Jan. 10, 1961 J. V. ATANASOFF ET AL 2,967,504

METHOD AND APPARATUS FOR SWEEPING A MINE

Filed April 24, 1947 4 Sheets-Sheet 1

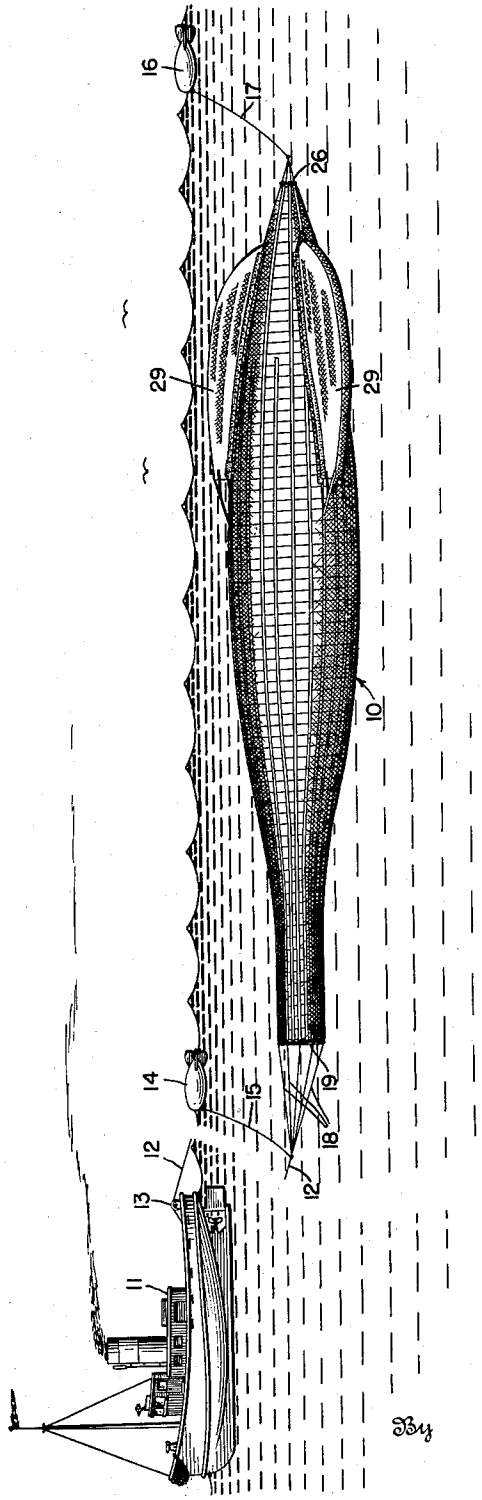


FIG. 1.

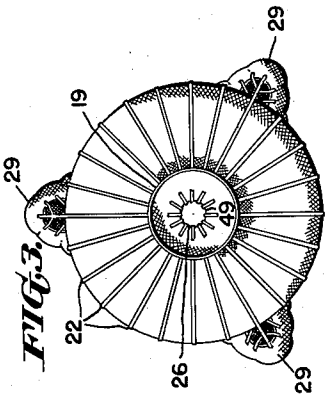


FIG. 3.

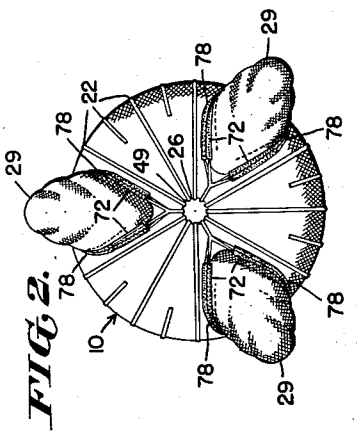


FIG. 2.

Inventors
J. V. Atanasoff
S. Legvold
By
Attorney

METHOD AND APPARATUS FOR SWEEPING A MINE

Filed April 24, 1947 4 Sheets-Sheet 2

FIG. 4.

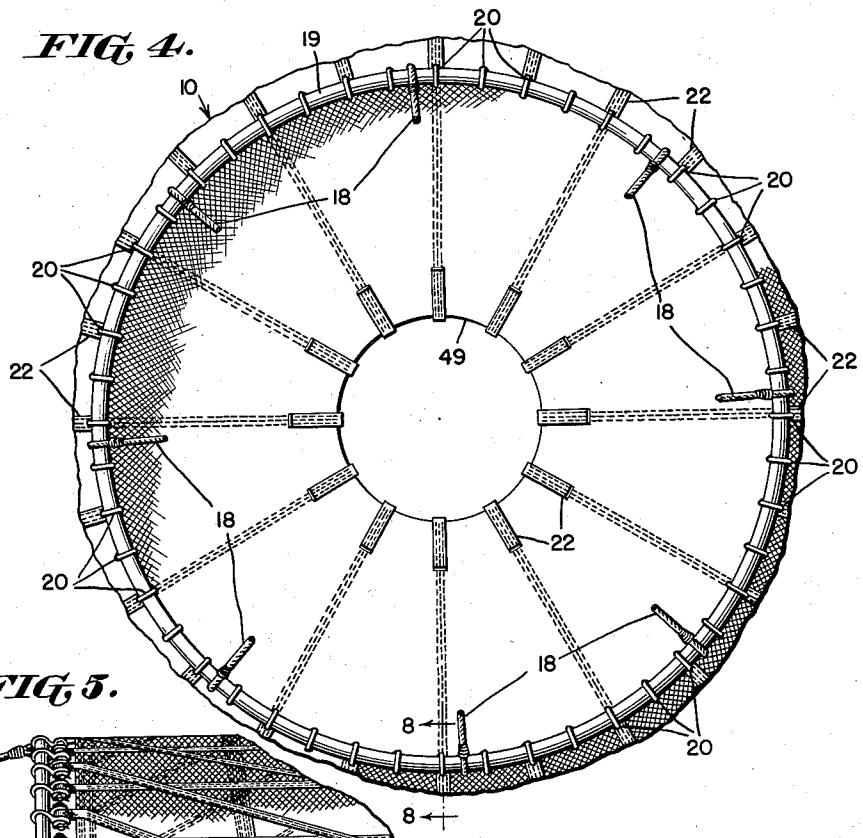


FIG. 5.

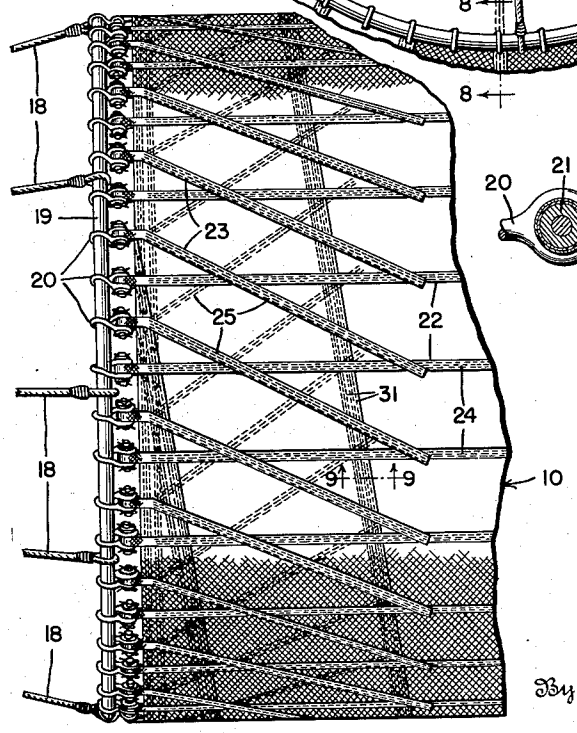


FIG. 8.

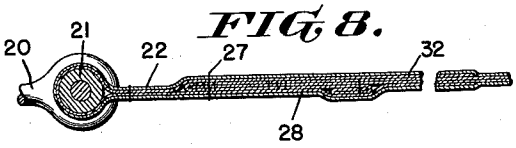
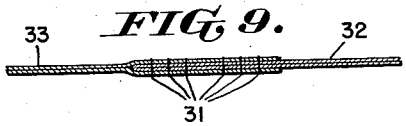


FIG. 9.



Inventors
J. V. Atanasoff
S. Legvold
By M. S. Hayes
Attorney

Jan. 10, 1961 J. V. ATANASOFF ET AL 2,967,504

METHOD AND APPARATUS FOR SWEEPING A MINE

Filed April 24, 1947 4 Sheets-Sheet 3

FIG. 10.

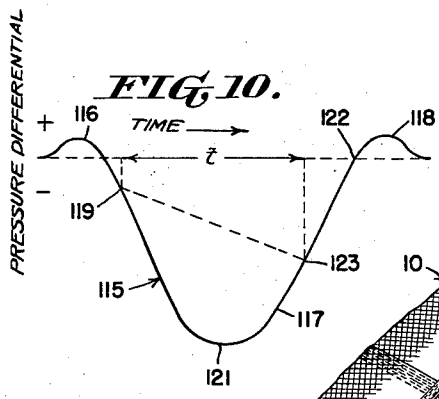


FIG. 6.

FIG. 7.

Inventors

J. V. Atanasoff

S. Legvold

By M. L. Hayes

Attorney

Jan. 10, 1961 J. V. ATANASOFF ET AL 2,967,504

METHOD AND APPARATUS FOR SWEEPING A MINE

Filed April 24, 1947 4 Sheets-Sheet 4

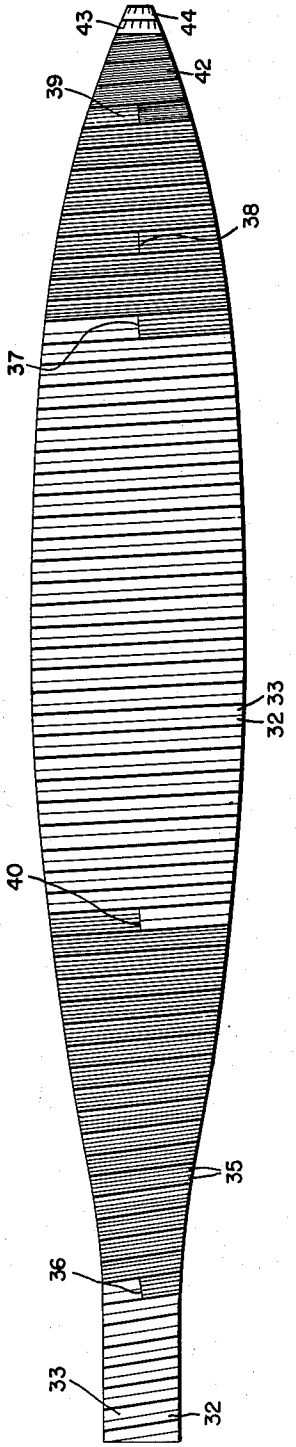


FIG. 13.

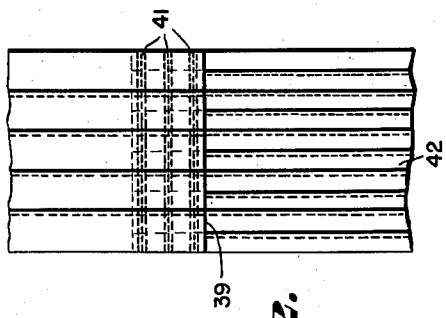


FIG. 18.

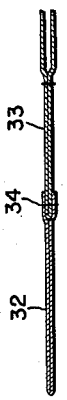


FIG. 16.

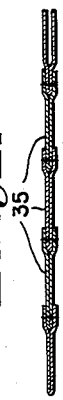


FIG. 17.

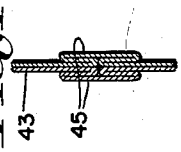


FIG. 12.

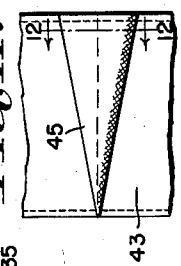


FIG. 11.



FIG. 15.

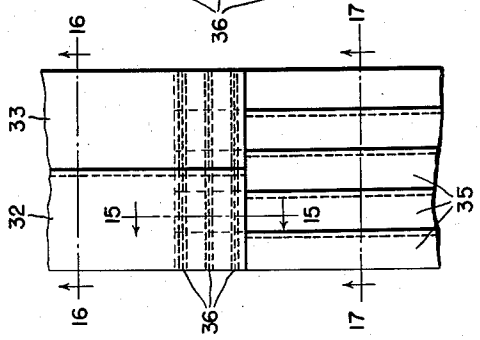


FIG. 14.

Inventors
J. V. Atanasoff
S. Legvold
By M. A. Hayes
Attorney

United States Patent Office 2,967,504 Patented Jan. 10, 1961

2,967,504

METHOD AND APPARATUS FOR SWEEPING A MINE

John V. Atanasoff, 3712 Longfellow St., Hyattsville, Md., and Sam Legvold, 129 N. Wilmoth Ave., Ames, Iowa

Filed Apr. 24, 1947, Ser. No. 743,578

14 Claims. (Cl. 114—235)

(Granted under Title 35, U.S. Code (1952), sec. 266)

This invention relates to means for sweeping an underwater mine and more particularly to a new and improved method and apparatus for sweeping an underwater mine in which firing of the mine is accomplished by a reduction in pressure of the surrounding water.

There are a variety of principles upon which the firing of pressure actuated mines can be made to operate. The fundamental principle involved in this type of mine is that the pressure time relations at fixed points of reference beneath a moving vessel are of a more or less well defined type and a device for the successful sweeping of a pressure mine requires simulation of these pressure time relations to a sufficient degree to fire the mine. It is a further principle in the design of a pressure fired mine that it must not be fired in response to variations of pressure generated by waves, seiches or tides. As a consequence there are conditions on the pressure-time relations which will fire the mine and these conditions must be met in a successful mine sweeping device.

In accordance with the present invention a pressure signal sufficient to fire the mine is generated within the water by the movement of a large mass of water entrained within a flexible body or envelope as the body is towed beneath the surface of the water by a vessel. The envelope is provided with an aperture at the front end thereof through which water is received. A smaller aperture is provided at the rear end of the envelope to restrict the flow of water within the envelope during the towing operation and to permit the escape of any air which may be trapped therein as the envelope is streamed from the towing vessel. The differential of the cross sectional area of the aforesaid apertures in the envelope is sufficient to maintain the envelope in a fully distended position at all times during the towing operation by reason of the difference in pressure of the water within the envelope and the water adjacent thereto. The envelope is towed preferably near the surface of the water in a submerged condition and maintained at this predetermined depth of submergence by a float secured to the tow line at a point near the leading end of the envelope.

As the water-filled envelope is towed through the water, the water surrounding this envelope is displaced along certain streamlines determined by the shape of the body. As a result of this displacement, various portions of water adjacent the envelope acquire different velocities and these velocities cause a decrease in the pressure of the water at the points corresponding in accordance with the well known law of Bernoulli. The envelope is of sufficient length to apply a continuous decreased pressure at a fixed point of reference therebeneath for a period of time sufficient to cause a pressure operated mine arranged on the bed of a body of water to fire. Stated differently, the envelope is so shaped and is towed at such a speed as will effect the pressure time relations within the water required to sweep the mine.

One of the objects of this invention is to provide a new and improved method and apparatus for sweeping

a marine mine adapted to be fired in response to a reduction in the pressure of the surrounding water.

Another object is to provide an underwater sweep for a pressure mine which will simulate the pressure signature of a moving vessel.

Another object is to provide a device for sweeping a pressure mine which is easy to launch, expendable, inexpensive to manufacture, reliable in operation, and which possesses all of the qualities of durability and dependability in service.

Another object is to provide a collapsible envelope having a contour which is tapered in such a manner as to effect the pressure time relations required to sweep a marine mine when the envelope and the water entrained therein are towed above the mine at a sufficient speed.

Another object is to fabricate a collapsible tapered envelope adapted to tow a ponderous mass of water entrained therein by winding a length of fabric material in a series of convolutions of varying diameter in accordance with the taper of the envelope and joining adjacent edges of the convolutions together.

Another object resides in the provision of a new and improved method of joining adjacent edges of a series of convolutions of fabric material together.

Another object is to provide a sweep which is adapted to be transported by a vessel in a collapsed condition, and which may be quickly streamed and inflated with water within the vicinity of the mine field, by employing a small complement of personnel.

A further object is to provide a device for prematurely exploding a pressure mine in which the sweep is composed of pliable material and is adapted to withstand the explosion of the mine without substantial injury thereto.

A still further object is to provide a flexible structure adapted to tow a ponderous mass of water entrained therein and which will withstand the stresses induced therein by the towing operation.

Still another object is to provide an elongated flexible envelope adapted to entrain a ponderous mass of water therein as the envelope is towed through the water thereby to sweep a pressure fired mine, in which means are provided for quickly emptying the envelope at the conclusion of the sweep operations.

An additional object is to provide a device for simulating the pressure signature of a vessel which possesses the desirable qualities of hydrodynamic stability in operation.

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

Fig. 1 is a view in elevation showing the device according to a preferred embodiment thereof being towed by a vessel;

Fig. 2 is a somewhat enlarged rear view of the device of Fig. 1 with the float and line removed;

Fig. 3 is a somewhat enlarged front view of the device of Fig. 1;

Fig. 4 is a greatly enlarged front end view partly broken away of the device of Fig. 1;

Fig. 5 is a fragmentary side view of the device of Fig. 4;

Fig. 6 is a view in perspective of the front end portion of one of the fins employed with the device and showing the method of attaching the fin to the main body of the device;

Fig. 7 is a view in perspective of the tail end of the fin of Fig. 6 and showing a portion of the main body;

Fig. 8 is an enlarged view in section taken along the line 8—8 of Fig. 4;

Fig. 9 is an enlarged view in section taken along the line 9—9 of Fig. 5;

Fig. 10 shows in diagrammatic form the relation between the pressure differential of the surrounding water and time as the sweep device passes above a fixed point of reference;

Fig. 11 is a detail view showing the method of reducing the diameter of the envelope rapidly at the rear end of the main body;

Fig. 12 is a view in section taken along the line 12—12 of Fig. 11;

Fig. 13 is a view of the envelope before the fins are attached, showing certain details of the envelope structure;

Fig. 14 is a detail view showing the method of attaching two-ply material to five-ply material at certain points in the main body structure;

Fig. 15 is a sectional view taken along the line 15—15 of Fig. 14;

Fig. 16 is a sectional view taken along the line 16—16 of Fig. 14;

Fig. 17 is a view taken along the line 17—17 of Fig. 14; and

Fig. 18 is a detail view showing the method of attaching 5-ply material to 10-ply material at certain points in the main body structure;

Referring now to the drawings for a more complete understanding of the invention and more particularly to Fig. 1 thereof, there is shown thereon the device of the present invention according to a preferred embodiment thereof and indicated generally by the reference numeral **10** submerged within a body of water and towed by a vessel **11** having a line **12** secured thereto and to the leading end of the device. The line **12** preferably passes over a roller **13** arranged on the fantail of the vessel and connected at the distant end thereof with a float **14** by the line **15**. The trailing end of the device is also provided with a float **16**, connected thereto as by the line **17**, the purpose of which will become more clearly apparent as the description proceeds. The line **12** is connected to a towing bridle comprising a plurality of flexible towing members **18** respectively connected at one end thereof to the tow line **12** and at the opposite end to a rigid annular member **19**. The annular member is provided with a plurality of shackle bolts **20** secured thereto at regular intervals and having sleeves **21** thereon to which are respectively connected the webs **22** and **23** in such a manner that each of the webs **22** is intermediate a pair of webs **23** at the point of connection of the webs with the associated shackle bolts.

The webs **22** and **23** are stitched to the body of the device by a plurality of rows of stitches **24** and **25** respectively, Fig. 5, in such a manner that the webs **22** are arranged longitudinally with respect to the body of the device and the webs **23** are arranged at an angle with respect to the webs **22**, the webs being additionally secured to the lead end of the body by an additional row of stitching **27**, Fig. 8, passing through the hem portion **28** of the body. The webs **22** and **23** are employed to distribute the towing force throughout the area of the body of the device whereby the throat of the device comprising the annular member or ring **19** and body adjacent thereto is prevented from being torn away from the remainder of the body by the towing force applied thereto by the line **12** as the device is towed through the water.

As clearly shown on Figs. 1, 2, and 3 the device **10** is generally circular in shape and elongated sufficiently to facilitate towing of the device through the water and to provide a structure which is adapted to maintain a condition of reduced pressure at a fixed point of reference therebeneath for a predetermined period of time as the device is towed past the point of reference. The device is provided with a ring member **26** secured at the trailing end thereof of lesser diameter than the ring **19**

whereby the device is adapted to be filled continuously with water at a pressure slightly in excess of the pressure of the surrounding water as the device is towed therethrough by reason of the differential in the size of the rings **19** and **26**. The ring **26**, it will be noted, is preferably connected by the line **17** to the float **16**, the float being generally similar to the float **14** thereby providing means whereby the trailing end of the device may be easily recovered when it is desired to stow the device on the vessel at the completion of the sweeping operations.

Hydrodynamic stability is obtained by a clindrically shaped throat portion of the body and a plurality of fin members **39** secured to the aft portion of the body, each of the fins being of hollow construction and adapted to be distended by the pressure of the water admitted thereto through an opening in the leading end of each of the fins respectively.

The general construction of the body and the fins of the device and the manner of securing the fins to the body will now be described.

The body and fins of the device are composed of high tensile strength fabric suitable for the purpose such, for example, as a fabric known in the art as nylon. As best shown on Fig. 13 the leading end of the body is composed of a length of fabric, nylon having been found satisfactory for this purpose. This length of material is a multi-strip length being composed of two strips **32** and **33** stitched together with six rows of stitching indicated generally by the dashed line **34**, Fig. 14. Each of the strips **32** and **33** is folded double, the folded portion of the strip **33** being arranged between a pair of edge portions of the strip **32** and stitched thereto by the stitching **34**, Fig. 16. This two-ply length of material is stitched together at **31**, Fig. 9, to form a helical fabric structure of double pitch comprising the cylindrically shaped throat of the body. Stitched to the end of the strips **32—33** is a length of nylon fabric comprising five elongated folded portions or strips **35** stitched thereto as by the rows of stitching **36**, Figs. 14 and 15. The leading tapered portion of the body is thus composed of a length of fabric of quintuple pitch, the type of fabric known as nylon having been found suitable for the purpose. Successive convolutions of this fabric, it will be understood, are stitched together by six rows of stitching similar to the arrangement employed in securing the successive convolutions of the length of material comprising the throat of the body.

The central portion of the body is composed of a length of material comprising two elongated pieces or strips of nylon fabric **32** and **33** stitched together in a manner similar to the arrangement employed in the construction of the throat of the body whereby the central portion of the body is composed of a strip of material helically wound on a double pitch, the junction **40** of the material composing the central portion of the body with the material composing the aforesaid helical portion of the body being generally similar to the junction of the material composing the tapered portion of the body with the material comprising the throat.

The tapered trailing portion of the body is composed of five strips of nylon fabric stitched to the central body portion at **37** by a plurality of rows of stitching. This length of material is stitched at **38** to five strips or plys of material known as nylon fabric.

The nylon fabric is stitched together thereby to form a tapered circular structure in quintuple pitch, one end of the fabric being stitched at **39** by a plurality of rows of stitching **41**, Fig. 18, to a length of fabric **42** of ten ply construction, thereby providing a ten pitch circular tapering and trailing tail portion of the body.

The trailing end portion of the body comprises two lengths of nylon fabric material designated **43** and **44** respectively, each of the lengths **43** and **44** having a plurality of uniformly spaced gores **45** formed thereon by

folding the material back on itself, as best shown in Figs. 11 and 12, sufficiently to provide a smooth tapering outline to the body when the lengths of material 43 and 44 are stitched thereto.

The juncture of the tapered portion 43 with the ten pitch material is made secure by a length of tape or webbing 46, Fig. 7, stitched along the junction of these parts and, in like manner, the tapered portion 44 is made secure to the tapered portion 43 by a length of tape 47 stitched thereto. The opposite end of the tapered member 44 is stitched to a length of tape 48 thereby forming an aperture 49 through which a relatively small quantity of water is continuously discharged while the device is being towed through the water in a fully inflated condition. From the foregoing it will be apparent that the generally cigar shaped body of the device as illustrated on Figs. 1 and 13 of the drawings is composed of fabric material of double thickness and sufficient strength according to the desired shape of the body and the stresses to be withstood by the various portions of the body during the towing operation.

The webs 22 extend rearwardly along the length of the body and are stitched thereto, throughout the length, thereby to distribute the towing pressure uniformly throughout the envelope comprising the body in accordance with the stresses applied thereto by the surrounding water and the water entrained therein, alternate ones of the webs 22 extending throughout the entire length of the body and passing over the tapes 46 and 47 and intermediate the tape 42 and the body portion 44, the ends of these tapes being formed in loops within which is arranged the ring 26, Figs. 1, 2 and 7.

The construction of the fins and the manner of attaching the fins to the body will now be described.

The body of each of the fins is composed of nylon fabric and comprises a plurality of gore sections indicated generally by the numeral 51 and stitched together by a plurality of rows of stitching 52 thereby to give the fins the general appearance as shown on Figs. 1, 2 and 3 when attached to the main body of the device and towed through the water by a vessel. The leading end of each of the fins is secured to a hoop, not shown, composed preferably of a continuous length of wire suitable for the purpose such, for example, as piano wire formed into a hoop with each convolution of the wire in contiguous relation with the remaining convolutions thereof and maintained in such relation by a wrapping of tape, not shown, thereabout. The leading end of the fin may be secured to the hoop in any convenient manner as for example by folding the leading end of the gore sections 51 inwardly and stitching the selvage portion thereof to the gore sections as at 55. The hoop 53 is enclosed between a pair of web sections, not shown, having the edge portions thereof folded inwardly and stitched to the gore sections 51 as at 57 and 58 respectively. There is also provided within each of the fins a plurality of flexible tension members, not shown.

The fin has also secured thereto as by the rows of stitching 71, a tab 72 comprising a length of nylon fabric having a cord 73 extending throughout the length of the tab and confined therein by the rows of stitching 74. The cord 73 is preferably formed from a length of nylon fabric rolled upon itself and maintained in the rolled condition by stitching, not shown. The leading end of the nylon strip 72 is reinforced by a length of nylon fabric 77 stitched exteriorly thereto and to the fin 29 by a plurality of rows of stitching, Fig. 6.

A complementary tab 78 comprising a length of nylon fabric is stitched to the body of the device by a plurality of rows of stitching 79 and stitched together at 81 to form a loop portion extending throughout the length of the strip within which is arranged a line or cord 82 constructed similar to the line 73. The fin is secured to the body of the device by a continuous lashing comprising the cord 83 wrapped or stitched about the loops formed

in the tabs 72 and 78 enclosing the lines 73 and 82 respectively. The leading end of each of the lines 73 and 82 is connected to a snap fastener 84 in engagement with an eye member 85 secured to a tape 86 stitched to the body of the device by rows of stiitching 87 and reinforced by a patch 88 stitched to the body of the device. The eye member 85 is also engaged by a snap fastener secured to a length of web or tape 89 stitched to the fin at the end portions thereof, Fig. 6. It will be understood that the tapes 86 are provided in duplicate for each of the fins and are employed for applying a towing force to the lines 73 and 82 and to the web 89.

There is also provided a tape 91 stitched to the body of the device as at 92 and having an eye member 85 secured thereto, the tape 91 being additionally secured to the body of the device by a patch 93 stitched thereto. Secured to the tape 91 is a snap fastener 84 having a length of web or tape 94 engaged therewith, the end portions of the tape being stitched to the fin as at 95 and 96 respectively, Fig. 6. Stitched to the web 89 by stitching 97 and 98 respectively in a length of web 99 looped through a fastener 85, the web 99 being stitched together along the length thereof as at 101 and stitched at 102 to a web 103 secured at the opposite end thereof to the fin 29 by stitching 104. The tapes or webs 86, 91 and 99 are secured to a web 22 by a plurality of rows of stitching and to the eye member 85 in engagement with the length of web 105, the various webs and tapes exclusive of the web 99 being stitched to the body of the device and to a patch 106 arranged intermediate the various webs and the body of the device and stitched thereto by stitching 107, the arrangement of the tapes 86, 91, 99, 101, 94, 89, 99 and 103 comprising a harness adapted to tow the fin through the water with the aperture formed within the hoop 53 disposed in a plane substantially normal to the direction of travel of the device through the water.

The trailing end of the lines 82 are stitched together and to the body of the device as at 108 and the lines 73 are stitched to the lines 82 respectively and to the body of the device as at 109. One of the lines 82 is stitched to a length of tape 111 and to the body of the device as at 112, the tape 111 being additionally stitched to the body of the device by a plurality of rows of stitching 113 and formed in a loop at the trailing end thereof within which is arranged the ring member 26. Within the rear portion of each of the fins are arranged a plurality of eyelets 114 thereby to provide an escape for the air trapped within the fins as the fins and the device are filled with water during the launching operation., The eyelets are sufficiently small to maintain a predetermined pressure within the fin as the device is towed through the water thereby to maintain the fins sufficiently rigid to impart dynamic stability to the structure.

The aforedescribed fin construction and manner of mounting the fins on the envelope 10 are disclosed in detail and claimed in the copending application of Graham B. Brown for Means for Sweeping a Mine, Serial No. 624,613, filed October 25, 1945.

The method of launching the mine sweeping apparatus of the present invention and the operation thereof in sweeping a pressure mine will now be described. Let it be assumed, by way of example, that the fins 29 are attached to the main body portion of the device and the floats 14 and 28 have been secured by the lines 15 and 27 to the tow line 12 and to the ring 26 of the device respectively. The device and the floats are now lowered into the water from the vessel 11. When the slack in the tow line 12 has been taken up, the annular member 19 is dragged through the water by the towing members 18 in such a manner that water is forced into the throat of the body as the member 19 is hauled forward by the vessel. The body of the device is thus caused to fill with water as the towing operation proceeds, any air which may have been trapped therein escaping through

the ring 27 at the tail of the body, and the body assumes a semi-rigid condition by reason of the ponderous mass of water entrained therein. Concurrently therewith the fins are filled with water flowing through the hoops respectively secured thereto, the trapped air within the fins escaping through the eyelets 114 located at the rear portion of the fins. The fins are thus caused to assume a semi-rigid condition during the dilation of the body of the device and thereby impart hydrodynamic stability thereto.

As shown in Fig. 1 the device is towed beneath the surface of a body of water by a vessel at a predetermined depth of submersion controlled by the float 14 and the length of line 15 secured thereto with a ponderous mass of water entrained therein. As the device passes over a fixed point of reference at the bed of the body of water beneath the device the degree of pressure at the reference point is changed, the pressure first being slightly increased, and then decreased below the normal hydrostatic pressure at the point of reference as the device passes over the point of reference in accordance with the well known law of Bernoulli's theorem, the pressure increasing by a small amount above the normal pressure as the tail of the device passes over the reference point. This condition is shown graphically on Fig. 10 by the curve 115 in which the slight increase in the pressure is indicated by the portion 116, the decrease in pressure by the portion 117 and the slight increase in pressure as the tail of the device passes over the point of reference by the portion 118 of the curve.

Let it now be assumed that a pressure fired mine 124 is arranged at the aforesaid point of reference, Fig. 1. As the forward end of the device passes over the mine the decrease in pressure of the water at the mine is sufficient to actuate the mine firing control mechanism, the device having moved to a position corresponding to a decrease in pressure indicated by the point 119 on the pressure curve 115. It is the usual practice to arrange the firing control mechanism for pressure mines in such a manner that a predetermined reduction in hydrostatic pressure is required to be continuously maintained or exceeded for a period of time in excess of the reduction in pressure at the mine caused by waves in order to fire the mine and to prevent the mine from being prematurely fired by wave action and, furthermore, this reduction in pressure of the surrounding water at the mine must be effected at a rate in excess of the reduction in pressure caused by tides to prevent the mine from being fired prematurely by tide action. It will be noted that the pressure at the point 119 of the curve 115 is decreasing at a relatively rapid rate, the pressure continuing to decrease as the device moves across the mine until the point 121 of the curve is reached, the pressure thereafter increasing until the pressure equals the static head of water at 122 and continuing to increase slightly thereafter until the point 118 of the curve is reached. In order to fire the mine 124, the mine firing control mechanism of the mine is required to be continuously controlled by a decrease in water pressure for a time *t*, Fig. 10, during which time the hydrostatic pressure at the mine does not rise above the pressure required to actuate the firing control mechanism. At the expiration of time *t*, it will be noted, the pressure has been decreased to a value in excess of the pressure required to actuate the mine firing mechanism initially and at no time during this interval is the pressure increased to a value equal to or higher than the pressure required to maintain the mine firing mechanism actuated. The mine, therefore, is fired at the expiration of the time *t* when the device has moved across the mine to a position corresponding to the point 123 of the curve 115.

When this occurs, the tail portion of the sweep mechanism is blown upwardly by the force of the explosion of the mine without sustaining serious damage thereto by reason of the flexible character of the body structure of the device.

In the event, however, that the device should be destroyed or damaged to a considerable extent by the force of the explosion of a mine in which the time *t* is sufficiently short to cause the mine to explode beneath the central portion of the envelope, a new device may be lowered into the water and the sweeping operations resumed within a few minutes after the damage is sustained.

When it is desired to stow the sweeping device on the vessel at the completion of a sweeping operation, the float 16 is hauled aboard the vessel and the device is brought aboard tail first, using the roller 13 whereby the water entrained within the device is emptied through the ring 19 as the device is hauled aboard.

Whereas the invention has been described with particularity with reference to a specific structure, it will be understood that the invention is not so limited as by suitably proportioning the body structure the pressure-time relation at a fixed point of reference therebeneath can be made to resemble the pressure-time relation which occurs as a result of the passage of a ship as closely as is desired.

Briefly stated in summary, the present invention contemplates the provision of mine sweeping apparatus including an elongated flexible body for entraining a ponderous mass of water which may be compactly stowed aboard a vessel and easily launched therefrom and which possesses the desired qualities of hydrodynamic stability, ease of towing, and which is adapted to produce a relatively rapid reduction in the pressure of the water at a fixed reference point on the bed of the body of water as the device is towed thereacross, which will maintain this condition of decreased pressure at the reference point for a predetermined period of time without permitting the pressure to rise above a predetermined value of decreased pressure meanwhile, and which possesses the desired quality of expendability in the event of destruction or damage thereto by the exploding mine.

While the invention has been described with reference to a particular example which gives satisfactory results, it will be understood by those skilled in the art to which the invention appertains, after understanding the invention, that various changes and modifications may be made without departing from the spirit and scope of the invention and it is my intention therefore in the appended claims to cover all such changes and modifications.

The invention herein described 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. The method of sweeping a marine mine adapted to be fired in response to a reduction in the pressure of the surrounding water as a vessel passes over the mine, which comprises the steps of entraining and enclosing a predetermined ponderous mass of water adapted to simulate the pressure signature of said vessel as the entrained mass of water is moved through the surrounding water, and moving said entrained water above the mine at a rate sufficient to produce said reduction in pressure thereabout, thereby to fire the mine.

2. The method of sweeping a marine mine adapted to be fired by the pressure signature of a vessel as the vessel passes above the mine, which comprises the steps of entraining a predetermined ponderous mass of water in a collapsible enclosure, and towing said enclosure and the water entrained therein above the mine at a rate sufficient to simulate said pressure signature, thereby to fire the mine.

3. The method of sweeping a marine mine adapted to be fired in response to a predetermined reduction in pressure of the surrounding water produced by the pressure signature of a vessel as the vessel passes over the mine, which comprises the steps of entraining a predetermined mass of water in a collapsible tubular enclosure, causing water to flow through said enclosure at a restricted rate

sufficient to cause complete dilation of the enclosure as the enclosure is towed through the water, and towing the enclosure and the mass of water entrained therein above the mine at a rate sufficient to simulate said pressure signature, thereby to fire the mine.

4. The method of sweeping a pressure mine which comprises streaming a flexible envelope from a vessel, filling said envelope with a ponderous mass of water, and in towing said water filled envelope at a predetermined depth of submersion within the water above the mine at a rate of travel such that the change in the pressure of the water at the mine simulates the pressure signature of a moving vessel.

5. The method of sweeping a pressure mine which comprises streaming a flexible envelope from a vessel, towing the envelope at a rate sufficient to cause the envelope to be completely dilated with a ponderous mass of water admitted through an aperture in the leading end thereof, and in towing said water filled envelope at a predetermined depth of submersion within the water above the mine at a rate of travel such that the change in the pressure of the water at the mine simulates the pressure signature of a moving vessel.

6. A method of performing a sweeping operation for a pressure mine which comprises stowing a flexible envelope on a vessel, streaming the envelope from the vessel into a body of water, inflating the envelope with a ponderous mass of said water through an aperture in the leading end thereof, towing the inflated envelope beneath the surface of said body of water by a line secured to the vessel, emptying the water from the envelope through said aperture at the completion of the towing operation by hauling the envelope aboard the vessel tail first, and thereafter stowing the envelope on said vessel.

7. In a device for sweeping a pressure mine, the combination of a circular elongated tapered flexible envelope adapted to entrain a ponderous mass of water therein and having a reduced cylindrical throat portion of greater length than its diameter with a circular aperture at the leading end thereof and an enlarged main body portion having a second circular aperture of lesser size at the trailing end thereof, said envelope being of gradually increasing taper from said cylindrical portion to a maximum diameter at the approximate center of the enlarged portion thereof and of gradually decreasing taper from said central portion to the trailing end and composed of a plurality of lengths of fabric material stitched together by a plurality of rows of spirally arranged stitching to form a cylindrical tapered body when the envelope is inflated with said entrained water, and towing means for said envelope including a rigid annular member encircling said first named aperture and secured to said throat portion.

8. In a device for sweeping a pressure mine, the combination of a circular elongated tapered flexible envelope adapted to entrain a ponderous mass of water as the envelope is towed through the surrounding water and having a throat portion with a circular aperture at the leading end thereof and a second circular aperture of lesser size at the trailing end of the envelope, said envelope being composed of a plurality of lengths of fabric material connected end to end and wound in a series of adjacent helixes of varying diameter according to the tapered contour of the envelope when the envelope is inflated by the water entrained therein, each of said lengths of material comprising a predetermined number of strips according to the contour of the portion of the envelope formed thereby, a plurality of rows of helically arranged stitching for joining adjacent ones of said strips and helixes of material together, and towing means for said envelope including a rigid annular member encircling said first named aperture and secured to said throat portion.

9. In a device for sweeping a pressure mine, the combination of a circular elongated tapered flexible envelope adapted to entrain a ponderous mass of water as the envelope is towed through the surrounding water and having a throat portion with a circular aperture at the leading end thereof and a second circular aperture of lesser size at the trailing end of the envelope, said envelope being composed of a plurality of lengths of fabric material connected end to end and wound in a helix comprising a series of convolutions of varying diameter according to the tapered contour of the envelope when the envelope is inflated by the water entrained therein, each of said lengths of material comprising a predetermined number of strips according to the contour of the portion of the envelope formed thereby, each of said strips being folded to bring the edges thereof in overlapping relation with respect to the folded edge of the strip adjacent thereto, a plurality of rows of helically arranged stitching for joining adjacent ones of said strips and adjacent ones of said convolutions together, and towing means for said envelope including a rigid annular member encircling said first named aperture and secured to said throat portion.

10. The method of fabricating an elongated tapered envelope of fabric material and having sufficient strength to entrain a ponderous mass of water therein as the envelope is towed through a body of water, which comprises the steps of winding a multi-strip length of a fabric material in a series of convolutions varying in diameter in accordance with the tapered contour of the envelope, varying the number of strips for different portions of said length of fabric in accordance with the degree of taper of the portion of the envelope formed thereby, and joining adjacent ones of said strips and adjacent ones of said convolutions with a plurality of rows of helically arranged stitching.

11. The method of fabricating an elongated tapered envelope formed of fabric material and having sufficient strength to entrain a ponderous mass of water therein as the envelope is towed through a body of water, which comprises the steps of winding a multi-strip length of fabric material in a series of convolutions varying in diameter in accordance with the tapered contour of the envelope, varying the number of strips for different portions of said length of fabric in accordance with the degree of taper of the portion of the envelope formed thereby, folding each of said strips to bring the edges thereof into overlapping relation with respect to the folded edge portion of the strip adjacent thereto, and joining adjacent ones of said strips and adjacent ones of said convolutions with a plurality of rows of helically arranged stitching.

12. An elongated tapered envelope of the character disclosed comprising, in combination, a plurality of lengths of fabric material connected end to end by stitching and wound in a helix comprising a plurality of rows of convolutions of varying diameter according to the tapered contour of the envelope, each of said lengths of material comprising a predetermined number of longitudinally extending strips according to the degree of taper of the portion of the envelope formed thereby, each of said strips being folded back upon itself to bring the edges thereof together thereby to form a strip of double thickness material, the edge portions of each strip being arranged in overlapping relation with respect to the folded edge portion of the strip adjacent thereto and said overlapping portions being joined together by stitching, and a plurality of rows of helically arranged stitching for connecting together the overlapping portions of adjacent ones of said plurality of rows of convolutions respectively.

13. In the method of fabricating an elongated tapered envelope of the character disclosed from a multi-strip length of fabric material by winding the length of material in a helix comprising a plurality of rows of convolutions of varying diameter according to the taper of the envelope, the method of joining together adjacent strips and adjacent convolutions of said length of mate-

rial which comprises the steps of folding the edges of each of said strips back upon itself, arranging the edge portions of each strip in overlapping relation to the folded edge portion of the strip adjacent thereto, arranging the edge portions of the outside strip of each convolution in overlapping relation with respect to the folded edge portion of the outside strip of the convolution adjacent thereto, and joining said overlapping portions of said strips and said convolutions together by stitching.

14. A collapsible elongated envelope of the character disclosed comprising, in combination, a throat in the form of a nose tube of greater length than the diameter thereof and of cylindrical configuration adapted to admit water into the envelope and having a length sufficient to render the envelope hydrodynamically stable as the envelope and the water entrained therein are towed through the surrounding water, and a main body portion of generally tubular configuration of gradually increasing diameter to a maximum diameter and thereafter gradually decreasing in diameter through a smooth curved transition and connected to said nose tube, said main body gradually blending into a frusto-conical portion terminating at the trailing end thereof in a circular opening of less diameter than the diameter of said nose tube whereby the pressure of the entrained water exceeds the pressure of the surrounding water, thereby to maintain the envelope fully extended.

References Cited in the file of this patent

UNITED STATES PATENTS

637,142	Miller	Nov. 14, 1899
717,890	Miller	Jan. 6, 1903
1,081,794	Vaniman	Dec. 16, 1913
1,849,965	Switlick	Mar. 15, 1932
1,960,846	Hein	May 29, 1934
2,391,926	Scott	Jan. 1, 1946
2,415,824	Katz	Feb. 18, 1947