A. BULL.

ACOUSTIC SIGNALING METHOD.

APPLICATION FILED APR. 11, 1916.

1,342,584.

Patented June 8, 1920.

2 SHEETS—SHEET 1.

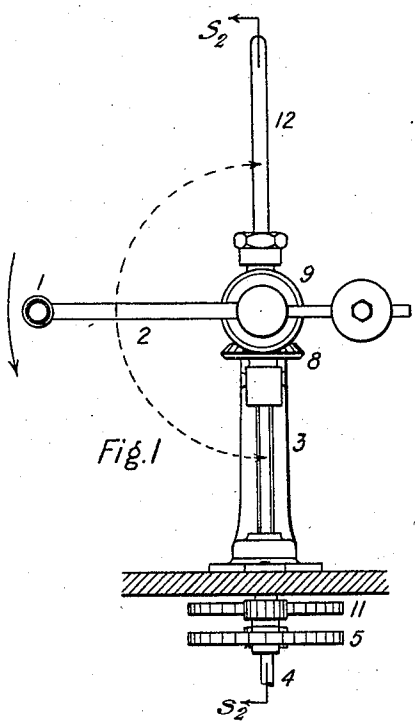


Fig. 1

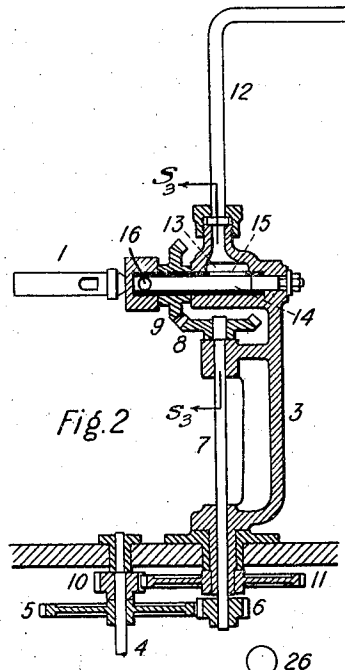


Fig. 2

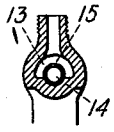


Fig. 3

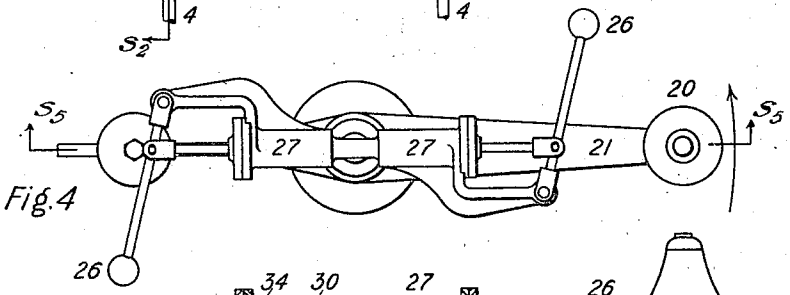


Fig. 4

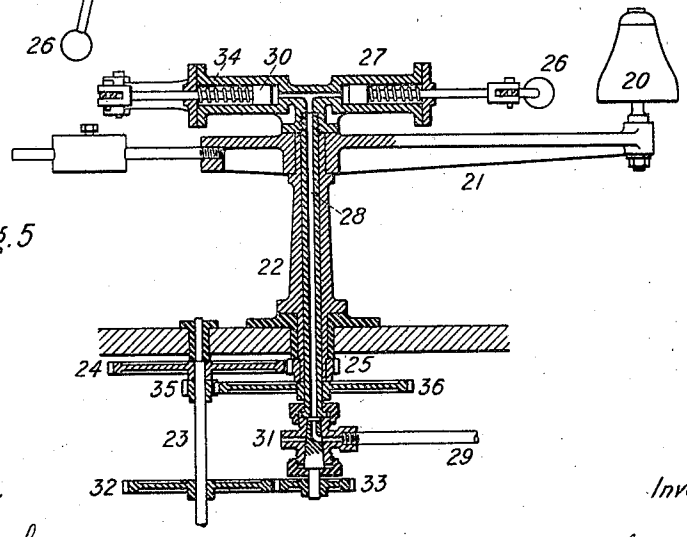


Fig. 5

Witnesses:

A. Borhm

H. C. Atwater

Inventor:

Anders Bull.

A. BULL.

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2 SHEETS—SHEET 2.

Fig. 6

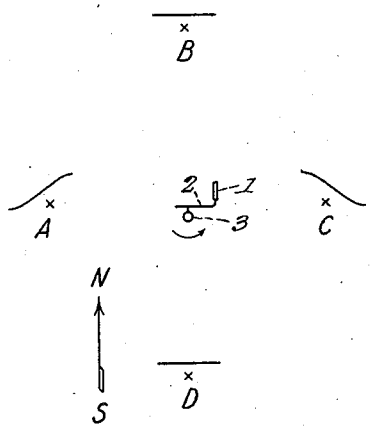


Fig. 8

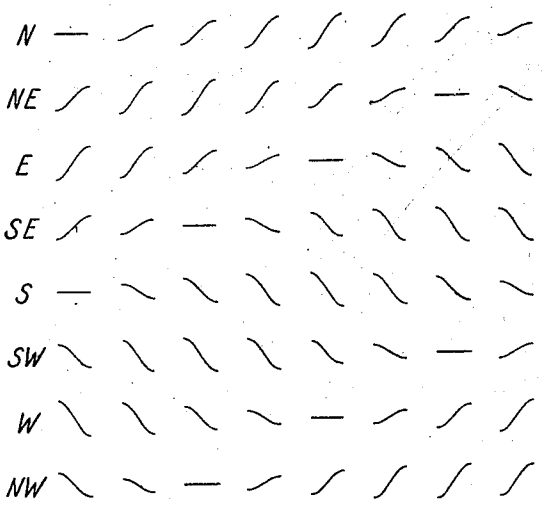


Fig. 7

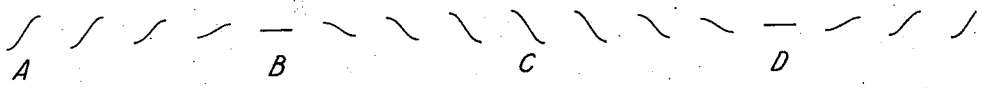


Fig. 9

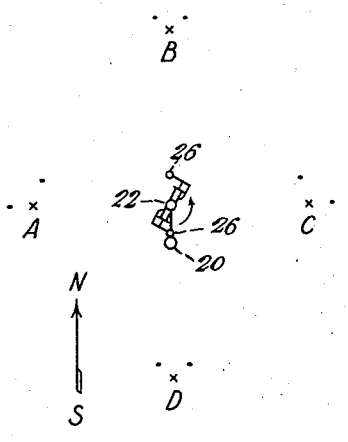
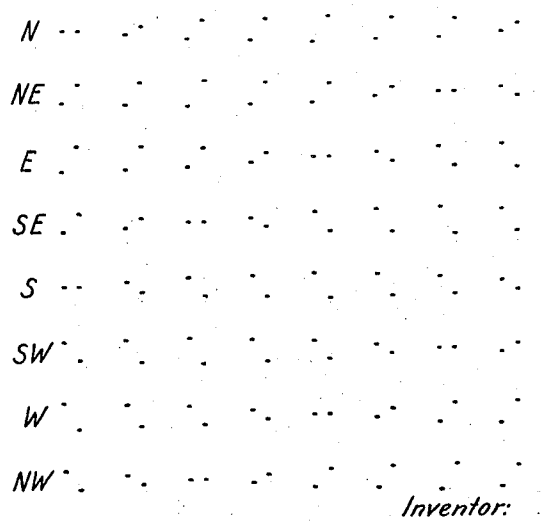


Fig. 10



Witnesses:

A. Bohm

H. C. Atwater

Inventor:

Albert Bull.

UNITED STATES PATENT OFFICE.

ANDERS BULL, OF CHICAGO, ILLINOIS.

ACOUSTIC SIGNALING METHOD.

1,342,584. Specification of Letters Patent. Patented June 8, 1920.

Application filed April 11, 1916. Serial No. 90,406.

To all whom it may concern:

Be it known that I, ANDERS BULL, a citizen of the United States, residing at No. 811 Rees street, Chicago, Ill., have invented a new and useful Acoustic Signaling Method, of which the following is a specification.

My invention relates to improvements in such acoustic signaling methods as are practised on board ships and on shore for warning purposes, and has for its object to enable the parties for whom the signals are intended to determine the bearing of the party sending the signals.

I attain this object by means of devices the construction and operation of which are explained by means of the accompanying diagrams, of which—

Figure 1 is a front view of a device operated in conjunction with a steam whistle; Figs. 2 and 3 are vertical sections through same, taken on lines S_2—S_2 and S_3—S_3 respectively; Fig. 4 is a top view of a device operated in conjunction with a bell; Fig. 5 is a vertical section through same, taken on line S_5—S_5; Figs. 6 to 10 are diagrams for explaining the operation of the apparatus.

My invention is based on the fact that when a sound emitting body (referred to in what follows as a "source") is in motion the frequency or pitch of the sound waves reaching a stationary observer will depend on the direction and speed of the motion relative to said observer.

Thus, when the observer is standing directly in the path of the source, the latter moving toward him, he will hear a tone of a higher pitch than the one emitted. This effect increases with the speed of the source; therefore, if the speed toward the observer is increasing the pitch will rise still higher, while if the speed toward the observer is decreasing the pitch will drop.

If, on the other hand, the source is moving away from the observer the conditions are reversed, the observer hearing a tone of a lower pitch than the one emitted. If, in the latter case, the speed of the source is increasing the pitch observed will drop still farther, while a decrease in speed will cause it to rise.

A rising pitch may thus be the result of either an accelerating movement toward the observer, or a retarding movement away from him, and vice versa.

These changes in pitch are easily explained by the laws of acoustics as follows: Due to the limited velocity of wave propagation, the sound waves emitted during one second by a stationary source will spread out over the surface of the earth in the shape of a steadily expanding circular belt. The velocity of sound in air being about 1120 feet per second, it follows that the radius of the belt is increased every second by this amount, while the width of the belt, representing the distance traveled by the sound wave front during the first second, remains constant at the same figure, about 1120 feet.

If, however, the source is in motion it will have more or less of a tendency to overtake the waves in front of it, at the same time farther out-distancing the waves in the rear. This will result in a deformation of the belt, the latter becoming narrower in front of the movement and wider in the rear while to either side, at right angles to the movement, the width remains practically the same as before.

Since the velocity of the waves does not change, it follows that the time it takes the belt to pass an observer must be proportional to its width. While thus a person standing in front of the movement will be passed in somewhat less than a second, another, standing back of it, will be passed in slightly more than a second; and as the number of waves in the belt is the same at any point, being equal to the number sent out in one second, the former person will hear a shorter tone of higher pitch, the latter person a longer tone of lower pitch, while observers to the right and left of the movement will hear a tone of the same duration and pitch as the one actually emitted.

A mathematical analysis of the case gives the following expression for the pitch p of the tone observed.

$$p = q\frac{v}{v \mp f},$$

where q stands for the pitch of the tone emitted, v for the velocity of sound and f for the speed component of the source's movement in the direction of the observer, the upper sign to be used when this component is directed toward him, and vice versa.

The human ear being very sensitive to changes in the pitch, it does not require high speeds to make the effect referred to very noticeable. The rise in pitch corresponding to half a step in the tone ladder (for instance, from *c* to *c* sharp) being approximately in proportion as from 1.00 to 1.06, the pitch of the tone reaching the observer may be raised or lowered by half a tone by moving the source toward or away from him, at the rate of about 65 feet per second.

The above fact may be taken advantage of, for the purpose referred to, by means of devices of widely different construction, of which the two forms illustrated in the diagram may serve as examples.

Figs. 1 and 2 show the whistle (1), carried by the counterweighted, hollow arm (2) which is journaled in the frame (3) and is rotated at uniform speed about a horizontal axis in the direction indicated by an arrow, the rotational force being transmitted from the main shaft (4) through gear wheels (5, 6,) shaft (7) and conical gears (8, 9). The frame is itself rotatable about a vertical axis, turning about the pivot-shaped base, and is driven from the shaft (4) by means of gear wheels (10, 11), the several gears being so dimensioned that the whistle will make, say, 16 revolutions for every full revolution of the frame.

Steam is fed to the whistle through the centrally arranged pipe (12) which is joined to the frame (3) in such a way that it does not impede the rotation of the latter. The pipe opens into a semi-circular chamber (13) in the bearing (see also Fig. 3), the whistle communicating with this chamber through the hollow arm (2), opening (16), hollow shaft (14) and slot (15).

During the right half revolution of the whistle, as referred to Fig. 1, the slot (15) will be covered, the steam supply being thus cut off. Sound is, therefore, emitted by the whistle only during its left half revolution, *i. e.*, while the arm (2) is moving through the angle indicated by a dotted line. In this way a series of short blasts, separated by intervals of silence, is produced.

Assuming an observer to be stationed at A (Fig. 6) while a blast is being produced, the arm (2) being at the time on the north side of the frame (3) as indicated, then the movement of the whistle (1) will, during the first half of the blast, be directed away from the observer and during the second half toward him, the component of the speed in the direction of the observer decreasing during the first, and increasing during the second half of the blast. According to what has been explained above, the observer at A will, therefore, hear the blast as a tone the pitch of which is steadily rising.

The component of the movement in the direction of stations B and D will, at the same time, be practically zero, and observers at these stations will, therefore, hear the blast as a tone of uniform pitch.

The conditions at station C being, finally, the reverse of those at A, the pitch of the tone heard by an observer at C will be steadily dropping.

The matter explained in the three preceding paragraphs is graphically represented in Fig. 6, where the different character of the blast, as it is observed at the different stations, is indicated by short lines the inclination of which at any point corresponds to the rate at which the pitch is rising or dropping.

If the shaft (14) were kept steadily pointing toward north, as in Fig. 6, all the blasts emitted by the whistle would sound alike to a stationary observer. While the latter would be able to tell with great accuracy whether the whistle were east or west of the meridian (the slightest rise in the pitch indicating an easterly bearing, and vice versa), he would not be able, from the pitch alone, to decide whether it were north or south of the parallel.

Considering however, that the frame is itself slowly rotating about a vertical axis in the direction indicated by an arrow in Fig. 6, the sounds observed at each of the different stations will gradually change. Thus, after a quarter revolution of the frame, the whistle will have the same position relative to station A as it had formerly to station B, and station A will, therefore, now hear a blast of the same character as did formerly station B; station B as did formerly station C, and so on, while, after half a revolution of the frame, station A will hear a blast of the character originally observed at station C. In this way, the sounds observed at any station will undergo a complete cycle of changes in the time it takes the frame to make one full revolution.

The relative speed of rotation of the whistle and the frame being as stated above, a cycle will have been accomplished after 16 consecutive blasts have been emitted by the whistle.

Starting with the position indicated in Fig. 6, the sounds observed at station A during a complete cycle may be represented graphically by the group of lines shown in Fig. 7. At the same time, the sounds observed at station B will also undergo a complete cycle of changes, with the difference that at the latter station the cycle will start with a sound having a character as represented by the line marked B. Similarly, at stations C and D the cycle will start with sounds having the character of lines C and D respectively.

It will now be evident that if, for instance, the whistle is started blowing by the operator applying steam when the position of

the apparatus relative to the meridian is as indicated in Fig. 6, and the blasts are kept up for, say, half a revolution of the frame, during which movement eight blasts will be produced, then it will be possible for the observer to tell from the character of the sounds in what direction of the compass the whistle is located.

This is clearly brought out in Fig. 8, representing the character of the sounds observed when the apparatus has a bearing relative to the observer as marked at the left of each group.

To quickly and accurately determine a bearing, the observer should watch for a blast of uniform pitch, at the same time counting its numerical position in the series. While the latter position may correspond to either one of two diametrically opposite bearings, as N. or S., ESE. or WNW., a confusion of them is easily avoided, the difference being manifest in the general character of the series. Thus a blast of uniform pitch, observed as No. 6 in a group starting with blasts of an ascending pitch, would indicate the bearing ENE.

The blast of uniform pitch, or the one most nearly approaching this condition, is readily picked out, both because the rate at which the pitch is changing is a maximum of this juncture, and also because the human ear is relatively more sensitive to small variations in pitch.

The device may also be used to advantage for imparting other information to the observer. On board ships it may thus be used for announcing the course the vessel is steering, a feature of no less import than the location of the vessel. This may be conveniently done by emitting blasts corresponding in number to the course steered, it being, for instance, agreed that one blast shall stand for due north, two for NNE., three for NE., and so forth.

The groups of blasts announcing the course could be produced alternately with those announcing the bearing, each group being separated by an interval of silence of, say, half a minute.

Figs. 4 and 5 show a construction in which the sound producing body is a bell (20), carried by a counterweighted bracket (21) which is supported by the upright (22). The upright has a pivot-shaped base and is rotated from the shaft (23) by means of the gears (24, 25), the bell being thereby carried past two clappers (26) the shafts of which are pivoted in the frame of two compressed air cylinders (27). The latter are mounted on top of a shaft (28), fitted into an axial boring in the upright (22). The shaft (28) is itself provided with an axial hole communicating with the two cylinders (27).

When compressed air from the pipe (29) is applied to the cylinders the pistons (30) will push the clappers out from the axis and into the path of the bell so that knells are produced. The inlet and outlet of the compressed air are controlled by the two-way valve (31) which is worked from the main shaft (23) by the gears (32, 33) in such a way that after two knells have been produced during one revolution of the bell, no knells will be produced during the next, when the cylinders will have been exhausted and the clappers withdrawn by the spiral springs (34).

As the clappers are mounted on opposite sides of the axis of rotation the two knells above referred to will be produced with the bell moving in opposite directions. If the clappers, during the first impact, have the position indicated in Fig. 9, observers at stations A, B, C and D will hear the two knells as tones the pitch of which is indicated graphically by dots, placed at different uniform height at the respective stations.

While the bell is revolving the clappers are gradually shifted by rotation in the same direction (indicated by an arrow in Fig. 9) by means of the gears (35, 36), the relative speed being such that the bell will make, say, 32 revolutions while the clappers make one. The clappers striking the bell during every second revolution only, as stated above, 16 double knells would thus be produced during a full revolution of the clappers.

As with the previous device, the gradual shifting of the clappers will result in the sounds observed at any station undergoing a cyclic series of changes. If the knells are started while the bell (20) and clappers (26) are in a position relative to the meridian as indicated and the compressed air is shut off after half a revolution of the clappers, the character of the eight double knells then produced will be different according to the direction from which the sound reaches the observer, as indicated in Fig. 10.

The following definitions will be governing for terms used in the claims:

The term "orbitally" serves to define a type of movement in which an object is being carried bodily through space relative to an exterior point along a path of regular shape. A rotation is thus considered an orbital movement only when the axis of rotation is outside the rotating object.

By the term "sound producing mechanism" is understood a device in which vibrations giving rise to sound waves are produced, while by the term "source of sound" is understood, in a broader sense, any device, mechanism, aperture or surface from which sound waves may be caused to emanate into space.

The term "fully exposed" serves to de-

fine an arrangement of the sound producing mechanism or source of sound by which the sound waves produced are allowed a free and unobstructed passage into space, without being purposely deflected or reflected with a view to concentrating the waves, or increasing the volume of sound, in a definite direction.

I claim:

1. A device of the character described comprising, a sound producing mechanism fully exposed and suitably mounted to move bodily through space relative to its support, means for effecting said movement, and means for automatically actuating said mechanism causing it to emit sounds of a uniform character during its movement.

2. A device of the character described comprising, a sound producing mechanism fully exposed and suitably mounted to move orbitally relative to its support, means for effecting said movement, and automatic means for intermittently actuating said mechanism causing it to emit a succession of sounds of a uniform character during its movement.

3. A device of the character described comprising, a source of sound fully exposed and suitably mounted to move through space relative to its support, means for causing said movement in various directions at substantially uniform speed, and means for automatically actuating said source at regular intervals causing it to emit sounds of a uniform character and duration during its movement in predetermined directions.

4. A device of the character described comprising, a sound producing mechanism fully exposed and suitably mounted to move through space relative to its support, means for causing said movement in gradually changing directions with respect to the meridian, and means for intermittently actuating said mechanism causing it to emit sounds of a uniform character during its movement.

5. A device of the character described comprising, a source of sound fully exposed and suitably mounted to move orbitally relative to its support, means for causing said movement at high and uniform speed, and means for automatically actuating said source at regular intervals causing it to emit sounds of a uniform character and duration during its movement.

6. The combination with a source of sound fully exposed and suitably mounted to move through space relative to its support, of means for causing said movement in constantly changing directions with respect to the meridian, and means for intermittently actuating said source causing it to emit a series of sounds of uniform character during its movement, the interval between each actuation being definitely related to the rate at which the direction of the movement is changing.

7. The combination with a source of sound suitably mounted to move orbitally in a vertical plane, of means for causing said movement, means for automatically changing the direction of said plane with respect to the meridian, and means for intermittently actuating said source causing it to emit sounds during its movement in predetermined directions.

8. The combination with a source of sound suitably mounted to move orbitally in a vertical plane, of means for causing said movement, means for intermittently actuating said source, and means for changing the position of said plane with respect to the meridian by a fixed angular amount between each successive actuation.

9. The combination with a source of sound suitably mounted to move orbitally in a vertical plane, of means for effecting said movement at uniform speed, means for intermittently actuating said source causing it to emit a succession of sounds of a uniform character during its movement, and means for changing the direction of said plane with respect to the meridian at a predetermined rate.

10. The combination with a source of sound suitably mounted to rotate orbitally about a horizontal axis, of means for causing said rotation at high and uniform speed, means for intermittently actuating said source during its movement, and means for progressively changing the declination of said axis with respect to the meridian.

11. The combination with a whistle, of a source of fluid for actuating said whistle, means for automatically controlling such actuation, supporting means permitting said whistle to rotate orbitally about a horizontal axis while said axis is being rotated in the horizontal plane, and means for causing said movements at a substantially uniform speed.

ANDERS BULL.

Witnesses:
A. BOEHM,
H. C. ATWATER.