Jan. 19, 1960 D. J. LESLIE 2,921,494

ELECTROSTATIC MUSICAL TONE GENERATOR SYSTEM

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FIG. 1.

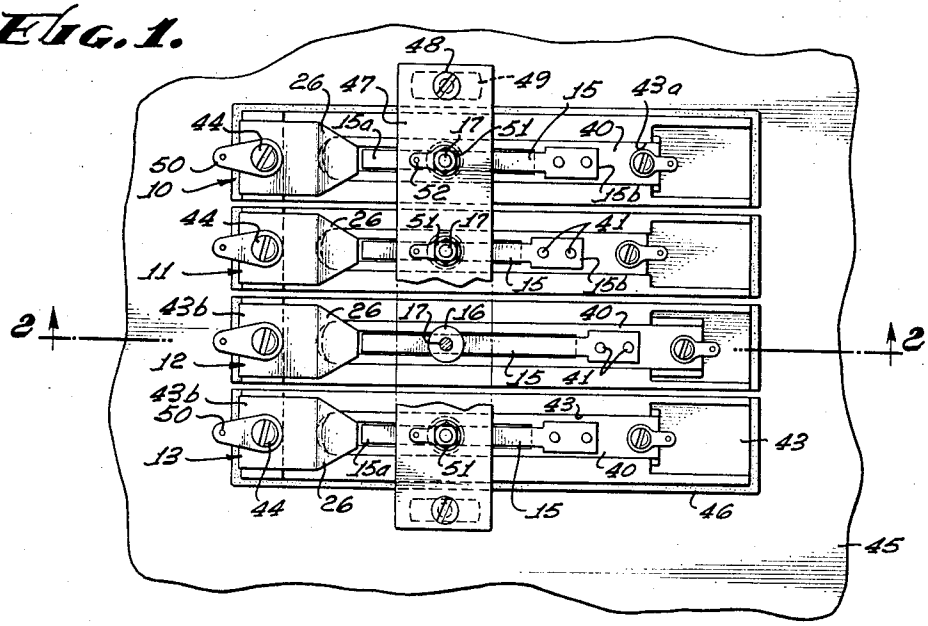


FIG. 2.

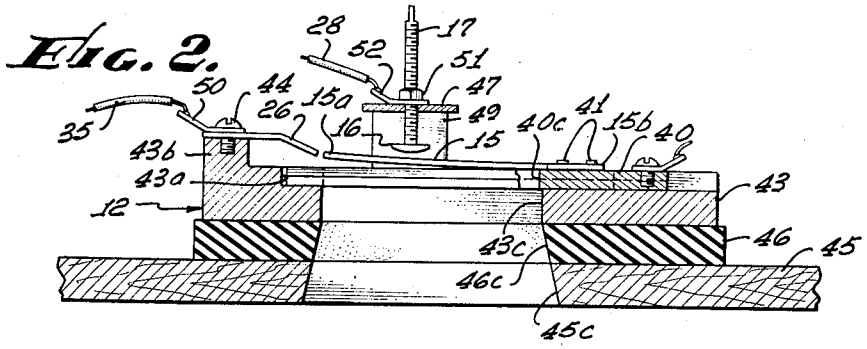
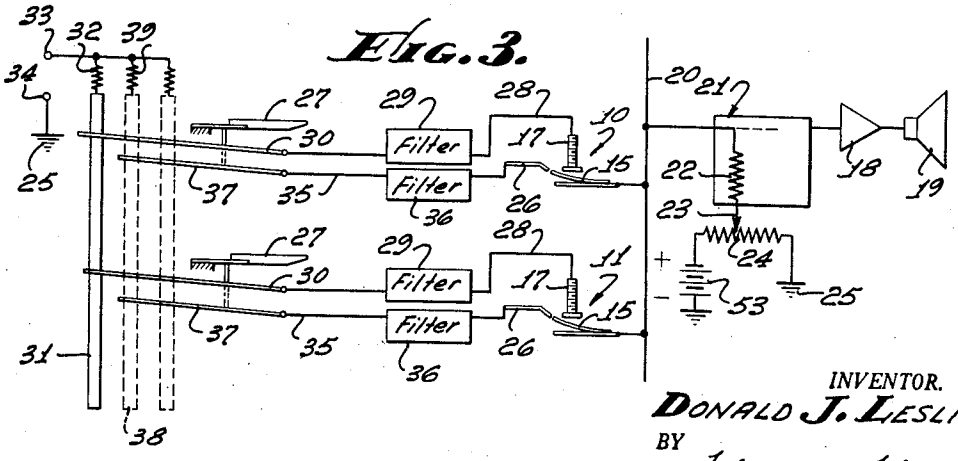


FIG. 3.



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Fig. 4.

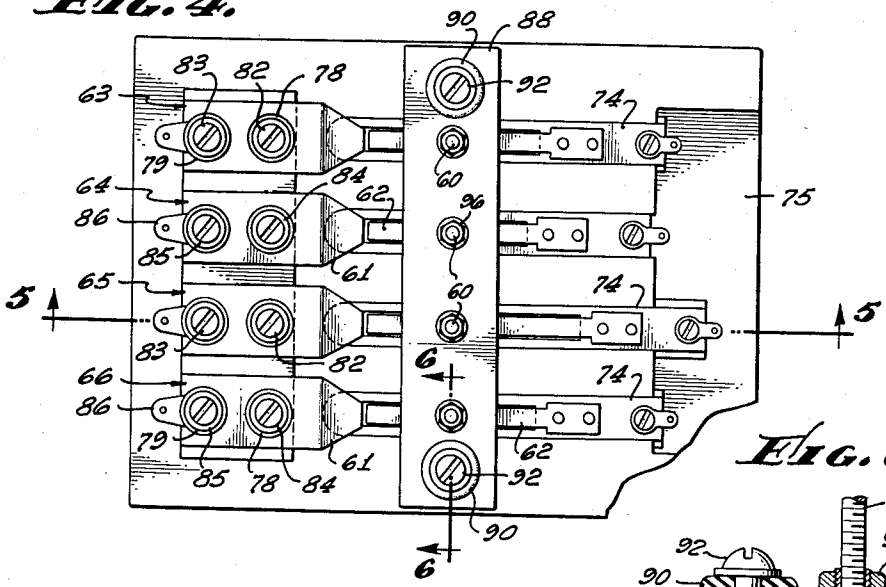


Fig. 6.

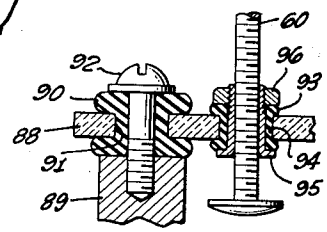


Fig. 5.

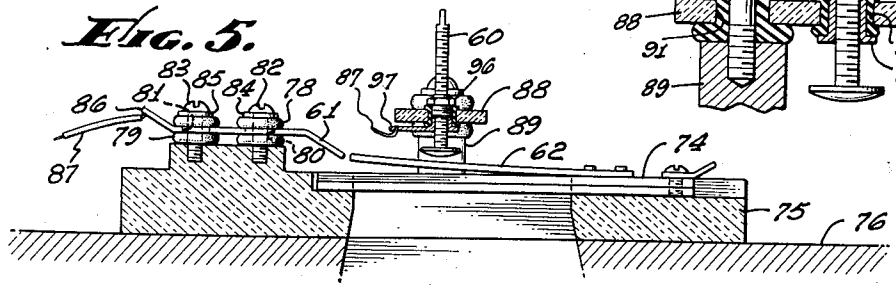
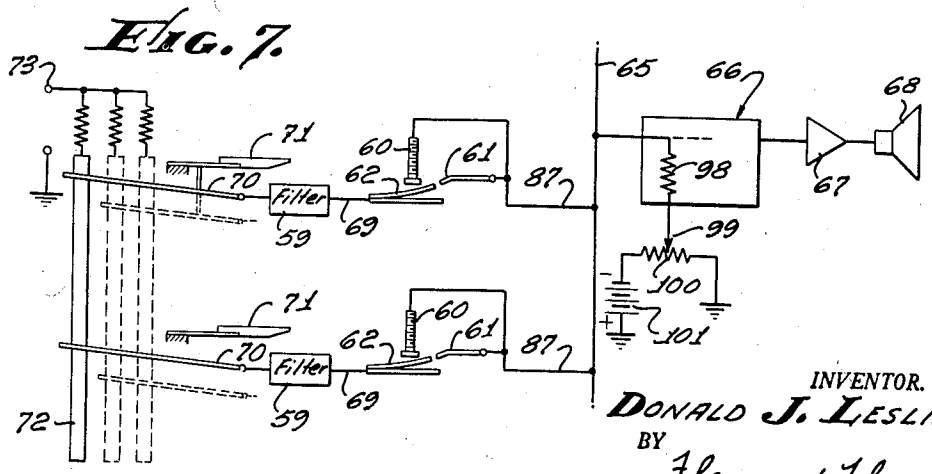


Fig. 7.



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ELECTROSTATIC MUSICAL TONE GENERATOR SYSTEM

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5 Claims. (Cl. 84—1.04)

This invention relates to electrical musical instruments in which tone generation is accomplished by electrostatic means, and particularly to electric organs of this character.

In such electric organs, a set of continuously vibrating elements or reeds is commonly provided, one for each pitch desired. Plates adjacent each vibrating element form with the element capacitors, the capacity of which varies in accordance with the vibration of the elements. By applying a direct current or polarizing voltage to one of the capacitor plates, the changing charge induced by the changing capacity is used to create a signal. The polarizing voltage is controlled by operation of playing keys respectively associated with the various capacitors, and the desired musical pitches are caused to appear in the output system.

While polarizing the capacitor results in the desired output from the generator system, a continuous residual electrical output also exists from all the vibrating elements whenever the instrument is operating, and despite the fact that the playing keys are in inoperative position. This residual weak output, which includes all of the available pitches of the instrument, is most disturbing and undesirable. While the cause of the residual signal is not clearly known, it may be induced by piezo-electric effects, air friction, thermoelectric effect, and the like, or a combination thereof.

Some attempts have been made to remove the residual signal by applying a low bucking voltage to one of the capacitor plates. This arrangement by itself is unsatisfactory since it produces only limited results. This is largely due to the fact that the phenomenon producing the residual signal is complex and cannot be equated to a direct current or any other simple form.

The primary object of this invention is to reduce or eliminate the residual signal output from the generator system. In order to accomplish this result, use is made of resilient mountings for each capacitor set. This arrangement mechanically isolates the capacitors one from the other, and so changes the characteristics of the residual signal output that a simple bucking voltage will very nearly, if not entirely, balance out the residual signal.

Referring to the drawings:

Figure 1 is a plan view of apparatus incorporating the present invention, some of the parts being broken away;

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

Fig. 3 diagrammatically illustrates the electrical system in which the apparatus of Figs. 1 and 2 is incorporated;

Fig. 4 is a plan view of the modified form of the present invention;

Fig. 5 is a sectional view taken along a plane indicated by lines 5—5 of Fig. 4;

Fig. 6 is an enlarged fragmentary sectional view taken along the plane indicated by the line 6—6 of Fig. 4; and

Fig. 7 diagrammatically illustrates the electrical system

in which the apparatus of Figs. 4, 5 and 6 is incorporated.

A plurality of generator units 10, 11, 12 and 13 are shown in Fig. 1 that are representative of a larger number comprising the full complement used in the usual electric organ. The generator units are all similar.

Each generator unit includes a vibrating reed 15 that comprises one plate of a condenser. The reed 15 is made of thin flexible strip material. One end of the reed is secured, and the other end is free. The free length of the reed determines the natural frequency of its vibrations. An enlarged head 16 of a tone screw pickup 17 spaced slightly above the central portion of the reed 15 forms the other plate of the condenser.

The reed 15 projects into a stream of air and is thereby vibrated. The vibration of the reed 15 causes a corresponding cyclic change in the capacity of the condenser. By applying a direct current, or polarizing, voltage between the elements 15 and 16 of the condenser, an alternating current is caused to flow to the plate. An audio frequency section, comprising an amplifier 18 and a speaker 19 is actuated by a signal created by the alternating current.

In Fig. 3, two generator units 10 and 11 are shown. It will be understood that there are generator units corresponding to each note in the musical range of the electric organ. The reeds 15 of each of the generator units are each connected to a common connection 20. An input circuit 21, including a load resistor 22, is provided for coupling to the amplifier 18.

The load resistor 22, through an adjustable potentiometer tap 23, connects through a portion of a potentiometer resistor 24 to a ground or neutral connection 25. The direct current of polarizing voltage is applied between the tone screw pickup 17 and the ground or common connection 25.

The change in capacity due to the vibration of the reed 15 of the condenser unit 15—16 is substantially sinusoidal due to the location of the enlarged head 16 with respect to the reed 15. The signal created by the condenser unit 15—16 is accordingly known as the "flute tone" and the tone screw pickup 17 is generally characterized as the "flute pickup."

In order to create tones that are richer in harmonics, use is made of a so-called trumpet pickup 26 forming a second condenser unit with the reed 15. The trumpet pickup 26 is in the form of thin strip material, the end edge of which is spaced slightly from the free vibrating left-hand end 15*a* of the reed 15. As the reed end 15*a* passes the end of the trumpet pickup 26, an abrupt change of capacity takes place. When a polarizing voltage is applied between the trumpet pickup 26 and the reed 15, a signal rich in harmonics and generally equivalent to a trumpet tone is created.

In order that the person operating the instrument selects which of the generator units is operative, circuit controllers operated by the usual key 27 are provided. When the key 27 is depressed, a circuit is established for applying a direct current potential either to the trumpet pickup 26 or to the flute pickup 17. When the key 27 is released, the polarizing voltage is removed and the vibration of the reed 15 will be ineffective to create the desired signal.

A lead 28 from the flute pickup 17 connects through a filter 29 with an arm 30 of the circuit controller associated with the key 27. When the key 27 is depressed, the arm 30 engages a conductor carried by a bar 31 providing the bar 31 is oriented in operative position (as by usual stops of the electric organ). The conductor carried by the flute bar 31 connects through a resistor 32 to a terminal 33. The direct current potential is applied

between this terminal 33 and another terminal 34 which connects to the common or neutral connection 25.

A lead 35 connects the trumpet pickup 26 of the generator unit 10 through a filter 36 with another arm 37 associated with the key 27. The arm 37 on depression of the key 27 is caused to engage a conductor carried by a trumpet bar 38 providing the trumpet bar is operatively oriented. The conductor carried by the trumpet bar 38 connects through a resistor 39 to the terminal 33.

The pickups associated with the other generator units also connect to the conductors carried by the bars 31, 38, etc. By selecting certain stops (not shown), all of the notes or groups of notes may have corresponding tonal characteristics.

As described previously, a residual output tends to exist even though the polarizing voltage is removed. In order to simplify the form of the residual output so that simple compensation means can be effective, the reeds are separately and resiliently mounted.

Each reed 15 is secured upon a block 40 as by the aid of rivets 41 at the right-hand end 15*b* of the reed 15, as viewed in Figs. 1 and 2. The block is slidably movable longitudinally upon a base 43. In order to guide the block 40 for longitudinal movement, the base 43 has a dovetail slot 43*a* receiving dovetailed flanges formed along the opposite longitudinal edges of the block 40.

The trumpet pickup 26 is also carried by the base 43. For this purpose, a machine screw 44 passes through an aperture of the trumpet pickup 26 and cooperates with a recess formed on an integral upwardly extending wall 43*b* of the base. The screw 44 also clamps a terminal lug 50 in place and in electrical conducting relationship to the trumpet pickup 26. The lead 35 is appropriately soldered to this terminal lug.

Longitudinal adjustment of the block 40 in the base slot 43*a* determines the effective minimum spacing between the trumpet pickup 26 and the reed 15 and thus controls the intensity of the signal produced. When the block is properly located with respect to the base, it is releasably locked in position, as by a set screw (not shown).

A resilient pad 46 for each base 43 is provided for resiliently mounting the base on a support. The pad 46 is secured on opposite sides to the base 43 and support 45 by mechanically separate means. In the present instance, an adhesive layer is provided between the contacting surfaces of the pad 46 and the support 45. Other suitable means could, of course, be provided.

A single pad for several bases could be used, but the bases should be spaced in order to avoid mechanical coupling by virtue of transmission of vibrations along the surface of the pad.

Each generator unit is mechanically or at least acoustically isolated from all others. Accordingly, the vibrations of the units which are at different frequencies, do not influence the residual outputs of the other units.

The reed block 40, base 43, pad 46 and support 45 all have registering apertures 40*c*, 43*c*, 46*c* and 45*c* for passage of a current of air to the reed 15. Suitable duct means (not shown) communicating with the apertures may cooperate with a suitable fan or blower structure (not shown).

The tone screw pickups 17 are mounted upon a bridge 47 that extends in juxtaposed relationship over a group of generator units. Posts 49 located laterally beyond the end units of a group of generator units provide rests for opposite ends of the bridge 47. Machine screws 48 threadedly engaging the posts hold the bridge in place.

Each tone screw pickup 17 is threadedly received in an aperture of the bridge 47. The apertures are so located that the respective tone screw pickups oppose the flat upper side of the corresponding reed 15.

A nut 51 mounted upon that end of the tone screw pickup 17 above the bridge 47 clamps a terminal lug 52 in place and in electrical conducting relationship with the tone screw pickup 17. The lead 28 is appropriately soldered to the terminal lug 52.

The position of the head 16 relative to the reed 15 can be adjusted simply by rotation of the tone screw pickup, the adjustment serving to determine the normal amplitude of the signal produced. The nut 51 locks the pickup in adjusted position.

The resilient and separate mounting of each of the reeds 15 ensures against a mechanical or acoustic coupling between them. The residual signal remaining when the polarizing voltage is removed accordingly assumes a simple wave form such that by applying a suitable constant bucking voltage, the residual signal can be substantially entirely eliminated.

The bucking voltage is applied through the audio frequency section of the apparatus. A battery or other source of direct current 53 impresses a direct current potential across the potentiometer resistor 24 which cooperates with the load resistor 22. By locating the tap 23 at its intermediate position along the potentiometer 24, a direct current potential will be impressed between the reed 15 and the corresponding pickup structures 17 and 26. By adjusting the position of the tap 23, an appropriate value of bucking potential can be applied to the condenser unit and the system will be relatively free of annoying undesired output.

Any slight relative movement between the trumpet pickup and the fixed end of the reed would result in an undesired wave form. It is for this reason that the trumpet pickup 26 is mounted on the same base 43 as the reed 15.

Slight relative movement between the reed and the flute pickup 17 does not materially influence the wave form. Accordingly these pickups 17 may be rigidly connected to the support 45 as by the bridge 47 and post 49. However, if desired, each of the tone screw pickups 17 may be separately mounted upon the reed mounting base 43 as are the trumpet pickups 26.

In the form shown in Figs. 4, 5, 6 and 7, several generator units 63, 64, etc. are shown. As shown in Fig. 7, a circuit arrangement similar to Fig. 3 is shown, except that the position of the pickups 60 and 61 in the circuit is reversed. The pickups 60 and 61 are connected together and to a common connection 65 to a coupling network 66 similar to the coupling network 21 in the previous form. An amplifier 67 cooperating with a coupling network drives a speaker 68. In the present instance, the reed 62 through a connection 69 and a filter 59 connects with a circuit controller arm 70 operated by a key 71. Depression of the arm 70 causes connection to a conductor bar 72. The bar 72 is connected to a terminal 73 that cooperates with the source of direct current for polarizing voltage. The circuit controller arms 70 of all of the generator units cooperate with the bar 72.

In the present instance, the reeds 62 are mounted upon blocks 74 that are slidably received in dovetailed grooves of a common base 75. The base 75 is in turn secured upon a support 76.

The pickups, which in this instance are in the audio frequency section, are all resiliently mounted so that they are isolated from the various vibrations of the reeds.

For resiliently mounting the trumpet pickups 61, a pair of rubber grommets 78 and 79 are provided. The grommets 78 and 79 are accommodated in apertures 80 and 81 formed in the trumpet pickup 61. Machine screws 82 and 83 acting through washers 84 and 85 and cooperating with threaded apertures of a common mounting block 77 fix the grommets 78 and 79 in place. The rearward end 86 (Fig. 5) of the trumpet pickup 61 provides a connection for a lead 87 to the common connection 65.

The flute pickups 60 are mounted upon a support in the form of a bridge 88 that extends over the group of

generator units. The ends of the bridge **88** are secured to posts **89** in such manner that vibrations of the support **75** are insulated from the bridge **88**. For this purpose, rubber grommets **90** are seated in apertures **91** of the bridge **88**. Machine screws **92** pass through the apertures of the respective grommets **90** and are in threaded engagement with the post **89**.

If desirable, each of the flute pickups **60** may be resiliently mounted at the apertures **94** of the bridge **88**. A resilient grommet **93** for each aperture is provided. Extending upwardly through the grommet aperture is a sleeve **95** that is provided with appropriate threads for adjustably accommodating the pickup screw **60**. The sleeve **95** has a lower flange held in place against the grommet **93** by the aid of a nut **96** threadedly accommodated on the opposite end of the sleeve and engaging the opposite side of the grommet **93**. The flange of the sleeve **95** has a tab **97** (Fig. 5) providing a post for connection to the lead **87**.

The reed block **74** and base **75** have apertures for passage of a current of air to the reed **62**.

The bucking network, comprising the load resistor **98**, tap **99**, potentiometer resistor **100**, and direct current source **101** similar to the bucking circuit shown in the previous form, impressed a voltage between the plates of each generator unit. Undesired residual output is substantially eliminated.

The inventor claims:

1. In a musical instrument: a unitary support; a plurality of mechanical vibrators mounted on the support; and an acoustic damping element between each of the vibrators and the support so that vibrations are not substantially transferred between the vibrators via the support.

2. In a musical instrument: a plurality of generators each including a pair of electrostatic members forming a condenser, the members being continuously moved through repeated cycles with respect to each other; manually controlled circuits applying polarizing voltage across selected generators; an amplifier including an input circuit connected to corresponding members; a unitary support for said corresponding members; an acoustic damping element between each of said corresponding members and the support so that vibrations are not substantially transferred between said members via said

support; and a bucking circuit impressing upon said input circuit a voltage for compensating the output of said generators existing when said polarizing voltage is not applied.

3. In a musical instrument: a plurality of reeds that are all continuously vibrated whenever the instrument is used; an electrostatic pickup for each reed, and spaced therefrom; key controlled circuits applying polarizing voltage across selected reed and pickup pairs; an amplifier including an input circuit connected to all of said reeds; a unitary support for said reeds; an acoustic damping pad between each of said reeds and said support so that individual vibrations of said reeds are not substantially transferred to each other via the support; and a bucking device impressing upon said input circuit a voltage for compensating the output of said reed and pickup pairs when none of the keys is operated.

4. The combination as set forth in claim 3 in which a common base is provided for each reed; each reed having an edge; the pickup being mounted on the base and cooperable with the edge of the reed; the acoustic damping pad being located between each base and the support.

5. In a musical instrument: a plurality of reeds that are all continuously vibrated whenever the instrument is used; an electrostatic pickup for each reed, and spaced therefrom; key controlled circuits applying polarizing voltage across selected reed and pickup pairs; an amplifier including an input circuit connected to all of said pickups; a unitary support for said pickups; an acoustic damping grommet between each pickup and the support so that individual vibrations of the pickups are not substantially transferred to each other via the support; and a bucking device impressing upon said input circuit a voltage for compensating the output of said reed and pickup pairs when none of the keys is operated.

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