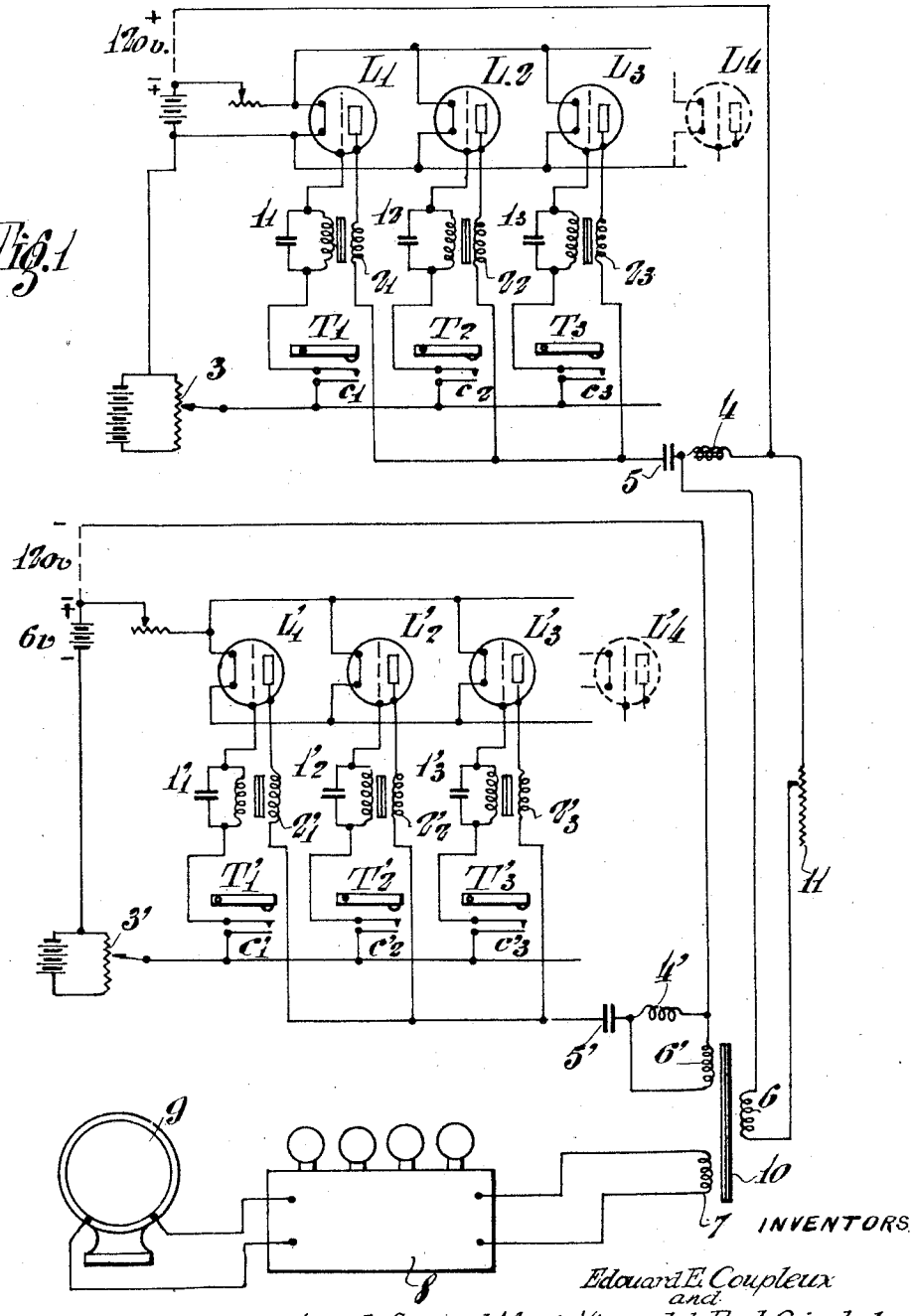
April 25, 1933. E. E. COUPLEUX ET AL 1,905,996

ELECTRIC ORGAN

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Fig. 1



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ELECTRIC ORGAN

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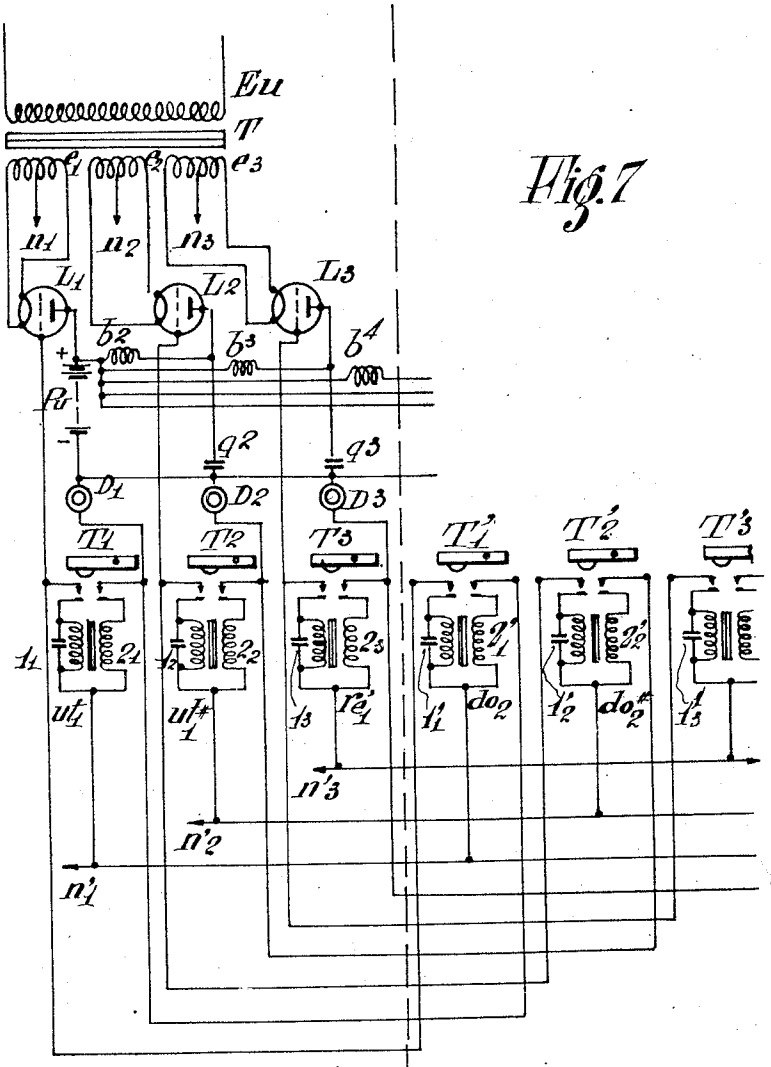


Fig. 7

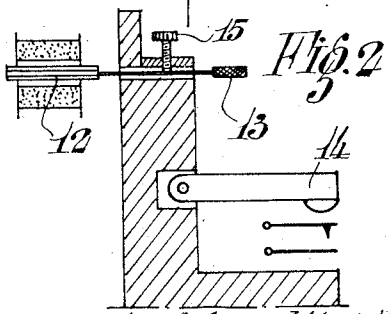


Fig. 2

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ELECTRIC ORGAN

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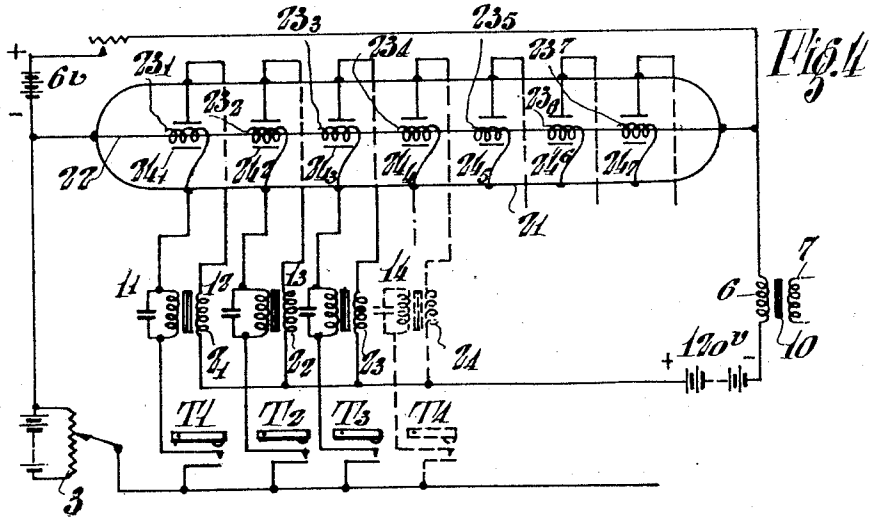
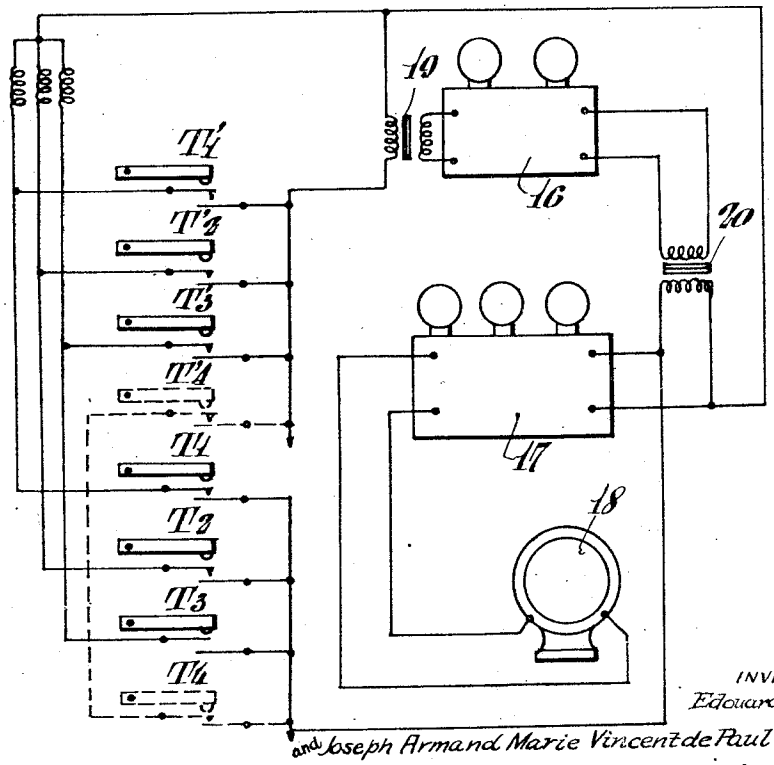


Fig. 4

Fig. 3



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ELECTRIC ORGAN

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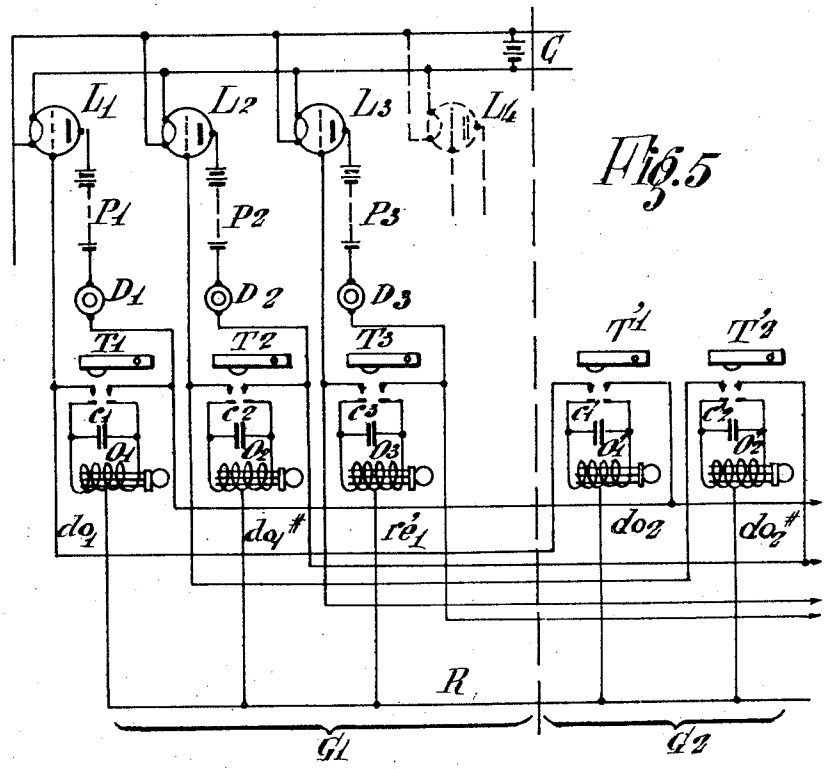
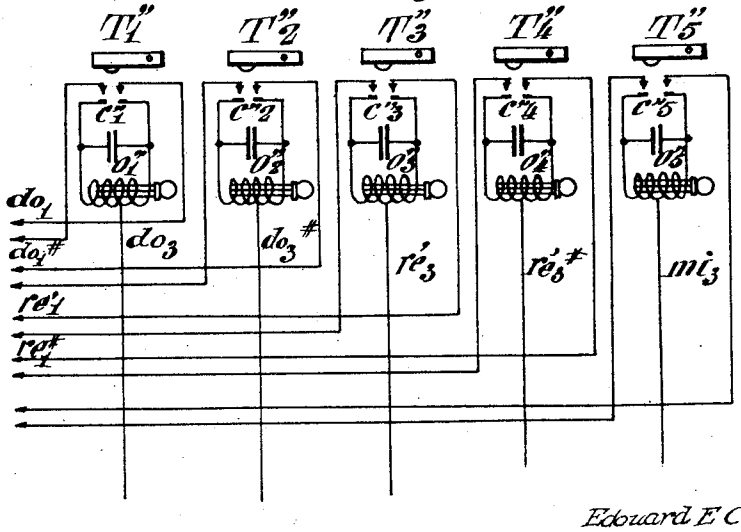


Fig.5

Fig.6



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UNITED STATES PATENT OFFICE

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ELECTRIC ORGAN

Application filed July 19, 1930, Serial No. 469,142, and in France July 26, 1929.

When oscillations having a musical frequency are produced by means of oscillating circuits controlled by keys, and when it is desired to produce several sounds at a time, musical currents are superposed in a common circuit or in several circuits which are suitably coupled. It is thus found that the harmonics of such musical currents interfere with one another and with the musical currents thus produced. If there is a slight difference in frequency between the currents supplying the harmonics, an interference arises and the resulting currents produce a hum or other disagreeable sound.

On the other hand, the construction of a musical instrument employing electric oscillations, and of a polyphonic nature, required a great number of oscillating circuits and valves.

The present invention relates to an electric organ in which all disadvantages due to the interference of harmonics are eliminated, and in which the circuits are simplified, while enabling the simultaneous production of a great number of sounds whose intensity and tone can be varied, or a quavering sound can be produced as in an ordinary organ, by the use of known means already specified in applicants' prior patents.

To obviate the interference of the harmonics, musical currents are produced which contain only harmonics of small amplitude, by suitably determining the relation between the self-induction and capacity of the oscillating circuits, by adopting a suitable coupling between the plate and grid circuits, by properly polarizing the grid in such manner as to operate the valve in the straight part of its characteristic curve, and by selecting suitable heating tensions and plate tensions.

Care will be taken to avoid all eventually faulty action due to variations of the plate tension or of the tension used to heat the incandescent cathodes, in the following manner.

The oscillation of the three-electrodes valve is regulated by the ratio:

$$\frac{\left(1+\frac{R}{\rho}\right)^{\frac{1}{2}}}{2\pi(CL)^{\frac{1}{2}}}$$

in which F is the frequency, ρ the internal resistance of the valve, R rheohmic resistance of the oscillating circuit, C and L the capacity and self-induction of the circuit; ρ will be made as large as possible, by employing a valve having a great internal resistance, and transmitting cathodes will be chosen whose electronic emission varies as little as possible with the temperature variations.

The pitch of the note is regulated by a self-induction with adjustable laminated core.

If harmonics capable of interfering still exist, the noise due to their interference is reduced to a minimum by filters which allow the high frequency musical currents to pass through, but which stop off the low frequency currents and hence the currents due to interference between the harmonics. A common filter will serve for a series of notes.

The variations of the tone are obtained as follows:

1. For a given series of notes, we change the ratio of the self-induction to the capacity of the oscillating circuit in such manner that the product of the two will remain constant. For a high self-induction, the representative point of the oscillations will move to the ends of the characteristic curve. The sinusoid is made irregular, and numerous harmonics are produced, so that the tone will resemble that of the violin. On the contrary, a high capacity will afford a tone containing but few harmonics, thus resembling the tone of a flute. These changes of tones are controlled by suitable switching means enabling the performer to produce with the right hand a melody or song, for

instance, while accompanying this with the left hand by an organ or flute tone.

2. By proportioning the harmonics by acting upon the elements of the filter herein mentioned, or by the use of special filters mounted in the circuit.

3. By changing the polarization of the grid for a set of notes, for instance, by means of a potentiometer.

4. By placing some of the notes out of accord, so that they will not be perceived by the ear, in order to obtain beats between the harmonics capable of changing the tone.

5. By producing certain notes which act the part of harmonics with but feeble strength, for instance by a weak coupling of the coil of the octave in consideration with the core of the output transformer.

The same electric organ can be divided into several sections, each corresponding to a different loud-speaker, either directly or by means of an amplifier.

The assembling of the number of valves of the electric organ producing a great number of sounds is effected as follows:

1. A single valve is used for a note and its sharped note, since these two notes are rarely produced together, and this affords seven lamps for an octave instead of twelve.

2. After each octave is mounted a frequency doubler, placed in circuit automatically by the set of keys corresponding to the notes of the next higher octave.

3. Special valves are used, consisting of a cylinder of glass or other insulating substance, traversed on its axis by a single filament upon which the grids and the plates are centered. For working upon alternating current, the filament is bent into a V shape, and as the two branches carry currents in the contrary direction, the humming effect will be annulled. Metallic screens or rings may be mounted between the elements of the valve, which allow the filament to pass through their central aperture, such screens being raised to the proper potential by a polarizing battery. The multiple lamp may also comprise *n* parallel filaments mounted on two supporting rods like the rounds of a ladder. Instead of the single filament, it is possible to employ a single grid or plate.

Polyphony can also be obtained with a more limited number of valves.

For this purpose, and supposing that the performer uses only one hand, although the method can be extended to the use of two hands or even several hands if there are several performers, it will suffice in order to poduce the polyphony, to use as many valves (which can oscillate at the same time) as there are keys pressed at the same time by a single hand. It would appear at first sight that five valves would be sufficient for the five fingers, but it should be observed that the fingers can be spread sufficiently to strike notes which are rather far apart, and even more than one octave. All the keys situated between these notes (obviously comprising the end notes) will be in principle provided with a valve, a battery for plate tension, a diffuser and an oscillating circuit with contacts permitting to obtain the proper notes. This affords a group which we will designate as "fundamental group", which may be situated in any place among the whole number of notes.

To obtain all the other notes of the keyboard, without using any more valves, it is simply necessary to electrically connect each set consisting of a valve with its plate battery and diffuser, to another oscillating circuit corresponding to another note, and the connections are changed by operating the keys of the keyboard.

Instead of sending the oscillating currents of the valves directly into the output transformer, such currents can be collected by induction by the use of the circuits coupled with the oscillating circuits of the valves. By tuning such intermediate circuits with the notes of the corresponding valves, the major part of the harmonics will be eliminated.

The accompanying drawings show by way of example various embodiments of the invention.

Fig. 1 represents the general diagram of the oscillating circuits and their controlling devices.

Fig. 2 relates to the adjustment of the pitch of the sound.

Fig. 3 shows a frequency-doubling device.

Fig. 4 shows a multiple valve with a single central filament.

Fig. 5 shows the diagram of the fundamental grouping and its connection with the next group, each group forming a complete musical scale.

Fig. 6 represents a grouping which differs from the fundamental grouping.

Fig. 7 shows the arrangement of the apparatus with a single battery for the plates, the filaments being supplied by a special transformer.

As observed in Fig. 1, each valve L_1, L_2, L_3, etc., or L'_1, L'_2, L'_3, etc., comprises an oscillating circuit $1_1, 1_2, 1_3$, etc., cooperating with the grid, and a coil $2_1, 2_2, 2_3$, etc., cooperating with the plate, or inversely. Thus two different circuits are employed for each lamp, i. e. the plate circuit and the grid circuit. For a certain group of notes, the grid circuits lead to a common potentiometer 3, and all the plate circuits are supplied by a filtered circuit consisting of a strong impedance 4, which may be traversed by the currents due to the beats of the harmonics as well as by the current of the battery supplying the tension, but which prevents all flow of the musical current itself, with the use of a condenser 5 which on the contrary is traversed by the musical currents

and stops the current due to the beats of the harmonics.

In this manner the musical current attains the primary winding 6 of a transformer whose secondary 7 is coupled with the loud-speaker 9 either directly or by means of an amplifier 8. Each group of notes, and in principle each octave, thus comprises a filter and a winding for inducing currents in the output transformer 10. Fig. 1 shows the arrangement for the notes of the second octave, with the valves L'_1, L'_2, L'_3, etc., as well as the oscillating circuits $1'_1$, $1'_2$, $1'_3$, etc., and the plate coils $2'_1$, $2'_2$, $2'_3$, etc., leading to the secondary 6' of the output transformer 10, the filter consisting of the impedance 4' and the condenser 5'. The primaries such as 6, 6', etc., may be more or less coupled with the transformer core, whereby the notes of the several octaves will be more or less produced. The same result will be obtained by means of a variable resistance such as 11, under the control, as also the coupling of the windings, of a pedal, a handle, or like means.

Fig. 2 shows the adjustment of the pitch of the note, by means of a laminated core 12 controlled by a handle 13 positioned above the corresponding key 14 and provided with a set screw 15.

Fig. 3 shows the arrangement of the device 16 for doubling the frequency which is mounted between the oscillating circuits and the amplifier 17, followed by the loud-speaker 18, through the medium of the transformers 19 and 20. The keys T_1, T_2, T_3, etc., of the lower octave are thus directly connected to the amplifier 26, but the keys T'_1, T'_2, T'_3, etc., of the higher octave are connected to the primaries of the transformer 20, thus operating the said frequency-doubling device 16, and thus with the use of the same oscillating circuits as employed for the lower octave, we obtain a double frequency and hence obtain notes corresponding to the next higher octave, whereby the number of valves in the electric organ will be suitably reduced.

Fig. 4 shows a multiple valve having the form of tube 21 containing a single central filament 22 and comprising sets of grids 23_1, 23_2, 23_3, etc., and sets of plates 24_1, 24_2, 24_3, etc., each set corresponding to a key T_1, T_2, T_3, etc., controlling the oscillating circuits 1_1, 1_2, 1_3, etc., and the coils 2_1, 2_2, 2_3, etc. Instead of employing a single filament, we may employ a single grid or a single plate, and in this case the other two electrodes of the three usual electrodes will consist of unit groups whereof each corresponds to a key.

Fig. 5 shows circuits O_1, O_2, O_3, etc., each corresponding to a valve. The grouping of the notes corresponds to the notes of the scale: DO, DO♯, RE, RE♯, MI, FA, FA♯, SOL, SOL♯, LA, LA♯, SI, but it is obvious that we may employ any other grouping of notes, and the one herein represented has been chosen simply by way of example.

Each valve L_1, L_2, L_3, etc., is provided with its plate battery P_1, P_2, etc., and with its diffuser D_1, D_2, etc., and it is controlled by the key T_1, T_2, etc., which acts upon the contacts c_1, c_2, etc., which intercalate the oscillating circuit e_1, e_2, etc., and this (Fig. 5) will produce the notes DO, DO♯, RE, etc.

For each valve, the contacts are repeated in each group of notes, that is, in each group of keys, and in the present example the valve L for the notes DO will be controlled at will by one or the other of the circuits c_1, c'_1, c''_1, etc., according as the performer presses the keys T_1, T'_1, T''_1, etc., thus obtaining DO DO_2, DO_3, etc., this being reproduced in the diffuser D_1.

The same operation takes place for all the grouped notes, and thus a single set of valves will serve for all the groups. They are provided with a common return circuit, connected to the middle of the winding.

Fig. 6 shows the arrangement of a subsiding group, which is the group of the piano scale 3. The different circuits are connected when the performer presses the desired key T''_1, T''_2, etc., corresponding to the valve L_1, L_2, etc., and the valve will oscillate at the desired frequency in order to produce the note DO_3, DO_3♯, RE_3, etc., corresponding to the key T''_1, T''_2, T''_3, etc., which is pressed.

It is obvious that the number of notes of the fundamental group may differ from the one indicated, and on the other hand, the same valve is employed for a note and its corresponding sharp.

It is to be observed that this disposition permits to reduce the number of valves employed.

It now remains to reduce the number of batteries in use.

A single plate battery may be employed, but in this case it is preferable to use choke coils and condensers in order to prevent all mingling of musical currents in the battery, with a single plate battery, even when employing choke coils, the currents can also be mingled by the heating battery. To obviate this disadvantage, we may employ a transformer having as many secondary circuits as there are valves to be supplied.

Fig. 7 shows such an arrangement. The oscillating circuits, which may have any form, consist for example of a coil 1_1, 1_2, etc., for the plate, and of a coil 2_1, 2_2, etc., for the grid; but the arrangement of keys T_1, etc., and of contacts c_1, etc., remains the same. Each valve L_1, etc., is provided with a diffuser D_1, D_2, etc., but a single battery Pu serves to supply all the plates.

The plate of L_1 is directly connected to one terminal of the battery Pu, but the other plates such as L_2, L_3, etc., are connected by

means of a choke coil such as b_1, b_2, etc., and this allows each valve to oscillate on its own account without interfering with the other valves. The diffuser D_1 is directly connected to the other terminal of the battery Pu, but the other diffusers D_2, D_3, which are also connected thereto, communicate with the plate of the corresponding valve L_2, L_3, etc., only by a condenser such as q_2, q_3, etc., which prevents the flow of direct current and thus prevents short-circuits, while allowing the alternating current to circulate, and hence the oscillations of musical frequency employed.

Fig. 7 shows the single supply by alternating current, due to the transformer T which has a single primary Eu and as many secondaries e_1, e_2, etc., as there are valves L_1, L_2, etc., employed. The middle terminal of each secondary e_1, e_2, etc., is connected at n_1, n_2, etc., to the common point of the windings used for the plate and the grid of the corresponding valve L_1, L_2, etc., at n'_1, n'_2, etc.

To allow the use of both hands, two keyboards are provided, one for the right hand and the other for the left. Any suitable number of keyboards may also be employed in the case of several performers playing at the same time.

We claim:

1. In an electric organ, valves having a plurality of electrodes, circuits electrically connected to the electrodes of said valves, keys of a keyboard provided with contacts actuating said circuits, a self-induction and a condenser included in the oscillating circuit, means for obtaining a determined ratio between the self-induction and the capacity of the oscillating circuits and for the polarization of the grid of said valves whereby the same will operate in the straight part of their characteristic curves, and means establishing a weak coupling between the plate and grid circuits of said valves.

2. In an electric organ, valves having a plurality of electrodes and a cathode of a determined inertia whereby the electronic emission will vary but slightly with the temperature, circuits electrically connected to the electrodes of said valves, keys on the keyboard provided with contacts actuating said circuits, a self-induction and a condenser included in the oscillating circuit, means for obtaining a determined ratio between the self-induction and the capacity of the oscillating circuits and for the polarization of the grid of said valves whereby the same will operate in the straight part of their characteristic curves, and means establishing a weak coupling between the plate and grid circuits of said valves.

3. In an electric organ, valves having a plurality of electrodes, circuits electrically connected to the electrodes of said valves, keys of a keyboard provided with contacts actuating said circuits, a self-induction and a condenser included in the oscillating circuit, said self induction having a laminated core branched in each oscillating circuit of said valves to regulate the pitch of the note, means for obtaining a determined ratio between the self-induction and the capacity of the oscillating circuits and for the polarization of the grid of said valves whereby the same will operate in the straight part of their characteristic curves, and means establishing a weak coupling between the plate and grid circuits of said valves.

4. In an electric organ, groups of oscillating circuits, means for adjusting the value of the self-induction and the valve of the capacity of each of said groups of circuits, and means to inter-relate the variation of the self-induction and the capacity whereby the product of said two values will remain constant.

5. In an electric organ of the character described, a sound producing valve, and a potentiometer for a group of notes, associated with the grid of said valve to change the polarization of the latter and produce variations in the timbre.

6. In an electric organ, valves having a plurality of electrodes, circuits electrically connected to the electrodes of said valves, keys of a keyboard provided with contacts actuating said circuits, a self-induction and a condenser included in the oscillating circuit, means for obtaining a determined ratio between the self-induction and the capacity of the oscillating circuits and for the polarization of the grid of said valves whereby the same will operate in the straight part of their characteristic curves, means establishing a weak coupling between the plate and grid circuits of said valves, and means for placing several notes out of tune to produce beats between the harmonics whereby to change the timbre.

7. In an electric organ, valves having a plurality of electrodes, circuits electrically connected to the electrodes of said valves, keys of a keyboard provided with contacts actuating said circuits, and means producing notes which form harmonics for other notes produced simultaneously, thereby operating to change the timbre.

8. In an electric organ, valves having a plurality of electrodes, circuits electrically connected to the electrodes of said valves, keys of a keyboard provided with contacts actuating said circuits, a frequency doubling element interposed in said circuits, and a set of keys for actuating said frequency doubling element.

9. In an electric organ of the character described, multiple lamps consisting of a cylinder of insulating substance, a single filament extending through the axis of said cyl-

inder, and lamp grids and plates centered upon said filament.

10. In an electric organ of the character described, multiple lamps having grouped grids and plates but provided with a single filament bent in V-shape, and metallic screens of a certain potential through which passes the filament and insulating the grouped grids and plates from each other.

11. In an electric organ of the character described, multiple lamps having a plurality of groups of filament, grid and plate, and a pair of supporting rods carrying the filaments in parallel relation.

12. In an electric organ, keyboards divided into groups of successive notes, each group having the same number of notes, a valve for each similar note in all the groups, coupled contacts, connections uniting said contacts to the valves, connections uniting the keys of the keyboards to the contacts, and means coupling each valve to the corresponding notes in all the groups.

13. In an electric organ of the character described, key-boards divided into groups of successive notes, each group having the same number of notes, valves corresponding in number to that of the notes in one group, each valve producing, by the coupling of the contacts of the keys, the notes corresponding in the group according to the key actuated, and a diffuser and a plate battery for each lamp.

14. In an electric organ of the character described, key-boards divided into groups of successive notes, each group having the same number of notes, valves corresponding in number to that of the notes in one group, each valve producing, by the coupling of the contacts of the keys, the notes corresponding in the group according to the key actuated, a diffuser and a plate battery for each lamp, transformers having a single primary and multiple secondaries, each secondary supplying the filament of a valve, and a single plate battery for all the valves and provided with a choke coil and condenser.

15. In an electric organ of the character described, key-boards divided into groups of successive notes, each group having the same number of notes, valves corresponding in number to that of the notes in one group, each valve producing, by the coupling of the contacts of the keys, the notes corresponding in the group according to the key actuated, a diffuser and a plate battery for each valve, transformers having a single primary and multiple secondaries, each secondary supplying the filament of a valve, a single plate battery for all the valves, and a plurality of key-boards for the simultaneous production of the same note.

16. In an electric organ of the character described, valves having an oscillating circuit, an intermediate circuit coupled with the oscillating circuit of the valves and tuned to the notes of the corresponding valves whereby to eliminate the harmonics, and keys actuating said intermediate circuit.

In witness whereof we have hereunto set our hands.

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JOSEPH ARMAND MARIE
VINCENT de PAUL GIVELET.