N° 22,940 A.D. 1914

(*Under International Convention.*)

Date claimed for Patent under Patents and Designs Act, 1907, being date of first Foreign Application (in the United States), 2nd Apr., 1914

Date of Application (in the United Kingdom), 23rd Nov., 1914

At the expiration of twelve months from the date of the first Foreign Application, the provision of Section 91 (3) (a) of the Patents and Designs Act, 1907, as to inspection of Specification, became operative

Accepted, 23rd Nov., 1915

COMPLETE SPECIFICATION.

Improvements in or relating to Measurement by the use of Sound Waves.

I, REGINALD AUBREY FESSENDEN, of 1677, Beacon Street, Brookline, Massachusetts, United States of America, Engineer, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the measurement of distances and other quantities by the use of sound waves and provides an improved method and apparatus especially applicable to sounding by ships or for the detection of icebergs and other floating or submerged bodies, but also adapted for many other purposes. It provides, in general, means by which, if two or more of the following quantities, time, distance, density and nature of the medium, are given, one or more of the remaining quantities may be found.

According to this invention a sound is emitted from a suitable source and its echo or return, or the sound which arrives at a distant point, is observed by a receiving mechanism which is in sensitive or operative condition only when the sounding device is silent, permitting the time elapsing between the sound emission and the reception of the echo to be readily and accurately measured. A measuring instrument is preferably employed which enables the time interval to be accurately observed and the receiving element of this instrument may be automatically rendered insensitive or inoperative while the sound is being emitted. The sound emitter may be dead beat or highly damped so that the sound is stopped instantly after a definite interval of emission.

The applications of the new method are numerous. For example, given the distance between two points in a mine, and having determined the time taken by a sound wave to travel between the points, it is possible to draw conclusions with regard to the probable nature of the rock between them, or if an echo be observed, or a refraction of the sound, it is possible to estimate the distance of the reflecting or refracting vein.

Again, if a sound be produced on a ship and the time elapsing between the production of the sound and its echo from the sea bottom be measured, it is

[*Price* 6*d.*]

possible to determine the distance between the ship and the bottom. If the intensity of the echo be determined, it is possible to determine approximately the character of the bottom, that is, whether it be mud, sand, gravel or rock. If the echo be from an iceberg or layer of melted ice surrounding the iceberg or from another ship, it is possible to determine the distance of the iceberg or the ship. In the case of an iceberg especially, it is found that the echo or return sound usually takes the form of sound diffraction fringes due to reflections and refractions at more or less irregular surfaces at different distances from the source and in measuring the distance the first diffraction fringe is observed. By observing the successive fringes inferences as to the dimensions of the iceberg may be made.

The method is not limited to measuring distance in any definite direction or in a single medium, but is applicable to all directions and mediums, and for determining other quantities besides distances, for example, the nature of the medium as above referred to.

That distance could theoretically be determined by sound echoes has long been known, but this knowledge has never been put into commercial use on account of the lack of any practical method or practical apparatus, which to be of service must permit of accurate measurement. For example, if a ship drawing twenty five feet is in a channel having a depth of fifty feet, the time taken by the sound of a bell in travelling from the bottom of the ship to the bottom of the channel and back to the ship would be only about one one-hundredth of a second, and to determine the depth to within one foot would necessitate a measurement of the time elapsing between the sound emission and the moment at which the echo returned, to the nearest four ten-thousandths of a second, which is impossible by any method heretofore suggested or in use. In addition, since the sound of the blow of the bell would be heard in the receiving apparatus as hitherto conceived the ear would be rendered insensitive and the echo would not be heard, being much fainter and thus drowned by the vibration of the bell persisting after the clapper had struck.

The present method comprises a number of new features and while all of them are not necessarily used in combination in all cases, they are adapted to co-operate to give good results in the cases most commonly met with.

One of these features is the electrical interconnection of the sound production and echo reception, so that the time elapsing between them is determined by the time elapsing between two electrical phenomena, which can be determined with great accuracy.

A second is that the receiver is cut out while the sound is being produced and *vice versa*.

A third is that the sound impulse is produced over a definite time and at a definite intensity and then ceases abruptly, instead of dying away gradually.

A fourth feature is that the depth may be recorded graphically on a moving tape.

A fifth feature is that the same apparatus (a magnetophone, for example) may be used to produce the sound and to receive it.

A sixth feature is that an electric impulse used for producing the sound by the motion of a current carrying conductor in the sound emitter may be derived from a direct current source.

There are other features which will be apparent from the description, and are novel in method and apparatus.

In the accompanying diagram of apparatus embodying my invention 11 is a source of sound, preferably the oscillator described in my Specification No. 18,765 of 1913. 12 is the diaphragm which, immersed in water in the fore part of a vessel or inserted in the skin of the ship, by its motion produces the sound. 13 and 14 are the terminals of a fixed winding 37 on the core 36, and 15 is a movable copper tube attached to the rod 18 by the discs 38, 39, which rod is fastened to the diaphragm. 16 is an electromagnet excited by the

coil 17. When an alternating or fluctuating current passes through the core winding 37 currents are induced in the copper tube 15 by transformer action, and the tube, which is in the strong magnetic field generated by a direct current in the coil 17, oscillates with great force, and actuates the diaphragm 12, producing a sound or sound impulse which ceases immediately the electric current ceases to pass through the winding 37.

A wheel or commutator 28 of insulating material and having a metallic segment 30 is rotated at a definite speed by the motor 29. The battery or other source of current indicated at 20 and the ammeter 19 are connected to the brush 21 and terminals 13, 14 of the oscillator winding 37, and the brush 22 is connected to the terminal 14.

When the brushes 21, 22 both touch the conducting segment 30, the battery 20 sends an electric impulse through the winding 37 and the diaphragm 12 is pushed out or in, producing a sound impulse in the water, and this occurs at each revolution of the commutator 28. In this way a musical tone may be produced whose pitch depends upon the number of revolutions per second of the commutator 28.

The oscillator above described also acts as a sound receiving transmitter, as on a sound wave striking the diaphragm 12, it is moved in and moves the tube 15, which, being a conductor moving in a magnetic field, has a current generated in it by the movement and this current in turn generates a current in the fixed winding 37 by transformer action, which current flows out by the terminals 13, 14 to the brushes 41, 42 on the hard rubber wheel 51, thence, when the conducting segments 50 pass beneath them, to the brushes 43, 44 and through the telephone receiver 23 and recording apparatus 35, either or both of which may be termed an indicating mechanism, to the two-way switch 49, and to the brushes 25, 26, whenever the segment 30 of the wheel 28 passes beneath them, thus completing the circuit.

It will be seen that the telephone receiver circuit is only completed when the segments 30 and 50 pass beneath the brushes in the receiver circuit, and this will occur at some time after the segment 30 has passed beneath the brushes 21, 22 to generate the sound. Consequently no sound will be heard in the telephone receiver 23 until the brushes 41, 42, 43, 44, 25, 26, are shifted by the movable arm 27, to which they are attached, to such a position that the segments 50, 30 pass under them at exactly the instant that the echo from the sound has come back from the sea bottom and struck the diaphragm 12. It will be apparent, since the wheels 28 and 51 revolve at a fixed speed, that the angle through which the brush arm 27 is moved will measure the distance of the reflecting bottom in the case of a sounding apparatus and this distance can be read off directly on the scale 33 in feet or other units.

In operation the brush arm is either shifted until the musical note is picked up, or the brushes 41, 42, 43, 44 are cut out by the switch 52, and the double pole switch 49 is thrown into a position to connect the receiver circuit through the brushes 45, 46 to the metal wheel 47 carrying the insulating segment 48 which is so placed that it cuts the receiver circuit out by passing under the brushes 45, 46 at exactly the instant that the battery current generates a sound by flowing across the conducting segment 30 from the brushes 21, 22. Thus the receiver circuit is connected to the oscillator except at the instant when the sound is being generated. In this way the sound echo may be first picked up, and then the double pole switch 49 and the switch 52 thrown to the normal position and the brush arm 27 shifted until the sound is heard, when the exact depth may be read off on the scale 33.

It will be of course understood that as shown in the drawing, the segments 48 and 30 are not in proper relation to secure the above result but a correct view would carry the segment 48 to the under side of the wheel so that it would not be seen in the drawing.

The recorder 35 may be of the usual automatic electric type, and the record

produced on the moving strip of paper 40; or the recorder may be operatively connected to the arm 27 and may then record mechanically.

The wheel 51 is for cutting out electrostatic disturbance which might be produced on the receiver 23 unless the circuit were opened at the ends of both leads to the receiver. At 34 is indicated diagrammatically a resistance device for measuring the intensity of the sound, which may be used if desired.

The apparatus may be used to locate icebergs or geological strata or other reflecting bodies. For measurement of long distances the speed of rotation of the wheel 28 may be slow, or an ordinary stop watch used to measure the time instead of shifting the arm 27. For icebergs a long wave length is preferably used to ensure reflection or diffraction fringes as already mentioned. The wave length may be as long as 100 feet or more.

In place of connecting the source of sound 11 to the echo indicating mechanism 23, the latter may be connected, by throwing the switch 53 to the position shown by dotted lines, to a second receiving transmitter 54, the oscillator 11 being used for producing the sound and the transmitter 54 for receiving the echo. This method is especially valuable when the depth of sounding is small and when the diaphragm 12 does not come to rest with sufficient abruptness. Also if the transmitter 54 is situated at a distance measurements of time intervals in the case of refracted or deflected sound may be made as already mentioned in connection with the localising of minerals in a mine.

To bring the diaphragm to rest substantially instantaneously a resistance 55, preferably non-inductive, may be placed across the terminals of the oscillator, as shown. Rapid damping of the sound may be applied to any type of emitter employed so as to make it dead beat or to stop the sound quickly after a definite interval.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. Means for measuring by the use of sound waves, in which a sound is emitted and its return or echo is received by a receiving mechanism in sensitive or operative condition only when the sounding device is silent.

2. Means for measuring by the use of sound waves, in which a sound is emitted and its return or echo is received by a receiving mechanism automatically rendered sensitive or operative after the sound emission has ceased.

3. Means for measuring by the use of sound waves, in which a sound is emitted and its return or echo is received by a receiving transmitter and by an indicating instrument which is connected to the said transmitter only when the sounding device is silent.

4. Measuring means as claimed in Claim 1, in which a sound is emitted and the time interval is measured between the emission and the first sound diffraction fringe received from a sound reflecting body (such as an iceberg) having irregular surfaces.

5. Means for measuring by the aid of sound waves, in which an electrical circuit is varied simultaneously with the emission of the sound and the sound affects at a distance a second circuit connected to a receiver or indicator at the emitting station, the time interval between the variations of the two circuits being measured.

6. Means for locating minerals in a mine, in which a sound is emitted at a selected point in the earth and the reflected or refracted sound is received and the time interval between the emission and reception of the sound measured.

7. Means for measuring by the aid of sound waves, comprising a rapidly damped or dead beat sound emitter adapted to give a sound impulse or a sound of short duration and a receiving mechanism so adapted to receive the echo of the said sound that the time interval may be observed..

Improvements in or relating to Measurement by the use of Sound Waves.

8. Means for measuring by the aid of sound waves comprising a sound emitter adapted to give a sound impulse or sound of short duration and to receive and transmit the echo of the said sound and an indicating instrument connected to the said emitter so as to receive the echo but not the emitted sound, for the purpose specified.

9. Means for measuring by the aid of sound waves, comprising a sound emitter, a receiving device for the echo, which receiving device is not responsive to the emitted sound, and a measuring device for measuring the time interval between the sound emission and the reception of the echo.

10. Means for measuring by the aid of sound waves, comprising a sound emitter, a receiving transmitter adapted to receive the echo of the said sound, an indicating instrument, a device for intermittently connecting the said instrument to the receiving transmitter when the sound emitter is silent and a second connecting device for connecting up the said instrument and transmitter at all times when the sound emitter is silent, the two connecting devices being inoperable simultaneously, for the purpose specified.

11. Means for measuring by the aid of sound waves, in which an electric oscillator is adapted to be intermittently excited by the aid of a rotating contact device and the echo is received by the oscillator (or by an independent receiving transmitter) intermittently connected to an indicating or recording instrument through part of the said rotating contact device, which is provided with movable contact brushes the displacement of which measures the time interval between the sound emission and the reception of its echo.

12. Apparatus for measuring by the aid of sound waves, having its parts arranged and adapted to be operated substantially as hereinbefore described with reference to the example illustrated in the accompanying drawing, for the purposes specified.

Dated this 23rd day of November, 1914.

HASELTINE, LAKE & Co.,
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Agents for the Applicant.

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EXTENSION OF PATENT.

The term of the Patent No. 22940, A.D. 1914, has been extended for three years from the expiration of the original Patent (1st April, 1930) by Order of the High Court.

E PATENT OFFICE,

23rd April, 1930.

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A.D. 1914. Nov. 23. No. 22,940.

FESSENDEN'S COMPLETE SPECIFICATION.

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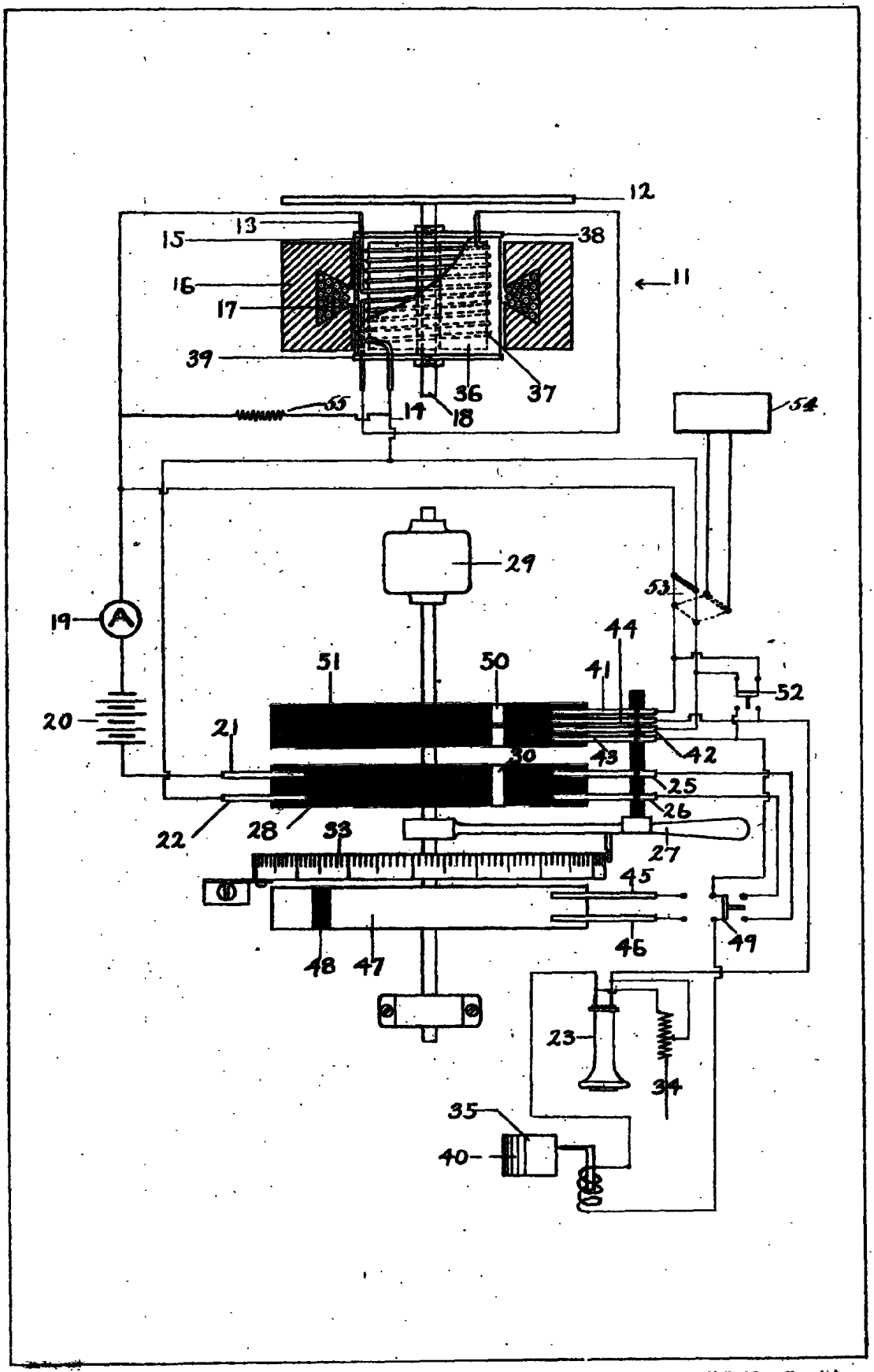

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