ABSTRACT: An electromechanical reverberation unit for musical devices having adjustable damping members which may be selectively positioned with respect to the ends of the vibratory spring coils to permit selection of different rates of spring vibration decay for the particular music or effect desired.
VARIABLE DECAY REVERBERATION UNIT

This invention relates generally to reverberation units for use with electrical musical devices such as organs, radios, and phonographs. More particularly, the invention relates to an improved reverberation unit whereby the reverberation time may be altered and adjusted.

Reverberation apparatus of the general type to which this invention is directed is used for the purpose of supply reverberation to the electrical output from a record player, radio, electrical musical instrument, or the like, the ultimate object of such apparatus being to simulate the acoustical reverberative effect of a room or auditorium within a relatively small listening space. Heretofore, reverberation units have had fixed reverberation or decay times, i.e., the time required for a sound signal imparted to the system to die out and become inaudible. In the sound recording and broadcasting field, however, it is often desirable to use different decay times with different types of music, sound or speech. A change in the length of the reverberation time also can substantially change the effect of the music. In the past, an entirely new unit would be necessary if a change in the decay time were desired. Moreover, it has often been difficult to locate a unit with an exceptionally long or short reverberation time since most units are designed with an average or optimum decay time corresponding to the personal preference of most listeners and applicability to most music.

Accordingly, it is an object of the present invention to provide an improved reverberation unit which is more flexible and adaptable to the needs of the sound recording, reproducing, and broadcasting fields. More particularly, it is an object of the invention to provide a reverberation unit having means for varying the rate of reverberation decay.

Another object is to provide a reverberation unit of the above kind in which the reverberation or decay time may be infinitely varied between predetermined limits which is more flexible and precisely transmits sound signals between the driver and pickup ends of the unit.

Still another object of the invention is to provide a reverberation unit as characterized above which has a variable damping means adapted to readily alter the decay time of the unit.

A further object is to provide a reverberation unit which more efficiently and precisely transmits sound signals between the driver and pickup ends of the unit.

Other objects and advantages will become apparent upon reading the following detailed description and by reference to the drawings in which:

FIG. 1 is a perspective view of an illustrative reverberation unit embodying the present invention;

FIG. 2 is an elevation view of the reverberation unit shown in FIG. 1 taken in the plane of line 2--2;

FIG. 3 is an enlarged fragmentary perspective of one end of the unit shown in FIG. 1 with the parts shown in an exaggerated relationship;

FIGS. 4 and 5 are transverse sections taken in the planes of lines 4--4 and 5--5 of FIG. 3, respectively;

FIG. 6 is an enlarged section taken in the plane of line 6--6 of FIG. 4;

FIG. 7 is an enlarged view of the end of the coil spring used in the illustrated unit showing the jointer with its associated annular permanent magnet and compliant support wire;

FIG. 8 is an enlarged fragmentary section taken along FIG. 8--8 FIG. 2 showing the vibratory and damping mechanisms of the apparatus;

FIG. 9 is a fragmentary section view similar to FIG. 8 but showing the damping mechanism in a different position;

FIG. 10 is a rear elevation view of a reverberation unit similar to the one shown in FIGS. 1--9 but having a modified form of a variable damping mechanism;

FIG. 11 is a rear elevation view of a reverberation unit having still another alternative form of a variable damping mechanism.

While the invention is susceptible to various modifications and alternative constructions, certain illustrative embodiments thereof have been shown in the drawings and will be described below in detail. It should be understood, however, that there is no intention to limit the invention to the specific forms disclosed, but, on the contrary, the intention is to cover all modifications, alternative constructions, and equivalents falling within the spirit and scope of the invention.

Turning now to the drawings and referring first to FIGS. 1 and 2, there is shown an illustrative reverberation unit 10 embodying the present invention. The unit comprises an electromechanical transducer driving assembly, generally indicated at 11, and a similar pickup assembly 12, both being suitably mounted on a frame plate 14. The driver assembly 11 and pickup assembly 12 are interconnected by a plurality of springs 15. The frame plate 14 is provided with slots 20 to facilitate attachment of the entire unit to a musical instrument, broadcast control panel or the like.

In the illustrated unit there are four springs 15 which are suspended in a stretched condition between the driver and pickup assemblies 11, 12. The springs are of approximately the same length but differ in coil diameter and wire size so that when a sound signal is applied to one end of the springs by means of a torsional moment vibrations will be transmitted to the other end of the springs at different rates, as is well known in the art.

To secure and support the driver and pickup assemblies 11, 12 and springs 15 in spaced relation on the frame plate 14, support brackets 21 are mounted on the rear side of the plate by bolts 22 or other suitable fastening means. An outwardly extending flange 24 of each support bracket 21 is equipped with rubber or other shock-damping mounting rings 25 which receive the ends of four support rods 26 suspended between the brackets 21.

The driver assembly 11 includes an end plate 28, damper plate 29, and transducer plate 30 mounted in parallel spaced relation at one end of the support rods 26 with the rods passing through the corners of the respective plates. The pickup assembly 12 supported at the opposite end of the rods 26 similarly includes an end plate 31, damper plate 32 and transducer plate 34. Since the pickup assembly 12 is substantially the same as the driver assembly 11, only the driver assembly will be described in detail.

Referring to the driver assembly 11 which is shown in detail in FIGS. 2 and 3, the end plate 28 is rigidly mounted on the rods 26 and supports one end of each of the springs 15 by means of a short straight compliant wire 35 attached to each end of the springs 15. The compliant wires 25 are fastened to the end plate 28 by an appropriate means such as by passing the wire 35 through a small aperture in the plate and attaching an enlarged plastic bead 36 to the end of the wire 35 so that the spring is stretched between the respective end plates 28, 31. The short straight wires 35 are considerably smaller in wire size than the spring wire and thus give the spring its compliance when moved in an oscillating rotational mode. The short compliant wires 35 each extend from the end plate 28 and pass through a damper washer 41 in the damper plate 29 and an opening or gap 39 in the transducer plate 30 before being connected to the spring coil 15. The four damper washers 38 are seated in the damper plate and each are secured by a retainer ring 37. The damper washers are made of rubber or other suitable damping material and surround and closely grip the compliant wires 35 to arrest torsional vibration of the wires, as will be explained in more detail below. A small-diameter annular permanent magnet 40 is concentrically carried near the end of each spring coil 15 so as to be positioned within the opening 39 of the transducer plate. As shown in FIG. 7, in the illustrated unit each spring 15 terminates in an axially extending straight section 42 which is secured to the end of the compliant wire 35 by the cylindrical magnetic core which is adhesively attached to the ends of the wires 42 and 35.

In keeping with the invention, to increase the coupling factor between the compliant wires 35 and springs 15, the latter are wound with tapered end portions 41. It has been found that such tapered ends enable more effective transmission of
torsional vibration signals from the magnet 40 and compliant wire 35 to the spring coil 15 and vice versa. Such coupling results in significantly less losses to the sound signals than is possible in previous reverberation units having more blunt connections.

As is well known in the art, sound waves may be transmitted through the springs in a torsional mode through the use of an electromechanical transducer which acts on the magnet 40 carried by each spring 15. In the illustrated embodiment, as best shown in FIGS. 3 and 5, the two openings 39 in the transducer plate 30 each contain a U-shaped piece 44 made of laminated highly permeable magnetic material. Upon one leg 45 of each U-shaped piece 44 a small wire coil 46 is disposed so that the leg 45 forms one pole of a magnetic circuit. The other leg 48 of each U-shaped piece forms the opposite side of the circuit. The coils in this case are connected in a series and terminate at appropriate input terminals 49 at the outer edge of the transducer plate 30 for easy access. The legs 45, 48 of each U-shaped piece 44 define the magnetic gap or aperture 39 within which are positioned and annular permanent magnets 40 carried by two of the springs 15. The permanent magnets 40 are magnetized across their diameter and placed in such manner between the pole pieces 45, 48 that when a signal is imparted to the coils, the magnets 40 move in a rotational manner.

Thus, when a signal is applied to the terminals 49 of the driver unit 11, the coils 46 are energized causing the magnets 40 to move rotationally. The torsional vibrations are communicated through the springs 15 and reach the opposite end of the springs a short time later, which is somewhat greater for the springs having a larger diameter and smaller wire size. The time required for the signal to travel from one end of the spring to the other is commonly referred to as the delay time. The delay time is fixed for each spring coil and cannot generally be altered.

When the vibration reaches the pickup end 12 of the unit and causes rotational movement of pickup magnets 50, a signal is generated in pickup coils 51 which is supplied to output terminals 52 of the pickup transducer plate 34. The signal is then reflected from the pickup end plate back through the springs. A wave will continue between the end plates of the device for a time and will eventually die out. The time required for the signal to die out is commonly referred to as decay time. The damper washers 58 in the damper plate 29 and similar washers 54 in the pickup damper plate 32, shown in FIG. 8, limit the decay time to a desirable period.

In accordance with the present invention, the decay time of the driven unit 11 may be varied to provide the selection of different decay times for the particular music and effect desired. To this end, means are provided for simultaneously adjusting the position of damper plates 29, 32 along the compliant wires 35. In the illustrated embodiment, the damper plates 29, 32 are slidably mounted on the rods 26 and a damper plate transport mechanism 55, shown in FIG. 2, is provided for selectively translating the damper plates along the rods. To facilitate such movement of the damper plates, the plates are provided with appropriate bushings 56 through which the rods 26 pass. The damper plate transport mechanism includes an adjusting knob 58 located in the front of the frame plate 14, having a shaft 59 rotatably mounted in the plate and extending through the plate into the space slightly above the spring coils 15. Cords 60 and 61 connect the shaft 59 to the damper plates 29, 32, respectively. The cord 60 is disposed around the shaft 59 and a pulley 62 rotatably disposed in the end plate 28. Upper and lower portions of the cord 60 pass through an opening 64 in the transducer plate 30 and through two apertures 65, 66 in the damper plate. The cord 60 is free to move through one of the damper plate apertures 65, but is affixed to the damper plate 29 at the other aperture 66 by an appropriate means, such as large knots or beads 68 in the cord disposed on opposite sides of the small aperture 66 so that the cord may not be pulled through the plate. It can be seen that when the knob 58 is rotated in either direction, the cord is moved around the shaft 59 and pulley 62 so as to translate the damper plate 29 along the rods 26. To maintain tension in the cord, a spring 69 is interposed in the cord at a location so that it will not interfere with limited movement of the cord in either direction.

As the damper plate 29 at the pickup end 12 of the unit may be similarly translated by the cord 61 disposed around the rotatable shaft 59 and a pulley 70 rotatably mounted in the pickup assembly end plate 31. The transducer plate 34 and damper plate 32 are formed with apertures 71 and 72, respectively, through which the upper and lower portions of the cord 61 may pass, the cord 61 being secured at one point to the damper plate 32 by the double knots or beads 74. In this case, the cord is twisted to form a figure-"S" type arrangement so that the damper plates 29, 32 move equal distances in opposite directions when the knob is turned. Although the damper plates 29, 32 and the washers 38, 54 are moved relatively to the compliant wires 35, due to the resilient character of the washers 38, 54, they maintain firm engagement of the wires 35 so as to act as effective dampers at any position along the wires.

It will be appreciated that by turning the knob 58 which would be disposed on the outside of the instrument in which the reverberation unit 10 is installed, the damper plates 29, 32 may be simultaneously adjusted with respect to the ends of the springs 15 to change the decay time of the unit. When the damper plates are moved to a position towards the spring ends, increased damping is applied which thus brings the torsional vibration to a relatively early halt, causing a decrease in decay time. If, on the other hand, the damper plates are moved a farther distance away from the end of the springs, damping from the damper washers is decreased resulting in a longer reverberation or decay time. It can also be seen that maximum and minimum decay times may be established by providing limits to the range of damper plate translation. In the illustrated unit, movement of the damper plates 29, 32 is limited in one direction by the transducer plates 30, 34 and in the other direction movement is limited when the ends of the damper plate bushings 66 abut against the end plates 28, 31.

In view of the above, it is apparent that the damper plates may be adjusted to provide the desired desired reverberation or decay time for the particular music or effect desired. Such units are thus highly versatile to the sound recording and broadcasting fields and may be conveniently assembled in recording equipment or a musical instrument with the adjusting knob conveniently exposed for ready access.

A modified form of the above mechanism is shown in FIG. 10 wherein similar parts have been given numbers corresponding to those previously described with the distinguishing suffix a added. In this embodiment, a bellcrank mechanism 80 is connected to a rotatable shaft 59a disposed in the frame plate 14a. The bellcrank mechanism includes radial arms 81 extending out from the shaft 59a adjacent a support disc 82 mounted on the shaft 59a and connecting rods 84 join the ends of the radial arms 81 to the damper plates 29a and 32a. Thus, when the shaft 59a is rotated by an appropriate knob 58a as described above, the ends of the rods 84 are moved longitudinally to simultaneously translate the damper plates 29a, 32a along the support rods 26a, in a direction toward or away from the ends of the springs 15a, depending upon the direction of shaft rotation. Appropriate openings are provided in the transducer plates to permit the rods to be passed through.

Still another modified form of adjustable damping mechanism is shown in FIG. 11 wherein similar parts have been given the distinguishing suffix b. In this case the adjusting mechanism includes a longitudinal rod 90 rotatably held between the end plates 28b. A rotatable shaft 59b carried by the frame plate 14b has a worm gear connection with a hobbed central portion 91 of the longitudinal rod 90. The ends 94 of the rod 90 are in threaded engagement with the damper plates 29b, 32b, while access openings permit the rod to pass
through the transducer plates 30b, 34b without contact. Thus, it can be seen by rotating the shaft 59b by a knob 58b, the damper plates are simultaneously translated along the support rods 26b. It is apparent that by using appropriately disposed threads the damper plates will move in opposite directions toward or away from the ends of the springs 15b.

It is understood that while in the illustrated reverberation units both damper plates were adjustable, variable decay may similarly be achieved through the use of one stationary damper plate and one movable damper plate. In such case, the movable plate may be at either the pickup or driver end of the unit.

I claim as my invention:

1. An apparatus for providing reverberation of an electrical signal comprising a coil spring, an electromechanical driver means for imparting vibrations to one end of said spring when an electrical signal is applied to said driver means, an electromechanical pickup means at the opposite end of said spring for producing reverberative output signals in response to vibrations of said spring, means including a compliant wire connected to each end of said spring for supporting said spring by the ends thereof between said driver and pickup means to permit vibrations in said spring to travel the length of said spring and be reflected at both ends thereof, a damping member engaging at least one of said compliant wires, and selectively operable means for adjusting the position of said damping member along said compliant wire to selectively vary the desired rate of decay of said spring vibration without disassembling said apparatus.

2. The apparatus of claim 1 in which said coil spring is formed with tapered end portions, and one of said compliant wires is secured to the end of each said tapered portion.

3. The apparatus of claim 2 in which said adjusting means may selectively position said damping members between fixed limits so that spring vibration decay time is maintained between maximum and minimum limits.

4. An apparatus for providing reverberation of an electrical signal comprising a plurality of coil springs, an electromechanical driver means including input terminals for imparting torsional vibrations to one end of said springs when an electrical signal is applied to said input terminals, an electromechanical pickup means including output terminals for providing reverberative output signals to said output terminals in response to torsional vibration of said springs, means supporting said springs by the ends thereof between said driver and pickup means to permit vibrations in said springs to travel the lengths of said springs and be reflected at both ends thereof, damping means engaging the ends of said springs for controlling the rate of decay of spring vibration, and selectively operable means for readily adjusting the position of said damping means to selectively determine a desired rate of spring vibration decay.

5. The apparatus of claim 4 in which said coil springs are formed with tapered end portions, and said supporting means includes a straight compliant wire connected to each said tapered end portion.

6. The apparatus of claim 4 in which said driver and pickup means each comprise a coil and a magnetic structure which forms a magnetic circuit and defines a gap, a magnetically polarized armature connected at the ends of each of said springs and positioned in said gap, said supporting means including a straight compliant wire connected to the end of each said spring, said damping means including damping rings engaging each of said compliant wires, and said adjusting means simultaneously translates said damping rings along said compliant wires equally with respect to the ends of said spring coils.

7. The apparatus of claim 6 in which said driver and pickup means are mounted on a frame plate, said adjusting means including a shaft rotatably mounted in said frame plate, and means connecting said rotatable shaft with said damping rings so that said damping rings are translated relative to the ends of said spring coils upon rotation of said shaft.

8. The apparatus of claim 6 including a frame plate, rods mounted on said frame plate supporting said pickup and driver means, and a damper plate slidably supported by said rods and containing said damping rings.

9. The apparatus of claim 8 in which said adjusting means includes a shaft rotatably disposed in said plate, a pulley rotatably supported at each end of said unit outwardly of said damper plates, an endless movable cord connecting each pulley to said shaft, said cord for each pulley being secured at one point to the damper plate nearest said pulley so that rotation of said shaft simultaneously translates said damper plates along said rods.

10. The apparatus of claim 8 in which said adjusting means includes a shaft rotatably disposed in said plate, a pair of bell-crank arms each secured at one end to said shaft, a connecting rod connecting the other end of each said arm to one of said damper plates so that rotation of said shaft uniformly moves said damper plates with respect to the ends of said springs.

11. The apparatus of claim 8 in which said adjusting means includes a rod rotatably supported by said unit and threadably engaging said damper plates so that rotation of said rod uniformly moves said damper plates with respect to the ends of said springs.