

Aug. 8, 1939.

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2,168,623

APPARATUS FOR THE PRODUCTION OF MUSIC

Filed April 28, 1937

2 Sheets-Sheet 1

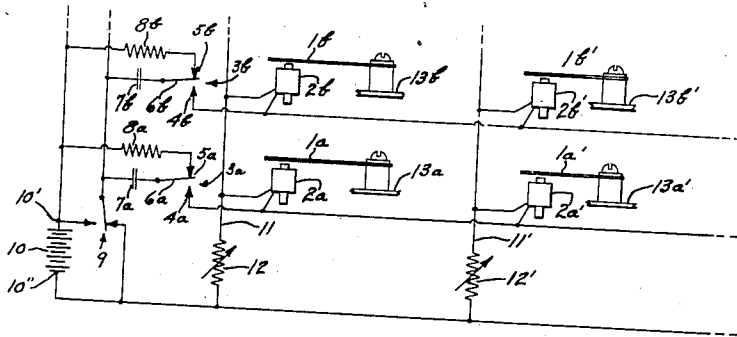


Fig. 1

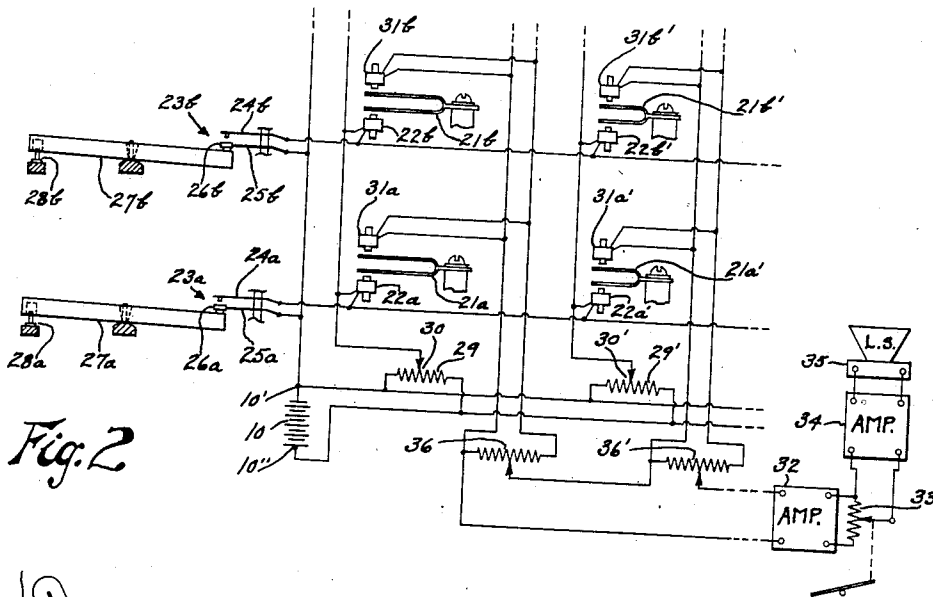


Fig. 2

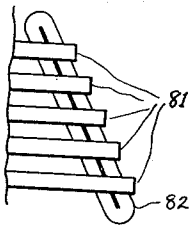
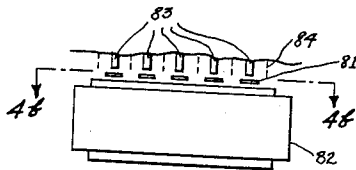


Fig. 4b

Fig. 4a.

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2 Sheets-Sheet 2

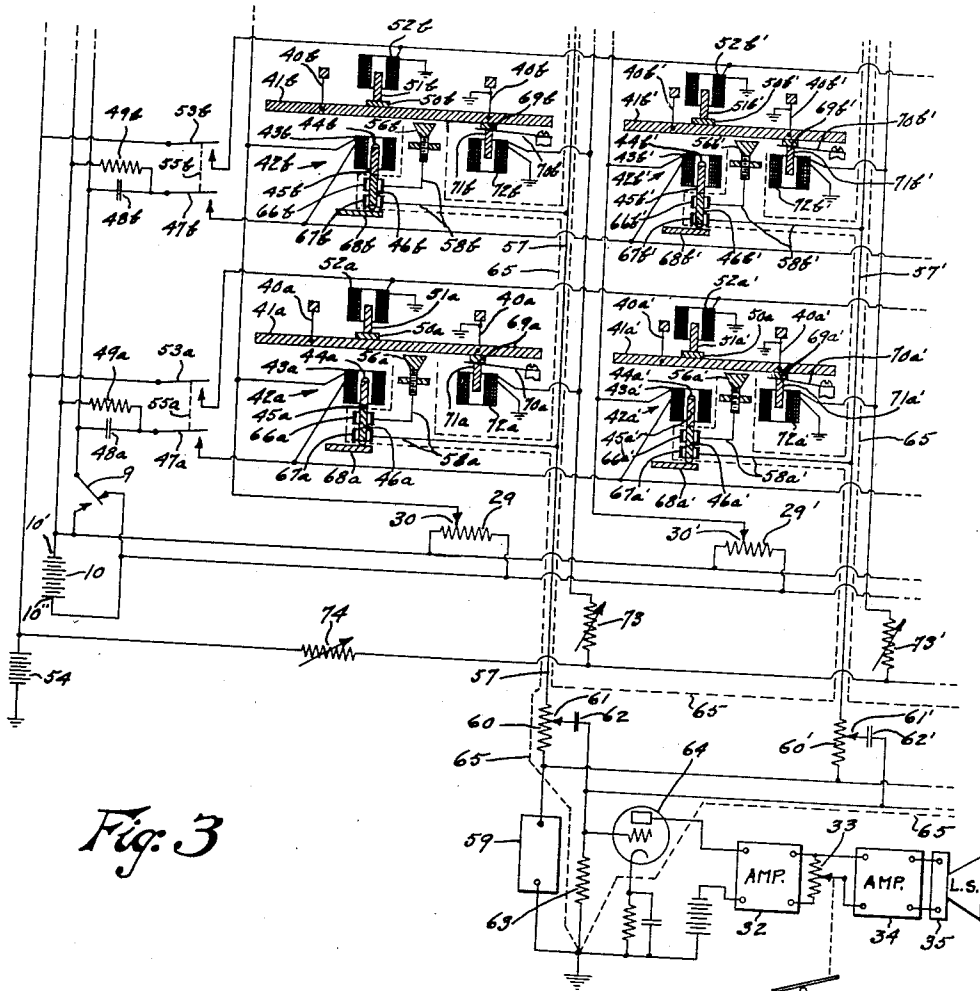


Fig. 3

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UNITED STATES PATENT OFFICE

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APPARATUS FOR THE PRODUCTION OF MUSIC

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Application April 28, 1937, Serial No. 139,493

16 Claims. (Cl. 84-1.13)

This invention relates to the production of music, and more particularly to that production from the vibrations of mechanical vibrators. It is a broad object of the invention to provide improved means and methods for such production. It is an allied object to provide an improved, and improvements for a, musical instrument whose output tones are derived from the vibrations of such vibrators.

The invention has particular reference to the production of damped tones, as distinguished from strictly continuous ones. It is an object to provide improved means and methods for the production of damped musical tones. It is an allied object to provide an improved, and improvements for a, damped-tone musical instrument.

It is another object to provide means and methods for control and regulation of the individual damping rates of the produced tones.

It is another object to provide improved means and methods for the control of the timbre or harmonic structure of the produced tones.

Still another object is the provision of improved means and methods for controlling the envelopes of the produced tones, including tone termination and particularly tone inception.

It is another object to provide improved arrangements of the vibrators and their exciting and control means in an instrument of the class described.

While not necessarily in all aspects limited thereto, the invention especially concerns the production of tones from the vibrators by mechanical-electro-acoustic translation—i. e., the translation of the mechanical vibrations first into electric oscillations and thence into sound. Particular objects of the invention are the fulfillment of the above stated objects specifically in such an instrument.

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

In the description hereinafter set forth reference is had to the accompanying drawings, of which:

Figure 1 is a partially elevational and partially schematic fractional view of an instrument embodying my invention in one form;

Figure 2 is a like view of an instrument embodying my invention in a modified form;

Figure 3 is a like view of an instrument embodying my invention in a further modified and somewhat elaborated form;

Figure 4a is an elevational view of an alterna-

tive arrangement of a plurality of vibrators and the exciting means therefor; and

Figure 4b is a cross-sectional view taken along the line 4b-4b of Figure 4a.

In U. S. Patent No. 2,007,302 issued July 9, 1935, to me, I disclosed certain electrical and electro-mechanical vibrating devices and systems for the impulse excitation into vibration of mechanical vibrators; purely typically, the vibrators were shown as strings, and the excitation systems were arranged to provide control of the output tone timbre by means of their controlling the vibrational waveforms of the respective strings. According to the present invention, as hereinafter more fully appears, I may subject the vibrators to impulse excitation in any one of the manners shown in that patent, or otherwise; but instead of employing a single vibrator of complex waveform for the production of each respective note, I may for each note rely on a plurality of simultaneously acting, harmonically related vibrators. Broadly the simultaneous action of a plurality of harmonically related vibrators is not new with this invention; but by effecting this simultaneous action by a simultaneous excitation of inherently damped vibrators, as well as by employing various structures and arrangements hereinafter more particularly described, I am able to achieve many special advantages in respect of simplicity, flexibility, availability for various controlling actions, and the like.

While no unnecessary limitation thereto is intended, the vibrators according to the present invention are preferably of a type whose vibration is principally of fundamental frequency, and of small harmonic development. Typical of such vibrators are tuning forks, reeds (which last term I employ broadly as denoting a strip, preferably thin, supported at one extremity, and not in the restricted sense of an air-blown such device), and bars (for example supported at the known nodal points of about $\frac{1}{4}$ of the bar length from each extremity). By way of alternative but non-limitative illustration I have shown these three forms of vibrator in the instruments of Figures 1, 2 and 3, respectively; and in these figures I have shown for exciting them, respectively, electrical impulse excitation by condenser charge or discharge through electromagnets, electrical impulse excitation with otherwise limited current flow through electromagnets, and electro-mechanical excitation through a magnetically operated hammer. Various control and translation features are also shown in various forms in one or more of the figures. It is dis-

tinety to be understood, however, that these and other exciting means may be interchanged in use with these and other vibrators, that any of the control and translation features is fully applicable with any form of vibrator and any manner of impulse excitation, and that no limitations are intended of the broader aspects of the invention by reason of the particularly illustrated groupings.

Reference being had to Figure 1, which fractionally shows a relatively simple instrument, there will be seen reeds 1a and 1b (vertically arranged in the drawing) tuned for example to frequencies of two successive notes of the musical scale; it will be understood that this restricted showing is simply typical of a larger plurality of progressively tuned reeds. To the right of the reed 1a will be seen the reed 1a' tuned to a higher frequency harmonically related to (for example, twice) that of the reed 1a, and to the right of the reed 1b will be seen the reed 1b' bearing a corresponding relation to the reed 1b; it will be understood that the showing for each note of a pair of harmonically related reeds is simply typical of a larger series of so-related reeds for each note.

Underneath the several reeds are shown the respective exciting electromagnets 2a, 2b, 2a', 2b'. First terminals of all the electromagnets of the "a" series may be connected in common to the throw-contact 4a of a double-throw single-pole switch 3a; likewise first terminals of all the electromagnets of the "b" series may be connected in common to the throw-contact 4b of a like switch 3b; etc., it being understood that an individual such switch will be provided for each note in the range of the instrument. The poles 6a, 6b, etc. of these switches may be connected to respective condensers 7a, 7b, etc., whose other sides are paralleled and connected to battery or other electrical energy source 10; this connection may be to either terminal of the source 10, as indicated schematically by the switch 9. The poles 6a, 6b, etc. are normally thrown away from the throw-contacts 4a, 4b, etc. to touch their other throw contacts 5a, 5b, etc.; each of the latter may be connected through a respective resistance 8a, 8b, etc. to a first terminal 10' of the source 10. Return circuits are provided, in manner hereinafter mentioned, from the second terminals of all the electromagnets to the second terminal 10'' of the source 10.

Assuming the switch 9 adjusted as shown, to connect the condensers with the source terminal 10'', each condenser will normally be maintained in a state of charge through the respective resistor, for example 8a or 8b; but upon downward throwing of the associated switch pole, for example 4a or 4b, the condenser will be discharged through all the electromagnets having similar letter designations to that of the pole so thrown. This provides simultaneous impulse excitation of all the harmonically related vibrators for the note whose switch was so manipulated. The same ultimate effect is achieved if the switch 9 be adjusted to connect the condensers with the source terminal 10', the difference being simply that the condensers are then normally maintained discharged, and are charged through the appropriate electromagnets upon throwing of the note-switch. Insofar as the functioning of the exciting means in itself is concerned, it is quite similar to that disclosed in the abovementioned patent in connection with Figures 1 and 3 thereof, and reference may be had

thereto for a fuller consideration of the details of the exciting action in itself. It is preferred in the instant case that the electromagnets have sufficient inherent resistance to render aperiodic the condenser charge or discharge therethrough. The electromagnets may be either polarized or unpolarized, as desired.

In the instant case the return circuits, from the second terminals of the electromagnets to the source terminal 10'', are made on the basis of individual partial tone components. Thus a return circuit 11 is provided for the electromagnets 2a, 2b, etc., which electromagnets are associated with the reeds tuned to the fundamental frequencies for the several notes; a return circuit 11' is provided for the electromagnets 2a', 2b', etc., which electromagnets are associated with the reeds tuned to the second partials of the several notes; etc. In each of these return circuits is connected a control device for the several electromagnets of that circuit; these devices have been shown in Figure 1 as the respective variable resistances 12, 12', serially included in the respective return circuits. It will be appreciated that by the adjustment of these devices there will be fully controlled the relative strengths of the excitations of fundamental, second partial, etc. reeds which occur simultaneously upon throwing of any note-switch—and that this control will be at once uniformly effected for all notes.

In Figure 1 the reeds have been shown mounted to the fractionally illustrated bases 13a, 13b, 13a', 13b'. These bases may be either integral or separate, and either rigid or of vibratile form. In the latter case the necessity for mechanico-electro-acoustic translation of the reed vibrations is obviated by the direct mechanico-acoustic translation so provided; this however, is simply typical, it being understood that however the reed vibrations are translated into output tones, those tones will be controlled as to relative partial component amplitudes and hence harmonic structure by the controls 12, 12' etc. abovementioned.

In the instrument of Figure 2 the vibrators are shown as tuning forks 21a, 21b, 21a', 21b', following the same scheme of arrangement and frequency relationships as in the instrument of Figure 1. Also in correspondence with that instrument, exciting electromagnets 22a, 22b, 22a', 22b' are provided for the several vibrators; and again first terminals of all the electromagnets of the "a" series are paralleled, first terminals of all the electromagnets of the "b" series are paralleled, etc. These groups of paralleled terminals are shown, however, connected to the respective contact springs 24a, 24b, etc. of respective normally open switches 23a, 23b, etc. These switches are formed by the springs just mentioned, and by respective weights 26a, 26b, etc. terminally secured on respective light springs 25a, 25b, etc. insulatedly spaced below the first-mentioned springs; the weights may normally rest on the rear extremities of the respective pivoted keys 27a, 28a, etc. Upon depression of the forward extremity of any key the respective weight will be moved upwardly; upon stoppage of the key movement by impingement on its downstop (for example, 28a or 28b) the weight, in view of its momentum, will continue upwardly to touch the contact spring thereabove—and to flex that spring and to remain in contact therewith, maintaining the switch closed, for a time dependent on the velocity of key movement. This touch responsive action in itself is detailedly explained in the abovementioned patent in connection with

Figure 6 thereof, and reference may be had thereto for a fuller consideration thereof. It is here used to excite simultaneously, with touch-responsive variations of length of a short current pulse, a plurality of harmonically related vibrators.

All the weights 26a, 26b, etc may be connected, through the respective springs, 25a, 25b, etc., together and to the terminal 10' of source 10 like that in the instrument of Figure 1. The return circuits for the second terminals of the exciting electromagnets to the source terminal 10'' are again shown as made on the basis of individual partial tone components, and as provided with control means for each of those components. Thus a respective potentiometer shunted across source 10, such as 29, 29', may be provided for each component; and to the movable contact (e. g., 30, 30') of each may be connected the electromagnet returns for all the vibrators for a particular partial component. It will be appreciated that this control arrangement, though involving potentiometric rather than series resistance controls, is essentially the same in effect as that of Figure 1.

In Figure 2 mechanico-electro-acoustic translation of the vibrator vibrations into sound, with magnetic mechanico-electric translating devices, has been shown. Thus there will be seen, in slight spaced relationships to the several forks, the respective polarized pick-up electromagnets 31a, 31b, 31a', 31b'. These are connected to the input of a cascade which may typically comprise amplifier 32, potentiometer or volume control 33 (pedal operated, if desired), further amplifier 34, and loudspeaker or other electro-acoustic translating device 35, it being understood that by the cascade the oscillations translated by the pick-up electromagnets from the vibrator vibrations will be amplified, controlled in respect of overall amplitude or volume level, and translated into output tones.

While the potentiometers 29, 29', etc., by controlling the relative strengths of excitations of the several vibrators for a single note, provide an effective control over harmonic structure, I have also shown in the instrument of Figure 2 certain harmonic structure controls appropriately incorporated in the translating means; these may be employed alternatively to the potentiometers 29, 29', etc., or additionally thereto—in the latter case for example as a special means for shifting the harmonic structure during the continuance of a tone. These means are provided on the basis of individual partial tone components, by connecting together (e. g., in parallel) and across a potentiometer 36 all the pick-up electromagnets associated with vibrators tuned to the fundamental frequencies for the several notes; by connecting together and across a potentiometer 36' all the pick-up electromagnets associated with vibrators tuned to the second partial components for the several notes; etc. Variable portions of the several potentiometers 36, 36', etc. are connected together (e. g., in series) and across the input of the cascade 32—33—34—35, for the application thereacross of tone-representing oscillations fully controllable, in respect of relative strengths of the several partial components of each represented note, by these last-mentioned potentiometers—independently of or in addition to the control thereover by potentiometers 29, 29' etc.

The showings of instruments in Figures 1 and 2 do not illustrate such details as vibration ter-

minators (on-and-off "dampers") for the vibrators, and the like, it being obvious how such may be applied thereto. I have, however, illustrated such terminators, as well as certain further special features over and above the showings of earlier figures, in the instrument of Figure 3. Herein the vibrators by way of example are shown as metal bars supported at the nodal points abovementioned; typically, the support may be a suspension by metallic cords passed through transverse holes (for example, horizontal) in the bars at these nodal points. Four bars 41a, 41b, 41a', 41b' are shown following the arrangement and frequency relationships of earlier figures; respective pairs of cords 40a, 40b, 40a', 40b' are shown as supports therefor of the character just described, suspending the bars from any suitable rigid members. For impulse excitation of the bars I have shown the respective electromagnetic hammer assemblies 42a, 42b, 42a', 42b', including respectively the coils 43a, 43b, 43a', 43b'. Movable within the coils are the respective suitably tipped and rod-shaped hammers 44a, 44b, 44a', 44b'; these have been illustrated as comprising the respective insulating, non-magnetic portions 45a, 45b, 45a', 45b' immediately adjacent the tips and normally lying principally within the coil length, and the respective magnetic portions 46a, 46b, 46a', 46b' extending downwardly from those insulating portions. It will be understood that upon passage of a current pulse through any of the coils it will operate as a solenoid to attract upwardly the associated magnetic hammer portion abovementioned, and thus to cause a sudden upward movement of the entire hammer to strike the vibrator. This electro-mechanical vibrator exciting arrangement is in general similar to that disclosed in the abovementioned patent in its Figure 2, excepting for the present desirable inclusion of the insulating hammer portions abovementioned.

The passage of the necessary current pulses through the coils abovementioned has been typically shown as produced by condenser charge or discharge, following as to each condenser system the arrangement of associated circuit and switch (slightly simpler than that of Figure 1 hereof) shown and described in connection with Figure 2 of the patent abovementioned. First terminals of all the coils (e. g., 43a, 43a') of the "a" series may be connected in common to one side of a normally open single-pole single-throw switch 47a; first terminals of all the coils (e. g., 43b, 43b') of the "b" series may be connected in common to one side of a like switch 47b; etc. The other sides of these switches are connected through respective condensers 48a, 48b, etc. to either terminal (through switch 9) of the source 10, and also through respective resistances 49a, 49b, etc. to the source terminal 10'. Return circuits from the second terminals of the coils to the source terminal 10'' are shown provided on the basis of individual partial components—through potentiometers 29, 29', etc. just as the return circuits for the exciting electromagnets in Figure 2. It will be understood that upon closing of any note switch (e. g., 47a or 47b) the associated condenser will be discharged or charged (according to the adjustment of switch 9) through the abovementioned coils associated with the several vibrators for that note; with this simplified switch there will occur after the initial pulse a small continued current flow through the coils, which is readily rendered of

negligible influence on the hammers by suitable choice of value for the resistances 49, 49a, etc. It will also be understood that by the adjustment of the movable contacts 30, 30', etc. of the potentiometers 29, 29', etc. there may be controlled, as in the instruments of earlier figures, the relative excitation strengths and hence vibration amplitudes for the several vibrators for each note—at once uniformly for all notes.

Vibration terminators are shown in the instrument of Figure 3 in the form of soft pads 50a, 50b, 50a', 50b' normally resting on the respective vibrators, and attached to upwardly extending magnetic shanks 51a, 51b, 51a', 51b'; and solenoids 52a, 52b, 52a', 52b' for lifting the shanks and pads at appropriate times. One terminal of each of these solenoids may be grounded (i. e., connected to some reference potential); the other terminals of all these solenoids of the "a" series may be connected to a normally open single-pole single-throw switch 53a, the other terminals of all these solenoids of the "b" series to a normally open like switch 53b, etc. These switches are electrically connected through common battery or other current source 54 to ground; and each may be arranged for closure, to energize its respective solenoids, during the closure of the associated note-switch (e. g., 47a or 47b) by an insulating tie (e. g., 55a, 55b) thereto. It will thus be understood that simultaneously with the closing of any note-switch the vibration terminators for the several associated vibrators will be lifted from the latter, will remain lifted throughout continued closure of the note-switch, and will fall again to stop the vibrations of those several vibrators upon release or opening of the note-switch.

By way of example, the translation of the vibrator vibrations into sound in the instrument of Figure 3 has been shown as effected by capacitive mechanico-electric translation, followed of course by electro-acoustic translation. Thus in slight spaced relationships to the several vibrators may be provided the respective pick-up electrodes 56a, 56b, 56a', 56b', each typically in the form of an adjustable screw of large flat head; this provides to each vibrator a capacity which will be varied by the vibration of the vibrator. All the vibrators may be grounded, as through one of each of the pairs of metallic cord supports, paralleling the vibrator sides of all these capacities.

A common conductor 57 may be provided for the electrode sides of all these capacities for vibrators for fundamental components, and each electrode (e. g., 56a, 56b) associated with such vibrators may be connected to this conductor (e. g., through the respective conductors 58a, 58b); a common conductor 57' may be provided for the electrode sides of all the capacities for vibrators for second partial components, and each electrode (e. g., 56a', 56b') associated with such vibrators may be connected to this conductor (e. g., through the respective conductors 58a', 58b'); etc. Each of these conductors 57, 57', etc. may be connected through a respective potentiometer 60, 60', etc., and through a common electrical potential source 59, to ground. This source will be of inaudible frequency potential—and the inaudible frequency may if desired be zero, in which case the potential is of course direct. In any event it will be understood that across the series combination of source 59 and potentiometer 60 will appear some potential from

the source modulated in accordance with the vibrations of the vibrators for fundamental frequency components; across the series combination of source 59 and potentiometer 60', some potential from the source modulated in accordance with the vibrations of the vibrators for second partial components; etc. At least the modulations of these potentials may be applied in regulable amplitudes from the movable contacts (e. g., 61, 61') of the several potentiometers through respective condensers (e. g., 62, 62') to a common load. This load may be the grid leak 63 of a repeater tube 64, in the output circuit of which may be connected the cascade 32—33—34—35 of earlier figures. If the source 59 be of zero frequency, the tube 64 may be operated as a simple amplifier; otherwise it may be operated as a demodulator, as will be understood. It will be appreciated that there is so provided translation of the vibrator vibrations into output tones—and control in that translation of the harmonic structure of the tones, analogous to that effected by 36, 36', etc. in Figure 2 and, like that control, employable alternatively or additionally to the vibration amplitude control by 29, 29', etc.

The potentiometers 60, 60', etc. and the grid leak 63 are preferably of very high resistance or impedance value; and these, the condensers 62, 62', etc., the repeater tube 64, the pick-up electrodes, and the associated conductors (e. g., 57, 57', 58a, 58b, 58a', 58b', etc.) may be relatively susceptible to stray electrostatic fields. Accordingly grounded electrostatic shielding schematically indicated as 65 may be provided about these elements.

In instruments of the character disclosed herein I may provide means for reducing or eliminating certain tone characteristics immediately attendant upon tone inception—for example, not only sound immediately occasioned by or translated from the initial abrupt vibrator movement or the impact of the mechanical hammer (when employed), but also the sound translated from the first few cycles of vibration of each vibrator when it is flexibly supported (as in Figure 3) and may require a short but finite time after excitation to stabilize in its proper position for vibration. Such tone envelope control means in their broadest aspects are known; but in Figure 3 I have shown them in the novel combination with flexibly supported vibrators (in which they have the special utility just mentioned) and also in a novel form. This form is similar to that of known ones in that it suppresses the efficiency of translation at and about the instant of vibrator excitation, but it differs in that it is serially interposed in the oscillation-transmitting connection (e. g., 58a) to the translating or pick-up device, and in that it operates by variable-capacity action—being useful independently of the frequency of the potential from the source 59. It may be noted that claims to this novel form of tone envelope control broadly are not made herein, as similar subject matter is disclosed and claimed in my co-pending application Serial No. 208,357, filed May 17, 1938.

In Figure 3 will be seen two thin co-axial and longitudinally spaced rings 66a and 67a, surrounding the magnetic portion 46a of the hammer 44a for vibrator 41a when that hammer occupies its normal position; these rings have negligible direct mutual capacity (i. e., directly to each other), but a substantial mutual capacity through the hammer portion 44a when the hammer is normally positioned, and this capacity is

serially interposed in the conductor 58a by connection of the two portions of that conductor to the two respective rings. Analogous rings, analogously connected, are provided in the case of each of the other vibrators, being designated with the same numbers but with appropriately varied letters and prime-marks, as will be understood. At the instant when any hammer is striking the associated vibrator its magnetic portion is raised above the associated rings, greatly reducing the capacity in series with the electrode conductor (e. g., with 58a) and rendering negligible the efficiency of translation by the electrode; on the quickly ensuing rebound of the hammer from the vibrator, however, the normal values of this capacity and of the translation efficiency are restored. The hammer may be prevented from bouncing at the conclusion of its rebound by employing for its downstop a weak permanent magnet (e. g., 68a, 68b, 68a', 68b') on top of which a non-magnetic bottom tip for the hammer may normally rest. The electrostatic shielding 65 should of course be extended to include all of the mentioned rings, and magnetic hammer portions when the latter are in their normal positions.

Another feature which I find it advantageous to incorporate in instruments of the character described herein is a control of damping rates, both in an absolute sense, and on a relative basis as to different partial tone components. In Figure 3 I show associated with each vibrator an individual damping means or damper—which term I employ to denote a device for increasing damping rate throughout a given vibration, rather than to denote a means for stopping that vibration (such as the terminators abovementioned). These dampers have been shown for the respective vibrators as small felt or other pads 69a, 69b, 69a', 69b', respectively supported on very light springs 70a, 70b, 70a', 70b' and thereby urged lightly against the bottoms of the respective vibrators in one or the nodal regions (i. e., only very close to a nodal point). Secured to the several such springs, and extending downwardly therefrom partially into the respective solenoids 72a, 72b, 72a', 72b', are the respective magnetic shanks 71a, 72a, 71a', 72a'; first terminals of all the solenoids may be grounded. Second terminals of all the solenoids for vibrators for fundamental components (e. g., 72a, 72b) are connected to variable resistance 73; second terminals of all the solenoids for second partial compounds (e. g., 72a', 72b') are connected to variable resistance 73'; etc. The several such variable resistances may be connected in common through variable resistance 74 to the non-ground extremity of current source 54 abovementioned. The energization of the solenoids from that source serves to reduce the pressures of the dampers against the vibrators or, when stronger, to eliminate those pressures by moving the dampers wholly out of contact with the vibrators; the pressure reduction or elimination may be adjusted for all the vibrators simultaneously by the resistance 74; and such reduction or elimination may be adjusted individually for each respective partial component group of vibrators by adjustment of the several resistances 73, 73', etc. Since the damping rate of each vibrator will depend inversely on this pressure, there are made available inversely corresponding adjustments of the tone and component damping rates, and these of course are unified for the instrument as a whole in manner corre-

sponding to the unification of the harmonic structure controls. Very striking tonal effects may be secured by the damping at different rates of the various partial components of each tone.

It will be understood that the mechanical arrangements in which I have shown my invention are purely typical, and that wide modifications may obviously be made therein. Thus in Figures 4a and 4b I have illustrated a grouping of a plurality of harmonically related vibrators 81, for example of reed form, over a single exciting electromagnet 82 therefor, obviating the necessity for a plurality of interconnected exciting devices for the vibrators of a single note. By way of example, mechanico-electric translating electrodes 83 frictionally appear above the several vibrators, mutually shielded as by shielding schematically indicated as 84.

And it will be understood that in still broader aspects my invention is not to be taken as unnecessarily limited by the details of the instruments specifically illustrated and described herein, these being necessarily illustrative and not comprehensive. The scope of my invention is rather to be gauged by the appended claims, wherein I undertake to set forth that scope as broadly as the state of the art will permit.

I claim:

1. A musical instrument for output tones of a plurality of musical notes, having for each note a plurality of damped vibrators respectively tuned to a uniform several partial tone components; a plurality of impulse excitation means each for simultaneously exciting all the vibrators for a respective note into damped vibrations; and a plurality of single electrical control elements each for correspondingly varying the harmonic structure of all the output tones in respect of a respective one of said partial tone components.
2. A musical instrument for output tones of a plurality of musical notes, having for each note a plurality of damped vibrators respectively tuned to a uniform several partial tone components; a plurality of impulse excitation means each for simultaneously exciting all the vibrators for a respective note into damped vibrations; and progressively adjustable control means associated at once with the excitation means for all notes for uniformly varying the harmonic structure of the output tones.
3. A musical instrument for output tones of a plurality of musical notes, having for each note a plurality of damped vibrators respectively tuned to a uniform several partial tone components; a plurality of impulse excitation means each for simultaneously exciting all the vibrators for a respective note into damped vibrations; and control means for varying the strengths of such excitation for all notes differentially as to the vibrators for the several said partial components.
4. In a musical instrument for output tones of a plurality of musical notes, including a mechanico-electro-acoustic translating system: a plurality of damped vibrators for each note respectively tuned to a uniform several partial tone components, all the vibrators influencing said translating system; a plurality of impulse excitation means each for simultaneously exciting all the vibrators for a respective note into damped vibrations; and control means for varying the response of said translating system differentially with respect to the vibrators for the several said partial components.
5. In a musical instrument for output tones of a plurality of musical notes, including a plurality

of mechanico-electric translating devices and load means responsive thereto: a plurality of damped vibrators for each note respectively tuned to a uniform several partial components, said translating devices being mechanically associated with said vibrators and electrically arranged in groups according to said partial components; a plurality of impulse excitation means each for simultaneously exciting all the vibrators for a respective note into damped vibrations; and control means for varying the response of said load differentially with respect to the several said translating device groups.

6. In a musical instrument for output tones of a plurality of musical notes, including a mechanico-electro-acoustic translating system: a plurality of damped vibrators for each note respectively tuned to a uniform several partial tone components, all the vibrators influencing said translating system; impulse excitation means for each note for simultaneously exciting all the vibrators therefor into damped vibrations; and distinct control means, respectively associated with said excitation means and with said translating system, each for varying the harmonic structure of the output tones.

7. A musical instrument comprising for a single note a plurality of damped vibrators of mutually different, harmonically related frequencies; impulse excitation means for simultaneously exciting said vibrators; and means, individually associated with said vibrators and influencing the same throughout their vibrations, for imparting respectively different damping rates thereto.

8. A musical instrument comprising for a single note a plurality of damped vibrators of mutually different, harmonically related frequencies; impulse excitation means for simultaneously exciting said vibrators; and decrement-control means, associated with said vibrators and influencing the same throughout their vibrations, for varying the relative rates of damping of said vibrators.

9. A musical instrument comprising for a single note a plurality of damped vibrators of mutually different, harmonically related frequencies; impulse excitation means for simultaneously exciting said vibrators; and decrement-control means, associated with said vibrators and influencing the same throughout their vibrations, for jointly varying the rates of damping of said vibrators.

10. A musical instrument for output tones of a plurality of musical notes, having for each note a plurality of damped vibrators respectively tuned to a uniform several partial components; impulse excitation means for each note for simultaneously

exciting all the vibrators therefor; and means associated with the several pluralities of vibrators for respectively different partial components and influencing the vibrators throughout their vibrations, for imparting respectively different damping rates to the several pluralities of vibrators for respectively different partial components.

11. A musical instrument for output tones of a plurality of musical notes, having for each note a plurality of damped vibrators respectively tuned to a uniform several partial components; impulse excitation means for each note for simultaneously exciting all the vibrators therefor; and decrement-control means, associated with said vibrators and influencing the same throughout their vibrations, for varying the relative rates of damping of the several pluralities of vibrators for respectively different partial components.

12. A musical instrument for output tones of a plurality of musical notes, having for each note a plurality of damped vibrators respectively tuned to a uniform several partial components; impulse excitation means for each note for simultaneously exciting all the vibrators therefor; and decrement-control means, associated with said vibrators and influencing the same throughout their vibrations, for jointly varying the damping rates of all said vibrators.

13. In a musical instrument having a system for mechanico-electro-acoustic translation: a flexibly supported vibrator influencing said system, impulse exciting means therefor, and means responsive to said exciting means for suppressing the efficiency of said translation at and about the instant of excitation of said vibrator.

14. In a musical instrument having a mechanical vibrator: damping means biased against said vibrator throughout its vibration, and electromagnetic means for progressively varying the bias of said damping means against said vibrator.

15. In a musical instrument having a mechanico-electric translating electrode: a mechanical vibrator, and metallic cord means supporting said vibrator in slight spaced relationship to said electrode and providing an electrically conductive connection to said vibrator.

16. In a musical instrument having for a single note mechanical means arranged for the production of a complex damped output tone: impulse exciting means for said mechanical means, and decrement-control means, associated with said mechanical means and influencing the same throughout said tone production, for independently varying the damping rates of a plurality of partial components of said tone.

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