June 28, 1938. L. F. SAVAGE ET AL 2,122,010

SYSTEM FOR THE RECEPTION AND REPRODUCTION OF SOUND

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Fig.1.

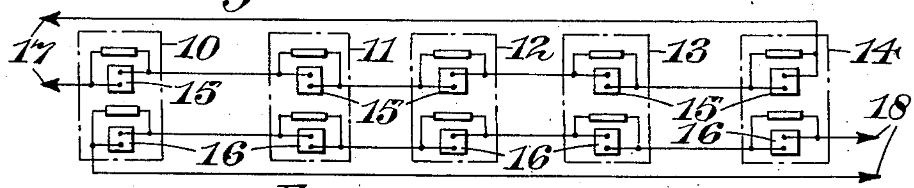

Fig.2.

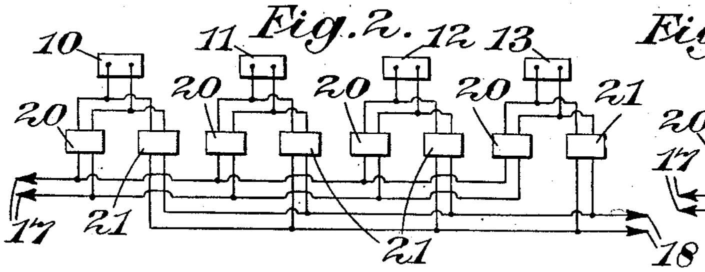

Fig.3.

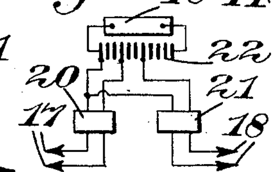

Fig.4.

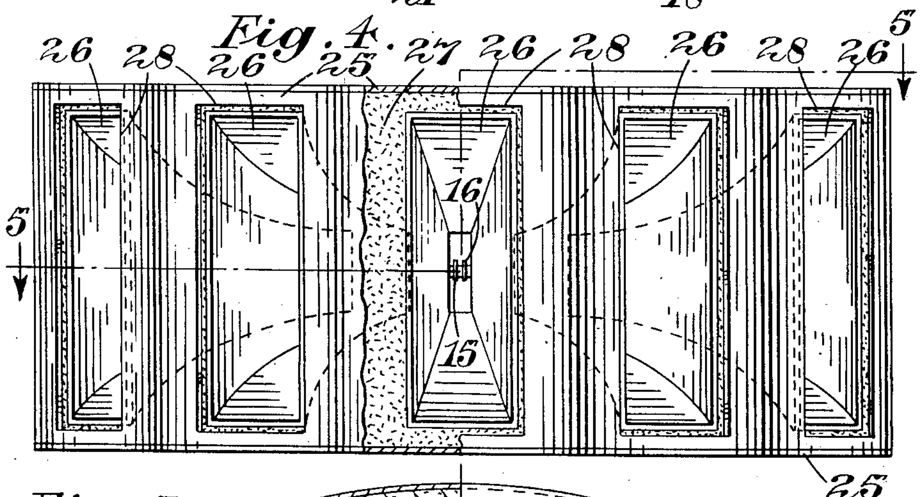

Fig.5.

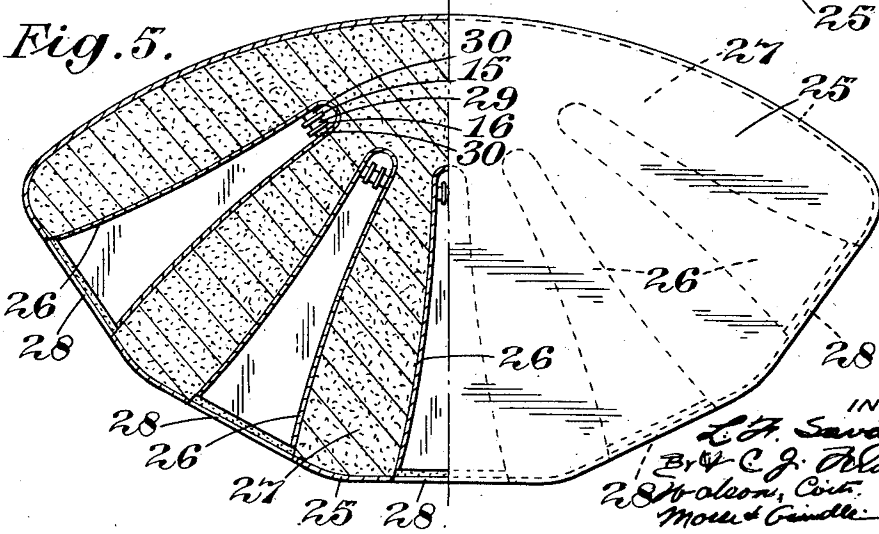

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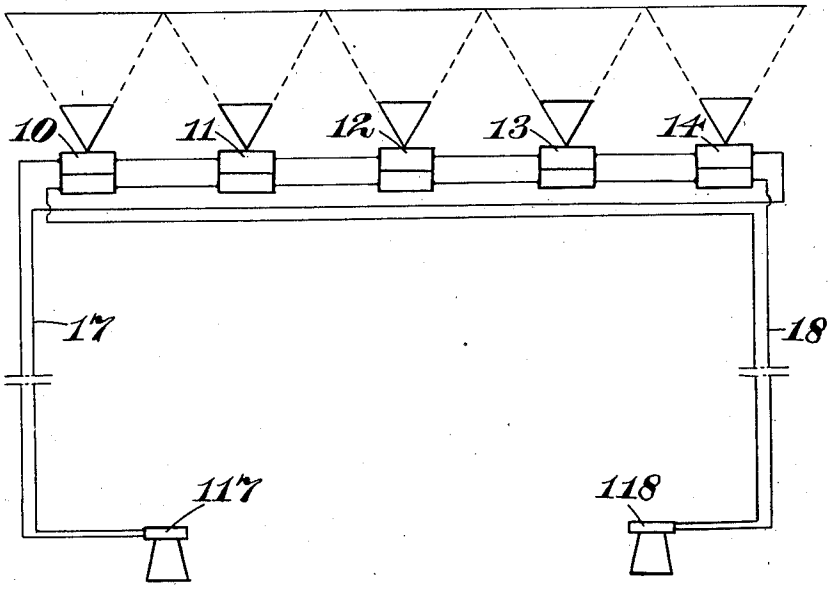
Fig. 6.



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Patented June 28, 1938 2,122,010

UNITED STATES PATENT OFFICE

2,122,010

SYSTEM FOR THE RECEPTION AND REPRODUCTION OF SOUND

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Application September 8, 1937, Serial No. 162,932
In Great Britain July 23, 1936

10 Claims. (Cl. 179—1)

This invention relates to systems for the reception and reproduction of sound such as to provide upon reproduction a binaural realization comparable with the binaural realization at the first instance. The invention is concerned with such systems of the kind in which a plurality of sound responsive devices is arranged to be differently responsive to a sound source depending on the position of this source within a given stage, the resulting signals being transmitted from the sound responsive devices through independent channels to means for the reproduction of the sound or for the recording of the sound for subsequent reproduction, by means of a plurality of reproducing devices, arranged to provide a sound distribution which is similar to the original sound distribution.

Such systems as heretofore proposed have not been wholly satisfactory in practice, with the result that the reproduction of the sound which occurred at the centre of the stage cannot easily be located by a listener to the reproduced signals, and the apparent width of the stage is restricted and its margins indeterminate from the point of view of the listener. Also the proportion of direct sound to indirect sound received is necessarily low. Moreover, most stages have different acoustics at points even a few feet apart and this also tends to increase the difficulty of obtaining satisfactory reproduction. It will be understood that by the term "stage" is meant in addition to the stage or platform of a theatre, any area within which sounds originate, which sounds are to be reproduced with binaural realization.

The present invention comprises a system of the kind referred to, wherein there is provided a plurality of sound responsive devices each having a restricted angular field and arranged in front of the stage to provide an overall response through a given angle greater than that of an individual sound responsive device.

Further, according to the present invention, there is provided a system of the kind aforesaid and comprising a plurality of sound responsive devices which are individually responsive substantially only to sounds originating in different parts of the stage, and means combining the resulting signal energy from the sound responsive devices in selected different proportions for transmission along each of two or more independent communicating channels.

According to another feature of the invention the sound responsive devices aforesaid are grouped together to form a single unit. The sound responsive devices thus formed as a unit may be transported and positioned as required with respect to the stage as easily as the simple microphone. In order to ensure that each sound responsive device is operative for only a part of the stage means such as horns or reflectors are conveniently employed for restricting the field of the sound responsive devices and preferably the unit device aforesaid comprises the combination with each sound responsive device of sound-directive means such as a horn for each sound responsive device and a non-resonant housing enclosing the sound responsive devices and their sound-directive means to form the single unit.

According to yet another feature of the invention each sound responsive device comprises a plurality of individual microphone elements connected in circuit for the communicating channels respectively. For instance, each sound-responsive device may consist of two microphone elements, one element to each sound responsive device being connected to one communication channel and the other element of each sound responsive device being connected to a second communication channel. In a preferred arrangement five sound responsive devices are employed and the total outputs of the outer sound responsive devices are applied respectively to different communicating channels. Alternatively, each sound responsive device may be connected for output to two or more communication channels through irreversible conducting devices such as thermionic valves and conveniently the irreversible conducting devices are connected to tappings on a potentiometer, connected across the output of the sound responsive device for the purpose of adjusting the output of each sound responsive device as applied to a given communication channel.

Specific embodiments of the invention, given by way of example, will now be more fully described with reference to the accompanying drawings, in which:—

Figure 1 is a diagram of a system comprising five sound responsive devices applied to two communicating channels;

Figure 2 is a diagram similar to Figure 1 showing an alternative manner of connecting the sound responsive device to two communication channels;

Figure 3 is a diagram showing a modification of Figure 2;

Figure 4 is an elevation partly in section showing a group of sound responsive devices formed as a single unit;

Figure 5 is a section on the line 5—5 of Figure 4, and

Figure 6 is a general diagram of the system of sound reception and reproduction.

Referring to the drawings, there is preferably employed an odd number of sound responsive devices and for example there are five such devices indicated at 10, 11, 12, 13 and 14 in Figure 6. These sound responsive devices are arranged in front of the stage A and it will be understood that the sounds to be reproduced may originate at any part of the stage and the sound sources may in addition move from one position to another across the stage. The stage is considered as being divided into a plurality of zones corresponding to the number of sound responsive devices and for a theatre or like stage these zones are contiguous with one another. These zones are conveniently of approximately equal angular width, although they may in some circumstances be of different width. The sound responsive devices 10, 11, 12, 13 and 14 are allocated respectively to the zones of the stage and each sound responsive device is arranged to be responsive substantially only to sound originating in the appropriate zone of the stage. In order to assist in rendering the sound responsive devices thus directive, means such as horns or baffles or reflectors, may be employed for each sound responsive device so arranged as to ensure that, as far as possible, only those sounds originating in a given zone of the stage produce any appreciable effect on the sound responsive device allocated to that zone. The sound responsive devices 10, 11, 12, 13 and 14 may be separately arranged in front of the stage or alternatively, grouped together as a unit, as hereinafter described. The output from the sound responsive devices is applied in appropriate proportion to two independent communication channels represented by the conductors 17 and 18 respectively which feed two loud speakers 117 and 118 arranged for reproduction of the sound with binaural effect.

Referring now more particularly to Figure 1, each of the sound responsive devices comprises two microphone elements 15 and 16. The microphone elements 15 of the sound responsive devices are connected in series for application of their electrical output to one communication channel represented by the conductors 17. Similarly the microphone elements 16 of the sound responsive devices are connected in series for the application of the electrical output of these microphone elements to a second communication channel indicated by the conductors 18. The two microphone elements 15 and 16 of the central sound responsive device 12 are arranged to provide equal outputs to the two communication channels. For the sound responsive device 11 the microphone element 15 is arranged to provide an output to the communication channel 17 which is somewhat greater than that applied to the communication channel 18 by the microphone element 16 and conversely in the sound responsive device 13 the microphone element 16 provides a greater output to the channel 18 than does the microphone element 15 to the channel 17. Also, the microphone element 15 of the sound responsive device 10 is arranged to supply a much greater output than the associated element 16 and conversely in the sound responsive device 14, the microphone element 16 provides a much greater output than the element 15. The useful output from the microphone elements may be controlled by means of shunts indicated at 19, the value of which is selected according to the balance required between the microphone elements of each sound responsive device and between the sound responsive devices themselves in any given circumstances. It is generally found in practice that no output is required from the microphone element 16 of the sound responsive device 10 and the microphone element 15 of the device 14, so that these microphone elements may be dispensed with.

Instead of utilizing separate microphone elements in each sound responsive device a single microphone may be used, the output of which is appropriately proportioned between the two communication channels in the manner above indicated, depending upon the zone of the stage to which any given sound responsive device is allocated. As shown in Figure 2, the total output of the sound responsive devices 10, 11, 12, 13 and 14 is in each case fed to two thermionic valve amplifiers 20 and 21, the outputs of the amplifiers 20 being connected in parallel for transmission along one channel indicated by the conductors 17 and the outputs of the amplifiers 21 being connected in parallel for transmission by the other channel represented by the conductors 18. The respective outputs from the amplifiers 20, 21 are adjusted according to the required relationship for the two communication channels as described with reference to Figure 1, and for this purpose the input connections for the amplifiers 20 and 21 may be appropriately tapped on to a potentiometer or more complicated electrical network comprising inductance, capacity and resistance, connected across the output of the associated sound responsive device. For example, as shown in Figure 3, there is connected across each of the sound responsive devices 10 to 14, a group of capacities 22 arranged as a potentiometer and the amplifiers 20 and 21 are connected to tappings on this potentiometer to apply the required proportions, and the total output to the communication channels.

It is preferred to form the sound responsive devices 10, 11, 12, 13 and 14 into a single unit and in the construction shown in Figures 4 and 5 there is employed a housing 25 in which are accommodated five sound directive horns 26 spaced apart with their axes lying appropriately in a single plane. The housing 25 is provided with openings 28 coinciding with the outer ends of these horns. These horns 26 are arranged with their inner ends somewhat close together and with their axes diverging towards the outer end of the horns. The space between the individual horns and between the horns and the housing is packed with a sound insulating material indicated at 27.

In each of the horns 26 there are mounted two microphone elements corresponding to microphone elements 15 and 16 in Figure 1. These microphone elements are preferably of the piezo-electric crystal (e. g. Rochelle salt crystal) type, and are arranged within the horn at a position spaced away from its inner end and in such a manner as to offer minimum restriction of the passage through the horn. The microphone elements 15 and 16 are preferably separated by a block of sponge rubber 29 and spaced from the walls of the horns by similar blocks of sponge rubber 30. Although microphone elements of the piezo-electric type are preferred it will be understood that other types of microphone may alternatively be employed in carrying out the invention.

For the reproduction of the signals either directly or following intermediate recording of the

signals, the signals transmitted by the two communication channels are applied to two loud speakers preferably spaced apart, but it is possible to provide two or more loud speakers arranged close together, for example, as a unit which loud speakers are provided with horns, baffles, reflectors or other directional means, such as to provide directional or mutually divergent fields. For instance, when two such loud speakers may be employed, it is preferable to provide a baffle between the loud speakers to prevent undesirable interaction, and the phase of the signal energy applied to the loud speakers is controlled to have the required phase relationship, for example, the same as that of the signals initially applied to the communication channel.

Alternatively, a plurality of loud speakers, for instance, equivalent in number to the sound responsive devices may be employed, in which case the loud speakers may be arranged to be fed from the channels of communication in a manner which is the inversion of that in which the microphones feed the communication channels.

By means of the system according to this invention, the disadvantages of previous systems as hereinbefore referred to are overcome, more especially in that the pick-up of the microphone arrangement is confined to the front and the ratio of direct to indirect sound is high. Furthermore, by the use of a unit device consisting of the several sound responsive devices the system is readily applicable to any stage.

It will be appreciated of course that the sound responsive devices, the communication channels, including amplifiers, loud speakers, and also an intermediate process such as the recording of the signals, shall be such as to maintain the initial identity of the individual sounds. Further, any of the components of the system may be augmented by other similar components in order to provide the required frequency range for the reproduced signals.

We claim:—

1. A system for the reception and reproduction of sound from a sound field, comprising a plurality of similar sound responsive devices, sound directive means associated with each sound responsive device for restricting its field to a part only of the said field, a plurality of sound reproducing devices laterally disposed with respect to the desired virtual source of the reproduced sound, an independent communication channel for each reproducing device for connecting said sound responsive devices thereto and means combining the outputs from the sound responsive devices in different selected intensity proportions progressively decreasing as the response field of each is more remote from the reproducing device representative of that field for transmission along said channels to each of said sound reproducing devices.

2. A system for the reception and reproduction of sound from a sound field, comprising a plurality of laterally disposed sound responsive devices, means rendering said sound responsive devices individually responsive substantially only to sounds originating in different parts of the said field, each of which sound responsive devices comprises a plurality of individual microphone elements, a like plurality of sound reproducing devices, communication channels connecting said sound responsive devices to said sound reproducing devices, means applying the output of one microphone element of each sound responsive device only to one of said channels and means applying the output of another microphone element of each sound responsive device only to a different one of said channels.

3. A system for the reception and reproduction of sound from a sound field, comprising at least five laterally disposed sound responsive devices which are individually responsive substantially only to sounds originating in different parts of the stage, a plurality of sound reproducing devices, communication channels connecting said sound reproducing devices to said sound responsive devices, means for applying the total output of the outer of said sound responsive devices each to a different one of said communication channels, the remaining of said sound responsive devices each consisting of a plurality of microphone elements, means applying the output of one microphone element of each of said remaining sound responsive devices to one only of said communication channels, means applying the output of another microphone element of each sound responsive device to only a different one of said channels and means progressively decreasing the output of said microphones in proportion to the sound volume received thereby as they become more remote from the outer sound responsive device connected to the same channel.

4. A system for the reception and reproduction of sound from a sound field, comprising a plurality of sound responsive devices, means rendering said responsive devices individually responsive only to sounds originating in different parts of the said field, a plurality of sound reproducing means, communication channels allotted one to each reproducing device for applying the output of said sound responsive devices to said sound reproducing devices, a separate irreversible conducting means connected between each channel and each responsive means, said conducting means proportioning the output of each responsive means between its associated channels in accordance with the part of the field to which it is responsive.

5. A system for the reception and reproduction of sound from a sound field, comprising a plurality of sound responsive devices, means rendering said responsive devices individually responsive only to sounds originating in different parts of the said field, a plurality of sound reproducing means, communication channels allotted one to each reproducing device for applying the output of said sound responsive devices to said sound reproducing devices, a potentiometer connected across the output of each sound responsive device and having a tap for each channel, and an irreversible conducting device connected to each tap on said potentiometer for individually feeding it to its corresponding communication channel.

6. A system for the reception and reproduction of sound from a sound field, comprising a plurality of sound responsive devices, means rendering said sound responsive devices individually responsive substantially only to sound originating in different parts of the field, a plurality of sound reproducing devices, communication channels connecting said sound responsive devices to said sound reproducing devices, means for applying the outputs of said sound responsive devices in progressively different relative proportions to one of said channels, and means for applying the outputs of said sound responsive devices in proportions differing progressively in the reverse order to a different one of said channels.

7. A system for the reception and reproduction of sound from a sound field, comprising a plurality of sound responsive devices, means rendering said sound responsive devices individually responsive substantially only to sound originating in different parts of the field, a plurality of sound reproducing devices, communication channels connecting said sound responsive devices to said sound reproducing devices, means for applying the outputs of said sound responsive devices in progressively different relative proportions to one of said channels, and means for applying the outputs of said sound responsive devices in proportions differing progressively in the reverse order to a different one of said channels and means for connecting the communication channels to the said sound reproducing devices in a manner which is the inversion of that in which the output of the sound responsive devices is applied to the communication channels.

8. A microphone unit comprising a housing, a plurality of sound responsive devices in said housing and sound directive means carried by the housing for rendering the sound responsive devices individually responsive over different areas.

9. A microphone unit comprising a plurality of sound responsive devices, a plurality of sound directive horns restricting the field of said sound responsive devices over different areas and a non-resonant housing enclosing said sound responsive devices and said horns.

10. A system for the reception and reproduction of sound from a sound field, comprising a plurality of laterally disposed sound responsive devices, means rendering said sound responsive devices individually responsive substantially only to sounds originating in different parts of the said field, each of which sound responsive devices comprises a pair of individual microphone elements, a pair of sound reproducing devices, means combining the outputs of one microphone of each responsive device for connection to one reproducing device, means combining the outputs of the other microphone of each responsive device for connection to the other reproducing device, the microphones of one set having diminishing outputs from a maximum at one end of the lateral row and the other set being reversely conditioned.

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