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METHOD AND APPARATUS FOR THE PRODUCTION OF MUSIC

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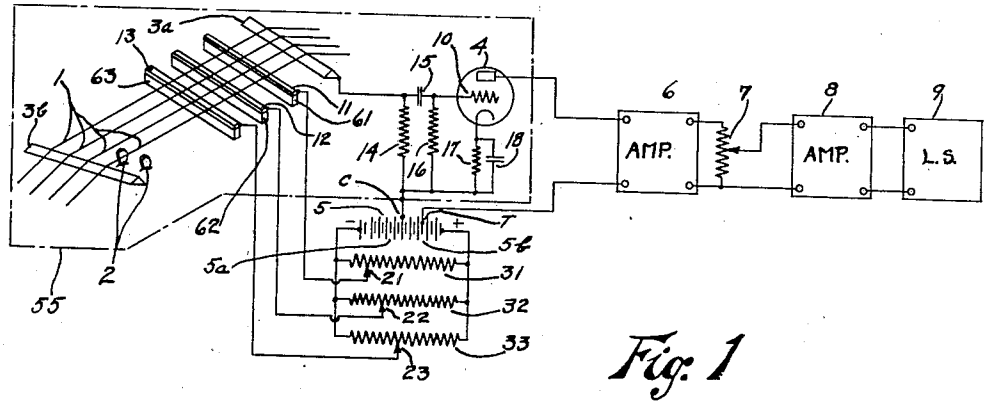


Fig. 1

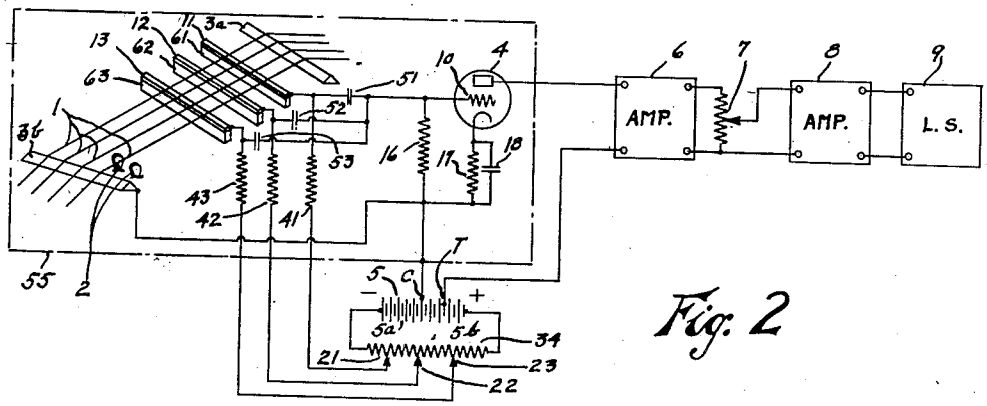


Fig. 2

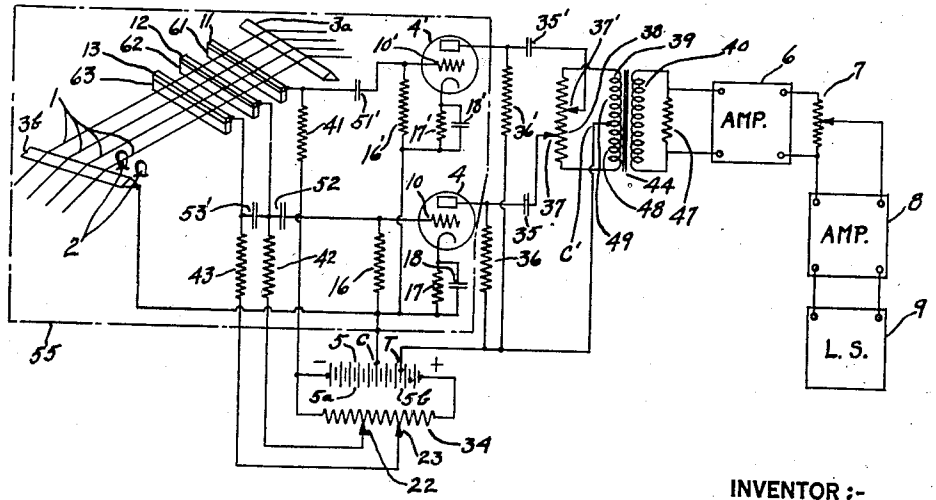


Fig. 3

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## METHOD AND APPARATUS FOR THE PRODUCTION OF MUSIC

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20 Claims. (Cl. 84—1)

This invention relates to musical instruments and more particularly to those including an electro-acoustic translating device and electric circuits operative in the energization thereof. A particular form of such instrument, for example, may comprise a plurality of tuned vibrators and mechanico-electric translating apparatus for translating their vibrations into electric oscillations, which oscillations are made to energize, and are translated into sound by, the electro-acoustic translating device.

A known type of mechanico-electric translating system for use in such instruments is the electrostatic type. Herein an electrostatic capacity is formed between the vibrators and a suitably placed conductive member; a charge relatively incapable of rapid variation is maintained in this capacity; and the vibratory variation of the field of the so-charged capacity, produced by vibration of any of the vibrators, in turn produces across the capacity an oscillatory voltage component. My invention has been illustrated in connection with translating systems of this type; while the broader aspects of the invention are generic to various types of translating systems, certain of the more specific aspects are peculiar to these particular systems.

In the U. S. Patent No. 1,906,607, issued to me May 2, 1933, there was disclosed and claimed an instrument wherein a group, of translating systems was employed, each system associated with each of a plurality of vibrators. The purpose of the use of a group of systems was as follows: The oscillations translated by each of the systems from any vibrator were of different waveform, by virtue of the difference in vibrational characteristics between the portions of the vibrator with which the systems were respectively associated. Before translation into sound these oscillations were selectively combined in any of a plurality of phase and amplitude relationships at will, with the resultant production of a wide range of sound tone qualities, or harmonic structures.

It is an object of this invention to provide an improved instrument of the type shown in the mentioned patent.

It is a further object to provide improvements in the means for selectively controlling and combining the oscillations in such an instrument.

It is a further object to provide an improved mechanico-electric translating system of the electrostatic type. It is a further object to provide a group of electrostatic translating systems for the purpose above described, improved in respect of simplicity and other characteristics.

Other and allied objects will more fully appear from the following description and the appended claims.

In the description reference is had to the accompanying drawing, of which:—

Figure 1 is a fractional view of a musical instrument, partly perspective and partly diagrammatic, illustrating a simple embodiment of my invention;

Figure 2 is a perspective and diagrammatic view illustrating a preferred embodiment; and

Figure 3 is a perspective and diagrammatic view illustrating the embodiment of Figure 2 together with a still further embodiment.

Reference being had to any of the figures, there will be seen a plurality of variously tuned strings 1. By way of example only these have been shown excitable by hammers 2, and strung over triangular bars 3*a* and 3*b*, it being understood that the active vibratory portion of each string is that lying between these bars. In slight spaced relationship to the several strings 1 will be seen a conductive strip 11; the strip 11 may for example be cemented to the top of a bakelite or other insulating strip 61 and this in turn secured in convenient manner to portions of the instrument not herein necessary to show. Likewise in slight spaced relationship to the several strings will be seen conductive strips 12 and 13, similar to conductive strip 11 and respectively cemented to insulating strips 62 and 63.

Consideration being given to any strip 11, 12, or 13, it will be understood that between the strip as one electrode and any string 1 as the other a small electrostatic capacity exists. These strip-to-string capacities are those in which there is to be maintained a charge relatively incapable of rapid variation and across which oscillatory voltage components will be produced upon string vibration. It will be observed that the three strips 11, 12 and 13 are opposite respectively different points along any string 1, which points of course vibrate with respectively different waveforms; the oscillatory voltages appearing upon vibration of any string across the three capacities of strings to strip 11, of strings to strip 12, and of strings to string 13 are therefore of respectively different waveforms. I shall hereinafter refer to the oscillatory voltage components appearing across each of these three capacities as a series of oscillations, it being understood that three such series are produced by any of the herein illustrated embodiments of my in-

vention. Of course the use of apparatus appropriate to three series of oscillations is illustrative only, my invention not being limited to the production of any particular number of series.

The construction and operation thus far described are similar to those shown in the mentioned patent. Therein each of the three series of oscillations was applied to the input circuit of a separate vacuum tube; a separate transformer was employed in the output circuit of each of these tubes; and separate potentiometers, connected across the respective transformer secondaries and having variable portions mutually in series, were employed in the selective control and combination of the oscillations of the several series. Although this arrangement is fully operative to produce the desired results it is susceptible of simplification and improvement, to which the instant invention is largely directed.

Reference is now had specifically to Figure 1. The source of charges for the strings-to-strip capacities is the battery or other high voltage direct current source 5, which may be divided into two equal voltage sections 5*a* and 5*b* at the center point C. The means for maintaining the charges relatively incapable of rapid variation is the high resistance 14, preferably of several megohms or more, connected between the source 5 (specifically the center point C thereof) and the strings (through the medium of the conductive bar 3*a*). It will be appreciated that the higher the value of the resistance 14 the more independent of oscillatory-capacity variations will be charges in the strings-to-strip capacities. The charging circuit for the strings-to-strip 11 capacity is completed through potentiometer 31 connected across source 5 and having movable contact 21 connected to strip 11. Similarly the charging circuits for the strings-to-strip 12 and strings-to-strip 13 capacities are completely respectively through potentiometer 32 with movable contact 22 and potentiometer 33 with movable contact 23. Preferably each of the potentiometers has a total resistance value which is a minor fraction of the value of resistance 14.

The amplitude of the oscillatory voltage variations at any frequency across any of the three strings-to-strip capacities is proportional to the D. C. voltage applied across that capacity, and the phase of the variations is dependent on the sign of the applied voltage. In Figure 1 it is readily seen that adjustment of any one of the potentiometers 31, 32 and 33, by motion of its movable contact progressively from one end of the potentiometer through the middle and to the other end, will control the voltage across the associated capacity progressively from half the voltage of the source 5 in one sign, through zero, and to a like voltage in opposite sign. Thus by D. C. potential variation there is afforded in Figure 1 complete control over the amplitude, and over phase in respect of reversal, of the oscillations of each of the three series. It will further be appreciated that the so-controlled oscillations of all of the series appear across the resistance 14, the strings being connected directly to one extremity thereof and each of the strips 11, 12 and 13 being connected to the other extremity through a system whose impedance to alternating currents is low compared to that of resistance 14. Thus the circuit of Figure 1 inherently combines the oscillations of the several series.

The further elements of Figure 1 may be briefly described as follows: Tube 4 may be supplied with anode current from a tap T on the source 5 whereat the voltage is positive with respect to the center point C. Its cathode may be maintained at a potential slightly positive with respect to the point C by anode current flow through small resistance 17, by-passed by condenser 18. Its grid 10 may be biased to the potential of the point C by connection thereto through grid leak 16, resulting in the bias of the grid slightly negative with respect to the cathode. In the anode circuit of the tube may be provided in cascade amplifier 6, potentiometer or volume control 7, further amplifier 8 if desired, and loud-speaker or other electro-acoustic translating device 9. Obviously the combined oscillations are applied from resistance 14 through condenser 15 to the input circuit of tube 4; they may be amplified by that tube and by amplifiers 6 and 8; are controlled in respect of amplitude by volume control 7; and finally energize, and are translated into sound by loudspeaker 9.

It is to be noted that the condenser 15 and grid leak 16 may if desired be omitted—the first by short-circuiting and the second by open-circuiting—and the high resistance 14 relied on as a grid leak for tube 4. In this case, however, should there exist any leakage between the strings and any points having a D. C. potential difference from point C, a portion of such potential difference will appear across resistance 14 and will alter the bias of the grid with respect to the cathode of tube 4. I have found that frequently leakage may exist sufficient seriously to upset the desired D. C. grid bias, although otherwise not noticeably harmful. It is for the avoidance of this effect of leakage on grid bias that I employ the elements 15 and 16.

In Figure 1 I have schematically shown electrostatic shielding 55 connected to point C and surrounding the strings 1 and tube 4 and elements connected or adjacent to strings and the grid 10, for the avoidance of sensitivity of these parts to stray electrostatic fields. The strings 1, however, in the aggregate may represent a relatively large mass and surface disposed over a relatively large area, and in Figure 1 are so connected in the circuit as to have a maximum sensitivity to the mentioned fields. These joint conditions as to the strings render somewhat rigorous the requirements of completeness and general excellence of the shielding 55, and this fact I consider a disadvantage of the circuit of Figure 1. It is absent in Figure 2, to which attention is now directed.

Herein the strings 1 are directly connected to the point C. The means for prevention of rapid charge variation are individual to the several strips 11, 12 and 13, taking the form of high resistances 41, 42 and 43, connected between the strips and the movable contacts 21, 22 and 23, respectively. The several strips are connected through condensers 51, 52 and 53 respectively to the grid extremity of grid leak 16, which is connected as in Figure 1 from grid 10 to the point C. It will be understood that the oscillations of each series are impressed through a respective one of these condensers across the grid leak 16 and are therein inherently combined. As in Figure 1, the amplitude and phase of the oscillations of each series are controllable, before combination, by the movable contacts 21, 22 and 23. As a simplification these contacts have been shown as portions of a single potentiometer 34 connected across the source 5, it being understood that each of the contacts is movable over the whole range of the potentiometer without disturbance of the position of either of the other contacts.

I have again shown electrostatic shielding 55 connected to point C, and surrounding parts of the apparatus. It is to be noted, however, that the strips 11, 12 and 13 and the few resistances and condensers connected thereto are now the elements most sensitive to stray fields; while the strings themselves not only do not require to be shielded, but by virtue of their connection to the same point as the shielding actually aid the latter in its function. The joint conditions of less extensive sensitive portions and partial shielding effect of the strings considerably relax the requirements to be met by the shielding 55 in Figure 2.

A characteristic—advantageous particularly in respect of simplicity—of the circuits shown in Figures 1 and 2 is that the amplitude and phase control system for a plurality of oscillation series (e. g., 31—32—33 or 34, with their movable contacts) is in shunt to a single circuit portion (e. g., source 5). This characteristic may be present in other circuit arrangements, such for example as that wherein separate vacuum tubes are utilized for respectively different oscillation series. This has been illustrated in Figure 3.

As to strips 12 and 13 the arrangement of Figure 2 has been carried over into Figure 3, with two exceptions. One is that the condenser 53 connecting strip 13 to the grid 10 (or grid extremity of grid leak 16) has been replaced by a condenser 53' connecting strip 13 to strip 12. The requirement being simply for a capacitive path from each strip to the grid (or grid leak extremity), these paths may either be separate as in Figure 2 or cumulative as in Figure 3, wherein condenser 52 forms a path active for both strips 12 and 13. The other exception is that the anode circuit of tube 4 is coupled to amplifier 6 through an intermediate coupling circuit hereinafter described.

In view of the similarity of the involved parts to those of Figure 2, it will be obvious that the tube 4 functions to amplify oscillations of the two series respectively produced across the strings-to-strip 12 and strings-to-strip 13 capacities. For the oscillations produced across the strings-to-strip 11 capacity, however, I provide another vacuum tube 4' having grid 10'. For this tube may be provided grid leak 16', small resistance 17' and condenser 18', respectively analogous in both connection and function to the elements 16, 17 and 18 associated with tube 4. Strip 11 may be connected through condenser 51' to the grid extremity of grid leak 16' the opposite extremity of which is connected to the point C. It will be understood, of course, that the oscillations produced across the strings-to-strip 11 capacity are applied without phase or amplitude control through condenser 51' to the input circuit of tube 4' and are amplified by that tube, strip 11 being connected through its resistance 31 to a point of fixed potential in source 5.

A circuit is illustrated for coupling the anode circuits of each of tubes 4 and 4' to the amplifier 6. This conveniently includes resistances 36 and 36', respectively connected from the anodes of tubes 4 and 4' to tap T on source 5 and providing paths for the D. C. components of the respective anode currents. Each of the resistances 36 and 36' preferably has a resistance value of several times the plate impedance of the associated tube. A transformer 44 is provided having secondary 40 connected to amplifier 6; and having primary 39 with center tap C' connected to a point in source 5, preferably tap T. The lower-shown and upper-shown halves of the primary are respectively designated as 48 and 49. Across the entire primary is shunted a potentiometer 38, provided with two movable contacts 37 and 37' each adjustable over the whole potentiometer range without disturbance of the position of the other. To these movable contacts are respectively connected the anodes of tubes 4 and 4', through respective condensers 35 and 35', whose function it is to confine the D. C. components of the anode currents to the paths 36 and 36' abovementioned.

It is contemplated that the amplifier 6 have a finite input impedance which is constant with varying frequency. A resistance 47, shown in Figure 3, may be employed to shunt any inherent input impedance which the amplifier may have, the value of resistance 47 being chosen low enough so that the effective input impedance of amplifier 6 (e. g., the inherent impedance and the actually included resistance 47 in parallel) shall meet the mentioned specification. The step-up ratio of each half of the primary 39 to the secondary 40 of the transformer 44 is conveniently made approximately equal to the square root of the ratio between effective amplifier input impedance and the output impedance of each of tubes 4 and 4'; and the inductance of each half of the primary 39 is desirably such that the inductive reactance at low frequencies is greater than such output impedance. Under these conditions, and considering the primary 39 apart from the preceding circuit, currents traversing either half of the primary encounter therein an effective impedance which is essentially resistive and approximately equal to the output impedance of either tube 4 or 4'. The total value of resistance of the potentiometer 38 may conveniently be twice such output impedance. It will be understood that I do not specify the quantitative relations between the different circuit elements with any limiting purpose in mind, but rather that a useful example of such relations may be presented for aid in an understanding of the circuit function.

Momentarily assuming that only one of the contacts 37 and 37' is connected to the potentiometer 38, it will be apparent that with this contact centrally located on the potentiometer, oscillations passing thereto from the associated tube anode through the associated condenser will divide and flow equally in two paths. One of these is the upper portion of potentiometer 38 and half-primary 49; the other the lower portion of potentiometer 38 and the half-primary 48. These currents being equal, they will mutually cancel in the primary 39 as a whole, and no oscillations will be induced in the secondary 40. If the contact be adjusted to the top extremity of potentiometer 38, the oscillations will again divide, the respective paths now being the half-primary 49 and the series path comprising the entire potentiometer 38 and the half-primary 48. The oscillations flowing in these two paths will again be in opposition to each other in the primary 39 as a whole; but because of the much higher impedance of the second path, only a minor fraction of the oscillations flows therein, and the opposition of the flow in the half-primary 49 by that in the half-primary 48 is relatively slight. There are therefore induced in the secondary 40 oscillations of finite amplitude and a certain phase. Still again, if the contact be adjusted to the bottom extremity of potentiometer 38, the effects will be similar but opposite to

those just discussed, and there will be induced in the secondary 40 oscillations of similar amplitude but of opposite phase to those last mentioned as induced therein. And at positions intermediate the three specially considered ones there will be induced in secondary 40 oscillations of respectively intermediate amplitudes and of phase dependent on the extremity of the potentiometer 38 to which the contact is nearer. A control over oscillation phase and amplitude quite analogous in effect to that obtained by the above described adjustment of such a contact as 21, 22 or 23 is thus obtained by adjustment of either contact 37 or 37'.

When both contacts 37 and 37' are connected to the potentiometer 38 as shown, the adjustment of one may cause some quantitative modification of the precise above described effects of adjustment of the other. Qualitatively, however, the effects of adjustment of either contact remain as described. Obviously when oscillations of one series only are applied to the input circuit of tube 4 (by virtue of an adjustment of one of the contacts 22 and 23 to a central position on potentiometer 34), the tubes 4 and 4' each pass to the coupling circuit a separate series of oscillations; and the oscillations of the two series are respectively controlled in respect of phase and amplitude by adjustments of contacts 37 and 37', are combined in the coupling circuit, and in combined form appear across the secondary 40 and are passed therefrom to the amplifier 6. This statement remains true when to the input circuit of tube 4 is applied any particular combination of oscillations of two series (by virtue of any particular adjustment of contacts 22 and 23), this oscillation combination then itself being identified as a series of oscillations. Thus in Figure 3 the amplitude and phase control system for a plurality of oscillation series—potentiometer 38 with its movable contacts—is in shunt to the single circuit portion comprising the primary 39 of transformer 40. While this potentiometer system has been illustrated for the control and combination of two series of oscillations, it is not limited in usefulness to this or any other particular number.

It will be understood that variations of the arrangements herein shown and described may be made without departure from the spirit or scope of my invention, which is intended to be expressed in the following claims.

I claim:—

1. In combination in a musical instrument: a plurality of capacities; means for oscillatorily varying said capacities; means for charging said capacities; means for limiting changes of charges in said capacities by said oscillatory variations; means responsive to oscillatory voltages across all of said capacities; and progressively adjustable means for varying the amplitudes and signs of the mean charges in said capacities.

2. In combination in a musical instrument: a plurality of capacities; means for producing oscillatory variation of said capacities at similar fundamental frequencies but with respectively different waveforms; means for charging said capacities; means for limiting changes of charges in said capacities by said oscillatory variations; means responsive to oscillatory voltages across all of said capacities; and means for varying the mean charges in said capacities.

3. In combination in a musical instrument: a tuned vibrator; a plurality of electrodes respectively associated with portions of said vibrator vibrating with different waveforms and forming with said vibrator a plurality of vibration-varied capacities; means for charging said capacities; means for limiting changes of charges in said capacities by vibrator vibration; means responsive to oscillatory voltages across all of said capacities; and means for varying the mean charges in said capacities.

4. In combination in a musical instrument: a plurality of capacities, one side of each of said capacities being electrically common; means for oscillatorily varying said capacities; capacity charging means, comprising means for maintaining the uncommon sides of said capacities at mean potential differences from said common side; means for limiting changes of charges in said capacities by said oscillatory variation; and an electrical work circuit responsive to oscillatory voltages across said capacities, said circuit being capacitively connected to the uncommon side of each of said capacities.

5. In combination in a musical instrument: a tuned vibrator; a plurality of electrodes respectively associated with said vibrator and forming therewith a plurality of vibration-varied capacities; capacity charging means, comprising means for maintaining said electrodes at mean potential differences from said vibrator; means for limiting changes of charges in said capacities by vibrator vibration; and an electrical work circuit responsive to oscillatory voltages across said capacities, said circuit being capacitively connected to said electrodes.

6. In the system of musical tone generation including the production of electric oscillations by the oscillatory variation, with similar fundamental frequency but respectively different waveforms, of a plurality of electrical capacities in each of which is maintained an electrical charge relatively independent of said variations, and including the translation into sound of said oscillations, the method of timbre control which consists in selectively controlling the amplitudes of the charges in the several said capacities and in combining oscillations appearing across said capacities to produce said first mentioned oscillations.

7. In the system of musical tone generation including the production of electric oscillations by the oscillatory variation, with similar fundamental frequency but respectively different waveforms, of a plurality of electrical capacities in each of which is maintained an electrical charge relatively independent of said variations and including the translation into sound of said oscillations, the method of timbre control which consists in selectively controlling the signs of the charges in the several said capacities, and in combining oscillations appearing across said capacities to produce said first mentioned oscillations.

8. In the system of musical tone generation including the production of electric oscillations by the oscillatory variation, with similar fundamental frequency but respectively different waveforms, of a plurality of electrical capacities in each of which is maintained an electrical charge relatively independent of said variations, and including the translation into sound of said oscillations, the method of timbre control which consists in selectively controlling the amplitudes and signs of the charges in the several said capacities, and in combining oscillations appearing across said capacities to produce said first mentioned oscillations.

9. In a musical instrument including an electro-acoustic translating device and an electric system operative in the energization of said device: the combination of a plurality of oscillation sources adapted to produce a like plurality of series of electric oscillations all having the same fundamental frequency but having respectively different waveforms; means in shunt to a single portion of said system for controlling the phases of the oscillations of each of a plurality of said series; means for combining the so-controlled oscillations of said plurality of series; and means for supplying said combined oscillations to said electro-acoustic translating device to energize the same.

10. In a musical instrument including an electro-acoustic translating device and an electric system operative in the energization of said device: the combination of a plurality of oscillation sources adapted to produce a like plurality of series of electric oscillations all having the same fundamental frequency but having respectively different waveforms; means in shunt to a single portion of said system for controlling the amplitudes and phases of the oscillations of each of a plurality of said series; means for combining the so-controlled oscillations of said plurality of series; and means for supplying said combined oscillations to said electro-acoustic translating device to energize the same.

11. In a musical instrument including an electro-acoustic translating device and an electric system operative in the energization of said device: the combination of a tuned vibrator and means for vibrating the same to produce in different portions thereof vibrations having the same fundamental frequency but having respectively different waveforms; a plurality of mechanico-electric translating systems respectively associated with different portions of said vibrator and each adapted to produce a series of electric oscillations; means in shunt to a single portion of said system for controlling the phases of the oscillations of each of a plurality of said series; means for combining the so-controlled oscillations of said plurality of series; and means for supplying said combined oscillations to said electro-acoustic translating device to energize the same.

12. In a musical instrument including an electro-acoustic translating device and an electric system operative in the energization of said device: the combination of a tuned vibrator and means for vibrating the same to produce in different portions thereof vibrations having the same fundamental frequency but having respectively different waveforms; a plurality of mechanico-electric translating systems respectively associated with different portions of said vibrator and each adapted to produce a series of electric oscillations; means in shunt to a single portion of said system for controlling the amplitudes of the oscillations of each of a plurality of said series; means for combining the so-controlled oscillations of said plurality of series; and means for supplying said combined oscillations to said electro-acoustic translating device to energize the same.

13. In a musical instrument including an electro-acoustic translating device and an electric system operative in the energizations of said device: the combination of a tuned vibrator and means for vibrating the same to produce in different portions thereof vibrations having the same fundamental frequency but having respectively different waveforms; a plurality of mechanico-electric translating systems respectively associated with different portions of said vibrator and each adapted to produce a series of electric oscillations; means in shunt to a single portion of said system for controlling the amplitudes and phases of the oscillations of each of a plurality of said series; means for combining the so-controlled oscillations of said plurality of series; and means for supplying said combined oscillations to said electro-acoustic translating device to energize the same.

14. In a musical instrument including an electro-acoustic translating device and an electric system operative in the energization of said device: the combination of a tuned vibrator and means for vibrating the same to produce in different portions thereof vibrations having the same fundamental frequency but having respectively different waveforms; a plurality of conductive members respectively in spaced relationship to different portions of said vibrator and forming therewith electrical capacities oscillatorily varied by said vibrations, means for maintaining in the respective said capacities electrical charges relatively independent of said capacity variations; means in shunt to a single portion of said system for controlling the amplitudes of said charges; means for combining oscillations appearing across the several said capacities; and means for supplying said combined oscillations to said electro-acoustic translating device to energize the same.

15. In a musical instrument including an electro-acoustic translating device and an electric system operative in the energization of said device; the combination of a tuned vibrator and means for vibrating the same to produce in different portions thereof vibrations having the same fundamental frequency but having respectively different waveforms; a plurality of conductive members respectively in spaced relationship to different portions of said vibrator and forming therewith electrical capacities oscillatorily varied by said vibrations, means for maintaining in the respective said capacities electrical charges relatively independent of said capacity variations; means in shunt to a single portion of said system for controlling the signs of said charges; means for combining oscillations appearing across the several said capacities; and means for supplying said combined oscillations to said electro-acoustic translating device to energize the same.

16. In a musical instrument including an electro-acoustic translating device and an electric system operative in the energization of said device: the combination of a tuned vibrator and means for vibrating the same to produce in different portions thereof vibrations having the same fundamental frequency but having respectively different waveforms; a plurality of conductive members respectively in spaced relationship to different portions of said vibrator and forming therewith electrical capacities oscillatorily varied by said vibrations; means for maintaining in the respective said capacities electrical charges relatively independent of said capacity variations; means in shunt to a single portion of said system for controlling the amplitudes and signs of said charges; means for combining oscillations appearing across the several said capacities; and means for supplying said combined oscillations to said electro-acoustic translating device to energize the same.

17. In a musical instrument including an electro-acoustic translating device and an electric system operative in the energization of said device: the combination of a tuned vibrator and means for vibrating the same to produce in different portions thereof vibrations having the same fundamental frequency but having respectively different waveforms; a plurality of conductive members respectively in spaced relationship to different portions of said vibrator and forming therewith electrical capacities oscillatorily varied by said vibrations; a source of direct current; a high resistance connected between said vibrator and a point in said source; a potentiometer system shunting said source and having adjustable contacts respectively connected to said conductive members; and means for supplying oscillations appearing across said resistance to said electro-acoustic translating device to energize the same.

18. In a musical instrument including an electro-acoustic translating device and an electric system operative in the energization of said device: the combination of a tuned vibrator and means for vibrating the same to produce in different portions thereof vibrations having the same fundamental frequency but having respectively different waveforms; a plurality of conductive members respectively in spaced relationship to different portions of said vibrator and forming therewith electrical capacities oscillatorily varied by said vibrations; a source of direct current; a connection from said vibrator to a point in said source; a potentiometer system shunting said source and having adjustable contacts; high resistances connected between said conductive members and said adjustable contacts, respectively; means for combining oscillations appearing across the several said capacities and means for supplying said combined oscillations to said electro-acoustic translating device to energize the same.

19. In a musical instrument including an electro-acoustic translating device and an electric system operative in the energization of said device: the combination of a tuned vibrator and means for vibrating the same to produce in different portions thereof vibrations having the same fundamental frequency but having respectively different waveforms; a plurality of conductive members respectively in spaced relationship to a plurality of portions of said vibrator and forming therewith electrical capacities oscillatorily varied by said vibrations; a work circuit operatively connected to said electro-acoustic translating device; a source of direct current; connections from said vibrator to a point in said source and from an extremity of said work circuit to a point in said source; high resistance means connecting said conductive members with said source; and capacitive means connecting all of said conductive members with the other extremity of said work circuit.

20. In a musical instrument including an electro-acoustic translating device and an electric system operative in the energization of said device: the combination of a transformer having a primary winding and a center-tap on said winding and having a secondary winding operatively connected to said electro-acoustic translating device; a potentiometer system shunting said primary winding and having adjustable contacts; and a plurality of oscillation sources adapted to produce a like plurality of series of electric oscillations all having the same fundamental frequency but having respectively different waveforms, each of said sources being connected between said center-tap and a respective one of said movable contacts.

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