This invention relates to a speaker system for electrical musical instruments, or the like, and particularly to a rotary apparatus for adding vibrato or tremolo to sounds.

In apparatus of this general character, tremolo or vibrato is usually produced by imparting orbital motion to a sound emitting opening. The operative opening may be the mouth of a dynamic speaker, which is rotated, or the opening of a rotary horn or drum registering with a stationary dynamic speaker.

Often the rotary drum or horn is desirable since, in that case, slip ring connections to the speaker are avoided, which might, unless carefully designed, introduce a substantial resistance drop as compared with the resistance of the voice coils of the speaker.

In either case, the horn or speaker is quite bulky, and motion of the opening in an orbit of substantial diameter and at substantial speeds to produce a substantial frequency deviation in accordance with the Doppler effect creates problems. Rumble may be present unless excellent bearings are provided; the driving motor must do a substantial amount of work, and the heat generated may adversely affect the delicate speaker structure. The high inertia of the horns or speakers may make the mechanism rather sluggish in response to an on-off control of the mechanism. Furthermore, in such structures it is difficult to provide particular shapes of the sound emitting opening in order to obtain desired radiation patterns.

The object of the present invention is to overcome these disadvantages by providing a rotary device the operation of which is an electrostatic speaker. Such speakers are quite lightweight, and relatively large orbital motions and speeds can be obtained without requiring large motors or specially designed bearings. Furthermore, inertia is minimized, and the mechanism can quickly come up to speed and can be stopped quickly in response to an on-off control. Also, since the electrostatic speaker is a high impedance device as compared with any dynamic speaker, simple slip ring connections can be used without material attenuation of the signal and without producing noise.

Furthermore, since the electrostatic speaker radiates sounds from an area, the speaker shape can be readily designed to provide appropriate frequency characteristics and desired radiation pattern.

A further object of this invention is to provide a simple yet effective and improved rotary apparatus for producing tremolo or vibrato.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of several embodiments of the invention. For this purpose, there are shown a few forms in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

Referring to the drawings:

FIG. 1 is a longitudinal sectional view of a cabinet housing and speaker system incorporating the present invention:

FIG. 2 is a sectional view, taken along the plane indicated by line 2—2 of FIG. 1;

FIG. 3 is a fragmentary sectional view showing a modified form of the present invention;

FIG. 4 is a sectional view, taken along the plane indicated by line 4—4 of FIG. 3;

FIG. 5 is a fragmentary sectional view similar to FIG. 3, but showing a further modified form of the present invention;

FIG. 6 is an enlarged fragmentary sectional view showing the mounting for the speaker and the two-part shaft structure; and

FIG. 7 is an enlarged fragmentary sectional view, taken along a plane corresponding to line 7—7 of FIG. 2.

A speaker cabinet 10 has a partition 11 forming separate spaces 12 and 13 in the cabinet, the upper space 12 accommodating the electrostatic speaker 14.

The operative elements of the speaker 14 are flexible juxtaposed plates across which the signal impulses are applied. The variable field created between the plates by the signal impulses causes the plates to vibrate. Since heavy magnetic structures necessary for operation of the dynamic speakers are not required, the entire electrostatic speaker can easily be rotated to create tremolo or vibrato. Orbital movement of the speaker causes tremolo or vibrato in accordance with the well-understood Doppler principle. To achieve this tremolo or vibrato effect, the sound should be propagated in a direction having a radial or tangential component. Accordingly, the propagating plates of the speaker should be oriented generally in a plane non-normal to the axis of rotation.

For supporting the speaker for orbital movement, a two-part shaft structure 21, 21a is provided. The lower shaft part 21 is journaled in and projects above a bearing 22 secured centrally of the cabinet partition 13.

Supporting members in the form of a supporting arm 27 and a brace 31 not only mount the speaker on the two-part shaft 21, 21a, but also serve as conductors for plates 14a and 14b of the speaker as shown in FIG. 7. The respective shaft parts serve as electrically separate slip rings connected respectively to the supporting arm 27 and the brace 31.

For insulating the shaft parts 21 and 21a from each other so that they may serve as slip rings, an insulation member 32 is provided. The member 32 has a socket 32a into which the upper end of the lower shaft part 21 extends. A set screw 60 secures the member 32 to the shaft part 21. A collar 34 of conductive material surrounds the lower end of the upper shaft part 21 and is secured thereto by a set screw 61. The collar 34, together with the upper shaft part 21a, is accommodated in a socket 32b at the opposite end of the insulation member 32. A set screw 62 secures the collar 34 to the insulation member 32. A pulley 23 is mounted upon the lower shaft part 21 between the insulation member 32 and the bearing 22. To this pulley the supporting arm 27 is secured. For this purpose, the arm 27 has an aperture 27a through which the shaft part 21 extends. Machine screws 39 secure the arm 27 at diametric positions on the hub 29 of the pulley 23.

The brace 31 is secured by a machine screw 37 to a radial flange 34a of the conductive collar 34.

The supporting arm 27 and the brace have at their ends ears 27b and 31a respectively secured to the speaker 14.

The bearing 22 forms a brush cooperating with the shaft part 21. An electrical connection is established through the bearing 22, shaft 21 and arm 27, the ear 27b being electrically connected to one of the speaker plates.

The brace 31 is connected to the other speaker plate. A brush 38 engages the upper end of the spindle 36 and serves as a means for establishing an electrical connec-
tion to the electrostatic speaker through the spindle 36, collar 34 and brace 31.

While the bearing 22 and brush 38 may represent substantial impedance drops that would be intolerable if the speaker 14 were of the dynamic type, this is unimportant since the speaker 14 has an exceedingly high impedance, and no significant loss is caused.

For dynamically balancing the speaker 14, a counterweight 39 is provided. The counterweight 39 is mounted on that end of the supporting arm 27 remote from the speaker 14. By bending the arm 27 more or less, the inertia of rotation of the counterweight 39 is adjusted. Accordingly, dynamic balance of the rotary structure is achieved accurately without requiring alteration or substitution of the counterweight 39.

Since the speaker 14 is rotated, its area is limited. Accordingly, the efficiency of the speaker 14 for low frequency sounds is low. Therefore, a low frequency section is required. A low frequency speaker 15 is supported by the aid of a wall 16 extending across the lower space 13 of the cabinet 10. The wall 16 has a central aperture 17 with which the cone of the speaker registers, the wall 16 accordingly forming a baffle for the front of the speaker 15.

A drum 18, provided with a sound channel registering with the speaker opening, is rotated by a small electric motor 19 for imparting tremolo to the sound issuing from the speaker 15.

Ports 20 at the top and bottom of the cabinet permit outward passage of the sound respectively from the drum 18 and from the high frequency electrostatic speaker 14.

A frequency dividing network 42 segregates the impulses from an amplifier 43 for appropriate energization of the respective speakers 14 and 15.

Connections 40 and 41 from the network 42 respectively connect to the bushing 22 and the brush 38. Connections 44 and 45 from the network 42 connect to the speaker 15.

The speaker 14 described an orbital movement, as indicated in FIG. 2. By rotating the shaft 21 at tremolo frequencies, such as from four or five to seven cycles per second, the radiation path produced by the speaker 14 cyclically changes and pleasing tremolo or vibrato is added to the sound. The width of the speaker 14 in the direction of movement in this instance is small so that the instantaneous velocity of sound issuing from all points of the speaker is substantially the same.

For controlling the frequency characteristics of the speaker 14, the size and shape of the speaker 14 may be varied. This is easily accomplished since the speaker comprises essentially two juxtaposed plates. The plates may be fluted, curved or otherwise formed for achieving desirable effects.

The electrostatic speaker 14 being particularly light as compared with the usual dynamic speaker, is efficiently used in tremolo apparatus. Thus the rotational inertia of the speaker 14 is remarkably small. The speaker can be located at a substantial distance from the axis of rotation without causing rumble and without requiring a large motor. The rotary apparatus quickly comes up to speed and quickly stops. A brake for the motor is not required since the slight inertia of the rotary speaker causes only slight coupling of the motor. A large frequency or phase deviation may be readily achieved, providing a pronounced tremolo effect.

In the form shown in FIGS. 3 and 4, an electrostatic speaker 50 is secured to the spindle 36 and is thus adjacent the axis of rotation. A very slight frequency or phase deviation is accomplished in this manner.

In the form shown in FIG. 5, a combination effect is achieved. The electrostatic speaker 14 is provided as before, and the electrostatic speaker 50 at the axis of the device is also provided. The speaker 50 is appropriately connected in parallel to the speaker 14.

The inventor claims:

1. Rotary apparatus for producing tremolo, comprising: a two-part rotary shaft; electrical insulation means between the shaft parts; a bearing for one of the shaft parts; an electrostatic speaker including a pair of plates; a pair of electrically conductive support members respectively mounted on the shaft parts and in turn mounting the speaker for angular movement about an orbit spaced from the shaft; the support members being respectively electrically connected to the speaker plates and forming electrical connections between the shaft parts and the speaker; a brush for the other shaft part; a pair of leads connected respectively to the brush and the bearing for connecting the speaker to an external circuit; and means for continuously rotating the shaft at tremolo angular velocity.

2. Rotary apparatus for producing tremolo, comprising: a rotary shaft; a first electrostatic speaker; means mounting the first speaker for orbital movement about the shaft; a second electrostatic speaker mounted on the shaft and describing an orbit substantially smaller than and entirely within the orbit described by said first speaker; brushes for connecting the speakers to an external circuit; and means for continuously rotating the shaft at tremolo angular velocity.

3. Rotary apparatus for producing tremolo or the like, comprising: a rotary shaft; an electrostatic speaker; bearing means for the shaft mounting the speaker for angular movement about the axis of the shaft; means for continuously rotating the shaft at tremolo angular velocity; and means including said bearing, forming high resistance brush structures for connecting the speaker to an external circuit.

4. In rotary apparatus for producing tremolo or the like, comprising: a rotary support; an electrostatic speaker mounted on the support for orbital movement about the support axis; and a motor for angularly rotating the support at tremolo angular velocity; the characteristic light weight of the electrostatic speaker providing a small angular moment of inertia whereby acceleration of the motor-speaker unit is large, and whereby the free degradation of the motor-speaker unit is correspondingly large.

References Cited in the file of this patent

UNITED STATES PATENTS

554,365 Guest ---------------- Feb. 11, 1896
1,789,554 Kyle ---------------- Jan. 20, 1931
2,815,928 Mizrahi ------------ Nov. 19, 1955
2,831,051 Teikowski --------- Apr. 15, 1958

OTHER REFERENCES