1/2

# THE WHITEHEAD TORPEDO.

Fig. 1.

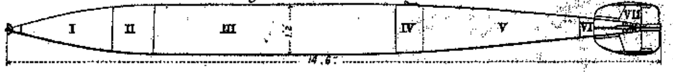


Fig. 2. Air Reservoir.

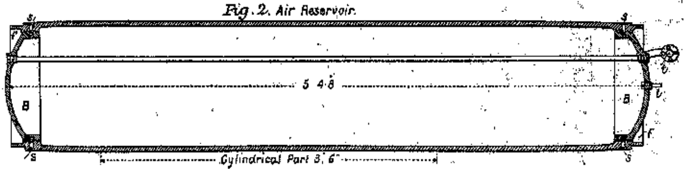


Fig. 3. Rear Cone.

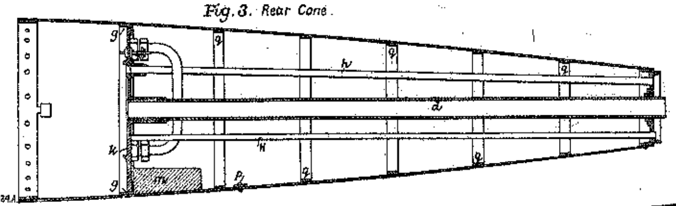


Fig. 7

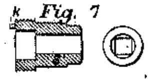


Fig. 4

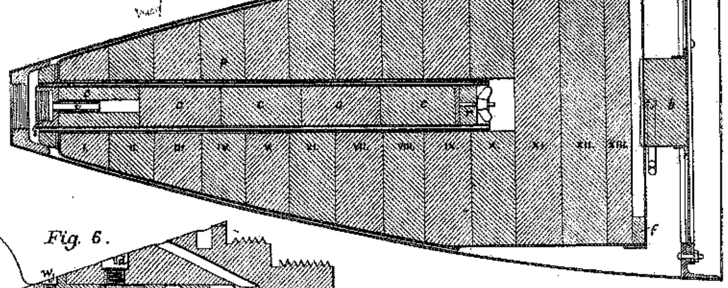


Fig. 6.

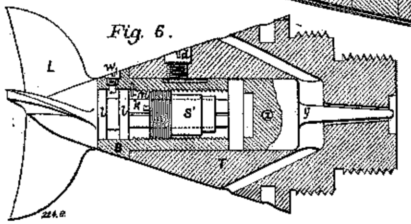


Fig. 5

Fig. 8.

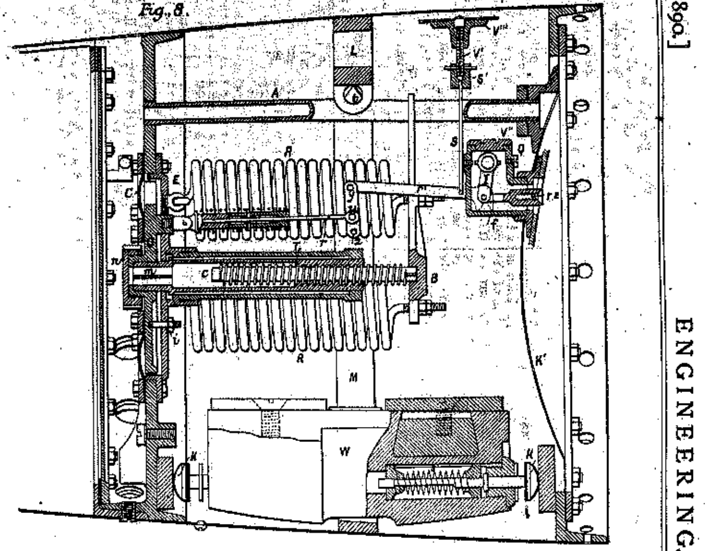
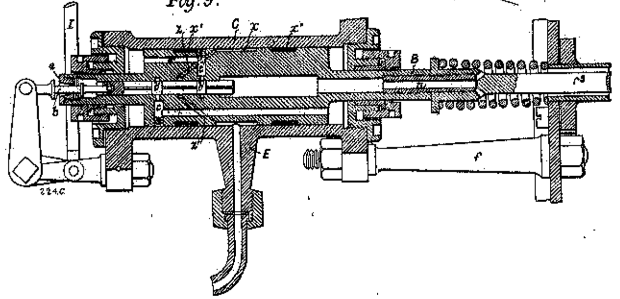


Fig. 9.



## AUTOMATIC TORPEDOES.

*Automobile Torpedoes, the Whitehead and Howell, with a Detailed Description of each.**

By Ensign John M. Ellicott, U.S. Navy.

The invention of the Whitehead automobile fish torpedo pointed out a new channel for human thought and ingenuity to follow in searching for destructive weapons of naval warfare. No patent rights existed to deter other people from imitating the weapon if they could, but at the same time its mechanism remaining a secret, prevented any improvement being made upon it except by the inventor himself. Thus for years the imitations were confined to their experimental stages in striving to overcome initial difficulties, while the Whitehead itself was, no doubt, somewhat retarded in its development. It was not until an imitation came into existence possessing a distinct and vital power which the Whitehead lacked, that torpedoists began to expect a rival weapon. This latter, the Howell torpedo, passed quickly through the experimental stages, has been much improved, and is now an adopted and regularly manufactured automobile fish torpedo both in the United States and Europe. It is, therefore, the first, and only one as yet, to reach a position of established rivalry with the Whitehead. Its mechanism is covered by patents, and therefore open to public examination. The mechanism of comparatively recent

---

* From the Annual of the U.S. Office of Naval Intelligence.

Whiteheads has also, in the last year or two, become public property through French publications. Hence a detailed description of each can be given here for the benefit of the service.

The Whitehead torpedo, Figs. 1 to 3, consists of a cigar-shaped envelope of steel or phosphor-bronze containing six compartments for its propelling, directing, and exploding mechanism. Its motive power is compressed air; it is propelled by two two-bladed screws revolving in opposite directions about the same axis in order to neutralise their individual tendencies to produce lateral deviation; and it is maintained at a constant depth by horizontal rudders, and on a straight course by vertical vanes set at an angle predetermined by experiment. The older models should maintain the prescribed depth and straight course for a distance of from 400 to 500 yards at a speed of from 20 to 24 knots. The latest models, more fish-like in shape, fuller forward and with a finer run, have attained a speed of 30 knots for 425 yards and 24 knots for 875 yards. For description the torpedo may be conveniently divided up as follows: (1) The magazine; (2) the secret chamber; (3) the reservoir; (4) the machinery chamber; (5) the buoyancy chamber; (6) the bevel gear chamber; (7) the tail.

*The Magazine.*—The forward compartment or magazine contains the explosive cartridge and the firing arrangement. The cartridge, Fig. 4, consists of a series of discs, I., II., III., IV., &c., of wet gun-cotton, of equal thickness, contained in a metallic case shaped to fit the chamber. The number of discs varies in different models, and a sufficient number of them, counting from forward, are pierced through their centres to receive the cartridge primer. These discs are held firmly in their case by an annular ring of felt $f$, at its after end. The cartridge case itself is held firmly in place by a buffer $b$ of felt, fitted in a circular socket attached to the after bulkhead of the magazine. The cartridge primer, which is inserted in a tube passing through the perforated discs, consists of a series of small cylinders of dry gun-cotton, $c\,c\,c$, contained in a metal case which is closed at its rear end by a disc of rubber $r$, and at its forward end by a countersunk brass cap, to which it is soldered. The forward cylinder of gun-cotton is pierced through its centre to receive a small copper tube $t$, which is flanged into the brass cap $s$ and closed at its inner end. The tube receives the detonating primer.

The detonating primer, Fig. 5, consists of a brass case $a$, containing compressed fulminate of mercury, which is protected from moisture by a layer of vermilion gumlac. Into this case is fitted a cup $u$ containing a percussion cap $i$ and an anvil $v$. The cup is pierced at $o$, and the anvil is guttered to allow the passage of flame. The whole is covered by a cap $h$ to protect it from accidental shocks. The firing arrangement, Fig. 6, is made up as follows: A small right-handed screw propeller L of four blades is retained in a sleeve S, by means of a lug screw, $w$, projecting in between two collars $l\,l$ on the shaft. The remainder of the shaft in rear of the collars is square in section, and on it travels an inner sleeve $S'$, screwing into S with a left-handed screw. The outer sleeve S fits into a cylindrical aperture in the stock T, but is prevented from rotating and limited in travel by the stud screw $d$ fitting in the slot $x$. In rear of this sleeve is the firing-pin $v$, held in place by a lead safety-pin $z$, passing through it and the stock. The stock T has two shoulders on which are screw threads of opposite pitch. The inner one screws into the brass cap in the head of the cartridge primer, and the outer into a bouching fitted to the magazine envelope (see Fig. 4). Thus, when the firing arrangement is unscrewed from the torpedo, the cartridge primer is withdrawn with it, and the torpedo rendered inoffensive. Before fitting the firing arrangement the inner sleeve $S^1$ is screwed back into the outer sleeve S until the lug $k$ brings up against the spur $m$ (this contact preventing the sleeve from jamming against the collar $l$). The action then is as follows: As the torpedo passes through the water the propeller L revolves, causing the inner sleeve $S^1$ to travel back along the square spindle until its base brings up in a socket $o$, in the head of the firing-pin $y$. The travel of $S^1$, thus arrested, is taken up by the outer sleeve S, which now travels forward, withdrawing the square spindle from the inner sleeve. For a short distance from its forward end the hole through the inner sleeve is circular (see Fig. 4). When, therefore, the square spindle recedes to this point rotation ceases to be transmitted to the inner sleeve, and the further revolutions of the propeller are of no effect. Contact with the target will now drive back the outer sleeve S upon the stock T, and, through the medium of the inner sleeve $S^1$, break the lead-pin $z$, and drive the firing-pin upon the detonating primer. This firing arrangement was first perfected in the Model 1886 torpedo, but has since replaced the old percussion point in all models.

*The Secret Chamber.*—This chamber contains the immersion regulators. It is just forward of the reservoir, as indicated in Fig. 1, and the transmitting rods pass through a tube in the latter, which is secured with an air-tight joint in each bonnet. The purpose of the mechanism in this chamber is to control the horizontal rudders after launching so as to bring the torpedo to a predetermined immersion and keep it there during its flight. This is accomplished as follows: The small compartment in front of the secret chamber (Fig. 8), has free communication with the water outside through several apertures in its walls. The pressure of water due to depth below the surface acts against a piston D, but the water is prevented from getting behind the piston by an annular diaphragm C of thin rubber. The motions of this piston, due to different pressures of varying depth, are communicated to the horizontal rudders by means of the rod $r$ (fixed to the piston), the link $y$ (pivotted at $z$), and the rods $r'$ and $r^2$, in such a manner that when the torpedo is below its plane of immersion the increased pressure will elevate the rudders, and when it is above, the decreased pressure will depress them. When the torpedo is in its plane of immersion the piston is kept in mid position by an equilibrium between the pressure of the water and the tension of three steel springs R R, 120 deg. apart, setting up against it through the crosshead B and the rod $c$ (screwed into the piston-stem T). To set the springs to the desired tension, the cap $n$ (on the piston-head) is removed, and a wrench inserted into the square socket $m$ in the piston-stem. Turning the wrench will screw the stem T up or down on the rod C, and increase or decrease the tension of the springs upon it as desired. The square head of the wrench has graduations marked upon its faces which, coming flush with the face of the piston-head, indicate the tension of the springs. Were the pressure of the water the only controlling force upon the horizontal rudders the oscillations of the torpedo above and below its plane of immersion would be excessive and perhaps continuous; for it is not alone necessary to throw a vessel's helm over when she is off her course, but to ease the helm as she approaches the course. To this end the motion communicated to the rods $r'\ r^2$ by the piston P is modified by pivotting the link $y$ at $z$ to the arm M of a pendulum W. The pendulum is free to swing about pivots $t$, on the ends of the bracket L, fixed to the envelope.

The resultant action is as follows: Suppose the torpedo, after its initial plunge, to be below its plane of immersion and pointed downward. The pendulum W has swung forward. For the moment the link $y$ has pivotted about $u$, the pendulum force being applied at $z$. The rods $r'\ r^2$ are thus forced aft and elevate the rudders. Almost immediately, too, the pressure of water upon the piston $a$ moves it aft, and with it the rod $r$. The link $y$ now pivots about $z$, and the rods $r'\ r^2$ are forced still further aft. The rudders are thus "hard up," and the effort upon the torpedo is to turn its point upward. As this is accomplished the pendulum swings gradually aft, reducing the rudder angle until, as the torpedo begins to point upward towards its plane, the action of the piston has been neutralised and the rudders are straight. Now the torpedo rises, and, the pressure upon the piston decreasing, the influence of the pendulum predominates. The latter being aft and the link $y$ pivotting for the time about $u$, the rods $r'\ r^2$ are drawn forward and the rudders slightly depressed. The tendency is now to steer the torpedo into its plane of immersion instead of allowing it to pass above. This cannot be accomplished at once, however, and the torpedo passes above its plane of immersion and pointed upward. The pressure of water upon the piston is now less than the tension of the springs R R, and they push the piston forward. With it the rod $r$ is drawn forward, carrying the link $y$ pivotting about $z$. The rods $r'\ r^2$ are thus still further drawn forward and the rudders are "hard down," exerting their maximum effort to turn the torpedo point downward. As this is brought about the rudder angle will be gradually diminished by the pendulum swinging forward, until it becomes zero as the torpedo begins to point downward and re-approach its plane. As the torpedo now goes downward the pressure of the springs against the piston is gradually neutralised by the increasing pressure of water against them, and the influence of the pendulum is thus again allowed to predominate. The latter being forward, the rudders are slowly raised, and tend to bring the torpedo into its plane of immersion without passing below it.

Thus it will be seen that by the controlling influence of this mechanism the vertical trajectory of the torpedo will be a wave-line passing alternately above and below the plane of immersion, with a continually decreasing amplitude until it becomes practically straight and lies in that plane. As a matter of fact, discovered from actual curves, only the first three or four oscillations are at all large when the mechanism is well adjusted. After that the trajectory is straight as long as the speed of the torpedo is constant. As the speed decreases with falling pressure the torpedo rises towards the surface. In the drawing $s\,s$ are springs of light tension which take up shocks or irregular motions of the pendulum. The rock-shaft I, between $r'$ and $r^2$, is necessary only to make their connection through the bulkhead water-tight. The impulses of the mechanism in the secret chamber are insufficient to move unaided the numerous cranks and rods connecting it with the horizontal rudders. A device called a servo motor is therefore interposed, so that the impulses of the regulators are transmitted only to a valve in the machinery chamber, and by the motion of this valve augmented impulses are transmitted to the rudder rods beyond by means of compressed air from the reservoir.

The servo motor, Fig. 9, consists of a bronze barrel C bolted to the after bulkhead of the machinery chamber by two standards $f$, and containing a hollow piston P within which works the valve T. Beneath the barrel is a nipple communicating with the compressed air. The piston P has three annular grooves $x\,x\,x$. The two extreme ones are packed with hemp packing, oiled and tallowed, and the middle one is of such length that when the piston is in its extreme positions the groove is still in communication with the air-pipe E. From this middle groove two channels $z\,z$ run diagonally, as shown, to the central aperture of the piston. On either side of the zone where these channels debouch is another channel; the one forward $c$ passing to the after end, and the one aft $c'$ passing to the forward end of the piston; both channels changing direction at right angles in the body of the piston in order to reach their respective ends. The valve T is of square cross-section, except at $b'$ and $b''$, where it is circular and fits closely the central aperture of the piston P. The valve stem $b$ passes freely through a screw cap $c$ in the head of the piston, but is limited in its travel by two collars as shown. The impulse of the immersion regulators in the secret chamber is transmitted by the rod $r^2$, Fig. 8 (through a bell-crank, the vertical rod I, and the bell-crank A, Figs. 8 and 9), to the valve-stem $b$ and the valve T. Suppose this impulse to push the valve aft (to the right). The cylindrical part $b''$ clears the channel $c'$, Fig. 9, and the compressed air, flowing through E, $x$, and $z\,z'$, passes the square part of the valve between $b'$ and $b''$ and flows out through the channel $c'$ to exert its pressure upon the forward (left hand) side of the piston P and move it aft. Any air on the after (right hand) side of the piston can exhaust through its channel $c$, and, since $b'$ has moved to the right, past the square part of the valve and around its stem $b$, into the machinery chamber. If the valve T were moved forward (to the left) by the regulators the channel $c$ would communicate with the compressed air and $c'$ would exhaust through the central aperture of the piston P and the channel $n$ in the stem B, and P would move forward. Thus any movement of the valve T results in a movement of the piston P in the same direction, and with greatly increased power. Both stems of the pistons are packed air-tight in stuffing-boxes, as shown, and the after stem B is screwed to the rudder rod $r^3$. This rod passes through the buoyancy chamber and connects with the horizontal rudders* through the connecting-rod $r^4$, the bell-crank $b''$, the connecting-rod $r^5$, the lever $l$, the connecting-rod $r^6$, and the lug $u$ on the rudders; the axis of the rudders being at $x''$.

*The Reservoir.*—The reservoir for compressed air, Fig. 2, is made of steel and forged on a mandrel. The ends are dome-shaped bonnets B B with outer flanges $f\,f$ to fit into the other sections of the torpedo. To insure air-tight joints both the shell and bonnets are heated before screwing together, the shell having the greater heat. The screw threads are at the same time carefully tinned. As a further precaution, the bonnets are secured by a number of small radial screws $s\,s$. On the after bonnet is a tuyere $t$ by means of which communication is made between the air reservoir and the main engine. The reservoir is secured to the other compartments by means of two lugs $l\,l$ (diametrically opposite) with bolts and nuts, and by numerous radial screws through the flanges. The reservoir is tested for strength up to 105 atmospheres with oil pressure. Flaxseed oil containing litharge is used. It penetrates the distended pores of the metal, and when the reservoir is drained after test an excellent air-tight coating is left upon the inner walls. Then the test for air-tightness is made up to 70 atmospheres, the condition being that the pressure shall not fall six atmospheres in four hours. In the last few years improvement in the quality of metal has made it possible to charge the reservoir to a much higher pressure.

(*To be continued.*)

## LAUNCHES AND TRIAL TRIPS.

On Thursday, October 30, Messrs. Edward Finch and Co., Limited, Chepstow, launched from their shipbuilding yard the iron screw tug Fastnet, built to the order of Messrs. Christie and Co, of Cardiff. Her dimensions are: Length between perpendiculars, 75 ft.; breadth, 15 ft.; depth moulded, 9 ft. 6 in. Her machinery consists of a pair of compound surface-condensing engines; diameter of high-pressure cylinder, 15 in.; low-pressure cylinder, 30 in.; stroke, 20 in.; working at a boiler pressure of 100 lb. per square inch.

On the 3rd inst. the trial trip took place of the large steel screw steamer Citta de Venezia, built for Messrs. Lavarello Brothers, Genoa, by Messrs. C. S. Swan and Hunter, Wallsend-on-Tyne. After making a series of progressive speed runs over the measured mile, a full speed trial run was made from Tynemouth Castle to Newbiggin and back, the vessel making an average speed of 14.6 knots per hour, which was considerably in excess of the speed guaranteed. The general dimensions of the steamer are: Length, 390 ft. over all; breadth, 44 ft.; depth moulded, 28 ft. The engines, which have been constructed by the Wallsend Slipway and Engineering Company, have cylinders 30 in., 50 in., and 79 in. in diameter by 54 in. stroke, and are capable of indicating 3300 horse-power. The steamer will carry about 2000 passengers in all.

The new Castle Line intermediate steamship Doune Castle, which has been built for Messrs. Donald Currie and Co. by Messrs. Barclay, Curle, and Co., went on her trial trip down the Clyde on Saturday, the 8th inst. She ran twice between the Cloch and Cumbrae Lights, and maintained a mean speed of 13¾ knots per hour. The Doune Castle is 4045 tons, and will carry 5000 tons. She has accommodation for first, second, and third-class passengers.

On Monday, the 10th inst., Archibald Denny and Son, Limited, Dumbarton, who now occupy the yard formerly owned by Messrs. A. McMillan and Son, launched a steam paddle passenger boat for foreign owners. The vessel, which is named the Petropolis, is 210 ft. long, 23 ft. broad, and 8 ft. 3 in. deep, and is expected to attain a speed of 16 knots per hour. The vessel was towed up to Glasgow, where she will receive her engines from Messrs. David Rowan and Son. This is the first launch by the new firm.

Gas at Paris.—Negotiations are pending between the municipality of Paris and the Parisian Company for Lighting and Heating by Gas with a view to an extension of the company's monopoly from 1905 to 1930. Should the proposed extension of the monopoly be conceded, the company will undertake to made a reduction in the price of its gas.

---

* These will be illustrated in detail in a future number.

11/6

gearing for disengaging the gear clutch at any point in the forward or return traverse. The slide bed upon which the saw-carrying saddle moves, has a traverse slide which fits the standard. The raising or lowering is done by hand through a worm and wormwheel, by a wire rope carried on suitable carrying pulleys on a drum; while the exact lowering or raising adjustment of the saw is done by means of a telescopically arranged spindle. The driving is from the main shaft on to pulleys on an overhead shaft carried in bearings across the top of the machine. Upon this latter shaft is a bevel pinion which gears with a bevel wheel supported on a bearing as shown, this bevel wheel communicating motion by a feather key to the vertical shaft which can slide through it. On the lower part of this shaft is secured a bevel pinion which gears with a bevel wheel on to the principal shaft of the sawing portion of the machine. The machine is self-contained, and the massive framed standard has a secure foundation plate.

## THE ENGINES AND BOILERS OF THE "BARHAM" AND "BELLONA."

We give this week a two-page engraving, together with other views on the present and opposite pages, illustrating the machinery of H.M.S. Barham and Bellona. These are sister vessels, and have been designed by Mr. W. H. White, the Director of Naval Construction. The Barham has been built at Portsmouth, and the Bellona at the Hebburn yard of Messrs. R. and W. Hawthorn, Leslie, and Co., by which firm the engines of both vessels have also been constructed. They are classed as twin-screw protected cruisers, and measure 293 ft. in length by 35 ft. in breadth. Their armament largely consists of 4.7 in. quick-firing guns, in addition to machine guns and torpedoes. The propelling machinery consists of two sets of triple-expansion engines having cylinders 27 in., 40½ in., and 60 in. in diameter, with a stroke of 27 in. We reserve a fuller description of the machinery till the appearance of further engravings, which we shall give in an early issue; meanwhile we will only say that the engines include many interesting features and that their performance on trial has been most creditable to their makers.

The natural draught trial of the Bellona took place in the North Sea off the mouth of the Tyne on Saturday, the 15th inst., on the long course between St. George's Church, Cullercoats, and Newbiggin Church, a certified distance of 9.6 knots, and the speed attained was as follows:

| | Knots | |
|---|---|---|
| First run north ... ... | 19.1 | Mean speed 19.46 knots. |
| Second run south ... ... | 19.86 | |
| Third run north ... ... | 18.58 | |
| Fourth run south ... ... | 20.32 | |

The time on the trial was 6 hours. The contract required 8 hours, and all arrangements were made for the running the full contract time, but a fog coming down at about the 6½ hours, the makers were compelled suddenly to stop the trial and 6 hours was accepted. The mean indicated horse-power was 3557 for the whole of the 6 hours, a maximum of 4200 horses was maintained for some time, but as 3500 was the contract natural draught power, it was deemed unnecessary by the officers in charge to exceed that power by more than a sufficient margin.

Mention has been made of weaknesses in the structure of these vessels, the Barham and Bellona. It is only necessary to say that during this trial, with a mean speed of 19½ knots and part of the time 20½ knots, there was a marked absence of any vibration whatever, either in the hull of the vessel or the engine seatings, where local vibration is not an uncommon circumstance. It will be seen from the engravings that more than usual care has been exercised in the design and construction of the seatings for the engines by means of strong transverse girders, to which the steel bedplates of the machinery are firmly bolted by continuous flanges and small bolts placed closely together, so making engines and ship one structure. These transverse girders are again supported and strengthened by long longitudinal kelsons running the full length of the engine space.

## AUTOMATIC TORPEDOES.

*Automobile Torpedoes, the Whitehead and Howell, with a Detailed Description of each.**

By Ensign John M. Ellicott, U.S. Navy.

(*Continued from page 574.*)

*The Machinery Chamber.*—Next abaft the reservoir comes the rear cone (Fig. 3),† containing two compartments, the machinery chamber and the buoyancy chamber. Between them is a bulkhead K bolted to a flange *g*. The flange is rivetted and soldered to the envelope, and the joint between it and the bulkhead is made watertight by a rubber gasket. To this bulkhead the propelling machinery is secured. This consists of a Brotherhood or Whitehead engine, a starting valve, and a pressure governor. Previous to 1880 the motor used was the Brotherhood engine, but in the models of that year, and later ones, the motor is a modification of the Brotherhood known as the Whitehead engine.*

The Whitehead engine consists of three cylinders, A A A (Fig. 11, page 632), fixed radially about the propeller shaft, with their axes 120 deg. apart. Within the circular inclosure at the junction of the cylinders the main crank is free to revolve and receives its impulse from the piston of each cylinder in succession. The compressed air is admitted behind the pistons and evacuated in proper order by means of three slide valves, each working in a separate chest S on the forward face of each cylinder, but all regulated by a single cam Q keyed to the main shaft.

The valves consist of a cylindrical disc T of bronze, cast in one piece with a stock *t* carrying four guide blades *l l l*, and it slides in a bronze sleeve C perforated with radial ports *o o* which open upon an annular aperture E in the valve chest, communicating with the cylinder space behind the pistons. The valve stem is in two parts, screwing one into the other to allow adjustment. One part simply sockets in the valve stock, as shown in the drawing, while the other is split and carries a small roller X in contact with the cam Q. The compressed air is admitted into the space *u* behind the valve disc T, and maintains the contact between the valve, the stem, and the cam in all positions. By removing the screw caps *v* from outside the torpedo the valves may be readily removed and overhauled, or the valve stems set.

In Fig. 10, page 632, the position shown is when the piston is about to commence its return stroke and the air is exhausting from behind it, shown by the arrows. When the piston has completed its return stroke the cam Q will have rotated until the valve T, moving toward the main shaft, opens communication through the ports *o* with the annular aperture E, and admits the compressed air into the cylinder behind the piston. The cam Q regulates the valve motion to cut off at about half-stroke. In the Model 1885 torpedo and later ones it is about four-tenths stroke. Thus as the air is acting at full pressure in one cylinder it is acting expansively in the next, and exhausting from the third.

When the torpedo is launched from a submerged frame or skeleton tube the working of the pistons and valves is much impeded by the water which backs up into the cylinders through the exhaust pipe. A little reservoir D is therefore provided for each cylinder. The water, when backed up through the channel *c*, lifts the metal ball *d*, and, entering the reservoir D, is retained there by the ball falling back again over the orifice.

To remedy the evil in the latest models the slide valves T are made in two parts, as shown in Fig. 12, page 632. When there is water in the cylinders it can escape upon compression through the holes *u*, separate T′ and T″, as shown in the second view, and pass off as indicated by the arrows. At other times T′ and T″ are kept together, as shown in the first view, by the air pressure behind T′. The slide valve is also a cylinder relief valve.

The piston-rods are fitted in the pistons with a ball-and-socket joint, as shown in both Figs. 13 and 14, and attached to the crank by means of blocks K, with feathers at each end fitting in annular grooves *q q* cut into the inner face of the crank webs. The crank has a counterbalance *g* forged in one piece with it. The crank and propeller shaft are of steel, the latter being hollow. The air exhausting through it acts as an additional propelling force. The piston-rods are also of steel, and the pistons, cylinders, and blocks K of bronze or brass.

The compressed air is turned on the machine by opening a valve (T, Fig. 15) which will be described further on, but before reaching the cylinders, it passes through a pressure governor (Figs. 13 and 14). The air-pipe T′ passes from the starting value T to the governor through the machinery bulkhead, and serves to secure the governor to the bulkhead as shown. The governor consists of a hollow cylindrical slide valve P, of bronze, closed at its upper end but perforated radially with three rows of square ports *e*, 1.4 in. across, opening upon three annular air ports *e′*, 1 in. across, which communicate with the air-pipe T′ (Fig. 14) through the channel *a*. At rest the valve ports should be squarely over the air ports, lapping them $\frac{1}{16}$ in. on either side. This can be adjusted by leather washers *w* under the cap *o* (Fig. 13), upon which the foot of the valve rests. Above the valve

## BOILERS OF H.M.S. "BARHAM."

CONSTRUCTED BY MESSRS. R. AND W. HAWTHORN, LESLIE, AND CO., LIMITED.

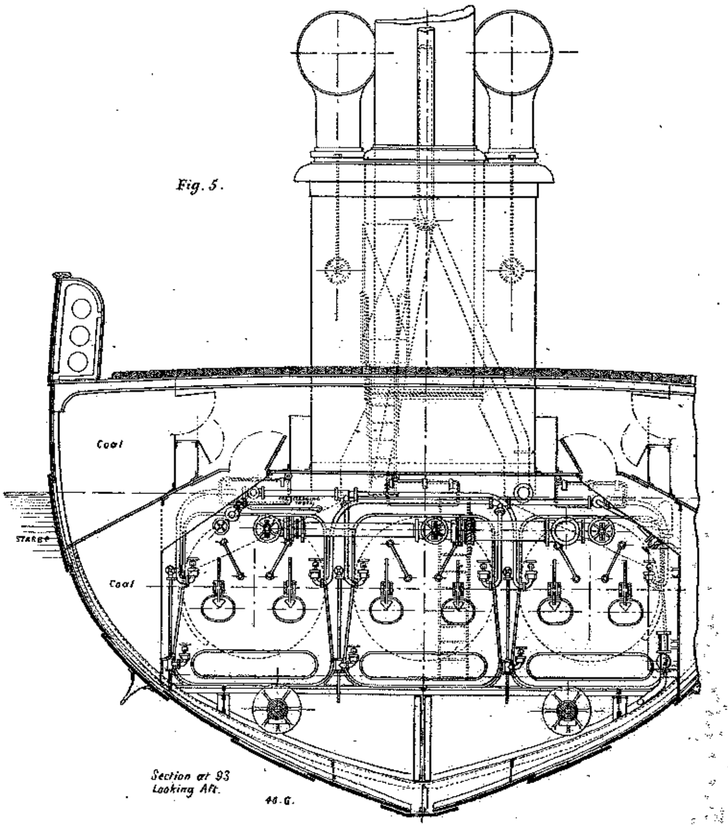


Fig. 5.

---

* From the Annual of the U.S. Office of Naval Intelligence.

† See page 573 *ante.*

* These we shall illustrate later. Brotherhood improves his engines continually, and they are very probably still used in torpedoes not manufactured at Fiume. Schwartzkopf also uses a patented type of three-cylinder engine.

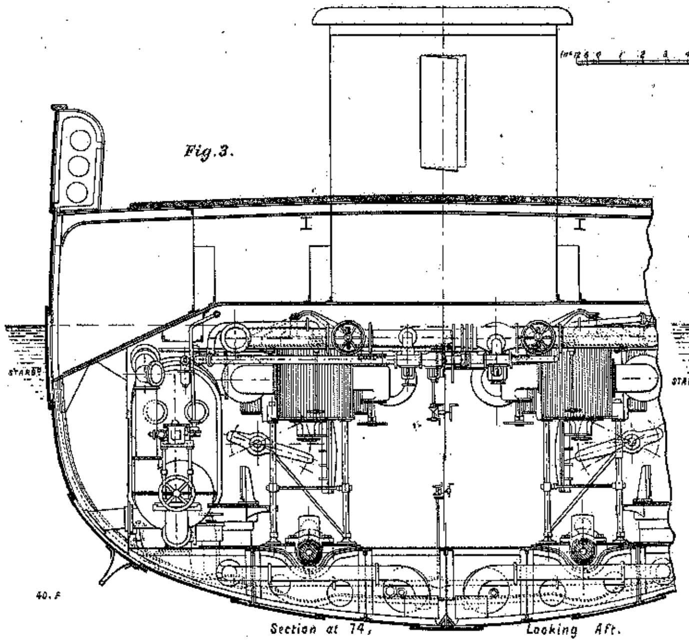
4/6

# TRIPLE-EXPANSION TWIN SCREW ENGINES OF H.M.S. "BARHAM."

## CONSTRUCTED BY MESSRS. R. AND W. HAWTHORN, LESLIE, AND CO., LIMITED, ENGINEERS, NEWCASTLE.

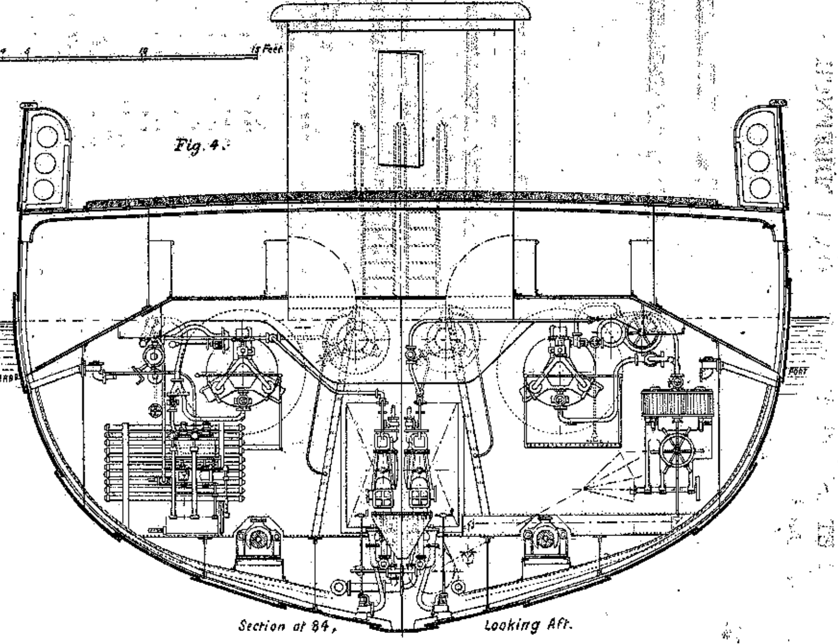
(*For Notice, see opposite Page.*)

Fig. 3.



Section at 74, Looking Aft.

Fig. 4.



Section at 84, Looking Aft.

is a spindle $t$ seated upon the barrel by a shoulder $s$, so that its foot, although inserted in a socket in the valve as shown, is not in contact with it by $\frac{3}{16}$ in. when the valve is at rest. The spindle is kept thus by a spring $r$ set to the desired working pressure by a set screw $j$ screwing into the casing K. The starting valve being opened the compressed air passes through T′ and $a$ (Fig. 14) and through the ports $e$ $e'$ into the valve. The latter at once rises into contact with the spindle above it, bringing the lower faces of both air and valve ports flush. The air flows out through openings under the foot of the valve into the air chamber R, as shown by the arrow in Fig. 14, and from this chamber to the slide valves of the main engine. The spring $r$ is set to a tension of about twenty-four atmospheres. This being much lower than the pressure in the reservoir the valve rises against the spring and thus partially closes the air ports until an equilibrium of pressure is established. The air pressure at the engine thus remains constant until the pressure in the reservoir is the same. The spring $r$ then seats the valve P, and the ports are opened full, allowing the engine to run under the continually diminishing pressure in the reservoir until the air is exhausted. The air chamber R has one and one half times the volume of one cylinder of the main engine and serves to store up air as a cushion to reduce irregular and violent motions of the valve P. This provision has proved superfluous since the introduction of the Whitehead engine, and in the Model 1886 torpedo the chamber R ceases to exist. To prevent the escape of air between the sliding faces of the valve P and the barrel C, two annular grooves are cut in the barrel above and below the air ports. These communicate through channels, as shown in Fig. 13, with a reservoir of oil $m$. The surface of this oil is in communication with the air in the reservoir through a tube $d$ and a passover pipe $f$, and the oil is thus pressed down through the channels $g$ into the annular grooves $n$ $n$ around the valve P, forming thus an oil packing. The reservoir $m$ is charged with oil from outside of the torpedo envelope by removing the screw plug V.

When the air chamber R was omitted the oil reservoir $m$ was shifted abaft the machinery bulkhead into the buoyancy chamber, its connections leading through the bulkhead as does the air pipe T′.

The starting valve is shown in Fig. 15. It connects through the machinery bulkhead with the air pipe T′, and is set up to the bulkhead by a nut E (see also Fig. 14). It is connected at its forward end with the charging valve, which is secured by a flange D to the envelope of the torpedo. Still further forward the pipe $a$ is secured by a flange to the tuyere on the after bonnet of the reservoir (see $t$, Fig. 2). The valve $d$ is kept seated by the spring $r$, under a compression of two atmospheres, and also, when the reservoir is charged, by the air pressure in the latter. When the lever L is thrown back, as shown by dotted lines, about the axis $o$, a cam C, acting against the valve stem $g$, opens the valve and allows the compressed air to flow from the reservoir to the governor, and thence to the main engine. The spring $g$, under compression, will retain the lever L in either open or shut position. The lever is thrown back, or open, by coming in contact with a lug in the launching tube when the torpedo is launched. In above-water discharge this scheme is defective, causing violent rotation of the propellers before the torpedo is submerged, and resulting in severe strains upon the machinery and useless consumption of compressed air. In the Model 1885 torpedo a new and delicately balanced starting valve was introduced, having on its lever a cross-vane which would be thrown back by the resistance of the water when the torpedo made its plunge. The idea came from the Russians, who applied it first in 1881. The action of this valve proved unreliable, so it was almost immediately abandoned, and, although the effort to perfect it is unceasing, the valve shown in Fig. 15, is the one still in use. To charge the reservoir, the screw plug $b$, Fig. 3, is removed from outside, and a nozzle screwed in having a pintle which presses the valve $c$ back from its seat. The spring $r'$ is under a compression of two atmospheres.

*The Buoyancy Chamber.*—This compartment is an air-tight shell (Fig. 3, page 573 *ante*), braced with annular rings $g$. Passing through it are two tubes H and $h$. H contains the connecting rods to the horizontal rudders and $h$ the connections for suspending the action of these rudders until the torpedo is submerged, and also those for stopping the torpedo after a certain length of run. The central tube $d$ contains the main shaft.

The purpose of the buoyancy chamber is to give a certain preponderance of buoyancy to the torpedo during flight, to insure its returning to the surface after an experimental run, or, by flooding the chamber, to cause the torpedo to sink if it misses its target or fails to explode upon impact in actual warfare. The air-tightness of the chamber can be verified by submersion, and, should it not be perfect, any water which gets in can be drained off through a small hole under the chamber by removing a screw plug $p$. There is also in this chamber a piece of lead ballast $m$, of such size, and so placed, as to counterbalance any tendency of the interior fittings of the torpedo to alter its trim, either horizontally or about its axis. The volume of the buoyancy chamber is 10 gallons for the Model 1880 torpedo.

*The Bevel Gear Chamber.*—Next abaft the rear cone, and secured to it as shown in Fig. 16, is the bevel gear chamber. The object of the gearing in this chamber is to cause the propellers to revolve in opposite directions. The after propeller is keyed on the main shaft A. To this shaft is secured the bevel gear wheel $b$. The forward propeller is keyed to a sleeve A′, free to rotate about the main shaft A. To the forward end of this sleeve is secured the bevel gear wheel $b'$. Rotation in opposite directions is transmitted from $b$ to $b'$ by means of two bevel gear wheels $g$ $g'$, free to turn upon a spindle $a$

3/6

# CAST-IRON GUNS (CANET SYSTEM) FOR COAST DEFENCE.

(*For Description, see Page* 626.)

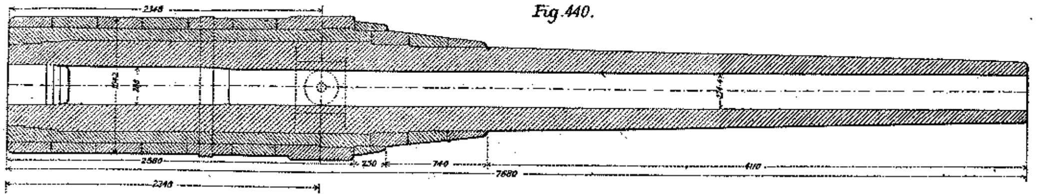


*Fig. 440.*

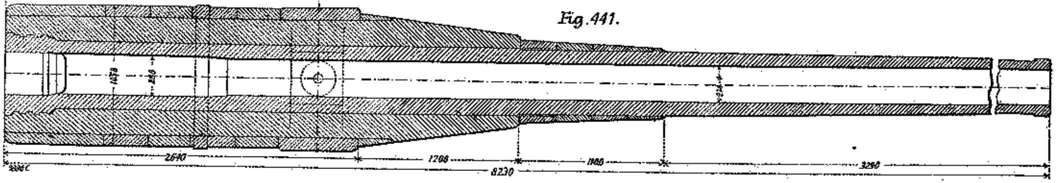


*Fig. 441.*

TABLE LIV.—BALLISTICAL DATA OF CAST-IRON GUNS FOR COAST DEFENCE (CANET SYSTEM); CONSTRUCTED BY THE FORGES ET CHANTIERS DE LA MEDITERRANÉE.

| Nature of Gun. | Calibre. | | Total Length. | | Length of Bore. | | Diameter of Chamber. | | Length of Rifling. | | Number of Grooves. | Terminal Angle. | Weight of Gun. | | Weight of Projectile. | | Weight of Charge. | | Initial Velocity. | | Total Energy. | | Thickness of Iron Plate Penetrated at Muzzle. | | Maximum Range. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | in. | mm | in. | mm | in. | mm | in. | mm. | in. | mm | | | lb. | kilos. | lb. | kls. | lb. | kls. | ft. | m. | ft-tons | m. tns | in. | cm. | yards | m. |
| Coast, 15 cm. short | 5.90 | 150 | 165.4 | 4200 | 155.3 | 3945 | 6.10 | 155 | 129.9 | 3300 | 24 | Uniform rifling at 7 deg. | 8928.6 | 4,050 | 77.161 | 35 | 19.84 | 9 | 1607 | 490 | 1383.0 | 428.4 | 6.92 | 17.6 | 10,940 | 10,005 |
| „ 15 „ long | 5.90 | 150 | 177.2 | 4500 | 167.1 | 4245 | 6.10 | 155 | 138.2 | 3510 | 46 | | 9033.9 | 4,100 | 77.16 | 35 | 26.45 | 12 | 1870 | 570 | 1871.4 | 579.7 | 8.62 | 21.9 | 12,341 | 11,285 |
| „ 19 „ short | 7.47 | 190 | 209.5 | 5320 | 196.8 | 4998 | 7.67 | 195 | 164.6 | 4180 | 30 | | 18188.0 | 8,250 | 154.3 | 70 | 39.68 | 18 | 1607 | 490 | 2762.8 | 865.8 | 9.60 | 24.4 | 11,421 | 10,445 |
| „ 19 „ long | 7.47 | 190 | 224.5 | 5700 | 211.3 | 5380 | 7.67 | 195 | 175.2 | 4450 | 58 | | 18298.0 | 8,300 | 154.3 | 70 | 55.11 | 25 | 1870 | 570 | 3742.8 | 1159.4 | 11.93 | 30.3 | 12,965 | 11,850 |
| „ 22 „ short | 8.66 | 220 | 242.5 | 6160 | 227.8 | 5786 | 8.89 | 226 | 190.6 | 4840 | 34 | | 28,219 | 12,800 | 242.5 | 110 | 61.73 | 28 | 1607 | 490 | 4346.2 | 1346.4 | 11.97 | 30.4 | 12,221 | 11,175 |
| „ 22 „ long | 8.66 | 220 | 259.8 | 6600 | 245.3 | 6230 | 8.89 | 226 | 203.2 | 5160 | 66 | | 28,439 | 12,900 | 242.5 | 110 | 83.77 | 38 | 1870 | 570 | 5381.9 | 1821.9 | 14.34 | 37.7 | 13,888 | 12,700 |
| „ 24 „ short | 9.45 | 240 | 264.5 | 6720 | 248.5 | 6312 | 9.72 | 247 | 207.9 | 5280 | 38 | | 36,596 | 16,600 | 308.6 | 140 | 77.16 | 35 | 1607 | 490 | 5332.1 | 1713.6 | 13.35 | 33.9 | 12,397 | 11,360 |
| „ 24 „ long | 9.45 | 240 | 283.5 | 7200 | 267.3 | 6790 | 9.72 | 247 | 221.7 | 5630 | 72 | | 36,928 | 16,750 | 308.6 | 140 | 108.02 | 49 | 1870 | 570 | 7487.3 | 2318.8 | 16.53 | 42.1 | 14,284 | 13,046 |
| „ 27 „ short | 10.63 | 270 | 297.7 | 7560 | 279.6 | 7100 | 10.91 | 275 | 233.9 | 5940 | 42 | | 52,029 | 23,600 | 440.9 | 200 | 110.23 | 50 | 1607 | 490 | 7903.7 | 2448.1 | 15.87 | 40.3 | 12,980 | 11,870 |
| „ 27 „ long | 10.63 | 270 | 318.9 | 8100 | 300.8 | 7640 | 10.94 | 278 | 249.2 | 6330 | 82 | | 52,581 | 23,850 | 440.9 | 200 | 154.32 | 70 | 1870 | 570 | 10695.0 | 3312.6 | 19.29 | 49.0 | 15,652 | 13,765 |
| „ 30.5 „ short | 12.01 | 305 | 336.3 | 8540 | 313.0 | 7950 | 12.36 | 314 | 263.8 | 6700 | 46 | | 75,068 | 34,050 | 639.3 | 290 | 154.32 | 72 | 1607 | 490 | 11459.6 | 3549.6 | 18.74 | 47.6 | 13,670 | 12,500 |
| „ 30.5 „ long | 12.01 | 305 | 360.2 | 9150 | 337.0 | 8560 | 12.36 | 314 | 277.6 | 7050 | 92 | | 75,833 | 34,400 | 639.3 | 290 | 220.4 | 100 | 1870 | 570 | 15506.0 | 4803.3 | 23.31 | 59.2 | 15,921 | 14,560 |
| „ 32 „ short | 12.60 | 320 | 352.8 | 8960 | 331.5 | 8420 | 12.99 | 330 | 277.2 | 7040 | 50 | | 86,641 | 39,300 | 749.6 | 340 | 187.39 | 85 | 1607 | 490 | 13436.0 | 4161.6 | 20.52 | 52.1 | 14,013 | 12,815 |
| „ 32 „ long | 12.60 | 320 | 377.9 | 9600 | 356.7 | 9060 | 12.99 | 330 | 294.9 | 7490 | 96 | | 87,523 | 39,700 | 749.6 | 340 | 264.55 | 120 | 1870 | 570 | 18180.0 | 5631.4 | 25.47 | 64.7 | 16,286 | 14,985 |

at right angles to the main shaft, screwed into the walls of the chamber and enlarged at its centre to allow a hole through it for the shaft A. The rods passing through the buoyancy chamber also pass through the bevel gear chamber. The propellers, besides being keyed, are secured to their respective shafts by washers *w w'*, screwed over them.

*The Tail.*—The tail of the torpedo consists of two parts, the rudder support and the rudders. The former consists of a conical stock K screwed on the bevel gear chamber, which carries four fins, two vertical, F F, and two horizontal (not shown). These fins are either cast in one piece with the stock or rivetted to flanges upon it. From the vertical fins shoes S S' extend aft, and to these the vertical vanes V V are secured. The upper shoe has a lug *u'* which fits in a longitudinal groove in the top of the launching tube and keeps the torpedo upright in launching. The lower shoe opens to form a frame *f f*, in which is pivotted the lever *l* of the horizontal rudders.

The after part of the tail consists of a stock K' with vertical vanes V V, which act as the vertical rudder, and with two horizontal rectangular frames R R in which are set the horizontal rudders H. To the outer extremities of these frames rods are attached which extend forward and fit in sockets on the outer edges of the horizontal fins of the forward part. By properly adjusting the set screws which secure the rods in their sockets, sufficient inclination can be given to the vertical vanes V V to counteract any tendency of the torpedo to lateral deviation. Experiments are always made to determine this correction.

There is an unnatural strain brought upon the shoes S S' by this method of inclining the vertical vanes, and sometimes, too, the free action of the horizontal rudder rods is impeded. A new arrangement introduced by Schwartzkopf has therefore been adopted since 1880, and is shown in Fig. 23. On the horizontal fins of the tail stock little vertical rudders *a a*, above and below the fins in the same vertical plane, are pivotted at *b b*, and are set to the required angle by set screws *c* passing through slots *d d*. It will be seen, too, in the figure that the framing is no longer carried around the horizontal rudders.

In the tail of the Model 1880 torpedo and earlier models is the mechanism for stopping after a certain run, and also that for suspending the action of the horizontal rudders. The first consists of the following arrangement: On the shaft of the forward propeller is an endless screw *v* engaging a toothed wheel W on whose face is a stud *s*. At each rotation of W the stud *s* engages the escapement wheel W' and moves it one tooth. The wheel W' is restrained by the spring *p'*, and has on its face a stud *s*. After a certain number of escapements of W' the stud *s'* comes in contact with the trigger *t*, and turning it about the axis *x*, causes the notch *u* to release the box X surrounding the shaft and containing the spring *p* under compression. This spring, acting between the after flange of the box and a collar on the shaft, causes the former to jump backwards, dragging with it, by means of a lug *u''*, the rod *d*. This, by means of the connecting-rod *c* (Fig. 17), the bell-crank *i k*, and the link *m*, pulls forward the lever L and closes the starting valve.

To recock the apparatus a hook is inserted in a slot in the tail stock, and the lug *u''* dragged forward until the notch *n* drops over the rear edge of the box X.

The slot *j* (Fig. 17) in the rod *c* allows the lever L to be thrown back as the torpedo leaves the launching tube without hindrance from the stopping mechanism, but if the latter is not set as described it can readily be seen that the lever L will not be thrown back and the torpedo would simply lie where it fell upon the water.

The escapement wheel W' is graduated on its face as shown in order that it may be set to stop the torpedo after a run of any desired distance. How to set this wheel, should no table be available, may be obtained as follows: Multiply the mean pitch of the propellers, minus the percentage of slip, by the number of teeth in the wheel W; divide the distance the torpedo is to run by this product, and the quotient will be the number of teeth in the wheel W' which must be traversed by the stud *s'* and the trigger *t*. Of course the mean pitch of the propellers must be expressed in the same denomination as the distance to be run by the torpedo.

The mechanism for restraining the action of the horizontal rudders is to protect them from the initial vagaries of the pendulum due to inertia and shocks upon launching. To this end an arm M free to turn about the axis *x* independent of the trigger *t*, has attached to it a claw C pressed downwards by a spring *p''*. Also attached to the arm M is a system of rods *y z*, which, in the machinery chamber, are connected to one end of an athwartship lever *l'*, Fig. 18, on a vertical axis *x'*; the other end of the lever having a flat edge *k'*, and fitting into a pair of jaws *j'*, Fig. 19, on the vertical rod I. This rod, therefore, cannot move until the stud *s*, Fig. 16, on the wheel W, engages the claw C and drags back the arm M and the rods *y z*. The latter, acting upon the athwartship lever, withdraws its further end from the jaws of the rod I and allow the immersion regulators to act upon the horizontal rudders. Once back, the claw C is inoperative, simply rising and falling each time the stud *s* passes it. This stud is adjusted by turning the wheel W (through the medium of the propellers) by hand. Its proper position varies with the mode of launching and in different models.

The jaw *j'* is adjustable along the rod I, so that the horizontal rudders can be rendered inactive at any inclination with the plane of their frames. Thus, not only can the duration of their inactivity be controlled, but their position during inactivity. Such adjustment has been found by experiment to be beneficial in guiding the torpedo more quickly to its plane of immersion, and an empirical table or curve of inclinations for different models and modes of launching is furnished.

In actual warfare it is desirable that a torpedo which has missed its target shall neither fall into the hands of the enemy nor float about as a danger. To this end a sinking arrangement is devised. It consists of a bronze valve Z (Fig. 17), kept seated in the machinery bulkhead by a spring P, and having a rectangular grip Z', into which drops the hooked end of a rod *y* attached to the lever *k*. The rod *y* passes through the slot of a bent lever U fixed upon the axis of the cam lever L of the starting valve. The upper arm of the lever U, being a spring of lateral tendency, catches in one of the two notches on the edge of the slot *o* in the envelope of the torpedo. When in the forward notch, as shown in Fig. 17, the rod Y is lifted from Z' and the arrangement remains inactive, but when in the after one the action is as follows: Before launching, when the starting valve is closed, the lip *h''* of the hook *h'* (Fig. 17) rests upon Z'. When the lever L is thrown backward, as the torpedo launches from the tube, the rod Y being drawn aft, allows the hook *h''* to fall into the grip Z' of the valve. Thus it remains until the end of the run, when the stopping arrangement, by closing the starting valve, as shown in dotted lines, opens the valve Z and floods the buoyancy chamber, causing the torpedo to sink. It is safer when practising with a torpedo to remove the rod Y entirely; otherwise a mistake in setting it might cause the loss of the torpedo.

In the Model 1885 and later ones the stopping arrangement and that for suspending the action of the horizontal rudders has been transferred to the machinery chamber. The new stopping arrangement (Figs. 20, 21, and 22) consists as follows: A ratchet wheel A, Fig. 20, is fixed on a shaft B and turned by a ratchet L worked by

# MODERN FRENCH ARTILLERY. (*See Page* 626.)

TABLE LV.—32-Cent. (12.6-In.) Cast-Iron Guns for Coast Defence (Canet System).

| — | | | 32-Centimetre Short Gun. | | 32-Centimetre Long Gun. | |
|---|---|---|---|---|---|---|
| Calibre | | | in.<br>12.6 | mm.<br>320 | in.<br>12.6 | mm.<br>320 |
| Total length of gun | | | 352.8 | 8960 | 377.9 | 9600 |
| Weight of gun | | | tons<br>33.68 | kilos.<br>39,300 | tons<br>39.08 | kilos.<br>39.700 |
| " shell | | | lb.<br>749.5 | 340 | lb.<br>749.5 | 340 |
| " powder charge | | | 187.39 | 85 | 264.5 | 120 |
| Initial velocity | | | ft.<br>1607 | metres<br>490 | ft.<br>1870 | metres<br>570 |
| Striking energy | | | foot-tons<br>13,482 | metre tons<br>4161.6 | foot-tons<br>18,175 | metre tons<br>5631.4 |
| Remanent velocities at | yds.<br>547 | metres<br>500 | ft.<br>1539 | metres<br>469 | ft.<br>1788 | metres<br>545 |
| | 1094 | 1000 | 1467 | 447 | 1769 | 521 |
| | 1641 | 1500 | 1407 | 429 | 1637 | 499 |
| | 2188 | 2000 | 1343 | 411 | 1565 | 477 |
| | 2735 | 2500 | 1293 | 394 | 1499 | 457 |
| Striking energy at | 547 | 500 | foot-tons<br>12,305 | metre tons<br>3812.5 | foot-tons<br>16.679 | metre tons<br>5167.4 |
| | 1094 | 1000 | 11,180 | 3463.3 | 15,128 | 4686.8 |
| | 1641 | 1500 | 10,295 | 3169.9 | 13,931 | 4315.9 |
| | 2188 | 2000 | 9,450 | 2927.9 | 12,730 | 3943.7 |
| | 2735 | 2500 | 8,684 | 2690.6 | 11,684 | 3619.9 |
| Striking energy in foot and metric tons per inch and per cent. of circumference of shell | At muzzle | | 343.3 | 41.87 | 464.5 | 56.65 |
| | 547 | 500 | 314.5 | 38.36 | 426.3 | 51.99 |
| | 1094 | 1000 | 285.7 | 34 84 | 386.6 | 47.15 |
| | 1641 | 1500 | 263.1 | 32.09 | 356.0 | 43.42 |
| | 2188 | 2000 | 241.5 | 29.46 | 325.4 | 39.68 |
| | 2735 | 2500 | 222.0 | 27.07 | 298 6 | 36.42 |
| Penetration in wrought iron | At muzzle | | in.<br>20.52 | cm.<br>52.1 | in.<br>25.47 | cm.<br>64.7 |
| | 547 | 500 | 19.25 | 48.9 | 23.94 | 60.8 |
| | 1094 | 1000 | 17.99 | 45.7 | 22.33 | 56.7 |
| | 1641 | 1500 | 16.97 | 43.1 | 21.11 | 53.6 |
| | 2188 | 2000 | 15.95 | 40.5 | 19.73 | 50.1 |
| | 2735 | 2500 | 15.04 | 38.2 | 18.98 | 47.2 |
| Range at different angles | deg.<br>3 | | yards<br>2,307 | metres<br>2,110 | yards<br>2,942 | metres<br>2,690 |
| | 5 | | 3,598 | 3,290 | 5,036 | 4,605 |
| | 7 | | 4,790 | 4,380 | 5,938 | 5,430 |
| | 10 | | 6,402 | 5,855 | 7,972 | 7,290 |
| | 15 | | 8,688 | 7,945 | 10,466 | 9,570 |
| | 20 | | 10,548 | 9,645 | 12,543 | 11,470 |
| | 25 | | 12,033 | 11,005 | 14,217 | 13,000 |
| | 30 | | 13,189 | 12,055 | 15,496 | 14,170 |
| | 35 | | 14,012 | 12,815 | 16,386 | 14,985 |

an eccentric on the main shaft A′. On the opposite side of the wheel is a detent L′, and both ratchet and detent are held against the wheel by the spring *p*. On the shaft B and abaft A is a screw thread, and also, at its rear end, a cam G, Figs. 21 and 22. Parallel to B is another shaft D, having keyed upon it, but free to slide along its length, a sector E with a screw-threaded periphery which engages the threads on B. On the rear face of the sector is a stud H, and on its upper edge is a latch P, which latches into the notched plates P′ and insures the periphery of the sector engaging the screw thread. Fixed on the same shaft D is a lever *d* which is connected to the starting valve lever by a connecting-rod F. When the propellers are set in motion the eccentric on A″, Fig. 20, causes the wheel A and shaft B to rotate; the screw thread on B carries the sector E aft until the latch P clears the notches in the latch-plates P′. Then the revolving cam G comes in contact with the stud H on the after face of the sector, lifts it and the lever *d* about the axis of D, and, through the medium of the connecting-rod F, Fig. 21, closes the starting valve. The sector E then springs forward along D under the action of the spring R, which is secured aft and doubled back over the roller *p* to secure to the lug *e* on the sector. When the starting valve is opened, as the torpedo is launched, the sector is latched into P′. Before placing the torpedo in the launching tube the sector can be set for a desired run by pushing the sliding leaf *m*, Fig. 21, which is in contact with the lug *e*′, along a longitudinal groove *v* in the torpedo envelope. The edge of this groove is graduated for different runs.

The shaft B extends forward of the wheel A, Fig. 22, and has fixed on its forward end a pinion *a*, Figs. 20 and 23, which works the arrangement for restraining the horizontal rudders. This consists of a bronze sector J, Fig. 20, pivotted at *j*³, and having a flange on its periphery, and also, pivotted to it on a stock at *j*′, a rack K. The spring *o* tends to press the rack and sector always to the right and to keep the teeth of the rack always up against the pinion *a*. To set this apparatus, move the horizontal rudders by hand to bring the jaws *j*″ on the vertical rod I in line with the flange *j*. Then insert a key, through a hole in the torpedo envelope, into a socket in a lug *t* on the sector J, and push the latter to the left. The flange *j* enters the jaws *j*″ and the rack K engages with the pinion *a*. The rod I is thus held immovable until, by the rotation of the propeller shaft A′, the rack K, released tooth by tooth, and forced to the right by the spring *o*, pushes the sector to the right until the flange *j* clears the jaws *j*″. The duration of immobilisation can be regulated by the set screw T working in the lug *s* on the rack, for its head T′, bringing up against the pinion *a* when the sector J is set, limits the arc of *j* engaged by the jaws *j*″. The sinking valve in these later models is inclined in the machinery bulkhead, but its mode of action is unaltered.

The following is an abridged, but not otherwise altered, description of the Howell automobile torpedo now being manufactured for the United States, furnished us by Mr. E. W. Very, of the Hotchkiss Ordnance Company.

(*To be continued.*)

Victorian Coal.—A diamond drill, which has been working at Korumburra, South Gippsland, passed, at a depth of 410 ft., through a seam of black coal 3 ft. thick.

Elliott's Smoke Annihilation.—Elliott's method of "annihilating" smoke from boiler and other furnaces is now being shown on the Thames Embankment near the City of London schools. The method consists in drawing the smoke from the smokebox by a fan, and delivering it into a box half filled with water. By means of a rotary paddle the water is churned up into spray through which the smoke passes. The object is to wash the carbon particles out of the smoke, together with the tar, ammonia, and sulphuric acid, and to let nothing escape but invisible and inodorous gases. As far as can be judged, this result is very fairly attained, but the apparatus is too small for a really adequate test. We understand, however, that the invention can be seen applied to a boiler of 100 horse-power, and that it has been found that the increased amount of fuel required to drive the fan which produces the artificial draught, is 2½ per cent. of the consumption. The inventor's address is 83, Queen-street, Cheapside, E.C.

## NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

*The Cleveland Iron Market.*—Yesterday the weekly iron market was very dull and unsatisfactory. The attendance was small and the tone was cheerless. Very little iron changed hands, buyers being difficult to find notwithstanding the lowness of prices. Some merchants were very anxious to sell. First thing in the morning business was recorded at 45s. 6d. per ton for prompt f.o.b. delivery of No. 3 g.m.b. Cleveland pig iron, but only a small quantity was sold at that figure, and those who obtained it were indeed fortunate. As the day wore on affairs eased considerably, and plenty of No. 3 might have been bought at 45s. 3d., but purchasers would not as a rule give more than 45s. Middlesbrough warrants were steady at 45s. cash buyers, but very little business was done in them. Grey forge iron was sold at 43s., but several sellers asked rather more than that figure. No. 4 foundry changed hands at 44s. To-day affairs were a little better and prices advanced slightly, but as a matter of fact very little business was done. A small lot of No. 3 secured 46s., but that was for a special brand. The general figure for No. 3 was 45s. 6d., and that price was paid. Middlesbrough warrants were rather better, closing 45s. 3d. cash buyers. The hematite pig iron trade is rather easier, but a somewhat better demand is reported from the Sheffield district. The price, however, does not improve at all, for Nos. 1, 2, and 3 east-coast brands of makers' iron can be obtained at 56s. 6d., and even less might be accepted.

*Manufactured Iron and Steel.*—In the manufactured iron industry there is very little new. All the works keep well employed, and some producers have a good number of orders on hand, but others are rapidly getting through their contracts, and are rather anxious about new work, which they experience difficulty in securing. Common bars are 6*l.*; ship-plates, 6*l.*; and ship angles, 5*l.* 17s. 6d, all less 2½ per cent. discount for cash. The steel trade is quiet, but heavy rails are in rather better demand at 5*l.* Steel ship-plates are 6*l.* 5s. to 6*l.* 7s. 6d.

*Cleveland Miners' Wages.*—On Tuesday the Cleveland Miners' Association made application to the Cleveland Mineowners' Association for a 53 hours' week for mechanics employed about the mines, and requested an advance of 1d. per ton for all men working in fours. The employers will give their answer in the course of a few days.

*Cleveland Institute of Engineers.*—A day or two ago the annual meeting of the Cleveland Institute of Engineers was held in the hall of the Literary and Philosophical Society, Middlesbrough, the retiring president, Mr. Charles Wood, in the chair. The chairman moved the adoption of the annual report, which showed that during the past year there had been a loss of seventeen members and eight new members had joined, leaving a decrease of nine. The total number of members was now 207. The balance-sheet showed the Institute in debt to the secretary to the extent of 30*l.* 19s. Eight new members were elected, and Mr. Charles J. Bagley was elected president of the Institute for the ensuing year and took his position as chairman of the meeting amidst applause. A hearty vote of thanks was accorded Mr. Wood for his services as president during the past year. The new president said a good many of their friends had recently visited America, and he was sorry that none of them had come forward to read a paper on their experience. As they had not done so he would relate some of his experience in a visit to America in 1886. He was more struck with the progress made in the blast furnaces of America than in any other branch of the iron trade. He pointed out that in England they were a long way behind in the production of pig iron. It behoved them to do all in their power to bring themselves in a line with their competitors in America. He trusted they would soon regain their position. Mr. W. Henry Fryer presented a paper on "Desiccation of the Blast in the Manufacture of Pig Iron," which was taken as read. A discussion on the paper followed.

*The Average Selling Price of Manufactured Iron and Steel.*—The report of Mr. Waterhouse in connection with the wages sliding scale arrangement of the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England, has just been published by the joint secretaries, Messrs. G. R. Winpenny and Edward Trow. The report is for the two months ending October 31, and regulates the wages for the ensuing months of December and January. Having collected all information on the sales of manufactured iron during the period under consideration, Mr. Waterhouse certified the net average selling price per ton to have been 6*l.* 0s. 9d., as compared with 5*l.* 19s. 11.30d. for the preceding two months, an increase of 9.10d. per ton. The detailed particulars show that 708 tons of rails have been sold at an average net selling price of 5*l.* 14s. 9.29d., 23,529 tons of plates at 5*l.* 19s. 7.86d., 15,184 tons of bars at 6*l.* 6s. 8.24d., and 6782 tons of angles at 5*l.* 11s. 11.89d. Totals 46,202 tons 5 cwt. 3 qrs., averaged net selling price 6*l.* 0s. 9.19d. against 41,242 tons 18 cwt. 1 qr. 10 lb., and 5*l.* 19s. 11.30d. average net selling price last month, showing an increase both in quality and price. The improvement is not yet sufficient to bring an advance of wages, which are at present on the 6*l.* basis, above which they will not rise until the net selling price gets above 6*l.* 2s. 6d., or below which they will not fall until it gets below 5*l.* 17s. 6d.

American Intercontinental Railway.—Commissioners appointed to consider the most feasible plan for a grand trunk railway to connect the northern and southern continents of America are about to assemble at Washington.

5/6

# THE WHITEHEAD TORPEDO.

(*For Description, see Page 628.*)

Fig. 10.

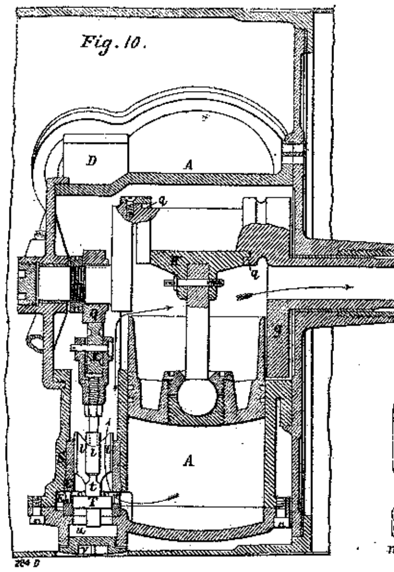


Fig. 11.

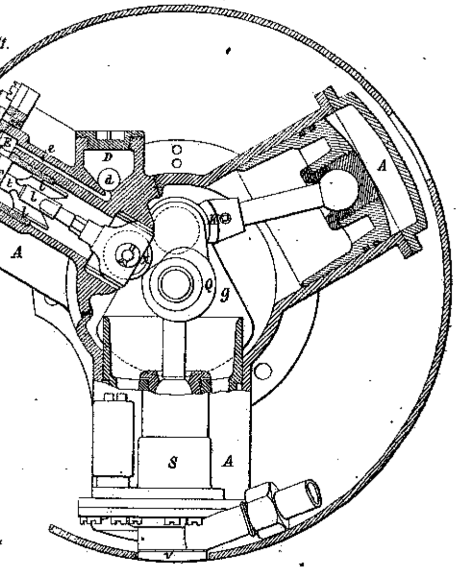


Fig. 12.

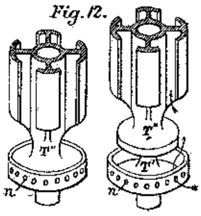


Fig. 13.

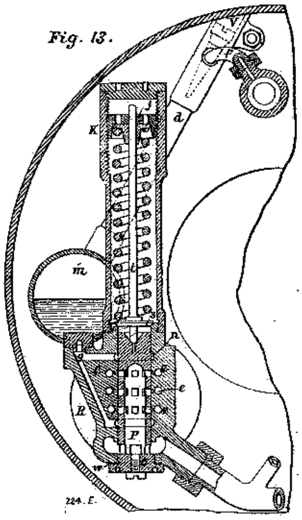


Fig. 14.

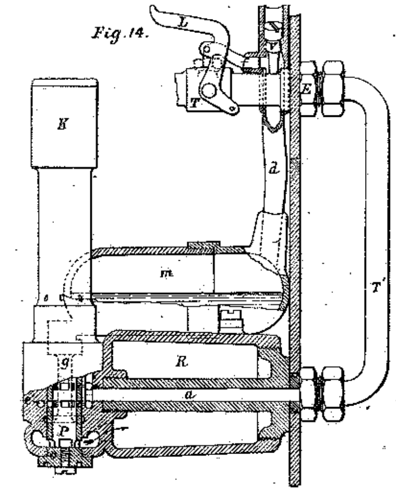


Fig. 20.

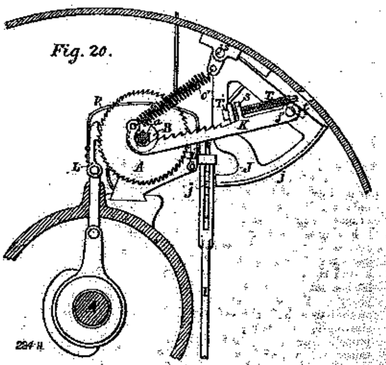


Fig. 15.

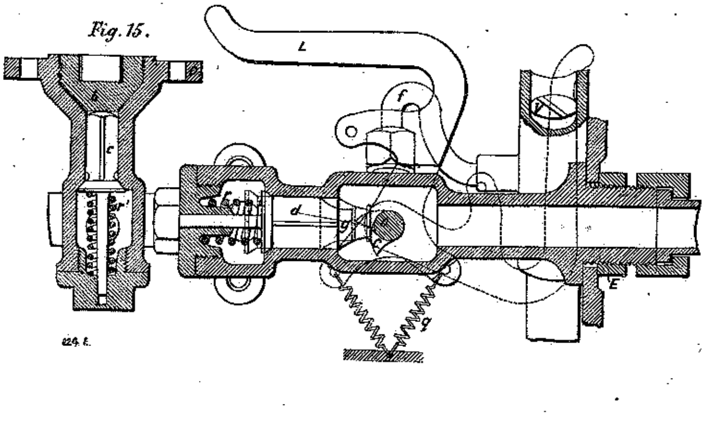
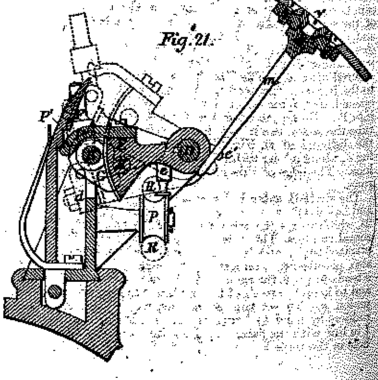
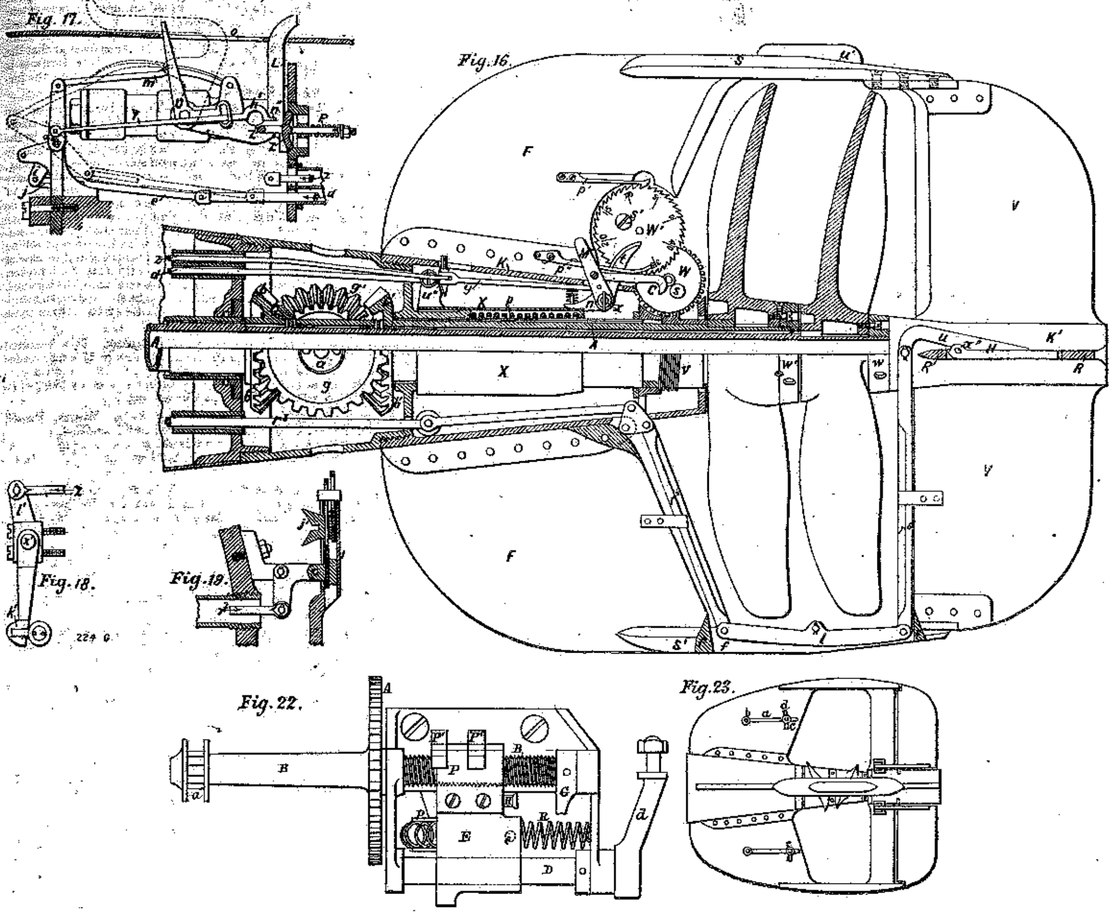


Fig. 21.



## THE WHITEHEAD TORPEDO.

(*For Description, see Page 628.*)



## FLOODING OF THE MANCHESTER SHIP CANAL WORKS.

Nature has claimed such honour as may attach to he first permanent flooding of the Manchester Ship anal. Many sections of the canal are practically nished, and the walls of the Salford Docks are comleted to water level. The River Irwell, which runs rallel with the canal in many places, having in one two points being diverted, overflowed by reason of cent great storms and floods, and filled the new wateray in some places to a depth of 30 ft. The advanced age of the works will not necessitate the pumping of l the sections, notably the Salford Dock. The flood me on Sunday and the swollen river gradually se until the Salteye cutting above Barton Bridge, hich has been finished, and adjoins the river at the stern end, became a small lake. Notwithstanding is outlet for the water, the surface level of the river ill rose, and gradually topped the embankment at e next lower section, pouring into and soon filling e channel from which the river had been diverted st above the Barton aqueduct, and which had been epared as the new waterway. The embankments ross the works were strengthened on Sunday; t the water, owing to the continued rainfall, reased in volume and power. At Stickins Island ovision had been made for collecting the water the fields south of the canal, and passing it gravitation over wooden aqueducts to the ver Irwell on the north side, the water level being wer than the ground south of the canal. The ods soon raised the river level to the outlet of the ueducts and the water passed over to the fields, ere it attained a level resulting in an overflow o the canal bed which is here hewn out of red sandstone. On Sunday night the water was 21 ft. deep, at noon on Monday 26 ft., and on Monday evening 30 ft. At the Manchester end of the Trafford Park section, which is nearly finished, a strong embankment separated the canal from the river which takes a bend at that point, but the force of the current at this elbow made a breach on Monday morning. Soon the breach was widened and the section completely filled. From Trafford Docks to Irlam the whole of the cuttings were flooded and many steam navvies and pumps submerged, but on Wednesday and Thursday the water gradually fell.

Mr. Leader Williams, the engineer, with other officials of the company and the representatives of the contractors, have since Saturday been in constant attendance at various parts of the works. The following official statement was issued on Monday morning: "The engineer's report with reference to the recent floods is that, so far as can be ascertained, no injury whatever has resulted to the permanent works. The greater part of the work within the area affected by the flood is either completed or so nearly so that the water will be allowed to remain where it is, and the remaining excavation will be completed by dredging. The Manchester and Salford Docks have been filled with water, and the former will have to be pumped out, as they are not quite finished. The walls of the Salford Docks are, however, completed above the highest water level, and the excavation also being finished, it will not be necessary to pump the water out. The Mode Wheel Locks, which are in a very forward state, will be at once pushed on to completion, when the large sluices there will admit of the river up to the Manchester docks being run off nearly dry in order to complete the works. Below Mode Wheel Locks the water will have to be pumped out, but the work will not be stopped, as the walls are considerably above water level. Lower down the river the Warburton cutting was filled with water, but it is fortunately completed, and the water will not therefore require to be pumped out." On Monday evening the following supplementary report was issued: "All the dams stood firm between Stickins and Irlam, but the River Irwell, overflowing the meadows above Stickins and finding a low course below Davyhulme, flowed into the cutting between the new locks at Irlam and Barton, washing away a portion of a field at the point at which it entered the cutting. There are now at work in this length seven centrifugal pumps, and four additional ones will be put to work at once, and it is expected that the water will be pumped out from the cutting and from Irlam and Barton locks before the end of the year. Part of the walls of the locks are above water-level and will allow of the work progressing, and as the water is lowered by the pumps more men will be put on each week. No damage has occurred to the work between Latchford and Eastham either from the gale or the flood, and the men and plant which have been thrown out of employment on the upper sections will be sent to work on the lower part of the canal for the present. There are no locomotives in the flooded cuttings, and fortunately there has been no loss of life."

---

## THE TAUNTON ACCIDENT.

To the Editor of Engineering.

Sir,—There is one aspect regarding the Taunton accident, of which I have seen no mention made in the numerous letters which have appeared in the public press, namely, the small, I may say very small, loss of life in comparison with what one would expect. The circumstances under which the accident occurred all tended to

## THE HOWELL TORPEDO.

(*For Description, see Page 740.*)


Fig. 24.

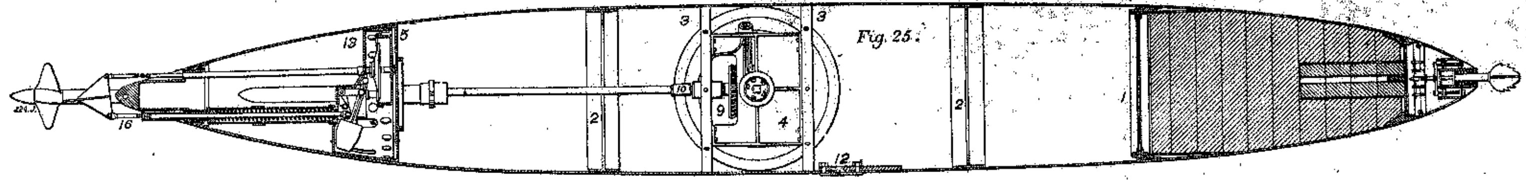


Fig. 25.

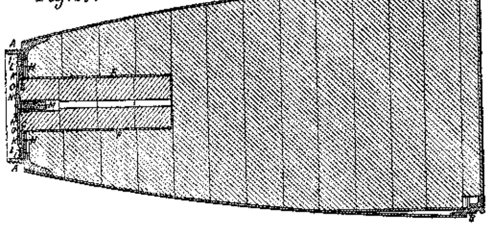


Fig. 29.

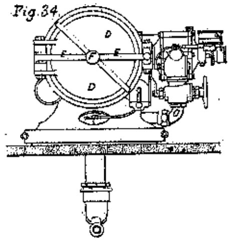


Fig. 34.

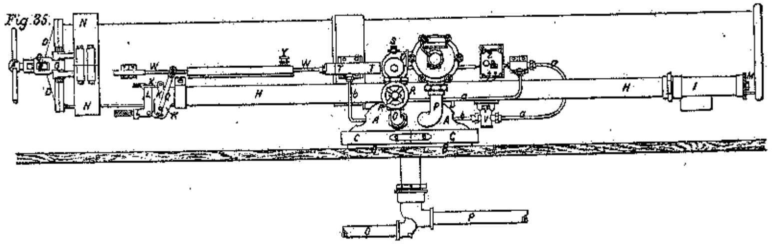


Fig. 35.

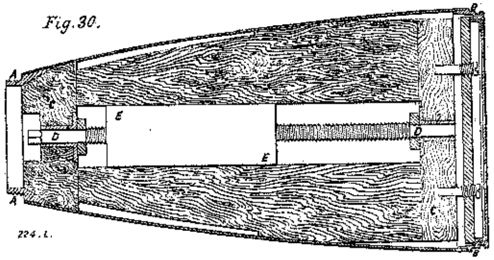


Fig. 30.

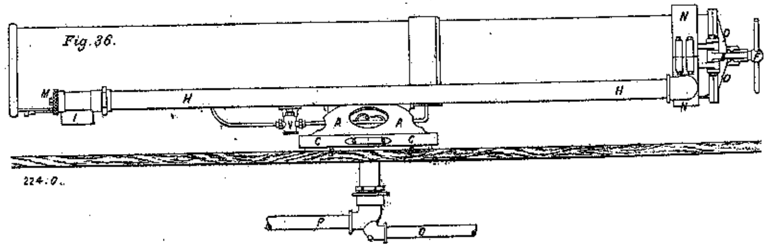


Fig. 36.

## INDUSTRIAL NOTES.

The closing month of the year 1890 seems destined to keep up the reputation of the previous eleven months in the matter of industrial disputes. Indeed, the indications at present are that the year 1891 will open with further developments in this respect. The cotton operatives seem to have chosen a most inopportune time for a strike, although the matter has since been settled by the concession of their demands of 5 per cent. advance. Some 628 members did not vote, but even adding these to the votes against, the majority was over 2000 in favour of a strike. This dispute would have affected about 25,000 persons engaged in the trade, covering eight large centres of the cotton industry and their adjacent districts. A great strike is also threatened all over the North-Eastern Railway system. The men have given in their notices demanding a reduction in the working hours, in accordance with what is known as the Darlington programme. In London, the potters' strike at Messrs. Doulton's continues, 130 men being out, and more threatening to come out, it is stated, because three boys have been employed as apprentices. The firm asserts that they are the sons of workmen employed, and that they will not discharge them. In the East-end the stickmakers are still out, this being the twelfth week; the men mostly depend upon outside assistance for strike pay and food. Although the proposed strike on the Scottish lines has been officially abandoned, yet there appears to be a good deal of uneasiness as to any possible turn in affairs which may result in a

### BALANCE-SHEETS.*

*Boiler Alone.*

| — | October 3. | April. |
|---|---|---|
| DR. | thermal units | thermal units |
| To calorific value of 1 lb. dry coal .. .. .. .. | 13,769 | 13,769 |
| To heat contained in coal and moisture .. .. .. | 8 | |
| To heat contained in air entering furnace .. .. .. | 137 | 77 |
| | 13,914 | 13,851 |

| CR. | thermal units | per cent. | thermal units | per cent. |
|---|---|---|---|---|
| By heat transferred to water | 8,186 | 58.83 | 7,240 | 62.27 |
| ,, carried off by flue gases: | | | | |
| By heat carried off by products of combustion .. | 1,519 | 10.92 | 1,155 | 8.34 |
| By heat carried off by air in excess .. .. .. .. | 1,662 | 11.95 | 929 | 6.71 |
| By heat lost in evaporating and superheating moisture mixed with coal .. .. | 68 | 0.49 | 66 | 0.48 |
| By heat lost by imperfect combustion .. .. .. | 883 | 6.33 | 873 | 6.30 |
| By heat equivalent of unburnt carbon mixed with clinker .. | 698 | 5.02 | 1,107 | 7.99 |
| By heat lost in hot ashes drawn from fire .. .. | .. | .. | 116 | 0.84 |
| By remainder, including heat transmitted through brickwork, and unaccounted for | 898 | 6.46 | 2,365 | 17.07 |
| | 13,914 | 100.00 | 13,851 | 100.00 |

* In constructing these balance-sheets all temperatures are reckoned from 32 deg. Fahr.

*Economiser Alone.*

| — | October 3. | April. |
|---|---|---|
| DR. | thermal units | thermal units |
| To heat received from boiler flues per pound of dry coal | 3249 | 2151 |
| To heat contained in air entering at chain holes .. .. | 40 | 48 |
| To difference in heat contained in water in economiser at beginning and end of trial estimated at .. | 40 | 195 |
| To difference of heat contained in brickwork at beginning and end of trial and error of observation .. | .. | 91 |
| | 3329 | 2585 |

| CR. | thermal units. | per cent. | thermal units. | per cent. |
|---|---|---|---|---|
| By heat transferred to water | 1152 | 34.60 | 1064 | 41.16 |
| ,, carried off in products of combustion .. | 664 | 19.95 | 616 | 23.83 |
| By heat carried off in excess air .. .. .. .. | 1120 | 33.65 | 843 | 32.61 |
| By heat carried off in superheated steam from moisture mixed with coal .. .. | 61 | 1.83 | 62 | 2.40 |
| By remainder, including heat transmitted through brickwork and unaccounted for | 332 | 9.97 | | |
| | 3329 | 100.00 | 2585 | 100.00 |

*Whole Apparatus.*

| — | October 3. | April. |
|---|---|---|
| DR. | thermal units | thermal units |
| To calorific value of 1 lb. dry coal .. .. .. .. | 13,769 | 13,769 |
| To heat contained in air, coal, and moisture .. .. .. | 185 | 130 |
| To difference in heat contained in water in economiser at beginning and end of trial .. .. .. .. | 40 | 195 |
| | 13,994 | 14,094 |

| CR. | thermal units. | per cent. | thermal units. | per cent. |
|---|---|---|---|---|
| By heat transferred to water | 9,338 | 66.73 | 8,304 | 58.92 |
| ,, carried off in products of combustion .. .. | 664 | 4.74 | 616 | 4.37 |
| By heat carried off in excess air .. .. .. .. | 1,120 | 8.00 | 843 | 5.98 |
| By heat carried off in superheated vapour .. .. | 61 | 0.44 | 62 | 0.44 |
| By heat lost by imperfect combustion .. .. .. | 883 | 6.31 | 873 | 6.19 |
| By heat equivalent of unburnt carbon .. .. .. .. | 698 | 4.99 | 1,107 | 7.86 |
| By heat lost in hot clinker drawn from furnace .. | .. | .. | 116 | 0.82 |
| By remainder, including heat transmitted through brickwork and unaccounted for .. | 1,230 | 8.79 | 2,173 | 15.42 |
| | 13,994 | 100.00 | 14,094 | 100.00 |

and turned out upon the floor. As one weighing was not always quite finished before the next was turned out, and as the hopper of the stoker was not allowed to empty itself entirely before being recharged, there was always a small floating balance between the rate indicated by the diagram and the actual rate of firing.

On comparing the balance-sheets for the two trials, a considerable saving is seen to have been effected. To what must this saving be attributed? Not to more careful firing and regulation of dampers, for the heat carried off in the waste gases was greater than in April. Neither can it be set down, except in a very slight degree, to the mechanical stoker and moving firebars, for the loss from imperfect combustion and unburnt carbon was but little less than at the previous trial. No, the saving was principally due to the thick furnace walls and better protection of the furnace front, whereby the quantity of heat lost by transmission through the brickwork was materially reduced.

The conclusion drawn from the results of the April trials seems, therefore, to be correct.

## AUTOMATIC TORPEDOES.

*Automobile Torpedoes, the Whitehead and Howell, with a Detailed Description of each.**

By Ensign JOHN M. ELLICOTT, U.S. Navy.

(*Continued from page* 631.)

THE general profile of the Howell torpedo is that of a spindle of revolution, the after body being a true spindle, the middle body a cylinder, and the fore body an approach to an ogive. There are four distinct detachable sections; the nose, which carries the firing pin and its mechanism; the head, which carries the explosive charge and detonator; the main section, which carries the flywheel and screw gears; the stern section, which carries the diving mechanism (pages 737 and 741).

*The Nose* (Figs. 26 and 27).—In order to guard as completely as possible against a premature discharge of the torpedo in handling, the percussion firing pin is so arranged as to be completely removable and also to be quickly attached at the last moment before inserting the torpedo in the launching tube. The entire firing pin mechanism is, therefore, permanently fixed in a single hollow bronze casting 17 17, which is attached to a projecting lip at the front end of the head by a simple bayonet, or slotted screw, joint, so that a few seconds only are necessary to attach and detach it. A stout steel pin 18 travels in guides formed in the nose casting, and is actuated by a strong spiral spring 19. It is held back in the armed position by a soft metal pin 20, which seats in a slot cut through the pin and bears against the outside of the nose. The outer end of the firing pin is provided with fan-shaped corrugated horns 21, which receive the impact blow, and are so shaped and arranged as to prevent glancing or sliding along the object struck when the impact is sharply angular. The force of the blow is intended to shear the soft metal stop-pin, and thus permit the firing pin to be driven violently down on the detonator by the spring.

Two small cams 22 22 are so pivotted and maintained by the small flat springs 23, 23, that normally they rest against the body of the firing pin just under a shoulder, so that if from any accident the pin after cocking should be so struck as to shear the soft metal stop-pin, it could not drive down and explode the detonator. Just in front of the cams is a crosshead 24, having projections which rest on the cams, so that as the crosshead is pushed to the rear the cams are turned out clear of the shoulder, leaving the firing pin clear. The crosshead is in connection with two small pistons 25 25, which are held forward by the cam springs. The front ends of these pistons come out flush with the outer surface of the nose and are entirely open. When, after launching, the torpedo strikes and rushes through the water, the direct pressure on these pistons forces them back against their springs, in turn pressing on the cams and turning them back clear of the firing pin, which is then completely armed for action. When the speed of the torpedo becomes so reduced as to permit the piston springs to overcome the pressure of water on the pistons, they come forward, the cams turn in under the shoulder, and the firing pin is again locked. The condition of the firing pin is at all times plainly visible. The length of the firing pin projecting beyond the nose shows whether it is cocked or not; the piston heads being plainly visible show at all times whether the cams lock the pin or not. When the nose is off the head, the front of the interior of the head is laid bare, so that the detonator itself may be kept out of the torpedo until the last moment. Small holes 26, inclining strongly backward, are pierced through the nose and are left open. These holes leak water into the hollow nose chamber when the torpedo is stationary, or at low speed, which overcomes the reserve buoyancy of the torpedo, sinking it and finally attacking and drowning the dry gun-cotton detonator; so that if the torpedo fails to make a hit it locks its firing pin, and sinks and drowns its detonator, being thus rendered completely innocuous.

*The Head* (Figs. 29 and 30).—The heads are distinguished as the dummy head and the fighting head. The shells of both are made of a single sheet of brass brazed and spun to shape and braced by strong rings A A, B B at the front and rear ends. Each of these rings is prolonged slightly beyond the end of the shell to form bayonet joint locks, the front one for holding the nose, the rear one for securing the main section.

The dummy head carries a heavy wooden block C C, quite filling the interior space. This block has a square hole cut through its axis, and carrying an iron threaded bar D D. Upon this bar is a square lead block E E. The outer end of the bar being squared, it is readily seen that by turning it the block is traversed back and forth. By this means the torpedo is balanced longitudinally. When the torpedo is launched, no matter whether it has buoyancy or not, its diving mechanism will keep it at its proper depth. It is desirable that the greatest weight of explosive possible should be carried and also that it should sink at the end of its run if it fails to make a hit. Therefore with the fighting head the buoyancy is practically *nil* and the torpedo is permanently balanced in its entirety for this condition. For exercise, however, the torpedo must not be allowed to sink, as it would be lost. The dummy head, therefore, is lighter than the fighting head, so as to give about 13 lb. buoyancy, and the lead block is introduced in order to keep the centre of gravity of the torpedo in the same position relatively to the centre of buoyancy as that occupied with the fighting head. Otherwise there would be a difference of leverage between the two conditions that would alter the steering adjustments. A single shop adjustment of this block is sufficient, and maintains its place unless moved by screwing the bar. A complete bulkhead plate screws water-tight into the rear end of both heads.

In the fighting head the main part is completely filled with wet gun-cotton; a small water-tight chamber F F, formed of a single piece of drawn copper, being reserved for the dry gun-cotton primer. This chamber is removable, having a flange G G at its mouth which seats on the diaphragm H H, screwed across the mouth of the front casting by means of a ring I I screwing down on a rubber gasket. A cap K K covers the primer chamber, being held in place by spring catches L L, and forming also the seat for the detonator M, which is held in place by the spring catches N N. By this arrangement the detonator may be removed, and as the dry primer is contained in a thin tin case, it also is readily removable, leaving the head with only the wet gun-cotton charge, which itself is at all times hermetically sealed in proper shape for stowage in a magazine, the primer and the detonator also stowing separately in their own magazines. Two small holes O O are drilled through the cap of the primer compartment and are filled with a substance that is soluble after long contact with the water. As above explained, the holes in the nose admit water at the end of a run. The water attacks the composition, filling the holes in the cover, and after a number of hours dissolves it out, and so drowns the dry gun-cotton primer.

*The Main Section.*—This section comprises the entire cylindrical body of the torpedo and portions of the curved part at either end. The shell consists of three sections of brass plate, corresponding to the cylindrical and curved portions, brazed, and spun to shape. The section is closed water-tight at both ends, and contains the flywheel with its frame, the propeller gears, and forward sections of shafting, and the thrust bearings.

The shell is braced against deformation or crushing by six ribbed rings. There is a bulkhead ring 1, Fig. 25, which is flanged, and in which are worked the sockets of a bayonet joint, by which the head is secured to the main section. The flange of this ring is threaded, and receives a complete water-tight bulkhead. As has been described, there is also a complete bulkhead plate at the rear of the head. These plates naturally lie on either side of the joint, and when the sections are connected they are only about $\frac{1}{100}$ in. apart. The space is so small that any leak that may occur through the joint does not admit water enough to be of any consequence, and so long as the joint is reasonably tight any water that may lie between the bulkheads is relieved from the pressure due to immersion, so that it will not be forced past their joints. The torpedo has been sunk to a depth of 40 ft. without showing any signs whatever of leakage.

Two intermediate rings 2 are inserted under the brazed joints of the shell. These are simply plain, flanged, bronze rings. Two rings 3 support the midship section, and at the same time form a part of the assemblage of the wheel frame, the other members of the frame being two plate castings 4 (shown in section Fig. 31, F F F F), forming the bearings for the flywheel, which are bolted to the rings. Finally there is a rear bulkhead ring 5, which, like the front one, holds a complete bulkhead and also forms the seats for the thrust bearings. It is impossible to connect the main and stern sections by a bayonet joint on account of the screw shafts, which prevent the twisting necessary to lock the joint. The strengthening ring of the stern section, therefore, has a lip which fits into an under cut in the flange of the main section ring and is held by screws S S S. As this joint comes in the compartment containing the diving mechanism, which must be free to water access, it is not necessary that it should be water-tight.

*The Flywheel and its Connection* (Fig. 31).—The flywheel A A A A is of gun-steel, drop-forged and treated similarly to the tube and jacket forgings of guns. It has a heavy rim with a solid web connecting it to the hub. Secured to the hub and symmetrically placed on each side of the web are two steel mitre wheels B B which gear into similar wheels 9 9, Fig. 25, secured to the inner ends of the screw shafts, the proportion of gearing being as five to four, so that each screw makes 800 revolutions to every 1000 of the flywheel. The axle of the flywheel C C G is a single solid steel axle, permanently secured in its seat in the wheel; its bearing ends resting on hard steel rollers D D D D in hard steel bearings E E E E, which themselves seat in sockets cast in one with the frame plates F F F F. The inner ends of the bearings E E and the bodies of the mitre wheels facing them, are grooved and hold steel balls G G G G, forming ball bearings to take the end thrust of the flywheel. Thus the wheel is provided with frictionless bearings, no matter what be the plane of the axle when rotating.

The connection between the flywheel and its motor, which forms part of the launching gear, is made through the starboard side of the torpedo by means of clutch couplings to the end of the axle. The right-hand end of

---

* From the Annual of the U.S. Office of Naval Intelligence. The description of the Howell automobile torpedo manufactured for the United States, was furnished to the author by Mr. E. W. Very, of the Hotchkiss Ordnance Company.

# THE HOWELL TORPEDO.

Fig. 26.

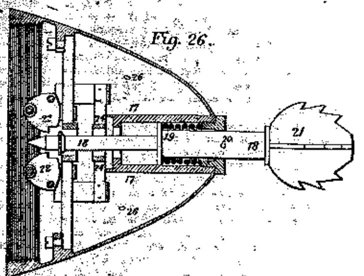


Fig. 27.

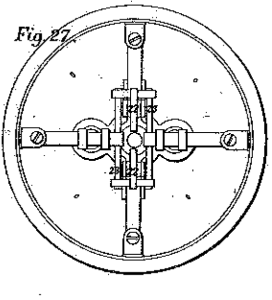


Fig. 28.

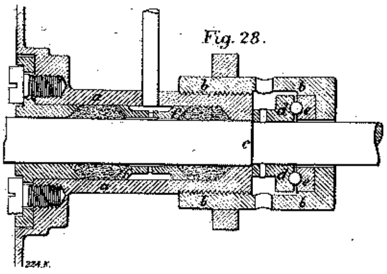


Fig. 31.

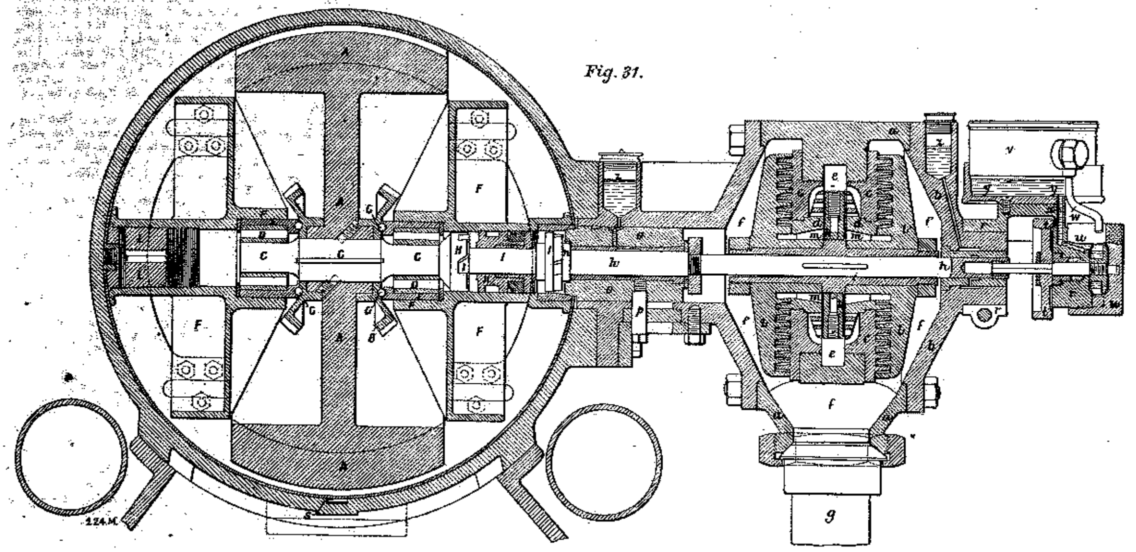


Fig. 32.

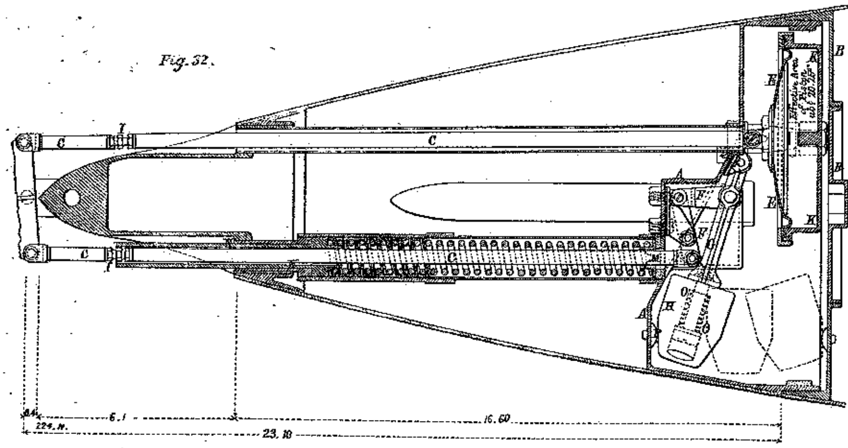
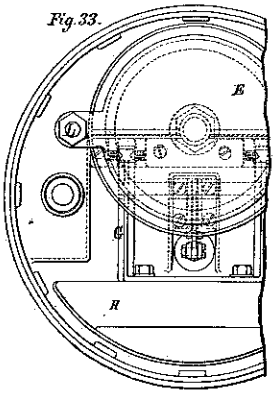


Fig. 33.



the axle is squared and carries pinned on it a steel end clutch H. A loose clutch I I is held in a stuffing-box K K seated in a prolongation of the frameplate which bears against the shell of the torpedo, a through-hole being cut in the shell and the joint being closed water-tight. This loose clutch I I is so made in order to free the flywheel from the friction of the clutch in the stuffing-box. After spinning up the wheel, the moment that the motor is unclutched this loose clutch commences to hang back, from its friction in the stuffing-box. This brings the rear sides of the clutch studs in bearing, and, as they are cut with a deep slope, the clutch is instantaneously driven out free of the wheel.

In order to preserve the balance of the torpedo the left-hand frame plate is carried out to the shell in the same way as the right-hand one. The interior of this projection is threaded, and a lead disc L L is screwed in to counterbalance the clutch and stuffing-box on the right-hand side. By means of this lead disc alone the entire torpedo is balanced transversely, for a small hole is tapped through the shell, through which a key may be inserted, and the disc may be screwed in or out to make the necessary adjustment. Once made it remains of itself.

The screw shafts proper end at the bearing 10 (Fig. 25) being secured to axles of the mitre wheels 9 9 by a mortise and tenon connection. This is done to prevent any skew tendency in the mitre wheel being transmitted to the shaft, and to enable the shafts to be entirely disconnected from the contents of the wheel frame. In order to neutralise the skew tendency of the mitre wheels, their short axles are held in close bearings in front of and behind the wheels, these bearings forming a part of the wheel-frame castings so as to remain constantly true. The screw shafts are carried straight to the rear through the box 8, forming a part of the rear bulkhead ring, and within which are the thrust bearings and a stuffing-box, made necessary by the proximity of the free water compartment. The thrust bearings being placed here relieve the mitre wheels of all thrust, and more room is allowed to make stout bearings than if they were placed further aft.

A broad stout plate is soldered to the bottom centre of the shell, to which, on the outside of the shell, is bolted a long stud 12 (Fig. 25). The function of this stud is to centre and guide the torpedo in the launching tube.

The composition of the thrust bearing and stuffing-box is as follows: Long seats *a a* (Fig. 28) are cast in with the rear bulkhead ring, over which screw caps *b b*. The shaft is slightly increased in diameter at the point *c*, forming a seat for the steel bearing ring *d d*, which has a companion bearing ring *e e* seated against the sleeve. Steel balls lie between these rings, thus forming a ball bearing. A bronze spanner clasps each of the caps and prevents them from unscrewing, while at the same time it resists any tendency to flexure or spreading of the shafts.

A small bronze loose sleeve *f f* is slipped on the shaft and lies in the stuffing-box section. This sleeve is pierced with holes, and its ends are packed. In this way the stuffing-box is formed, and at the the same time provision is made for oiling the bearings, for the oil coming down on the sleeve passes through the holes and is absorbed and distributed by the packing.

*The Stern Section.*—The stern section is divided by a water-tight bulkhead 13 into two compartments, Fig. 25, the forward one containing the diving mechanism and being open to the free access of water through the inlet holes E pierced through the shell, Fig. 24, whilst the rear compartment is closed water-tight, and is empty save the sleeves passing through it, within which are the screw shafts and tiller rods. The rear end of this section is closed by a casting called the tail-piece, which forms in one the butt of the tail and the screw-shaft tubes with their cross support F. The screw shafts are taken in bearings in the tubes F, and the screw propellers, which are right and left-handed, are screwed to the end of the shafts, being held fast by end nuts which are shaped off in long cones to give a fair run to the water passing the hubs. The triangular spaces between the tail body and the screw-shaft tubes, are covered with plates in order to give a fair flow of water to the rudder and screws. The small chambers thus formed also give additional buoyancy.

The rudder I is a steel rectangular plate completely filling the space between the outer ends of the screw-shaft tubes. In this position it is secure against damage in handling the torpedo, and fouling in running. A stout web stands at right angles to the plane of the rudder, forming a steering yoke, to the ends of which are pivotted the tiller rods 16, 16, which in turn are directly connected to the diving mechanism.

*The Diving Mechanism* (Figs. 32 and 33).—The bulkhead A separates the rear and water-tight compartment from the diving compartment, both being in the stern section. It is a single casting so shaped as to reduce the water space to the least possible dimensions consistent with the working of the mechanism, and has a broad flange seating on the shell to form a stout stiffening member of this part. The bulkhead B, which is the rear bulkhead of the main section, forms with A a complete water chamber. The tiller rods C C are pivotted to the rudder yoke and pass inside of sleeves through the water-tight compartment and bulkhead, their inner ends pivotting directly to their respective parts of the diving mechanism, the upper rod being attached to the hydrostatic piston E E, and the lower one to the compound lever of the pendulum F G H. These tiller rods are provided with screw junctions I I for taking up lost motion and regulating the angle of the rudder.

The forward compartment being in free communication with the exterior water the pressure due to depth of immersion is fully borne on the piston E E. This piston fits loosely in its cylinder K K, which is secured to the bulkhead by the posts and nuts L L. The posts are made hollow and connect with the interior of the cylinder so that there is free air connection between the space in the cylinder behind the piston and the whole air space in the rear compartment, so as to prevent any back pressure on the piston. A rubber disc covers the piston and is held water-tight about its edges, so as to prevent water getting into the cylinder, and at the same time to offer no opposition to the free movement of the piston.

Near the front end of the lower tiller rod a seat M M is fastened to it, against which abuts the forward end of a powerful spring whose rear end seats against a movable sleeve N N. This sleeve screws into the rigid main sleeve of the rod, and a key may be used on the end outside the torpedo to screw it in or out and so alter the tension of the spring which alters the depth of immersion.

Assume that the depth at which it is desired to run the torpedo is 10 ft., and that at that depth the total pressure on the hydrostatic piston due to the head of water is 100 lb. The rudder being held amidships, let the spring be adjusted to a tension of 100 lb. Since the tillers are directly connected, the one to the piston and the other to the spring, it follows that if pressure of 100 lb. be brought on the piston the tension of the spring will be balanced and the rudder will lie amidships. This will occur at the assumed depth of 10 ft. If the immersion be less there will be less pressure on the piston and the spring will hold the rudder partially down and so steer the torpedo down to its proper depth, and *vice versâ*. The tension of the spring varies inversely as its length, whilst the pressure on the piston varies directly with the depth. Therefore the helm is not thrown hard up or hard down as the torpedo departs from its proper depth, but it is eased over the proper amount to bring the torpedo easily to its proper depth. The point at which the helm is thrown hard over depends upon the length and strength of the spring.

As a matter of course the torpedo will always move in the direction of its longitudinal axis. Whilst, therefore, through the action of the hydrostatic piston, the rudder will be brought to a neutral position at the proper depth, the torpedo must be horizontal at that depth, or it will continue to go down or up, according to the direction in which it points. The piston cannot correct the direction of the axis of the torpedo except secondarily. It is, therefore, necessary to introduce a heavy pendulum H, suspended so as to swing in the fore and aft line of the torpedo. Whenever the axis of the torpedo dips down or up the pendulum swings forward or aft. The bob of the pendulum, which is very heavy, is mounted on springs O O on its supension rods, so that when the torpedo strikes the water in falling from a height the shock on the suspension points will not be too severe. The pendulum is connected to the front end of the lower tiller rod by a compound lever F F so as to increase its power. Assume that the torpedo is at its required depth, its axis horizontal, and its rudder amidships; leave for the moment out of consideration the action of the hydrostatic piston, and assume that from any cause the bow of the torpedo is tilted down. The pendulum bob at once swings forward and in so doing pushes the tiller rod back and forces the rudder up, thus tending to bring the torpedo to the horizontal again.

If the torpedo be pointed away from its proper depth line, and so long as it is leaving it, both piston and pendulum work the same way on the helm, and combine their efforts to turn the torpedo back, but when it turns back they commence to work against each other so as to ease it gently to its proper line, thus preventing violent oscillation.

A description of this torpedo is scarcely complete without including the launching tube designed by Mr. Elwell, the superintending engineer of the American branch of the Hotchkiss Ordnance Company; and the Dow steam turbine motor, by which the flywheel of the torpedo is "spun up." These descriptions are also quoted from material furnished by Mr. Very.

*The Centre Pivot Launching Tube* (Figs. 34, 35, and 36).—This gear is designed for open deck emplacements where all-around fire is permissible. The discharge tube is of bronze, bored to a diameter $\frac{5}{100}$ in. greater than the midship diameter of the torpedo. It is mounted on a low broad cone A A, whose base rests on a bedplate B B, bolted to the deck, the two being held together by a stout clip ring C C, so that the cone is free to revolve. A shallow groove *s* is cut the full length of the tube along the bottom of the bore to carry the guide stud of the torpedo. The rear end of this tube is closed by a door D D, hinged to swing laterally, its inside edge being coned and ground to close air tight. A steel crossbar E E, with a tightening screw F through its centre, is carried by the same hinges as the door, the free end of the bar being held by a stout bronze loop G G when the door is closed. To lock the door, it is closed, the loop is swung over the end of the bar and a few turns are given to the tightening screws.

Two brass air tubes H H H H are secured to the main tube underneath, one on each side, being connected together at the front end by a cross-pipe I. The tube on the right-hand side, called the firing tube, has screwed to its rear end a small bronze breech-piece K K, which is chambered to carry an ordinary metallic cartridge-case and has a simple breech-block L L, in which is fitted a hammer, sear, and main spring. The weight of powder used is less than half a pound, with which a discharge speed of over 35 knots can be obtained for a torpedo weighing nearly 500 lb. The front ends of both air tubes are closed by screw caps M that may be removed whenever necessary to sweep out the tubes. It will be noticed that the forward end of the firing tube is extended well beyond the cross-duct I. This is done in order to form a lodgment for bits of wad or unburned grains of powder that by the explosion will be driven past the duct and be caught and held in this space precisely as is the case with the cinder trap of a locomotive engine.

The rear end of the left-hand pipe, called the compression pipe, connects by an elbow with the main tube. Around the rear of the main tube is secured a hollow strap N N into which the elbow of the compression tube opens. The wall of the tube underneath this strap is pierced all around with small square ports cut at an angle such that the blast of air created by the explosion of the charge will be directed against the door of the tube first, instead of being taken directly on the tail of the torpedo. The air pressure thus created in the main tube drives the torpedo out. At a speed of ejection of about 35 knots, a torpedo discharged at a height of about 5 ft. will take the water fully 30 ft. from the ship's side.

The Dow motor is attached to the main tube on its right side, a hole being pierced through in the clutch line. The steam pipe O O, and the exhaust pipe P, to and from the motor, are carried down into the supporting cone, where a junction box is made so that the steam pipe goes through the deck inside of the exhaust. This junction is swivelled to permit the system to revolve. A throttle valve, with a handwheel R R, gives steam, which is controlled by a regulator valve S, and there is also connected to the throttle an automatic cut-off.

The small box V is a steam cylinder, whose piston projects up through the main tube into and filling the slotway for the torpedo guide stud and forming a stop. This piston is held up by a spiral spring underneath it. To load the torpedo into the tube it is simply necessary to push it in until its guide stud brings up against this stop, and then close and fasten the door. The clutch hole in the torpedo is then directly in line with the motor clutch, and the moment that these clutches are thrown in action the torpedo is held firmly against all movement.

A long rod W W performs the work of clutching, disconnecting, and firing. The torpedo being in its tube, the powder charge may be inserted. Lift the small spring latch X, open the breech, and insert the cartridge. It is to be remarked that unless the torpedo is clutched up ready for spinning, it is impossible to cock the hammer, and unless the torpedo is entirely free to leave the tube it is impossible to fire. The action of firing itself is automatic and is controlled by the lever Q. By pulling back on the handle Y the long rod W W is drawn to the rear, clutching the motor to the torpedo and bringing the lever Q into position, so that the movement of closing the little breech cocks the hammer. If the throttle valve be now opened, steam is given to the motor and the flywheel will be spun up, it being possible to set the regulator valve that the wheel will run at any desired speed of revolution.

Discharge is operated in the following manner: A small box Z contains an arrangement by which a small steam valve may be operated either electrically or by a firing lanyard. The valve works instantaneously, and admits steam into the small pipe *a a* communicating with the stop-pin. Steam coming on the upper side of this little piston forces it down, so that the pin comes clear of the guide stud on the torpedo, leaving it clear to leave the tube. As this piston descends, and after withdrawing the stop, a port is unmasked, admitting steam to the pipe *b b b*, passing to the cylinder T T, whose piston is attached to the long rod W W, driving it forward. As the rod moves forward, it first unclutches the motor, then cuts the steam off from the motor, and, finally, at the end of its course, trips the hammer and fires the cartridge. Thus all the movements are performed automatically, and they can only occur in their proper succession. The entire time from pulling the firing lanyard until the torpedo leaves its tube is but little over one second, most of this time being taken by the torpedo itself gathering movement.

*The Dow Steam Turbine Motor* (Fig. 31).—Rotation is communicated to the flywheel by means of the Dow motor, which is a permanent attachment of the launching tube. The body of the motor is a small cylindrical box about 8.75 in. in diameter by 4.5 in. in depth. The shell consists of a bronze casting *a a*, having covers *b b* through-bolted to it, which have projections cast in one with them to form bearings for the main shaft. Two discs *c c* screw permanently into the wall of the shell, having in turn two smaller discs *d d* screwed into and forming a part of them. The interior of the motor is thus divided into three chambers, of which the central one, *e e*, receives the live steam direct through the steam pipe (not shown in the figure), and the two outer ones, *f f*, take the exhaust steam which passes out of the motor through the exhaust pipe *g*. The main shaft *h h h* is journalled in the bearings formed in the covers, and is given a longitudinal play, so as to permit clutching with and unclutching from the machine required to be driven. A sleeve *i i* covers the central part of the shaft, being keyed to it, but having a slight independent longitudinal play, and to this sleeve is secured a steel disc *k k*, which partially divides the live steam chamber. Two bronze discs *l l* are also secured to the sleeve, and it is these discs that are revolved by the action of the steam, transmitting rotation to the main shaft.

Concentric ribs are cut on the opposing faces of the pairs of discs *c c* and *l l*, which intermesh, and through these ribs a number of angular slotways are cut, those on the stationary discs being at an opposite angle from those on the revolving ones. The live steam entering the steam space *e e* passes into the space *m m* and thence outward between the pairs of discs through their slotways, communicating rapid rotation to the revolving discs and shaft by expansion. After thus performing work it passes into the exhaust chambers *f f* and out through the exhaust pipe. In passing through the slotways the steam undergoes seven expansions.

The function of the steel disc *k k* is to balance the work done by the two pairs of discs, since practically there are two drivers mounted on a single shaft. Assume that for some reason the right-hand disc is driven harder than the left-hand one. The over-pressure will force the right-hand disc and with it the sleeve and other discs to the right, and by this movement the steel disc partially closes the right-hand steam entrance to the chamber *m m*, opens and gives more steam to the left-hand one, and thus automatically equalises the driving force on the two revolving discs.

The left-hand end of the main shaft ends in a clutch *n*, and its journal *o o* is free to move longitudinally, carrying the shaft with it. The longitudinal clutching movement is communicated to the shaft by the stud *p*, which works in a guide slot cut in the starting gear (see Fig. 35). The right-hand end of the shaft projects slightly beyond the end of the cover of the motor, and is hollowed to receive the squared end of an auxiliary shaft which forms part of the tachometer.

*The Elwell Tachometer.*—The body of the support of this gauge is a brass casting *r r*, whose inner end forms a collar clasping the end of the outer shaft bearing, and tightened by a screw bolt at *s*. The small handwheel *t t* attached to the auxiliary shaft does not belong to the tachometer, but is used when clutching up to engage the clutches. The cap *u u*, screwing over the outer end of the support casting, forms a small chamber connected with the gauge by the pipe *w*. Within this chamber and secured to the auxiliary shaft is a small cylinder having radial slits cut through it similar to the radial guides of a turbine wheel. As this cylinder is rapidly rotated these slits force the oil out against the sides of the chamber with a pressure proportional to the centrifugal force developed, which itself is proportional to the square of the speed of rotation. The pressure is communicated through the pipe *w* to the gauge and acts on the pointer. The small conduit *x x* leads to an oil reservoir *y y*, which keeps the pump chamber constantly full of oil. *z z* are oil cups for supplying oil to the main shaft bearings of the motor.

*(To be continued.)*

## AUTOMATIC TORPEDOES.

*Automobile Torpedoes, the Whitehead and Howell, with a Detailed Description of each.**

By Ensign John M. Ellicott, U.S. Navy.

(*Concluded from page* 742.)

From the foregoing descriptions three points in favour of the Howell torpedo are too evident to need comment, viz., the greater simplicity of its mechanism and its consequent inexpensiveness and usefulness in untrained hands. For other points in favour of one or the other of these two weapons we must compare actual torpedoes of successive periods and the results of their trials.

The first official trials of the Howell torpedo were carried out by the United States Torpedo Board in May, 1884. The torpedo was 8 ft. long, 14 in. in diameter, weighed 299 lb., and was designed to carry a charge of 50 lb. of gun-cotton. The Whitehead torpedo was then in the sixteenth year of its successful career and development, and the popular model was 14 ft. long, 14 in. in diameter, weighed 560 lb., and carried a charge of 66 lb. of gun-cotton. The following is a comparative Table of these two torpedoes and their accomplishments:

1884.

| — | Length. | Diameter. | Weight. | Charge. | Speed. | Distance. | Direction. | Submersion. | Per Cent. of Charge to Weight. |
|---|---|---|---|---|---|---|---|---|---|
| | ft | in | lb. | lb | kts. | yds. | | | |
| Whitehead | 14 | 14 | 560 | 66 | 24 | 600 | Fair | Good | .12 |
| Howell .. | 8 | 14 | 299 | 50 | 8.5 | 33 | Excellent | Very poor | .17 |
| Difference.. | 6 | 0 | 261 | 16 | 15.5 | 567 | Howell | Whitehead | .05 |

Thus we see that the Howell torpedo started in its competitive race with the important advantages of smaller size and consequent greater handiness; of much lighter weight even in proportion to its size; of a much greater proportion of explosive charge to weight of weapon, and above all, in the position of an unerring, self-maintaining directive force in the horizontal plane. On the other hand, its submersion proved totally unreliable and its speed not worthy of contrast with that of its successful rival and wholly insufficient to make it an effective implement of warfare. The good points of the weapon were, nevertheless, decidedly encouraging, and its bad ones susceptible of improvement. Therefore, a year later, an improved model was brought out, and exhaustive trials were made with it in the United States. The following is a Table comparing its results with the performances of a Whitehead of that year:

1885.

| — | Length. | Diameter. | Weight. | Charge. | Speed. | Distance. | Direction. | Submersion. | Per Cent. of Charge to Weight. |
|---|---|---|---|---|---|---|---|---|---|
| | ft | in | lb. | lb | kts. | yds. | | | |
| Whitehead | 14 | 14 | 560 | 66 | 25 | 433 | Fair | Good | .12 |
| Howell .. | 9 | 14 | 284 | 60 | 15.6 | 200 | Excellent | Poor | .21 |
| Difference.. | 5 | 0 | 276 | 6 | 9.4 | 233 | Howell | Whitehead | .09 |

Here we see that with but little change of weights and dimensions the Howell torpedo attained a speed which would have made it formidable at short range. The proportion of charge to weight is also improved. The Whitehead during the same time only shows one improvement, and that a doubtful one—an increase of 4 per cent. in uniform speed over a range shortened 28 per cent.

The submersion of the Howell was still poor and its speed and range still gravely inadequate as compared to that of the Whitehead. Yet its great possibilities of improvement were so evident that it soon passed into the hands of the Hotchkiss Ordnance Company for actual manufacture in Europe and the United States. Since then it has been experimented with and perfected without further official trials until the spring of the present year, when public trials were held at Villefranche.

During this period the manufacturers of the Whitehead have striven to their utmost to maintain the superiorities of their weapon and reduce its deficiencies, but in the latter respect their task has been difficult, for in order to meet the constant demand for increased speed and range, nearly the whole torpedo has to be taken up by the air reservoir and the steering and propelling mechanism. The torpedo has grown cumbersome and awkward to handle and the magazine space has been encroached upon. The latter evil is now to some extent counterbalanced by making the head extremely blunt, and this is in other ways an improvement, for it brings the bulk of the charge, and therefore the force of the explosion, nearer the point of impact, and, it is further claimed, enables the torpedo to glance under a net protection. That it would reach and explode against the ship's side after accomplishing this last feat is extremely doubtful.

The following is a Table comparing the performances claimed for this type of the Whitehead with the results of the latest trials of the Howell at Villefranche.*

1890.

| — | | Diameter. | Weight. | Charge. | Speed. | Distance. | Direction. | Submersion. | Per Cent. of Charge to Weight. |
|---|---|---|---|---|---|---|---|---|---|
| | ft. | in. | lb. | lb. | kts. | yds. | | | |
| Whitehead | 11.5 | 17.5 | *725 | 110 | 29 | 437 | Fair | Good | †.15 |
| Howell .. | 9.8 | 14 | 419 | 90 | 21 | 300 | Excellent | ,, | .21 |
| Difference .. | 1.7 | 3.5 | 356 | 20 | 8 | 137 | Howell | 0 | .07 |

* Estimated; certainly not less. † Estimated; certainly not greater.

Here we see in the Howell another increase in length and a considerable increase in weight, but a corresponding increase in weight of charge. In the Whitehead the length has been shortened, but at the expense of a large increase in diameter and weight. It is significant to note, too, that although the head of this torpedo has reached the extreme of bluntness, the proportion of explosive charge to weight of torpedo has only been pulled up 3 per cent. This is apparently as far as this weapon, with its present mechanism, can be improved in its proportion of charge to weight. It is also apparent that, while the Howell torpedo has attained a uniformity of submersion equal to the Whitehead, the latter can never, without adopting the principle of the Howell, attain that certainty of rectilinear motion in the horizontal plane which is one of the most vital elements of success in a missile of destruction. On the other hand elements of equal importance are speed and range, and the Table shows us that, although the Howell has attained a very efficient average speed for a range of 300 yards, it is still considerably behind its rival in both requisites. There are some points not shown in the Tables which are worthy of careful consideration. The speeds given for the Whitehead are uniform over the distances set down beneath them, while the speeds for the Howell are the average speeds, the velocity of the latter steadily decreasing from the moment it is discharged. This uniformity of speed is claimed as an advantage for the Whitehead. Be that as it may, it is really a necessity in order that that torpedo may maintain its submergence and direction. The moment its speed begins to decrease the torpedo rises toward the surface and its course becomes erratic.

Another consideration, too, against the Whitehead, is the possibility of its air reservoir being exploded, before the torpedo is launched, by an enemy's shot. When it is recollected that the pressure in this reservoir is over 1000 lb. to the square inch, and that the concussion might also explode the charge, the magnitude of such a disaster can be appreciated.

In order to obtain its speed the flywheel of the Howell has to be "spun up" to 9000 revolutions per minute by a machine separable from the torpedo before launching, and these revolutions must be maintained by the external machine during any delay in launching. The Whitehead, on the other hand, is in a state of constant readiness to be launched. This advantage in favour of the latter is less apparent upon closer investigation, however, for although it takes nearly two minutes to obtain 9000 revolutions per minute on the flywheel of the Howell, a very appreciable interval in battle, there will almost always be much more than two minutes warning of an approaching combat, and it has been easily demonstrated that the rotation can be maintained for an indefinite period, thus placing the torpedo in a condition of constant readiness for a first discharge at the opportune moment. These opportune moments in battle are but moments, and the intervals between them will no doubt always exceed the time necessary to "spin up" for another shot. On torpedo boats, the disadvantage of this preparing interval disappears, for after a first discharge of the ready torpedoes the boat would never remain under fire of machine guns to reload and try again, even if it took but the time necessary to insert the torpedo in the tube.

## SUBAQUEOUS FOUNDATIONS.†

By Walter Robert Kinipple, M. Inst. C.E.

(*Concluded from page* 618.)

### Lecture II.

I have in the sea works for which I have been engineer, carried on the monolithic system; thus at Girvan Harbour, Ayrshire, where I constructed a sea pier and a groyne, together about 1200 ft. in length, and both were solid throughout. On Fig. 50‡ is shown a section of the south pier founded at 17 ft. below high water, or 7 ft. at low water. The portion below low water was first constructed within a piled trench, the concrete for which was deposited *in situ* after being allowed to set for a short time. Owing to the great trouble experienced in keeping the joints in the sheeting piles and the lining of flooring boards, even when covered with canvas, cement tight, and preventing the mould from vibrating during heavy seas, I abandoned timber framings altogether, and used handy-sized dovetailed concrete blocks (see Figs. 10 and 11 given on page 516 *ante*), which answered exceedingly well, and these, together with the backing and grouting up, were all executed without further trouble or risk. A fine concrete of three to one was used to back up the blocks, and the hearting was of four to one fine cement concrete, with as many blocks of stone, or broken boulders, as could be inserted into it, having joints of fine cement of a few inches in thickness between each block.

In Mr. Vernon Harcourt's work on "Harbours and Docks," 1885, under the head of "Construction of Superstructure," page 114, it is stated—"the lower courses of the superstructure, being laid below low water, cannot be cemented together;" and again, at page 115,—"below low water no means could be used for filling up crevices, and the waves rushing caused a compression of the air inside them;" again, at page 126—"When the bottom is several feet below low water, it entails both the cost of building under water, and also the weakness of uncemented blocks;" and at page 127—"the weakest part of an upright wall founded below low water is close to the level of low water, where the uncemented blocks are liable to be forced out by the waves compressing the air through the joints;" and, on the same page, as to the "limits of application of the upright wall system," "the enhanced expense would preclude the erection of an upright wall in deep water." "The greatest depth in which an upright wall has been founded is in 40 ft. of water at Dover, and the great cost in this instance does not furnish an inducement for imitation elsewhere." From these quotations it would appear that no attempt by other engineers than myself had, up to 1885, been made to cement blocks together under water. Now, in the system I have inaugurated at the Hermitage Breakwater, Jersey, not only has the upright wall system been executed in 60 ft. at high water, and 20 ft. at low water, at extreme springs, but the whole of the rubble foundation bed, for several feet in thickness, has been cemented into a solid mass, in addition to the whole of the blocks having been cemented together under water from the foundation upwards, and, further, the whole of their faces have grooves and projections, which render it next to impossible for any of the blocks to become dislodged, even should they not be cemented together. These improvements have, in fact, put an end to most, if not the whole, of the risks of failure which hitherto seem to have been, from some cause or other, almost inherent in every method of construction yet used, more especially where blocks have been laid dry under water.

In order to make sure and to give confidence, if possible, to those who, up to 1882, had doubted my system of grouting—and I am sorry to say almost every engineer I know still doubts it—some experiments were carried out, under my direction, by Mr. William Smith, harbour engineer, at Aberdeen, in July, 1883, and also by Mr. G. H. Spencer, at St. Helier, Jersey, in November, 1884, to ascertain whether the system of grouting I had adopted for the bed and joints below low water of the face blocks at Girvan, might be advantageously extended. At Aberdeen, a timber box, 6½ ft. long, 12 in. wide, and 4 ft. deep, was filled with round smooth shingle, and pieces of whinstone, from 1 in. to 4 in. in diameter, and was lowered to the bottom of the tidal harbour in a depth of 18 ft. at high water of spring tides, and having a wrought-iron pipe 3 in. in diameter, the lower end of which was inserted into the box for about 12 in., and long enough for its upper end to stand a few feet above the water level. At high water a very thick grout, composed of four parts of neat fine Portland cement and one part of Sheppy cement, was poured down the pipe in sufficient quantity to fill up the whole of the interstices. After twelve days the box of concrete, which weighed nearly two tons, was actually lifted out of the water by means of the 3½ in. pipe alone, which, although only inserted for 12 in., had become so firmly cemented into the concrete as to admit of this being done. On removing the sides of the box, the concrete was found to have a smooth surface, and to be perfectly solid throughout. At Jersey,* two experiments were made by Mr. G. H. Spencer, in November, 1884, under my direction. First, a box of about 6 ft. cube was filled with shingle, and a gas pipe of 1½ in. diameter was inserted 18 in. into it, and when the tide had risen 20 ft. above the box, thick neat Portland cement grout was poured down the pipe. On opening out the box, its contents were found united into a solid mass, with the grain of the rough sawn timber of the box imprinted upon the surface of the concrete, so completely had the grout filled up all the interstices of the box. Second, a box of 2 ft. cube, filled with shingle, was suspended in a depth of 60 ft. of water in the strong tideway just outside of the Little Roads. A thick grout of Portland cement was poured through a tube reaching nearly down to the bottom of the box, which united with the shingle into a concrete block. The block† is here on the table, and is really the parent block of my new system of constructing subaqueous foundations in great depths of water, and, as far as I can judge, it can be done with equal success in 200 ft. or 300 ft. of water as in 60 ft. of water. The block is not so perfect as in the first experiment, owing to the bottom zinc tubing being crushed by the weight of the iron tubing above, which allowed the grout to escape; the failure, however, was only partial, for one-half of the block was thoroughly solid, and had sharp arrises.

These experiments confirm those I made in 1856-8, in endeavouring to prove the feasibility of cementing shingle together in foundations at great depths, grouting up fis-

---

* From the Annual of the U.S. Office of Naval Intelligence. The description of the Howell automobile torpedo, manufactured for the United States, was furnished to the author by Mr. E. W. Very, of the Hotchkiss Ordnance Company.

* The model tried at Villefranche differs in many minor details from the one described in this article. The latter has not yet had an official trial.

† Two lectures delivered before the Royal Engineers' Institute at Chatham. These lectures have been published and copyrighted by the Royal Engineers' Institute, and we are indebted to the Committee for special permission to reproduce them in Engineering.

‡ See two-page plate of issue November 21, page 616 *ante*.

* See Minutes, Inst. C.E., vol. lxxxvii., 1886-87, p. 166.

† Mr Kinipple has since presented this block to the authorities in charge of the Royal Engineers' Museum at Chatham.