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ELECTRICAL MUSICAL INSTRUMENT

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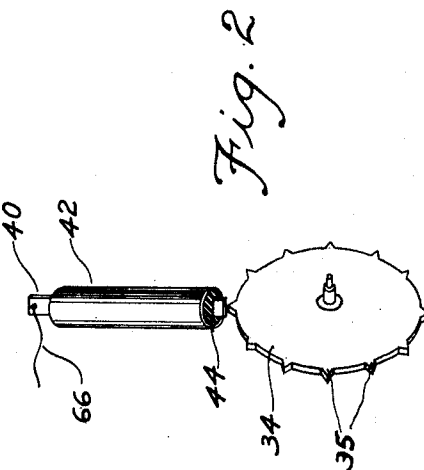
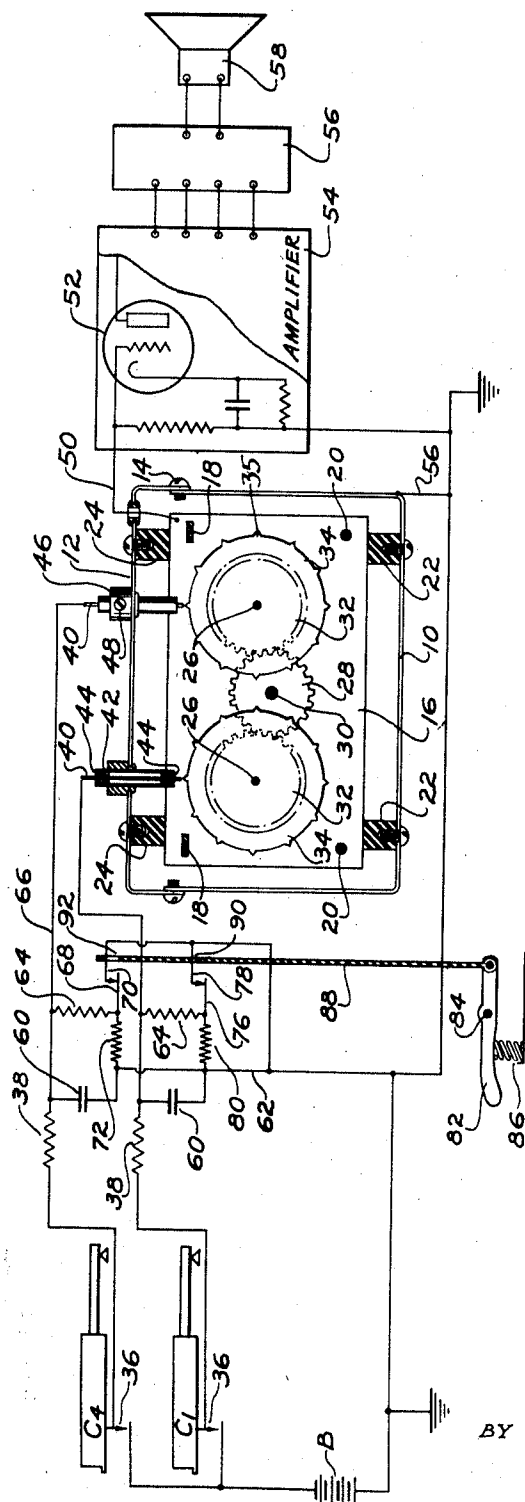


Fig. 1

Fig. 2

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## UNITED STATES PATENT OFFICE

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## ELECTRICAL MUSICAL INSTRUMENT

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Application August 7, 1937, Serial No. 157,969

2 Claims. (Cl. 175—363)

My invention relates generally to electrical musical instruments and more particularly to improvements in instruments of the character which are played by means of a keyboard, and in which electrical pulsations are generated electrostatically, amplified, and translated into sound.

It is an object of my invention to provide an improved electrostatic frequency generating system for use in electrical musical instruments.

Other objects will appear from the following description, reference being had to the accompanying drawing, in which:

Figure 1 is a diagrammatic view of the instrument showing the generator assembly in vertical cross-section and including a wiring diagram; and

Figure 2 is a perspective view of one of the phonic wheel electrostatic generators.

Referring to Figure 1, the instrument comprises a generator assembly enclosed in a metal casing of sheet steel or the like, comprising a box-like bottom 10, having a rigid cover 12 secured thereto by screws 14. The generator assembly comprises a plurality of vertical frame plates 16, which are held in properly spaced relation by a plurality of longitudinally extending bars 18 and rods 20. The generator assembly may be of the general construction disclosed in my prior Letters Patent No. 1,956,350 granted April 24, 1934.

The assembly of frame plates 16 is supported upon a plurality of blocks 22 of insulating material, and is held in spaced relation from the cover 12 by similar insulating blocks 24. A plurality of shafts 26 are rotatable in suitable bearings mounted in the vertical frame plates 16, and are rotated by means of a driving pinion 28, carried upon a driving shaft 30. The shaft 30 is driven at a very accurately maintained constant speed, preferably by a synchronous motor connected to the shaft by a flexible elastic coupling in the manner described in my aforesaid patent. The driving pinion 28 meshes with driven gears 32, which are preferably resiliently coupled to their respective shafts 26 in the manner disclosed in my aforesaid patent.

Phonic wheels or rotors 34 are preferably rigidly secured to their respective shafts 26, are made of brass or other suitable metal, and have their peripheries suitably formed, so as to generate a complex wave form which may be translated into sound having a pleasing tone quality. In the drawings the peripheries of the rotors are illustrated as having spaced projections 35. It will be understood that in the usual form of the instrument the number of the projections 35 upon

the rotors will be correlated with their speed of rotation so that electrical impulses of the frequencies of the notes of the tempered musical scale may be generated.

It is preferable that the shapes of the tooth-like projections 35 on the phonic wheels be such as to produce a wave having a long series of harmonic partials of gradually decreasing amplitude, although as previously stated, their shape may be such as to produce any desired tone quality. Generally speaking, however, a tone quality fairly rich in fundamental tone and having a large series of upper partials of gradually decreasing intensity will be found most practical in an instrument of this character.

It will be understood that there will be one phonic wheel for each tone to be produced, and that in an instrument having a full piano keyboard there will be 88 phonic wheels.

The instrument is provided with a suitable keyboard or manual including a key designated C<sub>4</sub>, representative of the keys of the treble register, and key C<sub>1</sub>, representative of the keys of the bass register. Each key is adapted to close a single contact switch 36, one terminal of which is connected to a direct current potential source shown as a battery B. The other terminal of the switch 36 is connected through a resistance 38 with an electrode 40 in the form of a narrow metal strip rigidly fixed in a metal tube 42 by means of insulating bushings 44. The inner ends of the electrodes 40 lie closely adjacent the peripheries of their respective phonic wheels 34, each with its associated phonic wheel constituting a continuously changing variable condenser.

The electrode tubes 42 are mounted for sliding movement in bushings 46 which may be peened or otherwise rigidly secured to the cover 12, each bushing being provided with a set screw 48 so that the dimensions of the air gaps between the inner ends of the electrodes 40 and the peripheries of the phonic wheels may be adjusted, and the electrodes clamped in adjusted position. The phonic wheels, their shafts, the vertical frame plates 16 and all the metallic parts of the generator assembly associated therewith are electrically interconnected so as to constitute, in effect, a single plate common to a plurality of condensers, of which the electrodes 40 form the other plates.

The frame plates 16 are electrically connected together and have connected thereto a conductor 50 which passes through a suitable insulating grommet secured in the cover 12. The conductor 50 is connected to the grid of a vacuum tube 52 which is in the first stage of an amplifier 54.

The housing or case 10, 12 is suitably grounded by a conductor 56.

Suitable means are provided to control the volume and tone quality of the output of the amplifier, such means being diagrammatically indicated at 56. The output of the amplifier is translated into sound by means of the loud speaker 58.

Upon closure of the key switch 36 associated with the key C<sub>4</sub>, the current from the battery flows through the resistance 38 to charge a condenser 60. By suitably selecting the values of the resistance 38 and condenser 60, the rate at which the potential upon the electrode 40 will be built up, may be accurately predetermined. It will be noted that one terminal of battery B is grounded. Each of the condensers 60 likewise has one plate connected to a conductor 62, which is grounded. A resistor 64 has one end connected to the conductor 66 which connects the resistance 38 with the electrode 40. The other end of the resistance 64 is connected to a contact 68 of a switch 70. The other terminal of switch 70 is connected to the grounded conductor 62. The resistance 64 is preferably of considerably higher value than the resistance 38. A resistor 72 of value several times as great as that of the resistance 64 is permanently connected between a switch terminal 68 and the grounded conductor 62.

The circuit for the key C<sub>1</sub> is similar to that described with reference to the key C<sub>4</sub>, and similar reference characters have therefore been applied to the corresponding elements except that the grounded resistance has been designated 80 instead of 72 and the switch parts have been marked 76 and 78. The key C<sub>4</sub> is representative of any key in the treble register of the instrument, while the key C<sub>1</sub> is representative of any note in the bass register.

Under some circumstances, as for example, if the resistances 72 and 80 are of relatively low value, all of the resistors 64 for the key circuits in the treble register may be connected to the common switch terminal 68, and the resistor 72 may be common for all of these key circuits. Similarly, all of the resistances 64 of the key circuits for the bass register may be connected to the common switch terminal 76 of the contact switch 78, and the switch terminal 76 connected to the ground conductor 62 by means of a resistor 80. Ordinarily it will be preferable to provide completely separate circuits for each key switch, in order to avoid the possibility of undesired tones being produced.

The switches 76, 78 are adapted to be operated by a substantial pedal 82 suitably mounted on a pivot 84 and returned to normal position by a spring 86.

The sustaining pedal is illustrated diagrammatically as having an insulating bar 88 pivotally connected thereto, so that the latter will be raised when the sustaining pedal 82 is depressed. The bar 88 is provided with an aperture 90 for the contact arms of switches 78, and a relatively larger aperture 92, for the contact arms of switches 76. In this way, upon depression of the sustaining pedal 82, the bar 88 will be raised, and during the initial portion of its upward stroke will open the switches 78, and upon continued upward movement thereof, will open switches 76.

In operation the phonic wheels will be rotated at constant speed continuously, and the instrument played in the manner of a piano or organ.

Upon depression of a key, C<sub>4</sub> for example, closure of the associated switch 36 will cause a gradual rise in the potential of the associated electrode 40. The rate at which the potential on this electrode is built up is determined by the values of the resistance 38 and condenser 60. During this period the effect of the leak to ground furnished by the resistance 64 will be relatively small because this resistance is considerably higher than resistance 38. As the potential of the electrode 40 is raised, a signal of gradually increasing amplitude will be impressed upon the conductor 50. The character of this signal will be predetermined by the shape of the periphery of the phonic wheel 34 which is rotating adjacent the energized electrode 40. The degree of amplification of the signal impressed through the conductor 50 upon the grid of the vacuum tube of the first stage of the amplifier may be controlled by the volume and tone control device 56, which may be actuated by means of a manual control, or, in addition, by a swell pedal of the type disclosed in my copending application Serial No. 91,284, filed July 18, 1936.

Upon release of the key C<sub>4</sub>, the potential upon the associated electrode 40 will drop gradually, due to leakage of the charge of the condenser 60 through the resistance 64 and switch 68, 70 to the grounded conductor 62. As a result, the strength of the signal in the conductor 50 will decay gradually at substantially a logarithmic rate. Whenever it is desired to sustain the signal for a period longer than its normal decay period, the sustaining pedal 82 is depressed, thus opening the switch 68, 70. Under these circumstances, the leakage of the charge from the condenser 60 will be very slow, the rate being determined by the values of the resistance 64 and 72 which form a series path to ground whenever the switch 68, 70 is open. Since the resistor 72 may be of high value relative to the resistor 64, the signal will decay very slowly and will be substantially a sustained tone.

If desired, the resistors 72 and 80 may be omitted and normal leakage relied upon to permit the gradual discharge of the condenser 60 when the sustaining pedal is depressed.

Depression of a key such as C<sub>1</sub> in the bass register of the instrument will result in operation similar to that described with reference to key C<sub>4</sub>. However, it is preferable that the value of the resistor 80 be slightly greater than that of the resistor 72, so that the decay of the bass tones will be at a slower rate than the decay of the tones in the treble register. By operating the sustaining pedal a sufficient distance to open only the switch 76, 78, the bass tones may be rendered sustaining while the tones of the treble register decay at the usual rate, whereas if the sustaining pedal is fully depressed, both the bass and treble tones will be sustained.

From the above description it will be clear that I have provided a very simple form of electrical musical instrument in which but a single switch is necessary for each key. If it is desired to have the instrument capable of producing differing tone qualities, suitable filter circuits may be included in the amplifier and provided with control switches so that selected frequencies will be attenuated. Because the phonic wheels generate tones rich in harmonics, the tone quality may be greatly varied by attenuating certain frequencies, which will result in giving the instrument individualistic tone quality characteristics. Since the key switches 36 are in the direct current por-

tion of the circuit, there is little possibility of producing objectionable transient frequencies in the output circuit when they are opened and closed.

5 The key and sustaining pedal operated switch completed circuits for controlling the excitation or energization of the electrostatic generators are not claimed herein, but form the subject matter disclosed in my co-pending application Serial No. 342,839, filed June 28, 1940, which is a con-  
10 tinuation in part of this application.

While I have shown and described a particular form of my invention, it will be apparent to those skilled in the art, that numerous alterations and modifications may be made without departing  
15 from the basic principles thereof. I therefore desire in the following claims to include such variations and modifications by which substantially the same results may be obtained in substantially the same way.

20 I claim:

1. In a variable capacity type of generator of electrical impulses corresponding to musical tones, the combination of a metallic casing, an electrode, insulating means rigidly securing said  
25 electrode to said casing, a metallic disc-shaped element having a plurality of spaced prominent

radial projections thereon, said projections being separated by spaces of greater width than the width of the projections measured along the path of movement of said projections, means for mounting said discs for rotation within said cas-  
5 ing with the path of movement of said projections in close propinquity to said electrode, said last named means including means for insulating said disc from said casing, and means for rotating said disc at a constant average speed. 10

2. A variable capacity type generator for electrical musical instruments comprising, a fixed electrode, means for energizing said electrode, and a metallic element movable at a constant average  
15 speed, said element having a plurality of substantially uniformly spaced prominent projections thereon moving in a path passing close to said electrode, said projections being substantially pointed and separated by spaces of greater width than the maximum width of the projections meas-  
20 ured along the path of movement thereof, whereby potential changes in said element upon energization of said electrode will comprise a fundamental frequency and a plurality of harmonics of said  
25 fundamental frequency.

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