

March 23, 1954

B. F. MIESSNER

2,672,781

VIBRATORY REED ELECTRONIC MUSICAL INSTRUMENT

Filed Oct. 15, 1951

3 Sheets-Sheet 1

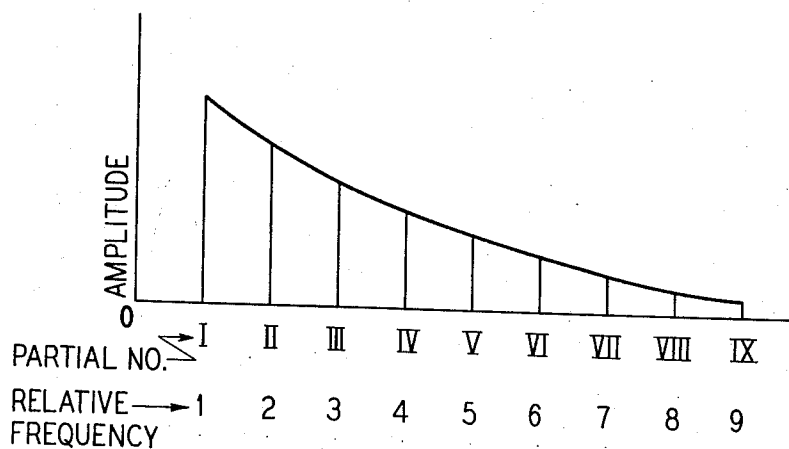
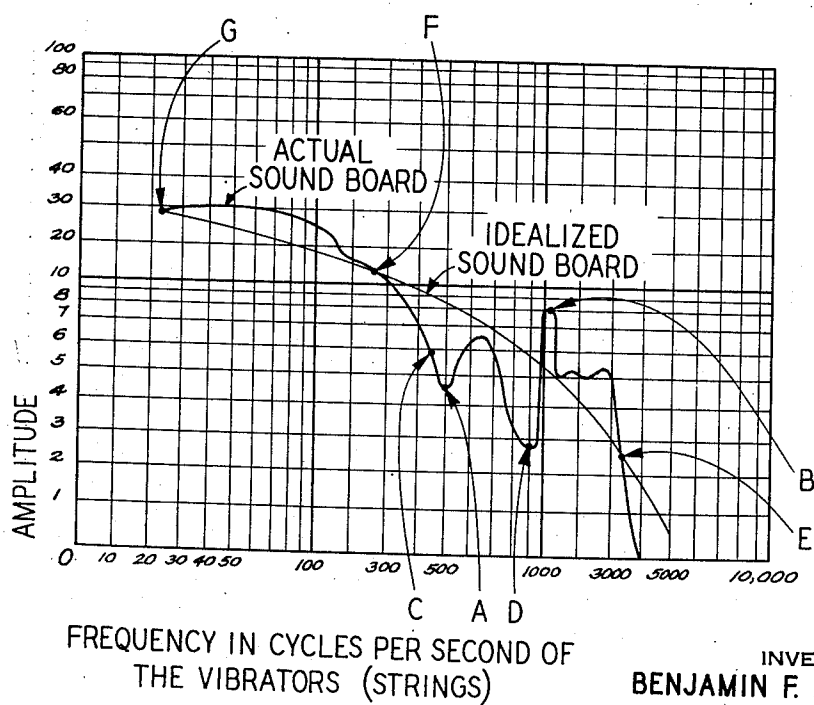


FIG. 1

FIG. 2



INVENTOR
BENJAMIN F. MIESSNER
BY
Gaylor, Giffels & Furick
ATTORNEY

March 23, 1954

B. F. MIESSNER

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3 Sheets-Sheet 2

FIG. 3

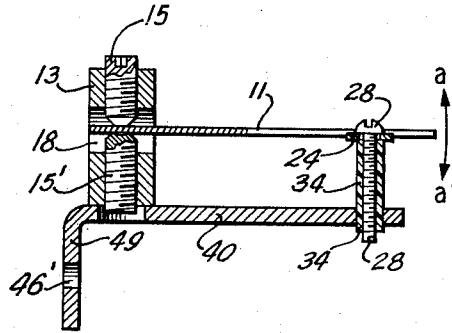
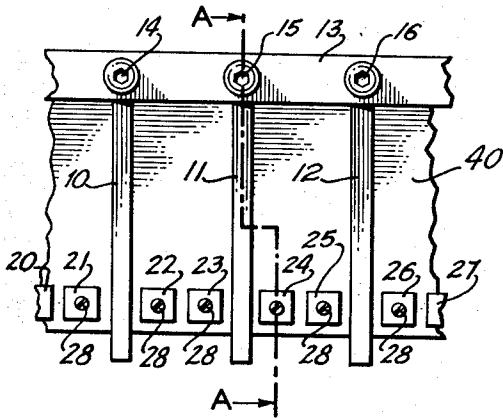


FIG. 5

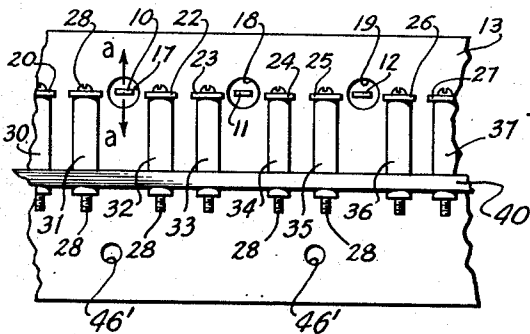


FIG. 4

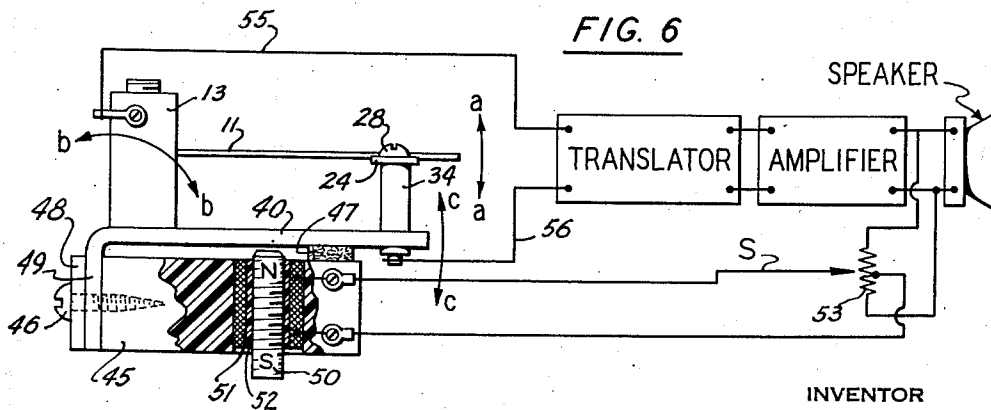


FIG. 6

INVENTOR
BENJAMIN F. MIESSNER

BY

Saylor, Rife & Furick
ATTORNEY

March 23, 1954

B. F. MIESSNER

2,672,781

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FIG. 8

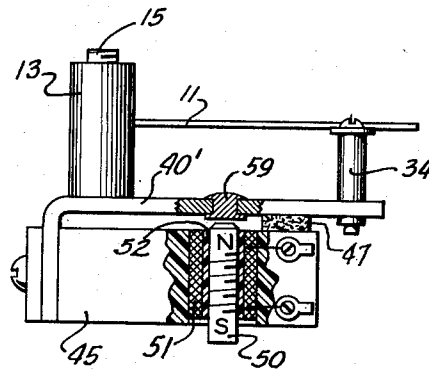
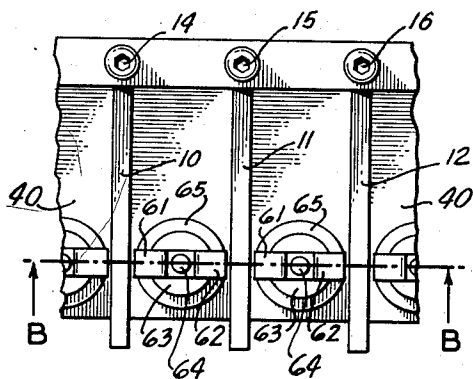


FIG. 7

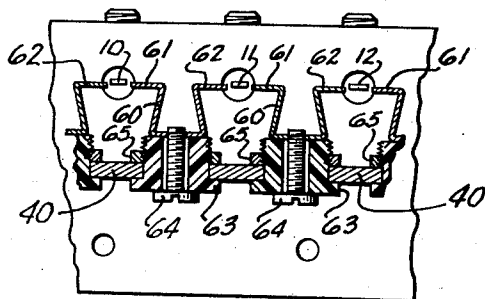


FIG. 9

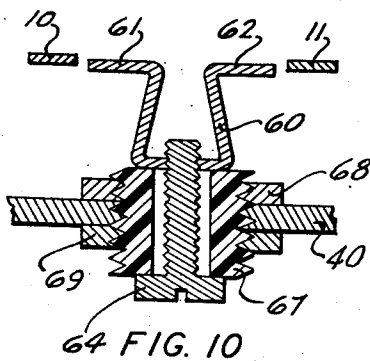


FIG. 10

INVENTOR
BENJAMIN F. MIESSNER
BY
Haydon, Giffen & Jurick
ATTORNEY

UNITED STATES PATENT OFFICE

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VIBRATORY REED ELECTRONIC MUSICAL INSTRUMENT

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

Application October 15, 1951, Serial No. 251,363

11 Claims. (Cl. 84-1.15)

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This invention relates to electronic musical instruments utilizing clamped-free vibratory reeds as tone generators and more particularly to a novel arrangement of the translating devices associated with such reeds for the production of desired tonal effects.

The complexion of the output tones of a tensioned-string piano is markedly affected by the natural frequency and energy-damping characteristics of the piano soundboard which effects are known as formant action or as formant effects. These generally occur within a single cycle of vibration but may extend over a number of complete cycles before extinction by more or less string damping influences, in which case they are more properly classed as broad-band resonant effects. Both kinds are present in piano soundboards but they will be referred to herein as formant effects because of their tone quality forming action. In essence, this formant action involves the generation of broad bands of vibration frequencies varying in mean or average value from one end of the piano bridge system to the other. Such vibration frequencies arise both by hammer impact action on the tensioned strings and by forced and resonant action and reaction between the strings and the bridge-soundboard structure. If, for example, a C key for a 130.8 cycle per second, lower register string be struck and the bridge-soundboard structure in the region of such string has a broad frequency response spanning 130.8 C. P. S., the bridge-soundboard structure will readily accept the 130.8 C. P. S. vibration partial I of the string. In fact, the structure will also accept the higher numbered, integrally-related vibration partials of the string and will radiate all such vibration frequencies as long as the string continues to vibrate. For those vibration frequencies of the soundboard having the strongest coupling, together with efficient radiation or other damping losses for strings having a group of partials within the soundboard's strongly coupled band of frequencies, those string partials within this band will be relatively more rapidly damped than other partials of the string. Also, for these frequencies the bridge-soundboard structure will react back on the string to influence string vibration, in the manner of all coupled, resonant vibrators, mechanical or electrical. The net acoustical effect of the formant action is to make those vibration partials which are rapidly transferred to the soundboard of strong, initial amplitude and shorter time constant.

In electronic musical instruments there is, pref-

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erably, no direct sound radiation of the tone generators and the introduction of the formant effect into the audible tones of such instruments must be accomplished without a soundboard as such.

An object of this invention is the provision of means for producing conventional soundboard effects in an electronic musical instrument utilizing beam type vibrators as tone generators.

An object of this invention is the provision of a novel mounting arrangement for translating means associated with vibratory reed tone generators.

An object of this invention is the provision of novel and improved means for coupling vibratory reeds, in an electronic piano employing such reeds as tone generators, to provide improved output tones throughout a wide pitch range.

An object of this invention is the provision of means for producing formant effects in an electronic piano employing vibratory reeds as tone generators together with means for selectively varying such effects to produce output tones of desired character.

An object of this invention is the provision of a tone-producing assembly for an electronic musical instrument said assembly comprising a series of tuned clamped-free reeds secured to a reed rail, vibration-translating pick-ups associated with the reeds, pick-up supporting means secured to the reed rail, a vibratile support for the pick-up supporting means, and electro-magnetic means for vibrating the vibratile support in a predetermined manner.

An object of this invention is the provision of a tone-producing assembly for an electronic musical instrument and comprising a series of vibratory reeds and associated pick-ups mechanically coupled to a common reed rail, a rigid base, resilient members disposed between the reed rail and the base, mechanico-electro-acoustic means for translating reed vibrations into sound, electro-magnetic means for vibrating the reed rail, and an electrical feedback circuit connected between the electro-magnetic means and the electro-acoustic means.

These and other objects and advantages of the invention will be apparent from the following description when taken with the accompanying drawings. It will be understood the drawings are for purposes of illustration and are not to be construed as defining the scope or limits of the invention, reference being had for the latter purpose to the appended claims.

In the drawings wherein like reference characters denote like parts in the several views:

Figure 1 is a curve illustrating the relative amplitudes of the vibration partials of a tensioned string mounted on a massive, non-vibratile support;

Figure 2 is a curve showing the variation of the amplitude of a soundboard (of a high quality, large-size, grand piano) related to the vibration frequency of the immediately proximate, tensioned string;

Figure 3 is a fragmentary, top plan view of a reed and pick-up assembly made in accordance with my invention;

Figure 4 is a front elevation of the assembly shown in Figure 3;

Figure 5 is a cross-sectional view taken along the line A—A of Figure 3;

Figure 6 is a side view of the assembly shown in Figure 5 and including a diagrammatic showing of my arrangement for vibrating the reed-pick-up assembly to provide desired formant effects;

Figure 7 is similar to Figure 6, with the electrical components omitted, and showing a modification of the invention wherein the plate supporting the pick-ups is made of non-magnetic material;

Figure 8 is a plan view similar to Figure 3, and showing another construction of the pick-ups and their supporting posts;

Figure 9 is a longitudinal, cross-sectional view taken along the line A—A of Figure 8; and

Figure 10 is a cross-sectional view similar to that of Figure 9, and showing a single pick-up and supporting post of another construction, drawn to an enlarged scale.

As is well known, the initial amplitudes of the vibration partials of a tensioned string, mounted on a rigid base, are not equal but, rather, decrease substantially uniformly as the partial number increases. Figure 1 illustrates the relative vibration amplitudes of the first nine vibration partials of a tensioned string, it being noted that the partials are integrally related and that the partials higher than partial IV have an amplitude less than one-half that of the fundamental partial I. The decrease in amplitude from one to the next higher partial is determined chiefly by the characteristics of the string, the softness and length of the striking hammer along the string, and the specific point on the string where the hammer strikes. However, any one of these partials may be entirely absent, or of abnormally lower amplitude, due to the damping action of the exciter hammer during actual impact with the string. In a piano, the striking point, along the string, is so chosen that the partial VII is so eliminated or damped out.

As stated above, the bridge-soundboard structure of a piano has a broad band frequency characteristic which varies throughout the scale of strings from the lower end of the bass bridge to the upper end of the treble bridge. Many factors influence this frequency characteristic from point to point along the scale such as: the distribution of the thickness, mass and longitudinal stiffness of the bridge, the bearing pressure of the tensioned strings upon the bridge, the proximity of the bridge to the fixed edges of the soundboard, the thickness of the soundboard and the nature of its reinforcing ribs, the specific shape of the soundboard, the internal resistive constants of the material of which these parts are made, the radiation efficiency of the sound-

board for different frequencies along its length from bass to treble ends, etc. Since the soundboard is, in effect, an upwardly and convexly arched membrane of irregular shape and variably loaded by the bridge, and since it is pressed downwardly by the pressure of all the strings into an equilibrium position against its own upwardly acting compliance, its natural vibration frequency varies along the entire bridge in a manner that is difficult to calculate or, in fact, duplicate in any given number of instruments. Pianos made by the same manufacturer and which appear, outwardly, quite identical in design and construction will sound differently in the same pitch ranges.

Of chief interest here is the fact that the soundboard frequency and damping characteristics markedly affect the complexion of the output tones by formant action, and this tonal complexion varies, or shifts, along the pitch scale of every such instrument in a way which is determined chiefly by these formant effects. In addition to the net overall difference in the formant effect as established by the initial physical relationships of the coupled parts, the damping rate of the soundboard varies with humidity. For example, a piano with a soundboard having little or no moisture content will sound bright and crisp. With continued exposure to high humidity atmosphere the soundboard will absorb moisture and its natural vibration frequencies will be lowered due to the added loading effect of this water content and the rise in its internal vibrational resistance, whereby the output tones will have a higher damping rate and will sound dull and lifeless.

In tests made on a small grand piano I have found that the natural vibration frequencies of the soundboard varied smoothly from 90 to 550 cycles per second, between the two extreme ends of the bass and treble bridges. In the larger grand pianos the frequency range has a larger spread and the frequency variation is more uniform over the scale range.

Figure 2 is a curve showing the vibration amplitude of a soundboard, at positions immediately below strings having the indicated fundamental frequencies, of a largest-size grand piano of European manufacture. Superimposed on such curve is a similar curve of an ideal soundboard. Ideally, of course, the soundboard should have a response frequency close to that of the adjacent strings and such curve should be smooth, starting at about 30 cycles per second and ending at 4,000 to 5,000 cycles per second. Then the correct impedance matching for uniform energy transfer from the strings to the soundboard would obtain and there would be no regions of the scale where the tone quality would be markedly different. For example, if a bridge-coupled string having a fundamental pitch of 500 cycles per second is vibrated adjacent to an actual soundboard having the response characteristics shown in Figure 2, the fundamental vibration of the string, falling at a low point A on the curve, would be depressed in amplitude. However, the vibration partial II of such string has a frequency of 1,000 C. P. S. falling at the relatively high point B on the curve and, consequently, this vibration partial is elevated, relatively, in output sound amplitude. Another string having a fundamental vibration frequency of 450 C. P. S. would have a relatively elevated amplitude for partial I (falling at the point C) while its partial II of 900 C. P. S. would be depressed (falling at the point

D). Since the quality of a piano tone changes as the string vibration amplitude falls off, the first example tone, having its partial II damped out at a rate greater than partial I, will have a noticeably different quality than the second example tone subject to the reverse damping effect.

Since soundboards are strongly damped mechanico-acoustic transducers, their vibrations do not continue much beyond the time confines of a few cycles of string vibration and their action is very closely similar to that of the formant effects in the mouth, nasal passages, larynx, etc. of the human voice apparatus. These members, in different individuals, produce different tone qualities at the same pitches due to the strongly damped but intra-cyclic resonant actions of these coupled resonators driven by the air puffs released by the vocal chords. In wind instruments, the formant action is varied from one instrument to another chiefly by the shape of the air column confined more or less within the boundaries of the instrument. In soundboard instruments employing the same kind of strings the formant action and output tone quality is varied from one to another chiefly by the soundboard design as to frequency and damping characteristics.

In electronic musical instruments having no soundboard, such as instruments employing vibratory reeds for tone generators, the formant effects must be provided by an added element whose vibration is induced by output of the tone generators and such induced vibrations is reintroduced into the translating system.

In order to provide formant effects, in a vibratory reed type of electronic musical instrument, simulating those of conventional instruments, the vibrational characteristics of the formant-producing system must correspond to those of the particular instrument being duplicated. Since the frequency damping characteristics of soundboard instruments are not yet entirely known and since their damping characteristics are very difficult to measure by reason of their high absolute values, the duplication, in an electronic instrument, of a particular conventional instrument must be accomplished by cut and try methods. When, however, the formant-producing system to be added to an electronic instrument is provided with variable frequency and damping controls along the scale of the tone generators the effects may be adjusted independently, until the listening ear accepts the electronically produced tone as comparable to the tone of a conventional instrument.

In carrying out my invention, as applied to a clamped-free reed type of electronic piano, I provide a vibratile support for the reed-vibration-translating pick-ups which support is attached to the reed-mounting rail in such manner that the reeds, when vibrating, tend to vibrate the pick-up support whereby the translating system will translate the combined vibrations of the reeds and of the pick-ups relative to one another.

Reference is now made to Figures 3, 4 and 5, Figure 3 being a fragmentary top plan view of one novel mounting arrangement for the pick-ups, Figure 4 being a front elevation thereof, and Figure 5 being a cross-sectional view taken along the line A—A of Figure 3. The vibratory reeds 10, 11, 12, are clamped to the rail 13 by suitable, hardened set screws 14, 15, 16, each such set screw being aligned with a cooperating similar screw such as the screw 15' shown in the cross-sectional view of Figure 5. The reed rail 13 is provided with transverse holes 17, 18, 19 afford-

ing unrestricted vibration of the individual reeds. This particular reed-clamping arrangement offers numerous, practical advantages. Each reed is adapted for excitation, percussively or otherwise, by any suitable means and will vibrate in the direction indicated by the arrows *a*—*a* in Figures 4 and 5. The vibration-translating pick-ups, here shown as the capacitive type, comprise the individual metallic plates 20 to 27, inclusive, each plate being secured to the associated post 30 to 37 as by the screws 28, such posts being made of suitable insulating material such as a plastic. It may here be pointed out that the posts are internally threaded to accept the fastening screws 28 and each of the pick-up plates is provided with an oversize hole whereby the spacing of the plate relative to the adjacent side of the reed may set to a predetermined value before the fastening screw is tightened. Further, if the plane of one or more of the pick-ups is to be altered with respect to the plane of the associated reed, when the latter is in the at rest position, this can be done by driving the insulator posts in one or the other direction in the holes provided in the metallic plate 40. The holes in the plate 40 are made slightly undersized relative to the outside diameter of the posts whereby the posts will be self-supporting when driven into such holes. Alternatively, the plane of each individual pick-up can be altered by placing shims between the pick-up and the top of the supporting post. Each pair of pick-ups is so positioned that the transverse axis thereof coincides with nodal point for the vibration partial II of the intervening reed. Thus, when the reed is excited by percussive means, such second vibration partial, which is dissonant relative to the reed's partial I, is eliminated from the translating system. The plate 40, preferably made of steel, is secured to the lower surface of the reed rail 13, by screws located between the reed-clamping screws, and is spaced from the plane of the reeds a distance sufficient to permit maximum amplitude of reed vibration. It will be apparent the pick-ups are electrically insulated from the reeds and that all reeds can be connected into an electronic circuit by means of a single lead attached to any part of the reed base 13 or plate 40, and that the pick-ups all can be connected by means of a lead secured to the ends of the fastening screws 28. Those skilled in this art will know the reeds and pick-ups form part of a radio-frequency circuit in which the oscillation frequency or amplitude is affected by the capacity between the reeds and the pick-ups and such frequency or amplitude will be modulated by the change in capacity brought about by vibration of one or more of the reeds relative to their associated pick-ups or of the pick-ups relative to the reeds. Such modulations are suitably amplified, demodulated, etc. to operate a loud speaker producing audible tones.

In order to superimpose desired formant effects into the audible output tones of the instrument I mount the assembly, shown in Figures 3-5, on a relatively thick, non-vibratile base and provide electro-magnetic means for vibrating the assembly in a specific manner by feedback energy derived from the electrical output circuit of the pick-up system.

Reference is now made to Figure 6 which shows the assembly of Figure 5, comprising the reed rail 13, reeds 11, pick-ups 24 and the supporting plate 40, secured to the side of a thick non-vibratile base 45 by means of screws 46, washers 48. The screws 46 pass through holes 46', see

Figures 4 and 5, provided in the offset arm 40 of the plate 40. A pad 47, of visco-elastic material such as felt, rubber, Vinylite, etc., may be cemented to both the plate 40 and the base 45. When the reed 11 is set into normal vibration, as indicated by the arrows *a, a*, such vibration will tend to develop torsional vibration of the reed rail 13 as shown by the arrows *b, b*. This tends to develop an angular vibration (of very small amplitude relative to that of the struck reed) of the plate 40 toward and away from the reed, as shown by the arrows *c, c*. Vibration of the reed base 13, and of the plate 40, is resisted by the compliance of the bend in the plate 40, the compression and compliance of the pad 47, as well as by its internal viscosity or vibrational resistance. In a musical series of tuned reeds the length of the individual reeds will vary, generally, from a maximum in the low frequency or bass section to a minimum in the high frequency or treble section. Since it is desirable to position each pair of pick-ups at the nodal point of vibration partial II for the intervening reed, it is apparent the width of the pick-up-supporting plate 40 will vary in like manner. I prefer to make the width of the plate 40 about 80% of the length of the immediately-above-disposed reed so that such plate width will also be a maximum at the low frequency reed position and a minimum at the high frequency reed position. The thickness of the plate 40 and the elasticity of the material of which the plate is made are so chosen that the plate's segmental vibration period is about equal to the fundamental frequencies of the immediately proximate reeds. The plate thickness for any given point may be found by forming such a plate segment equal to the center-to-center spacing of the reeds, attaching thereto a pair of support posts, pick-ups and fastening screws to represent the actual plate load, clamping such arrangement in a vice, vibrating the free end (carrying the pick-ups), and actually measuring the vibration frequency. The plate 40 preferably is made of steel, for purposes to be explained hereinafter, and its correct thickness is that which will give a frequency response equal to that of the proximate reed, with due consideration being given to such factors as the loading provided by the pick-ups and their supporting structure. If necessary, holes may be drilled through the plate to raise the natural vibration frequency above its normal value, or loading members of lead or other material may be added as specific points to lower the natural frequency, all for the purpose of producing a particular and varying frequency characteristic along the plate length, that is, the dimension in the longitudinal direction of the rail 13. I have found that for reeds having a thickness of 0.032 inch, the plate 40 may be made of $\frac{1}{16}$ inch thick steel, in order to have the approximately correct frequency response along the scale of reeds.

Since the damping characteristics of an actual piano soundboard, as shown by the curve of Figure 2, also vary along the piano bridge, this factor must also be simulated in my vibration-simulating pick-up support 40. For this purpose the width, thickness or viscosity of the pad 47 may be varied, along the length of the plate 40. By these means the desired variation of damping may be obtained as distinguished from an otherwise smooth curve such as the curve of the idealized soundboard shown in Figure 2. For such high damping regions as the points A and D on the curve the damping or energy losses must be

increased, while for the points B to E, and F to G, the energy losses must be decreased.

In a tensioned string piano, each string has a series of very nearly integrally-related frequency partials whereas a clamped-free reed has no such fortunate partial frequency relationship. The relationship of such partial frequencies to the fundamental frequency (partial I) is as follows:

Partial No.	Freq. of Partial to Fundamental	
	Tensioned String	Clamped-free Reed
I	1	1.0
II	2	6.27
III	3	17.5
IV	4	34.4
V	5	56.9
VI	6	85.0

When a tensioned string of a piano vibrates with varying pressure on an associated soundboard's bridge each and all of its many and closely-spaced vibration partials produce their own vibrating forces on the soundboard. Also, other neighboring and further distant strings having one or more partial frequencies equal to one or more partials of the excited string, and having more or less coupling to it, will respond by resonant vibration producing a complex tone. Also, the hammer impact on the string is transmitted to the soundboard producing a wide and continuous band of frequencies resulting in the characteristic "thump" or "rap." In the case of a clamped-free reed the vibration partials are much further separated, frequency-wise, and such partials are completely inharmonic. Thus, the nearest reed, in a musical scale series of tuned reeds, having a near resonant vibration component equal in frequency to partial I of an excited reed will be removed by a frequency spread of 6.27 times the fundamental frequency of the struck reed. Such frequency spread corresponds to about $2\frac{1}{2}$ octaves above the struck reed or a distance equal to about 30 reeds along the reed rail. This compares with a spacing of about 12 strings in a conventional piano. Consequently, the coupling in a tensioned string piano is tighter than in an electronic piano utilizing clamped-free vibratory reeds. Also, as already stated, partial II of a vibratory reed is dissonant with partial I. Therefore, the partial vibrations of a reed will find very few, if any, resonant partials, in a series of tuned reeds, to augment the translated reed vibrations. Because of these factors, the assembly and arrangement thus far described is not, of itself, sufficient to provide true tonal effects corresponding to those of a given conventional musical instrument such as, for example, the piano. I overcome such deficiency by introducing into the vibratile pick-up support many integrally related vibration partials, such partials being produced by the pick-up from the reed vibration partial I and electrically fed back to a vibration member associated with such support.

The feed-back device comprises, in its elemental form, an adjustable, polarized core 50 surrounded by a coil 51. The coil is secured in fixed position within an appropriate aperture in the base 45, by any suitable means, and the core 50 may be threaded to operate within the insulator tube 52 upon which the coil is wound. Several of such coil and core assemblies are spaced at intervals along the longitudinal di-

mension of the plate 40 and at different distances from the pick-up supports 34, as required. The coil or coils 50 are of low resistance and are connected across the voice coil of the loud speaker through an adjustable center tapped potentiometer 53. The reeds and pick-ups are connected to the translator circuit, as by the wires 55, 56 whereby the capacity variations between the pick-ups and vibrating reeds are converted into corresponding electrical waves which are demodulated, amplified and fed to the speaker voice coil. As disclosed in my copending United States patent application Serial No. 169,714, filed June 22, 1950, the pick-ups can be so positioned relative to the coating reeds that the wave form of the amplifier output current will include a full series of Fourier series partials 1, 2, 3, 4, 5, 6, etc., times the fundamental vibration frequency of any one or more vibrating reeds. Such wave forms are fed to the coils 50 resulting in a vibration of the plate 40 (and the attached members comprising the reed rail, reeds, and pick-ups) in a manner corresponding to the normal frequency partials of the strings in a conventional piano. The phase of the feedback current may be made aiding or opposing, as referred to the partial I of the vibrating reeds, and of desired amplitude, by adjustment of the slider S on the potentiometer 53. Such adjustments will depend upon whether more or less amplitude of partial I is desired in the output tones of the loud speaker. It will also be apparent the magnitude of the feedback current can be made still further controllable, as by a separate amplifier and controls fed from the speaker amplifier. When the reeds and pick-ups are so vibrated, through the medium of the plate 40, a corresponding relative vibration occurs between the reeds and the pick-ups which vibrations are superimposed upon the translating apparatus to correspondingly affect the audible output, tones from the speaker.

With such an arrangement, then, the feedback currents contain all the component frequencies for setting up resonant vibrations not only in the octave-related reeds but also in those reeds having vibration partial frequencies of 1, 2, 3, 4 etc., or $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$ etc., times the frequency of the excited reed. Furthermore, the broad, continuous band of frequencies of the vibratile pick-up-support plate provides innumerable other intervening frequencies corresponding to the "roar" of intermingled tones heard from a tensioned-string piano when played with the loud pedal depressed. Still further, the feedback-forced vibrations of the plate 40 will set up vibrations of the remaining, non-resonant reeds since such plate tends to vibrate, angularly, the fixed ends of all the reeds.

It is evident from the foregoing disclosure that the formant effects characteristic of any type of soundboard instrument may be simulated. In electronic sustained-tone instruments, such as organs and the like, it is customary to use electrical formant circuits in an effort to simulate various conventional sustained-tone instruments of the direct acoustic type. Such circuits may also be used with my reed type mechanical vibrator instruments of damped or sustained tone type. It may here be observed that these prior electrical formant systems, having no direct coupling with the tone generating means and particularly no such coupling which varies note by note through the pitch range according to the formant frequency characteristics of conventional instruments, can only be effective in the

particular pitch range for which they function. Such pitch range is only of a length of two or three octaves in the musical scale.

My direct mechanically-coupled electromechanical formant system can be so tuned and damped over its longitudinal dimension along the reed scale so as to secure any desired formant frequency effects in any or all parts of a scale having any desired pitch compass, or at least to a practical extent within the limitations imposed by the human ear.

While I prefer to make the vibratile plate, which supports the pick-ups, of magnetic material, the invention is not so limited. Reference is now made to Figure 7 wherein the pick-up supporting plate 40' is made of nonmagnetic material such as, for example, aluminum. Vibration of the plate is brought about by a plurality of soft-iron rivets 59, one such rivet spaced from each of the polarized cores 50.

In the Figures 3-7 embodiments of the invention the pick-ups comprise flat, metallic plates secured to individual posts of insulating material. A preferred form of pick-up and mounting arrangement, from the standpoint of facility of assembly and adjustment, is shown in Figures 8 and 9. Here the individual pick-ups comprise a substantially U-shaped member 60 having offset ends 61, 62 lying in planes parallel to that of the reeds 10, 11, 12. The pick-up 60 is secured to an insulator bushing 63 by means of a screw 64 which passes through a clearance hole in the bushing into a threaded hole in the base of the pick-up. The bushing 63 passes through a hole in the plate 40 and is secured thereto by a suitable nut 65. Thus, the pick-ups are insulated from the plate 40 and can be connected into the circuit by means of leads soldered to terminals disposed under the heads of the screws 64. It will be noted that a single pick-up is associated with two reeds and a slight amount of adjustment between the pick-up ends 61, 62 and the reeds can be accomplished by appropriately bending the body and ends of each pick-up. The transverse center line passing through the aligned ends of the pick-ups (such as the section line B-B of Figure 8) coincides with the nodal points for the vibration partial II of the reeds, for purposes already explained.

Figure 10 shows another construction of the individual pick-up supporting post for use with a U-shaped pick-up of the type shown in Figures 8 and 9. Here the pick-up 60 is secured to an insulator bushing 67 by the screw 64. The bushing 67 is provided with an external thread which cooperates with a threaded hole in the plate 40 whereby the plane of the pick-up ends 61, 62 can be adjusted relative to the reeds 10, 11. The bushing 67 is then locked in position by the nuts 68, 69 which may be made of metal and of a type such as those used for mounting conventional toggle switches.

Having now described several embodiments of my invention those skilled in this art will be able to make certain desired variations and modifications in the individual components and their assembled relationship without thereby departing from the spirit and scope of the invention as set forth in the following claims.

I claim:

1. In an electronic musical instrument of the class comprising a plurality of tuned reeds carried by a reed rail, reed-vibration translating pick-ups associated with the reeds and an electrical network for translating relative vibrations

between the reeds and pick-ups into electrical waves, the combination of electro-magnetic means adapted, when energized, to vibrate the reed rail and pick-ups, and feedback means energizing the said electro-magnetic means from the electrical network.

2. In an electronic musical instrument of the class comprising a plurality of tuned reeds carried by a reed rail, reed-vibration translating pick-ups associated with the reeds and an electrical network for translating relative vibrations between the reeds and pick-ups into electrical waves, the combination of a vibratile plate mechanically coupled to the reed rail and pick-ups, electro-magnetic means adapted when energized to vibrate the vibratile plate, and feedback means energizing the said electro-magnetic means from the electrical network.

3. The invention as recited in claim 2, wherein the said vibratile plate is made of magnetic material.

4. The invention as recited in claim 2, wherein the said vibratile plate carries magnetic material members magnetically coupled to the said electro-magnetic means.

5. A musical instrument comprising a plurality of tuned reeds carried by a reed rail, a vibratile plate secured to the reed rail; reed-vibration pick-ups associated with the reeds, said pick-ups being carried by and insulated from the said vibratile plate; an electrical network translating relative vibrations between the reeds and pick-ups into electrical waves; an electro-acoustic device energized by the electrical waves; a non-vibratile base secured to the vibratile plate, said base having a surface spaced from the said plate; electro-magnetic means carried by said base and adapted, when energized, to vibrate the vibratile plate; and a feedback circuit connected between the electro-magnetic device and the said electrical network.

6. The invention as recited in claim 5, including a member of visco-elastic material disposed between the said plate and base.

7. A musical instrument of the class employing an electrical network including an output circuit having an electro-acoustic device; said instrument comprising a reed rail; a plurality of vibratory reed secured to and spaced along the reed rail; a vibratile plate secured to the reed rail and spaced from the reeds; an offset end in the plate in the region of the reed rail; a non-vibratile base having a surface spaced from the said plate; means securing the offset end of the plate to the base; insulator members secured

to the said vibratile plate; reed-vibration-translating means carried by the insulator members, said translating means forming part of the electrical network; electro-magnetic means carried by the non-vibratile base and adapted, upon energization, to vibrate the vibratile base; and means energizing said electro-magnetic means from the output circuit of the instrument.

8. The invention as recited in claim 7, wherein the vibratile plate is made of magnetic material and said electro-magnetic means includes an adjustable, polarized core having an end spaced from the said plate.

9. The invention as recited in claim 7, wherein the vibratile plate is made of non-magnetic material and including a magnetic-material member secured to the said plate and in spaced alignment with said electro-magnetic means.

10. A musical instrument of the class employing an electrical network including an output circuit having an electro-acoustic device; said instrument comprising a reed rail, a plurality of vibratory reeds secured to and spaced along the reed rail; a vibratile plate secured to the reed rail and spaced from the reeds; an offset end in the plate in the region of the reed rail; a non-vibratile base having a surface spaced from the said plate; means securing the offset end of the plate to the base; a visco-elastic member disposed between the said base and plate; insulator members secured to the vibratile plate; capacity pick-ups carried by the insulator members and associated with the reeds; circuit elements connecting the reeds and pick-ups to the electrical network; electro-magnetic means carried by the base and magnetically coupled to the vibratile plate; and means energizing the electro-magnetic means from the output circuit of the instrument.

11. The invention as recited in claim 10, wherein the pick-ups are disposed at the nodal points of the vibration partials II of the reeds and including means for adjusting the magnitude and phase of the current energizing the electro-magnetic means.

BENJAMIN F. MIESSNER

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