A.D. 1860, *3rd March.* N° 590.

Apparatus for Diving, and for Raising and Lowering Heavy Bodies, &c.

LETTERS PATENT to William Bauer, of Munich, in the Kingdom of Bavaria, Submarine Engineer, for the Invention of "IMPROVEMENTS IN APPARATUS FOR DIVING, AND FOR RAISING AND LOWERING BODIES IN WATER, PARTS OF WHICH IMPROVEMENTS ARE ALSO APPLICABLE TO OTHER USEFUL PURPOSES."

Sealed the 29th May 1860, and dated the 3rd March 1860.

PROVISIONAL SPECIFICATION left by the said William Bauer at the Office of the Commissioners of Patents, with his Petition, on the 3rd March 1860.

I, WILLIAM BAUER, of Munich, in the Kingdom of Bavaria, Submarine Engineer, do hereby declare the nature of the said Invention for "IMPROVEMENTS IN APPARATUS FOR DIVING, AND FOR RAISING AND LOWERING BODIES IN WATER, PARTS OF WHICH IMPROVEMENTS ARE ALSO APPLICABLE TO OTHER USEFUL PURPOSES," to be as follows :—

The principal object of my improvements is to raise sunken ships from the bottom of rivers, lakes, or the sea, an operation which can be effected from any depth up to 500 feet, owing to the peculiar manner in which the person or persons conducting it are protected from all external influences, and subjected to no more than the ordinary atmospheric pressure, and its complete independence of the motion of the sea at its surface.

My improved apparatus for diving consists in a cylindrical or other con-

veniently shaped chamber made of metal plates, or of cast metal, of the requisite strength to enable it to resist the pressure of a column of water of 500 feet, as well as to secure it from any danger which might arise from accidental collision with other objects. This chamber, unlike an ordinary diving bell, is completely inclosed, with the exception of an opening at the top, through which the person or persons intending to conduct the operations are admitted, and which is subsequently hermetically closed, the internal space being filled with air of the ordinary atmospheric pressure. The bottom of the chamber is double, presenting a concave surface to the water, as well as to the interior of the chamber, and between the two bottoms there is a hollow space, which again is subdivided into two portions, the larger one for the reception of a body of water to act as ballast, variable at pleasure, by means of a force pump actuated from within, and the smaller one to receive a lamp with a powerful reflector, for the purpose of throwing light upon a certain range of external objects through an opening in the side of the chamber covered by a strong window or bull's-eye, and protected by an iron bar. Another reflector is introduced at a suitable height above the last named, and above this again, and at a convenient height for the eye of a person standing upright another opening admits of the operator observing the surrounding objects, so as to enable him to guide or steer the apparatus with precision and safety. A bull's-eye over head, and four or other convenient number of bull's-eyes placed at equal distances from each other, and on the same level as the one last mentioned around the sides of the chamber, enable the operator to observe what is going on above and around him. A screw propeller protected by a casing or box capable of being worked by hand from within the chamber, and the spindle or shaft of which passes through a stuffing box, admits of the apparatus being moved forward, whilst another similar but smaller screw propeller, placed at an angle of 90° from the former, serves the purpose of causing the apparatus to revolve round its vertical axis; the axis of the larger screw intersecting the vertical axis of the apparatus, whilst the axis of the smaller screw is parallel to that of the larger one. Besides these two propellers, and immediately underneath the larger one of them, a rudder is fitted to the apparatus, also capable of being actuated from within the chamber, by which rudder the apparatus can be steered in the ordinary manner. And as in the case of powerful currents having to be encountered, it might be considered necessary or desirable to prevent the apparatus from drifting, an anchor can be lowered by means of a handle and gearing acting upon a chain barrel from within the chamber. In order to enable the persons occupying the chamber in a case of emergency immediately to rise to the surface of the

water, a heavy weight nearly filling the cavity of the concave bottom can be suddenly detached from within by merely turning a spindle passing through a stuffing box in the centre of the floor, and from which the said weight is suspended. The diving chamber is in communication with the ship, which, as in other similar cases, is in constant attendance by means of an electric telegraph. A supply of fresh air can be obtained, when necessary, by means of two air tubes; one of them being in connection with the air pump on board the ship, and the other serving as an outlet to the vitiated air. The opening and closing of these tubes can be regulated at pleasure by taps within reach of the operator in the chamber. But I wish it to be particularly understood that the air space within the chamber is amply sufficient for several hours' consumption of three persons, and that therefore the admission of fresh air need only take place at such intervals; or, the air may even for a limited time be to a certain extent purified by the admission of oxygen, which is kept in store in a compressed state.

The raising of sunken ships or other objects is effected by means of flexible air bags or balloons, made of strong and impervious material, say, alternate layers of caoutchouc and canvass, protected against abrasion by friction, and rendered capable of supporting any strain they may be subjected to upon being inflated and attached to the object to be raised by a network of stout cords or ropes, to the lower part of which, and below the neck of the balloon, a strong iron ring is fixed. To this ring a chain is looped, from which is suspended a strong iron lever or arm, or other suitable instrument; the object of which is to be inserted into a port hole or any other convenient opening in the body of the ship to be raised, in the manner to be hereafter described. The balloon after having been partially inflated, so as to counterbalance to some extent the weight of the chain and arm, or other instrument suspended from it, is lowered from the ship with the air-supply tube inserted in it; the iron arm, where such an arm is used, is dropped between two strong lugs projecting from the body of the chamber in what may be called the front of the apparatus, and is there secured by a hook, which can be actuated from within the chamber, so as to release the arm at the proper moment. The apparatus may now be considered ready for action, the diving chamber being at first suspended by chains from the ship, but subsequently allowed to descend freely into the water as nearly over the ship or other object to be raised as may be considered desirable. The operator and his attendants within the chamber have it in their power to regulate the velocity of its descent, as well as its vertical position, by diminishing or increasing the volume of the water ballast by means of the force pump already mentioned, to move the apparatus slowly forwards or

backwards by means of the larger screw propeller, to turn it about its vertical axis by means of the smaller screw propeller, and to regulate its motion sideways by means of the rudder to the greatest nicety, the various windows or bull's-eyes enabling the operator to observe the surrounding objects in all directions.

The object in the case of a ship to be raised being to attach the balloon to some convenient part of the ship, the operator will, for instance, place the diving apparatus in such a position that the arm attached to the end of the balloon, and temporarily connected with the body of the chamber by the means previously mentioned, will assume a vertical position, and stand immediately over a window, port hole, or other suitable opening in the hull of the ship. The operator will then detach the arm by withdrawing the hook which held it, and thus allow it to drop into the opening, and as the arm is suspended from the chain in such a manner that that portion from the point of suspension upwards is heavier than the portion below that point, the arm will on being left to itself drop and place itself across the opening. The air pumps are then set to work at a signal giving by the operator, by means of his telegraph, and the balloon is inflated to the requisite extent. And it will be understood that as many balloons as may be considered necessary to effect the desired object are fixed to the ship in a similar manner. It is evident that, as, with a given weight of air contained in it, the volume of the balloon will increase as the the superincumbent column of water diminishes in depth, the inflation of the balloons can be so regulated that the effort to raise the object to which they are attached will commence with the tide running out, and be at its maximum at low water. As, however, the neck of the balloon is open, the air will begin to rush out in proportion as the ship or other object approaches the surface of the water, and it will thus be prevented from bursting by over pressure.

My improved diving chamber may also be used independently of the balloons for various other purposes, such as examining sea walls or other submarine structures, examining plants or other objects at the bottom of the sea, and for conducting other scientific investigations. For such purposes the construction of the apparatus may be suitably modified, and it may be fitted with various utensils in the shape of shovels, spoons, tongs or otherwise, to be actuated from within for the purpose of digging up plants, or taking hold of or grasping any objects which the operator may wish to raise to the surface of the water.

Besides that this my improved diving bell or chamber admits of operations being conducted at the great depth mentioned, all the time that the

operator and his assistants are exposed to and live in no other than the ordinary atmospheric pressure of air, my method of raising sunken vessels and other objects presents the further and very great advantage of not being affected or influenced in the least by the motion of the sea on the surface.

Instead of making use of an independent diving chamber, as above described, I also propose to cause the diving chamber to form a portion of a submarine ship, such as that described in my Patent dated 25th of May 1853, No. 1281. In this case I form a recess in the ship's side, the bottom of which is on a level with the ship's bottom, and which shall be large and high enough conveniently to admit a diver armed with a helmet and diving dress. I furnish the partition which separates this recess from the air chamber within the ship with a door opening outwards, and the second partition, which is in contact with the water, with another door, also opening outwardly, and fitted with a disc valve. This chamber inclosed by these two partitions is in communication with the air chamber of the ship by means of a valve orifice, capable of being closed from below by means of a valve attached to a floater, whilst the floor of the chamber is provided with a disc valve, by means of which a communication can be established with the hollow keel of the ship. As soon as the diver has entered the diving chamber by the door first mentioned he closes it, and admits the water from without by opening the disc valve in the second door. The water will consequently rush into the diving chamber, expel the air through the valve orifice above, and force it into the air chamber of the ship; and on the diving chamber becoming completely filled with water, the air valve orifice will, owing to the action of the floater, be completely closed. The water pressure within and without being now equalized, the diver opens the second door and is at liberty to step out and commence operations; it being understood that such diving operations can only be undertaken whilst the submarine ship rests at the bottom of the lake or sea. On the diver wishing to re-enter the ship, he has nothing to do but to admit himself through the outer door, and after having closed the same, to shut the disc valve with which it is provided, and to open the valve communicating with the hollow keel, when the water in the diving chamber will immediately discharge itself into the hollow keel, and the air will rush in through the valve orifice at the top. After all the water has thus been discharged, the diver closes the bottom valve, and is then at liberty to open the door communicating with the air chamber within the ship. As the diver cannot under these circumstances be in any way whatever in communication with the ship, it is necessary that he should be provided with the

means of re-inhaling the air he has been breathing in a renewed or purified state, and of ascertaining in what direction he is going. For this purpose the helmet is provided at the back with two short projecting tubes to each of which a flexible pipe is attached, reaching down to and being connected by means of a cock with a cylindrical elastic bag extended by powerful spiral springs to prevent it from collapsing. This bag is tied round the diver's waist, and contains in proper proportions oxygen and hydrated potash, and the vitiated air will pass into this bag through one or other of these tubes, and similarly re-issue into the space between the diver's head and his helmet in a partially purified state, and the diving helmet, is further fitted with a ship's compass, upon which the light is admitted by a bull's-eye in such a position that, on slightly raising his head, the diver can plainly see the position of the needle. In the front of the helmet and considerably below the bull's-eyes, through which the diver is enabled to observe the surrounding objects, I apply a disc valve, which the diver can open himself for the admission of fresh air, as soon as he gets back into the diving chamber, and the water has so far subsided as to leave the head free. The diving dress is caused to adhere about the shoulders by means of a broad and stout band of india-rubber, and the helmet can be hermetically connected with it by drawing another similar band over the first-mentioned one and inserting the shoulder piece of the helmet between the two, the lower edge of the shoulder piece being provided with a border rounded outwards, over which the second strap closes tightly. The necessary ballast is suspended underneath the bag in the shape of metal rings, embracing the diver's body, and supported by the iron strap, which holds down the helmet in the usual manner. It is scarcely necessary to observe that under these circumstances the diver cannot descend to a greater depth than about seventy feet.

SPECIFICATION in pursuance of the conditions of the Letters Patent, filed by the said William Bauer in the Great Seal Patent Office on the 3rd September 1860.

TO ALL TO WHOM THESE PRESENTS SHALL COME, I, WILLIAM BAUER, of Munich, in the Kingdom of Bavaria, Submarine Engineer, send greeting.

WHEREAS Her most Excellent Majesty Queen Victoria, by Her Letters Patent, bearing date the Third day of March, in the year of our Lord One thousand eight hundred and sixty, in the twenty-third year of Her

reign, did, for Herself, Her heirs and successors, give and grant unto me, the said William Bauer, Her special licence that I, the said William Bauer, my executors, administrators, and assigns, or such others as I, the said William Bauer, my executors, administrators, and assigns, should at any time agree with, and no others, from time to time and at all times thereafter during the term therein expressed, should and lawfully might make, use, exercise, and vend, within the United Kingdom of Great Britain and Ireland, the Channel Islands, and Isle of Man, an Invention for "IMPROVEMENTS IN APPARATUS FOR DIVING, AND FOR RAISING AND LOWERING BODIES IN WATER, PARTS OF WHICH IMPROVEMENTS ARE ALSO APPLICABLE TO OTHER USEFUL PURPOSES," upon the condition (amongst others) that I, the said William Bauer, my executors or administrators, by an instrument in writing under my, or their, or one of their hands and seals, should particularly describe and ascertain the nature of the said Invention, and in what manner the same was to be performed, and cause the same to be filed in the Great Seal Patent Office within six calendar months next and immediately after the date of the said Letters Patent.

NOW KNOW YE, that I, the said William Bauer, do hereby declare the nature of my said Invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

The principal object of my improvements is to raise sunken ships from the bottom of rivers, lakes, or the sea; an operation which can be effected from any depth up to 500 feet, owing to the peculiar manner in which the person or persons conducting it are protected from all external influences, and subjected to no more than the ordinary atmospheric pressure, and its complete independence of the motions of the sea at its surface.

My improved apparatus for diving consists in a cylindrical or other conveniently shaped chamber, made of metal plates or cast metal of the requisite strength, to enable it to resist the pressure of a column of water of 500 feet, as well as to secure it from any damage which might arise from accidental collision with other objects. This diving chamber, unlike an ordinary diving bell, is completely inclosed with the exception of an opening at the top, through which the person or persons intending to conduct the operations are admitted, and which is subsequently hermetically closed, the internal space being filled with air of the ordinary atmospheric pressure. The bottom of the chamber is double, and between the two there is a hollow space, which again may be subdivided into two or more portions for the reception of water ballast, variable at pleasure, by means of a force pump actuated from within. In

front of the apparatus, as well as on the sides, underneath, and over head, any convenient number of bull's-eyes, windows, or lights, suitably protected, may be introduced, for the purpose of enabling the conductor to observe surrounding objects, and to guide and steer the apparatus with precision and safety. A screw propeller protected by a casing or box, capable of being worked by hand from within the chamber, admits of the apparatus being moved forward, whilst another similar but smaller screw propeller placed on one side serves the purpose of causing the apparatus to revolve round its vertical axis. Besides these two propellers a rudder is fitted to the apparatus lower down, which is also capable of being actuated from within the chamber, and by which the apparatus can be steered in the ordinary manner. And as in the case of powerful currents having to be encountered, it might be considered necessary or desirable to prevent the apparatus from drifting, an anchor can be lowered by means of a handle and gearing acting upon a chain barrel from within the chamber. In order to enable the conductor or his assistants, in case of emergency, immediately to rise to the surface of the water, a weight or weights suspended from the bottom of the chamber can be suddenly detached from within by merely turning a spindle. This spindle, as well as all the other spindles or shafts which pass from the inside of the chamber outwards, are of course made to pass through suitable stuffing boxes, in order to exclude the water.

The diving chamber is placed in communication with the ship, which, as in all other similar cases, is in constant attendance, by means of an electric or other telegraph. A fresh supply of atmospheric air may be obtained when necessary by means of two pipes or tubes, one of them being in connection with an air pump on board the ship, and the other serving as an outlet to the vitiated air. The opening and closing of these tubes can be regulated at pleasure by cocks within reach of the operator or conductor in the chamber; but I wish it to be particularly understood that the air space within the chamber is intended to be made amply sufficient for several hours' consumption of three persons, and that therefore the admission of fresh air need only take place at such intervals; or, the air may be even for a limited time purified by the admission of oxygen, which is kept in store in a compressed state.

The raising of sunken ships or other objects is effected by means of flexible air bags or balloons, made of strong material impervious to water, say, alternate layers of caoutchouc and canvas, protected against abrasion by friction, and rendered capable of supporting any strain they may be subjected to upon being inflated and attached to the object to be raised by a network of stout cords or ropes, to the lower part of which, and below the neck of the balloon, a strong iron ring is fixed. To this ring a chain is looped, from which is sus-

pended a strong iron lever or arm, or other suitable instrument, the object of which is to be inserted into a port hole, or any other convenient opening in the hull or body of the ship to be raised, in the manner to be hereafter described. The balloon, after having been partially inflated so as to counterbalance to some extent the weight of the chain and arm, lever, or other instrument suspended from it, is lowered from the ship in attendance, with the air supply tube inserted in it; the iron arm (where such is used) is dropped between two strong lugs projecting from the body of the diving chamber, in what may be called the front of the apparatus, and is there secured by a hook, which can be actuated from within the chamber, so as to release the arm at the proper moment.

The apparatus may now be considered as readdy for action, and is first suspended by chains from the ship, but subsequently allowed to descend freely into the water as nearly over the ship or other object to be raised as may be considered desirable. The conductor or operator and his attendants within the chamber have it in their power to regulate the velocity of its descent, as well as its vertical position, by diminishing or increasing the volume of the water ballast by means of the force pump previously referred to, to move the apparatus slowly backwards or forwards by means of the larger screw propeller, to turn it about its axis by means of the smaller screw propeller, and to regulate its motion sideways by means of the rudder to the greatest nicety; the various lights, windows, or bull's eyes, enabling the conductor to observe the surrounding objects in all directions.

The object, in the case of a ship to be raised, being to attach the balloons to some convenient part of the ship, the conductor or operator will, for instance, place the diving apparatus in such a position that the arm or other instrument attached to the end of the balloon, and temporarily connected with the body of the chamber by the means previously mentioned, will assume a vertical position, and stand immediately over a port hole or other suitable opening in the hull of the ship. The conductor will then detach the arm or other instrument by withdrawing the hook which held it, and thus allow it to drop into the opening, when on being left to itself it will place itself across the opening, being made somewhat heavier on one side than on the other. The air pumps are then set to work at a signal given by the conductor through the telegraph, and the balloon is inflated to the requisite extent. And it will be understood that as many balloons as may be considered necessary to effect the desired object are fixed to the ship in a similar manner.

It is evident that as, with a given weight of air contained in it, the volume of the balloon will increase as the superincumbent column of water diminishes

in depth, the inflation of the balloons can be so regulated that the effort to raise the object to which they may happen to be attached will commence with the ebb tide, and be at its maximum at low water. As, however, the neck of the balloon is open, the air will begin to rush out in proportion as the object being raised approaches the surface of the water, and it will thus be prevented from bursting by over pressure.

My improved diving chamber may also be used independently of the balloons for various other purposes, such as examining sea walls or other submarine structures, examining plants or other objects at the bottom of the sea, and for conducting other scientific investigations. For such purposes the construction of the apparatus may be suitably modified, and it may be fitted with various instruments or utensils in the shape of shovels, spoons, tongs, or otherwise, to be actuated from within, for the purpose of digging up plants, or taking hold of or grasping any objects which the operator may wish to raise to the surface of the water. Besides that my improved diving bell or chamber admits of operations being conducted at the great depth mentioned, all the time that the operator or conductor and his assistants are exposed and live in no other than the ordinary pressure of air, my method of raising sunken vessels and other objects presents the further and very great advantage of not being in the least affected or influenced by the motion of the sea at the surface.

Instead of making use of an independent diving chamber, as above described, I also propose to cause the diving chamber to form a portion of a submarine ship, such as that described in my Patent dated 25th of May 1853, No. 1281. In this case I form a recess in the ship's side, which shall be large and high enough conveniently to admit a diver armed with a helmet and diving dress. I furnish the partition which separates this recess from the air-chamber within the ship with a door opening outwards, and the second partition, which is in contact with the surrounding water, with another door, also opening outwardly, and fitted with a disc valve. The chamber inclosed by these two partitions is in communication with the air chamber of the ship by means of a valve orifice, capable of being closed from below by means of a valve attached to a floater, whilst the floor of the chamber is provided with a disc valve, by means of which a communication can be established with the hollow keel of the ship. As soon as the diver has entered the diving chamber by the door first mentioned, he closes it, and admits the water from without by opening the disc valve in the second door. The water will consequently rush into the diving chamber, expel the air through the valve orifice above,

and force it into the air chamber of the ship; and on the diving chamber becoming completely filled with water, the air-valve orifice will, owing to the action of the floater, be completely closed. The water pressure within and without being now equalized, the diver opens the second door, and is now at liberty to step down into the bottom of the sea, and to commence operations, it being understood that such diving operations are only undertaken whilst the ship rests on the bottom of the sea.

On the diver wishing to re-enter the ship, he has nothing to do but to admit himself through the outer door, and, after having closed the same, to shut the disc valve with which it is provided, and to open the valve communicating with the hollow keel, when the water in the diving chamber will immediately discharge itself into the hollow keel, and the air will rush in through the now open valve orifice at the top. After all the water has thus been discharged, the diver closes the bottom valve, and is then at liberty to open the door communicating with the air chamber within the ship. As the diver cannot, under these circumstances, be in any way whatever in communication with the ship, it is necessary that he should be provided with the means of re-inhaling the air he has been breathing in a renewed or purified state, and of ascertaining in what direction he is going. For this purpose the helmet is provided at the back with two short projecting tubes, to which flexible pipes can be attached, reaching down to and being connected with a cylindrical elastic bag, extended by means of powerful spiral springs to prevent it from collapsing, and which bag is tied round the diver's waist, and contains, in proper proportions, oxygen and hydrated potash. The vitiated air will therefore pass into this bag through either the one or the other of the tubes and pipes above mentioned, and reissue in a partially purified state; and the diving helmet is further fitted with a ship's compass, upon which the light is admitted by a window or bull's-eye, in such a position that, on slightly raising his head, the diver can plainly see the position of the needle. In front, and considerably below the light window or bull's-eye, through which the diver is enabled to observe the surrounding objects, the helmet is fitted with a disc valve, which he can open himself, for the admission of fresh air as soon as he gets back into the diving chamber, and the water has so far subsided as to leave the head free. The diving helmet is hermetically connected with the upper part of the dress by a broad and stout band of india-rubber or caoutchouc, which embraces the shoulder piece of the helmet, and is overlapped by another similar band of caoutchouc attached to the dress. The necessary ballast is suspended about the diver's waist underneath the bag in the shape of metal rings, and the helmet and dress are further connected with

each other by an iron strap in the usual manner. It is scarcely necessary to observe that, under such circumstances, the diver cannot descend to a greater depth than about 70 feet.

In order that my said Invention may be more clearly understood and readily carried into effect, I will now proceed to describe the same, reference being had to the annexed Sheets of Drawings, and to the letters and figures marked thereon.

In Sheet 1, Fig. 1 is a side view; Fig. 2, a vertical section; Fig. 3, a horizontal section; and Fig. 4, an end view of one of my improved diving chambers, which I employ for the purpose of raising sunken vessels as well as for carrying on various other operations under the surface of the water.

The shell or body A of the chamber (see Figs. 2 and 3) is here represented of a cylindrical form, and constructed upon the cellular system in three parts. It may, however, be made of any other convenient shape or form, either of brass, cast-iron, or any other suitable metal, capable of resisting the pressure to which it is subjected when immersed to the depth at which operations are to be carried on.

In my Provisional Specification I have described the double floor or bottom of the apparatus to be concave in both directions, with spaces between the two for the reception of the water ballast and for a lamp (as in Fig. 9). I prefer, however, as shown in Sheet 1 of Drawings to make the bottoms convex, with the intervening spaces likewise for the water ballast; and instead of placing the removeable ballast weights in the cavity of the concave bottom, I adjust them externally to the lower convex bottom. The reflector lamp, instead of being stationary, may be a moveable one, so that it can be placed in whatever position it may be most wanted. The screw propeller *a*, which is protected against injury from without by the casing *b*, is intended to move the apparatus forward, and is worked from within by means of the crank handle a^1, which is attached to the spindle or shaft a^2. Another screw propeller *c* (see Fig. 4) serves the purpose of causing the diving chamber to revolve about its vertical axis when required, whilst by means of the rudder *d* (see Figs. 2 and 4), its motion can be directed to the right or to the left at pleasure. In cases where, owing to the prevalence of currents or other causes, it should be considered necessary to moor the apparatus, this can be done by means of an anchor *e* (see Figs. 1 and 4), by letting the same down by means of the chain *f* from which it is suspended, and which is wound upon the chain barrel *g*, to which motion is likewise given from within by means of the worm wheel *h*, and corresponding screw. The propeller *c* and the chain barrel *g* are respectively surrounded by the casings *i* and *k*,

for their protection from injury. Various and numerous lights, bull's-eyes, or windows *l*, inserted in the body or shell of the chamber and suitably protected, admit of the operator or conductor within observing any objects over head, underneath, in front, or behind, and steering or directing the apparatus accordingly. On the top of the chamber I erect a gallery consisting of a platform *m* fixed to the shell A by means of standards *n*, and of the hinged rails *o*, which being furnished with short arms o^1, taking into curved grooves in the plate *p*, can be placed in an upright position, as shown in Fig. 4, by turning the plate *p* round; the heads of the rails *o* being connected together by a rope o^2. Fig. 1 shows the rails *o* as being folded down with their heads towards the centre, in which position they are placed when not otherwise required. From the platform *m* a man-hole A^1 (see Fig. 2) admits the person or persons who are to conduct the operations into the interior of the diving chamber. Should it at any time be found necessary to let the diving chamber rise rapidly to the surface of the water, the weights *q* can be detached from it by simply turning the handles *r*, so as to cause the hooks r^1 to let go their hold. The space ⊕, ⊕, between the two bottoms is intended for the reception of water ballast, the volume of which can be varied by injecting or ejecting the water at pleasure by means of force pumps.

When my improved diving chamber is to be employed for the purpose of raising sunken vessels from the bottom of the sea or other waters, the lugs *s*, which are fixed externally to the shell A of the chamber, are used as a means of temporarily attaching the arm *t*, and the air bag or balloon B, (which is made of strong materials impervious to water, say, of alternate layers of caoutchouc and canvas, and surrounded by a network of stout cords or rope, so as to protect it against abrasion by friction, and rendering it capable of supporting any strain it may be subjected to,) suspended from it by the hook *u*. The hook *u* is of one piece with the spindle u^1, which latter can be moved from within the diving chamber by means of the handle u^2, and after the slot in the arm *t* has been brought opposite to the slot × between the lugs *s*, the hook *u* is moved forward by the conductor, so as to pass through the two slots, and thus to hold the arm *t* fast. When this is accomplished, the conductor has but to cause the apparatus to descend to the ship to be raised, and to insert the arm *t* into any convenient opening in the wreck, in the manner which will be hereafter described in reference to Sheet 2. For the purpose of admitting of the balloons being inflated to the required extent after they have been attached to the sunken ship or wreck, in cases where the air or gas hose or pipe *c* (which is in connection with the pump on board the ship in attendance), is to be inserted into the balloon from below, the

pipe C is fitted with a lug C^1 (see Fig. 1), which being furnished with a slot *, can be inserted between the lugs *s*, and thus temporarily connected with the diving chamber similarly to the arm *t*. The pipe or hose C can thus be conducted from one balloon to the other for the purpose of inflating each to the required extent. A battery *v*, with proper telegraphic signalling apparatus, is placed within easy reach of the conductor, and a wire D reaches up to the attending ship, so as to enable him to give the necessary directions as to the working of the pumps, or other matters connected with the operation.

It is evident that balloons of this kind could be applied with great advantage for the purpose of letting down into the water, and placing in their positions large stones or other heavy materials to be used in the erection of submarine structures, by causing them to carry the load and to keep the same in suspension. In this case the diving chamber would serve to guide the stones or other materials, and the conductor would be able, making due allowance for friction and for currents, to place them according to plan. The communication with the shore, or with the ship in attendance, as the case may be, would be kept up either by telegraph or in some other convenient manner, and the means of opening the valve B^2 of the balloon would have to be placed within reach of the conductor, so as to enable him to lower the stone or other material into its proper position at the right time, by allowing any desirable volume of air to escape from the balloon.

In Sheet 2, Fig. 1 represents a sunken vessel or wreck which is to be raised, and to which the balloons B have been or are being attached by means of my improved diving chamber, as described with reference to Sheet 1 of Drawings, Figs. 1 to 4; Fig. 2 shows a steamer in attendance, in which the diving chamber balloons and other objects required for the operation are supposed to have been conveyed to the spot, and which contains the air pumps by means whereof the balloons are inflated according to directions received from the conductor in the diving chamber by telegraphic communication.

After the diving chamber Fig. *a*, has been furnished with an arm *t*, (or other convenient instrument), it is lowered into the water from the ship in attendance, the conductor within lowering, propelling, and directing the same, by means of the appliances described in reference to Sheet 1, Figs. 1 to 4, down to any convenient part of the wreck, and selecting the openings wherein the arm *t*, (shown in Sheet 1, Fig. 1,) to which an air bag or balloon B, is attached by ropes, links, or chains, can be safely inserted. The weight of the arm *t* is counterbalanced by the partial inflation of the balloon from the air pumps in the ship (Fig. 2) through the pipe or hose C, which pipe or hose may be inserted into the balloon either from above or from below, (see Sheet 1,

Fig. 1.) The conductor in the diving chamber determines the degree of inflation of the balloon by directing the operations of the persons who work the air force pumps on board the attendant ship, through the telegraph, being in a position to ascertain the increase of pressure of water, and the velocity of the descent, from the indications of a manometer placed near him. After the conductor has placed the arm *t* immediately over a port hole or other convenient opening in the sunken ship or wreck, he releases it by turning the handle u^2, (see Sheet 1, Fig. 1,) and thus allows it to drop into the said opening, where, owing to its peculiar shape, it will assume a horizontal position, and thus connect the balloon with the wreck. The balloon is then filled with air or gas to the extent consistent with the strength of the portion of the wreck to which it is attached, and the pipe or hose (in cases where it is inserted into the balloon from below) is subsequently withdrawn from it. The same operation is repeated in the case of as many balloons as it may be considered necessary to fix to the sunken ship in order to effect its raising. The requisite number of balloons, which may be of different sizes, having been attached to the wreck, as shewn in Fig. 1, and the same having been inflated in the manner previously described so as nearly to float it, the next ebb tide, by reducing the height of the superincumbent column of water, will cause the balloons to expand to their utmost extent, and they will now therefore raise the wreck with a nearly uniform velocity to the surface of the water. Arrived in that position, the lighter portion of the raised ship will project beyond the surface, a circumstance which will admit of some spare balloons being placed underneath, whilst those balloons which are uppermost are gradually detached or placed lower down, until the wreck has finally passed from the position indicated in Fig. 1^a to that shewn in Fig. 1^b. The water with which the ship has been filled, owing to its immersion, will now either discharge itself, or if not, it can be pumped out, and the wreck is disposed of in any convenient manner.

Fig. 3 shows in its empty state, and Fig. 4 in a state of inflation, a balloon with a pair of hooks B^1 suspended from it, whilst Fig. *b* represents such a balloon in the act of being drawn down to the wreck by a rope passed round the funnel, and with the pipe or hose C attached to it. In cases where this pipe or hose is inserted into the balloon from above, it passes through an aperture in the top of the balloon, which, on its removal, is closed by the valve B^2. The pipe or hose can, however, be introduced into the balloon from below, as represented in Sheet 1, Fig. 1; and as in either case the balloon is open underneath at the throat, and the compressed air or gas can therefore escape freely during the progressive rise of the wreck, and the

consequent undue internal expansion, any explosion of the balloon is thus avoided. For greater convenience & security the valve B^2 may also be made self-regulative. The hooks B^1 may be usefully applied in many cases where the arm *t* (Fig. 1, Sheet 1,) is not conveniently applicable; and if the vessel to be raised should happen to present no suitable openings for the insertion of such instruments, the balloons can be attached to the sides or projections, or even under the keel, should either the bow or the stern of the ship be sufficiently elevated to admit of the latter operation.

When, amongst the various other purposes to which my system of diving apparatus can be applied, I intend to avail myself of it in order to take up from the bottom of the sea, and examine or repair telegraphic cables, I construct the bottom of the chamber with a recess *w* (see Sheet 1, Figs. 1 and 2). After having placed this recess exactly over the spot where the cable to be operated upon is lying, and between the jaws x^1 of the forks or tongs *x*, a pair of which tongs projects downwards on each side of the diving chamber, being hinged to the end of the spindle *y*, the conductor or his assistants in the chamber turns the handle *z* (see Fig. 2), which, by means of the bevil wheels z^1 and 1, sets in motion the spindle 2. As the screwed end 2^a of this spindle takes into the screw socket 3^a of the arm 3, a pin fixed in which takes into the slots of the tong levers x^2, the tongs close round the cable, and thus hold it in suspension. The conductor then, by means of the handle 4, worm 5, and worm wheel segment 6, lets down the lid 7 (which internally forms a trough) into the position in which it is represented in dotted lines in Fig. 2, which being accomplished he lifts up the cable by means of the screw spindle *y*, which he causes to rise by turning the handle 8 within the chamber, and thereby giving motion to the nut 9, into which the screw spindle *y* takes through the bevil wheels 8^a & 9^a, the spindle 2, which is fitted with a groove and feather, serving as a guide. As soon as the cable, guided by the springs 10^a, has arrived at the height of the stuffing box, marked 10, the lid 7 is replaced in its forma position (as shown in Fig. 2) by turning the handle 4 in the opposite direction. The cable is thus placed in a position in which it can be examined from within by the removal of the lid 11 (see Fig. 3); but before removing this lid the conductor has to open the tap 12, which is screwed into a socket in the top of lid 11, so as to admit of the escape of that small film of water which is contained between the lid 7 and its seating, as well as for the purpose of ascertaining whether there is any leakage. If no material leakage is discoverable, the lid 11 is taken off, and the water removed out of the trough 7, so as to facilitate operations. After the cable has been thoroughly exan ined and repaired, if required, the lid 11

is once more screwed down, the lid 7 opened, the forks or tongs *x* are replaced in their former position, and the cable released from their grip.

Fig. 5 represents in front elevation, partly in section, and Fig. 6 in side elevation, partly in section, an apparatus similar to the one above described, but in which I make use, for the purposes of locomotion, of a pair of peculiarly constructed paddle wheels, dispensing with the screw propeller, steering screw, anchor, and rudder. This apparatus is equally well adapted for propulsion at the bottom of the sea as in a floating position; but although it might be used for the purpose of raising sunken vessels in cases where the wreck is unencumbered by rigging, it is more especially suited for pearl and coral fishing, for the gathering of sponges, the cutting of seaweeds, the erection and examination of structures under the surface of the water, and scientific investigations. I shall, however, confine myself to the description of the wheels, and of a contrivance which I consider most suitable for use in pearl fishing.

The paddle wheels E consist of two rims *a*, which are connected together by the cross-pieces *b*, the latter serving at the same time as sockets to the outer pivots of the blades *c*, of which there are eight in each wheel, the corresponding inner pivots being supported by the nave *d*. Each blade is fitted near its inner pivot with a crank c^1, the pin c^2 of which takes into the curved groove 1 in the bush *e*, (see Figures 5, 5^a, and 7,) at the same time that it is guided in the nave *d* by the circular grooves 2 (see Figures 5, 5^b, and 7).

The curve of the groove 1 is such that during two-thirds of each revolution of the wheel the blades merely present their cutting edges to the water, whilst during the remaining one-third of each revolution they gradually begin to act upon the water with their surfaces, each blade presenting its full surface when at its lowest point. The bush *e* being moveable on the spindle *f* (see Figure 7), on which the nave *d* is keyed, or to which it is otherwise attached, it can be placed in such a position on the said spindle by means of the pinion e^1 and toothed flange e^2 as to cause the blades *c* to assume their respective positions of acting surface and cutting edge at any desirable part of the circumference, so as to propel the diving chamber either forward or backward, or to cause it to rise or to descend. The paddle wheels are set in motion from within by the ratchet levers *g* & the ratchet wheels g^1 (see Figures 5 and 7), which may, if required, be connected with each other in any convenient manner.

The instrument which I propose to employ in fishing for pearls consists of a scoop *h*, with lid *h*, the former being hinged to the rod *i*, and the latter to the

screw spindle k. After the diving chamber has been placed on or over a bed of pearl shells, as many as the scoop will hold are grasped by the scoop h; the rod i is then caused to descend in the nut l^1 of the rod l, which is fitted with a groove and feather by giving motion to the bevil wheels m and l^2, and after the two halves of the scoop have met, or as nearly so as may be necessary, the whole scoop is raised by the rotation of the bevil wheel k^1, through the instrumentality of the handle n and bevil wheel n^1, to a sufficient height to admit of the contents of the scoop being discharged into the trough o in the position in which it is drawn in dotted lines in Figure 6. It will be seen, on reference to Figure 6, that the projection o^1 of the trough o forms a portion of a nut, into which the screw p takes, which latter is moveable from within the chamber by means of the handle p^1. Now, whilst the trough o is in the position in which it is represented in dotted lines, the slide q is, by the superincumbent column of water, tightly pressed against its bearing surface, and prevents any water from entering the chamber through the aperture ×, ×, (see also Figure 7;) but so soon as the trough o is drawn back with its charge into the position shown in sharp lines, it releases the slide q, which is therefore at liberty to be moved sideways, so that the contents of the trough o can be easily got at through the apertures ×, ×, and deposited within the diving chamber. In order to collect a fresh charge of shells, the scoop h, h^1, is lowered by reversing the motion of the screw k and rods l^1 and i; and the process before described can be repeated as often as may be considered necessary or desirable.

The bell r (Figure 6) serves at the same time as a platform from whence an entrance can be effected into the diving chamber in the place of the platform and galleries shown in Figures 1, 2, 4, and 5. But the principal object of it is to serve as an air chamber in case it should become necessary to cause the diving apparatus to rise rapidly to the surface. For this purpose the conductor admits into it, by opening a cock from a reservoir or reservoirs, which may be placed in the chambers F (shown in section in Figure 8), a volume of highly compressed air or oxygen, which, by displacing the water, will produce the desired effect. In order, however, to guard against too great a velocity, the bell r is left open underneath, so that the velocity of ascension may at all times be in proportion to the volume of the bell, without being affected by the pressure of the column of water.

In Sheet 3, Figures 1 and 2 represent in elevation, the former partly, and the latter altogether in section, and Figures 3 and 4 in horizontal section, another modification of my improved diving chamber. In this case I propose to apply it as a telegraph station at sea, and collaterally also as a light ship.

The body of the apparatus is elliptical in vertical section, and moored to the bottom of the sea by three anchors, the chains or cables attached to which unite in one chain or cable *a*, which passes over the guide pulleys *b* and *c* (see Figure 2), and from thence upon the chain barrel *d*, of which *e* is the spindle. To the chain barrel *d* is cast the spur wheel *f*, which serves at the same time as one of the flanges, d^1 being the other flange; and into this wheel *f* gears the pinion *g* (see Figure 1), by means of which the chain or cable *a* can be wound up or unwound at pleasure through the instrumentality of the spindle g^1, and a handle from within the chamber. Upon the chamber A a tower B is erected; it is steadied by the stay rods B^1, and reaches as far as the floor or horizontal partition A^1 (see Figure 2), and it is fitted internally with spiral stairs B^2, and terminates in a gallery B^3 at the top. The projecting part of the tower B is besides surrounded by a gallery A^2, to which a ladder B^4 leads from the gallery B^3 (see Figure 1). The object of the tower B is chiefly to admit of a comparatively small volume of water ballast, being sufficient to immerse the structure, or to cause it to rise on forcing the water ballast out with a force pump. It is necessary that structures of this kind should preserve a certain tendency to rise, but this tendency can be checked to any required degree by winding a more or less considerable portion of the cable *a* upon its barrel, the slipping of the cable being prevented by the application of the break c^2. The water constituting the ballast is admitted through the pipe *h* (see Figure 2) into the cistern A^5 from without, and this admission can be regulated or stopped by means of the valve and valve rod *i*, whilst the discharge of the water can be effected by means of suitable force pumps. The upper compartments A^3 are intended for the accommodation of the persons in attendance, whilst the lower compartments A^4 are reserved for store-rooms of various kinds, kitchens, &c. The light is admitted from above by means of windows or bull's-eyes 1, or the various compartments may be lighted up by means of artificial light. The entrance is effected from the gallery A^2 by means of the ladder B^4 to the top of the tower, and from thence downwards by the stairs B^2 and the door B^5 (Figure 1).

During calm weather the chamber is made to float on or near the surface of the water, as shown in Figure 2, whilst when the sea goes high it is immersed as represented in Figure 1, deep enough to be out of the reach of the waves, so as to avoid exposing the cables to unnecessary strain, and the risk of dragging or breaking loose from the anchors. Previously to effecting this immersion, however, the valve B^6, at the top of the tower, and the orifice of which forms at the same time the entrance to the tower, is closed and screwed down so as to prevent any water from getting in. The screw *k*, which can be

set in motion from within (see Figures 2 and 3), serves in this case merely as a steering apparatus, by means of which the person on the watch has it in his power under the guidance of a ship's compass to prevent adverse winds or currents from twisting the cables. The ballast boxes A^6 (of which there are supposed to be 4, see Figure 4,) can be detached in case of necessity by means of the rods and hooks *l*, in a similar manner to that already described with reference to Sheet 1, Figures 1 and 2. The medium for respiration may either consist of atmospheric air at the ordinary pressure, if the chamber is large enough to contain a supply of a few days for the persons inhabiting it, or it may be produced artificially, or obtained from time to time by the use of pipes and floaters similar to those to which I have referred in the Provisional Specification of my Patent No. 1281, of 1853.

It has been already observed that diving chambers of this description could at the same time be made available as light ships, as during calm weather the flame might be displayed as usual from the top of the tower, whilst when the sea goes high, and during the consequent immersion of the structure, a small balloon carrying an electric light might be substituted. A balloon of this kind is represented in Figure 5, and might be either anchored independently, or be connected with the principal structure itself.

The electric light might either be produced in the balloon, Fig. 5, itself, by the means and appliances already known, or such a light might be maintained by electric communication with the batteries and machinery within the principal structure.

As the ends of the telegraphic cables which enter the sides of the chamber A through flexible stuffing boxes *m* (see Figure 1,) may in many cases have to be carried up from great depths to these floating stations, I propose to surround them under the outer spiral covering with a layer of wires placed longitudinally, so as to render them capable of resisting the strain upon them; and in order still further to secure them against being strained, broken, or damaged, I propose to suspend the same, at suitable distances, from small balloons (see Figure 1^a), so as to relieve them of a portion of their weight and to moderate the range of their vibrations.

By such means telegraphic cables could be supported even at considerable distances, and safely suspended over coral banks, rocks, or other unfavorable submarine formations or bodies. In such cases it would, however, be necessary to anchor the balloons separately, and prevent them by some means from dragging or rising. The shape of the structure is, of course, not essential for the carrying out of the principal of my Invention; and in the case under consideration I have been guided in my choice simply by the fact of an elliptical

body presenting a comparatively small hold to the winds and waves besides possessing great stability.

It is evident that apparatus of this description could be easily adapted for the examination and repairing of telegraphic cables, by introducing into them mechanism similar to that described in reference to Sheet 1 of Drawings, Figures 1, 2, and 3.

In Sheet 4, Figure 1 represents in side view, Figure 2 in front view, and Figure 3 partly from behind, a diver, fitted out with my improved diving helmet and chemical air renovating apparatus, whilst Figure 4 is a front elevation, partly in section, Figure 5 a side elevation, partly in section, and Figure 6 a view from above, partly in section, of a diving chamber attached to a submarine apparatus similar to that described in the Provisional Specification of my Patent No. 1281, of 1853. The diving helmet A (see Figures 1 and 2) is provided, within the casing which holds the upper light, with a ship's compass A^1, by which the diver, on raising his eyes, can at once ascertain in what direction he is proceeding. At the back the helmet is fitted with two flexible pipes or tubes B and B^1 (Figures 1 and 3), which latter are connected through the taps B^a and B^b, with a reservior C, consisting of caoutchouc and sailcloth, and extended by means of strong spiral springs, and which is attached to the waist of the diver by a strong belt, with hook and eye or clasp. This reservoir is supplied with a preparation of oxygen and hydrated potash, in passing and repassing through which the air which the diver has to breathe, and of which a small space left in front of the helmet is the only reservoir, is to some extent renovated and made available for respiration. The helmet A is made to close hermetically over the body of the diver's dress by means of flanges of caoutchouc A^3, and it is held in its position and firmly connected with the lower part of the dress by the iron strap A^4, in the usual manner. A valve A^5 (Figures 1 and 2) enables the diver, by opening it so soon as he raises his head out of the water, to immediately inhale fresh atmospheric air, and, in order that, in cases of urgent necessity, the diver may have it in his power to rise immediately to the surface, the body of the dress under the reservoir C is fitted with a number of rings or hoops of metal D, which he can at once throw off.

In order to make his way from the submarine ship to the open sea without danger or difficulty, the diver, in the first place, opens the door *a*, (see Figures 5 and 6), which after having stepped into the chamber E, he again closes. He then opens the disc valve *b*, and thus admits the water from without, which will continue to pour in until the floater *c* will have closed the valve *d* in the top of the chamber, after having dislodged the air from it, and

sent it back into the air chamber of the submarine ship. The pressure within and without being thus equalized, the diver proceeds to open the door *e*, by releasing the levers e^1 from their staples e^2, and having done so, he steps down to the bottom of the sea, where he is at liberty to move about, and conduct his operations independently of any communication with the ship. In order to get back into the ship, after having first stepped into the chamber E, he closes the door *e* after him, shuts the valve *b*, and opens the foot valve *f* by turning the handle f^1 on the spindle f^2, which admits the water into a reservoir in the keel of the ship. The air valve *d* will immediately descend from its seating, and admit the air from the air chamber within the ship; and after the whole of the water has been discharged from the chamber E, and the door *e* is therefore once more under the influence of the water pressure from without, the diver re-opens the door *a*, which at once admits him into the ship.

Having now described the nature of my Invention of "Improvements in Apparatus for Diving, and for Raising and Lowering Bodies in Water, Parts of which Improvements are also applicable to other useful Purposes," I wish it to be understood that, without confining myself to the precise arrangement of parts herein-before described, with reference to the annexed Sheets of Drawings, I claim as the Invention intended to be secured to me by the above in part recited Letters Patent,—

Firstly, with reference to Sheet 1 of Drawings, Figs. 1. 2, 3, & 4, the combination of mechanism, by means of which the diving bell can be propelled forward, caused to turn about its vertical axis, steered, and, if required, anchored.

Secondly, the combination of mechanism for grasping, raising, and lowering the telegraphic cable to be examined or repaired; the moveable lid and trough into which the cable is received, and which excludes the admission of water; and the cover or lid, by the removal of which free admission is obtained to the cable within the diving chamber.

Thirdly, with reference to Sheet 1 of Drawings, Figs. 5, 6, & 7, the application and use of wheels, fitted with blades, floats, or paddles, moveable about their longitudinal axes, and with the peculiar mechanism for causing the blades, floats, or paddles to change their position at any required point of the circumference.

Fourthly, the combination of mechanism for raising and lowering the scoop by which the shells, spunges, corals, or other objects are taken hold of and secured; the application and use of the sliding trough into which the objects are discharged in combination with the upper slide, which admits of the objects contained in the trough being reached from within the chamber, whilst preserving at all times a water-tight joint.

Fifthly, with reference to Sheet 1 of Drawings, Fig. 1, and to Sheet 2 of Drawings, the application and use of the independent diving chamber for the purpose of attaching to sunken vessels or other objects to be raised to the surface of the water, or to objects required to be placed in particular positions under the water, air bags or balloons, in which the degree of expansion after inflation adjusts itself according to the variation in the height of the superincumbent column of water.

Sixthly, with regard to Sheet 3 of Drawings, the applying my improved system of diving chambers as floating and immersable telegraph stations.

Seventhly, the peculiar arrangement of mechanism connected with the anchors and cables, whereby the cable is at the same time made to serve as variable ballast.

Eighthly, the application and use of the screw propeller for the purpose of keeping the telegraphic station at all times in its proper position, thereby preserving the telegraphic cables from injury by torsion.

In witness whereof, I, the said William Bauer, have hereunto set my hand and seal, the Third day of September, in the year of our Lord One thousand eight hundred and sixty.

(L.S.) WILLIAM BAUER.

LONDON:
Printed by GEORGE EDWARD EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty. 1860.

A.D. 1860. Mar. 3. Nº 590.
BAUER'S Specification.

(4 Sheets.)
Sheet 1.

FIG. 1.

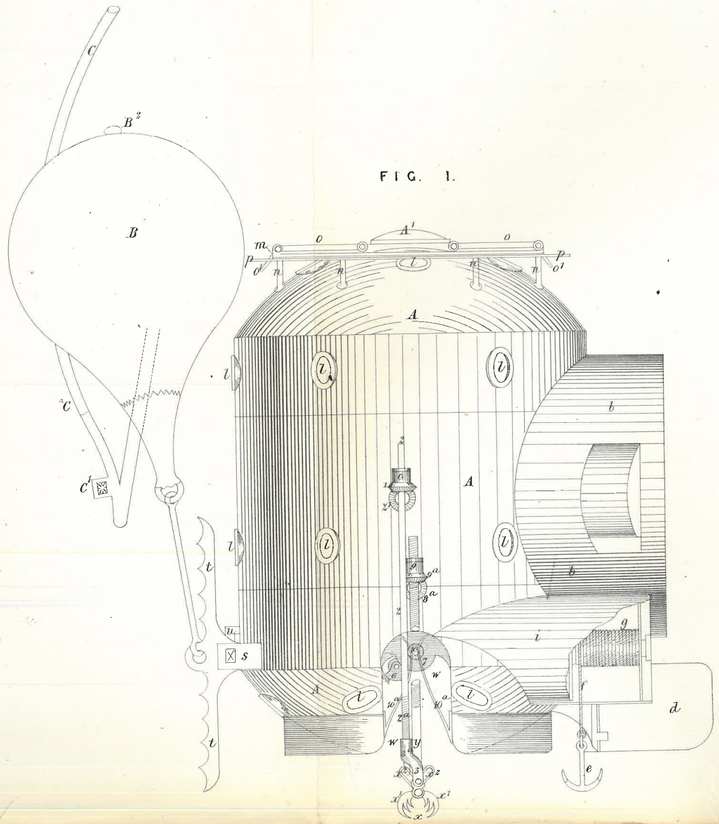


FIG. 2.

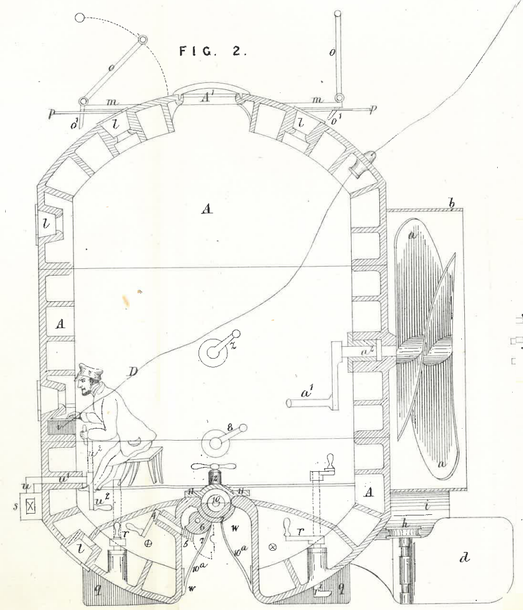


FIG. 3.

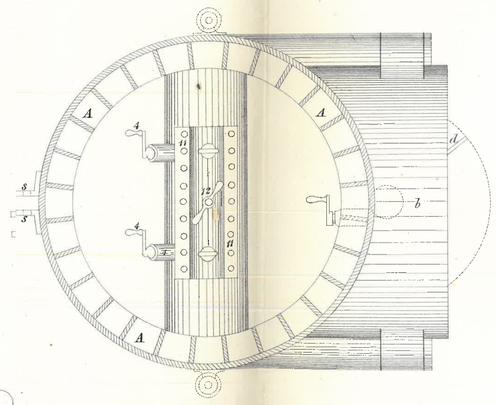


FIG. 4.

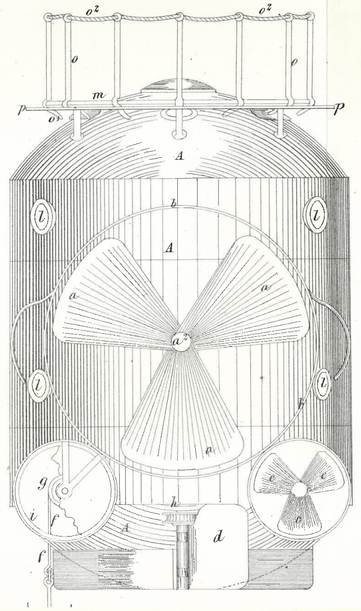


FIG. 5.

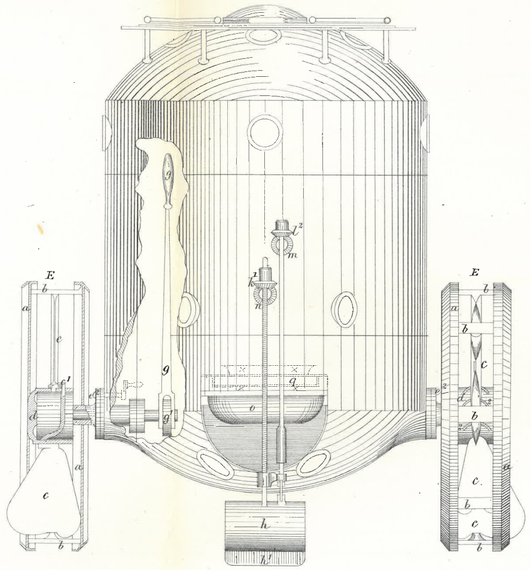
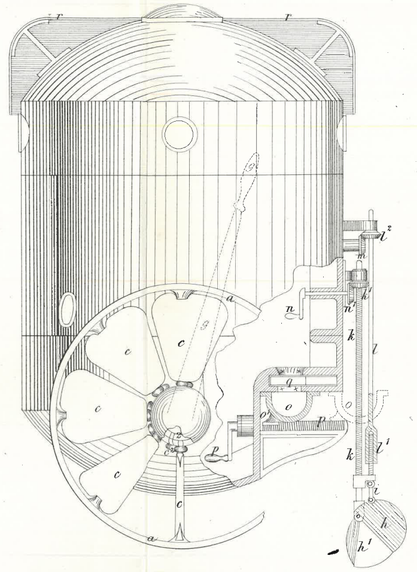


FIG. 5a

FIG. 5b

FIG. 6.



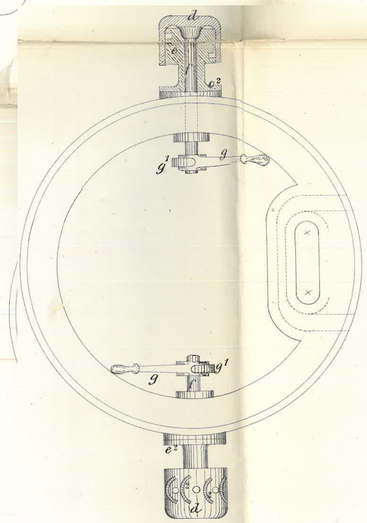


FIG. 8.

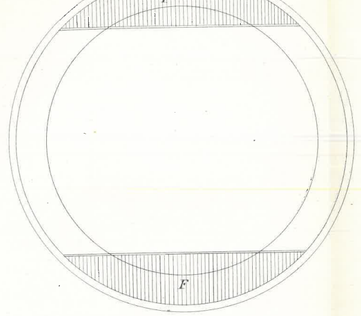
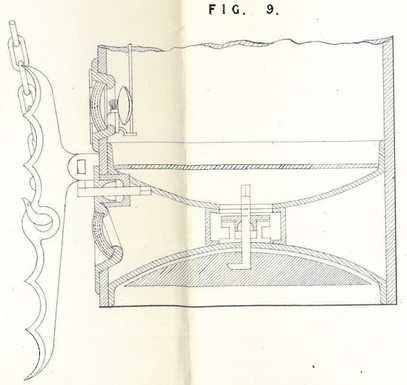


FIG. 9.



The filed drawing is not colored

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BAUER'S Specification.

(4 SHEETS)
SHEET 4

FIG. 1.

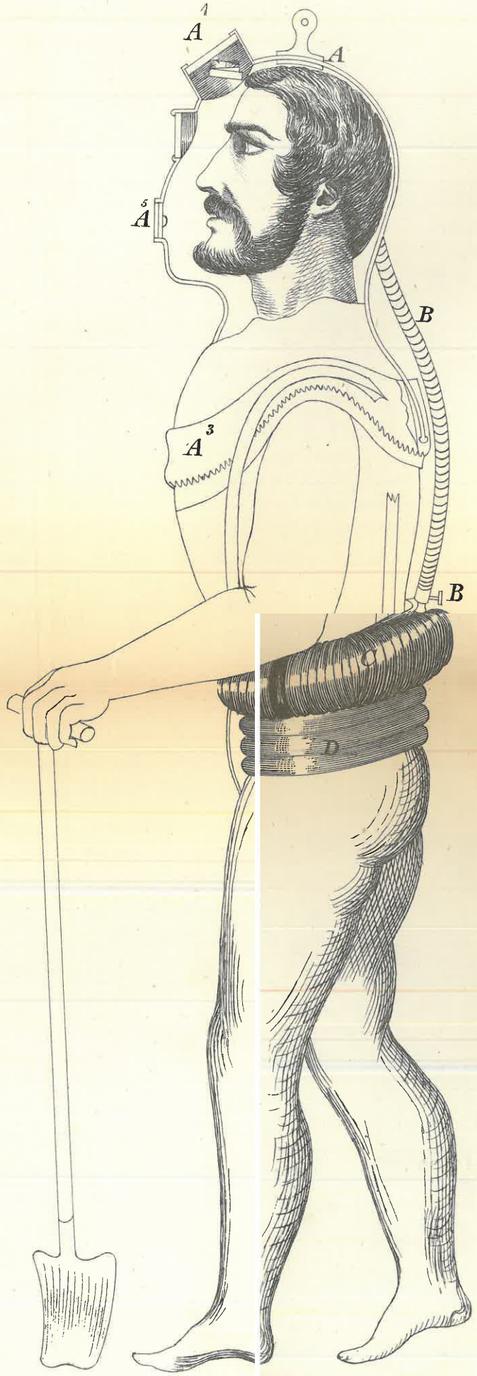


FIG. 4.

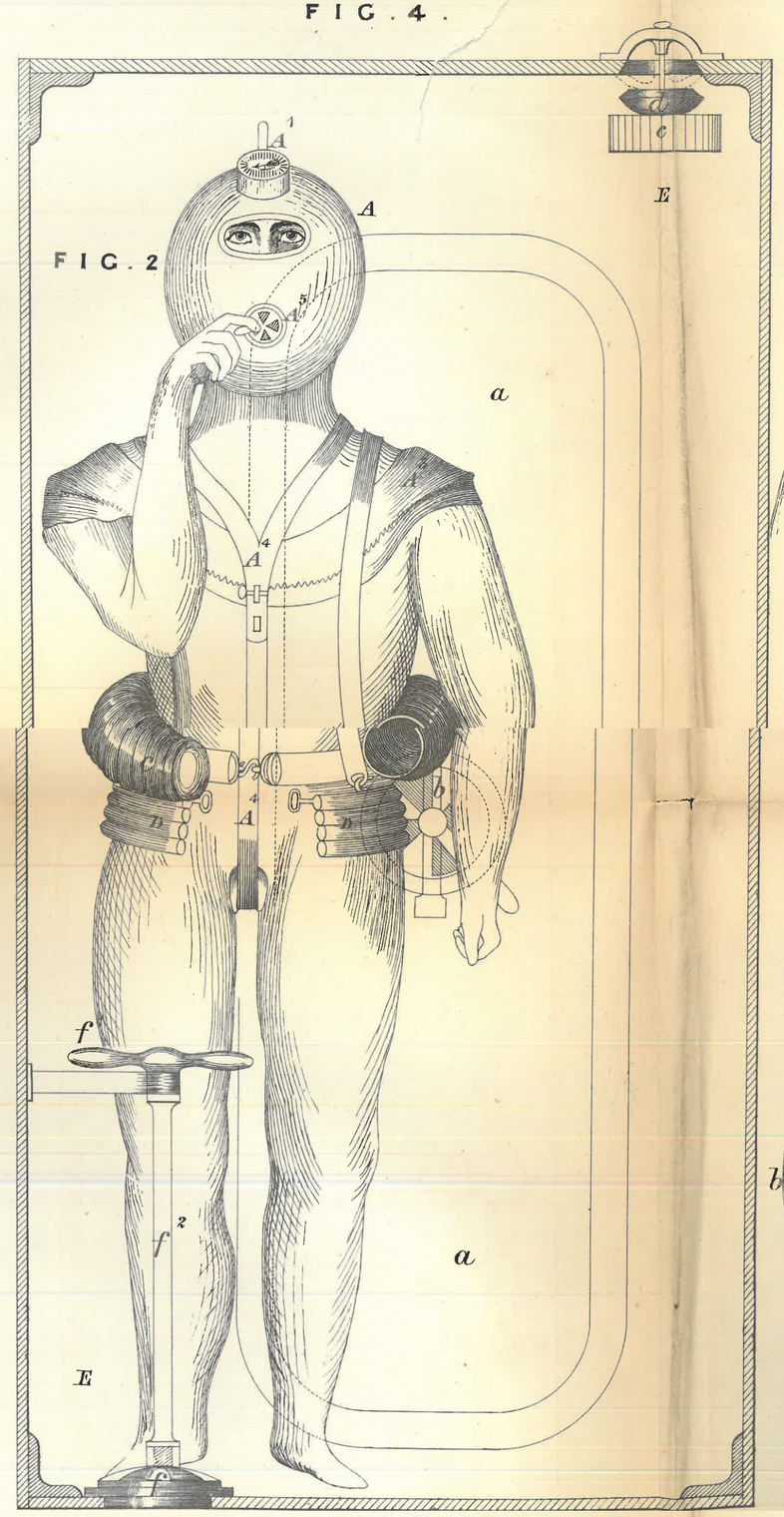


FIG. 3.

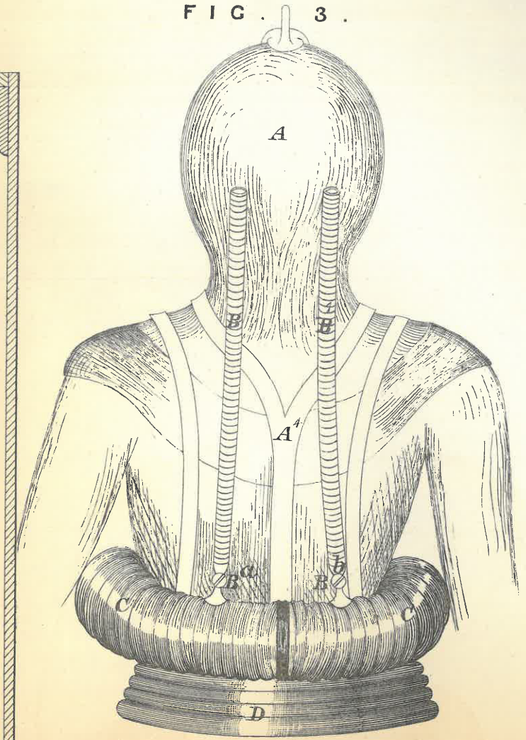
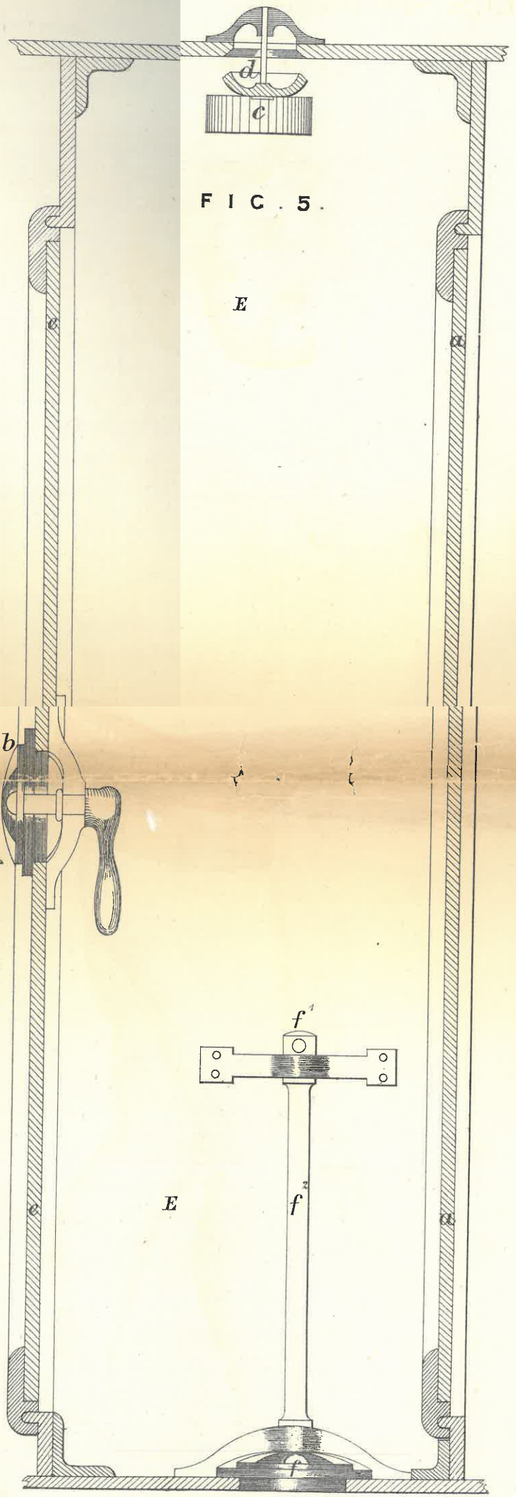


FIG. 5.



The filed drawing is not colored.

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FIG. 1b.

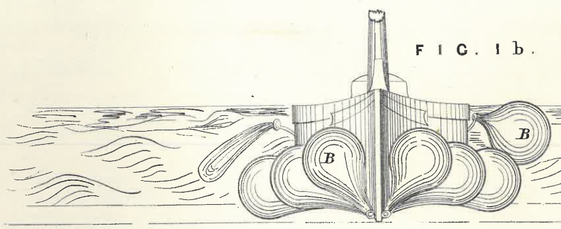

FIG. 1a.

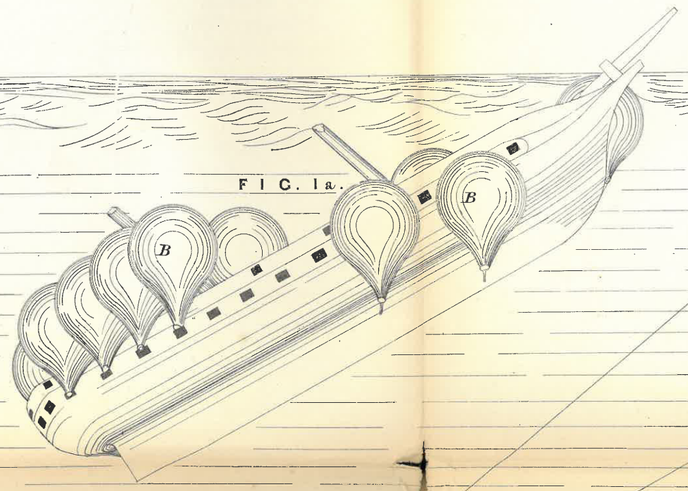

FIG. 2.

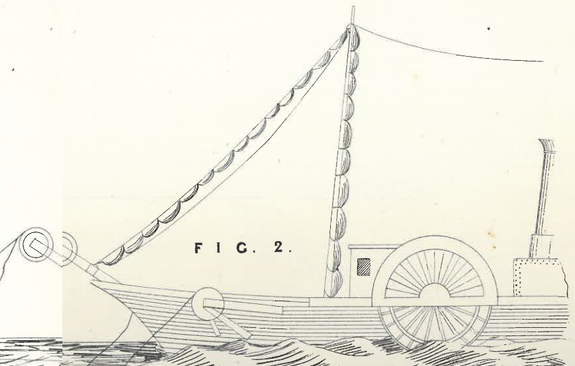

FIG. 3.

FIG. b.

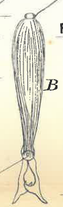

FIG. 4.

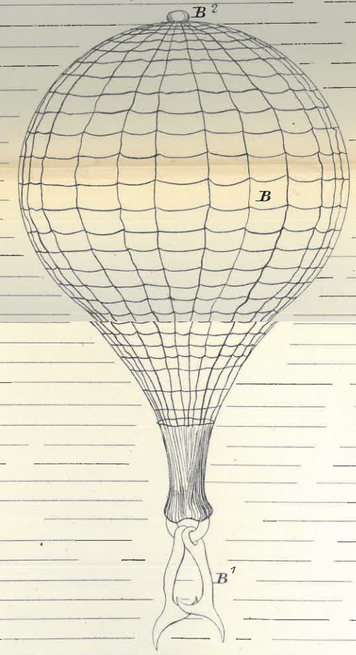

FIG. 1.

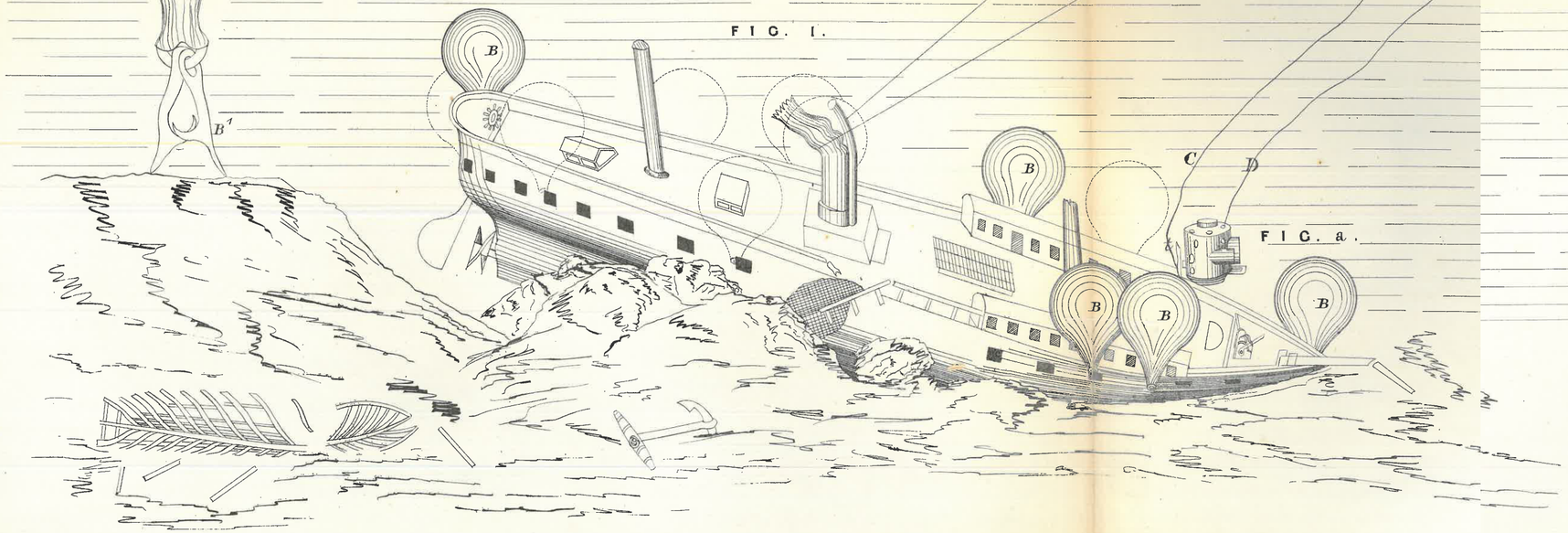

FIG. a.

The filed drawing is not colored.

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London: Printed by George Edward Eyre and William Spottiswoode,
Printers to the Queen's most Excellent Majesty. 1860.

FIG. 1.

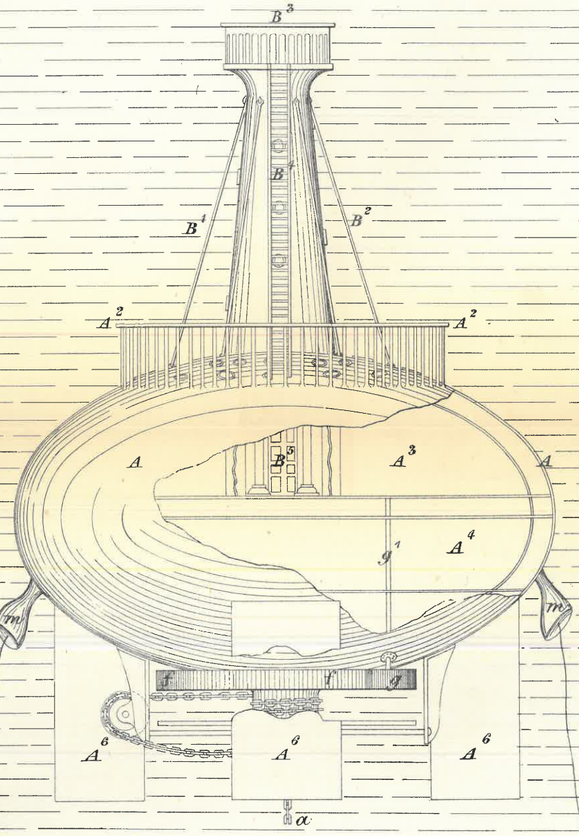


FIG. 3.

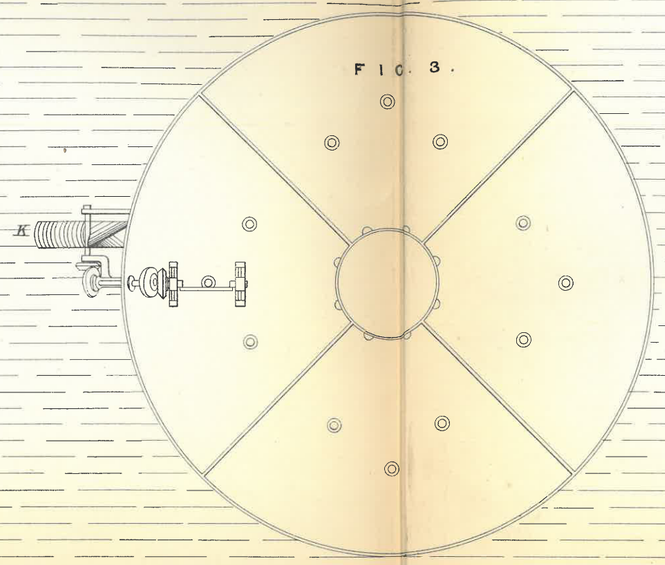


FIG. 4.

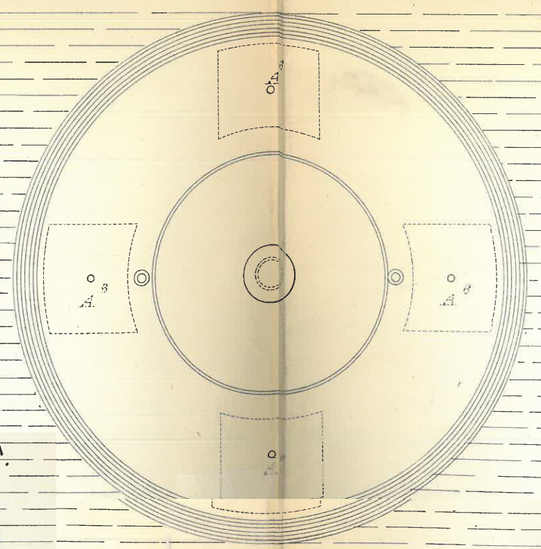
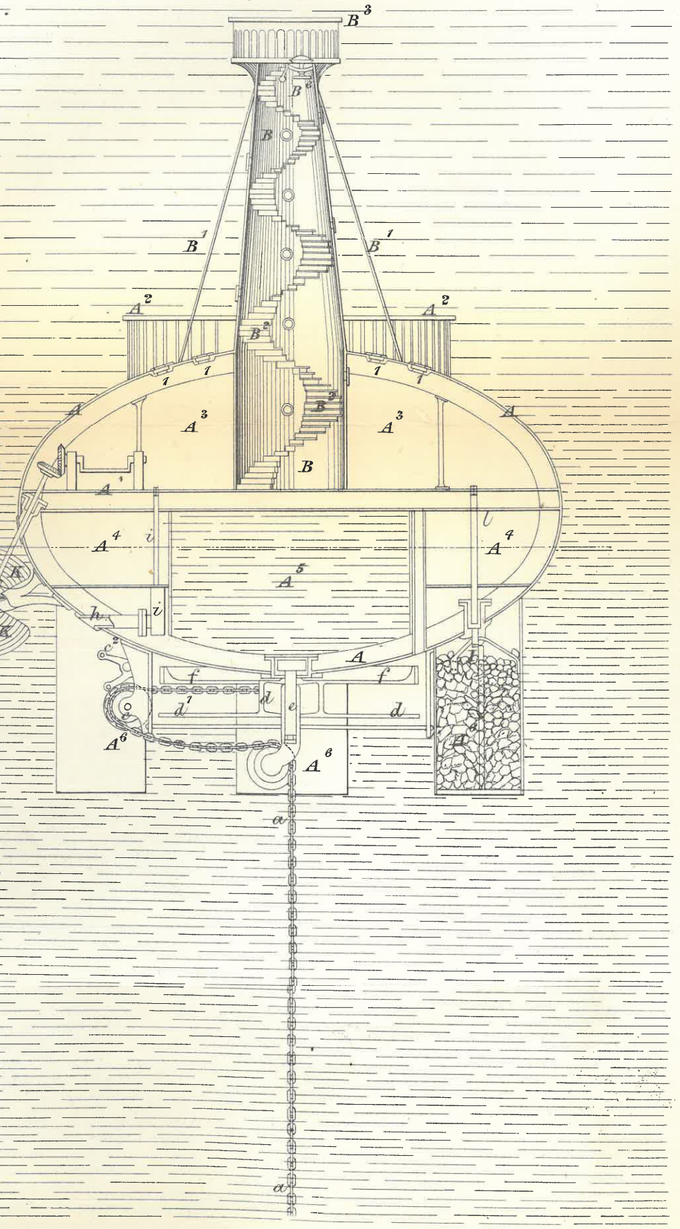


FIG. 1A.

FIG. 5.

FIG. 2.



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