MANUAL
OF
TORPEDO INSTRUCTIONS
AND
ELECTRIC LIGHTING.

Lieut Ch Lay RAN

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PART I.

WHITEHEAD TORPEDOES.

Patterns in Service.

There are four different patterns of Whitehead torpedoes in use in the Victorian navy, which are distinguished by the following names:—

R.L., Mark II.*—A torpedo manufactured at Woolwich.
Fiume, Mark IV.—A torpedo manufactured at Fiume.
Fiume, Mark V.—A torpedo manufactured at Fiume.
The 19-ft. Torpedo.—Two of which were manufactured at Woolwich and one at Fiume.

These torpedoes are all alike in principle, but vary slightly in manufacture and details.

General Description.

They may be all described as consisting of a steel cigar-shaped vessel, containing machinery for driving two screw propellers, actuated by compressed air stored in the torpedo. In the head a charge of gun-cotton, which is exploded on impact with any hard body.

Adjustments and Capabilities.

They can be adjusted to run for any distance within their prescribed range, to maintain any required depth (within certain limits) for the whole of their run, and to float or sink as required at the end of their run.

R.L. MARK II.*

The R.L. Mark II.* is divided into the following compartments, in the order named :—

The Head.
The Air Chamber.
The Balance Chamber.
The Engine-room.
The Buoyancy Chamber.
The Tail.

The Head.

The head is made of steel, $\frac{1}{16}$-inch thick, and contains the charge of wet gun-cotton hermetically sealed in a copper case. The practice and war heads are the same for this pattern of torpedo. In the fore end of the copper case is a recess to take the primer charge of dry gun-cotton, consisting of six 1 oz. discs, in a copper cylinder. The method of ignition is by means of a detonator, which consists of a small metal cylinder, containing 34 grains of fulminate of mercury. When the torpedo comes in contact with any hard substance, a striker, which is contained in the pistol (see page 16), is driven home against the detonator, thus exploding the detonator, which in its turn detonates the charge.

The after end of the head is closed by a watertight door, secured in its place by means of nuts, the head being secured to the fore end of the air chamber by means of a bayonet joint and four keep-screws.

The Air Chamber.

The air chamber is made of Whitworth's compressed steel, $\frac{5}{16}$-inch thick, the ends being screwed and sweated in with melting tin, and afterwards secured with rivets. It contains the compressed air which drives the engines. On the outside are placed the upper and lower vertical fins and side fins; also the side lugs, which are used when firing the torpedo from a carriage above water, they are of the old pattern, viz., $\frac{7}{8}$-inch wide in this torpedo and very short.

with a V thread
screwed

The Balance Chamber.

The balance chamber is secured permanently to the after end of the air chamber, and contains the mechanism for keeping the torpedo at the required depth; this adjustment being made at the bottom of the balance chamber by means of a spanner, which revolves a small wheel marked in feet, the required mark being brought in a line with a pointer. On the top is the air-escape valve, which allows the air to escape as the water enters, when the torpedo is set to sink. A plug, which, when removed, allows of the mechanism being worked by hand, and a brass screw which secures some of the internal parts. The after end is closed by means of a watertight door. In the door is the sinking valve, closed by a spiral spring, but which is opened by the sinking rod in the engine-room, when the torpedo is set to sink, and allows the water to flow into the balance chamber. In the bottom of the balance chamber is a drain screw, which on being removed allows any water which may have leaked in during exercise to drain out.

When the torpedo is being transported the drain screw is removed, a "long screw" with a projecting head being inserted in its place. The "long screw" secures the mechanism.

The Engine-room.

The engine-room, which forms the fore part of the buoyancy chamber, is secured to the after end of the balance chamber by means of screws. It contains the engines, which are of the three-cylinder Brotherhood type.

The reducing valve, which admits the air to the engines at a reduced pressure, thus allowing the torpedo to maintain a constant speed for the whole of its run.

The servo-motor, which is a small air engine, by means of which the motion of the mechanism of the balance chamber is communicated to the horizontal rudders.

The oil bottle, containing oil for lubricating the working parts. & also makes the reducer air tight

The valve box, through which the air is admitted to the air chamber when charging the torpedo, or to the reducing valve (from the air chamber) when running.

The air lever, which works the valves of the valve box.

The link, which works the air lever by means of the counter gear in the tail.

The sinking rod, which works the sinking valve.

The sinking lever (outside), by means of which the sinking rod is put in or out of gear. When the sinking lever is forward, the torpedo will float; to sink the torpedo the lever must be moved aft, and the cap of air-escape valve must be removed from the top of balance chamber.

The Buoyancy Chamber.

The buoyancy chamber and the engine-room are in one, the fore end of the former being closed by a watertight door. It contains nothing but three tubes, in which work the right wire, diving rod, and propeller shaft. The first connects the counter gear in tail with the link which works the air lever, and the second the servo-motor to the horizontal rudders.

The after end of the buoyancy chamber forms a steel cylinder, upon which the tail piece is screwed.

There is one drain screw in the bottom of the buoyancy chamber.

The Tail.

The tail contains—

The mitre wheels, by means of which opposite motion is given to the two propellers.

The propellers.

The counter, by means of which the air is shut off from the engines when the torpedo has run its set distance, the action being as follows:—To the main shaft is attached a worm wheel, into this gears a small toothed wheel so that as the shaft revolves this small wheel also revolves; on the spindle of the small wheel is a cam, which takes in the teeth of a large toothed wheel, moving the large wheel forward one tooth for every revolution of the small wheel. In the tail is a strong spring, compressed by means of a special spanner, and kept in compression by a trigger, the upper end of which passes through the shell of the torpedo. On the large wheel of the counter is a stud, and as the large wheel revolves (due to the revolution of the shaft) this stud approaches the trigger until at last it bears down on the upper end, raises the toe, and the spring is released. The right wire is in connexion with the spring, and when the spring is released the right wire is drawn aft, thus working the link and air lever, and closing the supply of air. Knowing the distance the torpedo will run for every revolution of the small wheel of counter, or, in other words, for every tooth of the large wheel, it is easy to adjust the large wheel so that the stud will just bear on the trigger when the torpedo has run its required distance.

In cocking the tail and setting the counter for range, always ascertain—(1) that the cam on small wheels is clear of teeth on large wheel; if it is engaged, turn the propellers by hand until clear. (2) That the stud is not bearing on the trigger; if it is, turn the large wheel backwards until clear.

The horizontal rudders are contained in the tail frame, fixed before the propellers, and are connected by one crank-head, to which is attached the diving rod. The upper and lower vertical fins of the tail piece contain the vertical rudders. These are capable of adjustment either way, to give port or starboard helm to the torpedo as required.

Particulars of R.L. Mark II.*

Particulars.

This torpedo can be used from the dropping gear only.
Length—14ft. 7in.
Speed—19 knots.
Number of yards per tooth of counter—40.
Pressure—Exercise, 750 lbs. Action, 1,000 lbs.
Weight of dry gun-cotton—34 lbs.
Weight complete, with air, &c.—575 lbs.
Type of slide valve—Rotatory.
Type of controlling gear—Depth.
Reducing valve—Three rows of ports.
Reduction of air per tooth—60 lbs.
Capacity of air chamber—5·25 cubic feet.
Horse power—12·5.
Number of revolutions—750.
Pressure—Engines work at 330 lbs.
Buoyancy, fully charged—Nil.
Weight of head complete without pistol—80 lbs.
Weight of air at 1,000 lbs. pressure—26 lbs.

Lead of Air.

The lead of air is as follows :—

1. When charging.—The air lever being forward, through charging nozzle and valve box direct to air chamber.

2. When running.—The air lever being aft, from air chamber through valve box. From valve box there are two leads, the first to the oil bottle, the object being to drive the oil down into the working parts; the second to the reducing valve, and through it to reduced pressure reservoir. From reduced pressure reservoir there are two leads; the first through rotatory slide valve to each cylinder in turn, exhausting through main shaft; the second is to the servo-motor.

THE MARK IV. FIUME TORPEDO.

The position of the compartments is the same as in the Mark II.* R.L.

The Head.

The head is bluffer, contains a larger charge, and is secured to the fore end of the air chamber by means of a bayonet joint and four diagonal screws. A copper war head is supplied for each torpedo, with the charge permanently stowed in it. A proportion of steel heads with a dummy wooden charge being supplied for exercise.

The Air Chamber.

The air chamber is similar to that already described.

The side legs are $\frac{7}{8}$-inch wide, but longer than the R.L. II.*

The Balance Chamber.

The balance chamber is similar in construction, except that the air inlet and stop valve is in this compartment. This valve is so constructed that when charging the torpedo the air passes through it direct to the air chamber, and when charged the valve can be screwed down by means of a spanner, thus preventing any leakage when making a passage. The adjustment for depth is made from the top instead of the bottom. There is no air-escape valve. The balance chamber is fitted with one drain screw.

The Engine-room.

The arrangement of the engine-room is slightly different to that of the R.L., the engines themselves being the same in principle, but each cylinder has a separate slide valve.

The reducing valve is the same in principle, but of different construction, there being two springs in extension, the adjustment being made from the side of the engine-room.

The servo-motor and oil bottle are nearly the same as in the R.L., with the exception that when the slide rod of the former is central—relative to the piston—the supply of air is cut off, thus preventing waste from leakage.

The oil bottle is a good deal larger, and is situated on the after side of buoyancy chamber door.

The counter gear is entirely of a different pattern, and is placed in the engine-room, being worked directly from the engines, and is adjusted from the outside of engine-room. The spring pawl, which is also worked from outside engine-room, must be always left at "Out," except when torpedo is actually ready for service.

The arrangement for sinking the torpedo is the same, except that sinking valve is in buoyancy chamber door, and there is no air-escape valve.

Buoyancy Chamber.

The buoyancy chamber is similar to that in the R.L., except that the fore end is closed by a removable bulkhead, and there are only two tubes in it—one for the screw-shaft, the other for the diving rod. (The counter being in the engine-room, the right wire is not required.) The chamber is strengthened by steel rings inside, and contains ballast for keeping the torpedo upright.

The air lever is in a recess on the top of the buoyancy chamber, and actuates the starting valve by a long connecting rod. The air lever is fitted with a "water-tripper," the action being that when the torpedo is discharged with a high velocity from above water, the air lever is not thrown back until the water strikes the water-tripper, thus preventing the engines racing in the air. When firing from dropping gear, the torpedo is so close to the water that the ordinary tripper is always used. The air lever being thrown aft draws back the long rod, thus opening the starting valve and admitting air to the engines. When the air lever is thrown back, it falls clear of, and disengages itself from, the connecting rod, so that when the torpedo has run its distance, and the counter works, it has only to draw forward the long rod, and thus close the starting valve. If it were not for this fitting the air lever and water-tripper would have to be drawn forward against the full pressure of the water.

In adjusting this torpedo for running, care must be taken to see that the air lever has engaged the long rod. Several "lost shots" have occurred through neglect of this precaution.

The Tail.

The tail is of different construction, the propellers being inside the tail frame and before the horizontal rudders. The vertical rudders are fixed above and below each horizontal side fin. An oil screw is at fore end of tail frame. This must be removed when oiling mitre wheels, and replaced when oil bottle is full. The general construction of this torpedo is weaker than the R.L., so that special care is necessary in handling it, especially at the tail frame, which is easily bent, and thus spoils the running.

Particulars of Fiume Mark IV.

Particulars.

This torpedo is fitted with a water-tripper and used from the dropping gear and the *Countess of Hopetoun's* tubes, but the side lugs must be reduced to ½ an inch, the vertical fin on air chamber removed, and, if required for the after tubes, a steel air lever substituted in place of the phosphor bronze one, and the water-tripper removed. When the end of the connecting rod is connected to the air lever the point of it must be close down on to the shell of the torpedo.

Length—14ft. 9in.

Speed—23·5 knots.

Number of yards per tooth—60.

Pressure in air chamber—Exercise, 750 lbs. Action, 1,050 lbs.

Pressure—Engines work at 410 lbs.

Reduction of air per tooth—75 lbs.

Type of reducing valve—Four rows of ports, springs in extension.

Type of slide valves—Three slides—each with relief valve.
Weight complete, with air—660 lbs.
Type of controlling gear—Distance.
Capacity of air chamber—5·2 cubic feet.
Horse power—20.
Number of revolutions—790.
Buoyancy, fully charged—2 lbs.
Weight of dry gun-cotton—58 lbs.
Weight of air at 1,050 lbs. pressure—26¼ lbs.
Weight of war head complete, without pistol or Holmes' light—114·4 lbs.
Weight of dummy complete, without pistol or Holmes' light—112·4 lbs.

Lead of Air.

The lead of air is as follows :—

1. When charging.—Through "charging and stop valve" to air chamber.

2. When running.—From air chamber through stop valve and starting valve (when air lever is thrown back), and from here branches (*a*) to oil bottle, and (*b*) reducing valve. There is no reduced pressure reservoir, the air after passing through reducing valve goes directly to each slide valve in turn, by an annular space round engine casting, the air passage to servo-motor being formed in the casting of the valve itself. An auxiliary valve is fitted, which can be worked by No. 26 box spanner from outside the torpedo, by means of which a small supply of air can be admitted to engines or servo-motor without working the air lever, the object being to save the counter gear, which is of rather delicate construction, the "spring pawl" having been frequently broken by careless handling. The air lever must never be thrown forward when the spring pawl is at "In."

THE MARK V. FIUME.

PARTICULARS.

This torpedo is almost identical with Mark IV., but is manufactured of phosphor bronze (with the exception of the air chamber), this metal being less liable to rust. The buoyancy chamber has a finer run, thus giving increased speed to the torpedo, and the air lever and "water-tripper" are placed outside the engine-room. The side lugs are $\frac{1}{2}$-inch wide and longer, *i.e.*, the same as the new pattern adopted in the home service.

The auxiliary valve fitted in the Mark IV. is here omitted, consequently, to work the engines slowly, the air-inlet plug must be removed, the stop-valve spanner screwed hard down, and the air lever thrown back, then, by opening the stop valve gradually, air is admitted slowly to the engines, servo-motor, &c.

The tail of this torpedo is very easily damaged, and great care is required in handling it, and therefore is only used from the dropping gear. It is not suitable for exercise.

THE 19-FT. TORPEDO.

There are three of these torpedoes in the service. Two having been manufactured at Woolwich and the other at Fiume. As its name implies, it is 19 feet long, and greatest diameter 15 inches. The principles of construction are the same as in any 14-inch torpedo, but the arrangement of the parts is different. The head contains the charge of 74 lbs. of dry gun-cotton, contained in a copper case.

Next to the head comes the balance chamber, the mechanism of which is the same as in the 14-inch, but to adjust this torpedo for any required depth the head must be removed, being replaced when the adjustment is made. Next to the balance chamber is the air chamber, which has one tube in it, through which runs a rod connecting the mechanism of the balance chamber to the servo-motor. The engine-room is secured to the after end of the air chamber by vertical screws, and is much the same as in the R.L. torpedo, except that each cylinder has a separate slide valve. The reducing valve and servo-motor are also similar to those fitted in R.L. The valve box is the same in principle, but the air lever, instead of being worked by a triangular link, is worked by an ordinary bell crank, to which is also connected the sinking rod, the whole being worked by the stopping gear in the tail.

The buoyancy chamber contains four tubes—one for main shaft, one for diving rod, one for right wire (which connects counter gear with bell crank), and the fourth is for the left wire, which connects counter gear with servo-motor slide; by this arrangement the servo-motor slide can be held in any position for the first 70 yards of the run. By adjusting the slide in certain positions, "up" or "down" helm may be given to the torpedo for this distance. Supposing it is required to free the rudders after the torpedo has run 40 yards, an adjustment is made at the counter by which the left wire is drawn back at this distance, this frees the servo-motor slide, and the mechanism of balance chamber comes into play in the ordinary way.

The arrangement of the tail is similar to that of the R.L., with the exception that the horizontal rudders are abaft the propellers, the propellers being inside the tail frame, as in the Fiume torpedoes.

Particulars of 19-Ft.

These torpedoes are fitted with water-trippers and used from ~~stem tubes of~~ *Childers'* ~~or her~~ dropping gear; a ~~vertical fin must be attached on top of air chamber when used from the latter~~.

Length—19 feet.
Speed—23·5 knots.
Number of yards per tooth—90.
Pressure in air chamber—Exercise, 750 lbs. Action, 1,050 lbs.
Weight of dry gun-cotton—74 lbs.
Weight complete—900 lbs.
Type of slide valve—Three slides.
Type of controlling gear—Distance.
Reducing valve—Three rows of ports.
Reduction of air per tooth—80 lbs.
Capacity of air chamber—7·6 cubic feet.
Pressure—Engine works at 325 lbs.
Buoyancy, fully charged—5 lbs.
Average weight of head complete without pistol or Holmes' light holder—116 lbs.
60
Weight of air at 1,050 lbs. pressure—38·4 lbs.

THE PISTOL.

The method of igniting the charge in all these torpedoes is by means of an arrangement which screws into the head, called a pistol. It consists principally of a striker contained in a cylinder. To the striker are attached whiskers, so that in case of the torpedo striking obliquely it will still be driven home. There are three safety arrangements to prevent premature explosions.

1. The safety pin, which is of steel, passes through a hole in the outer end of the striker and close in contact with the body of the pistol, so preventing the striker being driven home accidentally. This pin must be removed before the torpedo is discharged.

2. A fan which screws on to the outer end of the striker (which is threaded for this purpose), close up to the body of pistol. When the torpedo is discharged, the pressure of water—as the torpedo goes ahead—causes the fan to revolve, thus unscrewing it until the fan has run off the threaded portion. This occurs when the torpedo has travelled 28 yards. A small stud is screwed into pistol body, to prevent the fan from being screwed hard up and jamming.

3. A copper shearing pin which screws down through pistol body into the striker. This pin is sheared when the torpedo strikes a hard object, but prevents an explosion on torpedo passing through sea-weed, &c.

Before the pistol is fitted for service, the following points should be attended to. The striker should be half-an-inch inside cylinder when fan is screwed up and safety-pin in position, and should protrude half-an-inch when — safety-pin having been removed and fan unscrewed—the striker is driven home. The fan should work freely, and shearing pin must be screwed in. The dry primers are stowed in copper cylinders containing six 1 oz. discs of dry gun-cotton. One end of the cylinder is fitted to screw on to the pistol, and has a recess in it to receive the detonator, consisting of 34 grains of fulminate of mercury These detonators are stowed [illegible]etween slabs of cork in tin cylinders. These cylinders must [illegible]t on any account be stowed in the magazine.

PRECAUTIONS BEFORE FIRING TORPEDOES.

1. After the torpedo is charged, see that horizontal rudders are adjusted, and worked by moving mechanism of balance chamber.
2. That the tail is cocked (if using R.L.), counter set for three teeth, and engines run slowly in air, to see that the counter, tail-spring, and engines are in working order.
3. That the pistol or Holmes' light socket is screwed firmly on to a well-fitting washer, that the fan is screwed back against the stop and works freely, and that shearing pin is in position.
4. That the sinking lever is in proper position.
5. If time permits, that the torpedo is sunk to a depth of 20 feet for five minutes, examined, and tested for buoyancy.
6. That the drain screws are in.

AIR-COMPRESSING PUMPS.

The air-compressing pumps employed in the service are the Admiralty and Brotherhood's improved pump.

Description of Pump.	Where placed.	Time in minutes to pump 10 c. ft. to 1,500 lbs.	Steam pressure required, in lbs.	Capacity of reservoirs, in c. ft.	Charging Columns.	Separator Columns.
Admiralty pattern Small size, 1	Depôt ..	75	60	16 c. ft.	1	1
Ditto 1	*Fawkner* ..	75	60	8 c. ft.	..	1
Brotherhood's improved, 2	*The Countess of Hopetoun*	60	60	none fitted	..	2
Ditto 1 ..	*Childers* ..	60	60	4 c. ft.	1	1
The two firing reservoirs are 2 c. ft. each in addition to the 4 c. ft.						
Ditto 1 ..	Swan Island ..	60	60	32 c. ft.	3	1

The Admiralty Pump

Consists of four cylinders or barrels of different diameters. A plunger works in each, the plungers being all driven from the same shaft. The diameters of the barrels are—No. 1, 6 in.; No. 2, 3 in.; No. 3, $2\frac{3}{8}$ in.; No. 4, $1\frac{1}{2}$ in. The crank shaft works at 200 revolutions per minute, the air being sucked down into large barrel on down stroke of plunger through a non-return valve, and is forced into the second on up stroke, and so on until it reaches the fourth barrel, where it is driven through a convolution of copper piping in a water tank, the water in tank keeping the air cool. The pump will charge a reservoir of 10 cubic feet to a pressure of 1,500 lbs in 75 minutes.

Brotherhood's Pump

Is supplied to the *Childers* and Swan Island Depôt. The air goes through three compressions, one plunger only being used, which is of smaller diameter than the barrel, but is fitted with a collar fitting the barrel exactly. On the first down stroke air is sucked down into the barrel; on the up stroke it is forced into an annular space between plunger and barrel, through non-return valves in the plunger itself. On the second down stroke it is forced into a small chamber at the side of the barrel, and so into the convolution of piping in water tank, and thence to separator column.

This compressor works at 350 revolutions, being driven by an engine of 15-horse power. The compressor is tested to a pressure of 2,240lbs. per square inch, and will charge a reservoir of 10 cubic feet to a pressure of 1,500 lbs. in 60 minutes. The weight of the whole apparatus is 5 cwt.

In both pumps an arrangement is fitted by which a small amount of water and oil is made to pass through the internal parts with the air, thus lubricating them and keeping them cool. Also a pump worked from the shaft, which keeps up a circulation of cold water round the copper piping in the tank.

Separator and Charging Column.

In both cases the air, after leaving the copper piping, passes, by means of an ordinary stop valve, into the separator column, which consists of a steel tube $\frac{3}{16}$-inch thick, 5 feet long, and 2[illegible] inches internal diameter, the ends being closed by metal caps. The upper cap has two pipes in it. The pipe by which the air enters is continued down for a distance of 18 inches; the other one by which the air leaves is fitted with a non-return valve, and leads to the charging column. In the base of the separator column is a drain valve; when the air and oily water enter the separator, the water falls to the bottom and is blown out when the valve is opened, the dry air passing on to the charging column. The charging column is much the same in construction as the separator, being fitted with an inlet and outlet valve, and drain valve at bottom. Both columns are fitted with pressure gauges, each gauge being fitted with a stop and exhaust valve, by means of which the gauge can be tested. The stop valve shuts off the air from the column, and on opening the exhaust the indicator should return to zero. On closing the exhaust and opening the stop valve, the gauge should register the same pressure as it did before testing. The gauges must always be tested after charging a torpedo.

The reservoirs consist of a number of steel tubes of the same shape and size as the separator column, connected together by copper piping, each tube having a capacity of $\frac{1}{5}$th of a cubic foot. They are arranged in suitable frames, the lower tube being fitted with a drain cock. The air may be pumped either into the reservoirs and from there admitted through charging column to the torpedo, or, in case of necessity, it is possible to "pump direct" from the pumps through charging column to torpedo.

To Charge a Torpedo.

Test the gauge and drain the column.

Remove air-inlet plug, and screw in charging nozzle. The charging pipe is screwed on to this, the other end of charging pipe being screwed on to outlet valve on charging column. See that gauge stop valve is open, then open outlet valve. Then give the order—"Charge torpedo," and the man stationed at inlet valve from reservoirs opens it slowly, watching the gauge; when gauge indicates required pressure, the inlet valve is closed. The pressure on the gauge then shows the pressure in the torpedo. Close the outlet valve and test the gauge. The charging pipe is slowly unscrewed from nozzle so as to allow the air in the pipe to escape, the nozzle is unscrewed, and air-inlet plug replaced. Air pipes are to be blown through before use and good washers put in. Great care must be taken that the proper pattern charging nozzle for the mark of torpedo is used.

THE CONTROLLING GEAR.

The controlling gear varies in the different patterns of torpedoes. In the R.L. it is in the balance chamber, and the rudders are held in the required position until the torpedo has reached its set depth.

The amount of "up" or "down" helm required varies with the speed of the boat and type of torpedo, and can only be estimated by actual experience.

In the Mark IV. Fiume the rudders commence to release at 95 and clear at 115 yards if set for the full distance, but can be adjusted for any distance up to 95 yards.

Mark V. Fiume torpedoes can only be locked for 3 teeth, *i.e.*, for 30 yards and under.

The 19-ft. 15″ torpedo commences to release at 45 yards and clears at 90 yards if set for the full distance, but can be adjusted for any distance within the limit of 90 yards.

In the R.L. II.* the actual helm given due to the controlling gear is a fixed amount, whilst in the Mark IV. and V. Fiume and 19-ft. 15″ torpedoes the helm given due to the controlling gear can be varied within certain limits.

The Holmes' light, which is used when running torpedoes for exercise, consists of a hermetically sealed tin cylinder, shaped like a pistol, containing phosphide of calcium. Before discharging the torpedo, the strips must be torn off which expose the holes by which the water can enter. The action of the water on the chemical preparation produces a bright flame, with white smoke, by means of which the position of the torpedo at the end of its run is clearly indicated. The light will continue to burn for half an hour.

Adjustment of Controlling Gear.

Torpedo.	Speed of Boat.	Gear Fired from, and what Boat.	How Locked.	Distance Locked for.	Impulse Used.
R.L. II.*	0 up to 6 knots	Dropping gear, any boat	Rudders up	Releases at depth	Nil
,, ...	6 knots and up	,, ,,	Rudders down	,, ,,	,,
Mks. IV. & V. Fiume and 19-ft. 15″	0 up to 6 knots	,, ,,	1–16 up	20 to 35 yards	,,
,, ...	6 up to 12 knots	,, ,,	Horizontal	,, ,,	,,
,, ...	12 knots and up	,, ,,	1-16 down	,, ,,	,,
19-ft. 15″ ..	~~0 up to 6 knots~~	~~Stem tube~~	~~$\frac{1}{8}$ up~~	~~25 to 30 yards~~	$2\frac{1}{2}$ ats.
,, ...	~~6 up to 12 knots~~	,, ...	~~Horizontal~~	~~15 to 20 yards~~	,,
,, ...	~~12 knots and up~~	,, ...	~~$\frac{1}{4}$ down~~	~~30 to 45 yards~~	,,

NOTE.—15 lbs. per sq. inch equals one atmosphere.

ADJUSTMENT OF CONTROLLING GEAR.

Torpedo.	Speed of Boat.	Gear Fired from, Training of, and what Boat.	How Locked.	Distance Locked for.	Impulse Used.
Mark IV. Fiume	0 up to 5 knots	Stem tube	$\frac{1}{8}$ up	30 yards	4 ozs.
	5 to 12 knots	*The Countess of Hope-*	$\frac{1}{8}$ down	,,	
	12 knots and up	*toun.*	$\frac{1}{4}$ down	,,	4 ozs.
,, ,,	0 up to 5 knots	30° before to 10° abaft	Horizontal	,,	4 ozs.
	5 to 12 knots	,, ,,	$\frac{1}{8}$ down	,,	$4\frac{1}{2}$ ozs.
	12 knots and up	,, ,,	$\frac{1}{4}$ down	,,	,,
,, ,,	0 up to 5 knots	10° abaft to 35° abaft	$\frac{1}{8}$ down	,,	,,
	5 to 12 knots	,, ,,	,,	,,	,,
	12 knots and up	,, ,,	Horizontal	,,	,,

NOTE.—All data for adjustment of controlling gear is only approximate, and must be varied according to circumstances; sudden change of training does not necessarily entail altering the adjustment of the controlling gear, as long as there is sufficient depth of water, and will also insure the torpedo not coming to the surface.

Average Deflection.

The Countess of Hopetoun's revolving tubes—

From 20° to 30° before, allow 1° per knot.

From abeam to 20° before to 10° abaft, allow $\frac{3}{4}$° per knot.

From 10° abaft to 35° abaft, allow $\frac{1}{2}$° per knot.

Amount per knot varies with speed.

DEFLECTIONS

Allowed in *Childers* and second-class boats.

With dropping gear in the foremost position, as in the *Childers*, allow 3° on the director towards the torpedo to be fired for all speeds above 6 knots.

With the dropping gear in the after position on board *Childers* and in second-class boats allow 3° on the director away from the torpedo to be fired for all speeds above 6 knots.

DRILL FOR TORPEDO BOATS WITH MARKS IV. AND V. FIUME TORPEDOES FOR DROPPING GEAR.

The crew will consist of 2 men.

At the order—

Action. —Yards Range, —Feet Deep.	1 provides wrench for air inlet plug, stop valve key, spanner for depth pointed pin, small screwdriver for range, charging pipe nozzle and spanners, spanner for reducing valve No. 26; 2, screwdriver, oil feeder, spanner for pistol or Holmes' light, charging pipes, nose and tail lines. 1 then orders "Oil torpedo." 1 lifts vertical fin clutch, and the torpedo is launched back until the air inlet plug is clear of tongs and turned on one side; 1 turns propellers ahead; 2 oils torpedo; and 1 on clips. 1 then orders "Charge torpedo." 1 removes air inlet plug, sees stop valve open, screws in charging nozzle, and, assisted by 2, connects charging pipes and charges the torpedo; 2 attends charging column;

1 then adjusts for range, depth and reducing valve. When the torpedo is charged, 2 disconnects the charging pipe from nozzle; 1 removes nozzle and replaces air inlet plug; 1 adjusts controlling gear and sees it engaged; 2 fits and screws in pistol or Holmes' light; 1 orders "Launch forward;" 2 launches forward; 1 keys down vertical fin clutch, sees sinking lever in its place, spring pawl engaged, engages air lever and air lever tripper; 2 inserts blowing charge, closes blowing box door.

NOTE.—Care must be taken to see that no cardboard discs from previous blowing charges are left in blowing box.

PRELIMINARY DRILL.

TRIM TORPEDOES. —(*First or Second Position.*)	1 mans after winch handle, and removes davit-securing pin; 2 mans foremost winch handle and removes davit-securing pin. When out, 1 orders "Well," 1 and 2 screw in securing pins, down pawls; 2 inserts gun points.
READY. —(*Port or Starboard foremost or after Torpedo.*)	1 off clips; 2 take out air lever, firing bar, and pistol safety pins, giving them to 1, who then attends the firing gear, plugging up for torpedo ordered, and turns the catch to fire; 2 attending firing lever.
FIRE.	1 presses key and returns the catch to "safe" if a missfire occurs; 2 pulls the lever.

IF ARMED WITH R.L. II.* TORPEDOES.

The same, except 1 provides wrench for air-inlet plug, spanner for depth, cocking tail, reducing valve and charging pipe nozzle; 2 provides pin-screw driver, ordinary screwdriver, oil feeder, spanner for pistol or Holmes' light holder, nose and tail lines and charging pipes.

The torpedoes will be charged in the following order:—Starboard after, port after, starboard foremost, port foremost.

PICKING UP TORPEDOES.

At the order "Recover torpedo"—

Nos. 1 and 2 of opposite crew tend nose and tail lines or recovering hooks.

No. 1 at the tail; No. 2 at the nose.

No. 1 of crew keys up fin clutch, raises tripper, and removes after cotter key; then places tongs in position and puts in firing-bar safety pin.

No. 2 removes foremost cotter key and tends foremost winch handle, working under direction of No. 1.

Nos. 1 and 2 then trim torpedo into first position, and put securing pin in.

No. 1 then puts counter spring pawl to "Out," and blows through.

No. 2 off nose line, breaks off Holmes' light and takes out drain screws.

When torpedo is drained, he replaces them and reports "Drain screws in."

No. 1 then orders "Launch in," and keys down vertical fin clutch.

At the order "Secure," 1 on clips.

Nos. 1 and 2 out securing pins, trim torpedo into securing position, and ease springs.

DRILL FOR REVOLVING TUBES

IN 136-FT. TORPEDO BOAT, USING MARK IV. FIUME TORPEDOES.

CREW. The crew for the efficient working of the tubes consists of 4 men, who are to fall in by the rear part of tubes, 1 and 3 Starboard side, 2 and 4 the Port.

The discharging tubes are mounted as a pair round the after conning tower.

ACTION.—YARDS RANGE.—FEET DEEP—TRAINING.	At this order all numbers down rails and clear away on deck, 1 and 3 the Starboard side, 2 and 4 the Port; the numbers then clear away securing chain, 1 and 2 the after chains, 3 and 4 the foremost.

No. 1 then orders "Loading Position," naming the side required; 1 attends the stop; 4 the training winch; and, when in position, 1 orders "Stop;" 2 and 3 ship loading trough.

The Nos. then provide tools and gear as follows :—

1. Charging nozzle and spanners, wrench for air inlet plug, stop-valve key, spanner for depth, pointed pin, small screwdriver for range, and then ships the director.
2. Screwdriver, oil feeder, spanner for reducer, and oil screw in tail and cartridges.
3. Charging pipes, strop, rammer, nose and tail lines, and recovering hooks.
4. Spanner for screwing in pistol, and see everything ready below for fitting pistol (if for exercise), spanner for Holmes' light holder, and a screwdriver.

No. 1 then orders "Launch Back;" 1 and 2 open the door; 1 on clips and attaches the tail line; 2 attends the stop; 3 supplies the tail line; 4 pushes on torpedo from after end of tube; 1 and 3 man the tail line; and the torpedo is launched back on the trough and charged and adjusted under the direction of 1 in the usual manner, special care being taken to see the controlling gear properly adjusted, and the tripper correct.

When all the adjustments are made, 1 orders "Launch In," 2 attends the stop, 3 the rammer, and 4 the tail line; and when the nose of the torpedo has entered the tube, 1 orders "Well," and takes out pistol safety-pin (giving it to the officer in charge) as soon as the side lugs reach the door. 1 sees the torpedo square in the tube, and when the swell of the torpedo has passed the rear stop, 1 gives the order "In Stop"; and when the torpedo is against the stop, No. 1 orders "Well," and removes the tail line and clips, 1 and 2 close the door, 2 inserts the cartridge and joins up handholder.

No. 1 then orders "Loading Position" (opposite side), and the numbers perform the same duties as before.

No. 1 then orders "Fighting Position," and the tubes are trained as previously ordered, under the direction of 1, 4 at the training winch, 2 and 3 attending on deck to see everything clear, and assisting to train the tubes.

PREPARE STEM-TUBE TORPEDO.	The torpedo for the stem tube is then prepared in a similar manner.
READY.	1 and 4 attend at the after tubes; 1 the director, 4 the training winch; 2 and 3 at the stem tube; 2 opens bow cap; 3 opens director, scuttles and sees all clear ahead.
STAND BY.	1 removes safety-catches from firing levers; 3 removes safety-pin from firing bar.
	NOTE.—Stem-tube director is attended by the man at the wheel.
FIRE.	The torpedoes are fired; safety-pins replaced; 2 closes bow cap; and crews await next order.
MISSFIRES.	Should a missfire occur, safety-catches and pins are replaced by 1 or 3, handholders removed by 2 or 4, cartridge chamber cleared out by 2 or 4, and a new cartridge inserted.
CEASE FIRING.	Tube at the ready; safety-catches and pins replaced by 1 and 3; handholders removed by 2 and 4; 2 closes the bow cap.
UNLOAD.	Tubes are trained into position and loading-troughs shipped side required; and the Nos. then perform the same duties as in "Launch Back."
SECURE.	The tubes are trained into the securing position and everything replaced by the same Nos. as in clearing for action.
ADJUSTMENT OF TRIPPER.	For after tubes—water-tripper removed, and tube-tripper in proper position. For stem-tube—water-tripper to be used and tube-tripper raised.
HOISTING IN.	For stem-tube—hoist in with tail forward. For after-tubes—hoist in with tail aft.
AIR PUMPS.	The engine-room or torpedo artificer attends the air compressors, and renders general assistance where required.

Prepare for action in 136-ft. Torpedo boat—
- Coxswain in conning tower steering.
- 4 men prepare torpedoes.
- 1 Naval Brigade man—ammunition supply.
- 2 Naval Brigade men to each Nordenfelt gun.
- 2 pass up arms and look out, 1 forward and 1 aft attending on the commanding officer.
- 2 Naval Brigade men—electric light.
- 1 Naval Brigade man—signalman.

DRILL FOR THE 15″ 19-FT. TORPEDO WHEN FIRED FROM THE AIR GUNS ON BOARD THE "CHILDERS" TORPEDO BOAT, 1ST CLASS.

The crew will consist of 6 men, who will fall in in the torpedo room facing in-board in the following positions :—

4	3
6	5
2	1

Cancelled

NUMBER. Crew call their Nos. in succession from No. 1.

ACTION. All Nos. take up flooring and place it on the side lockers; 3 and 4 hook on the foremost lifting chains ; 5 and 6 the after ; 3, 4, and 5 man the foremost tackle chain ; 1, 2, and 6 the after. As soon as the shoots are high enough, 1 and 2 ship and key the after-lugs ; 3 and 4 ship and key the foremost lugs.

NOTE.—The foremost lugs only require keying in bad weather.

Unless otherwise ordered, the starboard shoot will always be lifted first.

As soon as the shoots are up, all Nos. replace the flooring, and 1 and 2 try the outer and inner doors, friction break, and firing gear, leaving the inner doors open.

The Nos. then provide the following tools :—

1. Charging nozzle, wrench for air inlet, spanners for charging pipes, depth and controlling gear, lever for cocking tail.
2. Screwdriver, oil bottle, and gauge for reducer.
3. Nose and tail lines and charging pipes.
4. Spanner for screwing in pistol, or Holmes' light holder, and a screwdriver.
5. Rammer, hoisting in strop, and check-line.
6. Pistol, primer, striker, and detonator.

The Nos. then close up on the outside of either shoot in the following positions :—

1. On the right } Abreast engines.
2. On the left } Abreast engines.
3. On the right } Abreast head.
4. On the left } Abreast head.
5. Between 1 and 3.
6. Between 2 and 4.

CHANGE ROUNDS.	1 becomes 5	4 becomes 6
	5 " 3	6 " 2
	3 " 4	2 " 1

—ATMOSPHERE'S IMPULSE. —YARDS RANGE. —FEET DEEP. 2 oils the engines; 4 turns the screws, then 4 on clips; 1 takes out the air inlet plug, screws on the charging nozzle and pipes, assisted by 3, who then attends the charging column and charges the torpedo; 1 then adjusts range depth and reducing valve, assisted by 2; 4 and 6 take out the screws of the head, lift off, and pass it into the gun. When 1 has adjusted for depth, they replace the head and screws; 5 connects the check-line and places rammer; 6 prepares and supplies the pistol to 4, who screws it in.

When all the adjustments are made, 1 attends inner door and friction break, and gives the order—

LAUNCH IN. All Nos. except 1 and 2 man the rammer, 3 attending the check-line, 2 places the firing gear in second position and puts in safety-pin.

When the nose of the torpedo has entered the gun, 1 orders "Well," and takes out the pistol safety-pin (giving it to the officer in charge).

Cancelled

When the swell of the torpedo has passed the rear stop, 1 gives the order "In stop," on which 2 shifts the firing gear from the second to the first position, and puts in safety-pin. As soon as the tail-frame of the torpedo reaches the door of the tube, 1 orders "Well," sees the torpedo square in the tube, cocks the tail, and orders "Launch in." The torpedo is forced slowly home; when nearly to the stop, 1 orders "Well;" 5 withdraws the rammer; 1 removes check-line and clips; 1 and 2 close the door, forcing the torpedo slowly home, and screw up; 1 goes to the wheel.

OPEN OUTER DOORS. — 4 and 5 open outer doors, seeing the locking gear to the firing gear clear after the doors are open.

STAND BY. — 2 and 3 open the stand-by and auxiliary valves, and then take out the safety-pins of firing gear; 4 goes to firing lever.

FIRE. — 4 and 5 close outer doors, see the locking-gear in safety position and open inner doors; 2 and 3 put in safety-pins, shut the stand-by and auxiliary valves.

(2. Port tube.) (3. Starboard tube.)

CEASE FIRING. — Torpedo in tube and tube at the ready. 2 and 3 replace safety-pins, shut off stand-by and auxiliary valves; 4 and 5 close the outer doors; 6 lifting over the bow cap on the outside.

UNLOAD. — 1 and 2 open the inner doors; 1 secures the launching line to the tail of the torpedo; 2 attends the firing gear and rear stop; 1 superintends, keeping friction-break free, all spare Nos. man the check-line. 1 gives the order "Launch Back," and when the tail of the torpedo is clear of the gun, "Well," eases up the tail-spring, and puts on the clips; 1 then orders "Launch Back," and, when the nose is clear of the gun, puts in the pistol safety-pin, and 5 hitches up the check-line, 2 easing up the reducer; 4 removes the pistol, and 6 returns it to the magazine.

Cancelled

Close Up. The Nos. then close up by the order of 1 as before.

Secure. All Nos. take up flooring and place it on the lockers; 1 and 2 unkey the after-lugs; 5 forward, and 6 aft, taking the weight if necessary with the tackles (if the forward upright and shoe are being used, 3 and 4 unkey the foremost lugs); 1 then orders "Lower," and the Nos. lower the shoot into its place under the direction of 1. When the shoots are placed, all Nos. replace flooring, 1 and 2 close the doors. Crew then falls in as for action.

Cancelled

TO HOIST TORPEDO IN.

The ends of the nose and tail lines are passed on board and taken by 3 and 4; 5 and 6 man the winch; 1 and 2 sling torpedo, making fast the extra nose and tail lines to the slings; 1, 2, 5, and 6 hoist up the torpedo, 1 and 2 assisting to keep it clear.

When the torpedo is high enough, 1 and 2 swing in. When fair over the deck shoot it is to be blown through, and the drain screws are taken out and replaced by 2; 1 then orders "Lower," and 5 and 6 lower the torpedo; 3 and 4 secure the nose and tail lines; and the Nos. close up.

NAMES OF PRINCIPAL PARTS OF DROPPING GEAR.

Davit.
Curved arm of davit.
Blowing box.
Tong tube.
Sprocket and spur wheel.
Pawl.
Cotter keys.
Securing pins.
Spreaders to tongs.
Chain.
Vertical fin clutch.
Pin for vertical fin clutch.

Firing lever.
Studs for working firing tube by lever.
Safety-pin (passing through tong tube and firing tube).
Winch handles.
Air lever trippers.
Tongs for holding the torpedo.
Handle for adjusting air lever.
Eccentric sheaves (which have to be shifted to suit each pattern of torpedo).
Steadying hooks.
Stay tube (rod inside connects winch handles).
End of firing tube.
Inclined planes.
Threaded bar (attached to firing tube for adjusting and working air-lever tripper).
Plumber block.
Bearing tube.

There are two descriptions, light and heavy.

The heavy pattern is fitted in *Childers*, and takes all patterns of torpedoes.

The light pattern is fitted in all second-class boats, and only takes 14-in. torpedoes.

In the second-class boats it is fitted to secure in two positions for firing, one for fine weather and one for rough.

DETAILS OF THE "COUNTESS OF HOPETOUN."

Crew—

Lieutenants or sub-lieutenants, 2; warrant officer, 1; engine-room artificers, 2; leading stoker and stokers, 6; petty officers, 3; A.B.'s and signalman, 7.—Total, 21.

Length, 135 feet. Draught aft, including propeller, 6ft. 2in.
Beam, 13ft. 6in. Draught aft, exclusive of propeller, 3ft. 8in.
Tonnage, 80 tons. Draught forward, 3ft. 4in.
Coal in bunkers, 14 tons. Distance at full speed, 218 knots.
Full speed, 20 knots per hour. Coal per hour, 30 cwt.
Revolutions, 413 per minute.
Economical speed, 10 knots. Distance at 10 knots, 1,200 knots.
Coal per hour, $2\frac{3}{4}$ cwt. Revolutions, 240 at 12 knots.

Displacement ranges from 70 to 95 tons, according to the load, and the draught from 3 inches less to 5 inches greater than the above.

The boat is divided into nine compartments by eight whole bulkheads, and, in addition, has two half bulkheads.

Her armament consists of—

1 fixed stem tube and 2 revolving tubes, mounted as a pair, for discharging 14-in. torpedoes.
2 two-barrelled Nordenfelt guns, with 96 rounds per gun.
10 rifles, with 70 rounds per rifle.
5 pistols, with 50 rounds per pistol.
10 cutlasses.

Air pumps—2 Brotherhoods, 10 cubic feet, 60 minutes, 1,500 lbs.

Compound dynamos, 8,000 c.p. projected, fitted with divergent lens.

DETAILS OF THE "CHILDERS."

Crew—

Lieutenants or sub-lieutenants, 2; warrant officer, 1; engine-room artificers, 2; leading stoker and stokers, 4; petty officers, 2; A.B.'s and signalman, 4.—Total, 15.

Length, 113 feet. Draught aft, including propeller, 7 feet.
Beam, 12ft. 6in. Draught aft, exclusive of propeller, 4ft. 6in.
Tonnage, 47 tons. Draught forward, 3 feet.
Coal in bunkers, 12 tons. Distance at full speed, 256 knots.
Full speed, 18 knots. Coal per hour, 19 cwt.
Revolutions, 380.

Economical speed, 11 knots. Distance at 11 knots, 1,200 knots.

Coal per hour, 2½ cwt. Revolutions, 200.

The above is estimated for at a load of 12 tons of coal.

The boat is divided into ten compartments, having nine whole bulkheads and two halves.

Her armament consists of—

4 sets of dropping gear, with 14-in. torpedoes, ~~and two stem tubes, with 15-in. torpedoes~~.
Two 1-in. Hotchkiss Q.F., 100 rounds of ammunition per gun.
8 rifles; 100 rounds per rifle.

10 cutlasses.
5 pistols; 50 rounds per pistol.

Air pumps—1 Brotherhood, 10 cubic feet in 60 minutes 1,500 lbs.

Dynamo series. 2,000 c.p., and projector fitted with a divergent lens.

SWAN ISLAND DEPÔT.

Air, at 1,500 lbs. pressure, 32 cubic feet in reservoirs; three columns for charging.
6,000 gallons of water, 40 tons of coal.
One Brotherhood pump, for charging.

"FAWKNER."

One admiralty air pump.
One reservoir, capacity 10 cubic feet; 1,500 lbs. pressure.

"NEPEAN" OR "LONSDALE."

Crew—

Warrant officer, 1; artificer, 1; leading stoker and stoker, 2; petty officers, 1; A.B.'s and signalman, 3.

Length, 63 feet. Draught, 4ft. 3in.

Beam, 7ft. 6in. 2 tons of coal—7 cwt. per hour at full speed; $\frac{3}{4}$ cwt. per hour economical speed.

Tonnage, 12 tons.

Speed, 17 knots full. Economical, 8 knots.

Distance, 100 miles. Distance, 420 miles.

Revolutions, 540.

The boat is divided into seven compartments by six whole and one half bulkheads.

Armament.—Two sets of dropping-gear for 14-in. torpedoes.

Ammunition supply :—

4 rifles ; 70 rounds per rifle.
5 cutlasses.
5 pistols ; 50 rounds per pistol.

"GORDON."

Crew—

Warrant officer, 1 ; artificer, 1 ; leading stoker and stoker, 2 ; petty officers, 2 ; A.B.'s and signalman, 5.

Length, 56 feet. Draught, 4ft. 11in.

Beam, 9ft. 6in. Coal carried, 30 cwt.—800 lbs. per hour at full speed ; distance for economical, 100 lbs. per hour.

Tonnage, 12 tons.

Speed, 14 knots full. Economical speed, 8 knots.

Distance, 62 knots. Distance, 260 knots.

Revolutions, 400 per minute. Revolutions, 210 per minute.

Armament consists of two sets of dropping gear for 14-in. torpedoes, and 3 two-barrelled 1-in. Nordenfelts.

Ammunition supply—

3 Nordenfelts ; 96 rounds per gun.
7 rifles ; 70 rounds per rifle.
5 cutlasses.
5 pistols ; 50 rounds per pistol.

Director.

Names of principal parts—

Radius bar.	Backsight.
Enemy's speed bar.	Clamping screws.
The arc.	Foresight.
Blocks and bevel edges.	Line of sight bar.

The radius bar represents the path and speed of the torpedo always.

Enemy's speed bar represents speed and course of enemy ; it is to be kept parallel to her course, the arrow denoting the direction in which she is steering.

Readings are taken at the bevel edges of the blocks.

The deflection of the torpedo and speed of your own ship are allowed for on the arc by the radius bar.

Ships' directors are generally a complete semicircle, but there is a smaller pattern for right-ahead fire and in boats.

The following are the circumstances under one of which you must be placed when using the torpedo director:—

1. Ship and enemy stationary. No tide.
2. Ship moving, enemy stationary. No tide.
3. Ship stationary, enemy moving. No tide.
4. Ship and enemy moving. No tide.
5. Ship under weigh, enemy at anchor in a tideway.
6. Ship in a tide and enemy under weigh.
7. Both under weigh in a tide.
8. Both at anchor in a tideway.

1. Get a bearing of the enemy by means of the sights on the torpedo carriage and fire direct.

2. For the torpedo to leave the ship on the beam—supposing your own ship to be going 10 knots—train the tube 15° before the beam, put the radius bar of the director on the beam, and fire when the sights come on.

> NOTE.—If your carriage happens to be trained 30° before the beam, and there is no time to alter, put the director 15° before, and fire as the sights come on.

3. Set the enemy's course and speed and speed of the torpedo on the director; put the radius bar and carriage on the direction you require, and fire when on.

4. To get a shot right forward train the carriage to its forward limit (say 30° before), put the radius bar at 15° (allowing 10 knots as speed of ship), put the enemy's course and speed of torpedo on the director, then fire when sights come on.

5. Suppose the tide to run 5 knots, ship steaming 18 knots, torpedo to be fired on the beam, train the carriage 27° before, allow for speed of torpedo, and put the enemy's course as against the current and her speed 5 knots, then fire as before.

6. Allow for the tide as if it were your own speed and course in the opposite direction to the current, and adjust the radius bar accordingly.

7. Make the usual corrections and allow nothing for tide.

8. Set the director with the enemy's course opposite to the direction of the tide and speed the same; then train the carriage so as to allow for tide as your own speed; ship going ahead.

Making for a Ship some way off.

To steer to meet her as soon as possible, put your speed and course on the radius bar (where marked for torpedo) and the enemy's as near as you can judge on the usual bar.

Then steer to keep your sights on with the enemy's ship.

Attacking a Ship.

If possible come down with the tide, as you are a shorter time under fire, and you are enabled to deliver your own fire sooner.

Note.—The *Countess of Hopetoun's* director has three foresights, the centre one for firing both tubes together; and the other two for firing each tube separately.

PART II.

Electricity can be put to many uses, and may be produced in various ways. Its use in the service is confined almost entirely to firing torpedoes, guns, &c., and also for producing what is called the "Search Light."

That used for firing guns, &c., is called Voltaic Electricity, and is produced by the chemical action of certain liquids on different metals.

That used for "Search Lights" is called Magneto Electricity, and is produced by the motion of coils of wire in a magnetic field.

Magneto and Voltaic Electricity have exactly the same properties.

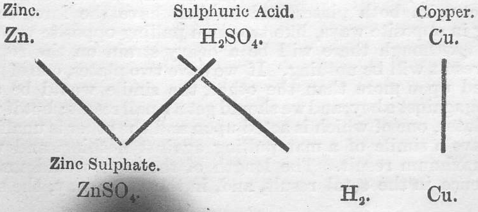
THE SIMPLE CELL.

A combination of two different metals, immersed in the same liquid, is called a Simple Cell. Suppose we take a glass jar containing weak sulphuric acid, and in it place a piece of commercial zinc, we observe that a violent action takes place. First of all we find the zinc is disappearing, or is being dissolved by the acid; secondly, the liquid begins to bubble violently, gas comes freely off the zinc plate; thirdly, the liquid gets hot. If we now place a sheet of copper into the same jar, taking care that the two metals do not touch, no change is apparent inside. But if we connect the top of the two plates by a copper wire, the action inside the jar will be altered and the wire will become endowed with wonderful properties.

First, inside the jar the bubbles will be seen to be rising from the copper plate instead of the zinc; secondly, the zinc will be dissolving faster than ever; and thirdly, the temperature of the liquid will cease to rise almost entirely. This is the explanation of the so-called electric current. By putting in a copper plate, and joining both plates by a wire, we have caught this heat and made it appear in the form of work outside. This heat is produced by what is called "chemical combination." To take an example—When coal is burnt chemical combination is going on, that is to say, a portion of the coal is uniting with the oxygen of the air, and a certain amount of heat is produced. If we burn the coal in the open air the heat produced by the chemical combination simply radiates through the air and we get no result, but if we burn the coal in the closed furnace of a boiler, the water is turned into steam, and we can get work done by it. So in the Simple Cell the zinc is being burned away by combining with a portion of the acid. The force which was holding the particles of zinc together is set free, and appears either as heat in the liquid or, if we join a wire between the plates, we can do work with the wire. Amongst other things we find the wire will deflect a magnet, by which means we can get motion. The wire will pick up iron filings, and the wire itself becomes hot, by which means we can, if we please, boil water and use the steam to drive an engine. We now see that if we place two metals in a vessel containing an acid, the metals being so chosen that one is more acted upon than the other, and we join the plates by a wire, we can obtain certain results from that wire. Now to examine the chemical action which takes place in a Simple Cell. For this we must use the chemical names of the plates and the acid.

Zinc., Zn.	Sulphur, S.
Copper, Cu.	Sulphuric Acid, H_2SO_4.
Carbon, C.	Sulphate of Copper, Cu., SO_4.
Manganese, Mn.	Ammonia gas, NH_3.
Hydrogen gas, H.	Peroxide of Manganese, MnO_2.
Oxygen gas, O.	Sal-ammoniac, NH_4Cl.
Chlorine gas, Cl.	
Nitrogen gas, N.	

The ordinary Simple Cell consists of a plate of zinc and a plate of copper immersed in dilute sulphuric acid, which expressed chemically is as follows :—



The action being that the zinc is dissolved, forming a zinc sulphate. Hydrogen gas is set free and the copper plate is unaltered.

This action shows the defects of the Simple Cell, which is that the hydrogen gas being set free deposits itself on the copper plate, and eventually stops the action of the cell. In Electrical language this is called Polarization of the passive plate, and at once condemns the Simple Cell for use in the service, since what we want is a cell that will remain constant and go on firing guns for an indefinite period without much attention. The terminals which are attached to the plates are called poles of the battery, and the names of the plates and poles in all cells are as follow :—

The plate which is most acted upon by the acid—Active plate.
The plate which is unaltered by the acid—Passive plate.
Terminal attached to active plate—Negative pole.
Terminal attached to passive plate—Positive pole.

A Simple Cell is called "inconstant" because, as already explained, the hydrogen being deposited on the passive plate stops the action of the cell, and the current obtained becomes less and less, and eventually ceases altogether.

We have seen that the force which gives rise to the current is produced by the consumption of zinc in the cell. This is called the electro motive force of the cell, and depends entirely on the nature of the plates and the acid used.

The greater the difference of the action of the acid on the two plates the greater will be the available force. To take a familiar instance—Suppose we have two zinc plates in the cell, the acid will act upon both plates, and we shall have the force set free acting in opposite ways, like two men pulling opposite ways on a rope. Although there will be a heavy strain on the rope, the total result will be nothing. If we have two plates, one of which is acted upon more than the other, the simile would be a man pulling against a boy, and we should get a small result; but if we use two plates, one of which is acted upon and the other is unaffected, we have a simile of a man pulling against nothing, and we get the maximum result. The length of the rope would make no difference in the total result, and, in the same way, the size of the plates and their distance apart do not affect the electro motive force (E.M.F.) of the cell, and we say that E.M.F. depends solely on the nature of the plates and the liquid used. The standard or unit of electro motive force is called one volt; in other words, E.M.F. is measured in volts, in the same way as weight is measured in pounds, or distance in yards.

The effect produced by the wire which joins the poles of the cell is usually called the "current," the original supposition being that something actually passed along the wire. This has long been disproved, but the name "current" still remains. What actually takes place is that the little particles of copper composing the wire are set in a state of vibration, and thus produce a strain in the surrounding atmosphere. Current is measured in ampéres, just as E.M.F. is in volts.

It will be easily seen that—take a given length of wire—the effect produced will increase with the number of particles or molecules of which this wire is composed; that is to say, that if we double the area of the wire we shall get double the effect from the same cell; if we halve the area, we shall get only half the effect. This is expressed by the term "resistance," and we say that if we double the area of a given length of wire we halve the resistance, and if we halve the area we double the resistance, so that, with any given cell, the electro motive force being constant, the current or "effect produced" varies inversely as the resistance. This is called Ohms Law, and is expressed thus:—

$$C = \frac{E}{R}$$

when C is the current,
E is the electro motive force.
R is all the resistance in the circuit.

The standard of resistance is one ohm, and the term resistance (R) includes all the resistance in the circuit, both between the terminals externally and between the plates internally.

Ohms Law is better expressed as—

$$C = \frac{E}{R + r}$$

when R is all the external resistance and r is all the internal resistance.

We have seen that the principal defect of the Simple Cell is that, when the cell is in action, hydrogen is deposited on the passive plate. This gas having been turned out of the liquid is naturally anxious to re-combine with it, and so tends to set up a force in the cell in the reverse direction. The more gas set free the greater becomes this opposing force, and the cell gets weaker. To get a constant cell it becomes necessary to get rid of this gas, before it reaches the passive plate, either by absorption or other means. Several methods have been tried, the most successful of which has been that of immersing the passive plate in another liquid contained in a porous pot, so that the hydrogen is absorbed by this second liquid before the passive plate is reached.

The zinc is immersed, as before, in sulphuric acid, the copper plate is immersed in sulphate of copper, both being contained in a porous pot. To express chemically the actions which take place in this cell—

Zinc.	Sulphuric Acid.	Copper Sulphate.	Copper
Zn.	H_2SO_4.	$CuSO_4$.	Cu.

Zinc Sulphate.	Sulphuric Acid.	Copper
$ZnSO_4$.	H_2SO_4.	Cu.

We have zinc sulphate formed as before, but the hydrogen forms a chemical combination with the copper sulphate, the copper being turned out and the hydrogen taking its place. The copper which is set free is deposited on the copper plate, leaving it practically unaltered, except that the deposited copper is clean and bright, and thus tends to slightly improve the cell.

Cells of this description are called two-fluid or Constant Cells, because no matter how long we keep the cell working the hydrogen is absorbed as fast as it is made, and the copper plate is unaffected, thus keeping the electro motive force of the cell unaltered. The cell described is called a Daniell Cell, after the name of the inventor. There are others of the same description, such as Grove's, Bunsen's, &c., but in which different plates and liquids are used. These cells, however, are not adapted to the service, because it is found that although the porous pot is of such a density as to prevent the ready mixing of the liquids, still, after standing 24 hours, they do creep through, and the cell has to be taken to pieces and rebuilt. For the service we require a cell which, when once built, can be placed in its position and then left for a long period of time, probably the whole of the ship's commission, without being disturbed.

The Le Clanché answers this purpose admirably, since the passive plate, instead of being immersed in a second liquid, is surrounded with a powder which is rich in oxygen, with which the hydrogen combines before it can reach the plate.

The Le Clanché Cell is supplied to the service in one size, called the Boat's Cell; it consists of—

(*a*) An ebonite containing vessel.
(*b*) A zinc plate.
(*c*) The carbon element.

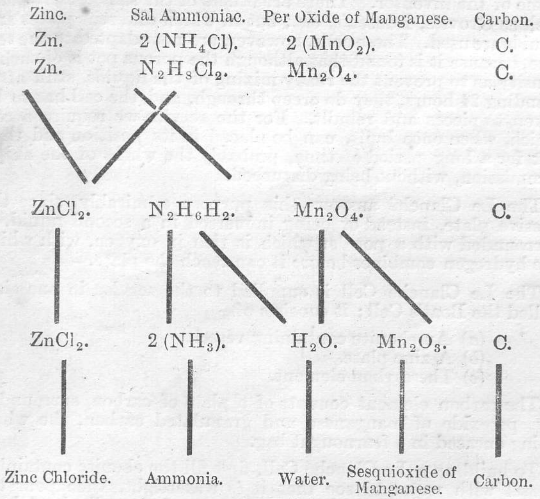
The carbon element consists of a plate of carbon, surrounded by peroxide of manganese and granulated carbon, the whole being encased in a fearnought bag.

To build up a Le Clanché Cell, first fill the ebonite containing vessel with water to see that it is watertight, then pour the water out again and pack in the bottom of the cell about half-an-inch of sal-ammoniac; then put in the zinc plate and carbon element, and pack more sal-ammoniac round the sides of the latter; lastly, pour in a saturated solution of sal-ammoniac to within 2 inches of the top of the cell, and allow the cell to stand for one hour before use.

Great care must be taken that none of the liquid is spilt over the connexions, otherwise they become corroded, and it is difficult to get a good electrical connexion.

The saturated solution is prepared by dissolving 6 ozs. of the crushed salt in 1 pint of hot water for each boat's cell. The solution must be allowed to cool down before use.

The action of the cell is as follows :—



By tracing this action it will be seen that when the cell is in action ammonia gas is formed, and also water. The former is given off, and escapes into the air; the latter dissolves the dry crystals which have been packed in the cell, and so keeps the solution up to its full strength. No action takes place until the external circuit is completed, but when this is done the hydrogen gas is given off freely and does not readily combine with the oxygen out of the peroxide of manganese to form water; for this reason this cell must never be put on circuit for any length of time. But, since for all service purposes, such as firing guns, &c., the action required is only momentary, the cell is admirably suited for this work, and has the great advantage that, when once built up, will last for years without much attention, because the zinc being immersed in a liquid and the carbon in a powder the two cannot mix, as is the case with most constant cells, and all that is necessary is to replenish the solution of sal-ammoniac after any waste due to evaporation. In this cell the zinc plate is "amalgamated," that is to say, is coated with mercury (quicksilver). To do this, wash the zinc plate in dilute sulphuric acid, then rub over with mercury, and it will be found that the mercury adheres to the zinc. Take care to rub off the surplus mercury.

It is found that this process gives the cell a slightly higher electro motive force, and also prevents "local action."

"Local Action" is due to impurities in the zinc plate, such as iron, &c., which gives us a number of small simple cells set up in the zinc plate itself, the result being that the zinc plate is eaten away even whilst the cell is not being used.

It has been already explained that the resistance of a wire depends upon the nature of the wire, and also upon its area and its length; this is called the External Resistance.

There is also the resistance inside the cell itself, which is called the Internal Resistance, and this depends solely on—

The size of the plates.

Their distance apart.

The conductivity of the existing liquids.

The greater the area of the plates the less will be their resistance.

The greater their distance apart the greater will be the resistance of the liquids between them.

Besides the Boat's Cell there are several other types of Le Clanché, the most common of which is that known as the Post Office Cell, which consists of a glass containing vessel, the carbon plate and peroxide of manganese being contained in a porous earthenware pot, the zinc being in the form of a rod. This form of cell is most useful for ringing bells, &c. As although the porous pot raises the internal resistance of the cell, at the same time it resists the free passage of hydrogen gas to the carbon plate, and so prevents the cell becoming polarized.

TEST BATTERY.

Another form of two-fluid cell employed in the service is known as the Menotti Test Battery, and is so constructed that it will send a current through a fuse, &c., without firing it.

The construction is as follows :—

A circular ebonite containing vessel. At the bottom of this is placed the copper plate in the form of a cup, and called the Copper Cup. In the cup are placed crystals of "sulphate of copper." Above this is placed a fearnought diaphragm. Above this 3 inches of pine sawdust, saturated in fresh water. Above this another fearnought diaphragm. And, on the top of all, the zinc plate. An insulated wire is connected to the copper cup, and another wire insulated is connected to the zinc plate. The wire from the copper cup is connected to a terminal on the top of the cell, and the wire from the zinc plate is connected to the nipple of the firing key.

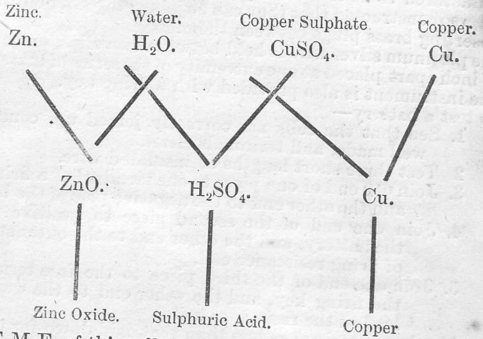
The requirements of a Test Battery are—

1. It should be portable.
2. It should be constant.
3. It should not under any conditions be possible to fire a fuse with it.

These conditions are obtained as follow :—

1. The exciting liquid (water) is absorbed in the pine sawdust, and so is not easily spilled, even should the cell be capsized.
2. The cell is so constructed that it remains constant.
3. The pine sawdust being a bad conductor, the internal resistance of the cell is so large that it is impossible to obtain sufficient current to fire a fuse.

The action is as follows :—



The E.M.F. of this cell is one volt, and the internal resistance should not be less than 30 ohms. The internal resistance varies with the degree of saturation of the sawdust. If the sawdust is too dry the internal resistance will be very high ; if, on the other hand, there is too much water present the internal resistance is lowered.

A galvanometer is always supplied, secured to the top of the test battery. The action and use of this instrument will be explained hereafter.

In order that the batteries may be maintained in working order, it is necessary that they should be occasionally tested. This is done by making the battery fuse a certain length of wire through a certain resistance.

The wire used is called platinum silver wire, and consists of an alloy of platinum and silver, ·0014 inches in thickness.

The instrument used is called a "Firing Resistance Coil," and consists of a mahogany box with an ebonite lid. On the top of the lid are a number of strips of brass, separated from one another above, but joined together underneath by coils of wire of varying lengths and thicknesses, and since the resistance of a wire depends upon its length and its area, these coils can be manufactured so as to offer any required resistance. The strips are also so constructed that they can be joined together electrically by inserting brass plugs between them.

The platinum silver wire is held between two clips, one quarter of an inch apart, placed at one extremity of the series of brass strips.

The instrument is also provided with a firing key.

To test a battery—

1. See that the cells are correctly joined up, connexions well made, and terminals clean.
2 Test three short lengths of insulated wire.
3. Join one end of one piece to one terminal of a firing key, and the other end to the negative pole of the battery.
4. Join one end of the second piece to positive pole of the battery, and the other end to the outer standard of firing resistance coil.
5. Join one end of the third piece to the free terminal of the firing key, and the other end to the wandering lead of the resistance coil.

Unplug a resistance less than that laid down for the test, and notice how much of the wire fuses; work the resistances up gradually (inserting a fresh piece of P.S. wire each time) until the wire is fused through the required resistance.

It is obvious that, directly the wire is fused, the circuit is broken at that point, and the action of the battery ceases. If, on the other hand, the P.S. wire is not fused when the keys are pressed the action of the battery continues; it is for this reason that it is necessary to commence the test with a small resistance to insure the fusing of the wire, and thus prevent the battery from becoming polarized.

The following are the tests laid down for the different batteries:—

One boat's cell -	To fuse or redden one part of P.S. wire	On short circuit.
Three boats' cells -	To fuse one part of P.S. wire	Through 3·5 ohms.
Ten boats' cells -	To fuse one part -	Through 18 ohms resistance.
One P.O. cell, pattern large size	45° on a 1,000 ohm galvanometer	Through 20,000 ohms.

One P.O. cell, pattern small size	45° on a 1,000 ohm galvanometer	Through 20,000 ohms.
Test battery -	To give a swing of 80°	On short circuit.

NOTE.—All batteries should have sufficient power to work their respective instruments through about double the resistance of the external circuit.

JOINING UP BATTERIES.

There are two methods of joining up cells so as to form a battery, and they are called respectively—

Joining up in series.

Joining up abreast or in quantity.

To join up in series, the carbon of one cell is connected to the zinc of the next, and so on in succession, the carbon and zinc of the two extreme cells forming the positive and negative poles of the battery.

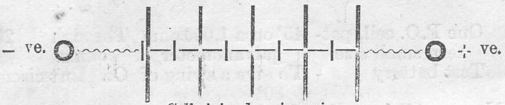
By joining up in this way we get a high E.M.F., because the cells are, so to speak, backing each other up, and the E.M.F. of the whole battery will be equal to the E.M.F. of one cell multiplied by the number of cells in series.

At the same time we increase the length of the conductor in the battery, since the current passes from one cell to another in succession, or, to speak correctly, the length of the chain of molecules to be polarized is increased, so that the internal resistance of the battery is increased and becomes equal to the internal resistance of one cell multiplied by the number of cells in series.

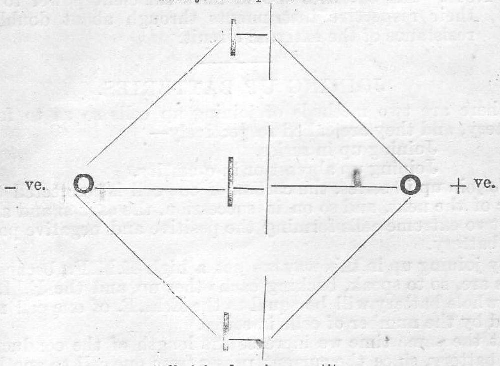
To join cells up in quantity (or abreast), all the carbons are connected to one terminal, which becomes the positive terminal of the battery, and all the zincs are connected to the other terminal, which becomes the negative terminal of the battery.

By joining up this way the E.M.F. of the battery is not increased, since the cells do not back each other up, and it remains equal to the E.M.F. of one cell.

But since the area of the conductor inside the cells is increased in proportion to the number of cells employed, the internal resistance of the battery becomes very small indeed, and is equal to the internal resistance of one cell divided by the number of cells in quantity.



Cells joined up in series.



Cells joined up in quantity.

To get the best result out of a given number of cells, always join them up so that the internal resistance is equal to the external resistance; that is to say, if the external resistance is high, join up in series; if it is low, join up in quantity; or else make your battery up of a combination of cells in series and in quantity, so as to obtain the required internal resistance.

Directions for Joining up a Battery for firing a Charge.

First.—When a complete wire circuit is used:—

1. The charge is fitted and tested, and the battery ends of the conducting wires insulated with tubing; provide a firing key which has been previously tested.

2. See that the battery cells are correctly joined up, connexions well made, and terminals clean.

3. Test three short lengths of insulated wire.

4. Join one end of a short piece of wire to one terminal of the firing key and the other end to the negative pole of the battery.

5. Join one end of a second piece of wire to the positive pole of the battery and the other end to the firing resistance (or test) coil.

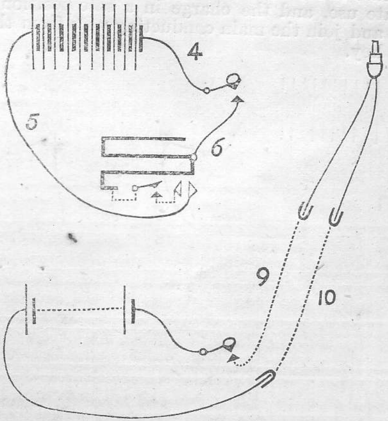
6. Join one end of a third piece of wire to the firing resistance (or test) coil and the other end to the unoccupied terminal of the firing key.

7. Test the battery and connexions.

8. Remove the firing resistance (or test) coil, insulate the end of the wire joined to the positive pole of the battery, and disconnect the loose wire from the firing key.

9. Take care to see the firing key at half-cock, and the charge in a safe position; remove the tubing from, and join the main conducting wire from the charge to the firing key.

10. Remove the tubing from, and join the return connecting wire from the charge to the wire from the positive pole of the battery, with a temporary junction.



Second.—When an earth circuit is used:—

1. The charge is fitted and tested, and the battery ends of the connecting wires insulated with tubing; provide a firing key which has been previously tested.

2. See that the battery cells are correctly joined up, connexions well made, and terminals clean.

3. Test two short lengths of insulated wire, and two earth plates.

4. Join one end of a short piece of wire to one terminal of a firing key, and the other end to the negative pole of the battery.

5. Join one earth plate to the positive pole of the battery, and put it overboard.

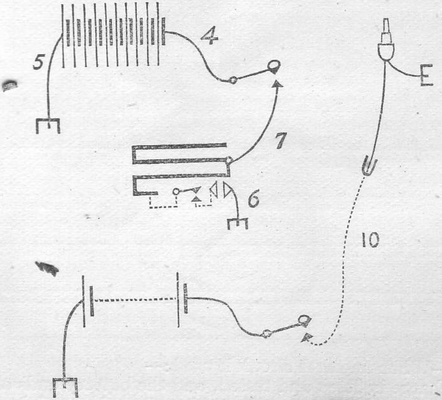
6. Join the other earth plate to the firing resistance (or test) coil.

7. Join one end of the second short piece of wire to the firing resistance (or test) coil, and the other to the unoccupied terminal of the firing key.

8. Test the battery and connexions.

9. Remove the firing resistance (or test) coil and disconnect the loose wire from the firing key.

10. Take care to see the firing key at half-cock, when required for immediate use, and the charge in a safe position; remove tubing from and join the main conducting wire from the charge to the firing key.



For all mining work the half-cock catch is to be removed from firing keys.

The ends of the wires are insulated by slipping a piece of india-rubber tubing over the end, bending it back and securing it to the wire firmly with twine.

To calculate the number of cells required to fire a tube through any resistance—

By Ohms law—

The current in any circuit is equal to the electro motive force of the battery, divided by the total resistance in the circuit, which may be expressed thus—

$$C = \frac{n \times E}{R + n\,r} \text{ if the cells are in series,}$$

or—

$$C = \frac{E}{R + \frac{r}{n}} \text{ if the cells are in quantity,}$$

when— C = Current in circuit.
E = Electro motive force of one cell.
R = External resistance.
r = Internal resistance of one cell.
n = Number of cells employed.

Example—

To find the least number of boats' cells, joined up in series, which will fire a tube through a resistance of 10 ohms—

The current required to fire a tube is $\frac{1}{3}$ ampères.
The E.M.F. of a boat's cell is 1·5 volts.
The internal resistance of a boat's cell is ·2 ohms.
The resistance of a tube is 1·6 ohms.

$$\therefore \quad \tfrac{1}{3} = \frac{n \times 1{\cdot}5}{10 + 1{\cdot}6 + n \times {\cdot}2}$$

$$10 + 1{\cdot}6 + n\,{\cdot}2 = 4{\cdot}5\,n$$

or— $$11{\cdot}6 = 4{\cdot}3\,n$$

$$2{\cdot}7 = n$$

Therefore the least number is 3 cells.

In the same way, having given the number of cells and the external resistance, we can find the total current.

Three times the battery power required is always to be used on firing circuits.

GALVANOMETERS.

A galvanometer is an instrument for detecting the passage of a current through any circuit, the principle of its action being that if a wire in which a current is flowing be held in close proximity to a freely suspended magnetic needle, that needle will be deflected out of the magnetic meridian.

Two descriptions of galvanometers are used in the service, one of which is called the single needle galvanometer, and the other (in which two needles are used) an astatic galvanometer.

The single needle galvanometer consists of a single needle suspended on a pivot in a brass case. The needle is surrounded by a coil of insulated wire, the ends of the coil being taken to two terminal screws outside the case.

The instrument is fitted with a dial face marked in degrees. A light pointer is secured to the needle pivot, so that as the needle moves the pointer also moves, and the number of degrees of deflection can be easily read off.

The coil of wire is wound on the line passing through the two zero points, so that if the instrument be turned round until the pointer is at zero the needle underneath must necessarily be in the line of the coils.

If a battery be joined up to the galvanometer, it will be found that the needle is deflected to the right or left, according to the direction of the current, and by adding on battery power the needle will be gradually deflected to an angle of 90°; or, in other words, to a position at right angles to the line of coils. No increase of battery power will deflect the needle to any greater angle than this. It is thus evident that, before using a galvanometer, it is necessary to see the pointer pointing at zero; otherwise, supposing it to be pointing at 90°, the passage of a current will have no further effect upon it.

To determine which way a needle will be deflected, the following rule is employed:—

Place yourself in the conductor; swim with the current; face the needle; and the north end will always be deflected towards your left hand. In applying this rule the current is always supposed to start from the positive pole of the battery, through the external circuit, and back to the negative pole.

The sensibility of a galvanometer depends on three things–

(1) The strength of the magnetism of the needle.

(2) The number of coils of wire passing round the needle.

(3) Their distance from the needle.

A single needle galvanometer is supplied with each Menotti Test Battery. The resistance of the coil is 20 ohms; and for this reason this instrument is usually known as the 20-ohm Galvanometer. A small bar magnet is supplied with this instrument, its use being to diminish the deflection of the needle when using strong currents. It has already been shown that before using a galvanometer the instrument must be turned round until the needle is at zero, or, in other words, until the line of the coils is in the magnetic meridian. If we now pass a current through the coils the needle will be deflected to a certain angle, and will remain in that position so long as the current is passing.

It is evident that there are two forces acting on the needle in directions at right angles to one another, namely—

(1) The magnetic attraction of the earth trying to pull the needle back into the meridian.

(2) The force due to the current trying to turn the needle in a direction at right angles to the meridian.

And when the needle is steady the effect of these two forces on the needle are exactly balanced.

If we wish to make a galvanometer more sensitive, *i.e.*, to show a large deflection for a small current, we must diminish the force due to the earth.

A magnet is supplied for the purpose of steadying the needle when there is motion or reducing the deflection when it is too great; when not required for use it is kept in a pocket in the strap of the leather containing vessel.

The other method used is to employ two needles on the same spindle, the upper needle being outside the dial face and acting as a pointer, the coil being round the lower needle.

The needles are mounted with the opposite poles over one another.

The instrument so constructed is called an astatic galvanometer.

By this arrangement the earth's force attracts and repels the corresponding ends of the two needles with almost equal force, and is thus almost neutralized, and a very small current will give a large deflection.

The coil is wound of thinner wire, and offers a resistance of 1,000 ohms. This instrument is usually called the 1,000-ohm galvanometer.

Although the coil is only wound round the lower needle, the upper needle is also affected by the current, and it will be found that, suppose for a moment we neglect the effect of the earth upon the needles, the deflection due to any current passing through the instrument is greater than that due to the same current passing through a single needle instrument.

WIRES.

The wire in general use in this service is named Naval Service wire (pattern 600); it is used for gun circuits, torpedo-boats firing circuits, firing charges laid out to be fired at once, and all ordinary leads.

The conductor consists of 36 tinned copper wires.

The insulation of this and all wires and cables used under water consists of what is termed Hopper's core, as shown in list.

Plaited twine, outside.
Felt tape.
Vulcanized india-rubber.
India-rubber prepared with zinc oxide.
Pure india-rubber.
Copper inside.

The cables in connexion with submarine mining are similar to the N.S. wire internally, but have jute yarns in place of the plaited twine, and on the outside (to prevent chafe against the bottom) galvanized iron wires which is called the armouring.

Wire with only one single wire for a core are supplied for bell circuits, &c.

The insulation of this wire and all other wires supplied for electric lighting, as they are not used under water, consists of—

Cotton braiding, outside.
Paper felt.
India-rubber tape.
Cotton.
Copper wire inside.

Junctions.

When it is necessary to join two or more insulated wires together, the two different methods of making the junctions in common use are called respectively the German junction and the Britannia junction.

The first of these is used when soft and pliable wires have to be joined to wires of a similar nature.

The second is used when a single thick wire has to be joined to a strand of finer wires, or to another single thick wire.

These junctions may be made either "permanent" or "temporary," the latter plan being adopted when it has to be made quickly, and is not expected to last a long time.

The essential point in all junctions is perfect cleanliness; the wires must be quite clean and bright to insure a good metallic contact, and there must be a perfectly clean surface of india-rubber for the tape to adhere to. The smallest trace of grease or dirt is sure to establish a leak sooner or later.

In all cases the outside covering must first be stripped back and the surface of the india-rubber thoroughly cleaned. This is very essential to a good junction, as, by neglecting this precaution, the water will creep up the tape to the bare wires, and form a leak in the insulation. This done, scrape the wires clean with a knife, being careful not to nick them.

The materials used in the service for permanently insulating a junction are india-rubber tape, ½-inch wide, and a solution of india-rubber dissolved in naphtha. When required for use, it is usual to cut the tape into 8-inch lengths.

India-rubber solution consists of pure india-rubber kept in moist condition by the application of naphtha; it is supplied in ½-lb. tins, which are hermetically closed. When using it care should be taken to keep the lid of the cylinder on as much as possible, as if it is left off the naphtha evaporates, leaving the india-rubber hard and of little use. It is desirable to use smaller containing cylinders for present use than those in which the solution is issued; suitable ones can easily be made in the ship out of any available pieces of tin.

Should the supply of india-rubber solution for torpedo purposes fail, it is useful to recollect that the india-rubber solution issued for repair of diving dresses can be used instead.

The materials used for temporarily insulating a junction are india-rubber tubing ·35 inch in diameter and twine. It is usual to cut the tubing into 4-inch lengths, as this is the most suitable size to employ.

To make a temporary German junction, remove the cross whipping and felt tape for about $2\frac{1}{2}$ inches from each end of the wires to be joined, and bare the wires for a little over an inch. Slip a piece of india-rubber tubing over one of the ends, then lay the ends across each other and twist them together, taking care that each wire is twisted round the other, for if this is not done the wire which remains straight is liable to be drawn out of the spiral formed by the other. After five or six turns have been taken, make a round turn with each end, press the wires close down and cover the bare part with twine; then draw the tubing over the junction and seize the ends with a west-country whipping, commencing from the inside on each side of the junction and working out to the ends.

To make a permanent German junction, prepare the wires as for a temporary junction, being very careful that the felt tape is entirely removed. Point off the insulation with a pair of scissors to show a clean surface to the tape, twist them together, as in the "temporary junction."

The junction is then insulated by serving it with india-rubber tape, which should be stretched while putting it on until it is half it usual breadth, and should always be used with clean hands. Too much solution should not be used, and when made the junction should be quite hard and stiff.

To make a Britannia junction, which is used either when stout wires have to be joined together, or one stout wire to be joined to a strand of smaller wires.

Proceed as follows :—Remove the outer coverings down to the insulating material, point off the insulation with scissors, and clean the bare wires as in other junctions. Now bend up about $\frac{1}{4}$-inch of each end of the conductors at right angles, place the two parts together and secure them between the uprights with binding wire, and press the uprights down on top of the binding wire so as to secure it, insulate it as before.

The junctions are made in the following manner :—Make a slit in the insulation of the fore and after at the required place of about $1\frac{1}{2}$ inches in length, carefully clean the wires, and strip back the felt tape on each side about $1\frac{1}{2}$ inches.

Prepare the end of the branch as for making an ordinary junction, being very particular to scrape each individual wire quite bright.

Twist the conductor of the branch wire round the conductor of the fore and after, nipping the turns taut with a pair of pliers.

Next solder, using resin instead of acid, then pare the india-rubber close to the wires, and it is also a good thing to use a small quantity of naphtha to insure all grease being removed.

Then carefully insulate the junction with tape and solution.

To make a junction in electric light cables, remove all the insulation for 6 inches from the ends, and remove the outside covering for another inch. Straighten out and clean each of the nineteen wires of the conductor, and cut off $2\frac{1}{2}$ inches from the ends of the seven centre wires. Bring the two parts together, allowing the ends of the seven centre wires to butt against each other, the remaining twelve overlapping 5 inches and laying along one another. Bind each end of the overlapping parts with some annealed No. 16 B.W.G. copper wire, from in out for a distance of $1\frac{1}{2}$ inches, and file off any sharp point.

Solder the junction thoroughly, allowing the solder to run well through the whole, using resin as a flux.

Insulate as usual with india-rubber tape and solution, and parcel the junction with white tape to make it the same diameter as the main cable.

When it is required to fork a branch cable into a main cable at right angles to it, the following method is adopted :—

Remove 6 inches of the insulation, and the outside covering for another inch, from the end of the cable to be spliced in, and similarly remove 6 inches of the insulation from the other cable where the splice is to be made. Put a whipping of binding wire on the conductor of the cable to be spliced in, close to the insulation, and straighten out and clean all the wires, cut off 5 inches from the seven centre wires, and divide the short ends into a fork, which place over the centre of the stripped part of the main cable, and grip the core of the main cable with these seven wires, cutting them so that they just meet around the core. Divide the remaining twelve wires into two parts, and lay them round the core of the main cable, six to the right and six to the left, each wire side by side, taking care that there are no riding turns. Solder well through the junction and insulate as before.

MAKING A PUDDING IN ARMOURED CABLE.

At each end of every armoured cable a pudding is formed in the following manner:—

1. About 8 inches from the end put on a good rope yarn whipping, unlay the armouring, and bend the wires out equally all round.

2. Take about 20 inches of galvanized flexible steel wire, and thoroughly clean and scrape the wires.

3. Scrape each wire of the armouring clean and bright for 2 inches from the whipping, and starting from one wire take a turn with the steel strand around each wire in succession, until the wire next to the one at which the frapping begins is reached.

4. Wind a yarn round the cable over the whipping and form a small pudding, bend the wires back on the cable, then cross the steel strands and dip them under the next armouring wire, draw them taut, and make a round turn with these round the same armouring wire, and lay up the two strands into one to form the armouring connexion.

5. Place each wire of the armouring neatly on the cable, and put on a good yarn seizing about 3 inches from the end of the pudding; cut off the remainder of the strands.

6. Place a stout canvas cap over the end of the pudding, and reeve the core and armouring connexion through; place the canvas down neatly on the cable, and serve over with three yarn spun yarn for about 4 inches. After making a pudding in a cable, the continuity of the conductor should always be carefully tested; and it should be borne in mind that the most common place to find a fault in the continuity of an armoured cable is just under the pudding, as from bending and twisting this part is more liable to become fractured than any other. The pudding is then gauged with the guage supplied for this purpose.

Splicing Armoured Cable.

Should junctions have to be made when connecting boxes are not available, or if it is inconvenient to use them, the following method of splicing the armouring can be employed, but it requires considerable care. Put a yarn seizing on the two pieces of cable to be joined, about one foot from the ends. Turn back the armouring to this seizing, scrape the strands bright, and, if possible, clean them with a piece of emery cloth. Bring two opposite strands of the armouring together (taking care that there is at least two or three inches of slack core), and twist them round each other. Proceed with the remaining strands in like manner, being careful that all when thus joined, are equally tight, so that they may bear equal strain and also that the junctions should not all come opposite to one another, or the cable becomes bulky at that point. Solder the junctions of the armouring with resin or candle (the candle served out on board ship is found to answer). By soldering the armouring the strands are prevented from oxidizing, which would impair their usefulness if required for a return circuit, for which the armouring is often used.

Stretch the cable well with a tackle, then join the two cores with a permanent junction, and parcel it with a piece of canvas as a protection against the armouring. After the core is spliced, the cable should be again well stretched with a tackle, having a test battery and galvanometer joined up to insure the core not broken under the process, and particular notice should be taken that the core is slack inside the armouring. The hemp covering is then placed evenly, and one or two seizings are passed round cable at the splice to prevent the armouring wires from opening so as to allow the core to protrude.

Lightning Conductors (for fuller details see p. 187, Vol. I., and p. 272, Vol. II.).

An efficient lightning conductor is a perfect safeguard to a ship against damage by lightning, but ships without conductors, or whose conductors are faulty, run grave risk of injury. The pattern of conductor varies in different ships, but in every case the upper end terminates in a pointed spindle, which is always to be kept shipped. The condition of the conductors is to be tested periodically (see p. 164).

Before testing electrically examine every part of the conductor, and make sure that it is everywhere of sufficient thickness to carry off a heavy current without fusing. Next provide a ten-cell battery, a firing-resistance coil, a piece of unarmoured wire long enough to reach from deck to spindle at masthead, and two earth plates of equal size.

I. Find highest resistance through which the battery will fuse one part of P.S. wire, through the piece of unarmoured wire. Call this resistance A.

II. Find highest resistance through which battery will fuse one part of P.S. wire, through the same piece of unarmoured wire and both earth plates. Call this B.

III. Now take one end of the unarmoured wire up to masthead and make it fast to the metal of the spindle, using binding wire to insure a perfect metallic connexion. Find highest resistance through which the battery will fuse one part of P.S. wire, through the lightning conductor, the piece of unarmoured wire and each earth plate separately. Call these two resistances C and D respectively. Then resistance of conductor = (A + B)—(C + D). It should be less than 1 ohm.

TESTING WIRES, FITTING CIRCUITS, ETC.

Whenever a charge is to be fired electrically, the wires, detonators, &c., must be tested before use.

Whenever two wires are lying alongside one another, as in the outrigger circuit, they must be tested—

(1) For non-contact.
(2) For continuity.
(3) For insulation.

To test for non-contact—

Join one end of either wire to the terminals of the Menotti; see the other ends insulated in the air. If the cores of the wires are nowhere in contact, then, on pressing the key, no current will pass, and the needle will remain stationary.

To test for continuity—

Join the two free ends together, press key, and the needle should swing. Before testing for continuity always stretch the wires along the deck, because if coiled in a small coil, although the cores may be parted, the two bare ends are liable to butt up against one another and the break would not be detected.

To test for insulation—

Disconnect one end from the positive pole of the Menotti and insulate it; join up a previously tested earth plate in its place and put it overboard or into a tub of salt water; coil the wire slowly into the tub, keeping the key pressed. If the core is anywhere exposed the current will pass through the leak, by the water, to the earth plate, thus completing the circuit, and the needle will swing. The position of the leak will probably be in that portion of the wire which has just been passed into the tub. When the test is completed dip the free end into the tub; if the needle swings it shows that the leads are properly joined up.

If testing armoured cable, the armouring takes the place of the earth plate and is joined up to the positive pole of the Menotti.

If firing a charge through an earth circuit, "never put the earth plate on the firing key," or an accident is very likely to occur, since it is quite possible that a sea breaking over the boat might complete the circuit from the other terminal to the hull of the boat, thus firing the charge without pressing the firing key.

When fitting a tube or detonator to the end of a circuit always take care that the other ends are insulated and in your sight, so that no one can join them up to a battery by mistake.

If laying out a charge from a ship or boat, the charge and circuit are always to be in the same boat. The charge having been dropped, the ends of the circuit are brought back and joined up to the battery. A charge when once fitted must never be tested until it has been dropped in the required position.

GUN CIRCUITS.

An electric circuit is fitted in the *Cerberus*, by means of which the turret guns can be fired either from the conning tower or from the turret itself.

The first is called the "Conning Tower" or "Director Circuit," and the second the "Local Circuit."

In each case an "Earth Circuit" is used, that is to say, a wire is led from the negative pole of the battery, through the firing keys and rubbing contacts, to one leg of the tube; the other leg is in contact with the hull of the ship, as also is the positive pole of the battery, the hull thus taking the place of the return wire.

The lead of the wires is as follows:—

From the negative pole of the battery a wire is led to one terminal of ~~three~~ firing keys, each side of the conning tower. From the other terminal of the starboard after key a wire is led

two

down under the water-line to the starboard half of the rubbing contact ring, this half being insulated from the port half of the ring by a piece of ebonite.

The whole ring is mounted on ebonite, and is attached to the turret spindle, so that it is incapable of movement. Attached to the turret itself is a brass spring contact, which is always bearing on the ring and moves round with the turret. If the guns are bearing on the starboard side, the spring contact is bearing on the starboard half of the ring; if on the port side, it bears on the port half.

From the spring contact a wire is led up into the turret, and branches in two directions to the gun branch boxes secured over each gun. The current then passes down one gun branch to one gun point, through the tube and back by the other gun branch to the hull of the ship, and so back to the positive pole of the battery.

To prevent the gun being prematurely fired from the conning tower a slot and bolt is fitted in the main gun branch, so that the circuit is broken until the order "Ready" is given. In order that the officer in the conning tower may know when any gun is at the ready, an instrument called a "Detector" is fitted in the conning tower. It consists of a 1,000-ohm galvanometer, the two terminals being joined up, one to the battery terminal of the firing key and the other to the two wires leading to either turret, and is fitted with a small switch so that it may be switched on to either turret at will. The galvanometer having a resistance of 1,000 ohms, it is evident that the tube in the gun will not fire, since we know that a 10-cell battery will only fire a tube through a resistance of 18 ohms; but the officer in the conning tower knows that a gun is ready by the deflection of the needle.

The circuit to each half ring of either turret is similar to the one already described.

~~The centre keys on either side connect the battery to both turrets simultaneously, and are used for firing all four guns together.~~

The several wires are distinguished by coloured bunting, as follows:—

From battery to firing keys—red.
From firing keys to gun branch boxes—blue.
Local circuit—yellow.

TESTING GUN CIRCUITS.

In testing a gun circuit it is not only necessary to see that the leads are in good condition, but also that the firing keys and connexions are clean and in good order. This is proved by the deflection of the galvanometer needle.

1. Place Menotti on shirt circuit, and note the deflection of the needle.

2. Disconnect the battery wires from the battery and join them up to the Menotti.

To test for continuity—

Place previously tested gun tubes on all gun points; see all slots and bolts disconnected, except on right gun in after turret; train the guns the starboard side and press starboard after firing key; on pressing Menotti key the needle should show the same deflection as on short circuit.

Disconnect slot and bolt of right gun and join up left gun, and proceed as before; ~~then test left gun with centre key~~.

Then test guns in fore turret in same way, and afterwards test both turrets on port side.

To test for insulation—

See all slots and bolts disconnected, and test after turret circuit by pressing ~~both~~ after key ~~and centre~~ key; the needle should remain stationary.

The leads to fore turret are tested in a similar manner, the turret being afterwards tested on the other broadside.

To set the dead points—

Make both guns ready in after turret, and press the after keys each side. Note the training of the turret when the circuit is broken, and also when again completed.

Do the same with the fore turret.

To test the firing keys—

Train the turret ~~on the~~ broadside, and switch the "Detector" to "On"; the needle of the detector should give a full swing on pressing the firing key, the detector needle should return to zero, and should show original deflection when firing key is eased up.

The circuit may be tested for continuity, and the dead points may be tested by means of the "Detector," keeping the firing battery joined up, but this should only be done in exceptional circumstances, as it is at all times unadvisable to keep a Le Clanché battery on circuit for any length of time.

The local circuit is fitted for firing the guns from the turret. The lead is as follows :—

An independent brass ring, similar to that used for the "Director" circuit, is connected to the hull of the ship; a spring contact rubbing on this ring is in connexion with the positive pole of the battery; from the negative pole a wire is led to one terminal of each of these firing keys, the other terminals being all in connexion with both gun branches; on either key being pressed, the current passes through both tubes to the hull of the ship, and so back to the positive pole of the battery.

The battery and circuit are tested in the same way as the director circuit.

In cutting off the lengths of the branches care must be taken that they are long enough to reach the vent easily, with the gun extreme trained to the right.

To the end of the branch wires solder on the gun points, then insert them through the hand holders No. 1, and having hauled them taut through, solder a brass washer on to each, close down to the hand holders, and put a turk's head on the wires the other side of them.

Then cut the return branch wire about 3 feet from the end, and attach the slot and bolt as follows :—

Clear the ends as for a junction, and reeve them through their holders, known as hand holders No. 2. Solder on the slot to the part with the gun point on it, and the bolt to the other part. Insulate with tape and solution, and haul the wire back so that the shoulders on the slot and bolt take against the holder. Seize a turk's head on the wire the other side of the holder. Then seize the two parts of the branches together.

When this is done the slot and bolt should be sufficiently separated to prevent their accidentally touching one another.

The other ends are then soldered to brass terminal plates, ready for placing on the terminals in the small compartment of gun branch box. Beckets are then fitted for hooking the branch up to the port and the fore sight of the gun.

When joined up, the wires are seized to a metal eye plate to prevent any strain coming on the terminals.

All junctions are made as described on page 57, but resin must be used instead of acid; this applies to junctions in all permanent circuits.

In consequence of the junctions of the branches with the fore and after being inside the casing, and therefore hidden from view (except at the periodical examination of the gun circuit), great care must be taken to insure, firstly, that the resistance shall not increase in time by the formation of oxides; and, secondly, that the insulation is perfect, as water may possibly lodge in the casings.

Only one holder is used for the gun points. Two holes are bored through it for the wires to reeve through, and it is fitted as already explained.

Where more than one wire has to be joined to a terminal of a firing key or battery, they must be soldered to a terminal plate, to prevent them accidentally being joined up to different terminals.

FUSES AND DETONATORS.

The principle on which all electrical fuses and detonators are constructed is that a current of electricity passing along a wire will heat it, the temperature to which a wire will be raised depending upon the nature, length, and thickness of the wire.

The result of various experiments has shown that an alloy of silver and platinum is raised to a red heat by the passage of a small current.

It is found that a quarter of an inch of this alloy will be raised to a bright-red heat by passing a current of one-third of an ampère through it, and that the wire itself will fuse by passing a current of five-ninths of an ampère through it, the wire itself being ·0014 inches thick.

The tubes and detonators employed in the service are of various forms and dimensions, but may be briefly described as consisting of two insulated copper wires passing through an ebonite or metal head, the wires being a quarter of an inch apart. The ends of these wires are called the poles of the fuse, and the platinum silver wire or bridge is soldered across the poles. The bridge is surrounded by fuse composition, which consists of a mixture of gun-cotton dust and mealed powder, contained in a case of suitable shape, the bottom being closed by a paper disc so as to keep the composition close round the bridge, the remainder of the fuse being filled with mealed powder; or, in the case of a detonator, it is filled with 25 grains of fulminate of mercury.

Now, supposing it is required to fire a gun, the tube is connected to the gun points and inserted in the vent; on the firing key being pressed, the current passes through the tube and heats the bridge to a sufficient temperature to ignite the fuse composition; this in its turn ignites the mealed powder, and the gun is fired.

The tubes, detonators, primers, blowing-charges, and cartridges used in the service are—

No. 10 tube, electric, for M.L. guns are supplied, 25 in a cylinder painted black.

No. 11 tube, electric dummy, for M.L. are supplied, 25 in a long tin cylinder painted black and yellow.

No. 19 disconnector, used for fitting charges for exercise, are supplied, 15 in a short tin cylinder painted black and yellow.

Tubes (V.S.E.), P. electric, for use with B.L. guns.

Tubes (V.S.E.), P. electric drill, for use with B.L. guns.

All vent sealing tubes are supplied in flat tin boxes painted black, 10 in a box.

Primers, electric, for 4·7 guns, are supplied in drab cylinders, 10 in each.

Blowing-charges, electric, for dropping gear, are made locally as required.

Cartridges, wireless impulse, 4oz. and $4\frac{1}{2}$oz., for discharging Whitehead torpedoes from tubes, are supplied 20 in quarter-metal lined cases; the primers for these are supplied separately.

Detonators, electric, No. 9, for exploding gun-cotton charges, are supplied, 25 in a tin cylinder painted red and yellow.

Detonators, No. 15, non-electric, for exploding gun-cotton charges with Bickford's fuse are supplied, 25 in a tin cylinder painted red.

Detonators for Whitehead torpedoes are supplied, five in small flat round tins painted black.

Cartridges for Bickford's fuse are supplied in small flat round tins, 25 in a tin, painted black; a special pistol is supplied for use with these cartridges and Bickford's fuse.

Bickford's fuse is supplied in round flat black tins, eight fathoms in each, and burns at the rate of one yard per minute.

Very's lights and pistols are supplied to each ship and torpedo boat.

All tubes and detonators must be tested in a place of safety before use, and are stowed in the gunner's store-room.

Care is requisite in handling them, as the bridge is easily broken or disconnected from the poles.

Great care must be taken in handling detonators, as they are highly explosive; they are stowed in tin cylinders—25 in a cylinder; each cylinder also contains a rectifier, which is used before inserting the detonator in the gun-cotton disc.

The cylinders and detonators are painted red and yellow.

They must always be tested in a place of safety, and must on no account be stowed in the magazine.

When refitting tubes the conducting wires must always be tested for non-contact before soldering the bridge across, after which they must be tested for continuity.

No. 15 detonator is not electric, but is used for detonating gun-cotton charges by means of Bickford's or the instantaneous fuse It resembles No. 9 in shape, but has no wires; the head is closed by a wooden plug, which on being removed exposes a strand of quick match leading down to the fulminate of mercury. One end of the instantaneous fuse is inserted at the head and secured by twine; when the flame has reached this end the quick match is ignited, which in turn ignites the detonating composition, and the charge is detonated. They are painted red, stowed in red cylinders—25 in each cylinder. In each cylinder of both No. 9 and No. 15 is a wooden rectifier, of the same shape as the detonator; it should always be used to enlarge the holes in the gun-cotton discs before inserting the primer.

When fitting detonators for detonating gun-cotton charges, it is sometimes found suitable to fit the detonators in series, and at other times to fit them in fork. In the first case, the current first passes through one detonator, and then through the other, and thus, although the resistance is doubled, it only requires one third of an ampère to fire them both; but if it should happen that the bridge of one detonator is broken, the whole circuit is broken, and neither detonator will fire.

If the detonators are fitted in fork, so that the current passes through both at the same time, then, although one detonator may be defective, still the other will be fired, and the charge will be detonated. In this case, the total current in the whole circuit must be two-thirds of an ampère, so that one-third may pass through each detonator.

The latter method is always employed in fitting outrigger charges, when the charge carried on the spar being small must always be close in contact to the ship's bottom before being exploded, and the shock caused by the contact is liable to break the bridge of one detonator.

The length of the bridge in all fuses and detonators is the same, namely, one quarter of an inch; and the resistance is 1·6 ohms.

Red signifies a detonator.

Yellow signifies for sea service.

White signifies for land service.

Black signifies high resistance bridge.

The explosive force of a detonator is considerable, and in using them certain precautions are therefore necessary.

1. Before joining up wires to a detonator, the opposite ends should be insulated.

2. Before testing they are always to be put in a place of safety, such as an empty 100-lb. case or the muzzle of a gun, and while soldering the junctions, they should be held in a similar place of safety with a pair of pliers, and the operation should only be performed by an armourer or other trained artificer.

3. On no account must a detonator be fired unless it is so placed that no person can be injured by the pieces, which often fly to considerable distances, a man having been badly cut by a piece of the tin at a distance of 70 feet.

4. No force should be used in inserting the detonator into the gun-cotton primer. If necessary, before inserting the detonator, the rectifier supplied for the purpose should be pushed into the hole up to the shoulder, and withdrawn by screwing.

5. Always handle detonators with the greatest care; never bring any strain on the wires, especially in withdrawing the mouthpiece from a primer tin.

6. No. 9 detonators are supplied in labelled tin cylinders, painted yellow and red, each containing 25 detonators and a wooden rectifier. These cylinders should not be opened until the detonators are required for use. Should a cylinder be opened, and all the contents not be expended, it should be again rendered air-tight.

Detonators are on no account to be placed in any magazine; they should be kept in the gunner's storeroom, or in a special detonator locker under lock and key.

No attempt is to be made to open a detonator.

Defective detonators should be invariably reported on, and when practicable samples should be transmitted home for examination, unless the failure can be clearly accounted for, as, for instance, if the detonator has become unmistakably damaged by moisture.

When placing a No 10. tube in the vent, care must be taken to see that it is inserted as far as the seizing, and the insulated wires bent as requisite just above it.

Electric gun tubes are always to be tested before use.

Should the supply of gun tubes be in danger of falling short, they may be refitted by fixing a new bridge of platinum silver wire in the same manner as for a drill tube; the head of a friction tube is then cut off, and the mealed powder cleared out of the upper quill, this quill is shipped over the ebonite head of the old tube, which is covered with a little shellac varnish. Care must be taken to select a quill that fits it accurately. Fill the quill with priming composition, taking care that it is completely filled by pouring in a small quantity at a time, and tapping the tube head gently on its side, then plug the end of the quill with a small piece of solid gun-cotton to prevent the priming composition leaving the bridge.

Next replace the lower part of the friction tube, sticking it with a little shellac varnish, and give the whole an exterior coat of any kind of varnish that may be at hand, "white hard varnish" being the best.

To refit a drill tube proceed as follows:—

Unscrew the plug from the head of the tube, scrape off the old paper disc from the outside of the head, wipe out and thoroughly dry the inside.

Examine the plug and terminal wires, and test the terminals for non-contract; the wires should be quite rigid in the plug; and should either or both of them be loose, they can be tightened by driving a small iron or copper wedge into the ebonite plug by the side of the terminals. This wedge can be easily made by pointing the end of a piece of wire with a hammer, and cutting off about $\frac{1}{8}$-inch of it.

Scrape the terminal wires with a knife, and with a fine file clean the extreme ends.

On a scrap of tin spread a few drops of soldering solution, touch the solution with the ends of the terminal wires, and tin them with a soldering iron that has been previously tinned; touch the solution again with the now tinned ends of the wire, stretch the platinum silver wire across from one terminal to the other, rest the soldering iron and touch the point of it again with the terminal and platinum silver wire, keeping the wire that forms the bridge above the point to be soldered to prevent the solder running along the bridge.

All the acid or moisture remaining on the wire should then be removed by carefully wiping or evaporating by heat, and the tube should be tested for continuity, then screw the plug into the head, and close the holes with the paper discs, and fill the head through the bottom with the priming composition, and screw in the stem, care being taken to see that the plug and stem are screwed home, as otherwise they are liable to blow off and do considerable damage; the tube should then be tested for continuity.

It is of the utmost importance that no acid or moisture be left on the wire forming the bridge, or inside the edge of the tube.

Care should be taken to keep the priming composition thoroughly dry, and to put it in a safe place whilst refilling the tubes, and not to use more than is necessary; 1 ounce being sufficient to fill 40 No. 11 tubes.

These fuses will be refitted in a similar manner to that detailed for a No. 11 drill tube, but after soldering and testing the bridge, place a small quantity of luting on the thread cut round the body, screw on the cap, fill with priming composition, then gum a paper disc over the hole, and lastly, coat the cap and lower part of body with shellac varnish.

The weight of the bodies of all the vent sealing tubes being so great in proportion to the strength of the conducting wires, great care must be taken in handling them, so that no undue strain may be given to the wires, and thus affect, and, perhaps, break the fine wire bridge.

Unscrew the outer and centre part of the body and see the gas escape holes clear; examine and test the wires for non-contact and continuity, solder on and test the bridge as already detailed for other tubes; place a plug of luting in each escape hole, screw on centre part of body, fill with priming composition, and then screw on outer part of body and test. Vent sealing drill tubes are supplied empty.

It is not advisable to fire these tubes outside the breech block, in consequence of their liability to burst if the escape holes get blocked.

All vent sealing tubes should be handled by their body and not by their wires.

These tubes will be refitted as follows:—

Unscrew the metal cap, solder the bight of a piece of P.S. wire to the centre spindle, and the two ends to the standards on casing, taking care to leave the wires a little slack; then fix a small piece of cork under the wires, and fill the body with priming composition, place a small quantity of dry gun-cotton over the wires, screw on the cap, and fill up the tube with priming composition through the hole in the cap, which is then closed by a disc of cork, and made watertight with varnish.

These tubes screw into the base of the metal cartridge case.

As every electric tube or fuse contains sufficient composition to do serious injury if fired close to the person, special care is to be taken when firing them.

Electric tubes, &c., may fail from the following causes:—

1. If the bridge is broken, it is evident the current will not then pass, as the circuit through it will be incomplete; this can be guarded against by careful handling, and the continuity of the bridge can be ascertained by testing and balancing.

2. If the priming composition does not surround the bridge, the latter may be fused without igniting the composition; this can be guarded against only by properly filling in the manufacture; it is one of the chief reasons that two detonators are used in every charge, so that chance of failure is thereby much reduced.

3. Should the priming composition be damp it will not ignite, and therefore cause failure; this is guarded against in the manufacture, and by keeping them in hermetically closed cylinders when in ships and in store.

Fuse composition consists of two parts of gun-cotton dust mixed with three parts of mealed powder, and is supplied in 2-oz. bottles which are supplied six in a wooden box.

EXPLOSIVES.

Gun-cotton is manufactured from ordinary cotton waste, treated with nitric and sulphuric acid; by this means the nature of the cotton is entirely changed. When all the excess of acid has been washed out by boiling and being washed in alkalies, the gun-cotton is reduced to a very finely powdered pulp; it is then compressed into convenient shapes and sizes, and is supplied either in a wet or dry state; the dry gun-cotton is wetted by adding 17 per cent. of its weight of fresh water to it for use in the war head of Whitehead torpedoes and 20 per cent. for all other charges.

Dry gun-cotton is supplied in tin cylinders, each containing four 9-oz. discs, the total weight being $2\frac{1}{4}$ lbs., also in copper cylinders for Whitehead primers, each containing six 1-oz. discs.

Wet gun-cotton is also supplied in discs of the same size, but stowed in a tin cylinder, the total weight of gun-cotton being $16\frac{1}{4}$ lbs. The $16\frac{1}{4}$-lb. tins are supplied in wooden boxes two in a box.

The primer tins both full and spare are supplied in wooden cases of 10 in each.

The Whitehead primers are supplied in wooden boxes, six in a box, with extractor and screw-driver.

All gun-cotton must be tested—the wet yearly and all plugs removed, the dry during the first six weeks in each half year. The dry—to see that no decomposition (due to the presence of any free acid) is taking place; and the wet—to see that the water has not evaporated.

The dry is tested by means of blue litmus paper, which has the peculiar property of turning red when in contact with any acid. The tin being opened, the two upper discs are taken out; drop two or three drops of fresh water (which must be previously tested with the litmus paper) on one disc; on this place a piece of the paper, and then press two tin discs together. If the colour of the paper remains unaltered the gun-cotton is correct, if the paper turns red the gun-cotton must be immediately wetted. The tins containing the wet gun-cotton cannot be opened, but a plug is screwed in at one end, which must be unscrewed to allow any gas to escape.

The tin is then weighed, and should correspond with the weight marked on the label; if under weight, fresh water must be added; if over weight, the plug must be left out and the water allowed to evaporate.

The explosive force of gun-cotton is six to eight times that of gun-powder.

It cannot be exploded by means of an ordinary gun tube, but must be detonated by means of fulminate of mercury; detonation is simply a very rapid explosion, and by using a detonator the whole of a charge is immediately turned into its component gases. It ignites at a low temperature, but then will only burn very rapidly without explosion.

Wet gun-cotton will not burn, but may be detonated by using a large amount of fulminate of mercury, or by using a small detonator in a charge of dry gun-cotton in close contact with it. This is the means usually employed, and the tins of wet gun-cotton are fitted with two holes through them, the centre one being to take the spar when firing outrigger charges, and the one at the side is to take the tin of dry gun-cotton, the discs surrounding the hole being cut away so as to fit closely round it.

The end of the wet tin which is fitted with the screw is thinner than the other, and when using two tins they must be placed with the screw ends together, so as to insure the contents of both tins being detonated.

The advantages of gun-cotton or any explosive that requires detonation is it does not require a strong case for its full force to develop in, and in the case of gun-cotton does not require keep ing dry if used at once, except for the primer.

DYNAMITE.

Dynamite consists of an earth called Kieselguhr which has been saturated in nitro-glycerine. This liquid is formed by treating ordinary glycerine with nitric and sulphuric acid, much in the same way as gun-cotton is treated. It is a highly dangerous explosive, and, if used in its natural state, would explode if shaken in a bottle, but if carried about in the form of dynamite is moderately safe. Its explosive force is about the same as gun-cutton. It is supplied in 2-oz. and 6-oz. rolls, wrapped up in water-proof paper. It should never be handled with the fingers, as the nitro-glycerine penetrates into the blood, causing violent headaches. It is not suitable for submerged charges unless enclosed in a watertight case, as the water washes the nitro-glycerine out of the Kieselguhr.

Dynamite can be detonated by detonating a small charge of dry gun-cotton in close proximity to it, but they need not be in actual contact with one another. Dynamite cannot be used for detonating gun-cotton.

If water has been in contact with dynamite, it must be carefully handled and thrown away, as it is probably charged with nitro-glycerine, which will float on the surface.

FULMINATE OF MERCURY

Is manufactured by dissolving mercury in nitric acid. Alcohol is then added, and fulminate of mercury will be deposited in fine crystals. It is one of the most violent explosives known, and must be treated with the utmost care, as a violent shake has been known to explode it. It is supplied in No. 9 and No. 15 detonators, and is used solely for detonating gun-cotton and dynamite charges.

SPAR TORPEDOES.

INSTRUCTIONS FOR FITTING.

1. Join up an earth-plate, and lead to single-test battery and galvanometer, and test through; the deflection should not be less than 80°. Ascertain that the conducting wires are of such a length as easily to reach the battery when the torpedo is in the firing position; a double length of 40 feet will be found sufficient.

2. Test the conducting wires for non-contact, continuity, and insulation; then insulate the battery ends.

3. Test two No. 9 detonators singly, putting them in a place of safety before doing so.

4. Reeve the legs of the two detonators up through the mouth-piece, with their heads on the same side as the heads of the bolts, and join them up in fork by crossing their legs outside.

5. Join the legs of the detonator to the conducting wires, keeping the insulated battery-ends of conducting wires in sight during the operation.

6. Place the mouth-piece in an empty primer-tin, in a line with the strengthening band, and screw up the nuts with the spanner supplied for this purpose, taking care that it is done uniformly, so that the iron plate does not touch the tin anywhere, or the india-rubber disc will not bear evenly against it. Submerge the primer-tin for one hour to a depth of at least 20 feet, and, whilst submerged, test the junctions of detonators for insulation; then re-insulate the battery ends of wires; if the tin is dry when opened it is ready for filling.

N.B.—In removing the mouth-piece no strain must be brought on the legs of the detonators.

7. Remove the lid of the filled primer-tin, take out the wad and gun-cotton, transferring the gun-cotton to the primer-tin which has been tested, except one disc; into which carefully insert the detonators. Then place this disc and the mouth-piece in the primer-tin together, and screw up.

The detonators should never be forced into the gun-cotton. If there is any difficulty in placing them, the rectifier should be inserted right up to the shoulder.

8. Secure the shifting iron end to the spar with the bolt and nut supplied, place the wooden disc over it, and then the two

cases of damp gun-cotton, with the ends fitted with screw plugs together, taking care that the holes for the primer-tins are not in one line. Insert the primer in the inner case, put on the iron cone, and screw up the nut; then stop the wires to the pole, and reeve them through the groove.

9. Test the three-cell boat's firing battery by fusing four parts of P.S. wire through the resistance of the test-coil, or, if no coil is available, by firing four drill-tubes in fork through an outrigger circuit.

SPAR TORPEDO ATTACK.

To insure everything being correct, as soon as the boat has been rigged, shove off without the firing battery, and, having rigged out the spar, the circuit should be tested for continuity and insulation, and the spar again rigged in.

The boat should then receive the firing battery, which should be joined up in its place by No. 1, and the manhole door to the after compartment of boat screwed up.

No. 1 then takes the wheel.
No. 2 attends the slip lanyard.
No. 1 presses firing key.
Length of spar—42 feet.
Least horizontal distance of charge—33 feet.
Depth of charge—10 feet.
Angle of contact—10° before and 15° abaft.
Weight of gun-cotton (wet)—Two $16\frac{1}{4}$-lb. tins.
Weight of dry primer—$2\frac{1}{4}$ lbs.
Detonators—Two No. 9 detonators.

N.B.—The test battery, test coil, and a torpedo work-box should be taken away in the boat to repair damages.

A $2\frac{1}{4}$-lb. tin is as much gun-cotton as should be used for exercise from a second-class boat.

FITTING CHARGES.

The routine for fitting all charges is to be observed as laid down to the end of paragraph 7 for spar torpedoes; the detonators being fitted in fork or series as required.

If using armoured cable the test for non-contact is omitted, and in paragraph 5 the armouring connexion takes the place of one of the conducting wires.

In this case it amounts to the same thing as using an earth circuit.

Precautions to be Observed.

When laying out defensive mines or charges of any sort.

1. When laying a defensive mine, see that the end of the electric cable is insulated with tubing and in charge of some responsible person.

2. See that there is no firing battery in the boat.

3. Always, when possible, drop the mine, and then pay the cable back to the ship or station, never leaving the end in the ship or station whilst the mine is in the boat unless absolutely necessary to do so, in which case the end of the cable should be secured to G flag, and triced up in a position visible from the boat laying the mine and cable.

In any case the end of the cable should remain insulated with tubing, and not be joined to a test battery, test table, or firing battery till everything is well clear of the loaded mine.

4. When blowing charges have to be attached to a mine after the mine has been laid out, the precautions in paragraph 3 are always to be carried out, and the wire from the mine to which the charge is to be attached should be long enough to reach the surface of the water. When required, the charge is laid at a safe distance and then joined up to the mine.

5. On no account allow a loaded mine to be tested unless in a place of safety; this caution also refers to testing a mine field when there are boats about.

6. After a charge or mine is laid it should never be handled or picked up, whether it has failed to explode or not, until the end of the cable is insulated, and either in the boat which is handling the charge, or triced up in view as mentioned in caution 3.

7. If it be required to pick up a mine with a blowing charge attached, this should first be crept for, picked up, or cut adrift from the mine, and the ends insulated, before attempting to pick up the mine. This caution applies strongly to the electro-mechanical mines.

8. When the mine is laid, if intended for exercise and loaded, its position should be shown by a conspicuous red flag secured to a buoy which is securely attached to the loaded mine.

9. If the mine is intended to be fired by bumping a detached circuit closer, at least 500 feet of conducting wire should be used to connect mine with circuit closer, and 100 yards should be the least admissible distance of mine from circuit closer.

10. The boat detailed for bumping should be in charge of some responsible person, who should never bump the circuit closer unless proceeding in a direction away from the loaded mine.

11. A mine should always be tested before attempting to fire it, and if it misses fire it should again be tested if practicable in order to assist in determining the cause of the failure, the same safety precautions being taken as if the mine had not been attempted to be fired.

12. Mechanical or electro-mechanical mines must be kept upright and handled gently, the latter being as far as possible kept dry.

Where the withdrawal of a safety-pin or the joining up a wire circuit renders the mine dangerous the operators must be at a safe distance.

13. All batteries and wires should be tested before use, and a record kept of their state.

Information required respecting batteries and wires to be employed when laying out charges.

Type of Cell or Battery.	E.M.F. in Volts.	Internal Resistance.	Tests for.
1 boat's cell ...	1·5	·2	To fuse or redden one part of Pt. Ag. wire on short circuit
3-cell battery ...	4·5	·6	To fuse one part through 3·5 ohms
10-cell battery ...	15·0	2·0	To fuse one part through 18 ohms
Menotti test ...	1·0	30 to 100	To give a swing of 80° on short circuit

Current required to redden or fire a fuse, $\frac{1}{3}$rd ampère.

Current required to fuse a 25-inch bridge of Pt. Ag. wire, $\frac{5}{9}$ths ampère.

Conductivity resistance of a 25-inch bridge of Pt. Ag. wire, 1·65 ohms.

Conductivity resistance of one mile of N.S. wire = 10 ohms.

Resistance of all bridges to fuses, detonators, primers, &c., used in the naval service, 1·65 ohms.

DYNAMOS.

In order to produce the current required to burn a search light, a machine called a "Dynamo" is employed. Before describing the machine it will be necessary to describe the properties of some of the principal parts.

A magnet is a bar of iron or steel which has the property of attracting small pieces of the same metals; and also, if suspended freely, will lie in a certain line called the magnetic meridian.

It is found that this attracting force is not equal at all parts of the magnet, but is strongest close to the ends, and disappears altogether in the centre.

The positions of the two points where the force is greatest are called the poles of the magnet; that end which points towards the north being called the "North Pole," and the other end the "South Pole."

To ascertain whether a bar has been magnetized or not, bring it close to a suspended magnet; then if one end attracts the north pole of the known magnet the other end should repel it.

A short rule for this is—

Like poles repel one another, unlike poles attract. The line midway between the two poles is called the "Neutral Line."

The space surrounding the magnet in which its effects can be felt is called the "Magnetic Field" of that magnet. A strong magnet has a large magnetic field, and a weak magnet a correspondingly small field.

The attracting force is supposed to act along certain lines of curves joining the poles; these lines are called the "Lines of Force" of that magnet.

For purposes of description and to enable certain definite rules to be laid down, the lines of force are always supposed to start from the north pole and run into the south pole, so that if we speak of facing the lines of force we face the north pole of the magnet. In the same way, if two magnets are lying parallel to one another, with opposite poles opposite to one another, the lines of force are supposed to flow from the north pole of one into the south pole of the other.

A steel or iron bar may be magnetized by winding insulated copper wire round it and joining the two ends of the wire up to a battery; this is then called an "Electro Magnet," and possesses exactly the same properties as an ordinary magnet, the end which is the north pole being determined by the following rule :—

Place yourself in the conductor; swim with the current; face the bar; and the north pole will be on your left hand.

In the case of the steel bar it will become permanently magnetized, but a soft iron bar will only become a magnet so long as the current is flowing.

Faraday discovered that if a conductor were revolved in a magnetic field so as to cut the lines of force, then a current would flow in that conductor.

This is the whole principle of a dynamo machine.

The magnetic field is produced by two or more electro magnets with their poles arranged round the arc of a circle. Inside the circle revolves the conductor, which is called the armature, and consists usually of many turns of insulated copper wire wound on a drum, revolved by means of a steam-engine. All that is now required is to conduct the current which is produced in the armature away to the search light or incandescent lamps.

In order to do this the ends of the several coils or sections of coils are connected to a corresponding number of copper strips, insulated from one another, built round the spindle of the armature; this arrangement is called the "Commutator." Two copper brushes bear on the commutator, and are so arranged that they are always bearing on two strips opposite to one another. The conducting wires are connected to these brushes—the one by which the current passes out of the machine being called the positive brush, and that by which it passes back after passing through the external circuit being called the negative brush.

In all dynamos a portion of the current produced in the armature is made to pass round the field magnet coils; these being made of iron are only slightly magnetized when the machine is at rest, but after a small number of revolutions of the armature the current produced by passing round the field magnets magnetizes them up to their full strength, and the machine works at its full power.

The machines in the *Victoria* and *Albert* are called "Compound Wound Machines." The current produced in the armature has two paths open to it.

1st. From the $+^{ve.}$ brush round the field magnets by a moderately thin wire and back to the $-^{ve.}$ brush. This is called the shunt wire.

2nd. From the + ve. brush round the field magnets by a thick wire to an independent terminal; from this a wire leads to the search light, and the current returns by a similar wire to another terminal in connexion with the – ve. brush. This is called the series wire.

These machines are so constructed that, with a given number of revolutions there will always be a certain E.M.F. or difference of potential between the brushes.

These machines are wound to give an E.M.F. of 55 volts. The current flowing through the circuit depends solely upon the resistance in the circuit; if the carbons of the search light are in contact with one another the resistance is very low, and consequently the current becomes a strong one.

Now, the series wire is only thick enough to take a current of 50 ampères; anything over this tends to heat the wire, melt the insulation, and so damage the machine, so that care is necessary when burning the light to prevent this.

The search light is produced by the heating of two carbon rods (by the passage of the current) to an intense white heat; these rods are contained in an apparatus called the hand lamp.

The current from the dynamo is led by means of a wire to a spring stud on the pedestal; the projector has a corresponding brass ring on its underneath side, so that as the projector is turned round the stud is always bearing on the ring; the ring is in connexion by means of an insulated wire with a brass rubbing piece inside the projector. There is a similar arrangement for the other wire. When the hand lamp is placed inside the projector a contact piece on either side bears up against the rubbing piece. One contact piece is connected by means of an insulated wire to the holder of the lower carbon, the other one being in connexion with the upper carbon holder. So that when the machine is working the current starting from the + ve. brush passes round the field magnets to the + ve. terminal, passes up by one wire to the spring stud, on to the brass ring, to the rubbing connexion between projector and hand lamp, passes through upper carbon to the lower carbon, and back by similar connexions to the – ve. pole of the machine.

The upper carbon is called the + ve. carbon, the lower one being called the – ve.

PART III.

ELECTRIC LIGHTING.

TESTING DYNAMO MACHINES.

The principles of testing may be applied to any type of machine when they are once thoroughly understood. The principal tests are *non-contact*, *continuity*, *insulation*, and *polarity*. First, test the battery and two short lengths of wire.

Disconnect leads from machine terminals.

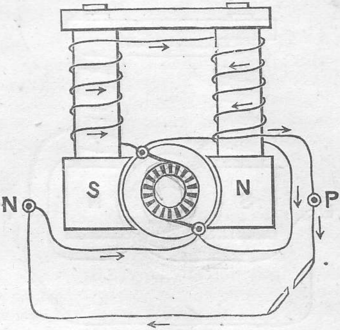
Non-contact.—This test is only necessary in the case of "compound" machines, to ascertain if there is any contact between the "shunt" and "series" magnet coils. Disconnect both ends of the "shunt" and "series" magnet coils (unless it can be done, as in the Victoria dynamo, without actually interfering with the wires), and join up the battery terminals to one end of each, leaving the others insulated in the air, test. If there is a contact, which would be shown by the deflection of the needle, localize the fault by testing separately between each pair of coils on the same core.

Continuity.—I. Series Machine. Join up battery to machine terminals, put switch to "on" and brushes on commutator; test. If there is a break, localize the fault by testing separately the armature and magnet coils.

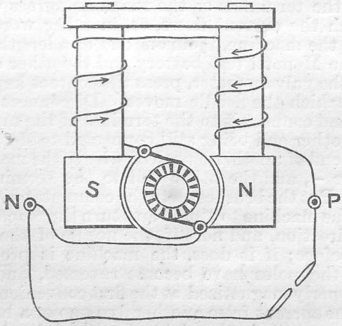
II. Shunt and Compound Machines. Disconnect shunt magnet coils, and test main and shunt circuits separately.

Insulation.—Disconnect the battery from one terminal of the machine, and connect it to the iron frame, and in the case of "shunt" and "compound" machines rejoin up the shunt coils; test. If there is a leak, localize it by testing separately the armature and the magnet coils, both "shunt" and "series," according to the type of machine.

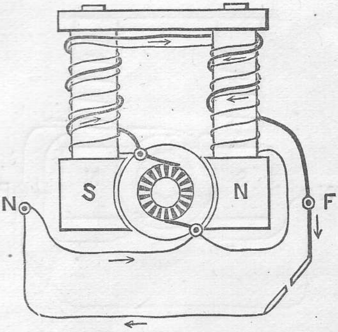
SHUNT WOUND DYNAMO.



SERIES WOUND DYNAMO.



COMPOUND WOUND DYNAMO.



Polarity of Machines.—In order to ascertain whether the marking of the terminals of the machine agrees with the direction in which the current flows, or, in other words, to test the "polarity of the machine," join one end of a length of wire to the + pole of the Menotti test battery and the other end to the free terminal of the galvanometer, press the contact key, and note the direction in which the needle moves. Disconnect the wire from the + pole and connect it to the terminal of the machine marked P or +, the other end being still connected to the galvanometer. Connect one end of another length of wire to the machine terminal marked N or −, and the other end to the terminal of the galvanometer. Put the brushes on to the commutator, put the switch (if fitted) of the machine to "on," and turn the machine by hand in the proper direction, and note if the needle of the galvanometer deflects as before; if it does, the machine is properly marked, but if not, the poles have become reversed, and the machine should be properly magnetized at the first convenient opportunity, by sending the current from another dynamo or a battery through the field magnet coils in the right direction, viz., in the case of a series machine by connecting the + terminal of the other machine or battery to the — terminal of the machine whose polarity is to be reversed and joining the other terminals similarly. Put the switch to "on" and put the brushes on the commutator. On working the other machine or completing the battery circuit the current generated will flow through the field magnet coils of the machine to be corrected, and will magnetize the field magnets in the proper direction.

In the case of a shunt machine, by connecting the + terminal of the other dynamo or battery to the positive terminal of the machine whose polarity is to be reversed, and similarly joining the two negatives, and proceeding as before.

In the case of a compound machine it is advisable to disconnect the ends of the shunt coil, and proceed to correct as for a series machine, or it can be done with the shunt coil by proceeding as in the case of a shunt machine, by connecting up to the detached ends of shunt coil, instead of to terminals of machine.

When the polarity of a machine has once been ascertained to agree with the markings of the terminals, the pole pieces should have their polarity marked on them, as then it can always be checked by any compass needle.

Until convenient to correct the polarity, the machine can be used for search lights as it is, by altering the leads from the terminals.

Testing an Inclined Hand Lamp.

Join up the test battery to the lamp terminals.

Non-contact.—Separate carbons; test. If there is a contact, which would be shown by the deflection of the needle, the lamp must be examined, and, if necessary, taken to pieces.

Continuity.—Bring carbons together; test. If there is a break, localize the fault by testing separately the different parts of the lamp.

Insulation.—As the frame of the lamp forms part of the circuit, there can be no no insulation test.

Testing Search Light Circuits.

1. One projector only.

Place the lamp in projector, disconnect the leads from machine terminals, and join them up to test battery.

Non-contact.—Put switch to "on," and separate the carbons; test. If there is contact between the leads, which would be shown by the deflection of the needle, it can be localized.

Continuity.—Bring the carbons together; test. If there is a break, test separately each lead and projector.

Insulation.—Disconnect the battery from one lead, and connect it to hull or earth; test. If there is a leak, localize it by testing separately each lead and projector.

2. Two projectors in divided circuit.

Place lamp in each projector, disconnect the leads from machine terminals and join them up to test battery.

Non-contact.—Put switches of both projectors to "on," and separate carbons; test. If there is contact between the leads, localize as above.

Continuity.—Leave switch of No. 1 projector at "on," and bring carbons together, putting switch of No. 2 projector to "off;" test. Next bring switch of No. 2 projector to "on" and carbons together, putting switch of No. 1 projector to "off;" test. In either case, if there is no continuity, the break must be localized by trying separate parts of the leads, observing it will probably be at some connexion.

Insulation.—Disconnect the battery from one lead, and connect it to hull or earth, bring carbons of each lamp together, and put both switches to "on;" test. If there is a leak, localize it as before.

Where a switch-board is fitted, the necessary connexions to these circuits must be made before testing.

X

Management of Machines when Running with Search Lights.

When not running the brushes should be removed from the commutator, and the switch put to "off."

When required to burn a search light the engines are started at a slow speed, and the brushes put on to the commutator; the speed should then be increased to the normal speed, the

X None at present in Service

throttle-valve being opened wide and the speed controlled by the governor. The switch is then put to "on," and the machine is ready for burning the light.

If violent sparking occurs at the commutator it may be due to the brushes not being in their right position or not bearing hard enough on the commutator, or from roughness of the commutator or brush, or from an excess of current caused by short circuiting, or, if it occurs at one strip of commutator only, that strip has probably become disconnected from the coils.

The electro-magnet coils and armature should not be allowed to get hotter than the hand can easily bear when touched. Re ducing the speed will remedy this.

If anything radically wrong occurs electrically, such as very violent sparking, short circuiting, or heating, immediately put the switch to "off."

If anything radically wrong occurs mechanically, stop the engine.

"Short circuiting" the machine may be caused by any conductor falling across two parts of the circuit or by keeping the lamp carbons closed. Its effect is to increase the load on the engine, aud unduly heat the coils of the field magnets and armature, which in time would cause the insulation to be melted and burned off the wires. Special care should therefore be always taken that this does not occur, the projector being the most likely place, as so many parts of the circuit are there exposed.

When the light is finished with, it should be put out by gradually stopping the engine instead of switching to "off," as the latter way throws a greater strain on the engine; and again, if it is necessary to put out the light while running, either to insert new carbons or from other causes, it is better to do so by *gradually* separating the carbons instead of switching to "off."

Never remove a brush from the commutator whilst the current is flowing, unless the brushes are fitted in halves, when one-half may be lifted and the whole current sent through the other.

The engine should always be controlled by the governor valve.

It is advisable not to approach a dynamo when running with one's watch on, as it is liable to be magnetized and so put out of order.

Management of Projector and direct current Search Light with Inclined Hand Lamp.

When not in use the switch on the projector should be at "off," and the carbons of lamp separated. Before burning the light the mirror should be cleaned from dust and moisture to prevent loss of light, using a feather duster, and a chamois leather only, for this purpose.

The carbons should be properly secured in the holders in such a manner that they are in line and the points in focus. The lower or negative carbon should be pointed before fixing it in the holder.

The carbons should never be left touching each other, as it might short circuit the machine.

When the machine is reported ready, and is running at its proper speed, put the switch to "on," bring the carbons together and immediately separate them. This should establish the arc. If the arc is not established, or if it fails at any time, bring the carbons together and separate them as before.

The goodness of the light depends to a great extent on the purity of the carbons and on their proper management; to the latter point too much importance cannot be attached.

To *obtain* a steady search light, it is first of all essential that the positive or upper carbon should have a well-formed crater, and that the negative, or lower carbon, should have a symmetrical and somewhat pointed end, the actual degree of pointedness being dependent chiefly on the nature of the carbon employed.

The necessity of a symmetrical negative is of primary importance, for on it depends the formation of the positive crater, for although it is generally assumed that the current flows from the positive carbon to the negative, the *appearance* of a good voltaic arc, when observed through a coloured glass shade, distinctly points to a flow of current streaming off from the point of the negative to the crater of the positive, which it *seems* to embrace, and this appearance bears a striking analogy to the flame of a blow-pipe directed on a piece of charcoal, which raises the latter to a state of incandescence, in a crater-like formation, which the flame embraces as in the arc light.

The greater part of the light emitted in a search light is that due to the crater, and a good crater must therefore be aimed at to obtain the same result.

With regard to the relative positions of the carbons, as a rule, with a good pointed formation of the negative, they should be in line with one another. It was for some time considered that the upper carbon should be somewhat behind the lower, in order to bring the crater well to the front, and this was necessary if the carbons were vertical, but with the inclined hand lamp, the crater is always formed on the front, due both to the inclination and to the tendency for the flame to rise and scour it out.

Again, it is found undesirable to bring the crater too far to the front, for although a temporary advantage is gained, yet it will be found that a good crater cannot be maintained when the front of the carbon becomes scoured out too much, the result being in the end unsteadiness, flaring, and possibly extinction of the arc, and it will be then necessary to re-form the carbon to produce the normal crater, a process taking some time, during which the light is inefficient.

As a rule the stream of current which *appears* to flow from the negative should just strike the lower edge of the upper carbon at the back, and the upper edge at the front.

Again, to obtain the above results, it is necessary that the carbons should be a definite distance apart, this distance varying with the particular machine used, with the reserve of the E.M.F., with the current employed, and with the particular carbons used, but in each case it is well defined.

The actual distance apart in any case is determined by that position which, with the above conditions of carbons, produces a "silent" arc. If the arc be shorter there will be hissing, excessive flame, badly maintained crater, a button formation on negative carbon, excessive current, lower E.M.F., unsteady and inferior light.

If the arc is too long its strength gets weak, it is easily extinguished, the light from the crater is not so great, and the current is reduced.

The actual distance between the centre of the crater of the positive carbon and the point of the negative will be found to vary between $\frac{1}{4}''$ and $\frac{3}{8}''$ in the case of our ordinary search lights.

The effects of bad carbons, and of wind playing on the projectors, considerably interfere with the successful production of a good light, and at times give great trouble, rendering frequent adjustment of the upper carbon holder necessary.

In the case of a bad positive carbon it is difficult to form a symmetrical crater; it becomes pitted and irregular. In the case of a bad negative carbon it is difficult to maintain a pointed formation, and the apparent flow of current often streams off from around the sides instead of the point.

To maintain a steady light the carbons require careful attention, and should be watched through the red glass spy-holes at the back and side. Looking through the former shows the crater, and through the latter that the points of the carbons are in focus vertically.

To keep them in focus horizontally, work the screws beneath the projectors and observe the beam; the rays should not cross one another when the carbons are in focus, but project an almost parallel beam of light. To keep them in "focus vertically" in case the carbons do not burn away proportionately it is necessary to raise or lower them together by means of the handle at the side of the hand lamp; if the carbons are out of focus vertically the section of the beam of light is irregular.

By these precautions, with the help of the adjusting motion or the upper carbon, a proper arc and focus should be easily maintained.

If the leads are joined up to the machine incorrectly, that is so that the positive carbon would be the lower one, the light would burn badly, and if this is suspected put out the light by separating the carbons, and the hottest carbon will be the positive one.

If either of the carbons break and the pieces fall in the projector and short circuit the lamp, immediately put the switch to "off," remove the broken pieces, and replace the carbon in the lamp.

Nothing whatever should ever be left in the projector whilst the light is being burnt.

The ventilation of the projector case should not be impeded during the working of the light by any covering used to protect it from the weather.

"Cerberus" Ammeter.

This instrument is made to fix against a wall or bulkhead with its base in a vertical position. From the terminals stout metal bands are led to a solenoid of thick insulated copper wire placed with its axis horizontal. A light steel spindle is pivoted so as to lie parallel to, and a little to the left of, the axis of the coil. It has attached to it a thin curved plate of soft iron; this piece of iron is nearly equal in length to the spindle, and extends through the length of the solenoid. A light aluminium pointer is also fixed to the spindle at right angles, and the spindle is so weighted that in the absence of a current the pointer is held in the zero position by the force of gravity.

Action.—When a piece of iron is placed in a solenoid, but out of the centre, the effect of a current is to bring the iron towards the centre. Therefore a current passing through the coil of the instrument, in endeavouring to rotate the curved piece of iron into the centre, raises it against the force of gravity through a distance depending upon the strength of the current. The pointer attached to the spindle travels, therefore, over the scale which is placed behind it, and thus indicates the strength of the current passing through the instrument.

This instrument requires to be calibrated.

Defects for ship's use.—It gives unreliable readings, due to the fact that the ship is not always upright, and the greater the list or more the ship rolls the more unreliable will be the readings.

Voltmeter.

Is constructed on exactly the same plan, except that the solenoid is replaced by a long spindle of insulated wire of high resistance.

Defects for ship's use.—(*a*) The same as in the ammeter. (*b*) The wire of the spiral or coil being small and of high resistance, a current passing through it heats the wire and increases its resistance, and consequently a given electro-motive force will send a weaker current through the coils after they are heated than before. *The instrument will therefore indicate a lower electro-motive force than that which actually exists,* in consequence of the fact that it measures the electro-motive force by the strength of the current set up by that difference.

In the latest pattern projectors the back with the rim holding the mirror is secured to the cylinder by a bayonet joint over four studs, so that it can be easily unshipped, if thought necessary, to prevent the possibility of breakage by the concussion from fire of heavy guns; when in place it is prevented from accidentally moving in the bayonet joint by a spring catch over one of the studs. To facilitate removal of the front glass door, for the same reason, the pin through the hinge is made with an eye at the top, so that it can easily be withdrawn. It is probable, however, that if the front of the projector be turned away from the guns it will not sustain any damage even with the mirror and glass door in place.

Diverging lenses, similar to those previously supplied, but much stronger, owing to the glass segments being made thicker, are supplied with some of the projectors. The lens has a divergence of 16° which will sufficiently illuminate a boat at 1,200 yards. In addition to this each flagship and depôt ship carries a lens giving a divergence of 30°, which gives a good light up to about 500 yards.

Electrical Measuring Instruments.

There are two descriptions of instruments in general use for ascertaining the condition of electric light circuits.—(1.) An ammeter to measure the amount of current flowing. (2.) A voltmeter to measure the electro-motive force which causes the current to flow.

The "ammeters" are connected up in the circuits of each machine in such a way that the whole current requiring to be measured passes through them, and they are therefore placed in the main wires from the dynamo terminals. The plan which has generally been adopted was to arrange one ammeter to measure the current from either machine as required.

The voltmeter is placed in circuit by connecting one terminal of the dynamo to one terminal of the instrument, and the other to the other.

The wires used for these connexions do not require to be large, Naval Service wire being suitable for the purpose.

Dynamo of H.M.V.S. "Cerberus."

Compound wound.
Current capacity, 90 ampères.
Electro-motive force, 60 volts. to 110 volts
Number of revolutions, 350 per minute.
Pressure of steam, 60 lbs.
Candle power, 18,500.
Foremost light required. Foremost switch down, after switch up.
After light required. After switch down, foremost switch up.
Both ammeters are in circuit on each occasion. Centre switch down in both cases.

* Dynamo of Gunboats "Albert" and "Victoria."

Long-shunt compound wound dynamo, by the Australian Electric Light Company.
Current capacity, 60 ampères.
Electro-motive force, 55 volts.
Number of revolutions, 800 per minute.
Pressure of steam, 60 lbs.
Candle power, 13,000.

Dynamo of Torpedo Boat "The Countess of Hopetoun."

Long-shunt compound wound machine.
Current capacity, 50 ampères.
Electro-motive force, 80 volts.
Number of revolutions, 690 per minute.
Pressure of steam, 100 lbs.
Candle power, 8,000.
Artificial resistance, ·25 ohms.

Dynamo Torpedo Boat "Childers."

Series wound machine.
Current capacity, 10 ampères.
Electro-motive force, 60 volts.
Number of revolutions, 1,600 per minute.
Pressure of steam, 90 lbs.
Candle power, 2,000.
Armature ring, All the other armatures are drum.

* Yard arm light - Incandescent lamps of 66 volt
switch & cut out under foremost projector pla[illegible]

TORPEDO PRACTICE, ETC., TO BE CARRIED OUT.

When to be done.	Nature.	Remarks.
Monthly ...	Test all circuits, batteries, and instruments.	To be tested the first week in each month, and also before use.
Quarterly...	Work each search light. Rig net defence. Examine india-rubber discs, &c., of Whitehead torpedoes. Run Whiteheads from boats ... ... Test lightning conductors for continuity.	At least 12 runs.
Half-yearly	Test dry gun-cotton ... Re-charge test batteries. Examine all Whitehead discharging apparatus. Balance lightning conductors. Dropping gears parted and cleaned.	To be carried out the first week in each half-year.
Yearly ...	Weigh wet gun-cotton, and remove screw-plugs. Weigh warheads of Whitehead torpedoes, and remove screw-plugs. Renew all india-rubber rings, discs, &c., of Whitehead torpedoes.	
Triennially	Internal examination of air chambers of Whitehead torpedoes.	

NAVIGATION FOR TORPEDO BOATS.

Place of Departure.	Destination.	Course.	Distance.	Leading Marks.
			Miles.	
Gellibrand Lightship	West Pile	S. by W. $\frac{1}{4}$ W.	20·5	
"	South Channel ...	S. by E.	28	
"	Governor's Reef ...	S. by W. $\frac{3}{4}$ W.	19	
"	Steamboat Buoy, Geelong	S.W. $\frac{1}{2}$ S.	$22\frac{3}{4}$	
West Pile	Swanspit	S.S.W.	$4\frac{1}{4}$	
Swanspit	Point King ...	S.E. by S. $\frac{3}{4}$ S.	...	Buoy No. 4R on with Swan Island Beacon, or Sorrento, just open of Point King
Buoy No. 5B, South Channel	Pinnance Channel ...	N.E. $\frac{3}{4}$ N.	2	Sorrento Jetty on with No. 4 red
Buoy No. 6R, South Channel	Rye Pier	S.E. by S. $\frac{1}{4}$ S.	3	Red light, fixed, visible three miles
West Pile Light ...	Clear Beacon, Symond's Channel	E. by S.	3	
Clear of beacon, Symond's Channel	Buoy No. 15B, South Channel	S.E. $\frac{1}{2}$ S.	8	

* Not very safe at low tide: least water, 8 feet.

NAVIGATION FOR TORPEDO BOATS.

NOTE.—Red Buoys have to be left on starboard hand bound in.

—	Clearing Marks, &c.
South Channel ...	South Pile and Arthur's Seat in line E. $\frac{3}{4}$ S.
Cole's ,, ...	Buoys Red in line S. $\frac{1}{4}$ W.
South ,, ...	Starboard side, Buoys No. 2 to 8, Red; port side, Buoys No. 1 to 15, Black; No. 11 being a gas buoy, Green; No. 15 gas buoy, White occulting.
West ,, ...	Starboard side, No. 2 to 16, Red; No. 12 being a gas buoy, White.
,, ,, ...	Port side, No. 1 to 7, Black.
Swan Island Depôt ...	Turn off at No. 3B, West Channel, coming from Pile Light.
Pope's Eye Shoal ...	Striped B. and W. Buoy S.W. of annulus.
Queenscliff Piers ...	Shallow water to the northward.
Sorrento Channel ...	Coming from Queenscliff, keep B Buoy on starboard hand and close to; steer down for R Buoy off pier, passing it on starboard hand; then leave B Buoy on port hand; pass close by Red Buoy off the Sisters on right hand; keep white cliffs on port bow, and make B Buoy off Canterbury Pier, leaving it on port hand; keep South Pile on port bow, and make No. 13 Buoy, South Channel.
Pinnance Channel ...	From No. 5B Buoy (South Channel), through Pinnance Channel N.E. $\frac{3}{4}$ N. 2 miles (Sorrento Pier on with No. 4 Buoy).
Channel to Rye Pier (Red light)	From No. 6R Buoy (South channel) S.E. by S. $\frac{1}{4}$ S.

From Swan Island round Pope's Eye through South Channel and back through West Channel, 29 miles.

From Swan Island round Pope's Eye through Capel Sound and back by West Channel, 31 miles. N.B.—In going through Sorrento Channel, boat must go at reduced speed.

Pope's Eye to South Pile, 8 miles.

Swan Spit to Pope's Eye, 2 miles.

ENTRANCE TO GEELONG.

BUOYS.

Red Cone Buoy, off Kirk Point, in 18 feet.

Red Cone Buoy, with perch (steam-boat buoy), off Wilson Point, in 18 feet.

Red Cone Buoy, with perch, end of Wilson Spit.

Striped B and W Buoy, on 20 feet perch, W.S.W. of Wilson Spit Buoy.

Black Buoy (2), Bellarine, south of Wilson Spit Buoy, in 20 feet.

Red Cone Buoy, with perch, at entrance to artificial cut.

Red B.B. on northern side of artificial cut.

Black Barrel Buoys (2) on southern side of artificial cut.

ENTRANCES TO GEELONG.

New Ship Channel.—After rounding steam-boat buoy, steer up ~~for light-ship~~ until beacons in channel are in line, then steer through keeping beacons on starboard hand.

South Channel.—Steer up for Red Cone Buoy artificial cut, and keep it and Red buoy on starboard hand till beacons are in line, then haul through from thence straight course to piers.

LIGHT, RANGE, AND VISIBILITY.

Name of—	
West Pile ...	Shows Red on left-hand side of West Channel round by St. Leonards up to Prince George's Bank Buoy. Shows White the remainder.
South Pile ...	White Sector from Beacon, north end of Symond's Channel, round westerly nearly to White Cliff. Red Sector, from close on White Cliff, round southerly to No. 13 buoy. White Sector over No. 15 buoy (gas).
Arthur's Seat ...	White Sector over No. 15 buoy (gas) to close along shore by Rye Pier. Red Sector shows to northward, coming from Gellibrand, and clearing gas buoy.
High Light ...	White Ray over Beacon, Symond's Channel, round by South Channel and entrance to Lonsdale Bight.
Low Light ...	Red Sector up to entrance of West Channel, White Ray clearing mark on left-hand side of South Channel, and passing close to Pope's Eye Buoy. When light changes to Red Sector, leading mark out through Heads.
Lonsdale Light ...	Red Sector (light red) over Corsair and Lonsdale Rock. Red Sector (deep red) clears all dangers inside of Point Nepean. Green Sector, leading in from seaward until low light Red, and high light White, leads you up.
Lightship, Geelong	White light, fixed, visible all round.
Light, South Channel, Geelong	Red through Channel. White Sector between steam-boat and Wilson Spit Buoy.
Drysdale Light ...	White, fixed.

By Authority: Robt. S. Brain, Government Printer, Melbourne.

CARE OF TORPEDOES.

(*a*) A pressure of air should always be kept in torpedoes which will indicate if the different joints are tight, the propellers being clamped, the engines run with air periodically.

(*b*) If possible, the different parts of the torpedo should be oiled and propellers turned by hand once a week. This must be done every day after a torpedo has been in the water until it is parted.

(*c*) Attention must be paid to the state of the indiarubber rings and discs in use; the discs should be examined every three months, and at shorter periods when torpedoes are exposed to great heat.

(*d*) Indiarubber gear must be kept free from oil or grease, and French chalk should be used to prevent it from sticking when making a joint.

(*e*) Spare discs and rings are supplied, packed in French chalk.

(*f*) Care to be taken that none of the oil used to clean the torpedo gets on the indiarubber rings or gear of the torpedo.

(*g*) All springs to be kept eased when not in use. When turning propellers by air, pressure must be reduced to below 500 lbs.

(*h*) It is most important that the buoyancy and balance are properly drained, as any water or moisture left in the chambers soon sets up galvanic action.

The drain screws cannot properly get rid of the water, therefore in II.* the cap on top of balance should be removed; put in the long screw and turn the torpedo over and allow all the water to drain out. In Marks IV. and V. Fiume the torpedo should be worked about to try and get rid of the water.

Water in no case should be allowed to lodge on the brazing.

Advantages of above-water Method of Discharge.

(1) It can be fitted to any ship or boat at comparatively small expense.

(2) In the case of tubes they can easily be fitted to train and elevate.

Disadvantages.

(*a*) Exposure to hostile fire, which is an increasing disadvantage owing to the development of the Q.F. gun.

(*b*) The blow of the torpedo on striking the water strains it, more particularly the tail and propellers, and therefore renders the torpedo liable to be put out of adjustment.

The force of the blow increases with the height of the tube above the water, the velocity of discharge, the speed of the ship, and any reduction in the inclination of the axis of the torpedo taking the water. This disadvantage is overcome in later torpedoes by having stronger tails, and also an air-delay valve.

Side Suspension Discharge.

Above-water tubes are fitted on the side suspension principle, the torpedo has two side lugs, one on each side nearly abreast its centre of gravity, and the weight of the torpedo while being shot out is taken by these lugs which travel in two strips or grooves inside the tube called the side-suspension grooves. These grooves extend the whole length of the tube.

On the torpedo being discharged when the side lugs slide out of the outer end of the grooves the nose of the torpedo begins to drop, and to prevent the tail being damaged, the underneath part of the outer end of the tube is cut away.

A sufficient impulse must be used to make the tail go clear of the lip.

Universal Tripper.

The Universal Tripper (see plate) consists of the tripper bolt A, tripper box B, a spring, and the lever C for raising the bolt A. It is fitted on the left upper side of the tube, the centre of it being $\frac{3}{4}$ of an inch from the centre line of the tube; the bolt is notched (see Fig. II.) to clear the tail of Fiume torpedoes. A collar D is formed on the bolt, against which the spring presses; the collar should be a loose fit in the box to prevent the possibility of the bolt being kept momentarily up by the pressure of impulse.

There is a slot in the head of the bolt A to prevent it being put in the wrong way; the other end of the slot is closed.

Care in Testing.

It is important that the spring should be a strong one; it should, therefore, be carefully tried before firing; it should be $3\frac{1}{4}$ inches long before compression, and with a weight of 40 lbs. should be compressed $1\frac{5}{8}$ inches.

Effect of a Weak Spring.

If the spring is weak and does not act quickly, there is a chance of the air-lever of the torpedo not being thrown aft, as when the tail of the torpedo is against the stop the part of the torpedo abreast the air-lever is of less diameter than it is under the tripper.

The face of the tripper in 14-in. torpedo is 6 feet from the face of the door.

The bolt should stand down $\frac{8}{20}$ of an inch below the liner for Mark VIII. R.L. and Fiume torpedo.

Advantage of Powder over Air Impulse.

Great saving in weight and simplicity in the fitting and working of the tubes. It is independent of the air service and pumps which may be shot away or break down without putting the tubes out of action so long as the torpedoes are charged; no liability to fail (especially in the dark) through leaky joints or faulty gauges.

Disadvantages.

The liability of the charge to be drowned by wet; the necessity of an electric circuit and battery to fire the charge, which may fail unless carefully attended to, especially in wet weather; not being able to vary the velocity of discharge to the same extent as can be done by air; the pressure on the torpedo is greater with powder than air for the same velocity, and the velocity of discharge is not quite so uniform; also the torpedo tubes need careful cleaning after practice to prevent corrosion from the products of the combustion.

Advantage of Powder over Air Impulse.

In the pattern of powder impulse used in C— of H—, called powder-impulse, with wireless cartridge, the defects just mentioned have been overcome, viz., the liability of the charge to be drowned, and with watertight battery and contacts the chance of failure is reduced to a minimum.

Door for Wireless Cartridges.

The new pattern powder impulse door (see plate) consists of a breech block B cast on the door A, and the rear end of the breech C is closed by a flap F hinged on one side and worked to and fro by a handle H. The breech C is closed at the fore end, except for eight holes D which are made in it for the escape of the powder gas into the torpedo tube.

The Cartridge.

The cartridge E of the base on an empty 3-pdr. Q.F. cartridge case, containing 4 or $4\frac{1}{2}$ ozs. of pebble powder closed at the front end by means of a water-proof cardboard disc, with a brass tube running up the centre to hold the electric tube G, which ignites the powder from the front through the gas escape holes.

How packed.

The cartridges are supplied with the wireless electric tube G in place, and are stowed in metal-lined cases, 20 in each.

The Wireless Electric Tube.

The tube G, which fits tightly in the central brass tube of the cartridge contains some priming composition which is ignited by a P.S. bridge of the usual description. This bridge is soldered between two wires, one of which is attached to the metal case of the tube, thus forming an earth, and the other end is attached to an insulated wire which passes through an ebonite plug in the brass end of the tube, terminating in a copper knob insulated but projecting from the end of the tube.

How supplied.

These tubes are supplied in the cartridge, and 50 per cent. additional are supplied in tin boxes, 10 in each, for testing purposes.

The Flap.

The flap F which closes the breech is prevented from being accidentally opened by the spring catch J. It contains a spring plunger K (carefully insulated from the flap), the point of which bears against the knob of the electric tube, completing the circuit from the handholder L when it is inserted in the slot of the cap M. To insure a good contact between the face of the handholder and the plunger K, after insertion it is jambed by giving it about one-eighth of a turn to the left; this revolves the screw cap M, pressing the face hard up against the plunger, and prevents it from being shaken out by vibration.

Watertight Contact Box.

The watertight contact box fitted on tubes for the wireless cartridge (see plate) consists of a spring contact B worked by the firing rod, and are arranged so that when the lever is pulled the contacts B comes between the metal strips C. This completes the circuit to the tube which ignites the cartridge. The battery and wires are also in a watertight box and casing.

The lever must on no account be eased up before the torpedo starts, otherwise the stop will be replaced, and when the impulse acts it will break the tail off.

Care of Tubes.

After using powder impulse, and after using three or four rounds, the torpedo tube should be carefully washed out with fresh water, and thoroughly cleaned.

ADVANTAGES OF DANN'S DROPPING GEAR.

(*a*) It insures the torpedo dropping into the water upright whatever heel the boat may have, it being arranged that the torpedo always hangs vertically, whether the gear is turned in or out.

(*b*) The tongs are close together, thus one pattern is sufficient for all 14-in. torpedoes; this always allows the tongs to grip the torpedo in a stronger part.

(*c*) It insures the tongs opening out together, and thus to drop the torpedo flat in the water.

(*d*) Certain and easy method of adjustment of the tripper.

POINTS TO BE LOOKED TO WITH DROPPING GEAR.

(*a*) That the torpedo is held so as to lie exactly parallel with the line of keel when turned out to the firing position.

(*b*) That the inclined planes do not lift the spreaders until the tripper has thrown the air lever back.

(*c*) That the spreaders cannot lift while they are in place.

(*d*) That the tongs grip the torpedo lightly and allow of no upward motion.

POSITION OF GEAR IN BOAT.

The position of the gear in the boat is important, as if it is too far forward the torpedo will deflect considerably outwards, and if too far aft it may deflect inwards, and possibly endanger the boat.

In most cases, however, there is a small deflection outwards which must be allowed for on the director—it is very constant for the same boat.

OUTWARD DEFLECTION.

This deflection has the disadvantage of preventing both torpedoes being fired at the same time, as if two torpedoes are dropped together from a boat, one will go on each side of a mark.

PRECAUTIONS ON FIRING.

For accurate practice, it is necessary that the torpedo is dropped flat in the water, so as to prevent an abnormal dive.

If a torpedo is dropped tail first, there is more tendency to dive than by dropping it very slightly by the nose.

This (*i.e.* dropped flat) can only be insured by the tongs fitting accurately, and the spreaders being set up equally tight, but not unduly so.

MANAGEMENT OF TORPEDO BOATS.

On torpedo boats being mobilized it is most important that all stores, ammunition, and torpedoes are placed on board in the most rapid manner. The boats coaled, steam raised, all engines tried, torpedoes charged and tested, and every precaution taken so as to be ready for immediate service.

Preparations before leaving Harbor.

Boats on leaving to make an attack should be prepared in every way to meet an enemy's ship at any moment. The torpedoes should be charged for action, adjusted for longest range, controlling gear (if used) locked and adjusted. Depth adjusted according to the ships likely to meet; it may be advisable to adjust one torpedo for a shallow run, in case of meeting a torpedo catcher. Torpedoes set to sink. Pistol fitted and screwed in. Circuit tested by firing a tube. Directors shipped, and adjusted for speed of torpedo.

Precautions for keeping Torpedo ready.

The torpedo should be topped up with fresh air every day, and oftener if requisite, to insure torpedoes running their full range. The pressure of air in the torpedoes can be gauged by screwing the gauge into the discharging nozzle, and then screwing the nozzle into charging socket.

Care of Small Arms.

Particular attention should be paid to the cleaning and preservation of small arms, batteries, electrical contacts, and torpedoes, which are liable to be seriously injured by salt water and the damp from the sweating of the iron surface of the boat; and the tubes in C. of H. should be frequently sponged out.

General Rules for Manœuvring Boats.

(1) The rule of the road is to be observed to avoid collisions, except that boats always get out of the way of ships. No ship ever gives way to a torpedo boat.

(2) A look-out is to be kept on the leading boat. If she makes any movement without signal the other boats of the flotilla are to regulate themselves thereby, in order to keep their appointed stations. The safety of the boats composing a flotilla depends on accurate station-keeping, and the greatest care is to be taken on this point.

(3) Should any boat be unable to keep proper station she is not to persist too long in endeavouring to do so, but is to haul out of line and form astern, doing all she can to keep up with the rest.

(4) In a fog or at night to keep touch the leader will sound his fleet number on the steam or mouth whistle, each boat following in succession.

(5) Boats altering course together are to preserve their compass bearing and distance, being guided by the movements of the boats to which they turn to avoid fouling.

(6) Boats altering course in succession are to preserve formation. When a large turn has to be made, following boats should be careful not to turn inside of the next ahead.

(7) No boat to pass through a column or between the lines.

In close order, length apart, distance between column to be number of boats × 2.

In open order, boats to be four lengths apart.

N.B.—For boat's length read 136 feet.

Attacking Ships under Weigh.

Boats attacking a ship under weigh should always attack from well before the beam; by this means the time under fire is comparatively short, and the bearing and distance of the boat changes so rapidly as to reduce the chance of being hit very considerably, as compared to attacking from abaft the beam. The disadvantage is that a better look-out will be kept before the beam than abaft it.

A boat on being discovered by a single ship may expect the ship either to ram her or to run away and so keep the boat longer under fire. Torpedo boats being chased and overtaken should, on a pre-arranged signal, scatter either by division or single boats, the boats opening out two points on either side of the leader. This will necessitate the enemy's ships opening out also, and thus one ship will be required for each boat. Any boat being then overtaken should, directly the enemy gets within 2,000 yards range, turn round and attack her, first seeing everything ready for firing, the speed of the boat giving a good guide to the enemy's speed.

Care to be observed when Attacking.

For all night attacks invisibility and noiselessness are of the most vital importance to insure success. Boats should therefore approach, particularly when near the enemy, at a dead slow speed until discovered; careful stoking is most necessary; the fan must never be used, as the mere sign of sparks from the funnel would probably put the ships on the alert. Even with good stoking, if the coal supplied is not of the best quality flames are at once shown from the funnel.

Lanterns and lamps below should be very cautiously used. All hatches should be kept shut, and painted dead black inside.

The enemy's guard boats should be avoided as much as possible; and, as it is important to keep the boats well in hand, the rear boats only should attack them and try and run them down.

Boats lighted up by the search light ought to remain in the beam, to prevent it being thrown around and other boats discovered by it.

As a rule it would be unwise to continue an attack if discovered at some distance from the ship.

A rendezvous in any case is most necessary, as perhaps one or more attacks might be attempted the same night.

Single line ahead is probably the best formation for attack, the leading boat turning and firing her torpedoes at the beam of the nearest ship, and then turning out to clear the other boats, the second boat passing her and firing at the next ship.

Torpedo boats are of very little use as scouts, as from their low freeboard their range of vision is so limited.

Tests and Precautions before running a Torpedo.

Before a torpedo is run it is necessary that the following points should be looked to :—

No water in any of the chambers, also that there are no leaks.

No air leak in balance chamber, or from the engine-room.

(2) That the horizontal rudders are square with each other, and that the rudder adjustments are correct by the history sheet, that the servo-motor is working correctly, and there is no backlash in the rudders.

(3) See the adjustment of the vertical rudder is correct.

(4) That the tail has been gauged.

(5) Air lever examined.

(6) Test the counter to see that it works correctly, and that the controlling gear is released at the proper distance.

(7) Oil every place marked "Oil," also the counter stopping arrangements and controlling gear.

(8) Propellers have been blocked and are the correct diameter.

(9) Turn the propellers by hand to see that the connecting rods or shafts are not bent.

(10) If for exercise, see the sinking gear is properly disengaged and the valve on its seating.

Causes of Failures to run.

Tripper not standing down the correct distance.

Tripper wedged up by mistake.

Tripper spring weak.

Collar on tripper bolt too good a fit in box, and the spring thereby failing to act quick enough to push it down before the air lever has passed it.

Stop not withdrawn.

Miss-fire due to a defective cartridge.

Circuits not correctly joined up.

Firing key or lever eased up too soon.

Air lever bent, either down, sideways, or broken.

Air lever shaking forward, due to a weak friction spring.

Connecting rod between the air levers broken.

Mark IV. Fiume.—Clutch of connecting rod not engaging pin on air lever, probably due to a weak spring.

Water tripper not thrown back on striking the water.

Tail or stopping spring not compressed; or firing premature, due to a defect in trigger.

Engines not free to revolve owing to a bent connecting rod, &c.

Loss of air pressure in air chamber, due to leaky valves.

Torpedoes not charged, either due to leakage of air, forgetting to charge, or omitting to open stop valve when charging.

Stop valve closed.

Reducing valve jambed "up" so that the ports are closed.

Causes which affect the Depth Keeping of Torpedo.

The adjustment of the controlling gear, and if it fails to release or does not do so at the proper distance.

Reducer working stiffly.

Leaky servo-motor, slide valve, or piston; the packing of cylinder end leaky.

Temperature of the water.

Balance chamber mechanism not correct.

Air leak in balance chamber.

Water in either of the chambers.

Diving rod bent or broken.

Pointed pin connecting diving rod to the cross-head for the horizontal rudders working out or broken.

Gab rod disconnected.

Indiarubber discs perforated.

Causes of a Torpedo curving.

Vertical rudders not adjusted correctly, or not properly clamped.

Horizontal rubbers not square with each other.

Dents.

Injuries to tail frame.

Air leaks.

Reducing valve not working evenly.

Propellers out of pitch.

Shafting not in line.

Bent connecting rods.

CAUSES OF TORPEDO RUNNING AWAY.

Rust or dirt under starting valve.
Failure of stopping gear—

1st. With Counter Gear at the Tail.

Weak pawl for counter wheel.
Stud on worm or counter wheel broken.
Teeth on worm wheel stripped.
Trigger bent.
Right wire broken or disconnected.

2nd. With Counter in Engine-room.

Weak spiral spring of ratchet.
Weak back pawl.
Burr on teeth of ratchet or on teeth of wheel.
Air lever bent or jambed under the shell of torpedo Mark IV. Fiume. Water tripper not disengaged from connecting rod when aft.
Counter broken.

PLANS, ETC.

The plans and figure spoken of in these additions are to be found in Whitehead Room.