Nov. 26, 1935. H. HECHT **2,022,038**

STREAM LINED SWORD CARRIER FOR SUBAQUEOUS SOUND APPARATUS

Filed Nov. 4, 1932 2 Sheets-Sheet 1

Fig. 1

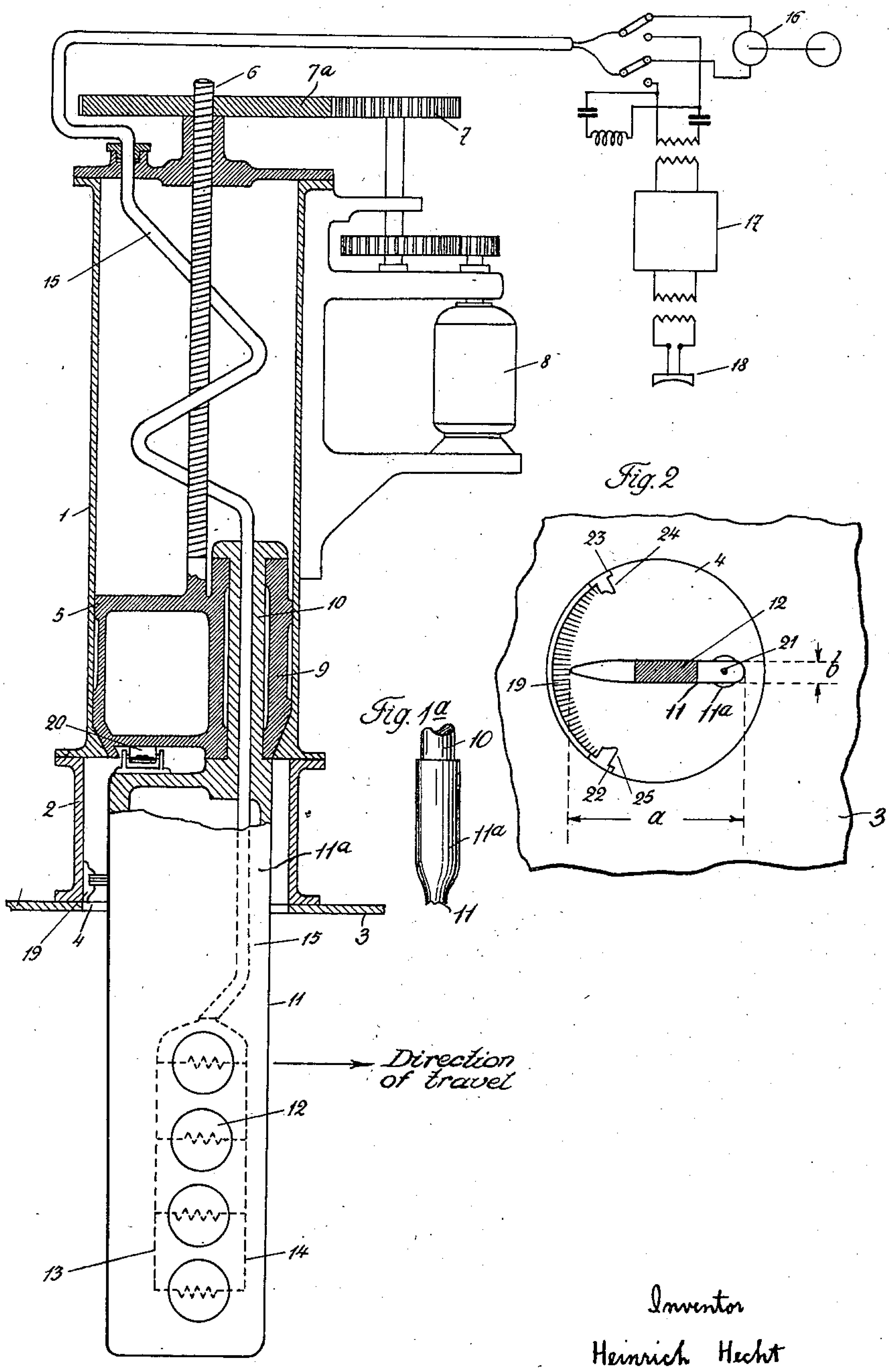

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Fig. 3

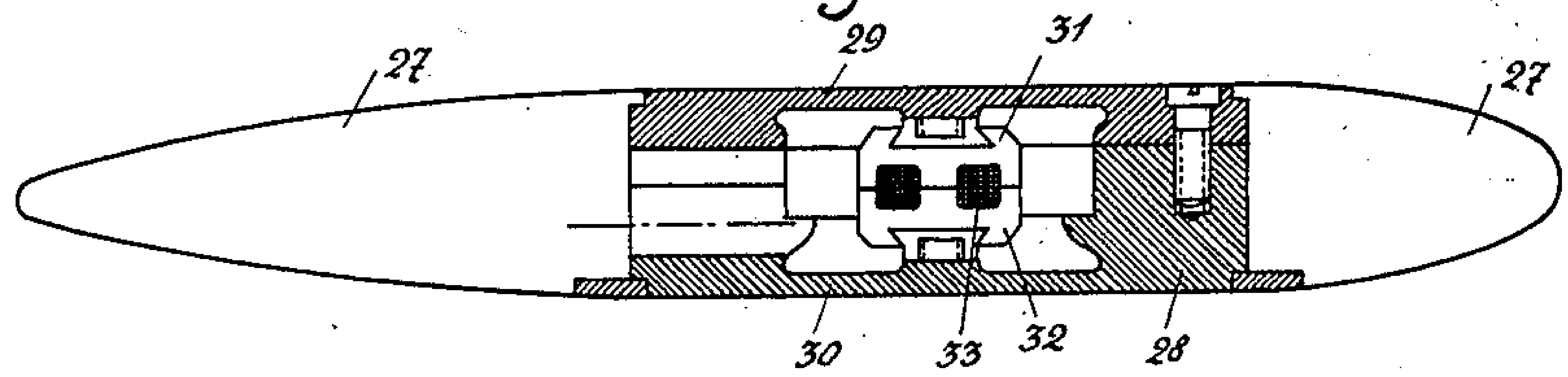


Fig. 4

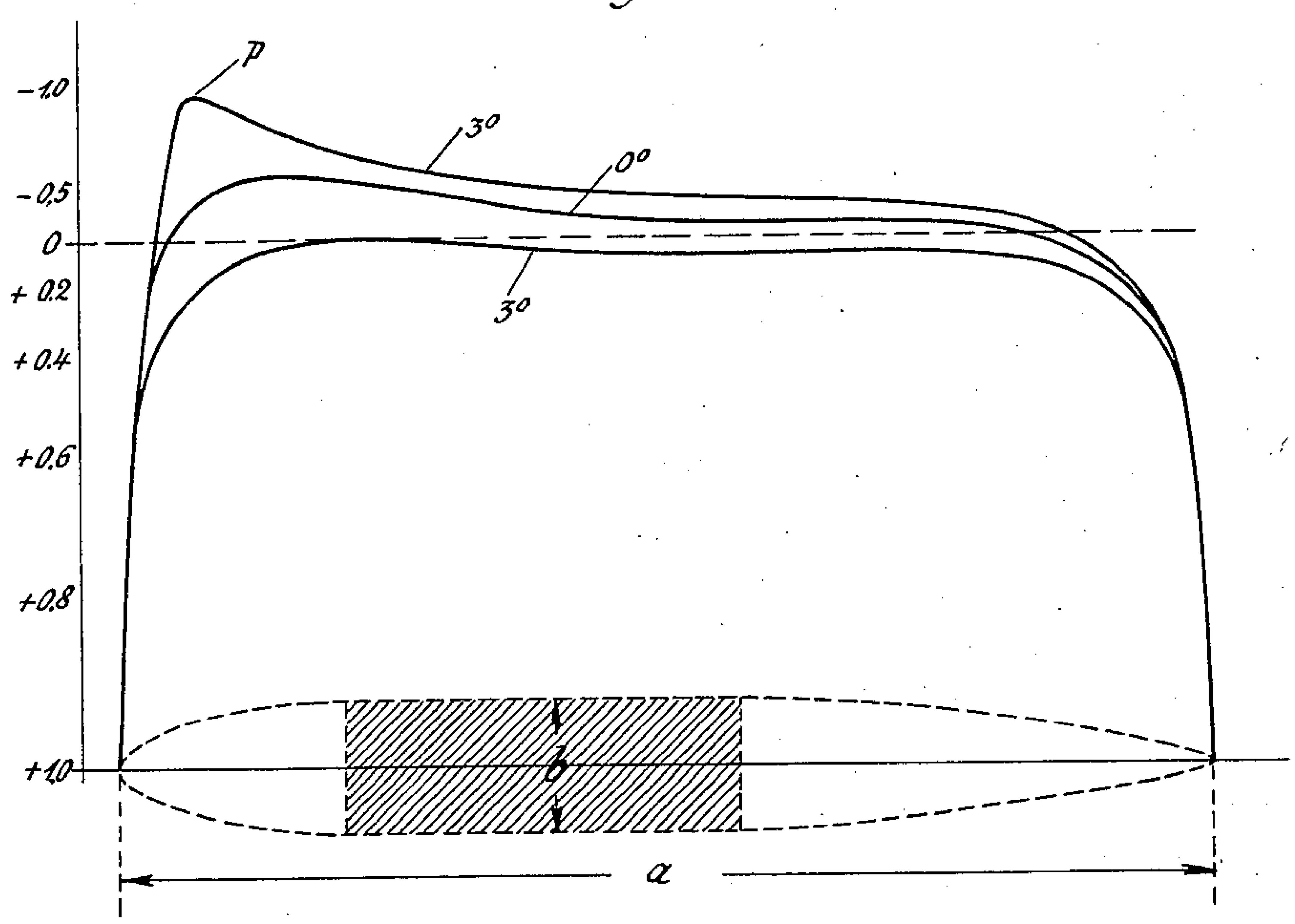
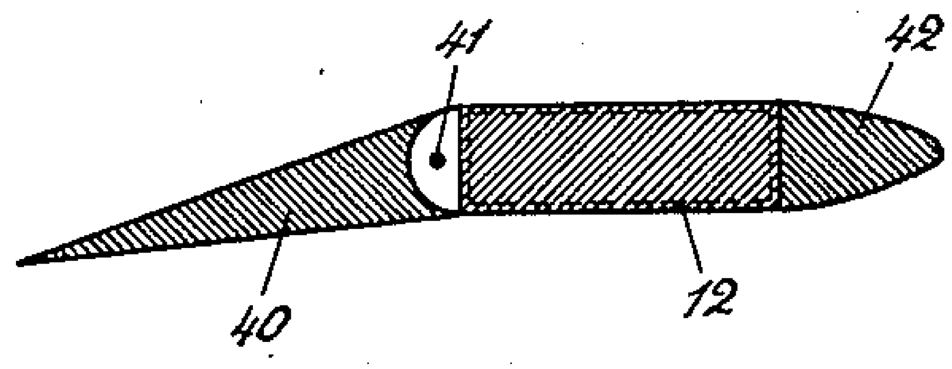


Fig. 5



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UNITED STATES PATENT OFFICE

2,022,038

STREAM-LINED SWORD CARRIER FOR SUBAQUEOUS SOUND APPARATUS

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In Germany November 27, 1931

7 Claims. (Cl. 116—27)

In order to transmit sound signals from ships well and uniformly in all directions under water and to receive sound signals well from all directions with vertical groups of transmitting-receiving apparatus, groups of this type of apparatus have already been built into a protrudable carrier of streamlined cross-section. Such a carrier is rigidly guided when protruded, so that its horizontal longitudinal axis extends parallel to the longitudinal axis of the ship. On turning the ship, in which case the ship, as is well known, undergoes a considerable lateral displacement, such rigidly guided apparatus is pulled through the water at a high speed at considerable inclination of its horizontal longitudinal axis to the prevailing travelling direction up to 15° and must therefore have great transverse strength and therefore a very compact form. This compactness of form results in a ratio of the horizontal longitudinal axis of the cross-section of the streamlined body to its thickness so unfavorable that eddy-free streamlined bodies can be designed only for speeds up to 13–15 knots. A more extension of the horizontal longitudinal axis of the streamlined body is not practicable, because thereby the size of the side-surface of the body and thus the stress on being pulled laterally through the current simultaneously increase and this effect must be compensated for again by a corresponding increase in the thickness of the body. With protrudable apparatus which are rigidly guided or rigid in themselves, therefore, the problem of constructing a streamlined body of acoustically perfect, eddy-free qualtities for speeds of more than about 15 knots cannot be solved.

The invention solves this problem by making the streamlined carrier body rotatable as a whole on an axis longitudinal of the carrier or, at least, by making its rear part rotatable, so that when the ship travels in a curve, the body adjusts itself to the prevailing direction of flow occurring at the body due to the relative movement between the vessel and the water. It is thereby relieved of the task of having to endure considerable lateral stresses when pulled partly in a transverse direction, and the ratio of the length of its horizontal longitudinal axis to its thickness can now be dimensioned to attain good and eddy-free streamline qualtities according to the requirements dictated by the maximum speed required.

For the speeds in modern high-speed ships of more than 25 knots, a ratio of the carrier thickness to the length of the longitudinal axis of its cross-sectional area is necessary which must not substantially exceed the value 1:8. Calculations and experiments have shown that with such dimensions at the said speeds, a cross-sectional shape which is paraboloidal in front and runs to a point at the rear is obtainable wherein, on moving the body with its cross-sectional longitudinal axis parallel to the relative water flow direction, or prevailing direction of travel, or at quite small angles (2°–3°) to the latter, drops in pressure along the side surfaces, which lead to acoustically disturbing eddies and detachments, do not arise.

Carriers having a cross-section of streamline character with a ratio of the thickness to the cross-sectional longitudinal axis of about 1:4 to 1:6 have hitherto already been constructed These carriers are rigidly fixed to the ship and therefore, owing to the considerable stresses at sharp turns of the ship, it was not possible to make the horizontal cross-sections of the carriers smaller. With an arrangement such as constitutes the subject of the invention, the carrier always adjusts itself to the prevailing direction of travel and thus is not subjected in practice to any lateral stresses during turning. Therefore a substantially thinner profile, say, at the ratio 1:8, 1:9 or still thinner can be chosen.

Several forms of construction of the invention are disclosed in the drawings in which

Fig. 1 shows an assembly of a complete protrudable apparatus according to the invention,

Fig. 1*a* is a front elevation of the upper carrier portion which is contained in the base **2**,

Fig. 2 is a view of the carrier apparatus from below,

Fig. 3 a transverse section through an apparatus carrier according to the invention,

Fig. 4 a diagram of the distribution of pressure at the surfaces of the carrier, and

Fig. 5 a different form of construction of the carrier.

In Fig. 1, **1** denotes a cylindrical casing mounted on the hull **3** through the agency of a base part **2** over a circular hull opening **4**. Movably arranged in the casing is a piston **5** which can be lifted and lowered by way of a spindle **6** and gear train **7**, **7***a* through a motor **8**. The piston has a hollow boss **9** in which a stud **10** is rotatably mounted. This stud is fixed to or integral with, the upper end **11***a* of streamlined carrier **11** which is thickened at the top portion located in base **2**, to permit the use of a sufficiently strong stud (Fig. 1*a*). This carrier contains in its lower portion the sound apparatus (transmitters and/or receivers). The sound apparatus are assumed to be electromagnetic devices which are connected by the lines 13, 14 of the cable 15 to the exciting generator 16 or the amplifier 17 and the telephone 18. The cable is arranged in the casing 1 in the form of a spiral and on moving the piston 5 the spiral is compressed to a corresponding extent. The carrier 11 can adjust itself in the direction of travel about the longitudinal axis of the stud 10. In order to prevent undesired oscillating movements, a frictional damping device 19 is provided (see also Fig. 2), and to relieve the load on the stud 10 the carrier is provided at its top rear end with a roller bearing 20.

In Fig. 2, the opening 4 in the ship's hull is seen from below as a circular opening. The centre of rotation of the carrier is about at 21. It is seen that the circle of rotation of the carrier intersects the circle of the hull opening at the points 22, 23. In order that the carrier may not go beyond these points, stops 24, 25 are provided. A sound apparatus (transmitter and/or receiver) is indicated here at 12.

In Fig. 3 is shown a transverse section through the carrier with an electromagnetic sound transmitter and/or receiver, wherein 27, 27 denote the body of the carrier, 28 the casing of the transmitter and/or receiver with the diaphragms 29, 30. The electromagnet halves 31, 32 between which the exciting coil 33 is mounted are fixed to the diaphragms.

As has already been mentioned in the preamble, it has become possible by this arrangement of the carrier to reduce its lateral stresses to a very great extent. Therefore it can be given an unusually thin form, which ensures the qualities of an excellent streamlined body even at high speeds of travel (25–30 knots). It has been found that the ratio of thickness to horizontal length of the streamlined body for the above-mentioned ranges of travel must not exceed the value 1:8. In Fig. 4 the distribution of pressure on the surface of such a body for inclination angles between 0° and 3° (horizontal angle of carrier inclination with respect to the direction of travel) is diagrammatically illustrated. The pressure *ps* produced by the damming-up of the water is influenced by conditions expressed by the formula

$$ps=\frac{v^2}{2_g}\cdot c$$

in which g is the earth acceleration, v the travelling speed, both in meters per second, and c a factor, whose value depends upon the point at the sword profile at which the pressure is observed. This factor is derived for the different angles of sword inclination to the travel direction from a group of curves empirically obtained for each sword profile. For instance, for the aforedescribed profile shown in Fig. 3, the curves represented in Fig. 4 prevail. The middle curve is for the inclination angle 0°, the lower curve for the angle 3° and for the high pressure side of the sword, and the upper curve for the angle 3° and for the low pressure side. The ordinates *ps* represent the pressure values, derived from the above formula

$$\frac{v^2}{2_g}\cdot c$$

which must be added to or subtracted from the normal damming-up pressure prevailing at the several points of the sword profile. The abscissæ represent the corresponding points on the profile line, which latter is inserted on the abscissa axis in dotted lines. This value

$$\frac{v^2}{2_g}\cdot c=ps$$

has the character of a water column (in meters) which corresponds in height with the hydrostatic pressures prevailing at the several points of the profile. For a speed of for instance 15 German knots per hour (the speed of 1 German knot= .5144 m/sec.) the ordinary damming-up pressure is

$$\frac{v^2}{2_g}=\text{approximately }\frac{7.7^2}{19.6}=\frac{59.29}{19.6}=$$

a water column 3 meters in height in round figures, or approximately 0.3 atmospheres. This value must be added with positive or negative sign, as the case may be, to the static pressure on the surface of the sword body. For instance, it appears from the graph in Fig. 4 that for a sword with a profile, there indicated, and at a speed of 15 knots, and a sword depth of 10 meters, and at an inclination angle 0°, the absolute pressure against the leading edge equals 2 kg/cm²+0.3 kg/cm²×1, which corresponds with the formula

$$P+\frac{v^2}{2_g}\cdot c$$

wherein P represents the static pressure. Thus the total damming-up pressure at this point amounts to 2.3 kg/cm². At an inclination angle of 0° at 10 meters depth and a speed of 15 knots (a practical case for very large vessels) the absolute pressure does not drop below 1.5 atmospheres at any point.

For the dynamic stresses exerted against the surface of the sword it is thus always important to ascertain the absolute damming-up pressure which is produced by the speed of travel, while for the avoidance of eddies, which are particularly detrimental for acoustic effects (eddy noises, air separation noises) the relative distribution of the absolute pressure along the surface of the sword is of importance. For instance, abrupt changes in pressure and negative pressures tend to lead to air separation and eddy formation, for example at the point p in the curve for 3° at the negative pressure side. In the present case and under the assumed conditions a pressure of 2−0.3×1=1.7 atmospheres prevails, which is still a sufficiently high pressure. However, even this case should be avoided as much as possible, because the considerable pressure increase at the right of point p may, in certain circumstances, already lead to detachments and eddy formations and care should be taken that the adjustment of the apparatus to the direction of travel is effected as completely as possible.

In order that the adjustment of the carrier to the real direction of flow may take place automatically, the carrier must, of course, be in dynamically stable equilibrium during travel. For this purpose, it is necessary that the vertical axis of rotation about which the rotation of the carrier takes place should be preferably in the front third-part of the carrier in order to obtain sufficient stability in travel.

A somewhat less complete solution of the problem is shown in section in Fig. 5 by way of suggestion. Here, not the whole carrier body rotates to follow the line of flow but only the rear part 40 after the fashion of an Oertz rudder; this part 40 may be hinged on a vertical axis, for instance, at 41 to the forward half of the carrier 42. At 12 is shown again the actual sound apparatus.

The profile shape must, of course, be adapted to the speed at which the apparatus is pulled through the water. At still higher speeds of travel of 35–40 knots, for instance, still thinner profiles must be used. The manner of damping may, of course, be different from that shown at 19 in Fig. 1. This primitive damping is only shown for the sake of simplicity in the drawings.

The manner of movement of the carrier may also be substantially different from that illustrated, the present showing being merely an illustration of one of the many ways in which the present invention may be reduced to practice. Any suitable means may be employed for turning the carrier, or part of it in the direction of flow.

Two main features result as the essential advantages of the invention, firstly the possibility of providing only a thin streamlined form of the carrier itself, and secondly its adjustability to the direction of flow prevailing at the time at the carrier.

I claim:—

1. An arrangement on a vessel for submarine sound communication, comprising in combination with the hull of the vessel an elongated carrier protruding through the hull at least during sound communication and containing the submarine sound apparatus, said carrier having a cross-sectional area of streamline shape, at least a part of said carrier being freely rotatable through a desired angle on an axis in parallel to the longitudinal carrier axis, to permit the adjustment of the freely rotatable part of said carrier to the flow direction of the water surrounding the carrier.

2. An arrangement on a vessel for submarine sound communication, comprising in combination with the hull of the vessel an elongated carrier protruding through the hull at least during sound communication and containing the submarine sound apparatus, said carrier having a cross-sectional area of streamline shape, at least a part of said carrier being freely rotatable through a desired angle on an axis in parallel to the longitudinal carrier axis, to permit the adjustment of the freely rotatable part of said carrier to the flow direction of the water surrounding the carrier, the ratio of the thickness of said carrier to the length of the longitudinal axis of its cross-sectional area being not more than 1:8.

3. An arrangement on a vessel for submarine sound communication, comprising in combination with the hull of the vessel an elongated carrier protruding through the hull at least during sound communication and containing the submarine sound apparatus, said carrier having a cross-sectional area of streamline shape, and means for freely rotatably supporting said carrier from within said hull on an axis in parallel to the longitudinal carrier axis, to permit the free adjustment of said carrier to the flow direction of the water surrounding the carrier.

4. An arrangement on a vessel for submarine sound communication, comprising in combination with the hull of the vessel an elongated carrier protruding through the hull at least during sound communication and containing the submarine sound apparatus, said carrier having a cross-sectional area of streamline shape, and means for freely rotatably supporting said carrier from within said hull on an axis in parallel to the longitudinal carrier axis and removed from the leading carrier edge not more than one-third of the length of the cross-sectional carrier area, to permit said carrier to freely follow the flow direction of the water surrounding the carrier.

5. An arrangement on a vessel for submarine sound communication, comprising in combination with the hull of the vessel an elongated carrier protruding through the hull at least during sound communication and containing the submarine sound apparatus, said carrier having a cross-sectional area of streamline shape, and means for freely rotatably supporting said carrier from within said hull on an axis in parallel to the longitudinal carrier axis and removed from the leading carrier edge not more than one-third of the length of the cross-sectional carrier area, to permit said carrier to freely follow the flow direction of the water surrounding the carrier, and means for limiting the angular movement of said carrier.

6. An arrangement on a vessel for submarine sound communication, comprising in combination with the hull of the vessel an elongated carrier protruding through the hull at least during sound communication and containing the submarine sound apparatus, said carrier having a cross-sectional area of streamline shape, and means for freely rotatably supporting said carrier from within said hull on an axis in parallel to the longitudinal carrier axis and removed from the leading carrier edge not more than one-third of the length of the cross-sectional carrier area, to permit said carrier to freely follow the flow direction of the water surrounding the carrier, and means for damping the angular movement of said carrier.

7. An arrangement on a vessel for submarine sound communication, comprising in combination with the hull of the vessel an elongated carrier of streamline cross-section protrudable through the hull and containing the submarine sound apparatus, a cylinder inside the vessel and a piston movable in said cylinder and serving as a support for the upper end of said carrier, a stud pivoted in said piston and fixed to the upper carrier end near its leading edge to permit the free rotation of said carrier on an axis extending longitudinally of said carrier near its leading edge, and permitting the carrier to freely follow the flow direction of the water surrounding the carrier, means for limiting the angle of rotation of said carrier, and means for damping its rotary movements.

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