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UNITED STATES PATENT AND TRADEMARK OFFICE GRANTED PATENT

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Link to Claims Section

June 5, 1956

# Sonobuoy

**INVENTOR:** BLONDER ISAAC S; RINES ROBERT H

**APPL-NO:** 392 (03)

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**CL:** 455, 342, 367, 455

**SUMMARY:**

The present invention relates to systems and methods of communication and more particularly to the generation, transmission and reception of radio waves. This application is a division of our copending application Serial No. 39,286, filed July 17, 1948, now Patent 2,539,594, issued January 30, 1951.

An object of the invention is to provide a new and improved system for the modulation of radio waves.

A further object is to provide a novel system for detecting underwater vibrations and modulating radio waves in response thereto.

Other and further objects will be explained hereinafter and will be particularly pointed out in the appended claims.

The invention will now be more fully explained in connection with the accompanying drawings in which Fig. 1 is a diagrammatic view of circuits and apparatus constructed in accordance with the present invention and illustrating the reception of underwater elastic vibrations such as sound waves of either audible or ultrasonic frequencies, and the transmission of radio waves modulated according to the principles of the present invention in response to the vibrations, and Fig. 2 is a similar diagram of a modification.

The present invention is particularly adapted for use as a sono-buoy. Though it will be described as so applied, it is to be understood, however, that it may be entirely used in air to detect air-borne elastic vibrations as well. In the embodiment of Fig. 1, a buoy 96 supports a horn or other sound-collecting device 84 which is disposed under water and may be provided at one end with a waterproof cover that passes elastic vibrations into the horn, in order preferably, though not essentially, directionally to receive ultra-sound or audible sound waves or other elastic vibrations under water. The received vibrations will vibrate a sound-responsive member, shown as a diaphragm 86 disposed preferably at the other end of the horn 84. A parasitic antenna 92-94, which may be energized with radio-wave energy, for example, by a radar station, not shown, may be provided with contactors 88 and 90. The antenna elements 92 and 94 will therefore become periodically tightly and loosely coupled or electrically connected and disconnected as the diaphragm 6 vibrates towards and away from the contactors 88 and in response to the received vibrations. The switching system 86-88-98 is preferably of very low inertia and may be in vacuum. The radio waves reflected from the antenna 92-94 will therefore be modulated by the make-and-break connection effected by the diaphragm 86 in response to the received vibrations in accordance with the phenomenon disclosed in the said copending application. A maximum modulation effect may be produced when the diaphragm or other switching device 86 is set into mechanical resonance by the vibrations. The sono-buoy of Fig. 1 thus does not require any source of power at the buoy whatsoever, being completely passive. As is also discussed in the said copending application, the switching device 86-88-90 need not be symmetri-

?=sincally disposed between equal elements 92 and 94 and the antenna elements need not have equal dimensions. Each of these elements, indeed, may be of sufficient dimensions continuously to be effective to return radio reflections to a receiving station, the transient effects produced by the adding of the elements to each other and the disconnecting of the same at the periodicity of the received elastic vibrations producing the modulation effects. Any other well-known audible sound or ultrasonic receiving system may be similarly employed, such as a vibratory piezoelectric crystal receiver, a magnetostric-tive receiver, or magnetomotive vibrators making make-and-break contact with the radio-frequency elements. A Pierce-type diaphragm receiver 98 is shown, as a further illustration, in Fig. 2 supported in the water by the buoy 96 at 106. Diaphragms of this nature are described in United States Letters Patent Nos. 2,063,944 through 2,063,947, issued to George W. Pierce, on December 15, 1936, and may assume many forms including flat plates, horns, strips, rods and the like. The diaphragm 98 will be set into mechanical vibration by audible sound or ultrasonic waves in the water, giving maximum resonant vibrational response when the wave-front of the impinging sound or ultrasonic waves lies in a plane oriented at an angle 6 to the plane of the diaphragm, as given by the equation . _, (velocity of the vibrations in the water) (velocity of the vibrations in the diaphragm)

As the diaphragm 98 vibrates, it will make and break electrical connection with a contactor or switch 104 disposed at a point along the transmission line 103 displaced from the antenna 169, periodically becoming tightly and loosely coupled to the transmission line 103 feeding the antenna and also, therefore, to the antenna itself. This switching system also should be of low inertia. The transmitting antenna is shown, as an illustration, as an omni-directional vertically disposed antenna, that is also supported by the buoy 96. The antenna may be fed by the transmission line 183 as it draws radio-frequency energy from a transmitting radio-frequency oscillator or other source 102, also supported by the buoy 96. The transmitted radio waves will be modulated in response to the opening and closing of the switch 104 caused by the vibrations of the diaphragm 98. The location of the switching at 104, remote from the antenna 100, enables the antenna Q and the antenna radiation pattern to remain substantially unchanged during the switching, since the switching is effected in the transmission line 103, preferably near the oscillator 102. The construction provides the buoy with reliable transmission properties.

If desired, the system of Fig. 1 may be driven from a transmitting source of energy such as 102, or the system of Fig. 2 may be passive or parasitic. In both the embodiments of Figs. 1 and 2, moreover, the buoys 96 may be rotated by motors, not shown, as is well-known in the art, to give directional indications of the source of the audible sound or ultrasound waves. The antennas, too, may be provided with reflectors or may be in array form to be directional. The make-and-break phenomenon, moreover, may be produced not only upon the antenna elements, Fig. 1, but upon the transmission lines connecting the antenna elements to the radio-frequency source of energy, Fig. 2, and even upon the conductors of the tank circuits of the electric system or source of radio-frequency energy.

Further modifications will occur to persons skilled in the art and all such are considered to fall within the spirit and scope of the invention as defined in the appended claims.

**ENGLISH-CLAIMS:**
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What is claimed is:

1. A radio system having, in combination, a buoy for floating upon the surface of a body of water, a radio-frequency-energy-generating electric system carried by the buoy, an antenna carried by the buoy in the air space above the surface of the water, a transmission line connected between the antenna and the electric system in order to cause the antenna to emit radio waves into space in response to electrical excitation supplied along the transmission line to the antenna by the electric system, a sound-vibratory member carried by the buoy below the surface of the water, a switching device, and means for disposing the switching device in cooperative relation with the sound-vibratory member and at a point along the transmission line displaced from the antenna in order periodically to make-and-break contact with the transmission line remote from the antenna in accordance with the vibrations of the sound-vibratory member, thereby to effect modulation of the radio waves emitted by the antenna in accordance with the vibrations of the sound-vibratory member.

2. A radio system having, in combination, a buoy for floating upon the surface of a body of water, an antenna element carried by the buoy in the air space above the surface of the water for transmitting or receiving radio waves, a transmission line connected to the antenna element, a sound-vibratory member carried by the buoy below the surface of the water, a switching device, and means for disposing the switching device in cooperative relation with the sound-vibratory member and at a point along the transmission line displaced from the antenna element in order periodically to make-and-break contact with the transmission line remote from the antenna element in accordance with the vibrations of the sound-vibratory member, thereby to effect modulation of the radio waves transmitted or received by the antenna element in accordance with the vibrations of the sound-vibratory member.

3. A radio system having, in combination, a buoy for floating upon the surface of a body of water, an antenna element carried by the buoy above the surface of the water for transmitting or receiving radio waves, a transmission line connected to the antenna element, a contactor element connected to the transmission line at a point thereof remote from the antenna element, a sound-vibratory member carried by the buoy below the surface of the water and vibratory in response to underwater vibrations, and means whereby the sound-vibratory member as it vibrates, connects with and disconnects from the contactor element at the periodicity of its vibrations, thereby to effect modualtion of the radio waves transmitted or received by the antenna element in accordance with the vibrations of the member.

4. A radio system of the character described in claim 3 and in which the sound-vibratory member has directional properties.

5. A radio system of the character described in claim 3 and in which the sound-vibratory member comprises a horn.

6. A radio system of the character described in claim 3 and in which the sound-vibratory member comprises a diaphragm.

7. A radio system of the character described in claim 3 and in which the sound-vibratory member comprises a diaphragm orientable at an angle 6 with respect to the plane wave-front of the underwater vibrations such that the following relation is substantially satisfied:

_, (velocity of the vibrations in the water) (velocity of the vibrations in the diaphragm)

8. A radio system of the character described in claim 3 and in which the sound-vibratory member is of dimensions sufficient to produce mechanical resonance therein in response to the underwater vibrations.

9. A radio system having, in combination, a buoy for floating upon the surface of a body of water, an antenna of the type that emits radio waves into space in response to electrical excitation by radio-frequency energy drawn from a radio-frequency-energy generating electric system prior to the emission of the radio-frequency energy as radio waves and carried by the buoy above the surface of the water, an electric system for generating radio-frequency energy carried by the buoy, means electrically connecting the antenna to the electric system in order that the antenna may draw radio-frequency energy from the electric system, thereby to cause the antenna to emit radio waves into space, means comprising a sound-vibratory member carried by the buoy below the surface of the water and vibratory in response to underwater vibrations, and a switching device cooperative with the sound-vibratory member and responsive to the vibrations thereof for periodically making and breaking contact with the said electrically connecting means at a region of the radio system between the electric system and the antenna displaced from the antenna in accordance with the vibrations of the sound-vibratory member during the emission of the radio waves by the antenna, thereby to effect modulation of the radio waves in accordance with the vibrations of the sound-vibratory member.

10. A radio system of the character described in claim 9 and in which the said region is at the electric system.

11. A radio system having, in combination, a buoy for floating upon the surface of a body of water, an antenna carried by the buoy in the air above the surface of the water for transmitting or receiving radio waves, a transmission line connected to the antenna, a soundvibratory member carried by the buoy below the surface of the water, a switching device protected from the air and water and cooperative with and responsive to the vibrations of the sound-vibratory member, and means for disposing the switching device in vibratory relation to the transmission line at a point therealong displaced from the antenna in order that the switching device may make-and-break contact with the transmission line remote from the antenna in accordance with the vibrations of the sound-vibratory member, thereby correspondingly to effect modulation of the radio waves transmitted or received thereby in accordance with the vibrations of the sound-vibratory member while maintaining the Q and the radiation pattern of the antenna substantially unchanged.

412. A radio system having, in combination, a buoy for floating upon the surface of a body of water, dipole antenna elements carried by the buoy in the air above the surface of the water for transmitting or receving radio waves, a transmission line connected at one end to the antenna elements and open-circuited at the other end, a sound-vibratory member carried by the buoy below the surface of the water, a switching device protected from the air and water and cooperative with and responsive to the vibrations of the sound-vibratory member, and means gr for disposing the switching device in vibratory relation to the said other end of the transmission line displaced from the antenna elements in order that the switching device may periodically shortand open-circuit the said other end of the transmission line in accordance with the go vibrations of the sound-vibratory member, thereby correspondingly to connect and disconnect the dipole antenna elements through the transmission line to effect modulation of the radio waves transmitted or received thereby in accordance with the vibrations of the soundgg vibratory member.

13. A radio system having, in combination, a buoy for floating upon the surface of a body of water, an antenna carried by the buoy in the air above the surface of the water for transmitting or receiving radio waves, a transmission line connected to the antenna, sound-vibratory diaphragm means carried by the buoy and vibratory in response to vibrations received underwater, a switching device protected from the air and water and supported by the buoy and comprising a portion of the ,7o sound-vibratory diaphragm means, and means for disposing the said switching device in vibratory relation to the transmission line at a point therealong displaced from the antenna in order that the switching device may make-and-break contact with the transmission line remote from the antenna in accordance with the vibrations of the sound-vibratory diaphragm means, thereby correspondingly to effect modulation of the radio waves transmitted or received thereby in accordance with the vibrations of the sound-vibratory diaphragm means while maintaining the Q and the radiation pattern of the antenna substantially unchanged.

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