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L. S. THÈREMIN

METHOD OF AND APPARATUS FOR THE GENERATION OF SOUNDS

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Fig. 1.

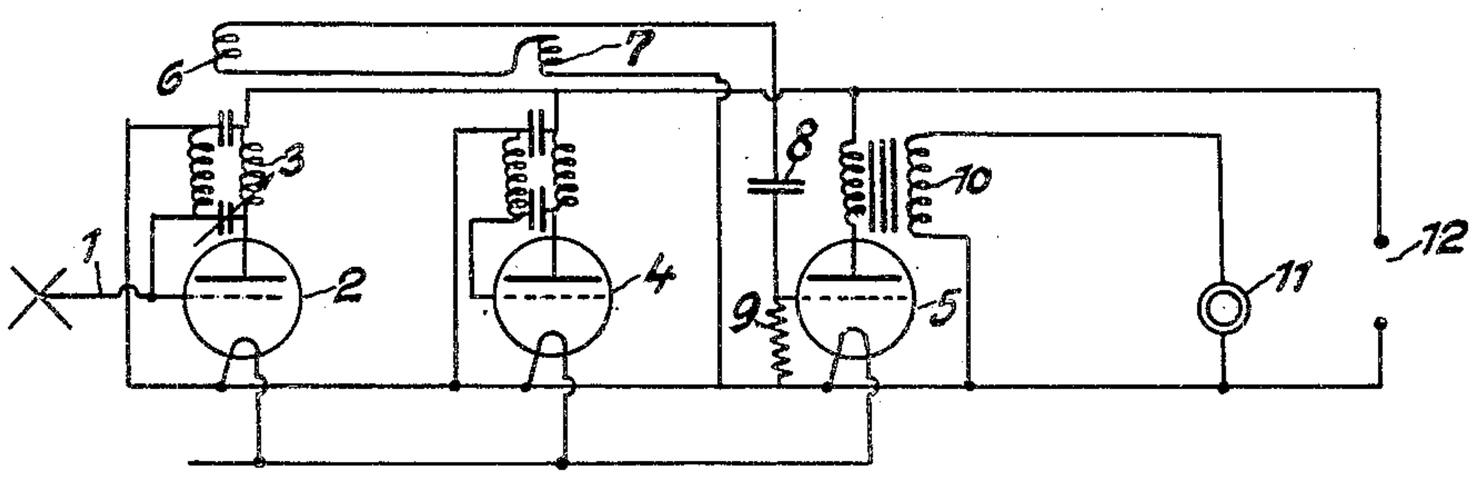

Fig. 1a.

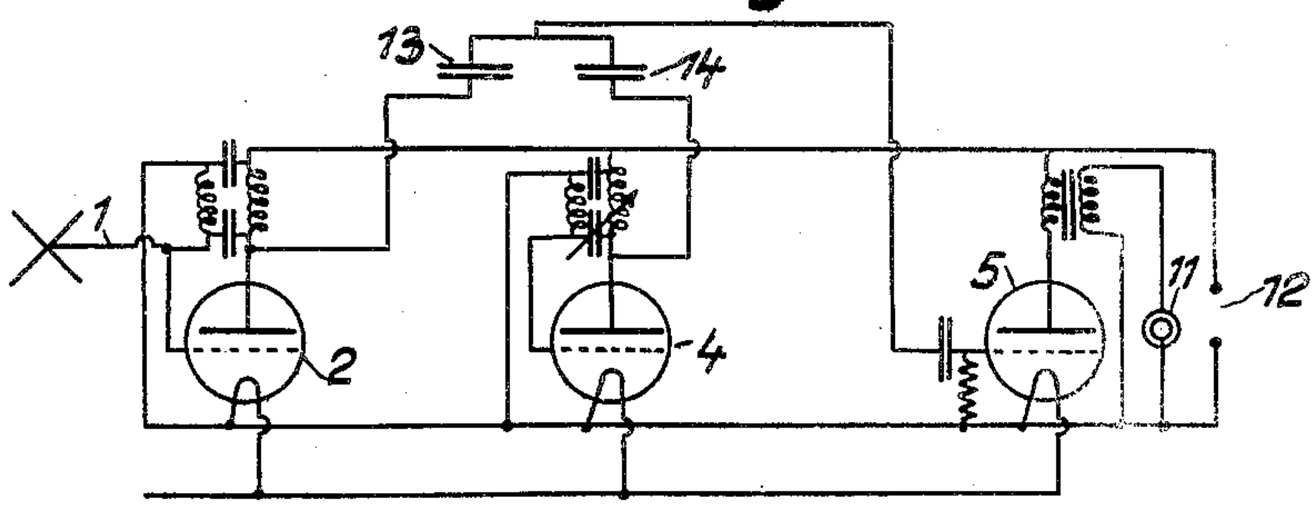

Fig. 2.

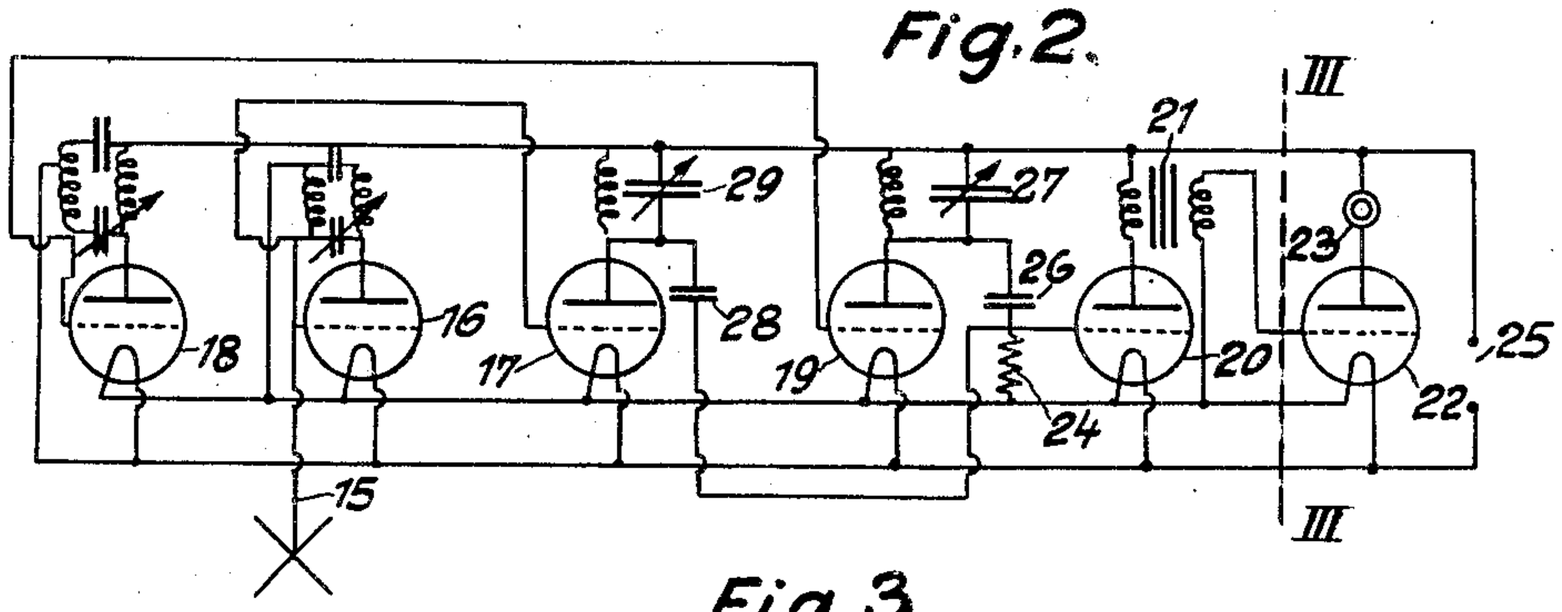

Fig. 3.

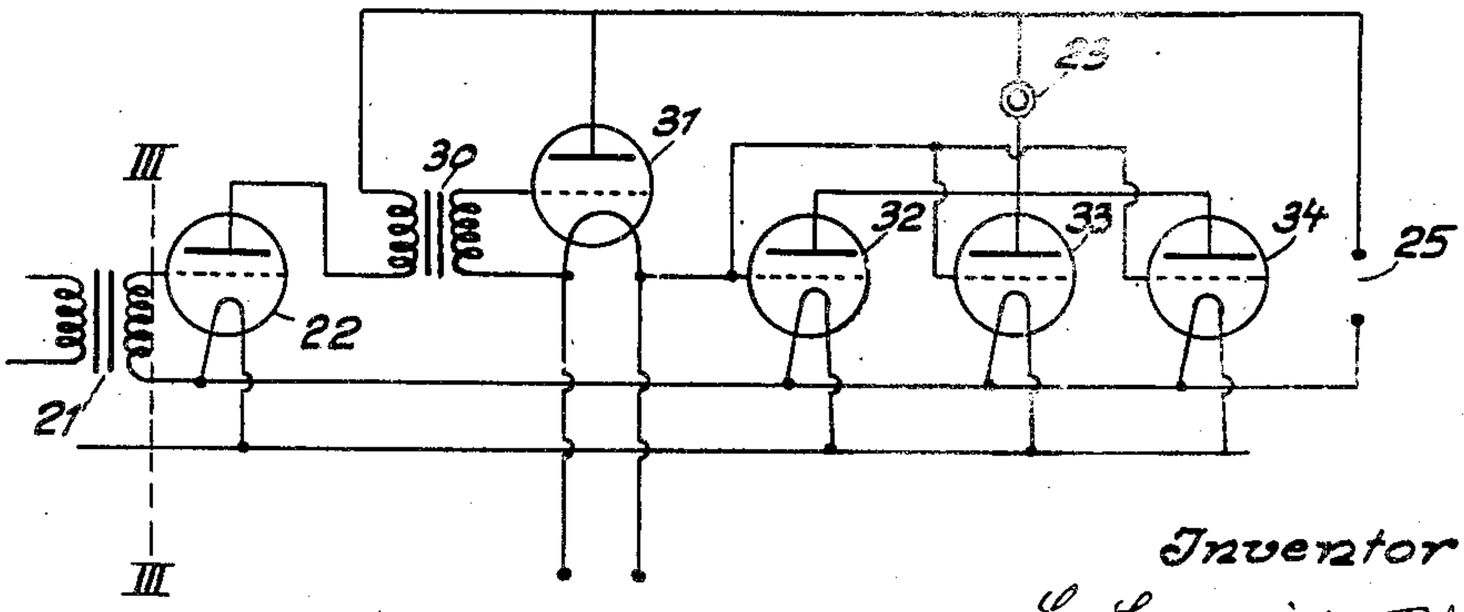

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Fig. 4.

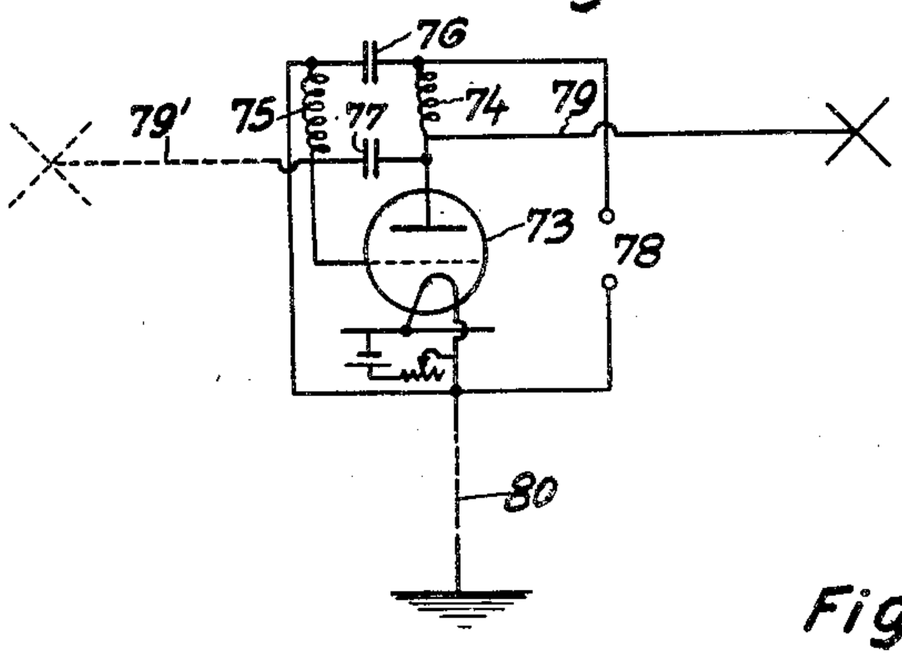


Fig. 5.

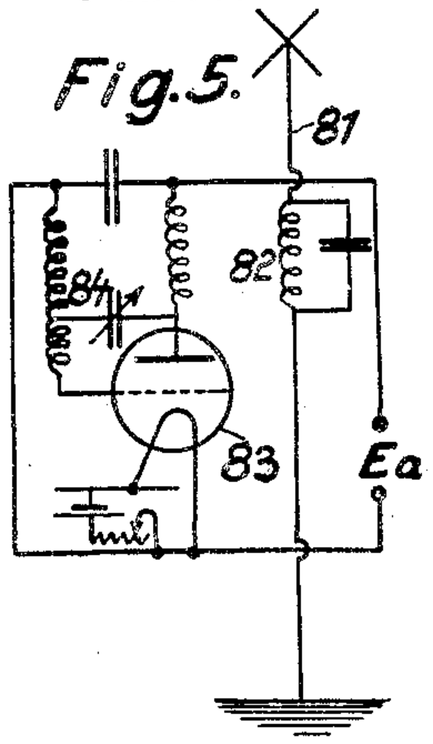


Fig. 6.

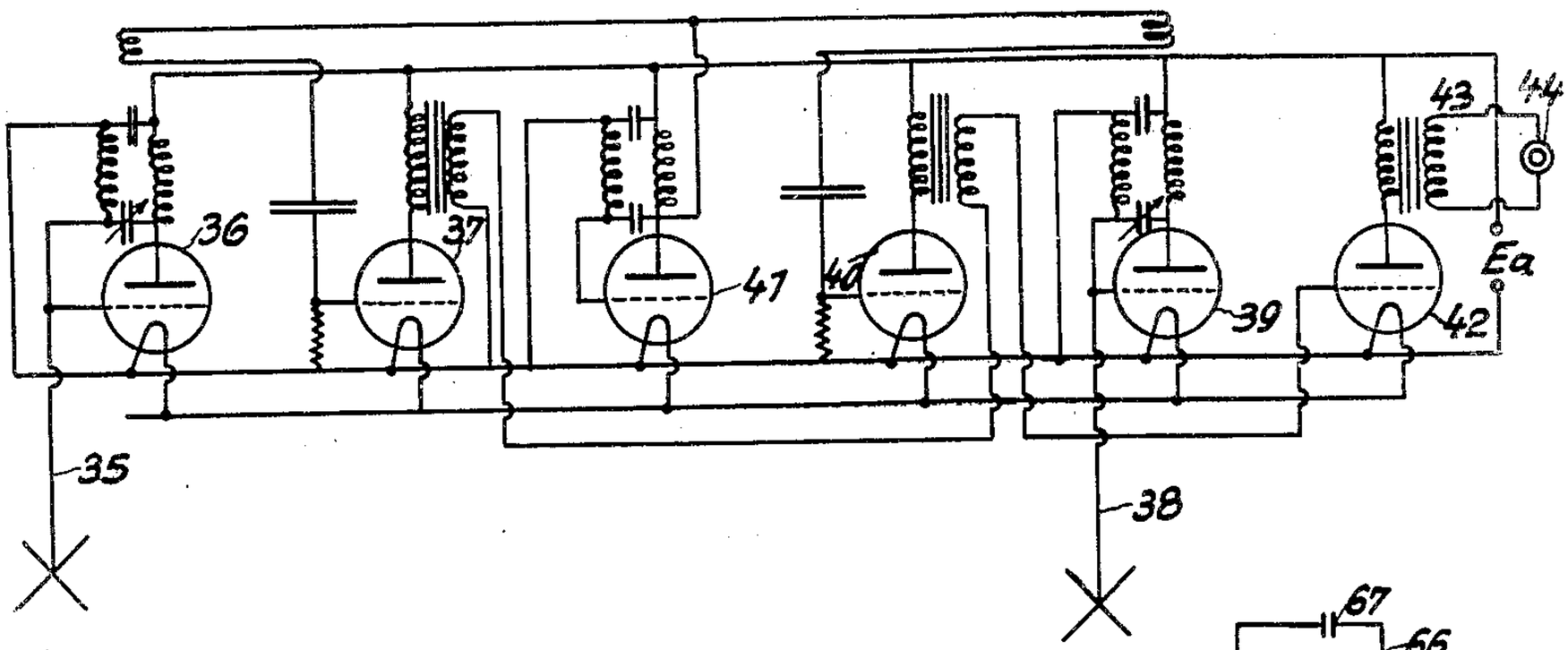
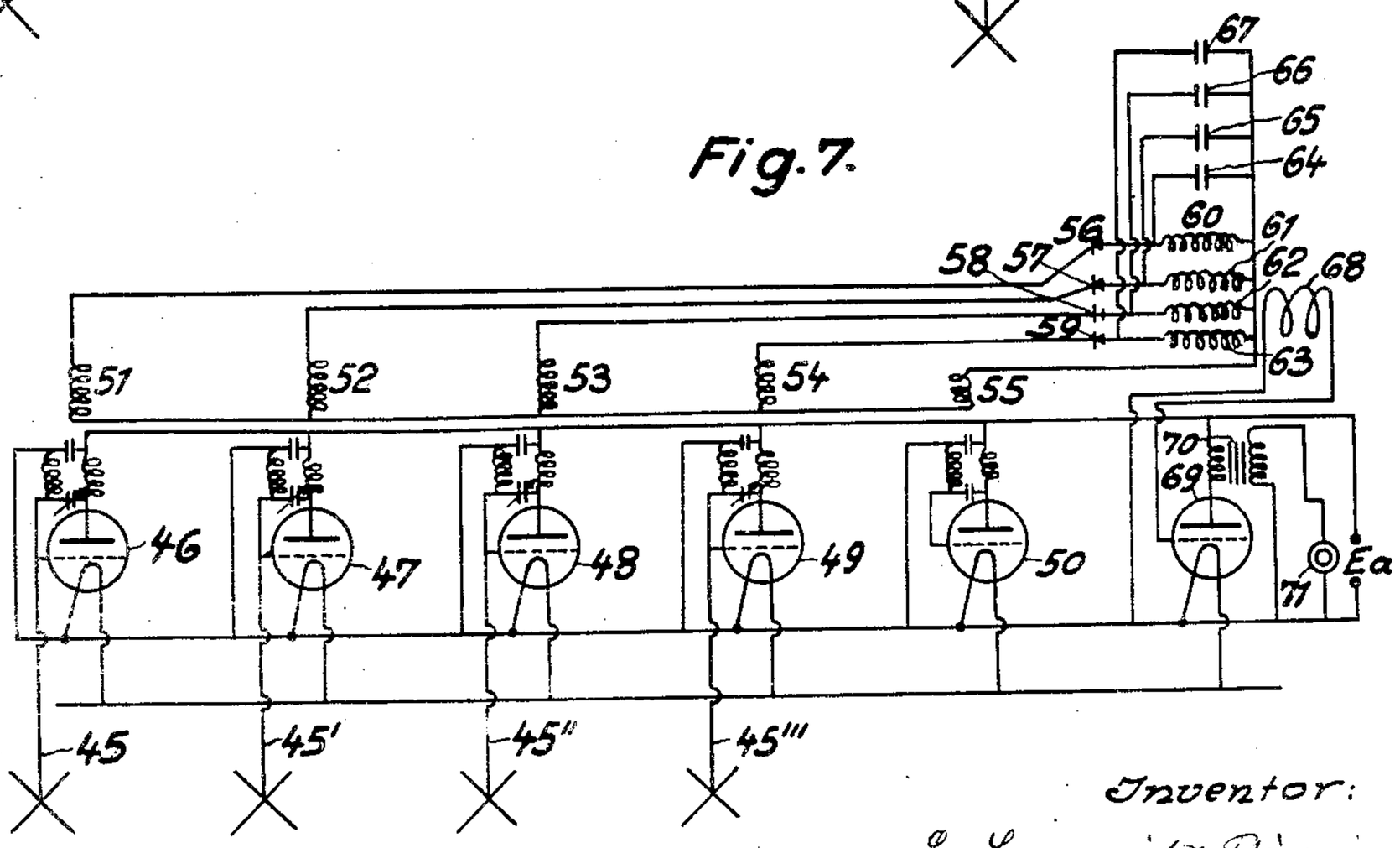


Fig. 7.



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METHOD OF AND APPARATUS FOR THE GENERATION OF SOUNDS

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Fig. 8.

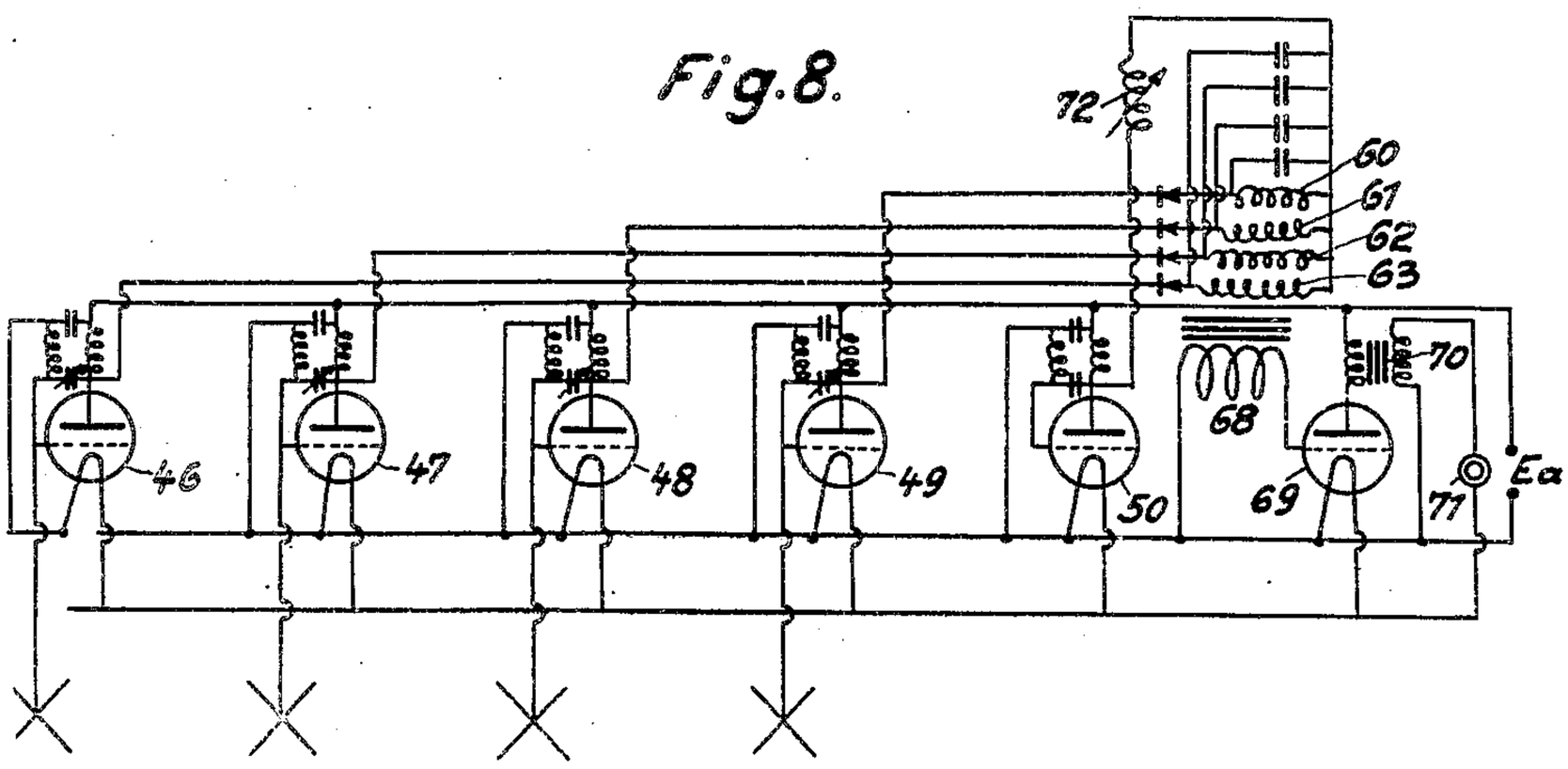


Fig. 9.

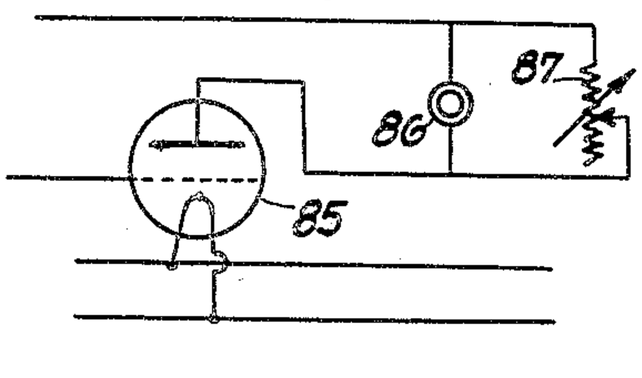
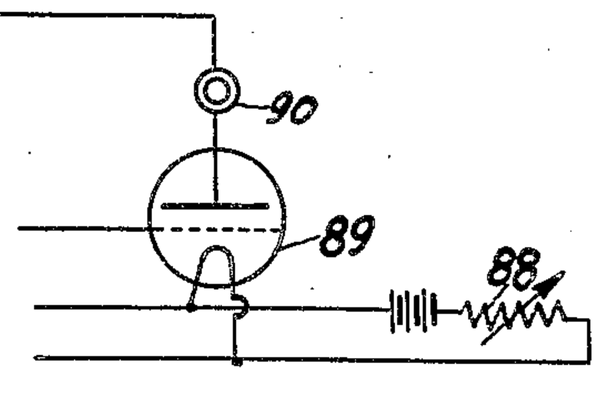


Fig. 10



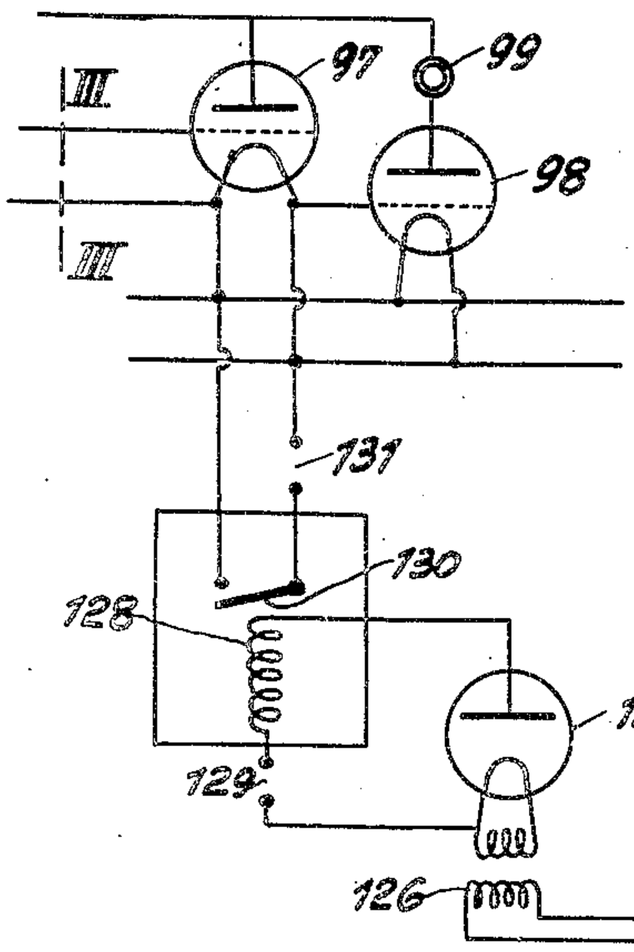


Fig. 19.

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Fig. 11.

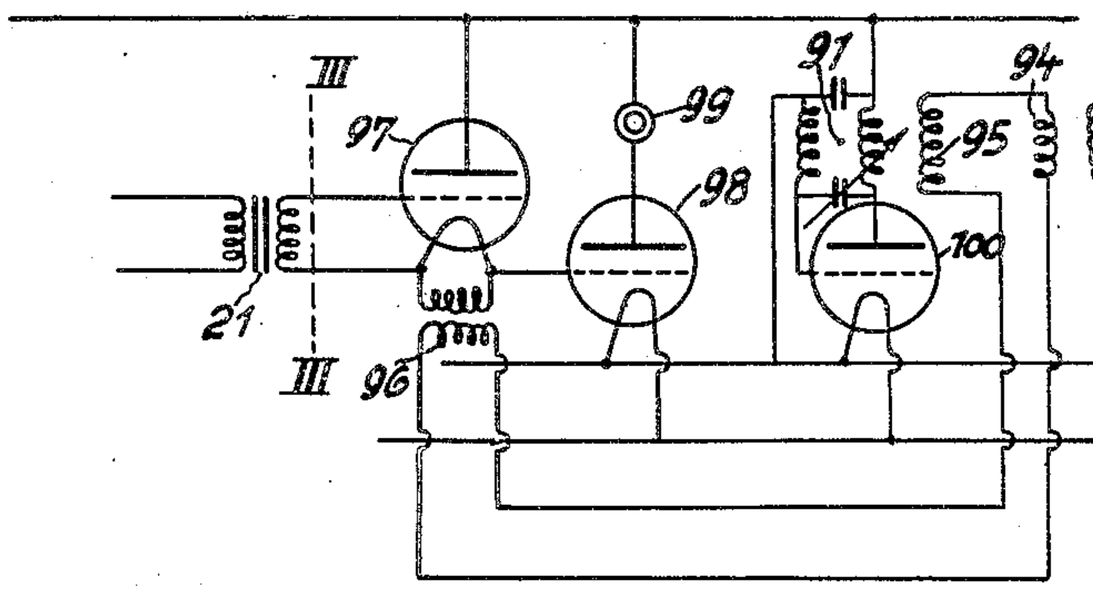

Fig. 12.

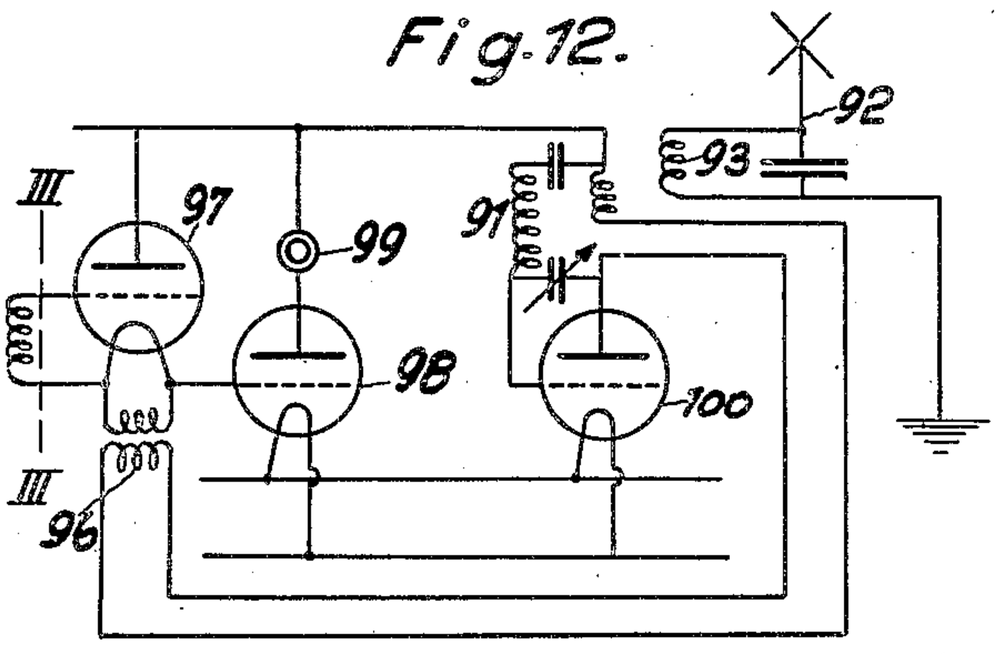

Fig. 13.

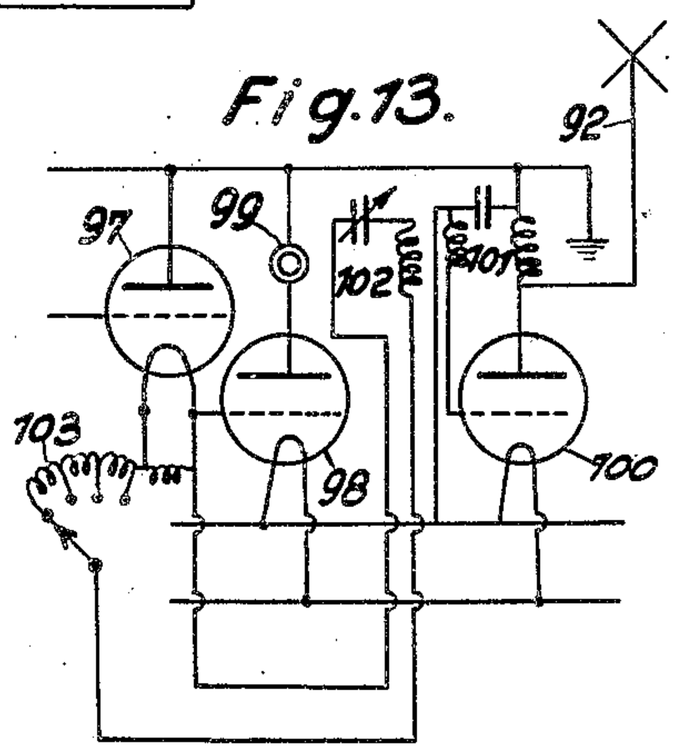

Fig. 14.

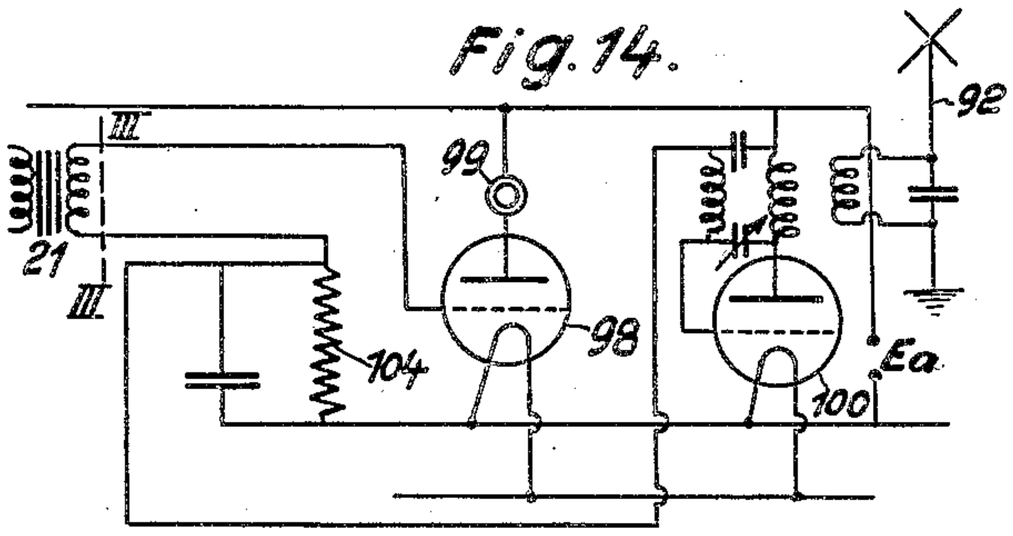

Fig. 18a.

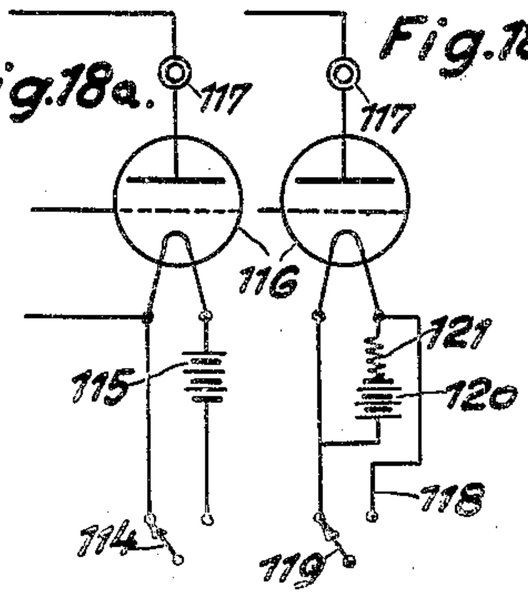

Fig. 18b.

Fig. 15.

Fig. 16.

Fig. 17.

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Fig. 20.

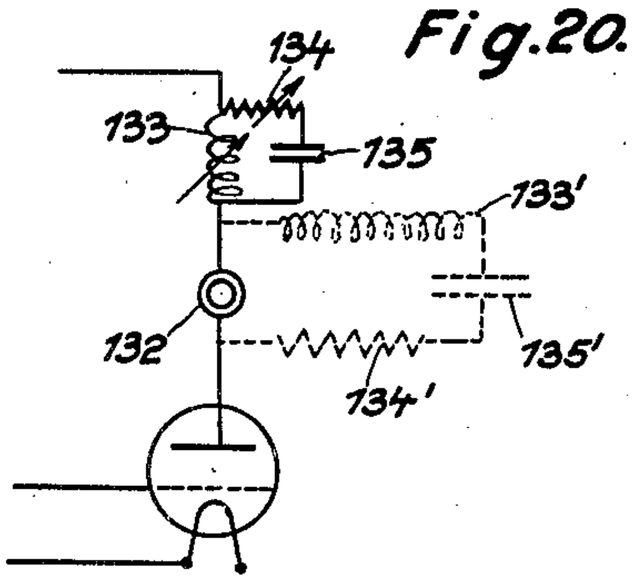


Fig. 21.

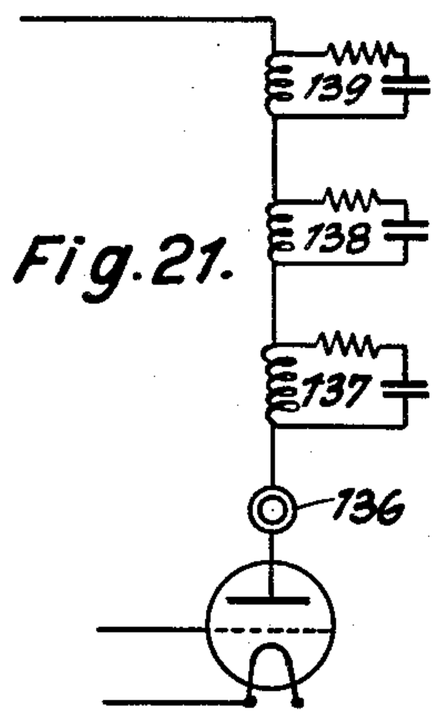


Fig. 22.

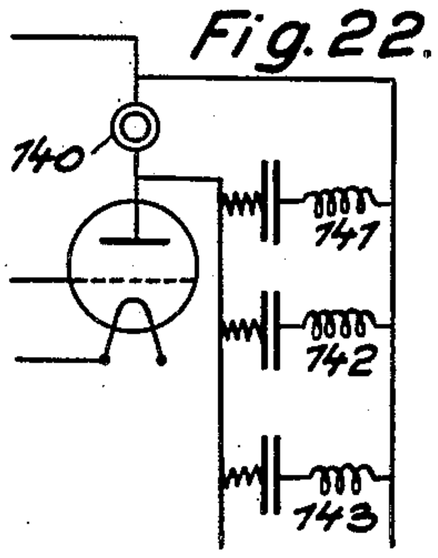


Fig. 23.

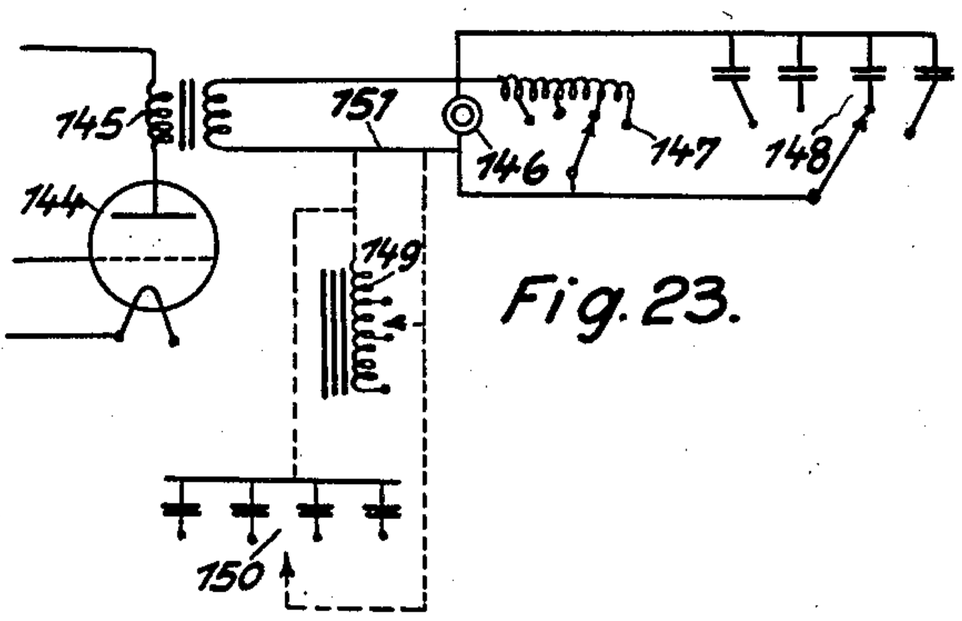


Fig. 24.

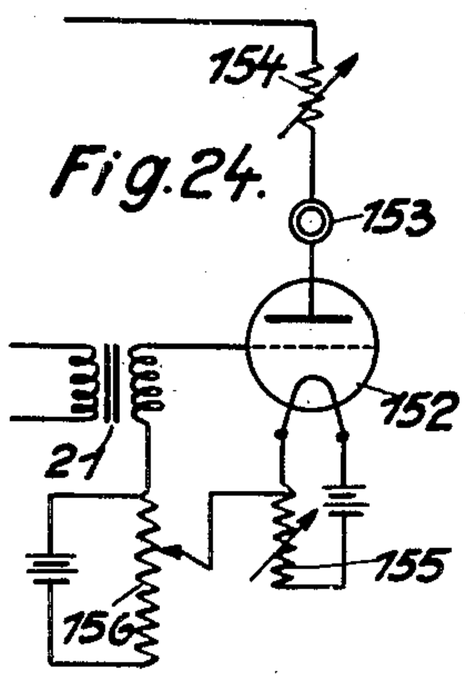
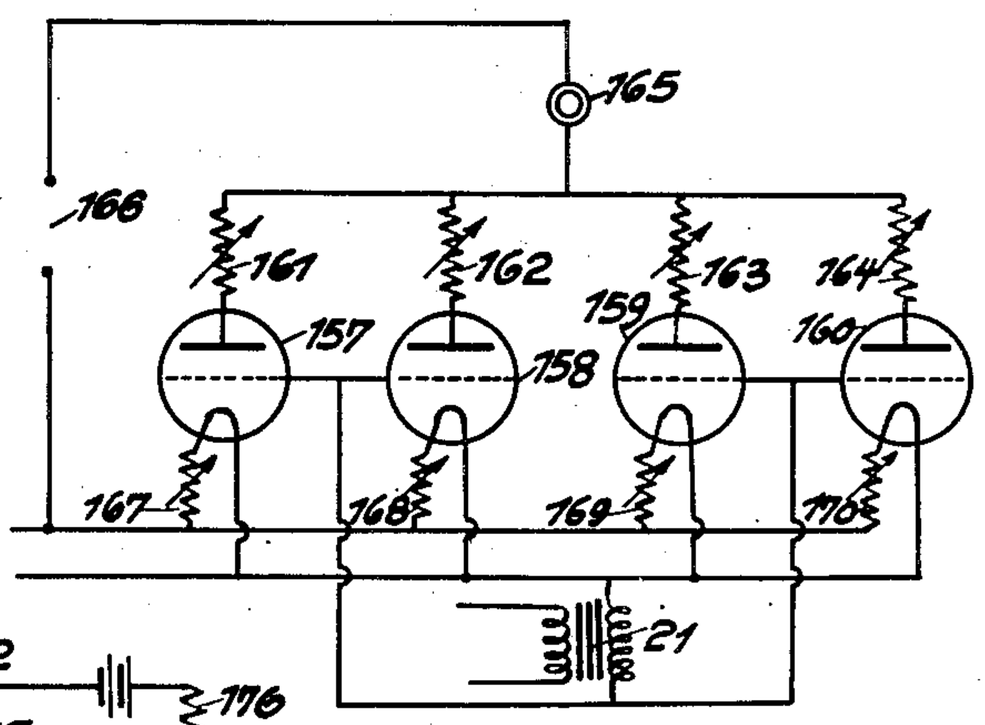


Fig. 25.



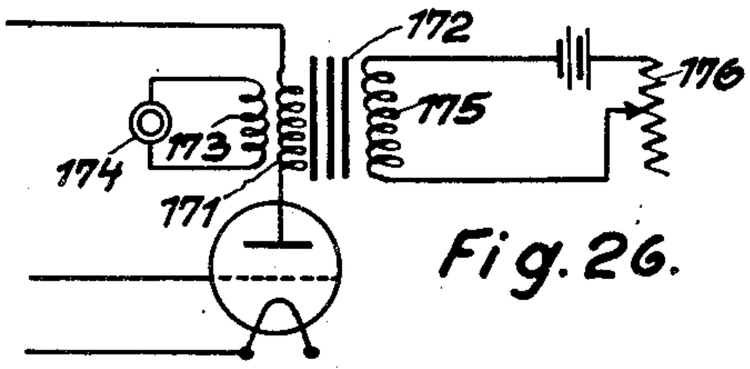


Fig. 26.

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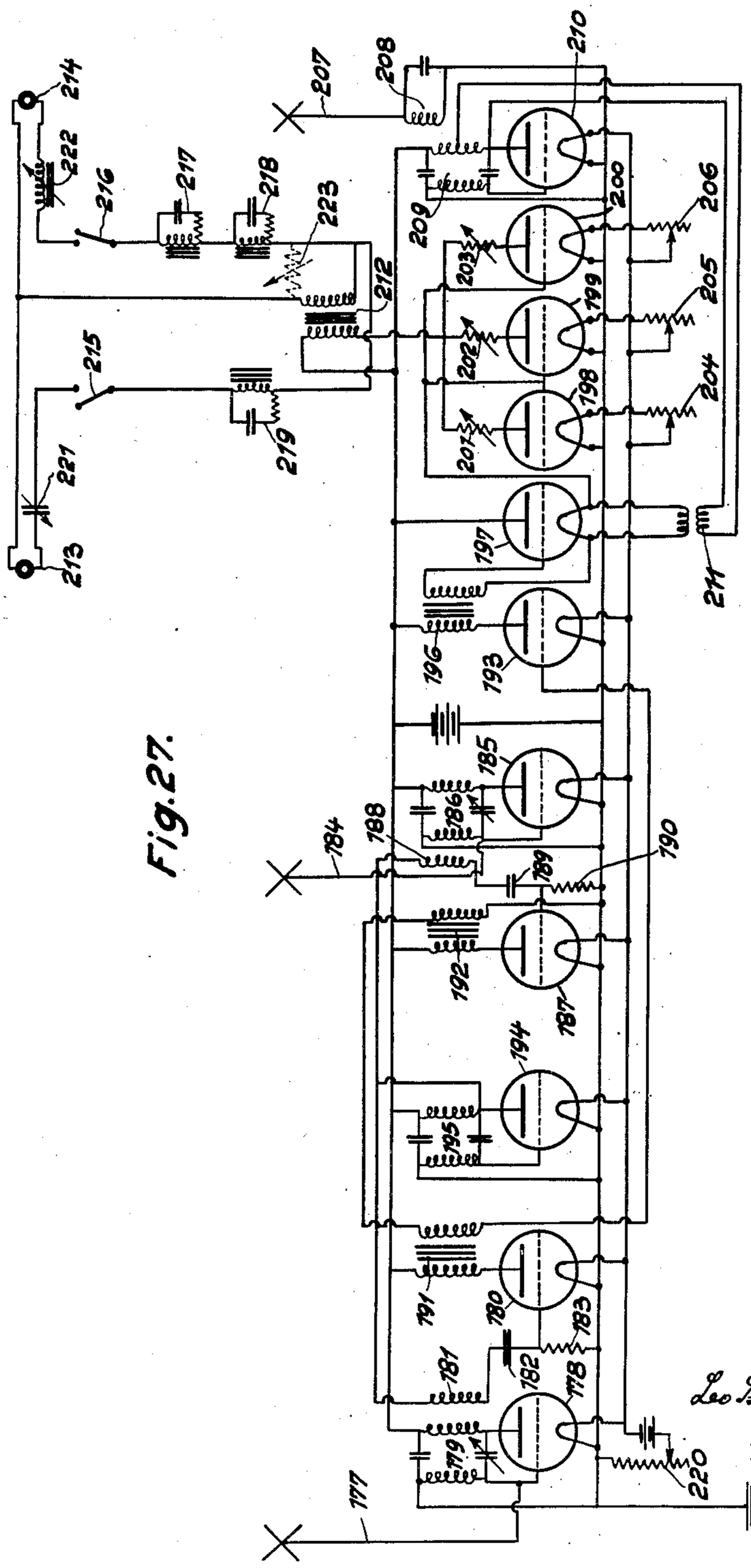

Fig. 27.

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UNITED STATES PATENT OFFICE.

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METHOD OF AND APPARATUS FOR THE GENERATION OF SOUNDS.

Application filed December 5, 1925, Serial No. 73,529, and in Germany December 8, 1924.

This invention relates to sound generating apparatus or instruments of the type embodying an electrical vibrating system. It aims to provide a novel method of and means for producing sounds in musical tones or notes of variable pitch, volume and timbre in realistic imitation of the human voice and various known musical instruments. One object of the invention is to provide a simple and inexpensive instrument capable of producing musical tones according to the method embodying the same, the pitch, volume and timbre of which sounds may be varied over a wide range, and with delicate graduations.

An instrument embodying the invention comprises a sound reproducer, such as a telephone receiver or loud-speaker, connected to an oscillating system adapted to be controlled or affected by an object or objects, such as the hands or fingers of an operator held in relative position in proximity to an element of the system. For example, an electrical oscillating system including oscillator tubes of the electro-ionic type may be employed, and the circuits of the system may be so correlated that the frequency or frequencies of the electrical oscillations will vary in accordance with the variations in the electrical capacity or other characteristic of the controlling circuit caused by the movements of external objects, such as an operators hand or fingers as above stated. The operator's hands, or the objects moved by him are not required to make physical contact with the instrument, but if the instrument is arranged to permit such contact, the generation or production and control of the sound is not effected directly thereby as is the case with the ordinary musical instruments.

In order to generate clear sound or musical tones and permit ready control thereof, a plurality of oscillators are employed, having a frequency above the audible range but interacting with each other to produce interference or beat-notes of audible frequency. The frequency of one or more of the oscillators is controllable by the operator to produce beat-notes of the desired pitch. The apparatus in preferred form also embodies means for controlling the volume and timbre of the music.

The improved method and means of this invention for producing sound or musical tones possess great advantages over ordinary musical instruments of the prior art. Apart from the simplicity in construction and operation of an instrument embodying the invention, it is capable of producing clear and pure musical tones in realistic imitation of a known instrument, such as the violin for example, and may be so constructed that the characteristics of the sound or music produced thereby may be changed as desired in imitation of various other instruments, whereas the ordinary musical instrument, such as the violin, produces sound tones of fixed and well-known characteristics. The instrument is not limited, however, to the production of music but may be employed to generate sounds or operate signals for various purposes.

Other objects and advantages of the invention, particularly with reference to electrical elements and circuits and their arrangements in systems for securing various results in different constructional embodiments which have been devised, will appear from the following description considered in connection with the accompanying drawings in which are shown several modified forms of the invention. Various practical embodiments of the invention are hereinafter described in order to make a full and complete disclosure, but the invention obviously is not limited to the specific arrangements shown and it is to be understood that no limitations thereon are intended beyond those set forth in the appended claims.

Referring to the drawings,

Fig. 1 is a diagrammatic view of electrical circuits and apparatus arranged in accordance with the invention for the production of a single tone of variable pitch;

Fig. 1[a] is a similar view of a modification;

Fig. 2 is a similar view of a further modification embodying amplifiers;

Fig. 3 is a diagrammatic view of a modified form of reproducer circuit;

Figs. 4 and 5 are diagrammatic views of different forms of control circuits;

Fig. 6 is a diagrammatic view of a system for producing two tones;

Figs. 7 and 8 are similar views of systems for producing four tones;

Figs. 9 to 14 illustrate means for regulating the volume of the sounds;

Figs. 15 to 18 illustrate systems for switching the tone on and off by means of a wire connection;

Fig. 19 shows a system for effecting the same result by a modified form of control;

Figs. 20 to 22 show systems for eliminating the natural oscillations;

Figs. 23 to 26 illustrate systems for regulating the timbre of the sound or tone; and

Fig. 27 illustrates a complete system for simultaneously producing a plurality of sound or musical tones on the same or different pitches, and embodying means for controlling the characteristics thereof.

A preferred form of instrument embodying the invention and operable according to the method embodying the same, comprises the following elements:

I. A control element or electrode with relation to which an object such as the hands or fingers of an operator are moved to control the pitch and character of the sound tones emitted by the instrument. Said element does not function like the antenna in a wireless receiver set or apparatus, i. e., it does not receive or detect radiant energy transmitted from a distant transmitting station, but has a novel and radically different function as will appear from the detailed description in connection with the various circuit arrangements illustrated in the drawings.

II. Oscillating circuits adapted to produce one or more beat-notes of audible frequency.

III. Means for regulating the volume of the sound tones.

IV. Means for switching individual sound tones on and off as desired.

V. Means for controlling the timbre of the sound tones.

VI. Means for eliminating or nullifying the natural oscillations of the amplifier or reproducer to prevent the production of undesirable noises or distortion of the sound tones.

In broad aspect, the means of the invention comprises an oscillating system capable of producing audible sound tones and adapted to be influenced or affected by an object or objects, such as the hands or fingers of an operator moved in proximitive relation to an element thereof, together with a sound reproducer operatively connected to said system. Stated differently, the invention embodies a method and means for producing sound or musical tones characterized by an oscillating system in which the period is varied and the characteristical sound emission from which is changed by the movement of an object or objects in proximitive relation to an element thereof. The said system may be electrical and so arranged that movement of an operator's hands or fingers will change the electrical characteristic thereof such as the electrostatic capacity between certain elements which determine the period of the oscillator; but while such a system is disclosed and hereinafter described in detail, it is obvious that other types of oscillating systems and other means of control may be employed to accomplish the same result.

In Fig. 1 of the accompanying drawings a system is shown embodying an electrode or control-element 1 operatively connected to an electrical oscillating system and an electrical sound-reproducer. The electrode or control-element is in this instance connected to an oscillator 2 of the electro-ionic type and to a resonant circuit 3 which is traversed by an oscillatory current, the frequency of which depends upon the constants of the circuit and of the circuits conductively or inductively related thereto. The oscillator 2 is represented as of the filamentary-cathode type operating by an electron discharge from the cathode, but other forms of oscillators may be used and are intended to be included by the phrase "electro-ionic."

A second oscillator 4 is shown connected to the circuit 3, said last mentioned oscillator with the oscillator 2 being arranged to control a third electro-ionic tube 5 through coils 6 and 7 which are inductively related to the two oscillators. A condenser 8 is represented as interposed between the coils 6 and 7 and the tube 5, and a grid-leak resistance 9 is shown connected between the grid terminal of said condenser and the cathode circuit. The output circuit of the tube 5 is connected through the audio transformer 10 to a tone reproducer or loud-speaker 11. The tubes 2, 4 and 5 are connected to a suitable source of current, such as a battery, as indicated at 12.

The oscillating frequencies of the oscillators 2 and 4 are preferably above the range of audibility, but are nearly the same so that the interference frequency produced in the circuit of the tube 5 will be relatively low and produce a beat-note of audible pitch in the loud-speaker 11. The frequencies of vibrations in the circuit of the tube 5 may be called audible frequencies as they will have substantially the same number of vibrations as the vibrations of an audible sound wave. The pitch of this note, and the presence and strength of the overtones are controlled by selection and arrangement of the condensers, inductances and other elements of the circuits in a known manner.

The frequencies of the oscillators 2 and 4 may be of the order of 500,000 cycles per second, the precise frequency being so chosen that no interference with radio broadcast reception is produced. The values of inductance and capacity employed in the oscillating circuit are selected in accordance with

well-known principles to provide the desired frequencies and the variation of the capacity of the variable oscillator is effected by the change of capacity of the control electrode, which change in capacity in instruments that have been built is of the order of 10^{-8} micro-farads. It will be understood that this change of capacity effected by external control is so correlated with the capacity in the oscillator circuit that the resultant range of pitch of the musical instrument covers several octaves.

The sound generated in and emitted through the loud-speaker is also controlled by the movement of an object or objects, such as an operator's fingers in proximitive relation to the electrode or control-element 1 which is connected to the oscillating circuit 3 and to the grid of the oscillator 2. The electrical characteristics of said control element influence the period or frequency of the oscillator 2 and the character of the beat-note in the reproducer. As the operator's fingers are moved in suitable relationship with said control element, the pitch of the beat-note in the reproducer 11 is varied, and continuous variations may be produced with most delicate graduations by the continuous movement of the fingers.

This control is primarily the result of changes occurring in the electrostatic capacity between the control element and the ground potential or between the control element and other elements of the circuits. Therefore, it is obvious that other objects than the operator's fingers would be operable to vary the tone produced. Furthermore, it will be appreciated that the amount and direction of the controlling movement will depend somewhat upon the dimensions and arrangement of the control element which may be of such character that movement of the fingers to the extent required to play any ordinary instrument such as the violin, will produce a corresponding effect and note change in the present sound generating instrument, so that one who has learned to play the violin or some other instrument will have little difficulty in playing the present instrument.

The system shown in Fig. 1[a] is similar to that shown in Fig. 1, except that coupling condensers 13 and 14 are substituted for the inductive coupling between the circuits of the latter. A great many other modifications of this kind may be made in the arrangement of the electrical oscillating system without departing from the scope of the invention.

In Fig. 2 a further modification including amplifiers is shown. Amplification of the electrical currents may be effected in various ways, but it is preferable to use an arrangement in which there is a minimum distortion of the sound tones. It is also generally preferable to amplify each of the high-frequency currents separately, rather than the low-frequency beat-note, although a low-frequency amplifier may also be utilized.

Referring to Fig. 2, an electrode or control-element 15 is shown connected to an oscillator 16, the output circuit of which is connected to an amplifier 17, preferably of the electro-ionic type as represented. A second or auxiliary oscillator 18 is shown connected to a second amplifier 19. The output circuits of said amplifiers 17 and 19 are connected to the input electrode or grid of an electro-ionic tube 20, whereby a beat-note of audible frequency is produced in the output circuit thereof. The output circuit of the tube 20 is connected through a transformer 21 and through an audio-frequency amplifier 22 to a loud-speaker 23. An anode battery 25 is connected in parallel to all of the electro-ionic tubes in the usual manner. A non-inductive resistance 24 is connected between the grid and cathode of the tube 20 and a condenser 26 is connected between the grid of tube 20 and the anode of the amplifier tube 19. A second condenser 27 is connected between the condenser 26 and the battery 25. This condenser is preferably variable as indicated. Condensers 28 and 29 corresponding with the condensers 26 and 27 are also provided in connection with the amplifier 17.

In the arrangement just described, the high-frequency oscillations of the controllable oscillator 16 and the auxiliary oscillator 18 are amplified separately, and then the combined oscillations are amplified together.

In Fig. 3, a further modification of the amplifier is shown. The left hand portion of Fig. 3 is the same as Fig. 2 as far as the line III—III. The amplifier 22 is shown connected with the transformer 21 to which are connected four amplifiers 31, 32, 33 and 34, the latter being inductively connected with the amplifier 22 through the transformer 30. In this instance, amplifiers 32, 33, and 34 are connected in parallel to obtain a direct-current intensification, and said three amplifiers are connected in group to the fourth amplifier 31. The tone reproducer 23 and the anode battery 25 are connected as in Fig. 2. This arrangement is suitable especially by reason of its high efficiency for comparatively low frequencies, particularly for bass tones.

The oscillations of the controllable oscillator and the fixed oscillator are made independent of each other, and for such reason the amplification of each current takes place separately. Each oscillation is thus first amplified individually, and then only is amplification of the combined oscillations effected.

The connection of the control-element to the oscillating system may be modified variously while still obtaining the desired re-

sult. A plurality of electrodes may be employed to produce a plurality of sound tones simultaneously from the same object moved in relation thereto. For example, two straight parallel conductors may be employed. If the object moved relatively thereto is equi-distant from both conductors, then the two tones produced therethrough will be the same if other conditions are equal. As the moving object approaches nearer to one conductor than the other, the pitch of one tone will increase while that of the other will decrease. Three or more conductors may be provided, preferably in symmetrical arrangement, or a plurality of symmetrical groups of conductors may be arranged and controlled by different objects or fingers of the operator's hand.

Connection of the conductor or conductors to the oscillator should be such that the changes in capacity will produce a considerable change in the oscillator. Connection may be made either to the grid or anode circuit of the oscillator, the most suitable connections being illustrated in the drawings.

In Fig. 4 a connection of the control element to the anode circuit is shown. With the controllable oscillator 73 is associated an oscillating circuit including inductances 74 and 75 and condensers 76 and 77. Energy is supplied to the oscillator by an anode battery indicated diagrammatically at 78. The control element 79 may be connected with the plate circuit as shown in full lines at 79, or with the grid circuit as shown in dotted lines at 79'. It makes little difference whether the control element is connected the one way or the other provided conditions are otherwise equal. But if this is not the case, the control element is connected preferably to the larger inductance. The sensitiveness of the system may be increased by grounding the circuit at 80, but as a rule this connection is not required in view of the large counterpoises of the oscillating circuit.

In the system illustrated in Fig. 5, the control element 81 is inductively coupled with the oscillator 83 through the medium of a coil 82. An adjustable condenser 84 is shown arranged in the oscillating circuit of the oscillator 83 by which the control circuit is tuned. In this system, by reason of the coupling coil 82, the control element may be at a somewhat greater distance from the oscillator 83.

In order to produce a plurality of sound or musical tones simultaneously, a plurality of interfering oscillators may be employed. For instance, three oscillators properly arranged will produce two tones, one resulting from interference between the first and second oscillators and the other resulting from interference between the second and third oscillators. In like manner, three tones may be produced by four oscillators and so on.

In Fig. 6 is represented an arrangement for producing two sound tones simultaneously by the use of three oscillators, each tone being separately controllable. One control electrode 35 is shown associated with an oscillator 36 and with a low-frequency detector tube 37. Another control electrode 38 is shown associated with an oscillator 39 and a low frequency detector tube 40. The said detectors 37 and 40 are both responsive to the fixed oscillator 41. An amplifier 42 responsive to both of the beat-notes or tones is shown connected through a transformer 43 with a sound reproducer 44.

Fig. 7 illustrates a further modification comprising four control electrodes, viz 45, 45', 45'' and 45''' respectively associated with oscillators 46, 47, 48 and 49, whereby four tones may be produced simultaneously. The four oscillators cooperate with a fixed oscillator 50 and are inductively connected with detectors 56, 57, 58 and 59 through coils 51, 52, 53, and 54. Each is also connected with one of the coils 60, 61, 62 and 63 of a transformer. Condensers 64, 65, 66 and 67 are connected in parallel with said coils 60, 61, 62 and 63. The neutral points of all four coils are connected with the coupling coil 55 of a fixed oscillator 50. A secondary coil 68 of the transformer is connected to the amplifier 69 which operates the reproducer 71 through the transformer 70.

Fig. 8 shows another four-tone system, but in this instance the high-frequency alternating potential is supplied directly from the plate circuit. The coupling coils 51, 52, 53, 54 and 55 are eliminated and replaced by a variable coupling coil 72 which is shown connected to the anode of the fixed oscillator 50 at one end, and to the neutral point of the four transformer coils 60, 61, 62 and 63 at the other end. The secondary winding 68 of the transformer controls the amplifier 69 from which the combined tones are transmitted to the reproducer 71 through the transformer 70.

The detectors used in connection with the above systems may be of any suitable type, crystal detectors being considered generally preferable.

For regulating the volume of the sound, the intensity of the current may be varied and variation of the current intensity may be effected in several ways.

Referring now to Fig. 9, a connection is shown in which the oscillator or amplifier 85 which generates the sound tones actuates the reproducer 86, to which an adjustable resistance 87 is connected in parallel. The resistance 87 is adjusted by means of a pedal or the like, and controls the volume of the sound. The adjustable resistance 87 may

also be connected in series with the reproducer.

Fig. 10 shows a further modification in which an adjustable resistance 88 for controlling the volume, varies the cathode current of the amplifier 89, which in turn controls the reproducer 90.

The system illustrated by the diagram of Fig. 11 is similar to that shown in Fig. 10, except that the cathode current is regulated inductively from the high-frequency circuit of the tube 100 in the amplifier, with utilization of a greater or lesser energy absorption in the conductor 92 as determined by its resonance with the oscillating circuit 91 variable according to the operator's movement of his fingers or other object with relation to the conductor.

The conductor 92 is connected with a coupling coil 93 which latter is inductively related to a coupling coil 94 connected in series with the coupling coil 95 for the oscillating circuit 91, and a coupling coil 96 for the cathode of the direct-current amplifier. Both coupling coils 94 and 95 cooperate so that maximum energy will be generated when the control circuit and oscillator circuits are in resonance.

The conductor 92 is a separate control element for regulating the sound volume and will be referred to as the "sound-volume" control element or electrode. Adjustment may be so effected that resonance occurs when the controlling object is either nearest to, or altogether removed from this electrode. Therefore, while one hand of the operator generates the various sound tones in the first or "sound generating" electrode, his other hand may regulate the intensity of the tone at the second or "sound volume" electrode.

The system in Fig. 11 is intended to be connected with the left-hand end of the diagram of Fig. 2, the line III—III in Fig. 11 indicating its point of connection with Fig. 2. The amplifier 98 which is also a direct-current amplifier controls the reproducer 99.

The system shown by the diagrams of Figs. 12, 13 and 14 are similar to that shown in Fig. 11.

In Fig. 12, the cathode current for the amplifier 97 is generated by direct connection of the transformer 96 with the oscillating circuit 91.

In Fig. 13, the resonance transmission of energy to the circuit 102 through the circuit 101 is utilized under the influence of the controlling object or its distance from the "sound volume" control electrode.

The "sound volume" control electrode 92 is directly connected to the anode or the circuit 101 of the oscillator 100, and the circuit 102 which is coupled therewith supplies current to the cathode of the amplifier 97 over the variable transformer 103.

In Fig. 14, the sound volume is regulated by varying the average grid potential in one of the amplifiers by means of the non-inductive resistance 104, which is also in the anode circuit of the oscillator 98. The circuit of the "sound volume" electrode 92 is coupled with the oscillating circuit of the tube 100, which is connected with the non-inductive resistance 104. If a finger or other object is made to approach the electrode 92 the resonant frequencies of the electrode circuit and of the oscillating circuit of the tube 100 will vary, whereby a corresponding voltage drop will be produced in the resistance 104 which by affecting the tube 98 causes a change in the volume of the sound.

The diagrams of Figs. 9 and 14 are most efficient under normal conditions.

The preferred means for switching the sound tones on and off comprise means for controlling the current serving for producing tones in the reproducer.

Fig. 15 shows an ordinary switch 105 in the plate circuit of the amplifier in series with the reproducer 106 as shown in full lines, or in parallel as shown at 105′ in dotted lines.

As shown in Fig. 16, the primary winding of a transformer 107 may be connected in the plate circuit of the amplifier and the tone producer 108 and the switch 109 connected in the secondary circuit of the transformer. This eliminates the undesirable constant component of the pulsating current through the reproducer.

The diagram of Fig. 17 is similar to that of Fig. 16, but the transformer 107 is replaced by a choke coil 110 from which a circuit is branched in parallel, the reproducer 111, the switch 112 and the condenser 113 being connected in series in this circuit.

In Figs. 18ª and 18ᵇ, the switch is in the cathode circuit. In Fig. 18ª the switch 114 controls the current from the filament battery 115 of an amplifier 116, in the plate circuit of which the reproducer 117 is arranged. In Fig. 18ᵇ, the switch 119 is in a shunt circuit 118 of the cathode heating circuit which is connected with the filament battery, said battery being in continuous connection with the filament wire in series with a resistance 121.

In Fig. 19 is illustrated an arrangement for switching the tone on and off by a control analogous to the arrangements for varying the volume of sound shown in Figs. 11 to 14.

The system of Fig. 19 is intended to be connected with the system of Fig. 2 along the line III—III as in the arrangement of Fig. 11. The two direct-current amplifiers 97 and 98 control the reproducer 99. A third control element 122 is provided for switching the tones on and off through the medium of the cathode current, and is

operated like the "sound generating" and "sound volume" electrodes. The control element 122 is coupled with a control circuit by a coil 123, which circuit includes coupling coils 124, 125, and 126. The coil 125 is coupled with the amplifier corresponding with the tube 100 in Fig. 11 and the coil 126 is coupled with the cathode current of the amplifier 127. Current from the anode battery 129 flows through a relay 128 which operates a switch 130. The switch controls the circuit of the cathode battery 131 for the heater of the direct-current amplifier 97. By the operator's movement of his hand or other object with relation to the electrode 122, the filament current of the amplifier 97 and consequently the tone, is cut on or off.

The systems of Figs. 16 and 17 are considered superior to that of Fig. 15, while the systems of Figs. 18 and 19 are regarded as preferable because the switching on and off will take place without any noticeable interval.

Elimination or neutralization of the various natural oscillations in the apparatus is desirable to improve the quality of the sound or musical tone and may be effected through compensation by means of an electric system of the same frequency and damping as is possessed by the oscillating system, the action of which is to be paralyzed.

In Fig. 20 is shown a reproducer 132 to which is connected a circuit with corresponding oscillation constants. This circuit comprises the inductance 133, the non-inductive resistance 134 and the condenser 135, which are connected in series and are variable. The resistance and the inductance in particular, are preferably variable individually.

As represented in dotted lines in Fig. 20, the arrangement may also be such that the circuit of these oscillation constants, comprising the inductance 133′, the condenser 135′ and the non-inductive resistance 134′, is connected in parallel with the reproducer 132.

Should natural oscillations of various parts exist, for example, if the horn of the loud-speaker possesses a natural oscillation and the diaphragm of the loud-speaker possesses another natural oscillation, a compensating oscillating circuit of the same period is employed for each natural oscillation, the circuits being connected either in series or in parallel.

Fig. 21 shows such a series connection. Three oscillating circuits 137, 138, 139, each of which comprises an inductance, a non-inductive resistance and a condenser, are shown connected to the reproducer 136.

According to Fig. 22 the arrangement may be such that parallel to the reproducer 140 are connected the oscillating circuits 141, 142, 143, each consisting of an inductance, a capacitance and a non-inductive resistance.

These means for eliminating the natural oscillations may find general application beyond the example stated above, for instance in sound amplifiers of any kind or their equivalents.

The variation of the quantitive composition of the over-tones in the sound or musical tones may be effected by various deformations of the primary alternating current, by utilizing the curved parts of the amplifier characteristics.

The composition of the overtones may also be varied by increasing or reducing the overtones of the higher order by inserting oscillating elements comprising capacitances and inductances of suitable values.

Fig. 23 illustrates such a system of connections. The oscillator or amplifier 144 supplies the transformer 145, the secondary winding of which controls the reproducer 146. A variable inductance 147 with a correspondingly variable capacitance 148 are connected in parallel with the reproducer. If the inductance alone is used, the overtone frequencies pass through the reproducer. If the capacitance alone is used, the overtone frequencies pass through the condensers and do not affect the reproducer. If both the inductance and capacitance are used together, the correct composition of the overtones is obtained. Instead of the arrangement described, a variable choke coil 149 and a variable condenser 150 may be connected in series with the reproducer 146 as indicated in dotted lines. In this case, the connection 151 is eliminated. Both arrangements may be provided together, but the connection 151 is eliminated in this case also.

Fig. 24 illustrates a simple expedient for varying the characteristic of one of the amplifiers for example. The plate potential of the amplifier 152 for the reproducer 153 may be varied by the adjustable resistance 154. The cathode current may be varied by the rheostat 155, or the grid potential by the rheostat 156. The connection to the other parts of the system as shown in Fig. 2 is effected by the transformer 21.

In the selection of such characteristics as are required for the given proportion of overtones, perfect results may be obtained by the combination of the characteristics of various electro-ionic tubes, for instance by the parallel connection of tubes with different operating characteristics.

In the diagram of Fig. 25, the transformer 21 which may be connected to the system of Fig. 2, controls the grids of four amplifiers 157, 158, 159 and 160. From each plate of said amplifiers, current flows to the reproducer 165 and the anode battery 166 through rheostats 161, 162 and 164, one for each amplifier. One of the rheostats 167, 168, 169 and 170 is arranged in the filament circuit

of each amplifier. These resistances correspond to the resistances 154 or 155, of Fig. 24. However, the corresponding resistance 156 is eliminated in this system. The system of Fig. 25 affords more delicate graduations than that of Fig. 24.

The timbre is regulated in the above cases by varying the characteristics of the tubes by suitably adjusting the resistances.

Fig. 26 illustrates a system of connections for varying the timbre by varying the magnetic induction of the transformer core connected in the plate circuit of one of the amplifiers. The primary winding 171 of a transformer 172 is connected in the plate circuit of an amplifier. A secondary winding 173 is connected to the reproducer 174. The transformer is furthermore provided with a third winding 175, the energization of which is varied by the rheostat 176. By adjusting the rheostat 176, the magnetization of the core 172 is changed, which causes a variation of the timbre in the reproducer 174. This system is simpler than that according to Fig. 25, but does not give such gradual adjustment.

Fig. 27 is a diagram of a complete instrument for two tones. The system comprises two "sound generating" control elements 177 and 184, for the first and second tones respectively, and a "sound volume" control element 207.

The "sound generating" control element 177 for the first tone is connected with the circuit 179 of an oscillator 178 and the circuit is grounded. A detector 180 is included in the first system and a detector 187 is included in the second system. Said detectors are connected by a coupling coil 181 and a condenser 182. A non-inductive resistance 183 is inserted between the grid and the filament of the detector 180 for the purpose of maintaining the grid of said detector substantially at the initial potential.

The "sound generating" control element 184 of the second system is similarly connected with an oscillator 185 and a circuit 186, the condenser 189, and the resistance 190.

The two detectors 180 and 187 transmit the low-frequency oscillations to the amplifier 193 by means of the transformers 191 and 192. The fixed oscillator 194 is connected to the calibrated oscillating system 195 in a corresponding manner and is also connected with the two tone systems or their first amplifier 193. The latter may then control the amplifier systems 197, 198, 199, 200 by means of the transformer 196 for the purpose of producing a better effect. These amplifiers are controlled by the rheostats 201, 202 and 203 in the plate circuit and by rheostats 204, 205, 206 in the filament circuit.

The "sound volume" control element 207 controls through the absorption system 208, the oscillating system 209 of the amplifier 210 for the sound volume regulation. The oscillating circuit 209 feeds the filament of the tube 197 by means of the high-frequency transformer 211. The amplifiers 197, 198, 199 and 200 then supply the reproducers 213 and 214 through the transformer 212, the switches 215 and 216 serving for switching the tones on and off, while correction systems 217, 218, 219 are furthermore provided for the reproducers 213 and 214.

The resistances 201, 202, 203, 204, 205, and 206 serve for producing different kinds of tones. The rheostat 220 permits a regulation of the filament current for all tubes. The condenser 221 serves for the regulation of the timbre in the reproducer 213, while the choke 222 exerts a similar effect upon the reproducer 214. If it is desired to dispense with the "sound volume" control element 207, the rheostat 223 indicated in dotted lines should be connected in circuit.

It will be readily understood that the systems of connection illustrated and described are only a few examples of how the invention may be enlarged upon. As a matter of course, it is possible to vary the individual systems in many ways according to developments made in the wireless industry.

By a phase displacement of the individual sound reproducing systems, an apparent wandering of the sound tones in space may be produced. The invention may if desired be used in conjunction with a broadcasting transmitter, whereby the frequency variation caused by the approach of a body towards the control element of the oscillating system will directly influence the broadcasting transmitter so that the electric oscillations corresponding with the sound oscillations are amplified and directly transmitted. In playing on this instrument, the microphone or microphones and the distortions caused thereby are eliminated, so that a clearer reproduction is assured.

I claim:

1. A tone generating system controlled by the hand and comprising an electrical circuit embodying an oscillation generator, means in said circuit including a conductor having a field which when influenced by a hand moving therein will vary the resonant frequency of said circuit according to the movement of said hand only, and a sound reproducer connected with said circuit for emitting tones according to the electrical variations occurring in the circuit.

2. A tone generating system controllable by an object moving relative thereto, comprising an electrical circuit embodying an oscillation generator, operating means associated with said circuit, including a conductor having a field which when influenced by said object moving therein will vary the

resonant frequency of said circuit, said object having a different dielectric constant than the medium in which the field occurs, a second electrical oscillation generator connected to said circuit and a sound reproducer connected to said generators for emitting tones produced by the interference of the oscillations of said generators.

3. A tone generating system for producing a plurality of superimposed tones, comprising an electrical oscillating circuit and a control electrode for each tone, the field of said electrode being controllable by the hand alone when moving therein, means including the control electrodes for varying the resonant frequencies of said circuits in accordance with the tones desired and a reproducer associated with all of said circuits.

4. A tone generating instrument played by hand comprising a circuit embodying an oscillation generator, means in said circuit including a conductor external thereto electrically influenced by the movement of the hand for varying the resonant frequency of said circuit at will, a second oscillation generator connected to said circuit to produce a beat frequency, a detector system coupled with said circuits, a sound reproducer controlled by said detector system and a transformer connected intermediate said reproducer and said detector system.

5. A sound or musical tone generating instrument comprising a circuit embodying an oscillation generator, a second oscillation generator producing a beat frequency therewith and means in said circuit including a conductor electrically influenced by body capacitance for varying the resonant frequency of said circuit to produce musical tones at will.

6. A musical instrument comprising a circuit embodying an oscillation generator, means including an electrode in said circuit for varying the resonant frequency of said circuit at will to produce the desired musical tones, a second oscillation generator connected to said circuit to produce a beat frequency, an amplifier in said circuit, a detector system connected to said amplifier and said second oscillation generator and a sound reproducer connected to be controlled by said detector system.

7. A musical instrument comprising a circuit embodying an oscillation generator, means including an electrode in said circuit for varying the resonant frequency of said circuit at will to produce the desired musical tones, a second oscillation generator connected to said circuit to produce a beat frequency, an amplifier connected to said second oscillation generator, a detector system connected to said amplifier and the first-mentioned oscillation generator and a sound reproducer controlled by said detector system.

8. A sound or musical tone generating instrument comprising an electrical oscillating circuit, means including an electrode electrically influenced by movement of the hand for varying the resonant frequency of said oscillating circuit at will to produce the desired musical tones, an electro-ionic tube having a plate and a grid connected to said oscillating circuit to cause an oscillating current to flow therein, said electrode being directly connected to said plate, and a sound reproducer in said circuit for emitting tones in accordance with the variations in the oscillations.

9. A musical tone generating instrument comprising an electrical oscillating circuit, means including an electrode electrically influenced by movement of the hand for varying the resonant frequency of said oscillating circuit at will to produce the desired musical tones, an electro-ionic tube having a plate and a grid connected to said oscillating circuit to cause an oscillating current to flow therein, said electrode being directly connected to said grid, and a sound reproducer in said circuit.

10. An instrument for producing musical tones comprising an electrical oscillating circuit, means including an electrode in said circuit for controlling said circuit to produce the desired tones in accordance with the movement of the hand, two inductances of different values in said circuit, said electrode being connected to the larger inductance, and a sound reproducer connected with said circuit.

11. A system for generating n musical tones comprising $n+1$ circuits, an electrode in each of a plurality of said circuits arranged to be responsive to manual control and a sound reproducer controlled by the beat frequencies of the currents traversing said circuits.

12. A musical sound generating instrument comprising oscillating circuits, means including a manual control electrode in each circuit for controlling the frequency of the oscillations therein, a detector system for each circuit, a resultant system to which all said detector systems are connected and a sound reproducer controlled by said resultant system.

13. A sound producing instrument comprising oscillating circuits, means including an electrode in each circuit for controlling the frequency of the oscillations therein at will, oscillating systems to one of which each of said circuits is coupled, each oscillating system comprising a coupling coil, a detector, a coil and a condenser connected in parallel to said last mentioned coil, said coils constituting the primaries of a transformer, a secondary in said transformer, a calibrated circuit, a coupling coil in said calibrated circuit connected to the neutral

points of each primary, a generating system to which the secondary of said transformer is connected and a sound reproducer controlled by said generating system.

14. A musical sound producing instrument comprising oscillating circuits, means including an electrode in each circuit for controlling the frequency of the oscillations therein at will, a detector connected galvanically to each circuit, coils connected in series with each detector, condensers connected in parallel to each coil, said coils constituting the primaries of a transformer, a secondary in said transformer, a variable inductance common to all detector circuits, a calibrated system comprising a plate and a grid circuit, said inductance being connected to said plate circuit, a generating system to which the secondary of said transformer is connected, and a sound reproducer controlled by said generating system.

15. An instrument for producing musical sound notes comprising oscillating circuits, means including an electrode in each circuit for controlling the frequency of the oscillations therein, at will, a detector connected galvanically to each circuit, coils connected in series with each detector, condensers connected in parallel to each coil, said coils constituting the primaries of a transformer, a secondary in said transformer, a variable inductance common to all detector circuits, a calibrated system comprising a plate and a grid circuit, said inductance being connected to said grid circuit, a generating system to which the secondary of said transformer is connected, and a sound reproducer controlled by said generating system.

16. An apparatus for producing music in imitation of musical instruments comprising an electrical oscillating circuit, means in said circuit including an electrode for controlling the oscillations therein, a sound reproducer in said circuit controlled by the oscillation controlling means, a cathode tube for said reproducer and means including a filament in said tube for regulating the volume of the sound in said reproducer, said last mentioned means also including a volume control electrode connected to the filament.

17. An apparatus for producing sound tones comprising an electrical oscillating circuit, means including an electrode for controlling the resonant frequency of the oscillating circuit, a sound reproducer connected with said circuit and means including a separate electrode for regulating the volume of the sound in said reproducer by varying the electrical field of the electrode.

18. An apparatus for producing sound tones comprising an electrical oscillating circuit, means including an electrode for controlling the resonant frequency of the oscillating circuit, a sound reproducer connected with said circuit, a detector provided with a filamentary cathode, a battery connected with the filament circuit of said detector, a shunt circuit, and a switch adapted to close either the filament circuit or said shunt circuit.

19. An apparatus for producing musical tones comprising an electrical oscillating circuit, means including an electrode for controlling the resonant frequency of the oscillating circuit, a sound reproducer connected with said circuit, means including a separate electrode for regulating the volume of the sound in said reproducer, a tube associated with said separate electrode, a relay energized by said tube, a detector and an amplifier comprising a filament connected with said detector and controlled by the armature of said relay.

20. An apparatus for producing musical sound comprising an electrical oscillating circuit, means including an electrode for controlling the resonant frequency of the oscillating circuit, a sound reproducer in said circuit and a second oscillating circuit, the electric oscillation constants of which correspond to the mechanical oscillation constants of said reproducer.

21. Apparatus generative of musical sound comprising an electrical oscillating circuit, means including an electrode for controlling the oscillations therein, a sound reproducer in said circuit, a plurality of electro-ionic tubes of different characteristics connected in parallel to each other and in series with said reproducer and separate resistances for regulating the plate and filament current of each tube.

22. Apparatus generative of musical tones comprising an electrical oscillating circuit, means including an electrode for controlling the oscillations therein, a sound reproducer in said circuit, a detector, a transformer, one winding of which is connected in the plate circuit of said detector and the magnetization of which transformer is regulated by its other winding, a circuit connected with said other winding, a resistance for controlling said circuit and a third winding in said transformer connected with said reproducer.

23. The method of obtaining a definite dependence of the change of the frequency of an oscillating system for producing relative changes in pitch of musical tones upon the degree of approach of an object toward a control electrode characterized by the steps of changing the electrical field distribution by varying the relationship of said electrode and said object, and generating sound according to the characteristics of said field.

24. The method of producing musical tones in accordance with the movement of

the hand, characterized by generating electrical oscillations in a circuit, varying the capacitance of a portion of the circuit by movement of the hand in its relation to the circuit, producing from said circuit sounds of variable pitch corresponding to the electrical oscillations and altering the variations to produce sounds of the desired timbre.

25. In a method of producing musical tones in an electrical continuously oscillating system, the steps of generating oscillations in the system and which comprises changing the electrical characteristics of said system by movement of a foreign object in proximitive relation to a part thereof to vary the electrical capacity of a portion of the system.

26. The method of producing musical tones in an electrical oscillating system embodying two oscillation generators arranged to generate an audible beat frequency characterized by moving the hand in relation to said system in a manner to change the electrical characteristics of one of said generators only.

27. The method of producing musical tones which comprises generating electrical oscillations of ultra-audible frequency, generating other oscillations of slightly different frequency, varying the frequency of one series of oscillations by altering the electrical characteristics of the generating system by moving a body in relation to said system and combining said oscillations to obtain a variable beat-note of audible pitch.

28. The method of producing musical tones of controllable pitch, duration and intensity which comprises varying the constants of the circuit of an electrical oscillator by moving the hand in relation to an element of said circuit, producing from said circuit sound vibrations of variable pitch corresponding to the electrical oscillations and controlling the sound vibrations to vary the duration and intensity of the tones.

29. A musical instrument comprising an oscillating system embodying means to be influenced in respect to the frequency of its oscillation by external conditions structurally unrelated thereto, a sound reproducer controlled by said oscillating system and means for controlling the volume of the sound in said reproducer.

30. Apparatus generative of musical tones comprising an electrical oscillating system embodying means including an outwardly projecting conductor subject to influence in respect of the frequency of its oscillation by external conditions neither conductively nor mechanically connected thereto and a sound reproducer controlled by said oscillating system.

31. Apparatus generative of musical tones comprising a plurality of electrical oscillating systems to produce a beat-note of audible frequency, one of said systems embodying an outwardly projecting conductor and subject to influence in respect of the frequency of its oscillation by external conditions neither conductively nor mechanically connected thereto and a sound reproducer controlled by said systems.

32. Apparatus for generating musical tones comprising two oscillators, each including a resonant circuit and adjusted to produce a beat-note of audible frequency, one of said oscillators having a portion thereof extending outwardly to a position for cooperation with the hand of an operator to vary the oscillations without moving the elements of the last mentioned oscillator, and a sound reproducer connected to said oscillators.

33. An electrical system generative of musical tones comprising tone-producing means, said means including electrical circuits, a sound reproducer connected to said tone-producing means and means for varying the volume and pitch of the tone emitted by said reproducer in accordance with the movements of an operator's hand in relation to said circuits to generate separate musical notes of the desired duration.

34. An apparatus of the class described responsive to a moving external object comprising an electrical circuit embodying an oscillation generator, means in said circuit including a conductor electrically influenced by the movement of said object for varying the resonant frequency of said circuit according to the movement of the object and means connected to said circuit for emitting tones according to the electrical variations occurring in the circuit.

35. An apparatus of the class described comprising an electrical oscillator, a sound reproducer connected to said oscillator, an electrode connected to the oscillator for effecting manual control thereof by variation of the electrical field around the electrode, means for operating the sound reproducer in accordance with the variations in the oscillator and means for controlling the volume of the sound from said reproducer.

36. An apparatus of the class described comprising an electrical oscillator, a sound reproducer connected to said oscillator, an electrode connected to the oscillator for effecting manual control thereof by variation of the electrical field around the electrode, and means for operating the sound reproducer to generate musical tones in accordance with the variations in the oscillator including means for controlling the timbre of said tones.

37. An apparatus of the class described comprising an electrical oscillator, a sound reproducer connected to said oscillator, an electrode connected to the oscillator for ef-

fecting manual control thereof by variation of the electrical field around the electrode, means for operating the sound reproducer in accordance with variations in the oscillator, a second electrode for effecting manual control of the volume of the tones emitted by said reproducer by variation of the electrical field around said electrode and means including said second electrode for controlling the volume of said tones.

38. A tone generating system for producing a plurality of registers of superimposed tones, comprising an electrical oscillating circuit and a control electrode for each register, the field of said electrode being controllable by the hand alone when moving therein, and means including the control electrodes for varying the resonant frequencies of said circuits in accordance with the tones desired.

39. An electrical musical instrument comprising means for controlling the volume of the tones thereof, including an electrode controlled by body capacitance.

40. In a method of producing musical tones in accordance with the movement of the hand, the steps of generating electrical oscillations in a circuit and varying the capacitance of a portion of the circuit by movement of the hand in its relation to the circuit.

In testimony whereof I have signed my name to this specification.

LEO SSERGEJEWITSCH THÈREMIN.