May 9, 1933. A. McL. NICOLSON 1,908,172

SOUND REPRODUCING DEVICE

Filed May 20, 1930

Fig. 1

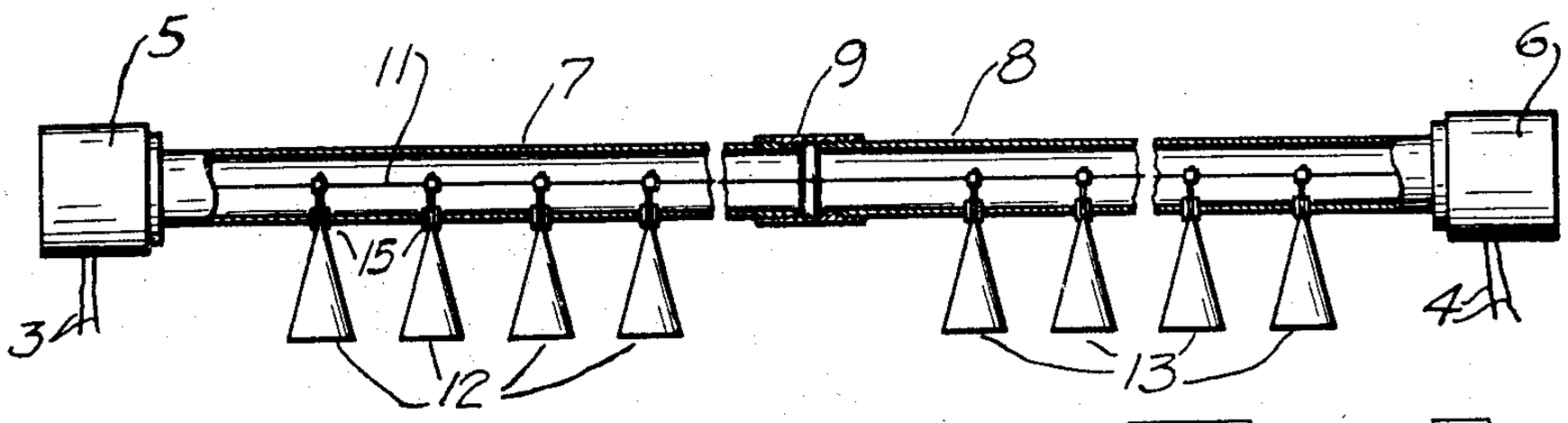


Fig. 2

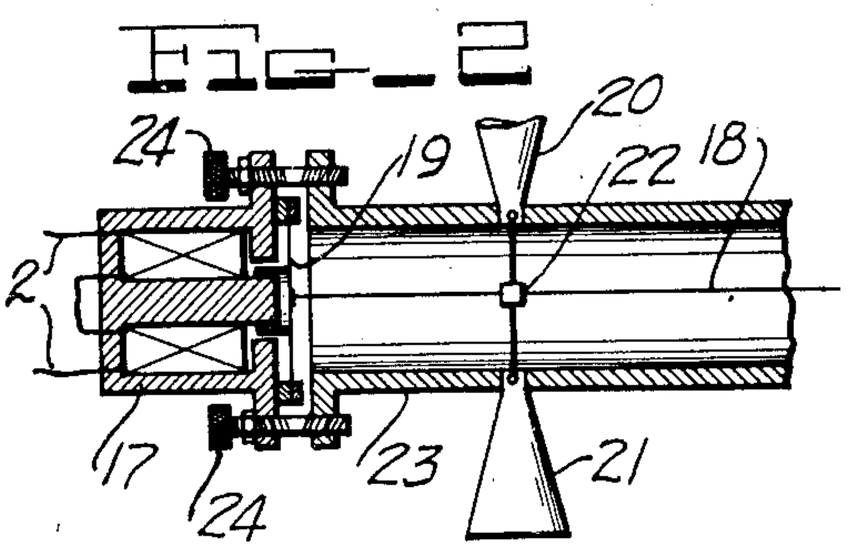


Fig. 3

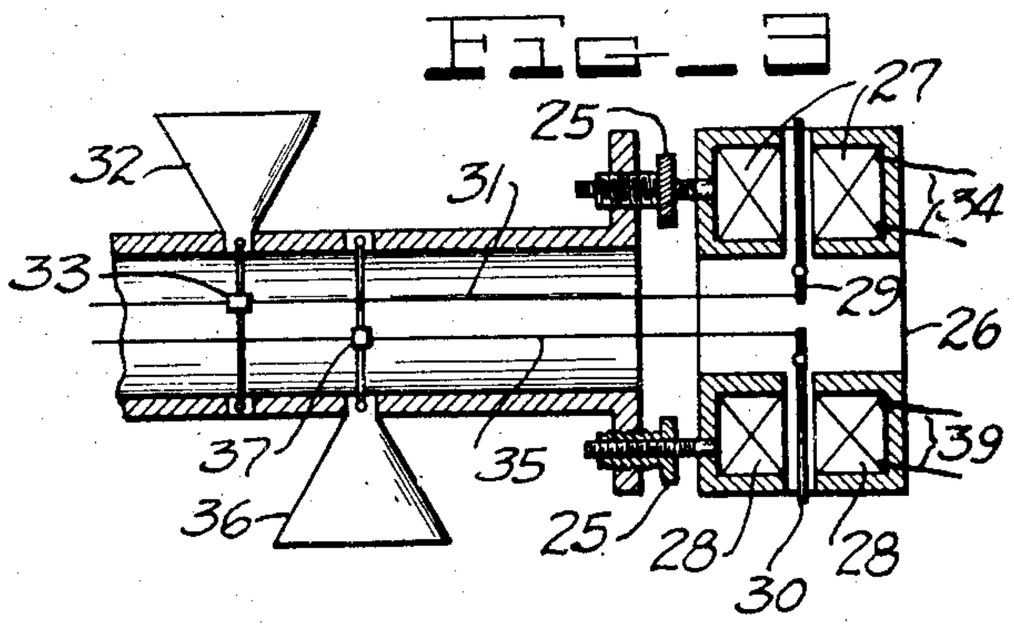


Fig. 4

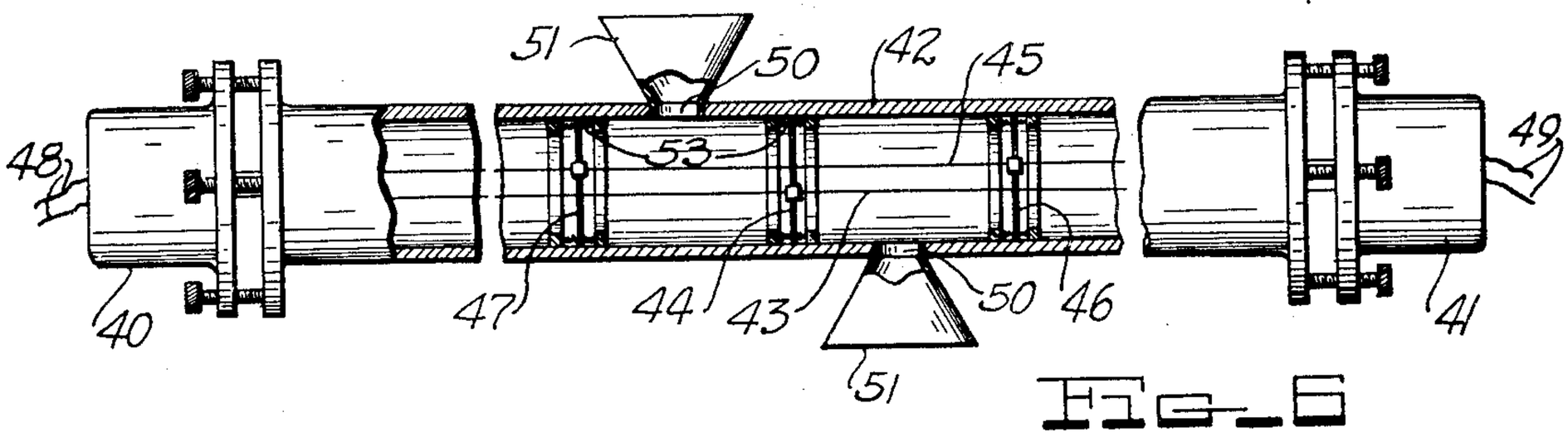


Fig. 5

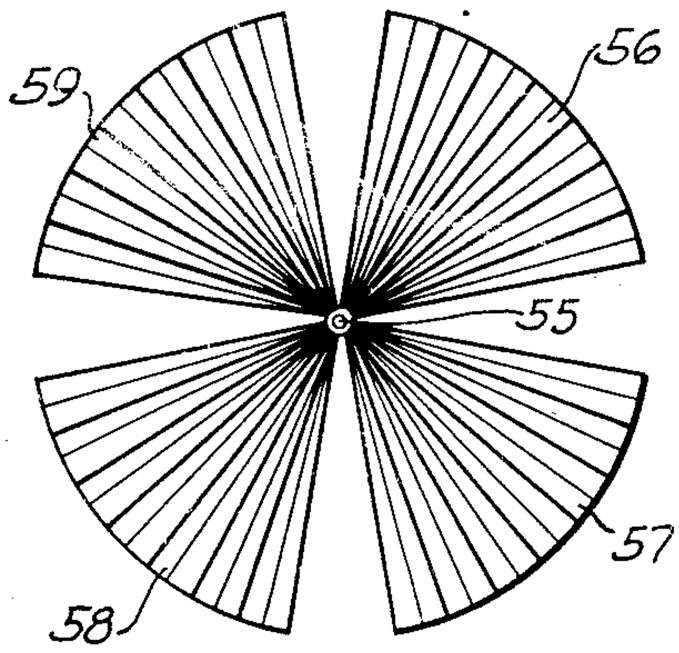
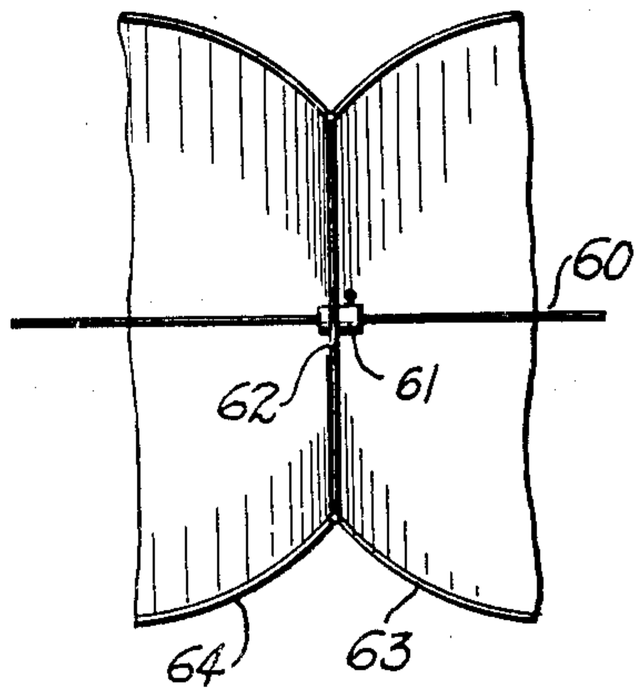


Fig. 6



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UNITED STATES PATENT OFFICE

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SOUND REPRODUCING DEVICE

Application filed May 20, 1930. Serial No. 453,987.

This invention relates to the reproduction of sound from electrical vibrations, and particularly to the reproduction of sound having the same phase at any instant.

An object of this invention is to reproduce sound at many points, the sound having the same phase and amplitude at each point.

Another object of the invention is to reproduce sound having good quality and constant phase displacement over a definite area.

In public address systems for auditoriums or outdoor presentations, in which a binaural or directional effect is desired, it is necessary to produce along a certain line or in a definite plane, sound from a particular pick-up device or microphone. These sound waves should be initiated in phase and at a constant pressure, to insure a good binaural effect over a considerable area. This may be accomplished electrically by connecting a group of loud speakers arranged along a line radiating from the sound source, in series or parallel with the proper polarization of the fields. However, the present invention contemplates reproducing sound from a mechanical oscillating medium which is driven electrically. In other words, a single electrical unit or, two units operating as a single unit, is arranged to drive a medium such as a tensioned wire from which sound is radiated from acoustic radiators disposed at uniform intervals along its length. In such an arrangement each point of propagation will be activated simultaneously, thereby projecting sound at the same instant. Also, each direct propagation means will be actuated with the same force and, therefore, project sound having the same amplitude at each point.

The driving medium or wire is tensioned so that its resonant frequency is as high as possible in the audio range, thereby decreasing acoustic resonance and motional impedance. The driving units may have electrodynamic or electromagnetic units or piezo-electric motors, to the moving elements of which the actuating wires are attached. The wire may be in free air or contained within a cylindrical container such as a pipe with outlets therein to permit the attaching of sound radiators or acoustic diaphragms.

The details of the invention will be more fully understood by reference to the accompanying drawing in which:

Figure 1 is a partial cross-sectional view of a single wire construction;

Fig. 2 is a cross-sectional view of a driving unit;

Fig. 3 is a cross-sectional view of a double range driving unit;

Fig. 4 is a double wire system in which sound is produced within a cylindrical container; and

Figs. 5 and 6 are views of two types of sound radiating mediums which may be employed in the above systems.

Referring particularly to Fig. 1, driving units 5 and 6 with their feeding conductors 3 and 4 are shown at the extremities of a cylindrical housing in the form of a pipe divided into two sections 7 and 8, respectively. These sections are joined together by a threaded coupling 9, which is the means for tensioning a wire 11 connecting the two units 5 and 6. The wire 11 may be free and continuous between operating elements at units 5 and 6 or may consist of two separate wires attached to fixed resilient members held in position by the coupling 9. The degree of tension desirable depends upon the separation between units 5 and 6, but is preferably not less than that required to make the frequency of the mechanical resonance above the audible range. Connected to the wire at definite intervals along its length are sound radiators 12 and 13, in the form of cone shaped members. These radiators are firmly attached to the wire 11 so that they vibrate longitudinally with the wire 11, the radiators being flexibly held in position by stops 15 which may be composed of soft sponge rubber or the like. The two driving members 5 and 6 work in synchronism, that is, any force directed in the right hand direction by unit 6 will be augmented or reinforced by the unit 5 acting in the same direction.

In Fig. 2 a driving unit 17 is shown with its diaphragm armature 19 similar to a tele-

phone receiver unit attached to a driving wire 18. The conductors 2 may be connected to the output of an amplifier system. In this modification of the system of Fig. 1, two sound radiators 20 and 21 are connected at one point on the wire 18 with a rigid coupling 22. These sound radiators may be composed of stiff paper, light wood or any light material having acoustic radiation properties and are preferably formed into hollow conical shaped extensions. They not only vibrate about their mounting points in the pipe, as shown in Fig. 1, but also have vibrations induced therein along the direction of their principal axes. The pipe 7, 8 of the system in Fig. 1, or pipe 23 of Fig. 2, may be of steel or cast iron or of non-metallic material such as hard rubber or Bakelite. Screws 24 connect the unit 17 with the pipe 23 and also are employed for tensioning the wire 18, the wire being either connected to the diaphragm armature of a similar unit or to a fixed resilient support at the end of the pipe 23. These diaphragm armatures and supports for the terminals of the wires are stretched and of comparatively heavy material to enable the wire which has a comparatively small mass to be properly tensioned.

In Fig. 3 a double driving unit is shown with tensioning screws 25 arranged in a slightly different manner from that in Fig. 3. In the unit 26 is shown two sets of driving coils 27 and 28 and respective armatures 29 and 30. These armatures are in the form of levers with short and long sections such that they permit the proper tensioning pull to be applied to the short sections thereof. Coils 27 may be energized from conductors 34, and coils 28 may be energized from conductors 39. Armature 29 drives a tensioned wire 31 to which is connected a sound radiator 32 at point 33. Armature 30 drives a tensioned wire 35 to which is connected a sound radiator 36 at 37. These connections are made in the same manner as in the systems shown in Figs. 1 and 2, but the radiators 32 and 36 are mounted on levers or acoustic diaphragms, which extend across the whole cross-section of the housing pipe and act as a damping means. These diaphragms may be perforated to reduce any resonance caused by reflection between diaphragms. As levers, they comprise a strip mounted at diametrically opposite positions within the pipe. The radiators 32 and 36, preferably hollow, have two modes of vibration as in Fig. 2, one being about the mounting points in the pipe, and the other along their principal axes.

In the system of Fig. 3, the armature 29 with its associate coils 27 may be constructed so as to be resonant at a frequency within the higher frequency range of the audio frequency band, while the armature 30 with its associate coils 28 may be adjusted to be resonant at a frequency in the lower portion of the audible range. Further improvement may be made by impressing the particular range of frequencies on the particular speaker constructed for that range. In such a case, the radiators 32 and 36 may be positioned on the same side of the pipe for reproducing a complete range of audible frequencies of much better quality than can be realized from a single unit.

With the units placed on opposite sides of the pipe as shown, they may be driven from sources of sound having various phase relationships for use in a large auditorium wherein the auditorium is divided into sections, each section having the same directional effects. Radiator 32 may be located on one side of a division, and radiator 36 on the other, each having an individual and distinct input. Such an auditorium system is disclosed in my copending application Serial No. 453,003 filed May 16, 1930.

In Fig. 4 another modification of a sound reproducing system is disclosed. The driving units 40 and 41 may be the same as the unit shown above in Fig. 3, the double driving units being placed at the extremities of a pipe 42, and energized over conductors 48 and 49, respectively. The acoustic radiation of this system is somewhat different from that of the others shown above. A tensioned wire 43 is connected to alternate internal diaphragms 44, and a tensioned wire 45 is connected to alternate internal diaphragms 46 and 47. The driving wire 43 passes through diaphragms 46 and 47 and the driving wire 45 passes through the diaphragm 44 without any connection between the respective wires and diaphragms. Sound is produced within the pipe by the respective diaphragms and propagated through holes 50 in the pipe which have a horn shaped extension 51 for obtaining a directional effect. The alternate diaphragms may be driven from two units which are resonant in different portions of the audio range, each of which will produce in alternate diaphragms high quality reproduction at that particular frequency. The two portions of the band being reproduced will combine within the respective sections and be projected outwardly through the horns 51. To obtain the proper elasticity and damping effect of the diaphragms, springs 53 are shown on opposite sides of the diaphragms as a fastening means. These springs may be of the coil type or may be in the form of felt washers or layers of paper.

Fig. 5 shows a form of sound radiator of the fan-shaped type in which a paper has been folded and compressed along one edge to a point which is attached to a driving wire 55. Four sections 56, 57, 58 and 59 have been brought together in this manner and disposed around the wire to form the four-sectional radiator, as shown.

In Fig. 6 a cup-shaped radiator is shown which is connected to a driving wire 60 by a lock collar 61. This radiator has a flat diaphragm 62 which is common to both cup-shaped portions 63 and 64. This type of radiator is especially desirable for use without the pipe construction, while the radiator of Fig. 5 may be used with a pipe which has been cut away to permit access to the wire at four points. The pipe will pass through the serrated portions of the radiator.

In using a system as above disclosed in an auditorium, they may be constructed in lengths of 10, 20 or 50 feet, and laid along the floor, under the seats, along the wall edges or along the upper corners of the auditorium, with the sound radiators extending into the room. For outdoor use they may be positioned on standards or laid along the ground in a radial direction from the source of sound. By having compound units spatially disposed to form listening areas separating various sections, the series of radiators on one side of the pipe may be projecting sound in one phase, while those on the other side of the pipe may be projecting sound of a different phase. The compound driving unit may also be projecting sound into the same area, different groups of radiators projecting different ranges of frequencies within the audible band.

Although this invention has been disclosed in one particular embodiment, it is to be understood that it is adaptable to systems within the scope of the appended claims.

What is claimed is:

1. In a sound reproducing system, a pair of oppositely disposed electrical driving units having movable members, means for mechanically connecting said members, and means connecting said units for tensioning said mechanical connecting means, said tensioning means enclosing said connecting means.

2. In a sound reproducing device, a plural-electrical driving unit having two sections each responding to a different range of frequencies, means for radiating sound waves having frequencies lying in the ranges to which said sections are responsive, means for actuating said radiating means from each of said units, and means for enclosing and tensioning said radiating means.

3. In a sound reproducing device, two electrical driving units oppositely disposed, an armature for each of said units, means for connecting said armatures, said armatures being driven in synchronism, a hollow cylindrical member separating said units and containing said connecting means, and means within said cylindrical member attached to said armature connecting means for transforming mechanical vibrations into sound waves.

4. In a sound reproducing device, a plurality of electrical driving units positioned apart from one another, an armature for each of said units, a mechanical connecting member between said armatures of said units, a hollow connecting member between said units for tensioning said connecting means, and means within said hollow member and projecting through openings therein for transforming mechanical vibrations into sound waves.

5. In a sound reproducing device, a plurality of electrical driving units positioned apart, an armature in each of said units, a mechanical connecting means between said armatures, said units being connected to drive said armatures in synchronism, a hollow member separating said units and containing and tensioning said connecting means, armatures positioned within said hollow member and attached to said mechanical connecting means, and radiating members attached to said armatures extending through said hollow member for transforming mechanical vibrations into sound waves.

6. In a sound reproducing device, a pair of electrical driving units positioned apart and adapted to operate in synchronism, a hollow rigid member for varying the distance between said units, an operating diaphragm at each of said units, mechanical means for connecting said diaphragms, said means being tensioned by said hollow rigid member, and means extending through openings in said rigid member and attached to said mechanical connecting means for transforming mechanical waves into sound waves.

7. In a sound reproducing device, a plurality of oppositely disposed electrical driving units, an armature for each of said units, means for connecting said armatures, a hollow rigid member separating said units and containing said connecting means, a plurality of diaphragms equally disposed within said hollow member and alternately attached to said connecting means, said diaphragms transforming mechanical waves into sound waves and forming air chambers therebetween.

Witness my hand this 14th day of May 1930, at Newark, in the county of Essex, and State of New Jersey.

ALEXANDER McLEAN NICOLSON.