July 28, 1942. S. P. FOLTZ ET AL 2,291,459

LOUD SPEAKER

Filed June 8, 1940

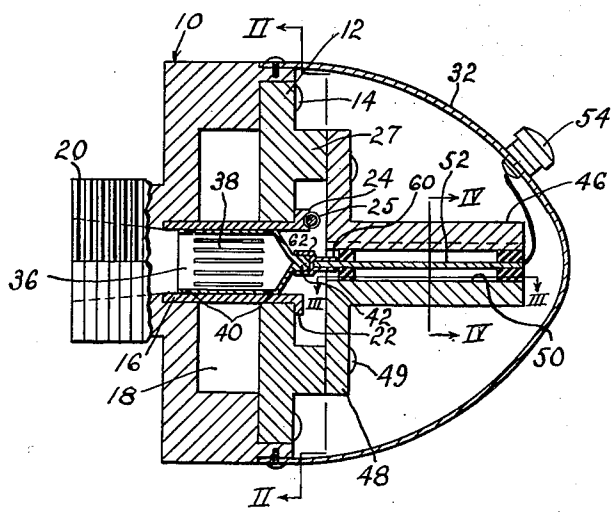



FIG. 1

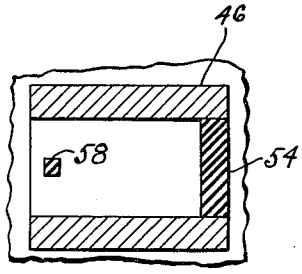



FIG. 3

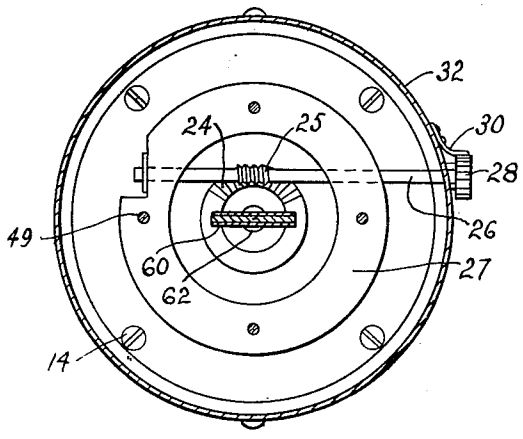



FIG. 2

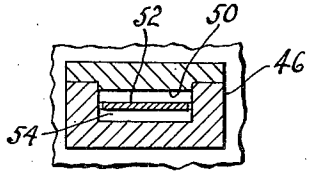



FIG. 4

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Patented July 28, 1942 2,291,459

# UNITED STATES PATENT OFFICE

2,291,459

## LOUD-SPEAKER

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New Castle, Pa.

Application June 8, 1940, Serial No. 339,514

3 Claims. (Cl. 179—110)

This invention relates to voice amplifying or reproducing equipment, and, more particularly, is concerned with an apparatus of the loud speaker type operated by compressed air or other fluid.

Heretofore, it has been proposed to provide a loud speaker in which compressed air is employed to produce the sound waves by controlling the escape of compressed air by electrical means actuated by electrical impulses controlled by sound waves. For example, a valve has been used to control the escape of compressed air to a loud speaker horn and the valve is controlled by magnetic means responsive to the electrical impulses generated in a microphone or an electrical pickup with or without amplification by a vacuum tube system. We have found, however, that the usual magnetic means for controlling the opening and closing of the compressed air valve are not sufficiently rapid or sufficiently responsive of a wide range of frequencies to effect a fine tone quality of reproduction of the sound. Also, we have found that known apparatus is relatively complicated in construction, expensive to manufacture, delicate in adjustment and maintenance and possesses undesirable, inherent "damping" characteristics.

It is the general object of our invention to avoid and overcome the foregoing difficulties of known pneumatic loud speakers by the provision of a relatively inexpensive, simple, rugged, undamped and easily adjusted compressed air speaker which is characterized by extremely high quality reproduction and wide frequency response range.

Another object of our invention is the provision of a piezo-electrical control for a compressed air loud speaker.

Another object of our invention is to provide a pneumatically-balanced valve for controlling the flow of compressed air to a loud speaker horn which valve has a light-weight, rotatable, closure member moved to the open and closed position by piezo-electric means.

Another object of our invention is the provision of an improved mounting for this piezo-electrical means whereby it is adapted for oscillation about an axis of rotation.

Another object of our invention is to provide a piezo-electric crystal mounted for oscillation about a given axis and adapted to open and close a valve connected directly to the oscillating portion of the crystal.

Another object of our invention is to provide an improved pneumatically operated loud speaker.

The foregoing and other objects of our invention are achieved by the provision of a valve adapted to be connected to a source of air under pressure, a pneumatic-balanced rotary plug in the valve, and piezo-electrical means connected to oscillate the plug and open the valve greater and less amounts upon activation of the piezo-electrical means by sound controlled electrical impulses.

For a better understanding of our invention reference should be had to the accompanying drawing wherein Fig. 1 is a longitudinal cross-sectional view through an apparatus embodying the principles of our invention; Fig. 2 is a transverse cross-sectional view taken on line II—II of Fig. 1; Fig. 3 is a fragmentary cross-sectional view taken on line III—III of Fig. 1; and Fig. 4 is a fragmentary cross-sectional view taken on line IV—IV of Fig. 1.

In the drawing, the numeral 10 indicates, as a whole, a cylindrical housing having a removable end plate 12 secured thereto, as by screws 14. The end plate 12 and the housing 10 are formed with a central or axial bore which snugly receives a tube 16. The ends of the tube 16 engage in sealing relation with the housing 10 and the end plate 12 but the center portion of the tube is surrounded by the chamber 18 in the housing which chamber is adapted to be connected to a source of gas or fluid, as for example air, by means not shown. The housing 10 is provided with a circular flange 20 which is adapted to have the small end of a loud speaker horn, or the like, secured thereto so that the horn will be positioned axially of the tube 16.

Suitable means are provided for holding the tube 16 in position and for also allowing a slight rotatable adjustment of the tube. For this purpose, one end of the tube 16 is formed with a flange 22 which engages with the outer surface of the end plate 12. A portion of the flange 22 is thickened and cut with an arcuate rack, as at 24, which engages with a worm or screw 25 cut or mounted on a shaft 26 journaled at its ends in a laterally extended flange 27 usually made integral with the end plate 12. A knurled knob 28 secured to the shaft 26 provides for the rotation of the shaft, and a spring finger 30, holds the knob 28, shaft 26, and tube 16 against rotation. The spring finger 30 is mounted on a cover 32, usually of streamline shape, which is fastened to the housing 10.

The tube 16 is formed with a plurality of circumferentially-spaced, longitudinally-extending slits or ports as more fully described and claimed in the co-pending application of Edward F. Chandler, Serial No. 310,361.

Rotatably received within the tube 16 is a thin-walled cup or plug 36 of light weight material slightly shorter in length than the length of the tube 16. The cup 36 is ordinarily made of duralumin or other relatively strong, hard, light-weight material and is provided with a plurality of circumferentially-spaced, longitudi-

nally-extending slits or ports 38 which are adapted to be moved into and out of register with the ports or slits formed in the tube 16. Obviously, when the slits in the cup 36 are completely in register with the slits in the tube 16, a large volume of air is passed from the chamber 18 out through the flange 20 and into the speaker horn. However, when the slits 38 of the cup 36 are not in register with the slits in the tube 16 substantially no air escapes from the chamber 18. The cup 36 may be provided with small circumferentially - continuous sealing grooves or means 40 at either end of the slits 38. The bottom of the cup is positioned at the end of the tube 16 adjacent the flange 22 and the cup terminates in a stud portion 42 which is axially aligned with the axis of the cup and tube.

As best shown in Figs. 1, 3 and 4, piezo-electric means are incorporated with the valve mechanism heretofore described to produce and control the operation of the valve. In the apparatus illustrated, the piezo-electrical means includes a substantially rectangular housing member 46 formed in upper and lower parts and terminating in a right angle flange 48 which is secured as by screws 49 to the circular flange 28. The rectangular housing 46 is formed with a rectangular aperture 50 through its center which is in alignment with the stud 42 formed on the end of the cup 36. A piezo-electrical crystal 52 usually of flat rectangular shape, is carried in the aperture 50 of the housing member 46 so as to be in spaced relation to the side, top and bottom walls of the aperture 50.

The piezo-electrical crystal is mounted so that it will be free to oscillate around a suitable axis, usually a central axis, which axis passes through the stud 42. Specifically, I employ strips 54 of resilient material, as for example sponge rubber, which strips engage with the top and bottom of the edge of the crystal 52 remote from the cup 36. Also, blocks 58 of the same sponge rubber material engage with the top and bottom of the crystal over only a small area usually positioned centrally of the crystal adjacent the end thereof closest to the cup 36. The result is that the piezo crystal 52 is resiliently mounted for substantially free oscillation movement around an axis, and specifically a central axis. Ordinarily, the resilient means are compressed but slightly in mounting the crystal therebetween.

The end of the piezo-crystal adjacent the stud 42 is secured, as by cement, to a channel shaped coupling member 60 which has a cup 62 formed thereon which cup surrounds the stud 42 and to which the stud may be secured by a suitable cement. The piezo crystal 52 may be electrically connected to binding posts 54 mounted on the cover 32 and electrically insulated therefrom.

It is believed that the operation of our improved pneumatic loud speaker will be evident from the foregoing description. However, briefly reviewing the operation, the apparatus is connected to a source of compressed air, an amplifying horn is mounted on the flange 20, and an amplifier is connected to the binding posts 54. Then the knob 28 is adjusted for any given condition so that without electric current flowing to the binding posts 54 there is no escape of air from the chamber 18 through the slits in the tube 16 and the slits 38. Usually, the knob 28 is turned to first align the ports 38 in the cup 36 with the ports in the tube 16 so that there is an escape of air. Thereafter, the knob is turned until the escape of air is just cut off. With the valve portion of the apparatus in this condition electrical impulses applied to the piezo-electrical crystal 52 causes it to oscillate about its central axis which oscillations act through the direct coupling means 60 and 62 to oscillate the cup 36 and bring the slits or ports 38 of the cup into and out of register with the ports and slits in the tube 16. Thus, greater and lesser amounts of air are permitted to escape from the chamber 18 out through the speaker horn connected to the flange 20. The result is a very loud sound amplification of the original sound waves, reproduced over a particularly wide frequency range and at high quality.

From the foregoing it will be evident that the objects of our invention have been achieved by the provision of relatively inexpensive apparatus employing a piezo-electrical crystal to control a pneumatic type loud speaker. The improved loud speaker of our invention is exceptionally rugged and can be used under various conditions of temperature and pressure with little or no adjustment. The apparatus can be used over long periods without repair and if it should become necessary to provide a new crystal the installation thereof is a simple matter. The valve portion of the apparatus is pneumatically balanced inasmuch as the air pressure acts equally on all sides of the cup and as a result the cup 36 is readily oscillated by the crystal 52 which is connected directly thereto.

While in accordance with the Patent Statutes we have specifically illustrated and described our advance in the art, it should be understood that we are not limited thereto or thereby but that the scope of our invention is defined in the appended claims.

We claim:

1. A pneumatic loud speaker comprising a tube, a housing providing an air chamber at least partially around the tube intermediate the ends thereof, a light weight cup received snugly within the tube, said cup and tube having ports adapted to be moved into and out of register upon rotation of the cup about its axis, a piezo-electrical crystal mounted at the closed end of the cup so that the axis of the cup passes through the plane of the crystal, the edge of the crystal remote from the cup being mounted resiliently over substantially the full width of the crystal and at right angles to the cup axis, the end of the crystal adjacent the cup being resiliently mounted only at a laterally-narrow, central area, and means connecting the adjacent end of the crystal to the cup.

2. In combination, a rotary valve for controlling the flow of fluid, a piezo-electrical crystal, means mounting the crystal for oscillation adjacent the valve and so that the axis of the valve passes through the plane of the crystal, and means connecting the crystal to the valve so that oscillations of the crystal will open the valve to greater and less amounts.

3. In combination, a rotary valve for controlling the flow of fluid, said valve being balanced, in a radial direction at all times during its control of fluid flow, a piezo-electrical crystal, means mounting the crystal for oscillation adjacent the valve and so that the axis of the valve passes through the plane of the crystal, and means connecting the crystal to the valve so that oscillations of the crystal will open the valve to greater and less amounts.

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