Oct. 24, 1944. C. CHILOWSKY 2,361,177

METHOD AND APPARATUS FOR THE DETECTION OF SUBMARINES BY AIRPLANES

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Fig. 1.

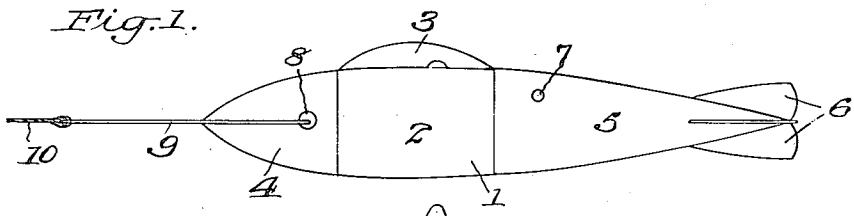


Fig. 2.

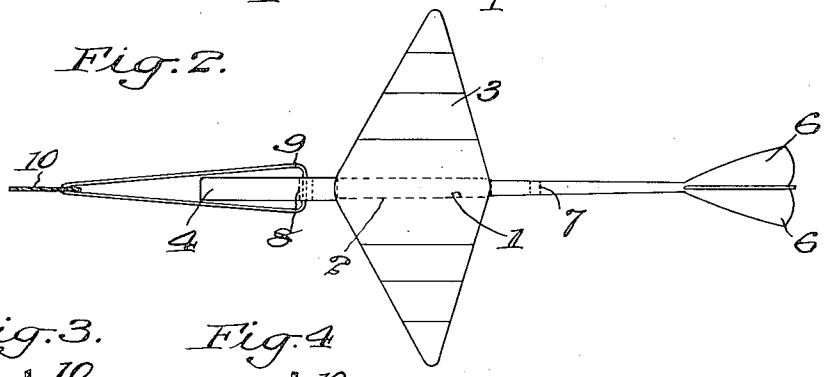


Fig. 3.

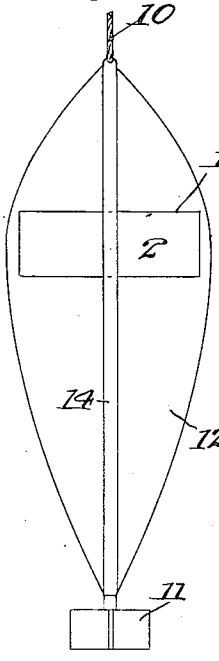


Fig. 4

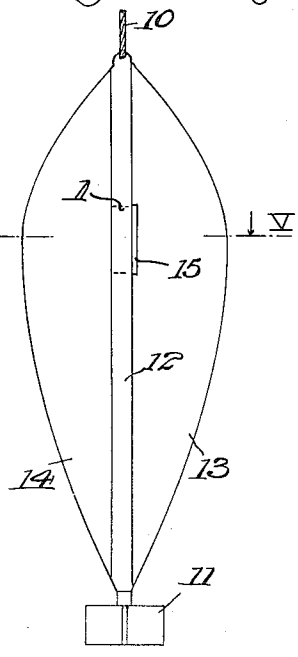


Fig. 5.

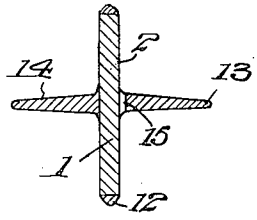
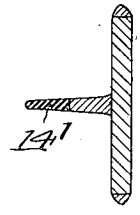


Fig. 6.



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METHOD AND APPARATUS FOR THE DETECTION OF SUBMARINES BY AIRPLANES

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Fig. 7.

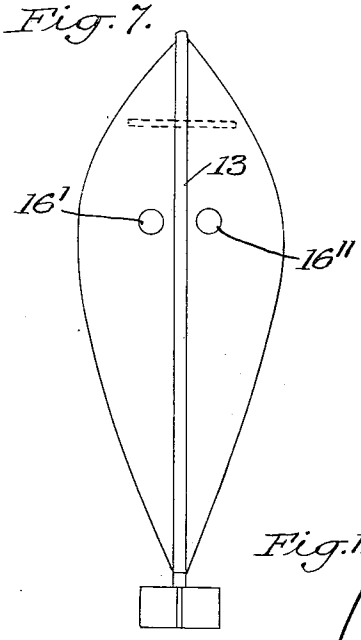


Fig. 8.

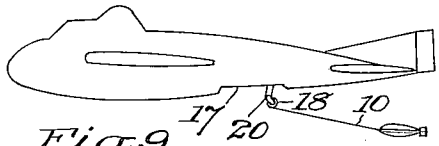
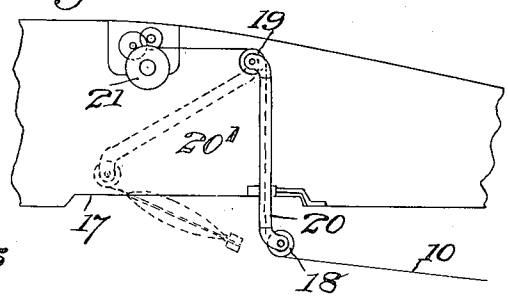


Fig. 9.



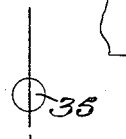


Fig. 12.

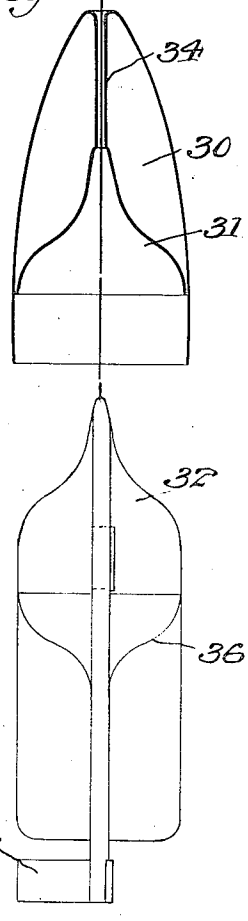


Fig. 11.

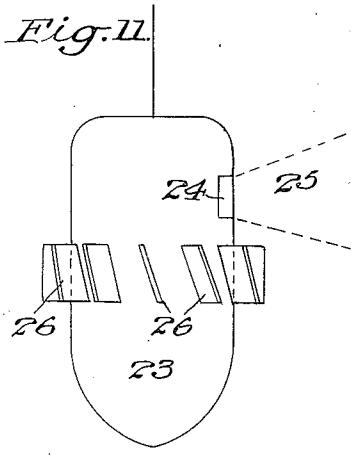
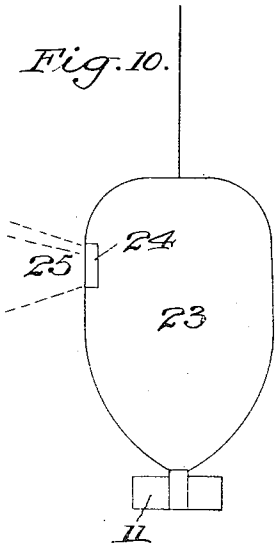


Fig. 10.



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METHOD AND APPARATUS FOR THE DETECTION OF SUBMARINES BY AIRPLANES

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Fig. 13.

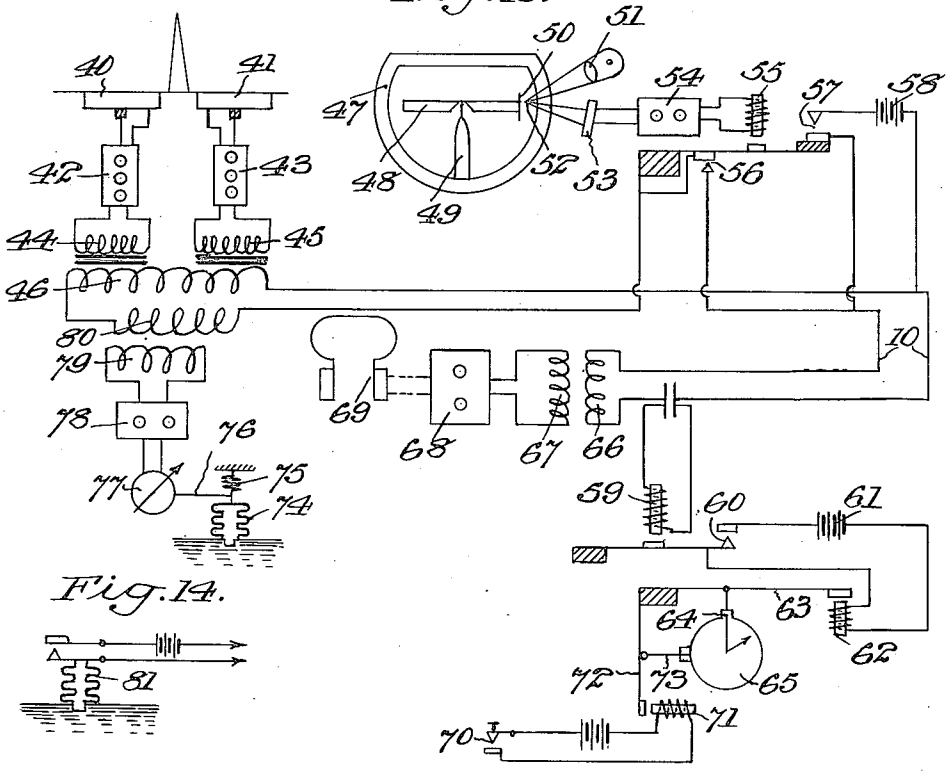
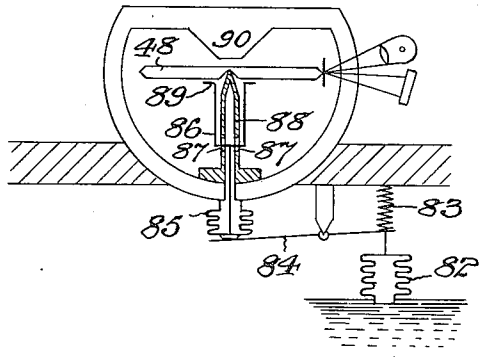


Fig. 14.

Fig. 15.



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METHOD AND APPARATUS FOR THE DETECTION OF SUBMARINES BY AIRPLANES

Filed April 25, 1941 4 Sheets-Sheet 4

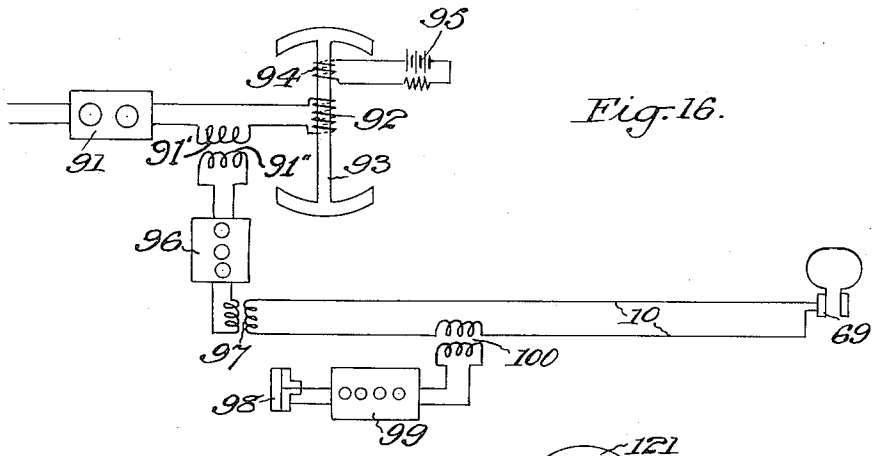


Fig. 16.

Fig. 17.

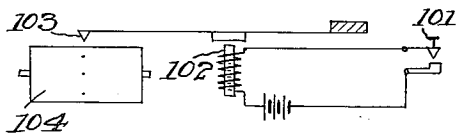


Fig. 18.

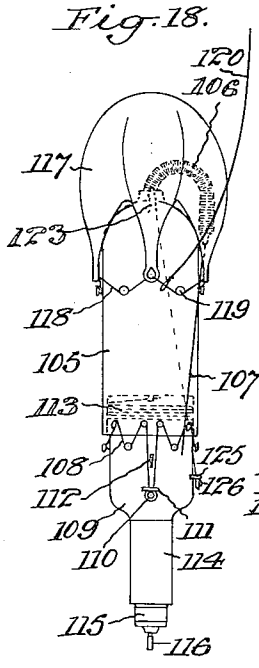


Fig. 19.

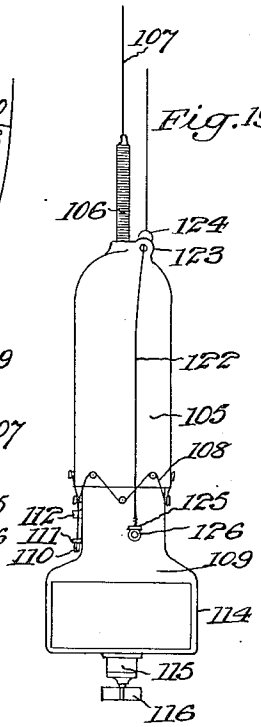


Fig. 20.

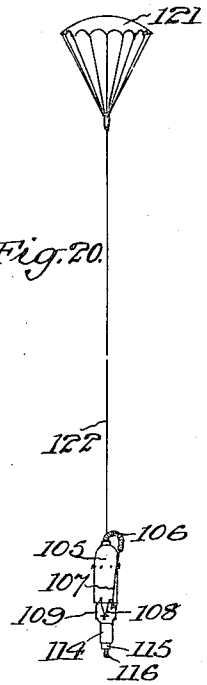
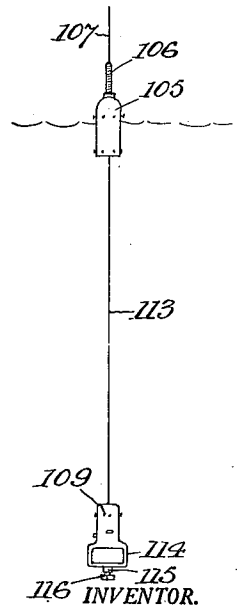


Fig. 21.



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UNITED STATES PATENT OFFICE

2,361,177

METHOD AND APPARATUS FOR THE DETECTION OF SUBMARINES BY AIRPLANES

Constantin Chilowsky, New York, N. Y.

Application April 25, 1941, Serial No. 390,254

9 Claims. (Cl. 177—386)

This invention relates to a method and apparatus for the detection of submarines by airplanes, and particularly by airplanes which are in continuous flight while making observations to detect and locate submarines below the surface of the sea.

Up to the present time, the detection and destruction of submerged submarines has taken place almost exclusively by means of surface vessels, the direct detection by aircraft in overhead flight being rather exceptional.

An object of the present invention is to provide for a method and devices permitting an aircraft to search for and systematically locate submerged submarines, and to destroy them subsequently without the assistance of surface vessels.

For this purpose according to the invention the aircraft assigned to such a task will be equipped with one or more compact submersible devices for directed listening. This device can be lowered from the aircraft in flight down to the surface of the sea, for instance by unwinding a cable from a windlass, this lowering of the device to be then continued either by the further unwinding of the cable or else by descent of the aircraft to a level permitting the listening device to attain a suitable depth below the surface (in order to effect, under favorable conditions, the submarine listening operations).

The descent of the listening device from the flying airplane to the surface of the water takes place in accordance with the method described by the applicant in U. S. Patent No. 1,829,474, granted on October 27, 1931, entitled Method and device for establishing communication between aircraft in full flight and the ground.

According to this method the airplane, in order to achieve contact with the ground, circles over the point selected for the contact while lowering a weight by a cable. This weight, instead of being thrown outward by centrifugal force, will stabilize itself at an appropriate cable length, near the ground, on an inner circle of a much smaller diameter, both circles having the same vertical in their center. On said small circle the weight will possess a much lower linear speed than that of the airplane, which will permit making contact with the ground or with the water surface without danger to the object suspended from the cable.

It is generally provided that the listening device, lowered by the airplane flying in a circle into the depth of the sea, is electrically connected with the airplane by means of the cable, which is capable of transmitting the under-water listening results to the airplane.

This cable may desirably consist of two mutually insulated concentric conductors, the inner conductor being a copper wire or cable, and the outer conductor being formed by a braiding of fine steel threads of very high mechanical resistance. This cable may further have an outer insulating covering, especially in its lower part, intended to dip into the water. The listening post, attached to the cable and submersible into the sea, comprises one or more orientable listening devices, tube amplifiers of the "listening" currents, with low and high voltage feeder batteries. The listening current will, after amplification, be transmitted by the cable to the airplane and into the pilots' listening device. This current may undergo further amplifications in the airplane, before being transmitted into the operator's listening device. The airplane will continue to circle over the listening post's immersion point. Because of this the part of the cable emerging from the water and stretched by the weight of the suspended body containing the listening device (this weight being of a density considerably greater than that of the water) will also move over a small circle with the same period as the airplane. The diameter of this circle will be substantially less than that of the circle described by the airplane.

This circular motion of the cable, decreasing in amplitude with the depth of immersion, will carry along the body suspended from the cable in a circular motion of smaller amplitude. The suspended body with the listening devices is so arranged as to have the listener cone constantly oriented substantially horizontally during the rotation of the aggregate, and have that cone make one complete turn of 360° around the submarine horizon at each revolution of the device and, coincidentally, of the airplane. The listening units may also desirably be arranged to be rotated independently of the motion of the airplane, as by means of motor-driven paddles, particularly in cases where the airplane is at a relatively high altitude or where the communication between the unit and the airplane is effected by wireless instead of by a cable.

Should a submarine vessel be within the field of the listening cone, the noise of its propeller and the beat of its propeller's blades, suitably amplified and transmitted by the cable to the airplane, will be heard by the aviator even at a great distance, horizontally, from the submarine. It is particularly provided that this listening post shall be lowered by the airplane to a sufficient depth (of the order, for instance, of 25 or even 50 met.) so as to safeguard the listening device from mirage phenomena which generally limit the listening range by reason of slightly curved propagation of the sound in water near the surface. This depth also safeguards the listening device sufficiently from surface noises.

The said submarine listening post comprises also devices for reporting automatically to the aviator the momentary orientation of the sub-

marine post in relation to the terrestrial magnetic field (N—S) at the moment when the submarine is brought within the field of the post's listening cone. In this way the pilot will be able to determine the direction of the submarine's location.

This transmission of the orientation of the listening device with respect to the magnetic field of the earth at the moment the propeller noise of the submarine is received by the device, can take place according to the invention in the following manner:

The listening unit will generally be made exculsively of non-magnetic material. It will contain rigidly incorporated into it a lineal element made of Permalloy (for instance a Permalloy rod) placed in such a way as to rest horizontally in the device when the latter assumes a listening position deep below the water's surface. The Permalloy rod will serve as the core of a transformer whose primary winding will carry for instance an alternating current of audible frequency, and the secondary winding will transmit by cable currents of the same frequency suitably amplified to the pilot's receiver. The shape and dimensions of the Permalloy will be selected in such a way that it will become saturated by the magnetic field of the earth whenever its orientation is north-south. In this position therefore the current in the secondary winding will be at a minimum or will pass through zero. This will repeat itself twice during each revolution of the listening device. The appearance of this minimum may be reduced if necessary to once in each revolution by superimposing on the Permalloy rod a permanent magnetic field of feeble intensity, as by a suitable electric current traversing a coil around the Permalloy.

The pilot can estimate the ratio of the time interval between the minimum directional signal and the maximum propeller noise, in relation to the interval between successive minimum directional signals, since the frequency modulation of the secondary current of the transformer and the propeller's noise are superimposed on the same cable. As such observations of maxima and minima are not quite accurate, although simple, provision is made to substitute for them observations of frequency variations. For that purpose the Permalloy, surrounded with a coil, forms the self-induction of an oscillating circuit composed of that self-induction and a capacity fed by a triode tube. The frequency of this circuit varies as a function of the orientation of the Permalloy rod in respect to the magnetic field of the earth. The oscillations are transmitted by cable to the aircraft and the pilot can thus recognize by frequency the momentary orientation of the Permalloy with respect to the magnetic field of the earth and therefore is able to determine fairly accurately the direction of the propeller noise at the moment of its appearance. If necessary provision may be made to follow the frequency variations by the needle of a frequency meter. As a further modification there may be provided a certain number of resonance circuits to be connected to the cable current and to light, under the control of this current, in a known manner a series of lamps arranged for instance in a circle, each of these lamps being connected to one of the resonance circuits. The lighted lamp would then indicate the momentary orientation of the submerged listening device. It is preferable in this case to use a non-audible supersonic frequency in order not to interfere with the audibility of the propeller noise.

Provision is also made to enable the aviator to control the depth at which the listening post is at each moment located, in such a manner that the aviator can maintain the post at the best suited depth, by either winding up or unwinding the cable, or by sending the airplane up or down. This can be achieved by means of a manometric chamber actuated by the hydrostatic pressure of water. These manometric chambers are able, by closing or opening an electric contact depending on depth variations, to actuate on the airplane, by means of the cable, various bells or other known devices, indicating the depth (for instance by switching in electric resistances controlled on the airplane by gauges). Alternatively the post may have an oscillating circuit, maintained by a variable capacity or induction coil, which is made to vary by the changes in a manometric chamber, connected with the said induction coil or capacity, such variations being a function of the depth and causing variation also in the frequency transmitted by the cable to the airplane.

To accurately locate a submarine in an area where its presence has been reported, there will be sent, preferably, two or more airplanes equipped with the described device. These airplanes, in communication with each other by optical means or by wireless, will make successive soundings at sufficiently distant points. As soon as the submarine's direction will be determined, one of the airplanes will fly in the submarine's direction, making a smoke trail. Thereupon the other airplane will also fly, in the direction indicated by its listening device, toward the submarine and, when crossing the smoke trail of the first airplane, will drop a bottle of white oil or the like, and this oil patch will mark the location of the submarine at the crossing point of the listener directions of the two planes. It will then be possible to proceed to destroy the submarine by dropping depth bombs, making, eventually, further use of the listening devices. But particular provision is made, in order to economize such bombs to use a special bomb type, lowered from the airplane by cable (in the same manner as the listening post) into the sea at the spot marked by the oil patch. This bomb will be equipped with a small device for oriented listening, directed horizontally, and with devices, described above, of control of the listening direction in relation to the terrestrial magnetic field. The listening operations will be controlled from the airplane. The bomb will, likewise, be equipped with depth control devices, described above. The bomb will also be provided with a small inclined fin, or any other appropriate device, insuring its rotation in the water during its descent into the depth. The listening device can be passive, i. e., it will permit determination of the direction of the noise of the propeller or the motor of the submarine. But in case the submarine, possibly warned, stops its motor, the listening device can be active, i. e., comprise, for instance, a small sending set for directed beams of ultra sound waves, permitting control from the airplane of the echoes of the ultra sound waves on the submarine.

The aviator will lower this bomb progressively into the depth, and, guided by the indication of the rotating listening device, will try to bring it as closely as possible to the submarine, by maneuvering his airplane in the direction of the

submarine. He will then explode it electrically at the depth best suited, by means of the electric current through a special conductor, or by a special frequency transmitted by the same cable.

The orientable listeners utilized in the listening post can be of any known system. It is particularly intended to utilize for this purpose ultrasonorous piezoelectric quartz sender-listeners. These listeners will preferably have a considerably greater horizontal dimension, than their vertical one, so as to result in a listening beam, spread vertically and narrow horizontally, sweeping the horizon fanwise.

Aside from the location and rapid destruction of submarines in areas where their presence has been reported, this method permits, with the help of a small squadron of suitably equipped airplanes, patrolling and keeping free of submarines wide cross-ocean sea-lanes, for instance between the United States and England, thus creating and maintaining a wide maritime route, bordered on both sides by wide cleared zones. Moreover, the described method, in conjunction with the method of automatic maritime control, described by the applicant, can constitute a most efficacious weapon against submarine warfare.

A practical embodiment of the apparatus to which this invention relates is shown in the accompanying drawings in which

Fig. 1 represents diagrammatically a side elevation of a listening unit having a form adapted for flight through the air as well as motion through the water;

Fig. 2 represents a top plan view of the unit shown in Fig. 1;

Fig. 3 represents, in side elevation, a modified form of unit which is intended to stand almost vertically in the water and to be rotated by self-contained mechanical means;

Fig. 4 represents a side elevation of the unit shown in Fig. 3, taken in a plane at right angles to said figure;

Fig. 5 represents a cross-sectional view of the unit shown in Figs. 3 and 4, taken at the line V—V of Fig. 4;

Fig. 6 represents a cross-sectional view similar to Fig. 5 of a modified form of unit in which the longitudinal fin on one side is eliminated;

Fig. 7 represents, in side elevation, a unit similar to that shown in Fig. 3, but having a modified form of listening device;

Fig. 8 represents a side elevation of an airplane as it retracts the listening unit into a cavity in the bottom of the fuselage;

Fig. 9 represents an enlarged detail of the lowering and retracting mechanism;

Fig. 10 represents, in side elevation, a bomb which is also equipped with a listening device and mechanical rotating means;

Fig. 11 represents a bomb similar to that shown in Fig. 10 but provided with vanes to effect rotation of the bomb;

Fig. 12 represents a modified form of listening unit associated with a float for maintaining the unit at a selected depth;

Fig. 13 represents diagrammatically a suitable wiring arrangement for use in cases where orientation of the listening unit is secured by means of a magnetic compass;

Fig. 14 represents a detail of the manometric device for activating the parts of the unit when it is placed in the water;

Fig. 15 represents a detail of the magnetic compass, including means for rendering it inactive except when submerged;

Fig. 16 represents a wiring diagram for the arrangement in which orientation of the unit is secured by means of a Permalloy rod;

Fig. 17 represents an orientation calculating device which may conveniently be used in connection with the arrangement shown in Fig. 16;

Fig. 18 represents, in side elevation, a modified form of listening unit adapted to be lowered by parachute to the surface of the sea;

Fig. 19 represents, in side elevation taken at right angles to Fig. 18, the same unit with its parachute removed and antenna extended;

Fig. 20 shows the descent of the unit shown in Figs. 18 and 19 from an airplane to the sea; and

Fig. 21 shows the same unit separated into floating and submerged elements after it has reached the sea.

Referring to the drawings, Figs. 1 and 2 show a submersible listening unit having a shape adapted for flight through air as well as to motion in the water, thus forming a kind of a flying fish. This form of the device is used particularly when the aircraft is flying in circles of large diameter at a relatively low altitude, in which case the device after being submerged describes a circle in a more or less horizontal position.

In these figures, 1 is the supersonic listening device of piezoelectric quartz for directed listening, having its vertical dimension smaller than the horizontal; 2 is the lateral surface of the listening device; 3, the supporting wings fastened to the upper part of the body; 4 and 5, the front and rear parts, respectively, of the body, utilized for locating amplifier batteries, oscillating circuit and other elements of communication with the air craft, including the manometric depth conductors, the Permalloy rod (or magnetic telecompass), etc.; 6 is the tail assembly; 7, the Permalloy rod; 8, the point of fastening of the bridle 9, connected with the electric cable 10.

In most cases, if the airplane flies circles of a moderate diameter at a medium speed and at a normal height (of the order, for instance, of 500 to 1,500 met.), the listening unit will, at a sufficient depth under water, assume a position close to the vertical. In such case the unit may desirably have the form shown in Figs. 3, 4 and 5 and will be maintained, in artificial rotation, under water, for instance by means of an electric motor, operating paddles 11; 12 is the flat hollow body of the unit, containing the electric apparatus. 1 is the ultra-sonorous listener for oriented detection; 2 is its oriented listening surface; 13 and 14 are fins perpendicular to the flat body 12 and resembling it in form and area, but without its thickness, and extending along the body from top to bottom. The fin 13 is cut away to form a recess 15 facing the listening surface 2, so as not to impede the vibrations of the listener. The fin 13, owing to its sound shadow cast on the listener, makes possible a maximum of oriented detection.

The ultra-sonorous piezoelectric quartz listener and particularly the resonance plates of the sandwich will be made of non-magnetic steel or of bronze or of aluminum.

Fig. 5 shows a cross-section of the unit shown in Figs. 3 and 4, details of the listening device not being shown.

Fig. 6 shows, in cross-section, a listening unit similar to that shown in Figs. 3, 4 and 5, but with the difference that the fin 13 is eliminated. In this case the fin 14 may be weighted with lead 14' to insure stability in air flight.

In an important modification of the unit, represented in Fig. 7, provision is made to substitute for the oriented listener 1, two separate listeners 16' and 16'', arranged on the body in differential connection, on both sides of the fin 13 and symmetrically thereto. These two listeners may be for oriented detection and can, if desired, be of smaller size. Provision is also made to utilize in this case non-oriented detection listeners of small size, the large surfaces of the body and the fins giving the whole system the faculty of oriented detection with a very distinct sound extinction.

Fig. 8 shows the airplane about to retract the listening unit into the recess 17. Cable 10 passes over the roller 18 at the free end of the pivotally mounted rod or tube 20, which can be raised into the recess 17 when the unit has reached roller 18. Fig. 9 shows in detail a form of this retracting mechanism in which 21 is the windlass for winding and unwinding the cable 10; 18 and 19 are rollers at the ends of the tube 20; when the unit reaches roller 18 the tube is caused to retract to and beyond the position 20' in order to bring the unit into the interior of the air plane body.

Generally, while hunting for a submarine or during a widely extended search by listening, the airplane drops its listening unit into the water several or many times. The aviator will effect all these immersions into, and emergences out of the water and shifts to other listening points preferably without each time raising the unit back into the airplane, and even, if desired, without shortening the cable. When lifted out of the water the unit will, due to its special aerodynamic form, rise into the air almost to the height of the airplane as soon as the latter stops circling and straighten its course, the airplane thus towing the unit almost like a glider until they reach another listening point, whereupon the unit will automatically descend toward the water surface as soon as the airplane starts circling. If the next selected location is close by, the airplane may, however, carry or move the post while continuing and shifting its own circling in the desired direction. For these operations the availability of an automatic pilot device on the airplane will facilitate its task.

Fig. 10 shows schematically a bomb 23 (for the final destruction of the submarine) adapted to be lowered from the airplane in the manner previously described at the spot where the submarine has been located; and the speed of descent of the bomb may also be lessened by the provision of a parachute in addition to the cable. The bomb 23 is preferably equipped with a small ultra-sonorous (active or passive) listening device 24; 25 indicates the listening cone; 11 designates the paddles, actuated by a motor, assuring rotation of the bomb for oriented listening before detonation. In case a simple bomb without listeners is used, it will naturally be unnecessary to provide means for rotating it.

The bomb shown in Fig. 11 differs from that of Fig. 10 in that the rotation of the bomb is effected not by rotation of the paddles 11, but by inclined vanes 26, a rotation couple resulting from the vertical motion of the bomb.

It will be easy for the operator to observe the direction, depth and approximate distance of the submarine and thus to bring the detector-bomb almost in contact with or in close proximity to the submarine and to cause it to explode at that moment; becaue of this, it may be smaller than the bombs dropped blindly by surface vessels hunting down a submarine. Also, because it is intended to be used only in the previously indicated vicinity of a submarine, the active ultra-sonic transmitter-listener can conveniently be used so that observation will be possible even if the submarine stops its motors.

At the moment of immersion of the unit, or the detector-bomb, its mechanism (amplifiers, motors, etc.) will be started by means of a manometric chamber contact device. Upon emergence from the water, the current will be cut off by the same device.

For the construction of the listening unit extensive use may be made of ebonite and Bakelite as substitutes for such magnetic materials as iron. Particularly, the listening device could be placed inside the body of the unit where it could receive the sound waves, in a capacity filled with water, through an ebonite window.

Provision is also made, according to the invention, to have listening units with active oriented detection, such units to be equipped with transmitter-receivers of ultra sound waves in the form of directed beams. In such case there will be transmitted to the airplane, not the propeller noises, but the echoes, on the submarine, of the ultra sonorous waves in the form of the noise caused by the return wave. If necessary, the time interval between the departure and the return of the waves may be measured on the airplane by appropriate known devices. The operator will thus be enabled to know not only the direction, but also the distance of the submarine. This will considerably facilitate the hunt for the submarines and may readily enable a single airplane to locate and destroy the submarine. Preferably, there will be utilized two or more transmitter-receiver sets, oriented in different directions.

In a modified form of listening unit provision is made to have the unit attached to a buoy which rests on the surface of the water and serves to maintain the unit at a constant depth as well as to indicate to the pilot the point of search. The distance between the buoy and the listening unit could be made fixed (for instance, 25 meters) so that the pilot would not need to regulate the depth of submersion of the device. An example of such an arrangement is shown in Fig. 12, wherein a buoy or floating device is fitting snugly to the upper part of the unit during its flight through the air, but is disconnected from the unit at the moment of submersion and then supports it at a fixed depth. In this figure 30 is the hollow float made of sheet metal and having the interior profile 31 shaped to fit the upper part 32 of the listening unit. The unit differs from that shown in Fig. 3, by having its upper part modified in such a way as to leave more room for the float while its body and lower fins have been more developed in order to facilitate its flight through the air. Fig. 12 also shows a rotor or paddle equipped with a single blade 33 in order to diminish the shock at the moment the unit strikes the water. The float has an axial channel 34 for the cable 10, and the cable has a stop 35 fastened to it at a suitable distance above the unit (for instance 25 meters). The unit may be provided with sheet metal side coverings or fairings 36 to properly complete at its rear the aerodynamic shape of the float during the flight and descent of the two parts. The float may also be painted white

and, if necessary, can be equipped with a red light of great intensity to assure its visibility.

If the float is not sufficient to support the unit at a fixed depth below the surface of the sea, it will still serve to check to a considerable extent the movement of the upper part of the submerged cable and to render in this way the submerged listening unit more immobile.

Fig. 13 shows the wiring between the several parts of the system in the particularly simple case where a magnetic compass is utilized. In this figure 40 and 41 are two listeners arranged symmetrically in relation to a fin (corresponding, for instance to the listeners 16' and 16'' in Fig. 7). 42 and 43 are the two respective amplifiers (or amplifier-rectifiers) of the listeners 40 and 41. The amplified (and, if necessary, rectified) currents pass respectively through the induction coils 44 and 45, each in an opposite direction to the other, forming the primary coils of a transformer, the secondary winding of which, 46, is connected with cable 10.

In the same figure there is schematically shown a magnetic compass 47 with its magnetic needle 48, mounted on pivot 49. The end of needle 48 carries a light mirror 50, and an optical device with bulb and lens 51 projects the light on point 52. When the needle 48 is in the position shown (which may be, for instance, the N—S position) the light is reflected by the mirror and thrown on the photoelectric cell 53; the current of this cell, suitably amplified by the amplifier 54, actuates a relay which, on one hand, opens contact 56, cutting off for an instant the current through the cable 10, and on the other hand closes contact 57, sending a current impulse from battery 58 through the cable toward the airplane and into the relay 59, which closes, by means of contact 60, the current circuit of battery 61 through the electromagnet 62. This magnet 62 pulls lever 63 and starts, by means of button 64, the chronometer 65, the hand of which is first each time returned to zero. Thus, at each complete turn of the listening unit under water, the light beam thrown by the lamp 51 into the compass will be reflected by the needle's mirror onto the photoelectric cell for a brief instant. Light projector 51, casing 47 of the compass (which may be transparent) and photoelectric cell 53 are attached to the rotating unit and turn with it. In this manner, at each turn of the unit or at each passage of the light beam on the mirror of the needle, the hand of chronometer 65 on the airplane is set back to zero and started again. Assuming that the listening device is set in such a manner that the detection is at that moment oriented toward the north, the operator will read on the chronometer accurately the successive passages of the unit's oriented detection through the north direction. He will also read on the chronometer the exact duration of a complete turn of the post.

On the other hand, in case the listener picks up the propeller noise of a submarine, the "listening" currents, induced in induction coil 46, will be transmitted (for instance, by the transformer 66, 67, located on the airplane, and the amplifier 68) to the pilot's head-set phone 69. The pilot will be able to estimate the moment of the maximum (or preferably the minimum) value of this oriented detection and, guided by the chronometer, will be able to measure in seconds the interval between the passage of the unit and its listening device through the direction north, and its passage through the direction of the propeller noise. For greater convenience, the aviator may have at his disposal a contact button 70 to stop the chronometer hand exactly at the moment of the maximum, or minimum, value of detection, by means of the relay 71, the lever 72 and the chronometer button 73. Knowing, in seconds, the total duration of the rotation about the horizon, the operator will thus know the angle, in degrees, between the direction of magnetic north and the direction in which the submarine is located. If the aviator receives at this moment from a second airplane, the approximate distance of which he knows, information on the direction of the submarine in relation to the second airplane, he can then readily calculate approximately the distance of the submarine and will, in case the submarine is still distant, move to a position where he can make a second, closer, sounding operation.

It is evident that it is, if necessary, possible to achieve satisfactory results by estimating the passage by listening alone, without the automatic operation of the chronometer.

Provision is made to have, if desired, several reflecting mirrors, or groups of such mirrors, arranged on a light ring attached to the magnetic needle 48, these groups of mirrors being distinct and able to individualize the different directions by the number and arrangement of the reflections and the electric impulses provoked by them, thus serving to make the sound reading more detailed. Instead of audible orientation signals, the impulses may be to control the rotation of a pointer hand or the like, synchronous with the rotation of the listening unit under water, in order to indicate visually the orientation of the listener.

In Fig. 13 there is also shown a manometric bellows 74, operating against a spring 75 and actuating, by means of the lever 76, the variable condenser 77. This condenser forms the capacity of a small tube generator 78 producing continuous oscillations of audible frequency which are transmitted by the induction coils 79 and 80, through the cable, to the headset 69 of the aviator. The frequency of the circuit varies with the depth of the unit, owing to variation of the capacity as a function of this depth, so that the operator, by observing the pitch of this sound (which should preferably be of small intensity), will know at each moment the depth of the unit and will be able to regulate it at will.

Fig. 14 shows schematically a manometric bellows 81 in communication with the water which, when the post dips into the water, closes the contact or contacts for starting the electric apparatus of the unit, including the motor for turning the paddle.

Fig. 15 shows schematically the mechanism by which the compass needle is lifted from its pivot and immobilized in this position, the needle being set free only when the post has reached a sufficient depth under water. At this moment, the pressure of the water, acting on the manometric bellows 82 with compression spring 83, actuates, by means of lever 84, the bellows 85, which, by means of the fork 86 passing through slits 87 in support 88, actuates the lifting surfaces 89. Thus the needle 48 is lowered onto its bearing support when the water pressure overcomes the force of the spring 83, and is raised and pressed against the projection 90 on the top of the compass when the water pressure is removed.

Fig. 16 is a wiring diagram for the case where a Permalloy rod is utilized in the listening unit to apprise the pilot of the north-south position by

frequency variation, and particularly by the passage through a maximum or minimum frequency, at the moment of the Permalloy rod's passage through the north-south position. In this figure 91 is a relatively low power tube generator of electric oscillations of audible or inaudible frequencies. The induction coil of this circuit is composed of winding 92 on a core, preferably solid, of Permalloy 93. At the passage of the rod through the north-south (or the south-north) position the oscillation of the generator's circuit will pass through a maximum of frequency. 94 is a winding through which passes the direct current of the battery 95, superimposing a constant magnetic field and determining the maximum of frequency in one of the two positions, for instance the north-south one, or at least establishing a distinct dissymmetry between the two positions. The current of generator 91 is amplified by the amplifier 96 and is sent through coupling 97 into the cable 10, and by this cable into the acoustic listening device 69 of the pilot on the airplane.

In the same figure, 98 is an oriented listener of the unit, the currents of which, amplified by amplifier 99, are transmitted by the same cable by means of coupling 100, superimposing themselves, in the pilot's headset, on the current coming from the generator 91.

Fig. 17 shows a registering contact device at the disposal of the pilot. For convenience in calculating the orientation of the listening unit, the pilot will press down on contact 101 at the moment of the listener's passage through the north-south direction, and again at the moment of the listener's passage through the indicated direction of the submarine. Relay 102 and pen 103 will register these moments on the cylinder 104, revolving at constant speed, and the pilot will be able to place the direction of the submarine in relation to the north-south direction. Alternatively, the pilot may utilize the chronometer, as previously described, but operated by himself.

If necessary, provision may be made to intensify the clearness of perception of the said maxima and minima, by combining the action of the Permalloy rod on variation of frequency of the generator 91 with the variation of the intensity of this frequency. To this end, the connection between the generator 91 and the amplifier 96 will be achieved not directly (for instance by means of induction coils 91' and 91''), but by utilizing the core of the winding 92 as a transformer. Induction coil 91'' will, accordingly, be placed over the Permalloy core and will form the secondary winding of the transformer.

The momentary depth of this type of unit can be controlled from the airplane in a manner similar to that described for the compass-equipped unit. But in order not to confuse the sounds received by the pilot it may be desirable to provide only a discontinuous control, transmitting to the aviator certain agreed signals when the device exceeds the desired depth limits.

It will be understood that it is possible to utilize on the airplane all known methods of frequency control, for instance by means of surging, etc.

The above described system for the detection and destruction of submarines lends itself well to all cases, and is of particular advantage when it is a question of searching and clearing large maritime areas. But in certain cases, where the presence of a submarine has been made known within a sufficiently circumscribed area, provision is made to utilize another method of putting the invention to practical use, such method being characterized by the fact that connection between the airplane and the listening unit is effected not by means of cable, but by electromagnetic short waves. A listening unit of the kind above described, but simplified as much as possible and of inexpensive design, is equipped with a float and is dropped by the airplane into the water, for instance by means of a parachute of sufficient size, so as to soften the impact. The buoy, equipped with a small antenna, carries a simple and inexpensive short-wave transmitter of limited range (for instance, similar to those used in observation balloons). The transmitter set is connected by an electric cable of a certain length (for instance 25 met.) with the above described oriented-listening unit, which has also been simplified as much as possible.

The listener currents, suitably amplified, modulate, through the said cable, the transmission set in the buoy; in the same manner are transmitted the signals showing the passage of the rotating unit through the north-south position. The pilot, flying in the vicinity of the unit, receives through his receiver set these indications and readily calculates from them the submarine's direction. The listening units, with their buoys, dropped from the airplane into the sea, are generally considered as lost, although their recovery in certain cases is naturally possible. The airplane carries a sufficient number of such posts to be able to explore a limited area wherein the presence of the submarine has been reported. The submarine can then be destroyed by the method described.

Figs. 18 to 21 show means and manner of carrying out this procedure. In Fig. 18, 105 is the buoy containing a short-wave radio transmitter. 106 is a resilient part of the antenna 107, shown in the position where it is folded downward, in order to decrease the size of the whole, the resilient part 106 being, for instance, a heavy rubber tube containing on the inside a spiral spring for tight windings.

Antenna 107 is kept in its folded position by the string 108, which at the same time provides the mechanical connection between buoy 105 and the under-water listening unit 109. The string is retained by a lozenge or plug 110, consisting of a substance easily soluble in water (starch, sugar, etc.), which prevents the string from coming out of the eyelet 111. When the unit drops into the water the lozenge dissolves, the string comes out of eyelet 111 and is cut by the knife 112, whereupon buoy 105 and unit 109 are separated, and antenna 107 is freed and straightens up, under the action of its resilient part 106, into the position shown in Fig. 19.

At the same time the electric cable 113, one end of which is connected to buoy 105 and the other to unit 109, is freed and the listening unit 109 descends into the water to a depth determined by the length of the cable 113. 114 is the part of the unit containing the oriented listening device; 115 is the motor; and 116 is the paddle, operated by the motor for rotating the unit.

In Fig. 18, 117 is a bag containing a folding parachute, supporting the whole and maintained on the body of the buoy 105 by the string 118 and the buttons 119. After the launching of the combined unit from the airplane it falls to the length of the cable 120 holding it to the air-

plane, the cable 120 cuts string 118, and the parachute opens. The whole then descends, as shown in Fig. 20, wherein 121 is the parachute and 122 is a rather long rope connecting the parachute with the unit, and which rope was previously folded within the bag 117.

Fig. 19 shows the listening unit 109 with its buoy 105 and its raised antenna 106, 107. There is also shown in this figure a possible method of attaching the rope 122 to the unit, in which the rope passes through the opening 123, and is kept stretched by the stop 124; its lower end forms a loop and is held in the eyelet 125 by the lozenge or plug 126, composed of a substance quickly soluble in water. As soon as the unit enters the water, lozenge 126 dissolves, rope 122 is released, and parachute 121 is free to drift away and drop, usually at a distance, without impeding the functioning of the unit.

It will be apparent that various changes may be made in the construction, form and arrangement of the several parts without departing from the scope of my invention and hence I do not intend to be limited to the particular embodiment herein shown and described, but

What I claim is:

1. A method of submarine detection by means of a listening unit adapted to be lowered into submerged position from an air plane in flight, which comprises, lowering said unit substantially vertically into the water by means of a cable continuously connecting the unit and the airplane, causing the airplane to describe circles about the point where the unit is submerged, rotating said unit, and communicating to said airplane signals indicative of the positon of the unit and of the vibrations received thereby.

2. A method of submarine detection by means of a listening unit adapted to be lowered into submerged position from an airplane in flight, which comprises, lowering said unit substantially vertically into the water by means of a cable continuously connecting the unit and the airplane, causing the airplane to describe circles about the point where the unit is submerged, rotating said unit by means independent of the motion of the airplane, and communicating to said airplane signals indicative of the position of the unit and of the vibrations received thereby.

3. A method of submarine detection by means of a listening unit adapted to be lowered into submerged position from an airplane in flight, which comprises, causing the airplane to describe circles about the point where the unit is to be submerged, lowering said unit substantially vertically into the water by means of a cable continuously connecting the unit and the airplane, maintaining the unit substantially immobilized within a relatively small area, rotating said unit, communicating to the airplane signals indicative of the position of the unit and of the vibrations received thereby, thereafter causing the airplane to cease circling and to assume a relatively straight line of flight, drawing the unit again into the air, conveying said unit to a different place while the unit follows the airplane as a towed glider, and thereupon repeating the steps of circling, lowering, and listening as set forth.

4. In a submarine detecting system, a listening unit comprising, a substantially flat body, a piezoelectric listening device having its face parallel with a surface of said body, a thin stabilizing element projecting from said body in a direction at right angles to the plane thereof, and means for maintaining said body in a substantially vertical plane when said unit is submerged, said body and element having a suitable aerodynamic form to facilitate the gliding motion of said unit through the air before it is submerged.

5. A listening unit according to claim 4 in which the flat body is shaped symmetrically with respect to a longitudinal axis and the stabilizing element lies in a plane passing through said axis.

6. A listening unit according to claim 4 in which the flat body is shaped symmetrically with respect to a longitudinal axis and the stabilizing element lies in a plane passing through said axis, and in which the unit is provided with means adapted to cause rotation thereof around said axis.

7. In a submarine detecting system, a listening unit including a device for oriented listening and means for rotating said device about a substantially vertical axis, a Permalloy rod rotatable with said device and an electric signal circuit associated with said rod and adapted to transmit signals the characteristics of which are varied in accordance with the orientation of said rod in relation to the field of terrestrial magnetism.

8. A system according to claim 7 in which the signals are varied in power or intensity and in frequency.

9. A system according to claim 7 in which the signals are varied in frequency.

CONSTANTIN CHILOWSKY.