

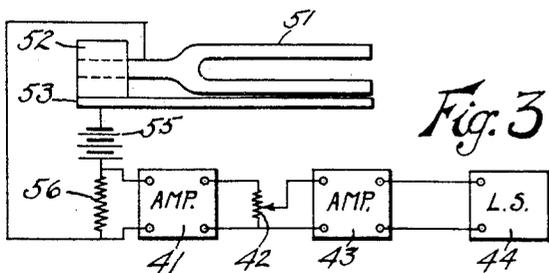
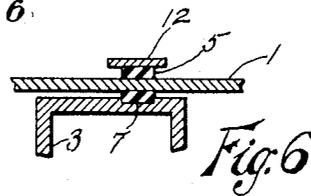
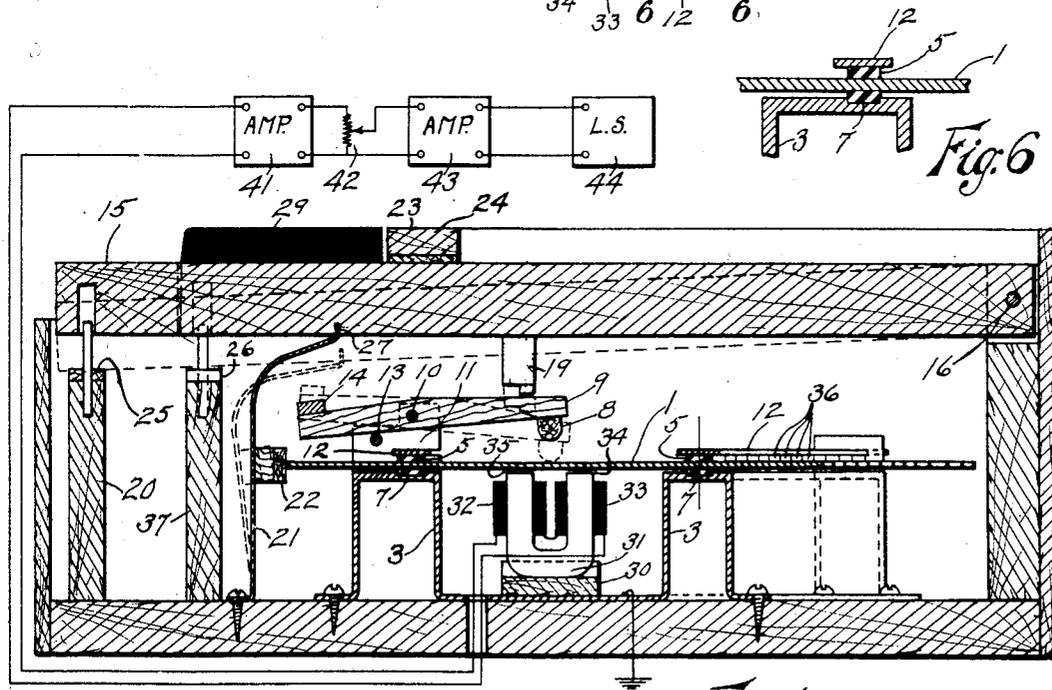
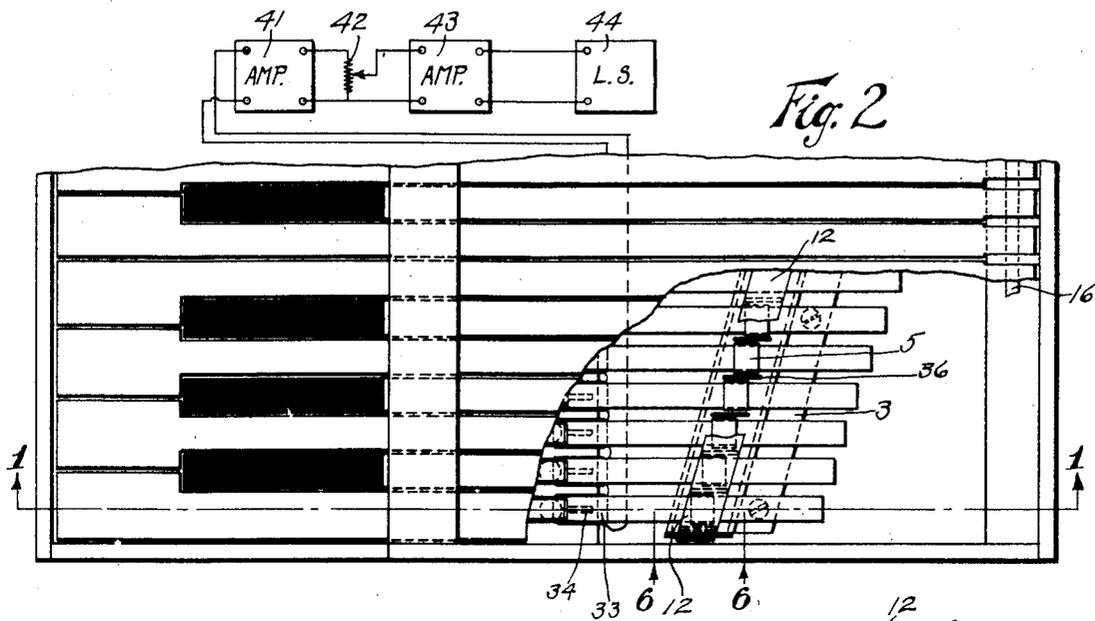
Oct. 3, 1933.

B. F. MIESSNER

1,929,027

METHOD AND APPARATUS FOR THE PRODUCTION OF MUSIC

Original Filed Jan. 30, 1931 2 Sheets-Sheet 1



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METHOD AND APPARATUS FOR THE PRODUCTION OF MUSIC

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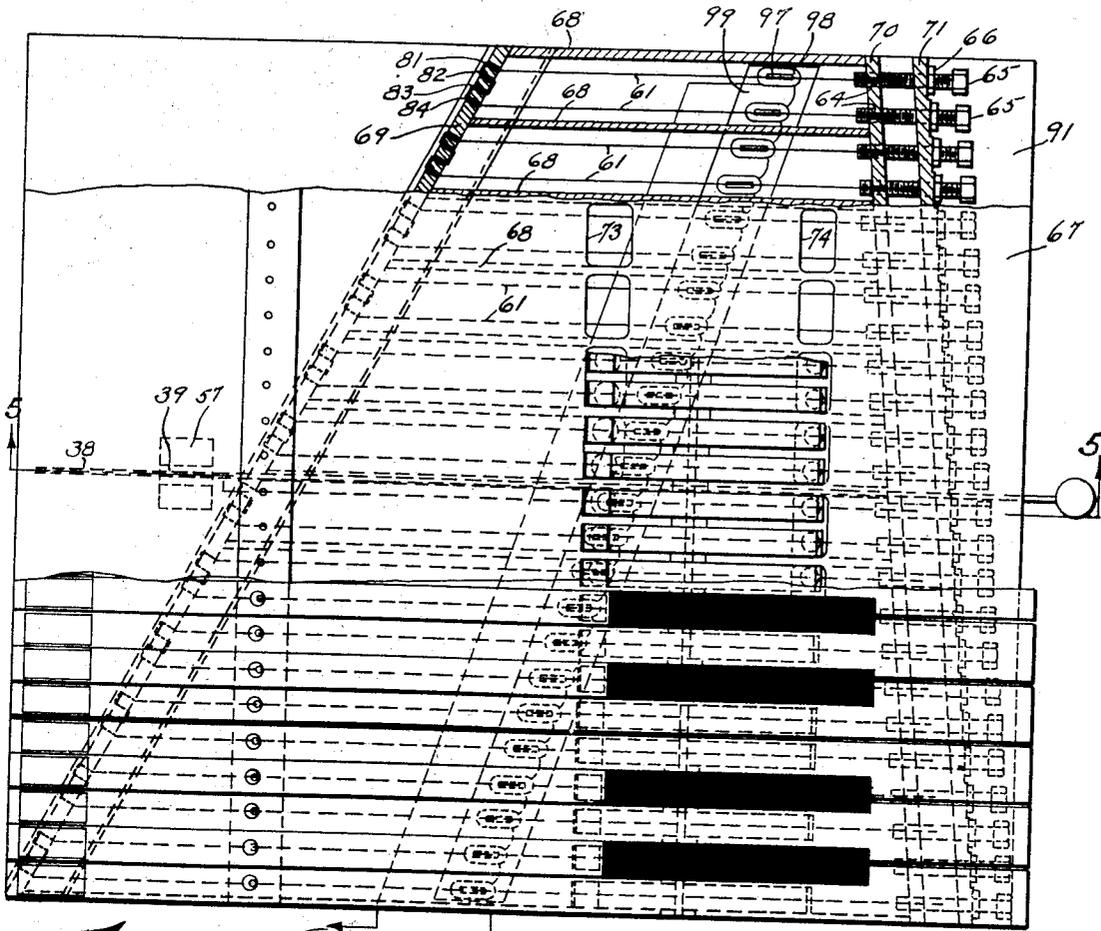


Fig. 4

To 41, 42, 43, 44

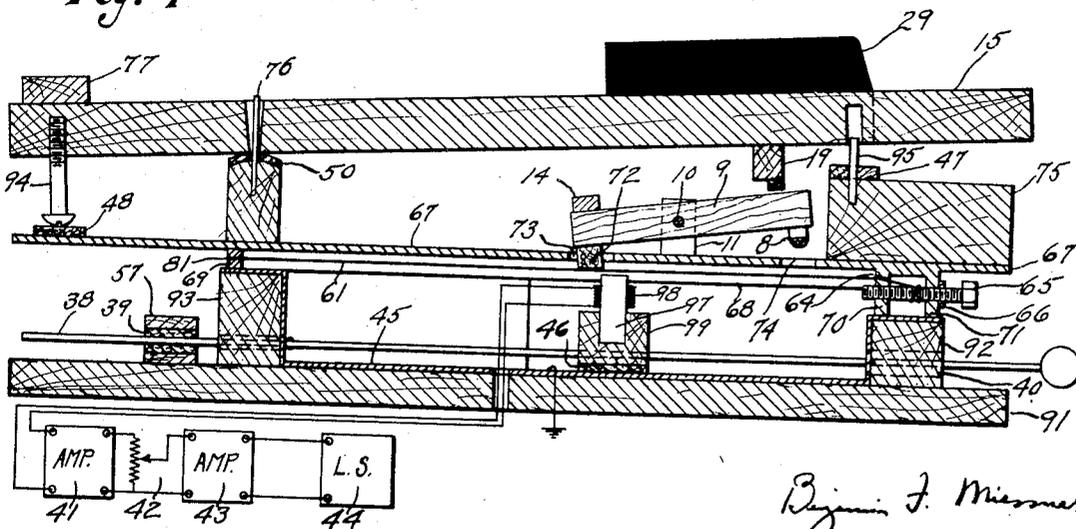


Fig. 5

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UNITED STATES PATENT OFFICE

1,929,027

METHOD AND APPARATUS FOR THE PRODUCTION OF MUSIC

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Application January 30, 1931, Serial No. 512,399
Renewed May 6, 1933

14 Claims. (Cl. 84-1)

This invention relates to electrically produced music and more specifically to methods and apparatus for producing and controlling sounds of various fundamental frequencies, or music, through electric media.

It is an object of my invention to provide mechanical-electrical methods whereby there may be produced selectively and controlled sounds of any one, or more than one simultaneously, of a plurality of fundamental frequencies. It is a further object of my invention to provide mechanical and electrical apparatus for the selective production and the control of such sounds. It is a still further object to provide an improved musical instrument employing electrical circuits whereby there may be produced selectively and controlled both single musical notes and chords. Other and allied objects will more fully appear from the following specification and the appended claims.

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

Figure 1 is a cross-sectional and Figure 2 a top view of one embodiment of my invention, Figure 1 being taken along line 1-1 of Figure 2;

Figure 3 illustrates certain modifications of my invention;

Figure 4 is a top view, and Figure 5 a cross-sectional view taken along the line 5-5 of Figure 4, of my invention in a further modified and the preferred form; and

Figure 6 is an enlarged view of a small portion of Figure 1 taken along the line 6-6 of Figure 1.

A general method illustrative of certain practices employed in my invention is the setting into decadent vibration of a suitable vibrator, the production by such vibration of electric oscillations of similar fundamental frequency, the amplification thereof by an electrical amplifying and controlling system and the actuation thereby of a loudspeaker or other electro-acoustic translating device.

In Figure 1 I show a cross-sectional view of a musical instrument employing metal bars as vibrators, taken longitudinally through one such bar. Vibrator 1 may consist of a bar of magnetic material, preferably of unhardened steel and mounted in a horizontal position by supports 3 symmetrically placed longitudinally about the center of the bar. In order to prevent the bar from shifting its position and at the same time to avoid excessive damping of the vibration of the bar by too rigid a fastening thereof to its supports, I prefer to surround the bar with continuous narrow bands of soft rubber, 5, at the

points of support and to provide recesses 7 in the supports into which such bands of rubber fit snugly. To hold down the bars pieces 12 may be employed and to prevent lateral shifting of the bars separators 36 may be used; pieces 12 and 36 may touch the bands 5 but not the bars. An enlarged cross-sectional view of a portion of a bar, a band of rubber, a portion of a support 3 and piece 12 is shown in Figure 6.

The exact positioning with respect to the ends of the bar of the bands of rubber and points of support affects the rate of damping of the vibration of the bar. It is well known that a bar symmetrically supported about the center tends so to vibrate as to establish two nodes, or points of no vibration; and for minimum rate of damping the points of support should be made to correspond with the nodes. I have found the nodes in the bars which I have utilized to be almost exactly two-ninths of the total bar length away from each end of the bar and I therefore prefer thus to position the bands of rubber.

For setting the bar into vibration, I show hammer 8 fastened at the end of rocker arm 9, which is pivoted as at 10 between supports such as 11. These supports may also carry block or rod 13 to limit the motion of the rocker arm, the end of which is provided with weight 14. Above the rocker arm I show key 15, pivoted as at 16 and provided with felt-tipped block 19. The possible downward motion of key 15 is limited by block 20 and felt washer 25, while a normally raised position for the key is maintained by the curved spring 21 attached to the key as at 27. To spring 21 is fastened the damper 22, preferably of felt. The spring 21 normally maintains damper 22 in contact with the end of bar 1. When key 15 is depressed as far as block 20 and washer 25 permit, however, spring 21 flexes and moves damper 22 away from the end of bar 1 and at the same time block 19 moves rocker arm 9 to a point such that hammer 8 almost contacts with bar 1. If the downward motion of the key be other than extremely gradual, the momentum developed by the rocker arm will cause the hammer to strike the bar, setting it into vibration. The amplitude of such vibration will depend on the degree of such momentum of the rocker arm, which in turn will be seen to depend on the manner, and particularly velocity, of the depression of the key; in other words, the striking action is touch-responsive. When the key is released or allowed to rise again, damper 22 again contacts with the end of bar 1, stopping its vibration. Key 15 is shown as a white key; an adjacent black

key as shown as 29, block 37 and felt washer 26 performing for the black keys the function performed by block 20 and washer 25 for the white. The upward motion of all the keys may be limited as by block 24 and felt piece 23.

Below each bar may be employed a mechanico-electric translating device, shown in Figure 1 as a horse-shoe magnet 31, supported as by block 30, preferably having smoothly ground ends and having a coil of many turns of fine wire surrounding each pole, the two coils, 32 and 33, being connected in series aiding. The magnet, the gaps 34 and 35 between the poles of the magnet and the bar, and the section of the bar between the gaps in general form a magnetic circuit threading through the coils; and variations of the gaps, produced by vibration of a section of the bar in a vertical direction, or the direction of its thickness, cause an a. c. voltage of fundamental frequency similar to that of the vibration of the bar to appear across the extremities of the coils. While I have shown the poles of the magnet itself passing through the coils and forming one side of each of the air gaps 34 and 35, it will be understood, of course, that soft iron or other pole pieces may be used if desired.

I prefer to connect all the coils, in this case comprising two for each bar of the instrument, in series, although a parallel or various forms of series-parallel arrangements may be employed; and to connect the extremities of the group to the input of an electrical amplifying system which I have shown in Figure 1 as comprising amplifier 41, potentiometer or volume control 42 and amplifier 43. It will be understood, of course, that the volume control may precede or follow the entire amplifier instead of lying between portions of it as shown. The output of the amplifier is connected to the input of a loudspeaker 44 or other electro-acoustic translating device.

It is well known that the fundamental frequency of transverse vibration of bars freely suspended in air or symmetrically supported about the center longitudinally is given by the expression $KTL - \frac{1}{2}$ where T is the thickness of the bar, L the length and K a constant depending on the material of the bar and the units of measurement employed for T and L. It may thus be seen that the fundamental frequency of the oscillations produced by this embodiment of my invention may be readily regulated by suitable dimensioning of the bar, thick and/or short bars being suitable for the production of high frequencies and thin and/or long bars for the production of low frequencies. It is to be noted that as the width of the bars does not appear in the expression for frequency, the width of the bars which may be employed in this embodiment of my invention may be varied within wide limits according to convenience; I have found it preferable, however, to maintain the width of the bar at a dimension at least a fraction greater than the thickness and in turn less than the mean separation between the centers of adjacent keys of a complete instrument.

In Figure 2 I show a top view of such an instrument as is shown in Figure 1. For the production of a different fundamental frequency by each bar, the bars are shown as of constant thickness but varying length; the length may be held constant, however, and the thickness varied, or both length and thickness varied, according to convenience and as will be understood from the expression given above for frequency.

Other forms of vibrators and other mechanico-electric translating devices may be substituted for the bars and magnet-coil assemblies respectively shown in Figures 1 and 2. Thus in Figure 3 I show a metal tuning fork 51 mounted close to metal plate 53 but electrically insulated therefrom by insulating mounting 52. Plate 53 is shown connected through a battery 55 or other source of d. c. potential to one side of a resistance 56, to the other side of which is electrically connected the tuning fork. Thus the electrostatic capacity between fork 51 and plate 53 is charged to the potential of battery 55, but its charge is prevented by the resistance 56 from changing rapidly. The vibration of the fork, which may be controlled by a striking and damping action similar to that of Figure 1, varies the electrostatic capacity between fork 51 and plate 53 at the fundamental frequency of vibration of the fork; and by virtue of the relative constancy of the charge in this capacity an a. c. voltage similar in frequency appears across the capacity and also across resistance 56. This potential may be applied to the input of an electrical amplifying and controlling system and loudspeaker, as in Figures 1 and 2.

Due largely to the paucity of harmonics of the fundamental frequency in the vibration of bars and of tuning forks, which harmonics are well known to add timbre or richness to musical tones, I prefer to employ as vibrators stretched strings of music wire or similar material, held under longitudinal tension in a suitable frame. A top view of such a frame, partially equipped with strings, a striking and damping action and a keyboard, is shown in Figure 4. It may consist of a base 67 carrying on the bottom struts or longitudinal compression bars 68, back end bar 69, front end bar 70 and pin piece 71. Tuning pins 65, equipped with lock nuts 66, may be screwed into both pin piece 71 and front end bar 70. Strings 61 may be secured to a tuning pin, passed through slanting hole 64 in the front end bar, through holes 81, 82, 83 and 84 in the back end bar and through the next hole 64 in the front end bar and secured to the next tuning pin, providing by a single length of string two vibrators; a single length may of course be utilized for one vibrator by being secured at the back end bar after passing through hole 81 and without passing through additional holes 82 and 83. I prefer to employ a frame carrying 24 strings so dimensioned that the length of the longest string will be between 3 and 4 times that of the shortest and that the distance between strings, measured perpendicularly thereto, will be the mean separation between centers of adjacent keys on the keyboard. Plate 67 may be provided with a row of holes 74, preferably at approximately $\frac{1}{8}$ of each string length away from the front end of that string; and I prefer so to angle the end pieces with respect to the strings that the row of holes 74 will fall in a straight line perpendicular to the strings. Another row of holes 73 may be provided a few inches nearer the back of the frame than row of holes 74.

A vertical cross-sectional view of the instrument of Figure 4 taken along a middle string, is shown as Figure 5 similar numbers in each view of course designating similar parts. The frame may be supported on base 91 by supports 92 and 93. Key 15 is shown rocking about vertical pin 76 on felt pad 50. The key may be counterweighted so that its front end is normally raised by means of weight 77 and may be provided with

back stop 94 and with felt tipped block 19. Front lateral guide pin 95 may be used to hold the key in lateral alignment. 47 and 48 may be felt pieces for reducing noise produced by key motion. Rocker arm 9, pivoted as at 10 between supports 11 and equipped with weight 14 and hammer 8 is shown, similarly to Figure 1. A damper 72, of soft material such as felt, is provided at the rear end of the rocker arm, so that it rests normally on string 61 through hole 73 in frame 67. When key 15 is depressed as far as block 75 and felt 47 permit, rocker arm 9 is moved so that damper 72 is raised from string 61 and hammer 8 approaches the string through hole 74. If the downward motion of the key be other than extremely gradual, the momentum developed by rocker 9 causes hammer 8 to strike the string, setting it into vibration. The amplitude of such vibration will depend on the degree of such momentum of the rocker arm, which in turn will be seen to depend on the manner, and particularly velocity, of the depression of the key; in other words, the striking action is touch-responsive. When key 15 is released or allowed to rise again, damper 72 again contacts with the string, stopping its vibration.

It is well known that the vibration of a stretched string possesses not only a fundamental frequency but also a large complement of harmonic frequencies. While the amplitude of fundamental frequency vibration of the string is normally greatest at one spot, the center of the string longitudinally, the amplitude of any particular harmonic frequency vibration is at a maximum at a plurality of longitudinal positions, known as loops for that harmonic, and is at zero at other, known as nodes. At each point between the center of the string and one end the ratios among themselves of the amplitudes of the vibrations at the fundamental and various harmonic frequencies are different. Thus by locating a mechanico-electric translating device at various positions between the center and one end of the string it is possible to vary the waveform of the output of the translating device and hence the quality of the output tone in respect of timbre. I therefore prefer to mount the translating devices, each of which consists as shown in Figure 5 of a bar magnet 97 surrounded near its upper extremity by coil 98, so that their longitudinal positions with respect to the strings may be varied, as on block 99, which is provided with felt 46 and which may be moved to and fro along the strings by rod 38 passing through felt 39 in block 57 and through felt 40 in block 92. The extremities of the group of coils 98, which may among themselves be connected in series, are shown connected to the input of an amplifying, controlling and translating system, as in previous figures. The trough formed by base 91 and blocks 92 and 93 may advantageously be lined with grounded metal shield 45 for the reduction of the sensitivity of the translating devices to stray electrostatic and other fields.

The principle of operation of the string and uni-polar translating device is similar to that of the bar and bi-polar translating device discussed above, excepting that the magnetic circuit now comprises the bar magnet, the gap between it and the string, portions of the string on each side of the gap and leakage paths from the string back to the magnet.

The fundamental frequency of vibration of a string varies inversely with length, inversely with the square root of mass per unit length and directly with the square root of tension. It may be

seen, therefore, that in the usual twelve note per octave instrument and with the frame construction shown in Figures 4 and 5 strings of similar mass per unit length, i. e., of similar wire, may be used throughout without necessitating large departure from a given tension in the cases of the different strings. For extending the pitch range of the instrument downward I have found it convenient to use another frame, similar to that shown in Figure 4 but with front and back end pieces parallel and separated by the greatest string length in the frame of Figure 4, using wire of progressively larger mass per unit length for progressively lower frequencies, employing soft-iron wound music wire for the lowest frequency vibrators.

The stringed instrument disclosed will be seen to be basically a piano, in which the strings are otherwise than customarily supported, in which a simplified action is employed, and in which no soundboard or other resonator is employed; the vibrations of the strings being translated, instead of directly into sound waves, into electric oscillations and these in turn into sound waves. The substitution of these mesne vibration-oscillation (mechanico-electric) and oscillation-sound (electro-acoustic) translations for the conventional direct vibration-sound (mechanico-acoustic) translation, as distinguished from their simple addition to such direct translation, results in substantial completeness of control over the output sound in respect of its amplitude—i. e., that effected by potentiometer 42—and of the control thereover in respect of quality—e. g., the control over timbre effected by the positioning of block 46.

It will be seen that I have disclosed an instrument and system wherein control over output tone volume may be effected both by manner of key depression and my manipulation of the volume control. Since such dual control of output tone volume makes available a variety of musical effects incapable of production if either control be omitted, claims are hereunto appended directed to this combination of control means.

While I prefer to set the vibrators into vibration by key actuated percussion, other methods may be employed including striking as by loose mallets, plucking or stroking as by the finger or by a suitable key-operated action, and the like. While I have illustrated bars with bi-polar magnetic translating devices, tuning forks with capacitive translating devices, and strings with uni-polar translating devices, it will be understood that these and other vibrators and translating devices may be interchanged. Likewise a single translating device may be employed opposite or in association with all or a plurality or group of the vibrators, thus reducing the required number of such devices. These and other modifications may be made without departing from the spirit and scope of my invention, as hereinabove disclosed and in the appended claims defined.

The specific translating devices disclosed will be seen to be characterized by portions in spaced relationship to the vibrators and to operate in accordance with vibratory variation of such spacing; they are directly responsive to oscillatory displacements of active parts of the strings. I do not wish, however, to limit my invention in all its aspects to the employment of such translating devices; and such limitation is intended only to the extent to which it is actually included in the appended claims.

I claim:—

1. In the production of musical tones from the

- mechanical vibrations of a single vibrator, which vibrations are characterized by a fundamental oscillation of predetermined frequency on which are superimposed oscillations of higher predetermined frequencies producing a resultant complex vibration, the method of timbre control which comprises converting said complex mechanical vibration into complex electric oscillations and selectively controlling the energy distribution between various of the component electric oscillations so produced.
2. In the production of musical tones from the mechanical vibrations of a single vibrator, which vibrations are characterized by component vibrations of a plurality of predetermined frequencies producing a resultant complex vibration, the method of timbre control which comprises translating said complex mechanical vibration into electric oscillations and controlling said translation selectively with respect to various of said component vibrations.
3. The method of producing musical tones from a tuned vibrator and of controlling their timbre which consists in producing complex mechanical oscillations of said vibrator comprising a plurality of harmonically related partial components, in translating said complex oscillations from said mechanical into an acoustic form substantially entirely by mesne translations thereof first into the form of complex electric oscillations and thence into the form of sound, and in selectively controlling the energy distribution between various of the partial components of said complex electric oscillations.
4. The method of producing musical tones from a tuned vibrator and of controlling their timbre, which consists in producing complex mechanical oscillations of said vibrator comprising a plurality of harmonically related partial components, in translating said complex oscillations from said mechanical into an acoustic form substantially entirely by mesne translations thereof first into the form of complex electric oscillations and thence into the form of sound, and in controlling the first of said mesne translations selectively with respect to various of said partial components.
5. The method of producing musical tones from a tuned vibrator and of controlling their quality, which consists in producing mechanical oscillations of said vibrator, in translating said oscillations from said mechanical into an acoustic form substantially entirely by mesne translations thereof first into the form of electric oscillations and thence into the form of sound, and in selectively controlling qualitative characteristics of the electric oscillations produced by the first of said mesne translations.
6. A musical instrument comprising a plurality of variously tuned vibrators; means selective with respect to said vibrators for producing in each vibrations having a plurality of harmonically related partial components; a mechanico-electric translating system associated with said vibrators and operative to translate said vibrations thereof into electric oscillators; means included in said mechanico-electric system for selectively controlling the harmonic structure of the said oscillations translated from each said vibrator; and means for translating said oscillations into sound.
7. A musical instrument comprising a plurality of variously tuned vibrators; means selective with respect to said vibrators for producing in each vibrations having a plurality of harmonically related partial components; a mechanico-electric translating system having sensitive portions respectively in spaced relationship to said vibrators, said system being operative to translate said vibrations into electric oscillations and being selective in such operation with respect to said various partial components of the vibration of each vibrator; means included in said translating system for altering at will its said selectivity with respect to partial components; and means for translating said electric oscillations into sound.
8. A musical instrument wherein substantially the entire output sound is translated from electric oscillations, comprising a plurality of variously tuned vibrators; means selective with respect to said vibrators for producing vibrations thereof; a mechanico-electric translating system associated with said vibrators and operative to translate said vibrations thereof into said first mentioned electric oscillations; and means included in said mechanico-electric system for selectively controlling qualitative characteristics of the said oscillations translated from each said vibrator.
9. A musical instrument wherein substantially the entire output sound is translated from electric oscillations, comprising a plurality of variously tuned vibrators; means selective with respect to said vibrators for producing vibrations thereof; a mechanico-electric system having sensitive portions respectively in spaced relationship to said vibrators and being operative to translate said vibrations thereof into said first mentioned electric oscillations; means included in said mechanico-electric system for amplifying said electric oscillations; and means included in said mechanico-electric system for selectively controlling qualitative characteristics of the said oscillations translated from each said vibrator.
10. A musical instrument wherein substantially the entire output sound is translated from electric oscillations, comprising a plurality of variously tuned vibrators; means selective with respect to said vibrators for producing in each vibrations having a plurality of harmonically related partial components; a mechanico-electric translating system having sensitive portions respectively in spaced relationship to said vibrators, said system being operative to translate said vibrations into said first mentioned electric oscillations, and being selective in such operation with respect to said various partial components of the vibration of each vibrator; and means included in said translating system for altering at will its said selectivity with respect to partial components.
11. In a musical instrument, the combination of a mechanical oscillator; means for exciting said oscillator to produce in different portions thereof mechanical oscillations of respectively different harmonic structures; a mechanico-electric translating device operative to translate into electric oscillations the mechanical oscillations of that portion of said oscillator with which said device may be associated; and selectively operable means connected with said device for associating the same with any of a plurality of said portions of said oscillator at will.
12. In a musical instrument, the combination of a plurality of variously tuned strings; means selective with respect thereto for vibrating the same at a plurality of their partial frequencies; mechanico-electric translating apparatus having sensitive portions respectively adjacent said strings; and means connected to said translating apparatus for moving the same, to move said sensitive portions thereof in the directions of the

lengths of the respectively adjacent said strings.

13. A piano wherein substantially the entire output sound is translated from electric oscillations, comprising a plurality of variously tuned strings; hammers respectively associated therewith and each operable at different velocities to produce in the therewith associated said string vibration of form dependent on hammer velocity; a mechanico-electric system associated with said strings and operative to translate said vibrations thereof into said first mentioned electric oscillations; and means included in said mechanico-electric system for selectively controlling the amplitude of said oscillations, whereby low sound amplitudes may be obtained with high hammer velocities, and vice versa, at will.

14. A piano wherein substantially the entire output sound is translated from electric oscillations, comprising a plurality of variously tuned strings; hammers respectively associated therewith and each operable at different velocities to produce in the therewith associated said string vibration of form dependent on hammer velocity; a mechanico-electric system associated with said strings and operative to translate said vibrations thereof into said first mentioned oscillations; and means included in said mechanico-electric system for selectively controlling characteristics of said oscillations.

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