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B. F. MIESSNER

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METHOD AND APPARATUS FOR THE PRODUCTION OF MUSIC

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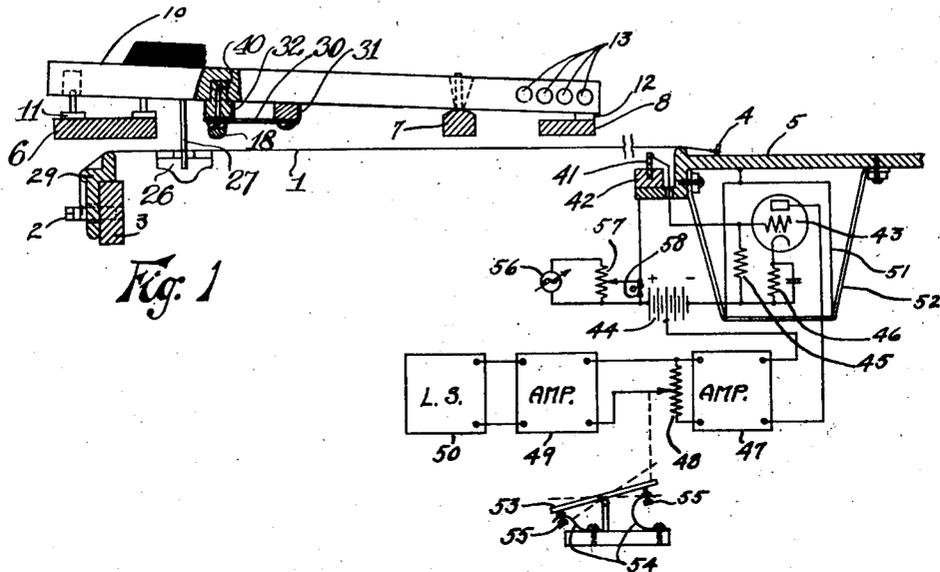


Fig. 1

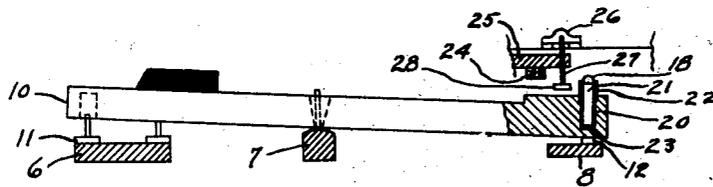


Fig. 2.

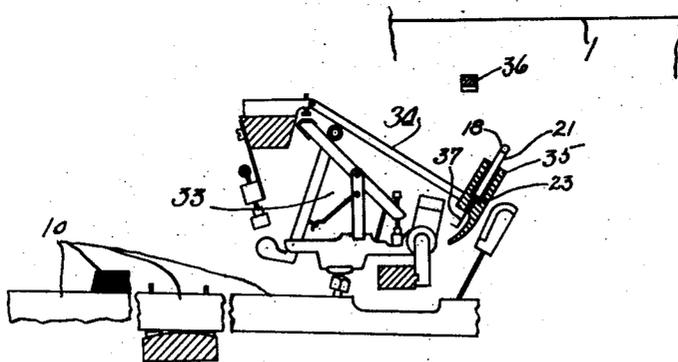


Fig. 3.

INVENTOR:-
BENJAMIN F. MIESSNER,
BY *Charles I. Jacoby*
ATTORNEY.

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METHOD AND APPARATUS FOR THE PRODUCTION OF MUSIC

Benjamin F. Miessner, Millburn Township, Essex County, N. J., assignor to Miessner Inventions, Inc., a corporation of New Jersey

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11 Claims. (Cl. 84—1)

This invention relates to musical instruments, and more particularly to those wherein the vibrations of a plurality of vibrators are translated first into electric oscillations and thence into sound. Such instruments have been broadly disclosed and claimed in my co-pending application, Serial Number 512,399, filed January 30, 1931, now Patent No. 1,929,027, dated October 3, 1933, of which application this is a continuation in part.

In such instruments it is usually desirable that the direct or purely acoustic sound output be minimized to as great an extent as possible, in order that the maximum degree of control of the total sound output may be effected by control of the translated electric oscillations. I have found that this minimization as well as other advantages of simplification and economy, can be secured by the use of certain means for exciting the vibrators, and in certain cases by effecting particular inter-relationships between the characteristics of the vibrators and their exciting means.

It is accordingly an object of my invention to provide improved means for exciting the vibrators in an instrument of the class described. It is a further object to provide improved combinations therein of vibrators and exciting means. It is a general object to provide an instrument of the class described characterized by low direct sound output.

It is a further object to provide improved means for controlling and amplifying the electric oscillations translated from the vibrators, and improved means for effecting such translation. Other and allied objects will more fully appear from the following description and the appended claims.

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

Figure 1 is a partial view of an instrument embodying my invention;

Figure 2 is a view illustrating a modification thereof in respect of the exciting means; and

Figure 3 is a view illustrating an alternative employment of the modification illustrated in Figure 2.

While the invention in certain of its aspects is useful with any form of tuned vibrator, it is especially useful and has been illustrated in connection with an instrument employing vibrating strings—e. g., an instrument of the piano type. In purely acoustic such instruments it is conventional to employ relatively heavy wire strings, placing them under great longitudinal tension

and employing as exciting means therefor hammers of quite appreciable mass. This large string mass, high string tension and large hammer mass are necessary to provide the requisite acoustic output. When, however, the sound output is to be obtained by translation of electric oscillations, these in turn having been translated from the original vibrations and amplified to any desired extent, the large masses and high tensions above mentioned are no longer requisite and according to the instant invention they are each greatly reduced. As a result, the sound directly produced by the instrument is minimized, since there is reduced the area of the string tending to vibrate the air, the amplitude of the string vibration, and the amplitude of vibration of supporting parts, etc., which the string may tend to vibrate. With the hammers of smaller mass it becomes especially convenient to employ simplified hammer-actuating mechanisms, and certain thereof are hereinafter described.

Reference being had to Figure 1, there will be seen a string 1, strung for example from tuning pin 2 in wrest plank 3 to hitch-pin 4 in plate 5. Wrest-plank 3 may conveniently be secured to a member 29 which may if desired be a portion of an integral casting including the plate 5. While only one string with its tuning pin 2 and hitch-pin 4 is shown it will be understood that a plurality thereof, variously tuned, will be provided.

Secured for example to the plate 5 may be provided front action rail 6, pivot rail 7 and rear action rail 8, and to these rails the action may be assembled. Keys 10 are shown, pivoting about the top of pivot rail 7 and each depressible at its forward (left-shown) extremity against a stop formed by washer 11 resting on front rail 6. The rear extremities of the keys may be made by weights 13 to rest through felt 12 on rear rail 8.

Each key may be equipped on its bottom with a spring 30, secured at one end to a spacing block 31 for example. The other end of the spring may carry light hammer head 18, and may normally have a slight upward tension so that it rests against felt block 32 secured to key 10. The spacings are arranged so that hammer head 18 comes into a position slightly separated from string 1 when key 10 is gradually depressed against its down-stop. If the hammer head develop any appreciable momentum, however, as it will upon depression of key 10 with any reasonable velocity, the hammer head will continue its motion and will strike the string, executing therefrom a rebound which will be checked by felt block 32. I have also shown damping means for each string, com-

prising a damper 26 secured by rod 27 to key 10 and normally bearing upwardly against the string.

With the embodiment of Figure 1 it is sometimes desirable to provide means for damping the motion of the spring and hammer head relative to the key, so that any excessive oscillation tendencies of spring and head may be eliminated. Thus I have shown felt block 32 in the form of a button of T-shaped cross-section having a small central hole and being inset into key 10. A plunger 40, adapted to move in this hole, may be secured to the top of spring 30. The friction of the plunger in the small hole provides the desired damping of the spring and head motion.

In Figure 2, which is an embodiment alternative to that which has already been described in connection with Figure 1, the keys 10 may conveniently be provided beneath the level of the strings. The rear end of each key may be provided with a vertical hole 20, preferably of square cross-section and not quite reaching the bottom of the key. The well formed by this hole may if desired be extended for a short distance above the top of the key by a square tubular extension 22. In this well may be disconnectibly carried an assembly comprising for example light square rod 21 having affixed to its bottom felt 23 and to its top light hammer head 18. The length of the disconnectible assembly may be such that the hammer head comes up into a position of slight separation from string 1 when the forward end of key 10 is gradually depressed against its down-stop 11. If the disconnectible assembly develop any appreciable momentum, however, as it will upon depression of key 10 with any reasonable velocity, it will continue its upward motion after the key 10 has stopped and the hammer head will strike the string, thereupon executing a rebound therefrom which will be checked upon the bottoming of felt 23 in hole 20. As in the case of the action of Figure 1, this action is touch-responsive.

It is convenient to provide an up-stop for the rear extremity of each key 10 in Figure 2 which will check upward motion of this extremity at the same moment as down-stop 11 checks motion of the forward extremity. This up-stop may comprise a felt block 24 carried on the bottom of a damper rail 25. Dampers 26 may be provided above and normally resting against each string 1, each damper being secured to a rod 27 which passes through a guide hole in damper rail 25 and which carries at its bottom a lifting button 28 adapted to be raised by the rear end of the associated key.

The principle of the hammer head moved by and with the velocity of a movable member, and arranged to continue its motion after stopping of motion of that member (by virtue of disconnection from or flexible connection to the member), is not limited to cases wherein the movable member comprises the playing key itself. The movable member may alternatively be one which is moved by the key through an intermediate system—e. g., it may be the hammer of the usual grand piano repetition action, or a member of roughly equivalent mass, a stop being provided to terminate its motion just short of actual striking of the string. By such an arrangement the usual action, with leverages, masses and adjustments undisturbed, may be retained and at the same time a low striking mass employed, appropriate to the preferred low-mass, low-tension strings. Thus I show in Figure 3 such an employment of the modification of Figure 2. In

Figure 3 the numeral 33 designates the usual grand repetition action, controlled by key 10 and actuating through shank 34 the dummy hammer 35. This may be of approximately the mass of the conventional hammer. A stop member 36 may be provided for limiting the upward motion of the dummy hammer 35, it being understood that the repetition action 33 will be adjusted to "trip" just as the motion of the dummy hammer is terminated by this stop. The dummy hammer may be provided with hole 20, as is the key in Figure 2, and with a disconnectible hammer head assembly comprising for example the hammer head 18, rod 21 and felt 23 of Figure 2. A hook 37 may be secured to the bottom of rod 21 through a small hole in the bottom of the dummy hammer to prevent the accidental loss of the disconnectible assembly.

Reference being had to Figure 1 for further details of the instrument therein illustrated, a typical mechanico-electric translating system may be seen. A conductive member or bar 41 may be passed under a point on each of the several strings. In order that this may not be subjected to undesirable vibrational influences from the plate 5 it may be made of material of high specific gravity—e. g., lead—and may be mounted to the frame in vibrationally as well as electrically insulative manner, as by a plurality of small soft rubber blocks 42. This strip may be electrically connected to the grid of a thermionic vacuum tube 43, whose cathode may be energized in any suitable manner, whose anode current may be supplied as from a tap on high voltage battery or the source 44, and whose grid may be biased through high resistance 45 to a point maintained at a potential slightly negative with respect to the cathode by virtue of anode current flow through condensively by-passed resistance 46. The negative terminal of source 44 may be connected to the last mentioned point and the positive terminal to the strings 1, through the medium of the plate 5, with which all the string may contact. In the anode circuit of tube 43 may be provided in cascade amplifier 47, volume control or potentiometer 48, further amplifier 49 if desired and loudspeaker or other electro-acoustic translating device 50.

Tube 43 and certain associated circuit components should be as near as practicable to the strip 41, and are therefore preferably secured in some manner to the plate 5 or other portion of the instrument proper. For the avoidance of undesirable vibration of their elements, however, by conduction from plate or other instrument portions, they are preferably vibrationally insulated. Thus I have shown them inside a can or other electrostatic shield 51, and the latter flexibly supported as by soft rubber strips 52 from plate 5. It will be understood, of course, that further portions of the amplifying system, such as amplifier 47, might be included in the flexible mounting with tube 43, etc.

Consideration being given to the manner of functioning of the translating apparatus shown, it will be seen that between each string and the strip 41 a small electrostatic capacity exists. These capacities in parallel with each other form a total capacity from strip to strings. This total capacity is charged to the potential of source 44 through resistance 45, but by virtue of the high value of the latter this charge is prevented from changing appreciably at musical frequencies. Upon vibration of any string, as produced by impact therewith of the associated

hammer head 18, the capacity between that string and the strip 41 will be varied oscillatorily in accordance with the frequency and waveform of the part of the string opposite the strip. The total strings-to-strip capacity will be likewise varied, though in reduced degree; and because of the small change in the charge of this capacity at the frequencies involved, the voltage across it will be similarly varied. The oscillatory variations in this voltage will appear as electric oscillations across the high resistance 45 and are applied therefrom to the grid of tube 43. By this tube and the amplifier 47 and 49 the oscillations are amplified; they may be controlled in respect of amplitude by volume control 48; and finally they are translated into sound by loud-speaker 50.

The manipulation of volume control 48 is most conveniently achieved by means of a foot pedal. Such a pedal I have illustrated as 53, of the general form of an organ swell-pedal for example—i. e., centrally pivoted—and having one end mechanically connected in any suitable manner to actuate the moving contact of the volume control. I have found for operation with an instrument of this type, however, and particularly when the volume control is arranged to effect large changes in the amplitude of the oscillations, that the usual free action of the organ swell-pedal renders difficult the precise and expressive control over amplitude which the musician desires. In a rapidly effected volume increase, for example, the stopping of the foot action at that adjustment position of the control which provides the desired final volume is not easy. To overcome this difficulty I provide means for mechanically biasing the foot-pedal 53 to an intermediate or mean position, from which it is readily moved but always against a force tending to restore it to that position. Such means may take the form for example of two simple flat springs 54, each imparting to the pedal an urge opposite to that of the other. In addition to the advantage of facilitating precise and expressive volume control, this arrangement automatically provides a single standard or normal volume level adjustment, which always obtains except when deliberately modified. This is a great aid to the player who is unaccustomed to the use of foot volume control. If desired, the resistance of the pedal to motion in either direction from the mean position, and the mean position itself, may be made adjustable as by a thumb screw 55 on each spring 54 operating to modify its tension.

In Figure 1 I have also shown means for effecting a "tremolo" of the tone output, the particular means shown being adapted for use with any translation system, such as the electrostatic, which is sensitized (or rendered operative) by a normally steady direct voltage. This tremolo means comprises an oscillator 56 in series with such steady voltage. The frequency of the oscillator may be controllable within useful tremolo limits (say from a fraction of a cycle to several cycles per second) and its output voltage may be regulated, as by potentiometer 57, from a value negligible in comparison to that of the steady source 44 to a peak value of the same order as the steady source voltage. A switch 58 may short-circuit the oscillator output when tremolo of the tone is not desired.

The principle of operation of this tremolo device is simply that of periodic variation of the sensitivity or efficiency of the mechanico-electric translating apparatus, it being understood that in

the case of the electrostatic translation particularly illustrated such sensitivity or efficiency is a function of the voltage supplied from source 44 and apparatus in series therewith. It is desirable of course that the time constant (capacity resistance product) of the strings-to-strip capacity and the resistance 45 be appreciably less than the tremolo period (or reciprocal of the tremolo frequency) in order that the charge in the strings-to-strip capacity may be appreciably varied by the output of the oscillator 56.

While I have above particularly disclosed the mechanico-electric translating apparatus as of the electrostatic type, it will be understood that my invention is in no way limited to use therewith, any alternative type of apparatus performing a similar function being readily capable of substitution therefor. Thus for example I may employ translating devices of the electro-magnetic type, comprising small polarized electromagnets each having a pole in slight spaced relation to a string or group of strings—i. e., in the position occupied by strip 41 in Figure 1. It will furthermore be understood that the advantages of high specific gravity and vibration insulation of the portion of the translating system in spaced relation to the strings are desirably retained with such alternative forms. I may also of course employ translation apparatus operative in accordance with other principles than that of vibratory variation of a spaced relationship. While I prefer and have shown strings as the vibrators, I do not intend any limitation of my invention thereto, as it is obviously capable of employment with a variety of other vibrators, such for example as tuning forks, bars, reeds, etc. It will finally be understood that various other modifications may be made without departure from the spirit or scope of my invention, as in the appended claims defined.

I claim:—

1. In the production of a musical tone from the vibrations of a string, the method of controlling characteristics of such tone which comprises translating electric oscillations from said vibrations, controlling characteristics of said oscillations, amplifying said oscillations and translating the same into sound, while limiting the production of other sound from said vibrations by maintaining said string under relatively low tension and said vibrations at a relatively low amplitude.

2. In the production of a musical tone from the vibrations of a string excited by percussion, the method of controlling characteristics of such tone which comprises translating electric oscillations from said vibrations, controlling characteristics of said oscillations, amplifying said oscillations and translating the same into sound, while limiting the production of other sound from said vibrations by maintaining said string under relatively low tension and the degree of said percussion at a relatively low value.

3. In a musical instrument, the combination of a plurality of tuned vibrators, means for vibrating the same, members supporting said vibrators and vibrating means, mechanico-electric translating apparatus in spaced relation to said vibrators and operative in accordance with vibratory variation of such spacing, and vibrationally insulative means securing said apparatus to said supporting members.

4. In a musical instrument, the combination of a plurality of tuned vibrators; means for vibrating the same; members supporting said vi-

brators and vibrating means; mechanico-electric translating apparatus having a portion of relatively large mass in spaced relation to said vibrators, said apparatus operating in accordance with vibratory variation of such spacing; and vibrationally insulative means securing said portion to said supporting members.

5 5. In a musical instrument, the combination of a plurality of tuned vibrators, means for vibrating the same, means supporting said vibrators and vibrating means, a conductive element of relatively high specific gravity in spaced relation to said vibrators and forming therewith electrical capacities, means for maintaining a relatively constant charge in said capacities, and vibrationally insulative means securing said conductive element to said supporting means.

10 6. In a musical instrument wherein the vibrations of a tuned vibrator are translated into electric oscillations and thence into sound, the method of producing a tremolo of the output sound, which consists in periodically varying the efficiency of said translation of vibrations into electric oscillations.

15 25 7. In a musical instrument wherein the vibrations of a tuned vibrator are translated into electric oscillations and thence into sound, the method of selectively producing a variety of tremolo effects in said sound, which consists in producing a periodic variation of the efficiency of said translation of vibrations into electric oscillations and in selectively adjusting at least one of the characteristics of frequency and amplitude of said variation.

30 35 8. In a musical instrument, the combination of

a tuned vibrator; means for vibrating the same; means for translating electric oscillations from the vibrations thereof, the efficiency of said means being variable by variation of a sensitizing voltage or current thereto supplied; and a source of pulsating voltage or current connected with said translating means for sensitizing the same.

5 9. In a musical instrument, the combination of a tuned vibrator; means for vibrating the same; conductive elements forming an electrical capacity having a field varied in accordance with the vibrations of said vibrator; means for maintaining in said capacity a charge relatively independent of said vibratory variation of said field; and means for periodically varying said charge at a relatively low frequency.

10 10. In a musical instrument wherein electric oscillations of sound frequency are generated and translated into sound, the combination of adjustable means for controlling the amplitude of said oscillations, and means normally biasing said first-mentioned means to an adjustment intermediate its adjustment limits.

15 25 11. In a musical instrument wherein electric oscillations of sound frequency are generated and translated into sound, the combination of adjustable means for controlling the amplitude of said oscillations, a centrally pivoted pedal connected to said controlling means and arranged to adjust the same upon rotation about its pivot, and resilient means normally biasing said pedal to a position intermediate the extremities of its range of rotation.

BENJAMIN F. MIESSNER.