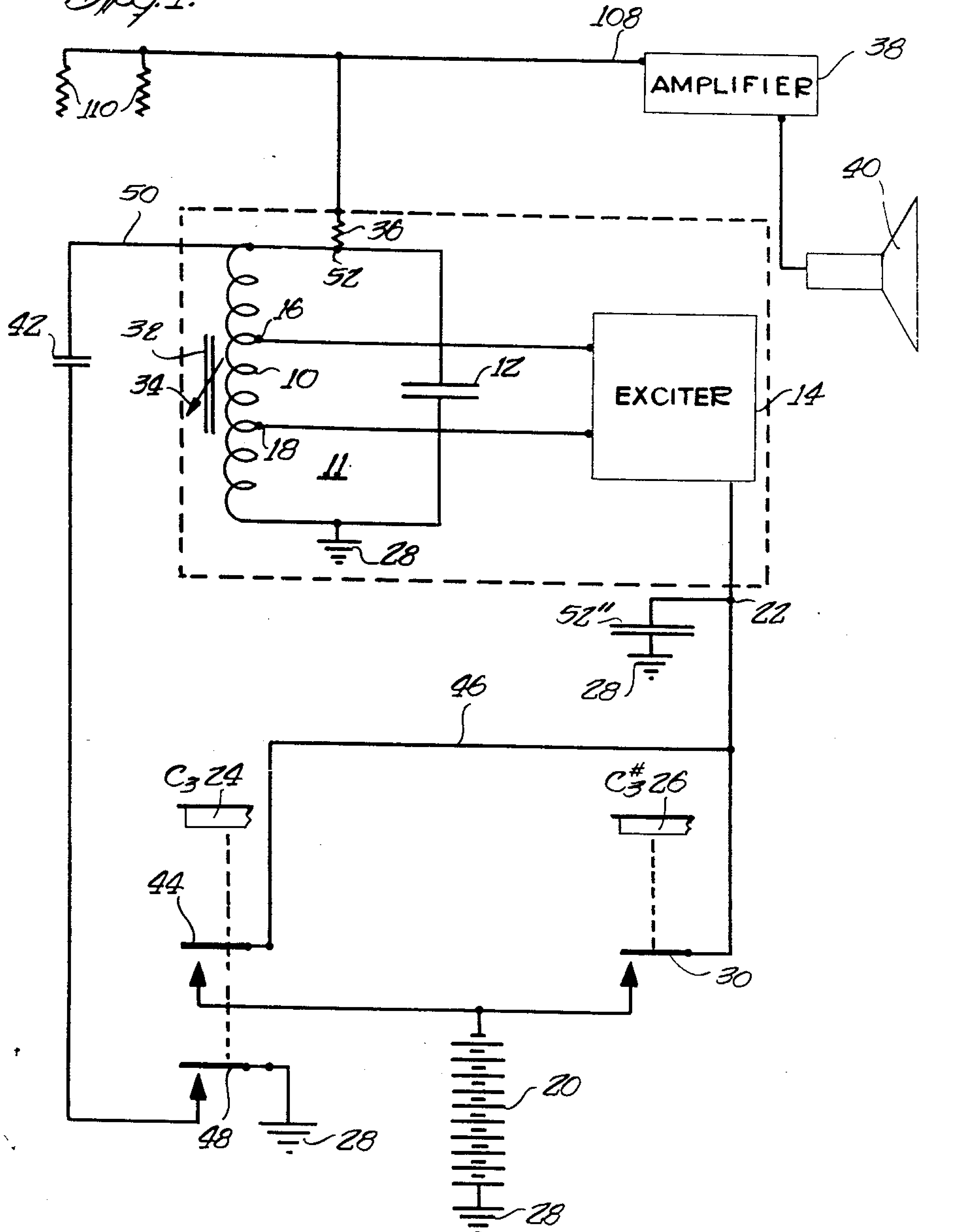
Sept. 20, 1960 R. H. PETERSON 2,953,053

KEY TUNING APPARATUS FOR ELECTRONIC MUSICAL INSTRUMENTS

Filed March 23, 1959

4 Sheets-Sheet 1

Fig. 1.



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Sept. 20, 1960 R. H. PETERSON 2,953,053

KEY TUNING APPARATUS FOR ELECTRONIC MUSICAL INSTRUMENTS

Filed March 23, 1959 4 Sheets-Sheet 2

Fig. 2.

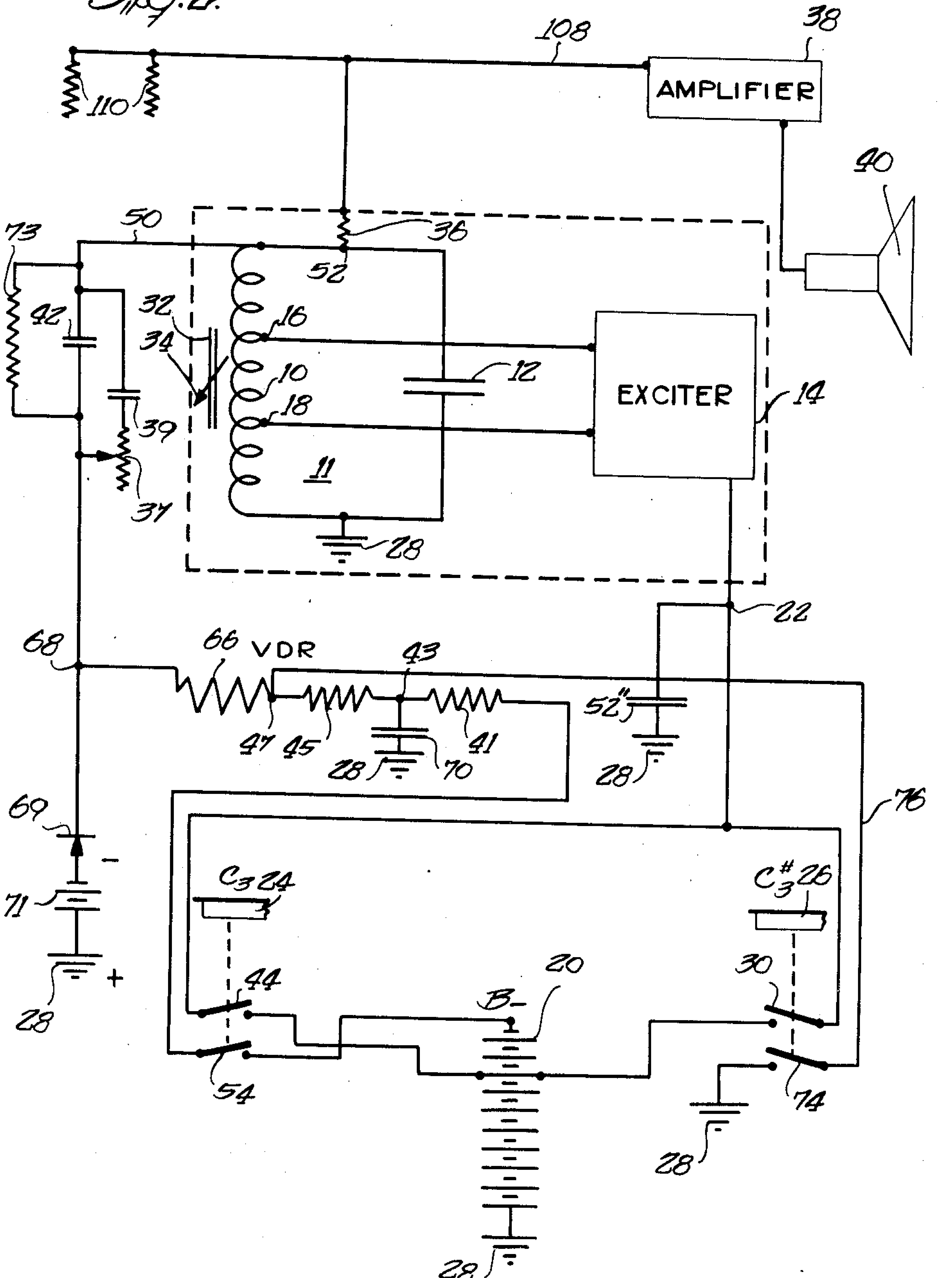

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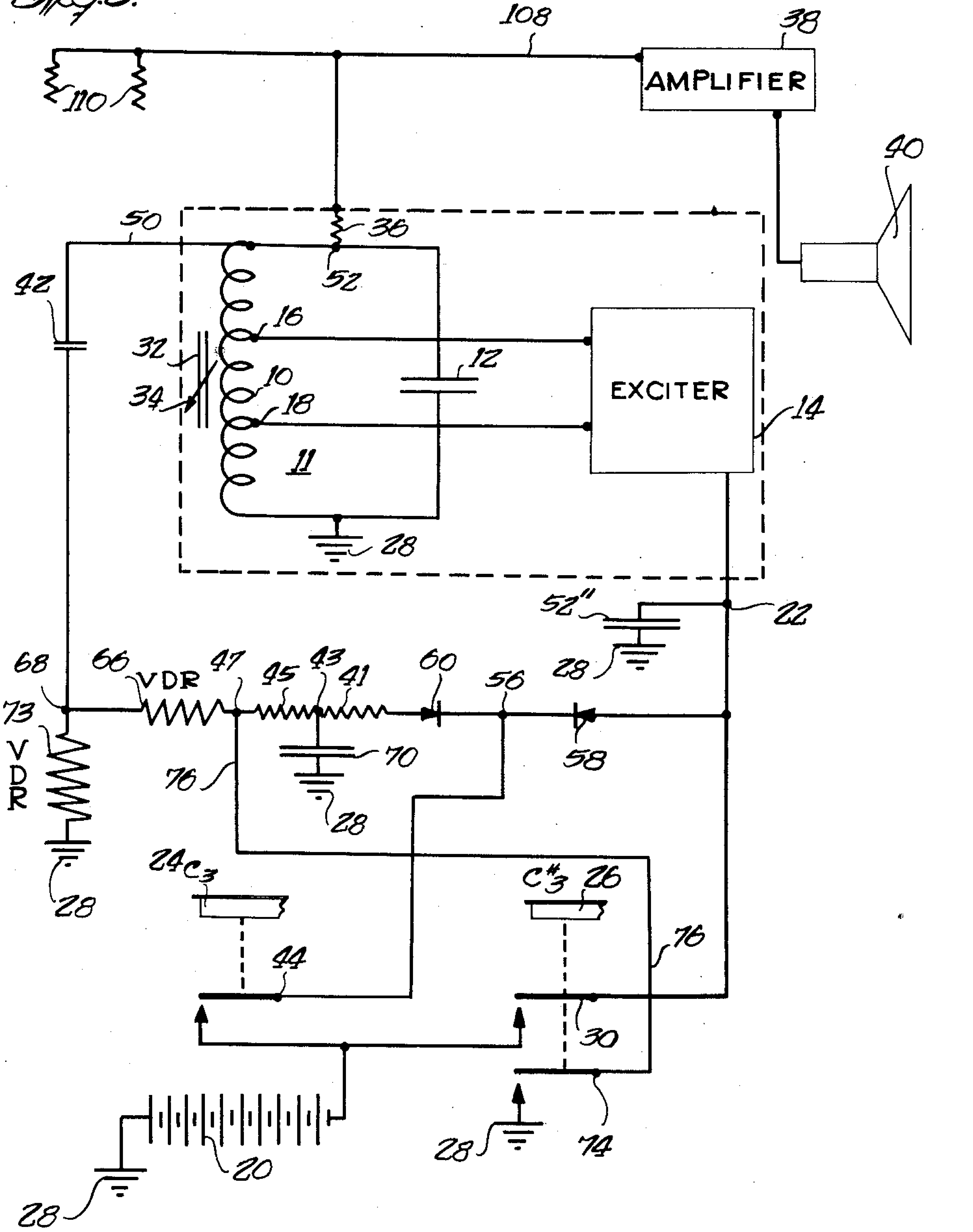
Fig. 3.



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KEY TUNING APPARATUS FOR ELECTRONIC MUSICAL INSTRUMENTS

Filed March 23, 1959 4 Sheets-Sheet 4

Fig. 4.

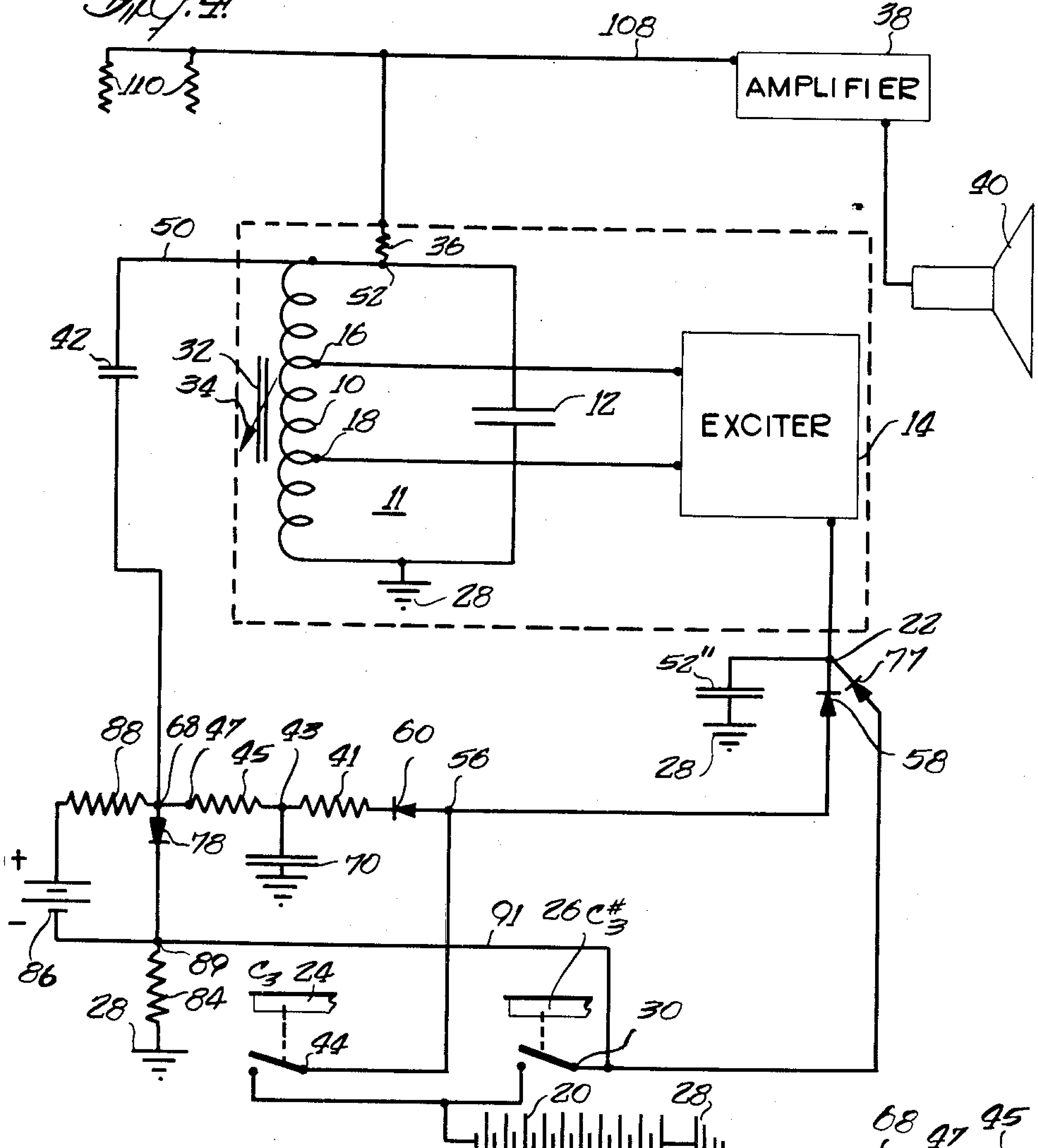


Fig. 5.

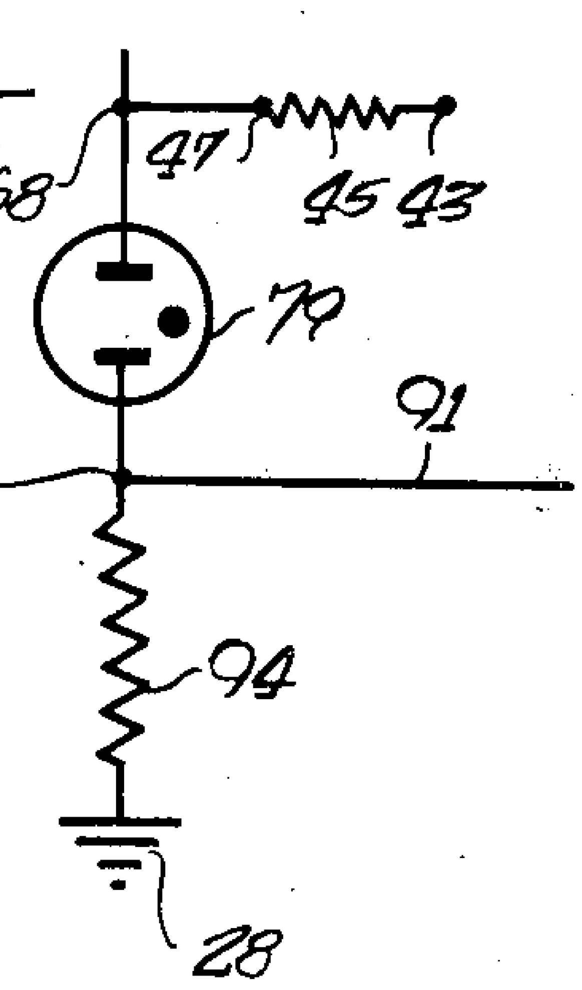
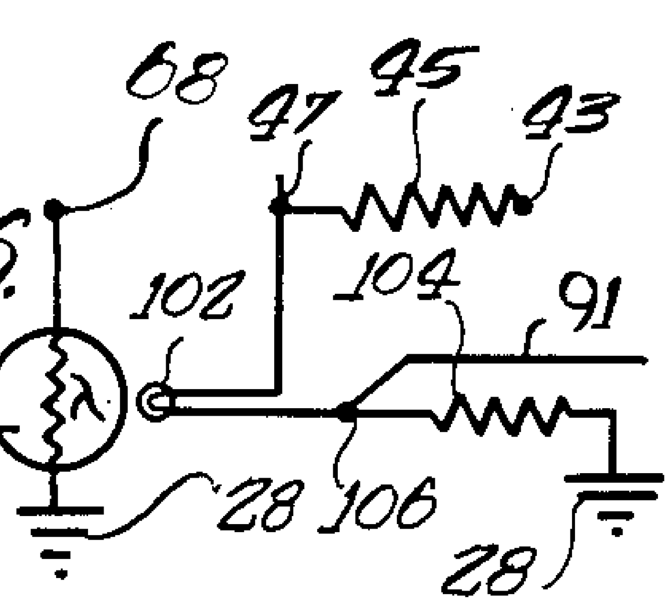


Fig. 6.



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United States Patent Office

2,953,053

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1

2,953,053

KEY TUNING APPARATUS FOR ELECTRONIC MUSICAL INSTRUMENTS

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Filed Mar. 23, 1959, Ser. No. 801,223

12 Claims. (Cl. 84—1.17)

This invention relates to electrical musical instruments, particularly to instruments of the organ type, that employ a plurality of electrical oscillators to produce tone signals of frequencies corresponding to the notes of the musical scale. More specifically, it relates to organs employing oscillators of the type that are normally not in oscillation, but that are rendered operative by the application of actuating potential through switches selectively controlled by the playing keys of the instrument. Such organs ordinarily employ large numbers of oscillators, generally one for each note of the musical scale over a range of several octaves. A complete organ, therefore, generally requires at least sixty and preferably seventy-two or more oscillators for even the smallest single key-board instrument.

One object of the invention is to provide a complete musical instrument that requires a greatly reduced number of oscillators but that nevertheless is capable of substantially the same musical performance as organs employing a separate oscillator for each note. Systems for making organs requiring less than one oscillator per note are well known and are substantially as old as the art itself, but no system has been completely satisfactory for use in high-quality instruments, and as a result of the limitations of these known systems, they have been employed only to a limited extent, and only in very simple low-cost instruments capable of rather limited musical performance.

In common with the relatively ineffective devices of the prior art, this invention takes advantage of the well-known fact that in ordinary organ literature, of either the popular or the classical variety, adjacent semi-tone frequencies are almost never known to be sounded at the same time. Therefore all such music could be produced with two of the key-board keys for adjacent semi-tones sharing the same oscillator because they will never be played at the same instant.

One objection to traditional shared-oscillator systems is that the switching apparatus required to utilize such oscillators in organs is generally quite complex, and therefore, if it is desired to employ such traditional organ effects as octave couplings and the like, the total switching apparatus becomes excessively complicated to the extent that the additional switching equipment may well be a greater drawback than the cost of providing the extra oscillators. It is another object of this invention, therefore, to provide an oscillator capable of supplying any one of a plurality of notes of the musical scale, wherein the switching apparatus required is no more complicated than it would be in organs employing separate oscillators for each note.

Another objection to known shared-oscillator systems is that the decay characteristics of the tones were influenced adversely by the sharing of the oscillator. Therefore, it is a further object of this invention to provide a shared oscillator system wherein desirable musical decay characteristics can be secured without interfering with tuning the oscillators to their various selected pitches.

2

Further objects and advantages of the invention will become apparent as the description proceeds.

In the accompanying drawings:

Figure 1 is a schematic wiring diagram of one oscillator of a shared oscillator system of the conventional type;

Figure 2 is a similar wiring diagram for one type of shared oscillator according to the invention;

Figure 3 shows a further development of the new inventive principle involved;

Figure 4 shows a more complete development, with respect to reducing the number of key switches;

Figures 5 and 6 show two more variations of voltage dependent resistors.

The oscillator of Figure 1 comprises essentially a tuned LC loop having an inductor **10** connected across the terminals of a capacitor **12**.

Oscillations are set up in this loop **11**, as by exciting means **14** coupled to the loop terminals **16** and **18**. The exciting means may be of any well-known type, such as a vacuum tube or a transistor.

United States Patent 2,649,006 shows one suitable vacuum tube exciter. With these or any other equivalent exciter, an energy source **20** is needed to deliver appropriate activating potential to the activating terminal **22** of the exciter. With the well-known vacuum tube a common activating potential is from plus 120 to plus 300 volts D.C. With a transistor exciter the voltage is 27 volts or less and may be either plus or minus. In Figure 1 the terminal **22** may receive activating potential from the source **20** through circuits set up by either of two adjacent playing keys, a playing key **24** for sounding one pitch, such as middle C, also called C_3, and a playing key **26** for sounding a pitch one semi-tone higher, $C\#_3$. Ground is identified by the reference character **28** and all of the ground connections illustrated in the drawing are to the same ground. Associated with key **26**, to be mechanically closed by depressing the key and opened by releasing the key, is a key switch **30** connected to the ungrounded terminal of source **20** and to the activating terminal **22**. Depression of key **26** will therefore deliver activating potential to the terminal **22** and the exciting means will initiate and maintain oscillation in the loop **11** as long as the key remains depressed. When the operator's finger is removed from the key the key will rise and the switch will open and the tone will stop. The frequency of this tone is substantially a mathematical function of the magnitudes of the inductor **10** and the capacitor **12**. It is customary to tune the entire oscillator by adjusting either the inductance or the capacitance in the loop and I have indicated a ferromagnetic core at **32** which is adjustable, as diagrammatically indicated by the arrow **34**. U.S. Patent 2,818,759 discloses the details of such tuning means.

With the tuning loop adjusted to deliver the note $C\#_3$ in the conventional way through protective resistance **36** to translating means including the amplifier **38** and the loudspeaker **40**, the means for causing the same oscillator to sound the note C_3, one semi-tone lower, comprises a much smaller capacitor **42** which may be connected in parallel with the capacitor **12** to add its storage capacity to that of the capacitor **12** and lower the inherent frequency of the oscillator itself to the precise degree necessary to secure the different and lower pitch. To accomplish this two switches are associated with the key **24**. The switch at **44** receives the same potential as the switch **30** and delivers it through conductor **46** to the appropriate terminal of the switch **30** and from there the current continues to terminal **22** as before.

A switch 48 of similar construction is electrically separate from the switch 44 but is mechanically depressed and closed by the same key 24. This switch connects one terminal of the capacitor 42 through the switch 48 to ground at 28, and the other terminal is connected by a conductor 50 to point 52 of the tuned loop 11. Closure of the switch 48 and the switch 44, therefore, energizes the exciting means and simultaneously includes the capacitor 42 so that the oscillator delivers the note C_3. Furthermore, if the key 26 is depressed at a time when the key 24 is being held closed, neither the hearer nor the oscillator will know the difference. In either case terminal 22 continues to receive activating potential and the repeated closing and opening of the key 26 will be entirely without effect.

However, the reverse is not true at all. With key 26 depressed and note $C\#_3$ sounding, depressing key 24 will move the frequency down to C_3 and release of the key 24 will move the frequency up again.

If this were all that is required in the rendering of conventional organ music of moderate complexity, there would be no need for the present invention. But with conventional instruments and with conventional music, when a note is being discontinued it does not cut itself off abruptly, with such a click as is commonly experienced when a telephone receiver is lifted or hung up, but the sound dies away gradually over a period that may vary from a fraction of a second up to three or four seconds. It is desirable for the electronic instrument to provide a slow decay when desired by the player, to get the right esthetic effect.

In Figure 1 I have indicated a capacitor 52″ connected between the exciting terminal 22 and ground. It will be obvious that when either key 24 or key 26 is depressed the energy of the source 20 will not only maintain the functioning of the exciting means and oscillator but it will charge capacitor 52″ up to its own full potential. Subsequently, when the playing key is released, this stored energy remains available at the terminal 22 to replace the source 20 momentarily and the sound will continue until this energy has been used up. But the decreasing potential resulting from the gradual discharge of the capacitor 52″ will cause the sound to decrease in intensity much as an ordinary musical note dies away. Various expedients are used to enable the player to change the amount of energy stored in such a capacitor to secure varying percussion effects, but no music is acceptable in which the minimum continuation of sound is not appreciable.

Consider now the equipment according to Figure 1 in which the capacitor 52″ is of a size to produce a decay period of one second, and let the player play staccato notes having a duration of one-quarter of a second. If the key 26 is momentarily depressed and released again, there will be the predetermined decay period and the oscillator will continue to speak with a decreasing volume of sound down to zero at the end of a second. If the key 24 is depressed after the key 26 has been released but before the end of the decay period for the note $C\#_3$, the inception of the new sound will mask and obscure the disappearance of the previous frequency to such an extent that the result is not offensive to the ear. However, every time the key 24 is depressed for either a quarter of a second or for any length of time whatsoever, when the key 24 is released, the release removes the capacitor 42 from the circuit with the abruptness of a telephone receiver being slammed down and the oscillator will decay in $C\#_3$, which changes the pitch one semi-tone in an unnatural way at the instant key 24 is released. No teenage boy whose voice is changing and unexpectedly shifts into falsetto can rival the absurdly grotesque effect that is produced in this way. No such freak noises can be tolerated in the production of music. Therefore the size of capacitor 52″ has to be almost nothing. But to simulate correctly the performance of an ordinary organ pipe requires a decay time that may be quite short, but not nearly as short as must be used with circuitry according to Figure 1.

In Figures 2, 3, and 4, I have indicated three embodiments selected to illustrate the invention. All of these achieve complete musical adequacy, so far as the player is concerned. The embodiment of Figure 4 also achieves musical adequacy with no additional key switches.

It will be noted that the entirety of the oscillator proper may be identical with that of Figure 1, but the switching means associated with keys 24 and 26 is substantially reorganized.

Key switch 24 closes switch 44 and another switch 54 corresponding to switch 48, in Figure 1. From the switch 54 potential passes through resistor 41 to terminal 43 and then through resistor 45 to terminal 47.

Resistors 41 and 45 are merely protective, to avoid sparking at the switch contacts by fully instantaneous discharge of capacitor 70. They also protect against short circuiting the source 20 when keys 24 and 26 are both depressed at the same time.

Terminal 47 is connected to electronic means for rendering the path from tuning capacitor 42 to ground 28, conductive or non-conductive to the A.C. signal in loop 11. Figures 2, 3, 4, 5 and 6 indicate five different types of electrical network for doing this.

In Figure 2 the non-polar voltage sensitive resistor 66 is of the type more fully disclosed for use as a distorter in U.S. Patent 2,649,006. At zero voltage, the resistance is at a predetermined high value. Application of voltage lowers the resistance smoothly without any discontinuity, to values of from one one hundredth to one one thousandth of the high resistance obtaining at zero voltage.

Capacitor 42 is connected to a junction 68. From terminal 47, the D.C. circuit runs through voltage sensitive resistor 66 to terminal 68, and from there to ground through two paths. The low resistance path is through rectifier and biasing battery 71. The high resistance path is through resistor 73, shunted around capacitor 42, conductor 50, and inductance 10, to ground.

Resistor 73 is of relatively high resistance. It is employed as a safeguard to make sure that biasing battery 71 keeps the potential drop at diode 69 in the direction of high resistance and at all times not less than maximum signal voltage. Theoretically, such a rectifier diode should bias itself by rectifying the signal from the capacitor 42, but some commercial diodes are not sufficiently dependable to be relied on for such a critical function, in which case I employ the double safeguard of adding the battery 71 and high reactance shunt 73.

When potential is supplied from source 20, the potential at point 68 changes enough to start a current flow through battery 71, in a direction opposite to the E.M.F. of that battery. Rectifier 69 becomes conductive and resistor 66 drops to its low resistance condition. The A.C. signal from capacitor 42 now passes freely through diode 69 and battery 71 to ground. There is also a parallel A.C. ground through resistors 66, 45 and capacitor 70. Capacitor 42 is now effective to lower the frequency of the loop 11, and the oscillator will deliver the note C_3.

The capacitors 12 and 42 are a commercial product and it is difficult to produce them at reasonable cost, with an accuracy better than 5%. The overall adjustment of the entire loop is taken care of by adjusting the inductor at 34. Then a capacitor 42 is selected from stock, of a size that will lower the overall pitch about 95% of a semi-tone. Trimming capacitor 39 in series with an adjustment resistor 37 is shunted around capacitor 42, and a final high precision adjustment is made at the factory on the resistor 37. It would be possible to get equivalent adjustment of pitch with a series resistor in conductor 50, but that would dissipate energy in the main signal and impair the functioning of the entire oscillator.

To provide the note C_3 with a decay period of proper length, a capacitor **70** is connected from junction **43** to ground **28**. When potential is first supplied, this capacitor picks up a full charge, and when key **24** is released, the charge on capacitor **70** cannot be dissipated through the switch **44** and will, therefore, cause a current through resistor **66** and diode **69** to ground. Thus, the capacitor **70** keeps the resistor **66** at its low value and the diode **69** conductive and the capacitor **42** operative at least as long as capacitor **52''** sustains the oscillation of the exciter itself, and a normal decay of unchanged C_3 frequency results.

When the player depresses key **26**, potential arrives at terminal **22** through the key switch **30** as in Figure 1.

When key **26** is depressed and the key **24** is also depressed before the normal decay period for the note $C\sharp_3$ has ended, the note C_3 takes over and the acoustical effect is not objectionable, just as in Figure 1.

But when key **24** is depressed and subsequently key **26** is depressed before resistor **66** has resumed its high resistance condition, the player might be unable to sound the note $C\sharp_3$ as soon as required by the music. To eliminate this interference, I provide a cutout switch **74** mechanically closed by key **26**. This switch grounds one end of a conductor **76**, and the other end of the conductor is connected at junction **47**. Now when key **26** is depressed before the tone resulting from depressing key **24** is at an end, the potential at junction **47** drops instantaneously to zero and the resistor **66** resumes its high resistance value and the oscillator **11** assumes the frequency $C\sharp_3$.

It will be apparent that with wiring according to Figure 2, rapid chromatic runs, or semi-tone trills, can be executed by the player at will, and the instrument will keep up with the player's fingers at all times.

Referring now to Figure 3, key **24** closes switch **44** as in Figures 1 and 2 but the activating potential is delivered by switch **44** to a tuning terminal **56**. From the terminal **56** potential passes through the diode **58** to terminal **22** and the oscillator receives the same exciting impulse as before. From the tuning terminal **56** potential passes also through the diode **60** to resistors **41**, **45** and **66**, as in Figure 2.

When the potential of the source **20** is delivered to the tuning terminal **56**, in Figure 3, it initiates a D.C. current flow through the ordinary resistors **41** and **45**, and voltage sensitive resistors **66** and **73**. A.C. signal passes freely to ground through both **73** and **66** and capacitor **42** becomes effective to lower the frequency of the loop **11**, and the oscillator will deliver the note C_3.

This circuit would be fully operative if resistor **66** were an ordinary resistor, but with both resistors **73** and **66** sensitive to voltage, a lower and more convenient working voltage becomes adequate. The same is true in Figure 2, and in Figures 4, 5 and 6, resistor **45** could be made voltage sensitive.

As in Figure 2, the capacitor **70** is connected from junction **43** to ground **28**. When potential is first applied, this capacitor picks up a full charge, and when key **24** is released, the capacitor **70** keeps the resistors **66** and **73** at their low values and the capacitor **42** operative at least as long as capacitor **52** sustains the oscillation of the exciter, and a normal decay of unchanged C_3 frequency results.

When the player depresses key **26**, potential arrives at terminal **22** through the key switch **30** as in Figure 1, but this potential is blocked by rectifier **58** and all the circuitry from there to capacitor **42**, and resistor **73** gets nothing and performs no function. This gives the note $C\sharp_3$, and releasing the key **26** will give a normal $C\sharp_3$ decay.

When key **24** is depressed and subsequently key **26** is depressed before resistor **66** has resumed its high resistance condition, the player might be unable to sound the note $C\sharp_3$ as soon as required by the music. To eliminate this interference, I provide the cutout switch **74** as in Figure 2.

Referring now to Figure 4, the oscillator proper is still unaltered, and the tuning contact **56** and diodes **58** and **60** remain the same. The key **24** and its associated circuits also remain unchanged. The switch **74** and conductor **76** of Figure 3 have been replaced by a diode **77** between switch **30** and terminal **22**. I have also replaced resistors **66** and **73** with a biased diode **78**.

When key **24** is depressed, potential is delivered through switch **44** tuning terminal **56** and diode **60** to the resistors **41** and **45**, and to capacitor **70**.

From junction point **68** the cut-in circuit runs through diode **78** and resistor **84** to ground **28**. The rectifier **78** is bridged by a biasing circuit including potential source **86** and resistor **88**. When key switch **44** is open, potential source **86** imposes a voltage on diode **78** opposite to the direction in which current can flow and greater than any signal voltage that might come to junction **68** through capacitor **42**.

When key **24** is depressed, the greater potential of source **20** will come to terminal **68** and overcome the potential of source **86**, and rectifier **78** will become conductive and render capacitor **42** effective to lower the frequency of loop **11**. The subsequent release of key **24** will leave the capacitor **70** charged to keep the rectifier **78** conductive at least as long as capacitor **52** keeps the exciter **14** in oscillation. But if switch **30** is closed before key **24** is released, or before the tone resulting from key **24** has decayed, the potential at junction **89** delivered by conductor **91** will immediately reverse the potential on rectifier **78**, and interrupt the functioning of capacitor **42**. Again rapid trills, or runs, in either direction, can be executed, and the oscillator will keep up with the fingers of the player just as in Figure 2. However, all these functions are obtained with only one switch contact for each key so that the multiple contact difficulty is also eliminated.

In Figure 5 I have indicated the junction point **68** connected through a neon tube **90** in series with a protective resistor **94**.

When the voltage of source **20** comes to point **68**, the tube **90** breaks down and D.C. and A.C. current passes freely through the tube **90** and resistor **94**. The cut-out circuit wire **91** may be connected at junction **98**. It will be obvious that resistors **84** in Figure 4 and **94** in Figure 5 must both be quite low to enable capacitor **42** to function with full effect.

In Figure 6 I have indicated a cadmium sulphide photoresistor at **100**, and a miniature incandescent light source **102**, connected to receive potential from terminal **47**, and protected by resistor **104**. The cut-out circuit wire **91** may be connected to junction **106**. The cadmium sulphide photo-resistor **100** can be made to change its resistance over ratios as high as 1,000,000 to 1 or even 1,000,000,000 to 1, or more by merely changing the amount of light impinging on the same.

The complete tone generator of an organ according to the invention will include the collecting bus **108** and as many additional protective resistors **110** as there are oscillators.

Summarizing the operation of Figure 4, the first key **26** has a first activating circuit running from the potential source **20** through the switch **30** and rectifier **77**, to the terminal **22**. The second key **24** has an activating circuit from the same source **20** through the switch **44** and terminal **56** and branching there from the rest of the activating circuit to pass through the rectifier **60**, the resistors **41** and **45**, biased rectifier **78**, and resistor **84**, to ground at **28**. The tuning circuit for lowering the frequency of the exciter is from terminal **52**, through capacitor **42** to terminal **68** and from there on in common with the cut-in circuit to ground. Only one more keying circuit is needed, to cut out the tuning circuit and render it inoperative whenever the first key 26 is depressed. This is a branch circuit from the source, through switch 30 and cross connection 91 to the terminal at 89.

Whenever terminal 22 receives activating voltage the oscillator functions and capacitor 52″ stores the appropriate amount of energy for providing the desired decay rate of the oscillation after activating potential is withdrawn. And whenever the cut-in circuit is activated by depressing key 24 capacitor 70 also stores energy, which energy becomes available after activating potential is withdrawn to continue the operativeness of the cut-in circuit at least as long as capacitor 52″ continues the oscillation of the oscillator.

It will be seen that in Figure 1 each key has an activating circuit individual to that key, but the two circuits may have certain parts in common. There is also a third, tuning circuit, which contains capacitor 42 and is controlled by key switch 48.

In each of Figures 2 to 6, there are two additional circuits, consisting of a cut-in circuit for rendering the tuning circuit operative, and a cut-out circuit for rendering the tuning circuit inoperative.

In Figures 2, 3, 4 and 5, part of the cut-in circuit is part of the tuning circuit also, but in Figure 6 the operative connection is optical rather than electrical, and the tuning circuit and cut-in circuit are electrically separate and distinct.

This application is a continuation-in-part of my copending application S.N. 596,544, filed July 9, 1956, now Patent 2,906,959, issued September 29, 1959.

Others may readily adapt the invention for use under various conditions of service by employing one or more of the novel features disclosed or equivalents thereof.

It will be obvious that the different types of cut-in circuits disclosed may include some which are best adapted to deal with notes of low pitch, and others which get the best results for notes of high pitch, and that different segments of a single keyboard may each have its own preferred type of cut-in circuit.

As at present advised, with respect to the apparent scope of my invention, I desire to claim the following subject matter:

1. In an electronic organ, in combination, an oscillator comprising a tuned LC loop circuit and an exciter operatively associated with said loop and adapted, upon receipt of activating potential, to initiate and maintain oscillation in said loop as long as activating potential is supplied; said exciter having a terminal for receiving activating potential; a tuning circuit adapted to change the frequency of said oscillator from one pre-selected note of the musical scale to a different note; first and second playing keys corresponding to unchanged and changed frequencies of said oscillator, respectively; first and second switch contacts, one for each key, respectively; a first activating circuit rendered operative by said first switch contact for delivering activating potential to said oscillator terminal; a second activating circuit rendered operative by said second switch contact for delivering activating potential to said oscillator terminal; a cut-in circuit rendered operative by depressing said second key, for rendering said tuning circuit operative; said tuning circuit being otherwise inactive, and inoperative to change the oscillator frequency; a cutout circuit rendered operative by depressing said first key for rendering said cut-in circuit inoperative; a source of activating potential for each of said switch contacts; a first energy storage means connected to said oscillator and adapted to have its energy content changed when activating potential is delivered to said terminal and to resume its initial condition by means of current through said oscillator after activating potential is withdrawn; whereby said oscillator continues to oscillate with decreasing amplitude for a pre-determined time; a second energy storage means connected to said cut-in circuit and adapted to have its energy content changed when activating potential is present in said cut-in circuit and to resume its initial condition by means of current through said cut-in circuit after activating potential is withdrawn; whereby said cut-in circuit remains operative for a pre-determined time after activating potential is withdrawn; said second energy storage means being adapted to keep said cut-in and tuning circuits operative after activating potential is withdrawn, at least as long as said first energy storage means maintains oscillation in said oscillator; said oscillator having an output circuit for delivering signal; and translating means for translating said output signal into musical sound.

2. A combination according to claim 1 in which said changed frequency is lower than said unchanged frequency by one musical semi-tone.

3. A combination according to claim 1 in which a single potential source is connected to supply activating potential to both activating circuits.

4. A combination according to claim 1 in which a single potential source is connected to supply the same activating potential to both activating circuits, and to said cut-in and cut-out circuits.

5. A combination according to claim 1 in which both said activating circuits contain substantial rectifiers adjacent to said activating terminal, for preventing the reception of activating potential from said terminal.

6. A combination according to claim 1 in which said cut-in circuit comprises a non-polar voltage sensitive resistor connected in series in said tuning circuit; and connections for applying D.C. potential to said resistor to reduce its resistance and render it conductive to A.C. signal.

7. A combination according to claim 1 in which said cut-in circuit comprises a substantial rectifier connected in series in said tuning circuit; biasing means for applying to said rectifier a potential difference in the direction of high resistance; said biasing means potential being greater than maximum signal potential; and means for delivering to said rectifier a second potential in the direction of low resistance; said second potential being greater than the sum of biasing means potential and maximum signal potential, to keep said rectifier continuously conductive to signal.

8. A combination according to claim 1 in which said cut-in circuit comprises a gas-filled tube and a potential source; said tube and source being connected in series in said timing circuit, with said source applying a voltage in the direction of conduction of said tube, but less than enough to maintain discharge in said tube; and means for applying to said tube additional voltage in the same direction, up to a total voltage greater than the breakdown voltage of said tube.

9. A combination according to claim 1 in which said cut-in and cut-out circuits are each controlled by their respective keys by means of additional key switches insulated from each other and from said first and second switch contacts.

10. A combination according to claim 1 in which said cut-in circuit comprises a cadmium sulphide photo-resistor connected in series in said timing circuit, and a light source responsive to source potential for illuminating said resistor.

11. A combination according to claim 10 in which said light source is a miniature incandescent filament.

12. In an electronic organ, in combination, an oscillator comprising a tuned LC loop and an exciter operatively associated with said loop and adapted, upon receipt of activating potential, to initiate and maintain oscillation in said loop as long as activating potential is supplied; said exciter having a terminal for receiving activating potential; a tuning circuit adapted to change the frequency of said oscillator from one pre-selected note of the musical scale to a different note; first and

second playing keys corresponding to the unchanged and changed frequencies of said oscillator, respectively; first and second switch contacts, one for each key respectively; a first activating circuit rendered operative by said first switch contact for delivering activating potential to said oscillator terminal but not for receiving activating potential from said oscillator terminal; a second activating circuit rendered operative by said second switch contact for delivering activating potential to said oscillator terminal but not for receiving activating potential from said oscillator terminal; a cut-in circuit rendered operative by activating potential in said second activating circuit for rendering said tuning circuit operative; said tuning circuit being otherwise inactive, and inoperative to change the oscillator frequency; a cut-out circuit rendered operative by activating potential in said first activating circuit for rendering said cut-in circuit inoperative; a source of activating potential for each of said switch contacts; a first energy storage means connected to said oscillator and adapted to have its energy content changed when activating potential is delivered to said terminal and to resume its initial condition by means of current through said oscillator after activating potential is withdrawn; whereby said oscillator continues to oscillate with decreasing amplitude for a predetermined time; a second energy storage means connected to said cut-in circuit and adapted to have its energy content changed when activating potential is present in said cut-in circuit and to resume its initial condition by means of current through said cut-in circuit when activating potential is withdrawn; whereby said cut-in circuit remains operative for a pre-determined time after activating potential is withdrawn; said second energy storage means being adapted to keep said cut-in and tuning circuits operative after activating potential is withdrawn, at least as long as said first energy storage means maintains oscillation in said oscillator; said oscillator having an out-put circuit for delivering signal; and translating means for translating said output signal into musical sound.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 2,953,053 September 20, 1960

Richard H. Peterson

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 8, lines 49 and 62, for "timing", each occurrence, read -- tuning --.

Signed and sealed this 11th day of April 1961.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

ARTHUR W. CROCKER

Acting Commissioner of Patents