Oct. 27, 1953 B. F. MIESSNER 2,656,755

APPARATUS FOR THE PRODUCTION OF MUSIC

Filed March 10, 1950 3 Sheets-Sheet 1

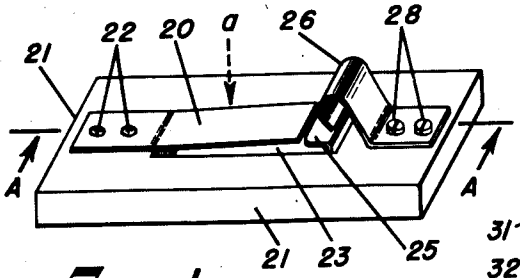


Fig-1

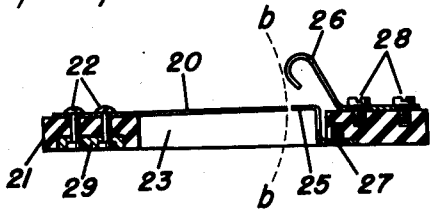


Fig-2

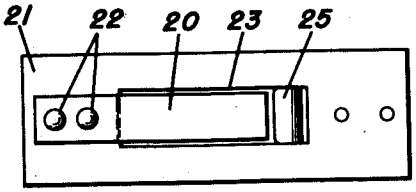


Fig-3

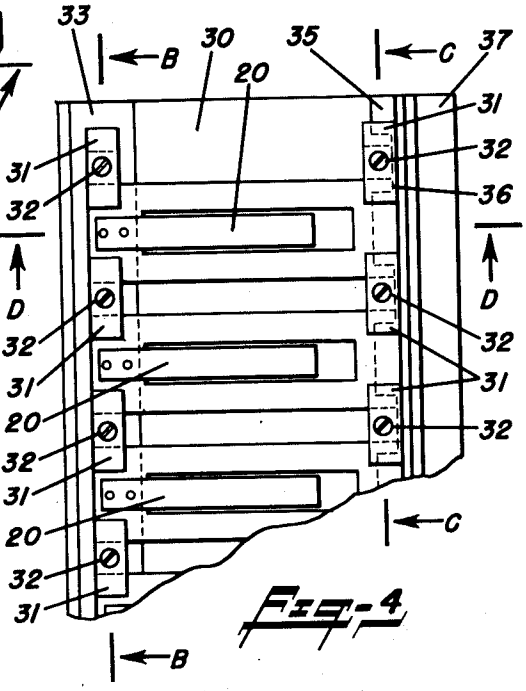


Fig-4

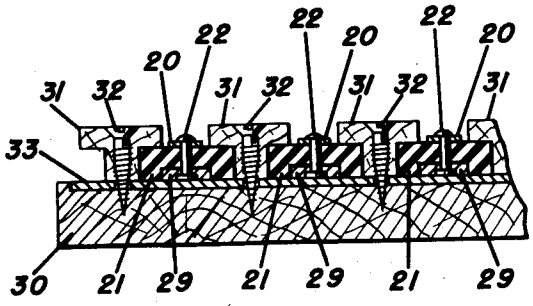


Fig-5

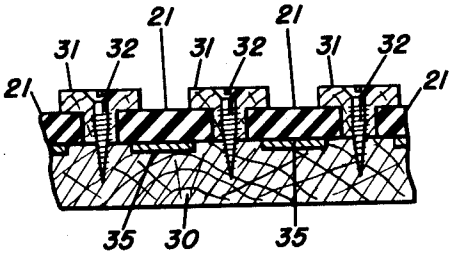


Fig-6

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Oct. 27, 1953 B. F. MIESSNER 2,656,755

APPARATUS FOR THE PRODUCTION OF MUSIC

Filed March 10, 1950 3 Sheets-Sheet 2

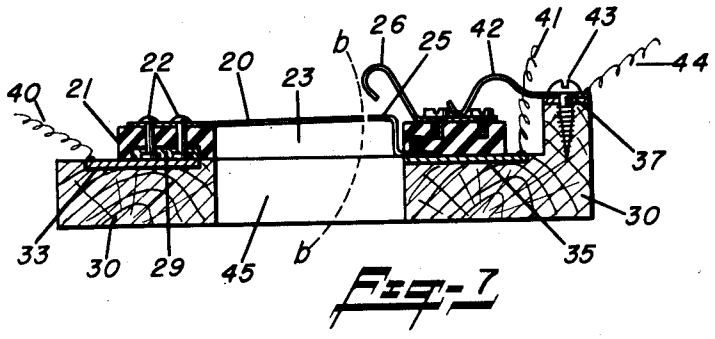


Fig-7

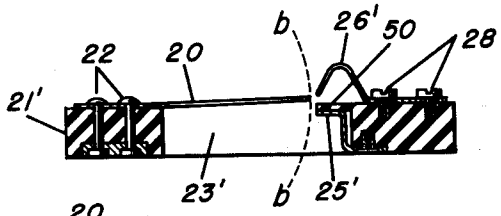


Fig-8

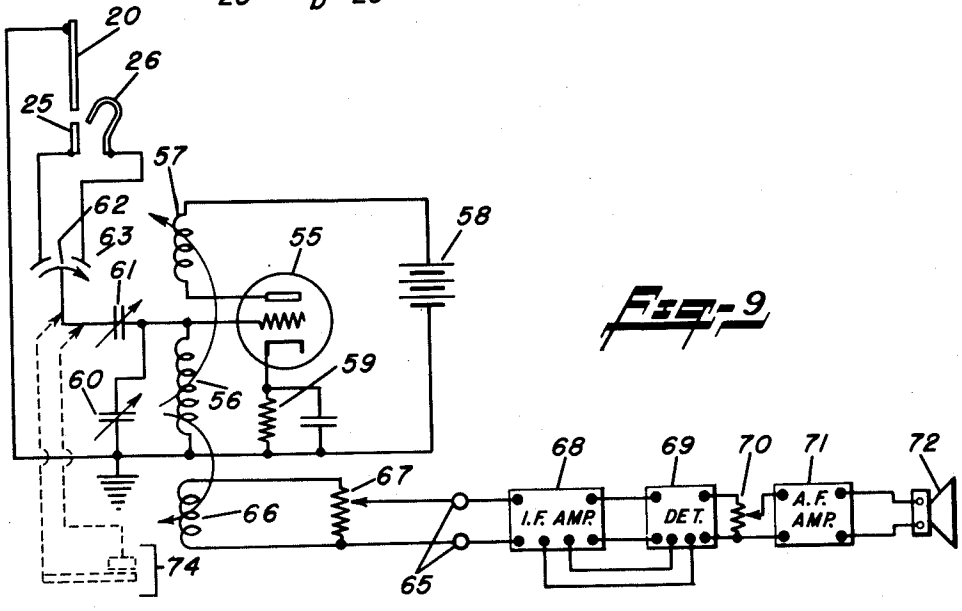


Fig-9

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APPARATUS FOR THE PRODUCTION OF MUSIC

Filed March 10, 1950 3 Sheets-Sheet 3

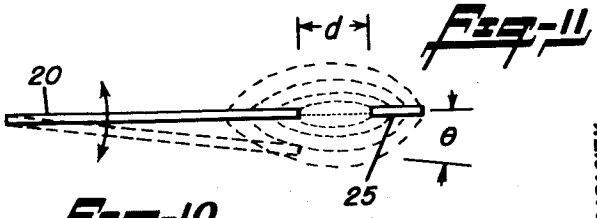
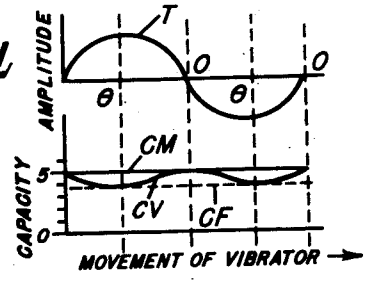


Fig-10

Fig-11



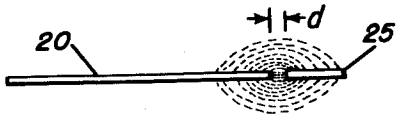
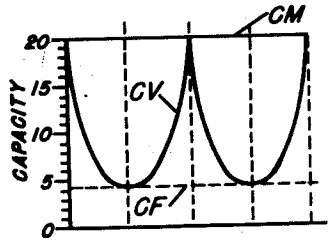


Fig-12

Fig-13



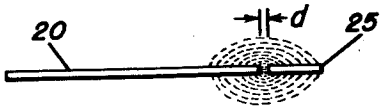
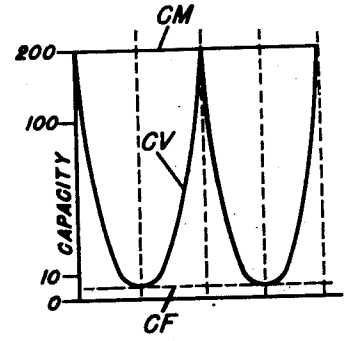


Fig-14

Fig-15



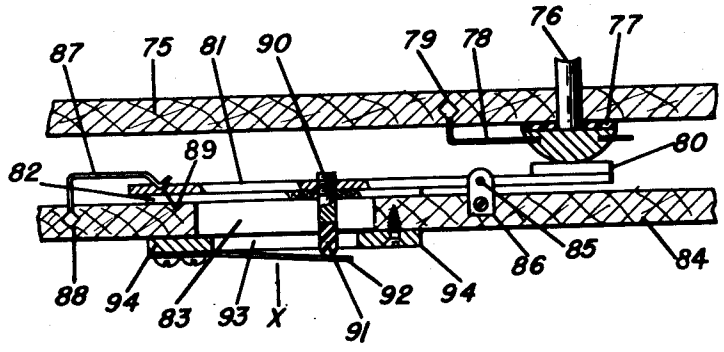


Fig-16

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Patented Oct. 27, 1953

2,656,755

UNITED STATES PATENT OFFICE

2,656,755

APPARATUS FOR THE PRODUCTION OF MUSIC

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 March 10, 1950, Serial No. 148,943

12 Claims. (Cl. 84—1.14)

1

This invention relates to vibratory reed type musical instruments and more particularly to a novel arrangement for translating physical vibrations of a reed into musical tones of controlled quality.

The invention will be described with specific reference to a bellows operated, portable type of reed organ, commonly known as an accordion but it will become apparent the invention has a much broader practical scope. In an accordion a selected reed is set into vibration by compressing or expanding the bellows and the vibration of the reed within an appropriate air chamber produces a tone or musical note corresponding to the vibration frequency of the particular reed. Ordinarily, two identically tuned reeds are required to produce a given tone, one reed being activated upon compression of the bellows and the other upon expansion of the bellows. Various flap valve and air passageway arrangements are provided to bring about the vibration of the reed or reeds. In my co-pending patent application Serial Number 117,992, filed September 27, 1949, now abandoned, I disclose a construction whereby a single vibratory reed is capable of vibration upon both compression and expansion of the bellows. In my other co-pending patent application Serial No. 128,580, filed November 21, 1949, I disclose an air chamber arrangement providing a unidirectional flow of air past a conventional reed regardless of whether the bellows are being compressed or expanded. The arrangement disclosed in my co-pending applications reduce by one half the number of reeds required in an accordion or the like. It is here pointed out that the specific construction or character of the individual reed is immaterial to the practice of the present invention; the novel pick-up and translating arrangement being adaptable for use with any type of vibratory reed construction.

Accordions, and most other instruments of this general class, have always possessed a tone of considerable stridency which might aptly be described as "wheezy" or "blatant," as compared to harmoniums which employ somewhat differently constructed reeds. The harshness, and often unpleasantness, of the tone is due primarily to the relative strength and number of the higher, partial frequencies which modulate the air flowing around the vibrating reed and through the associated reed aperture. The reed proper, or tongue, produces practically no sound when vibrated in the absence of an air stream flowing through its aperture. It is the pulsating flow of air through the aperture and the surrounding

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air chambers which produces the radiated sound. Consequently, the formation of the aperture and air chambers, together with the manner in which the tongue vibrates, determines the character of the air pulses which, in turn, is determinative of the quality of the emitted tone.

The wave form and harmonic content of the physical vibration of the tongue itself, however, are very much simpler than that of the sound waves produced by the air pulsations initiated by the motion of the tongue. Actually the tongue is, in effect, merely a vibratory air valve, self starting and stopping, under the control of the playing keys and having a fundamental frequency determined by its length, mass, stiffness, etc. The present invention obviates the need for reliance upon air pulsations to produce audible tones by translating the physical vibrations of the tongue into musical tones through an electrostatic pick-up operated in conjunction with a suitable electronic translating, amplifying and reproducing apparatus.

An object of this invention is the provision of an improved, electronic, musical instrument of the vibratory reed type including means for controlling tone quality.

An object of this invention is the provision of a novel capacity pick-up arrangement for translating physical vibrations of a vibrating tongue into electrical variations.

An object of this invention is the provision of a reed for musical instruments comprising a vibratory tongue having a distal end spaced from a set of electro-static pick-up electrodes said pick-up electrodes presenting different surface configurations to the end of the tongue and being adjustable with respect to each other and the tongue, whereby vibration of the tongue results in different and distinct variations in capacity between the tongue and each of the electrodes.

An object of this invention is the provision of a reed for electric accordions and the like and comprising a base having a longitudinally-extending aperture therein, a vibratory tongue alined with said aperture and having an end secured to the base, a first pick-up electrode secured to the base and having an end spaced from and alined with the free end of the tongue, and a second pick-up electrode secured to the base and having an end laterally offset with respect to the tongue, said second electrode having a surface formed to provide a non-uniform spacing with respect to the arc formed by the free end of the tongue when the latter is vibrating.

An object of this invention is the provision of

a vibratory reed type musical instrument wherein the vibratory tongue is associated with a set of capacity type pick-up electrodes that are connected in a tuned oscillator circuit and including manually adjustable control means for selectively varying the contribution of each pick-up to the combined frequency modulated action of the circuit.

An object of this invention is the provision of a vibratory reed having means for abruptly terminating the vibrations of the tongue.

An object of this invention is the provision of a reed rank comprising a plurality of reeds removably mounted upon a reed board and including novel means for securing the reeds to the said board whereby individual reeds may be replaced quickly and conveniently.

These and other objects and advantages will become apparent from the following detailed description when taken with the accompanying drawings which illustrate several embodiments of the invention. The drawings are for purposes of illustration and are not intended to establish the scope or limits of the invention, reference being had for the latter purpose to the claims appended hereto.

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

Figure 1 is an isometric view illustrating a reed provided with an electro-static pick-up arrangement made in accordance with this invention;

Figure 2 is a longitudinal, cross-sectional view taken along the line A—A of Figure 1;

Figure 3 is a plan view of the Figure 1 device with the upper pick-up electrode omitted to show how the lower electrode fills one end of the aperture in the reed base to prevent unnecessary air leakage therethrough;

Figure 4 is a fragmentary, plan view illustrating a plurality of reeds (minus the pick-ups) mounted on a reed board and showing the electrical bus bars to which the individual reeds and pick-ups are connected;

Figure 5 is a cross-sectional view taken along the line B—B of Figure 4 showing the construction for attaching individual reeds to the reed board and for establishing electrical connection to vibratory tongues;

Figure 6 is a cross-sectional view taken along the line C—C of Figure 4;

Figure 7 is a transverse, cross-sectional view taken along the line D—D of Figure 4 and includes a complete reed (with pick-up electrodes as shown in Figure 2) mounted on the reed board;

Figure 8 is a cross-sectional view similar to Figure 2 but showing a different arrangement of the pick-up electrodes;

Figure 9 is a diagram showing the vibratory tongue and pick-up electrodes connected to an electronic translating system;

Figures 10, 12 and 14 are representations of the vibratory tongue and an associated pick-up electrode with different spacing therebetween;

Figures 11, 13 and 15 are capacity curves for the Figures 10, 12 and 14 arrangements, respectively; and

Figure 16 is a central cross-sectional view illustrating my novel arrangement for the abrupt termination of the tongue vibrations.

Reference is now made to Figures 1 and 2 which illustrate the general construction and assembly of a reed and electrostatic pick-ups serving as a means for translating physical vibrations of the reed into corresponding electrical oscillations. A

vibratory tongue 20, made of steel or other suitable metal, has a proximal end fastened to a reed base 21 as by the rivets 22. The tongue 20 preferably is tapered both in thickness and in width to smaller dimensions at the distal or free end thereof in order to promote good harmonic content of its vibrations and to insure quick response and decay of its vibrations in response to the influence of air flow past its edges and through the associated aperture 23 in the base 21. The tapering of the tongue generally is desirable for reeds designed to have a natural vibration frequency in the middle or treble tone registers while for base tones the reed may be untapered, and even loaded, to secure low vibration frequency without excessive reed length.

As is well-known in the art, a tongue mounted upon a base as shown in the drawings will be set into vibration by air flowing in the direction indicated by the arrow, *a*. A metallic contact plate 29 is secured to the base 21 by the rivets 22, said plate serving to facilitate the establishment of electrical contact to the metallic tongue 20, as described hereinbelow.

In an instrument such as the accordion wherein air flow is established by alternate compression and expansion of a bellows it has, heretofore, been necessary to provide two identically tuned reeds for each tone, one reed being set into vibration when the bellows are compressed and the other when the bellows are expanded. The reed arrangement shown in Figures 1 and 2 is of this type, that is, it will not vibrate when the direction of the air flow is in a direction opposite to that indicated by the arrow, *a*. For purposes of clarity of disclosure and to facilitate a proper understanding of the present invention the companion reed of the dual reed complement is neither illustrated nor described, it being understood that the electro-static pick-up arrangements described herein with reference to the single reed apply to each reed employed in the particular musical instrument. It may also be stated here that my novel electrostatic pick-up arrangement is adapted for use with reeds that are designed to vibrate in response to air flow in either direction, such reed construction being shown in my copending application Serial No. 117,992, filed September 27, 1949.

Referring again to Figures 1 and 2, two capacitive pick-up electrodes 25 and 26 are mounted individually on the base 21 as by the screws 27 and 28, respectively. The electrodes 25, 26 are electrically insulated from each other and for this purpose the base 21 preferably is made of an insulating material having a low dielectric loss factor at radio frequencies, such as polystyrene, or similar plastic, capable of being molded or machined. Each of the electrodes 25, 26 is adjustable individually with respect to the distal end of the vibratory tongue 20, as by bending and/or by providing elongated slots through which the respective mounting screws 27, 28 pass, as shown.

Pick-up electrode 25 consists of a narrow strip of metal, or other conductor, of approximately the same cross-sectional dimensions as the tongue tip and having a flat end face presented to the flat end face of said tongue. Normally, the electrode is positioned so that the spacing between the electrode and the tongue is very small, say, from .001" to .005". Also, the width of the electrode equals the width of the aperture thereby preventing undesirable air leakage through this portion of the aperture, see Figure 3.

Pick-up electrode **26** is also a thin strip of metal, or other suitable material, but has a reversely bent end section such that the spacing between the end of the tongue **20** and the surface of the electrode gradually decreases as the reed moves upward toward the position of maximum amplitude. This will be apparent from Figure 2 in which the arc *b*—*b*, represents the arc described by the end of the tongue **20** during the vibration cycle.

A series of complete reeds, including the pick-up electrodes, may be mounted adjacent to each other on a reed board **30**, as shown in Figure 4, said reed block being made of wood or, if preferred, of a material having a low dielectric loss factor at high frequencies. Individual reeds may be secured into fixed position by means of T-shaped members **31** secured to the block **30** by screws **32**. The T-shaped members serve to space the reeds laterally along the block **30** and, in effect, act as clamps to secure the individual reed bases **21** to the block, as better shown in Figures 5 and 6.

A bus bar or contact strip **33** extends along one edge of the block **30** said strip serving as a common electrical connection to all of the vibratory tongues **20** of the individual reeds. As shown in Figure 5, which is a longitudinal, cross-sectional view taken along the line B—B of Figure 4, the attachment of the reed to the block **30** automatically establishes electrical contact between the tongue **20** and the contact strip **33** through the rivets **22** and the contact plate **29**. A somewhat similar contact strip **35** extends along the opposite edge of the block **30** and serves as a means for establishing electrical connection to each of the individual pick-up electrodes **25**. The contact strip **35** is, however, provided with a series of spaced notches **36** to clear the mounting screws **32** that secure the T-shaped members **31** to the block **30**, as shown in Figure 6 which is a longitudinal, cross-sectional view taken along the line C—C of Figure 3. A third contact strip **37** lies spaced from the contact strip **35**. Each of the longitudinally-extending contact strips **33**, **35** and **37** may be molded into the reed block **30** if the said block is made of moldable material such as polystyrene. Alternatively, the contact strips may be secured to the block **30** by small, flush type screws (not shown) in the event the block is made of wood. In any case the contact strips are fixed with respect to the block **30** and spaced for minimum capacity.

Figure 7 is a central cross-sectional view taken transversely of the block **30**, as along the line D—D of Figure 3, and longitudinally of a reed mounted thereon, said reed being identical to that shown in Figure 2. As explained hereinabove, the individual tongues **20** are electrically connected to the contact strip **33** (through the rivets **22** and the plates **29**) and, consequently, all of the tongues can be connected in parallel into an electrical circuit by means of a single wire **40** soldered to the strip **33**. Similarly, each of the individual pick-up electrodes **25** (one associated with each tongue **20**) are connected to the contact strip **35** through the flat surface by which each such electrode **25** is secured to the individual reed base **21**. Therefore, all of the pick-up electrodes **25** can be connected, in parallel, into an electrical circuit by means of a single wire **41** soldered to the contact strip **35**. It is again pointed out that electrical connection of the vibratory tongues **20** to the contact strip **33**, and of the electrodes **25** to the contact strip **35**, is accomplished through physical contact when the complete, individual reed is mounted upon the reed block **30**. Electrical connection to the other series of pick-up electrodes **26** is accomplished by a series of spring contacts **42** secured to the third contact strip **37** by screws **43**. Each of the spring contacts **42** is associated with a specific pick-up electrode **26** and makes a pressure contact therewith. As all contacts **42** are fastened to the contact plate **37**, all pick-up electrodes **26** can be connected into an electrical circuit, in parallel, by a single wire **44** soldered to the strip **37**. Alternatively, the contact strip **37** and the series of spring contacts **42** can be punched from a single piece of metal.

The above described construction facilitates the replacement of defective reeds. To remove a complete reed it is necessary merely to loosen the screws **32** of adjacent T-shaped members **31** and slide the complete reed in a direction away from the spring contact **42**. The installation of a substitute reed is done by reversing this simple procedure. The dimensions and disposition of the T-shaped members are prechosen so that the mounting of the reed results in an automatic alinement of the reed aperture **23** in the base **21** with the associated aperture **45** in the block **30**. To provide unrestricted air flow the aperture **45** may be made somewhat larger than the aperture **23**.

The specific construction of the air passageways for directing a flow of air against the individual vibratory tongues **20** is well-known in the art and, therefore, is neither shown nor described in this application. Side by side rows of complete reeds form reed ranks and these may be dispersed in any suitable manner in correlation with the control valves and playing keys, as best suits the design of the particular instrument.

Figure 8 illustrates a modified construction of the reed base and pick-up electrodes. In this case the length of the aperture **23'** is sufficient to afford proper vibration of the tongue **20**. The aperture beyond the distal end of the tongue is closed by the ledge **50** against which the active end section of the pick-up electrode **25'** abuts, as shown. It will be obvious that the reed base **21'** can be molded, or otherwise formed, so that the ledge portion, while integral with the base, will be disposed somewhat above the end of the tongue **20** whereby the end of the pick-up electrode **25'** will be alined with the adjacent end of the tongue. The other pick-up electrode **26'** has a bent end portion reverse to that of the electrode **26** of Figure 2. Specifically, the spacing between the electrode face and the end of the tongue increases as the tongue moves upward along the arc *b*—*b*.

It will be apparent the specific individual pick-up electrodes shown in Figures 2 and 8, and their relative disposition with respect to the vibratory tongue, can be intermixed on any individual reed to provide desired capacity variation characteristics. The tongue **20** need not be made of a solid metallic material and may comprise an insulating material having an electrical conductor coated or deposited upon the surface. The reed tongue may also be made of a high dielectric capacity material, moulded integrally with its base. In this case the reed varies the distributed capacity between the pick-up electrodes and surrounding conductors, as the reed vibrates. The pick-up electrodes should be made of a suitable material and so proportioned that they are not themselves

subject to vibration in order to preserve the capacity modulations for tongue vibrations only.

While the reeds illustrated and described are of the air operated type the electrostatic pick-up electrodes are not limited to use therewith as it will be apparent the mechanico-electrical translating arrangement (when used with reeds otherwise excited and combined with a suitable oscillator, detector, amplifier and loud speaker), will produce music electronically and, therefore, does not rely upon direct air pulsations set up by motion of the vibratory tongue.

The electronic translating system for transducing the modulations in capacity between the vibratory tongue and the pick-up electrodes may be of any known type such as, D. C. polarized, audio or radio frequency, amplitude modulated, or a frequency modulated circuit which is shown in Figure 9 as an example. The oscillator circuit comprises a three element oscillator tube **55**, an inductance coil 56 connected in the input circuit of the tube, an inductance coil **57** connected in the output circuit of the tube and variably coupled to the coil 56, a source **58** of plate potential included in the output circuit, and a grid bias resistance 59 common to the input and output circuits. The total capacity which, with the coil **56**, forms the tuning circuit of the oscillator, includes the variable condenser **60** shunted across that coil, the variable condenser **61** that is connected between the condenser 60 and the rotor plate **62** of the differential condenser **63**, and the capacity between the vibratory tongue 29 and each of the pick-up electrodes 25, 26; the tongue being connected to the cathode of the tube and the pick-up electrodes 25, 26 being separately connected to stationary plates of the differential condenser **63**, as shown.

With the coupling of the coil 56 to **57** suitably adjusted in phase and degree, the circuit will oscillate at an average frequency determined by the capacity values of the several condensers and the average or mean value of the capacities between the tongue and the electrodes. Upon vibration of the tongue the oscillatory variations in the last mentioned capacities will oscillatorily vary the total tuning capacity of the oscillator and hence the frequency of its oscillations. The amplitudes, frequencies and wave forms of the swings of the oscillator frequency will be directly responsive to the amplitudes, frequencies, and wave forms of the tongue vibrations as seen by the electrode system.

Adjustment of the condenser **63**, while it may necessitate a slight readjustment of either one of the condensers 60, 61 relative to the other to preserve precisely a predetermined mean frequency, will not materially change that frequency. This condenser is provided as a quality, rather than a frequency, control. Thus, movement of the rotor 62 of the condenser **63** will progressively vary the relative contributions, to the wave forms of the frequency swings, of the capacity between the tongue and the electrode **25** on the one hand and the capacity between the tongue and the electrode 26 on the other.

Frequency-modulated oscillations of the oscillator circuit are made available at the terminals 65 in any convenient manner, as by the coil **66** coupled to the coil 56 (or coil 57). To control the amplitude of the output oscillations the coupling of the coils 56 and 66 may be made variable and additionally or alternatively a potentiometer **67** may be employed. Figure 9 shows the output terminals **65** supplying output oscillations to the input of a tuned intermediate frequency amplifier **68** tuned to the two-thirds (⅔) resonant point with the average oscillation frequency of the tube **55**, and which may be followed in cascade by a detector or demodulator 69, volume control **70**, audio frequency amplifier **71** and loud speaker or other electro-acoustic translating device **72**. Alternatively, a conventional type of FM–RF discriminator, followed by an AF amplifier and loud speaker, may be used.

A more detailed description of the electronic translating system will be found in my United States Patent No. 2,273,975 issued February 24, 1942. The description given above is sufficient for an understanding of the functions of the illustrated reed and pick-up arrangements insofar as concerns their arrangement in a complete electronic device for the production of music.

The complete electrical translating and reproducing apparatus need not be self contained within the instrument. Reproduction of the instrument's electrical tonal output at a somewhat remote point without the use of a connecting wire or cable may be desirable. Such an arrangement is useful in professional entertainment use as in restaurants, stage productions, etc. where the accordionist may be required to stroll about as he performs. For this purpose a battery operated electronic translator may be utilized for the capacity variations between the vibratory tongues and associated pick-ups. This would comprise a diminutive, frequency-modulated R. F. oscillator, together with a small antenna or coil radiator, which transmits the frequency-modulated oscillations of the reed-modulated oscillator to a remote receiver fixed-tuned to the oscillator mean frequency. The amount of radiated power would be so low and of such frequency that it requires no license by the Federal Communications Commission since it will cause no more interference than normal I. F. oscillators of conventional A. M. and F. M. broadcast radio receivers.

As shown in Figure 2, the pick-up electrode 25 is opposite the free end of the tongue 29, that is, when the tongue is in the neutral, or "at rest," position the adjacent end faces of the tongue and pick-up are in substantial alinement. In such arrangement the end of the tongue sweeps past the end of the electrode a maximum velocity during its recurrent vibration cycle. This sets up capacity modulations between the tongue and the electrode which, with very small spacing between them, produces highly peaked pulsations in capacity. With the tongue and electrode connected in an oscillator circuit such peaked pulsations of the capacity produce correspondingly peaked modulations in the oscillator frequency which, after translation into sound waves by a suitable receiver and reproducer, are heard as reed tones having higher partials with considerable frequency doubling due to the asymmetrical action of the electrode. If the pick-up electrode is placed at the exact axis of the tongue vibrations the fundamental frequency will be completely eliminated and the tongues spectrum of frequencies will be doubled. Vertical adjustment of the electrode 25, therefore, acts as a control for the amount of this frequency-doubling action. Translation efficiency adjustments of the pick-up are made by minute adjustment of the clearance to the tongue tip, which also effects the tone quality of the reproduced tone.

The pick-up 26, by reason of its formation and

disposition with respect to the vibratory tongue **20**, produces a much slower variation in capacity because the tongue velocity is diminishing and reaches zero at its upper limit of travel and also because of the slow angular approach of the tongue tip to the face of the pick-up. It, therefore, strongly emphasizes the fundamental and lower order of partials of the reed vibration and, consequently, the tone reproduced at the receiver is of much fuller, deeper, less strident quality.

Output volume adjustments of the tone, while influenced by the above adjustments, may further be made by bending the pick-up electrode **26** laterally out of alinement with the tongue **20**. This provides a "variable area" type of adjustment which affects, almost wholly, only the volume of the reproduced tone and is particularly useful in compensating for irregularities in loud speaker characteristics.

For efficient translation by the pick-ups, their spacing from the vibratory tongue should be small, preferably not greater than the thickness of the tongue and, in general, of the order of a few thousandths of an inch. For large spacings the pick-up electrode "sees" the tongue as a whole with respect to its capacitative coupling with the tongue and, for these relatively large spacings, the capacity modulations, as the tongue vibrates, are relatively flat since the remote ends of the tongue and electrode are a relatively important part of the total capacity-forming electrodes. Figure 10 illustrates the tongue **20** and the electrode **25** separated by a large spacing denoted by the letter *d*. The spacings between the dotted lines represent an approximation of the capacitive flux lines, or a rough measure of the field intensity. The spacing of these lines is closer directly between the end faces of the tongue and electrode and this spacing increases in proportion to the relative lengths of the curved field lines between the two members.

Figure 11 shows a curve T representing the amplitude of the tongue deflection as the tongue vibrates through the angle θ on each side of its axial, "at rest," position. For the sake of simplicity the cycle of tongue vibration is considered as a sinusoidal wave motion. The straight line C_M represents the maximum capacity between the tongue and electrode which prevails when the tongue is in the "at rest" position. As the tongue moves to the dotted line position (Figure 10) the capacity decreases after which a reversal of tongue motion produces an increasing capacity. The varying capacity for one complete cycle is shown by the curve C_V. It will be noted the curve C_V is relatively flat; that it is less flat where the tongue passes through its zero or "at rest" position at which point its velocity is the maximum; that it is flatest at the angle θ at which point the tongue velocity is zero and a reversal of direction occurs; that there is some finite capacity C_F always present; that this finite capacity is large compared to the modulations of capacity; and that the capacity modulation frequency is twice that of the reed frequency. Such results are to be expected where the distance *d* is say 10 times the tongue or electrode thickness.

Figures 12, 13 and 14, 15 are similar to Figures 10, 11 but for smaller spacing between the vibratory tongue and electrode. In Figure 12 the flux lines are much more concentrated between tongue and electrode end faces with a relatively much smaller flux in the leakage flux field. Consequently, the maximum capacity C_M is substantially higher while the ever present finite capacity C_F remains the same. The modulated capacity curve C_V has correspondingly increased peaks where the tongue motion has maximum velocity but the frequency doubling feature remains. Figure 15 depicts the corresponding curves under the condition in which the spacing between the tongue and the electrode is of the order of one tenth the tongue thickness. The capacity ordinate has been made logarithmic in order to shown the relations between C_M and C_F on a reasonable scale. It will be noted that the modulated capacity peaks are very steep and that the modulated component outweighs by far the minimum finite capacity C_F.

A radically different set of capacity modulation curves will be obtained between the vibratory tongue and the second pick-up electrode **26** or **26'** and, in fact, for different positions of the electrode **25** (as, for example, the electrode **25'** of Figure 8) with respect to the end face of the tongue. These different capacity modulation effects can be utilized in the electrical circuit to produce desired, audible tonal effects.

In practice, a plurality of vibratory tongues, with individual pick-up electrodes, are used so that a single tongue and pick-up has shunted across it the combined individual capacities of the other tongues and pick-ups, as well as stray capacities between the connection strips and the capacities of trimmer condensers. Thus, in an actual musical instrument employing 100 tongues the total capacity may be 500 micro-microfarads. Of this total capacity the modulations produced by a single tongue must be ample to produce a significant change in the frequency of the oscillator. This can be achieved by employing a small spacing between the electrodes or by placing the two pick-up systems in a capacity bridge circuit which permits balancing out the relatively large unmodulated portion of the total capacity, as is well known in the art.

It has been pointed out that the electrode **25** (spaced end-wise with respect to the tongue **20**) has an asymmetrical frequency doubling action in translating the tongue's vibratory motion into capacity modulations. This is desirable for the development and amplification of the higher (relative to the lower) partials of the tongue's spectrum of frequencies in order to make available thinner, more string-like tone qualities in the sound output of the electro-acoustical apparatus. It may be pointed out that the asymmetrical action of the individual pick-ups in translating capacity modulations of the tongue vibrations into frequency modulations of the oscillator do not introduce distortions of the reproduced sound in the commonly accepted meaning of this term. Each pick-up distorts the translated wave form of its own tongue to introduce higher harmonic frequencies which may not be present in the wave motion of the tongue itself but in this action the effect is the same as if the tongue motion itself were changed to change the relative amplitudes among the individual components within the frequency spectrum.

It is further evident that both amplitude and tone quality voicing adjustments are provided for by the pick-up construction disclosed herein as by bending the pick-up electrodes.

In conventional acoustic reed instruments the physical size of the individual reeds increases from the high treble to low bass pitches in order to approach a balanced sound-power output be-

tween such reeds and higher pitch reeds which have ample individual tone power. The inherent difference in sound-power output is due to the relatively larger mass of air that must be vibrated, or pulsated, by the lower pitch reeds. However, there are physical limitations to the increase in length and width of the reeds. In conventional practice the individual reeds are increased in size up to a practical maximum and where this is still insufficient, multiple, like-tuned reeds of maximum size are used. In an electronic instrument, however, the physical size of the reeds has little or no significance, so that relatively small reeds may be used. This is advantageous in decreasing the overall size, weight, air volume requirements, etc., so as to make possible smaller, lighter and cheaper instruments.

Another feature of my invention pertains to the production of tremolo or vibrato effects. In the conventional accordion these effects are produced by use of one or more extra sets of reeds tuned 6–8, or so, vibrations sharp or flat from the main section of reeds. When so coupled to the playing keys or buttons that these extra, off-tone reeds are vibrated simultaneously with the main reeds, each such pair of simultaneously sounding reeds produce, in the listening ear, a pulsating beat equal in frequency to the difference between the individual reed frequencies. Produced also are summation tones equal to the sum of the reed frequencies. Secondary, tertiary and higher order sum and difference components are also produced between like numbered higher partials of the two reeds. A complete analysis of this phase of such operation is not here necessary since it is known by those skilled in the art, and since the net effect, useful to musicians, is merely a type of tonal effect known variously as tremolo, vibrato, vox-humana, etc. Nor need I discuss in detail the more subtle differences, physically, between tremolo and vibrato effects. Of chief interest in this connection is the provision, by electronic means, of tremolo and vibrato effects without resort to duplicate, off-tone reeds so that such reed ranks may be eliminated from the accordion structure.

To accomplish the above results I provide a 6 to 8, or so, cycle variation of a small capacity connected in the tuned oscillator circuit to cause corresponding modulations of the oscillator frequency. Such a "vibrato" condenser **74** (dotted lines in Figure 9), may consist of a heavily-loaded reed actuated by an air stream and provided with a capacity pick-up electrode, said reed and pick-up being connectable in series between the condensers **61**, **62**. In conventional accordion practice, these effects are obtained by a separate reed of large size disposed in the air reservoir for the purpose of modulating the air pressure effective upon the reeds. Such design is wasteful of air which must be supplied by compression or expansion of the bellows. Other methods for producing the "vibrato" effects are known such as, periodic variation of amplifier gain, rotating capacitors or air valves, etc., but, in general, these methods are more complicated and less reliable than the illustrated vibratory reed and pick-up.

In conventional, air-blown, direct-radiating instruments, the acoustic tone in air ceases abruptly when the key controlled pallet is closed even though the tongue vibrations continue for some length of time, determined by the natural decrement of the vibratory tongue. Obviously, in an electronic musical instrument the translating system remains fully sensitive so that the output tone continues as an overhang which limits the effective speed of repetition of a given tone, staccato effects, etc. This is especially noticeable with the lower fundamental frequency tongues which, when loaded, particularly emphasize this undesirable effect. Electrical time delay devices may be used under certain conditions to overcome this effect. In pianos and similar instruments where the vibrators act through air coupling devices such as sound boards, or in a celeste, carillon, etc. where the vibrator is directly relied upon as a sound radiator because of its large surface area, mechanical dampers are utilized to damp out the vibrations when the actuating key is released. In instruments such as the organ and accordion involving pulsating air waves, mechanical dampers are not of practical effect or significance. However, when the latter type instruments employ electronic amplification, mechanical, or other rapid means for selective tone termination, is both desirable and necessary.

In Figure 16 I show a simple and efficient mechanical damper of soft, yieldable, but energy-absorbing material attached to the pallet so that closure of the pallet places the damper in contact with the surface of the vibratory tongue thereby quickly terminating the vibrations when the air flow is stopped. The keyboard **75** carries the push-button **76** that passes through a close-fitting, free slipping hole therein. The push-button may be operated directly by the finger of the musician or by means of pivotally mounted keys, as is well known in the art. The inner end of the button is formed into a head which carries a washer **77** made of cork, rubber or the like, to provide an air-tight joint with the board **75**. A circumferential groove in the head of the button accommodates a wire spring **78** having a spade-shaped end **79** anchored in the board **75**, said spring insuring close contact between the washer **77** and the surface of the keyboard when the button is released.

The head of the button **76** is alined with a "click-silencing," felt or leather pad **80** affixed to the pallet **81** that comprises a wood, plastic or metal strip carrying the gasket **82** at the other end. This gasket, which may be made of any suitable material such as leather, rubber, etc., normally covers the aperture **83** in the reed block **84**. Pallet **81** is pivotally mounted on the reed block **84** by means of a pin **85** and bracket **86**. A wire spring **87** having a flattened, spade-shaped end **88** anchored in the reed block presses downward in the groove **89** in the upper surface of the pallet thereby maintaining the pallet in a normally closed position and preventing escape of air through the aperture **83**. Attached to the pallet is a post **90** extending into the aperture **83** and carrying a damper pad **91**. The post **90** may be threaded into the pallet providing an adjustment for the downwardly-acting pressure of the pad **91** against the vibratory tongue **92**, it being noted that the post and/or pad extends through the aperture **93** in the base **94** carrying the tongue. The pad **91** preferably is made of a visco-elastic material of soft, yieldable composition whose deformation requires energy expenditure, much of which is not recovered by the deformed tongue **92**, and which acts, therefore, to absorb vibrational energy from the tongue. The pad material must be sufficiently yieldable so that the tongue will not clatter noisily against it throughout the decaying vibrations preceding

actual termination of the tongue motion. Also the pad should not materially affect the pitch, or vibration frequency, of the tongue during the short damping period because the entire decadence of vibration is translated down to very low vibration amplitude of the tongue and will appear as reproduced sound in the reproducer. The damping rate is a critical factor as too high a rate will result in a "key-thump" transient in the entire system, including the reproducer. Furthermore, the pad 91 should not shed lint, hairs or other matter which could lodge in the narrow clearance space between the vibratory tongue 92 and the walls of the aperture 93, and its effectiveness should remain constant through wide ranges of ambient temperature and humidity. Such materials as Vinylite or butyl rubber in sponge form, with many fine air-passages or perforations therein, is satisfactory, and other suitable materials will suggest themselves to those skilled in this art. If such air-passages are open and of capillary nature, the air friction due to motion of the air through the passages, both during compression and expansion of the pad material, will further increase the compressional viscosity of the pad. It will be apparent other than compressional types of pad may be used such as those in which bending or shear stresses develop energy losses by internal hysteresis.

When the button 10 is depressed the pallet pivots to open the alined apertures 83, 93, and the passage of air therethrough sets the tongue 92 into vibration. The coacting parts are so designed that when the button is in the depressed position the pad 91 will be moved clear of the tongue when the tongue occupies a position of maximum deflection. Upon release of the button the pallet returns to the normal position wherein the gasket 82 closes the aperture opening thereby cutting off the flow of air past the tongue. At the same time, the pad 91 presses against the vibratory tongue thereby damping its vibrations. I prefer to adjust the effective length of the post 90 and pad 91 such that when the pallet is in the normal, aperture-closing position the pad will force the tongue to a point somewhat beyond that which it normally would occupy with respect to the adjacent surface of the base 94. Consequently, when the tongue is in the "at-rest" position it will be biased mechanically in a direction opposed to the direction of air flow through the apertures; direction of air flow being indicated by the line X. Such initial biasing of the tongue provides a beneficial effect in increasing the speed of vibration build-up to a maximum. Release of the pad pressure against the tongue permits the tongue to start its first cycle of vibration independent of, but in addition to, the force of the air stream when the pallet is opened. This construction increases the speaking speed of the tongue with respect to depression of the playing key and, also, as a reverse effect, accelerates the speed of vibration decay when the playing key is released.

For slow key depression this increase in the speaking speed of the tongue will not be effective but at increased speeds of key depression the speed of tonal attack will be increased thereby providing a very much desired response control for staccato effects. For slow key depression the tongue will build up its vibration amplitude at conventional speed since the damping pad will not move away from the tongue fast enough to impart any appreciable velocity thereto. Consequently, the tongue amplitude will start at zero and build up to a steady maximum determined by the air-pressure, as occurs in a conventional instrument.

A damper of the type described is useful in connection with other than reed-type, electrically-transduced, electronic instruments. It may be used with conventional, acoustical instruments such as the piano, accordion, celeste, etc., and with other types of vibrators such as tuned bars, rods of an electric carillon apparatus, etc.

From the foregoing disclosures it will be apparent my invention makes possible a more truly portable accordion. Novel tonal effects may be produced without resort to extra or duplicate reeds thereby reducing substantially the required air system of the instrument. The reeds may be of diminutive size which further reduces the load upon the bellows. The reproduced tone qualities are vastly superior, musically, to those of conventional accordions, especially the piano accordion. In effect the accordion becomes a portable type of electronic organ when tied in with a remotely positioned reproducer. Tone swelling is accomplished by bellows control so that many, if not all, of the effects producible by advanced types of organs are obtainable with my accordion.

Complete acoustical shielding of the inherent tone produced by the reed is possible by employing felt covered air inlet and exhaust apertures in combination with felt lined air ducts leading thereto. By eliminating the unmusical, sound-in-air tones produced by the air flow modulations through the reed apertures and utilizing electronic translation of the tongue's physical vibrations, I am able to produce tones of great beauty, selectively variable quality, and very wide range of amplitude. Quality and amplitude may be controlled by reed vibration amplitude through bellows manipulation or by electronic quality and amplitude controls located on the instrument within easy reach of the artist. Thus, with low amplitude reed vibration and high electronic amplification it is possible to produce strong output tones of smooth quality or, conversely, strident tones at low volume by the employment of high amplitude reed vibration and low electronic amplification.

Conventional pick-ups are, so far as I am aware, located in the path of travel of the vibratory member and, consequently, the pick-up sensitivity is limited by the maximum vibration amplitude which will not result in physical contact between the vibratory member and the pick-up. Such contact results in a short circuit producing the well-known, thunderous noise in the loud speaker. With my pick-up arrangement the vibratory member can never touch the pick-ups yet very high sensitivity is had.

Although the drawings illustrate practical embodiments of the invention, various modifications in the individual parts and/or their arrangement with respect to each other will suggest themselves to those skilled in this art. The specific form, location and relative disposition of the contact strips, that serve as a means for making electrical contact to the tongue or individual pick-up electrodes, are subject to considerable design choice. Functionally, these parts should be well spaced from each other to minimize the capacity between them and should be anchored firmly to prevent relative displacement. In this respect, a molded insert type of construction is desirable. Further, I do not limit

myself to the particular reed-vibration, translating device disclosed herein as other translating systems may be employed with my novel vibratory tongue and dual pick-up arrangement. Neither is the vibratory member limited to air blown reeds as it is apparent rods, bars, strings, or other mechanically excited types of vibrators may be employed.

It is intended that these and other variations and modifications occurring to those skilled in the art shall fall within the spirit and scope of the invention as recited in the following claims.

I claim:

1. A reed rank comprising a reed board having a series of apertures therein, individual reeds disposed on the surface of the reed board each of said reeds including a base having an aperture alined with an aperture in the reed board and T-shaped members removably attached to the surface of the reed block, the shank portions of individual T-shaped members being disposed between adjacent reed bases and the opposed arms of the T overlying a portion of the surface of adjacently disposed reed bases.

2. A reed rank comprising a reed board having a series of apertures therein, a first contact strip extending along one edge of the reed board, a second and a third contact strip extending along the opposed edge of the reed board, individual reed bases disposed over each aperture in the reed board, a metallic vibratory tongue carried by each reed base, means establishing electrical contact between each of the said tongues and the first contact strip, a first pick-up electrode carried by each reed base, means establishing electrical contact between each of said first pick-up electrodes and the second contact strip, a second pick-up electrode carried by each reed base, means establishing electrical contact between each of said second electrodes and the third contact strip, and means removably securing each of said reed bases to the reed board.

3. The invention as recited in claim 2, wherein the means securing the reed bases to the reed board comprises a plurality of T-shaped members engaging the top surfaces of adjacently disposed reed bases, and the electrical contact between the vibratory tongues and the first pick-up electrodes and the first and second contact strips respectively is made automatically when the reed base is secured to the reed board.

4. The invention as recited in claim 2, wherein the vibratory tongues are secured to the individual reed bases by electrical conducting members extending to the bottom surface of such reed base and into contact with the first contact strip, and the first pick-up electrodes extend to the bottom of the reed base and into direct contact with the said second contact strip.

5. The invention as recited in claim 4, wherein electrical contact between the third contact strip and the individual second electrodes is made by individual spring contact members.

6. A vibratory reed and pick-up arrangement for electronic musical instruments comprising a base of insulating material having an aperture therein; a vibratory reed alined with said aperture and having an end secured to one end of the base; a first pick-up in the form of a relatively-thin, rectangular plate secured to the other end of the base and having a free end that is longitudinally spaced from and substantially parallel to the free end of the reed; and a second pick-up in the form of a relatively-thin, rectangular plate having an end secured to the other end of the base and including a flat surface portion spaced from and inclined at an angle relative to the surface of revolution generated by the free end of the reed when the latter is vibrating.

7. The invention as recited in claim 6, wherein the free end of the first pick-up is alined with the free end of the reed resulting in a maximum capacity between the reed and pick-up when the reed is in the at rest position, and the said flat surface portion of the second pick-up lies in a plane forming an acute angle with the plane of the reed resulting in a maximum capacity between the reed and pick-up when the free end of the reed is in the maximum deflected position.

8. The invention as recited in claim 6, wherein the widths of the two pick-ups are substantially equal to that of the reed.

9. A vibratory reed and pick-up arrangement for electronic musical instruments comprising a base of insulating material having an elongated aperture therein; a metallic reed alined with the aperture and having one end secured to one end of the base; a first pick-up in the form of a relatively-thin, rectangular plate having one end secured to the other end of said base and including a flat surface portion lying in a plane substantially parallel to the plane of the reed, said flat surface portion terminating in an end that is substantially parallel to and spaced longitudinally from the free end of the reed; and a second pick-up in the form of a relatively-thin, rectangular plate having an end secured to the other end of the base, said plate having a transverse bend intermediate of the ends providing a surface portion that is spaced from and inclined at an angle relative to the surface of revolution generated by the free end of the reed when the reed is vibrating.

10. Th invention as recited in claim 9, wherein the widths of the two pick-ups are substantially equal to that of the reed.

11. The invention as recited in claim 9, wherein the reed and the second pick-up are each secured to the top of the base, the first pick-up is secured to the bottom of the base, and the first pick-up includes a central portion extending upwardly through the aperture in the base.

12. The invention as recited in claim 11 including a contact plate secured to the bottom of the base and electrically connected to the reed.

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