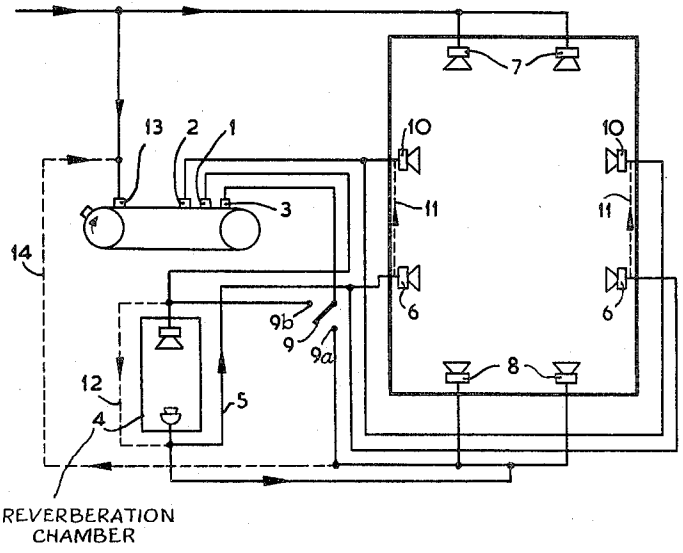
March 6, 1962 D. KLEIS 3,024,309

SOUND REPRODUCTION WITH ARTIFICIAL REVERBERATION

Filed Jan. 14, 1958



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United States Patent Office 3,024,309 Patented Mar. 6, 1962

3,024,309

SOUND REPRODUCTION WITH ARTIFICIAL REVERBERATION

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Filed Jan. 14, 1958, Ser. No. 708,861
Claims priority, application Netherlands Feb. 5, 1957
5 Claims. (Cl. 179—1)

The present invention relates to a method for the spatial reproduction of sound with artificial reverberation with the aid of a number of sound sources acting in part as primary sound sources and in part as secondary sound sources; the secondary sound sources are loudspeakers but the primary sources need not necessarily be loudspeakers. The invention further includes a magnetic delaying device comprising a recording head and a preferably continuous record carrier along which the recording head and a number of reproducing heads are arranged, the latter being connected to the secondary loudspeakers. As is known, this permits individually different delays to be obtained in accordance with the location of the loudspeakers.

Primary sound sources may be, for example, loudspeakers supplied with electrical oscillations from, say a sound record or a sound film, the electrical oscillations then being impressed without time delay by means of the recording head onto the record carrier. Other primary sound sources are, for example, an orchestra, a soloist or the like. The sound oscillations supplied by these sources can also be impressed by means of one or more microphones onto the carrier through the recording head without time delay.

The method according to the invention has the feature that the reverberation is at least substantially produced by means of a multidimensional reverberation device taken up in the channel of one of the reproducing heads, preferably the channel involving the longest delay; where the reverberation is not produced exclusively by the reverberation device, it is completed by coupling back the signal produced by the delaying device to the recording head, the back-coupling channel being kept separated from the channel comprising the multidimensional reverberation device. Said multidimensional reverberation device may, for example, be a reverberation chamber or a unilaterally supported plate of a material having little internal damping, for example a steel plate, which is driven at one point by the sound vibrations and scanned elsewhere.

The method according to the invention has the advantage that a greater number of reflections can be simulated per unit time, as compared with the result obtained by back-coupling of the signal of one reproducing head, as is customary. This result is moreover obtained in a comparatively simple manner. When using a reverberation chamber, as an example of multidimensional reverberation device, as will preferably be the case on account of its simplicity, the following possibilities are realized.

Since the reverberation device is provided only in the channel of one of the reproducing heads, preferably the last, one or more preceding reproducing heads permit the so-called primary reflections—those without reverberation—to be simulated; these primary reflections, as is known, determine the size of the virtual reproducing space for the hearer, this being the space suggested acoustically. If the reverberation is exclusively produced by means of a reverberation chamber having such a size as to imitate a number of reflections sufficient for the required reverberation throughout the frequency range to

be transmitted, it is necessary to choose the smallest dimension of the chamber such that it exceeds at least several times the wave length of the lowest frequency of the range. Alternatively, of course, the reverberation need not be exclusively produced by the reverberation chamber but in part also by said back-coupling of the signal produced by the delaying device to the recording head. In order to avoid undue emphasis of given frequencies of the spectrum with the device for one of these frequencies becoming unstable, the back-coupling channel should be kept separated from the channel comprising the reverberation chamber.

Should the optimum dimensions of the reverberation chamber be impracticably large and a chamber having a comparatively small size were to be used, for example having a volume of 0.5 m.^{3} then, in the method according to the invention, only that part of the frequency spectrum to be transmitted is sent through the reverberation chamber which exceeds a given limiting frequency for which the aforesaid relation between wave length and size holds. For a chamber having a volume of approximately 0.5 m.^{3} said limiting frequency will be approximately 1000 c./s.

If using a comparatively small reverberation chamber were used without the precaution mentioned above, the whole frequency spectrum would be sent through the chamber and the troublesome so-called coloration effect would occur, that is to say that the simulated reflections in the range of the low frequencies would in respect of time be spaced too widely apart and be too strongly audible.

As regards the frequencies below the limiting frequency the signals may either be transmitted without reverberation or, after the required delay, be fed back to the recording head, similarly to the first-mentioned case. Again, the back-coupling channel and the channel of the reverberation chamber should be separated from each other.

The back-coupling has the advantage that the reverberation time determined by the multi-dimensional reverberation chamber can be increased to any extent desired. This is of importance if the reverberation device alone would yield too short a reverberation time either on account of its nature or due to its preferably rather small size.

In order that the invention may be readily carried into effect, an example will now be described in detail with reference to the accompanying drawing in which the invention is shown as comprising three reproducing heads with the reverberation device being inserted in the circuit of one of the reproducing heads. In this arrangement a reverberation chamber **4** is inserted in the circuit of the reproducing head **1** yielding a time delay between the delays caused by adjacent heads **2** and **3**. The oscillations produced with reverberation by this device are supplied over a line **5** to a pair of secondary loudspeakers **6** emitting the sound with the same delay as that of the sound reproduced by the primary loudspeakers **7**. This delay is less than that associated with the secondary loudspeakers **8** connected to the reproducing head **3**, if a switch **9** is closed through a contact **9***a*, and exceeds the delay associated with the pair of secondary loudspeakers **10** connected to the reproducing head **2**.

The signal fed to the loudspeakers **6** may also be supplied to the pair of loudspeakers **10** with the shorter delay. This may be effected by connecting each loudspeaker **6** over a lead **11** to a loudspeaker **10**.

The device further permits the switch **9** to be closed through contact **9***b*, which results in the reverberation chamber also being included in the circuit of the reproducing head **3**. As a result the loudspeakers **8** involving

the longest delay will also reproduce the sound with reverberation. In this case also the oscillations with the greatest delay may be emitted by the loudspeakers **6** and **10** so that the sound reproduced by the latter also has a reverberation effect. For this purpose, an additional lead is required between the loudspeakers **8** and **6**. In this instance, the lead **5** to the loudspeakers **6** is superfluous. The device will preferably be used in this way, since it is the relatively simplest way to make all the secondary loudspeakers emit the sound with reverberation.

The whole frequency spectrum can be sent through the reverberation chamber **4** but it is not necessary to effect this with the maximum energy. In the last-mentioned case, it is possible to connect a lead in parallel with the reverberation device (broken line **12**).

If only frequencies exceeding a given limiting frequency for example 1000 c./s. are sent through the reverberation chamber, it is possible for the frequencies below the limiting frequency to be coupled back to the recording head **13** (broken line **14**) as a signal of one of the reproducing heads, for example that of the head **3** having the longest delay on closing the switch **9** via the contact **9***a*. From this it is seen that the back-coupling channel is kept separated from the channel comprising the reverberation chamber **4**.

If the frequencies below said limiting frequency are not coupled back, since it is not deemed necessary to reproduce them with reverberation, it will again be possible to use the parallel lead **12**.

For the sake of simplicity, the amplifiers required at several points of the system, which amplifiers permit intensity control of the signals, and the filters permitting frequency separation, have been omitted.

What is claimed is:

1. Apparatus for the spatial reproduction of sound with artificial reverberation in an auditorium or similar enclosure, comprising a source of sound signals, means for producing said sound signals without time delay in said auditorium, delay means for delaying in time said sound signals, a reverberation chamber for reverberating said delayed sound signals, and means for reproducing said reverberated delayed sound signals in said auditorium.

2. Apparatus for the spatial reproduction of sound with artificial reverberation in an enclosure, comprising a source of sound signals, means for producing said sound signals without time delay in said enclosure, delay means for delaying said sound signals in time relative to the undelayed signals, a reverberation chamber for said delayed sound signals, said chamber comprising an enclosed space containing a reproduction device fed with said delayed signal and a pick-up device, and loudspeaker means in said enclosure for reproducing the signal carried by said pick-up device.

3. Apparatus for the spatial reproduction of sound with artificial reverberation in an enclosure, comprising a source of sound signals, means for reproducing said sound signals in said enclosure without time delay, delay means for delaying in time said sound signals, said delay means constituting an endless magnetic tape having a recording head supplied with said undelayed sound signals and a plurality of reproducing heads, each of said reproducing heads being coupled to reproduction means in said enclosure, and a reverberation chamber interposed between one of said reproducing heads and said reproduction means.

4. Apparatus as set forth in claim 3, wherein said chamber constitutes an enclosed space containing a loudspeaker and a microphone, said loudspeaker being fed with signals from said one reproducing head, said microphone being connected to said reproduction means in said enclosure.

5. Apparatus for the spatial reproduction of sound with artificial reverberation in an enclosure, comprising a source of sound signals, means for reproducing said sound signals in said enclosure without time delay, an endless magnetic tape for delaying said sound signals, said tape having associated therewith a recording head supplied with said undelayed sound signals and a plurality of reproducing heads, each of said reproducing heads being coupled to reproduction means in said enclosure, and a reverberation chamber interposed between one of said reproducing heads and said reproduction means, said chamber constituting an enclosed space containing a loudspeaker and a microphone, said loudspeaker being fed with signals from said one reproducing head, said microphone being connected to said reproduction means in said enclosure, and means for feeding back the delayed signal from another of said reproducing heads to said recording head.

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