VICTORIAN NAVAL FORCES.

TORPEDO MANUAL.

WHITEHEAD TORPEDOES.

1889.

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TORPEDO MANUAL.

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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-foot 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. If fitted for exercise, this copper case is removed and replaced by a wooden dummy charge of the same shape, but two pounds lighter. 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 14), 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.

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 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 water-tight 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.

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 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 stopping 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.

Length—14 feet 7 inches.
Speed—19 knots.
Number of yards per tooth of counter—40.
Pressure—Exercise, 750 lbs. Action, 1,000 lbs.
Weight of dry gun-cottton—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.

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 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.

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.

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 is placed outside the Engine-room.

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. It is not suitable for exercise.

THE 19-FOOT 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 94 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-Foot.

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—94 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.

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 in to 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 between slabs of cork in tin cylinders. These cylinders must not 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, and examined and found watertight.

(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.

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 ten 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 2,240 lbs. per square inch, and will charge a reservoir of 10 cubic feet to a pressure of 1,500 lbs. in 30 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.

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 $2\frac{5}{8}$ 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—

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. If there is any air in the torpedo, the gauge will register it. 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 outlet valve is closed, 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. The gauge should be tested before the pipes are disconnected.

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. In all the others the rudders are locked in the required position, for any required distance within a hundred yards.

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 Victorian Naval Service—

(1) If firing from a stationary boat or up to a speed of six knots. In the R.L. torpedo, lock the rudders "up." In the Fiume and 19-foot, lock the rudders $\frac{1}{16}$-inch "up" for 30 yards.

(2) Between 6 and 12 knots, leave rudders free.

(3) Above 12 knots.—In R.L., lock rudders "down"; in Fiume and 19-foot, $\frac{1}{16}$-inch "down" for 30 yards.

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.

DRILL FOR TORPEDO BOATS.

MARK IV. AND V. FIUME.

The crew will consist of two men.

At the order—"Action,——yards range,——feet deep"—

The numbers will provide their tools as follows:—

No. 1. Wrench for air-inlet plug, air stop-valve key, spanner for depth, pointed pin, and box spanner for controlling gear, small screwdriver for range, charging pipe, nozzle and spanner, spanner for reducing valve.

No. 2. Screwdriver, oil feeder, box spanner for oil screw in Tail, spanner for screwing on Pistol (at exercise holder for Holmes light), nose and tail lines.

When the tools are provided, No. 1 will lift vertical fin clutch, and give the order—"Launch back."

When air-inlet plug is clear of tongs, he orders—"Well," then—"Charge torpedo." At this order—

No. 1 removes air-inlet plug, and, assisted by No. 2, screws in charging nozzle, and connects charging pipes.

Then adjusts range, depth, reducing valve, and controlling gear as ordered, and takes clips off propellers.

No. 2 fits and screws in Pistol or Holmes light, as ordered, and fills both oil bottles, while No. 1 is turning propellers ahead.

When torpedo is charged, No. 2 disconnects charging pipe from nozzle; No. 1 removes nozzle, and replaces air-inlet plug.

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

The torpedoes will be charged in the following order:—

Starboard after, port after, starboard foremost, port foremost.

If Armed with R.L. Torpedoes.

The same, except—

No. 1 provides wrench for air-inlet plug, spanner for depth, spanner for cocking tail, box spanner for reducing valve, charging pipe, nozzle, and spanners.

No. 2, pin screwdriver, ordinary screwdriver, oil feeder, spanner for screwing in Pistol, Holmes light holder, nose and tail lines.

When all torpedoes are charged and adjusted, the officer of the boat will give the order—"Trim torpedoes."

At this order—

No. 1 mans after-winch handle, and removes davit securing pin.

No. 2 mans foremost winch-handle, and removes davit securing pin.

When torpedo is trimmed into first position, No. 1 orders "Well." Nos. 1 and 2 screw in securing pins, and put the pawls down; No. 1 then sees sinking lever forward (unless otherwise ordered), engages air-lever tripper, and puts counter-spring pawl to "In."

No. 2 inserts blowing charge, closes blowing-box door, and inserts gun points.

At the order "Ready"—

The numbers man the winches as before, and the torpedo is trimmed out to the firing position and securing pins screwed in.

No. 1 (if using R.L., removes air-lever safety pin), then removes firing-bar safety pin.

No. 2 takes out Pistol safety pin, or tears strips off Holmes light, then joins up slot and bolt of firing gear.

At the order "Stand-by"—

No. 1 plugs up for his own torpedo, (seeing other plugs out), and turns catch to "Fire."

At the order "Fire," No. 1 presses firing key, keeping it down for at least fifteen seconds, then removes his plug and turns catch to "Safe."

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 aud 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 off tail line, puts counters 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"—

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

TORPEDO MANUAL.

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.

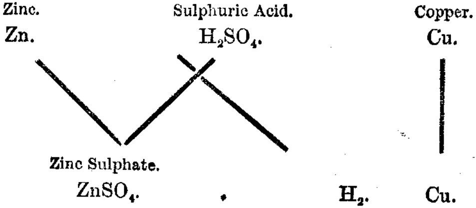
THE SIMPLE CELL.

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.	Per. Oxide 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 ampères, 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 Ohm's 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.

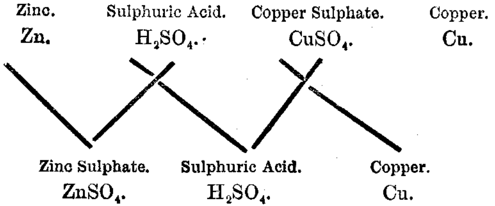
Ohm's Law is better expressed as—

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

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—



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 re-built. 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 two sizes, called the Ship's Cell and Boat's Cell, but both are of the same construction and consist of—

(*a*) An ebonite containing vessel.

(*b*) A zinc plate.

(*c*) The carbon element.

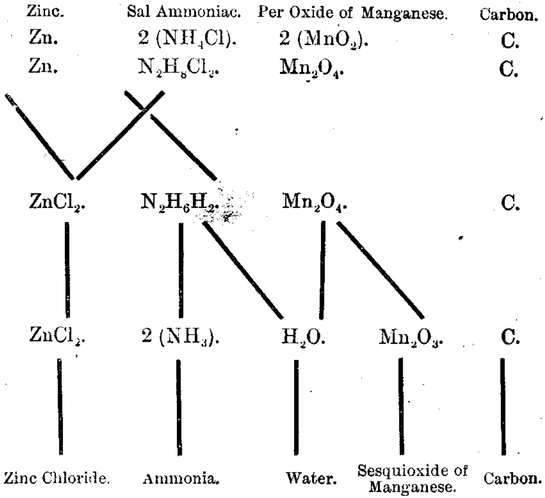
The carbon element consists of a plate of carbon, which is encased in a wooden skeleton framework; on the shelves of this framework are packed per-oxide of manganese and granulated carbon, the whole being encased in a fearnought bag.

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 two 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, or 24 ozs. in 4 pints of hot water for a ship'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 per-oxide 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 give 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.

As an example of this, the plates of a Ship's Cell are exactly four times as large as those of a Boat's Cell, but they are the same distance apart, so that the internal resistance of a Boat's Cell being ·2 ohms, the internal resistance of a Ship's Cell is only ·05 ohms, the E.M.F. of both being the same, namely, 1·5 volts.

Besides the Ship's and 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 per-oxide 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 small current through a fuze, &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 three 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 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.

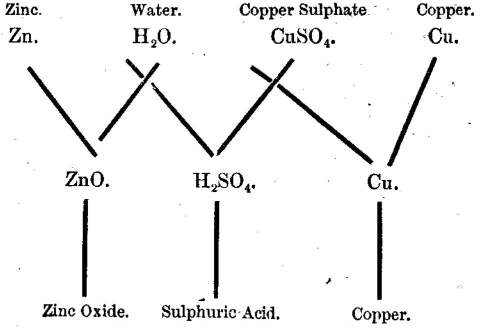
The requirements of a Test Battery are—

(1) It should be portable.
(2) It should be constant.
(3) It should not under any conditions be possible to fire a fuze 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 fuze.

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 four parts of P.S. wire	Through $\frac{9}{20}$ ohms resistance.
Ten boats' cells -	To fuse one part -	Through 18 ohms resistance.
One ship's cell -	To redden 24 parts	On short circuit.
Six ships' cell	To fuse one part -	Through 14 ohms.
Test battery -	To give a swing of 80	On short 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.

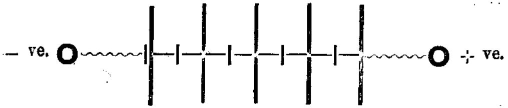
By joining up in this way we get a high E.M.F., because the cells are, so to speak, backing each other up, and the E.M.F. of the whole battery will be equal to the E.M.F. of one cell multiplied by the number of cells in series.

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.

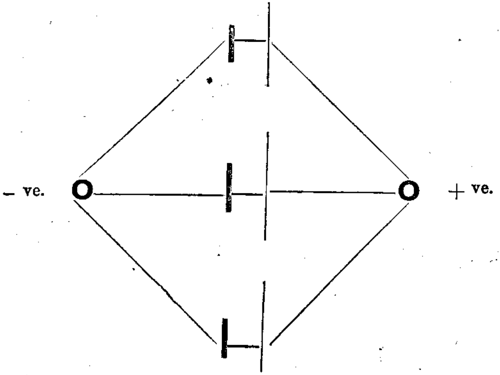
To join cells up in quantity (or abreast). All the carbons are connected to one terminal, which becomes the positive terminal of the battery, and all the zincs are connected to the other terminal, which becomes the negative terminal of the battery.

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.

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

By Ohm's 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.

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

or—

$$11{\cdot}6 + n\,1{\cdot}5 = 4{\cdot}5\,n$$
$$11{\cdot}6 = 3\,n$$
$$3{\cdot}8 = n$$

Therefore the least number is 4 cells.

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

GALVANOMETERS.

A Galvanometer is an instrument for detecting the passage of a current through any circuit, the principal 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.

This is done by means of a magnet, which is placed in the magnetic meridian, with its north pole opposite to the north pole of the galvanometer needle, thus neutralizing the earth's force.

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.

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 core 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 is 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 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.
Firing keys to starboard half rings—blue.
Firing keys to port half rings—red and blue.
Local circuit in turrets—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 short 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 test 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 three 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.

GUN CIRCUIT FOR B.L. GUNS.

The Bow and Stern Guns of *Victoria* are fitted with an electric firing circuit, the former gun being also fitted with night sights.

The circuit for bow gun is as follows :—

From battery to one strip of a double slot and bolt.

From this strip through the pistol to the corresponding strip.

From this by a wire through gun points and tube to a safety connexion, which is put in circuit when the needle holder is in position, but is automatically broken when the needle holder is removed.

From this by a wire to another safety connexion, through which circuit is made by closing the locking lever, to another safety arrangement, which comes in circuit when the breech is closed, and so back by a wire to the other pole of the battery.

The return wire from the pistol is also fitted with a slot and bolt, which must be connected before attempting to fire the gun.

The circuit for the sights is the same as far as the pistol, but when the pistol is at the ready a circuit is completed to a third wire which is in connexion with the sights.

When the pistol is fired, or half cocked, the sight circuit is broken and they go out.

Circuits are also fitted in the torpedo boats for firing the torpedoes electrically.

One pole of the battery is in connexion with the firing key, and from here leads are taken to the upper half of plug plates on either side of the conning tower; from the lower halves leads are led to the gun points on either side, a common return being in connexion with the other pole of the battery.

To fire either torpedo, all that is necessary is to plug up the corresponding plate and press the firing key.

Whenever an earth circuit is used, the slot and bolt are always put on the main gun branch; if this were not done, it is possible that the bolt might be touching some of the ironwork of the ship; if the firing key were pressed, the circuit would be completed, and the gun would fire.

When using a complete wire circuit, the slot and bolt are always on the return branch, so as to make a break on either side of the tube.

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 or 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.

Farraday 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 two 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 connection 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.

They are constructed of pure compressed carbon, with a light copper coating to increase their conductivity.

When desired to burn the light, start the machine slowly, then put the brushes on the commutator, bring the carbons together, and put the switch to "On"; then slowly separate the carbons about a quarter of an inch, or until the light is burning without noise. Separating the carbons is termed "Striking the Arc," and when burning without noise is termed a "Silent Arc." It will be observed that while the lower carbon burns away to a point a crater is formed in the upper one. This crater is the principal source of light, and for this reason the carbons are inclined at an angle, so that the light from the crater may be thrown on to a curved mirror at the back of the projector; the rays strike the mirror at all angles and are reflected back in parallel lines, and thus form a condensed beam. To get a good beam the crater must be in the focus of the mirror. To obtain this the hand lamp is worked backwards and forwards by a screw underneath. If it is desired to spread the rays out so as to cover a greater area the lamp is screwed outwards out of the focus.

To get a good light the carbons must be adjusted so as to lie on the same straight line. This is done by a small screw on the top, which gives lateral motion to the + ve. carbon. By another screw close to it the upper carbon may be moved backwards and forwards, so that the crater is formed on that side of the + ve. carbon which is nearest to the mirror.

When the light is no longer required, always ease the machine down to slow speed before switching to "off."

TESTING MACHINES AND LAMPS.

Since the field magnets of a compound machine are wound with two distinct wires, called the Series and Shunt Wires, they must be tested for—

(1) "Non Contact," *i.e.*, to see that the two wires are not touching one another.

(2) For "Continuity," *i.e.*, to see that the copper core is not broken.

(3) For "Insulation," *i.e.*, to see that the copper core is not touching the ironwork of the machine.

For (1)—Join one end of each wire to the poles of the Menotti, see the other ends insulated, press the key, and there should be no swing.

For (2)—Join the free ends together, press the key, and there should be a full swing of the needle.

For (3)—Disconnect the end of one wire from the positive pole and insulate it, join up a short lead in its place and rub any bright part of the machine with the other end, press the key; there should be no swing.

The last test is for "Polarity," that is, to see that the field magnets have not had their polarity reversed by any accident. If this were the case, we should find that the current in the external circuit would be reversed and the crater would be formed in the lower carbon, thus losing a great deal of light.

To test for "Polarity," put the Menotti on short circuit, and note which way the needle swings.

Now, we know that in any battery the current is supposed to start from the + ve. pole; knowing which is the + ve. pole of the battery, and to which terminal of the galvanometer it was connected, we know which way the current passed through it. If now we disconnect the battery and join up the dynamo to the galvanometer, so that the supposed + ve. terminal of dynamo is connected to the same galvanometer terminal as was the + ve. pole of the battery, and then turn the machine by hand so as to send the current from it through the galvanometer, if the needle swings in the same direction as it did in the previous operation, then we know that the current is flowing in the same direction, and that the terminal which we supposed to be + ve. is really positive, hence the magnetism of the field magnets must be correct.

The wires leading to the search light must be also tested for non-contact, continuity, and insulation.

To do this, disconnect the ends from the dynamo and join them up to the Menotti; see the hand lamp in the projector and the switch to "On." (Note.—Move switch to right for "On" and to left for "Off.") Separate the carbons and test for non-contact. Bring carbons together and test for continuity.

Disconnect the end from + ve. pole of Menotti and insulate it; join up a short lead in its place, and with the bare end touch the ironwork of the ship. Test for insulation.

The Dynamo in the *Childers* is of somewhat similar construction to that in the gun boats, with this exception, that the whole of the current produced in the armature passes first round the field magnet coils to the positive terminal of the machine, from here passes by an insulated wire to the search light, through the positive and negative carbons, then back to the negative brush by another insulated wire, and so back into the armature.

The field magnet coils and leads to search light being in series with one another, the dynamo is called a "Series Machine." The tests are the same as for the gun-boats machines, except that for "Non Contact," which in this case is omitted.

The projector is fitted with a divergent lens, which can be shipped or unshipped, as convenient. When in position the rays are spread out laterally to an angle of 16°. Although the light loses some of its intensity, at the same time a greater area of water can be lit up without working the light backwards and forwards.

The Dynamo in the *Cerberus* is of a totally different description, and is called Wylde's Alternating Current Machine. It consists of two fixed discs, round the circumference of which are arranged twelve electro magnets, so wound that the outer ends are alternately of North and South Polarity, and opposite poles are facing one another. Midway between the two fixed discs is a revolving disc carrying twelve "bobbins," these bobbins consisting of soft iron cores surrounded with coils of insulated wire. When the machine is at rest these cores become magnets by induction, but when the machine is in motion their magnetism is reversed at each twelfth part of a revolution. This reversal of magnetism produces a current in the wire surrounding the cores, and the current is reversed each time the magnetism is reversed. Two of the bobbins are wound in series, and the current from them is employed to excite the electro magnets on the fixed discs. For this purpose it is necessary to use a "Direct Current," and to obtain this a commutator of peculiar construction is employed, attached to the shaft of the machine; it is in two parts. One part is insulated from the shaft and is in connexion with one end of the coil passing round the two bobbins by an insulated wire. The other half and the other end of the coil are connected together by the shaft itself, both being uninsulated. Two copper brushes bear on the commutator, and are so arranged that, as the current in the coil is reversed, the brush slips from one half of the commutator to the other, thus producing a direct current in the external circuit.

The brushes are in connexion by insulated wires to two terminals on the top of the machine, from which it divides through both sets of electro magnets.

The current from these two bobbins is called the Minor or exciting current, in distinction from the Major current which burns the lights.

The Minor circuit is tested for continuity and insulation in the ordinary way.

To test for Polarity, join up two wires from the brushes to the galvanometer terminals, turn the machine one-twelfth of a revolution, and note the direction of the swing of the needle; on again turning the machine the same distance the needle should swing in the same direction, proving that the current has passed in the same direction.

The current from the remaining ten bobbins is used to burn the lights, and the coils surrounding them are wound in series. One end is connected to an insulated pin, and from this an insulated wire is led along the shaft to an insulated disc. The other end of the coil is connected to the shaft, and so is in connexion with another uninsulated disc. A brush bears on each disc, and the current is led to either projector by an insulated wire, the current passing from one light to the other by the hull of the ship, that is to say, the current starting from one brush passes by the insulated wire to one projector, through the carbons to the hull of the ship; from here it passes the reverse way through the carbons in the other projector, and so back by the second insulated wire to the other brush of the machine.

Since the current passes alternately up and down the carbons, they both burn away in points, and are placed vertically over one another, the rays instead of being reflected from a mirror pass directly through a glass lens of peculiar construction, called a "Holophote," and are thus bent into parallel lines. The light produced is very weak, being only 5,000 candle-power, as compared with those of the gun boats, which are 12,500 candle-power.

The Major circuit is tested for continuity and insulation in the ordinary way. To test for Polarity, join up from the brushes to the galvanometer, turn the machine one-twelfth of a revolution at a time; the needle should swing in opposite directions.

FUZES AND DETONATORS.

The principle on which all electrical fuzes 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 fuze 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 fuze, and the platinum silver wire or bridge is soldered across the poles. The bridge is surrounded by fuze 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 fuze 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 fuze composition; this in its turn ignites the mealed powder, and the gun is fired.

The tubes in use in this service are called—

No. 10 gun tube, for use with M.L. guns.
No. 11 drill tube, for use with M.L. guns.
P. electric, for use with B.L. guns.
P. electric drill, for use with B.L. guns.
No. 9 detonator, for exploding gun-cotton charges.

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 two 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 Fuze. 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 Fuze is inserted in 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 fuzes and detonators is the same, namely, one quarter of an inch; and the resistance is 1·6 ohms.

EXPLOSIVES.

Gun-cotton is manufactured from ordinary cotton waster heated 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.

Dry gun-cotton is supplied in tin cylinders, each containing four 9oz. discs, the total weight being 2¼ lbs.

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 16¼ lbs.

All gun-cotton must be tested yearly. 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 ensure the contents of both tins being detonated.

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-cotton. It is supplied in 2oz. and 6oz. 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.

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.