Sept. 13, 1932. R. C. HITCHCOCK 1,877,317

MUSICAL INSTRUMENT

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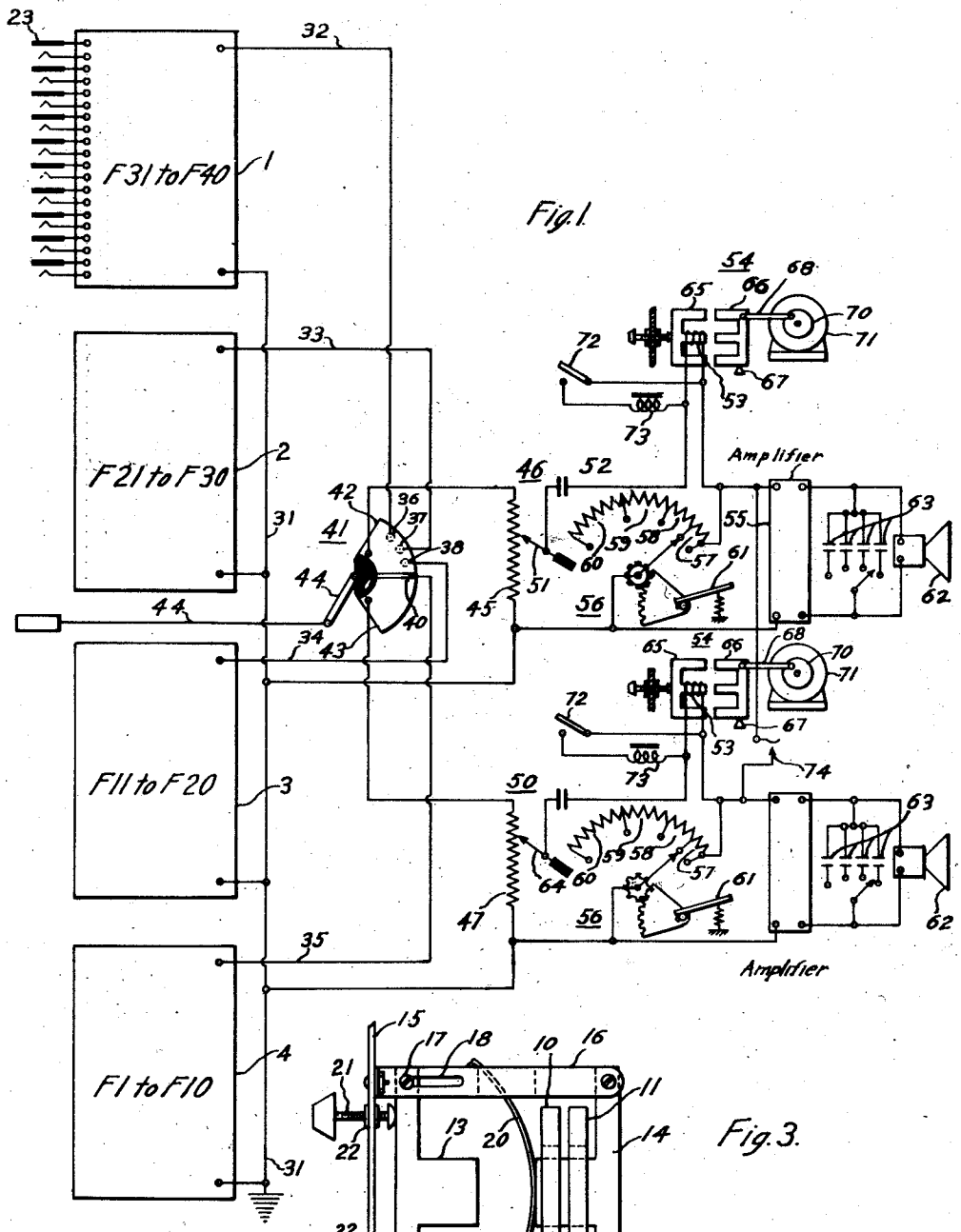


Fig. 1.

Fig. 3.

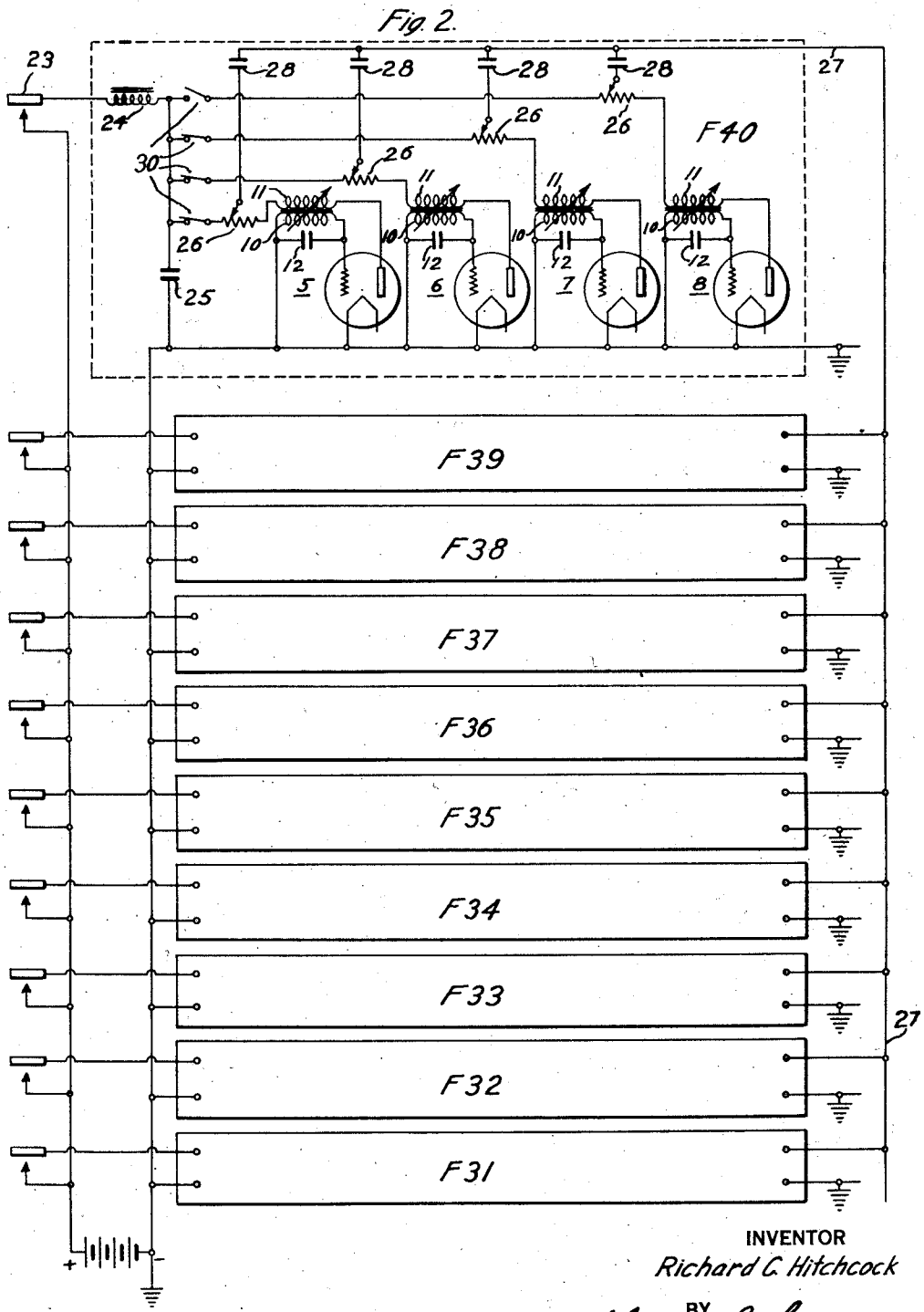
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Fig. 2.



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UNITED STATES PATENT OFFICE

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MUSICAL INSTRUMENT

Application filed January 20, 1930. Serial No. 421,953.

My invention relates to musical instruments and it has particular relation to the synthesis of musical tones by electrical means.

I am aware that previous attempts have been made to construct musical instruments wherein the various tones were produced by alternating current generators of different types. Such instruments, however, have never given entire satisfaction, one of the main causes for their lack of success being the failure to provide micrometrically adjustable means whereby the necessary harmonic frequencies could be introduced and controlled.

Furthermore, insofar as I am at present aware, no previously known musical instruments, of the type to which my invention pertains, were provided with adequate means for tone and volume-control and, consequently, they were incapable of reproducng musical compositions with the same tone-color and nuances of expression that could be obtained with pipe-organs and pianos.

In addition, the limitations of previously known electrical musical instruments were such as to preclude their proper tuning and they could not be satisfactorily utilized in orchestras wherein the other instruments were tuned to the tempered scale.

It is, accordingly, an object of my invention to provide an electrical musical instrument wherein each note of the scale shall be accompanied by the harmonic frequencies necessary to give it the requisite "color".

Another object of my invention is to provide, in an instrument of the type described, micrometrically adjustable means for controlling the fundamental and harmonic frequencies involved in the production of each musical tone.

Another object of my invention is to provide an electrical musical instrument comprising means whereby the character of the final sound-output therefrom is controllable as to the relative intensities of the treble and bass frequencies therein.

Another object of my invention is to provide, in an electrical musical instrument, a volume-control device that shall, insofar as its effect upon the intensity of the final sound-output of the instrument is concerned, be analogous to the volume-control devices associated with mechanical instruments, such as pipe-organs and pianos.

A still further, and more specific object of my invention is to provide, in an instrument of the type referred to, means whereby the inception of each note is not marred by the phenomenon hereinafter designated as "key-thump".

In practicing my invention I provide a controllable thermionic tube oscillator for each fundamental frequency and an additional oscillator for each harmonic frequency that must accompany the fundamental to give the requisite timbre to the note. The number of harmonic generators is optional. For example, if the instrument is to simulate the open diapason stop of a pipe organ, I have found it advantageous to provide three harmonic generators in addition to each fundamental, the frequencies of the harmonics being 2, 3 and 4 times the frequency of the fundamental. If other musical instruments are to be imitated, the auxiliary frequencies alone are altered, the fundamentals remaining unchanged.

The oscillators are, preferably, divided into major groups, each group comprising ten tones of the chromatic scale, and switching means are provided whereby the output from the several groups may be, at will, apportioned among a plurality of thermionic amplifiers each of which feeds a loud-speaker individual thereto. The loud-speakers may be so constructed as to, respectively, be preferentially responsive to predetermined frequency-bands.

Plate-potential is supplied to each minor

group of two or more oscillators, providing a single musical tone, under the control of individual keys in a key-board, and each keying circuit is provided with a filter to prevent the sudden rushes of current that cause "key-thumps."

Each amplifier is provided with an individual volume-control device that may be set to give the desired intensity of sound-output and additional, pedal-actuated, volume-control devices, individual or common to the several amplifiers, are provided whereby crescendo and diminuendo passages in the music may be properly rendered.

The novel features that I consider characteristic of my invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and its method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment, when read in connection with the accompanying drawings, in which:

Figure 1 is a diagrammatic view of a portion of an electrical musical instrument comprising a preferred embodiment of my invention,

Fig. 2 is a diagrammatic representation of one of the major groups of oscillators, a minor group thereof being illustrated in detail,

Fig. 3 is a view, in side elevation, of a reactance device, such as is utilized in connection with each individual oscillator, illustrating the mechanism whereby the generated frequency is controlled.

In connection with the following description of my improved electrical musical instrument, it should be borne in mind that I have chosen to illustrate it as applied to the generation and utilization of only forty of the eighty-eight notes comprised in a standard piano. It is to be understood, however, that the adaptation of my invention to a more extensive scale involves merely the duplication of the illustrated elements and does not require the exercise of invention. It should also be understood that many of the individual control-devices illustrated may be interconnected for simultaneous operation without departing from the spirit of my invention.

The apparatus illustrated in Fig. 1 of the drawings comprises a plurality of major groups of oscillators, indicated by the rectangles 1, 2, 3 and 4, each major group consisting of a plurality of minor groups of individual oscillation generators as shown in detail in Fig. 2.

Referring specifically to Fig. 2, each minor group of oscillators comprises a plurality of thermionic devices 5, 6, 7 and 8, each device having an input coil 10 and an output coil 11 that are disposed in inductive relation to each other. The frequency of each oscillator is approximately determined by a tuning condenser 12 individual thereto, the condenser being connected in shunt relation to the input coil, as illustrated, or in shunt relation to the output coil.

The exact tuning of each oscillator is accomplished by disposing a magnetic element in the field common to the input and output coils thereof and by providing means whereby the reluctance of the element may be micrometrically altered.

An oscillator-tuning device of a preferred type, such as shown in Fig. 3 of the drawings, comprises two E-shape laminated core-elements 13 and 14, of magnetic material, the latter element being rigidly supported from a panel 15 by a plurality of non-magnetic bars 16.

The laminations of the remaining E-shape core-element 13 are held together by a plurality of bolts 17 and the projecting end of each bolt fits into a slot 18 cut into the adjacent supporting bar 16, thus permitting the said element to have a limited range of movement toward and away from the fixed element.

A spring 20 of non-magnetic material is interposed between the fixed and movable magnetic elements and urges the latter against the heads of two adjusting screws 21 that extend through threaded-bushings 22 carried by the panel.

All of the oscillators comprised in a single minor group are supplied with plate-potential from a common source under the control of a key 23, the potential-supply circuit to each group including an individual key-thump filter, constituted by an inductor 24 and a large condenser 25, the inductor being of such value as to prevent the current from building up too rapidly.

Each plate-potential supply lead, individual to one of the thermionic tubes in a minor group, includes a resistor 26, an intermediate point on each resistor being connected to a common output conductor 27 through a coupling condenser 28. The coupling condensers play an important part in my improved device in that they prevent interaction between the several oscillators included in a minor group.

The amplitudes of the several harmonic frequencies impressed upon the common output conductor is determined by the positions of the intermediate points on the resistors 26, thus facilitating the adjustment of the device in simulating any desired musical instrument.

I have observed that, with any given setting of the aforesaid resistors, although the magnitude of the electrical power output of the several harmonic generators remains constant relative to the power output of the generator giving the fundamental, or "pitch" tone, the apparent loudness of certain har-

monics relative to the fundamental increases if the note is held for an appreciable time. It, accordingly, lies within the scope of my invention to provide means for maintaining the apparent loudness of the several harmonics, relative to the fundamental, invariable with time, by causing a gradual diminution of the electrical power supplied by certain of the harmonic generators. I have not illustrated any particular means for obtaining the desired harmonic amplitude reduction, such as clockwork devices, automatic biasing schemes, automatic variation of the points on the resistors 26 to which the coupling condensers 28 are connected, and the like, since their introduction into the drawings would result in needless complication.

In addition, an individual switching device 30 is included in the plate-potential lead to each thermionic tube, and the analogous switching devices of all of the major groups may be controlled from a single lever, or stop (not shown) whereby the tone-color of the music is changeable at will.

It is also perfectly feasible to utilize more than three harmonic generators, in addition to the fundamental frequency generator, in each minor group and to so tune the auxiliary generators that, when they are included in circuit, the music of other instruments, such as a saxophone, a clarinet, or the like, may be simulated. It is to be understood, in this connection, that the additional oscillators will be provided with simultaneously controllable plate-potential supply switches whereby the timbre of each note in the entire range shall be under the control of a plurality of stops analogous to those of the usual pipe-organ.

Referring again to Fig. 1 of the drawings, the major groups 1, 2, 3 and 4 have a common connection 31 to ground and are provided, respectively, with output conductors 32, 33, 34 and 35. The output conductors lead to contacts 36, 37, 38 and 40, respectively, with which is associated a switching device 41 having two movable, electrically dissociated blades 42 and 43, and being provided with an actuating handle 44 that extends to the front of the instrument.

The resistance element 45 of a potentiometer 46 is connected between one of the blades of the switching device and the common ground-connection 31 of the major groups, and the resistance element 47 of a similar potentiometer 50 is connected between the other blade and the said ground-connection.

The contact-arm 51 of the first-mentioned potentiometer 46 is connected, through a coupling condenser 52 and a coil 53 included in a tremolo device 54, to one of the input terminals of a thermionic power-amplifier 55, the other input terminal of the amplifier being connected to the grounded end of the resistance element 45, whereby the amplitude of the tone-frequencies impressed on the amplifier may be adjusted.

Further volume-control is obtained by connecting a variable resistance device 56, across the input terminals of the amplifier. The volume-control resistance device preferably comprises a plurality of individual elements 57, 58, 59, 60, etc., which increase in magnitude logarithmatically, and which may be progressively connected across the amplifier terminals by depressing an actuating pedal 61.

A loud-speaker 62 is connected to the output terminals of the amplifier and a plurality of fixed condensers 63 are disposed in shunt relation thereto whereby the ratio of high to low frequencies in the sound-output shall be under the control of the performer, thus enabling the production of deeper and more resonant tones.

The contact arm 64 of the second-mentioned potentiometer 50 is connected to the input terminals of an amplifier-loud-speaker assembly, similar to that described above, the component parts of which are similarly designated in the drawings.

The tremolo device, which is an important detail of my invention, is constituted by an adjustable E-shape magnetic element 65 on one arm of which the coil 53 is mounted, and an E-shape magnetic element 66 mounted upon a pivot 67 about which it is caused to rapidly oscillate in a small arc by reason of an eccentric connection 68 to a pulley 70 on the end of the shaft of a small electric motor 71. The rapid, recurrent variation in the air-gap between the two E-shape elements introduces corresponding variations into the inductance of the coil 53 thus offering a varying impedance to the tone-frequencies fed to the amplifier 55 and thereby greatly improving the impression made upon the ears of listeners by the sound delivered from the associated loud-speaker 62. When the tremolo effect is not wanted the coil 53 is removed from the input circuit of the amplifier by the closing of a switch 72, and a coil 73 substituted therefor in order that the input impedance of the amplifier shall not be changed.

In the rendition of certain musical compositions, it is highly desirable that the bass notes shall, at times, exceed the treble notes in loudness, or vice versa. To this end I have provided the switching device 41 whereby the major groups of tone oscillators may be collectively or selectively associated with the several amplifiers. For example, when the device is in the position shown in the drawings the major group producing frequencies 1 to 10 is connected to the lower amplifier and the other major groups are connected to the upper amplifier. Inasmuch as each amplifier is provided with an individual volume control device 56, the intensity of the sound out-

put from each loud-speaker is thus under the control of the performer and the desired result is obtained.

In certain instances it is desirable to simultaneously energize all of the amplifiers, irrespective of the position of the switch 41 and, to this end, I have provided a coupling device 74 which, when the contacts thereof are closed, conductively connects the input circuits of all of the said amplifiers.

It will, accordingly, be apparent that my improved musical instrument, by reason of the fact that provision is made for desired variations in amplitude, for variations in the harmonic frequencies introduced, and for altering, at will, the relative amounts of high and low frequencies in the ultimate sound-output therefrom, is an extremely flexible device. Furthermore, by reason of the fact that I obtain volume-control by electrical means, and not by acoustic means, such as are embodied in pipe-organs and pianos of well known types, a change in the volume of the sound-output from my new musical instrument causes no change in the quality thereof.

Another advantageous feature of my invention lies in the facility with which it may be utilized for radio-broadcasting. When so used, the amplifiers may be omitted and the tone-frequencies directly impressed on the transmitting apparatus. The distortion occasioned by the deficiencies of the usual microphone is, accordingly, obviated with the result that, when the radio program is received, the music is notably excellent in quality.

Although I have shown and described a specific embodiment of my invention, I am fully aware that many modifications thereof are possible. My invention, therefore, is not to be restricted except insofar as is necessitated by the prior art and by the spirit of the appended claims.

I claim as my invention:

1. In an electrical musical instrument, a plurality of oscillators adapted to generate the frequencies required for a musical tone, means for synthesizing the discrete frequencies, and means for preventing interaction between the said oscillators.

2. In an electrical musical instrument, a plurality of thermionic oscillators to jointly and collectively generate the fundamental and harmonic frequencies required for a musical tone, an amplifying device, and means for impressing the said frequencies on the amplifying device.

3. In an electrical musical instrument, a plurality of minor groups of oscillators, each minor group being adapted to generate the frequencies required for a musical tone, a source of potential for said oscillators, keying means individual to each minor group for controlling the application of potential from said source to said oscillators, and means for preventing "key-thumps".

4. A plurality of major groups of oscillators, each major group including a plurality of minor groups of oscillators, each minor group being adapted to generate the frequencies required by a musical tone, a plurality of amplifying devices, and means for collectively and selectively impressing the output currents from said major groups upon said amplifying devices.

5. In an electrical musical instrument, a plurality of oscillators, each adapted to generate the frequencies required for a musical tone, an amplifying device having an input circuit, and means including a volume-control device for impressing said frequencies upon said input circuit and for gradually varying the relative magnitudes of the frequencies composing a given tone.

6. In an electrical musical instrument, a plurality of oscillators respectively adapted to generate the frequencies required for a musical tone, an amplifying device having an input circuit, and means including a variable reactor for impressing said frequencies upon said input circuit, whereby a tremolo effect may be obtained.

7. In an electrical musical instrument, a plurality of oscillators respectively adapted to generate the frequencies for a musical tone, an amplifying device having an input circuit, means including a variable reactor for impressing said frequencies upon said input circuit, and means for causing rapid recurrent changes in the reactance of said reactor, whereby a tremolo effect may be obtained.

8. In an electrical musical instrument, a plurality of major groups of tone-oscillators, a plurality of amplifying devices, means for selectively and collectively impressing the output currents from said groups upon the amplifying devices, and means for unifying at will said amplifying devices.

9. In an electrical musical instrument, a plurality of oscillators respectively adapted to generate the fundamental and harmonic frequencies for a musical tone, an amplifying device having an input circuit, means including a volume-control device for impressing said frequencies upon said input circuit, and means for causing a decrease with time of the ratio of the volume of said harmonic frequencies to the volume of said fundamental frequency.

10. In an electrical musical instrument, a thermionic oscillator having an input coil and an output coil disposed in inductive relation to each other, a magnetic element disposed in the field of said coils, and means for varying the reluctance of said element, whereby the frequency of the generated oscillations may be controlled and tuning may be accomplished.

11. In an electrical musical instrument, a plurality of oscillators respectively adapted to generate the fundamental and overtones required for a musical note, an amplifying device having an input circuit and an output circuit, a sound-reproducing device connected to said output circuit, means for impressing said frequencies upon said input circuit, and means included in said output circuit for selectively controlling the ratio of high to low frequencies delivered to said sound-producing device.

In testimony whereof, I have hereunto subscribed my name this 18th day of January, 1930.

RICHARD C. HITCHCOCK.