SOUND ORIGIN DIRECTION FINDER

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References Cited

UNITED STATES PATENTS

2,350,080 5/1944 Sproule

2,397,746 4/1946 Lewis

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ABSTRACT

A sound origin direction indicator comprising a flat square-shaped form having four sound transducer/amplifier units mounted at its four corners, four rows of solid state lamps radiating from its center to the corners and an electronics system attached to the transducers and lamps to operate the device.

3 Claims, 4 Drawing Figures
FIG. 1.

FIG. 4.
SOUND ORIGIN DIRECTION FINDER

BACKGROUND OF THE INVENTION

1. Field of the Invention
This invention relates to sound wave detection devices. More particularly, this invention relates to sound wave detection devices which rely on the velocity of sound to operate.

2. Description of the Prior Art
In police work and military operations it is often desirable to determine, quickly and accurately, the direction from which a sound has come. For example, if a sniper is located somewhere in the area of policemen or a squad of soldiers, the policemen or the soldiers need to be able to detect the direction from which the sniper is firing. This is often difficult because of echoes and possible distortion of the sound of the sniper's weapon.

Sound direction locating systems hitherto in use primarily employ two bowl shaped sound transducers pivoted to rotate so that sound volume can be equalized. A line at right angles to the line of sound equalization then represents the direction from which the sound originated. The electronics systems measure the relative sound level between the transducers and interpolate the information into off center direction. Such systems are complicated, expensive and often cumbersome. They are also difficult to use. They are particularly difficult to use when the sound which causes them to operate is not repetitive or where reverberating echos interfere.

SUMMARY OF THE INVENTION

It has now been found that, with the proper electronics package, a system of sound transducer/amplifier units and solid state lamps can be arranged to accurately determine the direction from which a sound has emanated. The hereinafter described device solves problems associated with prior art sound direction locating systems by (a) being easily portable, (b) being simple to operate, (c) being inexpensive, (d) not being affected by echoes, and (e) not requiring repetitious sounds in order to operate.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a plan view of a sound origin direction indicator according to this invention.

FIGS. 2, 3 and 4 are schematic views depicting the several portions of an electronics system suitable for use in a sound origin direction indicator according to this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

For purposes of simplicity the device hereinafter described will be called a sound origin direction indicator (SODI) throughout the following specification. The SODI herein described is designed to indicate the direction of a sound source at any point within a full 360°. It will be recognized that the device could equally be altered so as to only cover 90°, 180°, or 270° if it were desired to do so.

A plan view of a 360° field SODI is shown in FIG. 1. The plan view depicts the device as having a box or housing with a square flat upper surface 11. A battery power supply 12 is shown as being packaged separately and is attached to an internal electronic package 14 by means of a power lead 13. It will be readily recognized that the power supply could be internally contained rather than being located externally as shown. Knobs 15, 16 and 17 are for sensitivity adjustment, reset and frequency adjustment respectively. Four sound transducer/amplifier units T-1, T-2, T-3 and T-4 are inserted at the corners of the upper surface of the device and four rows of solid state lamps R-1, R-2, R-3 and R-4 radiate to the corners from the center of the upper surface. All lamps are mounted below the actual upper surface of the device and are protectively covered by a transparent material.

The four rows of solid state lamps divide the device into four quadrants and terminate in quadrant indicating lamps DL-1, DL-2, DL-3 and DL-4. In a preferred SODI, each of the four rows contains 90 lamps. The four quadrant indicating lamps are the 90th lamps of each row. They are separated from the other 89 lamps in their particular rows by a short distance, i.e., about three-eighths to about five-eighths inch for reasons which will become apparent later. There is no lamp at the common center of the radial lamp rows.

When a sound wave strikes a SODI of this invention it will strike one of the four transducers before it strikes any of the others provided the sound source is not situated along a line perpendicular to a line passing through the like points on two neighboring transducers. For example, a sound wave coming from direction S in FIG. 1 will strike transducer T-3 before it strikes any of the other three transducers. The following is a description of how a calibrated and properly adjusted SODI according to this invention would act if it were struck by a sound wave coming from direction S. Also, from the following example, it will become apparent how the device would act upon being struck by a sound wave coming from any other direction.

EXAMPLE

The electronic circuitry of a SODI according to this invention is such that a sound wave coming from direction S (FIG. 1) and striking transducer T-3 will cause the solid state lamps in row R-3 to start blinking on and off, one at a time, in succession from the center of the instrument toward transducer T-3, until the wave has passed on and struck transducer T-2. When transducer T-2 is struck, the solid state lamp which is lit will remain lit. For purposes of this example, solid state lamp RL-1 may be considered to be the one lit after a wave coming from direction S has struck both transducer T-3 and the transducer directly across the instrument from it, transducer T-2.

From the drawing, it can be seen that a sound wave coming from direction S will strike transducer T-3 first and transducer T-1 second. The circuitry of a SODI according to this invention is such that upon striking transducer T-1, after having struck transducer T-3, the wave will cause the solid state lamps in row R-4 to commence blinking on and off in succession from the center of the instrument toward transducer T-4 and not toward transducer T-1. This successive action will occur until the wave strikes transducer T-4. At that time the solid state lamp which happens to be lit at the moment will remain lit. For purposes of this example, consider that lamp to be lamp RL-2.

From this example, it can be seen that the direction from which a sound has come is indicated by a straight line drawn from the second solid state lamp to remain.

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lit (RL-2) through the first solid state lamp to remain lit (RL-1). However, it will be realized that the successive blinking on and off of the lights in the two rows would be so fast that it would be impossible for an observer to tell whether the first lamp to remain lit was RL-1 or RL-2. Therefore, the circuitry is constructed so that a third lamp lights and remains lit. For a sound coming from direction S and striking transducer T-3 first, that lamp will be quadrant indicating lamp DL-3.

It may be desirable to calibrate a SODI according to this invention before it is operated. Calibration is a very simple and quick process. Calibration is accomplished by (a) positioning the SODI so that its upper surface is approximately parallel to the earth's plane, (b) activating the power supply, (c) adjusting the sensitivity adjustment knob so that the noise threshold of the immediately local area does not affect the device and (d) adjusting the frequency adjustment knob so that a sharp sound above the local noise threshold (such as a clap of the hands) produced several feet away from one corner of the device directly in line with one row of lamps results in the 89th lamp in the row and the quadrant indicating lamp remaining lit. In calibrating the device, a light in a row perpendicular to the one in front of which the sharp sound is produced may light and remain lit. This indicates that the sound is coming from a broad source. It can be remedied either by making the sound come from a point source or by moving the sound source farther away from the device.

It will be noted that, in addition to a sensitivity adjustment and a frequency adjustment, a reset control is also provided. After calibration or after use, this control is used to ready the device for use again. By requiring the device to be manually reset, two highly desirable functions are accomplished. Firstly, sounds subsequent to the sound of interest do not disturb the device until the user is ready for them to do so. Secondly, information regarding the direction from which the sound of interest came is retained and can be ascertained by the user until it is removed (erased) by a physical act of the user. This information is retained without the use of auxiliary equipment.

THE ELECTRONIC CIRCUITY

For purposes of this specification it is convenient to discuss FIGS. 2, 3 and 4 in conjunction with one another. They are schematics of electronic circuitry suitable for use in a SODI according to this invention.

Functions of the electronic circuitry are as follows:
1. Supply a controlled frequency square wave pulse output.
2. Light the correct quadrant indicator lamp.
3. Control of lamp row selection.
4. Gated control of oscillator output.
5. Counter and lamp sequence control.
6. Reset operating circuits to zero.

Function 1. — Several available solid state square wave generator circuits have been found suitable for use. When the SODI is connected to the power source, the oscillator becomes operative. Open leads numbered in the Figures are connected to similarly numbered leads in other related Figures.

Function 2. — The correct quadrant indicator lamp is lit when any one of the integrated circuit (IC) nand/nor gates A3, B3, C3 or D3 (FIG. 2) is operated. These gates operate only when the associated transducers operate nand/nor gates A1, B1, C1 or D1, respectively, as the first to be struck by the sound wavefront.

Function 3. — Description of the process for selecting the lamp row and sequence lighting direction is simplified by giving an example. All inputs on A2 are initially at a "1" logic level supplied by nand/nor gates A1, A10 and Y1. A sound wavefront striking sound transducer T-1 (FIG. 2) lowers the logic output level of inverter A10 which is applied to one gate of nand/nor gate A2. The lowered input voltage on one gate of A2, causes the A2 output to become a "1" logic level. The second and third input on A1 are initially at "1" level supplied by the output of B1 and E. The logic "1" level on the third gate of A1 now supplied by A2 locks the output of A1 at logic "0" level which, in turn, locks B1, A2 and A9 all with logic "1" level output preventing further subsequent operation of these circuits.

Nand/nor gates C1 and D1 initially supply A3 with two inputs of "1" level. The raised ("1") level output of A9 supplies the third input to lower the output of A3 and, in turn, to raise to "1" level the output of invert gate A6 to operate the silicon controlled switch (SCR) S1. Switch S1 controls the power applied to the row of lamps leading from the center of the SODI toward T-1.

Operation of A9 placed a "1" level on one input of C5 and D4. Nand/nor gates C4, C5 and D4, D5 have initial "1" level inputs supplied by C1 and D1, respectively. With this setting, whichever transducer T-2 or T-3 is next struck by the sound wavefront, the lamp row opposite, i.e., or away from the struck transducer will be activated. That is to say, that transducer T-2 will activate lamp row control D, by operation of C9, or T-3 will activate lamp row control C, by operation of D9.

Function 4. — The transducer first struck by a sound wavefront, T-1 for example, operates A1 through A2 to cause nand/nor gate B1 to become inoperative by removing the initial "1" logic level from a second gate input. Similarly, the second transducer to be struck, T-2 for example, will operate C1 and C2 in sequence to cause nand/nor gate D1 to become inoperative. It is to be understood that circuit component groups A and B, and C and D will operate in the same manner in the reverse direction order.

Simultaneously with the above described examples of circuit operations, the square wave oscillator (OSC, FIG. 2) output is connected in the following manner: Exclusive-OR gates X1 and X2 have an initial logic "0" input level on both gates. Continuing the previous example when A2 output becomes logic "1" level, X1 output also, goes to logic "1" level. This "1" level output of X1 connected to one gate of nand/nor circuit AB permits the second AB input gate connected to the output of the square wave oscillator to control (gate) and pulse the output B/R2 through Lead No. 5. Circuits X2 and BC are similarly connected through Lead No. 6 to B/R2 in the second half of the counter lamp control (FIG. 3).

Except for the third gate "Reset" circuit connections on circuits Y1 and Y2 from inverter circuit E (FIG. 2), the connections on nand/nor circuit Y1 and exclusive-OR circuit X1 from A2 and B2 are similar. Initial output of A2 and B2 is logic level "0," as previously indicated. The circuits Y2 and X2 are similarly connected to C2 and D2 for operation as Y1 and X1 operate with A2 and B2 in the example.

Transducer T-1 operated by a sound wavefront lowers one input to A2. Output of A2 goes from an initial
"0" level to a "1" level. This "1" level applied to X1 changes the initial X1 output level of "0" to a logic "1" level. The A2 output "1" level applied also, to one gate input of Y1 leaves the Y1 output unchanged due to an unchanged initial "0" level applied to a second gate input by B2. The sound wavefront advances to strike T-4 which operates B2 to raise the output to a logic "1" level. The logic "1" level from B2 applied to the second gate, and the "1" level from A2 on the first gate causes the output of X1 to return to a "0" logic level. This X1 logic "0" level output applied to AB, gates "off" the oscillator output to the counter clock circuit.

Function 5. — Lamp sequencing is accomplished by using the output of a controlled square wave generator. The output of the frequency generator is fed into an IC counter circuit. One circuit combination and equipment configuration is represented in FIGS. 2 and 3.

The circuit diagram of FIG. 3 represents the counting and lamp circuit for two rows of lamps in one diagonal line extending from one corner of the SODI to the opposite corner. The same circuit is duplicated and positioned on the SODI at right angle to the first diagonal line.

Two Signetics Corporation 10-bit buffer/registers S8202Y, or equal, are connected for counting and lamp control (FIG. 3). The buffer/registers B/R1 and B/R2 are connected as two ring counters. Counter B/R2 position P9 is used to control the clock circuit of counter B/R1. The gate controlled square wave generator clocks counter B/R2. Reset of the counter/lamp display circuits is performed when the complete SODI is reset. Initial reset is to "0" position on both counters and occurs simultaneous to the power turn-off at all SCR switches S1 through S4. The reset functions are described elsewhere.

Operation of SCR switch S1 (FIG. 2), through Lead No. 1 and resistor R8 (FIG. 3), applies power to a bank of 9 transistors which are each connected to a group of 10 solid state lamps. The moment after power is applied to the transistor/lamp banks, the square wave oscillator output operates the nand/nor circuit AB, connected to the clock circuit of counter B/R2, starting the lamp lighting sequence.

The group "0" transistor connected to the P0' position of B/R1 (FIG. 3) is turned on to pass power from Lead No. 1, limited by R8, to the first group of lamps. Count position P0 of B/R2 is connected to the negative side of the first lamp in each lamp group except the first group which has only 9 lamps. Because of this, initially, no lamp is lit and lamp L1 is the first lamp to light during a started sequence. The clock pulses applied to B/R2 step the counter from P0 position to P1 and P2 through P9. Lamps L0 through L9 in the connected lamp group are sequentially lit and then turned off.

Counter position P9 of B/R2 is connected through inverter K to the clock circuit of B/R1. When the count on B/R2 reaches position P9, in any sequence, the connected lamp is lit, however B/R1 is not stepped until the falling edge of the pulse occurs as B/R2 is stepped to position P0 for the next sequence. Stepping of the two counting circuits will continue through 89 counts before the lamp sequence stops. After a delay equal to 10 count cycles, the lamp lighting sequence would repeat except that the oscillator is gated off by operation of the fourth and last sound transducer when it is struck by the passing sound wavefront.

In addition to the nine groups of lamps powered through Lead No. 1 and R8, a second set of grouped lamps are connected in similar sequence to the numbered outputs of B/R2, in parallel with the inverters. These lamps receive their power from Lead No. 4, through resistor R7 and a second bank of transistor Group switches connected to the output positions of B/R1 in parallel with the other bank of transistor Group switches. Power cannot be applied to Lead No. 1 and Lead No. 4, or Lead No. 2 and Lead No. 3 at the same time. Since Leads Nos. 1 and No. 4, and Leads Nos. 2 and No. 3 control different diagonal rows of lamps, only one set of grouped lamps on each diagonal can be operated at a given time.

Function 6. — Reset of all circuits in the SODI is performed on operation of a normally closed double pole single throw spring loaded switch S5 or equivalent, (FIG. 2). One set of contacts opens the power circuit to the silicon controlled switches S1 through S4. A second set of contacts removes a 150 ohm grounding resistor R6 from the input to inverter E, permitting the input voltage to be raised to a logic "1" level by the power supply through resistor R5. The logic "1" level input to E lowers the output to a logic "0" level which is applied to one gate on each of the operationally locked gates, such as A1, B1 and Y1. The operationally locked gates resume their unoperated output state prior to the time that switches S1 through S4 again receive power by release of the reset switch.

Sound transducer/amplifiers employed each consist of a capacitor microphone and amplifier. Microphone output is amplified by transistor Q5 (FIG. 4) to which the sensitivity control is applied between the collector and base circuits. Output of Q5 is further amplified by transistor Q6. The positive pulse output of Q6 is limited by zener diode DD-1 to 3.5 peak volts and applied to one of inverters A10, B10, C10 or D10 shown on FIG. 2.

The only requirement for the sound transducer/amplifier combination is that the amplifier output be a voltage limited, fast rise, positive pulse compatible with the requirements of the associated IC inverter circuit. In other words, the type of transducer may be capacitive, carbon, ceramic, strain gauge, or other type having sufficient sensitivity and ruggedness.

Position of the four transducers at the instrument surface plane corners must be such that all the transducers have the same aspect relative to the sound wave. Flush mounting with the sound sensitive component facing up in each case, will satisfy this condition.

Nomenclature

FIG. 2.

R1, R2, R3, R4 = 2.5K
R5 = 5.1K
R6 = 150
All other resistors are 51K.
All diodes are 1N645
OSC is a square wave variable frequency oscillator.
Range 4,000 Hz to 6,000 Hz.
A1, B1, C1, D1 through A5, B5, C5, D5, respectively, are nand/nor circuits.
X1 and Y1 are exclusive-OR circuits.
X2 and Y2 are nand/nor circuits.
A6, B6, C6, D6 through A9, B9, C9, D9, respectively, are inverters.
A10, B10, C10, D10 and E are inverters.
S1 through S4 are silicon controlled switches (SCR) 2N2323. DL-1 through DL-4 are solid state lamps (Monsanto MV-50). Transistors Q1 through Q4 are 2N1305.

FIG. 3.

R7, R8 = 2.5K
All other resistors are 51K.
All integrated circuits are nand/nor circuits.
K is a nand/nor circuit.
B/R1, B/R2 are buffer/registers (Signetics S8202Y or equivalent).
All transistors are 2N1305.

FIG. 4.

R9, R10 = 15K
R11 = 500K
R12 = 51K
R13 = 510K
R14 = 500
R15 = 5K
C1 = 0.039f
C2 = 1μf
C3 = 0.0039f
Transistor Q5 is a 2N1711.
DD-1 is a 3.3 volt zener diode.
Transistor Q6 is a 2N3134.
Microphone (mic.) used was Shure Mod. B-162-4.
While suitable electronic circuitry has been described in considerable detail, it will be recognized that many of the parts specifically listed could be replaced by comparable parts and that certain other changes could be made in the circuitry and the arrangement of apparatus in the circuitry with no ill effects.

What is claimed is:

1. A sound origin direction indicator capable of determining the direction from which a sound wave has emanated within a full 360° circle around it; said indicator comprising:
   a. a housing having a square flat upper surface;
   b. four sound transducer/amplifier units inserted at the four corners of said upper surface;
   c. four rows of light devices radiating from the center of said upper surface toward the four sound transducer/amplifier units and ending adjacent thereto;
   d. electronic circuitry means coupling said sound transducer/amplifier units to said light devices and operating said indicator in a manner whereby the lights are caused to indicate the direction from which a sound wave has emanated after the indicator has been struck by said sound wave.

2. A sound origin direction indicator according to claim 1 in which the electronic circuitry means operates the indicator in a manner whereby directional information is retained by the indicator after it has been struck by a sound wave without the use of auxiliary equipment.

3. A system for detecting the direction from which a sound wave has emanated comprising:
   a. a plurality of receiving means for receiving said sound wave and employing the wave front thereof to operate electrical signal producing circuitry,
   b. illuminating means for visually indicating the angle associated with the direction from which said sound wave emanated, said illuminating means including a plurality of series of light devices wherein each series describes straight line and intersects each other series at substantially its mid-point; and
   c. electronic circuitry coupling said plurality of receiving means to said illuminating means and providing processed signal output to said illuminating means.

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