SUBFLOATING MINE

Filed Jan. 24, 1944 9 Sheets-Sheet 1

FIG. 1.

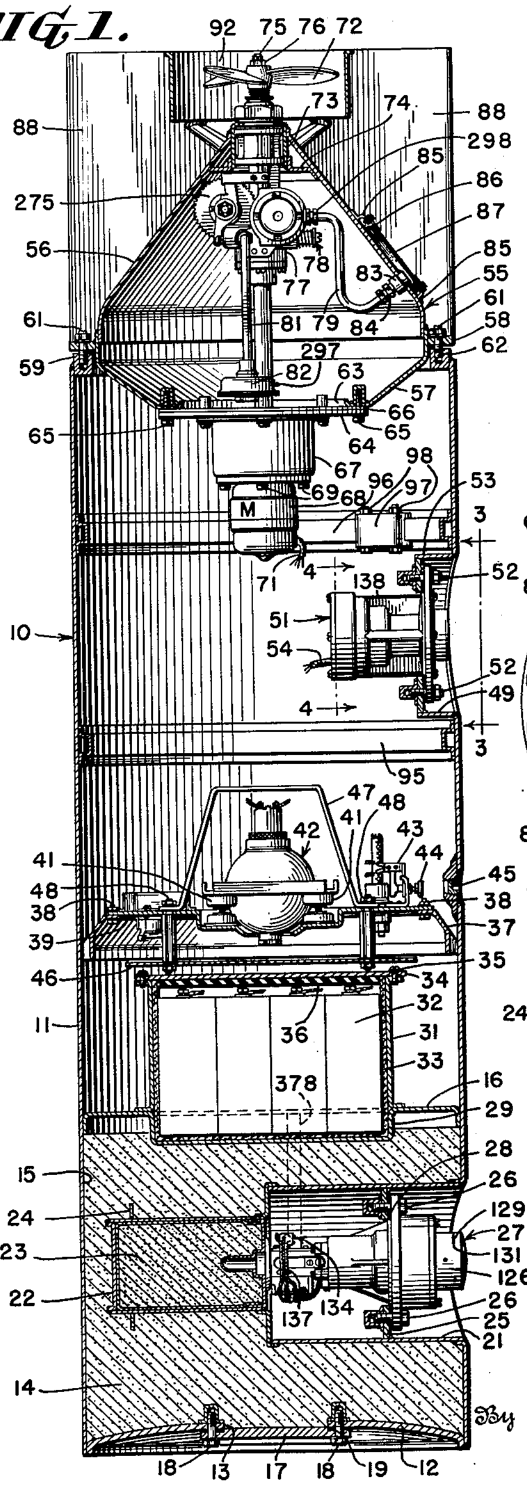



FIG. 2.

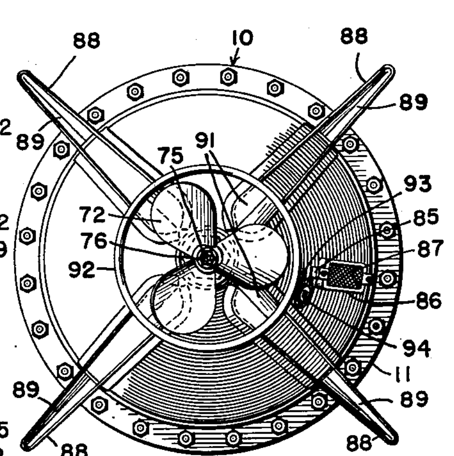
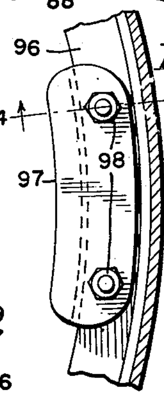



FIG. 23.



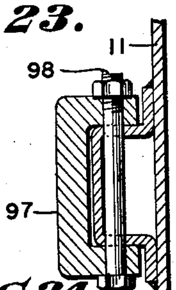




FIG. 24.

Inventors
J. D. Turlay
R. W. Townsend
By [signature]
Attorney

SUBFLOATING MINE

Filed Jan. 24, 1944

9 Sheets-Sheet 2

FIG. 3.

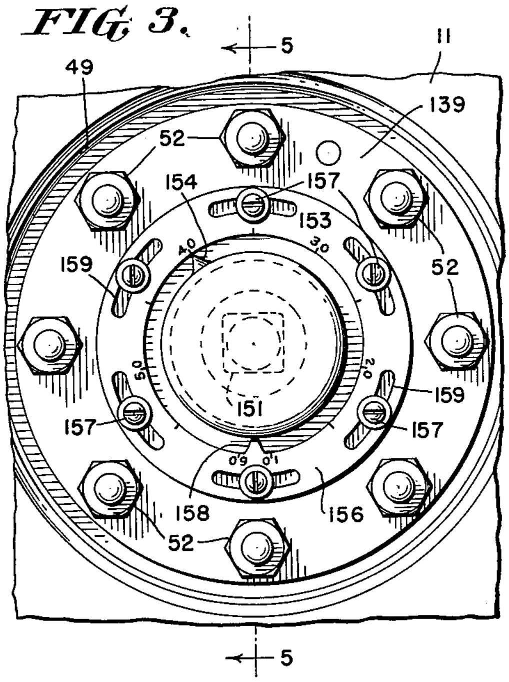



FIG. 4.

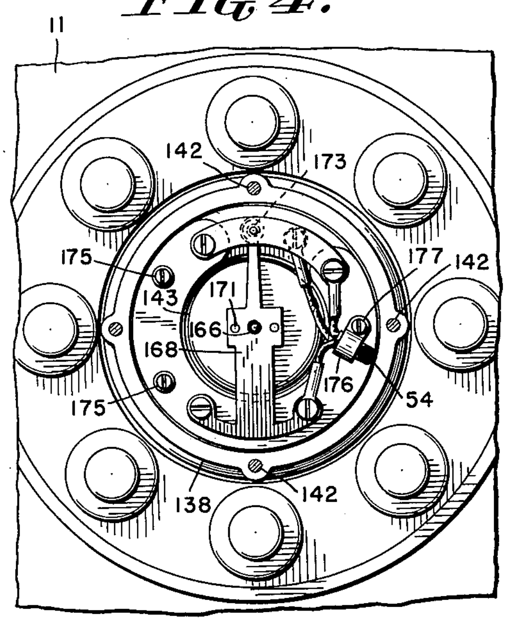



FIG. 5.

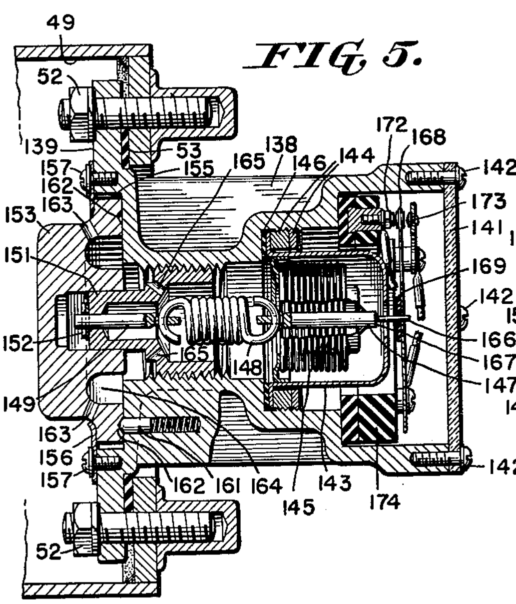
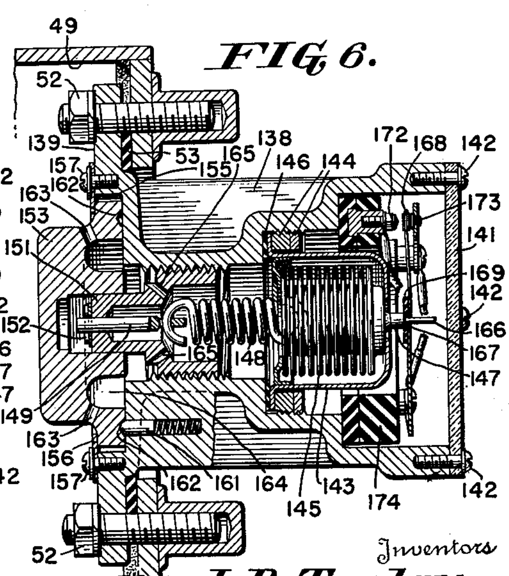



FIG. 6.




Inventors
J. D. Turlay
R. W. Townsend

By [signature]

Attorney

SUBFLOATING MINE

Filed Jan. 24, 1944 9 Sheets-Sheet 3

FIG. 7.

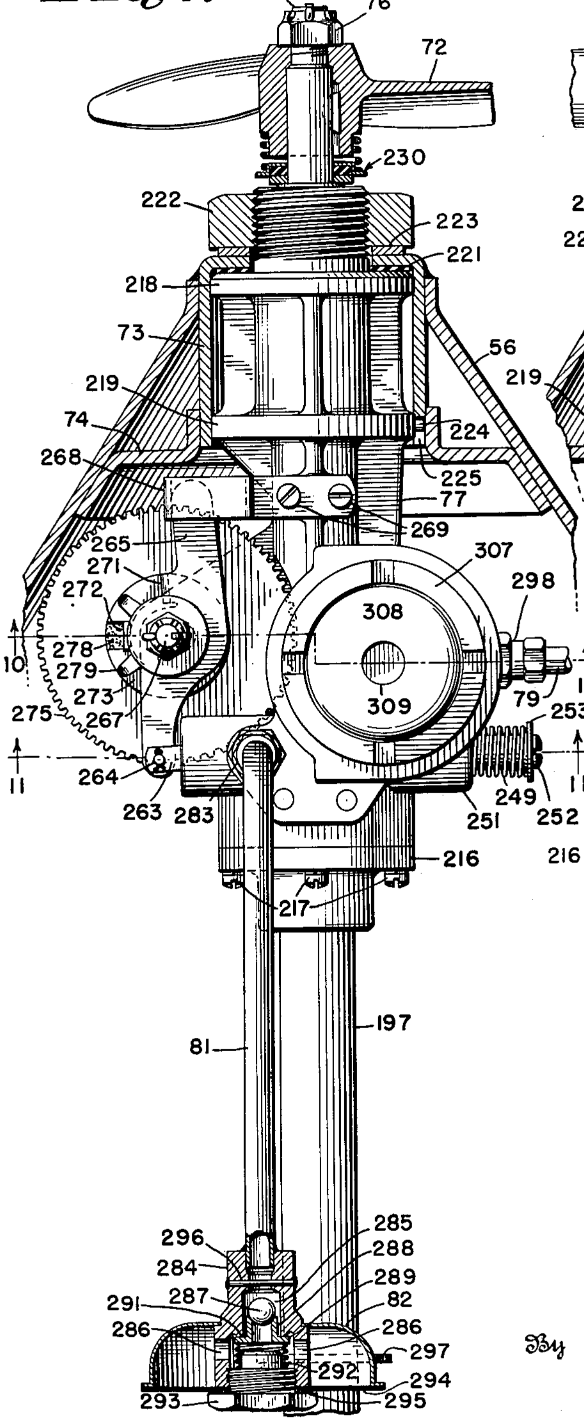
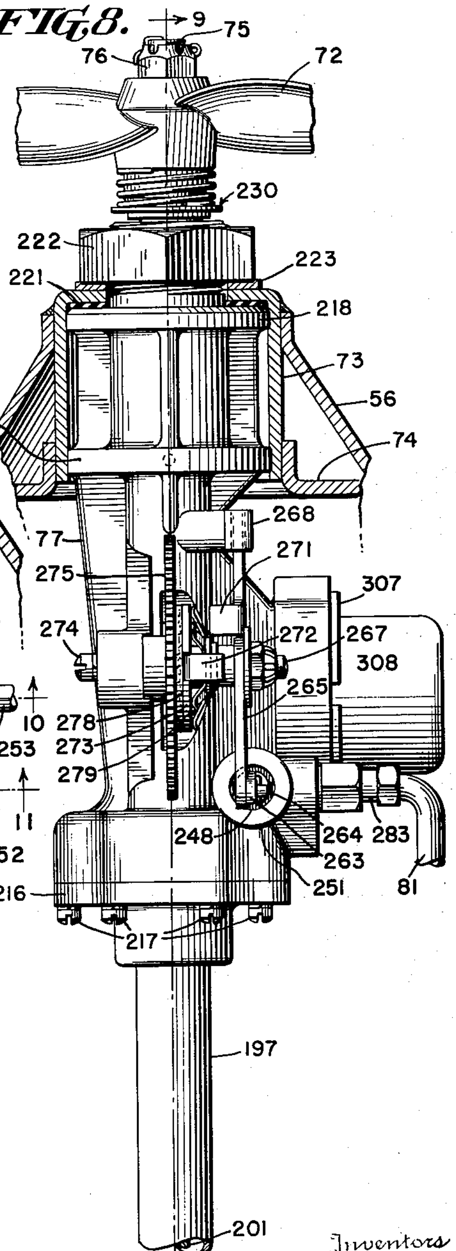



FIG. 8.




Inventors

J. D. Turlay
R. W. Townsend

By [signature]
Attorney

SUBFLOATING MINE

Filed Jan. 24, 1944 9 Sheets-Sheet 4

FIG. 9.

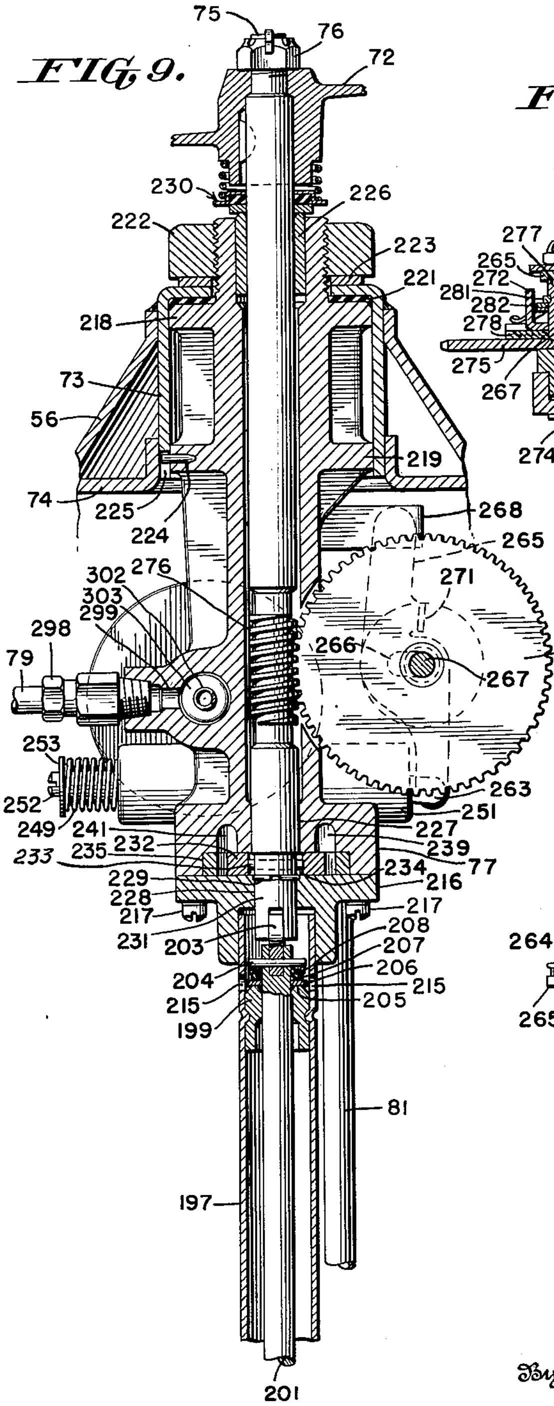



FIG. 10.

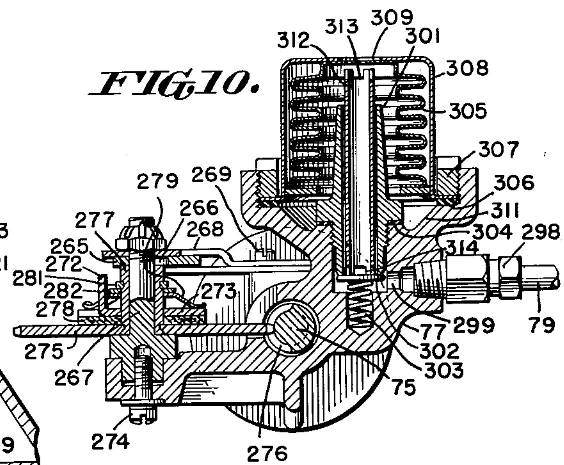
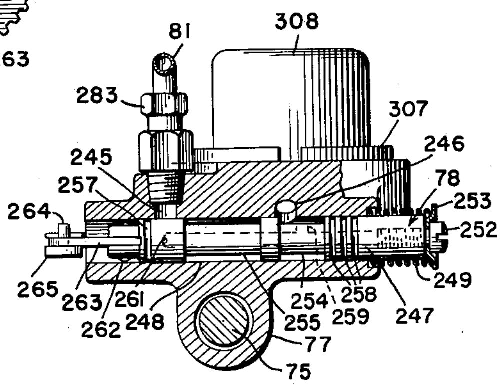



FIG. 11.




Inventors
J. D. Turlay
R. W. Townsend

By [signature]
Attorney

SUBFLOATING MINE

Filed Jan. 24, 1944 9 Sheets-Sheet 5

FIG. 12.

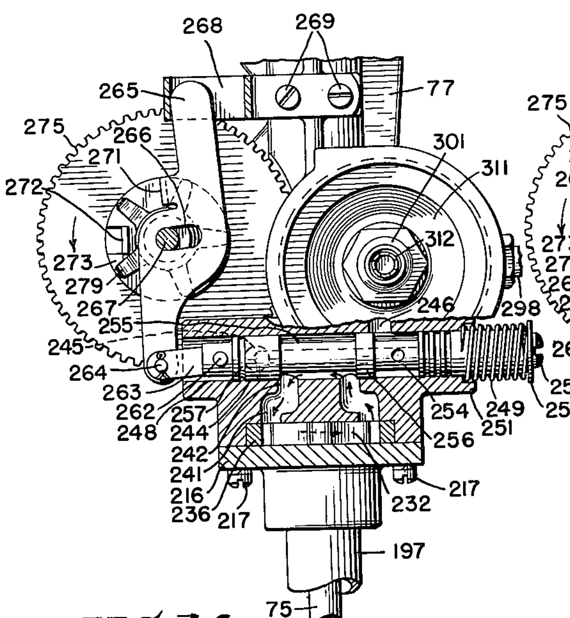



FIG. 13.

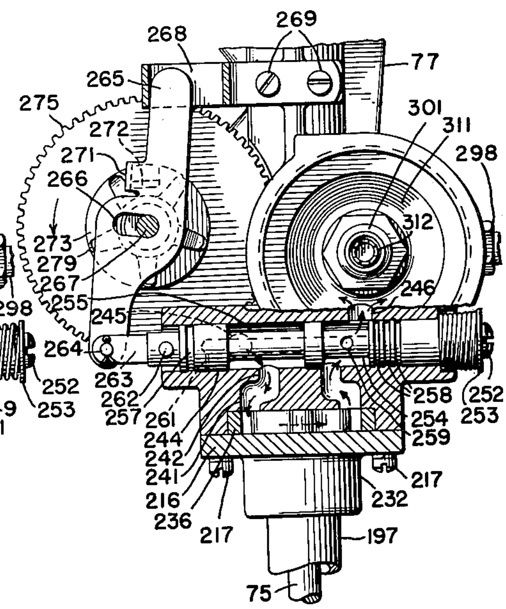



FIG. 14.

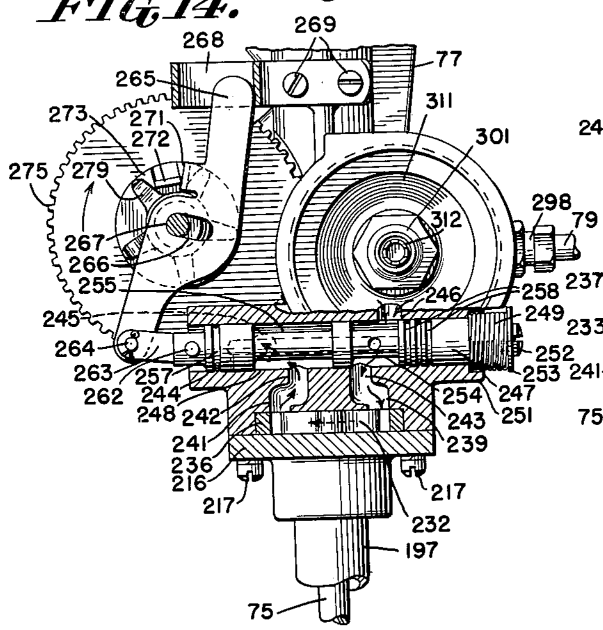
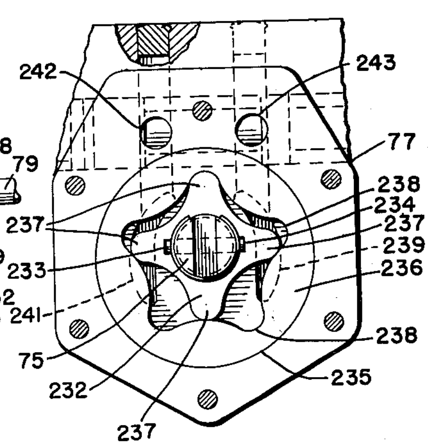



FIG. 15.




Inventors
J. D. Turlay
R. W. Townsend

By [signature]
Attorney

SUBFLOATING MINE

Filed Jan. 24, 1944 

FIG. 16.

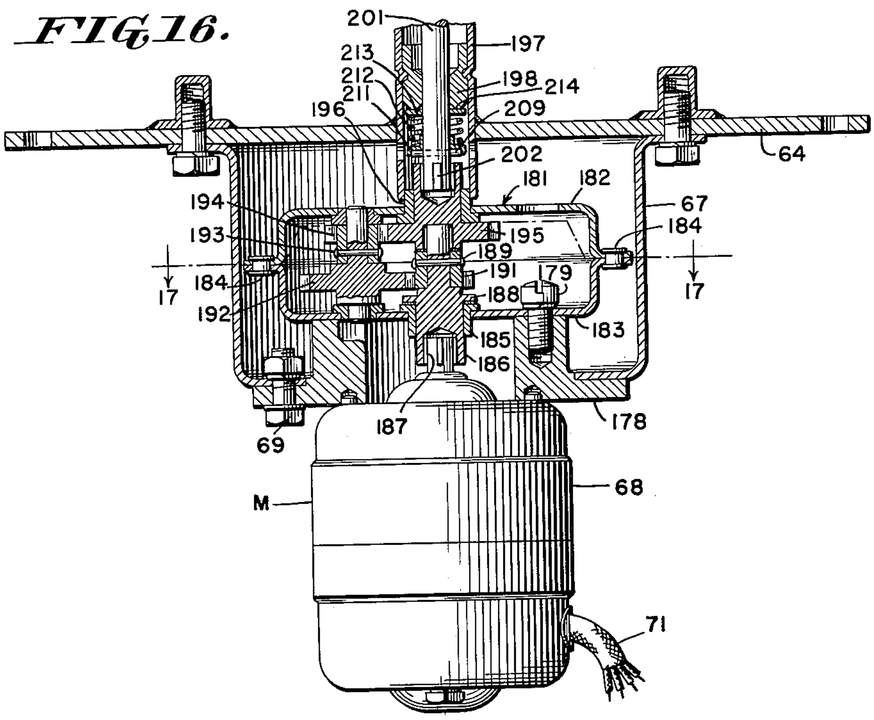
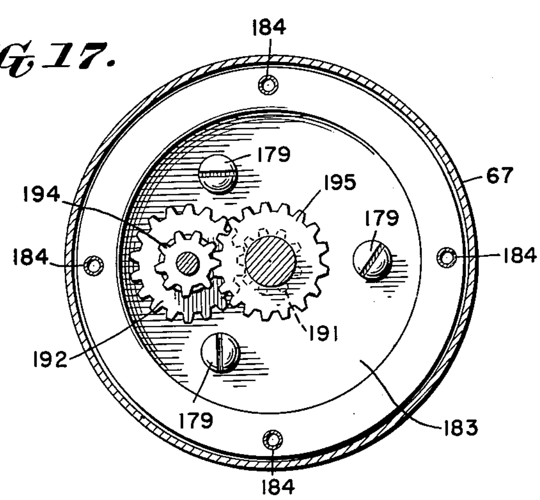



FIG. 17.




Inventors
J. D. Turlay
R. W. Townsend

By [signature]
Attorney

Dec. 5, 1961 J. D. TURLAY ET AL 3,011,438

SUBFLOATING MINE

Filed Jan. 24, 1944 9 Sheets-Sheet 7

FIG. 18.

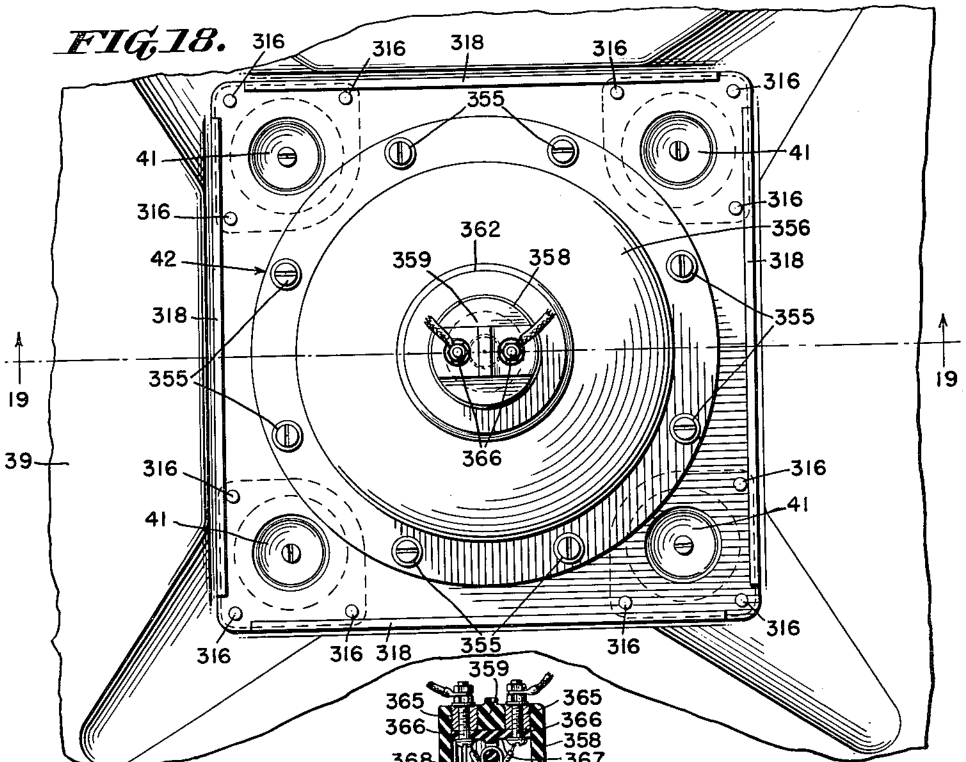


FIG. 19.

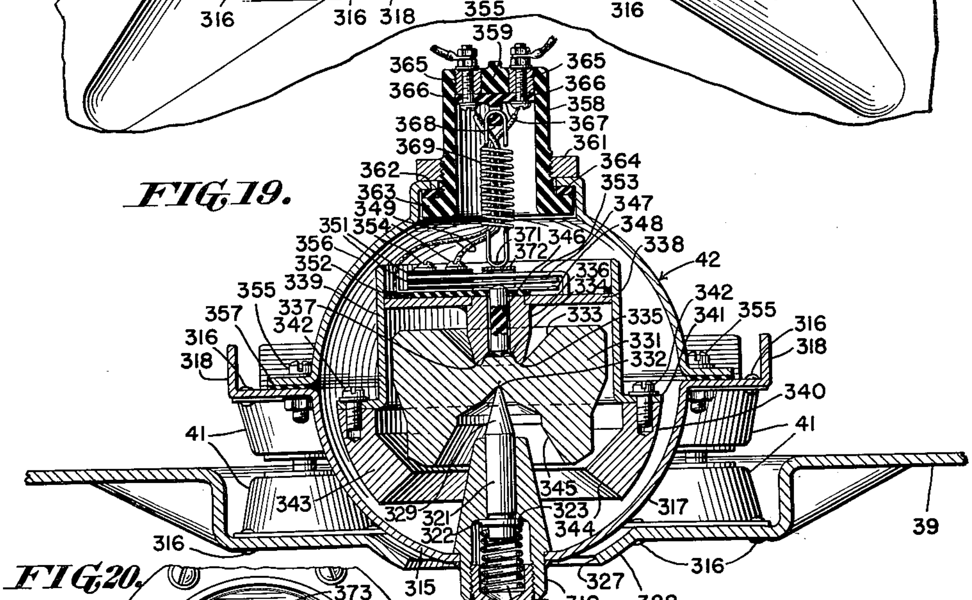
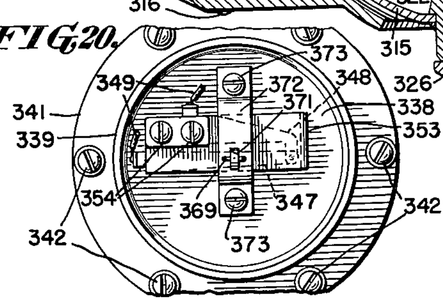


FIG. 20.



Inventors
J. D. Turlay
R. W. Townsend

By [signature]
Attorney

Dec. 5, 1961 J. D. TURLAY ET AL 3,011,438

SUBFLOATING MINE

Filed Jan. 24, 1944 9 Sheets-Sheet 8

FIG. 21.

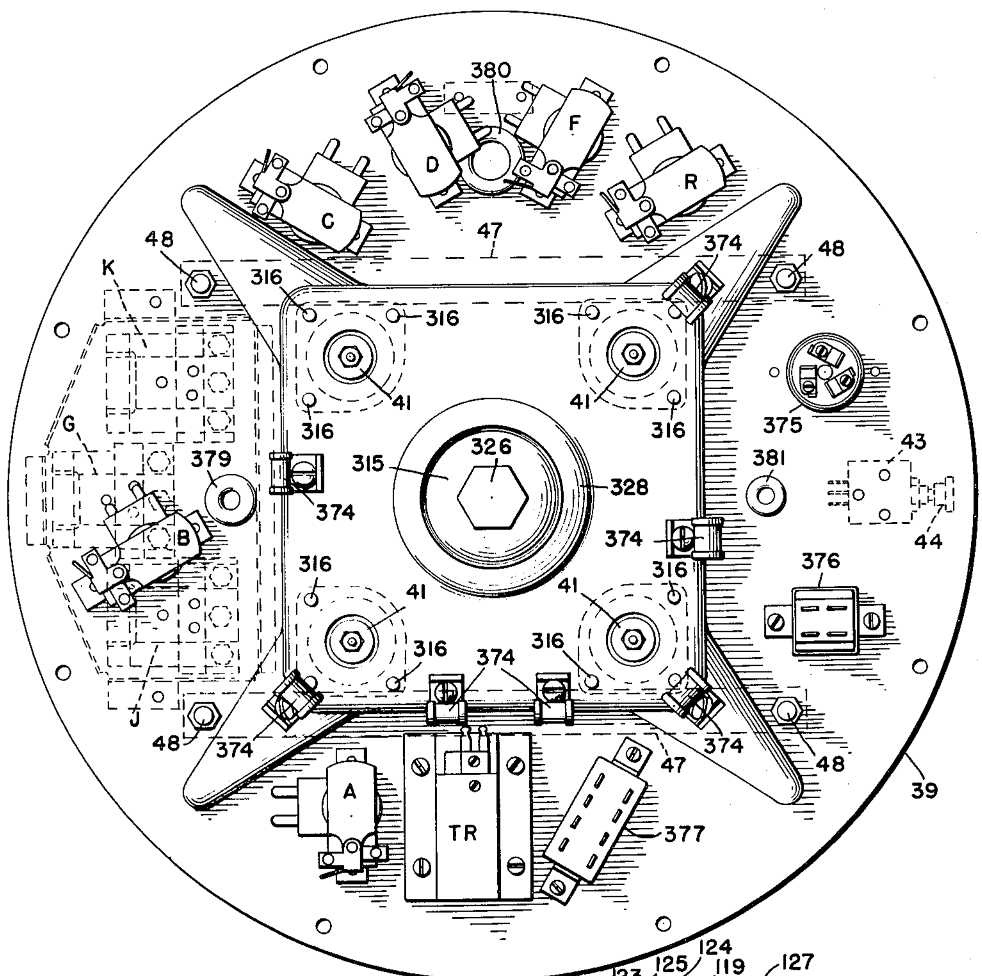
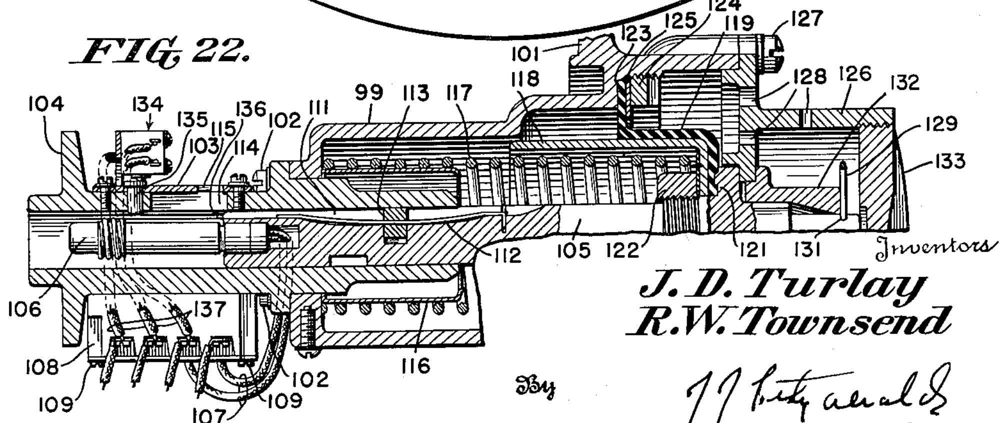



FIG. 22.




Inventors
J. D. Turlay
R. W. Townsend

By [signature]
Attorney

Dec. 5, 1961 J. D. TURLAY ET AL 3,011,438

SUBFLOATING MINE

Filed Jan. 24, 1944 9 Sheets-Sheet 9

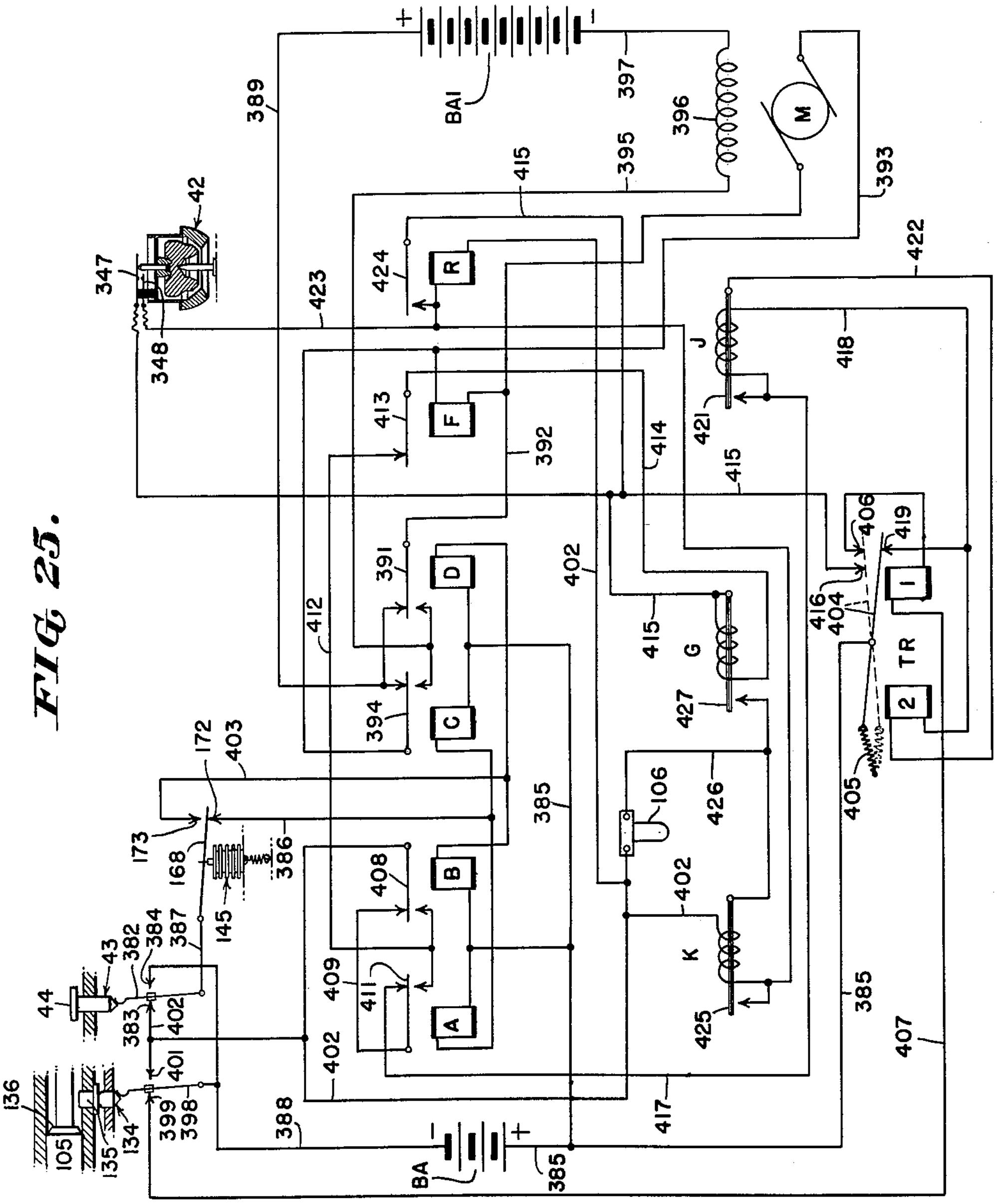


FIG. 25.

Inventors
J. D. Turlay
R. W. Townsend

By

Attorney

United States Patent Office

3,011,438

Patented Dec. 5, 1961



3,011,438

# SUBFLOATING MINE

Joseph D. Turlay, 4536 N. Chelsea Lane, Bethesda, Md., and Richard W. Townsend, 10 Milmarson Place NW., Washington, D.C.

Filed Jan. 24, 1944, Ser. No. 519,418
19 Claims. (Cl. 102—14)
(Granted under Title 35, U.S. Code (1952), sec. 266)

This invention relates to improvements in automatic depth regulating devices for a freely subfloating mine and inertia controlled means for firing the mine in response to a shock or lateral movement of predetermined character received thereby. More specifically, the invention relates to a freely subfloating mine having a new and improved depth regulating device for controlling the depth of submergence thereof in which the mine, after having been launched within a body of water, is caused to oscillate by electrical propulsion at a predetermined depth of submersion and the specific gravity thereof is adjusted automatically to the specific gravity of the surrounding water, in which the arming of the mine is delayed until a predetermined degree of adjustment of the specific gravity thereof has been effected, and in which an inertia controlled mechanism is employed to fire the mine in response to a shock or sustained lateral movement of predetermined character received by the mine.

It has been the general practice in devices hitherto proposed for effecting an oscillating movement of a subfloating body to adjust the specific gravity of the body to a value either greater or less than the specific gravity of the surrounding water, as the case may be, and to employ a screw propeller controlled by a hydrostat for reversing the movement of the subfloating body caused by the unbalanced condition of the specific gravity thereof. Still another device of this general character such, for example, as the Depth Regulating Device for Subfloating Bodies described and claimed in the copending application of Charles Moon and Raymond L. Driscoll, Serial No. 425,718, filed January 6, 1942, provides an arrangement in which the volume displacing mechanism is set into operation only when a predetermined number of revolutions of the screw propeller have been made and in which the specific gravity of the subfloating body is adjusted progressively by increments during successive oscillations of the body until the specific gravity of the body has been brought to equality with the specific gravity of the surrounding water.

The device of the present invention provides means for causing a subfloating body to oscillate by impulses received from a screw propeller during the time the body has passed the upper and lower control levels of oscillation respectively, in which the specific gravity of the body is automatically adjusted to the specific gravity of the surrounding water by varying the quantity of ballast fluid within a ballast chamber while the screw propeller is in operation and in which the ballast fluid propelling mechanism is continuously operated during the entire time the screw propeller is rotating, means being provided for rendering the fluid propelling mechanism ineffective to cause a change in the specific gravity of the body until a predetermined number of revolutions of the screw propeller has been made following a reversal in the direction of rotation of the propeller. Furthermore, the device of the present invention is adapted to reduce both the amplitude and frequency of oscillation of the body and the drain on the source of power as the specific gravity of the mine is adjusted to the specific gravity of the surrounding water during successive oscillations of the body.

It has been found that the density of the water varies in accordance with the depth of the water from the surface thereof, the water increasing in density as the distance from the surface of the water is increased. It is thought that this increase in density is due, generally, to the effect of temperature of the water, the water near the surface usually being warmer than water at a greater depth and, since the temperature of a body of water is continually changing as the result of tidal currents or changes in climatic conditions and differences in atmospheric temperature such, for example, as occurs between the conditions of day and night, it has been found necessary to provide means for continually compensating for the changes which occur in the temperature of water from any of the above causes, and for changes in density due to the degree of salinity of the water in order that a subfloating body may be maintained in a state of oscillation about a predetermined depth of submergence therein with a minimum consumption of energy required to maintain such oscillation.

The system of the present invention is particularly suitable for use with a marine mine of the type adapted to be planted from an aircraft in flight in which the firing of the mine is brought about by an electroresponsive detonator adapted to be moved to an operative position with respect to an explosive booster charge by the pressure of water against a hydrostatically controlled extender device operatively connected thereto and in which the premature movement of the detonating device from a safe position is prevented prior to the planting of the mine by an arming wire having one end thereof secured to the aircraft and adapted to be detached from the hydrostat device as the mine falls away from the aircraft. When the pressure of the surrounding water has been increased sufficiently to cause the detonator to be moved to an armed position with respect to the aforesaid booster charge, a switch mechanism is actuated by the detonator extender mechanism thereby setting into operation a motor controlling the screw propeller and volume changing mechanism and thereby causing the mine to be set into oscillation about predetermined limits of depth control. The propelling mechanism has connected thereto a pump adapted to force a fluid outwardly from a closed container within the mine or to cause sea water to flow inwardly into the container, as the case may be, after the screw propeller has made a predetermined number of revolutions in either of the two directions of rotation in excess of the number of revolutions of the propeller in the opposite direction. The direction of movement of the fluid within a duct or tube connecting the container with the surrounding water is controlled by a two-way valve mechanism which permits a flow of fluid therebetween when the propeller has made a predetermined number of revolutions in one direction in excess of the number of revolutions of the propeller in the opposite direction and which provides for a by-pass between the inlet and outlet connections of the pump during the time the pump is ineffective to cause a flow of fluid between the container and the surrounding water while the pump is operated.

The firing mechanism for the aforesaid mine comprises a plurality of electroresponsive devices controlled by a new and improved inertia operated device adapted to close a pair of normally open firing contacts when the inertia device receives a lateral blow of sustained duration, such for example, as may be caused by a vessel colliding with a mine or the mine is suddenly moved laterally by the motion of the water about the moving vessel and in which the premature closing of the aforesaid contacts in response to oscillatory or relatively slow translational movement of the mine as a result of wave action of the water is prevented, as will more clearly appear as the description proceeds. The firing mechanism is also adapted to fire the mine when the battery controlling the propelling mechanism is exhausted such that the motor M can no longer be operated thereby. Furthermore, the mine is constructed throughout in such a manner as to withstand the heavy blow or shock of impact received as the mine strikes the surface of the water when dropped from an aircraft flying at a considerable altitude, the construction and ruggedness of the parts comprising the mine and the firing mechanism therefor being sufficient to obviate the necessity for employing a parachute to retard the flight of the mine through the air along a path of travel controlled by a plurality of fin members secured to the tail of the mine as the mine drops within a selected target area. Furthermore, the mine is provided with a plurality of detachable ballast devices whereby the mine may be employed with equal effectiveness in fresh water or salt water, as the case may be.

One of the objects of the present invention is the provision of new and improved means for controlling the oscillation of a subfloating body in which the specific gravity of the body is continuously maintained in equality with the specific gravity of the surrounding water by selectively controlling the direction and rate of flow of a ballast fluid.

Another of the objects is to provide means for applying impulses in opposite directions to a subfloating body respectively at predetermined depths of submergence thereby to cause the body to oscillate without a change in the specific gravity of the body when the specific gravity of the body has been adjusted to equality with the specific gravity of the surrounding water progressively by steps corresponding respectively to a predetermined difference in the number of revolutions of the impulse applying means in each of the two directions of movement thereof.

Another object is the provision of new and improved means for causing a subfloating body to be continually submerged in close proximity to a predetermined depth of submersion of the body.

Another object is the provision of a new and improved freely subfloating mine adapted to be fired by a blow received by the mine or by a sudden lateral movement of predetermined character while the mine is floating at a predetermined depth of submersion.

Another object is to prevent the operation of an inertia controlled firing mechanism for a subfloating mine in response to a countermine shock.

Another of the objects is the provision of a new and improved inertia controlled firing member for a floating mine and adapted to fire the mine in response to a disturbance in the surrounding water of predetermined character caused by a vessel in which the premature firing of the mine as the result of wave action is prevented.

A further object is the provision of a new and improved freely subfloating oscillating mine in which the arming of the mine is delayed until the specific gravity thereof has been adjusted to substantially the specific gravity of the surrounding water during successive oscillations of the mine.

A still further object is the provision of new and improved means settable at will for controlling the depth at which the mine is to be submerged.

Still other objects, advantages an improvements will be apparent from the following description taken in connection with the accompanying drawings, of which:

FIG. 1 is a sectional view of a mine according to a preferred embodiment of the invention and showing certain of the control units thereof in elevation;

FIG. 2 is an end view of the device of FIG. 1;

FIG. 3 is an enlarged fragmentary view in elevation of the depth control mechanism taken along the line **3—3** of FIG. 1;

FIG. 4 is an enlarged rear elevational view of the depth controlling device taken along the line **4—4** of FIG. 1;

FIG. 5 is a sectional view taken along the line **5—5** of



FIG. 3 showing the pressure responsive element in an initial position;

FIG. 6 is a view similar to FIG. 5 showing the pressure responsive element in an extended position;

FIG. 7 is a view partly in section and partly broken away of the propelling and the fluid ballast control mechanism employed with the mine of FIG. 1;

FIG. 8 is a side view of the device of FIG. 7;

FIG. 9 is a vertical sectional view taken substantially along the line **9—9** of FIG. 8;

FIG. 10 is a sectional view taken along the line **10—10** of FIG. 7;

FIG. 11 is a sectional view taken along the line **11—11** of FIG. 7;

FIG. 12 is a view partly in section and partly broken away of the fluid ballast control valve mechanism showing the valve in a neutral position;

FIG. 13 is a view similar to FIG. 12 showing the valve in an open position whereby the ballast fluid is adapted to be forced outwardly from the mine by the pump;

FIG. 14 shows the valve in an open position whereby the ballast fluid is adapted to be forced into the ballast chamber;

FIG. 15 is a view of a pump suitable for use with the present invention with the cover removed;

FIG. 16 is a sectional view of the reduction gear mechanism and associated elements and showing the motor in elevation;

FIG. 17 is a sectional view taken along the line **17—17** of FIG. 16;

FIG. 18 is a fragmentary plan view of the inertia controlled firing mechanism and supporting means therefor;

FIG. 19 is a sectional view of the inertia controlled firing mechanism taken along the line **19—19** of FIG. 18;

FIG. 20 is a plan view partly broken away of the firing contacts and supporting means therefor with the casing removed;

FIG. 21 is an enlarged bottom plan view of the supporting plate for the inertia controlled firing mechanism and the circuit controlling devices mounted thereon;

FIG. 22 is an enlarged fragmentary sectional view of the detonator extender mechanism and the switch device controlled thereby;

FIG. 23 is an enlarged plan view showing a portion of the mine casing in section and one of the ballast devices detachably secured thereto;

FIG. 24 is a sectional view taken along the line **24—24** of FIG. 23; and,

FIG. 25 is a diagrammatic view of an arrangement of the electrical circuits and depth controlling and firing mechanisms employed therewith suitable for use with the mine of FIG. 1.

Referring now to the drawings on which like numerals of reference are employed to designate like parts throughout the several views and more particularly to FIGS. 1 and 2 thereof on which is shown a mine indicated generally by the numeral **10** comprising a casing **11** having an end portion **12** secured thereto and provided with an aperture **13** adapted to allow the introduction of an explosive charge **14** composed of TNT, torpex or the like disposed within an explosive chamber **15** formed by a wall or partition **16** extending laterally across the casing and secured interiorly thereto in any suitable manner as by welding the parts together. The aperture **13** is adapted to be sealed by a cover or cap **17** secured thereto as by the bolts **18**, a suitable gasket **19** being arranged between the cover and the end portion **12** to insure a watertight joint therebetween.

There is also provided within the casing of the mine a well **21** extending inwardly into the chamber **15** and having a receptacle **22** secured thereto within which is arranged an explosive booster charge **23**, the receptacle being preferably braced to the casing of the mine as by the member **24**. The well **21** is provided with a shoulder or flange **25** to which is secured as by the bolts **26**, a detonator extender mechanism indicated generally by the numeral 27, a watertight connection between the extender mechanism and the casing of the mine being maintained preferably by a gasket 28 arranged between the extender mechanism and the aforesaid shoulder 25. The partition 16 is provided with a recessed portion 29 having side walls in substantial alinement with the casing 31 adapted to receive and support a battery 32, a suitable wrapping of insulating material 33 being disposed between the battery and the casing in the manner illustrated to maintain the battery securely in a fixed position with respect thereto. The battery 32 is enclosed by a cover 34 secured thereto as by the screws 35, a resilient pad or cushion 36 of material suitable for the purpose such, for example, as rubber being preferably arranged between the cover and the battery.

There is also provided within the casing of the mine a circular support 37 to which is secured as by the bolts 38 a plate or base 39 having secured thereto as by the resilient mountings 41, an inertia controlled firing mechanism indicated generally by the numeral 42 arranged in substantial coincidence with the center of free rocking movement of the mine within the water. Supported by the plate 39 in any suitable manner are a plurality of control relays and thermal devices for arming the mine, controlling the operation of the depth control mechanism and for firing the mine in response to the operation of the inertia controlled mechanism 42 as the mine is subjected to lateral movement of predetermined character such, for example, as may be caused by the impact of a vessel striking the mine or relatively sudden movement of the water caused by the moving vessel, or in the event that the supply of power required to maintain the mine at a predetermined depth of submersion has been exhausted. The firing of the mine in response to a countermine shock received through the surrounding water is prevented by the resilient mountings 41 which reduce the movement of the firing mechanism 42 sufficiently to prevent the operation of the firing mechanism.

There is also secured to the plate 39 a switch 43 having a movable control element 44 adapted to be actuated from the exterior of the mine casing when a detachable plug 45 provided in the casing of the mine in substantial alinement with the control element 44 has been removed. The switch 43 is operated momentarily prior to the launching of the mine thereby to insure that the various electroresponsive elements comprising the firing and depth control circuits are in a predetermined initial condition before a cycle of operations thereof is performed, as will more clearly appear as the description proceeds. The inertia controlled firing mechanism and the aforesaid electroresponsive devices are protected during the assembly, testing and transportation of the firing and depth control mechanism by a plate 46 and a pair of brackets 47, the plate and brackets being disposed respectively below and above the plate and secured thereto by the bolts 48.

There is also provided within the casing 11 a recess or well 49 within which is disposed a hydrostatically controlled depth regulating device indicated generally by the numeral 51 secured in watertight relation with respect to the casing of the mine as by the nuts 52 and gasket 53. The device 51 is adapted to apply a control to the depth regulating circuit by way of the conductors within the cable 54 selectively in accordance with the instant depth of submersion of the mine within the water.

The tail of the mine is enclosed by a casing 55 comprising an upper portion 56 and a lower portion 57 secured thereto in any suitable manner as by welding the parts together and provided with an annular member 58 secured exteriorly thereto. There is provided on the tail portion of the casing 11 an annular member 59 to which the member 58 is secured as by the bolts 61 and maintained in watertight relation with respect thereto as by the gasket 62. The lower portion 57 of the casing is provided with an aperture 63 adapted to be enclosed



by a plate 64 secured thereto as by the bolts 65, a watertight connection being insured therebetween by a gasket 66. Secured to the lower portion of the plate 64 is a cup-shaped casing 67 adapted to support a reversible motor 68 secured thereto as by the bolts 69, the electrical power required for the operation of the motor being supplied thereto by way of the conductors within the cable 71. The motor is adapted to drive a screw propeller 72 at a reduced rate of speed by means of the provision of a reduction gearing within the cup-shaped casing 67. The upper portion 56 of the casing is provided with a cup-shaped member 73 secured thereto as by welding the parts together and preferably additionally braced to the portion 56 of the casing as by the annular support 74. The screw propeller 72 is secured to the shaft 75 by a nut 76, the shaft 75 also causing the actuation of a rotary pump within the support 77 thereby to effect a variation in the specific gravity of the mine in accordance with the extent of operation of the pump during the time that the valve indicated generally at 78 has been moved to an open position thereby to establish communication between the pump and the tubes or ducts 79 and 81.

The casing 55 is partly filled with a ballast fluid suitable for the purpose such, for example, as a fluid composed of one part of lard oil and three parts of kerosene adapted to be forced outwardly through the tubes 81 and 79 by the aforesaid pump into the surrounding water or adapted to be supplied with a quantity of water drawn inwardly through the tubes 79 and 81 by the pump, as the case may be, the direction of flow of the fluid being controlled by the direction of operation of the pump during the time the valve 78 is open, as will more clearly appear as the description proceeds. The tube 81 is provided at the lower end thereof with a ball check valve disposed within the casing 82 in communication with the ballast fluid, means being provided to permit the flow of fluid in either direction past the ball valve when the pump is in operation, the direction of movement of the fluid past the valve being controlled by the direction of rotation of the pump. The outer end of the tube 79 is secured to the cap 56 at a nipple 83, a watertight joint between the tube and the nipple being effected by the coupling 84. The nipple is preferably threaded to receive an external connection whereby the pump may be primed, if desired, prior to the launching of the mine. There is arranged on the exterior portion of the casing 56 a plurality of brackets 85 adapted to support a cup-shaped annular member 86 having a strainer 87 arranged across the opening thereof thereby to exclude the entrance of foreign sea growths and the like from the ballast control system.

Secured to the casing 56 in any well known manner as by welding the parts together are a plurality of fins 88 preferably composed of sheet metal having bentover portions adapted partially to enclose the fins at 89 and 91. Supported by the fins in coaxial relation with respect to the shaft 75 is preferably provided a cylindrical member 92 adapted to reduce the turbulence of the water as the screw propeller operates. The ballast fluid is introduced within the casing through a filler hole 93 adapted to be sealed by the plug 94, the filler hole preferably being arranged adjacent the valve 78 whereby the operation of the valve 78 may be made manifest during the testing of the device.

The casing 11 is preferably reinforced by the circular members 95 and 96, the member 96 being adapted to receive and support a plurality of weights 97 detachably secured thereto as by the bolts 98. When it is desired to plant the mine in a body of salt water, the weights are secured to the member 96 and the mine is thus roughly adjusted to a specific gravity substantially equal to the specific gravity of the salt water within which the mine is to be planted, the weights being of sufficient mass to render the specific gravity of the mine substantially the same as the specific gravity of fresh water when the weights are removed, whereby the mine is also adapted to operate with equal facility in either fresh water or salt water. By providing a plurality of detachable weights 97 in the manner disclosed, the mine is adapted to float at a predetermined depth of submersion in either salt water or fresh water, as the case may be, controlled by the setting of a single depth control dial it being merely necessary to remove the weights when the mine is to be planted in fresh water.

The explosive charge 14 is preferably poured into the explosive chamber 15 in a liquefied condition through the aperture 13 when the mine is arranged with the aperture uppermost. The aperture is then sealed by the cap 17 and the mine is turned over with the cap lowermost. The explosive charge solidifies in the position shown in FIG. 1 in close engagement with the dome-shaped end portion 12 of the mine casing and in contact with the lower portion of the recessed portion 29 of the partition 16. An arrangement is thus provided whereby, by employing a dome-shaped cap for the leading end of the mine casing, the mine is adapted to withstand the violent shock of impact of the mine against the surface of a body of water when the mine is launched from an aircraft in flight, without damage or injury thereto, the explosive charge being employed additionally to support the partition 16 and absorb the shock of impact of the battery 32 against the partition as the mine strikes the water.

The detonator extender mechanism 27 will best be understood by reference to FIG. 22, the extender mechanism comprising a casing 99 having a flanged portion 101 adapted to be secured to the shoulder 25 of the mine casing by the bolts 26, FIG. 1. The casing 99 has secured thereto as by the screws 102 an extension member 103 having a flanged portion 104 thereon adapted to maintain the receptacle containing the booster charge in predetermined fixed relation with respect to the extender mechanism when the extender mechanism is in the assembled position within the mine casing. Slideably disposed within the member 103 is a plunger 105 adapted to support an electroresponsive detonating device 106 and move the detonating device from a safe position to an armed position in operative relation with respect to the aforesaid booster charge in response to the pressure of the surrounding water when the mine has reached a predetermined depth of submergence therein. The detonator is provided with a pair of flexible conductors 107 secured at one end thereof and in electrical connection with terminals on a terminal block 108 attached to the extension member 103 as by the screws 109, the member 103 being provided with a suitable slot within which the conductors 107 are disposed thereby to facilitate the movement of the detonator into the armed position. The plunger 105 is provided with a slotted portion 111 within which is arranged a spring 112 adapted to urge a latch 113 outwardly and lock the detonator in an extended or armed position as the latch moves outwardly into the slotted portion 114 of the extension member 103. The member 103 is also provided with an aperture 115 whereby the latch 113 may be moved at will to the retracted position by a suitable tool inserted within the aperture 115 and the detonator extender mechanism may be moved from the armed position to the initial unarmed position, as may be required during the assembly and test of the extender mechanism.

A cup-shaped member 116 is arranged about the plunger 105 thereby to guide a spring 117 disposed thereabout and maintain the axis of the spring substantially coincident with the axis of the plunger 105. The other end of the spring 117 is in registered engagement with the bottom of a slideable cup-shaped member 118 employed for maintaining a flexible diaphragm 119 against a shoulder 121 on the plunger 105 as the clamping nut 122 is tightened. The outer edge of the diaphragm 119 is secured to a shoulder 123 on the casing 99 and clamped thereto by the clamping ring 124 and washer 125. The casing 99 is provided with a cap 126 secured thereto as by the screws 127 and provided with a plurality of apertures 128 whereby water is admitted to the exterior portion of the diaphragm 119 when the mine has been planted. The plunger 105 is also provided with an aperture within the outer end portion thereof adapted to receive an arming wire 129, the arming wire additionally passing through an aperture 131, FIG. 1, within the cap 126 and extending therefrom to a fixed connection on the aircraft whereby the arming wire is withdrawn from the plunger 105 as the mine falls away from the aircraft. With the arming wire arranged within the plunger 105 in the manner illustrated, inward movement of the plunger is prevented by reason of the provision of a cylindrical stop member 132 disposed about the plunger and in abutting relation with the cap 126 and adapted to be engaged by the arming wire and prevent substantial inward movement of the plunger until the arming wire has been withdrawn. The end of the cap 126 is preferably enclosed by a cover 133 threaded therein, whereby, by removing the cover, the insertion of the arming wire within the aperture 131 of the plunger is facilitated.

There is also secured to the detonator extender mechanism at the extension member 103 thereof a switch device 134 having an actuating element adapted to be moved by a plunger 135 as the plunger 135 is engaged and moved outwardly by the plunger 105 at the end portion 136 thereof during the movement of the plunger 105 to the armed position. The switch device 134 is preferably of the single pole double throw type adapted to transfer a circuit from one contact element to another contact element as the switch operates. The contact elements of the switch 134 are in electrical circuit with certain of the terminals of the terminal block 108 as by the conductors indicated generally at 137 connected thereto.

The hydrostatically controlled depth regulating device 51 comprises a casing 138 having a flanged portion 139 adapted to be secured to the casing of the mine by the nuts 52, the casing being provided with a cover 141 preferably composed of suitable transparent material secured thereto as by the screws 142 whereby the operation of the depth control mechanism may be observed during the testing of the device. Arranged interiorly within the casing is a cup-shaped member 143 secured thereto as by the clamping rings 144 and having an expansible bellows 145 arranged therein adapted to be moved to different settings by the pressure of the water within which the mine is planted, a gasket 146 being provided to maintain a watertight connection between the member 143 and the casing 138. The bellows has secured thereto in any suitable manner a rod or plunger 147 arranged coaxially therewith and having an eye formed in one end thereof for engagement with a retractile spring 148, the other end of the retractile spring being in engagement with a rod 149 rotatably disposed within the screw member 151 and maintained in fixed endwise relation with respect thereto by a pin 152 passing through the rod and engaging the outer end of the screw member 151. The screw member 151 is threaded within the casing 138 and provided with a knob 153 secured thereto and having a pointer 154 thereon for indicating the instant setting of the knob.

The knob is rotatably arranged within a recessed portion 155 within the casing 138 and maintained therein by the ring or dial 156 and screws 157. The dial is provided with a series of indicia thereon corresponding respectively to different depths of submersion controlled by the setting of the pointer 154 with respect thereto. The dial also includes a stop member 158 adapted to coact with the pointer 154 and limit the rotative movement of the knob to one revolution thereof. The screws 157 are respectively disposed within a plurality of arcuate slots 159 arranged within the dial whereby the dial may be adjusted to a predetermined setting within the limits of movement controlled by the aforesaid arcuate slotted portions in accordance with the tension of the spring 148. The arrangement of the screws and slots is such that the dial may, if desired, be moved through a greater distance than the distance afforded by the slots by removing all of the screws 157 and rotating the dial sufficiently for the screws to engage different ones of the slots respectively. When the desired setting of the dial has been attained, the screws 157 are tightened thereby preventing a change in the setting of the dial. The setting of the knob is retained by the provision of a spring pressed plunger 161 slideably disposed within the casing 138 and having a rounded or chamfered end adapted to coact with a plurality of closely spaced indents 162 circularly arranged within the knob.

The knob is also provided with a plurality of apertures 163 adapted to permit the flow of water into an annular recessed portion 164 thereof, the water being allowed to flow into the interior of the expansible bellows 145 by reason of the provision of a plurality of orifices 165 within the screw member 151.

The inner end of the rod 147 comprises a reduced portion 166 and a shoulder 167, the reduced portion 166 being adapted to slide freely within an aperture in a contact spring 168 having a washer 169 of suitable insulating material secured thereto in any suitable manner as by the rivets 171, FIG. 4, the washer 169 being employed to engage the shoulder 167 of the rod 147 and cause the contact spring 168 to be disengaged from contact 172 and be brought into engagement with contact 173 during the expansion of the bellows as the mine sinks within the water. The contact members 168, 172 and 173 are supported by a base 174 of suitable insulating material secured to the casing 138 as by the screws 175, an external electrical connection to the contact members 168, 172 and 173 being established by way of the conductors within the cable 54 having one end thereof secured to the base 174 as by the clamp 176 and screw 177.

The propulsion and automatic ballast control mechanism of the mine will now be described. As hereinbefore described, the plate 64 supports a cup-shaped casing 67 having a reversible motor 68 secured thereto with the shaft of the motor arranged vertically, the motor hereinafter being designated for the purpose of description, by the letter M. The member 67 has secured thereto as by the bolts 69 a support 178, FIG. 16, having a centrally arranged aperture therein within which the upper end of the motor shaft extends. There is secured to the support 178 as by the screws 179 a speed reducing mechanism indicated generally by the numeral 181 comprising an upper casing 182 and lower casing 183 held together in any suitable manner as by the rivets 184. The lower casing 183 supports a bearing 185 within which is rotatably mounted a stub shaft 186 preferably splined as at 187 for engagement with a complementary splined portion on the motor shaft and having a shoulder 188 thereon for engagement with the end of the bearing member 185. There is also secured to the shaft 186 as by the pin 189 a gear 191 in engagement with a relatively larger gear 192 journaled within the casings 182 and 183. Secured to the gear 192 as by the pin 193 is a relatively small gear 194 in engagement with a larger gear member 195 rotatably mounted within a bearing 196 secured to the upper casing 182. From the foregoing, it will be apparent that the gear member 195 is adapted to rotate at a relatively slow rate of speed with respect to the speed of rotation of the motor.

Secured to the plate 64 in any suitable manner, as by welding the parts together, is a tubular support 197 having bearings 198 and 199, FIG. 9, arranged therein within which is rotatably mounted a shaft 201, the lower end of the shaft being in splined engagement with the gear member 195 at 202. The upper end of the shaft 201 is provided with a grooved portion within which is arranged a coupling member 203 secured thereto as by the pin 204. The upper end of the bearing 199 is provided with a seat 205 adapted to be engaged by a washer or packing member 206 in engagement with a suitable packing 207 disposed beneath a washer 208 with which the end portions of the pin 204 are in engagement. The lower end of the shaft 201 is provided with a pin 209 having a cup-shaped member 211 in engagement therewith for applying pressure to a spring 212 and washer 213 in engagement with the bearing 198 at the seat 214 thereof thereby to apply tension to the shaft 201 and maintain a watertight joint at the seat 205 of the bearing 199. The tubular support 197 is provided with a plurality of apertures 215 above the upper bearing 199 thereby to allow the escape of water which may enter the mine about the propeller shaft from being forced by the pressure of the surrounding water through the tubular member 197 and thence into the reduction gearing and motor. The upper end of the tubular member 197 is slideably disposed within a cap 216 secured to the support 77 as by the screws 217. The upper end of the support 77 comprises a pair of circular flanges 218 and 219 adapted to be fittingly disposed within the cup-shaped member 73 and secured to the upper portion 56 of the ballast chamber, the upper end of the flange 218 being provided with a gasket 221 adapted to be clamped by the nut 222 threaded on the support 77 and thereby provide a watertight connection between the support 77 and the casing of the mine. A lock washer 223 is preferably provided between the nut 222 and the cup-shaped member 73 thereby to maintain the support 77 continuously in rigid clamped engagement with the portion 56 of the ballast chamber. The lower flange 219 of the support 77 is provided with a dowel pin 224 adapted to engage a slotted portion 225 within the cup-shaped member 73 and prevent rotative movement of the support with respect thereto.

The support 77 is also provided with a bearing 226 at the upper end thereof within which is rotatably mounted the shaft 75, the lower end of the shaft being journaled at 227 within the support 77 and at 228 within the cap 216. A water seal indicated generally at 230 is also provided to prevent leakage of water between the shaft 75 and the bearing 226. Downward movement of the shaft is prevented by a collar or snap ring 229 secured thereto and in engagement with the inner surface of the cap 216. The lower end of the shaft 75 is suitably slotted to receive the coupling member 203 thereby establishing an operative connection between the shaft 75 and the shaft 201. The lower end of the shaft also includes a portion 231 of reduced diameter having a rotor 232 secured thereto in any suitable manner as by the pin 233, the rotor being suitably slotted as at 234 to receive the ends of the pin.

The lower end of the support 77 has a circular recessed portion 235 therein within which is arranged a circular disk or pumping element 236 adapted to be rotated by the lobes 237, FIG. 15, of the rotor 232 at the recessed portions 238 thereof in succession as the shaft 75 is rotated by the motor 68. The pump also comprises two arcuately shaped recessed portions 239 and 241 in communication with the recessed portion 235 of the support 77, the recessed portions 239 and 241 being diametrically disposed with respect to the rotor 232 substantially as illustrated. The recessed portion 241 is in communication with a duct 242 and, in like manner, the recessed portion 239 is in communication with a duct 243 within the support 77. The ducts 242 and 243 terminate in ports within the cylindrical slide valve 244 adapted to be connected together or to the ducts 245 and 246 selectively in accordance with the position of the valve member 247 within the cylindrical bore 248 of the valve casing. Whereas in FIGS. 12 through 14, the ducts 242 and 243 are shown throughout their length in section, it will be understood that this has been done for the purpose of more clearly illustrating the manner in which the ducts are brought into the cylindrical valve.

The valve member **247** is slideably disposed within the bore **248** and urged normally to the position with respect thereto as shown in FIG. 12 by a spring **249** in registered engagement with the valve casing **251** and secured to one end of the valve plunger by a screw **252** and washer **253**. The valve is provided with a pair of recessed portions **254** and **255** separated by a cylindrical portion **256** fittingly slideable within the bore. With the valve in the position shown in FIG. 12, the recessed portion **255** thereof establishes a connection between the ducts **242** and **243** whereby the rotative movement of the pump in either direction is ineffective to cause a change in the liquid ballast of the mine. With the valve in the position shown in FIGS. 13 and 14, the pump is in operative communication with the fluid within the ballast chamber and with the water surrounding the mine and adapted to effect a change of ballast in the mine as the pump operates. The slideable valve member **247** is preferably provided with a plurality of annular grooved portions **257** and **258** arranged about the periphery thereof and adapted to effect a water seal between the slideable member **247** and bore **248**. The member **247** is provided with a duct **259** therein in communication with a relatively small orifice **261** thereby to insure a flow of liquid sufficient to render the grooved portion **257** of the member **247** effective as a water seal by the removal of any air which may seep into the groove.

The end of the valve member **247** is pivotally connected as at **262** to a link **263**, the opposite end of the link being pivotally connected as at **264** to a control member or lever **265**. The lever **265** is provided with a slotted portion **266** disposed about a post **267**, the opposite end of the lever **265** being adapted to move slideably within a stop member **268** secured to the support **77** as by the screws **269**. The lever **265** is also provided with a tab **271** formed thereon and adapted to be engaged by a complementary tab **272** formed on the valve actuating member **273** as the member **273** rotates about the post **267**. The post **267** is secured to the support **77** as by the screw **274** and has rotatably mounted thereon a worm wheel **275** in meshed engagement with a worm **276** formed on the shaft **75**. The worm wheel **275** is secured to a sleeve **277** about which the actuating member **273** is disposed. The actuating member **273** is frictionally driven by the worm wheel **275** by reason of a friction washer **278** arranged therebetween, the actuating member **273** being maintained in frictional engagement therewith by a washer **279** having a plurality of resilient arms thereon in engagement with the actuating member **273** and having a predetermined tension applied thereto controlled by the snap ring **281** and the washer **282** arranged betwen a snap ring and the resilient washer **279**, the degree of friction between the actuating member **273** and the worm wheel **275** being controlled in any suitable manner as by the thickness of the washer **282**.

From the foregoing, it will be apparent that engagement of the tab **271** by the complementary tab **272** of the actuating member **273** causes the valve member **247** to be moved from a closed position to an open position regardless of the direction of movement of the worm wheel **275** as shown on FIGS. 13 and 14 of the drawings. When the worm wheel **275** is rotating in the direction shown in FIG. 13, the upper end of the lever **265** is brought into engagement with the stop member **268** and pivots about the point of contact of the lever with the stop member **268** thereby causing the lower end of the lever **265** to be moved away from the valve casing until arrested by the engagement of the post **267** with the end of the slot **266** within the lever thereby opening the valve to permit the pump to effect a change in the fluid ballast of the mine. When this occurs, additional rotative movement of the actuating member **273** is prevented until the direction of rotation of the worm wheel **275** is reversed. When the direction of movement of the pump is reversed, the worm wheel **275** is rotated in the direction shown on FIG. 14 by the reverse movement of the shaft **75** and the disengagement of the tab **271** with the complementary tab **272** of the actuating member causes the lever **265** to be moved toward the valve casing by the spring **249** until the opposite end of the slot **266** therein engages the post **267** as shown in FIG. 12 and the valve to be closed until the tab **272** again engages the tab **271**. When this occurs, the lever **265** is pivoted about the post **267** as a fulcrum in a direction to open the valve and reestablish an operative fluid connection between the ballast fluid within the mine and the surrounding water. When the upper end of the lever **265** engages the stop member **268** in the manner illustrated in FIG. 14, further rotative movement of the lever **265** and the actuating member **273** is prevented. The worm wheel **267**, however, may continue to rotate by reason of the frictional coupling between the worm wheel and the actuating member. It will, of course, be understood that while the worm wheel is moving from the position shown on FIG. 13 to the position shown on FIG. 14, the valve will assume the closed position shown on FIG. 12.

The duct **245** is connected to the tube **81** by the coupling **283**, the lower end of the tube **81** being connected to the casing **82** disposed within the ballast fluid, the connection being established by way of a valve fitting **284** having an aperture **285** therein and a plurality of orifices **286** communicating with the interior of the casing **82**. Arranged within the aperture **285** is a check valve comprising a ball **287** in seated engagement with a thimble **288** having a flanged portion **289** thereon yieldably maintained in engagement with a seat **291** on the member **284** by a spring **292**, the opposite end of the spring being in engagement with a shoulder on a plug member **293** threaded within the fitting **284**. There is also preferably provided a screen or perforated disk **294** secured at the central portion thereof by the plug member **293** and washer **295** and secured at the periphery thereof in any suitable manner to the casing **82** thereby to prevent the entrance of dirt or foreign substances within the casing **82**. An arrangement is thus provided in which foreign matter in the ballast fluid is excluded from the pump and valves of the ballast control system. There is also preferably provided within the fitting **284** a pin or rod **296** adapted to arrest the upward movement of the ball **287** as fluid is drawn upwardly within the tube **81** by the pump. The casing **82** is provided with a bracing member **297** secured thereto and having an aperture therein of sufficient size slideably to receive the tubular support **197**.

The inward flow of water from the sea during the time that the pump is not operated is prevented by a valve mechanism arranged between the duct **79** and the orifice **246** extending to the valve mechanism. As most clearly shown on FIG. 10, the duct **79** is connected to the support **77** as by the coupling **298** whereby communication with the outside water is established to an orifice **299** within the support. Threaded within the support **77** is a guide member **301** having a seat at the lower portion thereof adapted to be sealed by a disk valve **302** yieldably maintained in engagement therewith by the spring **303** thereby to seal the orifice **299** when the valve **302** is in a closed position by reason of the provision of a gasket **304** arranged between a shoulder on the member **301** and a complementary surface on the support **77**. There is also arranged on the support **77** an expansible bellows **305** sealed at the lower end thereof to the support as by the gasket **306** and clamping ring **307**, a cover **308** having an aperture **309** therein being provided to protect the bellows and limit the upward movement thereof. The interior of the bellows is in communication with a recessed portion **311** and thence by way of the duct **246** with the valve member **247**. There is also slideably arranged within the guide member **301** a valve actuating mechanism **312** having a plurality of recessed portions 313 and 314 at the upper and lower ends thereof respectively. The disk valve 302 is adapted to open in response to a predetermined increase of pressure within the bellows 305 in excess of the pressure of the surrounding water or in response to a predetermined decrease in pressure within the bellows 305 from the pressure of the surrounding water, as the case may be, the operation of the valve 302 in the latter case being accomplished by the contraction of the bellows sufficiently to overcome the spring 303 and the pressure of the surrounding water on the valve 302 by reason of the movement of the valve actuating mechanism 312 by the bellows, as will more clearly appear as the description proceeds.

The inertia firing control mechanism employed with the mine of FIG. 1 comprises a supporting base 315 secured to the plate 39 yieldably as by the resilient mountings 41, the mountings 41 being attached to the base and plate in any suitable manner as by the rivets 316. The base 315 has a hemispherical portion 317 and a plurality of upturned edges 318 thereby to strengthen the base and increase the resistivity thereof to deformation as the result of the shock received during the planting of the mine. The base 315 is provided with a support 319 secured thereto in any suitable manner as by welding the parts together and having slideably arranged therein a plunger 321, the plunger having a shoulder 322 thereon adapted to be continuously maintained in engagement with a complementary shoulder 323 arranged within the support 319 by a spring 324 at all times except when a heavy shock is received during the planting of the mine. The opposite end of the spring 324 is arranged within a recessed portion 325 of a cap or plug 326 threaded within the support 319. The support 319 extends downwardly within an aperture 327 centrally arranged within the plate 39 whereby the lower portion of the base 315 is normally supported by the resilient mountings 41 at a distance from the curved portion 328 of the plate 39 sufficient for the portion 328 of the plate to be employed as a stop for the base 315 when the base 315 moves into engagement with the portion 328 of the plate 39 as the result of the shock received during the planting of the mine from an aircraft in flight.

The plunger 321 is tapered as at 329 thereby to form a conic section upon which is pivotally mounted a mass 331 suitably recessed at 332 to coact with the apex of the aforesaid conic section of the plunger 321 and pivotally support the mass thereon. The mass is of such a shape that the center of gravity thereof is slightly lower than the point of support and sudden translational movement of the plunger 321, therefore, causes the mass 331 to tilt.

The upper surface of the mass 331 comprises a conic recessed portion 333, a circular flat surface 334 coaxially arranged with respect to the conic recessed portion and a curved annular surface or seat 335 intermediate the flat surface and the conic recessed portion. A circular member 336 is tapered and rounded as at 337 thereby to coact with the curved annular surface 335 of the mass 331 and maintain the member 336 in predetermined spaced relation with respect thereto at all times when the device is not subjected to sudden translational movement of a predetermined character. The member 336 is secured to a circular plate 338 having a cylindrical member 339 secured thereto and extending both upwardly and downwardly therefrom substantially as shown. The lower portion of the cylindrical member 339 comprises a laterally extending flanged portion 341 to which is secured as by the screws 342 a circular mass 343 extending downwardly therefrom and having a truncated spherical surface 340 with a radius of curvature sufficiently less than the radius of curvature of the inside surface of the supporting base 315 whereby the shock of planting the mine is adapted to cause the circular mass to engage the inside surface of the base 315 and the mass 331 to be arrested by the mass 343 and the spring 324 to be compressed by the shock received by the mine as the mine strikes the surface of the water, thereby preventing damage or injury to the pivot support 321 at the tapered portion 329 thereof. The mass 315 is also provided with a tapered recessed portion 344 of sufficient size to permit considerable pivotal movement of the mass 343 as the device receives a translational impulse of predetermined character. In a similar manner the mass 331 is recessed as at 345 to permit tilting of the mass 331 about the pivot support therefor. When the firing mechanism is tilted sufficiently for the recessed portions 344 and 345 of the masses 315 and 331 respectively to engage the slideable support for the pivot member 321, the members 315 and 331 are tilted with respect to each other sufficiently to close a pair of firing contacts, as will more clearly appear as the description proceeds.



A structure is thus provided in which the elements 331 and 343 comprise a compound pendulum adapted to oscillate as a unit about the pivot support 321 in response to relatively slow translational impulses received thereby and in which relative motion between the masses 331 and 343 is effected as the result of the lateral component of a blow or sudden impulse of predetermined character received by the device by reason of the center of gravity of the mass 343 and supporting means therefor being disposed at a greater distance below the pivot 332 than the center of gravity of the mass 331 and by reason of the moment applied to the mass 331 by the horizontal component of the force applied thereto by way of the pivot member 321. Rotational movement of the mass 343 and supporting means therefor including the circular member 336, with respect to the mass 331, causes a plunger 346 slideably arranged within the member 336 to be moved downwardly by the combined force of gravity and the tension of the contact spring 347 thereagainst. When this occurs, the contact spring 347 is brought into engagement with the contact element 348 thereby closing the firing control circuit comprising the conductors 349 secured thereto. The contact members 347 and 348 are electrically insulated from each other and from the plate 338 as by the insulating devices 351 and 352, the insulating device 352 preferably being provided with an aperture through which the plunger 346 is adapted to move. Disposed about the contact members 347 and 348 is a guard 353 thereby to prevent excessive flexing of the contact members 347 and 348 sufficient to change the adjustment thereof regardless of the violence of the shock to which the device may be subjected. The aforesaid guard and contact members are secured to the plate 338 as by the screws 354. Secured to the base 315 as by the screws 355 is a hemispherical cover 356, a gasket 357 being arranged therebetween thereby to seal the spherical chamber within which the inertia switch contacts are disposed.

A cylindrical projecting member 358 having the upper end thereof closed at 359 is clamped to the upper portion of the cover 356 as by the nut 361, a watertight connection therebetween being assured by a gasket 362 disposed between a shoulder 363 on the member and a complementary recessed portion 364 within the cover. The projecting member 358 is composed of insulating material suitable for the purpose such, for example, as Bakelite and is provided preferably with a pair of inserts 365 adapted to receive the screws 366 and thereby establish an external circuit connection to the conductors 349 respectively secured thereto. There is arranged beneath the heads of the screws 366 a plate 367 having a downwardly projecting eye 368 therein adapted to engage and support one end of the spring 369. The other end of the spring 369 is secured to an eye 371 formed in the bracket 372 secured to the plate 338 as by the screws 373. An arrangement is thus provided in which the spring 369 is employed to lessen the pressure on the pivot 321, prevent excessive rotation of the pendulum about the pivot support, and apply a restoring force to the elements of the compound pendulum in a direction to assist the force of gravity in restoring the pendulum to an initial vertical position.

The plate 39 is also employed to support a plurality of relays and thermal responsive contact devices employed for controlling the operation of the motor M in response to the selective operation of the hydrostatically controlled depth regulating device 51, a suitable arrangement of the relays and electroresponsive control devices being shown on FIG. 21 in which the relays A, B, C, D, F, R, and TR are preferably located on the underside of the plate and interconnected by means of the conductors within a cable, not shown, securely clamped to the plate 39 as by the cable clamps 374. There is also mounted on the lower portion of the plate 39 a plurality of jacks 375, 376, and 377 adapted to receive plugs associated with flexible cables leading to the hydrostatically controlled depth regulating device, the motor M, the battery 32 and the terminal block 108, FIG. 22, the cable to the terminal block being arranged within a tube or cable duct 378 extending between the wall 16 and the well 21, FIG. 1. On the upper side of the plate 39, FIG. 21, is preferably arranged the thermal relays K, G, and J and the switch 43, the electrical connections between the electrical devices arranged on the upper and lower portions of the plate 39 being established by the conductors within the insulating bushings 379, 380 and 381 within the plate.

The operation of the mine will now be described. Let it be assumed, by way of example, that the hydrostatically controlled depth regulating device 51 has been set with the pointer thereof opposite the numeral 40 whereby the mine is adapted to oscillate between the control limits of 40 and 46 feet beneath the surface of the water, the lower control level of 46 feet being determined by the additional increase in pressure of the surrounding water necessary to expand the bellows 145 by an amount corresponding to the travel of contact 168 between contacts 172 and 173, FIG. 5. Let it further be assumed that a copious supply of ballast fluid has been introduced within the ballast chamber through the aperture 93 within the cap 56 caused by the removal of the plug 94 and that the plug 94 is thereafter assembled within the cap. The nipple 83 is connected to a filler tube thereby establishing an external fluid connection between a container having a quantity of ballast fluid therein and the pump, the strainer 87 being preferably removed sufficiently to establish the external fluid connection to the nipple. The plug 45 is now removed and the push button 44 is operated thereby causing the movable contact element 382 thereof, FIG. 25, to be disengaged from contact 383 and moved into engagement with contact 384 thereby closing a circuit from the positive terminal of battery BA by way of conductor 385, windings of relays A and C in parallel, conductor 386, contacts 172 and 168 of the hydrostat switch, conductor 387, contacts 382 and 384 of switch 43 and thence by way of conductor 388 to the negative terminal of battery BA thereby causing relays A and C to operate. The operation of relay C closes a circuit from the positive terminal of battery BA1, conductor 389, break contact and armature 391 of relay D, conductor 392, armature of motor M, conductor 393, armature 394 and make contact of relay C, conductor 395, field winding 396 of the motor M and thence by way of conductor 397 to the negative terminal of battery BA1 thereby setting the motor in operation in a direction to pump fluid from the aforesaid container into the ballast chamber. When the motor has operated for a period of time sufficient to prime the pump, the switch 43 is released by removing the pressure from the movable element 44 thereof and the contact element 382 is disengaged from the contact 384 and moved into engagement with contact 383. As contact element 382 moves away from contact 384, relays A and C release thereby interrupting at armature 394 of relay C and make contact thereof the operating circuit to the motor and causing the motor to come to rest. The plug 45 is now replaced in the casing of the mine, the filler connection removed from the nipple 83 and the strainer 87 replaced to cover the nipple 83. Let it also be assumed that an arming wire 129 has been assembled within the aperture 131 of the plunger 105, FIG. 22, the arming wire extending through an aperture 128 of the cap 126 and secured at the opposite end thereof to the aircraft.

As the mine falls away from the aircraft in flight, the arming wire is withdrawn thereby removing the mechanical restraint from the detonator extending mechanism. As the mine strikes the surface of the water, the plunger 321 of the inertia controlled firing device 42 is forced downwardly by the inertia of the masses resting thereon thereby extending the spring 369 and compressing the spring 324 until the circular mass 343 engages the curved portion 328 of the supporting base 315. The mass 331 also moves downwardly into engagement with the mass 343 and is arrested thereby. The contact elements 347 and 348 are momentarily engaged but without effect as the mine is unarmed. Concurrently therewith the supporting base 315 is moved downwardly by the force of inertia and the provision of the resilient mountings 41 into engagement with the curved portion 328 of the plate 39. Damage or injury to the inertia switch and operating means therefor is thus prevented. As the shock received by the mine at the moment of striking the surface of the water abates, the supporting base 315 is moved away from the plate 39 by the resilient supports 41 and the inertia elements are moved by the springs 324 and 369 to the position shown in FIG. 19.

As the mine continues to move downwardly within the water, the pressure of the surrounding water against the flexible diaphragm 119 of the detonator extender mechanism, FIG. 22, causes the plunger 105 thereof to be moved inwardly thereby compressing the spring 117 and moving the detonator 106 into an operative or armed position with respect to the explosive booster charge 23. During the movement of the plunger rod 105 from the initial position thereof to the armed position, the plunger 135 is operated thereby causing the switch 134 to be actuated and contact element 398 thereof, FIG. 25, to be disengaged from contact 399 and moved into engagement with contact 401. As contact 398 of the switch 134 engages contact 401, a circuit is closed from the negative terminal of battery BA by way of conductor 388, contacts 398 and 401 of the extender switch 134, conductor 402, contacts 383 and 382 of switch 43, conductor 387, contacts 168 and 172 of the depth control switch, conductor 386, windings of relays A and C in parallel, conductor 385 and thence to the positive terminal of battery BA thereby causing relays A and C to operate. The operation of relay C at armature 394 thereof closes a circuit from the positive terminal of battery BA1, conductor 389, break contact and armature 391 of relay D, conductor 392, armature of motor M, conductor 393, armature 394 and make contact of relay C, conductor 395, field winding 396 of motor M, conductor 397 and thence to the negative terminal of battery BA1 thereby causing the motor to run in a direction to drive the mine downwardly and to pump water into the ballast chamber by reason of the pump valve being in the position shown in FIG. 14 as the result of the prior operation of the pump during the priming thereof. The specific gravity of the mine is adjusted initially substantially to the specific gravity of the water in which the mine is to be planted or, if desired, slightly less than the specific gravity of the surrounding water.

When the mine reaches a depth of 40 feet, the bellows 145 is expanded sufficiently for the contact element 168 controlled thereby to be disengaged from contact 172 thereby releasing relays A and C and bringing the motor to rest. As the mine passes beyond the lower control level of 46 feet, the bellows 145 is expanded sufficiently by the pressure of the water therein to cause contact element 168 to be moved into engagement with contact 173. When this occurs, a circuit is closed from negative terminal of battery BA by way of conductor 388, contacts 398 and 401 of switch 134, conductor 402, contacts 383 and 382 of switch 43, conductor 387, contacts 168 and 173 of the depth control switch, conductor 403, windings of relays B and D in parallel, conductor 385 and thence to the positive terminal of battery BA thereby causing relays B and D to operate. As armature 391 of relay D engages its make contact, a circuit is closed from the positive terminal of battery BA1 by way of conductor 389, break contact and armature 394 of relay C, conductor 393, armature of motor M, conductor 392, armature 391 and make contact of relay D, conductor 395, field winding 396 of motor M, conductor 397 and thence to the negative terminal of battery BA1 thereby causing the motor to be set in operation in a direction to propel the mine upwardly. As the propeller shaft 75 rotates in a direction to propel the mine upwardly, the worm wheel 275 is rotated in the direction shown on FIG. 13 and the pump valve is moved by the spring 249 to the position shown on FIG. 12 during the first few revolutions of the propeller and remains in the position shown on FIG. 12 for a predetermined period of time such, for example, as 10 seconds until the worm wheel 275 has rotated sufficiently to move the valve to the position shown on FIG. 13, the worm wheel thereafter continuing to rotate without additionally moving the valve by reason of the provision of the frictional coupling between the worm wheel and the valve actuating member 273. While the valve is in the intermediate or closed position shown on FIG. 12, the pump is ineffective to change the quantity of fluid within the ballast chamber but merely circulates water through a by-pass in a direction indicated by the arrows on FIG. 12. As the valve moves to the position shown on FIG. 13 at the expiration of the aforesaid period of time, the pump causes ballast fluid to be forced outwardly from the ballast chamber in a direction indicated by the arrows thereby reducing the quantity of ballast fluid within the chamber and decreasing the specific gravity of the mine.

As the mine traverses the lower control level during the first upward movement thereof, contact element 168 is disengaged from contact 173 of the depth control switch thereby releasing relays B and D and bringing the motor to rest.

As the mine passes above the upper control level, contact 168 of the depth control switch is moved into engagement with contact 172 thereby operating relays A and C, the operation of relay C at armature 394 thereof causing the motor to operate in a direction to propel the mine downwardly. As the propeller starts to rotate, the worm wheel 275 is moved in a direction shown on FIG. 14 thereby closing the pump valve for 10 seconds during which time the pump circulates water through the by-pass in a direction reverse to the direction of the arrows on FIG. 12. At the completion of the 10 second period, the valve is moved to the position shown on FIG. 14 and the pump causes sea water to be drawn into the ballast chamber thereby increasing the specific gravity of the mine until the mine passes below the upper control level.

The mine continues to oscillate between the upper and lower control levels and effect changes in the specific gravity of the mine during the travel of the mine beyond each of the control levels when the time of each such travel exceeds a predetermined period of 10 seconds, the motor invariably being stopped during the travel of the mine between the upper and lower control levels. The specific gravity of the mine is thus adjusted progressively by increments of decreasing amounts until the specific gravity of the mine has been adjusted to equality with the specific gravity of the surrounding water, the time required for the mine to complete an oscillation being progressively increased and the frequency of the oscillations being correspondingly decreased as the specific gravity of the mine is adjusted to the specific gravity of the surrounding water. When this occurs, the oscillations of the mine are produced by the screw propeller alone without a change in the specific gravity of the mine by reason of the relatively short time of travel of the mine beyond each control level.

The winding of relay F, it will be noted, is connected by conductors 392 and 393 in parallel with the armature of motor M and the relay, therefore is operated whenever the motor is set in operation and releases when the operating circuit to the motor is interrupted. The manner in which relay J is employed in connection with relays A and B to operate relay TR and thereby arm the mine after the gravity of the mine has been adjusted substantially to equality with the surrounding water will now be described. Relay TR, it will be noted, is provided with an armature 404 adapted to be actuated selectively by a pair of windings 1 and 2 to the positions shown in solid outline and in dashed outline respectively. The armature 404 is maintained in either of the operated positions thereof by a spring 405. In the event that the armature 404 of relay TR should be in the position shown in dashed outline at the time battery BA is connected to the system or should be moved to the dashed line position as the result of a shock received during the planting of the mine, a circuit is closed from positive terminal of battery BA by way of conductor 385, armature 404 of relay TR and contact 406, to winding 1 of relay TR from whence the circuit is continued by way of conductor 407, contacts 399 and 398 of switch 134 and conductor 388 to the negative terminal of battery BA thereby energizing winding 1 of relay TR and moving the armature 404 thereof to the solid line position. As armature 404 moves away from contact 406 the operating circuit to winding 1 of relay TR is interrupted and winding 1 is deenergized.

As relays A and C operated in response to the operation of the extender switch 134 during the first downward movement of the mine through the water, negative battery is momentarily applied to one end of the winding of the thermal relay G over the following circuit: negative terminal of battery BA, conductor 388, contacts 398 and 401 of switch 134, conductor 402, armature 408 and break contact of relay B, conductor 409, armature 411 and make contact of relay A, conductor 412, break contact and armature 413 of relay F, conductor 414, winding of relay G from whence the circuit is continued by way of conductor 415 to contact 416 of relay TR. No current flows through the winding of relay G at this time, however, for the reason that armature 404 of relay TR is disengaged from contact 416. The foregoing circuit from the negative terminal of battery BA to the winding of relay G is interrupted by the operation of relay F in response to the movement of armature 394 of relay C into engagement with the make contact thereof.

As relays B and D operate in response to the first upward movement of the mine beyond the upper control level within the water, the movement of armature 408 of relay B into engagement with the make contact thereof applies negative battery by way of the break contact and armature 413 of relay F to the winding of relay G until relay F operates in response to the operation of relay D. Thermal relay G, however, is prevented from receiving a flow of current through the winding thereof at this time by reason of the disengagement of contact 416 with the armature 404 of relay TR. From the foregoing, it will be apparent that relay G cannot be operated until armature 404 of relay TR has moved to the armed position shown in dashed outline.

Relays A and C, it will be noted, are operated whenever the mine is above the upper control limit after the extender switch 134 has been actuated and relays B and D are operated whenever the mine is below the lower control limit, relays A, B, C, and D being unoperated while the mine is traveling between the upper and lower control limits. As the mine passes below the upper control limit during the first downward movement thereof within the water, relays A and C release. As armature **411** of relay A moves into engagement with the break contact thereof, a circuit is closed from negative terminal of battery BA by way of conductor **388**, contacts **398** and **401** of switch **134**, conductor **402**, armature **408** and break contact of relay B, conductor **409**, armature **411** and break contact of relay A, conductor **417**, winding of thermal relay J, conductor **418**, contact **419** and armature **404** of relay TR, conductor **385** and thence to the positive terminal of battery BA thereby heating the bimetallic thermal element **421** of relay J but not sufficiently for the thermal element to move into engagement with the make contact thereof. As the mine passes below the lower control limit, the operation of relay B interrupts the circuit to the heater coil of relay J at armature **408** and break contact thereof and the thermal element **421** begins to cool.

As the mine passes upwardly beyond the lower control limit of submersion relay B releases and the operating circuit to the heater coil of relay J is again closed thereby additionally heating the thermal element **421** until the mine passes above the upper control limit of submersion. When the mine has made a sufficient number of oscillations such that relays A and B are both released during the travel of the mine between the upper and lower control limits for a period of time sufficient for relay J *to* close its contact, a circuit is closed from the negative terminal of battery BA by way of contacts **398** and **401** of switch **134**, conductor **402**, armature **408** and break contact of relay B, conductor **409**, armature **411** and break contact of relay A, conductor **417**, make contact and element **421** of relay J, conductor **422**, winding **2** of relay TR, from whence the circuit is continued by way of contact **419** and armature **404** of relay TR and conductor **385** to the positive terminal of battery BA thereby energizing winding **2** of relay TR and causing the armature **404** thereof to be moved to the dashed line or armed position in engagement with contacts **406** and **416**. As armature **404** of relay TR moves away from contact **419**, positive battery is removed from winding **2** of relay TR and the heater coil of relay J thereby deenergizing winding **2** and allowing the thermal element **421** to cool and thereby be disengaged from the make contact thereof. The mine is now armed.

Let it now be assumed that the inertia controlled contacts **347** and **348** are closed by an approaching vessel as the result of sustained translational movement of predetermined character imparted to the mine by the bow wave of the vessel or by the vessel striking the mine, as the case may be. When this occurs, a circuit is closed from the positive terminal of battery BA by way of conductor **385**, armature **404** and contact **416** of relay TR, conductor **415**, contacts **347** and **348** of the firing control mechanism **42**, conductor **423**, winding of relays R and K in parallel, conductor **402**, contacts **401** and **398** of switch **134**, conductor **388** and thence to the negative terminal of battery BA thereby operating relay R and energizing the heating coil of the thermal relay K. The operation of relay R at armature **424** thereof closes a circuit in parallel with contacts **347** and **348** of the inertia switch thereby to maintain a flow of current through the windings of relays R and K after the contacts of the inertia switch are opened. Relay K is a thermal relay and for this reason the thermal element **425** thereof does not move into engagement with the make contact of the relay until a predetermined period of time such, for example, as 5 seconds has elapsed after the contacts of the inertia switch have closed thereby to delay the firing of the mine until the mine is opposite a vulnerable portion of the vessel.

As element **425** of relay K engages its make contact, a circuit is closed from the positive terminal of battery



BA by way of conductor **385**, armature **404** and contact **416** of relay TR, conductor **415**, armature **424** and make contact of relay R, conductor **423**, make contact and element **425** of relay K, conductor **426** to the detonating device **106** from whence the circuit is continued by way of conductor **402**, contacts **401** and **398** of switch **134** and conductor **388** to the negative terminal of battery BA thereby operating the detonator and firing the mine.

In the event, however, that the mine is not fired by an approaching vessel within a predetermined period of time after the mine has been launched, the mine continues to oscillate by impulses received from the screw propeller until the battery BA1 is exhausted sufficiently to prevent the operation of relay F during the time that the motor operating circuit is closed. When this occurs, a circuit is closed from the negative terminal of battery BA by way of a make contact of relay A or B, as the case may be, and thence by way of the break contact and armature **413** of relay F to the heater coil of the thermal relay G from whence the circuit is continued by way of conductor **415**, contacts **416** and armature **404** of relay TR to the positive terminal of battery BA thereby causing the bimetallic heater element **427** of relay G to become heated sufficiently to engage the make contact thereof. When this occurs, a circuit is closed from the positive terminal of battery BA by way of conductor **385**, armature **404** and contact **416** of relay TR, conductor **415**, thermal element **427** of relay G and make contact thereof, conductor **426** to the detonator **106** from whence the circuit is continued by way of conductor **402**, contacts **401** and **398** of switch **134** and conductor **388** to the negative terminal of battery BA thereby operating the detonator and causing the self-destruction of the mine when the depth regulating mechanism is rendered ineffective by the failure of the battery BA1 to continue to deliver sufficient power to operate the motor M.

Briefly stated in summary, the present invention provides a free floating mine adapted to oscillate at a predetermined depth of submersion within a body of water in which the pump mechanism employed for adjusting the specific gravity of the mine is operated whenever the propelling mechanism is set into operation and the pump is ineffective to change the specific gravity of the mine until the propelling mechanism has operated for a predetermined period of time during the travel of the mine beyond predetermined control limits of submersion within the water, and in which the frequencies of the oscillations are reduced as the specific gravity of the mine is adjusted to the specific gravity of the surrounding water. With the mine adjusted to the specific gravity of the surrounding water further changes in the adjustment of the specific gravity during the relatively short periods of travel of the mine beyond the aforesaid control limits of submersion is prevented. The present invention also contemplates the provision of a new and improved inertia controlled mine firing mechanism comprising a compound pendulum adapted to close a pair of firing contacts only in response to a sudden lateral movement of the mine of predetermined character when the lateral movement has been sustained for a predetermined period of time whereby the mine is not fired by wave action or tidal movements of the water, provision also being made for the self-destruction of the mine when the source of power has been exhausted sufficiently to prevent further operation of the depth controlling mechanism.

While the invention has been described in detail with respect to a preferred example thereof which gives satisfactory results, it will be understood by those skilled in the art to which the invention pertains, after understanding the invention, that various changes, modifications and instrumentalities may be employed without departing from the spirit and scope of the invention and it is our intention, therefore, in the appended claims to cover all such changes, modifications and instrumentalities.

The invention herein described and claimed may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In a subfloating body adapted to perform an oscillating movement about a position of equilibrium, a ballast chamber having a quantity of ballast fluid therein, a reversible pump adapted to vary the quantity of said fluid within the chamber, means for propelling the body alternately in opposite directions about said position of equilibrium, a source of power, a hydrostatic device, means controlled by the hydrostatic device for operatively connecting the propelling means to said source of power selectively thereby to cause the body to oscillate about said position of equilibrium, means controlled by said propelling means for operating said pump whenever the propelling means is operated, and means including a valve member for preventing a change in the quantity of fluid within said chamber until the propelling means has made a predetermined number of operations in a direction to propel the body toward said position of equilibrium.

2. In a subfloating body adapted to perform an oscillating movement about a position of equilibrium below the surface of the water, means for propelling the body alternately in opposite directions, a source of power, a hydrostat device adapted to connect said propelling means to the source of power selectively in accordance with the depth of submersion of the device thereby to cause the body to oscillate about said position of equilibrium, a ballast chamber having a ballast fluid therein, a reversible pump continuously connected to said propelling means and adapted to be operated thereby in either direction in accordance with the direction of movement of the propelling means, a fluid connection between the pump and said ballast fluid, a valve member adapted to control said fluid connection, and means controlled by said propelling means for actuating said valve member to a closed position when the direction of movement of the propelling means is reversed and to an open position when the reverse movement of the propelling means has continued for a predetermined period of time.

3. In a submersible body adapted to perform an oscillating movement about a position of equilibrium below the surface of a body of water, a source of power, means including a prime mover for propelling the body successively in opposite directions about said position of equilibrium, a hydrostatic device, means controlled by said hydrostatic device for causing the prime mover to be operatively connected to said source of power thereby to urge the body selectively in either direction toward said position of equilibrium during the time the body has passed beyond certain predetermined limits of control depth and to disconnect the prime mover from the source of power when the body has moved within said predetermined limits of control depth, a ballast fluid within said body, a reversible pump continuously connected to said prime mover and adapted to be operated in either direction thereby, a fluid connection between said ballast fluid and the surrounding water, and means including a valve member for interrupting said fluid connection until the pump has made a predetermined number of operations in a direction to urge the body toward said position of equilibrium.

4. In a device of the character disclosed for maintaining a submarine floating body in continuous oscillation about a position of equilibrium at a predetermined depth of submersion, a chamber having a ballast fluid therein, a reversible pump adapted to vary the quantity of fluid in said chamber, means for operating the pump alternately in opposite directions, and means controlled by the pump operating means for rendering the pump ineffective to vary the quantity of ballast fluid within said chamber until the pump has made a predetermined number of operations continuously in one of said opposite directions.



5. In a mechanism for adjusting the specific gravity of a freely subfloating body to equality with the specific gravity of the surrounding water, the combination of means for propelling the body alternately in opposite directions about a predetermined depth of submersion, a ballast chamber arranged within the body and having a quantity of ballast fluid therein, a reversible pump continuously connected to said propelling means and adapted to be operated in either direction thereby, a fluid connection between the pump and said ballast fluid, a second fluid connection between the pump and the surrounding water, means for interrupting said fluid connections until the pump has operated for a predetermined period of time in each of said directions respectively and for reestablishing said fluid connections as the pump continues to operate in each of said directions respectively, a pair of check valves respectively arranged in each of said fluid connections and adapted to prevent an increase in the quantity of ballast fluid within the ballast chamber when the pump is not operated, and means for causing said check valves to open in response to a change in the pressure of the fluid within each of said fluid connections thereby to permit a flow of fluid therethrough in either direction in accordance with the direction of operation of said pump.

6. In a buoyancy control mechanism for a subfloating mine of the class described, a ballast chamber having a quantity of ballast fluid therein, a reversible pump adapted to vary the quantity of fluid within the ballast chamber thereby to change the specific gravity of the mine, means for operating the pump alternately in opposite directions, means including a hydrostat in communication with the surrounding water for controlling the pump operating means selectively in accordance with the depth of submergence of the mine within the water, and means for rendering the pump ineffective to change the quantity of ballast fluid within the ballast chamber until the pump has made a predetermined number of operations in each of said directions respectively.

7. In a device of the character disclosed for controlling the buoyancy of a freely subfloating body by variations in the quantity of ballast fluid therein, in combination, a reversible rotary pump adapted to vary the quantity of said ballast fluid, a hydrostatic device, means controlled by said hydrostatic device for rotating the pump alternately in opposite directions during the travel of the body beyond predetermined control depths of submersion, a valve member adapted to be actuated to an open position and to a closed position, means included within said valve for rendering the pump effective to vary the quantity of ballast fluid within the body when the valve member is in said open position and to render the pump ineffective to vary the quantity of said ballast fluid when a portion of the valve establishes a fluid connection between the inlet and outlet of the pump while the valve is in said closed position, means controlled by said pump rotating means for moving the valve to said closed position for a predetermined period of time whenever the direction of rotation of the pump is reversed, and means effective when said predetermined period of time has expired for thereafter moving the valve to said open position during the additional continuous movement of the pump.

8. In a device of the character disclosed for controlling the buoyancy of a subfloating body by variations in a ballast fluid disposed therein, a fluid connection between said ballast fluid and the surrounding water, a reversible pump adapted to force fluid through said fluid connection in either direction selectively in accordance with the direction of operation of the pump, means controlled by the depth of submergence of the body within the water for causing said pump to operate in each of said opposite directions selectively in succession, a movable valve member associated with the pump and adapted to interrupt

said fluid connection when the valve member is moved to a close position, a rotatable member in continuous operative engagement with said pump operating means and adapted to be controlled thereby, a movable actuating element frictionally coupled to said rotatable member, a lever arm pivotally secured at one end thereof to said valve member and having a stop device thereon adapted to be engaged by said actuating element, means for yieldably urging said valve toward a closed position, and a pair of stop members adapted to engage said lever arm on opposite sides of said stop device selectively in accordance with the direction of movement of the actuating member thereby to open said valve member in predetermined time delayed relation with respect to the operation of said pump when the actuating element moves in either direction into engagement with said stop device.

9. In a device of the character disclosed for varying the quantity of ballast fluid within a ballast chamber, a reversible pump, rotatable means for operating the pump in either direction, a fluid connection between the pump and said ballast fluid, a valve included within said fluid connection and adapted to interrupt the fluid connection when the valve is closed, a rotatable member in continuous connection with said pump operating means and adapted to be operated thereby, and means controlled by said rotatable member for opening said valve when the rotatable member is moved in either direction through a predetermined angle from an initial position whereby the pump is rendered effective to change the quantity of ballast fluid within the ballast chamber when the pump has operated for a predetermined period of time in either direction.

10. In a subfloating mine adapted to perform an oscillatory movement about a position corresponding to a predetermined depth of submersion within a body of water comprising, a source of power, means including a motor for propelling the mine alternately in opposite directions, a hydrostatic device, relay means energized through operation of said hydrostatic device for causing the propelling means to be operated in one direction by said source of power when the mine is above an upper depth and for causing the propelling means to be operated in the opposite direction by said source of power when the mine is below a lower depth and to disconnect the propelling means from the source of power when the body is intermediate said upper and lower depths, means for adjusting the specific gravity of the mine to equality with the specific gravity of the surrounding water progressively of increments during the travel of the mine beyond said upper and lower depths, thermal relay means for arming the mine as said thermal relay means is energized, circuit means connecting said source of power to said relay means and the thermal relay means, and means included in said circuit and actuated by said relay means for causing deenergization of said relay means and energization of the thermal relay means when the specific gravity of the mine has been adjusted sufficiently to cause a predetermined relation between the time of travel of the mine beyond said upper and lower depths and the time of travel of the mine intermediate said upper and lower depths.

11. In a subfloating mine adapted to perform an oscillatory movement about a position corresponding to a predetermined depth of submerison within a body of water, a source of power, means including a motor for propelling the mine alternately in opposite directions, a hydrostatically operated switch adapted to be actuated to a closed position when the mine has reached a predetermined depth of submerison within the water, means for locking the hydrostatically operated switch in said closed position, a hydrostatic device having a movable contact element in electrical connection with said hydrostatically operated switch and adapted to engage a pair of contacts selectively when the mine traverses predetermined upper and lower limits of depth control respectively disposed at a greater depth than said predetermined depth of submerison, a pair of relays respectively connected to said pair of contacts and adapted to be operated selectively by said source of power as the movable contact element engages each of said contacts in succession, means controlled by said relays for reversing the motor as the mine passes beyond each of said depth control limits and for causing the motor to be brought to rest during the travel of the mine between said depth control limits, means for adjusting the specific gravity of the mine to equality with the specific gravity of the surrounding water progressively by increments during the travel of the mine beyond said upper and lower control limits, a thermal relay, means for energizing said thermal relay during the travel of the mine beyond each of said depth control limits, a pair of contacts on said thermal relay adapted to be closed when a predetermined relation exists between the time of travel of the mine beyond said depth control limits and the time of travel of the mine intermediate the depth control limits, and electroresponsive means for arming the mine in response to the closure of the pair of contacts on said thermal relay.

12. In a subfloating mine adapted to oscillate about a position corresponding to a predetermined depth of submersion within a body of water comprising, a source of power, means including a motor for propelling the mine alternately in opposite directions, a hydrostatic device, a first relay means controlled by said hydrostatic device for causing the propelling means to be operated in one direction by said source of power when the mine is above an upper depth control limit and for causing the propelling means to be operated in the opposite direction by said source of power when the mine is below a lower depth control limit, means for adjusting the specific gravity of the mine to equality with the specific gravity of the surrounding water progressively by increments during the travel of the mine beyond said upper and lower depth control limits, thermal relay means for arming the mine as said thermal relay means is energized, a second source of power, circuit means connecting said second source of power to said first relay means and the thermal relay means, means included in said circuit and actuated by said first relay means for causing deenergization of said first relay means and energization of the thermal relay means when the specific gravity of the mine has been adjusted to substantially the specific gravity of the surrounding water and means including an electroresponsive element operatively connected to said second source of power and controlled successively by said first relay means, said thermal relay and said first named source of power for firing the mine when the first named source of power is exhausted sufficiently to prevent the operation of said motor.

13. In a subfloating mine adapted to oscillate within a body of water, means for causing the mine to oscillate by progressively decreasing amounts beyond predetermined limits of submersion therein, an arming relay having a contact member adapted to be moved selectively to a safe position and to an armed position, means for yieldably maintaining said contact member in the safe position and in the armed position respectively, a contact element on said relay adapted to be engaged by said contact member when the contact member is in said armed position, means including a control circuit for restoring the contact member to the safe position whenever the contact member is moved to the armed position prior to the oscillating movement of the mine within the water, means controlled by the pressure of the water for rendering said control circuit ineffective after the mine has reached a predetermined depth of submergence therein, a second contact on said arming relay adapted to be engaged by said contact member when the contact member is in the safe position, and means including said

second contact for moving the contact member into said armed position when the travel of the mine beyond each of said predetermined control limits of submersion has been reduced to a predetermined period of time.

14. In a subfloating mine adapted to oscillate about a position corresponding to a predetermined depth of submersion within a body of water comprising, a mine casing, a source of power within said casing, means including a reversible motor energizable by said source of power for propelling the mine alternately in opposite directions, a ballast chamber within said casing and having a quantity of ballast fluid therein, a fluid connection between said ballast fluid and the exterior of the casing, a reversible pump connected to said reversible motor included within said fluid connection and adapted to force fluid through said fluid connection in either direction selectively in accordance with the direction of operation of the pump, a plurality of electroresponsive devices within the casing adapted to control the direction of operation of said motor, and manually operated switch means for initiating the operation of certain of said motor control electroresponsive devices to cause the motor to operate in a direction to force fluid into the ballast chamber through said fluid connection whereby the pump may be primed when the outer end of said fluid connection is in communication with an external source of fluid.

15. In a freely subfloating mine, in combination, a mine casing, a source of electrical power within said casing, a pair of normally open inertia controlled firing contacts, means including a pair of pivotally supported inertia elements for closing said firing contacts in response to a lateral impulse of predetermined character received thereby, an arming relay adapted to connect one of said contacts to said source of electrical power, a slow acting relay adapted to be connected to said source of power in response to the momentary closure of said firing contacts as a lateral impulse of predetermined character is received by said inertia elements, means controlled by the firing contacts for causing said slow acting relay to be continuously energized by said source of power after the firing contacts are disengaged, an explosive charge disposed within said casing, an electroresponsive detonating device adapted to fire said explosive charge, and means on said slow acting relay for operating said detonating device in predetermined time relation with respect to the closing of said firing contacts.

16. In a subfloating mine of the character disclosed adapted to oscillate about a position corresponding to a predetermined depth of submersion within a body of water comprising, a source of power, means including a motor energizable by said source of power for propelling the mine alternately in opposite directions, a hydrostatic device, electroresponsive means controlled by said hydrostatic device for causing the propelling means to be operated in one direction by said source of power when the mine is above an upper depth and for causing the propelling means to be operated in the opposite direction by said source of power when the mine is below a lower depth and to disconnect the propelling means from the source of power when the body is intermediate said upper and lower depths, means for adjusting the specific gravity of the mine to equality with the specific gravity of the surrounding water progressively by increments during the alternate travel of the mine beyond said upper and lower depths, time delay means for arming the mine as said time delay means is energized, circuit means connecting said source of power to said electroresponsive means and the time delay means, means included in said circuit and actuated by the electroresponsive means for causing deenergization of the electroresponsive means and energization of the time delay means, when the specific gravity of the mine has been adjusted sufficiently to cause a predetermined relation between the time of travel of the mine beyond said upper and lower depths and the time of travel of the mine intermediate said upper and lower depths, to effect the deenergization of said hydrostatically controlled electroresponsive means, and inertia controlled means responsive to a lateral movement of the mine for firing the armed mine selectively in accordance with a predetermined characteristic of said movement.

17. In a subfloating mine adapted to oscillate about a position corresponding to a predetermined depth of submersion within a body of water comprising, a mine casing, a source of power within said casing, means including a reversible motor energizable by said source of power for propelling the mine alternately in opposite directions, a ballast chamber within said casing and having a quantity of ballast fluid therein, a fluid connection between said ballast fluid and the exterior of the casing, a reversible pump connected to said motor included within said fluid connection and adapted to force fluid through said fluid connection in either direction selectively in accordance with the direction of operation of the pump, hydrostatically controlled relay means for causing said propelling means to operate in either direction selectively in accordance with the depth of submersion of the mine, a pair of normally open inertia controlled firing contacts, means including a pair of pivotally supported inertia elements for closing said firing contacts in response to a lateral impulse of predetermined character received thereby, a thermal relay, means actuated by said hydrostatically controlled relay means and connected to said source of power and the thermal relay for causing deenergization of the relay means and energization of the thermal relay during the travel of the mine intermediate predetermined depths of submersion, an arming relay adapted upon energization thereof to connect one of said firing contacts to said source of power, a pair of contacts on said thermal relay adapted to be closed to energize said arming relay when a predetermined relation exists between the time of travel of the mine beyond said predetermined depths and the time of travel of the mine intermediate the depths, a slow acting relay adapted to be connected to said source of power in response to the momentary closure of said firing contacts as a lateral impulse of predetermined character is received by said inertia elements, means controlled by the firing contacts as the contacts close for causing said slow acting relay to be continuously energized by said source of power after the firing contacts are disengaged, an explosive charge disposed within said casing, an electroresponsive detonating device adapted to fire said explosive charge, and means on said slow acting relay for operating said detonating device in predetermined time delayed relation with respect to the closing of said firing contacts.

18. In a subfloating mine of the character disclosed comprising electric motor means for propelling said mine between gradually diminishing upper and lower depth limits of oscillation about a position corresponding to a predetermined depth of submersion within a body of water, a hydrostatic device, relay means controlled by said hydrostatic device for reversing said motor to propel the mine alternately in opposite directions, said hydrostatic device controlling the operation of said relay means whereby said motor operates only beyond said upper and lower depth control limits, a thermal relay for arming the mine, said thermal relay being energized upon deenergization of said hydrostatically controlled relay means when said mine passes beyond said upper and lower depth control limits, circuit means connecting said relay means and the thermal relay, a resiliently mounted compound pendulum means responsive to a lateral movement of the mine for firing the armed mine selectively in accordance with a predetermined characteristic of said movement, and a firing circuit connecting said thermal relay and said pendulum means.

19. The combination of an oscillating mine having electric motor means for propelling said mine between

gradually diminishing upper and lower depth limits of oscillation about a position corresponding to a predetermined depth of submersion within a body of water, a hydrostatic device, relay means controlled by said hydrostatic device to initiate operation of said motor and for reversing the motor to propel the mine alternately in opposite direction, said hydrostatic device controlling the operation of the relay means whereby the motor operates only beyond predetermined fixed upper and lower limits, means for adjusting the buoyancy of the mine sufficiently to maintain the mine at substantially a predetermined depth of submergence, mine firing means, a compound pendulum having relatively tiltable portions for controlling said mine firing means, an arming relay, thermal relay means controlling the operation of said arming relay to render said firing means effective to fire the mine in response to sudden shocks received thereby after the buoyancy of the mine becomes sufficient to maintain the mine substantially at said predetermined depth, said compound pendulum portions having mutually coacting means adapted to maintain their respective vertical axes in coincidence thereby preventing operation of said compound pendulum controlled firing means in response to gradual lateral movement of the mine.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 913,524 | Leon | Feb. 23, 1909 |
| 996,412 | Jones | June 27, 1911 |
| 1,363,958 | Dalen | Dec. 28, 1920 |
| 1,382,374 | Maxim | June 21, 1921 |
| 1,440,596 | Hammond | Jan. 2, 1923 |
| 1,471,628 | Palmer | Oct. 23, 1923 |
| 2,319,107 | Brandt | May 11, 1943 |
| 2,325,908 | Edstrom | Aug. 3, 1943 |