Aug. 6, 1963 D. J. LESLIE 3,100,024

MULTIPLE SOUND CHANNEL TREMOLO DEVICE

Filed Feb. 16. 1960 2 Sheets-Sheet 1

FIG. 1.

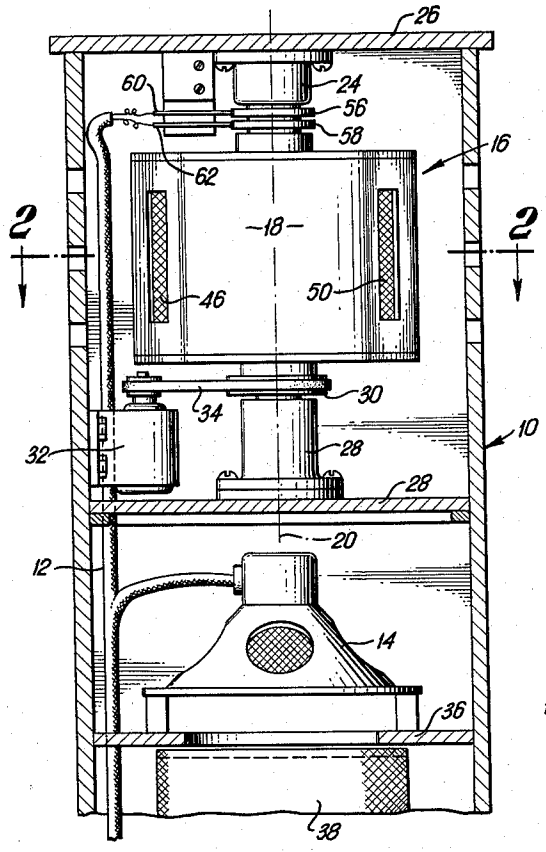


FIG. 2.

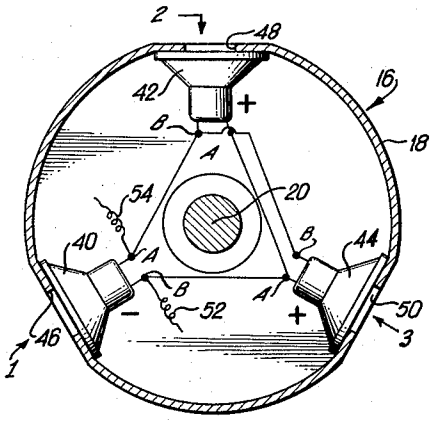


FIG. 3.

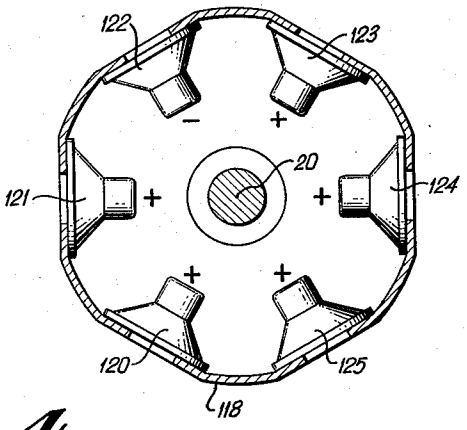
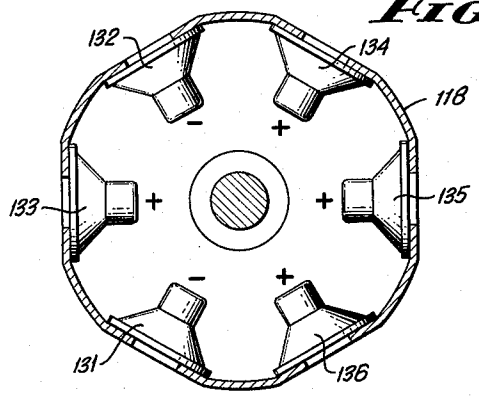


FIG. 4.



DONALD J. LESLIE
INVENTOR.

BY Flam and Flam
ATTORNEYS.

Aug. 6, 1963 D. J. LESLIE 3,100,024

MULTIPLE SOUND CHANNEL TREMOLO DEVICE

Filed Feb. 16. 1960 2 Sheets-Sheet 2

FIG. 5.

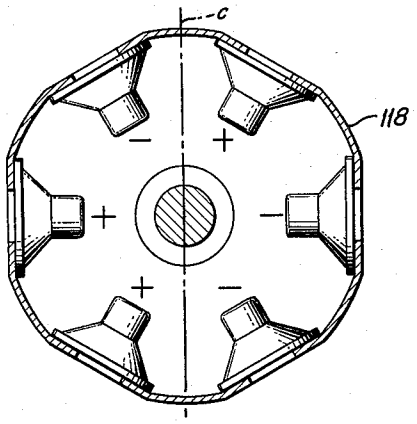


FIG. 6.

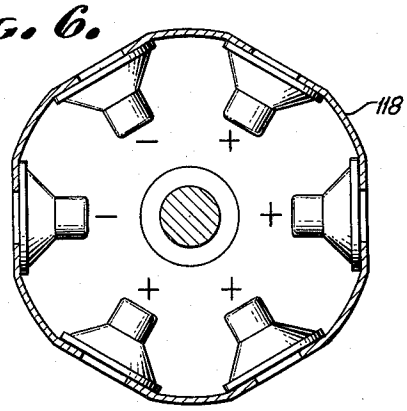


FIG. 7.

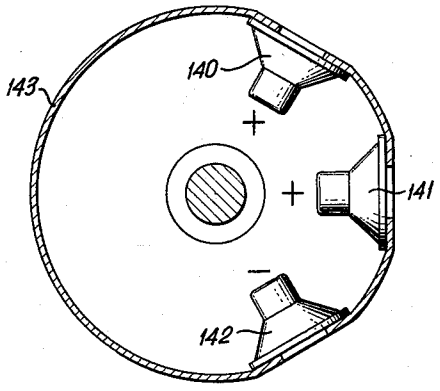
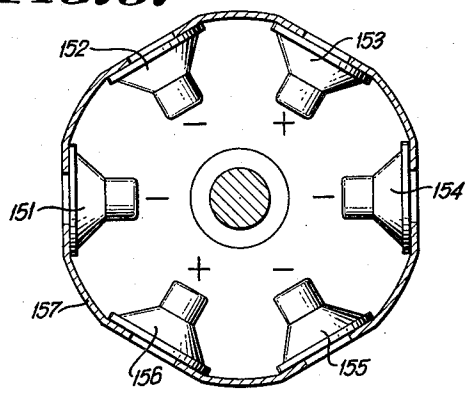


FIG. 8.



INVENTOR.
DONALD J. LESLIE
BY
Flam and Flam
ATTORNEYS.

United States Patent Office

3,100,024

Patented Aug. 6, 1963

3,100,024

MULTIPLE SOUND CHANNEL TREMOLO DEVICE

Donald J. Leslie, % Electro Music, 313 S. Fair Oak Ave., Pasadena, Calif.

Filed Feb. 16, 1960, Ser. No. 9,128
9 Claims. (Cl. 181—27)

This invention relates to speaker structures and particularly for electronic organs. Specifically this invention relates to acoustic apparatus for producing vibrato or tremolo.

Tremolo or vibrato is characterized by an amplitude or frequency change cyclically recurring at the rate of from five to eight per second. A rotating sound channel produces both tremolo and vibrato, vibrato perhaps being the more pronounced effect. A speaker, mounted on a rotary support conveniently forms a rotating sound channel.

It is sometimes desirable to increase the power output of a speaker system. Problems arise with rotating equipment. Thus, if a speaker is increased in size, the sound emitting opening can't effectively be confined to lie within a relatively narrow angle centered at the axis of rotation. Yet such confinement is vital in order to obtain a well defined vibrato. Another problem is that a speaker of large size requires counterbalancing. The added weight of the speaker and the counterbalance result in a sluggish system. A load is also imposed on the bearings supporting the rotating equipment. It has thus been proposed in the past to provide two or more speakers in equiangularly located relationship about the axis of the rotating equipment for purposes of increasing power handling capabilities and to provide other advantages, such as more uniform sound distribution in a space. This arrangement solves at once the dynamic balancing problem, and it also solves the problem of maintaining small the physical size of the speaker for producing a well defined tremolo. However, this arrangement introduces a serious problem in that if the rotation rate of the support is unaltered, recurrence rate of the speakers is no longer five or eight cycles per second, but instead a multiple of that. Accordingly, in order to restore the characteristic tremolo rate of about five to eight cycles per second, the angular speed of the support upon which the speakers are mounted must be reduced by a fraction corresponding to the number of equiangularly located speakers. This means that the actual linear velocity of the speakers is reduced by a corresponding fraction, and the frequency deviation accordingly is reduced. The depth of tremolo accordingly is sacrificed.

The only way in which the depth of tremolo can be restored in such an arrangement is to increase the radius at which the speakers act. There is of course a practical limit to this, and naturally there are practical and esthetic objections to a speaker system having undue bulk.

Accordingly, one of the objects of this invention is to provide a speaker system of substantial power handling capabilities which produces full reach tremolo and that is free of the foregoing difficulties. Thus, an object of this invention is to obtain smooth tremolo, free of flutter or roughness and despite the fact that several angularly spaced speakers or sound channels are employed in a device operating at the full tremolo speed of about six or seven cycles per second.

Another object of this invention is to provide a rotating device of this character in which several speakers may be placed asymmetrically and without resulting in any undesirable repetitive effect.

In order to accomplish the foregoing results, two related approaches are possible. The phase of the oscillatory movement of the diaphragms of various speakers

can be controlled or the speakers may be placed asymmetrically. By grouping equiangularly located but differently phased speakers, a repetition rate corresponding to the angular speed of the support can be maintained and the characteristic tremolo frequency is left intact. Similarly, this result obtains by an asymmetrical placement of speakers upon a common support. Of course, it is possible to use a combination of the asymmetrically located speakers and the asymmetrical phasing thereof.

Still another object of this invention is to provide an improved structure for producing tremolo and vibrato having the foregoing advantages and in which extra smoothness and broadness is imparted. Thus, by virtue of the fact that many speakers pass the observer during one revolution of the structure, the sound reaches the ear from many sources instead of just one. The improvement is due in part to the fact that music emanates from locations having different velocities relative to the listener. Richness is imparted.

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:

FIGURE 1 is a sectional view of a cabinet in which apparatus incorporating the present invention is housed;

FIG. 2 is a sectional view of the rotating support and taken along a plane indicated by line 2—2 of FIG. 1, there being legends adjacent the speakers to indicate relative polarities or phasing; and

FIGS. 3 through 8 are each similar to FIG. 2, and illustrate alternate arrangements.

The speaker structures presently to be described and located within the cabinet **10**, cooperate with an electronic organ (not shown). The electronic organ has output available by connections to conductors of a cable **12**. Some of the cable conductors may suitably cooperate with a bass speaker **14** and others with a medium and high-range speaker structure **16**.

The speaker structure **16** comprises a drum **18** revolvably mounted for rotation about an axis **20**. For this purpose, suitable bearings **24** and **28** are provided for cooperation with a shaft to which the drum **18** is secured. The bearing **24** is mounted on the inside of the top wall **26** of the speaker cabinet **10**, and the bearing structure **28** is mounted upon a horizontal partition **28**. The drum shaft is driven by the aid of a pulley **30**. A motor **32**, secured within the cabinet **10** serves as a means for driving the pulley **30**, there being a belt coupling **34** for this purpose. The motor **32** imparts constant rotation to the drum **18** whereby the tremolo and vibrato effects presently to be described are produced.

The bass speaker **14** is mounted on a ported partition **36** in registry with a revolving horn **38** whereby suitable tremolo is imparted to the pedal tones.

The present invention is embodied in the medium and high frequency speaker structure **16**. In FIG. 2 the drum **18** is shown as mounting three speaker structures **40**, **42** and **44** equiangularly about the axis **20**. The speakers **40**, **42** and **44** are of identical specifications.

The speakers are respectively mounted on the inside of a peripheral wall of the speaker drum **18**. Each registers with a generally vertically oriented slot **46**, **48** and **50** (see also FIG. 1) formed in the drum. These slots **46**, **48**

and 50 form the actual mouths of the sound channels 1, 2 and 3 the speakers 40, 42 and 44 forming the throats of the sound channels. The slots 46, 48 and 50 subtend a rather narrow angle in the direction of angular movements of the drum 18. This means that a radiation pattern especially effective for sharp, well defined tremolo is produced, and as set forth more fully in any prior Patent No. 2,622,692 issued December 23, 1952 and entitled Apparatus for Improving Vibrato or Sound.

The drum is rotated at a speed of about six or seven revolutions per second. Accordingly, speakers 40, 42 and 44 physically recur at the rate of about nineteen or twenty times per second. Despite this fact, a characteristic tremolo of six or seven cycles per second is produced because the speakers 40, 42 and 44 are asymmetrically driven.

Thus the speakers 40, 42 and 44 each have two terminals A and B for connections to their voice coils. The sound channels of which the speakers form a part are acoustically driven upon operation of the voice coils. The speakers are so connected that one of them, in this instance speaker 40, operates at 180° phase relationship to the other speakers 42 and 44. This is accomplished by connecting the A terminal of the peaker 40 to the B terminals of the speakers 42 and 44, and the B terminal of the speaker 40 to the A terminals of the speakers 42 and 44. This is diagrammatically illustrated by the connections in FIG. 2.

The speaker 40 is thus so connected to the source that its cone moves inwardly while the cones of the speakers 42 and 44 move outwardly. Leads 52 and 54 connect with slip rings 56 and 58 (FIG. 1) that are engaged by brushes 60 and 62. The brushes connect with leads of the cable 12.

The result of the asymmetrical connections is that the phase of the speakers 42 and 44 produce a dominant radiation pattern that recurs at the rate of once every revolution, and not three times in a revolution. Accordingly, tremolo is produced at the rate of six or seven cycles per second when the drum 18 is rotated at this speed.

The relative polarities of the speakers are denoted by the plus (+) and minus (—) legends adjacent the speakers. This may be noted as the equivalent of the connections explicitly diagrammed.

In FIG. 3 there is illustrated a drum 118 having in this instance six equiangularly spaced speakers 120, 121, 122, 123, 124 and 125 of identical specifications. In the present instance one of the speakers 122 is connected oppositely to the remaining speakers and a characteristic tremolo of six or seven cycles per second is produced by corresponding rotation of the drum 118.

FIGS. 4, 5 and 6 illustrate further possibilities for phasing the successive speakers on a common drum to produce tremolo at six or seven cycles per second by corresponding rotation of the drum.

In FIG. 4 two speakers 131 and 132 are connected for like operation, but opposite to the remaining speakers 133, 134, 135 and 136, as indicated by the minus (—) and plus (+) legends. In the present example, one speaker 133 of the group of four, separates the speakers 131 and 132 of the group of two. The sound pattern recurs only once per revolution.

In FIG. 5, the two groups of speakers mirror each other on opposite sides of a plane C, the number of plus (+) and minus (—) speakers being equal. Yet the pattern recurs only once per revolution.

In FIG. 6, an arrangement similar to FIG. 3 is provided, except that two adjacent speakers are of one phase while the remaining speakers are of the opposite phase.

In the forms previously described the speakers physically recur at a rate greater than the rotation rate of the drum, but nevertheless, the acoustic recurrence rate precisely corresponds to the rotation rate, which can thus be about six o seven revolutions per second. In each case there is one and only one distinct angular position of the drum at which speakers similarly placed operate similarly.

In the form illustrated in FIG. 7 there is illustrated an arrangement in which three speakers 140, 141 and 142 are placed asymmetrically on one half of the drum 143. While the acoustic recurrence rate corresponds to the rotational speed of the drum 143, whatever may be the phase of the respective speakers 140, 141 and 142, best results are obtained in this system by ensuring that speakers similarly driven are confined approximately to an angle of the order of 90°. Accordingly, the speaker 142 at one end is reversed in phase relative to the remaining two. By virtue of this combination of asymmetrical physical location and asymmetrical phasing, exceptionally good results free of rough and fluttering sounds are obtained.

In the form illustrated in FIG. 8, speakers 151, 152, 153, 154, 155 and 156 are equiangularly located about the axis of the drum 157. In the present instance there is a certain symmetry in that a motion through only 180° results in recurrence of the sound radiation pattern. Thus, speakers 153 and 156 that are 180° apart are connected in like phase and opposite to the phase of the remaining speakers. A tremolo rate can be maintained by reducing the angular speed of the drum 157 to something of the order of three or four cycles per second. By virtue of such rotational speed, the recurrence rate of the radiation pattern is now seven or eight cycles per second and the characteristic tremolo is obtained although the velocity of the motion is reduced.

The inventor claims:

1. In apparatus for producing vibrato: a support; means mounting the support for rotation about an axis; three or more sound channels mounted in spaced relationship about the support for rotation of the sound pattern created by each upon rotation of the support; means operatively associated with the sound channels for acoustically driving each sound channel from a common source so that a sound pattern is created by said channels that recurs a number of times each revolution that is less than the number of channels; and means connected to the support for rotating said support at a rate of about six or seven revolutions per second divided by said first named number.

2. In apparatus for producing vibrato: a support; means mounting the support for rotation about an axis; a plurality of sound channels mounted in equiangularly spaced relationship about the support for rotation of the sound pattern created by each upon rotation of the support; the sound channels being divided into two groups; means operatively associated with the sound channels for acoustically driving each sound channel from a common source so that one group of one or more channels is driven in out of phase relationship with respect to the remaining group of one or more channels, at least one of the groups having two or more channels located so that the angular span between successive channels of the group is nonuniform whereby the sound pattern recurs a number of times each revolution that is less than the number of channels; and means connected to said support for rotating said support at a rate of about six or seven revolutions per second divided by said first named number.

3. In apparatus for producing vibrato: a support; means mounting the support for rotation about an axis; a plurality of sound channels mounted in equiangularly spaced relationship about the support for rotation of the sound pattern created by each upon rotation of the support; means operatively associated with the sound channels for acoustically driving each sound channel from a common source so that a sound pattern is created by said channels that recurs once every revolution; and means connected to the support for rotating the support at a rate of about six or seven revolutions per second.

4. In apparatus for producing vibrato: a support; means mounting the support for rotation about an axis; a plurality of sound channels mounted in equiangularly spaced

relationship about the support for rotation of the sound pattern created by each upon rotation of the support; means operatively associated with the sound channels for acoustically driving each sound channel from a common source so that one group of at least two channels is driven in out of phase relationship with respect to the remaining group of one or more channels, the channels of said one group recurring in spatial array only once in a revolution; and means connected to the support for rotating said support at the rate of about six or seven revolutions per second.

5. The combination as set forth in claim 4 in which there are three channels, two of which are driven in out of phase relationship to the third.

6. The combination as set forth in claim 4 in which there are several channels in the first group and only one in the second group.

7. The combination as set forth in claim 4 in which there are more channels in the first group than in the second, the channels of the second group being separated by at least one of the channels of the first group.

8. The combination as set forth in claim 4 in which a mirror plane of symmetry exists with respect to which a channel of one group mirrors a channel in the other group.

9. An apparatus for producing vibrato: a support; means mounting the support for rotation about an axis; a plurality of sound channels mounted in spaced relationship about the support for rotation of the sound pattern created by each upon rotation of the support; the angular span between channels being non-uniform; means operatively associated with the sound channels for driving each sound channel from a common source so that some of the channels are driven in out-of-phase relationship with the remaining channels whereby a sound pattern is created by said channels that recurs a number of times each revolution that is less than the number of channels; and means connected to the support for rotating said support at a rate about six or seven revolutions per second divided by said first-named number.

References Cited in the file of this patent

UNITED STATES PATENTS

2,114,680	Goldsmith	Apr. 19, 1938
2,887,000	Leslie	May 19, 1959