ARTIFICIAL REVERBERATION CONTROL APPARATUS

Filed June 4, 1959

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Att'y.
The invention relates generally to acoustic systems and apparatus, and more particularly to a method and means for controlling the extent or intensity of the sound.

The invention comprises a novel form and method of reverberation control in which the degree or amount of reverberative effect is a variable factor depending upon the loudness of the sound produced, or reproduced. In the past, musicians have discovered that there is no single reverberative auditorium which is effective to produce the desired amount of reverberation for all classes of music. For example, in a large cathedral the long reverberative roll associated with the tones is highly effective for slow moving religious music of the choral or hymn type, but when the musician attempts to play fast moving music, in which full chorded progressions occur in rapid succession, he immediately discovers that the inherent long reverberation period causes the music to be blurred and musically ineffective. For music of the latter type, as well as rhythmic music in which interesting and rapid moving figures are employed, the musician finds it desirable to produce the music in a much smaller enclosure, such as an acoustically dead broadcasting studio or the like.

There is no optimum hall for all classes of music. The reverberative time is related to the musical or emotional character of the music being rendered. Furthermore, the loudness of the music itself is reflected in the character of the music. For example, slow moving music is highly effective when played softly whereas fast intricate contrapuntal music is far more effective when played at a higher intensity so that the listener may clearly hear the inner part music for the various voices. From this it is clearly seen that reverberative auditoriums are, musically speaking, limited in their usefulness.

These limitations are also found to be true for music having artificially introduced reverberation by such means as disclosed in the patent to Laurens Hammond No. 2,230,836. The reverberation apparatus shown therein is merely a substitute for, or reinforcement of, the natural reverberation occurring in the listening enclosure.

The purpose of the present invention is to devise a new form of reverberation in which the amount of reverberation is automatically related to the loudness of the signal. Thus, the amount of reverberation for any desired volume, or intensity level, is automatically set at an optimum without any effort being made on the part of the organist who is producing the music. For loud audio signals the amount of reverberation is automatically reduced. For soft signals the intensity of the reverberating component, relative to the non-reverberative component is very considerably increased, to approximate that of music heard in a large reverberative auditorium.

With the apparatus to be disclosed the basic difficulties encountered with naturally or artificially generated reverberation have been overcome.

Another important advantage gained by the use of this invention is a reduction in the discernible frequency response upset which is often produced by reverberation apparatus. This improvement comes about through the fact that at high volumes (where an unevenness of frequency response can readily penetrate beyond the threshold of pain) the music is chiefly of a non-reverberative character and therefore of a relatively smooth frequency response. At lower intensities this upset has no opportunity to penetrate beyond the threshold of pain, and a very large amount of the reverberative component may be employed, with correspondingly beautiful musical effects.

Of course, the system of his invention presupposes that the actual listening conditions are generally non-reverberative in character and that most of the reverberative phenomena is due to the electrical apparatus and not to the enclosure.

The nature of the invention may best be appreciated by an analogy as to how the results of the invention could be obtained by purely physical means. For example, the result of the invention could be obtained by having an enclosure in which the size and sound reflecting surfaces could be changed at will, depending upon the type and loudness of music to be rendered. For example, for the rendition of intricate music commonly included in "chamber music" it would be desirable to have the walls of the room be sound absorbing as, for example, by drawing numerous drapes, whereas when slow moving music is to be rendered the drapes could be removed to reveal hard sound reflecting surfaces, or the size of the room could be reduced by sliding partitions or the like.

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

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

FIG. 2 is a diagram, in part block and in part schematic, showing one system by which the objects of the invention may be attained; and

FIG. 3 is similar block and schematic diagram illustrating a modification of the invention.

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 electrical 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 at the maximum open position of a 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.

FIGURES 2 and 3 show two different systems for causing such deviation in intensity of the reverberative component relative to the intensity of the direct component of the sound produced at different intensities.

In FIG. 2 the source of the sound in the form of an
3 electrical signal is represented by a block 10. This source may be an electric organ, a phonograph, a pickup of music recorded on magnetic tape, or other similar means. The output terminals 11 and 12 are respectively connected to an output conductor 14 and ground. The conductor 14 is also connected to a plate 18 of a variable capacity volume control device comprising a second plate 28 connected to the mesh 16 and a movable plate 22 which may be swung into capacitive coupling relation either with the plate 18 or the plate 28, or partially in coupling relation with both plates 18 and 28. This ear response compensated volume control apparatus is disclosed and claimed in my prior Patent 2,464,468, but, of course, other types of volume control means, operated by the expression pedal of an electric organ, or other wise manually adjustable, may be used. The plate 22 of the volume control is connected by conductor 26 to one of the input terminals of an amplifier 29, the other input terminal being connected to ground. The output terminals of the amplifier are connected to a speaker 30, the ungrounded output terminal of the amplifier 29 is connected by conductor 32 to a control voltage means 34, comprising a plurality of resistors R36 connected in series with a coupling resistor R38.

A contactor 40 operated by the swell pedal or the like, together with the movable plate 22, is adaptable, upon being swung rightward, successively to shunt the resistors R36, thus increasing the amplitude of the signal appearing across resistor R38. The dotted line connecting the contactor 40 and the conductor 26 represents a mechanical linkage such that when the plate 22 is swung clockwise to increase the amplitude of the signal supplied to amplifier 29, the contactor 40 is swung counterclockwise to decrease the amplitude of the signal impressed across resistor R38, relative to that of the signal supplied to speaker 30.

The shunt resistor R38 is connected to the input terminals of a reverberation apparatus 42 which may be of any suitable type but is preferably that of the type shown in the patent of Laurens Hammond No. 2,230,836. The output of this reverberation unit is coupled to an amplifier 46 and the output of the latter supplied to a speaker 48. The resistors R36 and R38 are of values such that as the contactor 40 is swung counterclockwise from the position shown it successively makes contacts with the junctions between these resistors so that the amplitude of the signals impressed upon the reverberation unit will increase gradually, but at a lower rate than the amplitude of the signal impressed upon the speaker 30 and so that the reverberative component of the music, reproduced by the speaker 48, will increase less rapidly than the music reproduced by the speaker 30, generally as indicated by the curve B in FIG. 1.

The apparatus shown in FIG. 3 may be accomplished approximately the same results as that shown in FIG. 2. It, however, has the advantage that it does not require the use of a mechanically operated variable impedance devices such as a capacitor plate 22 and resistors R36 and contactor 40 in FIG. 1.

The system and apparatus illustrated in FIG. 3 may be used with any source of sound signals such as a phonograph having the usual volume control without making it necessary to make changes. The system shown in FIG. 3 comprises a source 50 of electrical musical tone signals and may include the volume control means 52.

The output terminals 53 and 54 of the source are respectively connected to a conductor 56 and ground. The output terminals 53 and 54 are also connected to a speaker 58 for providing the direct non-reverberative component of the sound. A reverberation unit 60, preferably of the type previously designated, has its input terminals connected to conductor 56 and ground respectively.

The output terminal 62 of the reverberation unit is connected to ground through a capacitor C64 in series with a voltage dividing resistor R66. The variable arm 63 of the voltage divider is connected to the control grid of a triode 70. The cathode of this triode is connected to ground through a self-bias resistor R72 in parallel with a capacitor C74.

The plate of the triode 70 is connected by capacitor C76 with the control grid 78 of a pentode 80. A second pentode 82 has its control grid 83 connected to the grid 78 of pentode 80 by resistor R34. The cathodes and suppressor grids of pentodes 80 and 82 are connected to ground through a common self-bias resistor R86 while the screen grids 90 of these pentodes remain at the proper operating voltage by dividing resistors R88 and R89 in series between ground and the B+ terminal of the power supply. The plates of the pentodes 80 and 82 are connected to a B+ terminal of the plate current source of resistors R92 and R93 respectively, and are coupled to a power amplifier 96 by capacitors C98 and C99 respectively. A speaker 100 is connected to the output terminals of the power amplifier.

The grid bias for the pentodes 80 and 82 is varied so as to cause the sound output of speaker 100 to follow the curve B of FIG. 1. As shown in the embodiment of FIG. 8 follows the curve A in said figure. This is accomplished as follows. The output signal from the source 50 as represented by the terminal 53 is connected to the ungrounded terminal of the primary winding L102 of a transformer T104 through a capacitor C106. The secondary winding L108 has one terminal connected to ground while the other terminal is connected to a conductor 110 through a rectifier 114. A relatively large filter capacitor C112 is connected between conductor 110 and ground. A variable resistor R116 is likewise connected between conductor 110 and ground.

As the intensity of the tone signal supplied by the source 50 is increased, the alternating current produced in the secondary L108 of the transformer increases in amplitude, and the current flowing through rectifier 114 during half the cycle will lower the direct current voltage on conductor 110 and hence on the control grids 78 and 83. The values of the various components which cooperate to change the grid bias on the control triodes 80 and 82 are such that the intensity of the sound produced by the speaker 100 will increase as the amplitude of the input signal from the source increases, but not as rapidly as the intensity of the sound produced by speaker 58 increases, as illustrated by the curves of FIG. 1. The desired result is that the relative intensity of the reverberation component increases less rapidly than the intensity of the direct component increases, as the intensity of the sound produced by the source is increased.

While I have shown and described particular embodiments 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 claim, 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:

A system for transmitting electrical musical tone signals from a source and translating the signals into sound comprising, a source of musical tone signals capable of imparting audio amplitude, a first speaker, means coupling the source to the first speaker to reproduce the signals directly as sound, a reverberation apparatus, means coupling the reverberation apparatus to the source, an amplifier coupled to receive the output of the reverberation apparatus, said amplifier including a terminal the potential of which
determines the degree of amplification, a second speaker
coupled to the output of the amplifier to supply re-
verberated sound, circuit means coupled to the source
and including rectifying means producing a direct current
voltage related to the amplitude of the signal derived
from the source, and means connecting the rectifying
means to said terminal of the amplifier in a sense to
decrease the degree of amplification of the reverberation
amplifier as the amplitude of the signal supplied to the
first speaker is increased.

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