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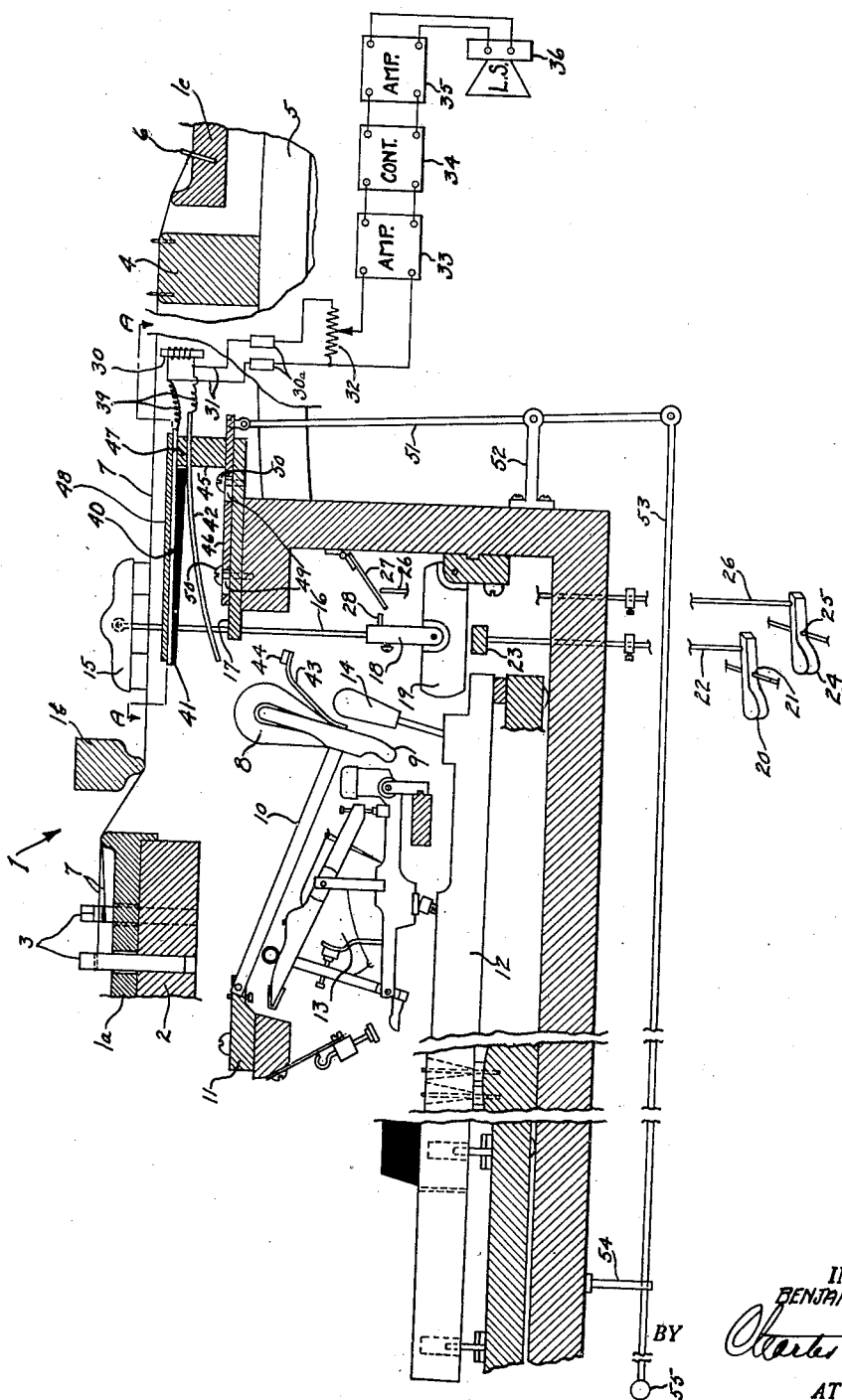
B. F. MIESSNER

2,233,058

APPARATUS FOR THE PRODUCTION OF MUSIC

Filed May 17, 1938

3 Sheets-Sheet 1



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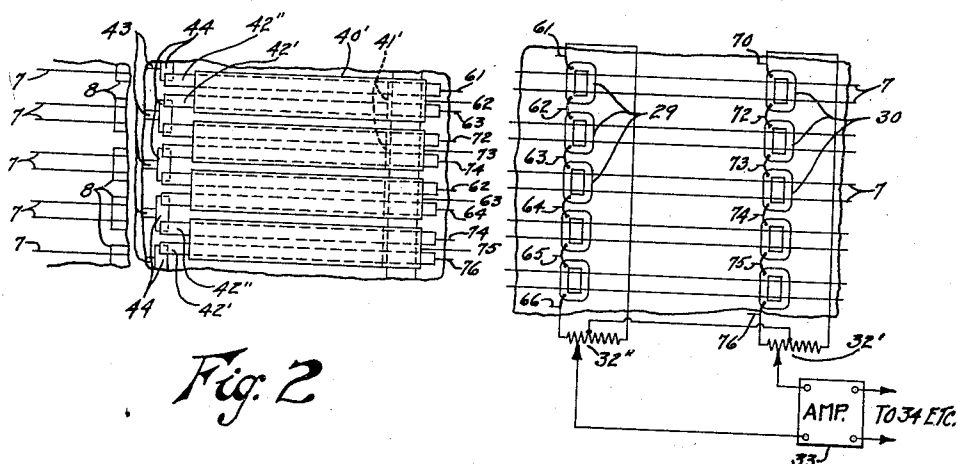


Fig. 2

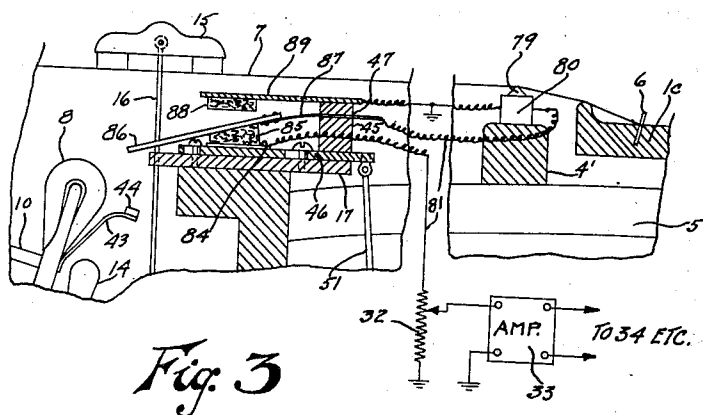


Fig. 3

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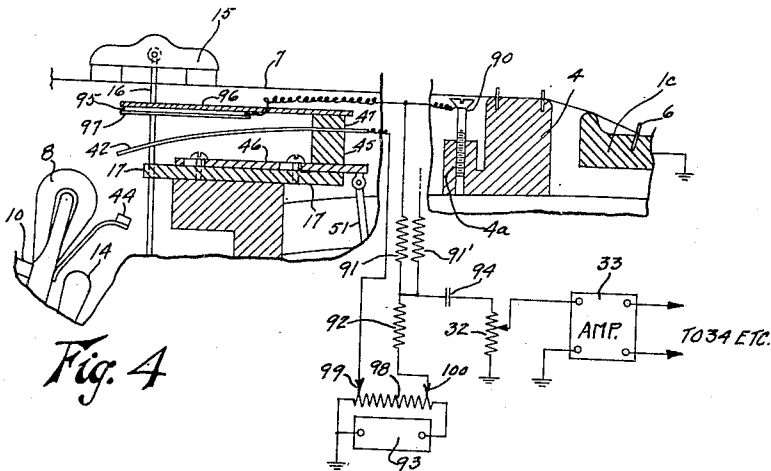
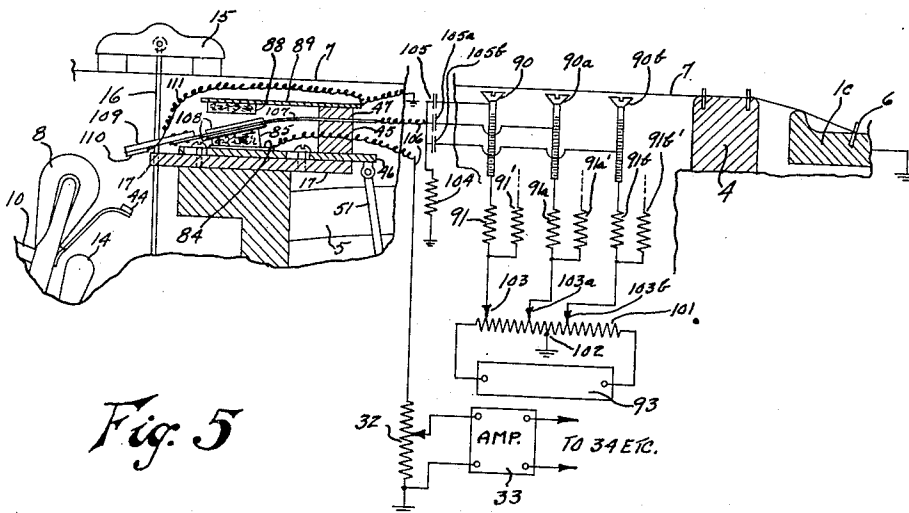
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,233,058

APPARATUS FOR THE PRODUCTION OF MUSIC

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Application May 17, 1938, Serial No. 208,357

19 Claims. (Cl. 84-1.13)

This invention relates to the production of music, and more particularly to such production from the vibrations of tuned vibrators through the medium of mechanico-electro-acoustic translation. The invention has especial reference to vibrators which are excited by impulse, such for example as struck or plucked strings or the like. An important object of the invention is the provision of improved arrangements whereby there may be produced from so-excited vibrators tones which are free of the influence of the excitation—for example, which are characterized by a smooth, rather than an abrupt, initial rise of amplitude, or inception.

Such arrangements are broadly known, having for example been disclosed in U. S. Patents Nos. 1,915,859 and 1,915,860, issued June 27, 1933, and No. 2,071,649 issued February 23 1937, all to Miessner et al., showing such arrangements especially as applied to pianos. In certain of the disclosed arrangements a tone could not be prolonged after the release of the key whose depression produced it. In certain other of those arrangements a tone could be prolonged after key release by the holding down of the sustaining pedal of the piano; but if the key were re-depressed before the sustaining pedal was released, the tone produced by the re-depression would be characterized by the typical pianistic, rather than a smooth, inception. It is an object of this invention to provide arrangements of the character described which permit the tone to be prolonged by an auxiliary means such as a piano sustaining pedal, but which provide the smooth tone inception upon any re-depression of a key even though the sustaining pedal may not in the meantime have been released.

It is an object of the invention to provide novel and advantageous means for varying the efficiency of the mechanico-electric translation in an instrument of the class described.

It is an object to provide such varying means capable of very rapid operation without the production of objectionable "clicks" or other transient effects in the output tone.

It is an object to provide improved forms and dispositions of switching means particularly adapted for the efficiency variations abovementioned.

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

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

Figure 1 is a partial vertical cross-sectional view of a piano wherein my invention has been embodied in simple form;

Figure 2 is a partial horizontal cross-sectional view of a piano wherein the embodiment of Figure 1 is slightly elaborated;

Figure 3 is a partial view of the nature of Figure 1 but illustrating the embodiment of my invention in modified form;

Figure 4 is a partial view of the nature of Figure 1 but illustrating the embodiment of my invention in further modified form; and

Figure 5 is a partial view of the nature of Figure 1 but illustrating the embodiment of my invention in still further modified form.

According to a preferred embodiment of the instant invention, the action of translation of electric oscillations and sound from the vibrator, or the efficiency of the mechanico-electro-acoustic translating device or devices associated with the vibrator, is momentarily reduced to at least substantially zero at the instant of excitation of the vibrator. While this may be done by suitable control of a polarizing or sensitizing voltage, or equivalent, for the translating device, by arrangements of the nature of those shown in one or more of the patents abovementioned, I have found it difficult to effect satisfactorily, and without objectionable "clicks" or the like, a thoroughly sufficient reduction of the sensitizing voltage in the minute interval between the beginning of key depression and the resulting excitation of the vibrator. I have found, however, that if the momentary reduction under discussion be effected in the signal or oscillation-output circuit of the translating device, it may be effected both with the necessary rapidity and with a substantial absence of clicks or other transient disturbances, and without difficulty.

In an instrument of the piano type I have found a very satisfactory way of carrying out this operation to be by suitable means associated with the hammer, and thereby rendered operative during the interval of the closest approach of the hammer to and its contact with the string; and for a disclosure of a simple embodiment of my invention, operating in this manner, reference is invited to Figure 1. Herein there are illustrated sufficient of the parts of a grand piano of the electronic type—i. e., operating by mechanico-electro-acoustic translation—clearly to show the association of my invention therewith.

A typical piano metallic frame or plate is shown as 1, having front portion 1a, capo bar 1b, 55

and rear portion 1c, these portions appearing in cross-section. Secured underneath the front plate portion 1a is a wrest-plank 2, in which are retained tuning pins 3 passing upwardly through the suitably apertured front plate portion 1a. From each tuning pin, under the capo or plate portion 1b, and over a bridge 4 to a respective hitch pin 6 in the rear plate portion 1c, is strung a respective string 7. Any number of strings per note may of course be employed; but it may be assumed for purposes of description that the two strings 7 shown in Figure 1 comprise a pair of strings for one note of the instrument. The bridge 4 over which the strings are strung is preferably supported for vertical vibration, as to a plurality of vibratile ribs 5 terminally secured to relatively rigid portions of the instrument.

The strings for each note are excitable by an individual hammer 8, having a tail 9, and a shank 10 pivoted to a stationary flange 11. For operating each hammer there is provided a respective pivoted key 12, operatively connected to the hammer through the usual piano action mechanism 13 interposed between the intermediate rear portion of the key 12 and the hammer shank 10. Near the rear end of the key is secured the upwardly extending back-check 14. Since the parts described in this paragraph are conventional, it will be understood that upon depression of the key (i. e., of its forward extremity) the associated hammer 8 will be propelled against and caused to strike the associated strings 7, immediately rebounding therefrom; and that, unless the key depression be of an extreme "staccato" nature, the hammer tail 9 upon the rebound will be driven into contact with and will frictionally engage the then-raised back-check 14, the hammer being held by this engagement in a partially raised position until key release.

Normally resting on the strings of each note and damping the same is an individual damper 15. Each damper is carried at the top end of a respective rod 16, which passes downwardly through an apertured guide rail 17 to a respective bushing 18, this bushing being pivoted to a respective flange 19 whose rear extremity is in turn pivoted to a suitable stationary member. The forward end of each damper flange is very slightly spaced above the rear extremity of the respective key, so that it and the damper will be raised upon and during depression of that key.

Pedals of the conventional "sustaining" and "sostenuto" types are schematically shown as 20 and 24, respectively, pivoted as at 21 and 25. To the rear pedal extremities are pivotally secured the respective rods 22 and 26, each rod being raised by depression of the respective pedal. The sustaining pedal rod 22 is pivotally connected at its top extremity to a horizontal rail 23 which passes underneath all the damper flanges 19, to raise all of them, and all the dampers from the strings, upon and throughout depression of the pedal 20. The sostenuto pedal rod 26 is pivotally connected at its top to a strip 27, which along its rear edge is hinged to a stationary portion, and which extends from that edge forwardly and downwardly toward the damper bushings 18; depression of the sostenuto pedal 24 accordingly rocks the strip 27 clockwise (when viewed as illustrated). Rearwardly from each damper bushing 18 extends a small lug 28 which, if its respective key is depressed, will be raised into the arcuate path of the forward edge of the strip 27; accordingly when the sostenuto pedal 24 is

depressed while any key is depressed, the lug 28 associated with that key will be engaged and held in an upward position, and the associated damper thus off the associated strings, throughout the continuance of the sostenuto pedal depression. It will be understood that quite simplified pedal arrangements have been shown, wholly however in the interest of simplicity of illustration.

For translating into electric oscillations the vibrations of the strings of the pair illustrated in Figure 1, I have shown an electromagnetic translating device or pick-up 30 having its pole in spaced relation to the strings; this is desirably mounted to the vibratile bridge support, or ribs 5. The output leads 31 from the device 30 (in which may for example be serially connected the translating devices 30a for other notes) may be led to a control potentiometer 32; and oscillations translated from string vibration by the device 30 (and devices 30a) and impressed across the potentiometer 32, may from the potentiometer be applied to the input of a cascade schematically illustrated as comprising amplifier 33, control system 34, further amplifier 35, and loudspeaker or other electro-acoustic translating device 36. It will be understood that these oscillations are amplified by 33 and 35; may be controlled in such respects as volume, bass and treble predominance, and the like by 34; and are translated into sound by 36.

In Figure 1 the control means for effecting the translation reduction concomitant with vibrator excitation comprises essentially a switch shunted immediately across the translating device 30, and closed by the hammer when that is in contact with the strings. To avoid "clicks," however, the switch is preferably not of simple abrupt-opening and -closing variety, but rather of a variable impedance form; also preferably, the normal or "open" impedance of the switch is finite, though high (i. e., several times the output impedance of the translating device 30 at the higher audio frequencies).

While the switch or variable impedance device may be constructed in any of a variety of ways, I have illustrated it in Figure 1 as comprising a resistance element 41 formed on the under side of a horizontal metal strip 40 parallel with and a little below the strings 7 above the damper guide rail 17; a spring 42 preferably touching the bottom of the resistance element at the rear element extremity, and curving forwardly and downwardly therefrom to have its own forward extremity slightly overhanging the front edge of the rail 17; and an arm 43 extending from the rear surface of the hammer 8 opposite the shank 10, upwardly and rearwardly to have its rear extremity in a position normally spaced below the forward spring extremity, and preferably carrying a lug 44 of insulating material on top of its rear extremity. The spring 42 may be secured at its rear extremity on top of an insulating rail 45 which extends upwardly from a shelf 46 of insulating material disposed on top of the damper guide rail 17 behind the damper rod 16. Above the rear spring extremity may be provided an insulating spacer 47, and the rear extremity of the strip 40 may be secured against the top of this spacer. The strip 40 and spring 42 form the electrical terminals of the switch or variable impedance device, and have been shown connected immediately across the translating device 30 by the leads 39.

The resistance element 41 extends, on the un-

der side of strip 40, forwardly from adjacent the spacer 47; it may be of any suitable material, such as carbon or graphite. Preferably it is arranged so that the resistance it provides between spring 42 and strip 40 is very high when the spring 42 touches (as it preferably normally does) only the rear extremity of its bottom surface, and so that that resistance decreases logarithmically or according to some other taper as the spring 42 is warped up into contact with more and more forward portions of that surface. To indicate such tapering, which it will be understood may be effected by suitable arrangement of one or more of the characteristics of material and thickness and area and the like of the element, I have illustrated the element as of forwardly diminishing thickness.

It will be understood that normally the high resistance between 40 and 42 provides a negligible shunt on the translating device 30. When, however, the key 12 is depressed and the hammer 8 is propelled upwardly to strike the strings, the hammer will carry with it the arm 43 and lug 44; and when the hammer has risen partially toward the strings the lug 44 will engage the forward extremity of the spring 42, the further rise of the hammer warping the spring upwardly into contact with more and more forward portions of the bottom surface of the resistance element 41. Preferably the spacings are such that at the instant the hammer strikes the strings the resistance between spring 42 and strip 40 will be at substantially zero or negligible value—e. g., the spring will be in contact with substantially the entire bottom surface of the resistance element. As the hammer rebounds from the strings the spring 42 will of course fly downwardly from the resistance element; and preferably the spacings are also such that hammer rebound to the partially raised position wherein its tail 9 is engaged by the back-check 14 will be sufficient to effect the restoration of the spring 42 to its normal position. Thus the efficiency of the translating device 30 (i. e., its ability to deliver string-vibration-representing oscillations to the potentiometer 32) is being reduced in the latter portion of the approach of the hammer to the strings; is substantially zero at the instant of striking of the strings by the hammer; and is immediately raised thereafter—at a rapid, but nevertheless finite, rate (determined of course by the rate of rebound and the tapering of the resistance element 41). Accordingly there is produced by the mechanico-electro-acoustic translating system a tone from which the influence of the impulse excitation is removed, and whose inception is smooth rather than wholly abrupt.

The efficiency of the translating device, restored to normal upon hammer rebound from the strings, is thereafter unaffected when the key is released; and so long as the strings are permitted to continue the vibrations caused by the striking (i. e., so long as the damper 15 is maintained raised from the strings) the translating device will continue efficiently to translate their vibrations, and the output tone will continue in correspondence with those vibrations. This action is clearly independent of whether the damper 15 is held raised by continued key depression or by depression of either of the pedals 20 and 24. It will further be observed that if, while the damper 15 is being held raised by either of the pedals to permit continuance of the string vibration and output tone, the key 12 is re-depressed to cause another striking of the strings,

the efficiency of the translating device 30 will be varied downwardly and upwardly in an identical manner to that already described; just before the striking of the strings the previous tone will be cut out at a rapid but finite rate, and immediately after the striking the new tone thereby occasioned will come in with a smooth inception. The variation of the translation efficiency in a sufficiently rapid manner for these actions, and yet without objectionable "clicks" or other transient disturbances, appears to be greatly facilitated by the fact that there is being varied no large sensitizing voltage or the like, but only the inherently small signal voltage.

It will of course be understood that an individual strip 40, resistance element 41 and spring 42 may be employed for each note of the instrument. Each spring 42 is preferably of very light material and of very light downward bias, so that it will occasion only a negligible alteration 20 of the required "touch" on the respective key 12. Each strip 40 may if desired be of light and springy material, in which case the spacings of the components will of course be adjusted to take into account a yielding of the strip as the respective spring 42 is warped up into contact with the respective resistance element 41; preferably, however, each strip 40 is arranged to remain quite stationary, and this may be insured if desired by a plate 48 of insulating material secured immediately above the strips 40.

It may frequently be desired to play the instrument without eliminating the influence of the impulse excitation on the output tones. For this purpose the operation of the switches or variable impedance devices may be readily suspended by a displacement of their entire assembly rearwardly by a small distance, to obviate the engagement of the springs 42 by the hammer lugs 44. Accordingly the shelf 46 has been shown as held on top of the rail 17 by means of screws 50 passing through forwardly elongated slots 49 in the shelf, these slots permitting the rearward displacement abovementioned. A means for moving the shelf has been schematically illustrated as a vertical lever 51 having its top extremity pivotally attached to the bottom of the shelf, immediately pivoted to a stationary standard 52, and having the forwardly extending horizontal rod 53 pivotally attached to its bottom extremity. The rod 53 may pass slidably through a hanger 54 to terminate in a knob 55 accessible to the player; by pulling forwardly on this knob he may move the shelf rearwardly, and vice versa, to selectively place the variable impedance devices out of and in operation.

While only a single translating device per note has been illustrated in Figure 1, it will be understood that the disclosed arrangements are capable of employment in instruments wherein a plurality of such devices are employed at different longitudinal positions along the strings for each note, as for tone quality variation purposes as disclosed in U. S. Patent No. 1,906,607 to Jacobs; I have illustrated a typical such employment in Figure 2. This is a partial horizontal sectional view of an instrument, otherwise similar to that of Figure 1, wherein there are included for each note a plurality of switches or variable resistance devices per note, for a corresponding plurality of translating devices per note; the line A—A of Figure 1 indicates the plane of the instrument corresponding to that on which Figure 2 is taken.

In the instrument of Figure 2 two translating devices, 29 and 30, are provided at different longi-

tudinal positions along the strings for each note. The devices 30 are connected in series and across potentiometer 32', while the devices 29 are connected in series and across potentiometer 32''; and these potentiometers may have fixed intermediate contacts connected together, and variable contacts connected to the input of amplifier 33, so that the oscillations from the devices 30 and those from the devices 29 may be mixed together in any of a variety of phase and amplitude relationships for tone quality control in well known manner.

There are again provided as many metal strips and associated resistance elements, designated respectively as 40' and 41', as there are notes, but the strips and elements are centered below the spaces between the string groups for the several notes rather than immediately under those string groups; and two mutually distinct narrow springs—a righthand spring 42' and a lefthand spring 42''—are provided below each resistance element 41'. The righthand spring 42' for each element 41' and the lefthand spring 42'' for the next element to the right are both adapted to be engaged by the single lug 44 of the hammer which strikes the string group straddled by those two elements; thus two switches or variable resistance devices per note are provided. Every other one of the strips 40' is electrically connected to every other one of the electrical junctions between successive translating devices 29; and the springs 42' and 42'' associated with each one of those strips are respectively connected to the junctions (between devices 29) immediately to the right and to the left of that junction to which that strip is connected. The intervening strips 40' are respectively connected to every other one of the junctions between successive translating devices 30; and the springs 42' and 42'' associated with each one of those strips are respectively connected to the junctions (between devices 30) immediately to the right and to the left of that junction to which that strip is connected. To simplify the drawing, these connections have been indicated in Figure 2 by the numbering of the inter-device junctions, and the partial showing of conductors from the strips and springs numbered correspondingly to the junctions to which those conductors are respectively to be connected. It will be understood that the manner of functioning of the instrument of Figure 2 is entirely similar to that already described in connection with Figure 1, excepting only that the striking of a string group by its hammer entails the momentary substantial shorting of each of the plurality of translating devices associated with that string group, rather than of only a single device associated with the group. It will further be understood that any of a variety of arrangements of the several strips, resistance elements and springs may be employed, the particularly illustrated arrangement being typical only.

In the instruments of Figures 1 and 2 each switch or variable impedance device has operated to short out the respective translating device during excitation of the associated strings; it will be understood, however, that the switch or equivalent device may otherwise act upon the translating device. Thus in Figure 3 I show an arrangement wherein the switch or equivalent device opens the signal circuit from the translating device to the cascade of potentiometer 32, etc. In this figure the translating device for the strings of one note has been schematically shown, by way of example, as a pressure-responsive device 80;

this is compressed between the top of the bridge 4' (which is at an appropriately lowered level, and supports the device 80), and a triangular member 79 (on top of the device 80) over which the strings are strung and against which they bear. Typically the device 80 may be a piezo-electric translating device. One of the output terminals of each device 80 may be connected to ground—i. e., established at a reference potential. The other output terminal of each device 80 may be connected, as by a respective conductor 81, to the top extremity of potentiometer 32—the bottom extremity of the potentiometer being shown connected to ground, and the amplifier 33 being connected from ground across a variable portion of the potentiometer.

In the conductor 81 for each note there is serially included a respective switch which is normally closed, but which is opened by the hammer during the brief interval of its proximity to and contact with the strings. It has been illustrated as comprising a small compressible conductive element 85 resting on top of a small metal strip 84 which is positioned on the shelf 46 above mentioned in connection with Figure 1; and an effectively pivoted metallic lever 86 normally resting on top of the element 85 and extending therefrom forwardly to overhang the front edge of the guide rail 17, to be raised out of contact with the element 85 by the hammer lug 44 during the mentioned brief interval. The lever 86 may be effectively pivoted at its rear extremity by being there secured to the front of a short leaf spring 87, which in turn is secured on top of the insulating rail 45 abovementioned in connection with Figure 1; spring 87 and metal strip 84 form the switch terminals which are serially interposed in conductor 81. The compressible conductive element 85 may be one whose resistance varies to at least some extent with its compression; purely typically, it may be a pad of felt or similar material, rendered conductive by impregnation with a colloidal graphite emulsion or the like. Both gravity and spring 87 may normally bias the lever 86 downwardly to compress the element 85, so that a moderate resistance only is normally present in conductor 81. When the lever 86 is raised by the hammer lug 44 the element 85 expands somewhat and its resistance smoothly increases to a relatively high value, before the lever actually leaves the element to fully open-circuit the conductor 81; conversely as the lever 86 returns to normal position (after string-striking) the conductor 81 is close-circuited with a relatively high serial resistance value, which thereafter smoothly decreases to the normal value as the element 85 re-compresses. This resistance variation in the switch is readily made sufficient to substantially obviate "clicks" and other undesirable transients.

It will be understood that the lever 86 will rest against the element 85 at all times except during the brief interval immediately preceding, at, and immediately following the striking of the string by the hammer—i. e., the interval during which the translating device of earlier figures was shorted, or in process of being shorted. Thus effects are produced on the translation efficiency broadly similar to those described above. It will further be understood that the action of the switches may be eliminated when desired by a movement of shelf 46 as above described, the means for moving the shelf having been fractionally illustrated in Figure 3.

Even when the conductor 81 is open-circuited by the lever 86 there may be a residual small

capacitative transfer of oscillations between the lever and the element 85, slightly impairing the perfection of the open-circuiting. To suppress such transfer the lever 86 may, as the hammer most closely approaches and touches the string, be closed and momentarily pressed against the bottom surface of a compressible conductive element 88 (which may be common for all notes) whose top surface is secured to the bottom of a grounded metal plate 89 extending forwardly from the top of the insulating spacer 47 provided above the insulating rail 45 as in Figure 1. Thus the translating device is not only open-circuited from slightly before to slightly after the string-striking instant, but is also short-circuited at that instant; its electrical output is thus positively diverted from the signal circuit to an inactive circuit at the critical instant.

In Figure 4 I illustrate a typical application of my invention to use with electrostatic mechanico-electric translating means. In this figure all the strings 7 are grounded, as by the grounding of the rear plate portion 1c. Spaced underneath the strings for each one note is disposed an electrode 90, which may be in the form of the head of a conductive screw; this screw may for example pass downwardly through and be supported by a forward extension 4a of bridge 4, as described and claimed in my co-pending application Serial No. 187,646, filed January 29, 1938, on which Patent No. 2,200,718 has since been issued). The screw or electrode 90 is connected through a respective high resistance 91 and a common high resistance 92 to a source 93 of sensitizing potential, which is in turn connected to ground. To illustrate the connection in circuit of the electrode for another note, I have shown a resistance 91' therefor, connected analogously to 91 for the illustrated note.

If the source 93 be a high voltage D. C. source, it will be understood that it will effect a charge in the string-to-electrode capacity; and that oscillatory variations in the capacity, produced by string vibration, will vary the voltage across the capacity and the voltages across the resistances 91 and 92, since the latter prevent abrupt changes of the charge. If the source 93 be a source of oscillations of super-audible frequency, it will be understood that it will produce a current flow through the string-to-electrode capacity, which will be modulated by the oscillatory variation in the capacity, to produce modulated voltages across the resistances 91 and 92. In either event the oscillatory components of the voltage across the common resistance 92 may be applied through a condenser 94 to the potentiometer 32 (the amplifier 33 being operated to demodulate, as well as to amplify, when the super-audible-oscillation source is employed).

To carry out my invention in the instrument of Figure 4 I may connect, from each electrode 90 to ground, a capacity which is normally of negligible value, but which is momentarily greatly increased when the hammer strikes the string. This I have illustrated by the employment of shelf 46, insulating rail 45, insulating spacer 47, and springs 42 as in Figure 1—but with each spring adapted to be raised into close adjacency with a respective small metal plate 95 secured, above the more forward spring portion, to the bottom of a common insulating plate 96 extending forwardly from the top of the spacer 47. Each plate 95 may be connected to a respective electrode 90, while all the springs 42 may be connected to ground. To obviate shorting of

each spring 42 against its respective plate 95 when it is warped up thereagainst by the hammer lug 44, a thin mica or other dielectric sheet 97 may be secured against the bottom of each plate 95.

As the hammer approaches the string and the spring 42 is warped upwardly, the capacity of the spring to the respective plate 95 is increased, to have a maximum value when the hammer strikes the string; its value may then be many times that of the associated string-to-electrode capacity, so that it then heavily loads, or largely shorts, the string-to-electrode capacity. This operates greatly to reduce the string-vibration-frequency oscillations (or modulations) in the voltages across resistances 91 and 92, because the capacity in series with those resistances is being oscillatorily varied in greatly reduced degree (i. e., the total such capacity has been greatly raised, with no increase in the variable component of the capacity).

When the source 93 is a D. C. source there is the further action of a momentary reduction of the voltage across the string-to-electrode capacity, since its charge is suddenly largely transferred to the capacity between spring 42 and plate 95, and time is required for re-charge through resistances 91 and 92; this D. C. voltage reduction will be understood to have a reducing effect on the translation efficiency. This additional action may be eliminated if the connection of the springs 42 be transferred from ground to the ungrounded terminal of source 93—i. e., to coincide with the connection of resistance 92 to the source—thus providing a reduction of the degree of elimination of impulse excitation components from the tone. I have accordingly shown a potentiometer 98 shunted across the source 93, and the springs 42 connected to a variable contact 99 on this potentiometer; by this contact their potential may be progressively varied between the terminal potentials of that source. A still further reduction of the impulse component elimination may be effected if, with the contact 99 at the non-ground extremity of the potentiometer and source, the connection of the resistance 92 to the source be varied away from that non-ground extremity; accordingly I have shown the resistance 92 connected to a variable contact 100 on the potentiometer, which is intended to be fully variable over the potentiometer independently of the position of the contact 99. By more extreme adjustments of the last-mentioned character it is in many cases possible to reverse the effects of the system, to provide an actual accentuation of the impulse excitation components of the output tones.

It will of course be understood that the mechanical control means, for moving the shelf 46 to remove the springs 42 from and to restore them to the paths of the hammer lugs 44, may still be employed, having been fractionally illustrated in Figure 4.

In Figure 5 I illustrate the application of my invention to an instrument wherein a plurality of electrodes 90, 90a and 90b are employed for the strings of each note. All the strings may be grounded, as in Figure 4; and a sensitizing voltage source 93 is provided, also as in Figure 4, but it may be shunted by a potentiometer 101 having a grounded center-tap 102 and having three independently variable contacts 103, 103a and 103b. The electrode 90 is connected through a respective high resistance 91 to the contact 103, the electrode 90a through a respective high

resistance 91a to the contact 103a, and the electrode 90b through a respective high resistance 91b to the contact 103b. Resistances 91', 91a' and 91b' for the electrodes associated with the strings for an adjacent note have been illustrated to indicate their manner of connection in circuit. For the three illustrated electrodes of each note there may be provided a single respective resistance 104, of high value and with one extremity grounded, and these electrodes may be connected to the non-ground extremity of resistance 104 through respective condensers 105, 105a and 105b. It will be understood that the system as so described will produce across resistance 104 oscillations of the fundamental frequency of the respective note (or oscillations modulated at that fundamental frequency, according to the nature of the source 93), the harmonic development of the oscillations (or modulations) being determined by the joint adjustment of the variable contacts 103, 103a, 103b. In carrying out the main aspects of my invention with the system of Figure 5, I may for example treat each resistance 104 in general as one of the translating devices 20 of Figure 3; I have accordingly shown a respective conductor 106 forming a signal circuit from the resistance 104 to non-ground extremity of potentiometer 32, and in this conductor I have serially interposed an appropriate switch operated by the hammer. Similarly to the switch of Figure 3, this may be made of double-throw variety, whereby to switch the resistance 104 from a normal connection with the potentiometer 32 to a connection with ground.

In Figure 5 I have shown each switch as of a capacitive form wherein the compressible conductive elements 85 and 88 are employed in arrangement and connection like those of Figure 3, but with a member therebetween movable to form a capacity alternately with the one and with the other element. This member may be a spring 107 electrically connected to the resistance 104, and extending forwardly from between rail 45 and spacer 47 to between the elements 85 and 88; on the top and bottom of the spring opposite those elements are secured thin mica or other dielectric sheets 108, which prevent actual contact of the spring with either element. To the forward extremity of the spring may be secured the Bakelite or other insulating extension 109, which overhangs the guide rail 17 to be engaged by the hammer lug 44. To prevent minute electrostatic effects upon contact of the lug 44 with the extension 109, a small metallic plate 110 may be secured underneath the forward extremity of the extension 109, and grounded as by flexible conductor 111.

Normally the spring 107 rests through the lower dielectric sheet 108 on the element 85, compressing the latter and providing a capacity thereto which completes the circuit of conductor 106. Operation of the hammer will of course move the spring 107 upwardly to interrupt this circuit, and to bring the upper dielectric sheet 108 into momentary compressing contact with the bottom of the element 88; this provides momentarily a capacity between spring 107 and the element 88 through which the voltage from resistance 104 is transferred to ground. In a switch of this character the abruptness of the switch action is tempered both by the capacity variation with spring movement and by the resistance variation with the element compression. This compression also provides a beneficial resili-

ent mechanical stop action for the spring movement—it being understood of course that the parts will be adjusted to avoid this compression noticeably interfering with the normal hammer movement. In the instrument of Figure 5 the mechanical control means for moving the shelf 46 has again been fractionally illustrated, for purposes apparent from preceding description.

While in the several figures I have disclosed certain particular combinations of various translating devices with various forms of switching means or equivalents, it will be understood that these particular combinations are intended to be illustrative rather than exhaustive, and that the elements may be widely interchanged—subject only to such broad qualifications as that the capacitive switching means are best adapted for high-impedance translating devices, and the like. And generally I intend no unnecessary limitations by virtue of the details of the disclosure, which obviously may be widely varied without departure from the spirit of the invention. In many of the appended claims I undertake to express the scope of the invention broadly, subject however to such proper limitations as the state of the art may impose.

I claim:

1. In a musical instrument having a tuned vibrator: the combination of impulse exciting means for said vibrator; a signal channel; means for effecting a translation of vibrations of said vibrator into corresponding electric oscillations in said channel; and variable impedance means, electrically connected within said signal channel and operated by said exciting means, for varying the efficiency of said translation.

2. In a musical instrument having a tuned string: the combination of a hammer movable to strike said string; a signal channel; means for effecting a translation of vibrations of said string into corresponding electric oscillations in said channel; and variable impedance means, electrically connected within said signal channel and operated by said hammer, for varying the efficiency of said translation.

3. In a musical instrument having a tuned vibrator: the combination of a hammer movable to strike said vibrator; means for effecting a translation of vibrations of said vibrator into electric oscillations; and switch means, associated with said hammer in position for and subjected to operation thereby only when the same is in close adjacency to said vibrator, for varying the efficiency of said translation.

4. In a musical instrument having a tuned vibrator: the combination of impulse exciting means for said vibrator; a signal channel; means for effecting a translation of vibrations of said vibrator into corresponding electric oscillations in said channel; and variable impedance means, operated by said exciting means, for substantially shorting said channel.

5. In a musical instrument having a tuned vibrator: the combination of impulse exciting means for said vibrator; a signal channel; means for effecting a translation of vibrations of said vibrator into corresponding electric oscillations in said channel; and variable impedance means, operated by said exciting means, for open-circuiting said signal channel.

6. In a musical instrument having a tuned vibrator: the combination of impulse exciting means for said vibrator; an amplifying circuit; 75

means associated with said vibrator for translating electric oscillations from the vibrations thereof; means normally applying said oscillations to said amplifying circuit; an inactive circuit; and means, operated by said exciting means, for diverting said oscillations from said amplifying circuit to said inactive circuit.

7. In a musical instrument having a tuned vibrator: the combination of impulse exciting means for said vibrator; a signal channel; means for effecting a translation of vibrations of said vibrator into electric oscillations in said channel; and switch means, connected within said signal channel, for varying the efficiency of said translation when said exciting means is operated.

8. In a musical instrument having a tuned vibrator: the combination of impulse exciting means for said vibrator; a signal channel; means for effecting a translation of vibrations of said vibrator into electric oscillations in said channel; and variable-impedance means, connected within said signal channel, for varying the efficiency of said translation when said exciting means is operated.

9. In a musical instrument having a tuned vibrator: the combination of impulse exciting means for said vibrator; a signal channel; means for effecting a translation of vibrations of said vibrator into electric oscillations in said channel; and variable-capacity means, connected within said signal channel, for varying the efficiency of said translation when said exciting means is operated.

10. In a musical instrument having a tuned vibrator: the combination of impulse exciting means for said vibrator; means for effecting a translation of vibrations of said vibrator into electric oscillations; switch means for varying the efficiency of said translation, disposable to be operated by said exciting means; and means, mechanically associated with said switch means, for moving the same to suspend the operation thereof by said exciting means.

11. In a musical instrument having a tuned vibrator: the combination of a hammer movable to strike said vibrator; means for effecting a translation of vibrations of said vibrator into electric oscillations; a lug secured to said hammer; switch means, having a movable element disposable in the path of said lug, for varying the efficiency of said translation; and means for moving said switch means relative to said hammer to carry said movable element out of the path of said lug.

12. In a musical instrument having a tuned vibrator: the combination of impulse exciting means for said vibrator; high-impedance means for effecting a translation of vibrations of said vibrator into electric oscillations; high-resistance means in series with said translating means; and variable-capacity means shunting said translating means and varied by said exciting means.

13. In a musical instrument having a tuned vibrator: the combination of impulse exciting means for said vibrator; an electrode forming a capacity with and varied by vibration of said vibrator; high-resistance means for charging said capacity; and variable-capacity means shunting said first-mentioned capacity and varied by said exciting means.

14. In a musical instrument having a tuned vibrator: the combination of impulse exciting means for said vibrator; a signal circuit; means for effecting a translation of vibrations of said vibrator into electric oscillations in said circuit; and means, connected in said circuit and comprising a compressible conductive element and a member movable into and out of compression against the same, for varying the efficiency of said translation when said exciting means is operated.

15. In a musical instrument having a tuned vibrator: the combination of impulse exciting means for said vibrator; a signal circuit; means for effecting a translation of vibrations of said vibrator into electric oscillations in said circuit; and means for varying the efficiency of said translation, comprising a compressible conductive element, a member movable into and out of compression against the same, and thin dielectric means interposed between said element and said member.

16. In a musical instrument having a tuned vibrator: the combination of a member arranged for movement to contact and excite said vibrator; a key depressible to cause said member movement; means for effecting a translation of vibrations of said vibrator into electric oscillations; and variable-impedance means, operated by said member upon depression of said key and free of operative influence by said key upon subsequent release thereof for momentarily varying the efficiency of said translation.

17. In a musical instrument having a vibrator and a system for the mechanico-electro-acoustic translation of its vibrations: impulse exciting means for said vibrator, and variable-capacity means responsive to said exciting means for varying the efficiency of said translation.

18. In a musical instrument having a vibrator and a system for the mechanico-electro-acoustic translation of its vibrations: a hammer movable to strike said vibrator, and variable-capacity means operatively associated with said hammer for varying the efficiency of said translation.

19. In a musical instrument having a vibrator and a system for the mechanico-electro-acoustic translation of its vibrations: impulse exciting means for said vibrator, an oscillation-transmitting channel in said translating system, and means serially interposed in said channel and responsive to said exciting means for varying the efficiency of said translation.

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