

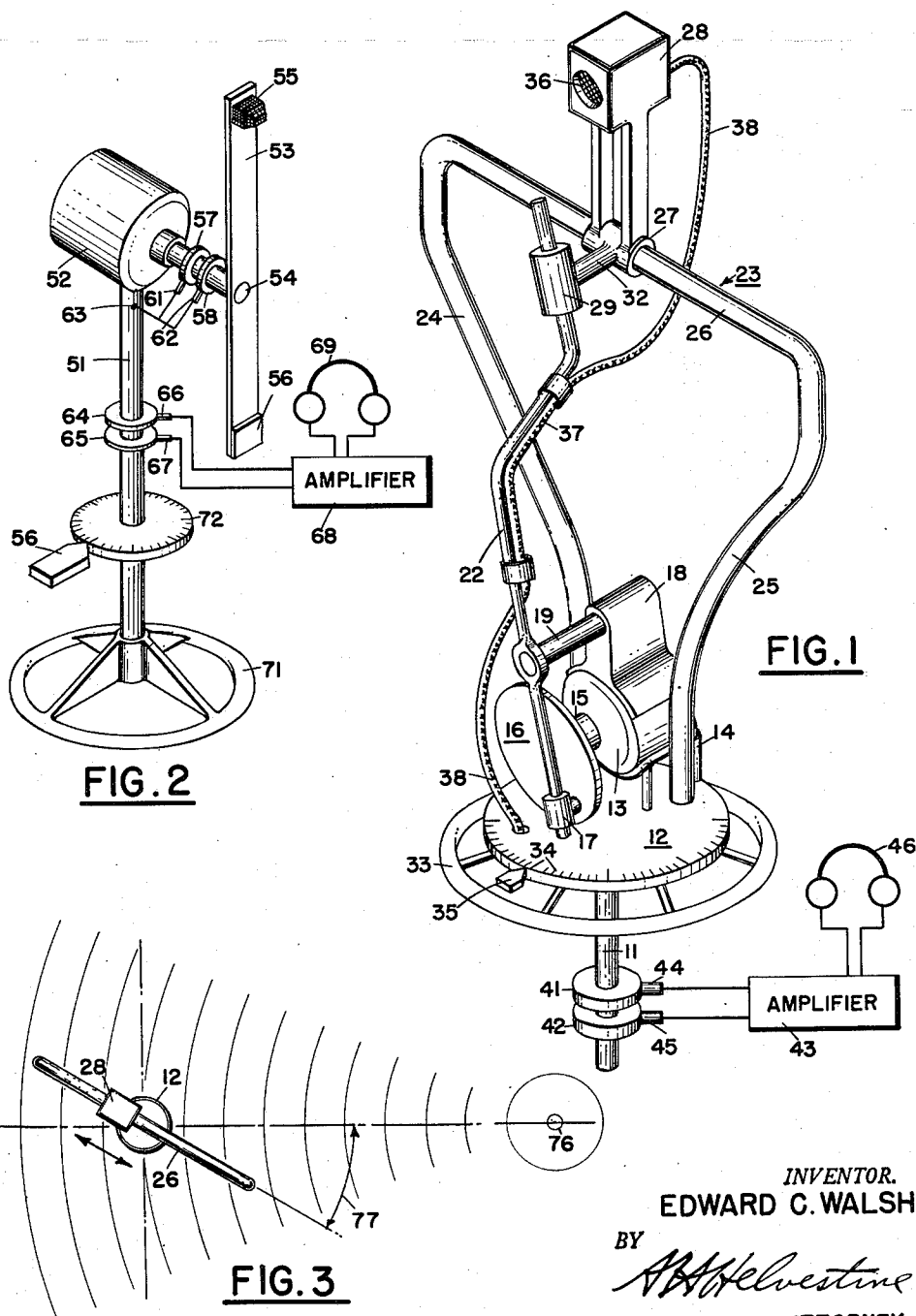
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METHOD OF DIRECTION FINDING

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METHOD OF DIRECTION FINDING

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The present invention relates to sonic direction finders and more particularly to a sonic direction finder which utilizes the Doppler effect.

Presently available systems of sonic direction finding employ the binaural method which requires two sound sensitive receivers spaced one from the other and rotatable as a unit. Each receiver is provided with a separate amplifier which feeds the amplified signal to a separate earphone of the operator's headset, the operator being thus enabled to detect any difference in the time of arrival of the signal at one receiver and the other. He then turns the spaced receivers until any difference disappears, at which time the plane of the two receivers is perpendicular to the direction to the source of sound. From the foregoing, it is apparent that such a system necessarily requires two amplifiers and a special headset for the operator.

The present invention utilizes a single amplifier and microphone and a conventional headset, the microphone being caused to move in an oscillatory manner in a selected plane, whereby when the selected plane is perpendicular to the line from a source of sound to the receiver, there is no motion of the microphone relative to the source of sound and the tone heard in the operator's headset corresponds to that of the sound source. However, if the plane in which the microphone is moved is not perpendicular to the line from the source of noise to the receiver, there is a movement of the receiver toward and away from the source of sound, and if the speed of the microphone is sufficiently high, the apparent frequency of the sound will be alternately increased when the microphone approaches the sound and decreased when it recedes from it. Since the human ear is very sensitive to small changes in frequency, the operator is able to accurately determine when the plane in which the microphone moves is perpendicular to the direction to the sound source.

An object of the present invention is the provision of an inexpensive sonic direction finder of high sensitivity and accuracy.

A further object is to provide a sonic direction finder which employs frequency variation instead of phase displacement as in binaural systems.

A final object is to provide a sonic direction finder in which the sound responsive receiver is caused to move so as to produce a Doppler effect without relative movement between the observer and the sound source.

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The exact nature of this invention as well as other objects and advantages thereof will be readily apparent from consideration of the following specification relating to the amended drawing in which:

Figure 1 is a view in perspective of the preferred form of the invention, in which a linear oscillatory motion is imparted to the sound responsive device.

Figure 2 is a view in perspective of a modification of the invention in which the sound responsive device is revolved about a circular path, and

Figure 3 is a sketch illustrating the operation of the device.

Referring now to Figure 1 of the drawings, a pintle 11 is supported in a vertical position in suitable bearings so that it may be revolved about its axis and support the weight of the device. Since the construction of the base and the bearings are conventional, they are not shown.

Attached to the top of the pintle is a horizontal support 12 which carries the electric motor 13 on an elevated mount 14, which mount may be of any desired type and is shown constructed of tubing only for the purposes of illustration. The motor carries on its shaft 15 a crank disc 16 to which a sleeve 17 is pivotally attached near the periphery of said disc for purposes described hereafter, and a bearing bracket 18 is attached to the motor frame parallel to and vertically displaced above the motor shaft to receive a stub shaft 19 attached to the lever 22 as will be described below.

Also attached to the support 12 is a frame indicated generally by the reference numeral 23 and comprising two tubular arms 24 and 25 extending upward from said support and carrying a horizontal tube 26 secured between their upper ends. This frame is suitably braced and may be formed as shown from a single length of tubing by bending and attached to the support by welding or other suitable method.

Supported by the tube 26 is a loose-fitting sleeve 27 to which is fastened a microphone carrier 28 and a sleeve 29 which is pivotally connected by the joint 32 between the sleeves.

The tubular lever 22 carries the stub shaft 19 placed somewhat below the middle of the lever, the shaft 19 being rotatably supported in the bearing bracket 18 mounted on the motor 13 as previously mentioned, and the ends of the lever fit loosely into the sleeve 29 secured to the microphone carrier 28 and the sleeve 17 on the crank disc 16 mounted on the motor shaft 15.

Also attached to the support 12 is a handwheel

33 by which the operator may rotate the device on the pintle 11, and a graduated indicator 34 which revolves with the support and is calibrated in degrees, mils, or other suitable units. Co-operating with the indicator 34 is an index 35 which may be made adjustable about the pintle to enable the operator to orient the device with a desired meridian, whereby azimuth or deflection angles may be read directly on the indicator without need for calculation.

The microphone 36 is mounted on the microphone carrier 28 by means of springs or sponge rubber, and may be of any desired type, such as a crystal microphone. The microphone leads 37 are brought along the lever 22 and are attached thereto by means of suitable clips, with suitable loops 38 being left between the clips and the points of attachment to the microphone carrier 28 and the support 12. The leads extend within the pintle 11 to a pair of conducting slip rings 41 and 42 mounted on and insulated from the pintle.

The amplifier 43 which is of conventional electronic type, has its input terminals connected to brushes 44 and 45 which make contact with the slip rings 41 and 42, and its output connected to headset 46, whereby the electrical response of the microphone is amplified and reproduced by the headset which is worn by the operator.

The motor 13 may be of any desired type, and is supplied with power from a suitable source, not shown. No speed control need be provided if the motor is of a type which operates at a substantially constant speed.

The microphone may be protected by a casing as shown or the casing may be omitted if desired. A filter may be included in the amplifier to remove the noise created by moving the microphone through the air and any noise mechanically induced in the microphone by the rapid reversal of the movement of the microphone.

When the device is in operation, the electric motor 13 revolves the crank disc 16 rapidly, causing the lever 22 to oscillate through an arc of a circle about its pivot 22 by reason of the movement of its lower end by the crank disc through the connection of the sleeve 17. The upper end of the lever 22 carries the microphone 36 rapidly across the tube 26, also in an oscillatory manner, such oscillation being produced by reason of the sliding connection between lever 22 and sleeve 27 on the microphone carrier 28.

With reference to Figure 3, the device operates in the following manner: Assuming that a noise is heard from a direction which is not perpendicular to the tube 26, the rapid movement of the microphone carrier 28 toward and away from the source of sound 76 will cause the apparent frequency of the noise to increase and decrease cyclically at a frequency which is proportional to the number of revolutions made by the motor 26, whereby the deviation in apparent frequency will be proportional to the linear speed of the microphone multiplied by the sine of the angle 77 between the direction to the sound and the axis of the tube 26. The deviation of course adds and subtracts from the true frequency of the noise approximately equal amounts, thus producing a large variation in the apparent tone, or Doppler effect.

The operator listens to the amplified response of the microphone in his headset, and adjusts the angular position of the tube 26 by means of handwheel 33 until the Doppler effect disappears, leaving only the actual "sound" of the noise, at

which time he notes its bearing on the indicator 34.

If the operator rotates the device in the direction away from the correct position 77, the Doppler effect increases as the operator turns the handwheel 33 and the frequency of the high portion of the cycle increases, thus indicating that the direction of rotation must be reversed.

The modification shown in Figure 2 is similar to that shown in Figure 1, except that the microphone is rotated about a circle instead of being moved along a single line. A vertical tube 51 is mounted in suitable bearings to support the weight of the device and to allow the device to be rotated about the vertical axis. Attached to the upper end of the tube 51 is an electric motor 52 which supports and drives an arm 53 secured to the shaft 54 at a point near the center of the arm, a suitable microphone 55 being attached to one end of the arm 52 while the other end is counter-weighted by a weight 56 or is made longer to dynamically balance the arm.

Also mounted on the motor shaft 54 but insulated therefrom and from each other, are two conducting slip rings 57 and 58 which are electrically connected to the terminals of the microphone 55. A pair of brushes 61 and 62 in contact with the slip rings 57 and 58 are connected by leads 63 to a pair of slip rings 64 and 65 mounted on and insulated from the vertical tube 51 which slip rings are contacted by the brushes 66 and 67 connected to the amplifier 68. The microphone is thus connected to the amplifier which applies the amplified sound currents to a headset 69 worn by the operator.

A hand wheel 71 is attached to the vertical tube 51 which enables the operator to rotate the device, which also rotates the indicator 72 attached to the tube, the indicator 72 being graduated in degrees, mils, or other units and co-operating with the index 73 to indicate the plane in which the microphone is revolving. The index 73 may be made movable about the indicator 72 to enable the operator to orient the device with respect to a compass, with the heading of a ship, or other desired meridian, so that azimuth or deflection angles may be directly read from the index.

If desired, the electric motor may be provided with a yoke and bearings to permit the axis of its shaft to be rotated in a vertical plane, thus allowing the operator to adjust to a desired plane or to locate the direction of the sound emitting object in three dimensions. Such a change could be easily made by those skilled in the art and the methods are too well known to require description.

The rotation of the arm 53 by motor 52 will cause the microphone 55 to move away from and toward any source of sound which is arriving from a direction not perpendicular to the plane in which the arm is revolving. Thus this modification operates in a similar fashion to the one illustrated in Figure 1.

It is obvious that changes in structure may be made in the device without departing from the invention. The frame 23 may be changed to carry the microphone on a slotted member, or the entire frame may be mounted in a horizontal instead of vertical position and secured to a large support.

Any other mechanical arrangement may be used to move the microphone carrier, such as a screw and nut arrangement, cam surfaces, or other suitable means. The motor could be re-

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placed by any source of mechanical power, including hand- or foot-operated mechanisms.

The microphone, electronic amplifier, and headset may be replaced by a mechanical sound system. The sound responsive element may be a horn or a diaphragm which is connected to the amplifier by means of tubes and flexible joints in any manner desired. The amplifier may consist of a sound powered diaphragm connected with a suitable chamber or mechanically connected by levers to a larger diaphragm, and the headset may be a stethoscope connected to the amplifying system.

The plane in which the microphone is moved may be changed to adapt the device to a particular purpose, and is not limited to vertical or horizontal planes.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

Having thus described the invention, what is claimed is:

1. In a device for determining the direction to a source of sound, a sound responsive element adapted to respond to sound received from said source of sound, amplifying means associated with said sound responsive element to amplify the response thereof, and reproducing means for reproducing said amplified sound, a linear guide, a support for said sound responsive element movable on said guide, an electric motor having eccentric means mounted on its shaft, a lever having a fixed fulcrum and mechanically associated to said support for said sound responsive element and to said eccentric means to impart to said sound responsive element a reciprocating

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motion along said linear guide whereby the movement of said sound responsive element relative to said sound source produces a variation in the apparent frequency of the received sound and means for orienting said linear guide to a direction perpendicular to the direction of said source of sound wherein said variations in apparent frequency are minimized.

2. In a device for determining the direction to a source of sound a microphone producing an electric signal in response to sound received from said sound source, an electronic amplifier connected to said microphone and to a headset for reproducing said amplified signal, a linear guide, a support for said microphone movable on said guide, an electric motor having a crank disc mounted on its shaft, a lever having a fixed fulcrum and mechanically connected to said microphone support and said crank disc to impart a reciprocating motion along said linear guide to said microphone whereby the movement of said microphone relative to said sound source produces a variation in the apparent frequency of the reproduced sound and means orienting said linear guide to a direction perpendicular to the direction of said source of sound wherein said variations in apparent frequency are minimized.

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