Aug. 11, 1942. H. C. HAYES 2,292,376

METHOD OF AND MEANS FOR GENERATING INTENSE SOUND SIGNALS IN AIR

Filed Oct. 9, 1939

Fig. 1

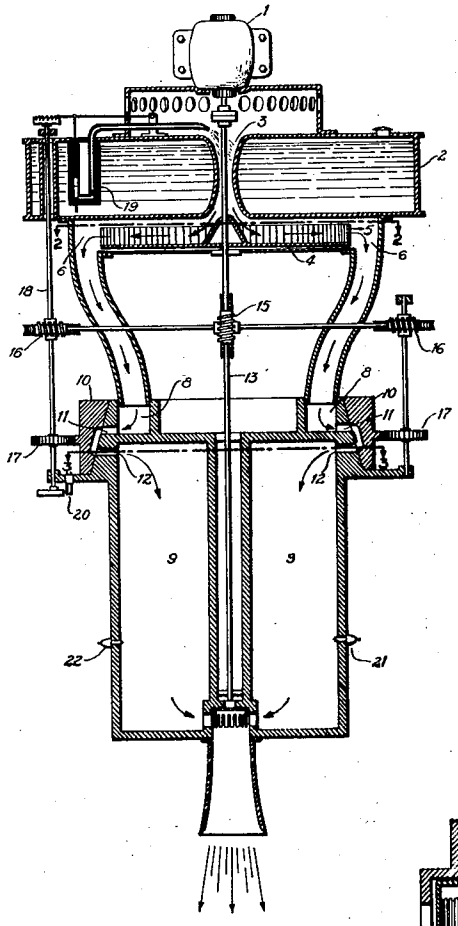



Fig. 2

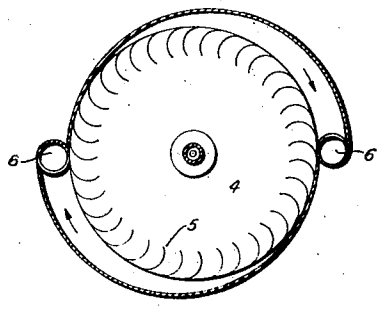



Fig. 3

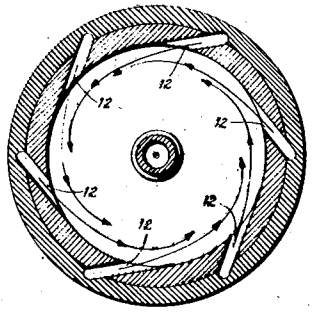
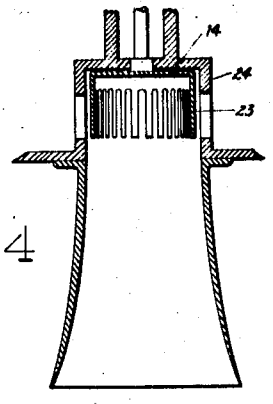



Fig. 4




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Patented Aug. 11, 1942 2,292,376

# UNITED STATES PATENT OFFICE

2,292,376

## METHOD OF AND MEANS FOR GENERATING INTENSE SOUND SIGNALS IN AIR

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Application October 9, 1939, Serial No. 298,634

6 Claims. (Cl. 116—147)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

This invention relates to methods of and means for generating intense sound signals in air.

The range to which a sound signal can be detected by ear or otherwise depends primarily on the product of two factors; first, the rate at which energy is supplied to the sound generator and second, its acoustical efficiency. In other words, the range of detection of a sound signal is determined by its intensity and not by its length. Increasing the signal length beyond the full time response of the receiver offers little or no advantage. A tenth second signal carries to the same range as does a signal ten seconds long, provided both have the same intensity, but the long signal absorbs 100 times more energy from the source than does the short one with a corresponding increase in the cost of power. Therefore, from the standpoint of economy, sound signalling devices should be designed to absorb some cheap form of energy at a high rate for a short interval and to efficiently transform it into sound. It is an object of the present invention to provide such economy by means of simplified and relatively inexpensive apparatus.

The cheapest and simplest known means of generating high power for a short interval is through the use of explosives. An exploding (rapid burning) mixture of air and gasoline at atmospheric pressure liberates about $6\times10^8$ ergs of energy per cubic inch of volume during a time interval somewhat less than a thousandth of a second. Thus the power generated averages about $6\times10^{11}$ ergs per second or 6 kilowatts. A cylinder 3'' long and 3'' in diameter charged with such a mixture generates approximately 120 kilowatts of power during the period of explosion. This energy, which takes the form of a heated and highly compressed gas, can be passed from the cylinder to the sound generator at a predetermined rate, depending upon the length of signal required. Experiment shows that except for very low pitched signals, the range of detection is not improved by lengthening the signal beyond one-tenth of a second. The average power supplied to a sound generator during a one-tenth second interval by the small cylinder approximates 1.2 kilowatts. A cylinder 6'' x 6'' will supply about 10 kw. for 0.1 second for generating a sound signal. It can be shown that one gallon of gasoline can supply this amount of energy for a signal every 20 seconds over a period of about 36 hours. Obviously, we have here a convenient and economical source of power for sound signalling if it can be readily and efficiently transformed into sound.

A considerable portion of this explosion energy is transformed into sound by letting it expand directly into the air from the cylinder outlet. Such a signal is substantially non-directional and sounds much like the report of a blank cartridge fired from a shot-gun. If the compression wave from the explosion chamber passes to the atmosphere through a properly designed horn, the sound becomes directed along the axis of the horn to a considerable extent and takes on a quality determined by the resonance frequency of the horn and its terminating explosion chamber.

The compressed gas from an explosion can be passed through a whistle whereby a portion of the energy is converted into sound whose frequency is determined by the design of the whistle. The sound will be non-directional or directional, depending upon the design of its passage from the whistle outlet to the atmosphere.

My preferred method of converting the compressional energy into sound is to interpose a siren in the opening from the cylinder and to pass the sound from the siren into the atmosphere through a properly designed horn. The siren modulates the gas stream to give a high acoustical efficiency at any desired pitch over a wide range and is able to handle more power than can a whistle. Since for coded signals, like fog signals, it becomes desirable to embody some kind of rotary timing device, this can also be driven by the siren motor with but little expenditure of energy.

Therefore, my method of producing intense sound signals in air consists of periodically and automatically charging a rigid walled chamber with an explosive or rapid burning mixture, igniting this mixture automatically at predetermined intervals by means of an electric spark and passing the expanded products of combustion into the atmosphere in such a manner as to convert a portion of their energy into sound.

Ways and means for making this method practical can take many mechanical forms, each of which is mainly concerned with automatically charging, firing, and recharging the explosion chamber to provide signals in conformity with a set code. The simplest of several types that have been successively tested provides no moving parts within the combustion chamber. The charging mixture is formed by injecting gas or gasoline directly into the entering air stream in proper proportion and it enters the chamber in such a way as to expel the residual gas from

the previous explosion with but slight intermixing.

In the accompanying drawing:

Fig. 1 is a vertical section of the complete assembly.

Fig. 2 is a horizontal section through the sirocco blower taken along line 2—2 of Fig. 1;

Fig. 3 is a horizontal section through the explosion chamber taken along line 3—3 of Fig. 1; and

Fig. 4 is a vertical section through the siren.

The principle of operation of this device is shown schematically by Figs. 1, 2, 3 and 4, wherein like parts in all the figures carry like reference numerals. Fig. 1 shows the complete assembly in vertical section wherein numeral 1 represents a small electric motor mounted centrally above a fuel tank 2, through the center of which passes a nozzle-like air passage 3, which opens centrally into the small sirocco blower carrying rotor 4, blades 5, and exits 6.

Fig. 2 represents a horizontal section through the sirocco blower, the two outlets 6 of which connect with a circular distributing manifold 8 centrally mounted on top of the explosion chamber 9. Connection between the manifold and explosion chamber is effected by rotating member 10 which at definite angular positions provides free passage between ports 11 which open into the manifold and associated ports 12 that open into the explosion chamber.

Fig. 3 represents a horizontal section through ports 12 and shows them entering the cylindrical chamber tangentially. The motor, through its extended shaft 13, serves to drive the blower fan 4 and the siren 14 through direct coupling. It also operates the rotating valve member 10 through reduction worm gears 15 and 16 and pinion gears 17. Shaft 18, in addition to driving pinion gear 17 also, through cam action, drives a fuel injection pump 19 and electrical contact points 20 which latter in conjunction with an E. M. F. and spark coil (not shown) operate spark plugs 21 and 22. It will be noted that the siren is designed to make the explosive wave pressure thereon sum up to zero. This is accomplished by making the siren a perforated cylinder 23, with the fixed ports located in a surrounding cylinder 24.

The performance of the apparatus described is as follows: Upon starting the motor, the sirocco fan 4 forces air into outlets 6 at a pressure depending upon its speed and dimensions. This compressed air passes from the manifold 8 into the explosion chamber 9 as often as and during the interval that the ducts of rotating member 10 pass across the ports 11 and 12. The air entering the explosion chamber is directed tangentially to the cylindrical surface, thereby forming a vortex about its axis. The resulting centrifugal action tends to hold the entering air against the side of the chamber and to force toward the axis and down through the siren the air that previously filled the chamber. This action prevents the new air entering the chamber from readily mixing with the old. A relatively weak signal is generated each time the old charge is forced through the siren by the entering charge.

Meantime at predetermined intervals the injection fuel pump 19 discharges a measured amount of fuel into the air stream entering the blower. This is thoroughly broken up into vapor and fine spray by the action of the high speed fan and from there on the air stream becomes an explosive or rapid burning mixture that can be ignited by the spark plugs 21 and 22, which, as described, are energized through current breaker points 20. Pinions 17 are designed to make one complete revolution while member 10 moves through the angle subtended by two adjacent ports, and the cam that operates breaker points 20 is oriented on shaft 18 to a position where the cylinder fires only when the ports 11 and 12 are closed. When the mixture within the cylinder is exploded, the internal pressure suddenly rises to something like 50 pounds above atmospheric pressure. The escaping gas stream, which is modulated into compression waves (sound) by the siren, generates an intense signal, the pitch of which is determined by the rate of passing of ports in the siren and the length of which is determined by the outlet area of the ports.

The apparatus, as described, automatically transmits sound signals continuously at equal predetermined intervals of time. This signal train is readily modulated into code by an automatically operated switch placed in series with the breaker points 20. Explosions can take place only when this switch is closed, and as a result it can be set for any desired number of consecutive explosions followed by any desired interval of silence. Such a switch, or contact maker, can take many well known forms, none of which needs illustration herein, but it should be noted that whatever form the mechanism may take it must be driven by interlocking to shaft 18 or some other rotating member of the device described to preserve proper phase relation between the instants of fire and the opening and closing of the charging ports.

While the description and illustration have been limited to one embodiment, it is to be understood that the invention is not to be limited thereby, but only by the scope and limitations of the subjoined claims.

The invention described herein may be manufactured and/or 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 set forth and disclosed the nature of this invention, what is claimed is:

1. Means for generating sound signals comprising a rigid walled chamber, a siren having inlet ports communicating directly with said chamber, said chamber having a series of equally spaced ports formed in the walls thereof and extending tangentially of the interior surface of said walls, a fuel tank, a passageway leading through said tank for conveying fuel therefrom to said chamber, means for injecting fuel into said passageway, a fan in said passageway adapted to finely divide said fuel, mix it with air and direct the resulting explosive mixture to said chamber, a rotatable manifold communicating with said passageway and having a series of small passageways therein, each of which communicates with one of said tangential ports when said manifold is properly oriented, means for igniting a charge of said mixture in said chamber, a power driven shaft extending through said passageway in driving relation to said fan and said siren, and means driven by said shaft to rotate said manifold, to periodically operate said fuel injecting means and to periodically operate said igniting means.

2. Means for generating sound signals comprising a rigid walled chamber, a siren having inlet ports communicating directly with said

chamber, said chamber having a series of ports formed in the walls thereof and extending tangentially of the interior surface of said walls, a fuel supply system including a tank, a passageway, means for injecting fuel from said tank into said passageway, a fan adapted to finely divide said fuel, mix it with air and impel said mixture through said passageway toward said chamber, and a rotatable manifold having a series of small passageways therein, each of which communicates with one of said tangential ports when said manifold is properly oriented, means for igniting the mixture in said chamber and power driven means driving said siren and said fan and periodically operating said fuel injection means and said igniting means.

3. Means for generating sound signals comprising a rigid walled chamber, a siren having inlet ports communicating directly with said chamber, a fuel supply system including a source of fuel, means operable to periodically inject fuel into said supply system, means for mixing said injected fuel with air and impelling the resultant mixture through said system, means movable with respect to said chamber and forming the terminus of said supply system, said means alternatively opening and closing communication between said supply system and said chamber during said movement, means for periodically igniting a charge of said mixture in said chamber, said chamber being so dimensioned as to interpose no pressure reducing constriction between said igniting means and said inlet ports and power driven means driving said mixing means and said siren and operating said injecting means, said movable means and said igniting means in timed relation.

4. Means for generating sound signals comprising, a rigid walled chamber, means for periodically charging said chamber with an explosive or rapid-burning mixture, means for igniting said mixture at predetermined intervals, a gas operated sound producing device arranged to receive the products of combustion of said chamber, and power driven means for driving said charging and igniting means in timed interrelation, said chamber being open only to said charging means and said sound producing device.

5. Means for generating sound signals comprising, a cylindrical, rigid-walled chamber, means for periodically charging into said chamber streams of an explosive or rapid-burning mixture directed tangentially with respect to the cylindrical walls thereof, means for igniting said mixture at predetermined intervals, a gas operated sound producing device arranged to receive the products of combustion of said chamber, and power driven means for driving said charging and igniting means in timed interrelation, said chamber being open only to said charging means and said sound producing device.

6. Means for generating short sound signals of great range, comprising, a gas operated sound producing device having gas inlet openings, an explosion chamber having its interior in such direct and free communication with said openings and so dimensioned that it will not impede the flow toward said openings of the products of explosion of an explosive charge exploded therein, and means for supplying and exploding an explosive charge in said chamber.

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