April 19, 1938. A. N. GOLDSMITH 2,114,680

SYSTEM FOR THE REPRODUCTION OF SOUND

Filed Dec. 24, 1934

Fig. 2

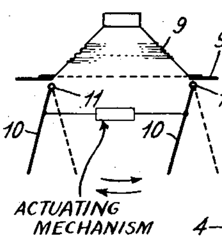


Fig. 1

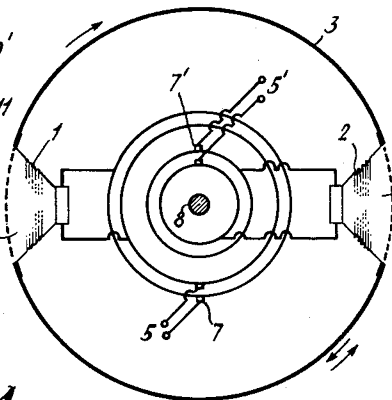


Fig. 3

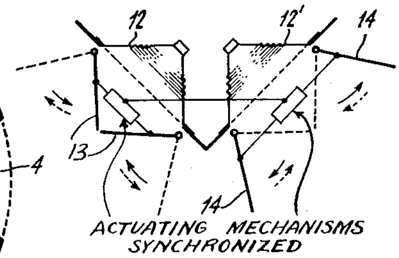


Fig. 1A

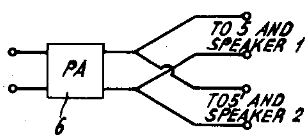


Fig. 1B

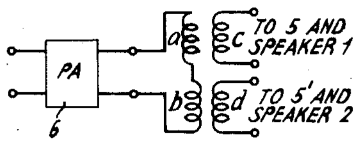


Fig. 1C

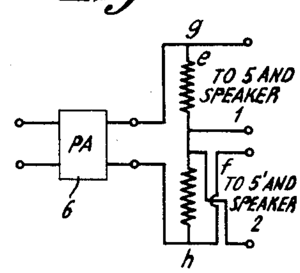


Fig. 4

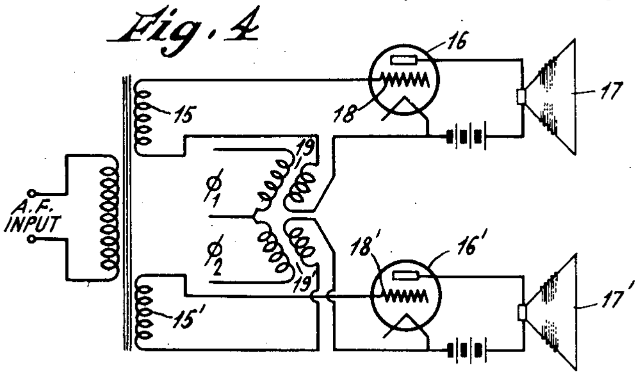


Fig. 4A

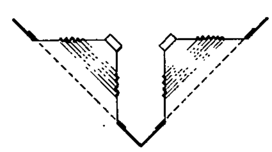


Fig. 4E

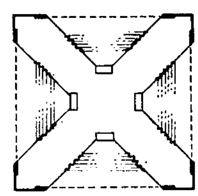


Fig. 4B

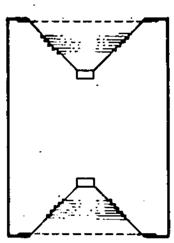


Fig. 4C

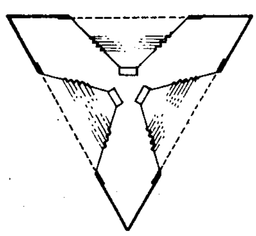
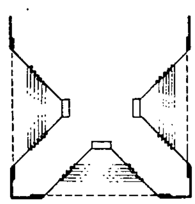


Fig. 4D



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UNITED STATES PATENT OFFICE

2,114,680

SYSTEM FOR THE REPRODUCTION OF SOUND

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Application December 24, 1934, Serial No. 758,888

10 Claims. (Cl. 179—1)

This invention relates generally to sound reproduction systems such as may be employed in radio receiving apparatus, electric phonographs, sound motion pictures and the like, and more particularly to methods and means for simulating at the sound output, as of a radio receiver, a large-area source of sound such as utilized at the sound input, as for example, the studio of a broadcasting station.

At the present time there are arranged at the transmitting station one or more microphones for picking up programs which originate from a large-area source of sound such as from an orchestra, while at the receiving set there is employed a loudspeaker or other suitable sound reproducer which is practically a point source of sound. With the use of such speakers the room reflection gives rise to wave patterns and an acoustic effect which, except in the case of speech, differs noticeably from that experienced by a listener in an auditorium in which an orchestra is playing. It is being recognized more and more that sound which comes from a sharply defined source has a peculiarly unnatural attack on the psychology of the listeners. I propose therefore in some fashion to make it more difficult or impossible to localize the source of sound in the loudspeaker of the receiver, so that the effect on the home listener of a musical rendition would be that it came from an area source, with a resulting increase in naturalness.

The idea underlying the invention is to have the usual wave patterns and sound-energy distribution in the room broken up and altered by an "averaging effect" produced by shifting the direction in which the reproduced sound enters the room, the shifting being cyclic, and for example, at a suitable sub-audible rate. Generally this may be accomplished by having two or more loudspeakers mounted on a turntable, with connections through slip rings, and the assembly rotated. If the two or more speakers always face in different directions, it is conceivable that the effect of the motion of the speakers would be to give the listener the impression that the sound was emanating from a source of large area. Another method for carrying out the invention consists in providing a multiplicity of speakers which face in different directions and commutating them into and out of the circuit in a cyclic or reciprocating way, and preferably at a sub-audible frequency.

It is therefore one of the objects of the present invention to produce at the receiver an effect which would simulate a large-area source rather than a point-source of sound, thereby rendering more natural the received program.

Another object is to produce such effect either mechanically or electrically.

A further object of the invention is to prevent the localization of the sound emanating from a loudspeaker and to transform the localized sound to a sound-source of large area.

Other objects and advantages will become apparent from the following detailed description when taken together with the accompanying drawing wherein Fig. 1 discloses one embodiment of the invention, Figs. 1A, 1B and 1C show different modes of connection for the loud-speakers of Fig. 1 to a power amplifier, Figs. 2 and 3 show other modifications according to the invention, Fig. 4 shows an electrical circuit for obtaining the desired results, and Figs. 4A to 4E inclusive illustrate different loudspeaker arrangements of two or more speakers capable of use in the modifications shown in Figs. 1 and 4.

Referring to Fig. 1, two loudspeakers 1 and 2 are arranged to face in opposite directions, that is, 180 degrees apart, and are mounted within an enclosure 3 which may be cylindrical or of other suitable shape. It will be obvious, of course, that as many speakers may be employed as desired, so that for example, when three speakers are employed, they will be disposed 120 degrees apart, and so on. The sound output of these speakers passes through openings 4 in the enclosure which therefore acts as a suitable baffle for the speakers. The output terminals of an audio power amplifier 6 (shown diagrammatically at 6 in Figs. 1A, 1B and 1C) are connected to the speaker voice-coils of 1 and 2 through the brushes and slip-ring connections 7, 7', respectively, the output terminals of power amplifier 6 being adapted to be connected to the brush terminals 5, 5' in one of a number of suitable ways, as shown for example in the Figs. 1A, 1B and 1C.

In Fig. 1A parallel-branched circuits are connected to the output terminals of the power amplifier 6, the terminals of one circuit leading to brush terminals 5, brushes and outer slip rings 7 and then to speaker 1; the terminals of the other circuit leading to brush terminals 5', brushes and inner slip rings 7' and then to speaker 2. In this arrangement the audio-frequency supply to the speakers are in the same phase.

In certain cases it may prove desirable to have the audio-frequency supply fed to the speakers in opposite phase. Arrangements for accomplishing this result are disclosed in Figs. 1B and

1C. In the former it will be noted primaries *a* and *b* are oppositely wound, while the secondaries *c* and *d* are wound in the same direction. Thus speaker 1 receives power in opposite phase to speaker 2. In Fig. 1C the mode of connection of the two speaker-feeding circuits *e* and *f* to the output resistance *g—h* is such that the same result is obtained.

The entire enclosure and speakers of Fig. 1 are rotated or oscillated preferably at a sub-audible frequency by means of the shaft 8 through suitable driving means (not shown). The exact number and arrangement of the speakers is subject to modification, the main purpose being however to modify the sound distribution throughout the room without changing average intensity to an objectionable extent.

In the modification shown in Fig. 2 a stationary speaker 9 is used and sound deflectors 10 are mounted in front of the loudspeaker and its baffle 9'. These are intended to throw a substantial portion of the acoustic output of the speaker in various directions. The deflectors are suitably hinged as at 11 so that they may be swung to and fro and thus alter the direction in which the sound is projected into the room. Preferably these oscillating deflectors operate at a suitable and preferably sub-audible frequency by suitable mechanical or electrical driving means (not shown).

In the arrangement shown in Fig. 3 two component speakers 12 and 12' are disposed in such fashion in order to radiate the sound waves in different directions, although it will be understood that the number of speakers and their angular disposition may be varied to obtain best results. Associated with the speakers 12 and 12' are the swinging deflectors 13 and 14, respectively, similar to the deflectors of Fig. 2 and which direct the sound radiation to and fro as described. However, the shutters 13 and 14 respectively are so interconnected mechanically or electrically by suitable means (not shown) that, when one pair is open, the other is shut. That is, they swing open and shut 90 degrees out of phase and as a result the output of each of the speakers reaches the room cyclically.

Fig. 4 illustrates an electrical method of securing equivalent results. The audio frequency signal obtained from the usual audio frequency amplifier is fed through the transformer secondaries 15 and 15' to two output tubes 16 and 16', which in turn feed loudspeakers 17 and 17'. These speakers are so mounted that they project sound into a room in such fashion as each to cause a different wave pattern or sound energy distribution in the room. Several speaker arrangements are shown in Figs. 4A to 4E and will be more specifically referred to below. Applied to the grids 18 and 18' of the output tubes through the transformers 19, 19' are auxiliary alternating voltages, preferably of sub-audible frequency. The magnitude of said auxiliary voltages is sufficient to vary the output of the corresponding tubes from a suitable maximum to approximately zero once during each cycle. That is, when the alternating voltage applied to the grid is negative, the output is approximately zero, and when the alternating voltage applied to the grid results in a positive maximum the output of the tube is normal (that is, a desired maximum). The voltages applied to the grids of the two tubes have a phase difference such that the output of one tube is a maximum when the output of the other tube is a minimum. It will be understood that when only two speakers are used the voltages applied to the grids are 180 degrees out of phase. These can readily be obtained from a single transformer with two secondaries suitably connected into the respective grid circuits. It follows that for three speakers, three-phase voltages 120 degrees apart would be applied to the grids of the three corresponding output tubes, and so on. The net result of such arrangement is that the source of sound in effect shifts from speaker 17 to speaker 17' and back at a frequency equal to that of the applied alternating grid voltage.

I do not desire to be limited to any specific spacial arrangement or interrelation of the various component speakers, and accordingly show in Figures 4A, 4B, 4C, 4D, and 4E various alternative spacial arrangements of the speakers, whether two or more are used.

In Figures 4A and 4B, two possible arrangements of two speakers are shown. In Figure 4A, the two speakers are so arranged as to radiate primarily in directions at right angles to each other; in Figure 4B they are arranged to radiate principally in opposite directions. It might prove desirable, for example, to use the arrangement of Figure 4A against a room wall or in a room corner, and to use the arrangement in Figure 4B for speakers located in a room and spaced from the walls thereof. However, I do not wish to be restricted to any particular mode of use or location of the speakers as shown but merely show these alternative arrangements to indicate that speaker directional characteristics and room acoustics may favor one or the other arrangement.

In Figures 4C and 4D are similarly shown arrangements for three loudspeakers in each instance; in one case, the speakers radiate principally in directions inclined to each other at 120 degrees, while in the second-mentioned case, the directions are inclined at 90 degrees to each other. In Figure 4E is shown an arrangement for four speakers, radiating primarily in directions inclined at 90 degrees to each other.

What I desire to accomplish is, by spacial and directional diversity of the radiation of the various component speakers, to create in each case (and to the maximum extent consistent with the directional radiation characteristics of the speakers and the acoustics of the speaker-containing room or chamber), the greatest possible difference between the acoustic radiation distribution of each speaker and that of all the others so as to simulate, so far as possible, a large-area source of sound. The exact arrangement of the speakers meeting this condition cannot be specified precisely in advance, depending among other things upon the size and configuration of the room; the several Figs. 4A to 4E are therefore to be taken only as illustrative.

It will also be understood that not only may the component speakers be arranged so that their acoustic radiations shall issue in different azimuths, but they may also be arranged to issue in different inclinations, or both.

It is to be understood that although I have illustrated and described several forms of my invention, the invention is not to be thus limited, but only in so far as defined by the scope and spirit of the appended claims.

What I claim is:

1. A sound reproducing system comprising a plurality of sound reproducers constructed and arranged to emit sound in different directions, energizing means therefor, and means for cy-

clically varying the direction of the emitted sound from each of said reproducers, said cyclically sound varying means comprising a plurality of synchronously movable sound deflector plates.

2. A sound reproducing system comprising a plurality of sound reproducers constructed and arranged to emit sound in different directions, energizing means therefor, a pair of sound deflector plates associated with each of the reproducers, the deflector plates of each pair being movable in synchronism with respect to the plates of the other pairs.

3. A system according to claim 2 wherein the sound deflector plates are so controlled that as one pair of plates is closed, another pair is open.

4. A sound reproducing system comprising a plurality of stationary sound reproducers radially spaced in a horizontal plane and arranged to emit sound in different directions, energizing means for said reproducers, and means cooperating with each reproducer for automatically cyclically varying the intensity of the sound emitted therefrom, said intensity varying means of the several reproducers operating out of phase with one another.

5. A sound reproducing system comprising a plurality of sound reproducers radially spaced in a horizontal plane and each adapted to emit sound in a different direction, an enclosure for all said reproducers which also serves as a common baffle, and means for rotating said sound reproducers and their enclosure as a unit about a vertical axis.

6. A sound reproducing system for cyclically varying the direction of sound radiation, comprising a loudspeaker positioned to normally radiate sound in a given direction, and a pair of cooperating deflector plates hinged adjacent the loudspeaker diaphragm periphery at opposite points thereof and movable in synchronism whereby sound radiation from said loudspeaker is cyclically varied in directions on either side of the normal given direction.

7. A sound reproducing system according to the preceding claim wherein a cyclical variation in direction occurs at a sub-audible frequency.

8. A sound reproducing system for cyclically varying the intensity of sound radiation in a plurality of different directions, comprising a plurality of loudspeakers positioned to normally radiate sound in different directions, a pair of cooperating deflector plates hinged adjacent the diaphragm periphery of each loudspeaker at opposite points thereof and movable in synchronism, the movement of one pair of deflector plates being synchronized with respect to another pair so that when the deflector plates of one pair are positioned to permit maximum radiation from their associated loudspeaker, the deflector plates of another pair are positioned to permit minimum radiation from their associated loudspeaker, and vice versa.

9. A sound reproducing system comprising a multiplicity of vacuum tube amplifiers, a multiplicity of spacially separated loudspeakers each being fed from the output of one of the amplifiers, means for controlling the amplification of each amplifier in a cyclic manner, said means including a multi-phase voltage source.

10. A sound reproducing system comprising a source of audio signals, a multiplicity of parallel channels each including a vacuum tube amplifier fed from said signal source, a multiplicity of loudspeakers constructed and arranged to emit sound in different directions, each of said loudspeakers being fed from the output of one of the amplifiers, means for controlling the amplification of each amplifier in a cyclic manner, said means including a multi-phase voltage source.

ALFRED N. GOLDSMITH.