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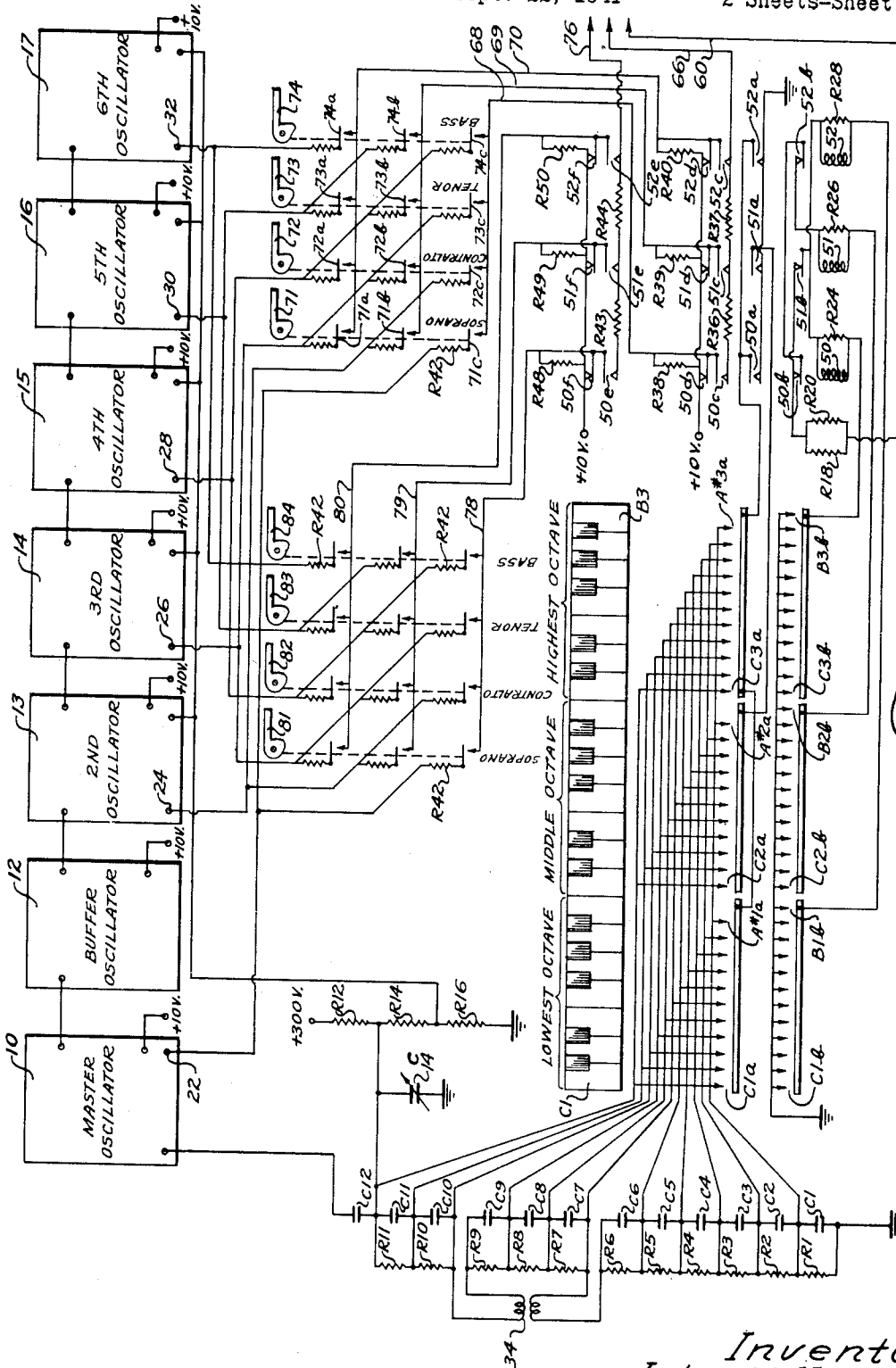
J. M. HANERT

2,310,429

ELECTRICAL MUSICAL INSTRUMENT

Filed Sept. 22, 1941

2 Sheets-Sheet 1



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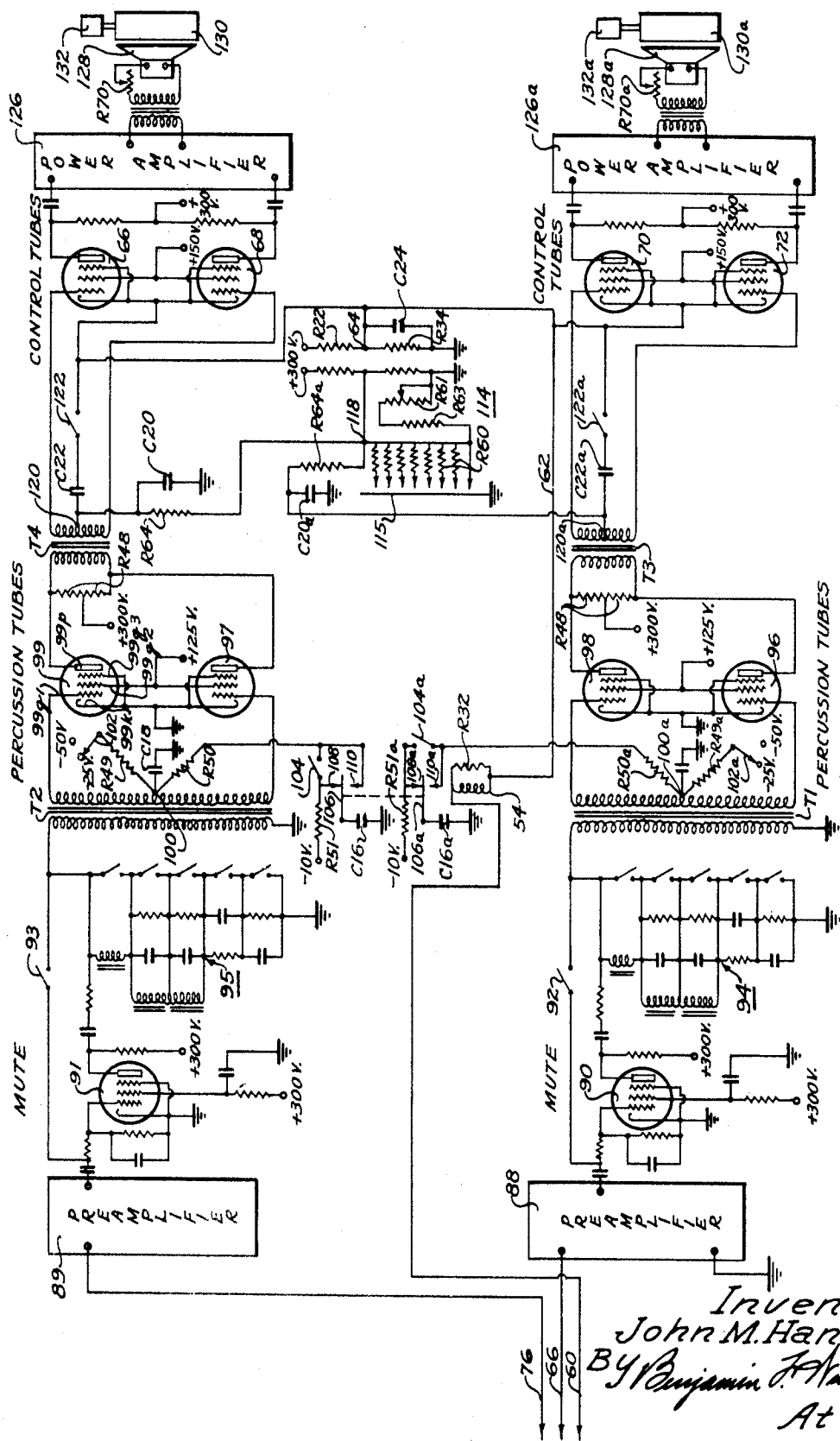
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ELECTRICAL MUSICAL INSTRUMENT

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,310,429

ELECTRICAL MUSICAL INSTRUMENT

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Application September 22, 1941, Serial No. 411,804

20 Claims. (Cl. 84—1.25)

My invention relates generally to electrical musical instruments, and more particularly to musical instruments of the melody type, and constitutes an improvement on the instrument disclosed in the patent to Laurens Hammond and John M. Hanert, No. 2,223,258, issued February 25, 1941.

In playing certain types of music, it is desirable at times to produce a plurality of melody tones which are related by octaves in much the same manner as in the orchestra, where a relatively large number of instruments may all be playing the melody part but are separated by octave intervals. At present, this effect may be achieved by a relatively large number of players, each playing a melody instrument of the type disclosed in the aforesaid patent to Laurens Hammond and John M. Hanert.

Inasmuch as all of these players are playing the same melody part, it would be desirable to produce this orchestral effect by a single player playing upon a single keyboard. This keyboard may or may not be attached to a piano, as illustrated in the aforesaid patent.

It is accordingly the main object of this invention to provide means whereby, with a single keyboard, the musician may produce a plurality of octave related tones which in themselves emit their sound from spatially separated electroacoustic translating systems, and may also be individually controlled as to dynamic envelope and quality of tone. Thus, the only relation which these sources of sound bear to each other is that they are of exact octave relationship. The fact that the tones have frequencies which do bear exact octave relation to each other is of course desirable from a tuning standpoint.

It is thus an object of my invention to provide an improved melody instrument having a keyboard of a range of several octaves by which a plurality of tones may be simultaneously sounded in octave or multioctave relationship but of different tone qualities.

A further object is to provide means for producing octave related tones from a plurality of electroacoustic translating sources to produce an orchestral acoustic perspective.

A further object is to provide means whereby a plurality of octave or multioctave tones may be produced with different dynamic tone envelopes.

A further object is to provide an improved relay keying system in connection with the keyboard having a plurality of contacts for transmission of octave or multioctave related signals

from a common generating source to a plurality of tone controlling meshes and electroacoustic translating means.

A further object is to provide a plurality of non-linear transmission systems for the production of a plurality of tones of differing tonal character.

A further object is to provide a unitary volume controlling system for simultaneously varying the acoustic output of a plurality of independent electroacoustic translating systems.

A further object is to provide a plurality of signal transmission systems in which individual switching means are provided for varying the intensity envelope.

A further object is to provide a plurality of electroacoustic translating means with signals of varying tone color and selectively imparting a tremolo or vibrato effect.

Other objects will appear from the following description, reference being had to the accompanying drawings in which:

Figures 1 and 2 constitute a complete wiring diagram of the instrument.

General description

As shown in Figures 1 and 2, the keyboard of the instrument comprises a plurality of keys, being designated C1 to B3, inclusive. The actual pitches of the tones produced upon depression of these keys may be varied as desired by register controlling switches such that the notes produced upon depression of the keys may be selectively in the bass, tenor, contralto or soprano registers. As a result, the keyboard may, by the use of such register controlling switches, be made to sound any note within a six octave range. A plurality of groups of register controlling switches are provided, and it is possible further to provide means for simultaneously sounding a plurality of octave related frequencies by each of these groups of register controls.

In general, the instrument comprises a single master oscillator 10 which is connected to control a series of six relaxation oscillators 12 to 17, inclusive, which are connected in cascade and have their frequencies of oscillation stabilized by a signal derived from the master oscillator 10. A plurality of tuning condensers C1 to C12 are provided for tuning the master oscillator, and a plurality of tuning resistors R1 to R11 function to condition the relaxation oscillators to successively divide the master oscillator frequency by a factor of two, thus providing a

series of six octave-related signals at their output terminals 22, 24, 26, 28, 30 and 32.

A small air core mutual inductance 34 serves to suppress sparks in the tuning system, and a small variable condenser C14 serves accurately to tune the range of the instrument. Resistors R12, R14 and R16, together with resistors R1 to R11, constitute a voltage dividing mesh for applying appropriate controlling grid bias to the controlled oscillators. The controlled oscillators 10 to 17 are illustrated merely as blocks for simplifying the wiring diagram. The complete circuits together with a description of their operation appears in the aforesaid patent to Laurens Hammond and John M. Hanert.

As disclosed in said patent, the frequencies of the master and controlled oscillators shift simultaneously upon depression of one of the playing keys (except the "B" keys), which results in connection of the corresponding tuning contacts C1a to A#3a to ground via one of the relay tuning contacts 50a, 51a or 52a. A second sequentially operated key switch C1b to B3b closes to operate relay solenoids 50, 51 or 52 via a circuit comprising interlocking relay contacts 50b, 51b and 52b, this circuit being completed through voltage dropping resistors R18 and R20 to conductors 60, through series relay coil 54, through conductor 62 to terminal 64, and thence through resistor R22 to a terminal +300 v. of the power supply system. A resistor R34 connects terminal 64 to ground. Thus, each of the keys in the lowest octave may operate relays 50 and 54, keys in the middle octaves operate relays 51 and 54, and depression of any key in the highest octave will operate relays 52 and 54. Resistors R24, R26, R28, R30 and R32 serve to suppress sparks which might otherwise be produced incidental to closing the circuits associated with relays 50, 51, 52 and 54, respectively.

It is to be noted that every time a playing key is depressed, the voltage at the junction point 64 of the voltage divider resistors R22 and R34 is reduced in value. This is because the resistance of the relay circuit is put in shunt with the resistor R34. As will be explained hereinafter, this change in potential results in the removal of the cutoff bias from control tubes 66, 68, 70 and 72.

In addition to opening switches 50b, 51b and 52b and closing switches 50a, 51a and 52a, the relays 51 and 52 close switches 50c, 51c and 52c. These switches are provided to operate in the manner disclosed in my co-pending application Serial No. 361,064, filed October 14, 1940. Resistors R36 and R37, which are connected in series with the lower contacts of the switches 50c, 51c and 52c and conductor 66, are provided for the purpose of matching the amplitude of the signal between the highest note (B1) of the lowest octave group, and the lowest note (C2) of the middle octave group, and also between the highest note (B2) of the middle octave group and the lowest note (C3) of the highest octave group. The relays 50, 51 and 52, upon energization, also open switches 50d, 51d and 52d respectively. The upper contacts of 50d, 51d and 52d are connected to a point of fixed direct current potential indicated as +10 v. providing a signal return terminal for unused signal circuits, thus preventing signal flow through spurious paths in unused register control circuits. The movable contacts of switches 50d, 51d and 52d are connected to collector buses 68, 69 and 70 respectively, and each of these buses is connected

to the terminal +10 v. through load resistors R38, R39 and R40 respectively.

Signals from the oscillators 10 and 13 to 17, inclusive, are selectively impressed upon the collector buses 68, 69 and 70 by operation of register control tablets 71, 72, 73 and 74 for effectively shifting the gamut of the keyboard to the "soprano," "contralto," "tenor" and "bass" ranges respectively. Each of the register control tablets 71 to 74 is adapted to operate three switches designated by the tablet reference character followed by the letters a, b and c respectively, as 71a, 71b, 71c. The lower contacts of the switches 71c, 72c, 73c and 74c are connected to the collector bus 68, while similarly, the lower switches of the contacts 71b, 72b, 73b, 74b are connected to the conductor 69, and the lower contacts of the switches 71a, 72a, 73a, 74a are connected to the bus collector 70. The upper contacts of the switches 71a to 74a, 71b to 74b, and 71c to 74c are respectively connected to appropriate output terminals 22, 24, 26, 28, 30 and 32 of the oscillators 10 and 13 to 17, inclusive, through decoupling resistors R42.

By selective operation of the register controls 71 to 74, signals from any three adjacent oscillators, or from any number of groups of three adjacent oscillators, may be conditioned for connection to the signal output conductor 66 upon depression of keys in the three octave groups.

The relays 50, 51 and 52, upon energization, also close switches 50e, 51e and 52e, and open switches 50f, 51f and 52f respectively. The switches 50e, 51e and 52e correspond respectively with the switches 50c, 51c and 52c, while the switches 50f, 51f and 52f correspond respectively to the switches 50d, 51d and 52d. The lower contacts of switches 50e, 51e and 52e are interconnected by resistors R43 and R44, which function in the same manner as resistors R36 and R37 and are connected to the output conductor 76.

The upper contacts of switches 50e, 51e and 52e are connected to collector buses 78, 79 and 80 respectively, these buses also being connected to a constant potential terminal +10 v., through resistors R48, R49 and R50 respectively. The upper contacts 50f, 51f, and 52f serve to connect unused collector buses 78, 79, 80 to the +10 v. terminal, and thus provide a negligible impedance shunt for any possible spurious signal paths. A second set of register control tablets 81, 82, 83 and 84 are each adapted to close three switches to complete signal circuits (similar to those previously described with reference to register controls 71 to 74) to the bus collector 78, 79 and 80. Suitable generator decoupling resistors R42 are provided in each of the tablet operated switch completed circuits.

From the foregoing it will appear that upon depression of a key, for example the key C1 in the lowest octave, the master oscillator 10 will be tuned to the "C" frequency (2093 c. p. s.), and as a result, all of the controlled oscillators 13 to 17 will be caused to oscillate at successively lower octave interval frequencies. The depression of the key C1 will also cause energization of the relays 52 and 54 through a circuit including the winding of the relay 52 (shunted by resistor R28), relay switch 51b, resistances R18 and R20, conductor 60, winding of relay 54 (shunted by resistor R32), and conductor 62 to terminal 64. Terminal 64 is normally at a potential of approximately +165 volts due to the voltage divid-

ing effect of the resistors R22 and R34. Upon operation of the relays, the circuit just described is effectively in parallel with the resistor R34, so that the potential at the terminal 64 will drop considerably to a value such as +50 volts.

Energization of the relay 52 will cause the following to occur:

(1) By opening the switch 52b, energization of the relay 51 is precluded from operating should an additional key be depressed in the middle octave while holding down the aforesaid key C1 in the lower octave.

(2) Closure of the switch 52a results in completion of the tuning circuit between tuning contact C1a and ground.

(3) Assuming that the register control 71 has been operated to close switches 71a, 71b and 71c, closure of the switch 52c will, by connecting the bus collector 70 to the conductor 66, complete a signal circuit from the output terminal 26 of the third controlled oscillator to the conductor 66.

(4) Opening contact 52d will disconnect the bus collector 70 from the terminal +10 v., which latter is effective as a signal return for unwanted signals.

(5) Assuming that the register control 84 has been operated to close its associated switches, closure of the switch 52e will result in connecting the terminal 32 of the sixth controlled oscillator through its decoupling resistor R42 to the bus collector 80, and the latter to the signal conductor 76.

(6) Opening of the switch 52f results in disconnecting the bus collector 80 from the +10 v. terminal which, prior to the opening of the switch, served as a return for the previously unused signal from terminal 32.

From the foregoing, it will be seen that the conductor 76 will thus have a signal of the lowest "C" (65.406 c. p. s.) impressed thereon from the sixth controlled oscillator 17, while the conductor 66 will have a signal of "C" (523.25 c. p. s.) from the second controlled oscillator 13 impressed thereon. While the oscillators are described as generating certain predetermined frequencies, it will be understood that the output signals therefrom are rich in harmonics, as more fully described in my co-pending application Serial No. 274,325, filed May 18, 1939.

The conductor 66 is connected to a preamplifier 88, while the conductor 76 is connected to a similar preamplifier 89. The outputs of the preamplifiers 88 and 89 are selectively fed through mute tubes 90 and 91 respectively, or shunted around these tubes upon closure of switches 92 and 93 respectively. The quality of the tones may be controlled by utilizing various sections of filtering meshes 94, 95, which are connected in the signal circuits. While the meshes 94 and 95 are illustrated as being identical, the values of the elements thereof preferably are made different so that the resonance peaks of one mesh occur at frequencies differing materially from the frequencies of the resonance peaks of the other mesh.

The mute tubes 90 and 91 operate non-linearly to change the quality of the tone signal fed there-through in a manner more fully disclosed and claimed in my co-pending application Serial No. 361,064, filed October 14, 1940. These tubes serve to reduce the harmonic content of the signal in a non-linear manner. The signal, as modified by the tone controlling mesh 94 and by the mute tube (if the latter is connected in the circuit), is supplied to the primary winding of a coupling

transformer T1. Similarly, the signal from the conductor 76 as modified by the filtering mesh 95 and by the mute tube 91 (if the latter is connected in the circuit), is supplied to the coupling transformer T2.

The secondaries of the transformer T1 and T2 are respectively coupled in push-pull arrangement with remote cutoff pentodes 96, 98 and 97, 99. These tubes serve selectively to control the intensity envelopes of the ultimate sound signal produced, insofar as percussion effects are concerned, and for this reason, will hereinafter be referred to as percussion tubes and are so designated in the drawings. These percussion tubes 96 to 99 inclusive preferably are of the remote cutoff type such as the 6K7G type.

The cathodes, such as 99k, are shown connected to ground, and the suppressor grids, such as 99g3, are shown connected to the cathodes. The screen grids, such as 99g2, are maintained at a fixed potential of +125 v. The plates of these tubes, such as 99p, are connected to a point of fixed potential of +300 v. through plate load resistors R48.

When the elements are thus connected, the tubes will function when a signal of suitable amplitude is impressed upon their grids, to produce output signals which may be varied in intensity by adjustment of the control grid bias. Such adjustment is shown as provided in the following manner. The center tap 100 of the secondary of transformer T2 is connected through a resistor R49 to a switch 102, which may be connected either to a terminal -25 v. or -50 v., depending upon the decay characteristics of the tone intensity envelope desired. When the switch 102 is connected to the terminal -25 v., the decay will be less rapid and will finally attain a medium level as represented by a negative 25 volt bias, and the signal will be maintained at this level as long as the key is held down. On the other hand, if the switch 102 is connected to the -50 v. terminal, percussive tones will decay relatively rapidly to substantially zero intensity, since the negative 50 volt bias on the control grids represents substantial cutoff for the type of tube used.

When the percussion effect is not desired, a switch 104 is closed, thus connecting the center tap 100 of the transformer T2 through an attack resistor R50 and an anti-spark resistor R51 to a terminal -10 v. of the power supply system. Under these circumstances, the resistors R50 and R51, together, are of low value with respect to that of resistor R49, so that when the switch 104 is closed, the potential on the grids will be maintained at a value approaching -10 volts. Thus, under these conditions, the percussion tubes 97 and 99 operate merely as repeaters and do not affect the intensity envelopes of the transmitted tone signals.

It will be recalled that when any of the playing keys is depressed, the relay 54 is energized. This relay, among other functions, controls the operation of a single-pole, double-throw switch, the movable switch arm 106 of which is connected to ground through an envelope controlling condenser C16. The switch arm 106 normally engages a contact 108, which is connected through the anti-spark resistor R51 to a constant direct current potential source indicated as -10 v., thus normally maintaining a charge of -10 volts across the condenser C16.

Upon energization of the relay 54, the movable switch arm 106 disengages contact 108 and en-

gages contact 110, and thereby connects the ungrounded terminal of the condenser C16 to the center tap 100 of the secondary of transformer T2 through the attack resistor R50. The rate at which the charge from the condenser C16 is effective to change the potential on the center tap 100 is determined by the relative values of the condenser C16 and resistor R50, as well as by a condenser C18, which latter condenser is connected between the tap 100 and ground. It will be understood that since the grids of the percussion tubes draw negligible current, the determination of the grid bias may be accomplished by small condensers and high value resistors, because the voltages present, rather than the current flow, are of primary importance in determining the gain of the percussion tubes.

The relay 54 also operates a switch arm 106a which is normally in engagement with contact 108a. Upon energization of the relay, the switch arm 106a breaks contact with 108a and completes a circuit with a contact 110a. The contact 108a is connected through an anti-spark resistor R51a to the terminal -10 v., while the contact 110a is connected to the center tap 100a of the transformer T1, through an attack resistor R50a.

The contacts 108a and 110a are adapted to be connected together by a manually operable switch 104a. It will be apparent that the switch 106a and its associated circuits are similar to switch 106 and its associated circuits respectively and control the percussion tubes 96 and 98 in the same manner that the switch 106 and its associated switch circuits control the percussion tubes 97 and 99 as above described. The secondaries of transformers T3 and T4 are respectively connected to the grids of tubes 70, 72 and 66, 68 which serve as control tubes determining the over-all volume of the outputs of the two systems, and for affecting the character of the attack and terminal decay portions of the intensity envelopes of the transmitted tones.

By virtue of the fact the tubes 96 and 98, as well as the tubes 97 and 99, are connected in push-pull, any transients in their plate circuits incident to the initiation and cessation of plate current, will be substantially cancelled. Also, the push-pull arrangement results in the cancellation of undesirable even order harmonic distortion terms.

The gain of the control tubes 70, 72 and 66, 68 are controlled by varying their grid bias, and for this reason, these tubes are preferably of the remote cutoff type such as the 6K7G. The volume or gain control may be of any suitable construction such as shown in Fig. 2, and comprising a mesh 114. This mesh includes a plurality of resistors R60 which may be of graded values and are adapted to be connected in parallel successively upon actuation of a manually or pedally controlled grounded contactor 115. The maximum volume, which occurs when all of the resistors R60 are out of the circuit, is controlled by an adjustable resistor R61, the resistor R61 being connected between ground and resistor R63. A resistor R63 provides a lower volume limiting means for the mesh 114, and is connected between a terminal 118 and the ungrounded terminal of the adjustable resistor R61. It will be noted that one terminal of each of the resistors R60 is likewise connected to the terminal 118. The terminal 118 is connected through a decoupling resistor R64 to the center tap 120 of the secondary of transformer T4, and

similarly, is connected through a decoupling resistor R64a to the center tap 120a of the secondary of transformer T3.

A condenser C20 is connected between the center tap 120 and ground, and a similar condenser C20a is connected between the center tap 120a and ground. The condensers C20 and C20a serve as a means for preventing abrupt changes in voltages at the center taps 120 and 120a respectively, upon operation of the volume control contactor 115, so that variations in volume of the output will be correspondingly gradual.

It is to be noted that the volume control mesh 114 functions merely to determine the voltage at the taps 120 and 120a, and that there is no appreciable current flow from the terminal 118 to these center taps. Thus, the volume control mesh 114 may be utilized to control any number of output channels similar to the two channels shown.

When it is desired to impart a slow attack to simulate the intensity envelope of a bowed string tone, the switch 122, or the corresponding switch 122a, is closed to connect the center tap 120 (or 120a) to the cathodes of tubes 66, 68 (or 70, 72), through a condenser C22 (or C22a). The condensers C22 and C22a affect the rate at which the cathode-grid bias on tubes 66, 68, 70, 72 changes upon changes in potential at the terminal 64 due to completion of a circuit through one of the relays 50, 51 or 52 and 54. In a somewhat similar manner, a large condenser C24 serves to render the decay envelope gradual upon release of any key. A detailed description of the manner in which the condensers C22 and C24 operate to control the characteristics of the intensity envelopes is disclosed in the aforesaid Patent No. 2,233,258.

The outputs of the tubes 66, 68 and 70, 72 are resistance-capacity coupled to suitable power amplifiers 126 and 126a, the power amplifiers being transformer-coupled to the voice coils of speakers 128 and 128a. In order to provide for variation in the outputs of the two channels, it is desirable to provide adjustable resistors R70 and R70a in the voice coil circuits of the speakers 128, 128a. In this way, the relative volumes of the two systems may be varied, and such variation will be substantially uniform throughout different settings of the volume control mesh 114.

The speakers 128 and 128a are preferably equipped with acoustic frequency modulators 130, 130a which may be of any suitable construction. These modulators may be of the general type disclosed in the co-pending application of A. W. Wells, Serial No. 404,099, filed July 26, 1941, which comprise a rotating sound deflecting surface operating to modulate frequencies at a vibrato rate due in part to the Doppler effect. The acoustic frequency modulators 130 and 130a are preferably each provided with individual controls 132 and 132a so that they may be selectively utilized by the player.

In operation, the musician depresses the keys C1 to B3 in the usual manner of a melody instrument, but instead of producing but a single tone, by suitably adjusting the various controls and switches, the musician has available the possibility of producing a large variety of tonal effects, not only as to a single melody tone but as to an accompaniment tone which may have characteristics of tone quality and tone envelope differing greatly from that of the melody tone. For example, if it is desired to play a musical selection in which the leading melody part pref-

erably consists of a rich full organ background, together with a percussive bell-like tone for accentuating the notes, the controls may be set as follows:

In order to produce the "full organ" effect, the register controls 72, 73 and 74 will be operated to close their respective switches. The switch 92 will be closed and the tone controlling mesh 94 adjusted for approximately uniform frequency response. The switch 104a will be closed so as to remove the percussion effect. The switch 122a will be closed so as to impart a slow organ-like attack to the tone. The control 132a will be operated to produce a frequency modulating vibrato effect in the output of the speaker 128a.

For the production of the bell-like percussive tone, the register control 81 will be operated to close its associated switches. Mute switch 93 will be opened to remove undesirable high order overtones, and the tone controlling mesh 95 will be appropriately adjusted to emphasize the low and high frequencies with a frequency response diminution for middle range frequencies. Switch 102 will be moved to contact the terminal -50 v., and switch 104 will be opened, thus producing a decided percussion effect whenever a key is depressed. Switch 122 is left open so that the tonal attack will be rapid, the control 132 for the frequency modulating vibrato will be turned to its "Off" position, and volume control resistance R70 will be suitably adjusted to match the volume of the bell tone with respect to the volume of the organ tone.

Since the speakers are spatially separated, the over-all musical effect will be that of two separate instruments playing simultaneously, one instrument simulating the organ and the other, bells. The tones emanating from the two speakers will be of pitches differing by two octaves under the conditions set forth.

To summarize, the following variations may be selectively employed to vary the tonal output of the two speaker channels:

(1) The pitch may be adjusted at will, in four octaves, by operation of the register controls 71 to 74 and 81 to 84. Also, these controls may be operated separately, or in combination to produce selective octave coupler effects.

(2) By selective operation of the switches 92 and 93, the harmonic development of the tones may be altered to a pronounced extent, the tonal differences corresponding generally to the differences between the sounds of two instruments of different orchestral tone families, such, for example, as the differences between reed and string tones.

(3) By adjustment of the tone control meshes 94, 95, the player may selectively determine the resonances and the general brightness or mellowness of the tones.

(4) By adjustment of the switches 122, 122a, 102 and 102a together with 104 and 104a, the player may selectively determine whether the tone shall be of decided percussion, of moderate percussion, or of slow attack organ-like intensity envelopes. A slow-attack slow-decay intensity envelope may also be produced by closing switch 122, opening switch 104 and setting switch arm 102 to the -50 v. terminal.

(5) By selective adjustment of the adjustable resistors R70 and R702, the relative volumes of the outputs of the two channels may be controlled.

(6) By selective operation of the controls 132, 132a, the musician may selectively impart a

vibrato effect to the outputs of either or both channels.

The keyboard of the instrument may be attached to a piano in the manner disclosed in said Patent No. 2,233,258, may be controlled electrically from the keyboard of a pipe organ or similar instrument, or may be set up for operation as a separate orchestral instrument. By increasing the number of output channels to three or more, the output of the instrument may be made more complex, enabling the musician to obtain an added variety of interesting and beautiful musical effects.

In order to add channels, it is necessary merely to provide additional sets of contacts for the relays 50, 52 and 54, and to provide additional sets of register controls such as the controls 71 to 74 and 81 to 84. In addition, the relay 54 would be provided with an additional switch and associated network similar to the switches 106 and 106a and their associated circuits. The volume control mechanism apparatus 114 could be common to all of the output channels, or, if desired, two similar volume control devices could be utilized, each controlling the output of one or more of the channels.

For the best musical results, it is usually desirable to provide a separate speaker for each channel, and to separate the speakers in space so as to provide the acoustical perspective associated with orchestral music. However, it may be desirable, for the purpose of reducing the cost of the instrument and possibly for other reasons, to mix the outputs of the control tubes of the various channels, and supply to a common power amplifier an electroacoustic translating system. Such mixing of the outputs of several channels may be accomplished without seriously limiting the flexibility of the instrument when more than two channels are employed. In any event, whenever outputs of several channels are mixed, some means will be provided to obtain the adjustment by the variable resistors R70 and R70a, to enable the musician to vary the relative amplitudes of the signals supplied by the several channels connected to the common power amplifier and electroacoustic translating system. When but two channels are employed with a common power amplifier and speaker system, the generating system preferably is provided with vibrato means in a manner similar to that shown in the aforesaid Patent No. 2,233,258.

When the instrument has one of its channels adjusted for percussion tones while the other channel is adjusted for sustained organ-like tones, the player has available the possibility of producing new and unusual musical effects dependent upon the manner in which the keys are depressed. For example, if the keys are depressed in a "detached" manner, that is, if the first key is released prior to the depression of a second key, the percussive note will be produced by the percussive channel, and the sustained note by the channel adjusted for such sustained tones. On the other hand, if the keys are played in a legato manner, that is, with the second key depressed before the first is released, substantially no signal for the second depressed key will be transmitted through the channel adjusted for the percussive tones, since its condenser such as C16 or C16a will have been discharged while the first key was held down. Thus, the player may, by playing legato, cause all except the first key depressed to cause production only of the sustained tone, but may, at any time a musical ac-

cent is desired, release all of the keys for an instant. In this case, upon the subsequent depression of a key, both the percussive tone channel and the sustained tone channel will be effective to transmit their tone signals, producing a very desirable musical accent. In playing a long run of notes which extends from one of the octave groups of keys into another octave group of keys, a percussive note will sound upon the depression of the first key depressed in each octave group of notes because of the arrangement of the circuits for the relays 50, 51, 52 and 54. However, for short runs within the range of one octave group of keys, the above described percussive or non-percussive control of the tones by the manner of key depression may be attained.

When it is desired to produce successive percussive tones, it is necessary merely to depress the keys in a detached or non-legato manner.

From the foregoing description, it will be apparent that the invention is not limited to the use of the particular frequency generating means diagrammatically illustrated, but that the broader principles of the invention may be applied in an instrument utilizing a single oscillator generator such as shown, for example, in my copending application Serial No. 361,065, filed October 14, 1940, wherein the signal output of a single generator has its intensity envelope controlled by the signal itself rather than by the keys.

While I have shown and described particular embodiments of my invention, it will be apparent to those skilled in the art that numerous variations and modifications thereof may be made without departing from the more fundamental principles of the invention. I therefore desire, by the following claims, to include within the scope of my invention, all such variations and modifications whereby substantially the results of my invention may be obtained through the use of substantially the same or equivalent means.

I claim:

1. In an electrical musical instrument, a variable frequency generating apparatus, a keyboard having a plurality of keys, means controlled by said keys for varying the frequency of operation of said generating apparatus, a plurality of separate output channels for the signals produced by said generating apparatus, separate intensity envelope determining means associated with each of said channels, means controlled by said keys for initiating the operation of said envelope determining means, a signal amplitude controlling means in each of said channels, means under the control of said keys for causing operation of said amplitude controlling means, and a volume control circuit common to all of said channels and operable to affect the amplitude controlling means thereof.

2. In an electrical musical instrument, the combination of a variable frequency oscillator, keyboard means for controlling the frequency of said oscillator, a plurality of output channels capable of connection to said oscillator to receive signals therefrom, means in each of said output channels selectively to control the intensity envelope of the transmitted signals, and means to translate into sound the signals transmitted by said channels.

3. The combination set forth in claim 2 in which said intensity envelope controlling means of all of said channels have their operation initiated by circuits under the control of said keys.

4. In an electrical musical instrument, the

combination of a set of electrical impulse generators operating at octave interval frequencies, playing keys, means controlled thereby for varying the frequencies of operation of said generators, a plurality of output channels, selective means capable of being rendered effective upon the depression of a single one of said playing keys for collecting impulses from a plurality of said generators into each of said output channels, and means in at least one of said channels for selectively altering the harmonic content of the impulses transmitted thereby.

5. The combination set forth in claim 4 in which each of said output channels includes a tone intensity envelope controlling means, and means energized by operation of said keys for controlling the operation of all of said intensity envelope controlling means.

6. In an electrical musical instrument, the combination of an electrical impulse generator, key controlled means for varying the frequency of operation of said generator, a plurality of output channels including electroacoustic translating means, selective means for transmitting impulses from said generator into said output channels, and means in at least one of said channels for selectively introducing a vibrato effect in the tones produced by its electroacoustic translating means.

7. In an electrical musical instrument, the combination of an electrical impulse generator, key controlled means for varying the frequency of operation of said generator, a plurality of output channels, selective means for transmitting impulses from said generator into one or more of said output channels, and means in at least one of said channels for selectively altering the harmonic content of the impulses transmitted thereby.

8. In an electrical musical instrument, a variable frequency generator of electrical musical tone signals, a key for controlling the frequency of operation of said generator, a plurality of output channels for receiving signals from said generator, each of said output channels including an electroacoustic translating means, and selectively operable means associated with each of said electroacoustic translating means to introduce an acoustic vibrato in the output thereof.

9. In an electrical musical instrument, the combination of a variable frequency generator, a plurality of separate signal transmission control means, selectively operable switches to connect said control means to said generator, a terminal on each of said control means whose D. C. potential has an effect upon the acoustic envelope of the signal transmitted by said control means, means connecting all of said terminals together, a keyboard, and circuits completed by operation of its keys for determining the frequency of said generator and for connecting said terminals to a source of D. C. potential for changing the potential of said terminals, thereby to cause said plurality of control means to transmit signals of desired frequency from said generator.

10. An electrical musical tone signal generating system, including a plurality of variable frequency generators interlocked to operate at octave interval frequencies and having a plurality of separate output channels, keys for controlling the transmission of signals from said generating system to said output channels and for determining the frequency of operation of

said generators, means associated with each of said channels for determining the rate of attack of the tone signals transmitted thereby, and a circuit completed upon operation of any one of said keys to initiate the operation of said rate of attack determining means.

11. In an electrical musical instrument, variable frequency signal generating means, a plurality of output channels for transmitting the signal produced by said means, a separate circuit associated with each of said channels for determining the rate of amplitude increase of the signals transmitted through said channels, a keyboard having a plurality of keys, means controlled by said keys for initiating the operation of said amplitude increasing circuits, an output volume control circuit associated with each of said channels, and electrical means common to all of said channels for controlling said volume control circuits.

12. In an electrical musical instrument, the combination of interlocked variable frequency generators of musical signals operating at octave interval frequencies, a plurality of output channels for receiving signals from said generators, key operated means determining the frequency of operation of said generators and for controlling the transmission of signals from said generators to said channels, a terminal in each of said channels, the direct current potential of the terminal determining the amplitude of the signal output of the channel, and variable direct current potential means connected to said terminals in all of said channels, thereby simultaneously to vary the amplitude of the signals transmitted by said channels.

13. In an electrical musical instrument having a multi-octave keyboard and a signal generating system tunable to any one of the semitone frequencies and its octaves, a cut-out relay for each octave of the keyboard, circuits controlled by said relays to render ineffective the remaining relays upon operation of one of them, a plurality of output circuits for signals produced by said generating system, each output circuit having tone intensity envelope determining elements, and a relay connected to be operated upon operation of any one of said cut-out relays and effective to control said envelope determining elements.

14. In an electrical musical instrument having a plurality of playing keys, a variable frequency signal generating system having its frequency of operation controlled by said keys, a plurality of signal transmission circuits, means forming a part of each of said circuits for determining the intensity envelopes of tone signals transmitted thereby, and circuits under the control of said keys for causing said generating system to supply tone signals to said transmitting systems and to control said envelope intensity determining means.

15. In an electrical musical instrument of the melody type, the combination of a keyboard comprising a plurality of keys, a variable frequency signal generating means having its frequency of operation controlled by said keys, a transmission

system for receiving signals from said generating means and having two terminals the potentials of which determine the amplitude of the output signal thereof, switches operable by said keys completing a circuit determining the potential of one of said terminals, and relay means energized by current flow through said circuit for determining the potential of the other of said terminals.

16. The combination set forth in claim 15 in which said relay means includes a resistance and a capacity for controlling the rate of change of the potential on its associated terminal.

17. In an electrical musical instrument, the combination of a variable frequency oscillator, a system of octave interval oscillators controlled thereby, a plurality of separately adjustable output channels, register control devices for selectively connecting one or more of said oscillators to either or both of said output channels, a plurality of playing keys, means controlled by said keys for determining the frequencies of oscillation of said oscillators, means controlling the signal amplitude transmission characteristics of said output channels, and a circuit completed upon operation of any one of said keys to initiate the operation of said last-named means.

18. In an electrical musical instrument, the combination of variable frequency means for generating musical signals, a plurality of output channels for receiving signals from said generating means, a playing key, means operated by said key determining the frequency of said generating means and controlling the transmission of signals therefrom to said channels, a non-linear distorting means in each of said output channels, switches for selectively rendering said distorting means operative, and means controlled by said keys for controlling the amplitude of the signals transmitted by said output channels.

19. In an electrical musical instrument, a variable frequency generator of electrical musical signals, a key for controlling the frequency of operation of said generator, a plurality of output channels for receiving signals from said generator, an adjustable intensity envelope determining means in each of the output channels, and means controlled by said key to initiate operation of said last-named means.

20. In an electrical musical instrument, the combination of a plurality of variable frequency generators of harmonically related frequencies, a plurality of playing keys, means controlled by said keys for determining the frequency of operation of all of said generators, a plurality of separate signal transmission channels, register controls for selecting any or all of said generators for connection to any or all of said channels, and a fixed potential control device in at least one of said channels for altering the intensity envelopes of the tone signals transmitted thereby, whereby the intensity envelopes of tone signals transmitted through said channels may differ from one another.

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