TORPEDOES.

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TORPEDO STATION,

NEWPORT, R. I.

EXAMINATION BOOK.

All questions to be entered in full.

Answer to follow each question.

The margin indicated by red line to be left for remarks of instructor.

(To be pasted in Blank Books.)

Torpedoes!

Ques. 1. Summary in Journalized form of weeks instruction.

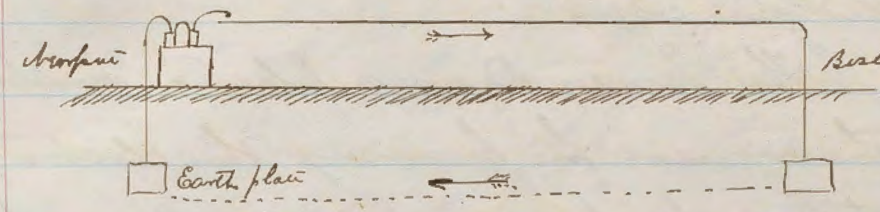
Particular attention is invited to kind of machine described, and used for torpedo purposes. What is an earth circuit; where can it be used: advantages of earth circuit. What element of safety in using it. Diagram of A. & C. machine connected with a torpedo in circuit: accidents observed that may prevent an explosion of torpedoes.

Ans. There are two kinds of electricity; the common kind recognized for many centuries produced by friction - called from the greek. 'electron', meaning amber. from which the name electricity is derived. The other not known until the end of the last century was discovered by Galvani and is called galvanism.
The former is sometimes called Statical electricity because it is accumulated by friction and is stationary until some way be provided for its escape. The latter form is known as dynamical electricity in distinction from the former. because at the moment of its production it is in motion. This kind never accumulates as

the statical does, but motion is necessary to its existence; if the way be not provided for its escape as fast as produced, it will not be produced at all. It is produced by chemical action. A relation exists between electricity & magnetism, as shewn by the fact, that if a wire be wound in a spiral form, leaving the ends free, one at each end of the coil; such a coil is called a helix and should be covered with some non-conducting material (if its parts touch each other) as silk or cotton. If now a bar of iron be introduced into this helix and the wires be connected with the poles of a battery, the iron at once becomes a magnet, which will attract various iron articles, but the moment the connection with the battery is severed it loses its magnetic power, showing that the magnetism of the iron results from galvanism, and a magnet thus temporarily made is called an Electro-magnet and the power thus developed is called electro-magnetism. On the other hand if a magnetized bar of iron be inserted in a helix it will produce a current of electricity in the wire forming the helix.

Frictional electricity has a high tension: produces little heat but has great power of overcoming resistance: it has a tendency to leave its conductor & escape to the earth, and is not suitable for use in firing torpedoes. The dynamic current whether produced by chemical action or by means of an electromagnet has a low tension; produces great heat, but has little power of overcoming resistance, also little disposition to escape from its conductor. (High tension may be compared to a small but rapid stream & low tension to a large but slow one.) Soft iron is quickly and easily magnetized but does not retain its power: steel is less easily magnetized, but is capable of receiving a high degree & retaining it. Cast iron retains its magnetic properties only in a slight degree ~~to best advantage~~. It has been discovered that when a magnetic needle is brought near a medium conducting an electric fluid or rather current of a closed voltaic circle, it is immediately deflected from its normal position, depending on the relative position of the needle and the wire; this has been utilized as a means of ascertaining whether the galvanic circuit is complete, before attempting to fire a torpedo: a resistance coil is placed under the needle in the firing key ~~board~~, and thus a very small portion of the electric current is allowed to make the circuit: not sufficient to fire the fuze, but enough to deflect the needle: (the needle should be allowed to assume its natural rest & the board made to correspond to it) The above is used with the "A" machine of the "Farmer Dynamo Electrical" type.: the C. machine has an electric bell the ringing of which corresponds to the deflection of the needle in the A machine firing key board. The electric bell is constructed on the principle of the electro magnet & its power to attract soft iron—: a piece of soft iron to which is attached the striker of the bell is placed close to the poles of an electro-magnet & the instant the voltaic current passes through the helix around the magnet - it attracts the soft iron - thus causing the striker to vibrate & ring the bell,

Earth Circuit. The earth is a good conductor of electricity and so is salt water, and in making a circuit for telegraph, torpedo or other purposes. it is only necessary to use one wire if the end, be connected to plates of conducting material - (as copper for the earth & zinc for the water) and buried in the earth as shown below -

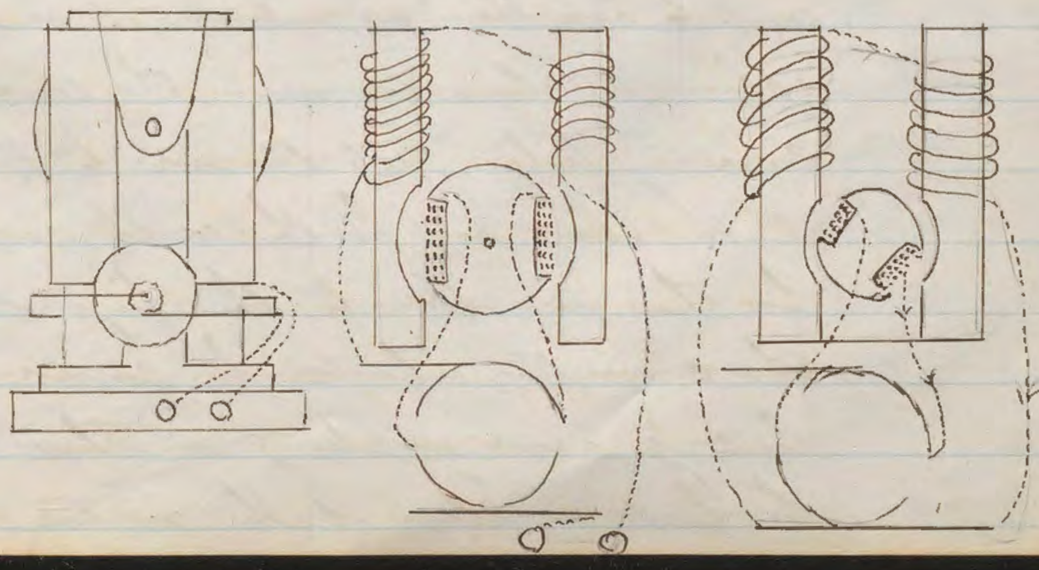


This can be used wherever it is convenient to have the above arrangement on land, or when salt water connection can be made, or when one end is on land and the other in salt water: a rocky formation may prevent in some cases the use of the earth circuit - Its advantages are, that only one wire is required in place of two. The chief element of safety in using it to fire spar torpedoes is, that no explosion can take place until the torpedo is submerged.

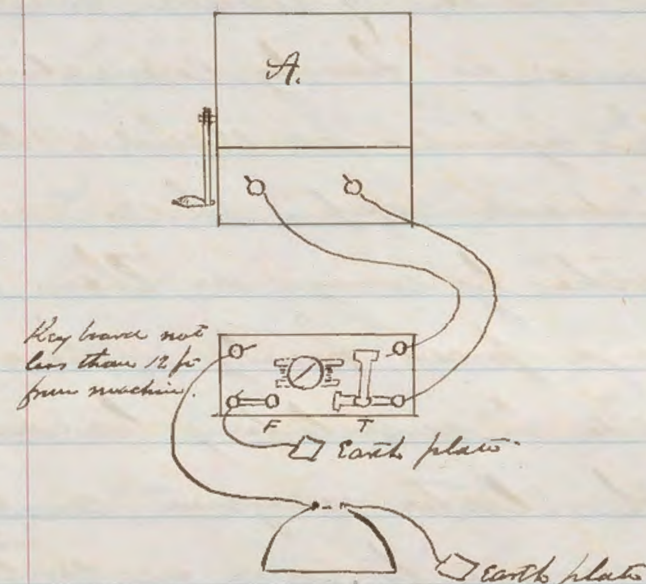
The fuze used in firing torpedoes by means of the 'Dynamo Electric machine', is a thin wooden cylinder filled with rifle powder: the wires to which are attached the battery and earth connections, are connected in the center of the cylinder with a fine piece of platinum wire, around which is wrapped a small quantity of gun-cotton the intense heat generated by the electric current, make this platinum wire red hot when the circuit is closed & that of course fires the gun-cotton.

The "Farmer Dynamo Electric Machine", is the one used for producing the electricity for torpedo purposes. It is composed of an Electro-magnet made of soft cast iron, and each slab, there being two, is wrapped with a coil of copper wire covered with coarse silk; the lower ends of the slabs are scored out to receive the armature. One iron plate connects them on top, having a lug at either end for the support of the axle of large cog wheel; a composition plate at bottom which has two lugs, one at front & one at rear of machine. The wires are wound on the upper end of the slabs, and are called field of force coils.

The armature lies between the poles of the electro-magnet. The armature (Siemens) is a cylinder of soft magnetic iron, having a longitudinal score cut, in which is wound a number of convolutions of moderately fine, silk covered wire, which form armature coil: The commutator is firmly attached to the front axle of the armature, it consists of a cylinder of Ebonite, or ivory, which slips over, and is firmly connected to the axle: to this cylinder are secured two thick, semi-cylindrical copper shells, insulated from each other by ivory: on these shells two brass springs press firmly; these springs are secured to insulating brackets on sides of the electro magnet, and are so arranged as not to come in contact with iron part of the magnet; when the cylinder, armature & commutator revolve, these springs must press alternately on the brass shells. The use of the commutator is to prevent a reverse current. The annexed is a sketch of the machine above described —



The following diagrams, illustrate the method of attaching torpedo to A & B. machine.



In the practice of torpedoes the principal information gained the past week, was in the manner of connecting the wires, testing the circuit & firing the torpedo. In connecting the insulated wire with the fuze, it is necessary to brighten up the ends of the wires, and to have them in contact; it is either spliced or clinched with the small brass connecting tubes, both the wire to the battery & the shute on for the earth circuit must be thus attached to the fuze & then the connection should be covered with a little greased wicking or other substance, to keep it clear of the metal of the torpedo; it is then inserted in the spindle of the torpedo so as to let the end reach the cannister containing the explosive material; this is then made water tight by means of an india-rubber plug, screwed in tight with a brass cap. to which the short wire is attached for the earth circuit; the light of the long wire should be firmly racked to the spar near the torpedo. Always keep the connection open until the torpedo is submerged. In using the A. machine the the two poles are connected to two poles or keys of the firing key board - and from the two others are led one wire to the torpedo & one to earth plate - When all the connections are made to test the circuit after submerging the torpedo - turn the crank rapidly with the sun, and press the key T, when if the needle is deflected the circuit may be assumed to be complete; to fire the torpedo, turn the crank as before & press the key F and keep it down & at the moment it is desired to fire the torpedo, press the key T.

The same applies in using the C

machine, except that the connections are made direct to the torpedo & earth plate, and a small bell answers the testing key if the circuit is complete.

The accidents which may prevent the explosion of the torpedo, are an accidentally closed circuit, or by turning the crank the wrong way.

Torpedoes! June 16th 1876.

Ques 1. Summary in formalized form of the weeks instruction.

Particular attention is called to the salient points in history of torpedo warfare; such as, the names, dates & brief accounts of the work of the various torpedo inventors, up to the present day.

Ans. History of Torpedo Warfare. To David Bushnell of Conn. (born 1742) may be accredited the idea of attacking a vessel beneath the water.

He made an original plan of a boat for submarine navigation, and constructed the first one of which there is any accurate record - An account of it was read before the American Philosophical Society - June 8th 1798. It was intended to swim low in the surface so as not to be seen easily, and could be sunk to any desired depth; be raised again to the surface or be rowed in any direction under water, and the operator could thus attach a vessel containing powder to the bottom of a vessel. The first attempt of any note to destroy a vessel by this machine was in about 1776 - against the British ship "Eagle", lying near Governors Island, in New York harbor. The operator went under the ship and attempted to attach his torpedo, but in attempting to fasten the wood screw - supposed he struck an iron bar; in attempting to move to another place he missed the vessel, and daylight coming on, the attempt was abandoned. There were after this, two attempts in the Hudson river, above the City of New York - but they effected nothing. Soon after this, the vessel carrying the sub-marine boat was sunk & the boat also - she was raised however, but could not be made serviceable again -

In 1777 Bushnell made an attempt with a whale boat, against the British frigate "Cerberus", between Connecticut River and New London, by throwing a machine against her side by means of a line. The machine was charged with powder, to be exploded by means of a gun lock. It fell in with a schooner at anchor astern of the frigate & was by some means exploded - demolishing the schooner, killing three men, & blew the only one left alive overboard. In Dec. 1777 an attempt was made in the Delaware to destroy the English shipping by means of kegs filled with powder and floated down among them - this failed from various reasons, but a boat was blown up with several persons in her - which gave the alarm that brought on, 'the battle of the kegs'. Bushnells vessel was completed in 1775. He served during the war of Independence, as a Captain in the corps of Sappers & Miners. From this time the subject seems to have been forgotten for twenty years, when it was revived by Robt. Fulton an American then living in France. In 1797 he constructed a machine intended "to impart to carcasses of gunpowder, a progressive motion under water to a given point, and there explode them": he applied without success to the French government, for aid to carry out his plans. Napoleon 1st after-wards gave him some encouragements, and a Commission was appointed to give him means, and to witness his experiments - On July 3d, 1801 in the harbour of Brest, he made experiments with a machine he called a submarine boat - in which he with others, remained one hour under water; he afterwards remained four hours and twenty minutes under water in her, having made some improvements - and was able to propel her in any direction at about one knot per hour. He placed under a small vessel (furnished for the purpose) - by means of his submarine boat, a torpedo containing twenty pounds of powder which tore her into fragments. This seems to have been the first instance on record of the effect of a submarine explosion on a vessel, and took place in Aug. 1801. In May 1804, Fulton under the name of Francis, laid his plans before the British Ministry; his scheme was investigated by a commission, and by them was pronounced impracticable. In Oct. 1804 an expedition was fitted out against the French shipping at Bologne, fitted with Fulton torpedoes, but for various causes it failed. A year later attempts were made against two French men of war at Bologne, but they failed and threw discredit on the system. In Oct. 15. 1805. Fulton destroyed the brig "Dorothea" at Deal with 170 lbs. of powder. In 1806 he laid his plans before the Secretary of State of the U.S. and a sum of money was authorized to be expended under Fulton direction & on July 20th. 1807 he blew up a vessel in New York harbor.

Mar. 30. 1810 Congress authorized the expenditure of $5000. in trying practical experiments with torpedoes - and a commission was appointed to witness the results. Fulton made arrangements to destroy the "Argus" in New York - but failed owing to the extraordinary precaution taken by the Naval Officers - in the way of nets. chains &c. Many such unsuccessful attempts Fulton finally took leave of the subject forever and devoted himself to the more important works which distinguished his name. During the war of 1812 the subject was again revived to some extent, and a Mr. Mix of Norfolk, made an attempt to destroy the British ship "Plantagenet" in Lynn Haven Bay - which created quite an alarm in the vessels in those waters -

The close of the war put an end to further experiments until 1829, when it was revived by Col. Samuel Colt, the inventor of the revolver -, June 4th. 1842 he exploded a torpedo in New York harbour by means of a galvanic battery, and on July 4th. following he produced a tremendous explosion opposite Castle Garden and destroyed the Gunboat "Boxer". On the 20th of Aug 1842 - he destroyed a schooner, while stationed five miles away from her, on the Potomac. Congress afterwards gave him $17000. Oct 18th 1842 - he blew up the "Volta" of 300 tons, in New York harbour, On Apr. 13th 1843 - a brig of 400 tons was blown up while underway; this was the last experiment of which there is any record, performed by Col. Colt. To him the credit seems to be due of having first discharged torpedoes by means of the electric current.

The Russians employed torpedoes for the

defence of Cronstadt and Sebastopol, but no direct results came from their use.
Two vessels (the "Merlin" & "Firefly") while reconnoitering Cronstadt, had a narrow escape from destruction by a torpedo. During the late war between France and Germany, the latter power effectually closed her ports by means of torpedoes against the French fleets. The late war in this country developed a great deal in the preparation and practice of torpedoes, and their use by the South was in the hands of a regular bureau.
The approaches to Wilmington, Mobile, Charleston, and parts of the James, Mississippi & other rivers were litterally lined with them, and a long list of ships destroyed and injured was on our side the result of them; among the most notable were the destruction of the "Tecumseh", "Cairo Jones" "Housatonic" and "Patapsco". Three forms were used by them. 1st "Frame torpedoes" 2d. "Floating torpedoes" 3d. Electric torpedoes." an immense variety of each of these classes were in use.
The most notable instance of their use by the Federal forces, was the destruction of the "Albemarle" by Lieut. Cushing —

The use of torpedoes was for a long time regarded as an unfair and cowardly system of warfare, but now has become a recognized and generally observed institution; since the late war the system of torpedoes has been perfected to a great extent & the Whitehead or Fish – the Harvey – Lay – Ericsson and spar torpedoes have become well known.

Ques. 2nd What branch of torpedo warfare is in the hands of the army?

Ans. The system of harbour defense is in the hands of the army.

Ques. 3d – The practical method of testing the various parts of a torpedo circuit, with only such instruments as are furnished to cruising ships?

Ans. To test the machine: turn the crank rapidly and then connect the binding screws with a piece of light metal & if the crank meets with resistance – the machine may be presumed to be in working order.

2nd Test each of the wires to be used in the circuit, by attaching both ends of them direct to the machine – if machine turns hard, wire good

3d Connect the two short wires to the two binding screws B.B. of the firing key – and

test the binding ^short^ circuit -
4th. Put a piece of metal across the other two keys or screws T.T. and test the testing circuit by pressing the T key - and seeing if the needle be deflected -
5th. Same as last except press both keys to see if firing circuit is complete -
6th. Test the fuze with wires ahead, tested.

A circuit through the fuze is not an infallible sign of its being good as there is a possibility of a short circuit, by contact with the metal inside the torpedo.

June 23d. 1876.

Ques. 1. Summary of weeks instruction in formalized form?

Spar Torpedoes! The first use made (only proposed) of this mode of attack was by Fulton in 1810 on board of his block ship: mention is also made of its use in the war of 1812. by Beman in New York. and from then we have no record of its use until the war of the Rebellion.

The Confederate iron-clad "Atlanta," after her capture by the "Nahant" and Weehawken" June 17th. 1863 - was found to be fitted with a spar torpedo: copper cased and to be fired by percussion.

A spar torpedo made of a barrell, was found on board the rebel iron-clad "Columbia" after the surrender of Charleston; others were also found at Richmond after its occupation, made from soda water tanks and fitted with percussion fuze.

The first Torpedo Boat of the late war, was built at the Tredegar iron works at Richmond Va. in 1861; another was built at Mobile Ala. in 1863, which was intended to go on the surface, or under water: a better form was made later at Savannah Ga. Selma and Mobile. to go on the surface, and these were known as "Davids" - nine of these were found at Charleston after its surrender. These vessels were built of boiler iron, or more and were "cigar shape". They presented but a small target to fire at, but were clumsy and dangerous in a sea way & could not steam over seven knots. They carried their torpedoes on the end of a spar about twelve feet long: the charge of powder varying from fifty to seventy pounds.

The first attempt made against a vessel with these boats was in 1863 - on the 5th of Oct - when one of these succeeded in exploding sixty pounds of powder alongside the "Ironsides" off Charleston. This vessel though injured was not damaged to such an extent as to render necessary her withdrawal from active service. The column of water from the explosion - partially filled the torpedo-boat, and her crew thinking she was sinking abandoned her: two of them, one the Captain, were found floating with life preservers. The Engineer after floating some time, found himself near the boat, and managed to get into her - & lighting the fires steamed back to Charleston.

The 2nd. attack of the kind was on the U. S. S. "Housatonic" Feb. 17. 1864 off Charleston, and she was sent to the bottom in a few minutes; in this case the Torpedo Boat & all hands went down also - supposed to be the result of the weight of water thrown upon her from the explosion: she was an iron boat thirty-five feet long and was manned by nine men, eight of whom worked the propeller by hand - the other controlling the motion of the boat.

The 3d. Case was an attempt against the U. S. S. "Memphis" in North Edisto River Mar. 6th. 1864 - but the attack failed as the Memphis steamed ahead and it is supposed her screw injured the spar or torpedo gear of the boat -

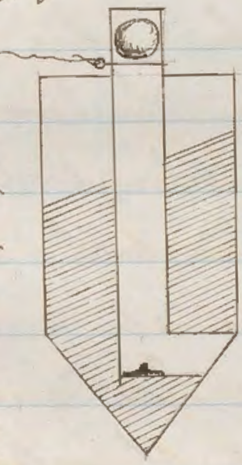
The 4th. case, was an attack on the

U. S. S. "Minnesota" off Newport News Va — Apr. 9th. 1864. by Hunter Davidson formerly of the U. S. Navy — he succeeded in exploding fifty-three pounds of powder alongside of her — and escaped unharmed with his boat, having severely damaged the frigate.

The 5th. case was an attempt against the U. S. Frigate "Wabash" Apr. 19th. 1864 off Charleston, but she slipped her cable & escaped. The rebel torpedoes were from 40 to 100 lbs. — and their spars from 10 to 30 lbs. long, and were generally fired with General Rains fuze.

The only really successful attempt was that of the destruction of the "Housatonic", — yet enough may be learned by the nearly successful attempts to show the praticability of this mode of attack, particularly with improved boats, and means of firing.

The first use of the spar-torpedo by the Federal forces was in the destruction of the "Albemarle" — Oct. 28th. 1864 by Lieut. W. B. Cushing — at Plymouth N. C — the torpedo used on this occasion was that known as the "Wood & Lay": it was of a buoyant character, and was by means of a line detached from the end of the spar, shooting some distance in the direction pointed and then rising towards the surface - it was fired by means of a grape shot - falling on a percussion cap - the shot being released by pulling on a line connected to a pin which supported it -



The Wood & Lay Torpedo.

May 5th 1864. The U.S.S. "Miami" - being fitted with spar torpedo, failed in using it, in an action with the "Albemarle" Later in the war a number of launches (steam) were fitted with spar torpedo's & furnished as picket boats to the different squadrons. The U.S.S. "Monticello" was also fitted to attack the "Stonewall" - the "Pinta" was also fitted with spar torpedo.

In the Spring of 1864 the nearest approach to a complete torpedo boat was built by Engineers Wood & Lay of the U.S. Navy. but she was not completed until too late to use in actual warfare - she was built of iron, 84'2" long: 20'8" beam, 9'11" depth of hold & draft when fully equipped 7'5½" - but ready for action with sinking tanks full - draw 9'1" - displacement 206.9 tons & side armor 5" - deck plating 3" - pilot house 5" - She had a bow valve through which the torpedo & spar were thrust - The only other vessels specially built or designed for torpedo use are the "Alarm" - which has three cast iron spars - ; one at the bow & one on each side - worked through water tight compartments & valves - The "Intrepid" which has only spars above water & the "Nina", which has one iron spar to work through the stem under water - spars for ordinary spar torpedo & arrangement for towing torpedoes -

The equipments furnished to U.S. vessels are of three classes. A. B. & C.

Class A. consists of 1 set of ship torpedoes; 1 set of Towing torpedoes & 1 set of Boat torpedoes -

Class B. 1 Set of Ships and 1 set of Towing torpedoes.

Class C. 1 Set of Ships torpedoes only.

The Bureau of Ordnance, designates the class for each vessel. A for a large ship with Steam launches: B for smaller vessels & C. for Monitors.

1 Set of Ships torpedoes includes the following articles – viz: 6. 100 pdr. torpedoes: 6, 100 pdr. sockets and keys; 1 Dynamo Electric Machine (A.) with firing key; 1 set of Machine connecting wires; 1 reel box containing 500 ft. of insulated wire: 6 exercise torpedoes with electric connections: 1 Wire box, containing 4 pieces of insulated spar leading wires 60 ft. in length; 24 Earth wires & 1 set of machine leading wires. 1 Supply Box, containing 6 connections: 6 rubber glands; 24 wire splices: 1 Copper funnel: 1 Monkey wrench: 1 open end wrench: 6 pieces of Emery cloth: 1 pair splicing nippers: 1 pair of cutting pliers: 1 spool waxed cotton wicking: 2 earth plates: 12 micro unions: 18 fuzes: 18 igniters: 2 sample splices, 1 spool of hemp twine & 1 knife.

One set of Boat Torpedoes - includes the following articles: 6, 75 pdr. torpedoes: 6, 75 pdr. sockets & keys - 1 Dynamo Electric Machine, (C) - & other articles same as the ship torpedoes with exception of Reel box -

The practical exercise of the week consisted of firing 4 - 75 pdr. torpedoes from steam launch - torpedo immersed 10 ft. & 20 from stem of boat -

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Fourth lecture - June 30th 1876

Ques 1. Summary in Tormalogic form of weeks instruction.

Particular attention is called to the present system of permanent electric fittings as supplied to cruising ships - Drawings of service articles are recommended -

Ans - The lecture treated principally of Spar torpedoes and fittings as at present used with description of the various articles furnished as supplies; dimensions, weight &c of torpedoes - Charges of powder - method of lashing socket to spar; preservation of supplies; electric fitting &c. All articles are marked in the invoices as of certain patterns, and those marked A - are of original design - B - are those which have had some modification, C - a second change - and articles not to be expended are underlined.

The 100 pdr. torpedo is of cast iron and the shell is cast in one piece - of about .35 of an inch thick; has a spindle of cast iron - hollow &

perforated with flame holes and is wrapped around with wire gauge to keep the powder from the torpedo from filling it - it passes through the torpedo longitudinally and has a lead washer at each end and the end which projects through the outer end of the torpedo is secured by a nut - and to prevent the turning of the torpedo on the spindle & consequent loosing of the crown (dome nut) nut - a dome is cut in the inner end of the torpedo in which a "feather" on the spindle fits - The present spindle is much heavier than the old pattern, which was not safe to tow at a greater speed than six to eight knots - There is also a slot or key way cut on one side of the spindle to secure it in the socket - There are also two filling holes with screw nuts at the inner end of the torpedo & when the spindle is properly connected - the fuze and filling holes are made air tight & the torpedo is immersed in water and submitted to an air pressure of 15 lbs. to the square inch: if any air escapes, it is rejected: if it stands the test it is coated with paraffine varnish and turpentine and is marked in red letters on the side "100 pdr. torpedo" - When complete but unfilled, it weighs 260 lbs. and has a capacity for 100 lbs. of "torpedo" (?) powder. (Torpedo powder is intended to be that made of under-burned charcoal) - It should be kept in a dry place - and the screw threads occasionally examined and coated with white lead and tallow -; a wooden plug is to be kept in the mouth of the spindle - The shape of the torpedo was designed for use ahead so that as now used abeam it is objectionable.

If the case were made of thin cast iron, it would not offer sufficient strength to obtain the maximum effect of the powder - The 100 pdr. torpedo is 40 inches in length and 1 foot in diameter - & the spindle is tapering & from two to three inches in diameter - In testing, the 75 pdr - cases burst with pressures ranging from 50 to 550 lbs - per sq. in - while one 100 pdr - did not burst at 1100 lbs,

The 75 pdr. or Boat Torpedo. is the same in form as the 100 pdr. and is submitted to the same test & preparation: it is 30 inches in length and 1 foot in diameter. Is marked in red letters "75 pdr. torpedo" & weighs with spindle (empty) 150 lbs.
The spindle is cylindrical, and two inches in diameter. Torpedo has a capacity for 75 lbs of powder.: this being carried on a boat spar is not so objectionable in regard to shape, but the weight is a greater objection for boat use, than that of the 100 pdr. for ship use.
100 Pdr. Socket & key: That part which lashes to the spar & to which the torpedo is secured is called the socket: it is of cast iron and is supposed to be sufficiently strong to stand towing steam at any rate of speed; the flat part is called the "socket tail".
The weight of the present pattern is 68 lbs. and it is packed with its key in the box with the torpedo.
In lashing it to the spar. place the outer end of the socket. flush

with the outer end of the spar; and if it be properly lashed to the spar - the latter is generally sound if made of oak or hickory. The lashings for 100 pdr. socket are - the first or outer one which passes through the slot cut for the purpose has ten turns of 15 thread ratline stuff - then three equidistant lashings on the "socket tail" of four turns each, of the same stuff -

The centre of the torpedo should be on a prolongation of the axis of the spar, in order to bring the least strain on the latter, and it is also best to have the end of the spar rounded or pointed - & covered with a metalic covering to prevent 'brooming'. That part of the torpedo which attaches it to the spar, should be concentric with the axis of the torpedo itself, and grasp it with a firm hold - The great weight (68 lb.) of the 100 pdr. socket is objectionable.

75 pdr. Socket - is of cast iron. and is sufficiently strong for boat use.; it weighs 48 lbs - & with its key is packed with the torpedo - It is of different

shape from the 100 pdr. socket - and has no slot cut in it through which to pass a lashing: it is lashed to the spar by five lashings of 15 thread stuff - four turns each - Three of the lashings being on the "socket tail" & the other two on the socket part itself - Its weight is also objectionable -

The reel box has 300 ft. of insulated wire, the inner end of which is connected to one side of the reel by a binding screw - to which a machine, or other wire may be attached thus rendering it unnecessary to unreel more than the actual length required - The reel wire has seven strands of No. 22 B.W.G. copper wire, coated with tin and covered with layers of pure rubber, semi-vulcanized rubber, vulcanized rubber, rubber tape and jute braiding: diameter of braided wire .53 of an inch - & without the braiding it is .25 of an inch - Its resistance is about 11 ohms per quarter of a mile, and has a tensile strength of 525 pounds -

The wire box should be kept in a dry place, where it is cool and dark.; the binding screw should be kept clean and bright, and no oil used on it; the evaporation of the tarry stuff in the jute cover seems to affect it. This wire is only supplied to ships for general use, and is only intended to supply the place of a permanent wire disabled, for firing torpedoes from the ship. Exercise torpedoes are made of tin and wood cases; they must be handled carefully and must not be towed; the charge is 5 lbs.; they are supplied in boxes of six each, and one box goes with each class of torpedo; the electric connections are in the torpedo. They can be safely exploded at a distance of ten feet, with 4 or 5 feet immersion. They will not injure a socket, so none are supplied.

The wire box, is marked on the cover and contains - 4 spare leading wires of 60 feet each; 24 earth wires and 1 set of machine connecting wires, of 4 pieces - 2 of 12 ft. and 2 of eight feet: (1 set of machine wires is kept in the machine) It is designed that one set of spar leading wires be hung up in the store room with fuze fitted. The earth wires are 3 ft long. One wire box is supplied with each set of torpedoes. In using the leading wires, rack them to the spar about every four feet.

Supply box is marked, and its contents are - 6 connections and glands: 24 Wire splicers: Copper funnel: 1 monkey wrench: 1 Open end wrench: 6 pieces of emery cloth: 1 pair of splicing nippers: 1 pair cutting pliers: 2 earth plates of copper covered with tin: 1 Spool of waxed cotton wicking: 12 service unions: 18 fuzes; long paper cases for use in service and exercise: 18 igniters, small copper cases for use in service or exercise or for making fuzes; they have small copper cases covered with water-proof compound & are packed in sawdust: 2 sample splices: 1 Skein of hemp twine for serving rubber tubes in splicing:

& 1 Knife — 1 Supply box with same contents is furnished, with each set of ship and boat torpedoes — & should be kept in a dry place. All the foregoing are packed for transportation and are numbered. The invoices showing the contents of each.

In addition to the above each vessel is supplied with Keywright covered copper wire 1/4 of an inch in diameter, as required for permanent wires, to lead from the bridge or pilot house to near the torpedo spear ends —; two electric switches and six terminal binding screws —; each vessel supposed to have four spars.

Keywright is not sensitive to heat or cold, but must be protected from the sun; gutta-percha is very sensitive to heat —

When keywright is used on board ship for permanent wires, it should be boxed in, or lead through pipes and no parts exposed to salt water —; joints should be covered with rubber tubes and terminals coated with wax or some similar composition. The electric switch must also be protected, by boxing in —

The terminal binding screws are pieces of black walnut with brass binding screws secured to them: the circular sunk space at the back of the wood should be filled with wax after the permanent wire is attached & before the terminal is screwed up in its place. The permanent wire is made fast to the back of the binding screw or rather of the terminal and is secured with a nut and covered with wax. The electric switch is a contrivance for either breaking or joining the connection between the battery and permanent wires - by means of which the current may be sent through one or both torpedoes, or neither - one is placed on each side of the vessel and both may be connected at the same time with the firing key - The practical instruction consisted in towing & firing 100 pdr. torpedo from the "Mina" & in towing the Harvey torpedo -

Electric Switch!

Fig's 1 & 2 -

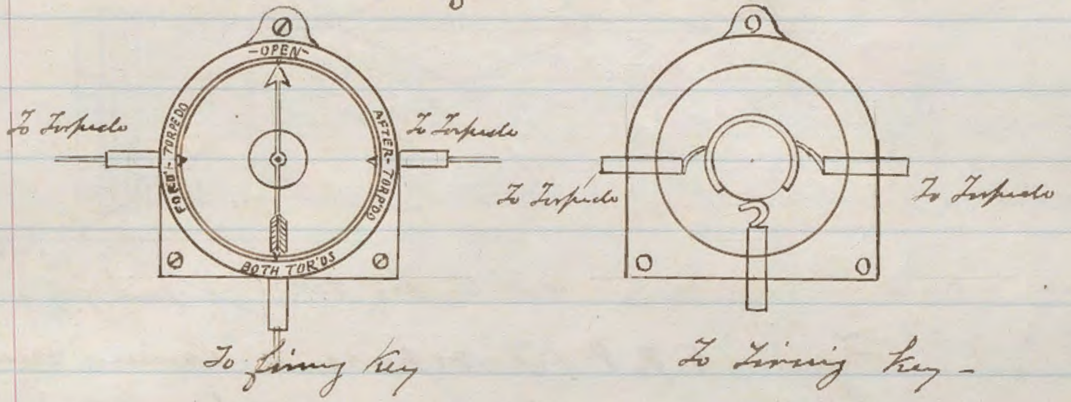
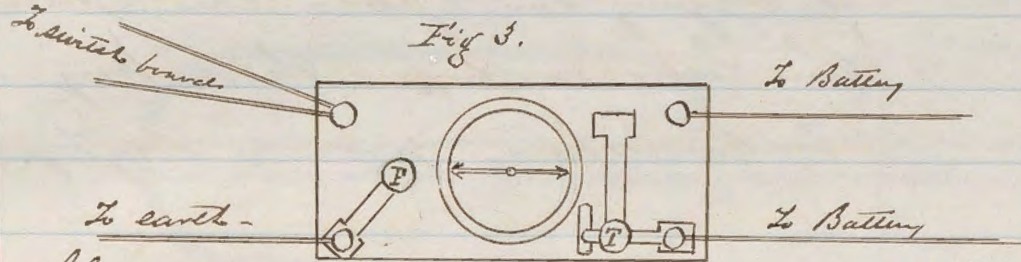


Fig 3.



Showing method of connecting Battery & Torpedoes!

Fig 4

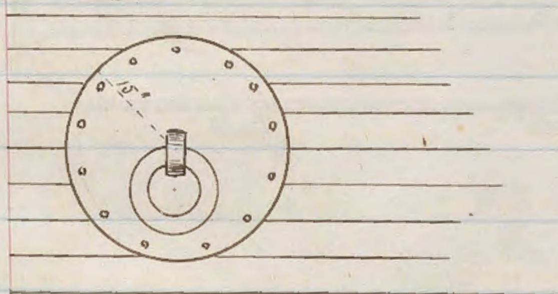
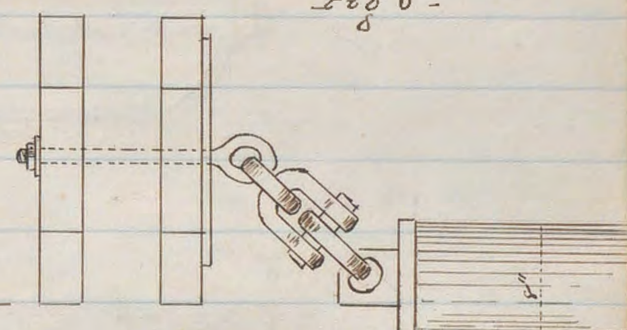


Fig 5 -



Figs 4 & 5 represent method of attaching spar to vessel!

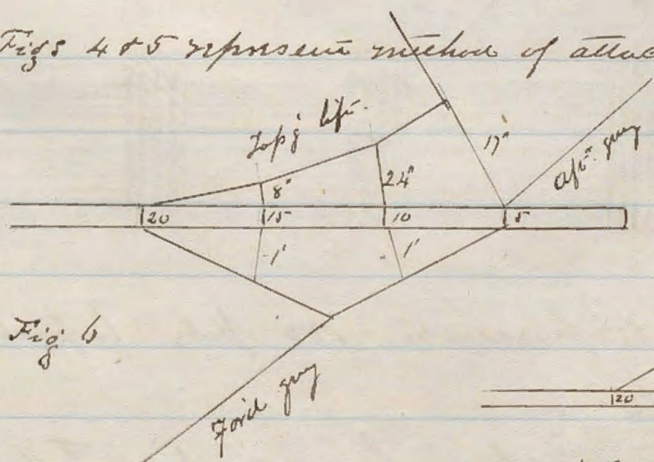


Fig 6

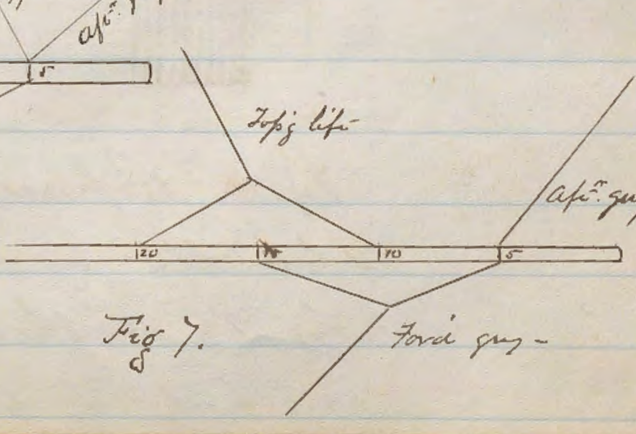
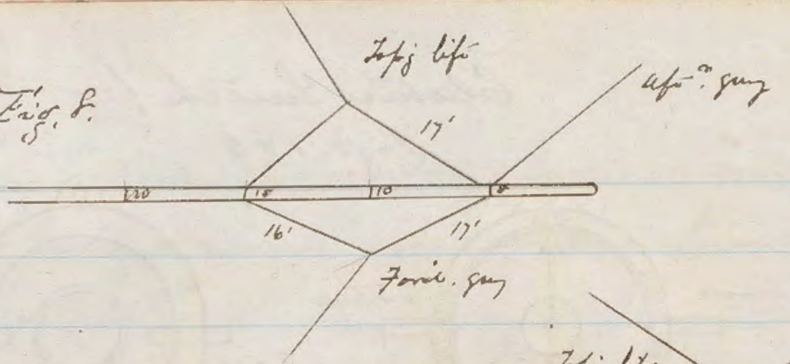


Fig 7.

Fig. 8.
5



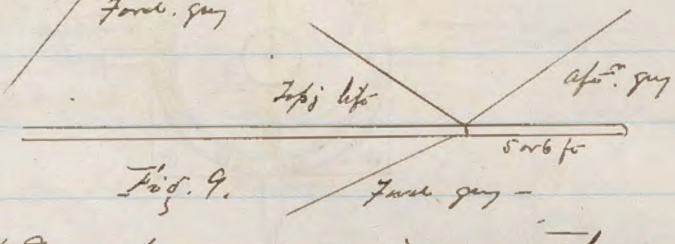


Fig. 9.
5

Figures 5.7.8 & 9 represent various methods of rigging the spar - the same being the latter methods; there being less vibration when rigged as in Fig 6 -

Fig 10
6

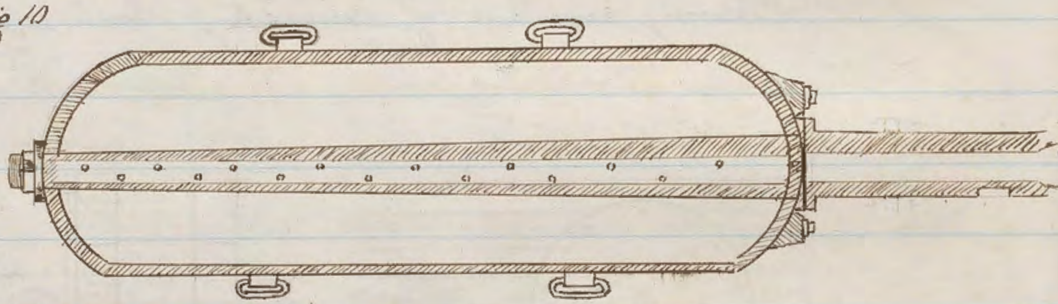


Fig 11.
6

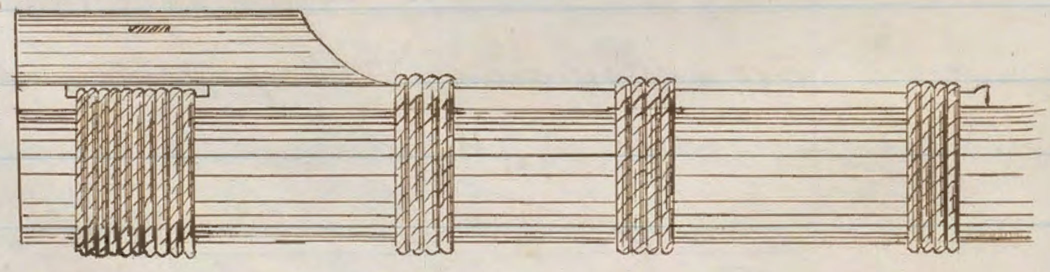


Fig. 10. Represents 100 pdr. torpedo and spindle -

Fig. 11 - Socket for 100 pdr. torpedo and method of securing it to spar -

Fig: 12.

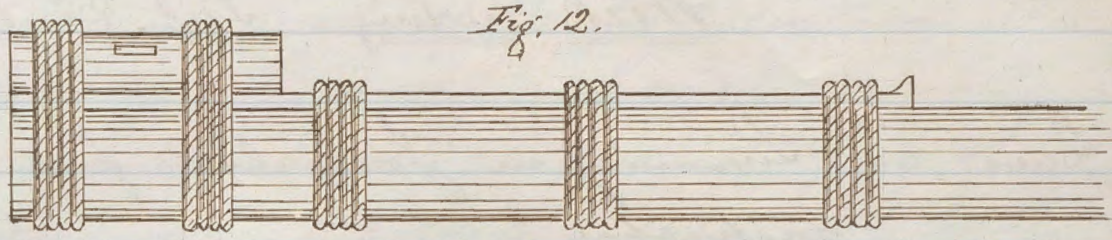


Fig. 12 - Socket for 75 pdr. torpedo with proper mode of securing to spar -

Fig: 13.

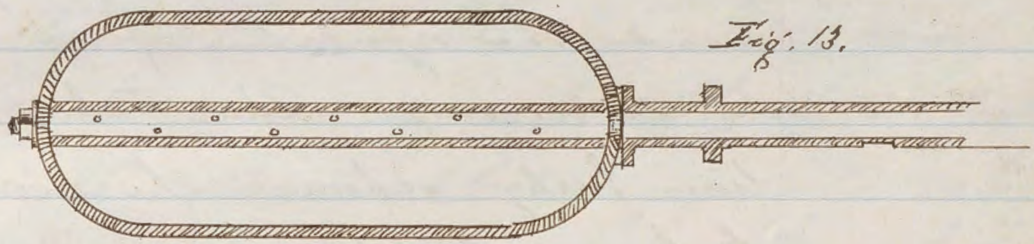


Fig. 13. Represents 75 pdr. torpedo & spindle.

Fig. 14 -

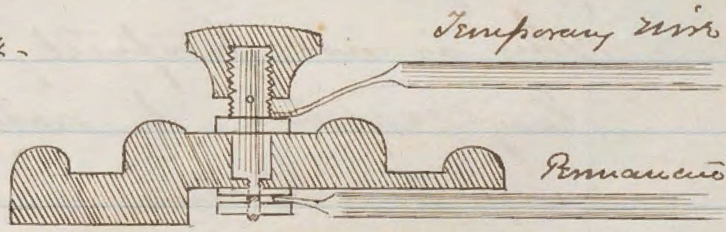


Fig. 14. Represents section of Terminal.

Week ending - July 8th. 1876.

Ques. 1. Summary in Journalizied form of weeks instruction?

Drawings of ships spar fittings and boats regulation fittings!

Ans. Attention was called to the friction band inside the regulation fuze connection: it is necessary that this band should turn freely, otherwise the wires are liable to become twisted and injured in screwing in the connection: The old pattern fuze connection of which there are some still in service, consists of four pieces, besides the rubber gland: this is not perfectly water tight, if long exposed to water. The use and construction of various kinds of insulating unions was also explained: ie: those of glass cylinder with rubber packing bands. & brass cover. & those with ebonite cylinder & brass outer cover. When a cable has been spliced, in order to prevent strain on the connection, a "half-crown" should be made of the part containing the splice. To make a branch union—remove the keyrite sufficiently from the wires; twist & solder & cover with rubber tube (service union) and put secure whipping on ends of the union.

The proper immersion for the 100 pdr. torpedo is 12 feet, and it may be exploded at not less than 25 feet, from the vessel, but a greater distance is recommended, when fired from large vessels. In action when maximum effect is required the immersion might be a little less; say 10 to 11 ft.

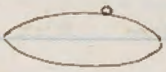
The proper immersion for 75 pdr. torpedo, is 10 feet, and distance (horizontal) from the boat 18 to 20 feet.

__Torpedo Spars.__ Four spars are the regular outfit supplied to vessels—; two abreast the fore, and two abreast the mizen mast—; hickory or oak is the regulation material; 45 feet in length, 8 in. diameter at heel and 6 in. at outer end: they should be straight grained: of best material and if possible, natural growth poles. Yellow oak is considered very superior: red oak is too brash: pasture growth hickory better than western hickory. The first spars issued to the navy were of spruce. & when used ahead were easily kept immersed: they were heavy & clumsy & when towed ateam - at an increased speed - would raise considerably.

The height at which a spar is secured to the vessels side, makes a great difference the matter of keeping it at proper immersion: the old regulation was 3 or 4 ft. above the water line, but spars secured as high as the chains, are more convenient in every respect & keep their immersion better.

Spars should be of hard wood of heavy material & if the forward edge were knifed & so placed as to give the spar a downward tendency when towed it would be better.

Cast iron spars are good for nothing: wrought iron not suitable - but steel is elastic and would ~~seem~~ to be an excellent material if made in form of hollow cylinder, especially for torpedo vessels where spars are worked by machinery.

A combination of wood and steel seems to offer superior advantages – both being elastic; and a spar of this description need not be of such weight or dimensions as to render it unwieldy –: the double convex lens shape  seems to be the best for the submerged part – and in a spar of this shape the topping lift should be so hooked as to give the forward edge a downward cant.

A spar of this description is in use on the "Unia" – it is 6 in. diameter at the inner or small end, and 8 in. at the larger: has a wrought iron cover on the outer end 5 feet long – made in two pieces and riveted at the edges –: two strips of steel 1½ x 1 in. are counter sunk into each side, 33 feet long – and near the outer end – short pieces are placed between the long ones at outer end 8 feet long – and the whole banded with clamping bands of wire –

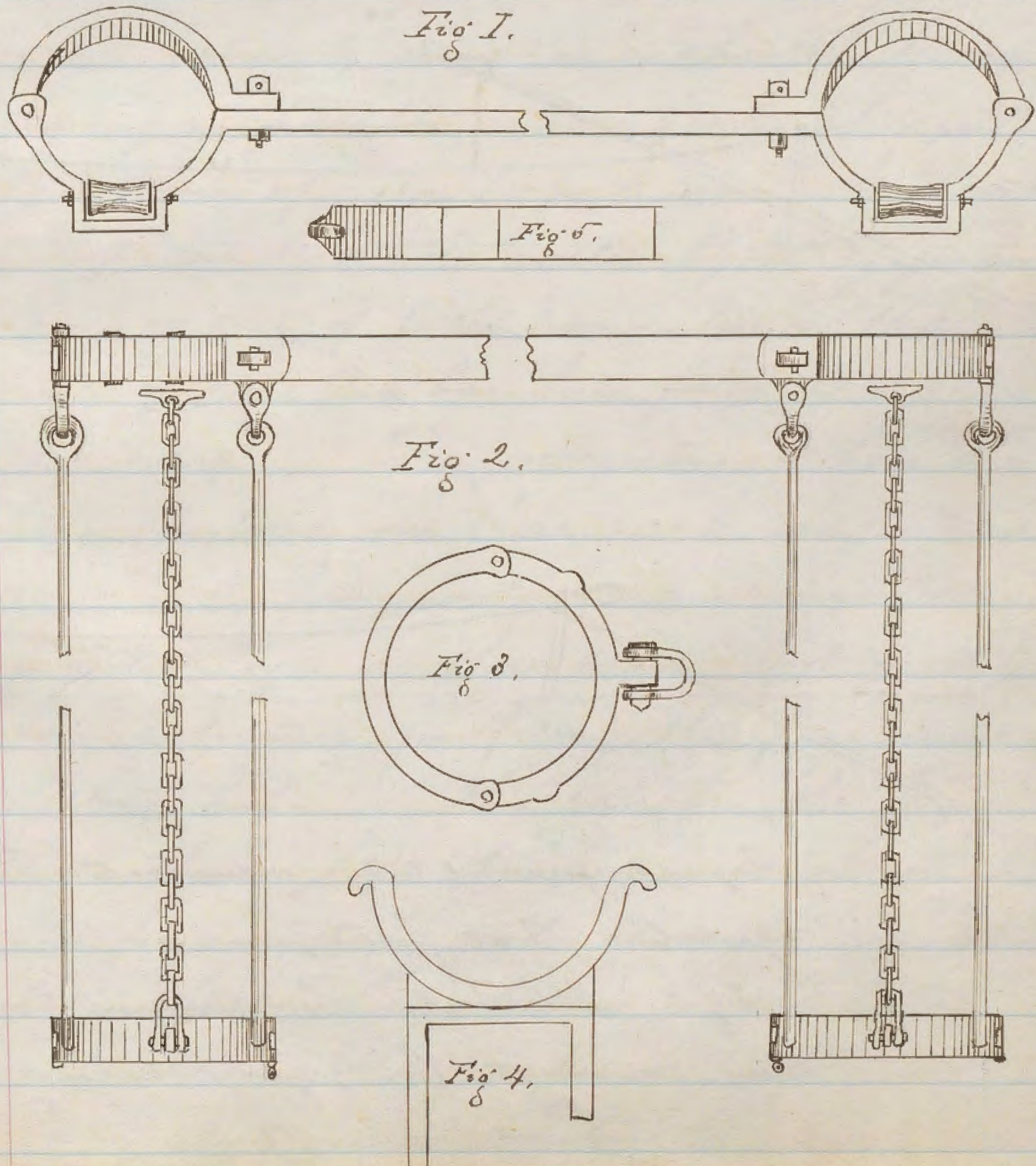
inches apart: this spar is rigged with guys as shown in Fig 6. Page 38. and has had several torpedoes fired on it without injury to the spar. and in towing it will keep its immersion up to the "Minas" highest speed - 8 or 9 knots without a torpedo on it -

The regulation pattern for heel fitting for spar is shown in Figs 4 & 5. Page - 38 -

Guys and Topping Lifts. The forward guy should have as long a drift as possible and be a single rope & so secured as to be let go as soon as the torpedo is exploded. The forward guys, topping lifts & spans for boat - should be made of galvanized iron wire rope - with primary wires .0359 in - No 19 - American wire guage.: rope three stranded The after guy to be of a single part of 3 in. manilla rope - Figs. 6. 7. 8. & 9 - on pages 38 & 39 - represent various methods of rigging guys & topping lifts -

Such an arrangement as will allow least vibration of the spar is the best. The tendency of spars is for the ends to buckle up when towing fast!

Boat fittings: Spar of spruce; 35 feet long; 6 in. diameter at heel & 5 in. at outer end.; This however is not sufficiently strong to steam ahead fast, against —; they should be of hickory. The iron work of boat fittings should be galvanized.



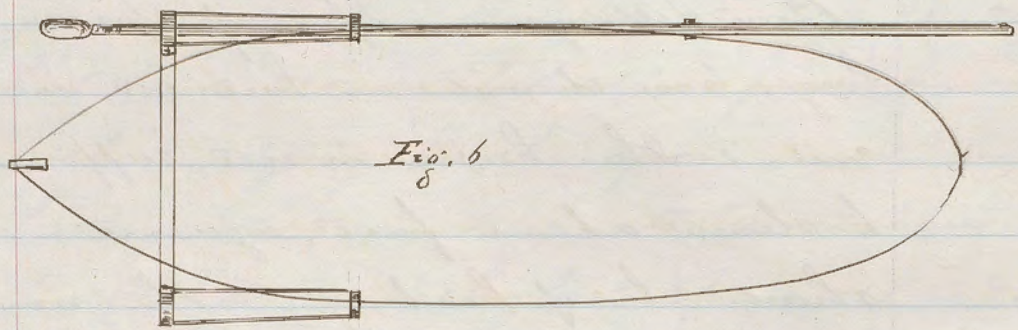


Fig. 6

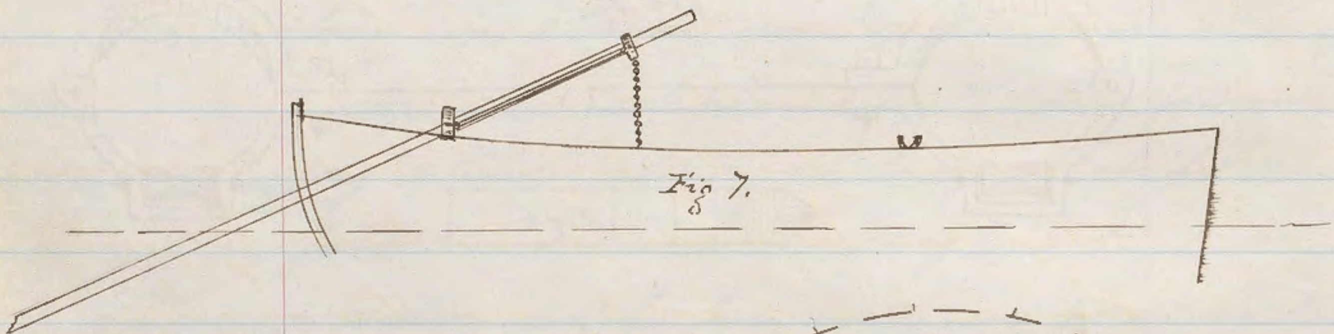


Fig. 7.

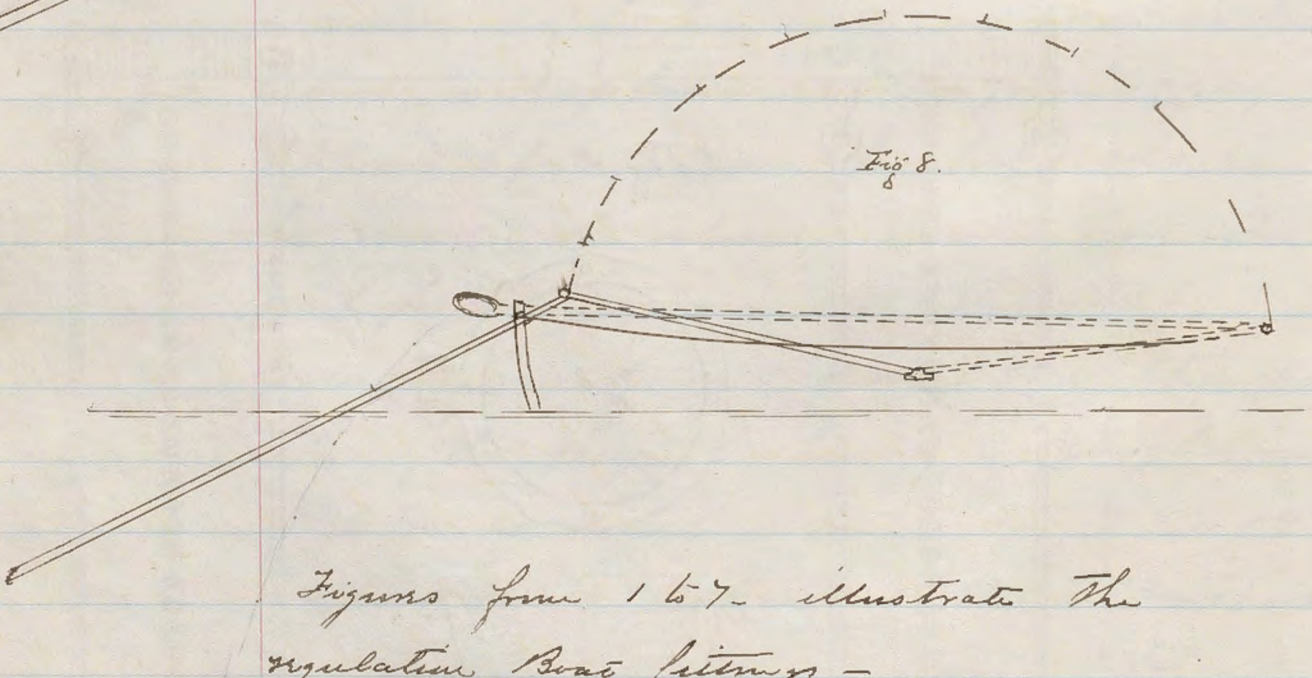


Fig. 8.

Figures from 1 to 7 – illustrate the regulation Boat fittings –

Fig. 8 – Illustrates the Danish method – very convenient for gigs & small boats –

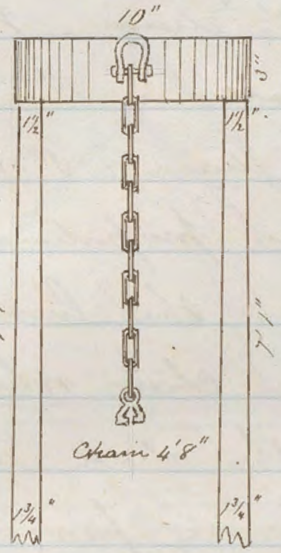
Week ending July 15th 1876

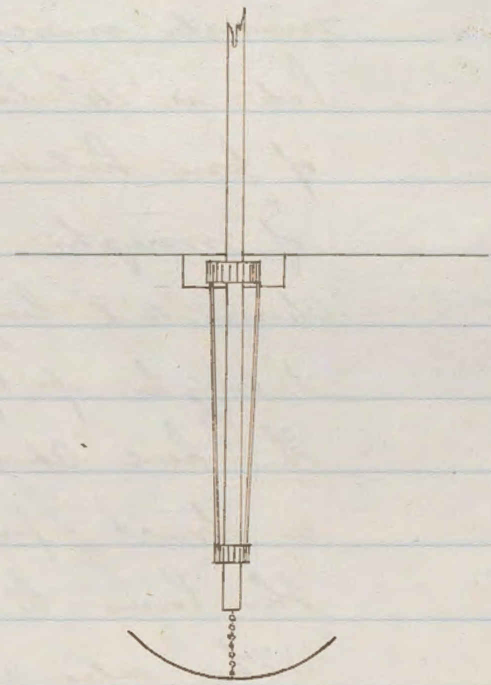
Ques. 1. Summary in journalized form of the weeks instruction. Drawings of monitor, Keg, and improved boat fittings?

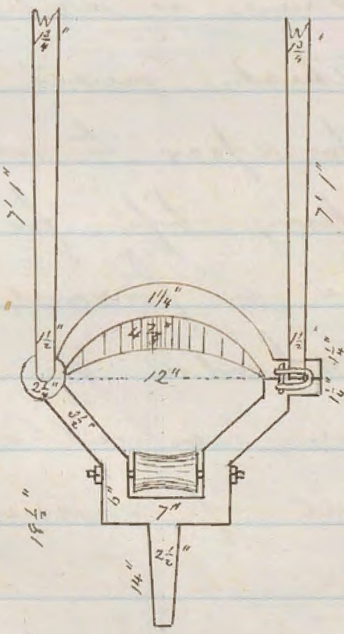
Ans. Improvised spar torpedoes can be made from kegs, casks, cans, jugs, bottles &c. or any vessel which can be made water tight. Kegs generally used and should be as strong as possible & additional strength by means of extra hoops &c. would be desirable. Kegs can be made water tight by giving them a coat of pitch, and two or three coats of coal tar has been found to answer very well. It is necessary to have the fuze centered in these make improvised cases. A fine grain powder can be used to advantage in these cases. Cork is the best substance for filling the fuze and filling holes. The cork for the fuze hole should have two holes cut in it for the fuze wires: after the corks are placed, they should have tallow or red lead rubbed over their exposed parts, or better still, some composition easily made as follows: 1 part (by weight) of tallow, 8 parts of pitch and 1 of beeswax: this becomes plastic at 150°. Far- and can be readily worked; another composition is, 6 parts (by weight) of rubber, 3 of paraffine, & 1 of Venetian turpentine: this can be applied hot or cold. If possible a keg or barrel torpedo should be fitted with a central fire tube: one of wood, tin or gauze can be readily made on board ship - & paper, bunting or fine sheeting may take the place of the wire gauze ordinarily wrapped around the spindle of the spar torpedo -

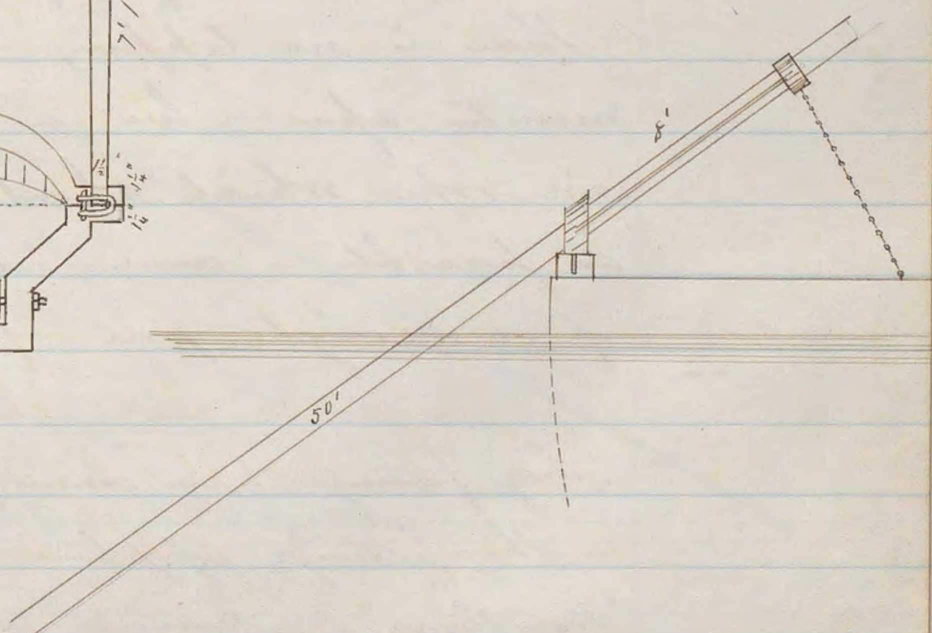
To fit such a tube, take one end of the keg out & bore hole in the centre for fuze wires: connect to the inside of this head, the impervious tube by means of a flange, so that the tube shall be in the line of the fuze hole: let the other end of the tube be plugged, and centered so as to rest in a saucer on the inner side of the other end of the keg.

Monitor fittings =









The above represent the fittings as applied to U.S. monitor "Dictator" - The dimensions are; length of side rods.

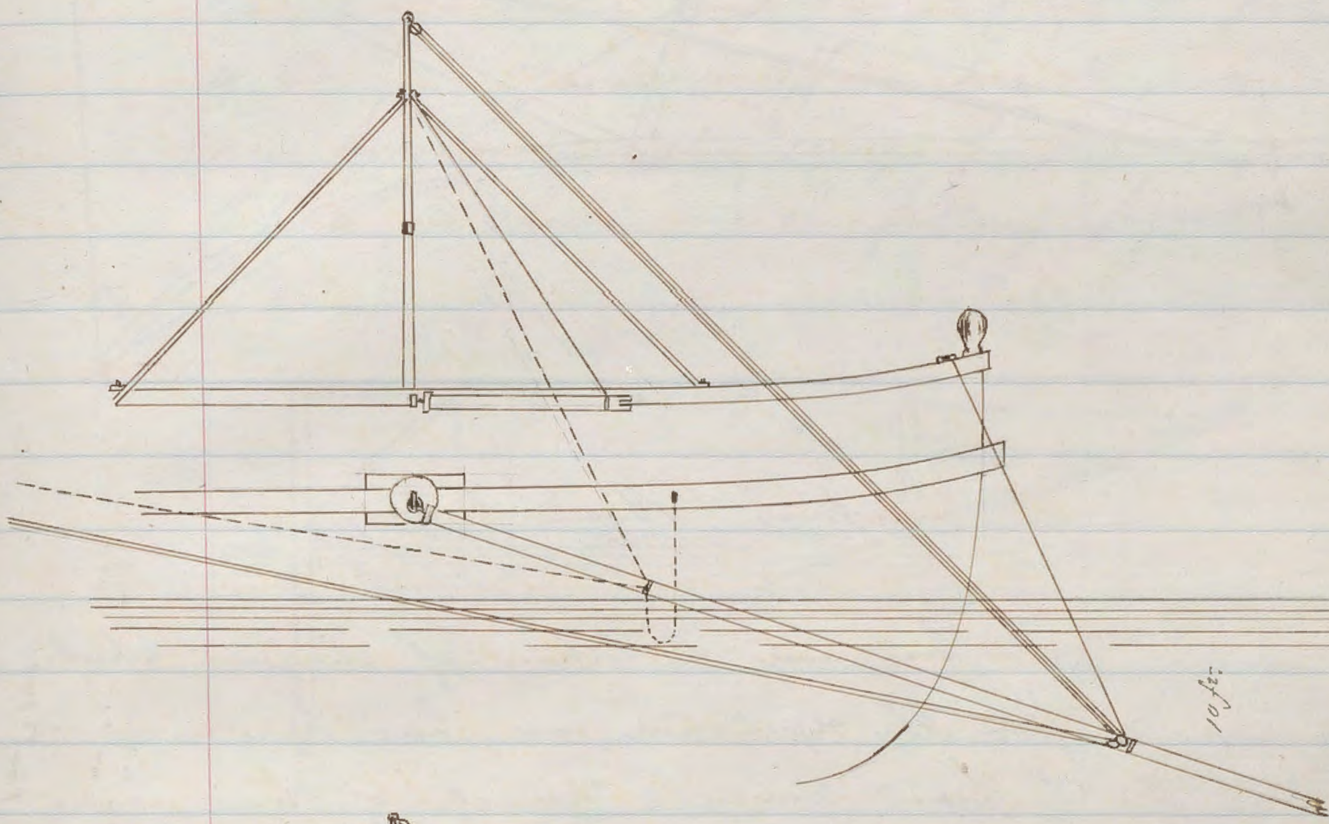
7' 1" - solid iron 1½" at the ends & in the middle increasing to 1¾" - diam. The swivel bolt is 14" long by 2½" diam. The width of part holding the roller is 7" - Inner band of wrought iron. 10" diam & 5" width - heel chain 4' 8" long & size proportionate to length & weight of spar. At the lower end of the heel chain is a claw which grasps a track fast to the deck and enables the boom to be traversed forward or aft.

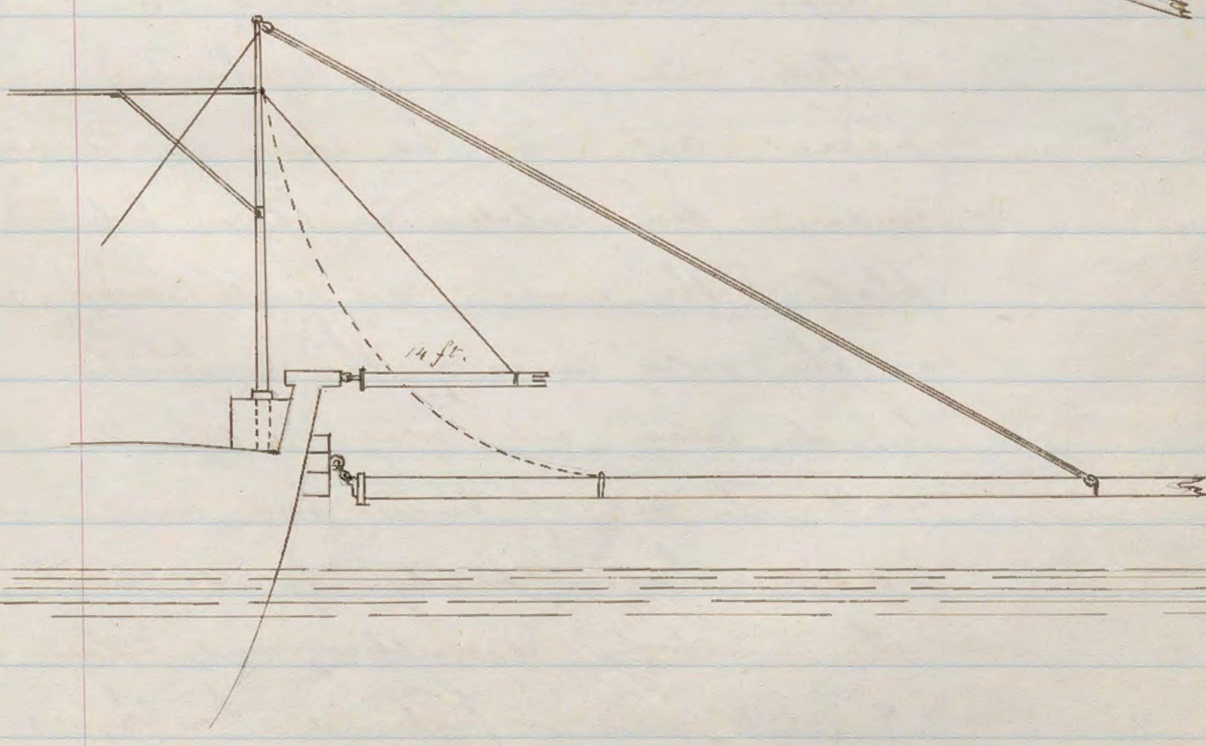
The outer clamp band is hinged on top, & is 12" diam. 1¼" thick, width 4 7/8" - it contains a roller for spar to work on.

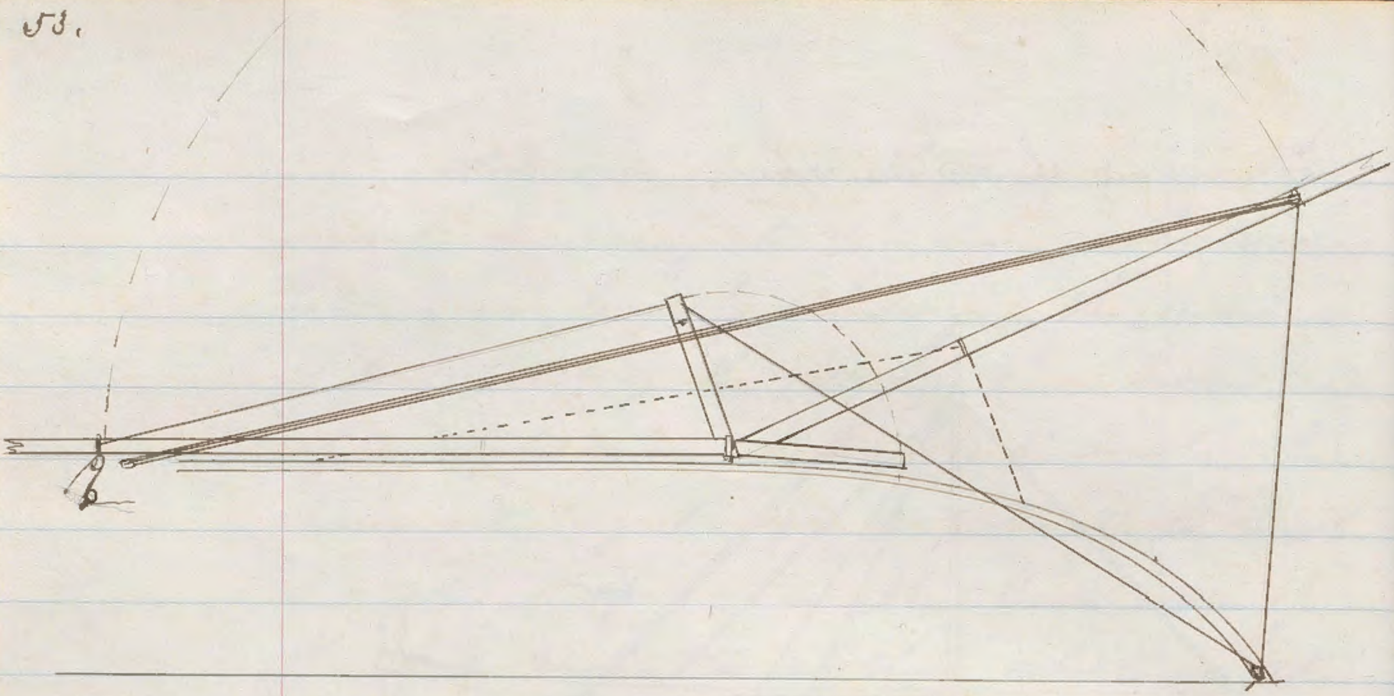
There is no topping lift for the monitor spar. but a forward guy of wire rope which should as long drift as possible - and an after guy of a single part of manilla -

Tug fittings (see drawings on next page)

The fittings applied to the U.S. Tug "Mayflower" - consist of the outrigger spar & a stanchion for topping lift (one on each side, braced together) & a small spar to assist in rigging on the main spar =



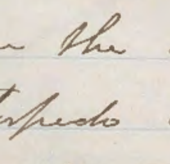




Improved Boat Fittings.

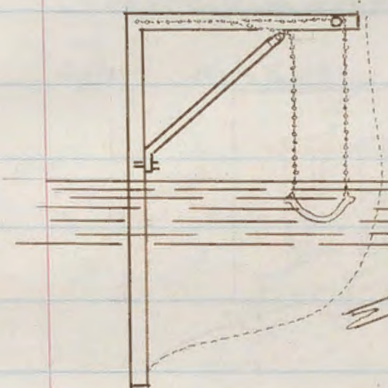
For boat use a torpedo of different shape from the regulation one has been designed by Lieut. Converse - made of thin layers of steel - in form of a cylinder - with pressed caps of the same material for ends -: tin solder is blown between the plates & the ends: no rivets used except on the outer layer of the cylinder. This torpedo case only weighs 37¼ lbs. against 150 lbs. the wt. of the 75 pdr. and costs but $12. has capacity for 75 lbs. of powder.

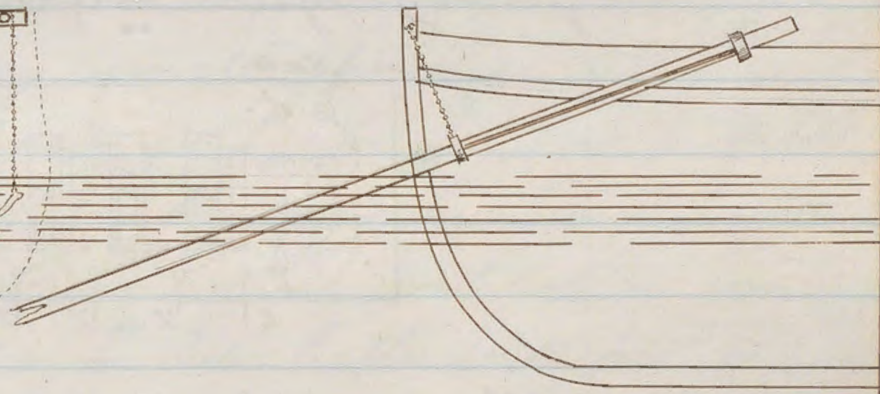
It is shaped something in this manner -

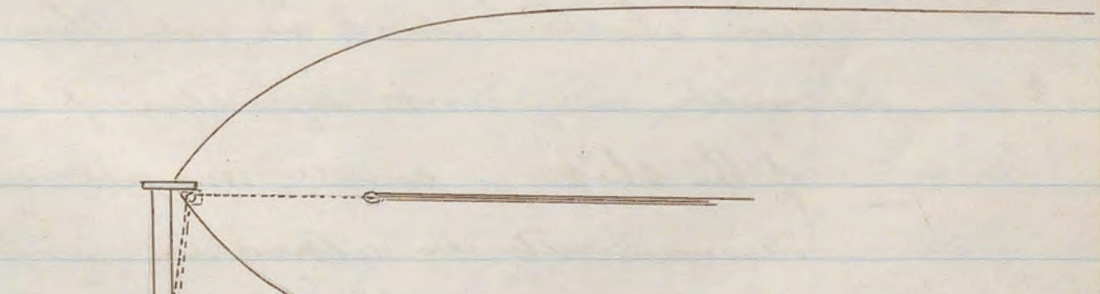


and is fastened to the end of the spar by a basket work.

frame -  which forms part of the torpedo. Flasks of this description are warranted to stand a pressure of 500 lbs. per sq. in - The same Officer has designed a new arrangement of fittings for boat spar torpedo as shewn in the following figures.

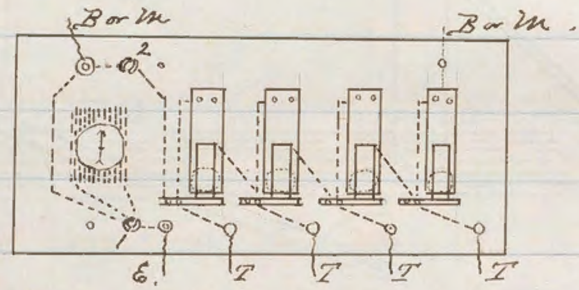




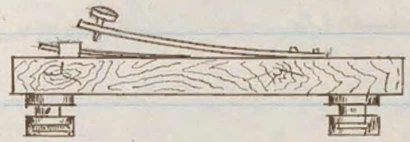


In the above it will be seen that the inner or after band remains stationary while the outer drops - & by this means the spar can be rigged out and kept above water until close to the object designed to be blown up.

In addition to the forgoing a combination of firing key & switch board, called a key-board, designed by Lieut. R. B. Bradford was explained – The following figure illustrates this –



The above is designed to be placed in a pedestal to which all the permanent wires shall lead & in order that the compass needle may work regardless of the position of the ship – a small magnet sufficient to overcome outside attraction is placed beneath the needle – This key board may be used with a galvanic battery or machine – If used with a battery keep pin No. 2 out, but to use Farmer or other similar machine keep pin No. 2. in as it makes the short circuit – The testing coil has about 200 ohms resistance - To test a circuit keep pin No. 1 out, and put it (pin 1) in when you wish to fire - Each key tests & fires its own Torpedo -



Permanent wires as at present lead on board ship are very much exposed.

They should go together from a pedestal to a point below the water line and thence to the points at which wanted - Two wires should be led to the cock pit or other safe place - to connect to battery or machine. Wires from spar end terminals should lead directly below the water line & thence connected to the pedestal. The leading wires near boilers or lifyer. lead pipe forms a good gutter - the ends of the pipe should be caulked with white lead, putty or something of the kind to keep the water out -

Week ending July 22nd. 1876.

Ques. 1. General summary in journalized form of weeks instruction: Description of the "Intrepids" torpedo fittings: Necessary qualities to be considered in constructing torpedo launches: discussion of the relative advantages of using bow and beam spars. Essential requisites of spar and torpedo for four launch.

Drawings of Keyboard & pedestal for the same: Improved terminal binding screw and plan of the "Intrepids" permanent wires? —

Ans. The wooden terminals for spar leading wires being frail are liable to accidents and also to corrosion from exposure, & to cover these defects another form has been designed, fitted with brass cap as shewn in Fig. 1 page — 63

Electric Bell wires: Cotton insulation if exposed to salt water becomes useless: paraffine and balsam is a good protector but is liable to destruction by rats. The wire recommended for electric bells on board ship is No. 18. B.W.G.– (.05 of an in. in diameter) insulated with Kerite to a diameter of .11 of an inch, made by A. G. Day – 120, Broadway N. Y.

1st Regarding ship fittings, it would seem to be desirable that the firing apparatus and the operator should be protected by a shield or something of the kind –

2d That the firing apparatus should be so simplified that the operator can fire any or all the torpedoes by closing a simple circuit, and should be capable of use, with either a machine or battery,

3d. That the firing apparatus should be always ready for instant use, with wires connected &. and yet protected from the weather and accidents –

4th. Permanent wires should be protected as far as possible from an enemy's shot, by laying below the water line wherever practicable;

5th. Battery and machine should be placed below the water line & a battery must be placed where it will not freeze.

6th. Uniform terminal binding screws should be used, "Intrepid's" torpedo fittings: The wooden deck of this vessel being only from 2½ to 3 ft. above the water line it is impracticable that any connection between permanent wires & spar leading wires should occur above the deck - accordingly 1¼ inch - holes were bored through both decks & in these holes were placed iron pipes made fast or rather water tight at the decks - connected with a brass casting on top, so constructed as to receive a rubber gland, packed with a brass cap. The short spar wires pass down these pipes and are connected to the permanent wires below. & when this is done the top of the pipe is made tight by packing with a rubber gland with one hole in it for the leading wire. & when no wire is in the pipe, it is closed with a solid gland.

The exploding apparatus was placed in the pilot house - and all permanent wires were lead to that point - The machine was placed on the berth-deck directly under the pilot house and the battery in the ordnance store room in the after part of the vessel: this battery consisted of 48 Le Clanché cells, connected 12 for series and 4 for conductivity.

This vessel was fitted with four spars; the two after ones being 40' long & diameter at base 8" tapering to 5" at outer end. (not regulation): the two forward ones were 45' long: 8" at base tapering to 6" at outer end. From the pilot house nine permanent wires lead as follows viz: two to the voltaic battery in ordnance store room: two to Farmers machine on berth deck, or rather to two terminals for that purpose: four to terminal binding screws about heels of spars for spar leading wire connections, and one to a permanent earth. As the whole of the inside of the ship is iron great care necessary to prevent chafe of insulation, for if a naked wire touches the ship an earth is formed at once. The four wires leading aft were led through a lead pipe, secured to a girder on the ships side near the bottom of the boilers. & this extended as far aft as the after spar terminal - from here one wire crossed the deck, protected by an iron beam, to the port after spar terminal, and two more wires continued aft to the battery. These latter were stapled to the wooden lining of the ship & covered with tin scotchmen. These last three wires were covered with an extra linen thread braiding, rubbed down with a paraffine mixture and varnished.

A piece of this same lead pipe lead from the pilot-house to berth deck forward to the machine terminals, the other two wires continuing on for forward spar leading wire terminals. The earth wire was lead through a small lead pipe to a berth-deck beam and then made fast by means of a brass binding screw.

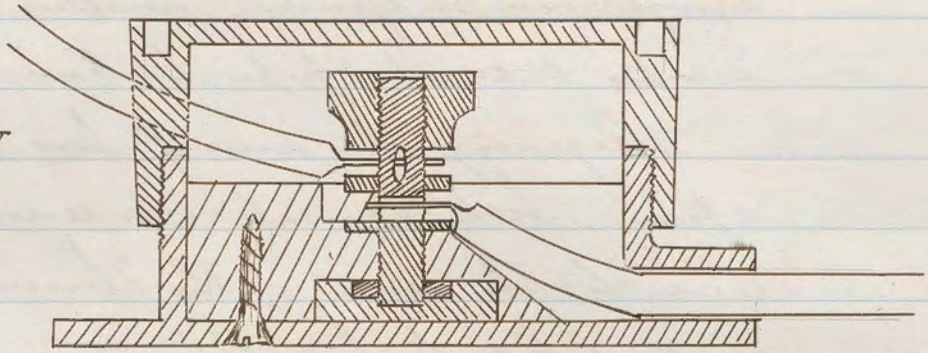
The firing and testing apparatus were the keyboard described in pages 55 and 56.

Among the qualities that would seem to be necessary for torpedo launches, are a bullet proof shield for the protection of the crew & machinery & a covered deck - or whale-back - to prevent swamping by water thrown in board by an explosion -;

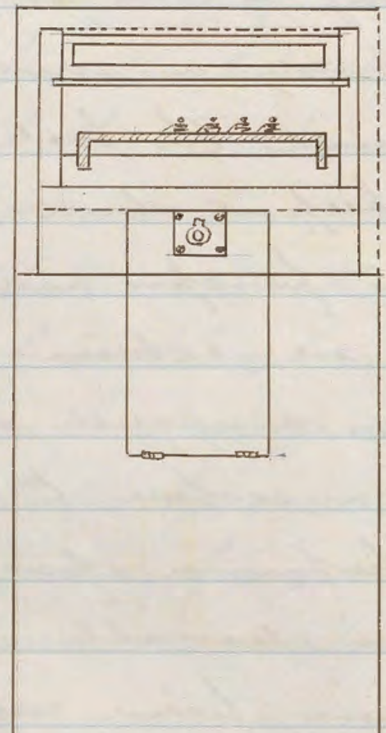
a high rate of speed: noiseless engines and escape & smoke pipe to lead under water.

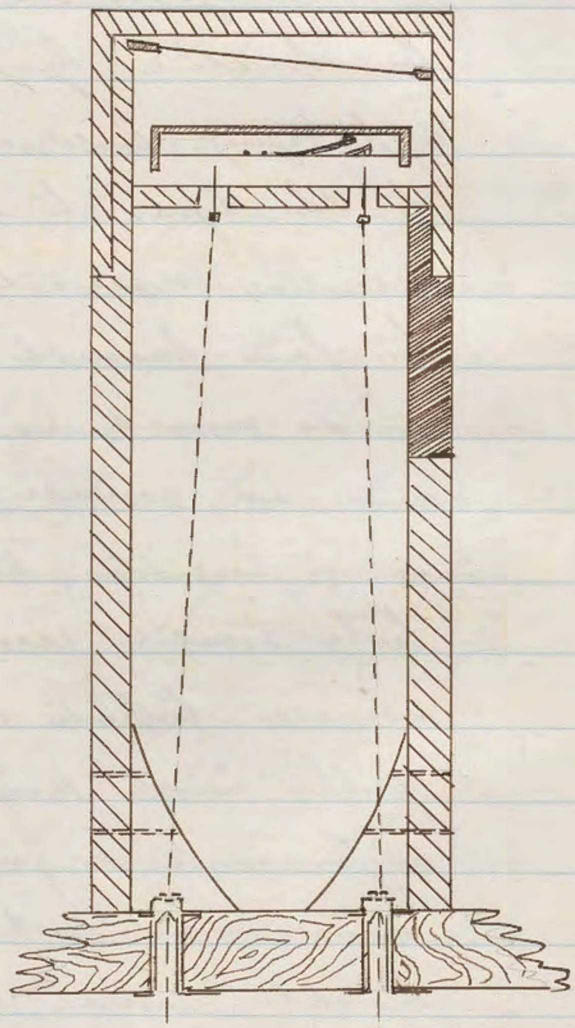
Regarding the use of bow and beam spars, both seem to off several advantages, and to the writer, the beam spar seems more likely to be efficient, and less dangerous to the operators; any danger of the spars rising to the surface might be obviated by having a small wire rope guy led under the boats bottom to the spar to keep it down. The essential requisites for spar and torpedo for fast launch are, extreme lightness, or as much as is compatible with strength and as small a surface to offer resistance as is possible, therefore a spar of steel tube would seem desirable and a small torpedo case filled with some of the more powerful explosives as dynamite or gun-cotton, the case to be also made of steel and of the double convex lense shape.

Fig I



Improved Binding Screw Terminal,





Fig, 2,

Fig, 3.

Figs. showing the lead of wires on U.S.S. "Enterprise".

Fig 1.

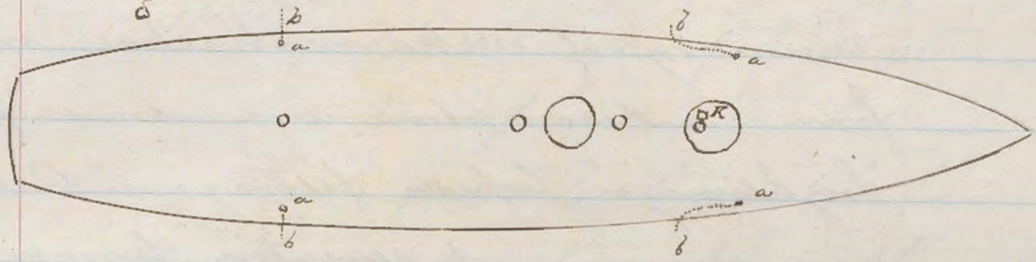


Fig 2.

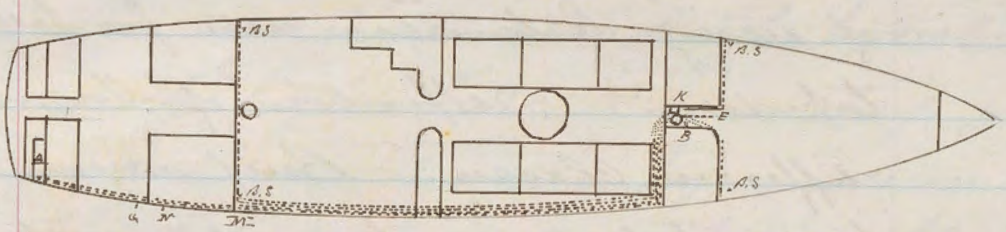


Fig 3.

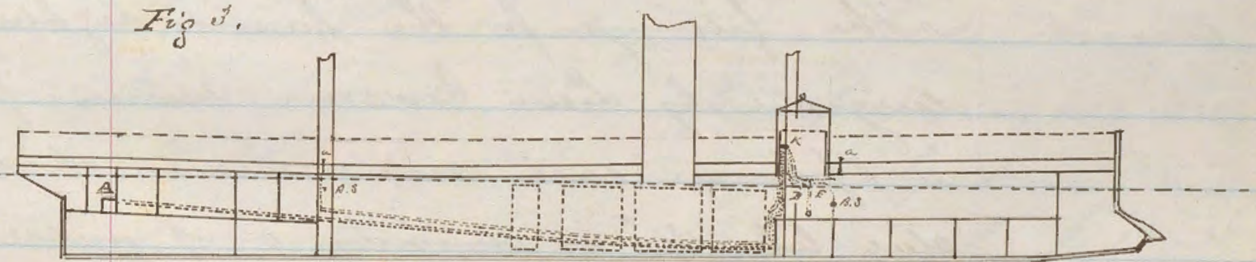


Fig 1. a, position of pipes leading through deck. a' - section of same; b, position of torpedo spars, K, Key board.

Figs. 2 & 3. A. battery; T. terminals for machine; K. Key board; B.S. Binding screws; E. earth.

See page 55 & 56 for drawings of keyboard.

Week ending - July 29th 1876.

Ques. Summary of weeks instruction in tabulated form: Description and drawings of "Lightnings" torpedo fittings: Description and drawing of sensation primer: Different kinds of electric bells and manner of using them: General method of using Leclanche's cells for bells and torpedoes: Definition of Towing torpedoes; different classes: Brief account of towing torpedoes experimented with at this station.

Ans. The fittings for the launch "Lightning" designed by Lieut Comm. consist of a spar on each side, made of a steel tube 1¾" in diameter & of metal from 1/10" to 1/12" thick - total length 25' 6". which will give an immersion of 10 feet and horizontal distance of 20 feet.

The torpedo is of steel; spherical in shape and 12½" in diameter: water capacity 34½ lbs. & will hold about 29½ lbs. of dynamite shaken into it.

The heel of the spars are fixed at

48 feet from the stem, which is 12 ft. from the stern: weight of the spar 34 lbs.

The torpedo is made of No. 17 steel; stamped out in two hemispheres and held by a clasp which passes outside the lower and inside the upper hemisphere, the ends coming together at the top & fastened there with a bolt which forms a handle.

This case is not intended to be water tight, but the fuze which is in a sharp pointed wooden case is; the fuze is secured in the torpedo by entering between two staples & then giving it a half turn under them: the leading wire leads through the spar. The spar proper is secured to the short solid rod A by driving on & fastening with a key: the torpedo clasp also forms at its inner extension, a solid rod, which ships into the outer end of the spar and is secured the same way. The spar or rather the inner solid rod is rigidly attached to a piece of iron or steel - fastened securely in the boat as shown in the drawing of the cross section (next page) which steps in bottom of the boat and turns in a fixed bearing at the gunwale - & these two, the spar & the upright are joined at a right angle & the upright so inclined as to give the spar the proper immersion when rigged out - The only guy attached to the spar is the one from forward, which runs through a steel brace as shown in Fig 2. The end being made fast to the neck of the torpedo, so it may be carried away by the explosion and the spar in consequence may tail aft.

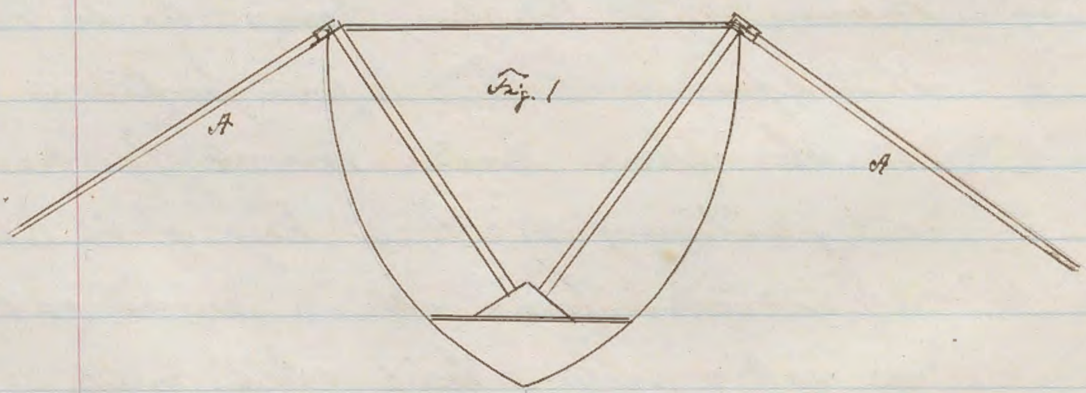


Fig. 1

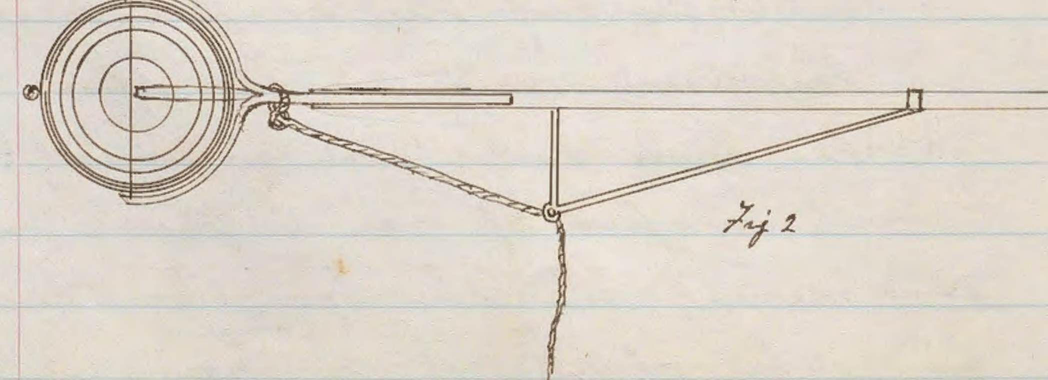
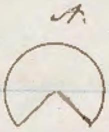
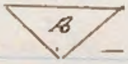
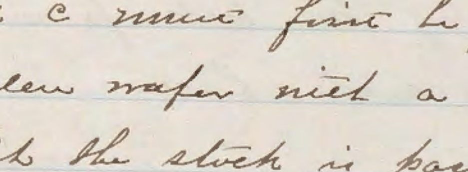
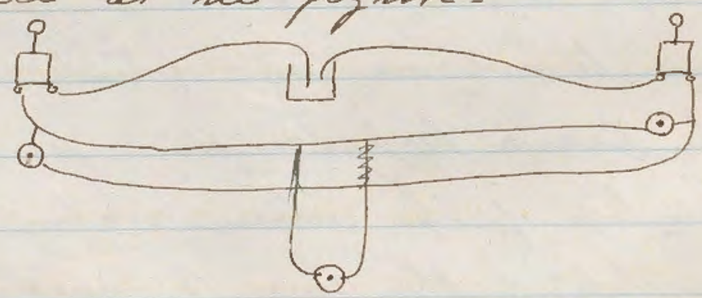


Fig 2

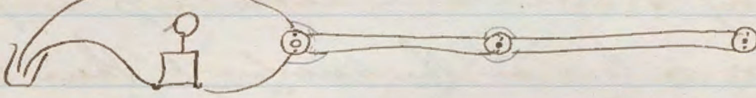
Sensitive primer -  cut a piece of paper of the shape shewn in A. and make it into a cone of shape  - which place in a conical cavity cut in a piece of wood to receive it - In the apex of the cone put a small quantity of ground quartz & above this, same of sensitive mixture made 33⅓ parts of sulphide of antimony, 60% pottasium Chlorate and 6 parts of red phosphorus (by weight -) mixed under alcohol - Then make a paper stock of form shewn in  which should be dipped in melted wax and filled with fine grain powder and over the top paste a little bit of tissue paper: the paper stock c must first be put in a small wooden wafer with a hole in it through which the stock is passed and the end turned over and glued down -; when the tissue paper is dry, put a little glue on top of the wooden wafer & turn it over on top of the cone B. containing the sensitive compound & when dry - coat with shellac - black for the top and yellow for the rest.



This is put in a brass tube with a plunger, which is protected by a spun copper cap water tight & a safety cap covers all.
Electric bells - are of the single striking & trembling kind rung by the direct action of the striker attached to the wire, which forms the armature & to those in which clock work is set in motion, by releasing the main spring - Four cells of the ordinary Leclanche cells are sufficient to ring bells on board ship - : a few crystals of sal-ammoniac in the bottom of the jars improves the battery - If it be desired to ring two bells from several places so that each shall answer the other - connect as in figure -



From the battery one pole goes to each bell, then connect the other wire from bell to a press button in contact with the other wire : pressing any button rings both bells, and any number of buttons may be pul in. To ring the same bell from more than one place – connect as in figure –



The following equations (formulae) represent the various performance of batteries –

Ordinary Leclanche – $S = \frac{E}{B+R}$; if $R = 0 = \frac{E}{B} = \frac{1.5}{3} = .5$ not enough to fire a fuse which requires .6 – ohms. (theoretically)

n ordinary Leclanche in series $S = \frac{nE}{nB+R} = \frac{E}{B+\frac{R}{n}}$ overcomes outside resistance & good for ringing bells.

Ex. 4 cells with 2 bells – 5 ohms R. each – $\frac{1.5}{3+\frac{10}{4}} = .27$

m. ordinary Leclanche for conductivity – $S = \frac{E}{\frac{B}{m}+R}$

Ex. R = 1. fuse .8 ohms. & m = 4 – $S = \frac{E}{\frac{B}{4}+.8} = \frac{1.5}{\frac{3}{4}+.8} = 1$

General Equation $S = \frac{E}{\left(\frac{B}{m}+\frac{R}{n}\right)}$, if m = 4 & n = 11 & R = 0 – then with "Nims" battery $S = \frac{1.5}{3/4} = 2 \div 6 = .3 +$

actual result, 6 fuses exploded in branch circuit –

$S = \frac{1.5}{\frac{3}{4}+\frac{.13}{11}} = 2 \div 6 = 0.3 +$ –

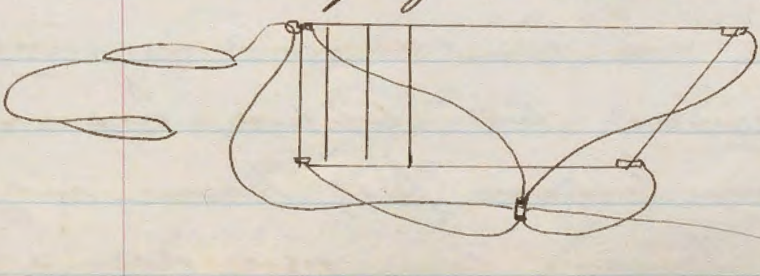
$S = \frac{E}{\frac{B}{m}+\frac{R}{n}}$ – when mn = no. of cells – n = no. in series & m = number for conductivity.

Law equation. $S = \frac{xE}{\left(\frac{Bx^2}{n}+R\right)}$ – when n = number of cells – x, number in series & $\frac{n}{x}$ = number for conductivity.

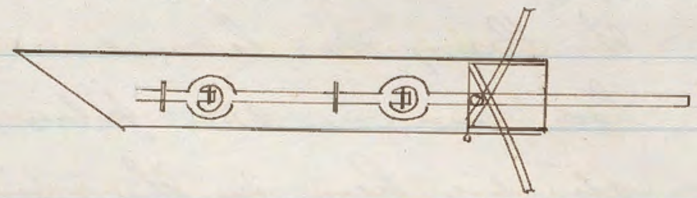
Firing Torpedoes – in general, may be described, as those which by virtue of their shape and manner of attaching tow line or both are caused when moving ahead, to diverge from the path of the towing vessel and take up a position more or less on the quarter & then resume their course parallel to the towing vessel -: generally speaking, there are two classes, viz: buoyant ones, containing a dropping magazine that is not buoyant, and those that are not buoyant, though towing on the surface, but readily sinking when the tow line is slacked - The towing torpedo forms a distinct class for naval use & in other countries they are sometimes called "otter torpedos".

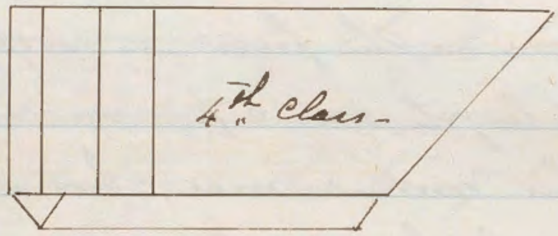
The first information had at this station was of the Harvey torpedo, which led to its investigation here -: it came into note in 1869 - and from such meagre information as could be obtained, an attempt was made to construct something of the kind here - In June 1870 the first one was made here: having a rectangular wooden case, containing a dropping magazine capable of containing 50 lbs of powder - its length was 18½ ft: width 14 inches -

and height 20 in. This first one had a dropping magazine which was fired with a sensitive primer; this turned well off the beam from 45° to 60° from course of the ship - none were exploded. In 1870 the size and form of the Harvey was learned and its form adopted here and on this plan a second was constructed here in the winter of 1870 having same as the first, a dropping magazine - its length was 5 ft; width 14 in & height 30 in. This worked well, but did not tow so well as the first: only one exploded & that satisfactorily - In the summer of 1871 ~~an~~ a more accurate description of the Harvey was obtained and in September of same year a torpedo of that type was made here - containing 60 lbs. of powder and the whole apparatus - 25 lbs. heavier than water; its length was 42 in; height 18 in and width 6 in - It had two ~~cork~~ wood buoys 28 in long by 7 in the centre & conical.

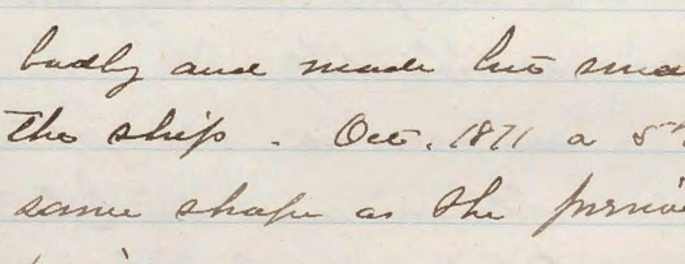


The buoys are to keep the torpedo pointed right so they shall not jump nor turn over. At the same time another was made of this type but with a dropping magazine, but the whole apparatus was buoyant –

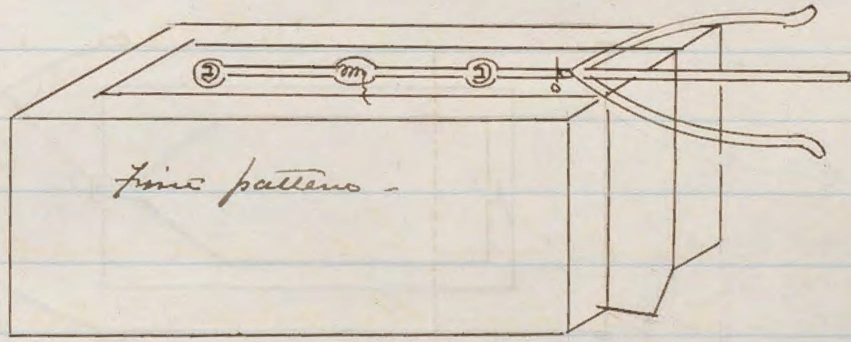


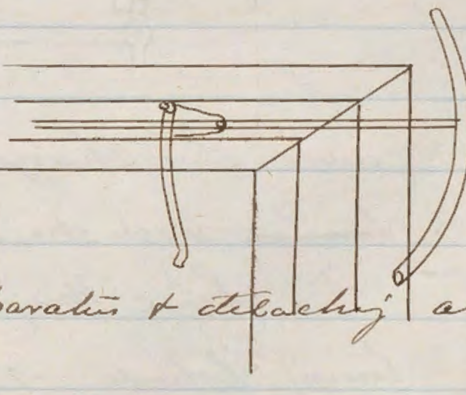


Both went badly and made but small angle from the ship. Oct. 1871 a 5th was made same shape as the previous one but capsized –



This did not work well and another was commenced, but stopped because the Harvey became fully known and in 1872 – January – some were received here: Sept 1872 Commander Matthews designed a "modified Harvey" (so called) which was finished in Spring of 1873 - a little larger than the Harvey but of the same shape - and open at the bottom & forward end: fitted with a dropping magazine with capacity for 60 lbs. of powder. This was however discarded by his successor and has never had a fair trial -





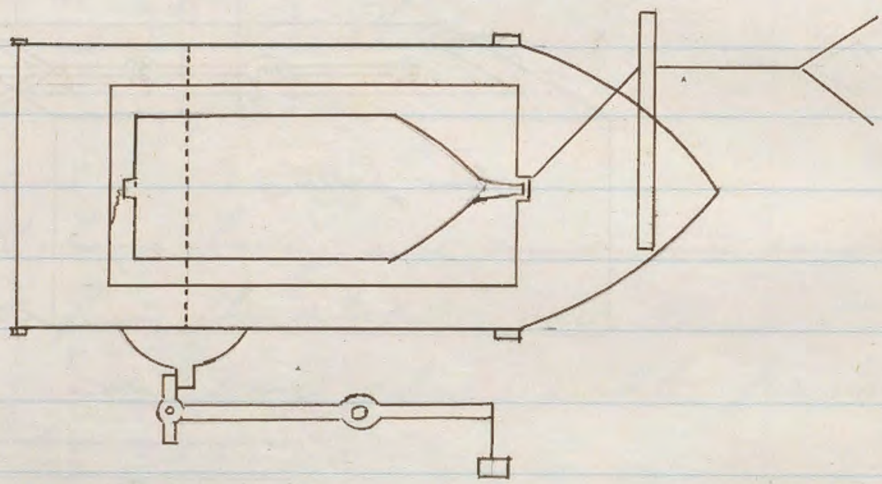
Improved firing apparatus & detaching also -

In this apparatus the magazine is dropped from the buoyant case by contact of the projecting horns & when the magazine has reached its proper immersion, the charge

primer to be discarded & now a percussion closing & Farmer's mech. are used

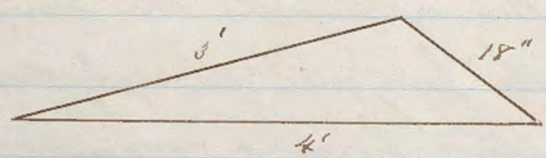
x is fired by a friction primer, exploded by the weight of the magazine. pulling on a lanyard made fast to the copper (brass) case containing the primer & to the buoyant case.

Admiral Porter designed a towing torpedo somewhat on the same plan. The magazine was of cast iron in the form of a rifle shell – weight 150 lbs – The case was 8 ft long. 30 inches wide & 20" high –



and the charge ignited by a ~~friction primer~~ ball dropped on a percussion cap.

Lieut Maynard also designed a towing torpedo of the following pattern –



& 20" high –

also one in the form of a cylinder with conical ends, intended to tow by a line made fast to the keel of the towing vessel - but neither of them have as yet given satisfactory performances.

The Danish and French have both given up the Harvey torpedo and have a bouyant case with dropping magazine -

Week ending - Aug 5th 1876.

Tues. — Summary of weeks instruction viz: a complete description of the Harvey Torpedo and all its attachments: mode of their construction care and preservation, and preparation for service and exercise, Tactics or manoeuvring: Drawings of figures 4. 5. 6. 8. 10. 11 & 13.? -

Ans. The Harvey Torpedo is the invention of James Harvey of the Royal navy - which in 1873 was regularly introduced into the U. S. Navy - Some purchased for European, tryed - in 1871

1 Set of Towing Torpedoes, includes the following articles: viz: 2 Harvey Sea Torpedoes (1 Starboard and 1 Port) 4 cork buoys and two buoy ropes: 1 firing bolt magazine (painted red) containing 2 loaded bolts: (1 starboard & 1 port, marked on the top S or P.): another firing bolt magazine containing two unloaded bolts (painted blue): 1 Towing reel complete with 100 fathoms ½ inch - galvanized iron wire rope: 1 Safety line reel, with 83 faths. of 15 thread hemp line: 2 iron leading blocks - for tow lines: 1 spanner: 12 large and six small lag screws for securing reels.

The Torpedoes are not alike and not

interchangable: the bow slopes out and the rudder is on the outboard side; stern is vertical and its bevel is on the inboard side. The outer case is made of white oak; sides and top 1/8 in. thick, bottom 1/2 in. thick - joints tongued and grooved; very strongly secured with screws: white leaded, and when put together water tight. (Harvey makes his of Elm wood.) The case is heavily strapped with iron and ballasted on the bottom with iron and lead; 76 lbs. of cast iron and 28 lbs. of lead, the latter on the very bottom to prevent accidents from dragging the torpedo over any loose powder at the place of filling. The ballast is designed for a speed of from 3 to 10 knots; with greater speed more ballast would be required.

The Magazine is a water tight copper case, 32 lbs. in weight, and of the same shape as the outer case; the top has in it, three brass bushings which project far enough to extend through the top of the outer case: The end holes are for filling and have a thread on the outside of the bushing for a water tight cap. The centre one contains a water tight copper tube which extends nearly to the bottom of the magazine. The magazine is placed in the outer case and wedged on bottom & sides equidistant from it -: melted pitch is then poured into the intervening space -

The magazine has a fresh water capacity of 66 lbs. The priming case screws into the central tube with a water tight joint: it is of brass, and is habitually kept in the torpedo: in the bottom of this tube is a magazine and when the torpedo is filled, the priming case must be removed, and its magazine filled also (with same powder): the magazine is nearly half the length of the tube. In the upper half is another tube into which the firing bolt is slipped: in the bottom of this inner tube is a steel pin 2 in. long by 3/16 - which extends up vertically in the centre.

The firing bolt case is supposed to be water tight, but in case of its leaking & thus forming an incompressible cushion of water, a hole is cut in it & covered with thin copper - so as to make a weak spot in it. The slings are from the four corners - and are spliced into galvanized wire loops with thimbles: when stretched taut along the side of the case - the towing thimble will extend one foot beyond the upper forward corner - when all four parts are stretched taut, the thimble must be in the same horizontal plane as the top of the torpedo - The angle between the forward sling and the case is 86°. (Fitted at Torpedo Station & not to be removed) The Levers - three in number, are to force down the firing bolt: they are called the side and forward & after top levers. The after top lever is backed with steel and rests in the slot of the firing bolt & the forward top lever shuts down on to its upper end.

The arm of the side lever, works on the outboard side. The torpedo complete when empty weighs 275 lbs. capacity 55 lbs. cannon powder or 57 lbs. musket powder, or 66 lbs of F.F. powder. (When in store room - a wooden plug with some tallow in a score at the bottom is kept in the place of the firing bolt to protect the firing pin. There are two Buoys made of the best cork to each Torpedo - built up on a galvanized iron tube, with cap and nut at each end to bind all parts together: the tube is one inch in diameter.

and open at the ends which are belled out; the buoys complete weigh 40 lbs. each, and the two together have sufficient buoyancy to support the torpedo. The specific gravity of the Torpedo is 40 lbs. heavier than water.

The Buoy-ropes are either 2 or 2¼ inch manila: 80 feet long, with an eye splice in one end, the other being whipped—; the ropes are rove through a ring at the upper after end of the case, then through the buoys—and an overhand knot put in so as to bring the buoys one fathom apart, and the forward one, two fathoms from the torpedo— If more ballast is added to the torpedo, another buoy must also be added.

Two loaded and two unloaded firing bolts are furnished—; a pressure of 50 lbs. is required on the firing bolt to explode the charge.

The bolt has several scores cut around it, and linen thread is wound in these and the intervals coated with Tallow to render it tight enough to stand the required pressure— (a pot of grease and spool of linen thread are kept in the magazine)

In the blue box are placed spare capsules to put over the end of firing bolts when used in exercise.

Each firing bolt has a brass handle and it should never be taken off until it is placed in the Torpedo. The bolts are all alike except the hole for the safety pin - which is cut so as to point towards the vessel when firing & care must be taken to see that the proper one is used. Each loaded firing bolt contains 3.33 grammes of potassium chlorate; .88 of white sugar, .29 of nutgalls (or 74 % of potass. chlorate; 19½ % sugar and 6½ %. of nutgalls.) This composition is put in the end of the firing bolts & stuffed in with a wooden driver, then a very small bulb containing sulphuric acid is put in the end, first being wrapped in cotton and tied up in very fine muslin - and packed snugly in the end of the firing bolt with cotton - the metallic capsule is slipped over the end, and choked in the score & the end dipped in shellac - The unloaded bolts are for practice and simply a capsule is put on the end to show whether or not the firing bolt has been driven home.

The towing rope is intended to be

plainly marked every five fathoms: any yard can be used to tow from, but the cross-jack, is most convenient and generally used: the reel must be so placed on deck that the tow line will lead fair to the yard; the yard towing block should be so placed as to hang just clear of the ships side, so that the torpedo may be dropped. The reel is screwed to the deck with lag screws and in placing it, see that the levers point forward and that the towline as it leaves the reel, comes from underneath. Should there be any trouble in checking the reels with the friction band a little resin on the drums will assist.
(Canvas cover recommended for the reels!)
The safety line reel is the same except in size as the large one, but has only one lever: the safety line must lead fair to its leading block on the rail, boat davit or wherever it may be. In preparing the "Harvey" for service: fill with powder, shaking it down well. red lead the screw threads & put on the caps: reeve the bowing rope through the large ring at rear upper end of torpedo so as to reach the eye of

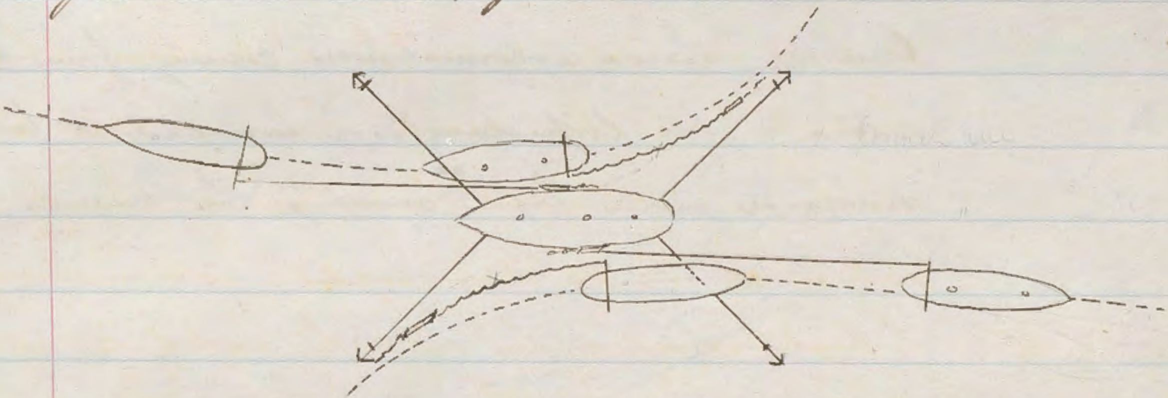
the slings and bend it to the end of the tow line after reeving the latter through the eye of the slings -: for exercise reeve the bay rope through the small ring at rear end of the torpedo -: ship the after top lever in slot of the firing bolt & ship the forward top lever on to its end - turn the side lever out at right angles from the case, and reeve the line which is made fast at the end of it (the line being greased) through the staples on top of the case - up through the hole in after lever - down again through the staples and make the end fast to one of the eyes of the hoisting bolts -: stop the forward lever down on the end of the after one (see drawings on page - 89) The becket for safety pin is bent through one of the eyes of the hoisting bolts on other side of the case - and stoppered to the eye with a split yarn, also a twine stop through the eye of the safety key around the firing bolt - and still another stop at the eye of the slings.

In launching the Torpedo, it is recommended to station men as follows: one at each lever of towing reel and one at friction bands - also men at the cranks and at safety line reel; one at torpedo and one at each reel. When ready, reel up the tow line and trice up the Torpedo - clear of the rail. Commander Harvey recommends putting the torpedo over first & then the buoys, but it has been found by practice at this station preferable to put the buoys over first & then the Torpedo. When ready, lower & veer line slowly and steadily and avoid slack line - especially in shallow water - when diving the torpedo would be apt to explode it on the bottom. Have a man stationed with an axe to cut the tow line in case of necessity. To dive the Torpedo - slack the line suddenly & then check it.

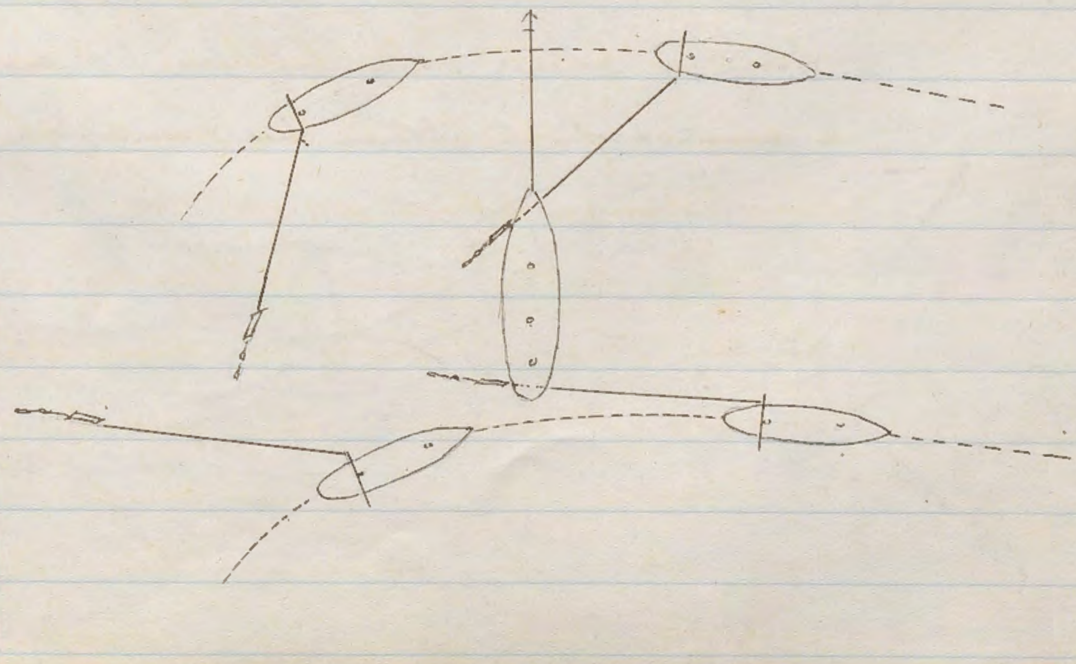
The best results of divergence have been obtained with fifty fathoms of line; at a speed of eight to ten knots the torpedo will diverge about 40°.

One of the great difficulties or objections to the Harvey torpedo is that there is no means of gauging the depth of the explosion and its successful use can never be insured but experience will no doubt give fair results.

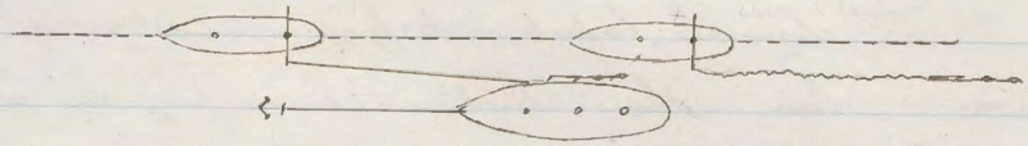
Tactics: For offensive use against a vessel moored head and stern: steer in for the bow or quarter and when between the moorings slack down the torpedo (drop it) and go on paying out line. Then check it and bring in contact if possible as in Fig. Case 1.



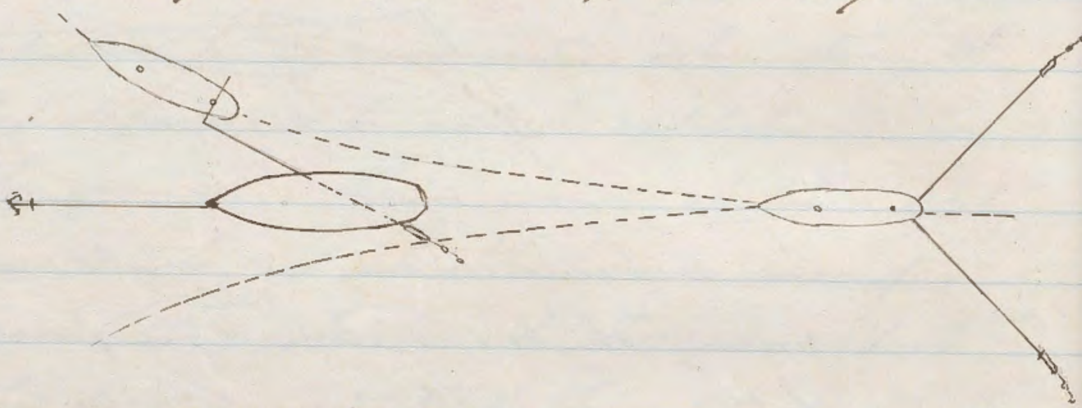
Case 2. Vessel riding at single anchor: By crossing the bow or stern: get full divergence before reaching the vessel.



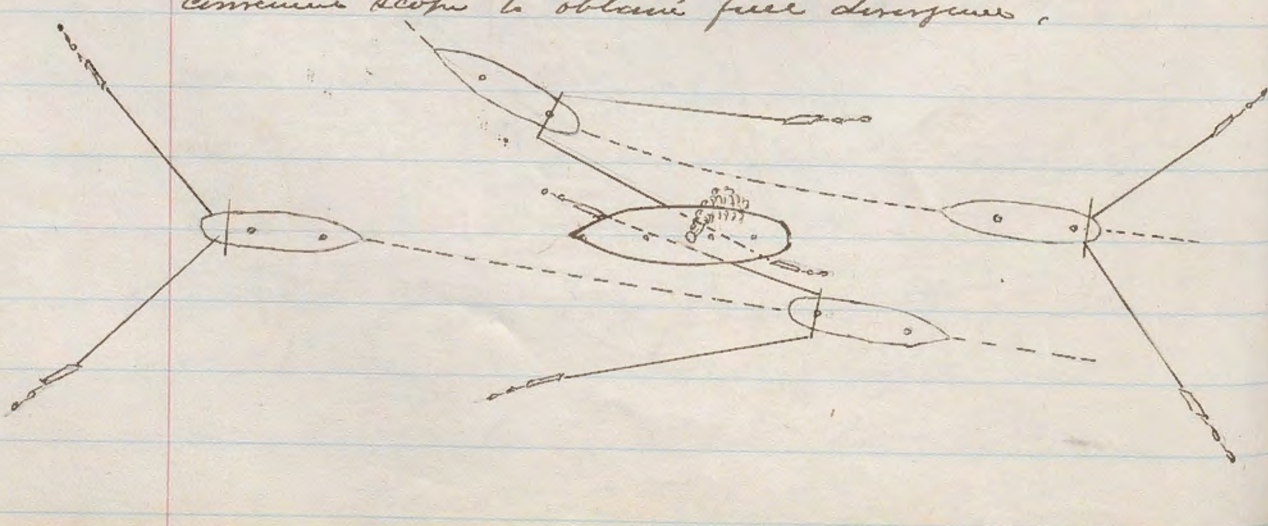
Case 3°. - Vessel at single anchor, pass on either side with a long scope of tow-line -



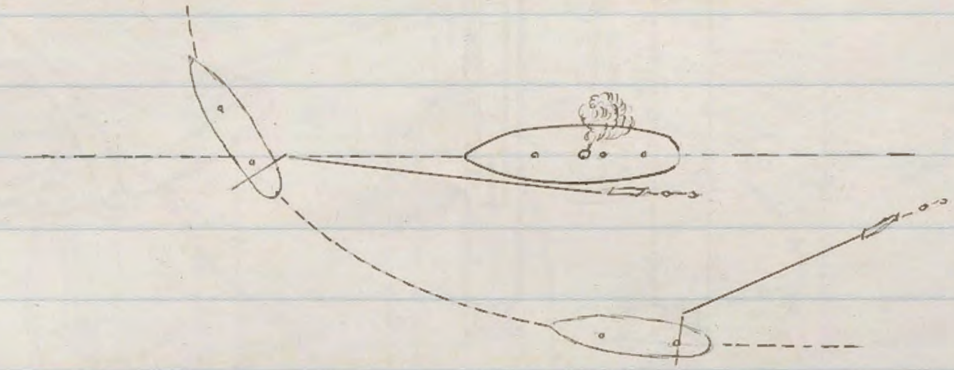
Case 4. Same circumstances, coming from right astern: two torpedoes are launched & free divergence given before reaching the enemy -



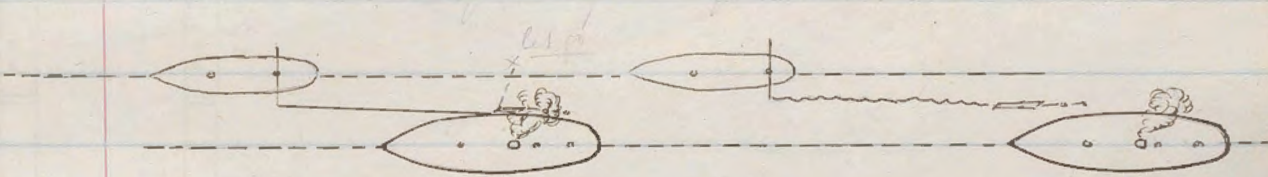
Case 5. Against a vessel underway, coming from astern or ahead: launch two torpedoes & give a convenient scope to obtain free divergence.



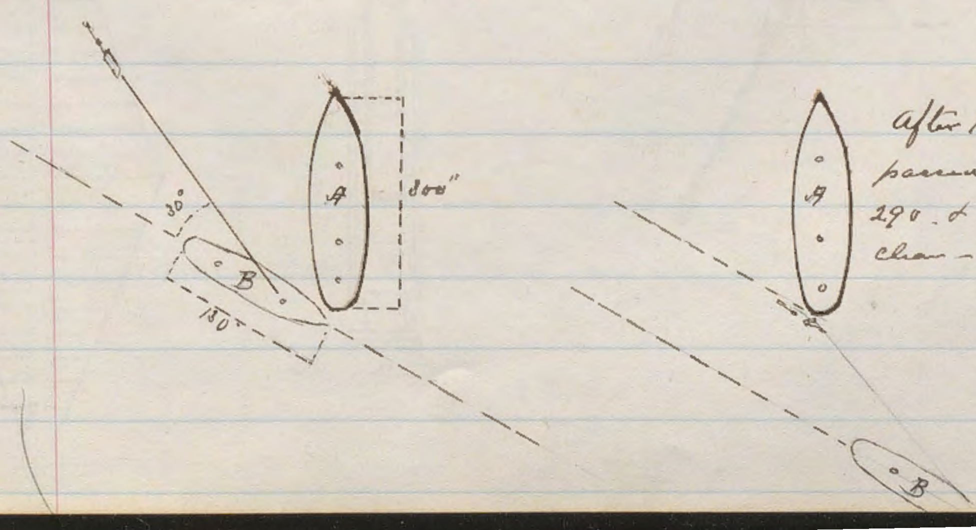
Case 6. Crossing an enemys bow!



Case 7. In the event of being chased try to gain a position on the bow of the enemy. ~~drop torpedo~~



To illustrate the impossibility of striking a vessel under way when passing astern even if the firing vessel go 16 knots to the other 10 -



After 10 sec - A has passed over 180' - B. 290 - & Torpedo passes clear -

Fig. 4

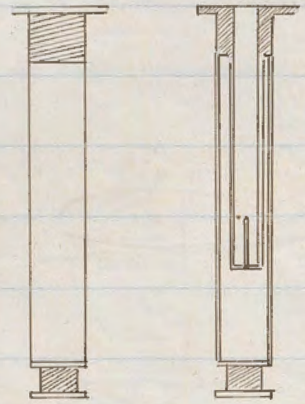


Fig. 5.

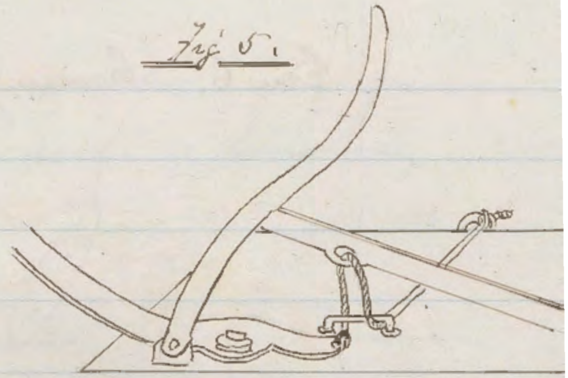


Fig. 6.

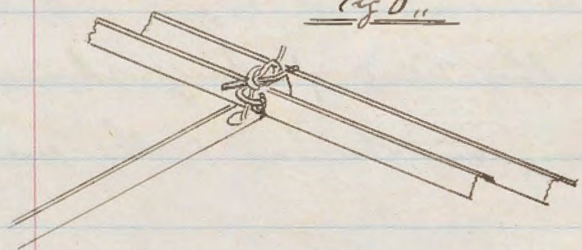


Fig. 8.

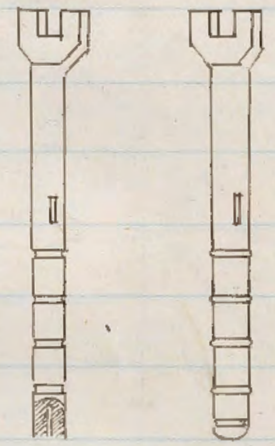


Fig. 10.

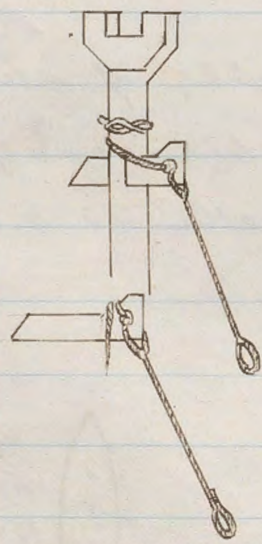
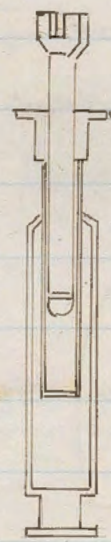


Fig. 11.



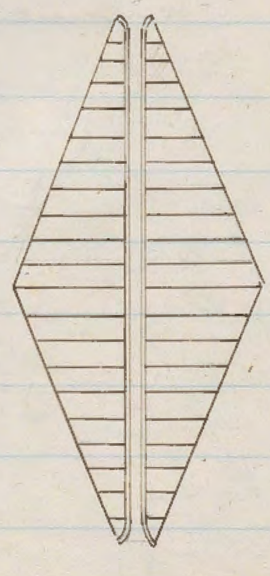
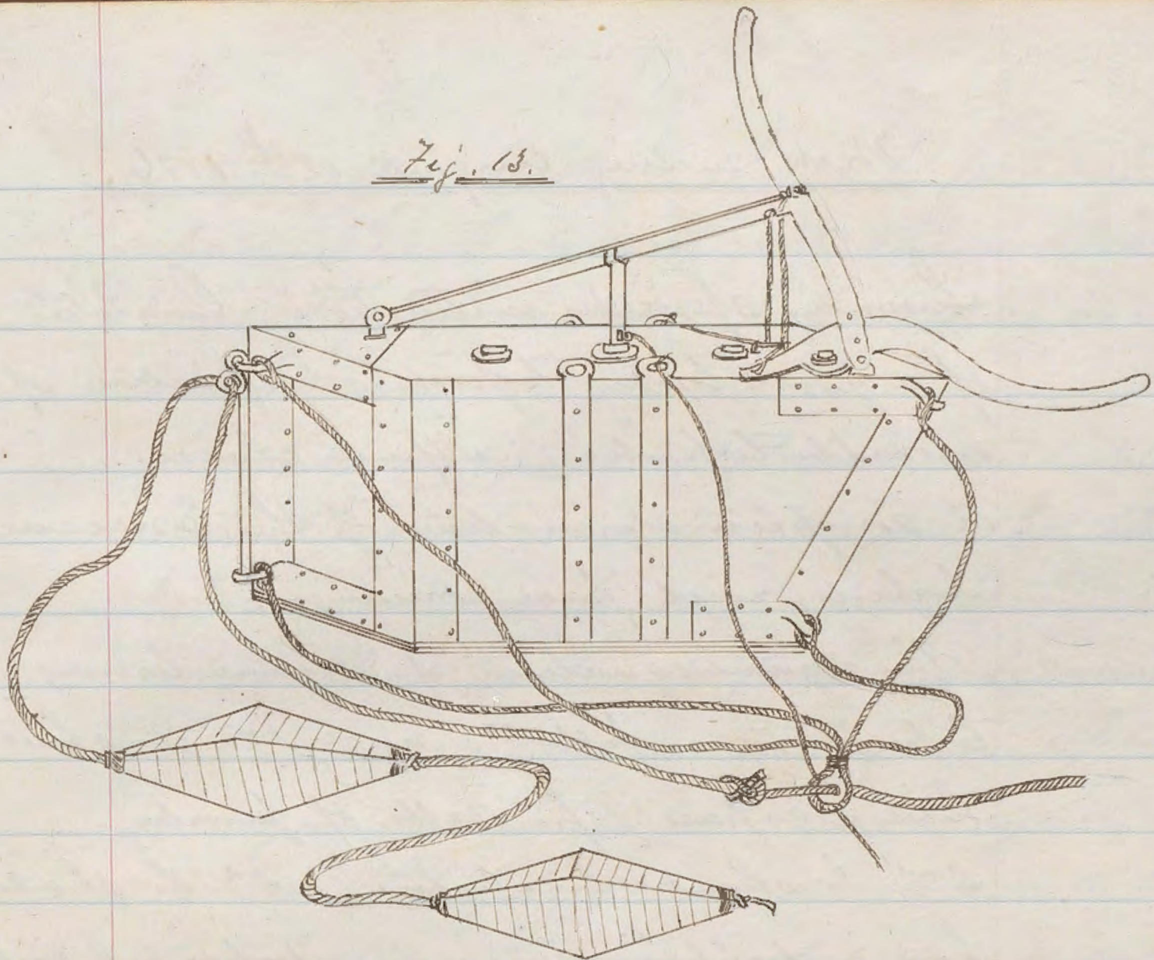


Fig. 13.



Week ending August 12th 1876.

Ques. 1. Summary of weeks instruction. Qualities of a good towing torpedo. Definition of movable torpedoes: different classes. A complete description of the Ericsson Torpedo, with free drawings?

Ans. The requisite qualities of a good towing torpedo are as follows - viz: 1st it should have a capacity for 100 lbs. of powder - 2nd It should be electric; 3d It should have a dropping magazine, dropped by contact or at will, in order to do away with the uncertain operation of diving and to insure the explosion at a proper immersion and at that depth only. Diving a towing torpedo at the proper moment would be next to impossible in the night, the time it is claimed that torpedoes will be most effective - 4th The torpedo must present as little resistance as possible to towing, and therefore must be buoyant and present a small cross section. 5th In order that the torpedo should have good holding power in the water and not drop astern at high rate of speed it should be provided with a keel. 6th. To do away with the complicated buoys - the torpedo should be long so as not to capsize end over end.

Strictly speaking, movable torpedoes include all except the anchored defensive type, but the term is here used to designate a species of Torpedo Boat, either surface or submarine, which carries its own motive power, an explosive magazine and is without human agency on board - This type may be divided into two classes viz: 1st movable torpedoes controlled from shore, 2nd automatic movable torpedoes. (Still another type but of little value so far, are the drifting or current torpedoes).

The plan of steering a boat by long yoke ropes from the shore was tried at the Washington Navy Yard - in 1864 - The boat was 30 ft. long & 3 ft. wide at its greatest cross section, and a number of oil lamps were used to heat the furnaces: The yoke was 5 ft. long - and the ropes were wound on drums on shore -

In this experiment - the lines soon became twisted and the boat would not steer -

In 1864 - the present Captain Jeffers - experimented with one similar in kind to the one first described and with the same result - the boat only being controlled a couple of hundred yards -

An Engineer by the name of Nystrom also made a similar experiment at Callao -

Of the 2nd type, those controlled from shore - may be classed the inventions of Mr. Ericsson; which are controlled by air pressure through a tubular cable. In 1854 he presented to Napoleon III - plans for a "Hydrostatic Javelin" - which was to carry a sixteen inch shell and Ericsson claims the application of hydrostatic rudders or fins as his own invention - In 1870 plans were first presented by Ericsson for a sub-marine torpedo boat. In 1872 he & Mr. Lay had a newspaper controversy, Ericsson claiming that 500 lbs. of nitro-glycerine in Lay's boat would not destroy a vessel on account of the shape of the magazine & this controversy led the latter to use a dropping magazine -

In 1872 Ericsson commenced his first torpedo boat at Delamater iron works in N. Y. & in the summer of 1873 - he experimented him-self with this boat. Changes were made in the steering gear after this. -

In the spring of 1874 he again communicated with the government and the boat was tried by Mr. Ericssons agents on board the "Intrepid", and the general result was, the torpedo could not be steered latterally, the diving apparatus worked well. After this trial the boat was returned to the Delamater works. In the winter of 1874, the "Arria" got the apparatus for working the torpedo boat and she was sent to this station for trial, changes having been made in the steering gear since the previous trial: in the summer of 1875 numerous experiments were made by Ericssons agents, and described by Lieut. Converse.

Description of the Ericsson Torpedo-

It is a submerged movable torpedo; propelled and steered by compressed air -: made of steel boiler plate - 3/16 of an inch thick; length 8'6": breadth 20": height 30" -: total weight 2000 lbs -: buoyancy 50 lbs. Propelled by two screws of opposite pitch turning in opposite directions to prevent lateral or vertical tilting: these propellers - 3'2" in diam - with 5' pitch - revolved by a geared crank shaft, direct to the shaft of the after propeller - and by means of an idler to the shaft of the forward propeller.

the shaft of the latter being hollow and placed over the former. The speed of the boat was averaged at 3 knots per hour. The body of the torpedo is divided into four compartments by wire bulkheads, the after one contains the gearing of the propeller shaft; the next one is fitted with the connection communicating between the rubber hose and feed pipes of the engine; the next contains the engine, and the forward one contains the diving apparatus and steering gear. The magazine is made of thin wire and bolts to the forward end of the torpedo and has a capacity for 150 lbs. of powder. The engine are of brough 6 by 6, oscillating, with box-wood bearings; placed directly above the shaft and lubricated by sea water. The diving apparatus: on each side of the torpedo are side fins or inclined planes which normally incline 30°. to the horizontal axis of the torpedo; these fins are attached to an axis passing transversely through the torpedo: from the centre of the axis an arm projects, the other end of the arm being fastened to a heavy wire weight which works piston tight in a large cylinder

The water acts directly on the bottom of this weight (or piston) and this is so graduated that when the torpedo has descended to a given depth, the hydrostatic pressure causes the heavy weight to rise in the cylinder rotating the axis of the fins and so reducing the angle of the inclined plane & if the torpedo rises so far as to alter the pressure the weight in the piston will descend & again alter the inclination of the fins -

Steering apparatus: It was intended to steer by means of a rudder or steering fin placed underneath the forward end, this was secured to a vertical spindle which passes up into the torpedo and is connected to the steering cylinder.

It was found necessary however during the trials of 1875 to replace the fin with a yoke; hang the rudder aft and work it from forward by means of yoke ropes from the forward yoke to rudder. Steering is accomplished by the change of pressure sent through the air tube; when working the torpedo, it has to be done at a constant air pressure and exceeding this pressure puts the rudder one way & diminishing it, the other - The tubular cable or hose which furnishes air to propell and steer the

torpedo, is made fast to a pipe projecting abaft the propeller - and is secured to the connection in the second compartment and was originally arranged to move freely to starboard or port, through an arc of 30°: the cable has an exterior diameter of 1½ inches - and interior diameter of 1 in., made of rubber and felt and buoyant; when the rudder was placed aft, the connecting pipe was secured amidships - to serve as a support to the upper end of rudder post.
There is a small pump driven by an eccentric on the shaft which throws water through a small rubber tube into main supply pipe where the compressed air, takes it to the engines where it serves as a lubricant - The gear to run the torpedo consists of steam power, and an engine capable of driving an air compressing pump and air pump with a cold water jacket; an air reservoir fitted with safety valve, and a reel capable of being turned by steam power - for reeling up the tubular cable - The inner end of the tubular cable is connected to the air reservoir by means of a pipe passing through the barrel of the reel. and at the end of the latter, between the reservoir and

cable is placed the throttle, governing the supply of air, and consequently the deviation of the torpedo.

The safety valve on the air reservoir is not only necessary to prevent the pressure from becoming too high, when pressure on the cable is reduced, but also to assure a supply of air for working purposes as a constant tension necessary for the proper working of the torpedo. A flexible steel rod 12 feet long secured vertically to the top of the torpedo has a disc on the end, painted different colors on the forward and after side, to show the position of the boat.

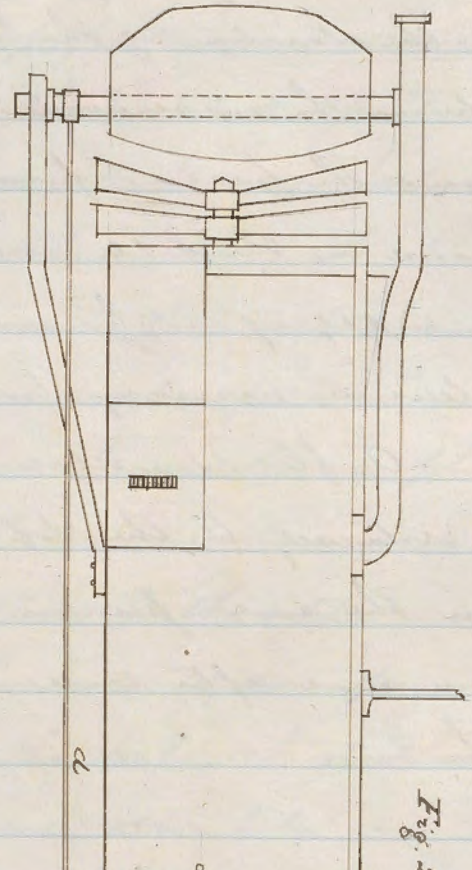


Fig. 2.

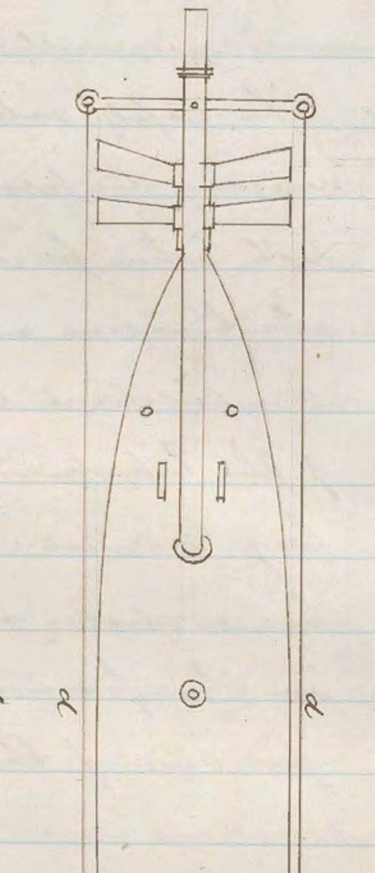


Fig. 1.

Fig. 3

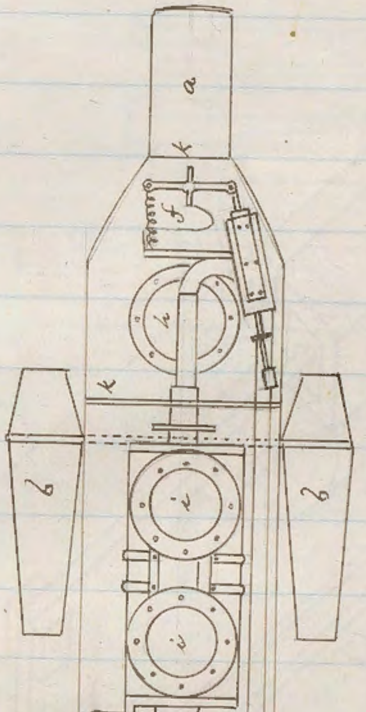


Fig. 4

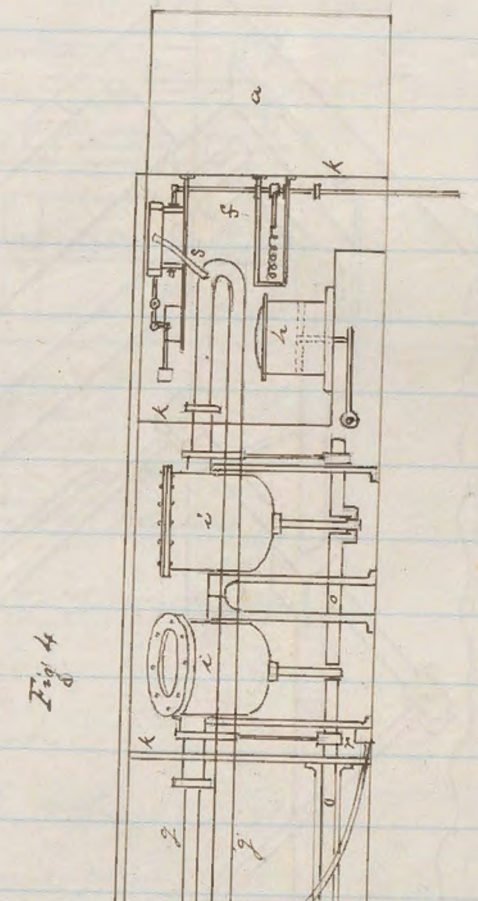
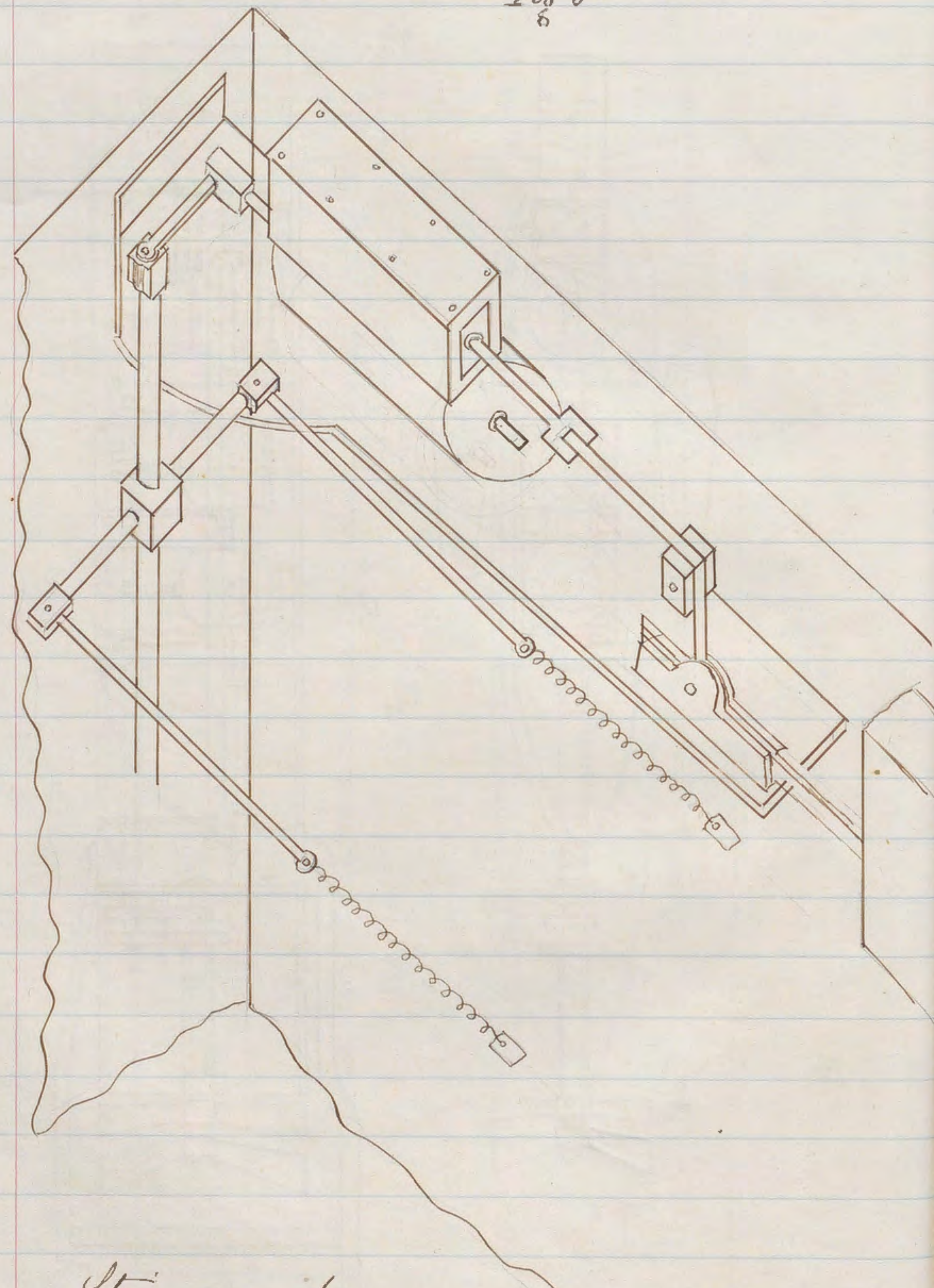


Fig 5-6



Steering gear!

Equilibrium rate of steering gear -

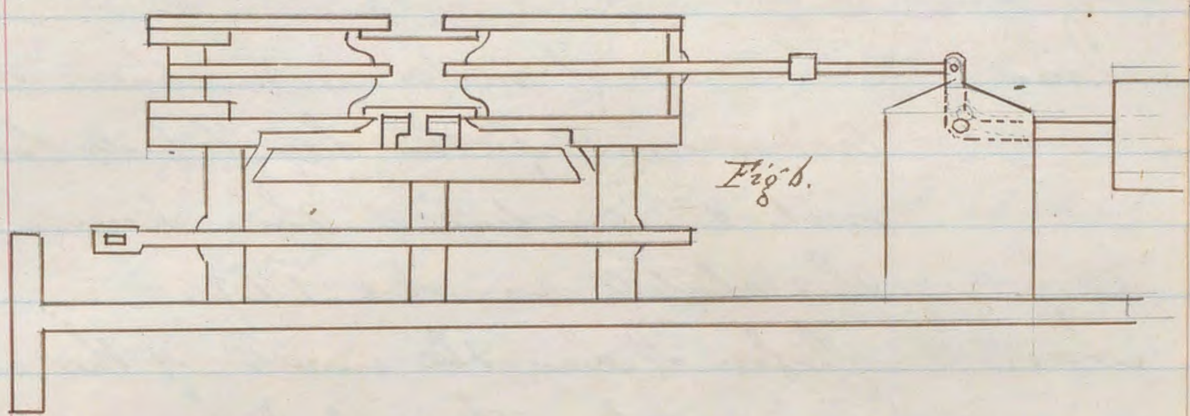


Fig 6.

Reference to planes.

Figs.	1.2.3.4.	Magazine	a.
"	1.2.3	Driving fins	b.
"	1.2	Yoke	c.
"	1.2	Yoke ropes	d.
"	2.	Original steering fin	e.
"	3.4	Steering gear	f.
"	3.4	Feed pipe to engines	g.
"	3.4	Driving apparatus	h.
"	3.4	Engines.	i
"	3.4	Bulkheads	k.
"	3.4	Gearing for propeller.	m.
"	4	Idler "	p
"	4	Pump for supplying water to air main to lubricate engines.	r
"	4.	Air tube connecting with steering gear	s.

Week ending Aug. 19th 1876.

Ques. Summary of weeks instruction viz:
An account of the Lay Torpedo Boat, with description of those known at this station as Nos. 1 & 2.

Ans. John L. Lay the inventor of the above, resigned from the U.S. Navy in 1865. & claims to be the inventor of the "Spuyten Duyvil" and also of the boat fittings & torpedo used by Lieut Cushing in the destruction of the "Albemarle". He was afterwards employed by the Peruvian government; next in Egypt, where he received $27000, to construct a boat, which he did in 1870 and took it there in 1872. His second boat was built & sold to the U.S. government in 1872. for which he received $12000. & he also received $10000. more from Egypt. The 3d. boat was completed in 1874 and was sent to Egypt. & his 4th boat was constructed in 1875 and tried here, at this station in the fall of that year, and again at Washington in April & May last but did not come up to contract in point of speed - Of the 1st & 3d boats, but little is known. All are "cigar shape" - propelled by liquid carbonic acid gas, and worked by electricity through a cable from shore - In Lay's first boats no attempt was made to start or stop the boat by electricity.

The 2nd boat built by Lay - is known here as the Lay Torpedo No. 1 - The contract called for a boat to run at the rate of 8 knots an hour, for two miles and to steer, start & stop by electricity for $12000 - & all these conditions were fulfilled except the speed - No 1 was cigar shaped or fusiform, with central section cylindrical: 29 feet long; greatest diameter 3 ft - : weight complete 4 tons; of sheet iron .125 of an inch thick; in sections, each being hammered to shape required over former; bolted together and the whole hull strengthened with longitudinal & transverse frames: motive power carbonic acid gas: governing power electricity: propeller four blades geared to crank shaft - 3 to 1: two main engines - oscillating: 2 more engines for working rudder; another for working throttle of main engines; - a portion of the hull on top can be removed at pleasure, the plate made tight by seams and rubber gaskets. The boat is divided into four compartments by bulkheads.

The forward compartment is the magazine and it has a capacity for 500 lbs. of gunpowder - to be exploded by contact, mechanical fuzes; the next compartment contains the flasks for carrying liquified carbonic acid; when the boat was received from Mr. Lay - these flasks were four in number, of wrought iron and altogether capable of containing 700 lbs. of gas: at present they are three in number & capable of containing 550 lbs of gas in the total. Before the boat is started the flasks are connected together: the gas is conducted aft to the engines by two pipes on the outside of the boat: at the bottom of this (the 2d) compartment are tanks which take in water to compensate for the weight of gas expended:

The 3d. Compartment is open to the sea water at the top and bottom, and contains a cable reel capable of holding 2 1/4 miles of insulated wire.: the one now in use consists of six steel wires & 1 copper one in the centre - 22 BWG. (made by Bishop of N. York) covered with gutta-percha to 1/4 of an inch in diameter.

the inner end on the cable reel passes through the barrel of the reel and connects with an insulated cap on the end of the reel axle; an insulated spring presses against the cap, leaving it free to revolve; this spring is connected to the relay instrument in the after compartment by an insulated wire; on the sides of the reel compartment are two more compensating water tanks. The next and rear compartment contains the relay instrument, the local battery, four large U shaped electro-magnets, for controlling the starting and stopping gear, also the rudder, the engines already referred to, the reducing apparatus, valve gear and all the machinery of the boat. The boat when afloat and properly ballasted has a buoyancy of about 200 lbs - the top of the central portion being just awash - The boat is guided by by watching two perpendicular rods, one near the bow & one near the stern - which carry flags by day or screened flags by night; these rods are hollow and connect with the interior of the boat by check valves, thus enabling the air from the water tanks as well as any gas that may have leaked, to escape. The main engines exhaust through check valves on the outside of the boat. This boat can be run two miles; can be started or stopped & steered during this time at will. The local or boat battery is composed of twelve large Bunsen bichromate cells: the shore or main battery is six small bichromate cells (Bunsens); the work of the shore battery is simply to close the circuit of the local battery on any one of the four magnets as desired: this is done by sending by means of a properly constructed key board, direct and reverse currents from the entire main battery and the same from only two cells of the same battery: by means of the relay in the boat, these four different currents will close the circuit of the local or boat battery in four different ways: 80 lbs. is the working pressure for the boat, and the reducing gear is set to that pressure.

Trials were made in the fall of 1872 before a board of Officers & were very satisfactory – but no speed or distance trial was made: afterwards she made all the requirements of the contract except speed. & was accepted and paid for in spring of 1873. In the summer of 1873. gas was made with Lay's apparatus at the station and the boat run twice; the first time by one of Mr. Lay's assistants & the 2nd time by Mr. Robeson, Officers of the Torpedo Station but not very successfully -

Mr. Lay used a portable apparatus - for making his gas - & in this apparatus, the gas is liquified by the pressure of the gas on itself & there is consequently considerable waste - but it can be set up anywhere where the materials required can be obtained & requires no engine or pump - The gas made at this station is compressed by a pumping engine -

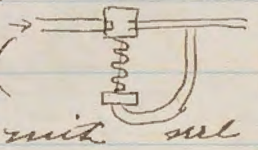
When the throttle is open for the engine a valve is also opened to let water in as the gas is expended. The gas passes from the tank to the throttle which is worked by a small engine, and then to reducing cock or chamber - and then to cylinders; the boat exhausts under water.

Improvements suggested for the No 1 Boat -

1st. Advises re-piping as joints were soldered and leaky - new joints to be made with a tapered thread 2d. - Valves to be put in to shut off gas from the boat - 3d. - Small engine to be low pressure and worked from the reducer - 4th. Old relay made to do the work of battery on shore without local battery but the shore battery to be larger. 5 - a reservoir to heat the gas on its way from flask to Engine -

The 3d Boat of Mr. Lay's was taken to Egypt - its length was 29 ft. diameter at greatest point 40 inches - dropping magazine, detached by a detaching bar run out ahead : charge 500 lbs - rudder abaft the propeller and supplied with diving fins : 3 cylinder engine - 6½ cyl - 5 in. stroke - working pressure 70 lbs - & will work up to 24 horse power - : speed 9½ knots : gas carried in one flask containing 800 lbs. of gas - : propeller 30" in diameter - 5 ft. pitch ; 3 blades - : 2½ miles of cable, 1 wire - ; local battery and relay instrument, and wire paid out from inside of coil - weight complete 5 tons : boat could start, stop, steer, back, dive & fire by electricity ; all done by one wire (electrical apparatus supplied by Mr. M. G. Farmer -)

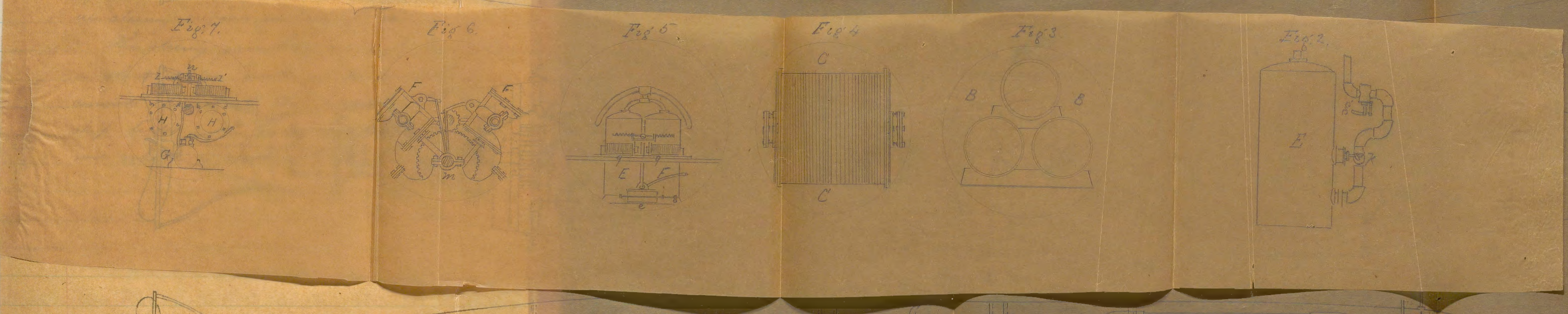
Lay's last boat known here as No. 2 - was the first one built without a relay instrument and local battery in the boat ; the contract calls for one that will run

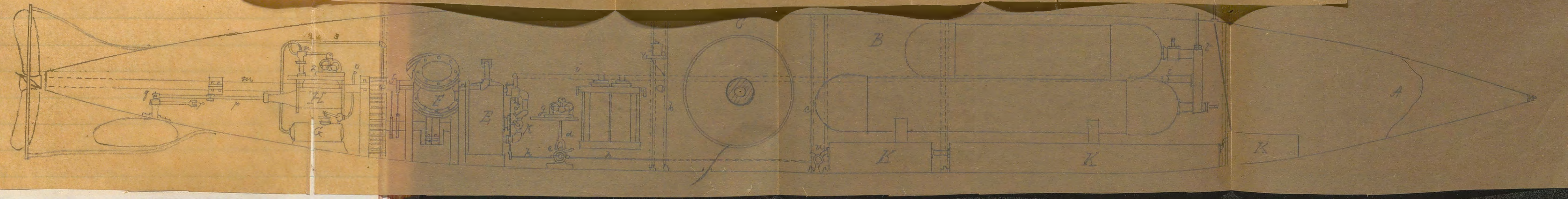
1/4 mile at a speed of 9 miles per hour - also that it shall be able to hit a moving vessel moving not over five knots, anywhere within a radius of 1/4 of a mile - also requires secrecy and that boat shall start, stop, steer & fire by electricity: this boat in general principles was similar to the one already described as No. 1 -: length 28'.8" - diameter at greatest point 2'6" -: made in four sections of No. 12 iron, hammered to shape on formers; put together and strengthened as in No. 1 - boat: five compartments: the forward of one is a dropping magazine with capacity for 300 lbs. of explosive material & it drops by a blow on a projecting bar to the length of a chain which regulates its immersion. 2nd Compartment, is a compensating water tank. 3d Compartment is the flask chamber, containing 1 wrought iron flask of 350 lbs. capacity (for liquid carbonic acid) & the reducing pipes: there are three reducing valves in the pipes () 4th Compartment is the reel chamber with reel paying out from the centre & the compartment open to the water at the bottom. 5th Compartment is the machinery chamber: it contains four axial magnets for controlling engines & steering gear, one end of the magnet wire being connected to its own cable and the other to Earth: a five wire cable is used (each wire insulated from the rest, four wires are for the magnets & one for firing.) The cable is 1 3/4 miles long - covered with gutta-percha & each wire had a resistance of 80 ohms - wires No. 20 B.W.G.: a later cable of No. 19 B.W.G - had a resistance of 40 ohms.: A three cylinder engine, 4 1/2 in. piston & 4 in. stroke for working the propeller - one small cylinder for working rudder and another for working throttle. The battery used would probably have to be as large as 20 "Station cells" - The Key-board is simply a convenient apparatus for connecting one pole of the battery to any one of the five wires of the cable, the other pole being to earth. The following are the advantages of this boat over No. 1 -

1st. Superior workmanship - 2nd. The detaching & dropping magazine, 3d - The placing of the main flask in a chamber open to the water to give more heat to the gas. 4th. Improve reducer or expanding apparatus. 5th. Paying out the cable from a drum instead of a reel. 6th. Doing away with air [illegible] batteries and relay instruments. 7th. Improve throttle engine.

Mr. Lay claims that the three cylinder engine is an improvement [illegible] the use of

Fig. 1 – Plate 2





the gas. 4th. Improved reducer or expanding apparatus. 5th. Paying out the cable from a drum instead of a reel. 6th. Doing away with [illegible] batteries and relay [illegible] 7th. Improved Throttle engine.

Mr. Lay claims that the three cylinder engine is an improvement [illegible]

an steering engine [illegible]

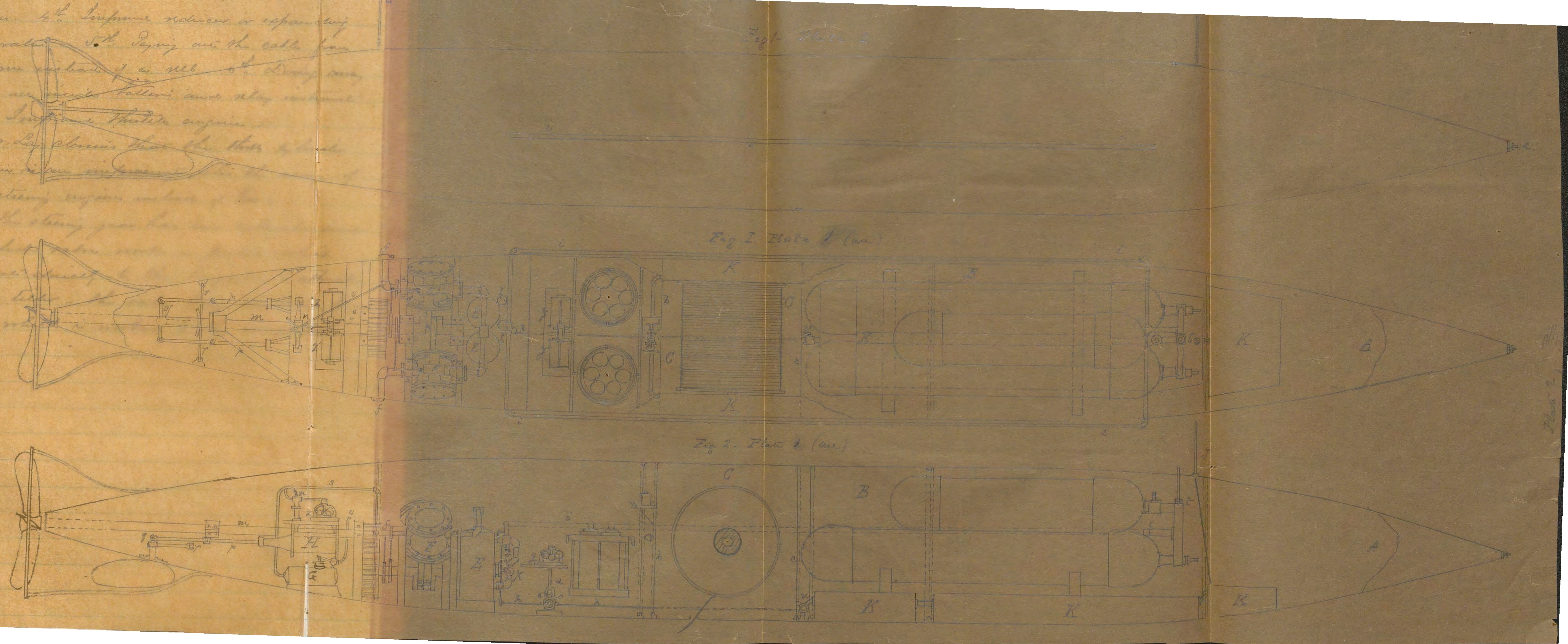
The steering gear has [illegible]

a short [illegible]

connected directly [illegible]

ship [illegible]

[illegible]



the gas - 4th. Improved reducer or expanding apparatus - 5th. Paying out the cable from a drum instead of a reel - 6th. Doing away with all inside battery and relay instruments 7th. Improved Throttle engine.

Mr. Lay claims that the three cylinder engine is an improvement, also the using of one steering engine instead of two -

The steering gear has one cylinder and a slide valve works a piston which connects directly to the horizontal or athwart-ship tiller - the valve being connected to a rod which is worked by the magnets -

Week ending Aug 26th 1876 –

Ques. 1. Summary of weeks instruction viz: Description of the various automatic torpedoes referred to viz: Whitehead; Station Fish; Rendel & Howell?

Ans. The Whitehead is the most widely known and generally adopted of any movable torpedo in existence. Its construction is a secret known only to purchasers: from best accounts it was proposed by Mr. Luppis in 1864 to Mr. Whitehead & was by the latter offered for sale in 1868 – and in that year was first tried by the Austrian government & in 1869. It has undergone many changes but the original principles are still adhered to: the general shape is fusiform; it moves under water & has compressed air for a motive power –: the forward part of the boat is a magazine, without which the boat is not complete in form, though both are made separate so that the magazine can be taken off for safety. The first offered for sale were 11' 7" long, 14" diameter at the largest section, weight 345 lbs – charge 40 lbs of gun-cotton – No. 2 – were 14' 1" long.

16" diameter - weight 650 lbs: charge 60 lbs. gun-cotton
The case was of iron and steel & shaped as former:
rudder abaft the screw, capable of regulating
the depth of torpedo, also of keeping it on a straight
line or on any curve: after starting, all control
of it ceases. During the Austrian experiments -
speed made was 720 ft. at the rate of 10.5 knots:
1440 feet at 9 knots: 4500 feet at 7.5 knots -
This one was size No. 1. The torpedo is of course
subject to the effect of currents & allowance must
be made for any - It is projected from a tube
or can be started by hand by simply starting
the engines. The launching tube is of bronze,
and the torpedo is ejected by means of compressed
air - The Austrians, British, French, Italians
and Germans have vessels fitted with launching
tubes for this torpedo - In the first trial the
vessel to be attacked was protected by a
netting: the torpedo was set to run 12 feet
below the surface at a bull's eye in the netting
3 ft × 24 in - and at a distance of 2000 ft.
the net being 200 ft long - & 24 ft. wide -
The first trial consisted of fifty-four
runs - out of which only eight hit the
netting - the average speed being 9.43 ft.

per second; afterwards thirty more trials were made and 50% of them caught in the net; the launching tube was 3 ft. below the surface of the water - No difficulty in firing this torpedo in after trials from vessels going ahead or astern, but found very difficult to hit a vessel underway - The price for the small ones was $600, and $1000. for the large ones. In the fall of 1874 the officers of the U.S.S. "Juniata" witnessed a trial of Whiteheads torpedo:- it was made of 1/8 in. steel, highly polished; six bladed propeller.; explodes by percussion when it strikes at an angle not less than 10°. weight 600 lbs - charge 66 lbs. First run 600 ft. at rate of 17 knots - & the torpedo was then recharged in five minutes; 2nd. Run. 600 ft. at about the same speed - 3d. Run; 4 runs of different intervals without recharging - making a total of 5100 ft. (Pressure in the flasks from 900 to 1000 lbs per sq. in.) To stand the enormous pressure of the compressed air, the workmanship must be very fine, and a reservoir like these can not be made in this country at the present time - Lieut. Comd. Folger says the manufacture now claims, 1st that his torpedo will run 600 ft. at the rate of 18 knots: 1500 ft. at 15 knots: 3500 ft. at 12 knots; 6000 ft. at 9 knots & 12000 ft. at 5 knots may be anticipated. The speed, immersion, and distance run within limits can be regulated at pleasure. The accuracy rapidly diminishes under 8 knots speed - & much grass or sea weed in the neighborhood, would render its action doubtful. The dimensions of the new Whitehead torpedo are 16'.5" in length: diameter 17.5": weight 750 lb: in the trials witnessed by Lt. Comd. Folger - the immersion was 5 feet: first shot arranged to run at 600 ft. speed 15 knots; accuracy very good. 2d. Shot: distance 600 ft: speed 16 knots: accuracy very good (Torpedo was recharged after first run) 3d. Shot: torpedo being recharged; distance 1000 ft. speed 14 knots: accuracy very good: 4th. Shot: torpedo not recharged: distance 1000 ft: speed 12 knots: accuracy good: 5th shot, not recharged, but set loose to see how far it would run - & ran 600 ft. at 5 knots - accuracy very poor: 6th. trial - Made a test shot of 600 ft. at 9½ knots - with good accuracy - There not being recharged it was regulated to run as far as possible at lowest speed to insure accuracy & the torpedo started seaward and made a circle — result was a failure and no satisfactory reason given — 8th Shot: torpedo recharged and the same thing tried: speed 9½ knots as desired; accuracy: at half a mile a divergence of 50 ft. and at 4500 ft. greater range and divergence had enlarged considerably. —

For short distances in smooth water where there is no current this torpedo is very efficient. The one seen by Lt. Com. Folger. had a rudder and vertical back fin also horizontal side fins. —

In 1869 an automatic torpedo of this description was commenced here and in the two succeeding years was perfected so as to make a fair weapon. Its length was 12 ft: diameter 13 in: weight 480 lbs: fusiform in shape. made of composition: diamond engine exhausting through the shaft. screw of four blades with two of them set abaft the other two —: submerging apparatus a rubber bellows. to the inner head of which is connected by means of bell cranks a pair of diving rudders —: over the head of the bellows is a stout spiral spring: no attempt made to apply lateral steering gear: torpedo runs by means of compressed air.

Rendel's Torpedo - is submerged and automatic: in the forward part is the magazine, then the submerging gear, air chamber and then the machinery: it keeps its depth by a difference of displacement: the submerging gear the same as that of the Stationary Fish torpedo so far as the bellows go-: runs by means of compressed air: the submerging is caused by the pressure of the water against a spiral spring, & a bellows arrangement in the bow & stern controlled by gravity keep it horizontal -

The engine is a cross head which works on a rubber arrangement - cylinder is fore and aft - & the propeller - is in form of an umbrella or parachute which expands & contracts - No horizontal rudders, and immersion entirely controlled by displacement which is altered by the pressure of the water at different depths. It was designed in 1871.

Howell's Torpedo was designed in 1872 - It was first a cylinder about 4 ft. long, with conical ends with a screw at each end - of the shaft which passed through the whole length - The whole cylinder which is the magazine was rigid on the shaft and the whole machine was intended to be revolved rapidly and then ejected into the water on the supposition that its momentum would be sufficient to propel it some distance through the water - on the surface: but very poor results were obtained from this.

Week ending Sept 3rd 1876.

Quest. Summary of weeks instruction: General discussion of the subjects of submarine projectiles & rockets, ground torpedoes and defence of ships against torpedo attacks?

Ans. The use of submarine guns was suggested in the latter part of the last century, but Fulton made the first practical use of them in 1814 - he succeeded in firing at & piercing a target representing the side of a first class man of war at a distance of 12 to 15 ft. he kept the water from entering the powder chamber by placing a hard oakum wad over the ball; in 1855 a Mr. Philippes of Indiana fired shot from a 6 pdr. gun - mounted in a submarine boat, through hulks anchored for the purpose. In 1861 - a Mr. Woodbury of Boston proposed to the government plans for a submarine gun, and has from time to time held further communication on the subject & offered improvements. The principles he employs - are a very long gun mounted at the desired depth below water line: when the gun is run in, the port is closed by a flap valve -: the gun loaded & the muzzle closed by a grand tin cylinder -: the gun is then run out, packing

itself water tight and raising the flap valve -
the principle of Mr. Woodbury's gun is, that the flight
of the projectile in the water, depends on the velocity
obtained in the air space before entering the water.
Since the introduction of armour for vessels, of war
all methods of submarine attack have become of
great importance & if a submarine projectile can
be driven with accuracy, a moderate distance it
will undoubtedly take the place of the torpedo,
except perhaps the anchored type -. Experiments in
England in 1864 with 110 pdr. Armstrong & a 24
pdr. Whitworth placed 4 ft. below water - demonstrated
that the sides of a wooden vessel could be
pierced - at a distance of 33 ft. & when the shell
exploded, a hole of 3 ft. diameter was made.
In this case the water was kept out of the
bore of the gun by a linen wad -: considerable
irregularity was observed in the flight of the
projectile. Lieut. Barber in presenting plans
for a submarine projectile, departs from the
preceding methods -: he would admit water
freely into the gun and use a small water
proof slow burning cartridge: he considers the
following requisites necessary in the projectile:
1st. To be of same weight as an equal

volume of water, with the centre of gravity coincident with the centre of figure; 2nd To be of large diameter & great proportionate length - with taping extremities - 3d To be given a rifle motion; The projectile proposed by Barber is 5 ft. long; 11 in. diameter, weight 175 lbs - bursting charge 49 lbs - (not expected to penetrate but to explode like a torpedo) -

Her Shunks are 6 ft. long & 15 in. in diameter, weight 400 lbs - charge 130 lbs - would have a much longer range in proportion - The short range of submarine projectiles which have been tried naturally led people to consider if it were not possible to have the projectile carry some motive power to continue their flight after once being started - rocket composition seems to be the most feasible, for this purpose -; the projectile then becomes a "submarine war rocket" - with a bursting charge in the forward end - Numerous rockets of this kind have been proposed since the commencement of the present century - though but few experiments have been tried - Among the principal ones are those of Major Hunt of the Engineers in 1862 -; he had a bronze tube fixed in a caisson; it had two slide valves -; Hunt & his assistants were

both smothered by escaping gas, having forgotten to raise the outer valve when a projectile was fired.
The next rocket, was that of Mr. Weir; it was (plans of same) presented to the Navy Department in 1874. Its length was 7 ft 7 in. Diameter 12 in, explosive charge 74 lbs - rocket composition 78 lbs - total weight 245 lbs - In his experiments with one of an fourth size - it had a range of 63 ft, submerged 4 ft - velocity 14 ft. per second; it struck the target from 4 ft 5 in to 4 ft 7 in, below the surface -: intended to have rifle motion, the composition was driven in and then bored out in the centre: it had spaces for compensating water to be admitted as the composition burned away: fires on contact or when all the composition was burned away -: fired from a tube with a ball and socket joint at ships side: tube has a lock breech and outer end of tube closed by a slide valve when trained to extreme; small charge in the tube to eject the rocket, protected from the water by a sabot - at the base of the rocket, made in three pieces to drop off when the projectile has left the tube: the charge also ignites the composition - & is fired by friction primer by turning the breech

screw. - Numerous rockets of this kind have been proposed - Lieut. Barber's rocket torpedo - ! length - 7 ft: diameter 12 in. displacement (equal wts) 287 lb.; centre of gravity coincident with centre of figure: explosive charge 48 lb.; composition 51 lb. composition tube 1/4 in. thick, of iron, surrounded by asbestos: spiral tube holds 53 lb. sea water: exterior of oak and rifled on Whitworth plan: water tight: safety caps on both ends -: the gas orifices are in prolongation of the direction of the rifling - The tube has ball and socket joints & two slide valves -: howitzer like carriage: rocket to be ejected by compressed air & the force of the air to drive in the corrugated disk on the base which is to ignite the composition (The above is only proposed however)

Ground Torpedoes! Stationary defence torpedoes are known at this station by the above title: and often called submarine mines. In this country - in England, Germany, Austria & probably in all other countries but France, ground torpedoes are under the charge of the Engineers - which seems proper, as neither torpedoes, guns nor obstructions will keep out a well appointed fleet when employed singly, but when combined offer a very formidable defense. In general, the plan of harbor defense by torpedoes contemplates placing them in such positions that a vessel cannot enter a harbor without passing over one or more; in order to prevent gaps in the line of defense, several rows of torpedoes one behind the other are used: Ground torpedoes may be divided into four different classes - 1st - mechanical, or those with contact mechanical fuzes; these are cheap, easily manufactured, from material generally on hand and are effective:- they are however very dangerous & close a channel to friend & foe. 2nd Electro-mechanical; these are exploded by electricity though not connected to the shore; the battery is in the anchor, or the torpedo may have a regular anchor & the battery another: (of English design -) safe to put down, though rather dangerous to take up & are liable to get out of order -; they are quite cheap and have no long cable to be grappled or cut. 3d Class - are Electric: they are exploded from a shore station or fort at will: they are perfectly safe to handle, can be passed over by a friendly vessel without danger; are without a complicated circuit closer and are so simple in all their parts that the chances of failure to explode, can be made very small; their great disadvantage is, to tell when a hostile vessel is within their radius of destruction. 4th. Electro-contact; these are exploded by electricity, the firing battery being brought into play by means of a vessel striking either the torpedo itself or a buoy placed over it.

These torpedoes in some systems are electric as well as electro-contact i.e.: may be fired at will, whether the buoy or torpedo is struck or not: This class presents all the advantages of the electric, except simplicity and will do the very important work of informing the operator when the vessel is over the torpedo itself.

Of the above different types of torpedoes, the electro-contact is by far the most important & the one that is generally intended to be used by all nations: probably some mechanical and a few electric will also be used.

Voltaic batteries are always now used for ground torpedoes: they should be powerful, constant, last a long time and not be easily disarranged by jars or shocks: the cable

should be very strong and armoured to prevent chafe: great care must be exercised in leading them into a fort or shore station; also in sinking them out of the way of drags and grapnels: the torpedo cases are usually of boiler iron, though the French use heavy cast iron cases.
The cases will remain on the ground when the water is not too deep & must be anchored & buoyant when it is: they should be of such a shape as to be affected as little as possible by the tide: cast iron mushroom anchors are generally used for securing buoyant cases and circuit closers. The circuit closers must be sure in their action: they should be enclosed in a very buoyant buoy & impossible to be injured by blows from friendly vessels & must be so planted as to be below the surface at low water. Wet gun-cotton seems to be at present considered a very advantageous explosive for ground torpedoes, though powder & dynamite are much used. A signal & firing apparatus to which cables are connected is very important; it should be able to tell the operator at all times, when the cables or torpedoes are tampered with: what

torpedo is struck and what ones have been exploded: it should permit of explosion at will, or be able to explode any torpedo immediately that, it or its buoy is struck: other qualities such as cutting off the battery from other torpedoes near the one exploded for a few seconds are of great use —

Proposed plans for operating against ground torpedoes — 1st. dragging with boats and scows drawing but little water; to be done at night or in a fog —: if wires are active they may be exploded or dragged away from their anchorage: Another method is counter mining with torpedoes (432 lbs. of gun-cotton exploded, will destroy any torpedo within a radius of 120 ft.) In clear water like the Bermuda's & Bahamas, torpedoes may be seen & cables cut by divers: a diver can carry an electric light so as to see cables & cut them. Another plan is to search along the shore and in shoal water at night or in fog — dragging sharp hooks to find cables and cut them: again hulks may be drifted over wires to drag grapnels & foul cables, or a "Lay boat" may be employed to carry a grapnel and return with line. Another plan suggested, is to fire simultaneously from two mortars a bomb from each connected together by a chain & with ropes or chains to drag them over the bottom. Small vessels surrounded with heavy laden hulks like the tow of canal boats might be employed to explode the mines in certain channels.

Defence of ships at anchor against torpedo attacks: In the summer of 1873, experiments were tried to protect H.M.S. "Monarch" against attacks of steam launches armed with spar torpedoes & a gun-boat with the "Harvey": the ship was surrounded by a frame work of her own spars; a topmast, trysail mast & other long ones being used: several wire and rope hawsers were also placed at different distances and at bow & quarters, spars, grapnels were hung to catch the tow line of the Harvey: it was thought that twenty-four hours would be necessary to prepare a vessel thus with her own resources: guard boats rowing around the ship supplemented this defence. On the approach of the steam launches, the alarm was given: the ship slipped and steamed ahead: a launch succeeded in hitting the ship, though nearly upset by a hawser. In several attacks of the Harry, ship was struck but once.

The British Torpedo Committee have decided, that vessels at anchor or moving slowly must be protected by wire netting which shall be 40 ft. from the vessels side; extend from the surface as low as the keel; such an one was tried with H.M.S. "Glatton", using her own spars & requiring 24 hours to rig it: it was found that with a tide or speed of 3 to 4 knots, the net would flap up against the ships sides and offer but little defence against Whitehead torpedo - but considered that the vessel was protected against spar torpedo boats, but not against larger vessels carrying spar torpedoes. Lieut. Lindsay R.A. has proposed for defending ships at anchor, the following method: jointed gas pipe spars 40 ft. long with vertical rods at the end equal in length to vessels draft & secured by a brace from the long spar: the brace and vertical one have one joint each and the spar three, for convenience in stowing -

kept lashed outside ready to open out: seven of them used: one on each side abreast each mast & one astern: the spars are supported by topping lifts from yard arms and mizzen mast & with guys. The wire netting is hung from the jib-boom & then secured to the vertical sides by lacing in & out of the mesh & between the spars, by spans to the yard arms: at sea to be carried in the boom boats. Ten feet inside the net a wire rope is stretched around the ship attached to each spar & ten feet inside this, a rope hawser. — Lieut R. B. Bradford USN, proposes the following: "in place of a net use a light chain one, heavily tinned to prevent corrosion (in an emergency, a strong seine or fish net might do). For defence purposes the regular torpedo spars may be utilized - six to be carried instead of four - one on each side abreast each mast, secured at the channels & kept up and down the forward shifter - Four more spars would be required one at each bow & one at each quarter: the four should be placed on bumpkins - so as to rig along-side like a lower boom - the netting to be in two pieces, hoisted out with yard arm whips and lowered to the water edge: spars being rigged out and lowered to the water edge: the foot of the netting is secured to them & both lowered to the desired depth -: the ends of the net are then laced together, hung from the jib-boom forward and outriggers aft, & yard arms -: as a further defence, stretch a hawser round the ship attached to the spars at their water line (say 30 ft. from ship) still further, before lowering the spars, run a wire rope round the ship just inside the netting passing it through thimbles in the spars & to this wire rope becket small cam torpedoes fitted for the purpose, say, three between each spar at equal distances apart; these kept always ready and of 20 pd. charges -: attach each three to spar leading wires in branch circuits -

The English recommend small field guns.

The "Oberon" experiments - (later ones)

In these experiments, the same hulk was used as on the previous occasion - with the "Hercules bottom" - which is double - the outer skin being of 3/4 in. iron & inner of 3/8 to 1/2 in -

distance between them 3'6" at keel to 2'3" at water line - transverse frames 21 inches apart, and longitudinal frames every four feet: every fourth transverse frame was a water tight compartment: hulk anchored in 16 ft. of water - 1st Charge - Harvey - 66 lbs. powder fitted with service bolts - arranged to be fired by electricity - immersion 9'3" - & 3 ft. from the ship's side near the bow, where the side was nearly perpendicular - 2nd Charge, wrought iron case, 33 lbs. slab gun-cotton - 25% of water with 2¼ lbs. dry gun-cotton for priming - immersion 9'3" - and 4 ft. from ship more under the bilge than No 1 - 3rd Charge - same as second, but of granulated gun-cotton - with dry primer of 2 lbs. 10 oz - on starboard side opposite No 2 - same depth and distance - A steam launch was placed on each side with Torpedo spar rigged out and everything in exact position to have exploded the gun-cotton charges provided they had been spar torpedoes; all these charges were in continuous circuit & exploded simultaneously by electricity -

Results! Steam launches not injured; charge No. 3 - did not damage - No 1, the leave. but No. 1 did a surprisingly large amount of damage however, and either charge would have caused the vessel to sink in a very short time -: holes were made through both skins by all the charges such as would have been impossible to have plugged -

Leclanche's improved battery!

The carbon element is composed of 40% of peroxyde of manganese, 55% of retort carbon & 5% of gum, all pressed together in a steel mold - capable of bearing 300 atmospheres (4500 lb. per sq. in) at a temp: of 212° Fah. 3 to 4% of bisulphate of potassa to dissolve the oxychlorides is placed in the inner element: the current is collected by a small carbon stick in the centre: the EMF. is 1.5.