C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

APPLICATION FILED SEPT. 18, 1917.

1,358,358.

Patented Nov. 9, 1920.

24 SHEETS—SHEET 1.

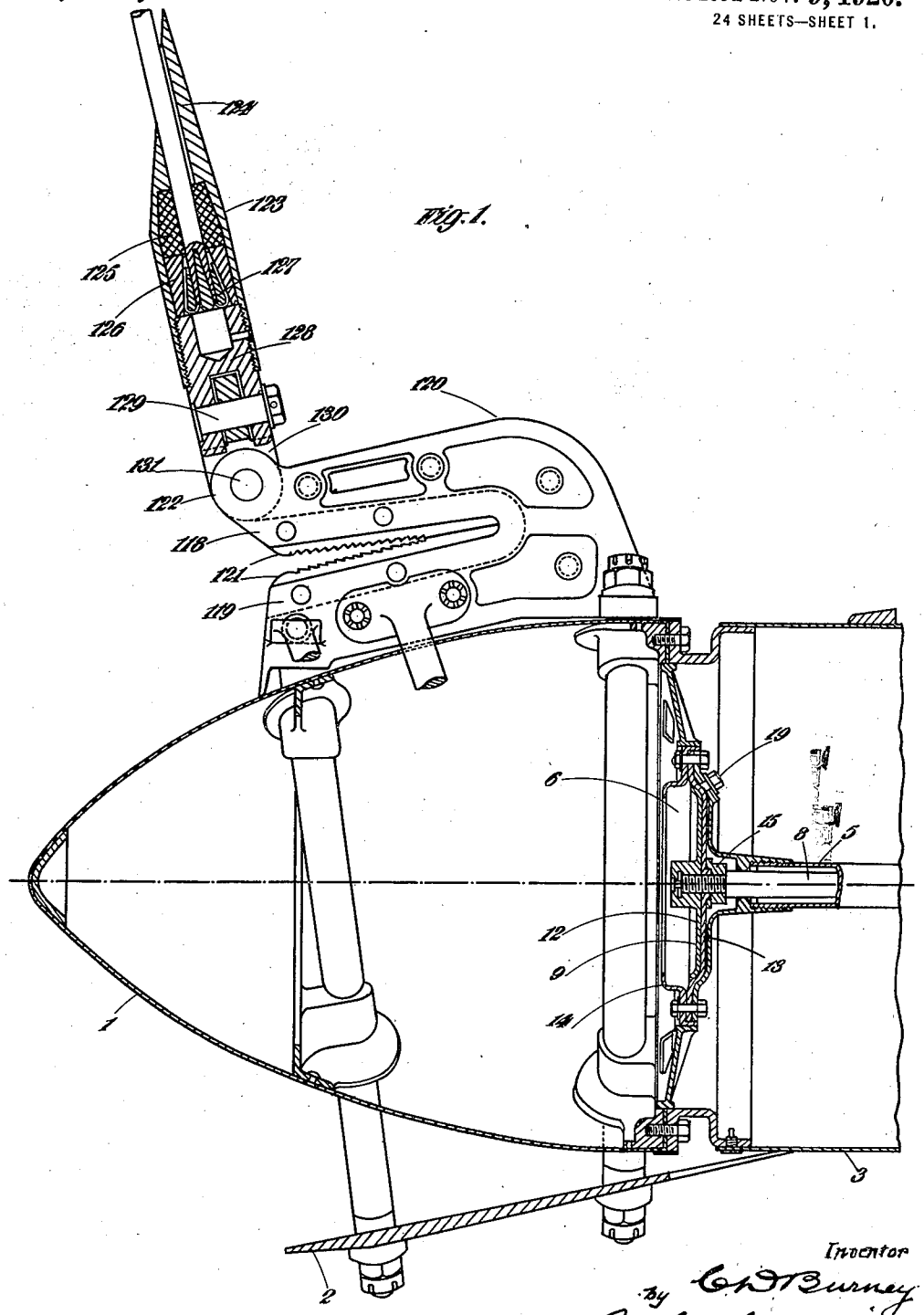

Fig. 1.

Inventor

by C. D. Burney

Lemuel Goldsborough & Neill

Attys

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

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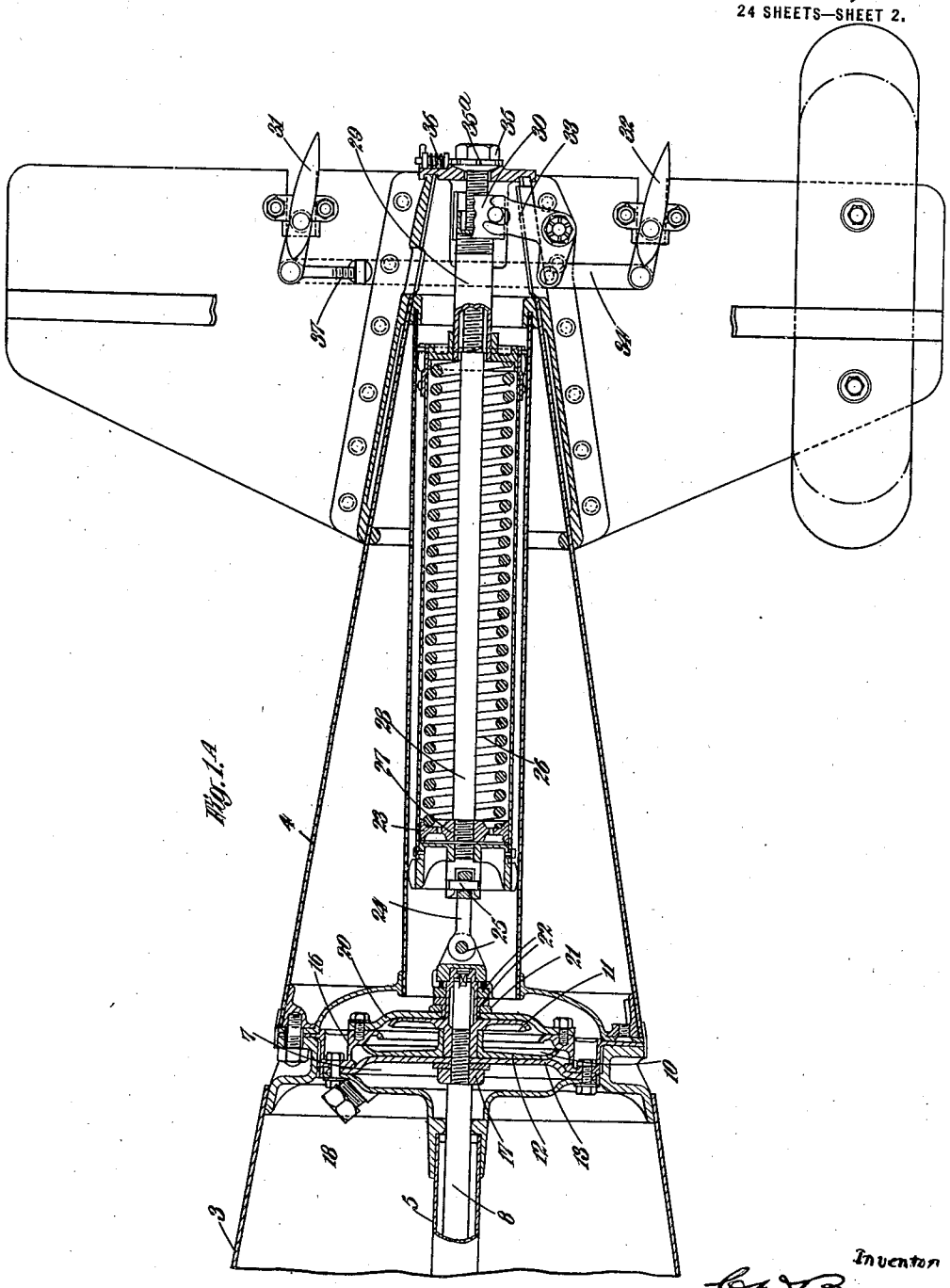
24 SHEETS—SHEET 2.



Inventor

C. D. Burney

by

Lemmie Goldsborough & Neill

Attys

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

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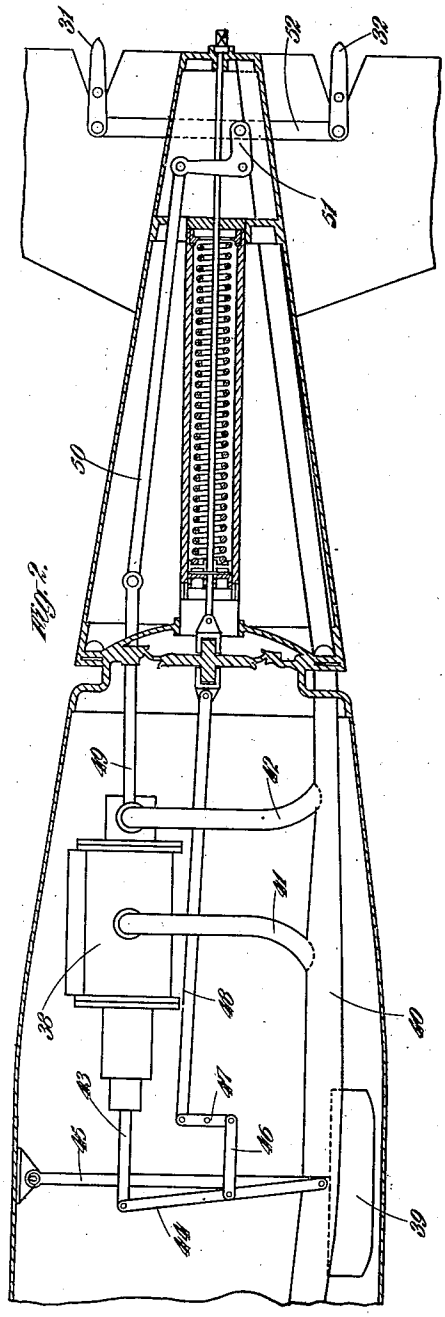


Fig. 2.

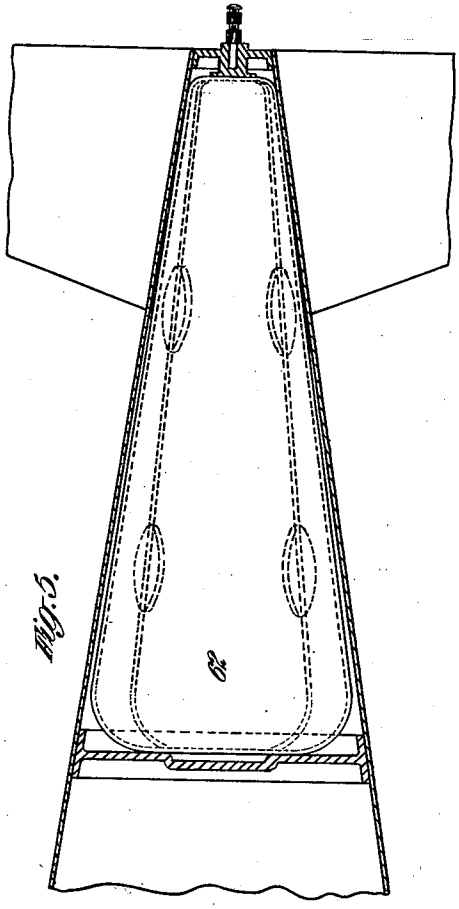


Fig. 3.

Inventor.

By C. D. Burney

Lemuel Goldsborough & Mitchell

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

APPLICATION FILED SEPT. 18, 1917.

1,358,358.

Patented Nov. 9, 1920.

24 SHEETS—SHEET 4.

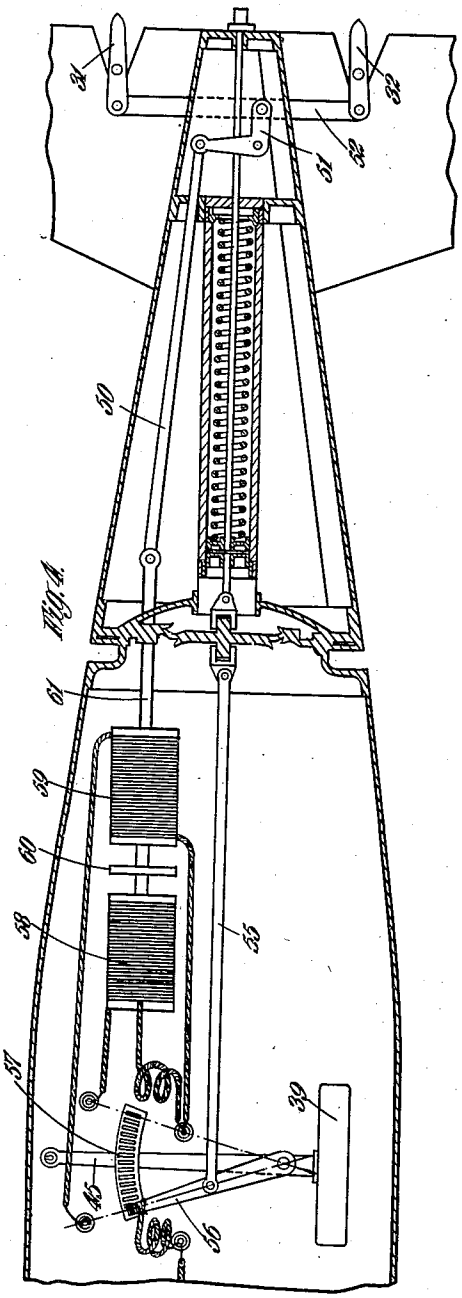


Fig. 4.

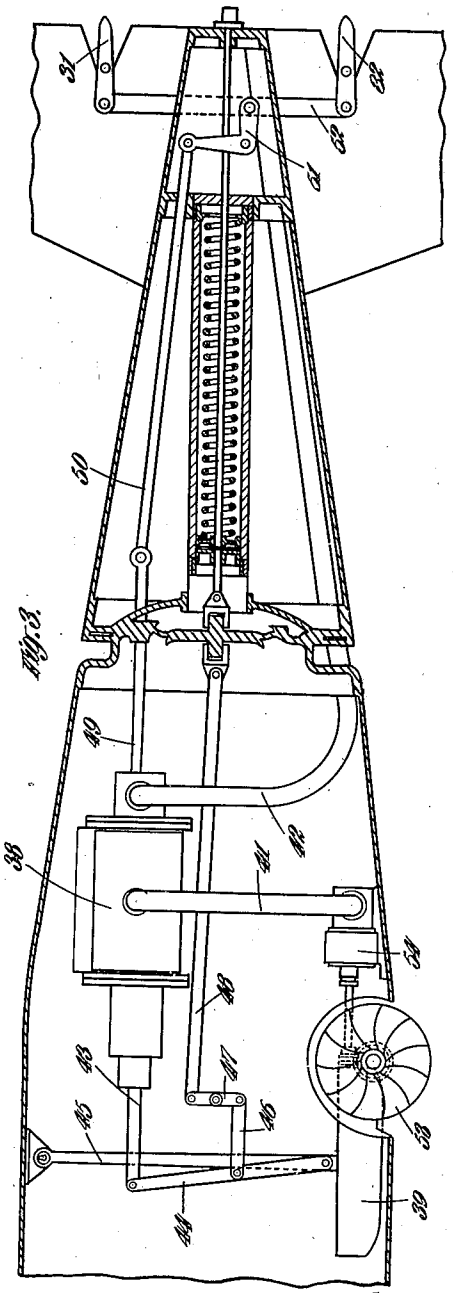


Fig. 5.

Inventor.

C. D. Burney

by Kenneth Goldsborough & Mill

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

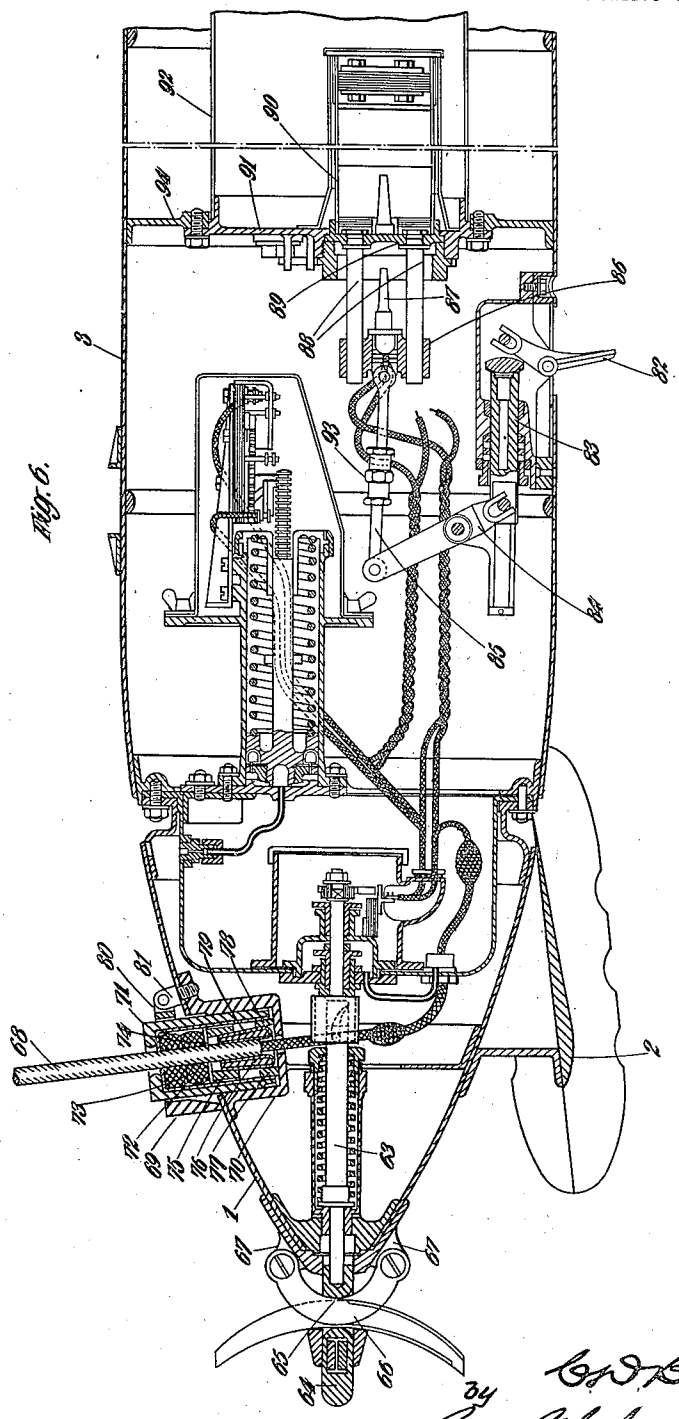
APPLICATION FILED SEPT. 18, 1917.

1,358,358.

Patented Nov. 9, 1920.

24 SHEETS—SHEET 5.

Fig. 6.



Inventor.

C. D. Burney

By Kenyon Goldsborough & Neill

Attys

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

APPLICATION FILED SEPT. 18, 1917.

1,358,358. **Patented Nov. 9, 1920.**

24 SHEETS—SHEET 6.

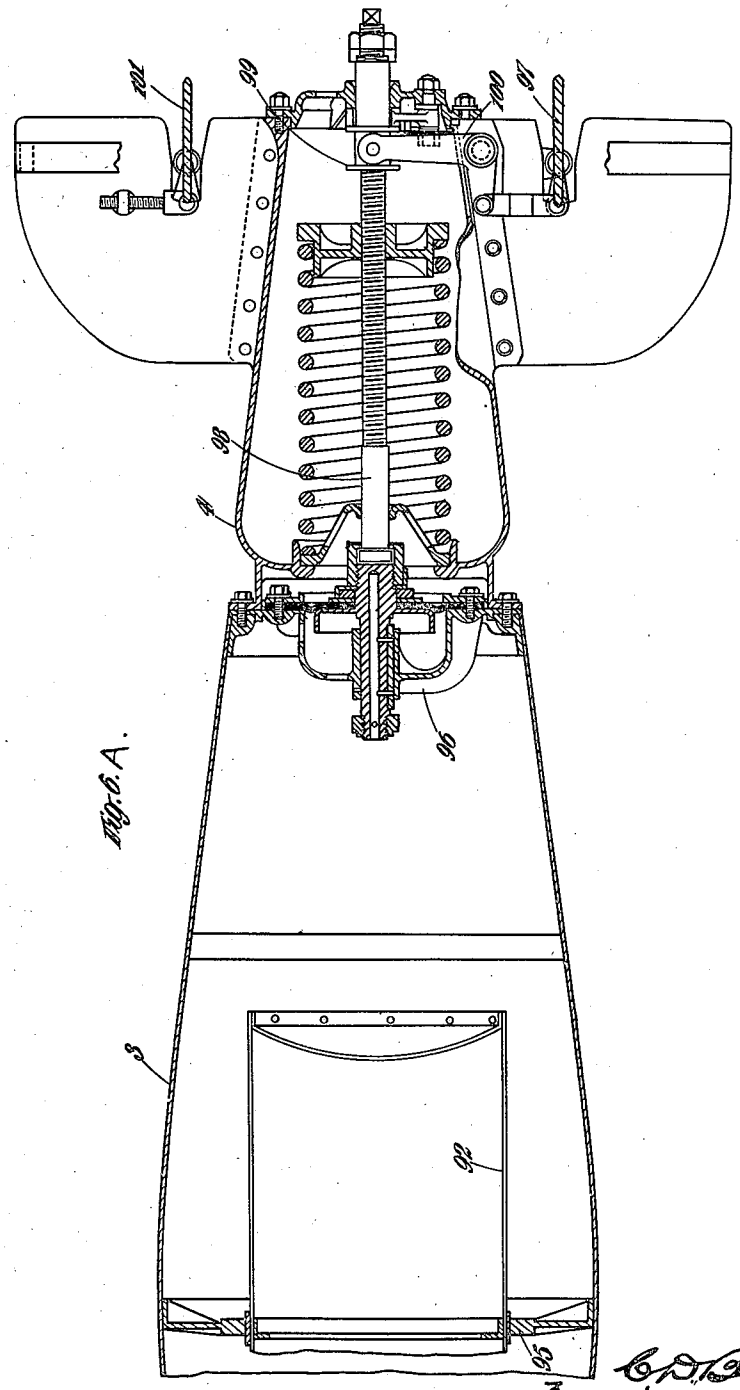


Fig. 6. A.

Inventor
C. D. Burney
By
Lewis Goldsborough & Neill
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C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

APPLICATION FILED SEPT. 18, 1917.

1,358,358. Patented Nov. 9, 1920.

24 SHEETS—SHEET 7.

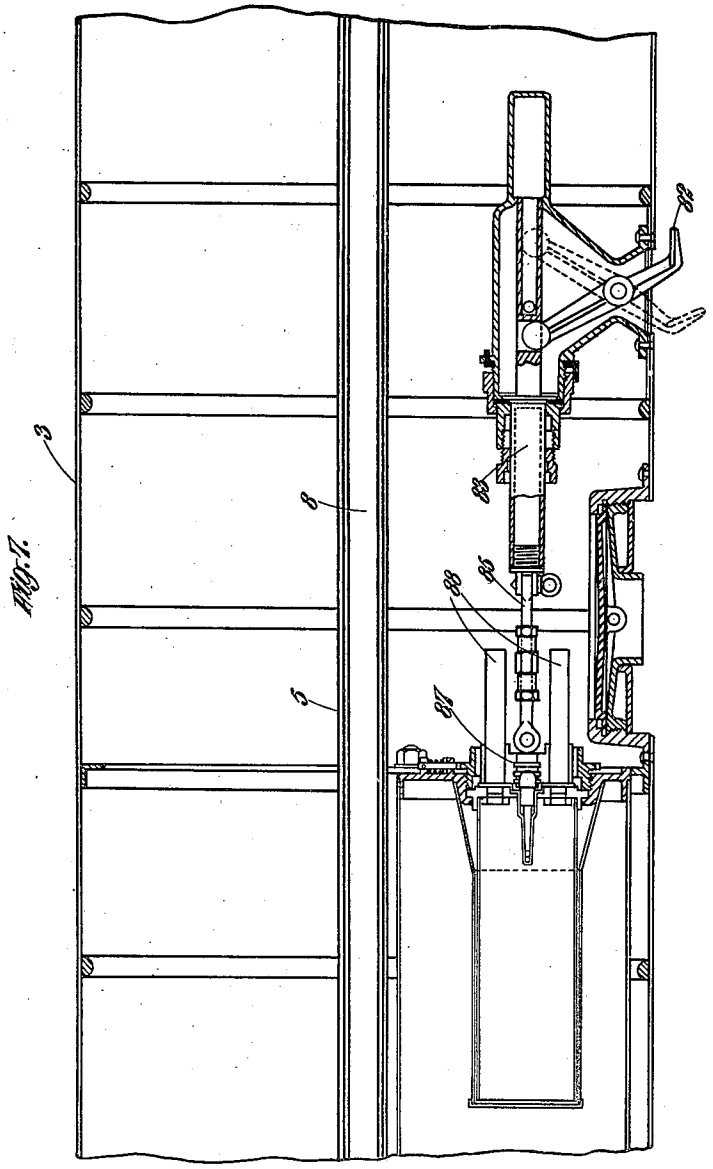


Fig. 7.

Inventor
C. D. Burney
By
Peirce Gibbons Foster & Neill
Attys.

C. D. BURNEY.

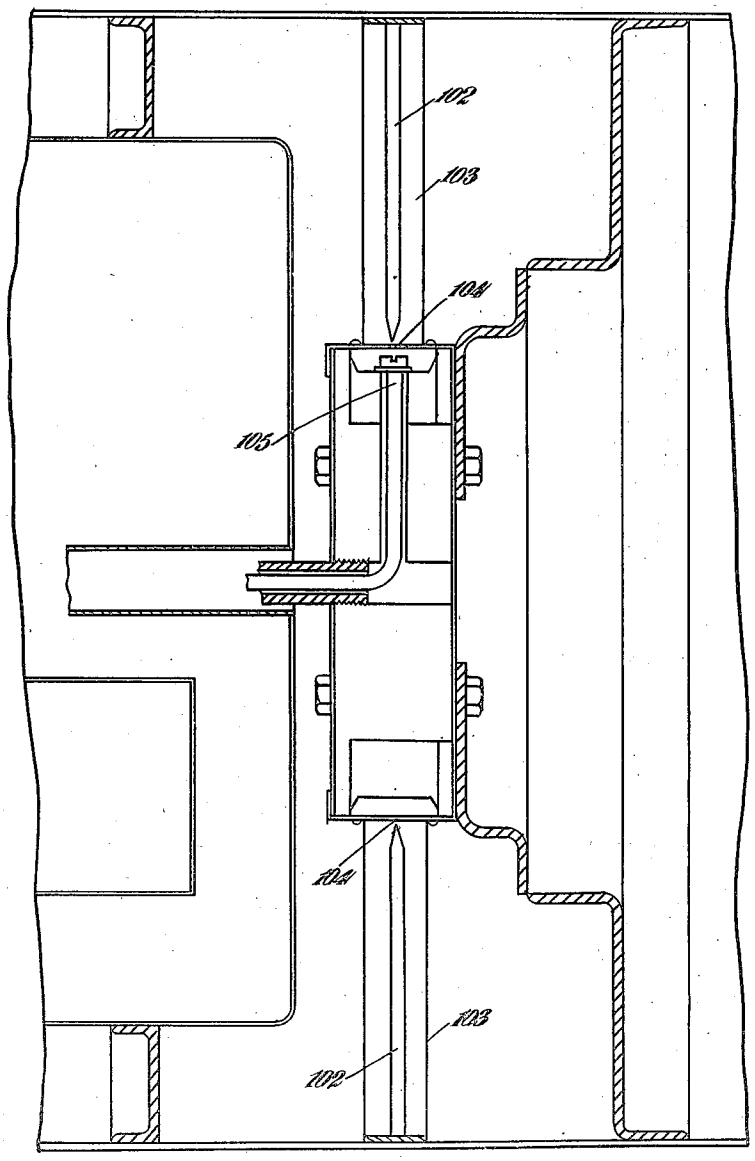
APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

APPLICATION FILED SEPT. 18, 1917.

1,358,358. Patented Nov. 9, 1920.

24 SHEETS—SHEET 8.

Fig. 8.



Inventor.

C. D. Burney

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C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

APPLICATION FILED SEPT. 13, 1917.

1,358,358.

Patented Nov. 9, 1920.

24 SHEETS—SHEET 9.

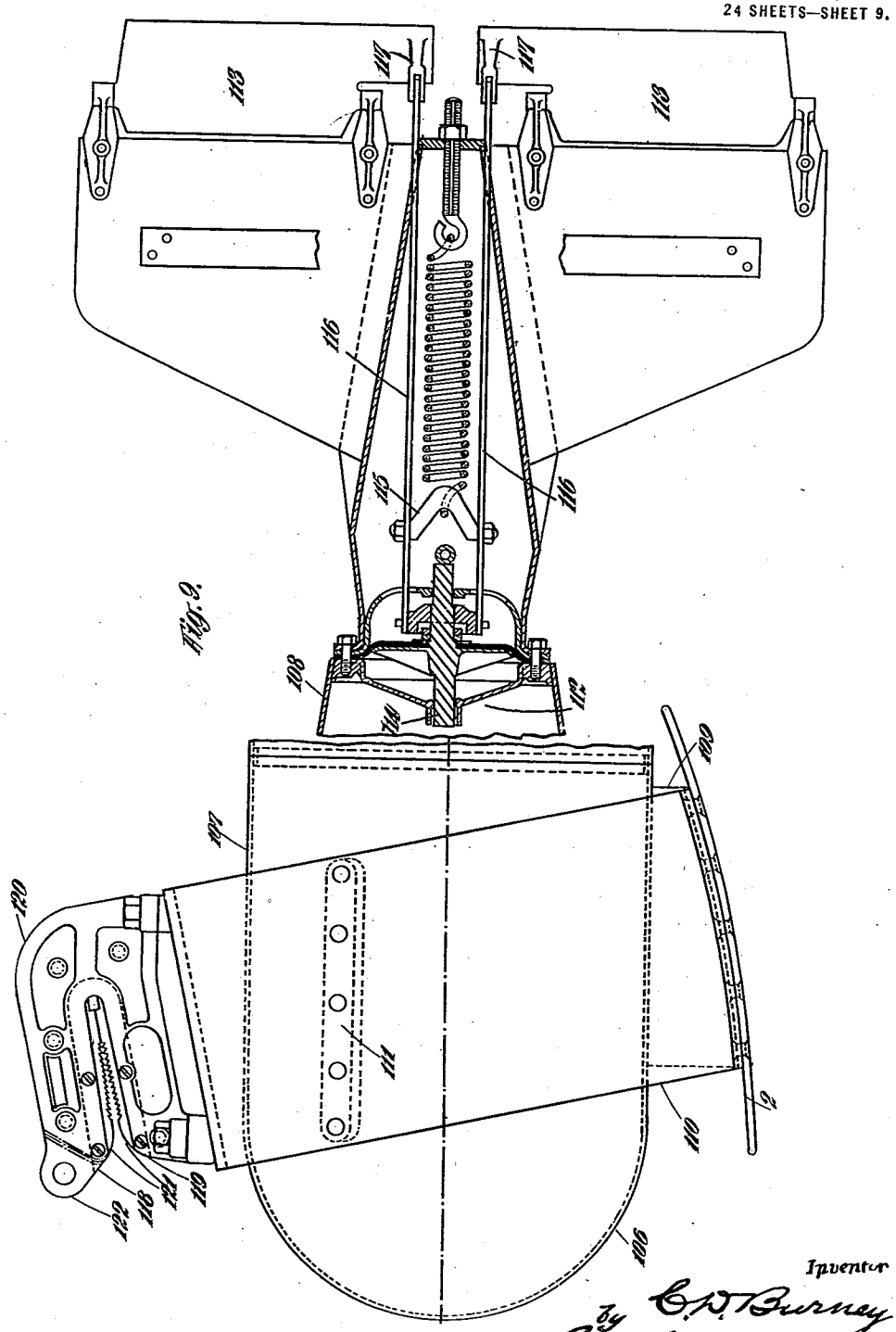


Fig. 9.

Inventor

C. D. Burney

By Lemuel Gilchrist Bronaugh & Hall

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

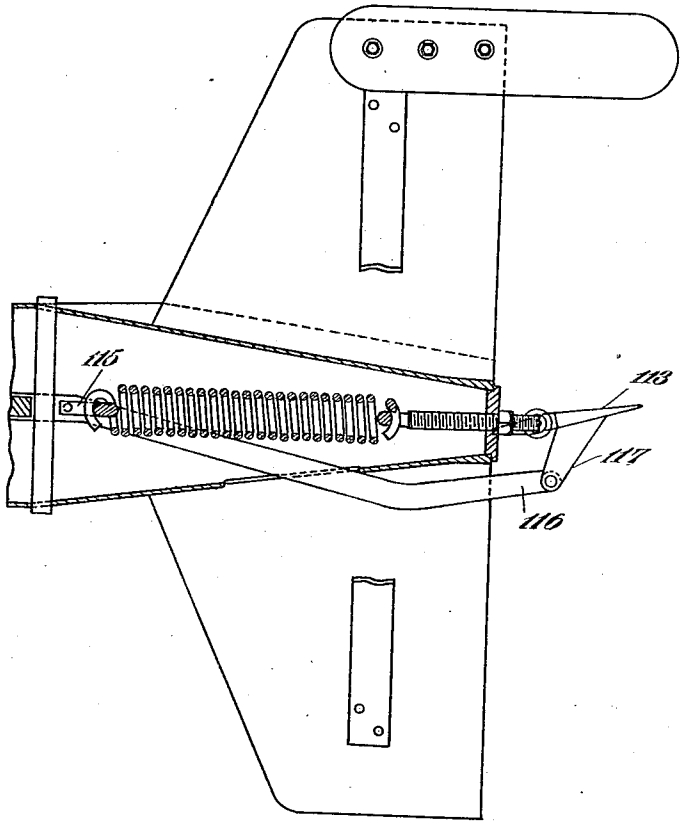
APPLICATION FILED SEPT. 18, 1917.

1,358,358.

Patented Nov. 9, 1920.

24 SHEETS—SHEET 10.

Fig. 10.



Inventor

By C D Burney

Bennie Goldsborough & Neale

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

APPLICATION FILED SEPT. 18, 1917.

1,358,358.

Patented Nov. 9, 1920.

24 SHEETS—SHEET 11.

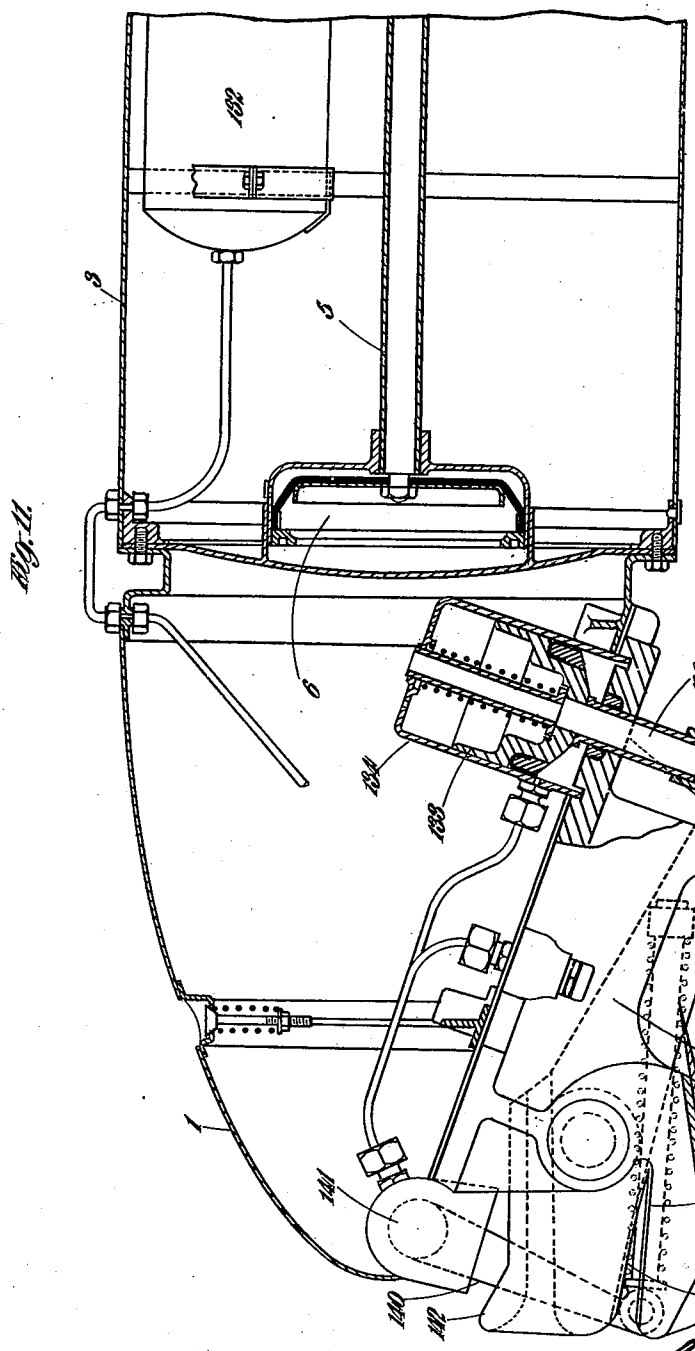


Fig. 11a.

Inventor.
C. D. Burney
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Kenyon Goldsborough & Mack
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C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

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24 SHEETS—SHEET 12.

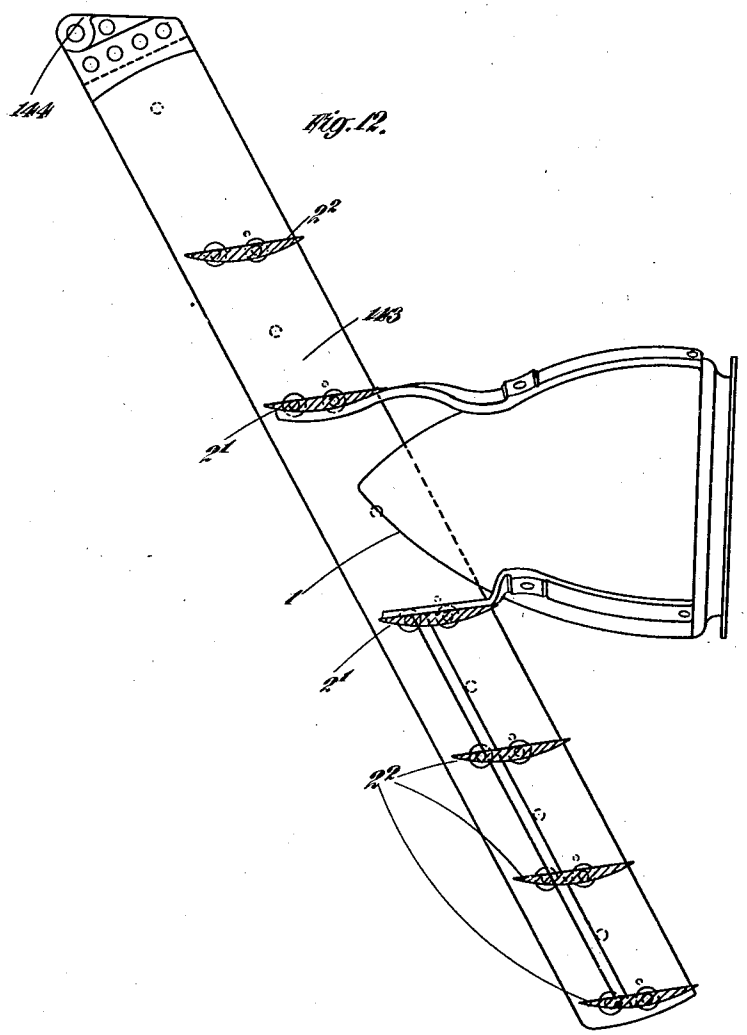

Fig. 12.

Inventor.

C. D. Burney

By Burns, Goldsborough & Neill

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

APPLICATION FILED SEPT. 18, 1917.

1,358,358. Patented Nov. 9, 1920.

24 SHEETS—SHEET 13.

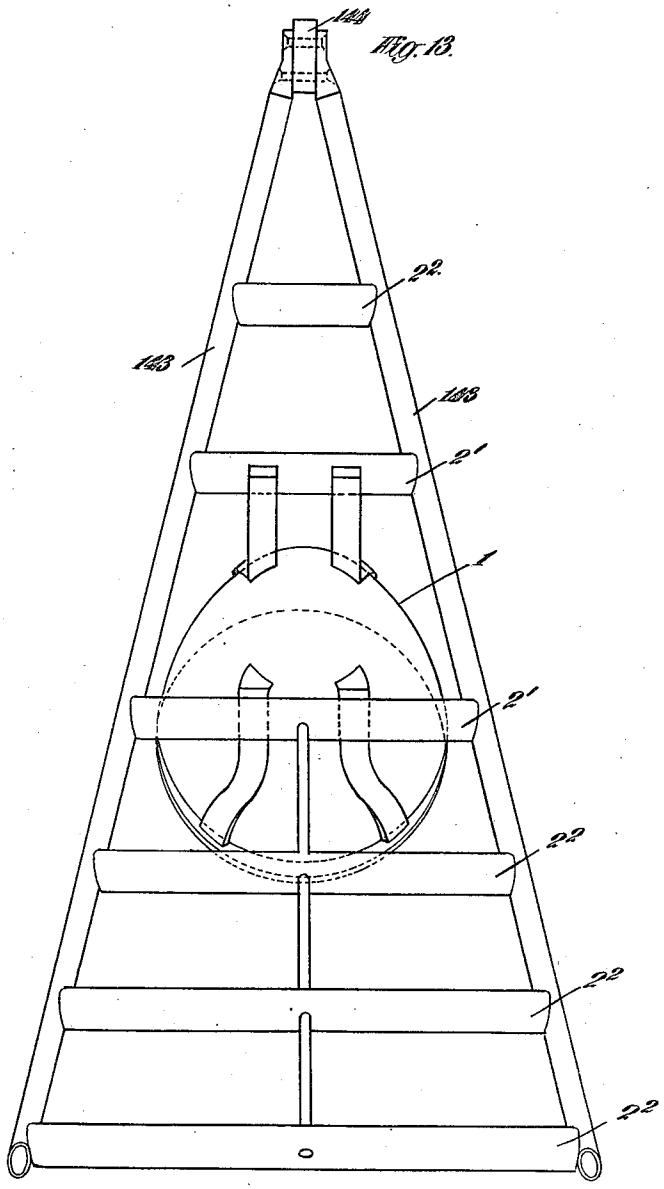

Fig. 13.

Inventor.

By C. D. Burney

Lewis Goldsborough & Neill

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

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24 SHEETS—SHEET 14.

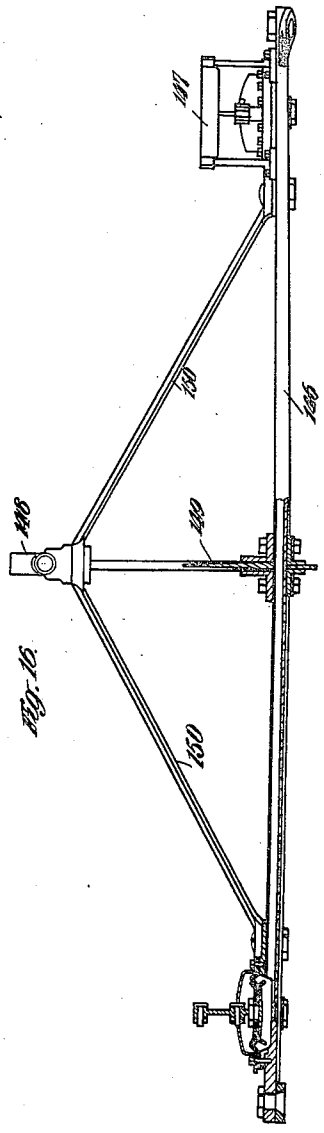

Fig. 16.

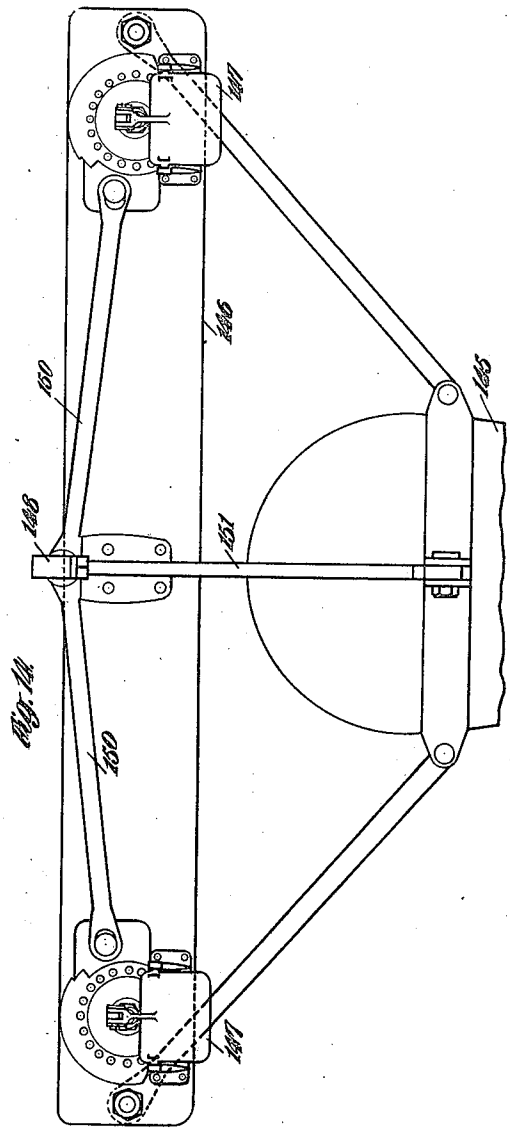

Fig. 14.

Inventor:

C. D. Burney

By Pennie Goldborough & O'Neill

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

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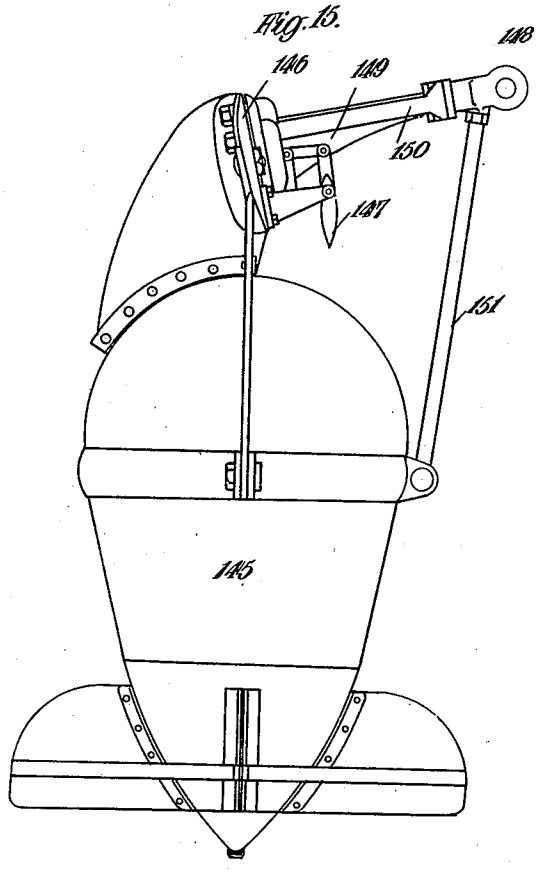
Patented Nov. 9, 1920.

24 SHEETS—SHEET 15.

Fig. 15.



Inventor

By C D Burney

Fenwick Goldsborough & Neill

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

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24 SHEETS—SHEET 16.

Fig. 17.

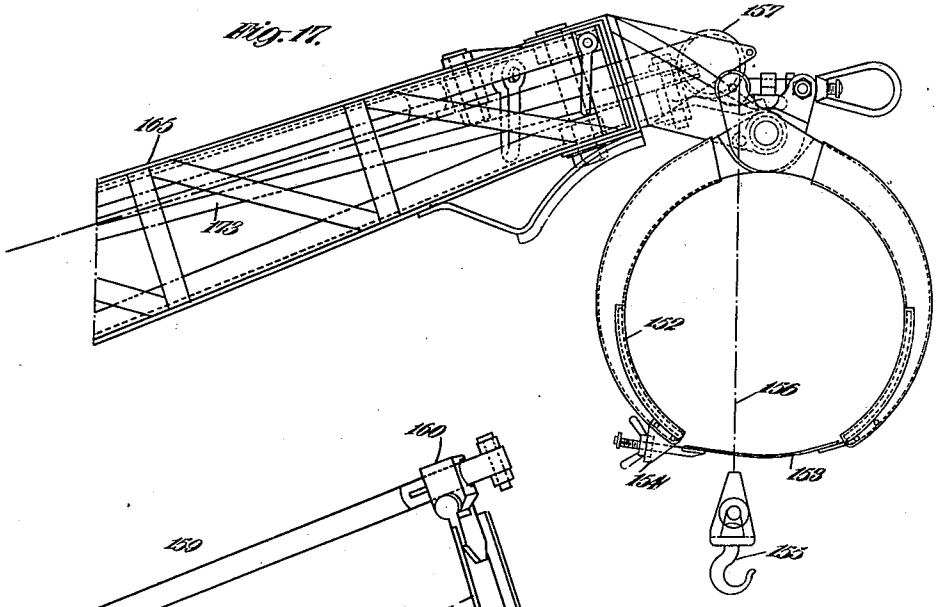
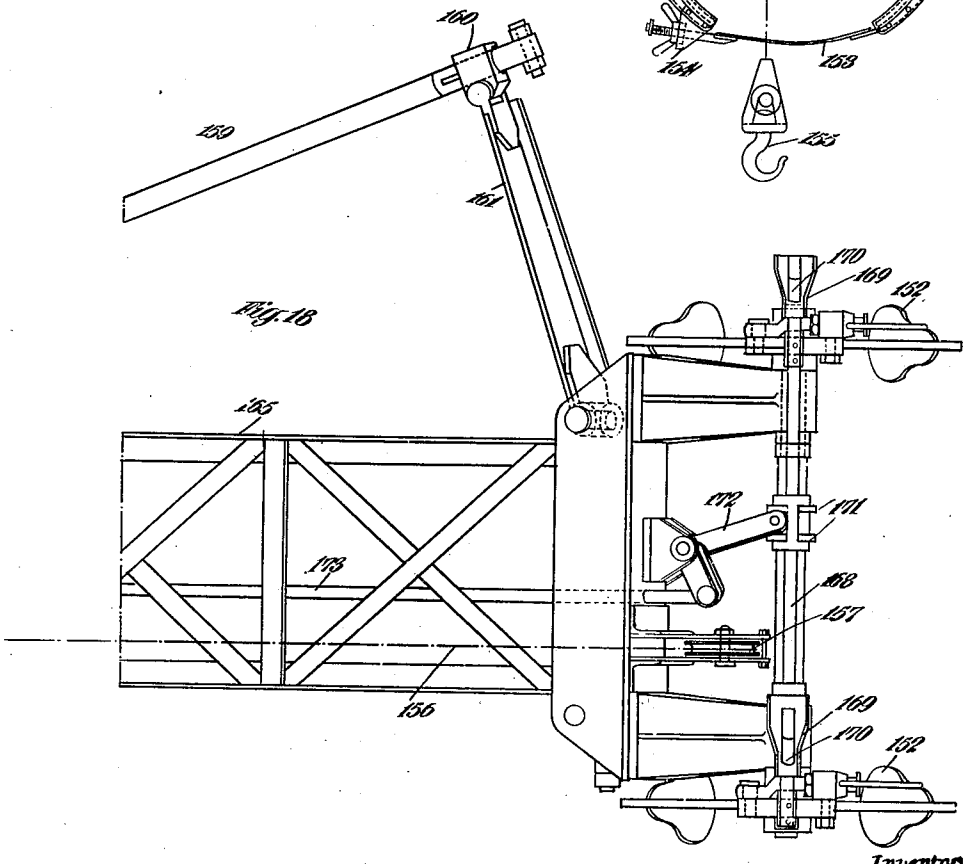


Fig. 18.



Inventor.

By C. D. Burney

Louis Goldsborough & Hill

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

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24 SHEETS—SHEET 17.

Fig. 17. A.

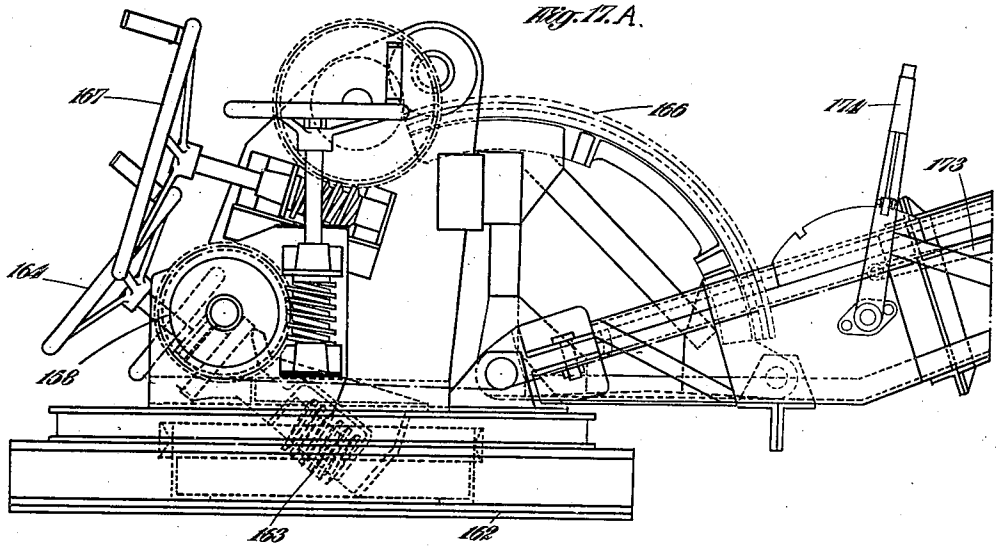
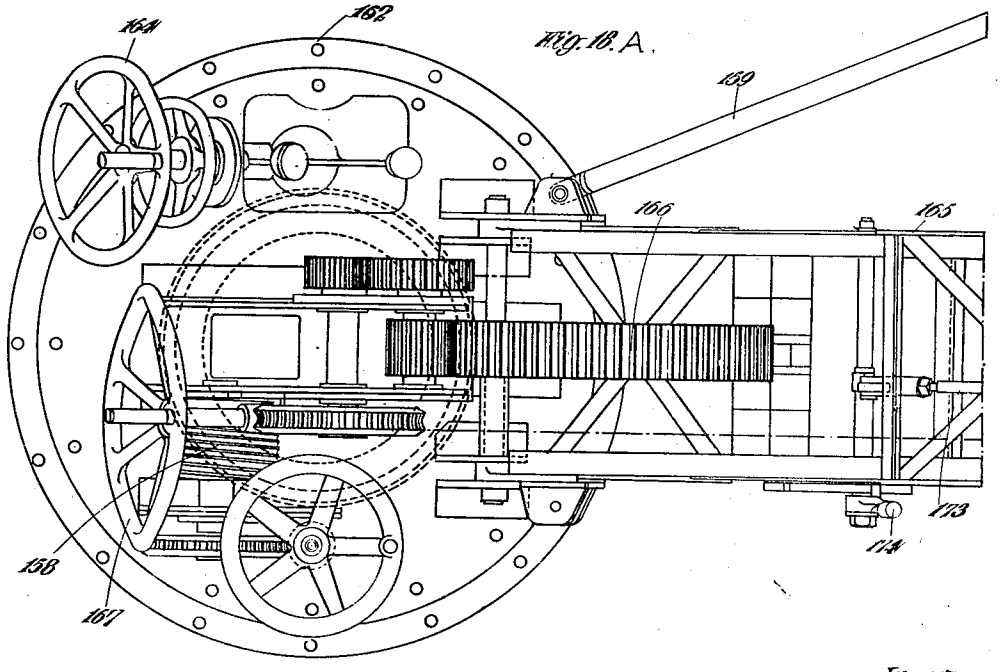


Fig. 18. A.



Inventor

C. D. Burney

By Penniman Goldsborough & Steell

Attys

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

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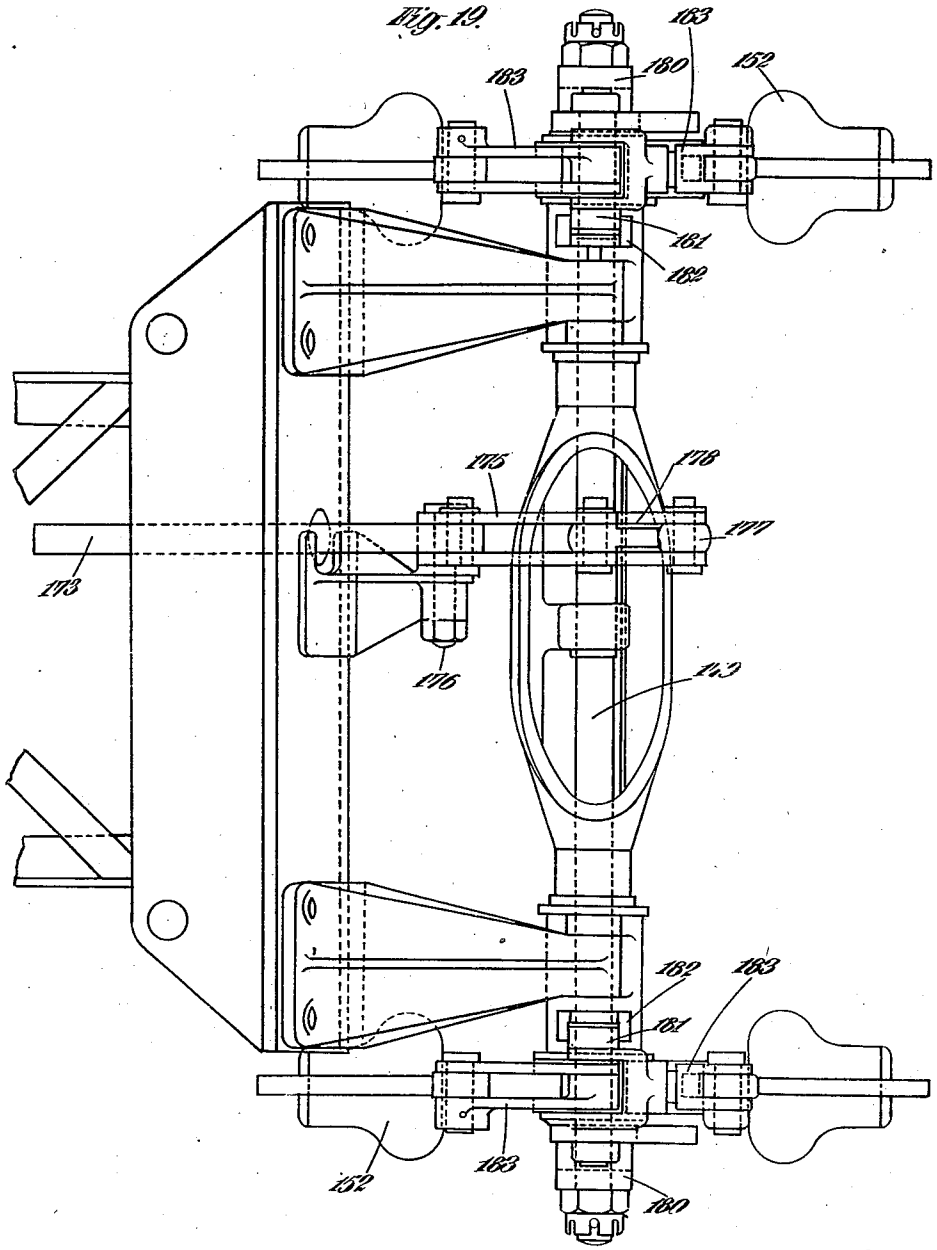
1,358,358. **Patented Nov. 9, 1920.**

24 SHEETS—SHEET 18.

Fig. 19.



Inventor

C. D. Burney

by Lemuel Gilbert Osborn & Neill

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

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1,358,358.

Patented Nov. 9, 1920.

24 SHEETS—SHEET 19.

Fig. 20

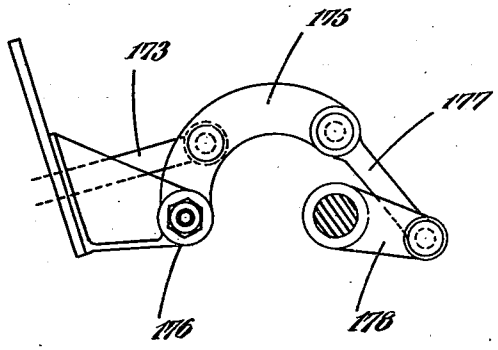
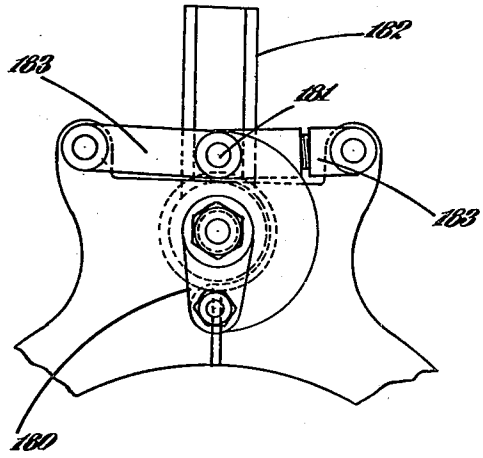


Fig. 21.



Inventor.

C. D. Burney

By Lemuel Gladborough & O'Neill

Attys.

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APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

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24 SHEETS—SHEET 20.

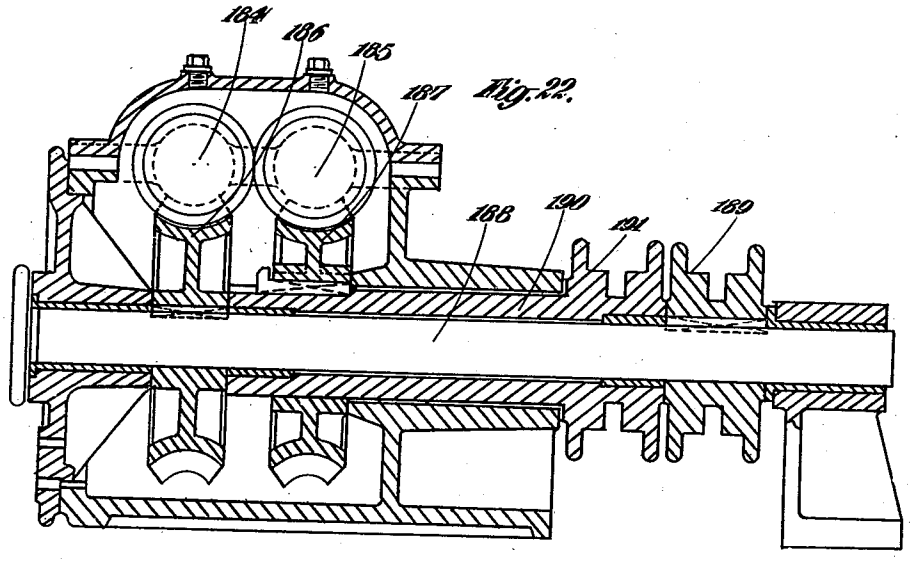

Fig. 22.

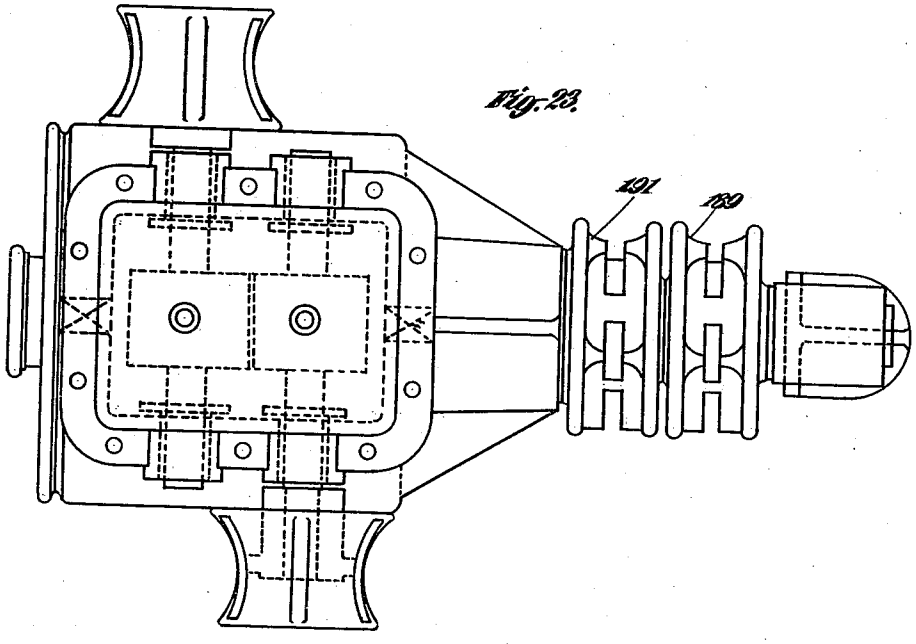

Fig. 23.

Inventor,

by C. D. Burney

Penny, Goldsborough & Neill

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

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1,358,358.

Patented Nov. 9, 1920.

24 SHEETS—SHEET 21.

Fig. 24.

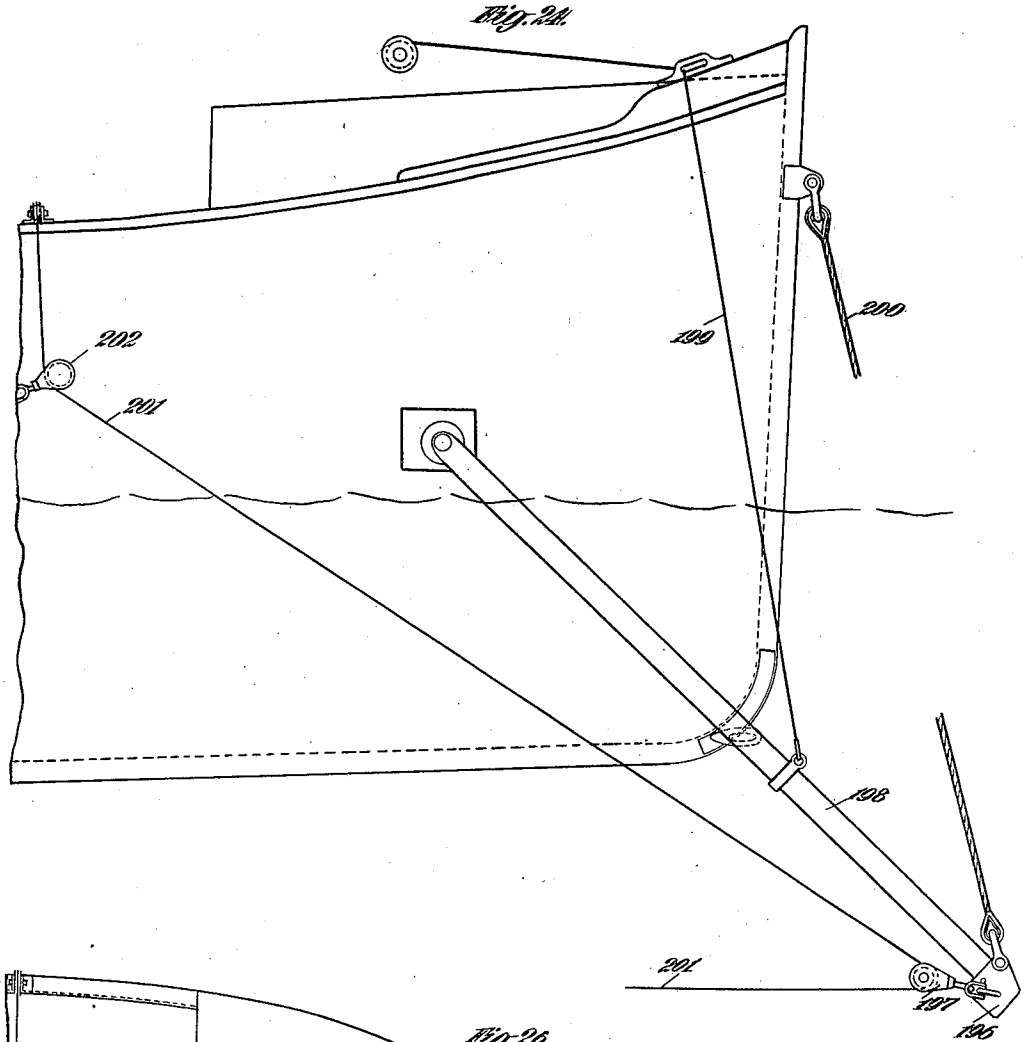
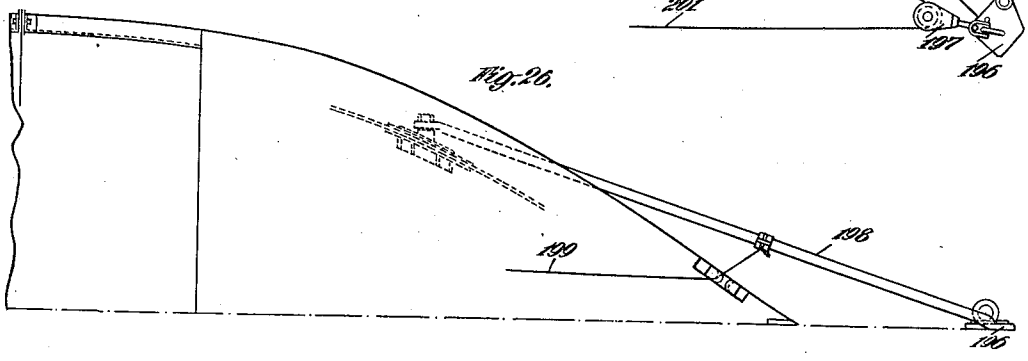


Fig. 26.



Inventor.

By C D Burney

Lewis Goldsborough & Watts

Attys

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

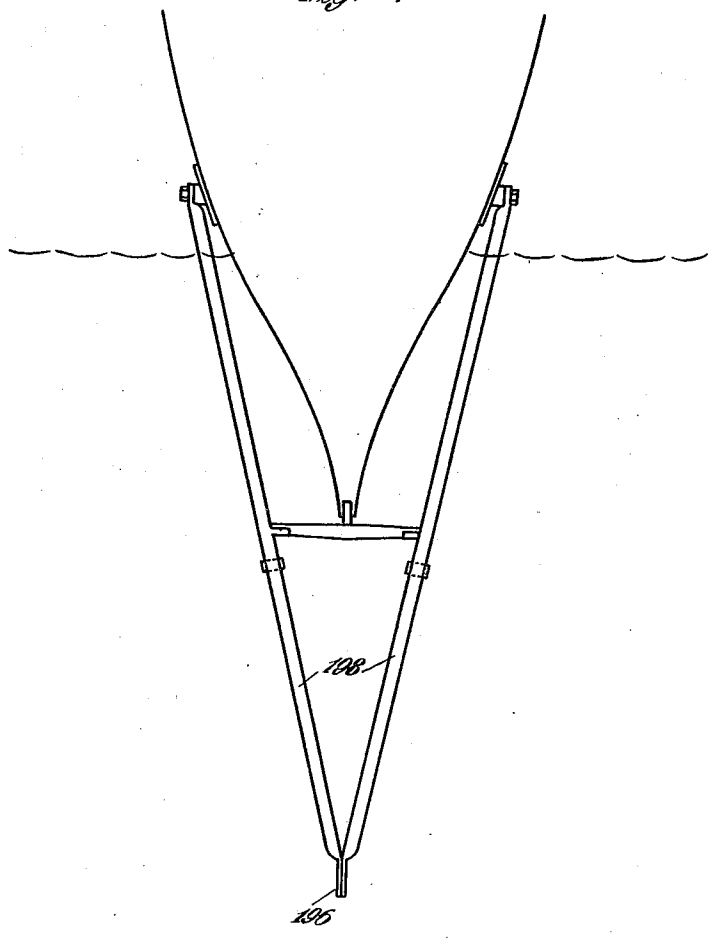
APPLICATION FILED SEPT. 18, 1917.

1,358,358.

Patented Nov. 9, 1920.

24 SHEETS—SHEET 22.

Fig. 25.



Inventor.

C. D. Burney

By Howson Goldsborough & Weik

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

APPLICATION FILED SEPT. 18, 1917.

1,358,358.

Patented Nov. 9, 1920.

24 SHEETS—SHEET 23.

Fig. 27.

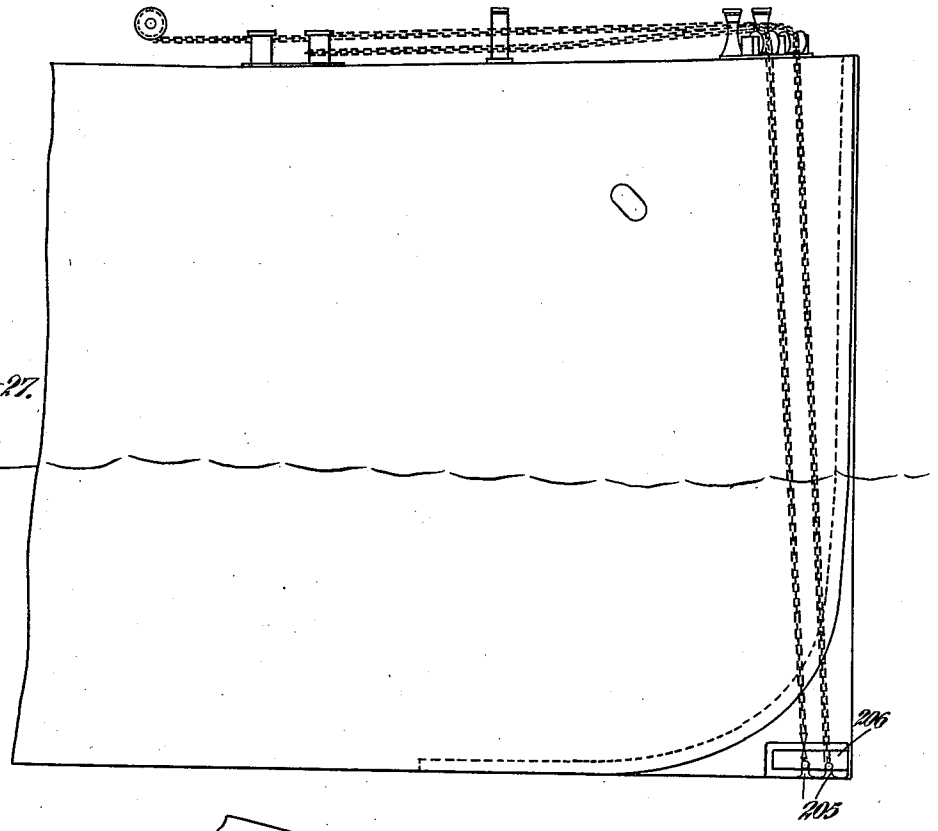
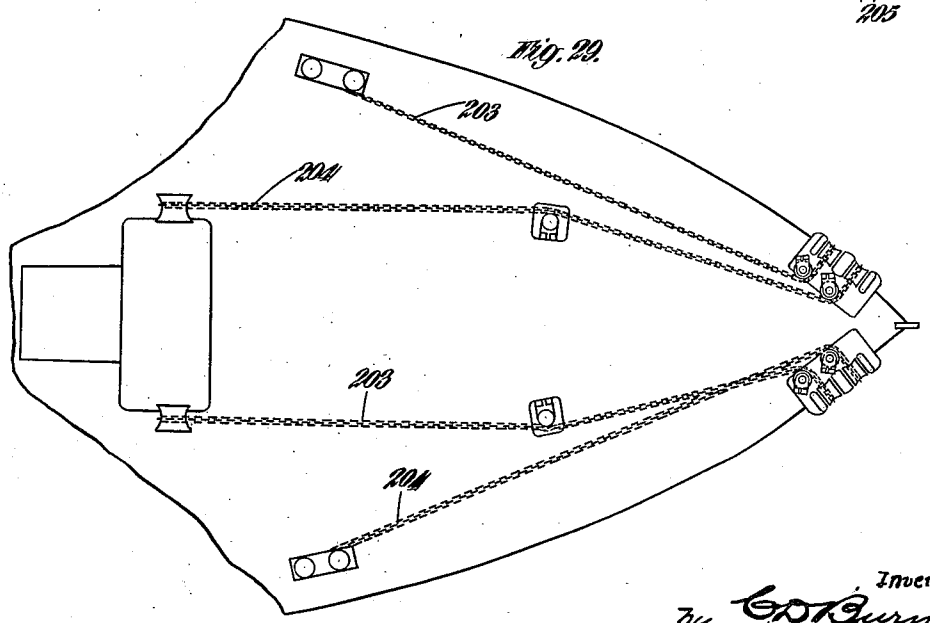


Fig. 29.



Inventor

by C. D. Burney

Lewis Goldsborough & Neill

Attys.

C. D. BURNEY.

APPARATUS FOR OFFENSE AND DEFENSE AGAINST SUBMERGED OR PARTIALLY SUBMERGED OBSTRUCTIONS.

APPLICATION FILED SEPT. 18, 1917.

1,358,358.

Patented Nov. 9, 1920.

24 SHEETS—SHEET 24.

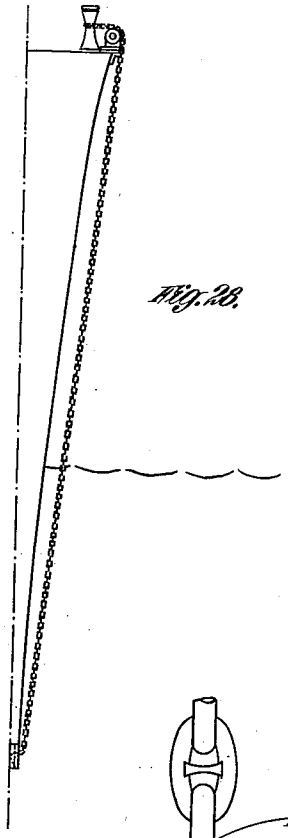


Fig. 28.

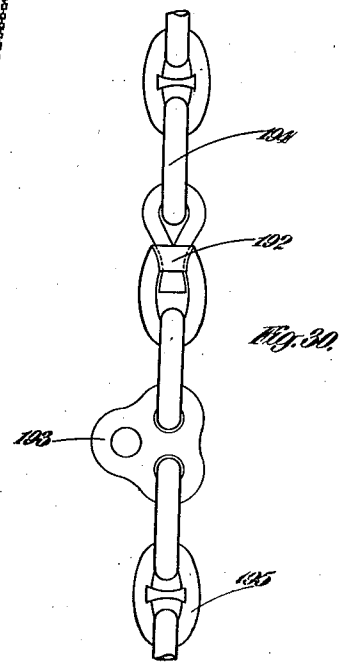


Fig. 30.

Inventor

C. D. Burney

By Pennie Goldsborough & Neill

Attys

UNITED STATES PATENT OFFICE.

CHARLES DENNISTON BURNEY, OF ALRESFORD, ENGLAND.

APPARATUS FOR OFFENSE OR DEFENSE AGAINST SUBMERGED OR PARTIALLY-SUBMERGED OBSTRUCTIONS.

1,358,358. Specification of Letters Patent. Patented Nov. 9, 1920.

Application filed September 18, 1917. Serial No. 192,019.

To all whom it may concern:

Be it known that I, CHARLES DENNISTON BURNEY, a subject of the King of Great Britain, residing at Dean Holme, Kilmeston, Alresford, in the county of Hants, England, have invented certain new and useful Improvements in Apparatus for Offense or Defense Against Submerged or Partially-Submerged Obstructions, of which the following is a specification.

This invention relates to apparatus of the kind described in my co-pending application Serial No. 192,018, filed of even date herewith, and consists of improvements and developments in the construction of such apparatus.

The aforesaid application describes a body which will tow out and down with respect to the fore and aft line of the ship, and which can be applied either as a means of offense against submarines, or as a means of protecting ships when traveling in mined waters; in both cases the offensive or defensive operation being possible at high speeds.

The aforesaid application further comprises a construction of winch and dropping davit for use with these bodies.

It may here be mentioned that the general term of "paravane" has now been applied to the class of body constructed on the principles set forth in the aforesaid specification, and by the aid of qualifying expressions the particular employment for which the body is adapted is designated.

For example:—

"Explosive paravane" for the submarine sweep. "Paravane mine" for the improved construction of mine specially applicable for keeping depth in a tide way.

"Deflector paravane" for the form adapted to deflect mines away from the path of a ship and then slip them, in which case the mine returns more or less to its original position undamaged.

"Protector paravane" for the form adapted to engage the mooring of a mine, deflect the mine away from the path of the ship, and then sever the mooring, whereupon the mine rises to the surface away from the ship, and can then be destroyed by gun fire or other means as desired.

"Depressor paravane" for a form adapted to tow well down and astern the ship to insure that no mines shall be missed.

These expressions having the interpretations as above set forth will be employed throughout the specification and claims.

For employment against mines, two deflector or protector paravanes, one on each side of the ship, are towed from some form of permanent or semi-permanent fitting situated on or below the line of the keel, and as far forward as possible. Each paravane when towed tends to keep a pre-determined depth line and to keep out at a considerable lateral distance from the fore and aft line of the towing vessel. The wires or cables connecting the paravanes to the towing vessel thus form a broad wedge shaped obstruction which, catching against the mooring rope of the mine, deflect it from the path of the vessel. The mine mooring, when thus deflected slips along the paravane wire until it reaches the paravane itself, where in the case of a deflector paravane it slips along and passes from the paravane, while in the case of a protector paravane it is led into a cutter on the head of the paravane and severed.

For small vessels, *e. g.* light cruisers, destroyers and smaller craft a pair of protector paravanes practically insures complete immunity from moored mines, so long as the ship is not pitching.

The difficulty of insuring immunity from moored mines, increases with the beam of the vessel to be protected, since the greater the beam, the farther out must the mine be deflected from the ship to clear it safely. For large ships, therefore, two pairs of paravanes are employed, one pair towed from the stem and the other pair a considerable distance abaft the stem. The pair towed from the stem may be deflector or protector paravanes while the pair towed abaft the stem are preferably protector paravanes.

The present invention consists in providing paravanes with means which automatically control the depth at which they will normally be in equilibrium, when towed or moored in a moving fluid, such means being operated automatically when a displacement from the set depth line of the paravane takes or tends to take place.

The invention further consists in an improved form of explosive paravane.

The invention further consists in a construction of deflector or protector paravanes suitable for merchant and other ships in

which the available power for towing paravanes is small.

The invention further consists in the construction of a cutter employed for severing the mooring of a mine, or other cable or wire.

The invention further consists in a depressor paravane which will tow at a predetermined depth astern the ship, and which may have a two-fold function, firstly to prevent any mines in the path of the ship being missed and secondly to keep the point of tow of the deflector or protector paravanes well down with respect to the ship's keel, also it may be provided with a charge of explosive and means for firing the same, in which case it may be employed as a submarine sweep.

The invention further consists in a combined explosive and deflector or protector paravane, whereby the same weapon may be used from the one ship either as a submarine sweep, or as a protection against mines.

The invention further consists in the provision of means in the explosive paravane, of firing the charge on the paravane shell suffering deformation such as might occur by a paravane when broadside on, colliding with a submarine.

The invention further consists in the means for securing the towing cables to the paravanes.

The invention further consists in improved constructions of winches and dropping davits, for use on the ship in connection with the paravanes.

The invention further consists in the ship's fittings specially adapted for use with under water towed bodies.

The invention further consists in a form of towing wire for use with under water towed bodies.

The invention further consists in the general construction and arrangement of the parts as hereinafter described.

The improvements and developments relating to paravane apparatus as comprised in this invention are illustrated in the accompanying drawings in which Figures 1 and 1A show in part sectional elevation a paravane provided with one form of control device, the paravane shown being a protector paravane with an improved form of cutting device, but it is to be understood that a deflector or explosive paravane may be provided with a similar control device.

Figs. 2, 3, 4 and 5 illustrate more or less diagrammatically other forms of control which may be employed. In these figures, only that part of the paravane containing the control device is shown.

Figs. 6 and 6A show in part sectional elevation, one improved form of explosive paravane.

Fig. 7 is a sectional elevation of part of the body portion of a combined submarine sweep and mine sweep. This form is obtained by employing a paravane having a head and tail and control device as shown in Figs. 1 and 1A, the head being provided with the firing gear shown in Fig. 6, the body portion having the detonator gear, and charge of high explosive arranged as in Fig. 7.

Fig. 8 is a sectional elevation illustrating a form of mechanism for firing an explosive paravane on deformation.

Fig. 9 is a sectional elevation of a protector paravane suitable for use with merchant ships and other vessels having the power available comparatively small.

Fig. 10 is a view of the tail at right angles to Fig. 9.

Fig. 11 is a sectional elevation of the head of a protector paravane having a pneumatic cutter.

Figs. 12 and 13 are part sectional elevation and front elevation of the forward end of a deflector paravane.

Figs. 14, 15 and 16 are views at right angles and a part sectional elevation of a depressor paravane.

Figs. 17, 17A and 18, 18A are elevation and plan of an improved form of dropping davit.

Figs. 19 to 21 are views on a larger scale of some of the details of the same.

Figs. 22 and 23 are sectional elevation and plan of a form of steam winch employed.

Figs. 24 to 30 are views of the ship's fittings employed with these underwater towed bodies.

Paravanes of the explosive type for use against submarines, or of the deflector or protector types, for protecting ships in mined waters or for mine sweeping operations, comprise a head 1, fitted with a depressing plane 2, a body portion 3, and a tail portion 4, all these parts being substantially as described in the patent specification above referred to.

The automatic depth controlling device is adapted to operate small rudders or vanes on the tail of the paravane in such a way that any movement of the paravane either upward or downward with respect to the normal depth line causes a displacement of the rudder to bring the paravane back to the desired depth.

In a form of control illustrated in Figs. 1, 1A, and 7 the complete device consists of two distinct portions connected by a universal joint link. The portions are (1) a triple valve comprising two mercury valves, and one hydrostatic valve; (2) a hydrostatic valve spring box, compression rod and rudder crosshead.

The triple valve consists of a steel tube 5, connecting two mercury valve cylinders 6, 7. Inside this tube and working in bearings at either end is a valve rod 8, on the ends of which are screwed the foremost mercury valve 9, and the after mercury valve 10, and the hydrostatic valve 11, the two latter being

conveniently rigidly secured together such as by welding.

The mercury valves each consist of a dished plate 12, prevented from unscrewing from the rod 8, such as by locking plugs. At the back of the mercury valve are mercury valve diaphragms 13, which may be of molded rubber and prevent the leakage of mercury past the valve disks 12, while allowing the full travel of the mercury valve. The forward mercury valve diaphragm is gripped at its outer edge between the flange of the valve cylinder 6, and a flange ring 14. At the center it is gripped between the foremost mercury valve 9 and a nut 15, which is screwed and fixed on the valve rod 8. The after mercury valve diaphragm is gripped at its outer edge between the flange of the valve cylinder 7, and the flange of a fixed ring 16. At the center it is gripped between the valve and a nut 17, secured similarly to the nut 15.

The whole space within the valve cylinders and the tube 5 between the mercury valve diaphragm is filled with mercury, filling and air outlet plugs 18, 19 being fitted on the valve cylinders.

The hydrostatic valve is similar in shape to the mercury valves and works in the ring 16 above referred to. It is open to the water on the after side through the tail tube of the paravane, and is rendered watertight on the forward side by the hydrostatic valve diaphragm. This is constructed and held in the same way as the mercury diaphragm, being gripped at the outer edge between the after flange of the ring 16 and a ring 20, and at its center, between the hydrostatic valve 11, and a washer 21, by nuts 22. The space between the hydrostatic valve and the mercury valve communicates with the body of the device, through a small hole in the ring 16. This enables any mercury that may leak past the after diaphragm to be discovered without parting the device.

The after end of the hydrostatic valve is connected to the spring box 23 by a link 24, with a universal joint 25 which permits free movement in all directions. This is provided to avoid any constraint or friction in the working of the valve, which might otherwise be caused by the spring box and tail bearings not being in perfect alinement with the valve rod bearings. The spring box 23 contains the hydrostatic valve spring 26, piston 27 and compression rod 28. It is closed at the rear end by a screwed cap, into which is fitted an externally threaded tube 29, carrying the rudder crosshead 30, and through which the spring compression rod passes. The spring box is fitted with rounded bearing strips at either end and slides freely in the tail tube, and guides under the action of the spring and triple valves. The spring box transmits its movement to the rudders 31, 32, by means of the crosshead 30, forked bell-crank 33 and connecting link 34.

The spring 26 is fitted around the compression rod, the forward end taking against the piston which is a loose fit in the spring case, The after end of the compression rod passes through a hole in the tail cover plate and a nut 35 is screwed onto it. This nut can be locked in any position by a small spring loaded detent 36 taking into slots 35A cut in the nut. By screwing up this nut, the compression rod can be withdrawn through the tail plate to any desired extent, compressing the spring a corresponding amount between piston and the cap of the spring case. The rudder 31 may be provided with a means of adjustment such as a screwed rod 37 connected to one end of the rudder and adjusted by means of a nut rotatably mounted on the rod 37, so that any initial setting of one of the rudders may be effected.

The operation of the control device is as follows:—

The direct working of the hydrostatic valve 11 is adapted to maintain the paravane at a set depth line; and the mercury valves correspond to and fulfil the same function as the pendulum weight and servomotor in a torpedo. On the paravane being inclined to any angle a head of mercury is produced in the tube 5 proportional to the sine of the angle of inclination. This head produces a certain pressure which, acting on the whole area of the lower mercury valve, exerts a force tending to cause the valve, valve rod, spring case, and rudders to move in such direction as will give helm to restore the paravane to the horizontal.

In addition to the force exerted by the mercury, there is the pressure of the water acting in opposition to the initial compression on the hydrostatic valve spring; and the combined action of the three forces mercury head, water pressure and spring gives the following results:—

(1) *Maximum down.*—Should the paravane be above its set depth with its head inclined upward, the head of mercury will act in conjunction with the hydrostatic valve spring and will give considerable down-helm.

(2) *Override up.*—Should the paravane be above its set depth and inclined head downward, the head of mercury will act in opposition to the hydrostatic valve spring and, if the inclination downward is sufficient, will overcome the effect of the spring and give up-helm.

(3) There will, therefore, be a degree of inclination of the paravane when above its set depth line at which the head of mercury will be just sufficient to counterbalance the compression of the hydrostatic valve spring and produce midship rudders. This degree of inclination is termed the "turning angle

down" and is, theoretically, the angle at which the paravane should go down to its correct set depth.

(4) *Maximum up.*—Similarly if, when the paravane is below its set depth line, its head is inclined downward, the head of mercury will be acting in conjunction with the water pressure on the hydrostatic valve and will give considerable up-helm.

(5) *Override down.*—When the paravane is below its set depth with its head inclined upward, the head of mercury will be acting in opposition to the water pressure on the hydrostatic valve and, if the inclination upward is sufficient, will give down-helm.

(6) And, again, when the paravane is below its depth there will be a certain inclination at which the mercury head will just counterbalance the effect of the water pressure on the hydrostatic valve and produce midship rudders. This inclination is termed the "turning angle up," and is, theoretically, the angle at which the paravane will rise to its set depth line.

Under the continuous influence of these various forces, therefore, the paravane will travel about its set depth line on an undulating course; its wave-like motion on each side of the set depth line being termed its oscillation.

The dynamic reaction on the plane of the paravane when it is drawn through the water can be resolved into two components, a force in the direction in the motion which is known as the drift, and a force at right angles to this direction which is known as the lift, the lift being negative when the force is in the downward direction, so as to depress the paravane as it is drawn through the water. The drift is a minimum when the paravane is of stream line form, and the dynamic reaction plane or surface should be formed so as to give the maximum lift-drift ratio, that is, the maximum deflecting force for a given drift.

In th form of controlling device illustrated in Fig. 2, a servomotor 38 of any suitable form in which the slide valve of the same is controlled by a pendulum weight 39, is employed in conjunction with a Venturi tube 40 and a hydrostatic valve which may be of similar construction to the hydrostatic valve 11 described with reference to Figs. 1, 1A and 7. Supply and exhaust tubes 41, 42 respectively, connect the Venturi tube to the cylinder of the servomotor, the movable part of which is connected at one side to a rod 43 connected to a link 44, the lower end of which is attached to an arm 45, pivoted at its upper end to the inside of the paravane and carrying the pendulum weight 39 at its lower end. Attached to the link 44 at a point intermediate to its ends is an arm 46 connected to one end of a lever 47, the other end of which is connected to a rod 48 secured to one face of the hydrostatic valve. The other side of the movable part of the servomotor is attached to a rod 49 connected to another rod 50 adapted to operate a bell-crank 51 or the like, which is operatively connected to a rod 52 adapted to operate the rudders 31 and 32.

When any diving or rising of the head or tail takes place the bell-crank 51 is operated to adjust the rudders to bring the paravane back to the desired depth line; on the same being reached the parts are restored to the normal equilibrium by means of the pendulum weight 39.

In the form of control illustrated in Fig. 3, a servomotor 38, a pendulum weight 39, and a hydrostatic valve, are used in conjunction with a water wheel 53 or the like, a pump 54, the water wheel and pump replacing the Venturi tube employed in the control mechanism shown in Fig. 2. The other parts of the mechanism operating the rudders are similar to that shown in Fig. 2.

In the form of control illustrated in Fig. 4 electrically operated means are employed in conjunction with the pendulum weight 39 and a hydrostatic valve. One face of the hydrostatic valve is connected by a link 55, to a contact arm 56, adapted to move over a series of contacts 57 so as to adjust the value of a current in electromagnets 58, 59, between which an armature 60 is mounted. The armature is carried on a rod 61 passing axially through the electric magnets and adapted to operate the rudders by the link 50, bell-crank 51, and rod 52 as in the controlling device above described.

The lower end of the contact arm 56 is attached to the pivoted arm carrying the pendulum weight 39.

Any diving or rising of the head or tail results in the armature 50 being attracted from one side or the other to adjust the rudders to restore the paravane to the said depth line. On this being reached, the parts are restored to the normal condition by the pendulum weight 39.

In the form of controlling device illustrated in Fig. 5, the rudders are dispensed with and the tail is provided with an air bladder 62 which is initially pumped up until the internal pressure equals the hydrostatic pressure at the set depth line. It may be observed that if the tail is too heavy for any particular position at which the paravane may be running, the paravane will rise, while if the tail is too light the paravane will dive. Consequently an expansion or contraction of the air bladder will result in the tail becoming more or less buoyant respectively so that any displacement from the set depth line will cause the weight of the tail to alter to restore the paravane to the set depth line.

Referring now to Figs. 6, 6A, which show

an improved form of explosive paravane for use against submarines, the improvements consist principally in the improved form of striker for firing the charge on impact against the submarine, the detonator gear, the method of anchoring the towing electric cable to the paravane, and in the provision of a control in the tail of the paravane.

According to the aforesaid specification the outer end of the striker rod is provided with fixed whiskers. These are open to the objection that if the impact on the submarine takes place near the extremity of the whisker the striker rod may tend to jam in its guide instead of moving inwardly.

According to the present invention the striker rod 63 is provided or formed with an outward extension 64 having a rounded slot or the like 65 through which pass whiskers 66 having the rear ends pivoted to lugs 67 secured to the nose of the paravane. It will be seen by this construction that on a whisker coming into contact with a submarine it will be turned on the pivot and will result in the force exerted, being substantially along the axis of the striker rod 63, so that the striker rod is moved inward. This inward movement fires the charge in the manner described in the aforesaid specification.

The towing cable 68 which is an armored electric cable is connected to an anchorage 69 in the head of the paravane. This consists of a plug 70 internally threaded and with an aperture in the lower face through which the inner core of the cable passes. A sleeve 71 is mounted on the armored part of the cable and carries an inner sleeve 72 adapted to rotate within the outer sleeve 71. The armoring of the cable is anchored in the following manner. Rubber buffers 73, a washer plate 74, a splicing bush 75 and a splicing ring 76 are fitted over the armoring, the splicing ring having a head or flange 77, formed with holes 78, through which the strands of the armoring are passed. The strands are then bent back as at 79 against the outside of the ring. The bush 75 and ring 76 are formed with divergent and convergent adjacent surfaces. On the required parts being assembled on the towing cable, the outer sleeve 71 is screwed into the plug 70 and when fully home all the parts are locked together, the adjacent surfaces of the bush and ring securely clamping the strands of the armoring. The head of the outer sleeve is preferably made of polygonal shape to receive a lock nut 80 adapted to fit over the head of the sleeve and to be retained in place by an eye bolt 81 screwed into the plug 70. When this has been done the rotation of the outer sleeve 71 is prevented, while rotation of the inner sleeve is still possible, the rubber buffers preventing vibration and chafing of the cable within the sleeve. This form of anchorage enables the towing cable and paravane to rotate relatively to each other, and at the same time prevents any slacking back of the outer sleeve.

The detonator inserting and withdrawing gear is adapted to be operated by the water pressure as in the aforesaid specification. The water flap 82 operates a plunger 83 and pivoted arm 84 which is connected to one end of a divided rod 85, connected at the other end to a sliding block 86, carrying the detonators 87 and mounted on two guide rods 88 secured to a flanged ring 89, covering the primer tube 90 and secured to a bulkhead 91, carrying the charge case 92. The rod 85 is threaded for a desired distance each side of the point of division, and connection is made between the two parts by one or more threaded sleeves 93 so that adjustment of the length of the rod 85 is possible.

The charge case 92 is secured at the detonator end by bolting the bulkhead 91 to a flanged ring 94 secured to the paravane shell, and is supported at its other end by a flanged ring 95.

The explosive paravane is provided with a control device which may be of any of the forms described with reference to Figs. 1, 1A, 2, 3, 4, 5 and 7.

As shown in Fig. 6A, the control device comprises a hydrostatic valve 96 adapted to operate a single rudder 97. The arrangement of the hydrostatic valve 96 is broadly similar to the hydrostatic valve above referred to the mechanical connection between the valve and the other parts of the controlling device hereinbefore described being now dispensed with.

The hydrostatic valve rod 98 carries a block 99 operating one end of a bell-crank lever 100, the other end of which is linked to the rudder 97. A second rudder 101 is provided, with a screw adjusting device similar to the rudder 31, to permit the rudder 101 to have any initial adjustment relatively to the rudder 97.

The combined explosive and protector paravane is formed of a head portion as illustrated in Fig. 1, provided with the firing gear shown in Fig. 6, a body portion as shown in Fig. 7, a tail portion as shown in Fig. 1A, and a central device as shown in Figs. 1, 1A.

In this form the charge case and detonator of similar construction to that shown in Figs. 6, 6A are arranged in the body portion, so as to be nearer the head than in the explosive paravane shown in Figs. 6 6A, such as by arranging the charge case forward of the water flap instead of aft, as shown in Figs. 6, 6A.

The plunger 83 operated by the water flap 82 is connected directly to the divided rod 85, the detonator carrier 87 being mounted on guide rods 88, similar to the arrange-

ment shown in Figs. 6, 6A, similar parts of the Figs. 6, 6A and 7 being referred to by the same reference numerals.

With this combined explosive and protector paravane, the same paravane may be used either as a sweep for submarines, or for a protection for ships when traveling in mined waters, so that a vessel fitted with this form of gear can perform the dual functions.

With explosive paravanes as hitherto constructed, firing was possible on the striker rod or whiskers coming into impact with a submarine, or by a dynamometer switch on the strain in the towing cable exceeding a predetermined amount, or at the will of the operator by closing a switch. If therefore an explosive paravane should collide, when broadside on with a submarine, the paravane may be deformed and either disturb the electrical circuits to render firing impossible, or may become free of the submarine, before the dynamometer switch gear is brought automatically into operation, or before the operator is able to close the switch, or is aware of contact between the explosive paravane and the submarine having taken place.

To insure the automatic firing of the explosive paravane when deformed by impact with a submarine, there is provided at one or more positions along the paravane, a device as shown in Fig. 8, consisting of rods or the like 102 carried on rings 103 on the inside of the shell of the paravane, and having the inner ends arranged adjacent contact strips or plates 104, the rods and strips being connected in circuit with suitable leads 105 to the firing circuit, so that on the shell of the paravane being deformed, the rods and strips engage with one another to close the firing circuit.

Referring now to the protector paravane illustrated in Figs. 9 and 10, which is especially suitable for vessels having the power available for towing these bodies the paravane is formed with a rounded forward end 106, a cylindrical body 107, and a tapering tail portion 108. The depressing plane 2 is supported from the underside of the paravane by a bracket 109, and from a stirrup or the like 110 bolted to the paravane as at 111. This stirrup supports the cutting device hereinafter described and a tow anchorage for the towing cable. The head portion is conveniently provided with a guard secured to the head and to the extremities of the plane to prevent the mooring of a mine from engaging with and being towed by any part of the head or the plane of the paravane. The tail portion of the paravane is provided with a hydrostatic control device 112, which is adapted to operate a pair of rubbers 113, pivotally mounted to the main tail fin of the paravane. The hydrostatic control device consists of a hydrostatic valve, the spindle 114 of which carries a block 115, which is connected to cranked rods 116 pivoted to lugs 117 on the rudders 113. The operation of this control is similar to that previously described in which a hydrostatic valve is employed.

Referring now to the cutting devices employed, two types are shown on the drawings namely, that shown in Figs. 1 and 9, and that shown in Fig. 11.

The cutting device illustrated in Figs. 1 and 9 consists of brackets or housings 118, 119, secured to a block 120 attached to the head of the paravane in any suitable manner, the brackets or housings receiving removable cutter blades consisting of two converging saw toothed or serrated steel blades 121. The jaw of the cutting device is outwardly flared so as to give a good lead to the mooring rope of a mine toward the cutter blades.

The upper and outer extremity of the block 120 is provided or formed with an eye plate 122 to which a tow anchorage 123 is shackled. This tow anchorage consists of a stream line sleeve 124 having a central bore, provided with rubber buffers 125, and a cup 126, coned internally. The strands of the towing cable are opened out and then bent back on themselves. If desired the inner strands may be removed, for any desired distance. The coned cup is then pushed up until all the wires are inside and the interior filled with liquid metal such as white metal. Resin is preferably added to the cup, to prevent sticking of the white metal to the same, so that the coned shaped pudding 127 on the end of the cable is free to rotate in the cup.

The sleeve 124 is screwed on to a plug 128 which is secured by a bolt 129 to a shackle 130 which in turn is secured by a bolt 131 to the eye plate 122 the two bolts being arranged at right angles so as to permit of universal movement between the tow anchorage and the cutter block, of the paravane. The end of the sleeve 124 remote from the anchorage is cut at an incline to permit the mine mooring passing readily from the towing cable to the anchorage without encountering any obstructions, the other end of the anchorage being arranged and constructed to prevent any obstruction arising to the passage of the mooring of the mine along the anchorage into the cutter jaws. If desired to prevent the turning movement of the plug 128 resulting in a portion of the plug abutting against the jaw of the shackle 130 to splay the same outward and cause an obstruction to the passage of the mooring rope of a mine the plug and shackle may be formed with inclined or cam shaped surfaces, thereby to limit the relative movement of the two parts.

On the mine mooring entering the cutter it is drawn into the converging jaw, and the drag due to the weight of the sinker and the forward movement of the paravane severs the mooring, to allow the mine to rise to the surface.

The form of cutter above described may be employed attached to a wire or other support or may if desired be used in conjunction with submarines, a wire or other guard being secured to the bows and taken to the extremities of the forward hydroplane and another set taken from the after part of the submarine to the extremities of the after hydroplane, and the connection between the guard and the hydroplane cutter in the form above described may be employed thereby preventing the moorings of mines being caught on the hydroplanes and towed by the same with the possibility of the mine being fired in close proximity to the hull of the submarine, and the mine moorings are led into the cutters and are severed.

The other form of cutting device shown in Fig. 11 comprises two cutting blades with knife edge or serrated cutting edges one or both of which are pivoted and are operated pneumatically to cut the mine mooring on the same entering the cutter jaws.

In this form a cylinder 132 of compressed air is carried in the paravane, to operate a spring plunger 133 carried in a cylinder 134 mounted in the head of the paravane. A supporting block 135 is secured to the head of the paravane and carries a fixed cutting blade 136 and a pivoted cutting blade 137 which is operated by an arm 138 connected to one end of the rod 139 of the plunger 133.

Adjacent to and projecting beyond the outer end of the cutter jaw is arranged an arm 140 adapted to operate a valve 141 in the air supplying cylinder.

The towing cable is connected to the upper portion 142 of the cutter block 135, and on the mine mooring traveling along the towing cable and engaging the cutter block, on entering the jaw of the cutter it trips the arm 140 to open the valve 141 and admit air into the cylinder, to operate the plunger and force the pivoted cutting blade toward the fixed blade, thereby to sever the mooring of the mine.

Referring now to the deflector paravane, the head portion only is shown in Figs. 12 and 13, the remainder of the paravane comprising the body, tail, and controlling device being substantially the same as that previously described.

The improvement in this type of paravane over the construction as comprised in the aforesaid specification resides in the means for slipping the mine.

When a mine mooring is engaged by the towing cable of a paravane two things happen; the paravane moves in toward the ship and the mine is pushed farther away. The total effect will vary according to the size of the paravane as compared with that of the mine and sinker, the mine and sinker exerting their maximum pull when both are moved bodily outward, and a minimum pull when the sinker does not move at all. In general a nip is formed in the mooring of the mine which may be sufficiently sharp as to hinder the transference of the mooring of the mine from the towing cable to the paravane.

The present invention comprises means whereby the nip of the mine mooring is transferred to a gradually diverging device whereby the mine mooring is, as it were, straightened out sufficiently to allow of easy slipping of the mooring. This is effected by securing to the head 1 of the paravane one or more depressing planes 2′, the ends of which are connected to two converging side members 143 preferably of stream line form, which are united at the apex. An eye plate 144 is provided at the apex to which the towing cable is shackled preferably through the medium of a tow anchorage constructed as above described. The side members 143 are provided, if necessary, with additional planes 2^2, to bind the same together and to keep the paravane well down.

In operation, on the mooring rope traveling down the towing cable, the nip is transferred to the apex of the device above described without any appreciable alteration in the nip, which then travels down the divergent side members and so is gradually opened or straightened out until at the end it is able to slip freely away, while at the same time it has been moved away farther from the ship.

Referring now to depressor paravanes illustrated in Figs. 14 to 16, the same consists of a buoyant stream line body or float 145 connected to a depressing plane 146, which is preferably provided with rudders 147 which may be operated by a control mechanism comprising a combined hydrostatic valve and gravity system as described with reference to Figs. 1, 1^A. The control mechanism may, if desired, be omitted and the rudders given any initial setting and then secured in place; the plane in this case may be a cambered plate.

A towing eye 148 is provided on a member 149 which is connected by stays 150, 151 respectively, to the plane or plate 146 and the float 145.

The depressor paravane may be arranged to carry an explosive charge and be towed by an electric cable whereby it may be em-

ployed as a weapon of offense against submarines.

Further, the depressor paravane may be provided with a cutting device similar to that hereinbefore described whereby the mine mooring may be severed.

Further, the towing cables of the deflector or protector paravanes may be brought to a member at the stem of the ship, which member is connected to the depressor paravane, whereby the points of tow at the stem of the ship can be kept well down.

The depressor paravane is towed from the stern of the ship and by its construction keeps well astern and low down, so that any mines which may be missed by the paravanes at the bows will be caught by the depressor, so that no mine will be left within the area of sweep of the paravanes, to be a source of danger to the ship following behind on the same course.

Referring now to the improved construction of dropping davits illustrated in Figs. 17 to 21, the tongs 152 are provided with a pivoted strap or the like 153 adapted to be secured to a lug 154 on one of the tongs such as by bolt and wing nut so as to form a complete closure of the tongs thereby preventing any accidental dropping, when the paravane is in the same. When the paravane is to be dropped, the wing nut is slacked off and the strap can then drop free.

Also to assist in picking up the paravane a shackle 155 is provided on a wire 156 passing over a pulley 157, on the end of the jib of the davit to a small hand operated winding drum 158.

Further, to support the tail of the paravane to prevent the possibility of injury to the same owing to the tail dropping at such times as the head is either carried by or is about to be inserted in the tongs of the davit an arm 159 is pivoted at one end to any suitable part of the davit and the other end engages in a block 160 carried by a pivoted arm 161 secured to the head of the davit. The arms 159 and 161 can therefore be folded up against the davit or drawn out for use, as required.

The dropping davit may either be provided with a runway as described and shown in the aforesaid specification, or may be of a rotary type, such as illustrated in Figs. 17 and 18. In this case the bed 162 of the davit is provided with a turn table rotated by toothed gearing 163, from a hand-wheel 164. The jib 165 of the davit is raised and lowered by the segmental rack 166 and toothed gearing from a hand-wheel 167 in a manner similar to that described in the aforesaid specification.

The operating mechanism for the tongs may be of a similar character to that described and shown in the aforesaid specification comprising a firing bar 168 with double wedges 169 and 170 and operated by a collar 171 connected to linkwork 172, operated by a rod 173 controlled by a hand lever 174, which is pivoted on the jib and is provided with means for locking it at any desired position.

As an alternative to the firing bar and double and double wedges the tongs may be operated by a system of toggles controlled by the rod 173, such form being illustrated in Figs. 19 and 21. The rod 173 is connected to a link 175 mounted on a pivot 176 and connected to another link 177 adapted to operate a link 178 to rotate a shaft 179 carrying at its ends arms 180 which are connected to studs or the like 181 mounted in guides 182. The studs 181 are pivotally connected to spreader arms 183 the outer ends of which are pivotally mounted to the upper ends of the tongs. On the rod 173 operating the toggle mechanism the studs 181 move up and down the guides 182 to operate the spreader arms 183 to open or close the tongs.

In the aforesaid specification, the winches proposed for use with the paravanes were of a hand operated type, those for employment with the submarine sweep or explosive paravane, being provided with dynamometer switch gear and adapted to effect the firing of the charge on the strain of the towing cable exceeding the amount governed by the dynamometer. It has been found that to get a paravane in to the ship when travelling at normal speed, a hand operated winch is inadequate, so that either the ship must be slowed down until the outward thrust of the paravane is small, or a power winch must be employed. The slowing down of the ship is undesirable in that it becomes an easy target for enemy submarines, so it is preferable to install power winches.

With such steam winches it is preferred to provide a geared brake drum provided with a band brake operated by hand.

Referring now to Figs. 22 and 23 which show a construction of winch arranged at the bows of the vessel for use in conjunction with two chains or the like for use in hauling up or paying out the towing cable of the paravane, the winch comprises two worms 184, 185, meshing with worm wheels 186, 187, respectively. The worm wheel 186 is keyed to a shaft 188 which is also keyed to a chain or like wheel 189. The worm wheel 187 is keyed to a sleeve 190 mounted on the shaft 188, and carrying a chain or like wheel 191 similar to the wheel 189. The worms 184, 185, are driven in opposite directions, so that the chain or like wheels 189 and 191 rotate in opposite directions. The chains passing over these two

wheels, are connected to a swiveling device 192 shown in Fig. 30, carrying an eye plate 193, to which the towing cable of the paravane is shackled.

The chain indicated by 194 will be referred to as the uphaul chain and the chain 195 will be referred to as the downhaul chain. It will be seen that by slacking off the down-haul chain and winding up the up-haul chain the eyeplate 193 will be hauled up, while by slacking off the up-haul and winding in the down-haul chain the eyeplate 193 will be taken down, and on reaching its desired downward position, by braking or otherwise preventing the winch from rotating the eyeplate will be kept in position, to keep the point of tow down at the desired position.

Referring now to the ship's fittings shown in Figs. 24 to 29, the kind illustrated in Figs. 24 to 26 comprises a plate or the like 196 carrying a sheave 197 and secured to a pivoted outrigger 198, which can be raised or lowered by the chains, cables or the like 199, 200, secured to any suitable part of the ship. The towing cable 201 of the paravane passes around the sheave 197 or is connected to another cable or wire passing around the sheave, the cable or the like then passing either directly to a fair lead on the ship or by way of a fair lead or sheave 202, to any suitable winding or retaining device.

Referring now to Figs. 27 to 29, each paravane is controlled by two chains 203, 204 in the manner hereinbefore described with reference to Figs. 22, 23. The chains pass through suitable eyes 205 in a clump piece or like projecting member 206 fitted to the forefoot of the ship, said chains being provided with an eyeplate similar to the eyeplate 193 shown in Fig. 30, to which the towing cables of the paravanes are shackled. By slacking off one of the chains and winding in the other the towing cables of the paravanes can either be brought on board or be let down.

When towing paravanes at moderately high speeds with a circular section towing wire, the eddy formations set up are found to cause intense vibration of the towing cable, which greatly fatigue the metal and ultimately break down its structure. To minimize vibration the cable is so constructed as to have the cross section of triangular shape.

According to one method, three wires are taken and stranded together to form one strand; three of such strands are then stranded up to form a compound strand; and three of such compound strands are stranded up to form the towing cable. Of course, if desired, the method may be repeated as often as desired to get the cable of the desired thickness, it being evident that the number of wires in any cable formed by this method is 3^N where N is the number of times stranding has taken place.

According to another method three wires are stranded about a central wire or core to form a compound strand. A number of these strands are then built up into a cable of triangular section. The cable so formed is then bound around with one or more layers of wire.

What I claim and desire to secure by Letters Patent of the United States is:—

1. In paravanes and other bodies of the kind referred to having a dynamic reaction surface or plane, a control device independent of the said plane, adapted automatically to bring back the paravane to the set depth line in the event of its becoming displaced from the predetermined depth but without alteration to the lift-drift ratio due to the dynamic reaction surface or plane.

2. In paravanes and other bodies of the kind referred to, having a dynamic reaction surface, an adjustable rudder, a hydrostatic control device comprising a hydrostatic valve adapted to operate the said rudder on the paravane leaving the set depth line as governed by the setting of the hydrostatic valve.

3. In paravanes and other bodies of the kind referred to, having a dynamic reaction surface, an adjustable rudder, a hydrostatic valve adapted to operate said rudder, a piston operating the hydrostatic valve and a gravity device employing mercury which acts upon the said piston to effect control of the hydrostatic valve and rudder, for the purpose specified.

4. In paravanes and other bodies of the kind referred to, having a dynamic reaction surface, a combined gravity and hydrostatic control device comprising a pair of pistons on a common rod, chambers containing the said pistons and connected by a common duct encircling the aforesaid rod and containing a liquid of such specific gravity, a hydrostatic valve connected to one of the pistons and a rudder normally held in position by the hydrostatic valve and operated on the paravane leaving its set depth line by the movement of the gravity and hydrostatic control device.

5. In paravanes and other bodies of the kind referred to, having a dynamic reaction surface or plane, a control device independent of said plane adapted automatically to bring back the paravane to the set depth line when displaced therefrom, and a rudder provided with an adjusting device by which it is given any desired initial setting.

6. In a body adapted to be towed through water and provided with a dynamic reaction surface which causes it to tow outwardly, a cutting device for mine sweeping

and like purposes comprising two blades with serrated edges and a support for the blades forming an inwardly converging jaw, the outer end of which is shaped to lead the member to be severed between the cutting blades.

7. A body to be towed from a ship comprising a rounded end provided with a depressing plane and a cutting device, a cylindrical body portion and a tapering tail portion provided with a rudder and a hydrostatically operated device controlling the said rudder, for the purpose specified.

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