NAVWEPS OP 1085 (THIRD REVISION): 21-INCH SUBMERGED TORPEDO TUBES MARKS 32, 33, 34, 35, AND MODS: INSTALLED IN SUBMARINES 215-525

Copy # 12

NAVWEPS OP 1085

THIRD REVISION

CHANGES 1 - 3 INSERTED

0609 108 5010

21-INCH SUBMERGED TORPEDO TUBES MARKS 32, 33, 34, 35, AND MODS

INSTALLED IN SUBMARINES 212 - 525

PUBLISHED BY DIRECTION OF
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Subj: Impulse Tank Pressures Listed in OP 1085; change of

Ref: (a) Conf Weapon System Accuracy Trials on USS VOLADOR (SS-490), Keyport Report #986 of Apr 1969
(b) OP 1085; 21" Submerged Torpedo Tubes Mk 32, 33, 34 and 35

Page 9 of reference (a) states that a Mk 14 Mod 5 torpedo was fired at 11 knots from the USS VOLADOR (SS-490) using 350 psi impulse flask pressure in lieu of the 250 psi pressure recommended by OP 1085 for this torpedo at the speed specified, and requested NUWS to advise as to the validity of the recommended impulse flask pressures listed in OP 1085, reference (b).

A review of Figure 223, "Impulse Tank Pressures" of OP 1085 was conducted utilizing data regarding impulse launchings upon which these charts are based. The review revealed that the impulse pressure of 250 psi recommended in the table for high speed launch at "Radar to periscope depth" should be changed to read 350 psi. A change sheet to OP 1085 will be issued to correct this impulse pressure. However, the recommended pressure in OP 1085 of 250 psi for surface launching at any speed will not be changed.

R. L. WINNICK
By direction

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Newport, Rhode Island 02840

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NAVWEPS OP 1085 (Third Revision) **CHANGE** 3

21-INCH SUBMERGED TORPEDO TUBES
MARKS 32, 33, 34, 35 AND MODS
INSTALLED IN SUBMARINES 212-525

3 May 1963

PAGE 1 OF 1 PAGE(S)

(With enclosures)

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1. Page x: Cut out item 1 on attached page and attach at bottom of page x using transparent cellophane tape.

2. Page 152: Cut out item 2 on attached page and attach to page 152 at end of step 6. Attach with transparent cellophane tape along top edge so that insert can be lifted to read succeeding step. After inserting new step 7, renumber existing step 7 and all subsequent steps.

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Item 1:

Caution: Failure to disconnect the torpedo control cable could allow the torpedo to start when the tube is fired (p. 152).

CHANGE 3

Item 2:

7. Remove the torpedo control cable connector from the torpedo tube breech door receptacle when an electrically set torpedo is in the tube being exercised.

Caution: Failure to disconnect the torpedo control cable could allow the torpedo to start when the tube is fired.

CHANGE 3

DEPARTMENT OF THE NAVY

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NAVWEPS OP 1085 (THIRD REVISION) **CHANGE** 2

21-INCH SUBMERGED TORPEDO TUBES
MARKS 32, 33, 34, 35, AND MODS
INSTALLED IN SUBMARINES 212-525

15 SEPTEMBER 1960

PAGE 1 OF 1 PAGE(S)

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1. Page x: After last paragraph, add

> "CAUTION: Failure to maintain the prescribed oil level in the gyro-setting tube-unit housing may result in freezing the spiral gears (installed by ORDALT 2600) and breaking the shaft couplings. The oil level should be maintained to the bottom of the drain hole and should be checked frequently, particularly after operation (pp. 76, 163)."

2. Page 76: After last paragraph, add

> "CAUTION: Failure to maintain the prescribed oil level in the gyro-setting tube-unit housing may result in freezing the spiral gears (installed by ORDALT 2600) and breaking the shaft couplings. The oil level should be maintained to the bottom of the drain hole and should be checked frequently, particularly after operation."

3. Page 163: After paragraph 6, add

> "CAUTION: Failure to maintain the prescribed oil level in the gyro-setting tube-unit housing may result in freezing the spiral gears (installed by ORDALT 2600) and breaking the shaft couplings. The oil level should be maintained to the bottom of the drain hole and should be checked frequently, particularly after operation."

4. Cancel NAVORD OCL T2-49.

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OP 1085 (THIRD REVISION) CHANGE 1

17 JULY 1959

21-INCH SUBMERGED TORPEDO TUBES
MARKS 32, 33, 34, 35 AND MODS
INSTALLED IN SUBMARINES 212-525

PAGE 1 OF 1 PAGE(S)
(With Enclosures)

Jack W. Clough, Captain, USN
By direction of Chief, Bureau of Ordnance

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1. Remove pages vii, viii, ix, x, 23, 24, 119, 120, 121, 122, 123, 124, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, and 160.

2. Insert pages vii, viii, ix, x, 23, 24, 58a, 58b, 58c, 58d, 58e, 119, 120, 121, 122, 123, 124, 147, 148, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, and 160.

NAVWEPS OP 1085

THIRD REVISION

21-INCH SUBMERGED TORPEDO TUBES MARKS 32, 33, 34, 35, AND MODS

INSTALLED IN SUBMARINES 212–525

PUBLISHED BY DIRECTION OF
THE CHIEF OF THE BUREAU OF NAVAL WEAPONS

11 SEPTEMBER 1957

DEPARTMENT OF THE NAVY

BUREAU OF ORDNANCE

WASHINGTON 25, D. C.

11 September 1957

ORDNANCE PAMPHLET 1085 (THIRD REVISION)

21-INCH SUBMERGED TORPEDO TUBES MARKS 32, 33, 34, 35, AND MODS INSTALLED IN SUBMARINES 212–525

1. Ordnance Pamphlet 1085 (Third Revision) contains detailed operating and general maintenance instructions for 21-Inch Torpedo Tubes Marks 32, 33, 34, 35, and Mods, as modified by NAVORD ORDALTS 2888, 3067, 3068, and 3069. These torpedo tubes are installed in Submarines 212 through 525.

2. This publication is intended for use by all personnel concerned with operation and maintenance of the subject torpedo tubes, and supplements the general instructions in the Bureau of Ordnance Manual.

3. This publication supersedes OP 1085 (Second Revision) dated 1 June 1955, and NAVORD OD 9386 dated 24 May 1954, which should be destroyed.

F. S. WITHINGTON

B. B. C. Lovett

B. B. C. LOVETT
Captain, U. S. Navy
Acting Assistant Deputy Chief
Bureau of Ordnance

CONTENTS

ILLUSTRATIONS

SAFETY PRECAUTIONS

Caution: To prevent damage to the breech door mechanism when the door is being opened, it must be held until it is fully open and the stops bear on the hinge bracket (pp. 22, 147, 154, 156, 158, 160).

Caution: To prevent the buffer plate and seal from striking the propeller nut and the guide stud from jamming against the stop bolt, the tail stop must be backed off before the breech door is closed (pp. 147, 154, 157).

Caution: The guide stud must be brought gently against the stop bolt to avoid bending the bolt or binding any parts of the stop bolt assembly (pp. 148, 155, 157, 159, 160).

Caution: After the impulse tank has been charged, do not open the filling valve or overflow valve as this would vent the upper chamber of the firing valve and fire the tube (pp. 149, 155, 157).

Caution: If the firing valve is leaking, report it at once to the Torpedo Control Officer. When the muzzle door is closed, even a small leak of air may build up sufficient pressure to crack the door open. In this instance, pressure in the after section of the tube will force the torpedo guide stud against the stop bolt and probably damage it. In addition, impulse tank pressure may be reduced to a point where the torpedo will not receive sufficient launching velocity. When the muzzle door is opened, an air leak will cause a surface bubble trail (pp. 149, 155, 157).

Caution: If the firing key or lever is held down less than two seconds, the firing valve may close before the torpedo receives its full impulse (p. 150).

Caution: Failure to lash down the torpedo before an air charge is fired may result in its sliding forward in the tube past the stop bolt, damaging the muzzle door mechanism, and possibly necessitating drydocking for repair (p. 152).

GENERAL DESCRIPTION

This publication explains the basic construction, operation, and maintenance of submerged torpedo tubes installed in Submarines 212 through 525. This revision reflects the modernization of the submerged torpedo tube mechanisms as performed on Submerged Torpedo Tubes Marks 32 through 35 and Mods; and includes those changes produced by installation of NAVORD ORDALTS 3067 (tripping latch modification), 3068 (stop bolt modification), and 3069 (modification for firing electrically set as well as mechanically set torpedoes). These ORDALTS are required on those submarines in active service status designated for firing electrically set as well as mechanically set torpedoes. NAVORD ORDALTS 3067 and 3068 are to be accomplished on all submarines employing torpedo Marks 32 through 35 tubes, including those not now in active service (upon activation overhaul availability).

Torpedo tubes in these submarines are basically similar, but few installations are exactly alike. Variance in the design of submarines of the same class is the result of construction methods used in different shipyards and of changes and improvements made in individual ships during construction. All tubes are equipped for firing mechanically set torpedoes. The tubes of certain designated submarines have been or will be modified to permit the firing of electrically set as well as mechanically set torpedoes. Chapters of this publication that apply only to the unmodified tubes, figure 1, have the subtitle, For Tubes Equipped for Mechanical Setting Only. Chapters that apply only to the modified tubes, figures 2 and 3, have the subtitle, For Tubes Equipped for Mechanical and Electrical Setting. Chapters without a subtitle apply to all tubes, whether modified or not.

Torpedo Tube Defined

Each submerged torpedo tube, figure 4, basically is an air gun; it launches a torpedo in a manner similar to that of a gun firing a projectile. However, the torpedo's initial velocity is derived from compressed air instead of from an explosive; and the torpedo tube's projectile, the torpedo, figure 5, propels itself during its run, whereas a gun's projectile receives all the energy for its flight at the time of firing. Certain electrically set torpedoes are fired from modified torpedo tubes by "silent" or "run-out" firing, in which compressed air is not used to eject the torpedo. Instead, the torpedo propels itself from the tube.

Each end of the torpedo tube has a door; the breech door at the inboard end (the loading and operating end) inside the submarine, and the muzzle door at the outboard end (the firing or ejecting end) opening out into the water. These doors are operated by separate controls located at and operated from the breech end of the tube, as are all tube operating control mechanisms. All of these mechanisms are related and interlocked for reasons noted later.

Before opening the breech door, the muzzle door must be closed and the tube drained of water. For this purpose, a system of drains and vents is provided and operated from the breech end. With the muzzle door closed and the tube drained, figure 6, the breech door may be opened and the torpedo loaded into the tube, figure 7.

A firing system, which releases the air that forces the torpedo out of the tube in impulse firing, includes an impulse tank charged from a high-pressure air system, and a system of control valves, indicating gages, and mechanical linkages.

Torpedo Tube Operation

In simplified diagrams, figures 6 through 13, the theory of flooding, firing by impulse air, and draining of a torpedo tube is reduced to its fundamentals.

In its simplest form, a torpedo tube consists of a barrel to receive the torpedo and means of providing and controlling the force required to discharge the torpedo or to allow it to run out under its own power from the barrel.

The breech end of the barrel is fitted with a door

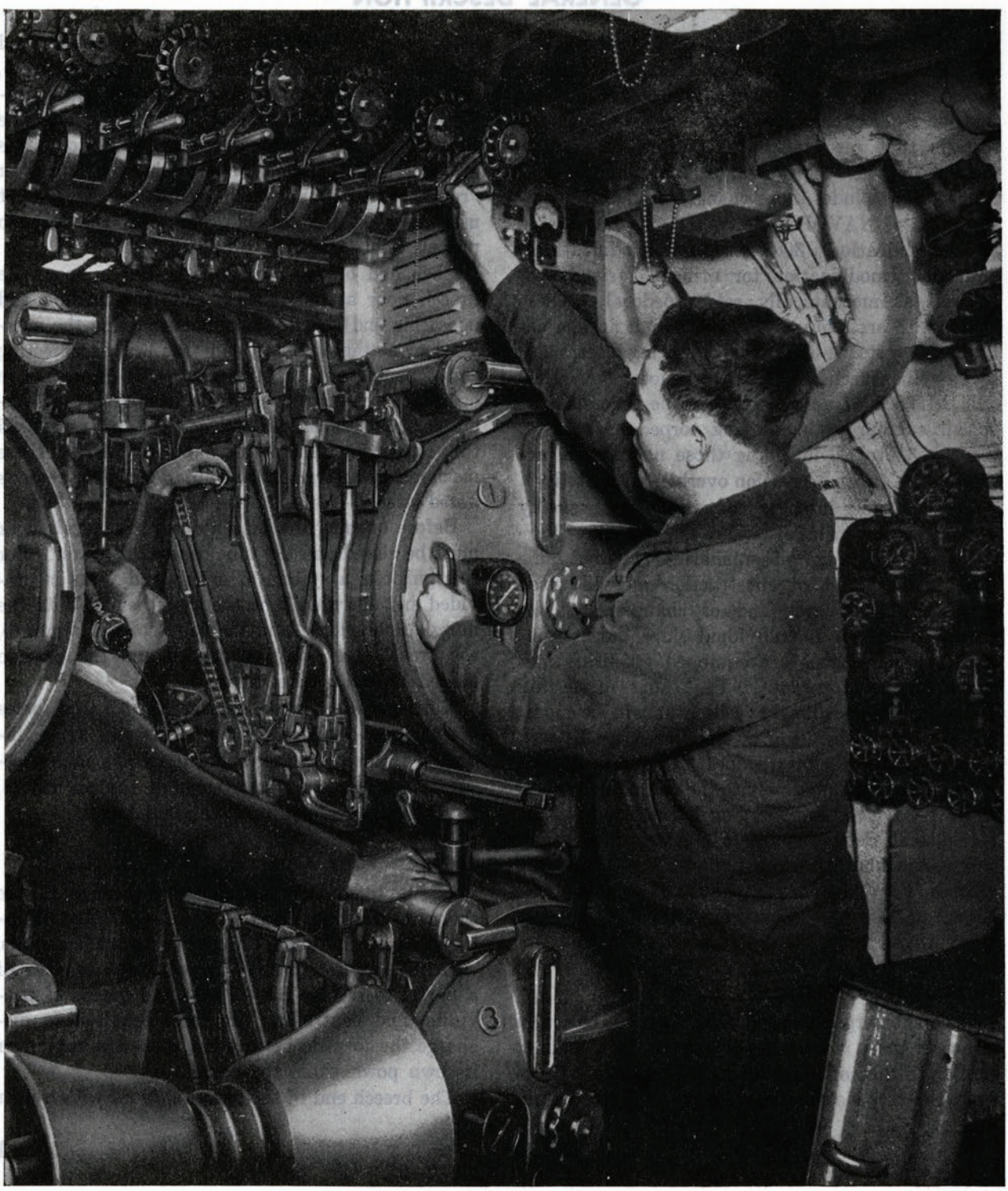


Figure 1—*"Stand By To Fire."*

which, during firing, prevents sea water from entering the submarine. In impulse firing, this door also blocks the escape of compressed air into the submarine so that the air must force the torpedo out of the tube to escape through the muzzle end of the barrel.

Since the muzzle is submerged in the sea, a muzzle door is required to shut out water while the breech door is open or while the tube is being drained. The tube, with its interlocked doors, acts as an air lock (like an escape hatch).

To prevent sea water from entering the submarine through the tube, one or the other of the doors must be closed. Interlocking devices on the tube prevent both doors from being open at the same time. When the muzzle door is closed, the breech door may be opened. When the breech door is closed, the muzzle door may be opened.

Water pressure increases with depth; therefore, pressure on the exterior of the submarine, including the muzzle doors, increases as the submarine descends to greater depths. To equalize this external pressure on the muzzle door so the door can be opened when required, an equal pressure is built up within the tube. This is done by admitting water into the tube while venting inboard the air displaced from the tube. If a torpedo tube is flooded from sea, the trim of the submarine is affected. To avoid this, the tube is usually flooded from the WRT tank within the submarine. After the tube

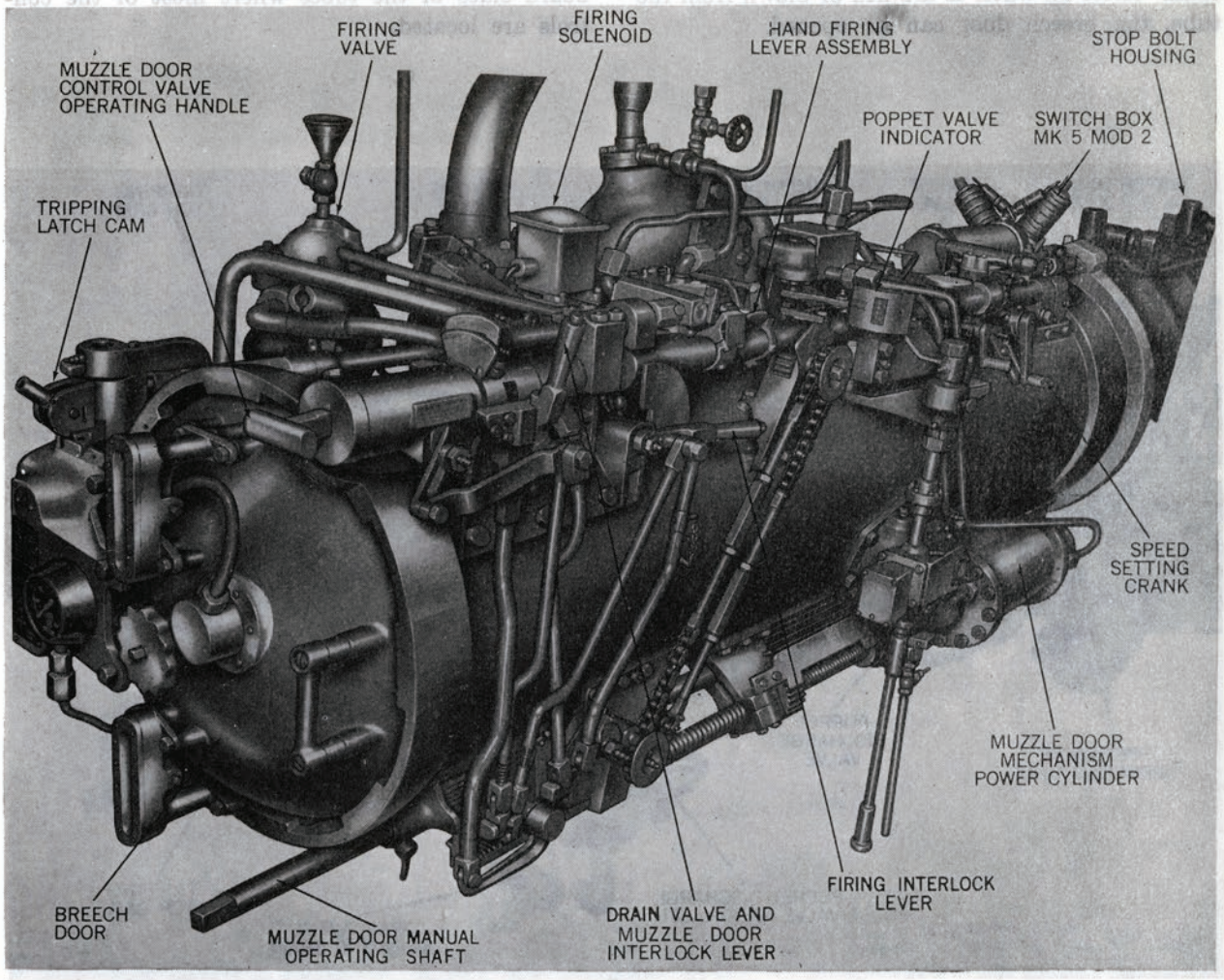


Figure 2—*Modified Torpedo Tube. View From Inboard.*

is flooded, the muzzle door is opened to make the tube ready to fire.

In impulse firing, opening a valve admits compressed air from a storage tank into the tube to force the torpedo out of the tube. A poppet valve is opened to vent the air back into the submarine to prevent air bubbles from rising to the surface where they might reveal the submarine's position. After the torpedo has left the tube, the barrel fills with water from the sea. The weight of water taken in is approximately equal to the weight of the torpedo, so the trim of the submarine is not appreciably affected.

When the tube has filled with water, the muzzle door is closed. A valve leading to the WRT tank near the tube is opened and air is admitted into the tube to force the water out of the tube into the tank. After all water is drained or blown from the tube, the breech door can be opened.

Mechanical Systems of the Torpedo Tube

Several mechanical groups or systems are required to operate the torpedo tube. The muzzle door mechanism, for example, includes the muzzle door and parts which support and operate it. The firing mechanism includes parts concerned with admitting the impulse air or releasing the torpedo to run out of the tube under its own power.

Location and Designation of Tubes

The group of tubes located in the forward torpedo room is the bow nest; the group in the after torpedo room is the stern nest. Half the tubes in any nest are on the port side, and half on the starboard side. A space between the two vertical rows (or banks) of tubes allows access to the inboard sides of the tubes where most of the controls are located.

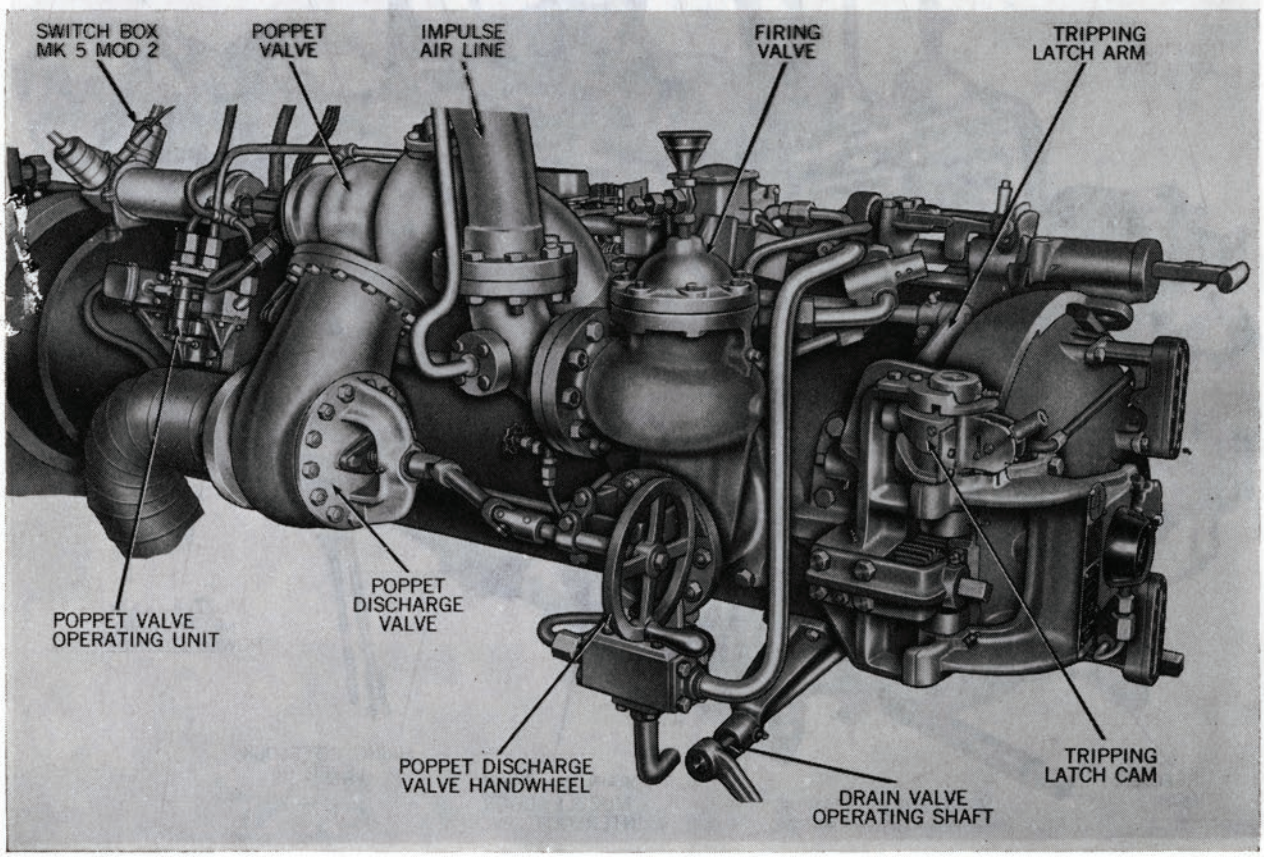


Figure 3—*Modified Torpedo Tube. View From Outboard.*

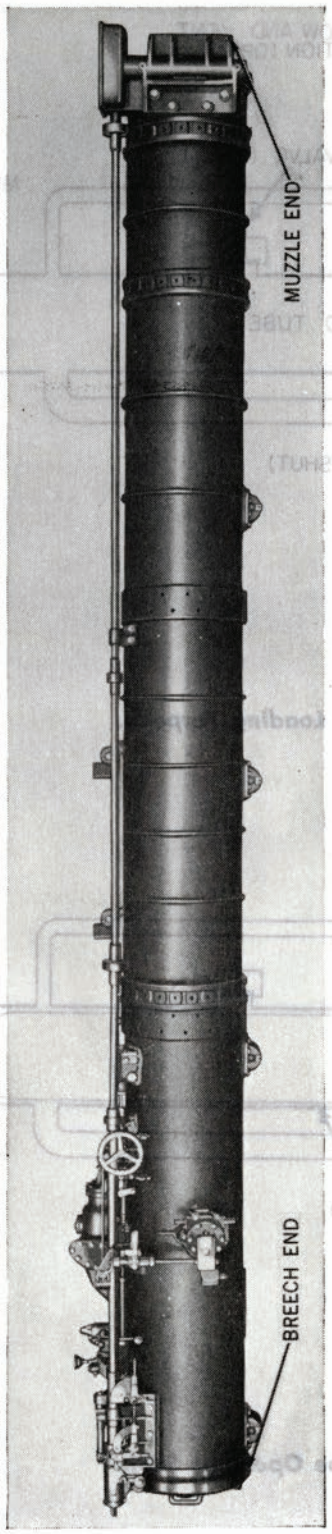


Figure 4—*Original Torpedo Tube. Inboard Side.*

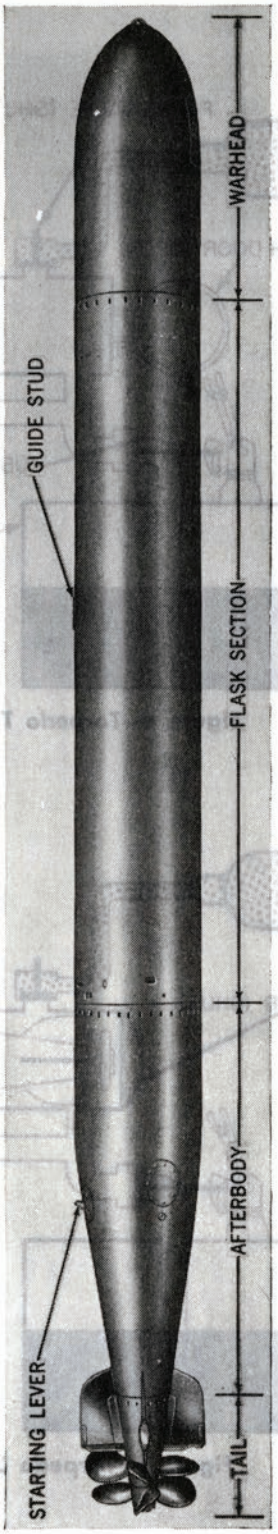


Figure 5—*21-Inch Torpedo.*

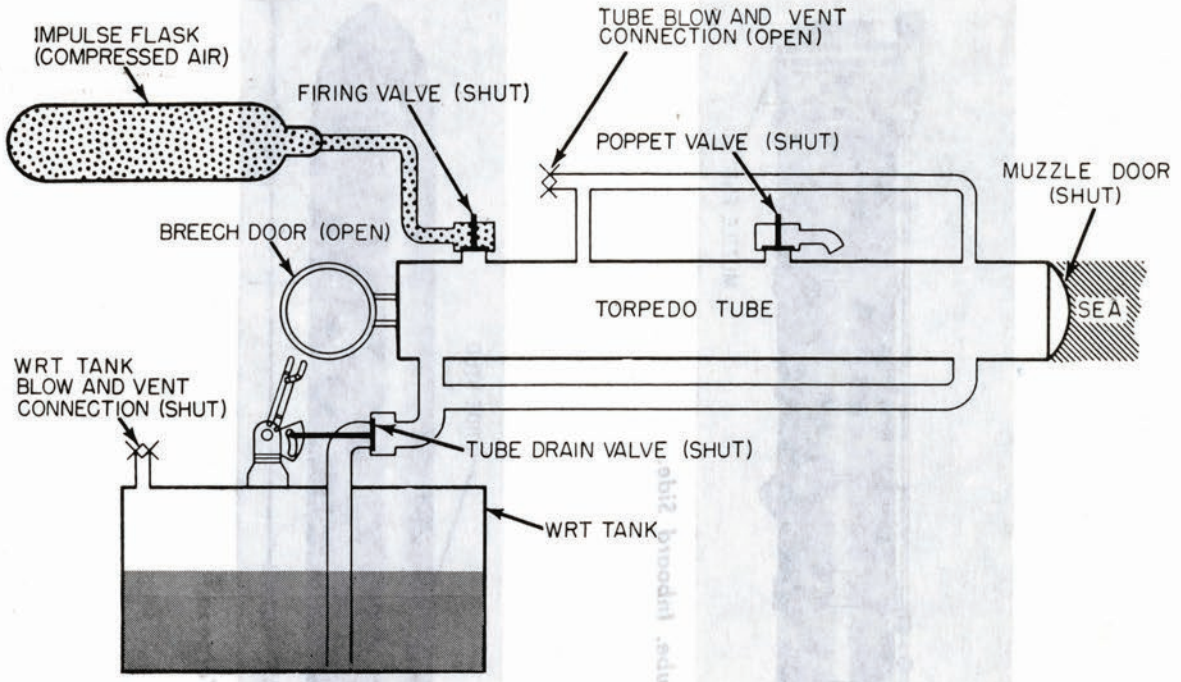


Figure 6—*Torpedo Tube Ready for Loading Torpedo.*

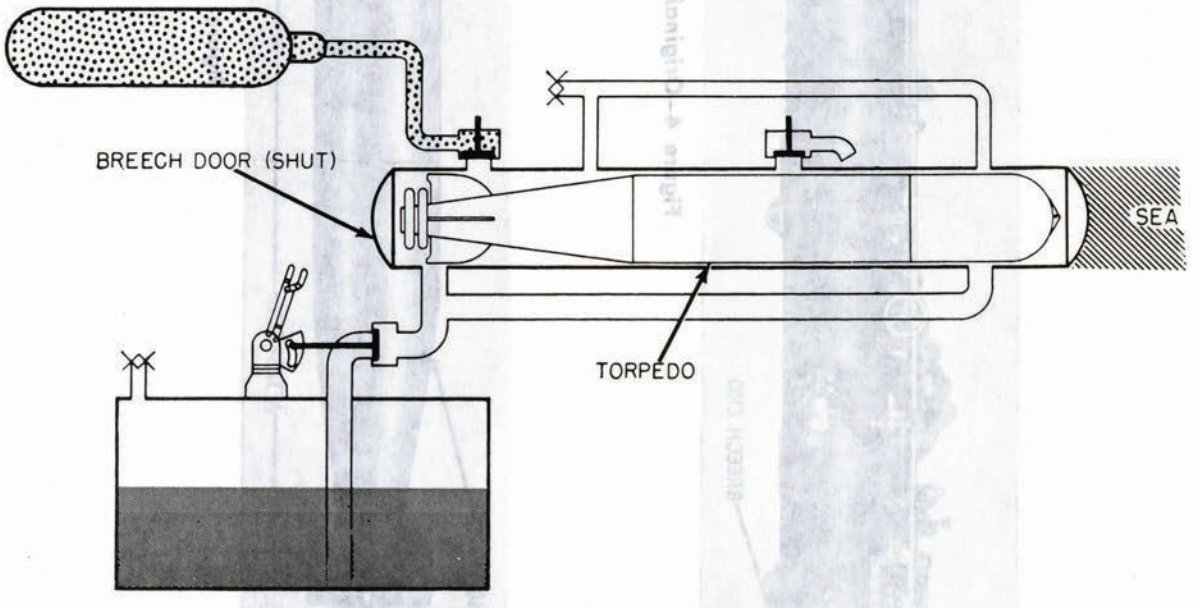


Figure 7—*Torpedo Loaded—All Tube Openings Shut.*

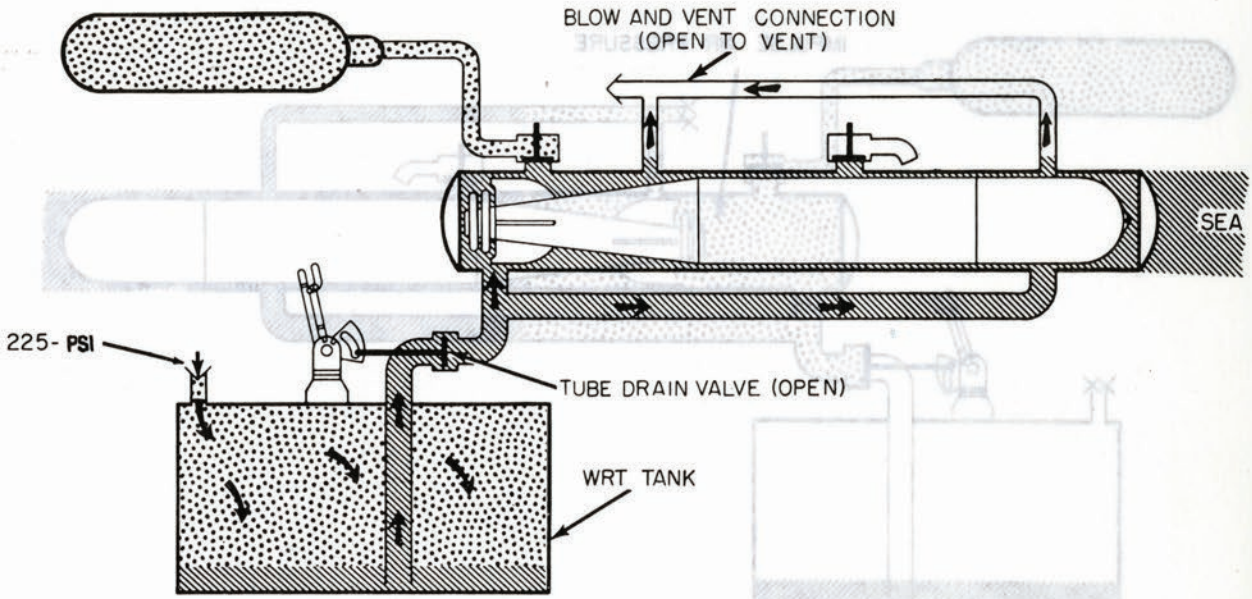


Figure 8—*Flooding Torpedo Tube from WRT Tank.*

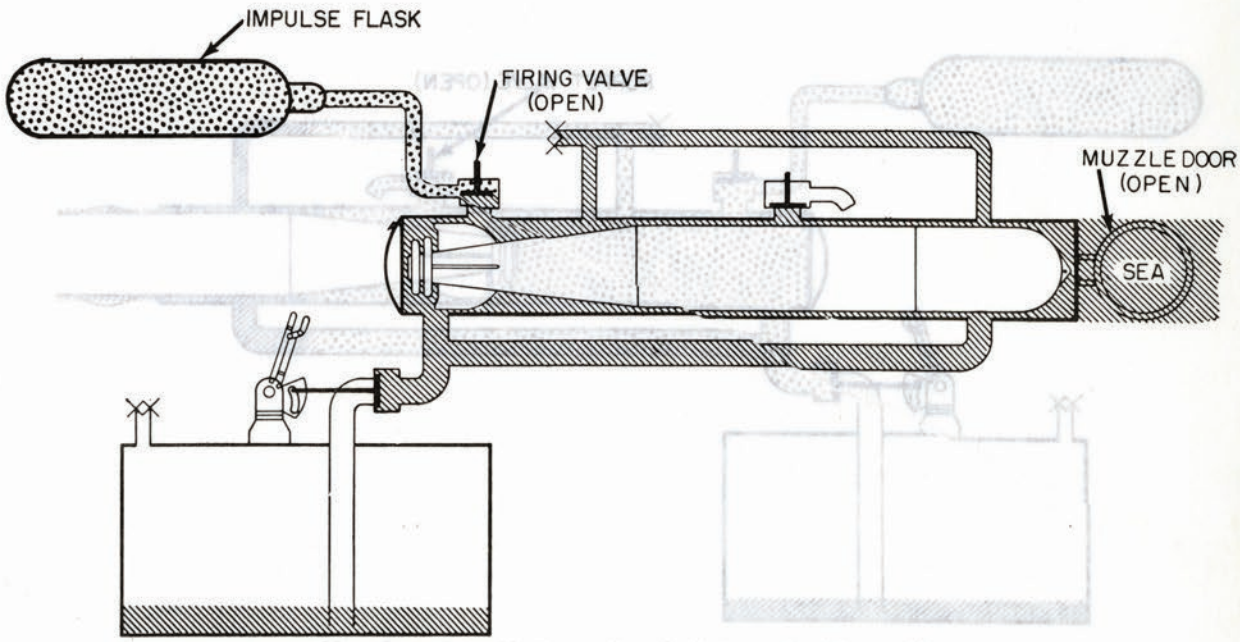


Figure 9—*Torpedo Tube at Instant of Firing.*

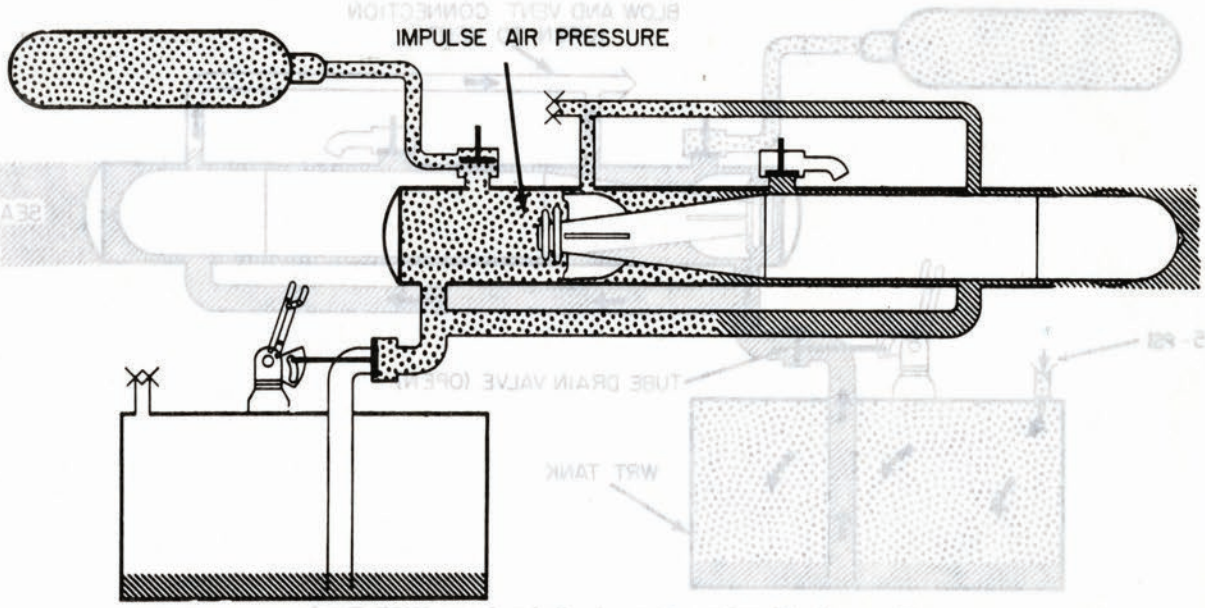


Figure 10—*Impulse Air Ejecting Torpedo From Tube.*

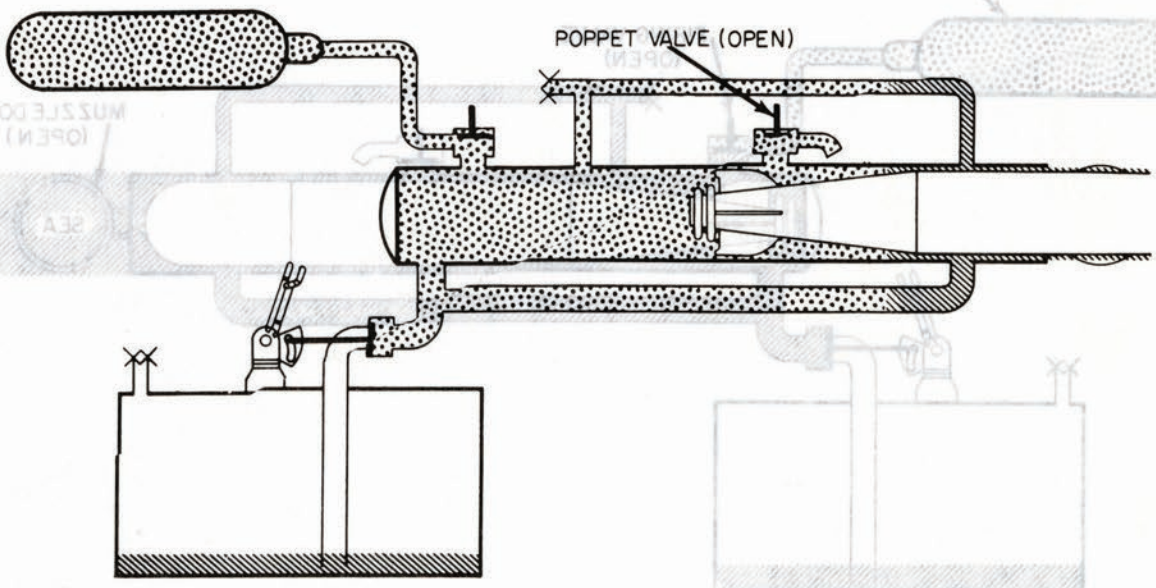


Figure 11—*Poppet Valve Open to Vent Impulse Air.*

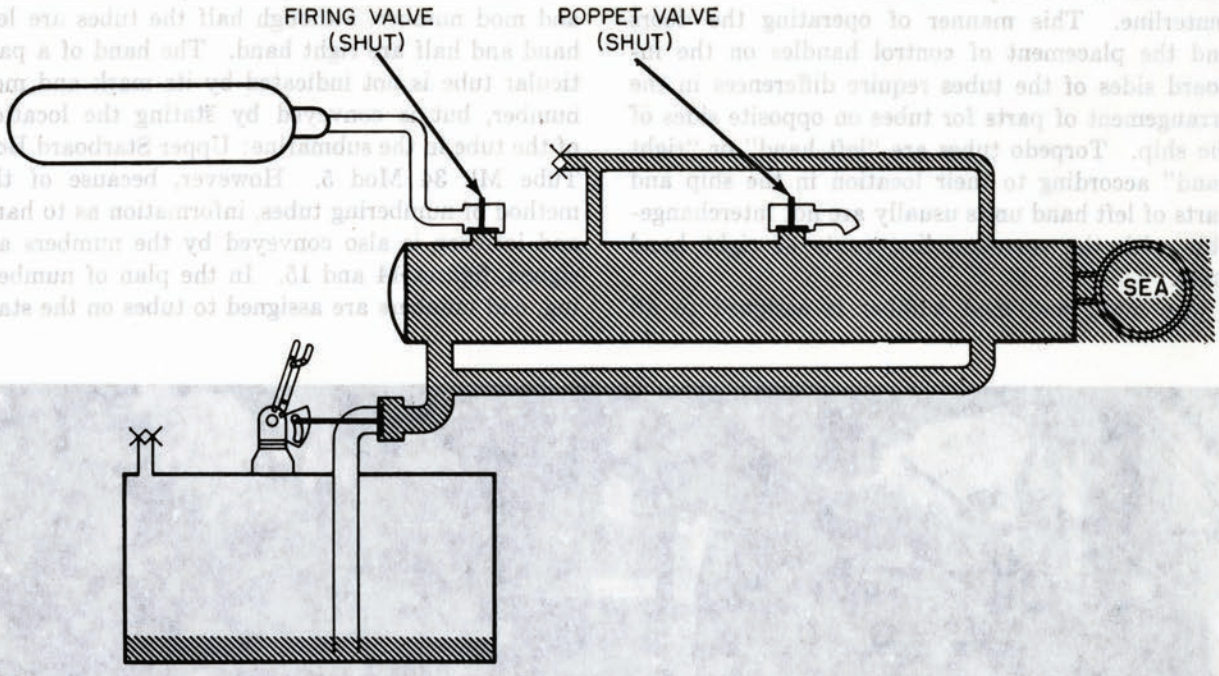


Figure 12—*Torpedo Ejected—Torpedo Tube Flooded From Sea.*

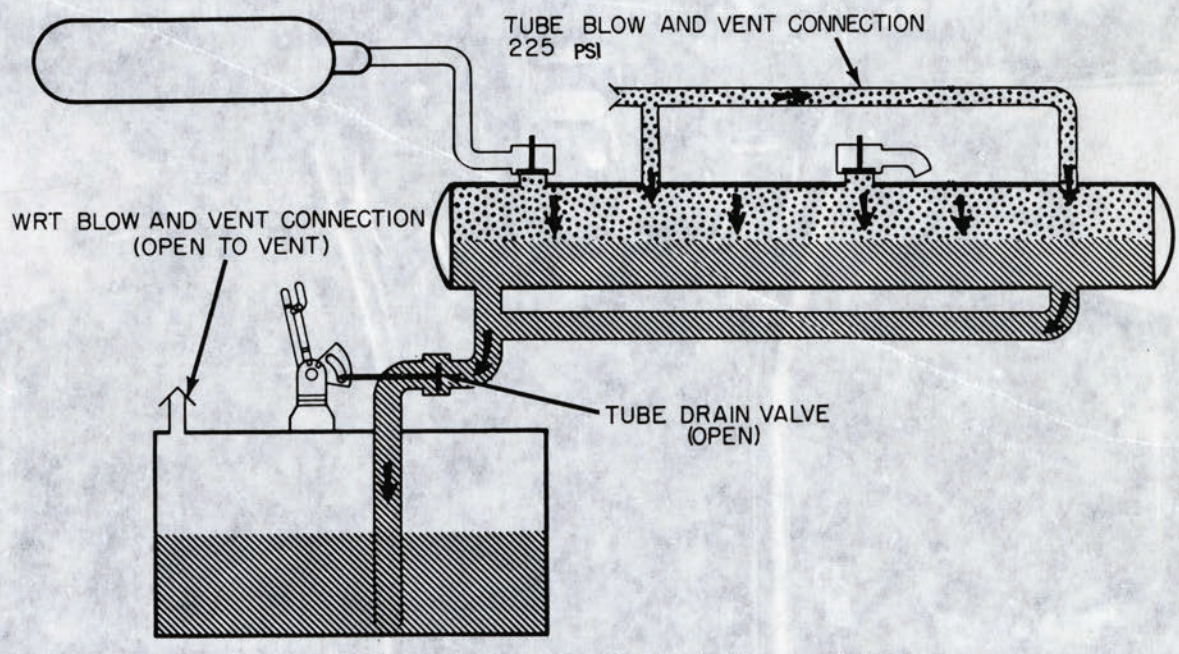


Figure 13—*Blowing Water From Torpedo Tube to WRT Tank.*

Breech doors are hinged to swing away from the centerline of the ship and muzzle doors toward the centerline. This manner of operating the doors and the placement of control handles on the inboard sides of the tubes require differences in the arrangement of parts for tubes on opposite sides of the ship. Torpedo tubes are "left hand" or "right hand" according to their location in the ship and parts of left hand units usually are not interchangeable with the corresponding parts of right hand units.

One mark and mod number is assigned to all tubes in a particular design of tube nest. Each tube in the nest is designated by the same mark and mod number, although half the tubes are left hand and half are right hand. The hand of a particular tube is not indicated by its mark and mod number, but is conveyed by stating the location of the tube in the submarine: Upper Starboard Bow Tube Mk 34 Mod 5. However, because of the method of numbering tubes, information as to hand and location is also conveyed by the numbers assigned, figures 14 and 15. In the plan of numbering, odd numbers are assigned to tubes on the star-

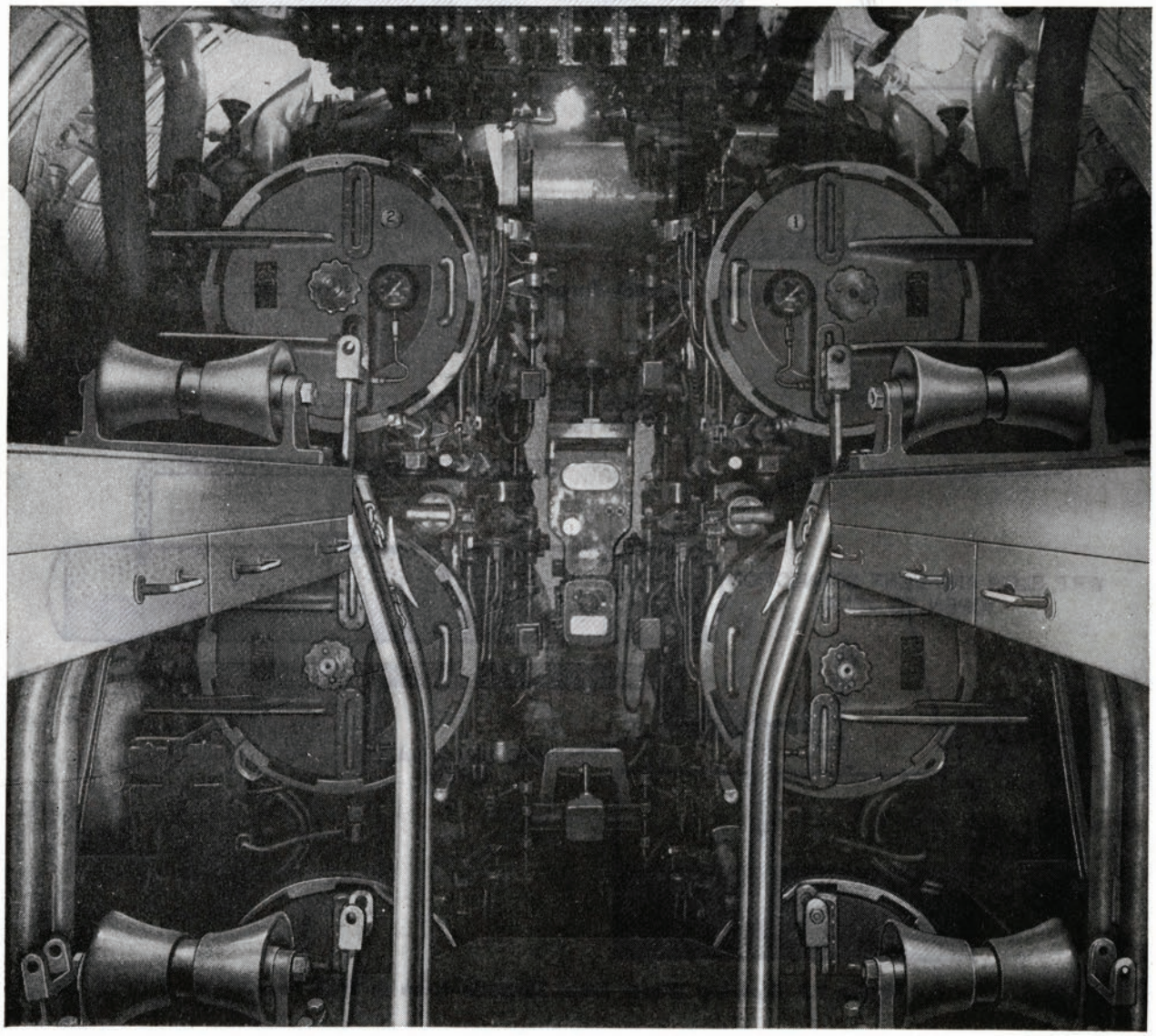


Figure 14—*Submarine Bow Nest—Starboard Tubes 1, 3, and 5; Port Tubes 2, 4, and 6.*

board side, and even numbers to those on the port side.

Tubes in the starboard side of the bow nest (numbers 1, 3, and 5) and those in the port side of the stern nest (8 and 10) are right hand, while the port bow tubes (2, 4, and 6) and the starboard stern tubes (7 and 9) are left hand. As the operator faces the nest (bow or stern), left hand tubes are to his left, and right hand tubes are to his right without regard for port or starboard. Although there is similarity of handing between bow tubes on one side of the vessel and stern tubes on the opposite side, minor differences in a few mechanical

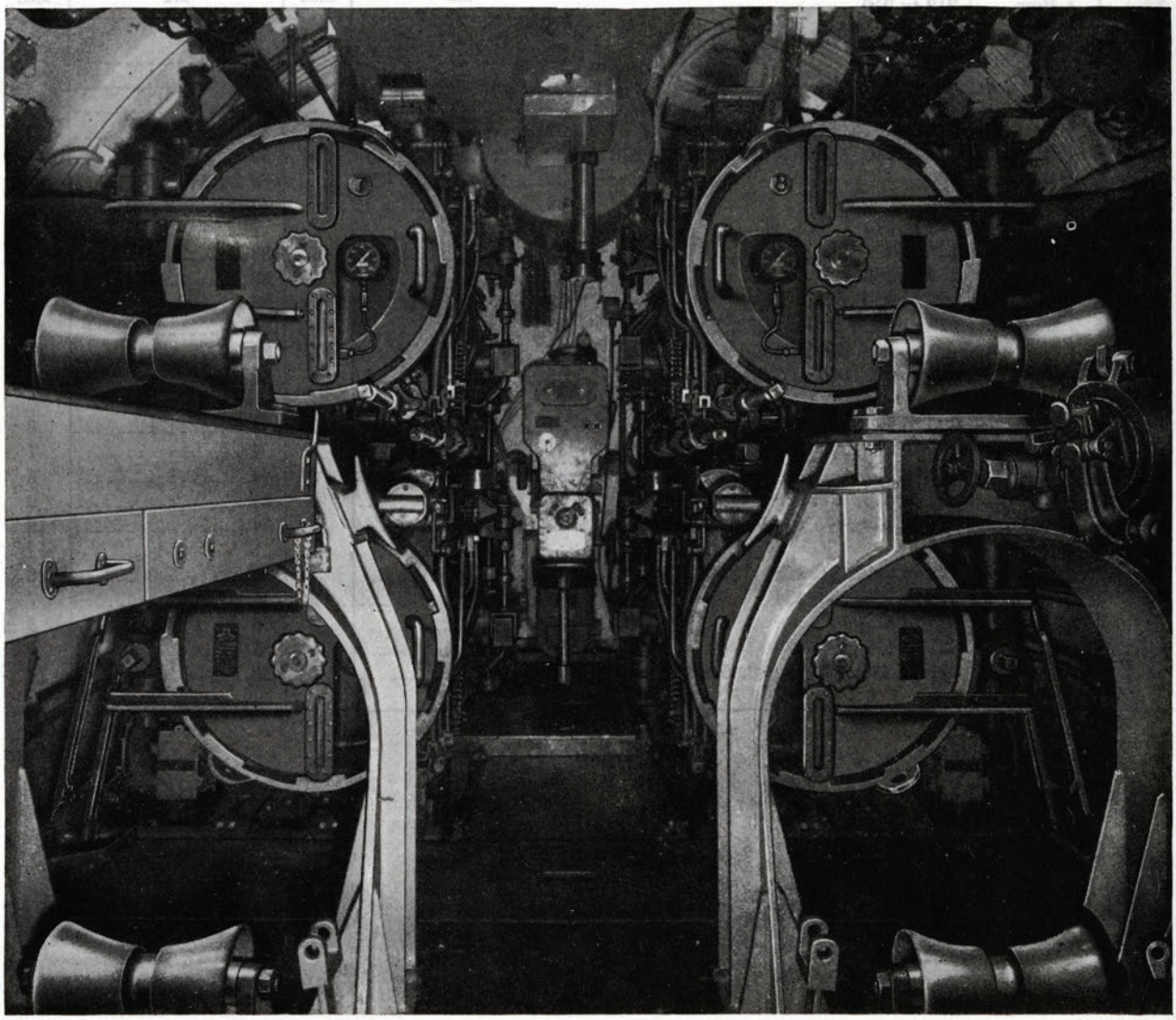


Figure 15—*Submarine Stern Nest—Starboard Tubes 7 and 9; Port Tubes 8 and 10.*

features exist because of the requirements of individual installations.

Designation of Tubes Originally Installed

The designation of torpedo tubes originally installed in submarines 212 to 525 is as follows:

Original		Location	Submarines (inclusive numbers)
Mk	Mod		
32	1	Bow	212 to 219
32	2	Bow	220, 221, 265 to 267
32	3	Bow	253 to 258
32	4	Bow	268 to 272
32	5	Bow	222 to 227, 240 to 242, 247 to 251, 259 to 264, 273, 274, 361 to 364
32	6	Bow	243 to 246, 252, 313 to 352, 365 to 378
32	7	Bow	435
33	1	Stern	212 to 219
33	2	Stern	220, 221
33	3	Stern	253 to 256
33	4	Stern	265 to 272
33	5	Stern	222 to 227, 240 to 252, 257 to 264, 273, 274, 361 to 364
33	6	Stern	313 to 352, 365 to 378, 435
34	1	Bow	228 to 239, 281, 282
34	2	Bow	275 to 280, 283, 284
34	3	Bow	285 to 312
34	4	Bow	381 to 416, 425, 426
34	5	Bow	417 to 424, 475 to 490, 522 to 525
35	1	Stern	228 to 239, 281, 282
35	2	Stern	275 to 280, 283, 284
35	3	Stern	285 to 312
35	4	Stern	381 to 416, 425, 426
35	5	Stern	417 to 424, 475 to 490, 522 to 525

Designation of Modified Tubes

NAVORD ORDALT 3069 converts the torpedo tubes for the firing of electrically set as well as mechanically set torpedoes. This ORDALT has been or will be accomplished only on submarines specifically designated. Accomplishment of this ORDALT changes the designations as follows:

Original		Becomes	
Mk	Mod	Mk	Mod
32	1	32	8
32	2	32	9
32	3	32	10
32	4	32	11
32	5	32	12
32	6	32	13
32	7	32	14
33	1	33	7
33	2	33	8
33	3	33	9
33	4	33	10
33	5	33	11
33	6	33	12
34	1	34	6
34	2	34	7
34	3	34	8
34	4	34	9
34	5	34	10
35	1	35	6
35	2	35	7
35	3	35	8
35	4	35	9
35	5	35	10

Chapter 2

BARREL AND ROLLERS

Barrel

The torpedo tube barrel is constructed in three sections—the breech section, middle section, and muzzle section. Sections are riveted together and sealed to form a continuous cylinder.

The entire inner surface of a barrel (the bore) may be machined smooth. Usually, however, the smooth finish is maintained on four raised areas (lands), which extend the length of the tube, leaving the remainder of the interior surface recessed. Figure 16 shows the interior of a barrel having the four lands. The torpedo rests upon rollers in the bottom of the tube, and is held in position by the lands. Each tube has a finished inside diameter which may vary from 21.125 inches to 21.145 inches.

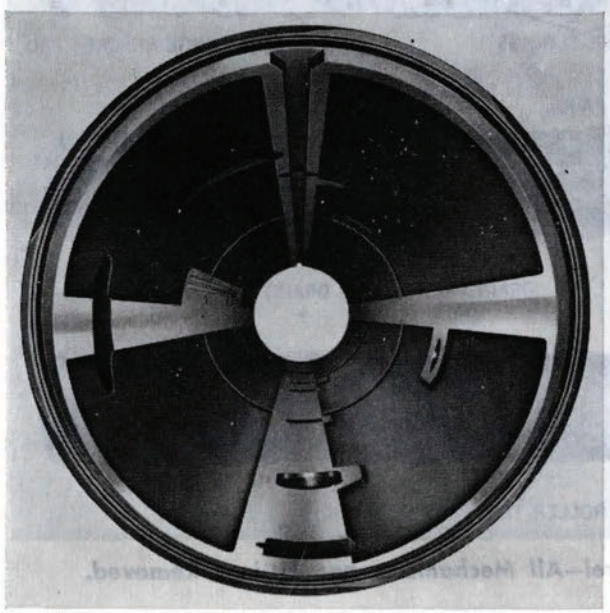


Figure 16—*Interior of Barrel Showing Lands.*

Bosses and pads on the barrel's exterior receive the various fittings or parts of the operating mechanisms. Figure 17 shows the barrel of a lower port bow tube.

The over-all length of a tube is the distance between the breech and the muzzle faces, measured along the horizontal axis. The effective length of a tube is determined by the maximum torpedo length which the tube can accommodate (breech and muzzle doors shut, stop bolt and breech door tail stop retracted, and torpedo projecting into the concave section of the breech door a maximum distance of 1⅜ inches). However, this does not necessarily indicate that a torpedo of such a length would be compatible with the tube; other factors such as relative location of the tube stop bolt and torpedo guide stud govern whether or not the torpedo would fit into the effective length of the tube. Over-all tube lengths and their corresponding effective lengths are as follows:

	Overall length (inches)	Maximum effective length (inches)
Bow tubes	250.0	248.235
	252.0	251.185
Stern tubes	276.0	275.115
	276.88	275.185

Bow tubes are designed to take torpedoes not more than 246 inches long. Stern tubes are designed to take torpedoes not more than 270 inches long.

A guide stud on top of the torpedo engages a guide slot running lengthwise through the top land in the barrel. This guide stud prevents the torpedo from rotating. It also insures matching of the depth setting, speed setting, and gyro setting spindles on the tube with the sockets for the corresponding mechanisms in the mechanically set torpedoes.

Rollers

Four rollers, mounted in brackets bolted to the bottom of the barrel, support the torpedo and facilitate its movement through the barrel. Each

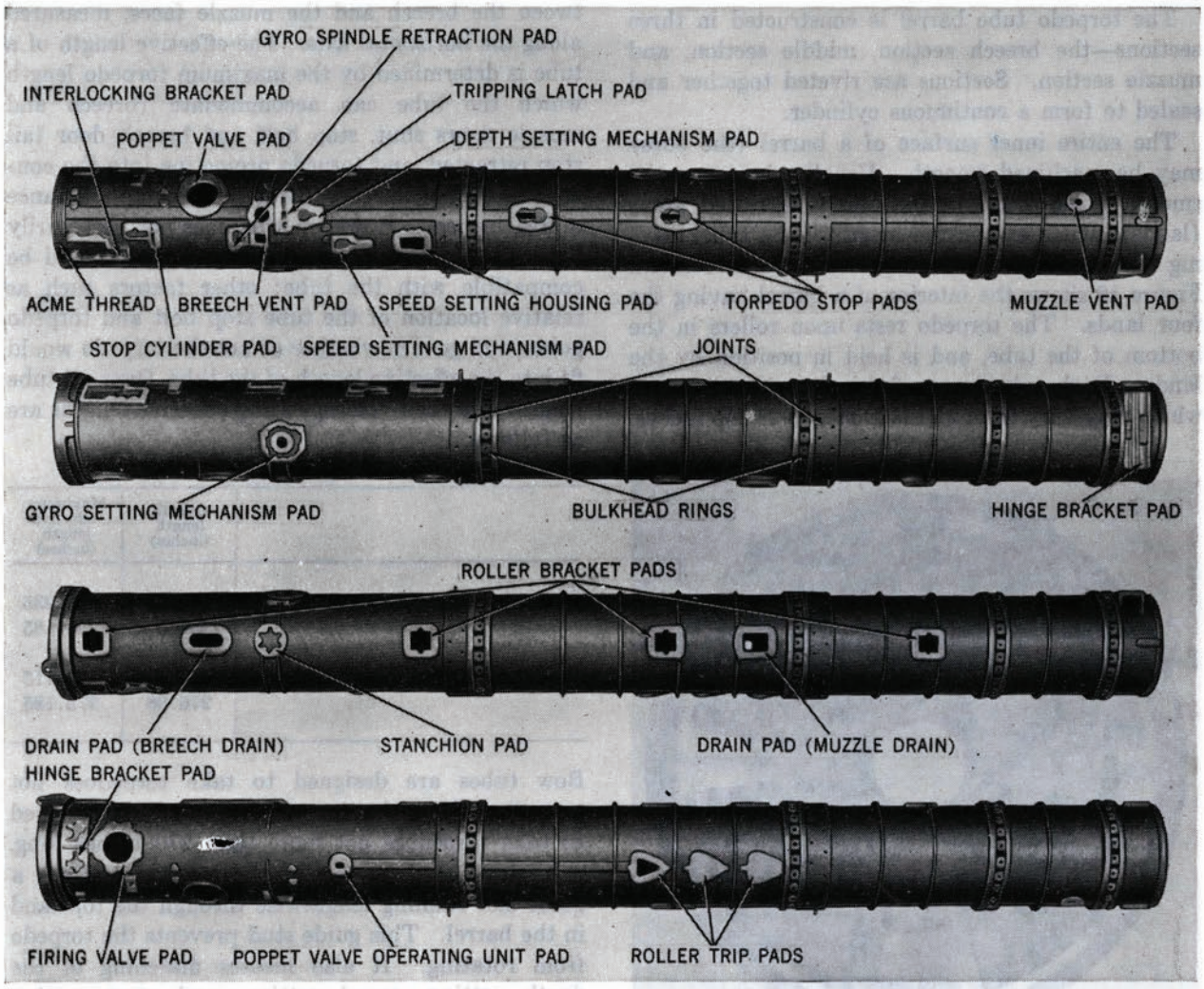


Figure 17—*Four Sides of Lower Port Tube Barrel—All Mechanisms and Fittings Removed.*

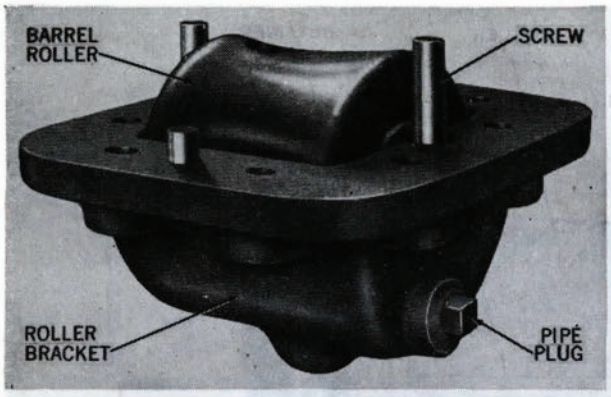


Figure 18—*Muzzle Roller in Bracket.*

roller is mounted in its bracket by means of a roller axle pin, whose ends are secured in slots in the bracket by two screws, figures 18 and 19.

The three muzzleward rollers, made of phenolic compound, consist of the six parts shown in figure 20. The roller fits tightly on the grooved sleeve, which turns on the roller axle pin. The inset ring retainer for the sleeve is held in position by the set screw. A grease fitting adapter fits into the radial hole in the roller and is secured by screwing into the tapped hole in the sleeve. A standard grease fitting is screwed into the adapter so that its top is below the surface of the roller.

The breech roller differs from the other three in that it is made of bronze, is grooved, and is fitted with a three-toothed cable cutter. Torpedoes Mk 18 have a hydrogen eliminator cable extending out of their tail section. The cable is led through the tooth spaces of the cable cutter and an opening in the breech roller bracket, figure 21, when this type torpedo is loaded into the tube. When the torpedo is fired, the edges of the end teeth cut the cable. A conical shaped plug on the cable fits into a conical hole in a cable gland to make the connection watertight.

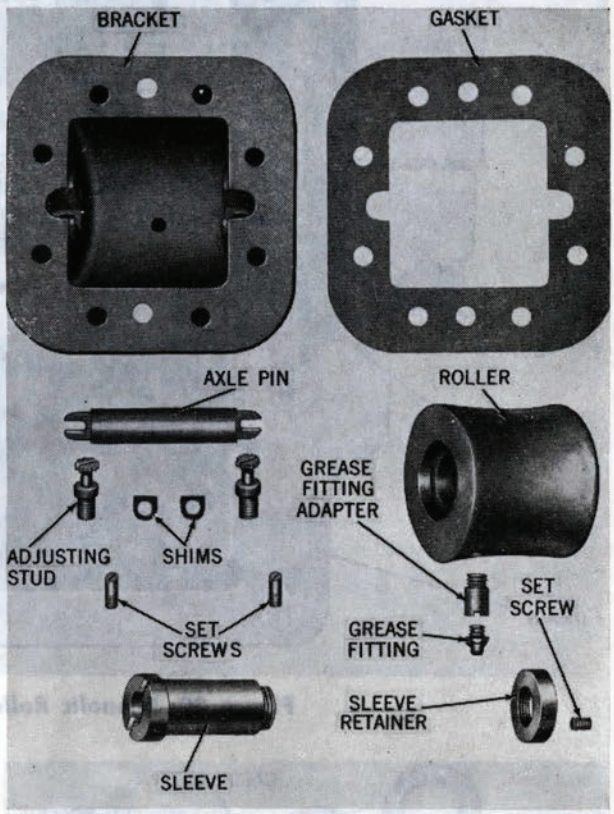


Figure 19—*Muzzle Roller and Bracket Disassembled.*

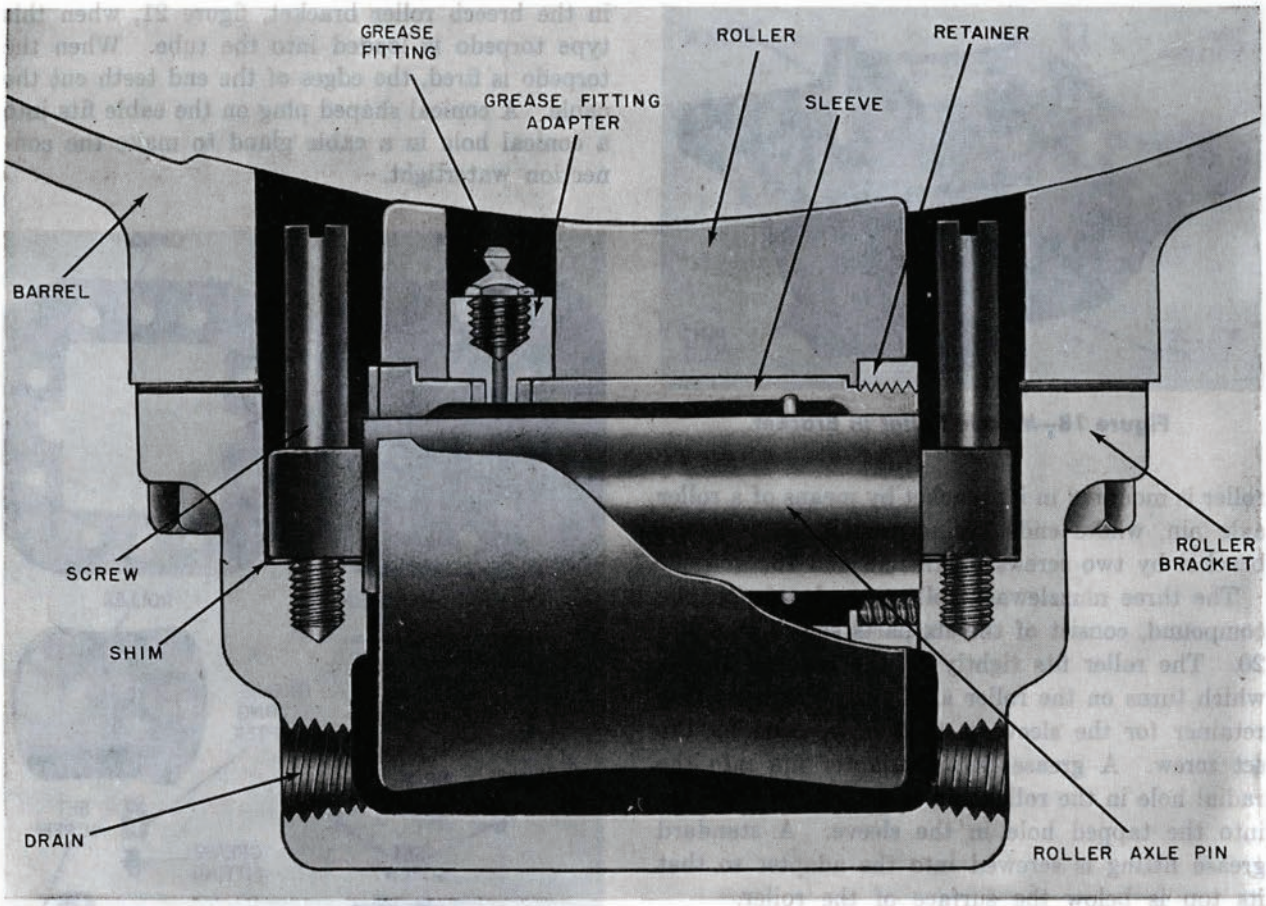


Figure 20—*Phenolic Roller Installed—Sectional View.*

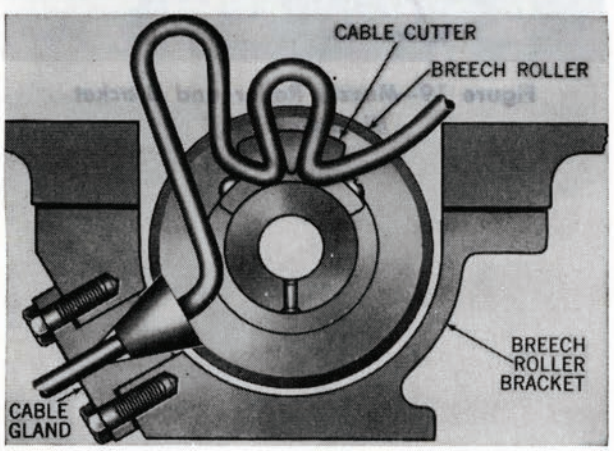


Figure 21—*Section through Breech Roller Bracket—Hydrogen Eliminator Cable Led Through Cutter.*

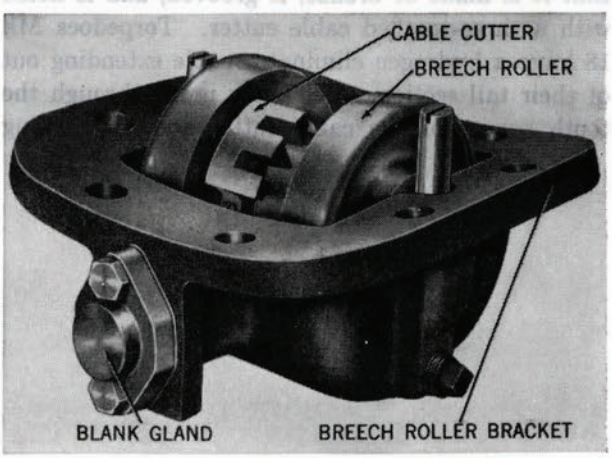


Figure 22—*Breech Roller in Bracket.*

When torpedoes other than Mk 18 are used, the cable cutter serves no function and the opening in the breech roller bracket is sealed with a blank gland, figure 22. Figure 23 shows the breech roller and bracket disassembled.

Adjustment of the projection of the rollers into

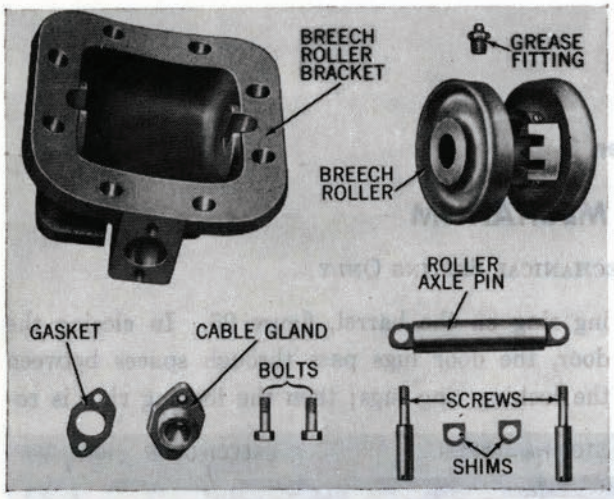


Figure 23—*Breech Roller and Bracket Parts for Use With Torpedo Mark 18.*

the tube is made by shimming under the ends of the roller axle pins. In general, the rollers should be set to project about 0.045 inch into the tube. When a torpedo is charged with air, the diameter of the air flask section of the torpedo increases to about 21.040 inches. Since the inside diameter of the tube is 21.125 inches, the 0.045-inch roller setting slightly varies the clearance between the outside of the torpedo and the inside of the barrel. This clearance is a minimum of about 0.035 inch at the top of the barrel, and gradually increases to a maximum of about 0.045 inch at the bottom. The underside of Torpedo Mk 18 will sag slightly between rollers; therefore, before these torpedoes are loaded in the tube, a check should be made to see that the rollers are adjusted correctly to project about 0.045 inch into the tube.

Chapter 3

BREECH DOOR MECHANISM

FOR TUBES EQUIPPED FOR MECHANICAL SETTING ONLY

Breech Door

The breech door, figure 24, has eight lugs which fit corresponding lugs on the inner surface of a locking ring on the barrel, figure 25. In closing the door, the door lugs pass through spaces between the locking ring lugs; then the locking ring is ro-

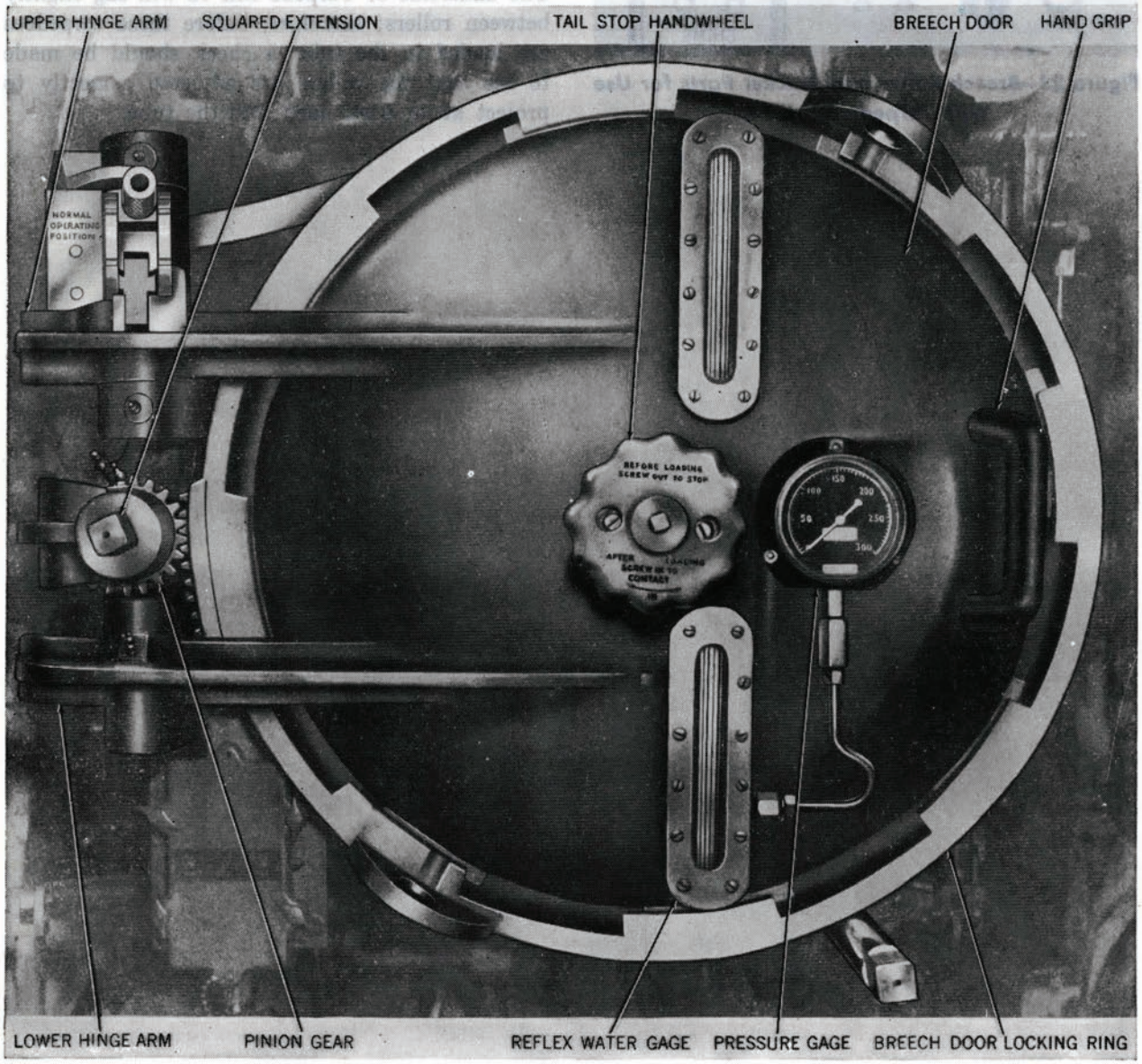


Figure 24—*Breech Door, Left-Hand Tube.*

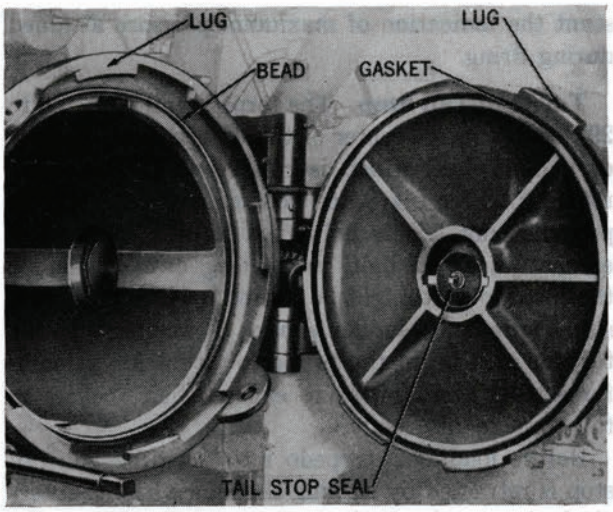


Figure 25—*Breech End of Right-Hand Tube, Breech Door Open.*

tated, bringing the locking ring lugs to bear against those on the door. The door is held against the barrel by the locking ring which is threaded on its inner surface to engage similar threads on the end of the barrel, figure 26. To make the breech door watertight when it is closed and locked, a gasket in a groove on the inner surface of the door presses against a bead on the end of the barrel.

On the outer surface of the door, two hinge arms extend to and are pivoted by a hinge bracket bolted to the outboard side of the barrel at the breech end. The free ends of the hinge arms bear against the bracket and limit the door's outward swing. The hinge bracket carries the door and the pinion gear, figure 27, which rotates the locking ring.

The pinion shaft has a squared extension to which an operating handle is attached for locking and unlocking the breech door, figure 28. As the operating handle is turned, action of the pinion gear on the gear segment on the side of the locking ring rotates the ring.

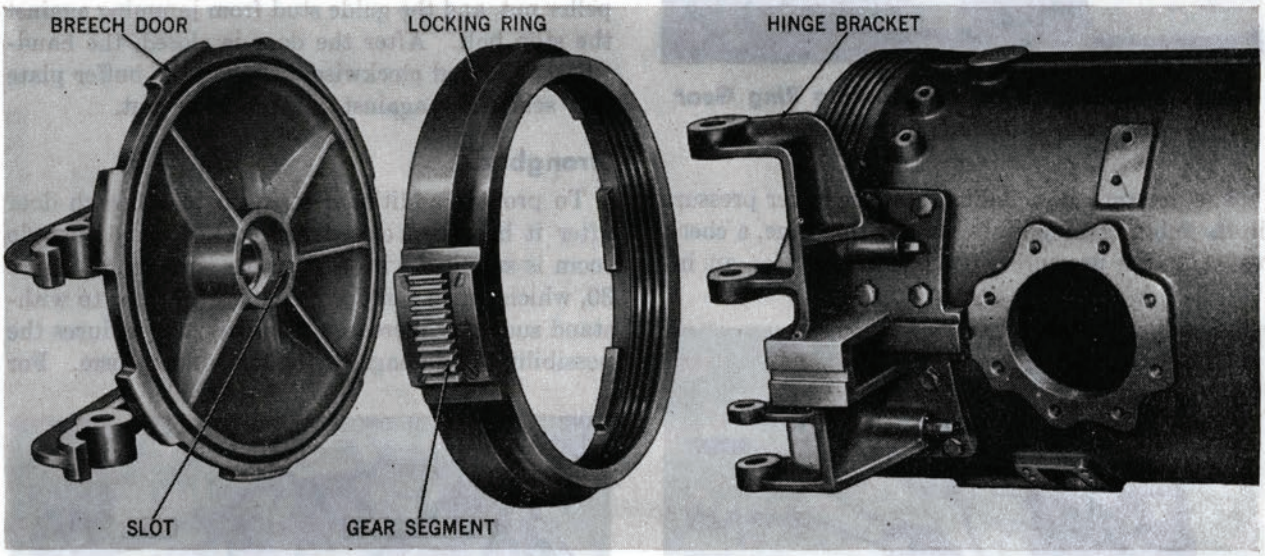


Figure 26—*Breech Door and Locking Ring Removed From Barrel.*

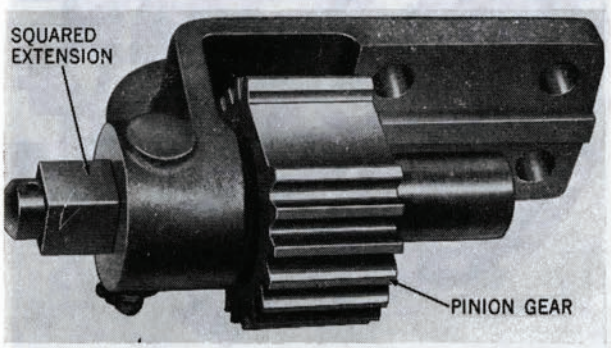


Figure 27—*Pinion Gear on Hinge Bracket.*

Movement of the breech door actuates the tripping latch which trips the torpedo starting lever when the torpedo is fired.

Also on the outer surface of the door are reflex water gages, a pressure gage, a hand grip for opening the door, and a handwheel for operating the torpedo tail stop. The reflex water gages permit observation of the water level in the tube during flooding and draining.

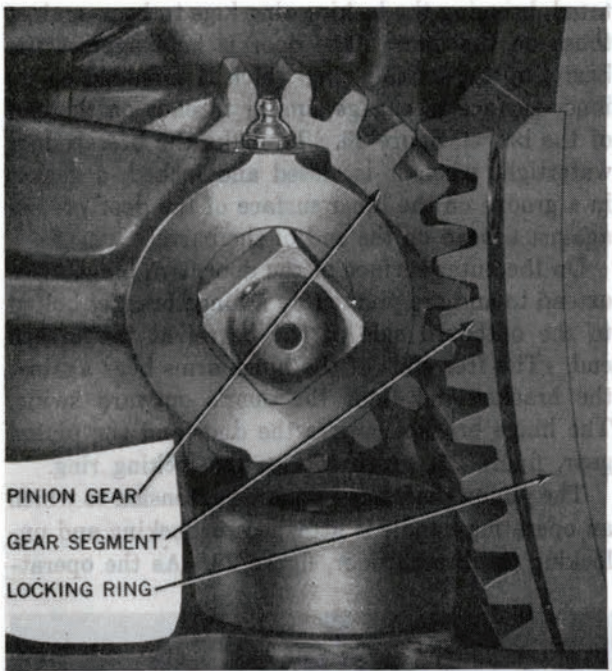


Figure 28—*Pinion Gear and Locking Ring Gear Segment—Installed Arrangement.*

The pressure gage indicates air or water pressure in the tube. To facilitate reading this gage, a check valve in the pressure gage line retains for an instant the indication of maximum pressure attained during firing.

Torpedo Tail Stop. The torpedo tail stop, figure 29, located in the center of the breech door, consists of a handwheel which is rotated to force a non-rotating buffer plate and seal against the torpedo propeller nut. This holds the torpedo guide stud against the stop bolt, preventing any motion of the torpedo that might be caused by changes in the ship's trim or by sudden shock. It insures that the torpedo will be in the proper position for spindles for setting mechanisms to engage their sockets in the torpedo afterbody.

Before loading a torpedo into the tube, the tail stop is retracted by turning the handwheel counterclockwise to the limit of its motion. When the breech door is closed, the retracted tail stop prevents the buffer plate and seal from striking the propeller nut, and the guide stud from jamming against the stop bolt. After the door is closed, the handwheel is turned clockwise, bringing the buffer plate and seal tight against the propeller nut.

Strongback

To provide additional strength to a breech door after it has been closed and locked, each torpedo room is supplied with a portable strongback, figure 30, which, when attached, enables the door to withstand suddenly increased pressures, and reduces the possibility of damage to the door mechanism. For

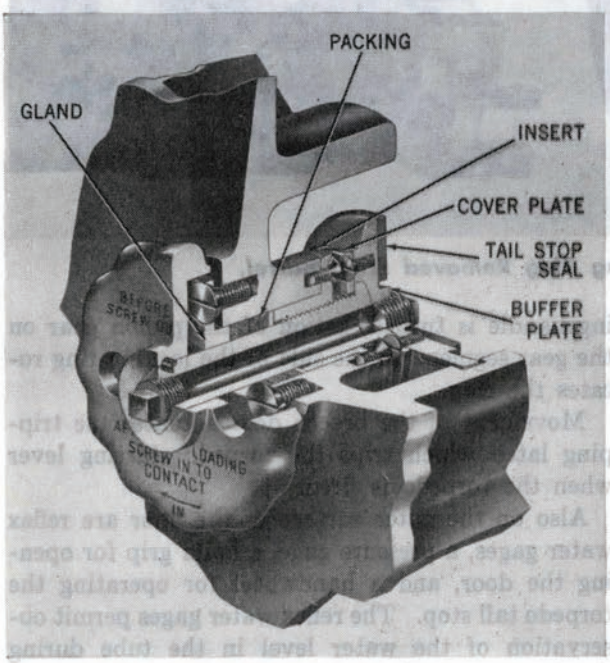


Figure 29—*Adjustable Tail Stop—Sectional View.*

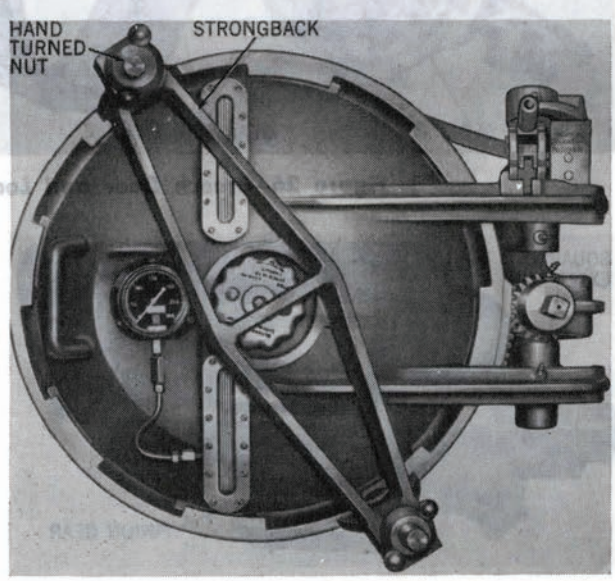


Figure 30—*Breech Door With Strongback Attached.*

example, a submarine when ready to fire has a muzzle door open. Detonation of a depth charge nearby at that time will cause a sudden increase of sea pressure against the inside of the breech door, and may damage it unless it is braced.

The strongback is placed across the outside of the door, its ends bolted to holes in the locking ring. A ring at the center of the strongback fits around the torpedo tail stop handwheel and presses against the middle of the door. Two hand-turned nuts permit quick attachment and removal of the strongback.

The buffer plate and seal, figure 31, are made in one piece, the seal being molded in place on the face of the buffer plate. Two projections on the buffer plate engage slots in the breech door, preventing the buffer plate from being rotated. The rubber seal prevents leakage of water into the tail cone of the torpedo when the tube is flooded.

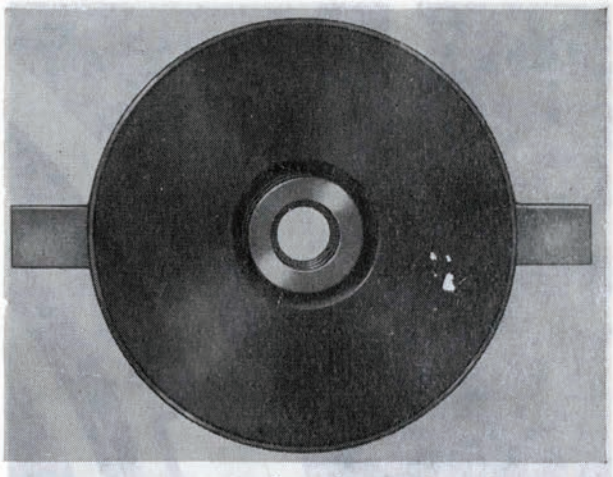


Figure 31—*Buffer Plate and Seal.*

door is unlocked. The breech door locking ring is directly involved in this interlock function. A lug

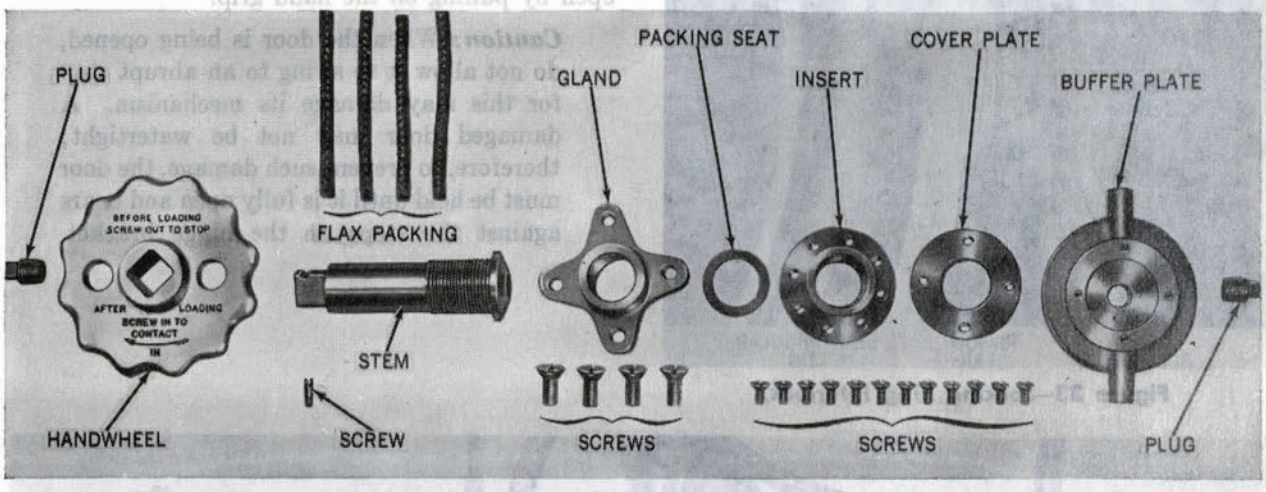


Figure 32—*Tail Stop Disassembled.*

The tail stop, including the buffer plate and seal, is shown disassembled in figure 32.

> NOTE: When a torpedo tube test set is used, it is secured by a pipe tap in the outer end of a tail stop stem (see NAVORD OD 717).

Interlock Features

The principal interlock feature of the breech door mechanism normally prevents this door from being unlocked if the muzzle door is not fully closed, and the muzzle door from being opened if the breech on its upper inboard surface contacts the breech and muzzle door interlock bolt in MUZZLE DOOR UNLOCKED position, preventing rotation of the locking ring and opening of the breech door.

Another interlock prevents the locking ring from being rotated to MUZZLE DOOR UNLOCKED position while the breech door is open. This is accomplished by attaching a lug to some part of the breech door casting or the locking ring so that it blocks movement of the locking ring while the door is open. Various forms of this interlock were installed by different builders, but all are similar in principle.

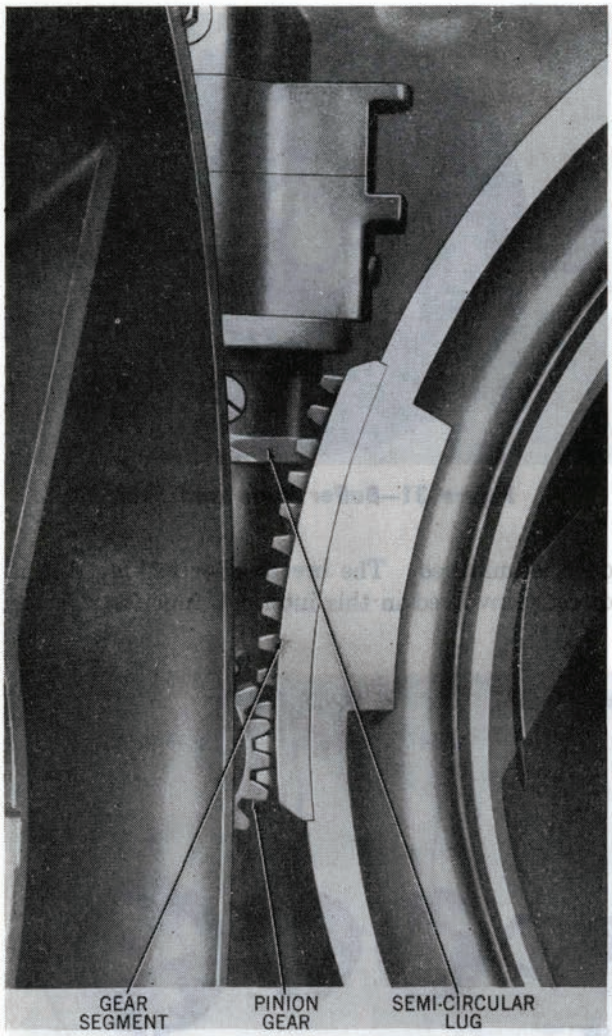


Figure 33—*Locking Ring Interlock.*

The type shown in figure 33 consists of a semi-circular lug attached to the hub of the upper hinge arm of the door. When the door is opened this lug swings into a tooth space in the locking ring gear segment, preventing movement of the locking ring.

Breech Door Operation

Before the breech door is opened, the muzzle door must be closed and the tube drained of water. Move the door interlock lever (at the inboard side and just over the breech end of the barrel) to BREECH DOOR UNLOCKED position on the indicator, figure 34. Attach the breech door operating handle to the squared extension of the pinion shaft and rotate it counterclockwise. Rotation of the pinion shaft turns the pinion gear which engages the gear segment on the locking ring. The locking ring turns, bringing its lugs in line with the open spaces on the breech door. The door then can be swung open by pulling on the hand grip.

> ***Caution:*** When the door is being opened, do not allow it to swing to an abrupt stop for this may damage its mechanism. A damaged door may not be watertight; therefore, to prevent such damage, the door must be held until it is fully open and bears against the stops on the hinge bracket.

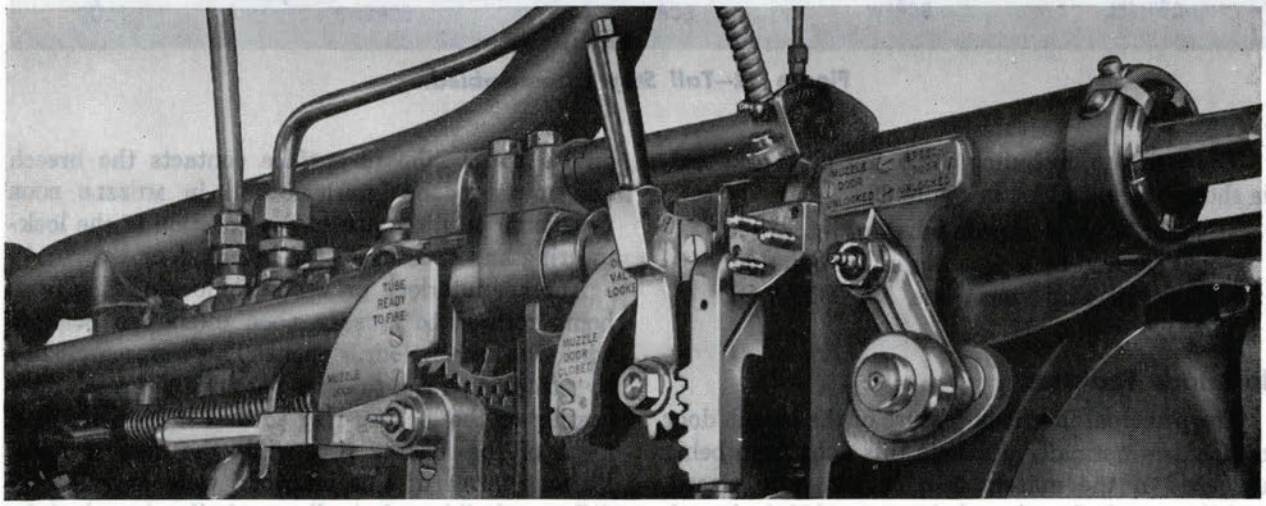


Figure 34—*Interlock Levers at Breech End of Tube, Inboard Side.*

Chapter 4

BREECH DOOR MECHANISM

FOR TUBES EQUIPPED FOR MECHANICAL AND ELECTRICAL SETTING

The breech door, its operating mechanism, and its interlocks are similar to those for tubes equipped only for mechanical setting of torpedoes, chapter 3. However, the change to permit the firing of electrically set torpedoes required the installation of a cable connector type door with different construction and additional interlock features.

Breech Door

The breech door, figures 35 and 36, has eight lugs which fit corresponding lugs on the inner surface of a locking ring on the barrel. When closing the door, the door lugs pass through spaces between the locking ring lugs. The locking ring is turned by a detachable operating handle, which

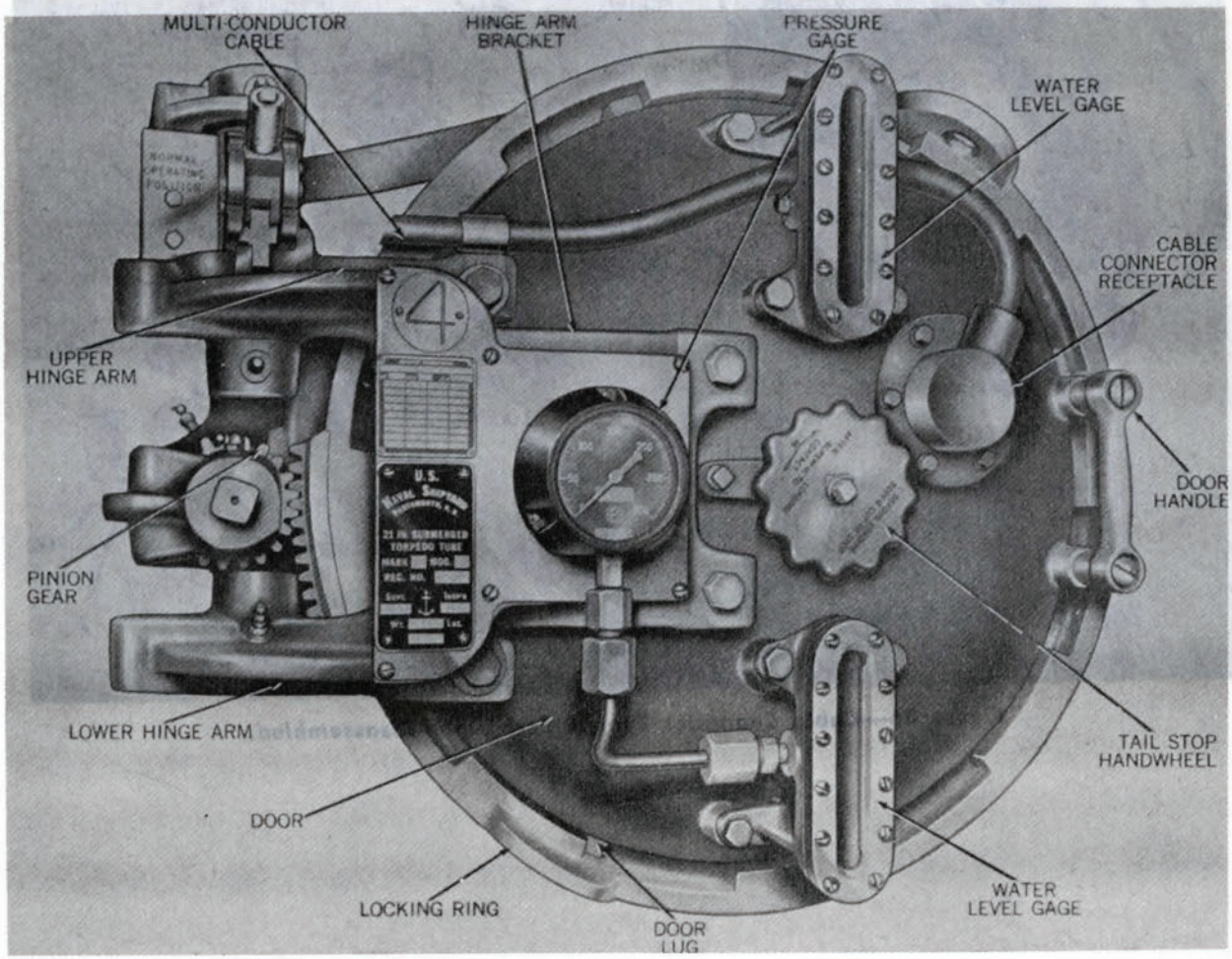


Figure 35—*Cable Connector Type Breech Door.*

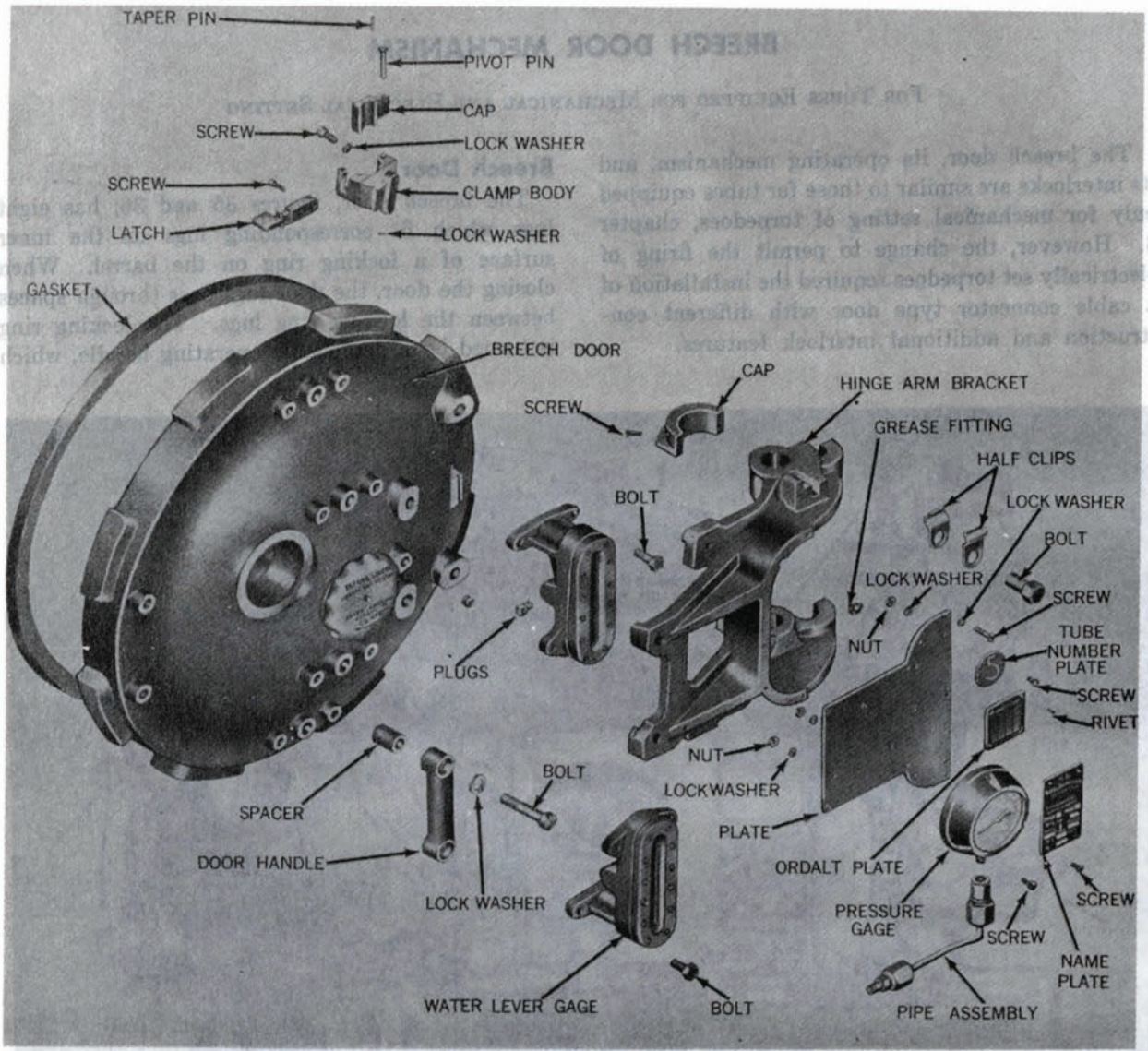


Figure 36—*Cable Connector Type Breech Door Disassembled.*

fits the squared extension on the pinion gear. Turning the locking ring brings its lugs to bear against those of the door; this forces the door toward the barrel. A ring gasket in a groove around the inner surface of the door, figure 37, presses against the bead on the end of the barrel to make the door watertight.

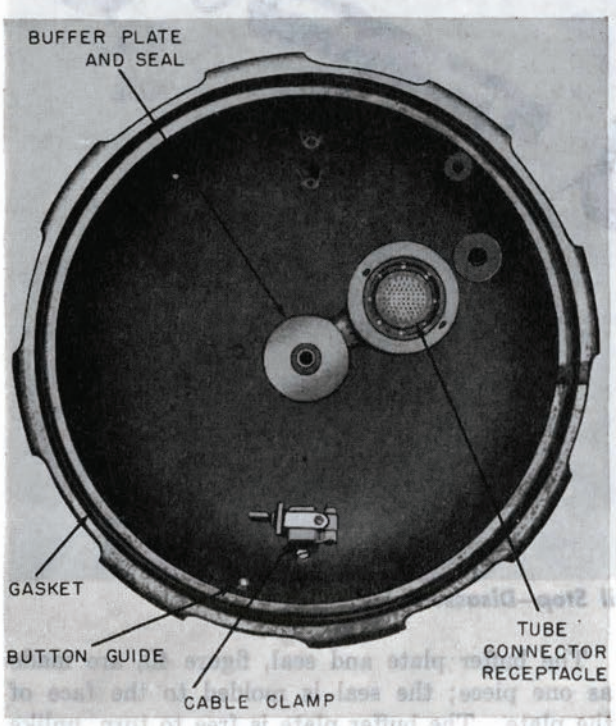


Figure 37—*Inside of Breech Door—No Plug in Place.*

Hinge Arm Bracket. Breech doors for mechanically set torpedoes had little curvature; their hinge arms were integral with the doors. The cable connector type door is more deeply dished to allow room for the cable connector. A bracket with two hinge arms is secured to the outboard face of the door with four cap screws. The arms curve toward the muzzle to fit within the same hinge bracket used with the earlier type door. The free ends of the hinge arms bear against the bracket to limit the door's outward swing. This bracket, bolted to the barrel, supports the door and the pinion gear that turns the locking ring. A tripping latch cam, chapter 8, is installed on the upper hinge pin.

Gages. Two water level gages are attached by cap screws to the outside of the breech door, figure 35. These indicate water level in the tube as the tube is flooded or drained.

A pressure gage, to indicate air or water pressure within the tube, is secured to the hinge arm bracket.

Torpedo Tail Stop. The torpedo tail stop, figures 38 and 39, is located in the center of the breech door. The handwheel is turned clockwise

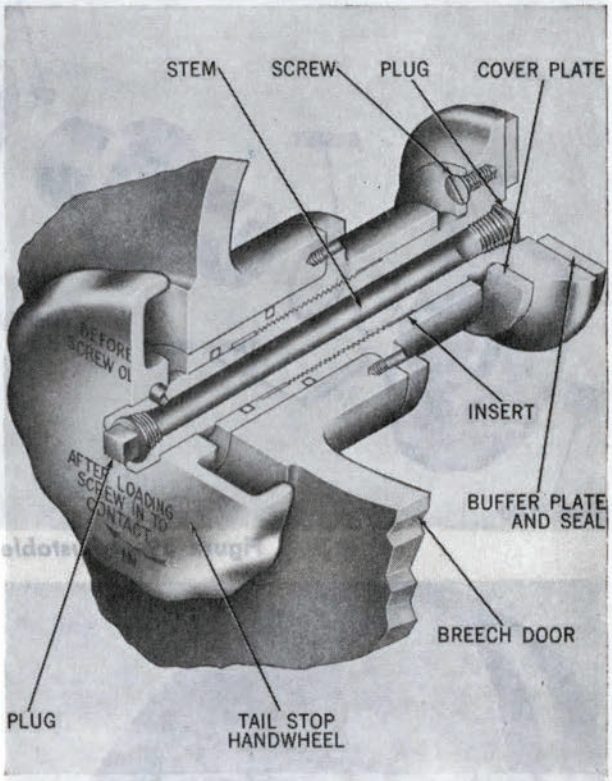


Figure 38—*Adjustable Tail Stop Installed—Sectional View.*

to force the buffer plate and seal, figure 37, against the propeller nut of the torpedo (21 inch only). This holds the torpedo with the guide stud against the stop bolt to prevent any movement of the torpedo that might be caused by changes in trim, ship's motion, or sudden shock. It also positions a mechanically set torpedo to allow the spindles of the setting mechanism to engage the sockets in the torpedo.

Before a torpedo is loaded into the tube, the buffer plate and seal is pulled back by turning the handwheel counterclockwise. This must be done to prevent the seal from striking the propeller nut as the door is closed.

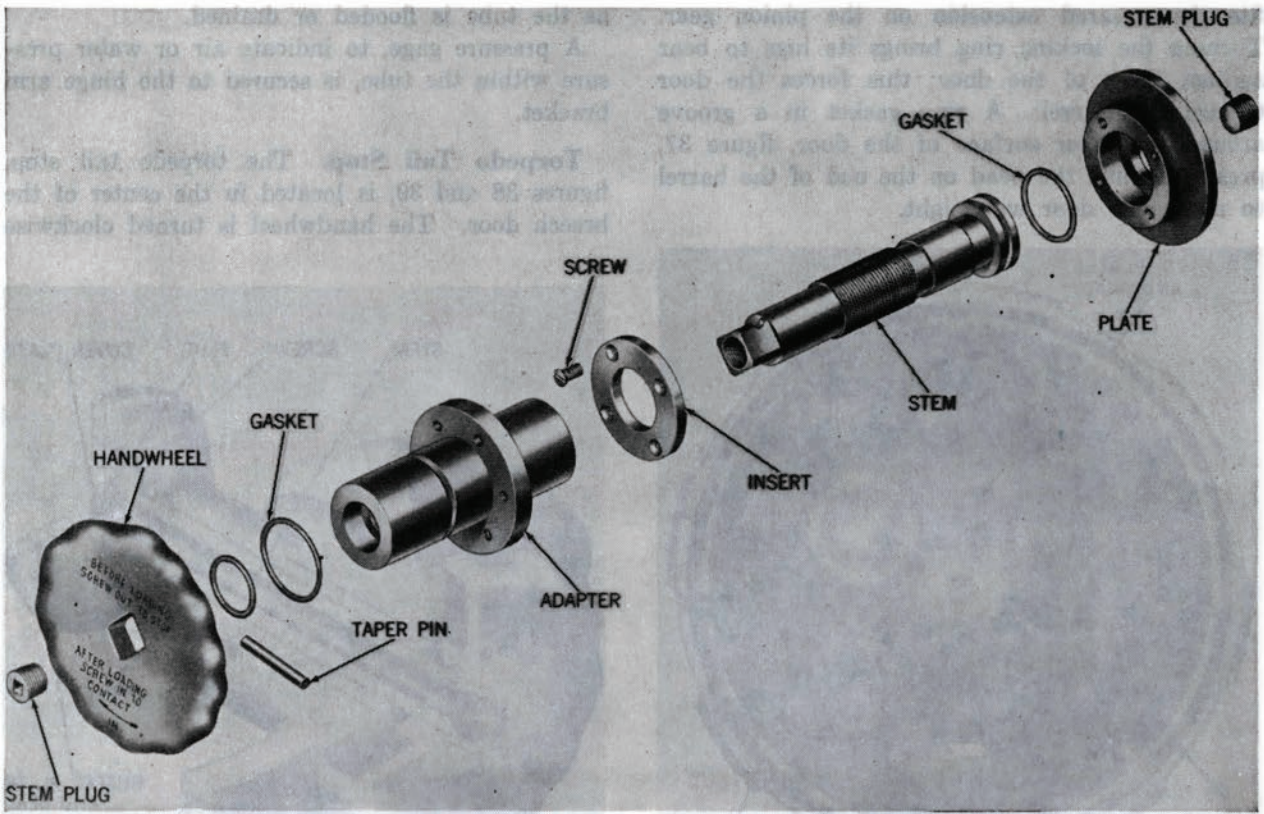


Figure 39—*Adjustable Tail Stop—Disassembled.*

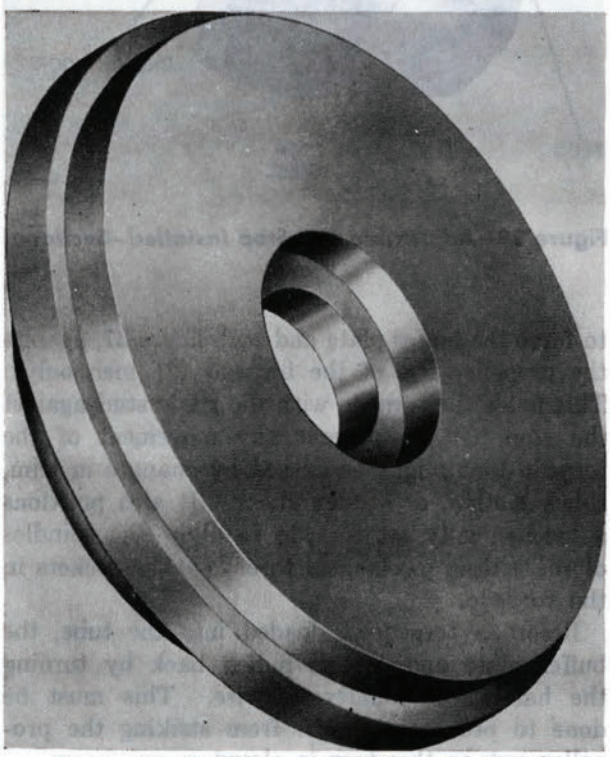


Figure 40—*Tail Stop Buffer Plate and Seal.*

The buffer plate and seal, figure 40, are made as one piece; the seal is molded to the face of the plate. The buffer plate is free to turn, unlike earlier types. Leakage of water into the tail cone is prevented by the seal.

Cable Connector. Torpedo-setting and firing circuit conductors are included in a multi-conductor cable connected to the fire control system. This cable is led through supporting clips to a tube door connector receptacle, figure 35, mounted in the tube door inboard of and just above the tail stop handwheel. Each electrically set torpedo has a corresponding cable that leads from the torpedo afterbody. A connector plug on the end of this cable plugs into the receptacle on the inside of the tube door to connect the torpedo setting and starting circuits to the fire control system. A cable clip and button guide, figures 37 and 41, provide a fair lead for the cable from the torpedo to the connector receptacle. A fuse in the connector plug acts to prevent blowing of the main firing circuit fuse on the fire control switchboard.

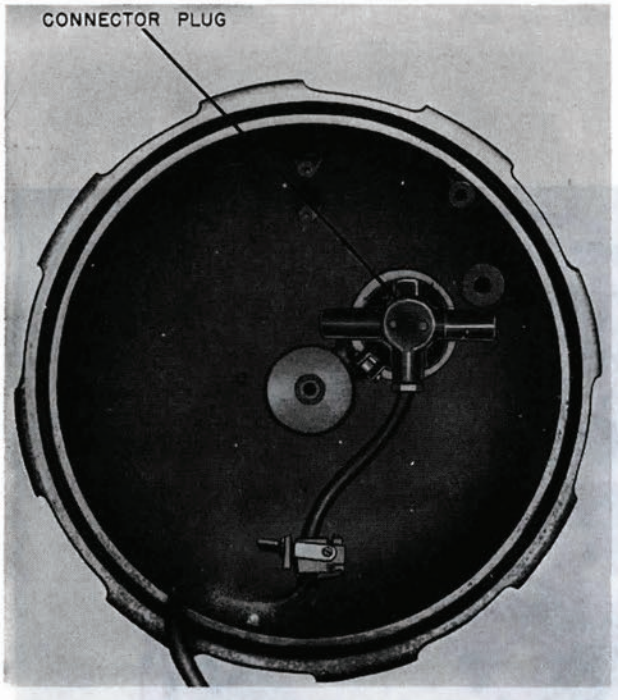


Figure 41—*Inside of Breech Door—Connector Plug in Place.*

Protecting Plug. The tube door connector receptacle must be protected at all times against possible damage by sea water or moisture in the air. A cable connector protecting plug is provided for each tube for use when a torpedo cable connector plug is not in use; that is, either when the tube has no torpedo in it or is loaded with a mechanically set torpedo.

Blanking Plug. A blanking plug is used during overhaul to keep the door watertight, if the cable connector receptacle is removed from the door.

Breech Door-Locking Ring Interlock. A lug on the locking ring is an important part of the breech door-muzzle door interlock. For this reason, it is very important that the locking ring not be turned while the breech door is open. To ensure that this does not happen, a wedge on the upper hinge arm of the door fits between two of the teeth of the gear segment on the locking ring when the door is open. Thus, with the door open, the locking ring cannot be turned.

Strongback

A new strongback, figure 42, to fit the curvature of the new breech door is provided. Its purpose and use are the same as described in chapter 3.

Interlock Features

Interlock features are the same as those described in chapter 3.

Breech Door Operation

Before the breech door is opened, the muzzle door must be closed and the tube drained of water. Move the door interlock lever (at the inboard side and just over the breech end of the barrel) to BREECH DOOR UNLOCKED position on the indicator. Attach the breech door operating handle to the squared extension of the pinion shaft and rotate it counterclockwise. Rotation of the pinion shaft turns the pinion gear which engages the gear segment on the locking ring. The locking ring turns, bringing its lugs in line with the open spaces on the breech door. The door then can be swung open by pulling on the hand grip.

When the door is being opened, allowing it to swing to an abrupt stop may damage its mechanism. A damaged door may not be watertight; therefore, to prevent such damage, the door must be held until it is fully open and bears against the stops on the hinge bracket.

After the torpedo is in the tube, remove the protecting plug from the cable connector receptacle inside the breech door. Lead the torpedo cable through the cable clip on the inside of the door, figure 41, and insert the cable plug into the door receptacle.

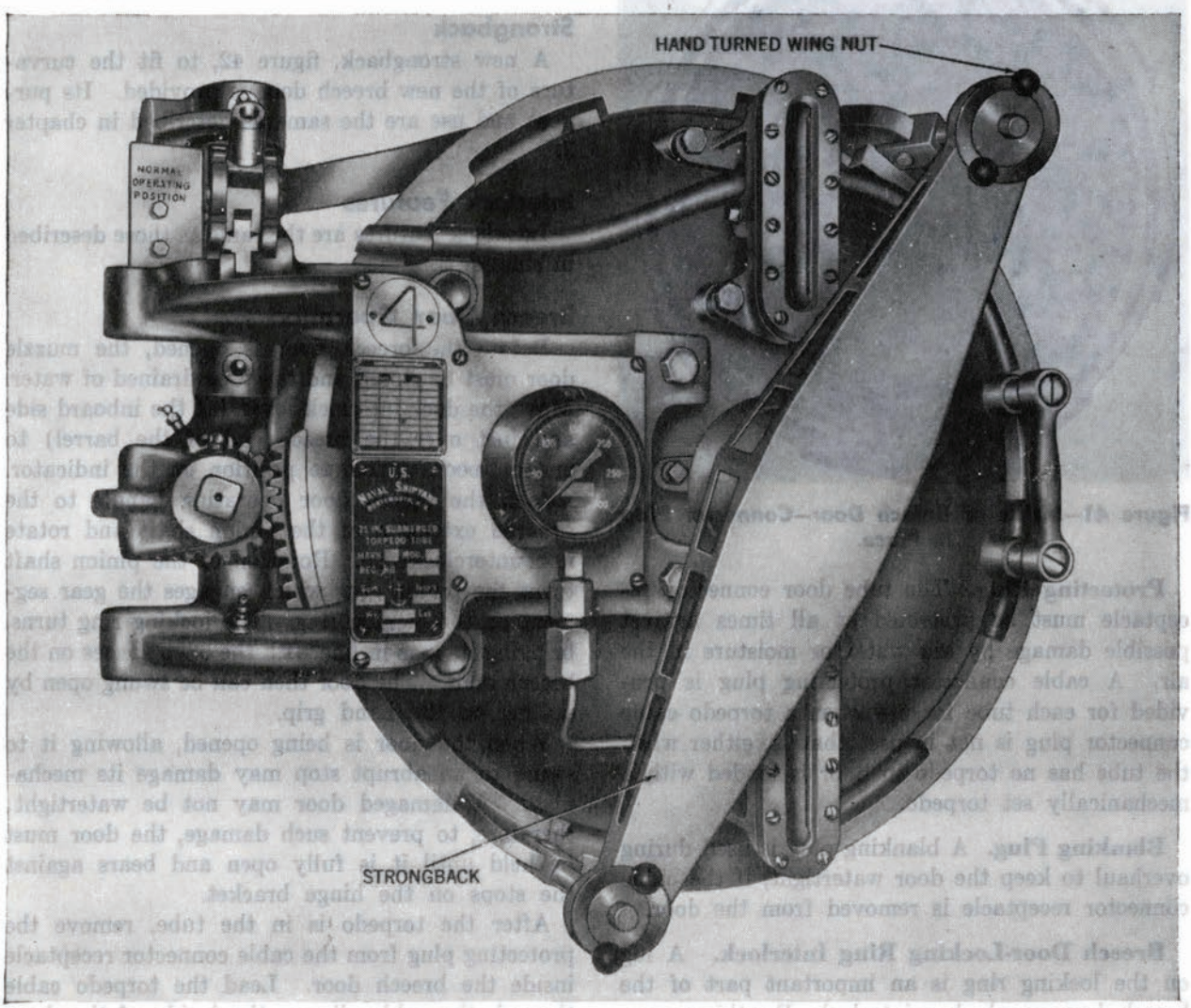


Figure 42—*Cable Connector Type Breech Door With Strongback Attached.*

Chapter 5

MUZZLE DOOR MECHANISM

When the muzzle door is closed, it covers and seals the muzzle end of the barrel permitting the barrel to be drained and the breech door opened.

Sea water pressure forces the closed muzzle door against the end of the barrel. A gasket in the door rim, figure 43, seats against the end of the barrel, seals the door, and prevents water from leaking into the barrel. When pressure inside the barrel exceeds pressure outside by about 10 pounds per square inch, the door arm and associated parts spring enough to open the gasket seal sufficiently to permit the escape of air and water from the tube into the sea.

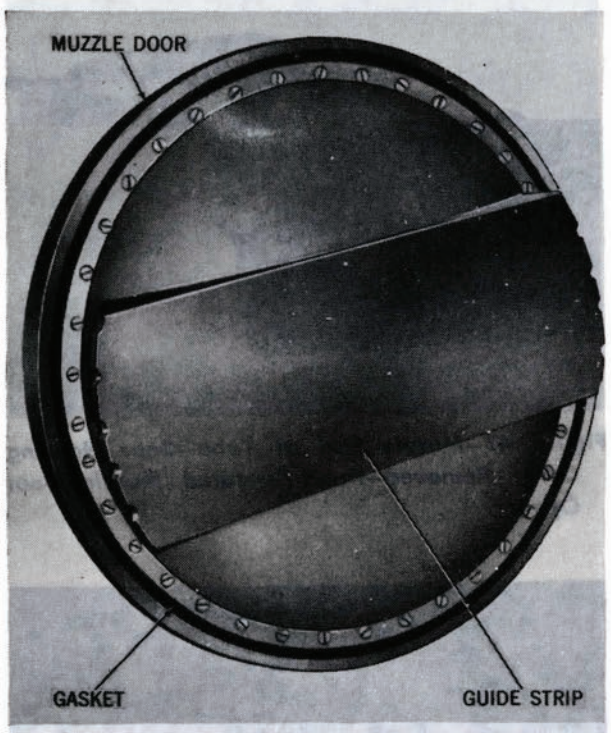


Figure 43—*Inside of Muzzle Door.*

When the muzzle door is open, the muzzle end of the tube is clear for ejection of a torpedo.

Some torpedo tubes have manually operated muzzle door mechanisms. Later tubes have muzzle doors operated by hydraulic power, requiring a more extensive interlock system; such tubes also have provisions for emergency hand operation. Both types of muzzle door mechanisms are described in this publication.

Muzzle Door and Shutter

The muzzle door is carried on an arm supported by a vertical shaft which rotates in bearings in a hinge bracket. In moving between the closed and open positions, the shaft, arm, and door swing through an arc of 90 degrees.

When the muzzle door opens, it swings away from the end of the barrel and inboard into a chamber in the side of the ship.

Bow tubes and many stern tubes are equipped with shutters which conceal the chambers at the muzzles of the tubes when the muzzle doors are closed. They make hull plating smooth and continuous, decrease water resistance, and protect the doors.

Each muzzle door and its shutter is controlled by an operating mechanism; as the door swings open the shutter moves inboard to a fore-and-aft position along the inboard side of the chamber. A flat guide strip on the inner face of the door and a similar strip on the face of the shutter line

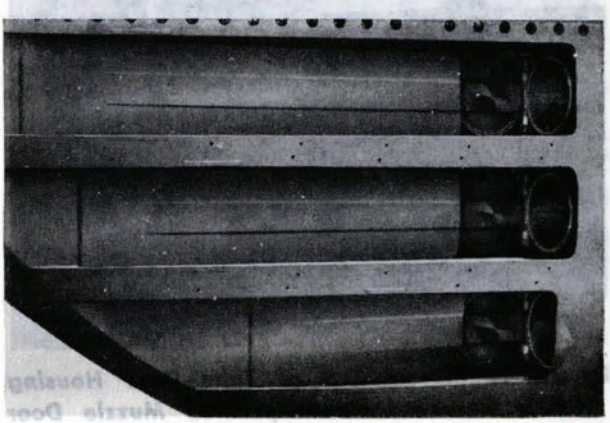


Figure 44—*Sliding Type Shutters—Doors Open.*

up to form a smooth surface along which the torpedo slides, if forced toward the door during ejection.

Most shutters are of the sliding type, figures 44 and 45, arranged so the "near" end is carried

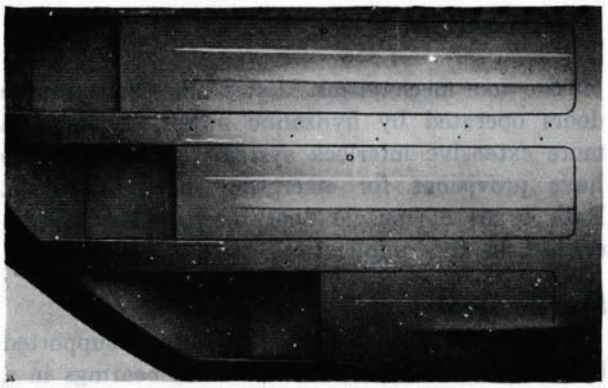


Figure 45—*Sliding Type Shutters—Doors Closed.*

by extended connections of the muzzle door arm. The "far" end rides on rollers which run in tracks built into the ship structure.

Some tubes are equipped with a hinged type shutter, in which the far end pivots on vertical pins while the near end is swung inboard (or outboard) by linkage to the muzzle door shaft. A locking mechanism holds this type shutter in the open position when the muzzle door is open.

Information on the type of shutters installed in any submarine may be obtained by referring to the builder's plans.

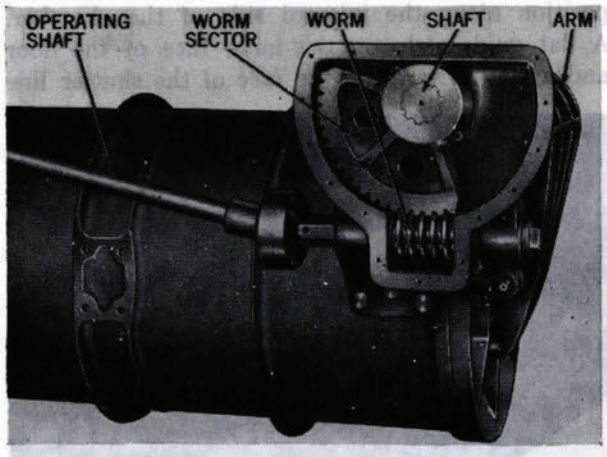


Figure 46—*Muzzle End of Tube—Gear Housing Cover Removed—Hand-Operated Muzzle Door Closed.*

Hand-Operated Muzzle Door Mechanism

In this mechanism, a single-thread, self-locking worm drives a worm sector keyed to the muzzle door shaft. The usual position of the worm gear housing is above the barrel, figures 46 and 47, but on some stern tubes it is below. The worm is driven directly by a muzzle door operating shaft which extends to the breech end of the barrel and terminates in a squared end so that a wrench may be applied to turn the shaft, figure 48. The 90° swing of the door is accomplished by 14½ revolutions of the shaft.

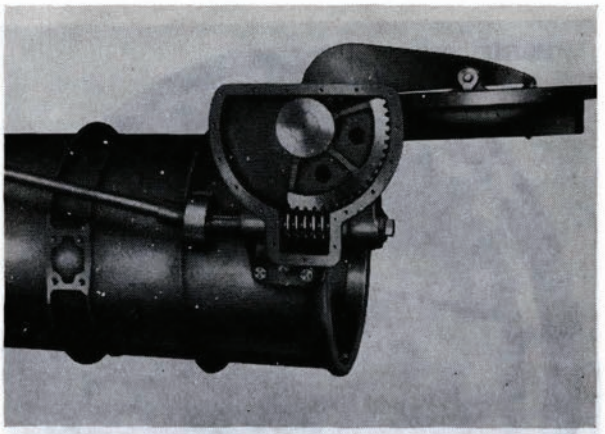


Figure 47—*Muzzle End of Tube—Gear Housing Cover Removed—Hand-Operated Muzzle Door Open.*

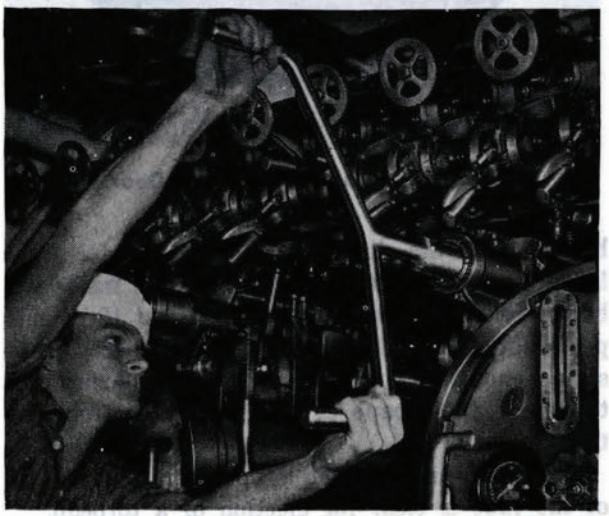


Figure 48—*Hand Operation of Muzzle Door.*

Stuffing boxes are installed where the shaft passes through watertight bulkheads, and universal joints are used where it departs from straight line operation. The breech section of the shaft passes through an interlock sleeve and is supported by a breech bracket.

A muzzle door indicator in the breech bracket indicates the movement and angular position of the muzzle door.

Interlock Features. Mechanical interlocking of the hand-operated muzzle door mechanism is accomplished through an interlock slide which moves back and forth inside the cylindrical portion of the breech bracket as the door is operated, figures 49 and 50. Internal threads on the slide engage corresponding threads on the muzzle door operating

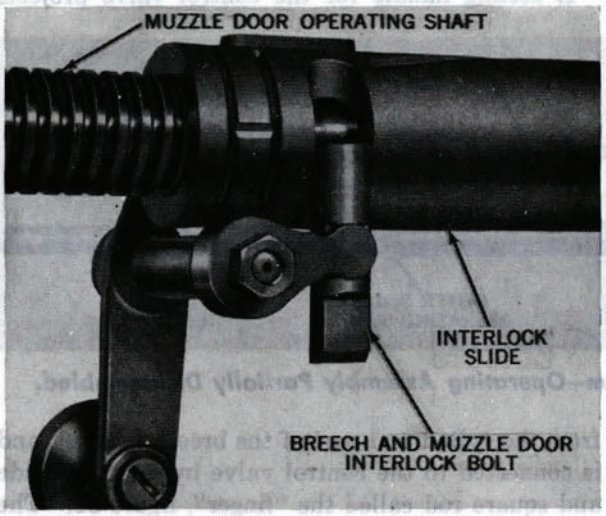


Figure 49—*Interlock Slide on Muzzle Door Operating Shaft—BREECH DOOR UNLOCKED.*

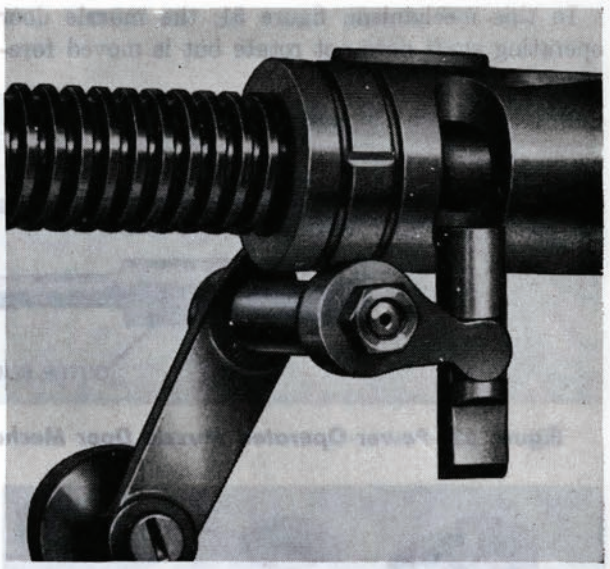


Figure 50—*Interlock Slide on Muzzle Door Operating Shaft—MUZZLE DOOR UNLOCKED.*

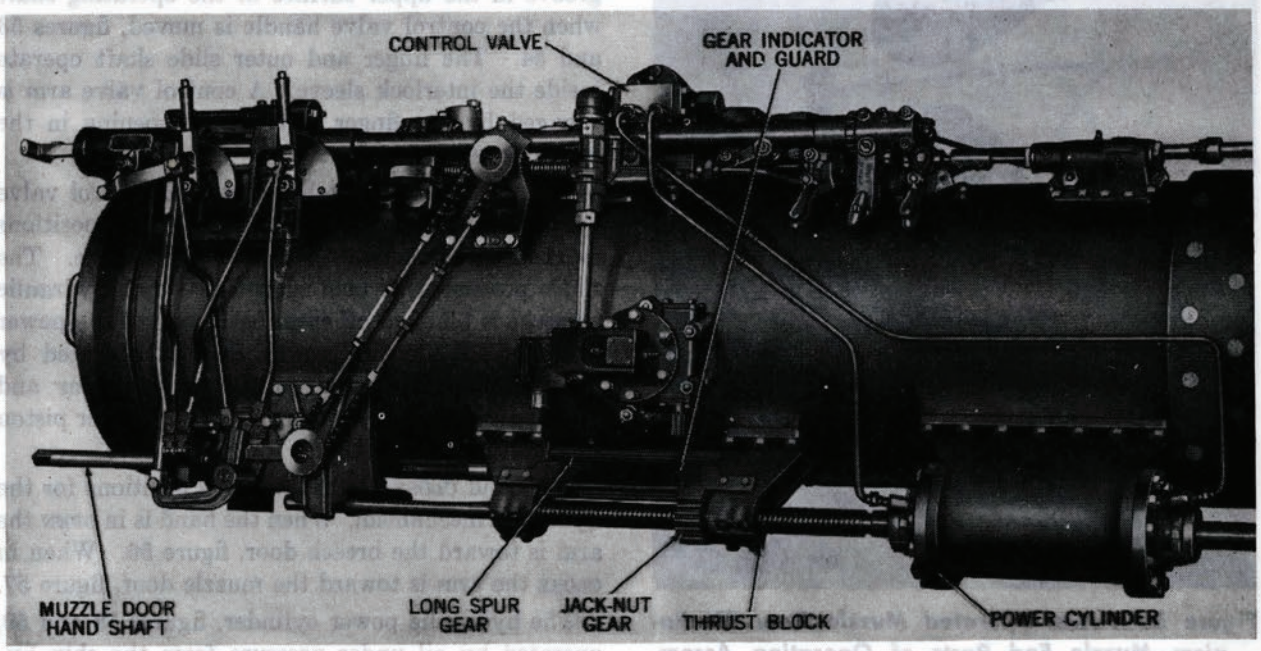


Figure 51—*Breech End of Power-Operated Muzzle Door Mechanism—Inboard Side of Torpedo Tube.*

shaft. It is prevented from rotating by a key in its upper surface. When the fore-and-aft movement of the interlock slide is blocked by engagement of one of the interlock bolts, rotation of the muzzle door operating shaft and movement of the muzzle door are prevented.

Power-Operated Muzzle Door Mechanism

In this mechanism, figure 51, the muzzle door operating shaft does not rotate but is moved fore-and-aft by a piston in a cylinder. This piston is subjected to oil pressure on one side or the other; the direction of motion is governed by settings made to a control valve.

The muzzle door shaft, carrying the muzzle door arm, is connected to the muzzle door operating shaft by a crank and connecting rod. Fore-and-aft movement of the operating shaft causes the muzzle door shaft, arm, and door to open or close.

A setting handle for the control valve projects

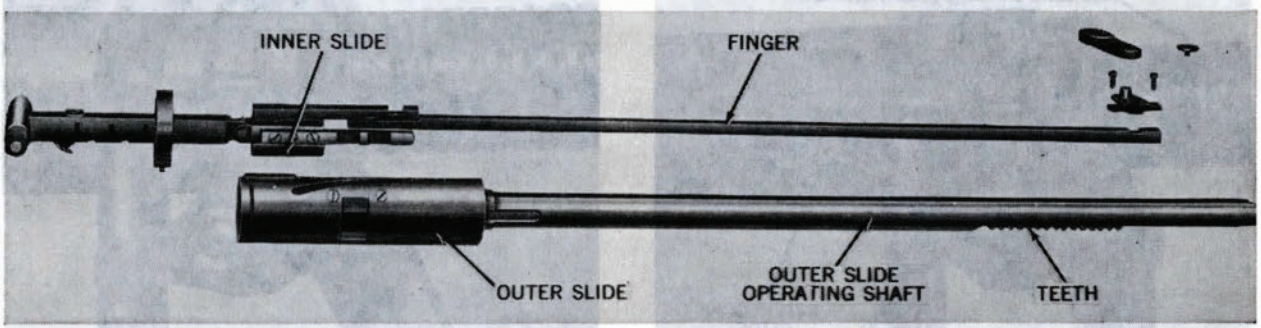


Figure 52—*Power-Operated Muzzle Door Mechanism—Operating Assembly Partially Disassembled.*

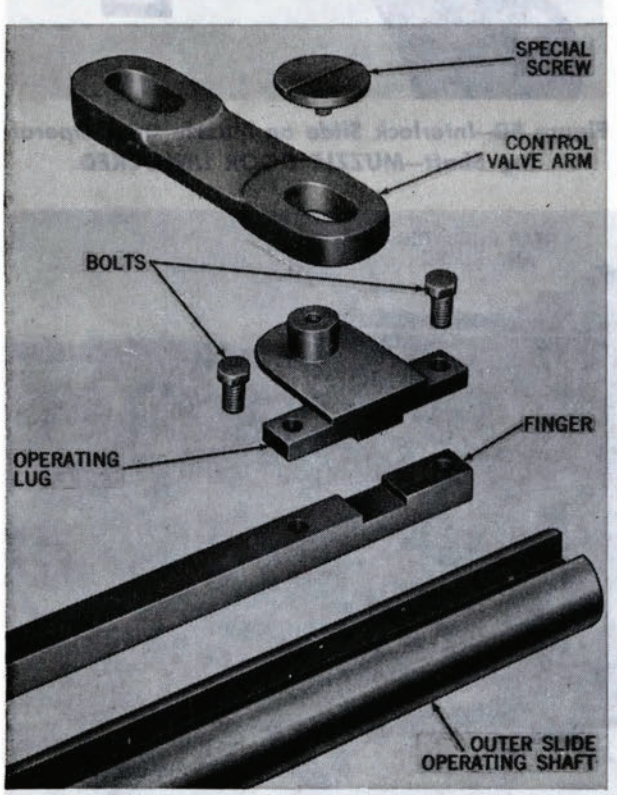


Figure 53—*Power-Operated Muzzle Door Mechanism—Muzzle End Parts of Operating Assembly.*

from the cylindrical part of the breech bracket, and is connected to the control valve by an inner slide and square rod called the "finger", figure 52. The inner slide and finger move in an outer slide and outer slide operating shaft. The finger slides in a groove in the upper surface of the operating shaft when the control valve handle is moved, figures 53 and 54. The finger and outer slide shaft operate inside the interlock sleeve. A control valve arm is engaged by the finger through an opening in the interlock sleeve.

A finger-operated latch secures the control valve operating handle in any of the three positions marked on the squared shank of the handle. The HAND position is a neutral one in which hydraulic pressure is blanked off from both ends of the power cylinder. While the muzzle door is operated by hand, a bypass in the control valve opens and allows oil to pass from one side of the power piston to the other, figure 55.

OPEN and CLOSE are the working positions for the hydraulic mechanism. When the hand is in OPEN the arm is toward the breech door, figure 56. When in CLOSE the arm is toward the muzzle door, figure 57.

The hydraulic power cylinder, figures 58 and 59, operated by oil under pressure from the ship hydraulic manifold is attached on the inboard side

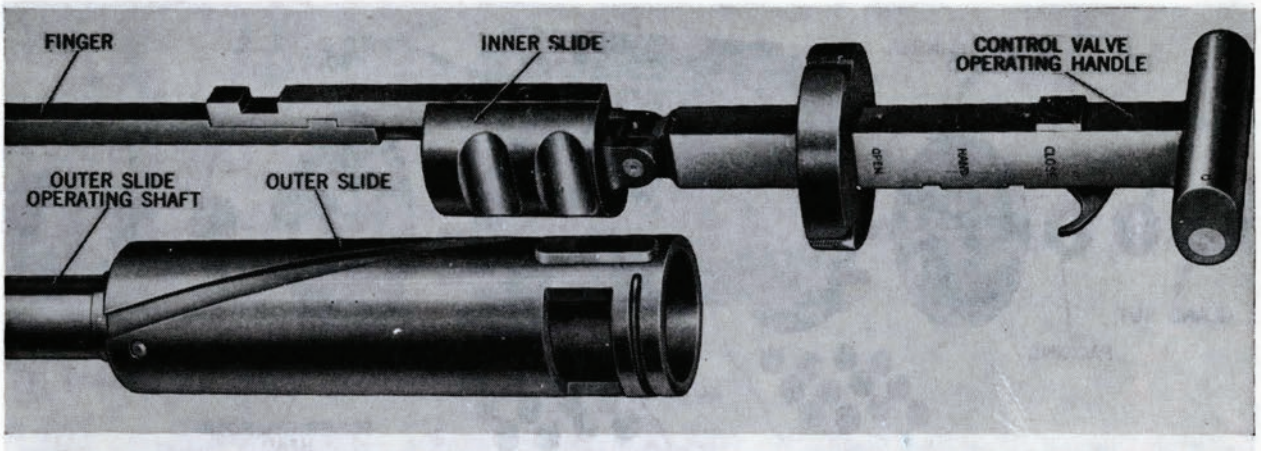


Figure 54—Power-Operated Muzzle Door Mechanism—Breech End Parts of Operating Assembly.

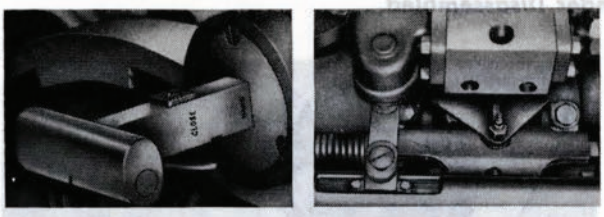


Figure 55—Power-Operated Muzzle Door Mechanism Controls Set for HAND Operation—Control Valve Operating Handle at HAND (Left) and Control Valve Arm in Center Position (Right).

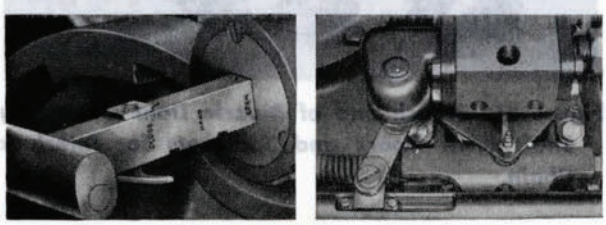


Figure 56—Power-Operated Muzzle Door Mechanism Controls—Muzzle Door Open—Control Valve Operating Handle at OPEN (Left) and Control Valve Arm Toward Breech (Right).

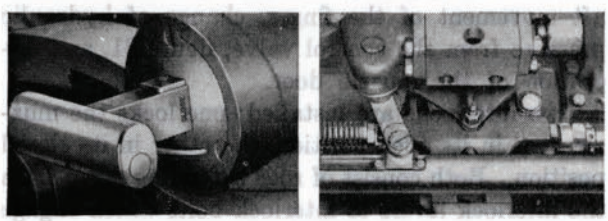


Figure 57—Power-Operated Muzzle Door Mechanism Controls—Muzzle Door Closed—Control Valve Operating Handle at CLOSE (Left) and Control Valve Arm Toward Muzzle (Right).

below the tube centerline. Normally, the operating shaft extends straight out from the power cylinder to the connecting rod near the muzzle door; in some installations, however, the connecting rod and crank are located above the tube. In such cases, a rocker arm pivoted at the side of the barrel transfers motion of the muzzle door operating shaft from below to above the tube centerline.

Emergency Hand Operation

The breech end of a hand operating shaft can be turned with a wrench. The other end of the shaft carries a spur gear which drives a jack-nut gear mounted on the muzzle door operating shaft. The jack-nut gear teeth engage the spur gear, and a screw thread on its inner surface engages the thread on the muzzle door operating shaft.

A clamp handle located near the breech end of the hand operating shaft locks the shaft when the muzzle door is power operated. It is simply a clamp which draws together two sides of a split bearing through which the hand operating shaft passes. When the clamp handle is rotated clockwise, the bearing draws together and locks the shaft; when the handle is rotated counterclockwise, the bearing opens and unlocks the shaft.

When the muzzle door is power-operated and the shaft locked, the jack-nut gear is prevented from rotating by its engagement with the spur gear. It rides along the muzzle door operating shaft between two thrust blocks, permitting full door movement.

In hand operation, the spur gear rotates the jack-nut gear which moves along the threads of the muz-

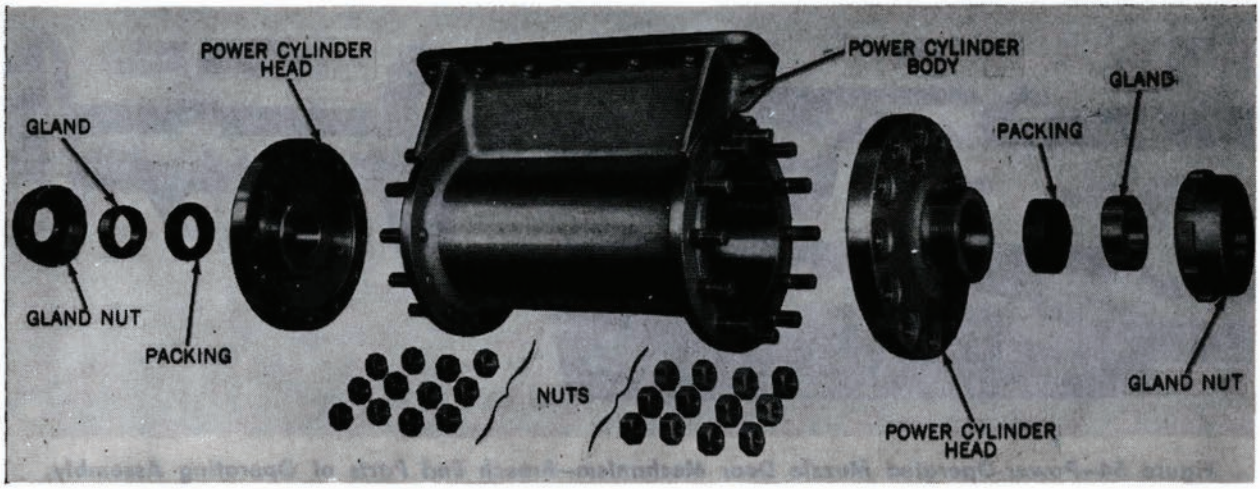


Figure 58—*Power Cylinder Disassembled.*

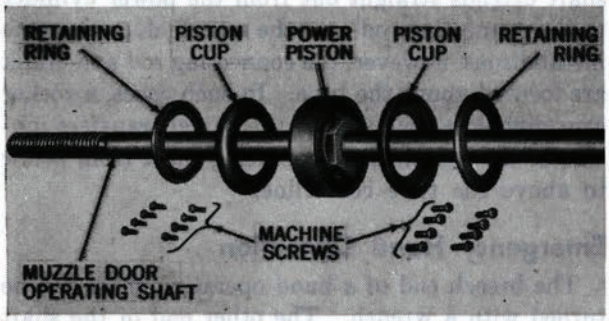


Figure 59—*Power Cylinder Piston and Packing Disassembled.*

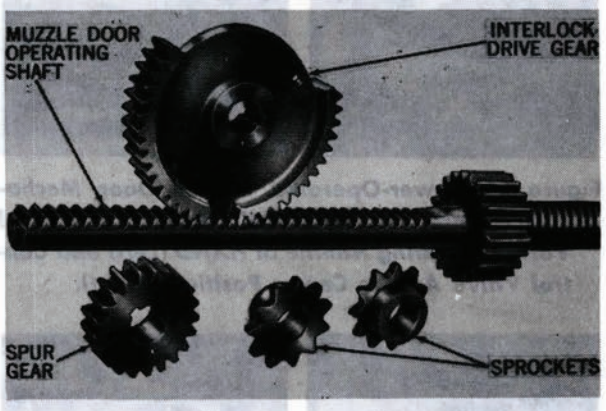


Figure 60—*Breech End of Muzzle Door Operating Shaft With Gears and Sprockets for Interlock Chain.*

zle door operating shaft (since this takes less force than to move the door) until it comes up against one of the thrust blocks. When it can move no farther along the shaft, its continued rotation forces the shaft to move fore-and-aft, operating the muzzle door.

Interlock Features. As the shaft moves fore-and-aft, teeth on its upper breech end engage an interlock drive gear at the lower end of an interlock chain, figure 60. Two turnbuckles in the interlock chain permit adjustment of the interlock mechanism relative to the muzzle door operating shaft. The chain connects at the top to a gear which engages (through an opening in the interlock sleeve) teeth on the under side of the outer slide operating shaft. The fore-and-aft movement of the muzzle door operating shaft is transmitted in the opposite direction to the outer slide operating shaft to move the outer slide. As it moves, a groove in its outer surface rotates the pointer on the muzzle door indicator. The outer slide is slotted and the inner slide grooved to permit engagement of an interlock bolt, whose position is controlled by the interlock lever. When engaged, these bolts prevent fore-and-aft movement of the finger, change of hydraulic pressure from the control valve, figure 61, and operation of the muzzle door.

Two interlocks are installed; one locks the muzzle door in its open position, the other in its closed position. Both consist of rods extending down from the interlock levers to interlock bolts which engage or disengage openings in the interlock drive gear. When engaged, these bolts prevent movement of the interlock drive gear and of the muzzle door operating shaft.

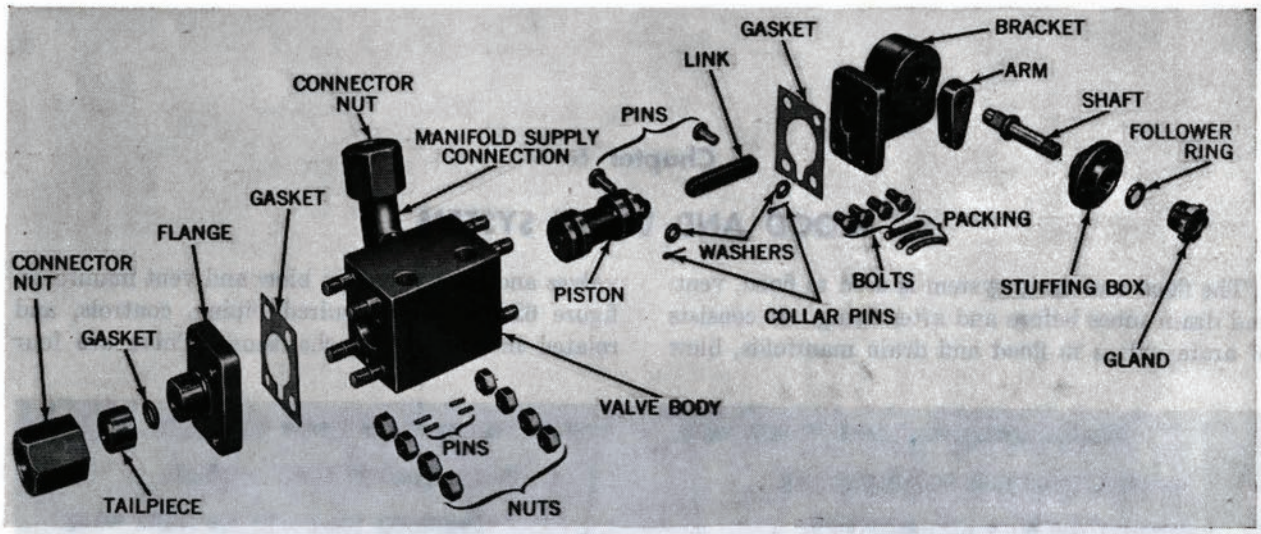


Figure 61—*Control Valve Disassembled.*

An interlocking mechanism also locks or unlocks the hand operating shaft. This mechanism consists of rods extending down from the interlock levers to dogs which engage or release a gear on the breech end of the hand operating shaft. Therefore, the setting of the interlock levers controls the positions of both the interlock bolts in the power mechanism and the dogs in the hand mechanism. In this arrangement, when the finger is prevented from moving fore-and-aft, the hand operating shaft cannot rotate.

Chapter 6

FLOOD AND DRAIN SYSTEM

The flood and drain system is used to flood, vent, and drain tubes before and after firing. It consists of drain valves in flood and drain manifolds, blow valves and vent valves in blow and vent manifolds, figure 62, and the required piping, controls, and related interlocking mechanisms. There are four

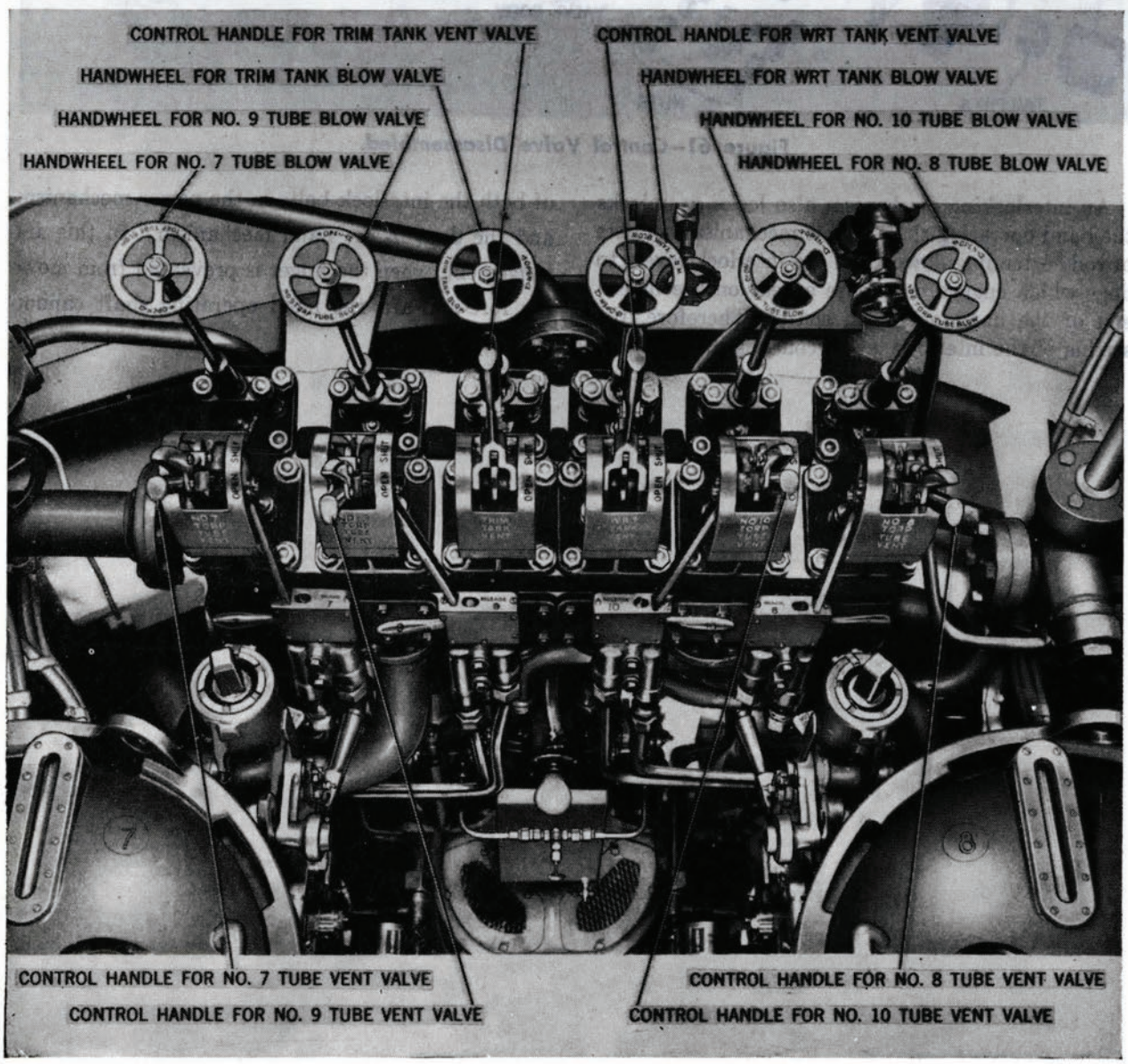


Figure 62—*Stern Nest Blow and Vent Manifold—Flood and Drain System Controls.*

flood and drain manifolds in a submarine, one below each bank of torpedo tubes. Each tube has two flood and drain lines (one forward and one aft) which join and lead to a drain valve in one of the flood and drain manifolds.

The flood and drain manifolds control flooding tubes from or draining tubes to the trim line, a trim tank, torpedo compensating tank, a WRT (water 'round torpedo) tank. Each manifold in a forward nest consists of three drain valves and each manifold in an after nest consists of two drain valves.

In an after manifold, each drain valve is operated by a lever directly connected to a drain valve operating shaft, figure 63. In a forward manifold, shafting transmits the movement of levers installed at deck level to operating shafts installed below the lower tube.

Shafts serving any one flood and drain manifold are adjacent to it, below the breech end of the lower tube in the bank. In all installations except bow banks in Electric Boat Co. designed ships, operating shafts are concentric (operating one inside the other). In the Electric Boat Co. design, the inboard drain valve in each forward manifold is installed to the side of and above the other two valves. In these manifolds only the shafts serving the two outboard valves are concentric.

A torpedo tube usually is flooded from and drained to the WRT tank located near the tube.

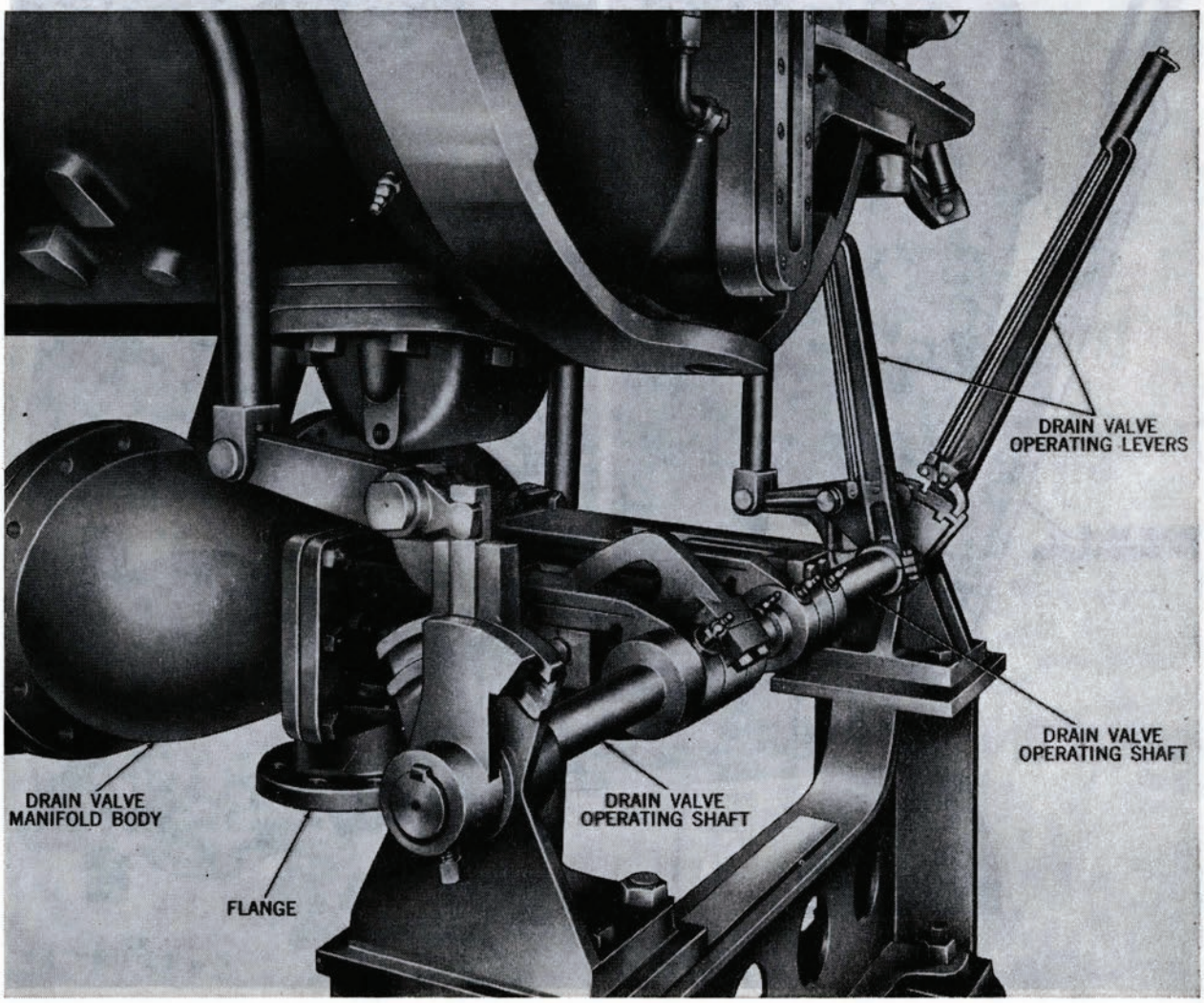


Figure 63—*Flood and Drain Manifold in Portsmouth Type Stern Bank—Outboard Operating Lever at OPEN—Inboard Lever at SHUT.*

Water from the trim tank or the sea also may be used.

The four roller brackets, chapter 2, are drained through openings in the bottom of the brackets to 3/8-inch inside diameter drain lines which connect to the tube drain line above the drain valve.

Two blow and vent lines from each tube (one forward and one aft) join and lead to a chamber in a blow and vent manifold. There are two of these manifolds in a submarine, one for each nest of tubes. Blow valves and vent valves in the manifold control air passage through a chamber, which connects to the following:

1. A blow and vent line from each tube.
2. A blow and vent line from the WRT tank.
3. A stop valve in the ship service air line.

Flood and drain system installations vary on different submarines; detailed information on these variations is given on builder's plans and in the ship's General Information book.

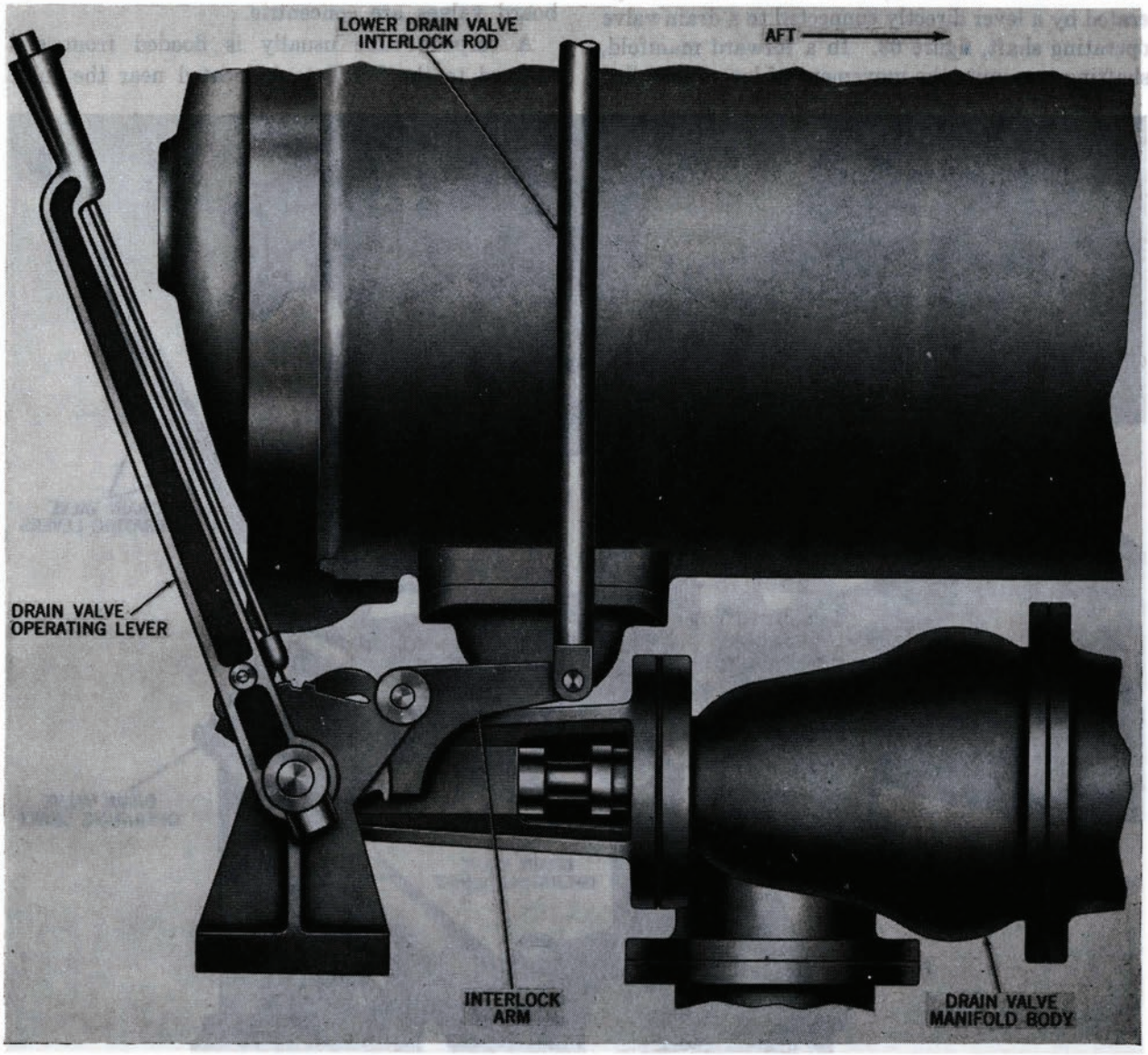


Figure 64—*Lower Part of Drain Valve and Muzzle Door Interlocking Mechanism in Portsmouth Type Stern Bank—Partial Section.*

Flooding and Draining

In the firing procedure, a torpedo is loaded into the tube, and the breech door is closed and locked. Air presssure forces water from the WRT tank to flood the tube and equalize pressure on both sides of the muzzle door. As the tube floods, air inside the tube vents out. The muzzle door and shutter then may be opened.

To drain the tube after the torpedo has been launched, the muzzle door and shutter are closed, and air is admitted through the vents forcing water through the forward and after drain lines to the WRT tank.

Interlock Features

An interlocking mechanism of the tube flood and drain system, controlled through a drain valve and muzzle door interlock lever, prevents tube drain valve and the muzzle door from being open at the same time. With the lever in MUZZLE DOOR CLOSED position, a drain valve interlock rod is raised into a slot in the interlock slide preventing movement of the muzzle door operating shaft.

On all Electric Boat Co. type tubes and on lower stern tubes of the Portsmouth Naval Shipyard type, with the lever in DRAIN VALVE LOCKED position, a drain valve interlock bolt blocks the rotation of a collar on the drain valve shaft preventing the drain valve from being opened.

On all bow tubes and upper stern tubes of the Portsmouth type, the lever in DRAIN VALVE LOCKED position causes a lug on an interlock arm, figure 64, to block rotation of the drain valve operating shaft and prevent opening of the drain valve.

Shafts, linkages, and interlock rods of different lengths connect the interlock levers with corresponding operating shafts to operate the interlocking mechanisms, figures 65 and 66.

Pressure Equalizing System

Normal operating procedure for flooding a tube is from the WRT tank, using the blow and vent manifold. Pressure inside the tube is equalized with sea pressure through the manifold before the muzzle door is opened. Should the muzzle door not be opened immediately, however, and the submarine change depth, pressure again must be equalized. To remove the need for using the blow and vent manifold to do this, a few submarines have had a pressure equalizing system added (SHIPALT SS332).

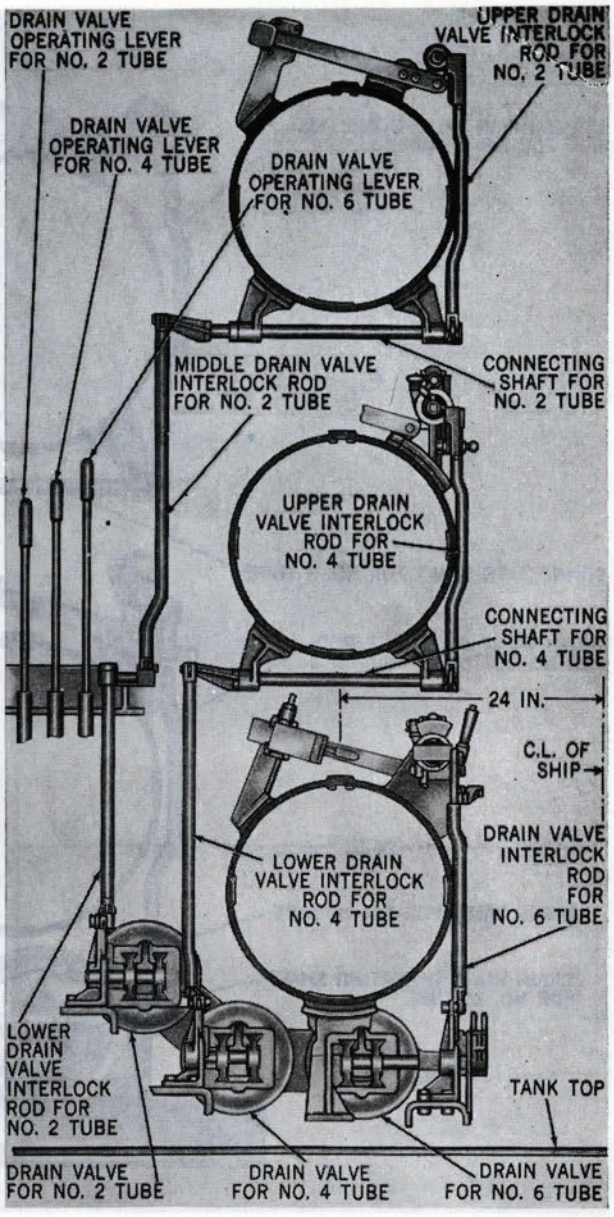


Figure 65—*Drain Valve and Muzzle Door Interlocking Mechanisms—Electric Boat Co. Type Bow Bank —Sectional View.*

Arrangement. For each tube bank, a 2- or 3-valve manifold is connected by piping to the sea pressure gage connection for the torpedo room. From the other side of each valve in the manifold, a pipe connection is made to one of the torpedo tube rollers. By opening the proper valve, any tube of a bank can be connected to sea through the compartment sea pressure gage connection. Thus, pres-

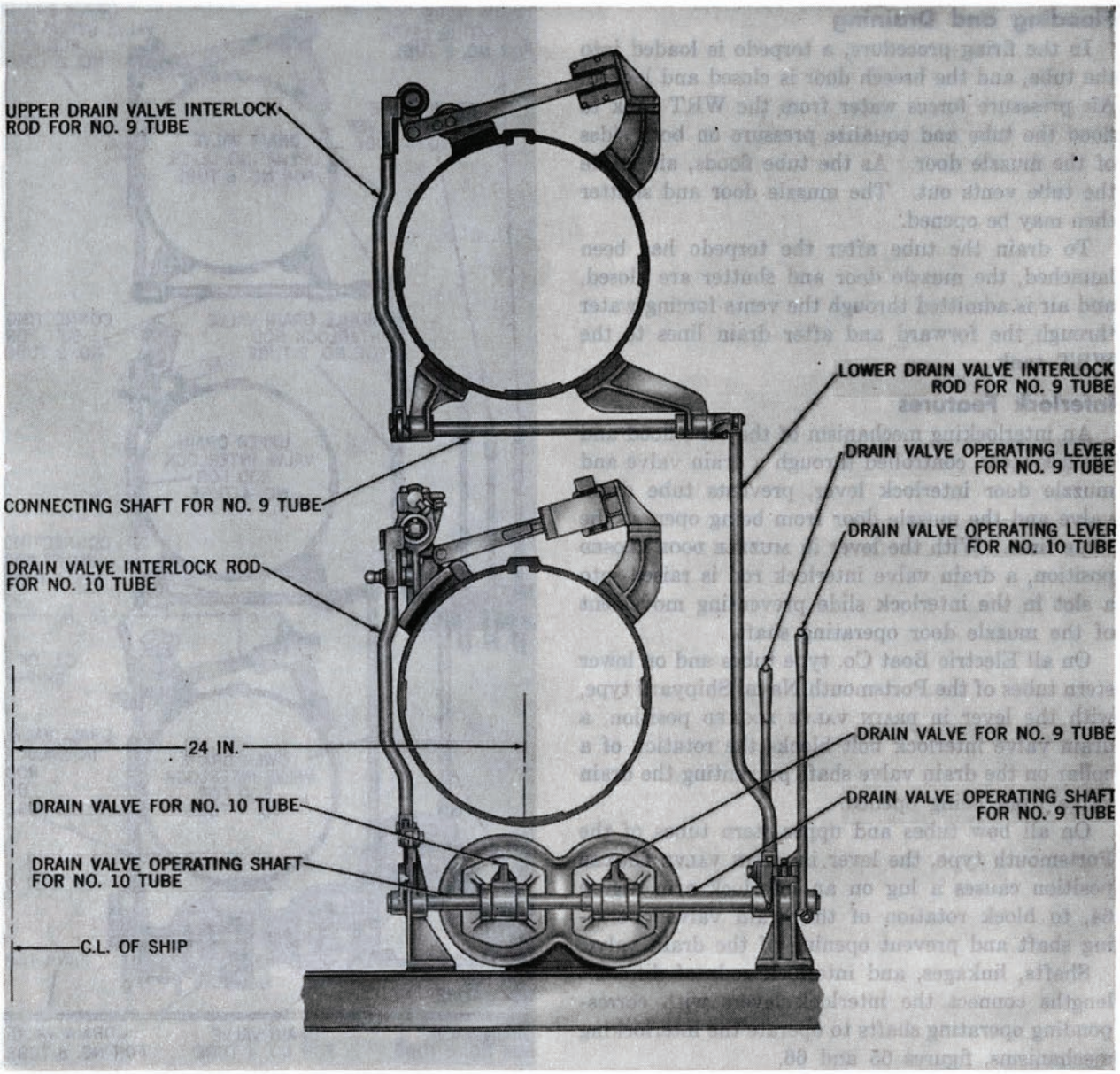


Figure 66—Drain Valve and Muzzle Door Interlocking Mechanisms—Portsmouth Type Stern Bank—Sectional View.

sure inside and outside the tube can be equalized without use of the blow and vent manifold.

Pressure Equalizing Manifold. The pressure equalizing manifold is located at the breech end of the tube bank. In three-tube banks, the manifold is between the two upper tubes. In two-tube banks, it is in a similar position between the tubes. Each valve in the manifold is a horizontal plunger that is spring-loaded to keep the valve closed. A vertical hand lever with a spring-loaded detent is used to move the valve to OPEN to connect the inside of the tube to sea pressure. Positive in action, the valve will remain at OPEN only as long as it is manually held there. When the hand lever is released, the valve returns automatically to CLOSED.

Chapter 7

TORPEDO STOP MECHANISM

The torpedo stop mechanism positions the torpedo when it is loaded into the tube. With the torpedo guide stud hard against the stop bolt, the torpedo sockets of mechanically set torpedoes are in correct position to receive the spindles of the depth, speed, and gyro setting mechanisms. Also, the torpedo starting lever is aligned with the tripping latch. When the tube is fired by impulse air, the torpedo stop mechanism automatically retracts the stop bolt to release the torpedo. On tubes equipped for firing electrically set torpedoes, the mechanism also actuates Switch Box Mk 5 in the fire control system.

An electrically set torpedo does not require positioning for spindles or for the tripping latch, but it must be held from moving in the tube. For either type torpedo, the torpedo guide stud slides in a slot in the top land of the barrel to keep the torpedo from turning in the tube. Movement of the torpedo as it is loaded into the tube is stopped by the stop bolt when the guide stud comes up against it. When the breech door is closed, a 21-inch torpedo is held in position by the adjustable tail stop and the stop bolt so that it cannot move fore or aft in the tube. The tail stop does not extend far enough into the tube to hold a 19-inch torpedo in position. This size torpedo has a slotted guide stud into which the stop bolt fits; thus, the stop bolt alone holds a 19-inch torpedo in position.

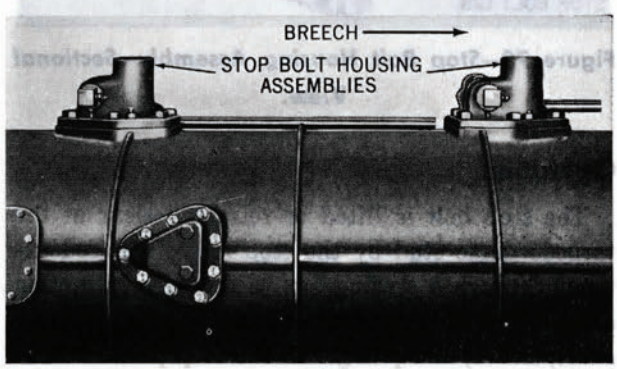


Figure 67—Stop Bolt Housing Assemblies.

Of the two stop bolt housing assemblies installed on top of the torpedo tube middle section, figure 67, the one toward the breech end must be used for Mine Mk 10 Mod 3. In all other cases, the stop bolt housing assembly toward the muzzle is used. Although there are two stop bolt housing assemblies, there is only one stop bolt which can be shifted easily from one assembly to the other. The housing assembly includes the parts shown in figures 72 and 73. Various views of the stop bolt housing assembly are shown in figures 68 through 73.

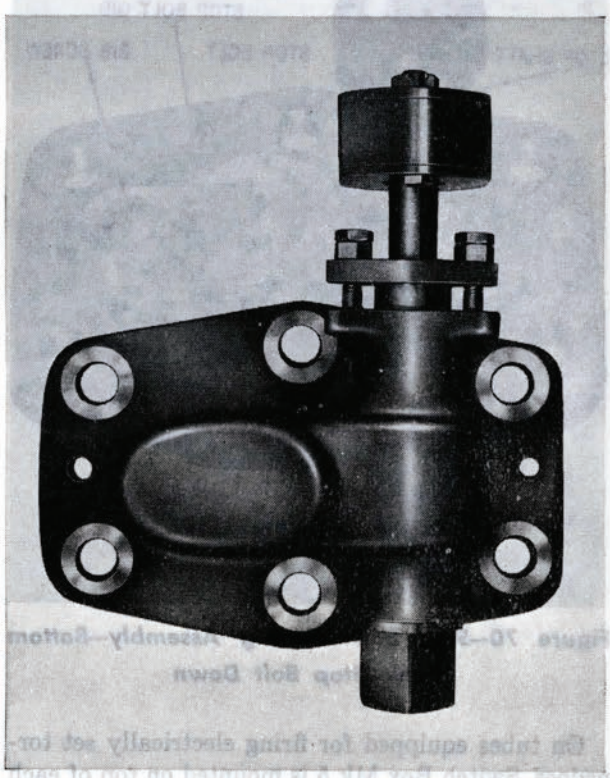


Figure 68—Stop Bolt Housing Assembly—Top View.

A hand retraction mechanism (NAVORD ORD-ALT 3068) allows manual lifting of the stop bolt for silent firing of 19-inch electrically set torpedoes or for loading certain special weapons.

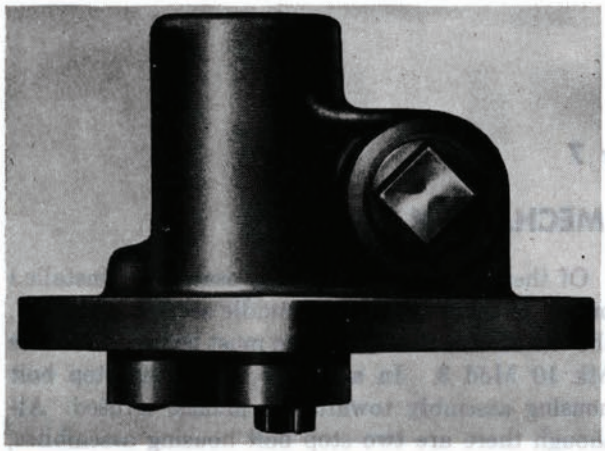


Figure 69—*Stop Bolt Housing Assembly—Side View.*

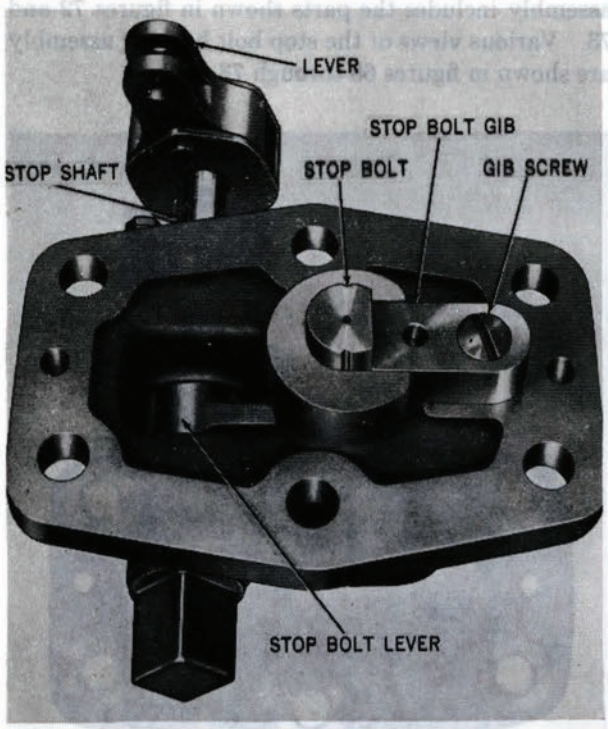


Figure 70—*Stop Bolt Housing Assembly—Bottom View—Stop Bolt Down*

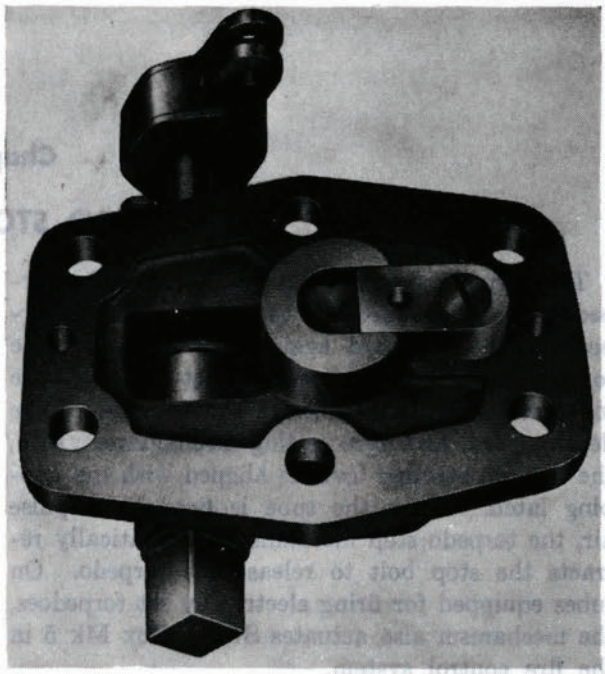


Figure 71—*Stop Bolt Housing Assembly—Bottom View—Stop Bolt Up.*

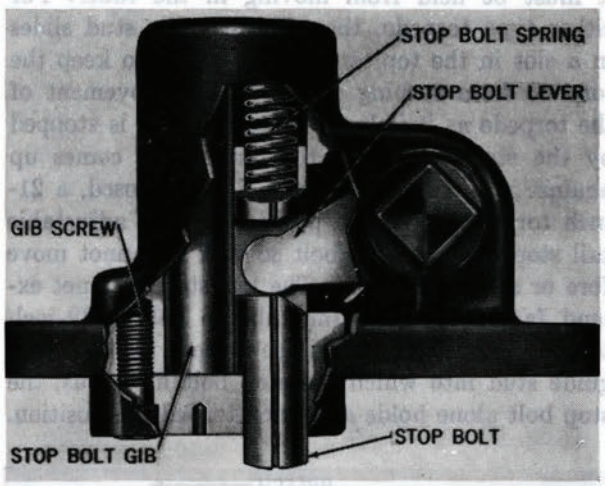


Figure 72—*Stop Bolt Housing Assembly—Sectional View.*

On tubes equipped for firing electrically set torpedoes, Switch Box Mk 5 is mounted on top of each torpedo tube. This switch, part of the fire control system, is operated by a cam attached to the torpedo stop rod. The switch box is actuated to break the torpedo setting circuits and to complete the torpedo starting circuit when the stop rod is moved either automatically or manually.

Operation

The stop bolt is lifted or retracted clear of the torpedo guide stud by the stop rod. This rod extends through a stuffing box to the gyro retraction slide, which is connected through an intermediate shaft, sleeve, and plunger to the stop piston rod of the torpedo stop cylinder, figure 74.

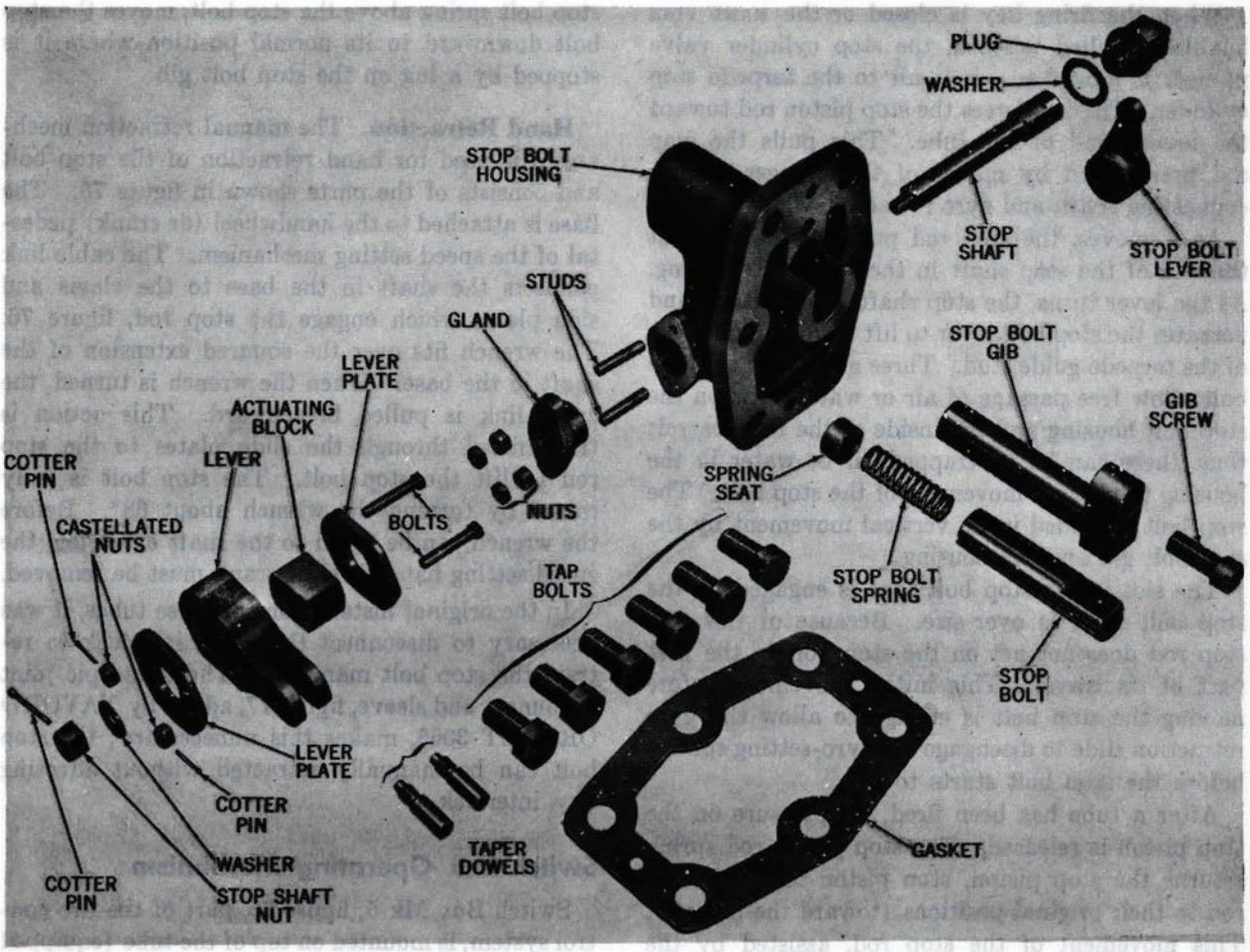


Figure 73—*Stop Bolt Housing and Parts Disassembled.*

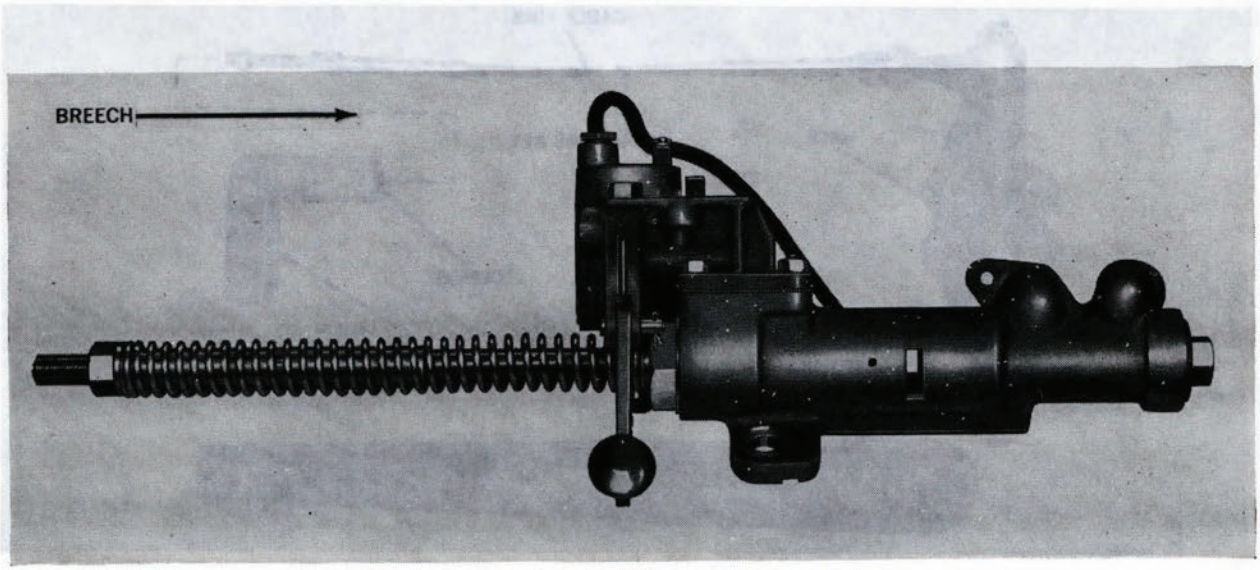


Figure 74—*Torpedo Stop Cylinder.*

When the firing key is closed or the HAND FIRE handle is pulled inboard, the stop cylinder valve plunger is moved to admit air to the torpedo stop cylinder. This air forces the stop piston rod toward the breech end of the tube. This pulls the stop rod breechward by means of the plunger, sleeve, connecting shaft, and gyro retraction slide.

As it moves, the stop rod pulls on the lever at the end of the stop shaft in the stop bolt housing. As the lever turns, the stop shaft turns with it and actuates the stop bolt lever to lift the stop bolt clear of the torpedo guide stud. Three grooves in the stop bolt allow free passage of air or water between the stop bolt housing and the inside of the tube barrel; thus, there can be no trapped air or water in the housing to prevent movement of the stop bolt. The stop bolt is guided in its vertical movement by the stop bolt gib and the housing.

The slot in the stop bolt that is engaged by the stop bolt lever is over-size. Because of this, the stop rod does not act on the stop bolt in the first part of its travel. This initial movement before moving the stop bolt is enough to allow the gyro retraction slide to disengage the gyro-setting spindle before the stop bolt starts to lift.

After a tube has been fired, air pressure on the stop piston is released. The stop piston rod spring returns the stop piston, stop piston rod, and stop rod to their original positions (toward the muzzle). This movement of the stop rod, assisted by the stop bolt spring above the stop bolt, moves the stop bolt downward to its normal position where it is stopped by a lug on the stop bolt gib.

Hand Retraction. The manual retraction mechanism is used for hand retraction of the stop bolt and consists of the parts shown in figure 75. The base is attached to the handwheel (or crank) pedestal of the speed setting mechanism. The cable link connects the shaft in the base to the clevis and side plates which engage the stop rod, figure 76. The wrench fits over the squared extension of the shaft in the base. When the wrench is turned, the cable link is pulled breechward. This action is transmitted through the slide plates to the stop rod to lift the stop bolt. The stop bolt is fully raised by turning the wrench about 68°. Before the wrench can be fitted to the shaft extension, the speed setting handwheel or crank must be removed.

In the original installations of these tubes, it was necessary to disconnect the firing interlock to retract the stop bolt manually. The telescopic joint of plunger and sleeve, figure 77, added by NAVORD ORDALT 3068, makes this unnecessary; the stop bolt can be manually retracted without affecting any interlock.

Switch Box Operating Mechanism

Switch Box Mk 5, figure 76, part of the fire control system, is mounted on top of the tube (equipped

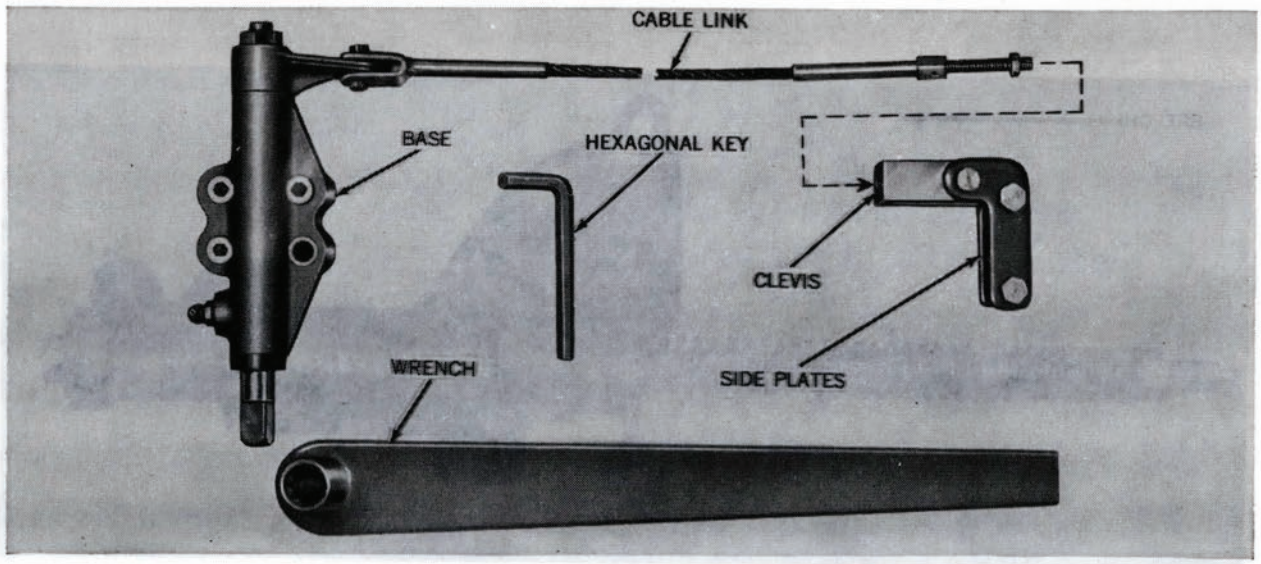


Figure 75—*Stop Bolt Hand Retraction Unit and Wrenches.*

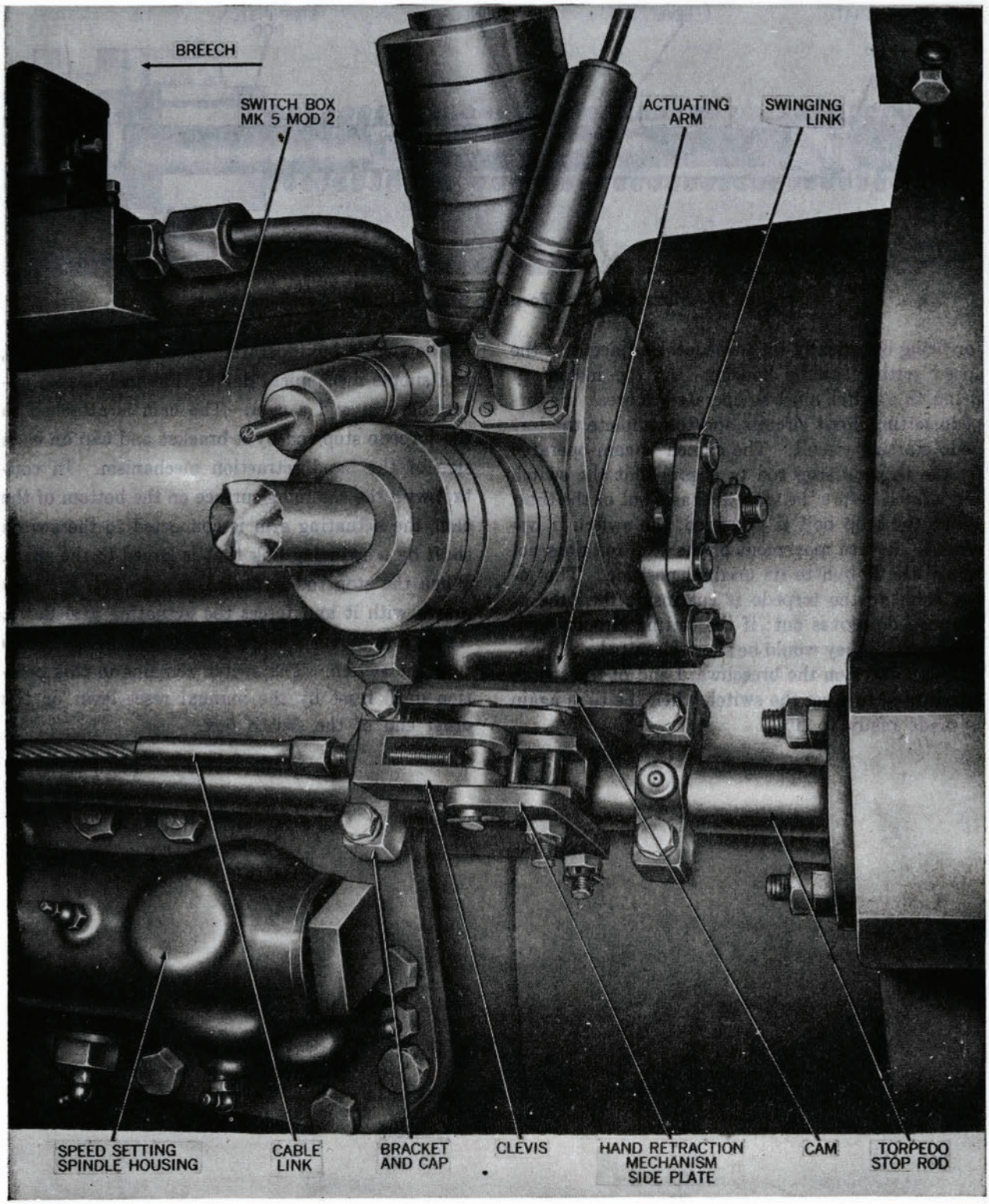


Figure 76—*Mechanisms for Hand Retraction and Switch Box Mark 5.*

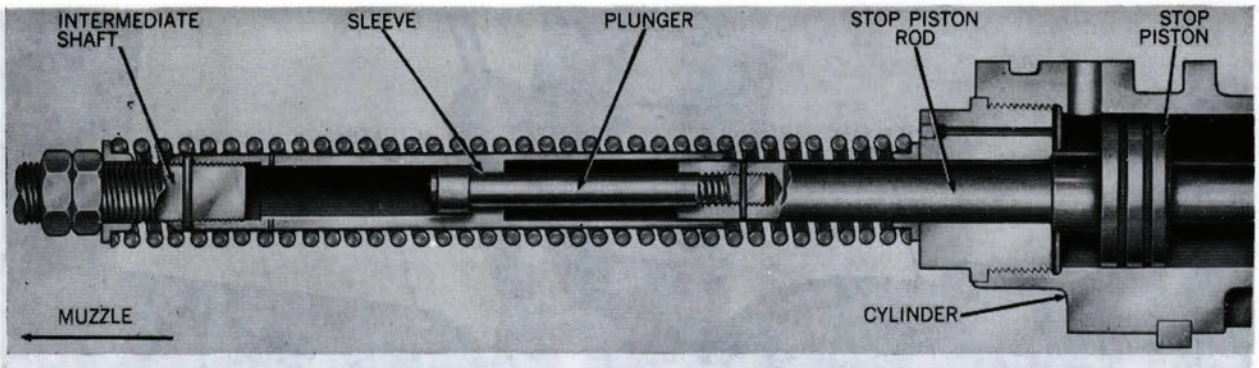


Figure 77—*Muzzle End of Torpedo Stop Cylinder—Sectional View.*

for firing electrically set torpedoes) adjacent to the speed setting spindle housing. At the instant of firing, this switch must be operated to break the torpedo setting input circuits and to complete the torpedo starting circuit. The switch is cam-operated by the torpedo stop rod to ensure that the switch is operated before the torpedo starts out of the tube. When the stop bolt is retracted, the switch is operated. Return movement of the stop rod does not return the switch to its original position. The input cable to the torpedo is cut inside the tube as the torpedo moves out; if the setting circuits were reconnected, they would be short-circuited. A manual reset lever on the breechward end of the switch box is used to reset the switch when the tube again is made ready to fire.

The switch box operating mechanism, figure 76, is a simple mechanical device that includes an actuating arm and a cam. The cam is attached to the torpedo stop rod by a bracket and cap on each side of the hand retraction mechanism. In contact with the camming surface on the bottom of the cam, the actuating arm is connected to the switch shaft by a swinging link that is keyed to the shaft. When the stop rod is pulled breechward, the cam moves with it and forces the actuating arm down. As the arm moves down, it pulls the swinging link to turn the switch. The switch remains in this position until reset by the manual reset lever on the other end of the switch box.

Chapter 8

TRIPPING LATCH MECHANISM

During ejection of a mechanically set torpedo, a tripping latch in the tube trips the torpedo starting lever to start the torpedo engine. This operation occurs when the torpedo has moved muzzleward approximately 1⅛ inches. Hammer-shaped, the tripping latch extends downward into the tube ¾ inch toward the muzzle from the starting lever of the torpedo. It is in this position only when the breech door is closed in normal tube operation.

NAVORD ORDALT 3067 has been or will be performed on torpedo tubes of all submarines numbered 212 through 525. This ordalt modifies the tripping latch mechanism so that, in normal operating position, the tripping latch is actuated by the opening and closing of the breech door. The latch can be manually retracted and locked into position as a "Rig for Depth Charge" operation. When this change is made, the tripping latch will not be actuated by the firing interlock lever, as it is now in some installations.

The mechanism that operates the tripping latch is a shaft and linkage arrangement, figure 78, that extends from the tripping latch housing on the top of the tube to the breech end of the tube. At this end, a tripping latch arm, figure 79, carries a cam roller that rides in a slotted cam on the breech door upper hinge pin. When the cam is turned, its movement is transmitted through the cam roller, shafts, and links to the tripping latch to raise or lower it. The tripping latch mechanism is shown disassembled in figure 80.

After accomplishment of ORDALT 3067, the tripping latch cam can either be turned manually or it can be latched so that it turns as the breech door is opened or closed.

Tripping Latch Cam

With the breech door closed, the tripping latch cam may be latched in either of two positions. These positions are indicated by plates attached to the cam. In NORMAL OPERATING POSITION, figure 81, the spring-loaded knurled handle is latched in its upper position and is parallel to the tube. In RIGGED FOR DEPTH CHARGE position, figure

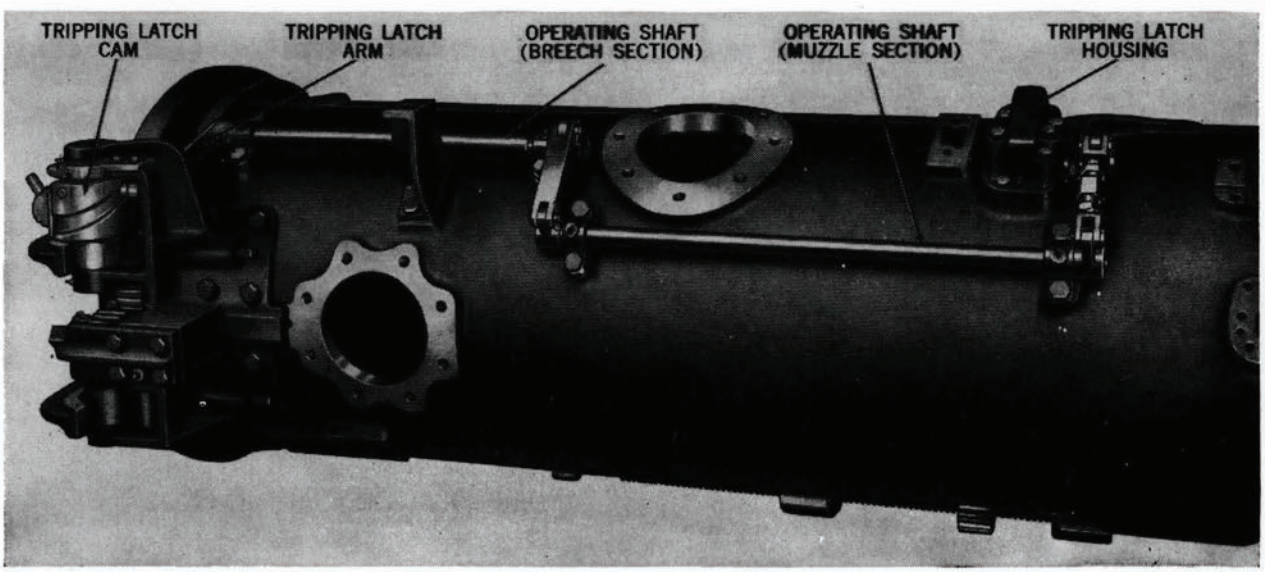


Figure 78—*Linkage From Tripping Latch Cam to Tripping Latch Housing.*

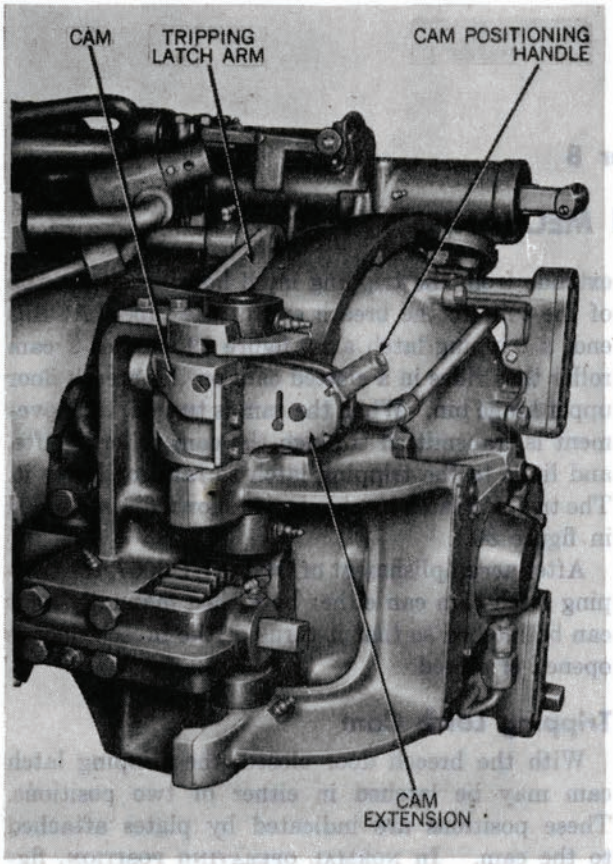


Figure 79—*Tripping Latch Mechanism—Breech End.*

82, NAVORD ORDALT 3067, the handle is latched in its lower position and is at right angles to the tube.

The cam positioning handle is mounted on a pin between two semicircular extensions of the cam. The inner end of the handle is pinned to a rectangular key, figure 81. As the handle is raised, it lowers the key; as the handle is lowered, it raises the key. To change the position of the cam, the handle is pulled outward to clear the detent lugs on either side of the handle from the recesses in the cam extensions. The handle is then moved up or down to its mid-position; the entire cam assembly can then be swung around to the desired position.

When the handle is swung to the NORMAL OPERATING POSITION and pushed up, figure 81, it pushes the rectangular key down into a recess on the breech door upper hinge arm. This locks the cam to the hinge arm so that the cam turns as the door is moved. When the door is opened, the cam forces the cam roller from its upper position, figure 82, downward. This moves the tripping latch arm and the shafts and links to raise the tripping latch clear of the tube. Closing the door cams the roller upward to lower the latch into the tube in the way of the torpedo starting lever.

When the cam is turned by the positioning handle

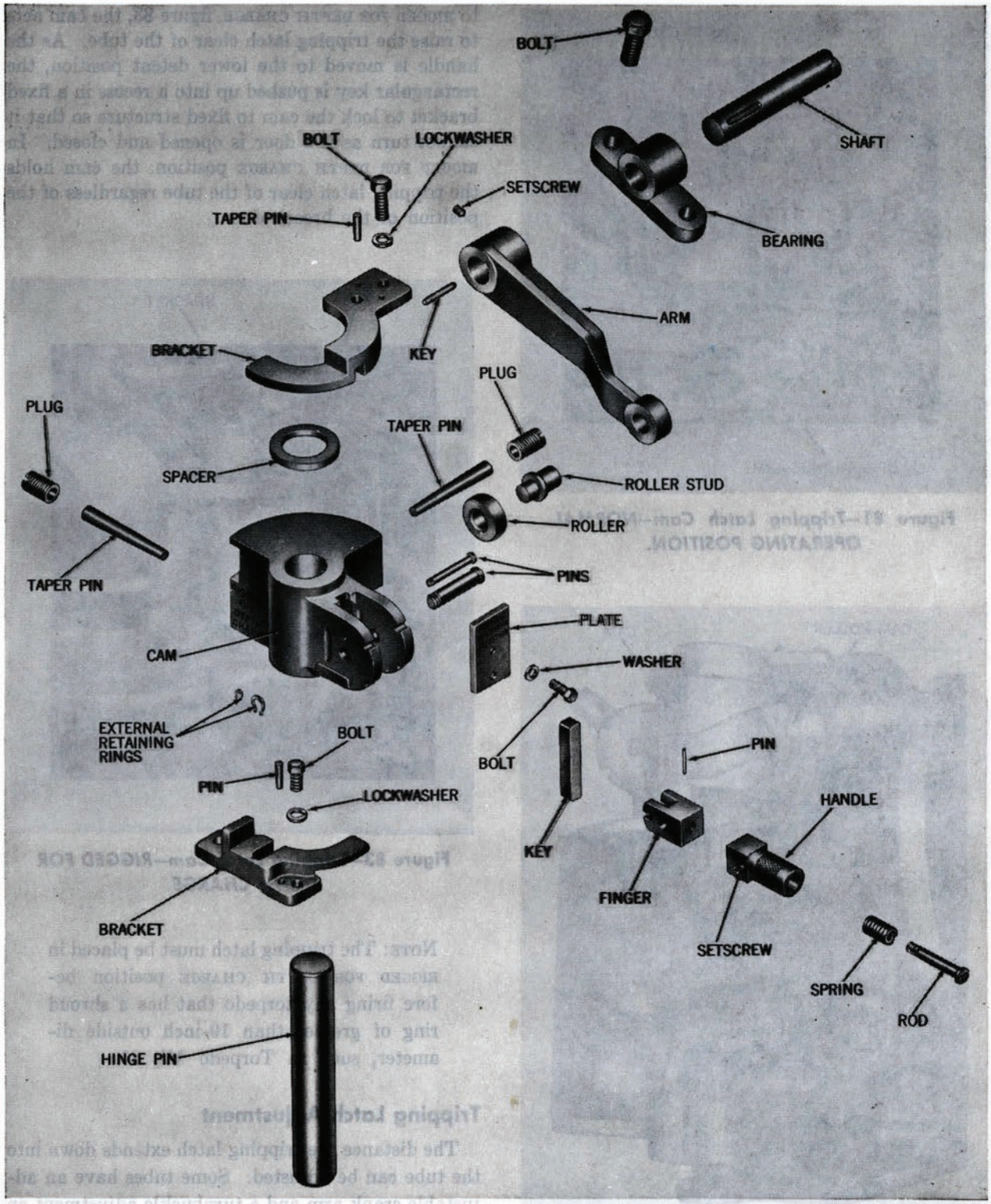


Figure 80—*Tripping Latch Mechanism Disassembled.*

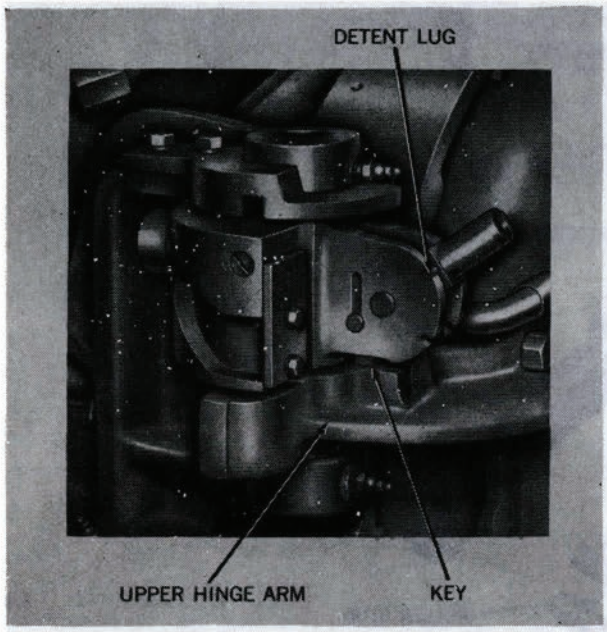


Figure 81—*Tripping Latch Cam—NORMAL OPERATING POSITION.*

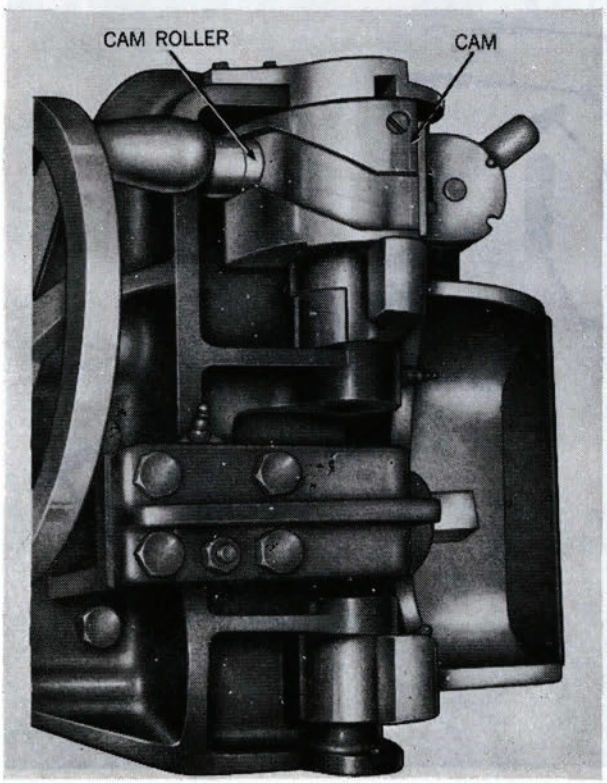


Figure 82—*Tripping Latch Cam and Roller—View From Outboard.*

to RIGGED FOR DEPTH CHARGE, figure 83, the cam acts to raise the tripping latch clear of the tube. As the handle is moved to the lower detent position, the rectangular key is pushed up into a recess in a fixed bracket to lock the cam to fixed structure so that it cannot turn as the door is opened and closed. In RIGGED FOR DEPTH CHARGE position, the cam holds the tripping latch clear of the tube regardless of the position of the breech door.

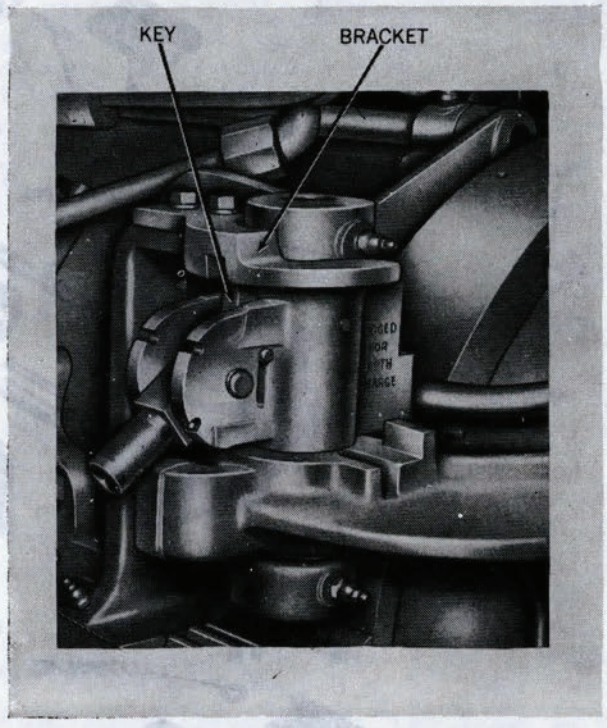


Figure 83—*Tripping Latch Cam—RIGGED FOR DEPTH CHARGE.*

NOTE: The tripping latch must be placed in RIGGED FOR DEPTH CHARGE position before firing any torpedo that has a shroud ring of greater than 19-inch outside diameter, such as Torpedo Mk 35.

Tripping Latch Adjustment

The distance the tripping latch extends down into the tube can be adjusted. Some tubes have an adjustable crank arm and a turnbuckle adjustment on a link that connects two sections of the operating shaft. Other tubes have an adjustable link that

connects the crank arm at the end of the operating shaft with the tripping latch itself, figure 84.

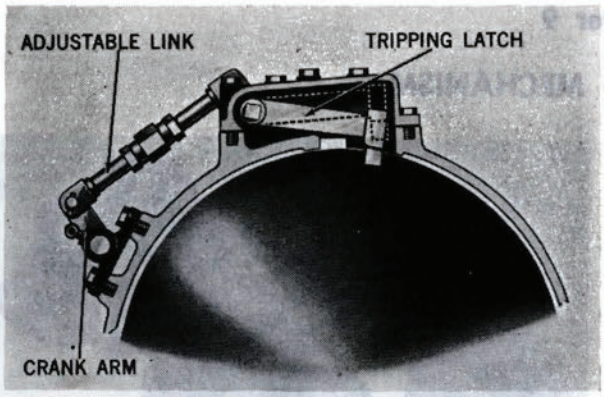


Figure 84—*Tripping Latch Housing—Sectional View.*

Reliable starting of torpedoes is dependent upon accurate positioning of the tripping latch. The latch should be carefully adjusted, using the Barrel Center Line Gage. The adjustment should be checked at frequent intervals.

To prevent accidental tripping of the starting lever while the torpedo is being handled prior to loading, a safety guard is inserted into the starting lever opening. This safety guard is removed, figure 85, when the torpedo is loaded into the tube.

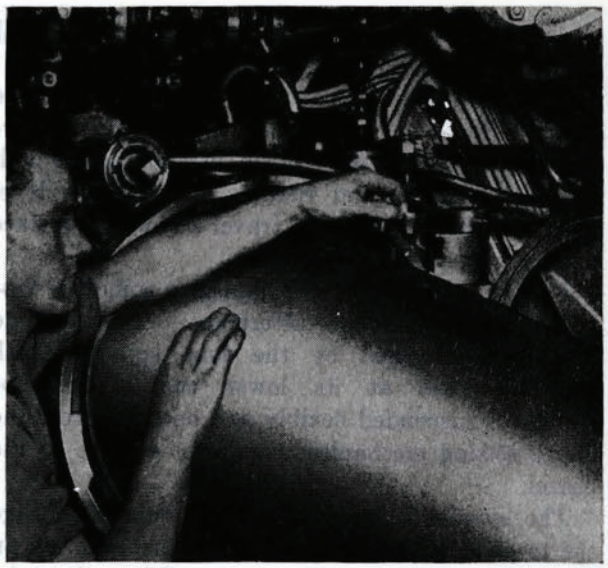


Figure 85—*Removing the Safety Guard.*

Chapter 9

DEPTH SETTING MECHANISM

The depth setting mechanism on the torpedo tube sets the depth mechanism in mechanically set torpedoes. The depth mechanism, in combination with the depth engine and rudders, controls the level at which the torpedo will travel below the surface of the water.

For setting the depth mechanism, a spindle is provided in the torpedo afterbody. This torpedo spindle is engaged by the tube spindle which has a socket at its lower end. The tube spindle is suspended flexibly and operates from the depth setting mechanism on the outer side of the barrel.

The spindle is lowered into the tube to engage the torpedo spindle, and raised to disengage, by an engaging and disengaging lever. When the tube spindle is engaged, the depth mechanism is set by means of a depth setting hand crank which can be turned only when the tube spindle socket is engaged with the torpedo spindle. One revolution of the crank is required for each two feet of depth setting.

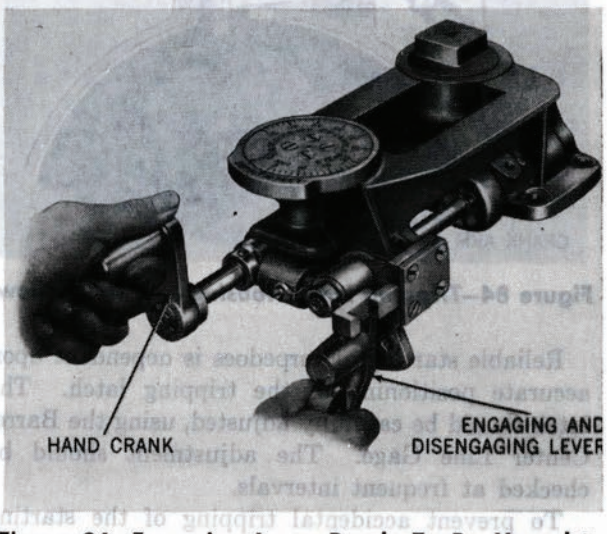


Figure 86—*Engaging Lever Ready To Be Moved to Spindle IN.*

Operation

Spindle Engagement and Retraction. The depth setting mechanism interlock bolt prevents the tube from being fired while the depth setting spindle is engaged, and keeps the spindle from being engaged when the tube is ready to fire. The depth setting interlock bolt has an outer slot on one side and an inner slot on the other. A lug on the collar of the interlock sleeve is always engaged in the outer slot; therefore, rotation of the interlock sleeve forces the interlock bolt in and out of its housing. As the engaging and disengaging lever is moved, a lug on the side of the lever engages or disengages the inner slot.

Figures 86 through 91 illustrate the interlock bolt action. In these figures, the right hand mechanisms are shown installed on the tubes; the left hand mechanisms are shown removed from the tubes.

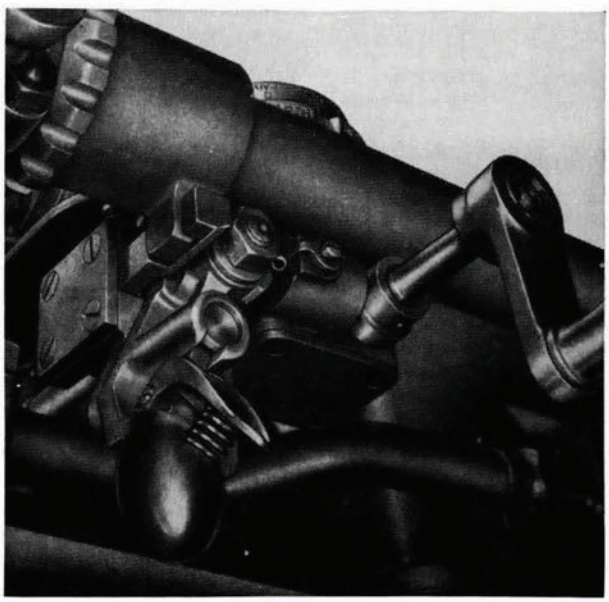


Figure 87—*Depth Setting Mechanism Installed—Right-Hand Tube. Spindle IN.*

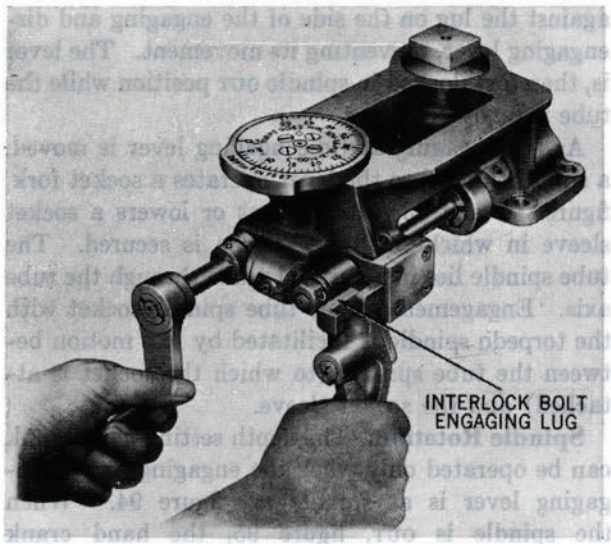


Figure 88—*Depth Setting Mechanism—Left-hand Tube—Spindle IN.*

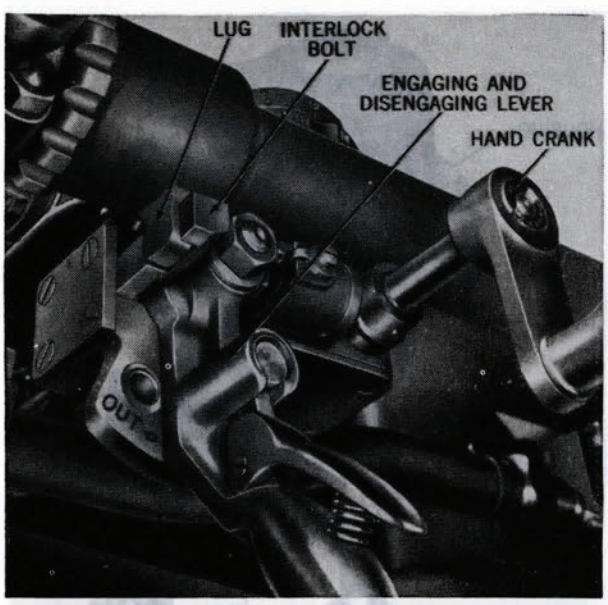


Figure 89—*Depth Setting Mechanism Installed—Right-Hand Tube—Spindle OUT.*

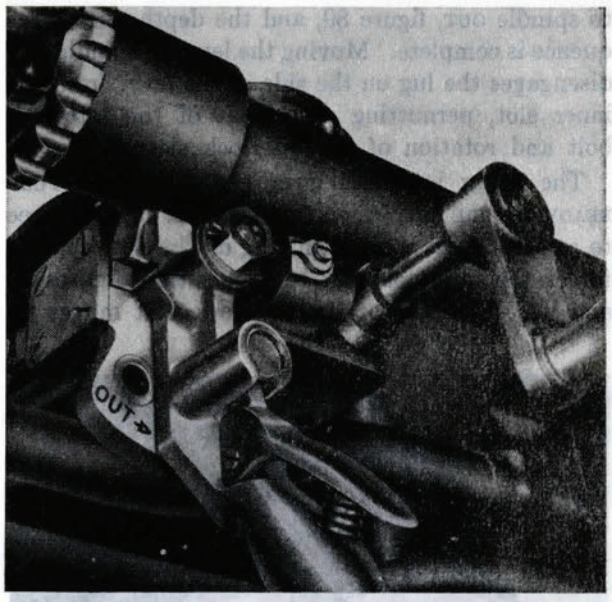


Figure 90—*Depth Setting Mechanism Installed—Right-Hand Tube—Spindle Locked OUT.*

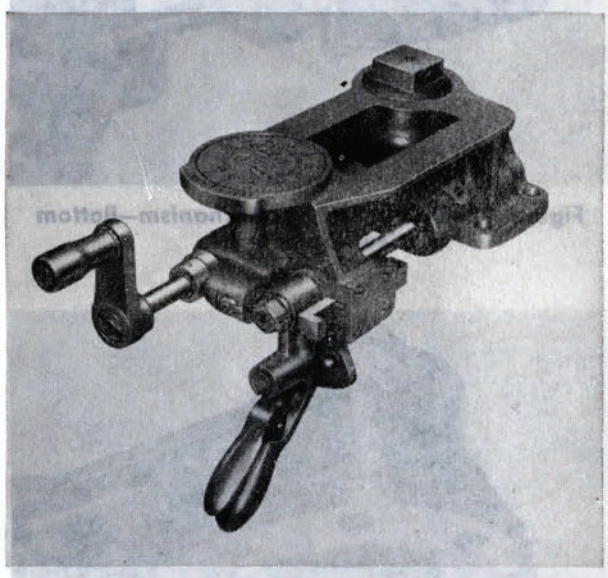


Figure 91—*Depth Setting Mechanism—Left-Hand Tube—Spindle Locked OUT.*

Movement of the firing interlock lever causes the interlock sleeve to rotate. When the engaging and disengaging lever is ready to be moved to spindle IN position, figure 86, the firing interlock lever is at MUZZLE DOOR UNLOCKED, and the depth setting interlock bolt is at OUT. The inner slot is aligned with the lug on the side of the engaging and disengaging lever, permitting the lever to be moved to spindle IN, figures 87 and 88; the lug on the side of the lever then engages the inner slot, locking the interlock bolt in OUT position, and preventing rotation of the interlock sleeve.

Depth setting is accomplished while the engaging and disengaging lever is at spindle IN, after which the engaging and disengaging lever is moved back

to spindle OUT, figure 89, and the depth setting sequence is complete. Moving the lever to spindle OUT disengages the lug on the side of the lever from the inner slot, permitting movement of the interlock bolt and rotation of the interlock sleeve.

The firing interlock lever can be set at TUBE READY TO FIRE only when the interlock sleeve is free to rotate. As it rotates, the lug on the sleeve collar forces the interlock bolt to IN position, figures 90 and 91. The side of the interlock bolt moves up against the lug on the side of the engaging and disengaging lever, preventing its movement. The lever is, therefore, locked in spindle OUT position while the tube is ready for firing.

As the engaging and disengaging lever is moved, a shaft attached to the lever operates a socket fork, figures 92 and 93, which raises or lowers a socket sleeve in which the tube spindle is secured. The tube spindle lies in a vertical plane through the tube axis. Engagement of the tube spindle socket with the torpedo spindle is facilitated by lost motion between the tube spindle (to which the socket is attached) and the socket sleeve.

Spindle Rotation. The depth setting hand crank can be operated only when the engaging and disengaging lever is at spindle IN, figure 94. When the spindle is OUT, figure 95, the hand crank is locked by a detent plunger, one end of which is engaged by another lug on the engaging and dis-

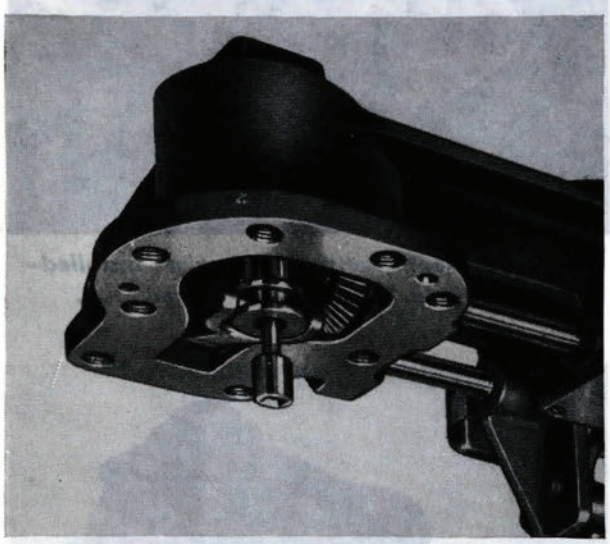


Figure 92—*Depth Setting Mechanism—Bottom View—Spindle IN.*

Figure 93—*Depth Setting Mechanism—Bottom View—Spindle OUT.*

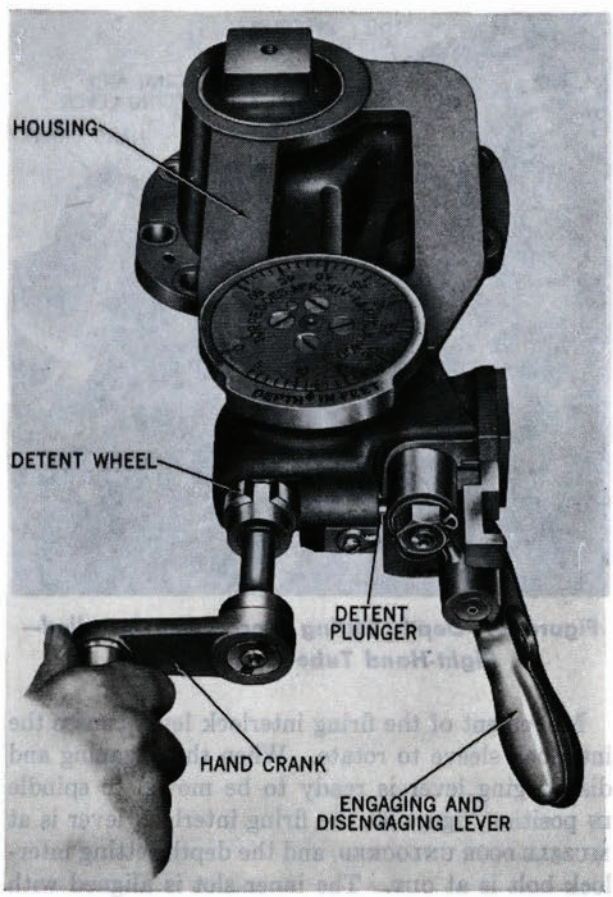


Figure 94—*Depth Setting Mechanism—Left-Hand Tube—Making Depth Setting.*

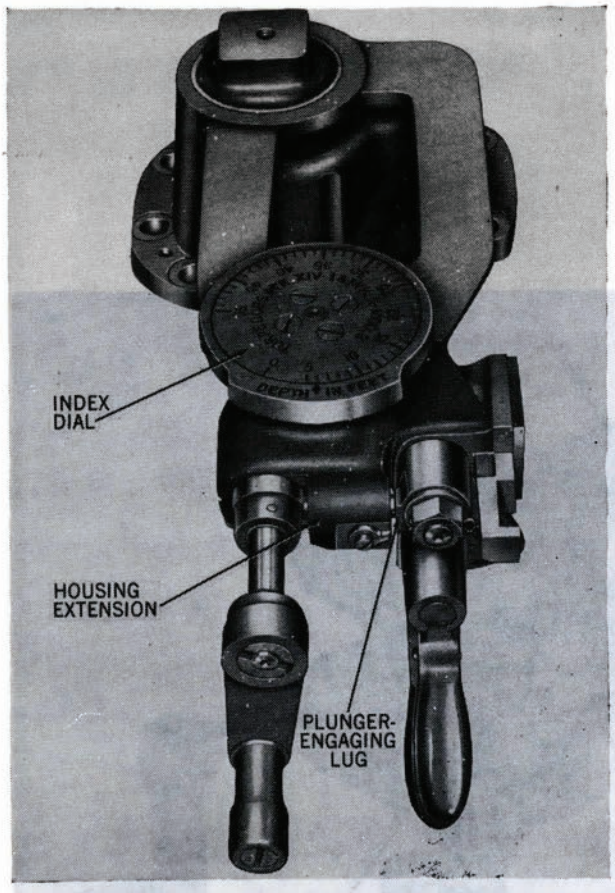


Figure 95—*Depth Setting Mechanism—Left-Hand Tube—Spindle OUT—Detent Plunger Engaged.*

engaging lever. The plunger passes through an extension of the housing, between the lever and the hand crank. The other end of the plunger engages a slot in a detent wheel, fixed on a depth setting operating shaft connected to the hand crank. In this position, the detent plunger prevents rotation of the detent wheel and hand crank. When the engaging and disengaging lever is moved to spindle IN, the lug is disengaged from the detent plunger, which is free to move out of the slot in the detent wheel, permitting rotation of the hand crank.

A bevel pinion gear at the end of the depth setting operating shaft, figure 96, meshes with a bevel gear keyed to the socket sleeve, in which the tube spindle is secured. Hand crank rotation is transmitted to the tube socket which engages the torpedo spindle and sets the torpedo depth mechanism.

An index dial, graduated from 0 to 50 feet, is driven from the depth setting operating shaft. Two types of index are in use. The dial shown in figure 94, used for middle and lower bow tubes and for lower stern tubes, has its graduations on the flat top surface to permit reading from above. The dial used for upper tubes has its graduations on the outer circumference to permit reading from the side.

Two slots in the detent wheel permit depth settings to the nearest foot. One revolution of the hand crank moves the index dial two graduations, the equivalent of 2 feet in depth. Slots in the detent wheel are wide enough to allow slight movement to either side of a graduation to help engage the tube socket with the torpedo spindle. If the index dial is not on a foot mark the slot will not line up with the detent plunger, and the engaging and disengaging lever cannot be moved to spindle OUT position.

Before loading a torpedo into the tube, the depth index dial on the tube depth setting mechanism must be set at ten feet. The depth setting spindle in the torpedo must be set as nearly as possible at ten feet, with two sides of the square parallel to the centerline of the torpedo.

Figures 97 and 98 show the depth setting mechanism disassembled.

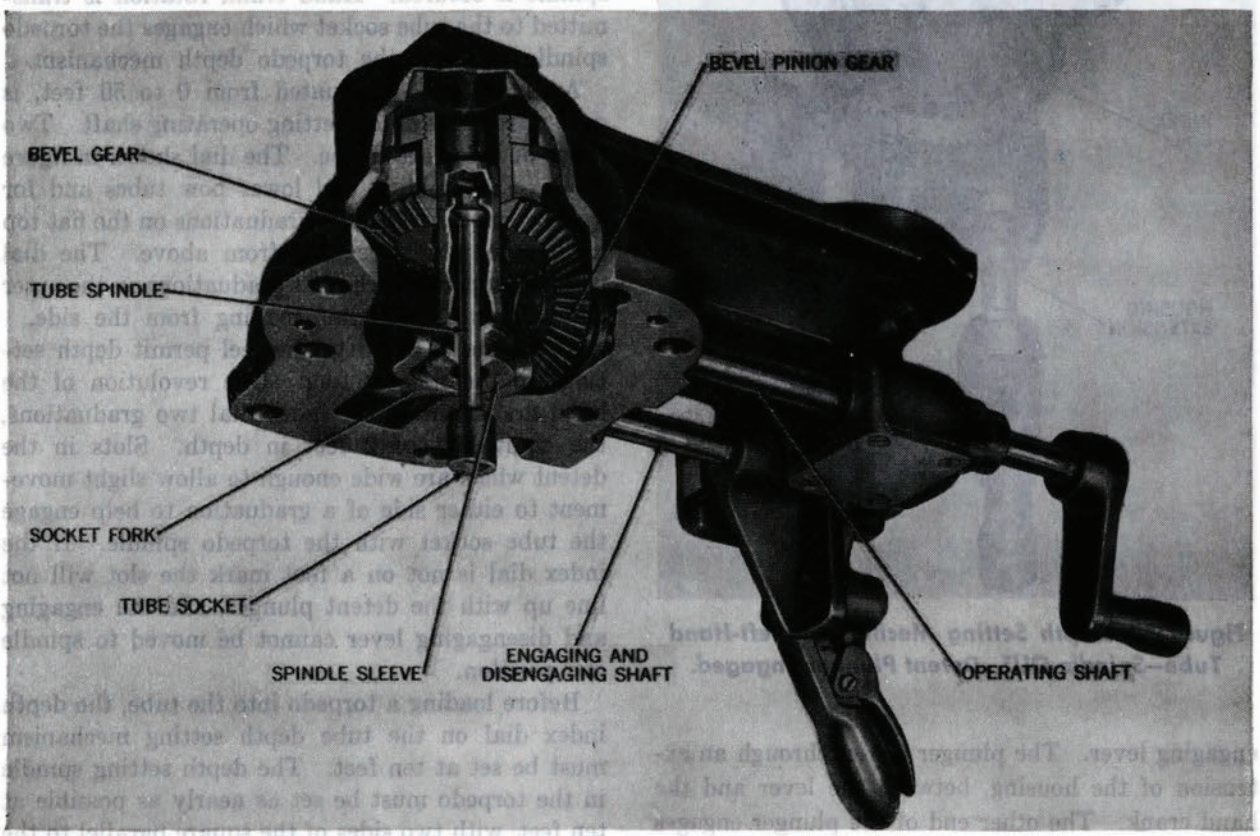


Figure 96—*Depth Setting Mechanism—Spindle IN—Sectional View.*

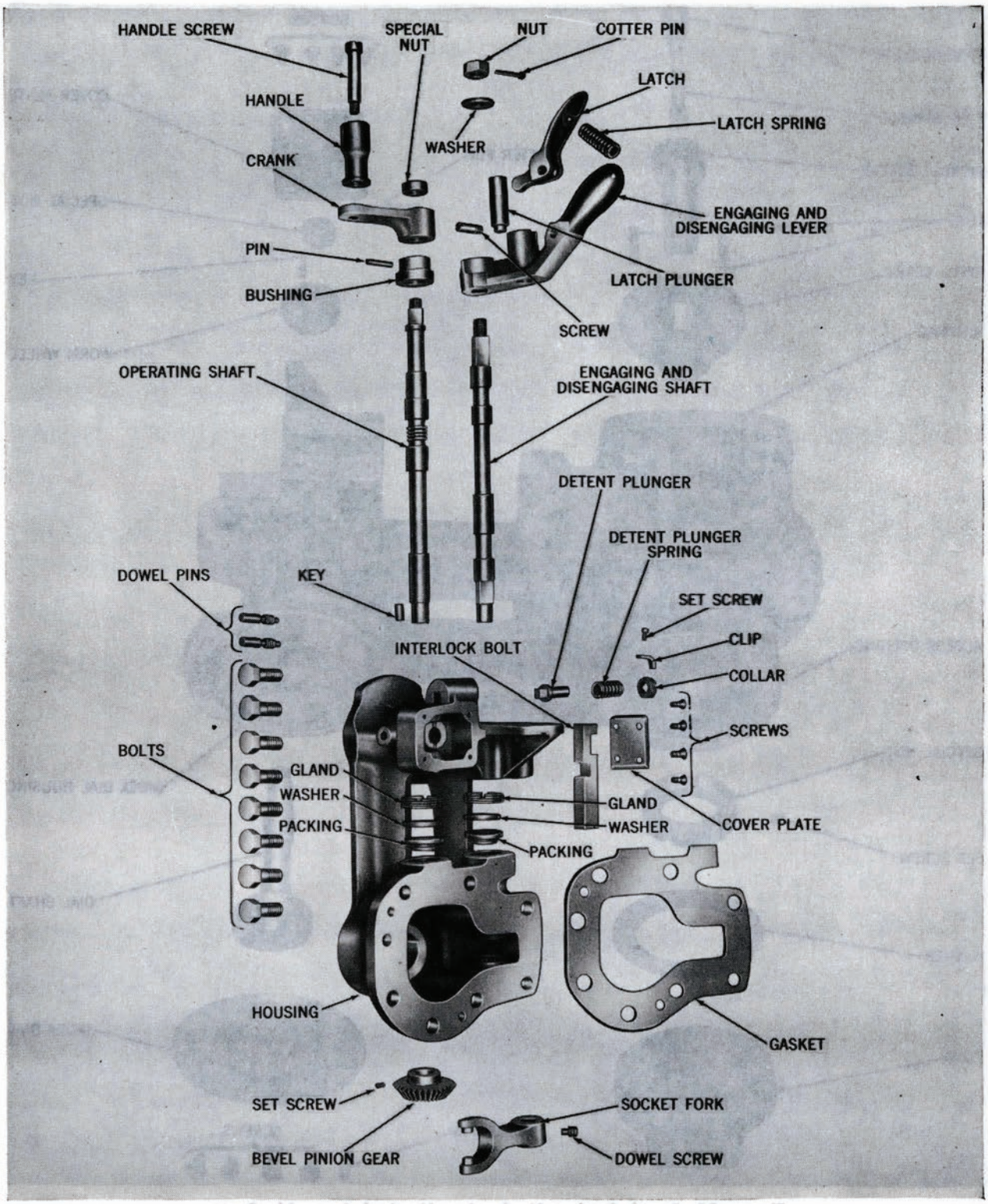


Figure 97—*Depth Setting Mechanism Horizontal Assembly Parts.*

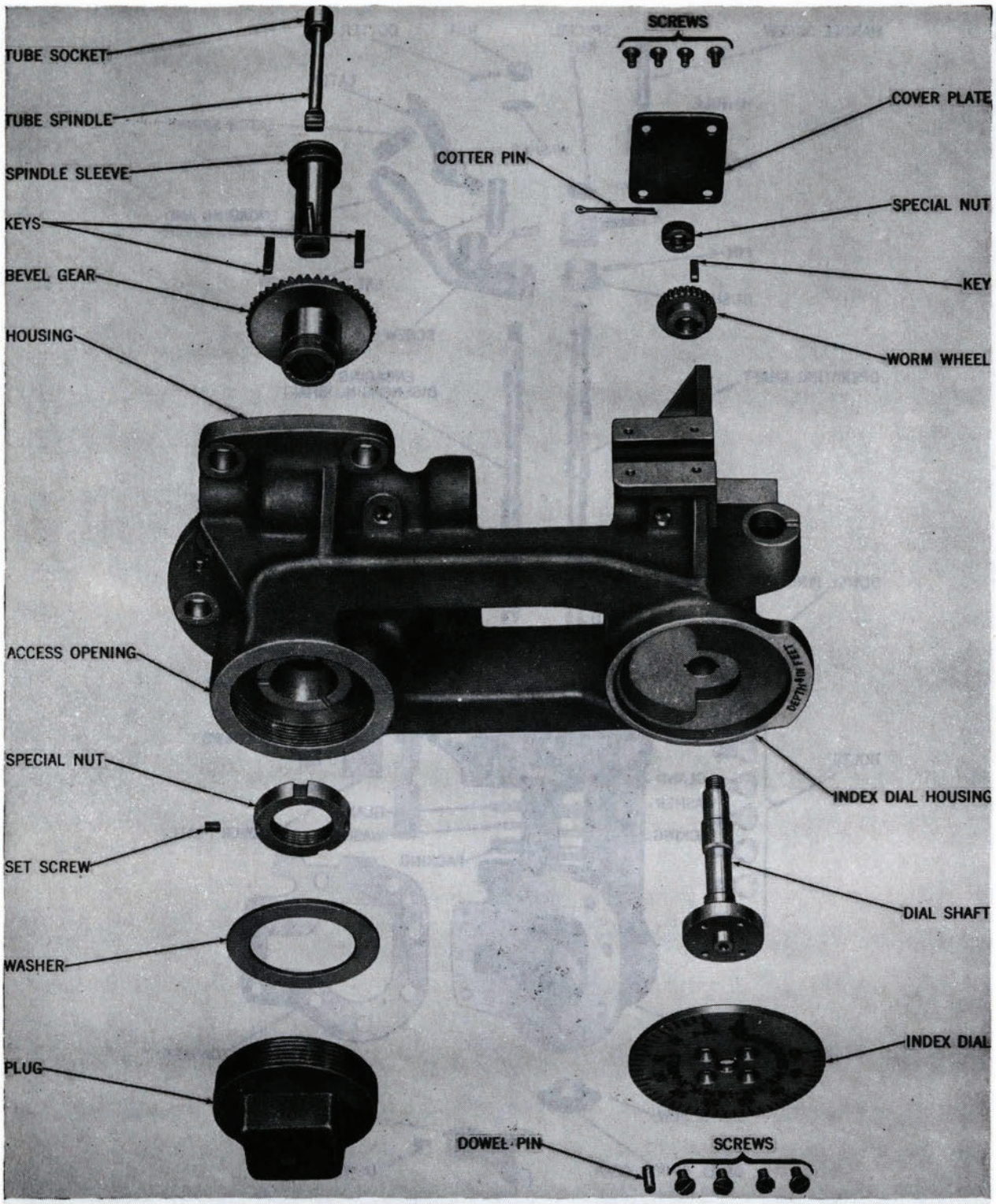


Figure 98—*Depth Setting Mechanism Vertical Assembly Parts.*

The following paragraphs pertain to the operation of the circle and depth setting mechanism installed on those tubes on which ORDALT 3557 has been performed

Operation

Spindle Engagement and Retraction. The operation for spindle engagement and retraction is identical to that described above for the depth setting mechanism. Figures 98A, 87, 98B, 89, 90, and 98C illustrate the interlock bolt action. In these figures, the right-hand mechanisms are shown installed on the tubes; the left-hand mechanisms are shown removed from the tubes.

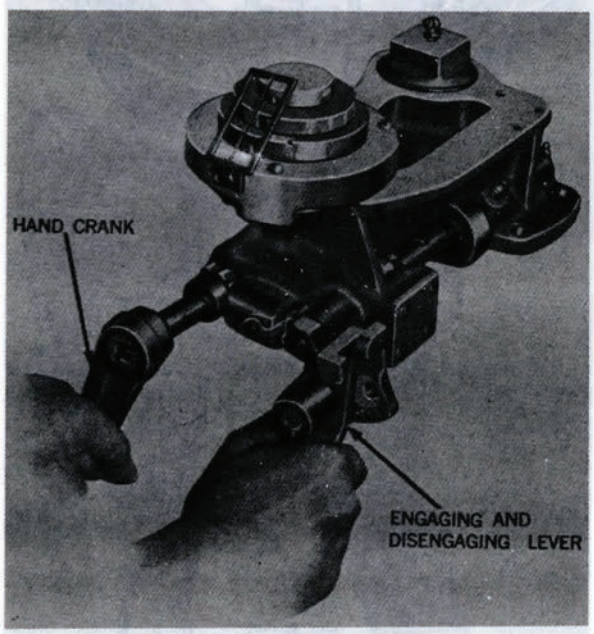


Figure 98a—*Circle and Depth Setting Mechanism, Middle and Upper Left-Hand Tubes, Engaging Lever Ready To Be Moved to Spindle IN.*

Spindle Rotation. The depth setting hand crank can be operated only when the engaging and disengaging lever is at spindle IN, figure 98D. When the spindle is OUT, figure 98E, the hand crank is locked by a detent plunger, one end of which is engaged by another lug on the engaging and disengaging lever. The plunger passes through an extension of the housing, between the lever and the hand crank. The other end of the plunger engages a slot in a detent wheel, fixed on a depth setting operating shaft connected to the hand crank. In this position, the detent plunger prevents rotation of the detent wheel and hand crank. When the engaging and disengaging lever is moved

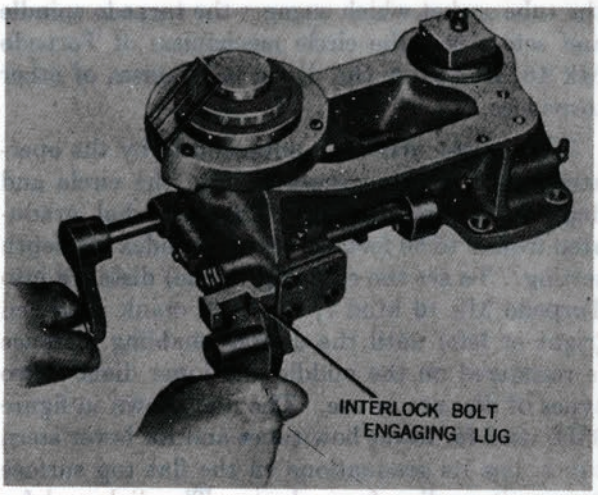


Figure 98b—*Circle and Depth Setting Mechanism, Middle and Upper Left-Hand Tubes, Spindle IN.*

to spindle IN, the lug is disengaged from the detent plunger, which is free to move out of the slot in the detent wheel, permitting rotation of the hand crank.

A bevel pinion gear at the end of the operating shaft, figure 98F, meshes with a bevel gear keyed to the socket sleeve, in which the tube spindle is secured. Hand crank rotation is transmitted to

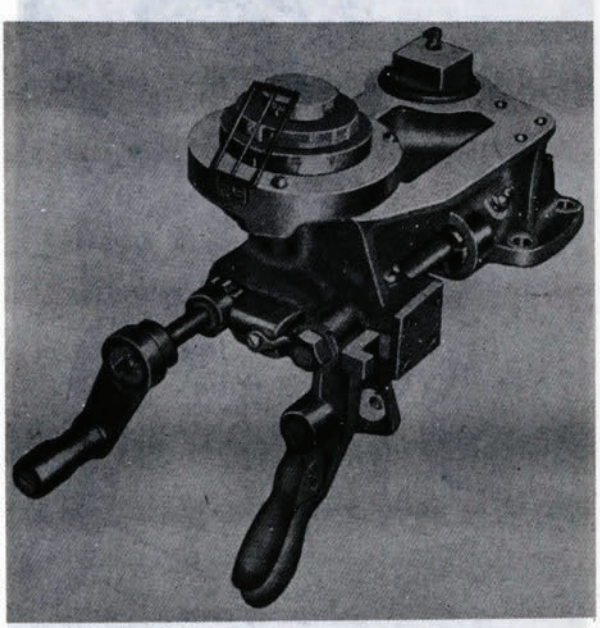


Figure 98c—*Circle and Depth Setting Mechanism, Middle and Upper Left-Hand Tubes, Spindle Locked OUT.*

the tube socket which engages the torpedo spindle and sets either the circle mechanism of Torpedo Mk 16 Mod 7, or the depth mechanism of other torpedoes.

Three dials, driven simultaneously by the operating shaft, are incorporated into the circle and depth setting mechanism. The outer dial, graduated from 0 to 50 feet, serves as an index for depth setting. To set the enabling (circle) distance into Torpedo Mk 16 Mod 7, the hand crank is turned (right or left) until the desired enabling distance is registered on the middle and inner dials. Two types of dial are in use. The dial shown in figure 98D, used for lower bow tubes and for lower stern tubes, has its graduations on the flat top surface to permit reading from above. The dial used for middle and upper bow tubes and upper stern tubes has its graduations on the outer circumference to permit reading from the side.

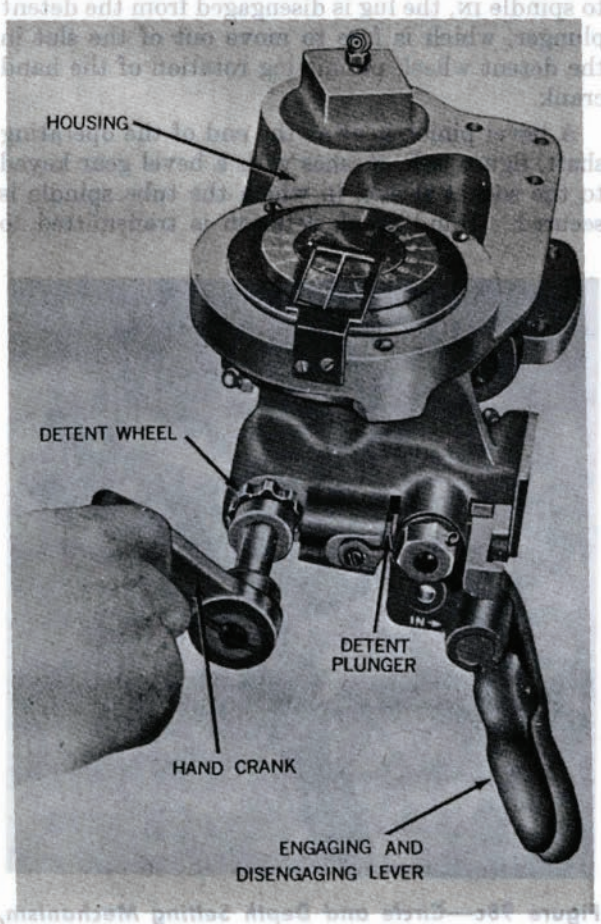


Figure 98d—*Circle and Depth Setting Mechanism, Lower Left-Hand Tubes, Making Setting.*

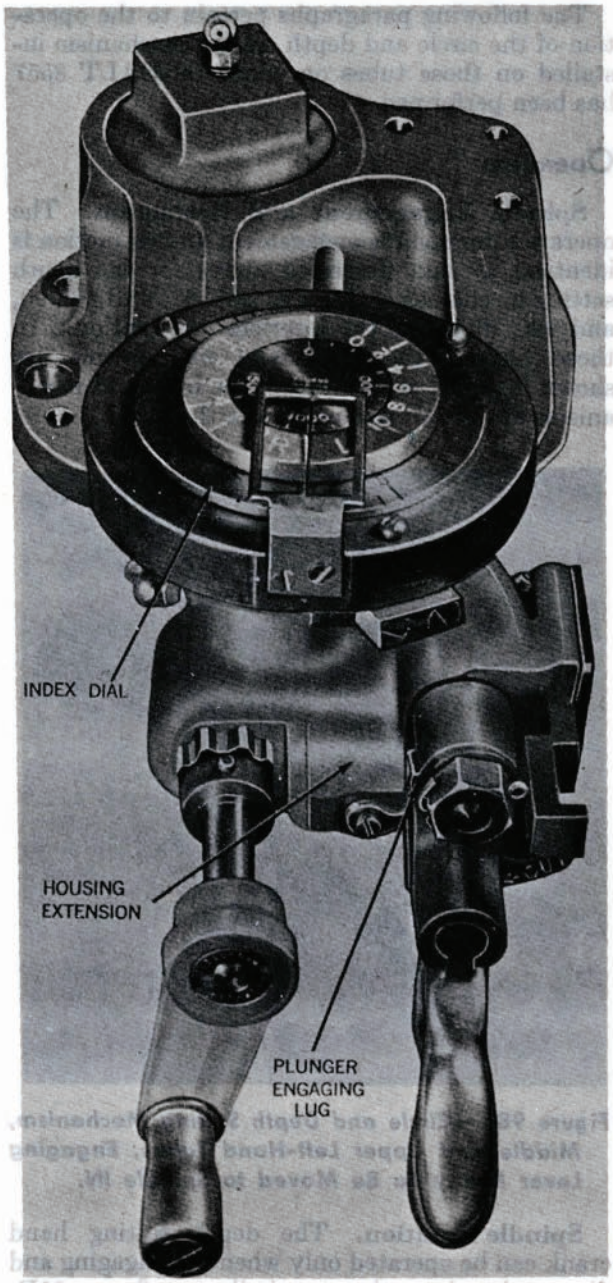


Figure 98e—*Circle and Depth Setting Mechanism, Lower Left-Hand Tubes, Spindle OUT, Detent Plunger Engaged.*

Before loading a torpedo into the tube, the depth index dial on the circle and depth setting mechanism must be set at 10 feet. The depth setting spindle in the torpedo must be set as nearly as possible at 10 feet, with two sides of the square parallel to the centerline of the torpedo to assure engagement with the tube socket.

For Torpedo Mk 16 Mod 7, the inner dial of the circle and depth-setting mechanism must be set at 1000 yards and the circle setting spindle in the torpedo must be set as nearly as possible at 1000 yards, with two sides of the square parallel to the centerline of the torpedo. To set a right circle, the operator must rotate the dial to the exact yardage specified. By doing this, the backlash in the gear train is eliminated. If the operator inadvertently rotates the dial beyond the specified setting, the dial must then be turned back at least 500 yards less than the specified setting, before resetting to the required distance. To set a left circle, the operator must rotate the dial to a position 500 yards less than the specified setting and come back to the exact setting required. The back lash in the gear train will then be eliminated.

Figures 98G and 98H show the circle and depth setting mechanism disassembled.

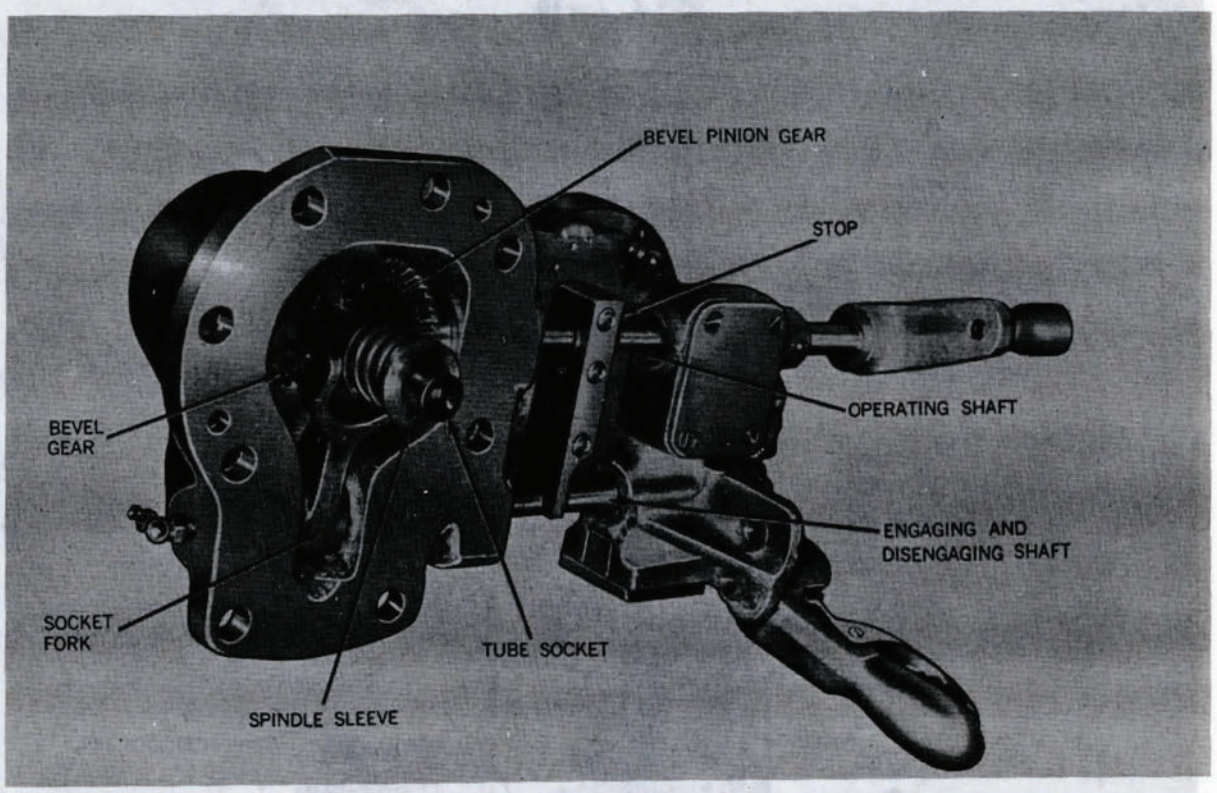


Figure 98f—*Circle and Depth Setting Mechanism, Spindle IN, Underside View.*

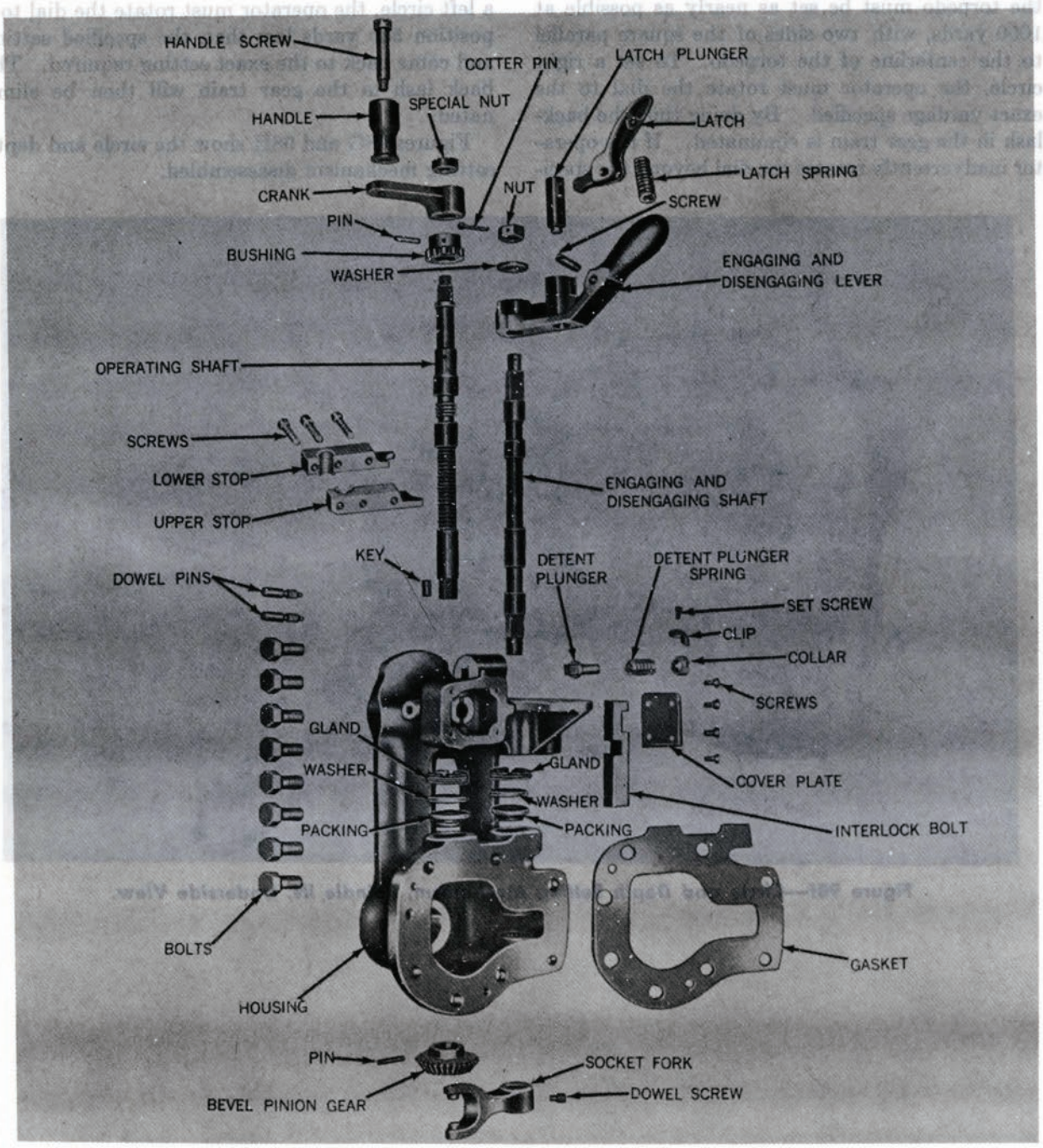


Figure 98g—*Circle and Depth Setting Mechanism, Horizontal Assembly Parts.*

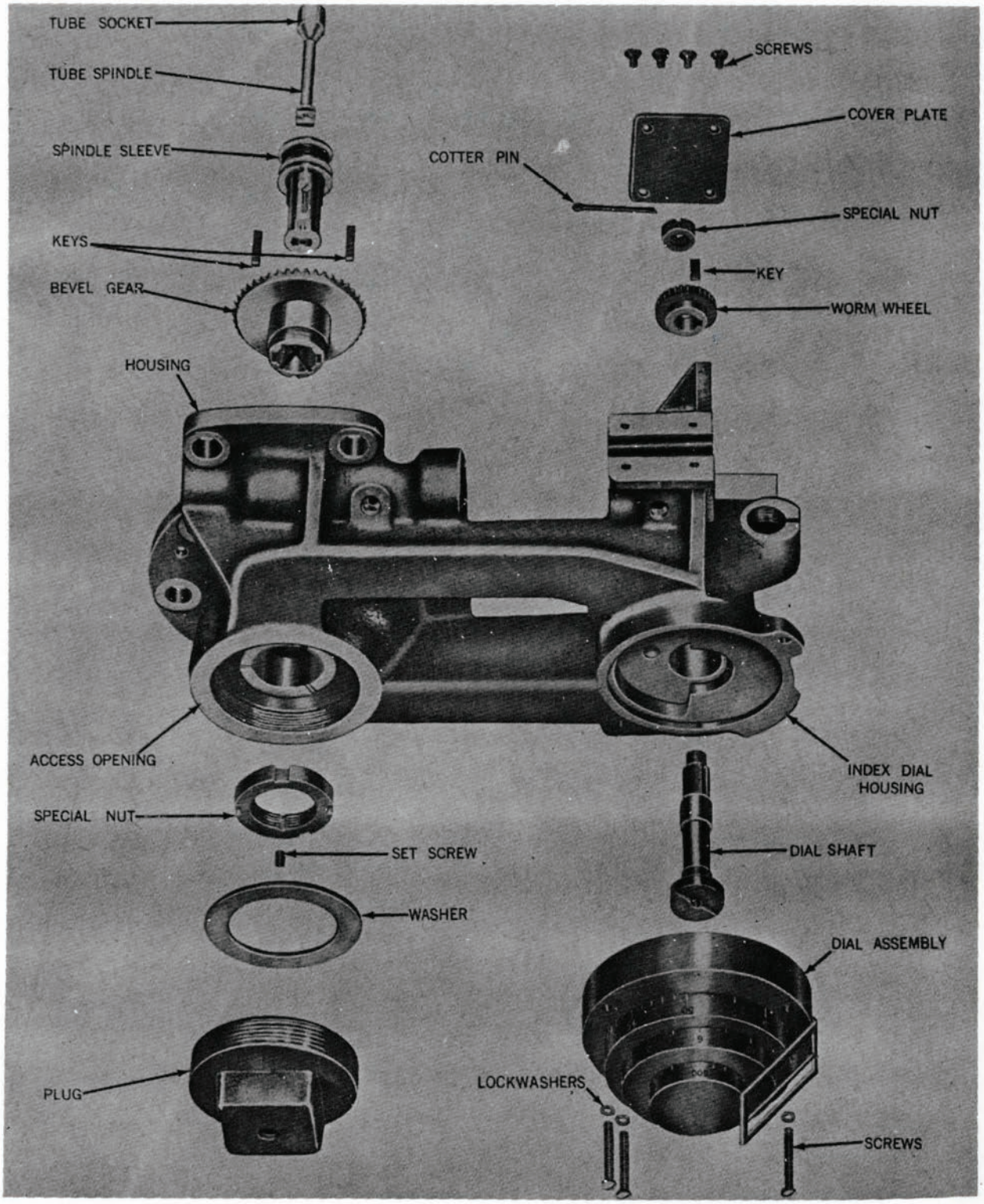


Figure 98h—*Circle and Depth Setting Mechanism, Vertical Assembly Parts.*

Chapter 10

SPEED SETTING MECHANISM

All torpedoes designed for firing from submerged tubes, except Torpedoes Mk 14 All Mods, are the single-speed type and require no speed setting. Torpedoes Mk 14 All Mods are the multiple-speed type and incorporate a mechanism which permits selection of high or low speed settings. The speed setting mechanism on the torpedo tube sets the speed mechanism in these torpedoes.

The torpedo speed mechanism controls the speed at which the torpedo will travel through the water and its range. A torpedo set for LOW speed will travel approximately twice as far as one set for HIGH speed.

The speed setting, like the depth and gyro settings, is determined according to factors existing at the time of firing. Therefore, the speed setting mechanism is installed so that it may be set at any time prior to moving the firing interlock lever to TUBE READY TO FIRE.

The speed setting mechanism consists of a spindle with a three-lobed head, means for raising and lowering the spindle in the tube, shafting and gearing for rotating the spindle, and an interlock mechanism. Handwheels or hand cranks are used to control the spindle rotation.

The interlocks prevents the tube from being fired when the spindle is engaged, and keeps the spindle from being engaged when the tube is ready to fire. The spindle cannot be rotated unless fully engaged in the torpedo socket, nor retracted unless the speed setting hand crank is moved to either HIGH or LOW speed position.

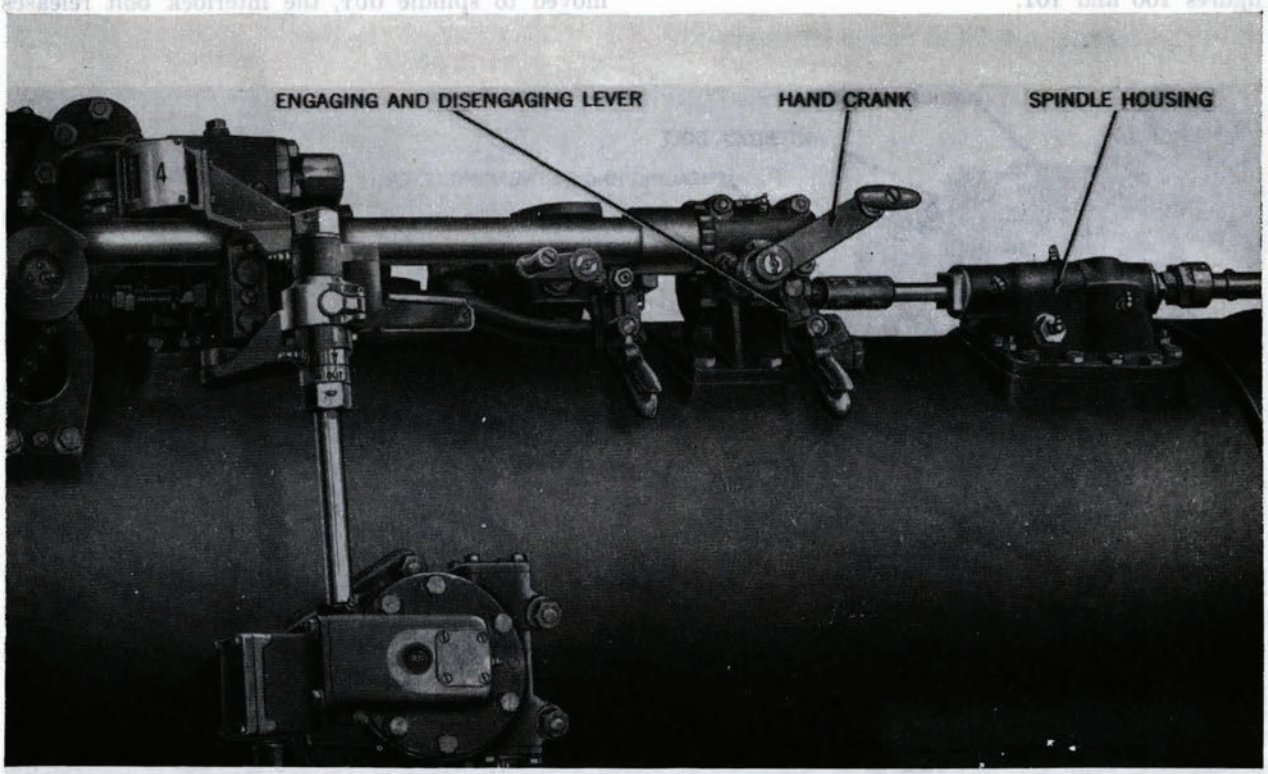


Figure 99—*Simple Type Speed Setting Mechanism Installed.*

When loading a torpedo into the tube, both the torpedo speed mechanism and the tube speed setting mechanism are set at LOW. Two types of speed setting mechanisms are used—the simple and the cross-over. Both types operate on the same principle.

When a torpedo is loaded into a left hand tube, both the torpedo speed setting socket and the speed setting mechanism controls are on the inboard side of the tube. Therefore, the simple type mechanism is attached to left hand tubes.

When a torpedo is loaded into a right hand tube, the speed setting socket and the speed setting mechanism controls are on opposite sides of the tube. Therefore, the cross-over type mechanism is attached to right hand tubes and transmits motion of the controls over the tube to the spindle housing.

Simple Type Speed Setting Mechanism

In this mechanism the speed setting controls and spindle housing are on the same side of the tube, figure 99. A speed setting operating shaft is actuated by both the speed setting engaging and disengaging lever and the speed setting hand crank, figures 100 and 101.

The engaging and disengaging lever imparts a fore-and-aft motion through a fork to the operating shaft. This motion is transmitted through a coupling to a socket shaft which raises or lowers the speed setting spindle in its housing.

The hand crank sets the torpedo speed mechanism through a speed setting shaft and gearing which rotates the operating shaft, socket shaft, and, through another set of gears, the spindle.

Speed Setting Interlock Bolt. Action of this bolt, which locks or releases the engaging and disengaging lever, is illustrated in figures 102, 103, 104, and 105. The lever is attached to the lever fork, which has a rounded extension fitting into the slot in one end of the interlock bolt. Rotation of the engaging and disengaging lever imparts a fore-and-aft motion to the interlock bolt, engaging or releasing a lug on the interlock sleeve collar. When the spindle is in, the interlock bolt is forced over on top of the lug. Therefore, the interlock sleeve cannot rotate, and movement of the firing interlock lever to TUBE READY TO FIRE is prevented.

When the engaging and disengaging lever is moved to spindle OUT, the interlock bolt releases

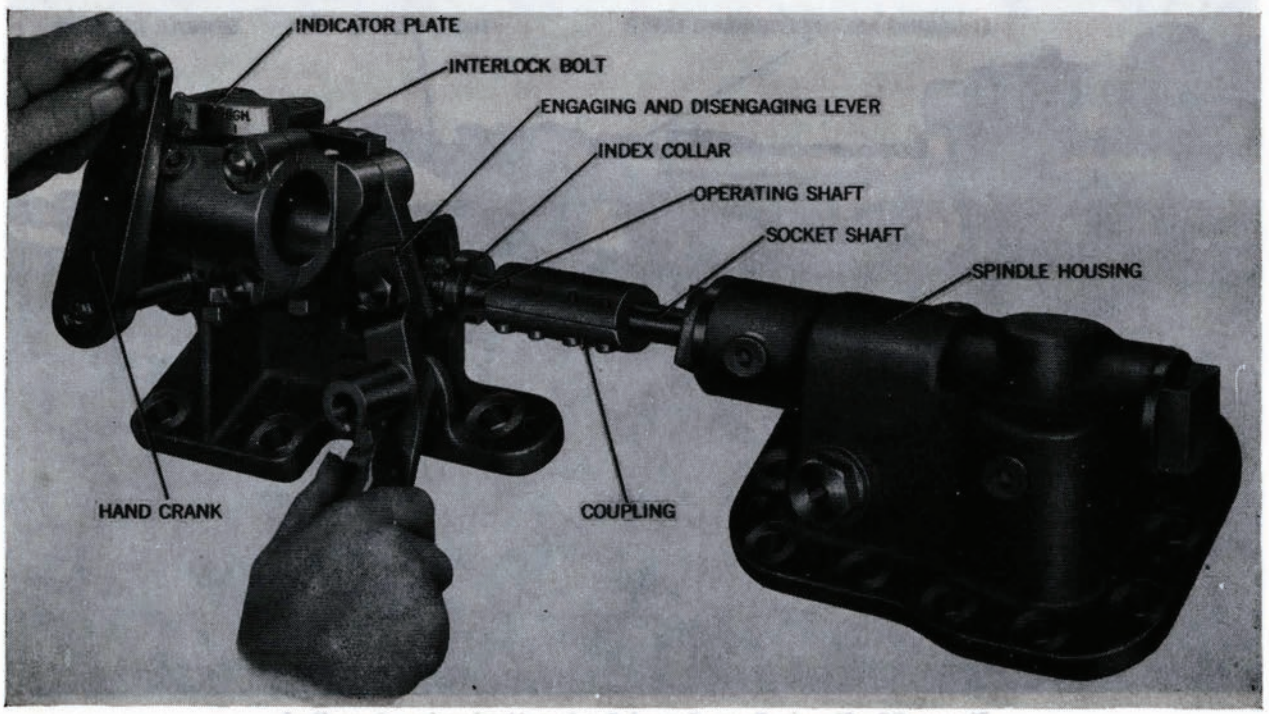


Figure 100—*Simple Type Speed Setting Mechanism—Spindle IN—Hand Crank at LOW.*

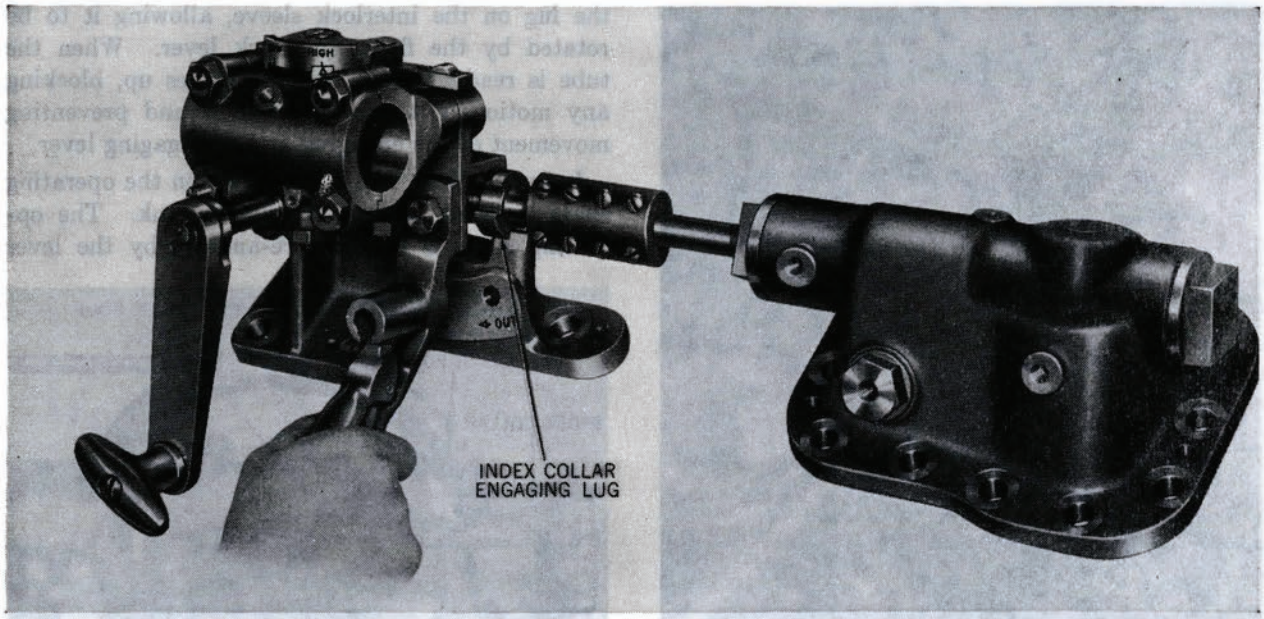


Figure 101—*Simple Type Speed Setting Mechanism—Spindle OUT—Hand Crank Locked at HIGH.*

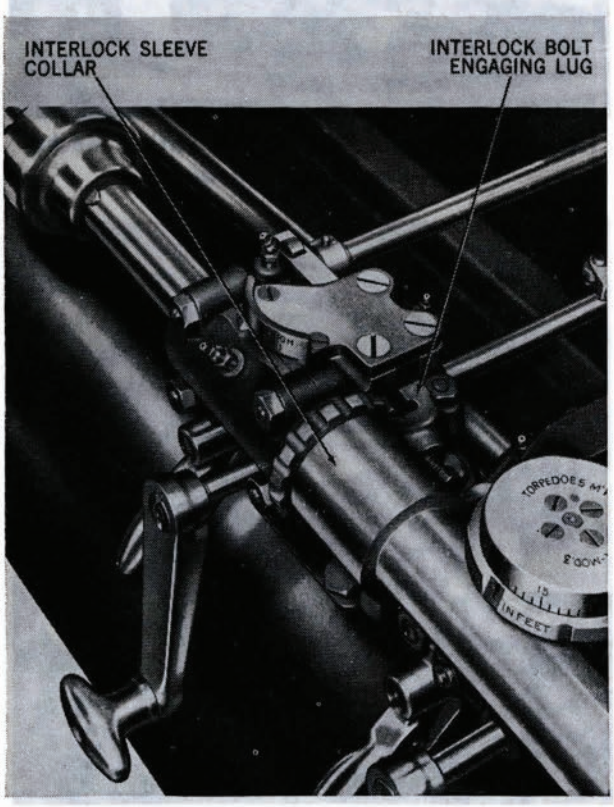


Figure 102—*Simple Type Speed Setting Mechanism Installed—Spindle OUT.*

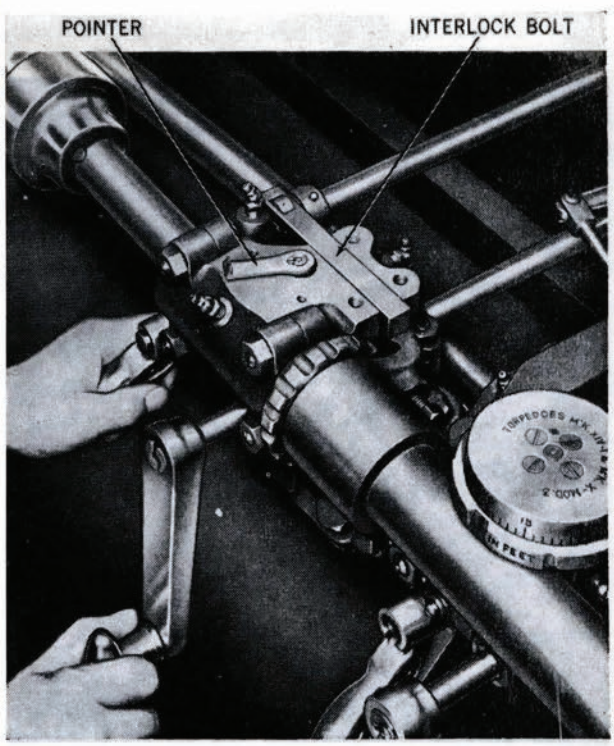


Figure 103—*Simple Type Speed Setting Mechanism Installed—Spindle IN—Indicator Plate Removed.*

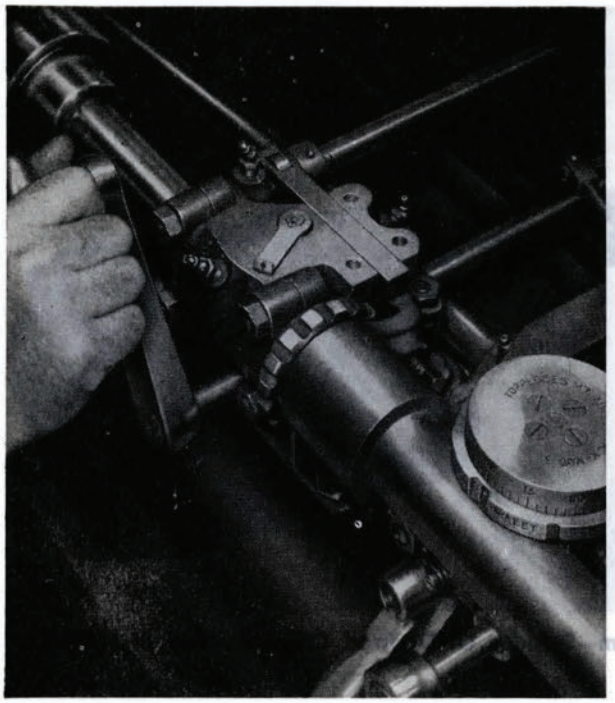


Figure 104—*Simple Type Speed Setting Mechanism Being Set to HIGH Speed Position.*

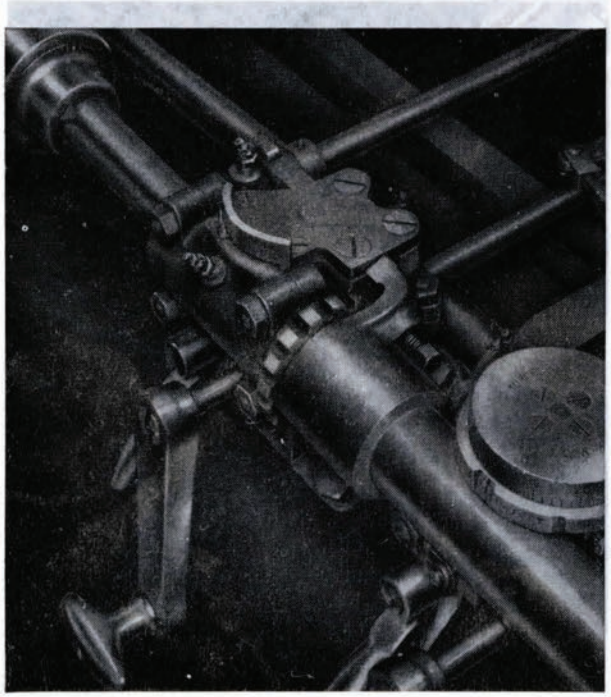


Figure 105—*Simple Type Speed Setting Mechanism—Spindle OUT.*

the lug on the interlock sleeve, allowing it to be rotated by the firing interlock lever. When the tube is ready to fire, this lug moves up, blocking any motion of the interlock bolt and preventing movement of the engaging and disengaging lever.

Index Collar. The index collar on the operating shaft locks or releases the hand crank. The operating shaft is moved fore-and-aft by the lever

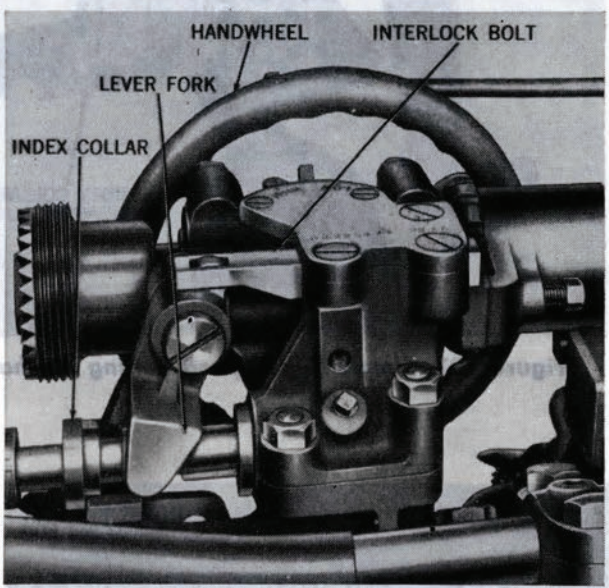


Figure 106—*Simple Type Speed Setting Mechanism—Rear View—Spindle IN.*

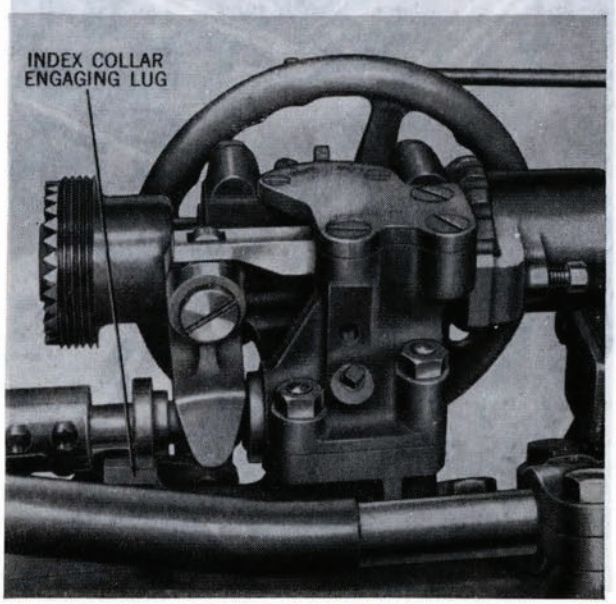


Figure 107—*Simple Type Speed Setting Mechanism—Rear View—Spindle OUT.*

fork as the engaging and disengaging lever is moved, figures 106 and 107. When the lever is in the spindle OUT position, the operating shaft is positioned so that one of two slots in the index collar engages a lug on the base of the housing, preventing rotation of the operating shaft and movement of the hand crank. When the lever is moved to spindle IN, the index collar clears the lug, permitting rotation of the operating shaft and of the hand crank to either HIGH or LOW speed.

Positive Stop. After the index collar has engaged the lug, excessive rotation of the hand crank could damage the speed setting shaft. Therefore, a positive stop is provided to limit hand crank rotation. The stop consists of an elongated hub on the speed setting shaft, upon which a stop collar is mounted, so that it is free to turn. A projection on the stop collar is engaged by pins fixed in the hand crank and the housing. The projection on the stop collar prevents the hand crank from turning more than 480°.

Spindle Engagement and Rotation. The hand crank rotates the speed setting shaft on which is a worm and a bevel pinion gear, figures 108 and 109. The worm engages a gear on an index shaft which moves the pointer of a speed setting indicator. The bevel pinion gear engages a bevel gear on the end of the operating shaft. Turning the hand crank

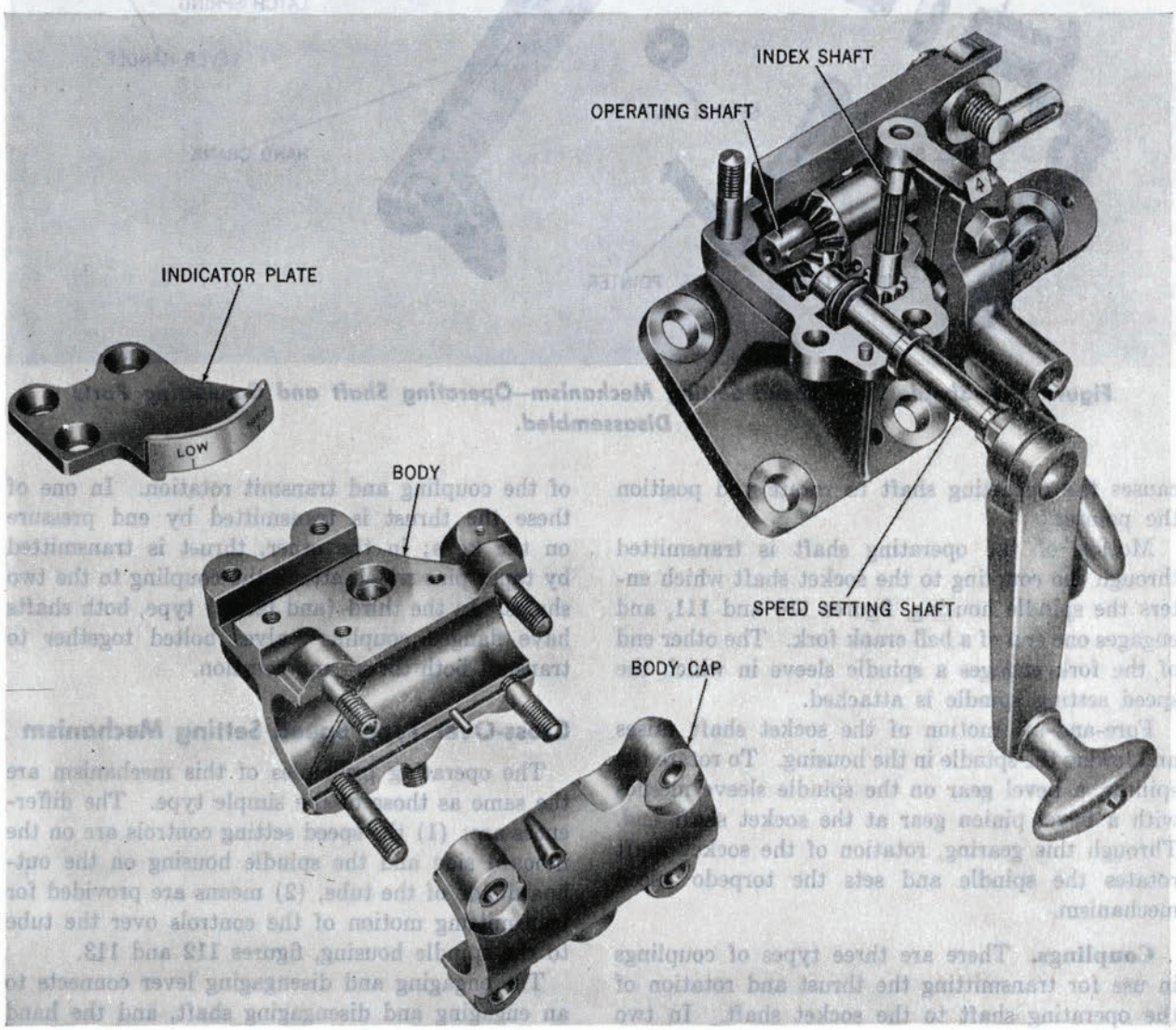


Figure 108—*Simple Type Speed Setting Mechanism—Control Section Partially Disassembled.*

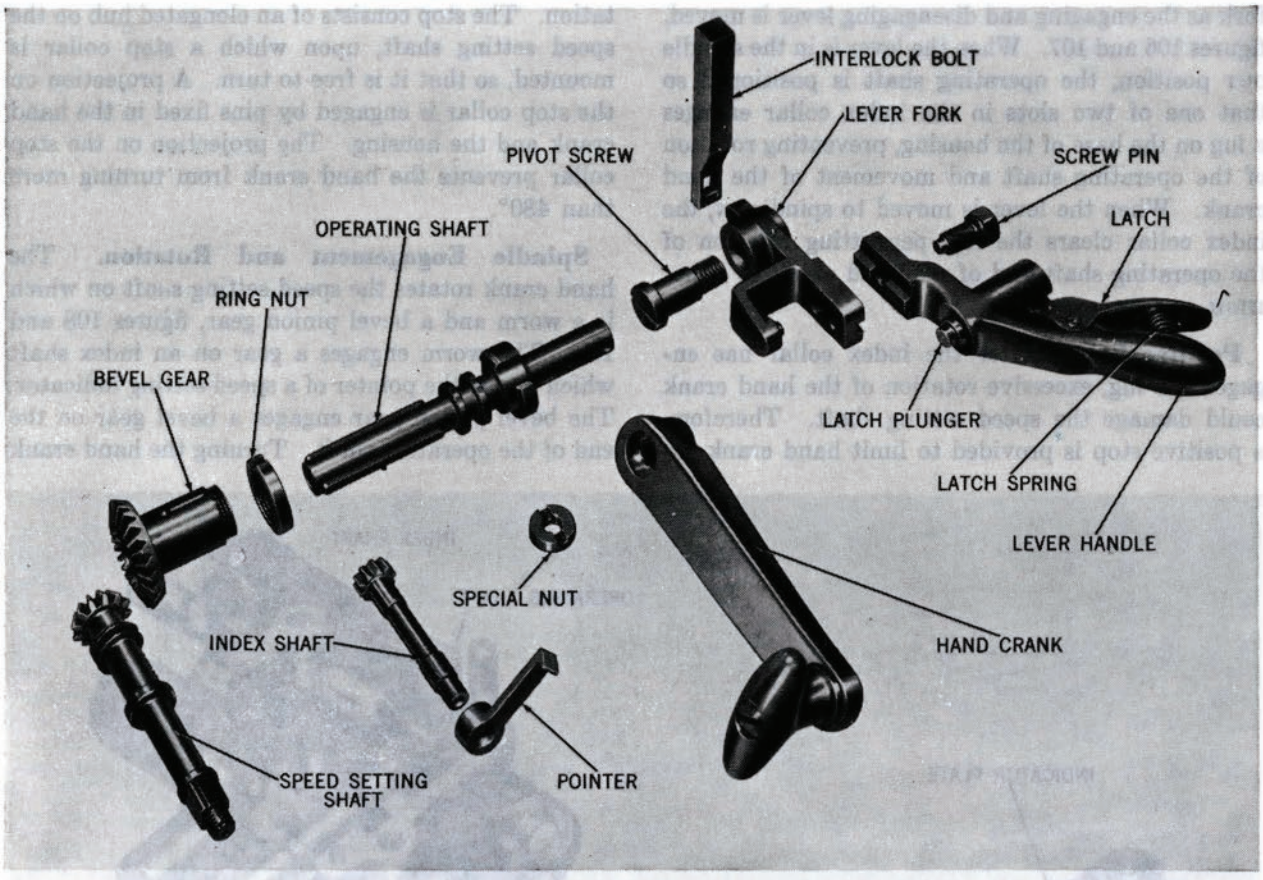


Figure 109—*Simple Type Speed Setting Mechanism—Operating Shaft and Connecting Parts Disassembled.*

causes the operating shaft to rotate and position the pointer.

Motion of the operating shaft is transmitted through the coupling to the socket shaft which enters the spindle housing, figures 110 and 111, and engages one end of a bell crank fork. The other end of the fork engages a spindle sleeve in which the speed setting spindle is attached.

Fore-and-aft motion of the socket shaft raises and lowers the spindle in the housing. To rotate the spindle, a bevel gear on the spindle sleeve meshes with a bevel pinion gear at the socket shaft end. Through this gearing, rotation of the socket shaft rotates the spindle and sets the torpedo speed mechanism.

Couplings. There are three types of couplings in use for transmitting the thrust and rotation of the operating shaft to the socket shaft. In two types, keys fitted in keyways run the greater length of the coupling and transmit rotation. In one of these the thrust is transmitted by end pressure on the keys; in the other, thrust is transmitted by taper pins which attach the coupling to the two shafts. In the third (and latest) type, both shafts have flanged coupling halves bolted together to transmit both thrust and rotation.

Cross-Over Type Speed Setting Mechanism

The operating principles of this mechanism are the same as those of the simple type. The differences are: (1) the speed setting controls are on the inboard side and the spindle housing on the outboard side of the tube, (2) means are provided for transmitting motion of the controls over the tube to the spindle housing, figures 112 and 113.

The engaging and disengaging lever connects to an engaging and disengaging shaft, and the hand crank engages a longer type speed setting shaft,

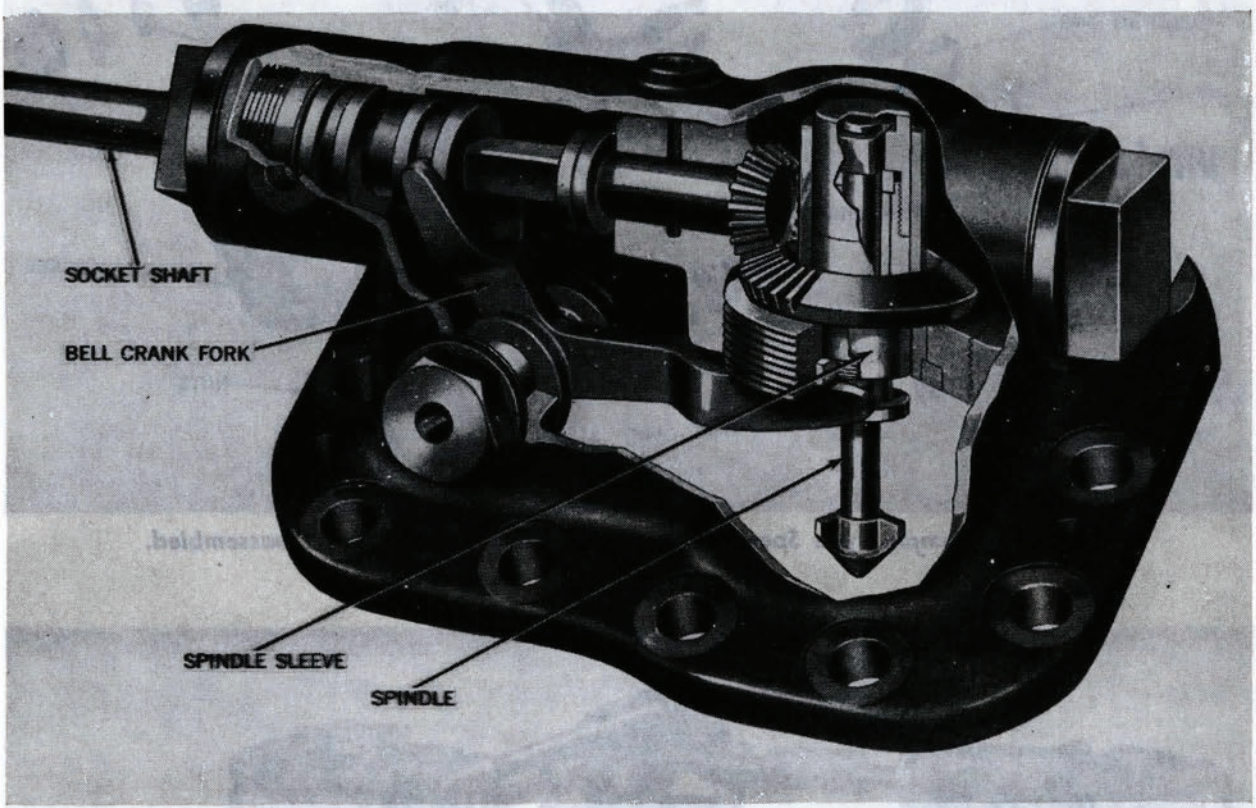


Figure 110—*Simple Type Speed Setting Mechanism—Spindle Housing—Sectional View.*

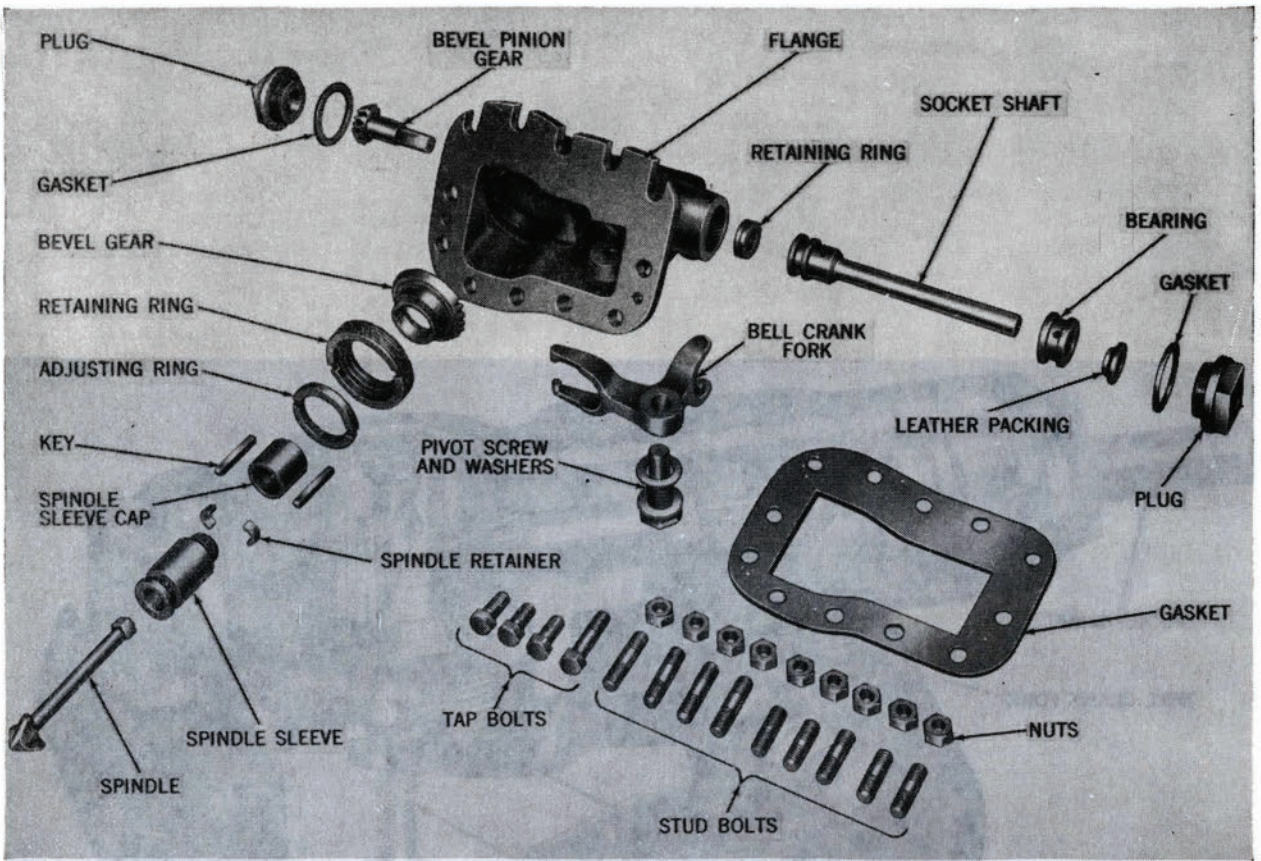


Figure 111—*Simple Type Speed Setting Mechanism—Spindle Unit Disassembled.*

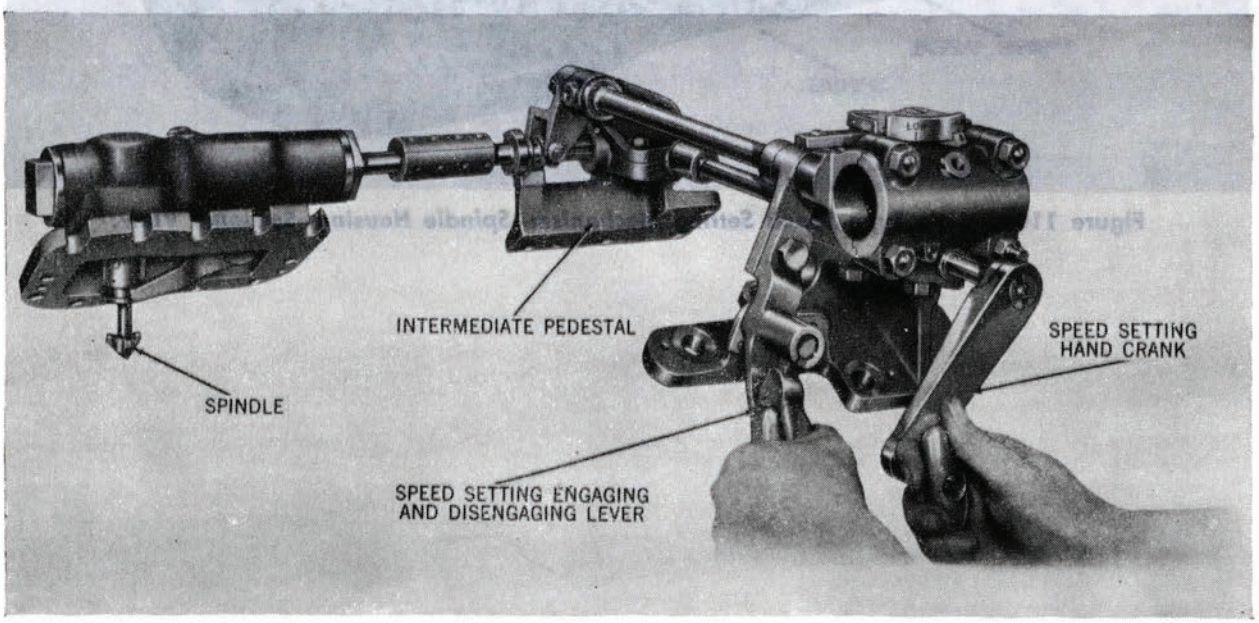


Figure 112—*Cross-over Type Speed Setting Mechanism—Spindle IN—Hand Crank at HIGH.*

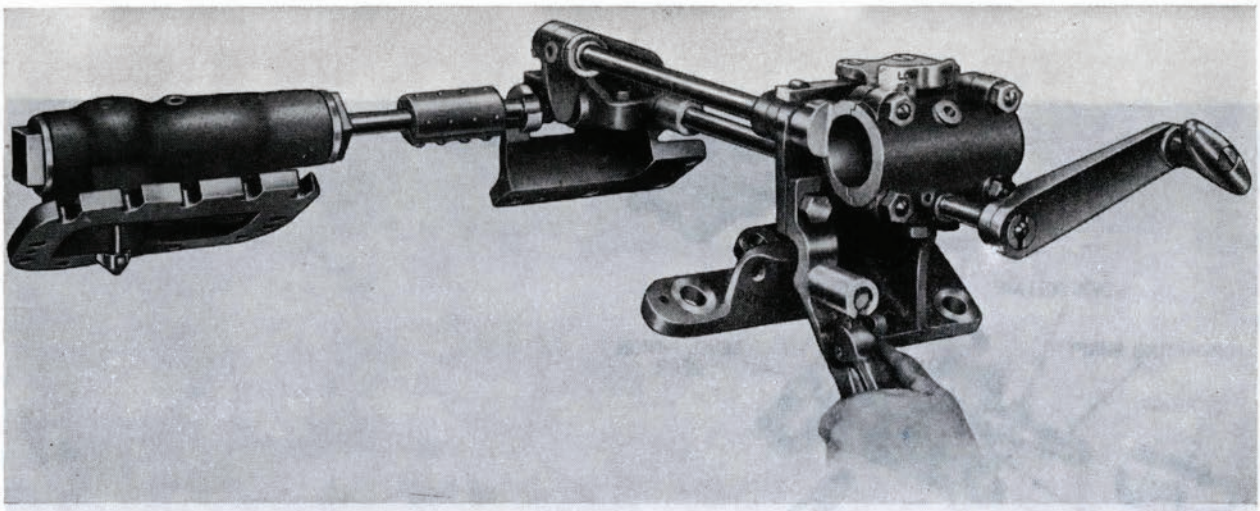


Figure 113—*Cross-Over Type Speed Setting Mechanism—Spindle OUT—Hand Crank Locked at LOW.*

figures 114 and 115. Both shafts extend across the top of the tube and enter an intermediate pedestal, figure 116. The engaging and disengaging shaft engages a fork which moves the operating shaft, and the speed setting shaft engages gearing which rotates the operating shaft. From this point, operation of the two types is identical.

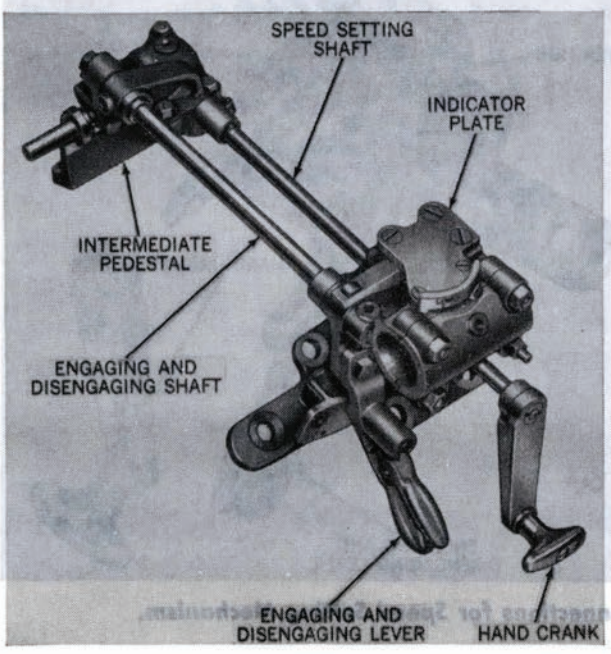


Figure 114—*Cross-Over Connections for Speed Setting Mechanism.*

Operation of the interlock bolt and index collar is essentially the same as in the simple type mechanism. Action of the index collar is shown in figures 117 through 121, which are outboard views of a cross-over type mechanism (the breech end of the barrel is to the observer's left). In studying these illustrations, note the following:

1. When the engaging lever is moved from spindle OUT, figure 117, to spindle IN, figure 118, the operating shaft moves muzzleward.

2. When the engaging lever is moved from spindle IN, figure 120, to spindle OUT, figure 121, the operating shaft moves breechward.

3. When the hand crank is moved from LOW to HIGH, figures 118, 119, and 120, the operating shaft rotates clockwise (as viewed from the breech). Reversing the sequence of these three illustrations makes apparent the counterclockwise rotation of the operating shaft when the hand crank is moved from the HIGH to LOW speed.

4. When the engaging lever is set at spindle OUT, the index collar prevents rotation of the operating shaft. In this case, when the hand crank is set at LOW, the index collar prevents clockwise rotation to HIGH, figure 117. When the hand crank is set at HIGH, the index collar prevents counterclockwise rotation, figure 121, to LOW speed.

5. When the hand crank is not set at LOW nor HIGH, the index collar prevents breechward movement of the operating shaft, figure 119, and, therefore, prevents retraction of the spindle.

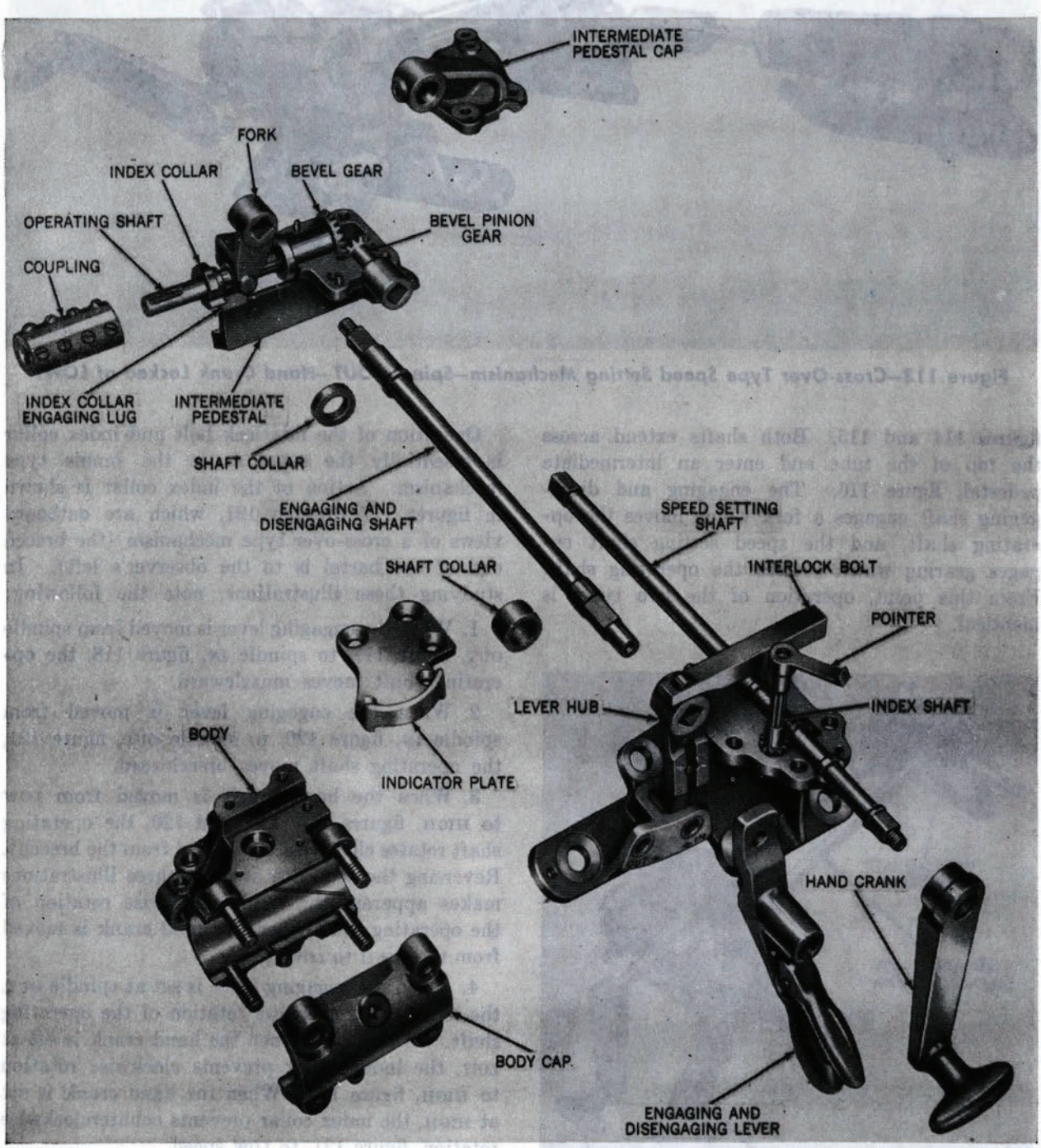


Figure 115—*Disassembly of Cross-Over Connections for Speed Setting Mechanism.*

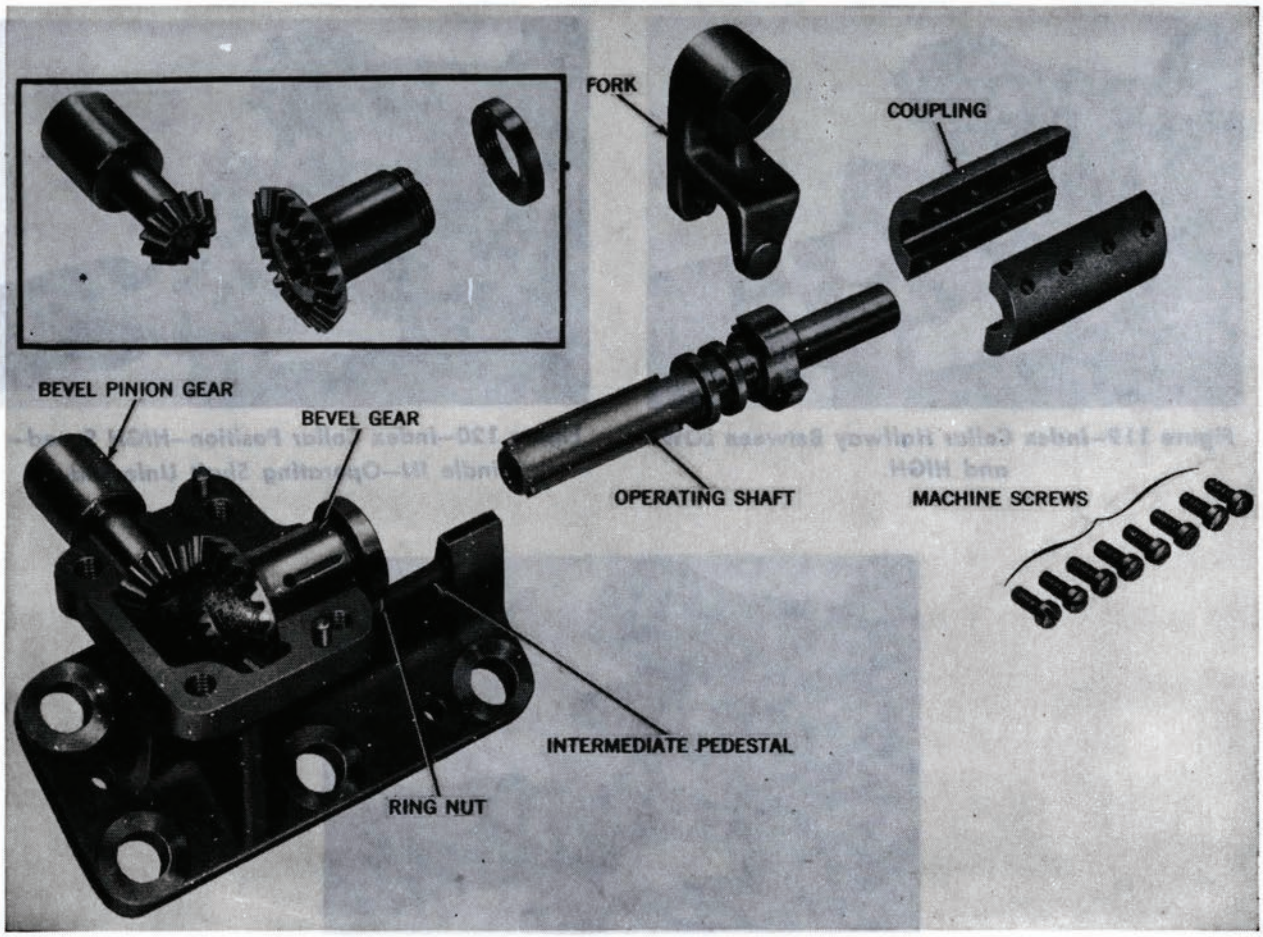


Figure 116—*Cross-Over Type Speed Setting Mechanism—Intermediate Pedestal Disassembled.*

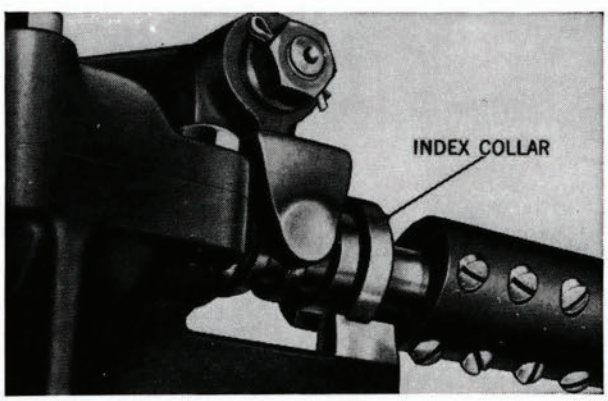


Figure 117—*Index Collar Position—LOW Speed—Spindle OUT—Operating Shaft Locked.*

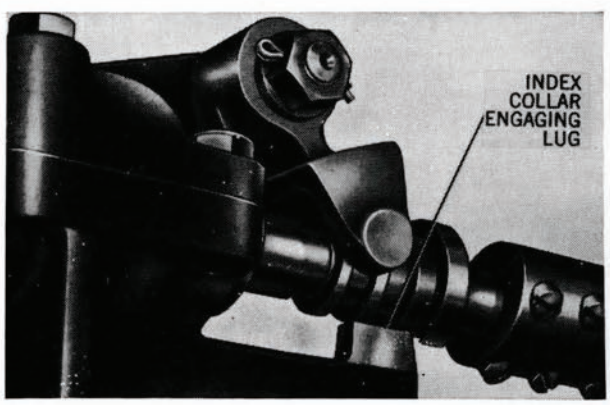


Figure 118—*Index Collar Position—LOW Speed—Spindle IN—Operating Shaft Unlocked.*

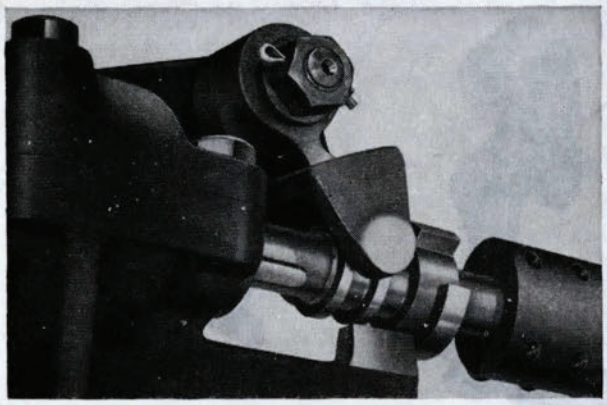


Figure 119—*Index Collar Halfway Between LOW and HIGH.*

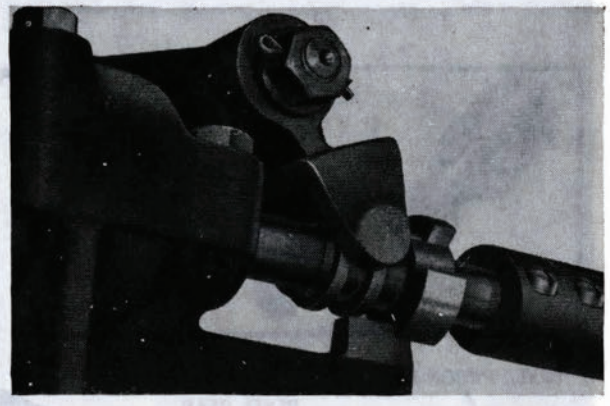


Figure 120—*Index Collar Position—HIGH Speed—Spindle IN—Operating Shaft Unlocked.*

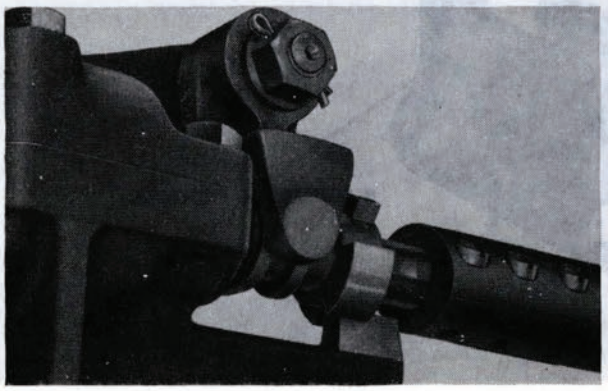


Figure 121—*Index Collar Position—HIGH Speed—Spindle OUT—Operating Shaft Locked.*

Chapter 11

GYRO SETTING MECHANISM

The gyro setting mechanism on the torpedo tube sets the gyro in mechanically set torpedoes, which, in combination with the steering engine and steering rudders, brings a torpedo around to any desired course and maintains it on that course during its run. When standing by to fire, the torpedo gyro mechanism is set continuously so that regardless of when the tube is fired, the gyro will be set at the correct gyro angle. Except when firing at a stationary target, it is not feasible to turn a submarine to aim the tubes, especially during action when delay would be dangerous.

The gyro setting mechanism, like the depth and speed setting mechanisms, is on the outside of the barrel. This mechanism has a spindle which projects into the barrel and engages or disengages a mating socket in the torpedo afterbody.

It consists of four units: gyro setting indicator-regulator, cross-shaft drive unit, figure 122, retraction unit, and tube unit. The gyro setting indicator-regulator is described in OP 1169; the other units are described herein. One cross-shaft drive unit is installed for each nest of tubes, but each tube has its own tube unit and retraction unit, figure 123.

When the gyro setting indicator-regulator is operated, gyros in all the torpedoes in the nest are set. Simultaneous setting is accomplished through the cross-shaft drive unit which has a centerline shaft extending out from the gyro setting indicator-regulator to a gear housing below the deck plates. Through gearing, the centerline shaft engages a cross shaft extending athwartships which, in turn, engages two vertical drive shafts, one for each bank of tubes.

Each drive shaft rises vertically inboard of the tubes and consists of several sections (three in a bow nest and two in a stern nest). Flexible couplings join the sections of the vertical drive shaft in succession to worm drive shafts in the tube units in each bank of tubes. Rotation of the centerline shaft is thus transmitted to all tube units in the nest. The gyro setting spindles, in the tube units, set the mating sockets of the torpedo gyro mechanisms to the gyro angle selected for the torpedo's course.

The gyro setting spindle is engaged manually; it may be retracted manually or automatically. When a tube is fired, the gyro retraction slide automatically retracts that tube's gyro setting spindle, but gyro settings being made in other torpedoes of the nest are not affected.

Retraction Unit

This unit, figures 124 and 125, engages and retracts the gyro setting spindle. Its engaging lever is attached to a clutch fork shaft, the lower end of which is connected to a clutch fork in a spindle housing. Arms of the clutch fork engage the spindle sleeve and permit the engaging lever to move the spindle in or out of the tube to engage or disengage its mating socket. As the lever is turned, IN or OUT is shown on an indicator plate on the clutch fork shaft and an arrow on a pointer plate.

Two types of clutch fork shaft are used: one with a solid shaft, the other with a coupled shaft. The upper end of the shaft connects to the retraction unit and the lower end to the tube unit. Disconnection at the coupling permits removal of either unit from the tube without disturbing the other. Figures 126, 127, and 128 show disassembly of the retraction unit and tube unit.

Manual Engagement and Retraction. Normally, the engaging lever is locked in a position parallel to the tube. Pressing down a handle lock release removes a handle lock bolt from a slot in a bracket of the engaging lever. This unlatches the engaging lever and permits it to be turned to spindle IN.

To retract the spindle manually, the engaging lever is reengaged with the clutch fork shaft by unlatching the engaging lever, and turning it until

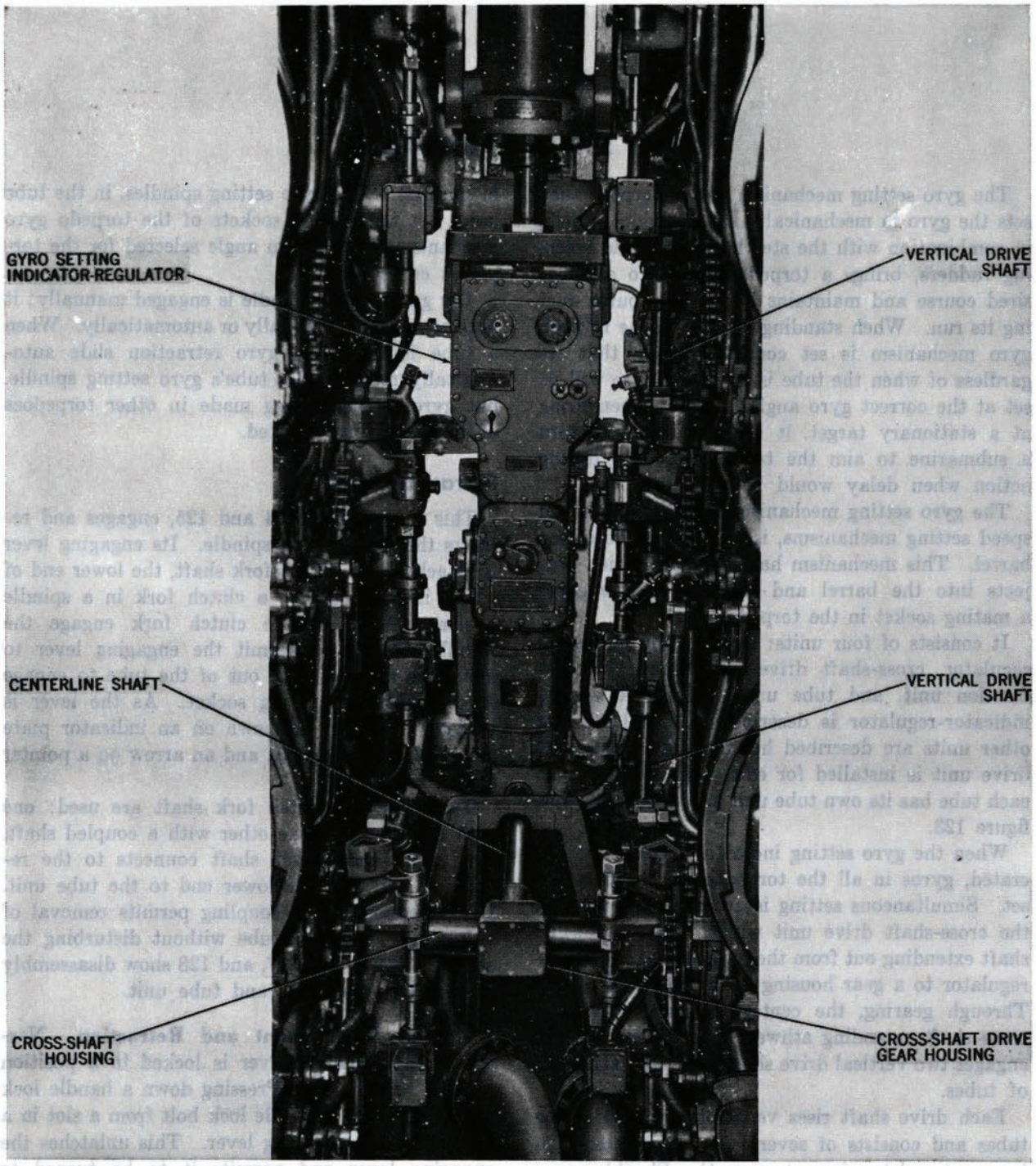


Figure 122—*Gyro Setting Mechanism—Cross Shaft Drive Unit.*

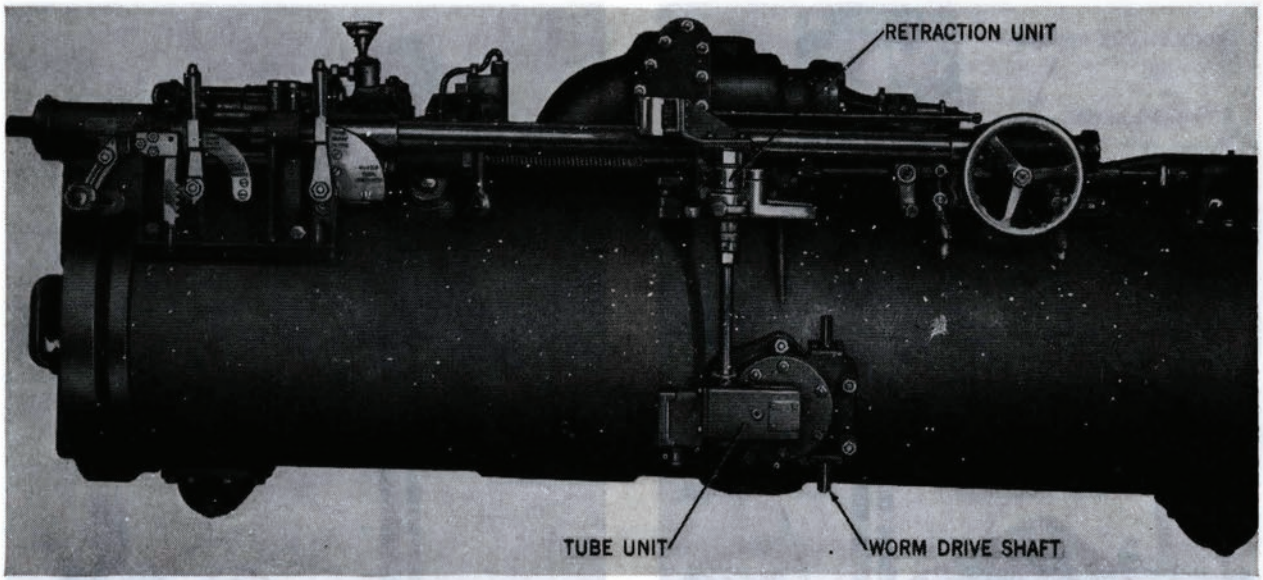


Figure 123—*Gyro Setting Mechanism Tube and Retraction Units Installed.*

the handle shaft bolt releases from the retraction lever and engages the engaging lever. The engaging lever then may be returned to its locked position, carrying with it the clutch fork shaft and connecting parts, thereby retracting the spindle.

Automatic Retraction. For automatic retraction of the gyro setting spindle, the clutch fork shaft is disengaged from the engaging lever and engaged with the retraction lever. This is accomplished by pressing down a shaft release button which disengages a handle shaft bolt from the engaging lever, and engages it with a mating toe on the retraction lever. The engaging lever may then be turned to locked position.

Automatic retraction of the spindle must be accomplished immediately before the firing valve is vented to launch the torpedo. When the firing key is closed, a stop piston rod in the firing mechanism is moved breechward, chapter 12. This moves the gyro retraction slide to which the stop piston rod is attached. At its other end, the gyro retraction slide connects to the stop rod, and transmits to it the motion of the stop piston rod, raising the stop bolt. The slide also is connected to the retraction lever and, therefore, to the clutch fork shaft. Thus, movement of the stop piston rod rotates the clutch fork shaft and disengages the spindle.

To connect the gyro retraction slide to the retraction lever, a slide block carried on a pin in the lower end of the intermediary multiplying lever, engages a slot in the retraction lever, figure 129. A sprocket (on the axle of the multiplying lever) and chain assembly, fastened to the gyro retraction slide, transmits motion of the gyro retraction slide to rotate the retraction slide lever which, in turn, rotates the retraction lever and the clutch fork shaft.

When the tube has been fired, the gyro retraction slide and stop rod are returned to their original positions by the stop piston rod spring, carrying with them the retraction slide lever and the retraction lever. Angular clearance in the driving slot of the retraction lever permits this to be done without throwing the spindle to engaged position.

Tube Unit

This unit provides means of transmitting the rotation of the drive shaft to the gyro spindle. Inside the spindle drive housing, the worm drive shaft (to which the drive shaft is keyed) meshes with a worm wheel in a 7:1 gear reduction ratio. A spindle sleeve in the worm wheel is secured to the gyro spindle. For inspection or replacement, the spindle may be removed from the spindle drive housing without removing the spindle sleeve.

The gyro setting spindle has a squared shank at its engaging end, figures 130 and 131, which must line up with the torpedo socket. The spindle is

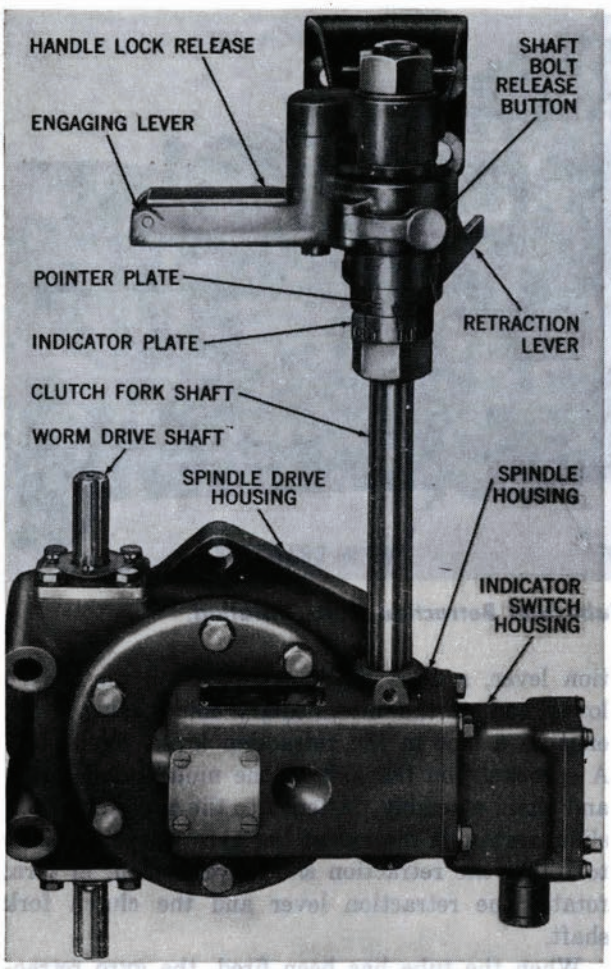


Figure 124—*Tube and Retraction Units Removed From Tube.*

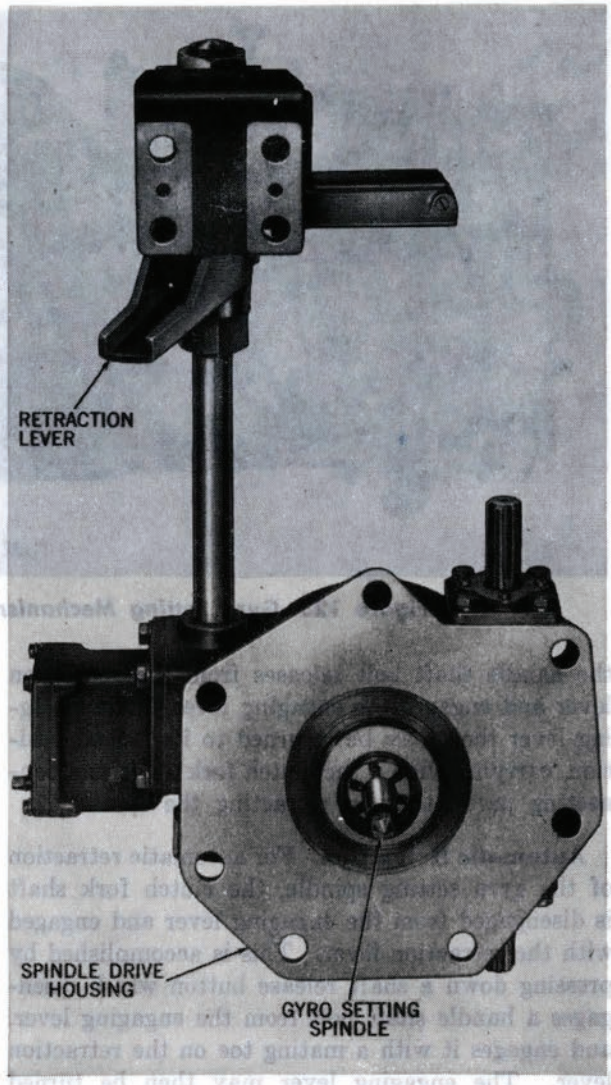


Figure 125—*Tube and Retraction Units Removed From Tube—Tube Side.*

attached to the spindle sleeve, with slight play, and centered in the sleeve by a spindle spring. This facilitates engagement and allows for slight misalignment. If the spindle does not enter the torpedo socket because of shank misalignment, it may be rotated slightly in either direction by the hand drive of the gyro setting indicator-regulator. Normally, this will align the spindle shank with the socket and permit engagement.

To insure alignment of the spindle and socket when loading a torpedo into the tube, the torpedo gyro must be set at 0. On a bow tube the gyro setting mechanism must be set at 0 and on a stern tube at 180.

The spindle sleeve passes through a stuffing box into the tube. A stuffing box drain in the housing base drains off any water which may leak into the tube unit housing. This drain must be kept free from obstruction.

Indicator Switch. A micro type indicator switch, mounted in a housing bolted to the spindle housing, is the normally open type. When the engaging lever is set at spindle IN, the switch is closed by action of a cam on the clutch fork and a lever. Closing the switch completes an electric circuit, lighting a lamp which indicates the spindle is engaged.

NOTE: ORDALT 2600 is to be accomplished on all active fleet submarines. This will reduce noise from the gyro set-

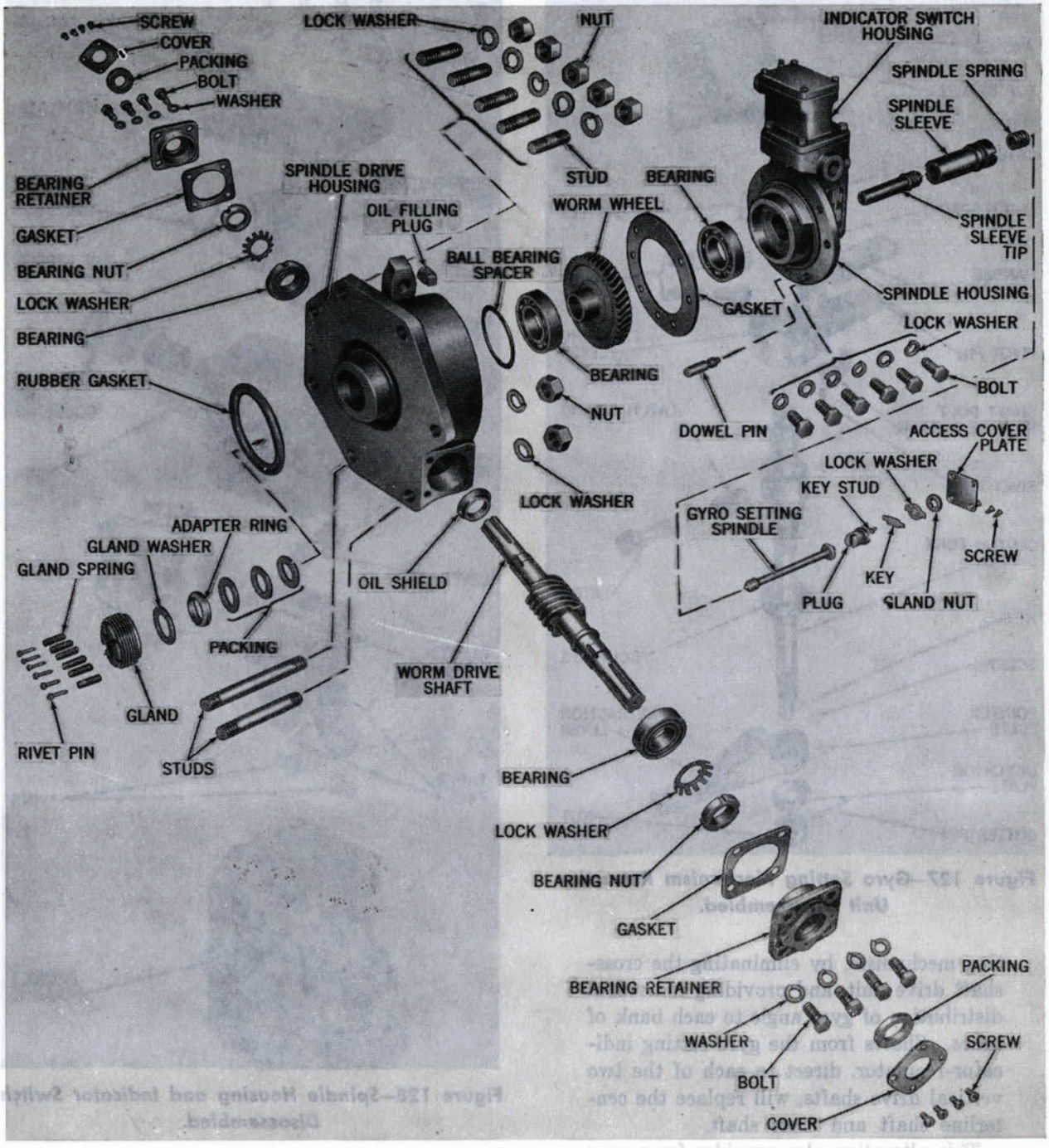


Figure 126—Gyro *Setting Mechanism Tube Unit Disassembled.*

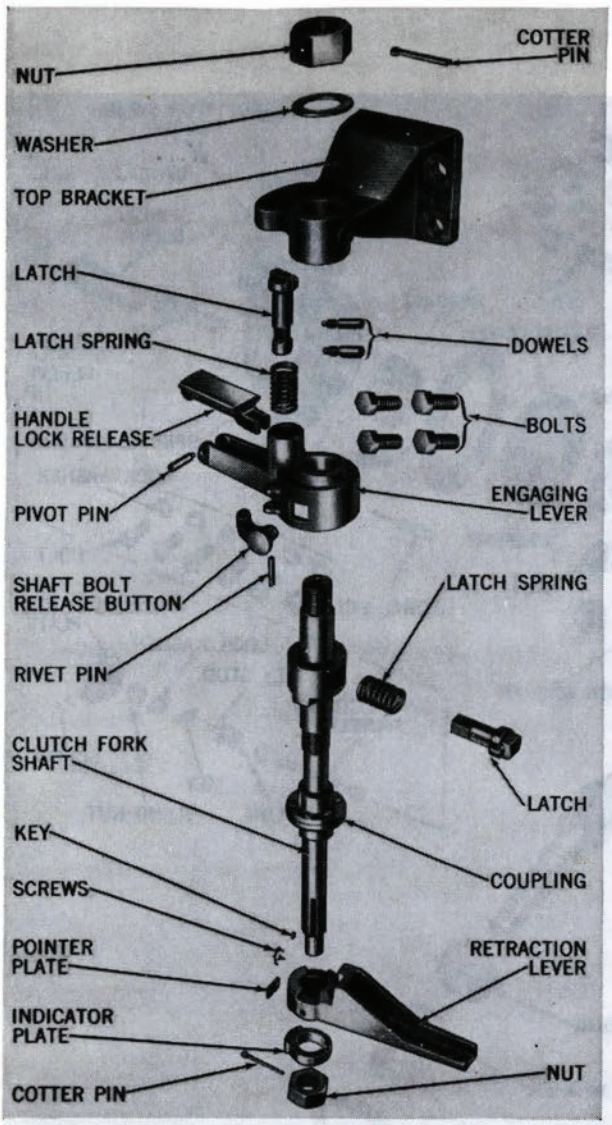


Figure 127—*Gyro Setting Mechanism Retraction Unit Disassembled.*

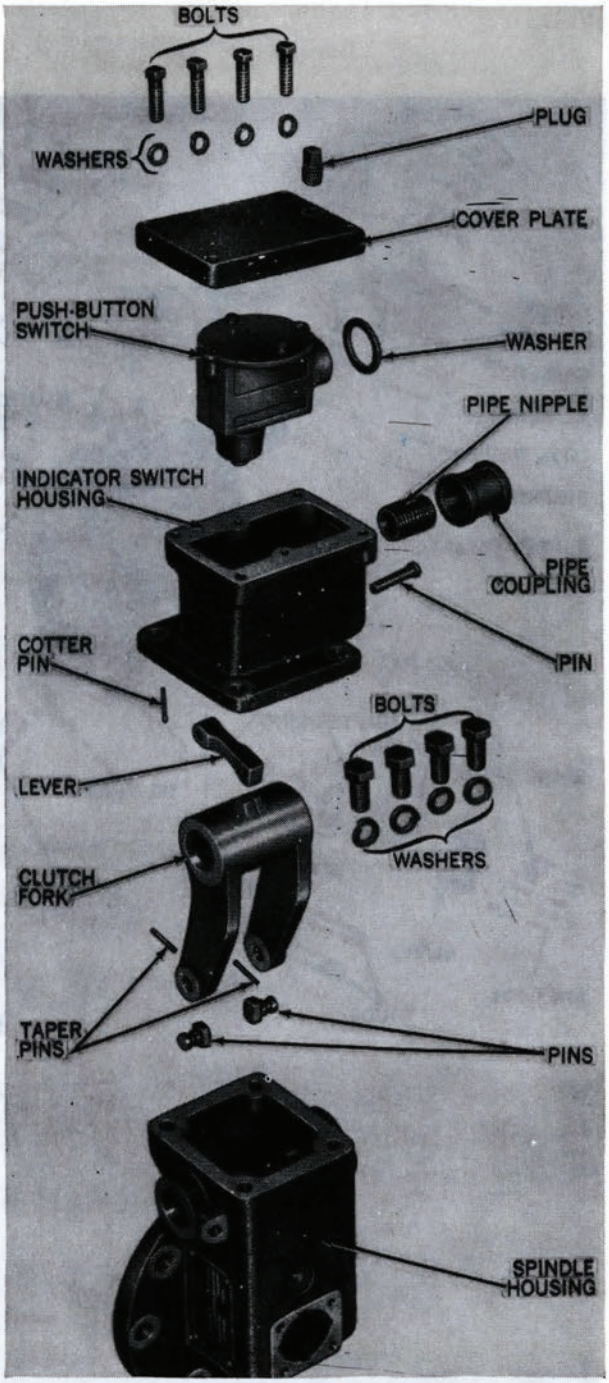


Figure 128—*Spindle Housing and Indicator Switch Disassembled.*

ting mechanism, by eliminating the cross-shaft drive unit, and providing individual distribution of gyro angle to each bank of tubes. Shafts from the gyro setting indicator-regulator, direct to each of the two vertical drive shafts, will replace the centerline shaft and cross shaft.

This alteration also provides for a gear reduction ratio of 7:1 at the gyro setting indicator-regulator, and a 1:1 gear ratio to replace the 7:1 gear reduction ratio in the tube unit. The shafting between the indicator-regulator and the tube unit will rotate only one-seventh as fast as formerly, thereby reducing the noise caused by the gears.

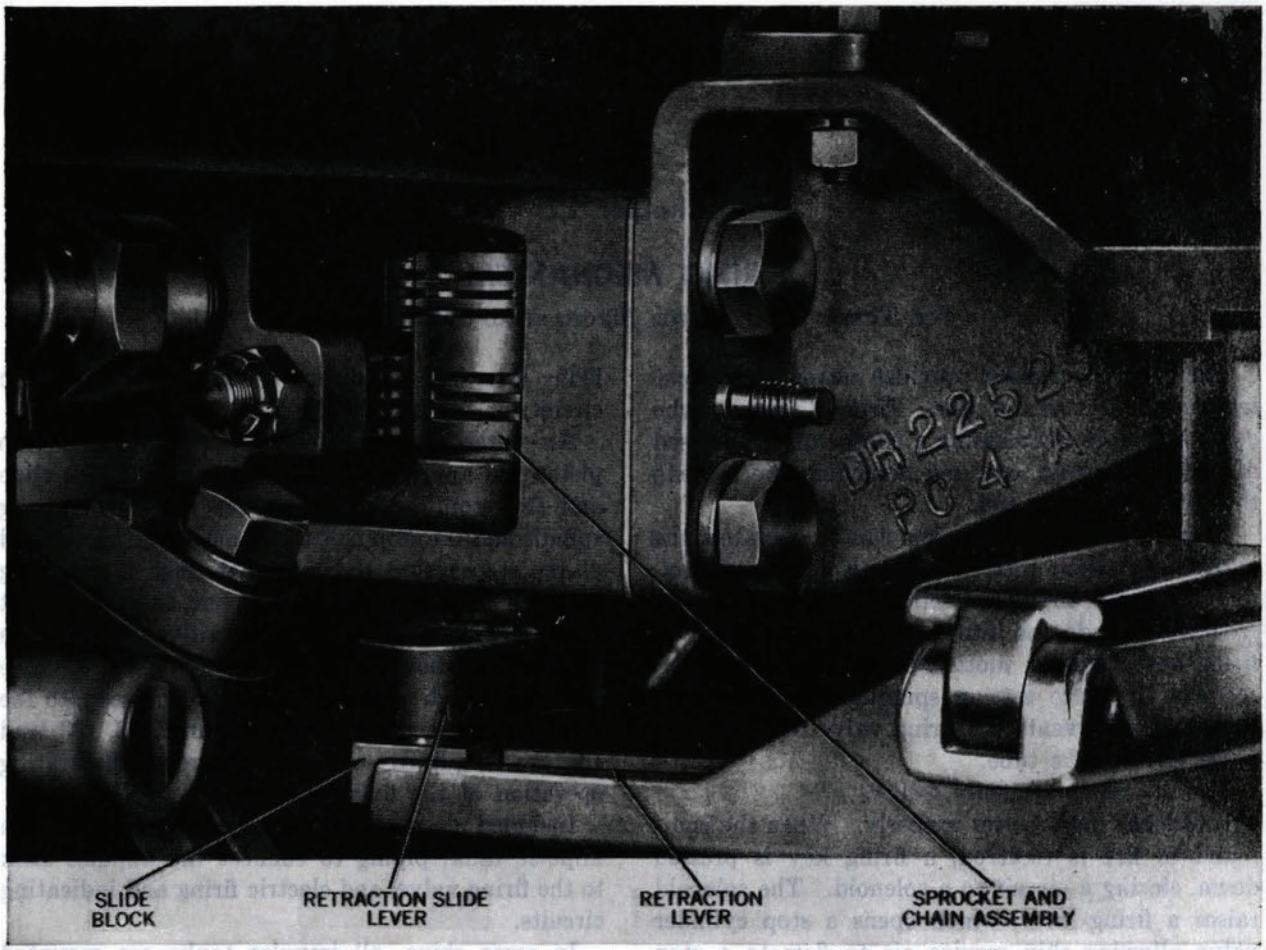


Figure 129—*Linkage for Automatic Retraction of Gyro Spindle.*

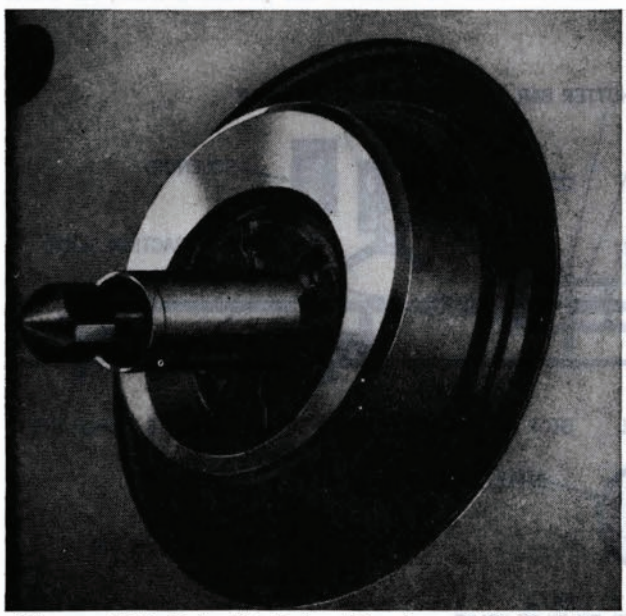


Figure 130—*Spindle Drive Housing—Spindle IN.*

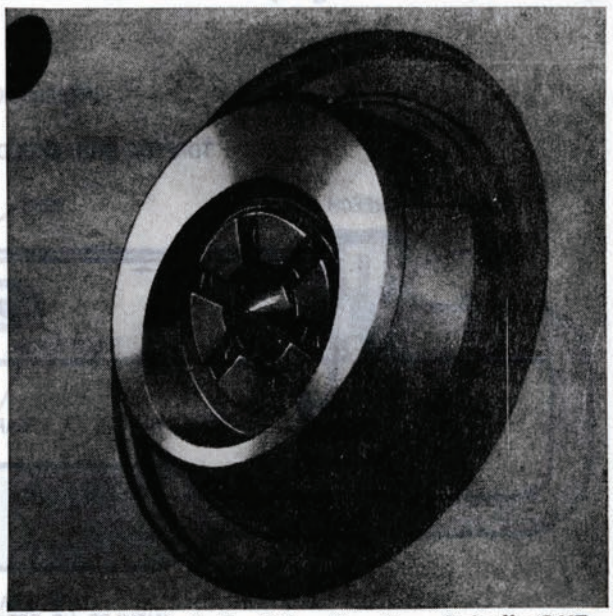


Figure 131—*Spindle Drive Housing—Spindle OUT.*

Chapter 12

FIRING MECHANISM

FOR TUBES EQUIPPED FOR MECHANICAL SETTING ONLY

The firing mechanism provides means for launching torpedoes from the tube. Firing a torpedo tube consists simply of releasing a charge of compressed air into the breech end and launching the torpedo through the muzzle end.

Before the firing mechanism can be operated, the entire interlocking mechanism must be properly set, and the depth and speed setting spindles retracted from the torpedo and into their housings. When the firing key is closed, motion of the stop piston rod retracts the gyro setting spindle, raises the stop bolt, and then vents the firing valve to admit impulse air into the tube.

The operating sequence follows:

Interlocks must be set properly. When the command to fire is received, a firing key is pressed down, closing a circuit to a solenoid. The solenoid raises a firing lever, which opens a stop cylinder valve allowing ship service air to flow to a stop cylinder. (A hand firing key also is attached to the firing lever for use during casualty to the electric circuit, or for testing the firing mechanism.

Air entering the stop cylinder moves the stop piston rod and, therefore, the gyro retraction slide and the stop rod. This causes the gyro setting spindle and the stop bolt to retract. The breech end of the stop piston rod moves through a matching hole in a firing interlock shutter bar, contacts a pilot valve stem and opens the pilot valve. This vents air pressure above the firing valve; the firing valve opens, and high pressure impulse air passes into the tube, launching the torpedo. Figures 132, 133, and 134 are simplified schematic diagrams illustrating operation of the firing system.

Included in the complete firing system are an impulse tank, piping to connect the impulse tank to the firing valve, and electric firing and indicating circuits.

In some ships, all impulse tanks are mounted either inside or outside the pressure hull; in other

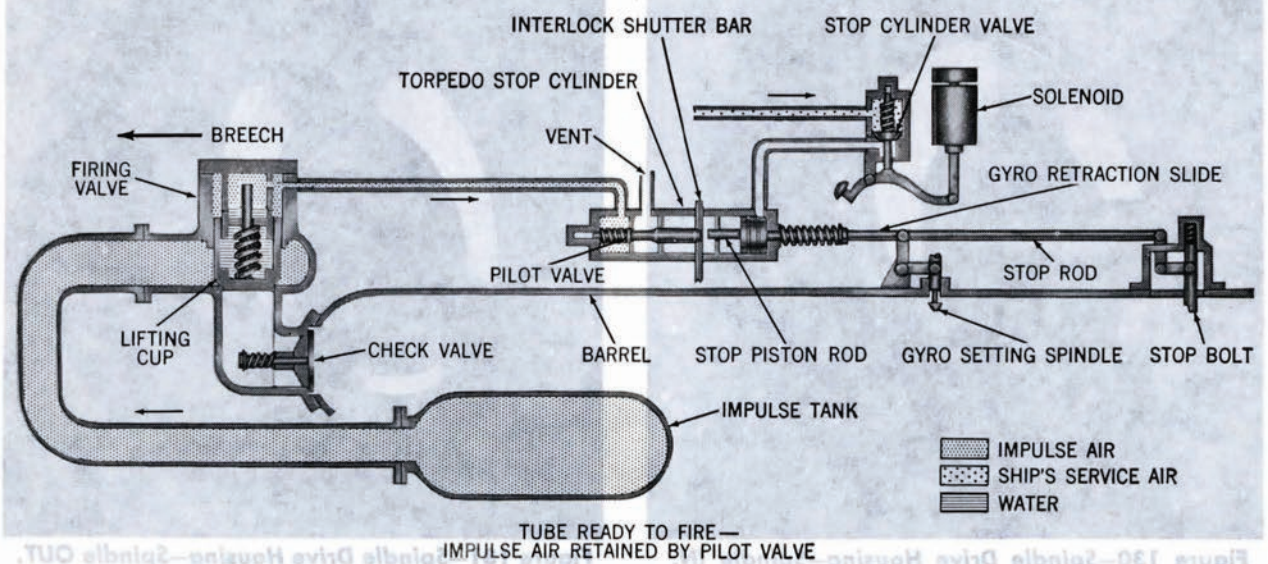


Figure 132—*Firing Mechanism Schematic Diagram—Tube Ready to Fire.*

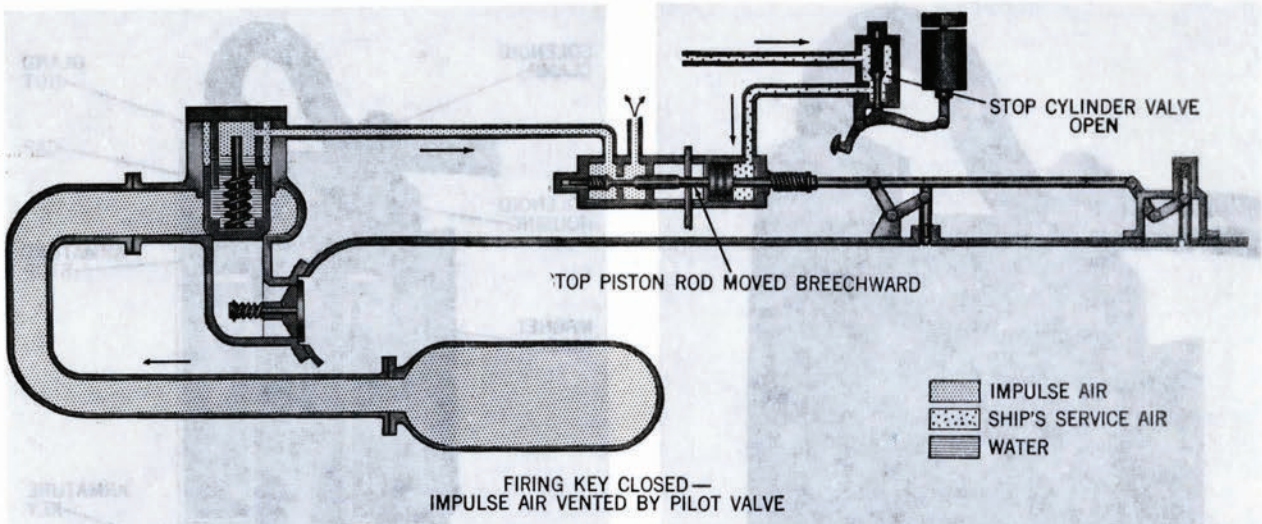


Figure 133.—*Firing Mechanism Schematic Diagram—Firing Key Closed.*

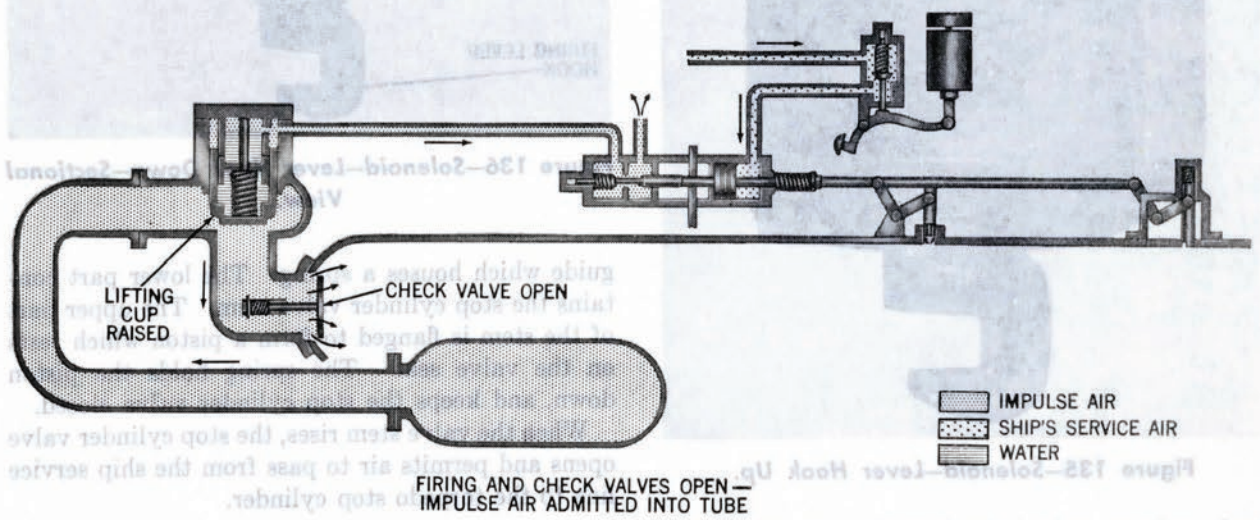


Figure 134—*Firing Mechanism Schematic Diagram—Firing and Check Valves Open.*

ships, forward tanks are mounted outside, and after tanks inside the pressure hull. Each impulse tank, serving one torpedo tube, has a capacity of seven cubic feet of compressed air and is charged from the submarine high pressure air system.

Firing Mechanism Units

There are eight (nine, if the impulse stop valve is installed) separate but related units comprising the firing mechanism. They are described in their operation sequence, although their operations, except for the impulse stop valve, are practically simultaneous.

Solenoid. The solenoid, figure 135, is mounted on a bracket secured to the stop cylinder casting; it is wired in series with the firing circuit. In the lower part of the solenoid, a firing lever hook is attached to a movable iron core or armature, figure 136. The magnetic field caused by the current passing through the solenoid winding draws the armature upward and raises the firing lever

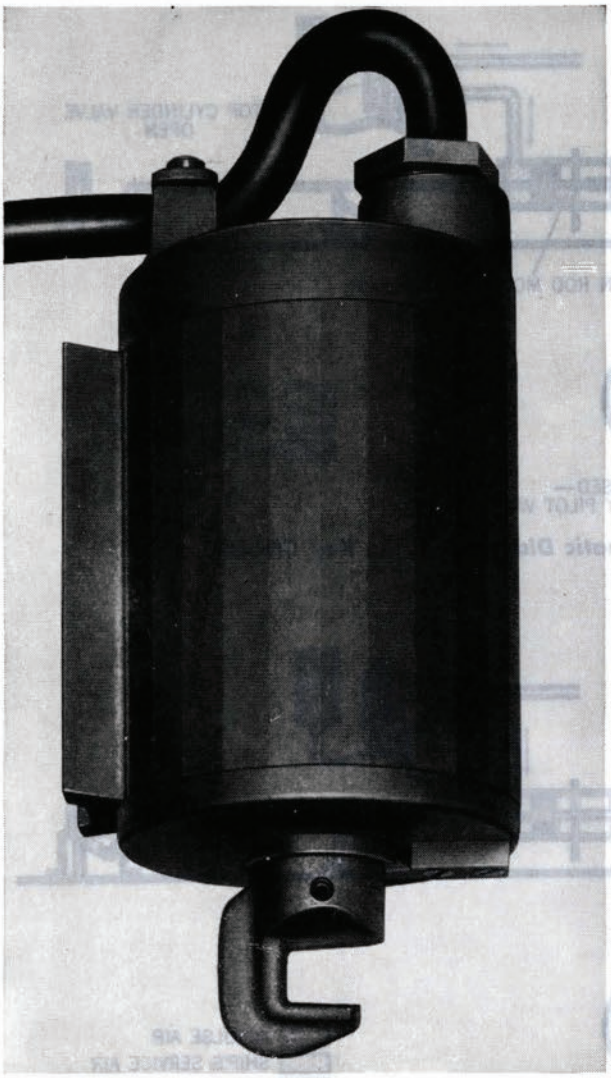


Figure 135—*Solenoid—Lever Hook Up.*

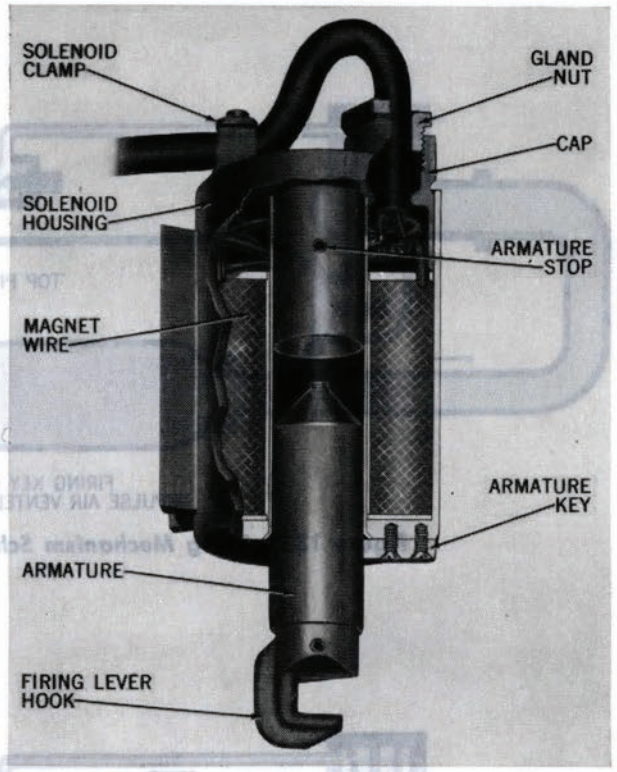


Figure 136—*Solenoid—Lever Hook Down—Sectional View.*

hook and one end of the firing lever to which the hook is attached.

Firing Lever. A projection on the upper end of the firing lever contacts the lower end of a stop cylinder valve stem, figures 137 and 138. A hand firing key is at the lower end of the firing lever. When the solenoid, or pressure on the hand firing key, raises the firing lever, the projection on the firing lever forces the stop cylinder valve stem upward. A guard placed around the firing lever prevents accidental operation of the firing mechanism, figure 139.

Stop Cylinder Valve. The upper part of the stop cylinder valve chamber contains a valve guide which houses a spring. The lower part contains the stop cylinder valve stem. The upper part of the stem is flanged to form a piston which rests on the valve seat. The spring holds the piston down, and keeps the stop cylinder valve closed.

When the valve stem rises, the stop cylinder valve opens and permits air to pass from the ship service line to the torpedo stop cylinder.

Torpedo Stop Cylinder. Ship service air entering the torpedo stop cylinder, figure 140, forces the stop piston rod (the breech end of which operates inside the torpedo stop cylinder) toward the breech of the tube. The muzzleward end of the stop piston rod is joined to the gyro retraction slide, which, in turn, is coupled to the stop rod so that all operate as a unit. As the stop piston rod moves breechward, its muzzleward end carries with it the gyro retraction slide and stop rod, retracting the gyro setting spindle and the stop bolt.

The breech end of the stop piston rod projects through the stop cylinder into a recess open to

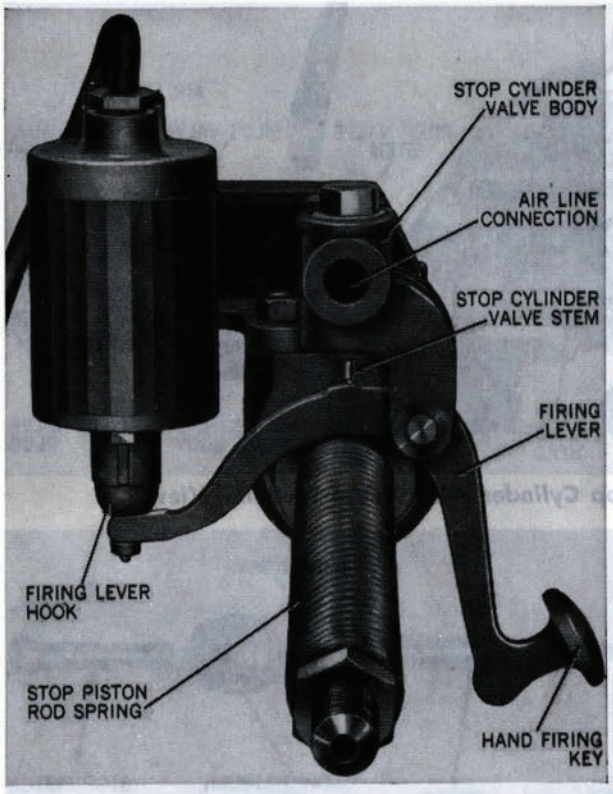


Figure 137—*Solenoid, Firing Lever, and Stop Cylinder—Lever Hook Down—Stop Cylinder Valve Closed.*

Figure 138—*Solenoid, Firing Lever, and Stop Cylinder—Lever Hook Up—Stop Cylinder Valve Open.*

atmospheric pressure. The interlock shutter bar slides through a slot in this recess. When the tube is ready to fire, the interlock shutter bar is positioned so that the end of the stop piston rod lines up with a hole in the shutter bar through which the stop piston rod passes. If the tube is not ready to be fired, the end of the stop piston rod engages a shallow bore in the shutter bar. This prevents movement of the stop piston rod, and the tube cannot be fired.

As the stop piston rod moves breechward it contacts and pushes a pilot valve stem, tripping a pilot valve which is contained in the same housing as the torpedo stop cylinder. The muzzleward end of this cylinder is closed by the stop cylinder head which has a hole through which the stop piston rod slides, figures 141 and 142. When closed, a spring holds the stop piston rod in its extreme muzzleward position.

The stop cylinder valve body is mounted on the top of the stop cylinder. A passage from the stop

Figure 139—*Guard Over Firing Lever.*

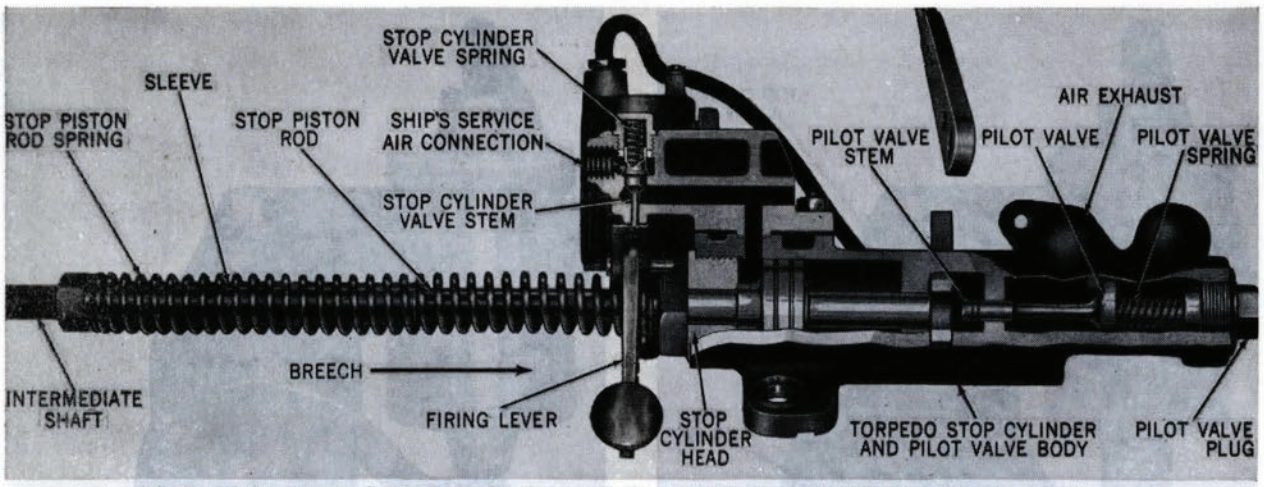


Figure 140—*Torpedo Stop Cylinder and Stop Cylinder Pilot Valve—Sectional View.*

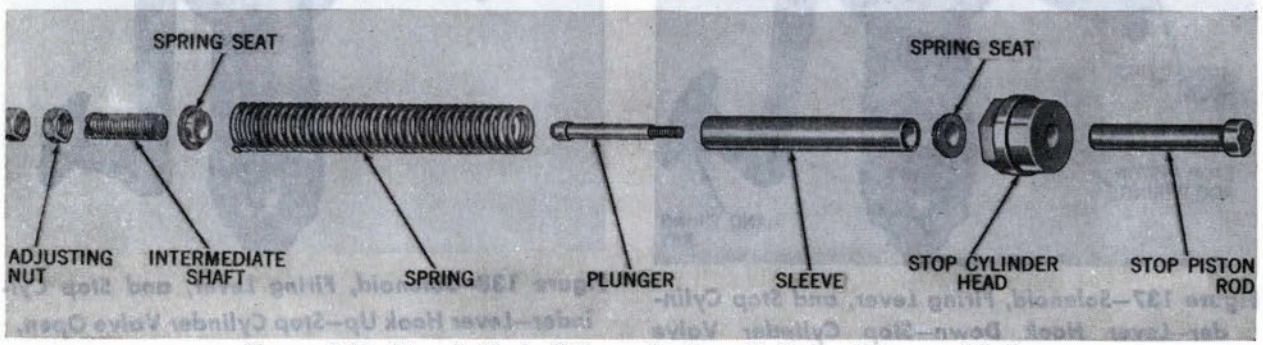


Figure 141—*Muzzle End of Torpedo Stop Cylinder Disassembled.*

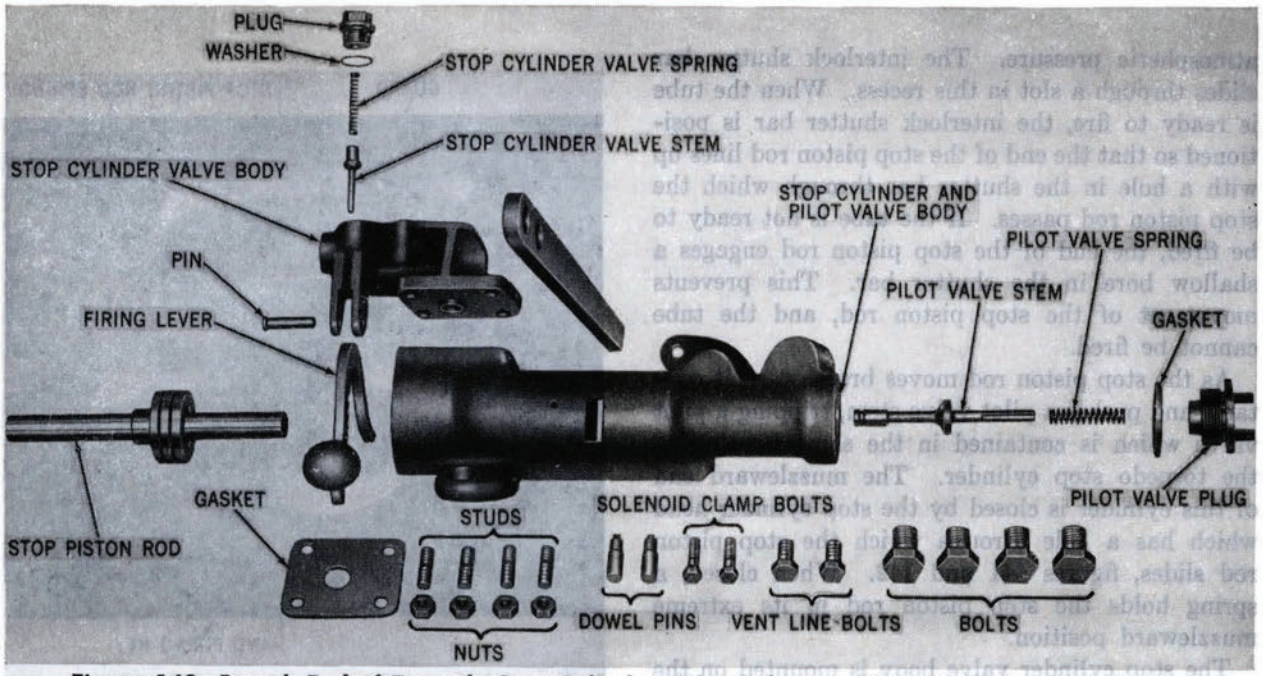


Figure 142—*Breech End of Torpedo Stop Cylinder, Pilot Valve, and Stop Cylinder Pilot Valve—Disassembled.*

cylinder leads up to the stop cylinder valve chamber into which the ship service air line is connected.

Pilot Valve. The pilot valve, in the breechward end of the stop cylinder and pilot valve body, consists of a pilot valve stem, flanged in the middle to form a piston which rests against the valve seat. Spring pressure holds the valve closed. When tripped by the stop piston rod, the pilot valve opens and vents the impulse air pressure from above the firing valve, allowing the pressure below to force the firing valve open. The breechward end of the housing is closed by a plug.

Impulse Stop Valve. Only a few submarines have impulse stop valves installed. As originally used in the firing mechanism, this valve provided a closure between the impulse tank and the firing valve. It is open except when used for access to the firing valve without "blowing down" the impulse tank.

The stop valve, installed in the air line leading from the impulse tank to the firing valve, has its seat inside a stop valve body. A bonnet attached to the valve body is bored for a valve stem and has a bracket for the interlock shutter bar, figure 143.

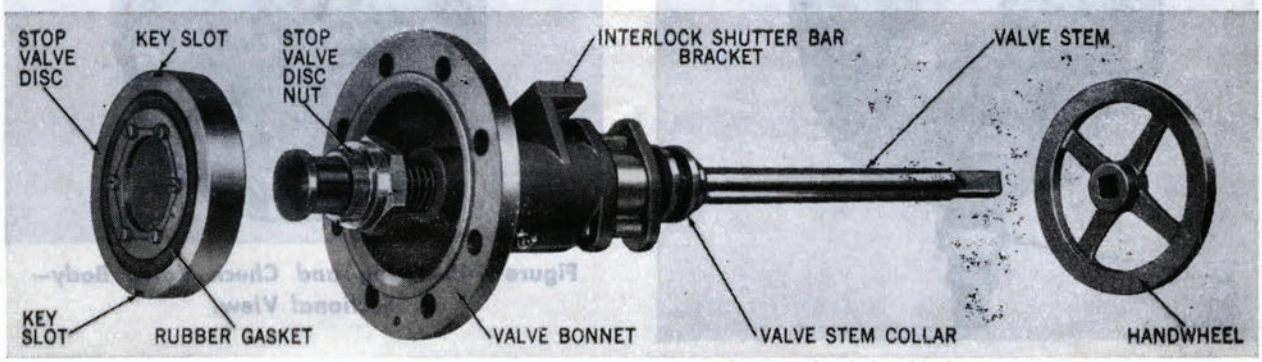


Figure 143—*Impulse Stop Valve Partly Disassembled.*

The valve stem projects through the bonnet and is turned by means of a handwheel attached to its outer end. A valve disc, which is prevented from turning by its engagement with two keys in the valve body, is mounted on the inner end of the valve stem. When the valve is closed, the valve disc comes up against the valve seat. A gasket mounted in the valve disc provides an air tight seal.

When the valve stem is turned, the valve disc moves longitudinally inside the valve body and operates the valve. When open, the valve admits high pressure air to the firing valve from the impulse tank. When closed, it prevents this flow of air.

Firing Valve. The upper part of the firing and check valve body, figure 144, houses the firing valve and the lower part houses the check valve. The firing valve, spindle type, is closed by a lifting cup, held against a valve seat by its own weight and spring pressure, figure 145.

The spring is opposed by an orifice cup, the upper circumference of which comes up against a skirt on a firing valve head which is attached to the top of the firing and check valve body. A lifting cup ring and an orifice cup ring fit into grooves in their respective cups, figure 146.

A throttling rod, of varying diameter, secured in the base of the lifting cup, extends upward through a hole in the center of the orifice cup and through a bearing in the firing valve head. The small clearance around this rod, where it passes through the hole in the orifice cup, constitutes an orifice through which some of the fresh water in the firing valve must pass when the lifting cup is forced upward by impulse pressure at the instant of firing. The effect of this feature is to retard somewhat the opening motion of the lifting cup, hence the impulse air is prevented from rushing into the barrel fast enough to build up excessive pressure behind the torpedo.

NAVORD ORDALT 2887 modifies firing valves to facilitate assembly by the addition of a spider attached to the throttling rod by a cotter pin. This spider prevents the firing valve head ring from escaping from its groove in the orifice cup as the

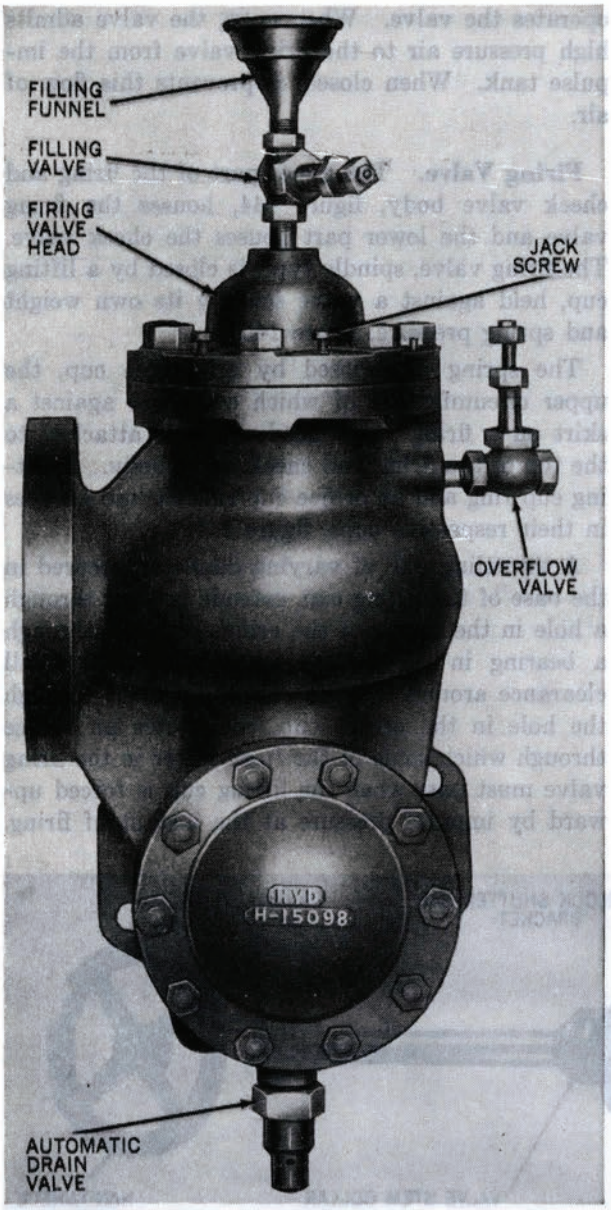


Figure 144—*Firing and Check Valve Body—Outboard Side.*

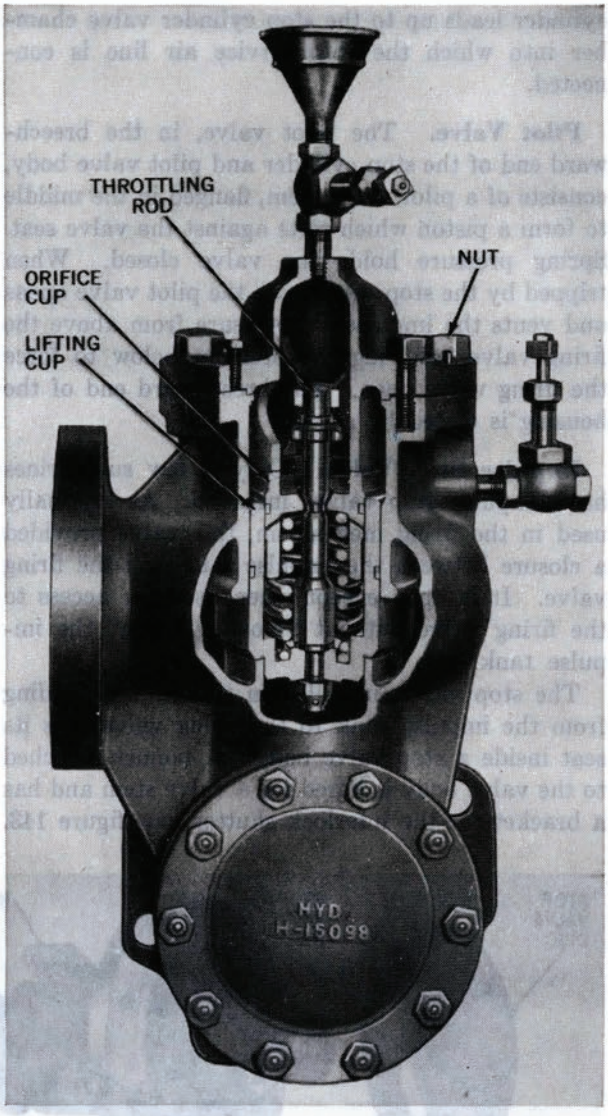


Figure 145—*Firing and Check Valve Body—Sectional View.*

firing valve is assembled. The lifting cup, spring, throttling rod, orifice cup, firing valve head ring, and spider can be completely assembled on a work bench and checked for freedom of operation. The complete assembly then can be installed in the firing valve body aboard the submarine without danger of jamming or scoring.

The firing and check valve body has a lower flange for attachment to the barrel, and an upper flange for connection to an air line from the impulse tank. A filling valve is installed in the top of the firing valve head, and an overflow valve in the upper part of the firing and check valve body. Each of these valves is operated by turning a square knob. A wrench is required to turn the knob, preventing unintentional operation. Another opening in the upper part of the firing and check valve body connects with a line to the pilot valve.

With no air, except atmospheric pressure, in the impulse tank and firing and check valve body, the firing valve is held seated by spring pressure and

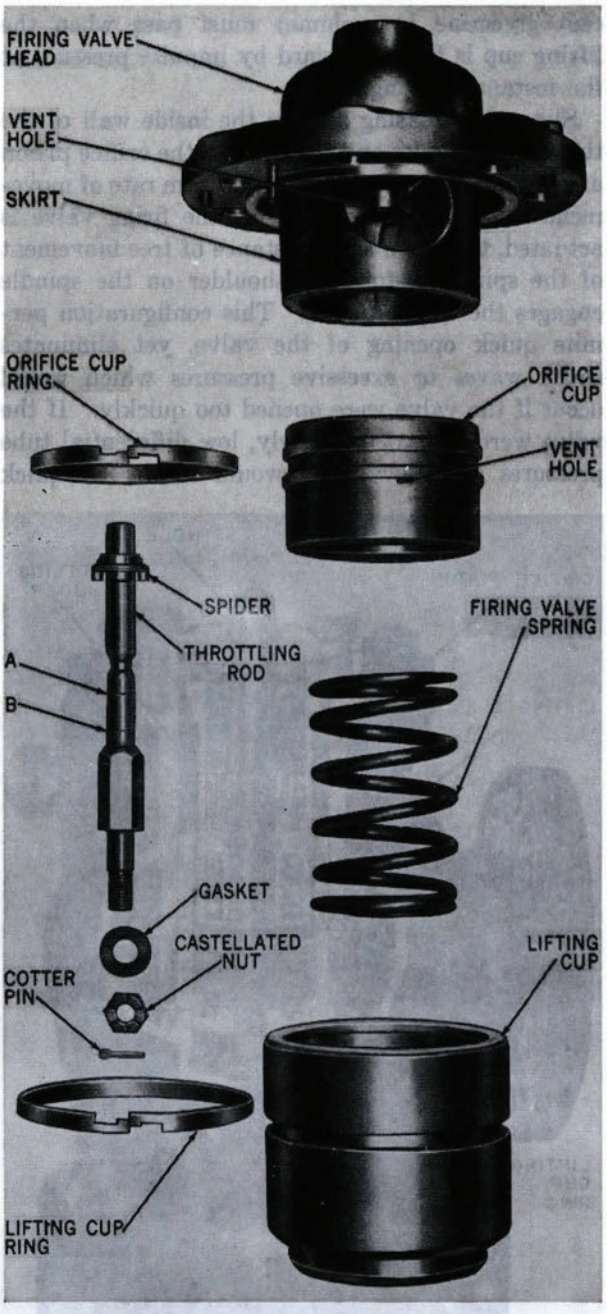


Figure 146—*Firing Valve Disassembled.*

gravity. The impulse stop valve, if installed, should be open. The filling and overflow valves are opened, and clean fresh water is poured into the filling funnel. The water fills the lifting cap, the upper part of the orifice cup, and lower part of the skirt on the firing valve head, up to the level of a vent hole in the skirt. This is a slow process, since water must filter through the small opening in the orifice cup to fill the lifting cup. The water passes through the vent hole to the space between the skirt and the inside of the valve body which is open to the overflow valve. When water cannot be added without the same quantity flowing from the overflow valve, the firing valve is filled. Then the filling and overflow valves are closed.

When the impulse tank is charged, impulse air passes into the firing and check valve body and around the lower exterior surface of the lifting cup. Pressure in the impulse tank is built up slowly to allow the air to leak by the lifting cup ring to the space above the lifting cup. Thus, the pressure above and below the lifting cup is equalized, and the firing valve remains closed. When the upper part of the firing and check valve body has filled with impulse air, the only force acting to open the firing valve is the impulse pressure on the outside bottom beveled surface of the lifting cup, immediately above the valve seat. The forces acting to close the valve are greater and consist of the weight of the lifting cap, spring pressure, and impulse pressure on the whole circular area of the lifting cup. Spring pressure and the weight of the cup are negligible compared to the impulse pressure force.

When the pilot valve is opened, the impulse pressure above the lifting cup is vented. The pressure acting on the outside beveled surface of the lifting cup then raises the lifting cup and the throttling rod, opening the firing valve and firing the tube. The diameter of the throttling rod, as it passes through the orifice, gradually decreases, thus increasing the area of the orifice and offering less resistance to the flow of water as the lifting cup rises. Simultaneously, the intensity of the impulse pressure is diminishing as a result of expansion into the barrel.

It is necessary to prime the firing valve for each shot, since a substantial amount of water is lost in firing. Excessive tube pressure will result from insufficient water in the throttling chamber.

The following description is applicable to sealed-throttle type firing valves for those torpedo tubes on which Ordalt 2888 has been accomplished.

The upper part of the firing and check valve, figure 147, houses the firing valve and the lower part houses the check valve. The firing valve, sealed throttle type, is closed by a lifting cup, held

against a valve seat by its own weight and spring pressure, figure 148. The spring is opposed by the throttling cylinder which is attached to the top of the firing and check valve body. A lifting cup ring fits into the groove in the lifting cup.

A spindle is secured to the base of the lifting cup by means of an adapter designed to compensate for any eccentricity existing between the valve body bore and the throttling cylinder. The spindle extends upward through the throttling cylinder. An orifice piston is secured to the spindle by means of a shoulder below and flat spring secured by two retaining rings above. Small holes drilled in the piston constitute the orifices through which the throttling fluid (80 percent distilled water—20 percent glycerine by volume) must pass when the lifting cup is forced upward by impulse pressure at the instant of firing.

Slots of increasing area in the inside wall of the throttling cylinder and the holes in the orifice piston are employed to impart a non-uniform rate of movement to the lifting cup. When the firing valve is actuated, there is a short distance of free movement of the spindle before the shoulder on the spindle engages the orifice piston. This configuration permits quick opening of the valve, yet eliminates shock waves or excessive pressures which would occur if the valve were opened too quickly. If the valve were opened too slowly, low differential tube pressures and slow firing would result. A quick

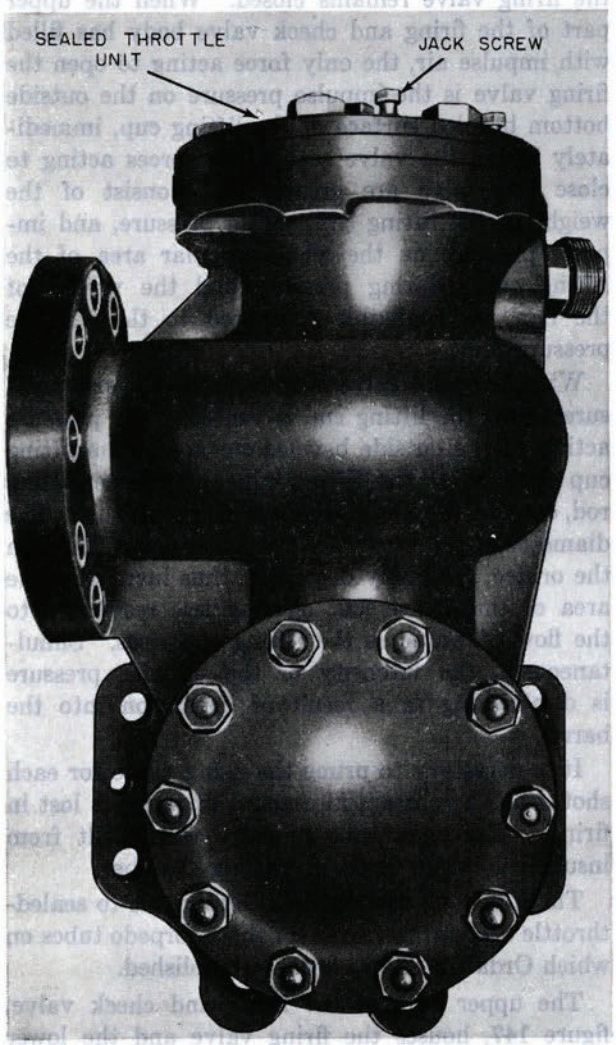


Figure 147—*Firing and Check Valve Body (Sealed Throttle Unit Installed) Outboard Side.*

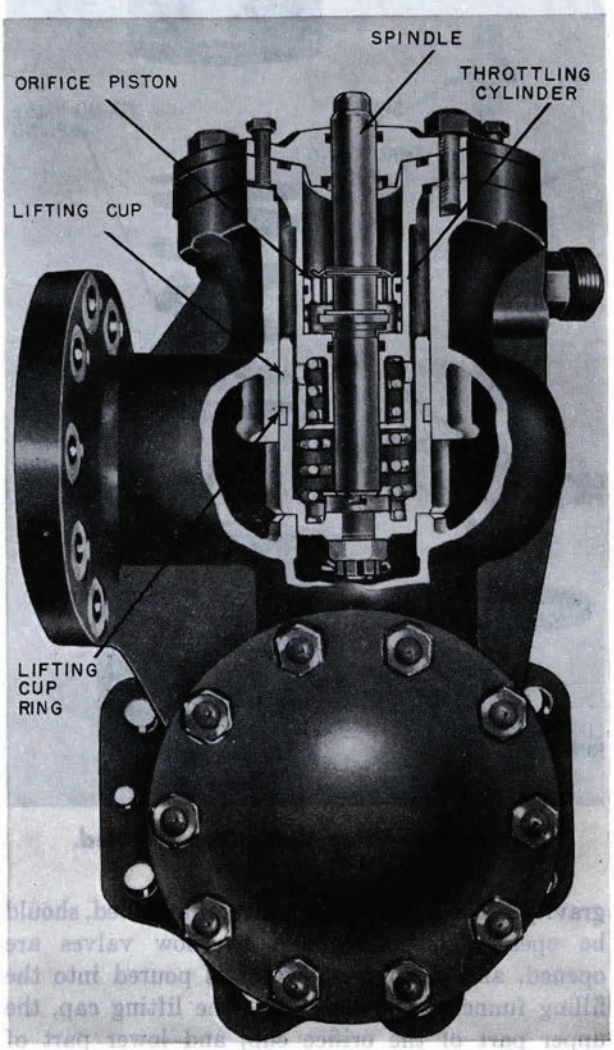


Figure 148—*Firing and Check Valve Body (Sealed Throttle Unit Installed) Sectional View.*

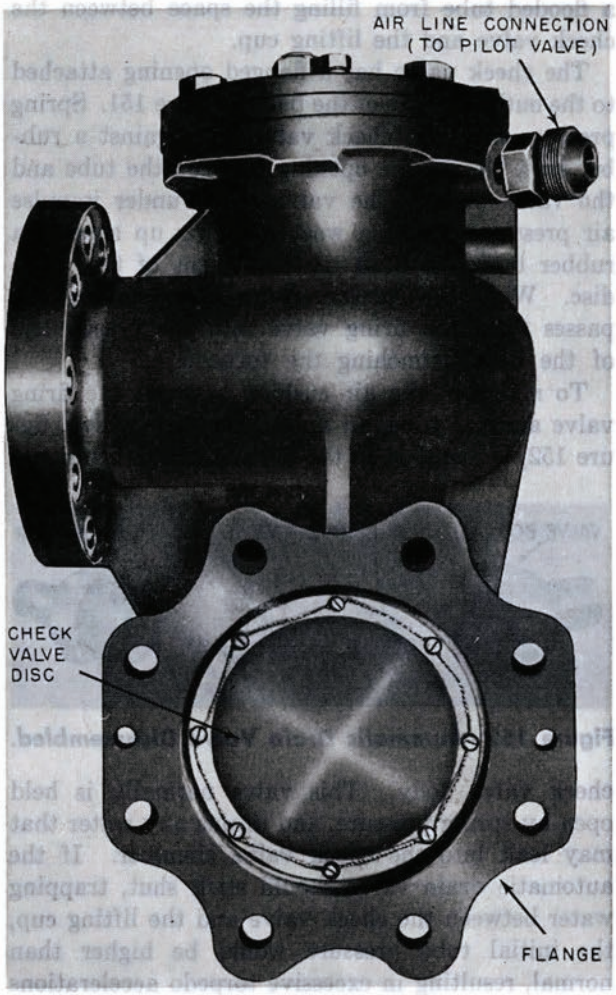


Figure 149—*Firing and Check Valve Body (Sealed Throttle Unit Installed) Inboard Side.*

return feature, consisting of four one-quarter-inch drilled holes, is incorporated in the orifice piston. When the lifting cup is reseated either by spring pressure or by service air from the lifting cup loading valve, the orifice piston does not retard the motion of the lifting cup because the drilled holes are uncovered during downward movement of the spindle. In this manner, the save-air feature of the firing system is efficiently employed.

The firing and check valve body has a lower flange for attachment to the barrel and an upper flange for connection to an air line from the impulse tank, figure 149. Two filling and vent plugs are incorporated in the throttle cylinder cover. An allen wrench is required to remove these plugs. Another opening in the upper part of the firing and check valve body connects with a line to the pilot valve. The opening in which the overflow valve was originally installed is now sealed with a pipe plug. This plug permanently seals the overflow opening and should never be removed.

With no air, except atmospheric pressure, in the impulse tank and firing check valve body, the firing valve is held seated by spring pressure and gravity. The impulse stop valve, if installed, should be open.

When the impulse tank is charged, impulse air passes into the firing and check valve body and around the lower exterior surface of the lifting cup. Pressure in the impulse tank is built up slowly to allow the air to leak by the lifting cup ring to the space above the lifting cup. Thus, the pressure above and below the lifting cup is equalized, and the firing valve remains closed. When the upper part of the firing and check valve body has filled with impulse air, the only force acting to open the firing valve is the impulse pressure on the outside bottom beveled surface of the lifting cup, immediately above the valve seat. The forces acting to close the valve are greater and consist of the weight of the lifting cup, spring pressure, and impulse pressure on the circular area of the lifting cup. Spring pressure and the weight of the cup are negligible compared to the impulse pressure force.

When the pilot valve is opened, the impulse pressure above the lifting cup is vented. The pressure acting on the outside beveled surface of the lifting cup then raises the lifting cup and spindle, opening the firing valve and firing the tube. As the spindle and orifice piston move upward, there is less resistance to the flow of throttling fluid due to the increasing area of the slots in the throttling cylinder wall. Simultaneously, the intensity of the impulse pressure is diminishing as a result of expansion into the barrel.

Check Valve. This valve, figure 150, presents full impulse tank pressure from being transmitted to the tube when the firing valve is first opened, and sea water from entering the firing system when the torpedo tube is flooded. To prevent damage to the torpedo afterbody from impulse air pressure when the firing valve is first opened, an air cushion is required between the firing valve and the afterbody. After firing, the check valve prevents water from passing the firing valve and backing up into the impulse air line, and also keeps sea water from

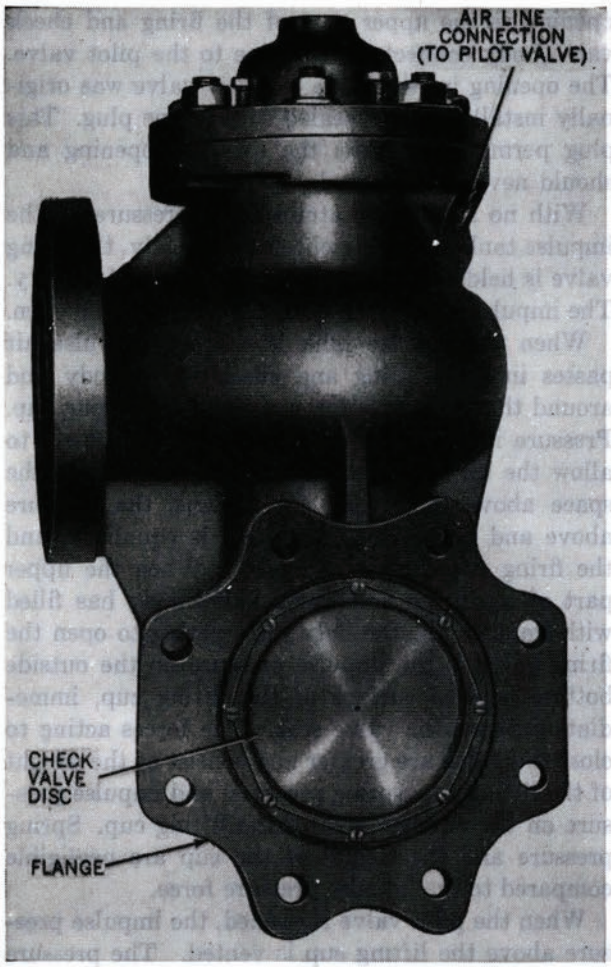


Figure 150—*Firing and Check Valve Body—Inboard Side.*

a flooded tube from filling the space between the check valve and the lifting cup.

The check valve has a flanged opening attached to the outboard side of the barrel, figure 151. Spring pressure seats the check valve disc against a rubber seat, closing the opening between the tube and the valve body. The valve opens under impulse air pressure, a spring washer taking up against a rubber buffer to limit the movement of the valve disc. When the check valve is open, impulse air passes from the firing valve into the breech end of the tube, launching the torpedo.

To maintain the air cushion between the firing valve and the tube, an automatic drain valve, figure 152, is installed in the bottom of the firing and

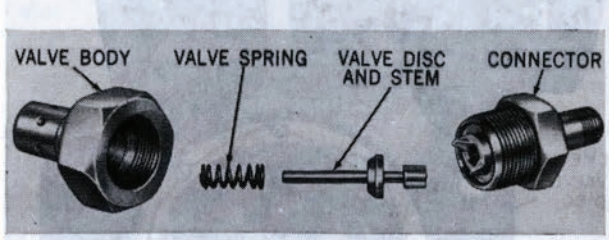


Figure 152—*Automatic Drain Valve Disassembled.*

check valve body. This valve normally is held open by spring pressure, and drains any water that may leak into the check valve chamber. If the automatic drain valve should stick shut, trapping water between the check valve and the lifting cup, the initial tube pressure would be higher than normal, resulting in excessive torpedo accelerations and possible damage to the torpedo.

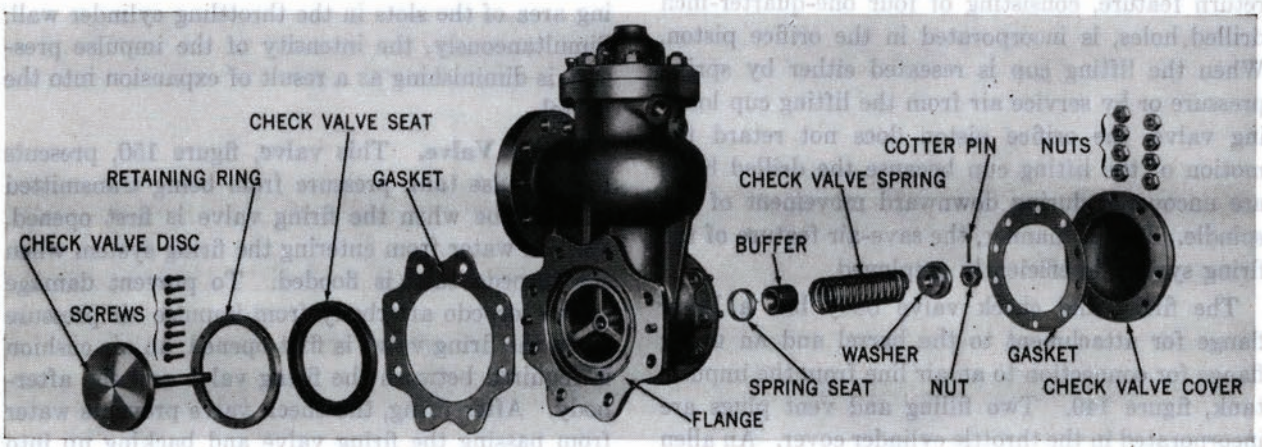


Figure 151—*Check Valve Disassembled.*

When the tube is fired, air pressure builds up in the check valve chamber and closes the drain valve.

NOTE: The automatic drain valve is removed only when its removal is required to carry out routine maintenance. When the valve is removed, the outlet is left open to prevent water from accumulating in the check valve chamber.

Interlock Features

Before the firing interlock lever can be set at TUBE READY TO FIRE, the following settings must be made:

1. Breech and muzzle door interlock lever set at MUZZLE DOOR UNLOCKED.
2. Drain valve and muzzle door interlock lever at DRAIN VALVE LOCKED.
3. Depth and speed setting spindles at OUT.
4. Impulse stop valve (if installed) at OPEN.

When the above settings are made, the muzzle door operating shaft is released; the muzzle door can be opened, and the firing interlock lever can be moved to TUBE READY TO FIRE. When this setting is made, the interlock sleeve is rotated, locking the other mechanisms and bringing the firing interlock bolt down. Movement of the muzzle door operating shaft is thereby prevented and the muzzle door is locked open, chapter 16. At the same time, the firing interlock shutter bar moves to lock open the impulse stop valve (if installed) and bring the opening in the shutter bar into line with the stop piston rod. Then the stop piston rod can contact the pilot valve stem, tripping the pilot valve and setting the firing valve in operation.

Electrical Circuits

The electrical firing and indicating circuits, while not part of the firing mechanism, are part of the firing system. For detailed information on these circuits, refer to the builder's plans, the ship's General Information book, and the Record of Electrical Auxiliaries, Volume 1, which are supplied to each vessel.

Three electrical circuits directly concerned with the operation of the torpedo tube are:

1. Torpedo control circuit (Circuit GA), comprising power and synchro circuits to the gyro setting indicator-regulator.
2. Torpedo firing circuit (Circuit 6PA), comprising means by which the firing solenoids are energized selectively from the firing station in the conning tower. Firing circuits are interrupted by switches on the battle order transmitters and by the firing interlock switch at each torpedo tube.
3. Torpedo battle order and ready light circuit (Circuit 6R), transmitting battle orders from the conning tower to the torpedo rooms and indicates, by ready lights at the torpedo firing station, the state of readiness of the tubes.

The electrical interlock consists of a plunger switch in series with the firing key. Setting the firing interlock lever at TUBE READY TO FIRE closes the switch and lights the ready lamp to indicate that the tube is ready to fire. When the firing interlock lever is set at MUZZLE DOOR CLOSED, the shutter bar keeps the switch open.

Chapter 13

FIRING MECHANISM

FOR TUBES EQUIPPED FOR MECHANICAL AND ELECTRICAL SETTING

Complete firing mechanism is used to start the ejection process of a torpedo from the tube by admitting impulse air near the breech end. It may be used, with or without the poppet valve, to eject either mechanically or electrically set torpedoes. For normal impulse firing, the mechanism is actuated mechanically by a solenoid that is energized by closing an electrical firing key. Alternately, the firing mechanism can be actuated manually by pulling out the HAND FIRE handle of the hand firing lever assembly.

For silent fire of electrically set 19-inch torpedoes, only the power transfer switch of the firing mechanism is used. The switch is thrown from NORMAL POWER to EMERGENCY POWER by pulling out the SILENT FIRE handle of the hand firing lever assembly. For this type of fire, the rest of the firing mechanism is inactive.

Runout firing of electrically set 19-inch torpedoes differs from silent firing in that the stop bolt is raised by ship service air instead of manually. To fire a runout torpedo, the tube is made ready to fire without pressure in the impulse flask and without use of the poppet valve. The tube may then be fired electrically or manually (hand firing) in the same way as for impulse firing. However, in runout firing, the tube firing circuit should be bypassed after five seconds (when firing electrically). The firing plunger should be returned manually 20 seconds after the stop bolt has lifted.

Before the firing mechanism can be operated, the entire interlocking mechanism must be properly set with the breech door closed, the muzzle door open, the drain valve closed, and the depth and speed setting spindles retracted from the torpedo into their housings. For electrically set torpedoes, the gyro setting spindle is retracted before loading the torpedo and is kept retracted. For mechanically set torpedoes, this spindle is automatically retracted by the firing mechanism.

Components

The firing mechanism includes parts of other tube assemblies as well as its own components. Each of these is shown schematically in figure 153 and is described in the following paragraphs.

Solenoid. The solenoid, figures 154 and 155, is mounted on a bracket, secured to the torpedo stop cylinder casting. It is wired in series with the 115-volt, 60-cycle, alternating current firing circuit through the transfer switch. The spring-loaded vertical plunger of the solenoid, figure 155, is pinned at the bottom to a plunger extension. The forked lower end of the extension is pinned to a lever arm at the breech end of a lever shaft, figure 156. The other end of this shaft has two lever arms that extend upward at right angles to the first arm. One of these arms engages the firing plunger extension; the other is engaged by the hand firing lever in HAND FIRE. When the solenoid is energized by closing the electrical firing key, the solenoid plunger and extension are pulled one-half inch upward. By the lever shaft and arms, solenoid action forces the firing plunger inboard, figure 157.

Torpedo Stop Cylinder Valve. The torpedo stop cylinder valve, figure 158, consists of a firing plunger that slides in a body secured to the top of the torpedo stop cylinder. From the position shown in figures 156 and 157, the firing plunger is forced inboard by solenoid or hand firing lever action. In this inboard (open) position, through an internal port, the plunger ports ship service air to the anti-refire valve. The firing plunger will remain in this open position without the electrical firing key or the hand firing lever being held in the "fired" position. Movement of the ready-to-fire interlock lever to MUZZLE DOOR UNLOCKED acts through a cam on the interlock sleeve and a finger on the valve body to return the firing plunger to its original (outboard) position. (See figures 153, 166, and 169.)

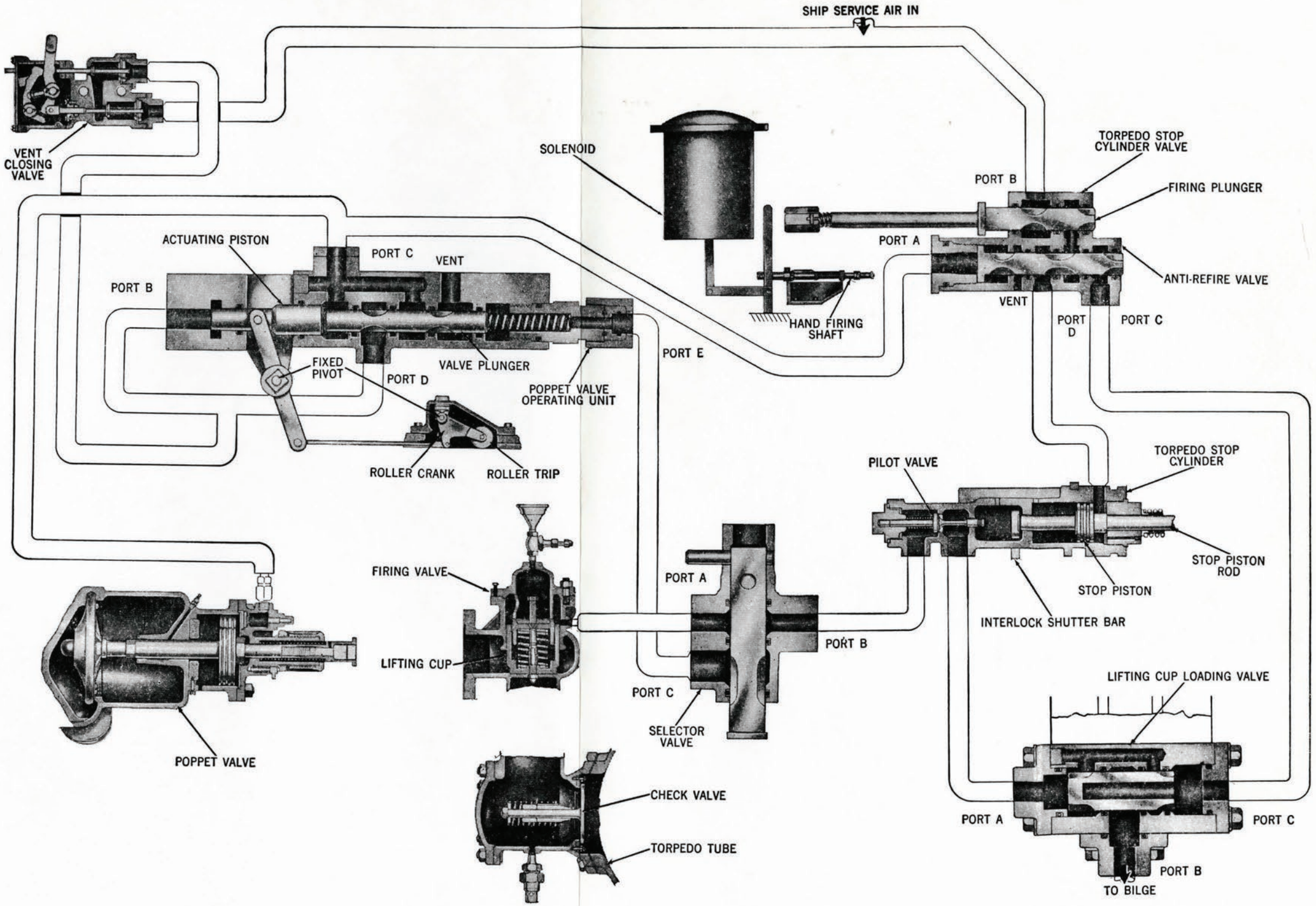


Figure 153—*Firing Mechanism Schematic Diagram—Ready to Fire Without Poppet Valve.*

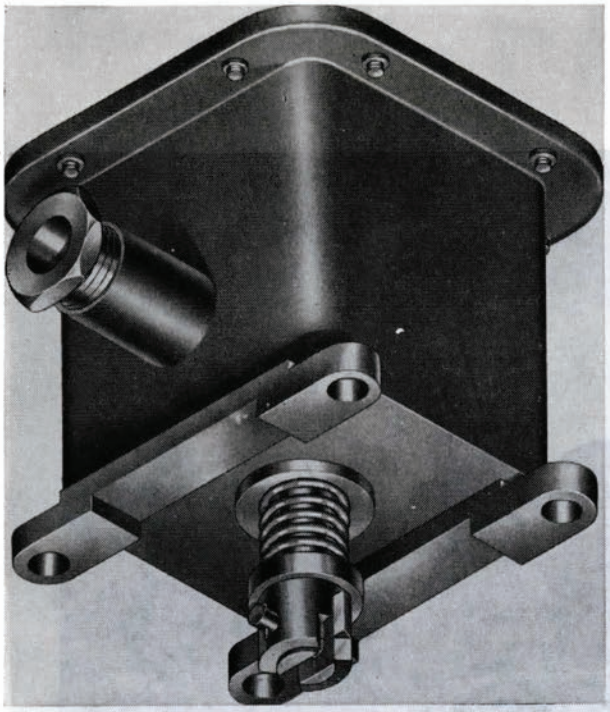


Figure 154—*Firing Solenoid.*

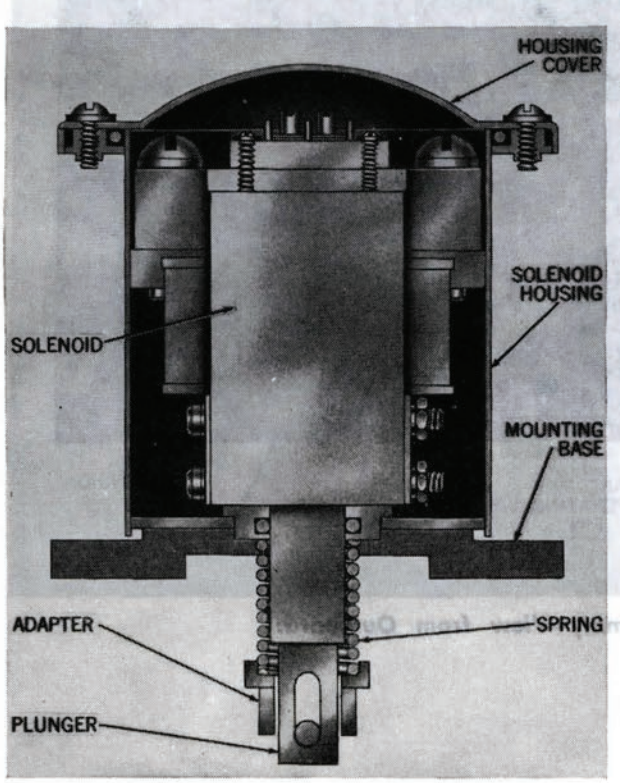


Figure 155—*Firing Solenoid—Sectional View.*

Anti-refire Valve. The anti-refire valve, figure 158, is a two-position plunger in the same body with the firing plunger of the torpedo stop cylinder valve. With other units of the firing mechanism, the anti-refire valve prevents accidental refiring of the tube. When the poppet valve is used in firing, and after the firing valve has opened, the anti-refire plunger is shifted by ship service air from the poppet valve operating unit. This cuts off ship service air to the torpedo stop cylinder and ports it to the lifting cup loading valve. The anti-refire plunger stays in this position until pushed back by the ready-to-fire interlock in the same manner as the firing plunger.

Torpedo Stop Cylinder. Primarily a part of the torpedo stop mechanism, the torpedo stop cylinder, figure 159, also forms a part of the firing mechanism. Forced breechward by ship service air from the stop cylinder valve through the anti-refire valve, the stop piston and rod act to lift the torpedo stop bolt; and, for mechanically set torpedoes, they retract the gyro setting spindle. At the same time, the stop piston rod opens a pilot valve in the stop cylinder against spring action. This vents the space above the firing valve lifting cup to cause the firing valve to open.

Pilot Valve. The pilot valve is a spring-loaded valve and stem in the torpedo stop cylinder. Normally closed, this valve holds the pressure above the lifting cup in the firing valve until forced open by the stop piston rod. At the same time that the poppet valve opens, the pilot valve is air-operated to re-open to load the top of the firing valve lifting cup again. For this action, the pilot valve is dependent on the positions of the anti-refire plunger and the lifting cup loading valve.

Lifting Cup Loading Valve. The lifting cup loading valve, figures 160 and 161, is a two-position plunger that is moved from one end of its cylinder to the other by air pressure. In one position, the valve connects the pilot valve in the torpedo stop cylinder to a vent line to bilge. This occurs when the stop piston rod forces the pilot valve off its seat to vent the space above the firing valve lifting cup. In its other position, the lifting cup loading valve connects ship service air supply from the anti-refire valve to the pilot valve. This happens when air pressure from the poppet valve operating unit moves the anti-refire plunger. With the lifting

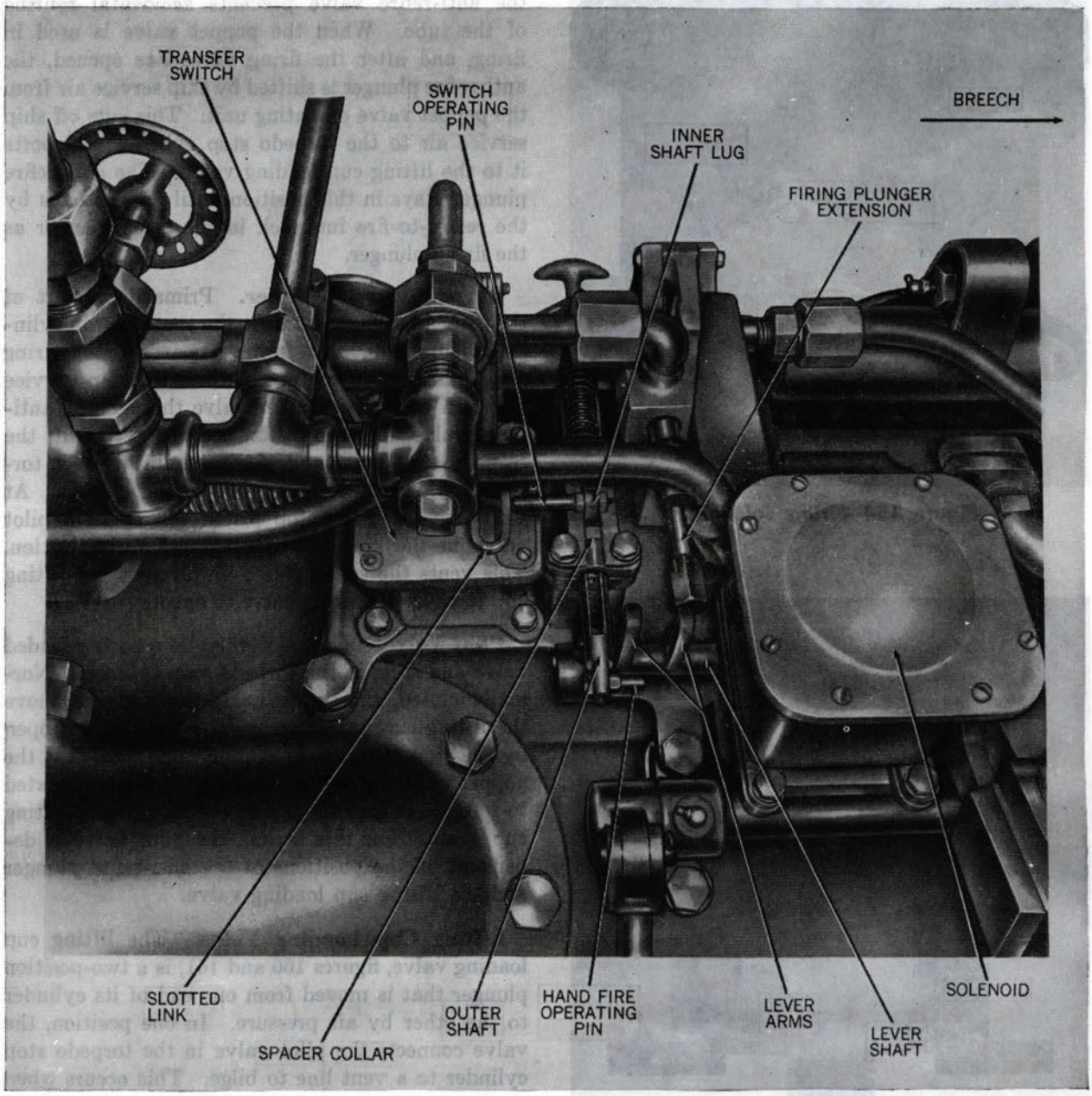


Figure 156—*Firing Lever Assembly—View from Outboard.*

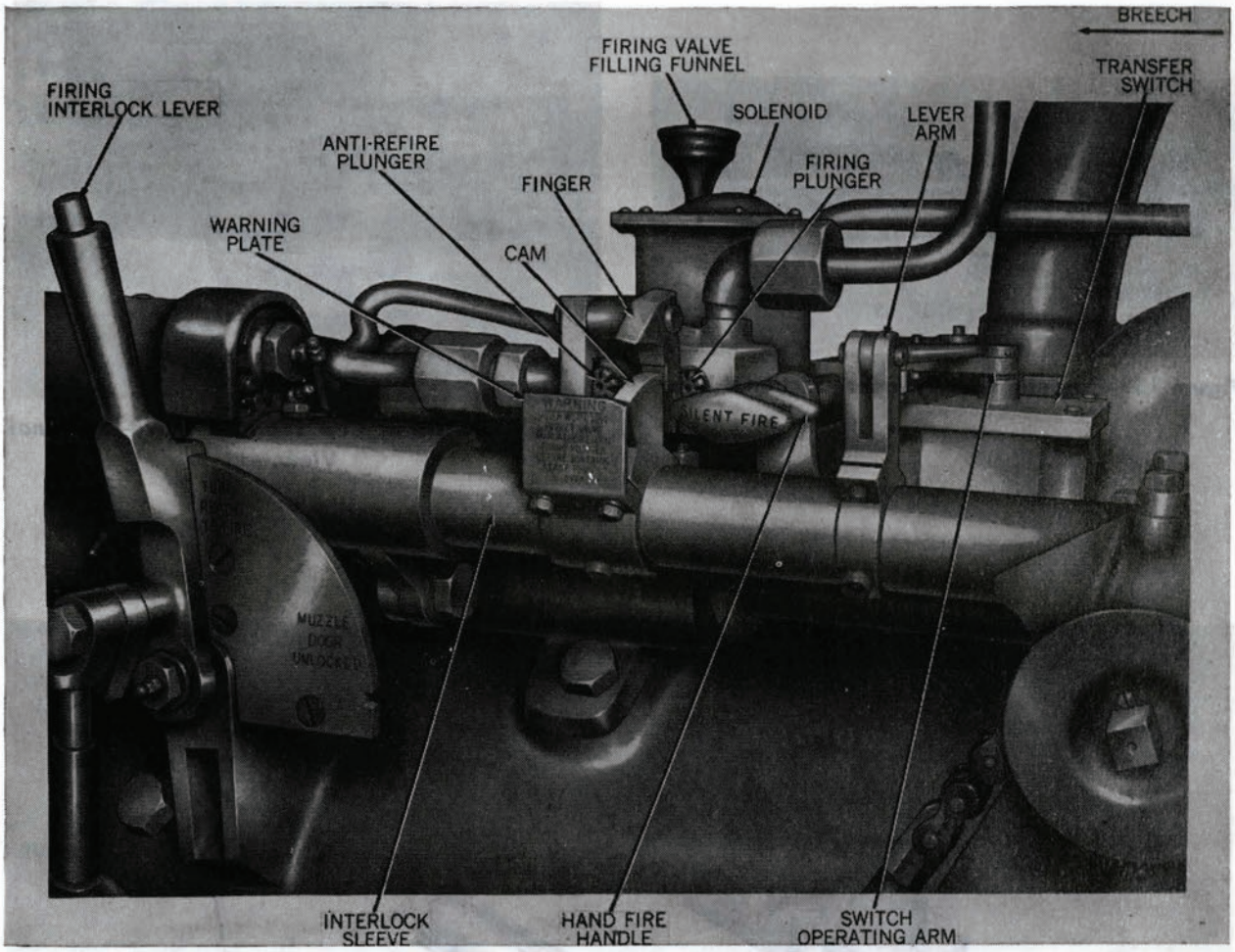


Figure 157—*Firing Lever Assembly—View from Inboard.*

cup loading valve in this position, the pilot valve is lifted by air pressure which passes to the top of the firing valve lifting cup to reseat it.

Selector Valve. The selector valve, figures 162 and 163, is a manually operated two-position plunger; one position is for normal impulse firing of torpedoes, the other is for firing water slugs. A toggle pin secures the valve in the desired position. In its normal firing position (toggle pin through the inner holes in the valve body), the selector valve performs no function in the firing cycle. In its water slug position, the selector valve connects the space above the lifting cup to the muzzleward end of the operating unit. This prevents movement of the valve plunger (normally prevented by the roller of the roller trip mecha-

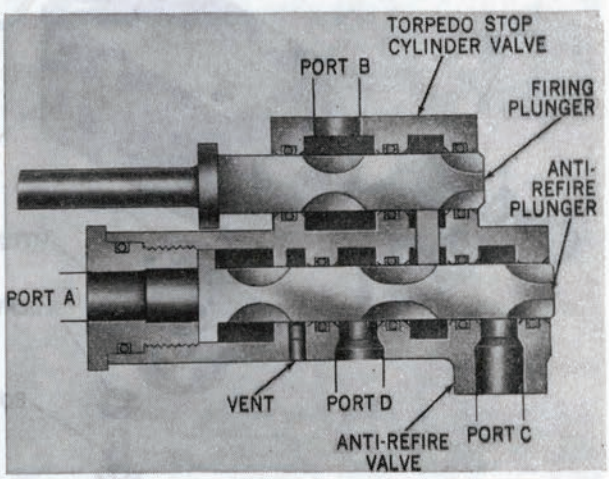


Figure 158—*Torpedo Stop Cylinder and Anti-Refire Valve—Sectional View.*

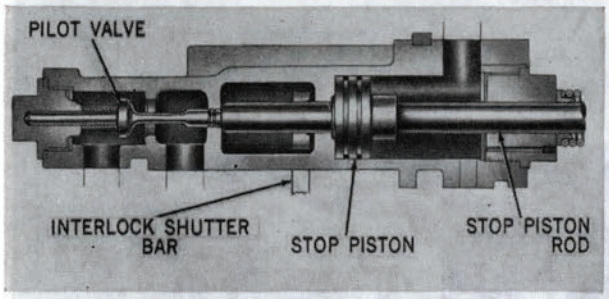


Figure 159—*Torpedo Stop Cylinder—Sectional View.*

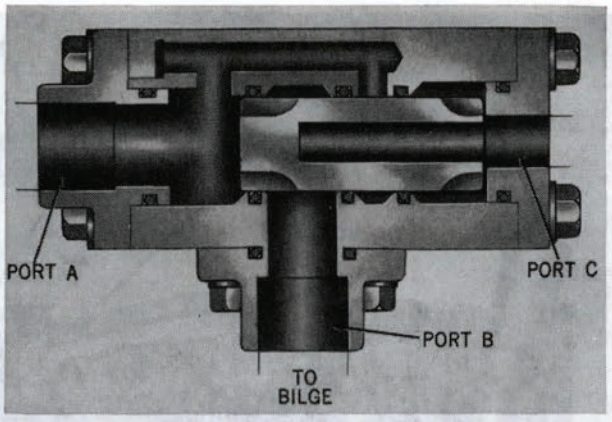


Figure 160—*Lifting Cup Loading Valve—Sectional View.*

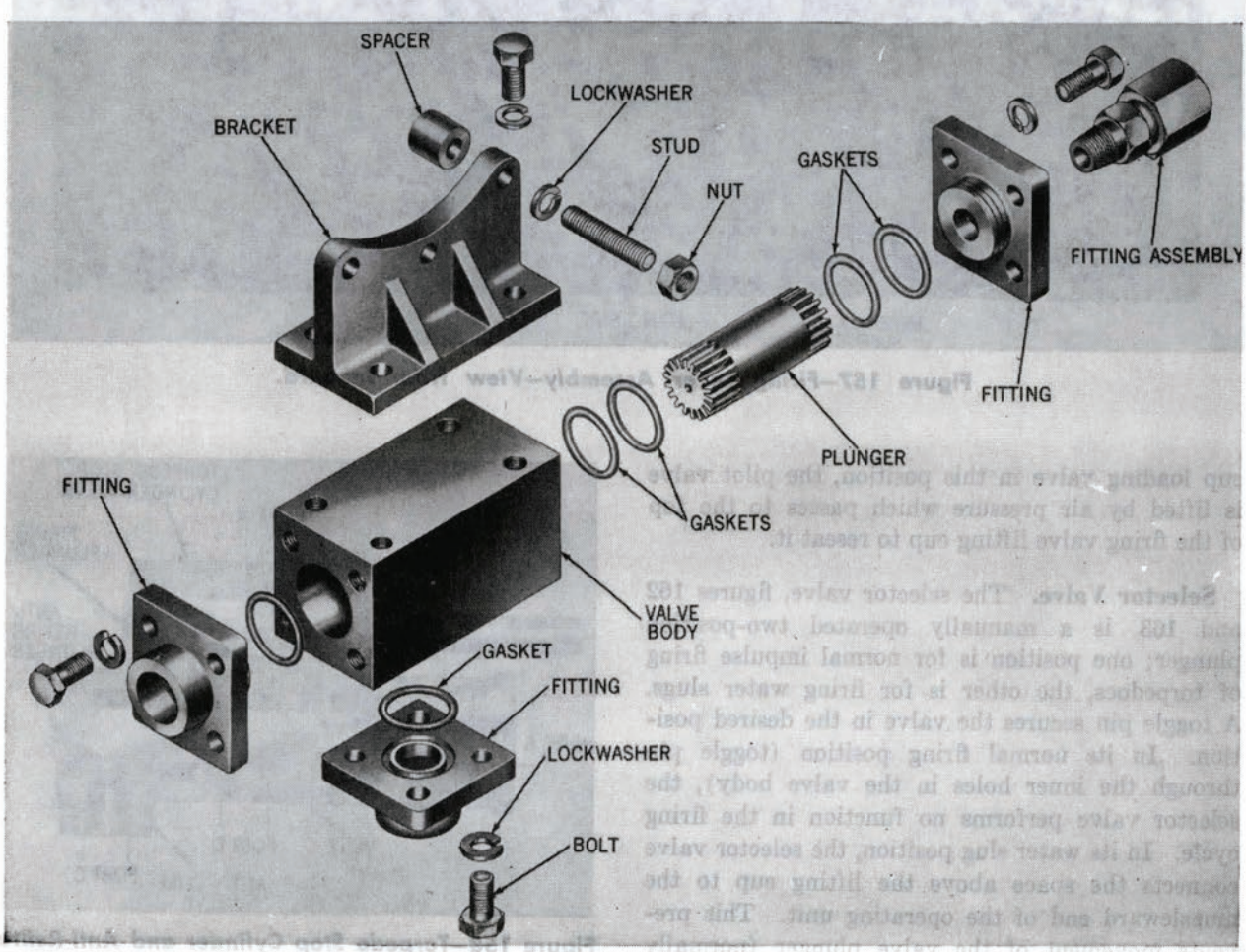


Figure 161—*Lifting Cup Loading Valve Disassembled.*

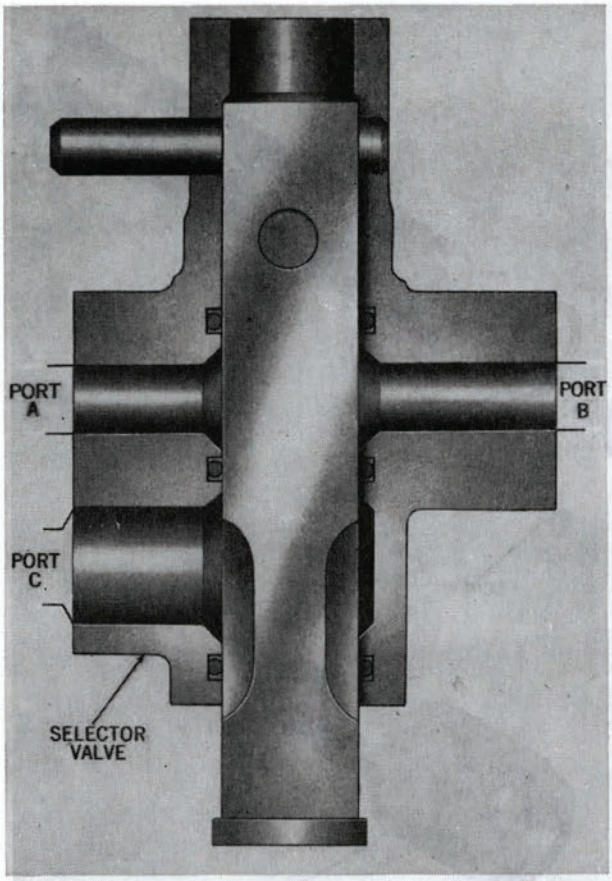


Figure 162—*Selector Valve—Sectional View.*

nism bearing on the torpedo body) until the firing valve lifting cup is vented. Use of the selector valve provides more realistic and thorough training of personnel.

> NOTE: If the poppet valve is to be used when water slugs are fired, the selector valve must be in water slug position and impulse pressure must be at least 250 pounds per square inch before the vent closing valve is cocked. Failure to have the selector valve in the proper position or an impulse pressure of less than 250 pounds per square inch when the vent valve is cocked will cause the poppet valve to open and the anti-refire plunger to move or attempt to move to the tube fired position.

Firing Valve. The firing valve admits impulse air from the impulse flask to the torpedo tube to eject a torpedo. The valve is the same as that described in chapter 12.

Check Valve. Located in the bottom of the firing and check valve housing, the check valve has two functions. It prevents full impulse tank pressure from being applied to the tube when the firing valve is first opened and it prevents sea water from backing up into the firing system from the tube. The valve is fully described in chapter 12.

Poppet Valve Operating Unit. In earlier installations, there was no direct connection between the poppet valve system and the firing mechanism. In this installation, when the poppet valve operating unit acts to port ship service air to the poppet valve to open it, it also ports ship service air to the end of the anti-refire valve plunger. This moves the anti-refire plunger to port ship service air (from another line) to the top of the firing valve to close that valve as the poppet valve opens.

Transfer Switch. The transfer switch is mounted on top of the tube, as shown in figures 156 and 157. It is a two-position rotary switch that is operated by the ready-to-fire interlock and the hand firing lever assembly. In NORMAL POWER position, the switch connects the normal power supply to both the tube-firing solenoid and the torpedo starting circuit. In EMERGENCY POWER position, the switch cuts the power supply to the solenoid and connects an alternate power supply to the torpedo starting circuit.

A lever arm, figure 157, and slotted link, figure 156, connect the interlock sleeve to a pin on the switch operating arm. When the ready-to-fire interlock lever is moved to MUZZLE DOOR UNLOCKED, the slotted link pushes the switch operating arm outboard to NORMAL POWER and locks it there. When the lever is moved to READY TO FIRE, the switch remains at NORMAL POWER. When either the HAND FIRE handle or the SILENT FIRE handle is pulled, a second pin on the switch operating arm is engaged by a horizontal pin of the hand firing lever assembly. This moves the switch to EMERGENCY POWER and cuts the tube-firing solenoid out of the circuit. Thus, when firing by hand, either by impulse air or silent, the tube-firing solenoid cannot operate.

Hand Firing Lever Assembly. The hand firing level assembly, figures 156 and 157, is mounted on top of the tube between the transfer switch and the torpedo stop cylinder. The assembly includes

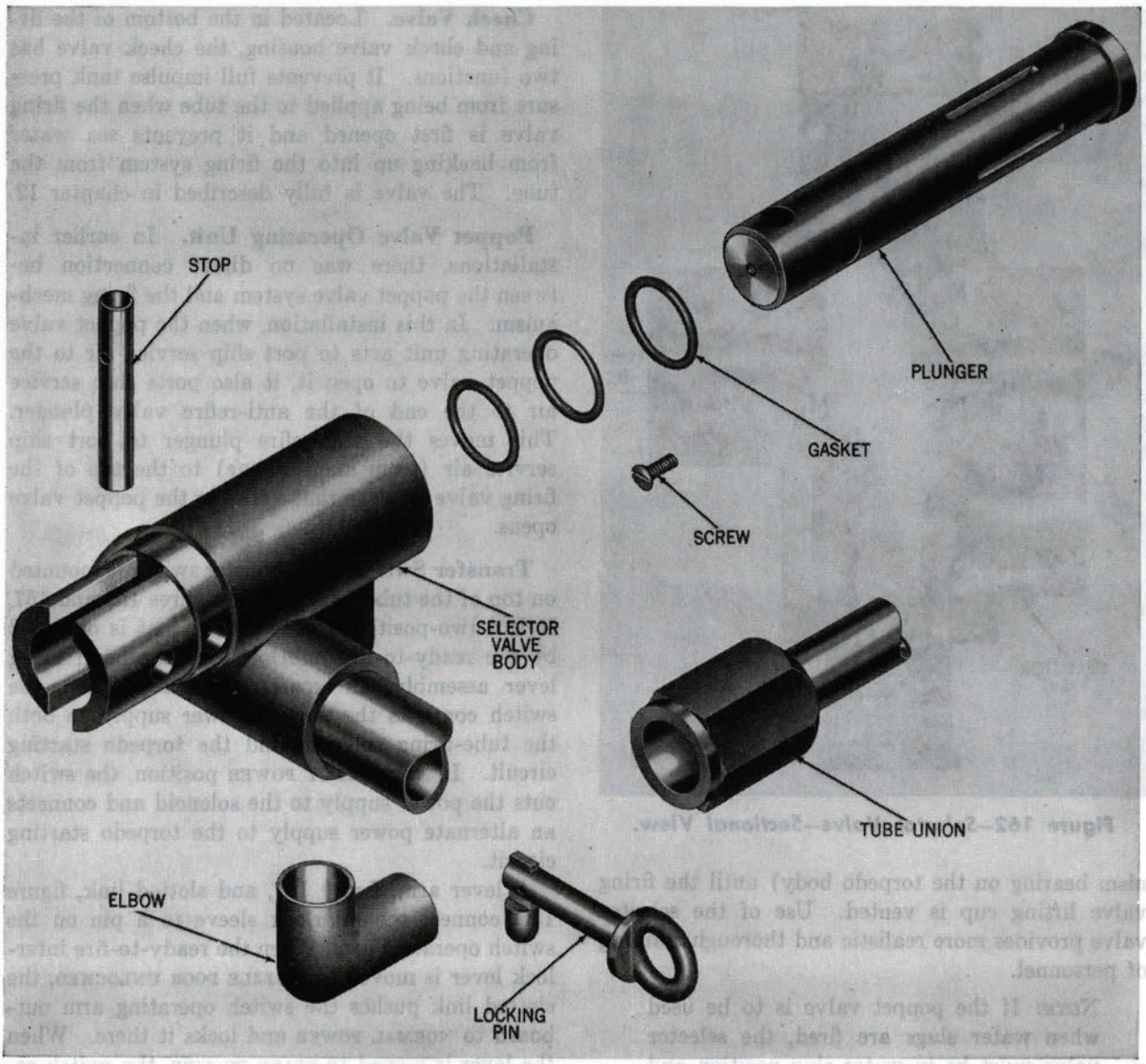


Figure 163—*Selector Valve Dissembled.*

a bracket, an inner shaft and handle, an outer shaft and handle, and two operating pins.

Marked SILENT FIRE on the handle, the inner shaft can be moved by hand within the outer shaft to either of two positions. A lug on the inner shaft extends upward through a slot in the outer shaft. A horizontal switch operating pin is secured in this lug. When the inner shaft is pulled inboard by hand, figure 164, the operating pin engages a vertical pin on the transfer switch operating arm and moves the switch to EMERGENCY POWER. This can only be done when the ready-to-fire interlock

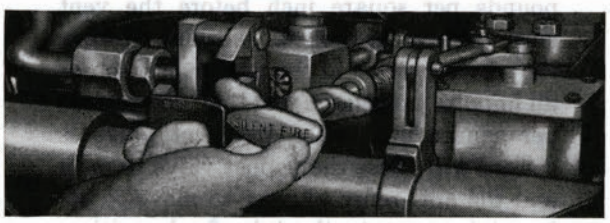


Figure 164—*Pulling SILENT FIRE Handle Inboard.*

lever is at READY TO FIRE. When the SILENT FIRE handle is returned to its outboard position, the transfer switch remains at EMERGENCY POWER until

moved back by movement of the ready-to-fire interlock lever to MUZZLE DOOR UNLOCKED. Movement of the inner shaft of the hand firing lever assembly has no effect on the outer shaft.

Marked HAND FIRE on the handle, the outer shaft can be pulled inboard against the force of its spring. Unlike the inner shaft, the outer shaft will return to its outboard position automatically when the handle is released. At the end of the outer shaft, an operating pin is secured in a horizontal position. When the HAND FIRE handle is pulled inboard, figure 165, this pin engages a lever arm to move the

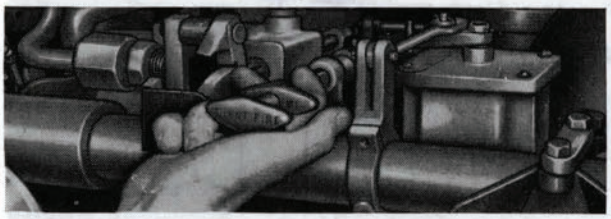


Figure 165—*Pulling HAND FIRE Handle Inboard.*

firing plunger to fire the tube. At the same time, a spacer collar, pinned to the shaft, engages the lug on the inner shaft to move the inner shaft with it. This throws the transfer switch to EMERGENCY POWER to insure that electrically started torpedoes will receive a starting current.

Because of the transfer switch link and lever connection to the interlock sleeve and the firing plunger cam and finger interlock, the HAND FIRE handle and the SILENT FIRE handle can only be pulled to fire the tube when the interlock lever is set at READY TO FIRE.

Operation

The firing mechanism is used in whole or in part to eject a torpedo from a tube as follows:

1. Impulse firing; electrically set or mechanically set torpedoes; with or without poppet valve; firing electrically or by hand.

2. "Silent" firing; electrically set (19-inch only) torpedoes; by hand operation of torpedo stop bolt and the transfer switch.

3. "Runout" firing; electrically set (19-inch only) torpedoes; firing electrically or by hand.

Impulse Firing—General

In impulse firing, the major difference in operation is between firing with the poppet valve and firing without the poppet valve. The size and type of torpedo make no difference, except for the position of the gyro setting spindle. Hand firing and electrical firing differ only in the method of operation of the mechanical linkage.

Interlock Features. Before the firing mechanism can be used to fire the tube with impulse air, the following steps must be taken:

1. Breech and muzzle door interlock set at MUZZLE DOOR UNLOCKED.

2. Drain valve and muzzle door interlock set at DRAIN VALVE LOCKED.

3. Depth and speed setting spindles retracted.

4. Gyro setting spindle engaged for mechanically set torpedo; retracted for electrically set.

5. Impulse stop valve (if installed) OPEN.

6. Muzzle door opened.

7. Firing interlock lever at TUBE READY TO FIRE; transfer switch at NORMAL POWER.

To fire the tube, the electrical firing key is closed or the HAND FIRE handle is pulled inboard; neither needs to be held in position.

Impulse Firing without Poppet Valve. When the poppet valve is not used, the vent closing valve is not cocked and service air is not admitted to the poppet valve system, figure 153. When the electrical firing key is closed or the HAND FIRE handle is pulled:

1. The linkage from the solenoid or hand firing lever assembly forces the firing plunger of the torpedo stop cylinder valve inboard, figure 166.

2. Ship service air passes through internal ports from the stop cylinder valve through the anti-refire valve to the torpedo stop cylinder.

3. Air pressure forces the stop piston breechward to lift the stop bolt, throw the switch of Switch Box Mk 5, and (for mechanically set torpedoes) to retract the gyro setting spindle. At the end of its travel, the stop piston rod forces the pilot valve off its seat.

4. Up to this time, with impulse air pressure above and below the firing valve lifting cup, the firing valve has been held closed by the pressure above the lifting cup acting on a larger area than the same pressure on a smaller area below the cup. With the pilot valve forced open by the piston rod, the space above the lifting cup is connected through

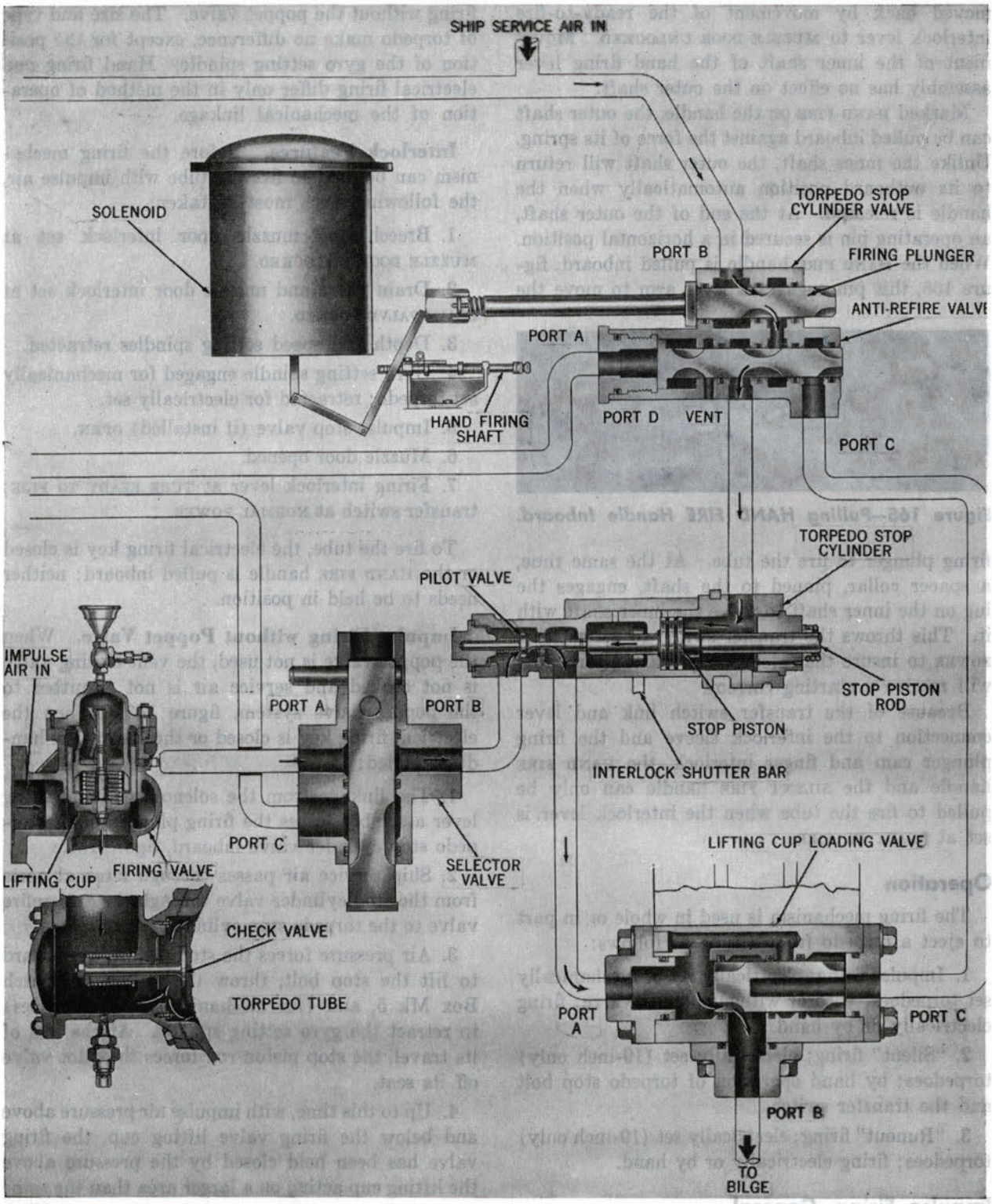


Figure 166—*Firing Mechanism Schematic Diagram—Tube Fired Without Poppet Valve.*

the open pilot valve to the lifting cup loading valve. Pressure in this line moves the loading valve plunger to vent the line to bilge.

5. Venting the space above the lifting cup unbalances the forces in the firing valve. Impulse air then acts on the lifting cup to open the firing valve to admit impulse air to the torpedo tube through the check valve.

With the poppet valve system inactive, the anti-refire plunger is not automatically moved to vent air pressure from the torpedo stop cylinder. Before the firing interlock lever can be returned to MUZZLE DOOR UNLOCKED, the firing plunger must be moved back to its original (outboard) position by hand. This shuts off ship service air and vents the stop cylinder; the stop piston moves clear of the interlock shutter bar, and the interlock lever can be shifted. A warning plate, figure 157, reads:

WARNING
WHEN NOT USING
POPPET VALVE
MANUALLY RETURN
FIRING PLUNGER
BEFORE LOWERING
"READY TO FIRE"
LEVER

Impulse Firing with Poppet Valve. In impulse firing with the poppet valve, the vent closing valve must be cocked to admit ship service air to the poppet valve operating unit. Air enters Port B to load the actuating piston and Port D to an internal chamber where it is trapped. The actuating piston is kept from moving by the roller bearing on the torpedo body. When the electrical firing key is closed or the HAND FIRE handle is pulled:

1. The same actions occur as in Impulse Firing without Poppet Valve, steps 1 through 5.

2. As the torpedo moves out of the tube, the roller of the roller trip is free to ride down the tapered afterbody of the torpedo. This allows movement of the actuating piston in the poppet valve operating unit. Ship service air from the vent closing valve through Port B forces the piston toward the tube muzzle, figure 167.

3. Moved by the piston, the operating unit valve plunger opens Port D to the space between the piston and the plunger. Ship service air pressure holds the plunger in position; at the same time, it acts on a larger area of the actuating piston than that at Port B to force the piston smartly back to its original position, figure 168. The piston acts through its linkage to retract the roller trip quickly so that the roller will not foul the torpedo propeller shroud rings, if installed.

4. Movement of the operating unit valve plunger, step 3, ports ship service air directly to the poppet valve to open it, figure 169. Through a branch

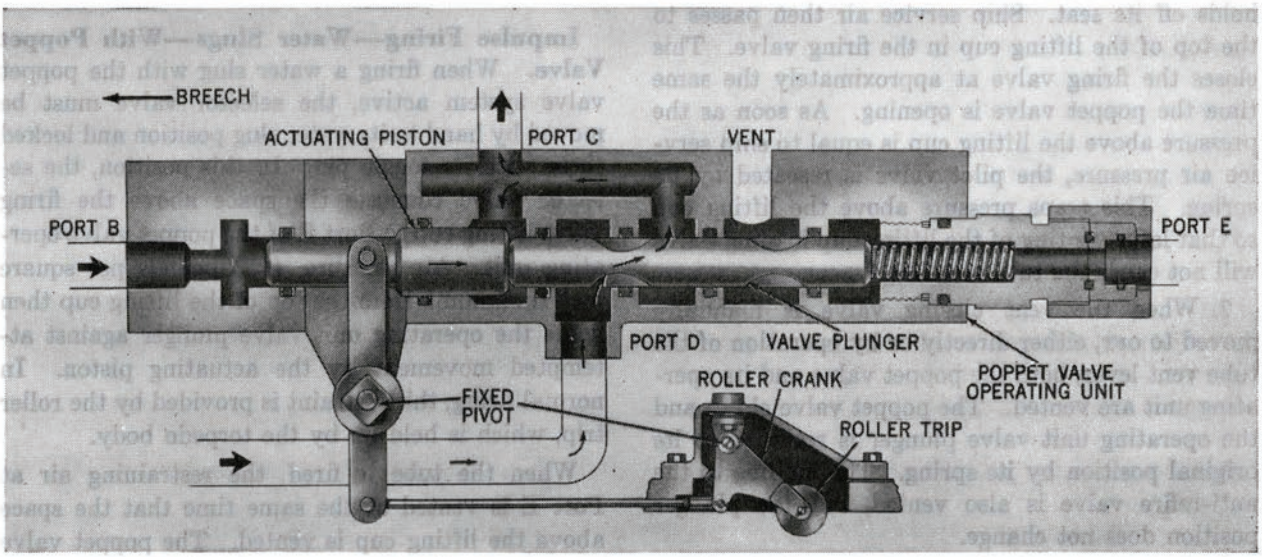


Figure 167—*Firing Mechanism Schematic Diagram, Poppet Valve Operating Unit, and Roller Trip Unit—Roller Trip Released.*

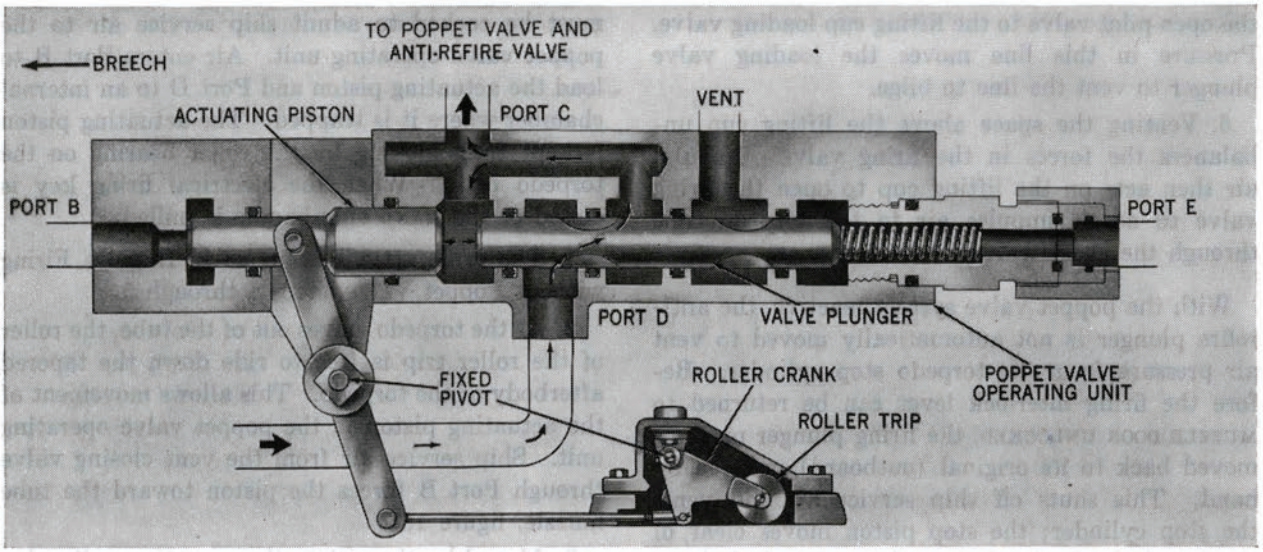


Figure 168—*Firing Mechanism Schematic Diagram—Roller Trip Retracted.*

line, it also ports air to Port A of the anti-refire valve to move its plunger inboard.

5. In its new position, the anti-refire plunger shuts off the air supply to the torpedo stop cylinder and vents the cylinder to atmosphere. The stop piston is spring-returned to its original position.

6. The anti-refire valve ports ship service air to Port C of the lifting cup loading valve. This shifts that valve plunger back to its original position to close the vent to bilge. Air passes through Port A of the loading valve to the pilot valve, which it holds off its seat. Ship service air then passes to the top of the lifting cup in the firing valve. This closes the firing valve at approximately the same time the poppet valve is opening. As soon as the pressure above the lifting cup is equal to ship service air pressure, the pilot valve is reseated by its spring. This traps pressure above the lifting cup so that later venting of the lifting cup loading valve will not cause the tube to refire.

7. When the vent closing valve is manually moved to OFF, either directly or by operation of the tube vent lever, both the poppet valve and its operating unit are vented. The poppet valve closes and the operating unit valve plunger is returned to its original position by its spring. The air line to the anti-refire valve is also vented, but the plunger position does not change.

8. Both the anti-refire plunger and the firing plunger are forced back to their original (outboard) positions by the cams on the interlock sleeve when the interlock lever is moved to MUZZLE DOOR UNLOCKED. The cams are arranged so that the firing plunger is moved back to position and gagged before the anti-refire plunger is moved. This prevents accidental refiring of the tube.

9. Return of the anti-refire plunger vents the line to the lifting cup loading valve and from that valve to the pilot valve. Air under pressure remains trapped above the firing valve lifting cup and in the line through the selector valve to the pilot valve.

Impulse Firing—Water Slugs—With Poppet Valve. When firing a water slug with the poppet valve system active, the selector valve must be moved by hand to its water slug position and locked there with its toggle pin. In this position, the selector valve connects the space above the firing valve lifting cup to Port E of the poppet valve operating unit. Air pressure, (250 pounds per square inch minimum) from the top of the lifting cup then holds the operating unit valve plunger against attempted movement by the actuating piston. In normal firing, this restraint is provided by the roller trip, which is held up by the torpedo body.

When the tube is fired, the restraining air at Port E is vented at the same time that the space above the lifting cup is vented. The poppet valve operating unit then operates in the same way as when firing an actual torpedo.

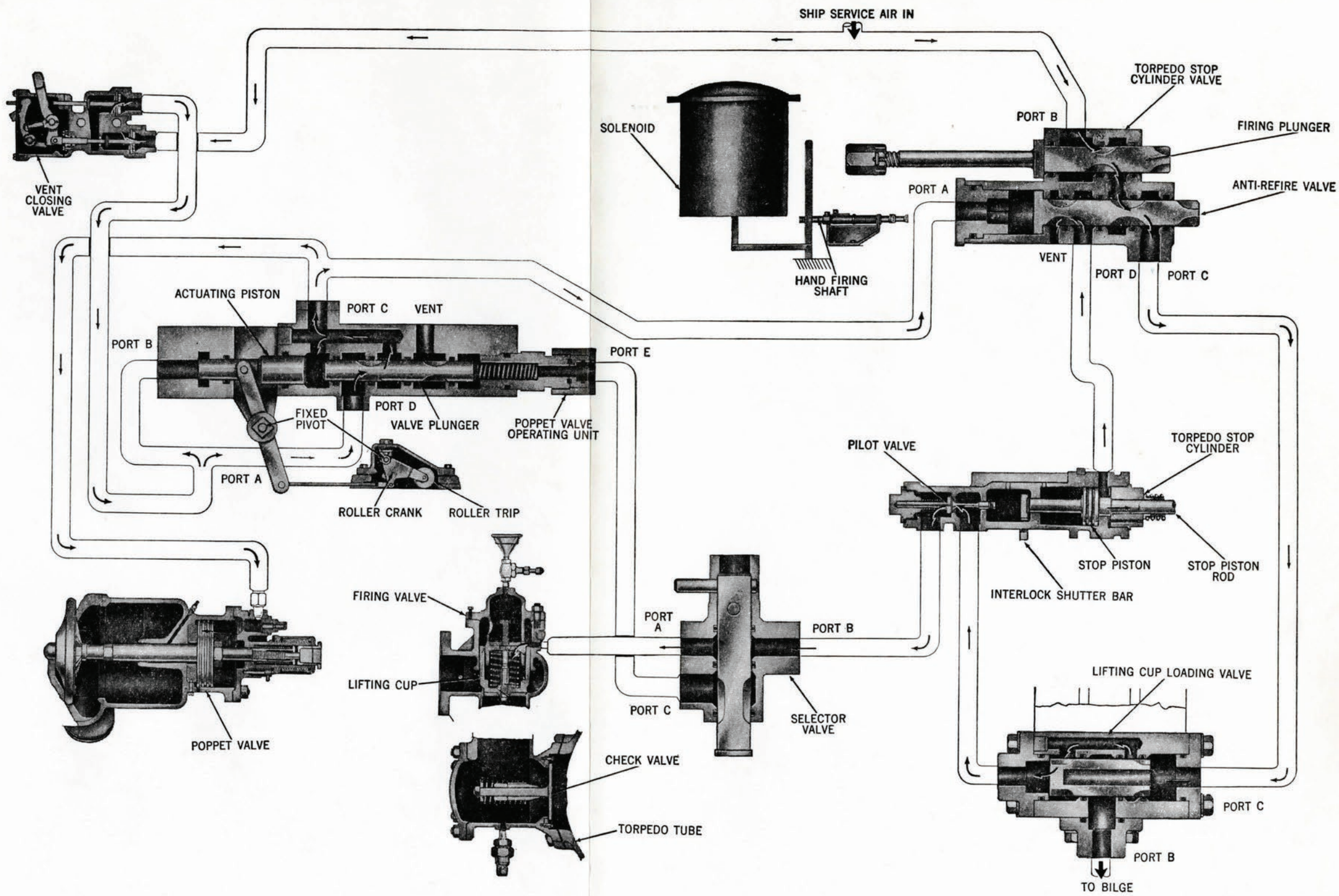


Figure 169—*Firing Mechanism Schematic Diagram—Tube Fired With Poppet Valve—Anti-refire Action.*

Except for air pressure acting in place of a torpedo to restrain the roller trip, all actions of the firing mechanism and poppet valve system are the same as for Impulse Firing with Poppet Valve.

Silent Firing

The term "silent firing" defines the method of release of certain self-ejecting torpedoes without power actuation of any torpedo tube mechanisms. It only can be used with 19-inch diameter torpedoes. These torpedoes are fitted with guides at top, bottom, and sides to center them in the 21-inch tubes. When the torpedo is started, it can run out of the tube under its own power because the clearance around it allows free flow of water from muzzle to breech as the torpedo moves out. Lack of clearance prevents use of this method for firing 21-inch torpedoes.

With doors and interlocks properly set, the only actions required for silent fire are:

1. Throw the transfer switch from NORMAL POWER TO EMERGENCY POWER by pulling out the SILENT FIRE handle.

2. Retract the stop bolt with the hand retraction mechanism. This releases the torpedo and throws the switch of Switch Box Mk 5 to energize the torpedo starting circuit of electrically started torpedoes. The torpedo starts and runs out of the tube under its own power. The hand retraction mechanism must be held with the stop bolt retracted for at least 20 seconds to ensure that the torpedo has left the tube.

Runout Firing

The term "runout" firing is applied to the release of self-ejecting torpedoes by air operation of the stop bolt. Hand firing and electrical firing differ only in the method of operation of the mechanical linkage.

Interlock Features. Before the firing mechanism can be used to fire a "runout" torpedo, the following steps must be taken:

1. Breech and muzzle door interlock set at MUZZLE DOOR UNLOCKED.

2. Drain valve and muzzle door interlock set at DRAIN VALVE LOCKED.

3. Depth, speed, and gyro setting spindles retracted.

4. Impulse stop valve (if installed) SHUT; zero pressure in the impulse flask.

5. Poppet valve gagged.

6. Muzzle door open.

7. Firing interlock lever at TUBE READY TO FIRE; transfer switch at NORMAL POWER.

To fire the tube, the electrical firing key is closed or the HAND FIRE handle is pulled inboard; neither needs to be held in position.

When the electrical firing key is used, the tube firing circuit should be bypassed 5 seconds after the stop bolt lifts. This will prevent damage to the tube firing solenoid.

With either electrical or hand firing, the firing plunger should be returned to its original position manually 20 seconds after the stop bolt lifts.

Operation of the firing mechanism is as described for Impulse Firing without Poppet Valve, except that the firing valve does not open.

Chapter 14

POPPET VALVE SYSTEM

FOR TUBES EQUIPPED FOR MECHANICAL SETTING ONLY

This system, figure 170, is employed when it is desired to prevent the impulse air from escaping into the sea and causing bubbles, which would disclose the submarine's location.

After the torpedo receives its launching impulse the poppet valve system automatically opens the poppet valve, figure 171, allowing the impulse air to vent within the hull; then, under manual control, it closes the valve to prevent excessive water from entering. Figures 172 and 173 are views of the poppet valve through the opening for the poppet discharge stop valve body, showing the positions of the valve disc when the valve is open and closed. Figures 174 and 175 show disassembled parts of the poppet valve.

A poppet valve operating unit, figure 176, is set to operate by opening the vent-closing valve, which puts the unit under ship service air pressure. This air pressure will open the poppet valve when triggered by a roller trip unit. The torpedo in the tube prevents the roller trip unit from moving instantaneously after firing; however, it is located so that the poppet valve will open when the torpedo has moved about nine feet along the tube.

Operating Unit

When the vent-closing valve setting lever is placed to ON, ship service air is admitted to a cylinder in the muzzle end of the operating unit and to a valve chamber in the breech end of the operating unit, figure 177. Air entering the valve chamber is retained there by a valve under spring pressure. Air entering the cylinder tends to force the operating unit piston toward the breech. However, the piston is restrained by a piston fork mounted on a shaft connecting at its lower end to a pull rod fork. Figure 178 shows the operating unit disassembled.

Roller Trip Unit

The pull rod fork engages a pull rod which extends muzzleward through a groove in the barrel,

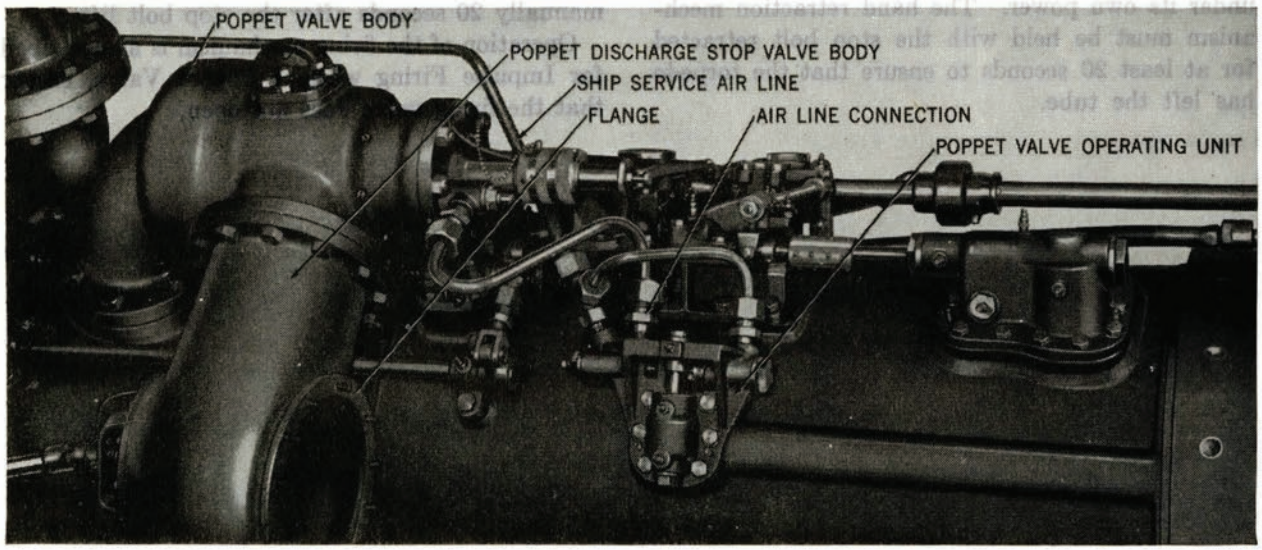


Figure 170—*Poppet Valve Installed on Tube—Poppet Discharge Pipe Removed.*

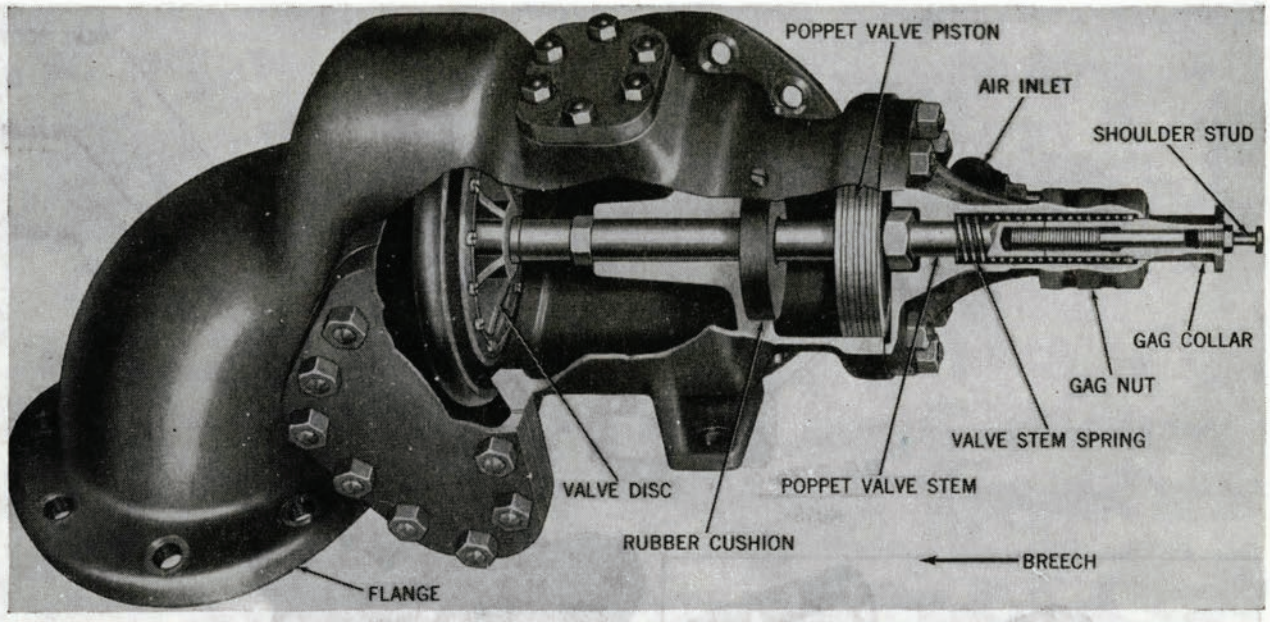


Figure 171—*Poppet Valve Housing—Sectional View.*

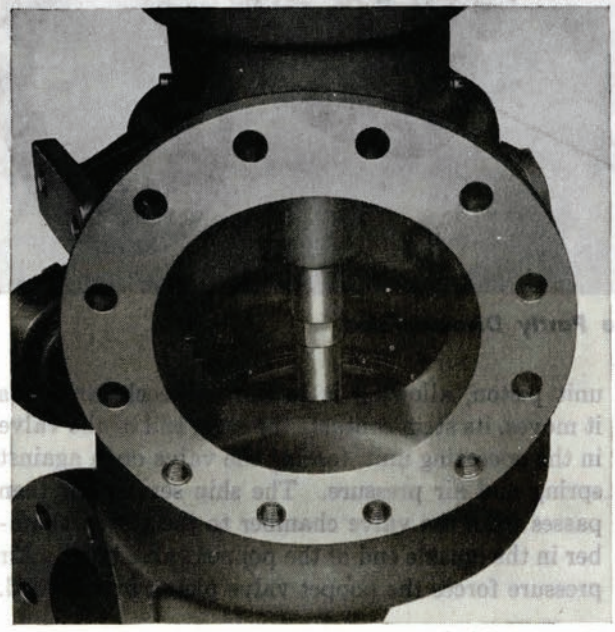


Figure 172—*Poppet Valve—Open Position.*

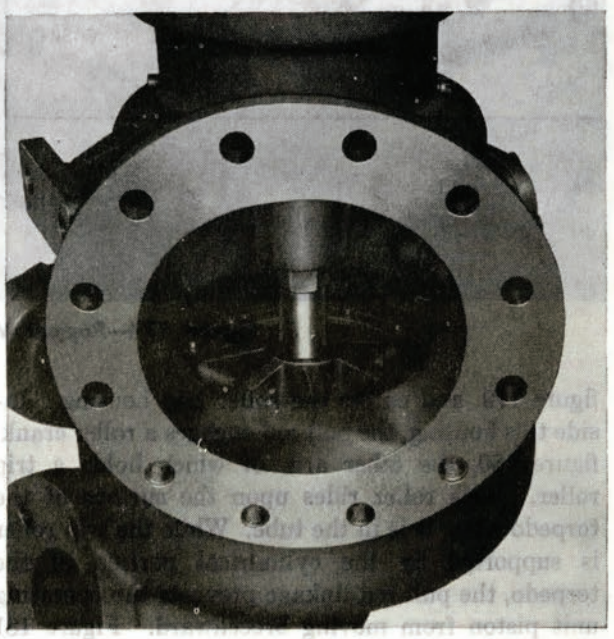


Figure 173—*Poppet Valve—Closed Position.*

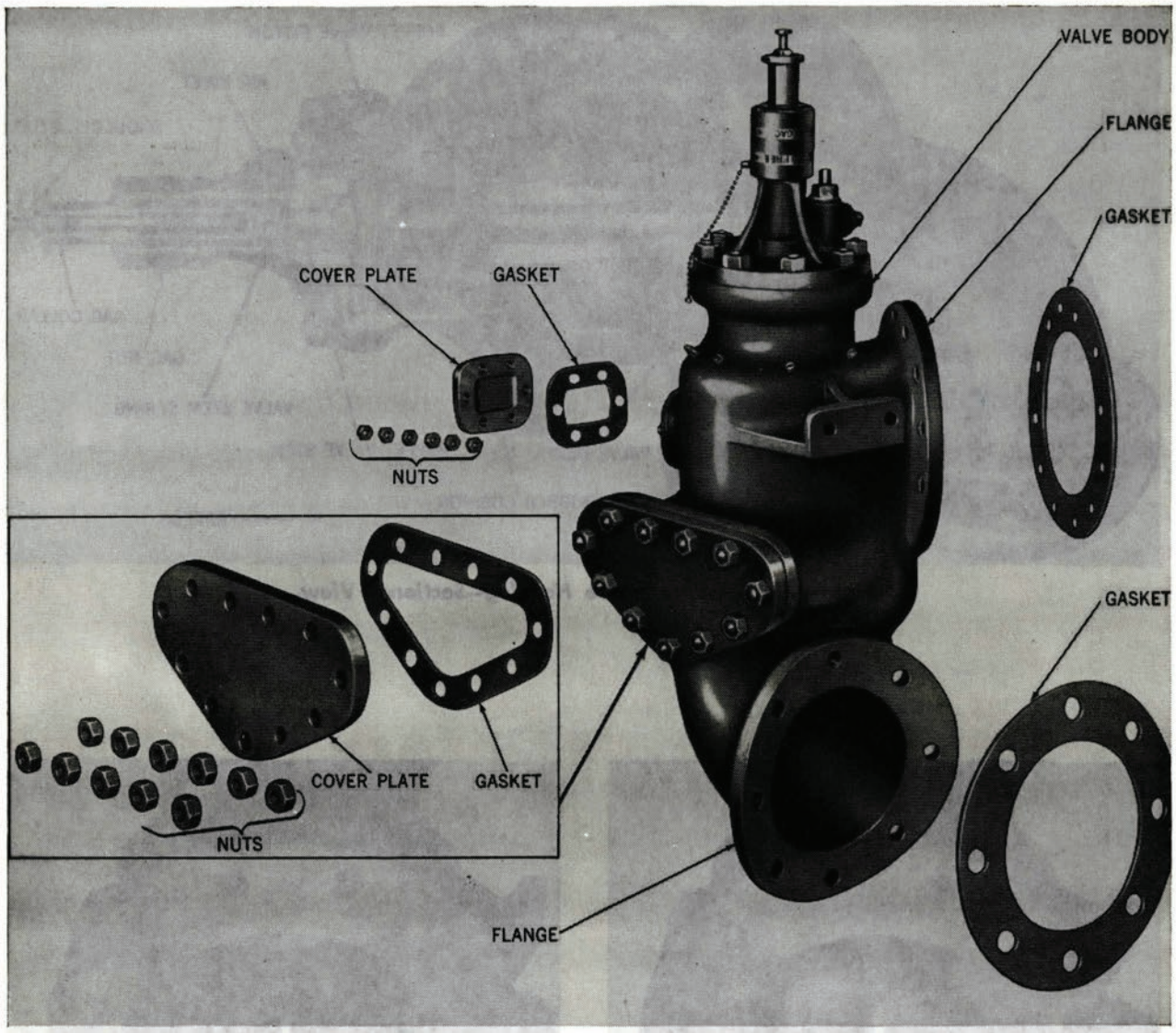


Figure 174—*Poppet Valve Partly Disassembled.*

figure 179, and enters the roller trip housing. Inside this housing, the pull rod engages a roller crank, figure 180, the other arm of which holds a trip roller. This roller rides upon the surface of the torpedo when it is in the tube. While the trip roller is supported by the cylindrical portion of the torpedo, the pull rod linkage prevents the operating unit piston from moving breechward. Figure 181 shows the roller trip unit disassembled.

When the torpedo is fired, it moves toward the muzzle end of the tube and the trip roller rides down the slope of the torpedo afterbody. This releases the restraint on the pull rod and the operating unit piston, allowing it to move breechward. As it moves, its stem contacts the stem end of the valve in the operating unit, forcing the valve open against spring and air pressure. The ship service air then passes from the valve chamber to the piston chamber in the muzzle end of the poppet valve body. Air pressure forces the poppet valve piston breechward.

Poppet Valve

The piston is attached to a vent valve disc which also is forced breechward, opening the poppet valve against impulse air pressure in the tube and allowing impulse air to vent through a poppet discharge pipe.

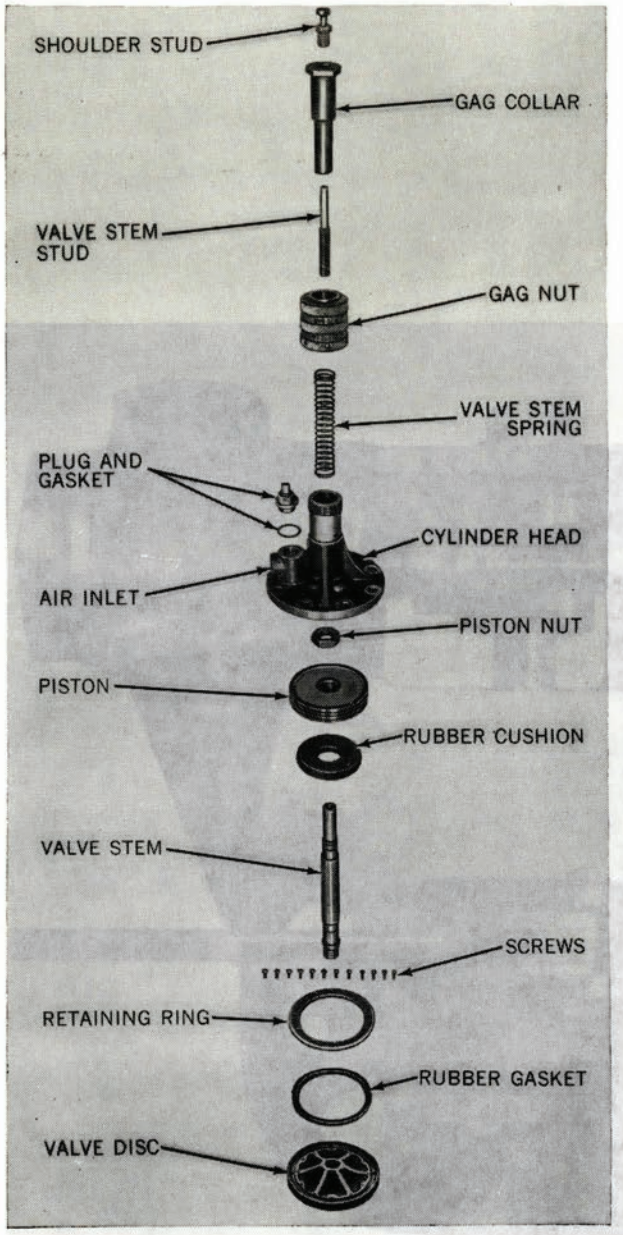


Figure 175—*Parts of Poppet Valve.*

After firing, the poppet valve is closed by placing the vent-closing valve setting lever to OFF, shutting off the supply of ship service air to the operating unit, and simultaneously venting the air supply line to the poppet valve. This relieves pressure against the muzzle side of the poppet valve piston, allowing water pressure (and air pressure, if any) from the tube to move the vent valve disc muzzleward, closing the poppet valve.

Poppet Valve Controls

The poppet valve controls, located above the breech end of the tube nest, figure 182, consist of a vent-closing valve and a quick-opening tube vent valve for each tube.

Each time it is to be used, the poppet valve must be set by moving the vent-closing valve setting lever to ON, figure 183, allowing ship service air to pass to the operating unit. After firing, the poppet valve must be closed by one of the following operations:

1. After pressing a latch release button, place the vent-closing valve setting lever to OFF, figure 184.
2. Place the tube vent valve to OPEN.

The operation described in (2) also moves the vent-closing valve setting lever to OFF by means of a link connecting the two valves, figure 185. This causes the poppet valve to close and the tube vent valve to open, so that the remaining air can escape. When venting is completed, the tube vent is closed.

NOTE: Closing the tube vent valve has no effect upon the poppet valve system.

Vent-closing Valve. The vent-closing valve body contains two poppet-type valves, figure 186, operated by the setting lever so that when one is open the other is closed. One of these valves is a shut-off and supply valve for the ship service air to the operating unit; the other vents the air line

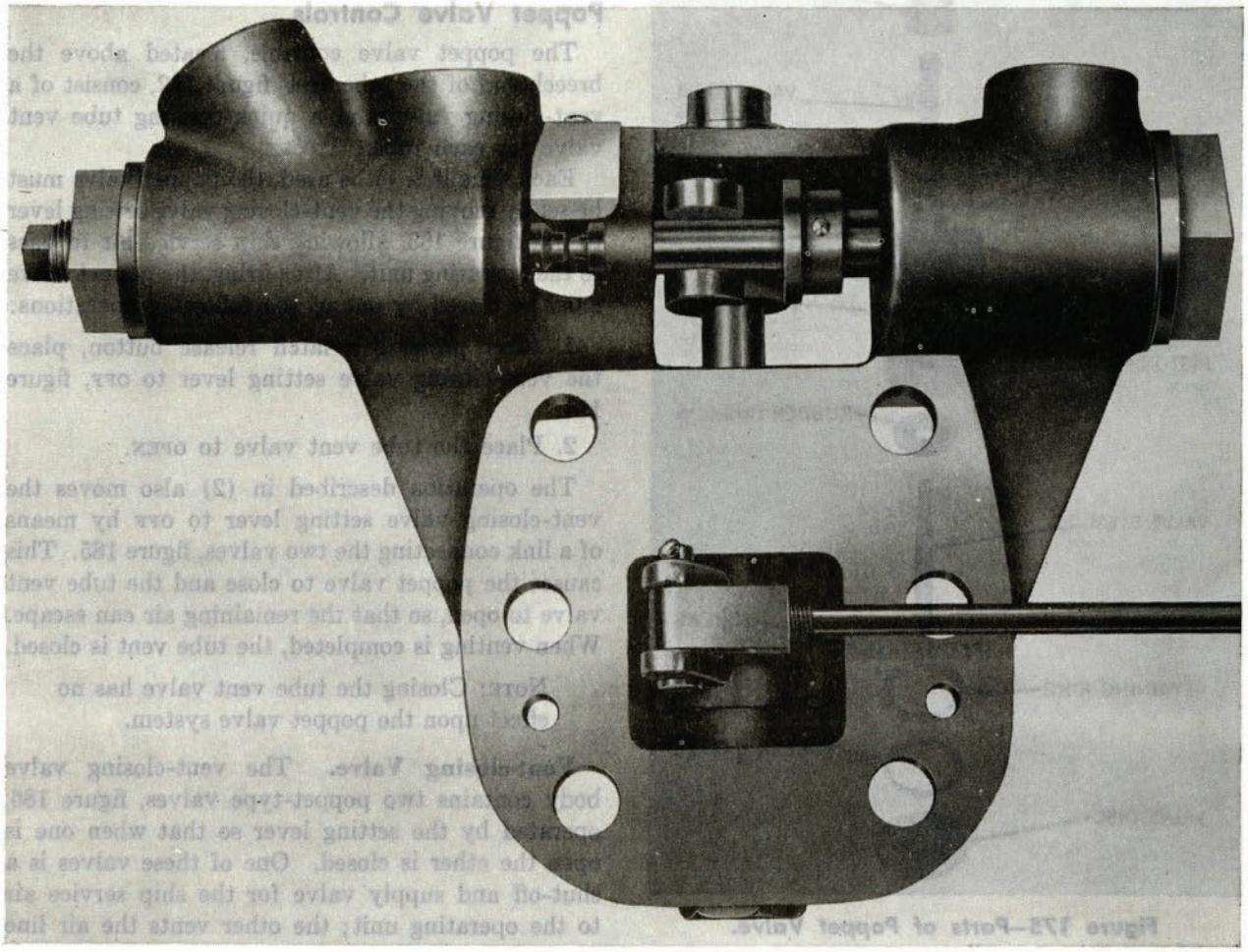


Figure 176—*Poppet Valve Operating Unit—Poppet Valve Open.*

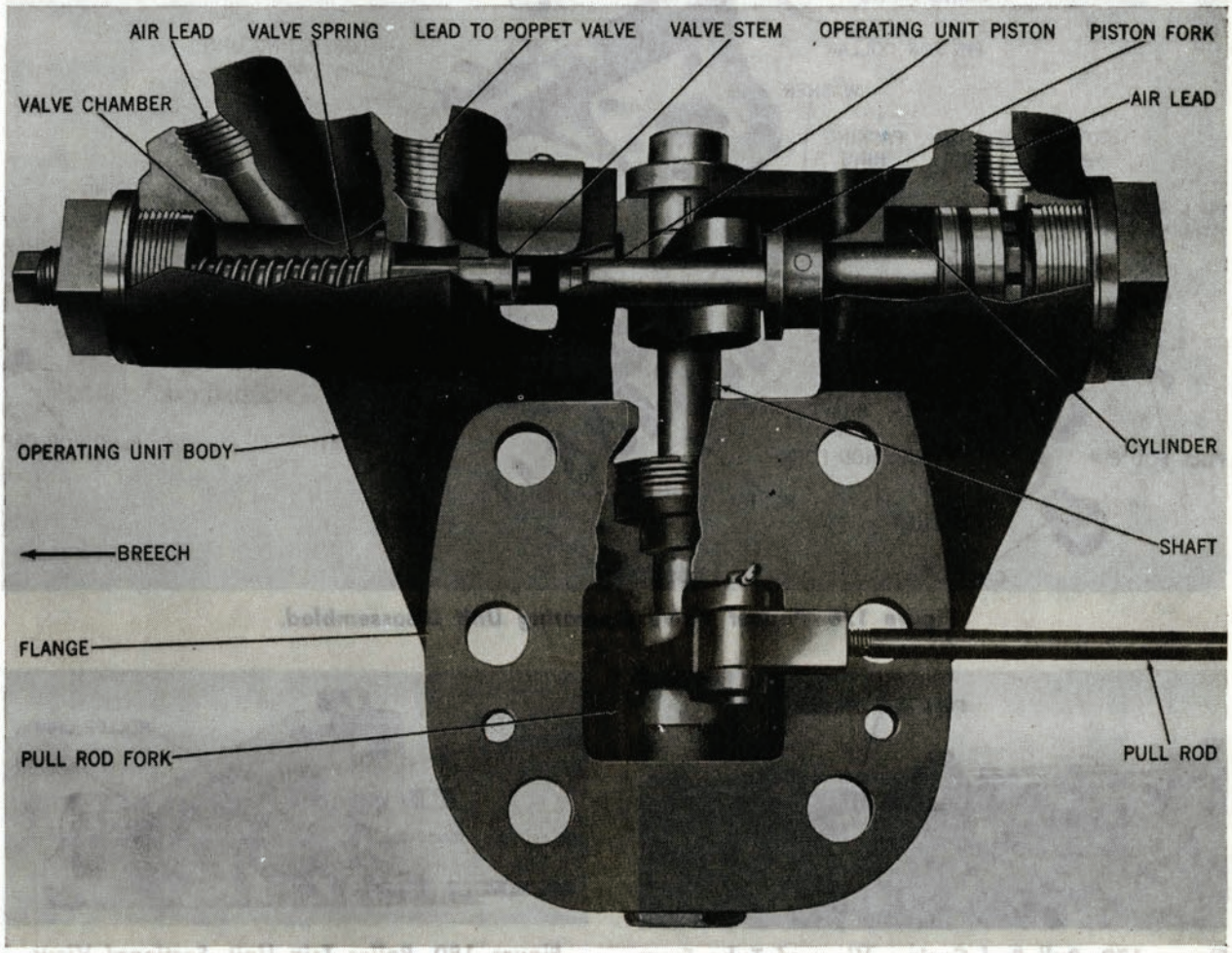


Figure 177—*Poppet Valve Operating Unit—Poppet Valve Closed—Sectional View.*

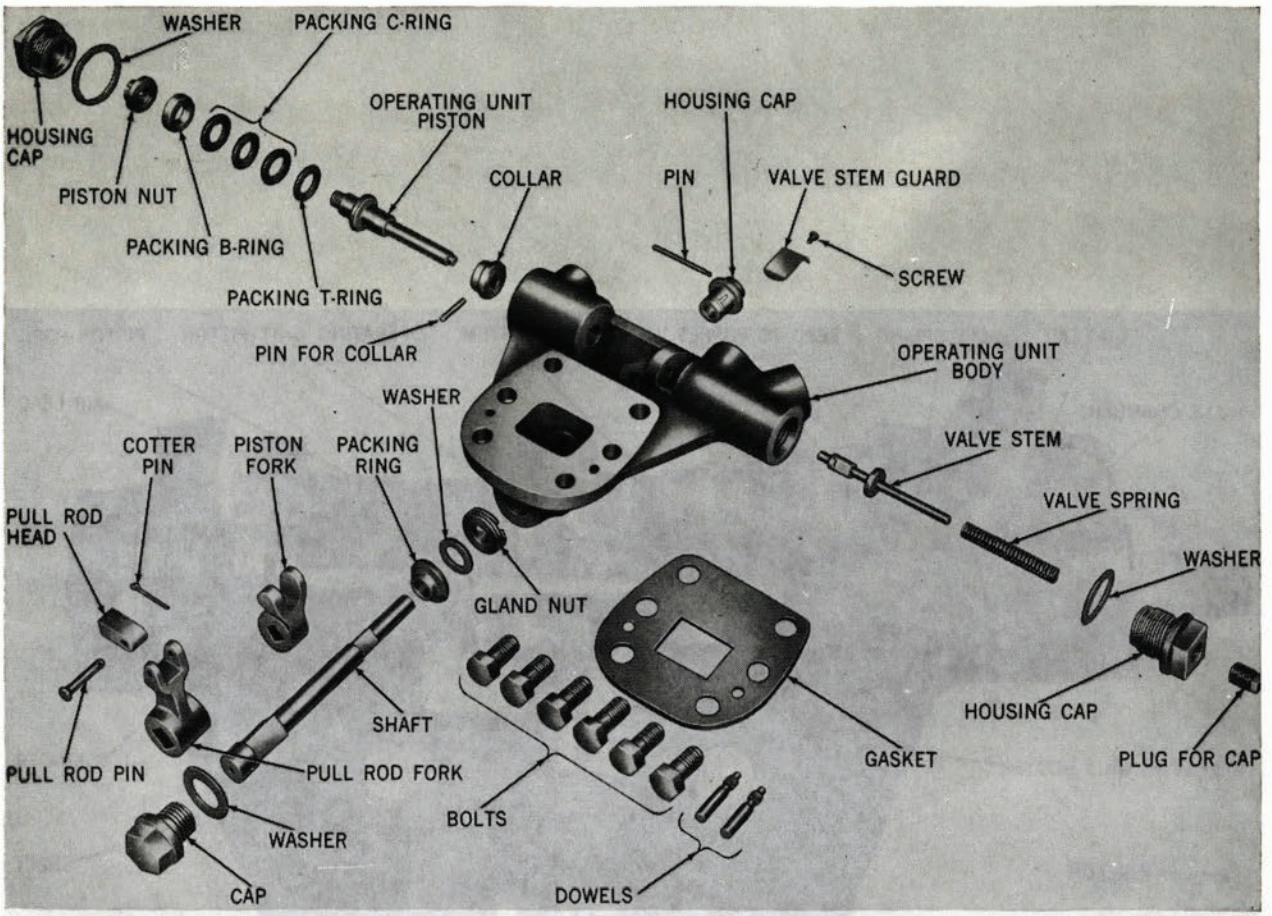


Figure 178—*Poppet Valve Operating Unit Disassembled.*

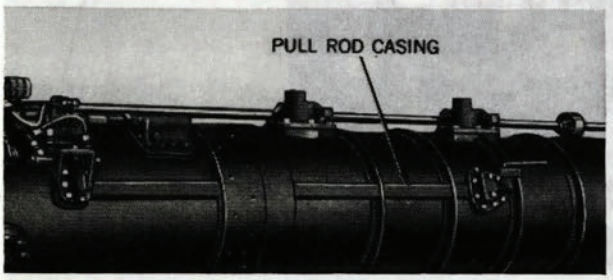


Figure 179—*Pull Rod Casing—View of Tube From Outboard.*

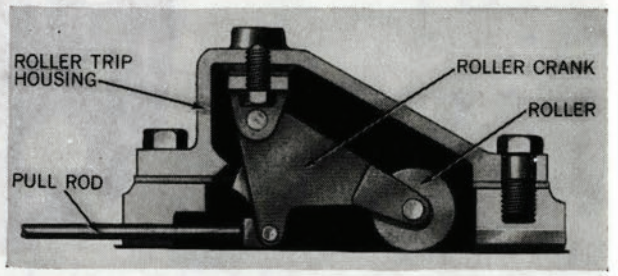


Figure 180—*Roller Trip Unit—Sectional View.*

to the poppet valve when the air supply is shut off.

When the vent-closing valve is set at ON, engagement of the setting lever with a hand lever latch holds the shut-off and supply valve open and the venting valve closed, permitting operation of the poppet valve system.

The hand lever latch is disengaged from the setting lever by pressing on a button on the latch. Continued pressure on this latch release button will force the setting lever down slightly. However, the setting lever must be pushed fully down to OFF, to insure that the shut-off and supply valve is closed and the venting valve open.

Gag Nut

When it is desirable positively to insure the poppet valve against opening, it may be locked

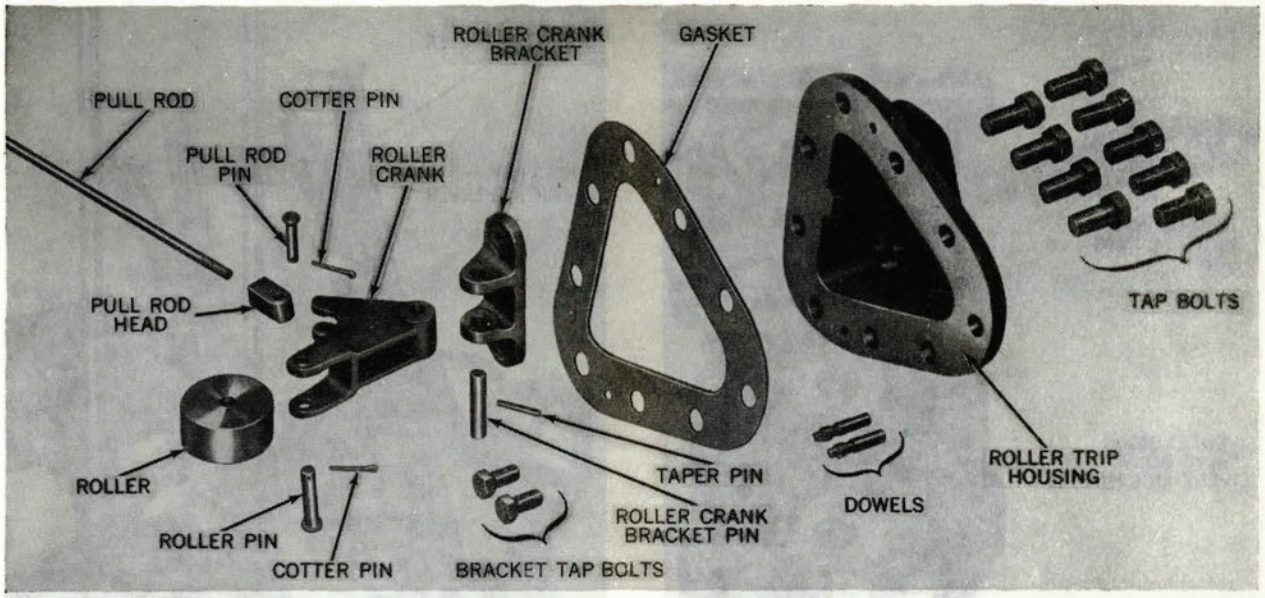


Figure 181—*Roller Trip Unit Disassembled.*

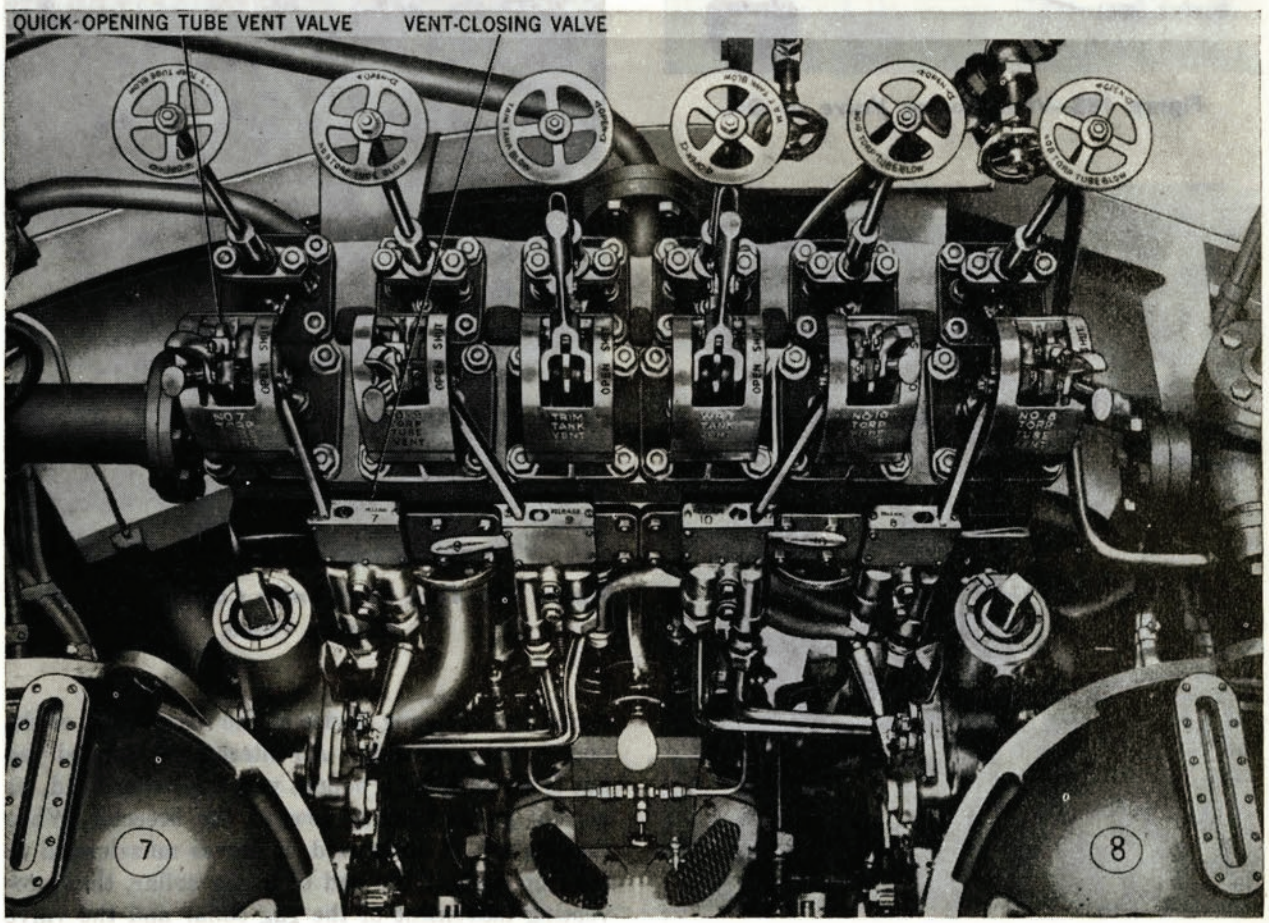


Figure 182—*Stern Nest Blow and Vent Manifold Controls.*

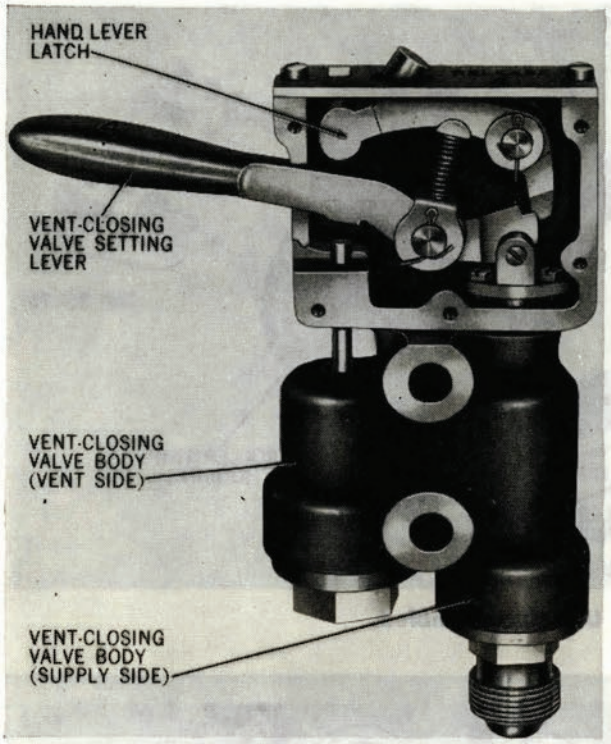


Figure 183—*Vent-Closing Valve at ON.*

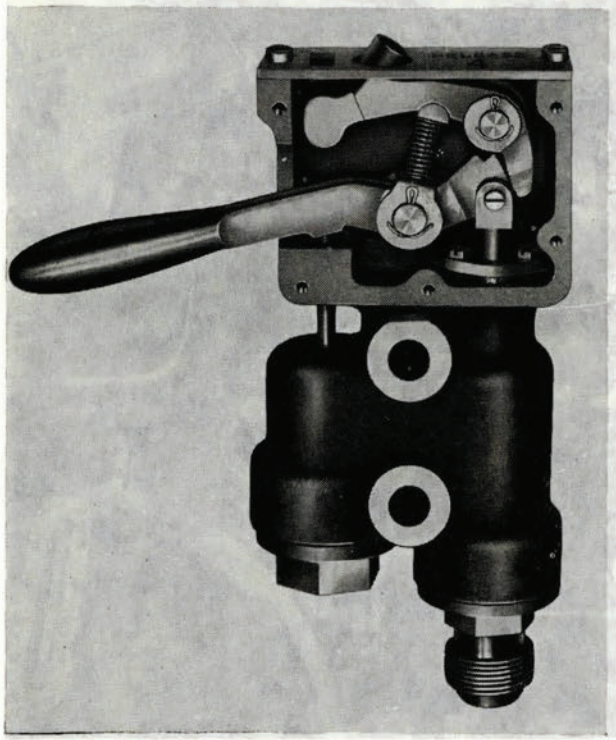


Figure 184—*Vent-Closing Valve at OFF.*

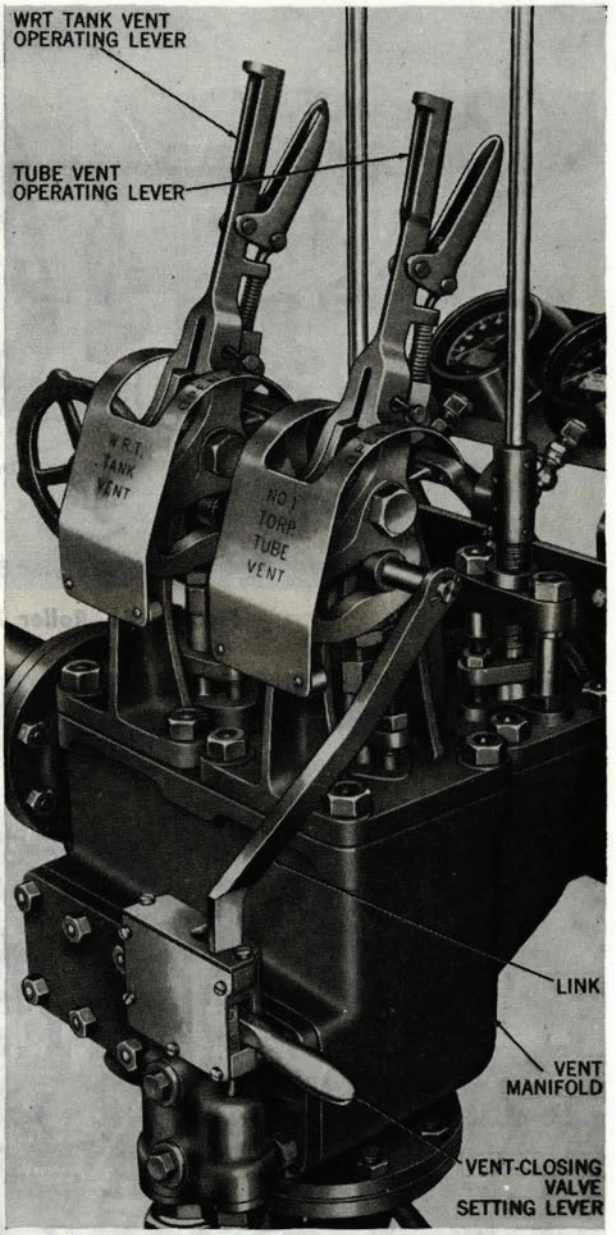


Figure 185—*Tube Vent Valve Connection to Vent-Closing Valve.*

closed by a gagging device at the muzzle end of the poppet valve housing. An internally threaded gag nut is attached to a poppet valve cylinder head, its normal position being toward the breech. When the gag nut is unscrewed, it moves muzzleward to take up against the end of a gag collar, thus preventing movement of the gag collar and the valve stem stud, making the poppet valve inoperative.

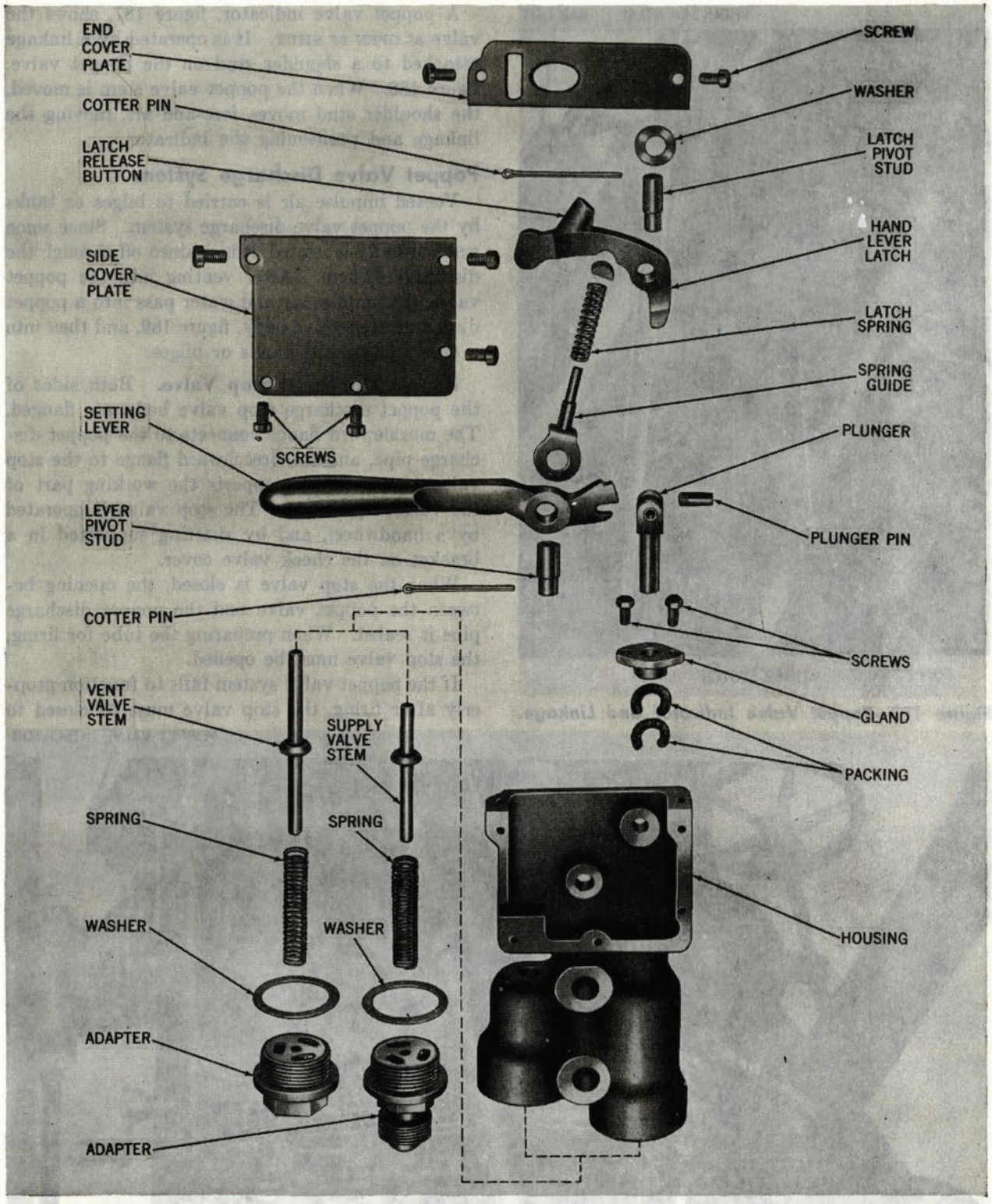


Figure 186—*Vent-Closing Valve Disassembled.*

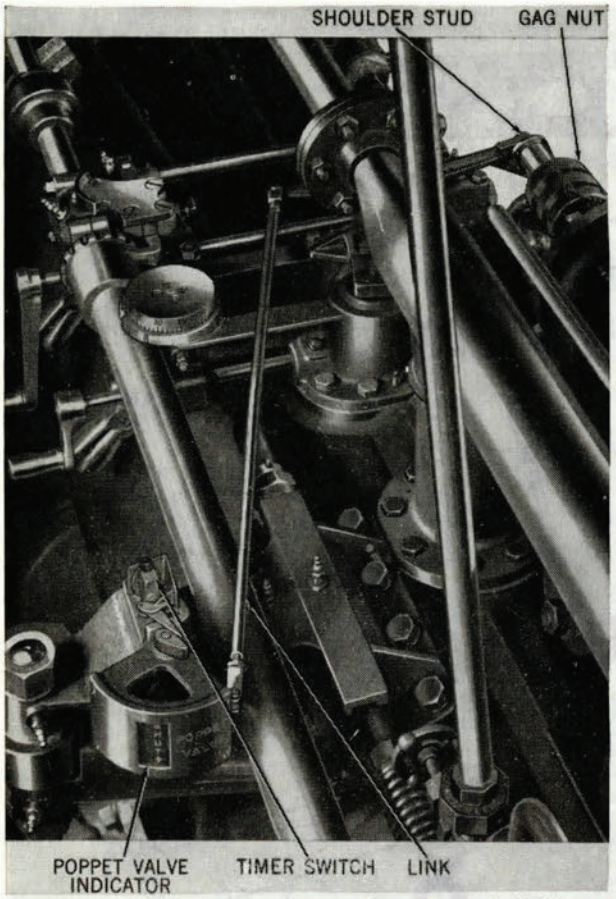


Figure 187—*Poppet Valve Indicator and Linkage.*

A poppet valve indicator, figure 187, shows the valve at OPEN or SHUT. It is operated by a linkage attached to a shoulder stud on the poppet valve, figure 188. When the poppet valve stem is moved, the shoulder stud moves fore-and-aft, moving the linkage and positioning the indicator.

Poppet Valve Discharge System

Vented impulse air is carried to bilges or tanks by the poppet valve discharge system. Since some water usually is vented, it is drained off through the discharge system. After venting into the poppet valve, the impulse air and water pass into a poppet discharge stop valve body, figure 189, and then into a discharge pipe to tanks or bilges.

Poppet Discharge Stop Valve. Both sides of the poppet discharge stop valve body are flanged. The muzzleward flange connects to the poppet discharge pipe, and the breechward flange to the stop valve bonnet which supports the working part of the valve, figure 190. The stop valve is operated by a handwheel, and by shafting supported in a bracket on the check valve cover.

When the stop valve is closed, the opening between the poppet valve and the poppet discharge pipe is sealed. When preparing the tube for firing, the stop valve must be opened.

If the poppet valve system fails to function properly after firing, the stop valve must be closed to

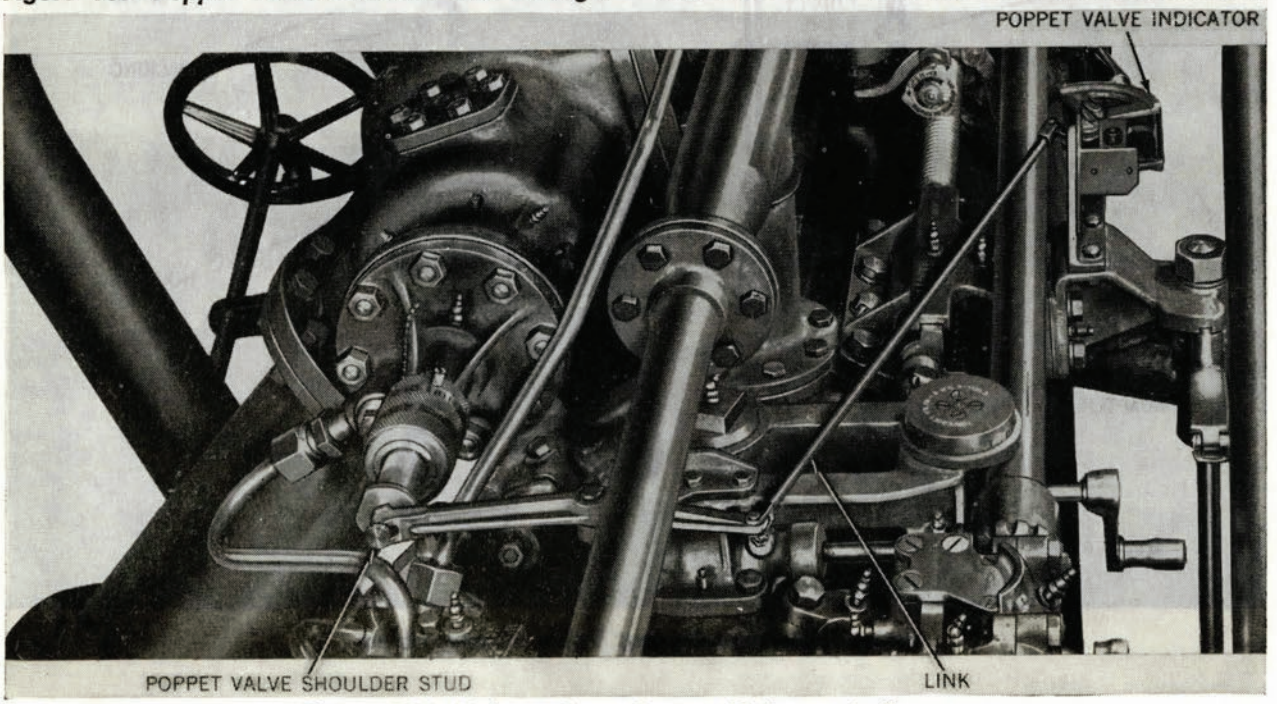


Figure 188—*Linkage From Poppet Valve to Indicator.*

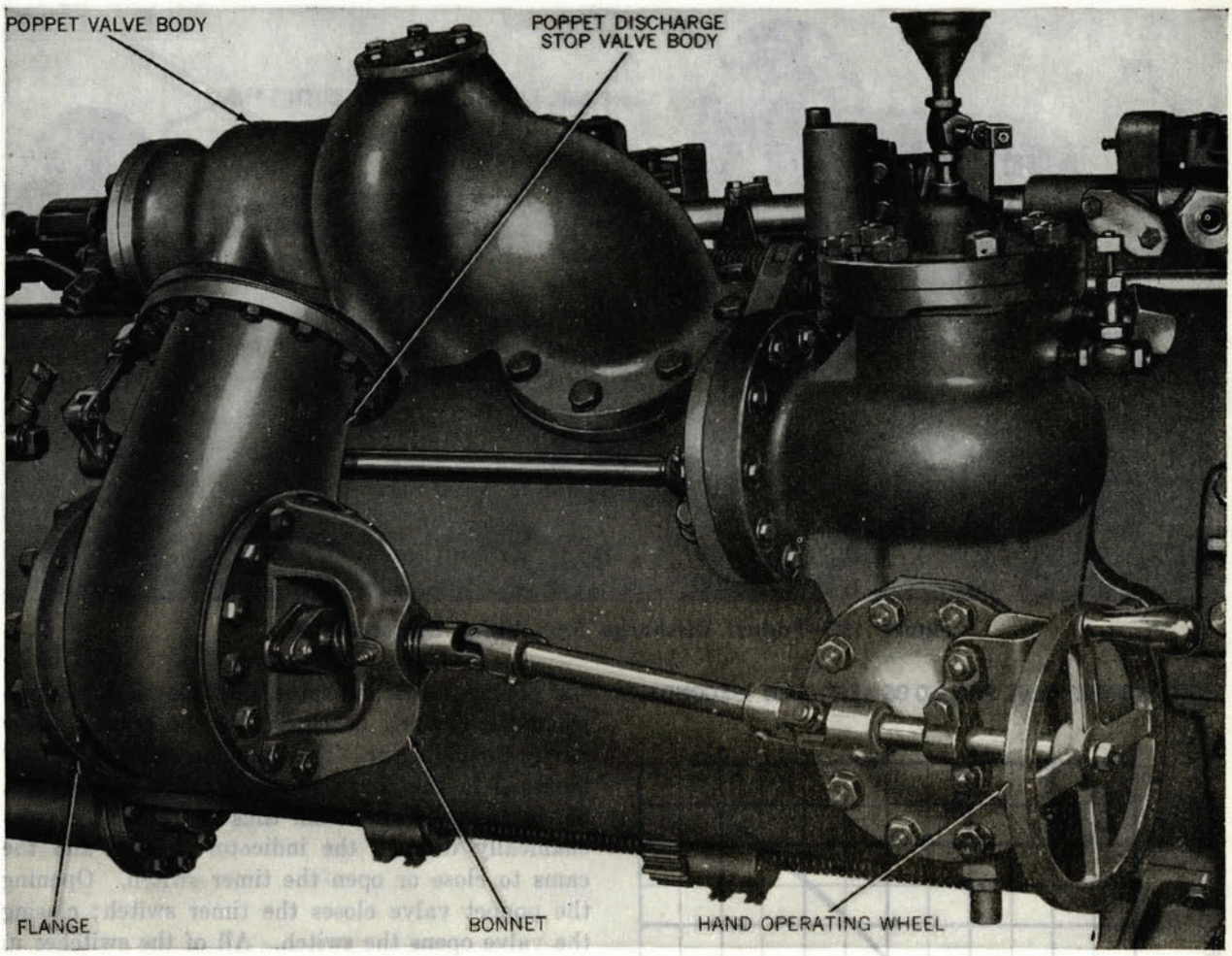


Figure 189—*Poppet Valve and Poppet Discharge Stop Valve Installed.*

prevent excessive water from entering the discharge pipe.

Poppet Valve Timing

Water pressure increases with depth. For any given impulse pressure, the greater the depth of the submarine the quicker the tube will fill with water after firing. Therefore, as depth increases, the length of time the poppet valve should remain open decreases, figure 191.

A single electrical timer for each tube nest is located where it can be seen easily by the poppet valve operator. The face of the timer includes an on-off switch, a red jewel indicator, and a dial that is marked in seconds from 0 to 10.

The on-off snap switch connects the timer to a power supply. The timer is started and stopped by a separate timer switch on the particular tube in the nest being fired.

One of the two hands on the timer dial is set manually to the desired number of seconds between opening and closing of the poppet valve. When the valve opens, the timer switch on the tube closes and starts a synchronous motor in the timer. The motor turns the second hand on the timer dial until the poppet valve is closed. At the point where the motor-driven hand matches the position of the manually set hand, a circuit in the timer closes to light up the jewel indicator. This red light indicates that the poppet valve should be closed. As the poppet valve closes, it opens the timer switch on the tube. The position of the motor-driven hand when it stops, shows the actual time the poppet valve was open.

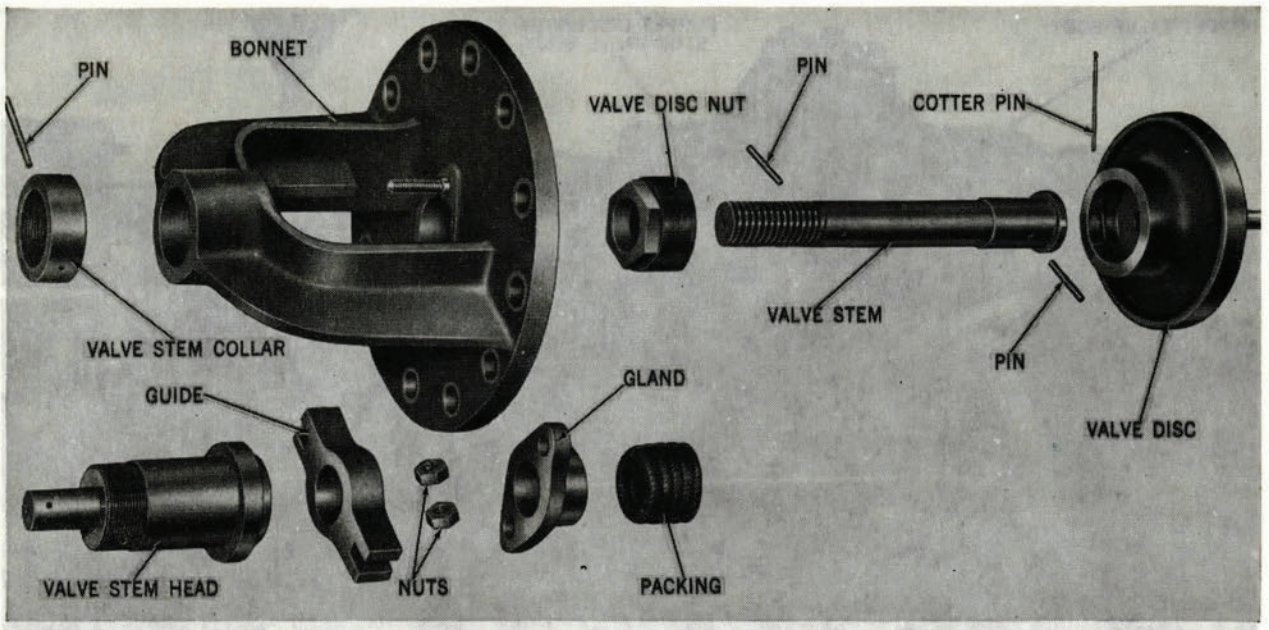


Figure 190—*Poppet Discharge Stop Valve Disassembled.*

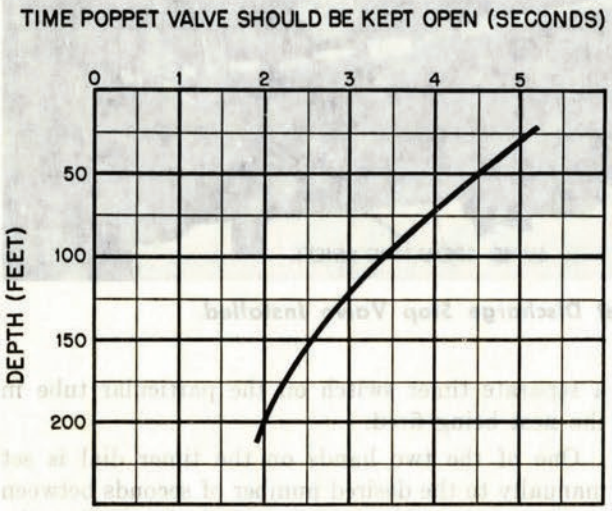


Figure 191—*Poppet Valve Timing*

Timer Switch. The timer switch is a cam-operated, normally open switch mounted on the gyro retraction slide bracket. A cam is pinned to the poppet valve indicator shaft so that it turns when the opening or closing of the poppet valve moves the indicator. This cam engages a cam lever mounted in the timer switch bracket. Movement of the poppet valve stem thus is transmitted mechanically through the indicator linkage and the cams to close or open the timer switch. Opening the poppet valve closes the timer switch; closing the valve opens the switch. All of the switches in the tube nest are connected in parallel so that any one of them can start and stop the timer motor.

Elapsed times for closing the poppet valve at various depths are shown graphically in figure 191.

If the poppet discharge pipe leads beneath the torpedo room into an open tank containing water, some of this water may be blown up into the torpedo room when impulse air begins to vent. This may appear to indicate that water already is entering the tank through the poppet valve, but it should not influence the operator to close the poppet valve prematurely.

Chapter 15

POPPET VALVE SYSTEM

FOR TUBES EQUIPPED FOR MECHANICAL AND ELECTRICAL SETTING

When a torpedo is ejected from a tube by impulse air, the poppet valve system acts to vent the air back into the submarine. This prevents the air from escaping from the tube into the sea where it would reveal the submarine's position. The system is arranged so that the poppet valve can be used when firing water slugs. Parts of the system are also used to control or operate units of the firing mechanism and the fire control system.

The poppet valve system includes the poppet valve itself, a vent-closing valve, and a poppet valve operating unit. Vent and ship service air supply piping interconnect these units; letter identification of each port is stamped next to it. A roller trip mechanism prevents movement of the operating unit until the torpedo has moved about nine feet toward the muzzle; this prevents excessive water from entering the submarine through the poppet valve ahead of the impulse air. A mechanical connection from the operating unit operates a switch in the tube firing circuit. At the time that the operating unit acts to open the poppet valve, it also acts to throw this switch to open the tube firing circuit.

Poppet Valve

The poppet valve is a quick-opening vent arranged as shown in figure 171. Ship service air from the vent-closing valve and the operating unit acts on the poppet valve piston to open the valve against impulse air and water pressure in the tube. This vents the impulse air from the tube into the submarine through a poppet discharge pipe. After firing, the ship service air supply to the poppet valve is vented by hand operation of the vent-closing valve. The poppet valve is then forced closed by water pressure in the tube.

Gag Nut

An internally threaded gag nut, figure 192, threads onto the poppet valve cylinder head. Turned by a spanner wrench, the nut is usually in the breechward position. To lock the poppet valve closed, the nut is unscrewed until it takes up against the gag collar near the outer end of the valve stem. This prevents movement of the valve.

Indicator

A poppet valve indicator, figure 187, shows the OPEN or SHUT position of the valve. It is operated by a linkage with a fork attachment to the shoulder stud at the end of the valve stem.

Timer and Timer Switch

The electrical timer for the tube nest is the same as that for tubes equipped for firing mechanically set torpedoes only, chapter 14.

Vent-Closing Valve

Manually operated, the vent-closing valve does two things:

1. It admits ship service air to the poppet valve operating unit to cock it.

2. It acts as a vent for the poppet valve operating unit and for the poppet valve.

The vent-closing valve actually includes two spring-loaded valves within a single housing. A manual setting lever may be set at ON or at OFF, figures 183 and 184. At ON, the lever acts through a valve plunger to force the supply valve open against its spring. With the lever in this position, the vent valve is closed. With the lever at OFF, the supply valve is closed and the vent valve is forced open by the lever, which pushes directly down on the vent valve stem. A mechanical connection to the tube vent valve, figure 185, shifts the lever from ON to OFF when the tube vent is opened. The setting lever is held to ON by a latch that engages an extension of the lever. To move the lever to OFF, either directly or by opening the

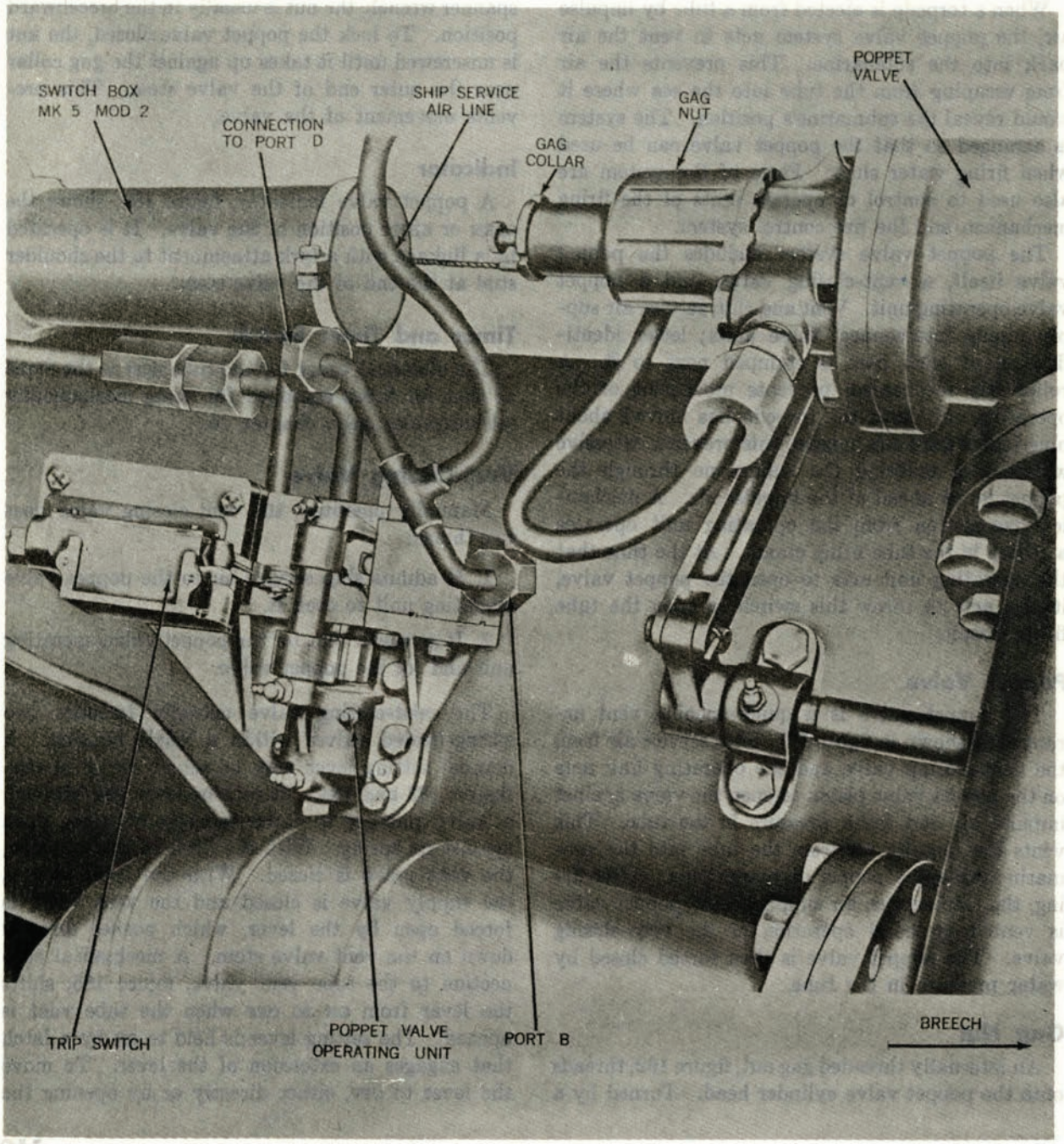


Figure 192—*Poppet Valve and Operating Unit Installed.*

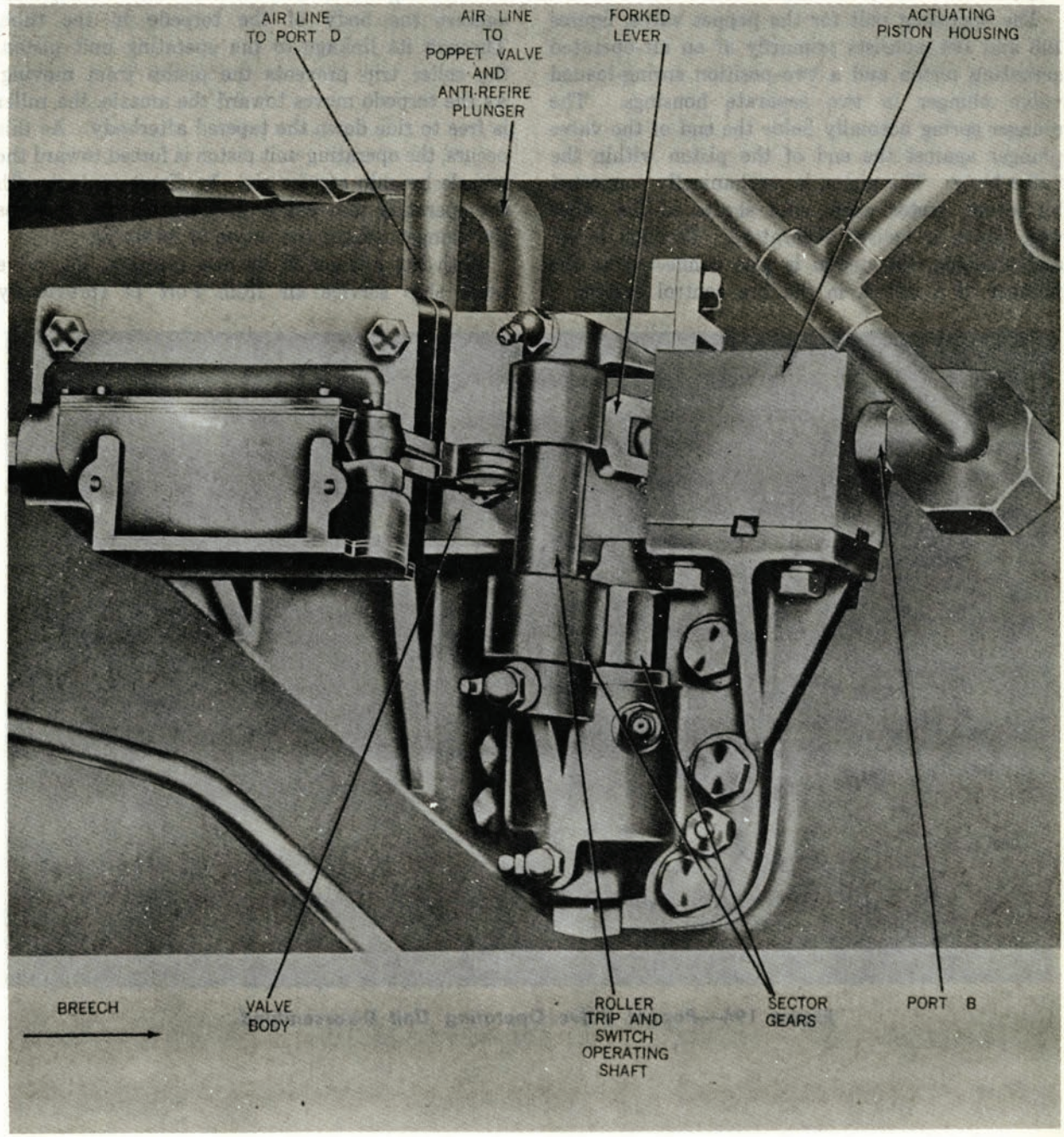


Figure 193—*Poppet Valve Operating Unit.*

tube vent, the RELEASE button on the vent-closing valve must be manually depressed.

Poppet Valve Operating Unit

The operating unit for the poppet valve, figures 193 and 194, consists primarily of an air-operated actuating piston and a two-position spring-loaded valve plunger in two separate housings. The plunger spring normally holds the end of the valve plunger against the end of the piston within the valve body. The piston is mechanically connected by levers, sector gears, and shafts to the roller trip, which is housed separately. Through levers and shafting, the piston is also connected to the plunger of a switch in the fire control system.

When torpedoes are fired by impulse air, with the poppet valve in use, ship service air is ported to the breech end (Port B) of the actuating piston by the vent-closing valve. The roller of the roller trip rests against the body of the torpedo in the tube. Through its linkage to the operating unit piston, the roller trip prevents the piston from moving. As the torpedo moves toward the muzzle, the roller is free to ride down the tapered afterbody. As this occurs, the operating unit piston is forced toward the muzzle by ship service air. In direct contact with the operating unit valve plunger, the piston moves the plunger against the action of its spring.

With the plunger in its new position, the valve ports ship service air from Port D (previously

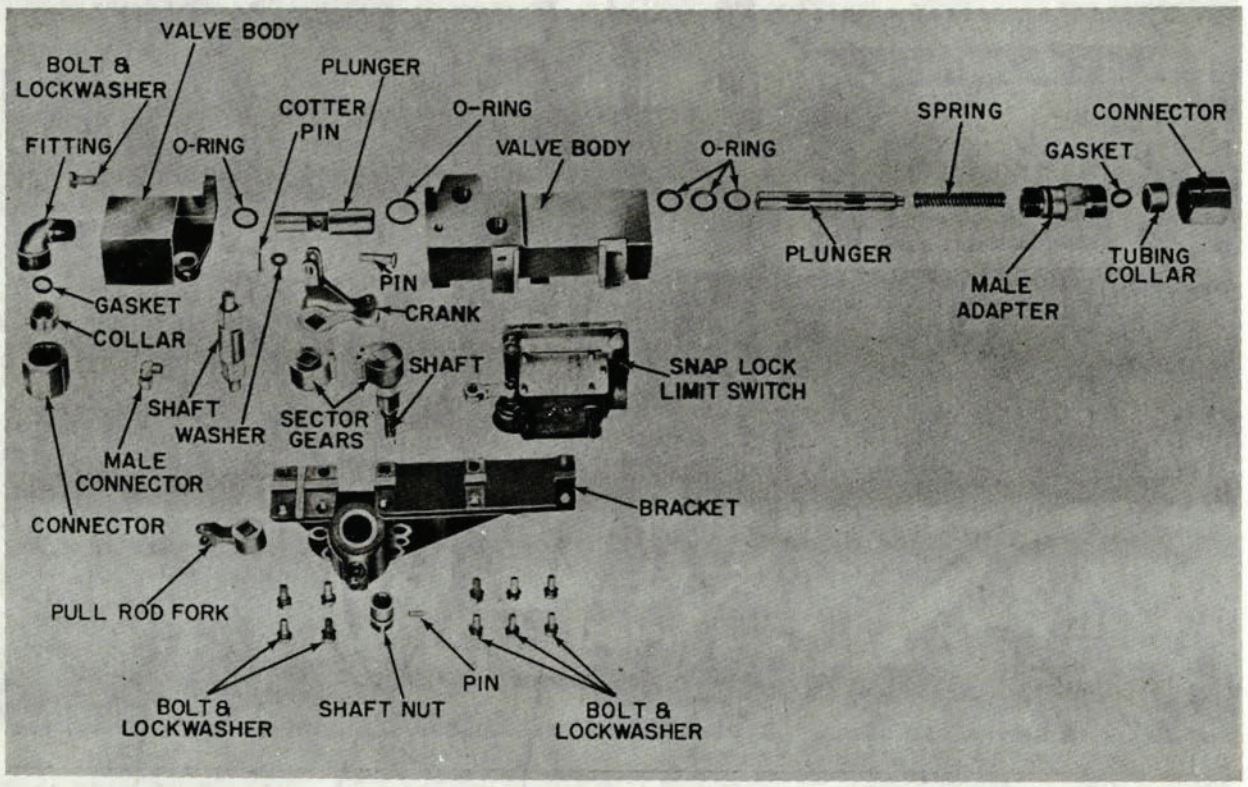


Figure 194—*Poppet Valve Operating Unit Disassembled*

trapped in the valve body) to the poppet valve, and also to the anti-refire plunger of the firing mechanism, chapter 13. Through internal ports, it also applies ship service air pressure to the space where the piston and valve plunger are in contact. This does two things: (1) it holds the plunger in position against the force of its spring, and (2) it forces the piston back to its original position toward the breech. As it moves smartly back to position, the piston pulls the roller up into its housing to clear torpedo propeller shroud rings. The valve plunger returns to its original position when the system is vented (by hand) after the poppet valve has been open the desired time. Two views of the poppet valve operating unit, with the poppet valve open and closed, are shown in figures 195 and 196.

When water slugs are fired with the poppet valve in use, the roller trip mechanism cannot restrain the operating unit piston because there is nothing

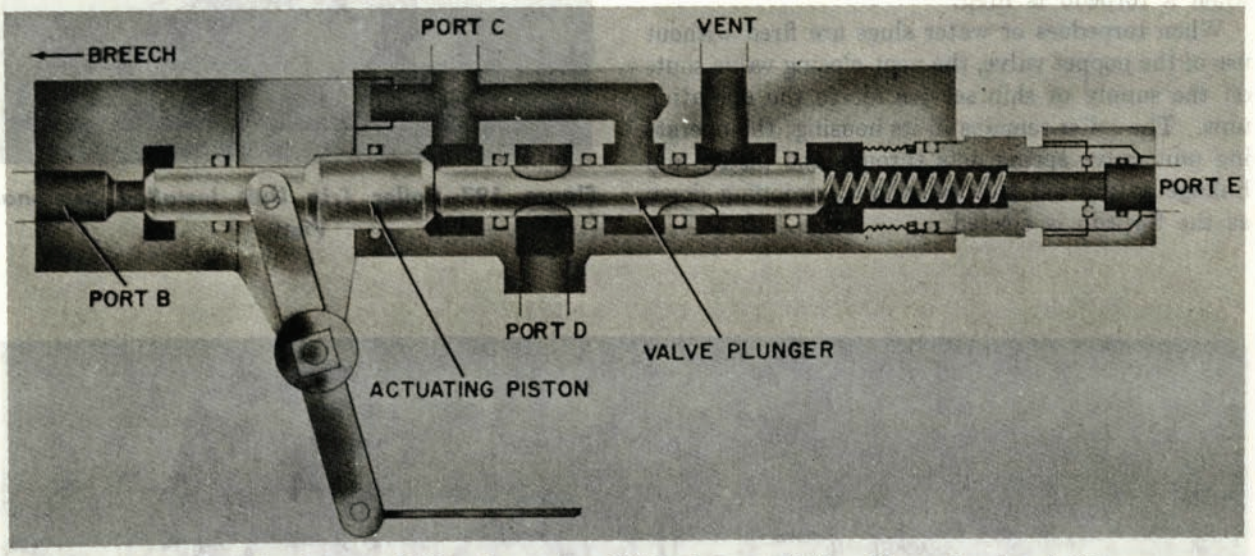


Figure 195—*Poppet Valve Operating Unit—Poppet Valve Shut—Sectional View*

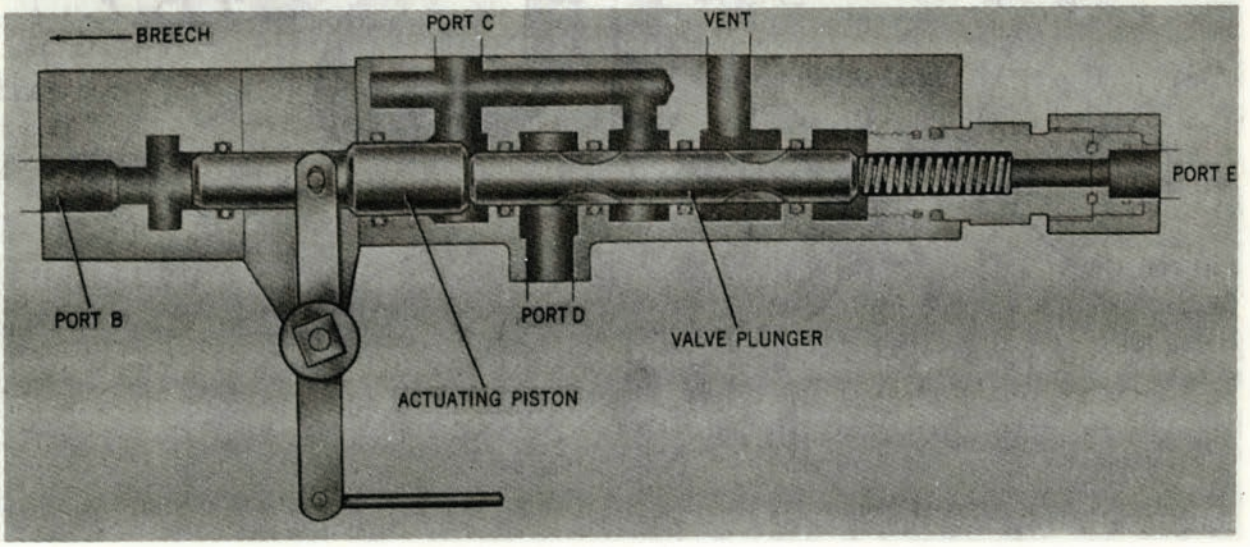


Figure 196—*Poppet Valve Operating Unit—Poppet Valve Open—Sectional View.*

in the tube to hold the roller up. A selector valve, chapter 13, manually placed and locked in the water slug position, connects the top of the firing valve lifting cup to the spring end of the operating unit valve. Pressure above the lifting cup then acts, in place of the roller trip, to prevent the valve plunger from being moved by the actuating piston. At the same time that the space above the lifting cup is vented to fire the tube, the pressure at the end of the valve in the operating unit is vented. The operating unit then acts in the same way that it does when a torpedo is fired.

When torpedoes or water slugs are fired without use of the poppet valve, the vent-closing valve shuts off the supply of ship service air to the operating unit. The roller remains in its housing; the operating unit valve spring acts through the piston and linkage to prevent the roller from dropping down as the torpedo is ejected.

Fire Control Switch

Fire Control System Mk 101 requires a normally open switch which will be closed for a short interval when the tube is fired. Operation of this switch opens the firing circuit of the tube which has been fired, steps the system to the next tube to be fired,

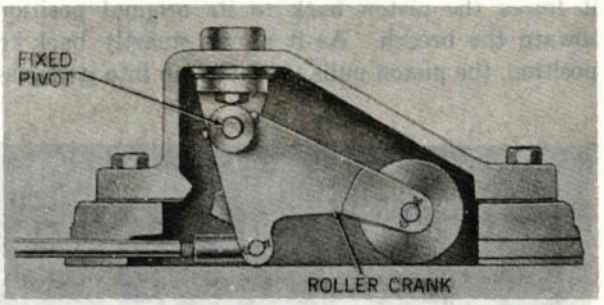


Figure 197—*Roller Trip Unit Installed—Sectional View.*

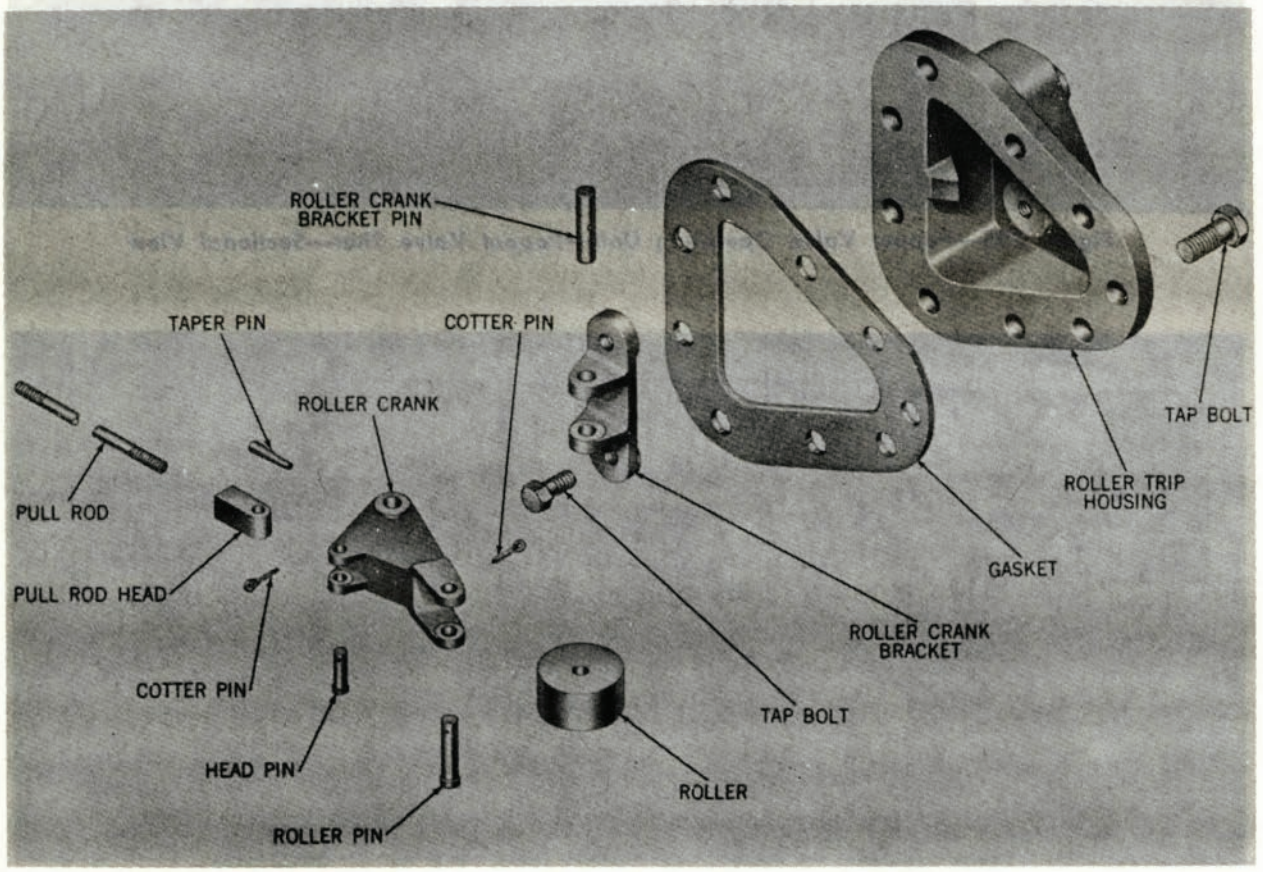


Figure 198—*Roller Trip Unit Parts.*

and starts the intervalometer. Fire Control System Mk 106 requires a normally closed switch which will be opened for a short interval after the tube has been fired. Operation of this switch in the Mk 106 system merely de-energizes the tube-firing circuit.

In either case, the switch is mounted on the poppet valve operating unit, figure 192. Through the lever arrangement shown in figure 193 the actuating piston of the operating unit operates the switch as the piston is moved first toward the muzzle and then toward the breech by ship service air. Adjustment of the time interval during which the switch is opened or closed is made with an adjusting screw, figure 193 which is then drilled and held in place by a cotter pin.

Roller Trip Mechanism

The roller trip mechanism consists of a roller, a roller crank, a housing, and a pull rod arranged as shown in figures 197 and 198. The pull rod is pinned to a fork in the operating unit housing. The upper end of the fork is pinned to a shaft to which a sector gear, figure 195, is also pinned. This gear meshes with a corresponding sector gear on the roller trip and switch operating shaft. A forked lever connects the operating unit piston to the operating shaft. Movement of the piston moves the roller trip through the operating shaft, sector gears, pull rod, and roller crank. Proper adjustment of the linkage between the operating unit and the roller trip is important and should be accomplished as follows: With the operating unit piston at hard stop muzzleward, adjust the pull rod heads until the roller protrudes $1\frac{3}{16}$-inch into the tube bore with all linkage backlash taken up.

Poppet Valve Discharge System

This system is the same as that described in chapter 14.

Operation

Because of its interconnection with the firing mechanism, operation of the poppet valve system is described with that of the firing mechanism, chapter 13.

Chapter 16

INTERLOCKING MECHANISMS

Diagrams of torpedo tube interlocking systems are shown in figure 199 (for a hand-operated muzzle door mechanism) and in figure 200 (for a power-operated muzzle door mechanism). These figures illustrate the drain valve and muzzle door interlocking mechanism fitted on all Electric Boat Company type tubes and on lower stern tubes of the Portsmouth type. The interlocking mechanisms shown are for a lower left-hand tube.

The interlocking mechanisms consist of three major sections, one each for the breech and muzzle doors, the tube drain valve and muzzle door, and the firing mechanism. Each is manually operated by movement of its respective interlock lever, figure 201.

The interlocking mechanisms prevent:

1. Opening the breech door while the muzzle door is open.

2. Opening the muzzle door while the breech door is open.

3. Opening the muzzle door when the drain valve is open.

4. Opening the drain valve when the muzzle door is open.

5. Firing the tube unless all the following steps have been performed:

   a. Muzzle door locked open,
   b. Breech door locked closed,
   c. Drain valve locked closed,

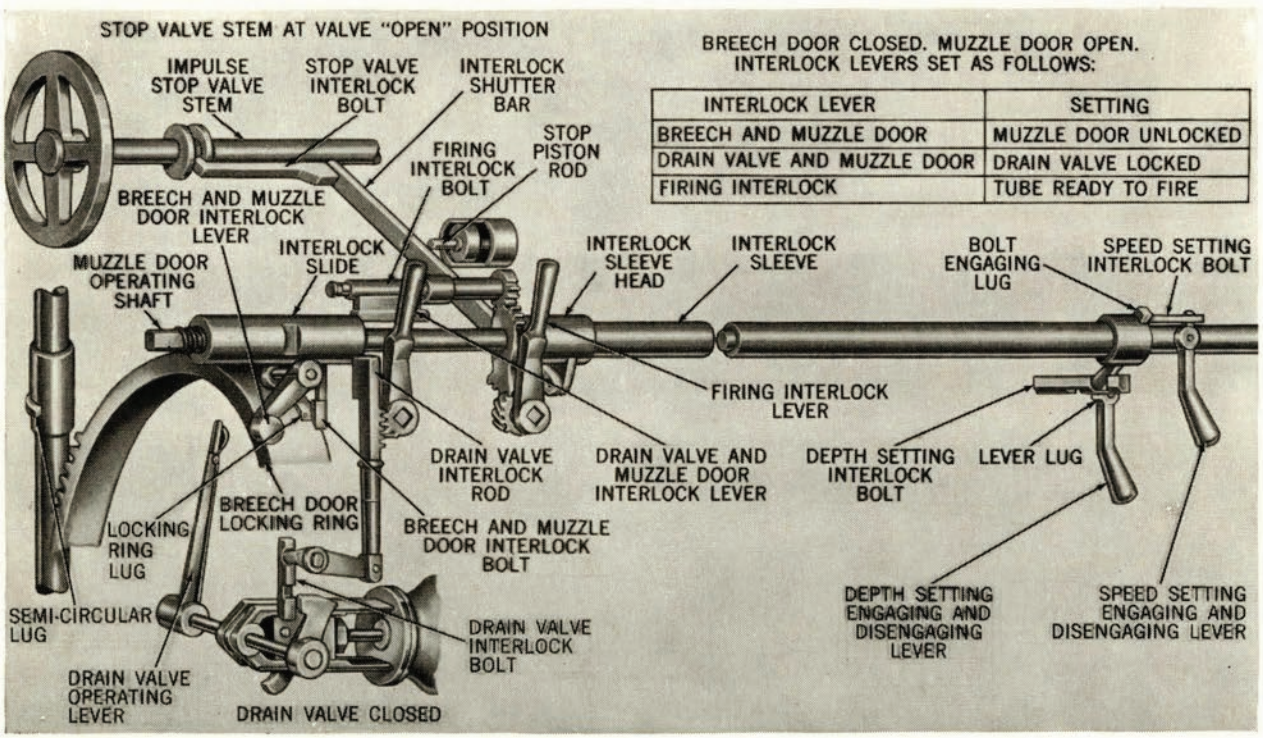


Figure 199—*Interlocking Mechanisms—Tube Ready to Fire—Tube Equipped With Hand-Operated Muzzle Door.*

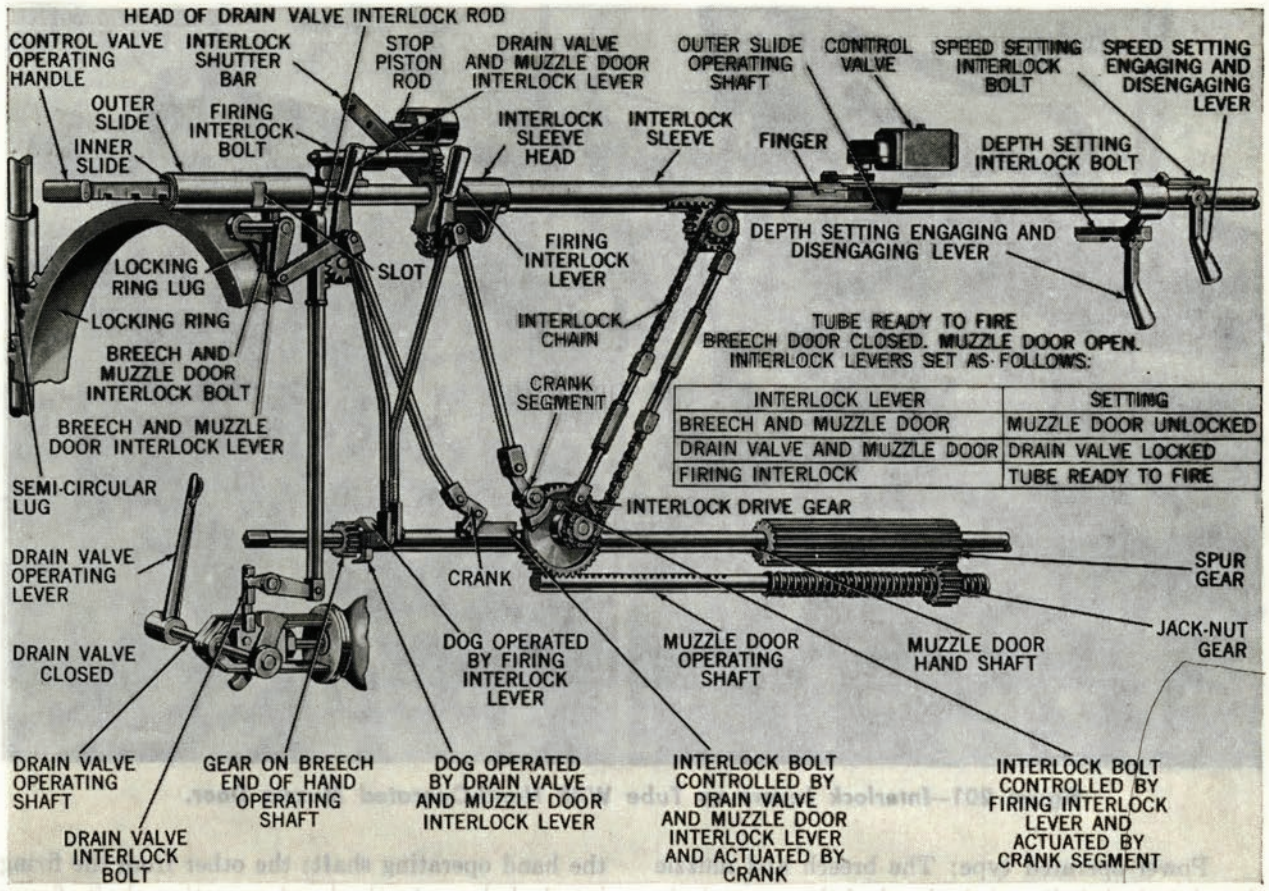


Figure 200—*Interlocking Mechanisms—Tube Ready to Fire—Tube Equipped With Power-Operated Muzzle Door.*

d. Depth and speed setting spindles retracted into tube, and

e. Impulse stop valve (if installed) locked open.

The interlocking mechanisms are centered about the muzzle door operating shaft, and on tubes fitted with hand-operated muzzle door mechanisms, act through the interlock slide or the interlock sleeve. In tubes fitted for power operation, they act through the outer and inner slides, the finger, and the interlock sleeve.

Differences between the interlocking mechanisms for tubes fitted with the two types of muzzle door mechanisms are:

1. Movement of the interlock slide and outer slide—

Hand-operated type: The interlock slide is moved fore-and-aft by threads on the muzzle door operating shaft.

Power-operated type: The outer slide (which corresponds to the interlock slide) is driven by gears, sprockets, and a chain from the muzzle door operating shaft.

2. Connection of the interlock levers—

Hand-operated type: The breech and muzzle door interlock lever is operated manually, independently of other gear.

Power-operated type: The breech and muzzle door interlock lever is linked to and operated by movement of the drain valve and muzzle door interlock lever.

3. To prevent the muzzle door from being opened—

Hand-operated type: The breech and muzzle door interlock bolt and the head of the upper drain valve interlock rod engage the interlock slide, preventing its movement.

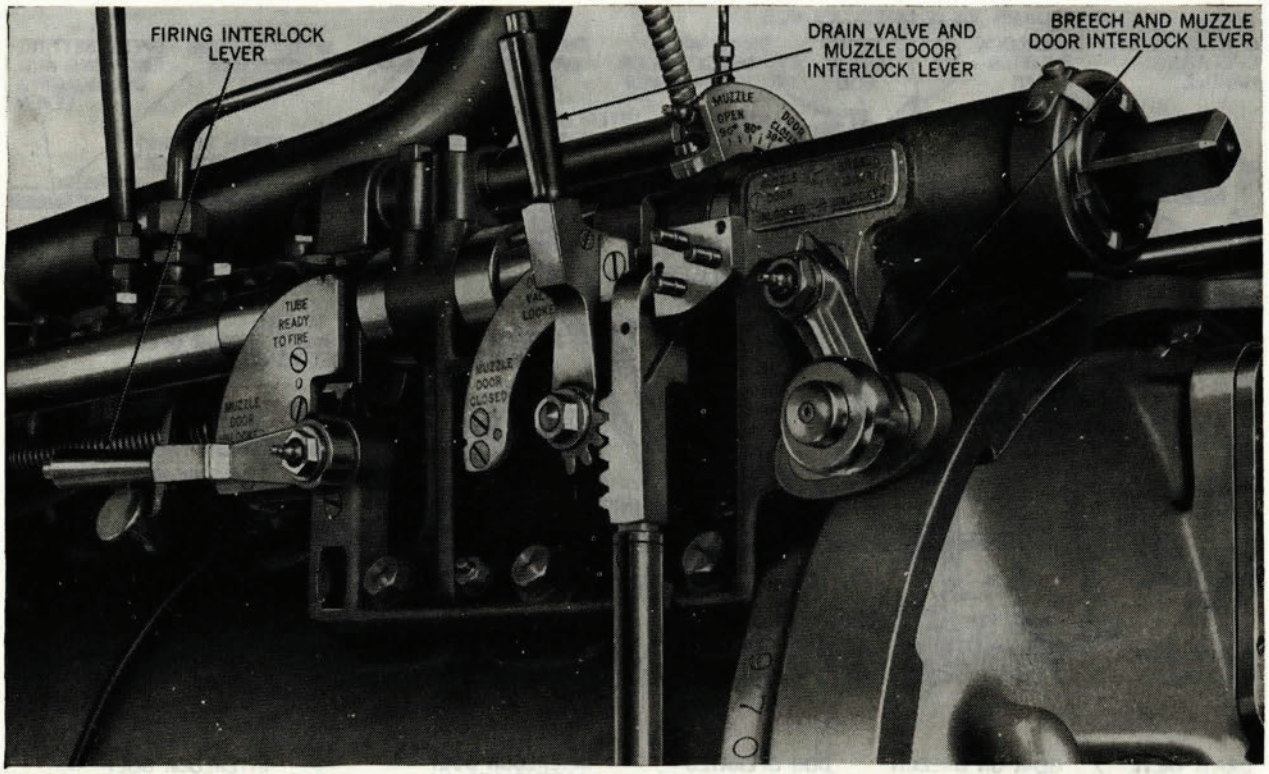


Figure 201—*Interlock Levers on Tube With Hand-Operated Muzzle Door.*

Power-operated type: The breech and muzzle door interlock bolt and the head of the upper drain valve interlock rod engage the inner slide, preventing fore-and-aft motion of the finger and thereby preventing action of the hydraulic control valve.

4. To prevent the muzzle door from being closed—

Hand-operated type: The firing interlock bolt engages the muzzle end of the interlock slide, preventing its movement.

Power-operated type: The firing interlock bolt engages the finger, preventing its movement.

5. Hand operating shaft interlocks—

Hand-operated type: No emergency hand operating shaft, or associated interlocks, are required.

Power-operated type: An emergency hand operating shaft is installed.

Two additional linkages are installed. Each consists of a connecting rod from an interlock lever to a dog which engages a gear on the breech end of the hand operating shaft. One linkage extends from the drain valve and muzzle door interlock lever to the hand operating shaft; the other from the firing interlock lever to the hand operating shaft, figure 202. These linkages perform the same function in relation to the hand operating shaft that the interlock bolts perform in relation to the power-operated gear.

6. To lock the muzzle door closed—

Hand-operated type: The condition described in paragraph 3, for hand-operated type, constitutes such a locking of the muzzle door operating mechanism.

Power-operated type: A special lock is operated through a rod extending down from the drain valve and muzzle door interlock lever. Downward movement of the rod engages a sliding bolt in a slot in the rim of the interlock drive gear, thereby locking the gear.

7. To lock the muzzle door open—

Hand-operated type: The condition described in paragraph 4, for hand-operated type, describes such a locking of the muzzle door operating mechanism.

Power-operated type: Interlock consists of a

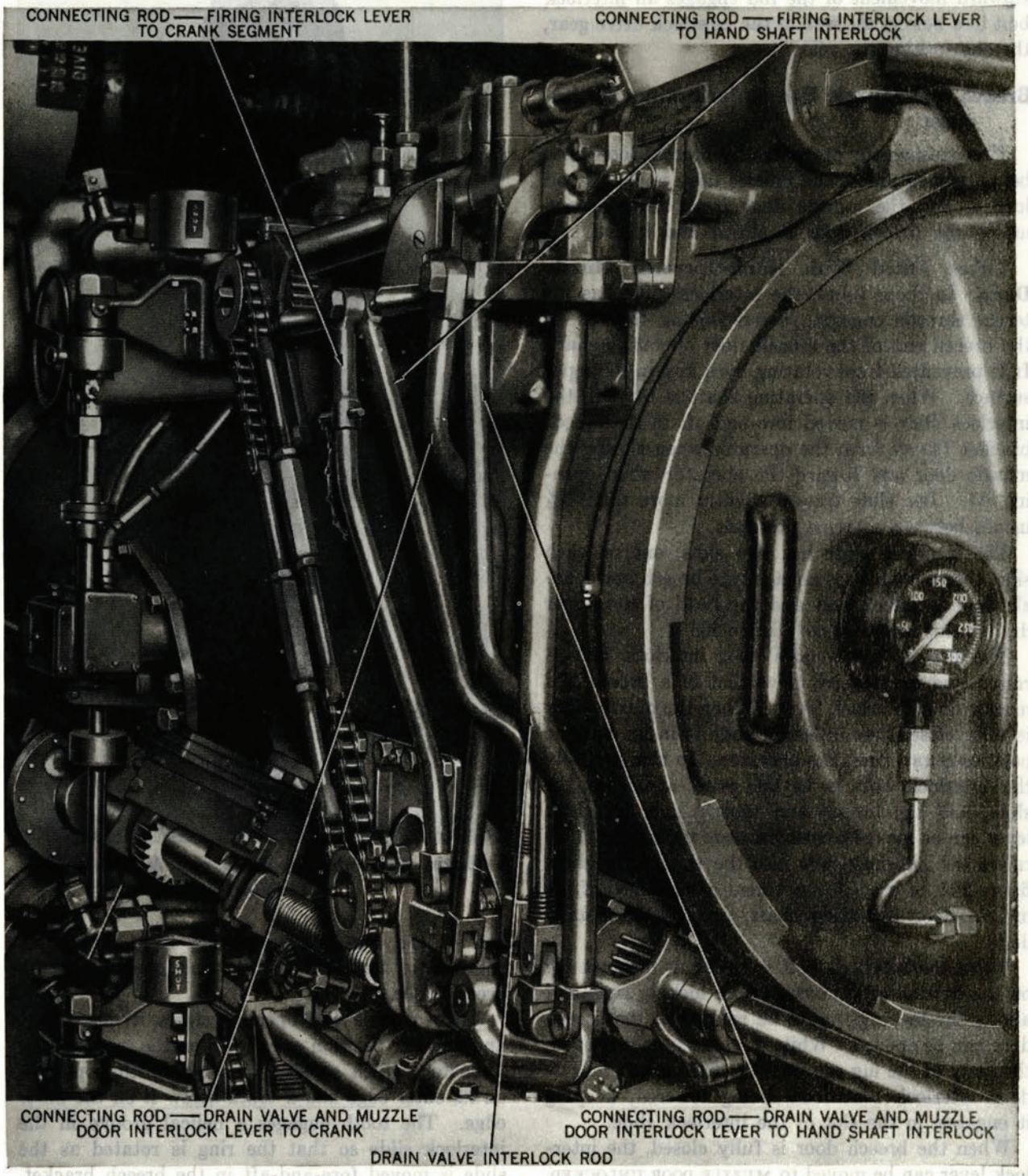


Figure 202—*Inboard Breech Station—Tube With Power-Operated Muzzle Door.*

rod extending down from the firing interlock lever. Upward movement of the rod engages an interlock bolt in a hole in the web of the interlock drive gear, thereby locking the gear.

Breech and Muzzle Door Interlocking Mechanism

This mechanism prevents the breech door from being opened unless the muzzle door is closed and locked, and the muzzle door from being opened unless the breech door is closed and locked.

Tubes Fitted With Hand-Operated Muzzle Door. In these tubes, the interlock slide has internal threads engaging corresponding threads on the breech end of the muzzle door operating shaft. It is prevented from rotating by a key in its upper surface. When the operating shaft is rotated, the interlock slide is moved fore-and-aft in the breech bracket (away from the operator when closing the muzzle door and toward the operator when opening it). The slide travels slightly more than 4¾ inches between extreme positions.

The interlock slide has two slots, one on each side, through which it engages the breech and muzzle door interlock bolt and the head of the upper drain valve interlock rod, figure 203.

The breech and muzzle door interlock bolt is raised and lowered by movement of a breech and muzzle door interlock lever. When the muzzle door is fully closed, the interlock slide is in its extreme position away from the operator. In this position, the interlock bolt is in line with a slot in the slide, and the breech and muzzle door interlock lever can be moved to BREECH DOOR UNLOCKED. This raises the interlock bolt into the slot in the slide, figure 204, to prevent movement of the slide, of the muzzle door operating shaft, and of the muzzle door.

When the interlock bolt is raised, it clears a lug on the outside of the breech door locking ring, and allows the locking ring to be rotated so the breech door can be opened. While the breech door is open, the body of the lug prevents the breech and muzzle door interlock bolt from being lowered, keeping it engaged in the slot of the interlock slide.

When the breech door is fully closed, the interlock lever can be moved to MUZZLE DOOR UNLOCKED. This lowers the interlock bolt, clearing it from the slot in the interlock slide, and the muzzle door can be opened. At the same time, it engages the end of the lug on the locking ring, preventing rotation of the locking ring and opening of the breech door.

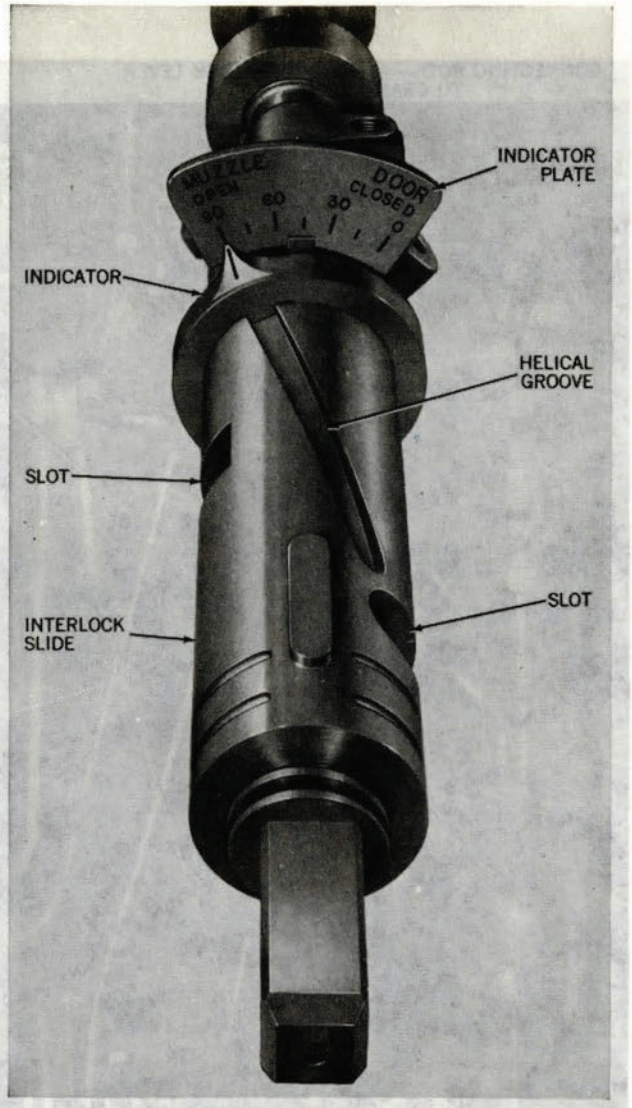


Figure 203—*Interlock Slide and Muzzle Door Indicator.*

As the muzzle door opens or closes, its movement and angular position are shown on the muzzle door indicator, which consists of a ring with a pointer on its outer edge and a tooth below it on the inner edge. The tooth engages a helical groove in the interlock slide so that the ring is rotated as the slide is moved fore-and-aft in the breech bracket. The pointer on the ring is moved in an arc across an indicator plate graduated in 15° increments from 0 to 90.

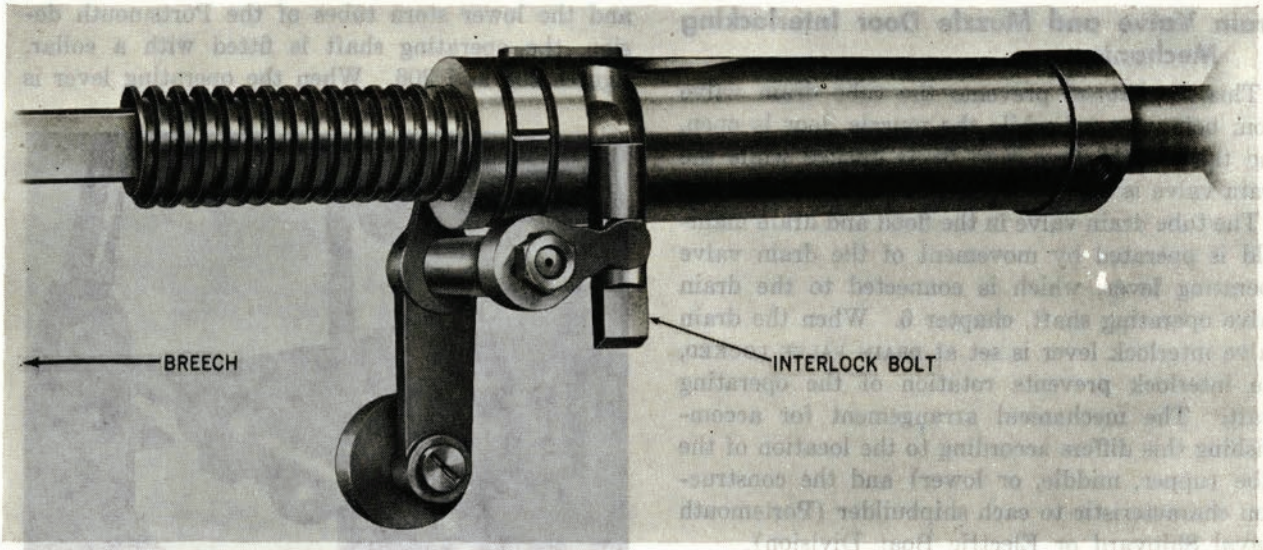


Figure 204—*Muzzle Door Closed and Locked—Breech and Muzzle Door Interlock Bolt Engaging Slide.*

To permit correct positioning of the interlock slide, means are provided for its adjustment by a saw-tooth coupling in the muzzle door operating shaft and a slide stop in the exposed end of the breech bracket. When the muzzle door is fully closed, the breech and muzzle door interlock bolt and the head of the upper drain valve interlock rod should freely enter their respective slots in the interlock slide. When the muzzle door is fully open, the slide should be in contact with the slide stop, and far enough away from the thrust collar so the firing interlock bolt can swing downward.

Tubes Fitted With Power-Operated Muzzle Door. In these tubes, the fore-and-aft movement of the muzzle door operating shaft is transmitted by gears, sprockets, and interlock chain to the outer slide operating shaft which is attached to the outer slide. The inner slide is positioned by setting the control valve operating handle. The outer slide is slotted and the inner slide grooved to permit insertion of the breech and muzzle door interlock bolt and the head of the upper drain valve interlock rod.

When the muzzle door is closed fully, the outer and inner slides are positioned so the breech and muzzle door interlock bolt is in line with the slot and one of the grooves. Therefore, the breech and muzzle door interlock lever can be moved to BREECH DOOR UNLOCKED, raising the interlock bolt so it engages the slot in the outer slide and the groove in the inner slide. This blocks fore-and-aft movement of the finger, attached to the inner slide, preventing operation of the hydraulic control valve. In this raised position the interlock bolt clears the lug on the locking ring, permitting the breech door to open, as in the hand-operated type. The outer slide indicator shows movement and angular position of the muzzle door.

When the breech door is closed, the breech and muzzle door interlock lever can be moved to MUZZLE DOOR UNLOCKED, locking the breech door closed, and permitting the opening of the muzzle door.

The drain valve and muzzle door interlock lever is linked to, and moves, the breech and muzzle door interlock lever. Setting the drain valve and muzzle door interlock lever at MUZZLE DOOR CLOSED also sets the breech and muzzle door interlock lever at BREECH DOOR UNLOCKED. Setting the drain valve and muzzle door interlock lever at DRAIN VALVE LOCKED also sets the breech and muzzle door interlock lever at MUZZLE DOOR UNLOCKED.

Each tube, whether it is fitted with a hand- or power-operated muzzle door mechanism, has an interlock which presents the locking ring from being rotated to MUZZLE DOOR UNLOCKED while the breech door is open. When the breech door is opened, a lug attached to the hub of the upper hinge arm of the door swings into a tooth space in the locking ring gear segment, preventing movement of the locking ring until the breech door has been closed.

Drain Valve and Muzzle Door Interlocking Mechanism

This mechanism prevents the tube drain valve from being opened while the muzzle door is open, and the muzzle door from being opened while the drain valve is open.

The tube drain valve in the flood and drain manifold is operated by movement of the drain valve operating lever, which is connected to the drain valve operating shaft, chapter 6. When the drain valve interlock lever is set at DRAIN VALVE LOCKED, the interlock prevents rotation of the operating shaft. The mechanical arrangement for accomplishing this differs according to the location of the tube (upper, middle, or lower) and the construction characteristic to each shipbuilder (Portsmouth Naval Shipyard or Electric Boat Division).

The operating shafts for any one bank of tubes are installed below the breech end of the lower tube. Since the lower tube is located close to its operating shaft, its interlock rod extends from its drain valve interlock lever to the parts which lock and unlock the shaft.

Because of location, such direct connection is not feasible for middle and upper tubes. Shafting and linkages transmit movements of the drain valve interlock lever to the interlocking parts. Upper stern tubes and middle bow tubes have two, and upper bow tubes have three interlock rods, all connected so that movement of the upper rod moves the other(s).

Tubes Fitted With Hand-Operated Muzzle Door. On Electric Boat Division designed tubes and the lower stern tubes of the Portsmouth design, the operating shaft is fitted with a collar, figures 205 and 206. When the operating lever is moved to open or close the drain valve, the operating shaft and its collar rides inside a curved slot in the interlock pedestal.

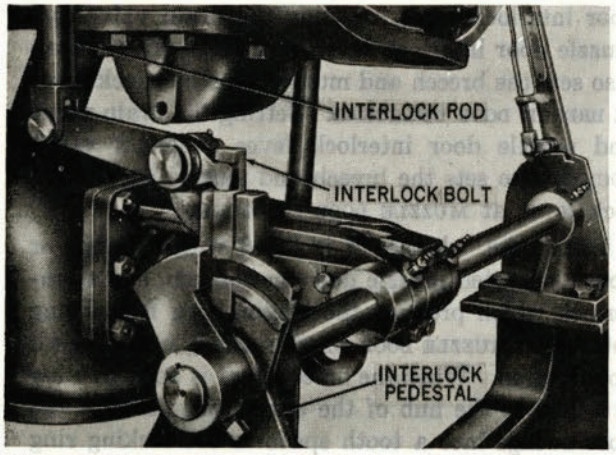


Figure 205—*Position of Drain Interlock Bolt—Interlock Lever at MUZZLE DOOR CLOSED.*

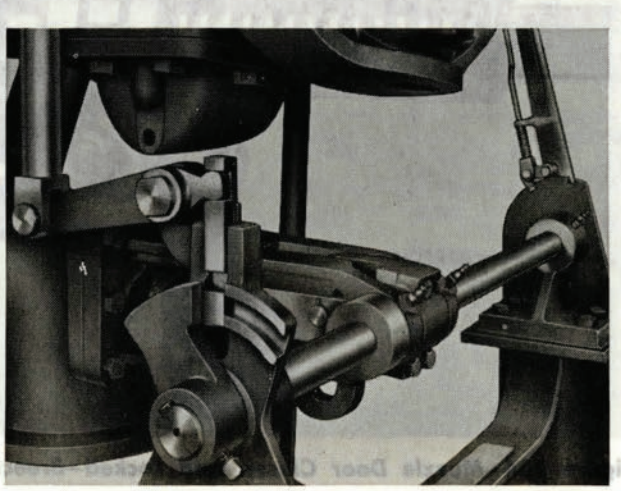


Figure 206—*Position of Drain Interlock Bolt—Interlock Lever at DRAIN VALVE LOCKED.*

A sector gear at the lower end of the drain valve interlock lever engages a rack gear on the head of the upper interlock rod. Movement of the interlock lever moves this interlock rod up or down to engage or disengage a slot in the interlock slide, figures 207 and 208. The lower end of the lower interlock rod connects to one end of a lever; the other end enters a slot in the top of the drain valve interlock bolt. The interlock bolt extends through the curved slot in the interlock pedestal, and has another slot in its lower end. Before the lug on the operating shaft collar can be moved fully from one position to the other, the lower slot of the interlock bolt must be lined up with the slot in the interlock pedestal.

When the muzzle door is closed, the interlock slide is positioned so that the slot in the interlock slide lines up with the head of the upper interlock rod. Setting the drain valve interlock lever at MUZZLE DOOR CLOSED raises this interlock rod so that its head engages the slot in the interlock slide, preventing movement of the slide and opening of the muzzle door. Raising the interlock rod(s) also forces the drain valve interlock bolt down, aligning the lower slot in the bolt with the slot in the interlock pedestal

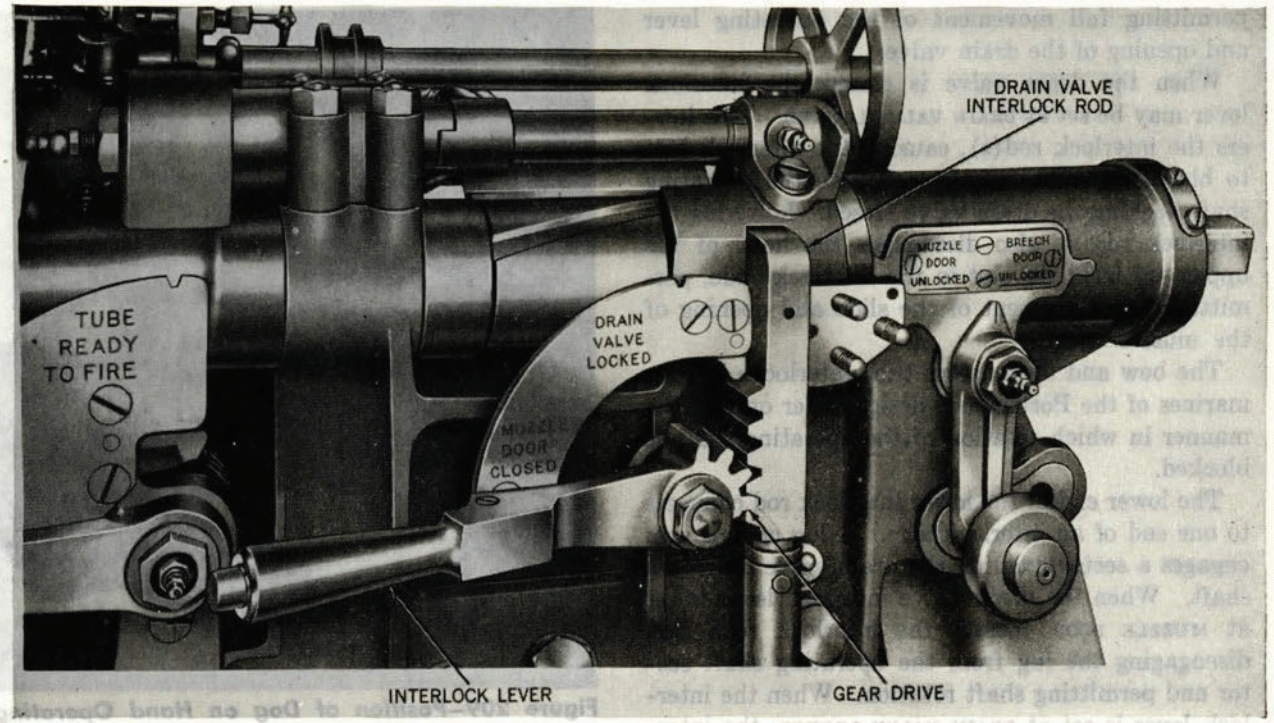


Figure 207—*Drain Valve and Muzzle Door Interlock Lever at MUZZLE DOOR CLOSED.*

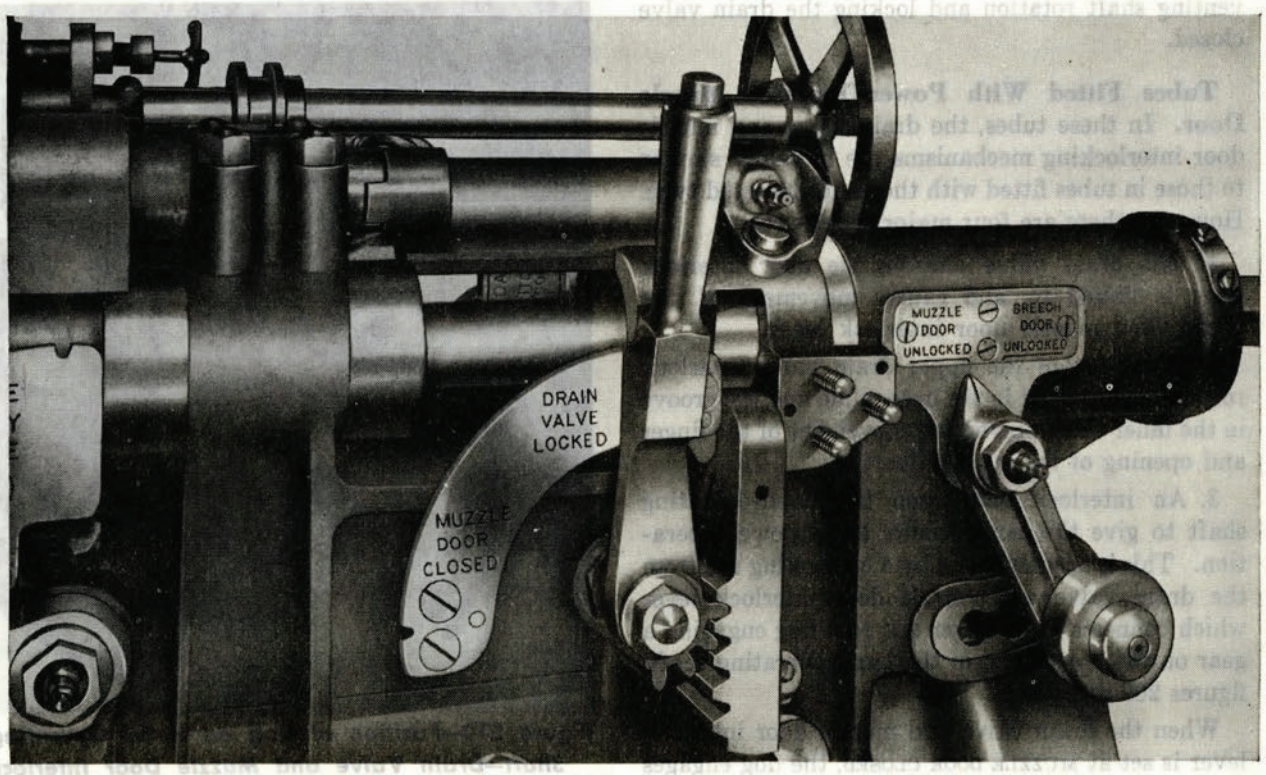


Figure 208—*Drain Valve and Muzzle Door Interlock Lever at DRAIN VALVE LOCKED.*

permitting full movement of the operating lever and opening of the drain valve.

When the drain valve is closed, the interlock lever may be set at DRAIN VALVE LOCKED. This lowers the interlock rod(s), causing the interlock bolt to block movement of the collar on the operating shaft, locking the drain valve closed. Lowering the interlock rod(s) also disengages the head of the upper rod from the slot in the interlock slide, permitting full movement of the slide and opening of the muzzle door.

The bow and upper stern tube interlocks in submarines of the Portsmouth design differ only in the manner in which rotation of the operating shaft is blocked.

The lower end of the lower interlock rod connects to one end of an interlock arm. A lug on this arm engages a sector fixed on the drain valve operating shaft. When the drain valve interlock lever is set at MUZZLE DOOR CLOSED, the interlock rods rise, disengaging the lug from the operating shaft sector and permitting shaft rotation. When the interlock lever is set at DRAIN VALVE LOCKED, the interlock rods fall, engaging the lug on the interlock arm with the operating shaft sector, thus preventing shaft rotation and locking the drain valve closed.

Tubes Fitted With Power-Operated Muzzle Door. In these tubes, the drain valve and muzzle door interlocking mechanisms are basically similar to those in tubes fitted with the hand-operated type. However, there are four major differences:

1. The drain valve and muzzle door interlock lever is linked to, and causes movement of, the breech and muzzle door interlock lever.

2. The head of the upper drain valve interlock rod engages the slot in the outer slide and the groove in the inner slide, preventing movement of the finger and opening of the muzzle door.

3. An interlock acts upon the hand-operating shaft to give the same results as in power operation. This is accomplished by a connecting rod from the drain valve and muzzle door interlock lever which connects at its lower end to a dog engaging a gear on the breech end of the hand-operating shaft, figures 209 and 210.

When the drain valve and muzzle door interlock lever is set at MUZZLE DOOR CLOSED, the dog engages the gear on the hand-operating shaft preventing its

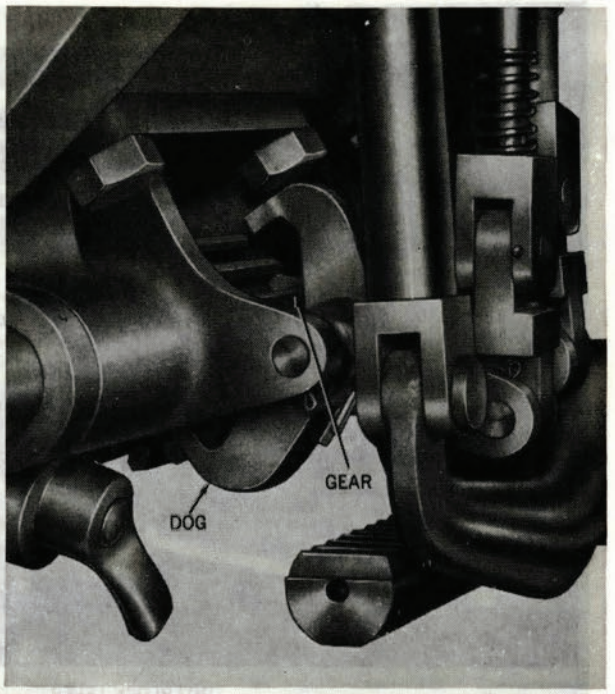


Figure 209—*Position of Dog on Hand Operating Shaft—Drain Valve and Muzzle Door Interlock Lever at MUZZLE DOOR CLOSED.*

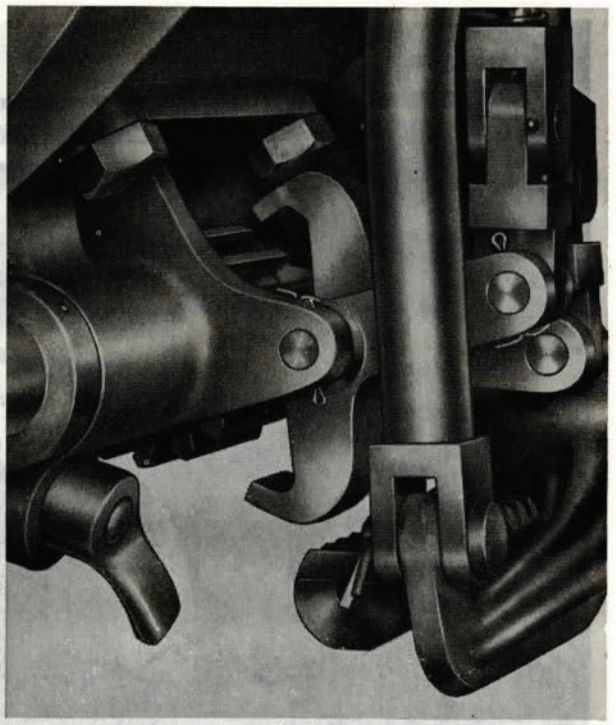


Figure 210—*Position of Dog on Hand Operating Shaft—Drain Valve and Muzzle Door Interlock Lever at DRAIN VALVE LOCKED.*

rotation. In general, when the finger is prevented from moving, the hand-operating shaft cannot be rotated.

4. An interlock locks the muzzle door in closed position. It consists, in part, of a rod extending down from the drain valve and muzzle door interlock lever, with its lower end connecting to a crank. The crank engages a pin in a sliding interlock bolt. Movement of the drain valve and muzzle door interlock lever rotates the crank, moving the interlock bolt. The bolt slides in a groove of an interlock bracket to engage and disengage a slot in the rim of the interlock drive gear, which meshes with the muzzle door operating shaft.

When the interlock lever is set at MUZZLE DOOR CLOSED, figure 211, the interlock bolt is moved in to engage the slot in the interlock drive gear, preventing movement of the gear and muzzle door operating shaft, and locking the muzzle door closed. If the muzzle door is not fully closed, the interlock drive gear is rotated so that the slot is not in line with the interlock bolt. The rim of the gear then prevents movement of the interlock bolt and of the drain valve and muzzle door interlock lever to MUZZLE DOOR CLOSED. When the drain valve and muzzle door interlock lever is set at DRAIN VALVE LOCKED, figure 212, the interlock bolt is moved out

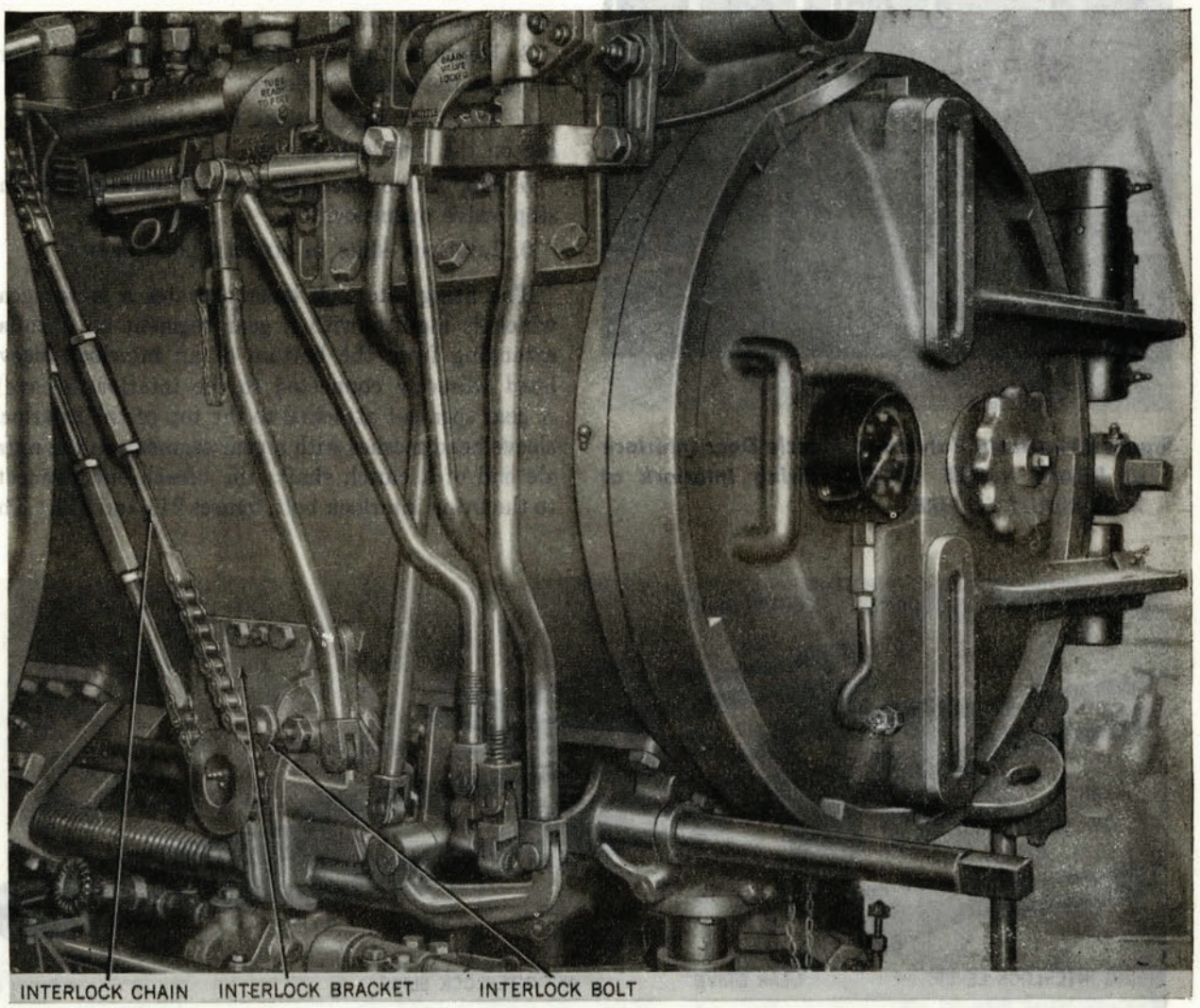


Figure 211—*Drain Valve and Muzzle Door Interlock at MUZZLE DOOR CLOSED—Firing Interlock at MUZZLE DOOR UNLOCKED.*

to disengage from the slot in the interlock drive gear, permitting the muzzle door to be opened.

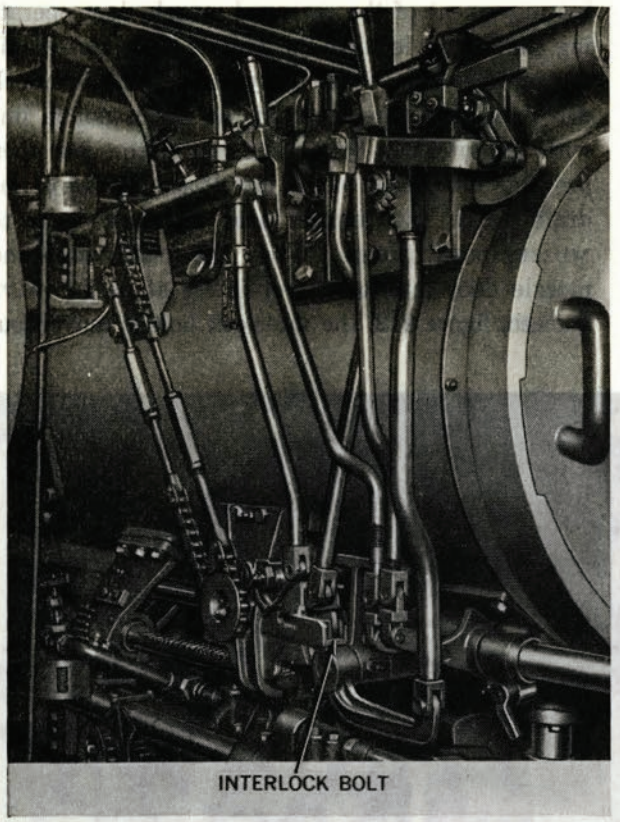


Figure 212—*Drain Valve and Muzzle Door Interlock at DRAIN VALVE LOCKED—Firing Interlock at TUBE READY TO FIRE.*

Firing Interlocking Mechanism

This mechanism prevents the tube from being fired until all other interlocks are properly set. In the firing procedure, the last step before closing the firing key is to set the firing interlock lever at TUBE READY TO FIRE.

Tubes Fitted With Hand-Operated Muzzle Door. In these tubes, the firing interlock lever cannot be set at TUBE READY TO FIRE until all other interlocking mechanisms are in position for firing, as follows:

1. Breech and muzzle door interlock lever at MUZZLE DOOR UNLOCKED.
2. Drain valve and muzzle door interlock lever at DRAIN VALVE LOCKED.
3. Depth setting interlock bolt disengaged from a lug on the interlock sleeve.
4. Speed setting interlock bolt disengaged from a lug on the interlock sleeve.
5. Stop valve interlock bolt (if installed) in the stop valve open position.
6. Interlock slide in MUZZLE DOOR OPEN.

The firing interlock lever operates a sector gear which is meshed with a gear segment on a collar extending from the bottom of an interlock sleeve head (directly connected to the interlock sleeve). A gear segment attached to the top of the interlock sleeve head meshes with a gear segment on the muzzle end of a clutch shaft; the breech end connects to the firing interlock bolt, figures 213 and 214. The

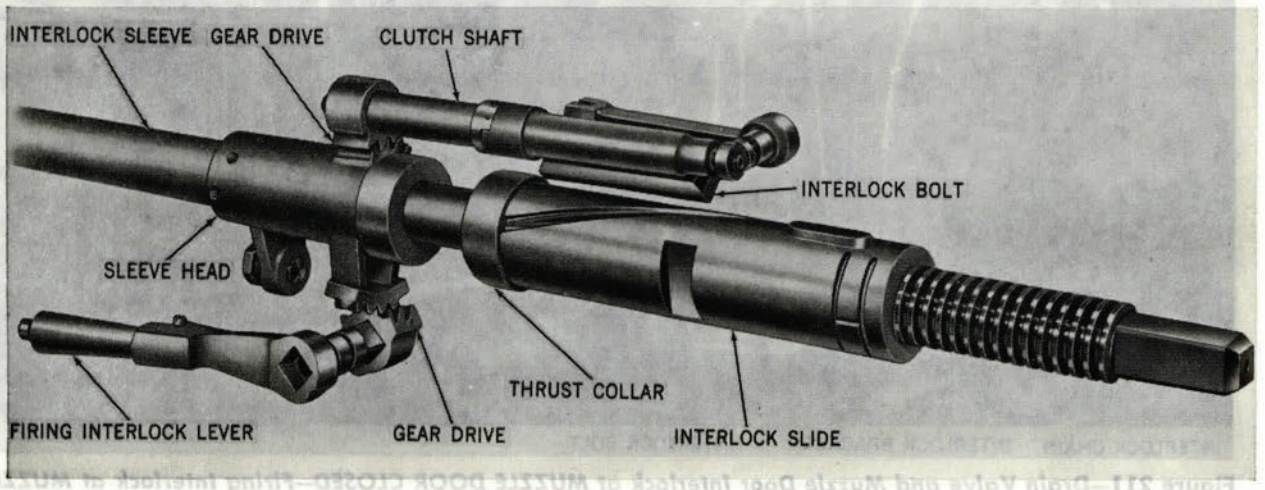


Figure 213—*Interlock Slide—Muzzle Door Closed and Unlocked.*

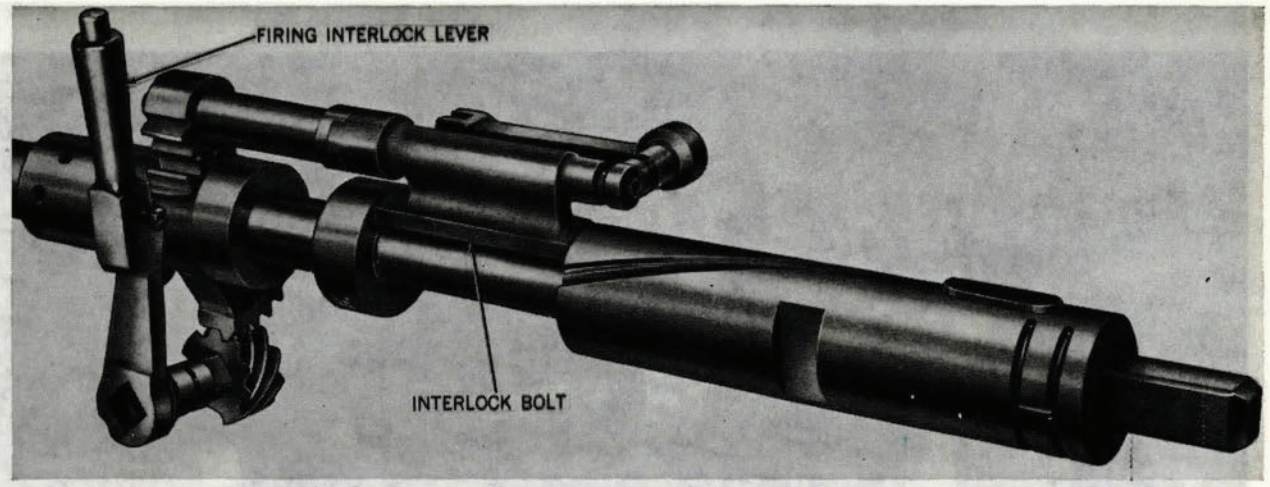


Figure 214—*Interlock Slide—Muzzle Door Open—Firing Interlock at TUBE READY TO FIRE.*

interlock shutter bar is attached to another projection from the underside of the interlock sleeve head.

Through this system of gearing, shafting, and linkages, movement of the firing interlock lever rotates the interlock sleeve head, interlock sleeve, and clutch shaft. Rotation of the interlock sleeve head also moves the interlock shutter bar. Rotation of the clutch shaft rotates the firing interlock bolt, figures 215 and 216, to engage or release the muzzle end of the interlock slide (or in the power-operated type, the finger) to control the locking and unlocking of the muzzle door operating shaft.

When preparing to fire, the firing interlock lever is at MUZZLE DOOR UNLOCKED during all but the last two steps of the firing procedure. In this position, the firing interlock bolt is in its up position, allowing movement of the muzzle door operating shaft and the muzzle door.

Before the firing interlock lever can be set at

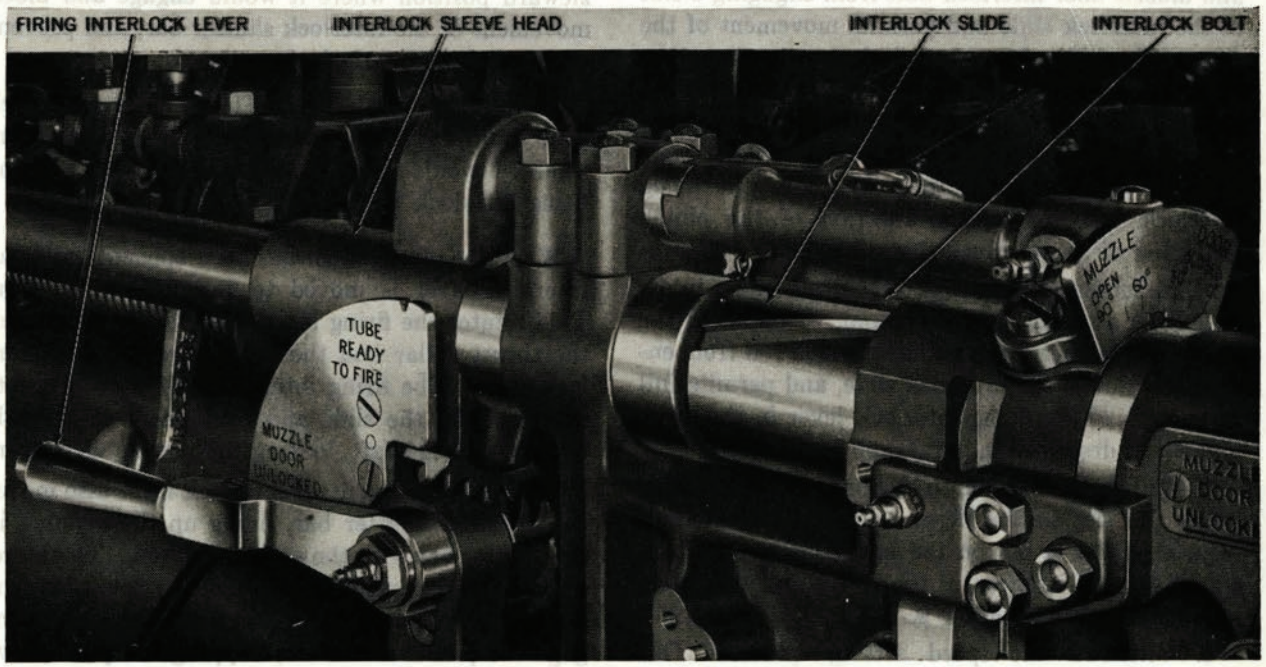


Figure 215—*Firing Interlock Lever at MUZZLE DOOR UNLOCKED.*

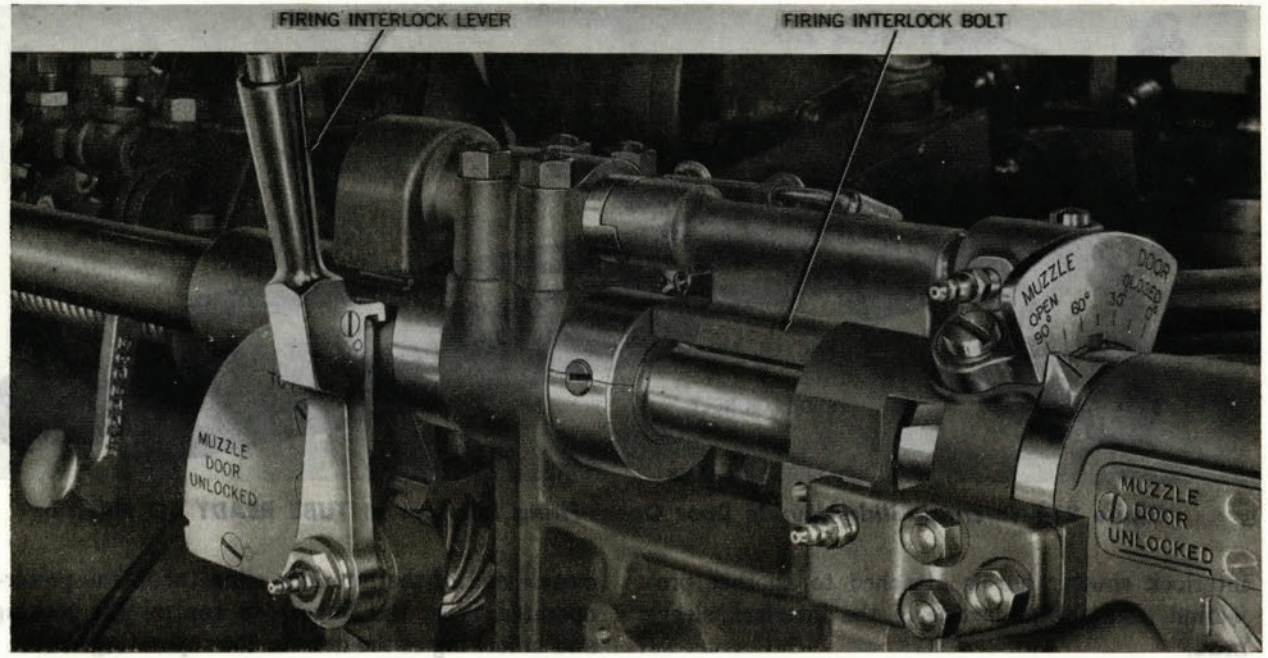


Figure 216—*Firing Interlock Lever at TUBE READY TO FIRE.*

TUBE READY TO FIRE, the following steps in the firing procedure are necessary:

1. Lock the breech door closed by setting the breech and muzzle door interlock lever at the MUZZLE DOOR UNLOCKED position. This keeps the breech and muzzle door interlock bolt from engaging a slot in the interlock slide and permits movement of the slide and of the firing interlock lever. Since the muzzle door must be closed at this point in the firing procedure, the interlock slide is in its muzzleward position. In this position, the body of the slide would block the downward rotation of the firing interlock bolt, preventing rotation of the clutch shaft and of the interlock sleeve head.

2. In flooding the tube, set the drain valve interlock lever at DRAIN VALVE LOCKED. This keeps the head of the upper drain valve interlock rod from engaging a slot in the interlock slide, and permits full movement of the firing interlock lever in the same manner as described in paragraph 1.

3. Withdraw the depth setting spindle. This keeps the slot in the depth setting interlock bolt from engaging a lug on the engaging lever, which would prevent rotation of the sleeve and the interlock sleeve head, chapter 9.

4. Withdraw the speed setting spindle. This keeps the body of the speed setting interlock bolt from engaging a lug on the interlock sleeve, which would prevent rotation of the sleeve and the interlock sleeve head, chapter 10.

5. Open the impulse stop valve. This keeps the stop valve interlock bolt from remaining in its muzzleward position where it would engage and block movement of the interlock shutter bar, and prevent rotation of the interlock sleeve head.

6. Open the muzzle door. This keeps the interlock slide from remaining in its muzzleward position, where it would prevent downward rotation of the firing interlock bolt.

When the muzzle door has been opened, the firing interlock lever is moved to TUBE READY TO FIRE. This rotates the firing interlock bolt down between the thrust collar and the muzzle end of the interlock slide. The firing interlock bolt then prevents movement of the slide and rotation of the muzzle door operating shaft, locking the muzzle door open.

Movement of the firing interlock lever also moves the interlock shutter bar, lining up the opening in the shutter bar with the stop piston rod. Therefore, when the firing mechanism is put in operation, the stop piston rod can pass through this opening to engage the pilot valve stem, tripping the pilot valve and venting the firing valve.

When the firing interlock lever is at MUZZLE DOOR UNLOCKED, the shutter bar is positioned so that if the stop piston rod is forced breechward by air leakage into the stop cylinder, the rod engages a recess in the shutter bar. In this condition, the stop piston rod locks the shutter bar so that the firing interlock lever cannot be set at the TUBE READY TO FIRE position. Movement of the shutter bar also actuates the electric interlock switch so that when the tube is ready to fire, an indicating lamp lights.

Tubes Fitted With Power-Operated Muzzle Door. The firing interlock mechanism in these tubes is basically similar to the mechanism in tubes fitted for hand operation. In power operation, there are three major differences:

1. To prevent the muzzle door from being closed, the firing interlock bolt engages the finger instead of the interlock slide.

2. A connecting rod extends from the firing interlock lever to the gear on the breech end of the hand operating shaft. When the firing interlock lever is set at TUBE READY TO FIRE, a dog at the lower end of the connecting rod engages the gear, preventing rotation of the hand operating shaft, figure 217.

3. If the hydraulic power fails after the door has been opened by power, an interlock locks the muzzle door open. An operating rod extends from the firing interlock lever, and connects at its lower end to a crank segment, figure 218. A helical tooth on the crank segment engages a slot in an interlock bolt. Movement of the firing interlock lever rotates the crank segment, moving the interlock bolt. The bolt extends through the interlock bracket to engage and disengage with a hole in the web of the interlock drive gear.

When the firing interlock lever is at MUZZLE DOOR UNLOCKED the interlock bolt is disengaged from the hole in the interlock drive gear, permitting movement of the gear and muzzle door operating shaft and closing of the muzzle door. When the firing interlock lever is set at TUBE READY TO FIRE, the interlock bolt engages the hole in the interlock drive gear, preventing movement of the muzzle door operating shaft and closing of the muzzle door. If the muzzle door is not fully open, the interlock drive gear is rotated so that the hole is not lined up with the interlock bolt. The web of the gear then prevents movement of the interlock bolt and of the firing interlock lever to TUBE READY TO FIRE.

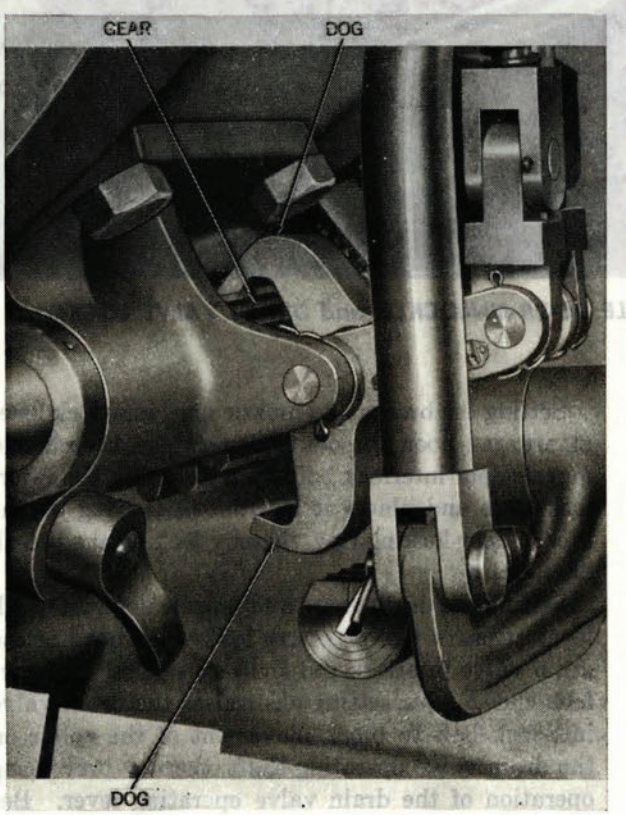


Figure 217—*Hand Operating Shaft Interlock Dogs—TUBE READY TO FIRE.*

Interlock Disconnect

To test the firing mechanism by firing an air charge inboard, the firing interlock mechanism may be disconnected. Before making this test, the lock on an interlock disconnect, figure 219, is unlocked and removed, and an interlock signal arm is raised to the vertical position, showing DANGER INTERLOCK DISCONNECTED warning flag, figure 220. This disengages the clutch shaft from the firing interlock bolt, permitting the firing interlock lever to be raised to READY TO FIRE and the stop mechanism and firing mechanism to function regardless of the position of the breech and muzzle door interlock lever and the drain valve and muzzle door interlock lever.

Operation of the Interlocking Mechanism

Hand-Operated Muzzle Doors. Figures 199 and 221 illustrate operation of the interlocking mecha-

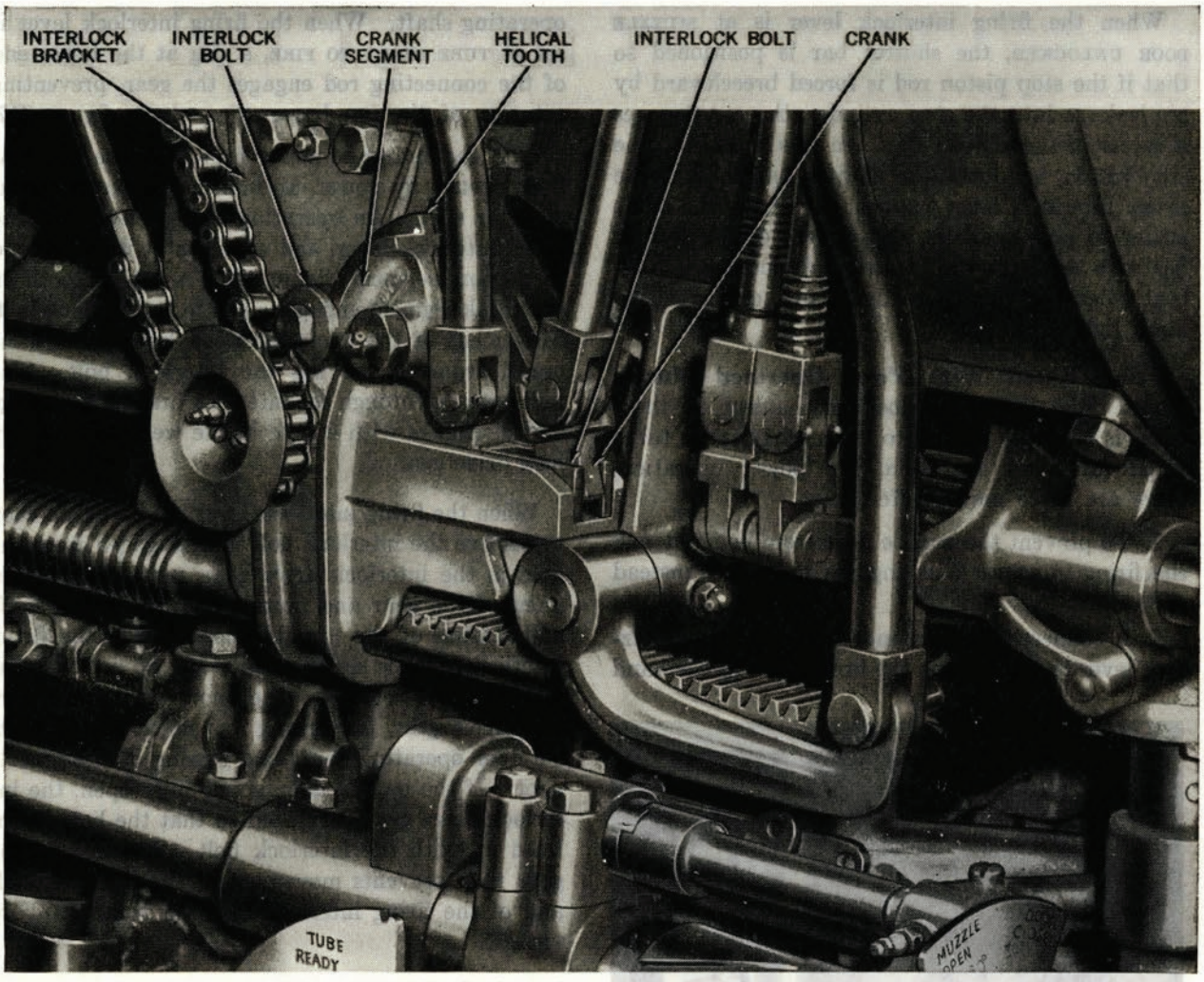


Figure 218—*Interlock Bracket and Cranks—MUZZLE DOOR UNLOCKED and DRAIN VALVE LOCKED.*

nism on a tube fitted with the hand-operated muzzle door mechanism. They give a general picture of the interlocking parts, and show their relationship to each other.

Functions of the different parts of the interlocking mechanism are as follows:

Threads on the muzzle door operating shaft give the interlock slide, which operates in the breech bracket, a muzzleward motion as the muzzle door is closed, and a breechward motion as the door is opened. Therefore, to open the muzzle door the interlock slide must be free to move. Therefore, the breech and muzzle door interlock bolt and the head of the drain valve interlock rod must be clear of their respective slots in the interlock slide.

Setting the breech and muzzle door interlock lever at MUZZLE DOOR UNLOCKED lowers the breech and muzzle door interlock bolt from its slot in the interlock slide and places it in front of the lug on the breech door locking ring, thereby locking the breech door closed.

Setting the drain valve and muzzle door interlock lever at DRAIN VALVE LOCKED lowers the head of the drain valve interlock rod from its slot in the interlock slide. This setting also raises the drain valve interlock bolt to block movement of the collar on the drain valve operating shaft, thereby preventing operation of the drain valve operating lever. Before this setting can be made, the drain valve must be fully closed. Making the setting locks the drain

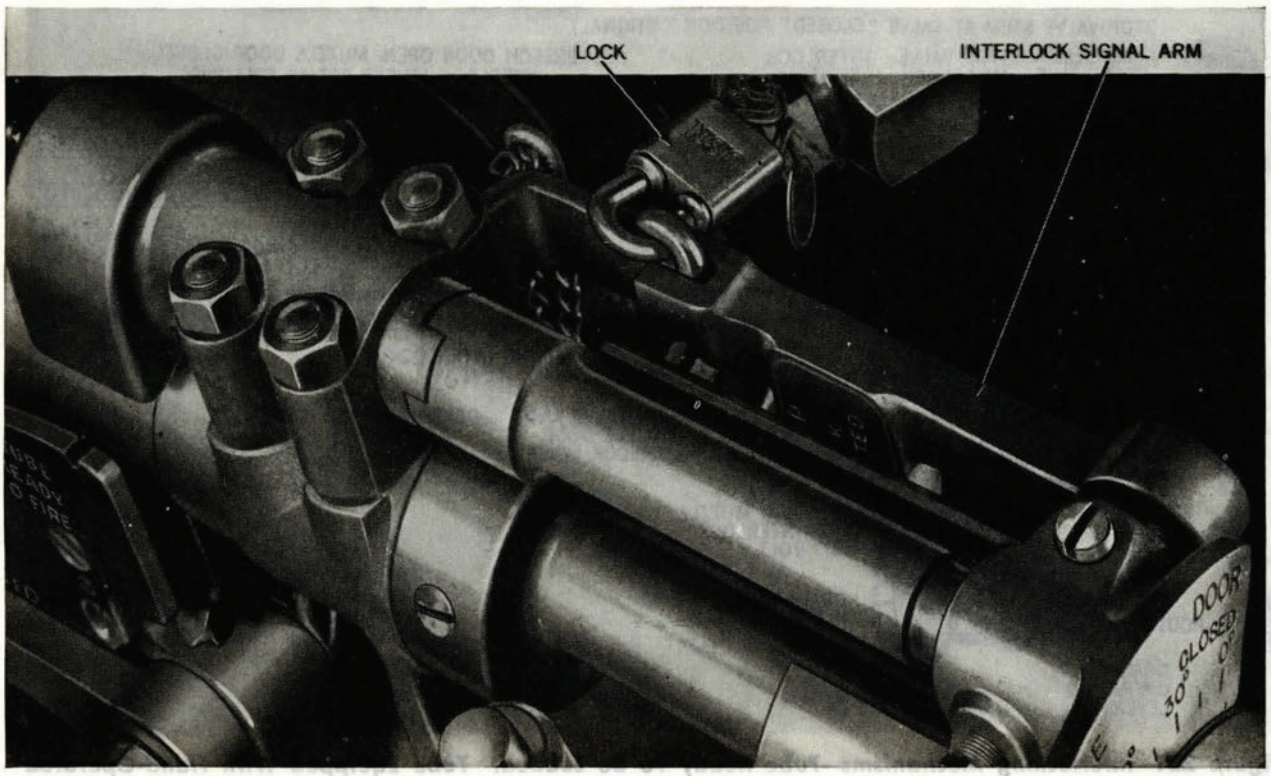


Figure 219—*Firing Interlock Disconnect—Interlock Connected.*

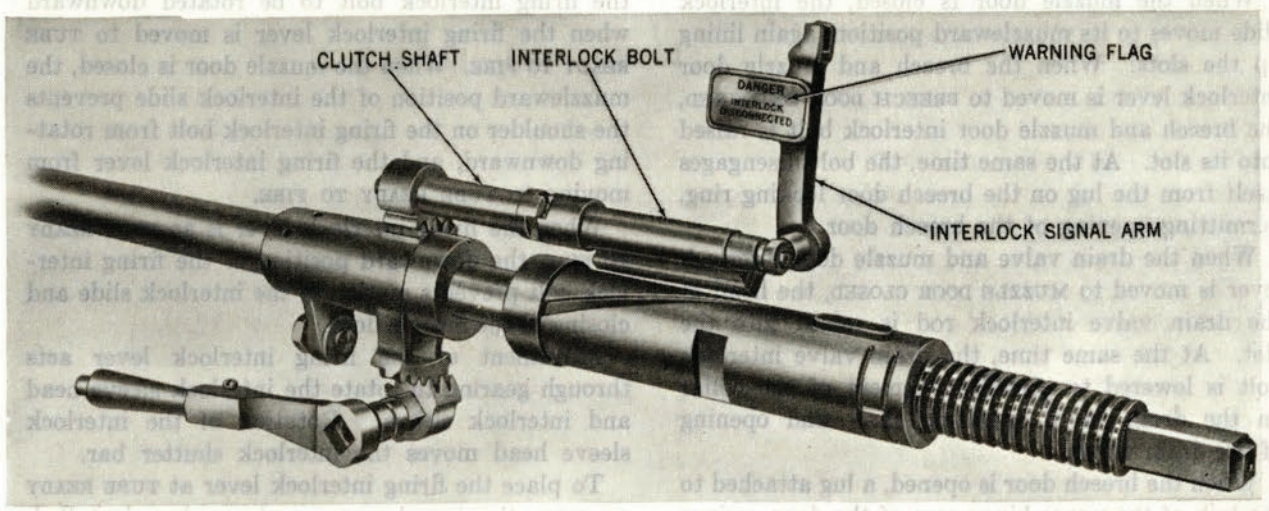


Figure 220—*Firing Interlock Disconnected.*

valve closed and leaves the interlock slide free to move so that the muzzle door may be opened.

When the door is open, the interlock slide is in its breechward position in which the slot no longer lines up with the breech and muzzle door interlock bolt and the head of the drain valve interlock rod; the body of the slide then prevents their upward movement. Therefore, while the muzzle door is open, the breech door and the drain valve are locked closed.

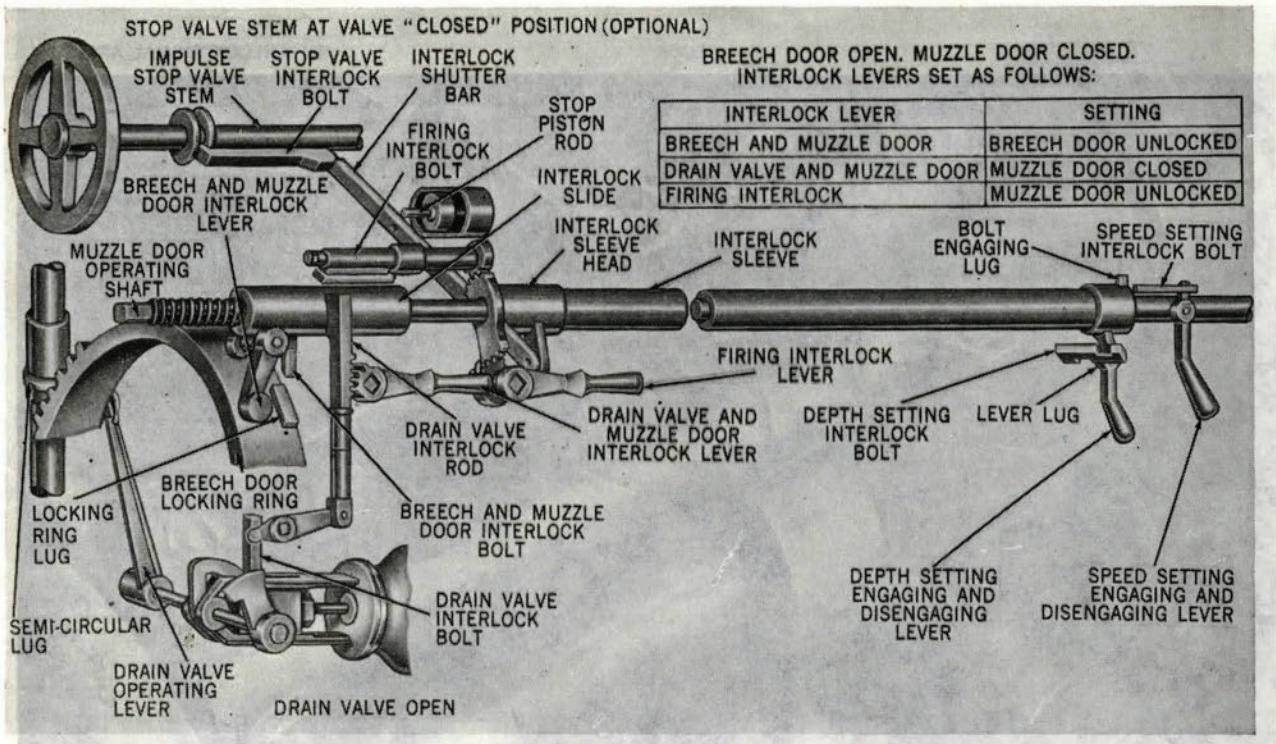


Figure 221—*Interlocking Mechanisms—Tube Ready To Be Loaded. Tube Equipped With Hand-Operated Muzzle Door.*

When the muzzle door is closed, the interlock slide moves to its muzzleward position, again lining up the slots. When the breech and muzzle door interlock lever is moved to BREECH DOOR UNLOCKED, the breech and muzzle door interlock bolt is raised into its slot. At the same time, the bolt disengages itself from the lug on the breech door locking ring, permitting opening of the breech door.

When the drain valve and muzzle door interlock lever is moved to MUZZLE DOOR CLOSED, the head of the drain valve interlock rod is raised into the slot. At the same time, the drain valve interlock bolt is lowered to permit movement of the collar on the drain valve operating shaft and opening of the drain valve.

When the breech door is opened, a lug attached to the hub of the upper hinge arm of the door, swings into a tooth space in the locking ring gear segment, preventing rotation of the locking ring while the breech door is open. When the breech door is closed, the lug swings clear of the gear segment, permitting rotation of the locking ring.

When the muzzle door is open, the breechward position of the interlock slide permits the shoulder on the firing interlock bolt to be rotated downward when the firing interlock lever is moved to TUBE READY TO FIRE. When the muzzle door is closed, the muzzleward position of the interlock slide prevents the shoulder on the firing interlock bolt from rotating downward, and the firing interlock lever from moving to TUBE READY TO FIRE.

When the firing interlock lever is at TUBE READY TO FIRE, the downward position of the firing interlock bolt prevents motion of the interlock slide and closing of the muzzle door.

Movement of the firing interlock lever acts through gearing to rotate the interlock sleeve head and interlock sleeve. Rotation of the interlock sleeve head moves the interlock shutter bar.

To place the firing interlock lever at TUBE READY TO FIRE, the impulse stop valve, when installed, must be open so that the stop valve interlock bolt on the impulse stop valve stem is removed from the path of the interlock shutter bar. When the impulse stop valve is closed, the stop valve interlock bolt prevents movement of the interlock shutter bar, to prevent setting the firing interlock lever at TUBE READY TO FIRE.

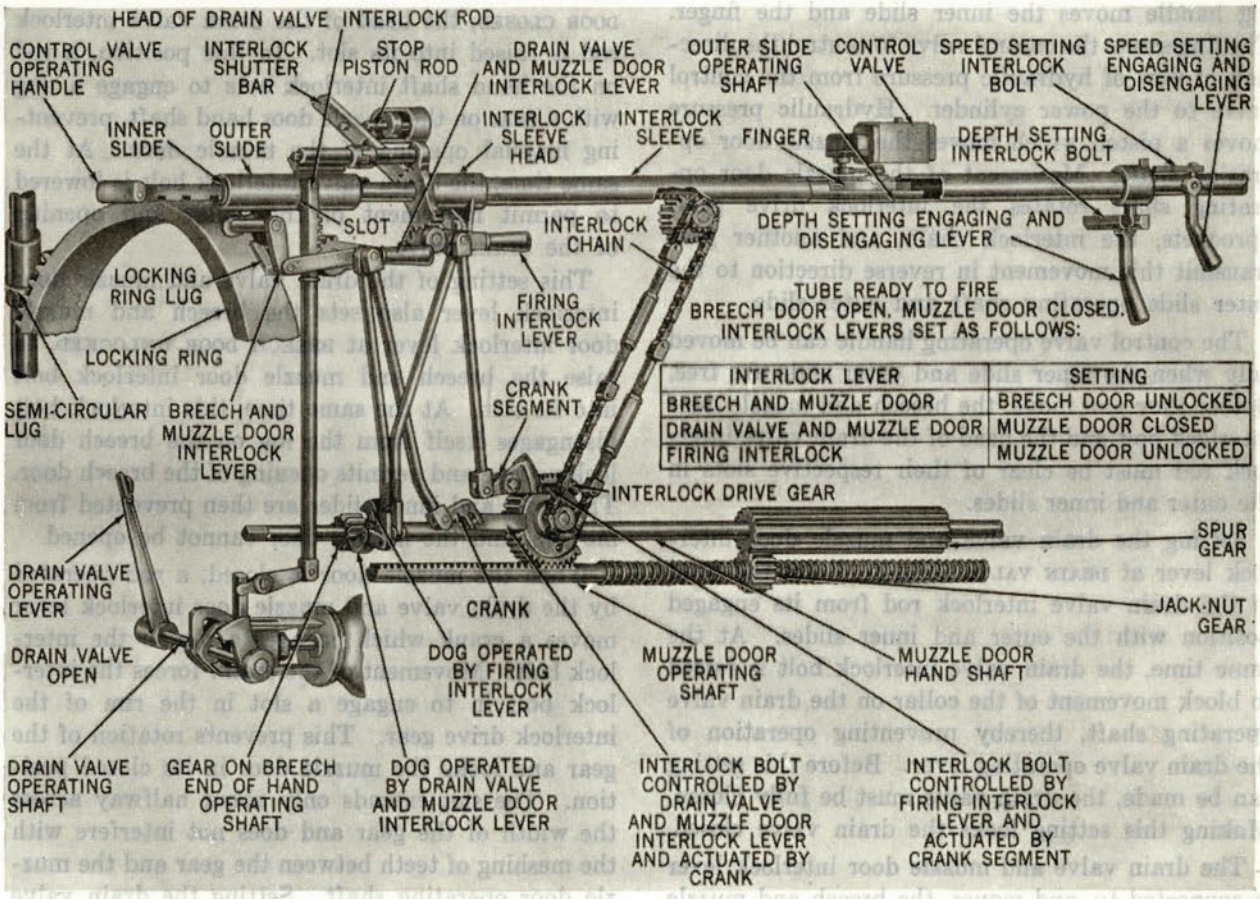
When the firing interlock lever is at TUBE READY TO FIRE, the interlock shutter bar prevents movement of the stop valve interlock bolt and closing of the impulse stop valve. The hole in the shutter bar is lined up with the stop piston rod, allowing the rod to pass through to engage the pilot valve stem, opening the pilot valve and venting the firing valve.

If an attempt is made to fire the tube when the shutter bar is not in correct position, the stop piston rod will engage in a recess in the shutter bar, locking it in its incorrect position. This prevents motion of the shutter bar until air pressure has been released from the torpedo stop cylinder, and the stop piston rod can return to its original position.

When the firing interlock lever is set at TUBE READY TO FIRE, both the depth setting engaging and disengaging lever and the speed setting engaging and disengaging lever are locked at spindle OUT. A lug on the side of the depth setting lever engages the body of the depth setting interlock bolt, preventing movement of the depth setting lever. Another lug on the collar of the interlock sleeve engages the end of the speed setting interlock bolt, preventing movement of the bolt and of the speed setting lever.

Before the two engaging and disengaging levers can be moved to spindle IN, the firing interlock lever must be set at MUZZLE DOOR UNLOCKED. This rotates the interlock sleeve and collar, forcing out the speed setting interlock bolt and lining up a slot in the bolt with the lug on the depth setting lever so that the lever can be turned to IN. At the same time, the lug on the collar of the interlock sleeve is rotated clear of the speed setting interlock bolt so that it can be moved and the speed setting lever can be turned to IN.

When the depth and speed setting spindles are engaged (or when the two engaging levers are set



INTERLOCK LEVER	SETTING
BREECH AND MUZZLE DOOR	BREECH DOOR UNLOCKED
DRAIN VALVE AND MUZZLE DOOR	MUZZLE DOOR CLOSED
FIRING INTERLOCK	MUZZLE DOOR UNLOCKED

Figure 222—*Interlocking Mechanisms—Tube Ready To Be Loaded. Tube Equipped With Power-Operated Muzzle Door.*

at spindle IN), the collar on the interlock sleeve is prevented from turning, thus preventing the firing interlock lever from being moved to TUBE READY TO FIRE. The lug on the side of the depth setting lever engages the slot in the depth setting interlock bolt, preventing movement of the bolt and of the interlock sleeve. The speed setting interlock bolt is moved so that its side engages the lug on the collar of the interlock sleeve, preventing movement of the interlock sleeve.

Power-Operated Muzzle Doors. Figures 200 and 222 illustrate operation of the interlocking mechanism on a torpedo tube fitted with the power-operated muzzle door mechanism. Functions of the different parts of this interlocking mechanism follow:

Setting the control valve operating handle at OPEN opens the muzzle door; setting the handle at CLOSE closes the muzzle door. Movement of the operating handle moves the inner slide and the finger. The finger sets the control valve to control the direction of flow of hydraulic pressure from the control valve to the power cylinder. Hydraulic pressure moves a piston which moves the muzzle door operating shaft. Movement of the muzzle door operating shaft rotates the interlock drive gear. Sprockets, the interlock chain, and another gear transmit this movement in reverse direction to the outer slide operating shaft and outer slide.

The control valve operating handle can be moved only when the inner slide and outer slide are free. Before they can move, the breech and muzzle door interlock bolt and the head of the drain valve interlock rod must be clear of their respective slots in the outer and inner slides.

Setting the drain valve and muzzle door interlock lever at DRAIN VALVE LOCKED lowers the head of the drain valve interlock rod from its engaged position with the outer and inner slides. At the same time, the drain valve interlock bolt is raised to block movement of the collar on the drain valve operating shaft, thereby preventing operation of the drain valve operating lever. Before this setting can be made, the drain valve must be fully closed. Making this setting locks the drain valve closed.

The drain valve and muzzle door interlock lever is connected to, and moves, the breech and muzzle door interlock lever. Thus, setting of the drain valve and muzzle door interlock lever at DRAIN VALVE LOCKED also sets the breech and muzzle door interlock lever at MUZZLE DOOR UNLOCKED. This lowers the breech and muzzle door interlock bolt from its engaged position with the outer and inner slides, and places it in front of the lug on the breech door locking ring, thereby locking the breech door closed. The outer and inner slides are then free to move and the muzzle door may be opened.

When the door is open, the outer and inner slides are in their breechward positions, in which the slots no longer line up with the breech and muzzle door interlock bolt and the head of the drain valve interlock rod. The body of the outer slide prevents their upward movement; therefore, while the muzzle door is open, neither the breech door nor drain valve can be opened.

When the muzzle door is closed, the outer and inner slides move to their muzzleward positions, again lining up the slots. When the drain valve and muzzle door interlock lever is moved to MUZZLE DOOR CLOSED, the head of the drain valve interlock rod is raised into its slot. In this position, a rod on the hand shaft interlock acts to engage a dog with a gear on the muzzle door hand shaft, preventing manual opening of the muzzle door. At the same time, the drain valve interlock bolt is lowered to permit movement of the collar and opening of the drain valve.

This setting of the drain valve and muzzle door interlock lever also sets the breech and muzzle door interlock lever at BREECH DOOR UNLOCKED, to raise the breech and muzzle door interlock bolt into its slot. At the same time, this interlock bolt disengages itself from the lug on the breech door locking ring and permits opening of the breech door. The outer and inner slides are then prevented from moving, and the muzzle door cannot be opened.

When the muzzle door is closed, a rod operated by the drain valve and muzzle door interlock lever moves a crank which engages a pin in the interlock bolt. Movement of the crank forces the interlock bolt in to engage a slot in the rim of the interlock drive gear. This prevents rotation of the gear and locks the muzzle door in its closed position. The slot extends only about halfway across the width of the gear and does not interfere with the meshing of teeth between the gear and the muzzle door operating shaft. Setting the drain valve and muzzle door interlock lever at DRAIN VALVE LOCKED removes the interlock bolt from the slot

in the gear, permitting the muzzle door to be opened.

When the muzzle door is open, the rim of the gear blocks movement of the interlock bolt, preventing the drain valve and muzzle door interlock lever from being set at MUZZLE DOOR CLOSED.

When the breech door is opened, a lug swings into a tooth space in the locking ring gear segment, preventing rotation of the locking ring. When the breech door is closed, the lug swings clear. This interlock functions in the same manner as it does in tubes fitted for hand operation of muzzle doors.

When the muzzle door is open, the breechward position of the outer and inner slides permits the firing interlock bolt to be rotated downward when the firing interlock lever is moved to TUBE READY TO FIRE. When the muzzle door is closed, the muzzleward position of the outer slide prevents the firing interlock bolt from being rotated downward, and the firing interlock lever cannot be moved to TUBE READY TO FIRE.

When the muzzle door control handle is in the HAND position, a notch in the finger lines up with a tongue on the breechward end of the firing interlock bolt. Then the firing interlock lever can be thrown to the READY position when the muzzle door has been opened by hand. This latter action moves the outer slide clear of the firing interlock bolt. When the tube is ready to fire, the tongue on the firing interlock bolt engages the notch in the finger to prevent shifting of the control handle.

> NOTE: When the muzzle door has been opened by power, the finger has moved far enough to the rear to allow the firing interlock bolt to swing down in front of it. This, also, prevents any movement of the control handle while the tube is in READY TO FIRE condition.

When the firing interlock lever is at TUBE READY TO FIRE, the firing interlock bolt engages a notch on the finger, preventing movement of the finger and closing of the muzzle door. At the same time, a rod on the hand shaft interlock acts to engage a dog with the gear on the muzzle door operating shaft, preventing manual closing of the muzzle door.

Movement of the firing interlock lever moves the interlock shutter bar to align and disalign the hole in the shutter bar with the stop piston rod. This phase of the interlock functions in the same manner as it does in tubes fitted for hand operation of muzzle doors. Since no impulse stop valves are installed on tubes fitted for power operation, there is no stop valve interlock bolt to block movement of the shutter bar.

The depth setting interlock bolt and the speed setting interlock bolt prevent rotation of the interlock sleeve when the depth and speed setting spindles are engaged. Lugs on a collar of the interlock sleeve prevent the spindles from being engaged when the tube is ready to fire. These interlocks function in the same manner as in tubes fitted for hand operation of muzzle doors.

When the muzzle door is open, a rod operated by the firing interlock lever rotates a crank segment, having a helical tooth which engages a slot in the interlock bolt. Rotation of the crank segment forces the interlock bolt in, to engage a hole in the web of the interlock drive gear. This prevents rotation of the gear and locks the muzzle door in its open position. Setting the firing interlock lever at MUZZLE DOOR UNLOCKED removes the interlock bolt from the hole in the gear, permitting the muzzle door to be closed.

When the muzzle door is closed, the web of the gear blocks movement of the interlock bolt and prevents the firing interlock lever from being set at TUBE READY TO FIRE.

Chapter 17

OPERATING AND TEST PROCEDURES

FOR TUBES EQUIPPED FOR MECHANICAL SETTING ONLY

Operating Procedures

Torpedoes. Torpedoes Mks 14, 16, 23, and 28 are designed to be fired from submerged torpedo tubes. Each has its starting lever, gyro setting socket, depth setting socket, and speed setting socket (when fitted) in the same locations relative to its center line and tail.

Torpedoes also are grouped according to locations of their guide studs. On all 21-inch diameter torpedoes fired from submerged tubes the distance from the tail to the front of the guide stud is approximately 141.4 inches, and the muzzleward stop bolt housings are used.

Determining Impulse Pressures. Impulse tank pressures for torpedoes are shown in figure 223. The table shows pressures recommended for firing at the surface and down to periscope depth (taken as 65 feet to the keel). The graphs of the table show pressures considered best for firing below periscope depth down to 200 feet to the keel. The graphs are not carried below this depth because the barrel

FIRING DEPTH	OWN SHIP SPEED	IMPULSE TANK PRESSURES PSI			
		BOW TUBES		STERN TUBES	
		TORPEDOES MK 14, 23 (ALL MODS)	TORPEDOES MK 18, 28 (ALL MODS)	TORPEDOES MK 14, 23 (ALL MODS)	TORPEDOES MK 18, 28 (ALL MODS)
SURFACE	ANY	250	150	400	350
"RADAR" TO "PERISCOPE"	LOW (<5Kn)	350	250	350	250
	HIGH (>5Kn)	250		400	

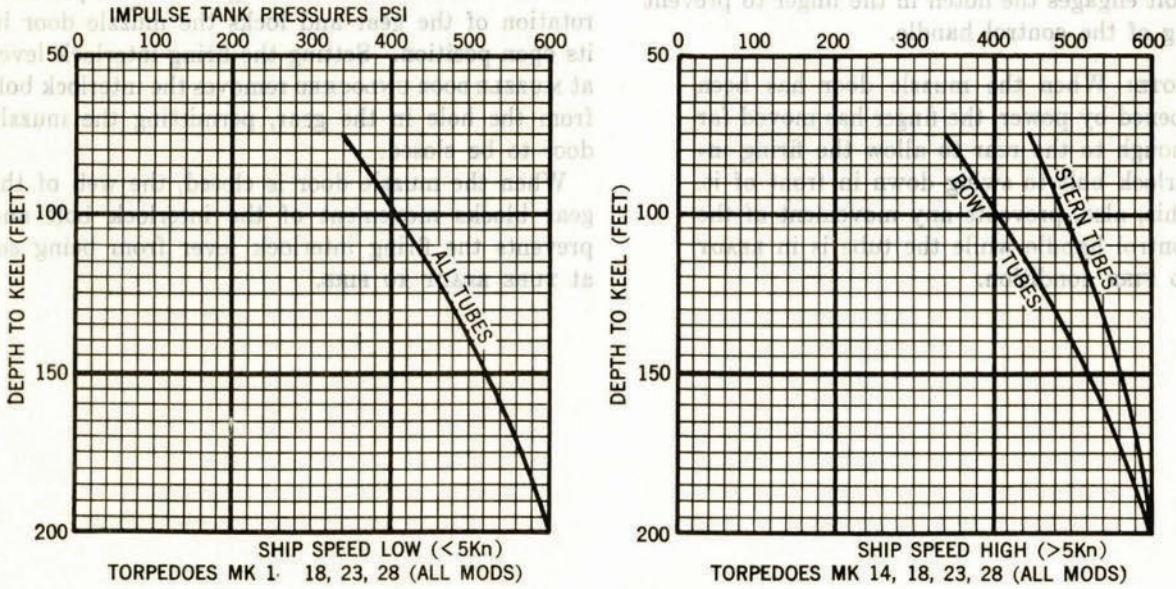


Figure 223—*Impulse Tank Pressures.*

pressures necessary to launch a torpedo satisfactorily are apt to collapse the torpedo afterbody.

Impulse pressure for Torpedo Mk 16 Mod 6 is 450 psi under all conditions of firing from surface to 100 foot depth. Impulse pressures for Torpedo Mk 16 Mod 7 are:

Firing depth	Own ship speed	Impulse tank pressures psi bow and stern tubes
Surface	Any	175
Periscope	Any	250

For depths greater than periscope, use figure 223.

NOTE: Torpedoes should not be fired at depths greater than those specified in the Torpedo OP.

Timing Poppet Valves. Poppet valves are used at all depths. The number of seconds the poppet valve must be kept open at various depths is shown in figure 191. This graph is an approximation of the depth-time ratio.

Firing Torpedoes. To fire a mechanically set torpedo from a submerged tube there are 28 major steps performed. The following sequence is generally recommended. However, the publication which refers to the specific torpedo should be consulted for the exact sequence of torpedo preparations.

1. Ready torpedo and tube setting mechanisms.

a. Set torpedo depth setting spindle as nearly as possible at 10 feet, with two sides of the square parallel to torpedo centerline. Set circle-setting mechanism of Torpedo Mk 16 Mod 7 as nearly as possible to 1000 yards, with two sides of the square parallel to torpedo centerline.

b. Set tube depth setting mechanism at 10 feet.

c. Set torpedo speed setting socket at LOW.

d. Set tube speed setting mechanism at LOW.

e. Set torpedo gyro at 0.

f. On a bow tube, set tube gyro mechanism at 0.

g. On a stern tube, set tube gyro mechanism at 180.

2. Open tube vent. Move tube vent valve lever to OPEN, figure 224.

3. Unlock and open breech door.

Caution: To prevent damage to breech door mechanism when the door is being opened, it must be held until it is fully open and the stops bear on hinge bracket.

4. Back off the tail stop. Turn tail stop handwheel to the left (counterclockwise) to the limit of its travel.

Caution: To prevent buffer plate and seal from striking the propeller nut, and the guide stud from jamming against the stop bolt, the tail stop must be backed off before the breech door is closed.

5. Inspect the bore. Use a flashlight or portable lamp to make sure that:

a. Tube is clear of foreign objects.

b. Stop bolt is down.

c. Tripping latch is up.

d. Spindles of depth, speed, and gyro setting mechanisms are retracted into their respective housings on the tube.

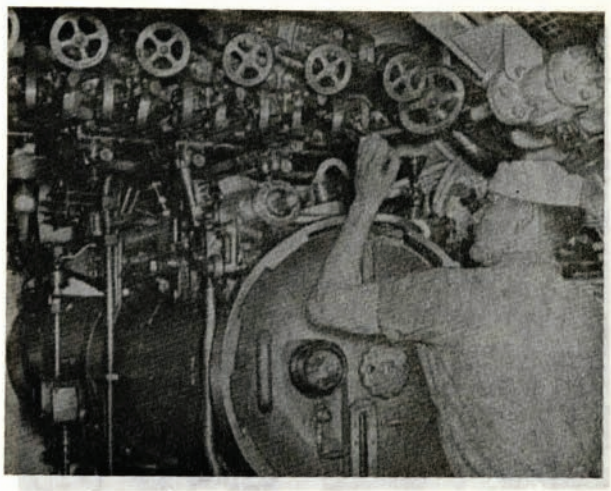


Figure 224—*Venting the Tube.*

6. Load the torpedo.

a. Insert one end of tail piece into torpedo propeller shaft (the other end of tail piece is fitted with a pulley).

b. Attach block and tackle to the two eyes on the breech door locking ring.

c. Lead line through pulley on the tail piece, figure 225.

d. Ease the torpedo along the runways, figure 226, and into the tube until guide stud on top of

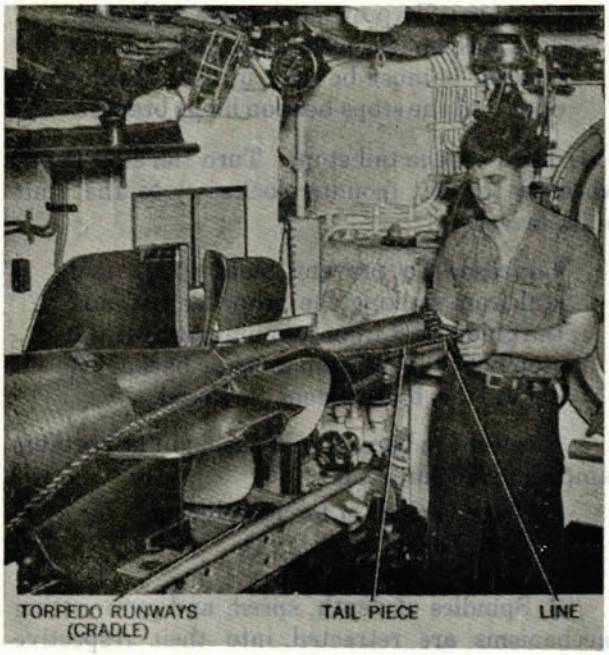


Figure 225—*Leading Line Around End of Pulley.*

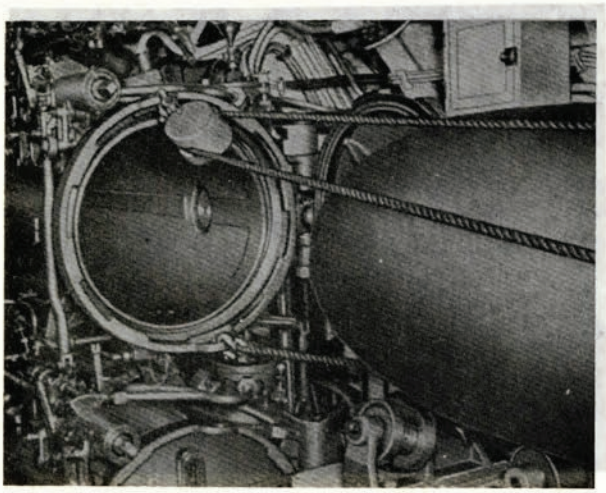


Figure 226—*Easing Torpedo Along Runways.*

torpedo enters guide slot in the top land of the barrel.

e. Remove propeller lock, figure 229.

f. Remove safety guard from starting lever.

g. See that index dials on gyro, depth, and speed mechanisms are set properly.

h. See that torpedo stop valve is open.

i. See that starting gear is set to run.

j. Ease the torpedo farther into tube, figure 227, until only propellers and tail piece project.

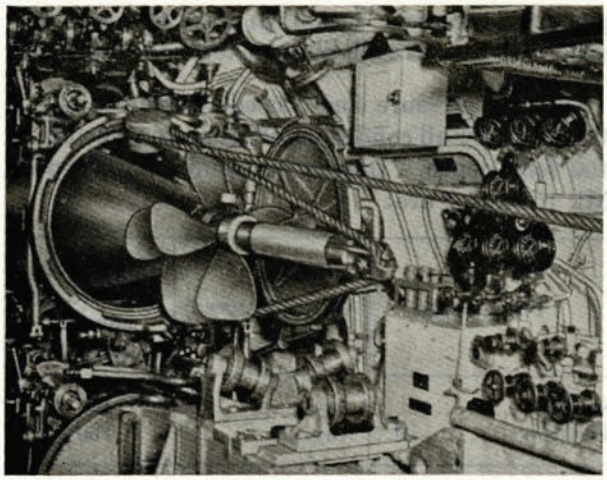


Figure 227—*Easing Torpedo Into Tube.*

k. Remove block and tackle from locking ring and tail piece.

l. Manually ease the torpedo all the way into the tube until guide stud bears against stop bolt.

Caution: Guide stud must be brought gently against the stop bolt to avoid bending the bolt or binding any parts of stop bolt assembly.

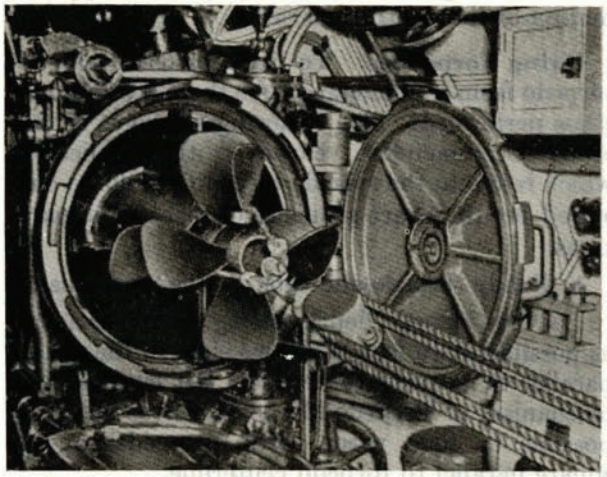


Figure 228—*Removing Torpedo From Tube.*

m. Remove tail piece from torpedo propeller shaft.

NOTE: If necessary to remove the torpedo from the tube after it has been loaded, see that the setting spindles are disengaged from their sockets in the torpedo and pull the torpedo gently out of the tube onto the

runways in the manner illustrated in figure 228.

7. Prime the firing valve.

a. With no charge in impulse tank, open filling valve in the firing valve head.

b. Open the overflow valve in firing and check valve body.

c. Using filling funnel, pour clean, fresh water into filling valve until water flows freely from overflow valve.

d. After the water stops flowing, close both valves.

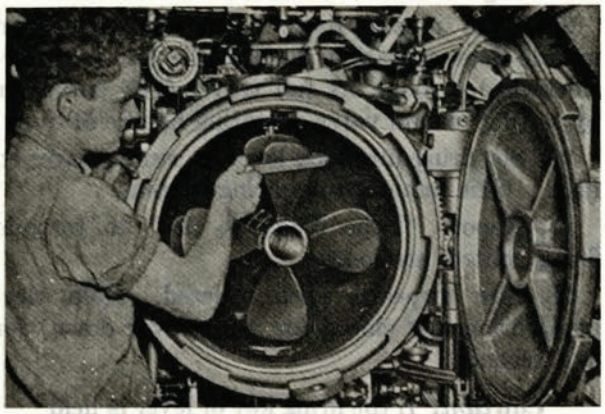


Figure 229—*Removing Propeller Lock.*

Caution: After the impulse tank has been charged, do not open the filling valve or overflow valve as this would vent the upper chamber of firing valve and fire the tube.

NOTE: The above procedure does not apply to torpedo tubes on which ORDALT 2888 has been accomplished since the firing valves of these tubes do not require priming between firings.

8. Charge impulse tank with the impulse stop valve open. (For determining impulse pressures, refer to table 1.) During charging of impulse tank, check on tightness of firing valve.

Caution: If the firing valve is leaking, report it at once to the Torpedo Control Officer. When muzzle door is closed, even a small leak of air may build up sufficient pressure to crack the door open. In this instance, pressure in the after section of the tube will force the torpedo guide stud against the stop bolt, and probably damage it. In addition, impulse tank pressure may be reduced to a point where the torpedo will not receive sufficient launching velocity.

When muzzle door is opened, an air leak will cause a surface bubble trail.

9. Close charging valve when impulse tank has been charged. Do not let the tank "ride" upon the line.

10. Close breech door.

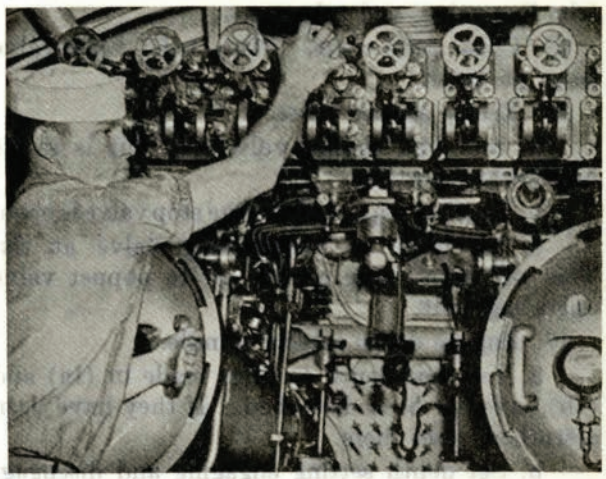


Figure 230—*Flooding Tube from WRT Tank.*

11. Place the tripping latch in NORMAL OPERATING POSITION.

12. Take up on tail stop. Turn tail stop handwheel to the right until disc bears firmly against the torpedo.

13. Lock breech door. Set breech and muzzle door interlock lever at MUZZLE DOOR UNLOCKED.

14. Flood tube when ordered.

Caution: When launching torpedoes from tubes 1 and 2 in the bow and 7 and 8 in the stern, while submarine is on the surface, it is necessary that ship trim be adjusted so that these tubes are completely submerged. This will assure that the tubes can be completely flooded, a requirement for proper torpedo launching.

a. Set drain valve interlock lever at MUZZLE DOOR CLOSED.

b. Check WRT tank valve open.

c. Open tube drain valve.

d. Open WRT tank blow valve to flood tube from WRT tank, figure 230; when tube is completely flooded, close blow valve.

e. Close tube drain valve.

f. Set WRT tank vent lever at OPEN and vent tank until gage shows atmospheric pressure.

g. Set drain valve interlock lever at DRAIN VALVE LOCKED.

NOTE: To flood a tube from the trim tank, follow the foregoing procedure using the trim tank blow and vent valves instead of the corresponding WRT tank valves in steps b to f.

To flood a tube from the sea, use the trim pump, trim line valve, and tube vent.

15. Close tube vent. Place tube vent valve lever at SHUT.

16. Ready poppet valve.

a. See that poppet valve gag nut is in its breechward position.

b. See that poppet discharge stop valve is open.

c. Set lever of vent-closing valve at ON. This will admit ship service air to poppet valve operating unit.

17. Engage depth setting spindle.

a. See that depth settings made in (1a) and (1b) have not been disturbed. If they have been disturbed, reset them.

b. Set depth setting engaging and disengaging lever at IN.

c. When firing Torpedo Mk 16 Mod 7 from tubes equipped with ORDALT 3557, the following instructions apply:

(1) Set the engaging and disengaging lever at the IN position.

(2) Turn the operating shaft until the dial registers the required circling distance.

18. Engage speed setting spindle.

a. See that speed settings made in (1c) and (1d) have not been disturbed. If they have, reset them.

b. Set speed setting engaging and disengaging lever at IN.

19. Engage gyro setting spindle.

a. See that gyro settings made in (1e), (1f), and (1g) have not been disturbed. If they have, reset them.

b. Grasp gyro setting mechanism engaging lever and press down on the handle lock release on top of the engaging lever.

c. Turn engaging lever to IN.

d. Press down on shaft bolt release button.

e. Hold shaft bolt release button in while turning engaging lever to its locked position.

f. Release pressure on the handle lock release.

20. Set torpedo depth mechanism, when ordered. Turn depth setting hand crank until the selected depth is indicated on index dial.

21. Withdraw depth setting spindle. Set depth setting engaging and disengaging lever at OUT.

22. Set torpedo speed mechanism, when ordered. Turn speed setting hand crank until selected speed is indicated on indicator plate.

23. Withdraw speed setting spindle. Set the speed setting engaging and disengaging lever at OUT.

24. Set torpedo gyro mechanism, when ordered. Turn gyro setting indicator-regulator handwheels until selected gyro angle is indicated on gyro angle indicating dials.

25. Open muzzle door, when ordered. Turn muzzle door operating shaft to the left (counterclockwise) through its full travel (14½ turns) or by setting control valve operating handle at OPEN.

26. Set firing interlock lever at TUBE READY TO FIRE. This unlocks tube firing system.

27. Report "Tube ready to fire" to torpedo firing control station.

28. Fire torpedo, when ordered. Hold electrical firing key closed (or firing lever down) for two seconds.

Caution: If the firing key or lever is held down less than two seconds, the firing valve may close before the torpedo receives its full impulse.

After firing the torpedo, perform the following steps:

1. Close poppet valve. After poppet valve has vented the impulse air, and when water begins to enter, set tube vent valve lever at OPEN. (For timing of poppet valves refer to figure 191.)

2. Close tube vent. When the tube is entirely vented, place tube vent valve lever at SHUT.

3. Unlock muzzle door. Set firing interlock lever at MUZZLE DOOR UNLOCKED.

4. Close muzzle door. Turn muzzle door operating shaft to the right through its full travel (14½ turns) or by setting control valve operating handle at CLOSE.

5. Drain tube, when ordered.

a. Set drain valve interlock lever at MUZZLE DOOR CLOSED.

b. Open tube drain valve.

c. Check WRT tank valve open.

d. Vent WRT tank by setting WRT tank vent lever at OPEN.

e. Blow water in tube into WRT tank by opening torpedo tube blow valve. (Keep pressure in tube down to about ten pounds per square inch to avoid leakage past muzzle door.) When tube is empty of water, close blow valve.

f. Close tank vent by setting WRT tank vent lever at SHUT.

g. Set tube vent valve lever at OPEN and vent tube until the gage shows atmospheric pressure.

h. Close tube vents by setting tube vent valve lever at SHUT.

i. Close tube drain valve.

NOTE: In submarines of the Portsmouth design, to drain a tube to the trim tank, use trim tank drain and vent valves instead of corresponding WRT tank valves in step b, c, d, and e.

To drain a tube to the sea, use trim pump, trim line valve, and tube vent.

In submarines of the Electric Boat Division design, a WRT tank overflow valve is provided for blowing tubes to trim tank when WRT tank is full. An interlock to close a quick-operating valve in WRT tank blow line prevents accidental blowing of WRT tank to trim tank when overflow valve is open. A loop around the quick-operating valve is provided with a check valve for venting. When overflow valve is closed, normal blowing and venting of WRT tank is accomplished. When overflow valve is open, water from the tube is transferred to trim tank by way of WRT tank.

Do not open breech door until all water is drained from the tube and the pressure in the tube equals that in the submarine.

Firing Mines. For operation of torpedo tubes in launching mines, refer to the Ordnance pamphlet relating to the specific mine being launched.

Variations in size, form, attachments, and firing devices of mines make a general procedure impracticable. The Ordnance pamphlet relating to a specific mine gives information as to the effects of own ship's speed, up- or down-angle, distance from the keel to the bottom, and other factors that affect mine-laying procedure.

The general formula for determining impulse tank pressure for launching moored or ground mines is:

$$p=150+2d,$$

where p is the impulse tank pressure in pounds per square inch and d is depth to the keel in feet.

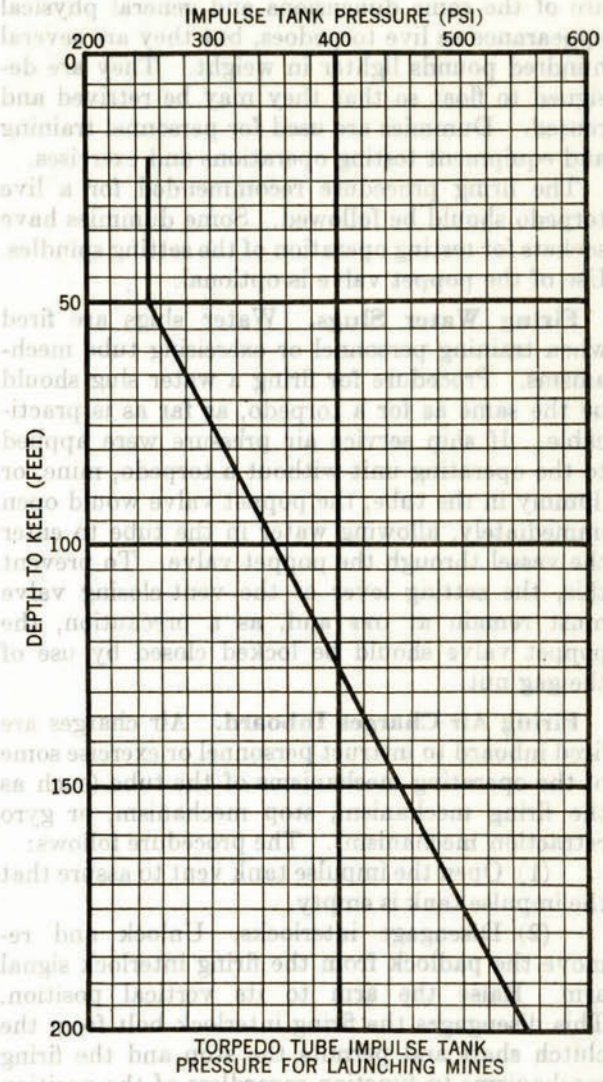


Figure 231—*Impulse Tank Pressures for Launching Mines (Bow Tubes).*

This formula applies directly to bow tubes. For stern tubes, the pressure can be reduced by 25 pounds per square inch at any depth, with a resultant decrease in the size of the bubble. In no case should impulse tank pressure be less than 250 pounds per square inch. The following graph, figure 231, is recommended for use in determining impulse tank pressures for launching mines for bow tubes.

Firing Dummy Torpedoes. Dummy torpedoes

are of the same dimensions and general physical appearance as live torpedoes, but they are several hundred pounds lighter in weight. They are designed to float so that they may be retrived and reused. Dummies are used for personnel training and equipment testing operations and exercises.

The firing procedure recommended for a live torpedo should be followed. Some dummies have sockets for testing operation of the setting spindles. Use of the poppet valve is optional.

Firing Water Slugs. Water slugs are fired when training personnel or exercising tube mechanisms. Procedure for firing a water slug should be the same as for a torpedo, as far as is practicable. If ship service air pressure were applied to the operating unit without a torpedo, mine, or dummy in the tube, the poppet valve would open immediately, allowing water in the tube to enter the vessel through the poppet valve. To prevent this, the setting lever of the vent-closing valve must remain at OFF and, as a precaution, the poppet valve should be locked closed by use of the gag nut.

Firing Air Charges Inboard. Air charges are fired inboard to instruct personnel or exercise some of the operating mechanisms of the tube (such as the firing mechanism, stop mechanism, or gyro retraction mechanism). The procedure follows:

(1) Open the impulse tank vent to assure that the impulse tank is empty.

(2) Disengage interlocks. Unlock and remove the padlock from the firing interlock signal arm. Raise the arm to its vertical position. This disengages the firing interlock bolt from the clutch shaft and permits the stop and the firing mechanisms to function regardless of the position of the breech and muzzle door interlock lever or of the muzzle door and drain valve interlock lever.

(3) Withdraw depth setting spindle.

(4) Withdraw speed setting spindle.

(5) Withdraw gyro setting spindle.

(6) With breech door shut and tripping latch cam in NORMAL OPERATING POSITION, raise firing interlock lever to TUBE READY TO FIRE position and then open breech door. For tubes not equipped with ORDALT 3067, place tripping latch in "rigged for depth charge" position before opening breech door.

(7) Retract torpedo completely from tube, if possible, and lash torpedo down securely. If torpedo stowage arrangement prevents retraction of the torpedo from tube, withdraw torpedo a few inches and lash down securely. The gyro retraction mechanism can *not* be exercised if the torpedo has been partially retracted from the tube.

> ***Caution:*** Failure to lash down the torpedo before an air charge is fired may result in its sliding forward in the tube past the stop bolt, damaging the muzzle door mechanism and possibly necessitating drydocking for repair.

(8) Insert gyro setting spindle if torpedo has been completely retracted from the tube.

(9) Shut impulse tank vent and charge impulse tank to a pressure of about 50 psi.

(10) Report "tube ready to fire air charge inboard" to torpedo firing control station.

(11) Fire tube remotely or locally when ordered.

After firing (completion of exercise) perform the following steps:

a. Unlock muzzle door. Set firing interlock at MUZZLE DOOR UNLOCKED.

b. Reengage interlocks. Lower firing interlock signal arm, then engage and lock padlock.

c. Place tube in orginial condition or in other condition as ordered.

Test Procedures

Firing Tests. A torpedo tube test set is used to determine test data on tube pressures and torpedo velocities, to insure that the firing system is operating properly. A description of the test set and instructions for its use are given in NAVORD OD 717.

Firing tests are made initially when the submarine is commissioned. These tests should be repeated after firing valve overhauls which involve replacement or repair of the firing and check valve body, firing valve head, lifting cup, orifice cup, or throttling rod. Such test data also should be taken occasionally to provide an operating check and to familiarize personnel with the various conditions encountered when launching torpedoes.

The short-time afterbody test pressure (external) of torpedoes is 135 pounds per square inch. The afterbody is designed to momentarily withstand this pressure without leakage. Do not exceed this pressure if recovery of the torpedo is planned.

Torpedoes should be launched with a velocity of at least 30 feet per second to insure that they will clear the tube and hull.

Bore Gaging. Tubes should be bore gaged to minimize the possibility of torpedoes sticking in the

tubes. During each drydock period a bore gage should be run through every tube. The standard bore gage is 21.08 inches in diameter and is longer than the cylindrical part of a torpedo. Torpedoes with air charge are about 21.045 inches in diameter, dummy torpedoes 21.06 inches, and mines used in these tubes are 20.8125 inches. Since the bore gage has a larger diameter than a torpedo, the roller height which best suits the gage will probably not be the best for the torpedo. Therefore, if roller settings are changed to permit passage of a bore gage, they must be readjusted for the torpedo when the ship again is waterborne.

Barrel Centerline Gage. The barrel centerline gage is used during each overhaul and when it is suspected that the stop bolt or one of the setting spindles has become worn or deformed. This gage is provided on tenders and at yards and bases customarily working with submarines.

At the time of gaging, registry of all spindles should be checked with their dial readings and each spindle swung through its maximum limits of movement to insure it will engage its mating socket in the torpedo, even though they are not directly in line with each other. This process also indicates whether or not each spindle centering spring has sufficient force to return the spindle to center, when its spindle is released after being swung out of line.

Bore Sighting. Tubes should be bore sighted to align their mean point of impact with the submarine's periscope. This is accomplished when the vessel is in drydock.

By means of a batten or a taut wire, the vertical centerline common to the starboard bow tubes should be extended to a point above the bow of the ship. The same method should be used for port tubes. The distance between the two centerlines is measured, and a point midway between them marked. This point is the zero train mark for the periscope. A similar point should be established aft for 180° train of the periscope. Then the azimuth ring should be adjusted so that the periscope reads 0° or 180° when trained on the forward or after midway point respectively. If there is a discrepancy between the two points, the difference should be halved in establishing the reference line. Bench marks are then permanently established on the submarine for use in future checking.

Chapter 18

OPERATING AND TEST PROCEDURES

For Tubes for Mechanical and Electrical Setting

Either mechanically set or electrically set torpedoes can be fired from tubes modified by ORDALT 3069. Impulse firing, either with or without the poppet valve can be used with all 21-inch torpedoes mentioned in the list which follows. However, inclusion of a torpedo in this list does not imply that each of the various torpedoes must be fired from tubes of any specific submarine. To avoid confusion, the torpedoes have been grouped as mechanically or electrically set and no reference has been made to the modification number of the torpedo.

21-inch Submerged Torpedo Tubes Mark 32 Mods 8–14; Mark 33 Mods 7–12; Mark 34 Mods 6–10; Mark 35 Mods 6–10.

Mechanically set torpedo Mark	*Electrically set torpedo Mark*
14	14
16	16
18	18
23	27
27 (preset)	28
28	35
	37

Silent fire and runout fire can be used only with 19-inch torpedoes. Many of the steps in preparing to fire and firing are the same for both methods of setting and for both sizes of torpedoes. Recommended sequences for preparing to fire and firing are given in the following paragraphs for each method of firing. In the recommended sequences for preparing to fire, it has been assumed that the tube is dry. However, before opening the breech door, it should be positively established that thert is no water in the tube. If the tube is not dry, it should be drained before the breech door is opened, described later in this chapter. The recommended sequences do not necessarily apply to all torpedoes; therefore, the applicable torpedo publication should be consulted to ascertain if the sequence applies.

Preparing To Fire and Firing

Impulse Firing, Mechanically Set 21-Inch Torpedo.

1. Ready the torpedo and tube setting mechanisms.

a. Set the torpedo depth setting spindle as nearly as possible at 10 feet with two sides of the square parallel to the torpedo center line. Set circle-setting mechanism of Torpedo Mk 16 Mod 7 as nearly as possible to 1000 yards, with two sides of the square parallel to torpedo centerline.

b. Set the torpedo gyro at 0.

c. Set the torpedo speed setting at LOW.

d. Set the tube depth setting mechanism at 10 feet.

e. Set the tube speed setting mechanism at LOW.

f. On a bow tube, set the tube gyro mechanism at 0. On a stern tube, set it at 180.

2. Lock the tripping latch in the NORMAL OPERATING POSITION.

3. Open the tube vent.

4. Unlock and open breech door.

> ***Caution:*** To prevent damage to the breech door mechanism when the door is being opened, it must be held until it is fully open and the stops bear against the hinge bracket.

5. Back off the tail stop. Turn tail stop handwheel to the left (counterclockwise) to the limit of its travel.

> ***Caution:*** To prevent buffer plate and seal from striking the propeller nut and guide stud from jamming against stop bolt, tail stop must be backed off before breech door is closed.

6. Inspect the bore. Use a flashlight or portable lamp to make sure that:

a. Tube is clear of foreign objects.

b. Stop bolt is down.

c. Tripping latch is up.

d. Spindles of the depth, speed, and gyro setting mechanisms are retracted into their housings.

7. Load the torpedo.

a. Insert one end of the tail piece into the torpedo propeller shaft (the other end of the tail piece is fitted with a pulley).

b. Attach the block and tackle to the two eyes on the breech door locking ring.

c. Lead the line through the pulley on the tailpiece.

d. Ease the torpedo along runways and into tube until guide stud on top of the torpedo enters the guide slot in top land of the barrel.

e. Remove propeller lock.

f. Remove safety guard from starting lever.

g. See that index dials on gyro, depth, and speed setting mechanisms are set properly.

h. See that torpedo stop valve is open.

i. See that starting gear is set to run.

j. Ease torpedo farther into tube until only propellers and tail piece project.

k. Remove block and tackle from locking ring and tail piece.

l. Manually ease torpedo all the way into tube until guide stud bears against stop bolt.

Caution: Guide stud must be brought gently against stop bolt to avoid bending bolt or binding any parts.

m. Remove tail piece from torpedo propeller shaft.

NOTE: If necessary to remove the torpedo from the tube after it has been loaded, see that setting spindles are disengaged from their sockets in the torpedo and pull the torpedo gently out of the tube onto the runways in the manner shown in figure 227.

8. Prime firing valve.

a. With no charge in impulse tank, open filling valve in firing valve head.

b. Open overflow valve in firing and check valve body.

c. Using filling funnel, pour clean, fresh water into filling valve until water flows freely from overflow valve.

d. After water stops flowing, close both valves.

Caution: After the impulse tank has been charged, do not open the filling valve or overflow valve because this would vent the upper chamber of the firing valve and fire the tube.

NOTE: The above procedure is not to be followed on those torpedo tubes on which ORDALT 2888 has been accomplished.

9. Charge impulse tank with impulse stop valve open. For correct impulse pressure, see chapter 17. Impulse pressures for Torpedo Mk 35 are the same as those specified for Torpedoes Mk 18 and 28. While charging impulse tank, check tightness of firing valve.

Caution: If the firing valve is leaking, report it at once to the Torpedo Control Officer. When the muzzle door is closed, even a small air leak may build up sufficient pressure to crack the door open. If this happens, pressure in the after section of the tube will force the torpedo guide stud against the stop bolt and probably damage it. Also, impulse tank pressure may be reduced so that the torpedo will not receive enough launching velocity. When the muzzle door is opened, an air leak will cause a surface bubble trail.

10. Close charging valve when impulse tank has been charged. Do not let the tank "ride" upon the line.

11. Before shutting the breech door of tubes on which ORDALT 3069 has been performed, check that the protecting plug is inserted in the breech door "A" cable receptacle.

12. Close breech door.

13. Take up on tail stop. Turn tail stop to right (clockwise) until buffer and seal bear firmly against the torpedo.

14. Lock breech door. Set breech and muzzle door interlock lever at MUZZLE DOOR UNLOCKED.

15. Flood tube when ordered.

Caution: When launching torpedoes from tubes 1 and 2 in the bow and 7 and 8 in the stern, while submarine is on the surface, it is necessary that ship trim be adjusted so that these tubes are completely submerged. This will assure that the tubes can be completely flooded, a requirement for proper torpedo launching.

a. Set drain valve interlock lever at MUZZLE DOOR CLOSED.

b. Check WRT tank valve open.

c. Open tube drain valve.

d. Open WRT tank blow valve to flood tube from WRT tank. When tube is completely flooded, close blow valve.

e. Close tube drain valve.

f. Set WRT tank lever at OPEN; vent tank until gage shows atmospheric pressure.

g. Set drain valve interlock lever at DRAIN VALVE LOCKED.

> NOTE: To flood a tube from the trim tank, follow procedure already listed, using the trim tank blow and vent valves instead of corresponding WRT tank valves in steps b to f. To flood a tube from sea, use trim pump, trim line valve, and tube vent.

16. Close tube vent. Place tube vent valve lever at SHUT.

17. Ready poppet valve.

a. If poppet valve is not to be used, see that the gag nut is in its muzzleward position, poppet discharge valve is closed, and vent-closing valve is set at OFF.

b. If poppet valve is to be used, see that gag nut is in its breechward position, poppet discharge valve is open, and vent-closing valve is ON.

18. Engage depth setting spindle.

a. See that depth settings made have not been disturbed. If they have, reset them.

b. Set depth setting engaging and disengaging lever at IN.

c. When firing Torpedo Mk 16 Mod 7 from tubes equipped with ORDALT 3557, the following instructions apply:

(1) Set the engaging and disengaging lever at the IN position.

(2) Turn the operating shaft until the dial registers the required circling distance.

19. Engage speed setting spindle.

a. See that speed setting made has not been disturbed. If it has, reset it.

b. Set speed setting engaging and disengaging lever at IN.

20. Engage gyro setting spindle.

a. See that gyro setting has not been disturbed. If it has, reset it.

b. Grasp gyro setting mechanism engaging lever; press down on handle lock release on top of engaging lever.

c. Turn lever to IN.

d. Press down on shaft bolt release button.

e. Hold shaft bolt release button in while turning engaging lever to its locked position.

f. Release pressure on handle lock release.

21. Set torpedo depth. When ordered, turn depth setting hand crank until selected depth is indicated on index dial.

22. Withdraw depth setting spindle.

23. Set torpedo speed. When ordered, set selected speed. Turn hand crank until speed is indicated on indicator plate.

24. Withdraw speed setting spindle.

25. Set torpedo gyro. When ordered, turn gyro setting indicator-regulator handwheels to set gyro.

26. Open muzzle door. Turn muzzle door operating shaft to the left through its full travel (14½ turns) or set control valve operating handle at OPEN.

27. Set poppet valve timer. When poppet valve is to be used, set timer for the nest at the interval corresponding to depth at which firing will occur.

28. Set firing interlock lever at TUBE READY TO FIRE.

29. Report "Tube ready to fire" to torpedo firing control station.

30. When ordered, fire the torpedo; close the firing key or pull the HAND FIRE handle inboard, figure 161. It is not necessary to hold either key or handle for any set length of time.

Impulse Firing, Electrically Set 21-Inch Torpedo.

1. Set Switch Box Mk 5. With reset lever, set switch box at READY position.

2. Lock tripping latch in NORMAL OPERATING POSITION for torpedoes that can be started mechanically or electrically. For electrically started torpedoes with shroud rings (Torpedo Mk 35), place tripping latch in RIGGED FOR DEPTH CHARGE position on those tubes upon which ORDALT 3555 has not been accomplished.

3. Open tube vent.

4. Unlock and open breech door.

> ***Caution:*** To prevent damage to the breech door mechanism when the door is being opened, it must be held until it is fully open and the stops bear against the hinge bracket.

5. Back off tail stop. Turn tail stop handwheel to left (counterclockwise) to the limit of its travel.

Caution: To prevent the buffer plate and seal from striking the propeller nut and guide stud from jamming against stop bolt, tail stop must be backed off before the breech door is closed.

6. Inspect bore. Use a flashlight or portable lamp to make sure that:

a. Tube is clear of foreign objects.

b. Stop bolt is down.

c. Tripping latch is up.

d. Spindles of depth, speed, and gyro setting mechanisms are retracted into their housings.

7. Load torpedo.

a. Insert one end of tail piece into torpedo propeller shaft (the other end of the tail piece is fitted with a pulley).

b. Attach block and tackle to two eyes on the breech door locking ring.

c. Lead line through pulley on the tail piece.

d. Ease torpedo along the runways and into the tube until the guide stud on top of the torpedo enters guide slot in the top land of the barrel.

e. Remove propeller lock.

f. See that torpedo stop valve is open.

g. See that starting gear is set to run.

h. Ease torpedo farther into the tube until only the propellers and tail piece project.

i. Remove block and tackle from locking ring and tail piece.

j. Manually ease torpedo all the way into tube until the guide stud bears against stop bolt.

Caution: The guide stud must be brought gently against the stop bolt to avoid bending the bolt or binding any parts.

k. Remove tail piece from torpedo propeller shaft.

8. Prime firing valve.

a. With no charge in impulse tank, open filling valve in firing valve head.

b. Open overflow valve in firing and check valve body.

c. Using filling funnel, pour clean, fresh water into filling valve until water flows freely from overflow valve.

d. After water stops flowing, close both valves.

Caution: After the impulse tank has been charged, do not open the filling valve or overflow valve as this would vent the upper chamber of the firing valve and fire the tube.

NOTE: The above procedure is not to be followed on those torpedo tubes on which ORDALT 2888 has been accomplished.

9. Connect torpedo cable.

a. Remove protecting plug from connector receptacle inside tube door.

b. Insert connector plug at the end of torpedo cable into connector receptacle. Secure cable with cable clamp.

NOTE: Proper lay of the cable in the bottom of the torpedo tube may be effected by twisting the cable before inserting the door plug into the breech door receptacle. If the cable has sufficient length, the quick-opening clamp on the inside of the breech door will clamp the cable when the door is fully open. If the combination of torpedo and tube results in the cable being too short, shut the breech door partially; then clamp the cable. Under this latter condition the breech door must never be opened fully before releasing the quick-opening cable clamp. Failure to observe this caution will result in forcing the cable cutter shear pin, and cause permanent damage to the "A"-cable by shearing some or all of the electrical conductors. Further information on control cables is contained in chapter 19, NAVORD Instructions 8510.68 and NAVORD Instruction 8510.75.

c. Check that plug is latched securely in breech door receptacle.

10. Charge impulse tank with impulse stop valve open. For correct impulse pressure, see chapter 17. While charging impulse tank, check tightness of firing valve.

Caution: If firing valve is leaking, report it at once to the Torpedo Control Officer. When muzzle door is closed, even a small

air leak may build up sufficient pressure to crack the door open. If this happens, pressure in the after section of the tube will force the torpedo guide stud against the stop bolt and probably damage it. Also, impulse tank pressure may be reduced so that the torpedo will not receive enough launching velocity. When the muzzle door is opened, an air leak will cause a surface bubble trail.

11. Close charging valve when impulse tank has been charged. Do not let the tank "ride" upon the line.

12. Close breech door.

13. Take up on the tail stop. Turn tail stop handwheel to the right (clockwise) until buffer and seal bear firmly against the torpedo.

14. Lock breech door. Set breech and muzzle door interlock lever at MUZZLE DOOR UNLOCKED.

15. Flood tube when ordered.

Caution: When launching torpedoes from tubes 1 and 2 in the bow and 7 and 8 in the stern, while submarine is on the surface, it is necessary that ship trim be adjusted so that these tubes are completely submerged. This will assure that the tubes can be completely flooded, a requirement for proper torpedo launching.

a. Set drain valve interlock lever at MUZZLE DOOR CLOSED.

b. Check WRT tank valve open.

c. Open tube drain valve.

d. Open WRT tank blow valve to flood tube from WRT tank. When tube is completely flooded, close blow valve.

e. Close tube drain valve.

f. Set WRT tank vent lever at OPEN; vent tank until gage shows atmospheric pressure.

g. Set drain valve interlock lever at DRAIN VALVE LOCKED.

NOTE: To flood a tube from trim tank, follow procedure just listed, using the trim tank blow and vent valves instead of corresponding WRT tank valves in steps b to f. To flood a tube from sea, use trim pump, trim line valve, and tube vent.

16. Close tube vent. Place tube vent valve lever at SHUT.

17. Ready poppet valve.

a. If poppet valve is not to be used, see that gag nut is in its muzzleward position, poppet discharge valve is closed, and vent-closing valve is set at OFF.

b. If poppet valve is to be used, see that gag nut is in its breechward position, poppet discharge valve is open, and vent-closing valve is ON.

18. Open muzzle door. Turn muzzle door operating shaft to left through its full travel (14½ turns) or set control valve operating handle at OPEN.

19. Set poppet valve timer. When poppet valve is to be used, set timer for the nest at the interval corresponding to depth at which firing will occur.

20. Set firing interlock lever at TUBE READY TO FIRE.

NOTE: Also rotate tripping latch cam to RIGGED FOR DEPTH CHARGE position for electrically started torpedoes with shroud rings (Torpedo Mk 35 Type) in tubes upon which ORDALT 3555 has been accomplished.

21. Report tube "Ready to fire" to torpedo firing control station.

22. When ordered, fire torpedo. Close firing key or pull HAND FIRE handle inboard, figure 164. It is not necessary to hold either key or handle for any set length of time.

Runout Firing, Electrically Set 19-Inch Torpedo.

1. With reset lever, set Switch Box Mk 5 at READY position.

2. Lock tripping latch in NORMAL OPERATING POSITION. If torpedo to be fired has a shroud ring of greater than 19-inch outside diameter, lock tripping latch in RIGGED FOR DEPTH CHARGE position.

3. Open tube vent.

4. Unlock and open breech door.

Caution: To prevent damage to breech door mechanism when door is being opened, it must be held until it is fully opened and stops bear against hinge bracket.

5. Inspect bore. Use a flashlight or portable lamp to make sure that:

a. Tube is clear of foreign objects.

b. Stop bolt is down.

c. Tripping latch is up.

d. Spindles of depth, speed, and gyro setting mechanisms are retracted into their housings.

6. Load torpedo.

a. Insert one end of tail piece into torpedo propeller shaft (the other end is fitted with a pulley).

b. Attach block and tackle to two eyes on the breech door locking ring.

c. Lead line through the pulley on tail piece.

d. Ease torpedo along runways and into tube until guide stud on top of torpedo enters guide slot in top land of barrel.

e. Remove propeller lock.

f. See that torpedo stop valve is open.

g. See that starting gear is set to run.

h. Ease torpedo farther into tube until only propellers and tail piece project.

i. Remove block and tackle from locking ring and tail piece.

j. Manually ease torpedo all the way into tube until guide stud bears against stop bolt.

Caution: Guide stud must be brought gently against stop bolt to avoid bending bolt or binding any parts.

k. Hold torpedo in place. Lift stop bolt with hand retraction gear.

l. Ease torpedo slightly into tube while lowering stop bolt. Stop bolt must fit into a notch in guide stud and position must be found by "feel".

m. Remove tail piece from torpedo propeller shaft. Also remove hand retraction gear.

7. Connect torpedo cable.

a. Remove protecting plug from connector receptacle inside tube door.

b. Insert connector plug at end of the torpedo cable into the connector receptacle. Secure cable with cable clamp.

NOTE: Proper lay of the cable in the bottom of the torpedo tube may be effected by twisting the cable before inserting the door plug into the breech door receptacle. If the cable has sufficient length, the quick-opening clamp on the inside of the breech door will clamp the cable when the door is fully open. If the combination of torpedo and tube results in the cable being too short, shut the breech door partially; then clamp the cable. Under this latter condition the breech door must never be opened fully before releasing the quick-opening cable clamp. Failure to observe this caution will result in forcing the cable cutter shear pin, and cause permanent damage to the "A"-cable by shearing some or all of the electrical conductors. Further information on control cables is contained in chapter 19, NAVORD Instructions 8510.68 and NAVORD Instruction 8510.75.

c. Check that plug is latched securely in breech door receptacle.

8. Close breech door.

9. Lock breech door. Set the breech and muzzle door interlock lever at MUZZLE DOOR UNLOCKED.

10. Flood tube, when ordered.

Caution: When launching torpedoes from tubes 1 and 2 in the bow and 7 and 8 in the stern, while submarine is on the surface, it is necessary that ship trim be adjusted so that these tubes are completely submerged. This will assure that the tubes can be completely flooded, a requirement for proper torpedo launching.

a. Set drain valve interlock lever at MUZZLE DOOR CLOSED.

b. Check WRT tank valve open.

c. Open tube drain valve.

d. Open WRT tank blow valve to flood tube from WRT tank. When tube is completely flooded, close blow valve.

e. Close tube drain valve.

f. Set WRT tank vent lever at OPEN; vent tank until the gage shows atmospheric pressure.

g. Set drain valve interlock lever at DRAIN VALVE LOCKED.

NOTE: To flood a tube from the trim tank, follow the preceding steps using trim tank blow and vent valves instead of the corresponding WRT tank valves in steps b to f. To flood a tube from sea, use the trim pump, trim line valve, and tube vent.

11. Close tube vent. Place tube vent valve lever at SHUT.

12. Check poppet valve. See that gag nut is in its muzzleward position, poppet discharge valve is closed, and vent-closing valve is OFF.

13. Open muzzle door. Turn muzzle door operating shaft to left through its full travel (14½ turns) or set control valve operating handle at OPEN.

14. Check to see that there is no pressure in impulse tank and that impulse stop valve is closed.

15. Set firing interlock lever at TUBE READY TO FIRE.

16. Report "Tube ready to fire" to torpedo firing control station.

17. Fire torpedo. When ordered, fire torpedo. Close firing key or pull HAND FIRE handle inboard, figure 161. It is not necessary to hold either the key or the handle for any set length of time.

Silent Firing, Electrically Set 19-Inch Torpedo.

1. Set Switch Box Mk 5. With reset lever, set switch box at READY position.

2. Lock tripping latch in NORMAL OPERATING POSITION. If torpedo to be fired has a shrould ring of greater than 19-inch outside diameter, lock tripping latch in the RIGGED FOR DEPTH CHARGE position.

3. Open tube vent.

4. Unlock and open breech door.

> ***Caution:*** To prevent damage to breach door mechanism when door is being opened, it must be held until it is fully open and the stops bear against hinge bracket.

5. Inspect bore. With a flashlight or portable lamp, make sure that:

a. Tube is clear of foreign objects.

b. Stop bolt is down.

c. Tripping latch is up.

d. Spindles of depth, speed, and gyro setting mechanisms are retracted into their housings.

6. Load torpedo.

a. Insert one end of tail piece into torpedo propeller shaft (the other end of tail piece is fitted with a pulley).

b. Attach block and tackle to two eyes on breech door locking ring.

c. Lead line through pulley on tail piece.

d. Ease torpedo along runways and into tube until guide stud on top of torpedo enters guide slot in top land of barrel.

e. Remove propeller lock.

f. See that torpedo stop valve is open.

g. See that starting gear is set to run.

h. Ease torpedo farther into tube until only propellers and tail piece project.

i. Remove block and tackle from locking ring and tail piece.

j. Manually ease torpedo all the way into tube until guide stud bears against the stop bolt.

> ***Caution:*** Guide stud must be brought gently against stop bolt to avoid bending the bolt or binding any parts.

k. Hold torpedo in place. Lift stop bolt with hand retraction gear.

l. Ease torpedo into tube slightly while lowering stop bolt. Stop bolt must fit into a notch in guide stud and the position must be found by "feel".

m. Remove tail piece from torpedo.

7. Connect torpedo cable.

a. Remove protecting plug from connector receptacle inside tube door.

b. Insert connector plug at end of torpedo cable into connector receptacle. Secure cable with cable clamp.

> NOTE: Proper lay of the cable in the bottom of the torpedo tube may be effected by twisting the cable before inserting the door plug into the breech door receptacle. If the cable has sufficient length, the quick-opening clamp on the inside of the breech door will clamp the cable when the door is fully open. If the combination of torpedo and tube results in the cable being too short, shut the breech door partially; then clamp the cable. Under this latter condition the breech door must never be opened fully before releasing the quick-opening cable clamp. Failure to observe this caution will result in forcing the cable cutter shear pin, and cause permanent damage to the "A"-cable by shearing some or all of the electrical conductors. Further information on control cables is contained in chapter 19, NAVORDINST 8510.68 and NAVORDINST 8510.75.

c. Check that plug is latched securely in breech door receptacle.

8. Close breech door.

9. Lock breech door. Set breech and muzzle door interlock lever at MUZZLE DOOR UNLOCKED.

10. Flood tube when ordered.

> ***Caution:*** When launching torpedoes from tubes 1 and 2 in the bow and 7 and 8 in the stern, while submarine is on the surface, it is necessary that ship trim be adjusted so that these tubes are completely submerged. This will assure that the tubes can be completely flooded, a requirement for proper torpedo launching.

a. Set drain valve interlock lever at MUZZLE DOOR CLOSED.

b. Check WRT tank valve open.

c. Open tube drain valve.

d. Open WRT tank blow valve to flood tube from WRT tank. When tube is completely flooded, close blow valve.

e. Close tube drain valve.

f. Set WRT tank vent lever at OPEN; vent tank until gage shows atmospheric pressure.

g. Set drain valve interlock lever at DRAIN VALVE LOCKED.

NOTE: To flood a tube from the trim tank, follow the preceding steps using the trim tank blow and vent valves instead of the corresponding WRT tank valves in steps b to f. To flood a tube from sea, use the trim pump, trim line valve, and tube vent.

11. Close tube vent. Place tube vent valve lever at SHUT.

12. Check poppet valve. See that the gag nut is in its muzzleward position, poppet discharge valve is closed, and vent-closing valve is OFF.

13. Open muzzle door. Turn muzzle door operating shaft to left through its full travel (14½ turns) or set control valve operating handle at OPEN.

14. Check to see that there is no pressure in impulse tank and that impulse stop valve is closed.

15. Set firing interlock lever at TUBE READY TO FIRE.

16. Shift to emergency power. Pull the SILENT FIRE handle inboard, figure 165, to shift transfer switch to EMERGENCY POWER.

17. Report "Tube ready to fire" to torpedo firing control station.

18. Fire torpedo. When ordered, retract stop bolt with hand retraction gear. Hold stop bolt retracted for at least 20 seconds to make sure the torpedo has left the tube.

After Firing *(All Methods)*

After firing the torpedo, perform the following steps. Recommended sequence for each type of firing is given under the appropriate heading.

Impulse Firing Without Poppet Valve.

1. Shift firing plunger. Move firing plunger outboard by hand.

2. Unlock muzzle door. Set firing interlock lever at MUZZLE DOOR UNLOCKED.

3. Close muzzle door. Turn muzzle door operating shaft to right through its full travel (14½ turns) or set control valve operating handle at CLOSE.

4. Drain tube. (This procedure is the same for all methods of firing; it is given under a separate heading.)

Impulse Firing With Poppet Valve.

1. Close poppet valve. When red indicator light on face of timer comes on, set tube vent valve lever at OPEN.

2. Close tube vent. When tube is entirely vented, shift tube vent valve lever to SHUT.

3. Unlock muzzle door. Set firing interlock lever at MUZZLE DOOR UNLOCKED.

4. Close muzzle door. Turn muzzle door operating shaft to the right through its full travel (14½ turns) or set control valve operating handle at CLOSE.

5. Drain tube. (This procedure is the same for all methods of firing; it is given under a separate heading.)

Runout Firing.

1. If electric firing key was used to fire the torpedo, bypass tube firing circuit. Shift switch five seconds after stop bolt lifts.

2. Return firing plunger to its outboard position by hand 20 seconds after stop bolt lifts. This must be done whether electric firing key or HAND FIRE handle was used to fire torpedo.

3. Unlock muzzle door. Set firing interlock lever at MUZZLE DOOR UNLOCKED.

4. Close muzzle door. Turn muzzle door operating shaft to right through its full travel (14½ turns) or set control valve handle at CLOSE.

5. Drain tube. (This procedure is the same for all methods of firing; it is given under a separate heading.)

Silent Firing.

1. Lower stop bolt with hand retraction gear and remove gear from the tube.

2. Unlock muzzle door. Set firing interlock lever at MUZZLE DOOR UNLOCKED.

3. Close muzzle door. Turn muzzle door operating shaft to right through its full travel (14½ turns) or set control valve operating handle at CLOSE.

4. Drain tube. (This procedure is the same for all methods of firing; it is given under a separate heading.)

Draining the Tube

1. Set drain valve interlock lever at MUZZLE DOOR CLOSED.

2. Open tube drain valve.

3. Check WRT tank valve open.

4. Vent WRT tank by setting WRT tank vent lever at OPEN.

5. Blow water in tube into WRT tank by opening torpedo tube blow valve. (Keep pressure in tube down to about ten pounds per square inch to avoid leakage around muzzle door.) When tube is empty of water, close blow valve.

6. Close WRT tank vent by setting vent lever at SHUT.

7. Open tube vent valve; vent tube until pressure gage on breech door indicates atmospheric pressure.

8. Close tube vent.

9. Close tube drain valve.

NOTE: In submarines of the Portsmouth design, to drain a tube to the trim tank, use the trim tank drain and vent valves instead of corresponding WRT tank valves in steps b, c, d, and e.

To drain a tube to sea, use trim pump, trim line valve, and tube vent.

In submarines of Electric Boat Division design, a WRT tank overflow valve is provided for blowing tubes to trim tank when WRT tank is full. An interlock to close a quick-operating valve in WRT tank blow line prevents accidental blowing of WRT tank to trim tank when overflow valve is open. A loop around quick-operating valve is provided with a check valve for venting. When overflow valve is closed, normal blowing and venting of WRT tank is accomplished. When overflow valve is open, water from the tube is transferred to trim tank via WRT tank.

Do not open breech door until all water is drained from tube and pressure in tube is the same as that in the submarine.

After firing an electrically set torpedo, remove the cut torpedo cable and plug from inside of breech door. Secure protecting plug in connector receptacle inside the door.

Firing Mines

For operation of torpedo tubes in launching mines, refer to the Ordnance pamphlet that relates to the particular mine to be launched.

Firing Water Slugs

Water slugs are fired to train personnel and to exercise tube mechanisms. The procedure for firing is the same as for firing actual torpedoes. When poppet valve is to be used, selector valve must be shifted to its water slug position and secured with its toggle pin; a minimum impulse pressure of 250 pounds per square inch must be used.

Firing Air Charges Inboard

The procedure for firing air charges inboard is the same as that given in chapter 17.

Test Procedures

Test procedures are described in chapter 17.

Chapter 19

MAINTENANCE

This chapter outlines only the general procedures for efficient maintenance of torpedo tubes and their associated mechanisms, and directs attention to cases where service experience has indicated that trouble may develop. For detailed maintenance information and instructions, refer to the applicable submarine torpedo tube operation and maintenance manual issued by Commander Submarines Atlantic Fleet or Commander Submarines Pacific Fleet.

Maintaining equipment in its best working order depends upon knowledge and skill of operating personnel and their thorough understanding of the construction and function of each unit.

In general, circumstances permitting, each working part should be exercised at least once a week, and maintenance performed as the necessity arises.

To exercise tube mechanisms, a water slug or an air charge should be fired from each tube weekly. Fire water slugs only when in clean water; at other times, fire air charges.

Lubrication. Maintain all working parts in a clean and properly lubricated condition. Refer to the lubrication charts included in the General Information books supplied to each vessel. In the absence of contrary instructions, dry and clean the inside of the barrel monthly. Do not coat it with oil; this would result in an oil slick when the muzzle door is open. Do not oil electrical contacts. When it is necessary to lubricate an exposed electrical part, use a light mineral oil, Navy symbol 2110, or equivalent.

Care is essential in selecting general lubricants, since some which are satisfactory for steel will corrode bronze or other materials, especially under salt and moisture conditions. Some oils thicken and harden, turn dark and lose their lubricating properties when affected by salt and moisture. Before renewing any lubricant, remove the old.

Wear and Deformation. Inspect working parts at every opportunity, to detect and remedy possible causes of failure. Examine the tripping latch linkage, stop mechanism, setting mechanisms, and interlocks for deformation and lost motion. Check to see that they operate properly.

To check the projection of the stop bolt or one of the setting spindles, use the barrel centerline gage. For testing the projection of the tripping latch inside the tube, use the tripping latch gage supplied in the tool kit, figure 232.

Adjustments. Before adjusting any of the torpedo tube mechanisms, refer to the applicable drawings and the specific instructions relating to the part to be adjusted. After adjustment, check all clearances to see that they are within the specified limits.

Stuffing Boxes. Tighten stuffing boxes only enough to prevent leakage. From the operating standpoint, it is better to allow a slight leak to continue until the box can be repacked than to take up on the stuffing box so that it binds a working part. This is particularly important with respect to the stop rod, since its improper action could cause a sluggish firing movement.

Keep down stuffing box friction upon the stop rod so the rod moves freely with ship service air at half its normal pressure.

Pressure Gages. Pressure gages are easily put out of adjustment especially when subjected to shock or excessive vibration. Calibrate them during each overhaul, when their accuracy is in doubt, and after they have been subjected to unusually hard usage. If practicable, calibrate them after each war patrol. During drill and exercise periods, a gage may be checked by comparing its reading with that of a similar gage on the same line.

Springs. Springs are subject to deterioration in service. A small decrease in wire diameter, even if only at one point, considerably reduces load-carrying capacity. Steel springs are likely to corrode whether or not they have been plated or

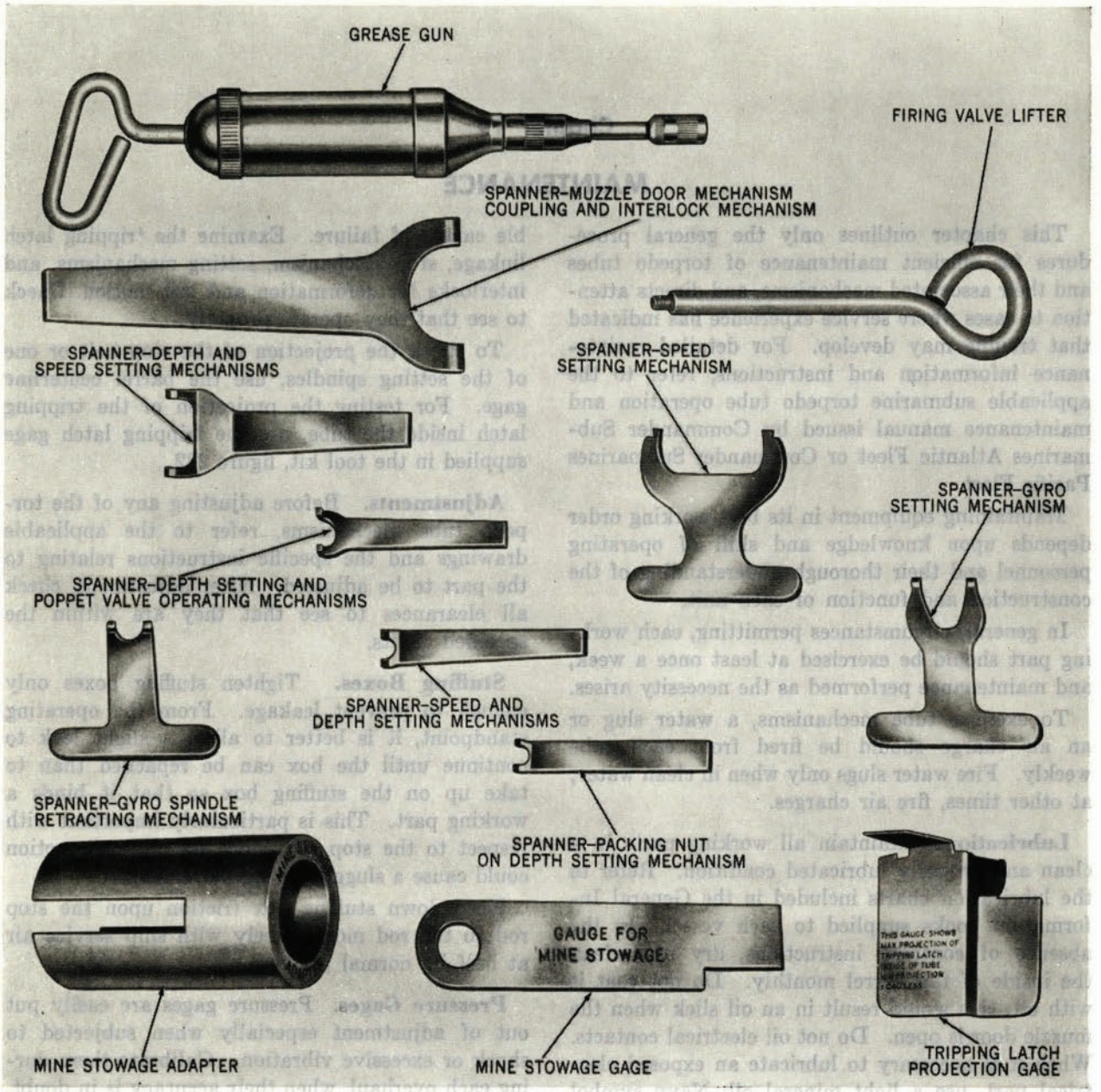


Figure 232—*Torpedo Tube Tools.*

subjected to other protective measures. Springs of non-ferrous metals tend to take a permanent set when under load.

To determine whether or not the load and deflection requirements shown on the detail drawings are met, calibrate springs during each overhaul. Replace springs which are corroded or appear to be incapable of accomplishing their intended purpose. Retain replaced springs for future calibration, and for use as spares, if serviceable.

Gaskets. Gaskets (including those for the breech and muzzle doors) which contain rubber are subject to deterioration especially under extreme temperature changes and exposure to oil. Replace them when they appear to be permanently deformed, checked, hardened, or sticky.

MUZZLE DOOR GASKET. The muzzle door section of the tube is not easily accessible for inspection when the ship is waterborne, since the doors are below the water line. Therefore, inspect the muzzle door gasket during drydocking and replace it if the degree of deterioration warrants.

Valves. About once a week, manually exercise those valves not frequently used to insure that they operate freely—e.g. the automatic drain valve at the bottom of the firing and check valve body.

CHECK VALVE. Wear and age reduce the length of the rubber buffer in the check valve. This may cause the valve to open too far so that the valve disc strikes the outboard rudder bearing on the tail vanes of the torpedo. If the buffer is too long, it will prevent the check valve from opening completely, and throttling of the impulse pressure may then occur at the check valve instead of at the firing valve cup.

During each overhaul, carefully inspect this rubber buffer to determine whether or not it is of correct length. Replace it if necessary.

PILOT VALVE. Do not disturb properly seated pilot valves except as required during overhaul. Leakage of this valve may cause the firing valve to flutter or to open. It is especially important that this valve and its seat be kept clean and in perfect condition.

STOP CYLINDER VALVE. After checking to see that the firing interlock lever is at MUZZLE DOOR UNLOCKED, manually exercise stop cylinder valve once a week. At the same time, check solenoid and firing lever.

Check to see that vent holes in stop cylinder and in stop cylinder head are clear. If stop cylinder vents are obstructed, firing action will be sluggish. If stop cylinder head vents are obstructed and the stop cylinder valve leaks, air pressure will build up in the stop cylinder. This will cause the breech end of the stop piston rod to move and engage the recess in the interlock shutter bar, preventing the firing interlock lever from being moved to TUBE READY TO FIRE.

Gyro Setting Spindle. To inspect or replace the gyro setting spindle, remove it from the spindle drive housing without removing or disturbing the spindle sleeve. To do this, remove plate covering the access opening in the spindle drive housing. Then, bend down ears on the locking washer which prevents a threaded and socketed plug from backing out. Remove plug by unscrewing and easing it out so that pressure of the spindle spring will not eject it violently. Remove the spindle rotating plug (with its key and locking washer), the spindle, and its spring. Some of these parts are small; be careful not to lose them. The spindle may be pushed out from within the tube to facilitate its removal. To reassemble the spindle, reverse the foregoing process.

There are four 0.06-inch chamfered spots, each ¼ inch long, at the horizontal and vertical center lines on the circumference of the 1½-inch diameter hole in the housing. In the spindle sleeve assembly, two faces on the square tip of the spindle are parallel with the slot in the visible end of the sleeve. When drive shafting, gears, and couplings are properly assembled, this slot lines up with two of the chamfered spots on the housing when the dials of the gyro setting indicator-regulator show 0° or 180° or any other angle which is a multiple of 1¼°, since one turn of the spindle equals 5° of gyro setting.

The spindle sleeve enters the tube through a stuffing box. The spring pressure on the chevron-type sealing rings in the stuffing box is not adjustable.

Do not use split sealing rings. Since these rings dry out and become hard in stowage, they should be placed in Neatsfoot oil and heated for approximately one-half hour or more at a temperature of 120 degrees to overcome this defect. The rings will then become soft and pliable again. After new rings are installed, exercise them for about 20 minutes by rotating and working the spindle in and out.

Breech Door Locking Ring. See that the breech door locking ring turns freely upon its threads on the breech door flange. Keep threads clean and well oiled. Avoid using abrasives, if possible; if they must be used, make sure that no particles remain on operating parts. Threads are triple and will go together in three different positions. Therefore, before disassembling the locking ring from the flange, mark the ring and flange at the point where they disengage, so they may be reassembled in their original positions.

Torpedo Stop Mechanism. During each overhaul, inspect stop bolt, stop rod, and connecting

levers, and maintain them in proper adjustment. A threaded adjustment spacer at the breech end of the stop rod (where it attaches to the gyro spindle retraction slide) permits adjustment so that when the stop bolt is all the way down, and the stop rod is at the extreme limit of its travel toward the muzzle end of the tube, the clearance between the rounded end of the stop bolt lever and the bottom of the slot in the stop bolt is 0.25 inch. Do not permit this clearance to exceed 0.45 inch.

The clearance between the rounded end of the stop bolt lever and the top of the slot in the stop bolt should be approximately 5/16 inch. This clearance, combined with the angular clearance in the stop shaft lever, insures that the gyro setting spindle will clear its socket in the torpedo and that the stop bolt will be raised before the pilot valve is opened to fire the tube.

Barrel Rollers. Sea water tends to corrode the roller axle pin and its screws, and may leave dirt deposits in the bottom of the bracket. A corroded axle pin may bind with its roller. Therefore, during each overhaul, remove each roller bracket assembly from the tube, and disassemble and clean all parts.

Between overhauls, inspect the rollers during the monthly cleaning of the inside of the barrel. When this inspection indicates, remove, clean, and reinstall the barrel roller, shims, axle pin, and screws.

To increase or decrease the distance the barrel roller projects into the tube, disassemble and install shims of the proper thickness.

Drainage System. During each overhaul, inspect rubber gaskets of drain valves, and replace them if they are worn or damaged. Keep the stuffing boxes on the drain and vent valves properly adjusted, and replace packing that has become unserviceable. Use the packing specification on the applicable drawing, or that called for by Bureau of Ships instructions.

Keep all drain grids and lines free from obstruction.

Electrical Circuits. Keep electrical circuits clean, dry, and free from oil and grease. Lightly lubricate moving metal parts, except electrical contacts.

Keep electrical contacts bright, except those which are silver coated.

To insure that the electrical interlock is not sticking in closed position, manually exercise it at least once a week.

Control Cables. The following paragraphs delineate maintenance instructions for control cables on those tubes equipped with ORDALT 3069.

For cable equipment located within the torpedo tube, inspection should be made just prior to torpedo firing exercise to determine evidence of damage as follows:

(1) Bent contact pins, male or female

(2) Cracked, burned, or otherwise defective inserts

(3) Missing or mislocated orientation lugs or pins

(4) Damaged "O"-ring seals

(5) Corroded mating surfaces of connector plugs or receptacles

(6) Salt crystal deposits or excessive amount of grease or other foreign matter that cannot be removed by cleaning.

If parts are found to be damaged, immediate replacement of the entire assembly should be made. If grease or other foreign matter is present, the connectors should be wiped clean of grease, then brushed with a stiff bristle brush and blown out with dry air. (NOTE: The use of cleaning fluids or detergents of any kind is NOT recommended.) After thorough cleaning, a very thin coat of grease (MIL–L–7711) should be applied to the external mating surface of the "A"-cable plugs and the "O"-ring seals. Extreme care should be taken to assure that no grease is deposited on the contact pins, male or female, or on the face of the connector inserts. (NOTE: Foreign matter between contacts or between outer contacts and housing can provide an electrical path to ground resulting in signal failure and possible permanent damage.) Inspection, cleaning and lubrication should be added to the ordnance check-off list for submarine shipboard maintenance and routine upkeep on a weekly basis. This includes all Torpedo Control Cables Mark 1, torpedo tube door receptacles and torpedo receptacles whether in stowage racks or in the tubes.

Further information is contained in NAVORDINST 8510.68 and NAVORDINST 8510.75.

Chapter 20

CORRECTIVE MAINTENANCE

The following charts list possible malfunctions of the tubes that might be encountered during operation and corrective maintenance procedure to overcome these malfunctions.

DETAILED TROUBLE ANALYSIS

MECHANICAL SETTING TUBES ONLY

TUBE FAILS TO FIRE

CAUSE	CORRECTION
1. No Service Air.	1. Return tube to "ready to fire" condition and turn on service air.
2. Firing interlock lever not set in "TUBE READY TO FIRE" position.	2. Release the hand firing lever, permitting the stop cylinder valve to close. When the stop cylinder piston has returned to the "normal" position, lock the interlock lever in the "TUBE READY TO FIRE" position. If the interlock lever does not latch into the "READY TO FIRE" position, check all the other interlocking mechanisms to ascertain that they are in position for firing.

CAUTION: Do not attempt to move the firing interlock lever while there is air pressure in the stop cylinder, as immediate firing may result.

3. No pressure in air flask.	3. Charge the air flask to the required pressure and check for causes of loss of pressure in the air flask.
4. Firing Circuit broken.	4. The tube may be fired by hand. As soon as possible, check the continuity of the firing circuit and repair as necessary.
5. Stop rod seized.	5. Loosen bulkhead stuffing box gland nut.
6. Pilot valve does not open.	6. Disassemble stop cylinder and clean or repair pilot valve as necessary. Check movement of shutter bar and travel of stop piston.
7. Tail stop forcing torpedo against stop bolt when breech door is closed.	7. Open breech door and back off tail stop. Follow instructions in chapter 17 for adjusting tail stop.
8. Gyro spindle bent because tail stop was not in position to secure torpedo.	8. Remove gyro setting spindle from tube, withdraw torpedo and set gyro on 0° or 180° as prescribed. Install repaired or new gyro spindle. Reload torpedo. Ascertain that tail stop is in correct position before inserting gyro spindle in torpedo.

Sluggish Firing Action

CAUSE	CORRECTION
1. Binding of stop shafting.	1. Lubricate the bearings. Loosen bulkhead stuffing box.
2. Sluggish pilot valve operation.	2. Disassemble stop cylinder and clean or repair pilot valve as necessary.
3. Sluggish pilot valve operation.	3. Check stop rod spring. Adjust length as necessary.
4. Firing valve loading valve clogged.	4. Disassemble and clean loading valve. Lubricate lightly with grease and reassemble.
5. Stop bolt bent.	5. Disassemble and straighten or replace stop bolt.
6. Firing cup piston ring not sealing properly.	6. Disassemble firing valve and renew lifting cup ring. NOTE: Bleeding down of impulse air prior to firing valve action is symptomatic of item 6. Since this casualty is not obvious, the lifting cup piston ring should be replaced immediately in all cases where the cause of sluggish firing action is not readily apparent.

Stop Mechanism Fails to Return to "Battery"

CAUSE	CORRECTION
1. Binding of stop shafting.	1. Lubricate the bearings. Loosen bulkhead stuffing box.
2. Stop cylinder vent hole plugged.	2. Clear the vent hole in the stop cylinder head.
3. Stop bolt bent.	3. Disassemble and repair or replace stop bolt.
4. Stop mechanism return spring not properly adjusted.	4. Adjust spring.
5. Gyro retraction mechanism not properly adjusted.	5. Adjust mechanism.

Breech Door Cannot Be Locked

CAUSE	CORRECTION
1. Breech door not completely closed.	1. Check to see that there are no obstructions and push on the door handle until the locking ring is free to move.
2. Tail stop extended into tube and striking tail nut of the torpedo.	2. Retract the tail stop into the door recess to "full stop", so that it clears the tail nut of the torpedo.
3. Dirt or galling in locking ring threads.	3. Disassemble, clean the threads, remove galling. Lubricate thoroughly.

Muzzle Door Cannot Be Opened

CAUSE	CORRECTION
1. Tube drain valve open.	1. Close tube drain valve.
2. Interlocks not properly positioned or out of adjustment.	2. Check positioning of interlocks. If properly positioned, check adjustments.
3. Damage to torpedo on launching. (Muzzle door not opening fully.)	3. Check adjustment of muzzle door mechanism and shutter clearances.

Firing Interlock Lever Cannot Be Shifted To Firing Position

CAUSE	CORRECTION
1. Muzzle door closed.	1. Open the muzzle door.
2. Breech door not fully locked.	2. Complete the locking of the breech door.
3. Depth and speed setting spindles not retracted.	3. Retract depth and speed setting spindles to "OUT" position.
4. Muzzle door not fully open or interlock chain not properly adjusted.	4. Check position of muzzle door. Adjust interlock chain.
5. Firing solenoid or firing lever stuck in "FIRING" position.	5. Disassemble and correct cause of sticking.
6. Stop cylinder valve leaking or sticking open.	6. Disassemble and repair the stop cylinder valve.

Torpedo Fails To Start

CAUSE	CORRECTION
1. Tripping latch does not extend down into the tube sufficiently to engage the torpedo starting lever.	1. Adjust tripping latch to extend the prescribed distance into the tube, and check to determine if the mechanism is operating properly.
2. Tripping latch cam in "RIGGED FOR DEPTH CHARGE" position.	2. Make sure that the cam is in "NORMAL OPERATING POSITION" when firing mechanical-start torpedoes.

Poppet Valve Malfunction

CAUSE	CORRECTION
1. Poppet valve opens prematurely.	1. Readjust roller trip in accordance with instructions outlined in chapter 15.

DETAILED TROUBLE ANALYSIS
MECHANICAL AND ELECTRICAL SETTING TUBES

Tube Fails To Fire

CAUSE	CORRECTION
1. No Service Air.	1. Return tube to "READY TO FIRE" condition and turn on service air.
2. Anti-refire plunger is in "FIRED" position.	2. Adjust cams on interlock sleeve to return anti-refire plunger to "AT BATTERY" position when the interlock lever is moved to the "MUZZLE DOOR UNLOCKED" position.
3. No pressure in air flask.	3. Charge the air flask to required pressure and check for causes of loss of pressure in air flask.
4. Firing circuit broken.	4. The tube may be fired by hand. As soon as possible, check the continuity of the firing circuit and repair as necessary.
5. Stop rod seized.	5. Loosen bulkhead stuffing box gland nut.
6. Pilot valve does not open.	6. Disassemble stop cylinder and clean or repair pilot valve as necessary. Check movement of shutter bar.
7. Linkage from the firing solenoid or the hand firing lever assembly deformed, damage, or out of adjustment, preventing it from forcing the firing plunger of the torpedo stop cylinder valve inboard.	7. Repair or adjust the linkage so that it forces the firing plunger of the torpedo stop cylinder inboard to full stop when the solenoid or hand firing lever is actuated.
8. Tail stop forcing torpedo against stop bolt when breech door is closed.	8. Open breech door and back off tail stop. Follow instructions in chapter 17 for adjusting tail stop.
9. Gyro spindle bent because tail stop was not in position to secure torpedo.	9. Remove gyro setting spindle from tube, withdraw torpedo and set gyro on 0° or 180° as prescribed. Install repaired or new gyro spindle. Reload torpedo. Ascertain that tail stop is in correct position before inserting gyro spindle in torpedo.

Sluggish Firing Action

CAUSE	CORRECTION
1. Binding of stop shafting.	1. Lubricate the bearings. Loosen bulkhead stuffing box.
2. Sluggish pilot valve operation.	2. Disassemble stop cylinder and clean or repair pilot valve as necessary.
3. Sluggish pilot valve operation.	3. Check stop rod spring. Adjust length as necessary.
4. Firing valve loading valve clogged.	4. Disassemble and clean loading valve. Lubricate lightly with grease and reassemble.
5. Stop bolt bent.	5. Disassemble and straighten or replace stop bolt.

SLUGGISH FIRING ACTION—Continued

CAUSE	CORRECTION
6. Firing cup piston ring not sealing properly.	6. Disassemble firing valve and renew lifting cup ring. NOTE: Bleeding down of impulse air prior to firing valve action is symptomatic of item 6. Since this casualty is not obvious, the lifting cup piston ring should be replaced in all cases where the cause of sluggish firing action is not readily apparent.

STOP MECHANISM FAILS TO RETURN TO "NORMAL"

CAUSE	CORRECTION
1. Binding of stop shafting.	1. Lubricate the bearings. Loosen bulkhead stuffing box.
2. Stop bolt bent.	2. Disassemble and repair or replace stop bolt.
3. Firing plunger not manually returned to "AT BATTERY" position. (Poppet not used.)	3. Return firing plunger manually to "AT BATTERY" position.
4. Stop mechanism return spring not properly adjusted.	4. Adjust spring.
5. Gyro retraction mechanism not properly adjusted.	5. Adjust mechanism.

BREECH DOOR CANNOT BE LOCKED

CAUSE	CORRECTION
1. Breech door not completely closed.	1. Check to see that there are no obstructions and push on the door handle until locking ring is free to move.
2. Tail stop extended into tube and striking tail nut of the torpedo.	2. Retract the tail stop into the door recess to "FULL STOP," so that it clears the tail nut of the torpedo.
3. Dirt or galling in locking ring threads.	3. Disassemble, clean the threads, remove galling. Lubricate thoroughly.

Muzzle Door Cannot Be Opened

CAUSE	CORRECTION
1. Tube drain valve open.	1. Close tube drain valve.
2. Interlocks not properly positioned or out of adjustment.	2. Check positioning of interlocks. If properly positioned, check adjustments.
3. Damage to torpedo on launching. (Muzzle door not opening fully.)	3. Check adjustment of muzzle door mechanism and shutter clearances.

Firing Interlock Lever Cannot Be Shifted To Firing Position

CAUSE	CORRECTION
1. Muzzle door closed.	1. Open the muzzle door.
2. Breech door not fully locked.	2. Complete the locking of the breech door.
3. Depth and speed setting spindles not retracted.	3. Retract depth and speed setting spindles to "OUT" position.
4. Muzzle door not fully open or interlock chain not properly adjusted.	4. Check position of muzzle door. Adjust interlock chain.

Mechanical-Start Torpedo Fails To Start

CAUSE	CORRECTION
1. Tripping latch does not extend down into the tube sufficiently to engage the torpedo starting lever.	1. Adjust tripping latch to extend the prescribed distance into the tube, and check to determine if the mechanism is operating properly.
2. Tripping latch cam in "RIGGED FOR DEPTH CHARGE" position.	2. Make sure that the cam is in "NORMAL OPERATING POSITION" when firing mechanical-start torpedoes.

Electrical-Start Torpedo Fails To Start

CAUSE	CORRECTION
1. Firing circuit broken.	1. Check firing circuit, i.e. (a) Power on, (b) Fuses O. K. (c) Power available at U and AK at Breech Door Receptacle. (d) Ring Out "B" Cable if necessary. (e) Remove "A" Cable from torpedo and ring out. Replace defective component.

ELECTRICAL-START TORPEDO FAILS TO START—Continued

CAUSE	CORRECTION
2. Switch box not actuated sufficiently to make firing circuit contacts.	2. Check actuating linkage between stop rod and switch box and adjustment of actuating cam on stop rod. NOTE: This casualty occurs most frequently during "SILENT FIRE" and the proper adjustment of the actuating linkage should be checked periodically by silent firing tube, using Indicator Panel Mk 21.
3. Switch-Box deranged internally.	3. Remove switch box and replace. Return switch box to Tender for repair.
4. Tube previously had been flooded without blanking plug in breech door "A" Cable receptacle.	4. Replace blown fuses. Clean and dry Breech Door Receptacle. Be sure that either an "A" Cable plug or a protecting plug is securely latched into the breech door receptacle before flooding the tube.

TORPEDO RUNS IN TUBE (SILENT FIRE)

CAUSE	CORRECTION
1. Stop bolt not raised enough to clear guide stud.	1. Be sure that stop bolt is fully raised when silent firing 19-inch torpedoes.
2. Stop bolt clears forward guide stud, but torpedo hangs up on after guide stud.	2. Be sure to hold stop bolt in fully raised position until torpedo has cleared the tube.

POPPET VALVE MALFUNCTION

CAUSE	CORRECTION
1. Poppet valve opens prematurely, i.e. when Vent Closing Valve is cocked.	1. Readjust roller trip in accordance with instructions outlined in chapter 15.

APPENDIX

TORPEDO TUBE IMPULSE PRESSURES

1. Spindle-Type Firing Valve.

The impulse tank pressures for firing torpedoes which appear in figure 223 in chapter 17 are those which have been associated with optimum average torpedo performance during the firing of a large number of torpedoes, under closely controlled experimental conditions which covered a wide operating range. Special attention was paid to instrumentation, which was somewhat more elaborate than that ordinarily used in the performance of firing tests or trials by submarines. The greater portion of this work is recorded in "The Pilotfish Experiments in Torpedo Tube Adjustments and Torpedo Performance," published 1 May 1944 by Commander Submarines, Atlantic Fleet. Subsequently, additional work was done to extend the data to cover the higher submerged speeds of Guppy type of submarine.

The point of demarcation between High and Low speeds of own ship in the table cannot be definitely established upon the basis of existing experimental data, but there is indication that this point lies at about five knots.

Adherence to the prescribed values of impulse tank pressure will not guarantee a successful shot in all cases, because there are other factors (and undoubtedly some chance causes) which will prevent a passed and proved torpedo from running as intended. Among controllable factors may be listed:

Malfunction of firing valve (valve opens too rapidly) because of an inadequate charge of fresh water in the throttling cup. This results in an abnormally high tube pressure. The effect can be duplicated by blocking the automatic drain in the bottom of the firing-valve body, designed to contain a volume of cushioning air. If this firing-valve body then is allowed to fill with water (as by a leaking tube check valve), the cushioning effect is lost, and on the first surge of pressure as the firing valve opens, no matter how slowly, the tube pressure will approach the impulse tank pressure.

2. Sealed-Throttle Type Firing Valve. Malfunction of firing valve (valve opens too rapidly) resulting in abnormally high tube pressures. The following chart is a list of possible malfunctions that would cause excessive tube pressures.

Malfunction	*Correction*
1. Throttle cylinder not completely filled.	1. Refill with solution (80 percent water—20 percent glycerine by volume) to overflowing.
2. Orifice piston holes out of size.	2. Extrude the metal into the orifice holes until the tube pressures fall within the accepted range of 63±5 psi.
3. Orifice piston not reseating.	3. Remove cover of throttling unit and check flat springs and retaining rings. Replace if necessary.
4. Gasket leak.	4. Tighten set screws or replace copper gaskets if necessary.
5. "O" Ring on orifice piston damaged or deformed.	5. Replace "O" Ring.

Malfunction of firing valve (valve opens too slowly) resulting in tube pressures which are lower than normal. Disassemble the throttling unit and valve, clean all parts, reassemble, and refill to overflowing with clean, fresh, throttling fluid. If this procedure has no effect on tube pressures, enlarge the orifice holes until the desired tube pressure is reached.

3. Firing Valve Open Too Short a Time. This gives a slow launch, and in extreme cases will cause the torpedo to be driven back into the tube by static pressure after it has started to emerge from the tube.

Also, adherence to the prescribed pressures will not give uniform launching velocities at all depths, because other considerations have been rated more important (e. g. possible crushing of torpedo afterbodies, exceeding safe pressures in operating equip-

ment). These variations of velocity, however, (and also those occurring from shot to shot from chance causes), even though significant numerically, do not affect the Uy (U-sub-y) factor in the fire control problem as greatly as other chance variations during the torpedo run, which are considered uncontrollable.

In attempting to analyze the fundamental physical causes why particular impulse tank pressures appear to give the best launches under particular conditions, the following line of reasoning appears the best to correlate theory with experimental results:

There are two possibilities involved in the launching of torpedoes from submarines which will cause a mechanically sound torpedo to perform erratically. These are COLLISION with own ship and DERANGEMENT of the controlling mechanisms of the torpedo.

1. COLLISION is associated with bow-tube launching. There are no known cases of factually established collision involving stern tubes. Among bow tubes, collision has been most frequently associated with the two lowest tubes (in the conventional submarine, numbers 5 and 6). The hull configuration forward of these tubes is such that after clearing the tube a torpedo runs along in a sort of trough in the submarine's side for a distance which in some submarines is almost 15 feet. It is therefore possible to conceive that collision could be caused by firing during radical maneuver or pitching of the firing ship. However, an explanation considered more plausible is based on the attraction exerted upon each other by bodies moving in water on parallel courses and very close together.

This attraction is explainable upon the basis of Bernoulli's theorem to the effect that the energy of a hydraulic system remains constant. The system in our case is a zone of ocean-water at the launching depth. As the torpedo is ejected, skin-friction or drag tends to pull some water along with the torpedo, thus imparting some forward velocity to the water around its tail. This moving water then has kinetic energy, and since its total energy must remain constant, its pressure falls below that of the rest of the (still) water at the same depth. On the off side of the torpedo (the side away from the submarine), the adjacent still water, under higher pressure, immediately tends to equalize the lower pressure of the water moving with the tail of the torpedo. On the near side (towards the submarine), this cannot occur so rapidly because of the physical proximity of the submarine; therefore, an unbalanced force acts upon the off side of the torpedo and swings its tail toward the submarine.

As a practical matter, it appears that collision of torpedo with firing ship can be prevented by giving the torpedo sufficient launching velocity. However, launching velocity must be limited in accordance with conditions outlined in the succeeding paragraph.

2. DERANGEMENT of the depth control mechanism of the torpedo can occur at launching, due to fore-and-aft accelerations of the torpedo. Positive acceleration, i. e. speeding up, tends to swing the pendulum to the rear to cause down-rudder, with a dive on the part of the torpedo. Conversely, negative acceleration (slowing down) tends to swing the pendulum forward and thus to cause a broach. Since the depth mechanism controls are compounded of a pendulum (tending to stabilize attitude) and a hydrostat (tending to stabilize depth), the initial performance of a torpedo in depth is influenced by the three factors: Firing Depth, Set (running) Depth, and Fore-and-Aft Acceleration. Hence, it appears evident that, under the influence of a given POSITIVE acceleration during launching, a torpedo would be expected to take a longer dive if fired SHALLOW to run DEEP than if fired DEEP to run SHALLOW. Conversely, under the influence of a NEGATIVE acceleration at launching, a torpedo would be expected to pursue an erratically upward path longer if fired DEEP to run SHALLOW than if fired SHALLOW to run DEEP. These hypotheses appear to be confirmed by such experimental evidence as exists.

The practical effect of the foregoing is to indicate: (1) positive acceleration during the launching period should be restricted to the minimum compatible with other requirements (see paragraph 1); and (2) negative acceleration during the launch is to be avoided, and if this is not entirely possible, minimized.

Passing now to the causes of negative acceleration during the launching of a torpedo: The velocity which a torpedo has at any instant during its launch is compounded of (1) Firing Impulse, (2) Self-propulsive Effort, and (3) Own Ship's Speed. The effect of Firing Impulse alone would be to impart a relatively high velocity in a short time, reaching maximum velocity and starting to diminish before

the torpedo leaves the tube, and diminishing very rapidly thereafter. The effect of Self-propulsion Effort alone (assuming the propellers surrounded by solid water, which does not actually occur in normal firing until after the torpedo has cleared the tube) would be to start the torpedo slowly, to achieve a measurable period of maximum and practically constant acceleration, and finally to taper-off the acceleration as final running-speed is approached. Own Ship's Speed is, of course, directly additive to torpedo launching velocity for bow tubes and directly subtractive for stern tubes (it is for this reason that figure 223, chapter 17, prescribes different impulse tank pressures for bow and stern tubes except at low speeds of the firing ship).

It can be understood from considering the effects of the three impulses to which the torpedo is subject during launching, particularly those of the firing impulse and the self-propulsive effort, that these are capable, in combination, of producing wide variations of torpedo speed during the launching period, and of producing high and even rapidly-reversing accelerations.

The practical application of the foregoing, then, infers that impulse tank pressures should give the smoothest torpedo launching practicable. However, in establishing these pressures, account must be taken of the self-propulsive acceleration characteristics of different torpedoes (e. g. Torpedo Mark 14, although a faster, more powerful torpedo than Torpedo Mark 18 takes several times as long to come up to full power), and also of the fact that impulse pressures, below certain minima not definitely established, appear to increase the chance of collision of an air-fired torpedo with own ship, as discussed under paragraph 1. On the other hand, an impulse pressure which favors the smoothest obtainable launch of a certain type of torpedo may be unacceptable because it causes a bubble regardless of manipulation of the poppet valve.

One conclusion which may be drawn from the preceding information is that although certain theorizing can be done to rationalize and explain the behavior of torpedoes launched with various air impulse tank pressures, theory alone should not be relied upon in establishing these pressures for service use, but resort should be had to a considerable number of carefully instrumented experimental firings, such as those upon which the data in figure 223, chapter 17, are based.

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