Jan. 1, 1935. F. R. O'LEARY 1,986,599

FREQUENCY STABILIZING MEANS

Filed Dec. 4, 1933 4 Sheets-Sheet 1

Fig. 1.

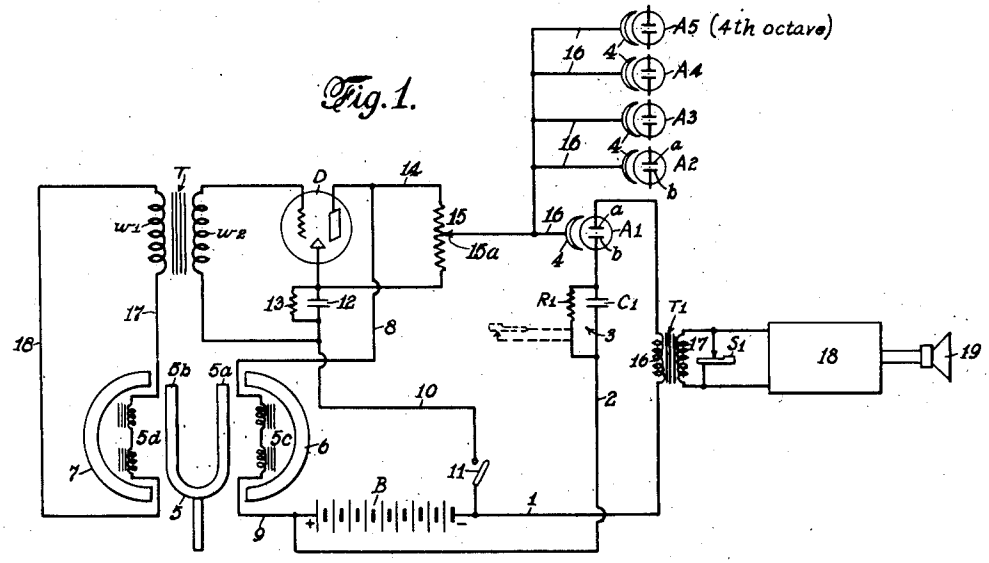


Fig. 2.

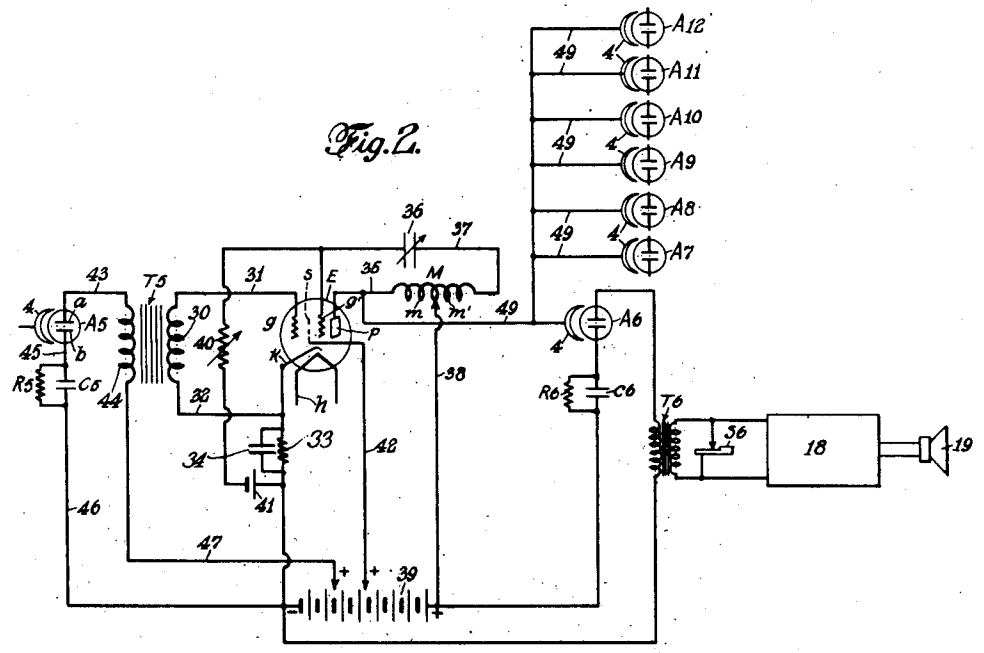
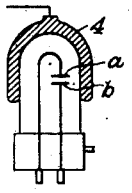


Fig. 6.



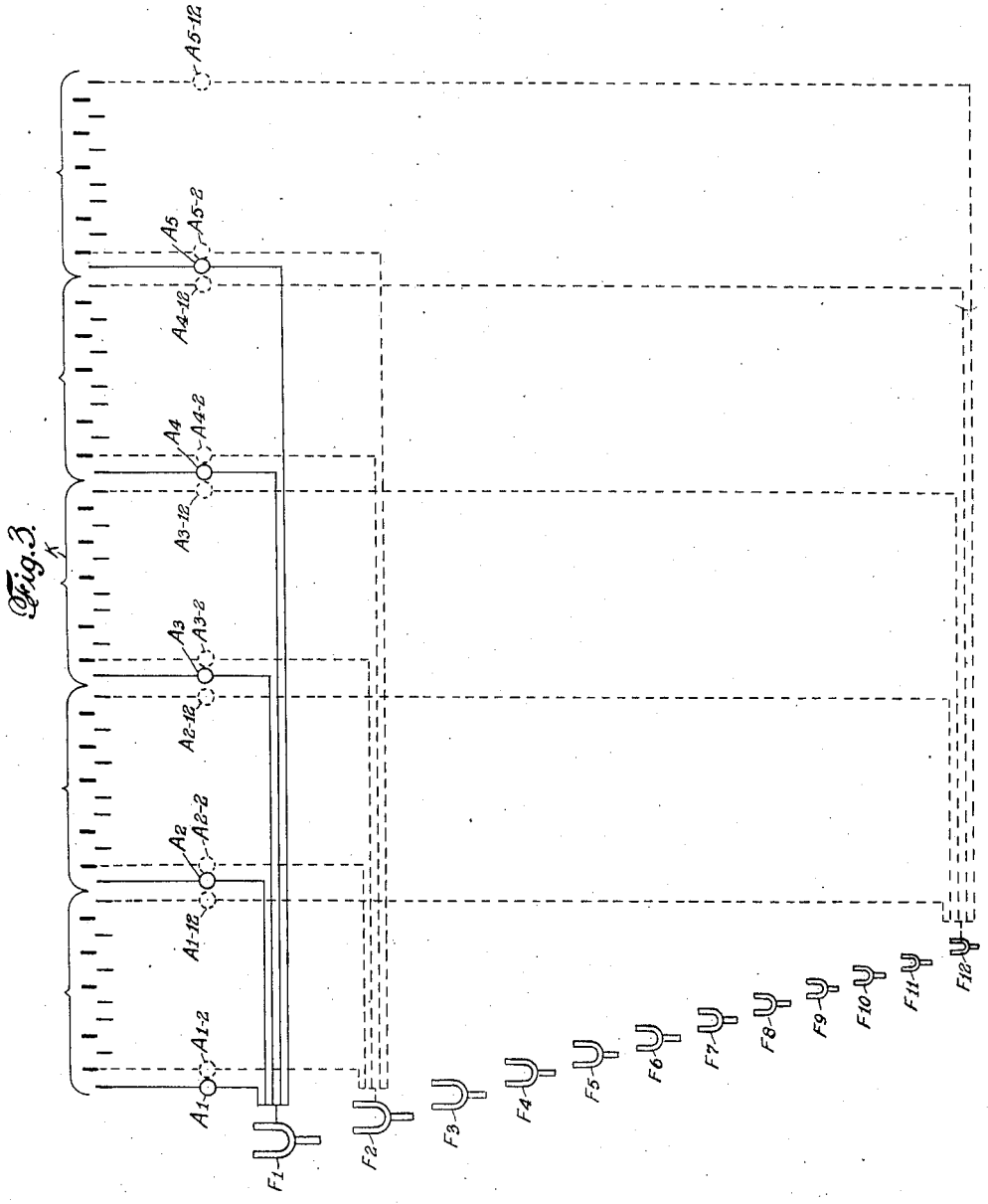
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FREQUENCY STABILIZING MEANS

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Fig. 3



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FREQUENCY STABILIZING MEANS

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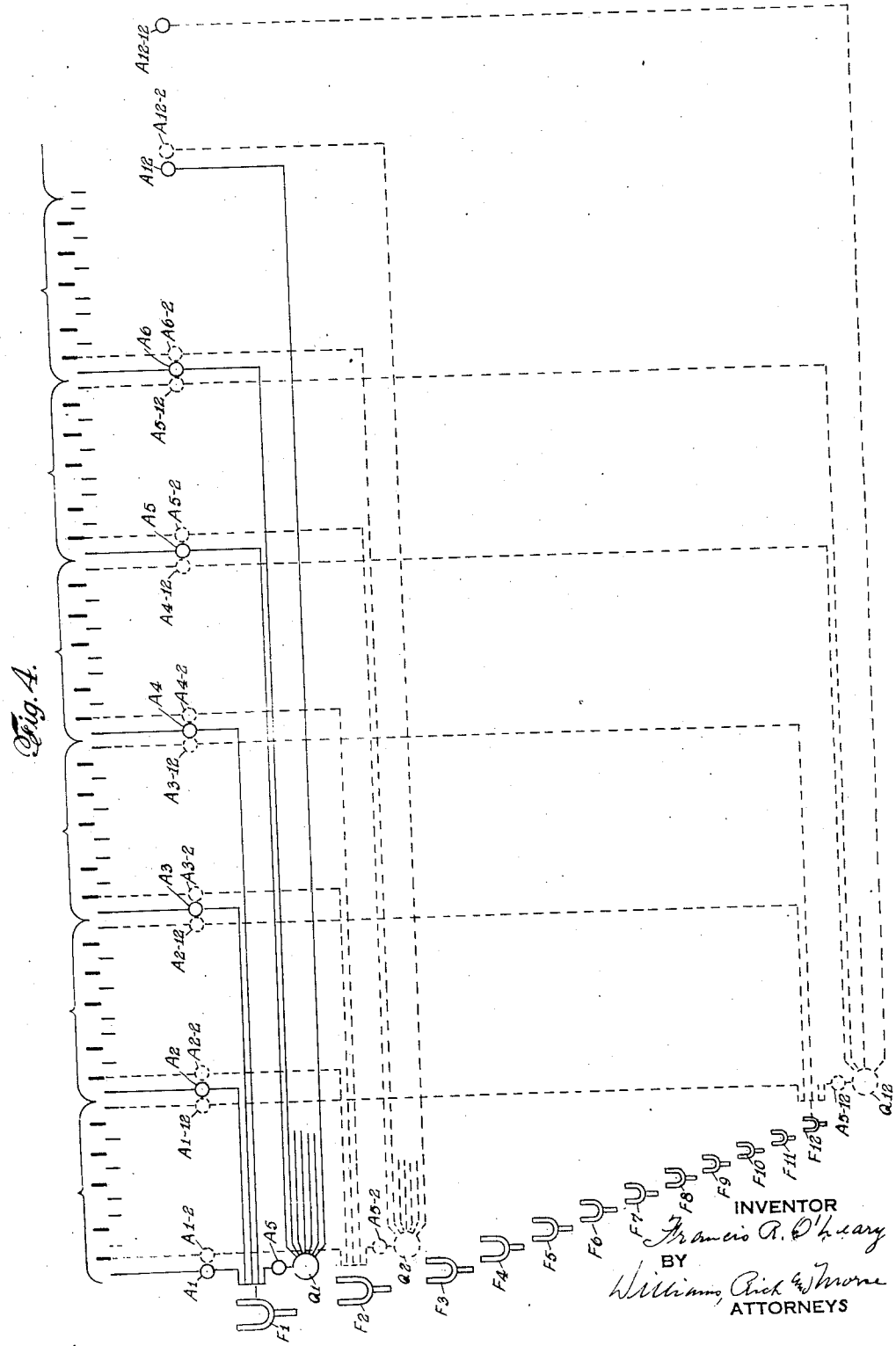


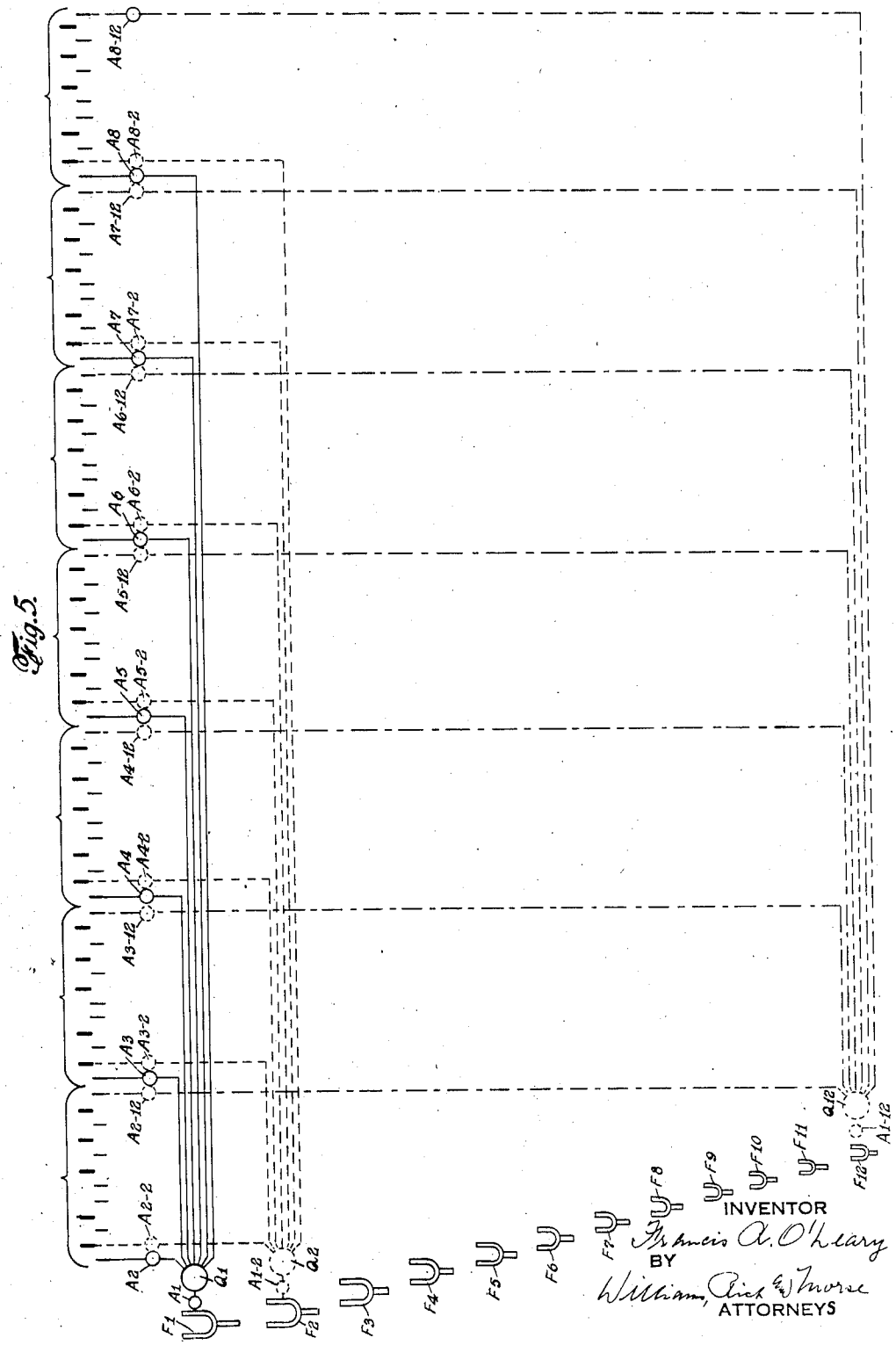
Fig. 4.

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FREQUENCY STABILIZING MEANS

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Fig. 5



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FREQUENCY STABILIZING MEANS

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Application December 4, 1933, Serial No. 700,855

20 Claims. (Cl. 84—1)

My present invention has for its object to provide an oscillatory circuit especially adapted for producing electrical oscillations in the audible range, which may be amplified and used for musical purposes. The invention further comprehends a novel control means for stabilizing the frequency of an oscillatory circuit employing a two-element gaseous discharge tube as one of its elements, so that the circuit will not, by reason of changes due to tube aging or other causes, produce frequencies different from that to which it is initially adjusted or tuned.

My invention has for its further object to provide a system of two-element tube oscillatory circuits for producing a plurality of musical notes, each of which circuits is stabilized in frequency. I effect this frequency stabilization with the assistance of electromechanical devices and, as a further feature of the invention, the means I employ for imparting frequency control from these devices to the two-element tube oscillatory circuits is such that a single electromechanical device may be used as a frequency controlling element for several of such oscillatory circuits.

In addition to the foregoing my invention also comprehends the use of a controlled two-element tube oscillatory circuit for controlling other oscillatory circuits of the same nature, by the interposition between the first and second mentioned circuits of a thermionic type of amplifier. In this way with the same electromechanical devices the frequency control can be extended to much greater number of note-producing circuits. An extension of this idea includes provision for also making this repeater an oscillator tuned to the frequency of the oscillatory circuit feeding into it. In this manner, high amplification and frequency stabilization are combined.

To these and other ends my invention covers certain improvements and arrangements of parts all as will be further described, the novel features thereof being set forth in the appended claims.

In the drawings:

Fig. 1 is an illustration of an oscillatory circuit for producing a note of given frequency and one embodiment of my invention for effecting its stabilization as well as that of others (not shown).

Fig. 2 is an illustration of one of the gaseous tube oscillatory circuits which may be controlled in frequency as shown in Fig. 1 and of a subsequent repeater circuit, also acting as an oscillator, for extending the control features shown in Fig. 1 to a large number of additional note-producing circuits (only one being shown).

Fig. 3 is a schematic representation of an arrangement of parts useful with a keyboard of five successive octave intervals, particularly illustrating the various fork-drives and gaseous oscillatory circuits necessary for sounding its sixty notes when utilizing the embodiment shown in Fig. 1.

Fig. 4 is a similar diagram showing the manner in which the range of notes may be extended by the use of intervening repeater circuits.

Fig. 5 is an illustration of still another arrangement of parts by means of which the various notes of a keyboard comprising a large number of successive octaves may be sounded.

Fig. 6 is a view showing the shielding of a gas filled tube.

Similar reference numerals in the several figures indicate similar parts.

In the production of a musical instrument in which the notes produced are originated by an oscillatory tube circuit, a large part of the initial cost can be eliminated by using the simpler and more easily constructed type of two-element gaseous discharge tubes. This type of tube also possesses the further advantage that it lends itself to a simple type of oscillatory circuit so that the apparatus required for a keyboard instrument comprising several octaves may be assembled in a comparatively small compass. In my investigations of this subject in a practical way I have learned that the chief drawback to the use of a gaseous discharge tube is its tendency to change its internal resistance and other operating characteristics for one cause or another, such as changes in internal pressure, gas absorption by the electrodes or like effects, generally included in the expression aging of a tube. The sensitiveness of this type of tube to these factors and others, such as temperature changes, makes it difficult to maintain its associated circuit in tune over any considerable period of time. Besides, it is unreliable during operation in that its frequency of discharge in response to its tuned circuit is not steady.

One of the objects of my invention is to combine with a two-element gaseous tube oscillatory circuit a form of control device or stabilizer which will act upon the tube itself and exert such influence upon the discharge or breakdown of the tube, created by its tuned circuit, that the frequency of the oscillations generated will remain constant.

In illustrating my invention I have shown in

Fig. 1 a gaseous discharge tube A1, having the two interior electrodes *a* and *b* connected in a circuit including the wires 1 and 2 leading to opposite poles of a source of potential such as the battery B. In the wire 2 is a tuned circuit 3 comprising a resistance R1 and a condenser C1, the relative values of which are selected to create the desired frequency of the oscillations which are to be produced by the alternate charging and discharging of the condenser, as will be understood.

The condenser C1 charges instantaneously each time the potential across the electrodes *a* and *b* reaches a value causing a discharge to occur through the conducting gas, and thereafter discharges progressively through the resistance R1. For a gaseous tube having given operating characteristics, the frequency of the oscillations would be solely determined by the respective values of the condensers C1 and resistance R1, provided these characteristics did not change during the operation of the device. However, as already stated, changes in the operating characteristics of gaseous discharge tubes are very likely to occur, due to various factors, and I therefore deem it essential that some means be provided to counteract the effects of these changes and thereby stabilize the frequency of the oscillations produced by the alternate charging and discharging of the condenser C1. A method which I have found very effective for accomplishing such frequency stabilization is illustrated in Fig. 1. Broadly stated, this method consists in creating in the vicinity of the electrodes *a* and *b* an external potential at all times positive, but varying at a predetermined frequency, which may be the same as that to which the oscillatory circuit 3 is tuned. The selected frequency of this control potential I render stable by an electromechanical device, which, as will hereinafter appear, may be utilized to control several other oscillatory circuits related to one another and to that of the circuit 3 by frequency multiples, Fig. 1 showing the possibility of employing five different tubes, A1 to A5, in association with the same control circuit in this manner. To this end I provide each of the tubes with a cap or shield 4, preferably of lead, which closely surrounds the exterior of the tube envelope and encloses the interior electrodes, as shown in Fig. 6. The area covered by the cap is sufficient to create a shielding or capacitance effect around the electrodes and, as I have discovered, the desired frequency stabilization is produced when a potential varying at the proper frequency is applied to the cap or shield. That is, the voltage value at which discharge takes place through the conducting gas is maintained substantially constant.

I have found in practice that the potential supplied to the shield on a given oscillator tube should have a frequency equal to the desired frequency to be established by the oscillatory circuit associated with said tube or related thereto by a multiple thereof. The external shield then apparently acts as a starting electrode for the gaseous discharge tube. Theoretically, breakdown of the tube or the discarge therethrough should occur each time the space charge in the gap between the interior electrodes is neutralized, which corresponds to the condition the tuned circuit reaches when breakdown is required to establish the desired frequency. Under normal conditions, however, breakdown is apt to occur just prior or just after neutralization of the charge, which affects the frequency of the tuned circuit. The pulsating potential supplied to the shield neutralizes at the proper frequency part of the space charge, which causes the breakdown of the tube to occur at the frequency to which the oscillatory circuit of the tube is tuned.

I have used successfully for the controlling potential impulses a separate oscillatory circuit controlled in its periodicity by a mechanical vibrator such as a tuning fork 5, capable of vibrating at a constant frequency. As will hereinafter appear, the frequency of the potential impulses supplied to the shield 4 is determined by the natural period of vibration of the fork 5 and is selected to cause the above mentioned relation between the controlled oscillations and the controlling potential impulses. One means by which my invention may be carried out is illustrated in Fig. 1 in which the output of a three-element thermionic vacuum tube D supplies the periodic potential impulses above mentioned for stabilizing purposes and also for maintaining the tuning fork in continuous vibration for any desired length of time.

The tuning fork 5 is mounted to permit its prongs 5*a* and 5*b* to vibrate freely. In proximity to the prong 5*a* electromagnets 5*c* are arranged so that, when a current impulse passes through their windings a magnetic attraction will be created on this prong and by its recurrence serves to keep the fork in a state of constant vibration. Adjacent the other prong 5*b* are similar electromagnets 5*d*. Associated with both sets of magnets and connected in any suitable manner to their yokes are permanent magnets 6 and 7. One terminal of the windings 5*c* is connected by wire 8 to the plate of the vacuum tube D and the other terminal is connected by wire 9 to the positive pole of the plate-supply source or battery B. The plate-cathode circuit of the tube is completed via wire 10 leading from the negative pole of the battery and includes a switch 11 and a by-pass condenser 12 shunted by a high resistance 13. The grid of the tube is connected through the secondary winding *w*2 of a transformer T to the wire 10. The resistance 13 is chosen to furnish the desired grid bias for the particular type of vacuum tube D employed. The output circuit of the tube comprises the wire 14 connecting the plate and cathode and containing the voltage divider 15 having a slider 15*a* connected by the conductors 16 with the shields 4 on the various tubes A1 to A5.

Changes in potential on the grid of the tube D in accordance with the set frequency of the tuning fork are obtained by connecting the terminals of the primary winding *w*1 of transformer T by wires 17 and 18 to the terminals of the windings of magnets 5*d*. Each to and fro movement of the prong 5*b* will set up an induced current in the circuit thus formed, which causes a corresponding potential impulse to be impressed through the transformer T upon the grid of the tube D.

It will be seen from this arrangement that, with each change in potential of the grid, there is a corresponding change in the flow of current in the plate circuit, which varies the energization of the electromagnets 5*c* to impart movement to the prong 5*a*. It is apparent therefore that, with proper values of grid bias for a given tube, energy will be supplied to the magnet assembly at the determined frequency of the tuning fork. The latter will thus be maintained in continuous vibration and the tube D will act as an amplifier of the potential impulses impressed on the grid.

The output wave supplied through the resistance 15 provides a potential at the shields 4 fluctuating at the natural period of vibration of the fork 5 and the intensity of which may be adjusted by the slider 15*a*, this potential stabilizing the frequency of discharge in the tubes A1 to A5, provided their circuits are related to one another by frequency multiples, as already explained.

When the disclosure herein is used in a musical instrument, the gaseous oscillatory circuit may feed through a transformer T1, the primary winding 16 of which may be in the wire 1. The secondary winding 17 of this transformer is then connected to an amplifier 18 leading to a sound producing device, such as the loud-speaker 19. A switch S1 is provided for sounding the note derived from the electrical wave supplied from the gaseous oscillatory circuit and may be arranged as a musical instrument key, as shown. This switch in its normal position short-circuits the secondary 17 of the output transformer, this preventing impulses passing to the amplifier until the key is depressed to open the switch contacts and cause the note to be sounded. If desired, the note-sounding key may be connected, as shown in dotted lines, in the tuned circuit 3 in series with the resistance R1.

It is understood that the four additional tubes A2 to A5, shown in Fig. 1 as also being controlled from the same fork-oscillator, may each be connected in a separate oscillatory circuit similar to that in which A1 is connected and feed through a separate transformer provided with a similar note-controlling key into the same amplifier 18. The five circuits may all be tuned to different frequencies all related to the controlling frequency at the shields 4 in the manner described. In this manner a given note and four successive octaves of that note may be sounded at unvarying or accurate pitches.

In Fig. 3, I have shown in simplified manner the circuit lay-out of Fig. 1 extended to include such additional circuits as are necessary for the playing of the various notes composing a keyboard. It will be observed from this figure that this simple arrangement affords a keyboard of sixty notes or of five successive octaves of the lowest note thereon. The keyboard is represented by the symbol K and the various fork-oscillators required by the symbols F1 to F12. The symbols A1 to A5—12 represent the various gaseous tubes, some of which are not shown for purpose of clarity. It is understood that each of these tubes is associated with the other elements comprising its respective note-producing circuit. A single master vibrator, or tuning fork and its associated vacuum tube circuit, is required for each set of five note-producing circuits related by octaves. For the particular keyboard illustrated a total of twelve-master vibrators and a total of 60 note-producing circuits are required.

In order to provide for the sounding of a large number of notes, for example to permit rendition of musical effects comparable with an organ having three or four manuals and a large variety of stops, I have provided means whereby greater power can be obtained so that an increased number of oscillatory note-producing circuits can be controlled from the same fork-oscillator.

Fig. 2 shows an extension circuit which may be used in association with each or at least some of the various fork-oscillators. In the embodiment illustrated, this extension circuit not only operates as an amplifier, but is designed to independently produce oscillations of the same frequency as that of the oscillations which are supplied. It is controlled in operation by the stabilized frequency of the input oscillations and in turn controls the frequency of the potential impulses supplied to the shields controlling the note-producing circuits. It comprises a thermionic vacuum tube E, preferably of the multi-element type, wherein I am able to utilize a particular element combination providing a repeater tube effect and at the same time employ another causing it to act as a generator.

In the arrangement disclosed the tube E comprises a cathode *k*, adapted to be raised to electron-emitting temperature by the heater *h*, a grid or input element *g*, a suppressor grid *g'* and a plate *p*. Current may be supplied to the heater *h* from any suitable source, such as the power mains through a suitable transformer. Located between the two grids is a screen *s*. The grid-cathode circuit of the tube comprises the secondary 30 of an input transformer T5, one terminal of this secondary being connected by a wire 31 to the grid *g* and the other terminal being connected by a wire 32 to the cathode *k*. Means are provided for transferring energy from the plate *p* to the suppressor grid *g'* and in the embodiment disclosed this means comprises a mutual inductance M, one winding of which is connected by a wire 35 to said plate, a condenser 36 being provided in the wire 37 connecting the other winding *m'* to said suppressor grid. The plate-cathode circuit is established by connecting the intermediate terminal of the mutual inductance by a wire 38 to the positive terminal of a potential-supply 39, the negative terminal of which is in electrical connection through a biasing resistance 33 and condenser 34 in parallel therewith with the cathode *k*. This potential-supply 39, it is understood, may be derived from any convenient source, such as the power mains through a suitable rectifier, and for convenience here is indicated as a battery. A resistance 40, through which the condenser 36 periodically discharges, is connected at one end to the suppressor grid *g'* and at the other end through a biasing source of potential, herein shown as a battery 41, to the cathode *k*. Operating potential at the screen *s* is supplied from the source 39 by a wire 42.

The oscillations supplied through the transformer T5 to the tube E may be derived from any stabilized frequency source and in the present instance I have shown the latter as comprising one of the five oscillatory circuits the two-element tubes of which are shown as being controlled by the shields 4 in Fig. 1. In practice I utilize one of the series of tubes that is strongly stabilized by the circuit of Fig. 1, usually the one providing the fourth octave below fork frequency. In the embodiment illustrated in Fig. 1, the tube A5, designated "4th octave", would thus be employed. Its circuit is shown in Fig. 2 and includes the wire 43 connecting one of its electrodes *a* to the primary 44 of the transformer T5 and the wire 45 joining its other electrode *b* to the condenser C5 across which the resistance R5 is connected. Said condenser and resistance are connected by a wire 46 to the negative terminal of the battery 39, the other terminal of the primary 44 being connected by a wire 47 to a point of positive potential on said battery.

It will be seen from the above description that the stabilized frequency impulses supplied from the circuit of tube A5 through the transformer T5 across the grid *g* and cathode *k* of the tube E will be repeated in amplified form because of the

energy resulting from the electron stream from the cathode *k* to the plate *p*. A fluctuating potential of increased amplitude is produced at the plate *p*, which may be used to impart frequency control to a large number of gaseous tube oscillatory circuits. To this end, the plate conductor 35 is connected by wires 49 to the shields 4 fitted on the various tubes of such circuits, in this instance seven tubes A6 to A12, being shown. These circuits, one of which is illustrated, may derive their energy from the battery 39 and may each feed, in the manner as already described, through a separate transformer provided by a note-sounding key into the amplifier 18 having the loud speaker 19 connected thereto.

Increased amplification is effected as a result of the self-oscillations created by the tube E and parts associated therewith, and, as I have found, this method of insuring high amplification is particularly advantageous in that frequency stability is in no way impaired. As will be hereinafter more clearly understood, by proper adjustment of certain parts these self-oscillations are caused to take place at the same frequency and in phase with the input oscillations supplied to its grid from the oscillatory circuit of tube A5. The manner in which the self-oscillations are established will be presently described and for convenience in description it will first be assumed that such input oscillations are not present.

Observing that the space current in the plate-cathode circuit of the tube E flows through branch *m* of the inductance M, its fluctuations cause an induced voltage to be established across branch *m'* due to the inductive coupling of the two branches. Assuming a time when the space current is rising, the induced voltage across branch *m'* acts around the loop 36, *g'*, *k*, 39 and *m'* in such a direction as to change the potential at the suppressor grid *g'* in a positive direction, i. e., it renders the suppressor grid potential less negative (for the particular connections of the battery 41) and finally positive with respect to the cathode *k*. A current is thus caused to flow in the suppressor grid-cathode circuit, which causes the condenser 36 to become charged. With increase of potential at the suppressor grid the space current approaches a maximum. Since induced voltage depends on varying current and since the space current now approaches a steady state, the induced voltage in branch *m'* diminishes and the suppressor grid *g'* rapidly becomes more negative, the induced voltage in branch *m'* finally ceasing to act. As this occurs, the plate-cathode resistance increases reducing the space current and an opposite induced voltage appears in the loop 36, *g'*, *k*, 39 and *m'*, further increasing the negativeness of the suppressor grid *g'* until the point is reached corresponding to which space current is practically cut off. The suppressor grid is now maintained negative by the charge accumulated by the condenser 36 during the rectifying phase. This charge is dissipated through the resistance 40 over a period of time determined by the relative magnitudes of the condenser 36 and resistance 40 until the suppressor grid *g'* becomes sufficiently less negative to permit a sensible rise in space current, after which the succeeding cycle is initiated.

The actual current fluctuations in the plate-cathode circuit of the tube E are not, however, the self-oscillations described, but fluctuations produced by reason of the fact that the tube acts simultaneously as an oscillator and as an amplifier. Such repeated or amplified fluctuations derived from the oscillatory circuit of tube A5 also set up induced voltages in the inductance branch *m'* and therefore have a controlling effect on the operation of the tube E as an oscillator. In other words the self-oscillations are forced to keep in step with the repeated oscillations, this, nevertheless, depending on the requirement that the self-oscillations be tuned to or at least tend to take place at the frequency of the repeated oscillations. Such tuning may be effected by proper adjustment of the relative values of the capacity 36 and resistance 40, which values govern the time rate of discharge of the capacity through the resistance. Adjustment of the natural frequency of the self-oscillations may also be effected by proper selection of the suppressor grid supply-potential 41, which determines the time at which each cycle is initiated upon discharge of the condenser, further by proper design of the mutual inductance M, on which depends the amount of energy transferred from the plate-cathode circuit to the condenser as a charge.

From the above description it is seen that the electron stream fluctuating at frequencies controlled by the grid *g* is used as a coupling means between a source of stabilized frequency and a generator of oscillations utilizing the suppressor grid *g'* as its own controlling grid. The static-controlled oscillatory circuit of gaseous discharge tube A5 provides the stabilized frequency oscillations, which through the medium of the transformer T5 are supplied to the grid-cathode circuit of tube E. The screen *s*, having a positive potential, functions as a plate with respect to the grid *g*, a certain amount of space current flowing through the screen-cathode circuit. It acts in effect to isolate the two grids *g* and *g'* from one another, preventing the potential impulses at one affecting those at the other. Due to the porosity of the screen, most of the electrons from the cathode pass on to the plate *p*, causing a modification in the self-oscillatory action of the tube E. This electronic control, when circuit constants are properly chosen to have the suppressor grid controlled self-oscillatory circuit in tune or substantially in tune with the stabilized frequency oscillations in the grid-cathode circuit, tends to greatly stabilize the frequency of the resultant oscillations in the plate-cathode circuit. The feeble energy of the oscillatory circuit of tube A5, which has been stabilized in frequency, is therefore considerably amplified without loss of stability, the amplified energy appearing in the form of potential impulses at the plate *p*, which impulses may be used, as already explained, to stabilize a large number of other gaseous discharge tube circuits.

In Fig. 4 I have shown the arrangement of Fig. 3 extended to provide additional octaves by the use of a repeater circuit as shown in Fig. 2 for each of the fork-oscillators. As observed, each of the repeater circuits, represented by Q1 to Q12, is disposed between one of the gaseous tube oscillatory circuits directly controlled by a fork-oscillator and a plurality of additional note-producing circuits, the possibility of seven others being illustrated. The various gaseous discharge tubes necessary are represented by the symbols A1 to A12—12. For a keyboard of 11 successive octave intervals, 12 fork-oscillators, 12 repeater circuits and 144 gaseous discharge tube oscillatory circuits would be required.

In the arrangement shown in Fig. 5, the fork-oscillators, F1 to F12, do not directly control any of the note-producing circuits, but control gaseous oscillatory circuits, A1 to A12, supplying their

oscillations to the repeater circuits Q1 to Q12. The various note-producing circuits, the gaseous tubes of which are represented by A2 to A8—12, are directly controlled by the repeater circuits. This arrangement of parts, for a keyboard of 7 successive octave intervals, necessitates 12 fork-oscillators, 12 repeater circuits and 96 gaseous oscillatory circuits.

What is claimed is:

1. The combination with an oscillatory circuit employing a gaseous discharge tube, of means for stabilizing the frequency of the oscillations in said circuit comprising a metallic shield disposed in the vicinity of the electrodes of said tube and a device for supplying to said shield a potential fluctuating at a predetermined stable frequency.

2. The combination with an oscillatory circuit employing a gaseous discharge tube, of means for stabilizing the frequency of the oscillations in said circuit comprising a metallic shield surrounding the interior electrodes of said tube and a device for supplying to said shield a positive potential fluctuating at a predetermined stable frequency.

3. The combination with an oscillatory circuit employing a gaseous discharge tube, of means for stabilizing the frequency of the oscillations in said circuit comprising a metallic shield closely surrounding the envelope of said tube and enclosing its interior electrodes and a device for supplying to said shield a positive potential fluctuating at a predetermined stable frequency.

4. The combination with an oscillatory circuit employing a gaseous discharge tube, of means for stabilizing the frequency of the oscillations in said circuit comprising a metallic shield disposed in the vicinity of the electrodes of said tube and a device for supplying to said shield a varying potential of stabilized frequency equal to the desired frequency to be established by said circuit or related thereto by a multiple thereof.

5. The combination with an oscillatory circuit employing a gaseous discharge tube, of means for stabilizing the frequency of the oscillations in said circuit comprising a metallic shield disposed in the vicinity of the electrodes of said tube and a fork-oscillator for supplying a varying potential of predetermined stable frequency to said shield, said fork-oscillator comprising a fork having a natural period of vibration corresponding to said predetermined frequency and a thermionic repeater tube circuit having input and output branches respectively electromagnetically cooperating with the two prongs of said fork.

6. The combination with an oscillatory circuit employing a gaseous discharge tube, of a metallic shield disposed in the vicinity of the electrodes of said tube, a thermionic tube amplifier, and means for supplying oscillations of predetermined stabilized frequency to the input of said amplifier, the potential oscillations at the output of said amplifier being communicated to said shield at said stabilized frequency.

7. The combination with an oscillatory circuit employing a gaseous discharge tube, of a metallic shield disposed in the vicinity of the electrodes of said tube, a combined repeater and self-oscillatory thermionic tube circuit, and means for supplying oscillations of predetermined stabilized frequency to the repeater input of said thermionic tube circuit, the self-oscillations created by said thermionic tube circuit being caused to take place in step with the repeated oscillations, the resultant potential oscillations at the output of said thermionic tube circuit being communicated to said shield at said stabilized frequency.

8. The combination with an oscillatory circuit employing a gaseous discharge tube, of a metallic shield disposed in the vicinity of the electrodes of said tube, a repeater and self-oscillatory circuit comprising a thermionic tube having a hot cathode, a plate and two grids, said second circuit also comprising a resistance in electrical connection at its ends with said cathode and one of said grids, said second circuit also comprising a condenser and coupling means for transferring potential impulses from said plate through said condenser to said one grid, said condenser alternately accumulating a charge and discharging through said resistance, and means for supplying oscillations of predetermined stabilized frequency across said cathode and the other of said grids, the self-oscillatory fluctuations in the plate current being caused to take place in step with the fluctuations derived from said input oscillations, the resultant potential oscillations at said plate being communicated to said shield at said stabilized frequency.

9. The combination with a plurality of gaseous discharge tube oscillatory circuits tuned to frequencies related by multiples to one another, of means for stabilizing said frequencies comprising a plurality of metallic shields one for each circuit in the vicinity of the electrodes of its tube and a device for supplying to said shields a varying potential of stabilized frequency equal to the frequency to which one of said circuits is tuned or related thereto by a multiple thereof.

10. The combination with a plurality of gaseous discharge tube oscillatory circuits tuned to frequencies related by multiples to one another, of a plurality of metallic shields one for each circuit in the vicinity of the electrodes of its tube, a thermionic tube amplifier, and means for supplying to the input of said amplifier oscillations of stabilized frequency equal to the frequency to which one of said circuits is tuned or related thereto by a multiple thereof, the potential oscillations being communicated to said shields at said stabilized frequency.

11. The combination with a plurality of gaseous discharge tube oscillatory circuits tuned to frequencies related by multiples to one another, of a plurality of metallic shields one for each of said gaseous discharge tube oscillatory circuits in the vicinity of the electrodes of its tube, a combined repeater and self-oscillatory thermionic tube circuit, and means for supplying to the repeater input of said thermionic tube circuit oscillations of stabilized frequency equal to the frequency to which one of said gaseous discharge tube oscillatory circuits is tuned or related thereto by a multiple thereof, the self-oscillations in said thermionic tube circuit being caused to take place in step with the repeated oscillations, the resultant potential oscillations at the output of said thermionic tube circuit being supplies to said shields at said stabilized frequency.

12. In a musical instrument, a plurality of groups of note-producing gaseous discharge tube oscillatory circuits, all of such circuits being tuned to frequencies corresponding to the respective notes of a keyboard and each of said groups having the frequencies to which its circuits are tuned related to one another by successive octave intervals, a plurality of metallic shields one for each of said circuits in the vicinity of the electrodes of its gaseous discharge tube, and a plurality of devices for supplying potential impulses of predetermined stabilized frequency to said shields, there

being one of said device for each of said circuit groups and each of said devices supplying potential impulses of frequency equal to the frequency to which one of the circuits of its associated group is tuned or related thereto by a multiple thereof.

13. The combination with a gaseous discharge tube oscillatory circuit, of a metallic shield disposed in the vicinity of the electrodes of the gaseous discharge tube of said circuit, another gaseous discharge tube oscillatory circuit, another shield disposed in the vicinity of the electrodes of the gaseous discharge tube of the second-mentioned circuit, means for supplying to the second-mentioned shield potential oscillations of stabilized frequency equal to the frequency to which the second-mentioned circuit is tuned or related thereto by a multiple thereof, the frequency to which the second-mentioned circuit is tuned being equal to that to which the first-mentioned circuit is tuned or related thereto by a multiple thereof, and amplifying means to which potential oscillations from the second-mentioned circuit are supplied and supplying its output potential oscillations to the first-mentioned shield at the stabilized frequency to which the second-mentioned circuit is tuned.

14. The combination with a gaseous discharge tube oscillatory circuit of a metallic shield disposed in the vicinity of the electrodes of the gaseous discharge tube of said circuit, another gaseous discharge tube oscillatory circuit, another shield disposed in the vicinity of the electrodes of the gaseous discharge tube of the second-mentioned circuit, a fork-oscillator for supplying to the second-mentioned shield potential oscillations of stable frequency, equal to the frequency to which the second-mentioned circuit is tuned or related thereto by a multiple thereof, said fork-oscillator comprising a fork having a natural frequency of vibration equal to the frequency of the oscillations to be supplied to the second-mentioned shield and a thermionic repeater tube circuit having input and output branches respectively electromagnetically cooperating with the two prongs of said fork, the frequency to which the second-mentioned circuit is tuned being equal to that to which the first-mentioned circuit is tuned or related thereto by a multiple thereof, and amplifying means to which potential oscillations from the second-mentioned circuit are supplied and supplying its output potential oscillations to the first-mentioned shield at the stabilized frequency to which the second-mentioned circuit is tuned.

15. The combination with a gaseous discharge tube oscillatory circuit, of another gaseous discharge tube oscillatory circuit, a metallic shield for each of said circuits disposed in the vicinity of the electrodes of its gaseous discharge tube, means for supplying to the shield associated with the second-mentioned circuit potential oscillations of stabilized frequency equal to the frequency to which the second-mentioned circuit is tuned or related thereto by a multiple thereof, the frequency to which the second-mentioned circuit is tuned being equal to that to which the first-mentioned circuit is tuned or related thereto by a multiple thereof, and a combined repeater and self-oscillatory thermionic tube device to the repeater input of which potential oscillations from the second-mentioned circuit are supplied, the self-oscillations created by said device being caused to take place in step with the repeated oscillations, said device supplying its resultant output potential oscillations to the shield associated with the first-mentioned circuit at the stabilized frequency to which the second-mentioned circuit is tuned.

16. In a musical instrument, a plurality of groups of note-producing gaseous discharge tube oscillatory circuits, all of such circuits being tuned to frequencies corresponding to the respective notes of a keyboard and each of said groups having the frequencies to which its circuits are tuned related to one another by successive octave intervals, a plurality of metallic shields one for each of said circuits in the vicinity of the electrodes of its gaseous discharge tube, and a plurality of fork-oscillators one for each of said groups for supplying potential impulses of predetermined stabilized frequency to its shields, each of said fork-oscillators comprising a fork having a natural frequency of vibration equal to the frequency to which one of the circuits of its associated group is tuned or related thereto by a multiple thereof and a thermionic repeater tube circuit having input and output branches respectively electromagnetically cooperating with the two prongs of its fork.

17. In a musical instrument, a plurality of groups of note-producing gaseous discharge tube oscillatory circuits, all of such circuits being tuned to frequencies corresponding to the respective notes of a keyboard and each of said groups having the frequencies to which its circuits are tuned related to one another by successive octave intervals, a plurality of metallic shields one for each of said circuits in the vicinity of the electrodes of its gaseous discharge tube, and a plurality of devices one for each of said groups for supplying potential oscillations of predetermined stabilized frequency to its shields, each of said devices comprising an auxiliary gaseous discharge tube oscillatory circuit tuned to a frequency equal to that to which one of its associated group of note-producing circuits is tuned or related thereto by a multiple thereof, each of said devices also comprising an auxiliary metallic shield disposed in the vicinity of the electrodes of its gaseous discharge tube, each of said devices also comprising means for supplying to its shield potential oscillations of stabilized frequency equal to the frequency to which its gaseous discharge tube oscillatory circuit is tuned or related thereto by a multiple thereof, each of said devices also comprising amplifying means to which oscillations from its gaseous discharge tube oscillatory circuit are supplied and the output potential oscillations of which are supplied to the shields cooperating with its associated group of note-producing circuits.

18. In a musical instrument, a plurality of groups of note-producing gaseous discharge tube oscillatory circuits, all of such circuits being tuned to frequencies corresponding to the respective notes of a keyboard and each of said groups having the frequencies to which its circuits are tuned related to one another by successive octave intervals, a plurality of metallic shields one for each of said circuits in the vicinity of the electrodes of its gaseous discharge tube, a plurality of combined repeater and self-oscillatory thermionic circuits one for each of said groups, and means for supplying to the repeater input of each of said thermionic tube circuit oscillations of stabilized frequency equal to the frequency to which one of its associated group of note-producing circuits is tuned or related thereto by a multiple thereof, the self-oscillations in each of said thermionic tube circuits being caused to take place in step with the repeated oscillations therein, each of

said thermionic tube circuits supplying its resultant output potential oscillations to the shields cooperating with its associated group of note-producing circuits at the stabilized frequency of the oscillations supplied to its repeater input.

19. In a musical instrument, a plurality of groups of note-producing gaseous discharge tube oscillatory circuits, all of such circuits being tuned to frequencies corresponding to the respective notes of a keyboard and each of said groups having the frequencies to which its circuits are tuned related to one another by successive octave intervals, a plurality of metallic shields one for each of said circuits in the vicinity of the electrodes of its gaseous discharge tube, and a plurality of devices one for each of said groups for supplying potential oscillations of predetermined stabilized frequency to its shields, each of said devices comprising an auxiliary gaseous discharge tube oscillatory circuit tuned to a frequency equal to that to which one of its associated group of note-producing circuits is tuned or related thereto by a multiple thereof, each of said devices also comprising an auxiliary metallic shield disposed in the vicinity of the electrodes of its gaseous discharge tube, each of said devices also comprising a fork-oscillator for supplying to its shield potential oscillations of stabilized frequency, each of said devices also comprising amplifying means to which oscillations from its gaseous discharge tube oscillatory circuit are supplied and the output potential oscillations of which are supplied to the shields cooperating with its associated group of note-producing circuits, each of said fork-oscillators comprising a fork having a natural frequency of vibration equal to the frequency to which its associated auxiliary gaseous discharge tube oscillatory circuit is tuned or related thereto by a multiple thereof and a thermionic repeater tube circuit having its input and output branches respectively electromagnetically cooperating with the two prongs of its fork.

20. In a musical instrument, a plurality of groups of note-producing gaseous discharge tube oscillatory circuits, all of such circuits being tuned to frequencies corresponding to the respective notes of a keyboard and each of said groups having the frequencies to which its circuits are tuned related to one another by successive octave intervals, a plurality of metallic shields one for each of said circuits in the vicinity of the electrodes of its gaseous discharge tube, and a plurality of devices one for each of said groups for supplying potential oscillations of predetermined stabilized frequency to its shields, each of said devices comprising an auxiliary gaseous discharge tube oscillatory circuit tuned to a frequency equal to that to which one of its associated group of note-producing circuits is tuned or related thereto by a multiple thereof, each of said devices also comprising an auxiliary metallic shield disposed in the vicinity of the electrodes of its gaseous discharge tube, each of said devices also comprising means for supplying to its shield potential oscillations of stabilized frequency equal to the frequency to which its gaseous discharge tube oscillatory circuit is tuned or related thereto by a multiple thereof, each of said devices also comprising a combined repeater and self-oscillatory thermionic tube repeater tube circuit to which oscillations from its gaseous discharge tube oscillatory circuit are supplied and the output potential oscillations of which are supplied to the shields cooperating with its associated group of note-producing circuits.

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