June 17, 1947. A. A. STUART, JR 2,422,446

SONIC DIRECTION FINDING

Filed May 15, 1941 2 Sheets-Sheet 1

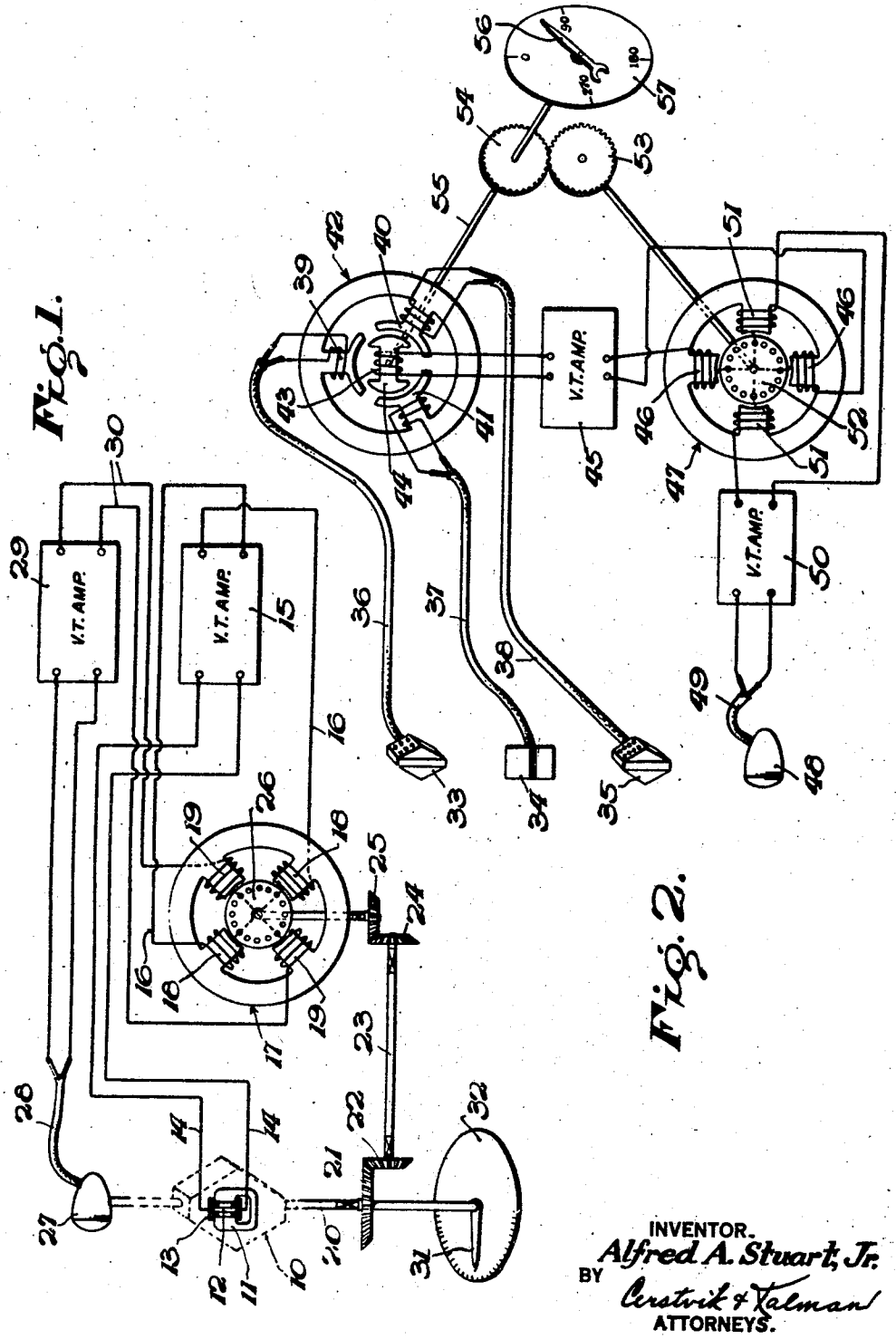


Fig. 1.

Fig. 2.

INVENTOR.
Alfred A. Stuart, Jr.
BY Cerstvik & Talman
ATTORNEYS.

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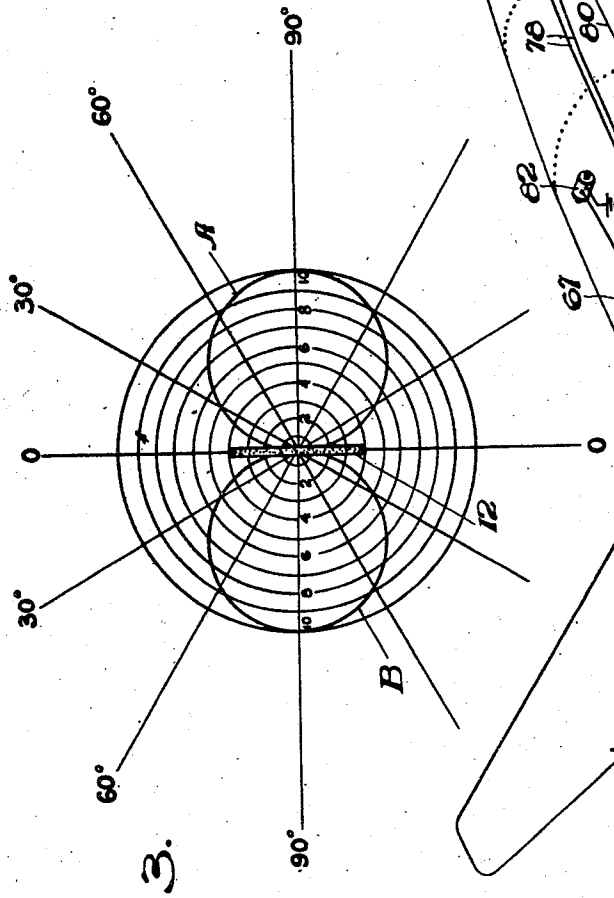


Fig. 3.

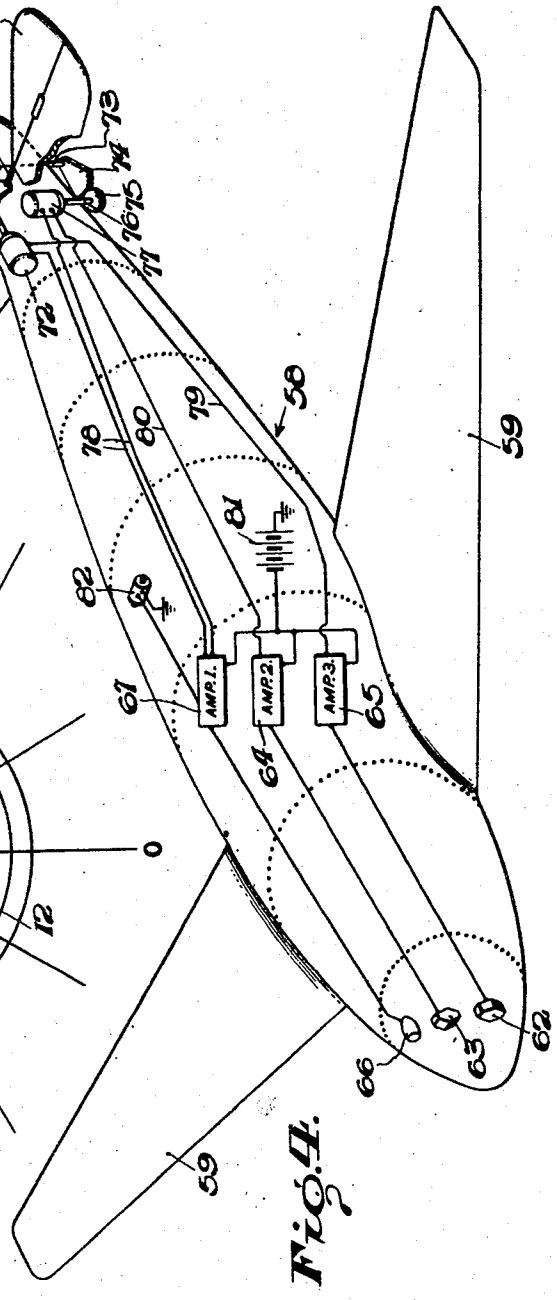


Fig. 4.

INVENTOR.
Alfred A. Stuart, Jr.
BY Cerstvik & Kalman
ATTORNEYS.

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UNITED STATES PATENT OFFICE

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SONIC DIRECTION FINDING

Alfred A. Stuart, Jr., Hasbrouck Heights, N. J., assignor to Bendix Aviation Corporation, Bendix, N. J., a corporation of Delaware

Application May 15, 1941, Serial No. 393,685

11 Claims. (Cl. 177—352)

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This invention relates to sonic direction finding devices and more particularly to devices responding to and adapted for ascertaining the direction of a source of sound, whereby a device will be automatically guided or directed toward, or in the direction of, the sound source.

An object of the present invention is to provide novel means for indicating the direction of sound waves emanating from a desired source.

Another object is to provide a novel automatic remote indicator for indicating the direction of a source of sound in accordance with the sound waves emanating therefrom.

A further object of the invention is to provide a novel apparatus comprising directional and non-directional microphones adapted for intercepting sound waves emanating from a given source of sound whereby, upon a displacement of the directional microphone from a predetermined relationship with respect to the emanating sound waves, the latter microphone is caused to be turned bodily to its null position to thus continuously point to the direction of the source from which the sound waves are radiating.

Another object is to provide a novel apparatus comprising a non-directional microphone and a plurality of directional microphones so arranged as to be adapted to intercept sound waves radiating from a given source, whereby the apparatus continuously indicates the direction of the source from which the sound waves radiate.

A further object of the invention is to provide the novel combination of a rotatable directional microphone and a non-directional microphone adapted for intercepting sound waves radiating from a given source, and an induction motor whereby the latter is energized in accordance with the output of the microphones to rotate the directional microphone to its null position after a relative movement between the directional microphone and the source, thus continuuosly indicating the direction of the source of the sound waves intercepted by the microphones.

Still another object is to provide a novel apparatus comprising a plurality of stationary directional microphones and a non-directional microphone, and a multi-phase induction motor the phases of which are energized in accordance with the output of the microphones so as to operate an indicator to thereby indicate the direction of the source of sound.

Another and equally important object of the present invention is to provide novel means for automatically directing an object towards a desired source of sound.

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A further object of the invention is to provide a novel automatic target-seeking dirigible bomb controlled by mechanism responsive to sound.

A still further object of the invention is to provide an automatic glider type device equipped with novel sound responding apparatus for directing or steering the glider in the direction of a desired source of sound.

A still further object of the invention is to provide a novel glider device having control surfaces thereon with a novel sonic responsive apparatus the output of which is utilized to control the glider surfaces thereby automatically directing the glider to a source of sound.

An additional object of the present invention is to provide a target seeking dirigible bomb in the form of a glider having a rudder and elevator control surfaces with a novel sonic responsive apparatus comprising a pair of directional microphones and a non-directional microphone, whereby the rudder and elevator surfaces are controlled in response to the output of the microphones so that the target seeking dirigible bomb is automatically directed toward a desired target which may constitute a source of sound such as that defined by the propeller or engine of an enemy bomber while in flight.

The above and other objects and novel features of the invention will more fully appear from the detailed description which follows when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purposes of illustration only and are not intended as a definition of the limits of the invention, reference for the latter purpose being had primarily to the appended claims.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

Fig. 1 is a schematic representation of one form of the novel arrangement of the microphones in accordance with the present invention,

Fig. 2 is a schematic representation of a second form of the present invention embodying the use of a plurality of directional microphones and a non-directional microphone in combination with indicating means for indicating the direction of a source of sound,

Fig. 3 is a graphic representation or pattern illustrating the output characteristics of the directional microphone when it is rotated 360° in azimuth, and

Fig. 4 is a diagrammatic and partially schematic representation of a novel target seeking

dirigible bomb equipped with the novel means of the present invention.

The present invention contemplates the use of sonic responsive devices the voltage output of which is dependent upon the angular displacement of the devices with respect to a source of sound, and which is utilized to either operate an indicator to thereby indicate the direction of a sound source, or which may be converted into driving power for automatically driving or steering a projectile having control surfaces thereon to the source of sound. The sonic responsive devices may comprise either a rotatably mounted directional microphone together with a non-directional microphone, the output voltage of both of the microphones being amplified to energize an induction motor, whereby the latter operates to rotate the directional microphone to its null position, or a plurality of directional microphones together with a non-directional microphone so arranged with respect to a sound source that the output voltage of the microphones due to the sound waves intercepted thereby is communicated in amplified form to operate indicating means which indicate the direction of the source from which the sound waves emanate.

In both of the above-mentioned forms the ultimate output voltage of the microphone arrangement is utilized to operate indicating means for continuously indicating the direction of the source of sound. However, an equally important application of the above principle is contemplated in that the output of the microphones may be ultimately utilized to automatically direct a device having control surfaces thereon toward the source of sound. The device having the control surfaces thereon and adapted to be automatically controlled by the ultimate microphone output may be another airplane, glider, target seeking dirigible bomb, etc.

A particular and desirable use of the above-described automatic apparatus is for purposes of warfare. For example, in defensive warfare, a bomb built in the form of a glider having both elevator and rudder surfaces may be carried by an aircraft flying at an altitude higher than the altitude flown by enemy bombers and then dropped in the general direction of the enemy bombers whose engines or propellers by virtue of their sound will energize the microphones of the gliding bomb so as to operate the rudder and elevator controls to thus direct the bomb to the enemy craft. A refined feature of this particular use may lie in the provision of a detonator which in response to automatic volume control may be energized to detonate the bomb within any desired distance from the enemy target. It is to be noted that the glider device is not provided with any motivating power of its own and thus will tend to fall toward the earth only and will deviate from this path in response to the sound waves emanating from the enemy target at an altitude lower than the altitude of the craft from which the bomb was dropped and in a position away from the plane dropping it. This feature avoids the possibility of the bomb following the plane which has discharged it, for the reason that the latter plane is at a greater altitude and the glider bomb itself cannot reverse its direction so as to fly upwardly.

Referring now to the drawings for a more detailed description of the present invention, and more particularly to Fig. 1 thereof, there is illustrated a directional microphone 10 which may

be of the ribbon or velocity type. Microphone 10, in the present instance, is shown as a ribbon type microphone having a magnet 11 between the poles of which is supported a ribbon 12 by means of suitable means such as Bakelite 13. The ribbon 12 is connected by way of leads 14 to a suitable and conventional vacuum tube amplifier 15, the output of which is, in turn, connected by way of leads 16 to one phase of a two-phase induction motor 17 whose stator poles 18 comprise the one phase while stator poles 19 comprise the second phase.

If it be desired to mount the structure of Fig. 1 upon an aircraft so as to at all times inform the pilot of the direction of a source of sound in which he is interested, the directional microphone 10 will be mounted upon a suitable shaft 20 which in turn has splined thereto a gear 21 meshing with a gear 22 carried by shaft 23 at one end thereof, the shaft being provided at its other end with a suitable gear 24 for meshing with a driven gear 25 which is operated from the rotor 26 of the two-phase induction motor 17.

Mounted above the directional microphone 10 and in close proximity thereto is a non-directional microphone 27, which may be of the crystal type, having its output connected by way of a suitable flexible cable 28 to the input of a conventional and suitable vacuum tube amplifier 29 whose output in turn is connected by way of leads 30 to the second phase 19, 19 of the two-phase induction motor 17.

By virtue of the fact that directional microphone 10 is a ribbon or velocity type microphone and the non-directional microphone 27 is of the crystal type, for example, the outputs of both microphones due to their inherent operating characteristics, are substantially 90° out of phase and since both amplifiers 15 and 29 are of a similar type, the two inputs to the induction motor 17 in phases 18, 18 and 19, 19 are 90° apart which provides the desired condition for maximum torque of the induction motor 17.

For a better understanding of the output characteristics of the directional microphone 10, reference is now made to Fig. 3 of the drawings wherein the form of the microphone output is shown in its relation to the angular position of the microphone with respect to the sound source. The voltage output of the microphone throughout a rotation of 180° takes the form of a circle A while at a reversal and a rotation of 180° by the microphone and its ribbon 12 in an opposite direction the voltage output takes the form of a second circle B, the two taken together forming a familiar figure eight pattern. It may be noted further that 180° ambiguity in indication will be prevented for the reason that for each 180° rotation of the directional microphone a phase reversal of 180° ensues in the output so that the rotation of the induction motor is reversed for each 180°.

When the plane of the ribbon 12 of the directional microphone 10 is parallel to the direction of the sound source, the sound waves act equally upon both sides of the ribbon 12 so that the latter does not vibrate and thus there is no output voltage in leads 14 from the microphone. Even though the output voltage of non-directional microphone 27 is uniform so that at all times phase 19, 19 of motor 17 is energized, phase 18, 18 is de-energized and rotor 26 will not move.

As soon, however, as microphone 10 is displaced angularly with respect to the sound source, the plane of ribbon 12 is no longer parallel to the

sound waves emanating from the source but is at some angular relationship with respect thereto and thus the ribbon is caused to vibrate and in proportion to the amount of its vibration a voltage is induced in leads 14, and amplified in the vacuum tube amplifier 15 to energize phase 18, 18 of the induction motor whereby the rotor is now caused to turn, driving gear 25 which in turn drives gears 22 and 24 mounted on shaft 23 to angularly move gear 21 and shaft 20 therewith until microphone 10 is moved angularly to a position wherein its ribbon 12 is again placed in a relationship parallel to the sound waves emanating from the source. At this point the output of microphone 10 is zero since it is in its null position and phase 18, 18 is de-energized, stopping rotation of rotor 26 and thus maintaining microphone 10 in its null position. Shaft 20 may be provided with a suitable pointer 31 to cooperate with a stationary dial 32 carried by the craft so that at all times pointer 31 will indicate the direction of the sound source.

The same result as obtained with the use of the structure of Fig. 1 for indicating the source of sound may be obtained by a slightly modified form of apparatus which comprises, as shown in Fig. 2, and which constitutes the subject matter claimed in divisional application Serial No. 422,910, filed December 13, 1941, three directional microphones 33, 34 and 35, each of which is similar to the ribbon type directional microphone 10 of Fig. 1. These microphones 33, 34 and 35 are arranged or mounted one above the other, closely adjacent each other, in a cluster and in such a manner that the ribbon of each is displaced 120° with respect to the other. In this arrangement the microphones are stationary on the craft and their output constitutes three different voltages, each depending upon the angular relation of its respective ribbon with the sound source, and these outputs are in turn communicated by way of cables 36, 37 and 38 to each of three phases 39, 40 and 41 of an inductive device generally designated at 42.

With a change in the heading of the craft carrying the novel apparatus of Fig. 2, the output of each of the three microphones 33, 34 and 35 varies in accordance with the angular displacement of the respective microphones with respect to the sound source and this change in voltage in being communicated to the three phases of the inductive device 42 produces or sets up a magnetic field whose resultant changes to thereby induce a voltage in a coil 43 carried by a rotor 44 of the inductive device 42. The voltage thus induced in coil 43 is amplified in a vacuum tube amplifier 45 to energize phase 46 of a two-phase induction motor 47 which in all respects is similar to the induction motor 17 of Fig. 1.

Arranged either above or below the cluster of microphones 33, 34 and 35 and in close proximity thereto, is a non-directional microphone 48, similar to non-directional microphone 27 of Fig. 1, whose uniform output is communicated by way of cable 49 to the input of a suitable vacuum tube amplifier 50, similar to amplifier 45, the output of which constantly energizes the second phase 51 of the induction motor 47.

Induction motor 47, upon proper energization of both of its phases, drives its rotor 52 which is coupled by suitable means to driving gear 53, meshing with a gear 54. The latter gear is carried by a suitable shaft 55 which at one end is connected with the rotor 44 of inductive device 42 and at its other end carries a pointer 56 cooperating with a stationary scale 57.

If it be assumed that the craft upon which the novel apparatus of Fig. 2 is mounted is in such a position that the outputs of the microphones 33, 34 and 35 are of a value whereby the rotor 44 of inductive device 42 is maintained in a position shown in Fig. 2 and subsequently the craft changes its heading with respect to the sound source, the relationship of the microphones changes with respect to the source and this change produces three different voltages in cables 36, 37 and 38, whose ratios depend upon the amount of angular displacement from the direction of the sound source, thus producing a different energization of each of the three phases of the inductive device 42 whereby the magnetic fields created by each of the phases vary, thus having a different resultant due to which a voltage is induced in coil 43 of rotor 44. This voltage is amplified by way of amplifier 45 to energize phase 46 of induction motor 47. Since the second phase 51 of the induction motor 47 is already energized due to the output of non-directional microphone 48, rotor 52 of the induction motor is caused to move angularly thereby driving gear 54 by way of gear 53 to angularly move rotor 44 to a new position in which the voltage within coil 43 is reduced to zero. This is the null position for the rotor 44 and phase 46 of the induction motor is de-energized and at the same time that rotor 44 of the inductive device 42 has been turned to its null position pointer 56 has been moved relatively with respect to dial or scale 57 to thus indicate the direction of the source of sound.

It will now be apparent to those skilled in the art that the apparatus of Fig. 2 is adapted for continuously indicating the sound source and differs from the structure of Fig. 1 in that in the latter, microphone 10 is always urged bodily in the direction of the sound source whereas in the structure of Fig. 2 the microphones are all mounted stationarily with respect to the craft.

The above-described apparatus together with its principle of operation is adapted for many uses, one of which is of great importance in that it may be applied to a self-directed sound seeking glider type missile for use against night-flying enemy aircraft. This latter use is diagrammatically illustrated in Fig. 4 wherein is shown a glider 58 having wings 59 and elevator and rudder control surfaces 60 and 61. Mounted in the nose of the glider are two directional microphones 62 and 63 arranged one above the other and displaced angularly with respect to each other so that their ribbons are substantially 90° apart, the output of each being fed into the input of two suitable vacuum tube amplifiers 64 and 65.

Likewise mounted in the nose of the glider 59 and either above or below, and closely adjacent the microphones 62 and 63, is a non-directional microphone 66, whose output in response to the sound waves emanating from a source of sound is 90° out of phase with the outputs of microphones 62 and 63 and is fed into the input of a suitable amplifier 67, similar in all respects to amplifiers 64 and 65 of the directional microphones.

The elevator control surfaces 60 are joined by a common shaft 68 having mounted thereon a gear sector 69 which meshes with a worm 70 driven by the shaft 71 of an induction motor 72. This induction motor is a two-phase induction motor similar in all respects to those illustrated in both Figures 1 and 2.

The rudder surface 61 is mounted for movement with a suitable shaft 73 carrying a gear sector 74 meshing with a gear 75 driven by shaft 76 of a second induction motor 77 constituting a two-phase induction motor of the same type as motor 72.

One phase of each of the induction motors 72 and 77 is energized by ways of leads 78 from the amplifier 67 of the non-directional microphone output. The second phase of induction motor 72 is connected by way of lead 79 with the amplifier 65 of the output of the directional microphone 62 which may be termed in this instance the elevator control microphone, while the second phase of the induction motor 77 is connected by way of lead 80 with the output of amplifier 64 connected to the output of the directional microphone 63 which may be termed the rudder control microphone. Each of the amplifiers 64, 65 and 67 may be connected with a suitable source of power 81.

For a better understanding of the operation of the novel device of Figure 4, let it be assumed that a defensive plane is flying over an enemy bomber which may be invisible due to either fog or night flying. The defensive plane discharges glider 58 and the latter will begin to glide and descend while the defensive plane may go into a slight climb to avoid energizing the controls at the nose of the glider. Since the glider has no motive power of its own, it is incapable of climbing and will thus tend to glide, or under the effect of gravity be pulled earthwardly. Initially, the accuracy of the glider is low, but as it travels downwardly the volume of the sound waves from the source increases and the directive accuracy of the glider increases for the reason that microphones 62, 63 and 66 at the nose of the glider become energized, in the manner hereinabove set forth in connection with Figures 1 and 2, so that in accordance with the angular relation of the directional microphones 62 and 63 with respect to the source of sound, the second phases of the induction motors 72 and 77 will become energized so as to operate both rudder and elevator surfaces 60 and 61 to change the direction of flight of the glider 58 until the latter is flying toward its target or the source of sound. Even if the target changes its heading, the glider will nevertheless follow it for the reason that the change in heading changes the sound source thus changing the outputs of directional microphones 62 and 63 which in turn causes a variation in the operation of induction motors 72 and 77 to again operate the rudder and elevator surfaces to direct the glider after the target.

From the foregoing it will now be apparent to those skilled in the art that a novel automatic sound directed device has been provided which may be termed a target seeking dirigible bomb of the sonic type which is particularly adapted for use against night-flying enemy aircraft. The projectile may be further provided with a suitable relay 82 which is connected to the output of amplifier 67 of the non-directional microphone 66 and may constitute a marginal relay which will only respond to a predetermined amount of volume in amplifier 67 which may be provided with a suitable well-known automatic volume control device. This feature is useful in that the target seeking dirigible bomb need not actually strike or hit its target but may be detonated due to the energization of relay 82 when the target seeking bomb is within a predetermined distance of the target which distance is determined by the volume of the sound waves emanating from the sound source.

In order to protect the ground crew should the target seeking dirigible bomb fail to reach its target or a predetermined distance of its target, the glider may be provided with some well-known altitude control means whereby upon reaching a predetermined height above the earth the bomb may be discharged, thereby protecting the ground forces.

There is thus provided a novel apparatus adapted to either indicate the source of sound waves or to control and automatically direct a device such as a target seeking dirigible bomb toward the sound source which consists in the conversion of sound waves into electrical power which may or may not be amplified so as to drive indicating or control means as a function of the direction of the sound source.

Although three embodiments of the invention have been illustrated and described in detail, it is to be expressly understood that the invention is not limited thereto. For example, various types of directional microphones besides the ribbon type microphone hereinabove described may be used and the non-directional microphone may be other than the crystal type discussed. The directional microphones together with the non-directional microphone must be arranged one above the other and in close proximity to each other so that the sound waves intercepted by each are of a like phase so as to assure proper operation of the indicating or control means. Various changes may also be made in the design and arrangement of the parts without departing from the spirit and scope of the invention as the same will now be understood by those skilled in the art. For a definition of the limits of the invention reference will be had primarily to the appended claims.

What is claimed is:

1. In combination, a plurality of directional microphones arranged in a predetermined manner and a non-directional microphone, the respective outputs of said directional microphones being a function of the angular displacement of said microphones with respect to a sound source, said non-directional microphone having a substantially continuous energy output, driven means, means energized in accordance with the outputs of said microphones to drive said driven means, and means operated by said energized means to counteract the torque produced by said energized means.

2. In a system for indicating the direction of a sound source, a rotatably mounted directional microphone normally maintained in a predetermined position with respect to said source so as to have a zero voltage output in such position and having a varying voltage output as a function of its angular displacement from said predetermined position relative to said sound source, a non-directional microphone having a substantially uniform voltage output in response to sound waves emanating from said source, driving means connected directly with the output of said microphones operative during a displacement of said directional microphone from said predetermined position to drive said directional microphone to said predetermined position whereby said driving means are deenergized, and means driven by said driving means for indicating the direction of said sound source.

3. In a system for indicating the direction of a sound source, a rotatably mounted directional microphone normally maintained in a predeter-

mined position with respect to said source so as to have a zero voltage output in such position and having a varying voltage output as a function of its angular displacement from said predetermined position relative to said sound source, a non-directional microphone having a substantially uniform voltage output in response to sound waves emanating from said source, amplifiers for each of said outputs, a polyphase induction motor connected to said amplifiers and having its phases energized by the amplified outputs of said microphones whereby, upon a relative displacement of said directional microphone with said sound source, said directional microphone is driven to its normally predetermined position and the motor is deenergized, and means driven by said motor for indicating the direction of said sound source.

4. In a system for indicating the direction of a sound source, a plurality of directional microphones arranged in a predetermined manner so that their respective outputs vary as a function of the relative position of each of said microphones relative to said sound source, a non-directional microphone having a substantially uniform energy output in response to sound waves emanating from said source, means for indicating the direction of said sound source, means associated with the output of said non-directional and directional microphones operative during a relative displacement of said directional microphones and said sound source for operating said indicating means, and means operated simultaneously with said indicating means for counteracting the driving torque produced by said operating means.

5. In a system for indicating the direction of a sound source, a plurality of directional microphones arranged in a predetermined manner so that their respective outputs vary as a function of the relative position of each of said microphones relative to said sound source, a non-directional microphone having a substantially uniform energy output in response to sound waves emanating from said source, means for indicating the direction of said sound source, a polyphase induction motor having its phases energized by the outputs of said non-directional and directional microphones and operative during a relative displacement of said directional microphones and said sound source for operating said indicating means, and means operated simultaneously with said indicating means for counteracting the driving torque produced by said motor.

6. In a system for indicating the direction of a sound source, a plurality of directional microphones arranged in a predetermined manner so that their respective outputs vary as a function of the relative position of each of said microphones relative to said sound source, a non-directional microphone having a substantially uniform energy output in response to sound waves emanating from said source, an inductive device having stator windings energized by the outputs of said directional microphones and a rotor winding having a voltage induced therein in response to a relative displacement of said directional microphones and said sound source, means for indicating the direction of said sound source, and a polyphase induction motor having certain of its phases energized by the output of said non-directional microphone and other of its phases energized by the voltage induced in the rotor winding of said inductive device during said displacement of the directional microphones and the sound source for simultaneously operating said indicating means and said rotor winding whereby the driving torque produced by said motor is counteracted.

7. In a system for indicating the direction of a sound source, a plurality of directional microphones arranged in a predetermined manner so that their respective outputs vary as a function of the relative position of each of said microphones relative to said sound source, a non-directional microphone having a substantially uniform voltage output in response to sound waves emanating from said source, an inductive device having stator windings energized by the outputs of said directional microphones and a rotor winding having a voltage induced therein in response to a relative displacement of said directional microphones and said sound source, means for indicating the direction of said sound source, and a two-phase induction motor having one phase energized by the output of said non-directional microphone and the other phase energized by the voltage induced in the rotor winding of said inductive device during said displacement of the directional microphones and the sound source for simultaneously operating said indicating means and said rotor winding whereby the driving torque produced by said motor is counteracted.

8. In a system for indicating the direction of a sound source, a plurality of directional microphones arranged in a predetermined manner so that their respective outputs vary as a function of the relative position of each of said microphones relative to said sound source, a non-directional microphone having a substantially uniform energy output in response to sound waves emanating from said source, an inductive device having stator windings energized by the outputs of said directional microphones and a rotor winding having a voltage induced therein in response to a relative displacement of said directional microphones and said sound source, means mechanically coupled with said rotor winding for indicating the direction of said sound source, and a two-phase induction motor having one phase energized by the output of said non-directional microphone and the other phase energized by the voltage induced in the rotor winding of said inductive device during said displacement of the directional microphones and the sound source for operating said indicating means and said rotor winding whereby the latter attains a null position to de-energize said other phase of said induction motor.

9. In a system for determining the direction of a sound source, a two-phase induction motor, a rotatably mounted directional microphone normally maintained in a predetermined null position with respect to said source so as to have a zero voltage output in such null position and having a varying voltage output as a function of its angular displacement from said null position relative to said sound source, one phase of said motor being directly connected for energization with the output voltage of said directional microphone, a non-directional microphone having a substantially uniform voltage output in response to sound waves emanating from said source, the other phase of said motor being directly connected for constant energization by the output voltage of said non-directional microphone, and connecting means actuated by said motor upon a relative displacement of said directional microphone from said null position relative to said source for driving said directional

microphone to its null position and de-energizing said one phase of said motor.

10. In combination, directional microphone means the output of which is a function of the angular displacement of the microphone means with respect to sound waves emanating from a sound source, a non-directional microphone having a substantially continuous energy output in response to sound waves transmitted from said source, an indicator for indicating the direction of the sound source, a polyphase induction motor having one of its phases energized by the directional microphone means and another of its phases energized by the non-directional microphone, whereby a driving torque is produced by the motor in proportion to the direction of the sound source with respect to the position of the directional microphone means, and means driven by said motor to counteract the driving torque produced by said motor and to simultaneously move the indicator to a position corresponding to the direction of the source of sound.

11. In combination, directional microphone means the output of which is a function of the angular displacement of the microphone means with respect to sound waves emanating from a sound source, a non-directional microphone having a substantially continuous energy output in response to sound waves transmitted from said source, a polyphase induction motor having one

of its phases energized by the directional microphone means and another of its phases energized by the non-directional microphone, whereby a driving torque is produced by the motor in proportion to the direction of the sound source with respect to the position of the directional microphone means, means driven by said motor to counteract the driving torque produced by said motor, and means associated with said driven means adapted to move simultaneously with said driven means to a position corresponding to the direction of the source of sound.

ALFRED A. STUART, JR.

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