

Oct. 29, 1935.

R. H. RANGER

2,018,924

APPARATUS FOR PRODUCING MUSICAL TONES

Filed Oct. 29, 1932

2 Sheets-Sheet 1

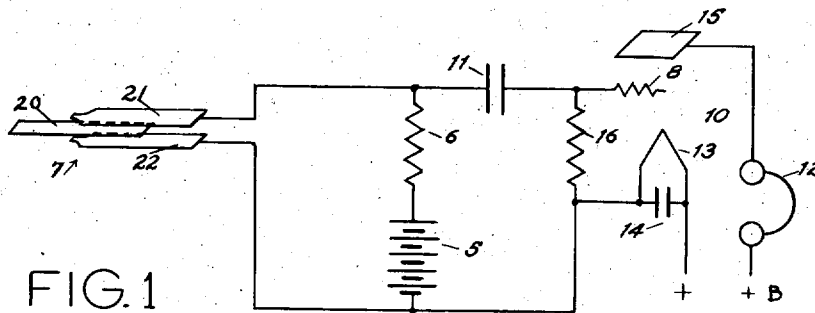


FIG. 1

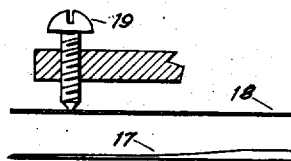


FIG. 2

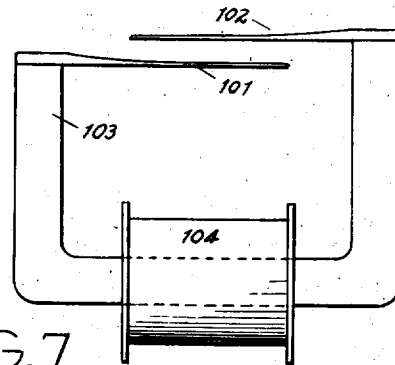


FIG. 7

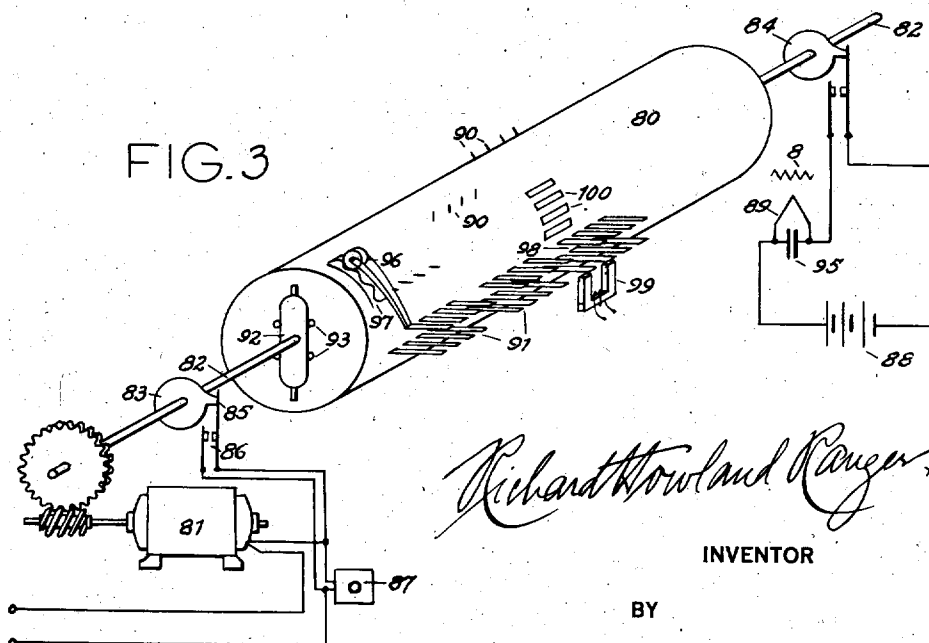


FIG. 3

Richard Howland Ranger

INVENTOR

BY

ATTORNEY

Oct. 29, 1935.

R. H. RANGER

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2 Sheets-Sheet 2

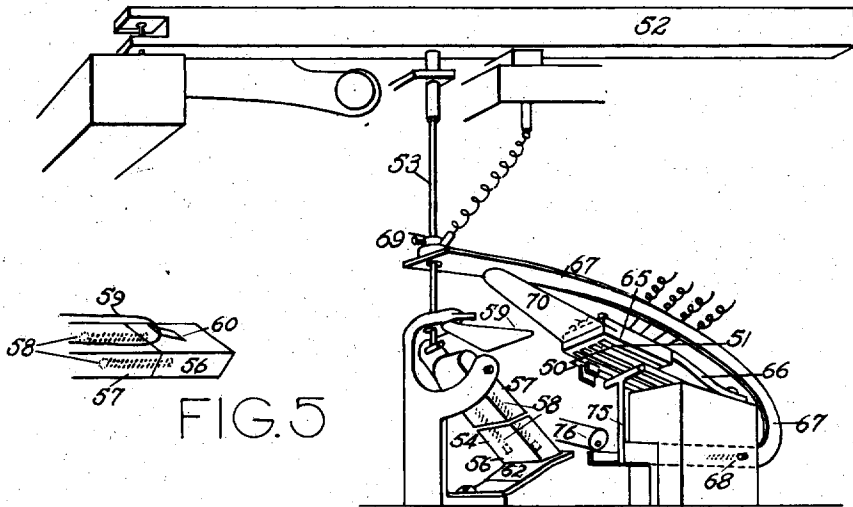


FIG. 4

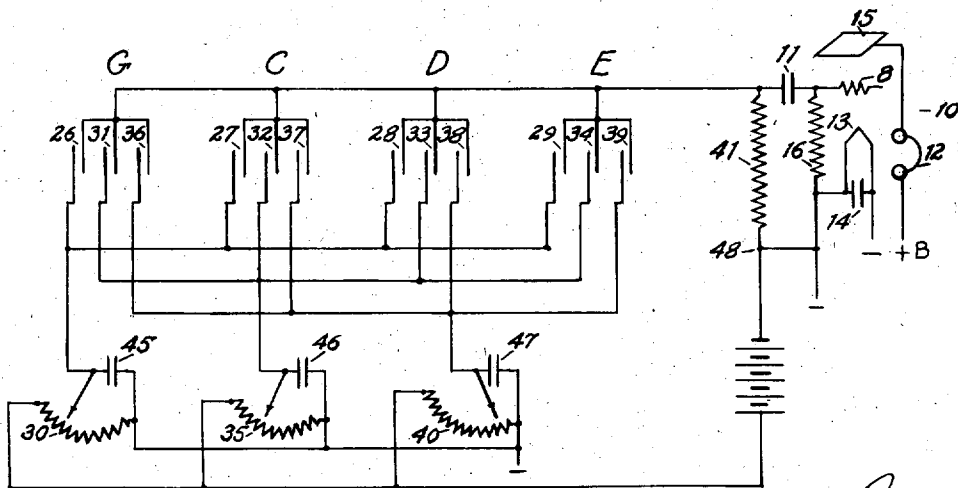


FIG. 6

Richard Howard Ranger
INVENTOR.

BY

ATTORNEYS.

UNITED STATES PATENT OFFICE

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APPARATUS FOR PRODUCING MUSICAL TONES

Richard Howland Ranger, Newark, N. J.

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12 Claims. (Cl. 84-1)

The present invention relates to electrical apparatus for producing musical sounds. The invention has been developed more particularly in connection with the construction of an apparatus for producing chimes and such an embodiment will be described for the purposes of illustrating the principles involved, but it will be understood that the particular description is illustrative merely and is not intended as defining the limits of the invention.

In apparatus of the type to be described, a musical note is produced by impressing upon the grid of an amplifier a voltage which is varied in accordance with the quality of the note desired. If, for example, a pure fundamental tone is desired, the voltage impressed upon the grid may be an alternating voltage or an oscillatory voltage in which the alternations follow substantially the sine curve pattern. If a note of more complicated tonal structure as, for example, one including the fundamental and overtones or a number of overtones without the fundamental, is desired, the pattern of the voltage oscillations becomes more complicated but the principle involved is the same. Several methods of impressing the desired voltage variation upon the grid have been proposed.

The present invention has for an object to provide an improved arrangement for impressing upon the grid an alternating voltage according to a desired pattern. It is an object to provide an arrangement of this type in which no incidental mechanical noises will be reproduced in interference with the musical notes produced.

Another object is to provide a voltage varying device which will produce an effective smooth wave of substantially the sine wave pattern.

A further object is to provide an arrangement wherein the pitch or the intensity of the tonal structure can be changed after a note is struck and while it is still sounding.

A further and important object consists in providing an apparatus of extreme simplicity which can be economically and expeditiously manufactured.

The nature and various objects of the invention will be better understood from a description of particular illustrative embodiments for the purposes of which description reference should be had to the accompanying drawings forming a part hereof and in which—

Figure 1 is an electrical diagram of an illustrative hook-up embodying the invention.

Fig. 2 is a detail view showing a simple form of condenser,

Fig. 3 shows an illustrative chime operating mechanism,

Fig. 4 shows a manually operate device for a single chime note,

Fig. 5 is a detail view showing means for holding the plucking element retracted,

Fig. 6 is an electrical diagram showing a chime hook-up, and

Fig. 7 is a detail view of another form of pick-up embodying one feature of the invention.

In accordance with the present invention a variable condenser is employed in a suitable circuit to effect the desired alternating voltage. In the illustrative arrangement to be more particularly described, a suitable generator capable of providing a relatively high potential, a relatively large resistance and a variable condenser are connected in series to provide a direct current circuit which is open at the condenser, but which upon an oscillatory variation of the capacity of the condenser will cause a variation of voltage of alternating character. This varying voltage is referred to in this description as an "alternating voltage" regardless of the fact that its average may be other than zero. Such alternating voltage is impressed upon the grid of an audio frequency amplifier, the connection ordinarily including a coupling condenser permitting the passage of the alternating but not of the direct.

Referring more particularly to the drawings, 30 Fig. 1 is an electrical diagram of an arrangement for producing a pure fundamental tone or a note combining a fundamental and overtones. A generator arranged to develop a voltage of the order of 200 volts and indicated conventionally as a battery 5 is connected in circuit with a resistance 6 which may be of the order of 2 or 3 megohms and a variable condenser 7 which may have, for example, a capacity of the order of 0.0005 microfarads. The generator is preferably, but not necessarily, arranged with its positive terminal connected to the resistance and the connection to the grid is preferably extended from between the resistance and the condenser as indicated in the diagram. Upon oscillatory variation of the capacity of the condenser at, for example, audio frequencies, an alternating current will be induced in the resistance and what is more important in connection with the present invention, an alternating voltage will be induced in the conductor between the condenser and the resistance. This alternating voltage is impressed upon the grid 8 of an amplifying tube 10. A coupling condenser 11 is shown between the source of alternative voltage and the grid in order that only the al-

ternating current will pass to the grid. When the alternating voltage is thus impressed upon the grid 8, the amplifier tube if energized will produce a fundamental tone in the ear phones conventionally illustrated at 12, the filament 13, condenser 14 and plate 15 performing their functions as usual in devices of this type. A bias resistance 16 and, if desired, a bias battery may be introduced between the grid and filament as usual to maintain the grid at the desired voltage, usually slightly below zero.

The bias resistance and the filament, especially if grounded, may also be connected to the one side of the battery 5, as indicated in the drawings.

The alternating voltage to be impressed on the grid is set up by oscillatory variation of the capacity of the condenser 7. The arrangement shown is intended primarily for producing musical sounds and for this purpose the rate of change of the capacity of the condenser should be of audio frequency. Accordingly in this description, the condenser will be described as variable at an audio frequency rate. It will be understood, however, that this description is illustrative merely; the operability of the arrangement shown is not limited to frequencies which are in fact audible to the human ear.

As a convenient arrangement for varying the capacity of the condenser at an audio frequency, at least one of the condenser plates is formed as a vibrating reed and suitable means is provided for causing the desired vibration. In Fig. 2 is shown a simple condenser consisting of two plates 17 and 18 one of which is a vibratory reed and the other of which is adjustable by a set screw 19 to vary the normal capacity of the condenser and therefore the voltage induced and the loudness of the note produced. The condenser 7 of Fig. 1 is substantially the same in principle but consists of a longitudinally adjustable condenser plate 20 with two vibratory reeds 21, 22 of different periods of oscillation. Either reed may be vibrated alone to produce a corresponding fundamental or both may be vibrated together to produce a note comprising a fundamental and two or three overtones. In the arrangement shown the reeds vibrate directly toward and from the companion relatively fixed plate as distinguished from an arrangement in which the movement is in the plane of the plate but so arranged as to increase and decrease the capacity of the condenser. The sound and the damping effect vibrating in air is probably greater in this arrangement, but it is not ordinarily objectionable. It will be understood that means may be provided for maintaining continued vibration as by an air blast but such continued vibration is not desired in the arrangement herein described. The amplitude of vibration must be such that there is no contact between the plates for obvious reasons.

It will be noted that one condenser element, for example the vibratory reeds may be grounded and the other element in that case must be insulated for obvious reasons. As either or both reeds are vibrated, the note becomes audible in the ear phones 12. It is usually desirable, however, to amplify the note further to operate a loud speaker in accordance with usual practice.

In chimes, as illustrative of various types of musical notes, a complex harmonic structure is desired rather than a pure fundamental note. The note of bell chimes usually contains as its outstanding components or frequencies a fundamental and its overtones $5/4$, 2 , 3 , 4 , 5 , $5\frac{1}{2}$, 6 , 7 , 8 and 9 . The *c* chimes of this type may then be pro-

duced in accordance with the principle embodied in the diagram of Fig. 1 by providing a number of voltage inducing circuits of the type described and impressing all of the alternating voltages thus set up on the grid 8. In the several circuits the reeds of the respective condensers would be tuned to the frequencies of the fundamental and overtones respectively and the "fixed" plates of the respective condensers would be adjusted in accordance with the intensity of the respective overtone in the chime note. Certain of the overtones, however, are of minor importance and for practical purposes it is sufficient to select, for example, the fundamental and two or three of the more important overtones, as the sufficient components of the synthetic chime note.

The several component frequencies are preferably of different amplitudes to produce the desired tonal structure. For this reason the amplitude of each should be determined by suitable adjustments. The amplitude of the alternating voltage can be varied by modifying the amplitude of oscillation of the reed, by suitable variations of the normal capacity of the condenser, by variation of the voltage, or by variation of the amount or arrangement of the resistance.

It is not necessary that several, in this case twelve, entirely separate circuits be employed for producing the several alternating voltage components. Instead one battery and one principal resistance may be sufficient.

It is even possible to provide one large fixed condenser plate and several reeds opposite it and in the same circuit. There are, however, compensating advantages in providing at least separate condensers, each comprising a relatively fixed plate and a vibratory plate or reed.

The voltage output from a number of reeds can be impressed upon the grid of one amplifier but better results are obtained if only a limited number of reeds are connected to impress their respective alternating voltages upon one grid. An octave of 12 notes may ordinarily be handled by one amplifier tube. The output from several tubes can be placed in parallel in an appropriate combining transformer in accordance with known practice.

In Fig. 6 is illustrated an electrical diagram of an arrangement for Westminster chimes in which the notes *g*, *c*, *d*, *e* are each compounded of the fundamental, the eighth and the twelfth, being respectively and accurately the first, second and third multiples of the fundamental. The fundamental tones of the respective notes are produced through condensers 26, 27, 28 and 29, all connected to the variable resistance or potentiometer 30. The first overtone condensers 31, 32, 33 and 34 are similarly connected to the resistance 35 and the second overtone condensers 36, 37, 38 and 39 to the variable resistance 40. By this arrangement the condensers of the fundamental tones will all have the same resistance in their respective circuits and so too with each of the overtones. The resistances provide means for varying the voltages at the condenser and indirectly the voltages of the alternating voltage components impressed upon the grid and therefore of the corresponding components of the note. The desired tonal structure may therefore be obtained by adjustment of the resistances. The tonal quality of the four notes will be of the same synthetic character for the reason that the overtones in each case have the same relative strength and therefore the same influence on the tone quality. The fixed condenser elements are pref-

erably adjustable even in this arrangement in order that further individual adjustments may be made as desired. As indicated in the diagram, a resistance 41 is connected between the delivery side of the condensers and the negative terminal of the battery, the variable resistances 30, 35 and 40 acting as potentiometers being connected between the opposite side of the condenser and the other terminal of the battery. It will be obvious that the amount of resistance introduced by the variable resistances and the ratio between it and the main resistance will determine the strength of the alternating voltage impressed upon the grid. Condensers 45, 46 and 47 are introduced in the resistance circuits as indicated for the purpose of smoothing out any variations in the supply voltage from the battery. The free ends of the resistances 30, 35 and 40 are grounded and the circuit is also grounded at a suitable point as, for example, between the resistance 41 and the battery, as indicated at 48. Inasmuch as the amplifying tube of this figure may be an exact duplicate of the amplifying tube of Fig. 1, the same reference characters are applied to the corresponding parts.

In Fig. 4 there is shown apparatus for manually operating chimes, certain novel control features being embodied therein. The mechanism for one note only is shown as sufficiently illustrating the structure.

In this arrangement the one chime note comprises a fundamental and three overtones. Accordingly there are four condensers consisting of four vibratory reeds 50 and four separate relatively fixed plates 51. A plucking device is provided for plucking the four reeds simultaneously. As shown, a key 52 operates a striking rod 53 which engages at its lower end and operates a pivoted member 54, the outer member or head 56 of which, constituting the plucking element, is movably connected to the body member 57 by yieldable springs 58 which normally hold it in a position such that it will engage and pluck the reeds 50 lightly, that is to say, the plucking members will engage the reeds through only a relatively small arc if the key is operated slowly. If, however, the key is operated more rapidly, the plucking element 56, because of the action of centrifugal force as it swings about its pivot, will engage the reeds while moving through a greater arc and will, therefore, pluck more violently to provide a greater amplitude of vibration. The action of the plucking element against the reeds tends to force it back toward its pivot, so that, upon its return movement, it will not again engage the reeds. It is, however, desirable to insure the retraction of the plucking element and to prevent its too immediate return to its outermost position, as for example, by the arrangement indicated in Fig. 5, in which a spring wire loop 59 engages a sloping projection 60. The spring loop 59 is adjusted to engage the plucking element at about the time that the reeds are plucked and to maintain contact therewith during a small portion of the return movement. The spring loop may furthermore be tensioned to quicken the return movement of the plucking device. This arrangement provides for the plucking of the reeds more or less actively by a perfectly natural more or less vigorous striking of the key 52. In its lowermost position the plucking member rests upon a stop 62. The relatively fixed elements of the condensers are formed as separate parts electrically insulated from each other rather than as one integral structure, in order that the ar-

range may be satisfactorily employed in a circuit of the type illustrated in Fig. 6, wherein different resistances are connected with the several plates.

It is a feature of the arrangement shown in Fig. 4 that the intensity of the note can be further modified at will to provide, for example, a finger controlled tremulo. This is accomplished by imposing a difference of capacity upon the condensers. The simple method shown consists of movement of the relatively fixed elements of the respective condensers toward the vibrating elements.

The so-called fixed condenser elements are carried in the insulating block 65 which in turn is movably supported by spring 66 secured to the framework. An arm 67 pivoted at 68 is engaged by an adjustable collar 69 on the striking rod 53. When the key 52 is held in its lowermost position, the arm 67 by engaging the arm 70 projecting from the block 65 will move the fixed condenser elements toward the vibratory reeds. A damping member 75 is also carried by the arm 67 in position to engage and damp the vibrating reeds when the key 52 is entirely released. It is desirable to provide means whereby the damping member may be held in inoperative position independently of the operation of the keys and also to provide means for moving the fixed condenser elements toward the reeds and holding them in adjusted position. To this end an eccentric member 76 is positioned to engage the lower extension of the arm 67. A small partial rotation of this eccentric will withdraw the damping element from contact with the reeds and a further movement will move the fixed condenser members by engagement of the arm 67 with the arm 70. The eccentric may then be held fixed in any desired position to effect correspondingly the intensity of the note.

In Fig. 3 there is shown diagrammatically an automatic arrangement for operating chimes of a type embodying the invention herein described. In this arrangement a drum 80 is rotated by a small electric motor 81 through suitable worm gearing. The drum shaft 82 carries a motor control cam 83 and a filament control cam 84. The motor control cam carries a riser engageable with a follower 85 to open the motor control circuit switch 86. A push button 87 (which is merely representative of any hand or automatic switch) is provided for starting the motor. This switch need be held closed only until the cam riser releases the follower to permit closing of the motor control switch. The drum and cam will then make one complete rotation until the riser again opens the control switch. The cam 84 will close the circuit through the battery 88 and the filament 89 of the amplifier while the tone control circuits are energized in the same manner as above described.

The drum 80 carries plucking pins 90 engageable with corresponding reeds 91 of suitably arranged condensers of a chime arrangement constructed in accordance with the principles hereinabove outlined. The plucking pins and reeds may be arranged in accordance with the notes desired following the well-known principles of music box construction. The arrangement diagrammatically illustrated is merely suggestive.

It is important that the several reeds of each chime note may be plucked simultaneously. It is impossible mechanically to obtain absolute accuracy. In order to increase the accuracy of such simultaneous striking, the drum is some-

what yieldably connected to its shaft, whereby as one reed of a set slips from the plucking pin, the drum may have a tendency to move quickly forward thereby to more immediately pluck the other reeds.

To this end a rubber connection is provided between the drum and shaft. In the structure illustrated a resilient rubber member 92 is secured to the shaft and engages between four pins 93.

Each time that the chimes are sounded, the drum 90 makes a complete rotation and the plucking pins engage all of the reeds. The control to provide for sounding the chime is obtained by lighting the filament of the amplifier under control of the chime control cam 84 when the shaft starts turning. This cam is arranged to close the filament circuit and to cause it to be maintained closed for only a sufficient length of time to provide for the sounding of the desired notes. A condenser 95 is placed across the filament terminals in order to prevent too abrupt a breaking of the circuit through the filament. This condenser should be of a capacity of the order of 2000 micro-farads, for example, an electrolytic condenser such as is well known in the art. The switch arrangement controlling the filament circuit may be of any suitable construction. When the riser of cam 84 again engages the follower the circuit is again opened, but the filament will dim gradually due to the effect of the condenser, thereby preventing an unpleasant sound.

It is a feature of the invention that the intensity of the note as a whole or the intensity of a component may be varied in accordance with any desired pattern.

In the manual operation arrangement of Fig. 4 the fixed condenser plates are moved manually toward and from the vibrating reeds under control of the finger on the key to provide a tremulo or other desired effect. In the mechanical control of Fig. 3, a cam control providing as an example of tremulo. As a pleasing variation only one of the component tones, preferably the fundamental, is given the tremulo effect by movement of its condenser plate. It is one of the novel features of the invention that this particular type of tremulo effect is provided. Essentially this is accomplished by providing means for producing more or less independently the component tones with means for independently varying the intensity of at least one component without varying the intensity of all the components. The principle involved can of course be carried much further and other types of variations of one or more of the component tones can be varied in numerous ways in pitch or intensity. From the condenser plate for the fundamental an arm 96 projects into engagement with a cam 97 formed on the drum. This cam may provide, for example, a tremulo as indicated or it may be designed to effect only an increase or only a decrease of intensity of note.

This feature of the invention is applicable to other arrangements than that herein described, in which a variable condenser controls the alternating voltage impressed on the grid. This will be more clear if we consider the reed broadly as a vibratory element and the opposed condenser plate as a pick-up element. The intensity of the voltage induced is then increased and reduced as the pick-up element is moved toward and from the vibratory element. Various pleasing effects, of which the tremulo is an example,

can be obtained by suitably controlled relative movement of the pick-up element when the alternating voltage is generated by the method herein described or by other methods.

A further feature of the invention provides a variable note, for example, a tremulo of the character in which the pitch of the note is varied. This is accomplished by introducing an influence to change the rate of vibration of one or more of the reeds. The principle involved is illustrated in Fig. 3, wherein two reeds 98 of one chime note are of magnetic material and are subjected to the action of an electromagnet 99 and wherein soft iron inserts 100 in the drum 90 pass close to the ends of the reeds at suitably spaced intervals to modify the rates of vibration and provide a pleasing tremulo. Each insert temporarily closes the magnetic circuit through two reeds.

This feature also is applicable to other types of pick-up, wherein a vibratory reed and a pick-up element are arranged to produce an alternating voltage which is impressed upon the grid.

The three plate condenser 7 as indicated in Fig. 1 comprising two vibrating reeds produces a novel effect in that alternating voltages of three or four different periods may result; to wit, those having the frequency of the two differently tuned reeds and those having frequencies corresponding to the sum and difference of the two frequencies. If the reed frequencies are of 2 to 1 ratio the difference is, of course, the same as the lower reed frequency.

The principle involved wherein two reeds of different frequencies are vibrated adjacent each other to provide a note having both frequencies and additional overtones can be otherwise applied. For example, as indicated in Fig. 7, the two reeds 101, 102 of magnetic material having frequencies related in the ratio of 3 to 1 may be connected to a magnetic core 103 of a coil 104 with the free vibrating ends spaced but overlapping. Either reed may be vibrated to cause an alternating voltage of corresponding frequency or both may be vibrated to produce a complex alternating voltage having four frequency components of the ratios 1, 2, 3 and 4. Such an arrangement produces a note having a certain definite quality.

The foregoing particular description is illustrative merely and is not intended as defining the limits of the invention. It will be understood that the principles of the invention can be variously embodied and the embodiments described can be variously modified without departing from the spirit of the invention, as defined in the appended claims.

I claim:—

1. In apparatus for producing musical sounds, in combination an audio frequency amplifier having a grid, and means for impressing upon the grid an alternating voltage of audio frequency comprising an electric circuit including in series a high voltage current generator, a resistance and a variable condenser, with means for varying the capacity of said condenser substantially in accordance with a sine wave pattern at an audio frequency rate together with a second means for independently varying the capacity of said condenser in accordance with a wave curve pattern at a relatively slow rate to provide a tremulo.

2. In apparatus for producing musical sounds, in combination an amplifier having a grid, means for impressing on said grid an audio frequency alternating voltage comprising an electric circuit including a current generator, a resistance and

a variable condenser one plate of which consists of a vibratory element comprising magnetic material and having a period of vibration corresponding to the frequency of tone to be produced, together with means for setting up a magnetic field through said element and means for periodically introducing magnetic material into said field for varying the impedance in said field and thereby modifying the rate of vibration of said vibratory element.

3. In apparatus for producing musical sounds, the combination with a vibratory element having a period of oscillation corresponding to a tone to be produced of a pick-up element and means cooperating with the vibratory element for producing electrical response in the pick-up device together with magnetic means for varying the period of oscillation of the vibratory element to produce a tremulo.

4. In apparatus for producing musical sounds, in combination, a reed, a manually operable key, a plucking element operatively connected to said key for actuating said reed and means causing said plucking element to be projected more or less toward the reed to pluck the same more or less actively as the key is actuated more or less rapidly.

5. In apparatus for producing musical sounds, in combination, a reed, a manually operable key, a plucking element, operatively connected to said key, for actuating said reed, said plucking element being pivotally supported for movement in an arc with spring means yieldably drawing it toward the point of pivotal support and so tensioned that when actuated more or less rapidly it will move radially from the pivot more or less under the action of centrifugal force and engage the reeds more or less effectively.

6. Apparatus for producing musical sounds, as defined in claim 5, wherein means is provided for holding the plucking element radially inward after its operative engagement with the reeds.

7. In apparatus for producing musical sounds, in combination, a reed, a manually operable key, a plucking element operatively connected to said key for actuating said reed, a pick-up element positioned adjacent said reed, and means operatively connected to said key to be actuated when said key is near its extreme operative position to re-

duce the distance between the vibratory reed and the pick-up device to increase the over-all response.

8. In apparatus for producing musical sounds, the combination with an amplifier having a grid of means for impressing an alternating voltage on said grid comprising a condenser having two vibratory elements of different periods of oscillation with a third element therebetween and means cooperating with the condenser including an electric circuit to pick-up the vibrations and produce an alternating voltage compounded of the frequencies of the two vibratory elements and the frequencies corresponding to the sum and difference of said first mentioned frequencies.

9. In apparatus for producing musical sounds the combination with means for producing the component tones simultaneously to produce a musical note comprising one or more overtones of means for varying the intensity of one component relative to the intensity of the other or others to provide a tremulo effect.

10. In apparatus for producing musical sounds, the combination with a vibratory element having a period of oscillation corresponding to a tone to be produced of a pick-up element and means cooperating with the vibratory element for producing electrical response in the pick-up device together with magnetic means for varying the period of oscillation of the vibratory element in accordance with a predetermined pattern.

11. In apparatus for producing musical sounds the combination with means for producing the component tones simultaneously to produce a musical note comprising one or more overtones of means for varying the intensity of one component relative to the intensity of the other or others in accordance with a predetermined pattern.

12. In apparatus for producing musical sounds the combination with means for producing the component tones simultaneously to produce a musical note comprising one or more overtones of means for varying one component relative to the other or others to provide a tremulo.

RICHARD HOWLAND RANGER.