

Oct. 29, 1929.

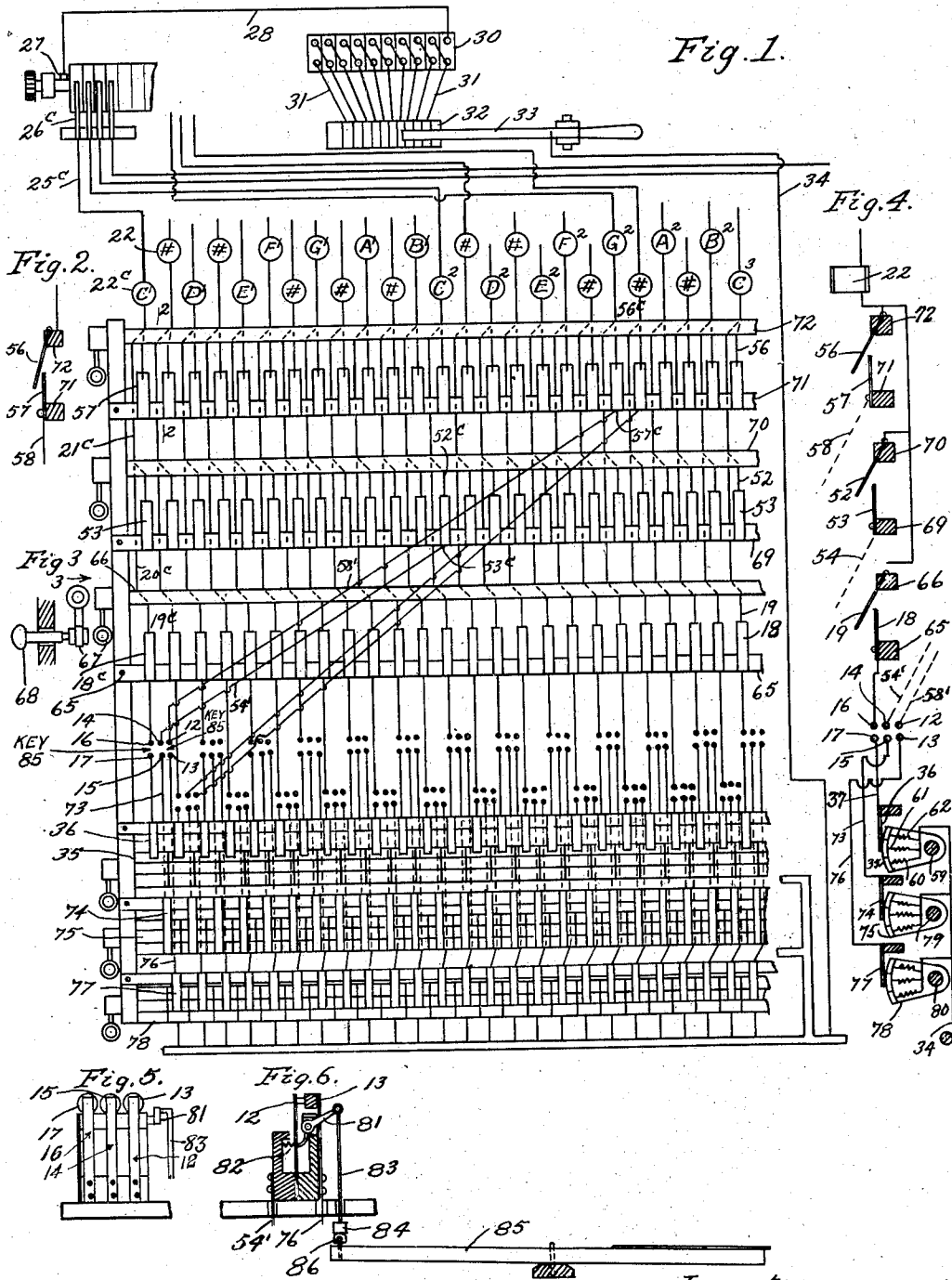
M. L. SEVERY

1,733,630

METHOD OF AND MEANS FOR PRODUCING SYNTHETIC TIMBRE EFFECTS

Filed Aug. 29, 1917

3 Sheets-Sheet 1



Inventor,
Melvin L. Severy,
By Nestall and Wallace
His Attorneys

Oct. 29, 1929.

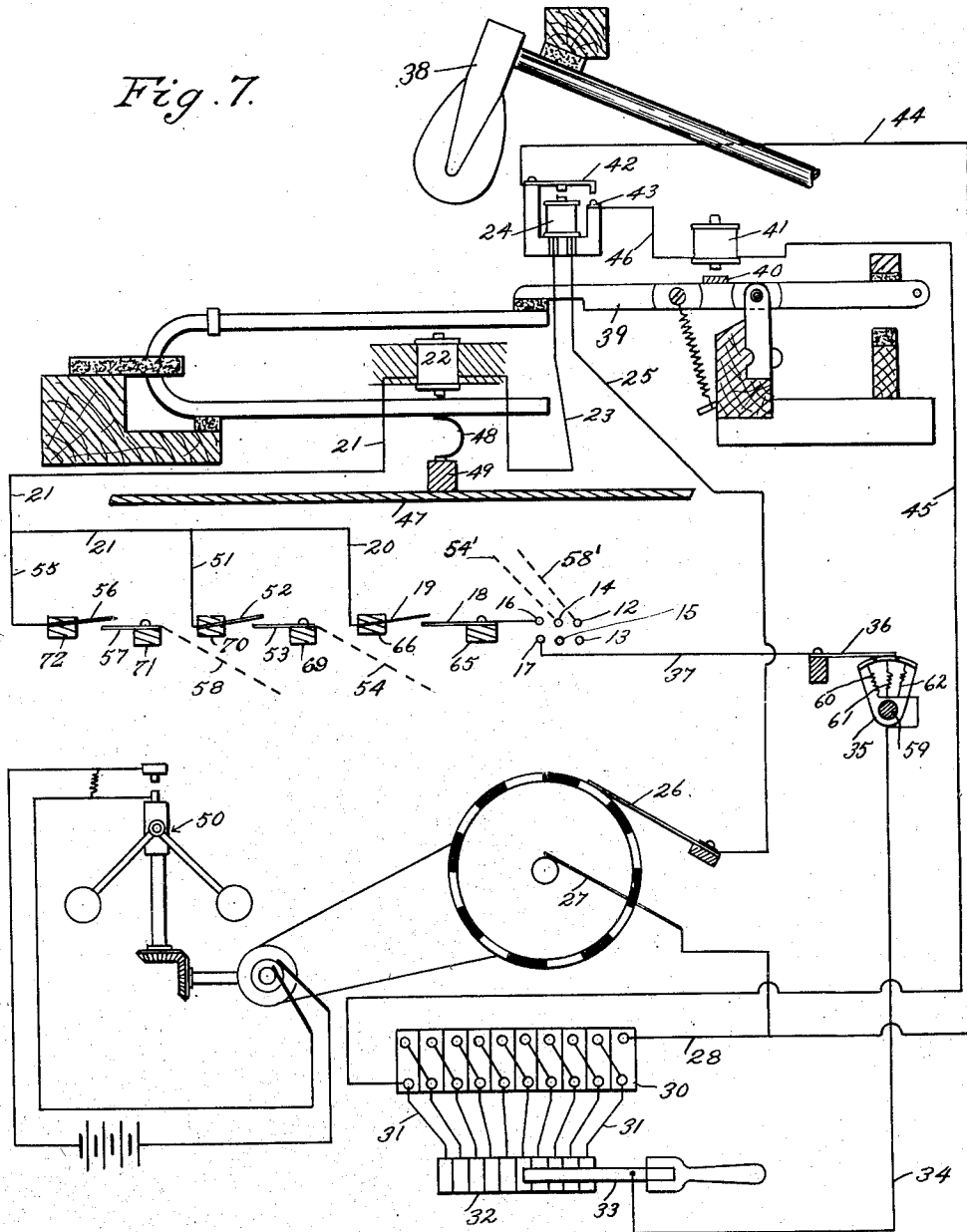
M. L. SEVERY

1,733,630

METHOD OF AND MEANS FOR PRODUCING SYNTHETIC TIMBRE EFFECTS

Filed Aug. 29, 1917

3 Sheets-Sheet 2



Inventor,
Melvin L. Severy,

By *Westall and Wallace*

His Attorneys,

Oct. 29, 1929.

M. L. SEVERY

1,733,630

METHOD OF AND MEANS FOR PRODUCING SYNTHETIC TIMBRE EFFECTS

Filed Aug. 29, 1917

3 Sheets-Sheet 3

Fig. 8.

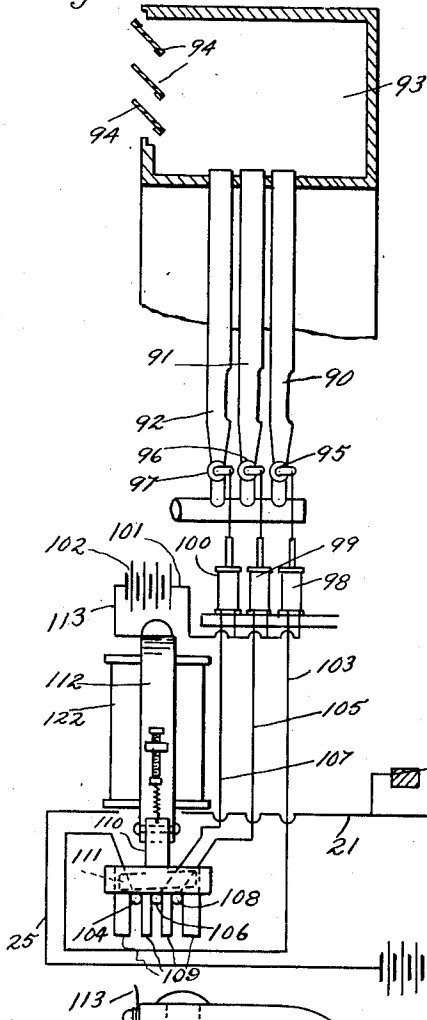


Fig. 9.

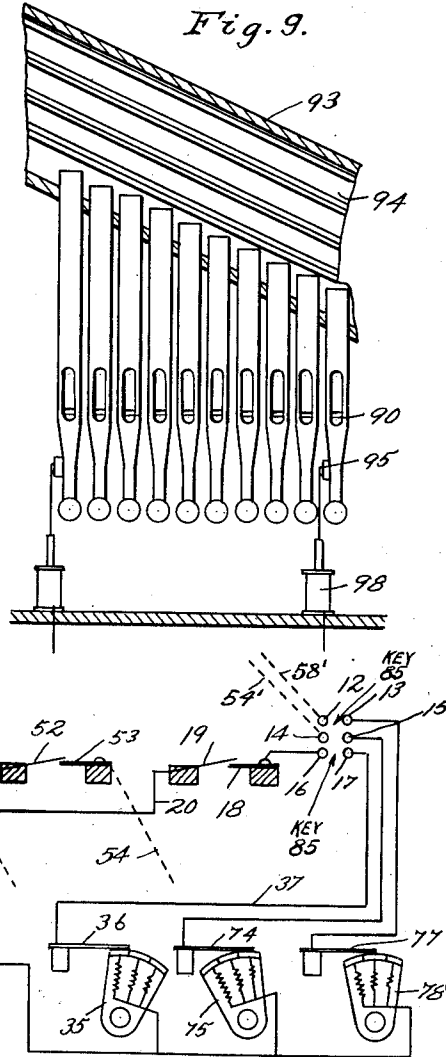
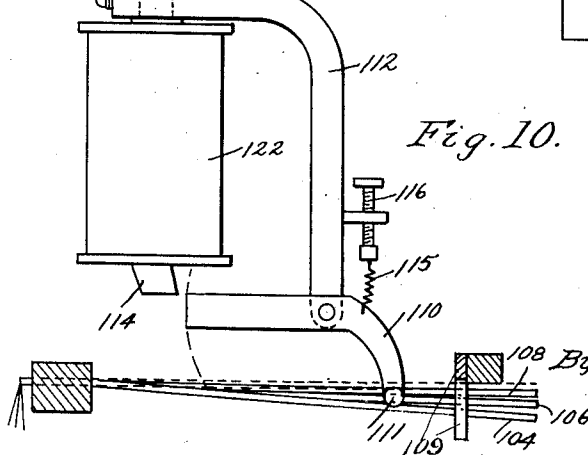


Fig. 10.



Inventor
Melvin L. Severy

By *Nestall and Wallace*

His Attorneys.

UNITED STATES PATENT OFFICE

MELVIN L. SEVERY, OF LOS ANGELES, CALIFORNIA, ASSIGNOR TO THE VOCALSERVO COMPANY, OF LOS ANGELES, CALIFORNIA, A CORPORATION OF DELAWARE

METHOD OF AND MEANS FOR PRODUCING SYNTHETIC TIMBRE EFFECTS

Application filed August 29, 1917. Serial No. 188,814.

This invention relates to a method and means of producing complex tones by combining elemental tones.

5 An object of this invention is the production of different tone qualities by a building up or synthetic process.

A further object is the control and utilization of these tones in the production of music, and sound effects generally.

10 Now, it is well known that in modern instruments tuned to the equally tempered scale the various harmonic over-tones of a given sound are not in tune with any notes of such musical scale, except those at one or more
15 exact octaves from the fundamental. Since in the embodiment of my invention here set forth, the fundamentals of the various notes throughout the range of the instruments are assumed to be those of the equally tempered
20 scale, it will be seen that if a way can be found to make these tones of relatively simple quality, like, for example, the quality of certain tuning-forks, and they be then used
25 as well, selected and proportioned in intensity with due regard to the timbre or quality desired, the complex result will be musically serviceable, and will produce most pleasing synthetic tones, when the proper method is
30 used.

One of the chief objects of my invention is the production of tones preferably of practically a simple or sine wave characteristic, of definite pitches suitable to the musical
35 ratios of the scale in use—usually the equally tempered scale; the controlling of the loudness or relative dominance of these tones; the selection of any desired number of these tones to be used as partials and to be sounded
40 simultaneously; the controlling of the relative loudness of these partials and the production of synthetic tones by the simultaneous sounding of these fundamentals and these
45 partials. I do not, however, restrict myself to the production of tones of a simple or sine wave characteristic, nor to the employment of the equally tempered scale.

It is desirable to have the so called fundamental or elemental tones as simple and sinusoidal as possible, because such tones serve

better for mixing, but many mixtures may be obtained where the elemental tones are not perfectly simple. For example tuning-forks which usually are considered as producing
55 simple tones do not give those which are absolutely simple or elemental but rather those which are near enough to true fundamental tones for all practical purposes. In the application of my invention, I have shown tuning-forks and organ pipes for sonorous bodies,
60 because both of these may be made to give very nearly simple vibrations. I do not confine myself, however, to any particular sonorous bodies, as it is evident a wide range of articles might be used, as strings, reeds, diaphragms and many more.
65

To simplify the disclosure and to illustrate the type of instrument cheapest of production, I have illustrated a set of sonorous
70 bodies of a single type, in each case showing a system, where a sonorous body which is being used to sound for a fundamental, may at the same time be commanded to speak as a harmonic to another fundamental, and yet the
75 relative loudness of all sounding sonorous bodies be correctly maintained. I have also shown expression-control mechanism, operating to control at all times the loudness of the synthesized result without distorting the
80 quality in any way. It is obvious that different types of tuned sonorous bodies may be employed in carrying out the present invention, and the invention is hence not confined to the employment of a single type in any
85 single or given instrument, since one form of tuned sonorous body may be employed for the fundamentals and another or others for the partials, the invention consisting broadly in combining sound waves or vibrations independently produced by different tuned sonorous
90 bodies whatever be the form or type of such bodies.

I accomplish the results above set forth by means of the embodiments of my invention illustrated in the accompanying drawings, in
95 which:

Fig. 1 is a wiring scheme mostly in diagram. Fig. 2 is a section as seen on the line 2—2 of Fig. 1. Fig. 3 is a side elevation of a detail looking in the direction indicated
100

by the arrow 3 in Fig. 1, a support for the stop being shown in section. Fig. 4 is a schematic side elevation of the construction shown in Fig. 1. Figs. 5 and 6 are front and side elevations respectively of the key switch. Fig. 7 is a schematic diagram showing the connections for operating the tuning fork type of instrument. Fig. 8 is a schematic diagram showing the connections for operating the organ pipe type of instrument. Fig. 9 is a schematic front elevation of the swell box, pipes, and solenoids which control the pipes, only two of the solenoids being shown for the sake of clearness of illustration. Fig. 10 is an elevation on an enlarged scale of the actuating magnet shown in Fig. 8, with the parts in the positions they assume when the magnet is energized.

Referring more particularly to Fig. 7 a key switch controlled by a key of the key board is indicated by contacts 12, 13, 14, 15, 16, and 17. As shown, the switch has three pairs of contacts and is more particularly shown in Figs. 5 and 6. Contact point 16 is connected by an electrical conductor to a coupler comprising contact finger 18, which co-acts with a rocking contact finger 19. A conductor 20 is electrically connected with contact 19 and makes connection with a conductor 21, which leads to a terminal of the actuating magnet 22. The other terminal of the magnet 22 is connected by a conductor 23 to one terminal of a damper relay-magnet 24. The other terminal of the damper magnet is connected by a conductor 25 to a brush 26, which bears upon the interrupter of a pulsator. This pulsator may be replaced by any suitable mechanism which delivers correctly timed current impulses. The pulsator shown comprises a toothed disk having the teeth on its periphery separated by suitable insulation and having a contact surface upon which a brush 27 bears uninterruptedly. Brush 27 is connected through a conductor 28 to one terminal of a battery of storage cells. The cells are connected by conductors 31 to a switch 32 of the end cell type. Each cell has a contact for engagement by a movable contact 33, whereby the number of cells in circuit may be regulated, thereby the voltage impressed on the system regulated, and the intensity of the tones controlled. Contact 33 is connected by a conductor 34 to a rocking resistance segment 35. Bearing upon rocking segment 35 is a contact finger 36, which is connected by a conductor 37 to contact point 17 co-acting with contact point 16 to control the circuit. Assuming contact finger 19 to be in such position that it makes electrical contact with 18, which is its normal position, the following occurs: Current from the storage cells 30 passes by way of a conductor 31 through the switches 32 and conductor 34 to the resistance segment 35. From the resistance segment 35 current passes by

way of contact finger 36 to the contact point 17, then to contact point 16, through fingers 18 and 19, conductors 20 and 21 to actuating magnet 22. From actuating magnet 22 the current passes by conductor 23 to damper relay magnet 24, then by conductor 25 to brush 26 of the pulsator. Current then passes through the pulsator to brush 27, being interrupted in its passage to produce impulses in the circuit. Current passes from the brush 27 by means of conductor 28 back to the storage cells 30, completing the circuit.

In the instrument shown in Fig. 7, a hammer 38 is shown, providing another means for actuating the forks. A pivotally supported damper 39 has one end thereof provided with a felt cushion normally resting upon one prong of the fork. Mounted upon the damper is an armature 40, which co-acts with an electro-magnet 41, so that when electro-magnet 41 is energized the damper will be lifted. Electromagnet 41 is controlled by damper relay magnet 24. The construction shown is known in the art and is merely shown herein for purposes of illustration, as various other types of dampers may be used. An armature 42 forms one contact of a switch which co-acts with contact 43. The natural period of vibration of armature 42 is made low enough so that the electromagnet 24 will hold the armature down in closed position, when the proper pulsating current passes through the magnet, and the relay is made sufficiently sensitive to work when the voltage of battery 30 is reduced to the lowest point required in practical operation. Armature 42 is connected by a conductor 44 to conductor 28, and thereby to one terminal of the storage battery. Contact 43 is connected by a conductor 46 to electromagnet 41, the other terminal of electromagnet 41 being connected by a conductor 45 to the other terminal of the battery of storage cells. It is obvious that when current passes through electromagnet 24, contact 42 will be drawn against contact 43 making the circuit and permitting current to flow through magnet 41, thereby energizing the latter. This causes the damper to be lifted from the tuning fork, allowing the latter to vibrate freely. The period of the pulsations passing through electromagnet 22 is preferably the same as the natural period of the tuning fork. If, however, it be desired to impress upon the tuning fork a rate of vibration other than its natural rate, the frequency of the pulsations passing through the electromagnet 22 will be made to correspond to such desired rate of vibration. A sounding board is indicated by 47. A spring 48 connects one prong of the tuning fork to the bridge 49 of the sounding board. The other details of the tuning fork mounting are not material features of my invention, and therefore, will not be further described.

The pulsator interrupter is revolved by a timed revolving device indicated generally by 50. As the details of this device are not material to my invention and as the construction shown is described in detail in other patents issued to me, it will not be further described herein.

The preferable form of construction just described will cause each tuning fork to vibrate at a rate to educe its fundamental. In order to adjust the intensity of the fundamentals, I have provided the resistance segment 35. The segment has on its periphery three longitudinal rows of contacts, each contact insulated from all its neighbors whether in the same longitudinal or transverse rows. The contacts shown in Fig. 7 are connected by resistances 60, 61 and 62 to the common conductor 34. The segment is mounted upon a rock shaft 59, so that it may be rocked to bring any one of the longitudinal rows of contacts in touch with the row of fingers 36. In this manner any one of three different resistances may be selected and placed in circuit, thereby varying the magnitude of the current and the intensity of the tone of the tuning fork. A greater number of resistances may be used, if desired, to give a greater variety of effects.

Connected to conductor 21 are branch conductors 51 and 55. These conductors are for the purpose of leading the current to the actuating magnet 22 of a fork tuned to an approximate harmonic of the fork controlled by contacts 16, 17. Conductor 51 is connected to a rocking contact finger 52, which co-acts with a contact finger 53. Contact finger 53 is connected by a conductor 54 to a contact on another key switch, not shown in Fig. 7. Conductor 55 is connected to a rocking contact finger 56, which co-acts with a contact finger 57, the latter being connected by a conductor 58 to a contact on another key switch, not shown in Fig. 7. Conductors 54' and 58' are connected to contact points 12 and 14 respectively on the key switch shown in Fig. 7. Conductors 54' and 58' are of the same group as conductors 54 and 58. As the complete circuits for conductors 54' and 64, 54 and 58 are not shown in Fig. 7, the conductors are shown in dotted lines.

Referring to Fig. 1, I have shown an assembly of elements, of which one is shown in Fig. 7. A series of contacts 18, one for each tuning fork, is fixed to a bar 65. A series of rocking brushes 19 is mounted on the rock shaft 66, and rock shaft 66 is pivotally mounted so that it may be rocked by means of the crank 67, which is secured to one end of the shaft. A convenient means of rocking the shaft comprises a stop 68 connected to the crank 67. By operating the stop, the circuit may be either opened or closed to sound the fundamental or to keep it silent. Usually the contacts would be closed as the fundamen-

tal of the corresponding pitch is usually desired.

Suppose it is desired to sound the second harmonic, this will mean the same condition with each note throughout the instrument at that time and with that setting. Conductor 54' is connected to contact point 14 and to contact finger 53C. There is a series of fingers 53 mounted on the bar 69, a particular one of these being marked 53C. The rocking contact fingers 52, which coact with the fingers 53 are mounted upon a rock shaft 70. Rock shaft 70 may be operated by a stop in the same manner as rock shaft 66. If it is desired to omit the second harmonic, the fingers 52 and 53 are moved apart to break the circuit. A cross wire 58' connects contact point 12 with contact finger 57C. A series of fingers 57, one for each of the sonorous bodies, are fixed to the bar 71, a particular one of these being marked by 57C. A series of rock contact fingers 56 are mounted on the rock shaft 72 so that the fingers may be moved into or out of engagement with each other. A stop mechanism like that heretofore described may be used for rocking the shaft. If it is desired to have the second harmonic silent, the shaft 72 is rocked so that fingers 56 and 57 are apart.

The intensity of any of the upper partials or harmonics may be controlled. As seen in Figs. 1 and 4, a conductor 73 connects contact point 15 with a finger 74, which bears upon a rocking resistance segment 75 of similar construction to the rocking resistance segment which controls the first partial or fundamental. Contact point 13 is connected by a conductor 76 to a contact finger 77, which bears upon a rocking resistance-segment 78, whereby the resistance in its circuit may be controlled. The set of fingers 36 bearing on resistance-segment 35 is fixed to a cross-bar, while the segment 35 is mounted upon a rock shaft 59, which may be operated by a stop. The set of fingers 74 are fixed to a cross-bar, and the segment 75 is mounted upon a rock shaft 79, which is operated by a stop. In a similar manner, the segment 78 is mounted upon a rock shaft 80 which is operated by a stop. By rocking the proper segments, the intensity of the fundamentals and each of the upper partials may be controlled. By rocking the shafts 66, 70 and 72 the fundamental or any one of the upper partials may be silenced or made to speak.

The key switch indicated by the contact points 14 to 17 inclusive in Figs. 1, 4 and 7, is more fully shown in Figs. 5 and 6. The switch consists of three co-acting pairs of contacts, that is, pairs 12 and 13, 14 and 15, and 16 and 17. The contacts 12, 14 and 16 are spring fingers, which tend to move into engagement with their respective co-acting members of the pairs. They are, however, normally held out of engagement by means of

a swinging arm 81, which is acted upon by a tension spring 82. Connected to one end of the arm 81 is a rod 83 having at its free end a foot 84. The instrument key 85 has a capstan-screw 86 mounted upon one end thereof and disposed to abut against the foot 84 and raise the rod 83, thereby moving arm 81 to withdraw the end thereof and permit the contacts 12, 14 and 16 to engage the members of their respective pairs. Upon operating a key, the contacts in the key switch close the circuits leading to the fingers associated with the fundamental and to each of those associated with its higher partials.

Assuming that the key to sound the note C¹ is operated, then the key switch will be closed, and current will flow as follows. Current passes from one side of the battery 30 through one conductor 31, regulating switch 32, conductor 34, segment 35 to finger 36 and contact 17. From contact 17 it flows to contact 16 and finger 18C, one of the fingers 18. Assuming that rocking fingers 19 are engaged with the fingers 18, current will flow from finger 18C through finger 19C, one of the brushes 19, along conductor 20C to conductor 21C, and then through the magnet 22C. From the other terminal of magnet 22C, current flows through the damper magnet not shown in Fig. 1, through conductor 25C to the brush 26C. Current then passes from the brush 26C through the pulsator, which is conventionally shown, to the brush 27, through the conductor 28, and to the set of storage cells.

For the first upper partial or harmonics, current passes from the storage battery 30 through the switch 32, conductor 54', rocking segment 75, conductor 73, through the closed contact points 15 and 14 and cross wire 54' to the finger 53C. From the contact finger 53C, current passes to the rock fingers 52C, then by conductors through magnet C² to a pulsator brush 26, and then to the common return brush 27 and conductor 28 to the battery 30.

For the second upper partial or harmonic current passes from the storage battery 30 through the switch 32, conductor 34, to segment 78. From segment 78, current passes by way of the contact 77 and conductor 76 to contact 13. From contact 13, current passes through contact 12 and conductor 58' to contact finger 57C. From contact finger 57C, current passes through rocking contact 56C, and then through magnet G² to a brush, not shown on the pulsator, and then by way of the brush 27 and the common return 28 to the battery 30.

In this manner closing of the key switch for sounding the note C¹ will sound the fundamental and the partials C² and C³. The intensity of the fundamental and of each of the aforesaid partials, or the elimination of any one of them may be accomplished by operat-

ing the appropriate stop. While I have shown one fundamental and two upper partials, I am not limited to such number, but by using a suitable number of contacts in the key switch, and suitably increasing associated parts and using appropriate cross wiring, any number of partials may be used.

In Figs. 8, 9 and 10, I have shown an embodiment of my invention employing organ pipes as sonorous bodies. The diagram shown in Fig. 8 omits the battery switch 32 and the damping magnet 24, shown in Fig. 7 as the intensity of the synthetic tone may be otherwise regulated, as by the swell-box. Instead of the actuating magnet 22, I use a relay type of magnet indicated by 122. So much of the construction as I have just described for the tuning-fork type is identical herewith, with the exceptions noted.

For each note there are three unison pipes thus 90, 91 and 92. These open into a swell box 93 having the usual slats 94. Each one of a group of pipes is controlled by a valve, as 95, 96 and 97. Each valve has a valve arm connected by suitable linkage to the plunger of a solenoid. The solenoids are indicated by 98, 99 and 100. A terminal of each one of the solenoids is connected by a common conductor 101 to a battery 102. The other terminal of solenoid 98 is connected by a conductor 103 to a contact 104. A terminal of solenoid 99 is connected by a conductor 105 to a contact 108. A terminal of solenoid 100 is connected by conductor 107 to a contact 106. Contacts 104, 106 and 108 are spring fingers guided between the teeth of a comb 109, and form contacts of a key switch, the other contact thereof being the head 111 of pivoted lever 110. The head 111 is so inclined that when closed, it makes contact successively with 104, 106 and 108, thereby successively energizing solenoids 98, 100 and 99, since current passes through lever 110, bracket 112 and conductor 113 back to the other side of battery 102. It will be noted that bracket 112 which is of magnetic material is fixedly secured to the core of magnet 122 and supports the lever 110, so that the end of said lever which faces the magnet core and acts as an armature, will in its movement follow the arc of a circle indicated by the dotted lines. The core of the magnet 122 is in the form of a horn 114, having a curved face at an angle to said arc of the circle. When magnet 122 is energized, the lever 110 is moved to bring the cross head 111 successively in engagement with contacts 104, 106 and 108. The curvatures of the horn 114 and path of the lever 110 are adjusted so that the pull will be substantially constant for constant current, but will cause the armature and head 111 to traverse distances differing in proportion to the strength of the actuating current. A tension spring 115 and an adjusting screw 116 are shown for the purpose of holding the

cross head 111 normally in its upper position. Fig. 10 shows the position of lever 110 when the magnet is fully energized.

Referring particularly to Fig. 8 it is obvious that when the key switch is closed, thereby closing contacts 16 and 17 magnet 122 will be energized provided fingers 18 and 19 are in contact. This causes the lever 110 to be moved into contact with spring contact 104, and, if the strength of current flowing is sufficient, then successively with spring contact 106 and spring contact 108. Solenoids 98, 100 and 99 are successively energized, and the valves 95, 97 and 96 successively opened. If the segment 35, is so positioned as to give a small current flow, then the pull on lever 110 will be only sufficient to cause the head 111 to make contact with spring contact 104 and to energize only solenoid 98, thereby opening only one of the organ pipes and giving only a predetermined fraction of the maximum volume of tone for the note, for these pipes may be voices of unequal loudness. If the segment 35 is moved to a position to decrease the resistance, thus, if it is on the second contact, the current strength passing through magnet 122 with 75 and 78 in former position will be greater and the travel of the head 111 will be correspondingly increased, and where, as would be the case in practice, each note had a sufficient number of pipes to be fully sensitive and responsive to all associated rheostat positions, this would cause the energization of more solenoids, the speaking of more pipes and an increased intensity of tone of that particular pitch. If the segment 35 is positioned so that the contact with least resistance therein is in contact with brush 36, then lever 110 will be moved even farther.

It is to be borne in mind that for simplicity of illustration and explanation and in order more perfectly to parallel my tuning-fork type of instrument, I have shown in my organ-pipe type of construction but three pipes to a group or note. This perfectly illustrates the principle involved, but many more pipes per group would be required with their associated mechanisms to make a construction as responsive to all rheostat positions and as flexible in variety of possible timbres as my tuning-fork type of construction. Such an extension however is perfectly practical but its showing would be needlessly complicated for the purposes of this application.

With this explanation the operation of the device will be understood. The electro-magnet 122 and the three pipes forming a group for each note are merely for the purpose of grading the intensity of the tone and permitting the control thereof by means of the rocking resistance-segments and rocking contact fingers.

Various other constructions are possible embodying the principle of my invention. The two types of instruments described here-

in are sufficient to illustrate the possibilities. The details of structure have been shown in as simple a form as possible, in order to simplify the description and avoid confusion, but it is to be understood that the instrument or apparatus may be elaborated to any extent desired within the above disclosure and with a view to producing special sound effects, as for instance, through the use of one type of tuned sonorous bodies for the fundamental and another type or other types of tuned sonorous bodies for the production of the partials.

It will of course be understood that in any musical instrument the sonorous bodies whose vibrations produce the tones desired, are tuned according to certain scales which are commonly referred to as of "equal temperament", "just temperament", or the like, according to the intervals into which the scale is divided, and it is in this sense or with this meaning that the terms "scale", "temperament" and "tuned" are employed in this specification and in the claims.

What I claim is:

1. The herein described method of selectively and synthetically producing any of a series of tones in musical relation and of predetermined quality or timbre, which consists in simultaneously producing air vibrations of the frequencies to produce the selected fundamentals, and other vibrations of frequencies and intensities to produce in proper strength any desired partials to be associated with such fundamentals, and permitting the different sets of vibrations to mingle in the air.

2. The herein described method of synthetically producing musical tones of instantly changeable timbre or quality, which consists in simultaneously producing a plurality of sets of air vibrations of predetermined frequencies corresponding to the frequencies subsisting between the fundamental and the several other partials of the selected tone, and of predetermined intensities, and permitting the selected vibrations to mix and thus to produce upon the ear the effect of a tone of the desired quality.

3. The herein described method of synthetically producing musical tones of predetermined timbre or quality and at will varying such timbre or quality, which consists in simultaneously producing a plurality of sets of air vibrations of predetermined frequencies and intensities, and at will varying such intensities, the selected vibrations being permitted to mix and produce the composite vibrations affecting the ear as a tone of the predetermined quality desired.

4. The herein described method of synthetically producing musical tones of any predetermined timbre or quality and at will varying such timbre or quality, which consists in simultaneously producing at the will

of the operator a plurality of sets of air vibrations of approximately simple sine-wave form, of predetermined frequencies, and of relative intensities instantly controllable at the will of the operator, the selected vibrations being permitted to mix and thereby to produce a composite vibration affecting the ear as a tone of the quality predetermined and desired.

5. The herein described method of synthetically producing, and varying the timbre or quality of, musical tones, which consists in simultaneously producing at the will of the operator a plurality of sets of air vibrations of approximately simple sine-wave form, of predetermined frequencies, and of relative intensities instantly variable at the will of the operator, the selected vibrations being permitted to mix and to produce a composite vibration affecting the ear as a tone of the quality predetermined and desired, and instantly varying the intensity of all said vibrations without altering their relative intensities or the quality of the composite tone produced.

6. The herein described method of synthetically producing musical tones, which consists in simultaneously producing at the will of the operator a plurality of sets of air vibrations of approximately simple sine-wave form and of predetermined frequencies, the selected vibrations being permitted to mix and to produce a composite vibration affecting the ear as a tone of the quality predetermined and desired.

7. The herein described method of producing synthetic tones of predetermined quality and intensity, which consists in producing at the will of the operator, vibrations comprising both those of the fundamentals and of the chosen other partials of the selected tones in their proper relative intensities, and permitting such vibrations to mix in the air.

8. The herein described method of producing synthetic tones of predetermined quality and intensity, which consists in simultaneously producing, at the will of the operator, vibrations of frequencies comprising both those of the fundamentals and those of the chosen other partials of selected tones throughout the range of a musical instrument, and permitting said vibrations to mix in the air.

9. The herein described method of synthetically producing, and varying the timbre or quality of, musical tones, which consists in producing in the air at the will of the operator, any one set of vibrations of approximately simple sine-wave form from a group of sets of differing periodicities, arranged in musical relation; and simultaneously selectively producing from said group other sets of air vibrations of appropriate relative in-

tensity or intensities, and permitting the vibrations to mix in the air.

10. The herein described method of synthetically producing, and varying the timbre or quality of, musical tones, which consists in producing in the air at the will of the operator, any one set of vibrations of approximately simple sine-wave form from a group of sets of differing periodicities, arranged in musical relation; simultaneously selectively producing other sets of air vibrations from said group; and combining at the will of the operator these sets of vibrations in any predetermined degree of relative loudness so that tones of the desired timbre are produced.

11. The herein described method of synthetically producing, and varying the timbre or quality of, musical tones, which consists in producing in the air at the will of the operator, any one set of vibrations of approximately simple sine-wave form from a group of sets of differing periodicities, in musical relation; simultaneously selectively producing other sets of air vibrations from said group; combining at the will of the operator these sets of vibrations in any desired degree of relative loudness so that tones of definite desired timbre shall result; and varying at will the loudness of the composite tone without altering the relative loudness of the component sets of vibrations or the quality of the composite tone.

12. The herein described method of producing substantially throughout the range of a musical instrument, synthetic tones of the same or different qualities as desired, by mixing elemental tones in the atmosphere, said method consisting in producing and combining tones used as partials, said tones being in any desired musical relation, and said partials having suitable frequencies and being used at the will of the operator, as fundamentals.

13. The herein described method of actuating tuned sonorous bodies which produce simple tones, for the purpose of producing complex musical tones, which consists in selectively actuating any one of said bodies having a periodicity corresponding to that of any fundamental in the musical scale selected, to produce air vibrations of the periodicity of the fundamental of the selected tone; and simultaneously therewith actuating others of said bodies to produce air vibrations of predetermined relative intensities and of periodicities of other partials of said tone, and permitting said vibrations to mix in the air.

14. The herein described method of actuating tuned sonorous bodies which produce simple tones, for the purpose of producing complex musical tones, which consists in selectively actuating any one of said bodies having a periodicity corresponding to that of

any fundamental in the musical scale selected, to produce air vibrations of the periodicity of the fundamental of the selected tone; simultaneously therewith actuating others of said bodies to produce air vibrations of periodicities of other partials of said tone, and permitting said vibrations to mix in the air; and instantly controlling at will the relative loudness of the selected partials.

15 15. The combination of a set of tuned sonorous bodies; means for selectively actuating any one of said bodies to produce a fundamental tone; means for simultaneously actuating others of said bodies to produce partials to be associated with said fundamental tone; and means for varying the intensity of the selected partials relatively to the fundamental tone and to one another.

20 16. The combination of a set of tuned sonorous bodies; means for selectively actuating any one of said bodies to produce a fundamental tone; means for simultaneously actuating others of said bodies to produce partials to be associated with said fundamental tone; means for varying the intensity of the selected partials relatively to the fundamental tone and to one another; and means to couple and uncouple said first and second means.

30 17. The combination of a set of tuned sonorous bodies; means for selectively actuating any one of said bodies to produce a fundamental tone; means for simultaneously actuating others of said bodies to produce partials to be associated with said fundamental tone; and means selectively to control the relative intensities of said partials.

40 18. The combination of a set of tuned sonorous bodies; means for selectively actuating any one of said bodies to produce a fundamental tone; means for simultaneously actuating other of said bodies to produce partials to be associated with said fundamental tone; means for selectively controlling the intensities of the associated partials; and means for controlling the intensity of the composite tone without altering the relative intensities of said partials or the quality of said composite tone.

50 19. The combination of a set of tuned sonorous bodies; means for selectively actuating any one of said bodies to produce a fundamental tone; means for simultaneously actuating others of said bodies to produce partials to be associated with said fundamental tone; means to couple and uncouple said last-mentioned means and said first-mentioned means; and means for selectively controlling the relative intensities of said partials.

60 20. The combination of a set of tuned sonorous bodies; means for selectively actuating any one of said bodies to produce a fundamental tone; means for simultaneous-

ly actuating others of said bodies to produce partials to be associated with said fundamental tone; means to couple and uncouple said last-mentioned means and said first-mentioned means; means for selectively controlling the intensity of said partials; and means for controlling the intensity of the composite tone without altering the relative loudness of said partials.

70 21. The combination of a set of tuned sonorous bodies; means for selectively actuating a plurality of said bodies to produce fundamental tones; means for simultaneously increasing the loudness of the tones produced by selected ones of said actuated bodies; and means for actuating others of the sonorous bodies to produce partials to be associated with the selected fundamentals.

80 22. The combination of a set of tuned sonorous bodies; means for selectively actuating a plurality of said bodies to produce fundamental tones; means for simultaneously increasing the loudness of the tones produced by selected ones of said actuated bodies; means for actuating others of the sonorous bodies to produce partials to be associated with the selected fundamentals; and means for controlling the relative intensities of all the associated partials of each composite tone.

95 23. The combination of a set of tuned sonorous bodies; means for selectively actuating a plurality of said bodies to produce fundamental tones; means for increasing the loudness of the tones produced by selected ones of said actuated bodies; means for actuating others of said bodies to produce partials to be associated with the selected fundamentals; means for controlling the relative intensities of any one or more of the associated partials of each composite tone; and means for varying the intensities of the resulting tones without altering the relative intensities of said partials.

105 24. In a musical instrument, the combination of a set of tuned sonorous bodies; means for selectively actuating any one of said bodies to produce a fundamental tone; and timbre-change means to actuate simultaneously others of said bodies to produce partials to be associated with said fundamental tone, said timbre-change means being operable instantly at will to associate corresponding partials with all of the fundamentals which may be produced by said bodies.

110 25. In a musical instrument, the combination of a set of tuned sonorous bodies; means for selectively actuating any of said bodies to produce fundamental tones; timbre-change means to actuate simultaneously others of said bodies to produce partials to be associated with said fundamental tones, said timbre-change means being operable instantly at will to associate corresponding partials with all of the fundamentals which may

70

75

80

85

90

95

100

105

110

115

120

125

130

be produced by said bodies; and means to vary instantly the relative loudness of all of the corresponding associated partials in the same degree.

5 26. In a musical instrument, the combination of a set of tuned sonorous bodies; means for selectively actuating any of said bodies to produce fundamental tones; timbre-change
10 means to actuate simultaneously others of said bodies to produce partials to be associated with said fundamental tones, said timbre-change means being operable instantly at will to associate corresponding partials with all
15 of the fundamentals which may be sounded by said bodies; means to vary instantly the relative loudness of all of the corresponding associated partials in the same degree; and means to control the loudness of the resulting tones without altering the relative loudness
20 of said partials.

27. In a musical instrument having sounders adapted to produce simple harmonic motion in the air and to furnish a musical scale, means for exciting such motion in various
25 predetermined combinations of said sounders, said means including playing controllers each arranged to put into play simultaneously with relatively different degrees of intensity one of said sounders to furnish a fundamental
30 and a plurality of other said sounders to furnish harmonics of said fundamental.

28. A musical instrument comprising the structure stated in claim 27 and including means for relatively varying the intensities
35 of tones produced by the sounders.

29. A musical instrument comprising the structure stated in claim 27 and including one or more other controllers each arranged to determine which harmonics are to be put
40 into play under the control of the playing controllers.

30. A musical instrument comprising the structure stated in claim 27 and including other controlling means arranged to determine which harmonics are to be put into play
45 with the fundamentals and to determine the relative intensities of the fundamentals and harmonics.

31. In a musical instrument having sounders adapted to produce simple harmonic motion in the air and to furnish a musical scale, means arranged to connect for conjoint operation
50 predetermined combinations of sounders harmonically related to each other and means for exciting such motion with different relative degrees of force in the sounders connected as stated.
55

32. In a musical instrument having sounders adapted to produce simple harmonic motion in the air and to furnish a musical scale, playing controllers to which said sounders are related, respectively, as fundamentals, means controlled by said playing controllers for operating the sounders, means to couple
60 with each fundamental sounder for co-operation therewith a plurality of other sounders harmonically related thereto, and means to regulate the intensities, relatively one to another, of the tones produced by the sounders.
65

33. In a musical instrument having sounders adapted to produce simple harmonic motion in the air and to furnish a musical scale, electrical means for exciting such motion in said sounders individually, and means for connecting electrically for conjoint operation
70 predetermined combinations of harmonically related sounders, the latter said means including a plurality of resistance elements of different degrees of resistance for each sounder, said resistance elements being arranged to be put into use selectively under control of the said connecting means.
75

34. In a musical instrument having sounders adapted to produce simple harmonic motion in the air and to furnish a musical scale, means for exciting such motion in the sounders, said means including playing controllers by or through which the sounders are put into play as fundamentals, and means by or through which each playing controller is caused to put into play, with different relative degrees of intensity, one or more other sounders harmonically related to the fundamental sounder appertaining to the playing controller.
80

35. In a musical instrument having sounders adapted to produce simple harmonic motion in the air and to furnish a musical scale, electromagnetic means for exciting such motion in the sounders individually, said means including playing switches to which the sounders are related as fundamentals respectively, and means responsive to the control of the playing switches respectively to connect for conjoint use with each fundamental sounder, one or more other sounders harmonically related thereto.
85

In witness that I claim the foregoing, I have hereunto subscribed my name, this 14th day of August, 1917.

MELVIN L. SEVERY.

70

75

80

85

90

95

100

105

110

115

120

125

130