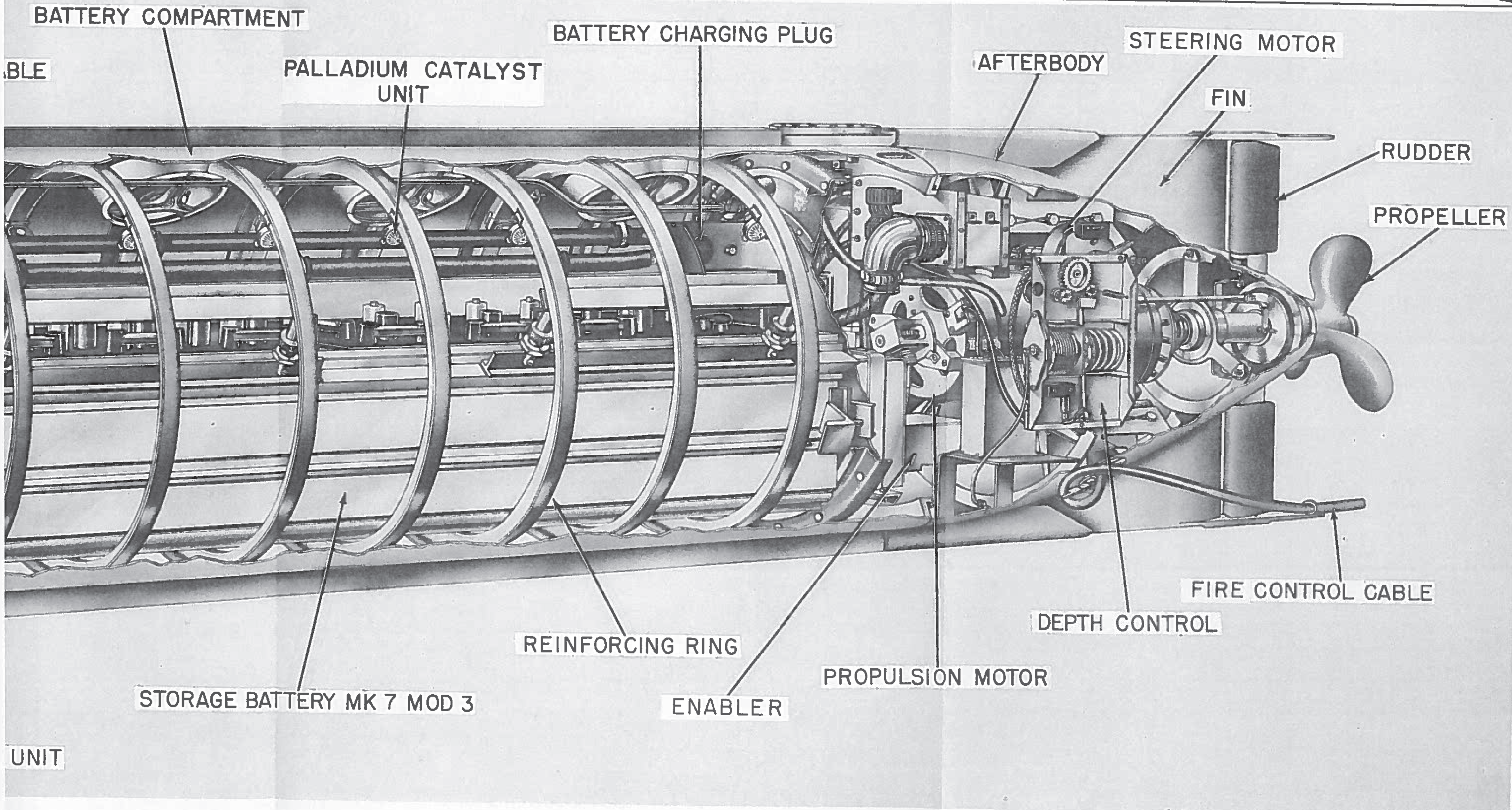

Figure 2—Torpedo Mk 27 Mod 4, Cutaway View.

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the run, the torpedo is acoustically disabled (that is, the acoustic circuits are "deafened" so that the torpedo will not respond to any noise which may be detected by the hydrophones).

When the torpedo has run for the distance preset into the enabler mechanism, the enabler operates and causes the torpedo to enter the acoustic search phase of the run. In this phase, horizontal steering is under acoustic control and vertical steering is under combined acoustic and hydrostatic depth and pendulum control. Until the hydrophones detect the target, the torpedo will run in a circular search course to port at the preset running depth. When the target is detected, the acoustic control circuits cause the torpedo to steer toward the target.

In addition to the horizontal and vertical steering controls, other circuits and devices are provided in the torpedo to afford protection to the launching vessel and to affect the operation of the steering controls so that attack will be executed in an optimum manner.

Major Components

Torpedo Mk 27 Mod 4 is composed of three major components: the afterbody, battery compartment, and head, which are bolted together to form the complete torpedo, figure 2. The afterbody contains the propulsion motor, steering controls, and enabler. The battery compartment contains the propulsion battery, hydrophones, control panel, and associated electrical components. Three different heads may be used with the torpedo. Warhead Mk 27 Mod 2 contains an explosive charge which is detonated by Exploder Mk 11 Mod 2 and Booster Mk 9 Mod 0. Exercise Head Mk 48 Mod 3 is a recording exercise head and Exercise Head Mk 48 Mod 2 is an inert head. The exercise heads are used in place of the warhead for exercise and proofing runs.

Afterbody

The afterbody is the aftermost section of the torpedo, figures 3 through 6. Its principal components are:

Afterbody shell and fixed fins
Rudders and elevators
Torpedo shell connector receptacle
Propeller
Propulsion motor
Drive shaft assembly
Steering motor, yoke, and stub shaft assemblies
Pendulum
Depth control assembly
Junction box
Gyroscope Mk 29 Mod 0
Enabler

Afterbody Shell and Fixed Fins. The afterbody shell is a curved, conical section fabricated from steel approximately ⅛ inch thick. It contains three reinforcing rings. The four fins, located at positions 90 degrees from each other, are welded to the afterbody shell. The fins extend approximately one inch beyond the maximum diameter of the afterbody shell and are faired into the guide rails on the battery compartment by means of fin extensions mounted on the forward part of the afterbody shell.

The upper starboard section of the afterbody shell is fitted with a mounting flange for the gyroscope. A hand hole cover, which contains a lucite window, seals the gyroscope during runs, but must be removed during workshop testing to gain access to the gyro latch mechanism and gyro angle dial.

Rudders and Elevators. The rudders and elevators are located at the trailing edge of the fins, and are supported by bearings mounted in gudgeon plates on the fins, and watertight inboard bearings welded to the shell. The two elevators and the upper rudder are splayed approximately 7 degrees in a counterclockwise direction (looking at the after end of the afterbody) with respect to their stubs. The lower rudder is permanently fixed in a position 7 degrees to the right of a vertical plane running through the axis of the torpedo. This splaying is incorporated in order to compensate for the torque resulting from the use of a single propeller.

Torpedo Shell Connector Receptacle. The torpedo shell connector receptacle is located in the lower port section of the afterbody shell. This connector receives the cable by which the torpedo circuits are connected to the external fire control system.

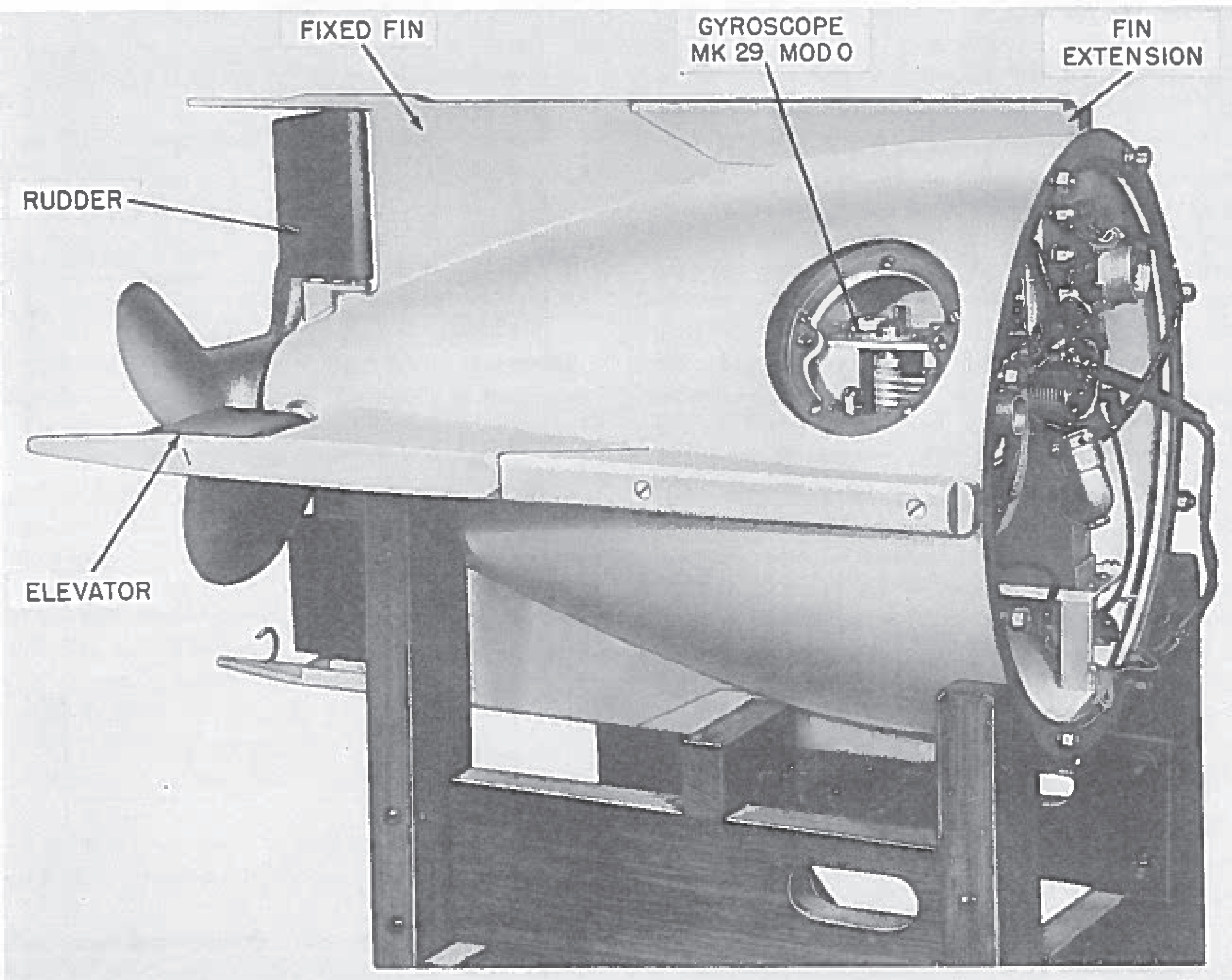


Figure 3—Afterbody, Starboard View (Gyro Cover Removed).

Propeller. The propeller is three bladed. It is keyed to the propeller shaft and secured by means of a fairwater nut and fairwater retaining screw.

Propulsion Motor. The propulsion motor is located on the axis of the afterbody section, and is supported by three brackets shock-mounted with rubber. It is a compound-wound, DC motor which can deliver 11.5 horsepower at 1350 rpm. It is coupled to the propeller by the drive shaft assembly.

Drive Shaft Assembly. The drive shaft assembly is supported by a spider mounted on the after reinforcing ring. The drive shaft assembly includes the housing, drive shaft, and a waterproof mounting for attaching the bearing to the after end of the afterbody assembly.

Steering Motor, Yoke, and Stub Shaft Assemblies. The elevator and rudder steering motor assemblies are mounted on brackets attached to the main motor frame. The motors are coupled to the rudders and elevators by means of connecting rods, yokes, and stub shafts. The stub shafts mount in the bearings welded to the after portion of the afterbody shell and are made watertight by pressure sealing type shaft seals.

Pendulum. The pendulum is mounted on a bracket in the lower port forward section of the afterbody, adjacent to the main motor. It is electrically connected to the afterbody junction box by means of a cable.

Depth Control Assembly. The depth control assembly is mounted on flanges welded to the port forward side of the afterbody shell. It is coupled

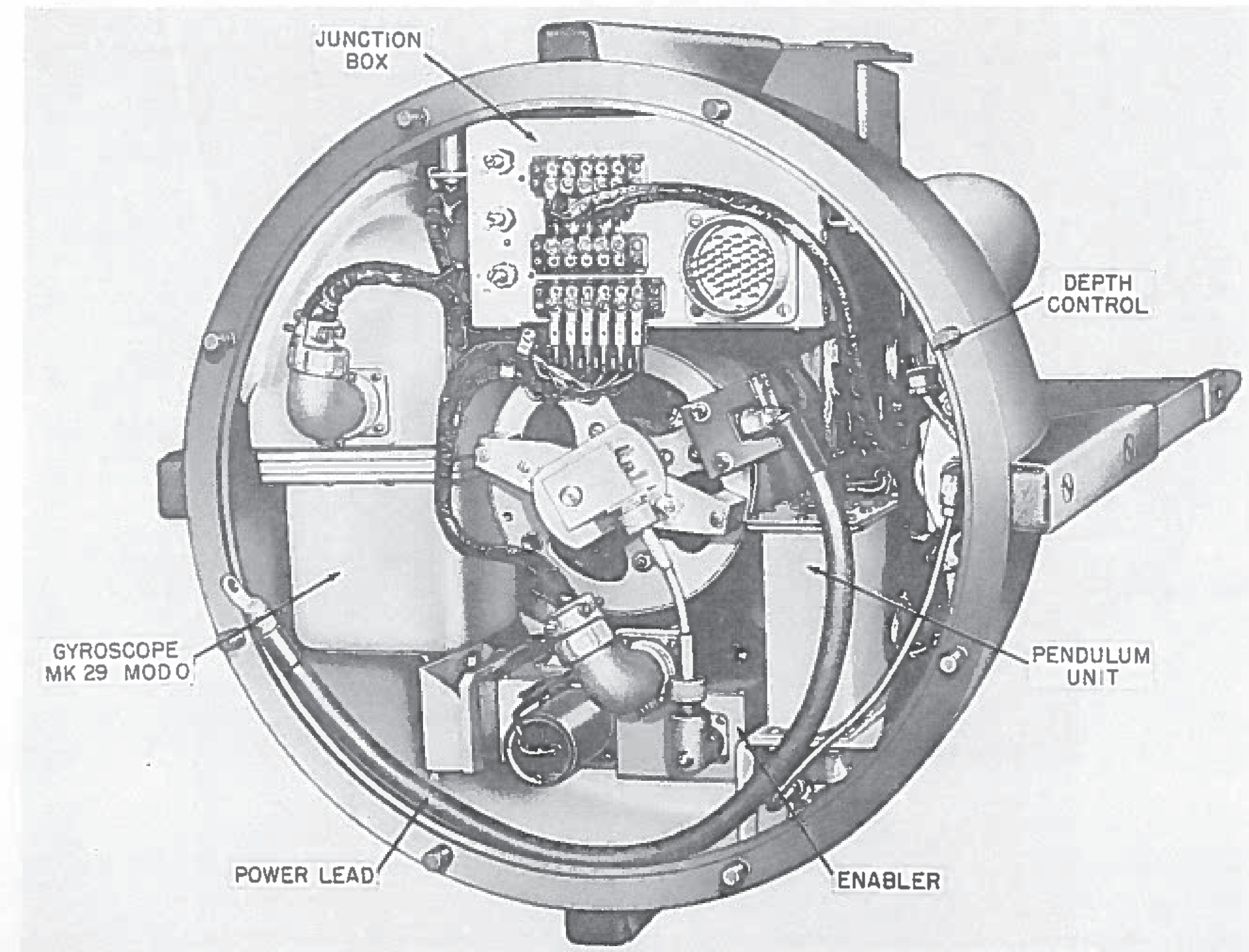


Figure 4—Interior of Afterbody.

to the depth vent by means of copper tubing. It also is connected electrically to the afterbody junction box by means of cabling.

Junction Box. The afterbody junction box assembly is mounted in the upper forward section of the afterbody. This junction box is the main electrical control point for the afterbody assembly. To it are coupled the main cylinder cable from the control panel in the battery compartment, and the cable from the afterbody shell connector receptacle. Cables from the afterbody junction box connect to the depth control, pendulum, gyro, enabler, steering motor assemblies, and other control assemblies located within the afterbody. The afterbody junction box contains, in addition to the cabling terminal strips, the gyro steering relays, the stratum stepping relay, the enabler control relays, the climb and dive angle limit switches, and potentiometers associated with the pendulum and depth control assemblies.

Gyroscope Mk 29 Mod 0. Gyroscope Mk 29 Mod 0, figures 7 and 8, is located in the starboard forward section of the afterbody, where it is mounted to a flange welded to the afterbody shell. This gyroscope is electrically driven throughout the warmup and gyro run portions of a complete torpedo run. The position of the gyro pickoff commutator is determined by an electrical setting made with Fire Control System Mk 101 or Mk 106 or with Test Set Mk 183 Mod 1.

Enabler. The enabler assembly, figure 85, is located in the lower forward section of the afterbody. It consists of an electrical cam in contact with a geared pickoff disc mechanically driven

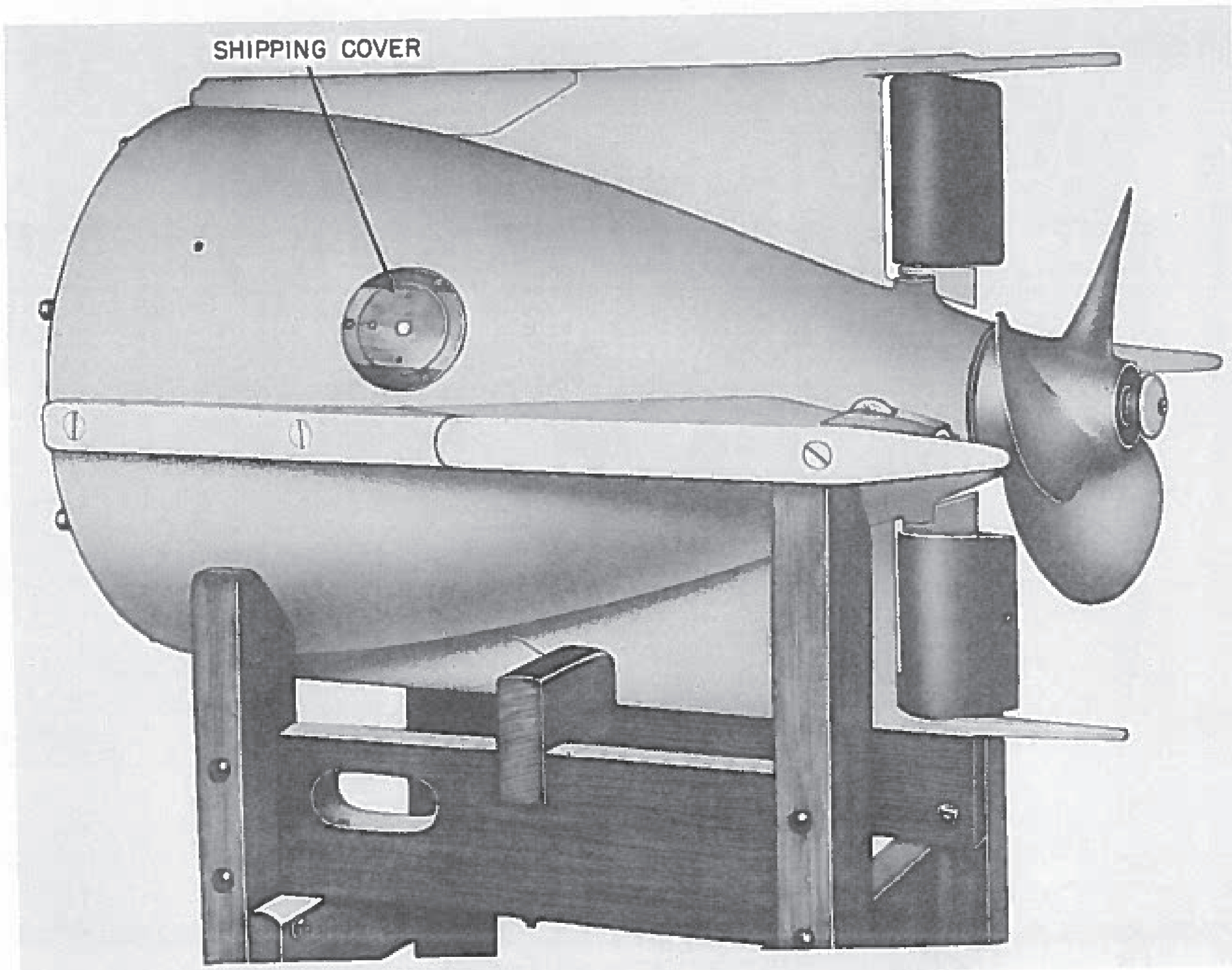


Figure 5—Afterbody (Supported on Starboard Side) Shipping Cover on Torpedo Shell Connector.

through a flexible shaft by the main motor assembly. It also is connected electrically to the afterbody junction box by means of cabling.

Battery Compartment

The battery compartment, figures 9 through 15, consists of the following major components:

- Battery compartment shell
- Control panel
- Auxiliary control unit
- Cylinder cable
- Hydrophones
- Palladium catalyst units
- B power supply
- Stratum switches
- Propulsion battery
- Main motor relay

Battery Compartment Shell. The battery compartment shell is constructed of steel approximately ⅛ inch thick and is fitted with 10 reinforcing rings. It contains a welded angle frame in which the propulsion battery is mounted and panel mounting brackets and studs which form part of the foremost reinforcing ring. The outside of the battery compartment shell is fitted with guide rails located 90 degrees from each other in top, bottom, port, and starboard positions, which serve to support the torpedo within a standard 21-inch torpedo tube. The afterguide stud is bolted to a mounting plate at the after end of the upper guide rail.

The heavy positive power cable which attaches to the positive terminal of the propulsion battery is grounded through a ground strap assembly on

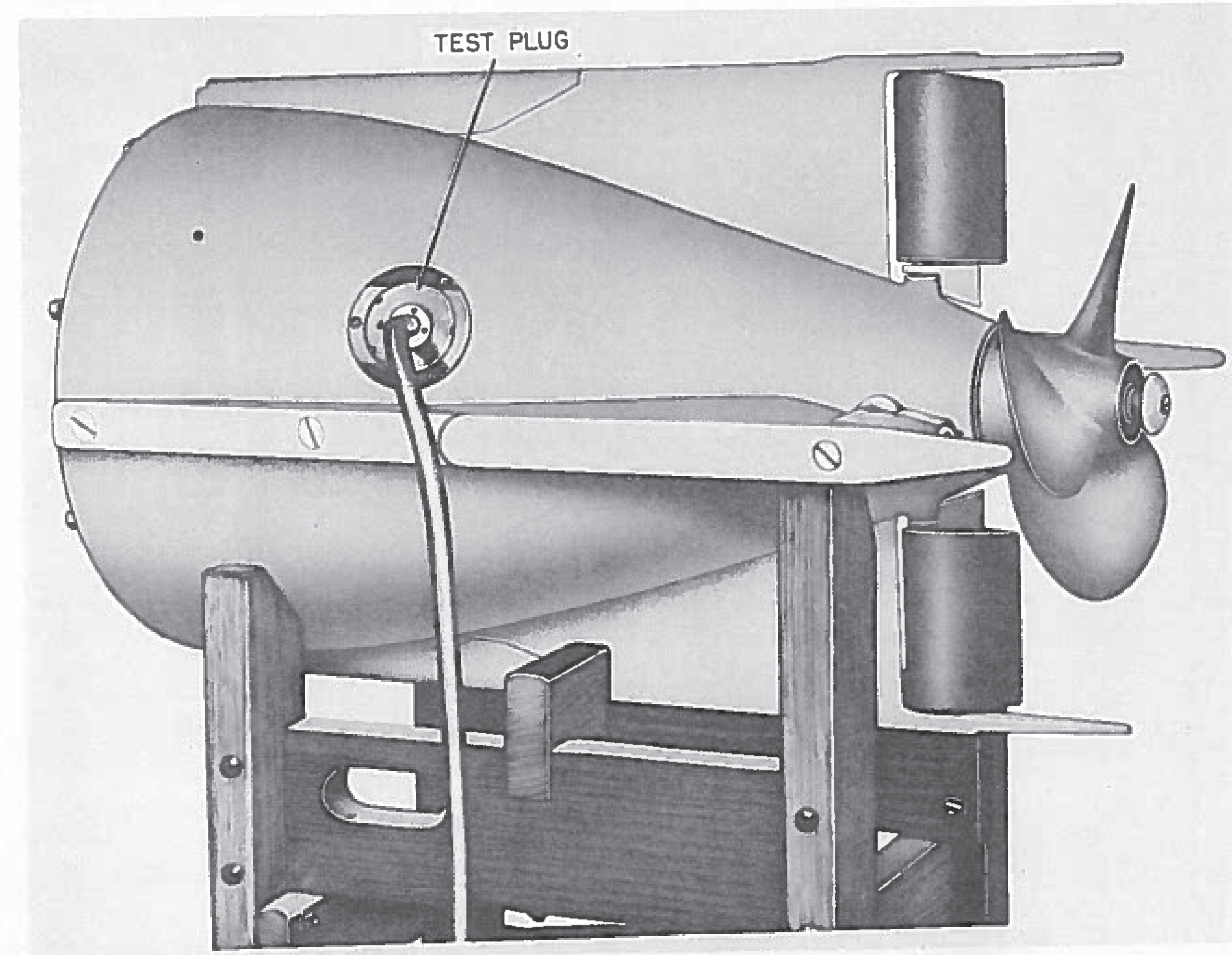


Figure 6—Afterbody (Supported on Starboard Side) Test Plug and Cable in Place.

the port side of the battery compartment shell. A charging receptacle, accessible through the aftermost hand hole, is mounted on the micarta insulating strip which supports the ground strap. The heavy negative power cable, which connects to the negative battery terminal, leads aft through the after bulkhead where it is connected to the main motor relay located in the top of the aftermost section of the battery compartment.

Control Panel, Auxiliary Control Units, and Cylinder Cable. The control panel is mounted on studs welded to flanges on the front reinforcing ring. The control panel is connected to the main cylinder cable, which passes aft through the cylinder along the upper starboard side. This cable is also connected to the auxiliary control unit assembly mounted on the forward bulkhead just behind the control panel. The cable terminates in an AN connector for connection to the afterbody junction box. A two-prong connector and an octal connector are attached to sections of the cable which branch off just behind the after bulkhead, and provide a means for connecting the B power supply. Another branch from the main cylinder cable fans out into terminal lugs for attachment to the −24, −28, and −48-volt terminals on the propulsion battery. These terminals are just aft of the forward bulkhead.

The control panel contains all of the electronic steering controls for the torpedo, and the auxiliary control unit contains all of the start and switching control relays other than those located in the afterbody junction box.

Hydrophones. Four magnetostriction hydrophones are mounted in rings welded to the battery compartment shell directly between the first and

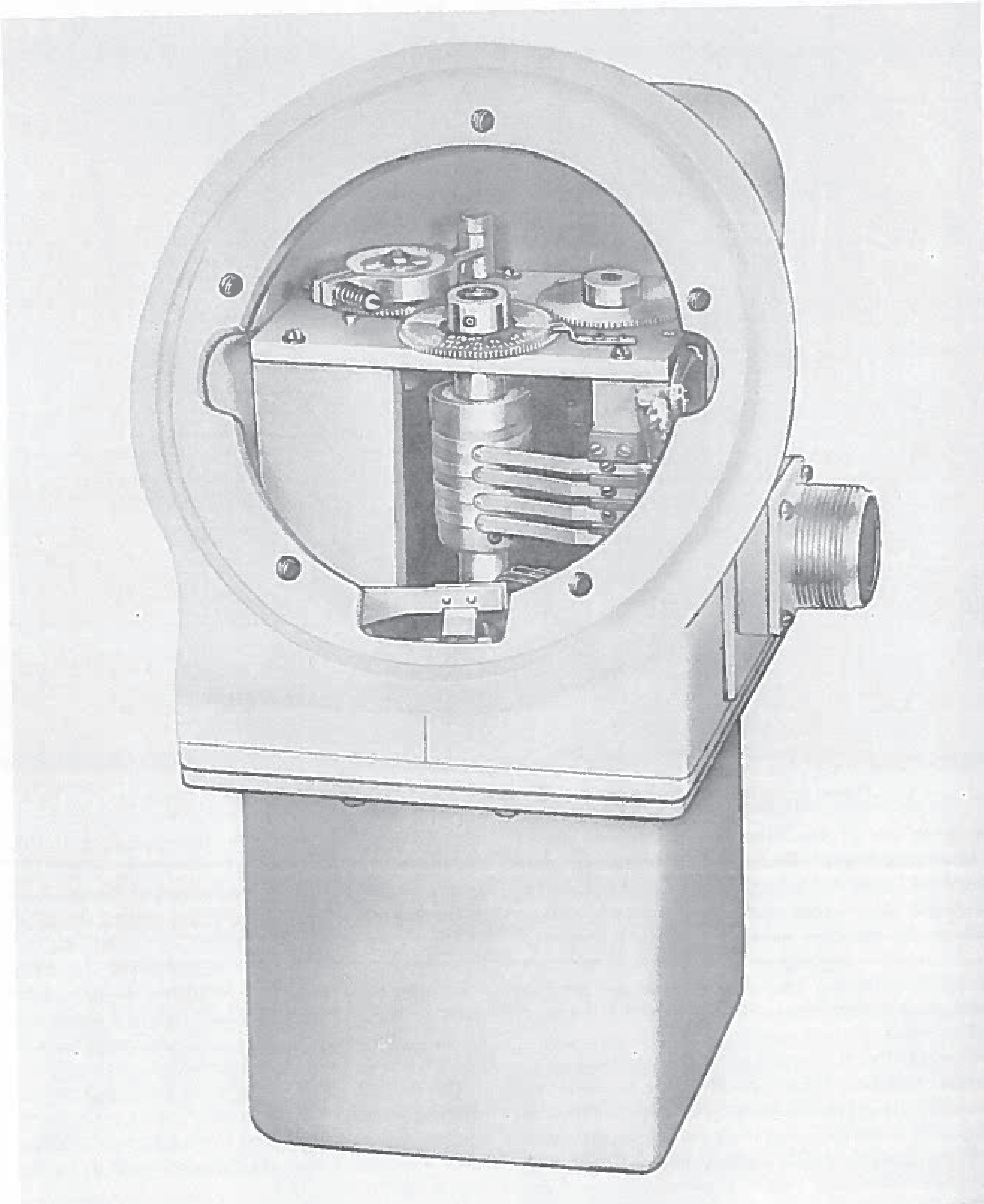


Figure 7—Gyroscope Mk 29 Mod 0.

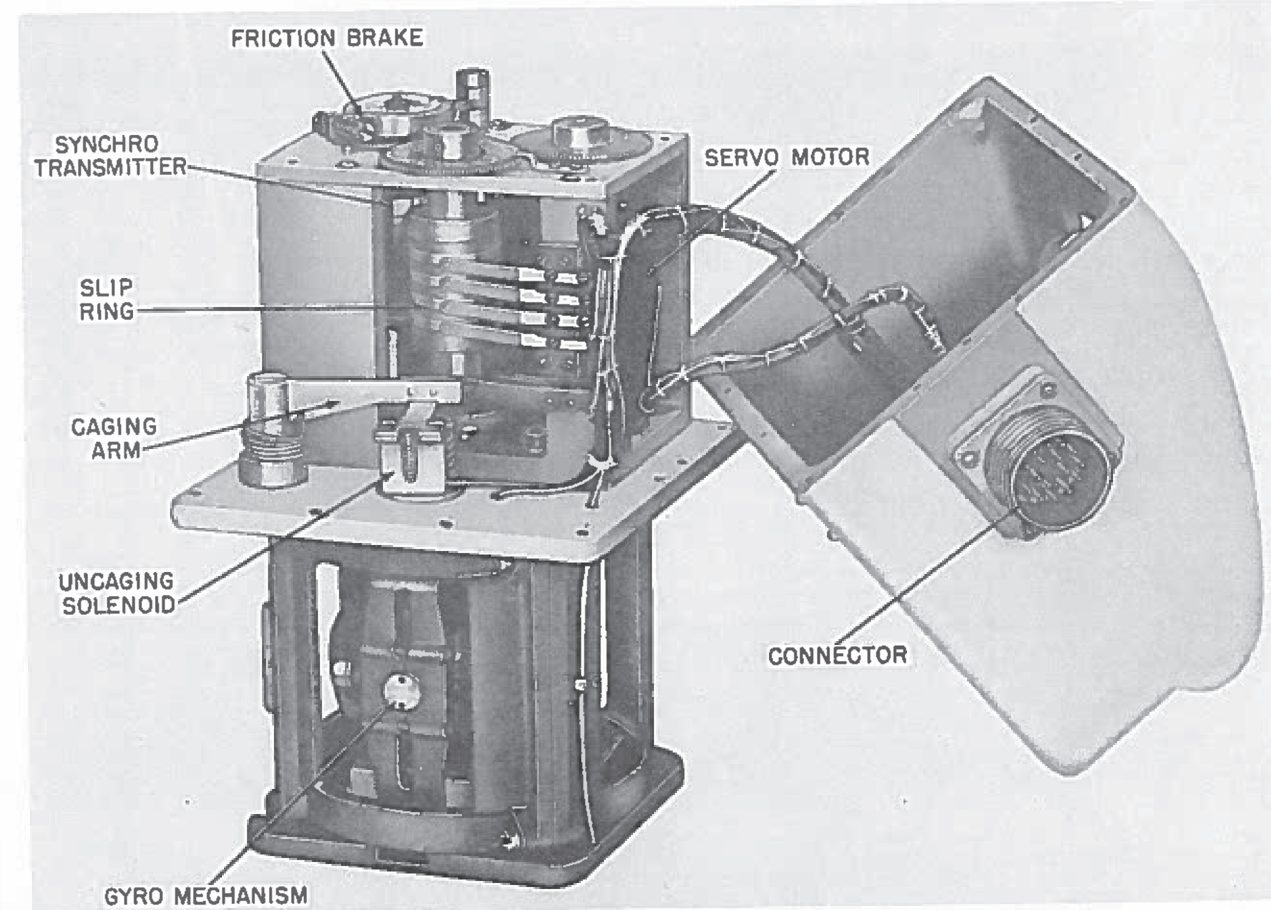


Figure 8—Gyroscope Mk 29 Mod 0, Covers Removed.

Mk 44 Mod 2

second reinforcing rings in the forward portion of the battery compartment adjacent to the auxiliary control unit. They are located 90 degrees from each other in top, bottom, port, and starboard positions. Each hydrophone is fitted with a special coaxial cable for connection to the control panel.

Palladium Catalyst Units. Fifteen palladium catalyst units are mounted within the battery compartment. These units contain palladium-coated pellets which cause the hydrogen gas evolved by the battery to combine with the oxygen in the air enclosed within the torpedo. The palladium does not enter into this reaction but causes the action to continue until all of the oxygen has been used in forming water vapor. Two palladium catalyst units are mounted in spring clips on each of the seven reinforcing rings of the battery compartment and one unit is mounted on the after bulkhead cover.

B Power Supply. The B power supply, which develops all of the plate, screen, and bias voltages required by the control panel, is secured to the after side of the after bulkhead by means of a mounting bracket. The supply is mechanically isolated from the bulkhead and the bracket by means of special rubber strips and pads, so that vibration will not be transmitted to the magnetostriction hydrophones through the battery compartment shell.

Stratum Switches. The stratum switches are connected to short pipe sections welded to the battery compartment shell in the lower portion of the battery compartment between the first and second reinforcing rings. The pipe sections connect to vents in the shell.

Propulsion Battery. The propulsion batteries used with the Torpedo Mk 27 Mod 4 are Storage Battery Mk 7 Mod 3 (for war shots) and Storage Battery Mk 8 Mod 4 (for exercise runs). These

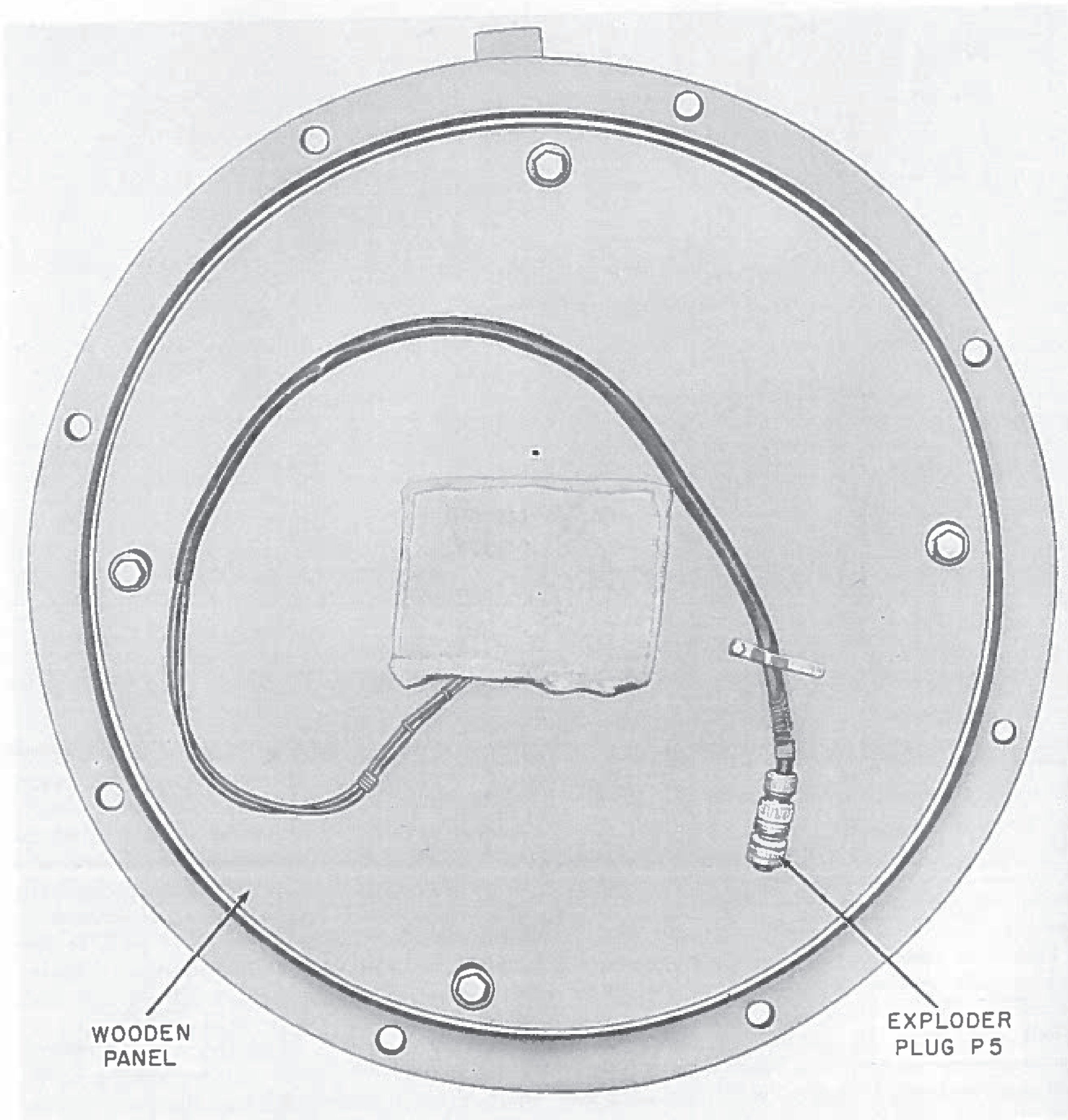


Figure 9—Battery Compartment, Forward End Showing Wooden Panel Cover and Exploder Cable.

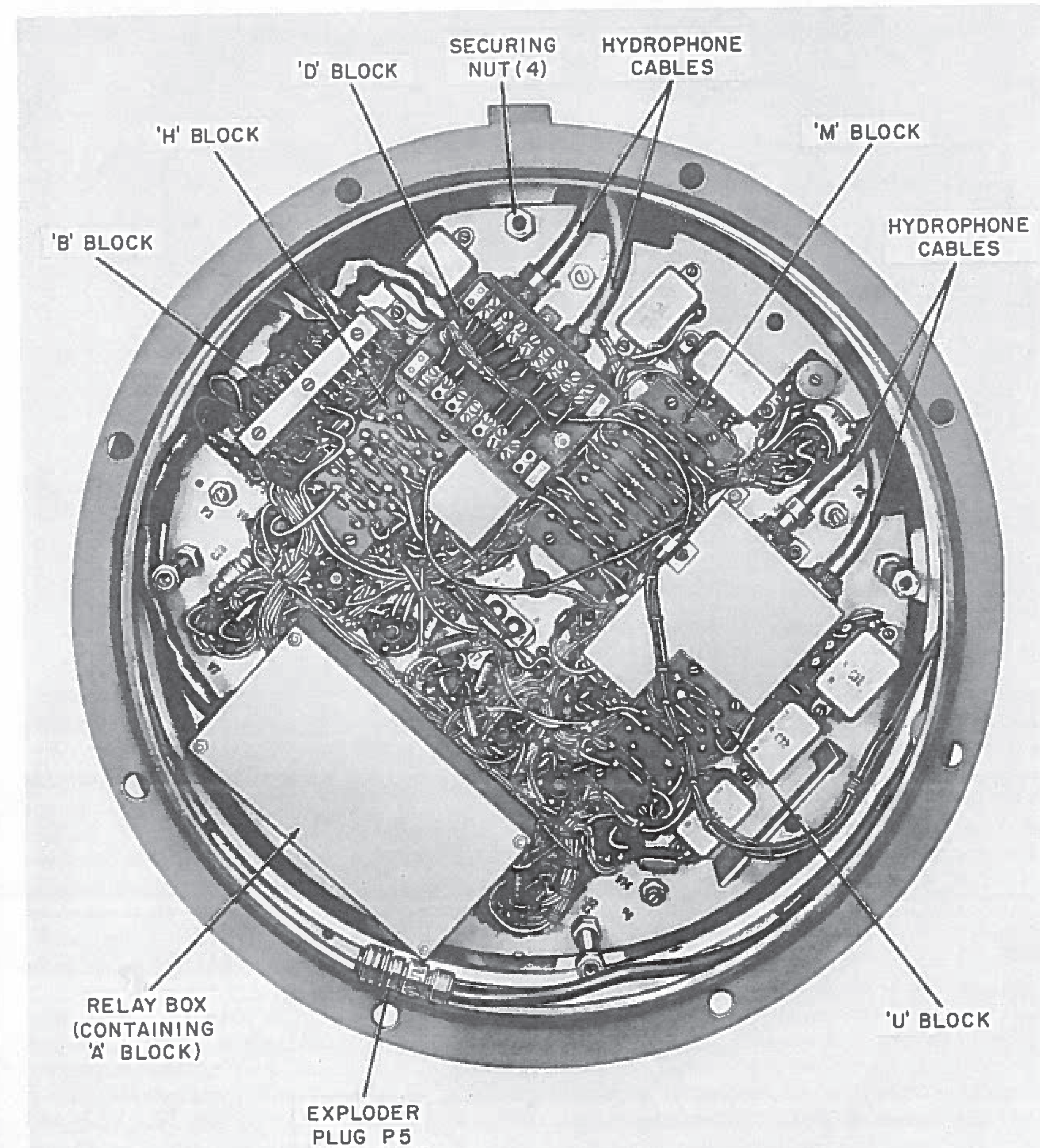


Figure 10—Battery Compartment, Forward End Showing Control Panel.

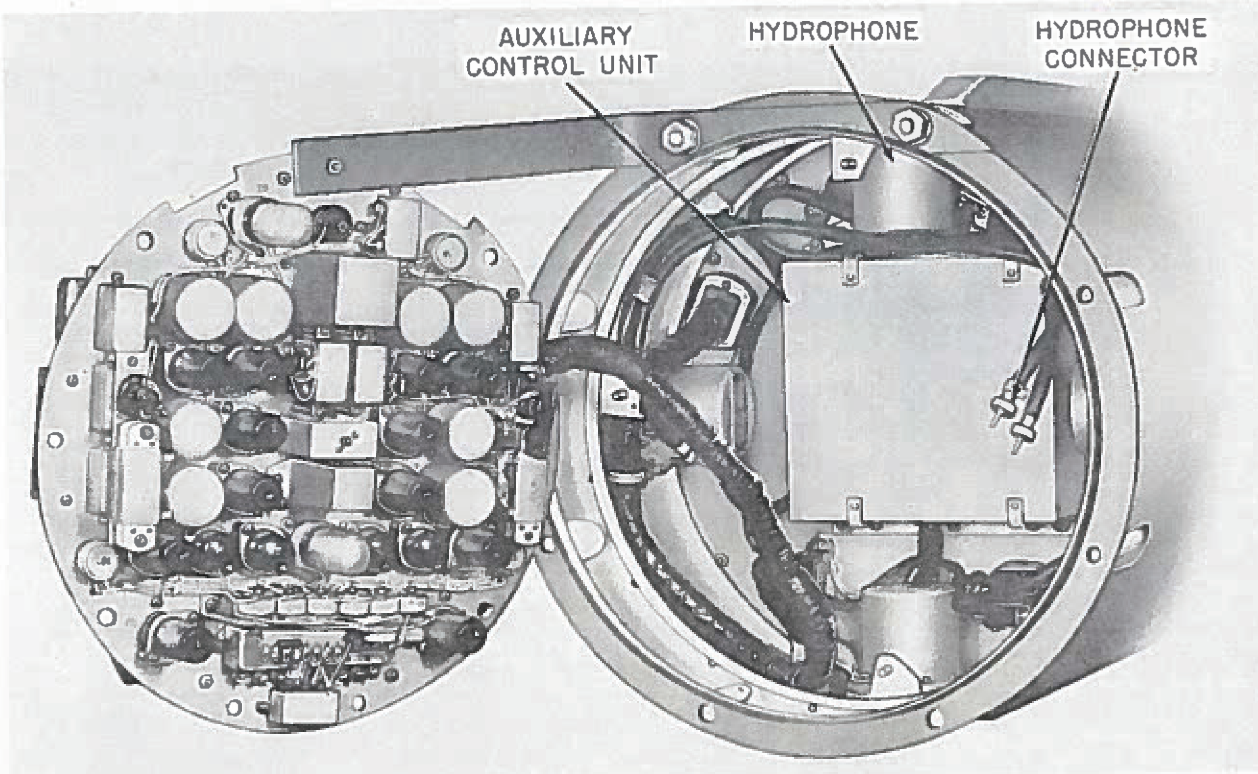


Figure 11—Battery Compartment, Forward End Showing Control Panel on Support Arm.

batteries have similar outline dimensions, and either may be mounted in the battery frame in the center of the battery compartment. The battery is held in place by means of four hold-down brackets, which press at an angle against flanges on the battery case, and by means of a single channel bracket, which bears against the afterend of the battery, forcing it against the forward battery stop.

Heads

Warhead Mk 27 Mod 2. The warhead is fabricated from steel approximately ⅛ inch thick. Welded to the top of the warhead is a solid steel guide stud. An inner sheet steel bulkhead retains the explosive charge which consists of approximately 124 pounds of HBX. An exploder receptacle at the front of the warhead extends into the explosive cavity. This receptacle provides a mounting for Exploder Mk 11 Mod 2 and Booster Mk 9 Mod 0. A conduit runs from the receptacle to the space above the bulkhead which retains the explosive charge. This conduit contains the cable through which the exploder is supplied with −24 volts DC.

Two exercise heads are used with Torpedo Mk 27 Mod 4 to replace the warhead for exercise and proofing runs.

Exercise Head Mk 48 Mod 3. Exercise Head Mk 48 Mod 3 contains a primary test unit, an oscillator-projector,* and (for hit shots only) an inertia cutoff device. The outline dimensions, weight, and center of gravity location are the same as those of the warhead.

Exercise Head Mk 48 Mod 2. The shell of Exercise Head Mk 48 Mod 2 is similar to the warhead shell but contains inert material in place of the explosive charge. The exploder receptacle is filled with an inert plug. A time delay relay and (for hit shots only) an inertia cutoff switch are installed in the head. Exercise Head Mk 48 Mod 2 also has outline dimensions, weight, and center of gravity location the same as those of the warhead.

* The oscillator-projector assembly, which is used primarily as range equipment has been replaced with a removable arm weight, in some units.

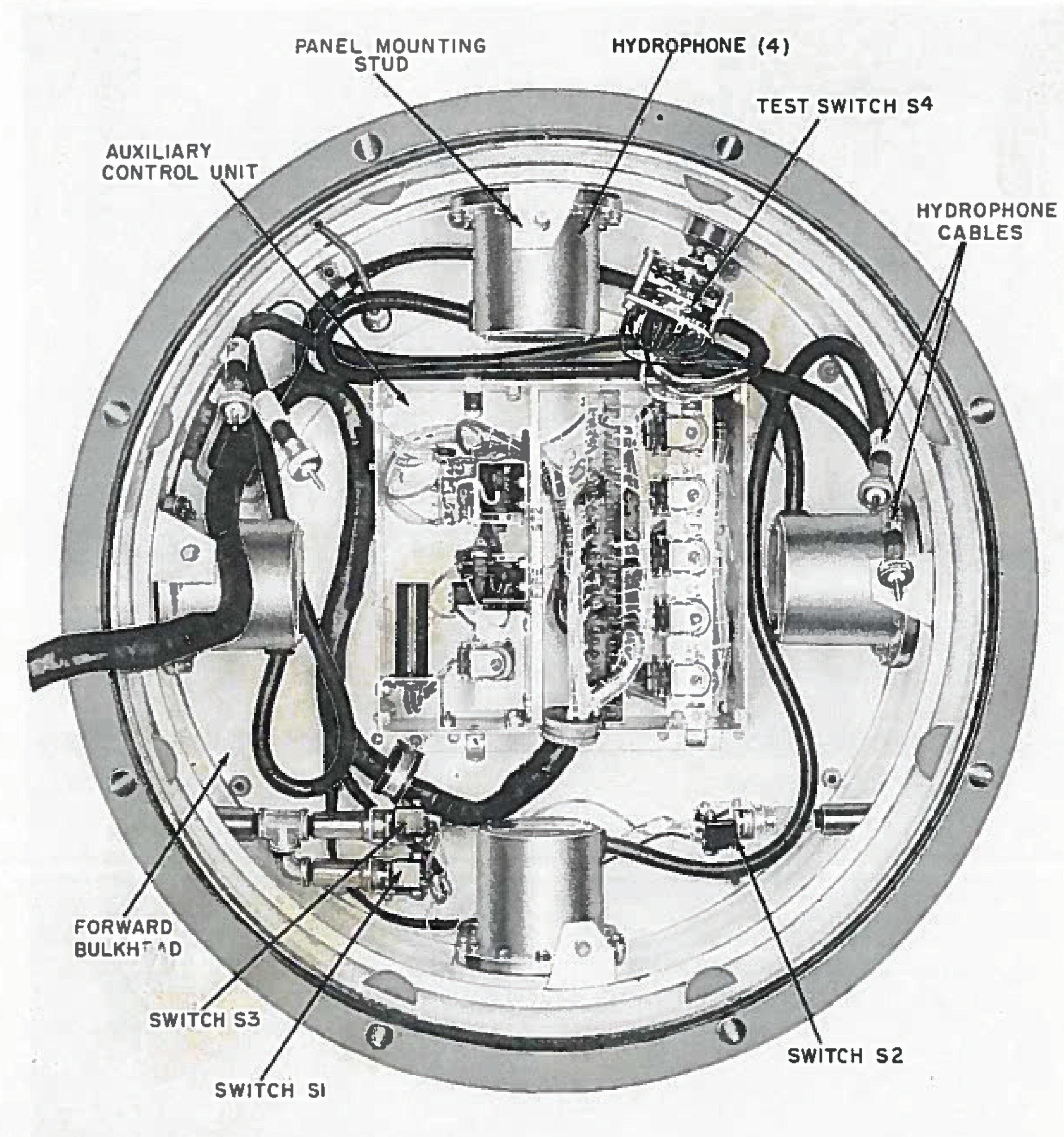


Figure 12 - Battery Compartment, Forward End With Control Panel Removed From Auxiliary Control Unit.

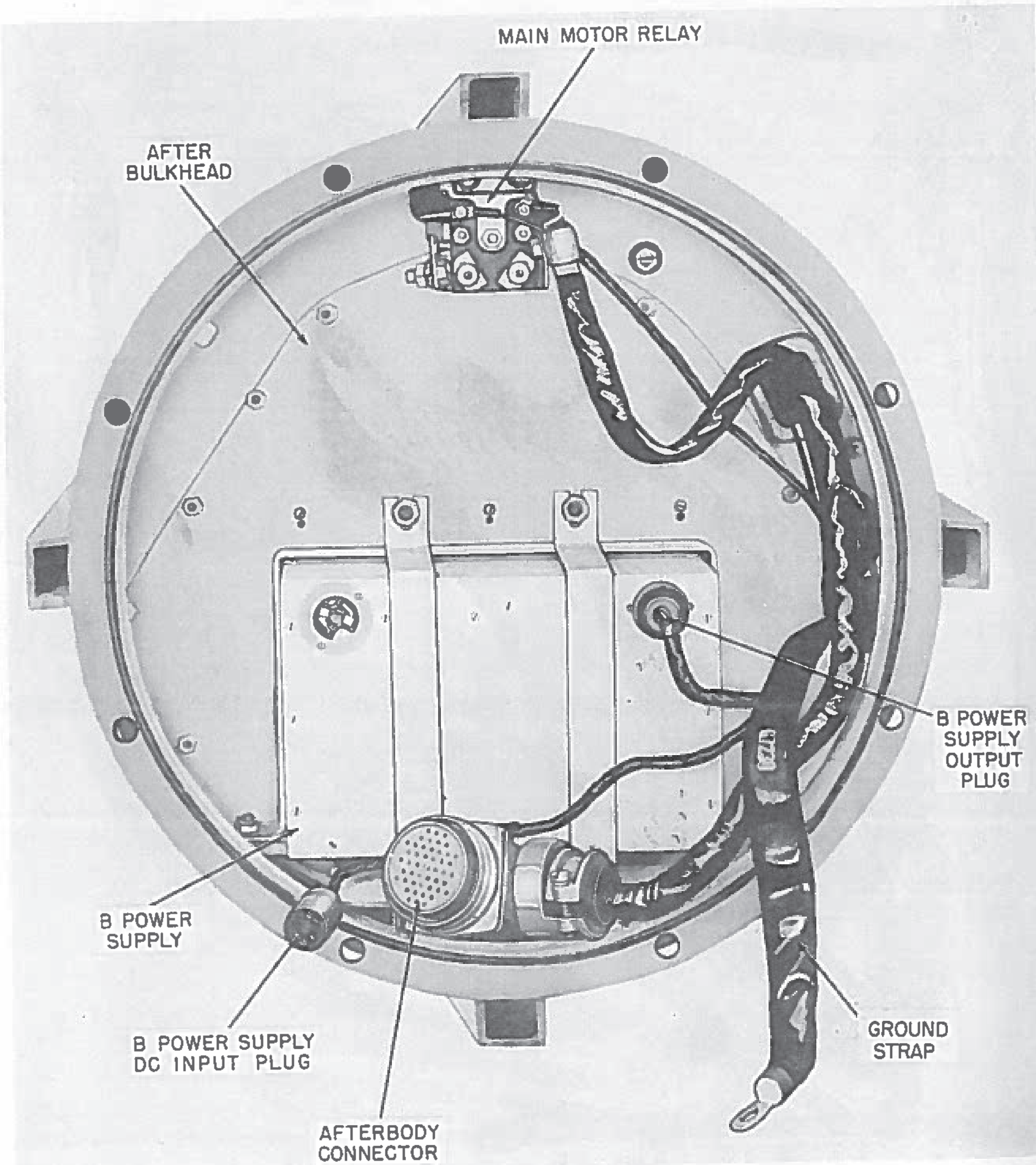


Figure 13—Battery Compartment, Rear View.

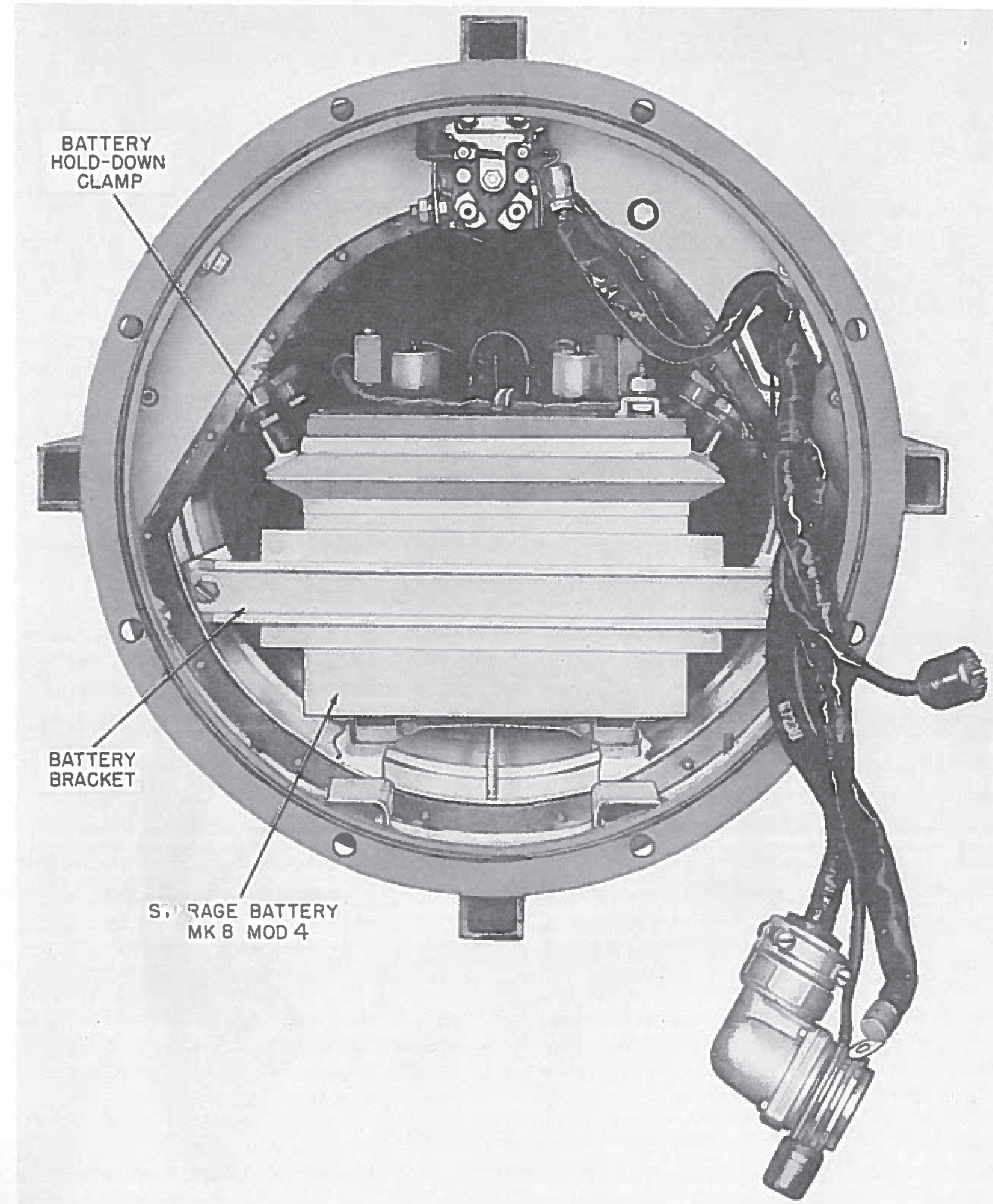


Figure 14—Battery Compartment, Rear View with After Bulkhead Removed.

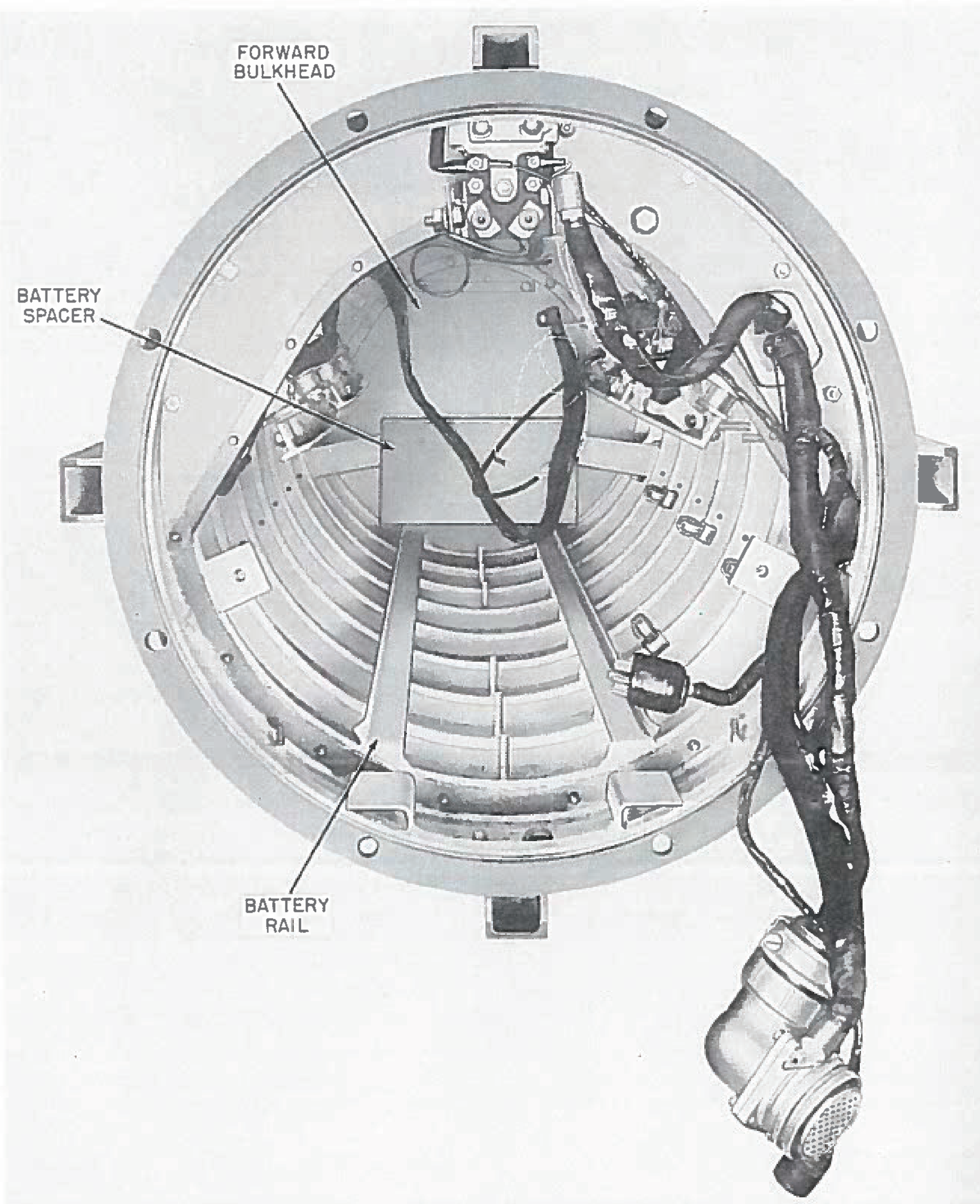


Figure 15—Battery Compartment, Rear View with Battery Removed.

Chapter 3

TORPEDO CHARACTERISTICS

This chapter describes the operating characteristics of Torpedo Mk 27 Mod 4 and the factors involved in employing the weapon under various conditions. This information is general in character and is intended only to aid operating and maintenance personnel in obtaining a more complete understanding of the functioning of the torpedo and its control devices. Information relating to the considerations involved in the actual employment of the weapon against specific types of targets is beyond the scope of this publication.

General Operation of Torpedo Mk 27 Mod 4

Torpedo Mk 27 Mod 4 is used for firing from submarines against other submarines, or against surface vessels and snorkling or surfaced submarines.

Firing Against Deep Submarines (Below Limit). The torpedo is loaded into the tube, where it is clamped by the stop bolt at either the forward or the after guide stud, or by the slot in the forward guide stud in single stop bolt tubes. The control cable plug is inserted in the shell connector and clamped in place, and the remaining fire control connections are properly made before the torpedo tube door is closed.

The torpedo is provided with 24-volt DC external power and synchronous-setting voltages when the relay-transmitter OFF-STANDBY-ON switch is in the ON position.

> NOTE: When using Test Set Mk 183 Type, 24-volt DC external power and synchronous-setting voltages are applied when the test set switch is in the STANDBY position.

Power is supplied to the filaments of the torpedo control power vacuum tubes, the gyro motor comes up to controlling speed, the power supply Mark 74 and the thermal time delay relay are energized. In approximately 15 seconds, the contacts of the time delay relay close and complete the firing circuit to the fire relay.

... abling run order may be externally set by the servo system incorporated in the relay transmitter portion of the fire control system. Any angle up to ±180 degrees from the tube line can be set, however, the ACR circuits will operate and stop the torpedo if any angle greater than approximately 135 degrees has been set. If the enabling range is set to less than 600 yards, the enabler will oscillate about the 600-yard position, and the relay transmitter will not show synchronization. If the range is set beyond 3100 yards, the enabler will oscillate about the 3100-yard position, and the relay transmitter will again fail to show synchronization. These features have been incorporated in order to allow a minimum gyro run distance for the safety of the launching submarine and to assure that the torpedo will have sufficient acoustic search and attack time left after enabling, the maximum useful gyro range being 3000 yards.

When the target submarine is at a depth of more than 35 feet, the torpedo is set in BELOW LIMIT condition and the launching submarine should operate at some keel depth less than 85 feet in order to be safe from attack by the torpedo. When the torpedo is fired, the gyro unlatches, thereby allowing the self-locking start controls to close. The closing of these controls starts the propulsion motor. The torpedo then swims forward in the tube and emerges from the tube in approximately 10 seconds. As the torpedo swims forward in the tube, it pulls the cable tight, and operates the cable cutter.

After leaving the tube, the torpedo will dive to a depth of 125 feet under pendulum, gyro and hydrostatic controls, where it continues on gyro course for the preset enabling distance. If the steering circuit should be faulty, causing the rudders to turn further than 17 degrees in either direction, the propulsion motor will be stopped ... e torpedo ... ro should ... one side, causing the torpedo to circle, the anti-circling run control (ACR) will be operated when the torpedo has turned past 135 degrees. The ACR circuit then opens the start circuits, thus stopping the propulsion motor permanently, and the torpedo … The electrically controlled exploder

Although the exploder is electrically controlled it is first mechanically armed, through impeller action, after the torpedo has run approximately 300 yards. It does not become electrically activated until the torpedo enables at 600 to 3100 yards. Thereafter, it becomes inactive at depths of less than 85 feet.

yards. During the gyro run, climb and dive angle limit switches in the depth control circuit prevent the torpedo from diving or climbing too steeply.

When the torpedo enables, it will circle to port under combined hydrostatic and pendulum control in depth, and a fixed steering bias in azimuth. In order to prevent excursions in depth immediately after enabling occurs, a delay circuit is incorporated to prevent the torpedo from "gating" for approximately 15 seconds. This allows the acoustic circuit to stabilize after it is activated. Upon receipt of sufficient target noise, the torpedo will turn toward the target, remaining near the set running depth of 125 feet. To produce steering in depth, the vertical acoustic circuit must buck depth and pendulum control until the target noise level becomes equivalent to approximately 30 db spectrum in either vertical hydrophone. At this point, providing the torpedo is at a depth of more than 85 feet, the torpedo will "gate," that is, the elevators will be entirely under acoustic control. The torpedo will then home directly at the target. If the torpedo rises above the 85-foot depth, the hydrostatic and pendulum controls will again influence the vertical steering. If the target is at a depth of less than 65 feet, the torpedo will start to attack, but as it passes through the 65-foot stratum level it will be acoustically deafened and the exploder will be inactivated. Since deafening returns the torpedo to hydrostatic depth and pendulum control, it will assume hard down elevator, and will dive to below the 65-foot depth, at which time the acoustic circuit and the exploder will again become active. This process will be repeated until the torpedo loses the target or the target moves to below the 65-foot stratum depth. If the target is below the 85-foot stratum, the torpedo will attack until a hit occurs or until the storage battery is depleted, at which time the torpedo will sink due to its negative buoyancy. There is no floor control and therefore the torpedo is free to attack a target at any depth below 65 feet. The shell construction is such that the torpedo will not crush at depths less than 450 feet.

Firing Against Surface Vessels and Snorkling or Surfaced Submarines (Above Limit). For firing at targets at or near the surface, the torpedo … ABOVE LIMIT condition. With the … same functions … LOW LIMIT … the launching procedure is the same.

In order to be safe from attack by the torpedo, the launching submarine should operate at some keel depth below 150 feet. When the torpedo is fired, through application of 115 volts 60 cycle AC, the gyro unlatches, the self-locking start controls are closed, and the propulsion motor starts. The torpedo then swims forward in the tube and emerges from the tube in approximately 10 seconds. As the torpedo swims forward in the tube, it pulls the cable tight and operates the cable cutter.

The torpedo then rises to a running depth of 70 feet under hydrostatic and pendulum control and follows the set gyro course. If the torpedo tends to circle, or if the steering controls are faulty, the 17-degree rudder safety circuit or the anticircling run circuit will operate in the same manner as described previously. The exploder is impeller armed at a distance of approximately 300 yards and the electrical control for the exploder is active at all depths less than 85 feet. During the gyro run, the climb and dive angle limit switches in the depth control circuit prevent the torpedo from diving or climbing too steeply.

When the torpedo enables, it will circle to port near the running depth of 70 feet under combined hydrostatic and pendulum control in depth and a fixed steering bias in azimuth. In order to prevent excursions in depth immediately after enabling occurs, a delay circuit is incorporated to keep the vertical system from being influenced by the target noise for approximately 15 seconds. This allows the acoustic circuit to stabilize after it is activated. Upon receipt of sufficient target noise, the torpedo will turn toward the target in azimuth, remaining at the set running depth of 70 feet, until the vertical signal increases with closing range and triggers the vertical steering control when the torpedo is close to the target. The torpedo will then start to steer in depth toward the target but the hydrostatic and pendulum controls will remain active. Thus, the acoustic controls are required to buck the hydrostatic and pendulum controls even after the acoustic controls become active. These features have been incorporated in order to prevent the torpedo from broaching when attacking shallow targets. If the target is below 85-foot depth, the torpedo will dive toward the target. However, as the torpedo passes below 85 feet, the acoustic controls are deafened, the exploder circuit is deenergized, and the vertical steering is entirely controlled by the hydrostatic depth and pendulum devices. This causes UP elevator, and the torpedo will rise until it passes back through the 85-foot stratum level. If noise is still received from the deep target, the process will be repeated until the storage battery is depleted, until the target rises above 85 feet and a hit occurs, or until the target is lost.

If the target is near the surface and the signal is sufficiently high to operate the vertical trigger, the torpedo will buck the hydrostatic and pendulum controls and rise toward the target. If the depth of the target is less than 30 feet, the ceiling switch will operate as the torpedo passes above that level and 10 db of attenuation will then be inserted in the UP channel. This will keep the torpedo near the 30-foot depth until the sound received from the target is of sufficient intensity relative to the self-noise of the torpedo to develop a net UP differential greater than approximately 13 db. The torpedo will then steer up and attack the target. This action applies only to targets whose propellers are at a depth of less than 30 feet. If the torpedo does not hit the target before depletion of the storage battery, it will sink due to its negative buoyancy of 70 pounds.

No Limit Firing. It is possible to switch the stratum control to NO LIMIT condition, which makes the acoustic controls and exploder active at all depths. For such firing, the only safety devices protecting the launching submarine are the 300-yard impeller safety, the anticircling run and rudder angle controls which are active during the gyro run, and a minimum gyro run of 600 yards. After enabling, the torpedo is free to attack a target at any depth. However gating cannot occur at depths shallower than 85 feet, and the ceiling control operates as described previously to keep the torpedo from broaching or running on the surface.

The launching in this case is no different from that previously described, and the torpedo has a nominal running depth of 125 feet. The sequence followed by the torpedo in making an attack is similar to the two conditions previously described, with the exception that in this case no stratum controls tend to keep the torpedo in a given stratum.

Homing Characteristics

Any vessel moving through the water radiates a certain amount of noise. Although this noise field is usually stronger in certain directions than in others, it is assumed for the purpose of this discussion that it extends uniformly in all directions from the vessel. The amount of noise radiated depends upon the speed of the vessel, the type of vessel, the depth of the vessel in the case of a submarine, and the condition of the screws. The intensity of the noise field decreases approximately as the reciprocal of the square of the distance from the vessel. There is, therefore, a certain range, called the critical range, beyond which a torpedo cannot hear the submarine from which it has been fired. The area of influence of the firing vessel can thus be visualized by a circle, whose radius is the critical range, surrounding the vessel and moving along with it. When the enabling distance of the torpedo is such that the acoustic controls become active outside of this critical-range circle, the torpedo will not home on the firing vessel.

Table 1—Maximum Critical Range for Various Firing Vessel Noise Levels (in Absence of Target Noise)

Firing Vessel Noise Level (dbs at 200 yds, 24.5 kc)	Critical Range (yds)
15	150
20	260
25	420
30	670
35	1020
40	1440
45	2010
50	2650
55	3380

If the torpedo enables anywhere within the critical-range circle, it is capable of hearing the firing vessel, in the absence of other noise. Normally, however, the noise from the target will be of greater intensity than that from the firing vessel, and the firing vessel will not decoy the torpedo. In the limited number of cases in which the torpedo may be so decoyed, the stratum feature still affords protection, as described earlier in this chapter.

Table 1 shows the critical ranges for different strengths of firing vessel noise fields in the absence of any other noise field. These are average values and will vary with water conditions.

Chapter 4

PRINCIPLES OF UNDERWATER ACOUSTICS

Introduction

Since an understanding of the operation of the steering control circuits is dependent on a knowledge of the basic principles of acoustics, these principles are developed briefly in this chapter, and are then used in explaining the characteristics of underwater sound. In chapter 5, these principles are applied in explaining the theory of acoustic steering.

Nature of Sound

Sound is produced when mechanical vibration of a body sets up vibrations in the surrounding medium. An example of a source of underwater sound is one of the small bubbles produced by the cavitation of a propeller. As the bubble collapses, it alternately increases and decreases in size. When the bubble increases in size, it increases the pressure in the layer of water adjacent to its surface, and when it decreases in size, it decreases the pressure in this layer of water. These compressions and rarefactions spread away from the source in the same way that ripples spread from a point on the surface of the water when the surface is disturbed. It is not necessary for the source of underwater sound to be such an oscillating bubble. Any vibrating body will send out sound waves. For example, the vibration of a submarine hull due to operation of machinery on board, or even due to the walking about of the crew, will produce compressions and rarefactions which are propagated in the water as sound. In the case of the bubble, which is nearly spherical, the sound spreads out uniformly in all directions from the source. However, a vibrating body, such as a submarine hull, may radiate more sound in some directions than it does in others.

If a hydrophone is placed at some distance from the sound source and is connected to an oscilloscope, it will be observed that the hydrophone produces an oscillating output. If the source is vibrating at one frequency only, a sine wave will be observed. If the vibration is complex, as is the case with ordinary noise, the wave observed on the oscilloscope will be very irregular. This indicates that there are many frequencies present in the vibrations.

Sound Pressure. As stated in the preceding paragraph, sound consists of compressions and rarefactions which are propagated through the water. These compressions and rarefactions represent pressure changes above and below the normal static pressure in the water. The amplitude of this variation in pressure is called the "sound pressure". In general, the sound pressure is very small when compared to the static pressure. The accepted unit for measuring sound pressure is expressed in dynes per square centimeter. If the sound pressure is given as 0.0002 dyne per square centimeter, this means that the sound causes the water pressure alternately to increase above the static pressure by 0.0002 dyne per square centimeter and to decrease below the static pressure by the same amount.

Velocity of Propagation. The velocity with which the increase or decrease in pressure moves forward through the water is called the velocity of propagation. This is analogous to the velocity with which a wave on the surface of the water moves forward, and has no relation to the actual velocity of the water particles themselves. The velocity of propagation of underwater sound is approximately 5000 feet per second at the surface of sea water of normal salt content, at a temperature of 70° F. The velocity increases approximately 6 feet per second for each degree (F) increase in temperature, about 4 feet per second for each additional part of salt per 1000 parts of water, and 1.8 feet per second for each 100 feet increase in depth.

Intensity. The propagation of sound through the water is actually a propagation of energy. If a small area perpendicular to the direction of propagation is considered, energy will flow through the area at a rate depending on the sound pressure.

The rate of flow of energy is called power. If an area of one square centimeter is considered, the power passing through that area is called the intensity. Two units are used to express intensity: the erg per second per square centimeter, and the watt per square centimeter (equals ten million ergs per second per square centimeter).

Factors Affecting Direction of Sound Propagation

If a sound wave traveled through a perfectly uniform medium, it would always move in the same direction away from the source. However under ordinary conditions, factors are present which causes the direction of movement to change. These factors are described in the following paragraphs.

Reflection. When sound strikes a dividing surface between two media such as water and air, reflection takes place; that is, a portion of the energy striking the surface bounces off. If the surface is smooth, the reflection is specular; that is, the angle of reflection is equal to the angle of incidence as in the case of light striking a mirror. However, if the surface is rough, the reflection is diffused; that is, the reflected sound travels in various directions. In order for a surface to be smooth enough to produce specular reflection, the irregularities in the surface must be smaller than the wave length of the sound. Therefore, a surface may be smooth for a sound having a low frequency (and hence a long wavelength), but will be rough for a sound having a high frequency (and hence a short wavelength). Under standard conditions in sea water, a sound at a frequency of 500 cps has a wavelength of nearly 10 feet, while at a frequency of 24 kc, the wavelength is only 2.5 inches.

Sometimes, two volumes of water having greatly different temperatures may be adjacent to each other, and at the boundary between the two volumes, the temperature may change very sharply within a few feet. Since the density of water depends on its temperature, the density of the two volumes of water may be sufficiently different so that the boundary area between them forms a reflecting surface for sound. When such a rapid temperature change occurs at a given depth, it is said that a "thermocline" exists at that depth.

Refraction. The velocity of sound increases with increase in temperature. If the temperature of the water is higher near the surface than at a greater depth, the sound will travel faster near the surface. This difference in velocity at different depths causes a sound wave which starts in the water in a horizontal direction to be bent downward. This bending of the sound waves is called refraction. Refraction can also result if the salt content of the water varies with depth since the velocity of sound in the water depends on the salinity. In some cases, refraction may cause "shadows" or "blind spots" in which the sound cannot be detected. In certain areas, the water temperature may change so rapidly with depth that the homing range of weapons similar to Torpedo Mk 27 Mod 4 may be decreased seriously. However, this condition occurs very rarely.

Diffraction. A sound wave striking an obstacle bends around that obstacle. This bending around an obstacle is called diffraction. Diffraction is of importance in considering the way the propeller noise of a torpedo bends around the side of the torpedo and reaches the hydrophone.

The Decibel

The decibel is used to express power levels in relation to a reference power level. The number of decibels by which a power, P, exceeds the reference power, Po, is equal to 10 log (P/Po). (The logarithm is expressed to the base 10.) For example, if the reference power Po is equal to 2 watts and P is equal to 4 watts, then the number of decibels by which P exceed Po is equal to $10 \log (4/2) = 10 \log 2 = 10 \times 0.3 = 3$ decibels. When a power level is expressed in decibels, a reference power must always be specified. If the power level is smaller than the reference value, the number of decibels expressing the power level is negative.

In the case of sound, power is given by the formula, $P = p^2/dC$; where P is power, p is the sound pressure, d is the density of the medium, and C is the velocity of sound in the medium. (This relationship is similar to the expression for electrical power, $P = E^2/R$). The product of density and velocity, dC, is called the specific acoustic resistance of the medium. In salt water and specific acoustic resistance is approximately 146,000 acoustic ohms.

Since power is proportional to sound pressure squared, the number of decibels by which the power of one sound having a sound pressure of p_1 exceeds the power of another sound having a sound pressure of p_2 is given by the expression 20 log (p_1/p_2). This relationship indicates that the change in the number of decibels is twice as great for a given ratio between sound pressures as it is for the same ratio between the powers. For example, doubling the power produces a change of three decibels (as previously explained). However, doubling the sound pressure produces a change of six decibels. It should be remembered that in both cases, the number of decibels actually indicates the amount by which one power level exceeds the other. The effect of doubling the sound pressure is to quadruple the power; the effect of tripling the sound pressure is to increase the power by a factor of nine; and so on.

In most work in underwater acoustics, a reference pressure of 0.0002 dyne per square centimeter is used. (This value has no particular significance in underwater acoustics but is a holdover from general practice in air acoustics. In air acoustics, this pressure is used as the threshold of hearing.)

Spectrum Level. The term, spectrum level, is used to express the magnitude of underwater noise. Before this term can be explained, the following concepts concerning noise must be understood:

A noise consists of many vibrations at different frequencies. Any continuous range of these frequencies is called a frequency "band," and the difference in the number of cycles per second at the low end and high end of the range is called the "band width".

The vibrations of which the noise consists may have different power levels at different frequencies. Therefore, when a particular power level is stated for a noise, it is usually necessary to specify the frequency at which this power level occurs. In some cases, the percentage differences in power between all the frequencies in a band are small. The noise is then said to be "flat" or "white" over that band, and the power level can be specified for the entire band without considering each of the individual frequencies in the band. Ordinarily, if a very narrow band is used, the noise in the band may be considered flat.

The term spectrum level is defined as the sound pressure expressed in decibels over a reference level of 0.0002 dyne per square centimeter for a frequency band one cycle per second wide. (Actually, the measurement of spectrum level is not made for a band one cycle per second wide, because a filter for such a narrow band is not practical. The measurement is made through a filter for a broader band and a correction is applied. Sound Measuring Set Mk 1 Mod 0 which is used to measure noise levels is calibrated to read directly in spectrum level.)

The hydrophones used in Torpedo Mk 27 Mod 4 do not have a uniform response to all frequencies in a noise. They have a significant response only to frequencies in a narrow band whose center frequency is approximately 24.5 kc. Noise in this bandwidth is a portion of the total noise resulting from propeller cavitation. Since the hydrophone response is only to frequencies in the region of 24.5 kc, spectrum level measurements used in connection with these hydrophones are made for a band one cycle per second wide whose center frequency is 24.5 kc.

Spectrum level is sometimes referred to as "db spectrum" and is usually abbreviated to "dbs".

Addition of Noise Levels. When the addition of two noise levels expressed in decibels is to be performed mathematically, each noise level is first converted from decibels to actual power units. The powers are then added algebraically and the resulting sum is converted to decibels. The same result may be obtained more easily by using the curves shown in figure 16. These curves may be used for adding any two noise levels which do not differ by more than 10 decibels. The curves are used as follows:

1. Subtract the lower of the two noise levels from the higher level. For example, if the noise levels are 19 db and 22 db, $22 - 19 = 3$ db.

2. Find the point on the LOWER LEVEL curve of figure 16 which corresponds to the difference determined in step 1 (3 db).

3. On the SUM curve, note the point directly above the point determined in step 2. The height of this point above the HIGHER LEVEL line indicates the number of decibels by which the sum exceeds the higher level. In the example, the sum is 1.8 db above the higher level.

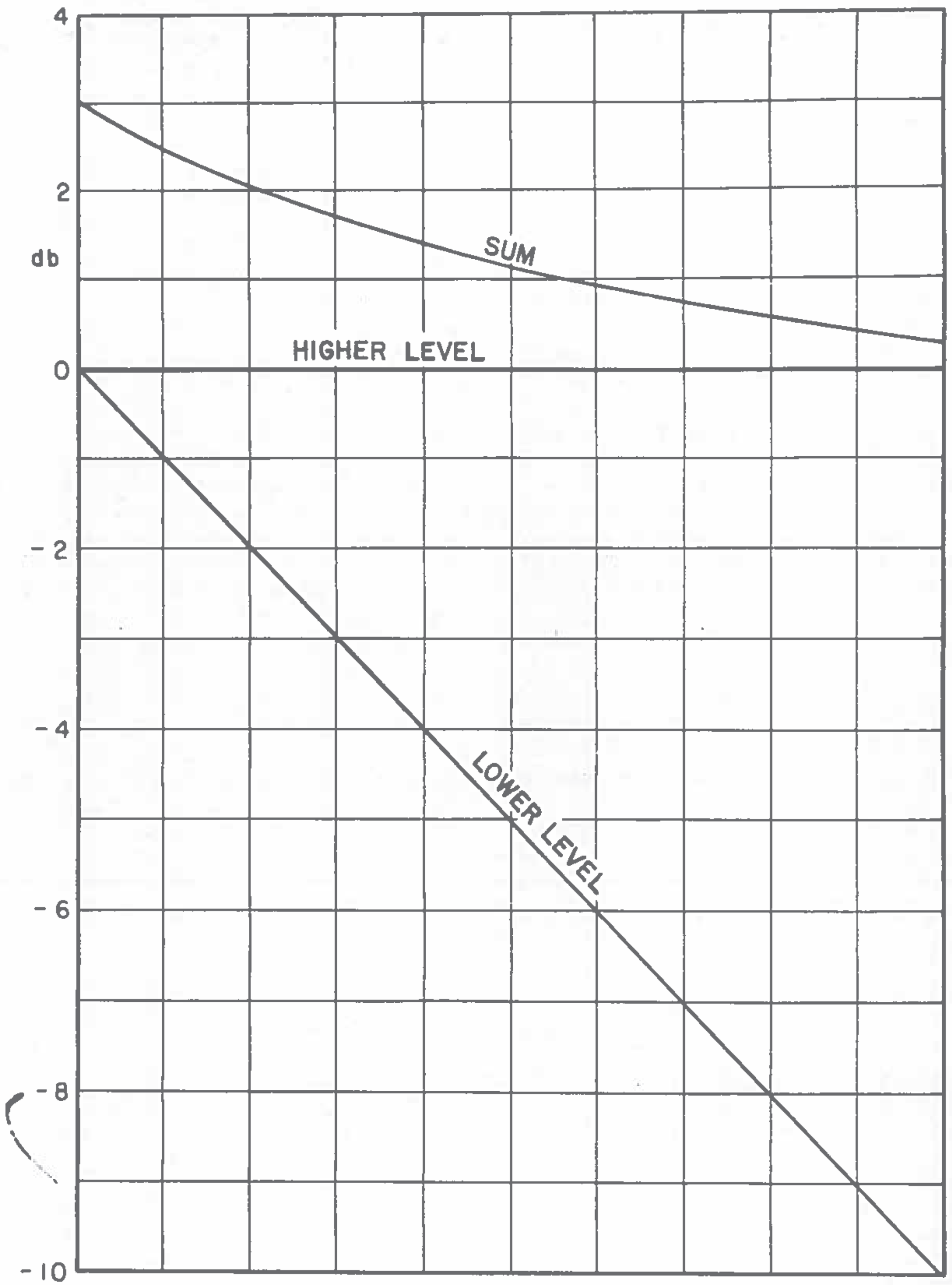


Figure 16—Curves for Adding Two Noise Levels in Decibels.

4. Add the value determined in step 3 to the higher level. The result is the sum of the noise levels expressed in decibels. In the example, 22+1.8=23.8 db.

Underwater Sound Levels

The following paragraphs explain how the level of underwater sound propagated from a sound source varies with distance and describes the properties of sound produced by various sources.

Variation of Sound Level with Distance. The level of a sound decreases as the distance from its source increases. This decrease in level is the result of a number of factors and a knowledge of these factors makes it possible to estimate the sound level at any distance from the source, providing the sound level at one distance is known. In the following paragraphs, the factors affecting the change in sound level with distance are described in the order of their importance.

Inverse Square Law. The intensity of sound received from a source is inversely proportional to the square of the distance between the source and the receiver. This decrease in intensity occurs because the sound spreads as it moves away from the source.

The cause of the decrease in intensity can be visualized by considering the sound source to be located at a point which is the common center for two imaginary spheres; one sphere having twice the radius of the other. If no sound power is absorbed between the spheres, all the power from the source must flow through both spheres. Since the radius of the outer sphere is twice as great as that of the inner sphere, the outer sphere has a surface area four times the area of the inner sphere. Therefore, the power flowing through a unit area of the outer sphere is equal to one-quarter of the power flowing through an equal area of the inner sphere.

A decrease in sound power level to one-quarter of its former value corresponds to a decrease of 6 dbs. That is, whenever the distance from the sound source is doubled, the spreading of the sound causes a decrease of 6 dbs. This variation in sound level due to the inverse square law is shown by curve A in figure 17.

Absorption. As sound waves travel through the water, part of the energy is absorbed due to the viscosity of the water and part is absorbed by foreign particles or bubbles in the water. The total absorption is usually expressed in decibels per thousand yards. In cool waters of uniform temperature, such as the North Atlantic, the absorption is equal to about 3 db per thousand yards at 25 kc, and this absorption rate does not change greatly. Data taken in tropical waters near Pearl Harbor indicate an absorption rate of approximately 5 db per thousand yards at 24 kc, and also indicate that there may be considerable variation from this value.

Refraction. As previously stated, temperature gradients or salinity gradients in the water will cause sound waves to bend. If a curve representing the sound path is drawn through the sound source and tangent to the surface of the water, it can be predicted that very little sound will reach any point between this curve and the water surface beyond the point of tangency. This region is said to be in a shadow. Such shadows may cause sharp changes in level but they rarely occur at less than 1000 yards from the sound source.

Interference. Interference is the cancellation or addition of sound waves which are out of phase or in phase when they arrive at the same point. The interference usually occurs between sound arriving along the direct path from the source and sound reflected from the surface of the water. This interference results in a fluctuation of the sound level as the relative position of the sound source and hydrophone changes, or as the surface of the water moves.

Total Variation With Distance. All of the factors described in the preceding paragraphs combine to produce the total variation of sound level with the distance from the source. Under practical conditions, interference can be expected, because there is always relative motion between the target and hydrophone and there are always surface waves. However, the only effect of interference is a rapid fluctuation about an average value. When considering the relationship between sound level and distance, this fluctuation may be disregarded. Refraction must be considered only in special cases where it results in shadow zones. Shadow zones rarely occur at less than 1000 yards from the target, and therefore refraction usually may be disregarded as a factor affecting the operation of an acoustic torpedo.

The variation of sound level with distance due to the inverse square law (spreading) and to absorption is shown graphically in figure 17. Curve A shows the variation due to spreading alone. Curve B, marked 3 db per thousand yards shows the total variation due to spreading and absorption in northern waters. Curve C, marked 5 db per thousand yards, shows the total variation due to spreading and absorption in tropical waters. Note that the curves show sound level relative to the value at 200 yards from the source. The use of this chart is illustrated by the following example:

If the noise level of a submarine is 38 dbs at 200 yards and the steering threshold of a torpedo is 18 dbs, at what range will the submarine influence the torpedo? The noise level of the submarine decreases with distance but will be above the steering threshold of the torpedo until it has decreased by 20 db (38−18=20 db). In northern waters (curve B in figure 17), the noise level is decreased by 20 db at a range of approximately 1600 yards from the target. In tropical waters (curve C in figure 17), the noise level is decreased by 20 db at a range of approximately 1100 yards. At any range lower than these limits, the submarine noise will influence the torpedo.

Ambient Noise. Ambient, or background, noise may be caused by one of several factors or by any combination of these factors. Manmade disturbances, waves, rain, and marine life activity are all sources of ambient noise. These factors are discussed briefly in the following paragraphs:

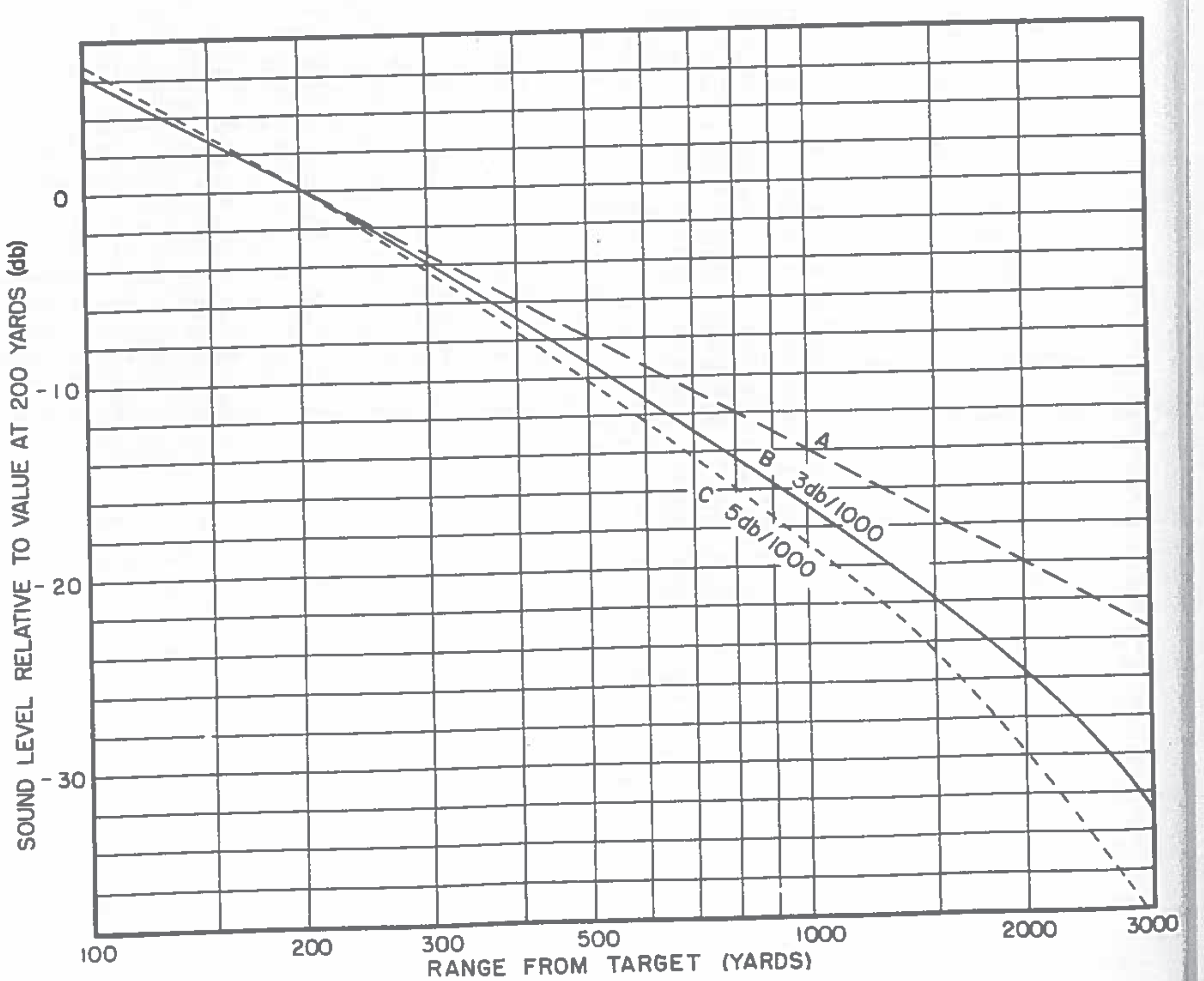


Figure 17—Sound Level Versus Range at 24 kc (Deep Water).

[redacted]

Manmade Noise. Manmade noise consists of sounds such as are caused by minesweeping operations, projectiles striking the water, and other similar disturbances. These noises may interfere seriously with making measurements of underwater sound and with the operation of acoustic torpedoes. Since the sources of manmade noise are usually concentrated in a small area, the noise is directional in character and will cause the torpedo to home on the source if the sound level is high enough.

Waves. Noise due to ordinary water disturbances far from shore originates at the surface when waves break and spray strikes the surface. In a calm sea when no whitecaps are formed, the noise level will be low, while in a rough sea it will be high. On the basis of measurements made at many places, a correlation between ambient noise and sea state has been determined. This correlation is shown by curve A in figure 18. The correlation cannot be exact, since sea state is normally based on wave height. (For comparison purposes, curve B in figure 18 shows the variation of wave height with sea state. This curve is based on values given in standard works on navigation.) Although a better correlation probably could be obtained by relating ambient noise to whitecap spacing and wind velocity, the curve A in figure 18 is useful for estimating the ambient noise under different sea conditions.

Water noise due to whitecaps is nondirectional in the horizontal plane, and therefore will not influence the horizontal steering of an acoustic torpedo. However, as will be explained later, it may decrease the homing range. In the vertical plane, the water noise due to whitecaps initially is directed predominantly downward, since the noise originates at the surface.

In very deep water, most of the sound will be absorbed, either before it reaches the bottom, or before it comes back up after it is reflected from the bottom. If the bottom is soft mud, much of the sound will be absorbed due to reflection loss. Therefore, in deep water, noise due to surface disturbance always is predominantly downward.

In shallow water, little sound is absorbed in the water. If the bottom is hard, smooth rock, the

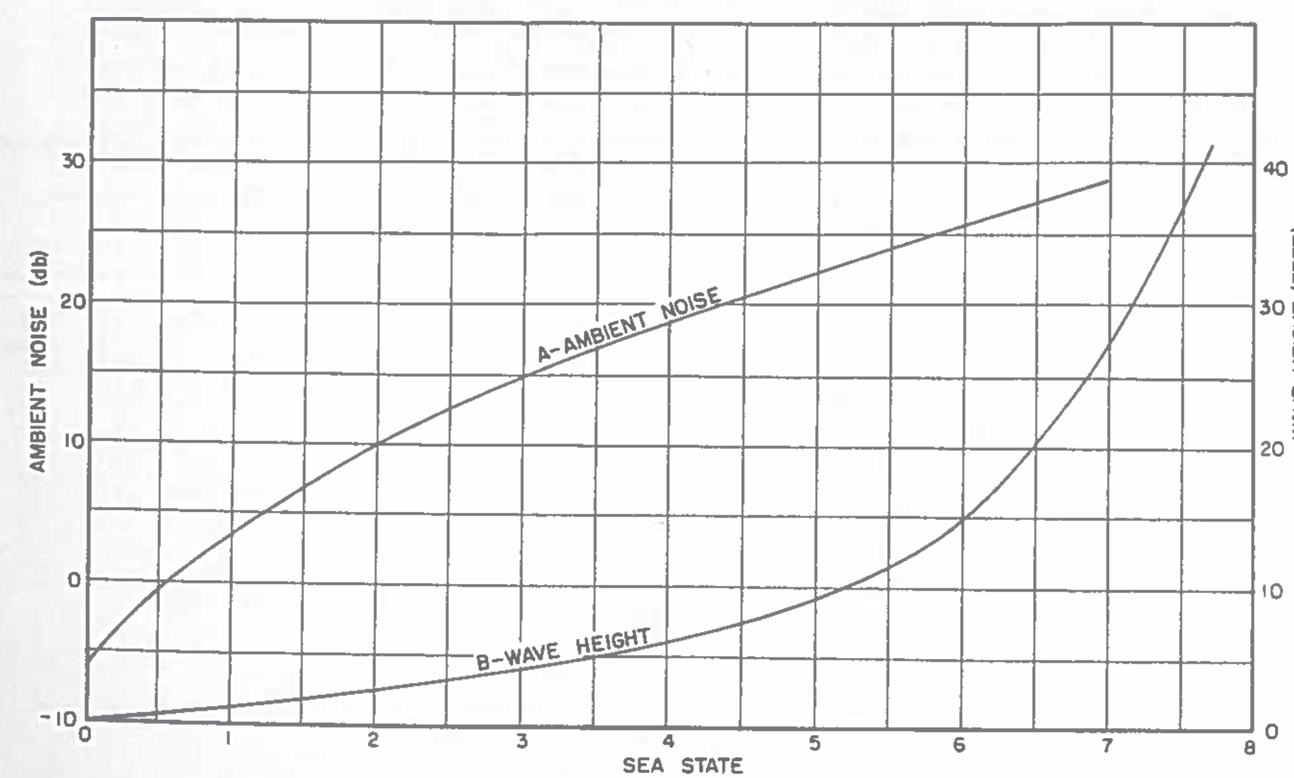


Figure 18—Wave Height and Ambient Noise at 24.5 kc Versus Sea State.

[redacted]

reflection loss is also low and the sound will be reflected upward with little loss in intensity. Since the sound traveling upward is practically equal in intensity to the sound traveling downward, the ambient noise is almost nondirectional in the vertical plane as well as in the horizontal plane.

RAIN. Ambient noise resulting from the impact of raindrops on the surface has characteristics similar to the noise produced by whitecaps. The intensity of the noise caused by rain is directly proportional to the intensity of the rainfall. During extremely heavy tropical storms, the ambient noise may reach extremely high levels for short periods of time.

SNOW. Snow produces a large ambient noise level in the high frequency region. This noise is probably due to the rapid melting of the ice crystals as the snow strikes the water.

MARINE LIFE. Some ambient noise results from the activity of marine life such as porpoises and snapping shrimp. For sounds in the low frequency region, the only important source of noise is the snapping shrimp. These shrimp exist in beds of water having a depth of less than 200 feet and a winter temperature above 52° (F). Measured levels of shrimp noise range from very low values to values as high as 50 dbs at 24 kc. The average value for shallow water is approximately 35 dbs. Since shrimp noise occurs only in certain localities and only in relatively shallow water, it is rarely necessary to consider it as a factor affecting the operation of Torpedo Mk 27 Mod 4, particularly since this torpedo is seldom used in such shallow water.

Submarine Noise. Measurements of noise level at various frequencies have been made for many submarines operating at periscope depth and greater depths. Figure 19 shows the variation of noise output with speed at various depths for a Type XXI U-boat, and U-2513. Figure 20 shows similar curves for two fleet submarines, the U. S. S. *Hake* and the U. S. S. *Hoe*. The curves indicate that the noise output of a submarine operating at low speed and great depth is so low that the homing range of the torpedo will be quite small. For this reason, Torpedo Mk 27 Mod 4 must be enabled as close as possible to the position of the target submarine. Tests have indicated that the noise levels of some submarines operating at low speed may be much lower than shown by the curves in figures 19 and 20. The noise at these low speeds and great depths is almost entirely machinery noise, which may be expected to vary greatly from one submarine to another. The steep slope of the curves in figures 19 and 20 is caused by the inception of cavitation. This effect occurs at progressively higher speeds as the keel depth of the submarine is increased.

Ship Noise. Curve A in figure 21 represents the variation of surfaceship noise level with speed. This curve represents the average level of the noise produced by a variety of ships. Curves B and C represent maximum and minimum measured values. DDs and DDEs produce noise levels very close to the average curve.

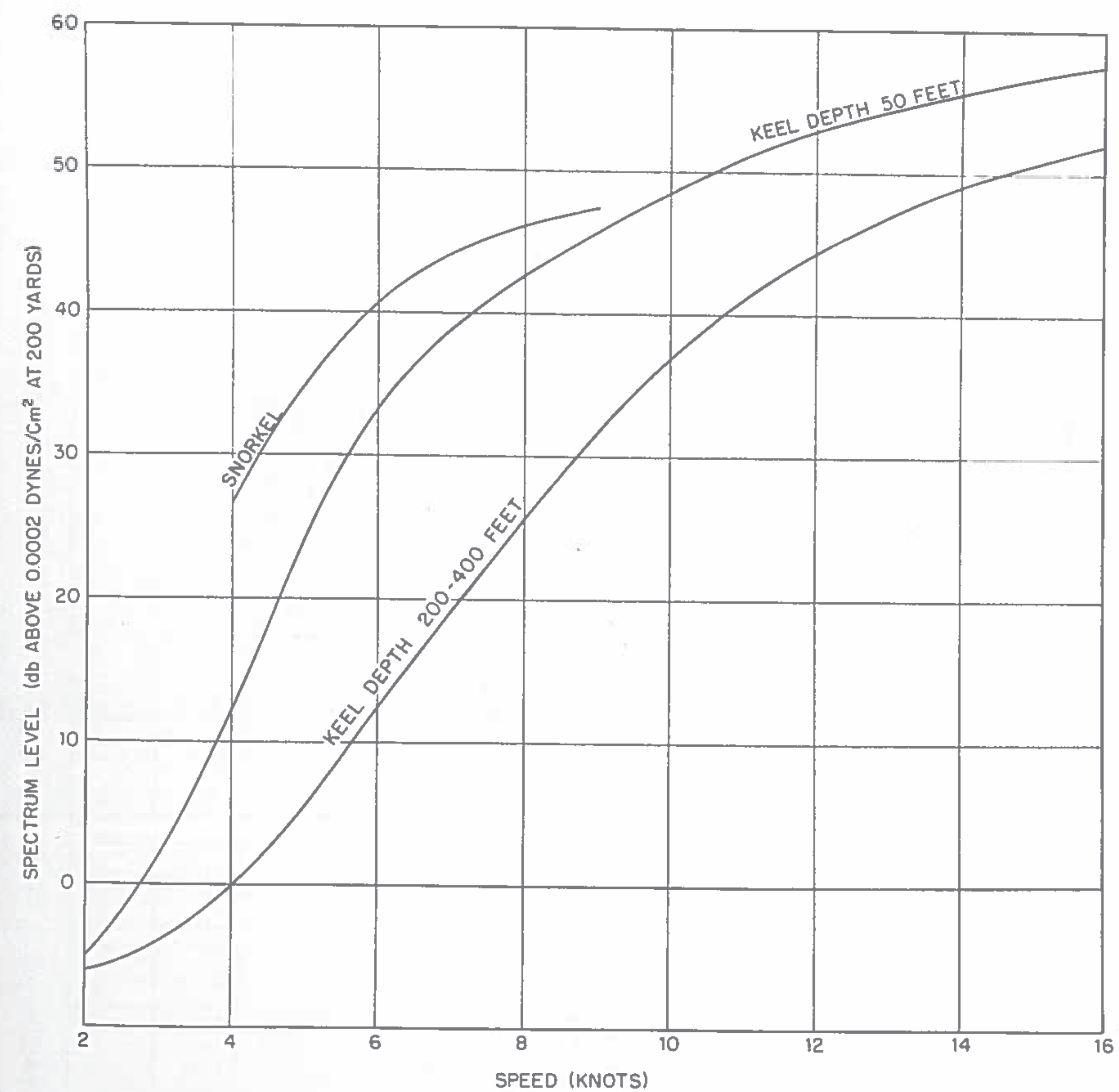


Figure 19—Sound Pressure Level Versus Speed at 24.5 kc for Type XX1 U-Boat (U-2513).

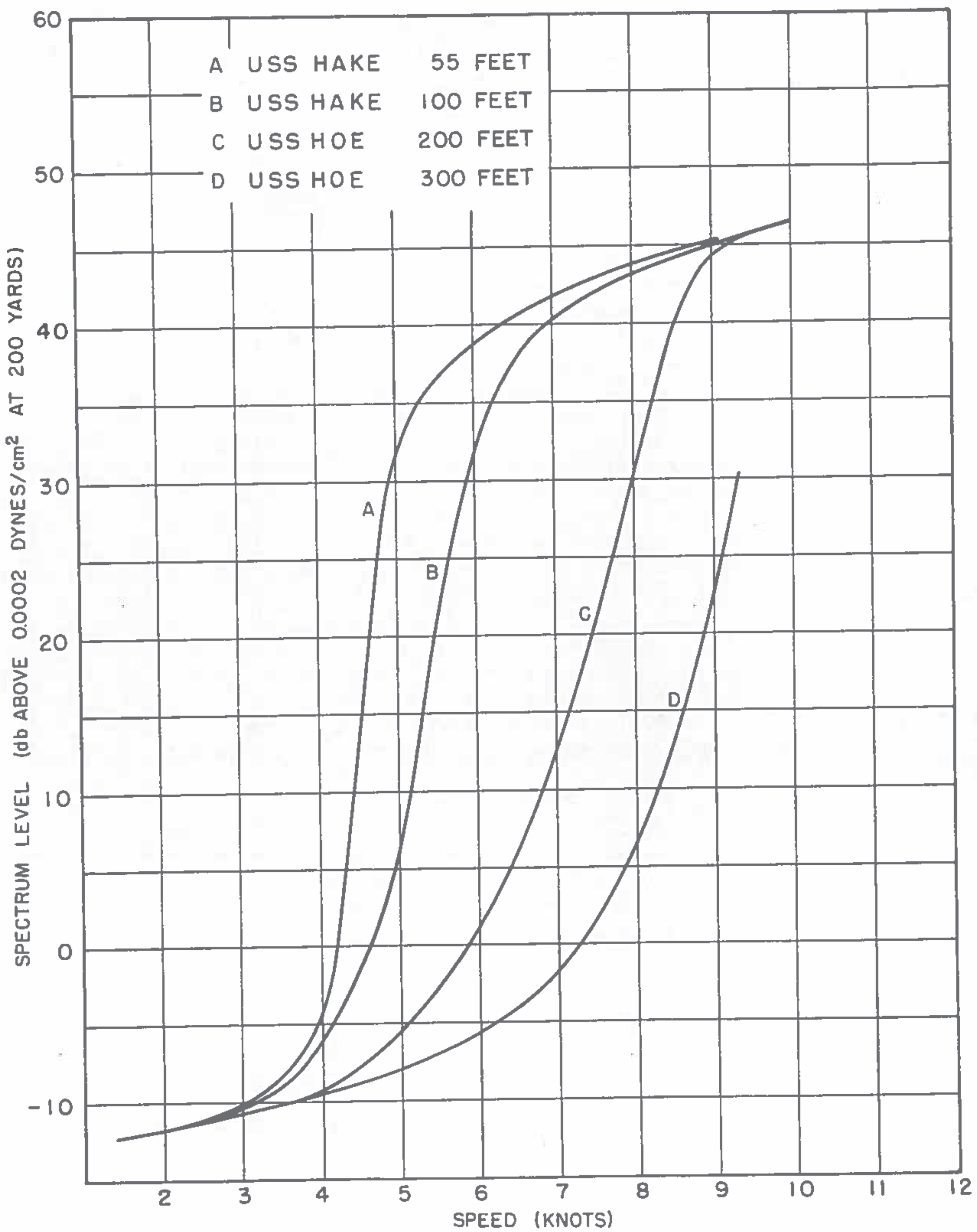


Figure 20—Sound Pressure Level Versus Speed at 24.5 kc (U. S. Fleet-Type Submarines).

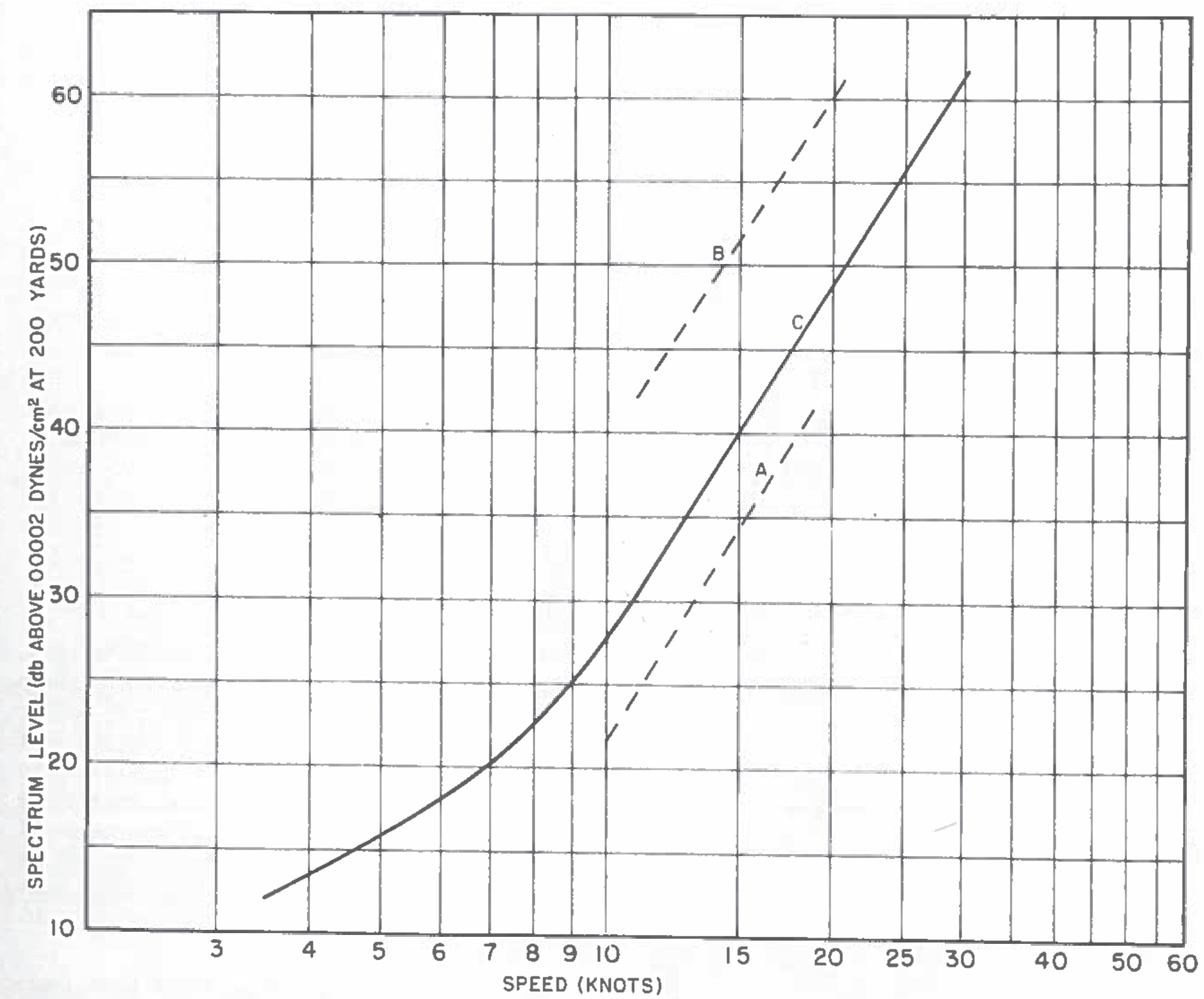


Figure 21—Sound Pressure Level Versus Speed at 24.5 kc (Surface Ship).

Chapter 5

ACOUSTIC CONTROL SYSTEM

Introduction

The acoustic control system of Torpedo Mk 27 Mod 4 consists of four hydrophones and the electronic circuits which convert the output signals of the hydrophones into control signals for the torpedo steering motors.

In this chapter, the four-tube magnetostriction hydrophone is described and its operating principles are explained. These principles are used in explaining the factors affecting the use of the hydrophones in the acoustic steering system. A general description of the steering control system is given to clarify the relationships between the acoustic steering control circuits and the other steering control circuits of the torpedo. A detailed functional description is then given of the horizontal and vertical acoustic steering control circuits.

Four-tube Magnetostriction Hydrophone

The four-tube magnetostriction hydrophone is shown in figure 22. Four of these elements are used in Torpedo Mk 27 Mod 4; two provide input signals for the horizontal acoustic steering control circuit and two provide input signals for the vertical acoustic steering control circuit.

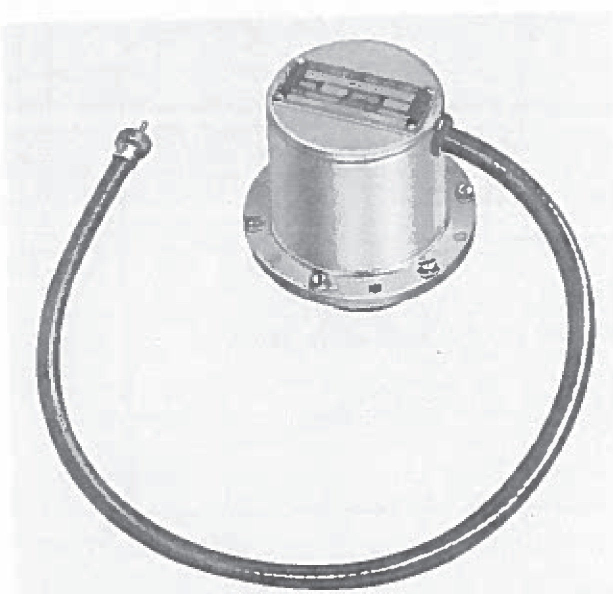


Figure 22—Four-Tube Magnetostriction Hydrophone.

Description. The arrangement of the internal parts of the hydrophone is shown in figure 23. The dural diaphragm is acoustically coupled to the torpedo shell by means of a rubber pad. Clamped to the diaphragm are four magnetostrictive annealed nickel tubes. The dimensions of the tubes, the tube spacing, and the size of diaphragm are chosen so that the hydrophone has a mechanical resonance frequency of 24.5 kc and has the desired directional pattern. The nickel tubes are split in order to reduce eddy current losses. Around each tube is a coil, firmly held by Bakelite end caps. Inside each tube is a permanent Alnico magnet, cemented in a magnet holder. The magnets give a permanent magnetic polarization to the tubes and coil assemblies.

Operation. When sound strikes the torpedo, the torpedo shell is caused to vibrate. These vibrations are transmitted through the rubber pad of the hydrophone to the diaphragm and to the tubes, causing the tubes to vibrate in the longitudinal direction. Since the tubes are mechanically resonant at a frequency of 24.5 kc, they vibrate with greater amplitude when subjected to 24.5 kc sound than when subjected to sound of equal intensity but of different frequency.

The vibration of the tubes causes their magnetic permeability to vary at the frequency of the vibration. This variation in the permeability causes a corresponding variation in the magnetic field of the permanent magnets. Since the magnetic field links with the turns of the hydrophone coils, the changing magnetic flux induces an AC voltage in the coils. The coils are all connected in series with the hydrophone cable. The capacitance in the hydrophone, cable, and control panel input circuit electrically

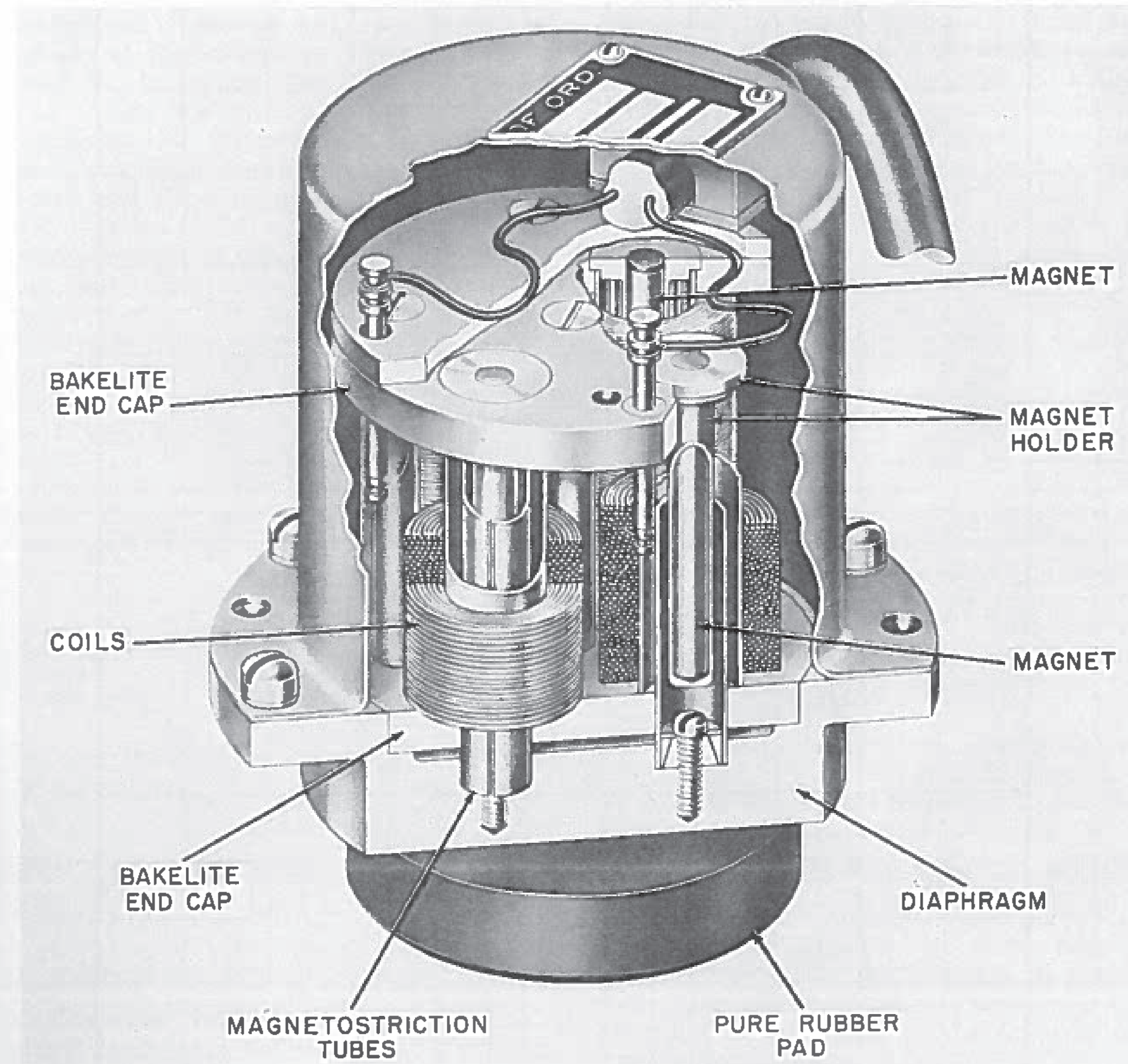


Figure 23—Cutaway View of Hydrophone.

tunes the hydrophone and the input circuit to resonate at a frequency of 24.5 kc.

Frequency Response. The curve in figure 24 shows a typical frequency-response for a four-tube magnetostriction hydrophone. The output voltage shown for the hydrophone is that developed across a load circuit (similar to the input circuit of the torpedo control panel) consisting of a loading coil, a 0.82-megohm resistor, and the grid of a 6SH7 vacuum tube. The height of the curve at each frequency represents the voltage that the hydrophone develops across the grid of the input stage of the control panel when the hydrophone is subjected to pure tone of that frequency. The sound pressure is the same for all the frequencies. The frequency response curve represents the characteristics of the hydrophone when subjected to sound originating on the axis of the hydrophone, in the direction of the maximum hydrophone sensitivity.

The voltage output of the hydrophone subjected to a "flat" field (sound pressure same for

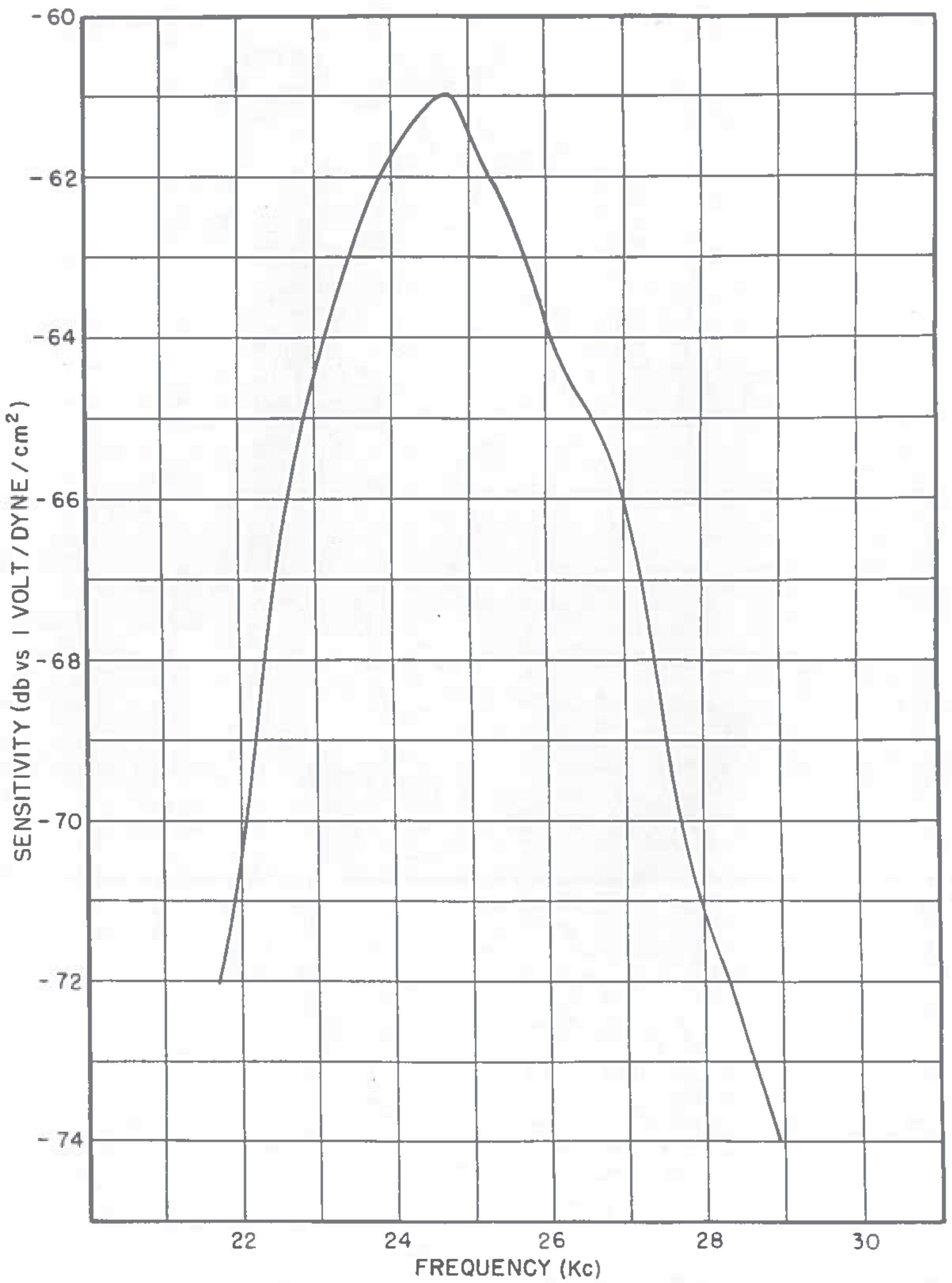


Figure 24—Frequency Response of Four-Tube Magnetostriction Hydrophone.

all frequencies) depends on the bandwidth of hydrophone response as well as on the peak sensitivity of the hydrophone. Two methods are used for determining the voltage output. In one method the peak pure-tone sensitivity is combined with the bandwidth, determined by integrating the area under the frequency response curve, and the reference level is changed from 1 dyne/cm² to .0002 dyne/cm². The second method merely consists of measuring the voltage across the panel input circuits while the hydrophone is subjected to a flat field of known level. The noise sensitivity obtained represents the voltage developed by the hydrophone on the grid of the input circuit when the hydrophone is subjected to a sound field of .0002 dyne/cm²/cycle in the direction of the maximum hydrophone sensitivity.

Each hydrophone is stamped with a letter designating its noise sensitivity. Table 2 gives the noise sensitivities designated by the letters.

Table 2—Hydrophone Sensitivity Characteristic Markings

Characteristic Letter	Spectral Sensitivity
D	−99
E	−100
F	−101
G	−102
H	−103
I	−104
J	−105

Directional Patterns. The polar graphs in figure 25 show how hydrophone sensitivity varies with direction. These graphs are called hydrophone patterns. The patterns shown in figure 25 apply to either a horizontal pair of hydrophones or to a vertical pair. If the patterns are for the horizontal pair, the solid curve is the pattern for the port hydrophone, and the dotted curve is the pattern for the starboard hydrophone.

Acoustic Steering and Self-Noise

In the following paragraphs, the manner in which hydrophones are used to obtain steering signals is explained and the influence on steering of torpedo self-noise is described.

Acoustic Differential. Examination of figure 25 shows that the two hydrophones in a pair have equal output signals only if the sound originates directly ahead or directly astern of the torpedo. For all other directions, either one hydrophone or the other develops a stronger signal. The difference in the signals for a particular direction is called the "acoustic differential" for that direction. The acoustic differential is equal to the difference in the output voltages expressed in decibels for the particular direction under consideration.

Self-Noise. The self-noise of a torpedo is noise reaching the hydrophones through either the water or torpedo shell from sources within the torpedo itself. Self-noise may result from motor vibration, cavitation produced by the torpedo propeller, and other causes.

Although propeller cavitation is considered as a possible source, it is probably not an important factor in the creation of self-noise in Torpedo Mk 27 Mod 4. The relatively great depth at which the torpedo searches in combination with the low propeller tip speed tend to prevent cavitation. During attacks, when the torpedo may run at very shallow depths, it is possible that cavitation may be produced. Cavitation noise reaches the hydrophones primarily through the water, but some of the noise may be picked up by the shell and then transmitted along the shell to the hydrophones.

The major factor contributing to the self-noise of Torpedo Mk 27 Mod 4 is the machinery within the torpedo. Although the main motor is mounted on rubber supports and the supports themselves are further isolated acoustically from the shell by means of canvas, there is some mechanical vibration which reaches the shell and is transmitted through the shell to the hydrophones. The steering motors are another source of noise. The steering motor mounts are acoustically isolated with canvas, and the connecting rod, steering yokes, and rudders are also provided with some acoustic isolation. However, some noise still is transmitted from this source through the shell to the hydrophones.

The horizontal self-noise of Torpedo Mk 27 Mod 4 is approximately 18 to 25 dbs at 70-foot depth (above limit operation) and 15 to 17 dbs for 125-foot depth (below limit and no limit operation).

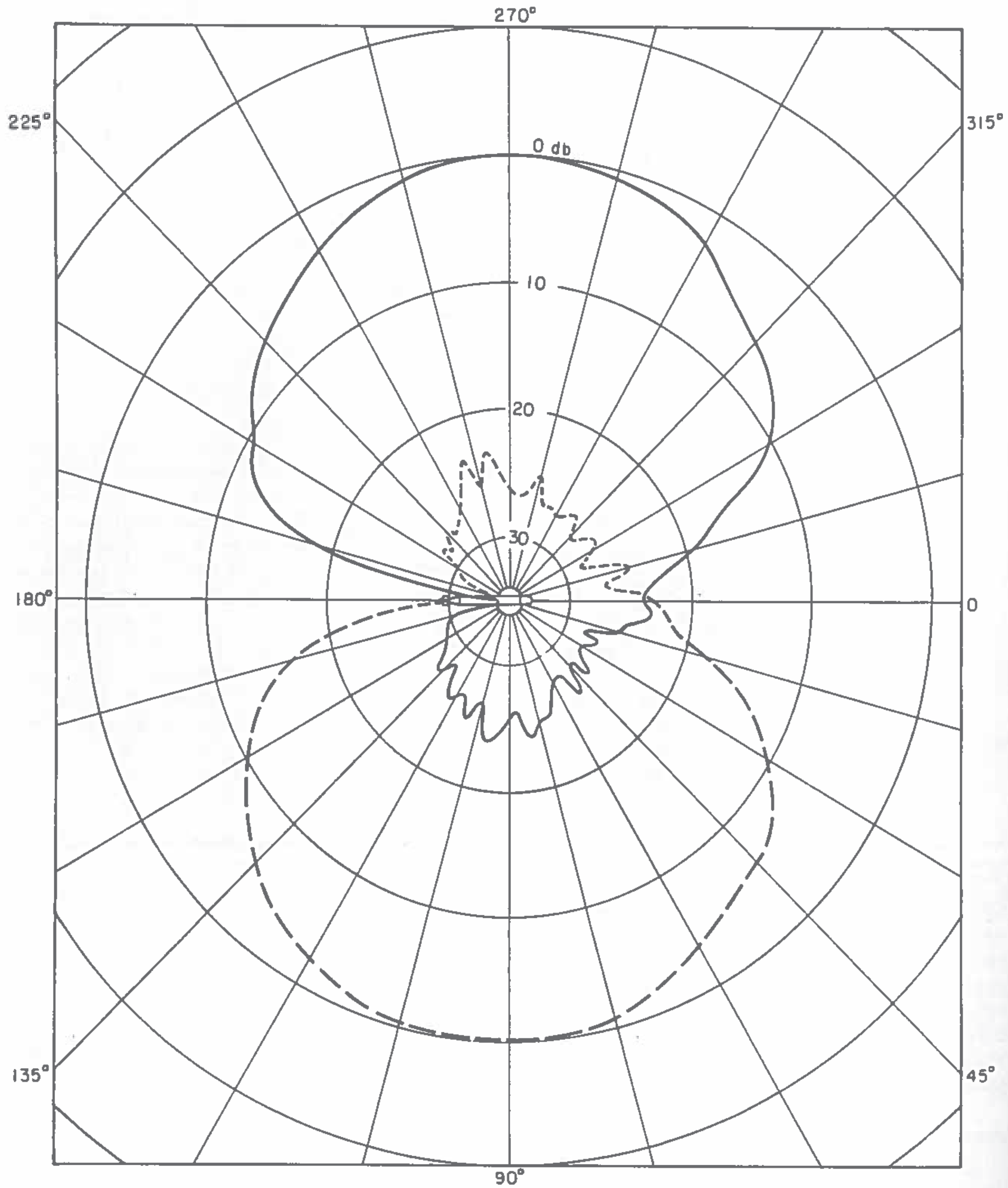


Figure 25—Hydrophone Pattern.

Figure 18 shows the ambient noise levels corresponding to various sea states. The noise levels shown by the curve were measured with a nondirectional hydrophone. The hydrophones of Torpedo Mk 27 Mod 4 are directional, and the directivity patterns are such that the apparent levels picked up by the hydrophones will be approximately 11 db lower than the values indicated by the curve. Since the self-noise of the torpedo is considerably higher than any uusal ambient water noise picked up by the hydrophones, self-noise is the controlling factor.

The self-noise of the torpedo has the effect of masking the hydrophone output for all angles of incident target sound. If the target sound level is 30 db or more above the self-noise level of the torpedo, the hydrophone output is not affected appreciably by self-noise and the sensitivity pattern remains essentially as shown in figure 25. At long ranges, the torpedo self-noise has a greater influence. When the self-noise level is equal to the target sound level, the pattern shown in figure 26 is obtained. At the maximum of either hydrophone directional pattern, which occurs when that hydrophone is pointing directly at the sound source, the two signals add to give a resultant 3 db above self-noise. Thus an acoustic differential of 3 db is created. At other angles, the acoustic differential decreases gradually until it reaches zero at the forward and aft crossover points. In figure 26, the acoustic differential is the difference between the self-noise level and the curve representing the sum of self-noise level and target sound level. As the target sound level increases (as in figures 27 and 28), the shape of the curve representing the sum of self-noise level and target sound level becomes more and more similar to the hydrophone pattern shown in figure 26. The curves become identical to the hydrophone pattern when the target sound level is so high as to make the effect of self-noise insignificant. The influence of self-noise on the shape of the steering pattern indicates that the controlling factor limiting the acoustic range of the torpedo is the self-noise level.

Acoustic Steering Threshold. The acoustic steering threshold is defined as that noise level which will just cause the torpedo to leave its search circle and home on the source of noise. Measurements indicate that the acoustic steering threshold of Torpedo Mk 27 Mod 4 in above limit condition (70-foot running depth) is 16 to 22 dbs, and that in either below or no limit condition (125-foot running depth) the threshold is 16 to 20 dbs.

Surface Reflected Self-Noise. When the torpedo is operating in above limit condition, it searches at a running depth of approximately 70 feet. Under certain sea conditions, the self-noise of the torpedo can be reflected back from the surface into the "up" hydrophone, and may cause the torpedo to be attracted upward. It is for this reason that a ceiling switch control has been included in the torpedo. If the torpedo is attracted above a depth of 30 feet, the ceiling switch operates to introduce a 10 db attenuation into the up channel.

Homing Range. The homing range of Torpedo Mk 27 Mod 4 depends on the sound level of the target. This sound level varies considerably with target speed, and (in the case of submarines) with target depth.

Homing Range Against Submarines. The homing range of Torpedo Mk 27 Mod 4 against submarines may vary from over 2000 yards to very small ranges, depending on the speed and operating depth of the target. As examples of the variation which can be expected, figure 29 shows the theoretical homing range against a fleet-type submarine and figure 30 shows the theoretical homing range against a Type XXI U-boat. These curves which apply for tropical water conditions, were obtained by combining the data shown by curve C of figure 17 with data shown in figures 19 and 20, assuming that the acoustic threshold of the torpedo is 18 dbs for the below limit condition and 20 dbs for the above limit conditions.

Homing Range Against Surface Craft. Figure 31 shows the variation of homing range with target speed for surface targets. This curve, which represents an average estimate for tropical water conditions, was obtained by combining the data shown by curve C of figure 17 with the data shown by curve A of figure 21, assuming that the acoustic threshold of the torpedo is 20 dbs for the above limit conditions.

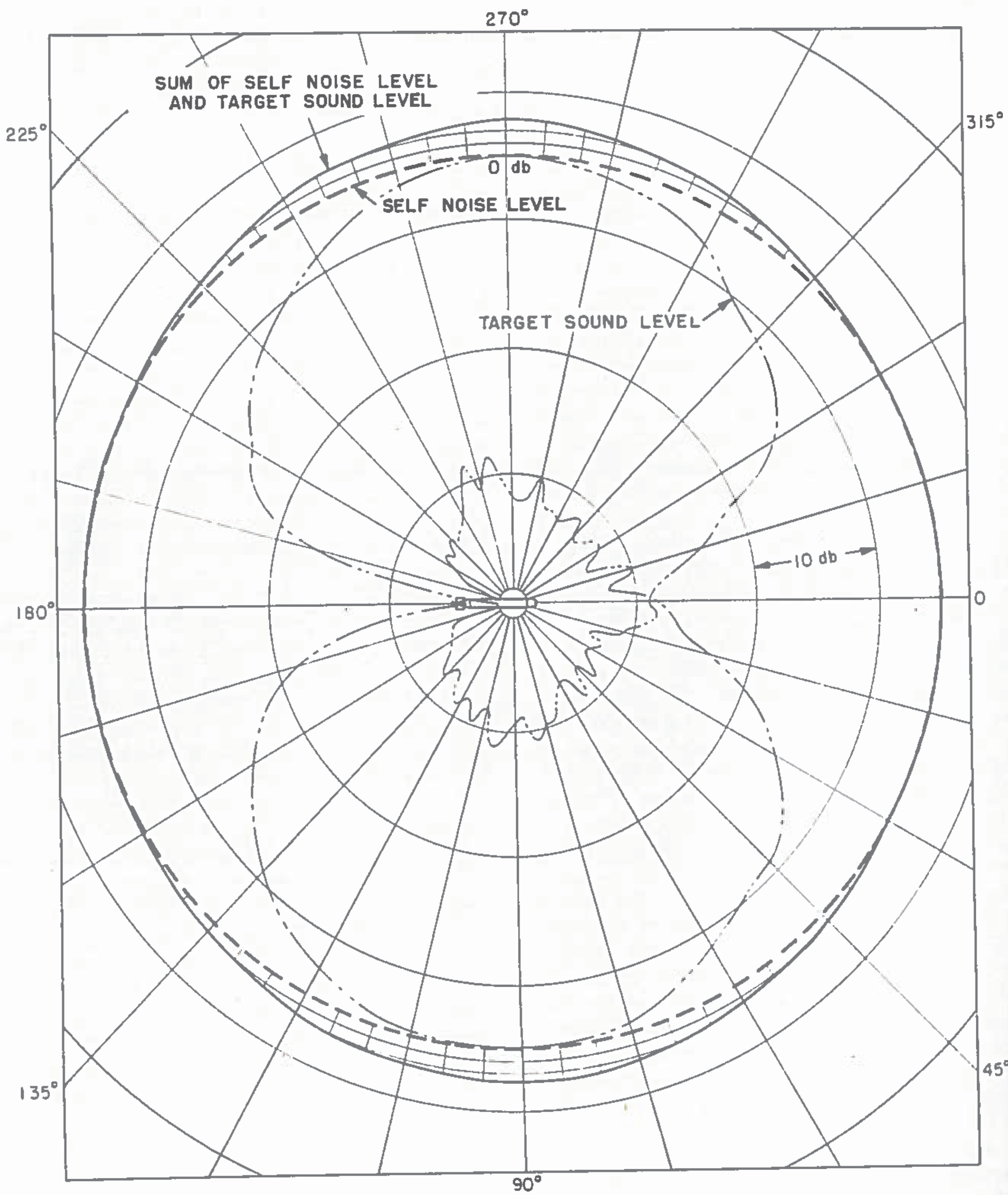


Figure 26—Steering Pattern (Target Sound Level Equal to Self-Noise Level).

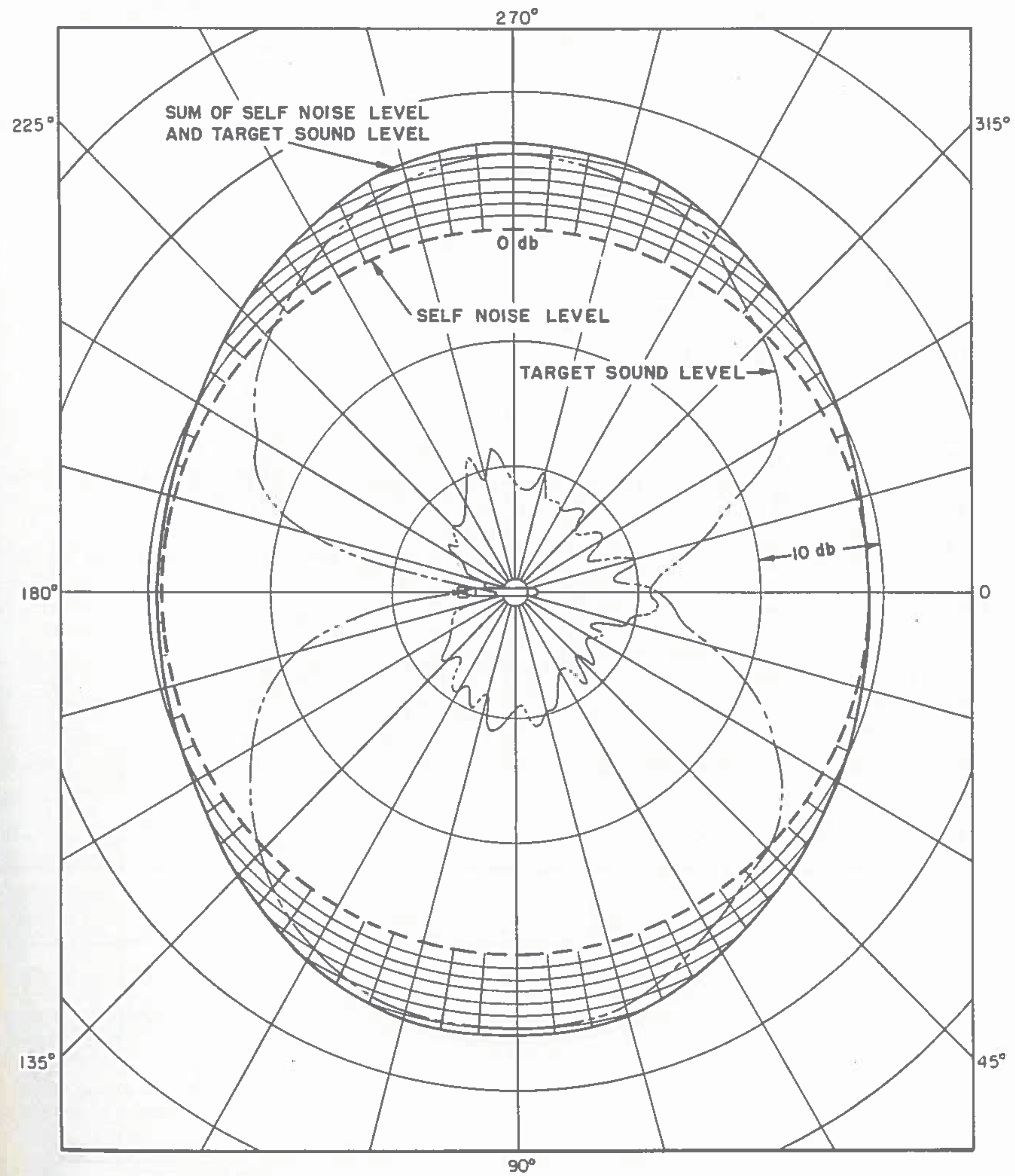


Figure 27—Steering Pattern (Target Sound Level 6 db above Self-Noise Level).

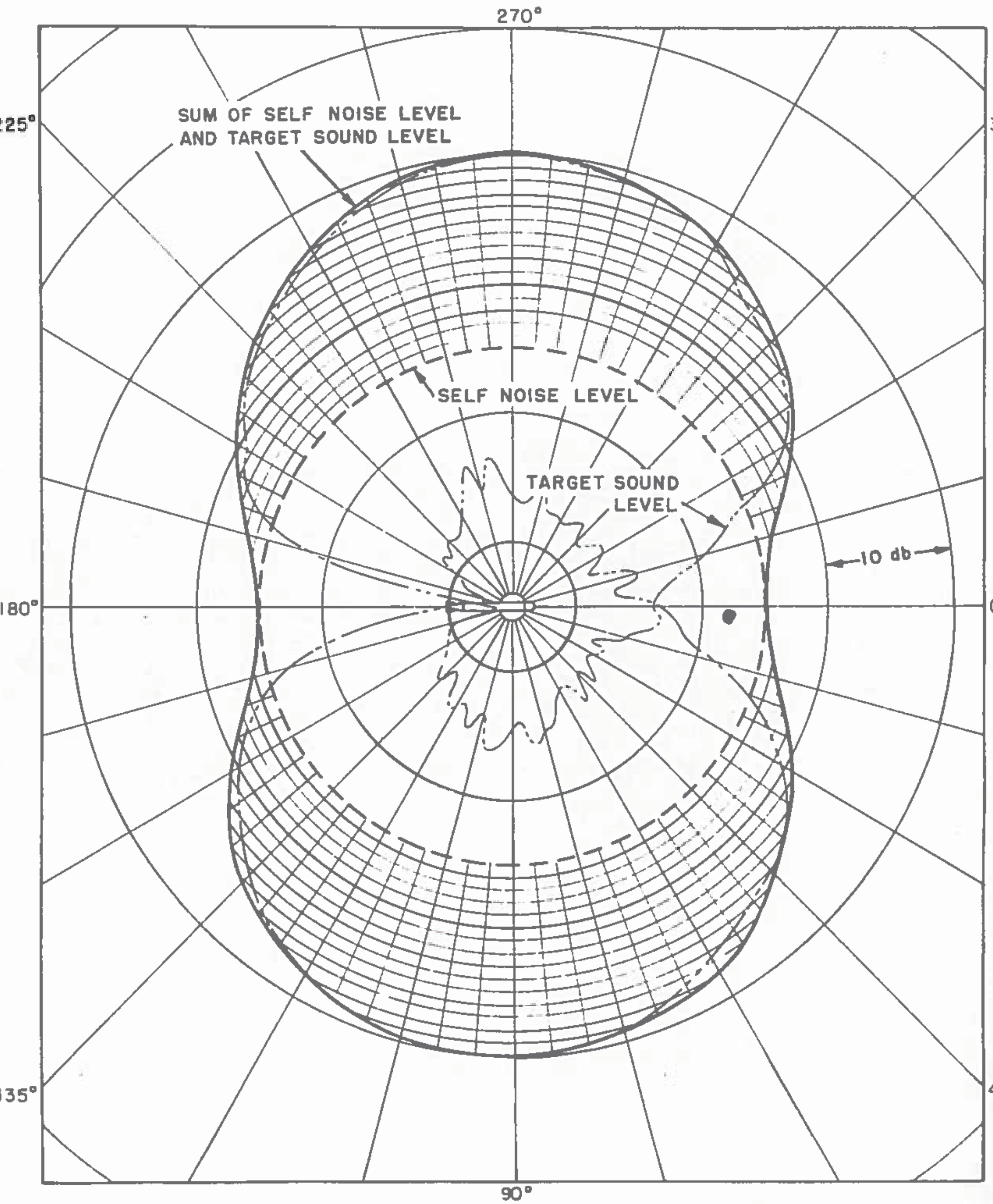


Figure 28—Steering Pattern (Target Sound Level 15 db above Self-Noise Level).

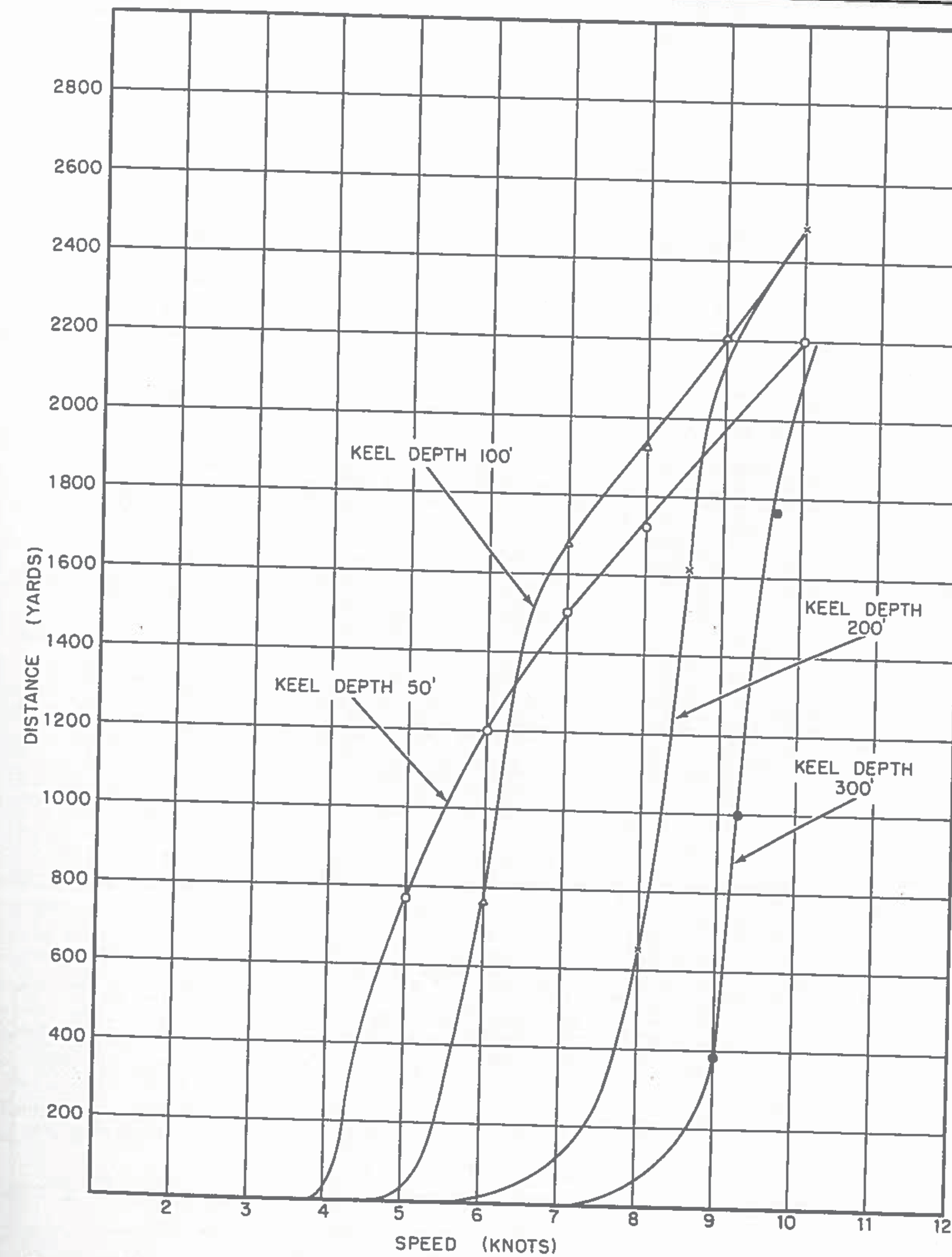


Figure 29—Theoretical Homing Range of Torpedo Mk 27 Mod 4 against a Fleet-Type Submarine.

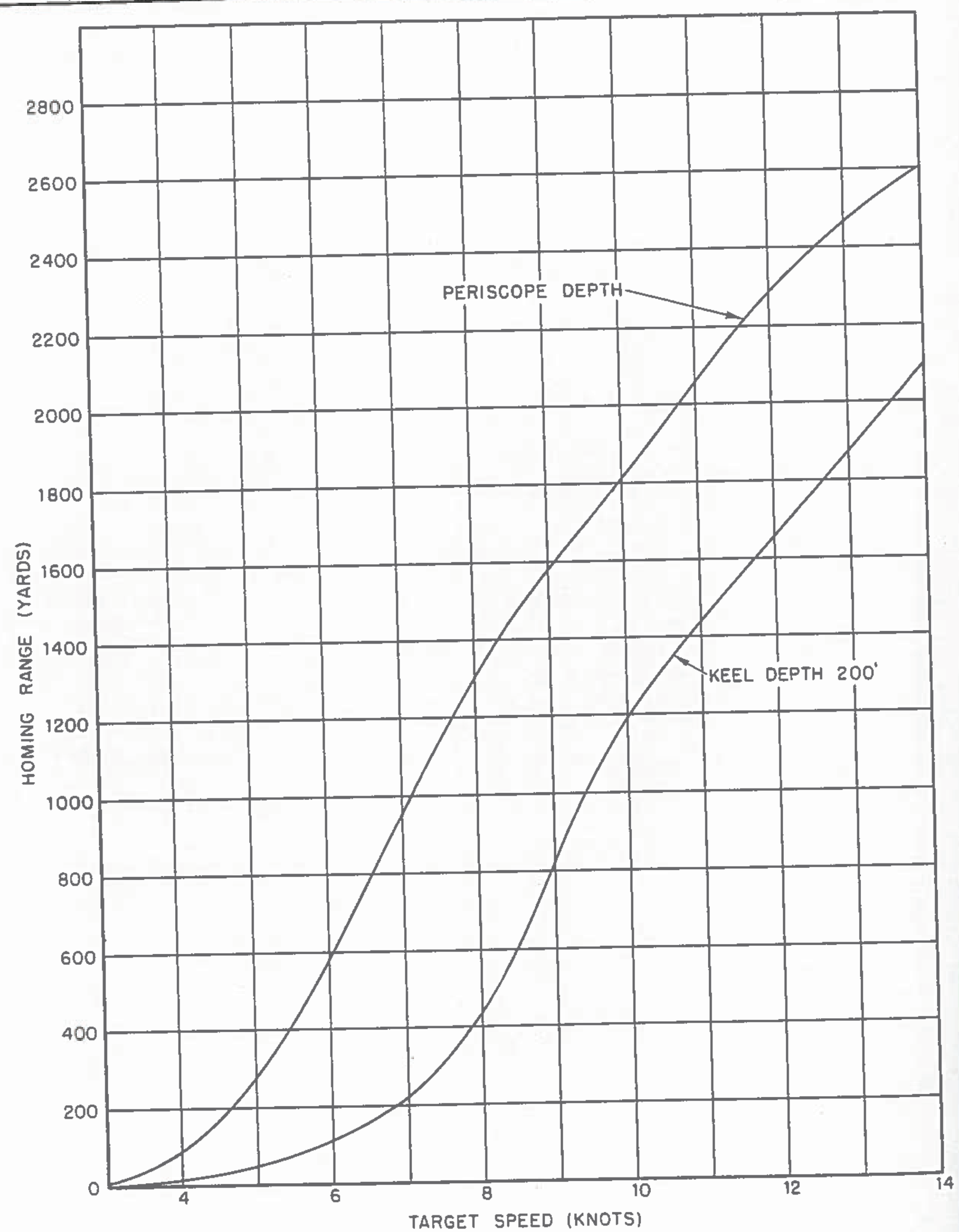


Figure 30—Theoretical Homing Range of Torpedo Mk 27 Mod 4 against a Type XX1 U-Boat.

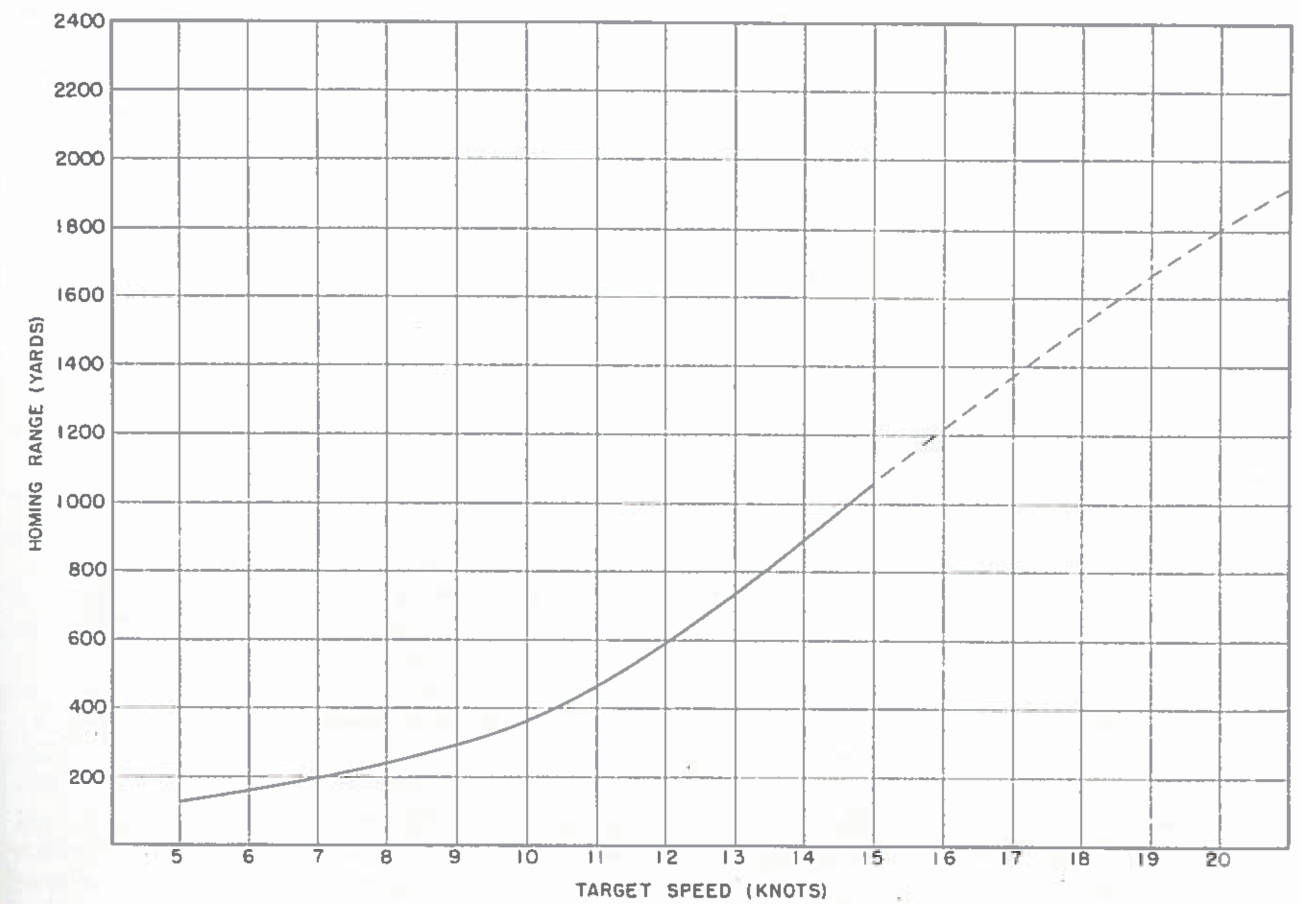


Figure 31—Theoretical Homing Range of Torpedo Mk 27 Mod 4 against Surface Craft.

Acoustic Steering Control Circuits

The acoustic steering control circuits of Torpedo Mk 27 Mod 4 consist of the electronic circuits which receive the hydrophone signals and convert these signals into control signals for the torpedo steering motors. In the following paragraphs, a general description of steering control is given to clarify the relationships between the acoustic steering circuits and the nonacoustic steering devices of the torpedo. This general description is followed by a detailed explanation of the acoustic steering control circuits.

General Description of Steering Control. Torpedo Mk 27 Mod 4 incorporates several different methods of steering control and is equipped with a number of devices which are related to steering control.

Steering of the torpedo is accomplished by two steering systems; one controlling the direction of movement in the horizontal plane, and the other controlling the direction of movement in the vertical plane. The manner in which each of these systems steers the torpedo changes during the torpedo run and the method of control in use at a given time depends on which phase of its run the torpedo has entered.

Immediately after the torpedo is fired, it enters a phase designated as the enabling or gyro run.

In this phase of operation, the acoustic controls are inactive. Horizontal steering is under control of the gyro, which maintains the torpedo on a preset course. Vertical steering is accomplished by the combined action of the hydrostatic depth control and the pendulum control, which maintain the torpedo at a constant depth (70 feet for above limit operation, or 125 feet for below limit or no limit operation). The distance traveled by the torpedo during the enabling run may be any distance between 600 and 3100 yards as determined by an electrical setting made prior to firing. The torpedo is provided with the following three devices related to the control of steering during the initial phase of the torpedo run:

a. The climb and dive angle limit switches prevent the torpedo from climbing or diving too steeply while it is seeking its running depth.

b. The ACR (anticircling run) device protects the firing vessel by completely deenergizing the torpedo if, during the enabling run, the torpedo turns through an angle greater than 135 degrees either side of the tube firing line.

c. The 17-degree cam on the horizontal steering motor deenergizes the main motor if the rudder angle exceeds 17 degrees. A rudder angle greater than 17 degrees is an abnormal condition which might result in a circling run.

At the end of the enabling run the torpedo enables and enters the "search" phase of its run. When the torpedo enables, the gyro control circuit is made inoperative, the gyro motor is deenergized, the ACR device is made inoperative, and the acoustic controls are activated. In the absence of a directional noise of a level high enough to influence the acoustic controls, the torpedo begins to travel in a port circle approximately 100 yards in diameter. The hydrostatic depth and pendulum controls remain active to keep the torpedo at the same depth as in the enabling run. Since the ACR device is inoperative there is no limit to the angle through which the torpedo can turn.

The search phase ends when the hydrophones receive a directional noise of a level high enough to influence the acoustic controls. When this happens, the torpedo enters the attack phase of its run. If the level of the target noise is low, the horizontal acoustic steering control is the first to be influenced, and the torpedo starts to home on the target in bearing but remains at its running depth under hydrostatic depth and pendulum control. As the torpedo approaches the target, the noise level increases. If the noise reaches a high enough level it will influence the vertical acoustic steering. The behavior of the torpedo at this point depends on what the stratum setting is and on the depth of the target. The various possibilities are as follows:

a. If the torpedo is set for the below limit condition, it homes in bearing and bucks depth and pendulum control in elevation until the target noise level is high enough to operate the "gate" circuit in the vertical acoustic channel. (Gating can only occur if the torpedo is below a depth of 85 feet.) The gate circuit deactivates the hydrostatic depth and pendulum controls and the torpedo attacks entirely under acoustic control.

> NOTE: A delay circuit is provided so that gating can not occur until 15 seconds after enabling. This gives the vertical acoustic circuit sufficient time to stabilize after acoustic control is activated and thus prevents excursions in depth immediately upon enabling.

If the target attacked is at a depth of less than 65 feet, the torpedo may start the attack, but when it reaches a depth of 65 feet, the stratum control circuit interrupts the attack by acoustically deafening both control channels. This causes the torpedo to seek its running depth of 125 feet. As the torpedo passes down through the 65-foot depth level, the stratum control circuit activates the acoustic controls, thus returning the torpedo to the search condition. If the torpedo is still in the sound field of the same target, it will repeat the attack and will continue to do so unsuccessfully until the propulsion battery is exhausted. However, if the torpedo leaves the sound field of the target after an unsuccessful attack, it will return to the 125-foot depth and search for a new target.

b. If the torpedo is set for the no limit condition, it homes in bearing until the target noise level is high enough to operate the "gate" circuit in the vertical acoustic channel. As in the below limit condition, this circuit deactivates the hydrostatic depth and pendulum controls and the torpedo attacks entirely under acoustic control. If the target attacked is at a depth of less than 85 feet, the stratum control circuit operates the gate circuit to reactivate the hydrostatic depth and pendulum controls when the torpedo reaches an 85-foot depth. Above this depth, the vertical acoustic control remains active but is required to buck the depth and pendulum controls. If the target is at or near the surface, the ceiling switch operates when the torpedo reaches a depth of 30 feet and introduces a 10 db attenuation into the up hydrophone channel. The bucking action of the hydrostatic depth and pendulum controls and the attenuation introduced by the ceiling switch have been incorporated to prevent the torpedo from tending to broach if it should attack the "image" of the target noise which is reflected from the surface.

c. If the torpedo is set for the above limit condition, it remains at its running depth of 70 feet and homes only in bearing until the target noise level is high enough to trigger the vertical acoustic channel, indicating close proximity to the target. In this stratum condition, gating can not occur and the hydrostatic depth and pendulum controls remain active throughout the attack. The vertical acoustic control bucks the hydrostatic depth and pendulum control and causes the torpedo to leave its running depth and home on the target. The ceiling switch also is active in the above limit condition. This switch and the bucking action of the hydrostatic depth and pendulum controls act to prevent the torpedo from broaching as explained in paragraph *b.* They also prevent the torpedo from tending to home on the "image" of its own self-noise reflected from the surface while the torpedo is searching in the above limit condition.

If the target attacked is at a depth of more than 85 feet, the torpedo starts the attack, but when it reaches a depth of 85 feet, the stratum control circuit interrupts the attack by acoustically deafening both control channels. The action of the hydrostatic depth and pendulum controls causes the torpedo to seek its running depth of 70 feet. As the torpedo passes up through the 85-foot depth level, the stratum control circuit activates the acoustic controls, thus returning the torpedo to the search condition. If the torpedo is still in the sound field of the same target, it will repeat the attack and will continue to do so unsuccessfully until the propulsion battery is exhausted. However, if the torpedo leaves the sound field of the target after an unsuccessful attack, it will return to the 70-foot depth and search for a new target.

If during an attack in any stratum condition described in paragraphs *a*, *b*, and *c*, the noise toward which the torpedo is homing diminishes below the level required to influence the acoustic control circuits, the torpedo returns to the search condition until it again receives a sufficiently strong noise signal.

HORIZONTAL STEERING CONTROL CIRCUITS. The functional relationships between the major circuit units of the horizontal steering control system are shown in figure 32. (The lines in this figure represent the general flow of signals in a highly simplified manner and are not to be construed as representing actual circuit connections.)

While the torpedo is on its enabling run, the gyro is in control of the horizontal steering system. During this run, the enabler mechanism causes circuits to be completed for applying an acoustic disabling voltage to the input switching circuit, thus causing the acoustic control to be inoperative. If the torpedo is to the left or right of the course called for by the gyro setting, the gyro closes contacts which cause the bridge circuit to become unbalanced. The signal resulting from the unbalance is applied to the horizontal steering relay through the DC amplifier circuit. The bridge circuit is adjusted so that the unbalance created by the closing of the gyro contacts will cause a port rudder angle of approximately 8 degrees when the torpedo is heading to the right of the desired course, and will cause a starboard rudder angle of approximately 8 degrees when the torpedo is heading to the left of the desired course.

At the end of the enabling run, the enabler causes the gyro to be disconnected from the horizontal bridge circuit and removes the acoustic disabling voltage from the input switching circuit. This places the horizontal steering control system under acoustic control. The hydrophone picks up energy from the target noise field in a frequency band centered at approximately 24.5 kc. The hydrophones are alternately connected to the input of the same amplifier channel by means of an electronic switch in the input switching circuit. The same amplifier is used for both hydrophones to insure equal amplification

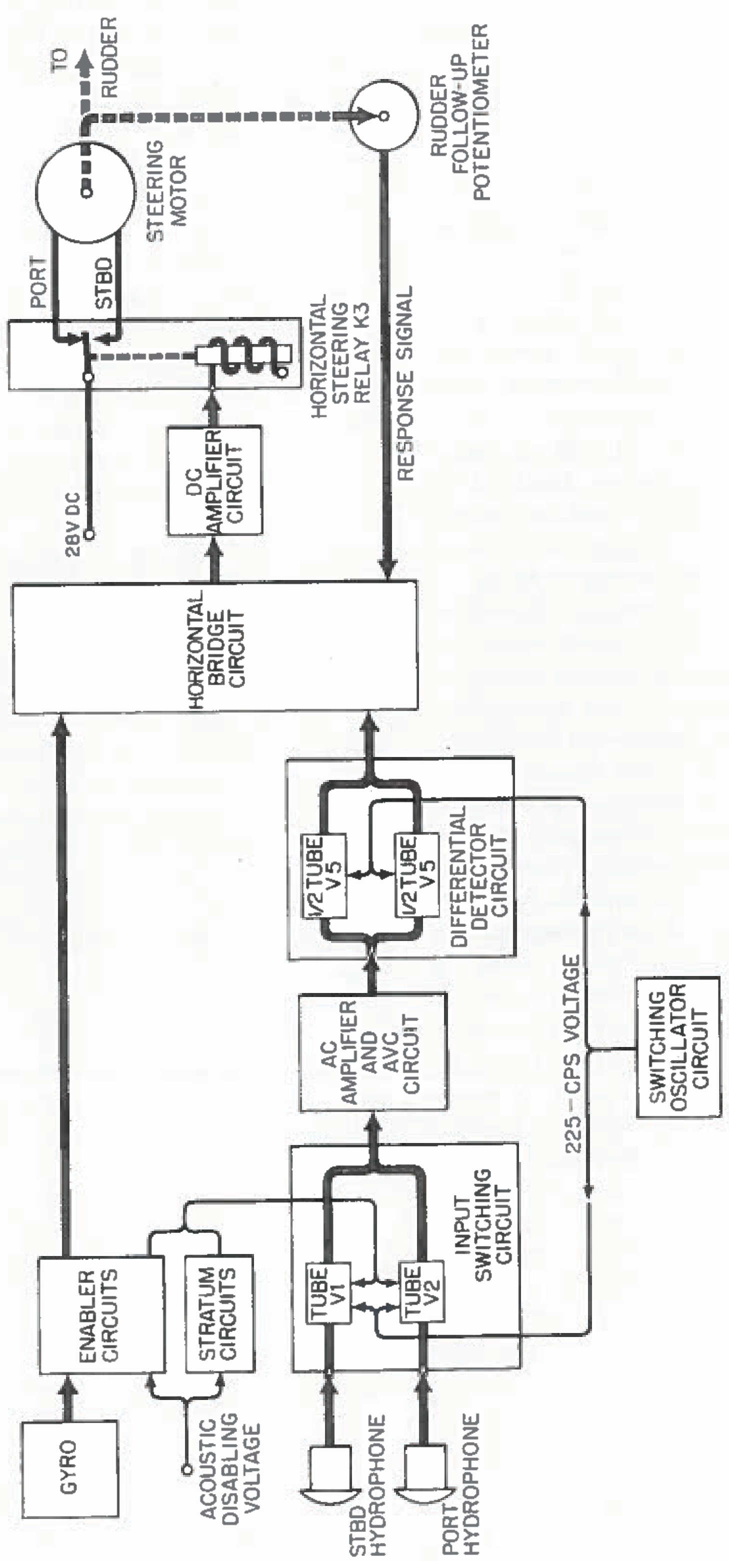


Figure 32—Functional Block Diagram of Horizontal Steering System.

of the output voltages developed by the hydrophones. The switching action is controlled by a signal from the switching oscillator. This oscillator also provides a signal for switching the outputs of the AC amplifier alternately to two detector stages in the differential detector circuit. In this circuit, the amplifier outputs are rectified, and the resultant DC voltages are impressed on a one-megohm resistor which forms a link between the bridge circuit and the grid of the first DC amplifier tube. If the voltages are equal, they nullify each other. The bridge circuit is adjusted so that a small residual unbalance exists when a null signal is received from the detector circuit. This small unbalance keeps the steering relay in a just operated condition, causing a port rudder angle of approximately 6 degrees which keeps the torpedo traveling in a port circle of approximately 100 yards diameter during search. If the hydrophones pick up a noise which causes one hydrophone to develop a stronger signal than the other, a small difference voltage, either positive or negative, appears across the one-megohm resistor. Depending on its polarity, this voltage causes the steering relay either to open or to close, thus energizing the steering motor. The steering motor drives the rudder in the same direction as that from which the sound is apparently arriving; that is, to port if the port hydrophone is developing the stronger signal or to starboard if the starboard hydrophone is developing the stronger signal. As the steering motor drives the rudders, it also drives the contact arm of the rudder follow-up potentiometer. The potentiometer voltage is applied across the bridge circuit so that its polarity is opposite to the polarity of the difference voltage across the one-megohm resistor. When the bridge unbalance caused by the potentiometer voltage is equal in magnitude to the difference voltage appearing across the one-megohm resistor, the effect of the difference voltage is canceled, and the rudder stops and oscillates about the position at which the voltages balance. The rudder angle at which the balance occurs is proportional to the difference in the output of the two hydrophones, which in turn is proportional to the angle between the heading of the torpedo and the direction of the sound source.

As mentioned previously, the torpedo may be set to operate in any of the three different stratum conditions. Should the torpedo attempt to attack a target outside of the stratum in which it has been set to operate, the stratum controls will be operated and will apply the acoustic disabling voltage to the input circuit, thus deafening the horizontal controls.

Vertical Steering Control Circuits. The basic functional relationships between the major circuit units of the vertical steering control system, figure 33, are similar to those of the horizontal system. The major differences between the circuits are the following:

1. The vertical system is provided with limit switches which operate during the gyro run to prevent the torpedo from diving or climbing too steeply.

2. The vertical system has a gate circuit which controls the application of the hydrostatic depth and pendulum control signals.

3. The vertical system is provided with a ceiling switch.

4. A trigger circuit in the vertical system is provided so that in above limit operation the sound from the target will have no effect on vertical steering until the signal level is relatively high, indicating close proximity to the target.

5. A time delay is provided in the vertical circuit to prevent gating or triggering for approximately 15 seconds after enabling.

During the gyro portion of the torpedo run, the enabler causes circuits to be completed for applying an acoustic disabling voltage to the input switching circuits, thus deafening the torpedo. During this portion of the run, the signals from the depth and pendulum potentiometers are applied to the vertical bridge circuit to control the torpedo elevators. These signals combine to hold the torpedo at the running depth for which it has been previously set. If the torpedo starts to climb or dive too steeply during the gyro run, the climb or dive angle limit switch will disconnect the depth control so that the pendulum signal will assume full control and reduce the climb or dive angle to within the allowable limits.

At the end of the enabling run, the enabler causes the acoustic disabling voltage to become disconnected but does not disconnect the depth and pendulum controls Also at this time, the dive and climb angle limit switches are by-passed so that they will no longer function. After

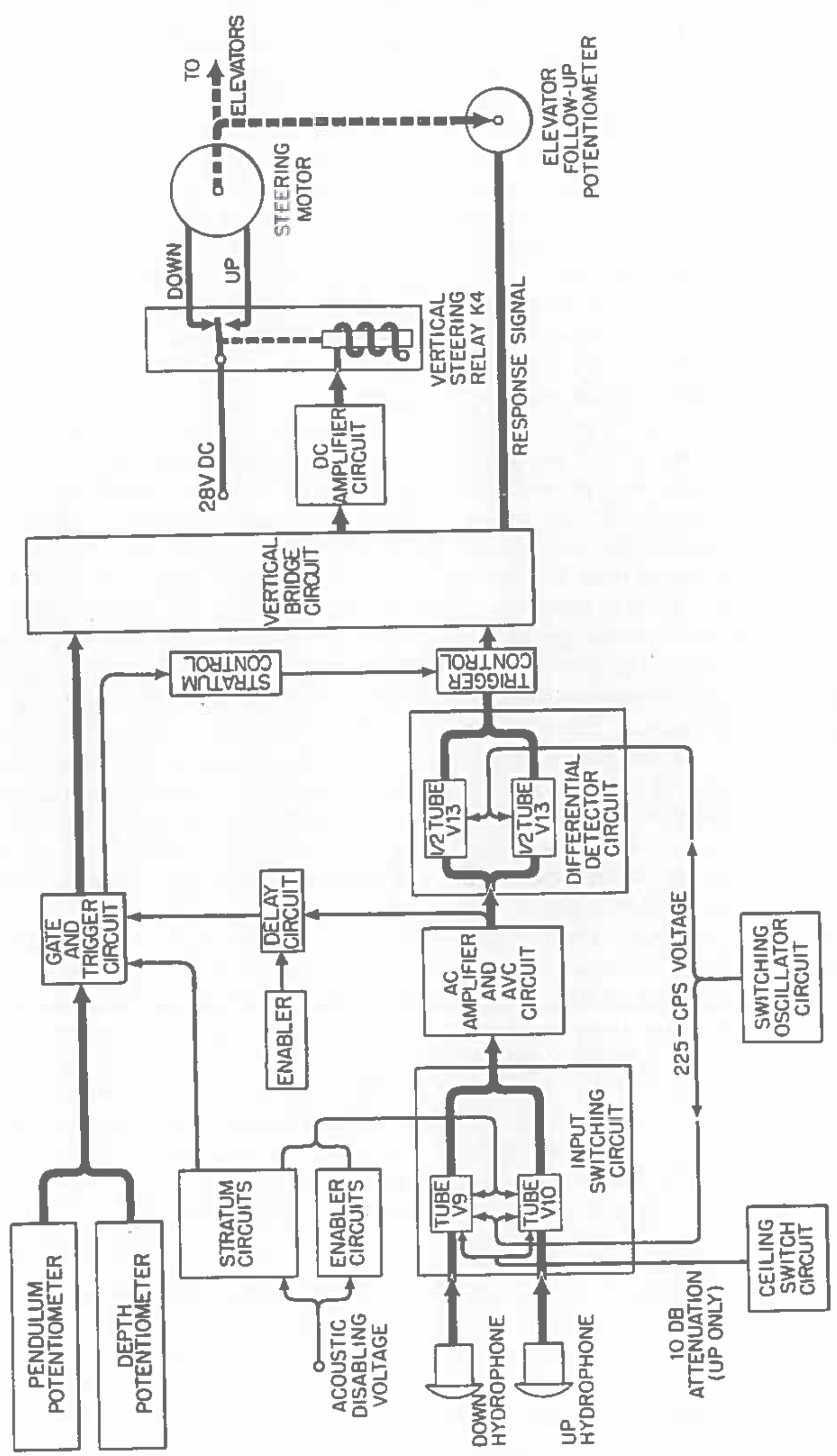


Figure 33—Functional Block Diagram of Vertical Steering System.

enabling occurs, the action of the vertical system depends on what stratum setting is being used.

In the below limit and no limit conditions, the vertical acoustic control becomes active immediately when the torpedo enables. In the absence of target noise while the torpedo is in search, the torpedo remains at its running depth under control of the depth and pendulum potentiometers. When the horizontal hydrophones pick up a target noise, the torpedo steers toward the target in bearing, and as the torpedo approaches the target, the noise level in the vertical channel grows progressively greater. However, the torpedo will not leave its running depth of 125 feet until the noise level is great enough to produce a signal differential which bucks depth and pendulum control. If the torpedo is operating below a depth of 85 feet in the below limit condition or in the no limit condition, the gate circuit will operate when the target noise level in the vertical channel is sufficiently high. Operation of this circuit disconnects the depth and pendulum potentiometers from the circuit and leaves the torpedo in full acoustic control. For depths less than 85 feet, gating is prevented by the action of the stratum control circuit. A delay circuit is provided in the torpedo to keep the gate circuit from operating for approximately 15 seconds after enabling occurs. Therefore, if the torpedo should happen to enable close to the target in the presence of a high noise level, gating will be delayed long enough to permit the acoustic circuit to stabilize after the acoustic disabling voltage is disconnected.

In the above limit condition, the vertical acoustic control is not activated immediately after the torpedo enables. Although the action of the enabler immediately disconnects the acoustic disabling voltage, the output signal of the vertical channel will remain shorted out until the target noise level is sufficiently high to cause operation of the trigger circuit. Therefore, when the horizontal hydrophones pick up a target noise, the torpedo steers toward the target in bearing but remains at its running depth of 70 feet under control of the depth and pendulum potentiometers. As the torpedo approaches the target, the noise level in the vertical channel grows greater and when the noise has reached a level indicating close proximity to the target, the trigger circuit will function to permit the acoustic signals to influence the vertical steering. (The same delay circuit previously mentioned prevents triggering for 15 seconds after enabling occurs.) After the trigger circuit functions, the acoustic control bucks depth and pendulum control to steer the torpedo toward the target in depth.

If the torpedo is in the above limit condition or is operating in the no limit condition, and it attempts to attack a target at or near the surface, the ceiling switch circuit operates when the torpedo reaches a depth of 30 feet. Operation of this circuit causes a 10-db attenuation to be introduced into the vertical acoustic channel. This reduces the sensitivity of the up hydrophone channel so that the torpedo will have less tendency to attack the "image" of its own self-noise reflected from the surface.

The operation of the remaining circuits of the vertical steering control system is the same as previously explained for the horizontal system. Detailed explanations of the acoustic channel circuits of both the horizontal and vertical systems are given in the following paragraphs. The functional details of the gyro circuit, depth and pendulum circuit, and other associated control circuits are explained in chapter 6.

Function of Horizontal Acoustic Steering Control Circuits. The acoustic circuits of the horizontal steering control channel include the switching oscillator circuit, input switching circuits, AC amplifier circuit with AVC, differential detector circuit, a portion of the horizontal bridge circuit, and the DC amplifier circuit. These circuits provide signals for operating the horizontal steering relay which controls the horizontal steering motor. A response voltage for the control system is provided by the follow-up potentiometer driven by the horizontal steering motor.

Switching Oscillator Circuit. In acoustic steering, signals produced by the hydrophones are amplified, detected, and applied to the bridge circuit. In order to insure equal amplification for hydrophone signals, the same amplifier is used for both signals. This is accomplished by means of an electronic switching circuit which alternately connects the signals to the amplifier input. The signals are switched at the rate of approximately 225 times per second under control of the switching oscillator circuit, figure 34, which is a tuned-plate, push-pull oscillator.

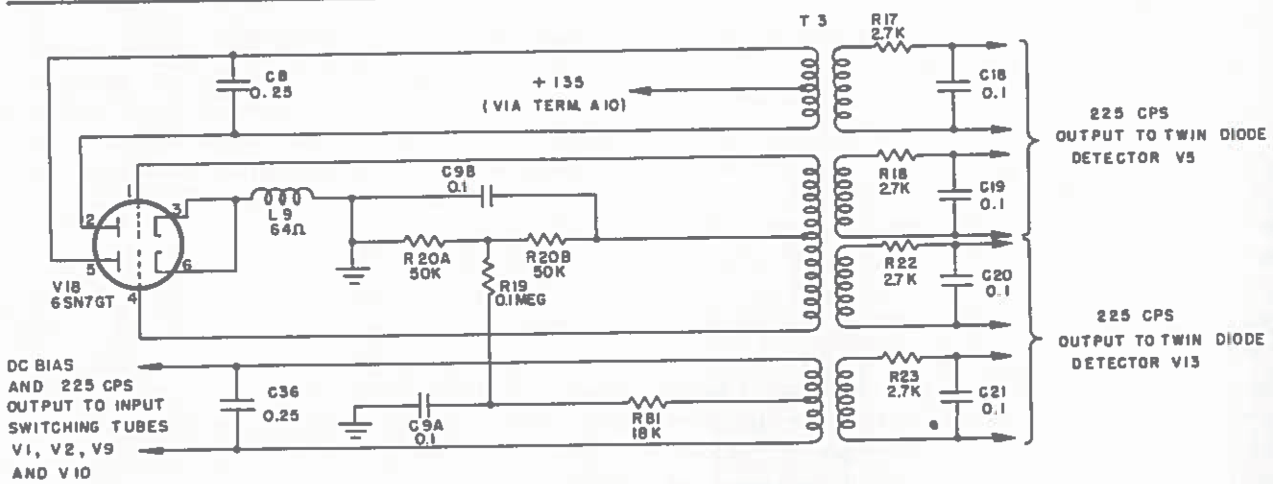


Figure 34—Switching Oscillator Circuit.

The plates of the oscillator vacuum tube V18 are connected for push-pull operation across one primary winding of transformer T3. Capacitor C8 tunes the plate circuit. Grid bias for the oscillator is supplied by a resistance-capacitance network (R20A, R20B, and C9B) connected between a tap on the grid winding of transformer T3 and the cathodes of vacuum tube V18.

During the positive half-cycle of oscillation in each side of tube V18, the control grid of that side goes slightly positive. For the time that the grid is positive, a current flows in the grid circuit, and therefore flows through the resistance-capacitance network. The grid currents from the two sides of vacuum tube V18 flow in the same direction through the network and the resultant of the currents is a direct current which pulsates at double frequency. Capacitor C9B reduces the voltage pulsations across resistors R20A and R20B. The resulting DC voltage provides a negative bias of approximately 14 volts for the oscillator grids. The midtap of the network is connected through resistors R19 and R81 and through a winding of transformer T3 to furnish a 7-volt negative DC bias for the control grids of vacuum tubes V1 and V2 in the horizontal input switching circuits, and vacuum tubes V9 and V10 in the vertical input switching circuits.

The oscillator circuit has five 225-cps AC outputs. One output is used for both the vertical and horizontal input switching circuits. Of the remaining four outputs, two are used for the vertical detector circuit and two for the horizontal detector circuit.

Horizontal Input Switching Circuit. The input switching circuit, figure 35, alternately connects the output of starboard hydrophone J1 and port hydrophone J2 to the horizontal AC amplifier. The input circuit includes tuning coils L1 and L2 which (in combination with the tuning capacitance associated with the hydrophones, the inductance of the hydrophone coils, and the capacitance of the hydrophone leads) make the input circuit resonant at a frequency of approximately 24.5 kc. The plate circuits of vacuum tube V1 and V2 are both connected to the same load circuit. The load circuit is tuned for resonance at 24.5 kc by coil L5 and capacitor C26. Potentiometer P1 is used for balancing the two halves of the input circuit. The cathode circuits of vacuum tubes V1 and V2 include a resistance-capacitance network (consisting of potentiometer P1, resistors R69, R70, and R87, and capacitor C38A) which provides negative feed-back for the vacuum tubes. This feed-back (approximately 12 db) tends to stabilize the operation of the two halves of the input circuit by holding the gain of each half substantially constant despite minor differences in vacuum tube constants and changes in the power supply voltages.

The control grids of vacuum tubes V1 and V2 receive the sum of three voltages: the 7-volt negative DC bias from the switching oscillator circuit, the 225-cps AC voltage from the switching oscillator circuit, and the signals from the associated hydrophones. Vacuum tube V1 receives the signal from the starboard hydrophone and

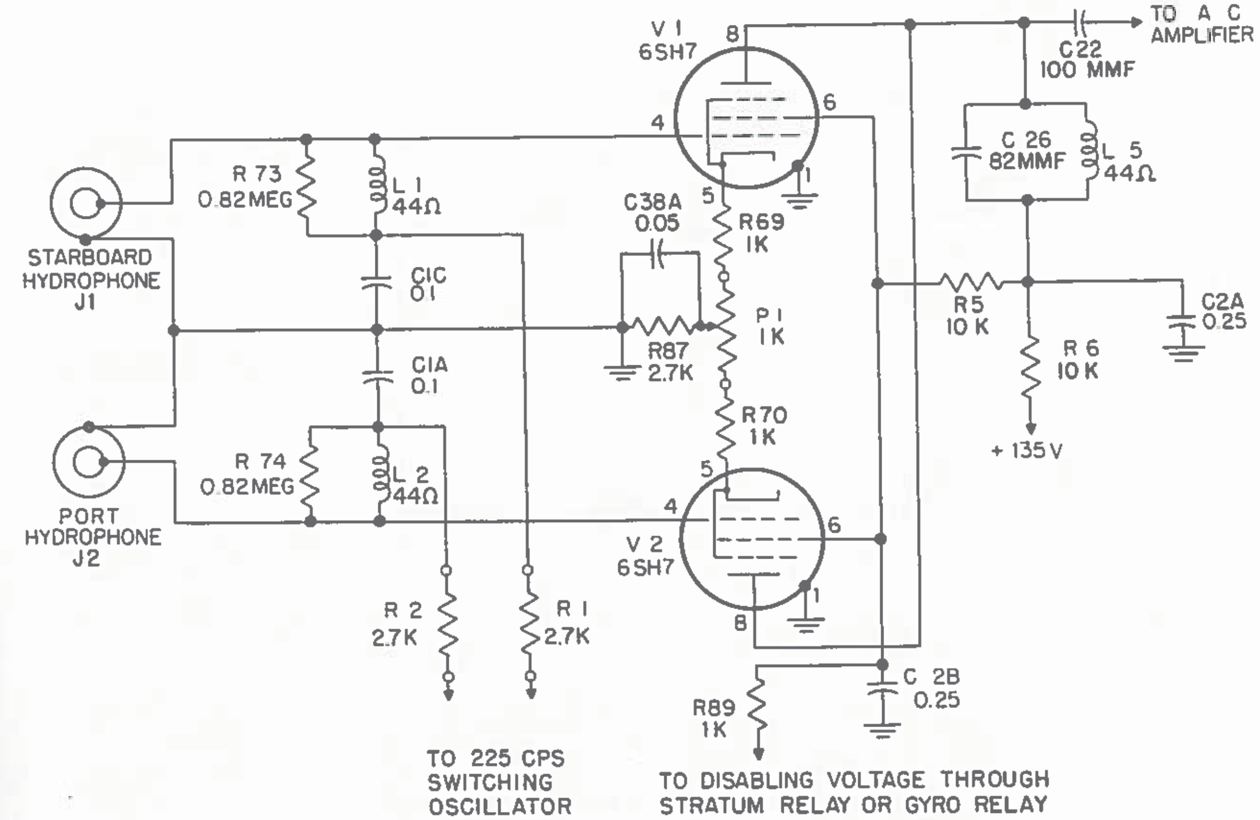


Figure 35—Input Switching Circuit (Horizontal).

vacuum tube V2 receives the signal from the port hydrophone. The 7-volt negative DC voltage by itself is sufficient to bias both vacuum tubes beyond cutoff. The 225-cps AC voltage causes the vacuum tube receiving a postive half-cycle to conduct, while the other vacuum tube, which is receiving the negative half-cycle, remains cut off. On the next half-cycle, the vacuum tube which previously was conducting is cut off and the other vacuum tube becomes conducting. The 225-cps oscillator voltage causes this change to occur 225 times per second, with the result that the 24.5 kc signals from the port and starboard hydrophones pass through the vacuum tubes and enter the common load circuit in alternate spurts of 1/450 second duration. This process is illustrated in figure 36. The 225-cps carrier does not pass through to the amplifying circuit because of the 24.5 kc tuning in the load circuit of the input switching circuit.

Figure 35 also shows the circuit through which the acoustic disabling voltage is applied to the input switching circuit for deafening the horizontal steering control channel. The acoustic disabling voltage is a minus 24-volt DC voltage supplied either through the gyro relay (during the entire enabling run), or through the stratum relay (whenever the torpedo is outside its preset depth stratum). The voltage is applied through resistor R89 to the screen grids of vacuum tubes V1 and V2. The normal voltage on the screen grids is approximately 120 volts positive. When the circuit to the source of the disabling voltage is completed through the stratum relay or gyro relay, the screen voltage decreases to approximately 19 volts negative. This is a result of the combined effects of the minus 24-volt DC disabling voltage and the voltage drop in resistors R5 and R6 caused by the current flow from the 135-volt screen grid voltage supply to ground through the source of the disabling voltage. The change in the screen grid voltage blocks the tubes and thus prevents the passage of the hydrophone signals.

Horizontal AC Amplifier Circuit With AVC. The AC amplifier circuit raises the level of the signals it receives from the input switching

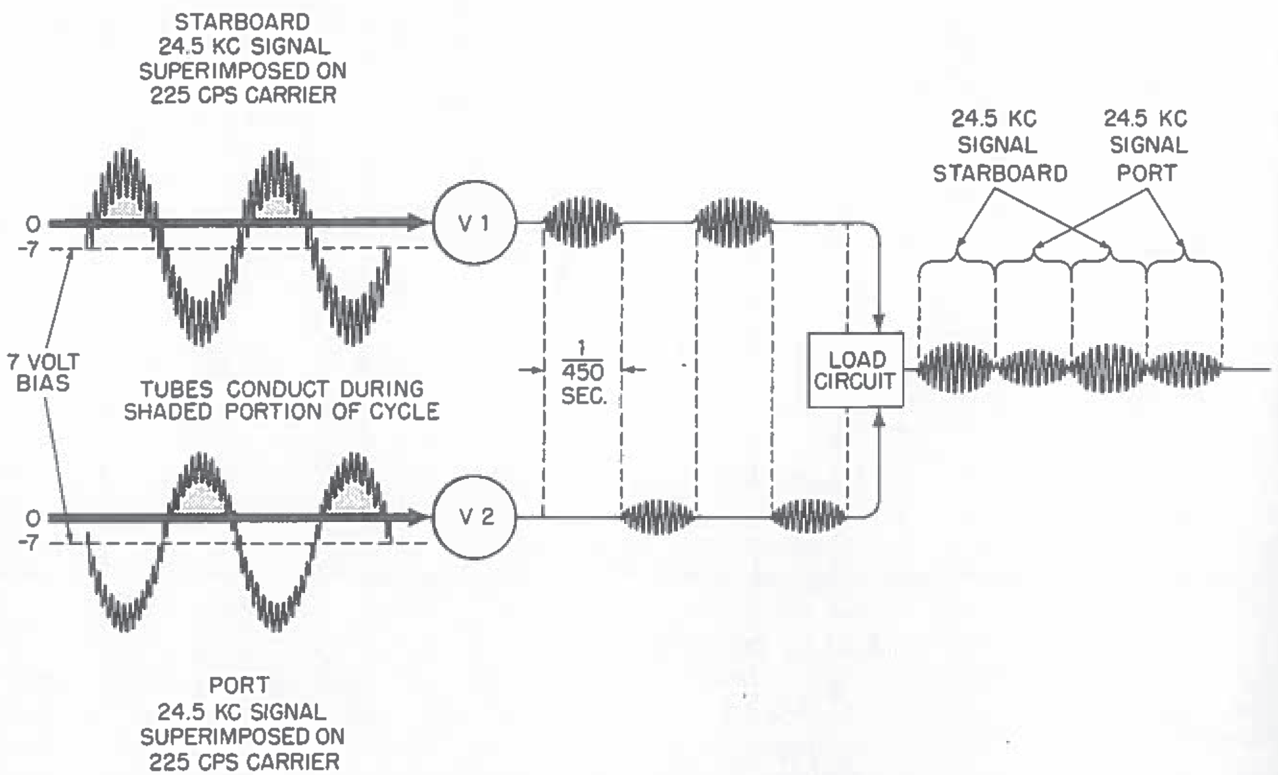


Figure 36—Waveforms in Input Switching Circuit.

circuits. The output of the amplifier is applied to the detector circuit.

The AC amplifier circuit, figure 37, includes two amplification stages in vacuum tubes V3 and V4 and is provided with automatic volume control (AVC) by one-half of the twin-diode vacuum tube V8. (The other half of the tube is not used in this torpedo and its cathode is grounded.) The AVC cathode of vacuum tube V8 is biased at approximately 30 volts positive through a resistance network connected to the 135-volt B supply. The cathode is connected to the plate of vacuum tube V4 through capacitor C24. When the peak values of an amplified AC voltage at the plate of vacuum tube V4 are sufficiently high, they overcome the 30-volt bias and drive the AVC cathode of vacuum tube V8 negative with respect to its plate. The resulting rectified plate current flows to ground through the resistance-capacitance network consisting of resistors R13 and R38 and capacitors C3A and C3B. The time constant of this network is of such a value that for a constant AC amplifier output, a relatively steady DC potential is developed across the network. The potential of terminal H4 becomes negative with respect to ground because of the DC voltage drop in resistor R13. This potential provides a negative bias for the control grids of vacuum tubes V3 and V4. As the strength of the incoming signal increases, the bias becomes greater and causes the amplifier gain to be reduced. In this way, nearly uniform amplifier output is obtained for a wide range of input signal levels. The AVC holdover time is such that the differential effect between the port and starboard signals is not lost. In other words, the time constant of the AVC circuit is long compared to the switching frequency.

Resistors R8, R76, and R77 in the grid circuit of vacuum tube V3 are strapped as required for adjusting the AC amplifier sensitivity. The output of the amplifier is tuned to 24.5 kc by capacitor C27 and the winding of transformer T1.

It is convenient to rate the sensitivity of the AC amplifier in terms of the input signal level at which AVC action just begins (actually about 1 db above this threshold). This signal level is designated in decibels below 1 volt. The

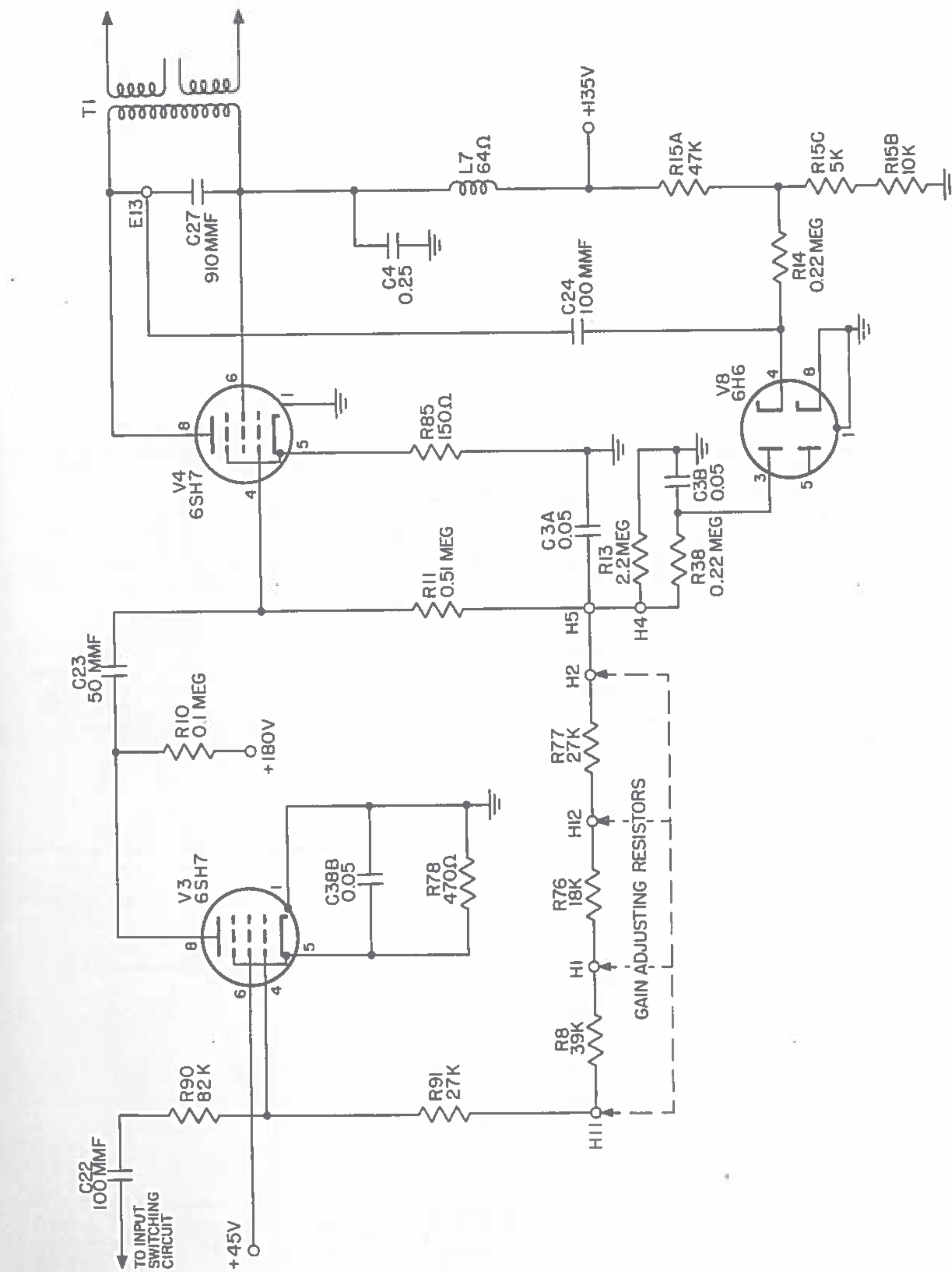
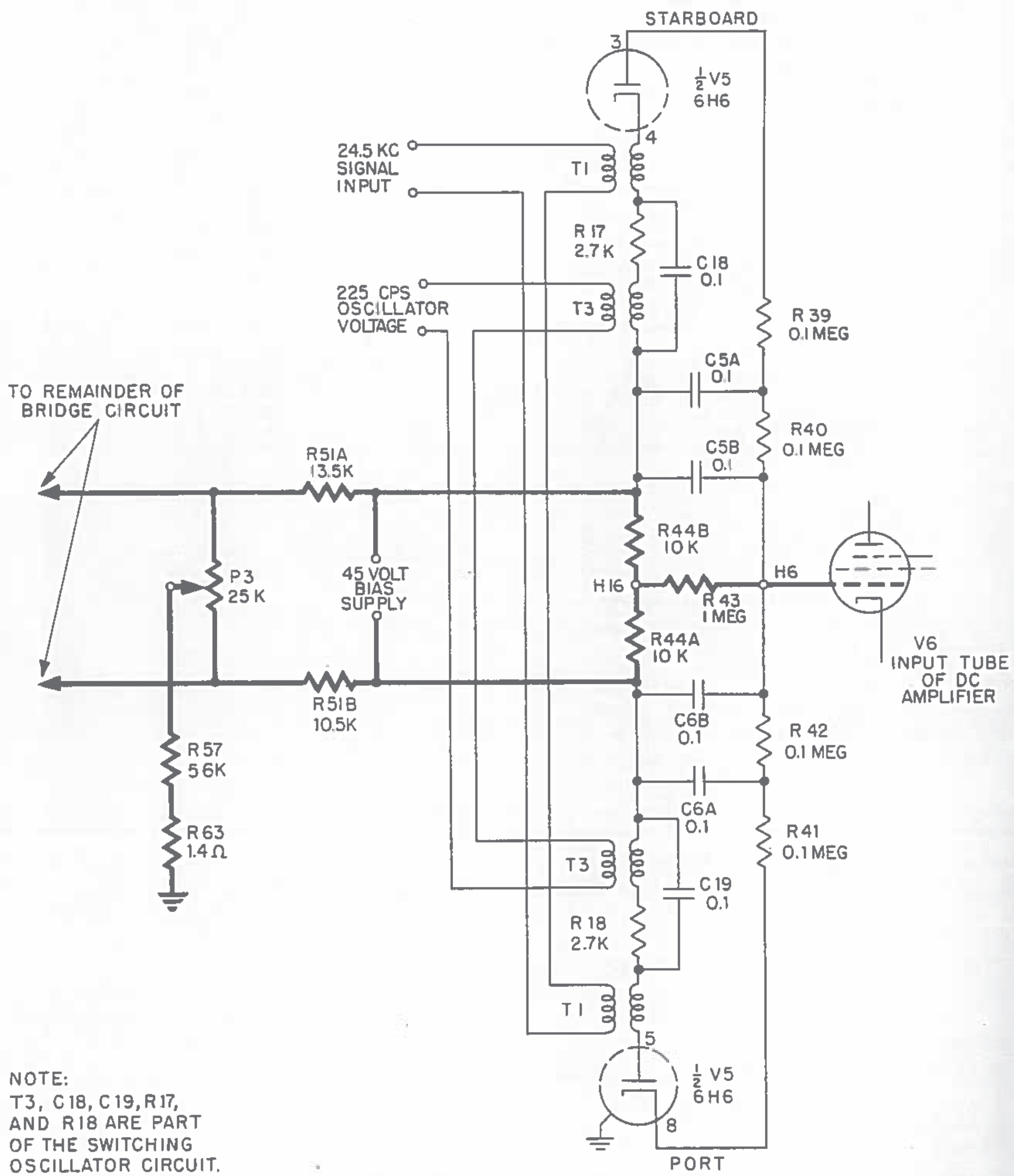


Figure 37—AC Amplifier Circuit (Horizontal).



NOTE:
T3, C18, C19, R17,
AND R18 ARE PART
OF THE SWITCHING
OSCILLATOR CIRCUIT.

Figure 38—Detector Circuit (Horizontal).

horizontal AC amplifier sensitivity is adjusted so that AVC action initiates (as indicated by the first perceptible increase in negative bias on terminal H4) at about −80 dbv on pure tone.

Horizontal Differential Detector Circuit. The output of the AC amplifier circuit consists of alternate spurts of 24.5-kc energy which are proportional in magnitude to the signal levels from the port and starboard hydrophones. The purpose of the differential detector circuit, figure 38, is to produce a DC voltage proportional to the difference in magnitude between the individual spurts. The polarity of this voltage is determined by which hydrophone is producing the stronger signal.

The output of the AC amplifier is impressed on the double-diode vacuum tube V5 of the differential detector circuit through transformer T1. This vacuum tube is connected to the 45-volt horizontal bias supply through the output windings of oscillator transformer T3 and signal transformer T1 in such a way that the plate of each diode is biased approximately 22.5 volts negative with respect to its cathode.

NOTE: The input winding of transformer T1 and the input winding of transformer T3 are shown in figure 38 as divided into two parts for clarity. Actually, the primary windings of these transformers are single windings.

The circuit shown in heavy line is a portion of the bridge circuit. The complete bridge circuit is explained later.

The 225-cps oscillator output voltage is adjusted to make its peak value slightly less than the 22.5-volt biases so that with no signal input, the diodes are nonconducting. When the signal, superimposed on the oscillator voltage, is sufficiently strong, figure 39, the biases are overcome, and spurts of rectified current flow into the output network of the diodes. (The pulses shown in figure 39 actually flow in opposite directions in the RC network as explained in the following paragraph, because of the manner in which the halves of vacuum tube V5 are connected. See figure 40.) The function of the oscillator voltage is to cause the diodes to con-

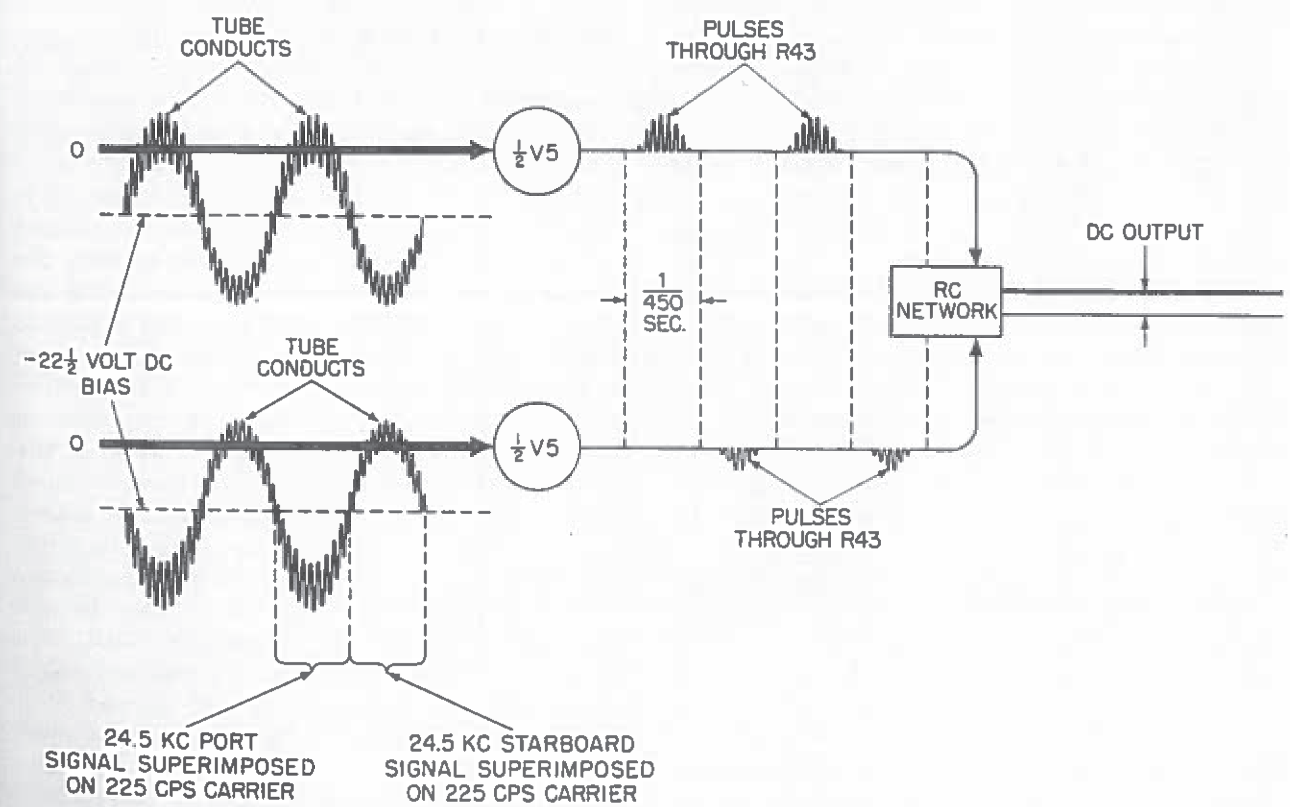


Figure 39—Waveforms in Detector Circuit.

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duct alternately in synchronism with the similar alternate conduction in vacuum tubes V1 and V2 in the switching circuit. The overall effect is the same as if there were separate input and detector circuits for each hydrophone, with only one AC amplifier, which is switched first into one circuit and then into the other.

During the half-cycle of the 225-cps wave that a diode is conducting, rectified current flows into the output network of that diode. Capacitors C5A and C5B are charged by starboard signals and capacitors C6A and C6B are charged oppositely by port signals. When the corresponding diode is not conducting, each charge dissipates at a relatively slow rate through a one megohm resistor R43. The time constant is designed to give a period of discharge that is long compared to the 1/450-second period during which the diode is not conducting. Therefore, for a steady acoustic input, the spurts of signal energy, rectified by the diodes, maintain a relatively constant DC potential across resistor R43. The signals flowing from the two diodes produce opposite potentials across resistor R43 so that the net potential is of the polarity of the stronger signal. Also, the net potential is proportional to the difference between the two signals (approximately 0.5 volt per db).

With equal signal inputs to the starboard hydrophone and port hydrophone, potentiometer P1 in the input switching circuit is adjusted so that the net potential produced at terminal H6 relative to terminal H16 is zero. This adjustment compensates for any inequalities in circuit characteristics. Actually, potentiometer P3 is adjusted to the reference balance position first, as will be explained later, and then with equal electrical signal inputs, potentiometer P1 is adjusted to maintain the balance.

The rectified signal current flows through the starboard detector channel as follows: Current flows from plate to cathode in the starboard diode of vacuum tube V5, through the starboard winding of signal transformer T1 and the starboard winding of oscillator transformer T3, and then flows through resistor R44B to terminal H16, and through resistor R43 to terminal H6. From terminal H6, the return path is through resistors R40 and R39, back to the plate of the diode. When the starboard signal is stronger than the port signal, the net current in resistor R43 is in the direction of terminal H6. This current flow through resistor R43 produces a potential at terminal H6 which is negative with respect to the potential at terminal H16. This potential biases the grid of vacuum tube V6 more negatively with respect to ground. (Vacuum tube V6 is the input tube of the DC amplifier circuit.)

When the port signal is stronger than the starboard signal, the net current in resistor R43 produces a potential at terminal H6 which is positive with respect to the potential at terminal H16. This potential biases the grid of vacuum tube V6 less negatively (or more positively) with respect to ground.

HORIZONTAL BRIDGE AND DC AMPLIFIER CIRCUITS. The horizontal bridge circuit is the heart of the steering control system. This circuit supplies the DC amplifier and the output of this amplifier controls the horizontal steering relay K3. The complete bridge circuit, the DC amplifier circuit, and the related circuits concerned with steering control are shown in figure 40. The bridge circuit is shown in heavy line. In the following paragraphs, these circuits are explained to show how steering relay K3 functions in response to rectified signals from the detector circuit and how the followup potentiometer P3 operates in conjunction with these signals to produce rudder angles proportional to the acoustic differential.

When the torpedo is enabled, gyro relay K8 is released. This connects point B33 to ground through resistor R63 in the same way as when the GL (gyro left) relay K19 is operated during the gyro run, except that in this case the circuit to ground also includes resistor R103. When there is no acoustic signal, the effect of connecting point B33 to ground is to create an unbalance in the bridge circuit. To restore the balance, the slider of the rudder followup potentiometer must move toward B1. This potentiometer is geared to the steering motor and to move the potentiometer slider toward point B1, the steering motor must drive the rudder to port. Due to the current limiting action of resistor R103, the balance point is reached when the rudder reaches a position only 5 degrees to port instead of 8 degrees, which is the rudder throw under gyro control.

The followup potentiometer and the two 10,000-ohm resistors, R44B and R44A, form a bridge

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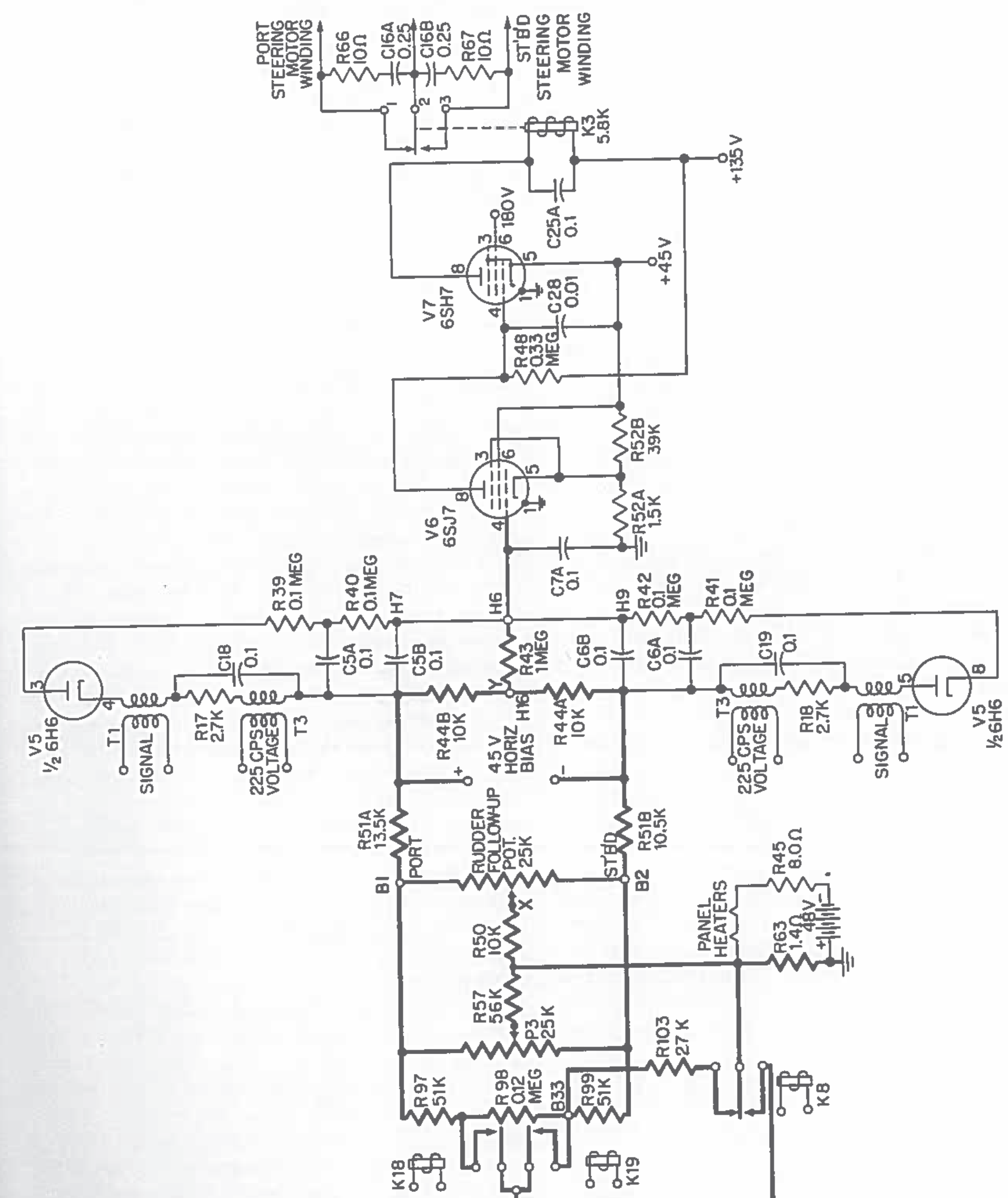

Figure 40—Bridge and DC Amplifier Circuits (Horizontal).

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network energized by the 45-volt horizontal bias supply. When the balance condition is obtained, there is no difference in potential between points X and Y, and therefore, no grid potential due to the bias supply is applied to the grid of vacuum tube V6 (the input tube of the DC amplifier). However, if the followup potentiometer is driven past the balance position, a potential difference between points X and Y is created and this potential appears on the grid of vacuum tube V6. This potential is either positive or negative, depending on the rudder angle and causes relay K3 to operate or release. The steering motor therefore reverses, and tends to bring the rudder back to a position of 5 degrees port. In normal operation, the steering motor always drives the rudder a few degrees past the balance position. Therefore, with no acoustic signal input, the rudder hunts about the 5-degree port position, oscillating through an angle of a few degrees. The frequency of the oscillation is approximately 3 oscillations per second.

In a perfectly balanced bridge circuit, the potential difference between the terminal H16 and the slider of biasing potentiometer P3 is zero. This slider is connected to ground through two resistors, R57 and R63. Resistor R63 carries the vacuum tube heater current. The voltage drop across resistor R63 produces a small negative voltage with respect to ground at the slider of biasing potentiometer P3. When the bridge is balanced, the same negative voltage with respect to ground appears at terminal H6. If the potentiometer slider is moved away from the balance position, a positive or negative potential difference is produced between terminals H6 and H16, depending upon the position of the slider. This potential adds algebraically to the original negative voltage with respect to ground at terminal H6. Therefore, the bias applied to the control grid of the first vacuum tube in the DC amplifier is controlled by the setting of biasing potentiometer P3.

The resistance network (consisting of resistors R52A and R52B) connected to the cathode of vacuum tube V6 produces a positive potential of about 2.0 volts between the cathode of this tube and ground. The actual amount of bias produced by these resistors depends upon the actual voltage at the 45-volt tap on the B power supply. The effect of the variation of the bias with the B power supply voltage is to keep the plate current of vacuum tube V6 and the grid voltage of vacuum tube V7 substantially constant in spite of changes in the B power supply voltage. For this reason, the network consisting of resistors R52A and R52B is called the "B supply compensating network." Compensation for changes in heater voltage is accomplished by biasing voltages developed across resistors R63 and R45, and applied through the bridge circuit to the control grid of vacuum tube V6.

The desired bias of vacuum tube V6 is approximately 2.5 volts negative between the control grid and cathode (0.5 volt negative between control grid and ground). When the grid is made slightly more negative than this value, the plate current decreases and the positive plate potential increases. This raises the grid potential applied to vacuum tube V7 enough to cause a saturation plate current of about 10 milliamperes. The cathode of vacuum tube V7 is biased approximately 45 volts positive by direct connection to the B power supply.

The sum of the bias voltages between the control grid and cathode of vacuum tube V6 produced by the heater battery and B supply compensating network is approximately 4.2 volts negative. Therefore, to balance the steering circuit, bias potentiometer P3 must be set so as to provide a positive potential of approximately 1.7 volts between the control grid and the cathode. The net bias on vacuum tube V6 will then be the desired 2.5 volts negative.

The polarities in the differential detector circuit, DC amplifier, and the steering relay are such that a negative potential produced by the differential detector circuit as the result of an acoustic signal will produce a starboard rudder deflection. A positive potential will produce a port rudder deflection.

A strong starboard signal causes the differential detector to produce a relatively great negative voltage at terminal H6. This voltage is applied to the input of the DC amplifier and causes the saturation current to flow in the amplifier output tube V7. The flow of current through steering relay K3 causes the relay to operate so that power is supplied to the starboard winding of the steering motor. As the steering motor drives the rudder to starboard, it also drives the slider of rudder follow-up potentiometer R124 toward

point B2. This displacement of the potentiometer slider toward the negative terminal of the 45-volt bias supply causes the development of a steadily increasing positive voltage at terminal H16. This positive potential is connected through resistor R43 to terminal H6. When this positive potential is equal to the negative voltage created across resistor R43 by the acoustic input, the bridge is again balanced and steering relay K3 is caused to release momentarily. This reverses the steering motor so that the motor tends to drive the rudder to port. However as soon as the rudder starts moving to port, the resulting movement of the slider of follow-up potentiometer R124 unbalances the bridge. This unbalance causes the steering relay to close so that the steering motor is again reversed and tends to drive the rudder to starboard. This action continues, causing the rudder to oscillate about a starboard position roughly proportional to the magnitude of the starboard differential produced by the hydrophones. This proportionality exists for all differentials up to approximately 4 db, port or starboard. At this level, the differential is sufficiently great to move the rudder through an angle of 22 degrees measured from the mid position. At this angle the rudder limit switches are operated. The action of these switches is described in chapter 6.

Function of Vertical Acoustic Steering Control Circuits. The acoustic circuits of the vertical steering control channel include the switching oscillator circuit, input switching circuits, AC amplifier with AVC, differential detector circuit, a portion of the vertical bridge circuit, delay circuit, gate circuit, trigger circuit, and DC amplifier circuit. These circuits provide signals for operating the vertical steering relay which controls the vertical steering motor. A response voltage for the control system is provided by the follow-up potentiometer driven by the vertical steering motor.

The switching oscillator circuit is the same circuit which provides switching voltages for the horizontal channel and therefore is not described here. Most of the other circuits are generally similar to the corresponding circuits in the horizontal channel. For this reason, the vertical circuits are described mainly by pointing out the differences between them and the corresponding horizontal circuits.

Vertical Input Switching Circuit. The vertical input switching circuit, figure 41, is similar to the input switching circuit of the horizontal channel, but has an additional resistor (R72) in the feed-back (cathode) circuit of the up channel. In normal running, this resistor is by-passed by relay K5. If the torpedo goes above a depth of approximately 30 feet, relay K5 is released by the ceiling switch and the by-pass is removed. The added resistance increases the feed-back and thus reduces the gain in the up channel by approximately 10 db. Potentiometer P2 is adjusted to produce equal gain in the up channel and down channel when resistor R72 is bypassed.

Vertical AC Amplifier Circuit With AVC, Time Delay, and Gate Relay. The vertical AC amplifier circuit, figure 42, is similar to the horizontal AC amplifier circuit. However, the vertical AC amplifier has a lower gain than the horizontal amplifier. (The reason for this difference in gain is explained later.) The lower gain is achieved by differences in the values of the gain adjusting resistors. That is, a 0.22-megohm resistor (R33) is used in the AVC circuit instead of a 2.2-megohm resistor (R13 in the horizontal amplifier). The vertical AC amplifier sensitivity is adjusted by strapping resistors R26, R46, or R53 so that action initiates at approximately −67 dbv on pure tone.

The upper half of vacuum tube V16 as shown in figure 42 performs the AVC function in the same manner as previously explained for the horizontal AC amplifier. The lower half of this tube is used in conjunction with the gate relay circuit as follows:

Providing the time delay relay K1 is energized, the lower half of vacuum tube V16 functions when the vertical hydrophone output is sufficient to produce approximately −70 dbv of noise at the grids of vacuum tubes V9 and V10 in the input switching circuit. (This is equivalent to an attenuator test set input voltage of −66 dbv on pure tone.) When a signal having this amplitude or a greater amplitude is received, the lower diode of vacuum tube V16 conducts. This occurs when the voltage impressed on the cathode through capacitor C32 is great enough to override the positive bias. The diode current passes through the closed contacts of time delay relay K1 and develops a voltage across the 2.2-megohm load resistor R55. This voltage charges capacitor

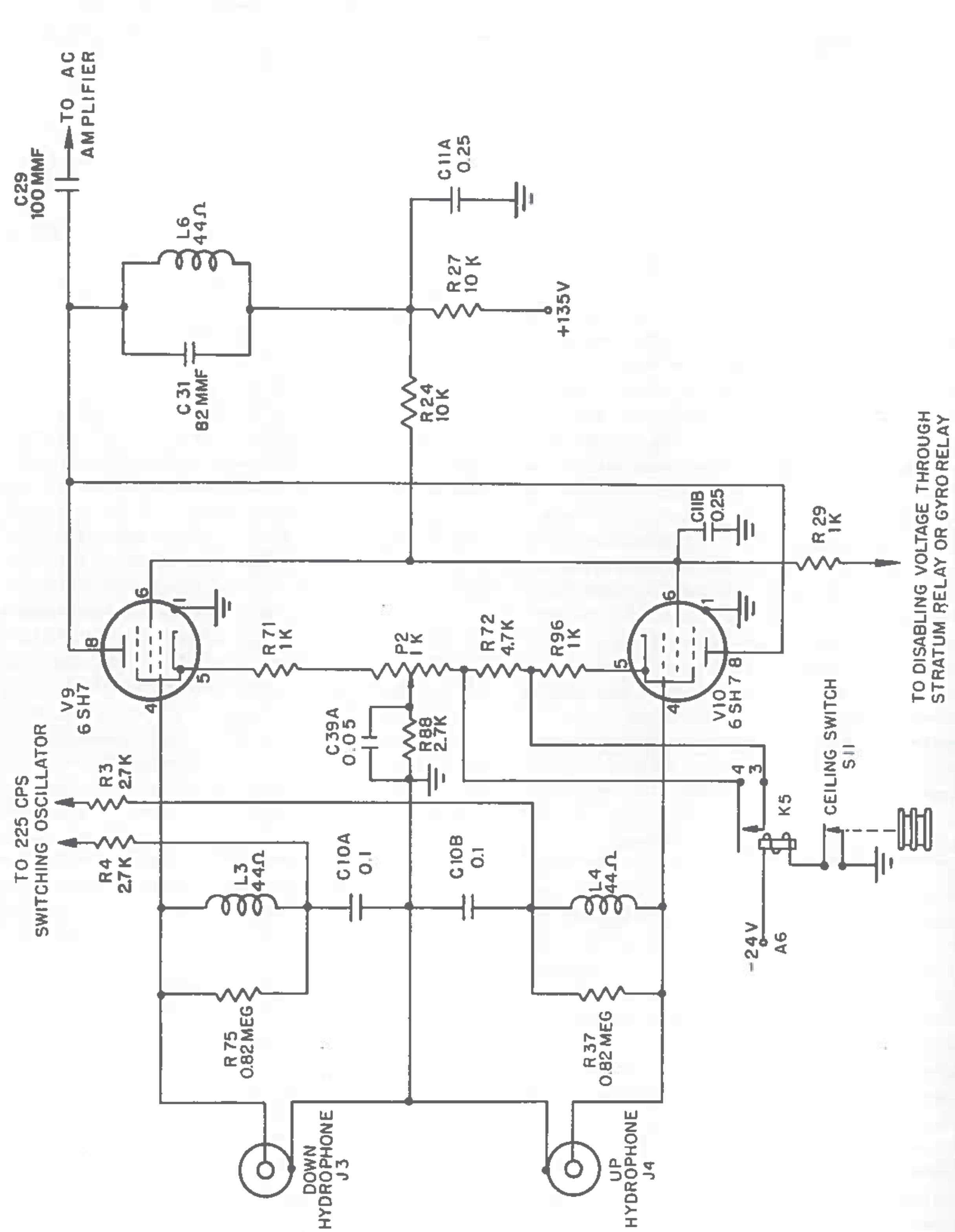

Figure 41—Input Switching Circuit (Vertical).

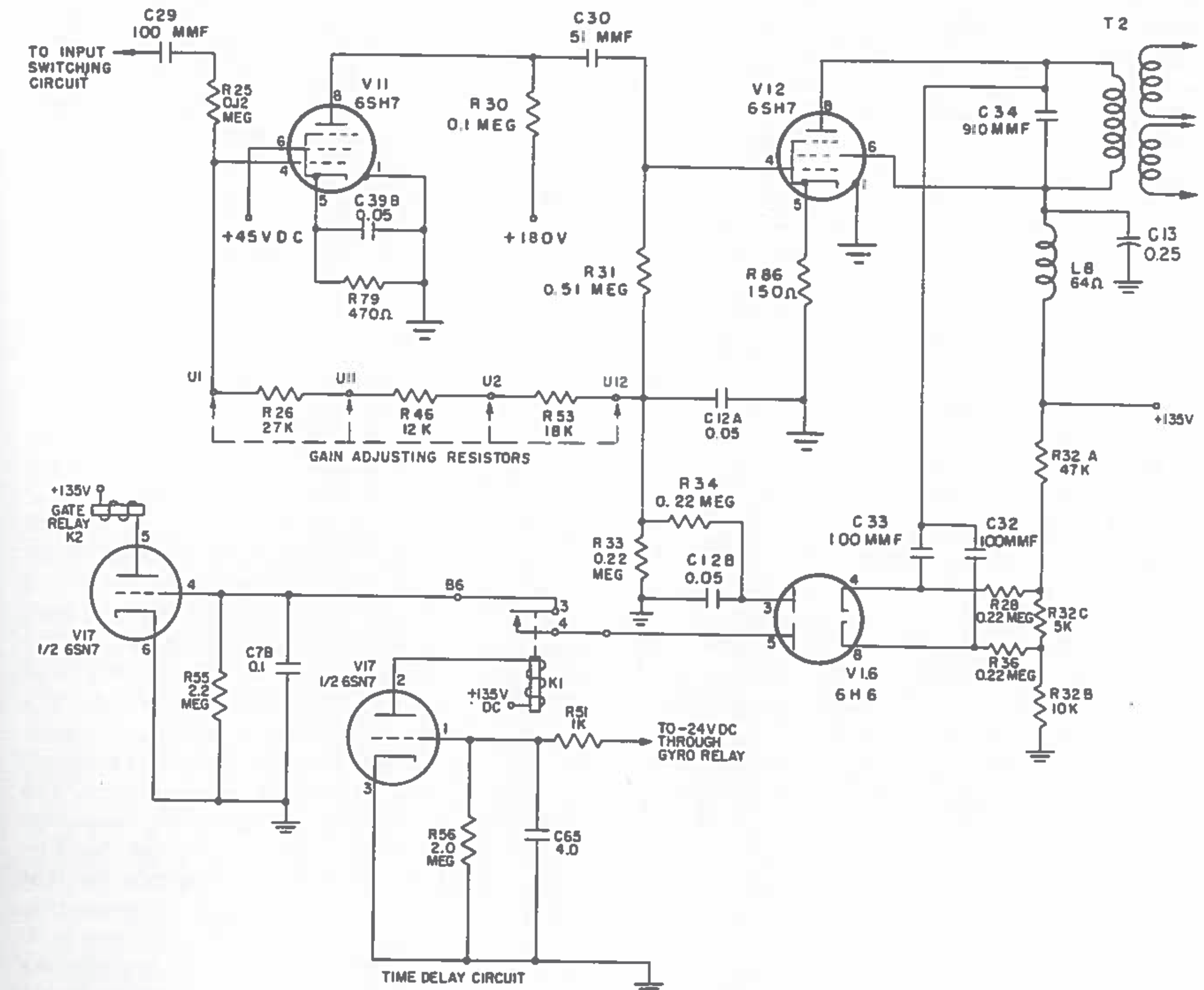

Figure 42—AC Amplifier Circuit (Vertical) and Gate Relay Circuit.

C7B, thus producing a negative bias between the grid and cathode of a triode which is one half of vacuum tube V17. (The other half of vacuum tube V17 is in the time delay relay circuit.) When the triode is given a sufficiently negative bias, it cuts off and releases gate relay K2. The changes caused by this release of the gate relay are described in the explanation of the vertical bridge circuit.

The time delay circuit is provided to prevent release of the gate relay for 15 seconds after the torpedo is enabled. This is done to give the acoustic circuit sufficient time to stabilize after the acoustic disabling voltage is removed, thereby keeping the torpedo from making excursions in depth immediately after enabling occurs. The time delay relay K1, keeps the plate circuit of the lower diode of V16 open until the relay is operated by the plate current of one triode section of vacuum tube V17. After the torpedo is fired, the −24-volt supply is connected to the grid of vacuum tube through the contacts of gyro relay K8. This grid voltage biases the vacuum tube past the cut-off point. Since the tube is cut off, no plate current flows and relay K1 is de-energized. The −24-volt supply also charges 4.0-microfarad capacitor C65.

When the gyro relay releases at the instant enabling occurs, the −24-volt supply to the grid of the vacuum tube is interrupted. However, the vacuum tube will not conduct until most of the initial charge on capacitor C65 has leaked off through 2.0-megohm resistor R56. The time constant of the circuit is such that approximately 15 seconds elapse before the voltage on the grid of the vacuum tube decreases to a value at which the plate current is sufficient to operate relay K1.

Vertical Differential Detector Circuit. The action of the vertical differential detector circuit is the same as that of the horizontal differential detector circuit. The vertical differential detector circuit is shown in figure 43.

Vertical Bridge, Gate, Trigger, and DC Amplifier Circuit. The complete vertical bridge circuit, the DC amplifier circuit, the gate circuits, and the related circuits concerned with vertical steering are shown in figure 43.

The action of the bridge circuit, DC amplifier, vertical steering relay K4, and the elevator follow-up potentiometer are similar to that of the corresponding circuits in the horizontal channel. Immediately after the torpedo enables, it remains at its set running depth and searches in a circle at that depth. If the torpedo is operating in the below limit condition, or is below a depth of 85 feet in the no limit condition and it starts to home on a target in bearing, it will remain at its set running depth until the signal received in the vertical hydrophone is sufficient to develop a differential across resistor R58, thus causing the torpedo to leave its running depth as it starts to buck hydrostatic depth and pendulum control. When the signal level is high enough to de-energize the gate relay K2 as previously explained, gating will occur and vertical control of the torpedo will be entirely acoustic. If the torpedo is operating in above limit condition, or is attacking a target shallower than 85 feet in no limit condition, gating cannot occur because of the action of stratum switch S2 which is positioned as shown in figure 43 at depths less than 85 feet. In these conditions, the differential developed across resistor R58 will be bucked by the signal resulting from the displacement of the depth and pendulum potentiometers.

In the above limit condition, relay K2 performs the function referred to as triggering. In this condition relay K9 is energized through the stratum selector switch so that relay contacts 11 and 12 are closed. Before the gate relay releases, contacts 4 and 5 of this relay are also closed with the result that resistor R58, across which the acoustic signals are developed, is shorted out. This means that the signals from the vertical hydrophones can have no effect on vertical steering until the vertical signal is strong enough to cause release of relay K2. This feature is incorporated so that the torpedo will not steer in depth during above limit operation before the level of the acoustic signal indicates close proximity to the target, thus reducing the tendency of the torpedo to broach when running near the surface.

The differential voltage produced across resistor R58 is impressed on the grid of the first DC amplifier stage, vacuum tube V14. The vertical DC amplifier is exactly the same as the horizontal DC amplifier. The polarities in the detector and DC amplifier circuits are such that the production of an up differential (as a result of a stronger signal from the up hydrophone than from the down hydrophone) creates a potential at terminal U16 which is negative with respect to the potential at terminal U6. This negative potential, when added to the bias normally present on the grid of vacuum tube V14 when the bridge is in balanced condition, causes vacuum tube V14 to cut off. The consequent increase in grid voltage on vacuum tube V15 causes vacuum tube V15 to conduct the saturation current. The flow of current through steering relay K4 causes the relay to operate so that power is supplied to the up winding of the steering motor. When relay K4 is released, power is supplied to the down winding of the steering motor. Operation of the steering motor moves the slider on the elevator follow-up potentiometer until the voltage produced by the potentiometer at terminal U6 is equal in amplitude to, and opposite in polarity from, the voltage produced across resistor R58 by the acoustic signal. The elevators then hunt about this position in a manner similar to that described for the rudder. If the torpedo has gated, it is entirely under acoustic control, and the elevator action just described will cause the torpedo to point directly at the source of the sound, oscillating as it travels about the cross-over point of the patterns for the vertical hydrophones, figure 25.

As shown in figure 43, the sliders of the depth potentiometer and pendulum potentiometer are connected to ground through the gate relay K2

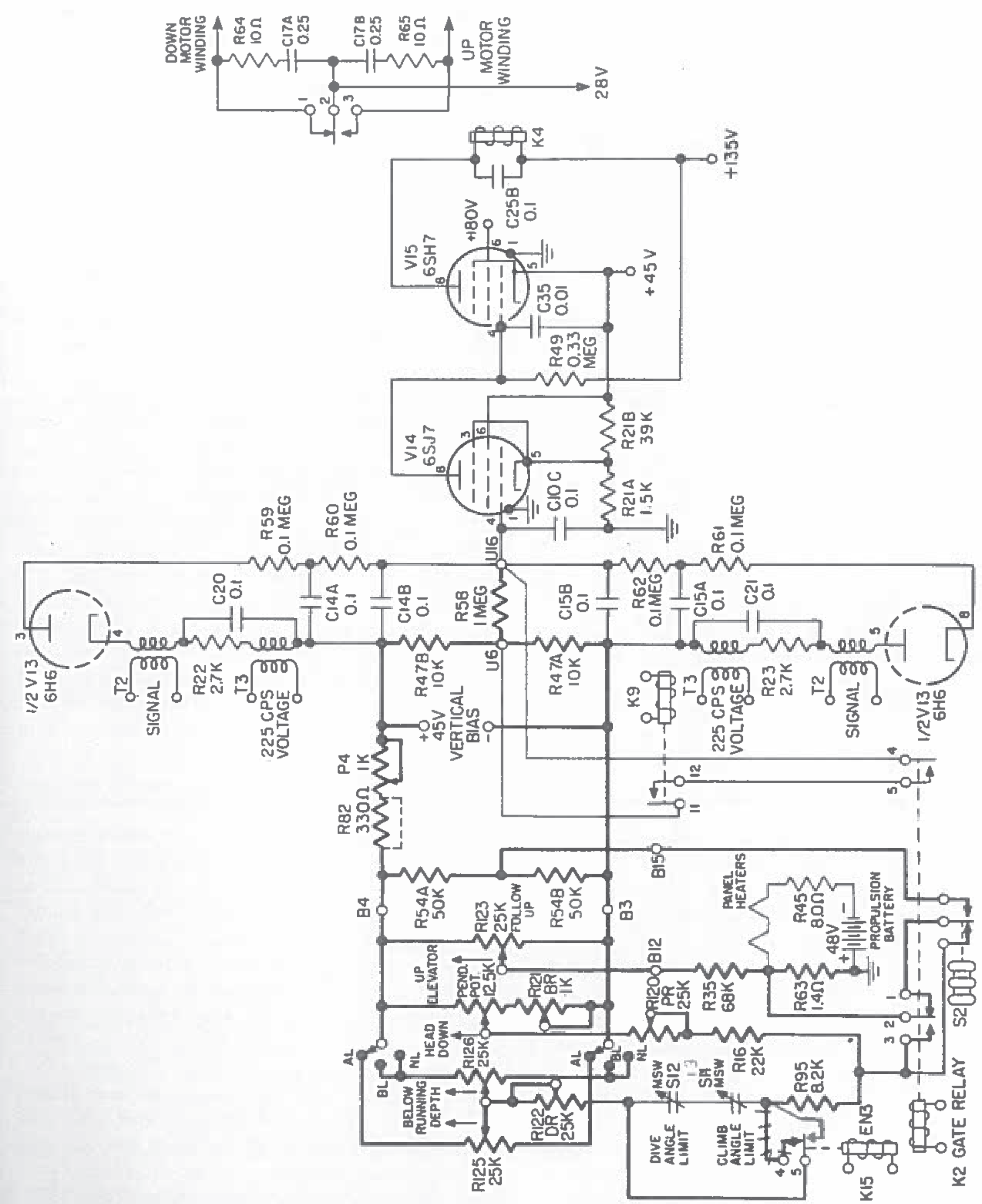

Figure 43—Bridge, Gate, Detector, and DC Amplifier Circuits (Vertical).

when the relay is energized. When the gate circuit operates and causes the release of relay K2, and when the torpedo is at a depth of more than 85 feet so that swinger of stratum switch S2 is connected to terminal B15, the sliders of the depth potentiometer and pendulum potentiometer are disconnected from ground, making these controls inactive. In its released position, relay K2 then connects the midpoint of resistors R54A and R54B to ground. The function of the depth and pendulum controls and the related adjustments are explained in chapter 6.

Steering Stiffness. The number of degrees of rudder or elevator movement caused by the differential circuit potential when 1 db of differential exists is called the "stiffness" of the rudder or elevator. Both the rudder controls and elevator controls are designed for a steering stiffness of approximately 5 degrees per db.

The term "stiffness" is also used in connection with the various vertical controls. In the case of the depth potentiometer, approximately 1.5 degrees of elevator deflection is caused by a change in the depth (from the running depth) which results in a one psi pressure change. Therefore, the stiffness of the depth control is 1.5 degrees per psi. When the torpedo tilts one degree, the pendulum potentiometer causes an elevator deflection of from 1.3 to 1.7 degrees. Therefore, the stiffness of the pendulum control is approximately 4 degrees per degree of tilt.

Pendulum stiffness action is limited to 20 degrees from horizontal. Depth stiffness action is limited to 69 psi.

Chapter 6

POWER CIRCUITS AND CONTROL DEVICES

Introduction

This chapter describes the control devices used in Torpedo Mk 27 Mod 4 and explains the function of the related control and power circuits. These explanations are concerned only with the nonacoustic circuits. The function of the acoustic circuits is explained in chapter 5, and the basic acoustic theory applicable to these circuits is explained in chapter 4.

The nonacoustic controls of the torpedo include gyro control, hydrostatic depth and pendulum control, stratum control, and the general switching and power circuits. The circuits related to each of these controls are explained in this chapter with the aid of simplified schematic circuit diagrams. These diagrams are derived from the complete schematic diagrams, included in the supplementary data of this publication, which show the circuits of the control panel, battery compartment, and afterbody. Tables 4 and 5 at the end of this chapter list the symbol number and function of every relay and switch in Torpedo Mk 27 Mod 4.

After the torpedo is fired, the electrical power required for operating all of the control circuits is supplied by the propulsion battery. The propulsion battery also supplies the power for prerun tests. While the torpedo is in the tube prior to launching, the power required for the warm-up circuit and fire relay are supplied by the fire control system. This power is supplied from shipboard sources so as not to deplete the propulsion battery of the torpedo. The fire control system supplies the power inputs shown in table 3.

Torpedo Mk 27 Mod 4 can be fired only from submarines equipped with Fire Control System Mk 101, Fire Control System Mk 106, or Test Set Mk 183 Mod 1. These fire control systems include the elements necessary for electrically setting gyro angle, enabling range, and the choice of stratum, and provide the power inputs required for the warm-up circuit and fire relay. The electrical connections between the fire control system and the torpedo are made by means of a special cable assembly which plugs into the torpedo shell connector located in the lower port side of the torpedo.

Table 3—Torpedo Power Inputs Supplied by Fire Control System

CIRCUIT	VOLTAGE	CURRENT (amp.)
Warm up	24 volts DC	12.0
Fire relay	115 volts AC (60 cps)	3.0

NOTE: When using Fire Control System Mk 101 or Mk 106, warm-up and setting voltages are applied to the torpedo when the relay-transmitter OFF-STANDBY-ON switch is in the ON position. When using Test Set Mk 183 Type, warm-up and setting voltages are applied when the test set switch is in the STANDBY position.

Test Set Mk 183 Mod 0 is a special electrical setting instrument incorporating circuits equivalent to those portions of Fire Control System Mk 101 or Mk 106 which are directly related to Torpedo Mk 27 Mod 4. This test set is used for testing the torpedo in the workshop and can be used for the electrical setting, warm-up, and firing of the torpedo in proofing or exercise runs. Test Set Mk 183 Mod 1 is Test Set Mk 183 Mod 0 placed in a special case so that it can be lowered through a submarine hatch.

Gyro Control

The gyro determines the direction in which the torpedo runs before the torpedo is enabled and can acoustically locate and attack targets.

Purpose of Gyro. The purpose of the gyro is to steer the torpedo along a straight-line course directed toward the estimated or computed position of a specific target. The gyro may be set for angle shots so that the torpedo will take any desired course within 135 degrees either side of the direction in which it is launched. If the torpedo turns more than 135 degrees from the direction in which it is launched, either because the gyro is inadvertently set for too great an angle or for any other reason, the gyro actuates an anticircling run (ACR) device. This device protects the firing ship by deenergizing all control circuits, the torpedo exploder, and the propulsion motor so that the torpedo stops its run and sinks. The length of a normal gyro run is determined by the enabler setting. After the torpedo has run the preset distance, the enabler disconnects the gyro control and activates the acoustic controls.

Function of Gyro. The gyro is actually the rotor of a high-speed DC motor. This rotor is supported in a universal mounting consisting of an inner gimbal and an outer gimbal, figure 44. Before the gyro is started, the gimbals are held by a caging mechanism so that the rotor axis is horizontal and the fore-and-aft gimbal axis points in the direction of the longitudinal centerline of the torpedo. During the warm-up period before firing, the gyro motor is energized so that the gyro comes up to operating speed. When the torpedo is fired, the gyro caging mechanism is unlatched and the gyro is then supported freely by the gimbals. The high speed and inertia of the rotor cause the gyro to maintain a fixed angular position in space, regardless of how the rest of the torpedo turns. This property of the gyro is used to steer the torpedo as follows:

The gyro contact disc above the gyro has one continuous contact ring and another ring split into two parts. Mounted on the outer gyro gimbal is a slider with two prongs. One prong touches the continuous contact ring. When the other prong touches either of the segments of the split ring, it establishes electrical continuity between the segment and the continuous contact ring. The continuity is broken when the prong for the segments is in the space between the segments. This arrangement of contacts is shown in figure 44.

Before the torpedo is fired, the desired course is set by rotating the gyro contact disc to some definite angle. This setting is made electrically by means of a servo motor controlled by synchros.

To illustrate the relationship between the contacts figure 45A shows the condition for a starboard angle shot. After the torpedo is fired, and the steering circuit becomes operative, the electrical contact with the starboard segment causes the rudders to be deflected to starboard. Since the contact disc is fixed to the torpedo and the slider (which is mounted on the gyro) remains fixed in space, the opening between the segments moves toward the slider as the torpedo turns. The torpedo continues to turn until the opening passes the slider and the port segment is contacted, figure 45B. This causes the rudders to be deflected to port thus tending to turn the torpedo back to port. However, as soon as the torpedo turns slightly to port, the starboard segment is again contacted and the torpedo turns back to starboard. This process repeats continuously so that the torpedo oscillates slightly about the heading at which the slider is centered between the segments.

If the torpedo should turn more than 135 degrees either side of the direction in which it is launched, the ACR segment, which is fixed to the torpedo, will touch the ACR contact, which is fixed to the outer gimbal of the gyro, figure 44. The electrical continuity thus established between the contact and the segment actuates a relay which completely deenergizes the torpedo.

Gyro Contact Circuits. The contact circuits of the gyro and their relationship to the circuits of the torpedo are shown in figure 46.

The gyro contacts and gyro motor are supplied with −24 volts DC through the contacts of enabler relay K15. This voltage is supplied through the contacts of the start relay (ST2) K14. A 0.001-mfd capacitor across the brushes of the gyro motor bypasses the commutator noise of the motor to ground. The gyro contacts control the application of the −24-volt DC supply to the gyro right relay (GR) K18 and the gyro left relay (GL) K19. When either of these relays is operated, it causes an unbalance in the horizontal bridge circuit and thus causes the torpedo to steer in the required direction.

The ACR segment is supplied with −24 volts DC through the contacts of the start relay (ST2) K14 and the winding of ACC relay K10. If during the gyro run, the torpedo turns more than 135 degrees from the tube line, the ACR contact touches the segment and completes the −24-volt

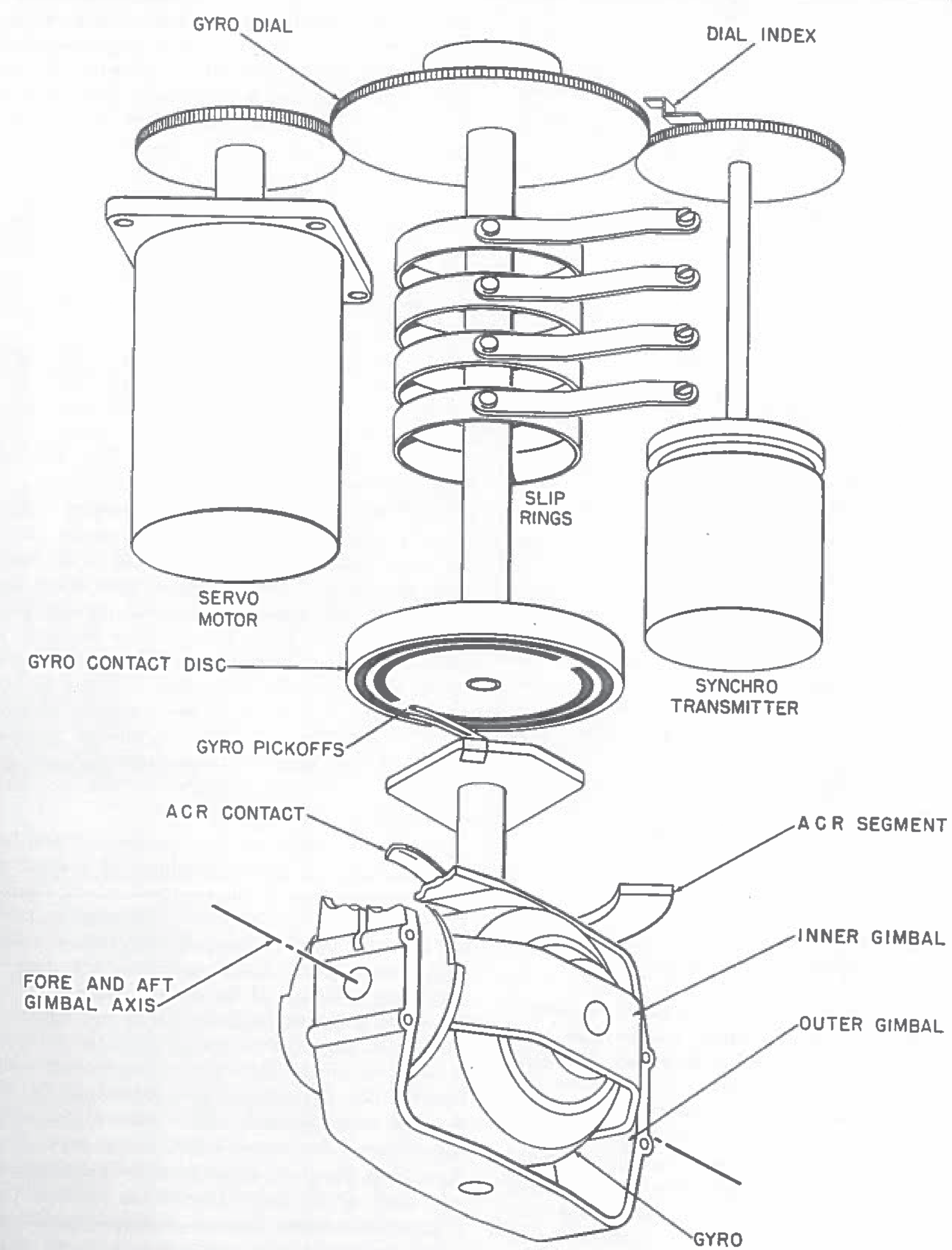

Figure 44—Gyro Mechanism and Contacts (Pictorial).

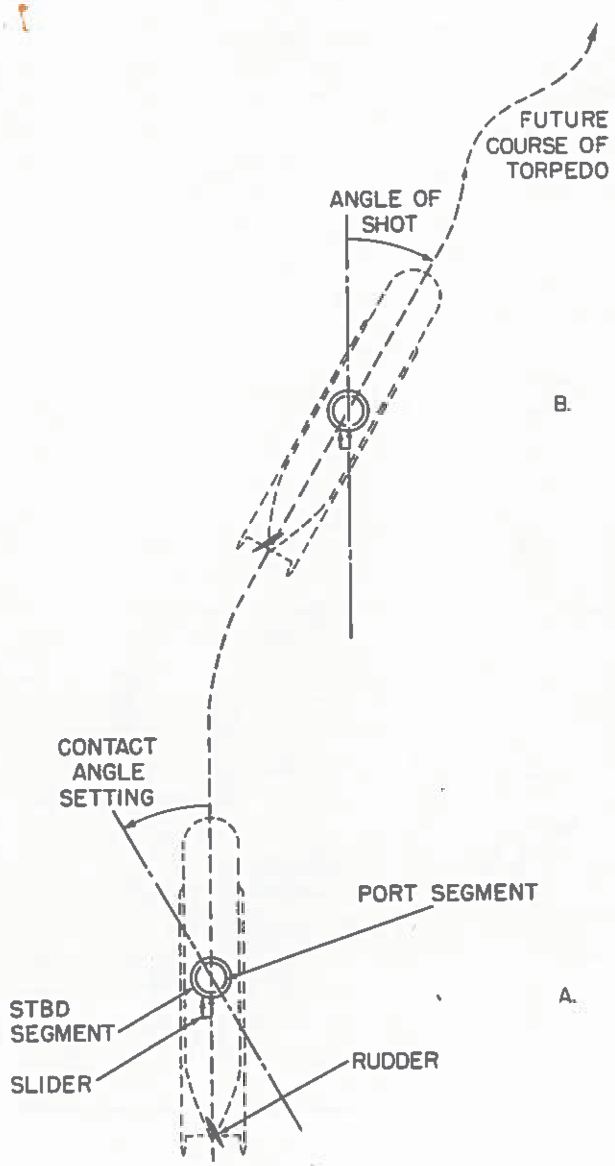

Figure 45—Function of Gyro Contacts in a Starboard Angle Shot.

circuit through the ACC relay winding to ground. The operation of this relay de-energizes start relays (ST1) K6 and (ST2) K14 and thus completely de-energizes the torpedo.

The active gyro unlatch contacts are used to uncage the gyro at the instant of firing. They are also used to initiate the start sequence of the torpedo whereby operative power is transferred from external to internal power. When fire relay K13 closes, —24 volts DC is supplied through gyro unlatch contacts to gyro unlatch magnet. The magnet actuates the gyro caging arm to unlatch the gyro and simultaneously opens the gyro unlatch contacts so that the unlatch magnet remains de-energized for the remainder of the run. At the same time, the unlatch contacts also remove ground from the ACC relay K10 thereby deactivating ACC relay. The deactivation of the ACC relay causes the external —24 volts DC to be supplied to the start relays (ST1) K14 and (ST2) K6 which upon activation transfer external power to internal power for running the gyro and locking in the relays. The gyro is recaged by manual operation of the caging arm before the next firing.

Gyro Setting Circuit. Figure 47 shows the control circuit used for setting the initial angle between the gyro contact disc and the slider. The setting is made electrically by means of a synchro-controlled servo system. The control circuit functions as follows:

Function of Synchros. The synchro transmitter is geared to the servo motor, gyro contacts, and gyro dial. The dial is adjusted to the contacts so that the dial reading is zero when the slider is in the space between the contact segments with the gyro caged. The synchro is adjusted so that it produces an electrical zero signal when the dial reads zero. (Refer to OP 1303 for an explanation of the operation of synchros.) The electrical signal produced by the stator of the synchro transmitter defines the angle by which the contacts are rotated with respect to the slider.

The stator signal of the synchro transmitter is applied to the stator windings of a synchro control transformer in the electrical setting equipment used with the torpedo. The angular position of the synchro control transformer rotor with respect to its stator represents the desired gyro angle setting. If the setting represented by the signal received on the stator is not equal to the desired gyro angle represented by the position of the rotor, the synchro control transformer rotor produces an AC signal. The magnitude of the signal is proportional to the error, and its phase is determined by the direction of the error; that is, an error signal produced when the stator signal represents a gyro angle that is too small is 180 degrees out of phase with an error signal produced when the stator signal represents a gyro angle that is too great.

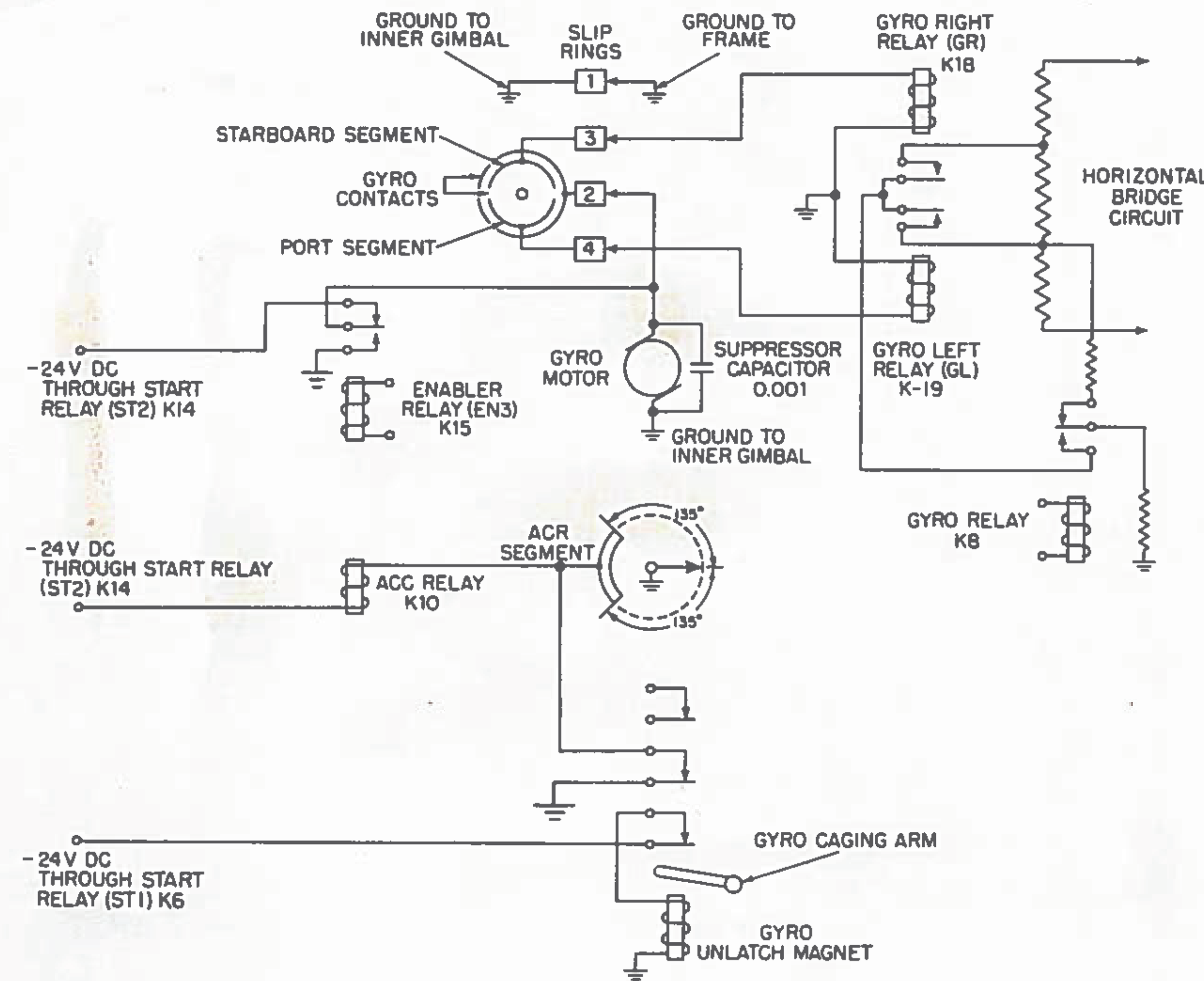

Figure 46 - Gyro Contact Circuit.

The error signal is amplified and is applied to the servo motor in the torpedo. The servo motor drives the contact disc in the direction required to remove the error. In other words, if the gyro angle setting in the torpedo is too small, the servo motor drives the contact disc to increase the angular displacement of the contacts with respect to the slider. This changes the synchro transmitter signal. The servo motor continues to drive until the synchro transmitter signal represents the gyro angle called for by the position of the synchro control transformer rotor. When this condition exists, the error signal has been reduced to zero and the servo motor stops. The angular displacement between the contacts and the slider is now equal to the gyro angle called for by the synchro control transformer.

Damping. The error signal circuits in the electrical setting equipment include a resonant damp circuit and a filter circuit in addition to the servo amplifier.

The resonant damp circuit develops a voltage which is approximately proportional to the rate of change of the error signal. This voltage prevents the system from overshooting and helps the system to follow immediately when gyro angle order changes.

When the system is approaching synchronism, the error signal decreases. The resonant damp circuit then produces a voltage which bucks the

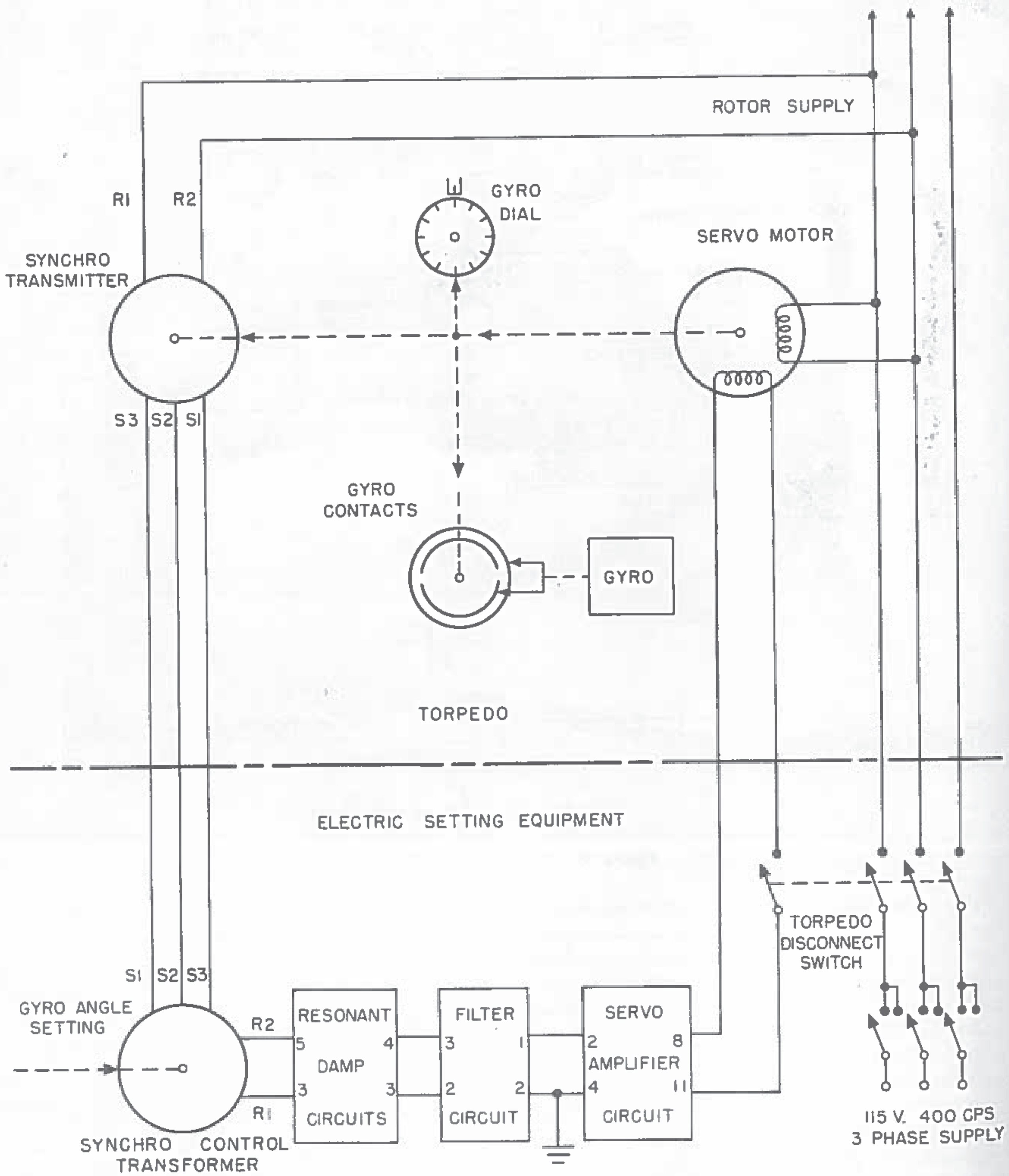

Figure 47—Gyro Setting Control Circuit.

error signal and thus applies a braking action which causes the servo motor to slow down and stop at the synchronous position. If this braking action did not occur, the motor would tend to coast past the synchronous position. When the gyro angle order is changed rapidly, the system tends to lag, and this results in an increasing error signal. The resonant damp circuit then produces a voltage which aids the error signal and thus applies a greater torque which causes the servo motor to speed up and reduce the lag.

The filter circuit suppresses the 800-cps second harmonic contained in the 115-volt 400-cps supply voltage. This filter circuit is necessary because the second harmonic may be strong enough to saturate the system if it is not eliminated.

Gyro Steering Circuit. The gyro steering circuit, figure 48, consists of the gyro contacts, relays K18 and K19 controlled by the gyro contacts, the bridge circuit, DC amplifier circuit, and horizontal steering relay K3. The bridge circuit, DC amplifier circuit, and steering relay are common to both gyro steering and acoustic steering. The operation of these circuits under gyro control is described in the following paragraphs. Their operation under acoustic control is described in chapter 5.

The circuit in figure 49 is a simplified representation of the gyro steering circuit arranged to emphasize the bridge configuration. Since resistors R44A and R44B are equal in value, they are balanced with respect to the 45-volt DC bias supply. Therefore, the bridge balance depends on the setting of balance potentiometer P3, on the position of the rudder followup potentiometer, and on the connection made by the gyro contacts.

Balance potentiometer P3 is adjusted so that the rudder angle resulting from closing of the starboard gyro contact is equal in magnitude to the rudder angle resulting from closing of the port gyro contact. In other words, potentiometer P3 is set so that if neither gyro contact were closed and the position of the rudder followup potentiometer corresponded to zero rudder angle, steering relay K3 would be at the borderline between operate and release. That is, the voltage at terminal H6, after passing through the DC amplifier, would just operate, or very nearly operate, the steering relay. However, under actual operating conditions, this situation is never obtained because one gyro contact or the other will be closed. The resulting unbalance will hold the steering relay either in the operated condition (causing starboard rudder) or in the released condition (causing port rudder).

If during the gyro run the torpedo turns to the left of the preset gyro course, the starboard gyro contact will close. This operates the gyro right (GR) relay which connects the junction of resistors R97 and R98 to ground. The resulting unbalance in the bridge circuit causes relay K3 to be operated, thus producing a starboard rudder angle. If the torpedo turns to the right of the preset course, the port gyro contact will close. This operates the gyro left (GL) relay which connects the junction of resistors R98 and R99 to ground. The resulting unbalance in the bridge circuit causes relay K3 to release, thus producing a port rudder angle.

In either case described in the preceding paragraph, the steering motor rotation producing the rudder deflection also produces a movement of the slider of the rudder followup potentiometer. This slider motion is in the direction necessary to compensate for the unbalance resulting from the operation of the gyro left relay or gyro right relay. The rudder angle increases until the balance change produced by the rudder followup potentiometer is equal and opposite to the unbalance produced by operation of the gyro left relay or gyro right relay. At this point, the bridge circuit is balanced and steering relay K3 is at the borderline between operate and release. Actually, the rudder motor will run slightly beyond this point and the rudder followup potentiometer will move past the balance position. This unbalances the bridge circuit in the opposite direction and causes the steering motor to reverse. The motor then again runs slightly beyond the balance point. The reversing of the steering motor continues so that the rudder oscillates with an amplitude of one or two degrees about a position approximately eight degrees off center. This condition remains the same as long as the same gyro contact remains closed.

As a result of the eight-degree average rudder angle produced by the closing of one of the gyro contacts, the torpedo corrects its course. Actually, the torpedo turns slightly past the correct course so that the opposite gyro contact closes. This causes the steering motor to drive the rudder past center to the opposite side where it again

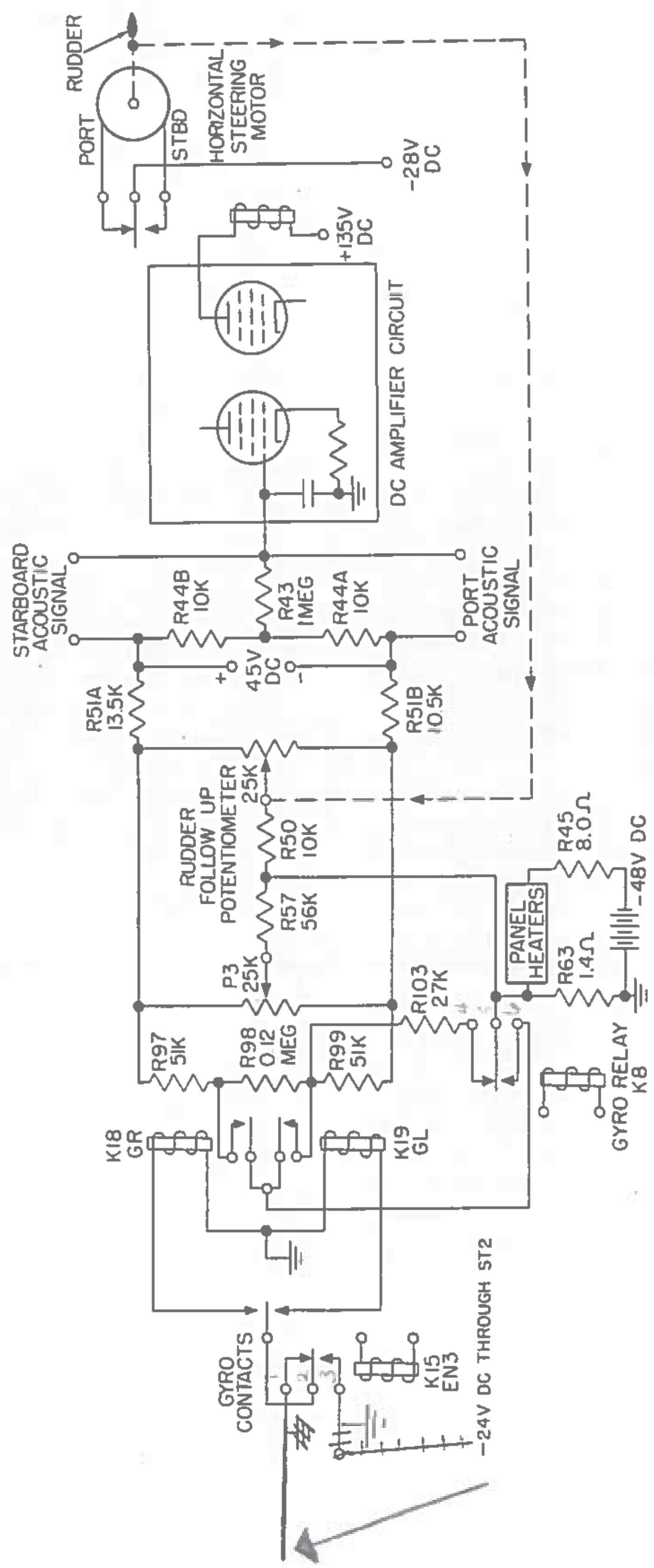

Figure 48—Gyro Steering Circuit.

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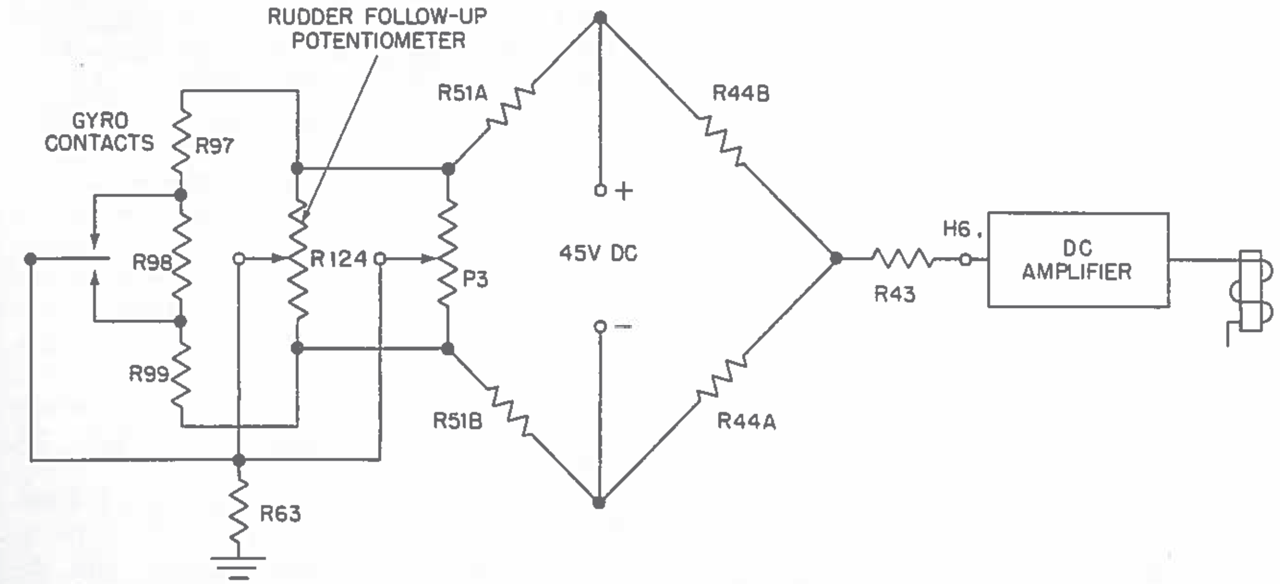

Figure 49—Horizontal Bridge Circuit (Simplified).

oscillates momentarily about a position eight degrees off center. This rudder angle steers the torpedo back toward the correct course. The torpedo again turns slightly past the correct course and the rudder again reverses. This action continues throughout the gyro run so that the actual course of the torpedo is a wavy line about the desired course, figure 50.

Horizontal Steering Motor Circuits. The circuits directly associated with the horizontal steering motor are shown in figure 51. The application of the —28-volt DC supply to the motor is controlled by horizontal steering relay K3. When relay K3 is operated, the voltage is applied to the starboard winding of the motor through starboard limit switch S9. The limit switch is operated when the starboard rudder angle reaches 22 degrees, just before the positive limit stop is engaged. The switch disconnects the —28-volt supply from the starboard winding and applies it to the port winding, thus reversing the motor. As soon as the rudder angle reduces to less than 22 degrees, the motor again reverses. The result of this action is that the rudders oscillate about the 22-degree position. The port limit switch S8 functions in a similar way when steering relay K3 is in the released condition. The resistance-capacitance networks across the contacts of relay K3 and of the limit switches suppress arcing at the contacts.

In normal operation, the limit switches do not operate during the gyro run, but only come into effect when the hydrophones receive a very strong acoustic signal. During the gyro run, a rudder angle greater than eight degrees is an abnormal condition and may tend to produce a circling run with consequent danger to the firing vessel. To minimize this possibility, a cam is provided on the steering motor to disconnect the —24-volt supply to the main motor relay if the rudder angle exceeds 17 degrees during the gyro run. This deenergizes the propulsion motor until the rudder angle reduces to less than 17 degrees. If the rudders are jammed or for any other reason do not return to a smaller angle, the propulsion motor remains de-energized. The 17-degree cutout switch S10 is bypassed at the end of the gyro run when gyro relay K8 is released.

Hydrostatic Depth and Pendulum Control

The hydrostatic depth and pendulum mechanisms control the depth at which the torpedo runs.

Purposes of Hydrostatic Depth and Pendulum Devices. The hydrostatic depth and pendulum mechanisms perform several functions related to the control of depth and vertical steering.

Before enabling, vertical steering is completely under control of the hydrostatic depth and pendulum mechanisms. In above limit operation,

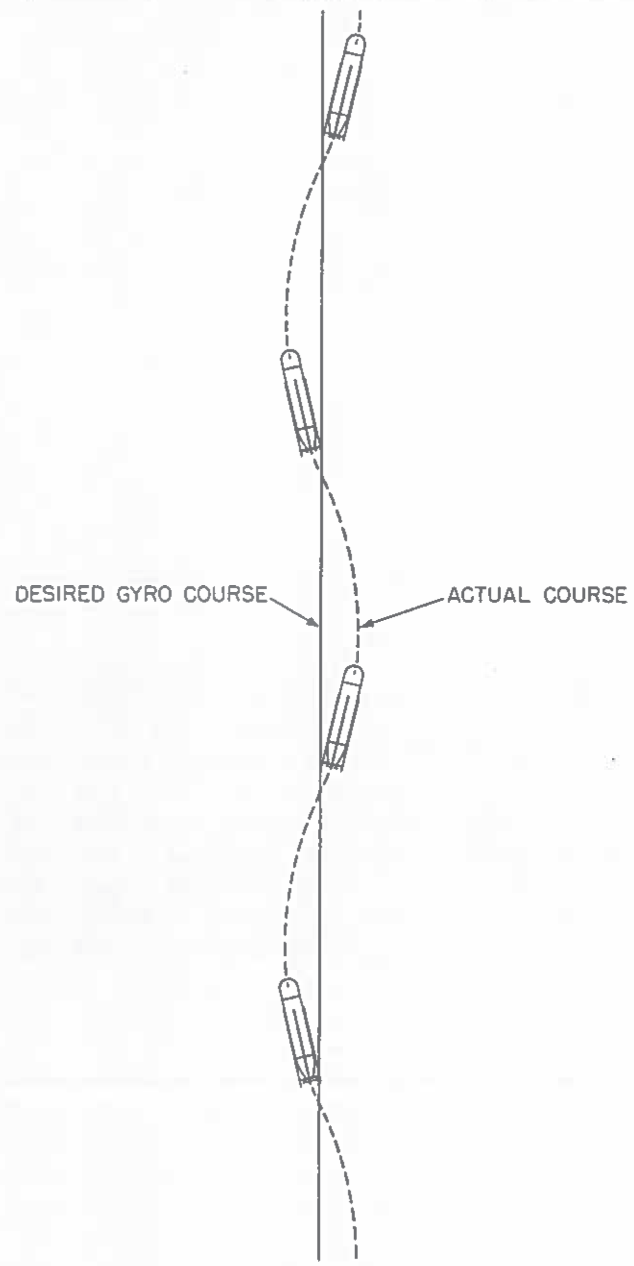

Figure 50—Gyro Course of Torpedo.

the hydrostatic depth mechanism causes the torpedo to seek a depth of 70 feet and then to maintain this depth. In below limit or no limit operation, the hydrostatic depth mechanism causes the torpedo to seek and maintain a depth of 125 feet. In all of these operating conditions, the pendulum mechanism stabilizes vertical steering by tending to keep the torpedo level. Without this stabilizing effect, the torpedo would tend to overshoot the desired running depth and would follow a path similar to that shown in figure 52. The action of the pendulum mechanism reduces the amplitude of the depth variation so that the torpedo runs at an approximately constant depth.

After enabling, the hydrostatic depth and pendulum mechanism retain control of vertical steering until the vertical hydrophones receive a target noise of sufficiently high level. In below limit operation, or in the no limit operation, the torpedo "gates" when it is below an 85-foot depth and the noise level received by the hydrophones is high enough to operate the gate circuit. This circuit then disconnects the hydrostatic depth and pendulum controls and leaves the torpedo in full acoustic control.

In the above limit operation, or when the torpedo is above an 85-foot depth in no limit operation, the gate circuit cannot operate and the hydrostatic depth and pendulum controls remain active. Therefore, the acoustic control must buck hydrostatic depth and pendulum control. This bucking action prevents the torpedo from steering sharply upward and tending to broach if it should attempt to attack the image of the target noise which is reflected from the surface.

Depth Control Unit. The depth control unit, figure 53, consists of a depth bellows loaded by the depth spring, and two potentiometers operated by the depth bellows through a gear sector arm and gear train. The ceiling switch is operated by an arm attached to the sector arm.

When the torpedo is in the water, water pressure is applied to the depth bellows through tubing connecting the pressure inlet of the bellows to the depth vent of the torpedo. This pressure causes the bellows to expand against the depth spring. Since the water pressure depends on depth, the amount of bellows expansion is a measure of the torpedo depth. The expansion of the bellows moves the sector arm about the fixed pivot, and this motion is transferred through the gears to move the sliders of the depth potentiometers. The position reached by the potentiometer sliders for a given depth pressure can be adjusted by setting the depth spring adjusting screw to produce the required initial compression in the depth spring, and by individual adjustments to the cases of the potentiometers. These adjustments are made so that the potentiometer slider is at the electrical midpoint of the resistance when the pressure applied to the bellows corresponds to the

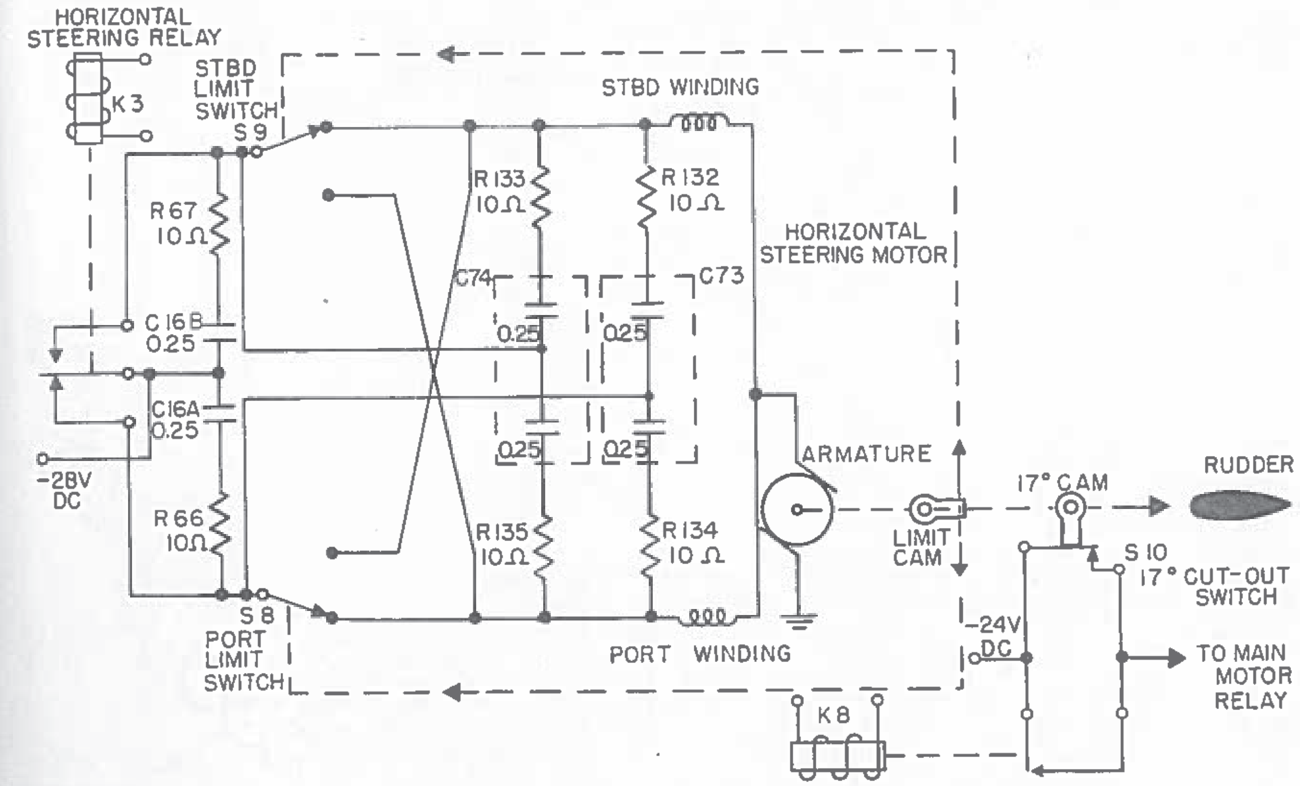

Figure 51—Horizontal Steering Motor Circuit.

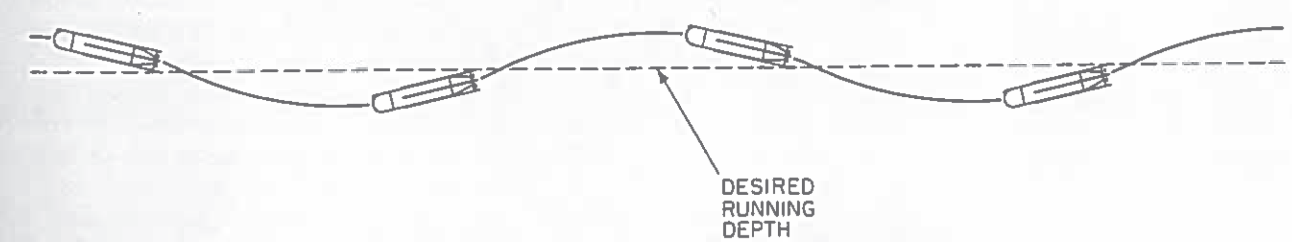

Figure 52—Depth Variation without Pendulum Control.

desired running depth. This depth is 70 feet for the "shallow" potentiometer and 125 feet for the "deep" potentiometer. The ceiling switch adjusting screw is set so that the switch operates at a pressure corresponding to a depth of 30 feet.

Pendulum Assembly. The pendulum assembly, figure 54, consists of a pendulum weight supported by a flexible spring steel suspension. Fastened to the pendulum weight is a contact which rolls along a curved resistance strip. The contact and resistance strip function as a potentiometer.

When the torpedo is level, the roller contact must be at the electrical midpoint of the resistance. This condition is obtained by adjusting a variable resistor connected in series with the resistance strip.

Hydrostatic Depth and Pendulum Steering Circuit. The hydrostatic depth and pendulum steering circuit, figure 55, consists of the depth potentiometers, pendulum potentiometers, the bridge circuit, DC amplifier, and vertical steering relay K4. The bridge circuit, DC amplifier circuit, and steering relay are common to both acoustic steering and depth and pendulum steering. The operation of these circuits under depth and pendulum control is described in the following paragraphs. Their operation under acoustic control is described in chapter 5.

The vertical bridge circuit is basically similar to the horizontal bridge circuit previously described, but differs from it in some details, particularly in the provisions for adjustment.

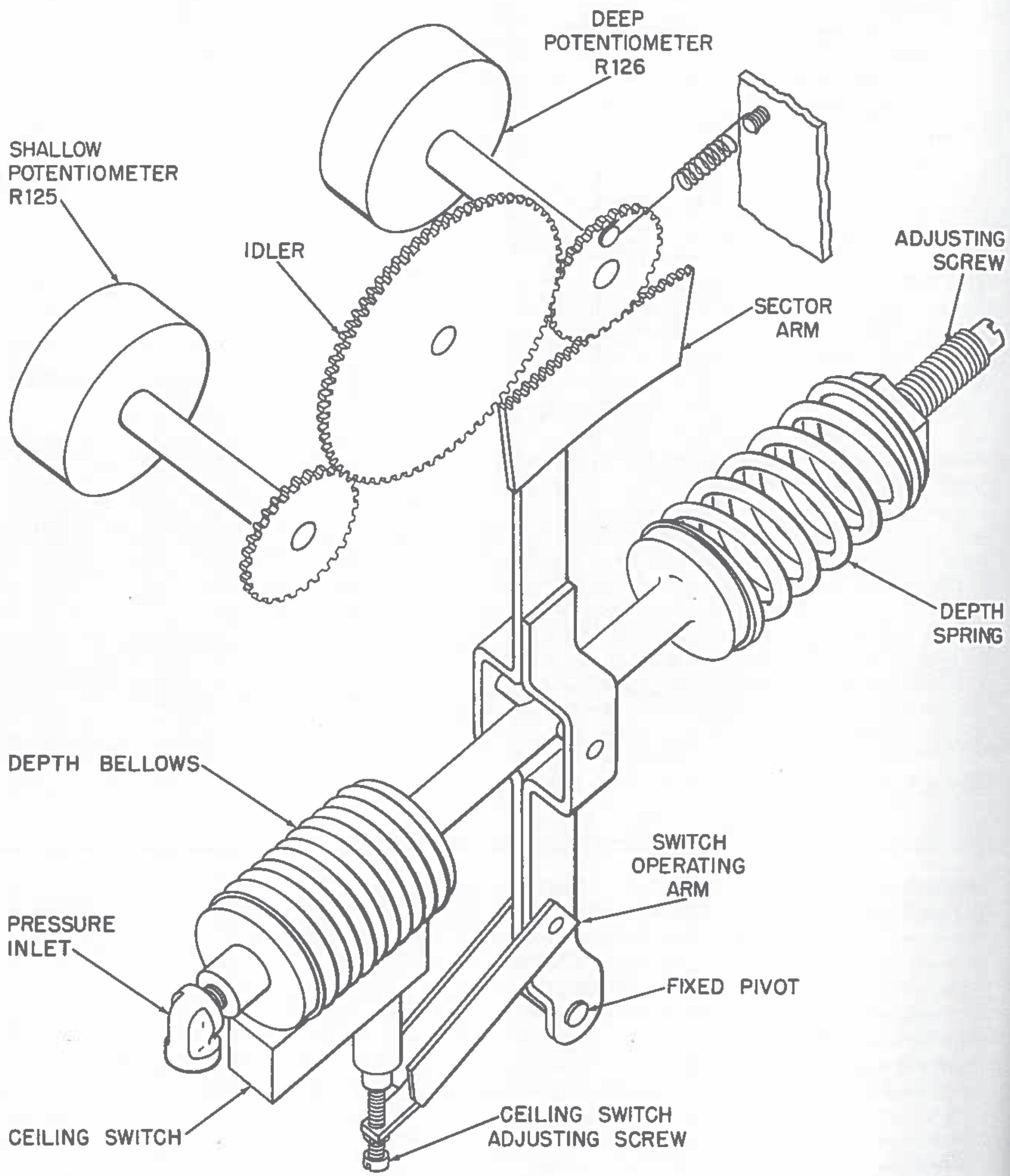

Figure 53—Depth Control Unit.

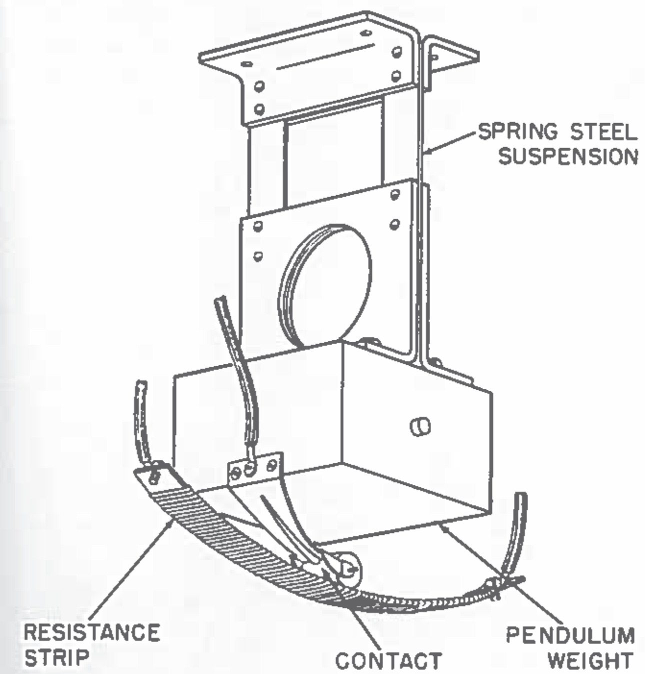

Figure 54—Pendulum Assembly.

The vertical bridge circuit does not include series resistors (such as resistors R51A and R51B in the horizontal bridge circuit) because a larger voltage drop is required across the elevator followup potentiometer. If the voltage drop across this potentiometer were the same as across the rudder followup potentiometer, the elevator stiffness would be too great because of the shunting effect of the depth and pendulum potentiometers and of compensating resistors R54A and R54B. That is, a greater movement of the elevator followup potentiometer slider would be required to produce a given voltage change at the grid of the DC amplifier input vacuum tube. To produce the same stiffness, the voltage across the potentiometers of the vertical bridge circuit must be approximately 36 volts as compared to approximately 16 volts for the horizontal bridge circuit.

The vertical bridge circuit is adjusted for balance by setting potentiometer P4 which affects the total resistance around the bridge rather than by varying the point at which the bridge is connected to ground. Resistor R82 in series with potentiometer P4 may be strapped as shown by the dotted line to increase the adjustment range of the potentiometer.

Potentiometers R122 (DR) and R120 (PR) are used to adjust the stiffness of the depth and pendulum controls. Potentiometer R121 (BR) is used to adjust the electrical zero of the pendulum potentiometer.

Torpedo Mk 27 Mod 4 has two depth potentiometers: R126 for a running depth of 125 feet and R125 for a running depth of 70 feet. In below limit operation or no limit operation, stratum selector relay K20 connects depth potentiometer R126 to the bridge circuit. In above limit operation, relay K20 connects potentiometer R125 to the bridge circuit.

The vertical bridge circuit is adjusted so that the voltage at the input to the DC amplifier is just great enough to hold vertical steering relay K4 at the borderline between operate and release when the torpedo is level, is near its preset running depth, and has its elevators centered. The depth control mechanism is adjusted so that the slider of potentiometer R126 is approximately at its electrical midpoint when the pressure on the bellows is 55 psi (corresponding to a running depth of 125 feet) and the slider of potentiometer R125 is at its electrical midpoint when the pressure on the bellows is 31 psi (corresponding to a depth of 70 feet). Pendulum balancing resistor R121 (BR) is adjusted so that when the torpedo is level, the contact of the pendulum potentiometer is at the electrical midpoint of the resistance branch formed by resistor R121 and the pendulum resistance strip.

If the pendulum contact moves off center as a result of a tilt of the torpedo, or if the slider of the active depth potentiometer moves off center as a result of an increase or decrease in depth from the set running depth, an unbalance is created in the bridge circuit. (Resistors R16, R35, and R95 in series with the potentiometer sliders keep the circulating currents at sufficiently low values to prevent one potentiometer from reacting on another when the sliders are off center.) The unbalance in the bridge circuit results in a change in potential at terminal U16 and consequently causes the vertical steering motor to run until the elevator followup potentiometer has developed an equal and opposite potential.

If the torpedo is at a depth greater than the set running depth of 70 feet or 125 feet, the slider of the active depth potentiometer moves toward the positive side of the 45-volt vertical bias supply. If the head of the torpedo is tilted downward, the contact of the pendulum potentiometer

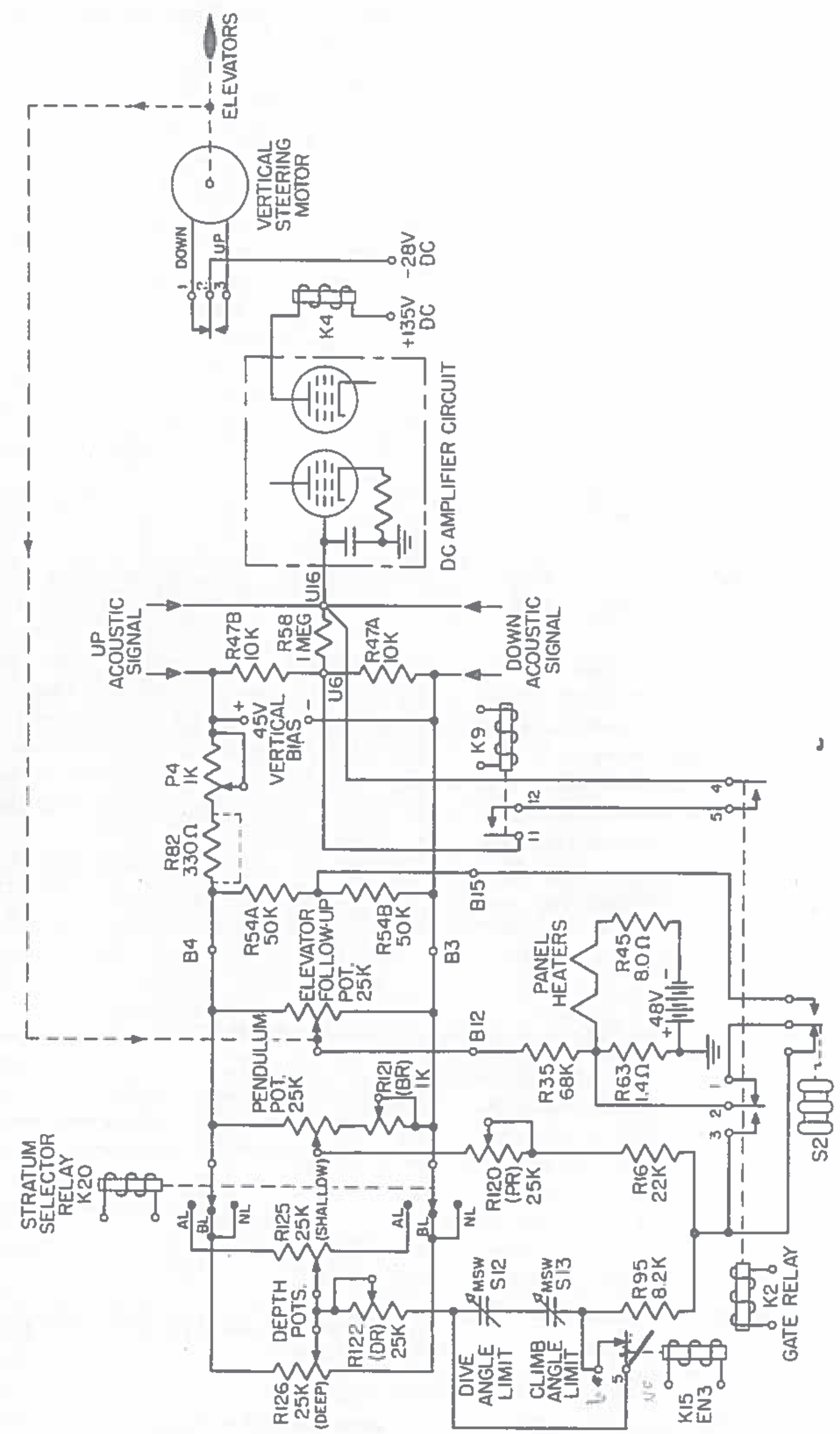

Figure 55—Hydrostatic Depth and Pendulum Steering Circuit.

also moves toward the positive side of the 45-volt vertical bias supply. Either of these potentiometer slider motions causes a negative potential at the grid of the input stage of the DC amplifier. This negative potential causes vertical steering relay K4 to be operated and thus causes the up winding of the vertical steering motor to be energized. As the motor turns in the up direction, the slider of the elevator followup potentiometer is moved toward the negative side of the 45-volt bias supply until the negative potential at the grid of the DC amplifier input stage is cancelled.

The function of the circuit of relay K2 is explained in chapter 5. If the torpedo is operating below a depth of 85 feet in either the below limit or no limit condition and the target noise is of a sufficiently high level, relay K2 is deenergized with the result that the connection to ground through resistor R63 is removed from the sliders of the depth and pendulum potentiometers, thus causing the depth and pendulum potentiometers to be inactive in controlling the torpedo. When this occurs the junction of resistors R54A and R54B is connected to ground through resistor R63. The resulting connection produces the same condition of balance in the bridge circuit as would be produced before gating if the depth and pendulum potentiometers were at their electrical midpoints. After gating occurs, the vertical steering circuit is entirely under acoustic control. The functioning of the bridge circuit under acoustic control is explained in chapter 5.

Figure 55 also shows that before enabler relay K15 is deenergized at the end of the gyro run, the ground connection of the depth potentiometer sliders is made through the climb angle limit switch S13 and the dive angle limit switch S12. These are mercury switches which are normally closed but will open if the climb or dive angle of the torpedo exceeds 10 degrees (±2 degrees). If either switch opens before enabling, the depth potentiometer control will be disconnected, leaving the pendulum in full control of vertical steering. The action of the pendulum potentiometer will then cause the dive or climb angle to decrease until it is within the allowable limits, at which time the depth potentiometer will again influence vertical steering. This feature has been included to prevent the torpedo from diving or climbing too steeply while seeking its running depth during the gyro run. After enabling occurs, relay K15 is deenergized, thus completing a circuit which bypasses the mercury switches.

Vertical Steering Motor Circuit. The vertical steering motor circuit is shown in figure 56. The application of the −28-volt DC supply is controlled by vertical steering relay K4. When relay K4 is operated, the voltage is applied to the up winding of the motor through up limit switch S7. When relay K4 is released, the voltage is applied to the down winding through down limit switch S6. The action of these switches and the associated arc suppressor circuits is the same as previously described for the limit switches of the horizontal steering motor.

Enabler

The enabler determines the distance that the torpedo runs under gyro control and hydrostatic depth and pendulum control before the torpedo becomes acoustically active and can locate and attack targets.

Purpose of Enabler. The purpose of the enabler is to permit the torpedo to run the distance necessary to bring it to the immediate vicinity of the estimated or computed position of a specific target. During its run toward this position, the torpedo is acoustically inactive so that it cannot attack the firing vessel or be distracted by noise from any other vessel. The distance run by the torpedo before enabling may be any value from 600 yards to 3100 yards as predetermined by an electrical setting made before the torpedo is fired. After the torpedo has run the preset distance, the enabler disconnects the gyro control and activates the acoustic controls.

Enabler Contacts. The basic element of the enabler is an electrical contactor consisting of an enabler contact segment, a limit contact split ring and five pickoff contacts. The arrangement of these parts is shown in figure 57. The disc on which the segment and split ring are mounted is driven by the propulsion motor through a gear reduction. Before the torpedo is fired, the pickoff disc is rotated by a servo motor until contact A is displaced from the end of the enabler segment by some definite angle. In this condition, both pickoff contacts touch the segment so there is electrical continuity between contacts A and B.

After the torpedo is fired, the propulsion motor rotates the segment disc, but the pickoff

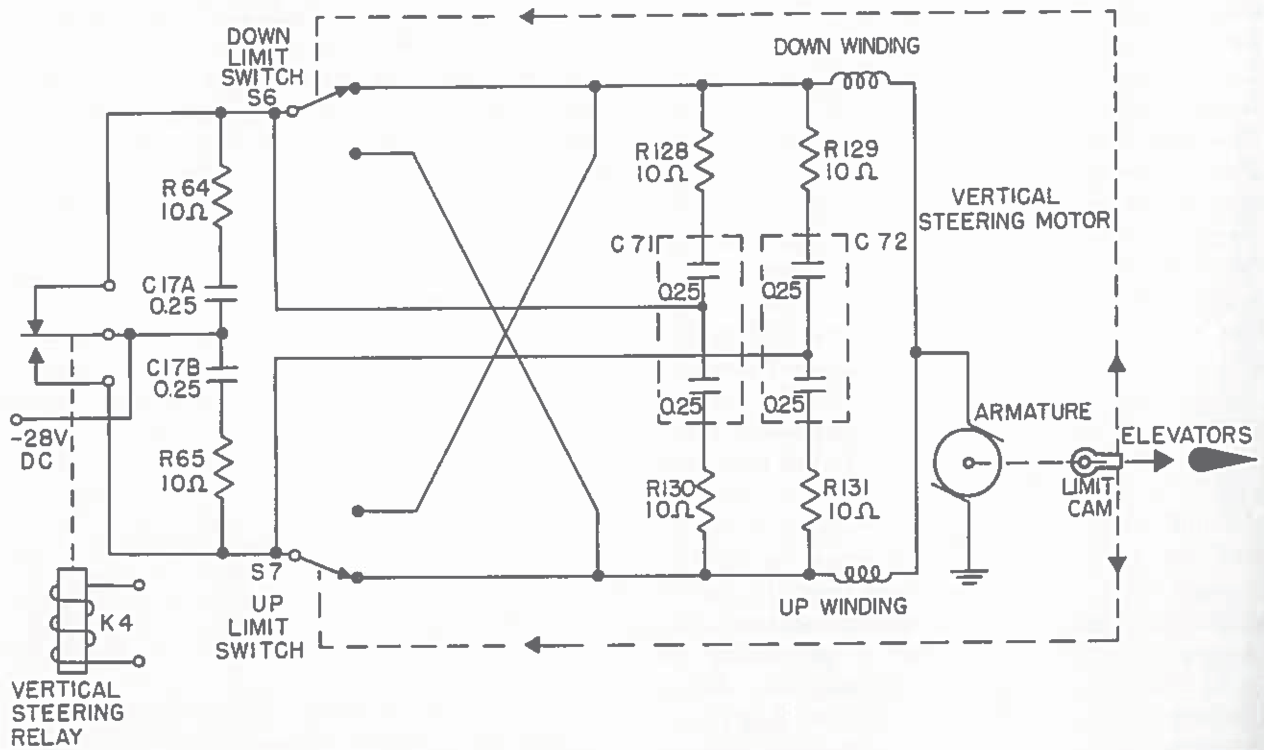

Figure 56—Vertical Steering Motor Circuit.

disc remains at its set position. Because of the large reduction ratio of the gearing, the segment disc rotates very slowly and the end of the segment gradually approaches pickoff contact A. When the end of the segment passes pickoff contact A, the electrical continuity between contacts A and B is broken. This de-energizes enabling relay K15, thus causing the torpedo to become enabled.

The number of times the propulsion motor rotates before the end of the segment passes contact A depends on the angle by which contact A was initially displaced from the end of the segment. Since the torpedo travels a definite distance for each revolution of the propulsion motor, the initial angle setting determines the distance the torpedo runs before enabling occurs.

NOTE: The segment continues to rotate after the torpedo is enabled. However, it will not rotate far enough to re-connect contacts A and B, because a complete revolution of the segment disk is equivalent to 36,000 yards. The entire torpedo run in a war shot or exercise run is never more than 7000 yards.

The limit contacts shown in figure 57 prevent the enabler from being set for ranges greater than 3100 yards or less than 600 yards. When the range setting is within the limits, the outer limit pickoff contacts touch the split ring and the center contact is in the open space of the ring. When the range setting reaches either the upper or lower limit, the contacts and contactor ring complete circuits for operating enabler limit relays K16 and K17. The action of these relays prevents the servo motor from driving the pickoff disk past the positions representing the range limits. The limit contact spacing, the size of the opening in the limit contactor ring, and the relative positions of the limit contacts and enabler contacts are arranged so that the

The basic element of the enabler is an electrical contactor consisting of an enabler contact split ring, a concentric limit contact split ring, and five pickoff contacts. The arrangement of these parts is shown in figure 57. The disc on which the split rings are mounted is driven by the propulsion motor through a gear reduction. Before the torpedo is fired, the pickoff disc is rotated by a servo motor until contact A is displaced from the end of the enabler split ring by some definite angle. In this condition, only one or neither of the pickoff contacts touches the split ring, thus there is no electrical continuity between the pickoff contacts A and B.

After the torpedo is fired, the propulsion motor rotates the split ring disc, but the pickoff disc remains at its set position. Because of the large reduction ratio of the gearing, the split ring disc rotates very slowly and gradually approaches pickoff contact A. When the end of the segment passes pickoff contact A, electrical continuity is made between contacts A and B. This energizes the enabling relay K15 which in turn enables the torpedo. The number of times the propulsion motor rotates before the end of the split ring passes contact A depends on the angle by which contact A was initially displaced from the end of the segment. Since the torpedo travels a definite distance for each revolution of the propulsion motor, the initial angle setting determines the distance the torpedo runs before enabling occurs. The initial angle setting is pre-set in terms of enabling range in yards.

Note: The split ring continues to rotate after the torpedo is enabled. However, it will not rotate far enough to break the continuity between contacts A and B, because a complete revolution of the split ring disc is equivalent to 36,000 yards. The entire torpedo run in a warshot or exercise run is never more than 7,000 yards.

limits of the enabling range setting are 3100 yards and 600 yards. The approximate setting accuracy of the enabling system is ±50 yards.

Enabler Control Circuit. Figure 58 shows the control circuit used for setting the initial angle between pickoff contact A and the end of the segment. The setting is made electrically by means of a synchro controlled servo system. The control circuit functions as follows:

FUNCTION OF SYNCHROS. The synchro transmitter driven by the servo motor produces an electrical signal which defines the angular position of the pickoff disk. (Refer to OP 1303 for an explanation of the operation of synchros.) This signal is applied to the stator windings of the synchro differential transmitter. The rotor of the synchro differential transmitter is geared to the propulsion motor and the position of the rotor with respect to the stator defines the angular position of the segment disk. The electrical signal produced by the rotor windings represents the difference in the angular positions of the pickoff disk and segment disk. The synchros are alined with each other so that the signal produced by the rotor of the synchro differential transmitter represents enabling range.

The rotor signal of the synchro differential transmitter is applied to the stator windings of a synchro control transformer in the electrical setting equipment used with the torpedo. The angular position of the synchro control transformer rotor with respect to its stator represents the desired enabling range. If the enabling range represented by the signal received on the stator is not equal to the desired enabling range represented by the position of the rotor, the synchro control transformer rotor produces an AC signal. The magnitude of the signal is proportional to the error, and its phase is determined by the direction of the error; that is, an error signal produced when the stator signal represents a range that is too small is 180 degrees out of phase with an error signal produced when the stator signal represents a range that is too great.

The error signal is amplified and is applied to the servo motor in the torpedo. The servo motor drives the pickoff disk in the direction required to remove the error. In other words, if the enabling range setting in the torpedo is too small, the servo motor drives the pickoff disk to increase the angle between contact A and the end of the segment. This changes the synchro trans-

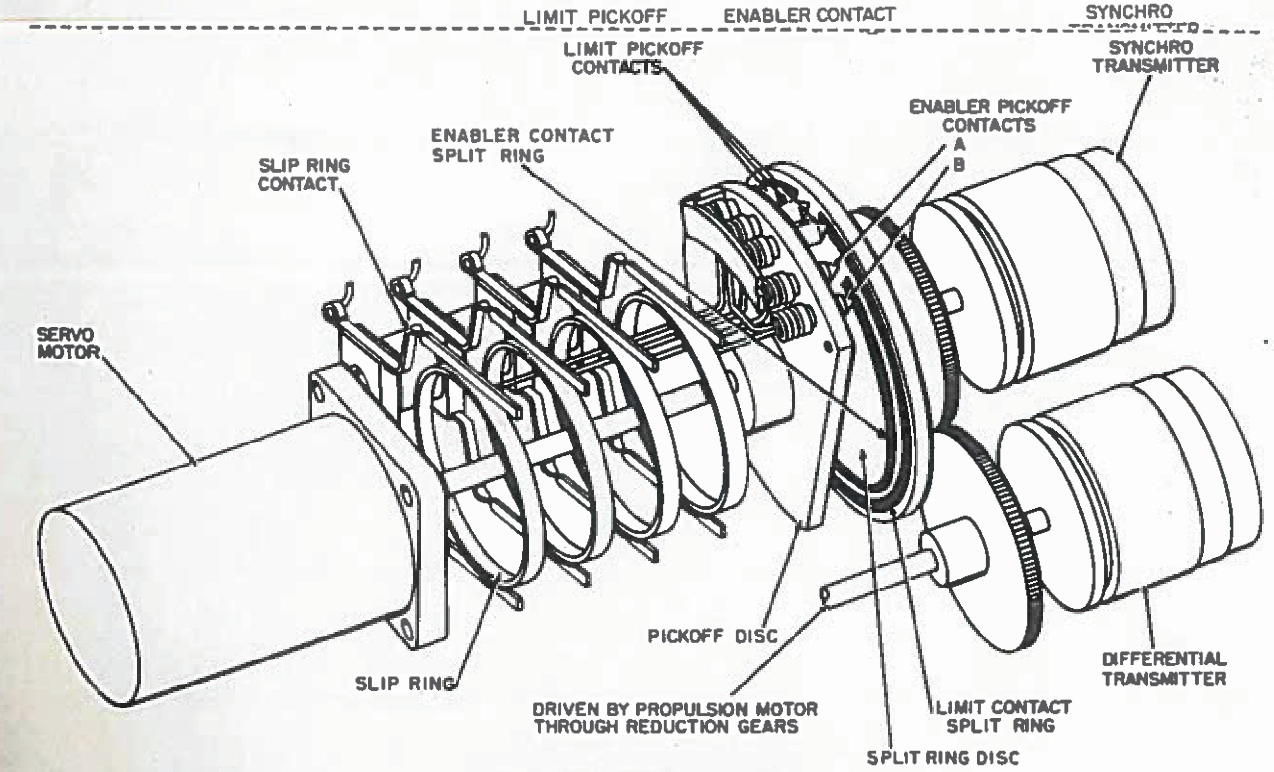

Figure 57 - Enabler Circuits.

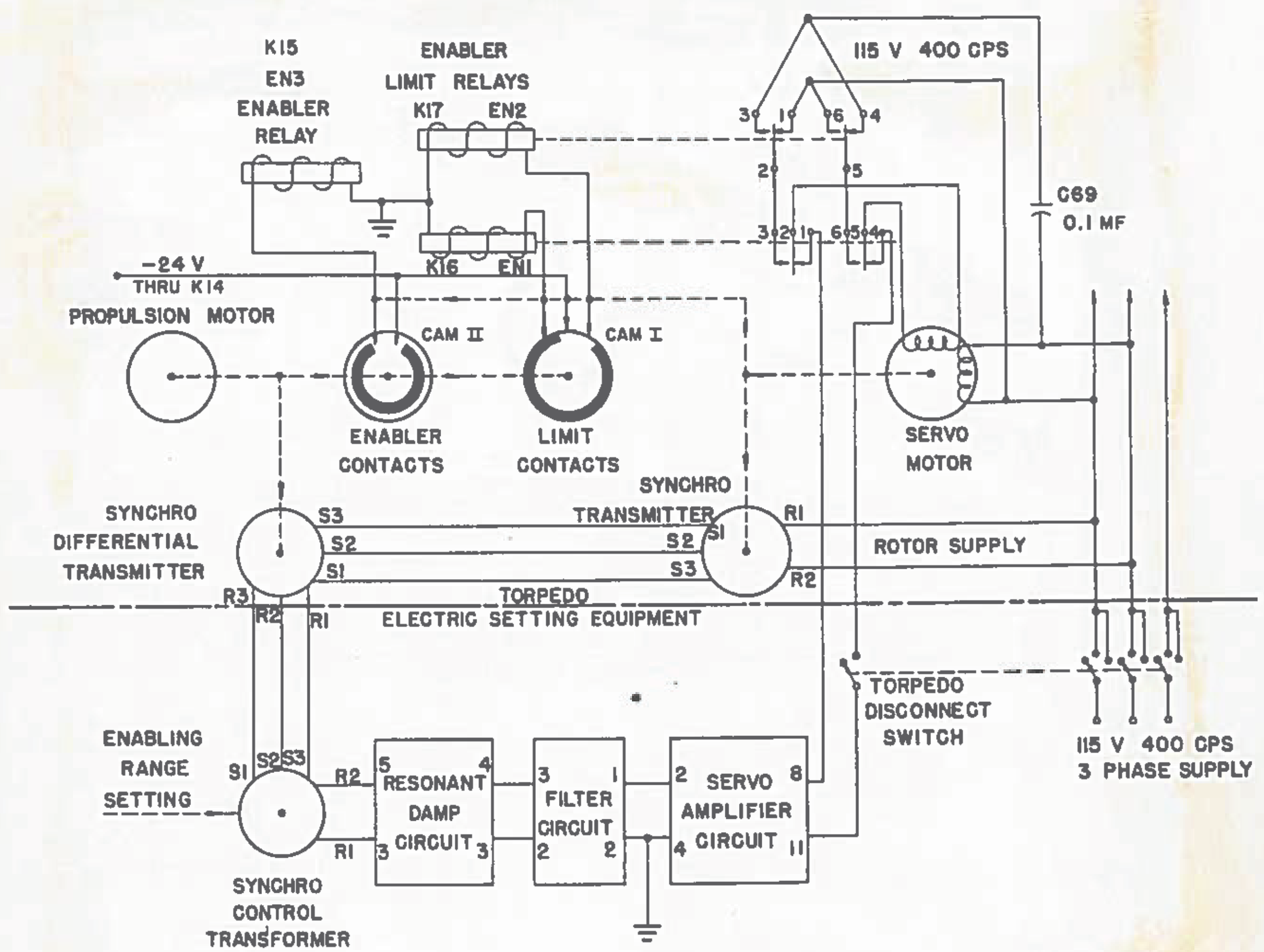

Figure 58 Enabler Control Circuit

mitter signal and therefore changes the rotor signal of the synchro differential transmitter. The servo motor continues to drive until the rotor signal of the synchro differential transmitter represents the enabling range called for by the position of the synchro control transformer rotor. When this condition exists, the error signal has been reduced to zero, and the servo motor stops. The angular displacement between contact A and the end of the segment is now equivalent to the enabling range called for by the synchro control transformer.

The synchros in the enabler control circuit are alined with each other so that the rotor of the synchro differential transmitter produces an electrical zero signal when the enabler contacts are positioned for an enabling range of 1000 yards. The control transformer is alined so that its electrical zero positions coincides with a range setting of 1000 yards.

Damping. The error signal circuits in the electrical setting equipment include a resonant damp circuit and a filter circuit, in addition to the servo amplifier.

The resonant damp circuit develops a voltage which is approximately proportional to the rate of change of the error signal. This voltage prevents the system from overshooting and helps the system

to follow immediately when enabling range order changes.

When the system is approaching synchronism, the error signal decreases. The resonant damp circuit then produces a voltage which bucks the error signal and thus applies a braking action which causes the servo motor to slow down and stop at the synchronous position. If this braking action did not occur, the motor would tend to coast past the synchronous position. When the enabling range order is changed rapidly, the system tends to lag, and this results in an increasing error signal. The resonant damp circuit then produces a voltage which aids the error signal and thus applies a greater torque which causes the servo motor to speed up and reduce the lag.

The filter circuit suppresses the 800-cps second harmonic contained in the 115-volt 400-cps supply voltage. This filter circuit is necessary because the second harmonic may be strong enough to saturate the system if it is not eliminated.

Limit Circuit. The limit circuit is controlled by enabler limit relays K16 (EN1) and K17 (EN2). As the enabling range set into the synchro control transformer is increased or decreased, the servo system follows the signal until the synchro control transformer setting passes the lower limit of 600 yards or the upper limit of 3100 yards. At either limit, the limit circuit operates to prevent the enabler setting from exceeding the limit value by causing the servo motor to oscillate about a setting near the limit. This limiting action does not prevent the enabling range order from being set to value beyond the limits but only prevents the enabler in the torpedo from following beyond the limits.

When the enabler setting reaches the lower limit, limit contacts 1 and 2 are connected and relay K16 becomes energized. This relay disconnects the servo amplifier signal from the control winding of the servo motor and substitutes a fixed 400-cps signal supplied through the deenergized contacts of relay K17. The phase of the fixed signal is such that the servo motor immediately reverses and drives the enabler back out of the limit. Limit contacts 1 and 2 and relay K16 become deenergized, thus reconnecting the servo amplifier signal to the motor. The motor again drives into the limit and the entire cycle repeats itself, with the result that the servo oscillates about some value slightly above the limit.

Just before the enabler setting reaches the upper limit, limit contacts 2 and 3 are connected and relay K17 becomes energized. This relay reverses the phase of the fixed 400-cps signal but there is no immediate effect because relay K16 is still deenergized. When the enabler setting reaches the limit, contact 1 also becomes connected with contacts 2 and 3 and relay K16 becomes energized. This relay substitutes the reversed 400-cps supply for the amplifier signal and the servo reverses to drive the enabler back out of the limit. The servo then oscillates about some value below the upper limit as previously described for the lower limit.

Enabler Switching Circuits. Before the torpedo is enabled, enabler relay K15 (EN3) is energized. When the torpedo has run the pre-set enabling distance, the continuity between the enabler contacts is broken and relay K15 becomes deenergized. When this happens, the circuits controlled by the enabler are in the condition shown in figure 59.

When relay K15 becomes deenergized, the climb and dive angle limit switches are bypassed and the —24-volt DC supply is disconnected from the gyro motor and from the gyro steering contacts, making steering relays K18 and K19 inoperative. The DC supply to the coil of ACC relay K10 is deenergized so that this relay can no longer function if the torpedo turns more than 135 degrees from the firing line. Gyro relay K8 is also deenergized. The contacts of relay K8 make the following changes in the torpedo circuits:

a. Contacts 5 and 6 open and disconnect the swingers of steering relays K18 and K19 from ground, thus completing the deactivation of gyro steering control. Contacts 4 and 5 close and connect the junction of bridge resistors R98 and R99 to ground through resistors R103 and R63. This results in a fixed steering bias which causes the torpedo to turn in a port search circle approximately 100 yards in diameter.

b. Contacts 10 and 11 close and by-pass the switch of the 17-degree cam. This makes the 17-degree cam inactive during the remainder of the run.

c. Contacts 8 and 9 open and disconnect the —24-volt DC supply from the time delay circuit. This circuit acts to prevent the torpedo from

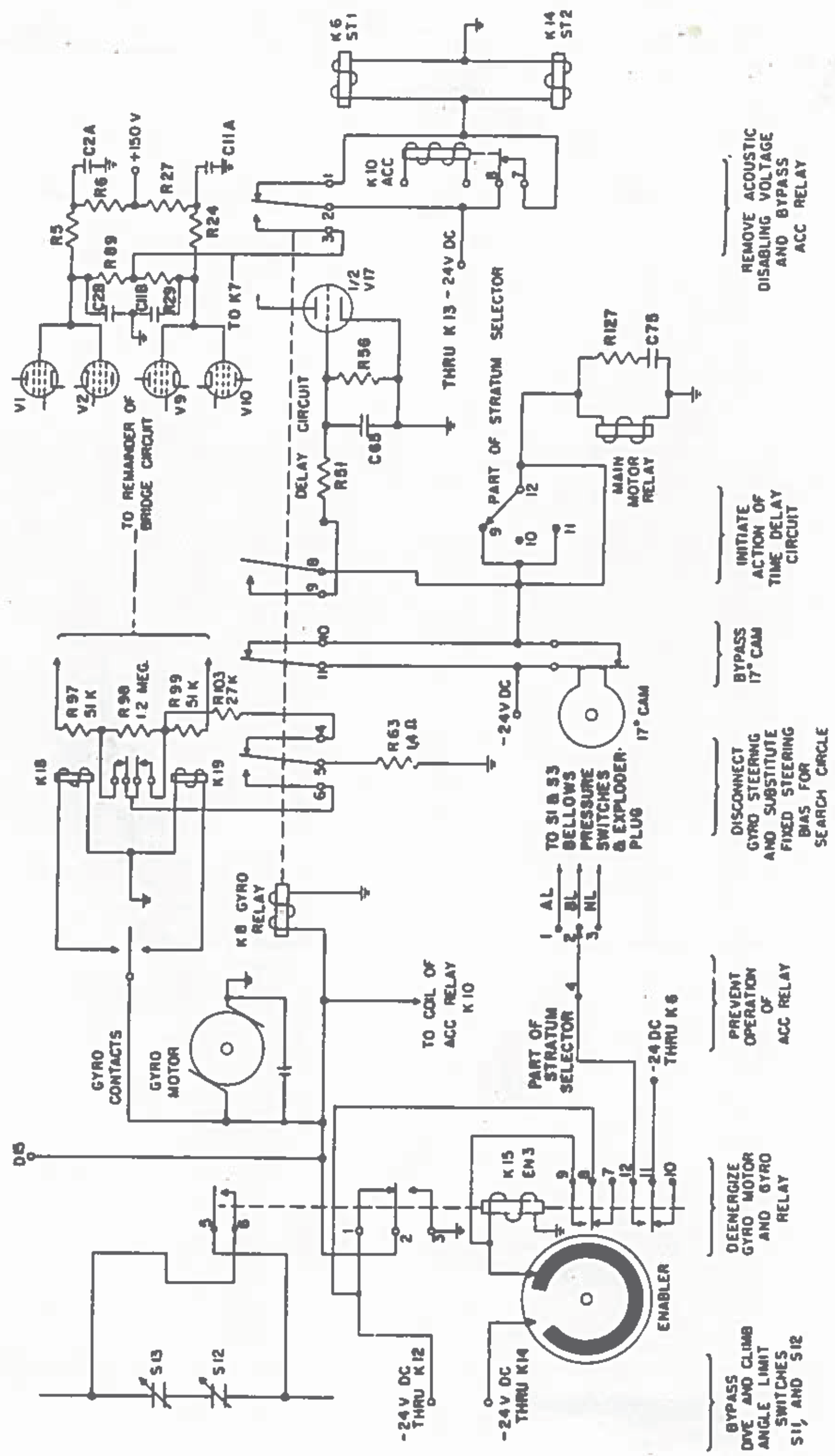

Figure 59 - Enabler Switching Circuits.

Enabler Switching Circuits

Before the torpedo is enabled, enabler relay K15 (En 3) is de-energized. When the torpedo has run the preset enabling distance, the continuity between the enabler contacts is made and relay K15 becomes energized and is held in by a locking circuit. The circuits controlled by the enabler are shown with enabler relay K15 de-energized in figure 59.

The contacts of the enabler relay K15 make the following circuit changes in the torpedo performance during the gyro and enabled conditions of operation:

a. Contacts 1 and 2 are closed when the enabler relay is de-energized. This applies the -24 volt DC supply to the gyro motor, the gyro steering contacts, the ACC relay, and the gyro relay K8. The ACC relay does not become energized until the torpedo turns more than 135 degrees from the firing course. Contacts 2 and 3 are closed when the enabler relay is energized. This places both ends of the above mentioned circuits at ground potential.

b. Contacts 5 and 6 close and by-pass the climb and dive angle limit switches when the enabler relay is energized. These limit switches are operative during the initial and gyro phases of the torpedo run to prevent the torpedo from climbing or diving too steeply while seeking its running depth.

c. Contacts 8 and 9 operate a "fail-safe" feature which locks the enabler relay in the energized condition. This prevents the enabler relay from becoming de-energized due to premature or intermittent opening of the pickoff contacts on the enabler split ring.

d. Contacts 11 and 12 close when the torpedo is enabled and place the -24 volt DC source across the exploder terminals when the torpedo is in the preset operating stratum. Thus this circuit prevents the exploder from being activated until after enablement.

The contacts of the gyro relay K8 cause the following changes in the torpedo performance during the gyro and enabled conditions of operation:

Prior to Enablement

The gyro relay K8 is energized during the gyro run of the torpedo prior to enablement.

a. Contacts 2 and 3 are closed and apply the -24 volt DC acoustic disabling voltage to the screen grid circuits of vacuum tubes V1 and V2 in the horizontal input switching circuit and vacuum tubes V9 and V10 in the vertical switching circuit.

b. Contacts 5 and 6 are closed connecting the swingers of steering relays K18 and K19 to ground through R 63 for gyro steering control.

Change 2

c. Contacts 8 and 9 are closed, connecting the -24 volt D.C. supply to the 15 second time delay circuit.

d. Contacts 10 and 11 are open, which makes the 17 degree cam active during the gyro run.

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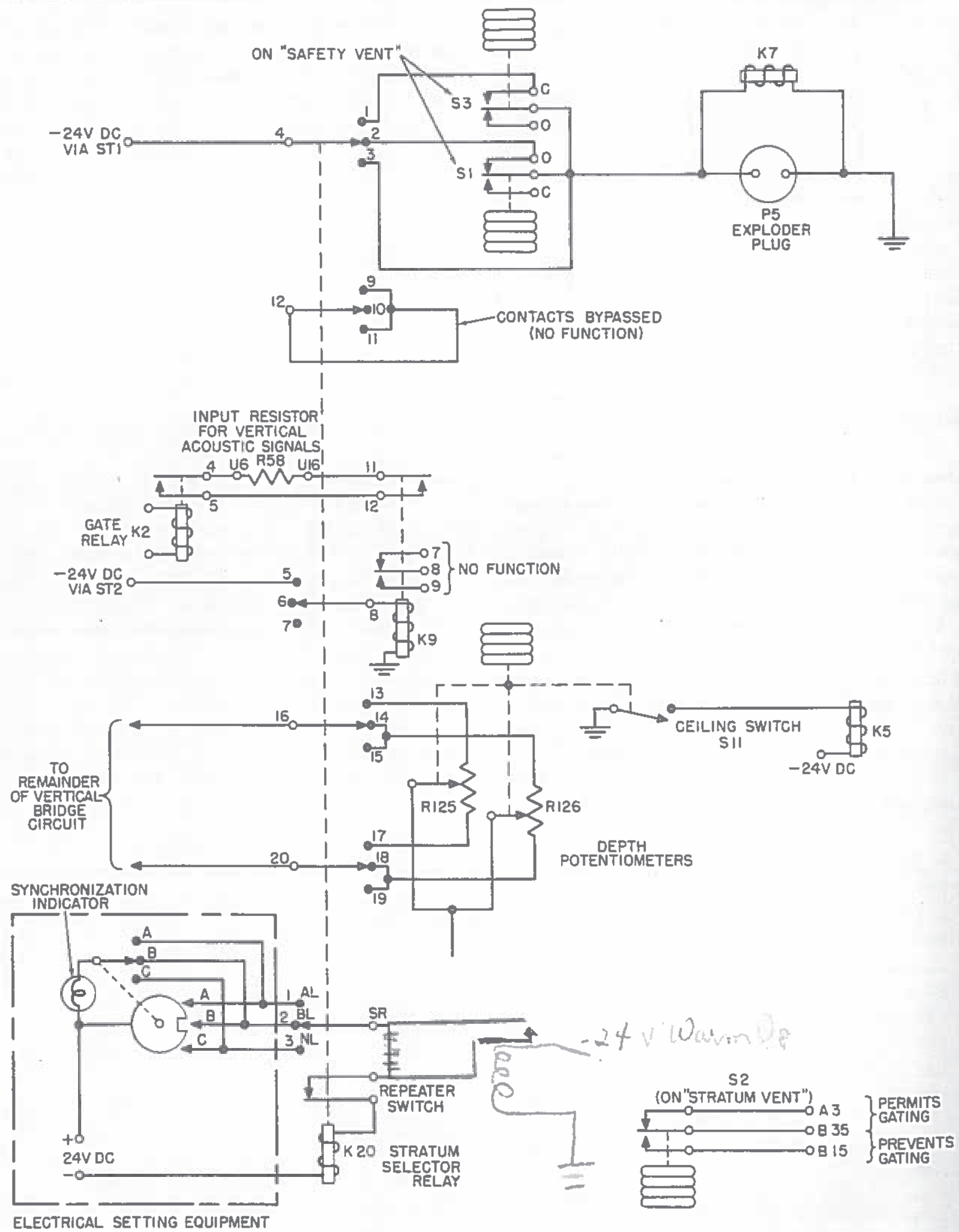

Figure 60—Stratum Control Circuit.

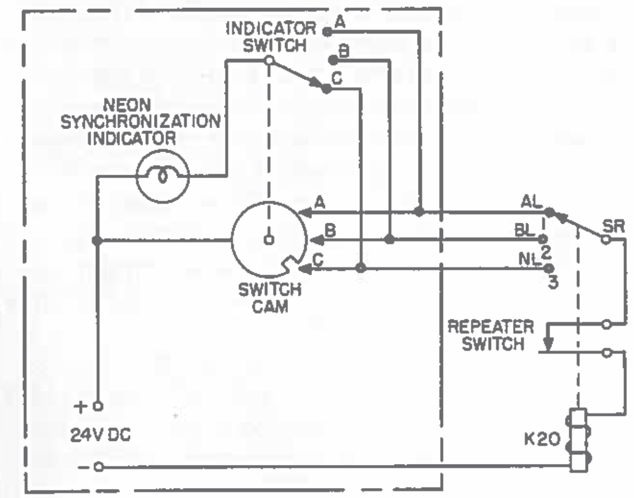

Figure 61—Stratum Setting Circuit (Before Synchronizing).

for another operation cycle. In position 2, the 24-volt supply voltage circuit is completed through contact B of the switch cam. This causes the relay to operate again, thus moving the stratum selector to position 3. In this position, the 24-volt supply circuit to the relay is open because contact C does not touch the switch cam. Therefore, the relay remains in the NL position called for by the setting of the three-position switch. The 24-volt supply is applied to neon lamp of the synchronization indicator through contact C of the indicator switch, and the lamp lights to show that the stratum relay has reached the desired setting.

Stratum Switching Circuits. The action of the stratum switching circuits shown in figure 60 is controlled by the position of stratum selector relay K20.

Contacts 1, 2, and 3 of the stratum selector control the function of stratum switches S3 and S1. At depths less than 85 feet, the swinger of switch S3 closes with contact C, and at depths greater than 85 feet, the bellows are expanded so that the swinger of the switch closes with contact O. Therefore, −24-volt DC is supplied to the exploder and relay K7 only while the depth is less than 85 feet in above limit operation. At depths greater than 85 feet, the exploder plug is disconnected from the −24-volt DC supply and relay K7 releases and applies the acoustic disabling voltage to the acoustic circuits. When the depth is more than ~~65~~ 85 feet in below limit operation the bellows associated with switch S1 is expanded and the swinger of the switch closes with contact O, thus energizing relay K7 and the exploder plug. At depths of less than ~~65~~ 85 feet, the exploder plug and relay K7 are disconnected from the −24-volt supply. In no limit operation, the stratum switches are bypassed so that the exploder and relay K7 remain energized at all depths.

Contacts 9, 10, 11, and 12 of the stratum selector are bypassed and have no function.

Relay K9 is controlled through contacts 5 and 8 of the stratum selector. In above limit operation relay K9 is energized and contacts 11 and 12 of this relay close. Thus, until the acoustic signal is strong enough to cause release of relay K2, signal input resistor R58 in the vertical acoustic channel remains bypassed and prevents the acoustic signal from influencing vertical steering. This action is called "triggering" and is explained in chapter 5.

Contacts 13 through 20 of the stratum selector control the selection of the depth potentiometer used in the vertical bridge circuit. In above limit operation, depth potentiometer R125 is connected to the bridge circuit to produce a running depth of 70 feet. In below limit operation and no limit operation, depth potentiometer R126 is connected to the bridge circuit to produce a running depth of 125 feet.

The stratum switch S2 is not controlled by the stratum selector. In all stratum conditions, this switch acts to prevent gating when the depth of the torpedo is less than 85 feet.

The ceiling switch, operated by the depth bellows, is also independent of the stratum selector. At depths less than 30 feet, the ceiling switch closes and causes relay K5 to operate. When this relay operates, it introduces a 10 db attenuation into the up acoustic channel.

General Switching and Power Circuits

The general switching and power circuits distribute the required voltage supplies to the control circuits of the torpedo. Figures 62 through 66 show the general switching and power circuits and illustrate their functioning under the various conditions of operation.

Test Circuit. The general switching and power circuits may be controlled by the test switch S4 to provide a convenient means for testing the acoustic steering circuits of the torpedo. The test switch has three positions. In the RUN position the general switching and power circuits are set for normal operation and the test circuits are not active. The other two switch positions set the circuits for two different test conditions designated as TEST 1 and TEST 2.

TEST 1 CIRCUIT. The circuits which are active when test switch S4 is set to the TEST 1 position are shown by the heavy lines in figure 62. In this condition, the —24-volt supply from the propulsion battery is connected through contacts 1 and 2 of the test switch to the B power supply. From contact 2 of the test switch, the —24-volt supply also is applied to the panel vacuum tube heaters through normally closed contacts 5, 4, 10, and 11 of start relay K14 (ST2). Since the vacuum tube heaters and the B power supply are energized, the electronic acoustic control circuits of the torpedo are completely energized. Since contacts 1 and 2 of deenergized relay K6 are closed resistor R80 is bypassed. This is done to account for the fact that the heater supply used in this test condition is 24 volts instead of the 48-volt supply used normally.

The —24-volt supply is also applied through normally closed contacts 11 and 10 of start relay K6 (ST1) and contacts 13 and 14 of the test switch to the coil of test relay K12. This relay

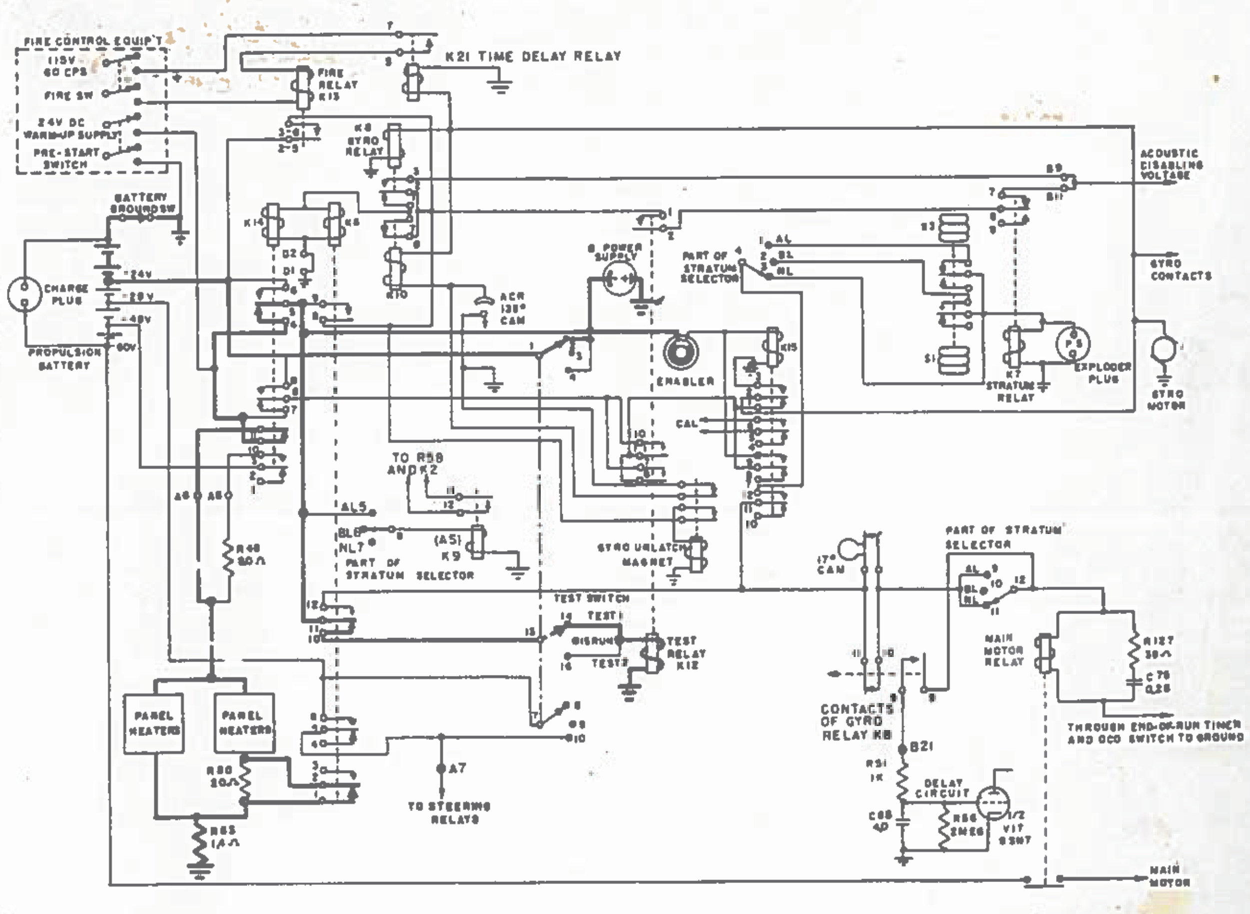

Figure 62 - Test 1 Circuit.

operates and prevents the application of the —24-volt supply to the gyro motor and gyro relay K8 since operation of the gyro control circuit is not desired during test. ~~Thus, although enabler relay K15 is operated in the TEST 1 condition, the gyro control circuits remain deenergized.~~

With relay K12 energized, contacts 1 and 2 of this relay are open. This open circuit is necessary to prevent the grids of vacuum tubes V9 and V10 in the vertical acoustic channel and vacuum tubes V1 and V2 in the horizontal acoustic channel from being grounded through the relatively low resistance of the winding of relays ST1 and ST2.

As shown in figure 62, the —28-volt DC supply for the steering motors remains disconnected in the TEST 1 condition. Therefore, although the electronic acoustic control circuits are energized, they cannot have any effect on the rudders and elevators.

TEST 2 CIRCUIT. The circuits which are active when test switch S4 is set to the TEST 2 position are shown in figure 63. The circuits are the same as for the TEST 1 position except that the —28-volt DC supply from the propulsion battery is connected through contacts 7 and 10 of the test switch to panel terminal A7. This voltage is applied to the rudder and elevator steering motors through the contacts of steering motor relays K3 and K4. Since the electronic acoustic control

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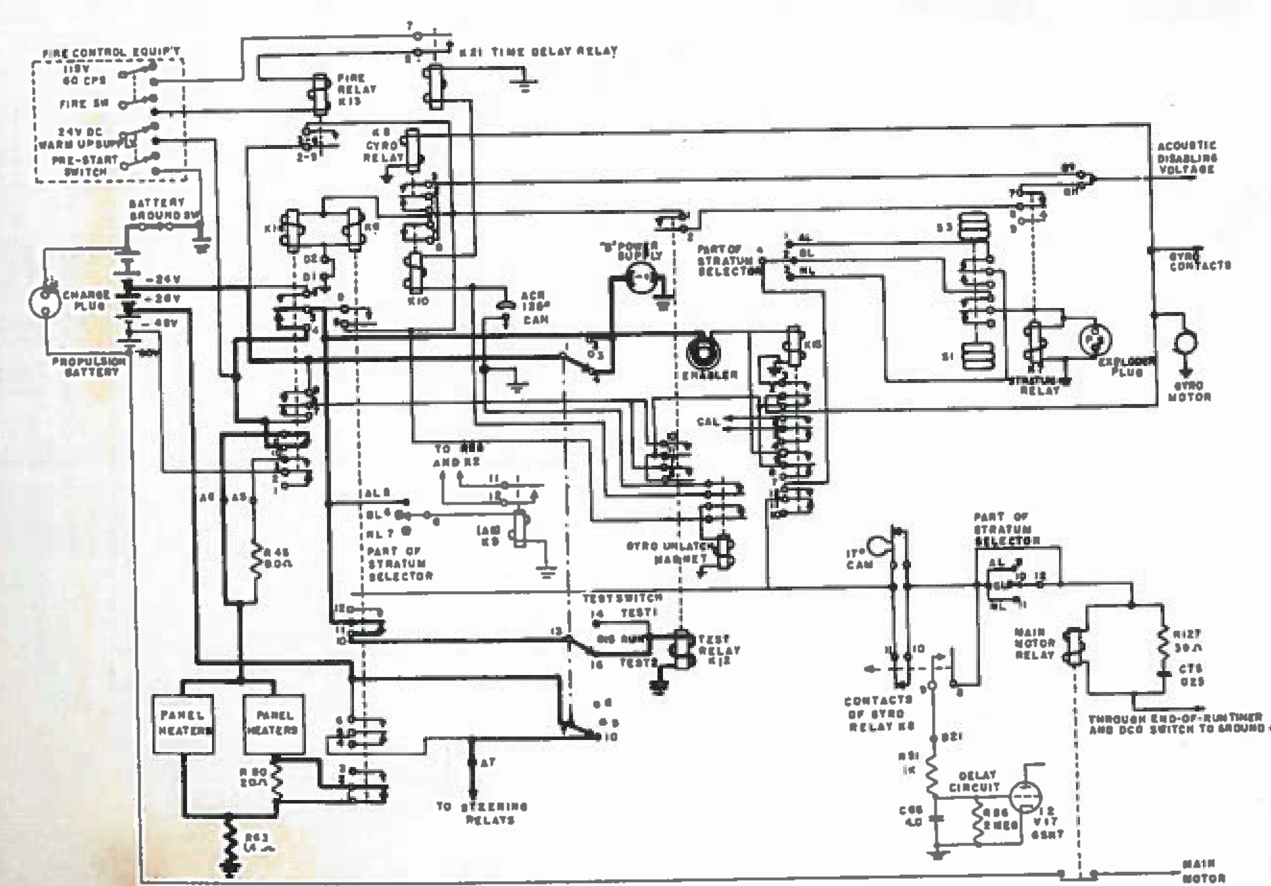

Figure 63 - Test 2 Circuit.

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circuits are energized and the −28-volt DC supply for the steering motors is available, the acoustic control circuits are fully active in the TEST 2 position. The steering circuits become active as soon as the vacuum tubes warm up.

Warm-up Circuits. After the torpedo has been loaded into the tube prior to firing, 24-volt DC external power is supplied to the torpedo when the relay-transmitter OFF-STANDBY-ON switch is in the ON position. This supply voltage is distributed through the warm-up circuits of the general switching and power circuits to preheat the panel vacuum tube heaters, to bring the gyro motor up to speed, and to energize the B power supply.

NOTE: When using Test Set Mk 183 Type, 24-volt DC power is supplied to the torpedo when the test set switch is in STANDBY position.

The circuits which are active during warm-up are shown by the heavy lines in figure 64. The 24-volt DC warm-up supply is applied through normally closed contacts 4 and 5 of start relay K14 (ST2) to the B power supply ~~and to the winding of enabler relay K15 (EN3) through the enabler contacts.~~

Warm-up power is also applied through normally closed contacts 7 and 8 of start relay K14 (ST2) to gyro relay K8 and to the gyro motor. The path of this supply is from terminal 8 of

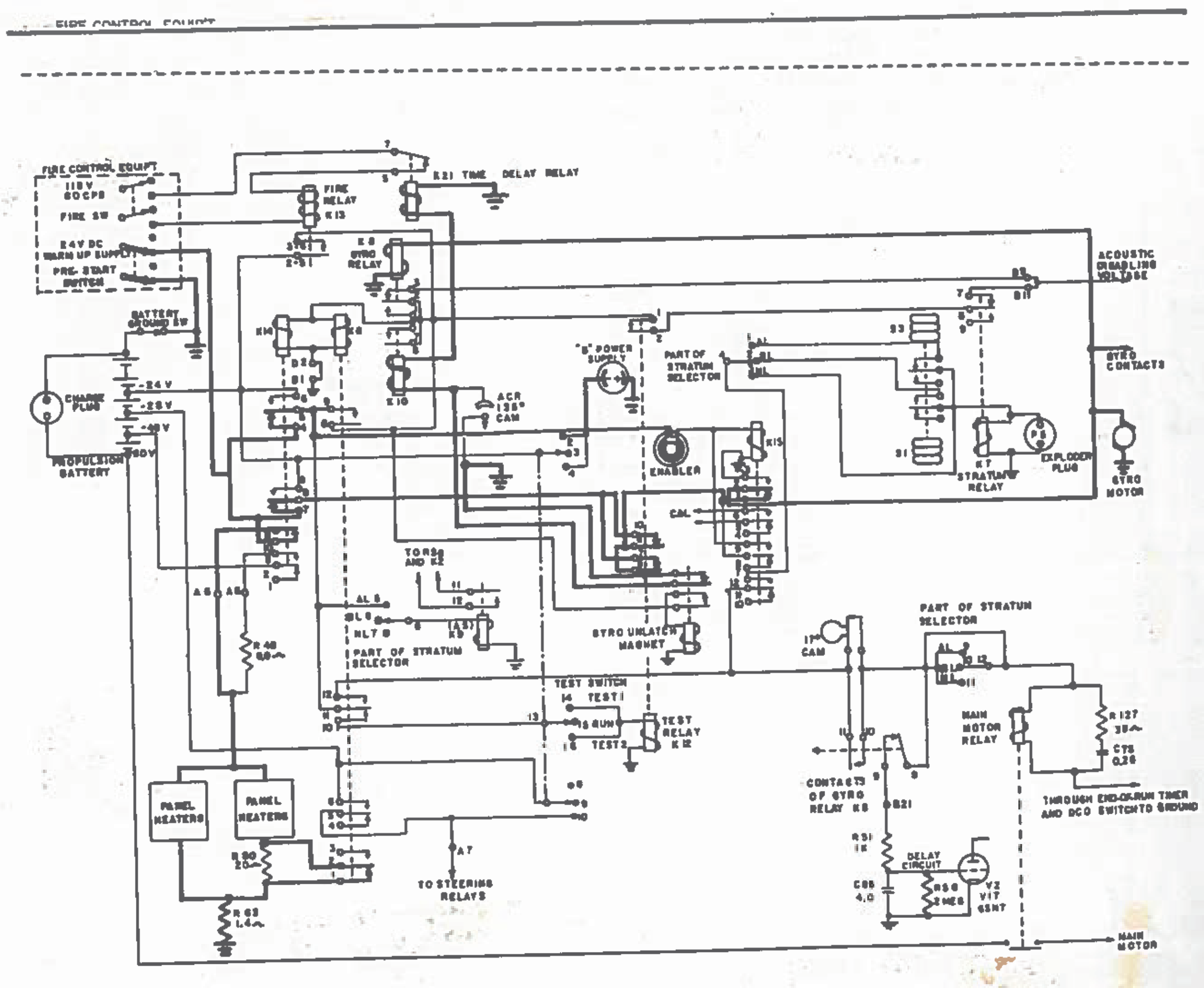


Figure 64 - Warm-up Circuit.

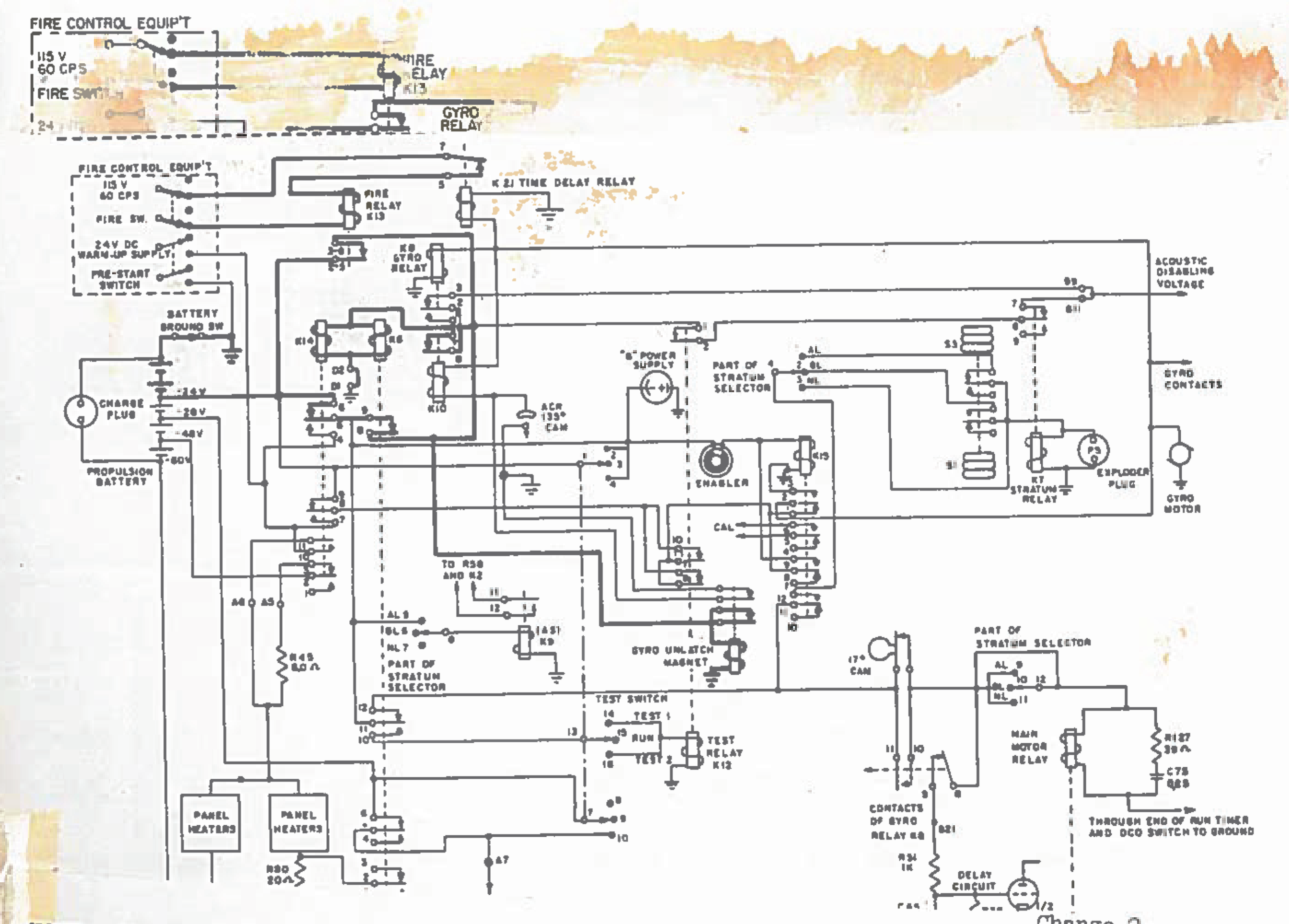
relay K14 through the contacts of test relay K12 and through the NORMALLY closed contacts of enabler relay K15 (EN3). This prepares the gyro circuits for operation and causes the gyro motor to come up to speed before the torpedo is fired. *

The third branch of the warm-up supply voltage is through normally closed contacts 11 and 10 of start relay K14 (ST2) to terminal A6 of the control panel for preheating the panel vacuum tube heaters. Resistor R80 is by-passed by closed contacts 1 and 2 of relay ST1 to account for the fact that the warm-up supply is 24 volts instead of the 48-volt supply normally used.

The fourth branch of the warm-up supply voltage which prepares the gyro circuits for operation also applies power to the ACC relay (K10) which in turn operates the ACC relay.

Fire Circuit. The circuits which are active at the instant the fire switch is closed are shown in figure 65. The 115-volt, 60-cps firing voltage is supplied through the fire control equipment and is applied almost at the same instant as the stop bolt is raised. NOTE ATTACHED

The firing voltage is applied only momentarily. (The impulse applied to fire relay K13 must last only for a time somewhat greater than 0.050 second.) When fire relay K13 becomes energized, the −24-volt DC supply from the propulsion battery is connected to the gyro unlatch contacts and to the gyro unlatch magnet through fire



NOTE: The fire relay K13 cannot be energized until the time delay relay K21 has closed its contacts. The relay has been added to prevent inadvertent firing of the torpedo under the following conditions: (1) Prior to warm-up; (2) test switch not in RUN position; (3) torpedo is in an enabled condition.

* In addition, approximately 15 seconds after warmup voltage is applied, the contacts of the time delay relay K21 close and complete the circuit to the fire relay K13.

relay contacts. Upon operation of the gyro unlatch magnet, the ground return of the ACC relay K10 is removed and the relay is deenergized. The —24-volt DC propulsion battery supply is then connected through contacts 7 and 8 of ACC relay K10 to start relays K14 (ST2) and K6 (ST1). When these relays are energized, the —24-volt supply is connected through contacts 6 and 5 of relay K14 and contacts 9 and 8 of relay K6. Through this path, the —24-volt supply also passes through contacts 7 and 8 of ACC relay K10 to start relays K14 (ST2) and K6 (ST1). Thus, contacts 5 and 6 of relay K14 and contacts 8 and 9 of relay K6 act as holding contacts so that the start relays will remain energized after the fire relay K13 becomes deenergized.

As soon as relays K6 and K14 are actuated, the circuits of the torpedo become energized as shown in figure 66. Therefore, it should be realized that the circuits shown in figure 65 are intended only to illustrate the action of the fire and start relays in the transitional phase between warm-up and the fully energized condition and do not show all of the circuits energized either during warm-up or after the start relays are energized.

Start Circuits. The circuits which are active after start relays K14 and K6 have been operated are shown in figure 66. As indicated in the figure, the connections to the fire control equipment are cut when the cable is severed as the torpedo leaves the tube.

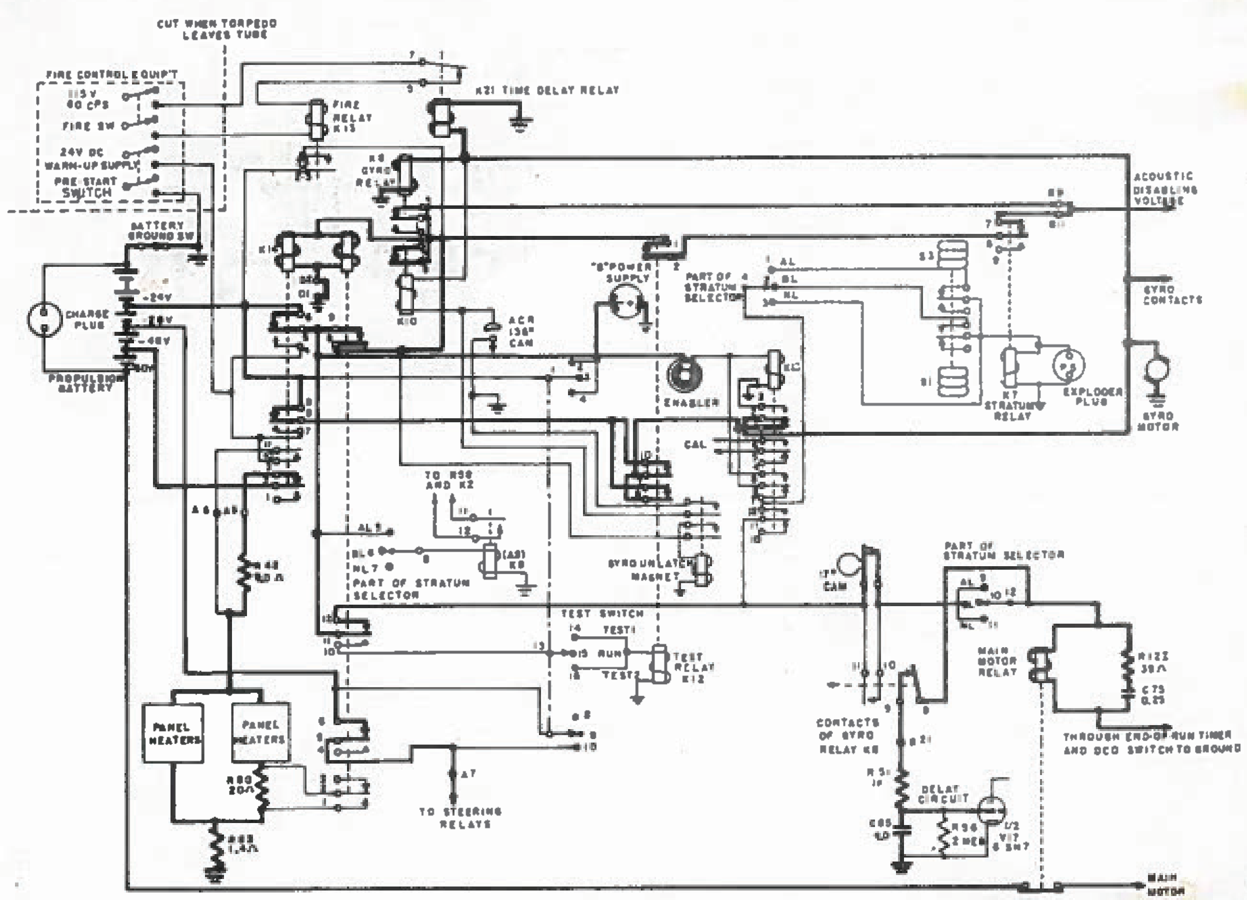


Figure 66 - Start Circuit (Below Limits).

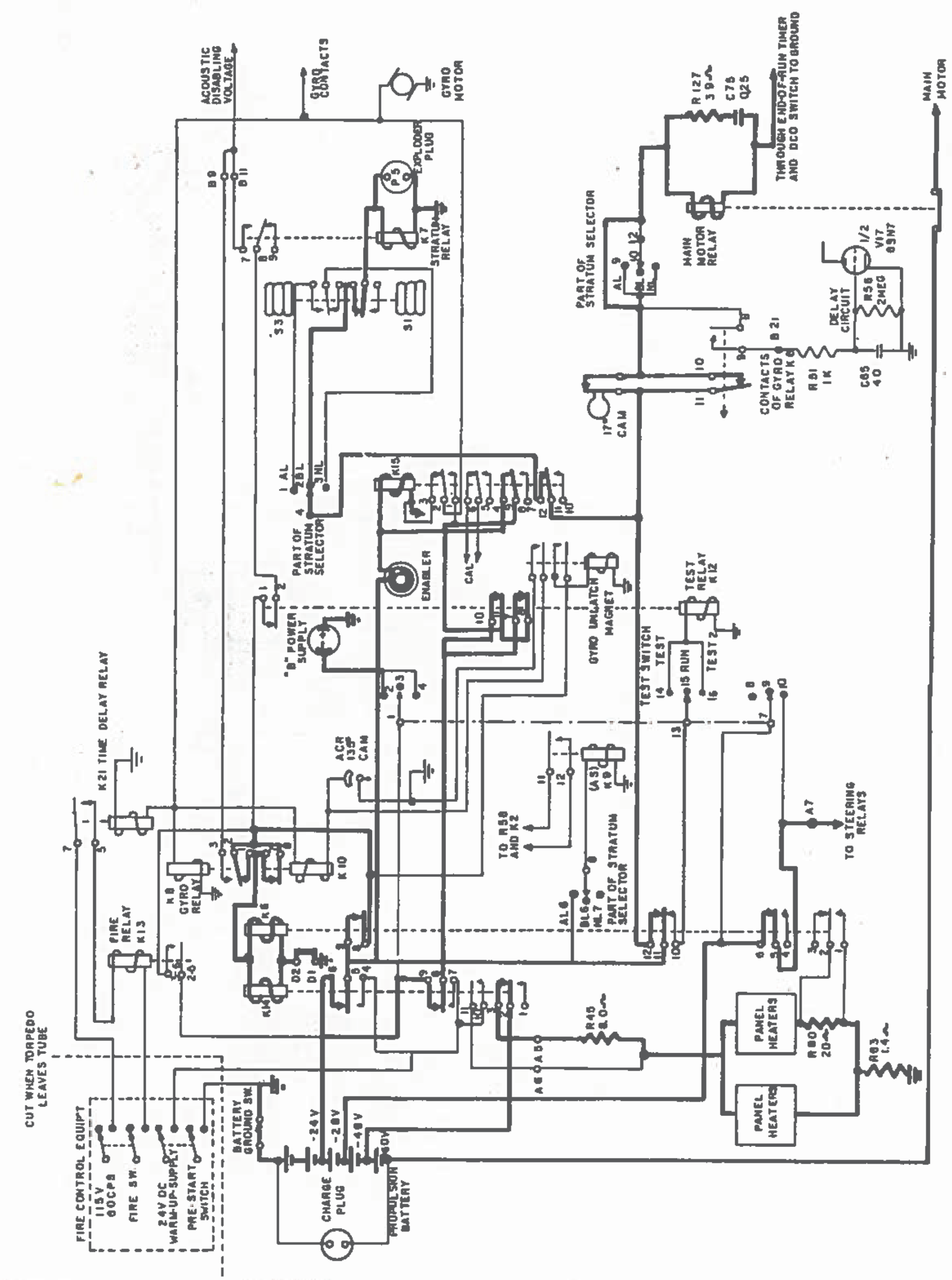


Figure 66A - Energized Circuits After Enabling (Below Limits).

Control of Start Relays. At the time of firing, gyro relay K8 is already operated by the warm-up voltage and when the start relays are energized, gyro relay K8 remains energized until enabling occurs. Before enabling occurs, the start relays remain operated as long as the torpedo does not turn more than 135 degrees, thus causing ACC relay K10 to be operated. After the torpedo becomes enabled, gyro relay K8 releases and bypasses the contacts of the ACC relay so that the torpedo will continue to operate even if relay K10 is operated. The strap shown between terminals D2 and D1 on the ground side of start relays K6 and K14 is removed when an exercise head is used, and the circuit to ground is completed through the timing circuits of the exercise head. At the end of the preset running time, the circuit to ground is opened, thus releasing start relays K6 and K14 and deenergizing the entire torpedo.

Main Motor Control Circuit. The application of the −60-volt supply from the propulsion battery to the propulsion motor is controlled by the main motor relay. Figure 66 shows that the stratum selector contacts in the main motor relay circuit are bypassed by a jumper.

The −24-volt supply to the main motor relay passes through contacts 6 and 5 of start relay K14 and through contacts 12 and 11 of start relay K6. Before enabling occurs, gyro relay K8 is operated and therefore contacts 10 and 11 of this relay are open. Hence, the −24-volt supply passes through the contacts of switch S10 operated by the 17-degree cam. If the steering control circuit becomes defective while the torpedo is under gyro control so that the rudders turn through an angle greater than 17 degrees either side of zero, switch S10 is opened, thus releasing the main motor relay and deenergizing the propulsion motor. After enabling occurs, gyro relay K8 is deenergized and contacts 10 and 11 of this relay close and bypass the 17-degree switch.

The −24-volt supply for the main motor relay is bypassed around the stratum selector and passes directly to the main motor relay. The supply is also connected through closed contacts 8 and 9 of the gyro relay K8 to charge capacitor C65 in the delay circuit. After relay K8 releases upon enabling the charge in the capacitor leaks off through resistor R56 until the grid voltage on vacuum tube V17 is reduced to the point where the tube will unblock and operate a relay in the gate circuit. This action which insures that gating can not occur for approximately 15 seconds after enabling, is described in detail in chapter 5.

Trigger Control. The −24-volt DC supply through contacts 5 and 6 of relay K14 is connected to contact 5 of stratum selector relay K20. When the torpedo is set for above limit operation, relay K9 becomes energized and its contacts 11 and 12 close. These contacts and contacts of relay K2 act to bypass signal input resistor R58 in the vertical acoustic channel until the acoustic signal reaches a high level indicating close proximity to the target. Relay K2 then releases, removing the bypass from resistor R58, thus permitting the acoustic signal to influence vertical steering. This action (called "triggering") can occur only in above limit operation. The triggering action is explained in detail in chapter 5.

Gyro Circuits. When start relays K14 and K6 are energized, −24 volts DC is supplied through contacts 6 and 5 of relay K14 ~~and contacts 9 and 8 of relay K6~~ to the enabler ~~contacts. Since these contacts are closed, enabler relay K15 is operated.~~ AND B POWER SUPPLY. Contacts 9 and 8 of relay K14 close and complete the path for the −24-volt supply through the closed contacts of the test relay K12 and through closed contacts 8 and 9 of relay K15 to the gyro motor, gyro contacts and gyro relay K8.

Panel Circuits. The −48-volt DC supply from the propulsion battery is connected through contacts 2 and 3 of relay K14 and through terminal A8 to the panel heaters. The B power supply is provided with the −24-volt DC supply through contacts 6 and 5 of relay K14.

The −28-volt DC supply for the steering motors is connected through contacts 6 and 5 of relay K6 to panel terminal A7. Since contacts 11 and 10 of relay K6 are open, and since the test switch is set to RUN, the test relay K12 will be deenergized.

Acoustic Disabling. Figure 66 shows the stratum selector set for below limit operation. In this type of operation, the torpedo is fired from a submarine at a depth less than 66 feet, and therefore the stratum relay K7 and the exploder plug will not be energized when the torpedo is fired because stratum switch S1 will be open. While relay K7 is deenergized the −24-

volt DC acoustic disabling voltage is applied to panel terminal B11 through contacts 1 and 2 of test relay K12 and contact 8 and 7 of stratum relay K7. This path is opened when the torpedo reaches a depth of 35 feet and remains open as long as the torpedo remains below this depth because switch S1 closes and energizes stratum relay K7.

Before enabling, gyro relay K8 is energized and the acoustic disabling voltage is supplied through contacts 2 and 3 of this relay to panel terminal B9.

B Power Supply Circuit. The B power supply unit produces the following output voltages:

a. The horizontal and vertical DC bias voltages for the bridge circuits.

b. The 45-volt bias voltage for the cathodes of the DC amplifiers and screen grids of the AC amplifiers.

c. The 180-volt supply for the screen grids of the DC amplifiers and plates of the AC amplifiers.

d. The 135-volt plate supply for the control panel.

The B power supply used with the torpedo is of the vibrator type. In this unit, the 24-volt DC supply from the propulsion battery is converted to AC in a vibrator and is then stepped up to the required values by means of a transformer T101, figure 97. The output of each transformer secondary winding is rectified and filtered to supply the DC output voltages.

The 45-volt bias voltages are rectified by means of a full-wave selenium rectifier units. The 180-volt screen grid supply and the plate supply voltage for the control panel are rectified by an ionically heated cathode full-wave gas rectifier tube.

Functions of Relays and Switches. Table 4 lists all the relays in Torpedo Mk 27 Mod 4 and briefly describes their functions. Table 5 gives the same type of information for all of the switches in the torpedo.

Table 4—Relays in Torpedo Mk 27 Mod 4

Symbol No.	Name	Function
K1	Time delay relay	Prevents gating for 15 seconds after enabling.
K2	Gate relay	Disconnects depth and pendulum controls and substitutes fixed resistors when gate circuit operates and also provides triggering action.
K3	Horizontal steering relay.	Controls horizontal steering motor.
K4	Vertical steering relay.	Controls vertical steering motor.
K5	Ceiling relay	Applies 10 db down bias at depths less than 30 feet. Operated by ceiling switch S11.
K6 (ST1)	Start relay 1 and contacts 4 and 12 of relay K15.	Controls application of −24 volts to torpedo switching and power circuits.
K7 (ST2)	Stratum relay	Controls exploder and acoustic disabling circuits. Operated by switch S1 and switch S3 through stratum selector relay K20.
K8 (GY)	Gyro relay ~~[illegible]~~ K13.	When the torpedo enables, remove gyro control and activates acoustic control. Before enabling supplies power to gyro and deactivates acoustic control.
K9 (AS)	Trigger relay	Makes connections necessary for triggering action in above limit operation.
K10 (ACC)	Anti-circling control.	Releases relays K6 and K14 if torpedo turns more than 135 degrees before enabling.
K12 (TEST)	Test relay	Prevents application of power to gyro motor and opens acoustic disabling circuit when torpedo is in Test 1 or Test 2 condition.
K13 (FIRE)	Fire relay through safety circuit contacts 3 and 4 of ~~K8~~ time delay relay K21	Operates start relays K6 and K14 when fire switch is closed.
K14 (ST2)	Start relay 2	Controls application of −24 volts to torpedo switching and power circuits.
K15 (EN3)	Enabler 3	Enabler relay energized through enabler contacts. Controls relay K8 and gyro motor.
K16 (EN1)	Enabler 1	Enabler limit relay. Prevents enabler from being set for ranges greater than 3100 yards or less than 600 yards.
K17 (EN2)	Enabler 2	Reverses phase of fixed voltage used in limit circuit of enabler.
K18 (GR)	Gyro right relay	Operates when torpedo heading is to the left of course and produces starboard rudder.
K19 (GL)	Gyro left relay	Operates when torpedo heading is to the right of course and produces port rudder.
K20 (SR)	Stratum selector	Controlled by fire control equipment. Sets proper stratum circuits before firing.
MMR	Main motor relay	Controls application of power to propulsion motor.

K21) Thermal time Delay relay — Controls application of power to fire relay K13.

Table 5—Switches in Torpedo Mk 27 Mod 4

Symbol No.	Name	Function
S1	Stratum switch	Pressure operated stratum switch. Controls stratum relay K7 and exploder through stratum selector relay K20. (For below limit operation.)
S2	do	Pressure operated stratum switch. Prevents gating at depths shallower than 85 feet.
S3	do	Pressure operated stratum switch. Controls stratum relay K7 and exploder through stratum selector relay K20. (For above limit operation.)
S4	Test switch	Used for testing acoustic control circuit either with or without steering motors running.
S6	do	Lower limit switch for elevator steering motor.
S7	do	Upper limit switch for elevator steering motor.
S8	do	Port limit switch for rudder steering motor.
S9	do	Starboard limit switch for rudder steering motor.
S10	17-degree cut-out switch.	Cam-operated switch which deenergizes propulsion motor if rudder angle exceeds approximately 17 degrees while torpedo is on gyro run.
S11 (In depth unit)	Ceiling switch	Controls relay K5 to apply 10 db down bias when torpedo is at depths shallower than 30 feet.
S12	Dive angle limit switch.	During gyro run, disconnects depth control if torpedo dives too steeply.
S13 (In junction box)	Climb angle limit switch.	During gyro run, disconnects depth control if torpedo climbs too steeply.

Chapter 7

PREPARATION FOR WAR SHOT

General

This chapter describes the procedures followed in the workshop for readying Torpedo Mk 27 Mod 4 for a war shot and gives instructions for the handling of the torpedo and for its stowage aboard a submarine. Detailed instructions are given for the installation of the exploder and booster and patrol maintenance operations are described. The chapter is concluded with a description of the procedures for loading and launching the torpedo and for recall (removing an unfired torpedo from an underwater tube).

When fully prepared for a war shot, Torpedo Mk 27 Mod 4 is equipped with War Head Mk 27 Mod 2 which contains approximately 124 pounds of HBX explosive. This charge is detonated upon firing of Exploder Mk 11 Mod 2 and Booster Mk 9 Mod 0 which are installed in the warhead. In the war shot condition, the torpedo is powered by Storage Battery Mk 7 Mod 3. This battery weighs approximately 99 pounds more than the exercise battery, thus giving the torpedo a negative buoyancy. The warm-up, electrical setting, and firing of the torpedo are effected by Fire Control System Mk 101, Mk 106, or Test Set Mk 183 Mod 1. The torpedo cannot be fired from submarines not equipped with one of these fire control systems. The manner in which the fire control system is used to determine the torpedo settings for specific problems involves doctrine which is beyond the scope of this publication. For the general considerations related to the employment of the torpedo in a war shot, refer to chapter 3.

Before Torpedo Mk 27 Mod 4 is actually fired in a war shot, it is prepared as follows:

The torpedo is completely tested in the workshop and is then fitted with a war head. However, for safety in handling, the booster and exploder are not installed at this time. The torpedo is then transported to the submarine to which it is assigned and is loaded into the torpedo room. Loading the torpedo aboard certain submarines requires the use of a loading tray, figures 67 and 68. The loading tray facilitates lowering the torpedo through the hatch of the submarine and helps in handling the torpedo within the torpedo room.

After the torpedo has been stowed aboard the submarine, it is given a brief test and is fitted with the exploder and booster. The torpedo can then be loaded into the racks or it can be loaded into a torpedo tube.

Readying War Shot Torpedo in Workshop

After Torpedo Mk 27 Mod 4 is received from the factory, proofing facility, or storage and before it is prepared for transporting to a submarine, it is tested in the workshop and is then assembled in the war shot condition except for the installation of the booster and exploder.

The purpose of the tests performed in the workshop is to insure that all circuits are functioning correctly and that the torpedo is prepared in all respects to perform successfully. As received from the factory, proofing facility, or storage, the torpedo has been carefully adjusted and should pass the workshop test. However, if any of the test requirements are not met, the defective portion of the torpedo should be tested according to the more complete procedures described in chapters 10, 11, and 12 of this publication in order to localize and remedy the defect.

In the following paragraphs, the workshop equipment necessary for readying the torpedo for a war shot is listed and instructions are given for performing the required tests and assembly operations. The instructions are outlined in a form that can be used in the preparation of checkoff sheets.

Workshop Equipment Required. Readying the torpedo for a war shot requires the following workshop equipment:

General Purpose Equipment (Refer to Chapter 14)
Test Set Mk 183 Mod 0
Gyro Test Stand

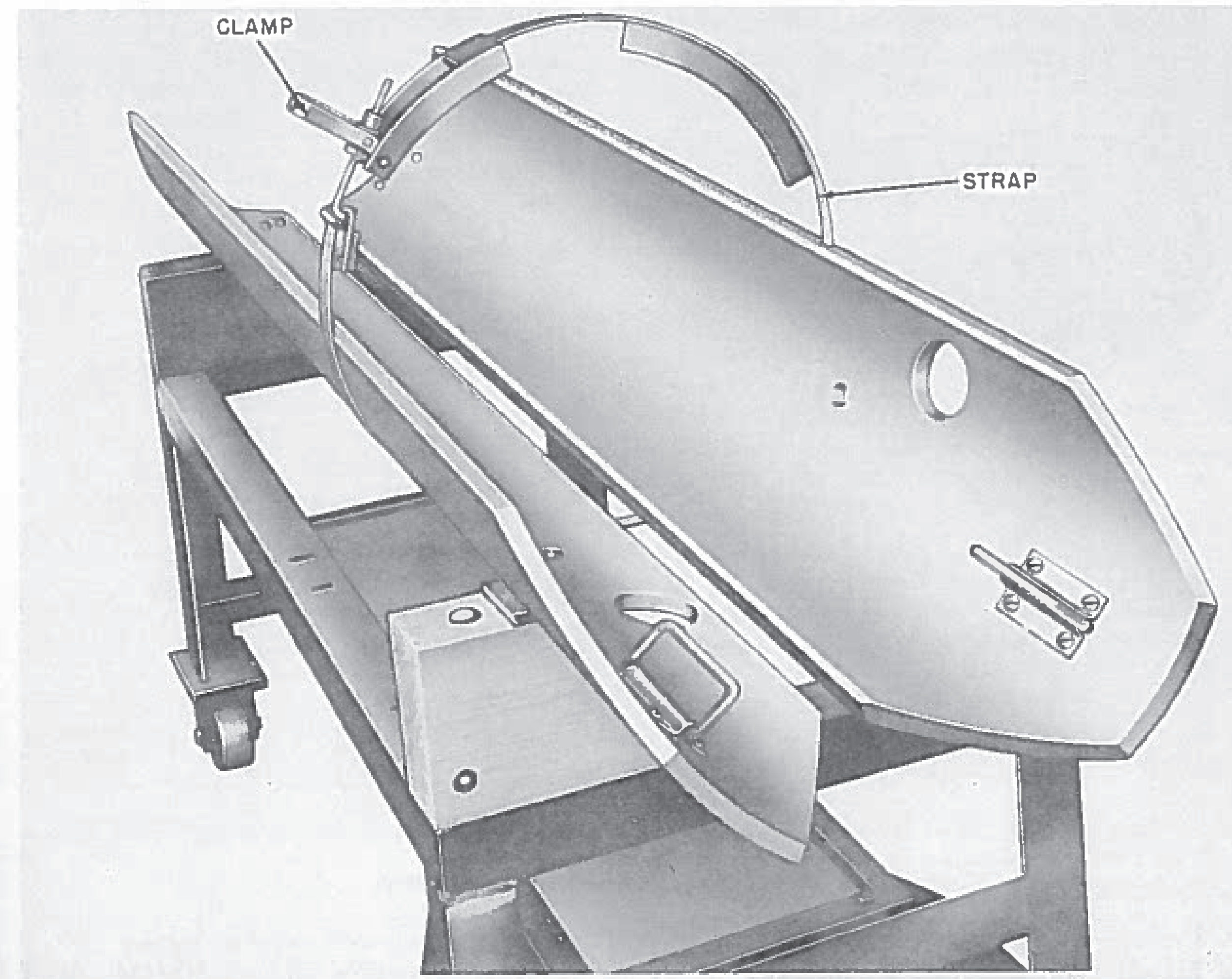


Figure 67—Loading Tray.

Pressure and Vacuum System, Dwg. 794436 (or equivalent)
24- and 48-Volt DC Power Source

Preparation for Test. Before the tests are made, the following preparations are necessary:

1. Unpack torpedo and place it on dollies. (Refer to instructions in chapter 9.)
2. Remove shipping bulkhead from battery compartment.
3. Unbolt battery compartment from afterbody, and swing afterbody aside.
4. Remove all handhole covers from afterbody and battery compartment.
5. Remove B power supply and its bracket from after end of battery compartment, and then remove after bulkhead.
6. Untape cables, remove desiccant bags from afterbody and battery compartment, remove pendulum clamp, and check interior of battery compartment and afterbody for loose or damaged equipment.
7. Remove battery clamp. Obtain fully charged Storage Battery Mk 7 Mod 3 and slide battery into battery compartment, taking care not to catch and break any interior wiring. The positive terminal of battery must be forward. Clamp battery by using knurled screw adjustment to tighten adjustable clamp assemblies. When clamp assemblies are tight, lock them in place by tightening hex nut of each assembly. Replace battery clamp and tighten it securely.

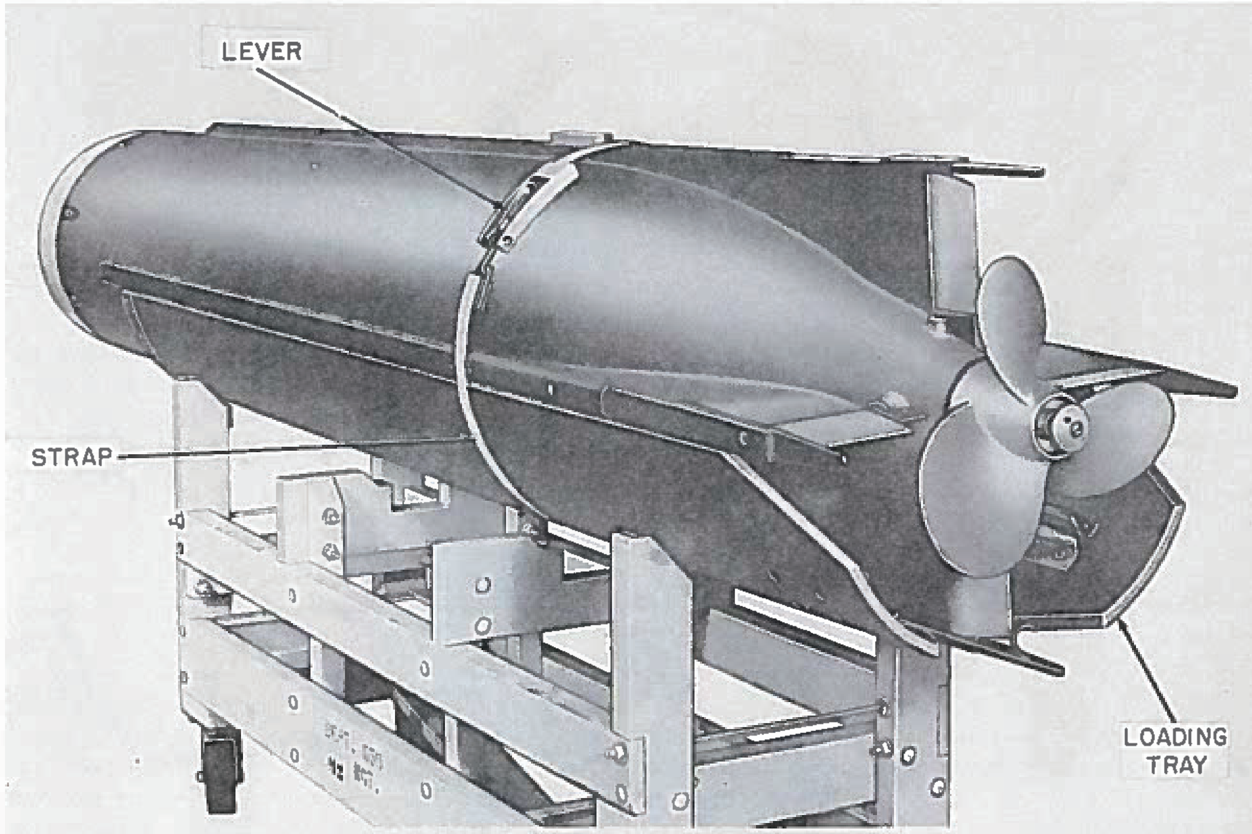


Figure 68—Loading Tray Strapped to Torpedo.

8. Connect heavy ground cable to positive battery terminal. Tighten nut on terminal securely to make good electrical connection. At this time, do not connect heavy cable leading from main motor relay to negative battery terminal.

9. Replace after battery compartment bulkhead and B power supply and its bracket, making sure that B power supply is isolated by special rubber spacers.

10. Connect main cable to afterbody junction box and connect input and output cables to B power supply. Connect ground strap between afterbody shell and battery compartment shell.

11. Remove gyro from afterbody, and check its precession in accordance with instructions in chapter 10. If necessary, readjust gyro so that precession requirements are met. Re-install gyro in afterbody.

12. For test purposes, connect battery power cable (accessible through forward hand hole) and 28-volt lead of torpedo to an external source of DC power (either a battery, motor-generator, or DC supply). This power source must be capable of supply 24±2 volts DC at 15 amperes and 48±2 volts DC at 3 amperes. For purposes of these tests, the 28-volt lead of torpedo may be connected to a 24-volt source.

13. Make sure that ground strap in after hand hole is not clamped.

14. Remove wooden panel subassembly from forward end of battery compartment.

15. Remove shipping plate assembly from shell connector receptacle on afterbody, and plug workshop fire control cable into receptacle.

16. Plug other end of workshop fire control cable into Test Set Mk 183 Mod 0 and

turn on AC and DC power of test set. (Refer to chapter 14 for operating instructions for Test Set Mk 183 Mod 0).

17. Connect a source of adjustable air pressure to DEPTH vent of afterbody and to both vents of battery compartment.

18. When ready to make prerun tests, connect ground strap (accessible through after hand hole).

Prerun Tests for Battery Compartment and Afterbody. Conduct prerun tests for battery compartment and afterbody as follows:

1. Turn Test Set Mk 183 Mod 0 to STANDBY and set stratum switch to AL position. Turn Test Set Mk 183 Mod 0 to OFF. Apply air pressure of approximately 31 psi to pressure vent. Turn the pressure applied to vents, elevators should go up. Lower afterend of afterbody. At 10±2 degrees, elevator should suddenly go down. Return afterbody to level position.

6. Adjust air pressure on vents until elevators are level. (When elevators are level, pressure should be 31±2 psi.)

7. Raise afterend of afterbody. Elevators should turn up. Return afterbody to level position.

8. Measure voltage at exploder cable connector. This should be 24±2 volts DC. Increase pressure on the vents. Voltage across exploder cable should become zero at an air pressure of 38±3 psi, and should remain zero at any pressure

Change 2

NOTE: The fire relay K13 will not operate unless the warm-up time has been long enough to operate the thermal time delay relay K21. The K21 relay shall close in 15±3 seconds.

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Change 2

8. Lower after end of afterbody; elevators should turn down. Return afterbody to level position.

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Change 2

15. Stop torpedo by disconnecting -24 volt D.C. lead of cylinder cable at power source, then reconnect lead.

16. Relatch gyro. Turn Test Set Mark 183 Mod 0 to STANDBY. Set stratum switch to NL position. After torpedo has been in STANDBY condition for 30 seconds, turn Test Set Mark 183 Mod 0 to ON and operate fire switch. Turn Test Set Mark 183 Mod 0 to OFF.

17. Check to see that steering motors start immediately after firing switch is operated.

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Level afterbody. With more than 38 psi pressure.

18. Actuate ACC relay by grounding terminal E22-9 of afterbody junction box, or by changing heading of afterbody by an angle greater than 135±10 degrees from its original position. Check to see that ACR circuit operates to stop torpedo.

19. Relatch gyro. Turn Test Set Mk 183 Mod 0 to STANDBY. Turn off —24-volt DC warm-up power furnished by power supply of Test Set Mk 183 Mod 0. Turn control switch on Test Set Mk 183 Mod 0 to ENABLER. Set enabler to a range of —100 yards (349 degrees). Turn control switch back to GYRO, and set gyro to 0 degrees. Turn HIGH VOLTAGE switch on power supply of Test Set Mk 183 Mod 0 to OFF. Reconnect —24 volts DC warm-up power.

20. Set stratum switch to AL. After 30 seconds on STANDBY, turn Test Set Mk 183 Mod 0 to ON, and operate fire switch. Turn Test Set Mk 183 Mod 0 to OFF.

21. Torpedo should now be enabled, and a change in position of afterbody should not affect rudder or elevator position. Rudder should be at an angle of approximately 2 to 7 degrees to port, and, with zero pressure on depth vents, elevators should be down.

22. Check pressure required to make the elevators level. This should be 31±2 psi.

23. Conduct a rub test as explained in step 1.

Rub starboard.
Rub port.
Rub up.
Rub down.

24. Reduce air pressure applied to vents. At 9 psi, hard rubbing on up hydrophone should not make elevators level.

25. Increase air pressure on vents. At pressures greater than 39±3 psi, rudder and elevators should not respond to rubbing on hydrophones.

26. Turn Test Set Mk 183 Mod 0 to STANDBY, and set stratum switch to BL position. Turn Test Set Mk 183 Mod 0 to OFF.

27. At pressures less than 29±3 psi, elevators and rudder should not respond to rubbing.

28. Check air pressure required to make elevators level. This should be 55±5 psi.

29. Rub briskly on up hydrophone. Gate relay K2 should release, and elevators should respond quickly in up direction.

30. Turn Test Set Mk 183 Mod 0 to STANDBY and set stratum switch to NL. Turn Test Set Mk 183 Mod 0 to OFF. Rub up hydrophone while gradually reducing air pressure on vents. At pressures lower than 39±3 psi, elevators should not respond as readily as in step 29 (due to lack of gating). At pressures lower than approximately 14 psi, the elevators should respond even less readily.

31. Stop torpedo by disconnecting —24-volt DC lead of cylinder cable at power source, and then reconnect lead. Turn HIGH VOLTAGE switch of Test Set Mk 183 Mod 0 to ON.

32. Connect —24 volts DC from an external supply to main motor relay, and connect heavy power cable on main motor to other side of main motor relay (MMR). Attach positive lead from external power supply to main motor.

33. Relatch gyro. Turn Test Set Mk 183 Mod 0 to STAND BY. Turn on -24 volts DC warm-up power furnished by power supply of Test Set Mk 183 Mod 0. Turn control switch on Test Set Mk 183 Mod 0 to ENABLER. Set enabler to a range of 1000 yards. Turn control switch back to Gyro, and set Gyro to 0 degrees. Set stratum switch to BL.

set enabler to 1000 yards.

34. After 30 seconds on STANDBY, turn Test Set Mk 183 Mod 0 to ON, and operate fire switch. Turn Test Set Mk 183 Mod 0 to OFF.

35. Main motor and steering motors should start immediately.

36. Increase air pressure on vents to make elevators level. This should occur at 55±5 psi.

37. Change heading of afterbody to starboard of original heading and then to port. Rudder should turn through an angle of 6 to 10 degrees to port and then turn through the same angle to starboard.

41. Check to see that voltage at exploder cable is 24 ± 2 volts DC with 55 ± 5 psi air pressure applied.

41a.

42. Turn Test Set Mk 183 Mod 0 to STAND BY, and set stratum switch to AL. When STRATUM light indicates torpedo is in AL condition turn Test Set Mk 183 Mod 0 to OFF. Check to see that exploder voltage has disappeared. Elevators should be hard up and no elevator or rudder response should occur when hydrophones are rubbed. Reduce air pressure and check for appearance of 24 ± 2 volts DC at exploder cable when pressure reaches 39 ± 3 psi.

43. Check air pressure required to make the elevators level. This should be 31 ± 2 psi.

~~44. Rub briskly on UP hydrophone. Gate relay K2 should release and elevators should respond quickly in UP direction.~~

45. Turn Test Set Mk 183 Mod 0 to STAND BY, and set stratum switch to NL. When STRATUM light indicates torpedo is in NL condition turn Test Set Mk 183 Mod 0 to OFF.

45a.

46. Check to see that voltage at exploder cable is 24 ± 2 volts DC, at all pressures.

47. Stop torpedo by disconnecting -24 volt DC power lead from external power source.

Change 2

41a. Rub briskly on UP hydrophone. Gate relay K2 should release and elevators should respond quickly in UP direction.

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Change 2

44. Conduct a rub test as explained in step 1; then, reduce air pressure applied to vents. At pressures lower than approximately 14 psi, it should require harder rubbing on the UP hydrophone to get elevator response.

45a. Check air pressure required to make elevators level. This should be 55±5 psi. Rub UP hydrophone while gradually reducing air pressure on vents. At pressures lower than 39±3 psi elevators should not respond as readily as in step 41a, due to lack of gating. At pressures lower than approximately 14 psi, the elevators should respond even less readily.

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Change 1

38. Torpedo should enable in approximately one minute due to higher speed of the unloaded propellers. When torpedo enables, gyro motor and gyro relay K8 should become de-energized, gyro should start to slow down, and the exploder cable will be electrically armed.

down.

39. Elevators should still be level with air pressures at 55±5 psi, and rudder should be at an angle of approximately 2 to 7 degrees port, depending upon noise in vicinity of torpedo. ______

40. Conduct a rub test to see that elevators and rudder respond correctly. (Refer to step 1.) ______

Rub starboard. ______
Rub port. ______
Rub up. ______
Rub down. ______

~~41. Stop torpedo by disconnecting —24-volt DC power lead from external power source.~~ 41 thru 47 Page 103A

War-Shot Assembly. The war shot torpedo is assembled as follows:

1. Remove ground strap (accessible through after hand hole). ______

2. Disconnect temporary power lead from main motor relay, and connect heavy battery lead to main motor relay. ______

3. Connect other end of heavy battery lead to negative terminal on battery (at afterend). Tighten connections securely. ______

4. Attach main control cable leads to terminal strip on the propulsion battery as follows:

Color of Lead Sleeve	Battery Terminal	
Red	—48 volts DC	______
Black	—28 volts DC	______
Green	—24 volts DC	______
Yellow	Charging	______

5. Position Warhead Mk 27 Mod 2 in front of battery compartment. Remove cover nut from warhead, using cover nut spanner wrench. Replace wooden panel cover. Tie a piece of twine to exploder cable behind cable receptacle and feed twine and cable into conduit in warhead. Be sure that exploder receptacle is clear and that exploder cable connector and twine can be reached through front opening of exploder receptacle. ______

... compartment after lubricating mating surfaces and gaskets with castor oil. Tighten mounting nuts evenly, using just enough pressure to compress gasket firmly. ______

8. Install all hand hole covers on battery compartment with the exception of the after hand hole cover. Assemble hand hole cover bolt, metal bolt washer, and bolt gasket, being careful to place metal washer directly beneath bolt head. Place this assembly into bolt hole of hand hole and engage bolt and spider threads. Be sure that hand hole cover spiders are correctly positioned and that cover gaskets are lubricated with castor oil. To avoid distorting cover spiders, tighten cover bolts only with a torque wrench. For steel spider (377893) torque should be from 10 to 20 pound-feet. For bronze spider (TP77305) torque should be from 10 to 50 pound-feet. ______

9. Relatch gyro. ______

10. Replace gyro hand hole cover. Be sure that gasket is lubricated with castor oil, and that both bolts are tightened securely with torque wrench. ______

11. Attach afterbody to battery compartment after lubricating mating surfaces and gaskets with castor oil. Tighten mounting nuts evenly, using just enough pressure to compress gasket firmly. ______

12. Connect ground strap. Apply leveling pressure to DEPTH vent. Turn TEST switch to TEST 1 for 30 seconds, and then to TEST 2. Conduct a final rub test. (Refer to step 1 of prerun tests.)

Rub starboard. ______
Rub port. ______
Rub up. ______
Rub down. ______

13. Disconnect ground strap. Install and secure battery compartment after hand hole cover, using the special vacuum fitting bolt.* Attach hose to this bolt and draw a vacuum of 20 inches of mercury.

* NOTE: afterbody test cable must not be installed during vacuum test.

Close valves on vacuum system and check vacuum meter at intervals for a 15 minute period. Vacuum should not decrease more than one-quarter inch of mercury.

NOTE: DO NOT ALLOW TORPEDO TO STAY IN EVACUATED CONDITION FOR MORE THAN 15 MINUTES. RELIEVE VACUUM AS SOON AS POSSIBLE. IF VACUUM IS RETAINED TOO LONG SIDES OF PENDULUM ASSEMBLY MAY BE COMPRESSED AFTER RELIEF FROM VACUUM AND INTERFERE WITH MOVEMENT OF PENDULUM.

14. If result of step 13 indicates that a leak is present, the leak can be located as follows: Apply an air pressure of 5 psi to after hand hole fitting. (Do not exceed this pressure.) Apply soap solution to all joints and seals, and look for bubbles. If a leak is known to exist and cannot be located with the soap solution, it must be assumed to be caused by the gasket, (O–ring) or sealing surface in the exploder cavity. Inspect sealing surface for scratches or grooves if replacement or O-ring gasket does not eliminate the leak.

NOTE: If the leak cannot be located, the exploder cavity O-ring is possibly defective. Relieve pressure and remove the cavity plug. Install a new O-ring, lubricate, and repeat the vacuum test.

15. When torpedo has passed leak test, relieve vacuum and replace vacuum fitting bolt in after hand hole cover with a standard hand hole cover bolt. Tighten with torque wrench.

16. It is advisable to leave grounding strap in after hand hole disconnected until torpedo has been loaded aboard the vessel to which it is assigned. Replace after hand hole cover using standard bolt. Tighten with torque wrench.

17. Remove exploder cover nut and cavity plug. If the warhead is supplied with exploder cover nut, reinstall the cover nut and seal off cavity with adhesive tape; if the warhead is NOT supplied with the cover nut, seal ONLY with the adhesive tape. Install afterbody test cable

18. Turn Test Set Mk 183 Mod 0 to STANDBY and set STRATUM switch to ABOVE LIMIT. Turn Test Set Mk 183 Mod 0 to OFF and disconnect test plug from torpedo shell receptacle in afterbody. If desired, replace shipping cover over torpedo shell receptacle.

Handling and Stowage

The following paragraphs describe the procedures for handling the torpedo in transport and for stowing it aboard the vessel to which it is assigned. This description is followed by instructions for performing a simple check to see that the torpedo has not been damaged in handling.

Handling and Stowing Procedures. Torpedo Mk 27 Mod 4 must be handled carefully to avoid damage. To prevent leakage of the battery electrolyte, do not rotate the torpedo more than 45 degrees from normal during handling. This torpedo is handled in the same manner as other torpedoes when it is loaded aboard a submarine, with the exception that a loading tray may be used for protection. ~~When sliding the torpedo through the loading hatch, make the snubbing line fast to the hooks at the after end of the loading tray rather than to the torpedo itself. The torpedo is prevented from sliding out of the tray by a~~ strap fastened around the torpedo and ~~tray~~. The tray must remain on the torpedo during all handling and stowage aboard a submarine and it is not to be removed until immediately before the torpedo is loaded in the tube. *

Since Torpedo Mk 27 Mod 4 is approximately

WARNING: When sliding the torpedo through the loadin[g] fast to the loops in the loading band, and not to the loading tray. These handles are used to withdraw the has been loaded into the tube.

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torpedo is stowed, ... the following checks

to be sure that the torpedo has not been damaged in handling:

1. Examine exterior of torpedo to see if there is any damage to propeller, gudgeons, vanes, or any other part.

2. Open after hand hole and securely connect grounding strap.

3. Purge torpedo of hydrogen by connecting a low-pressure air line to fitting inside after hand hole. Apply 25 psi of compressed air for at least 15 ~~8~~ minutes.

4. Check torpedo circuits by performing a "tickle" test as follows: NOTE *

a. Using test switch tool, turn TEST switch on port side of battery compartment to TEST 1 for 30 seconds and then to TEST 2. Rudder should turn through an angle of approximately six degrees to port, elevators should turn down through an angle of approximately 10 degrees or greater, and both rudder and elevators should oscillate about these positions with an amplitude of several degrees. Rate of oscillation should be approximately three cycles per second. (Oscillation may be somewhat erratic, particularly if there is noise in vicinity of torpedo.)

b. Rub hand briskly over shell near port hydrophone. Rudder should move to port. When rubbing is stopped, rudder should return to its original position.

c. Rub hand briskly over shell near starboard hydrophone. Rudder should move to starboard. When rubbing is stopped, rudder should return to original position.

d. Rub hand briskly over shell near up hydrophone. Elevators should move up. When rubbing is stopped, elevators should return to original position.

e. Turn TEST switch back to RUN position.

f. Return elevators and rudder to center position by grasping each pair of stub shaft wings between thumbs and fingers and exerting pressure firmly but slowly in required direction of motion. Do not exert pressure on vanes or apply force suddenly to stub shaft wings. To prevent damage to the steering mechanisms, force must be applied equally to both stub shaft wings of a pair.

5. Replace after hand hole cover and tighten bolt using a torque wrench.

* NOTE: Perform an explosimeter test to ensure that hydrogen concentration is within safe limit.

Installing Booster and Exploder *

* For information concerning exploders equipped with dummy shutter housings refer to OP 1999 (rev. ...)

The following paragraphs describe the procedure for installing Booster Mk 9 Mod 0 and Exploder Mk 11 Mod 2 in Warhead Mk 27 Mod 2, figure 69.

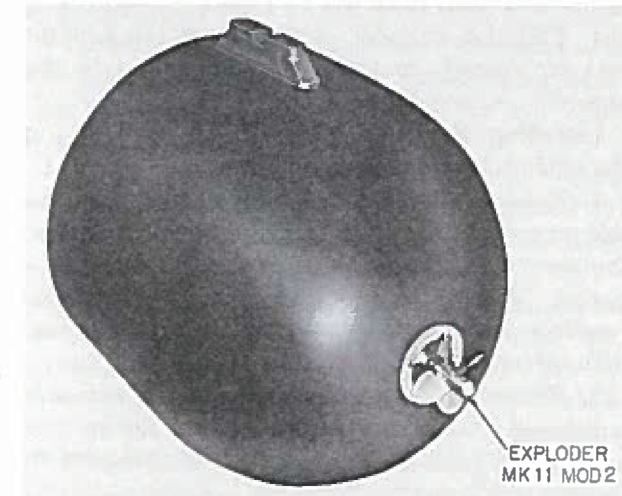

Figure 69—Exploder Mk 11 Mod 2 Installed in Warhead.

WARNING

BEFORE INSTALLING AN EXPLODER BE ABSOLUTELY CERTAIN THAT THE EXPLODER HAS BEEN CHECKED AND TESTED AS EXPLAINED IN OP 1999.

Preparing Cavity and Installing Booster. Prepare the exploder cavity and install Booster Mk 9 Mod 0 as follows:

1. Remove exploder cover nut from head, using cover nut spanner wrench, and check to see that exploder cavity is clear. Be sure that exploder cable coming down into cavity from above has a piece of twine tied to its free end. Inspect threads and O-ring sealing surface.

2. Push the exploder connector back into the the inner conduit. The retrieving twine should remain in the exploder cavity. Insert into the bottom of the cavity as many corrugated fiber spacers as required to hold the booster firmly against the base of the exploder.

WARNING

HANDLE THE BOOSTER WITH EXTREME CARE. DO NOT DROP OR DEFORM THE BOOSTER IN ANY WAY.

3. Insert Booster Mk 9 Mod 0 into the exploder cavity and push it all the way back.

4. Pull the exploder cable out of the conduit just far enough to make the connection to the exploder; remove twine.

Installing Exploder. Install the exploder in the exploder receptacle as follows:

1. Remove the exploder and impeller from the shipping container. Carefully remove the tagged shorting wire from the exploder. Inspect the gasket (O-ring) to be sure it is in serviceable condition; replace if necessary. Lubricate O-ring with castor oil.

2. Connect the exploder cable to the exploder and carefully slide the assembly into the cavity, alining the guide pin on the exploder flange with the slot in the cavity.

3. Remove the cover nut from the cylindrical spacer in the shipping container and screw it into the warhead to hold the exploder in position. Tighten the nut securely, using the exploder-cover nut spanner wrench.

Exploder Setting. The impeller is installed and the distance dial is set as follows:

1. Place the impeller over the plunger. Push the impeller into the exploder until seated and the spur gear on the impeller shaft is meshed with the No. 1 gear. Hold the impeller in this position and do NOT release it until the dial is set.

WARNING

THE IMPELLER WILL SPRING OUT OF THE EXPLODER WITH CONSIDERABLE FORCE IF IT IS NOT HELD IN SECURELY WHILE THE DIAL IS BEING ROTATED.

2. Place the setting wrench over the square end of the dial spindle. Push the wrench in to set the dial, which can be turned only when the shaft is in, and turn the spindle to rotate the dial clockwise to the 300-yard setting. The dial cannot be set for less than 300 yards.

CAUTION: Do not attempt to turn the dial counterclockwise, i. e., from SAFE to ARM to 100. Turning the dial in this direction may damage the gears and render the exploder inoperable.

3. Remove the setting wrench. The impeller should now be firmly fixed in the exploder.

CAUTION: The impeller shaft is relatively weak and brittle. Exercise extreme care when handling and stowing the torpedo to prevent damaging or breaking this shaft.

4. Perform vacuum test of torpedo.

Inspection

After the exploder and booster have been installed in the war head, inspect the torpedo as follows:

1. Check to see that gyro is latched and zeroed. This can be done by looking through window in hand hole cover in afterbody.

2. Check to see that vanes, propeller, gudgeon plates, and exploder impeller are not damaged, that cylinder bolts are tight, and that hand hole covers are bolted down securely.

The torpedo is now ready for patrol.

Patrol Maintenance

Patrol maintenance consists of a regular schedule of purging the hydrogen gas evolved by the battery while the torpedo is in stowage, and a regular schedule of recharging the battery so that it is maintained in a fully charged condition. The torpedo should also be given a "tickle" test at periodic intervals. Should it be found that a torpedo fails to pass a "tickle" test or shows evidence of external damage, certain limited repairs can be made aboard ship. If repairs are necessary, reference should be made to the maintenance section of this manual. No repair should be undertaken if it requires tools and instruments not available on the vessel.

Prevention of Hydrogen Explosions in Torpedo. When the torpedo is sealed, the air enclosed within the shell contains oxygen. If no precautions were taken, the hydrogen gas evolved by the battery would mix with the air and the presence of the oxygen could create an explosive mixture which may be ignited by sparks at relay contacts or at the motor commutator when the torpedo is fired. The resulting internal explosion could damage the torpedo.

To prevent an explosive mixture from developing, the palladium catalyst unit causes the hydrogen, as it is evolved, to unite gradually with the oxygen to form water vapor. (The catalyst is not consumed in this process but merely causes the chemical action to occur at ordinary temperatures.) The hydrogen continues to unite with the oxygen until all of the oxygen has been consumed. After this point, hydrogen gas continues to be evolved by the battery but since there is no further supply of oxygen, the gas mixture in the torpedo is not combustible and there is no danger of an explosion.

Desiccator assemblies are mounted on each of four hand hole spiders to absorb the moisture produced when the hydrogen and oxygen combine inside the torpedo. Each of these assemblies consists of a one-pound bag of silica-jel held in a perforated container. Replacement assemblies are furnished in a sealed metal can containing three units. All four desiccator assemblies in a torpedo should be replaced each time the battery is charged and each time the torpedo is purged of hydrogen. Because of the high humidity in the torpedo room, the replacement assemblies should be installed only after all other work has been done, and the can of replacements should not be opened until immediately before the assemblies are to be installed.

Clearing Torpedo of Hydrogen. The torpedo must be cleared periodically of hydrogen gas evolved by the battery.

WARNING

TO AVOID THE POSSIBILITY OF AN EXPLOSION, KEEP FLAMES AWAY AND DO NOT SMOKE IN AREA. HANDLE TOOLS CAREFULLY TO AVOID SPARKS.

Purging Torpedo of Hydrogen. TORPEDOES STOWED ON RACKS / or in tubes SHOULD BE PURGED OF HYDROGEN EVERY TWO DAYS BY MEANS OF A LOW PRESSURE AIR LINE CONNECTED TO THE FITTING INSIDE THE AFTER HAND HOLE. USE A PRESSURE OF NOT LESS THAN 25 PSI AND KEEP THE AIR LINE CONNECTED FOR NOT LESS THAN THREE MINUTES.* During the purging process, all hand hole covers must be removed.

Explosimeter Tests for Hydrogen. Before ventilating periods, torpedoes in racks / on tubes should be tested for hydrogen gas concentration. This test is made by using the explosimeter as follows:

1. Lift bar on explosimeter switch, and turn switch clockwise until meter needle points to zero.

2. Squeeze aspirator bulb five or more times to purge instrument.

3. Remove lock bolt from one of the hand hole covers, and lower free end of explosimeter sampling hose down about a foot into battery compartment through bolt hole.

4. Draw gas from battery compartment by squeezing aspirator bulb, and allowing bulb to return to normal, repeating this operation at least ten times. This process is called "aspiration". During aspirating process, watch explosimeter scale. (The scale reads from 0 to 100. A reading of 100 denotes a hydrogen in air concentration of approximately 4 percent, which is the minimum hydrogen-air mixture in which a gas explosion is possible.) If at any time during aspirating process, pointer moves to center scale deflection, or greater, purge torpedo of hydrogen as previously explained.

5. After completion of test, rotate explosimeter switch counterclockwise until switch points to OFF. In off position, bar should drop into slot of switch. In order to conserve explosimeter batteries, do not leave switch on any longer than necessary.

NOTE: Detailed instructions concerning the use and maintenance of the explosimeter are furnished with each instrument.

Battery Charging. The following paragraphs contain instructions for charging the storage battery during patrol.

WARNING

CHARGING OF STORAGE BATTERY SHOULD BE DONE IN A WELL VENTILATED PLACE BECAUSE HYDROGEN GAS EVOLVED MAY RESULT IN AN EXPLOSIVE MIXTURE IF BATTERY IS CONFINED. KEEP ALL FLAMES AWAY. DO NOT SMOKE IN AREA IN WHICH BATTERIES ARE CHARGED OR WHERE TORPEDOES CONTAINING

* Verify the return of air to the battery compartment through the vent pipes. Torpedoes may be stowed on racks with the forward and aft handhole covers removed to permit ventilation of Battery compartment. Purging is not required for any torpedo stowed with these covers removed.

881656 O—56——8

BATTERIES ARE STORED. AT 100 DEGREES (F) IT IS POSSIBLE FOR HYDROGEN DISCHARGED FROM BATTERY TO BUILD UP AN EXPLOSIVE MIXTURE IN AN UNVENTED TORPEDO IN APPROXIMATELY 24 HOURS. LESS HYDROGEN IS DISCHARGED AT LOWER TEMPERATURES. DURING CHARGING, IT IS NECESSARY TO PURGE THE BATTERY COMPARTMENT PERIODICALLY TO PREVENT EXPLOSIVE MIXTURES FROM ACCUMULATING. NEVER TURN TEST SWITCH WITHOUT FIRST CHECKING HYDROGEN CONCENTRATION WITH EXPLOSIMETER.

The storage battery in the torpedo must be maintained in good operating condition by careful attention to charging. The specific gravity of the electrolyte should be kept above 1.250, because a decrease of 0.025 in gravity from the fully charged condition represents a 16 percent loss in available power at 80 degrees (F). Give the battery a freshening charge at intervals of eight to ten days, or whenever the specific gravity, corrected to 80 degrees (F), drops to 1.250. The temperature of the electrolyte during the idle period affects the self-discharge rate and consequently affects the allowable period between freshening charges. At 70 degrees (F) the idle period between freshening charges can be considerably greater than it can at 80 degrees, 90 degrees, or some higher temperature.

Checking Specific Gravity. Check the specific gravity of the electrolyte as follows:

1. Perform an explosimeter test for hydrogen.
2. After testing for hydrogen, remove all hand hole covers and select two cells for sampling. Remove vent caps from these cells.
3. Measure specific gravity with extension hydrometer. If specific gravity of sample cells is approximately 1.250 (corrected to 80 degrees F.) or less, battery should be given a freshening charge. Replace vent caps on sample cells.

NOTE: Use the same two cells for making specific gravity measurements throughout this entire charging procedure. However, each time the battery is checked for determining whether a freshening charge is necessary, use two different cells.

Procedure for Freshening Charge. To give the battery a freshening charge, proceed as follows:

1. Remove ground strap.
2. Insert charger plug through rear hand hole and connect it to charging receptacle, turning plug clockwise in receptacle. (Battery charging receptacle is located inside battery compartment across from rear hand hole. Plug and socket are polarized to insure correct connections.)

WARNING

WHEN CHARGING BATTERY, ALWAYS BREAK CONNECTIONS AT CHARGER CONTROL PANEL BY REMOVING FINE ADJUSTMENT PLUG BEFORE CONNECTING OR DISCONNECTING CHARGER PLUG AND CHARGING RECEPTACLE. THIS IS DONE TO AVOID POSSIBILITY OF EXPLOSION FROM ELECTRIC SPARKS. KEEP THE TOP OF THE BATTERY DRY AND CLEAN.

3. Charge battery at two-ampere rate for five hours. (Do not exceed two-ampere rate.) During this period leave all hand holes open. If ambient temperature inside torpedo room is high, storage battery thermometer should be used at intervals throughout charging period to make readings of electrolyte temperature. Except in an emergency, do not allow battery electrolyte temperature to rise above 120 degrees (F).
4. After completion of freshening charge, remove vent caps from same two cells selected previously as samples and test specific gravity and temperature. Hydrometer reading should be between 1.280 and 1.285 (corrected to 80 degrees F.). If necessary, continue charging at two-ampere rate until reading is within this range.
5. If necessary, refill battery with distilled water. (Check electrolyte level every two weeks.) To obtain correct electrolyte level (⅜ inch above plate separators), use filling and leveling syringe provided. Insert nozzle of syringe in filling hole of battery cell as far as possible, then use syringe to draw out all excess electrolyte reached by nozzle.
6. Replace vent caps. Clean top of battery. Remove charger cord, ~~replace ground strap, and~~

Measurement of Battery Ground Resistance

Stray leakage paths and grounds occasionally occur in storage batteries installed in this type of weapon. These faults can decrease the effectiveness of the battery and can result in conditions dangerous to personnel handling the torpedo. The ground condition should be checked whenever a battery is installed in the battery compartment or when refilling and recharging are performed. Most leakage paths are formed by electrolyte that has been spilled on the battery or that has leaked from surface cracks. A voltmeter is used to measure the ground resistance of the installed battery. A 100 ohm per volt voltmeter can be used if the 50 volt range is utilized. Otherwise, use a 1000 ohms per volt, or higher, voltmeter with a 5000 ohm ∠ 10%, 5 watt resistor connected across its input terminals. With either voltmeter the ground voltages measured must not exceed 1/10 of the terminal voltage of the battery.

Perform the measurements in the following manner:

NOTE: DO NOT TOUCH TORPEDO OR BATTERY TERMINALS IF DECK AREA IS WET. REMOVE WEAPON TO A DRY AREA OR USE AN INSULATING PAD UNDER SHOES.

Step 1. Disconnect ground link in after hand hole.
Step 2. Connect positive lead of voltmeter to positive terminal of battery. Touch negative lead of voltmeter to a bare spot on the compartment shell or to ground link. Note voltmeter reading.
Step 3. Connect negative lead of voltmeter to negative terminal of battery. Touch positive lead of voltmeter to a bare spot on the compartment shell or to ground link. Note voltmeter reading.
Step 4. Add two readings obtained. If total exceeds 1/10 of battery terminal voltage, excessive leakage is present. Remove battery from compartment and inspect for spilled electrolyte or cracks if leakage is evident.
Step 5. ALLOW TORPEDO TO VENTILATE AT LEAST TWO HOURS AFTER REFRESHING TO PREVENT POSSIBLE HYDROGEN EXPLOSIONS.

7. IF TORPEDO IS TO BE TUBE LOADED ALLOW IT TO VENTILATE FOR TWO HOURS AFTER COMPLETION OF CHARGE. THE TORPEDO SHOULD THEN BE PURGED, GROUND STRAP CLOSED, AND HAND HOLE COVERS INSTALLED, RENEWING GASKETS IF NECESSARY.

8. IF TORPEDO IS NOT TO BE TUBE LOADED, ALLOW IT TO VENTILATE FOR TWO HOURS AFTER COMPLETION OF CHARGE. THE TORPEDO SHALL THEN BE PURGED AND HAND HOLE COVERS INSTALLED, RENEWING GASKETS, IF NECESSARY.

9. TORPEDOES, BOTH TUBE LOADED AND IN THE RACKS, SHOULD BE CHECKED FOR HYDROGEN CONCENTRATION, WITH AN EXPLOSIMETER, APPROXIMATELY 12 HOURS AFTER COMPLETION OF A FRESHENING CHARGE. PURGE THE TORPEDO, IF THE EXPLOSIMETER READING IS 20 OR GREATER.

NEW MATERIAL ATTACHED PAGE 109A

Loading in Tube and Launching

The torpedo is loaded in an underwater tube and launched as explained in the following paragraphs.

Table 6—Control Cable and Torpedo Tube Data

Torpedo Tube	Control Cable	Length (inches)
Mks 32 to 35, 43, 45, 47, 50, 51.	Mk 1 Mod 9*	89
	Mk 1 Mod 5	89
	Mk 1 Mod 1	89
Mks 44, 46, 48	Mk 1 Mod 8*	69
	Mk 1 Mod 6	69
	Mk 1 Mod 2	69

*Preferred.

"Tickle" Test. Before loading the torpedo into the tube, perform a "tickle" test to make certain that the torpedo is functioning correctly. The procedure for conducting this test is described earlier in this chapter as a part of the post-loading check procedures.

Loading. After performing a tickle test, load the torpedo into the tube as follows:

1. Open breech door of tube.
2. Slide torpedo part way into tube, leaving afterbody accessible.
3. Remove straps holding torpedo to tray and remove tray.
4. Inspect gyro to be sure that it is latched.
5. Remove shipping cover from torpedo shell receptacle in afterbody, and insert connector

. Turn
cable in
h hook
torpedo
p bolt.
pe (see
Table 6) into door receptacle. Be sure that cable is clamped at lower end of door and is positioned so that it still passes through hook in lower gudgeon extension, and will not foul propeller. Close door carefully. This completes the loading procedure.

Launching. After the torpedo has been loaded, the standby, electrical setting and firing functions which follow should be executed in accordance with instructions pertaining to the fire control system being used. It should be remembered that Torpedo Mk 27 Mod 4 requires a minimum warm-up period of 30 seconds.

NOTE: When using Fire Control System Mk 101 or Mk 106, warm-up and setting voltages are supplied to the torpedo when the relay-transmitter OFF-STANDBY-ON switch is in the ON position. When using Test Set Mk 183 Type, the warm-up and setting voltages are supplied to the torpedo when the test set switch is in the STANDBY position.

WARNING

DO NOT KEEP TORPEDO ON WARM-UP FOR CONTINUOUS PERIODS GREATER THAN 15 MINUTES IN ORDER TO PREVENT DAMAGE TO GYRO BEARINGS AND CONSEQUENT MALFUNCTION OF THE GYRO.

*The Mod used is determined by the cable length required to accomodate the torpedo and the tube it is to be fired from. (See Table 6).

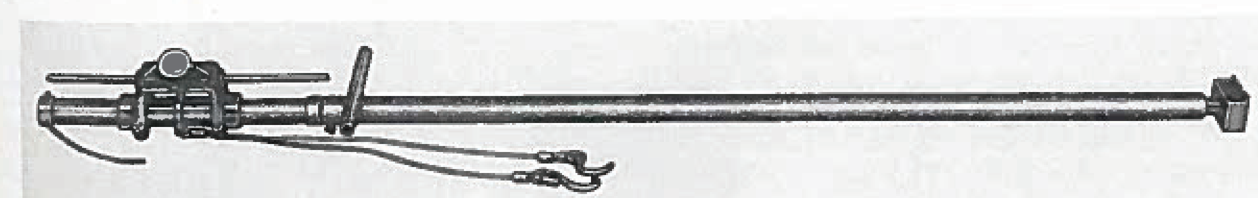

Figure 70—Loading Pole.

Change 2

The torpedo should be withdrawn from tube every two days, for purging. (See page 107, Purging Torpedo of Hydrogen.) The torpedo should also be withdrawn from the tube whenever a freshening charge is required. The period between withdrawals for charging will vary with the temperature. (See page 108 of Battery Charging.)

(Refer to patrol maintenance ...

If a submarine tube has been flooded with the torpedo in standby condition and the torpedo is not fired, the tube should be blown free of water and the torpedo removed from the tube as soon as possible. This must be done to avoid corrosion or the development of short circuits in the torpedo shell connector. To remove the torpedo after blowing the tube free of water proceed as follows:

1. Open breech door and carefully attach loading pole to propeller fairwater.

2. Disconnect torpedo control cable plug from door receptacle, being careful to prevent salt water from entering the receptacle.

...ck to ... cable. ... dgeon ... n torpedo shell receptacle. Inspect cable. If there is any evidence knife has cut cable, set cable aside for repair.

6. Strap tray to torpedo and slide torpedo out of tube.

7. Wipe all salt water off torpedo body, being careful to prevent salt water from entering torpedo shell connector.

8. Replace shipping cover on torpedo shell connector.

9. Purge torpedo of hydrogen.

10. Perform a "tickle" test to be sure torpedo is functioning correctly.

Chapter 8

PREPARATION FOR EXERCISE AND PROOFING RUNS

General

Torpedo Mk 27 Mod 4 may be run several times before it is expended in a war shot. These runs include proofing runs for torpedo acceptance, fleet exercise runs, and exercise runs conducted for the instruction of operating personnel. The procedures for conducting a proofing run are described in the proofing specification of latest issue, and the procedures for conducting an exercise run are determined by the particular tactical problem under consideration. Therefore, in this chapter, the procedures for conducting proofing runs and exercise runs are described only in general terms.

However, the procedures for preparing the torpedo to be run, firing the torpedo, and the post-run procedures are all essentially the same regardless of what methods are used for the actual run except that in proofing, the torpedo may be launched from an above water rack. This chapter gives complete instructions for these procedures by covering the following points:

a. A list is given of the shop and proving ground test equipment required for the procedures. (This equipment is described in chapter 14.)

b. Detailed checkoff lists are given for the pre-run assembly and test procedures which must be conducted before every run.

c. Detailed checkoff lists are given for the loading and launching procedures to be followed for firing the torpedo. These lists are preceded by instructions for preparing the torpedo to be fired.

d. A checkoff list is given for the maintenance and post-run procedures to be followed in preparing the torpedo for shipment or storage after a proofing run or exercise run.

e. The analysis of the tape record produced by Exercise Head Mk 48 Mod 3 (recording) is explained and illustrated by typical examples.

Equipment Used. For an exercise run, the warhead of the torpedo is replaced by either Exercise Head Mk 48 Mod 2 (nonrecording) or Exercise Head Mk 48 Mod 3 (recording). The nonrecording exercise head is loaded with an inert material to simulate the warhead in weight and includes devices for stopping the exercise run when a hit has occurred or after a specified time has elapsed. The recording exercise head produces a tape record of the depth run of the torpedo and impulse indications of any four desired functions within the torpedo. It also provides a maximum depth safety control, a means for controlling the time or length of the run, and for stopping the torpedo when a hit has occurred. (The maintenance of these heads is described in chapter 12.)

During a proofing run, the warhead is replaced by Exercise Head Mk 48 Mod 3 (recording). The nonrecording head is not used in proofing. The functions within the torpedo that are recorded by the four impulse indications must be those called for by the proofing specifications.

During exercise and proofing runs, the war shot battery of the torpedo is replaced by Storage Battery Mk 8 Mod 4. This propulsion battery is specifically intended for exercise or proofing runs. It is lighter than the war shot battery to give the torpedo a positive buoyancy (of approximately 20 pounds in salt water) so that it will float to the surface and can be retrieved after a run.

Readying the torpedo for an exercise run or proofing run requires the following workshop equipment:

- General Purpose Test Equipment (Refer to Chapter 14.)
- Test Set Mk 183 Mod 0
- Gyro Test Stand
- Pressure and Vacuum System (Dwg. 794436), or equivalent
- 24- and 48-volt DC Power Supply

Presetting the torpedo and firing during exercise runs or proofing runs requires the use of Test Set Mk 183 Mod 0, Test Set Mk 183 Mod 1, or the relay transmitter portion of Fire Control System Mk 101 or Mk 106.

Conducting a run and locating the torpedo requires the following proving ground equipment:

Target (Torpedo) Mk 1 Mod 0
Sound Measuring Set Mk 1 Mod 0
Ordnance Locator Mk 1 (Torpedo) Mod 1 or 2.

General Description of Runs. Although the firing conditions for a proofing run must be determined from the proofing specifications of latest issue and the conditions for an exercise run depend on the particular tactical problem under consideration, the following general description is applicable to all runs.

In all cases, the torpedo is set for stratum condition, enabling range, and gyro angle. During warm up, the torpedo is powered from an external source. Immediately upon firing, the torpedo is launched from the tube. As the torpedo leaves the tube, the control cable is pulled aft, and is sheared off by the cable cutter. The torpedo then runs under gyro control for the preset range and angle and then enables, at which time it either searches in a circle or homes on the target. If Exercise Head Mk 48 Mod 3 (recording) is used, the length of the run is determined by the action of an inertia cutoff switch which stops the torpedo when a hit occurs or by the time setting in the exercise head. At the end of this predetermined time, the main motor circuits are interrupted, the elevators assume extreme up position, and the torpedo glides up to the surface. Forty-five seconds after the motor circuits are interrupted, the start control circuits are opened, completely deenergizing the torpedo.

At the end of the run, the oscillator and projector assembly within the exercise head is energized. The oscillator and projector assembly furnishes an acoustic signal as an aid in locating the torpedo. If during the exercise run the torpedo should dive below the preset floor depth, the main motor will be stopped, and the oscillator-projector assembly will be energized to produce the acoustic signal. Even if the torpedo does not rise to the surface, the oscillator-projector assembly will continue to operate, and the torpedo can be located by means of Ordnance Locator Mk 1 (Torpedo) Mod 1 or 2.

If the torpedo is equipped with an Exercise Head Mk 48 Mod 2 (nonrecording), the length of the run is determined by the action of an inertia cutoff switch which stops the torpedo when a hit occurs or by a time delay relay which deenergizes the torpedo after a preset time of six minutes. If the time delay relay is not used, the length of the run is determined by the condition of the exercise battery. The torpedo will run the preset gyro course, will then enable, and will either conduct an acoustic search or attack a target for as long as the battery voltage holds up. Usually, the determining factor is the release voltage for the start relays (ST1 or ST2), or main motor relay. Whenever any one of these relays opens due to insufficient holding voltage, the propulsion circuit will be deenergized causing the torpedo to stop and float back to the surface.

Readying Torpedo for Exercise or Proofing Run

The purposes of the final assembly tests described in the following paragraphs are to determine that all circuits are functioning properly and that the torpedo is prepared, in all respects, to perform successfully. These tests should be performed before every exercise run. As received from the factory or proofing activity, the torpedo has been carefully adjusted and should satisfy the tests. If it does not, or if it fails to run properly during an exercise run or proofing run, it should be tested according to the more complete procedures described in the maintenance instructions of this publication.

The following instructions for readying the torpedo have been presented in a form that can be used in the preparation of checkoff sheets. These instructions are based on the assumption that the torpedo sections are still in their shipping containers. If the torpedo has been unpacked previously, omit the related steps in the procedures.

Preparation for Test. Before prerun tests can be made on the torpedo, the following preparations must be made:

1. Uncrate torpedo and place it on dollies. (Follow instructions in chapter 9.)
2. Remove shipping bulkhead from battery compartment.
3. Unbolt battery compartment from afterbody and swing afterbody aside.
4. Remove all hand hole covers from afterbody and battery compartment.

5. Remove B power supply and its bracket from after end of battery compartment and then remove after bulkhead.
6. Untape cables, remove drying bags from afterbody and battery compartment, and check interior of battery compartment and afterbody for loose or damaged equipment.
7. Install exercise battery as follows: Remove battery clamp. Obtain fully charged Storage Battery Mk 8 Mod 4 and slide it into battery compartment. Take care not to catch and damage any interior wiring. Positive end of battery must be forward. Clamp battery by tightening knurled screws of adjustable clamp assemblies. When screws are tight, lock them in place by taking up on hex-nuts of clamp assemblies. Replace battery clamp and tighten securely.
8. Connect heavy ground cable to positive battery terminal. Tighten nut on terminal securely to obtain good electrical connection. (Do not connect heavy cable leading back from main motor relay to negative battery terminal at this time.)
9. Replace after battery compartment bulkhead and B power supply with its bracket. Be sure that B power supply is isolated by special rubber spacers.
10. Connect main cable to afterbody junction box and connect input and output cables to B power supply. Connect a ground strap between afterbody and battery compartment shells.
11. For test purposes, connect battery power cable (accessible through forward hand hole) to an external source of DC power. (The source may be either a battery or motor generator. The 28-volt lead may be attached to the 24-volt source for the purpose of these tests. The external power source must be capable of delivering 24±2 volts DC at 15 amperes, and 48±2 volts DC at 3 amperes.)
12. Check to see that ground strap (accessible through after hand hole) is not clamped.
13. Remove wooden panel subassembly from forward end of battery compartment.
14. Remove shipping plate assembly from shell connector receptacle on afterbody, and attach workshop fire control cable.
15. Plug workshop fire control cable into Test Set Mk 183 Mod 0 and turn on AC and DC power at Test Set Mk 183 Mod 0. (Refer to chapter 14 for operating instructions for Test Set Mk 183 Mod 0.)
16. Connect a source of adjustable air pressure to DEPTH vent in afterbody, and to both vents in battery compartment.
17. When ready to make prerun tests, connect ground strap (accessible through after hand hole).

Prerun Tests for Battery Compartment and Afterbody. Before the torpedo is assembled for an exercise run or proofing run, make the following tests on the battery compartment and afterbody:

1. Turn Test Set Mk 183 Mod 0 to STANDBY and set stratum switch to AL position. Turn Test Set Mk 183 Mod 0 to OFF. Apply air pressure of approximately 31 psi to pressure vent. Turn test switch to TEST 2 position. After control panel has warmed up and steering motors are operating, conduct a rub test by rubbing on hydrophones. Rubbing starboard hydrophone should give a starboard rudder deflection; rubbing port hydrophone should give a port rudder deflection; rubbing up hydrophone should give an up elevator deflection; and rubbing down hydrophone should give a down elevator deflection.

Rub starboard.
Rub port.
Rub up.
Rub down.

Turn test switch to RUN.

2. Check to see that gyro is latched.
3. Turn Test Set Mk 183 Mod 0 to STANDBY. Set gyro to 0 degrees. Switch Test Set Mk 183 Mod 0 to ENABLER and vary control setter dial to see that enabler limiter operates at 600

and 3100 yards. It should not be possible to set enabler to less than 600 or more than 3100 yards.

4. Set enabler to 1000 yards range. Turn Test Set Mk 183 Mod 0 switch to ON and operat...

NOTE: The fire relay K13 will not operate unless the warm-up time has been sufficient to operate the thermal time delay relay K21. Closing time for K21 is 15±3 seconds.

Cut on dotted lines and paste in OP 699 on page 114

body. At 10±2 degrees, elevator should suddenly go down. Return after body to level position.

6. Adjust air pressure on vents until elevators are level. (When elevators are level, pressure should be 31±2 psi).

7. Raise after end of afterbody. The elevators should turn up. Return afterbody to level position.

8. Lower after end of afterbody; elevators should turn down. Return aft to level position.

Cut on dotted lines and paste in OP 699 on page 114

~~psi.~~ 9. Turn afterbody to a port heading. Rudder should turn to starboard through an angle of 6 to 10 degrees.

10. Turn afterbody to a starboard heading. Rudder should turn to port through an angle of 6 to 10 degrees.

11. Stop torpedo by disconnecting minus 24-volt DC lead of cylinder cable at power source, and then reconnect lead.

12. Relatch gyro. Turn Test Set Mk 183 Mod 0 to STANDBY. Set stratum switch to BL position.

13. After torpedo has been in STANDBY condition for 30 seconds, turn Test Set Mk 183 Mod 0 to ON, and operate fire switch. Turn Test Set Mk 183 Mod 0 to OFF.

14. Check to see that steering motors start immediately after firing switch is operated.

Change 2

15. Stop torpedo by disconnecting -24 volt D.C. lead of cylinder cable at power source. Reconnect lead after torpedo has stopped.

Change 2

Set Mark 183 Mod 0 to STANDBY. Set stratum switch ...s been in STANDBY condition for 30 seconds, turn Test ...rate fire switch. Turn Test Set Mark 183 Mod 0 to

...eering motors start immediately after firing switch is

18. Actuate ACC relay by grounding terminal E22-9 of afterbody junction box, or by changing heading of afterbody by an angle greater than 135±10 degrees from its original position. Check to see that ACR circuit operates to stop torpedo.

~~19. Relatch gyro. Turn Test Set Mk 183 Mod 0 to STANDBY. Turn off minus 24-volt DC warm-up power furnished by power supply of Test Set Mk~~ ...n Test ... Set ...s (349 ...ck to Turn ...upply Re- ...rm-up power.

~~20. Adjust stratum switch to AL. After 30 seconds on STANDBY, turn Test Set Mk 183 Mod 0 to ON, and operate fire switch. Turn Test Set Mk 183 Mod 0 to OFF.~~

~~21. Torpedo should now be enabled, and~~

Change 1

21. The torpedo cannot be fired in an enabled condition because ~~the safety~~ contacts ~~of gyro relay K8 are not closed.~~ *of the thermal time delay relay K21 will not close* This is true for any position of the stratum switch: AL, BL, or NL.

should be down.

~~22. Check pressure required to make elevators level. This should be 31±2 psi.~~

~~23. Conduct a rub test by rubbing on hydrophones. Rubbing starboard hydrophone should give a starboard rudder deflection; rubbing port hydrophone should give a port rudder deflection; rubbing up hydrophone should give an up~~

11. Check to see that voltage at exploder cable is 24 ∠ 2 volts DC with 55 ∠ 5 psi air pressure applied.

11a attached

12. Turn Test Set Mk 183 Mod 0 to STAND BY and set stratum switch to AL. When STRATUM light indicates torpedo is in AL condition turn Test Set Mk 183 Mod 0 to OFF. Check to see that exploder voltage has disappeared. Elevators should be hard up and no elevator or rudder response should occur when hydrophones are rubbed. Reduce air pressure and check for appearance of 24 ∠ 2 volts DC at exploder cable when pressure reaches 39 ∠ 3 psi.

13. Check air pressure required to make the elevators level. This should be 31 ∠ 2 psi.

~~14. Rub briskly on up hydrophone. Gate relay K2 should release and elevators should respond quickly in UP direction.~~ Below.

15. Turn Test Set Mk 183 Mod 0 to STAND BY, and set stratum switch to NL. When STRATUM light indicates torpedo is in NL condition turn Test Set Mk 183 Mod 0 to OFF.

15a attached

16. Check to see that voltage at exploder cable is 24 ∠ 2 volts DC at all pressures

17. After 6 minutes from time of firing, time delay should operate and stop torpedo.

Change 2

11a. Rub briskly on UP hydrophone. Gate relay K2 should release and elevators should respond quickly in UP direction.

14. Conduct a rub test as explained in step 1. Then reduce air pressure applied to vents. At pressures lower than approximately 14 psi it should require harder rubbing on the UP hydrophone to get elevator response.

15a. Check air pressure required to make elevators level. This should be 55±5 psi. Rub UP hydrophone while gradually reducing air pressure on vents. At pressures lower than 39±3 psi elevators should not respond as readily as in Step 11a, due to lack of gating. At pressures lower than approximately 14 psi the elevators should respond even less readily.

elevator deflection; and rubbing down hydrophone should give a down elevator deflection.

Rub starboard. ____

Rub port. ____

Rub up. ____

Rub down. ____

24. Reduce air pressure applied to vents. At 9 psi, hard rubbing on up hydrophone should not make elevators level. ____

25. Increase air pressure on vents. At pressures greater than 39±3 psi, rudder and elevators should not respond to rubbing on hydrophones. ____

26. Turn Test Set Mk 183 Mod 0 to STANDBY, and adjust stratum switch to BL position. Turn Test Set Mk 183 Mod 0 to OFF. ____

27. At pressures less than 29±3 psi, elevators and rudder should not respond to rubbing. ____

28. Check air pressure required to make elevators level. This should be 55±5 psi. ____

29. Rub briskly on up hydrophone. Gate relay K2 should release, and elevators should respond quickly in the up direction. ____

30. Turn Test Set Mk 183 Mod 0 to STANDBY, and adjust stratum switch to NL. Turn Test Set Mk 183 Mod 0 to OFF. Rub up hydrophone while gradually reducing air pressure on vents. At pressures lower than 39±3 psi, elevators should not respond as readily as in step 29 (due to lack of gating). At pressures lower than approximately 14 psi, elevators should respond even less readily. ____

31. Stop torpedo by disconnecting minus 24-volt DC lead of cylinder cable at power source, and then reconnect the lead. Turn HIGH VOLTAGE switch on power supply of Test Set Mk 183 Mod 0 to ON. 31. TURN B STBY switch of TEST SET MK 183 MOD 0 to ON ____

If an exercise run is to be conducted with an Exercise Head Mk 48 Mod 2 (nonrecording), conduct the tests as follows:

1. Remove straps from control panel "D" block and connect cable of exercise head to "D" block. ____

2. Connect minus 24 volts DC from an external supply to main motor relay, and connect heavy power cable on main motor to other side of main motor relay (MMR). Attach positive lead from external power supply to main motor case. ____

3. Relatch gyro. Turn Test Set Mk 183 Mod 0 to STANDBY, and set stratum switch to BL. Set gyro to 0 degrees, and set enabler to 1000 yards. ____

4. After 30 seconds on STANDBY, turn Test Set Mk 183 Mod 0 to ON, and operate fire switch. Turn Test Set Mk 183 Mod 0 to OFF. ____

5. Main motor and steering motors should start immediately. ____

6. Increase air pressure on vents to make elevators level. This should occur at 55±5 psi. ____

7. Change heading of afterbody to starboard of original heading and then to port. Rudder should turn first through an angle of 6 to 10 degrees to port and then turn through the same angle to starboard. ____

8. Torpedo should enable in approximately one minute due to higher speed of unloaded propellers. When torpedo enables, gyro motor and gyro relay K8 sho become de-energized, gyro should start to slow down, and the exploder cable be electrically armed. ____

9. Elevators should still be level with air pressure at 55±5 psi, and rudder should be at an angle of approximately 2 to 7 degrees port, depending upon the noise in the vicinity of the torpedo. ____

10. Conduct a rub test to see that elevators and rudder respond correctly. (Refer to step 24 of preceding test.)

Rub starboard. ____

Rub port. ____

Rub up. ____

Rub down. ____

~~11. After 6 minutes from time of firing, time delay relay should operate and stop torpedo.~~ ____

If the exercise run is to be conducted with Exercise Head Mk 48 Mod 3 (recording), conduct the tests as follows:

1. Be sure that the recording exercise head has been tested previously. Posi-

tion exercise head in front of battery compartment. ______

2. Remove straps from control panel terminals D1 through D5 inclusive. ______

3. Connect cable of exercise head to D block. Connect extra leads to ~~D9~~, D10, D13, or D15 as desired. Record connections made.

K1. ______

K2. ______

K3. ______

K4. ______

4. Wind recorder motor. Set recorder to 3 minutes, and depress clutch CL to take up backlash in gears. ______

5. Connect a source of adjustable air pressure to pressure vent of exercise head. Connect exploder cable to plug PG5. ______

6. Remove paper carriage of recorder. ______

7. Turn TEST switch to TEST 1 and then to TEST 2 to see that brake CL of the recorder is not actuated in either position. Turn TEST switch to RUN. ______

8. Set depth cutoff in exercise head for a depth of 150 feet. Tighten adjusting screw. ______

9. Relatch gyro. ______

10. Connect minus 24 volts DC from an external supply to main motor relay (MMR), and connect heavy power cable of main motor to other side of main motor relay. Connect positive lead from external supply to main motor frame. ______

11. Turn ~~control setter~~ Test Set Mk 183 mod 0 to STANDBY. Set gyro to 0 degrees, and set enabler to 1000 yards. ______

12. Set stratum switch to BL. ______

13. After 30 seconds on STANDBY turn Test Set Mark 183 Mod 0 to ON, and operate fire switch. Turn Test Set Mark 183 Mod 0 to OFF. ______

14. Clutch CL should operate and cycler motor should start. Gyro should unlatch, and main motor and steering motors should start. Torpedo should be in "gyro run" condition. ______

15. Increase air pressure on vents. At a pressure of approximately 68 psi, depth cutoff switch in exercise head should operate, and main motor should stop. Elevators should move to extreme up position. ______

16. Decrease air pressure until main motor starts, and then adjust pressure to make the elevators level. This should be 55±5 psi. ______

17. Change heading of afterbody to port and then to starboard. Check to see that gyro steering causes rudders to turn first through an angle of 6 to 10 degrees to starboard and then through the same angle to port. ______

18. Approximately one minute after the fire switch is operated, torpedo should enable and gyro motor should become deenergized. AND THE EXPLODER CABLE CONNECTOR WILL BE ELECTRICALLY ARMED

19. With air pressure adjusted to make elevators level (55±5 psi), conduct a rub test.

Rub starboard. ______

Rub port. ______

Rub up. ______

Rub down. ______

20. ~~Reduce air pressure. At 29±3 psi, elevators and rudder should not respond when hydrophones are rubbed.~~ ______

21. Three minutes after the fire switch is operated, main motor should stop due to actuation of cycler contact D1, and elevators should move to extreme up position. ______

22. Approximately 45 seconds after actuation of cycler contact, steering motors should stop, and power should be disconnected from the B power supply, and panel heaters. ______

23. Turn cam in test head back to three minutes, and manually actuate clutch to take up backlash. Install paper magazine filled with paper in recorder, and re-
...ers ______

24. Apply air pressure in 10 psi steps from 0 to 60 psi, and then in 20 psi steps back to 0 psi. At each pressure, depress clutch CL, and drive the paper forward momentarily to obtain marks used for calibration of depth record for an exercise. ______

25. Release impulse scribers and check to see that they make firm contact with the paper. ______

26. Rewind recorder motor. Rotate cam forward until it is again set at 3

[redacted]

[redacted]

20. Check to see that voltage at exploder cable is 24 ± 2 volts DC with 55 ± 5 psi air pressure applied.

20a attached

21. Turn Test Set Mk 183 Mod 0 to STAND BY and set stratum switch to AL. When STRATUM light indicates torpedo is in AL condition turn Test Set Mk 183 Mod 0 to OFF. Check to see that exploder voltage has disappeared. Elevators should be hard up and no elevator or rudder response should occur when hydrophones are rubbed. Reduce air pressure and check for appearance of 24 ± 2 volts DC at exploder cable when pressure reaches 39 ± 3 psi.

22. Check air pressure required to make the elevators level. This should be 31 ± 2 psi.

~~23. Rub briskly on up hydrophone. Gate relay K2 should release and elevators should respond quickly in UP direction.~~ Below

24. Turn Test Set Mk 183 Mod 0 to STAND BY, and set stratum switch to NL. When STRATUM light indicates torpedo is in NL condition turn Test Set Mk 183 Mod 0 to OFF.

24a attached

25. Check to see that voltage at exploder cable is 24 ± 2 volts DC. at all pressures

20a. Rub briskly on UP hydrophone. Gate relay K2 should release and elevators should respond quickly in UP direction.

Cut on dotted lines and paste in OP 699 on page 117A

Change 2

23. Conduct a rub test. Then reduce air pressure applied to vents. At pressures lower than approximately 14 psi it should require harder rubbing on the UP hydrophone to get elevator response.

Cut on dotted lines and paste in OP 699 on page 117A

Change 2

24a. Check air pressure required to make elevators level. This should be 55±5 psi. Rub UP hydrophone, while gradually reducing air pressure on vents. At pressures lower than 39±3 psi elevators should not respond as readily as in step 20a. due to lack of gating. At pressures lower than approximately 14 psi, the elevators should respond even less readily.

minutes, and depress clutch CL to take up backlash. ______

32 ~~27~~. Depress clutch CL and manually actuate one of the scribers to obtain a one minute time record. ______

33 28. To indicate zero setting of record, manually actuate each of the impulse scribers and apply an air pressure of 60 psi applied to the vents. ______

Prerun Assembly. The following assembly procedures apply to final preparations of the torpedo for an exercise or proofing run regardless of which exercise head is used:

1. Remove ground strap (accessible through after hand hole). ______

2. Disconnect temporary power lead from main motor relay and connect heavy battery lead in its place. ______

3. Connect other end of same lead to negative terminal of battery (after end). Tighten securely. ______

4. Attach main control cable leads to terminal strip on propulsion battery.
   - Red sleeve: —48 volts DC. ______
   - Black sleeve: —28 volts DC. ______
   - Green sleeve: —24 volts DC. ______
   - Yellow sleeve: charging. ______

5. If a hit shot is to be fired, check to see that inertia cutoff switch is properly set. (Refer to chapter 12.) Lubricate mating surfaces and gaskets of exercise head and battery compartment with castor oil. Attach exercise head to battery compartment. Draw up evenly on mounting nuts, using just enough force to compress gasket firmly. ______

6. Lubricate hand hole cover gaskets with castor oil and replace all hand hole covers on battery compartment, using special vacuum fitting bolt in after hand hole cover. Assemble hand hole cover bolt, metal bolt washer, and bolt gasket, being careful to place metal washer directly beneath bolt head. Place this assembly into bolt hole of hand hole cover and engage bolt and spider threads. Be sure that spiders are properly positioned. To avoid distorting cover spiders, tighten hand hole cover bolts only with a torque wrench. For steel spider (377893) torque should be from 10 to 20 pound-feet. For bronze spider (TP77305) torque should be from 10 to 50 pound-feet. ______

7. Relatch gyro. ______

8. Lubricate gyro hand hole cover with castor oil, and replace gyro hand hole cover. Tighten both bolts securely. ______

9. Lubricate mating surfaces of battery compartment and afterbody with castor oil, and attach the afterbody to the battery compartment. Draw up evenly on mounting nuts, using just enough force to compress gasket firmly. ______

10. Support the torpedo on a sling. ______

11. Connect ground strap. Apply air pressure to DEPTH vent and adjust pressure to make elevators level. Turn test switch to TEST 1 for 30 seconds, and then to TEST 2. Conduct a final rub test.
   - Rub starboard. ______
   - Rub port. ______
   - Rub up. ______
   - Rub down. ______

Turn test switch to RUN. ______

12. Disconnect ground strap.* ______

13. Attach vacuum hose to fitting on after hole cover and evacuate torpedo to a pressure of 20 inches of mercury. Close valves on vacuum equipment, and check vacuum meter over a 15 minute period. During this time, vacuum should not decrease by more than ½ inch of mercury. ______

NOTE: DO NOT ALLOW TORPEDO TO STAY IN EVACUATED CONDITION MORE THAN 15 MINUTES. RELIEVE VACUUM AS SOON AS POSSIBLE. IF VACUUM IS RETAINED TOO LONG, PENDULUM ASSEMBLY MAY BE DISTORTED AND INTERFERE WITH MOVEMENT OF PENDULUM.

14. If step 13 indicates that a leak is present, apply an air pressure of 5 psi to the after hand hole fitting. Do not apply a greater pressure. Wipe soap solution over all joints and seals, and look for bubbles. ______

* NOTE: afterbody test cable must not be installed during vacuum test.

15. When torpedo has passed leak test, relieve vacuum, and remove vacuum fitting bolt in after hand hole cover. *Install afterbody test cable*

16. Reconnect ground and apply leveling pressure. ______

17. Turn test switch to TEST 2 and conduct tilt tests:

Tilt nose down, elevators UP. ______

Tilt nose up, elevators DOWN. ______

Turn test swith to Run. ______

18. It is advisable to leave grounding strap in after hand hole disconnected until torpedo is ready to be loaded in a tube or rack for launching. Replace after hand hole cover, using standard bolt, and tighten with torque wrench. ______

19. Attach propeller guard, if required. ______

20. Turn Test Set Mk 183 Mod 0 to STANDBY, and set stratum switch to ABOVE LIMIT. Turn Test Set Mk 183 Mod 0 to OFF, and disconnect test plug from torpedo shell receptacle in after body. If desired, replace shipping cover over torpedo shell receptacle. ______

21. Remove pressure fittings from vents. ______

This completes the prerun assembly of the torpedo.

ON BOARD MAINTENANCE - attached

Loading and Launching

On Board Maintenance. Special precautions are necessary to ensure that an explosive mixture does not develop as a result of hydrogen gas evolved by the battery. Make explosimeter test and purge torpedo periodically, in accordance with procedures listed on pages 106 through 110. Do not operate test switch without first checking hydrogen concentration with explosimeter.

NOTE: Steps 7 through 15 apply, when using Test Set Mark 183 type. If Fire Control System Mark 101 or 106 is used, refer to applicable instructions.

1. Open after hand hole. Securely connect ground strap. ______

2. Turn test switch to TEST 1 for 30 seconds, and then to TEST 2. Conduct a rub test.

Rub starboard. ______

Rub port. ______

Rub up. ______

Rub down. ______

3. Return test switch to RUN position. ______

4. Replace after hand hole cover and tighten bolt using a torque wrench. ______

Loading and Launching Procedures. After the torpedo has been prepared for loading, it is loaded and launched on a run as follows:

1. Manually center rudders and elevators by pushing on stubs. ______

2. Turn ~~oscillator switch on exercise head to ON.~~ *Below ** ______

3. Slide front of torpedo into tube, but leave afterbody accessible. ______

4. Remove shipping cover from torpedo shell receptacle in afterbody, and plug in torpedo control cable. Turn plug to lock in place, attach cutter. ______

5. Set cable in cutter yoke, and secure with fine wire. Then engage cable with hook on lower gudgeon extension. ______

6. Push torpedo forward into tube and engage stop bolt. Attach the Control Cable Mk 1 type (see table 6) to door receptacle. Be sure that cable is positioned so that it remains engaged with hook in lower gudgeon extension, and does not foul propeller. Close tube door carefully. ______

NOTE ATTACHED

7. Connect fire control cable to control setter. Check firing fuse, and replace if it is blown. ______

8. Turn on power supply filament switch of control setter for 30 seconds, and then turn on the high voltage switch. Turn the main control to STANDBY.

... tion ... ed enable ... rds should ... pensate for ... e consumed ... epth.

10. Set servo control switch to GYRO, and set desired angle (counterclockwise, or increasing angle, for starboard angle shot, and clockwise, or decreasing angle, for port angle shot). Record setting in degrees (port, stbd.). ______

11. Turn control setter to OFF until ~~one minute~~ *30 seconds* before firing. ______

12. ~~One minute~~ *30 Second* before firing, turn control setter to STANDBY. ______

13. Ten seconds before firing, turn control setter to ON, and open guard on fire switch. ______

** 2. If an oscillator-projector is installed in the exercise head, set the oscillator switch to ON.*

14. Fire torpedo by closing fire switch for approximately two seconds and then releasing switch. ______

15. After firing torpedo, disconnect fire control cable from control setter, and then turn control setter to OFF. Check firing fuse to see if it is blown, and if so, replace it. ______

16. When tube door is opened, remove torpedo control cable plug from door receptacle, taking care that receptacle does not get wet. ______

Post-Run Treatment

Upon recovery of the torpedo from the water after an exercise run, follow these procedures:

WARNING

STAND CLEAR OF PROPELLERS

1. Flush exterior of forward and after handhole covers with fresh water and dry with compressed air. Remove handhole covers and disconnect ground strap in after handhole using a single ended insulated wrench. Purge torpedo for not less than ~~three~~ *fifteen* minutes. Replace handhole covers. ______

2. Remove shell connector plug from receptacle. ______

3. Flush exterior of torpedo with fresh water. Make sure that water flows into all recesses, including torpedo shell connector. Dry torpedo with compressed air, removing any water which may remain in bolt sockets or other recesses of torpedo dry. ______

4. Remove exercise head. Check to see that oscillator switch in head is turned off. ~~If torpedo was fired in a hit shot, reset inertia cutoff. (Refer to Chapter 12.)~~ *If an oscillator-projector is installed, check to see that oscillator switch is set at OFF.* Remove record from recorder, and route it through proper channels. ______

5. Remove exercise head connections from panel, and disconnect exploder cable from plug PG5. Strap terminals D1, D2, D3, D4, and D5 together. ______

Post-Run Maintenance

1. Connect ground strap. ______

2. Turn test switch to TEST 1 for 30 seconds, and then to TEST 2. Rub port and starboard hydrophones to see that steering system is operative. ______

Rub starboard. ______

Rub port. ______

3. Turn test switch to RUN. ______

4. Disconnect ground strap (accessible through after handhole). Unbolt afterbody, and swing it aside. Disconnect heavy main motor lead from main motor relay MMR. ______

5. Remove gyro handhole cover, and relatch gyro. Check for leakage, and wipe any water from handhole cover and flange. ______

6. Replace handhole cover, and tighten it firmly against handhole gasket. ______

7. Replace shipping cover on shell connector receptacle. ______

8. Disconnect main control cable from afterbody junction box, and disconnect input and output cables from B power supply. Move afterbody out of the way. ______

9. Remove B power supply and mounting bracket from afterend of battery compartment, and remove after bulkhead. Remove battery retaining bracket. Remove battery compartment handhole covers, and loosen battery hold-down clamps. Disconnect positive and negative power cables from battery, and tape ends of cables. Disconnect main control cable power leads from terminal strip of battery, and lay leads outside battery compartment so that they are out of the way. Remove battery from battery compartment. ______

10. Tape main control cable power leads, and tape heavy power cables to battery frame in battery compartment. ______

11. Replace after bulkhead and B power supply with its bracket. Plug input and output cables into B power supply. ______

12. Clean main motor relay contacts with fine sandpaper. ______

13. Check interior of afterbody for water or acid. If any acid is present, neutralize it and wipe afterbody dry. ______

14. Draw water out of depth bellows by disconnecting tube fitting at depth mechanism. Flush depth bellows with rust inhibitor, and then fill bellows with light

oil. Reconnect tube to bellows, and check for leaks.

15. Apply air pressure to vents in battery compartment, and remove pressure quickly so that water will be expelled. Roll battery compartment over on its side and fill the stratum switch system with rust inhibitor or light oil. Apply air pressure in bursts to force rust preventative into all recesses. Roll battery compartment back to its normal position.

16. Grease afterbody mating studs.

17. Loosen rudder and elevator bearing set screws, and back off steering bearings with large screw driver. Pack bearings with grease. Tighten bearings moderately, and then back off one-half turn. Grease the set screws and tighten them.

18. Inspect propeller, rudders, and elevators for damage.

19. Check battery compartment mating surface gaskets, and replace them if they are damaged.

20. Clean and grease propeller.

21. Install bags of desiccant in battery compartment.

22. Check to see that no tools are left in afterbody or battery compartment.

23. Connect main control cable to afterbody junction box.

24. Tape heavy power cables out of the way.

25. Bolt afterbody to battery compartment.

26. Reconnect grounding strap in battery compartment, and replace all hand hole covers. Tighten cover bolts moderately using a torque wrench.

27. Remove relay cover of control panel. Burnish contacts of relays and replace cover.

Analysis of Exercise Head Records

Figures 71 and 72 show the appearance of the records produced by Exercise Head Mk 48 Mod 3. Figure 71 shows the records for three actual runs and figure 72 shows the calibration and deck run records made in preparation for these same runs.

Calibration and Deck Run Record. The calibration record is made before a run to determine the scale of the record. As explained in the prerun test procedures given in this chapter, the time calibration is made by running the recorder motor and manually actuating one of the scribers at the beginning and end of an interval of exactly one minute. The length of this record establishes the time scale for distances measured in the direction of the tape movement.

The depth calibration is made by varying the pressure on the depth vent in steps and at each pressure depressing the clutch to drive the paper forward momentarily to obtain the calibration marks. This is done for both increasing and decreasing pressures and each calibration line is marked with the depth corresponding to the pressure used. The vertical distance between the calibration lines establishes the pressure scale represented by vertical movement of the depth scriber.

The deck run record shows the results of the prerun test of the exercise head. The time scale of this record is not important because the record is not usually analyzed and in any case is used only to determine generally that the torpedo and exercise head are functioning correctly before launching.

Records of Actual Runs. The range from the launching point to the target was 300±50 yards for all runs shown in figure 71. The enabling range set into the torpedo was 700 yards and the torpedo was aimed to pass directly over or under the target during the gyro run.

BELOW-LIMIT RUN. Torpedo Mk 27 Mod 4 Register No. 122137, run 1, was fired in the below limit setting at a stationary target 140 feet below the surface. This torpedo enabled 1 minute 11 seconds after firing as indicated by energizing of the gyro relay scriber solenoid. Just after the initial port search circle was started, the target signal was received strongly in the port hydrophone resulting in demand for full port rudder (see horizontal steering indication at 1:15), indicating that acoustic homing had begun. At 1:29 a sound field strong enough to cause momentary gating was encountered. An increasingly stronger sound field level is indicated by the longer times of gate relay operation. As the stationary target was approached, the weapon headed for a point between the actual target projector and the reflection from the water surface, resulting in a rise in depth. At 1:50

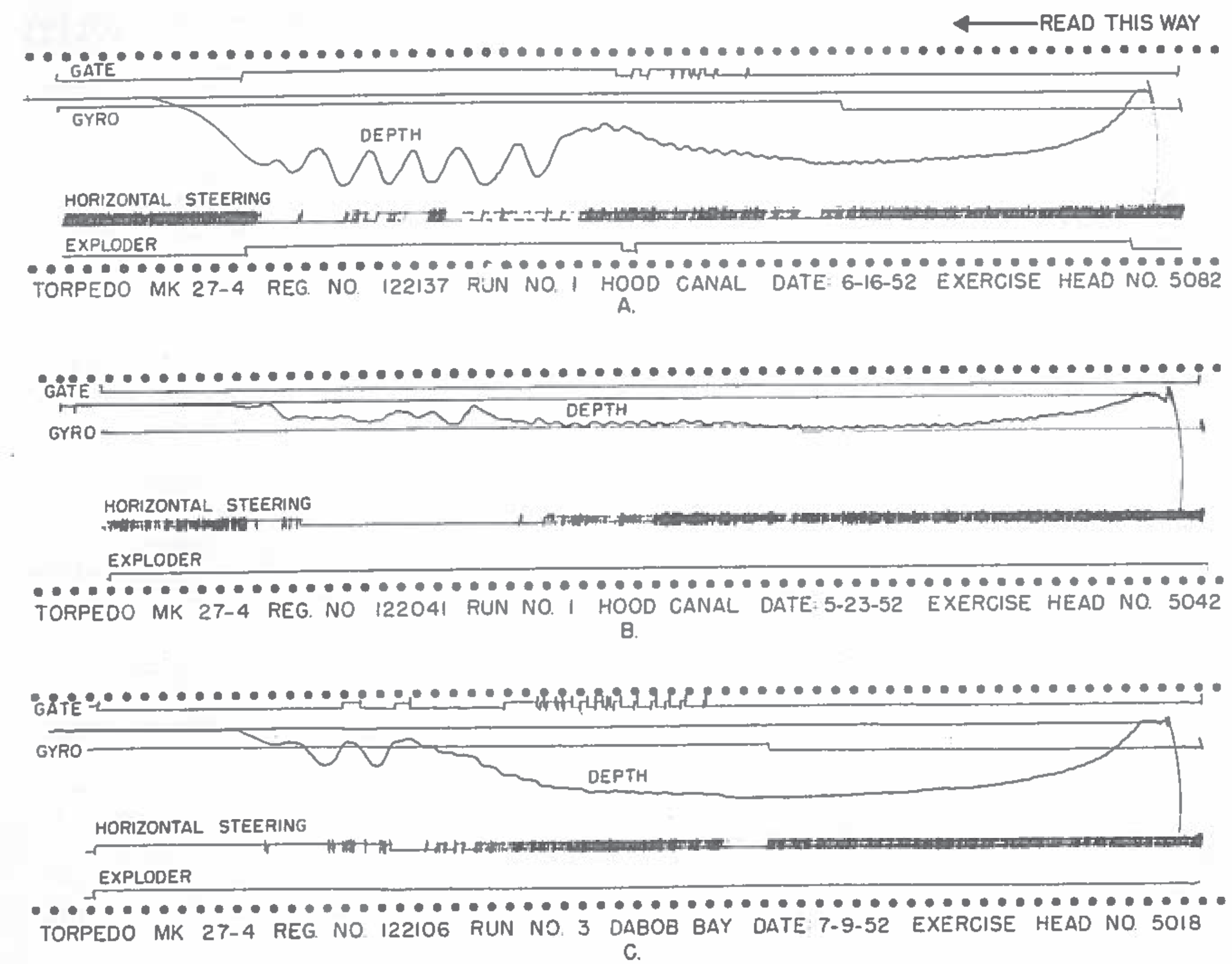

Figure 71—Exercise Head Record, Actual Run.

stratum depth was penetrated resulting in ungating and acoustic deafening of the weapon and its return to full hydrostatic control. As soon as it dived below stratum depth at 1:52, it immediately gated and again rose through stratum. The second rise through stratum depth at 1:54 further resulted in the momentary deenergizing of the exploder safety switch.

The initial attack on a stationary target at or below the running depth of the torpedo is almost always downward. The minimum turning radius of the weapon limits the minimum time required for reattacks to approximately eight to nine seconds. It is therefore apparent that each downward pass through target depth was an attack. Times of target attacks are: 2:07, 2:16, 2:29, 2:38, 2:47, and 2:59. Violent rudder steering demand during reattacks is indicated by the non-oscillation of the horizontal steering scriber for several seconds at a time. The run was terminated at 3:15 by the primary test unit clock mechanisms as indicated by deenergizing of the gate relay and exploder relay, and the smooth rise in depth as the torpedo floated to the surface.

ABOVE LIMIT RUN. Torpedo Mk 27 Mod 4 Register No. 122041, run 1, was fired in the above limit setting at a target 15 feet below the surface. Enabling time is measured at 1:21, initial acoustic homing occurred at 1:23, a near miss at 2:12, and the first successful attack at 2:20. This is evidenced by the occurrence of full rudder demand at about 2:13, indicating the start of a circle for a

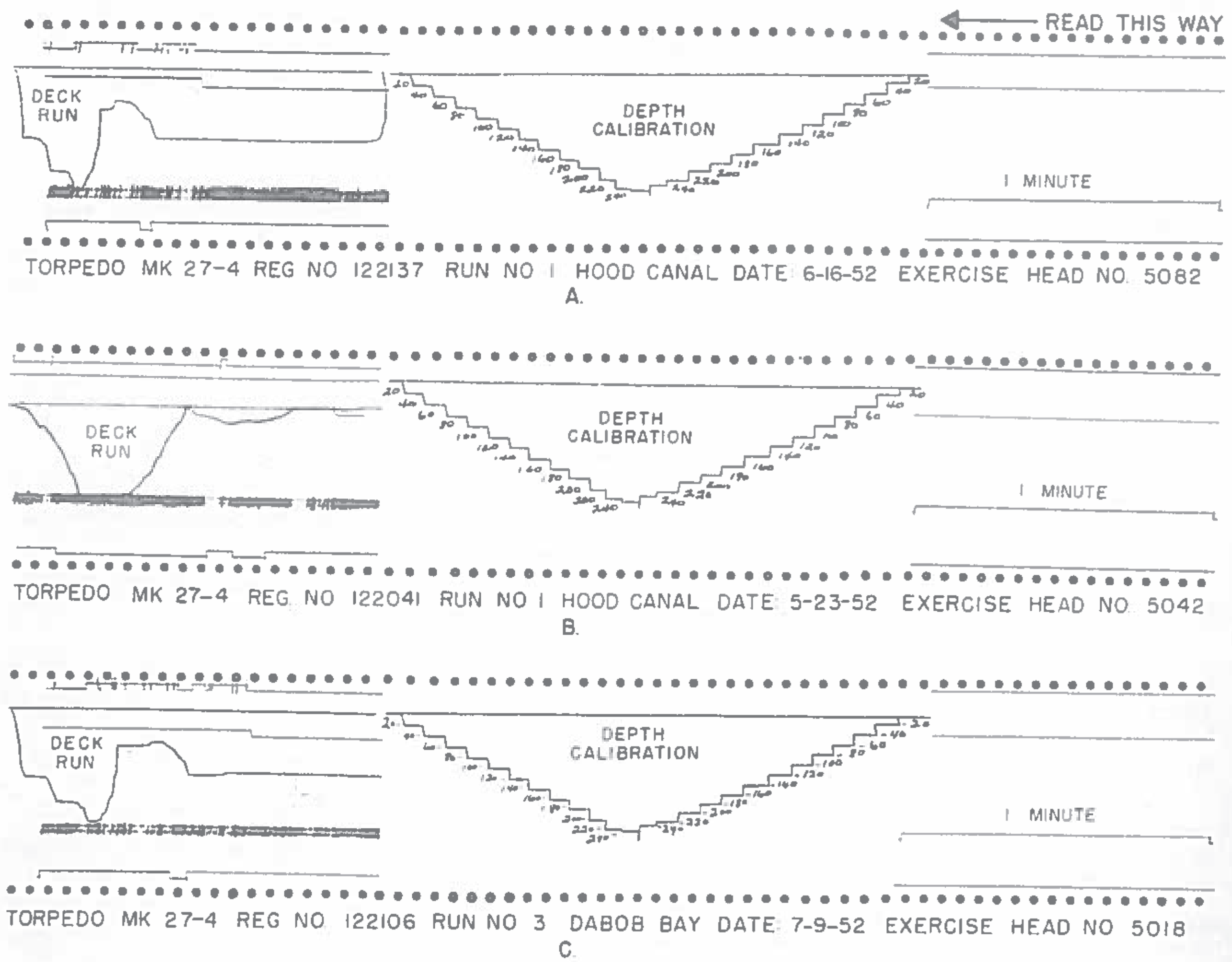

Figure 72—Exercise Head Record, Calibration.

reattack, and the fact that the torpedo had not risen above 30 feet at that time, some 15 feet below the target projector.

It is usually more difficult to determine times of each reattack when the torpedo is fired in above limit setting because the vertical acoustic signal must always override the effect of depth and pendulum control. Reattacks appear from the depth record to have occurred at 2:29 and 2:38. The extremely long period of time of nonoperation of the horizontal steering relay shows in this case, however, that the weapon was in a tight circle even though all reattacks are not obvious from the depth record. The fact that this weapon surfaced at the target buoy at the end of the run adds further evidence that reattacks were occurring.

No Limit Run. Torpedo Mk 27 Mod 4 Register No. 122106, run 3, was fired in the no limit setting at a target 30 feet below the surface. The only characteristic identifiable on the PTU tape distinguishing a no limit firing from a below limit firing is that the weapon may attack above stratum depth. The exploder switch must not operate when stratum depth is penetrated. Ungating of the torpedo, as stratum depth is penetrated, is very effectively demonstrated.

Chapter 9

GENERAL MAINTENANCE INSTRUCTIONS

Introduction

The instructions given in this chapter include general notes on basic maintenance procedures, notes on general care of the torpedo, and unpacking and repacking instructions for the various torpedo components.

For instructions on preservation and packaging for storage and shipment refer to OP 1105.

These instructions are intended as an introduction to the detailed maintenance instructions given in chapters 10, 11, 12, and 13. Usually, a torpedo received from the manufacturing activity will be free of defects, and should require no other maintenance than the general care described in this chapter. However, it is possible that a torpedo may be damaged in shipment, or may have some defect which causes the unit to fail prerun tests at the proofing activity or other fleet station. If this occurs, the trouble must be localized, and defective parts must be repaired or replaced before the torpedo is run.

This chapter describes the procedure for disassembling the complete torpedo into its major sections in preparation for maintenance or testing. The procedures for performing the disassembly, overhaul, reassembly, and test of the torpedo components are described in detail in chapters 10, 11, 12, and 13.

General Notes on Maintenance

Torpedo Mk 27 Mod 4 can be kept in good operating condition only by careful and conscientious maintenance. Most defects can be prevented by taking a few simple precautions to avoid deterioration and corrosion. However, the components of the torpedo are relatively complicated and under normal conditions of use and storage, it is almost impossible to prevent some defects from developing. These defects can be discovered and corrected by following the detailed instructions for electrical and mechanical testing given in chapters 10, 11, 12, and 13. The procedures for testing are presented in the form of preassembly checkoff lists which give the sequence of steps required for preparing each major component for final assembly of the torpedo. The sequence of these steps should be followed exactly.

The work accomplished in a general overhaul of the torpedo includes the following basic operations:

- Disassembly
- Examination of all parts for defects
- Cleaning of all parts
- Replacement or repair of defective parts
- Assembly and adjustment
- Application of lubricants or preservatives where required
- Test of individual mechanisms and circuits
- Test for correct functioning of assembled torpedo

Since the control functions in the torpedo are accomplished primarily by means of electrical circuits, a large part of the maintenance work consists of making electrical checks.

General Care of Torpedo

The following general notes on the care of the torpedo give the important precautions which must be observed in order to keep the torpedo in good condition and to prevent the development of defects due to deterioration and corrosion.

Keep the interior of the torpedo clean and dry.

Store all parts in a clean, dry place.

When torpedo is not being used, be sure that it is protected from corrosion. Instructions for applying greases, oils, and other corrosion inhibitors are given in the maintenance checkoff lists.

When torpedo is handled, be careful not to nick or deform the propeller, fins, rudders, or elevators. Force must never be applied to any of these parts when the torpedo is handled.

Make sure that all joints and vents are perfectly water-tight before the torpedo is fired.

Water-tightness is extremely important because serious damage to the torpedo can result if salt water leaks into the interior. All gaskets must be examined carefully before they are installed. If there is any indication that a gasket is not in perfect condition, discard it and replace it with a new one. After the torpedo is completely assembled, be sure to perform the vacuum test for leaks as described in chapter 8.

When working on the torpedo, be particularly careful to avoid causing mechanical damage to the electrical components and wiring and to keep all electrical equipment free of oil or moisture. Grounds, shorts, and open circuits caused by moisture, corrosion, and mechanical injury are the most common troubles in the electrical circuits. Poor relay operation resulting from faulty contact is another common source of trouble. Keep all relay contacts clean and smooth. Do not lubricate relay bearings unless specific instructions to do so are given in this publication.

Keep batteries clean and free of grounds at all times. Detailed instructions for the care and charging of batteries are given in chapter 13. All personnel concerned with batteries must be familiar with these instructions and understand them thoroughly to avoid damage to the batteries or injury to personnel.

The assembled torpedo should be kept in a horizontal position whenever possible. Tilting the torpedo more than 90° or rolling it more than 90° from its normal running position may cause electrolyte to be spilled.

To facilitate handling and to avoid damage, the battery compartment and afterbody should be placed on their dollies during all shop work. Always use the correct dolly for each unit and be sure that the unit is mounted firmly.

Descriptions of the workshop test equipment used for maintenance and overhaul and instructions for their use are given in chapter 14. The tools and general workshop equipment required for servicing the torpedo are listed in the supplementary data given at the end of this publication.

Unpacking Instructions

The various sections of the torpedo are shipped in separate containers. When components of the torpedo sections are supplied as spare parts, they are shipped in special containers. The following instructions give the items shipped in the container for each major section of the torpedo, and give step-by-step procedures for unpacking the containers. Separate instructions are given for the battery compartment and afterbody, batteries, and heads. These instructions must be followed with care so that the containers and packaging materials will remain in good condition for use in repacking the torpedo.

Unpacking Battery Compartment and Afterbody. The battery compartment and afterbody are shipped in the same container, figure 73. Gyroscope Mk 29 Mod 0 is included with the afterbody and the B power supply is included with battery compartment. Unpack the container as follows:

1. Place container on level floor, preferably beneath a power hoist. Have battery compartment and afterbody dollies ready.
2. Release air pressure through filler valve by removing valve stem. Replace stem and cap.
3. Remove forward cover and aft cover of container.
4. At forward end, remove bumper bar.
5. At aft end, remove nuts holding locking bar.
6. Push torpedo and carriage out of aft end of container until center of gravity of torpedo is outside container, figure 74.
7. Use power hoist, lift torpedo slightly to just pick up weight and withdraw torpedo from container.
8. Remove top sections of bands and lift torpedo from carriage. Set torpedo carefully on dollies.
9. Remove nuts from battery compartment shipping bulkhead, and remove bulkhead from battery compartment.
10. Remove nuts holding battery compartment to afterbody joint, and separate the two sections.
11. Remove shipping cover assembly from torpedo shell connector. (This connector is located in lower port quadrant of afterbody.) Loosen screws in cover with a screwdriver, and then turn cover assembly counterclockwise to unlock it. Pull cover off shell connector.

Unpacking Batteries. Batteries for Torpedo Mk 27 Mod 4 are shipped in individual containers. The following instructions apply to Storage Battery Mk 7 Mod 3 (for war shots), or Storage

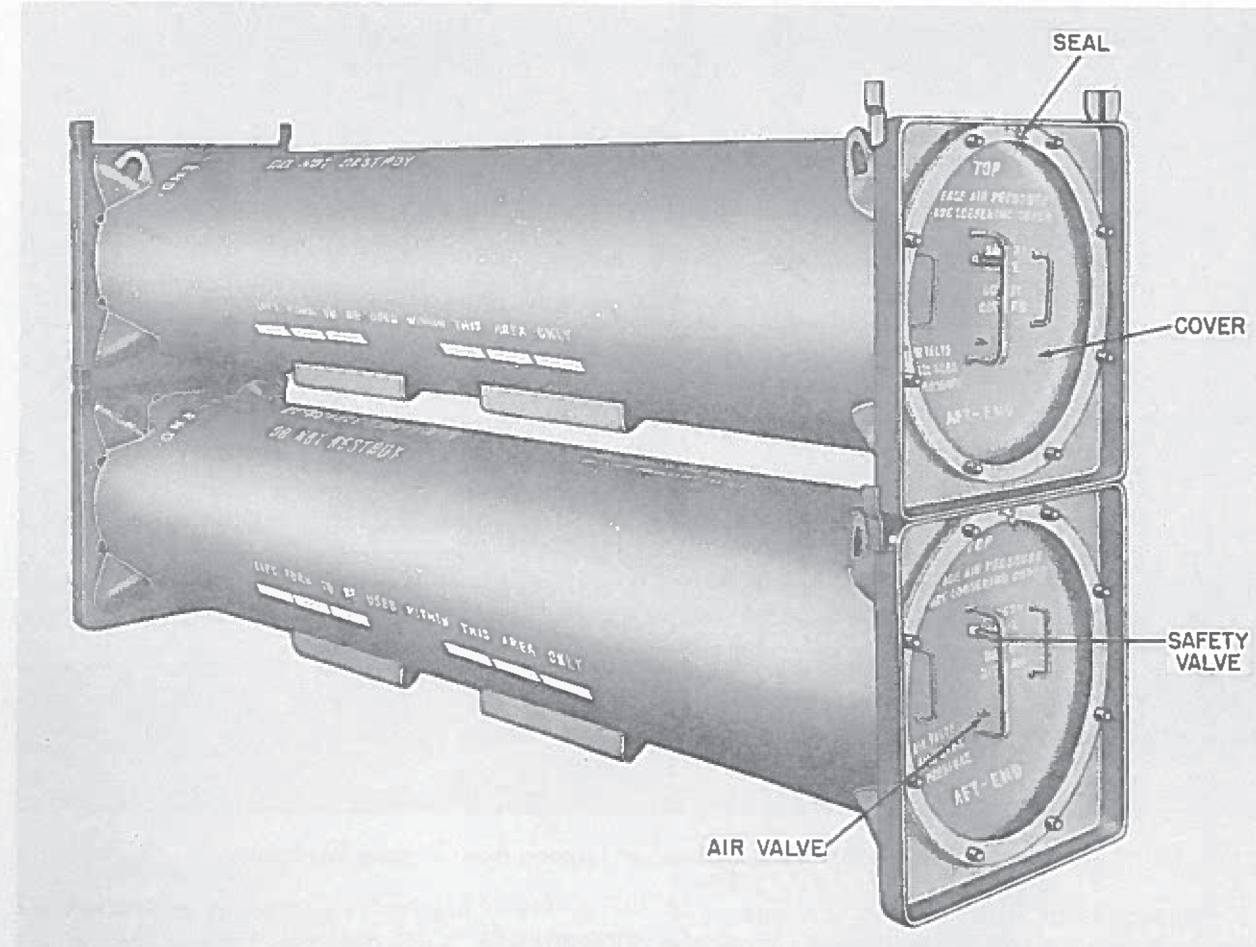

Figure 73—Shipping Containers Stacked.

Battery Mk 8 Mod 4 (for exercise runs). Unpack the battery as follows:

1. Remove screws holding cover of battery shipping container.
2. Lift cover off container.
3. Lift battery out of container, using sling and hoist.

Unpacking Heads. The following instructions apply to War Head Mk 27 Mod 2, Exercise Head Mk 48 Mod 2, and Exercise Head Mk 48 Mod 3. Unpack the head as follows:

1. Place shipping container on level floor with bottom of container on floor. (Clamping ring is at bottom of container.)
2. Unbolt clamps and remove them.
3. Using handle, lift body of container off bottom of container. Head remains fastened to bottom of container.
4. Unbolt head and cross members from bottom of container.
5. Remove nuts from studs on head, and lift off head shell protecting ring.

Repacking Instructions

For instructions on preservation and packaging for storage and shipment refer to OP 1105.

Instructions for Disassembly of Complete Torpedo

A completely assembled torpedo is disassembled into its main sections as follows:

1. Place torpedo on a battery compartment dolly and an afterbody dolly, taking care that joints of torpedo are properly centered between the dollies.

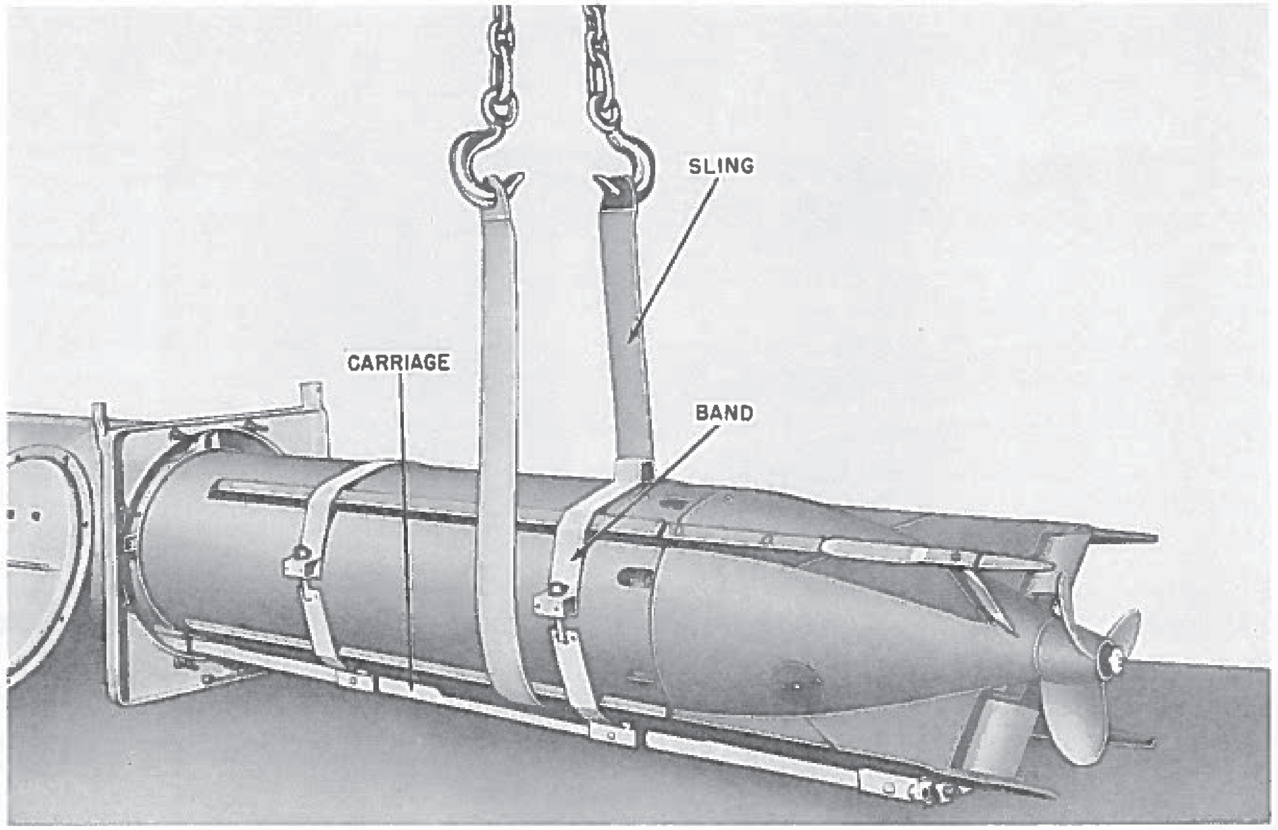

Figure 74—Installation for Removal of Torpedo from Shipping Container.

2. Support head with a sling attached to a hoist, and remove nuts from head mounting studs.
3. Move head away from battery compartment, and place it on floor or on another battery compartment dolly. In some instances, special head dollies may be provided.
4. Remove nuts from afterbody mounting studs.
5. Remove after handhole cover to gain access to ground strap, and disconnect strap.
6. Move battery compartment and afterbody apart.
7. Disconnect propulsion motor lead from main start relay in upper rear portion of battery compartment.
8. If so desired, afterbody may be disconnected from battery compartment by unplugging cable leading into afterbody junction box.

Chapter 10

MAINTENANCE OF AFTERBODY

Section 10.1—General

The proper functioning of the afterbody is dependent upon the care and accuracy with which the mechanisms within it are overhauled and adjusted. This chapter describes the procedures for overhauling the afterbody components, adjusting them for proper operation, and testing their condition. It is imperative that these procedures be carefully followed. In the general overhaul of a torpedo it is necessary first to completely test and adjust the afterbody because the afterbody is later used in adjusting and testing the battery compartment.

The afterbody contains the following major components:

- Afterbody Junction Box
- Gyroscope Mk 29 Mod 0
- Enabler
- Depth Mechanism
- Pendulum
- Propulsion Motor
- Rudder and Elevator Steering Motor Assemblies
- Torpedo Shell Connector
- Drive Shaft Assembly
- Propeller

The function and operation of the various components within the afterbody are covered in chapters 2 and 6.

The tests and adjustments covered in this chapter are required ONLY if:

a. The torpedo has failed in pre-run tests as described in chapter 7 and 8.

b. Has failed in a proofing run.

c. Or is in need of general re-check after several exercise runs.

Section 10.2—Disassembly, Overhaul and Reassembly

Disassembly of Afterbody

A complete overhaul requires that all components be removed from the afterbody shell. Refer to figure 75 for location of parts.

The screws and nuts that mount parts in the afterbody are secured in place with wire to prevent loosening. To detach these screws and nuts, cut and remove the fastening wire. When re-installing the part, replace the wires.

Removing Gyroscope Mk 29 Mod 0.

1. Remove two bolts holding gyro hand hole cover to afterbody shell. (55, 60)
2. Pry afterbody hand hole cover loose from shell. (55, 60)
3. Unscrew cable connector from gyro assembly within torpedo.
4. Unscrew four screws holding gyro to gyro mounting flange on afterbody shell. (These screws are accessible from outside surface of gyro mounting flange.) (83)
5. Slide gyro assembly forward out of afterbody and place assembly on a bench for later inspection and adjustment.

Removing Enabler.

1. Unscrew flexible shaft coupling from forward end of propulsion motor.
2. Unscrew flexible shaft coupling from side of enabler assembly. Remove flexible shaft from afterbody.
3. Remove two nuts and lock washers from screws holding enabler to enabler mounting bracket. (63)
4. Disconnect cable connector from enabler assembly.
5. Pull enabler assembly forward out of afterbody shell and place enabler on a bench, taking care not to damage pickoffs or mechanical parts of enabler.

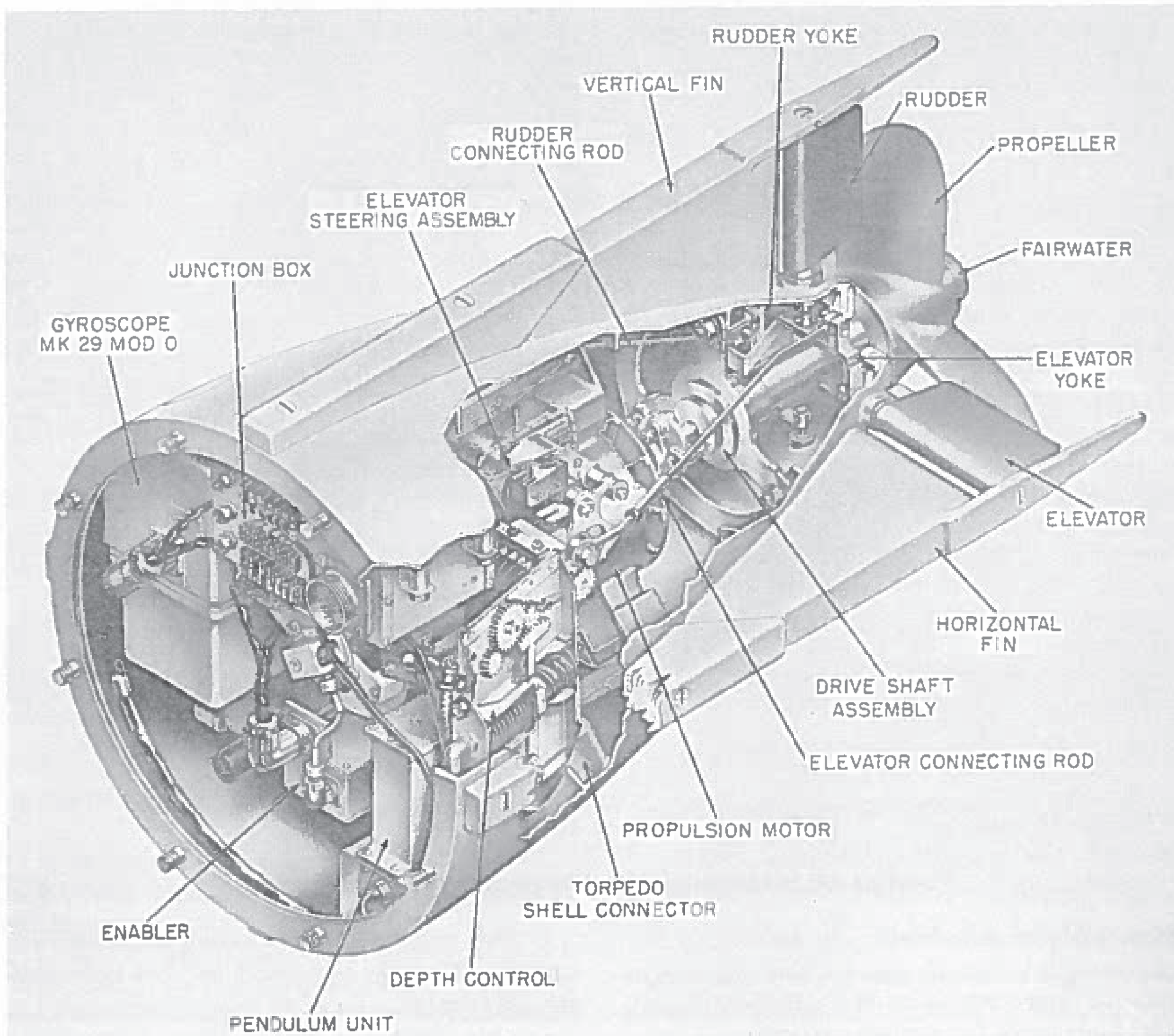

Figure 75—Afterbody, Port View, Cutaway.

Removing Junction Box.

1. Remove four bolts which secure junction box to bosses at top of afterbody shell. See figure 76. (67)

2. Slide junction box forward, taking care not to damage cables connected to terminal strips on side and rear surfaces of box.

3. Disconnect cable fanning strips, E–16, E–17, E–18 and E–19, from multiconnector terminal strips on afterbody junction box. This frees junction box so that it can be removed from afterbody.

Removing Pendulum Assembly.

1. Remove four screws and nuts holding pendulum assembly to bracket in lower port section of afterbody shell. (85, 63)

2. Wiring connected to pendulum assembly is cabled in with wiring from control assembly. If it is desired to remove pendulum assembly separately, unsolder three wires connected to terminals on top of pendulum assembly. Mark these wires to facilitate reconnection. (43)

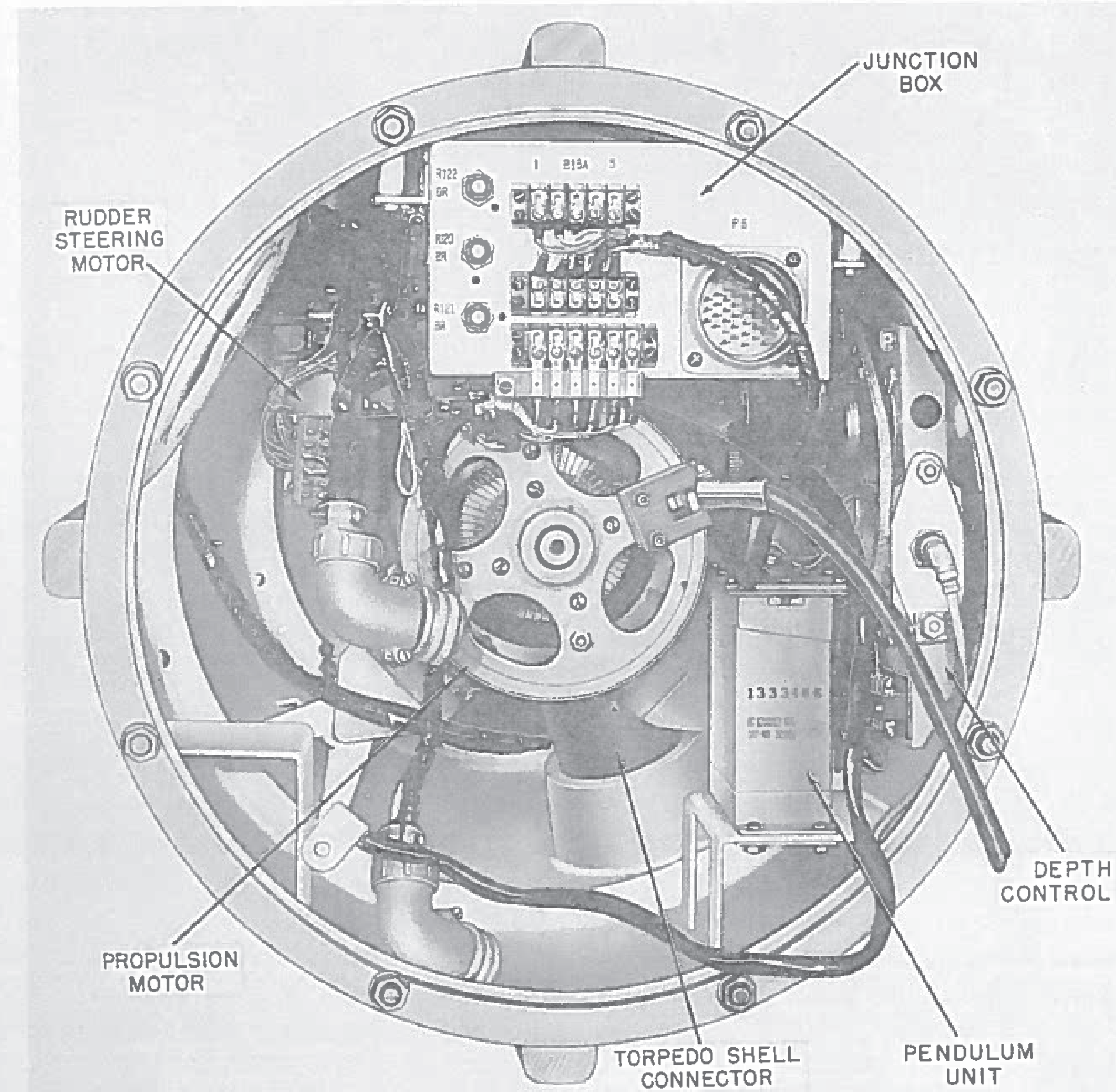

Figure 76—Afterbody, Less Gyro and Enabler.

Removing Depth Control Assembly.

1. Disconnect compression fitting (⅜ inch across flats) from elbow at DEPTH vent in afterbody shell. (63)

2. Remove three mounting bolts (7/16 inch across flats) holding depth control assembly to bosses in afterbody shell and lift assembly out of afterbody. (64)

Removing Torpedo Shell Connector.

1. Remove three socket head screws holding torpedo shell connector to shell connector mounting flange. (These screws are accessible from outside of afterbody shell.) (81)

2. Carefully tap torpedo shell connector out of afterbody mounting flange. (49)

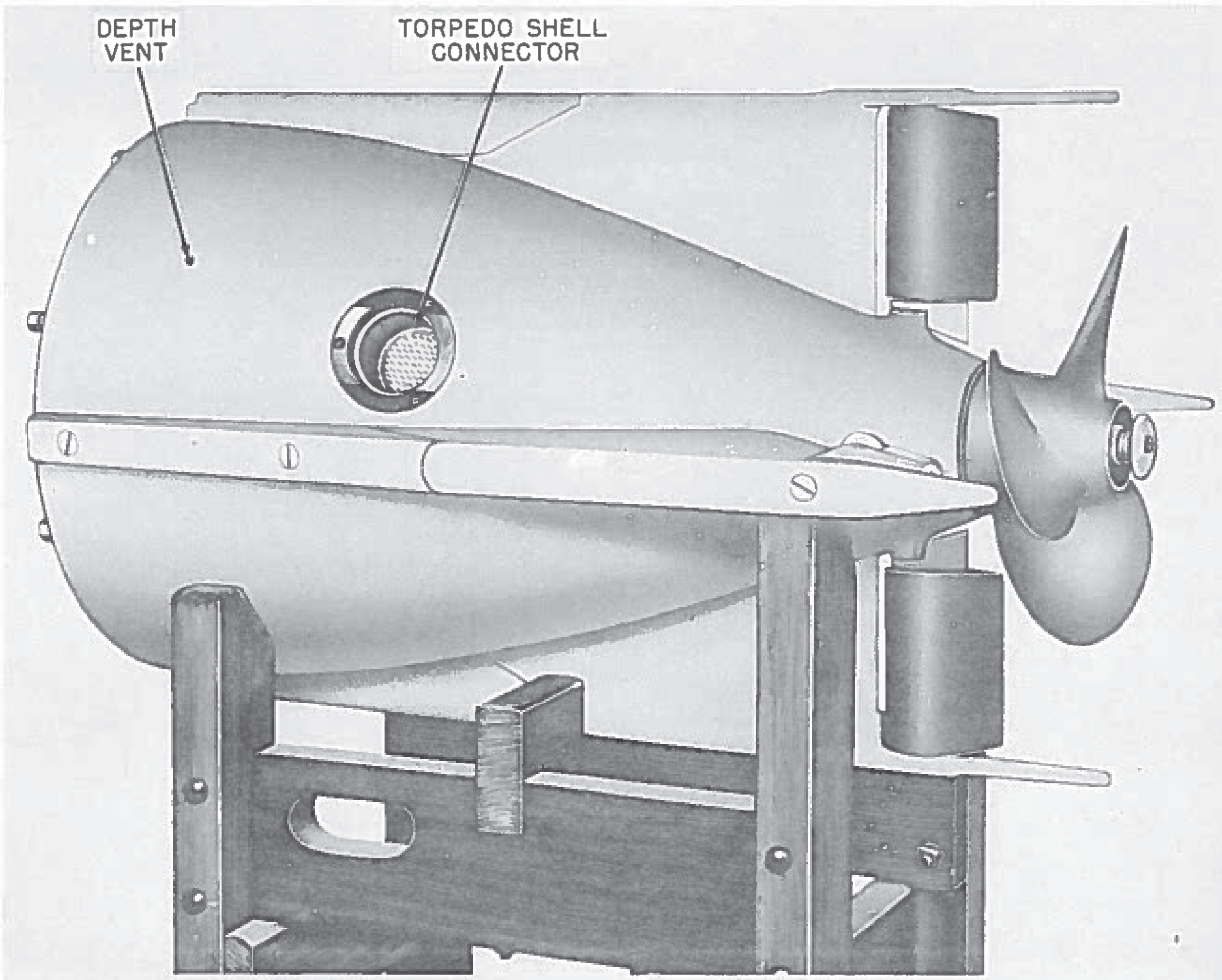

Figure 77—Afterbody Showing Torpedo Shell Connector.

3. When shell connector is free, carefully pull it and its attached cable out of afterbody shell. (49)

Removing Propulsion Motor.

1. First remove afterbody junction box, gyro, enabler, pendulum assembly, and torpedo shell connector as previously explained.

2. Remove screws (¾ inch across flats) holding elevator and rudder connecting rods to segment gears of steering motor assemblies. See figure 83. (65)

3. Using two wrenches, one to turn bolt and other to hold nut (both 9/16 inch across flats), remove three mounting bolts from each of three motor mounting brackets. (61, 55, 68)

4. Disconnect mounting bracket for flexible shaft connector by removing two screws holding bracket to motor frame. Unscrew small flexible shaft from end of motor shaft. (85, 70)

5. Screw puller rod of motor puller into threaded end of motor shaft and position puller bar over two studs at open end of the afterbody shell. Start motor out of its support by tightening nut of puller rod. (5, 70)

6. When motor is loose in its support, complete removal by hand. Do not attempt to lift motor by its mounting brackets as they are attached only by friction.

7. Take out set screws holding male part of splined flexible coupling to main motor shaft and pull coupling off motor shaft. Take care not to lose shaft key.

8. Remove main motor mounting brackets by pulling them from their mounting lugs. (81)

Removing Steering Motor Assemblies.

1. After propulsion motor has been removed from afterbody, take out two hexagonal screws (9/16 inch across flats) holding elevator steering motor to propulsion motor frame and remove elevator steering motor. (Removal of elevator steering motor exposes mounting screws for rudder steering motor so that rudder steering motor can be removed.) (68)

2. Take out two hexagonal screws (9/16 inch across flats) holding rudder steering motor to propulsion motor frame and remove rudder steering motor. (68)

NOTE: Elevator motor and rudder motor can be removed without removing propulsion motor from afterbody. Elevator motor must be removed first.

Removing Connecting Rods, Yokes, Stub Shafts, and Associated Watertight Seals. See figures 78 and 79.

1. Loosen set screws in extensions of all four fins. (77)

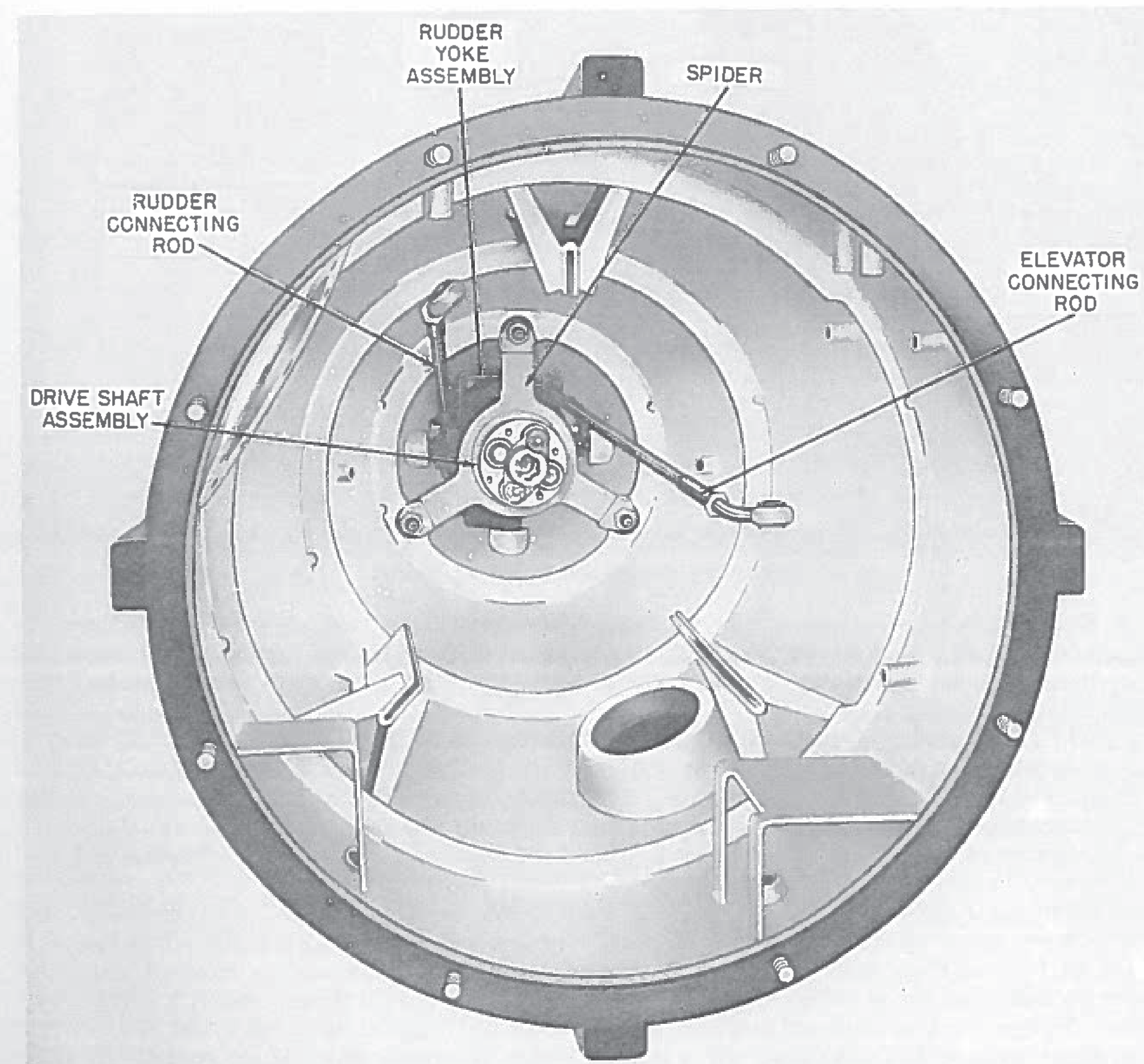

Figure 78—Afterbody Shell Showing Connecting Rods, Cross Strut and Stern Bearing, and Yoke Assemblies.

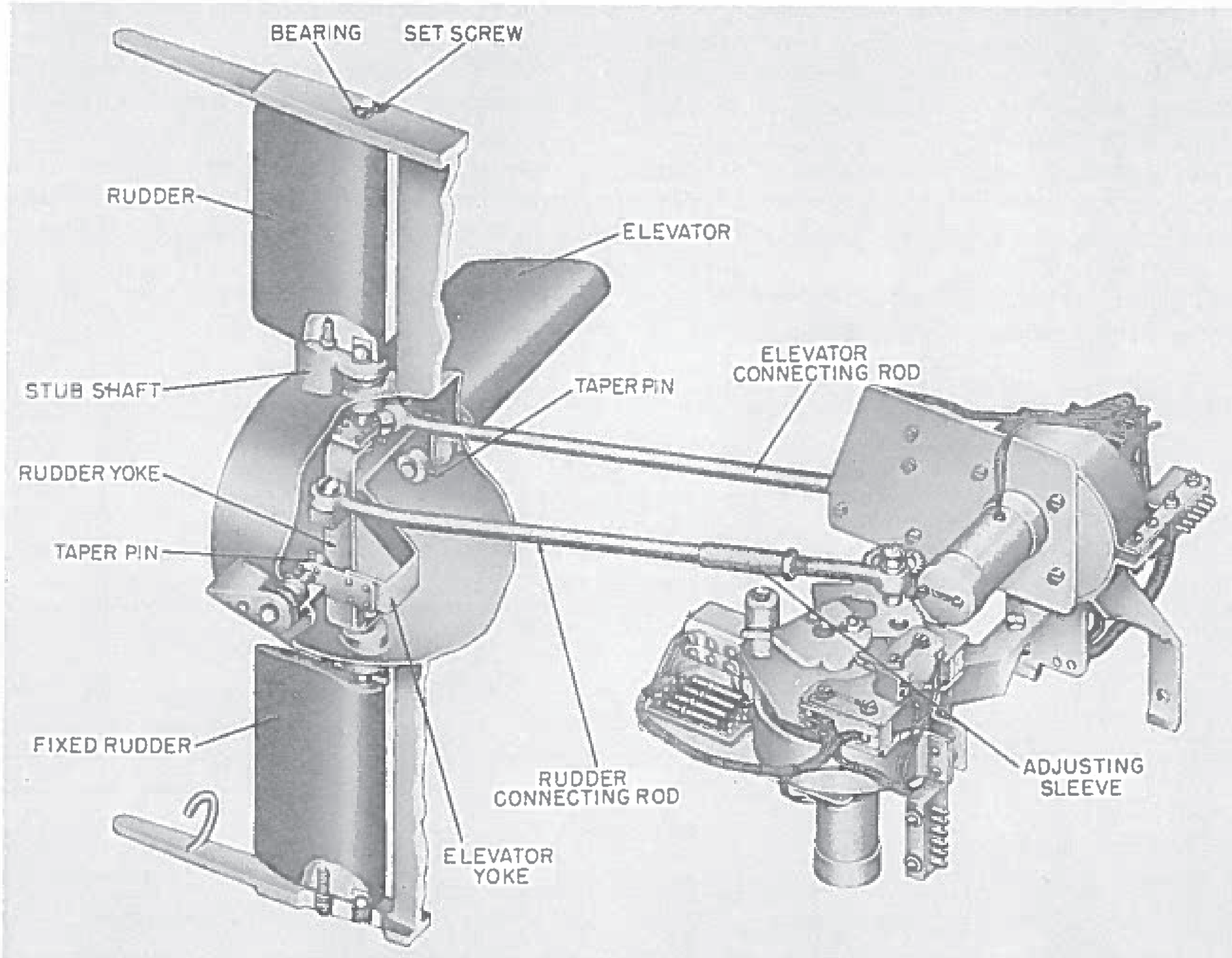

Figure 79—Rudder and Elevator Linkages.

2. Remove rudder and elevator bearings from fin extensions with a large screwdriver. (83)

3. Remove rudder and elevator vanes by lifting them off stub shafts.

NOTE: Remainder of parts cannot be removed until propulsion motor has been removed from afterbody. End of screw securing each connecting rod to its yoke is expanded and screw cannot be removed readily; therefore, yoke and connecting rod are taken out as a unit.

4. Remove taper pins holding yokes to stub shafts as follows: Place taper pin remover over taper pin with small end of pin in recess of bearing plate. Tighten screw of taper pin remover, using a wrench or screwdriver, until taper pin is loose. Withdraw taper pin remover and complete removal of taper pin by hand. To take out three horizontal taper pins, place horizontal taper pin remover (long handle) over pin with large end of taper pin in recess of screw member. Use vertical taper pin remover (short handle) in same manner to remove vertical taper pin. (3, 70)

5. Remove each stud shaft by pulling on stub shaft wing from outside of afterbody, drawing shaft out of yoke and through watertight seal.

6. Draw each yoke and connecting rod unit out of afterbody.

7. To remove defective watertight seals, first remove outer stud shaft bearing. (This bearing is pressed into cup and can be removed by tapping against its edge.) Insert end of a chisel under spun-over edge of watertight seal and pry upward to remove seal. Work carefully to avoid damaging bearing surface of cup. Discard seal. (45)

Removing Propeller. The propeller is keyed to its shaft and is held in place by the fairwater and the fairwater retaining screw. Remove propeller as follows:

1. Remove fairwater retaining screw. (83)

2. Using fairwater spanner wrench, unscrew and remove fairwater (left hand thread). (29)

3. If propeller cannot be removed by hand, use propeller puller. Position circular bearing plate of puller against propeller shaft with screw of puller against plate at seating recess provided. Set hooks of puller over propeller blades, with tips of hooks close to propeller hub. Turn screw of puller tightly against bearing plate. After puller is tight, tap end of screw sharply with a hammer. When removing propeller, be careful not to lose shaft key. (4, 49)

Removing Cross Strut and Drive Shaft Assembly. The cross strut and stern bearing, figure 80, cannot be removed until the propulsion motor, propeller, connecting rods, and yokes have been removed.

1. Unscrew three nuts (⅝-inch across flats) holding cross strut to studs on afterbody shell, after freeing them from bent-over tabs of locking plates. (Cross strut itself is removed with the drive shaft assembly.) (65, 85)

2. At outside end of the afterbody shell, remove four nuts (⅝-inch across flats) holding drive shaft assembly to afterbody, thus freeing outer gasket and plate.

3. Remove outer gasket and plate, figure 83. (69)

4. Withdraw strut and drive shaft assembly from inside of afterbody. Remove inner gasket.

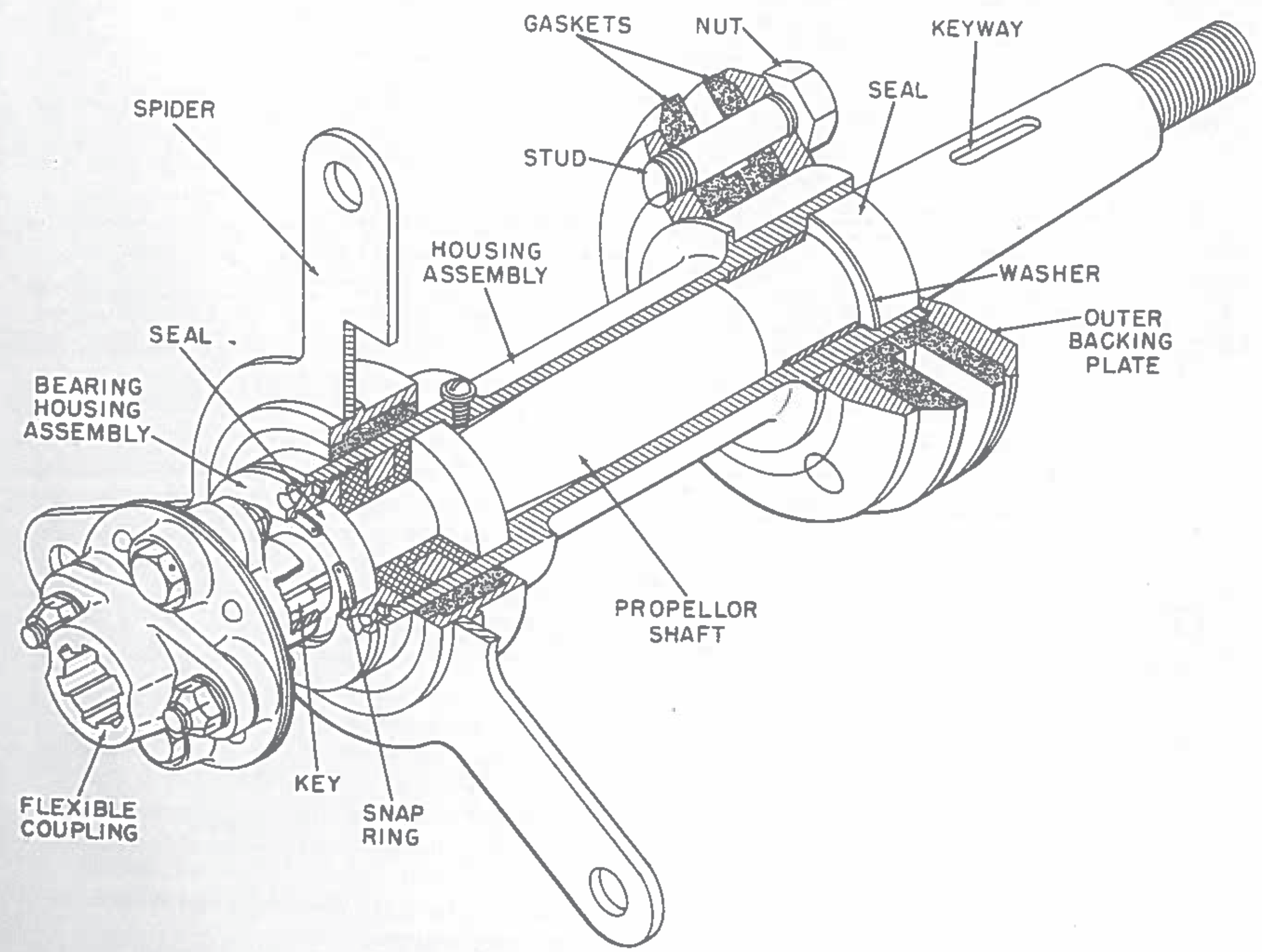

Figure 80—Cross Strut and Drive Shaft Assembly.

5. Take out set screw in female half of splined flexible coupling and remove coupling from shaft, taking care not to lose shaft key. (81)

6. Drive shaft assembly is gripped in rubber seat of cross strut. Ordinarily, it should not be necessary to remove cross strut from drive shaft assembly. However, if required, separate strut from assembly by working them apart.

Overhaul of Component Parts of Afterbody

Overhaul of Afterbody Shell.

1. If necessary, wash out afterbody shell, using clean, fresh water.

2. Blow out shell with air hose.

3. Clean all corroded surfaces.

4. Apply one coat of touch-up paint where needed and allow paint to dry.

5. Inspect studs of shell to see if they are bent or if threads are damaged. Remove any damaged studs, using a pipe wrench. When installing new studs, first coat threads with pipe compound. Engage outer threaded portion of stud with threads of socket in stud tightener and screw tapered threads of stud tightly into afterbody, using a pipe wrench. If old studs are straight but threads are slightly damaged, repair threads with rethreading die. Apply a light coating of Tectyl 506 to threads of all studs. (71, 24)

6. Tighten any loose studs, using stud tightener and wrench. (24, 71)

7. Blow out vent and pressure line for depth control assembly.

Overhaul of Propulsion Motor.

> NOTE: The propulsion motor should be disassembled only when necessary to clean or repair parts. If the armature or field coils are damaged or burned out, new parts should not be installed. Instead, the defective motor must be replaced with a complete new motor. In handling the motor, it is important to avoid touching the commutator and to keep the surface free of oil, grease, scratches, or nicks. If the motor has been in contact with salt water, or requires any repairs other than replacement of the brushes, it should be overhauled by a competent electrician in accordance with standard motor overhaul procedures.

1. Remove cover over brushes by loosening clamping screws and sliding cover off end of motor frame. (85)

2. Inspect each brush. To remove brush, disconnect stranded wire lead by taking out terminal screw, remove brush holder frame, and then pull brush out of brush holder, figure 81. Replace any badly damaged brush and note whether brushes make contact over their entire contact area. (85)

3. Replace each brush in holder. (Perform step 2 in reverse order.)

4. Fit new brushes or brushes making partial contact as follows:

a. Insert a strip of No. 00 sandpaper under brush to be fitted, with abrasive side of paper against face of brush. Hold sandpaper flat and taut against face of commutator.

b. Rotate armature back and forth to sand brush.

> CAUTION: Do not let sandpaper slide under other brushes that do not require sanding.

c. Remove sandpaper and turn armature by hand for a few revolutions.

d. Remove brush from holder and inspect contact surface. Entire surface should be slightly glazed, showing full contact. If entire surface is not glazed, repeat sanding operation until it is.

*5. After brushes are installed, replace cover over motor frame and tighten clamping screws. (85)

> NOTE: If the torpedo has been used in an exercise run of four minutes duration or longer, it may be found that the armature has thrown some solder. This is not a serious condition, but the commutator should be carefully cleaned and the brushes should be inspected and replaced if necessary.

Overhaul of Steering motor.

> NOTE: If inspection of the steering motors indicate that one is damaged or requires repairs more extensive than the simple replacement of brushes, it should be replaced by a new motor. The following instructions for the replacement of brushes and for adjusting the limit switches and follow-up potentiometers apply to both the horizontal and vertical steering motors.

1. Remove cover at end of motor casting. (85)

*4e. Prior to installing brushes, make certain that brush holders are securely tightened.

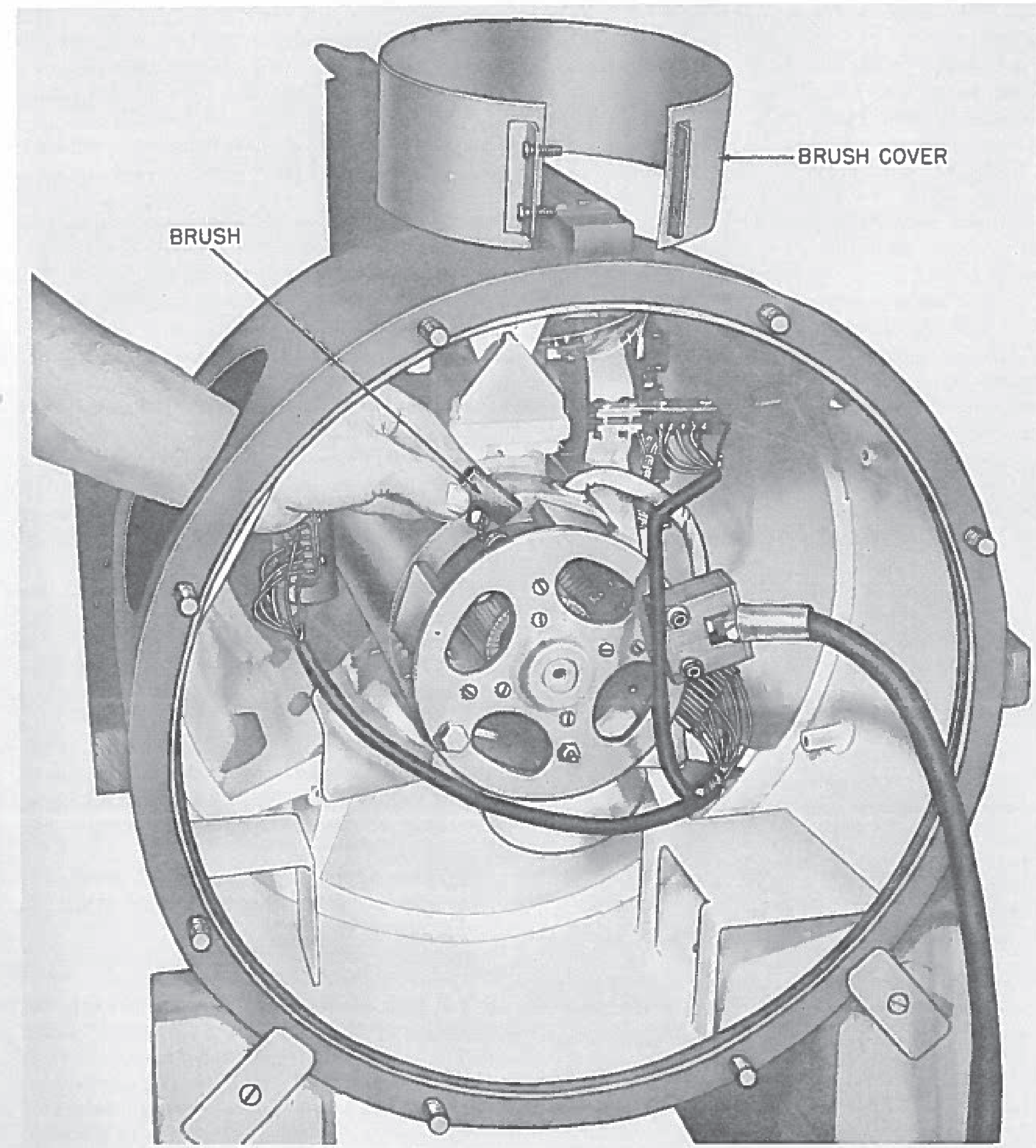

Figure 81—Brush Replacement in Propulsion Motor.

2. Remove spring clip holding brush mechanism assembly, figure 82, and remove brush mechanism.

3. Disconnect motor wire from its terminal. (85)

4. Inspect commutator. If necessary, clean commutator by rubbing it lightly with fine sandpaper and using carbon tetrachloride (or some other suitable solvent) to remove grease.

5. Install replacement brush mechanism assembly. (The brush mechanism assembly supplied for replacement is complete with brush holder, brush spring, brush, wire, and fiber mounting.) (85)

6. Run motor before replacing cover to check for sparking at commutator.

7. Operate motor using a 12-volt dry battery (preferably a No. 6 cell.) Connect positive battery terminal to motor case and negative battery terminal to free solder lug of one of the limit switches. At end of segment travel, switch arm should operate limit switch just before bumper strikes bumper post. If necessary use bending tool to bend switch arm until correct operation of limit switch is obtained. Repeat entire step to adjust other limit switch arm. (9)

8. By operating motor, position prongs of bumper so that their inner edges are equidistant from center of bumper post. This must be done accurately. Any convenient gauging means may be employed.

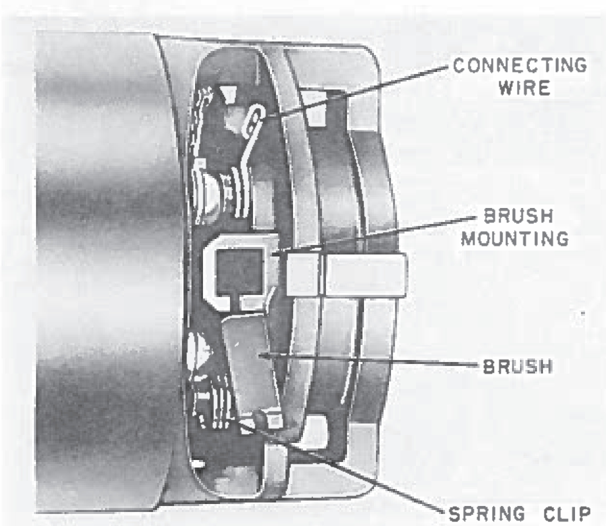

Figure 82—Brush Holder and Brush Assembly, Steering Motor.

9. With bumper prongs centered on post, measure total resistance of potentiometer between its end terminals and resistance between the center terminal and each end terminal. Total potentiometer resistance should be between 22,000 ohms and 28,000 ohms. Resistances between center terminal and each end terminal should not differ from each other by more than 500 ohms.

10. If adjustment of potentiometer is required, loosen lock nut on top of potentiometer, using a thin open end wrench. Turn potentiometer as required, tighten lock nut, and recheck resistance. Take care not to ground potentiometer terminals on potentiometer mounting bracket. (66)

Overhaul of Drive Shaft Assembly and Spider. If a stern bearing has seized, heats excessively, or produces a loud squeal during simulated runs in the workshop, the bearing assembly must be replaced, figure 80. No attempt should be made to repair the drive shaft assembly. In most cases it will be more convenient to install a complete new drive shaft and spider assembly rather than to attempt to install a new bearing assembly in the old cross strut.

Overhaul of Propeller. Small nicks in the propeller may be repaired by filing and minor bends may be repaired by careful hammering (tools 47 and 49). However, if a propeller is badly bent or otherwise damaged it should be replaced with a new one.

Overhaul of Torpedo Shell Connector. In case of a leak or other failure in the torpedo shell connector or its associated cable, the complete assembly should be replaced by a new component.

Overhaul of Depth Control Assembly. See figures 83 and 84.

> NOTE: Apply air pressure by means of pressure and vacuum system using the fitting (tool 18) provided to connect the system to the pressure fitting on the depth control assembly.

1. Fill bellows with fresh water and apply an air pressure of 55 psi to pressure fitting of depth control assembly. If any leaks occur, replace entire assembly. Check operation of mechanism as pressure is applied. If parts tend to stick, lubricate mechanism sparingly with light machine oil. If this does not remedy trouble or if bellows are distorted, replace entire assembly.

2. Increase pressure on bellows-spring assembly to 66 psi. Adjust tension on spring by means of

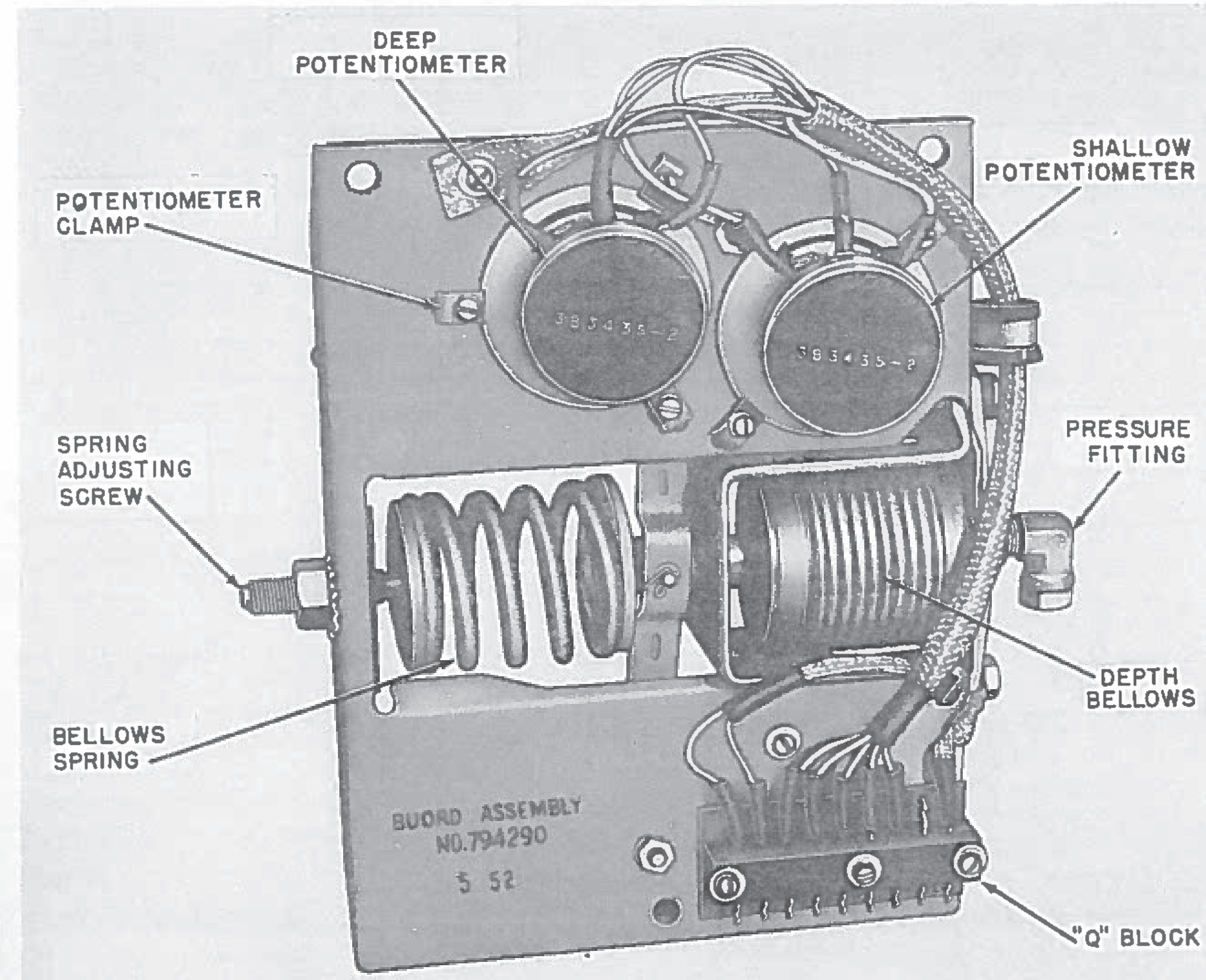

Figure 83—Depth Control Assembly, Potentiometer Side.

spring cap so that bellows assembly touches frame at a pressure of 66 ± 1 psi.

3. Check resistance of potentiometer as follows:

a. Total resistance of potentiometer R126 as measured between terminals Q4 and Q5 should be between 22,000 ohms and 28,000 ohms. Record actual reading.

b. Total resistance of potentiometer R125 as measured between terminals Q6 and Q7 should be between 22,000 ohms and 28,000 ohms. Record actual reading.

4. Check electrical midpoint of potentiometer R126. Decrease pressure, noting when resistance between terminals Q3 and Q4 is half that recorded in step 3*a*. Electrical midpoint should correspond to a pressure of 55 ± 3 psi.

5. If potentiometer R126 is not centered correctly, loosen three screws holding its circular mounting plate. (Plate is marked with an arrow to indicate that it can be turned.) Then, with a 55 psi air pressure applied, turn potentiometer housing until procedure of step 4 indicates potentiometer is centered. When potentiometer is centered, tighten screws.

6. Measure resistance between center and one end terminal of potentiometer R126 at pressures of 61 and 49 psi. Change in resistance for this change in pressure (in decreasing direction) should be 8 ± 3 percent of total potentiometer resistance. If this requirement is not met, replace potentiometer.

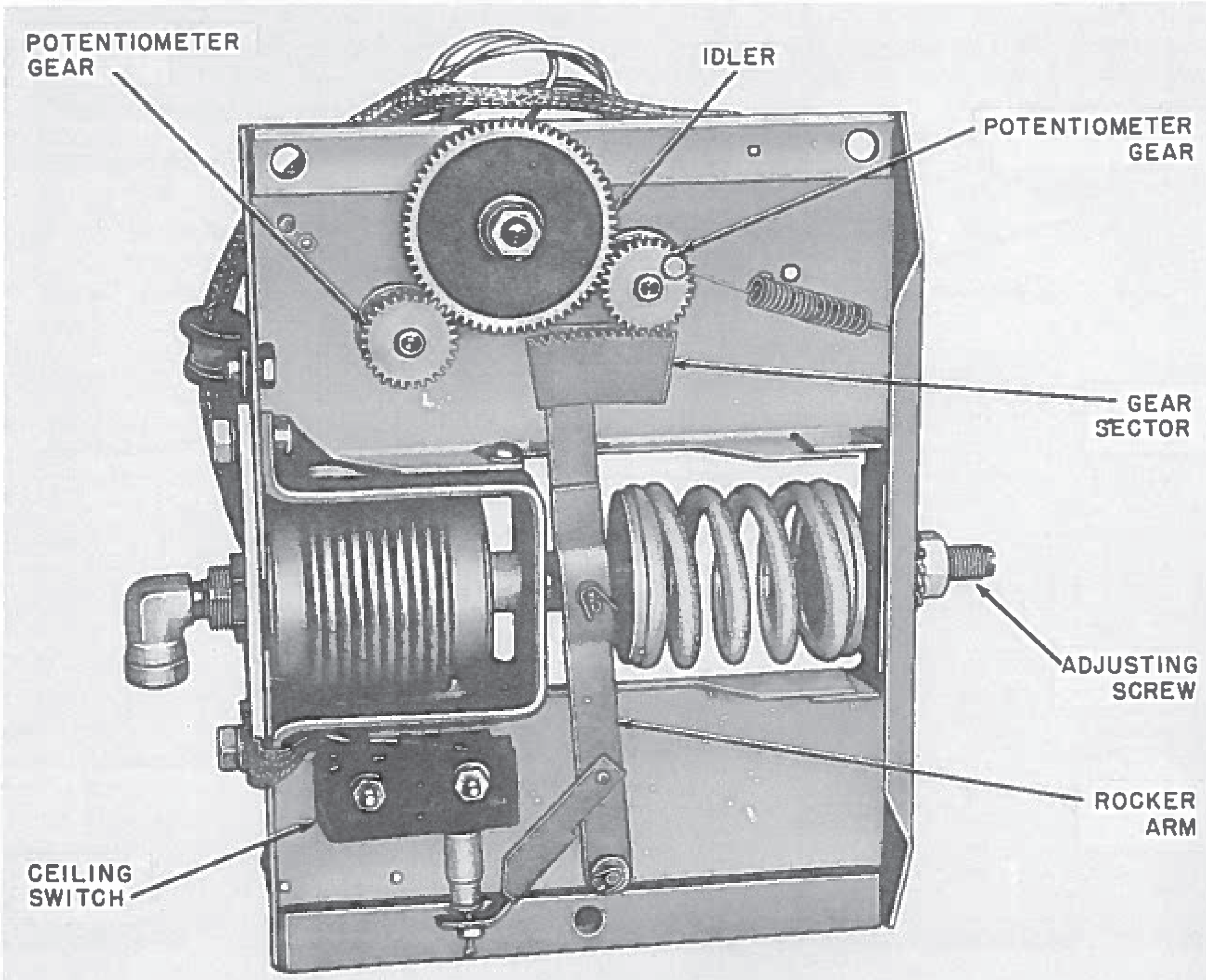

Figure 84—Depth Control Assembly, Gear Side.

7. Increase air pressure from 49 psi to 61 psi in steps of approximately 5 psi. Each increase in pressure should cause a corresponding increase in resistance measured between terminals Q3 and Q4. At each step, record pressure and corresponding resistance between center and one end terminal of potentiometer. Then decrease pressure in steps to produce same resistance values recorded for ascending pressures, recording each pressure. The two pressures recorded for a given resistance should not differ by more than 3 psi.

8. Determine electrical midpoint of potentiometer R125. This setting should be made with decreasing pressure, noting when resistance between terminals Q3 and Q6 is half that recorded for the total resistance of potentiometer R125 in step 3*b*. Electrical midpoint should correspond to a pressure of 31±2 psi.

9. If potentiometer R125 is not centered correctly, loosen three screws holding its circular mounting plate. With 31 psi air pressure applied, turn potentiometer housing until procedure of step 8 indicates potentiometer is centered. When potentiometer is centered, tighten screws. (86)

10. Measure resistance between center and one end terminal of potentiometer R125 at pressures of 39 and 27 psi. Change in resistance for this change in pressure (in decreasing direction) should be 8±3 percent of total potentiometer resistance.

11. Increase air pressure from 27 psi to 39 psi in steps of approximately 5 psi. At each step record pressure and corresponding resistance between center and one end terminal of potentiometer. Then decrease pressure in steps to produce same resistance values recorded for ascending pressure, recording each pressure. The two pressures recorded for a given resistance should not differ by more than 4 psi. Also, resistance should change smoothly with pressure with no evidence of a discontinuity on potentiometer or sticking of moving parts. Repeat tests with ohmmeter connected between center and other end terminal of the potentiometer. An increase in pressure should cause an increase in resistance measured between terminals Q3 and Q6.

12. Measure leakage resistance between all adjoining circuits and depth control assembly chassis. This value must not be less than 5 megohms.

13. Check operation of ceiling switch. Switch should actuate its contact (as evidenced by a closed circuit between terminals Q1 and Q2) at a pressure of 14.0±3 psi on increasing pressure. It should also release (open circuit between terminals Q1 and Q2) at a pressure of 14.0±3 psi on decreasing pressure. To perform this check, apply air pressure to compression fitting of rocker arm bellows. Raise pressure to approximately 20 psi and release pressure slowly. Note point at which switch operates, as evidenced by an audible click. If adjustment is required, loosen locknut on adjustment screw in rocker arm. Then adjust screw until proper operation is obtained and tighten locknut. If a coarse adjustment is required, loosen screw securing switch to frame and move switch until it is in correct position with reference to rocker arm, then tighten screw. (Decreasing gap between rocker arm adjustment screw and switch increases operating and release pressures.) (70, 63, 85)

14. Flush out bellows and treat with 14L17 (ORD) oil (W14–O–2834–15).

Overhaul of Pendulum Assembly.

1. To check operation of a pendulum assembly that has been removed from a torpedo, place assembly in a level position using a spirit level. Connect a 1000-ohm potentiometer to terminal A. Adjust potentiometer so that resistance measured between terminals B and C does not differ by more than 200 ohms from resistance measured between terminal B and unconnected terminal of potentiometer. Resistance measured between terminal C and unconnected terminal of balancing potentiometer should be between 14,345 ohms and 10,655 ohms. (39)

2. Tilt pendulum assembly about its longitudinal axis. Electrical resistance measured between terminal B and terminals A and C should change smoothly over entire range of angular motion of pendulum. Angular range of motion freedom of pendulum should correspond to a tilt from −25°±5° to 25°±5°.

3. Measure resistance change between terminals B and C as pendulum assembly is tilted first 5° in one direction and then 5° in other direction. Determine these tilts as accurately as practical. Observed resistance change should be 1200 ohms (1.5 percent of total resistance measured between terminal C and the unconnected end of the balancing potentiometer).

NOTE: The actual balancing potentiometer used with the pendulum assembly is potentiometer BR in the afterbody junction box.

4. Look for signs of any oil leak in case of unit. A slight oil leak around cover screws of unit may be repaired by removing screws, carefully cleaning off oil, and coating screws with white lead or other sealing compound.

Overhaul of Connecting Rods, Yokes, Stub Shafts, and Associated Watertight Seals.

1. Inspect yokes and connecting rods. If they are bent or otherwise damaged, replace them with new assemblies.

2. Whenever watertight seals are removed, be sure to discard them and replace them with new seals.

3. If stub shafts, rudder or elevator vanes or rudder bearings are found to be damaged, replace them with new parts.

Overhaul of Junction Box. The junction box provides connection points for all cabling within the afterbody. In addition to inter-terminal wiring, the junction box contains relays K15, K16, K18, K19, and K20 and the dive angle and climb angle limit switches. Instructions for the maintenance and adjustment of the relays are given in chapter 11 with the instructions relating to the relays of the battery compartment.

If any trouble is traced to the junction box, refer to figure 159 as an aid in locating the source of the trouble.

Overhaul of Enabler Assembly. See figures 85, 86, and 87.

ADJUSTMENT.

1. The gearing in the enabler is provided with oilite bearings and hence should not require lubrication. However, if inspection indicates that lubrication is necessary, use a very light machine oil and apply the oil sparingly.

2. The electrical contact surfaces of the enabler cam must be free of tarnish, fungicide varnish, paint, or any other foreign material. If any contamination is found, polish cam surfaces with ~~very fine emery paper~~ degreaser, such as solvent (AN-C-126) and then coat surfaces with a very light film of DC-4 silicone compound (AN-C-128a).

3. Check all set screws in mechanism to be sure they are tight.

4. Connect enabler assembly to Test Set Mk 183 Mod 0 for remainder of tests.

5. Before proceeding with tests, adjust dial of Test Set Mk 183 Mod 0 to read 0 degrees ±6 minutes and check to see that synchro control transformer in test set is at electrical zero.

6. Connect test set to enabler and energize equipment. (Refer to chapter 14 for details on operation of Test Set Mk 183 Mod 0.) Rotate test set dial to see that enabler pickoff contact rotates about cam and synchronizes with setting of test set dial. Adjust brake shoe assemblies so that no oscillation of servo system in enabler occurs at any position of test set dial over 360 degrees of rotation. Tighten adjustment screws by one additional turn. (85)

~~7. Loosen screws holding housing of Synchro Transmitter Mk 22 Mod 1 to enabler casting. Adjust test set dial to read 350 degrees ±12 minutes. Now rotate housing of Synchro Transmitter Mk 22 Mod 1 until light indicating con-~~

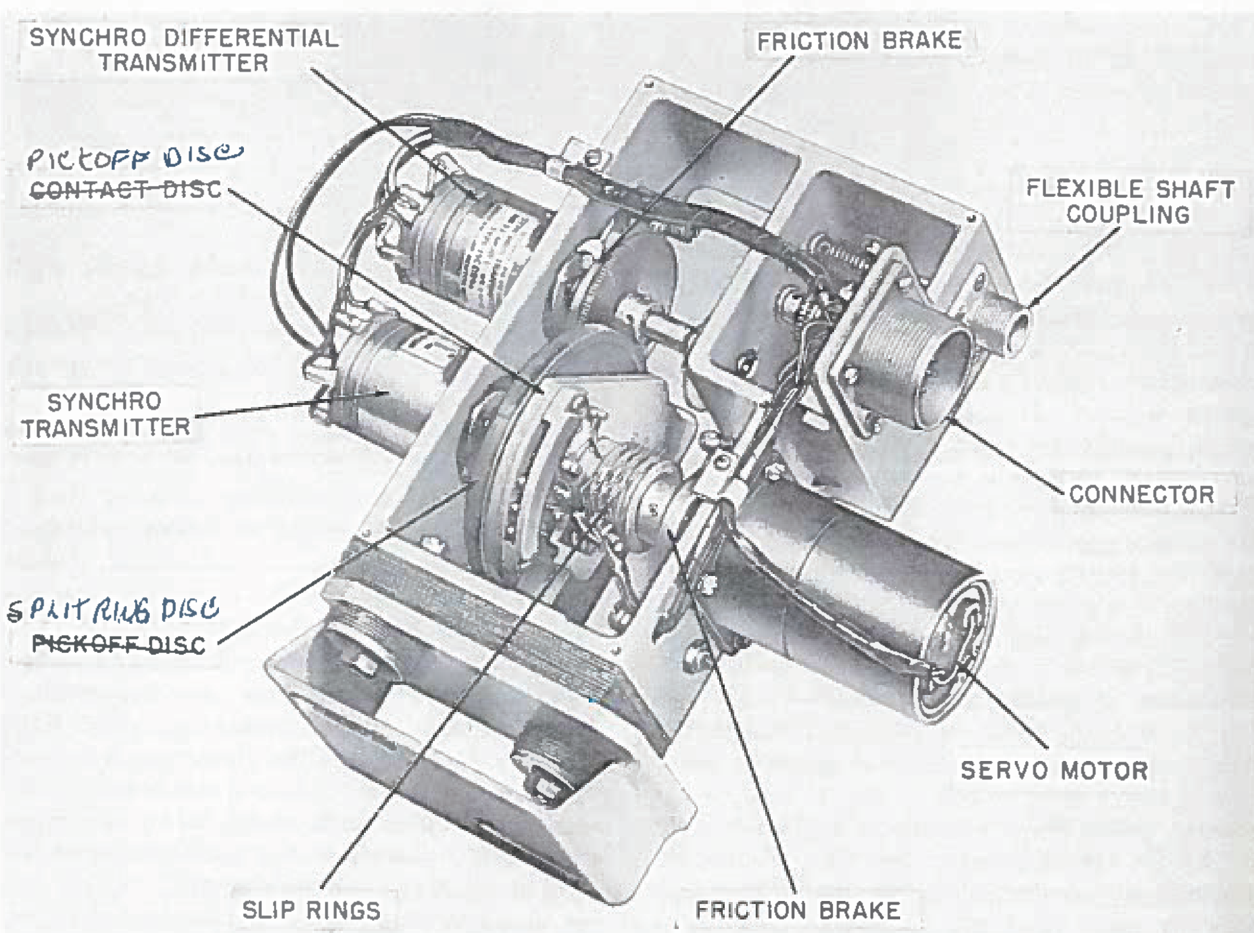

Figure 85—Enabler Assembly.

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* 7 Below

8. Rotate the test set dial towards 1,000 yards until the yellow LIMIT light is extinguished. Then rotate dial back and note setting at which the yellow LIMIT light goes on. Light should go on at 600 ± 50 yards. (85)

9. Rotate test set dial to approximately 3,100 yards and note the range dial setting at which the yellow LIMIT light goes on. This yellow LIMIT light should go on at a range dial reading of 3,100 ± 50 yards.

10. Rotate the test set dial in a direction of increasing range, and check to see that the blue ENABLER light goes on at a range greater than 3,600 [redacted] yards.

11. Rotate dial back and recheck settings made in steps 7, 8, 9 and 10.

NOTE: When test set dial is rotated in direction of increasing range from -2,000 yards, red PORT light must go on between the range positions at which yellow LIMIT light goes out and relights.

12. Set test set dial at 600 ± 20 yards and then de-energize Test Set Mk 183 Mod 0. By means of a flexible shaft, connect mechanical drive connector on enabler to a small, high-speed electric motor. Turn on motor and drive pinion gear in mechanical connector in a counter-clockwise direction until enabling light comes on. Re-energize Test Set Mk 183 Mod 0 and rotate the range setting dial until the enabling light goes on. The range dial setting should be 0 ± 50 yards. Failure to meet this requirement indicates that the Synchro Differential Transmitter Mk 33 Mod 1 is adding, instead of subtracting, angular errors. If this occurs, the enabler synchro wiring must be checked for an error.

<u>Change 1</u>

7. Loosen screws holding housing of Synchro Transmitter Mk 22 Mod 1 to enabler casting. Adjust test dial to read 0 ± 50 yards range. Now rotate housing of Synchro Transmitter Mk 22 Mod 1 until the blue ENABLER light of the Test Set Mk 183 Mod 0 goes on. Tighten synchro housing in this position. Rotate the setting dial on the test set and check to see that the blue ENABLER light goes on at a setting of 0 ± 50 Yards range.

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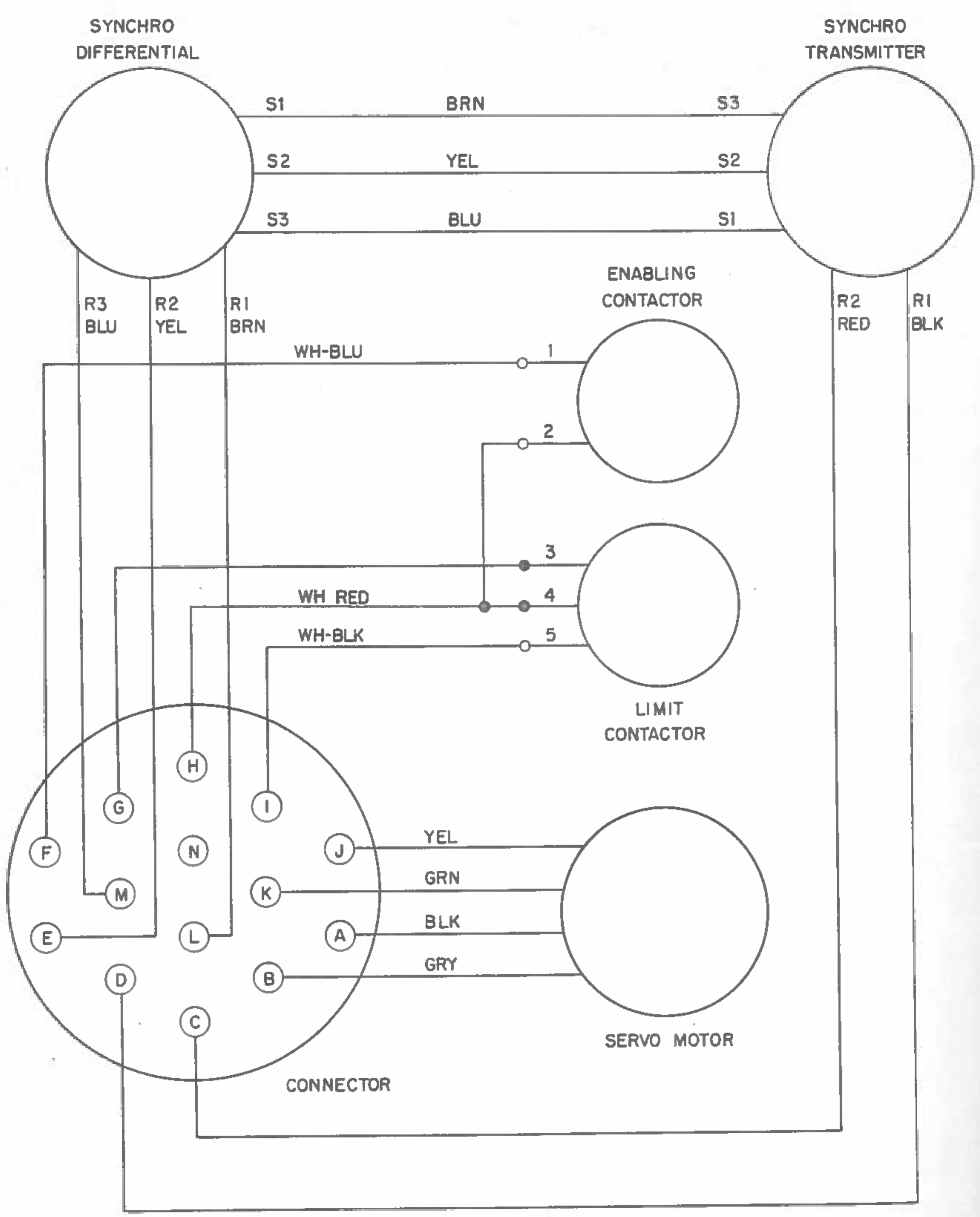

Figure 87—Enabler Wiring Diagram.

This can be remedied by polishing of the contact surfaces and by careful checking of wiring and solder connections. Be sure that the surfaces of the enabler contacts are adequately protected with a thin film of DC4 silicone grease (AN–C–128a).

If the servo motor or either synchro proves to be defective, the defective unit should be replaced and no attempt should be made to effect repair.

Oscillation of the enabler during electrical setting can be remedied by careful tightening of the brake shoe subassemblies on the two shafts. The brakes should be set only just tight enough to eliminate oscillation.

Overhaul of Gyroscope Mk 29 Mod 0. See figures 88, 89, and 90.

Adjustment of Electrical Setting Mechanism. The following adjustments require the use of Test Set Mk 183 Mod 0. Before proceeding with tests, adjust Test Set Mk 183 Mod 0 dial to read "0 degrees ±6 minutes" when the Synchro Control Transformer Mk 14 Mod 0 in the test set is at electrical zero. Check the gyro as follows:

1. Connect test set to gyro and energize equipment. (Refer to chapter 14 for details of operation of Test Set Mk 183 Mod 0.) Be sure that gyro is in a horizontal plane and that gyro is latched. Energize servo system in test set and remove grounding connection from gyro case. (This will deenergize gyro motor.)

2. If gyro setting system oscillates, tighten brake on synchro transmitter gear hub until oscillation ceases. Check to see that oscillation does not occur at any gyro setting throughout entire range of 360 degrees. Tighten brake sufficiently by means of adjustment screw to insure that no oscillation will occur.

3. Rotate test set dial back and forth through zero, checking to see where, with respect to zero, indicator lamps light. If lamps light at equal angles (±21 minutes) on either side of zero, system is properly zeroed. When test set is at zero degrees, dial on gyro should also read approximately zero degrees. In addition, rotation of test set dial through zero-degrees position in direction of increasing angle should cause gyro dial to rotate in a counterclockwise direction when viewed from above, and should cause port lamp (red) on test set to go out, and starboard lamp (green) to light.

If the angle-setting mechanism has been disassembled for repairs, or if the gyro does not meet the conditions set forth above, the electrical setting mechanism must be adjusted as follows:

1. Set dial on test set to zero.
2. Loosen indicator gear on gyro pickoff shaft.
3. Rotate pickoff shaft by hand in counterclockwise direction until port lamp (red) on the test set goes out, and starboard lamp (green) just lights, in order. Any clockwise motion of pickoff shaft from this position should cause starboard lamp to go out and port lamp to light. This is the true zero position of the pickoff shaft.
4. Deenergize servo system by turning off B STBY switch of test set. Remove indicator gear from pickoff shaft. Replace gear, remeshing it with motor and synchro gears so that dial indicates approximately zero. Tighten gear on shaft by means of its set screw.
5. Turn on B STBY switch and rotate test set dial back and forth through zero, checking to see where, with respect to zero degrees, indicator lamp lights. If both lamps light at equal angles (±21 minutes) on either side of zero, system is properly zeroed. If lamps light at unequal angles, adjust pickoff screw at top of outer gimbal until lamps light at equal angles. If starboard lamp (green) lights closer to zero, turn screw clockwise; if port lamp (red) lights closer to zero, turn screw counterclockwise. Repeat adjustment until lamps light at equal angles (±21 minutes).
6. After adjusting pickoff screw, adjust dial on indicator gear and set pointer so that dial reads 0±2 degrees when test set dial is set at zero.
7. Check contact pressure for each spring contact on gyro slip ring assembly, using a gram gage.

NOTE: Read gage at instant contacts just open. Adjust all contacts to have break pressures of 21±7 grams.

Adjustment of Unlatching Mechanism.

1. Mount gyro assembly to bracket on gyro test stand, using screws provided. Connect gyro assembly to test cable on stand and connect alligator clip lead to ground.
2. Attach power lead of gyro test stand to a source of 14 volts DC.
3. Press UNLATCH switch of test stand. Unlatching mechanism should operate positively. Latching lever should swing free, completely

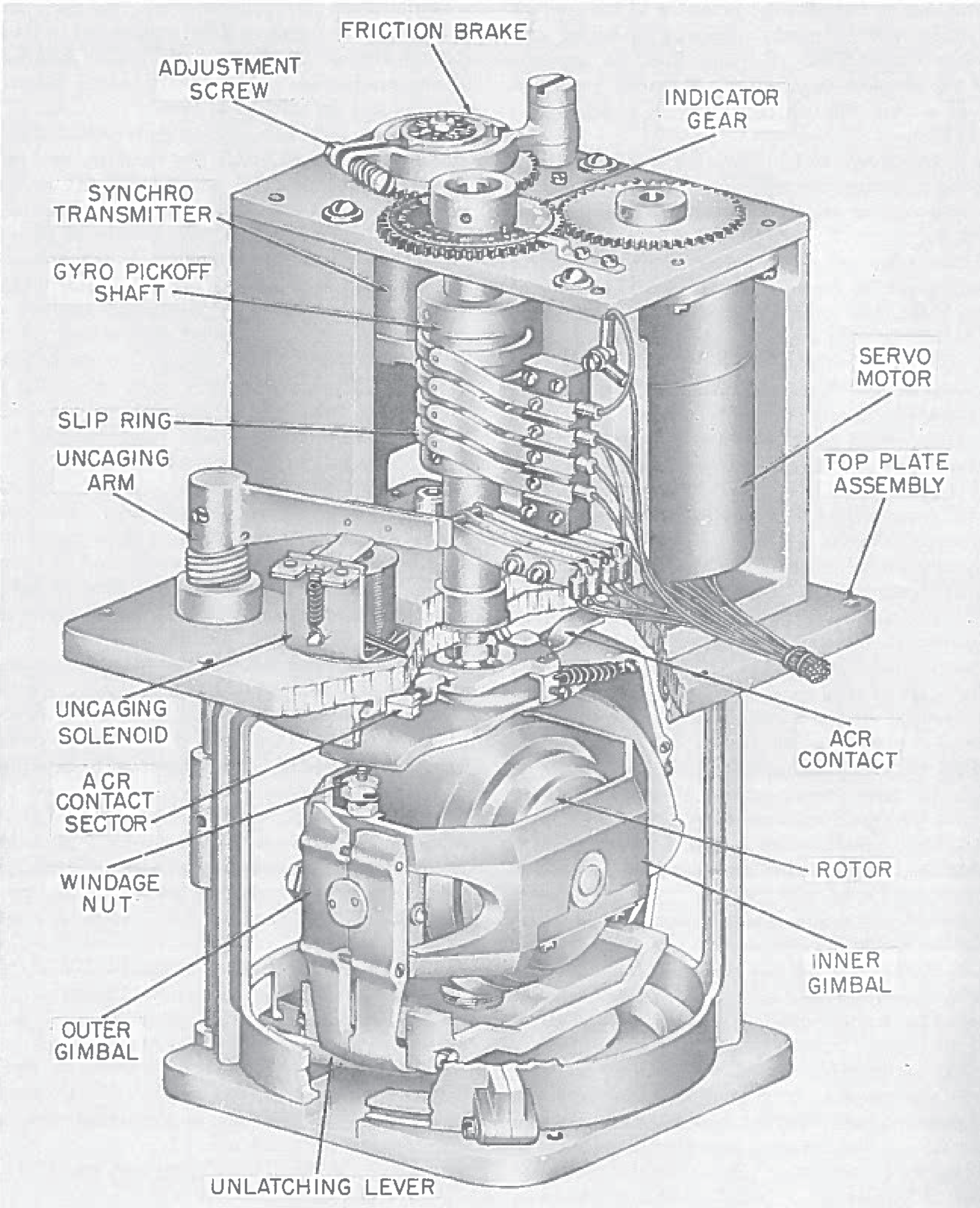

Figure 88—Gyroscope Mk 29 Mod 0 (Cutaway).

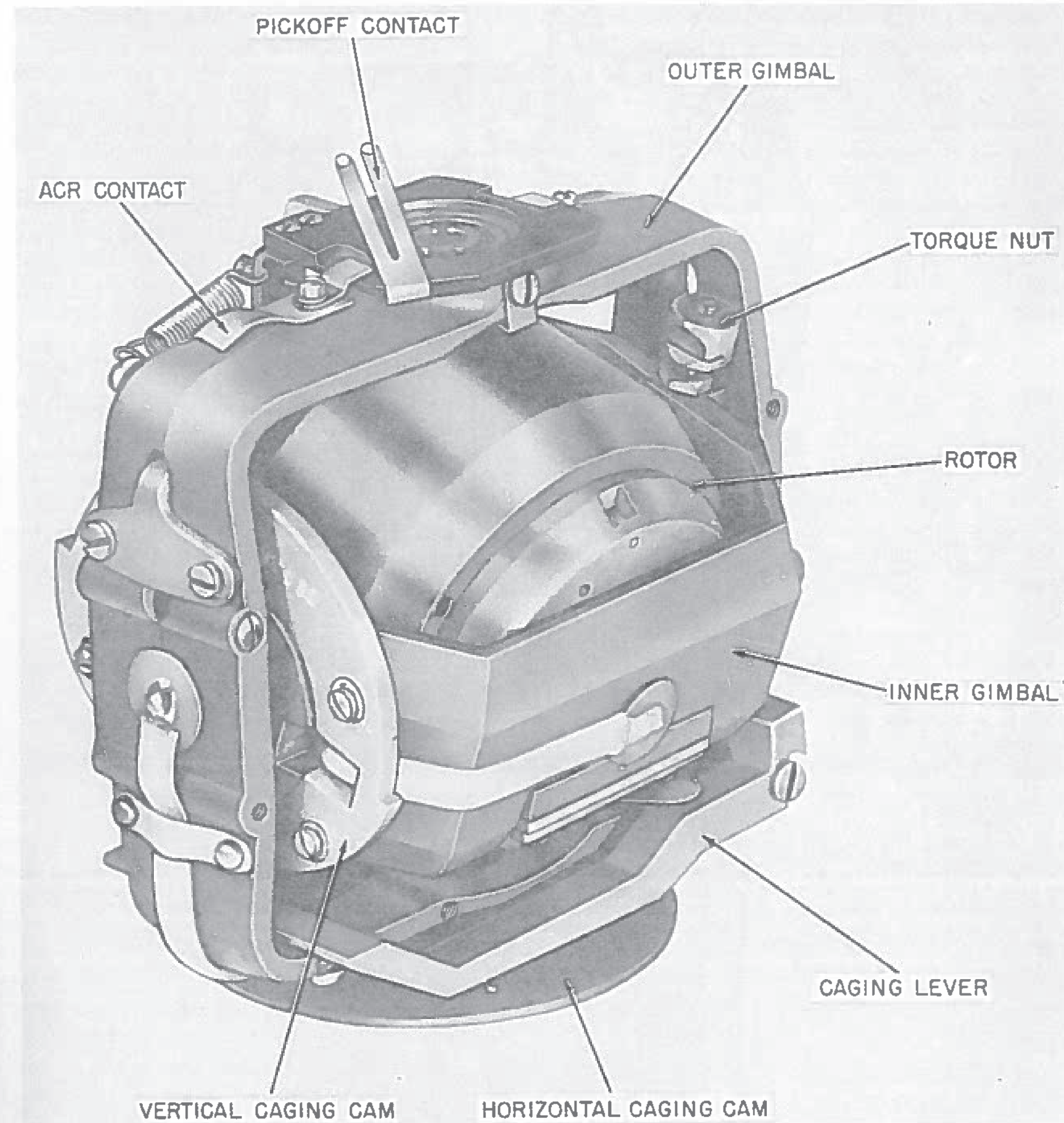

Figure 89—Gyro Mechanism.

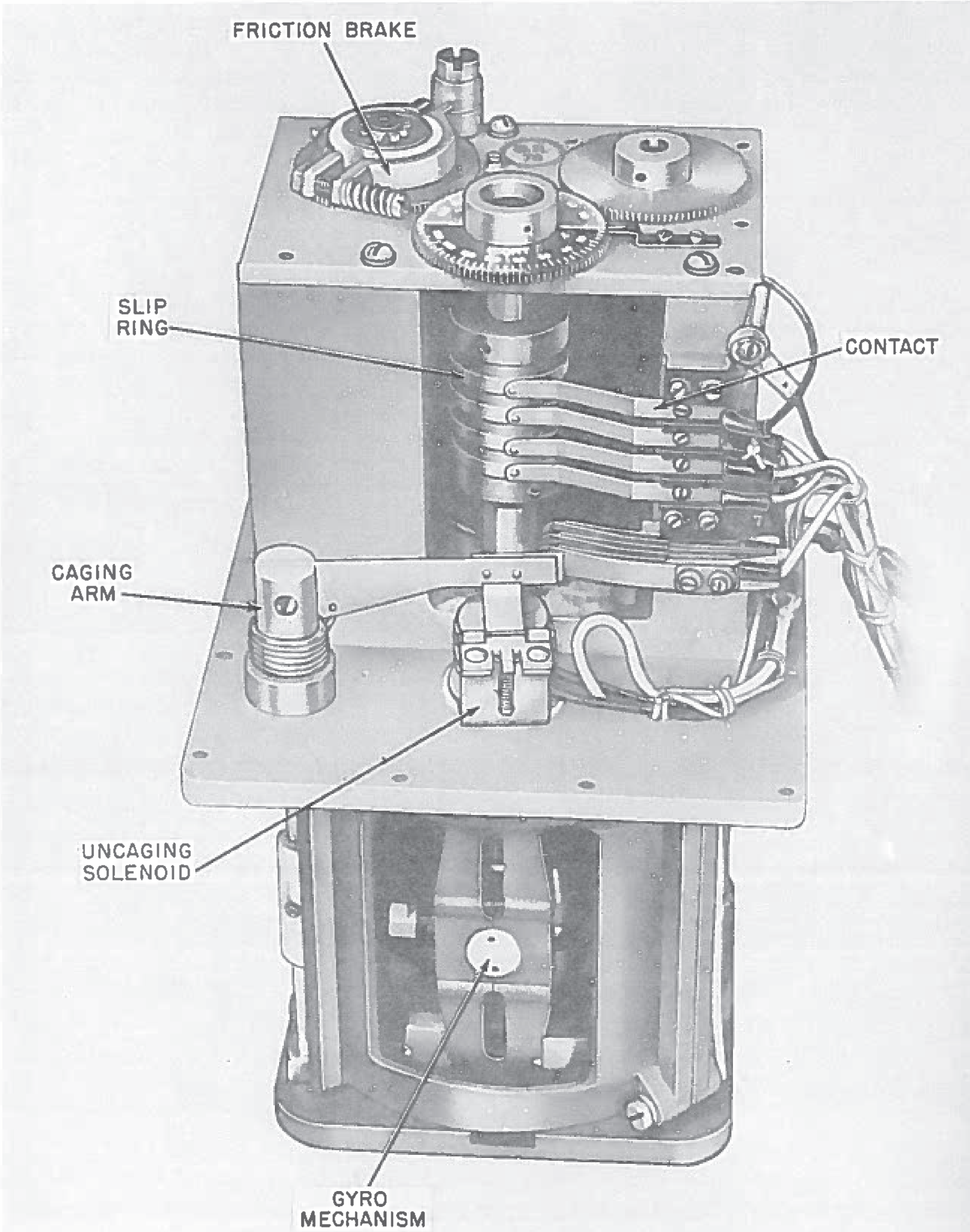

Figure 90—Gyro Top Plate Assembly.

freeing gimbals, except that rotation of inner gimbal may be restrained to an agle of approximately 75° in a vertical plane.

4. Attach power lead of gyro test stand to a source of 10 volts DC.

5. Press UNLATCH switch of test stand. Unlatching mechanism should not operate.

6. Failure to meet requirement of steps 3 and 5 indicate incorrect adjustment of latching mechanism. Latching lever must be positioned properly with respect to inner and outer gimbal cams, and securely tightened to its shaft by means of a set screw located below top plate assembly. Inspect components of latching mechansim for bent or damaged parts and make necessary repairs.

Precession and Inner Gimbal Tilt Measurement.

1. Mount gyro on bracket of gyro test stand. Attach power leads of test stand to a source of 24±2 volts DC. Connect gyro electrically to test stand by means of cable provided.

2. Make sure that gyro is latched and that gyro angle setting is zero. Start gyro motor by operating GYRO switch of gyro test stand. Turntable should be in a horizontal position with key latched in test set frame.

> NOTE: It is sometimes desirable to disengage keys on test set frame and rotate turntable clockwise through an angle of 15 degrees before continuing with tests. If gyro is unlatched in this position, any pendulous properties of inner gimbal will be revealed by a precession greater than that observed when gyro is unlatched with turntable in a horizontal position.

3. When gyro motor has attained full speed, hold turntable at approximately zero rotation angle and uncage gyro by operating UNLATCH switch.

4. Without any delay, rotate turntable left and right and note angle at which red light just goes on. Record angle at which red light just goes on when turntable is turned to left (clockwise as viewed from above) as zero reference position.

5. Two minutes after gyro is unlatched rotate turntable in bearing through 90 degrees in each direction and then return turntable to zero position. Next, disengage latch on test stand frame and, holding turntable at a reading of zero degrees in bearing, tilt it to angles of plus and minus 70 degrees. Return turntable to a tilt of approximately +45 degrees and engage dog-pin end of handle with arm used to oscillate turntable. Engage turntable oscillating arm with its dog-pin. Close both toggle switches to start motors. Turntable will now oscillate about 45-degree position at 10 cycles per minute with an amplitude of ±15 degrees and simultaneously will oscillate about an axis perpendicular to turntable at 10 cycles per minute with an amplitude of ±10 degrees.

6. Permit turntable to oscillate for 3 minutes (total of 5 minutes after gyro is unlatched). Return turntable to horizontal position. To do this, turn off the motor switches, disengage handle from arm, and swing turntable to approximately zero degrees where latch can again be engaged with test stand frame.

7. Repeat step 4 and record angle at which red light goes on. In addition, record total time elapsed from time of recording original zero reference position until the final rechecking of the zero reference position.

8. Determine precessing of gyro by dividing total angular difference (expressed by degrees) between original zero position and final zero position by total elapsed time recorded in step 7. This quotient must be within the limits indicated in figure 91 for the latitude at which the test is conducted.

> NOTE: Because of earth rotation, a perfectly statically balanced gyroscope will appear to rotate clockwise to an observer in northern latitudes, and counterclockwise to an observer in southern latitudes. This apparent rotation is called "creep" and its magnitude may be calculated from the following formula:
>
> $$C=\frac{T \sin L}{4}$$
>
> Where: C is creep angle in degrees
> T is elapsed time in minutes
> L is latitude in degrees
>
> It can be seen that there would be zero degrees creep at the equator and a maximum of ¼-degree per minute at the poles. (1.25 degree per 5 minutes.) Figure 91 should be used in determining whether

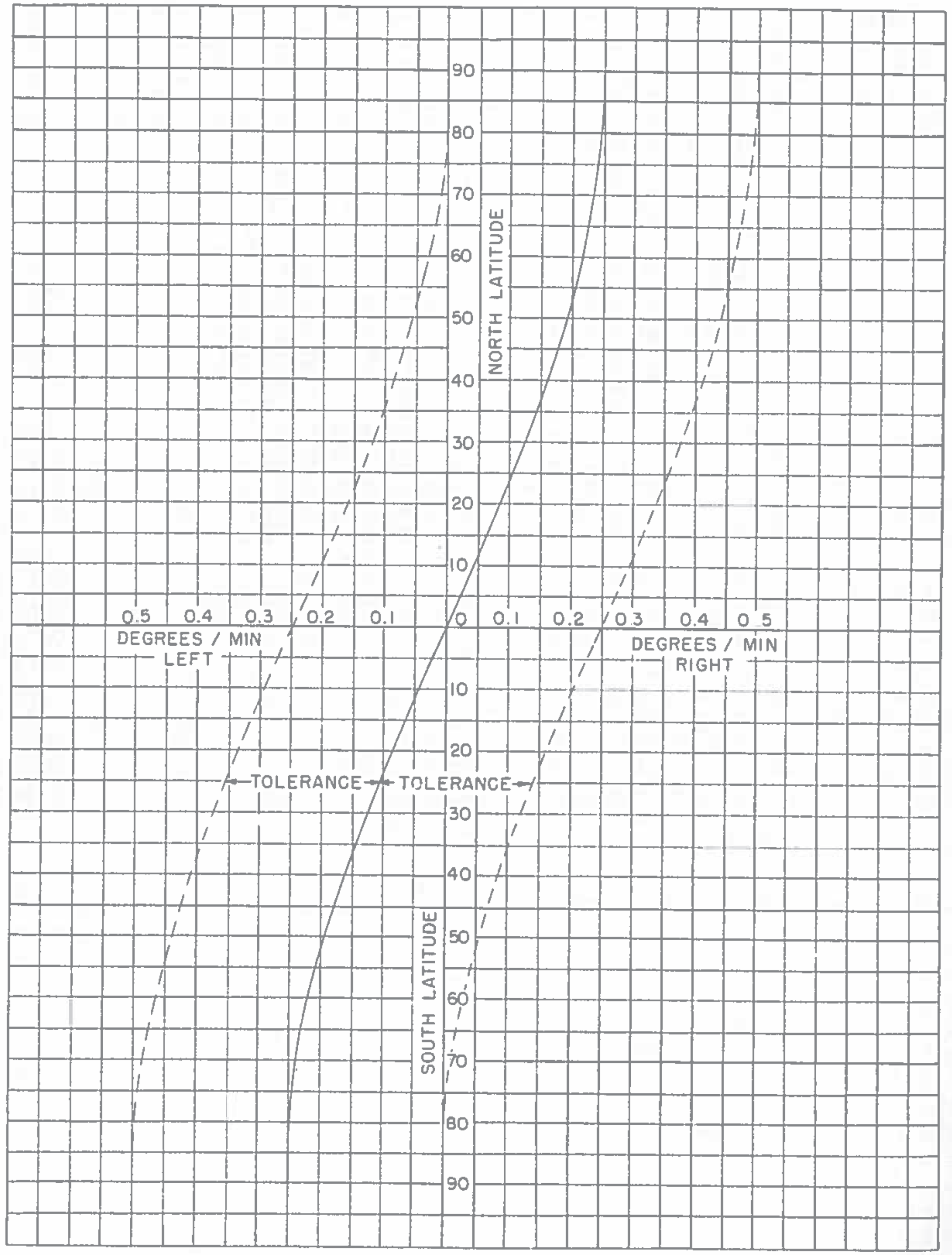

Figure 91—Latitude Correction Chart.

the precessions observed in the test are correct for the latitude at which the test is conducted.

9. After precession has been measured, determine tilt of inner gyro gimbal. This tilt should not exceed 10 degrees in either direction.

Check of ACR Contact Operation. Check the operation of the gyro ACR contact cam by unlatching the gyro while it is mounted and running on the gyro test stand with the turntable held at zero bearing and latched at zero tilt. Rotation of the turntable to a bearing angle of 135 ± 10 degrees in either direction from the zero position should cause the ACR contacts to close as indicated by lighting of the ACR indicator light on the turntable.

Static Balance Adjustment of Gyro. After repair or overhaul of a gyro mechanism, the two gimbal assemblies must be carefully adjusted for static balance in accordance with the following procedure:

1. Clamp outer gimbal in a fixed position.
2. Tilt inner gimbal and allow it to seek a position of rest.
3. Repeat step 2 several times. If inner gimbal comes to rest at same position each time, it is out of static balance.
4. Screw balancing hex nut and milled windage nut in or out as necessary to obtain balance. It may be necessary to loosen screws which hold motor shaft clamps on inner gimbal and slide motor and its shaft in one direction or another. Recheck static balance after each adjustment. When adjustment is complete, tighten motor shaft clamp screws.
5. As a final check of inner gimbal static balance, place a piece of putty weighing five grains on one side of outer gimbal just above motor shaft. Position inner gimbal so that motor shaft is horizontal and then release gimbal. Repeat this test with same piece of putty on opposite side of outer gimbal directly above motor shaft. Observed angle of inner gimbal rotation should be approximately equal to angle previously noted.
6. After inner gimbal has been statically balanced, test outer gimbal and inner gimbal together by permitting gimbals to rotate together slowly and come to rest. This should be done in such a way that ACR contact does not touch sector cam on lower surface of top plate assembly. Repeat check several times. Gimbals should not come to rest at same position each time. (This is a rough check but it must be made in order to permit a preliminary adjustment of static balance of the complete gyro mechanism.)
7. To adjust balance, first unsolder flat conductor from bearing on side of outer gimbal. Then slightly loosen two screws on either side of inner gimbal bearing (mounted on outer gimbal) and screw bearings in or out so as to shift position of inner gimbal. (Bearings must be tight enough to prevent movement of inner gimbal within outer gimbal but not tight enough to cause binding.) After adjustment, retighten four screws on outer gimbal and recheck complete assembly for static balance. Finally, solder flat lead to contact on inner gimbal bearing.

Adjustment for Precession. The gyro is mounted in the afterbody of the torpedo with the precession adjusting nut facing aft. Although the nut is adjusted approximately during the setting and balancing of the inner gimbal, final adjustment must be made on the basis of the results of the precession test previously described. If the precession to port is outside of the limits specified in figure 91, unscrew the nut slightly. (Precession to port is defined as a counterclockwise shift in the zero position as determined at the start and at the end of the precession test.) If the precession to starboard is outside of the specified limits, screw in the precession nut slightly.

A comparison of precession measurements made with the gyro unlatched while the turntable is horizontal and unlatched with the turntable tilted 15 degrees counterclockwise at the time of unlatching will reveal a condition of unbalance in the inner gimbal assembly. The top of the inner gimbal assembly is heavy if the tilt run gives greater precession to starboard than the horizontal run. Conversely, the bottom of the inner gimbal is heavy if the tilt run gives a greater precession to port than the horizontal run.

Tilt Adjustment. If during the precession test, the inner gimbal tilts more than 10 degrees in either direction, one of the following adjustments should be made:

For large adjustments, turn the trimming nut on the vertical screw projecting from the inner gimbal to adjust the angle that the milled face of the nut makes with the air stream from the gyro rotor. To compensate for counterclockwise tilt, set the milled face so that it is turned more or less toward the left; for clockwise tilt, set the milled face so that it is turned to the right. The exact position must be determined by trial. While making this air reaction adjustment, turn the nut no more than a full turn to avoid disturbing the inner gimbal balance.

Compensation for tilt may also be achieved by the following adjustment:

If tilt is counterclockwise (looking inboard), screw outboard inner gimbal bearing outward by rotating the bearing through an angle of approximately 5 degrees. The inboard bearing must be screwed in a corresponding amount to maintain bearing clearance.

If tilt is clockwise (looking inboard), reverse the above procedure.

> NOTE: Inner gimbal tilt and precession are interdependent, therefore, if an adjustment is made for tilt, it will be necessary to recheck both the tilt and precession.

TROUBLESHOOTING. If troubles are encountered which are not corrected by the preceding adjustments, check the following points:

1. Failure of the motor to operate is usually found to be due to an open in the motor power circuit at the base of the gyro. The soldering lug may have broken free from the insulated contact in the center of the bottom bearing of the outer gimbal.

2. Other electrical circuit failures may be due to corroded slip rings or bent contacts. A failure of the electrical setting mechanism to synchronize with either fire control equipment or Test Set Mk 183 Mod 0 may be due to improper connection of the synchro leads. Reference should be made to figure 92 in tracing out the wiring.

Reassembly of Afterbody

These reassembly instructions are based on the assumption that all of the parts have been removed from the afterbody. If this is the case, the sequence of reassembly should be followed as given. If only certain components have been removed, the sequence of reinstallation follows the same general outline.

Installing Cross Strut and Drive Shaft Assembly.

1. Examine inner and outer gaskets and replace them if they are nicked or torn.

2. Install female part of flexible coupling, making sure key is in place and setscrew has been replaced. (81)

3. Place inner gasket over studs of bearings with flat side of gasket toward strut.

4. Insert assembled drive shaft and strut through afterbody and fasten strut. (65, 85)

5. Place outer gasket over stud (flat side toward propeller end of shaft).

6. Place outer plate over studs.

7. Tighten nuts a little at a time working progressively around plate. Nuts must be tight and must have uniform tension in order to assure a watertight joint. (69)

Replacing Propeller.

1. Position propeller for reinstallation, remove key from propeller shaft, and push propeller on shaft by hand as far as it will go. Measure distance of propeller from end of afterbody.

2. Remove propeller and replace key in shaft.

3. Coat shaft with petrolatum, heavy oil, or cup grease.

4. Install propeller on shaft, seating it so that distance of propeller from end of afterbody is not more than that measured with key removed. If necessary, obtain correct seating by placing a piece of wood against propeller hub and tapping wood with a hammer. When propeller is correctly seated, clearance between afterbody and propeller hub should not be less than 3/32 inch, nor more than 5/16 inch. If undue difficulty is experienced in seating propeller, examine shaft key to determine whether filing is necessary to obtain a proper fit. (49)

5. Replace fairwater (left hand thread). (29)

6. Replace fairwater retaining screw. (83)

Installing Connecting Rods, Yokes, Shafts, and Associated Watertight Seals.

1. After watertight seals have been removed, clean inside of each cup thoroughly, using a pocket knife or similar tool, taking care not to scratch surface. Coat lower outside edge of each replacement watertight seal with a small bead of pipe compound and seat seal firmly in cup. After seals are installed, remove excess pipe compound. Coat watertight seals lightly with lubricating oil, petrolatum, or silicone grease. Replace outer stub shaft bearings, tapping them with a hammer to seat them securely. (49)

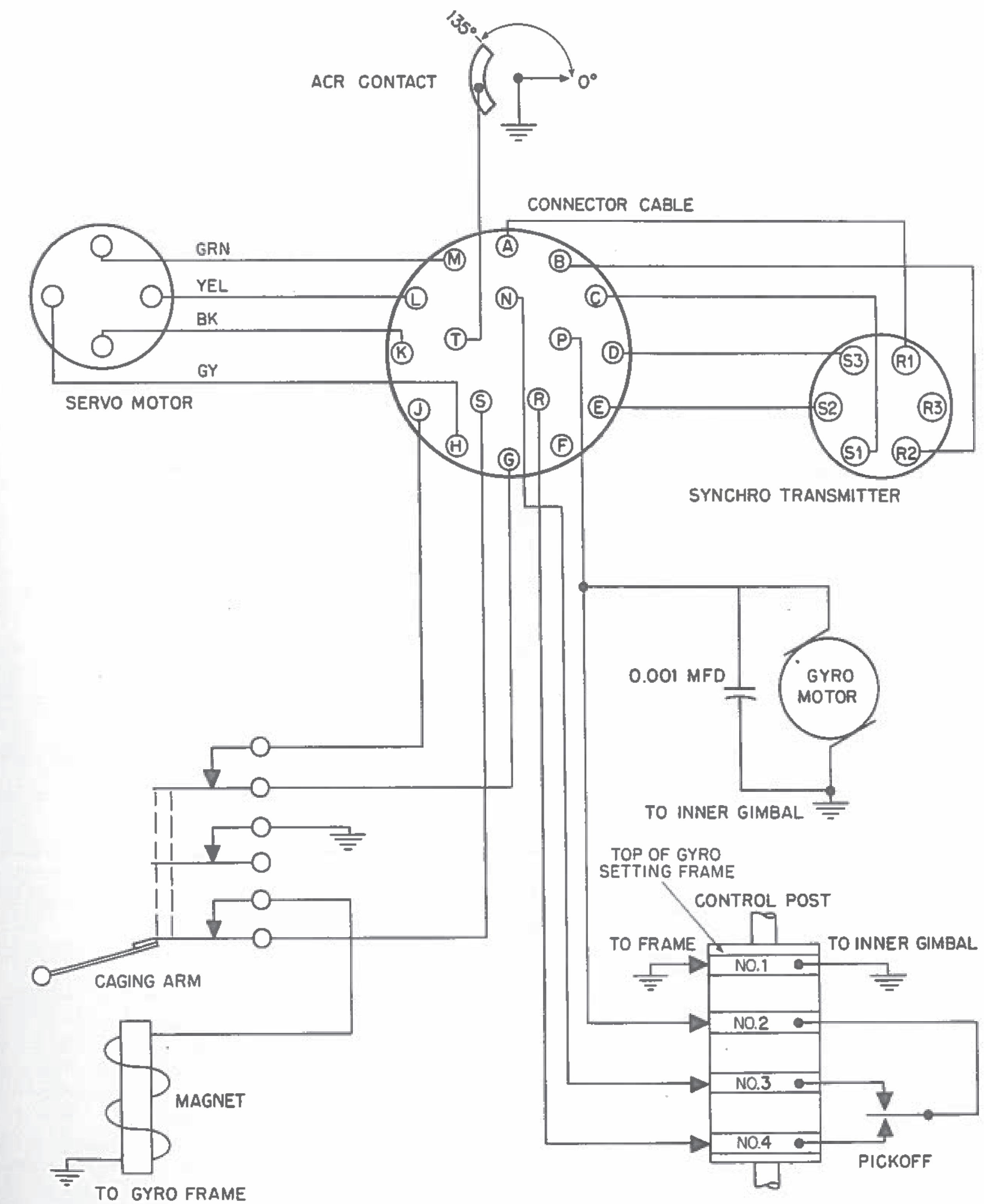

Figure 92—Gyroscope Mk 29 Mod 0, Schematic Diagram.

2. Before installing stub shafts, coat them with petrolatum. To install shafts, push them part way through watertight seals, engage them with yokes, and then adjust their positions to line up taper pin holes. Insert taper pins. Tighten horizontal pins with taper pin hammer by placing hook of hammer against end of pin and driving forward with impact weight. Tighten vertical taper pin by placing shaft of pin hammer on top of pin and striking downward on tool with an ordinary hammer. It is important for taper pins to be tight to avoid play in the connecting rod linkages. (26, 1)

3. Replace rudder and elevator vanes.

4. Tighten outer vane bearings securely, after first greasing screws then back off approximately one-half turn and tighten set screw in side of gudgeon plate. Make sure that vanes do not bind at any point throughout a travel of approximately 20 degrees each side of center position. (83, 77)

NOTE: If it is difficult to seat vanes in their bearings, examine rubber bushings in stub shaft wings. If a bushing is too long, trim it slightly or replace it with a new bushing.

5. Swing each vane into position inside gudgeon plate.

6. With rudders, stub shafts, yokes, and steering rods positioned and adjusted, measure force required to move elevator and rudder connecting rods approximately as they normally are moved by steering motors. This force must not exceed 7 pounds while connecting lugs on yoke assemblies are moved from approximately 20 degrees aft of their center position to approximately 20 degrees forward of their center position.

Replacing Steering Motor Assemblies. See figure 93.

1. Mount rudder steering motor on propulsion motor frame and fasten with two hexagonal screws (9/16-inch across flats). (68)

2. Mount elevator steering motor on propulsion motor frame and fasten with two hexagonal screws (9/16-inch across flats). (68)

Installing Propulsion Motor.

1. Replace male part of splined flexible coupling on motor shaft, sliding it over shaft key. Tighten set screws to secure coupling to shaft. (81)

2. Replace three mounting brackets on motor, holding canvas pad inserts smoothly around bottom and three sides of rubber cushions. Reseat rubber cushions in motor mounting brackets, taking care that canvas separates cushions from inner walls of mounting brackets at all points so that canvas acts as an acoustic insulation between propulsion motor and afterbody shell.

3. Set followup potentiometers of steering motors to their electrical midpositions.

4. Make sure that half of flexible coupling on motor and motor mounting brackets with their rubber cushions and canvas pad inserts are firmly secured in place.

5. Coat blades of mounting brackets liberally with petrolatum.

6. Start blades into their supports, inserting them evenly to prevent binding. Push motor in by hand. If necessary, aline motor by placing a piece of wood against each mounting bracket end, in turn, and tapping with a hammer. Do not tap on motor shaft. (49)

7. After motor has been pushed in by hand, use motor puller as a pusher. (Thread tightening nut on motor end of screw.) Connect screw to threaded end of motor shaft, positioning puller bar over two studs of afterbody shell. Fasten puller bar to studs by means of nuts. Push motor into afterbody by slowly turning tightening nut. When halves of flexible coupling are close to engagement, turn them to mesh properly by feeling with the fingers. Use a small mirror to aid in making connections. After halves of coupling are engaged, push motor in until holes in mounting brackets and holes in supports are in line. If necessary, complete the alinement by driving a drift pin through holes. (5, 70, 40)

8. Insert bolts in supports and tighten them securely. (55, 61, 68)

9. Turn motor by hand to make sure than it rotates freely.

Assembling Connecting Rods to Steering Motors.

1. Run rudder steering motor by applying 12 volts DC between terminals N6 (+) and N4 (−), or N5 (−), until rudder follow-up potentiometer is electrically centered. Satisfactory centering is indicated when resistance between terminals N1 and N2 is equal to resistance between terminals N2 and N3 within 500 ohms.

2. Run elevator steering motor by applying 12 volts DC between terminals H6 (+) and H4 (−), or H5 (−), until elevator follow-up potentiometer is electrically centered. Satisfactory

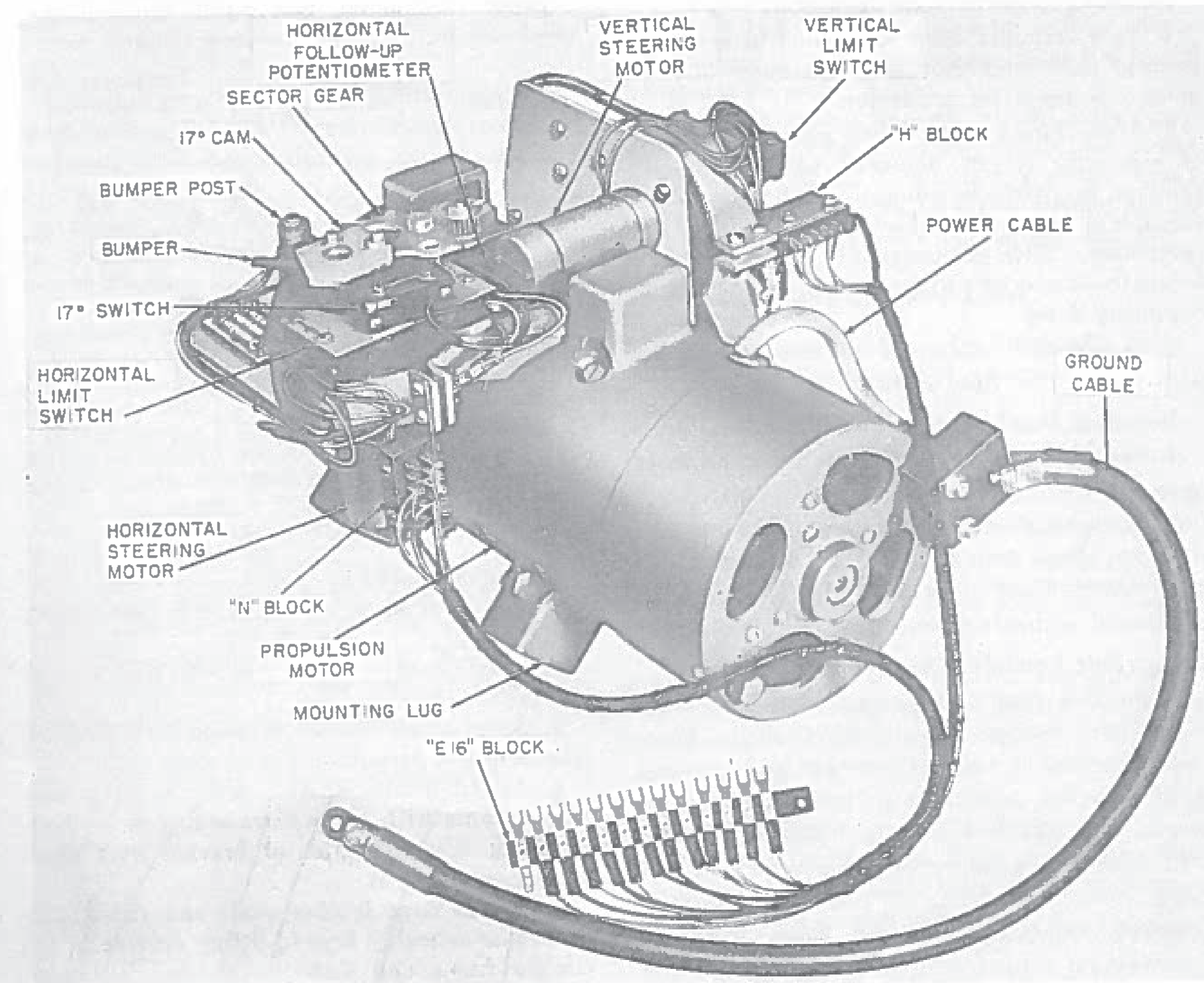

Figure 93—Propulsion Motor and Steering Motor Assemblies.

centering is indicated when resistance between terminals H1 and H2 is equal to resistance between terminals H2 and H3 within 500 ohms.

NOTE: After steering motors are positioned, they must not be displaced from these reference positions during the following adjustment procedures.

3. Have a man hold rudder (or elevators) exactly at center position, as indicated by punch marks in afterbody shell. Place washers and screw in connecting rod and check to see if screw enters tapped hole in gear sector of steering motor, making sure that rudder or elevator is exactly in center position as this is being done. Do not move gear sector.

4. If necessary, loosen check nut on connecting rod and adjust length of rod so that screw properly enters hole in gear sector. Tighten check nut.

5. Tighten connecting rod screw until it is firmly in place in gear sector. Check to see that rudder or elevator is still centered by measuring resistances as in steps 1 and 2. (70, 65)

6. Operate steering motors, using 12-volt battery, to check for binding or excessive play. This may be done by connecting battery between terminals H6 (+) and H4 (−) or H5 (−) to operate elevator motor, and between N6 (+) or N4 (−) or N5 (−) to operate rudder motor.

7. Position rudder and elevators at 0 ±1 degree and recheck resistances of followup potentiometers as in steps 1 and 2.

Installing Torpedo Shell Connector.

1. Pass terminal strip and cable attached to torpedo shell connector into afterbody through mounting flange for connector.

2. Make sure that "O" ring gasket on outside of connector is not damaged and is properly centered in groove in connector shell. Lubricate outside surface of connector shell with DC4 compound. Slide connector into flange and aline holes in connector with the tapped holes in mounting flange.

3. Secure shell connector to mounting flange with three socket head screws.

Installing Depth Control Unit.

1. Mount depth control unit by means of three mounting bolts (7/16 inch across flats). (64)

2. Connect compression fitting (3/8 inch across flats), to elbow fitting at DEPTH vent in afterbody shell. Coat threads of fitting with pipe compound to insure a watertight joint. (63)

Installing Pendulum Assembly.

1. Position pendulum assembly on bracket in lower port section of afterbody shell. Place pendulum with terminal C forward and terminal A aft. Secure pendulum to bracket with four screws, nuts, and lock washers. (63, 85)

2. Pendulum wiring is cabled in with wiring of depth control assembly. If pendulum has been removed separately, resolder three wires to terminals on top of pendulum assembly. Refer to figure 159 for required connections. (43)

Installing Junction Box.

1. Place junction box near afterbody and connect cables of torpedo shell connector, steering motor, depth control unit, and pendulum assembly to junction box terminal strips as indicated in table 7. (85)

2. Connect fanning strips on gyro cable to terminals on starboard side of junction box. (85)

3. Lift junction box into top forward section of afterbody shell and secure it to bosses on shell with four bolts and lock washers. (67)

4. Attach enabler cable to terminal strips E20B and E21B on forward and bottom sides of junction box in accordance with table 7. (85)

Table 7—Junction Box Cable Connections

Cable	Fanning Strip	Terminal	Terminal Location on Junction Box
Torpedo Shell Connector.	E–17B	E–17A	Lower rear side. Note: Spare lead attached to terminal E–16A–3.
Steering Motors	E–16B	E–16A	Top rear side.
Depth Unit and Pendulum Unit	E–18B	E–18A	Top forward side.
	E–19B	E–19A	Center forward side.
Enabler	E–20B	E–20A	Lower forward side.
	E–21B	E–21A	Forward bottom.
Gyro	E–22B	E–22A	Starboard side top.
	E–23B	E–23A	Starboard side bottom.

Installing Enabler.

1. Place enabler in afterbody in position shown in figure 75.

2. Secure enabler to bracket with lock washers and nuts. (63)

3. Screw ~~small flexible coupling~~ coupler into threaded hole in end of propulsion motor shaft. (70)

4. Attach enabler drive gear box assembly to propulsion motor frame with two screws and lock washers.

5. Couple flexible shaft to enabler drive gear box assembly. Couple lower end of flexible shaft to enabler with right angle connector. Adjust screws in slots of gear box assembly to keep flexible shaft as straight as possible for reduction of noise and friction.

be necessary to rotate propeller slightly in order to engage right angle coupling with splined fitting on small flexible coupling attached to propulsion motor shaft. Tighten both right angle connectors securely.

6. Attach enabler cable to connector on forward side of enabler frame and complete connection by attaching two fanning strips to terminals E20A and E21A on junction box. (85)

Installing Gyroscope Mk 29 Mod 0.

1. If gyro cable is not already connected to junction box, connect fanning strips to terminals E22A and E23A. (85)

2. Check that "O" ring gasket is properly located in mounting space on gyro top cover assembly.

3. Slide gyro assembly into afterbody and position it against mounting flange on afterbody shell.

4. Fasten gyro to mounting flange with four screws. These screws extend through mounting flange on shell into mounting surface of gyro cover assembly. (83)

5. Attach gyro cable connector to electrical connector on forward side of gyro.

6. Check afterbody hand hole cover gasket for breaks or damage and if necessary replace with a new gasket. Apply caster oil to gasket and install hand hole cover.

7. Inspect rubber washers on two screws provided for securing afterbody hand hole cover. If necessary, replace them with new ones. Apply caster oil to rubber washers and tighten screws into after hand hole mounting flange. (55, 60)

Section 10.3—Afterbody Overhaul and Preassembly Check-Off List

Before it is assembled with the remainder of the torpedo, the afterbody must be carefully inspected and tested to make certain that it is in satisfactory condition and is properly adjusted. The following procedure is recommended for making this check. The procedure is given in the form of a checkoff list and it is recommended that all torpedo maintenance and overhaul facilities use this or a similar list. Some steps in the procedure summarize tests made in the procedures described in section 10.2. These steps may be omitted if the tests are made immediately following an overhaul.

...Adjustment

...al damage, ...ged motor ______

...r water or ... shell dry. ______

...p 2, determine where leak occurred and repair or replace parts. ______

4. Inspect gaskets and replace if necessary. ______

5. Disconnect tube to bellows and flush bellows with fresh water. Blow out tube, reconnect bellows, and check for leaks. Fill the bellows with a light machine oil (Ord. Spec 14L–17). ______

6. Loosen set screws and back off rudder and elevator bearings with a large screwdriver. Pack rudder and elevator bearings with grease. Tighten bearings moderately, then back off one-half turn. Grease set screws and tighten in place. ______

7. Check propeller for damage. Clean and grease. ______

8. Remove, rinse, dry, relubricate, and reinstall afterbody shell connector receptacle. ______

Electrical Tests and Adjustment of Afterbody

Test Equipment. The following equipment is required to perform the electrical tests and adjustment of the afterbody:

Voltmeter (1000 ohms per volt minimum impedance)

Test Set Mk 183 Mod 0

12-volt DC source with suitable length leads of No. 16 wire, a 5-ampere fuse and fuse-mounting terminal, test prods, and clips.

Pressure and vacuum system 794436 or equivalent.

Setup for Tests.

1. Place afterbody on dolly and adjust until level. Check with spirit level placed on forward mating surface of afterbody.

2. Connect Test Set Mk 183 Mod 0 to afterbody by means of workshop fire control cable. Plug workshop fire control cable into afterbody shell connector and then into the large TORPEDO connector on test set switching panel. (Refer to chapter 14, section 14.3 for operating instructions for Test Set Mk 183 Mod 0.)

3. Set voltohmmeter for a range covering 25,000 ohms or more.

Test Procedure. In the following steps, all pin connections mentioned have reference to pins in connector P6, the large connector on the afterbody junction box. In order to facilitate measurements, it is convenient to provide a special terminal board with the terminals marked to conform with the lettered pin designations on connector P6. Such a terminal board can then be wired to a connector (AN–3108–36–8F) for connection to P6. Figure 159 shows the circuits of the afterbody.

1. Attach positive lead of 12-volt DC source to propulsion motor frame and negative lead to the following pins of connector P6 and check to see that rudders and elevators move in proper direction: connection to pin w should cause rudder to move to full port position and connection to pin v should cause rudder to move to full starboard position. Connection to pin u should cause elevators to move to full down position and connection to pin t should cause elevators to move to full up position. For all of these connections, rudder and elevators should oscillate about their full deflection position, thus indicating proper operation of limit microswitches. Failure to meet these requirements can be caused by a defective motor, defective wiring, or improper adjustment of reversing switch arm on a steering motor assembly.

2. With rudder centered (alined with double prick punch mark on afterbody shell) measure resistance of each half of rudder followup potentiometer as follows: Resistance between pins x and y should be between 22,000 ohms and 28,000 ohms and resistance between pins x and z should not differ from that between pins y and z by more than 500 ohms. Failure to meet this requirement indicates incorrect adjustment of rudder steering linkage, a defective potentiometer, or an open circuit or ground in associated wiring.

3. With elevators centered (alined with double prick punch mark on afterbody shell) measure resistance of each half of elevator follow-up potentiometer as follows: Resistance between pins m and p should be approximately 6000 ohms (due to shunting effect of depth and pendulum potentiometers). Resistance between pins m and n should not differ by more than 500 ohms. Failure to meet this requirement indicates a misalinement of elevator steering linkage, a defective potentiometer, or an open circuit or ground in associated wiring.

4. Test rudder followup potentiometer by connecting voltohmmeter (set for resistance measurements) between pins y and z, and touching negative lead of 12-volt source to pin w. Rudder should move to port and resistance indicated on voltohmmeter should decrease. Then connect voltohmmeter between pins x and z and touch negative lead of 12-volt source to pin v. Rudder should move to starboard and resistance indicated on voltohmmeter should decrease.

5. Test elevator followup potentiometer by connecting voltohmmeter between pins n and p and touch negative lead of 12-volt source to pin u. Elevators should move down and resistance indicated on voltohmmeter should decrease. Then connect voltohmmeter between pins m and n and touch negative lead of 12-volt source to pin t. Elevators should move up and resistance indicated on voltohmmeter should decrease.

6. Test stratum circuit as follows: Set stratum selector switch on Test Set Mk 183 Mod 0 to AL, BL, and NL. Check to see that stratum selector relay within junction box is functioning by listening for its operation and see that it is synchronizing properly as indicated by proper operation of stratum synchronization light on Test Set Mk 183 Mod 0. Further indication of proper synchronization may be obtained by making continuity tests between pin s and pins S, a, and Z. For each stratum setting continuity should be indicated between pin s and the pin specified below and no continuity should be indicated for the other two pins: AL—pin Z, BL—pin a, NL—pin S.

7. Test depth mechanism as follows: Make sure afterbody is level. Connect voltohmmeter between pins p and X, set stratum selector switch of test set to AL, and apply air pressure to depth vent. Resistance indicated on voltohmmeter should decrease as pressure increases. At a pressure of 31±2 psi, resistance measured between pins m and X should be equal to resistance measured between pins p and X. With stratum selector switch of test set on NL or BL, resistance between pins p and X should decrease with increasing pressure and at a pressure of

55±5 pounds per square inch, resistance measured between pins p and X should be equal to resistance measured between pins m and X.

8. Check operation of ceiling switch as follows: Connect voltohmmeter between pins e and M. With decreasing pressure applied to depth vent, voltohmmeter should indicate that switch opens at a pressure of 14±3 psi. Failure to meet this requirement is indicative of a faulty microswitch, faulty wiring, or incorrect adjustment of operating point of ceiling switch.

9. Check operation of pendulum assembly as follows: With afterbody level, adjust potentiometer BR on afterbody junction box until resistance measured between pins m and K is equal to resistance measured between pins p and K within 200 ohms. Lock potentiometer at this setting. Tilt after end of afterbody upward. This should cause an increase in resistance measured between pins m and K. Failure to meet this requirement is indicative of a faulty potentiometer BR, faulty wiring, or a defective pendulum assembly. The resistance between terminals E18-4 and P6-X should read between 0 and 25,000 ohms depending on the setting of the DR potentiometer when −24 volts DC is connected to terminal E20-4 with the positive lead grounded to the afterbody. If the afterbody is tilted 10±2 degrees, head up or head down, the circuit between E18-4 and P6-X should show an open.

10. Check gyroscope in accordance with instructions outlined in section 10.2. With gyroscope installed in afterbody, check to see that gyro setting mechanism synchronizes correctly with setting dial of Test Set Mk 183 Mod 0. Check to see that zero on test set dial corresponds to zero on gyro indicator gear. Set a positive angle on the test set (corresponding to a starboard angle) and check to see that indicator gear on gyro turns into green sector by a corresponding angle.

11. Enabler can be tested while installed in afterbody in accordance with test outlined in section 10.2. To perform these tests, remove cable connector from enabler and connect enabler test cable from Test Set Mk 183 Mod 0. After performing these tests, replace enabler cable and conduct tests for proper synchronization of enabler with Test Set Mk 183 Mod 0 when test set is connected to afterbody through workshop fire control cable. (Enabler limit circuits will not operate while afterbody is not connected to a battery compartment.)

12. Check operation of warmup circuit as follows: Set control switch of Test Set Mk 183 Mod 0 to STANDBY. This should cause −24 volts DC to appear at pin Y.

13. Check operation of fire circuit as follows: Set control switch of Test Set Mk 183 Mod 0 to ON and operate FIRE switch. This should cause −24 volts DC to appear at pin K.

Chapter 11

MAINTENANCE OF BATTERY COMPARTMENT

Section 11.1—GENERAL

The proper functioning of the battery compartment is dependent upon the care and accuracy with which the mechanisms within it are overhauled and adjusted. This chapter describes the procedures for overhauling the battery compartment components, adjusting them for proper operation, and testing their condition. It is imperative that these procedures be carefully followed.

In the general overhaul of a torpedo, the adjustment and testing of the battery compartment is dependent upon the use of a previously adjusted afterbody assembly because it is necessary in certain of the tests to check the battery compartment operation when it is connected electrically to the afterbody. Therefore it is necessary to obtain an afterbody assembly and determine that it is in good working condition in accordance with tests outlined in chapter 10 before the battery compartment can be tested.

The battery compartment contains the following major components:

Control Panel
Auxiliary Control Unit
Four Magnetostriction Hydrophones
Palladium Catalyst Units
Main Motor Relay
Cylinder Cable Assembly
Propulsion Battery
Test Switch Assembly
B Power Supply
Stratum Pressure Switch Assemblies

The function and operation of the various components within the battery compartment are covered in chapters 2, 5, and 6.

The tests and adjustments covered in this chapter are required ONLY if:

a. The torpedo has failed in a prerun test as described in chapters 7 and 8.

b. Has failed in a proofing run.

c. Or is in need of a general recheck following several exercise runs.

For trouble analysis, it is necessary to perform only those tests associated with the mechanism which is giving trouble.

Section 11.2—Disassembly, Overhaul, and Reassembly

Disassembly of Battery Compartment

A complete overhaul requires that all components be removed from the battery compartment shell. Refer to figure 94, and figures 9 to 15, inclusive, for location of parts. Before beginning the disassembly of the battery compartment, remove the forward and after hand hole covers. To avoid short circuits, disconnect the ground strap within the after hand hole and disconnect the four leads from the propulsion battery terminals within the forward hand hole.

Removing B Power Supply.

1. Disconnect octal plug from B power supply.

2. Remove four wing nuts and lockwashers holding B power supply bracket to after bulkhead and flanges on battery compartment.

Removing Propulsion Battery.

1. Remove B power supply as previously explained.

2. Remove nuts and lockwashers securing after bulkhead to its mounting studs. Pull after bulkhead free from studs, rotate it slightly, and remove it from battery compartment. (75)

3. Remove two bolts holding battery bracket to two flanges on either side of battery compartment shell.

4. Loosen lock nuts on battery hold-down

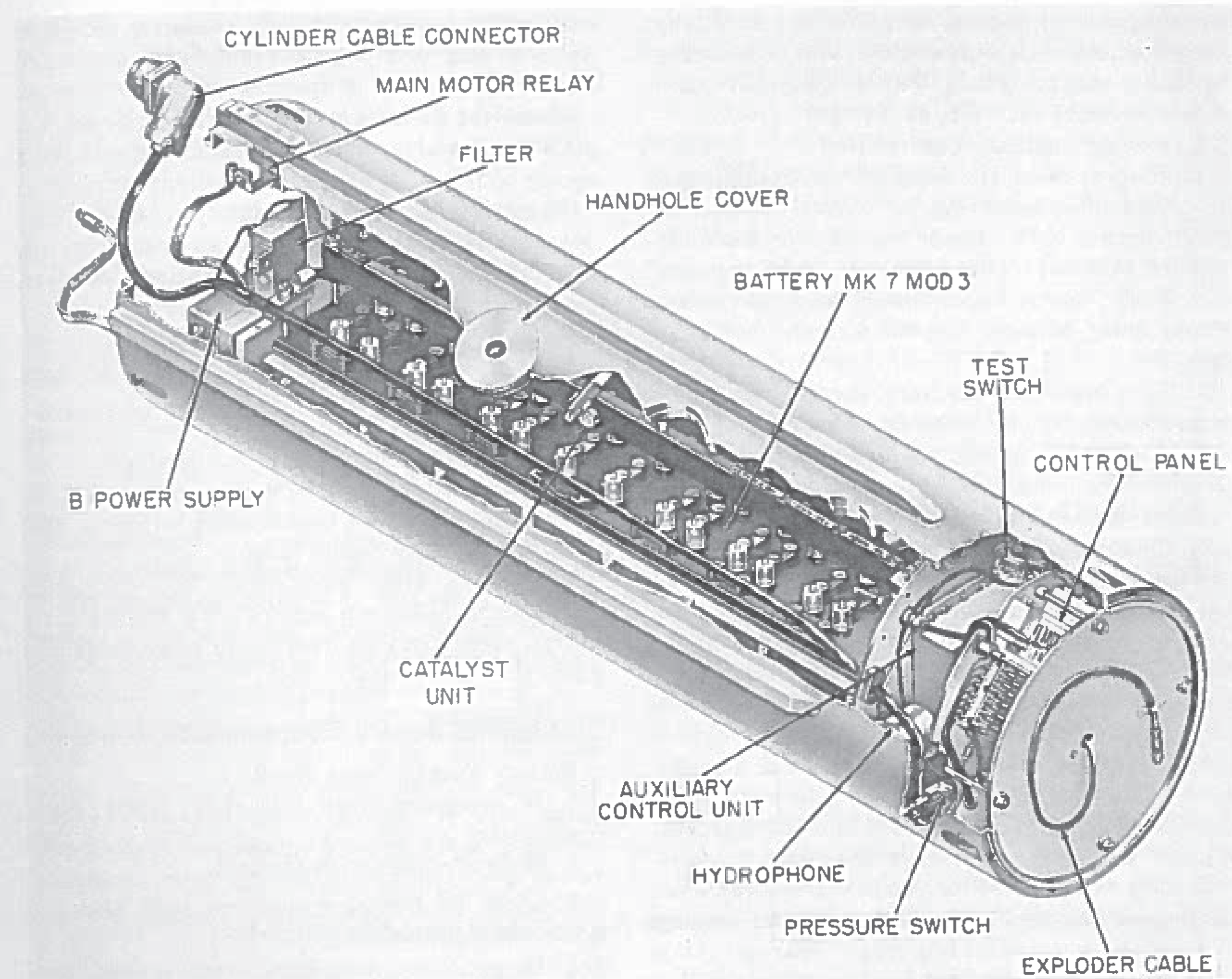

Figure 94—Battery Compartment Cutaway.

clamps. These may be reached through hand holes. To loosen bracket, turn knurled adjustment sleeve clockwise thus drawing bracket away from battery.

5. Disconnect heavy power leads from positive and negative terminals of battery and disconnect light power leads from terminal strip. (70)

6. Pull battery out of battery compartment. A battery table built to same height as track within battery compartment (when battery compartment is mounted on dolly) will facilitate this unloading procedure. Otherwise, it is necessary to slide battery slightly out of battery compartment and then support it with a sling from a hoist. Care should be taken not to over-balance battery compartment on its dolly. (85)

Removing Control Panel.

1. To expose control panel, remove wooden panel cover by taking out four mounting screws. Disengage exploder cable from clip on panel cover.

2. If panel is to be suspended from support arm, attach arm to two top battery compartment mounting holes as shown in figure 11. (55, 56, 57)

3. Disconnect four hydrophone cables from hydrophone connectors on upper portion of panel.

4. Unscrew four long hexagonal nuts holding panel to its mounting studs. Grasp handle on lower port side of panel with one hand and terminal strip support on upper starboard side with other hand and pull out panel. Use care in holding terminal strip support to avoid disturbing

connecting wires of resistors mounted at terminals. Rotate panel 45 degrees counterclockwise so that relay compartment is downward, and attach panel by its top mounting hole to stud of support arm as shown in figure 11. (55, 56, 57, 70)

Removing Auxiliary Control Unit.

1. In most cases, the auxiliary control unit may be tested after removing its cover. To remove cover, spring back clamps on edge of assembly.

2. If auxiliary control unit is to be removed completely, unscrew four hexagonal nuts (7/16-inch across flats) holding unit to forward bulkhead. (64)

3. To disconnect auxiliary control unit from control cable, unsolder all wires from control cable at F block. If this is done, tag wires to facilitate reconnection. (43)

Removing Hydrophones.

1. Remove control panel to expose hydrophones and inspect each hydrophone. Hydrophones need not be removed unless tests indicate that they are faulty. Evidence of oil around hydrophone mounting is not an indication of hydrophone deterioration as it is with some crystal hydrophones. Oil is intentionally put on the shell under hydrophone pads in order to effect a good acoustic match between hydrophones and torpedo shell. Since only a film of oil is required for this purpose, wipe off any excess oil near hydrophone.

2. If it is necessary to remove a hydrophone, remove six fillister head machine screws holding hydrophone to its mounting ring. (85)

Removing Pressure Switches.

1. First disconnect leads attached to switch by removing screws attaching soldering lugs to terminals on switch housing. (85)

2. Unscrew single pressure switch using a small pipe wrench.

3. To remove other two switches, first remove auxiliary control unit from forward bulkhead. Then unscrew switches with their pipe fittings from nipple attached to boss on battery compartment shell. (71)

Removing Test Switch.

1. Using ½-inch, open end volume control wrench, loosen nut securing switch collar to supporting yoke. Slide switch out of slot in yoke. (66)

2. To remove a defective switch for replacement, unsolder wires from switch terminals. Tag wires to facilitate reconnection.

3. If switch has been leaking, the watertight seal must be replaced. To remove old seal, unscrew plug and yoke assembly with a wrench, and pry out seal. (70)

Removing Palladium Catalyst Units. To remove palladium catalyst units, pull each unit out of its spring holder.

Removing Main Motor Relay.

1. Disconnect heavy battery leads by unscrewing hex nuts and removing lock washers. (68)

2. Unscrew nut and lock washers from terminals on front of relay and remove leads to main control cable and to capacitor. (74)

3. Remove four screws holding relay to mounting plate in top of battery compartment. (85)

4. If capacitor must be replaced, remove two screws which secure it to mounting bracket. (85)

Removing After Guide Stud.

1. Remove after guide stud by unscrewing four socket head cap screws. To facilitate removal, screws can be inserted in extra holes and guide stud pried loose. (81)

Overhaul of Battery Compartment Components

Battery Compartment Shell.

1. If necessary wash out shell, using clean, fresh water.

2. Blow shell out with air hose.

3. Clean all corroded surfaces, bare spots, or spots where varnish is chipped.

4. Hammer out any dents, using a lead hammer while a solid steel block is held against opposite side of battery compartment shell.

5. Apply one coat of touch-up paint (retouching enamel, baking, No. 19, dark green) where needed and allow to dry.

6. Inspect rubber gaskets on battery compartment mating surfaces. If gaskets are damaged or loose, remove old gasket and clean surfaces of mating ring. Then coat mating ring surface with rubber cement, covering area against which gasket will seat. Slip new gasket over mating surface until it is in place on projecting ring. Gasket should bear tightly against end of battery compartment wall and should be seated smoothly without spiraling.

B Power Supply.

1. Open B power supply by removing flat head machine screws on chassis case. Exercise care in

removing top plate and side plate of B power supply so as not to disturb wiring. Some components mounted on top plate are wired directly to components within remainder of chassis. (85)

2. Perform complete electrical tests of B power supply according to procedure given in section 11.3 of this chapter.

3. If B power supply does not satisfy requirements specified in section 11.3, locate trouble in power supply and replace defective parts. Refer to figures 97 through 101.

4. To assemble B power supply, reverse procedure of step one. (85)

Propulsion Battery. Complete information on maintenance and charging of Storage Battery Mk 7 Mod 3 and Mk 8 Mod 4 is given in chapter 13.

Control Panel. The necessity for overhaul of the control panel is dependent upon the results of the electrical tests outlined in section 11.4 of this chapter. Overhaul will usually consist of the replacement of defective parts after they have been located by trouble analysis procedures.

Whenever parts are removed or replaced, care should be taken to be sure that the original lockwashers under nuts, locking clamps, or other bracing hardware are replaced. If any panel component except a relay fails, no attempt should be made to repair the component, but it should be discarded and replaced with a new one. Complete information on the location of troubles and on the steps to be taken in eliminating them is included in section 11.4 of this chapter.

Auxiliary Control Unit. The auxiliary control unit contains a number of relays. Complete maintenance information for these relays and for the relays mounted on the control panel is given in section 11.4. For locating troubles in the auxiliary control unit, refer to figure 95.

Hydrophones. If either hydrophone of a pair is suspected of being faulty, both hydrophones of the pair should be replaced by new ones having similar characteristic sensitivity letters. The old hydrophones should be returned to stores for factory recalibration and inspection. Such hydrophones should be plainly marked with a tag indicating that they have been used and are suspected of improper operation. Faulty operation of a hydrophone usually can be detected by the failure of the control circuit to respond to rub tests.

Pressure Switches.

1. Clean pressure switches by rinsing out bellows cavity with fresh water. Coat inside of cavity with a light machine oil.

2. Adjust pressure switches to operate at air pressures of 29±3 psi for S1, and 39±3 psi for S2 and S3, increasing and decreasing. Make this adjustment by means of knurled nut on switch.

3. If a switch is found to leak or shows excessive spread between operating and release pressures, discard switch and replace it with a new assembly.

Test Switch. If the test switch proves to be defective, it should be replaced with a new assembly.

1. If a leak has occurred at test switch, pry out watertight seal within threaded boss in which switch yoke, plug, and shaft are assembled. Be careful not to damage surfaces of boss in which watertight seal is mounted.

2. After seal has been removed, clean inside of boss thoroughly, using a pocket knife or similar tool.

3. Coat lower edge of replacement watertight seal with a small bead of pipe compound (52–C–14 type A) and seat seal into boss.

4. After seating seal, remove excess pipe compound.

5. Coat seal lightly with lubricating oil, petrolatum, or silicone grease.

Palladium Catalyst Units. Replace any palladium catalyst unit in which the ceramic body is cracked.

Main Motor Relay.

1. Inspect main motor relay for damage to armature spring or deterioration of contacts.

2. Clean contacts by polishing them with fine sandpaper.

3. If armature spring is weak or damaged, replace it with a new spring.

After Guide Stud. If the after guide stud has been damaged by being bent or badly nicked, replace it with a new guide stud. Keep guide stud covered at all times with a rust-preventive grease such as Tectyle 506.

Reassembly of Components Into Battery Compartment

Replacing After Guide Stud.

1. Place guide stud in position and tap into place.

2. Secure guide stud to battery compartment by means of four socket head cap screws. (81)

Replacing Main Motor Relay.

1. Mount capacitor to flange on battery compartment with two screws and lock washers. (85)
2. With four screws, mount main motor relay to same flange with contacts of relay extending aft. (85)
3. Connect main control cable and capacitor leads on two coil terminals. Tighten leads in place with lockwashers and nuts. (74)
4. Reconnect heavy propulsion battery power cable to heavy starboard terminal stud. Tighten securely. (68)

Replacing Palladium Catalyst Units. If palladium catalyst units were removed, replace them in their spring holders. The perforated metal side of each unit should face upward.

Replacing Test Switch.

1. Resolder leads to test switch. (43)
2. Place switch in its center position.
3. Coat threaded surfaces of yoke assembly with pipe compound and screw yoke assembly tightly into boss. (70)
4. Insert shaft of assembly through yoke assembly and watertight seal.
5. To install switch, slide it into slot in yoke so that it mates with shaft.
6. Position test switch so that slots in shaft (as viewed from outside battery compartment) are approximately in line with RUN mark on outside of shell. Secure switch in this position by means of lockwasher and nut ½-inch across flats). (66)

Replacing Pressure Switches.

1. Coat threads of pipe fittings and switches with pipe compound. Assemble switches S1 and S3 with pipe fittings and then screw assembly into threaded vent boss. (71)
2. Screw switch S1 into its threaded vent boss. (71)
3. Reconnect leads to terminals on switches. (85)
4. Apply air pressure to vents and check to see that switches S1 operates at 29±3 psi and that switches S2 and S3 operate at 39±3 psi, on both increasing and decreasing pressure.

Replacing Hydrophones.

1. Before mounting a hydrophone, wipe shell area inside of ring and rubber pad on hydrophone free from dirt and foreign particles.
2. Coat shell area inside of mounting ring and rubber pad on hydrophone liberally with castor oil.
3. Hold hydrophone in position and insert screws part way. Spacing of screw holes is not uniform so that hydrophone can be mounted only in one position. (85)
4. Tighten screws evenly until there is approximately $\frac{1}{16}$-inch clearance between hydrophone mounting surface and surface of ring. Tighten screws in rotation around hydrophone, so as to keep hydrophone parallel with ring mounting surface.
5. Complete tightening using torque screwdriver, adjusted for a torque of ten inch-pounds. (90)

NOTE: It should be remembered that two hydrophones of a horizontal or vertical pair must have same sensitivity letter. However, it is not necessary for both pairs of hydrophones to have same sensitivity letter.

Replacing Auxiliary Control Unit.

1. If necessary, solder leads from main control cable to terminals on F block. (43)
2. Position auxiliary control unit over four studs on forward bulkhead.
3. Secure auxiliary control unit to studs with lockwashers and nuts. (64)
4. Replace cover and close four snap locks.

Replacing Control Panel.

1. If control panel is mounted on support arm, unscrew retaining nut, and remove panel from arm. (70)
2. Rotate panel 45 degrees clockwise, so that relay compartment is at lower left as viewed when facing forward end of battery compartment. Slide panel over mounting studs and fasten panel by means of four hexagonal nuts and lockwashers. (55, 56, 57)
3. If panel was removed completely, resolder cable wires to A and B terminal blocks. (43)
4. Remove support arm from battery compartment. (70)
5. Replace hydrophone leads to proper jacks.
6. Replace wood panel cover and secure with four mounting bolts. Insert exploder cable in cable clamps. (55, 56, 57)

Replacing Propulsion Battery.

1. Slide battery into battery compartment, taking care not to catch and break any interior wiring. Positive end of battery must be forward.

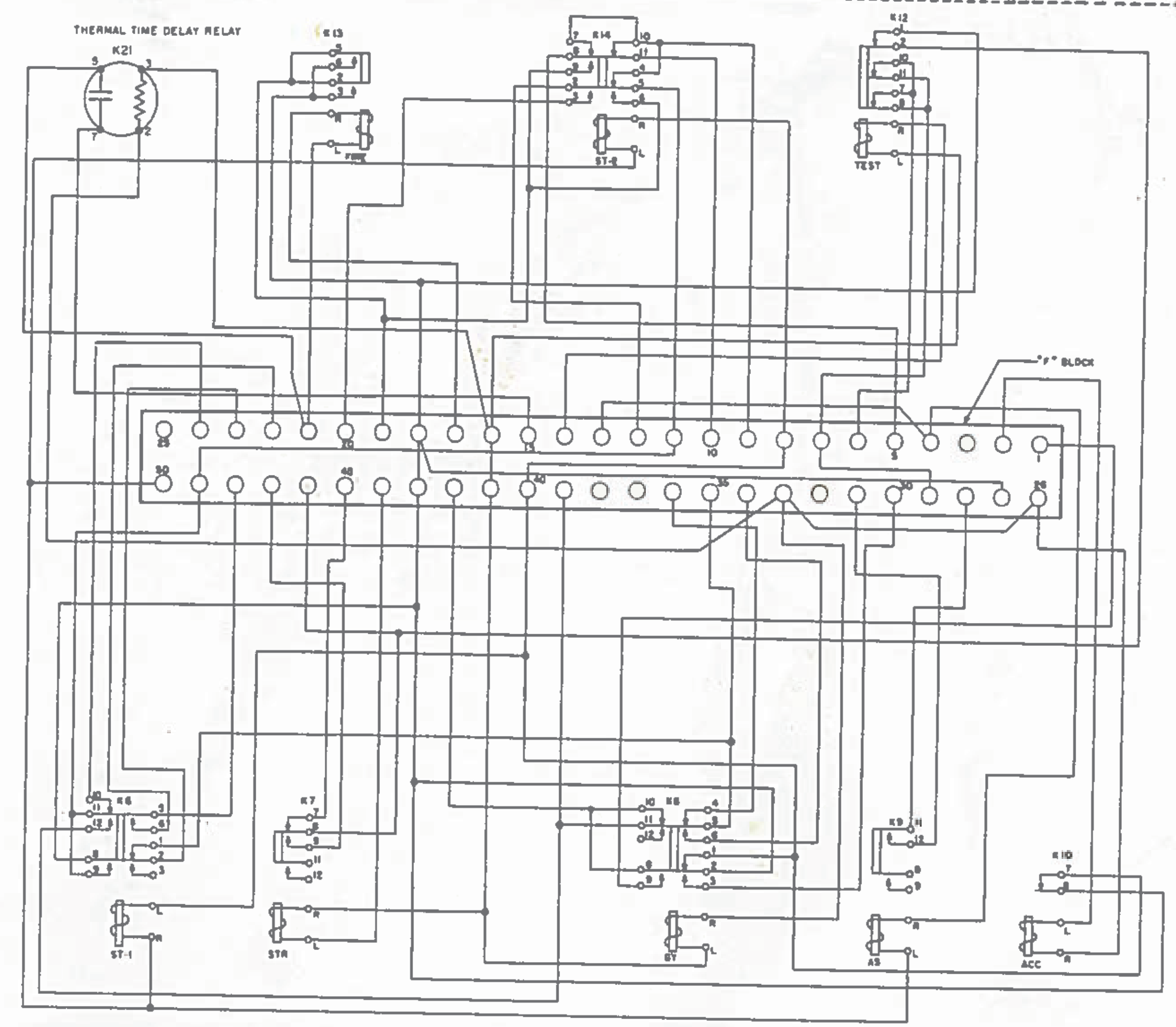

Figure 95 - Auxiliary Control Unit, Schematic.

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2. Tighten hold-down clamps by reaching through handhole. To tighten clamps, turn knurled adjustments counterclockwise. When clamps are tight, tighten hexagonal lock nuts. (70)

3. Replace battery clamp. (70)

4. Connect heavy battery leads to positive and negative battery terminals. Connect panel leads and switching power leads to terminal strip on battery. (70, 85)

Replacing B Power Supply.

1. Check gasket on after bulkhead and replace it if necessary. Fasten gasket to bulkhead with rubber cement or vulcalock cement.

2. Replace after bulkhead on its mounting studs and secure it in place with lockwashers and nuts. (75)

3. Mount B power supply in its mounting brackets. Make sure that rubber acoustic isolation material is all in place. If rubber strip is damaged, replace it and cement new strip with vulcalock cement. Make sure that no metallic contact exists between B power supply and mounting brackets. Check pad of acoustic insulating rubber on back surface of B power supply.

4. Place B power supply in its mounting bracket against afterbulkhead, positioning holes in bracket over two studs on bulkhead and two studs welded to battery compartment shell. Secure bracket in place with lockwashers and wing nuts.

Section 11.3—Electrical Tests of B Power Supply

Testing with Control Panel

The best way to test the B power supply is to measure its output voltages while it is supplying power to a control panel that is known to be in good operating condition.

To make this test, connect the B power supply to the battery compartment in the usual manner. Use a fully charged propulsion battery (or other DC source) to supply 24±2 volts between the ground strap (positive) and the −24-volt lead accessible within the aftermost handhole so that the correct voltages (including heater voltage) are furnished both to the control panel and to the B power supply.

Turn the test switch to TEST 1 position and measure the output voltages of the B power supply at the control panel terminals as indicated in table 8. Make these voltage measurements with a DC vacuum tube voltmeter having an input impedance of at least 11 megohms.

Testing with Dummy Loads

If no suitable battery compartment is available, the B power supply may be tested by connecting dummy loads across its output and measuring the output voltages when the unit is furnishing specified currents. Figure 96 shows a dummy test block suitable for making these test measurements. The voltage measurements should be made with a vacuum tube voltmeter having an input impedance of at least 11 megohms. If the B power supply is in good condition, the load voltages will be within the limits specified in the voltage column of table 9.

Table 8—B Power Supply Output Voltages

Input: 24±2 volts DC to panel terminals A2 (+) and A5 (−).

Test Terminals	Nominal Voltage	Minimum Voltage
A2 (−), A9 (+)	45	40
A2 (−), A10 (+)	150	120
A2 (−), A11 (+)	180	160
A13 (−), A14 (+)	45	40
A15 (−), A16 (+)	45	40

Table 9—B Power Supply Output Voltages to Dummy Test Block

Input to B power supply: 6 amperes at 23±1 volts DC

Test Pins	Current (ma)	Voltage
1 (−), 2 (+)	6±0.2	40 to 65
1 (−), 3 (+)	70±5.0	130 to 165
1 (−), 4 (+)	12±0.5	165 to 215
5 (−), 6 (+)	4±0.5	39 to 60
7 (−), 8 (+)	11+0.2	39 to 59

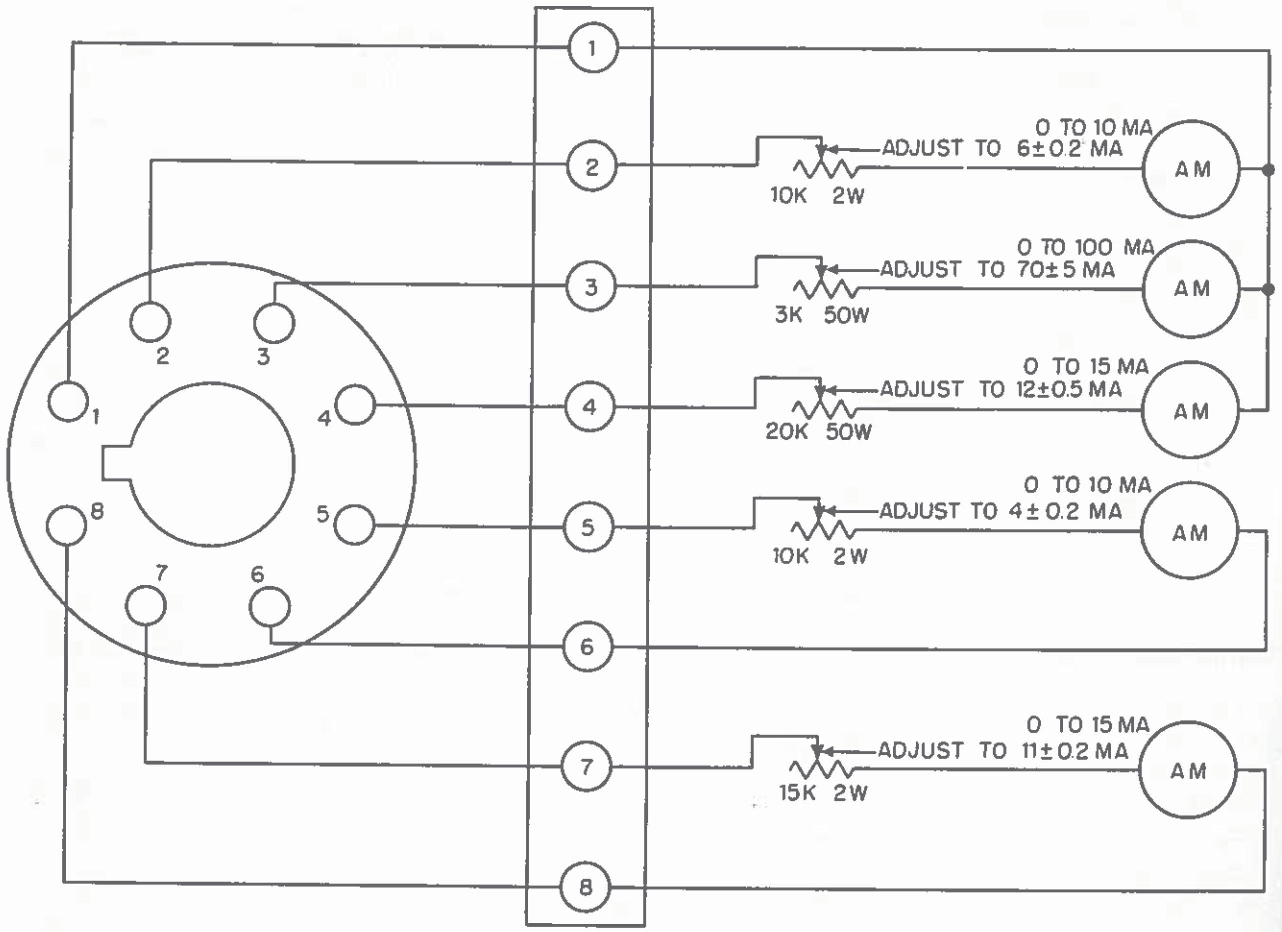

Figure 96—Dummy Test Block for B Power Supply.

Table 10 shows the approximate current drain from the B power supply under various operating conditions of the control panel.

Trouble Analysis

If the preceding tests indicate that repairs are required, trouble analysis of the B power supply is facilitated by use of the schematic diagram, figure 97. For use in tracing actual connections and for locating components refer to figures 98, 99, 100, and 101.

Table 10—Current Drain from B Power Supply

Control Panel Condition	B Power Supply Currents (ma)				
	45V Tap	150V Tap	180V Tap	Hor. Bias	Vert. Bias
K3 and K4 operated	−22	70	9	3	5
K3 and K4 unoperated	3	55	2	3	5
K3 operated, K4 unoperated	−12	65	6	3	5
K4 operated, K3 unoperated	−12	60	6	3	5

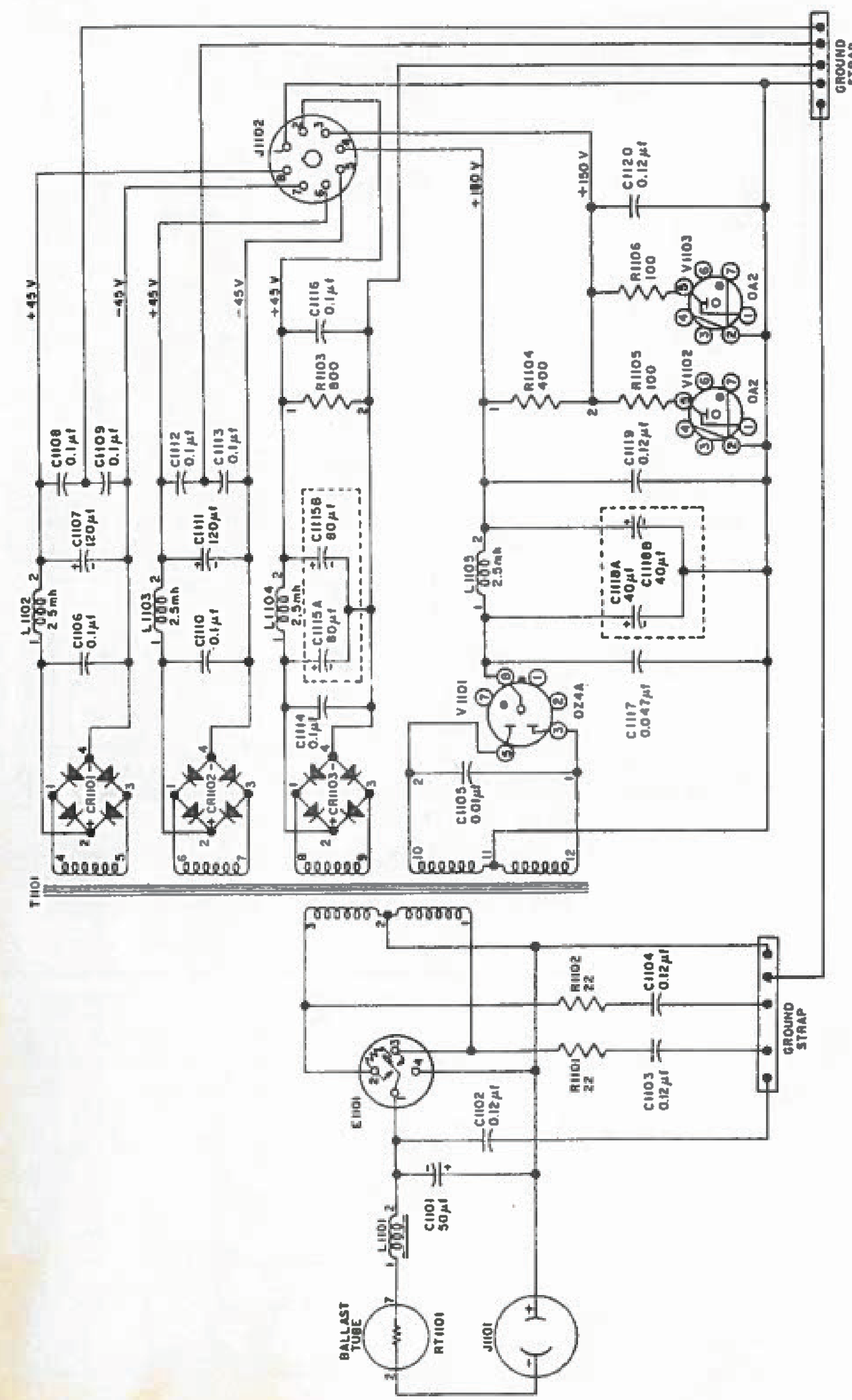

Figure 97 Mk 74 Mod 2 Power Supply, Schematic Diagram.

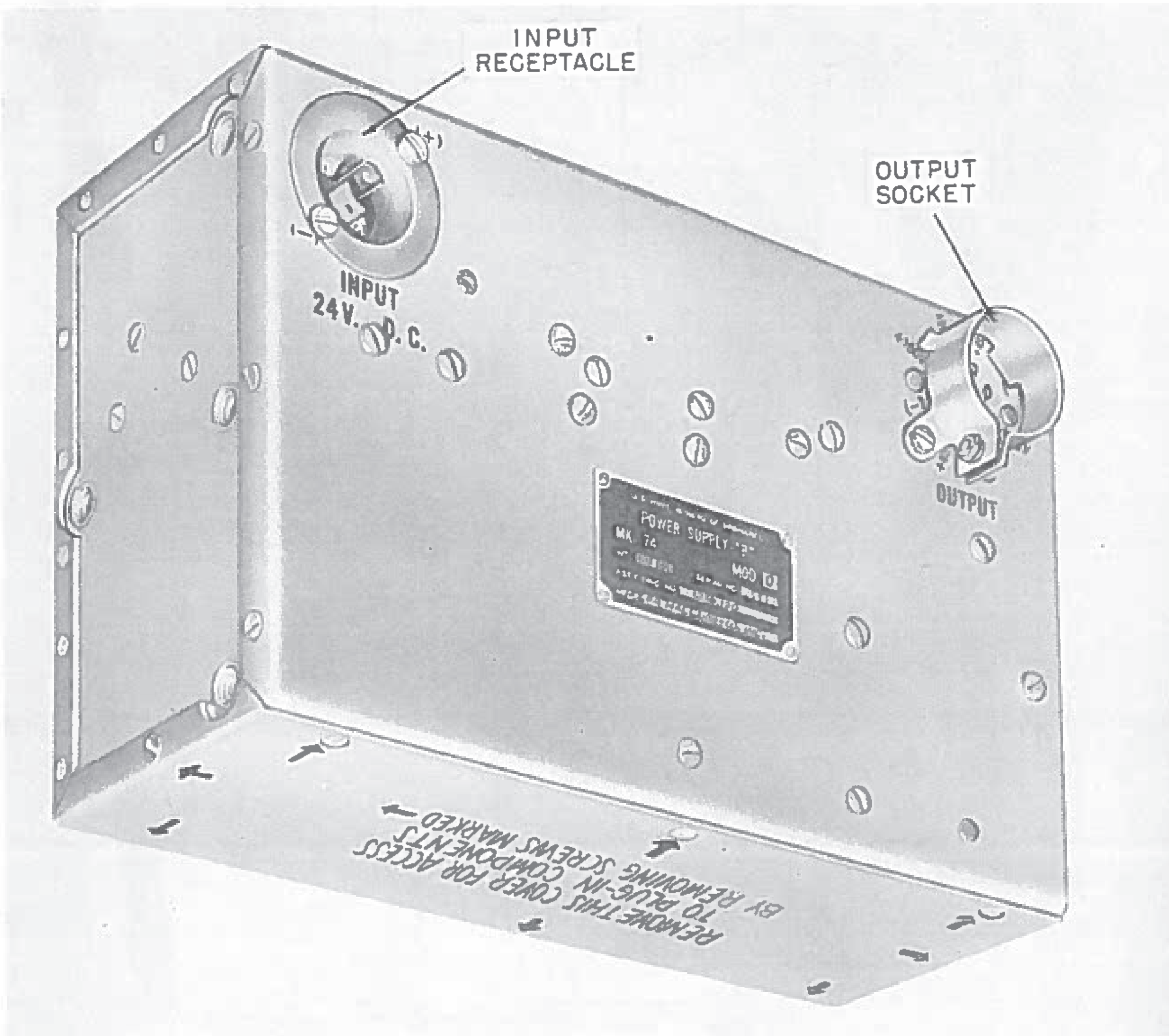

Figure 98—B Power Supply (Vibrator).

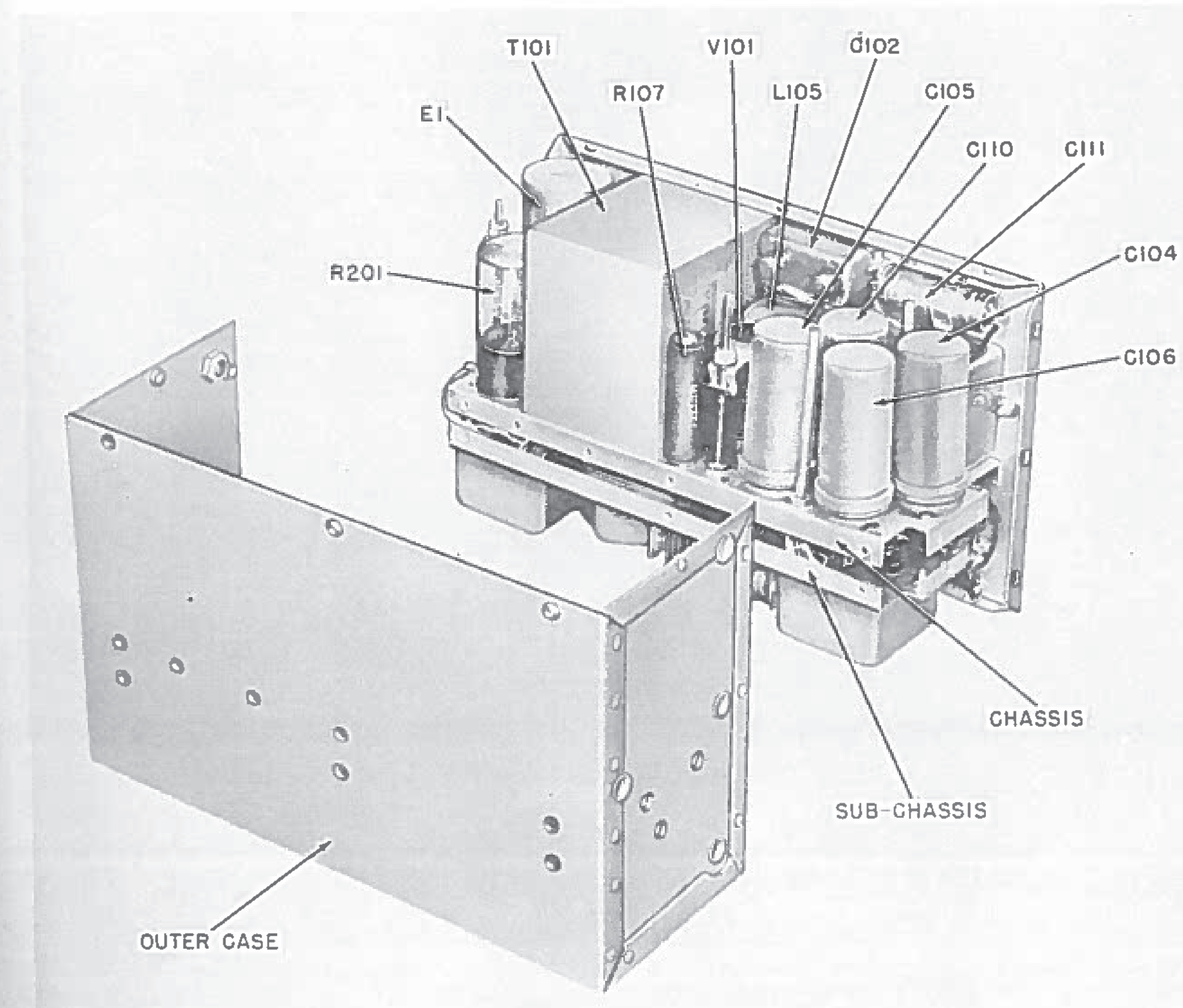

Figure 99—B Power Supply (Vibrator) Chassis.

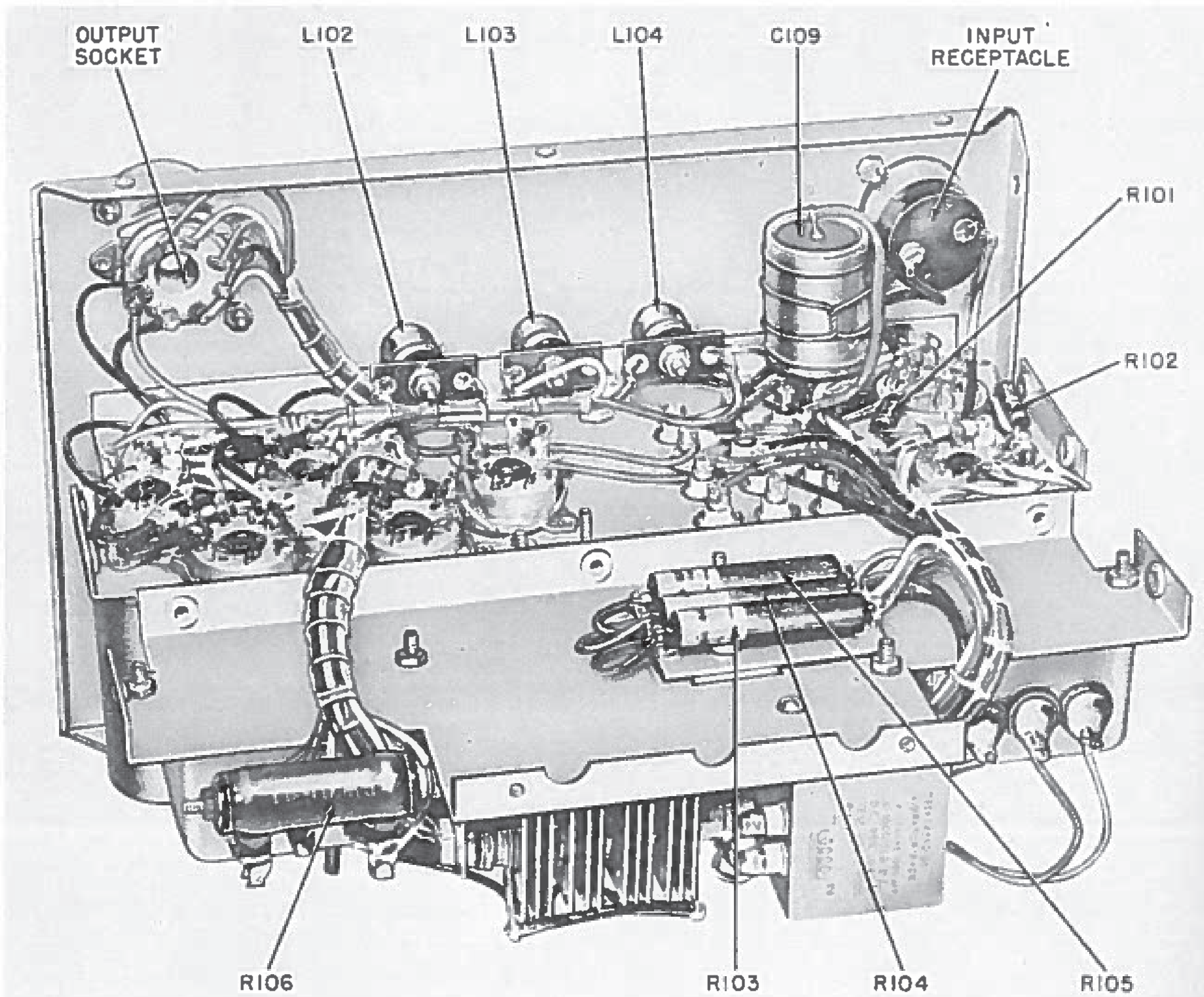

Figure 100—B Power Supply (Vibrator) Underside of Chassis and Subchassis.

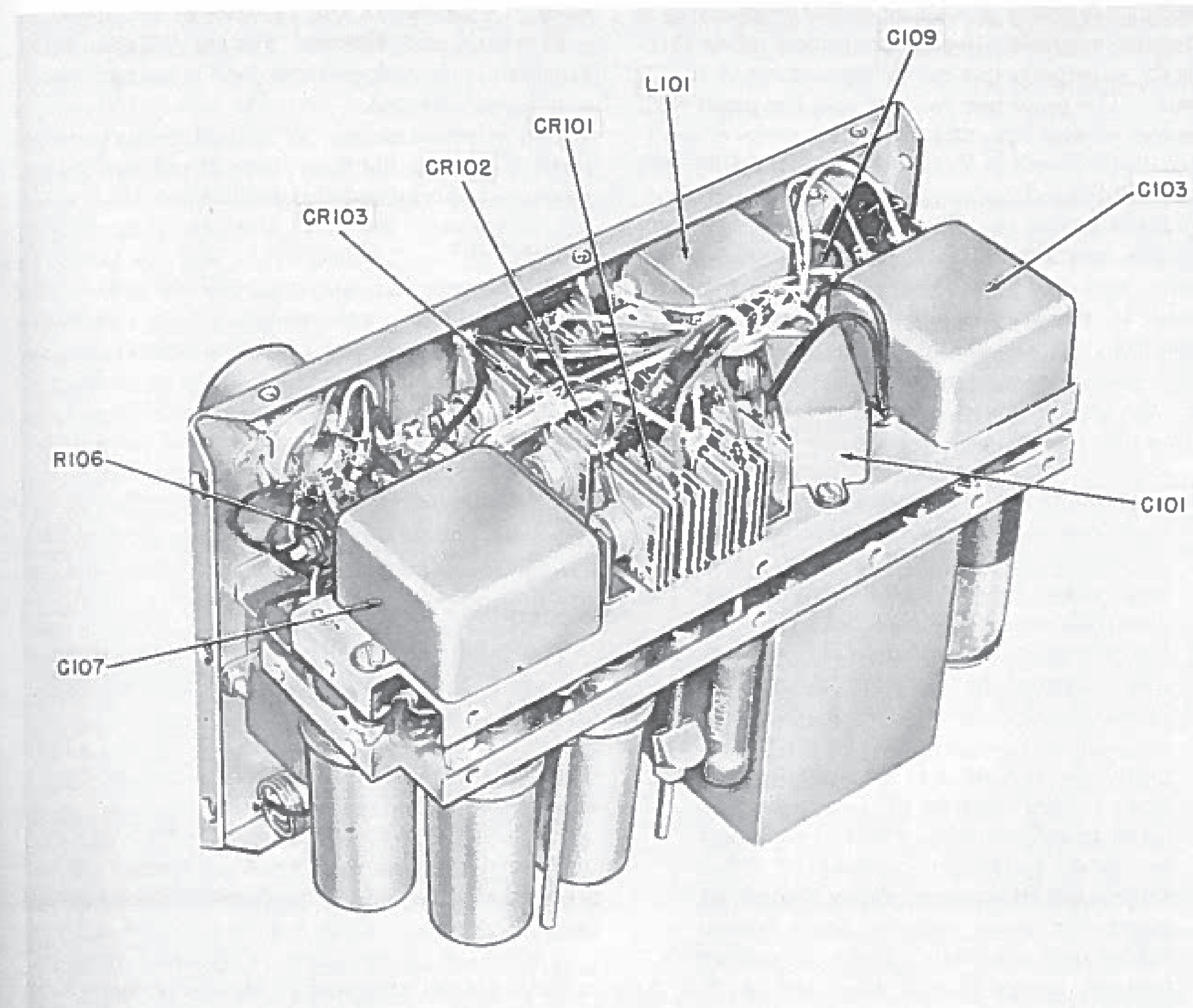

Figure 101—B Power Supply (Vibrator) Subchassis.

Section 11.4—Electrical Tests of Control Circuits

General

Torpedo Mk 27 Mod 4 is subjected to rigorous inspections and tests before it leaves the factory. It is unlikely that the control circuits will require further adjustment unless the torpedo is damaged in shipment or a failure to meet the prerun tests described in chapter 7 and chapter 8 reveals the failure of circuit components, thus making repairs necessary. The electrical tests described in the following paragraphs will facilitate locating and identifying defective parts.

The voltage tests, switching oscillator tests, and AC amplifier tests, are concerned principally with the control panel. The adjustments described are not final in all cases but may be modified by final adjustments described in connection with the over-all steering circuit tests. The latter tests are concerned with the adjustment of the complete torpedo assembly including components within both the battery compartment and the afterbody.

The detailed test instructions include sugges-tions for locating and correcting the more common sources of trouble. No effort is made to cover all possible sources of trouble since this publication is intended primarily for torpedo personnel thoroughly experienced in servicing electronic equipment. The procedure for checking the panel with the test oscilloscope, which covers a series of semi-quantitative tests of the control panel, is included as an additional technique for test, adjustment, and trouble analysis. Some experience in employing this method of testing with the aid of an oscilloscope may be necessary before the operator learns to recognize proper and improper performance. In any event, if trouble is present which cannot readily be corrected, it is advised that the control panel be removed and replaced with a new assembly.

CAUTION: The torpedo circuits contain no fuses. Hence, care must be exercised to avoid short circuits when making tests and repairs. Particular care must be taken to avoid short-circuiting the propulsion battery. The heavy power leads connecting the propulsion motor to the main motor relay should be left unconnected unless it is specifically required for the propulsion motor to operate. It is recommended that a fused source of DC power be employed if available. If it is necessary to use a propulsion battery or other source of DC power, fuses should be inserted in series with the battery leads before tests are made. Use a 15-ampere fuse in the —24-volt lead and a 5-ampere fuse in the —48-volt lead.

Test Equipment Required

The electrical tests of the control circuits require the use of the following test equipment or the specified substitute equipment:

General Purpose Test Equipment.
Signal Generator, TS–382/U
Attenuator, TG–7244
Vacuum-Tube Voltmeter, AN/USM–34
Cathode-Ray Oscilloscope, AN/OS–8( )/U
Multimeter, TS–352/U

Test Set Mk 183 Mod 0. No substitute equipment is available.

—24-volt, —48-volt DC Power Supply. Substitute Equipment may be Storage Battery Mk 7 Mod 3 or Mk 8 Mod 4 or any other available source of DC power capable of furnishing 24 volts at 15 amperes and 48 volts at 5 amperes.

Pressure and Vacuum System 794436. Any available metered pressure and vacuum source may be substituted.

For information as to the characteristics or method of operating these items of test equipment, refer to chapter 14 of this publication.

Precautions

Unless tests indicate that trouble exists, continuity tests are not necessary. If continuity tests must be made for trouble analysis purposes, use a voltohmmeter or its electrical equivalent.

CAUTION: Never use a buzzer for making continuity tests. The panel circuits include coils which may be permanently magnetized and thus rendered useless if heavy direct current passes through them.

Preparations for Tests

The following procedure is recommended for preparing the battery compartment, afterbody, and test equipment for electrical tests:

1. Place afterbody on a tilting dolly and adjust dolly until afterbody is level as determined by a spirit level placed against mating surfaces.
2. Place battery compartment on a dolly and position dolly close to the test equipment. Place afterbody dolly directly behind the battery compartment.
3. Connect large cable connector on main control cable at after end of battery compartment to receptacle on afterbody junction box. Provide a ground return connection between afterbody shell or motor frame to battery compartment shell. This may be done by means of a large clip lead. Connect octal connectors and two terminal plugs on main control cable to B power supply.
4. Remove control panel and suspend it on panel mounting bracket. Connect coaxial leads from test equipment to hydrophone connectors on control panel.
5. Connect a Workshop Fire Control Cable 794483 to afterbody cable receptacle and to large TORPEDO connector on switching panel of Test Set Mk 183 Mod 0.
6. Connect switching input cable of Test Set Mk 183 Mod 0 between the GYRO connector of electronic chassis and GYRO INTERCONNECT connector on switching panel. Attach DC Supply Cable 779103 to DC SUPPLY connector on switching panel and to a source of 24-volt and 48-volt DC power. Finally, connect torpedo power cable to small TORPEDO connector on switching panel and mount other end of cable on forward hand hole. Then connect power leads within torpedo to appropriate terminals on terminal strip at end of torpedo power cable. Connect —24-volt lead and —28-volt lead to —24-volt terminal on terminal strip. Connect —48-volt lead to —48-volt terminal on terminal strip, and connect heavy ground strap to ground terminal. The —60-volt lead on the torpedo is left disconnected for these tests.
7. Connect a metered source of compressed air to both vents on battery compartment and to DEPTH vent on afterbody. Pressure and vacuum system 794436 includes hose, fittings, meters, and pump necessary for supplying pressure during test.
8. Center rudder and elevator vanes by pushing on stubs. Set each stub wing on center mark of punched scale.
9. Remove cover from control panel relay.

Voltage Tests

Test Equipment Settings. Set general purpose equipment and Test Set Mk 183 Mod 0 in OFF position. Turn test switch to TEST 1 position.

Tests. Using DC voltmeter, measure voltages at terminal block A as indicated in table 11 with DC power source set for 24±2 volts and 48±2 volts.

Table 11—"A" Block Voltage Test

Test Terminals		Nominal Voltage	Minimum Voltage
A6 (—) and A2 (+)	Heater	24	22
A2 (—) and A9 (+)	Plate and Screen	45	40
A2 (—) and A10 (+)	Plate and Screen	150	130
A2 (—) and A11 (+)	Plate and Screen	180	165
A13 (—) and A14 (+)	Horizontal bias	45	39
A15 (—) and A16 (+)	Vertical bias	45	39

NOTE: The approximate current drains for the B power supply are shown in table 9. The negative currents in the 45-volt circuit are due to the plate currents of vacuum tubes V7 and V15.

Switching Oscillator Tests

Torpedo and Test Equipment Settings. Set Test Set Mk 183 Mod 0 and general purpose equipment in OFF position. Turn test switch to TEST 1 position.

Tests and Adjustments.

1. Connect vacuum tube voltmeter, adjusted to measure DC voltages, between ground and terminal 1 of resistance board M to measure DC bias voltage of vacuum tube V1. This voltage should be between —6.0 volts and —8.6 volts.

NOTE: A bias voltage less negative than —6.0 volts may indicate a faulty resistor or capacitor in the DC biasing circuit, consisting of resistors R20A, R20B, R19, or capacitor C9B.

2. Remove DC voltmeter probes and use AC probes at same terminals to measure AC bias voltage of vacuum tube V1. This voltage should be between 4.0 and 8.0 volts rms.

NOTE: Low AC bias voltage may indicate a faulty oscillator tube (V18). Multiplying the AC bias voltage by 1.4 should give a value approximately equal to the DC bias voltage measured in step 2.

3. If either bias voltage measured in steps 1 and 2 is outside specified limits, measure DC and AC voltages between ground and terminals M14, M3, and M16. Permissible limits in each case are same as those stated in steps 1 and 2.
4. If step 3 fails to disclose trouble, measure AC voltages between ground and terminals M9, M24, M11, and M22. In each case, measured voltage should be between 10.5 and 14.5 volts rms.
5. Connect vertial terminals of a cathode-ray oscilloscope to terminal M13 and ground. Set internal sweep of oscilloscope to a range including 225 cps. Adjust sweep to observe the wave form of oscillator output. Wave should closely approximate a sine wave.

NOTE: An unsymmetrical wave shape may indicate a defective oscillator tube.

6. Leave vertical oscilloscope terminals connected as in step 5. Turn off internal sweep and

connect an external audio oscillator to oscilloscope binding posts marked "X" AXIS AMPLIFIER or HORIZONTAL AMPLIFIER. Adjust frequency of external oscillator until pattern on oscilloscope screen is a stationary circle, ellipse, or straight line. Frequency of external oscillator is now same as that of switching oscillator, and should be between 180 and 280 cps.

NOTE: A frequency outside the acceptable limits may indicate a faulty oscillator tuning capacitor (C8 or C36.)

AC Amplifier Tests

The AC amplifier tests include four separate procedures which make up a complete test of both the horizontal and vertical AC amplifiers. These procedures are the following:

a. Measurement of frequency of maximum response (FMR) and sensitivity of horizontal channel.

b. Measurement of frequency of maximum response (FMR) and sensitivity of vertical channel.

c. Input-output voltage measurements.

d. Checking wave forms of AC amplifier output.

Torpedo and Test Equipment Settings.

1. Set Test Set Mk 183 Mod 0 to OFF position. (Torpedo may be set in any stratum condition.)

2. Connect pure tone oscillator to OSC and GND terminals of attenuator test set. Adjust oscillator to 24.5 kc and set its output to 2.0 volts rms as measured at test set terminals.

NOTE: When the oscillator output is 2.0 volts and the differential attenuator is set on zero, the setting on the input attenuator equals the voltage applied to the hydrophone simulating network in db below one volt. If the differential attenuator is at a setting different from zero, the voltage applied to the channel network to which the dial is turned is increased by one-half the differential setting, and the voltage applied to the other channel is decreased by one-half the setting.

3. Turn test switch to TEST 1 position. Check to see that voltage between terminal A2 and terminal A6 is −24±2 volts DC.

4. With test switch in TEST 1 position and no input signal applied to hydrophone simulating circuits, the voltage between terminals E–13 and ground, and E–14 and ground, shall be 10 volts or less as measured with Vacuum Tube Voltmeter AN/USM–34.

Measuring Frequency of Maximum Response (FMR) and Sensitivity of Horizontal Channels.

1. Connect one cord (J1–J3) of attenuator to jack J1 on control panel.

2. Set input attenuator at approximately −70 dbv and set differential attenuator at zero.

3. Connect AC probe of vacuum tube voltmeter between control panel terminal E13 and ground. Adjust attenuator so that voltmeter indicates approximately 15 volts, and then vary oscillator frequency on either side of 24.5 kc to obtain a maximum voltmeter reading. If necessary, adjust attenuator to keep this reading below 15 volts. With output applied to jack J1, frequency at which maximum reading is obtained is frequency of maximum response of starboard channel.

4. Remove cord (J1–J3) from jack J1, and insert cord (J2–J4) in jack J2. Repeat step 3 to determine FMR of port channel. FMR of port channel and FMR of starboard channel should both be between 23.5 kc and 25.5 kc.

5. Compute average FMR for horizontal channel by taking average of starboard and port values. These values should not differ by more than 1.0 kc, and average should be 24.5±1.0 kc. Set oscillator to this average frequency.

6. Set input attenuator at −40 dbv, and read vacuum tube voltmeter. AC output voltage of amplifier should be 29.0±5.0 volts.

7. Remove output cord (J2–J4) from jack J2, and insert output cord (J1–J3) in jack J1. Repeat step 6. AC output voltage should meet requirements of step 6.

NOTE: If amplifier fails to meet requirements of steps 5 through 7, make test given in step 8 on each amplifier channel. If amplifier meets requirements of steps 5 through 7 proceed with step 9.

8. Set attenuator to obtain a reference AC amplifier output of approximately 15 volts, making certain that oscillator is adjusted to supply 2.0 volts rms. Note attenuator setting and measure output voltage. Vary oscillator frequency by 3 kc above and below FMR, adjusting attenuator in each case so that amplifier output is again at reference value. For both amplifier channels, decrease in input attenuator setting should be between 11 db and 21 db.

NOTE: If the amplifier fails to meet these tuning requirements, the fault may be that the general purpose equipment is out of alinement (see chapter 14) or that a tuning coil or capacitor in the amplifier is defective. Incorrect voltage output when the attenuator is set at −40 dbv may be due to imporper amplifier tuning, a defective amplifier tube or AVC tube, or a leak to ground in the AVC circuit.

9. Connect both test cords of attenuator to jack J1 and jack J2 of control panel. Set oscillator output to 2.0 volts rms at average FMR, set input attenuator at −40 dbv, and set differential attenuator at 0. Output voltage of AC amplifier at terminal E13 should be 29±5.0 volts, as indicated by vacuum tube voltmeter.

10. Disconnect AC probe from terminal E13 and connect DC probe of vacuum tube voltmeter between terminal H4 and ground to measure AVC voltage. Adjust input attenuator to −110 dbv and read voltmeter. AVC voltage should be between −1.0 volts and +0.1 volts.

11. Set input attenuator at −86 dbv and decrease attenuator setting in 1 db steps until AVC voltage suddenly goes more negative by at least 0.05 volt. This setting of input attenuator is defined as the "sensitivity" or "threshold" of the horizontal channel and should be between −78 and −82 dbv.

Measuring Frequency of Maximum Response (FMR) and Sensitivity of Vertical Channel.

1. For these tests, relay K5 must be held operated. This can be done by applying air pressure (over 9 psi) to afterbody depth vent or by connecting a temporary strap between terminal B27 and ground.

2. Measure FMR and sensitivity of vertical channel in same way as previously described for horizontal channel, with the following exceptions:

Panel Jacks J3 and J4 are used.

AC amplifier output voltage is read at terminal E14.

AVC voltage is read at terminal U14.

Sensitivity of vertical channel should be between −68 dbv and −69 dbv.

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NOTE: If adjustments are necessary to obtain correct vertical channel sensitivity, change strapping on resistors R26, R46, and R53. Use very short leads to avoid making the amplifier unstable.

Input-Output Voltage Measurements.

1. With same circuit arrangement used in determining sensitivities, connect AC probe of vacuum tube voltmeter to measure output voltages of amplifiers. Make these connections between terminal E13 and ground for horizontal channel and between terminal E14 and ground for vertical channel.

2. Set signal generator on pure tone at average FMR and adjust its output to 2.0 volts, as measured with the voltmeter.

3. Vary input attenuator setting to values shown in table 12 or 13, as applicable, reading voltmeter at each setting to see whether output is within prescribed limits.

Table 12—Horizontal Channel Gain

Input Attenuator Setting	AC Output Voltage (rms)
−86	7.0 to 23.0
−76	23.0 to 32.0
−56	24.0 to 33.0
−36	25.0 to 34.0
−16	27.0 to 51.0

Table 13—Vertical Channel Gain

Input Attenuator Setting	AC Output Voltage (rms)
−74	5.5 to 21.5
−64	17.5 to 37.5
−53	23.0 to 43.0
−43	26.0 to 50.0
−28	28.0 to 58.0
−19	34.0 to 70.0

NOTE: Failure of the amplifier output to be within the required limits may indicate a defective amplifier tube or AVC tube, or leaks to ground in the AVC or detector circuit.

Waveforms of AC Amplifier Outputs.

1. Apply attenuator output to appropriate panel input jacks (horizontal channel, J1, J2; vertical channel J3, J4). Set oscillator frequency at average FMR for channel under test and set oscillator output voltage at 2.0 volts rms.

2. Set attenuator to a level of −50 dbv.

3. Connect vertical input terminals of oscilloscope between ground and AC amplifier output terminal (horizontal channel E13; vertical channel E14). Observe waveform of output on oscilloscope screen. Waveform should be similar to that shown in figure 102A. Width of intervals between pulses should be from 1/20 to 1/3 of pulse width.

4. Set differential attenuator at plus 1 db; observe change in waveform. Wave should now appear as shown in figure 102F. Change differential attenuator setting to minus 1 db. Wave should change to the type shown in figure 102G.

NOTE: Failure to obtain a distinctive pulse pattern may indicate an oscillating amplifier. If the spaces between pulses are too short or too long, or if the pulses overlap, the DC bias voltages on vacuum tubes V1 and V2 (or vacuum tubes V9 and V10) may be faulty. Failure of the pulse heights to change properly may indicate a faulty AVC circuit. If a faulty AC amplifier is suspected, measure the sensitivity as previously explained.

Detector, Bridge, and DC Amplifier Tests

Balance of Bridge and DC Amplifier Tests.

Torpedo and Test Equipment Settings.

1. Turn Test Set Mk 183 Mod 0 to STANDBY and set stratum control for AL condition. Turn off Test Set Mk 183 Mod 0.

2. Disconnect attenuator test cables from panel input jack.

3. Turn test switch to TEST 1 position.

4. Measure voltage between terminals A2 (+) and A6 (−). This should be 24±2 volts DC.

Tests and Adjustments.

1. With rudder manually set so that stub is at zero degrees, DC voltage measured between terminals B1 and B8 should agree within 2 volts with voltage measured between terminals B2 and B8. This voltage must be of opposite polarity and must be approximately 8 volts.

2. With afterbody level, apply a pressure of 31 psi to vents, and set elevators manually so that stubs are at zero degrees. DC voltage measured between terminals B3 and B12 should agree within 2 volts with voltage measured between terminals B4 and B12. This voltage must be of opposite polarity and must be approximately 20 volts.

NOTE: If the voltage difference between the two halves of either potentiometer exceeds the specified limit, align the potentiometer as explained in chapter 10.

3. With after body level, measure DC voltage between terminals B3 and B22 and DC voltage between B4 and B22. Measured values must agree within 2 volts. These voltages must be of opposite polarity and must be approximately 20 volts. If necessary, adjust potentiometer BR located on after body junction box to obtain values within specified limits. After potentiometer BR has been adjusted, tighten lock nut.

4. Measure voltage between terminals B3 and B18 and voltage between terminals B4 and B18. These voltages must agree within 2 volts and be of opposite polarity when pressure applied to vents is 31±2 psi.

5. Turn on Test Set Mk 183 Mod 0 and change stratum setting to BL. Repeat measurement of step 4. Voltages should now agree within 2 volts at a pressure of 55±5 psi. Change stratum setting back to AL.

6. Set rudder vane and elevator vanes so that stubs are at zero degrees to center followup potentiometers. Set depth and pendulum potentiometers at their midpositions. Connect DC voltmeter leads to measure grid to ground voltage of DC amplifier tubes (horizontal channel, terminal H6 to ground; vertical channel, terminal U16 to ground). Adjust balancing potentiometers (horizontal, P3; vertical, P4) until steering relays (horizontal, K3; vertical, K4) are just operated. When this adjustment has been made, grid to ground voltage of DC amplifier tubes should be between −1.0 and +0.3 volts DC.

NOTE: Failure of a DC amplifier to meet the specified voltage requirements may be due to inaccurate centering of the related followup potentiometer, incorrect biasing voltages from the heater or B voltage compensating resistors, faulty detector tube, or faulty DC amplifier tubes. If the steering relay will not operate or release at some voltage within the stated limit, the trouble is probably in the DC amplifier or in the relay. If the DC amplifier is suspected of being faulty, perform step 7.

7. With no signal input to control panel, and with DC amplifier grid (terminal H6 or U16) grounded to panel, measure voltage between ground and each tube socket terminal of DC amplifier tubes (horizontal, V6 and V7; vertical, V14 and V15) using DC leads of the vacuum tube voltmeter. These voltages should agree approximately with values in table 16 given in section 11.5. Remove ground connection from DC amplifier grid terminal and apply to input of faulty channel a pure tone signal of approximately −40 dbv at average FMR of channel. Connect DC leads of vacuum tube voltmeter between ground and pin 8 of second DC amplifier tube (horizontal, V7; vertical, V15). Vary differential attenuator over its entire range, and note voltage variation indicated by voltmeter. Voltage should vary over a range extending at least from 90 to 120 volts.

NOTE: Failure of the DC amplifier to meet this requirement may be due to a defective vacuum tube or trouble in associated circuits. If the voltage varies properly but the steering relay fails to release over this range, the relay is probably out of adjustment. (Refer to relay maintenance instructions in this section.)

Tests of Horizontal Steering Circuit.

Torpedo and Test Equipment Settings.

1. Set rudder vane to center position.

2. Set stratum control for AL condition.

3. Connect attenuator cables to panel jacks J1 and J2.

4. Turn test switch to TEST 1 position.

5. Measure voltage between terminals A2 (+) and A6 (−). This should be 24±2 volts DC.

Tests and Adjustments.

1. With no input to panel (attenuator at −110 dbv, or preferably, terminal H15 grounded by a lead as short as possible), adjust potentiometer P3 until steering relay K3 just operates.

2. If terminal H15 was grounded in step 1, remove ground connection. Apply to panel jack J1 and J2 a pure tone signal of approximately −60 dbv at average FMR of horizontal channel.

3. Set differential attenuator at zero and adjust potentiometer P1 until relay K3 just operates.

4. Connect cathode-ray oscilloscope between terminal E13 and ground, and observe waveform of output pulses. Pulses must be of equal height.

NOTE: A failure to meet this condition may indicate a faulty detector tube V5, a faulty DC amplifier, incorrect adjustment of the rudder follow-up potentiometer, or a faulty bridge circuit.

Tests of Vertical Steering Circuit.

Torpedo and Test Equipment Settings.

1. Turn Test Set Mk 183 Mod 0 to STANDBY and set torpedo in AL stratum condition. Turn off test set.

2. Connect attenuator cables to panel input jacks J3 and J4.

3. Manually set elevator vane at center position by pushing on stub shaft wings and check to see that the elevator followup potentiometer is electrically centered.

4. Check to see that pendulum potentiometer is electrically centered.

5. Apply air pressure of 31±2 psi to vents.

6. Turn test switch to TEST 1 position.

Tests and Adjustments.

1. With no input to the panel (terminal U5 grounded with a lead as short as possible), adjust potentiometer P4 until steering relay K4 just operates. Strap terminal B6 to terminal B14.

2. Remove ground connection from terminal U5. Apply a pure tone signal of about −60 dbv at average FMR of panel to panel jacks J3 and J4. Set differential attenuator on zero and then adjust potentiometer P2 until steering relay K4 just operates.

3. Connect cathode-ray oscilloscope between terminal E14 and ground and observe waveforms of vertical amplifier output. Pulses should be of equal height. Remove strap between terminals B6 and B14.

NOTE: A failure to meet the specified condition may be due to a fault in the detector tube V13, DC amplifier, AC amplifier, or bridge circuit.

Tests of Differential Sensitivities.

Torpedo and Test Equipment Settings. Make all the settings required for the preceding tests of the horizontal steering circuit and vertical steering circuit.

TESTS AND ADJUSTMENTS.

1. Apply a pure tone signal at average FMR of channel to be tested to input jacks of channel (horizontal, J1 and J2; vertical, J3 and J4). Set input attenuator at −46 dbv and set differential attenuator at zero.

2. Vary differential attenuator setting, noting difference in its setting between operation and release of associated steering relay (horizontal, K3; vertical, K4). Repeat this procedure with input attenuator set at −60 dbv and −70 dbv. At each input attenuator setting, difference in differential attenuator settings between the operation and release of steering relay should be no more than 0.3 db. However, with input attenuator settings of −60 dbv and −70 dbv, difference in settings for operation and release of relays may be as great as 1.0 db, without any noticeable reduction in performance.

> NOTE: If the differential sensitivity fails to meet requirements, the steering relay may require adjustment, or the DC amplifier may be faulty.

Test of Vertical Acoustic Trigger Circuit.

TORPEDO AND TEST EQUIPMENT SETTINGS.

1. Turn Test Set Mk 183 Mod 0 to STANDBY and set torpedo in AL stratum condition. Turn off test set.

2. Connect attenuator to panel input jack J4.

3. Manually center elevator vanes by pushing on the stub shaft wings.

4. See that elevator followup and pendulum potentiometers are electrically centered. Apply air pressure of 31±1 psi to vents.

5. Set test switch to TEST 1 position.

TESTS AND ADJUSTMENTS.

1. Apply a pure tone signal at average FMR to jack. Set input attenuator to −70 dbv with zero differential.

2. Connect DC voltmeter between terminals U6 and U16.

3. Increase output of attenuator in 1 db steps until there is a sudden increase in voltage indicated on voltmeter. (This increase occurs when relay K2 releases.) Signal level at release of relay K2 (trigger level) must be 66±2 db.

Over-All Steering Circuit Tests

Rudder Limit Cut-off.

1. Set test switch to RUN position.

2. Manually operate gyro relay K8.

3. Manually operate rudder first to port and then to starboard until an ohmmeter (set to a low scale) connected between terminals F39 and F42 in auxiliary control unit indicates an open circuit. Note angle of rudder at which open circuit appears. (Limits: 16±2.5 degrees port or starboard.)

Depth Stiffness. Depth stiffness is defined as the number of degrees of elevator deflection caused by a change of one psi in the pressure applied to the depth vent. Check the depth stiffness as follows:

1. Set torpedo in AL stratum condition with afterbody level.

2. Turn test switch to TEST 2 position.

3. Apply pressure of approximately 31 psi to vents. Vary pressure until elevators oscillate about zero position. (No input should be applied to the input jacks.)

4. Increase pressure applied by 6 psi. Elevators should assume an average position of 7 to 10 degrees up.

5. Decrease pressure to 6 psi below pressure determined in step 3. Elevators should assume an average position 7 to 10 degrees down.

6. Adjust potentiometer DR (counterclockwise for increasing stiffness) until conditions of steps 4 and 5 are met. (Limit: 1.3 to 1.7 degrees per psi.)

Pendulum Stiffness. Pendulum stiffness is defined as the number of degrees of elevator deflection caused by a tilt of one degree. Check the pendulum stiffness as follows:

1. Turn Test Set Mk 183 Mod 0 to STANDBY and set stratum switch to BL. Turn off test set.

2. Apply a pressure of approximately 55 psi to vents.

3. Tilt after end of afterbody 5±0.5 degrees up. Elevators should assume a position of 7.5 ±1 degrees up. Adjust potentiometer PR (R120) and afterbody junction box to meet this requirement. After adjustment, lock potentiometer.

4. Apply leveling pressure to depth vent (approximately 55 psi). Tilt forward end of afterbody up and then down, in each case noting tilt angle from zero degrees and corresponding

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Gating

6. If desirable to perform the time delay test, the following should be done: Connect -24 volts DC from external supply to main motor relay, and connect heavy power cable on main motor to other side of main motor relay (MMR). Attach positive lead from external power supply to main motor case.

7. Set test switch to RUN position. Relatch gyro. Turn Test Set Mk 183 Mod 0 to STAND BY, and set stratum switch to AL. Set gyro to 0 degrees, and enabler to 1,000 yards. Apply leveling pressure to depth vents and S2 stratum switch.

8. Apply a pure tone signal at average FMR to J3 and J4 at a level of -60 dbv with 3 dbv differential (down channel).

9. After 30 seconds on STAND BY, turn Test Set Mk 183 Mod 0 to ON, and operate fire switch. Turn Test Switch Mk 183 Mod 0 to OFF.

10. Measure the voltage between D15 and ground; this should be 24 ± 2 volts. When torpedo enables, the DC voltage at D15 will disappear. A time delay of 15 ± 5 seconds will occur from No Voltage until the operation of the K2 relay accompanied by a down position of the elevators.

elevator deflection. Compute pendulum stiffness by dividing elevator deflections by tilt angles. Pendulum stiffness should be approximately 1.3 to 1.7 degrees per degree.

Gating. Gating is defined as the transfer to full acoustic control. This occurs when the acoustic signal is large enough to remove the depth and pendulum controls from vertical steering. Gating can only occur when the torpedo is in BL or NL stratum condition, and then can occur only below a depth of 85 feet. The release of relay K2 removes depth and pendulum control below 85 feet. Gating level may be determined as follows:

1. Connect attenuator to input jacks J3 and J4.
2. Turn test switch to TEST 1 position.
3. Apply a pure tone signal at average FMR for vertical channel at a level of −70 dbv. Set differential attenuator to zero.
4. Apply a pressure greater than 41 psi to depth vent.
5. Increase output of attenuator in 1 db steps until relay K2 releases. Signal level at which relay K2 releases is defined as gating level. (Limit: −66±2 dbv.)
6. Apply a pure tone signal at the average FMR for the vertical channel at a level of −60 dbv. Turn test switch to TEST 2 position for several seconds. Turn test switch back to TEST 1 position. A delay of 15±2 seconds should occur between operation of the test switch and operation of relay K2.

Final Horizontal Circuit Adjustments.

1. Disconnect hydrophones and connect attenuator cables to panel input jacks J1 and J2.
2. Turn test switch to TEST 2 position.
3. With no input to panel (terminal H15 grounded by a lead as short as possible) adjust potentiometer P3 until rudder assumes a position of 0 ±3 degrees.
4. Disconnect terminal H15 from ground. Apply a pure tone signal at average FMR for horizontal channel at a level of approximately −60 dbv to panel jacks J1 and J2.
5. Set differential attenuator at zero and adjust potentiometer P1 until rudder is at 0±3 degrees.
6. Apply noise at a level of −40 dbv and make a final adjustment of potentiometer P1 so that rudder is at 0±3 degrees when differential attenuator is set at zero. Lock potentiometer P1 in this position.
7. Set test switch to RUN position (be sure gyro is caged). Set Test Set Mk 183 Mod 0 to STANDBY and set enabler to ~~1000~~ 0 yards. Set test set to ON and operate FIRE switch.
8. Swing afterbody to port. Rudder should move to port. Swing afterbody to starboard. Rudder should move to starboard. Adjust potentiometer P3 to produce equal port and starboard rudder angles. (Limit: 8±2 degrees.)
9. Disconnect −24-volt lead from power source to stop torpedo.
10. Relatch gyro and set enabler to zero yards. Set Test Set Mk 183 Mod 0 to STANDBY for 30 seconds. Reconnect −24 volt lead to power source.
11. Set test set to ON and operate FIRE switch. Rudder should assume a position 2 to 7 degrees port with no signal applied. Lock potentiometer P3 in this position.

Final Vertical Circuit Adjustments.

1. Using Test Set Mk 183 Mod 0, set torpedo in AL stratum condition.
2. Connect attenuator to panel jacks J3 and J4. Turn test switch to TEST 2 position.
3. With no input to panel (terminal U5 grounded with a lead as short as possible), with a pressure of 31±1 psi applied to vent, and with afterbody level (±1 degree), adjust potentiometer P4 until elevators assume an angle of 0±3 degrees. Lock potentiometer P4 in this position.
4. Disconnect terminal U5 from ground. Apply a pure tone signal at average FMR for vertical channel at a level of approximately −60 dbv to input jacks J3 and J4. Set differential attenuator at zero and adjust potentiometer P2 until elevators assume a position of 0±3 degrees.
5. Apply noise at a level of −40 dbv to panel input jacks J3 and J4 and make a final adjustment of potentiometer P2 until elevators are at 0±3 degrees when differential attenuator is set at zero. Lock potentiometer P2.
6. Turn test switch to RUN position. Turn Test Set Mk 183 Mod 0 to BL stratum position. Set enabler to zero yards. With no input to panel, turn Test Set Mk 183 Mod 0 on and operate fire switch. Adjust pressure applied to vent until elevators are level. Pressure should be 55±5 psi.

Repeat this measurement with torpedo in NL stratum condition.

Tests of Ceiling Switch.

1. Set torpedo in AL stratum condition, disconnect —24 volt lead to torpedo and set enabler to zero yards.

2. Reconnect —24 volt lead to torpedo. Level afterbody and apply leveling pressure (31±2 psi) to vents.

3. Apply noise at a level of —40 dbv to panel input jacks J3 and J4 and set differential attenuator at zero.

4. Remove lead from terminal E18–1 on afterbody junction box.

5. Turn test switch to TEST 2 position.

6. Increase up differential until elevators are level. Record differential. (Limit: 10±2 db.) Replace lead on terminal E18–1.

7. Change up differential to 5 db. Slowly lower pressure applied to vents and note pressure when elevators suddenly swing down due to operation of ceiling switch. (Limit: 14±3 psi.) Set test switch back to RUN position.

4. At 39±3 psi, the 24-volt DC supply to exploder plug P5 should be disconnected. This voltage should reappear at the plug at all pressures less than 36 psi.

Below-Limit Condition.

1. Turn Test Set Mk 183 Mod 0 to STANDBY, set stratum selector to BELOW LIMIT, and latch gyro. Turn off —24 volts DC warmup power on test set and set enabler to —100 yards (—11 degrees). Turn off HIGH VOLTAGE switch on test set power supply, and turn —24 volts DC warm-up power back on. After test set has been on STANDBY for 30 seconds, turn test set to ON and operate firing switch. Turn off test set.

2. With no input to panel input jacks J3 and J4, pressure required to level elevators should be 55±5 psi.

3. Apply a noise input of —50 dbv and decrease pressure applied to vents. At pressures lower than 29±2 psi there should be no rudder or elevator response.

4. Set pressure at 40 psi and apply a noise ... J4.

Test and Adjustment of Thermal Time Delay Relay K21.

1. Place the torpedo Mk 27 Mod 4 Test Switch to the RUN position.

2. Latch the gyro.

3. Place the OFF-STBY-ON switch on the Test Set Mk 183 Mod 0 to the STBY position.

4. Place the GYRO ANGLE-ENABLING RANGE Switch on the Test Set Mk 183 Mod 0 to the ENABLING RANGE position and set the enabler to a range of + 1,000 yards.

5. Place the OFF-STBY-ON switch on the Test Set Mk 183 Mod 0 to the OFF position. Allow the THERMAL TIME DELAY RELAY (K21) to cool for approximately 5 minutes before proceeding with step 6.

6. Place the OFF-STBY-ON switch on the Test Set Mk 183 Mod 0 directly to the ON position, and at the same instant operate a stop watch.

7. Within a few seconds after placing the OFF-STBY-ON switch to the ON position, operate the FIRE switch on the Test Set Mk 183 Mod 0.

NOTE: The torpedo will not fire immediately because the normally open contact of the DELAY RELAY (K21) has not closed to complete the circuit to the FIRE RELAY (K13). The DELAY RELAY (K21) will operate and close its contact in approximately 15 seconds after warm up voltage was applied.

8. When the torpedo fires, note the time that has elapsed from the instant the OFF-STBY-ON switch was turned to the ON position until the torpedo fires. This time should be 15 ± 3 seconds.

NOTE: If K21 does not operate within 15 ± 3 seconds with 24 V D.C. warm-up voltage applied, reset K21 by turning adjusting screw on top of relay IN to shorten time or OUT to lengthen time. Allow 5 minutes cooling period between each test.

3. Decrease pressure on vents from 55 psi until relay K2 operates. Pressure at which relay K2 operates should be equal to or less than 29 ±3 psi.

4. Twenty-four volts should be present on exploder plug P5 at all pressures applied to vents.

Adjustment and Replacement of Relays

There are slight differences between the individual relays of the torpedo, but the procedure for checking and adjusting them is the same in all cases. Adjustments of the relays are made by changing the tensions of the various springs, and by varying the armature air gaps, contact separation, and spring follow-ups. The "unoperated" air gap is adjusted by bending the armature stops. The "operated" air gap is adjusted by means of the residual-air-gap adjusting screw, where this screw is provided. The contact separations and spring follow-ups are adjusted by positioning the springs.

Burnishing Contacts. If relay contact trouble is suspected, clean the contacts with the burnishing tool (Tool 42). To clean the contacts, first insert the burnishing blade between a pair of normally open contacts, and then manually operate the relay by pressure on the armature. A few short strokes of the burnishing blade will remove any foreign matter from the contact surfaces. To clean normally closed contacts, manually operate the relay and then insert the burnishing blade between a pair of contacts. Release the armature, and then clean the contacts with a few short strokes of the blade.

> NOTE: When operating a relay manually, be careful not to disturb the wiring in the vicinity of the armature. If it is found that the wiring interferes with free movement of the armature, carefully bend the wiring out of the way without straining any of the soldered connections.
>
> Keep the burnishing tool blade clean. If dirt or grease accumulates on the blade, wipe it clean with a lint-free cloth dampened with carbon tetrachloride. After wiping, flush the blade with carbon tetrachloride and permit it to dry without further wiping.

Visual Inspection. Careful visual inspection of the relays will usually show whether they are in good mechanical condition. Each relay should meet the following requirements:

1. When operated manually, the armature should move freely and without binding.

2. On relays in which the contact spring nearest the winding is a back contact, the armature studs should not touch the armature spring when the relay is unoperated.

3. On relays in which the first spring is an armature spring, it should have sufficient tension to make the armature rest against the armature stop.

4. The residual-air-gap adjusting screw (when present) should be tightly secured in place by its lock nut.

5. All contact springs should be lined up uniformly, both with respect to each other and with respect to the relay structure. When the contacts are closed, no pair should be out of line by more than ⅓ its diameter.

6. When the relay is operated manually, all "break" contacts should open at approximately the same time, and all "make" contacts should close at approximately the same time.

7. On "break-make" contact spring combinations, the contact separations and follow-up should be such that the "break" contact opens before the "make" contact closes.

8. On relays having more than one set of "break" contacts, all contact springs should have approximately the same tension.

9. All contact springs should be adjusted so that they have no sharp bends or kinks, and so that none are bowed or subjected to excessive tension.

10. The electrical connections of the relay winding should be securely soldered to the relay terminals.

Electrical Inspection. If visual inspection shows that the electrical connections to the relay winding are in good condition, but the relay does not operate properly, check the continuity of the winding and measure its resistance with an ohmmeter. Table 14 gives the winding resistance of each relay and lists convenient terminals for checking the resistance. If the resistance check shows the winding to be neither open nor short-circuited, measure the current at which the relay operates and releases and adjust the relay as necessary. To do this, proceed as follows:

1. Set test switch at RUN and disconnect ground return of external battery, thus disconnecting power from the panel.

2. Connect an analyzer, arranged for voltage measurement, across terminals shown in table 14.

3. Vary setting of rheostat until relay just operates and record voltage drop across winding.

4. Vary setting of rheostat until relay just releases and record voltage drop across winding.

5. For values recorded in steps 3 and 4, divide voltage by resistance of winding to obtain current required to operate relay and release relay.

6. If current is not as specified, adjust relay to obtain required operating and release voltages. This is done by changing spring tension and air gaps. To adjust spring tension, use spring bender (Tool 41). With spring bender, grasp spring near its base and bend it slightly, being careful not to kink spring or bend it excessively. Increasing spring tension raises operating voltage. Adjust unoperated air gap by bending armature stops and adjust operated air gap by means of residual-air-gap adjusting screw. Increasing unoperated air gap or increasing operated air gap raises operating voltage. Several adjustments of spring tension and air gap may be required because a change made to one may necessitate a change in the others.

7. If a relay can not be adjusted to meet requirements, replace entire relay. Unsolder and tag wires connected to relay, remove mounting screws, and pull relay off its mounting to gain access to its winding terminals. Unsolder and tag wires connected to winding terminals and remove relay. Connect new relay and perform steps 2 through 5. If necessary, adjust new relay

Table 14—Relay Test Data

Relay	Winding Resistance (ohms)	Test Terminals	Operating Current (ma)	Release Current (ma)
K1	5800±10%	Pin 2 of V17 and M7 (+)	4.2 max. 4.0 min.	3.4 max. 3.2 min.
K2	5800±10%	Pin 5 of V17 and M7 (+)	4.2 max. 4.0 min.	3.4 max. 3.2 min.
K3	5800±10%	Pin 8 of V7 and M7 (+)	4.2 max. 4.0 min.	3.4 max. 3.2 min.
K4	5800±10%	Pin 8 of V15 and M7 (+)	4.2 max. 4.0 min.	3.4 max. 3.2 min.
K5	300±5%		72	51
K6	500		33	25
K7	500		20	16
K8	500		33	25
K9	500	F4 and F50 (+)	20	16
K10	500		33	25
K12	500±5%	F14 and F41 (+)	30	25
K14	230±8%		83	52
K15	300±5%		47	34
K16	300±5%		47	34
K18	300±5%		72	51
K19	300±5%		72	51

NOTE: For those relays where test terminals are not listed there are conditions when other circuits might be in parallel with the coil. A positive check of the coil should be made by unsoldering one winding terminal. Relay K13 is operated by a 60-cps AC supply by the fire control equipment and is also operated by a 24-volt DC supply by Test Set Mk 183 Mod 0. Winding resistance is 445 ohms±8 percent. Test terminals are F17 and F15. Operating voltage ranges from 85 volts AC to 100 volts AC and release voltage ranges from 35 volts AC to 55 volts AC.

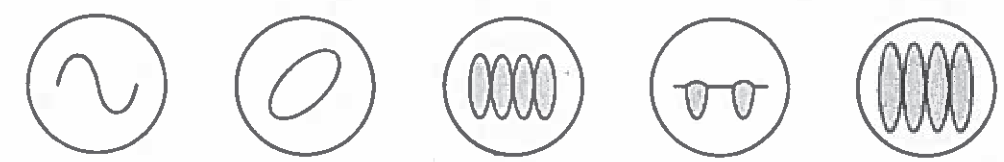
and then fasten it in place with its mounting screws.

Checking Panel With Test Oscilloscope

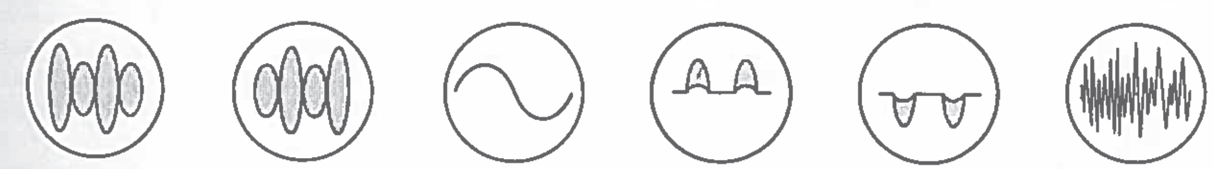
The following paragraphs outline checks made by oscilloscope for quickly determining the overall performance of the control panel, or for isolating trouble rapidly. In the hands of experienced personnel, this method of checking the panel can greatly accelerate readying the unit for firing. In all of the tests listed, the rudders and elevators are centered, the torpedo is set in above limit stratum condition, and a pressure of 31 psi is applied to the vents. The test switch is set to the TEST 1 position. THE OSCILLOSCOPE USED MUST HAVE A HIGH IMPEDANCE PROBE-TYPE INPUT.

Checking Oscillator. Turn the unit on, and connect the vertical input terminals of the oscilloscope from M1 to ground (or M17 to ground) to check the waveform of the switching oscillator. Set the sweep selector on a range which includes the oscillator frequency. The waveform should be sinusoidal, as shown in figure 102A. The absence of a sinusoidal waveform may indicate a defective oscillator tube, incorrect oscillator tube potentials, or open circuits between the oscillator and the point of connecting the oscilloscope.

To check the oscillator frequency, leave the vertical input terminals of the oscilloscope connected as above, set the sweep selector switch on AMPLIFIER and connect the horizontal input terminals to the output terminals of an audio oscillator. With the panel turned on and the audio oscillator operating, adjust the audio oscillator frequency until a practically stationary circle or ellipse, as shown in figure 102B appears. At this point, which should be between 180 and 280 cps, the audio oscillator is set to the switching oscillator frequency. Inability to obtain a circle or an ellipse within these frequency limits usually can be traced to a faulty audio oscillator or to incorrect adjustment of the oscilloscope. However,



	A	B	C	D	E
OSCILLOSCOPE VERT. INPUT	M1 (M17)-GND.	M1 (M17)-GND.	H11 (U1)-GND.	H15 (U5)-GND.	E13 (U14)-GND.
SWEEP (CPS)	INT. 60-220	AMP.-AUDIO OSC.	INT. 60-220	INT. 60-220	INT. 60-220
TEST SET (DBV)			-25 TO -15	-25 TO -15	-60; -80 TO -25
DIFF. ATT. (DB)			REFERENCE	REFERENCE	REFERENCE



F	G	H	I	J	K
E13 (14)-GND.	E13 (E14)-GND.	PIN 4, V5-GND.	H8 (U18)-GND.	H10 (U20)-GND.	SEE PARAGRAPH
INT. 60-220	INT. 60-220	INT. 60-220	INT. 60-220	INT. 60-220	"TROUBLESHOOTING
-80; -40 TO -25	-80; -40 TO -25		-40 TO -60	-40 TO -60	WITH THE
5 PORT (OR STBD.)	5 STBD. (OR PORT)		REFERENCE	REFERENCE	OSCILLOSCOPE"

Figure 102—Oscilloscope Test Pattern.

a faulty tuning capacitor (C8) may be causing the trouble.

Finding the FMR. Set the oscilloscope sweep selector to SWEEP. Apply an input signal of −85 dbv (−80 dbv for the vertical channel) to the panel, plugging only one of the input leads from the attenuator into jack J1 (or J3). Connect the vertical input terminals of the oscilloscope between pin 4 of vacuum tube V8 (or pin 4 of vacuum tube V16) and ground. Rock the dial of the signal generator slowly between 22 and 27 kc. Observe the frequency at which the oscilloscope pattern is highest. Repeat, using the same attenuator lead plugged into jack J2 (or J4). The average of the two signal generator readings is the average FMR.

Checking AC Amplifiers. Apply an input signal of approximately −16 to −25 dbv to the panel. Connect the vertical input terminals of the oscilloscope between terminals H11 (or terminal U1) and ground. With the oscilloscope vertical gain full on, a pattern of about 1 inch high will appear, as shown in figure 102C. (This height varies with oscilloscope sensitivity and with differences between panels. The stated height of 1 inch was obtained with a DuMont model 164E oscilloscope having a vertical gain of 43.)

Change the vertical input connections of the oscilloscope to terminal H15 (or terminal U5) and ground, leaving all other connections as they were for the procedure described in the preceding paragraph. The pattern appearing on the screen should look distorted, as shown in figure 102D, and should be higher than the pattern obtained at terminal H11 (or terminal U1).

Change the vertical input connections of the oscilloscope to terminal E13 (or terminal E14) and ground, leaving the other connections unchanged. Set the attenuator on −60 dbv. With the oscilloscope vertical gain on a low value, a pulse pattern about 2 inches high should appear on the screen, as shown in figure 102E. Increase the input signal in 10-db steps from −60 dbv to −20 dbv. There should be no material change in the height of the pattern on the oscilloscope screen. Continue to increase the gain 2 or 3 db at a time. The pulses will enlarge and become unequal. This inequality can be corrected with a change of about one-half db in the differential attenuator, and is normal.

Set the attenuator on −70 dbv, leaving all connections and the oscilloscope settings unchanged. Rotate the differential attenuator 5 db to port from its reference setting. The port and starboard pulses should show unequal reduction in height, as shown in figure 102F. Turn the differential attenuator 5 db to starboard from its reference setting. Corresponding changes in pulse heights should occur, as shown in figure 102G. Repeat at attenuator settings of −40 dbv and −25 dbv.

Checking Detectors. Set the input attenuator at −110 dbv. Connect the vertical input terminals of the oscilloscope between pin 4 of vacuum tube V5 (or pins 4 or 5 of vacuum tube V13) and ground. The switching signal should appear on the screen, as shown in figure 102H.

Connect the vertical input terminals of the oscilloscope between terminal H8 (or pin 3 of vacuum tube V13) and ground. The detected signal should appear on the screen, as shown in figure 102I. Repeat with the vertical input terminals connected between terminal H10 (or pin 8 of vacuum tube V13) and ground to check the other half of the detector. The signal should appear on the screen as shown in figure 102J.

Trouble Analysis With Oscilloscope. Tests can be made in the sequence shown in figure 102, or other approaches may be employed, depending on what the technician is trying to accomplish. In some cases, it may be desirable to reverse the sequence in order to establish more quickly the point at which trouble first appears.

Connecting the vertical terminals of the oscilloscope between terminals H18 or H20 (or terminals U9 or U10) and ground should result in no deflection of the oscilloscope sweep, since the filtering action of the RC filter is very efficient under normal conditions. The appearance of a pattern similar to those shown in figures 102I and 102J indicates an open capacitor C5A, C6A, C14A, or C15A.

If the panel input is set at −20 dbv, the oscilloscope sweep is set between 60 and 220 cps, and the vertical input terminals of the oscilloscope are connected between terminal H14 (or terminal U4) and ground, no pattern should appear, since the filtering in this circuit is very good when no trouble is present. (A small sawtoothed figure may result with higher input signals when the vertical oscilloscope gain is turned to maximum. This can be disregarded.) The presence of a

pattern similar to that shown in figure 102K indicates an open capacitor C3B (or C12B).

With the oscilloscope controls set as in the preceding paragraph and the vertical input terminals connected between pin 4 of vacuum tube V17 and ground, a very small sawtoothed pattern may be discerned on the screen. The presence of a pattern similar to that shown in figures 102I and 102J indicates an open capacitor C10C or C1B.

With the vertical input terminals of the oscilloscope connected between terminal E13 (or terminal E14) and ground, the appearance on the screen of a pattern similar to that shown in figure 102K indicates an open ground connection at capacitor C3C (or C12C), or C7C (this capacitor is common to both the horizontal and vertical channels).

A similar pattern, figure 102K, of much smaller amplitude will appear on the screen with the vertical input terminals of the oscilloscope connected to terminal E13 (or terminal E14) and ground if capacitor C3A or C3B (or capacitor C12A or C12B) is open.

Test Form for Principal Electrical Test Requirements

Table 15 summarizes the electrical test requirements for the various tests described in this section. It is recommended that this or a similar form be used to record the results of tests of the control circuits. The headings within the table refer to the paragraph in which the test procedure is described.

Table 15—Principal Electrical Test Requirements

	Test Switch Position	Test Points	Limits	Observed Value
		Voltage Tests		
Heater Voltage	TEST 1	A1–A5 (−)	21 to 27V	
Heater Voltage	TEST 1	A1–A6 (−)	21 to 27V	
B Voltage	TEST 1	A1–A9 (+)	40 to 65 V	
B Voltage	TEST 1	A1–A10 (+)	130 to 165V	
B Voltage	TEST 1	A1–A11 (+)	165 to 215 V	
Horizontal Bias	TEST 1	A13–A14 (+)	39 to 60 V	
Vertical Bias	TEST 1	A15–A16 (+)	39 to 59V	
		Balance of Bridge and DC Amplifier		
Rudder	TEST 1	B1–B8	7 to 9V	
		B2–B8	7 to 9V	
Elevator	TEST 1	B3–B12	19 to 21V	
		B4–B12	19 to 21 V	
Pendulum	TEST 1	B3–B22	19 to 21 V	
		B4–B22	19 to 21 V	
Depth	TEST 1	AL B3–B18	19 to 21 V	
		AL B4–B18	19 to 21 V	
		BL B3–B18	19 to 21V	
		BL B4–B18	19 to 21V	
		Rudder Limit Cut-Off		
Rudder	RUN	F39–F42	13.5–18.5 deg. Port 13.5–18.5 deg. Stbd	

Table 15—Principal Electrical Test Requirements—Continued

	Test Switch Position	Test Points	Limits	Observed Value
AC Amplifier				
Horizontal:				
J1	TEST 1	E-13	23.5 to 25.5 kc	
J2	TEST 1	E-13	23.5 to 25.5 kc	
Threshold	TEST 1	H4	−78 to −82 dbv	
Vertical:				
J3	TEST 1	E-14	23.5 to 25.5 kc	
J4	TEST 1	E-14	23.5 to 25.5 kc	
Threshold	TEST 1	U-14	−63 to −67 dbv	
Gating				
Gate	TEST 1	(Relay K2)	−64 to −68 dbv	
Depth Stiffness				
Stiffness	TEST 2		1.3 to 1.7 deg./psi	
Pendulum Stiffness				
Stiffness	TEST 2		1.3 to 1.7 deg./deg	
Tilt	TEST 2 (BL)		0 to 14 deg. UP	
Final Horizontal Circuit Adjustments				
Gyro steering	RUN		5 to 11 deg. Port 5 to 11 deg. Stbd	
Search	RUN		2 to 7 deg. Port	
Final Vertical Circuit Adjustments				
Leveling Pressure	RUN (AL)		29 to 33 psi	
Leveling Pressure	RUN (BL)		50 to 60 psi	
Leveling Pressure	RUN (NL)		50 to 60 psi	
Tests of Ceiling Switch				
Down Bias	RUN (AL)		8 to 12 db	
Tests and Adjustments of Stratum Switches				
S3	RUN (AL)		36 to 42 psi	
S1	RUN (BL)		~~26 to 32 psi~~ 36 to 42 psi	
S2	RUN (BL)		36 to 42 psi	
S1	RUN (NL)		~~26 to 32 psi~~ 36 to 42 psi	
S2	RUN (NL)		36 to 42 psi	
Tests of Exploder Cable				
Exploder cable energized	RUN (AL)		Pressures less than 36 to 42 psi	
Exploder cable energized	RUN (BL)		Pressures greater than ~~26~~ 36 to ~~32~~ 42 psi.	
Exploder cable energized	RUN (NL)		All pressures	

Section 11.5—Control Panel Test Voltages and Resistances

The following tables of DC voltages and resistances are given as an aid for troubleshooting. A marked difference between any measured value and the corresponding value shown in the applicable table may indicate a source of trouble. However, the measured value will probably not be exactly equal to the value in the table, even when no trouble is present. There will always be variations in these values due to small differences between vacuum tubes, resistors, capacitors, and other electronic components and as a result of variations in power supply voltages. Hence, trouble will be indicated only when the measured values are greatly different from the expected values and when they do not conform with values measured in other portions of the panel circuits.

DC Voltage Data

The voltages listed in tables 15 and 16 are based on the following test conditions:

- Afterbody connected
- Elevators and rudder centered
- Hydrophones disconnected
- Afterbody level
- Torpedo in AL stratum condition
- Leveling pressure applied to depth vent
- Test switch in TEST 1 position
- Heater voltage 24 ±2 volts (between terminals A2 and A6)
- B supply voltages (nominal)
  - 45 volts (between terminals A1 and A9)
  - 150 volts (between terminals A1 and A10)
  - 180 volts (between terminals A1 and A11)
  - 45 volts (between terminals A13 and A14)
  - 45 volts (between terminals A15 and A16)
- Relays K3 and K4 just operated
- All voltages less than 100 volts DC measured with a Measurements Corporation Vacuum Tube Voltmeter Model 62 with input shunted by a 10-megohm resistor.
- All voltages greater than 100 volts DC measured with a Simpson Model 260 Voltohmmeter (20,000 ohms per volt).

Table 16—DC Voltage to Ground at Vacuum Tube Pins

Vacuum Tube	Pin Number							
	1	2	3	4	5	6	7	8
V1	0	−2.0	+1.6	−7.0	+1.60	+135	−7.9	+135
V2	0	−7.9	+1.65	−7.0	+1.65	+135	−13.0	+135
V3	0	−13.0	+0.63	0	+0.63	+43	−19.0	+100
V4	0	−18.5	+1.45	−0.02	+1.45	+135	−24.0	+145
V5	0	−2.0	+0.40	+22.5	−21.5	0	−7.9	+0.35
V6	0	−24.5	+2.00	+0.30	+2.00	+40	−19.0	+40
V7	0	−19.0	+37.5	+37.5	+37.5	+175	−13.0	+105
V8	0	−7.9	−0.02	+32.5	0	0	−13.0	0
V9	0	−2.0	+1.55	−7.0	+1.55	+135	−7.9	+135
V10	0	−7.9	+1.50	−7.0	+1.50	+135	−13.0	+135
V11	0	−13.0	+0.60	0	+0.60	+43	−19.0	+100
V12	0	−18.5	+1.45	0	+1.45	+135	−24.0	+135
V13	0	−13.0	+0.30	+20.5	−20.0	+0.3	−19.0	+0.35
V14	0	−13.4	+2.10	+0.30	+2.10	+40	−19.0	+38
V15	0	−19.0	+37.5	+37.5	+37.5	+175	−24.5	+105
V16	0	−19.0	0	+32.5	−0.02	+23	−24.5	+22.5
V17	−0.9	+92.5	0	−0.02	+90.0	0	−7.5	−2.0
V18	−13.5	+137.5	+0.07	−13.5	+137.5	+0.07	−13.5	−7.9

Table 17—DC Voltage to Ground at Terminal Blocks A, B, M, and E

Terminal	A Block	B Block	M Block	Terminal		E Block
1	0	−6.0	−6.75	E–1	1	−6.8
2	0	−8.25	−6.75		2	+1.25
3	−0.02	−20.0	−7.0		3	+1.35
4	0	+15.0	−6.75		4	−2.2
5	−24.5	0	+130.0	E–2	1	+1.2
6	−24.5	+0.07	+130.0		2	−2.1
7	0	−0.9	+135.0		3	+1.2
8	−24.0	−1.7	+130.0		4	+1.3
9	+39.0	+130.0	+22.5		5	−7.0
10	+135.0	−2.0	+20.5	E–3	1	+175
11	+175.0	+130.0	−21.5		2	+105
12	−2.0	−2.4	−20.0	E–4	1	+175
13	−21.5	+0.07	−6.8		2	+105
14	+22.5	0	−6.8	E–5	1	+32.5
15	−20.0	+0.07	−7.0		2	+32.5
16	+20.5	0	−7.0		3	+135
17	0	0	+130.0		4	+135
18	0	−2.4	+135.0		5	+32.5
19	0	+37.0	+130.0		6	+32.5
20	0	−2.0	+130.0	E–6	1	−2.0
21		−0.9	+22.5		2	−2.15
22		−1.2	+20.5	E–9	1	+135
23		0	−21.5		2	+135
24		−2.0	−20.0	E–10	1	+135
25		+0.07			2	+135
26		−0.025		E–11	1	−0.02
27		−0.025		E–12	1	0
28		+38.0		E–13	1	+145
29		+135.0		E–14	1	+135
30		+6.0		E–15	1	−6.8
31		−8.25			2	−6.8
32		+3.0				
33		−3.25				
34		−3.25				
35		+0.07				
36		−2.0				

Resistance Data

The resistance values listed in tables 18, 19, and 20 are based on the following test conditions:

Elevators and rudder centered
Afterbody connected
Test switch in OFF position
No voltages applied to control panel
Resistances measured with a Simpson Model 260 Voltohmmeter

Table 18—Resistance to Ground at Vacuum Tube Pins

Vacuum Tube	Pin Number							
	1	2	3	4	5	6	7	8
V1	0	1.18	4,250	175,000	4,250	1,000	2.4	6,000
V2	0	2.4	4,750	175,000	4,750	1,000	1.8	6,000
V3	0	2.0	600	2.5 meg	600	5,000	1.5	100,000
V4	0	1.4	200	3.0 meg	200	1,700	0.8	1,800
V5	0	1.2	1.2 meg	28,000	26,000		4.8	1.3 meg
V6	0	0.7	1,700	1.2 meg	1,600	5,500	1.4	380,000
V7	0	1.4	5,100	380,000	5,000	1,600	1.5	8,000
V8	0	4.8	3.0 meg	300,000			6.0	0
V9	0	1.4	4,700	175,000	4,700	1,750	2.3	5,750
V10	0	2.4	9,000	175,000	9,000	1,200	1.9	5,750
V11	0	1.8	570	285,000	570	5,000	1.4	100,000
V12	0	1.4	210	800,000	200	1,800	0.8	1,800
V13	0	6.0	1.4 meg	30,000	30,000	1.2 meg	4.6	1.4 meg
V14	0	1.6	1,600	1.2 meg	1,600	5,500	1.4	375,000
V15	0	1.4	5,500	375,000	5,200	1,600	0.6	8,000
V16	0	4.6	500,000	290,000	0	9,000	0.8	280,000
V17	1,100	8,000	0	0	8,000	0	2.2	1.2
V18	110,000	1,700	60	110,000	1,700	60	1.7	2.4

Table 19—Resistance to Ground at Terminal Blocks A, H, M, D, and U

Terminal	A Block	H Block	M Block	D Block	U Block
1	0	2.0 meg	180,000	0	290,000
2	0	2.0 meg	180,000	0	280,000
3	0	2.0 meg	180,000	0	0
4	0	2.0 meg	180,000	0	500,000
5	9.5	2.0 meg	1,000	0	800,000
6	1.0	1.0 meg	6,000		30,000
7		1.0 meg	1,600		
8		1.5 meg	6,000		
9	5,000	1.0 meg	25,000		1.4 meg
10	1,700	1.5 meg	25,000	26,000	1.4 meg
11	1,700	2.0 meg	25,000	37	250,000
12	1.2	2.0 meg	25,000	0	250,000
13	22,000	0	170,000	0	250,000
14	22,000	3.0 meg	170,000	0	250,000
15	28,000	3.0 meg	170,000	0	250,000
16	28,000	28,000	170,000	0	1.2 meg
17	6.6	1.2 meg	6,000		
18	4.8	1.2 meg	1,600		
19	7.2	1.2 meg	6,000		1.2 meg
20	4.8	1.2 meg	1,200		1.2 meg
21			22,000		
22			28,000		
23			22,000		
24			28,000		

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Table 20—Resistance to Ground at Terminal Blocks B and E

Terminal	B Block	Terminal	E Block
1	20, 000	E-3 1	1, 500
2	20, 000	2	110, 000
3	28, 000	E-4 1	1, 600
4	28, 000	2	110, 000
5		E-5 1	300, 000
6		2	18, 000
7	1, 200	3	1, 700
8	100	4	1, 700
9	100	5	17, 000
10	1. 4	6	290, 000
11	120	E-6 1	1. 0
12	30, 000	2	20, 000
13		E-13 1	1, 700
14		E-14 1	1, 700
15		E-15 1	160, 000
16		2	180, 000
17	0		
18	38, 000		
19	400, 000		
20	45, 000		
21	1. 0		
22	30, 000		
23			
24	51, 000		
25			
26			
27	0. 2		
28	5, 000		
29	1, 700		
30	19, 000		
31	19, 000		
32	55, 000		
33	22, 000		
34	22, 000		
35			
36	1. 4		

Chapter 12

MAINTENANCE OF TORPEDO HEADS

Introduction

This chapter contains instructions for the maintenance of three heads used with Torpedo Mk 27 Mod 4. These heads include Warhead Mk 27 Mod 2, Exercise Head Mk 48 Mod 3 (recording), and Exercise Head Mk 48 Mod 2 (nonrecording).

The maintenance instructions for each head are preceded by a general description of the construction and functional characteristics of the head in order to provide the background information necessary for effective maintenance. The maintenance instructions cover all of the operations necessary for keeping the heads in good working order, including, where applicable, instructions for disassembly, overhaul, reassembly, test, and adjustment.

Warhead Mk 27 Mod 2 and Exploder Mk 11 Mod 2

To avoid unnecessary danger to personnel, the warhead is not ordinarily installed unless the torpedo is actually being assembled for a war run. Since the warhead is loaded with HBX explosive, it is normally stowed in a magazine designed and equipped to ensure continued stability of the explosive and to minimize the danger of accidental explosion.

General Description. The warhead, figure 103, is approximately 18.25 inches long and weighs 200 pounds. The HBX explosive charge weighs 124 pounds and is located in the lower portion of the warhead in a cavity formed by sheet metal bulkheads. A conduit is provided for leading the exploder cable into the exploder receptacle. This cable supplies the 24-volt DC power required for firing the exploder.

Exploder Mk 11 Mod 2, figure 104, is installed in the exploder receptacle at the front of the warhead to initiate detonation when the torpedo strikes the target at the end of a war run. A Booster Mk 9 is installed behind the exploder to produce a shock wave of the type required to detonate the HBX explosive. Instructions for installing the exploder and booster are given in chapter 7 of this publication. For detailed instructions pertaining to the operation, maintenance, and overhaul of the exploder refer to OP 1999.

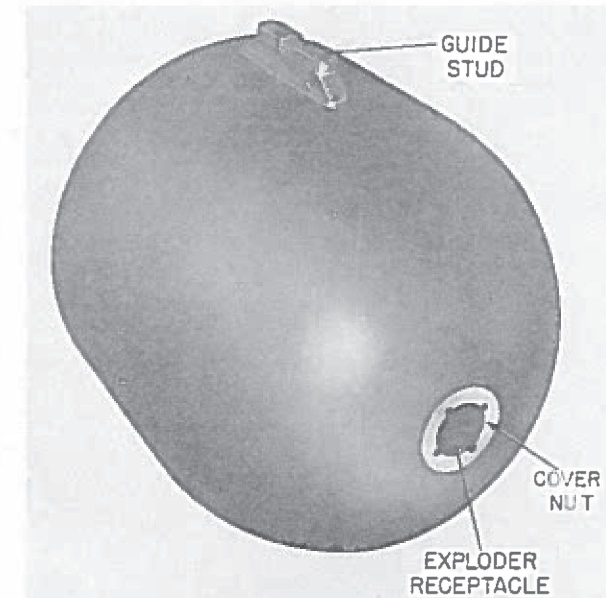

Figure 103—Warhead Mk 27 Mod 2.

Overhaul Instructions. The warhead does not contain any working parts and overhaul and maintenance consist merely of proper stowage and the prevention of corrosion. The warhead should be kept in the magazine until it is needed.

Since HBX explosive can be detonated only by a shock wave of sufficient intensity, the explosive charge is ordinarily inert and will safely withstand the minor shocks incident to handling. Care should be exercised in handling so that the shell will not be dented or otherwise damaged.

The head should be inspected at regular intervals, bearing in mind the following points:

1. The threads of the joint studs and of the exploder receptacle should be kept lightly coated with oil.

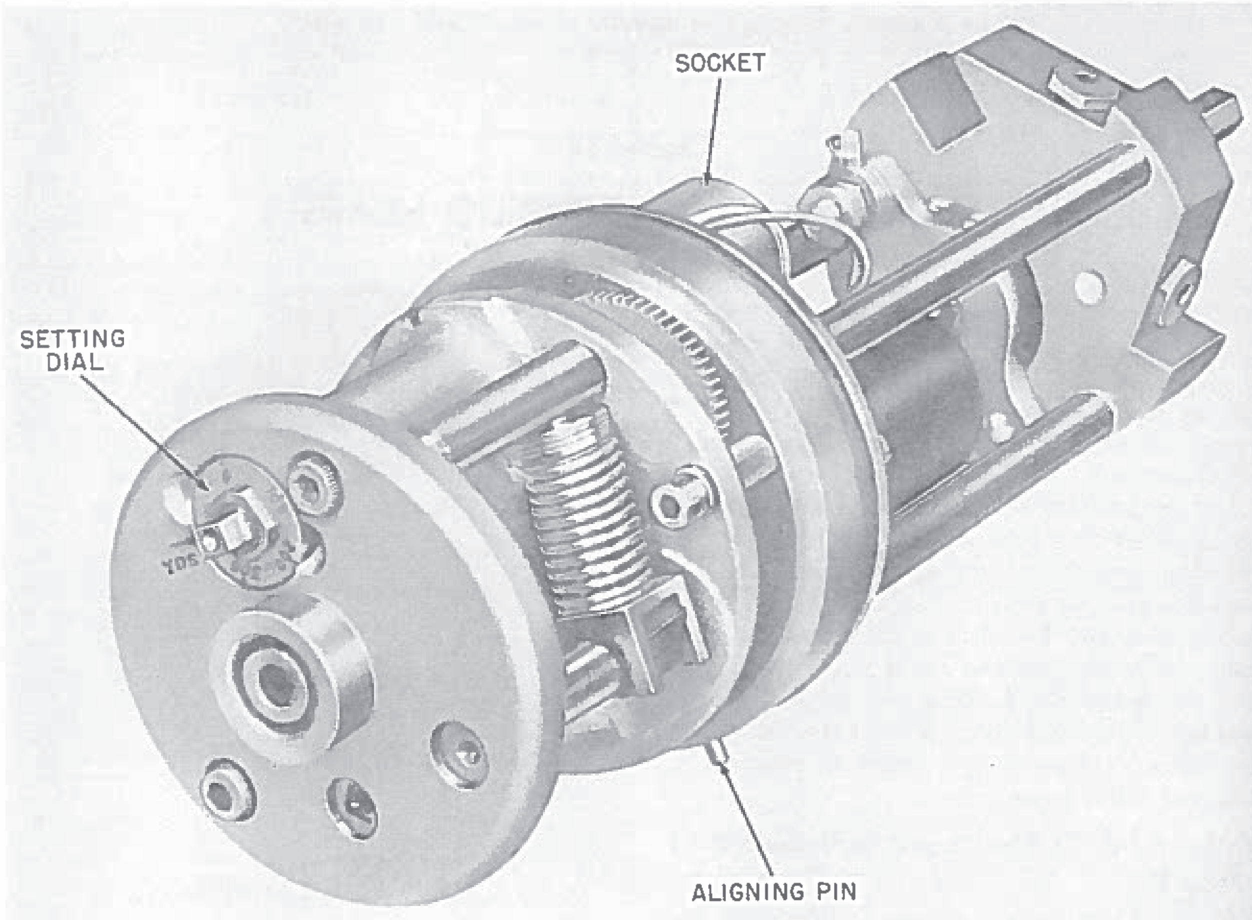

Figure 104—Exploder Mk 11 Mod 2.

2. Corrosion and chipped paint should be corrected immediately by light sanding and a coat of touch-up paint.

3. Particular care should be exercised to protect the inner surface of the exploder receptacle from damage. The surface of the cavity which mates with the O-ring seal of the exploder must be smooth and of accurate size.

Exercise Head Mk 48 Mod 3 (Recording)

Exercise Head Mk 48 Mod 3, figure 105, is used for exercise and proofing runs. This head contains devices for recording certain torpedo functions, for controlling the length of the torpedo run, and for producing a sound signal used for locating the torpedo at the end of a run. (This signal is also used to indicate when the torpedo exceeds a preset depth). *

General Description. Exercise Head Mk 48 Mod 3 has the same general outline dimensions as Warhead Mk 27 Mod 2 and is trimmed to have the same weight. The head is approximately 18.25 inches long and weighs approximately 200 pounds. Mounted within the head are a primary test unit and an oscillator-projector assembly. For hit shots, an inertia cutoff switch is installed.

The primary test unit consists of a recorder and cycler assembly powered by a clock spring motor. The unit performs the following functions:

1. Provides a continuous chart record of the depth of torpedo during an exercise run, and impulse records of various relay operations and other circuit operations within the torpedo.

2. Deenergizes the main motor and the steering controls of the torpedo at a preset time, produces UP elevator to bring the torpedo to the surface, and energizes the oscillator-projector.

3. Deenergizes the main motor and the acoustic or hydrostatic steering controls of the torpedo, produces UP elevator, and energizes the oscillator-projector during the time that a preset depth is exceeded.

* The device for producing a sound signal has been replaced by a removable trim weight in

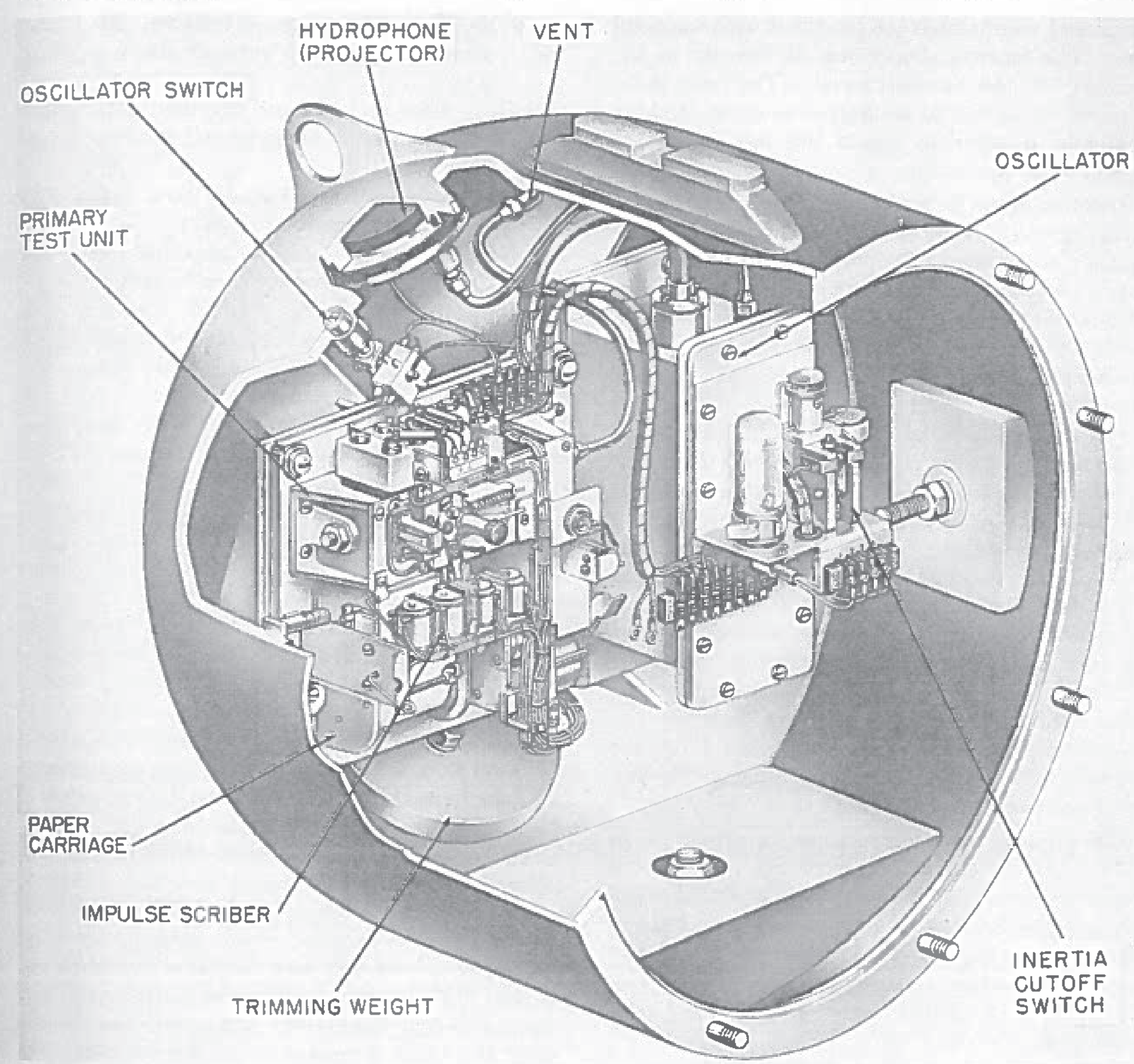

Figure 105—Exercise Head Mk 48 Mod 3 (Recording).

The oscillator-projector is a waterproof, self-contained assembly which produces sound signals when it is energized through the action of the primary test unit. (The oscillator-projector is sometimes called a "pinger"). The sound signals produced by the oscillator-projector are detected by Ordnance Locator Mk 1 which is used to aid in finding the torpedo after the end of a run. The sound signals are also used as an indication that the preset depth has been exceeded.

The inertia cutoff switch is actuated by the shock produced when the torpedo strikes a target. Actuation of this switch deenergizes the main motor and steering controls of the torpedo, produces UP elevator to bring the torpedo to the surface, and energizes the oscillator-projector. The switch incorporates a ~~time delay~~ rack feature so that it can not be actuated for approximately ~~20 seconds after~~ firing. before enable.

The recording exercise head is connected to the torpedo control panel by means of a cable assembly which terminates in a fanning strip and two additional wires which are provided with terminal lugs. The fanning strip connects directly to the D-block on the control panel. The two independent wires may be connected to other D-block terminals in order to obtain impulse records of desired relay operations.

Functioning of Recording Exercise Head. The circuit through which Exercise Head Mk 48 Mod 3 controls and records the performance of the torpedo is shown in figure 106. This figure is a schematic diagram of the primary test unit and oscillator-projector and also shows the inertia cutoff switch wired into the circuit. (The inertia cutoff switch is used only for hit shots). As shown in the figure, the motor-driven cam has a single set of transfer contacts, D1, and three sets of break contacts, D2. The timing cam is driven by the clock motor which is controlled by the magnetic brake, CL. There is a time interval of about 45 seconds between actuation of the break contacts. The depth cutoff switch, DCO, is operated by the hydrostatic bellows. There are four impulse scribers (numbered "1," "2," "3", and "4"). Plug PG5 is connected to impulse scriber 4 which is used to indicate the operation of the exploder safety switch of the torpedo. The exploder cable is plugged directly into this connector.

The exercise head is prepared for operation as follows: At the control panel of the torpedo, the straps are removed from terminals D1 through D5, and the fanning strip of the exercise head is connected to the D-block, thus affecting the proper connections to terminals D1 through D8. The D-block terminals make the following connections:

- D1—Ground.
- D2—Connects to low side of start relays ST1 and ST2.
- D3—Connects to low side of main motor relay coil.
- D4—Connects to positive lead of DC power input to B power supply.
- D5—Connects to panel ground (terminal A1).
- D6—Connects to —24 volts DC through start relay ST1 (operates CL brake).
- D7—Connects to terminal B4 (causes UP elevator when grounded).
- D8—Connects to stratum relay (indicates operation of relay K7).
- D10—Connects to panel terminal B5 (indicates operation of vertical steering relay K4).
- D13—Connects to panel terminal B23 (indicates operation of horizontal steering relay K3).
- D15—Connects to coil of gyro relay K8 (indicates operation of relay).

NOTE: The two additional wires associated with the exercise head cable are connected to impulse scribers 1 and 2. These wires may be connected as desired to terminals D10, D13, and D15 to obtain indication of the relay operations.

When the inertia cutoff switch is used the circuit to the low side of relays ST1 and ST2 is completed through the contacts of the inertia cutoff switch as shown in figure 106. The solenoid for the inertia switch lock ~~and the time delay tube K101 are~~ connected to the —24-volt supply at terminals J6 and J1.

After the electrical connections are made, the cam in the exercise head is turned manually to the desired time setting. When this setting is made, the cam can be turned only in the direction of decreasing time. The tips of the contact springs are used as a scale index. After the cam is set, the transfer and break contacts are in the positions shown in figure 109. The oscillator switch is then turned on. The inertia cutoff switch is set as follows: Depress inertia weight and press ~~ceramic~~ button to close switch contacts. Release ~~weight and then release button.~~ ~~Press down~~ switch lock plunger ~~at top of unit and~~ turn arm into notches to hold the plunger in the ~~down~~ position. This completes the preparation of the exercise head. After the head is mounted on the torpedo, the torpedo is ready for firing.

During the exercise run, the sequence of operations within the exercise head are as follows: When the torpedo is fired, the torpedo circuits function normally, except that operation of start relay ST1 also causes the magnetic brake in the exercise head to release, thus allowing the cycler to operate. At the time of enable the inertia cutoff switch lock is energized. The solenoid then rotates and a pin on the solenoid rotor pushes the plunger arm out of the notches, thus releasing the spring-loaded plunger. This unlocks the inertia switch and at the same time opens the circuit to the solenoid which has no further use during the run.

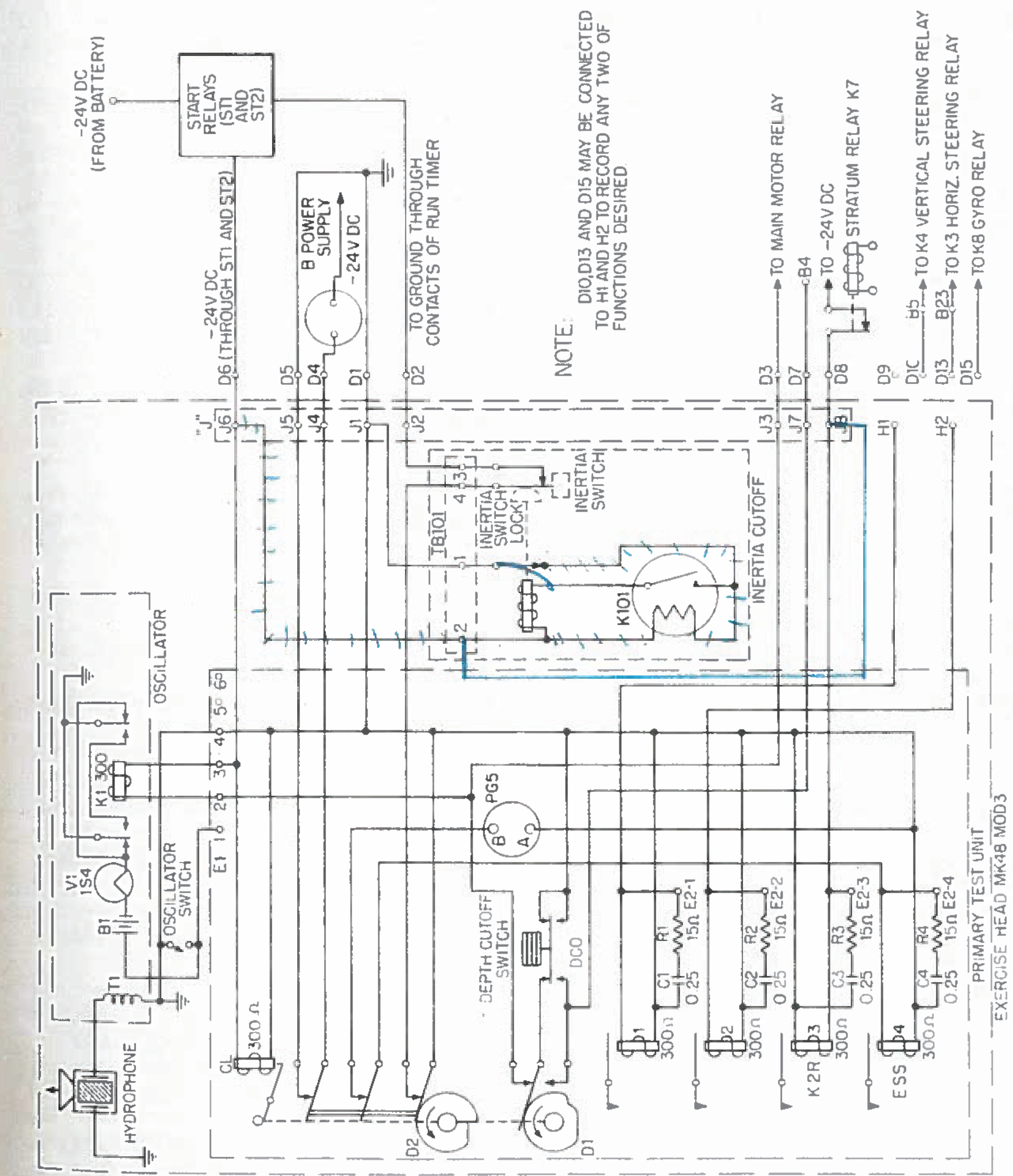

Figure 106—Circuits of Exercise Head Mk 48 Mod 3.

[redacted]. If during the run the torpedo passes below the depth corresponding to the setting of the depth cutoff switch, switch DCO opens. This breaks the ground connection to the main motor relay, causing the relay to open and thus de-energize the propulsion motor. At the same time, switch DCO grounds panel terminal B4, through terminals J7 and D7. This creates an unbalance in the vertical steering bridge circuit, and causes UP elevator. Operation of switch DCO also allows relay K1 in the oscillator to open, thus causing the oscillator to operate. All of those actions associated with operations of switch DCO will continue in effect until the torpedo rises to a depth less than the cutoff depth setting.

During the run, the impulse scribers record the operations of the relays to which they are connected. Operation of stratum relay K7 is indicated by scriber relay 3 connected through terminals D8 and J8. Activation of the exploder circuit is indicated by scriber relay 4 connected through AN connector PG5. Scriber relays 1 and 2 indicate the operation of the particular relays selected by making the desired connections to terminals D10, D13, or D15.

If the torpedo hits a target during the run, the inertia switch opens, thus opening the circuit to the low side of the start relays. This causes essentially the same effect as occurs at the end of the preset run time as explained in the following paragraph.

At the end of the preset run time, cam D1 associated with the double acting switch allows the switch to operate, closing the lower contact. This action disconnects relay K1 in the oscillator from ground, thus causing the oscillator to operate, and also breaks the ground connection through terminals D3 and J3 to the main motor relay (MMR), thus causing the propulsion motor to stop. At the same time, panel terminal B4 is grounded through terminals J7 and D7, causing UP elevator. With the propulsion motor stopped and with the elevators UP, the torpedo will glide rapidly up to the surface. The action of cam D1 also causes the oscillator to be turned on to produce the sound signal used in locating the torpedo. Forty-five seconds after the operation of cam D1, cam D2 causes the single acting switches to open. The top contacts (associated with terminals J4 and J5) act to deenergize the B power supply. The bottom contacts act to cause start relays ST1 and ST2 to open by breaking the ground connection through terminal D2 to the relay coils. This completely deenergizes the torpedo because start relays ST1 and ST2 cannot be actuated except by applying voltage to fire relay K13.

Disassembly Instructions. When necessary for maintenance or overhaul, the exercise head can be disassembled by removing the oscillator, projector, (if installed) and primary test unit from the head. If the inertia cutoff switch is installed, it can be removed by disconnecting the electrical circuits and taking out the four screws holding it to the cover of the oscillator case. or to the trim weight mounting brackets

Removal of Oscillator and Projector. The oscillator, projector, and associated parts may be removed from the head as follows:

1. Remove screws holding cover plate to oscillator case and take off cover. This gives access to oscillator for any necessary repairs or replacements. (85)
2. If it is necessary to remove control wires leading into oscillator case through water seal, disassemble water seal by removing four screws holding end plate. (85)
3. If a faulty connection between oscillator and projector is suspected, remove copper tubing connecting oscillator and projector and install a new wire. (70)
4. Remove projector after taking out mounting screws. (85)

Removal of Primary Test Unit. The primary test unit may be removed as follows:

1. Disconnect all leads from top terminal strip E1. (85)
2. Disconnect copper tubing leading to pressure vent.
3. Remove primary test unit assembly after taking out four mounting screws located at corners of assembly. (83)

Overhaul Instructions. The following paragraphs contain instructions for overhaul of Exercise Head Mk 48 Mod 3. These instructions include procedures for making tests to discover possible defects and describe the methods used to effect the required repairs.

Test and Repair of Oscillator-Projector. The oscillator is powered by four dry cell batteries. Filament current is supplied by two standard 1.5-volt flashlight cells connected in parallel and plate current is supplied by two 45-volt batteries

(Eveready No. 455 or Burgess No. XX30), connected in series. Starting with fresh batteries, the oscillator should operate continuously for approximately 72 hours with sufficient output to be heard with Ordnance Locator Mk 1. With intermittent use, the batteries should last for several weeks.

If the oscillator is not functioning correctly, first check the batteries and battery connections. In any case, the filament battery should be replaced if its load voltage is less than 1.2 volts, and the plate battery should be replaced if its load voltage is less than 40 volts. This will insure sufficiently long oscillator operation in the event the torpedo fails to surface after a run and must be located.

If the installation of fresh batteries does not remedy the faulty operation of the oscillator, replace vacuum tube V1 (1S4).

To test the operation of the oscillator, proceed as follows:

1. Connect vertical input terminals of an oscilloscope to output terminals between transformer T1 and hydrophone.
2. Turn on oscillator switch on shell of exercise head.
3. Observe transformer output on oscilloscope. This should be a voltage of approximately 45 kc.

The operation of the oscillator-projector assembly can be checked by two different methods. If an Ordnance Locator Mk 1 is available, hold the hydrophone of the locator against the exercise head shell while the oscillator is turned on. The locator should produce an audible tone, indicating that the oscillator-projector is functioning correctly. An alternative method is to use an oscilloscope and a crystal hydrophone of the type used in Mine Mk 24. Connect the terminals of the hydrophone to the vertical input terminals of the oscilloscope. While the oscillator is turned on, press the hydrophone against the exercise head shell in the vicinity of the projector and observe the oscilloscope. The oscilloscope should show a sine wave pattern with a frequency of 45 kc. The amplitude of the pattern will depend on the force with which the hydrophone is pressed against the exercise head shell.

If the preceding tests indicate that the oscillator is functioning but the projector is not operating, replace the wire inside the copper tube leading from the oscillator box to the projector. (The copper tubing is the return conductor). If the projector is still inoperative, install a complete new oscillator-projector assembly in the exercise head.

If relay K1 in the oscillator box is not functioning correctly, it can be adjusted by the use of a relay spring bender (Tool 41) according to the same general procedure used for the adjustment of the control panel relays. (Refer to chapter 11. Relay K1 is similar to relay K5.) The winding resistance of relay K1 is 300 ohms (±10 percent) the maximum operating current is 54 milliamperes and the minimum operating current is 39 milliamperes. The magnetic brake CL of the primary test unit has the same winding resistance and the same operating current requirements as relay K1. All of the relay contacts and the cam spring pilots should be burnished occasionally with the burnishing tool (Tool 42).

Repair of Primary Test Unit. The usual setting of depth cutoff switch DCO is 150 feet, although other settings may be used. A change in the setting can be made with the aid of the graduated scale associated with the switch. The operation of the depth cutoff switch can be adjusted by a suitable change of the plunger associated with the depth scriber, so that it actuates the depth cutoff microswitch at the desired depth.

The mechanical maintenance of the exercise head consists mainly of cleaning, lubricating, and adjusting the primary test unit. Carefully remove any corrosion from the test unit using fine emery paper and apply a light coat of gyro oil to surfaces. Occasionally apply a light coating of graphite to the moving parts of the clock motor, roller assembly, and depth recorder. Lack of lubrication may cause these moving parts to stick.

Usually, operational faults in the mechanism of the test unit can be traced to incorrect adjustment and the required remedy can be determined by careful analysis. Slow operation of the clock mechanism may be caused by bent or fouled governor vents. To check the vents, remove the spring-held cap from the governor housing on the side of the clock motor. If necessary, the speed of the motor may be adjusted by setting the governor weights. A chart record shorter than normal is indicative of excessive drag of the stylus on the paper, or too much tension in the paper roll brake. If necessary, carefully bend the stylus or brake spring in such a way as to relieve the excessive tension.

After continued use of the exercise head, a leak may occur at the seal of the oscillator switch, permitting moisture to enter the head. The effect of this moisture on terminal B4 of the recorder unit may result in faulty elevator action. For this reason, it is advisable to check the torpedo by operating the test switch after the exercise head is connected electrically to the torpedo but before the head is bolted in place. If the elevator deflection is not correct, disconnect the terminal block of the recorder unit and dry it thoroughly. Also replace the seal of the oscillator switch. To do this, first disconnect the wires from the switch, tagging them to facilitate reconnection. Then unscrew the switch yoke from the mounting box. Replace the seal and complete the reassembly.

ADJUSTMENT OF INERTIA CUTOFF SWITCH. The inertia switch is locked in until the torpedo enables, preventing it from operating due to launching shocks. Proper operation of the locking feature is determined by applying 24-volts DC between terminals TB101-1 and TB101-2 The rotary solenoid L101 should operate and release the plunger when the voltage is applied.

screw should be set so that the tension of the spring is 0.5±.05 pounds when the inertia weight is not tilted.

Notes on Reassembly of Components. If the overhaul of the exercise head requires the removal of any of the components of the head, the reassembly must be performed in accordance with the applicable portions of the following notes:

1. Treat all fittings for copper tubing with pipe compound before installing tubing.
2. When tightening screws in cap of waterproof connector on oscillator case, be careful to tighten screws uniformly so that cap remains parallel to flange surface. This is necessary to insure a tight seal.
3. When replacing cover of oscillator case, be careful not to damage gasket and be sure to replace all insulating strips. Tighten screws uniformly to insure a watertight seal.
4. After oscillator and projector are installed, check for watertightness by covering all external joints with soap solution and applying an air pressure of 12±4 psi to the interior of the assembly. To apply air pressure, remove plug in cover of oscillator case and insert air line in hole. Inspect for leaks carefully and make any necessary repairs to seals. After completing leak test, be sure to replace plug in oscillator case cover.
5. After replacing watertight seal for oscillator switch, be sure to tighten switch firmly and to reconnect switch wiring correctly.
6. If primary test unit was removed, mount it carefully and tighten its four mounting screws securely. Reconnect wiring to terminal strip E1 in accordance with figure 106.

Overhaul and Pre-Assembly Tests. After overhaul of the exercise head and before installing the head on the torpedo, the head must be checked thoroughly in accordance with the following instructions. These instructions are arranged so that they can be used in the preparation of a check off list.

1. Inspect assemblies for damage, loose parts, and moisture.
2. Blow out interior of head with low-pressure air, and wipe clean with a dry cloth.
3. Apply air pressure of 30 psi to depth recording vent and test for leaks by applying soap solution at shell and depth bellows.
4. Set depth cutoff switch DCO for desired depth.
5. Check clock winding lever for freedom from binding.
6. Apply one drop of gyro oil at vane shaft and winding lever of clock mechanism.
7. Place four feet of fresh paper in holder.
8. Check alinement of holes in paper with sprocket teeth.
9. Check pressure of rollers on paper.
10. Insert paper carriage and check for tightness.
11. Operate clock manually and check for uniform feeding of paper.
12. Set recorder to three minutes, and take up slack by depressing armature on magnetic brake CL until paper just moves.

13. Depress armature on magnetic brake CL and allow clock to run until double acting switch controlled by cam D1 operates. Indicate time required. (Limits: 3 minutes ±15 seconds).
14. Check recorder scribers for proper marking and spacing.
15. Turn oscillator switch on and check for operation of projector, using an external hydrophone and oscilloscope.
16. Check voltage under load of filament battery in oscillator. (Limit: Greater than 1.2 volts).
17. Check voltage under load of plate battery in oscillator. (Limit: Greater than 40 volts).
18. Turn oscillator switch off.
19. Check operation of depth recorder by applying pressures, in steps of 20 psi, to depth recording vent. At each pressure, depress armature on magnetic brake CL in order to record movement of depth scriber. Increase in scriber movement should be approximately proportional to increase in pressure.
20. Weigh exercise head. (Limit: 200.5 ±3 pounds).
21. Apply 24 volts between terminals J6 (−) and J1 (+). Magnetic brake CL should operate, allowing cycler to move. Relay K1 in oscillator also should operate, turning off oscillator. If ~~inertia cutoff switch is installed, solenoid in the switch should operate after voltage has been applied for 20±5 seconds and plunger should rise. Reset switch and check inertia switch contacts to be sure they are closed.~~
22. Apply 24 volts to pin 1 (−), and pin 2 (+) of connector PG5. Scriber 4 should operate. Removing voltage should cause scriber 4 to release.
23. Apply 24 volts between terminals J1 (+) and J8 (−). Scriber 3 should operate. Removing voltage should cause scriber to release.*
24. Apply 24 volts between terminals J1 (+) and H2 (−). Scriber 2 should operate. Removing voltage should cause scriber 2 to release.

*If inertia cutoff switch is installed, solenoid in the switch should operate when voltage is applied and plunger should release. Reset switch and check inertia switch contacts to be sure they are closed.

25. Apply 24 volts between terminals J1 (+) and H1 (−). Scriber 1 should operate. Removing voltage should cause scriber 1 to release.
26. With sufficient air pressure applied to exercise head vent, switch DCO should operate and connect terminal J7 to ground. Switch DCO should also disconnect terminal J3 from ground and release relay K1, thus energizing oscillator.

Instruction for Interchanging Depth Recording Assemblies. In conducting exercise runs against deep targets (greater than 150 feet) it is advisable to use the 450-foot depth recording assembly that is issued with the recording exercise head as a replacement part. The following instructions give the procedure for interchanging the shallow depth recorder assembly and deep depth recorder assembly.

1. Disconnect copper tubing by unscrewing fitting on depth recorder. (70)
2. Disconnect wires leading from terminal strip E1 to oscillator assembly.
3. Take out four mounting screws in corners of primary test unit and lift primary test unit out of head. (83)
4. Disconnect mounting bracket holding four capacitors and resistors on primary test unit base plate by removing two screws from underside of plate. Move bracket aside, taking care not to damage or break wiring. (85)
5. Unlock and remove paper carriage.
6. Take out two mounting screws holding mounting bracket for connector PG5 to depth recorder case. Move connector and bracket to one side, taking care not to damage or break wires. (85)
7. Take out two mounting screws holding depth cutoff switch bracket on depth recorder case and move bracket to one side, taking care not to damage or break wires.
8. Remove depth recorder assembly by taking out four mounting screws accessible at ends of case and sliding assembly back under capacitor and resistor bracket. (85)
9. Mount new depth recorder on primary test unit base by reversing the procedure outlined in steps 7 and 8.
10. Remount mounting bracket for connector PG5 depth recorder case. (85)

11. Remount depth cutoff switch bracket on depth recorder case. (85)

12. Remount bracket holding capacitors and resistors on back of primary test unit base. (85)

13. Slide paper carriage back in place and lock carriage.

14. Remount primary test unit in exercise head by means of four mounting screws and vibration absorbers. (83)

15. Connect copper tubing to fitting on depth recorder assembly, after first coating fitting with pipe compound.

16. Set pointer of depth recorder assembly by loosening knurled knob on top of pointer and retighten in desired position.

17. Loosen set screw on locking collar associated with spring and plunger assembly which operates depth cutoff switch. To vent on exercise head, apply an air pressure of 87.0 psi (for deep depth recorder) or 43.5 psi (for shallow depth recorder), and adjust position of plunger until depth cutoff switch is just operated. With plunger in this position, tighten set screw in locking collar on plunger shaft. Check operation of depth cutoff switch by gradually increasing air pressure and noting whether or not the depth cutoff switch operates at the desired pressure. If switch does not operate at desired pressure, readjust collar as necessary. (76)

18. Aline stylus on depth recorder assembly to coincide with zero pressure on depth recorder bellows assembly. This can be done by suitable adjustment of screws locking stylus to index pointer. (85)

Exercise Head Mk 48 Mod 2 (Nonrecording)

Exercise Head Mk 48 Mod 2, figure 107, is used in exercise runs in which no recorded information is desired. This head contains a time delay relay which limits the length of the run to six minutes and (for hit shots only) employs the same type of inertia cutoff used in the recording exercise head, figure 108.

General Description. The nonrecording exercise head has the same outline dimensions as the warhead, is approximately 18.25 inches long, and weighs approximately 200 pounds. The construction of the head is similar to that of the warhead, with the exception that the exploder cavity is filled with approximately 124 pounds of inert material.

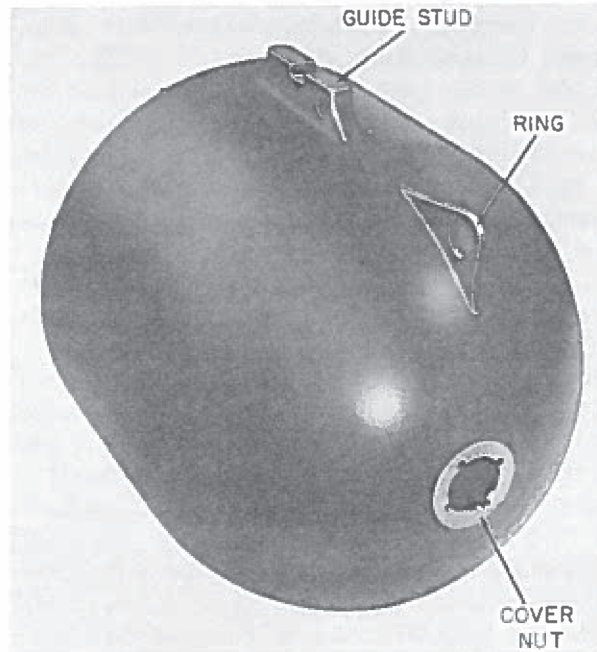

Figure 107—Exercise Head Mk 48 Mod 2 (Inert).

The function of the inertia cutoff switch is explained in connection with the description of the recording exercise head. The time delay relay which limits the length of the torpedo run to six minutes consists of a small, speed-regulated DC time motor provided with a clutch mechanism, solenoid, and microswitch. Figure 109 is a schematic diagram showing how the device is connected in series with the inertia cutoff switch in the torpedo circuit. When the torpedo is fired, the solenoid is energized and engages a spring clutch in a gear reduction drive through which the motor drives a spring-loaded switch operating arm. The starting position of the switch arm is determined by the location of an adjustable stop. As the time motor runs, the switch arm is rotated slowly toward the microswitch. The time setting of the device depends on the location of the switch arm stop. This stop must be adjusted until the time required for the switch arm to traverse the arc between the stop and the microswitch is equal to six minutes. Actuation of the microswitch breaks the ground circuit to relays ST1 and ST2, thus deenergizing the torpedo and also deenergizing the clutch solenoid so that switch arm is returned to the adjustable stop by the spring.

Overhaul Instructions. The adjustment of the inertia cutoff switch is covered in the overhaul

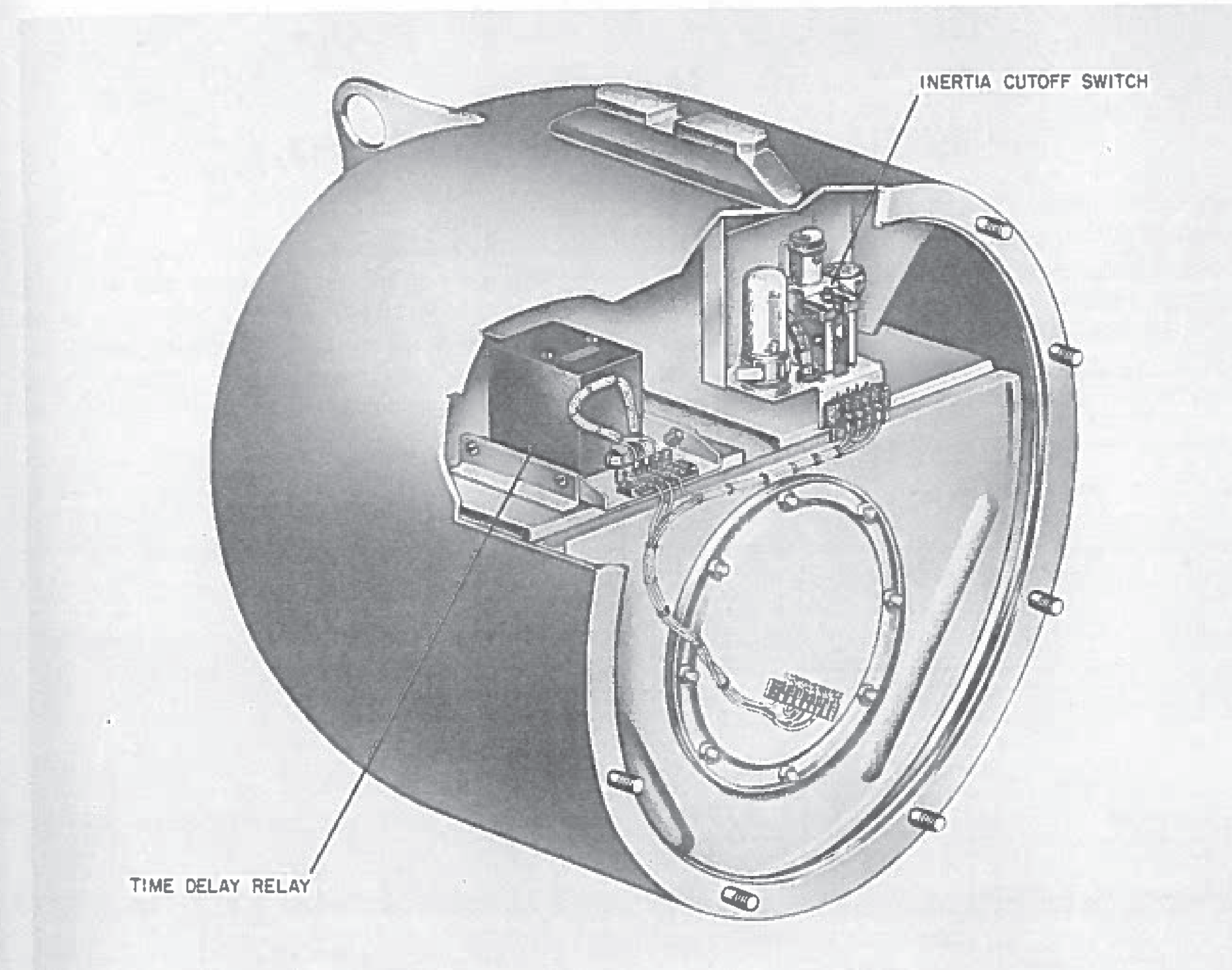

Figure 108—Exercise Head Mk 48 Mod 2 (Showing Inertia Cutoff and Time Delay).

instructions for the recording exercise head. The time delay relay requires no adjustment other than setting the switch arm stop to obtain a running time of 6 minutes (±15 seconds). Access to the adjustment may be obtained by removing the cover of the unit. If the time delay relay develops any other mechanical or electrical defect, it should be replaced with a new unit.

Normally, the head itself should require very little overhaul. Simple maintenance, such as occasional repainting, replacement of damaged mounting studs, and removal of dents in the head shell, are all that are necessary. Specific information covering the principal dimensions, weights, and trim of the head may be found in the supplementary data at the end of this publication.

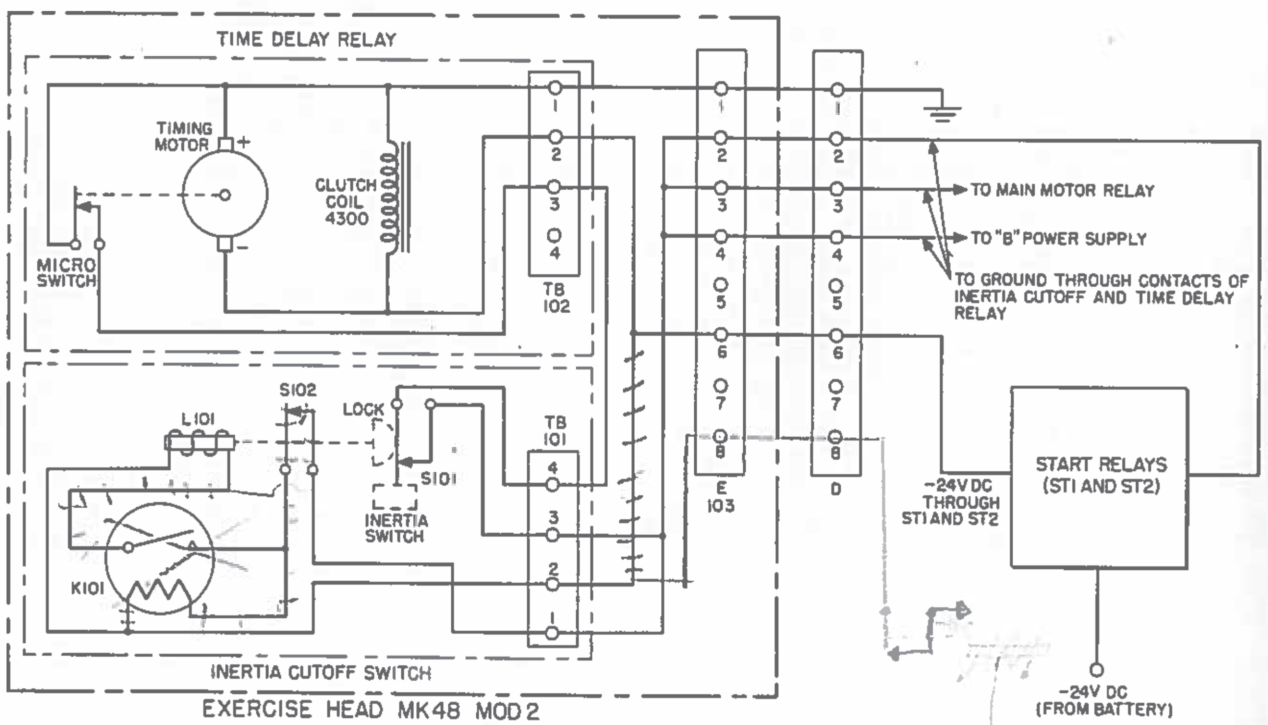

Figure 109—Circuits of Exercise Head Mk 48 Mod 2.

Chapter 13

CHARGING AND CARE OF BATTERIES

General

This chapter includes descriptions of the construction and characteristics of the storage batteries used with Torpedo Mk 27 Mod 4 and contains instructions for giving these batteries an initial charge. The chapter also includes general instructions for the maintenance, charging, and care of the batteries and gives the precautions to be observed in working with the batteries.

Two types of batteries are used with Torpedo Mk 27 Mod 4; one type for war shots and the other type for exercise runs. The war shot battery, Storage Battery Mk 7 Mod 3, figure 110, contains 30 large cells and is capable of delivering

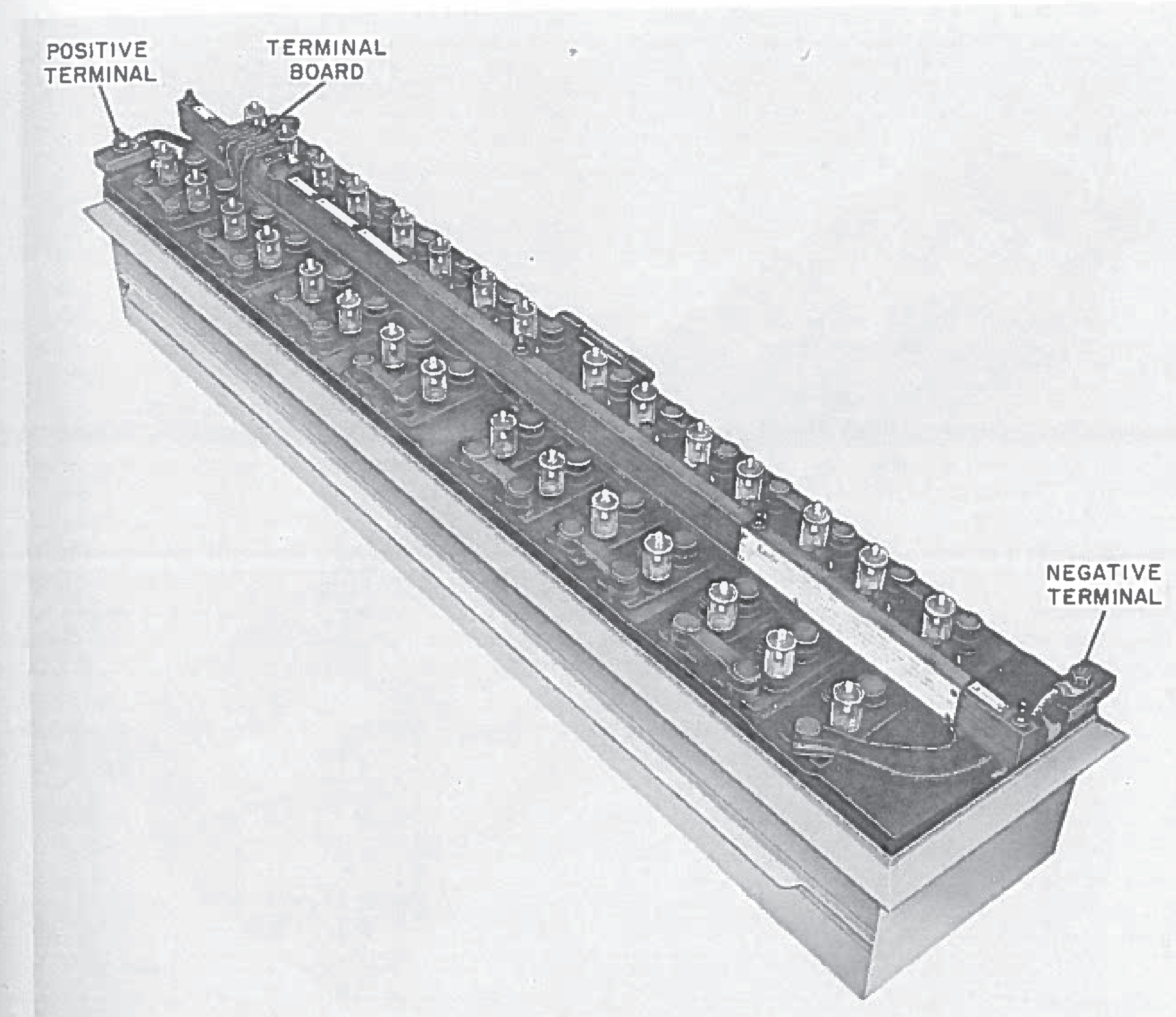

Figure 110—War Battery Mk 7 Mod 3.

sufficient power to run the torpedo for a minimum of 12 minutes. With the war shot battery installed, the torpedo has a negative buoyancy of approximately 70 pounds so that it will sink at the end of its run if it does not score a hit. The exercise battery, Storage Battery Mk 8 Mod 4, figure 111, is lighter than the war shot battery, and with the exercise battery installed, the torpedo has a positive buoyancy of approximately 20 pounds so that it will float to the surface and may be recovered at the end of an exercise run. Storage Battery Mk 8 Mod 4 has 33 small cells and is capable of delivering sufficient power to run the torpedo for a minimum of 9 minutes.

Battery Construction and Characteristics

The basic characteristics of the batteries used with Torpedo Mk 27 Mod 4 are shown in table 21.

Except for the number and size of the cells, Storage Battery Mk 7 Mod 3 is essentially the same as Storage Battery Mk 8 Mod 4. The cells of each battery are connected in series and the ends of the circuit (60 volts) are provided with heavy threaded terminals for connecting the propulsion motor cables, figure 112. The battery is tapped to provide voltages of −48, −28, and −24 volts DC for the torpedo control circuits. The wires from these taps are connected to a terminal strip.

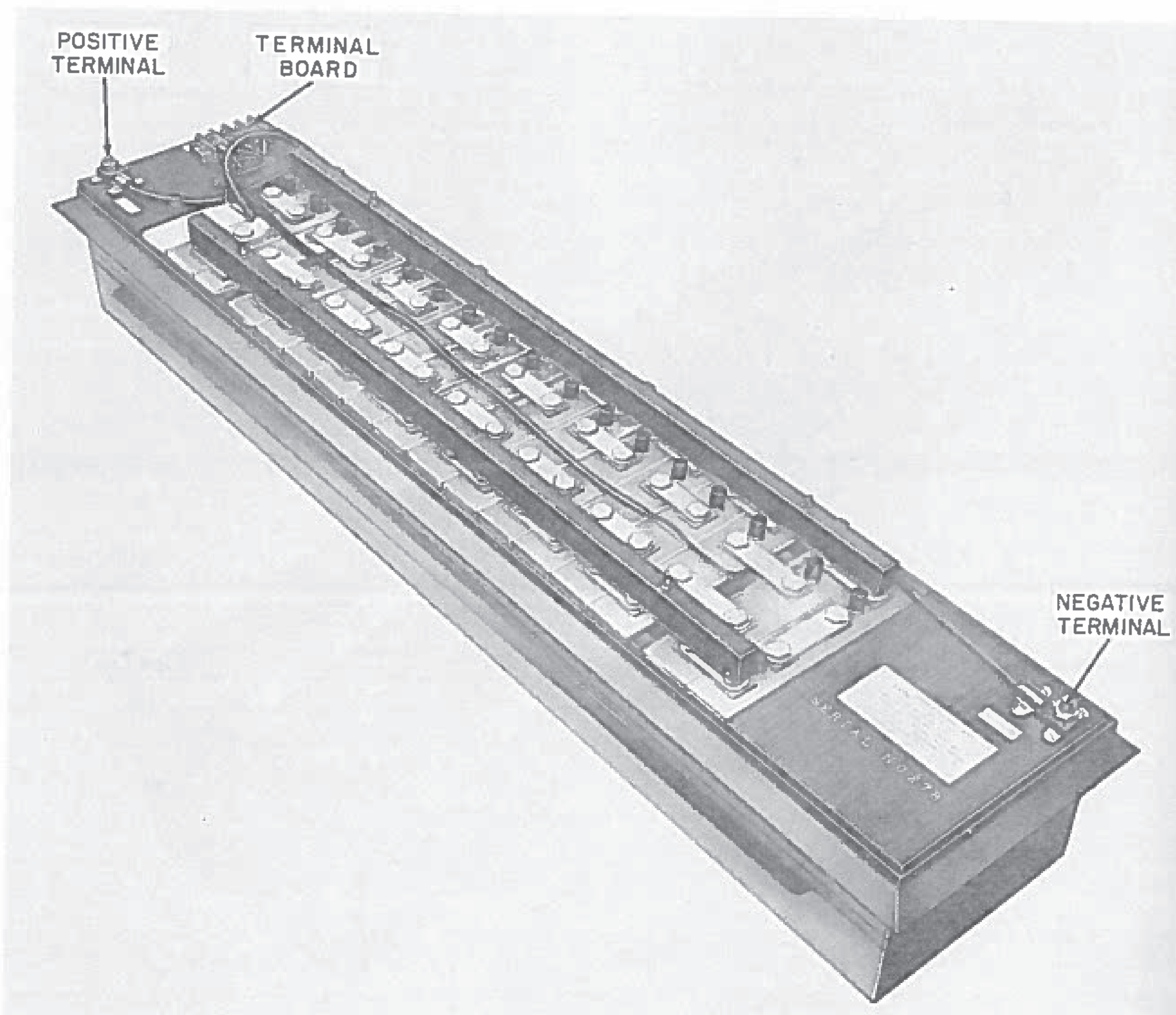

Figure 111—Exercise Battery Mk 8 Mod 4.

Table 21—Battery Characteristics

Storage Battery Mk	Storage Battery Mod	Use	Part No.	No. of Cells	Weight Filled (pounds)	Rated Discharge Current (amp.)	Rated Discharge Time (minutes)
7	3	War	TG7527	30	410	210	12.0
8	4	Exercise		33	311	210	9.0

The battery cells are constructed with lead peroxide on the positive plate, and pure spongy lead on the negative plate. The electrolyte is dilute sulphuric acid. When the plates are immersed in the electrolyte, a chemical action takes place which builds up a positive charge on the lead peroxide plate, and a negative charge on the pure lead plate. The voltage produced by the chemical action depends to some extent upon the specific gravity of the electrolyte, but is independent of the quantity of active elements. It is approximately 2.06 volts for a specific gravity of 1.210 and 2.10 volts for a specific gravity of 1.280. The size of the cell has no influence on the magnitude of the voltage.

When the terminals of the cell are connected to an electrical circuit, the voltage produced by the charge causes a flow of current and chemical action occurs to maintain the charge. As long as sufficient chemical elements are available, the only limiting factor to this action is the impedance of the electrical circuit. Since the internal resistance of the cell is small (approximately 0.01 ohm, if the cell is in good condition) very large currents are possible. As the cell discharges, both the negative lead plate and the positive lead peroxide plate change to lead sulphate, and the specific gravity of the electrolyte is reduced because some of the acid is used up in forming the lead sulphate and because water is formed in the chemical reaction.

The chemical reaction is reversible by electrolysis. That is, the cell may be restored to its original condition by passing a charging current through the battery. If the density of the charging current is too large, electrolytic action occurs at a faster rate than the chemical reaction. This causes decomposition of the water in the battery with the result that excess oxygen and hydrogen are given off at the plates. This decomposition of the water will cause the specific gravity of the electrolyte to become too great.

Since the specific gravity is reduced during discharge and increased during the charging process, the value of the specific gravity in the cell is a measure of its state of charge. When the specific gravity has decreased to approximately 1.150, the cell is considered to be fully discharged. At lower values of specific gravity, the lead sulphate tends to change from the normal form in which it is deposited to an insoluble form which will not decompose when the cell is recharged. The formation of this insoluble material decreases the amount of active material and thus reduces the capacity of the cell. In addition, the insoluble material forms a coating on the plates which results in a significant increase in the internal resistance of the cell. A cell which has been injured in this manner is said to be "sulphated". Prolonged idleness also causes sulphation unless the cell is kept fully charged. This makes periodic freshening charges necessary.

The open circuit voltage of a fully charged cell is approximately 2.10 volts. When discharged, the open circuit voltage is reduced to approximately 1.80 volts. The capacity of a cell is usually expressed in terms of how great a current it can generate over a period of time, the unit being the ampere-hour. That is, a 100-ampere-hour cell will provide 100 amperes for one hour, or 200 amperes for one-half hour, and so on. Practically all types of lead-acid cells will increase their initial capacity after several charge-discharge cycles, and maintain this increased capacity during the greater part of their useful lives.

Temperature affects both internal resistance and the rate of diffusion of the electrolyte during discharge so that both the capacity and voltage

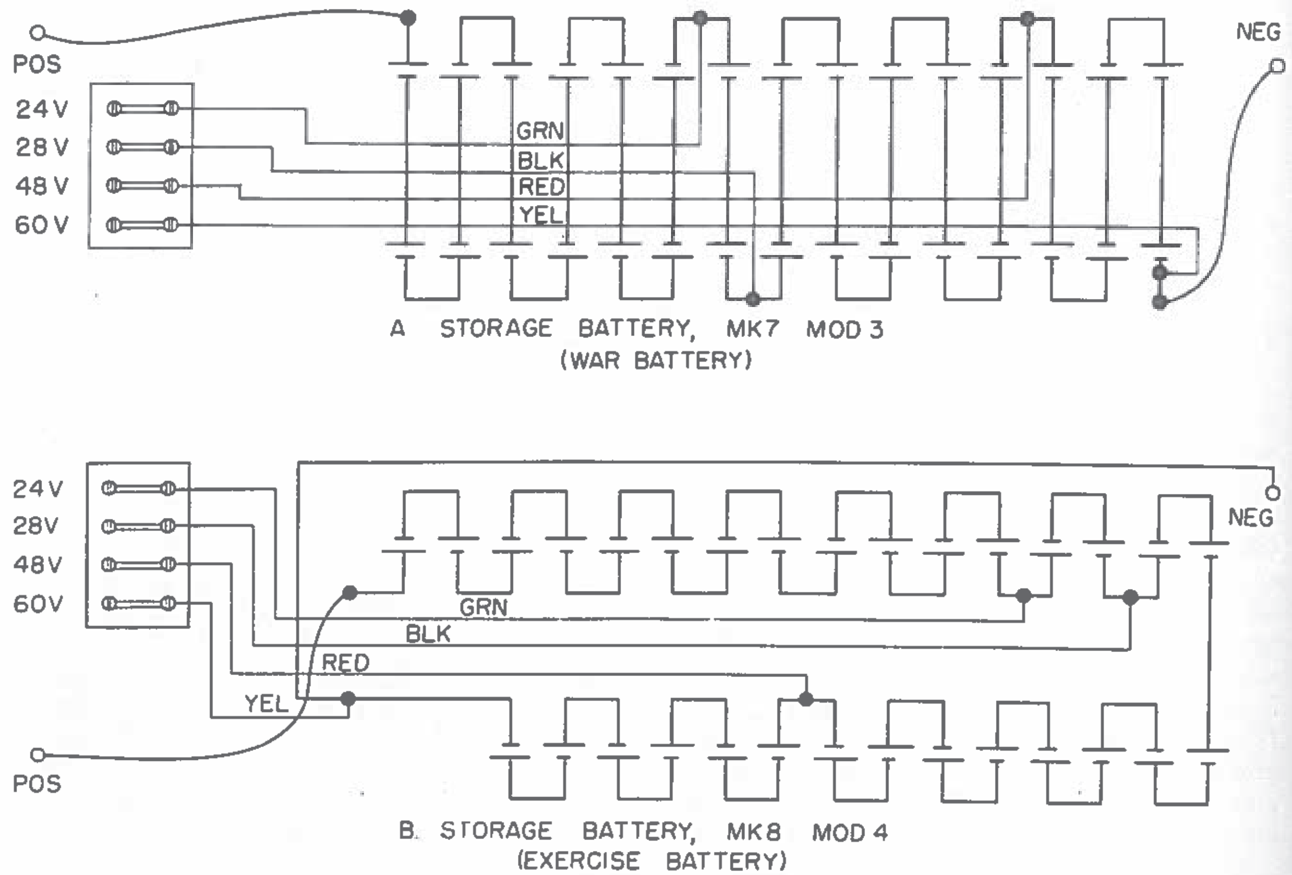

Figure 112—Battery Connections.

are lower at lower temperature, and greater at higher temperatures.

Some latitude is permissible in selecting the rate at which a battery is charged. However, the rate should not be great enough to cause excessive temperatures and gassing. To meet this requirement, a relatively low charging rate must be used during the latter part of the charge. A moderate amount of overcharging may be done without causing serious harm, except for the loss of water. However, excessive overcharging in ampere-hours should be avoided, because the plates may be damaged by excessive concentration of acids and by dislodging of the plate materials.

At the factory, the battery is given a forming charge which forms the lead peroxide and sponge lead on the plates. The plates are then dried rapidly. The battery is assembled dry, sealed, and shipped from the factory in this dry-charge condition. It can be kept in this condition for a year or more if stored in a cool place, out of direct sunlight. When the battery is to be placed in service, it is filled with the proper electrolyte and given an initial charge.

Initial Filling and Charging Procedure

A battery in dry-charge condition should be prepared for service in accordance with the manufacturer's instructions.

> CAUTION: To avoid damage to the battery and to insure optimum performance, these instructions must be followed exactly.

The following general instructions include the essential steps of the initial filling and charging procedure and are given here for purposes of familiarization:

1. Remove vent plugs and fill each cell with prepared electrolyte up to level of stop at bottom of vent.

> NOTE: The electrolyte must be dilute sulphuric acid of sufficient purity for storage battery use. The specific gravity of the electrolyte must be 1.300 corrected to 77° F. and its temperature must be between 32° F. and 50° F.

2. Make certain that separators are completely saturated with electrolyte. This may be accomplished by either of the following methods:

a. After cells are filled to correct level (step 1), permit electrolyte to soak into separators for one hour, then add electrolyte to restore correct level. Thereafter, add electrolyte as needed twice daily, until electrolyte level remains constant at correct point. This is a relatively slow method.

b. Absorption of electrolyte can be accelerated by alternately putting battery under partial vacuum and then exposing it to normal air pressure as follows: After cells are filled to correct level (step 1), place battery in battery compartment of torpedo and bolt afterbody and head to battery compartment. Using vacuum fitting, evacuate torpedo to a pressure of approximately 20 inches of mercury and maintain this pressure for 15 minutes. Then relieve vacuum and after battery has been exposed to normal pressure for 15 minutes, add electrolyte to restore correct level in cells. Repeat entire procedure two more times. Under normal conditions, three cycles of vacuum and normal pressure should result in full saturation of separators.

3. Wipe off any electrolyte spilled on battery. Use a cloth dampened with bicarbonate of soda solution (one pound of soda to one gallon of water).

4. Replace vent plugs in cell.

5. Connect battery to charging circuit. Make certain that positive terminal of battery (marked POS, or +, or painted red) is connected to POSITIVE terminal of charger and that negative terminal of battery (marked NEG, or —, or painted black) is connected to NEGATIVE terminal of charger.

6. Charge war battery at a rate of 3 amperes to 4 amperes or exercise battery at a rate of 2 amperes until four consecutive hourly readings show no increase in specific gravity or voltage for cell having lowest values. If this charge rate is maintained, length of charging time will be at least 18 hours for the war battery and 28 hours for the exercise battery. If temperature exceeds 110° F, reduce charging rate by 25 percent and continue charge for a proportionately greater time. Electrolyte temperature must never be permitted to exceed 120° F. to avoid permanent damage to plates.

7. After completion of charging time, check specific gravity and electrolyte level in each cell. If desired, check voltages. Specific gravity and voltage readings must be corrected as follows for any variation from normal temperature of 77° F: For each 10° F above 77° F, add 0.003 to specific gravity reading and add 0.03 volt to charge voltage for each cell. If temperature is less than 77° F, the same values are subtracted.

> Example: If hydrometer reading is 1.275 and temperature is 87° F, add 0.003 to 1.275 to obtain a corrected reading of 1.278. If voltage on charge is 2.10 volts per cell and temperature is 87° F add 0.03 to 2.10 to obtain a corrected reading of 2.13 volts per cell. Specific gravity for a fully charged cell of war battery should be between 1.280 and 1.285, corrected to 77° F, with electrolyte at a level ⅜ inch above top of separators. Voltage of fully charged cell of exercise battery should be between 2.33 and 2.40 volts.

8. If specific gravity or voltage measured in step 7 is not correct, add a small amount of filling electrolyte to obtain required gravity, or replace some electrolyte with water to decrease gravity. After adding electrolyte or water, mix solution by charging battery for one hour and then measure specific gravity again.

9. When correct gravity value has been obtained, remove vent plugs and wash any accumulated deposit from bottom of vent. Make sure all vent openings are clear and replace vent plugs.

Maintenance, Charging, and Care of Batteries

After a battery has been given its initial charge, it must be kept in good condition by careful treatment and thorough maintenance. (Refer to chapter 7 for patrol maintenance instructions.)

Keep the exterior of the battery clean and dry at all times. Do not store the battery in the battery compartment of a torpedo unnecessarily. If the torpedo is to be stored for a long time, remove the battery. If possible, avoid storing the battery where the temperature is extremely high. Particularly in warm climates, store the battery in as cool a place as possible.

If a charged battery is stored in the battery compartment of a torpedo, the torpedo must be purged of hydrogen ~~at least once each week~~ at least two hours. To purge the torpedo, attach an air line (not less then 25 psi) to the vent fitting inside the after hand hole and pass air through the torpedo for ~~several minutes~~. at least fifteen minutes.

NOTE: The preceding method for charging requires the use of a voltmeter. If no meter is available, reduce charging rate to 4 amperes when pronounced gassing of cells is observed through vent plugs. Charge at 4 amperes and measure specific gravity at hourly intervals. Charge is complete when specific gravity of electrolyte remains same for two successive hourly readings.

While a charged battery is in storage, water must be added and the battery given a freshening charge every 8 to 10 days. (Refer to <u>Patrol Maintenance</u>, of Chapter 7, for maintenance instructions.)

NOTE: The manufacturer of the exercise battery recommends that if the battery is idle it should be charged daily at 4 amperes for 1 to 1½ hours and should be given a refresher each week.

Whenever a battery is used in an exercise or proofing run, it must be recharged within six hours after the end of the run. Add water and recharge the battery as follows:

1. Before charging, remove vent caps and use filling and leveling syringe to add enough pure water to bring electrolyte up to level of stop in vent.

NOTE: Only distilled water should be used for this purpose. However, if distilled water is not obtainable, drinking water may be used if it is known to contain no excessive chemical impurities.

2. Replace vent caps.

3. Charge battery at a start rate of 8 amperes. Continue charging until voltage across "+" and "−60" terminals is 72 to 74 volts while charging current is flowing. Make this measurement with a voltmeter.

4. After voltage specified in step 3 is obtained, reduce charging rate to approximately 4 amperes. Continue charging at this rate and measure voltage as in step 3 at hourly intervals. Charge is complete when voltage remains same for two successive hourly readings. Specific gravity should also stay constant on charge at some value between 1.270 and 1.285. (If battery has been discharged or has been in storage for an extended period, check all cells individually before releasing battery for service.)

5. Replace vent caps and remove any electrolyte spilled on battery.

atteries, observe the following precautions:

1. Charge storage batteries only in a well-ventilated room. In a confined space, hydrogen gas evolved in charging may result in an explosive mixture. Keep all flames away. Do not smoke in areas where batteries are charged, or where charged batteries are stored.

2. To avoid possibility of explosion due to electric sparks, always be sure charger is turned off before connecting or disconnecting a battery. Break electrical connections at points remote from battery.

3. After a battery has been given an initial charge, keep battery (or a torpedo containing a charged battery) in as cool a place as possible. Preferably, storage temperature should be below 60° F. If stored in a warm place, battery will lose its charge more rapidly, and require more frequent recharging. However, before torpedo is used, battery temperature should be 70° F or more, otherwise power that can be drawn from battery is reduced.

4. Do not store battery in a torpedo unnecessarily. Remove battery if torpedo is to be stored for a long time.

5. Keep battery dry and clean.

6. Be sure to maintain level of electrolyte above top of plate separators. Add PURE water only. Avoid over-filling.

7. Never add electrolyte, except to replace a known loss due to spilling. Any electrolyte added should be of same specific gravity as electrolyte in adjacent cells.

8. Never permit any foreign matter to get into cells of battery.

9. Never permit temperature of battery to exceed 125° F. Charge at rates low enough to keep cell temperature below 115° F.

10. Never allow battery to gas violently, or material will be dislodged from plates. While cells are gassing, do not charge at rates higher than specified by manufacturer.

11. Keep idle batteries fully charged. Do not "trickle" charge unless recommended by manufacturer.

12. Take specific gravity readings only when electrolyte is thoroughly mixed.

13. If any cell heats while battery is standing idle, examine it for a short circuit, or internal current. Short circuits can be caused by impurities in electrolyte, buckled plates, excessive sediment in cell, defective separators, or spilled electrolyte on top of battery.

14. Do not permit battery to stand uncharged in cold weather, as it may freeze. A fully charged battery will freeze at approximately −92° F.

15. Inexperienced personnel must never mix battery acid. In making solutions from concentrated acid (1.835 specific gravity), pour acid into water slowly. NEVER POUR WATER INTO ACID. Use an acid-proof container, such as a hard rubber vat, for mixing. Wear splash-proof goggles.

16. Overcharging storage batteries can cause excessive gassing which may raise the hydrogen content in the torpedo in spite of the palladium catalysts. To avoid possible explosions from such a condition, allow any battery that has been refreshed to ventilate for <u>two</u> hours. Low pressure air should then be used to purge any accumulated gases. An explosimeter reading should be taken on any torpedo which must be used without a full ventilation cycle. Refer to OP 1516, "Lead-Acid Batteries for Torpedoes" for further information.

Chapter 14

WORKSHOP AND PROVING GROUND EQUIPMENT

Section 14.1—Introduction

Various items of test and accessory equipment are used in adjusting and maintaining Torpedo Mk 27 Mod 4 and in conducting exercise and proofing runs. This equipment includes the following items:

- General Purpose Equipment
  - Signal Generator TS-382/U
  - Oscilloscope OS-8A/U
  - Multimeter TS-352/U
  - Vacuum Tube Voltmeter AN/OSM-34
  - Attenuator TG-7244
- Test Set Mk 183 Mod 0 (Dwg. 794437)
- Gyro Test Stand (Dwg. 827496)
- Sound Measuring Set Mk 1 Mod 0
- Target Torpedo Mk 1 Mod 0
- Ordnance Locator Mk 1 (Torpedo) Mods 1 and 2

The sound-measuring set, target, and ordnance locator are described in other ordnance pamphlets. (Refer to list of references in chapter 1.) Therefore these items are not covered in this chapter. Some of the items of the general purpose equipment have instruction books supplied with them and accordingly, these items are treated briefly in this chapter to clarify their use with Torpedo Mk 27 Mod 4. The other items of equipment are described in this chapter and their use is explained. Where applicable, the instructions for these items include information on their adjustment, overhaul and maintenance. The individual items are covered in separate sections. Each of these sections may be used independently of the others and constitutes a complete set of instructions for the item. Refer to list of references in Chapter 1, for added information on Workshop Equipment.

Section 14.2—General Purpose Equipment

Description and Function

In the following paragraphs, each item of the general purpose equipment is described briefly and its function is explained.

Attenuator Test Set TG 7244. The attenuator test set, figure 113, is a self-contained portable unit which is designed to attenuate a given input signal and then apply plus and minus differentials of the attenuated input to the output jacks. The unit is used in conjunction with either the noise generator or pure-tone signal generator.

The input signal level to the control panel is varied by means of a 100 db (10 db per step) attenuator and a 10 db (1 db per step) attenuator. The output of these attenuators is applied to a differential attenuator which can produce differentials up to 11 db (variable in 0.5 db steps) to either of the two pairs of hydrophone-simulating networks and output cables. Each hydrophone-simulating network consists of a 0.1 microfarad series blocking capacitor, and a 0.39 megohm resistor shunted in the output by a variable capacitor. The output of the hydrophone-simulating networks is fed into two special coaxial cables which simulate the cables attached to the hydrophones in the torpedo. The attenuator output simulates the torpedo's horizontal (side) hydrophones, or the torpedo's vertical (top and bottom) hydrophones.

The attentuator test set also contains a potentiometer which simulates either the rudder or elevator follow-up potentiometer of the torpedo for tests, and a 1.5 volts bias-voltage supply which can be used to suppress the AVC voltage during certain tests of the control panel.

Audio Oscillator TS382/U. The audio oscillator, figure 114, is a self-contained pure-tone signal generator which serves as a source of pure-tone voltage for making control panel measurements.

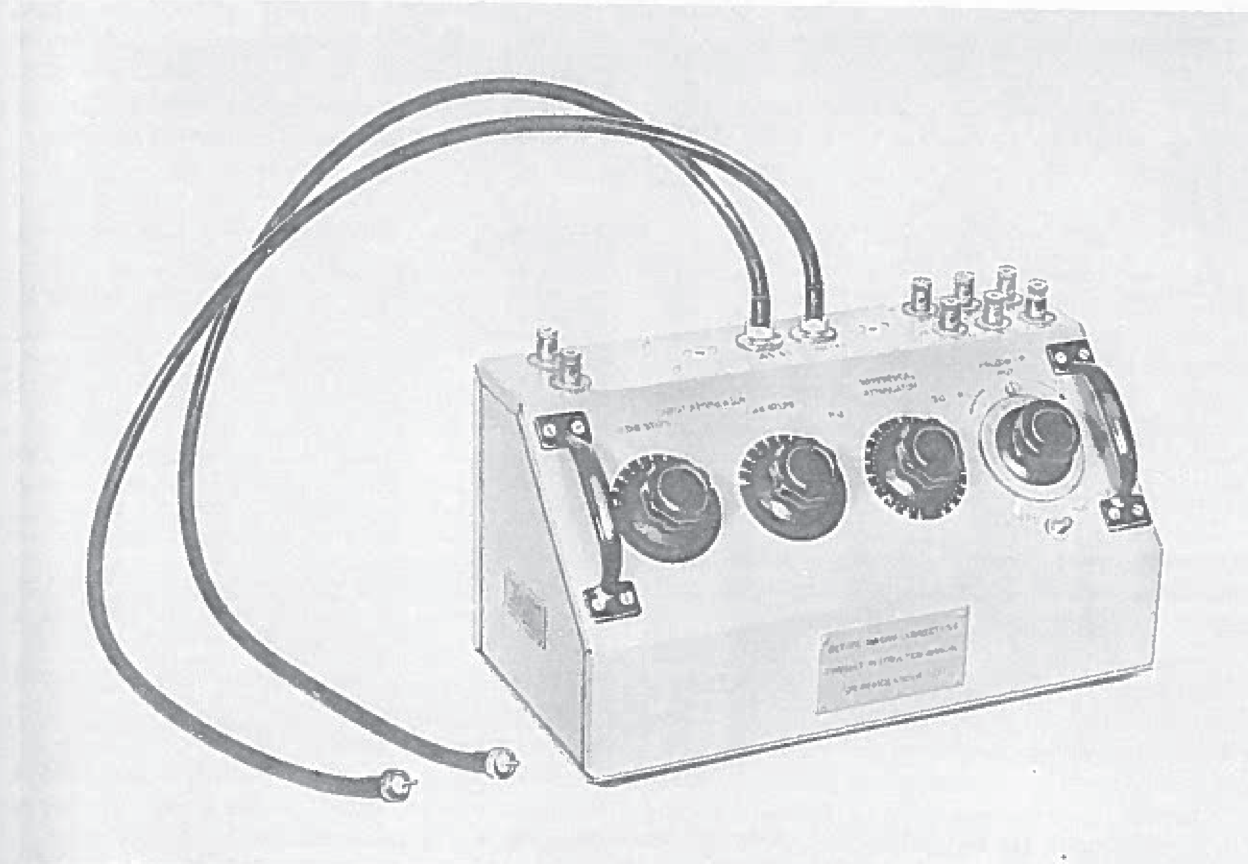

Figure 113—Panel Test Set TG7244.

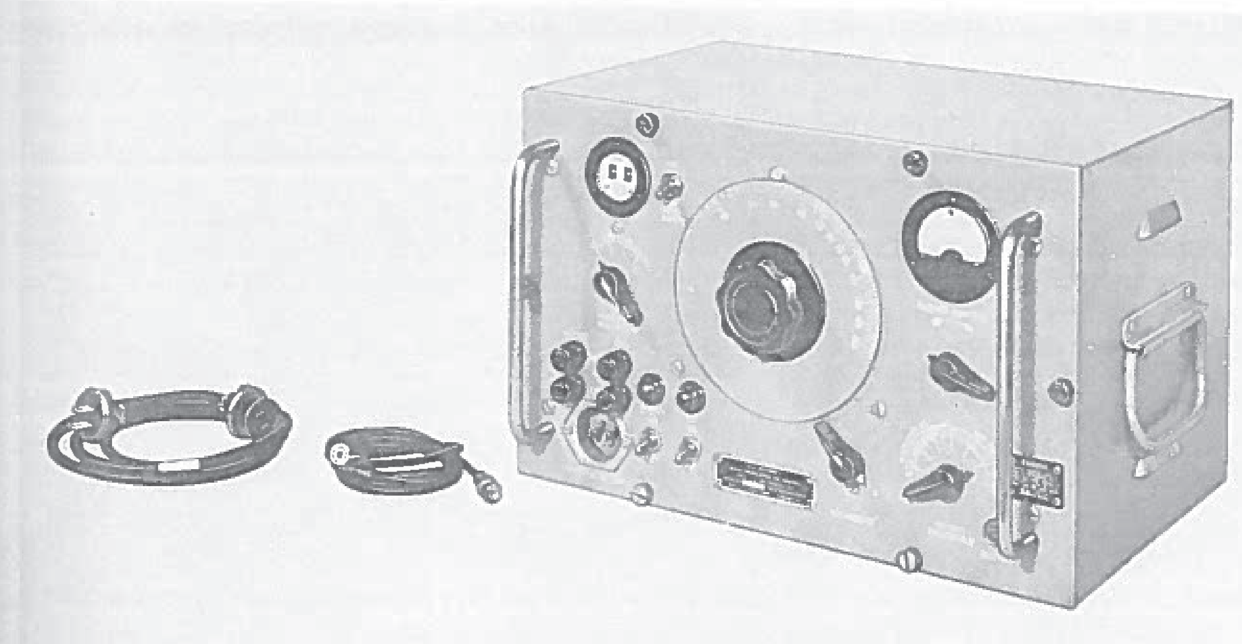

Figure 114—Audio Oscillator TS382/U.

The output frequency of this unit is variable from 20 to 200,000 cps. The frequency range (with an accuracy of ±2 percent of dial calibration) is covered in four bands and may be selected by a range switch as follows:

Band 1 20 to 200 cps.
Band 2 200 to 2000 cps.
Band 3 2000 to 20,000 cps.
Band 4 20,000 to 200,000 cps.

The output voltage is variable from 0 to 10 volts on all bands while the output power is 100 milliwatts and the rated load is 1000 ohms (resistive). The power supply is 115 volts, 50 to 1600 cps. For complete circuit details and operating instructions, refer to the instruction book supplied with the equipment.

Cathode-Ray Oscilloscope OS-8A/U. The cathode-ray oscilloscope, figure 115, is a conventional test oscilloscope and is used for tracing signal voltages through the control panel.

The oscilloscope uses a cathode ray tube with a 3-inch screen and has a linear time base with a horizontal sweep range of 3 to 50,000 cps. The necessary operating power supply is 104 to 126 volts, 60-cycle AC. For complete circuit details and operating instructions, refer to the instruction book supplied with the equipment.

Vacuum Tube Voltmeter AN/USM-34. The vacuum tube voltmeter, figure 116, is a multi-purpose instrument and may be used for measuring AC and DC voltages and all resistances which will ordinarily be encountered in the control panel. The unit is shipped with the necessary probes to facilitate taking voltage measurements across the high impedance tube circuits in the control panel. The input impedance is about 12 megohms and the necessary power supply is 115 volts, 60 cycle AC. The complete circuit details and operating instructions are available in the instruction book supplied with the equipment.

Operating Instructions

When measurements in the control panel circuits are made with the general purpose test equipment, the following procedure should be followed:

1. Place the test equipment on a workbench or table, and connect the power input cords to a source of 115-volt, 60-cycle AC power.
2. Turn the power switches of the signal generator, cathode-ray oscilloscope, and the vacuum tube voltmeter to ON.
3. With a patch cord, connect the output terminals of the signal generator to the input terminals on the panel test set.
4. Set the signal output control switch (BAND) of the signal generator to X1000 and adjust the

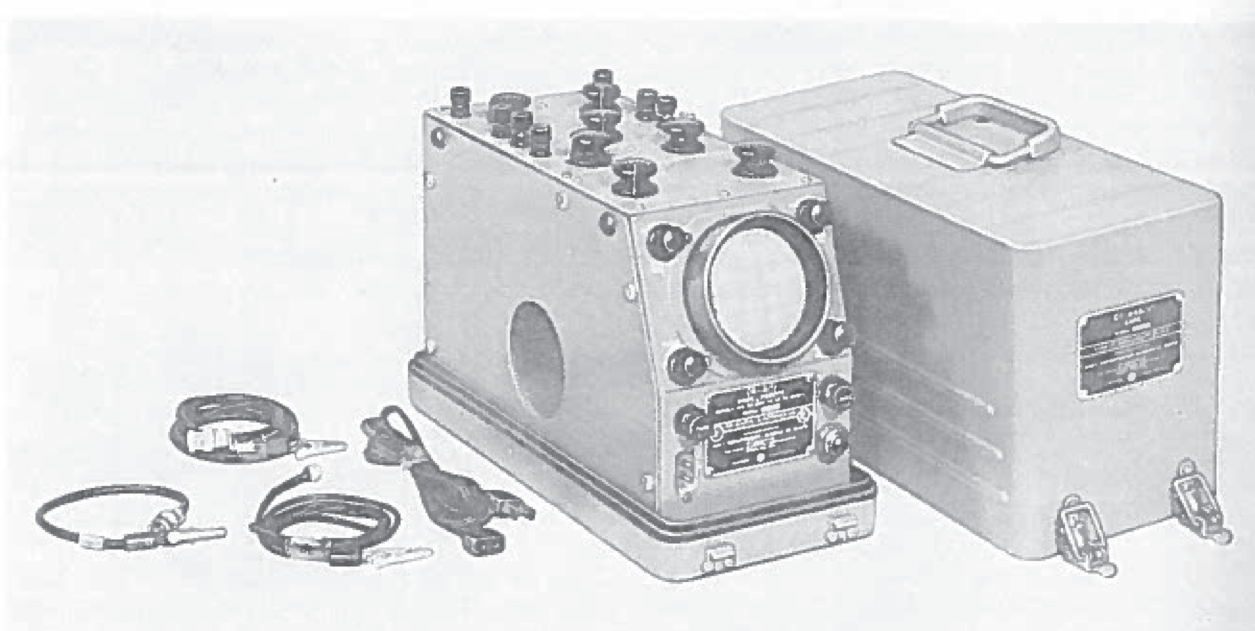

Figure 115—Cathode-Ray Oscilloscope OS-8/U.

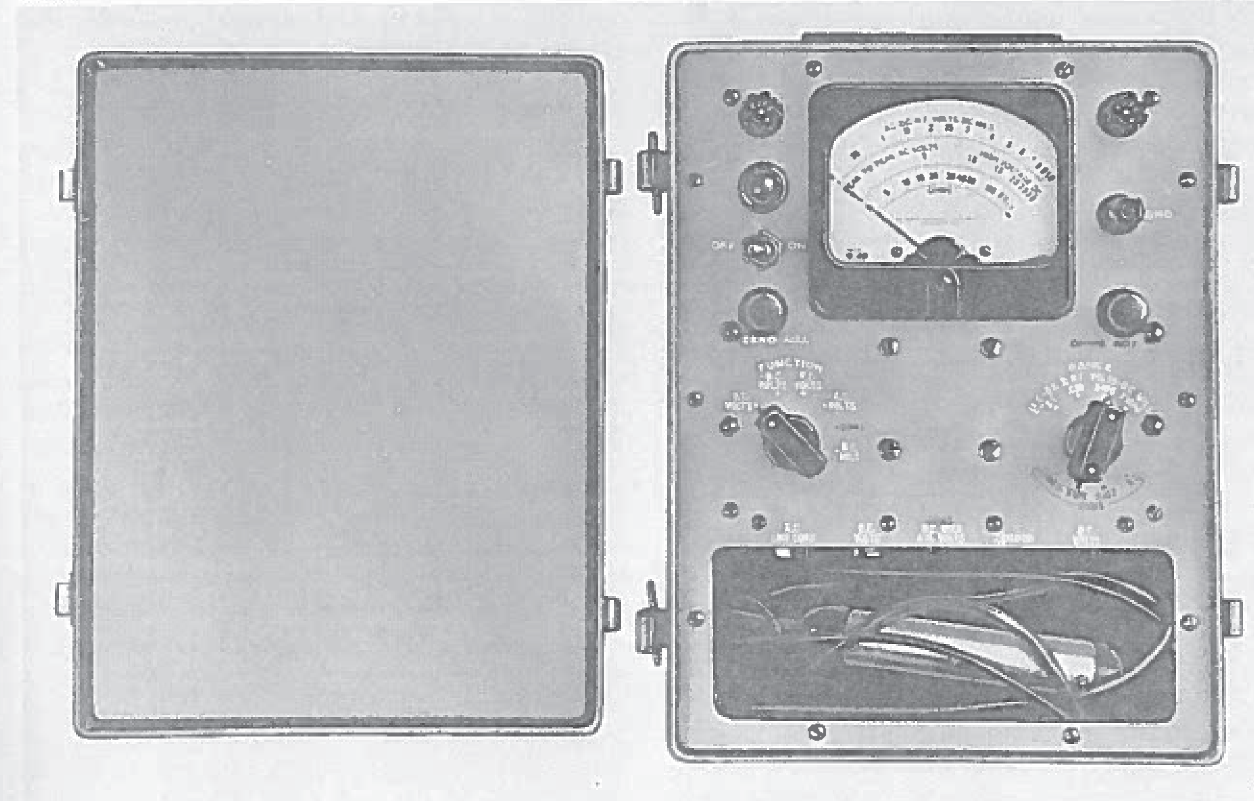

Figure 116—Vacuum Tube Voltmeter AN/USM-34.

frequency control knob to 24.5 kc. Adjust the output-level knob of the signal generator so that the voltmeter indicates exactly 2 volts. The pure-tone signal level fed into the hydrophone-simulating networks may now be read directly from the two attenuators marked DB LEVEL by adding the readings of the two. The sum is the signal level in db below 1 volt.

5. The variable condensers of the hydrophone-simulating networks of the test set are adjusted by the manufacturer to function with the particular coaxial cords furnished with the set. The shafts of the condensers are accessible through holes in the test set case adjacent to the output jacks and can be turned by a small screwdriver, after the caps covering the holes have been unscrewed. Care should be taken not to disturb the adjustment unnecessarily. If, however, the coaxial cords have been replaced, or if it is suspected that the set is out of adjustment, proceed as follows: On a torpedo control panel known to be in good operating condition, determine the frequency of maximum response of one of the horizontal channels by the procedure given in chapter 11. Connect one of the test set output cords to the port control panel jack. Adjust the signal-generator frequency to obtain a maximum voltmeter reading. Then, leaving the signal generator set at this frequency, adjust the variable capacitor associated with the connected test set output cord to obtain a maximum voltmeter reading. Continue to adjust both the signal-generator frequency and the variable capacitor alternately until a maximum voltmeter reading is obtained. Repeat these adjustments, using the other test set cord of the same pair connected to the same control panel input jack. When both variable capacitors have been thus adjusted, connect first one and then the other cord to the control panel, using the same input-attenuator setting and the same panel jack for both. The voltmeter reading should be the same for both cords. If the voltmeter readings differ by more than 2 volts, the hydrophone-simulating networks or the test set may be defective. The same procedure may be used to adjust the variable capacitors associated with the UP and DOWN channels of the test set.

6. For making control panel measurements, the two hydrophone-simulating test cables may be plugged into the control panel jacks and the channel to be tested will be dependent upon the position of the jacks on the control panel.

7. The terminals marked B1, B2, B3, B4, B8, B10, and B12, the follow-up potentiometer, and the ELEVATOR-RUDDER switch on the test set panel constitute a follow-up potentiometer simulating network which is intended for use in testing the control panel of Mine Mk 24 independently of the mine. If it is desired to use this circuit for testing the follow-up circuits of Torpedo Mk 27 Mod 4, it will be necessary to open the resistor box on the reverse side of the test set panel and change the values of some of the resistors shunting the follow-up potentiometer. The values of the resistors to be changed can be determined by studying the follow-up circuits of Torpedo Mk 27 Mod 4.

8. If it is desired to use the −1.5-volt DC AVC suppressing voltage of the test set, first check the output voltage of the single flashlight-type cell. This voltage should be within −0.15 volt of the specified −1.5 volt, and should have the correct polarity.

9. The oscilloscope is of conventional design, and is used in the same manner as any commercial test oscilloscope.

10. Included with the general purpose test equipment are instruction manuals containing operating instructions and circuit diagrams.

Maintenance Instructions

Most of the general purpose test equipment does not require any active maintenance other than the usual good care applied to commensurate precision apparatus. Should servicing be required, examination of the schematic and wiring diagram of the unit should enable any qualified electronic technician to locate and correct any faults that may occur.

Substitute Test Equipment

The following items of test equipment may also be used for testing the torpedo control circuits:

Signal Generator. An audio signal generator furnishing 225-cycle and 24.5-kilocycle signals is necessary for testing the frequency response of the panel circuits. A Hewlett-Packard Audio Oscillator, Model 200D, or any equivalent commercial signal generator, is suitable for this purpose.

Voltmeters. Pure-tone measurements must be made with a measuring instrument whose readings are equivalent to those of a thermocouple meter. A vacuum tube voltmeter is satisfactory for this purpose, provided that it has an input impedance (at 24.5 kc) of approximately 11 megohms, and is calibrated to read 0.707 of the peak of a sine-wave voltage. The RCA Advanced Voltohmyst, Model WV75A, the Measurement Corporation Vacuum Tube Voltmeter, Model 62, the Hickok Model 512, or any other equivalent voltmeter, will be satisfactory.

Cathode-Ray Oscilloscope. Any reliable commercial cathode-ray oscilloscope will be adequate for making the measurements and observations required for the control panel tests. The DuMont Cathode-Ray Oscilloscope, Model 164E, the RCA Cathode-Ray Oscillograph, Model 155C, or any other oscilloscope of equivalent quality, will serve.

Voltohmmeter. Any laboratory-type voltohmmeter may be used for making the resistance measurements required for the control panel tests. If available, the RCA Advanced Voltohmyst, Model WV75A, or Hickok, Model 512, listed above as satisfactory vacuum tube voltmeters will be suitable.

Section 14.3—Test Set Mk 183 Mod 0

General

Test Set Mk 183 Mod 0, figures 117 and 118, is used in the testing and exercise firing of Torpedo Mk 27 Mod 4 and in the testing of the gyro and enabler assemblies of the torpedo. Test Set Mk 183 Mod 0 simulates those portions of Fire Control Systems Mk 101 and Mk 106 that pertain to Torpedo Mk 27 Mod 4. These portions include Switch Box Mk 5 Mod 0, Firing Panel Mk 29 Mod 0, Control Panel Mk 73 Mod 0, Relay Transmitter Mk 20 Mod 0, and Amplifier Mk 58 Mod 0.

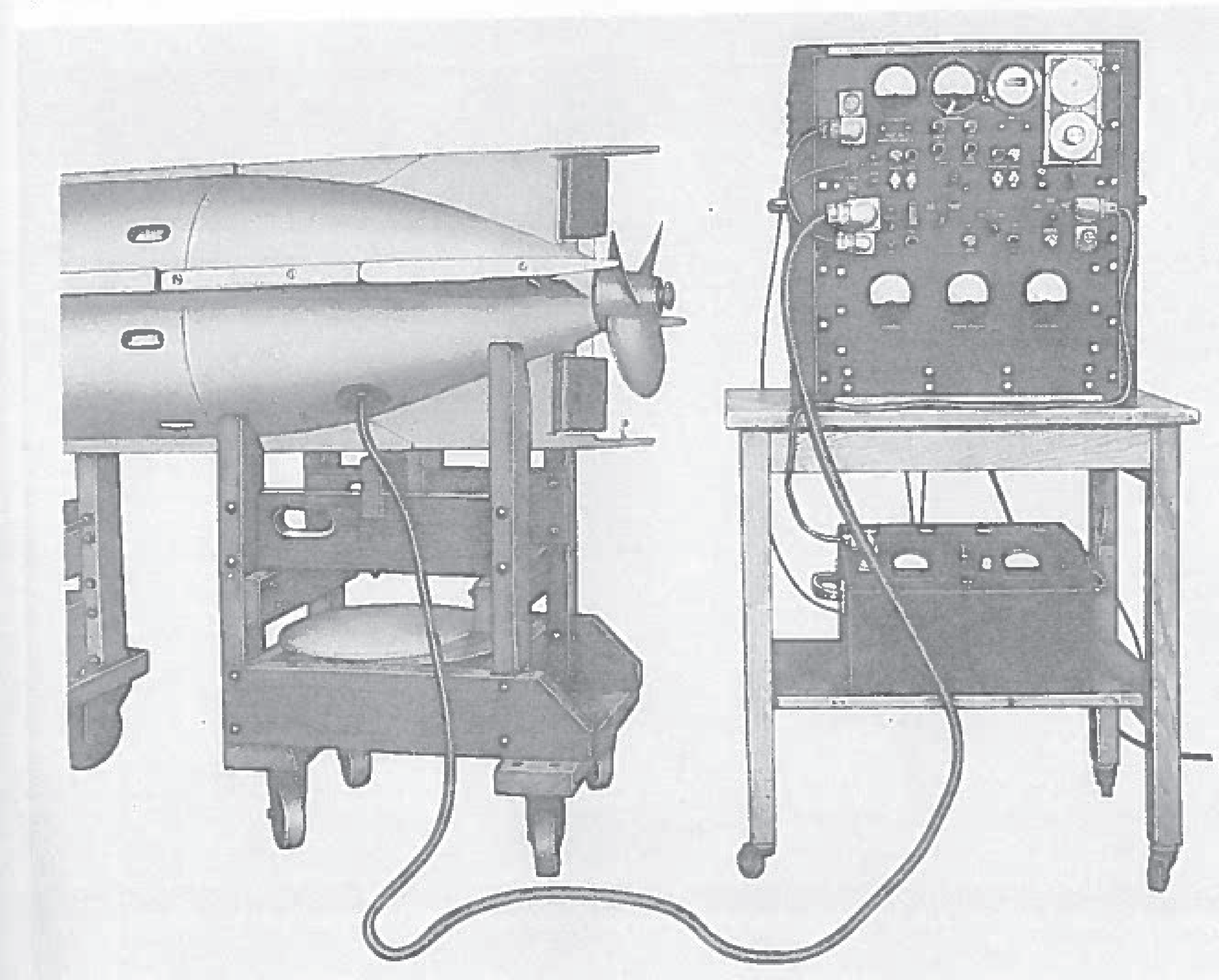

Figure 117—Test Set Mk 183 Mod 0 Connected to Torpedo.

Description and Functioning

Test Set Mk 183 Mod 0 consists of the following three main components assembled in a cabinet:

- B Power Supply
- Electronic Chassis
- Switching Panel

In addition, the following auxiliary equipment exists and is supplied if specifically ordered:

- DC Power Supply, Dwg. 794443 (4 batteries required, Dwg. 779059)
- Gyro Cable, Dwg. 779100
- Enabler Cable, Dwg. 779101
- Switching Input Cable, Dwg. 779102
- Torpedo Power Cable, Dwg. 779105
- −24-V., −48-V. Power Cable Assembly, Dwg. 779103
- Workshop Fire Control Cable, Dwg. 794483
- Exercise Fire Control Cable (below water), Dwg. 794485

B Power Supply. The B Power Supply, which is the bottom unit shown in figure 117 and which is shown in detail in figure 119, is supplied with 115-volt, 60-cycle AC and provides the voltage outputs shown in table 22.

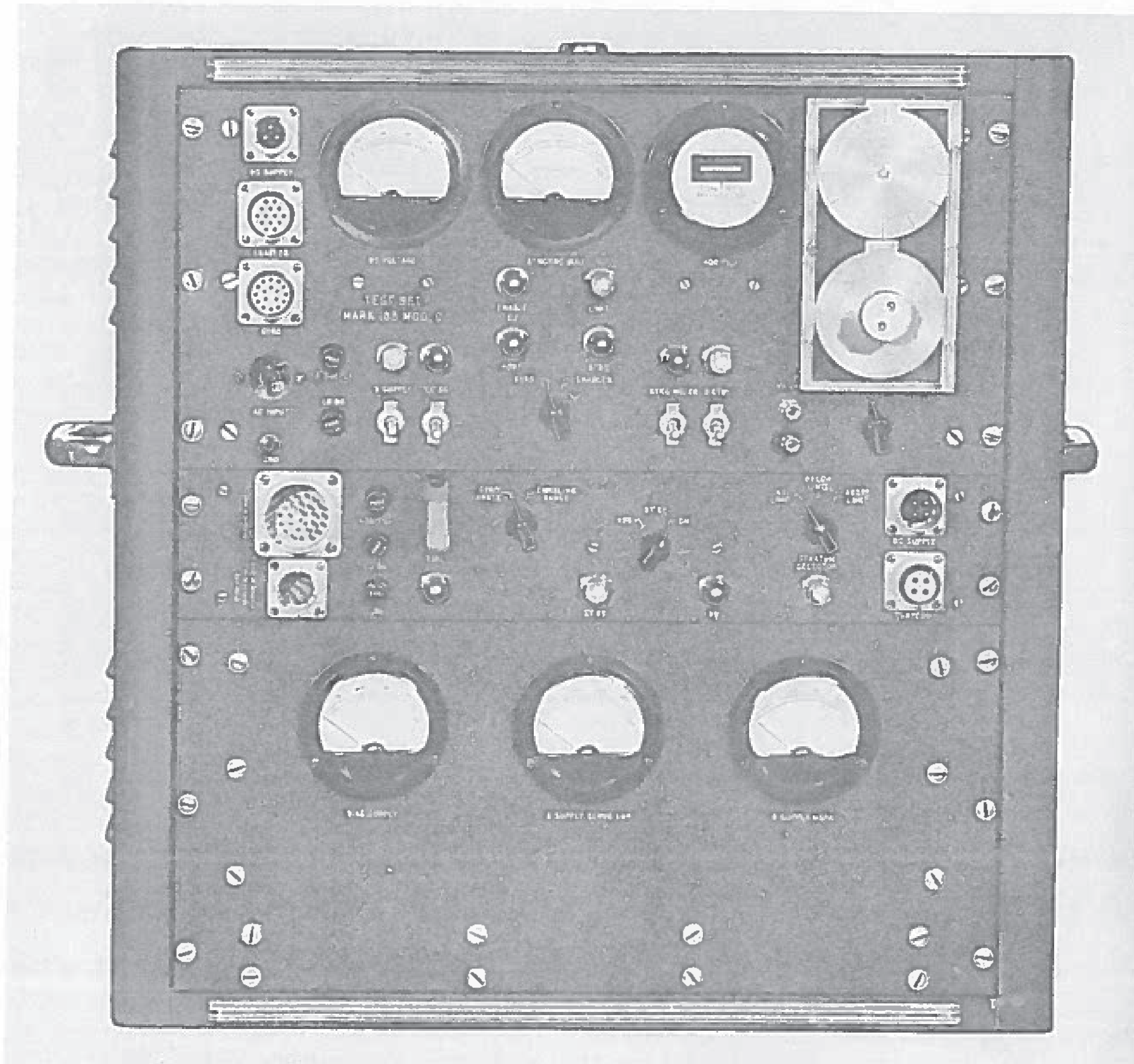

Figure 118—Test Set Mk 183 Mod 0, Panel.

Three of the voltages shown in table 22 are monitored by means of meters on the front of the unit. The meter on the left measures the —30-volt bias supply for the MOPA, the center meter measures the 300-volt supply, and the meter on the right measures the 400-volt supply.

Electronic Chassis. The electronic chassis is the upper panel in figure 118. The chassis is shown in detail in figure 120. Two voltages are monitored by means of meters on this panel. The meter at the left measures the voltage supplied through the DC supply connector at the upper left, and the meter in the center of the unit is a 0 to 200 microampere meter used as the synchro null indicator. The null indicator meter is used to determine whether the gyro or enabler synchro is following properly, and is used to provide some measure of the accuracy of the setting. The meter at the right is a frequency meter centered at 400 cps and calibrated from 380 to 420 cps in 5 cps steps. This meter provides a rough check on the MOPA output voltage frequency.

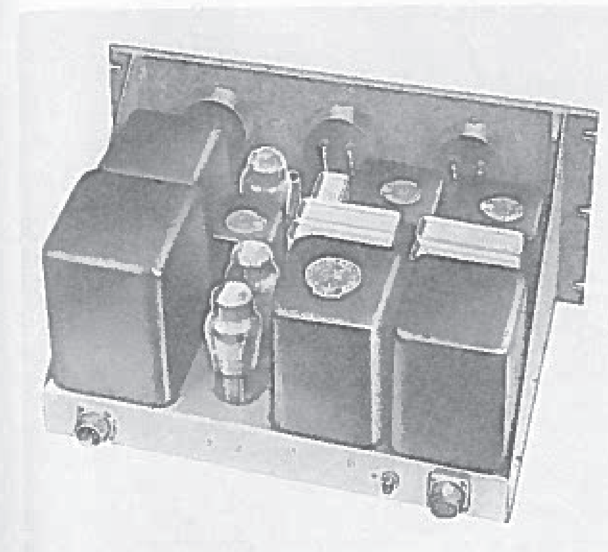

Figure 119—B Power Supply.

Table 22—B Power Supply Voltage Outputs

Voltage Output	Purpose
300 volts DC at 300 ma	Servo amplifier plate supply and MOPA screen supply.
400 volts DC at 200 ma	MOPA plate supply.
150 volts DC at 5 ma (regulated).	Servo amplifier plate supply (input stages).
—30 volts DC at 1 ma	MOPA bias supply.
6.3 volts, 60-cycle AC at 5.5 amp.	MOPA servo amplfier heaters.

The range and angle control for setting the synchronous function is located on the right side of the panel. This assembly consists of a 12-to-1 gear train and associated dials by means of which the desired range may be set into the enabler or the desired gyro angle may be set into the gyroscope. The dials are calibrated both in degrees and yards, the reference point on the dial being 0 degrees or 1000 yards. These values correspond to the electrical zero setting of the synchro control transformer.

The OPERATE-SYN ZERO switch is located directly beneath the range and angle control. When this switch is set to the right, circuits are automatically established so that the control transformer can be electrically zeroed by obtaining a minimum reading on a vacuum tube voltmeter connected to the GR terminals to the left of this switch. With this switch thrown to the left, the individual gyro or enabler assemblies can be checked through the GYRO or ENABLER cable connectors located on the left side of the panel. The GYRO-ENABLER switch in the lower center portion of the panel is used to select DC circuits used for checking the gyroscope or enabler. With this switch in the ENABLER position, the DC circuits in the enabler unit are energized, thus permitting performance of the enabler to be checked by means of the ENABLER and LIMIT lights in the center of the panel and by means of the synchro null indicator. When the switch is in the GYRO position, the DC circuits in the gyro unit are energized and the performance of the gyro can be checked by means of the pilot lights marked PORT and STBD and by means of the synchro null indicator. A special ground lead may be plugged into the ground jack located in the lower left corner of the panel in order to provide a ground return for the gyro motor power.

The DC SUPPLY connector located in the upper left corner of the panel may be connected to the DC power supply or to any other source of 24-volt DC while the test set is used for testing either the gyro assembly or enabler assembly. The 110-volt, 60-cycle input connector is located between the GYRO cable connector and the ground terminal on the left side of the panel. Four power control switches and corresponding pilot lights are located along the lower side of the panel. The B SUPPLY switch to the left is used to energize the heaters of the vacuum tubes in the MOPA and in the servo amplifier and also to energize the heater of the bias rectifier in the B power supply. This switch also controls power to a ventilating fan. The LO DC switch to the right supplies 24-volt DC power.

The GYRO MOTOR switch supplies 24-volt DC power to the gyro motor if the ground jack in the left corner of the panel is connected. The B STBY switch is used to energize the plate transformers in the B power supply. The fuse labeled B SUPPLY protects the 110-volt, 60-cycle circuits. This fuse is rated at 10 amperes and is located between the B SUPPLY pilot light and the 110-volt, 60-cycle input. The LO

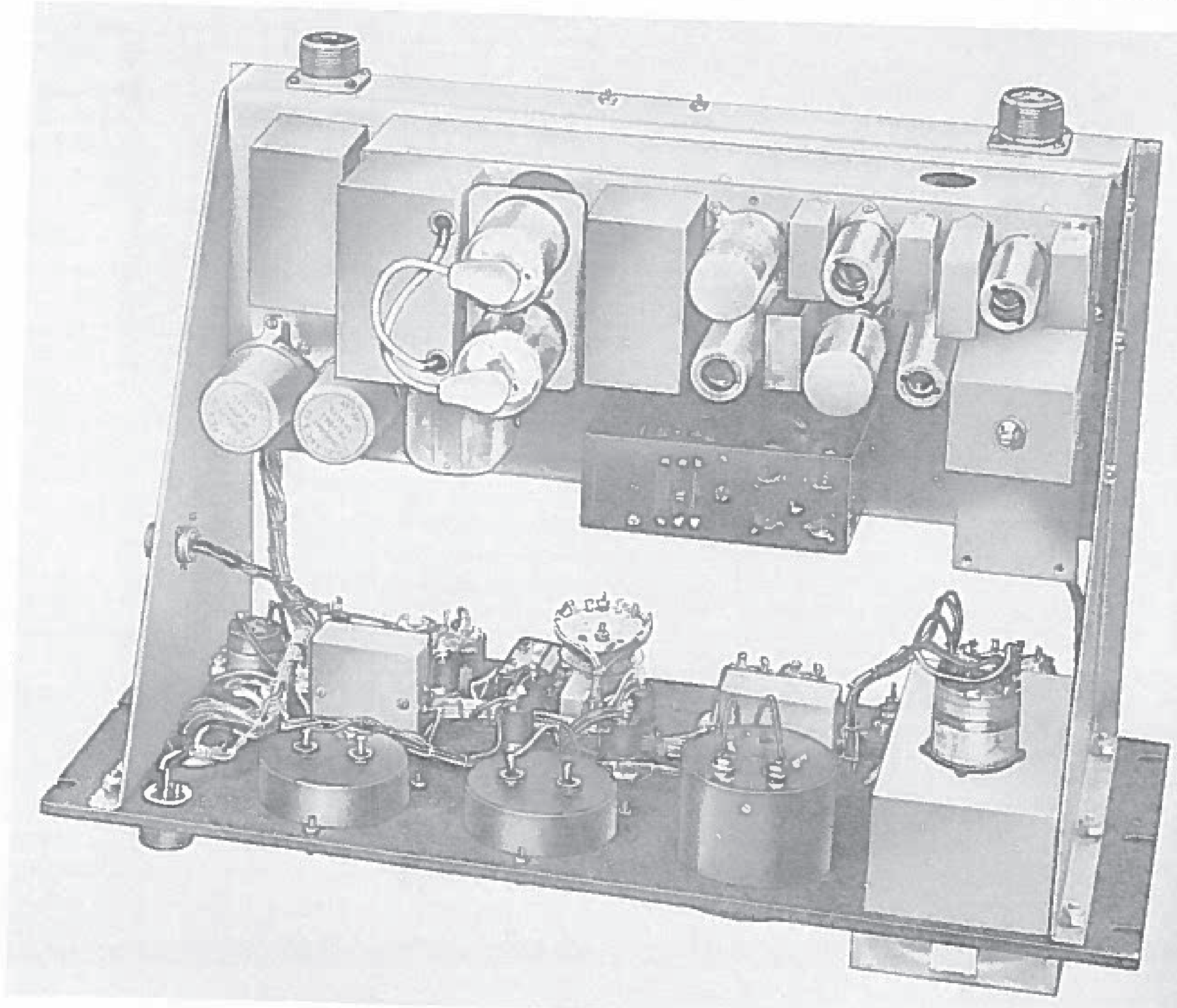

Figure 120—Electronic Chassis.

DC fuse is located directly beneath the B SUPPLY fuse. This fuse is rated at 5 amperes.

The servo amplifier and the associated resonant damp and filter networks for the servo system are mounted on the electronic chassis behind the panel. All of these components are standard items used in Fire Control Systems Mk 101 and Mk 106.

The MOPA is a self-contained, plug-in oscillator unit which supplies 400-cycle, 115-volt power. This unit provides all of the 115-volt, 400-cycle power required for operating the servo system. Figure 121 shows the location of the frequency adjustment on top of the oscillator assembly and figure 122 shows the amplitude adjustment on the resistor board within the assembly.

Switching Panel. The switching panel, located in the center of the test set, figure 118, is used in workshop testing or exercise firing of a complete torpedo. Provision is made for connecting the switching panel to the electronic chassis by means of the switching input cable connected to the GYRO connector on the electronic chassis and the GYRO INTER-CONNECT connector on the switching panel. Just above the GYRO INTER-CONNECT connector is a connector labeled TORPEDO. This connector accommodates any one of the various cable assemblies which connect directly to the afterbody shell

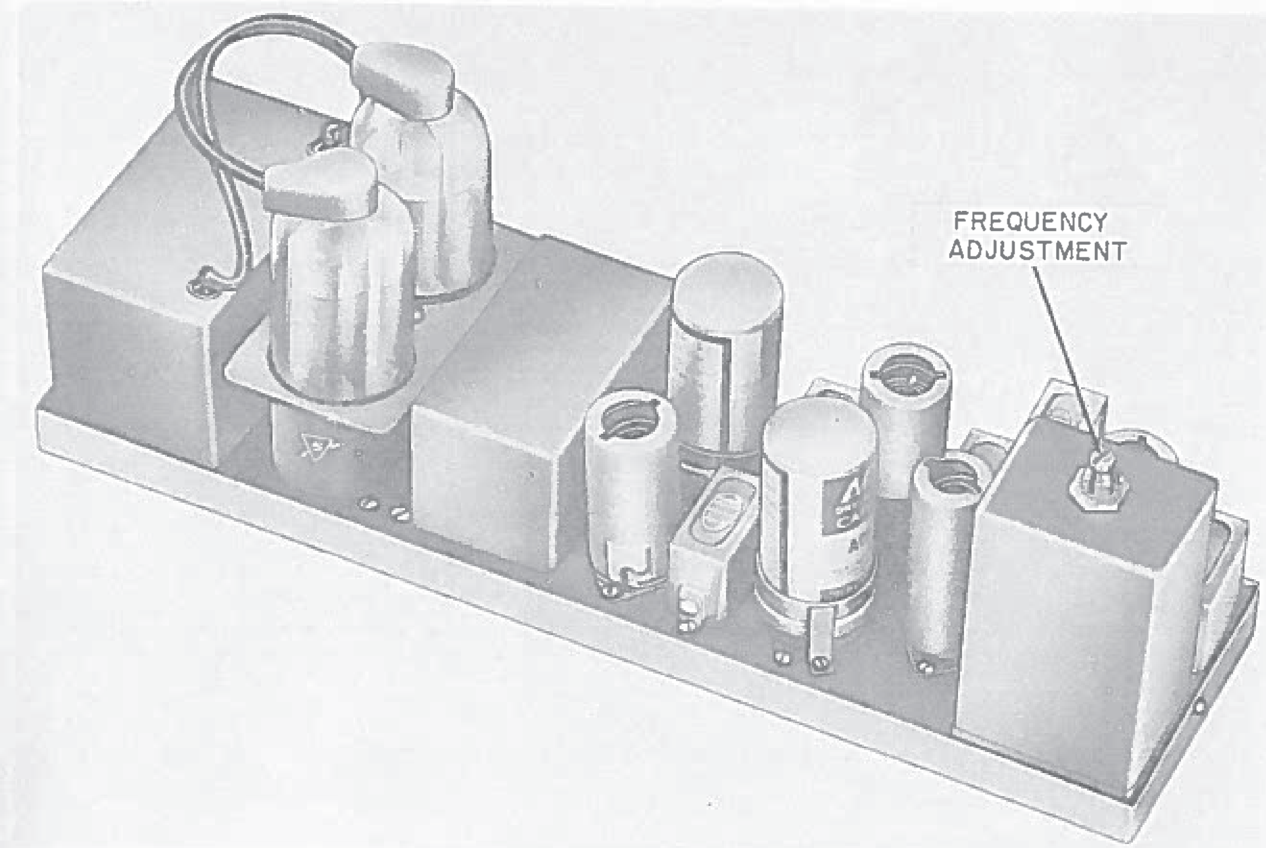

Figure 121—MOPA (Master Oscillator Power Amplifier), Top View.

connector on the torpedo or connect to tube door connectors.

In the upper right hand corner of the panel is a connector labeled DC SUPPLY. This connector accommodates the —24-V., —48-V. power cable which can be connected to a torpedo propulsion battery or to a workshop DC power supply, figure 123. The —24-V., —48-V. cable is used to supply —24 volts DC and —48 volts DC to the switching panel. Below this connector is another connector labeled TORPEDO. This connector receives the torpedo power cable which connects the —24-volt and —48-volt DC power source to the torpedo power lead located inside the forward handhole cover. Through the use of these two cables and an external DC power supply, the torpedo can be powered during workshop tests. During these tests, power is supplied while the torpedo is in warmup or standby condition as well as after the torpedo has been fired. Warmup power is switched into the workshop fire control cable through the TORPEDO connector. After the torpedo is fired, DC power is supplied through the torpedo power cable.

The master control switch is located on the center of the switching panel. This is a 3-position switch labeled OFF-STBY-ON. Pilot lights are provided for the STBY and ON positions. To the left of this switch is a switch labeled GYRO ANGLE-ENABLING RANGE. This switch selects either the gyro or the enabler of the torpedo during electrical setting. Both units cannot be set at the same time (as is the case with the Fire Control Systems Mk 101 and Mk 106) since Test Set Mk 183 Mod 0 contains only one servo system. When settings are made through the switching panel, the GYRO-ENABLER switch on the electronic chassis must be in the GYRO position. The stratum selector switch located to the right of the master control switch is a 3-position switch labeled NO LIMIT—BELOW LIMIT—ABOVE LIMIT. This switch controls stratum selector stepping relay K20

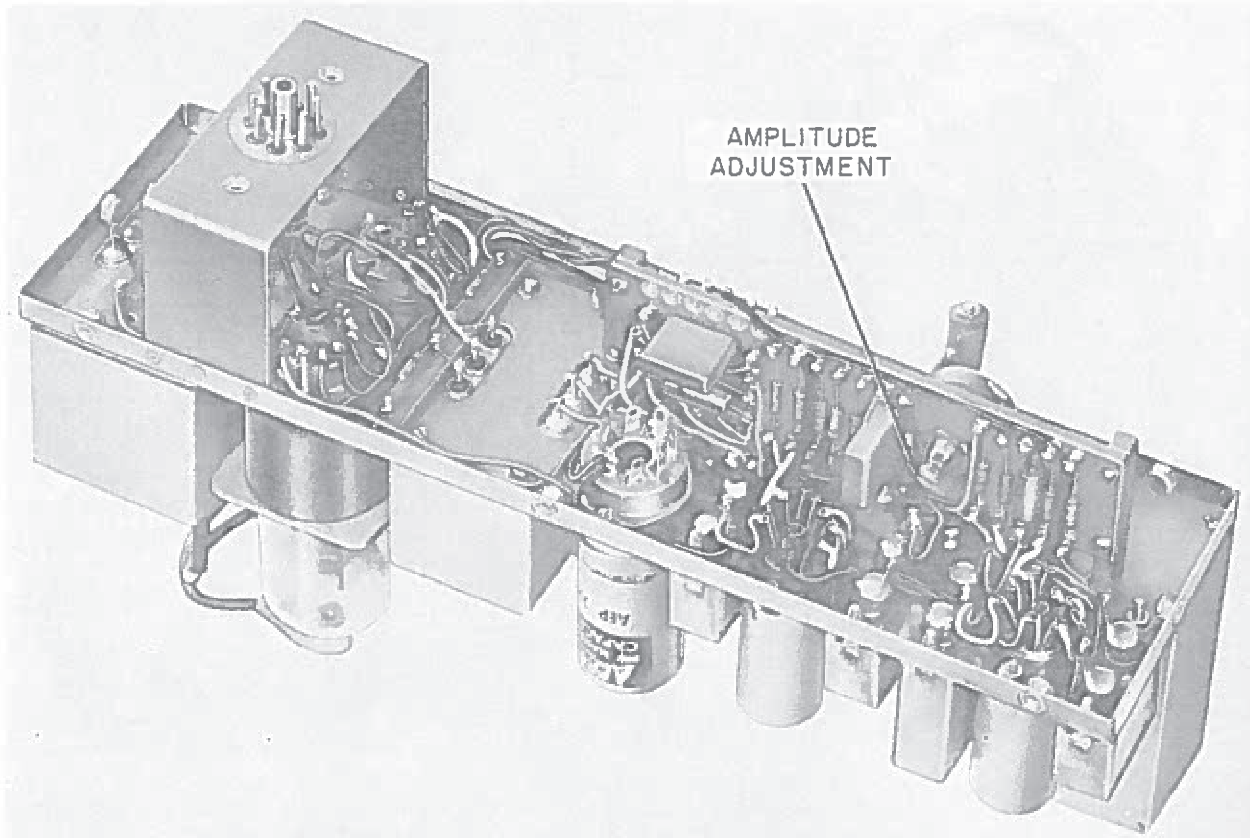

Figure 122—MOPA (Master Oscillator Power Amplifier), Bottom View.

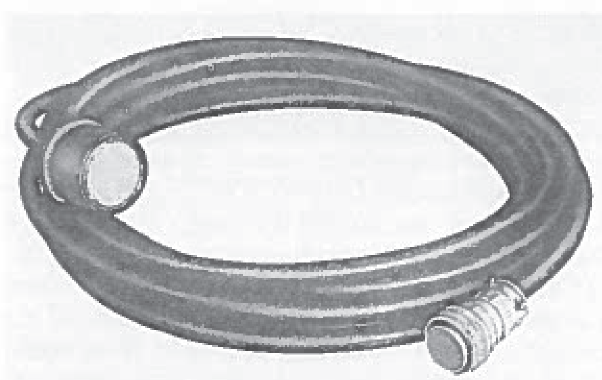

Figure 123—Workshop Fire Control Cable.

in the torpedo afterbody. An indicator light directly below the stratum selector switch gives an indication of whether or not relay K20 is following the setting of the selector switch. If the light remains lighted, the stratum selected on the test set has been set in the torpedo.

The FIRE switch is located to the left of the GYRO-ENABLER switch. This switch is activated only when the master control switch is in the ON position. Operation of this switch supplies 24 volts DC to fire relay K13 in the torpedo, causing it to operate.

Three fuses are located between the FIRE switch and the TORPEDO connector. These fuses are rated as follows: 400-cycle supply fuse, 0.5 amperes; LO DC fuse, 30 amperes; fire fuse, 5 amperes.

DC Power Supply. The DC power supply, figure 124, consists of a battery box with a built-in charging circuit. It is intended for use with Test Set Mk 183 Mod 0 only when the test set is used in testing individual gyroscopes or enablers in the workshop. The power supply does not have sufficient capacity for use as a primary source for the torpedo during workshop testing or ranging. It contains four motorcycle-type storage batteries with a 23-ampere-hour rating. The trickle charger can be operated continuously while the power supply is in daily use. Since the trickle-charging rate is so low (50 ma)

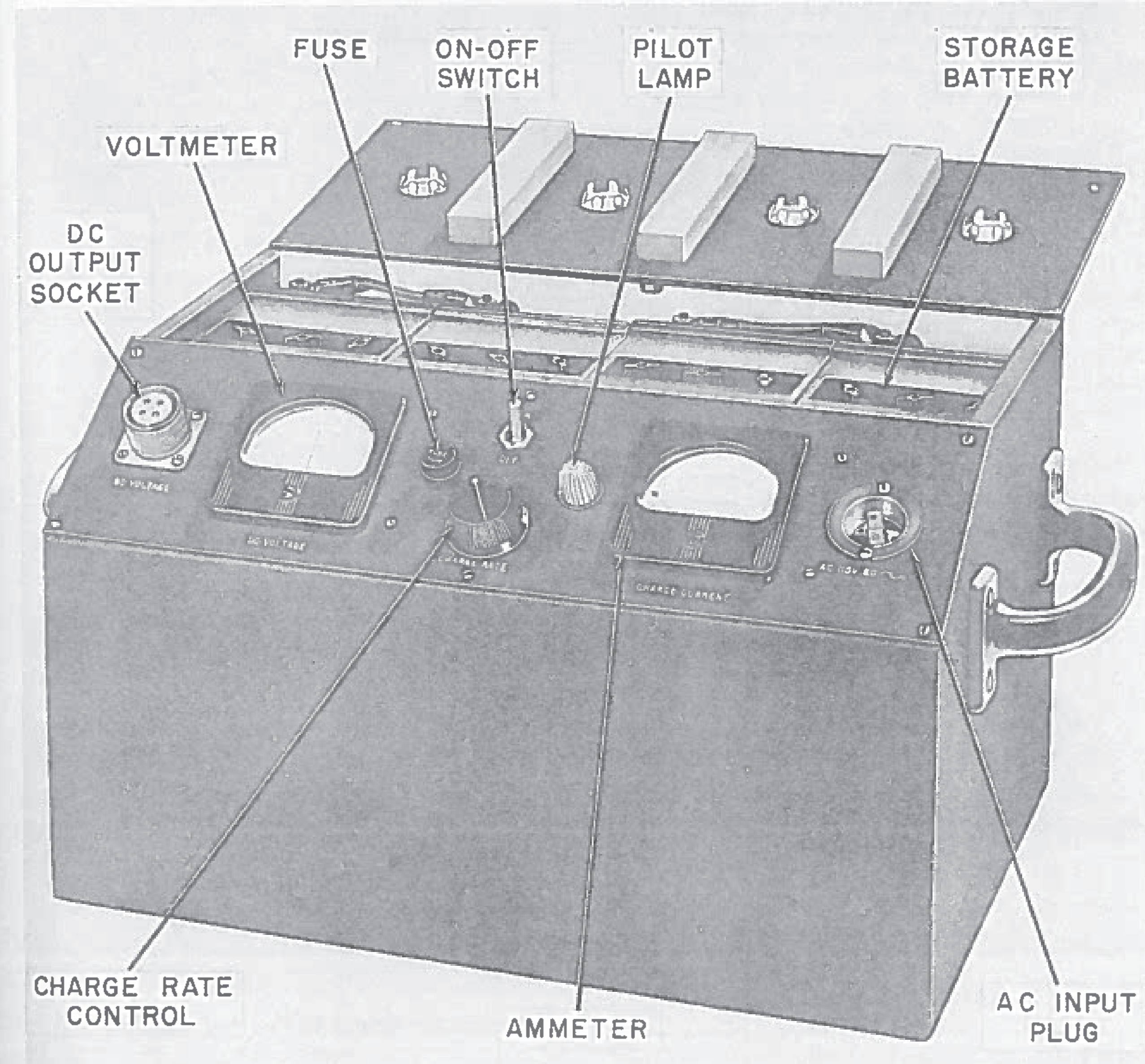

Figure 124—DC Power Supply.

there is little probability of overcharging the batteries.

Auxiliary Cables. The auxiliary cables are shown in figures 125 to 130. Instructions for using the cables with Test Set Mk 183 Mod 0 are given with the operating instructions of this section.

Checks and Adjustments

In preparation for making adjustments to Test Set Mk 183 Mod 0, connect the test set to a source of 115-volt 60-cycle AC power. Then connect either a gyro or an enabler to the GYRO or ENABLER cable connectors on the electronic chassis by means of the cables provided.

> NOTE: Test Set Mk 183 Mod 0 should not be operated for any appreciable time without a suitable load on the servo amplifier. A suitable load can be provided by connecting an enabler or a gyro to the test set, or the torpedo can be connected to the test set through the TORPEDO

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connector on the switching panel by means of the gyro interconnect cable. If the servo amplifier is allowed to operate without a load, the amplifier may be permanently damaged.

B Power Supply Voltages. Turn the B SUPPLY switch on the electronic chassis to ON. Wait approximately 30 seconds to allow the power tubes in the MOPA to warm up, and then turn the B STBY switch to ON. The B supply MOPA meter should indicate 400±40 volts and the B supply servo amplifier meter should indicate 300±30 volts. The bias supply meter should indicate exactly 30 volts. This voltage can be adjusted by means of a potentiometer located at the rear of the B supply chassis.

MOPA Voltage and Frequency. The frequency and output voltage of the MOPA are both adjustable. Although the 400-cycle meter on the electronic chassis gives a rough indication of the MOPA frequency, a frequency standard should

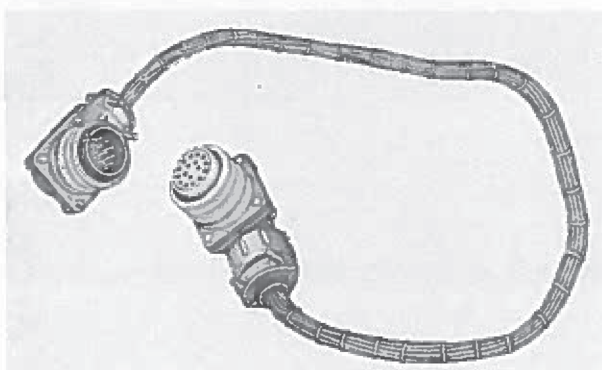

Figure 125—Gyro Cable.

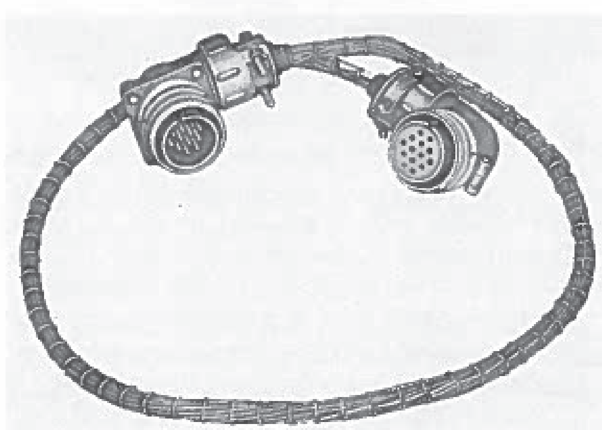

Figure 126—Enabler Cable.

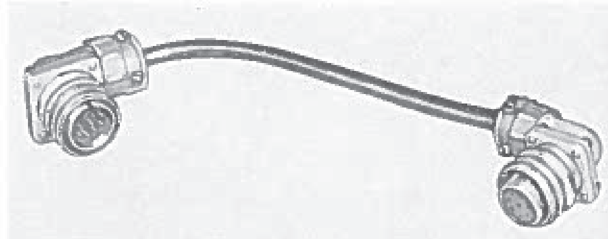

Figure 127—Switching Input Cable.

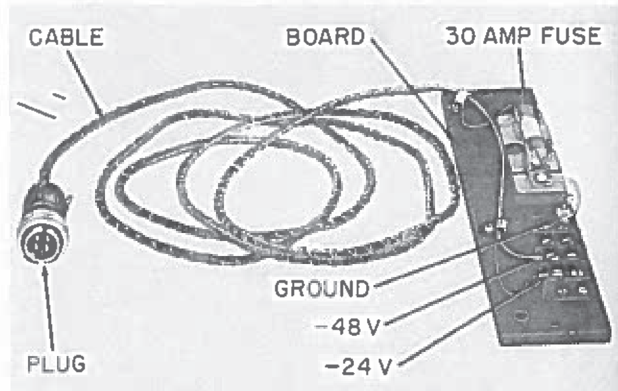

Figure 128—Torpedo Power Cable.

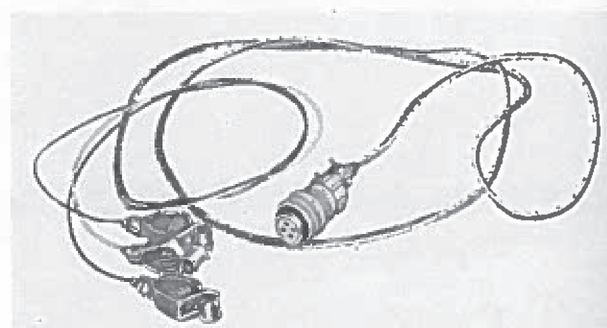

Figure 129—Minus 24 Volt and minus 48 Volt Power Cable.

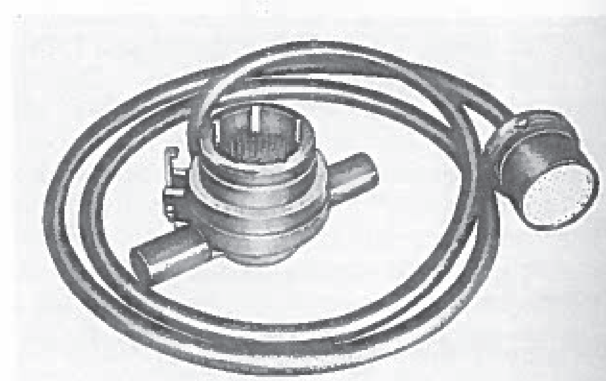

Figure 130—Exercise Fire Control Cable.

be used to make a fine adjustment of the frequency. The frequency can be checked by connecting a cathode-ray oscilloscope to the terminals of the 400-cycle frequency meter on the electronic chassis, and then comparing the voltage output to the output of the frequency standard. If the frequency is not 400±2 cps, adjust the frequency by means of the potentiometer located on the top of the oscillator assembly. If no frequency standard is available, adjust the potentiometer until the frequency indicated by the 400-cycle meter is as close to 400 cycles as possible. Measure the output voltage of the MOPA across the terminals of the 400-cycle meter. Adjust the voltage by means of the potentiometer located at the side of the MOPA until it is 115±11.5 volts.

Fuses. When the test set is used as fire control equipment for exercise runs or as workshop fire control equipment, the switching panel fuses should be checked periodically.

Synchro Electrical Zero. The electrical zero position of the synchro control transformer in the test set must coincide with the 0-degree or 1000-yard position of the setting dial. This electrical zero setting is used as the reference position for all synchros in the electrical setting of torpedoes.

The electrical zeroing procedure involves two steps; the first a rough adjustment, and the second a fine adjustment. The first step is used to select the correct zero setting and the second is used to determine the zero accurately after the correct setting has been selected.

Rough Adjustment. Make the preliminary rough setting as follows:

1. With test set deenergized, connect synchro terminals to a source of 115-volt, 400-cycle AC power as shown in figure 131.
2. Loosen synchro housing and set dial to 0 degrees.
3. Rotate synchro housing until a minimum reading is obtained on vacuum tube voltmeter.
4. Tighten synchro housing slightly.

Fine Adjustment. Refine the rough setting as follows:

1. Set OPERATE-SYN ZERO switch to SYN ZERO position to produce the synchro circuits shown in figure 132.
2. Connect a high impedance AC vacuum tube voltmeter across GR terminals.
3. Hold setting dial at zero and loosen synchro housing. Rotate housing slightly until a minimum voltage appears on vacuum tube voltmeter. This denotes true electrical zero, provided the approximate position of electrical zero has been found by the rough adjustment.
4. Tighten synchro housing screws securely and then recheck position of voltage null as indicated on vacuum tube voltmeter in comparison with the reading of setting dial. The null should appear within one fine division either side of zero degrees.

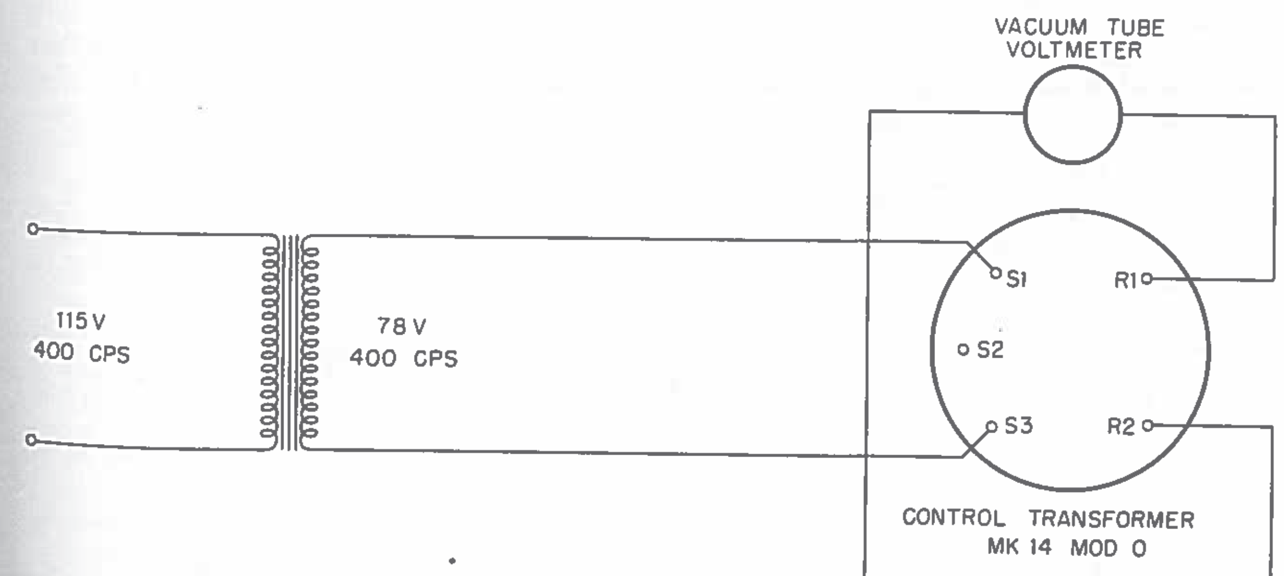

Figure 131—Electrical Zero (Rough Adjustment).

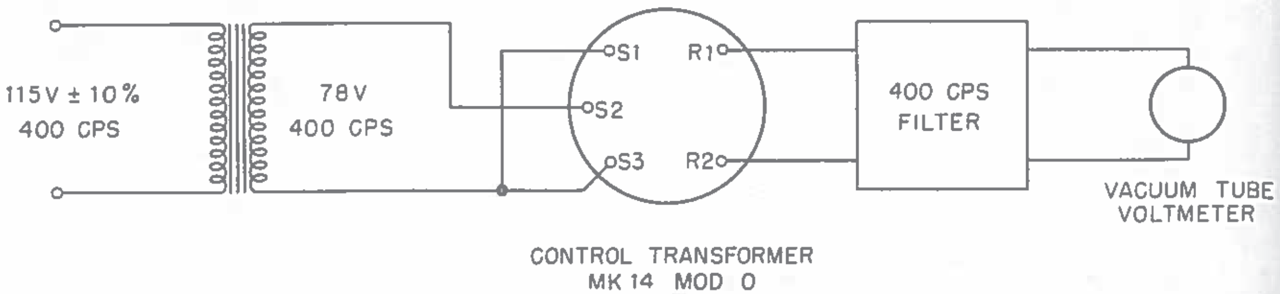

Figure 132—Electrical Zero (Fine Adjustment).

If this is not the case, loosen synchro housing and repeat adjustment.

Operation

The following paragraphs give instructions for using Test Set Mk 183 Mod 0 in performing tests and in firing the torpedo in exercise or proofing runs.

Testing and Adjusting Gyroscope Mk 29 Mod 0. The test set is used as follows in testing and adjusting Gyroscope Mk 29 Mod 0:

1. Connect gyro cable from electronic chassis to gyro. Connect DC battery supply cable from electronic chassis DC SUPPLY connector to DC output connector on DC power supply or to some other source of 24 volts DC. Connect power cables on DC supply and electronic chassis to a source of 115-volt, 60-cycle AC.

   NOTE: The switching panel is not required for any of the tests on the gyro assembly. Therefore no cabling connections should be made between the electronic chassis and the switching panel during the testing of Gyroscope Mk 29 Mod 0.

2. Turn B SUPPLY switch on. This causes the following voltages to be applied: 6.3-volt, 60-cycle AC to heaters of vacuum tubes in MOPA and servo amplifiers; 115-volt, 60-cycle AC to fan; 6.3-volt, 60-cycle AC to heaters of vacuum tubes in B power supply.

3. After waiting for approximately 20 to 30 seconds, turn B STBY switch on. This supplies the following DC voltages to the electronic chassis: 400 volts±40 volts to plates of power tubes in MOPA, 300 volts±30 volts to screens of vacuum tube in MOPA and to plates of servo amplifier, 150 volts±30 volts to input stages of servo amplifier, −30 volts (adjustable) bias supply to MOPA.

   NOTE: All AC circuits are now activated and the MOPA is furnishing 115-volt, 400-cycle AC through the gyro cable to the reference field of the servo motor within the gyro assembly and to terminals R1 and R2 of Synchro Transmitter Mk 22 within the gyro assembly.

4. Turn LO DC switch on. This supplies −24 volts to one side of all indicator lights.

5. Turn GYRO-ENABLER switch to GYRO. This switches ground side of ENABLE-GJ light to pin G of gyro cable connector. If gyro has been properly latched, ENABLE-GJ pilot light should light. (The gyro should be latched before starting any gyro testing.)

6. To test gyro motor, connect a ground lead from GND terminal on electronic chassis to frame of gyro assembly. Next, turn GYRO MOTOR switch on. This should apply −24 volts to gyro motor, causing motor to run.

7. If it is desired to test alignment of gyro pickoff contact with respect to electrical zero of synchro transmitter in gyro, proceed as follows: Disconnect ground lead between electronic chassis and gyro case. Turn GYRO MOTOR switch on, thus energizing PORT and STBD indicator lights. These lights are connected to relay K103 in the electronic chassis which in turn is connected to the port and starboard pickoff cam in the gyro assembly. Contact of outer gimbal pickoff contact in gyro with the port or starboard cam is indicated by operation of corresponding light. When outer gimbal pickoff contact touches port contact, ground is connected to pin R on gyro cable connector thus energizing coil P1–B1 in relay K103. This causes contact C1 to close with contact G in relay K103 and energizes PORT light on test set. When pickoff contact touches starboard contact, coil B2–P2 in relay K103 is energized, thus closing contacts C2 and G within relay K103 and operating STBD light. Thus, the PORT and STBD indicator lights can be used to indicate alignment of the gyro pickoff assembly with respect to electrical zero of the synchro transmitter in the gyro. For further details of this alignment procedure refer to chapter 10.

Testing and Adjusting Enabler. The enabler may be tested with a test setup similar to that used for Gyroscope Mk 29 Mod 0. However, the gyro test cable must be disconnected from the electronic chassis and the enabler cable must be connected from the enabler to the ENABLER connector on the electronic chassis.

NOTE: At no time should both an enabler and a gyro be connected to the test set at the same time.

Proceed with the test as follows:

1. With the exception of the test cable change described above, follow steps 1, 2, and 3 of procedure for Gyroscope Mk 29 Mod 0. When these steps have been completed, MOPA is activated and 115-volt, 400-cycle AC is fed to enabler through enabler test cable. This voltage is applied to the reference field of the enabler servo motor and to terminals R1 and R2 of the synchro transmitter in the enabler unit.

2. Turn on LO DC switch, thus energizing DC indicator circuit in electronic chassis.

3. Turn GYRO-ENABLER switch to ENABLER. This connects the following circuits: The −24-volt supply is applied to pin H of ENABLER connector; ground side of the ENABLER pilot light is connected to enabler contact relay on K101; ground side of LIMIT pilot light is connected to contact on limit relay K102.

4. After the preceding steps have been completed the enabler may be tested in accordance with the testing procedure described in detail in chapter 10. The adjustment procedure consists of adjusting the synchros in the enabler so that the number of yards set into the enabler cam and pickoff assembly is equal to the number of yards on the electronic chassis angle setting dial. In addition, the spacings of the contacts within the enabler are checked to see that the limit contacts open and close at the correct ranges. When both of the enabler contacts in the enabler make contact with the enabler cam, −24 volts is applied to pin F of the ENABLER connector. This causes operation of relay K101 which in turn activates the ENABLER indicator light. When one or the other of the enabler contacts moves off the cam, the pilot light goes off, indicating that the enabler is set outside of the allowable range (600 to 3100 yards).

Pin H of the ENABLER connector applies −24 volts to the center limit contact. When the cam is positioned so that both this contact and the contact connected to Pin I of the ENABLER connector are touching the limit cam, relay K102 is energized through the enabler cable. When relay K102 is energized, the LIMIT light goes on. When contacts G and H are both touching the limit cam, DC voltage is connected to relay K103 in such a manner as to light the PORT light. Thus, when all three contacts are touching the limit cam, both the PORT light and the LIMIT light will be on.

Workshop Testing of Torpedoes. The following paragraphs give instructions for using Test Set Mk 183 Mod 0 for testing torpedoes in the workshop.

EQUIPMENT. For workshop testing of a complete Torpedo Mk 27 Mod 4, the following auxiliary equipment will be needed in addition to a Test Set Mk 183 Mod 0:

- Switching input cable
- Torpedo power cable
- −24-V., −48-V. power cable
- Workshop fire control cable

PREPARATIONS. Before testing the torpedo, make the following preparations for the test.

1. Plug workshop fire control cable into afterbody shell connector and into large TORPEDO connector on switching panel.

2. Plug switching input cable into GYRO connector on electronic chassis and into GYRO INTERCONNECT connector on switching panel.

3. Plug −24-volt, −48-volt power cable into DC supply connector on switching panel and connect other end to a source of 24 and 48 volts DC (such as the workshop DC power supply previously described).

4. Plug torpedo power cable into small TORPEDO connector on switching panel and strap other end of cable to battery compartment of torpedo adjacent to forward handhole.

5. Within the torpedo, connect power leads to appropriate terminals on terminal strip at end of torpedo power cable. Connect both the −24-volt and −28-volt leads to the −24-volt connector on the terminal strip. This terminal strip contains a common fuse, rated at 30 amperes, in the ground supply line in order to protect circuits within the torpedo.

6. Connect power cable between AC input connector on electronic chassis and a source of 115-volt, 60-cycle AC.

7. Turn on B SUPPLY switch to supply heater power to vacuum tubes within Test Set Mk 183 Mod 0.

8. Turn OFF-STBY-ON switch to STBY. STBY pilot light should light indicating that 24-volt DC power is applied to torpedo through pin R on TORPEDO connector. This warmup power is applied to vacuum tubes within control panel, to B power supply, to gyro motor, and to DC control circuits within torpedo.

9. Turn on B STBY switch to energize servo system.

GYRO ANGLE SETTING. To set a gyro angle into the torpedo, proceed as follows:

1. Turn GYRO-ENABLER switch on electronic chassis to GYRO for all tests involving use of switching panel.

2. Turn GYRO ANGLE-ENABLING RANGE switch on switching panel to GYRO ANGLE. This connects stator leads of synchro control transformer of range and angle setting control in electronic chassis to stator leads of synchro transmitter in gyro assembly. In addition, input of gyro servo motor is connected to servo amplifier.

3. Rotate setting dial to produce desired setting of gyro pickoff cam. Correct follow up can be observed on synchro null indicator on electronic chassis. When setting dial is stopped, synchronization should occur and synchro null meter indication should drop to zero. It should also be noted that setting an increasing angle on setting dial (counterclockwise rotation from zero) should cause gyro indicator dial to turn into green portion of dial.

ENABLER SETTING. To set a desired range into the enabler, proceed as follows:

1. Turn GYRO ANGLE-ENABLING RANGE switch on switching panel to ENABLING RANGE. This connects stator leads of synchro control transformer in electronic chassis to stator leads of synchro transmitter in enabler assembly of torpedo and connects output of servo amplifier to servo motor of enabler.

2. Set desired enabling range by referring to range graduation on range and angle setting control dial of electronic chassis. Ordinarily, enabling range cannot be set to values less than 600 yards or more than 3100 yards. The limit cam and contacts are so set up that any attempt to set range outside these limits will result in oscillation of the servo system about one or the other of the limits. This will be indicated on the synchro null indicator as an off-scale deflection. Correct follow-up within limits will be indicated by normal operation of the synchro null indicator. If it is desired to set enabling range to less than 600 yards, it is possible to do so by interrupting the −24-volt DC supply to the switching panel. After the desired setting has been made, the B STBY switch on the electronic chassis should be turned off before the −24-volt supply is again connected to the switching panel.

STRATUM CONTROL SETTING. To make a desired stratum setting to the torpedo, proceed as follows:

1. Set main control switch on switching panel to STBY. This causes stratum control circuits to be activated.

2. Set stratum selector switch to desired position (ABOVE LIMIT, BELOW LIMIT, or NO LIMIT). When this switch is turned to desired position, 24 volts DC is applied to two positions of stepping relay K20 in afterbody. This relay then steps until the third, or unenergized, position is reached. Correct follow-up of stepping relay is indicated by the pilot light below the stratum selector switch. Failure of light to go on indicates that stepping relay is not synchronized with stratum selector switch.

FIRING. All of the pre-firing functions have now been accomplished and the torpedo is ready to be fired. Proceed as follows:

1. Turn main control switch on switching panel to ON position. This allows warm-up power to remain on but in addition activates firing switch.

2. To fire torpedo, push back switch guard on firing switch and depress switch momentarily. This operates relay K408, which is self-locking. Relay K408 applies 24 volts to fire relay in torpedo through pin E in large TORPEDO connector on switching panel. In addition, relay K408 operates relay K401, which in turn interrupts all power circuits to torpedo with exception of firing circuit. Correct application of firing voltage through fuse of firing circuit and into torpedo is indicated by the FIRE indicator light directly below the firing switch.

TORPEDO DECK RUN. Even though all power is disconnected from the workshop fire control cable upon firing of the torpedo, the torpedo is energized by the 24-volt and 48-volt DC power supplied through the torpedo power cable. The power cable supplies voltages that normally would be obtained from the torpedo propulsion battery. If it is desired to stop the torpedo run, it is necessary only to interrupt the connection between the −24-volt, −48-volt power cable and the −24-volt source. A switch is available on the workshop DC power supply to facilitate this operation. Once the torpedo has been stopped, the complete warmup and firing procedure must be repeated in order to make another run. In addition, it is necessary to turn the main control on the switching panel back to STBY position in order to deenergize relay K401 so that continuity can again be established in the power circuit.

Exercise Firing of Torpedoes. The following paragraphs give instructions for using Test Set Mk 183 Mod 0 for firing torpedoes in exercise runs:

EQUIPMENT. For exercise firing of Torpedo Mk 27 Mod 4 from submerged tubes, the following auxiliary equipment is required in addition to Test Set Mk 183 Mod 0:

Switching input cable
−24-volt, −48-volt power cable
Exercise Fire Control Cable Assembly (below water)

PREPARATION. Before the torpedo is fired, the following preparations must be made:

1. Plug exercise fire control cable into tube door connector and then plug it into TORPEDO connector on switching panel of test set.

2. Plug switching input cable into GYRO connector on electronic chassis and into GYRO INTERCONNECT connector on switching panel.

3. Plug −24-volt, −48-volt power cable into DC SUPPLY connector on switching panel and connect other end to a suitable source of −24 volts DC capable of delivering 15 amperes.

4. Connect power cable to AC input of electronic chassis and to a source of 115-volt, 60-cycle AC.

5. Load torpedo into tube, plugging Torpedo Control Cable Mk 1 Mod 0 into torpedo shell connector and into tube door connector. This completes electrical connection of torpedo to Test Set Mk 183 Mod 0.

WARM-UP AND SETTING. The procedure for warming up the torpedo and effecting the various synchronous and nonsynchronous settings is the same as the procedure described under "Workshop Testing of Torpedoes."

FIRING. After a warmup of at least 30 seconds, the torpedo may be fired by turning the main control switch on the switching panel to ON and operating the FIRE switch.

POST-FIRING PROCEDURE. After the torpedo has been fired, proceed as follows:

1. Disconnect Torpedo Control Cable Mk 1 Mod 0 from tube door connector.

2. Turn main control switch on switching panel from ON position to OFF position. Turn B STBY switch on electronic chassis off. (If above procedure is reversed, relay K401 will drop out and circuits to setting cable will be reenergized, thus allowing shorting of some of the power leads through cut end of cable. The power circuits are fused to protect Test Set Mk 183 Mod 0, but it is recommended that the above procedure be followed.)

Maintenance and Repair

The following paragraphs give instructions for the maintenance and repair of Test Set Mk 183 Mod 0. Refer to figures 133 through 137.

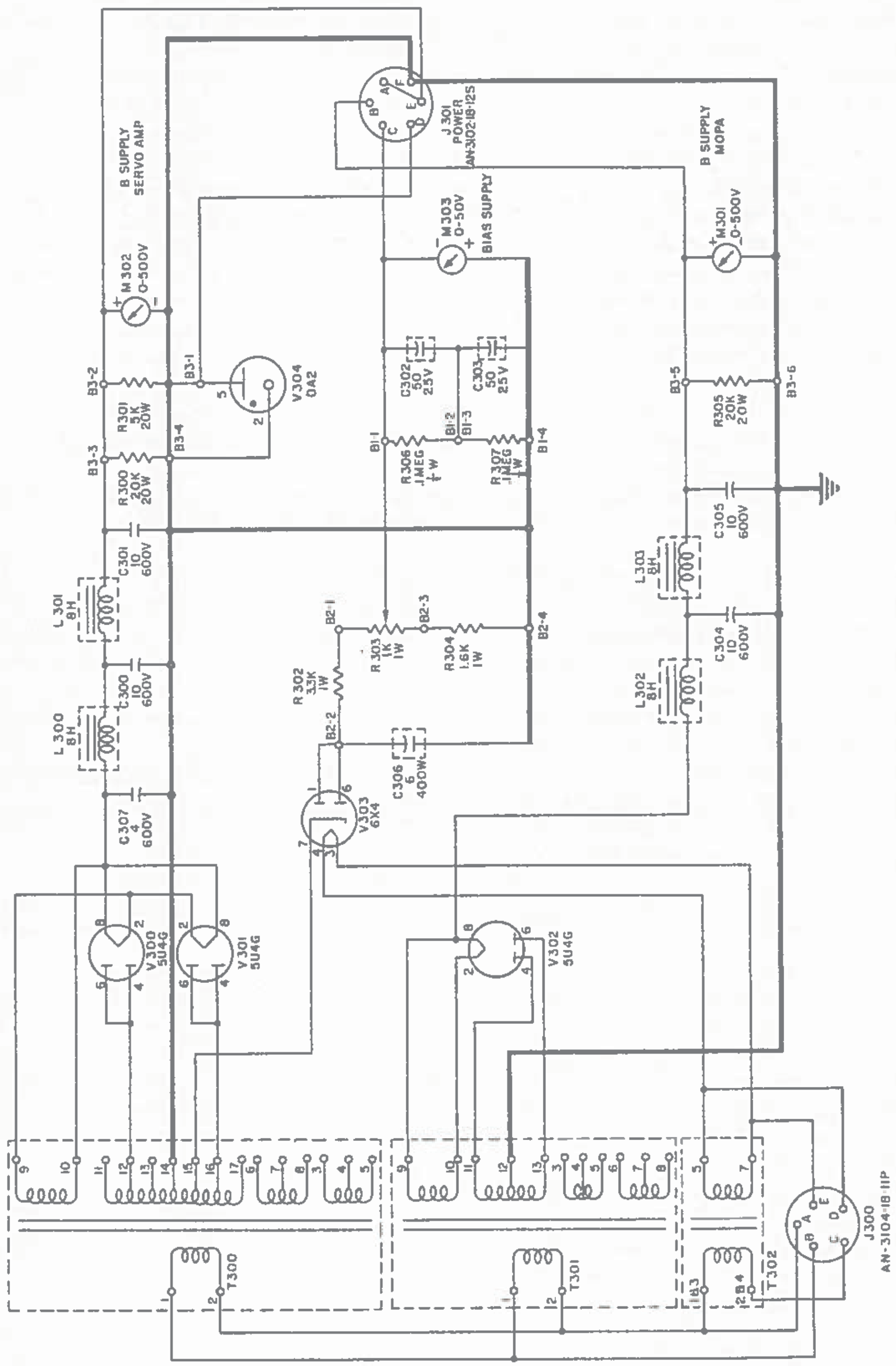

Figure 133—B Power Supply Schematic Diagram.

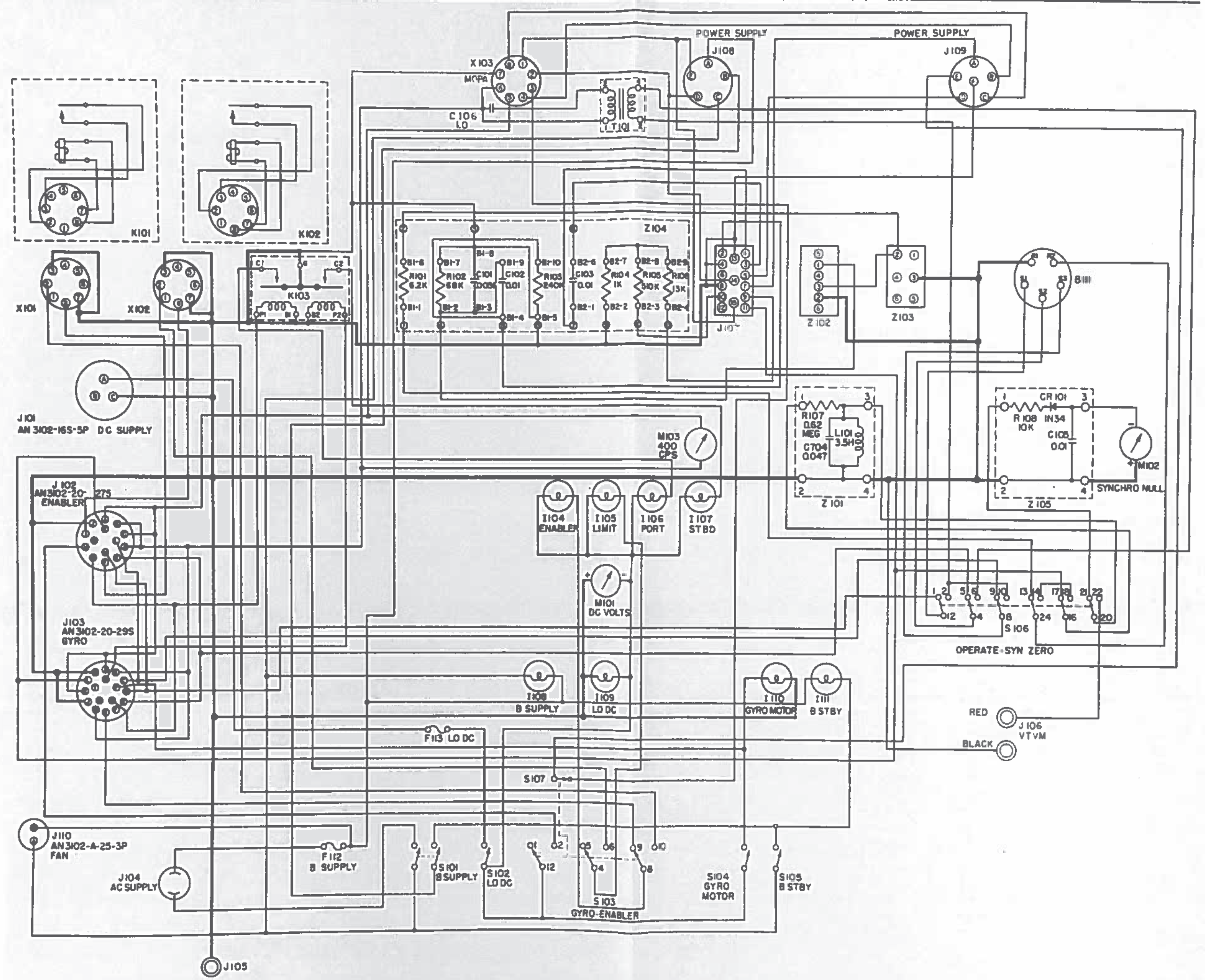

Figure 134—Electronic Chassis Schematic Diagram.

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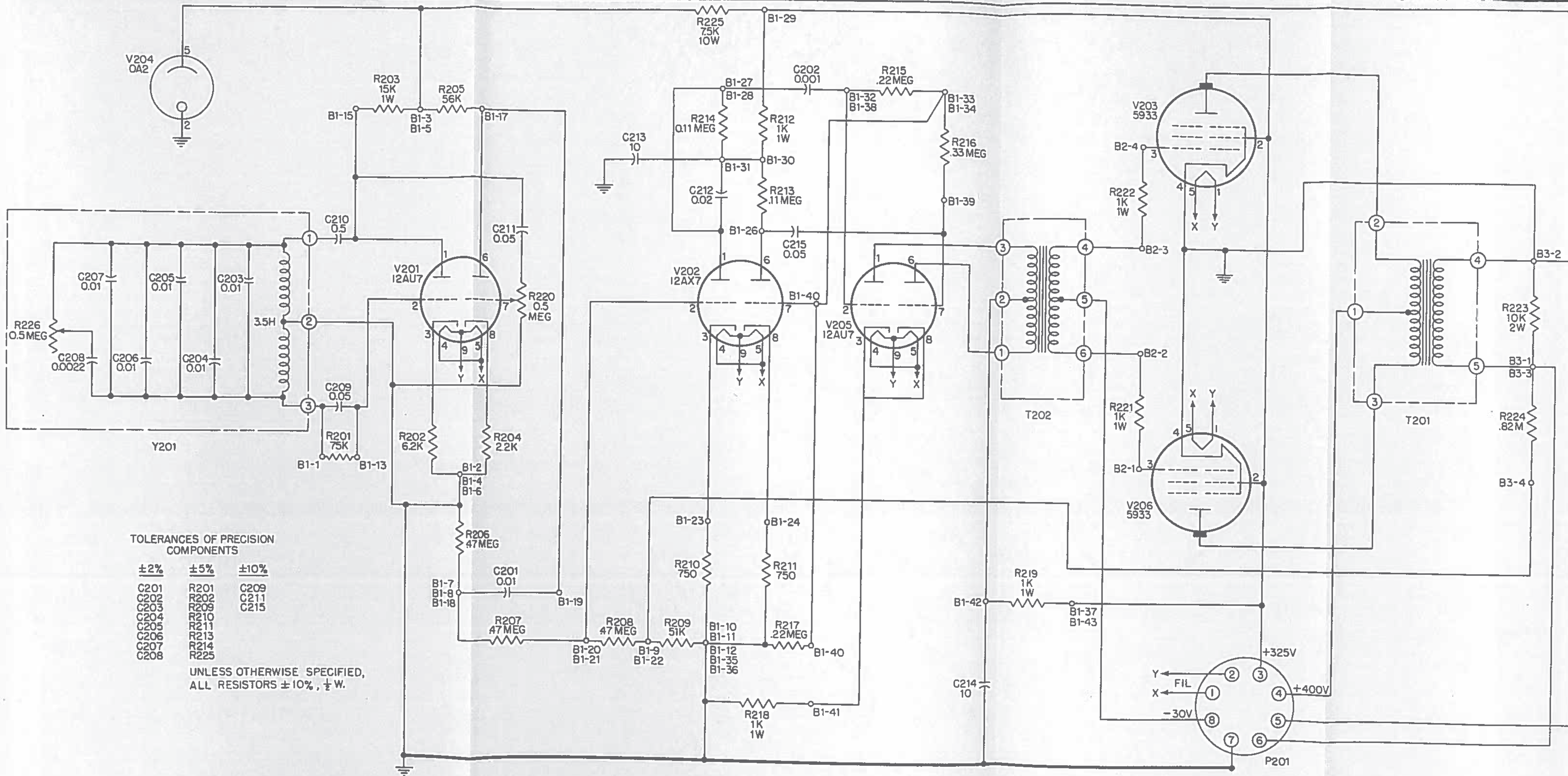


Figure 135—MOPA Schematic Diagram.

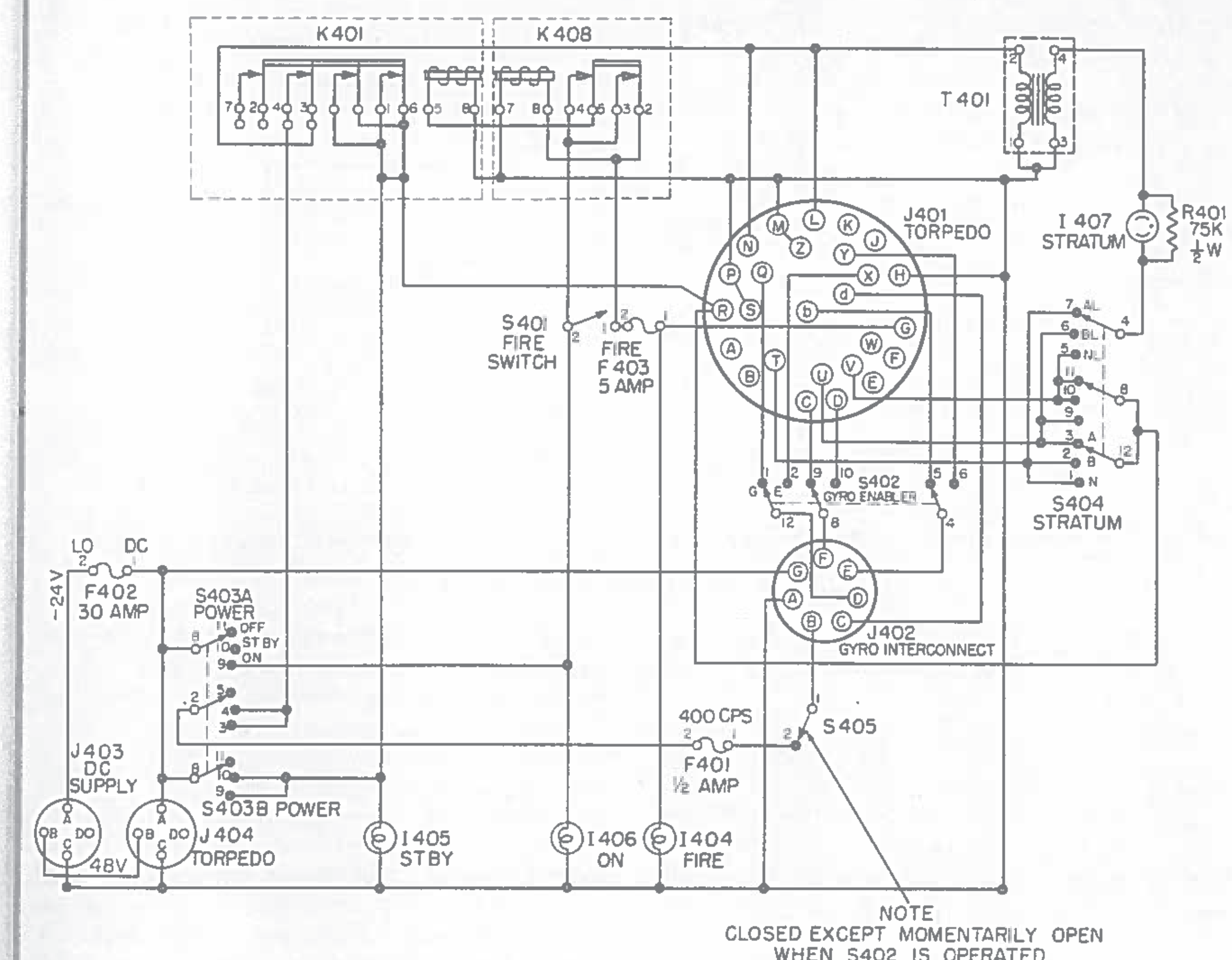


Figure 136—Switching Panel Schematic Diagram.

B Power Supply. The B power supply contains two primary high-voltage circuits. One is a 300-volt supply rated at 300 ma and the other is a 400-volt supply rated at 200 ma. A 30-volt bias for the MOPA is obtained from a tap on the 300-volt power supply transformer. A separate transformer is included for both the MOPA and servo amplifier vacuum tube heaters. A regulated 150-volt supply is obtained from the primary 300-volt supply by means of a bleeder resistor and an OA2 voltage regulator tube.

For troubleshooting and testing of the B power supply, use the following resistive loads connected to plugs J301 and J300.

300 volts DC (pin A or E, J301) 1800 ohms, 50 watts

400 volts DC (pin B, J301) 4000 ohms, 50 watts

150 volts DC (pin D, J301) 75,000 ohms, 1 watt

−30 volts DC (pin C, J301) 50,000 ohms, ½ watt

6.3 volts AC (pins D and E, J300) 1 ohm, 50 watts

These resistive loads should be connected to chassis ground or pin F of plug J301. With 115 volts ±10 percent, 60-cycle AC applied to pins A and B or A and C of plug J300 and with the specified loads on the power supply, the output voltages should be as follows:

300-volt DC supply—228.5 volts ±10 percent
400-volt DC supply—400 volts ±10 percent
150-volt DC supply—150 volts ±5 percent

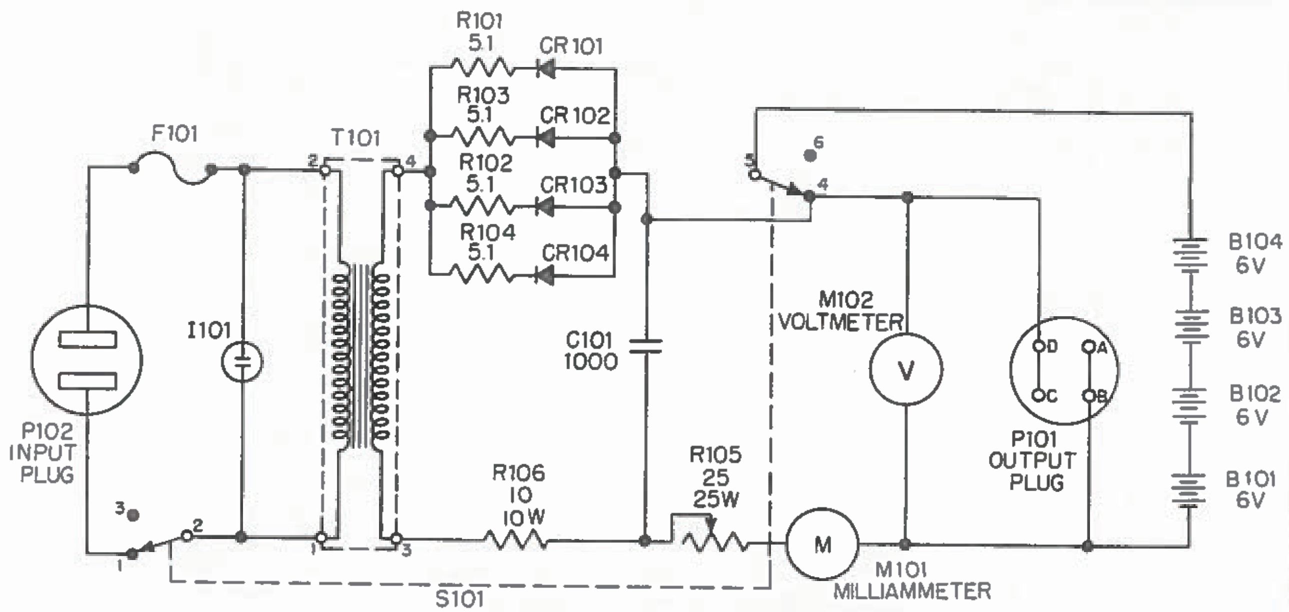


Figure 137—DC Power Supply Schematic Diagram.

−30-volt DC supply— −30 volts ±10 percent
60-cycle heater voltage— −6.3 volts ±10 percent

MOPA. The MOPA is a self-contained, plug-in, electronic source of 115-volt, 400-cycle power. As used in Test Set Mk 183 Mod 0, the MOPA operates into a load of approximately 1000 ohms. The harmonic content of the voltage output is approximately 1.4 percent under this load the the regulation is less than 5 percent.

To test the MOPA, connect the unit to the following power sources having the indicated current ratings:

Pins 1 and 2—6.3-volt, 60-cycle AC at 5 to 6 amp.
Pin 3—300 volts DC at 100 ma
Pin 4—450 volts DC at 200 ma
Pin 8— −30 volts DC at 1 ma (impedance of supply should be less than 5000 ohms)
Pin 7—ground

Before high voltage is applied to pins 3 and 4, the heaters should be energized for 30 seconds. Test and adjust the MOPA as follows:

1. Connect a 1000-ohm resistor (20 watts) and a 1-mfd capacitor (400 volts) between pins 5 and 6 (400-cps output) of plug P201.

2. Turn on high-voltage supply and adjust potentiometer R220 until output across the 1000-ohm resistor is 115 volts.

3. Connect an oscilloscope across the 1000-ohm resistor and by means of lissajous figures, check frequency range over which MOPA is adjustable. This should be approximately 396 to 404 cps. The extent of the adjustment is not critical. It is more important that the unit can be adjusted to 400 cps during all phases of operation and that its output remains at this frequency after a sufficient warm-up period. The output voltage will change slightly as the frequency is varied. If oscillation should stop as the frequency of the MOPA is varied between the specified limits, oscillator tube V201 should be checked. A temporary remedy in some cases is to replace the cathode resistor of V201–A with a resistor of slightly lower value.

4. Turn off high voltage and replace 1000-ohm load resistor with a 5000-ohm potentiometer, leaving the 1-mfd capacitor connected. Turn on high voltage and vary load resistance from 350 ohms to 3500 ohms. Output voltage should remain in range of 115 volts ±10 percent over these limits. Distortion over this range of loads should be less than 5 percent. If regulation is poor, 807 vacuum tubes should be checked and replaced if they have low transconductance.

5. If any trouble is indicated by these tests, check circuits of MOPA in accordance with data in tables 23, 24, and 25.

Table 23—MOPA DC Voltage Measurements—1000 Ohm Load

Pin	V201	V202	V203	V204	V205	V206
1	132	170	−24	NC	−300	−24
2	0	0	300	0	0	300
3	6. 8	1. 1	−30	NC	14. 5	−30
4	−30	−30	0	NC	−30	0
5	−30	−30	−30	150	−30	−30
6	65	170	NC	NC	300	NC
7	0	0	NC	NC	0	NC
8	2. 4	1. 15	NC	NC	14. 5	NC
9	−24	−24	NC	NC	−24	NC

NOTE: These measurements represent average values obtained under normal test conditions and are subject to a ±10 percent variation, except for the voltage at Pin 3, V201, which should be within ±5 percent of the stated value.

Before these measurements are made, the frequency of oscillation should be adjusted to 400±1 cps and the amplitude across a 1000-ohm load should be 115 volts ±10 percent. All measurements are to be made with a voltmeter having 5000 ohms per volt or higher impedance.

Table 24—MOPA AC Voltage Measurements—1000 Ohm Load

Pin	V201	V202	V203	V204	V205	V206
1	7. 8	4. 8	0	NC	37	0
2	7. 6	0. 3	0	0	2. 4	0
3	6. 8	0. 2	11. 8	NC	0. 08	11. 8
4	0	0	0	NC	0	0
5	0	0	0	−1	0	0
6	7. 4	2. 8	NC	NC	35	NC
7	0. 1	. 08	NC	NC	2. 8	NC
8	. 38	. 03	NC	NC	. 08	NC
9	0	0	NC	NC	0	NC

NOTE: These measurements represent average values obtained under normal test conditions and are subject to ±10 percent variation, except for the voltage at Pin 3, V201, which should be within ±5 percent of the stated value.

Before these measurements are made, the frequency of oscillation should be adjusted to 400±1 cps and the amplitude across a 1000-ohm load should be 115 volts ±10 percent.

All measurements were made with a Ballantine Model 300 Vacuum Tube Voltmeter.

Table 25—MOPA—Regulation and Distortion vs. Load

Output Load (ohms)	Output Voltage	Percent Second Harmonic	Percent Third Harmonic	Power Output (watts)
350	106	1. 29	1. 29	33. 1
1000	119. 5	1. 19	0. 1	14. 3
1500	121	1. 52	0. 22	9. 75
3500	125	1. 48	0. 24	4. 7

NOTE: These are average measurements for a typical unit. The distortion should be less than 5 percent. All voltage measurements were made with a Ballantine Model 300 Vacuum Tube Voltmeter. The load resistors should be within ±10 percent of the specified value.

Servo System. In order to make a complete check of the servo system, it is necessary for a gyro or enabler to be connected to the electronic chassis or for the complete test set to be connected to a torpedo as for workshop testing. However, the following partial tests are suggested in order to trace troubles arising from faulty components within the servo system.

Servo Data System. To trace troubles in the servo data system, proceed as follows:

1. Remove servo amplifier.

2. Energize servo loop by turning on B SUPPLY switch.

3. After waiting 30 seconds, turn on B STBY switch and set OFF-STBY-ON switch to STBY position. (It is not necessary for purposes of this test to connect any DC power to DC supply cable connectors.)

4. Connect a vacuum tube voltmeter (Ballantine Model 300 or equivalent) across terminals R1 and R2 of synchro control transformer. As synchro dial is rotated through 360 degrees, measured amplitude of AC output voltage should

appear as a sine wave when plotted against angular position of setting dial. Two nulls exactly 180 degrees apart should be observed in 360 degrees of rotation. Voltage at the nulls should not exceed 0.2 volts and voltage sensitivity of control transformer should be approximately 1 volt per degree.

Resonant Damp and Filter. To trace troubles in the resonant damp and filter circuits, proceed as follows:

1. Remove servo amplifier.
2. Turn off B STBY switch and B SUPPLY switch.
3. Disconnect R2 lead from control transformer and connect a variable frequency oscillator between R2 lead and ground. Connect a vacuum tube voltmeter from pin 2 of J107 to ground (chassis).
4. Vary oscillator frequency from 350 cps to 450 cps, holding oscillator voltage constant at 0.5 volts. Curve of attenuation versus frequency should be approximately as shown in figure 138.
5. If test of step 4 is not conclusive, phase measurements must be made. Using same procedure as outlined for checking servo data system, connect input and output voltages of resonant damp and filter circuits to "X" and "Y" inputs of an oscilloscope. Meaure phase angle of the two voltages between 350 and 450 cycles per second. Curve of phase angle versus frequency should be approximately as shown in figure 139. If either resonant damp or filter is found to be faulty, replace with a new assembly.

Servo Amplifier. To trace trouble in the servo amplifier, proceed as follows:

1. Plug in servo amplifier and disconnect R2 lead from control transformer.
2. Connect a load resistor of 925 ohms (20 watts) across output of servo amplifier (pins 11 and 8).
3. Connect a variable freqiency oscillator between R2 lead and ground, and connect a vacuum tube voltmeter between pin 11 of servo amplifier and ground.
4. Turn on B SUPPLY switch, wait 30 seconds, and turn on B STBY switch.

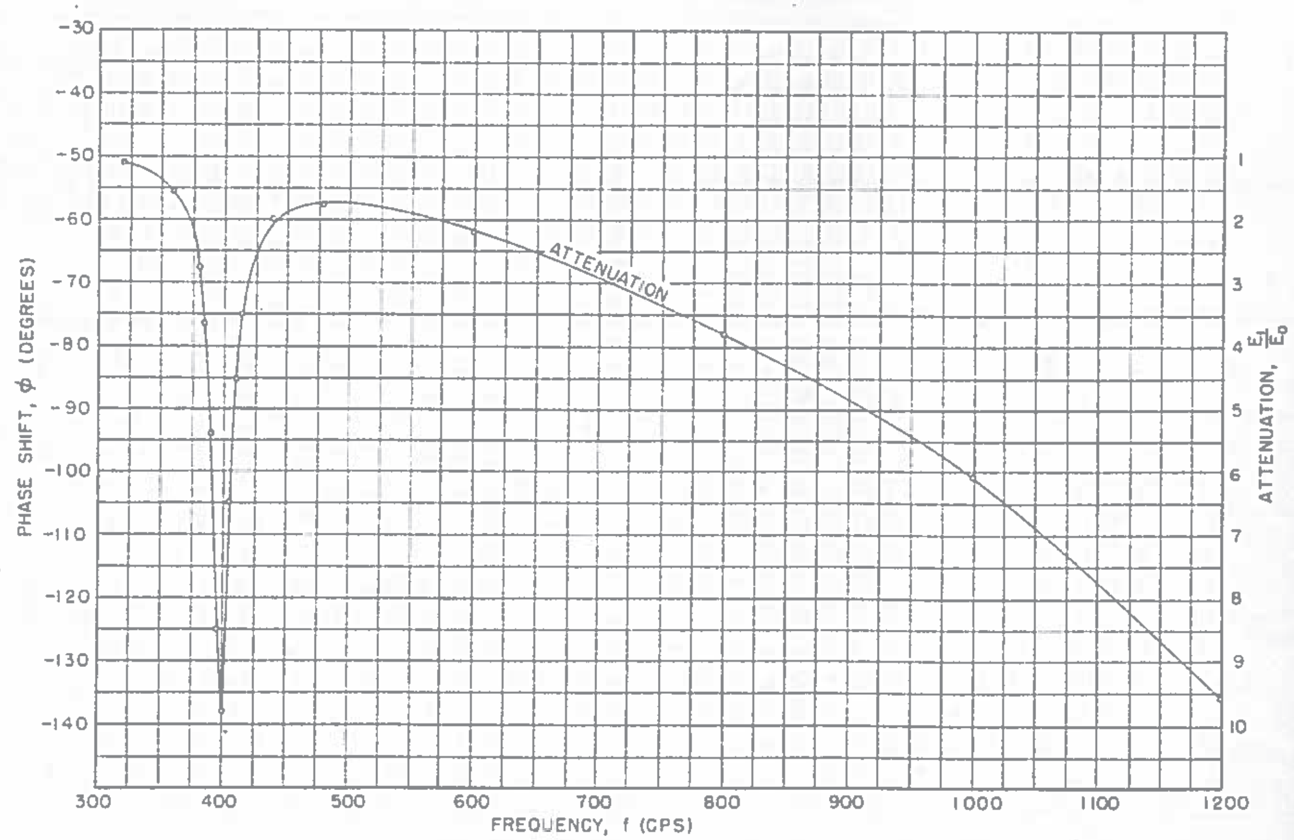


Figure 138—Combined Attenuation Characteristic of Resonant Damp and Filter.

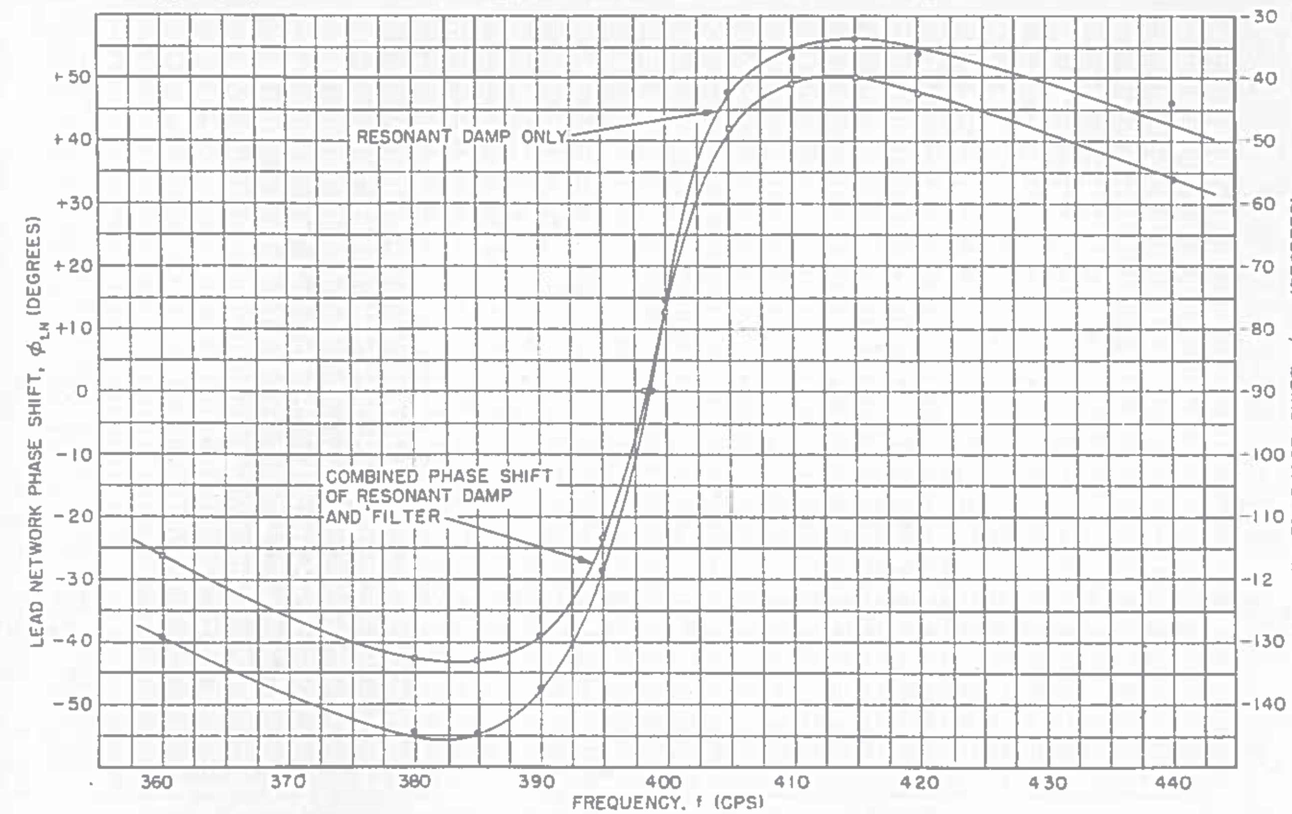


Figure 139—Phase Shift Characteristics of Resonant Damp and Filter.

5. Turn main control switch to STBY position.
6. Adjust oscillator frequency to 400±2 cps.
7. Vary input of amplifier. Output should be linear up to 115 volts. Gain of amplifier should be 3450±20 percent. Net gain should be 345±20 percent due to 20 db attenuation in resonant damp. Curve of input versus output voltages should fall within limits indicated in figure 140. If it does not, amplifier should be replaced.

Symptoms of Trouble. Oscillation and erratic performances are important symptoms of trouble in the servo system. If there is mechanical oscillation of the gyro or enabler servo motor, in most cases such oscillation is caused by a defective resonant damp in the electronic chassis of the test set. The resonant damp should be checked as previously explained.

In some cases there may be no coordination between the range and angle setting control on the test set and the response of the servo motor within the gyro or enabler. In most cases this erratic performance can be traced to the data system. The "S" leads may be open or may be connected through circuits having high resistance contacts. Also, the "high" amplifier output lead may be open. To find the source of the trouble, perform the following checks:

1. Check to see that leads on control transformer or synchro transmitter are tight.
2. Check torpedo shell connector pins for good contact.
3. Check for discontinuities in "S" lead and high amplifier output circuits within test set or cabling.

Additional Test Data

The following test data were measured on a Test Set Mk 183 Mod 0 considered to be in good operating condition and are given here as an aid in troubleshooting.

PIN J108 (AN-3102-18-11S)

A. One side of 115-volt, 60-cycle line.
B. Other side of 115-volt, 60-cycle line (active when B SUPPLY switch is on).
C. Other side of 115-volt, 60-cycle line (active when B STBY switch is on).
D. 6.3-volt, 60-cycle AC.
E. Ground side of heaters.

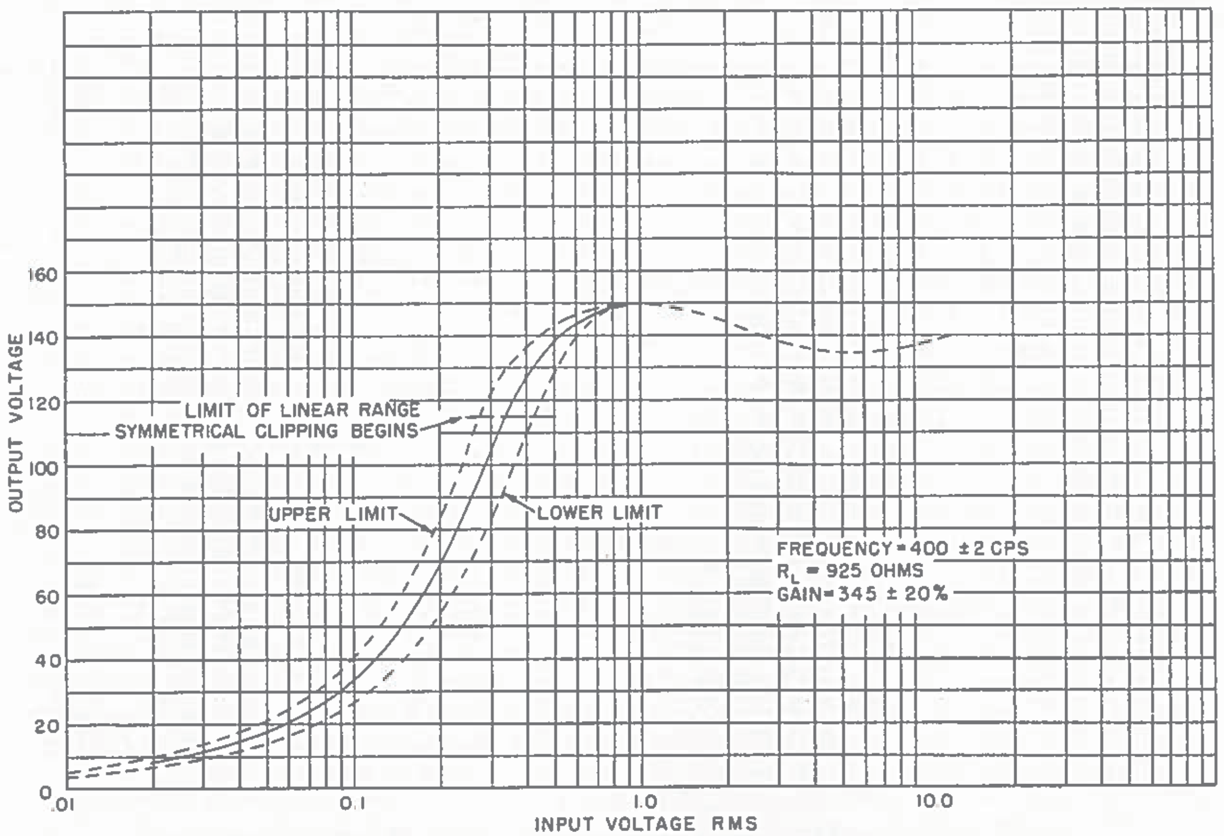


Figure 140—Amplitude Response (Servo Amplifier, Resonant Damp and Filter)

PIN J109 (AN-3102-18-12S)

A. 284 volts DC, ripple 0.1 volt AC.
B. 400 volts DC, ripple 0.7 volt AC.
C. —30 volts DC, ripple 1.4 volts AC.
D. 150 volts DC, ripple 0.09 volt AC.
E. 284 volts DC, ripple 0.1 volt AC.
F. Ground AC, 0 volts DC.

PIN DC SUPPLY, J101

A. —24 volts DC, 0 volts AC.
B. Not connected.
C. Ground 0 volts DC, 0 volts AC.

PIN J102, ENABLER (GYRO ENABLER Switch on ENABLER)

A. Ground (motor control field) AC, 0 volts DC.
B. 115 volts, 400 cps AC (motor control field) 0 volts DC.
C. Ground (R2, enabler synchro), 0 volts DC.
D. 115 volts, 400 cps AC (R1, enabler synchro), 0 volts DC.
E. S2 lead.
F. —24 volts DC (when enabler is enabled), 0 volts AC.
G. —24 volts DC (when reversing contact is closed).
H. —24 volts DC, 0 volts AC.
I. —24 volts DC (when limit contact is closed), 0 volts AC.
J. Ground (control field servo motor), 0 volts AC.
K. 115 volts AC (output servo amplifier to control field servo motor), at null 0 volts AC.
L. S3, 0 volts DC, AC varies with synchro position.

PIN J103, Gyro (GYRO ENABLER Switch on GYRO)

A. Ground (R1) AC, 0 volts DC.
B. 115 volts, 400 cps (R2), 0 volts DC.
C. S3, 0 volts DC, AC varies with synchro position.

D. S1, 0 volts DC, AC varies with synchro position.
E. S2, 0 volts DC, AC varies with synchro position.
F. Not connected.
G. Ground side of gyro "GJ" light.
H. 115 volts, 400 cps AC (motor reference field), 0 volts DC.
J. Ground return for "GJ" light (indicates gyro is latched).
K. Ground (motor reference field) DC, 0 volts AC.
L. 55 volts AC, (output of servo amplifier to motor control field) at nul 0 volts DC.
M. Ground (motor control field) 0 volts DC, 0 volts AC.
N. —24 volts DC (when starboard pickoff in gyro is closed), 0 volts AC.
P. —24 volts DC (when GYRO MOTOR switch is on), 0 volts AC.
R. —24 volts DC (when port pickoff in gyro is closed), 0 volts AC.
S. Not connected.
T. —24 volts DC, 0 volts AC.

PIN X103, MOPA Connector

1. Ground side of filaments, 0 volts DC, 0 volts AC.
2. 6.3-volt, 60-cycle AC, 0 volts DC.
3. 284 volts DC, 0.1 volt AC.
4. 400 volts DC, 0.7 volt AC.
5. Ground side of 400 cps AC, 0 volts DC.
6. 115 volts, 400 cps AC, 0 volts DC.
7. Ground, 0 volts AC, 0 volts DC.
8. —30 volt DC bias, 1.4 volts AC.

PIN J107, Servo Amplifier

1. 0 volts AC, 0 volts DC.
2. 0.018 volts AC (error signal to amplifier) at null.
3. 0 volts AC, 0 volts DC.
4. Ground, 0 volts DC.
5. 150 volts DC, 0 volts AC.
6. Not connected.
7. 284 volts DC, 0.1 volts AC.
8. Ground, 0 volts DC.
9. Approximately 12 volts AC at null, 0 volts DC.
10. 0.056 volts AC at null, 0 volts DC.
11. 55 volts AC at null (servo amplifier output).
12. Not connected.
13. Ground, 0 volts AC, 0 volts DC.
14. 6.3-volt, 60-cycle AC, 0 volts DC.
15. Ground side of filaments, 0 volts DC, 0 volts AC.

TERMINAL Output of Synchros (Set at Null)

R1 Ground.
R2 Approximately 0.2 volts AC.

PIN J401, Torpedo (Switching Panel)

A. Not connected.
B. Ground.
C. Output of servo amplifier (gyro), variable, approximately 2 to 45 volts, 400 cps AC at null.
D. Output servo amplifier (enabler), variable, approximately 2 to 45 volts, 400 cps AC at null.
E. Not connected.
F. Not connected.
G. —24 volts DC (when FIRE switch closed).
H. Ground.
J. Not connected.
K. Not connected.
L. 115 volts, 400 cps AC.
M. Ground.
N. 115 volts, 400 cps AC.
P. Ground.
R. —24 volts DC (when on STANDBY or ON).
S. Ground.
T. —24 volts DC in BL or NL, not connected in AL.
U. —24 volts DC in AL or NL, not connected in BL.
V. —24 volts DC in AL or BL, not connected in NL.
W. Not connected.
X. S1 lead on ENABLER.
Y. S2 lead on ENABLER.
Z. Ground.
a. S1 lead on GYRO.
b. S2 lead on GYRO.
d. Common S3 lead.

Section 14.4—Gyro Test Stand

General

The gyro test stand, figures 141 and 142, is used in measuring the precession of the gyro assembly of Torpedo Mk 27 Mod 4. The test stand consists of a heavy frame which supports a tilting and rotating turntable. On this turntable is mounted a bracket to which the gyro is secured during testing. The tilting assembly is fitted with suitable weights so that it is in approximate balance while the gyro is attached to the bracket. Two electric motors, controlled by switches mounted on the frame, can be mechanically coupled to the turntable so as to oscillate the turntable in the vertical plane through an angle of ±15 degrees measured about the 45-degree position at a rate of ten cycles per minute, and simultaneously to oscillate the turntable through an angle of ±10 degrees about an axis perpendicular to the turntable at a rate of ten cycles per minute. On the turntable are mounted a micropositioner and two 24-volt lights, one red and one green. These lights indicate the position of the gyro pickoff contact. Also mounted on the turntable are a switch for controlling the gyro motor, a push-button switch for operating the gyro unlatching mechanism, and a connector and cable for supplying power to the gyro during tests. The turntable is supplied with 24 volts DC through two slip-ring assemblies on the turntable shaft.

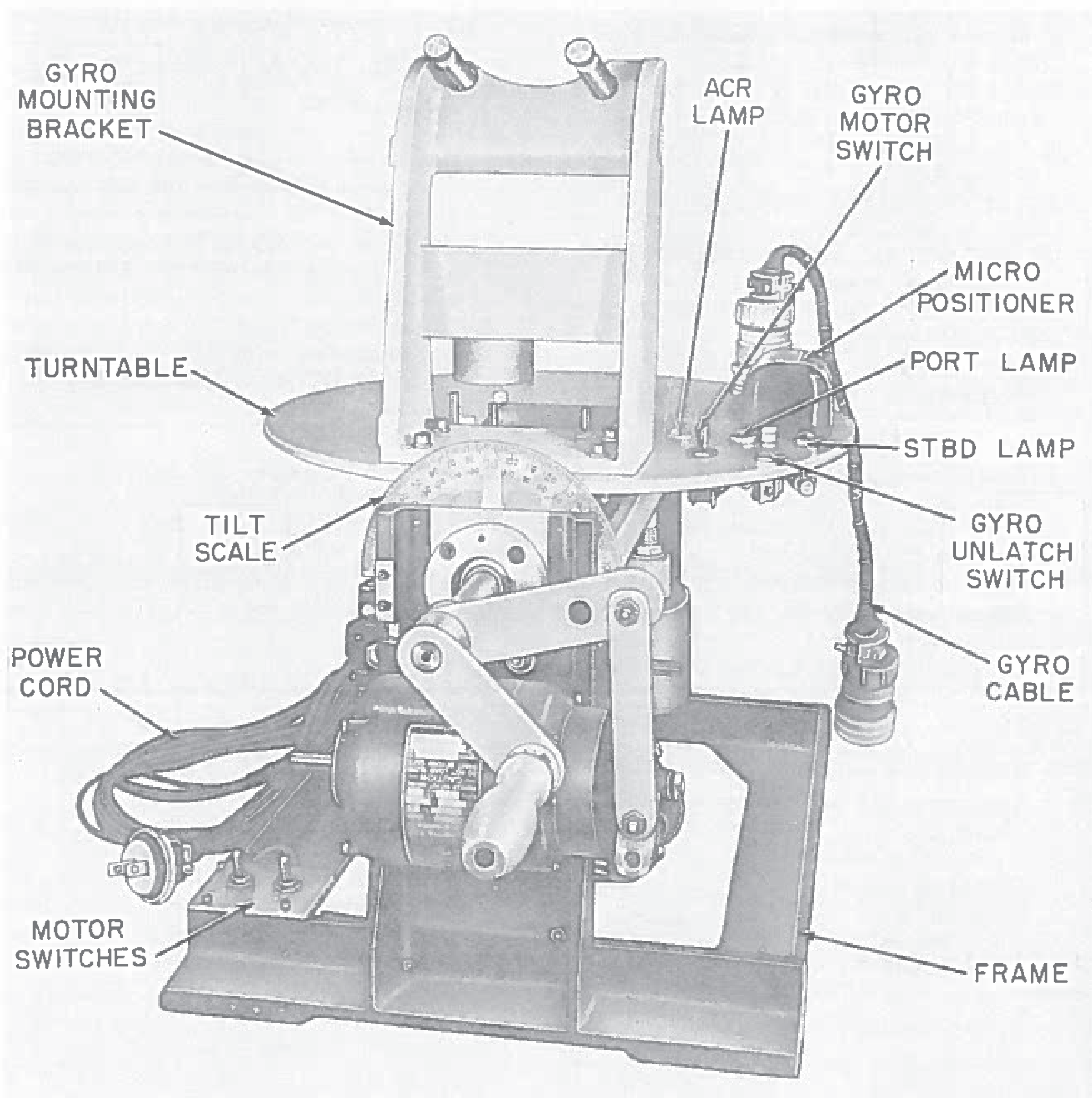


Figure 141—Gyro Test Stand.

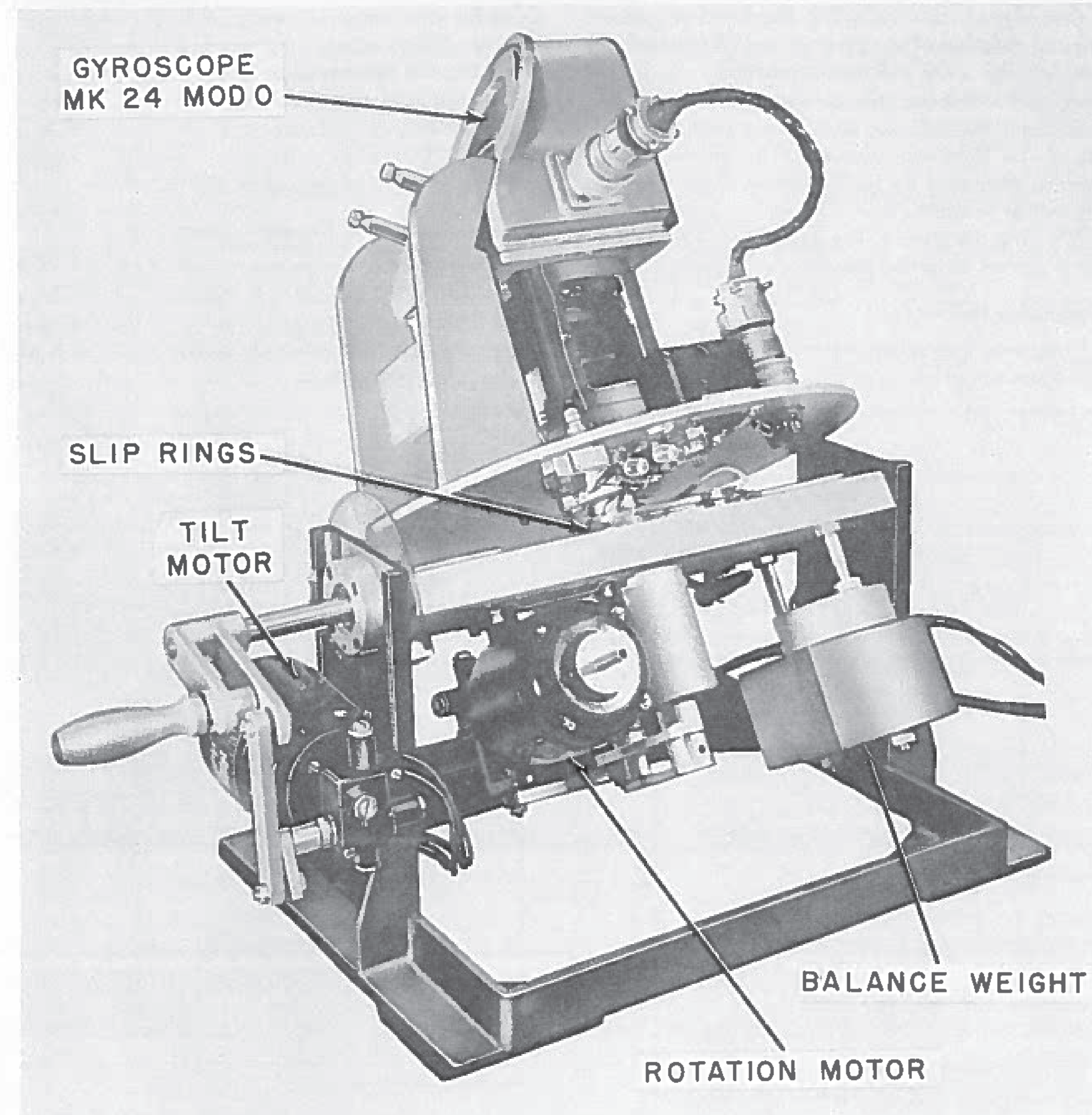


Figure 142—Gyro Test Stand, Lower View.

One edge of the turntable is engraved to indicate angular rotation of the gyro up to 15 degrees either side of the zero reference position. A plastic scale and indicator arm mounted on the front of the frame provide an indication of the angular tilt of the turntable about the horizontal. This scale is calibrated up to 90 degrees either side of a horizontal position.

A wiring diagram of the gyro test stand assembly is shown in figure 143.

Operating Instructions

Complete operating instructions for the gyro test stand are given in chapter 10 with the instructions for the dynamic testing of a gyro assembly. Further information may be found in NavOrd OS 6365, the specification for the gyro assembly.

Operation of the gyro test stand requires the following supply voltages: 115-volt, 60-cycle AC, 24 volts DC, and 17 volts DC. The DC supplies must be capable of delivering five amperes.

Maintenance and Repair Instructions

Normally, no maintenance of the gyro test stand assembly should be required other than periodic lubrication of the moving parts, replacement of burned out indicator lights, or adjustment of the micropositioner.

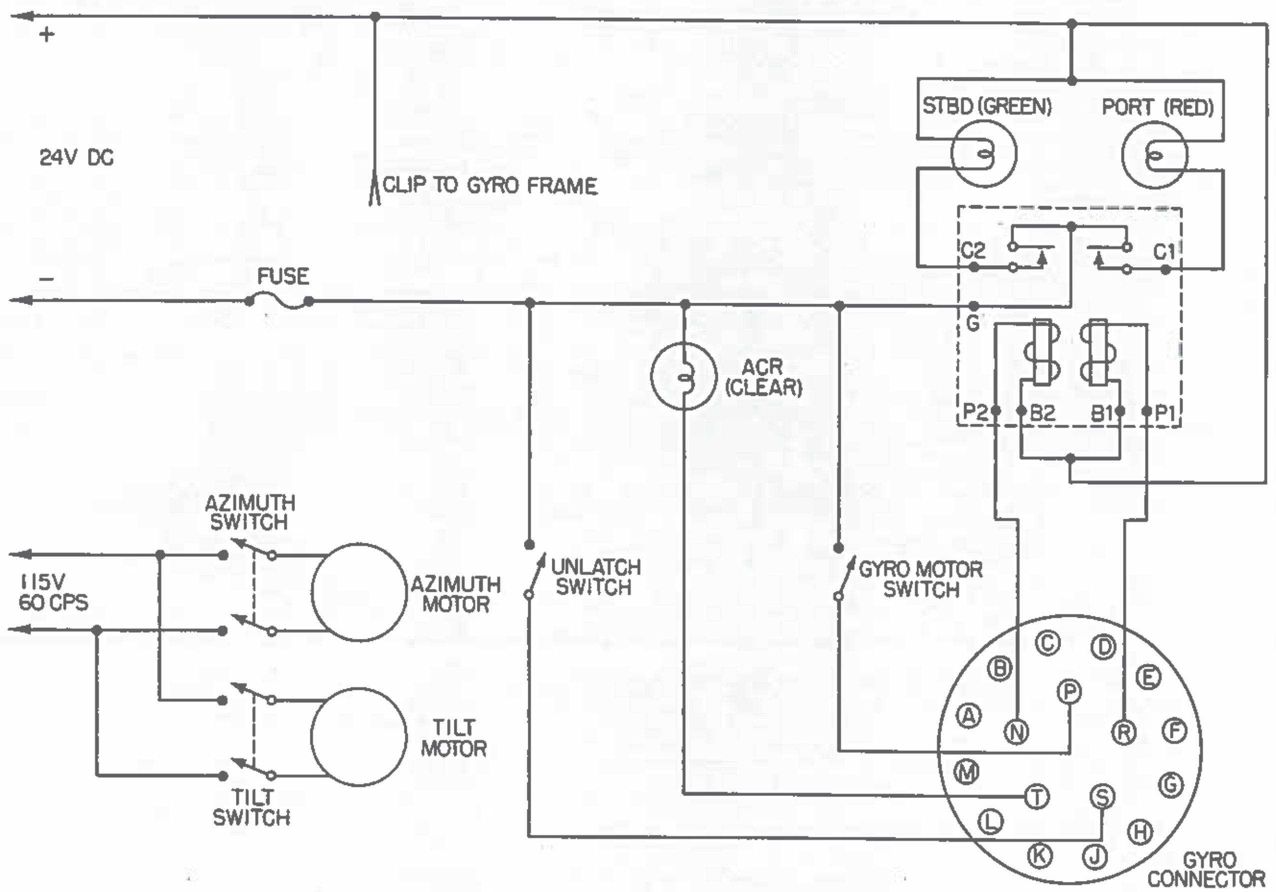


Figure 143—Gyro Test Stand Wiring Diagram.

Chapter 15

SUPPLEMENTARY DATA

Tabulated Data

Designation Mks and Mods

Assembled Torpedo	Mk 27 Mod 4
Warhead	Mk 27 Mod 2
Exercise Head (Recording)	Mk 48 Mod 3
Exercise Head (Nonrecording)	Mk 48 Mod 2
Exploder	Mk 11 Mod 2
Booster	Mk 9 Mod 0
War Battery	Mk 7 Mod 3
Exercise Battery	Mk 8 Mod 4
Gyroscope	Mk 29 Mod 0
B Power Supply (Vibrator)	Mk 74 Mod 1

Principal Dimensions (inches)

Shell Diameter	19. 00
Guide Rail Diameter	21. 00
Height to Top of Guide Studs	21. 375
Overall Length	125. 75
Length of War or Exercise Heads (Less Impeller)	18. 25
Length of Battery Compartment	71. 469
Length of Afterbody	33. 781

Approximate Weights (pounds)

Warshot Torpedo	1174
Warhead Mk 27 Mod 2	200. 5
War Battery Mk 7 Mod 3 (Wet)	410
Afterbody	237
Battery Compartment	326. 5
Exercise Torpedo	1075
Exercise Head Mk 48 Mod 3 (Recording)	200. 5
Exercise Head Mk 48 Mod 2 (Nonrecording)	198
Exercise Battery Mk 8 Mod 4 (Wet)	311
HBX Explosive in Warhead	124

Trim and Stability

Displacement (Salt Water Sp. Gr. 1.025)	1100 pounds
Warshot Buoyancy (Salt Water)	−74 pounds
Exercise Buoyancy (Salt Water)	25 pounds
Center of Displacement (From Tip of Head)	55.7 inches
Warshot Center of Gravity (From Tip of Warhead)	55.6 inches
Warshot Center of Gravity (Below Axis)	1.15 inches
Exercise Center of Gravity (From Tip of Head)	56.2 inches
Exercise Center of Gravity (Below Axis)	1.07 inches
(Exercise Center of Gravity on Vertical Center Line)	
Warhead Mk 27 Mod 2, Exercise Head Mk 48 Mod 2, and Exercise Head Mk 48 Mod 3	
Center of Gravity from Mating Surface of Joint Ring	9.1 inches
Center of Gravity below Horizontal Axis	2.3 inches (warhead)
(Center of Gravity on Vertical Center Line)	1.4 inches (exercise head)
Center of Gravity from Negative End of Battery Case	25.6 inches
Battery Mk 7 Mod 3	
Center of Gravity from Negative End of Battery Case	26.1 inches
Exercise Torpedo Pull Around Torque	1150 pound-inches
Warshot Torpedo Pull Around Torque	1300 pound-inches

Propulsion Characteristics

Propulsion Motor. (4-pole, compound wound, DC).

Horsepower	11.5
Design Voltage	57
Design Current (11.5 hp. load).	192 amps
Design Speed at 40 pound-feet torque.	1500 rpm

Acoustic Characteristics

Homing Threshold—AL	18–22 dbs
Homing Threshold—BL, NL	16–20 dbs
Self-Noise	20–24 dbs

Hydrophone Sensitivity Characteristics Markings

Characteristic Letter	Spectral Sensitivity
D	−99
E	−100
F	−101
G	−102
H	−103
I	−104
J	−105

Dynamic Characteristics

Accumulated Speed to 3000 yards (Battery Mk 7 Mod 3).	15.5 knots
Running Time to 3000 yards	5 min. 45 sec.
Minimum Attack Time	4 min. 15 sec.
Total Probable Running Time	10 min.
Search Depth (AL)	70 feet
Search Depth (BL, NL)	125 feet
Search Circle Radius (approximate).	50 yards
Attack Circle Radius (approximate).	16 yards
Deflection Accuracy 1000 yards (mean deviation).	±19 yards
Deflection Accuracy 2000 yards (mean deviation).	±44 yards
Deflection Accuracy 3000 yards (mean deviation).	±74 yards
Swim-out Time from Submerged Tube Mk 33.	10 sec.
Enabler Accuracy	±120 yards
Drag (at 17 knots)	144 pounds
Rudder and Elevator Torque Compensation.	40 inch-pounds
Motor and Propeller Speed (Mk 7 Mod 3 Battery)	
Initial	1400 rpm
At End of 6 Minutes	1325 rpm

Electrical Setting Characteristics

Gyro Accuracy	±0.5 degrees
Enabler Accuracy	±50 yards
Gyro and Enabler Synchronization Time	180 degrees 3 sec. max.

Identification

The registry number is the torpedo identification number. This number is stamped on the upper forward section of the afterbody shell.

All components of the torpedo are identified by means of serial numbers either marked or stamped on the part. These include the battery compartment, control panel, gyroscope, hydrophones, B power supply, and other components.

Tools and Other Workshop Equipment

Base Maintenance Tools

The tools in the following list are provided with code numbers by means of which they are referenced in the maintenance sections of the manual. These tools include all of the tools necessary for servicing Torpedo Mk 27 Mod 4 during base maintenance. Various special tools are shown in figures 144 through 148.

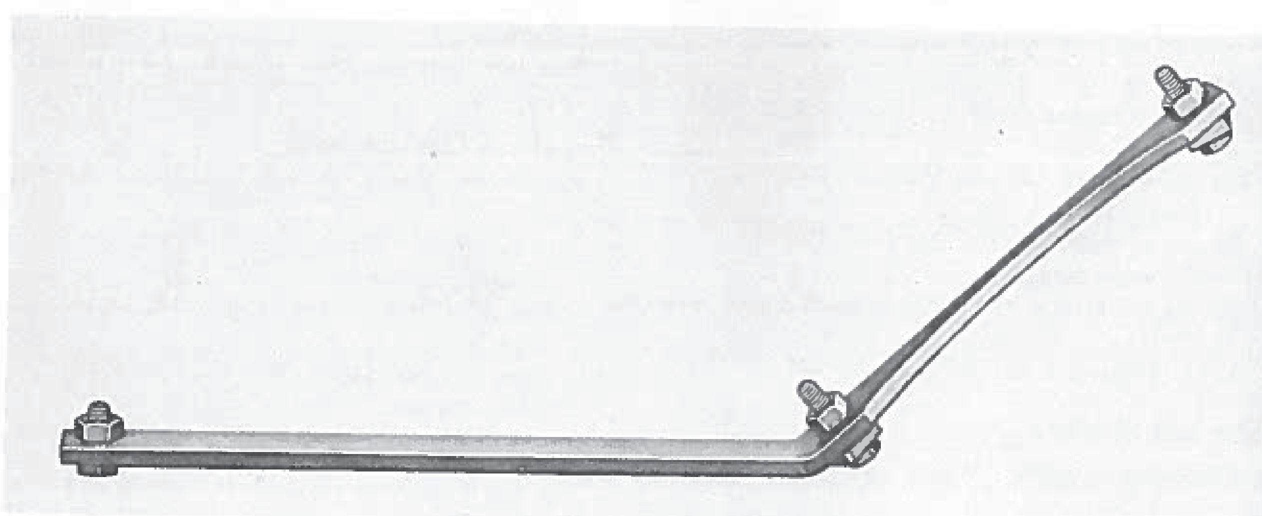


Figure 144—Panel Support Arm (No. 8).

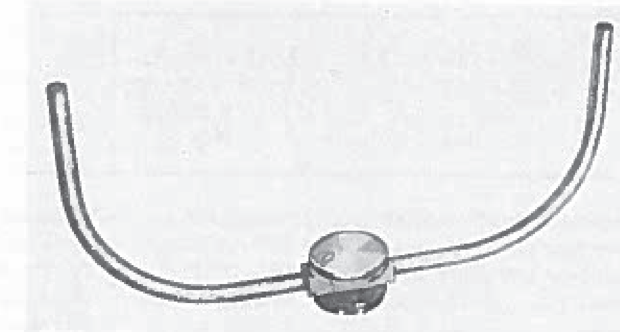


Figure 145—Nose Lifting Handle (No. 7).

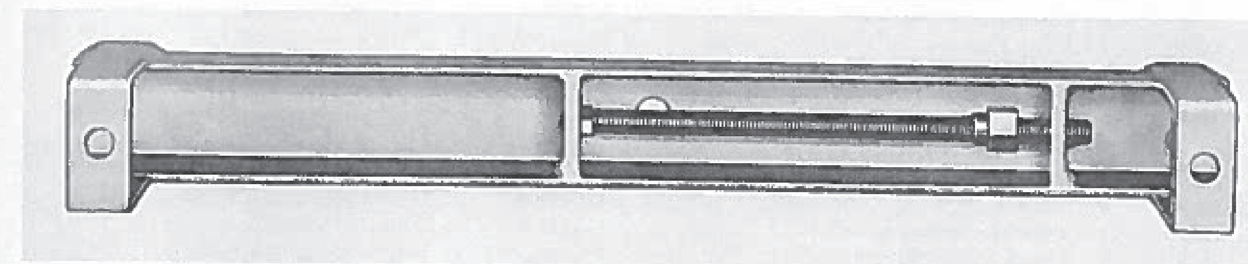


Figure 146—Motor Puller (No. 5).

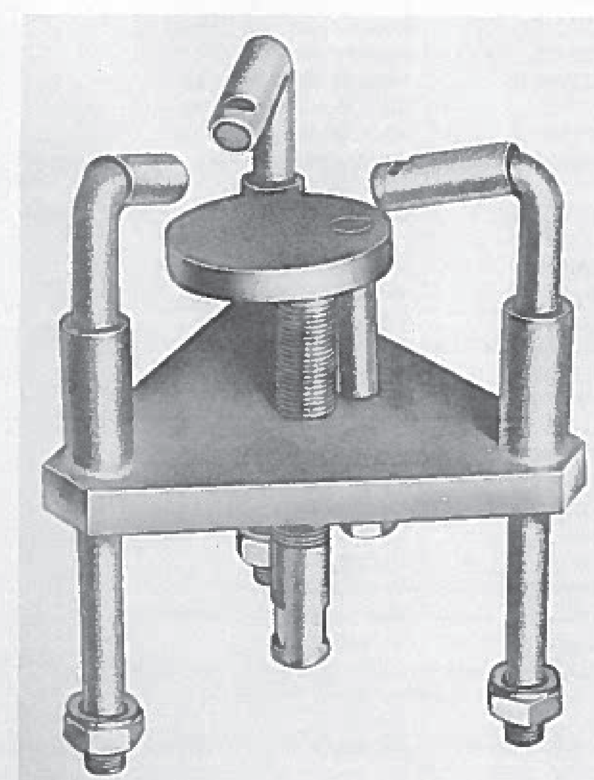


Figure 147—Propeller Puller (No. 4).

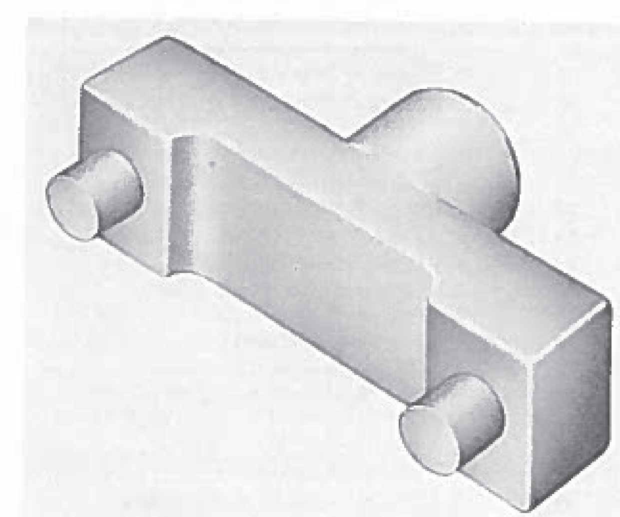


Figure 148—Cap Spanner Wrench (No. 31).

Tool No.	Quantity	Tool	Drawing No. or Standard Navy Stock No.	Use
1	1	Taper Pin Tightener (horizontal)	WA-16524	To install taper pins.
2	1	Taper Pin Remover (horizontal)	WA-16523	To remove taper pins.
3	1	Taper Pin Remover (vertical)	WA-16525	To remove taper pins.
4	1	Propeller Puller	378588-4	To remove propeller.
5	1	Motor Puller	378591-7	To remove propulsion motor.
6	2	Motor Puller Extension	WA-16552	To remove propulsion motor.
7	1	Nose Lifting Handle	378595-4	To lift heads.
8	1	Panel Support Arm	378603-1	To support control panel.
9	1	Switch Arm Bender	378608-3	To adjust steering motor limit switches.
10	1	Vent Puller	WA-16542	Remove vents.
11	1	Explosimeter and Bulb	388670-9	To test for hydrogen.
12	1	Explosimeter Line	388670-9	To test for hydrogen.
13	1	Exploder Circuit Test Cord	827322	To test exploder circuit.
14	2	Exploder Circuit Test Lamp	WA-16540	To test exploder circuit at connector.
15	4	Air Fitting	388633-1	Air and vacuum system.
16	4	Gasket	388633-3	Air and vacuum system.
17	1	Pressure Switch Adapter	765014	Air and vacuum system.
18	1	Depth Unit Adapter	765015	Air and vacuum system.
19	4	Leak Meter Fitting	WA-16547	Air and vacuum system.
20	1	Battery Air Fitting	765019	Air and vacuum system
21	6	Hose Connection, screw on (commercial).	765012	Air and vacuum system.
22	6	Hose Clamp (3/8" OD hose)	33-C-71-900	Air and vacuum system.
23	1	Charging Cord Adapter	765020	Battery charging.
24	1	Stud Tightener	378596-2	Tighten connecting stud.
25	1	Wrench, Test Switch	765013	To operate test switch.
26	2	Drift Pin	378608-2	Aline propulsion motor.
27	1	Tap, special (commercial)	765016	To tap depth and pressure switch vents.
28	1	Tap Wrench, adjustable	41-W-3507	To tap depth and pressure switch vents.
29	1	Spanner Wrench, Fairwater	378600-3	To remove fairwater nut.
30	1	Spanner Wrench, Thrust Bearing	378606-4	To open stem bearing.
31	1	Spanner Wrench, Cap	827314	To remove fuze cap.
32	1	Spanner Wrench, Control Cable	827311	To install and remove control cable.
33	1	Spanner Wrench, Vent	827321	To remove vent fittings.
34	1	Hydrometer Case	388670-4	Battery testing.
35	1	Filling Syringe	388672-1	Battery testing.
36	1	Voltohmmeter and Leads	388672-3	Electrical tests.
37	1	Spare Leads for Voltohmmeter	388672-4	Electrical tests.
38	1	Flashlight	17-F-13550	General.
39	1	Level, Carpenter's 18"	388671-4	To level afterbody.
40	1	Mirror, Splicers	388671-5	General.
41	1	Spring Adjuster	388670-1	Relay adjustment.
42	1	Contact Burnisher	388670-3	Burnishing relay contacts.
43	1	Soldering Iron, 125 watt	41-I-688	General.
44	1	Die, Rethreading, 7/16-20 NF-2	41-D-923	Rethread afterbody and head mating studs.
45	1	Cold Chisel, 7/16" x 5½"	41-C-1108	General.
46	1	File 6", bastard cut	41-F-1153	General.
47	1	File 6", smooth warding cut	41-F-1614	General.
48	1	File Handle	41-H-1116	General.
49	1	Hammer, Ball Peen, 1 lb	41-H-523	General.

Tool No.	Quantity	Tool	Drawing No. or Standard Navy Stock No.	Use
50	1	Socket Wrench, Battery Terminal	827305	To remove leads from battery.
51	1	Pliers, slip joint, combination, 6", with cutter.	41-P-1631	General.
52	1	Pliers, diagonal cutting, 6"	41-P-1714	General.
53	1	Pliers, duck bill, 6"	41-P-1720	General.
54	1	Pliers, needle nose, 6", with cutter	41-P-1991	General.
55	2	Ratchet, 3/8" square drive, reversible	41-H-1504-560	General.
56	2	Extension Bar, 3/8" square drive, 3"	41-B-304-800	General.
57	1	Socket Wrench, 9/16", 12 point	41-W-2999-125	General.
58	1	Socket Wrench, 5/8", 12 point	41-W-2999-175	General.
59	2	Socket Wrench, universal joint, 5/8", 12 point.	41-W-2999-210	Mating nuts.
60	2	Socket Wrench, 3/4", 12 point	41-W-2999-250	General.
61	1	Socket Wrench, offset, 9/16" sq	388672-13	General.
62	1	Wrench, check nut 9/16"	41-W-851-50	General.
63	1	Wrench, open end, 5/16" and 3/8"	41-W-1176-10	General.
64	1	Wrench, open end, 7/16" and 1/2"	41-W-1176-18	General.
65	1	Wrench, open end, 5/8" and 3/4"	41-W-1176-33	General.
66	1	Wrench, tappet 1/2" and 9/16"	41-W-3576	General.
67	1	Wrench, box, double offset 7/16" and 3/8"	41-W-598	General.
68	1	Wrench, box, double offset 1/2" and 9/16"	41-W-600	General.
69	1	Wrench, box, double offset 5/8" and 11/16"	41-W-602	General.
70	1	Wrench, adjustable, 22½°	41-W-486	General.
71	1	Wrench, pipe, adjustable	41-W-1661	General.
72	1	Wrench, spintite, 1/4"	41-W-2877-109	General.
73	1	Wrench, spintite, 5/16"	41-W-2877-126	General.
74	1	Wrench, spintite, 11/32"	41-W-2877-134	General.
75	1	Wrench, spintite, 3/8"	41-W-2877-144	General.
76	4	Wrench, hex key, No. 4, short arm	41-W-2444	General.
77	4	Wrench, hex key, No. 6, short arm	41-W-2445	General.
78	4	Wrench, hex key, No. 8, short arm	41-W-2446	General.
79	4	Wrench, hex key, No. 10, short arm	41-W-2449	General.
80	4	Wrench, hex key, No. 10, long arm	41-W-2410-4	General.
81	4	Wrench, hex key, 1/4", short arm	41-W-2450	General.
82	1	Screwdriver, cabinet, 2½", 3/16" blade	41-S-1056	General.
83	1	Screwdriver, heavy duty, 4", 5/16" blade	41-S-1068-15	General.
84	1	Screwdriver, double offset, 5", 5/16" blade.	41-S-1397-25	General.
85	1	Screwdriver, general purpose, 4", 1/4" blade.	41-S-1102	General.
86	1	Screwdriver, closequarter, 1¾", 1/4" blade.	41-S-1063	General.
87	1	Pin Punch, 3/16"x4", solid	41-P-3641	General.
88	1	Wrench, open end brake, 5/16" and 3/8"	388672-9	General.
89	1	Hydrometer Syringe and Float	721506	Battery testing.
90	1	Screwdriver, Roto Torque		To mount hydrophones.
91	1	Torque Wrench, 50 lb-ft	41-W-3629-75	For all hand hole cover bolts.
92	1	Socket Wrench, 3/4", ½ drive	41-W-3017	For all hand hole cover bolts.

Patrol Maintenance Tools

These tools include all of the tools necessary for ship board maintenance of Torpedo Mk 27 Mod 4. Except for two open-end wrenches, these tools are duplicates of base maintenance tools, and are listed with same reference number.

Tool No.	Quantity	Tool	Drawing No. or Standard Navy Stock No.
11	1	Explosimeter and Bulb	388670
12	1	Explosimeter Line	388670
24	1	Stud Tightener	378596
25	1	Wrench, Test Switch	765013
34	1	Hydrometer Case	388670
35	1	Filling Syringe	388672
36	1	Voltohmmeter and Leads.	388672
37	1	Spare Leads for Voltohmmeter.	388672
38	1	Flashlight	17-F-13550
44	1	Die, Rethreading, 7/16–20NF-2.	41-D-923
46	1	File, 6″, bastard cut	41-F-1153
47	1	File, 6″, smooth warding cut.	41-F-1614
48	1	File Handle	41-H-1116
49	1	Hammer, Ball Peen, 1 lb.	41-H-523
51	1	Pliers, slip joint, combination, 6″, with cutter.	41-P-1631
55	2	Ratchet, 3/8″ square drive reversible.	41-H-1504-560
56	2	Extension Bar, 3/8″ square drive, 3″.	41-B-304-800
59	2	Socket Wrench, universal joint, 5/8″, 12 point.	41-W-2999-210
60	2	Socket Wrench, 3/4″, 12 point.	41-W-2999-250
61	1	Socket Wrench, offset, 9/16″.	388672
62	1	Wrench, check nut	41-W-851-50
70	1	Wrench, adjustable, 22½°.	41-W-486
71	1	Wrench, pipe, adjustable.	41-W-1661
77	4	Wrench, hex key, No. 6, short arm.	41-W-2445
82	1	Screwdriver, cabinet, 2½″, 3/16″ blade.	41-S-1056
83	1	Screwdriver, heavy duty, 4″, 5/16″ blade.	41-S-1068-15
85	1	Screwdriver, general purpose 4″, 1/4″ blade.	41-S-1102
89	1	Hydrometer Syringe and Float.	721506
91	1	Torque wrench, 50 lb-ft.	41-W-3629-75
92	1	Socket wrench, 3/4″, 1/2″ drive.	41-W-3017

Other Workshop Equipment

In addition to the appropriate tool kit and required test equipment, a torpedo workshop should be supplied with the following equipment to facilitate overhauling torpedoes conveniently and safely.

Description	Recommended Type
1. Several complete sets of dollies.	BuOrd Dwgs. 794296 and 794312.
2. Power or chain hoist capable of lifting at least one ton.	Any reliable hoist.
3. Slings for lifting torpedo and its components.	Heavy cotton webbing of suitable dimension.
4. Battery charger	BuOrd Dwg. 778994.
5. Compression and vacuum system (for outlying bases).	BuOrd Dwg. 794436.
6. An extra vacuum tube voltmeter.	
7. Fresh water supply and hose.	

Record of NAVORD INSTRUCTIONS

Functional descriptions in the text of this manual are based on the accomplishment of modifications directed by the following NAVORD Instructions.

No.	*Title*
8510.7B	Torpedo Overhaul Policy.
8510.19	Removal of Pendulum Clamp.
8510.37	Use of Explosimeter.
8510.43A	Torpedo Propulsion Batteries, Care of and Measurement of Ground Voltage.
8513.10	Palladium Catalyst Installation.
8513.13	Replacement of Junction Box Mercury Switches.
8510.57	Torpedo Exploder History Record.
8513.17	Enabler System, Characteristics of.
8513.15	Torpedo Mark 27 Mod 4; wiring changes to gyro unlatching circuit.

* 8513.21 ... TORPEDO MK 27 MOD 4 BELOW LIMIT STRATUM SWITCH SETTING; CHANGE TO.

SAFETY PRECAUTIONS

The following safety precautions appear in the text on the specified pages and are repeated here to draw the special attention of personnel handling the Torpedo Mark 27 Mod 4.

WARNING

(p. 105) Before installing an exploder be absolutely certain that the exploder has been checked and tested as explained in OP 1999.

WARNING

(p. 107) To avoid possibility of an explosion, keep flames away and do not smoke in area. Handle tools carefully to avoid sparks.

WARNING

(p. 107) Charging of storage battery should be done in a well ventilated place because hydrogen gas evolved may result in an explosive mixture if battery is confined. Keep all flames away. Do not smoke in area in which batteries are charged or where torpedoes containing batteries are stored. At 100 degrees (F) it is possible for hydrogen discharged from battery to build up an explosive mixture in an unvented torpedo in approximately 24 hours. Less hydrogen is discharged at lower temperatures. During charging, it is necessary to purge the battery compartment periodically to prevent explosive mixtures from accumulating. Never turn test switch without first checking hydrogen concentration with explosimeter.

WARNING

(p. 108) When charging battery, always break connections at charger control panel by removing fine adjustment plug before connecting or disconnecting charger plug and charging receptacle. This is done to avoid possibility of explosion from electric sparks. Keep the top of the battery dry and clean.

CAUTION

(p. 172) The torpedo circuits contain no fuses. Hence, care must be exercised to avoid short circuits when making tests and repairs. Particular care must be taken to avoid short-circuiting the propulsion battery. The heavy power leads connecting the propulsion motor to the main motor relay should be left unconnected unless it is specifically required for the propulsion motor to operate. It is recommended that a fused source of DC power be employed if available. If it is necessary to use a propulsion battery or other source of DC power, fuses should be inserted in series with the battery leads before tests are made. Use a 15-ampere fuse in the —24-volt lead and a 5-ampere fuse in the —48-volt lead.

CAUTION

(p. 172) Never use a buzzer for making continuity tests. The panel circuits include coils which may be permanently magnetized and thus rendered useless if heavy direct current passes through them.

WARNING

(p. 209) Never pour water into acid. Use an acid-proof container, such as a hard rubber vat, for mixing. Wear splash-proof goggles.

WARNING

(p. 109) Do not keep torpedo on warm-up for continuous periods greater than 15 minutes in order to prevent damage to gyro bearings and consequent malfunction of the gyro.

Record of Ordnance Alterations

3200	Main Motor Coupling Improvement
3301	Guide Rail Extension Notching
3330	Modification for Grounding Power Supply Mk 74 Mod 0
3394	Test Switch Seal
3422	Anti-Broach in Above Limit Stratum Setting
3425	Input Socket Power Supply Mk 74 Mod 1
3440	Installation of Modified Enabler and Circuit Changes for Fail-Safe Operation
3441	PTU - Replacement of Exploder Input Socket
3554	Modernization of Gyro Mk 29 Mod 0
3643	Installation of Fuse in Battery Charging Circuit

No page 250

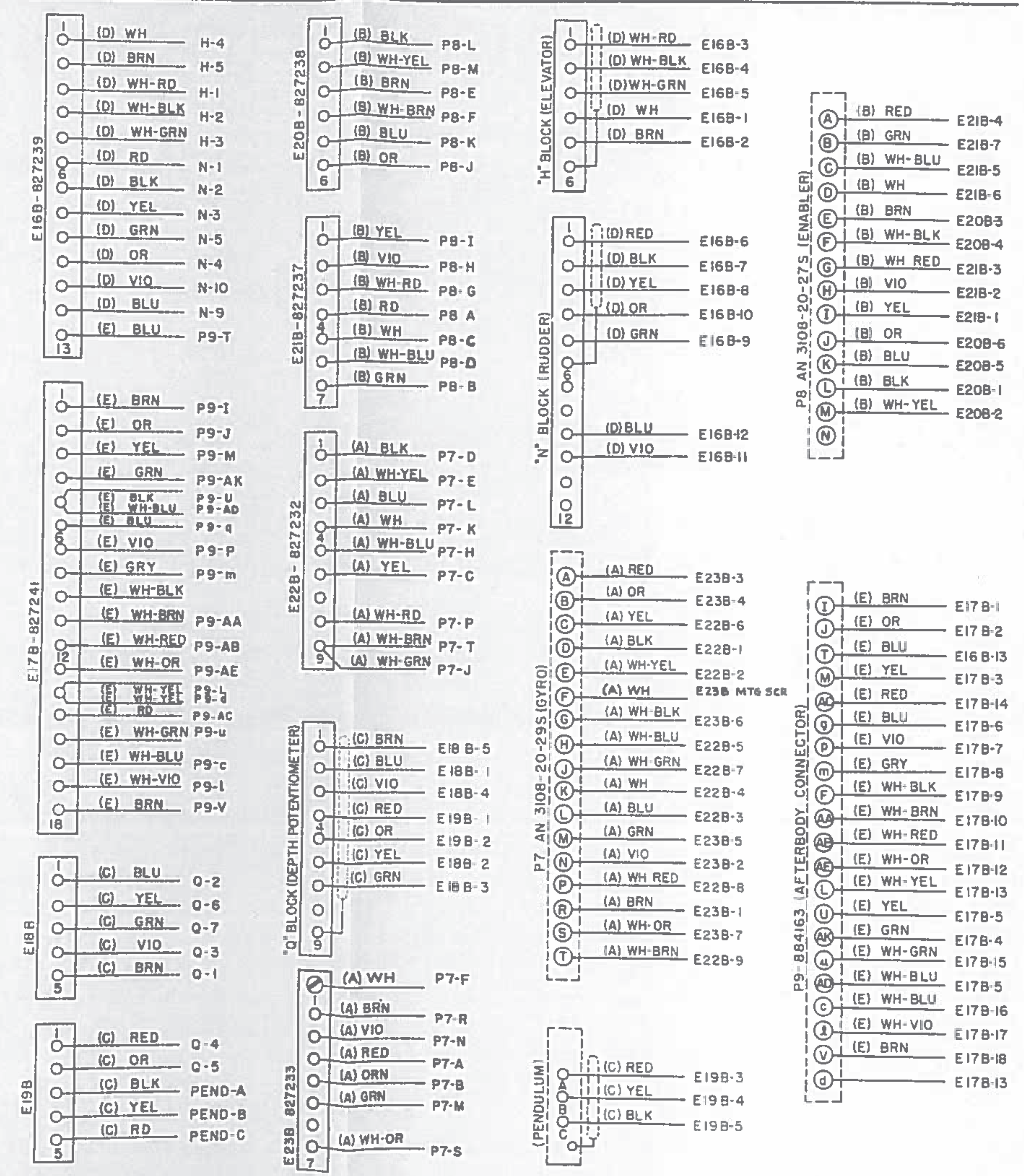
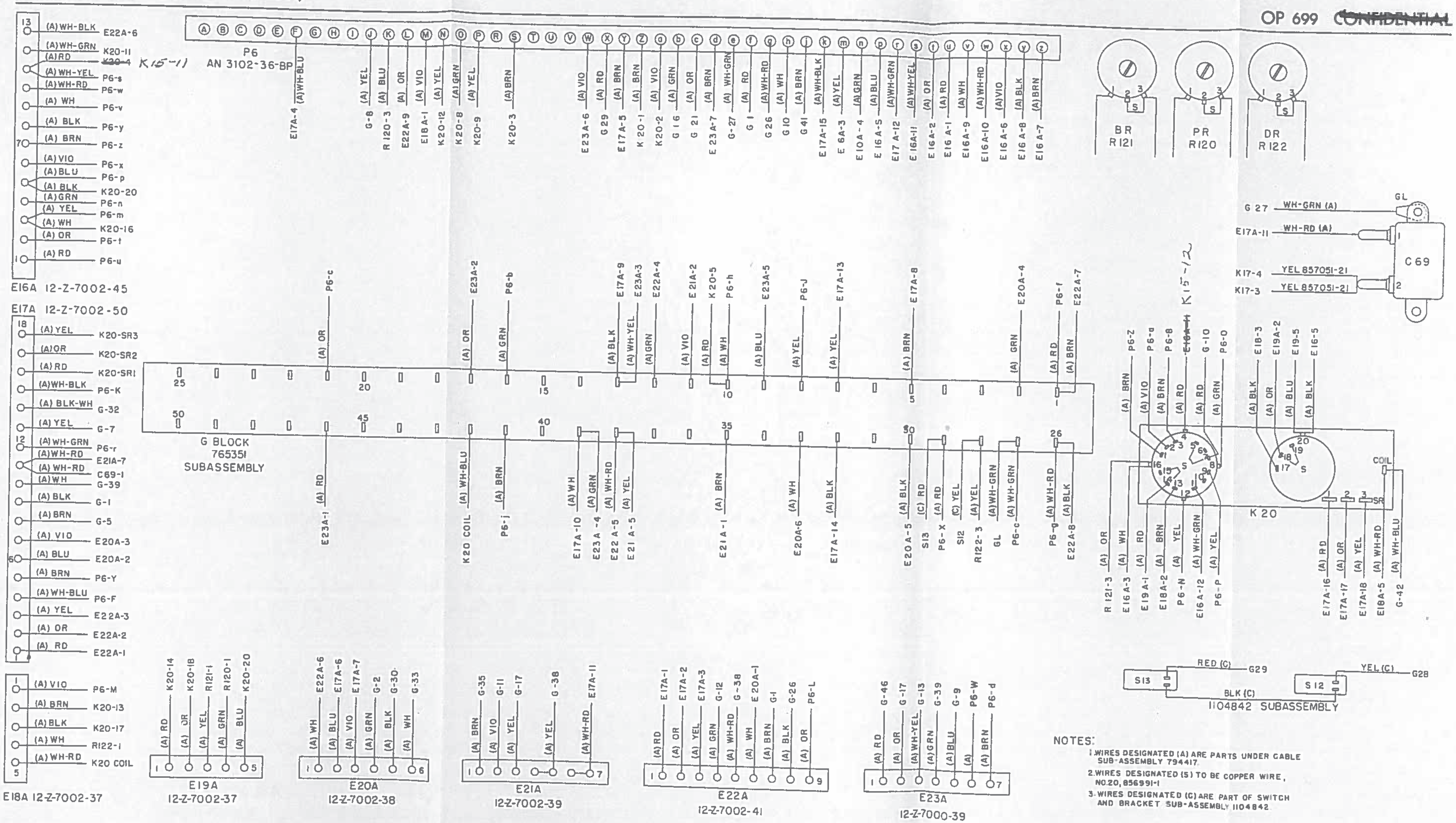


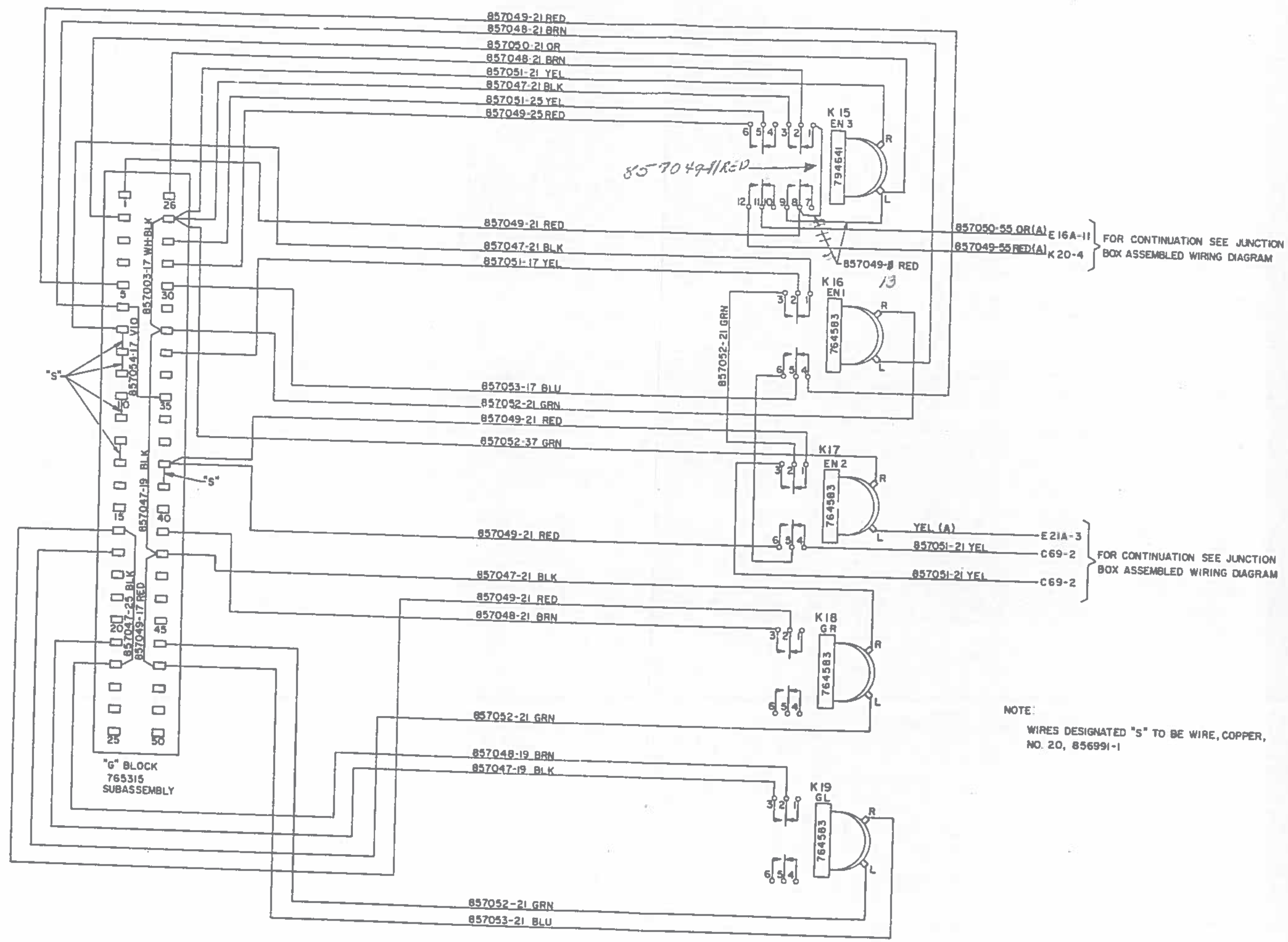
Figure 149—Afterbody Assembled Wiring Diagram.



NOTES:

1. WIRES DESIGNATED (A) ARE PARTS UNDER CABLE SUB-ASSEMBLY 794417.
2. WIRES DESIGNATED (S) TO BE COPPER WIRE, NO.20, 856991-1
3. WIRES DESIGNATED (C) ARE PART OF SWITCH AND BRACKET SUB-ASSEMBLY 1104842

Figure 150—Junction Box Assembled Wiring Diagram.



NOTE:

WIRES DESIGNATED "S" TO BE WIRE, COPPER, NO. 20, 856991-1

Figure 151 Relay and "G" Block Wiring Diagram

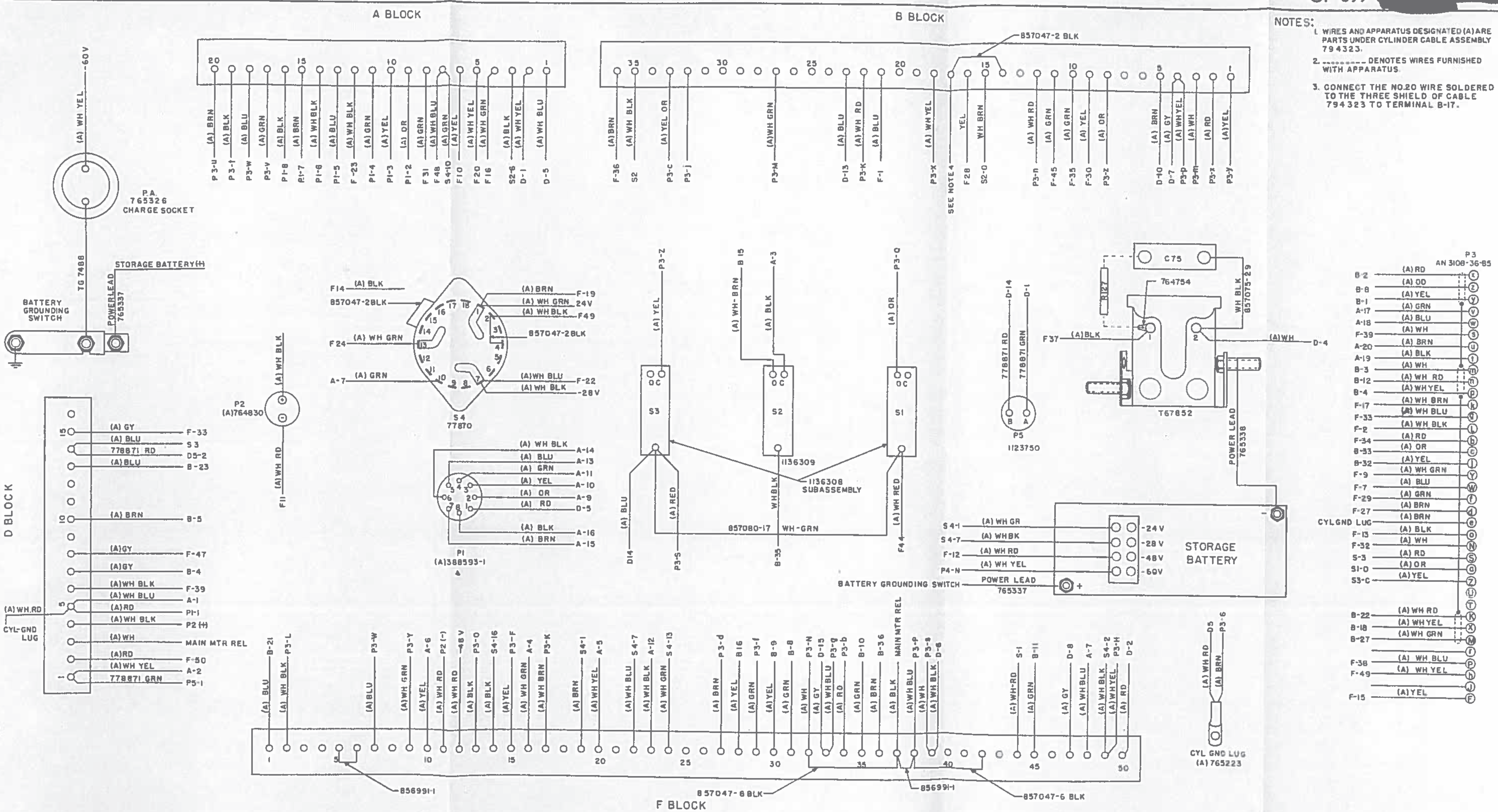


Figure 152—Battery Compartment Assembled Wiring Diagram.

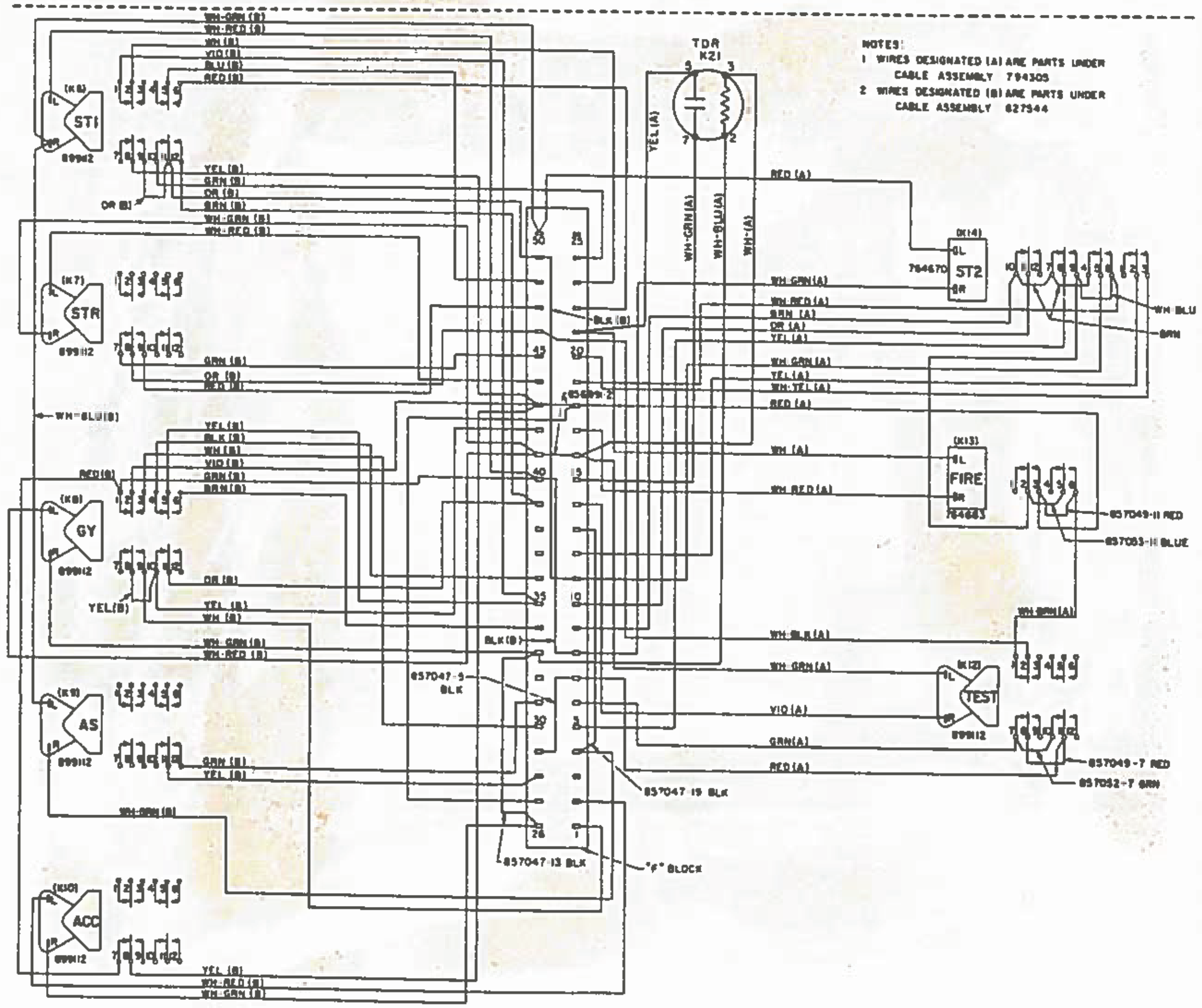


Figure 153 - Auxiliary Control Unit, Assembly Wiring Diagram.

Cut on dotted lines and attach to pages 259-260.

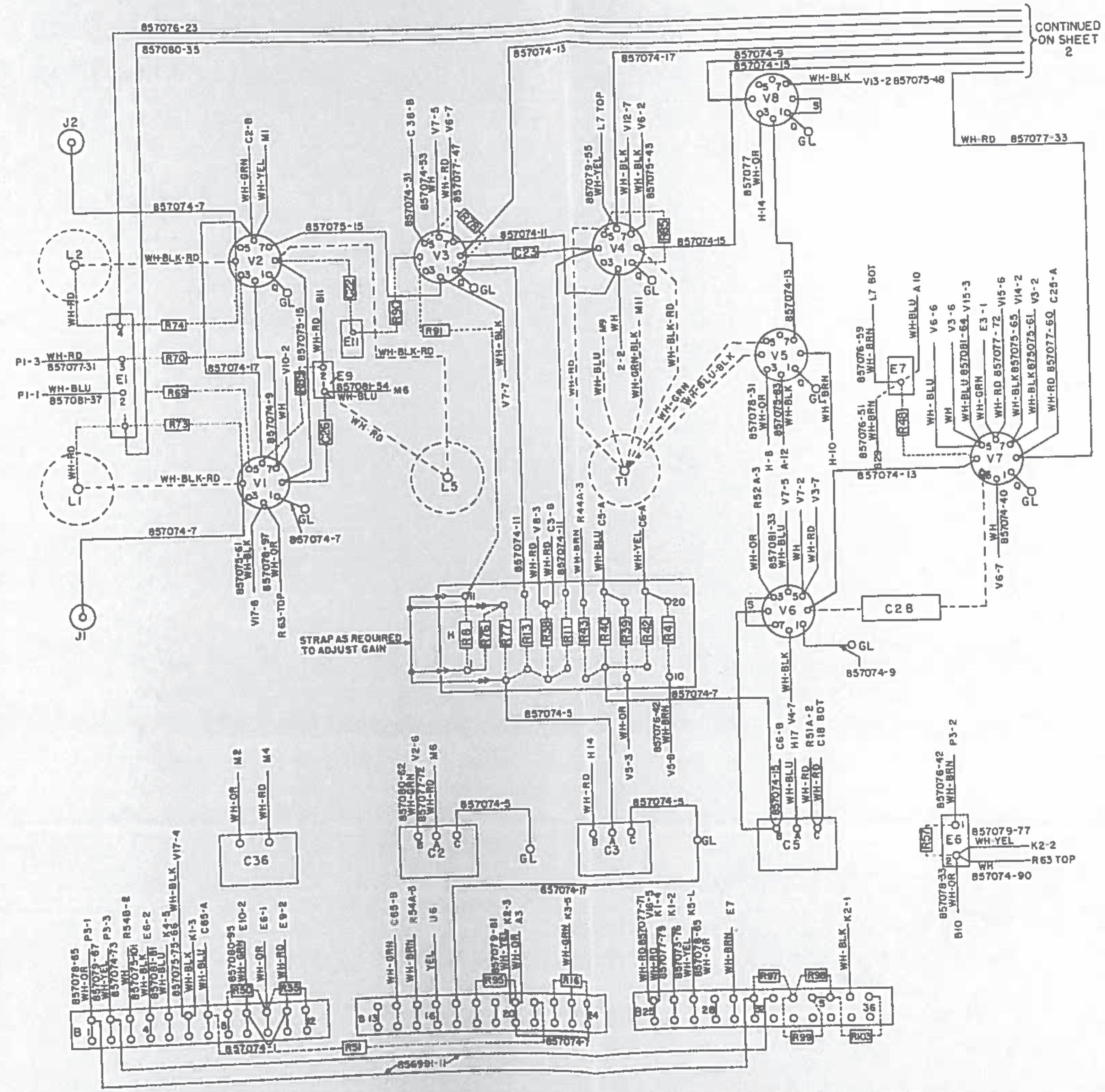


Figure 154—Control Panel Assembled Wiring Diagram (Sheet 1).

381656 O - 56

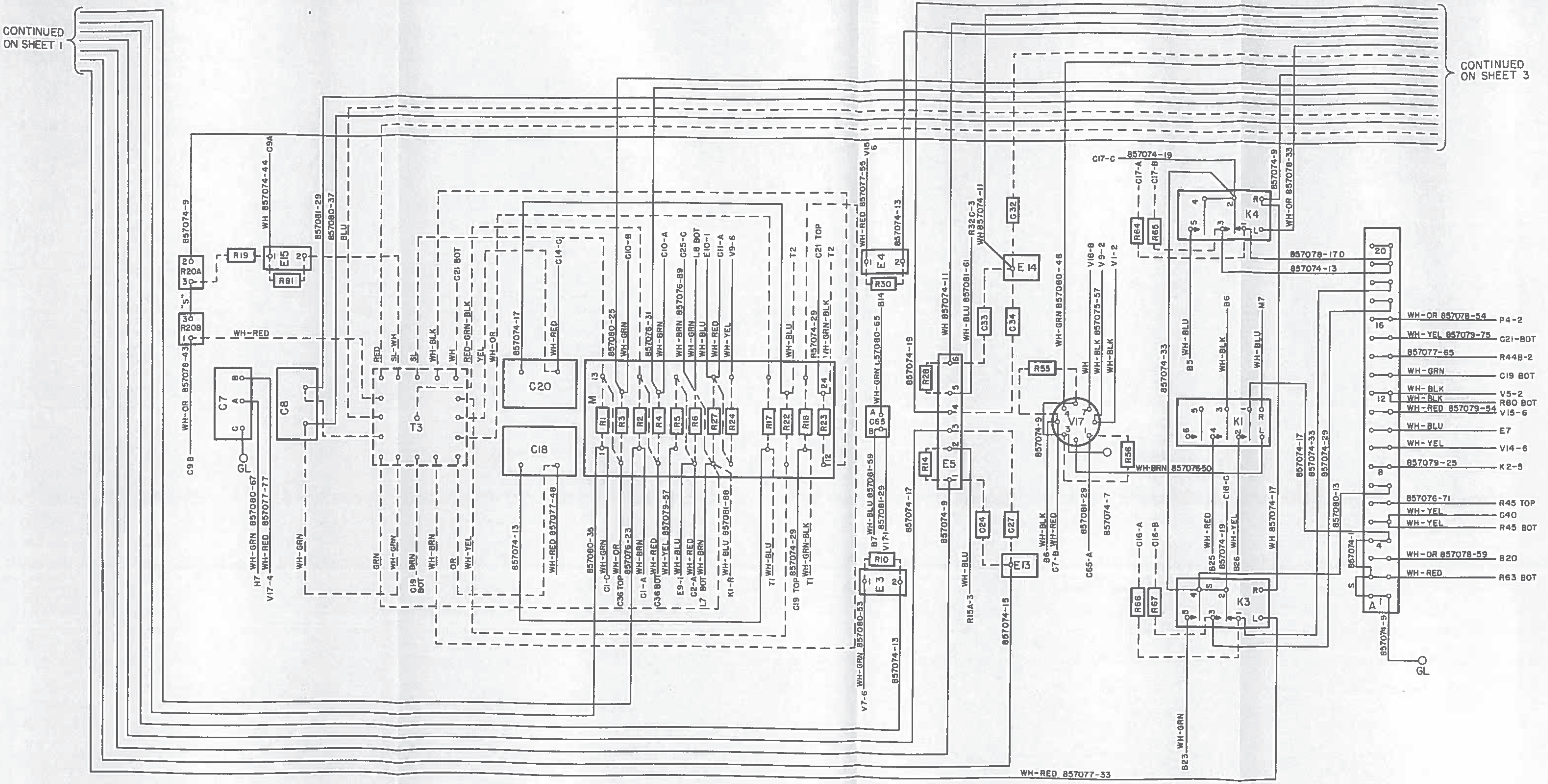


Figure 155—Control Panel Assembled Wiring Diagram (Sheet 2).

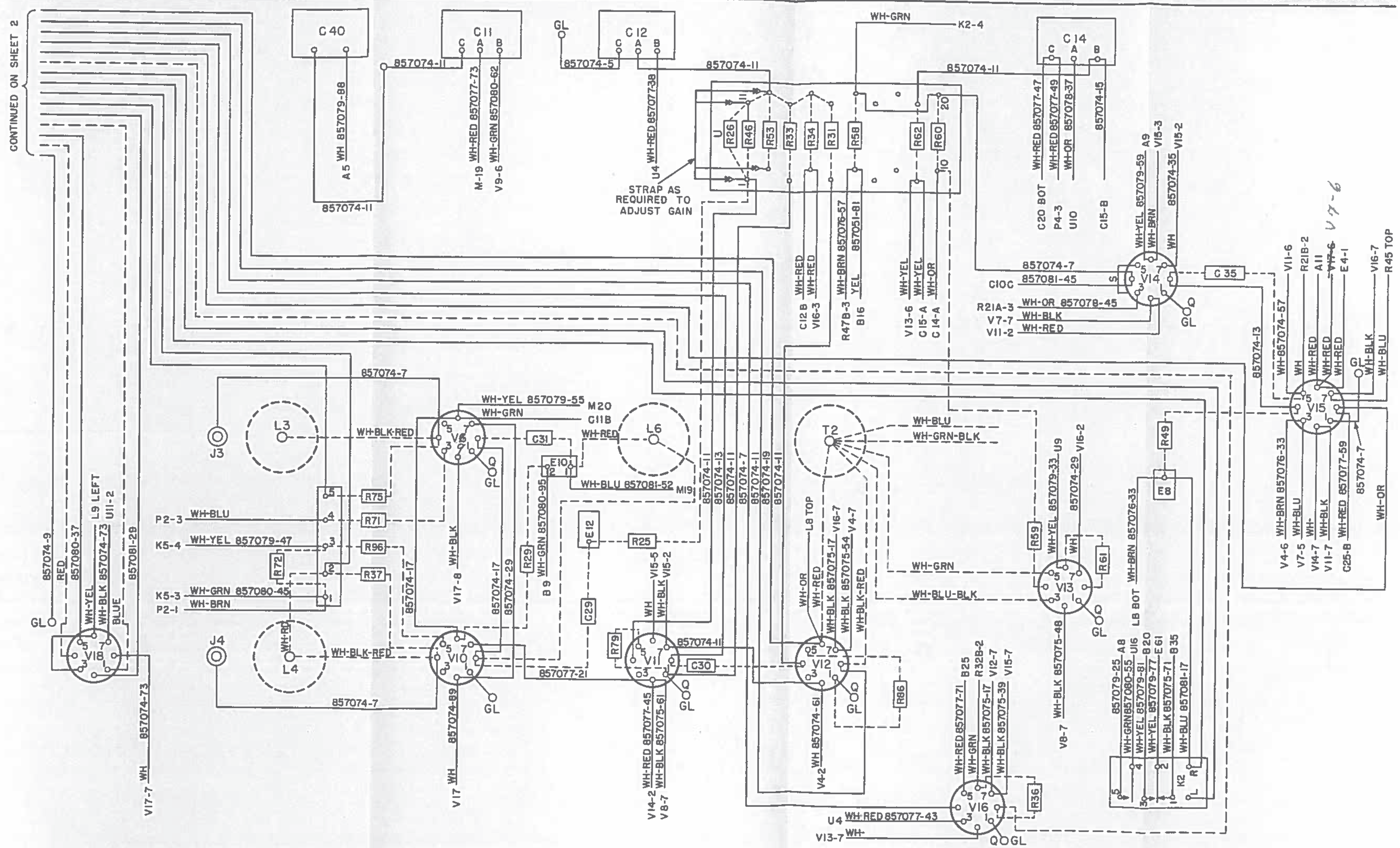


Figure 156—Control Panel Assembled Wiring Diagram (Sheet 3).

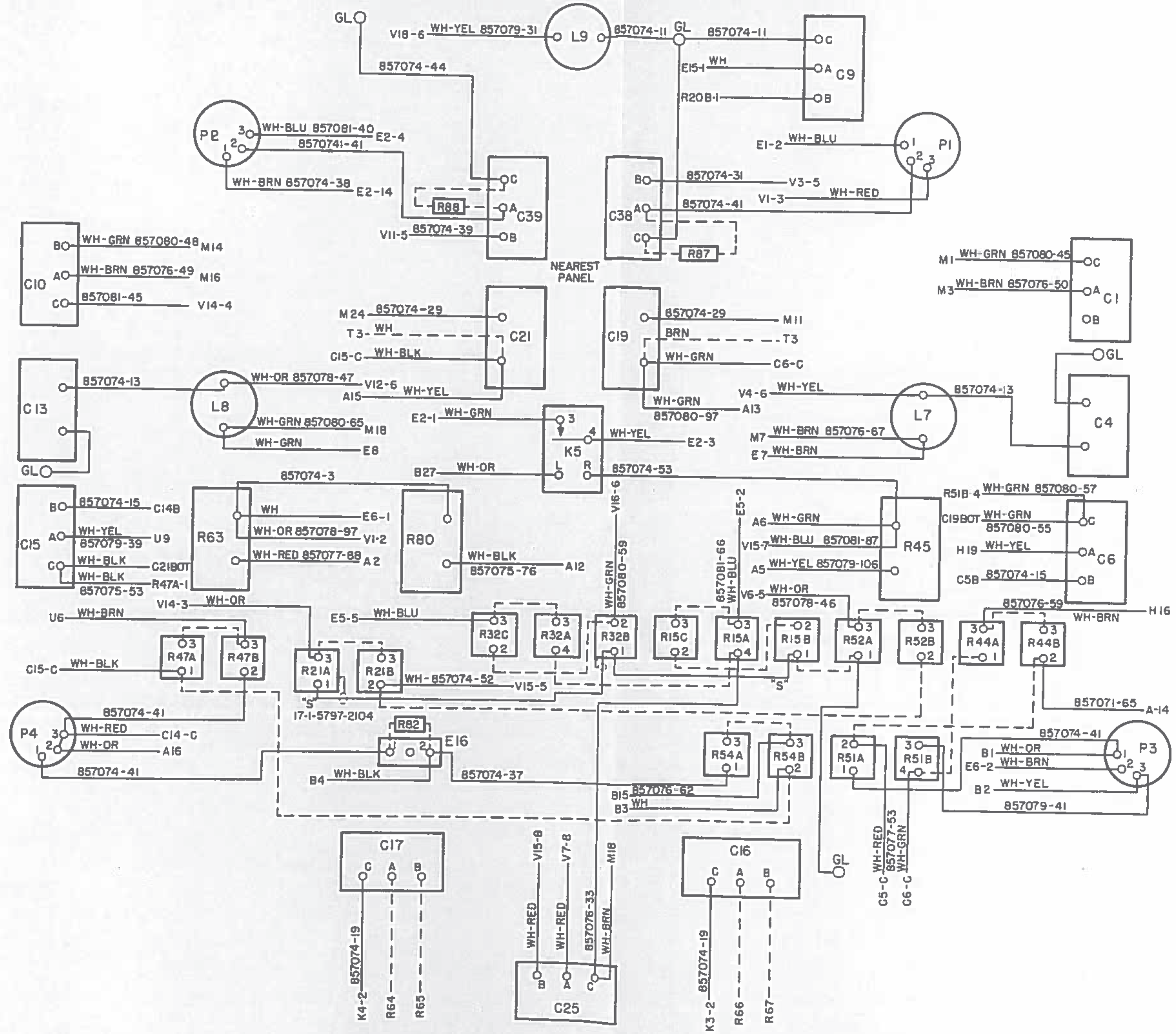
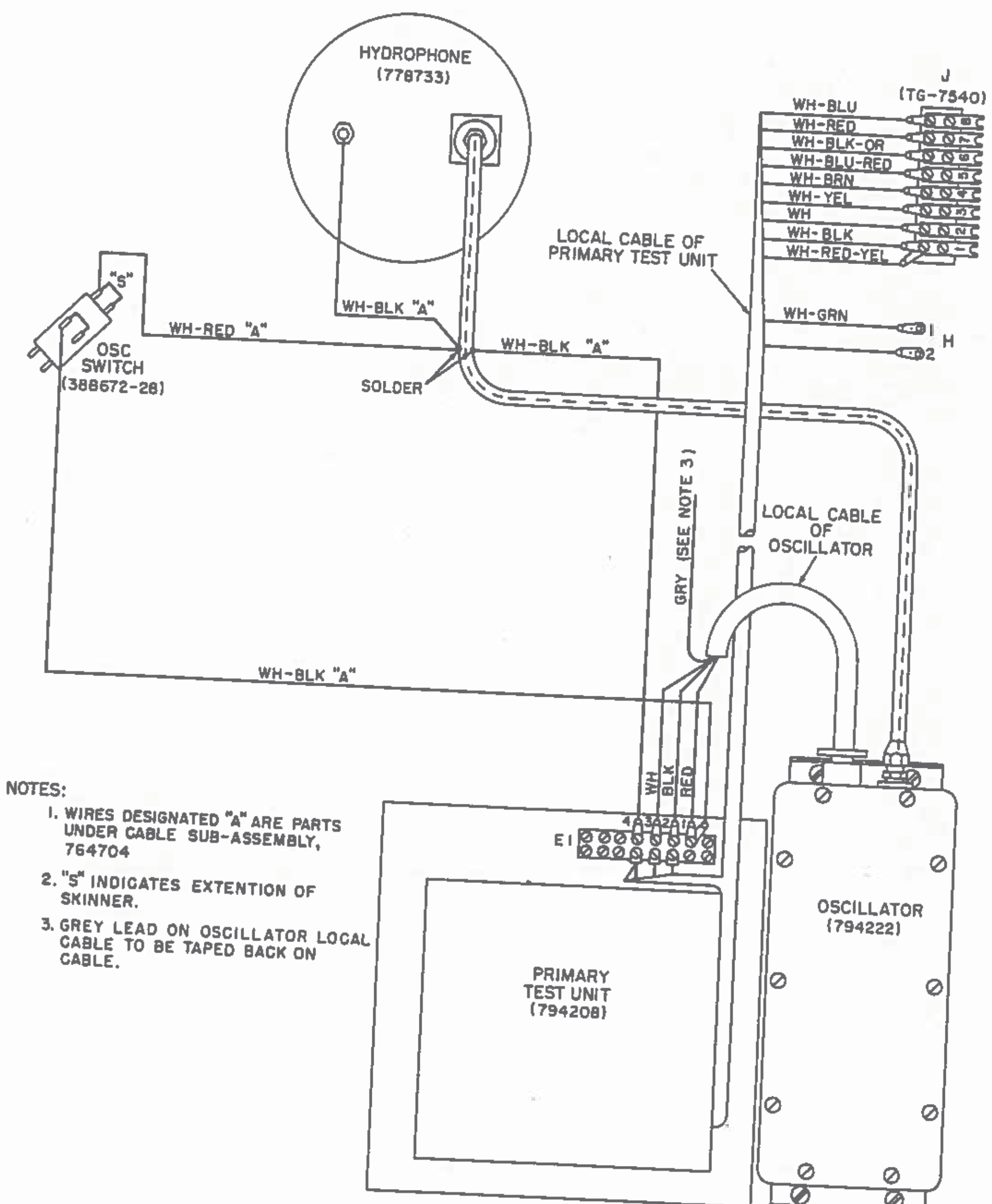


Figure 157—Control Panel Assembled Wiring Diagram (Sheet 4).

381656 O - 56



NOTES:

1. WIRES DESIGNATED "A" ARE PARTS UNDER CABLE SUB-ASSEMBLY, 764704
2. "S" INDICATES EXTENTION OF SKINNER.
3. GREY LEAD ON OSCILLATOR LOCAL CABLE TO BE TAPED BACK ON CABLE.

Figure 158—Exercise Head Mk 48 Mod 3 Wiring Diagram.

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3 April 1956/1500/1

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