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METHOD AND APPARATUS FOR THE PRODUCTION OF MUSIC

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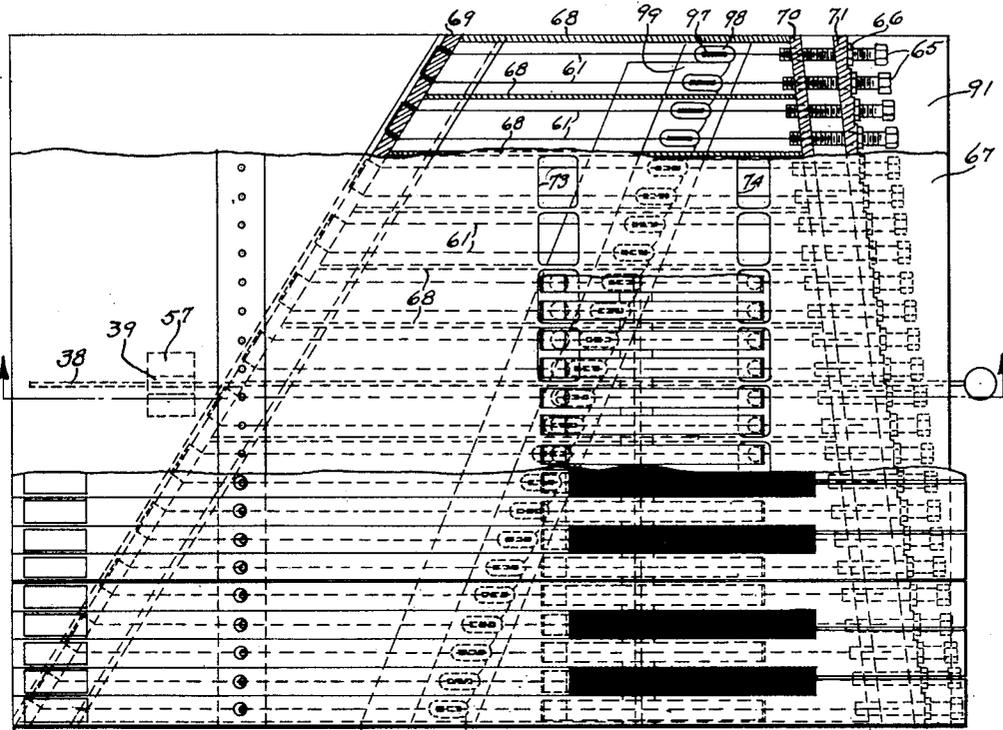


Fig. 1

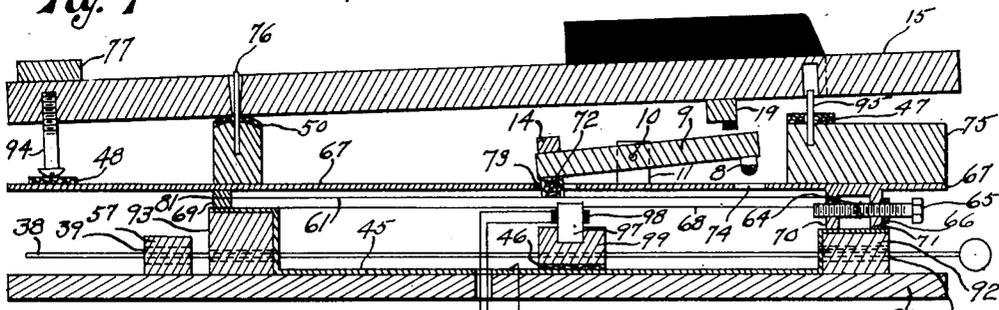
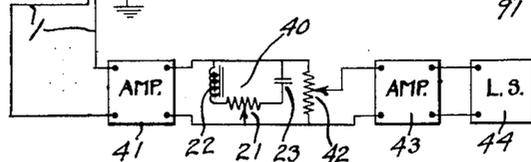


Fig. 2.



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METHOD AND APPARATUS FOR THE PRODUCTION OF MUSIC

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12 Claims. (Cl. 84—1)

This invention relates to the production of music through electric media and more specifically to mechanical and electrical methods and apparatus for the control of such production.

5 This application deals in part with improvements on the methods and apparatus disclosed in my co-pending application Serial Number 512,399, filed January 20, 1931.

It is an object of my invention to provide, in a musical instrument of the type wherein the vibrations of mechanical vibrators are successively translated into electric oscillations and into sound, control means and methods for selectively varying the quality, in respect of timbre, of the output tone or tones produced. Other and allied objects will more fully appear from the following description and the appended claims.

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

Figure 1 is a top view of a portion of a musical instrument embodying certain of the principles of my invention; and

Figure 2 is a cross-sectional view taken along line 2—2 in Figure 1, in which certain electrical and electro-acoustic apparatus also embodied in my invention appear schematically.

A simple embodiment of my invention may include tuned strings which may be set into vibration, mechanico-electric apparatus for translating the vibrations of the strings into electric oscillations, an amplifier for such oscillations and a loudspeaker or other electro-acoustic apparatus for translating the amplified oscillations into sound; and various control devices associated therewith, as hereinafter more fully appears.

Thus in Figure 1 I show a top view of a frame carrying a plurality of tuned strings, a simple action for selectively setting the strings into vibration and for damping the vibrations of the strings, and a key-board for operating such action. The frame 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 hole 64 in front bar 70, thru a hole 81 in rear bar 69, and back through adjacent holes 81 and 64 to the adjacent tuning pin, providing by a single length of string two vibrators; a single length may of course be utilized for one vibrator if desired, it being secured at the back end bar after passing through hole 81. I have preferred 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 69 and 70 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 1, taken along a middle string, is shown as Figure 2. 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. 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 arm 9 causes hammer 8 to strike the string, setting it into vibration. When key 15 is released or allowed to rise again, damper 72 again contacts with the string, stopping its vibration. Such a striking action will be seen to be "touch-responsive", in that the amplitude of vibration of the string depends on the velocity of the hammer at the moment of impact, and this in turn on the manner, and particularly velocity, of depression of the key.

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 with the frame construction shown in Figures 1 and 2, strings of similar mass per unit length, i. e., of similar wire, may

be used throughout without necessitating large departures 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, which may if desired be similar to that shown in Figure 1 but with front and back end pieces parallel and separated by the greatest string length in the frame of Figure 1, using wire of progressively larger mass per unit length for progressively lower frequencies, and employing soft-iron-wound music wire for the lowest frequency vibrators.

Below each string may be employed a mechanico-electric translating device, shown in Figures 1 and 2 as a bar magnet 97, supported as by block 99, carrying near its upper extremity or pole a coil 98. The magnet, the gap formed between its upper pole and the associated string, and the leakage paths from various portions of such string back to the magnet in general form a magnetic circuit threading the associated coil; and variations of the gap, produced by vibration of the string, vary the reluctance of this circuit and cause an A. C. voltage of fundamental frequency similar to that of the string, and of harmonic structure substantially similar to that of the vibration of the mean point of the string opposite the magnet, to appear across the extremities of the coil. The coils of the several translating devices may be connected together, preferably in series; and A. C. voltages appearing across the extremities of any one will then appear across the extremities of the group or entire translating system, such extremities being shown as wires or leads 1 in both Figures 1 and 2.

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 others, known as nodes. At each point between the center of the string and one end thereof the ratios among themselves of the amplitudes of the vibrations at the fundamental and various harmonic frequencies are different. Thus by associating a mechanico-electric translating device selectively with various portions of the string between the center and one end it is possible to vary the waveform of the output of the translating device and hence the timbre of the tone produced by this embodiment of my invention. I therefore prefer to mount the translating devices 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 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 specific electromagnetic form of translating system disclosed will be seen to be characterized by sensitive portions in spaced relationship to the strings and to operate in accordance with vibratory variation of such spacing; it is directly responsive to oscillatory displacements of active parts of the strings. I do not wish,

however, to limit the various features of my invention to use with such translating devices, since it will be apparent that other types of translating devices may be suitably arranged to carry out the basic principles herein disclosed.

In Figure 2 the leads 1, representing the electrical extremities of the group of translating devices, will be seen to be connected to the amplifier 41. Connected to the output of amplifier 41 is shown tone control circuit 40, comprising for example potentiometer 21 and inductance 22 and capacity 23 and hereinafter more completely discussed; and volume control 42. This may be followed if desired by further amplifier 43, to the output of which may be connected loudspeaker or other electro-acoustic translating device 44. Thus A. C. voltages appearing across the leads 1 may be amplified, controlled both in respect of volume and of harmonic structure as hereinafter more fully set forth, and translated into sound. It will be understood, of course, that a single amplifier may be employed in place of the two amplifiers 41 and 43; and that either or both the tone control 40 and volume control 42 may precede or follow the entire amplifier, as desired.

The tone control 40 as shown comprises a potentiometer 21, preferably having a total resistance of several times the output impedance of amplifier 41, and an inductance 42 and condenser 43, arranged so that the inductance and capacity are each shunted across the output of amplifier 41, each in series with a resistance the value of which may be raised for one and simultaneously lowered for the other. When the movable contact of the potentiometer is in the central position, sufficient resistance is in series with each to make negligible its effect as a shunt across the amplifier output. If, however, the movable contact of the potentiometer be moved toward either inductance 22 or capacity 23, that element will be made more effective as a shunt, and will attenuate low or high frequency components, respectively, of the oscillations in the output of the amplifier. The choice of the values of inductance and capacity to be employed in a particular case will depend on the associated circuit parameters, particularly the output impedance of the preceding amplifier 41, and on the maximum degree of low and high frequency attenuation which it is desired to effect, as will be understood.

While the use of adjustable tone controls in association with electrical amplifiers is in general old, I hereinafter claim as my invention the use of such a control with a musical instrument of the class described; and I have found that special and otherwise unattainable results may be achieved by its use. For example, it is well known that the relative violence of the percussion of a vibrator varies its mode of vibration—i. e., alters not only the absolute but also the relative amplitudes of the various partial components of its vibration. Thus in the instant example high volumes of sound may be produced by violent percussion of the tuned vibrators, which at the same time causes their vibration to contain a relatively large complement of higher partials; and at the same time this high volume of output tones may be accompanied by a harmonic structure of such tones relatively weak in higher partial components, due to an adjustment of the tone control 40 to attenuate the higher frequencies. It will be understood that a variety of forms of tone control 40 may be employed, it being intended to illustrate a device whereby the relative amplitudes of components of the electric oscillations

may be controlled on an absolute frequency basis. This result differs from that produced by motion of translating devices along the strings, as effected by rod 38, in that the latter effects a control on the basis, not of absolute frequency, but of particular partial components of the vibration of each vibrator.

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 control thereover in respect of quality—e. g., the controls over timbre effected by the positioning of rod 38 and block 46 and by the adjustment of the tone control circuit 40.

It will be understood that the various control devices comprising my invention are capable of employment with wide modifications of the apparatus shown, without departure from the spirit or scope of my invention. Thus for example other forms of vibrators than strings may be employed; other methods than key-actuated percussion used for vibrating the vibrators; other forms of mechanico-electric translating devices than the magnet and coil assemblies may be employed; a single translating device may be used in association with all or a group of the vibrators, thus reducing the required number of such devices; etc.

I claim:—

1. The method of producing musical tones from a tuned vibrator and of controlling their timbre, which comprises vibrating said vibrator at a plurality of its partial frequencies, translating the vibration of said vibrator into electric oscillations, selectively controlling the relative amplitudes of components of said oscillations on the basis of particular partials of said vibration of said vibrator, and selectively controlling the relative amplitudes of components of said oscillations on the basis of the absolute frequencies thereof.

2. 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 relative amplitudes of the various said partial oscillation components intermediately of said two translations.

3. In the production of musical tones from the mechanical vibration of a single vibrator, which vibration is 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, controlling said translation selectively with respect to various of said component vibrations, and thereafter selectively controlling the relative amplitudes of the various frequency components of the electric oscillations produced by said translation.

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 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, in controlling the first of said mesne translations selectively with respect to various of said partial components, and in selectively controlling the relative amplitudes of the various said partial oscillation components intermediately of said two translations.

5. In the production of music from a plurality of selectively operated sources of electric oscillations of respectively different fundamental frequencies, the oscillations from each source comprising a plurality of harmonically related partial components, the method of timbre control which comprises selectively controlling the energy distribution between various of the said partial component oscillations from each source, combining the oscillations from the several sources, and selectively controlling the relative amplitudes of different frequency components of said combined oscillations.

6. A musical instrument wherein substantially the entire output sound is translated from electric oscillations, comprising an electro-acoustic translating device for effecting such translation; 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 oscillations; means for transmitting said oscillations to said electro-acoustic translating device; and means included in said transmitting means for selectively varying the relative amplitudes of different frequency components of said oscillations.

7. A musical instrument wherein substantially the entire output sound is translated from electric oscillations, comprising an electro-acoustic translating device for effecting such translation; 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 oscillations; and means for transmitting said oscillations to said electro-acoustic translating device, said means including a reactive circuit containing a resistance element selectively adjustable to vary the relative amplitudes of different frequency components of said oscillations.

8. 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 oscillations; an electro-acoustic

translating device; means for transmitting said oscillations to said electro-acoustic device; means included in said transmitting means for selectively varying the relative amplitudes of different frequency components of said oscillations; and means included in said mechanico-electric system for selectively controlling the harmonic structure 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 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 said first mentioned electric oscillations; means following said translating system for selectively varying the relative amplitudes of different frequency components of said oscillations; and means included in said translating system for selectively controlling the harmonic structure 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 oscillations and being selective in such operation with respect to said various partial components of the vibration of each vibrator; means following said translating system for selectively varying the relative amplitudes of different frequency components of said oscillations; and means included in said translating system for altering at will its said selectivity with respect to partial components.

11. A piano 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 a complex vibration having partial frequency components of relative amplitudes dependent on hammer velocity; a mechanico-electric translating system associated with said strings and operative to translate said vibrations thereof into electric oscillations; an electro-acoustic translating device; means for transmitting said oscillations to said electro-acoustic translating device; and means included in said transmitting means for selectively varying the relative amplitudes of different frequency components of said oscillations.

12. A piano wherein substantially the entire sound output is translated from electric oscillations, comprising an electro-acoustic translating device for effecting such translation; a plurality of variously tuned strings; hammers respectively associated therewith and each operable at different velocities to produce in the therewith associated said string a complex vibration having partial frequency components of relative amplitudes dependent on hammer velocity; a mechanico-electric translating system associated with said strings and operative to translate said vibrations thereof into electric oscillations; means for transmitting said oscillations to said electro-acoustic translating device; and means included in said transmitting means for selectively varying the relative amplitudes of different frequency components of said oscillations.

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