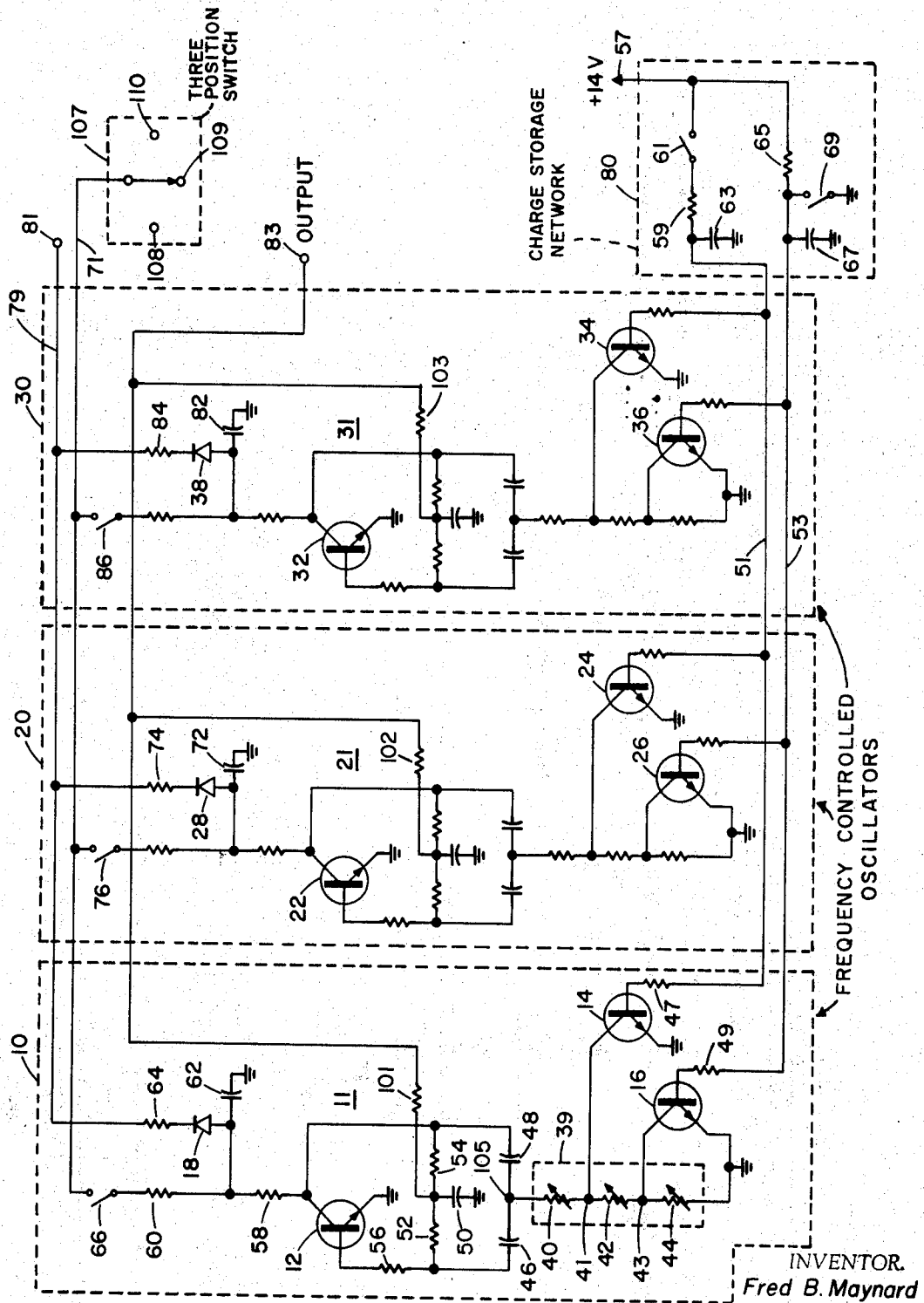


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F. B. MAYNARD
TRANSISTOR FREQUENCY GLIDE CONTROL FOR MUSICAL
TWIN-T OSCILLATOR TONE GENERATORS
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3,535,430



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3,535,430

**TRANSISTOR FREQUENCY GLIDE CONTROL
FOR MUSICAL TWIN-T OSCILLATOR TONE
GENERATORS****Fred B. Maynard, Phoenix, Ariz., assignor to Motorola,
Inc., Franklin Park, Ill., a corporation of Illinois****Filed Jan. 23, 1967, Ser. No. 610,924****Int. Cl. H03b 5/26; H10h 1/02, 5/04****U.S. Cl. 84-1.08****5 Claims****ABSTRACT OF THE DISCLOSURE**

Electronic tone oscillator and associated frequency control circuitry adapted for use in an electronic organ or other similar electrical musical equipment. Variable impedance transistors are connected to the feedback networks of individual tone oscillators within the electronic circuitry, and selected biasing circuits are connected to these transistors for either rapidly or gradually changing the respective transistor impedances. The effect of such biasing operation is to produce either frequency key shifts or glides in the tone frequency of the musical equipment within which the oscillators are located.

SPECIFICATION

This invention relates generally to electronic circuitry adapted for use in electronic musical instruments and more particularly to tone oscillator and associated frequency control circuitry for providing key shifts and glides in the frequency of tone oscillators.

BACKGROUND OF THE INVENTION

Frequency key shifts and gliding tone effects in electronic musical tone generators are well known, and these two effects can be obtained in a number of musical instruments at the will of the player. Many standard musical instruments provide the gliding tone function and among these instruments are included the Hawaiian guitar, the slide trombone, the violin; and the whole character of Hawaiian music, for example, depends almost entirely on the gliding tone function. A player of a Hawaiian guitar may, for example, desire to play a melody note C and in accordance with a particular musical requirement he may very well prefer to approach this note from some lower note by sliding quickly up to C while the sound producing element such as a string is still vibrating. In a like manner, down slides or glides as they are sometimes called are also used.

The frequency key shift features is also well known in the musical arts, and some pianos for example have been built with a mechanical shift of the string hammers in order to achieve the key shift function.

The use of electronic tone generators and associated electrical systems for selectively energizing these tone generators in order to produce key shifting, gliding and other variations in tone frequencies are also well known in the art of electrical music instrumentation. One system of this type is disclosed in Pat. No. 3,205,294 issued to Fred B. Maynard and assigned to the present assignee. In the operation of electronic musical instruments having tone generators which may be selectively energized, there are at least two known techniques for shifting the tone frequency of a tone generator in order to produce an audi-

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ble key shift or glide effect in the sound of the musical instrument. One such technique involves shifting the frequency of the tone oscillator by applying a so-called destabilizing DC voltage thereto. This destabilizing voltage produces a frequency shift or vibrato effect within the tone oscillator circuit. However, it has been observed that although the application of a destabilizing voltage will cause a frequency shift within the oscillator, this technique of destabilizing a tone oscillator lacks the positive control necessary to insure that close and reliable tolerances in oscillator frequency shift from oscillator to oscillator in a given musical instrument will always be met.

Another disadvantage of using the voltage destabilized oscillators is that it is extremely difficult to achieve both up and down frequency key shifts and glides within a particular electronic musical system without making a sensitive input impedance adjustment for the oscillators prior to making successive frequency shifts and glides. In the voltage destabilized system, it has been found that by carefully adjusting the voltage input conditions (which are different from oscillator to oscillator) it is possible to obtain a very good up glide of one semitone. However, for the same system it is impossible to subsequently shift down one semitone merely by making a change in the voltage level applied to a particular tone oscillator.

Another technique which has been used to vary the frequency of tone oscillators in a musical instrument involves the opening and closing of mechanical switches in order to selectively energize or deenergize a relatively large number of oscillators in a given instrument. However, since it is normally desired to simultaneously control the conductivity of a relatively large number of oscillators in response to a single movement (i.e., the pressing of a key in an electronic organ) mechanical switches are costly, relatively slow in operation, and are subject generally to problems of wear and failure which are inherent in all mechanical switching systems.

SUMMARY OF THE INVENTION

An object of this invention is to provide improved electronic circuitry which may be positively controlled by electronic means in order to vary the frequency of tone generators in a musical instrument.

Another object of this invention is to provide improved electronic circuitry which is operative to produce frequency key shift and glide effects for tone oscillators in an electronic musical instrument, and which circuitry is of simple construction and may be built at a relatively low cost.

Another object of this invention is to provide improved electronic circuitry of the type generally described above which does not rely upon mechanical switching systems or tone oscillator destabilizing schemes in order to change the frequency of a tone oscillator in a musical instrument.

It is a further object of this invention to provide improved electronic circuitry of the type generally described above which is operative to produce both up and down frequency glides and frequency key shifts using a minimum number of electronic circuit components.

The present invention features electronic frequency control circuitry which may be connected to a plurality of tone oscillators in an electronic musical instrument, and this frequency control circuitry is operative to provide two-way (up or down) frequency key shift and glide

effects for the tone oscillators as they are selectively energized by the player of the particular musical instrument.

Another feature of this invention is the provision of a resistive impedance network connected to the feedback circuit in each of the tone oscillators. One or more variable impedance transistors are connected at various points on the resistive impedance network and are adapted to undergo rapid or gradual impedance variations in order to rapidly or gradually shunt out preselected portions of the resistive impedance network. A gradual or rapid removal of insertion of preselected portions of the resistive impedance network will gradually or rapidly change the operating tone frequency of a particular tone oscillator.

A further feature of this invention is the provision of charge storage circuits within the tone oscillator frequency control circuitry, and these circuits may be selectively energized and deenergized in order to vary the impedance of the variable impedance transistors at a gradual or rapid rate in order to obtain a frequency glide or shift effect respectively from a particular tone oscillator. Such a gradual or rapid change in oscillator frequency is made possible by the fact that the variable impedance transistors are coupled to the respective oscillator circuits through the respective resistance impedance networks, and there is no collector voltage supply for these transistors. Thus, when a variable bias voltage is available at the control electrode of the variable impedance transistors, it is possible to change the impedance thereof from a value of megaohms down to R_{SAT} , the saturation resistance of the variable impedance transistors and which is commonly in the order of 20 to 50 ohms. These variable impedance transistors have an active resistance region in which the transistor impedance is controlled in accordance with the bias level applied thereto.

Briefly described, the electronic circuitry of the present invention includes a plurality of tone oscillators which may be selectively energized by the player of a particular electronic musical instrument in order to produce selected audible tone frequencies. The above electronic circuitry further includes specific frequency control circuits which are connected respectively to each of a plurality of oscillators within an electronic musical instrument. These frequency control circuits each include a resistive impedance network connected within the feedback circuit of each tone oscillator, and one or more variable impedance transistors are connected at preselected points on each resistive impedance network in order to effectively shunt out preselected portions of the resistive impedance networks. This effective shunting out and subsequent reinserting of preselected portions of the resistive impedance networks is controlled by charge storage circuits within the frequency control circuitry, and these charge storage circuits are connected between a source of supply voltage and individual ones of the variable impedance transistors. As an electrical charge is stored and released from the charge storage circuits, the bias voltages which are applied to the variable impedance transistors may be increased and decreased, either rapidly or gradually, in order to provide a rapid or gradual shunting out or subsequent reinserting of preselected portions of the resistive impedance networks. The frequency control circuitry described above enables a two-way (up or down) frequency key shift or glide effect to be obtained from the individual tone oscillators which are used in an electronic musical instrument.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is illustrated in a single schematic circuit embodiment of the tone oscillator circuitry and associated frequency control circuitry.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Identification of circuit components

Referring in detail to the drawing, there is shown a

schematic diagram of one embodiment of an electronic organ tone oscillator and associated frequency control circuitry which has been constructed in accordance with the teachings of this invention. This circuitry shows a portion of an electronic organ including three frequency controlled oscillator sections 10, 20 and 30. These sections include respectively three twin-T oscillators 11, 21 and 31 which are connected in parallel, and in a complete organ there may be many of these sections. However, it should be emphasized at the outset that this invention may be practiced in various musical equipment wherein frequency controlled tone oscillators are utilized other than electronic organs. Each of the sections 10, 20 and 30, including the respective twin-T oscillators 11, 21 and 31 are identical in circuit construction, and therefore the description of the sole figure will be made primarily with reference to the section 10 and the oscillator and associated frequency control circuitry shown therein.

The section 10 of the electronic organ circuitry includes a twin-T type resistance-capacitance oscillator circuit 11 having an NPN transistor 12 which is connected between a source of collector potential via switch 66 and ground potential. The NPN transistor 12 has a relatively high current gain (H_{fe} or beta) of 250 or over. A pair of serially connected collector load resistors 58 and 60 are connected between the collector of transistor 12 and the energizing or key switch 66, and these resistors as well as other resistors which will be identified below may be selected so that they have the typical component values which are given in the table at the end of the specification. The twin-T feedback network of the oscillator 11 further includes a low pass T section consisting of serially connected resistors 52 and 54 and shunt capacitor 50 which is connected between the midpoint of resistors 52 and 54 and ground. A high pass T section includes serially connected capacitors 46 and 48 and a resistive impedance network consisting of three serially connected resistors 40, 42 and 44.

The twin-T network identified above is a phase shift feedback loop connected between the collector and base of transistor 12, and this feedback loop is necessary to provide positive feedback in order to sustain oscillations for the twin-T oscillator 11 as it is well known in the art. Resistors 52 and 54 provide a DC current feedback path between the base and collector of transistor 12, and the capacitors 46 and 48 typically have identical values whereas the shunt capacitor 50 is normally twice that of either capacitor 46 or 48. By selecting various capacitor values for capacitors 46, 48 and 50, the twin-T oscillator 11 may be designed to oscillate at any one of a very wide range of frequencies. In a typical musical instrument, the frequency range would preferably be from approximately 32 cycles per second to some value in excess of approximately 4000 cycles per second. This bandwidth represents a seven octave musical range, and since there are twelve musical intervals in each octave, 85 or more of these twin-T oscillators may be required in some musical instruments in which the present invention is used. However, most electronic organs use a frequency range which is somewhat less extended than the frequency range described above.

The twin-T oscillator circuits 21 and 31 oscillate in a manner identical to the oscillation of the twin-T circuit 11, and for some musical equipment it may be desirable to connect 100 or more of these oscillators in parallel as shown in the drawing in order to produce the desired number of musical tones or combination of musical tones. However, the selection of a particular number of oscillators and the selection of operating frequencies frequency shifts and frequency glides may be made by those skilled in the art and having a knowledge of the particular musical instrument in which the frequency controlled oscillators are to be used.

The frequency control portion of the electronic organ circuitry in the drawing includes as an integral portion

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thereof the resistive impedance network 39 consisting of serially connected resistors 40, 42 and 44. The effective resistance of this resistive impedance network 39 is controlled in such a manner that the frequency of the twin-T oscillator 11 may be shifted or glided up or down the frequency scale. The frequency control portion of the electronic organ circuitry further includes variable impedance transistors 14 and 16 which are connected between intermediate points 41 and 43 of the resistive impedance network and ground potential. The variable impedance transistors 14 and 16 are further connected via series current limiting resistors 47 and 49 to the respective voltage buses 51 and 53. The transistors 14 and 16 in section 10 of the schematic diagram find their respective transistor counterparts 24 and 26 in section 20 and counterparts 34 and 36 in section 30 of the electronic organ circuitry.

The frequency control portion of the electronic organ circuitry further includes a charge storage network 80 which is connected to the voltage buses 51 and 53 and energized via a voltage supply terminal 57. The charge storage network 80 includes a first series resistance 59 which is connected between the current limiting resistor 47 and a switch 61. A first charge storage means in the form of capacitor 63 is connected between the bus 51 and ground potential, and upon the closure of switch 61 the capacitor 63 charges from the voltage supply terminal 57 through the first series resistance 59. The charge storage network 80 further includes a second series resistance 65 which is connected between the voltage supply terminal 57 and the current limiting resistor 49, and a second charge storage means in the form of a capacitor 67 is connected between voltage bus 53 and ground potential. A switch 69 is connected in parallel with capacitor 67 and is used for purposes to be described in the following description of the operation of the tone oscillator and frequency control circuitry identified above.

Operation

Any one, two or all three of the twin-T oscillators 11, 21 and 31 may be energized by closing the switches 66, 76 and 86 respectively which connect the collector circuits of NPN transistors 12, 22 and 32 to the voltage bus 71. A second voltage bus 79 connects each of the resistors 64, 74 and 84 of the oscillator circuits to a voltage supply terminal 81, and an output signal bus 83 is connected to the parallel connected resistors 101, 102 and 103.

A three position switch 107 having contacts 108, 109 and 110 provides a selective voltage supply connection for the bus 71. Such a selective voltage supply connection is frequently desired in musical instruments in which keying level designations such as medium loud, loud and very loud are desired. For example, in the electronic organ circuit which applicant actually built and successfully tested, voltages of +7 volts, +14 volts, and +21 volts were available at terminals 108, 109 and 110, respectively in order to enable operation of the oscillator circuits at the medium loud, loud and very loud levels.

Assume for example that switches 61 and 69 in the charge storage network 80 are both open; assume that key switches 76 and 86 are open and that the key switch 66 is closed to energize the twin-T oscillator 11. The frequency of the oscillator 11 is dependent upon the values of resistors 40, 42 and 44 in the resistive impedance network previously described, and the oscillator frequency of the twin-T oscillator 11 will increase as the effective resistance between midpoint 105 of capacitors 46 and 48 and ground potential is decreased. Such a decrease in resistance in the high pass T section of the oscillator feedback circuit shifts the null balance point of the oscillator and produces a corresponding increase

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in the frequency of oscillation of oscillator 11. Conversely, when the shunt resistance of the high pass T section of the oscillator 11 between point 105 and ground is increased, the frequency of oscillator 11 will be decreased. Prior to removing any of the shunt resistance in the high pass T section (network 39) of oscillator 11, the oscillator may for example be oscillating at a middle C frequency of 261.63 cycles per second.

Assume now that it is desired to produce a rapid shift up (increase) in the frequency of oscillations of the oscillator 11 in order to switch from the middle C tone upward in scale to an E tone of approximately 329.63 cycles per second. If the value of the first shunt capacitance 63 is selected to be sufficiently small and the value of resistor 59 is also sufficiently small, then the capacitor 63 will be charged rather rapidly when the first switch 61 is closed. The rapid charging of capacitor 63 will rapidly increase bias potential on the variable impedance transistor 14 and establish a relatively low impedance path between point 41 and ground. Since transistor 14 (as well as transistor 16) has no collector supply voltage, this transistor exhibits a saturation resistance R_{SAT} value which is between 20 and 50 ohms, a value which is sufficiently low to effectively short out resistors 42 and 44 in the resistive impedance network 39.

As transistor 14 is rapidly biased through its active resistance region to a low impedance value of R_{SAT} , the frequency of oscillations of the twin-T oscillator 11 will be rapidly increased since the resistance between point 41 and ground is effectively removed from the oscillator circuit. This switching action produces an upward key shift in frequency of the oscillator 11.

Suppose now that it is desired to provide a down glide in tone frequency which is much less rapid than the upward frequency shift previously described. If switch 61 is now opened, the charge on capacitor 63 will gradually discharge through transistor 14 and remove the positive bias on this transistor. As the bias on transistor 14 is gradually removed, series resistors 42 and 44 are reinserted in the high pass T section of the oscillator 11, causing the frequency thereof to decrease and produce a down glide in the audible tone from a loud speaker or other like means coupled to the output bus 83.

Assume now that it is desired to first produce a down shift in frequency of the oscillator 11 and thereafter produce an upward glide effect. Previously, switch 69 has been open and the capacitor 67 was charged through resistor 65 to the fourteen volt supply voltage at terminal 57. With capacitor 67 charged up to the supply potential, the variable impedance transistor 16 is biased via current limiting resistor 49 to its saturation resistance R_{SAT} , and the resistor 44 is virtually shorted out. Under this condition, resistors 40 and 42 control the frequency of the oscillator 11 as long as the key switch 66 is closed. Switch 66 may, for example, be controlled directly by one of the C keys on an organ keyboard, and the oscillator 11 will produce a C oscillation frequency as long as the variable impedance transistor 16 is biased to R_{SAT} .

Now suppose that the upglide switch 69 is closed, rapidly discharging the capacitor 67 and removing the bias voltage from the base of the variable impedance transistor 16. This latter switching action inserts resistor 44 into the high pass T bridge section of the oscillator 11, resulting in a rapid down shift in frequency to a lower pitch, for example, to a B key from a higher pitched C key. When the switch 69 is closed, line 53 is placed at ground potential and the fourteen volt supply voltage applied at terminal 57 is shorted to ground through the series resistor 65. The resistor 65 is selected sufficiently large in value (approximately ten kilohms) so that power dissipation therein is negligible.

If it is now desired to produce an upglide in frequency of the oscillator 11, switch 69 will be opened and current from the fourteen volt supply voltage will flow through resistor 65 and begin to charge up capacitor 67. As the

capacitor 67 charges, the variable impedance transistor 16 is biased through its active resistance region at a gradual rate until it reaches its R_{SAT} condition. During this time, the frequency of oscillator 11 may rise, for example, from the B pitch to the C pitch at which it was previously oscillating, resulting in a one semitone upglide.

The particular bias connections for the first and second variable impedance transistors 14 and 16, and the particular resistive impedance network 39 is given only by way of illustration. The frequency glide or shift of the oscillator 11 may be made larger or smaller than described above by selecting the resistors 40, 42 and 44 with larger or smaller resistance values or by changing the tap positions 41 and 43 in the impedance network 39.

The electronic oscillator and associated frequency control circuitry according to the present invention also features suppress and sustain operations in the following manner: Assume that key switches 76 and 86 are open and that the key switch 66 is closed. The capacitor 62 will rapidly charge up to the voltage on the bus 71, and the frequency of oscillator 11 will be established by the frequency control circuitry as previously described. If now the key switch 66 is opened and the voltage on bus 79 is at ground potential, the charge stored on capacitor 62 is dissipated primarily in the oscillator circuit 11, tending to keep the oscillator 11 running with decreasing amplitude as the charge on capacitor 62 is gradually dissipated. Such a gradual dissipation of the charge stored on capacitor 62 produces the well known sustain effect.

If, however, it is desired not to have this sustain effect, but rather immediately suppress all tone once the key switch 66 is open, the bus terminal 81 will be connected to some negative voltage. A -30 volt potential on bus 79 has been successfully used for a suppress operation and applied through resistor 64 and diode 18 to the capacitor 62. This negative voltage opposes and neutralizes the charge stored on capacitor 62 and dissipates such charge much more rapidly than in the previous case. The negative voltage on bus 79 tends to suppress the amplitude of the oscillating signal immediately after the key switch 66 is opened.

The diodes 18, 28 and 38 have been included in the electronic circuitry according to this invention in order to prevent any adverse electrical interaction between the different oscillators 11, 21 and 31 as the various key switches 66, 76 and 86 are closed. The diodes 18, 28 and 38 prevent current from flowing from bus 79 into the collector circuits of the oscillators 11, 21 and 31 when a positive potential appears on bus 79 via collector circuits of adjacent oscillators.

The following table of values is given by way of illustration only, and this table includes those component values which were used in the twin-T oscillator 11. These values correspond to circuit components which were used in an electronic organ circuit which was successfully built and tested, but these values should not be construed as limiting the scope of this invention.

TABLE

Components:		
Resistor:		Values
40	-----ohms---	6K
42	-----do-----	11K
44	-----do-----	13K
47	-----do-----	15K
49	-----do-----	15K
52	-----do-----	100K
54	-----do-----	100K
56	-----do-----	56K
58	-----do-----	6.8K
59	-----do-----	10K
60	-----do-----	600
64	-----do-----	10K
65	-----do-----	10K
101	-----do-----	500K

Capacitor:

46	-----μfd---	.01
48	-----μfd---	.01
50	-----μfd---	.02
62	-----μfd---	50
63	-----μfd---	500
67	-----μfd---	500
Bus 79	supply voltage	volts-- 0-30
Bus 71	supply voltage	volts-- +7, +14 or +21
Terminal 57	supply voltage	volts-- 14

The output bus 83 is connected through the relatively large valued resistors 101, 102 and 103 to the respective midpoints of the low pass filter T sections of the twin-T oscillators 11, 21 and 31. The signals produced at these midpoints are relatively pure sinewave signals, and it is often desirable to use such signals in musical instruments for flute and tibia voicing effects. However, there are two other points in the oscillator circuits where output signals may be taken if desired, and one of these is the collector output of each of the 12, 22 and 32 transistors. The collector output signal of these transistors is relatively large in magnitude and may typically be in the order of six to ten volts. The collector output signals are particularly useful for driving binary divider chains. A third output may be derived from the center points, i.e., point 105, of the high pass twin-T networks of the oscillators 11, 21 and 31 and this output is much richer in high harmonics than the other two outputs. An output signal at point 105 may be desired, for example, to simulate string and reed voicing effects in an electronic musical instrument.

The above description of the schematic oscillator circuitry shown in the drawing has been directed to a type of system known as an all-oscillator or tibia type organ wherein individual oscillators are required for each different note to be played. As previously indicated, this type of organ might include up to 85 or more individual oscillators with the output taken from bus output terminal 83. However, in the divider organ which is a somewhat different type of widely used organ, the basic tone generator circuitry is quite standardized and consists typically of twelve oscillators which are tuned to the chromatic intervals (C, C#, D, D#, etc.) in one of the higher octaves of the frequency spectrum, i.e., an octave between approximately 2000 Hz. to approximately 4000 Hz. Each of these twelve oscillators drives a cascaded chain of binary dividers which are well known in the art and have the property of dividing an input frequency by a factor of two. Such frequency division enables a chain of frequency dividers to be connected to the output of one of the twelve oscillators and track the key shift and glide effects of the tone oscillators.

In the divider organ the tone oscillators are always oscillating and the collector keying described above is not used. In addition, the output signal coupling from the tone oscillators and dividers are different from those described above, and the keying suppress and sustain operations are handled in separate, well known circuits. However, it will be appreciated by those skilled in the art that the twin-T type of oscillator and associated frequency control circuitry described above are equally adaptable for operation in the divider organs as in the all-oscillator or tibia type of organ.

I claim:

1. In electronic circuitry operative in electrical musical equipment utilizing a plurality of tone oscillators which may be selectively energized to oscillate at a plurality of tone frequencies respectively, the improvement comprising:

- frequency control means including impedance means connected to each of said tone oscillators for setting the frequency of oscillation thereof;
- said frequency control means further including a separate variable impedance transistor connected in parallel with a portion of each of said impedance means, said variable impedance transistors operative

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to be gradually or rapidly biased through an active impedance region and shunt out selected portions of said impedance means, thereby changing the tone frequencies of selected ones of said tone oscillators in accordance with the desired tone of said electrical musical equipment,

(c) said frequency control means further including capacitance means connectable to a voltage supply terminal and connected to individual ones of said variable impedance transistors, said capacitance means chargeable to a predetermined voltage for biasing said variable impedance transistors to a low impedance state it thereby shunt said selected portions of said impedance means when it is desired to raise the tone frequency of selected ones of said tone oscillators; and

(d) said frequency control means further including switching means for disconnecting said capacitance means from said voltage supply terminal and allowing said capacitance means to discharge, thereby removing the bias voltages on said variable impedance transistors and switching said variable impedance transistors to a high impedance state.

2. In electronic circuitry operative in electrical musical equipment utilizing a plurality of tone oscillators which may be selectively energized to oscillate at a plurality of tone frequencies respectively, the improvement comprising:

(a) frequency control means including impedance means connected to each of said tone oscillators for setting the frequency of oscillation thereof,

(b) said frequency control means further including a separate variable impedance transistor connected in parallel with a portion of each of said impedance means, said variable impedance transistors operative to be gradually or rapidly biased through an active impedance region and shunt out selected portions of said variable impedance means, thereby changing the tone frequencies of selected ones of said tone oscillators in accordance with the desired tone of said electrical musical equipment,

(c) said frequency control means further includes a first resistance-capacitance network connected between said voltage supply terminal and a control electrode of at least one of said variable impedance transistors,

(d) first switching means connected to said first resistance-capacitance network for energizing said resistance-capacitance network and rapidly charging up the capacitance therein to apply a bias voltage to one of said variable impedance transistors, and

(e) means for disconnecting said first resistance-capacitance network from said voltage supply terminal to allow the capacitance in said resistance-capacitance network to gradually discharge through said one variable impedance transistor and produce a gradual reduction in frequency of the tone oscillator to which said one variable impedance transistor is connected.

3. Electronic circuitry according to claim 2 which further includes:

(a) a second resistance-capacitance network connected between said voltage supply terminal and another variable impedance transistor shunting a further portion of said resistive impedance means; and

(b) second switching means connected in parallel with the capacitance of said second resistance-capacitance network and adapted to rapidly discharge said capacitance when connected in shunt therewith, said second switching means rapidly removing the bias from said another variable impedance transistor and producing a corresponding rapid down shift in frequency of said oscillator to which said another variable impedance transistor is connected; said capacitance in said second resistance-capacitance network gradually charging when electrically connected to

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said voltage supply terminal and gradually biasing said another variable impedance transistor through its active impedance region to its saturation impedance, thereby producing a corresponding upslide in oscillator frequency as said another variable impedance transistor gradually shunts out a selected portion of said resistive impedance means.

4. Electronic circuitry operative in electrical musical equipment and including, in combination:

(a) at least one transistor oscillator circuit including a high pass T filter network and a low pass T filter network which together form a twin T feedback network for producing the required phase shift to sustain oscillations at a selected audio frequency,

(b) frequency control means including a resistive impedance network connected between said oscillator and a point of reference potential, said frequency control means further including at least one variable impedance transistor connected to said resistive impedance network and adapted to shunt out a selected portion of said resistive impedance network when said variable impedance transistor is biased through its active impedance region,

(c) means for applying a bias voltage to said variable impedance transistor for biasing said variable impedance transistor to its saturation voltage and thereby effectively removing a selected portion of said resistive impedance network from the high pass T filter network of said oscillator and increasing the frequency of oscillation of said oscillator circuit, and

(d) said means for biasing said variable impedance transistor through its active impedance region includes a resistance-capacitance network connected between a control electrode of said variable impedance transistor and a voltage supply terminal, said resistance-capacitance network including a capacitor coupled to said voltage supply terminal and adapted to charge up to a given voltage level and bias said variable impedance transistor rapidly to its saturation condition and rapidly short out a selected portion of said resistive impedance network, said capacitor adapted to gradually discharge when removed from said voltage supply terminal to enable said variable impedance transistor to be gradually biased through its active impedance region to a high impedance state, thereby gradually reinserting a selected portion of said resistive impedance network between said oscillator and said point of reference potential and producing a frequency glide effect in said oscillator circuit.

5. Electronic circuitry according to claim 4 which further includes:

(a) a second resistance-capacitance network connected between said voltage supply terminal and a second variable impedance transistor, said second variable impedance transistor connected in parallel with another selected portion of said resistive impedance network, said second resistance-capacitance network including a serially connected resistor and capacitor connected between said voltage supply terminal and a point of reference potential, said capacitor chargeable by the voltage at said voltage supply terminal for gradually biasing said second variable impedance transistor through its active impedance region and to a state of low impedance and shunting said another selected portion of said resistive impedance network; and

(b) switching means connected in parallel with said capacitor in said second resistance-capacitance network for shorting same and rapidly removing the bias voltage on said second variable impedance transistors, thereby rapidly biasing said second variable impedance transistors into its high impedance state and effectively reinserting said another selected portion of said resistive impedance network between

said oscillator circuit and said point of reference potential.

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84—1.13, 1.24; 331—110, 142, 179