May 13, 1952 D. J. LESLIE 2,596,258

ELECTRIC ORGAN SPEAKER SYSTEM

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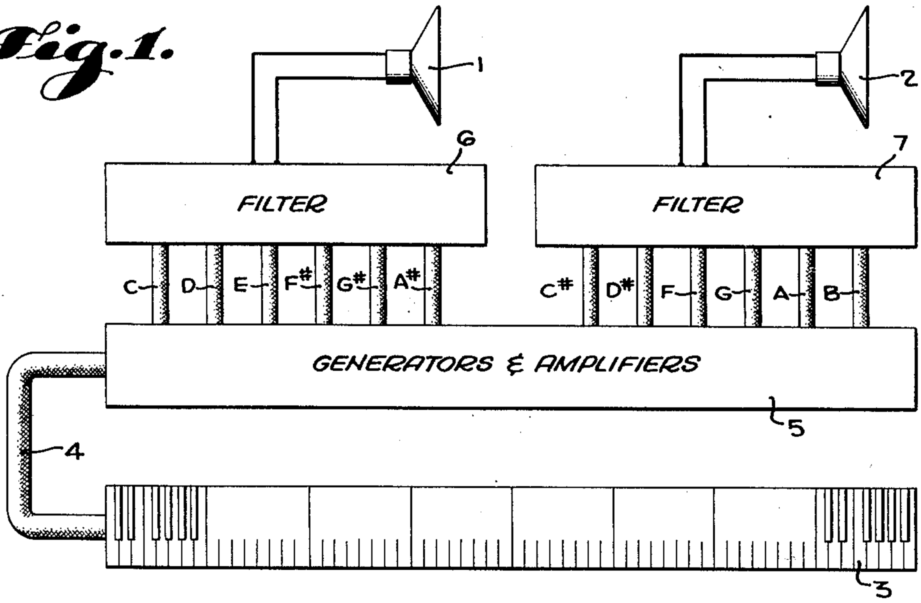
Fig. 1.



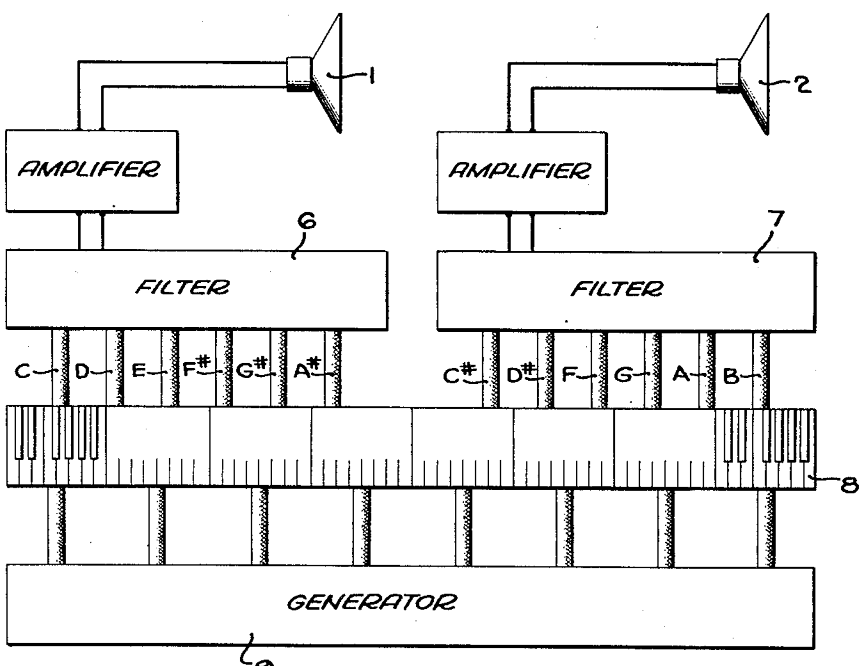


Fig. 2.

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ELECTRIC ORGAN SPEAKER SYSTEM

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4 Claims. (Cl. 84—1.01)

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This invention relates to a sound reproducing system, and especially for use with an instrument (such as an electric organ) that incorporates electrical devices for producing the musical tones.

Such electrical devices often include oscillator tubes that generate electrical impulses corresponding to the musical tones to be produced. Each key or switch of a keyboard causes a corresponding tone of a definite fundamental pitch to be produced by connecting to an operating oscillator or by causing an oscillator to operate at the corresponding frequency, and by translating the electrical impulses produced by the oscillator into sound, as by a loud speaker. It has been common in the past to provide a single loud speaker system for this purpose, which speaker system accordingly reproduces all of the tones corresponding to all of the keys that may be in operative position.

These electrically operated musical instruments, when utilizing such a loud speaker system, do not give a perfect illusion of pipe organ quality. Apparently, some of the trouble lies in the fact that the generator systems for producing the proper electrical impulses have phase relations producing identical repetitive effects, and that also all of the electrical impulses corresponding to the musical tones are transmitted through only one electrical channel and reproduced by one sound reproducer system, such as a loud speaker or several loud speakers connected together.

On the other hand, the music from a pipe organ is produced by many organ pipes which do not produce sounds that have fixed phase relationships with regard to one another. The mixing of the various frequencies is thus done acoustically with one ear hearing sounds under different conditions than the other ear.

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This difference in generating and combining the components or tones of the music is readily perceptible. In the case of the electric organ, the undesirable effects due to these conditions are very noticeable.

One of these effects is the interference between harmonics that is developed as a result of the use of the tempered scale. This is especially noticeable when fourth or fifth musical intervals are played; and, since most tone qualities contain at least some of the lower harmonics, almost all tones exhibit the harmonic interference. When these fourth or fifth intervals are played, certain beats are immediately heard in the electronic organ that are not generally apparent in the pipe organ. For example, it can be shown that, in the case of the fifth interval (occurring in all major chords), the third harmonic of one note has a frequency very close to that of the second harmonic of the other note. This is shown in table form below, using as an example the notes A and E as the fundamentals of the tones, and assuming that the key of A above middle C is utilized. However, this condition exists no matter which notes are used to produce the fifth interval.

Note								
A	Harmonic	1	------	2	3	4	------	5
	Frequency	440	------	880	1,320	1,760	------	2,200
E	Frequency	------	659.26	------	1,318.52	------	1,977.78	------
	Harmonic	------	1	------	2	------	3	------

It is to be noted that the adjacent frequncies, corresponding to the second harmonic of the note E and the third harmonic of the note A, are within two cycles of each other.

The fourth intervals, also often used in many chords, produce the same undesirable beat. In the case of the fourth interval, it is the fourth harmonic of one note that beats with the third harmonic of the other, as shown in the table below.

Note									
A	Harmonic	1	------	2	------	3	4	5	------
	Frequency	440	------	880	------	1,320	1,760	2,200	------
D	Frequency	------	587.33	------	1,174.66	------	1,761.99	------	2,349.32
	Harmonic	------	1	------	2	------	3	------	4

In this case, also, the beating involved is of the order of a few cycles per second. Other intervals also produce beats, but they are generally less apparent and do not appear to be as undesirable. When tremolo is applied, the harmonic beating becomes even worse, and destroys any illusion of a pipe organ.

When electrical instruments, such as electronic organs, utilize but one electrical channel, such as a single amplifier and loud speaker system, the conditions for perfect cyclic reinforcement and cancellation exist, and persist throughout the entire sounding of the tones. The resultant beating of adjacent frequencies is therefore very noticeable.

On the other hand, when musical tones are sounded by pipe organs, the individual pipes having different locations, the mixing of the two adjacent frequencies is acoustic, instead of electric; that is, the mixing takes place after the sound is produced. Furthermore, since each ear hears a different wave form, as regards phase relationship, it is clear that the conditions for cyclic reinforcement and cancellation of adjacent frequencies are quite poor. Therefore, if any beating at all is observed, it is quite vague, instead of being aggravated.

Other factors further contribute to the reduction of the beating effect when using organ pipes which are spaced at different distances from the ears of the user. The two ears of a user are spaced at a distance of approximately a quarter-wave length or more of the frequencies of the sound involved in the beating. Perfect mixing is impossible, as compared to the one electrical channel used in electronic organs. Reflection of sound from walls and other surfaces, and movement of the observer, further reduce the chances for noticeable beating between adjacent harmonics.

If a separate speaker system for each tone were provided, the electric mixing could be avoided and acoustic mixing obtained. Under such circumstances, conditions would occur similar to those in ordinary pipe organs. It is one of the objects of this invention to provide a loud speaker system utilizing plural loud speaker channels in which it is assured that perfect mixing of beating frequencies cannot be accomplished.

Although it is possible to attain this object by using a separate loud speaker for each tone, this involves much duplication of equipment. Accordingly, it is another object of this invention to make it possible to utilize an inexpensive installation to effect the desired results.

This object is attained by providing a few channels for the tones and arranging them in connection with the keyboard in such manner that fourth and fifth intervals cannot be produced in the same channel. Accordingly, there is no electric mixing of any chords of these intervals.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from a consideration of a form in which it may be embodied. This form is shown in the drawings accompanying and forming part of the present specification. It will now be described in detail for the purpose of illustrating the general principles of the invention; but it is to be understood that such 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 represents diagrammatically a system utilizing the invention; and

Fig. 2 is a diagram of another form of the invention.

In Fig. 1, two loud speakers 1 and 2 are provided. These loud speakers are physically separated sufficiently to reduce cyclic beating between the tones emanating from these loud speakers. The tones to be reproduced are segregated between these speakers.

Loud speaker 1 is arranged to reproduce only some of the musical notes that are played, and the loud speaker 2 reproduces all of the others. By carefully segregating the tones between the two speakers, the production of a fourth interval, or a fifth interval, by one speaker alone is impossible. This is accomplished, for example, by ensuring that loud speaker 1 can transmit only those tones corresponding to the notes C, D, E, F♯, G♯, and A♯, and all of their octaves. The remainder of the notes of the scale, and all of their octaves, are segregated for production through loud speaker 2. These notes are C♯, D♯, F, G, A, and B. Thus it is seen that alternate half tones are segregated. Although, in the drawing, only one octave is represented, it is understood that all higher octaves are similarly segregated and connected to the octave shown.

The entire octave of twelve half-tones is capable of being reproduced by both of the loud speakers acting in conjunction; but the keyboard 3 is so arranged that, when any note is played, either the loud speaker 1 or 2 is used to transmit the tone.

The keyboard 3 can be connected, as by connections represented by cable 4, to the generators and amplifiers represented generally by the rectangle 5. Thence connections are made to the filter systems 6 and 7 (respectively associated with speakers 1 and 2) from the generators and amplifiers.

Each note, as well as all of its octaves, can be sounded by appropriate operation of a key at the keyboard 3.

It can readily be shown that, if a fourth or fifth interval be played, it is not possible to obtain such an interval without using both of the loud speakers 1 and 2.

By this means, utilizing separate speaker systems at somewhat different locations, acoustic mixing of the harmonics will take place, rather than electrical mixing. By using rotary horns for the loud speakers 1 and 2, a natural tremulant is obtained due to the motion of the horns. In this way, there will be still less chance of perfect cyclic cancellation and reinforcement that would result in undesirable beats.

By separating the keys in this manner, the source of the sound changes location as the electric organ is played. This effect creates dispersion of sound similar to that occurring in ordinary pipe organs, since, in such pipe organs, the sound shifts from pipe to pipe. This added perspective is advantageous, due to the binaural effect of the two ears.

While, of course, only two channels are needed corresponding to the loud speakers 1 and 2 for obtaining the desirable results noted, further channels could be added further to split the octave and produce similarly desirable results. For example, each of the twelve notes, and all its octaves, of a complete scale could be appropriately wired to a different loud speaker.

When using only the two channel system illustrated in the drawings, the filter systems indicated (each included in the rectangles 6 and 7) need be provided only for two channels. When using a vacuum tube as a source of electrical impulses, it is common to employ the so-called formant system of harmonic control. The signals from the generated tubes are purposely made rich in harmonics, and the filter networks are employed to reduce or eliminate certain of the harmonics to produce various tone qualities.

In the form just described, the oscillators or generators indicated by rectangle **5** are so arranged that they operate only when the corresponding keyboard switch is operated on the keyboard **3**.

Other ways of supplying the oscillations may be used: for example, in the form shown in Fig. 2, the keyboard and its switches, indicated by the rectangle **8**, are arranged between the filters **6** and **7** and the constantly operated generators, represented by rectangle **9**. In this connection the switches on the keyboard serve to connect and disconnect the individual oscillators as required by the player.

The inventor claims:

1. In a system for producing musical tones: a pair of spaced loud speakers; a plurality of electrical circuits for creating impulses corresponding to the notes of a musical scale, the notes corresponding to the respective circuits being arranged to be half-tones apart; and means for connecting the circuits to the loud speakers in such manner that any circuit is connected to only one loud speaker, and circuits corresponding to adjacent half-tones of the scale being connected respectively to the two speakers.

2. In an electrically operated musical instrument: means for producing electrical impulses corresponding to tones of a musical scale; a pair of loud speakers for converting said impulses into sound; and a pair of series of connections from said impulse producing means; each of the connections from both series being connected to one only of the speakers; each of the series of connections corresponding to a distinct group of

tones, the tone groups being such that the production of any fourth musical interval requires the use of more than one speaker.

3. In an electrically operated musical instrument: means for producing electrical impulses corresponding to tones of a musical scale; a pair of loud speakers for converting said impulses into sound; and a pair of series of connections from said impulse producing means; each of the connections from both series being connected to one only of the speakers; each of the series of connections corresponding to a distinct group of tones, the two groups being such that the production of any fifth musical interval requires the use of more than one speaker.

4. In a system for producing musical tones in accordance with electrical impulses: a pair of loud speaker systems; means producing electrical impulses corresponding respectively to the notes of a musical scale, separated by half-tone intervals; means controlling the transmission of said impulses to the speaker systems; and connections between said controlling means and the speaker systems, those connections to one of the speaker systems being connected to one set of means producing alternate half tones of the musical scale, and those connections to the other of the speaker systems being connected only to the other set of means producing the other half tones of the musical scale.

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