Oct. 16, 1962 D. J. LESLIE 3,058,541

ROTARY ELECTROSTATIC SPEAKER

Filed July 9, 1956 2 Sheets-Sheet 1

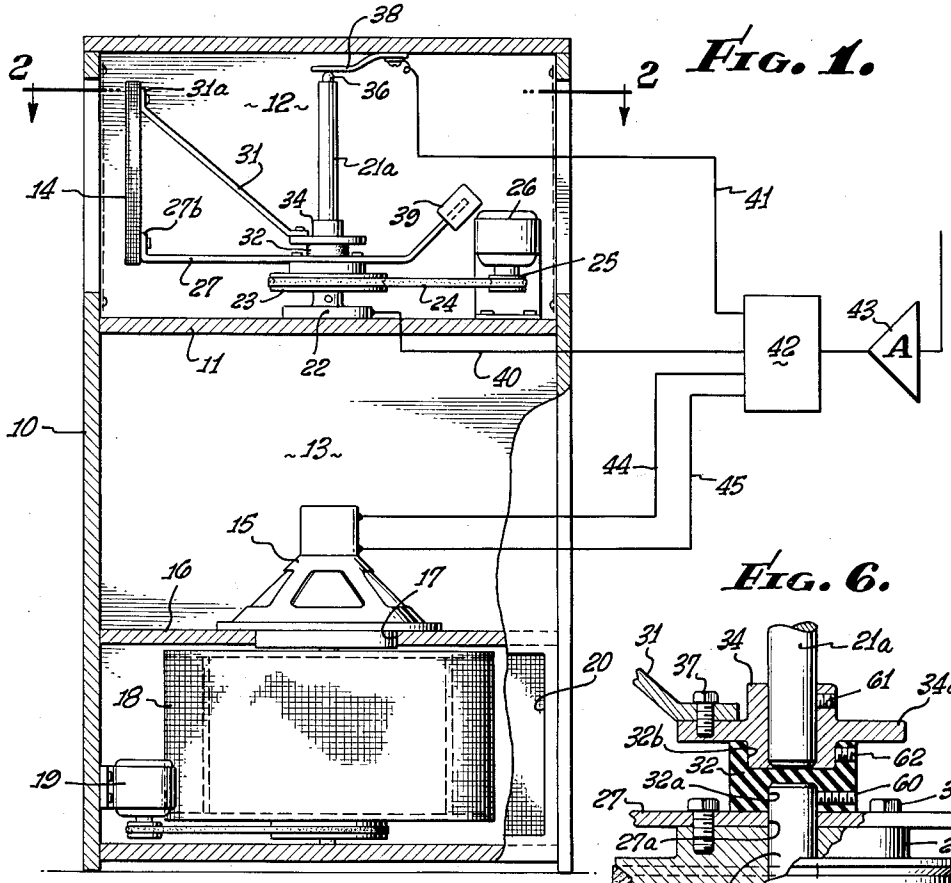

FIG. 1.

FIG. 6.

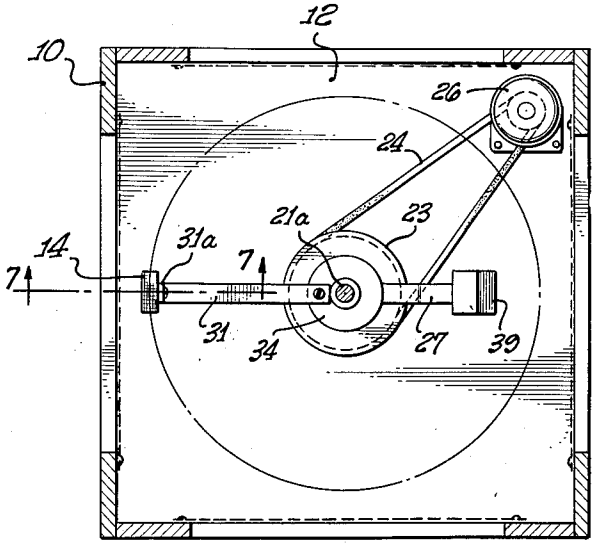

FIG. 2.

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FIG. 3.

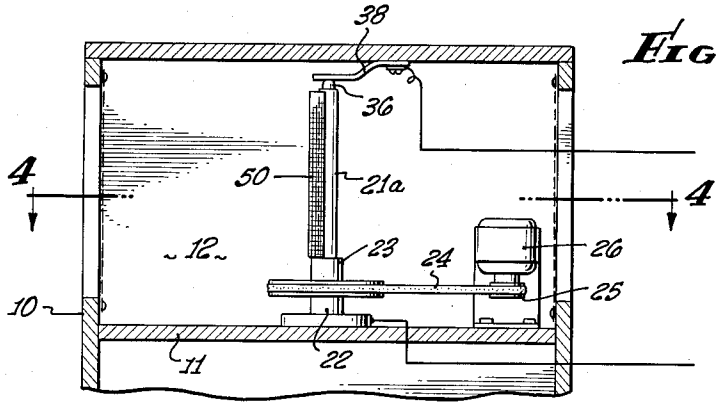


FIG. 7.

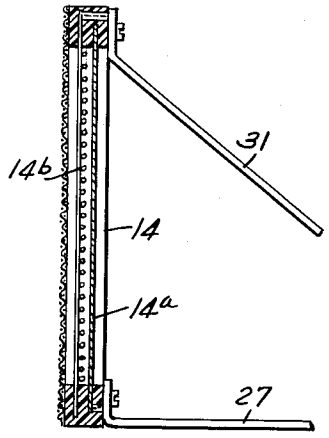


FIG. 4.

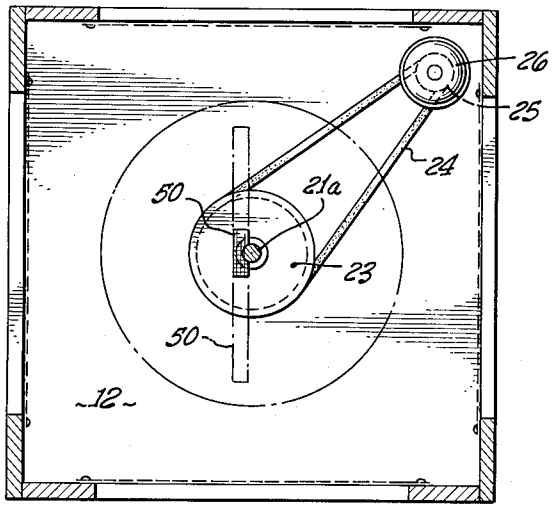
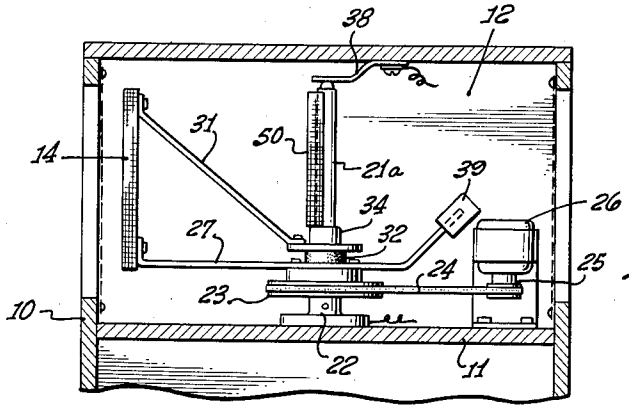


FIG. 5.



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3,058,541

ROTARY ELECTROSTATIC SPEAKER

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4 Claims. (Cl. 181—27)

This invention relates to a speaker system for electrical musical instruments, or the like, and particularly to 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 operative element 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.

These 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:

FIGURE 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**, **21***a* is provided. The lower shaft part **21** is journaled in and projects above a bearing **22** secured centrally of the cabinet partition **11**.

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**, **21***a*, but also serve as conductors for plates **14***a* and **14***b* 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 **21***a* from each other so that they may serve as slip rings, an insulation member **32** is provided. The member **32** has a socket **32***a* 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 **21***a*, is accommodated in a socket **32***b* 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 **27***a* through which the shaft part **21** extends. Machine screws **30** 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 **34***a* of the conductive collar **34**.

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

The bearing **22** forms a brush cooperable with the shaft part **21**. An electrical connection is established through the bearing **22**, shaft **21** and arm **27**, the ear **27***b* 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 electircal 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 coasting 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 deceleration 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
2,813,928	Mizrahi	Nov. 19, 1955
2,831,051	Teikowski	Apr. 15, 1958

OTHER REFERENCES

Electronics, "Electronic Organ Uses," by J. Markowitz, July 1955, pp. 116–118.