Jan. 23, 1940. V. J. MOHLER 2,187,910

MUSICAL INSTRUMENT

Filed April 23, 1938 4 Sheets-Sheet 1

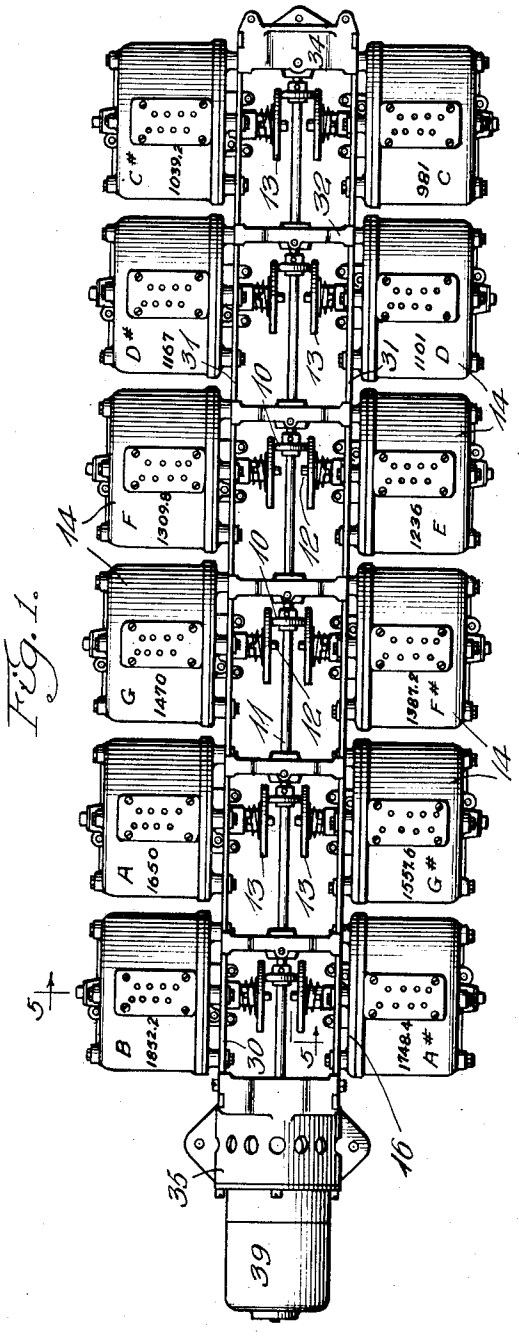

Fig. 1.

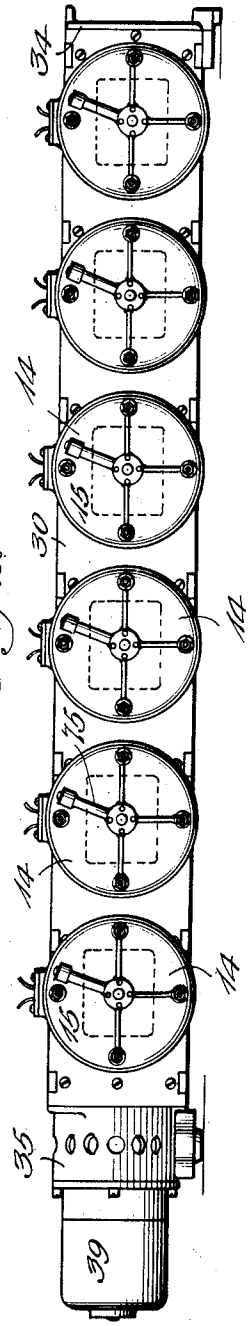

Fig. 2.

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MUSICAL INSTRUMENT

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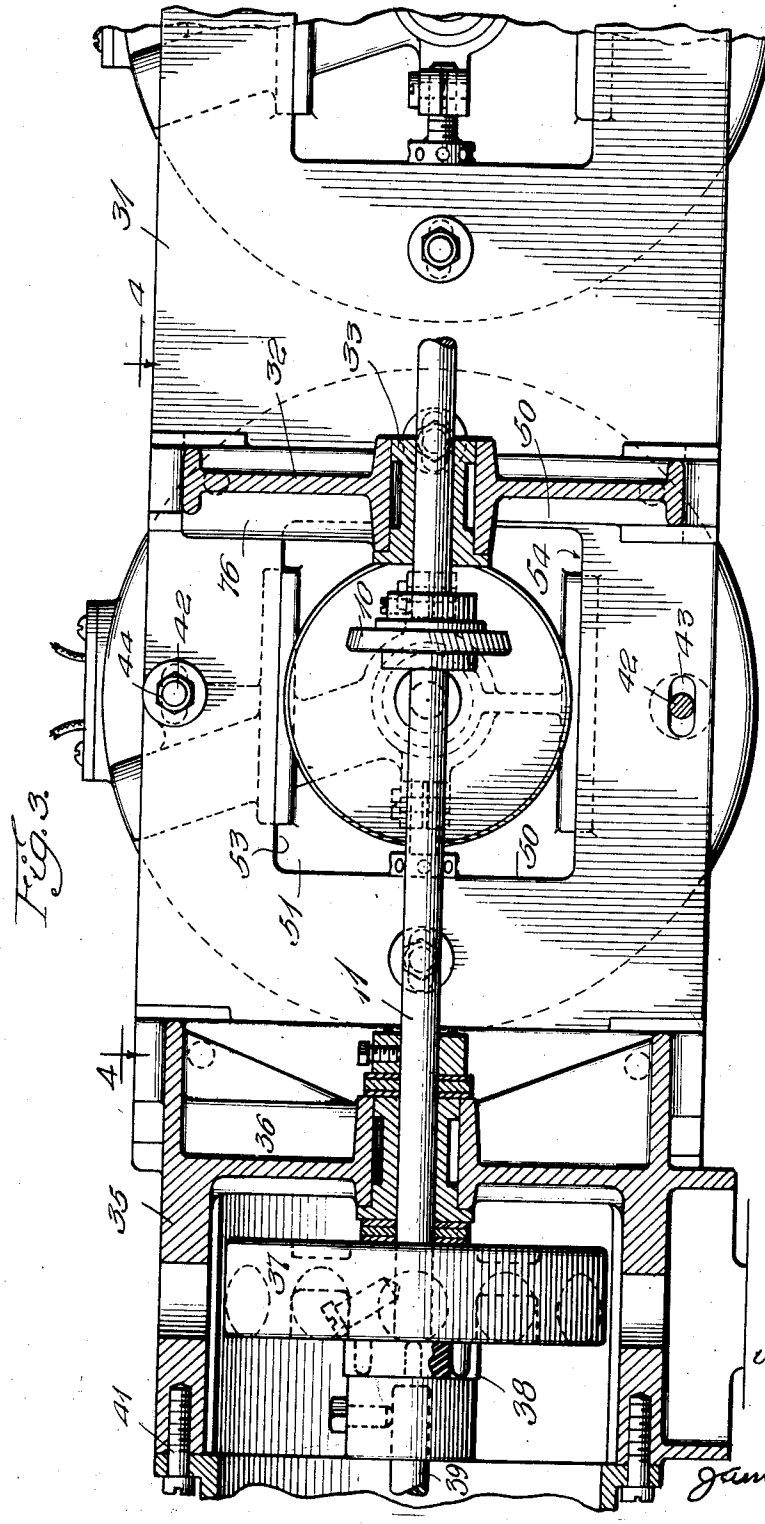

Fig. 3.

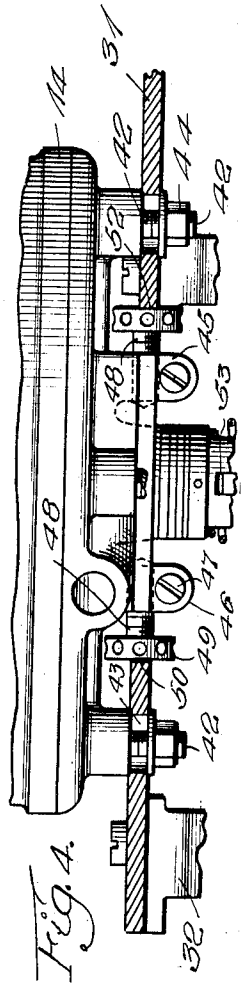

Fig. 4.

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Jan. 23, 1940. V. J. MOHLER 2,187,910

MUSICAL INSTRUMENT

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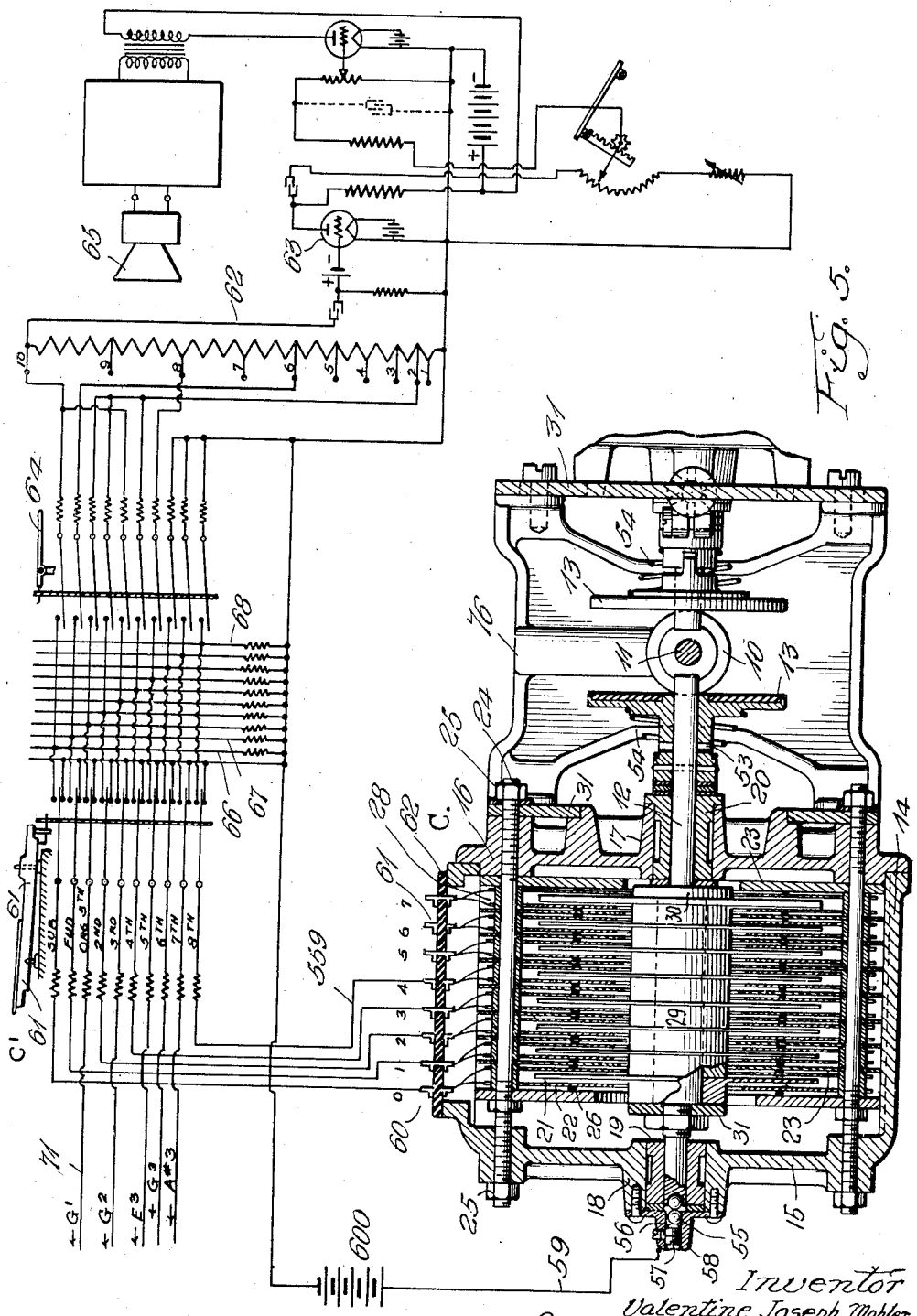

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MUSICAL INSTRUMENT

Filed April 23, 1938 4 Sheets-Sheet 4

Fig. 6.

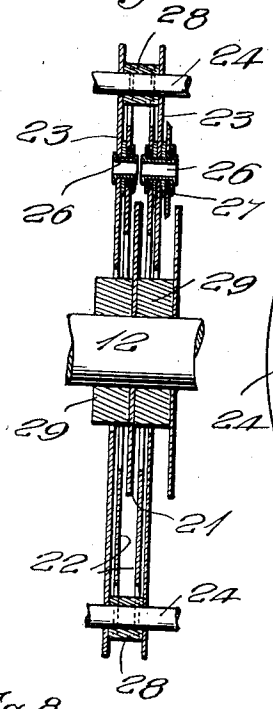


Fig. 7.

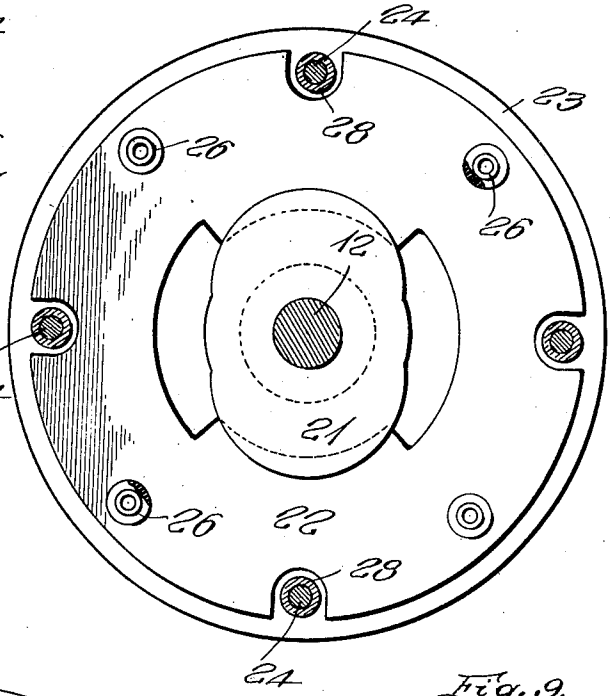


Fig. 8.

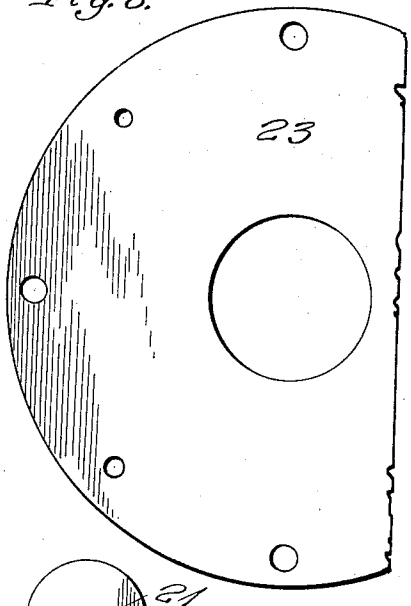
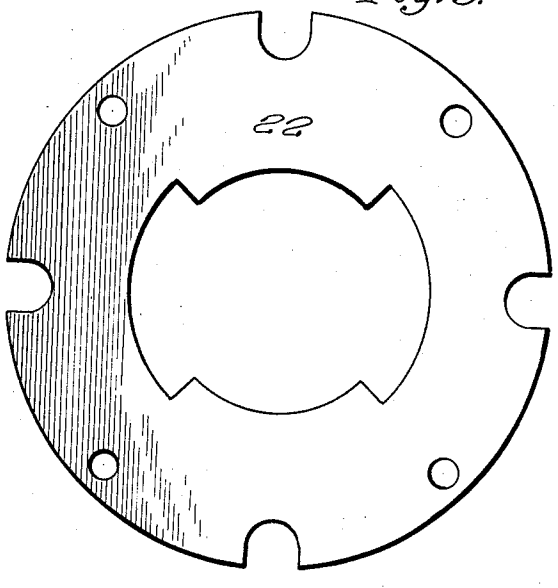


Fig. 9.



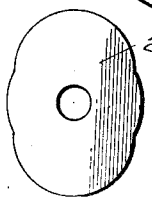


Fig. 10.

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Patented Jan. 23, 1940 2,187,910

UNITED STATES PATENT OFFICE

2,187,910

MUSICAL INSTRUMENT

Valentin J. Mohler, River Forest, Ill., assignor to Central Commercial Company, a corporation of Illinois

Application April 23, 1938, Serial No. 203,891

13 Claims. (Cl. 84—1.17)

This invention relates to musical instruments.

The invention is directed more particularly to improved means for producing music from electrical pulsations or alternating currents of controlled pitch.

Certain of the more important objects of the invention are as follows, to wit:

(1) To provide an exceedingly simple organization of alternators for producing alternating voltages at tone frequencies to serve all manuals of the instrument.

(2) To provide mechanism enabling any pitch relation of the produced alternating voltages readily to be controlled as desired.

(3) To provide an organization of alternators, the power transmission for which is wholly devoid of toothed driving and driven gears.

(4) To provide an organization, the power transmission for which is characterized by a small number of driving and driven elements serving by their novel forms and arrangements to insure absolute dependability of operation of the respective alternators, each at its proper speed.

(5) To provide an organization of alternators which is compact and of light weight and capable of being readily accommodated in a small portable console.

(6) To provide an organization of alternators embodying means whereby the relative speeds of the alternators can be determined after the alternators are fully incorporated in said organization thus enabling voicing the instrument at any desired pitch.

(7) To provide a multiple condenser employing rotary scanning electrodes mounted upon a common rotary support and coacting capacitatively with associated waveform members to provide individual co-axially related condensers, which condensers are separated from each other so that any condenser will be effectively protected from the electrostatic effects of shifting flux fields produced by others of the condensers.

(8) To provide a multiple condenser, each electrostatically effective part of which is a flat planar body, such that when the several bodies are assembled, a dielectric of constant axial dimensions is provided between coacting capacitatively effective bodies, thus to insure generation of a waveform which accurately conforms to a precalculated or specially configured waveform pattern. The term "pattern" employed in the sense stated shall mean not only the shapes and forms of the parts employed but also their fixed axial relationship to each other to hold definitely constant the sizes of the dielectrics between them, whereby the capacitance changes will always be controlled in accordance with a sinusoidal function.

(9) To provide a frequency producing organization which is freely removable from and insertable in a console as and when occasion therefor shall arise and whereby the several electrostatic assemblies of the organization can be connected to a work circuit by simple removable jacks or plugs.

(10) To provide in an organization of the class stated, means for automatically and yieldingly maintaining operative rolling frictional contact between the driven friction elements of the frequency producing assemblies and the driven frictional elements of the power transmission and for rendering the elements self-compensatory to changes necessarily occurring when shifting the driven element of an assembly across the frictional surface of a coacting driving element to change the rotative speed of the scanning electrodes of an assembly while all assemblies are operating.

The invention further consists in the combinations and various sub-combinations hereinafter more fully set forth in the hereto appended claims.

In the accompanying drawings illustrating a preferred embodiment of the invention—

Figure 1 is a view in top plan of the complete organization of frequency assemblies;

Figure 2 is a view in side elevation of said organization;

Figure 3 is a view partly in section and partly in elevation of the power transmission.

Figure 4 is a section taken substantially on the line 4—4 of Figure 3;

Figure 5 is a longitudinal section through a frequency producing assembly showing same electrically connected to a source of potential and to the input leads of a work circuit employing means for the conversion of electric energy into sound energy;

Figure 6 is a section through a portion of an assembly showing a complete condenser in detail;

Figure 7 is a view in side elevation of the parts shown in Figure 6 with parts broken away and the shaft in section;

Figure 8 is a plan view of a portion of one of the shields and stator mountings;

Figure 9 is a plan view of a stator removed from its supporting shield, and

Figure 10 is a plan view of one of a rotor for said condenser.

In Figure 1 is shown a complete tone generating organization consiting of twelve alternators or reactance assemblies, each consisting of a plurality of variable condensers. These assemblies are designated C assembly, C# assembly, D assembly, D# assembly, and so on throughout the octave to and including the B assembly.

The aforestated assemblies are mounted in parallel rows, each row consisting of six assemblies disposed in the same horizontal plane and related to the assemblies of the opposite row so that any assembly of a row is directly opposite and substantially coaxial relative to an assembly of the other row. For instance, the C assembly of the lower row in Figure 1 is directly opposite the C# assembly of the upper row in said figure. The D assembly of the lower row is opposite the D# assembly of said upper row, and so on to the extreme left of the figure where it is noted that the A# assembly of the lower row is directly opposite the B assembly of said upper row. It follows that the assemblies are arranged in pairs of substantially coaxially related assemblies in which each assembly of a pair is driven from a single driving element 10 fixed to a longitudinally disposed transmission shaft 11, there being as many of the driving elements 10 as there are pairs of assemblies in the complete organization.

The several reactance assemblies are identical in every respect to each other, whereby any assembly may serve accurately to produce alternating voltages for any notes of the same letter of the scale if and when driven at an assigned constant speed necessary to provide electrical pulsations conforming to the vibration frequencies of said notes.

Although I show assemblies, each formed and adapted electrostatically to originate alternating voltages, I do not propose to be limited in this respect as it obviously follows that other voltage producing devices now well known in the art can be substituted therefor without departing from the spirit and intention of the invention. In the instant embodiment of the invention, however, the electrostatic type of generator is employed because of the many patentably novel features it presents in the particular environment in which it is used.

As the invention is directed to a class of electrical musical instruments having one or more qualities of tone for the pitches of the instrument's gamut for a scale tuned in equal temperament, it will suffice to say for the moment, that each assembly of frequency producers has a shaft 12 provided with a driven element 13, preferably but not necessarily in the form of a friction disc. As the assemblies of the complete organization are arranged in pairs as aforementioned, it is noted upon reference to Figure 1 that the discs 13 of each pair are disposed parallel to each other and with their friction faces in running frictional engagement with the peripheral edge of a coacting driving element 10 of the power transmission shaft 11. Thus by properly correlating the driven face of a disc 13 with the driving element 10, the shaft 12 of the assembly of which it is a part can be driven at any desired rotative speed. Its speed also can readily be predetermined relative to the proper speeds of all other assemblies of the organization.

Having briefly described the general characteristics of the invention, reference is now made to Figure 5 in which it is noted that the individual reactance assembly therein disclosed consists of a short length cylindrical housing 14 having end heads 15 and 16, the latter adapted readily to be removed from the housing and is provided with a hub 17 disposed in alignment with a hub 18 on the opposite head 15. The shaft 12 of said assembly is journaled in aligned bearings 19 and 20 in the respective hubs 17 and 18, and firmly secured to and equi-distantly spaced apart upon said shaft and rotatable therewith, are scanning members in the form of flat planar primary electrodes 21 of thin gauge sheet brass. Each scanning member is disposed between and capacitatively related to parallel spaced apart flat planar secondary electrodes or waveform annuli 22, 22. One such scanning electrode and two coacting waveform annuli constitute an individual variable condenser. In the present embodiment of the invention, each assembly comprises eight of these condensers. The secondary electrodes form parts of a frame structure which has axially spaced apart flat steel discs 23 which form electrostatic shields for isolating one condenser from the effect of shifting electrostatic flux fields induced at any other condenser. The frame which includes said electrostatic shields, the rotative electrodes or scanners 21 and coacting waveform electrodes 22 is firmly retained in the housing by bolts 24, the ends of which are passed through the respective heads 15 and 16 and clamped thereto by adjusting nuts 25.

The extreme outermost discs 23 of the assembly shown in Figure 5 are of heavier gauge material than the intermediate discs of the assembly, thus to give necessary strength and rigidity to the structure as a unit and enable it to be handled as desired and readily inserted in or removed from the housing. In practice, each secondary electrode which is functionally complementary to an associated primary electrode is secured to one face of an adjacent electrostatic shielding disc 23 by fastenings 26, being effectively insulated from said disc by suitable well known electrical insulation 27. Suitable spacing ferrules or sleeves 28 on the bolts 24 serve uniformly to axially space the shields from each other and to provide for the correct interpositioning between the respective variable condensers of shielding capable of functioning as previously set forth. Similar spacers 29 on the rotary shaft 12 serve in coaction with a fixed annular flange 30 on the shaft and a clamping washer and nut assembly 31, firmly to secure the rotary electrodes 21 to said shaft.

As all frequency producing assemblies are in every respect identical to each other, it will suffice to say that the C assembly shown in Figure 5 has eight primary electrodes or scanners 21 and sixteen secondary electrodes or waveform members 22, there being two such secondary electrodes for each primary electrode in order that the power of the produced alternating voltage may be entirely ample for the purpose intended. The waveform members or secondary electrodes of each pair are correspondingly configured and adapted in coaction with a properly configured primary electrode or scanner to produce periodic changes in capacitance between said secondary electrodes and production of alternating voltage of substantially sinusoidal waveform and predetermined tone frequency. In Figure 6 of the drawings is shown a rotary electrode and its associated waveform members or secondary electrodes. Each flat planar secondary has effective capacity areas 30, 30, configured so that when

scanned by the effective and properly configured capacity areas 31, 31, of the scanner or primary electrode 21, the capacitance between said secondary electrodes will vary according to a sinusoidal function. The said primary and secondary electrodes of each set thus provide an individual variable condenser for producing alternating voltage of a predetermined tone frequency.

If the shaft 12 of the C assembly is driven at 981 R. P. M., the condenser at the exteme left of the assembly will generate 32+ vibrations per second which corresponds to the vibration frequency of the lowest C of said assembly. The condenser denoting C^1 will have four capacity areas and will produce 65+ vibrations per second. The condenser denoting C^2 will have 8 capacity areas and will produce 130+ vibrations per second. The condenser denoting C^3 will have 16 capacity areas and will produce 261+ vibrations per second, and so on up to and including the last condenser denoting C^7 which will have 256 capacity areas and will produce 4186+ vibrations per second. Thus it follows that for an instrument tuned in equal temperament and at concert pitch, speed ratios of the twelve assemblies will be as follows:

C	= 981 R. P. M.	F#=1387.2	R. P. M.
C#=1039.2	R. P. M.	G =1470	R. P. M.
D	=1101 R. P. M.	G#=1552.6	R. P. M.
D#=1167	R. P. M.	A =1650	R. P. M.
E	=1236 R. P. M.	A#=1748.4	R. P. M.
F	=1309.8 R. P. M.	B =1852.2	R. P. M.

To attain the aforestated speeds and also to enable the pitch relation of the tone producing assemblies to be altered as and when desired, the assemblies are mounted as shown in Figure 1 and are driven by the aforestated transmission which includes the driving shaft 11, its driving friction discs 10 and the driven friction discs 13, the latter mounted on the shafts 12 of the respective assemblies.

It is noted that the aforestated transmission includes a supporting frame consisting of parallel plates 31, 31, rigidly connected together by intermediate transverse brackets 32 having aligned bearings 33 in which the driving shaft 11 is journaled. It further includes a bracket 34 at one end of the frame in which one end of the shaft is journaled and a housing 35 at the opposite end of the frame. In the head 36 of said housing the opposite end of the driving shaft is journaled and is provided with an inertia element 37 of desired mass. Said element is contained in the housing and is coupled at 38 to the shaft 39 of a synchronous motor 40, the latter having its frame suitably secured at 41 to the housing 35.

In order that each group of two alternators can be driven from a single driven element 10 and so that the rotative speed of any alternator of said group can be shifted as desired and without affecting the rotative speed of the other alternator of that group or the alternator of any other group, each alternator has its housing provided with stud bolts 42 which extend through longitudinal slots 43 in an adjacent frame bar 31 as clearly shown in Figure 4. These bolts extend to the opposite side of the bar 31 and are adapted to firmly engage with said side and adjustable on the bolts are clamping nuts 44. Thus, when the nuts are loosened and except as otherwise will be referred to, the entire housing can be shifted horizontally in either direction to thereby shift the driven element 13 of the housing across the periphery of the driving element 10. In this manner the rotative speed of an alternator, hence the pitch of the produced tones can be regulated as desired. In order that the alternator can then be held at the desired speed, means are employed consisting of clamps 45 on the inner face of the housing 14, the jaws 46 of which can be opened and closed by screws 47 and either firmly secured against screws 48 between said jaws or released therefrom. The outer ends of said screws have heads 49 which can be brought into effective impingement with the vertical end walls 50 of a rectangular slot 51 in said bar 31. When it is desired to adjust the housing horizontally to change the speed of the driven disc 13, the clamps 46 are first released from the screws 48. The screws are then retracted from their positions in which their heads 49 bear against the walls 50, to provide necessary clearance between said walls and said heads to permit of longitudinal movement of the entire housing 14. The nuts 44 are next released from the inner face of the bar 31, at which time the housing can be moved as desired and the relation of the driving and driven elements 10 and 13 altered for any pitch speed of the alternator that is necessary. When the required speed change has been made the screws 48 and the nuts 44 are readjusted to the positions shown in Figure 4. In order that the entire weight of an assembly shall not wholly be borne by the bolts 42, the housing 14 of the assembly is provided with combined guiding and weight sustaining rectilinear lugs 52 which bear respectively against the upper and lower walls 53 and 54 of the aforementioned slot 51.

In order that the speed of any alternator can be changed without affecting the speed of any other alternator, each driven element 13 of a group of alternators is splined at 53 to its shaft 12 and is yieldingly urged into rolling frictional contact with the coacting driving element 10 by a coil spring 54.

Upon referring again to Figure 5 of the drawing, it is observed that steel balls 55 are in coaxial alignment with and bear against each other by a spring 56, whereby one of the balls, bears yieldingly against one end of the shaft 12, the other ball is directly in front of said spring and the tension on the latter is controlled by an adjusting screw 57 in a metallic cap 58 at the center of the housing head 15. One lead 59 from a source 60 of charging potential is electrically connected to said cap 58, whereby all of the primary electrodes 21 will be charged through the shaft 12.

No claim is made to the form of circuit for converting electric energy into sound energy, other than with respect to the output leads 559 which run from each of the alternator assemblies. Each of these leads is provided with a plug 60. Each pair of secondary electrodes 22 for each primary electrode are electrically connected together and terminate at or join electrically to a socket 61 in an insulating cap plate 62 at the top of the assembly housing 14. In this manner, and upon breaking the connection between the leads 59 and the caps 58 of all housings 14 of the organization, the organization can be removed from or inserted in a console as and whenever desired, such as when originally assembling an instrument or when it is required to remove the organization from the console for repair thereof.

It will suffice to say that the leads 559 and the polarizing source 600 are parts of a network employing keys 61 for connecting the individual

variable condensers of an assembly in the input circuit 62 of an amplifier 63 for amplification of the produced voltages or such thereof that combine through a tappet 64 to provide any desired tonal timbre. The amplified voltages are converted into audible sound by means of a loud speaker 65.

The alternators for the C notes (Figure 5) are connected in the network as follows:

The condenser denoting the sub-partial or lowest C note feeds alternating voltage to bus-bar 66 in the aforestated electrical network. The alternator denoting C^1 feeds voltage at this tone frequency to bus-bar 67 and so on through and including the condenser for C^4 which supplies voltage at this frequency to bus-bar 68. The key 61 shown in Figure 5 has the usual sticker 69 for making electrical connection with the respective bus-bars through the multiple contacts 70. In the key setup shown in this figure, provision is made for the conduction of ten partials to a corresponding number of bus-bars in said network. The partial denoting "org. 5th" has a lead 71 designated G^1 adapted to be connected to the G alternator assembly shown in Figure 1. The 3rd partial is adapted to be connected by lead 72 with condenser G^2 of said G alternator assembly in Fig. 1. The 5th partial has a lead 73 adapted to be connected with the E^3 condenser of the E alternator assembly in Fig. 1. The 6th partial has a lead 74 adapted to be connected with the G^3 condenser of the G alternator assembly in said Fig. 1, and the 7th partial has a lead adapted to be connected to the A#3 condenser of the A# alternator assembly in Fig. 1. The above brief description of the network is simply illustrative of the manner in which any tonal quality can be had by selective use of the respective frequency producing assemblies and by the control of a timbre denoting tappet of the instrument.

Incidental structural features of the invention consist in providing oil wells or feeding ducts 75 in the housings 14 for supplying lubricant to the shafts 12 and their bearings, and similar wells or ducts 76 in the cross frame members 32 for supplying lubricant to shaft 11 and its bearings.

What I claim as my invention is:

1. In a musical instrument, coaxial variable condensers for producing alternating voltages at harmonically related tone frequencies, each condenser comprising a scanning electrode; electrostatic shields isolating a condenser from the effects of shifting electrostatic flux fields generated at any other condenser; and a secondary waveform electrode for each primary scanning electrode and mounted upon an adjacent electrostatic shield and axially spaced from and disposed parallel to said primary electrode.

2. In a musical instrument, a set of coaxially related variable condensers, each condenser embodying a fixed part having one or more capacity areas and a rotatable part also having one or more capacity areas, the latter capacitatively related to the capacity areas of the fixed part; means providing a common rotatable support for the rotatable parts; and electrostatic shields for guarding any condenser from the effects of shifting electrostatic flux fields generated at any other condenser during operation of said set.

3. In a musical instrument employing an electrical circuit having means for converting electric energy into sound energy; rotary reactances for originating alternating voltages at respectively different tone frequencies; means enabling regulation of the angular velocity of a reactance relative to any other reactance; and means by which voltage from any reactance can be conducted to said circuit.

4. In a musical instrument, variable condenser assemblies, each assembly embodying a set of primary electrodes and a set of secondary electrodes, the latter capacitatively related to and coacting with the former to vary the capacitances between the primary and secondary electrodes and cause simultaneous production of alternating voltages at different tone frequencies; a power transmission common to all assemblies for driving each thereof at a predetermined speed; and means enabling the speed of any assembly to be regulated while all assemblies are operating.

5. In a musical instrument, an assembly of coaxially related variable condensers, each condenser comprising a primary electrode and a secondary electrode, said primary and secondary electrodes having capacity areas formed, disposed and preshaped to cause sinusoidal capacitance changes between same and production of alternating voltages of predetermined tone frequencies; means for rotatably supporting all primary electrodes; means providing a common support for all secondary electrodes and for axially spacing and insulating same from said primary electrodes; and means for charging all condensers through said rotatable support.

6. In a musical instrument, a frame having a power transmission shaft journaled therein and provided with spaced apart frictional driving elements; and parallel rows of rotary alternators supported by the frame at opposite sides thereof; and a driven frictional element for each alternator, the relation to each other of the alternators of said parallel rows of alternators being such as to provide pairs of alternators, the driven frictional elements of which are common to a single driving element of said power transmission shaft.

7. In a musical instrument, a frame having a power transmission shaft journaled therein and provided with frictional driving elements; parallel rows of rotary alternators supported by the frame at opposite sides thereof; a driven frictional element for each alternator, the relation to each other of the alternators of said parallel rows of alternators being such as to provide pairs of alternators, the driven frictional elements of which are common to a single driving element of said power transmission shaft; and means by which any alternator can be adjusted on the frame to correlate the driven frictional element thereof with its coacting driving element of said shaft for any desired regulation of the speed of said alternator.

8. In a musical instrument, an assembly of coaxial, variable condensers, each comprisng a fixed electrode and a rotary electrode; a driven shaft common to all of the rotary electrodes; means insulating the fixed electrodes and for axially spacing same from the rotary electrodes; and axially spaced apart electrostatic shields separating the condensers from each other.

9. A musical instrument having twelve identical rotary alternators, each alternator formed and adapted when driven at an assigned constant speed to produce alternating voltages conforming to fundamental tones of different pitch; means for driving the alternators so that the speed of each alternator is to that next thereto substantially as one is to the twelfth root of two; and means enabling the speeds of the alternators indi-

vidually to be changed while said alternators are operating.

10. A variable condenser organization comprising a rotary shaft of conductive material; a plurality of axially spaced apart electrodes carried by and connected with said shaft and adapted to be charged therefrom when the shaft is electrically connected to a polarizing source; axially spaced apart electrodes capacitatively related to the first named electrodes; said first and second named electrodes being respectively formed, designed and adapted to provide a plurality of individual condensers, the capacitance of each of which is variable at a rate electrostatically to originate alternating voltage of a predetermined tone frequency which is different from that originated by any other condenser; a metallic ball; and means for resiliently urging said ball axially of and against one end of the shaft, said means including an electrical conductor adapted to be connected to a polarizing source and enabling the shaft to be charged from said source through said ball.

11. In mechanism of the class described, an organization of coaxial variable condensers, each condenser embodying a pair of identical planar electrodes axially spaced apart from each other and electrically tied to a common conductor, said electrodes having oppositely related capacity areas of predetermined shapes in parallelism; a metallic shield for and against which each electrode is secured flatwise; and a planar electrode rotatably mounted between said identical electrodes and axially spaced apart therefrom and having capacity areas of predetermined shapes disposed and adapted to periodically scan the capacity areas of the aforestated identical electrodes and adapted when polarized, electrostatically to develop alternating voltage of a frequency and waveform determined by the angular velocity of said rotatable electrode and the relative shapes of the capacity areas of the respective electrodes.

12. In a musical instrument, a set of axially spaced apart continuously varying reactances, each reactance including a fixed electrode and a movable electrode capacitatively related thereto and coacting therewith to develop alternating voltage of predetermined tone frequency and substantially sinusoidal waveform, each of said electrodes characterized by a planar member of thin gauge sheet material having electrically conductive surfaces, and means disposed in the spaces between adjacent reactances for guarding each of said reactances from the effects of shifting flux fields.

13. In a musical instrument, a plurality of alternator assemblies, each assembly producing when driven at an assigned speed alternating voltages at tone frequencies of notes in octave relation, and a transmission for driving all assemblies at their assigned speeds and including driving elements, the total number of which is less than the total number of said assemblies.

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