July 23, 1946. W. R. HARRY 2,404,375

ELECTROMECHANICAL DEVICE

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FIG. 1

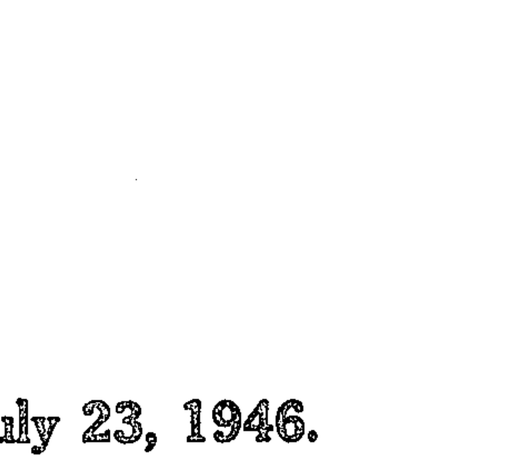


FIG. 2

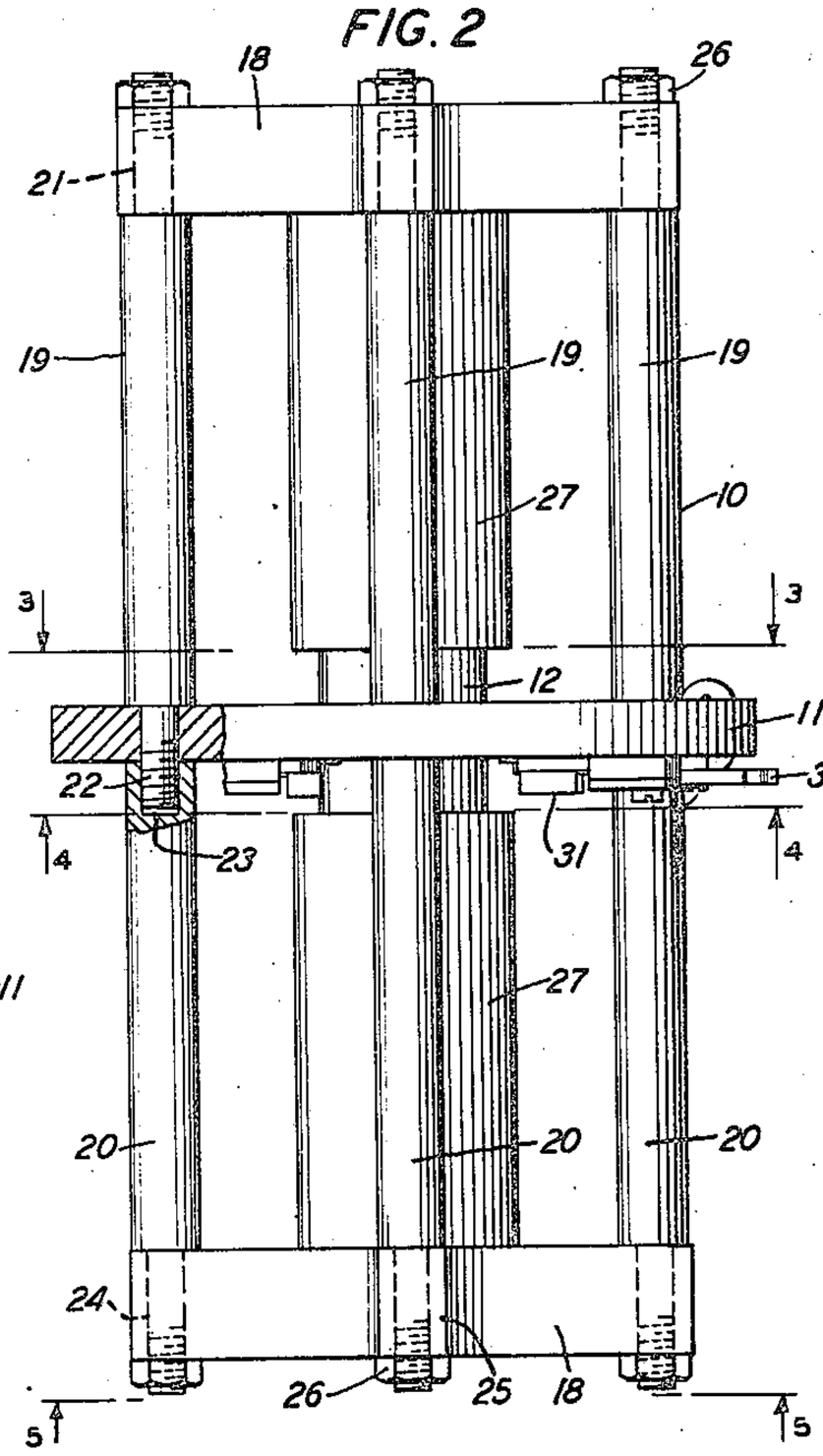


FIG. 3

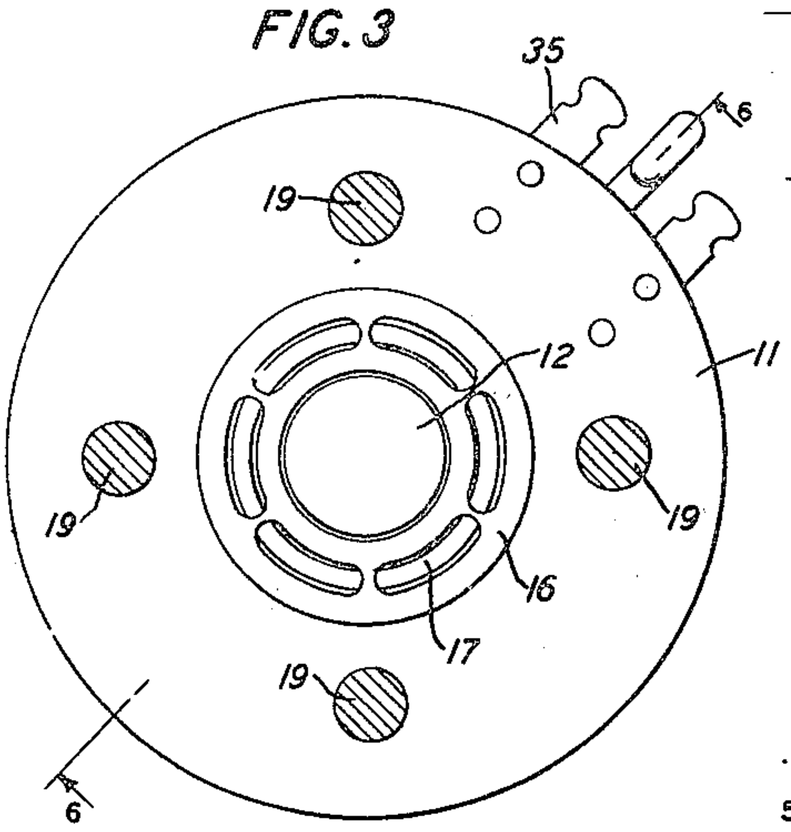


FIG. 4

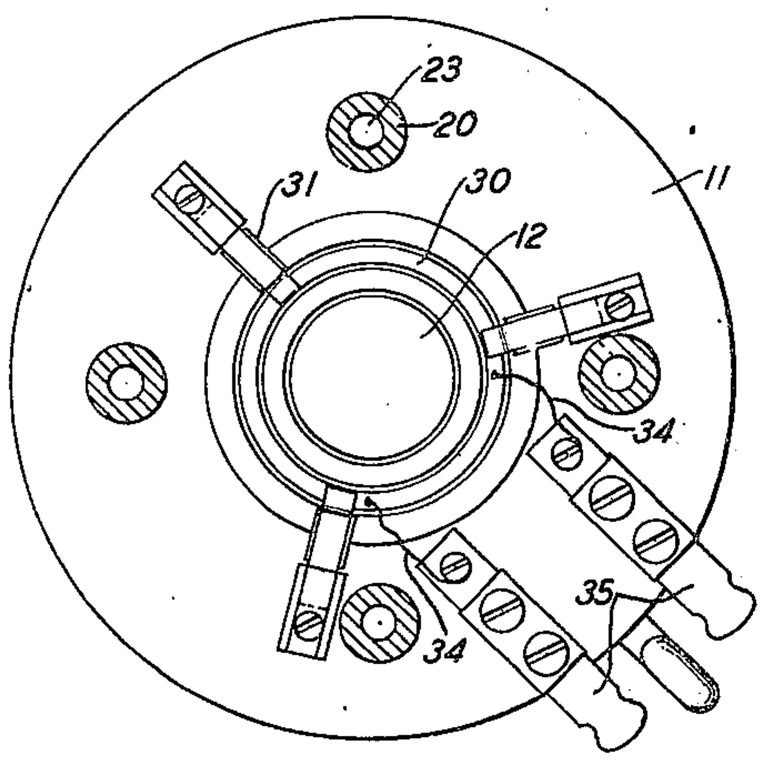
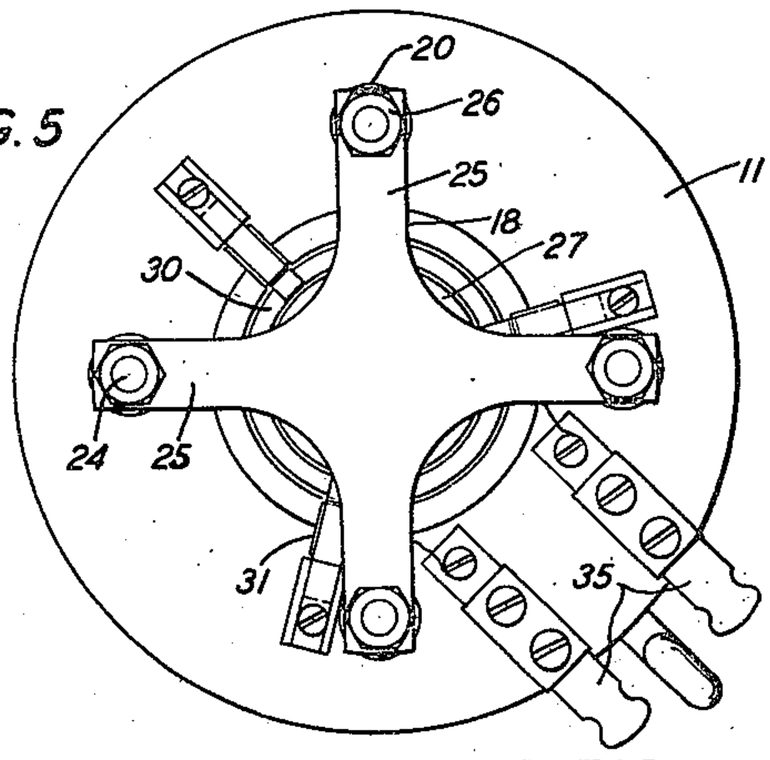


FIG. 5



INVENTOR
W. R. HARRY
BY
Robert J. Flueboy
ATTORNEY

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FIG. 6

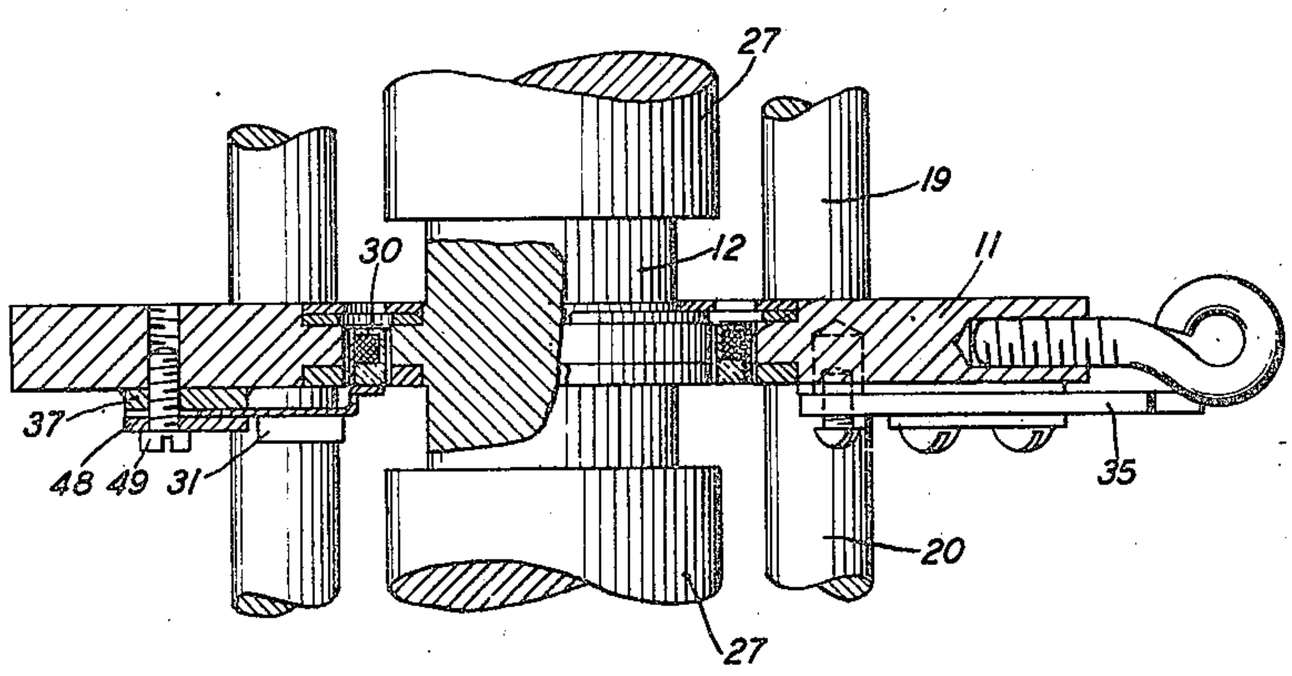


FIG. 7

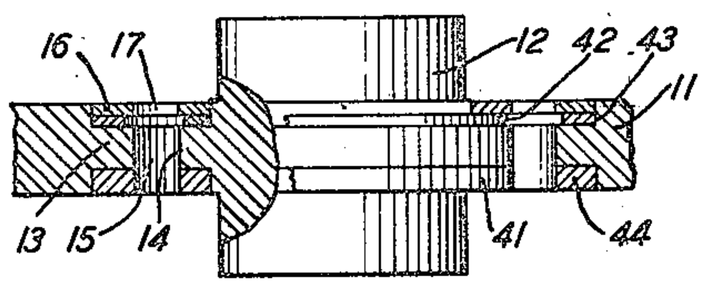


FIG. 8

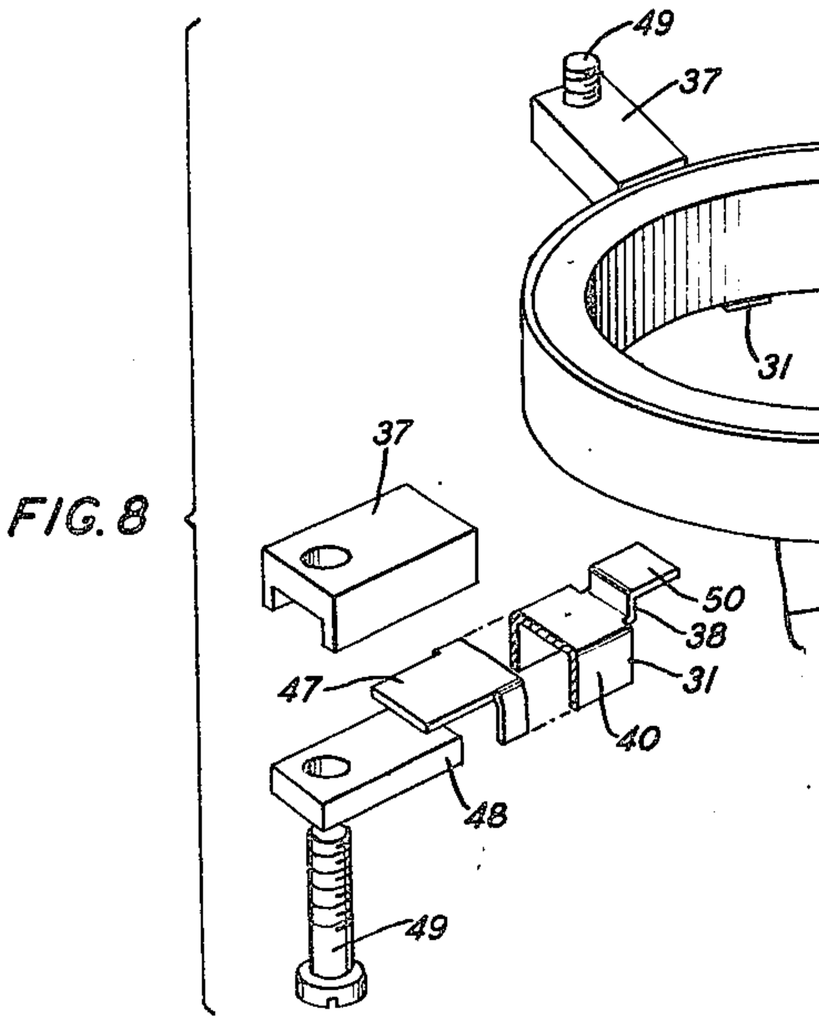
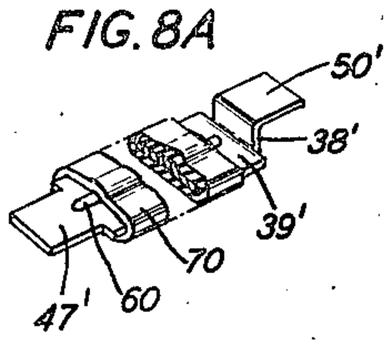


FIG. 8A



INVENTOR
W. R. HARRY
BY
Robert J. Flusbey
ATTORNEY

Patented July 23, 1946 2,404,375

UNITED STATES PATENT OFFICE

2,404,375

ELECTROMECHANICAL DEVICE

William R. Harry, New York, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application October 15, 1941, Serial No. 415,013

6 Claims. (Cl. 177—386)

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This invention relates to electromechanical devices and, more particularly, to submarine signal detectors or microphones.

An object of the invention is to improve the structure and the operating performance of submarine signal detectors.

In accordance with the invention, the submarine signal detector is of the pressure gradient type, that is, its signal wave or under water disturbance responsive element is caused to move as a result of the pressure gradient established between different portions thereof by the signal wave. The movable element may comprise an annular member disposed in an annular air-gap and exposed on all its surfaces to the water, but presenting a pair only of annular parallel planar surfaces on which the signal wave may act. The annular member comprises a spool having a peripheral closure member or ring. The annular member is supported by a plurality of edge-stiffened flexible members, or by a plurality of longitudinally stiffened, damped flexible members, that permit movement of the winding member in two directions only, 180 degrees apart. Since the signal responsive element of the device is exposed to the water on all sides, the device does not require any means to compensate for the effect of hydrostatic pressure. The planar surfaces of the signal responsive element are exposed to the water on opposite sides of a plate pole member having a central opening in which a second pole member is positioned to form the annular gap in which the signal responsive element is located.

A more complete understanding of this invention will be derived from the detailed description that follows, read with reference to the appended drawings, wherein:

Fig. 1 illustrates how a microphone embodying the features of this invention may be suspended or immersed in a liquid medium, for example, water;

Fig. 2 is a side elevational view of a submarine signal detector or microphone constructed in accordance with the invention;

Fig. 3 represents a cross-sectional view of the device of Figs. 1 and 2 taken along the lines 3—3 of Fig. 2;

Fig. 4 represents another cross-sectional view of the device of Figs. 1 and 2 taken along the lines 4—4 of Fig. 2;

Fig. 5 is a bottom plan view of the device of Figs. 1 and 2;

Fig. 6 is an enlarged view of the central portion of the device of Fig. 2 partly in section and

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partly broken away to show details of construction more clearly;

Fig. 7 is a partial section of the central portion of the device of Figs. 1 and 2 with the annular member removed from the air-gap;

Fig. 8 is an enlarged showing in perspective of the signal wave or disturbance responsive element of the device of Figs. 1 and 2, partly broken away and partly in section, to show details of its construction together with the spring supporting means provided to locate and support the wave responsive element in an air-gap; and

Fig. 8A shows another construction for the spring supporting means for locating and supporting the wave responsive element in the air-gap.

The invention is disclosed as embodied in a submarine signal detector or microphone 10. The microphone comprises a centrally located annular plate pole member 11 and a symmetrically shouldered center pole member 12 each of magnetic material. The inner diameter of the annular projecting portion 13 of the plate pole and the outer diameter of the annular projecting portion 14 of the center pole are such that they present spaced parallel pole faces defining an annular air-gap 15. The pole members are coaxial and are maintained so by the annular plate 16 containing elongated apertures or slots 17.

A pair of cross-shaped spiders or yokes 18 are supported from the plate member 11 by a plurality of spacers, studs or cylindrical rods 19, 20, each yoke and stud being of magnetic material. Each stud 19 has a threaded extension 21 or 22 at each extremity, whereas each stud 20 has a threaded recess 23 at one end and a threaded extension 24 at its other end. Each extension 22 projects through a passage in the plate member and threads into a recess 23 whereby the studs and the plate member are rigidly united. The extensions 21, 24 extend through passages at the outer ends of the symmetrically spaced arms or branches 25 of the yoke and are rigidly united thereto by the fastening members or nuts 26. Cylindrical permanent magnet members 27 are clamped, by pressure exerted by the nuts 26, rigidly between each yoke and the center pole 12, like poles of the magnet members being adjacent the center pole.

The signal wave or disturbance responsive element of the microphone comprises an annular element or coil 30 supported and positioned in the air-gap 15 by a plurality of symmetrically located spring members 31. The element 30 comprises an annular spool or frame 32 of non-magnetic ma-

terial having a peripheral annular groove or channel containing a multiturn winding **33** of small insulated wire. The frame is provided with passages for the ends **34** of the winding, which are terminated at the terminal strips **35** supported on and insulated from the plate pole member. The winding is confined and sealed within the frame channel by a tightly fitting peripheral closure or annulus **36** of non-magnetic material. The closure **36** may be omitted if, after the wire is wound in the channel, it is vacuum impregnated in a Bakelite varnish medium.

Each spring member **31** comprises a strip of spring metal having a clamping portion **47** spaced from one surface of the plate pole by a spacer **37**, and clamped against the spacer **37** by a plate **48** and screw **49**, an L-shaped portion **38** whose horizontal leg **50** is suitably fastened to an annular planar surface of frame **32**, and an intermediate stiffened portion **39** stiffened by virtue of the angular edge portions **40**. These spring members provide a flexible support for the element **30**, enabling it to move in two directions only, 180 degrees apart, with its lateral surfaces moving substantially parallel to those of the pole faces. Fig. 8A shows another construction of spring member that may be utilized to locate and support the member **30** in its air-gap. It comprises a strip of spring metal having a clamping portion **47'**, an L-shaped portion **38'** whose horizontal leg **50'** is adapted to be secured to the lower annular surface of frame **32**, and an intermediate stiffened portion **39'**, stiffened by virtue of the elongated boss or ridge **60**. A sleeve **70** of damping material, for example, of rubber, fits around the portion **39'**. The clearance of space between the lateral surfaces of the element **30** and the pole faces is so small that, although water may flow therethrough, signal waves or disturbances to which the microphone is intended to be responsive are presented with a very high impedance and hence are excluded. The winding **33** normally is located in the region between the projecting portions **13**, **14** of the pole members. Washer members **41—44** are fastened to the horizontal surfaces of the portions **13**, **14** to confine the action of the water and of the signal waves or disturbances to the parallel upper and lower, annular planar surfaces of the element **30**.

In a microphone constructed in accordance with this invention and of the proportions substantially those of Figs. 2 to 5, the magnet members **27** were of an aluminum-nickel-cobalt steel alloy (Al—10%; Ni—17%; Co—12%; Cu—6%; Fe and C balance); the pole members, studs and yokes were of Swedish steel; the spool and the peripheral closure of the element **30** were of a plastic, and the winding **33** of 130 turns of No. 33 B. and S. enamel-coated aluminum wire; the spring supports **31** were of phosphor bronze shaped from strip material approximately .002 inch in thickness and one-eighth inch in width. The air-gap was .125 inch wide, and the projecting portions **13**, **14** of the pole members were approximately .125 inch in thickness. The mass of the element **30** and of the spring supports **31** was proportioned to be approximately equal to the radiation mass of the water. The flux density at the pole faces was of the order of 3000 gauss.

The microphone described may be used in a liquid medium, and, specifically, in water to detect marine or submarine signal waves or disturbances over a broad band of frequencies, for

example, up to 20,000 to 30,000 cycles per second. It may also be employed as a standard microphone for calibrating microphones of similar or of different construction intended for use in water.

The microphone described is of the pressure gradient type, i. e., its signal responsive element **30** responds to the pressure gradient between, or the difference in pressures established on, its parallel upper and lower surfaces by a signal wave or disturbance incident on the microphone. The coil or element **30** is completely exposed to the water so that the signal wave has access at least to the parallel portions exposed on opposite sides or surfaces of the plate pole member; because of the proportions of the clearances between the coil and the pole faces, the signal wave is not effective on the lateral surfaces of the element **30**, and a signal wave originating on one side of the plate pole member must travel around the latter to be effective on the other surface of the element **30**. If the signal wave should be incident on the microphone from such a direction that the portions of the wave acting on the upper and lower surfaces of the element **30** are in phase, the element remains stationary. If, however, the portions of the signal wave acting on the surfaces of the element **30** are out of phase, the coil or element will be caused to move to an extent determined by the intensity and the magnitude of the difference in phases of the signal wave on the two surfaces. The microphone of the invention has a directional response characteristic. This characteristic, it is evident, may be taken advantage of in arrangements in which it is desired to maintain the microphone in a stationary or in an adjustable position. Movement of the element **30** in the air-gap in response to signal waves or disturbances in the frequency range to which the microphone is responsive, generates currents corresponding thereto in the winding **33** which currents may be detected or translated in suitable observation equipment to which the microphone may be connected over the wires **55**.

Although this invention has been disclosed with reference to a specific embodiment, it is not restricted thereto, but is of a scope evidenced by the appended claims.

What is claimed is:

1. A microphone for use in a liquid wave transmission medium, comprising magnet structure providing a radial flux across an annular air-gap, a signal wave responsive element to be actuated directly by the signal wave disturbance in the medium and exposed on all of its surfaces to said medium, and means to mount said element for translational movement in said magnetic field, said element comprising an annular member having a peripheral channel containing a multiturn winding.

2. A microphone for use in a liquid wave transmission medium, comprising magnet structure providing a radial flux across an annular air-gap, a signal wave responsive element to be actuated directly by the signal wave disturbance in the medium and exposed on all of its surfaces to the medium, and means to mount said element for translational movement in said magnetic field, said element comprising an annular member having a peripheral channel containing a multiturn winding and a peripheral closure member confining said winding in said channel.

3. A microphone for use in a liquid wave transmission medium, comprising magnet structure

providing a radial flux across an annular air-gap, a signal wave responsive element to be actuated directly by the signal wave disturbance in the medium and exposed on all of its surfaces to the medium, means to mount said element for translational movement in said magnetic field, said element comprising an annular member having a peripheral groove containing a multiturn winding, and means from which said element is supported, said mounting means comprising a plurality of flexible members intermediate the support means and said element and secured to each.

4. A microphone for use in a liquid wave transmission medium, comprising a plate pole member having a central opening, a second pole member positioned in said central opening and forming an annular air-gap with the plate member, a source of magnetic flux for said pole members to establish a magnetic field across said air-gap, a signal wave responsive element to be actuated directly by the signal wave disturbance in the medium and exposed on all its surfaces to the medium and comprising an electrical conductor positioned in said air-gap, and means to support said element in said air-gap for movement therein.

5. A microphone for use in a liquid wave transmission medium, comprising a plate pole member having a central opening, a second pole member positioned in the central opening and forming

an annular air-gap with the plate member, a source of magnetic flux for said pole members to establish a magnetic field across said air-gap, a signal wave responsive element to be actuated directly by the signal wave disturbance in the medium and exposed on all its surfaces to the medium and comprising an electrical conductor positioned in said air-gap, and a plurality of flexible members extending between said plate member and said element to support the latter in the air-gap for movement therein substantially in two directions only 180 degrees apart.

6. A microphone for use in a liquid wave transmission medium, comprising a plate pole member having a central opening, a second pole member positioned in the central opening and forming an air-gap with the plate member, a source of magnetic flux for said pole members to establish a magnetic field across said air-gap, a signal wave responsive element to be actuated directly by the signal wave disturbance in the medium and exposed on all its surfaces to the medium and comprising a winding positioned in said air-gap, and a plurality of edge-stiffened flexible members extending between said plate member and said element to support the latter in said air-gap for movement therein substantially in two directions only 180 degrees apart.

WILLIAM R. HARRY.