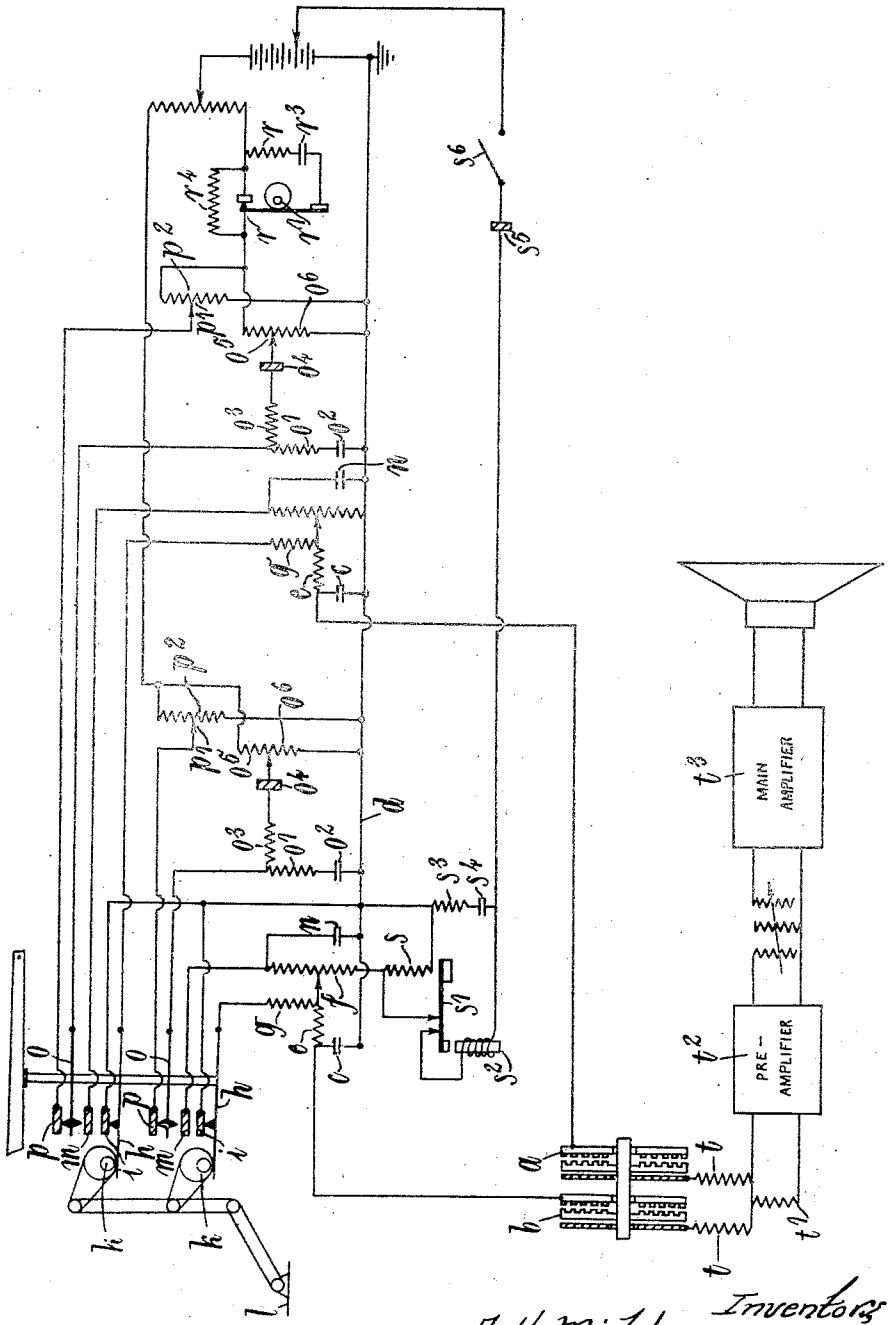
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ELECTRICAL MUSICAL INSTRUMENT

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ELECTRICAL MUSICAL INSTRUMENT

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This invention relates to electrical musical instruments of the kind in which electrical vibrations or an undulating potential of any desired controlled frequency and wave form are produced electrostatically and converted into sound waves.

An object of the present invention is to provide an improved form of instrument of the above character capable of producing the tones of various musical instruments such as an organ, orchestral and percussive instruments and also a variety of new tones of musical quality.

The invention consists in an electrical musical instrument of the kind referred to having means for controlling the intensity of the attack and also the decay or die-away of any particular note so that there may be produced effects ranging through percussion, sustained tones, reverberation tones and tones which build up in intensity.

Further features of the invention will be apparent from the description given hereafter.

The accompanying drawing illustrates diagrammatically one arrangement of instrument in accordance with the invention.

In carrying our invention into effect in one convenient manner, as, for example, in its application to a musical instrument provided with a single manual of six octaves compass, we provide the apparatus with two generators *a* and *b*, each of which may be generally on the lines of that described in our prior application Serial No. 221,212 filed July 25, 1938. Each generator, however, instead of being provided with one rotor to generate six octaves and another to generate two octaves, has two generators each of which is adapted to generate six octaves of the musical scale and the speed is so arranged that the lowest note shall be FFF and the highest note F4. The set of rotors belonging to one generator *a*, which we may term the fundamental generator, is arranged to produce undulating potentials of pure sine wave form, while those of the other generator *b*, which we may term the harmonic generator, are associated with stationary members of a triangular or other shape in order to produce a saw-tooth wave form which comprises a fundamental and a long series of harmonics. Each generator is controlled from a set of contacts operated by keys on the keyboard, and as each generator will be associated with sets of contacts, resistances and condensers which are the same for each generator, we will describe only those for what we have termed the fundamental generator *a*.

Each member of the generator to be charged is connected to one terminal of a condenser *c* of about .005 microfarad capacity, the other terminal of which is connected to the negative or a ground conductor *d*, and each member is also connected to one end of a charging resistance *e* of about 5 megohms, the other end of which makes contact (which may be variable) about midway on a regulating resistance *f* of about 10 megohms. The same end of the charging resistance also connects to one end of a discharge resistance *g* of about 100,000 ohms, the other end of which is connected to a key switch *h*, which for convenience we will term the key earthing switch. All the key earthing switches in their normal position make contact with a common busbar *i* connected to ground and they also abut against an eccentrically mounted cam or like member *k* which is connected by cranks and levers or otherwise to a sustaining pedal *l*. One end of the regulating resistance *f* is connected to the negative or ground conductor and the other end is connected to a stationary contact *m* under each key, which we may term the key charging contact, while across the regulating resistance is connected a condenser *n* of about .1 microfarad. A key charging switch *o* is adapted to make contact with the key charging contact *m*, but in its normal position it makes contact with a supply busbar *p* which is connected to an adjustable contact *p'* on a potentiometer resistance p^2 connected between the positive and negative mains of the H. T. supply and this potentiometer may for convenience be referred to as the "attack" potentiometer. The key charging switch *o* is connected to one end of a resistance *o'* of about 250,000 ohms, which may be termed the "supply" key resistance, and the other end of which is connected to one terminal of a condenser o^2 of about .1 microfarad capacity, the other terminal of this condenser (termed the "supply" condenser) being connected to the negative main *d*. The end of the supply key resistance *o'* (remote from that to which the supply condenser is connected) is connected to one end of a resistance o^3 *of* about .5 megohm, which may be termed the supply condenser potentiometer resistance, and the other ends of these last-mentioned resistances are connected to a common busbar o^4 which is connected to an adjustable contact o^5 of a potentiometer resistance o^6 connected between the positive and negative H. T. supply mains, and which for con-

venience may be termed "delay" potentiometer.

Between the positive ends of the attack and delay potentiometers and the positive terminal of the H. T. supply we insert make-and-break contacts r operated by a cam r' which may rotate at about 7 revolutions per second, the contacts being shunted by a resistance r^2 and condenser r^3 in series and also being shunted by a series resistance r^4, the whole arrangement constituting a tremulant.

When it is desired to obtain a percussive tone, such as that of a piano, the contact on the attack potentiometer p^2 is set at maximum potential and that on the delay potentiometer o^6 at minimum potential, so that under these conditions the supply condenser o^2 will be charged at maximum potential. If now a key be depressed, the supply condenser o^2 will be connected to the regulating resistance f through the supply key resistance o', key charging switch o and charging contact m, and thus the regulating condenser c will be gradually charged and the generator member will be charged through the charging resistance, thus giving the note a gradual attack. Thus the note will take a fraction of a second to build up to its maximum intensity and thereafter it will decay slowly because the supply condenser will be discharging through the regulating resistance and through the supply condenser potentiometer resistance. If it is required that the note shall not decay entirely, the delay potentiometer contact o^5 is moved slightly away from its minimum position so that the supply condenser will be maintained at a very low potential.

During the time when the key is depressed, the key earthing switch h is held away from the earth busbar i, and when the key is released the earthing switch again makes contact with the earth busbar, while the key charging switch o makes contact with the supply busbar p and the supply condenser o^2 will again be charged and the note will decay more rapidly due to the regulating condenser discharging through the regulating resistance and the low value earthing resistance. If it is desired to sustain the note after the key has been released, the sustaining pedal is depressed so as to maintain the key earthing switches out of contact with the earth busbar, and thus all the notes which were sounding when the sustaining pedal was depressed, or any other notes which may be struck after depression of the pedal, will be sustained.

If it be desired to obtain the tone of an organ or like instrument, both the attack and the delay potentiometers are adjusted to their mid-potential positions. Under these conditions the supply condenser will be charged to one-half its maximum potential, and when a key is depressed the note will start gradually and attain its maximum intensity. It will, however, continue to sound so long as the key is depressed because the supply condenser is now being charged from the delay potentiometer through the supply condenser potentiometer resistance. When the key is released the note will decay gradually due to the regulating condenser discharging through the regulating resistance, earthing resistance and earthing switch making contact with the earth busbar.

If the attack potentiometer is adjusted to its minimum position and the delay potentiometer to its maximum position, the potential of the supply condenser will be at a minimum value, and when a key is depressed the note will gradually sound and attain its maximum intensity very slowly due to the supply condenser being charged through the supply condenser potentiometer resistance which is of high value. The note will continue at its maximum intensity until the key is released, when it will gradually decay as before, and it will be seen that solo effects can be obtained by holding certain keys depressed for a longer period than others.

It will be evident that not only can the attack and delay be varied by the positions of the potentiometer switches but also the charging potential to the generator members and therefore the volume of sound, and by varying adjustments of the potentiometers of both the generators, tones such as the piano, organ, flute, strings, etc., are readily obtained and many special effects are possible.

When the cam of the tremulant is rotated, this will produce a potential variation in the voltage supply to the potentiometers and thereby cause a wavering or vibrato effect on the whole of the notes played. In the case of the harmonic generator, however, a slightly different form of tremulant is used. Thus the regulating resistance f of each key, instead of being connected to the negative or earth lead, is connected to one end of a resistance s the other end of which is connected to the earth lead, and this resistance s we will term the "tremulant" resistance. The tremulant consists of a loaded reed s' which is kept in motion by an electromagnet s^2 energised from the source of supply, the magnet coil circuit being completed between a stationary contact and a contact on the reed, as in the case of an ordinary electric bell. Across these contacts is a resistance s^3 and condenser s^4 connected in series in order to suppress sparking, and the other ends of the magnet coils are connected to a busbar s^5 between which and the positive terminal of the supply is connected a switch s^6. The junction of the regulating resistance f and the tremulant resistance s is connected to a stationary contact which makes contact with the reed when the latter is at rest. When the reed vibrates the tremulant resistance is being short-circuited periodically, thereby varying the charging potential on the particular generator member and producing a vibrato effect. It will be seen that each note is provided with a separate tremulant and the speed of the vibration of the reeds is arranged to increase progressively towards the top of the keyboard.

The output terminals of each set of generators are connected to a l megohm resistance t, the other ends of which are connected together and to one end of a further l megohm resistance t', the other end of which is connected to the negative main. The output voltage produced across this resistance is amplified by a pre-amplifier t^2 and then passes through a constant resistance volume control to the main amplifier t^3 which supplies the loud-speakers.

The invention is not to be limited to any particular form of generator nor to any particular construction and arrangement of parts for the tremulants, as these and other details may be variously modified to suit any particular requirements; for example, instead of generating the saw-tooth wave form as above described, we may generate a true sine wave and take the output of each generator to separate input valves of the pre-amplifier having anode mixing and bias one valve to cut off so as to produce a wave rich in harmonics. Moreover, in order still further to

vary the quality of the tones obtainable, the attack and delay potentiometers may have a series resistance or resistances in circuit so that the voltage across the potentiometers may also be varied.

We claim:

1. In an electrical musical instrument, the combination of a set of electrostatic generators for the fundamental tones of the instrument and a second set of generators for tones rich in harmonics, a source of current, a variable resistance between the source of current and all the generators of each set for varying the voltage supply to the generators in order to vary the attack of the tones produced by said generators, and electrical circuits connecting the variable resistance with the corresponding set of generators, each of said circuits comprising a fixed charging resistance and condenser permanently connected to the respective generator and a second supply condenser and resistance, and a key and switches operated by movement of the key such that in the normal position of the key the charging resistance and condenser are connected to earth, and the supply condenser is connected to the source of current while in the depressed position of the key the charging resistance and condenser are disconnected from earth and are connected together with the corresponding generator to the supply resistance and condenser.

2. In an electrical musical instrument the combination of a set of electrostatic generators for the fundamental tones of the instrument and a second set of generators for tones rich in harmonics, a source of current, a key for each of the tones of the generator sets, a fixed charging resistance and charging condenser connected to each generator, a switch operable by a key for earthing the charging resistance and condenser when the key is in its normal position, a key charging switch also operable by each key, a supply condenser and resistance connected to each charging switch, a variable resistance for each set of generators connected between the source of current and a contact common to all the supply condensers and resistances of said generators, a contact common to all the key charging switches and making contact therewith when the keys are in normal position and connected with the source of supply through a second variable resistance so that said supply condensers are charged when the keys are in normal position, and a second contact common to all key charging switches and positioned so that when a key corresponding to any particular generator is depressed the corresponding charged supply condenser and resistance will be connected to the generator charging resistance and condenser which, simultaneously, are disconnected from earth by the depression of the key.

3. An electrical musical instrument according to claim 2 having means for disconnecting the charging resistance and condensers from earth on release of a key when sustatined notes are required.

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