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ARTIFICIAL REVERBERATION CONTROL APPARATUS

Filed Feb. 26, 1959

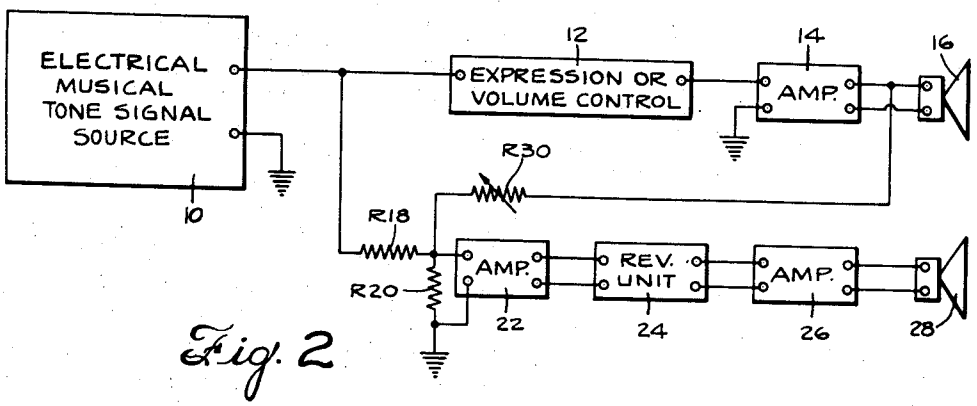



Fig. 2

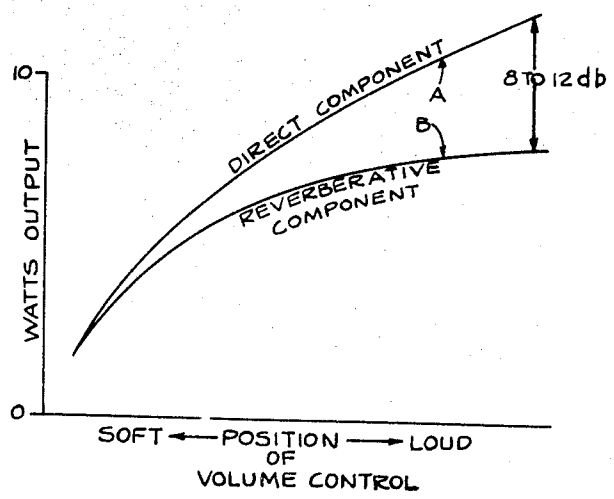



Fig. 1

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# ARTIFICIAL REVERBERATION CONTROL APPARATUS

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6 Claims. (Cl. 84—1.24)

The invention relates generally to a means and method for improving the degree of reverberation of a musical tone signal as heard by the listener.

It is well understood by musicians that when music is played softly it is most pleasantly heard in a room having a considerable reverberation time. When music is played at low sound level in an acoustically "dead" room, the reverberative sound is of such low intensity that it is substantially at the lower limit of audibility. On the other hand, if music is played loudly in a highly reverberative enclosure the frequency upsets introduced by the reverberation are much too pronounced and the reverberated sound of one note tends to overlap the sound heard directly from the source, and thus gives the effect of "mushiness," that is, sound of the pitches of succeeding tones in a musical selection may produce a discordant effect due to this overlapping in time of the direct and reverberated sounds of different pitch, with the result that the music lacks clarity and incisiveness.

Many musical selections, particularly when played by symphony orchestras, are intended to be rendered with large changes in intensity in different portions or movements, or even in individual notes. As a result of these factors, orchestral halls and auditoriums are designed as a compromise between a highly reverberative and a relatively non-reverberant enclosure, and even in such enclosures people who have musically experienced and sensitive ears tend to select seats at medium distance from the orchestra and from the walls of the enclosure.

It is the object of the invention to provide means for producing music with a relatively long reverberation time when soft music is being played but in which the reverberative content of the sound as heard by the listener is substantially reduced in intensity and duration when music is being played loudly.

In electrical musical instruments in which a direct signal and a signal with reverberation are supplied to the output system through a common volume and expression control device, the music produced at high intensity levels has the same effect on the ear as if the music were played in a large hall but, in addition, due to the frequency upsets some frequencies will be at a relatively high amplitude and will tend to be distorted in transmission through the amplifier and speaker. Increasing the maximum wattage of the amplifier and speaker is a method of partially overcoming this undesirable effect when the direct and reverberated signals are transmitted and sounded at a high intensity level, but this is only a partial remedy for the above mentioned undesirable features when the music is played loudly.

Other objects will appear from the following description, reference being had to the accompanying drawing in which:

Fig. 1 is a chart illustrating the objects and results of the invention; and

Fig. 2 is a schematic wiring and block diagram of an output system for an electrical musical instrument.

Referring to Fig. 1, the vertical coordinate (ordinate), in this case represents the output in watts, on a logarithmic scale, and the horizontal coordinate (abscissa) represents the relative position of the swell pedal of an electric organ, or output voltage of some other musical signal source. Curve A represents the "direct signal" and is approximately a straight line, while the curve B represents the reverberative portion of the signal. These curves show that at low wattage output the intensity of reverberative component rises generally as the intensity of the direct component, but that as the output voltage of the signal source increases to an extent to make the sound "loud" the reverberative component changes little in intensity. At the maximum output voltage of the source, or the maximum open position of the swell pedal, the intensity of the reverberative component of the sound is approximately 8 to 12 db (decibels) lower than that of the direct signal.

Means for causing such deviation in intensity of the reverberative component relative to the direct component of music produced at different intensities is shown in Fig. 2. In this figure an electrical musical tone signal source **10**, such as an electric organ, or the like, is connected to an expression or volume control device **12** and the output of the latter is coupled to an amplifier **14** which feeds a speaker **16**.

In addition, however, a signal from the source is impressed across series resistors **R18** and **R20**. An amplifier **22** has input terminals connected across the resistor **R20**. The output of the amplifier is coupled to a reverberation unit **24** whose output is in turn coupled through an amplifier **26** to a speaker **28**. Furthermore, a signal derived from the output of the amplifier **14** is transmitted through a variable impedance device, such as a resistor **R30**, to the input of the amplifier **22**. Thus, a controllable amount of the direct signal, of amplitude as modulated by the expression control, may be added to the signal supplied to the reverberation unit. Because the signal supplied to the amplifier **22** directly from the source is of relatively constant amplitude, the intensity of the reverberative component supplied to the speaker **28** would be relatively constant irrespective of the position of the expression or volume control device if it were not supplemented by the signal supplied through resistor **R30**. Therefore, as the volume or intensity of the music is increased by operation of the volume control, the intensity of the output of the speaker **16** will change correspondingly, but the input to the reverberative channel leading to speaker **28** will increase at a lower rate, and the reverberative component of the music will not increase in intensity in the same manner as the intensity of the non-reverberative component transmitted directly from the source. The output of the amplifier **14** for the direct component adds to the direct signal input of the amplifier **22** through the path including the adjustable resistor **R30**, and depending upon the relative values of resistor **R18** and **R30**, the amplitude of the signal supplied to the reverberation device is varied because as the amplitude of the direct signal supplied by amplifier **14** increases it also tends to increase the amplitude of the signal transmitted through the reverberation channel.

The signal derived from the amplifier **14** should be in phase with the signal supplied to the coupling resistor **R20** through resistor **R18** in order to prevent undesirable distortion, and to cause the two signals impressed across resistor **R20** to be additive.

From the foregoing it will be apparent that as the expression volume control is operated to increase the intensity of the output of the directly transmitted signal the intensity of the sound transmitted through the reverberative channel will not increase nearly as rapidly.

The reverberation unit may be of any suitable construction but is preferably of the type shown in the patent

to Laurens Hammond No. 2,230,836, except that the direct signal path represented by the circuits including adjustable resistors R24 in Fig. 1 of said patent is preferably omitted and instead two speakers, as disclosed herein, be used to translate the electrical signals into sound. The speakers 16 and 28 should preferably be placed in a position such that the listener does not have the impression of hearing the music from two different sources but rather as hearing it directly with a reverberative acoustic component, as if the music were being produced in an enclosure of relatively large size when the music produced is played softly, and as if heard in a smaller room or enclosure when the music is played loudly.

The values of the resistors R18 and the value to which the resistor R30 is adjusted are preferably such that there is a difference of from 8 to 12 db between the intensity of direct component and the intensity of the reverberative component when the music is played at maximum loudness.

While I have shown and described a particular embodiment of my invention, it will be apparent to those skilled in the art that numerous modifications and variations may be made in the form and construction thereof, without departing from the more fundamental principles of the invention. I therefore desire, by the following claims, to include within the scope of my invention all such similar and modified forms of the apparatus disclosed, by which substantially the results of the invention may be obtained by substantially the same or equivalent means.

I claim:

1. An electrical musical instrument comprising, a source of electrical musical tone signals, first and second signal transmission channels coupled to the source, each including an amplifier and a speaker, an adjustable volume control in the first channel, a reverberation apparatus in the second channel, and means providing a coupling from a point in the first channel, at which the amplitude of the signal may be varied by the volume control, to a point in the second channel before the signal is supplied to the reverberation apparatus.

2. An electrical musical instrument comprising, in combination, a source of electrical musical tone signals having an insufficient reverberative component when the signals are translated into sound at a low intensity level, a first amplifier having an adjustable volume control means, means coupling the first amplifier to the source, a first speaker coupled to the output of the first amplifier,



a reverberation apparatus, a second amplifier, a second speaker coupled to the output of the second amplifier, means including a first impedance coupling the source to the input of the reverberation apparatus, and means including a second impedance coupling the input of the reverberation apparatus to the first amplifier at a point at which the amplitude of the signal may be varied by the volume control means, the values of said impedances being such as to cause the intensity of the sound produced by the second speaker to increase less rapidly than the intensity of the sound produced by the first speaker as the volume control is adjusted to increase the intensity of the sound produced by both speakers.

3. The combination set forth in claim 2 in which the relative values of the two impedance means are such that at low intensity adjustment of the volume control means the intensity of the sound produced by the two speakers will be nearly equal, and that at very high intensity adjustment of the volume control means the intensity of the sound produced by the first speaker will be approximately ten decibels greater than the intensity of the sound produced by the second speaker.

4. The combination set forth in claim 2 in which there is included a third amplifier having an input coupling impedance across which the signals from the source and the signals modulated by the volume control means are supplied for the input of the third amplifier, and in which the output of the third amplifier is coupled to the reverberation apparatus.

5. The combination set forth in claim 2 in which the first and second impedances are resistors.

6. An electrical musical instrument comprising, in combination, a source of electrical musical tone signals, a first amplifier and speaker, an adjustable volume control means coupling the first amplifier to the source, a reverberation apparatus, a second amplifier and speaker, means including a first impedance and an amplifier coupling the source to the input of the reverberation apparatus, and means including a second impedance coupling the input of the reverberation apparatus to the first amplifier at a point at which the amplitude of the signal may be varied by the volume control means.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,017,153 | Kellogg | Oct. 15, 1935 |
| 2,852,604 | MacCutcheon | Sept. 16, 1958 |