

Nov. 5, 1957

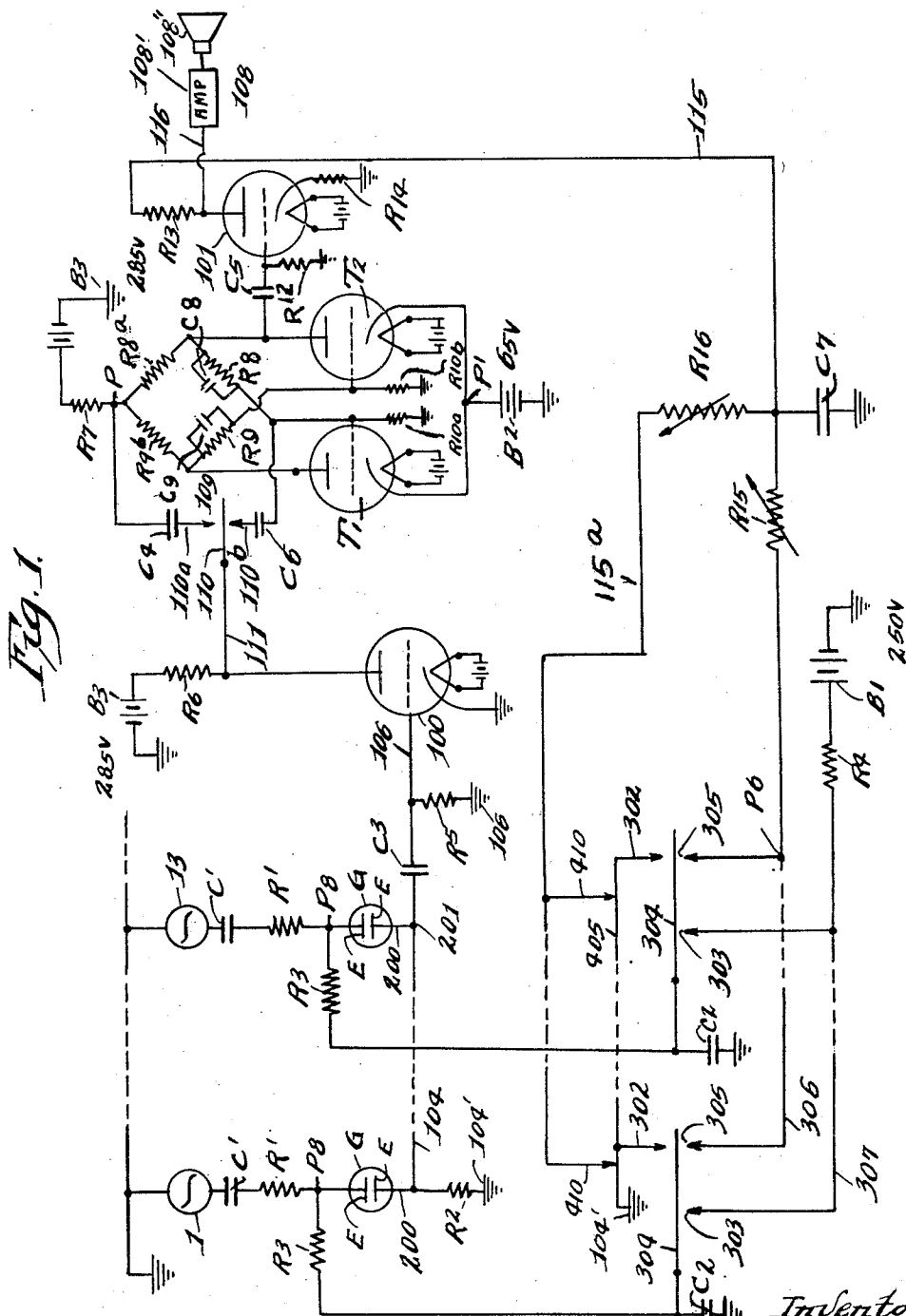
W. J. ANDERSON ET AL

2,811,887

ELECTRICAL MUSICAL INSTRUMENT

Filed Oct. 12, 1954

4 Sheets-Sheet 1



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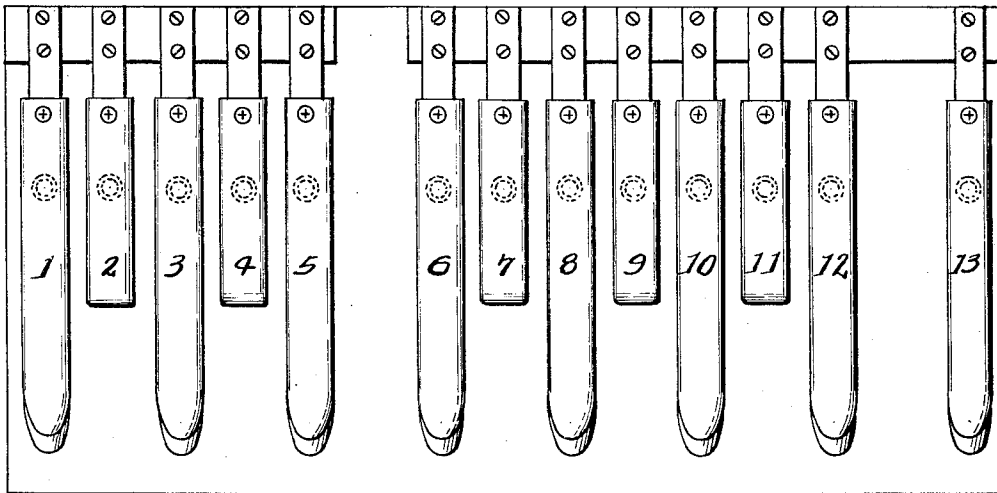
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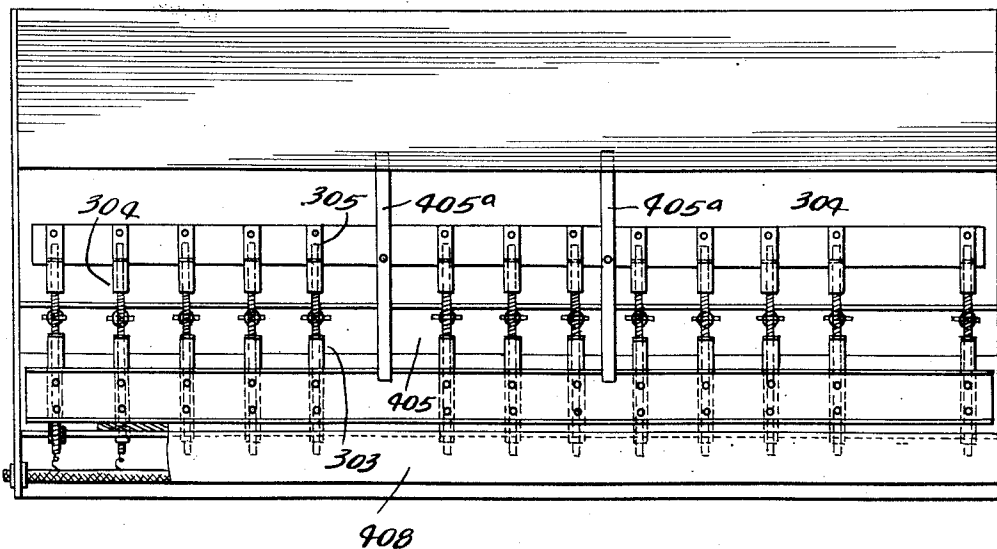
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Fig. 2.



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Fig. 3.



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4 Sheets-Sheet 3

Fig. 4.

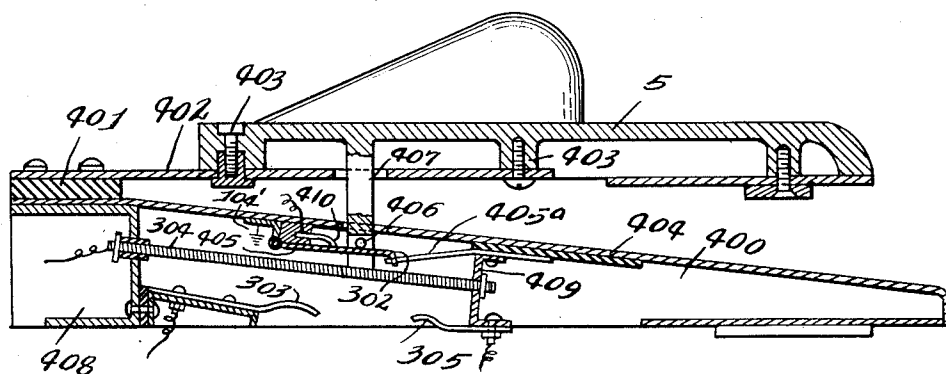


Fig. 5.

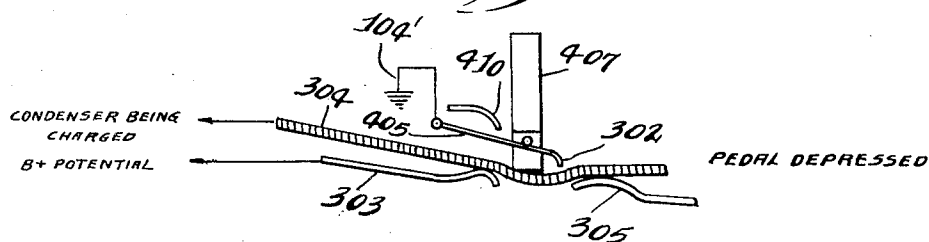
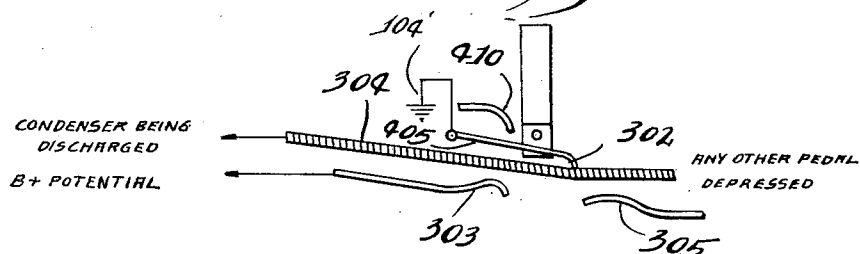


Fig. 6.



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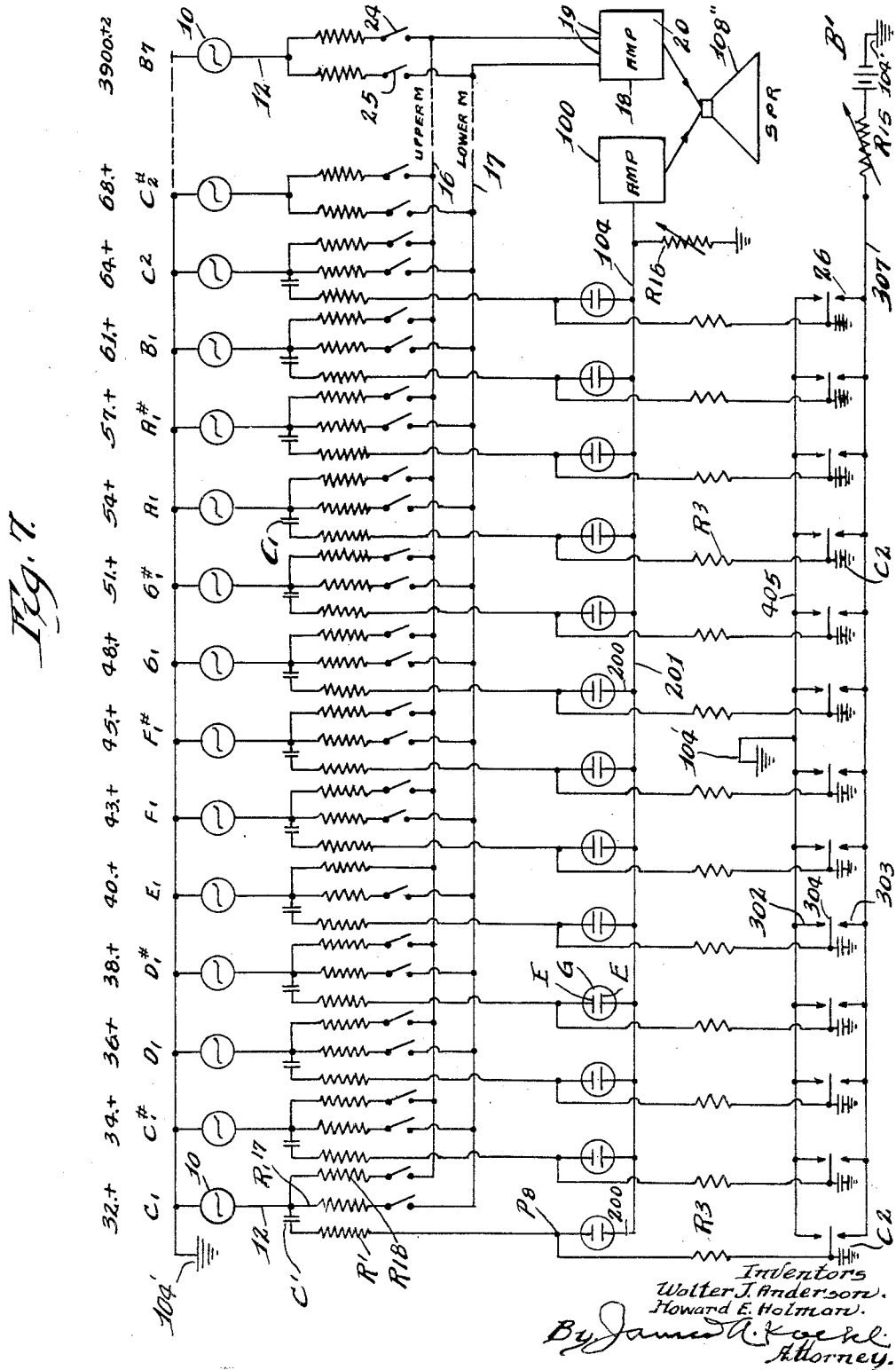
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ELECTRICAL MUSICAL INSTRUMENT

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4 Sheets-Sheet 4



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2,811,887

ELECTRICAL MUSICAL INSTRUMENT

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Application October 12, 1954, Serial No. 461,798

10 Claims. (Cl. 84—1.01)

This invention relates to pedal claviers for electric organs of the class employing generators respectively producing tone signals at the vibration frequencies of the notes of the tempered scale. It is preferred that the invention be used with an instrument having at least one manual embracing a useful number of octaves for playing music as written and a sufficient number of pedal keys for eliciting bass tones. It is also a purpose of the invention to combine a pedal clavier with a system of comprising a minimum number of tone signal generators respectively producing output signals at the vibration frequencies of eight-foot tones, such that, and assuming that the manual embraces six octaves, the tone frequencies will be from 64.+ cycles per second to 3900.+ cycles per second. Thus, the frequencies in pipe organ nomenclature correspond to eight-foot tones. As the pedal clavier should be capable of producing heavier bass tones than would be available from these frequencies, it is an important feature of our invention to provide means for utilizing signal voltages in the lower frequency range of the manual to halve the frequencies of these voltages so that when translated into audible sounds, the bass notes will be twice as heavy as said normal eight-foot tones.

Among the more important objects of our invention, the following are illustrative:

(1) The provision of an electronic organ having a minimum number of tone frequency generators and means enabling use of output signals from a given number of said generators to provide bass tones that are exactly an octave lower than said output signals and therefore twice as heavy as are the tones normally developed when said output signals are translated into audible sounds, as when playing the manual of the instrument.

(2) The provision of means enabling either eight-foot or sixteen-foot tones to be elicited from the pedal clavier.

(3) The provision of means for controlling the rate of growth of sounds elicited when playing the pedal clavier with assurance of desired reverberation effects.

(4) The provision of means for controlling both the rate of growth and decay of sounds elicited from the pedal clavier.

(5) The provision of means for controlling the rate of growth and decay of tones with avoidance of latching or other devices heretofore employed in pedal claviers for maintaining a latched condition of a depressed pedal until same is released by subsequent depression of another key of the pedal clavier.

(6) The provision of a single electronic signal time control blocking and amplifying device at the audio amplifier of a sound translating system and a plurality of keying circuits each having therein an inexpensive electronic time control blocking device, the said time control blocking and amplifying device at the input circuit of the audio amplifier being common to all of the aforesaid electronic time control blocking devices in said keying circuits and connected therewith so that when the electronic time control blocking device in any key-

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ing circuit is activated as when a key of the pedal clavier is depressed, said time control blocking and amplifying device at the input of the audio amplifier is activated for uninterrupted conduction of signal voltage to said time control blocking and amplifying device from a respective generator, and whereby and by means of the time control blocking devices in said keying circuits, the time control blocking and amplifying device at the input of said audio amplifier remains activated as a function of time with a resultant reverberation effect.

(7) The provision of positively functioning time control means in the output circuits of tone frequency generators that are common to the keying circuits of the keys of the pedal clavier for blocking the flow of signal voltage from any of the generators when the keys are not depressed and for inactivating all of said circuits except the one associated with a key that is depressed at any instant, thereby preventing interaction between said circuits and with avoidance of audible beats.

The invention will be described with reference to the accompanying drawings in which:

Figure 1 is a schematic illustration of the electrical network of an electronic organ embodying our invention;

Figure 2 is a view in top plan of the pedal clavier;

Figure 3 is a bottom plan view of the pedal clavier;

Figure 4 is an enlarged transverse section taken approximately on line 4—4 of Figure 2;

Figure 5 is a schematic illustration of the switch organization for each pedal of the pedal clavier, the figure showing the parts in coactive relationship to each other as when a pedal is depressed;

Figure 6 is a view similar to Figure 5 showing the relationship of the elements of the switch organization of all pedals except the one that is depressed at any instant;

Figure 7 is a schematic illustration of the network of an electronic organ embodying a slightly modified form of our invention.

Wherever herein like elements and parts are disclosed in the accompanying drawings, like reference numerals, letters and subscripts will identify same.

The herein disclosed invention embodies continuously operating generators respectively producing output tone signals for any desired number of octaves of notes in the tempered scale. The output lead from each generator is generally provided with a plurality of parallel resistive output paths through which equally divided portions of the output signal may be supplied different keying circuits of the instrument when a signal of the same tone frequency is used more than once at the same instant. For example, and assuming that the instrument has two manuals and a pedal clavier and that a given generator produces a signal having the vibration frequency of note $C_1=64.+$ cycles per second, divided portions of the signal voltage may be concurrently supplied manual keys and also a key of the pedal clavier in which the frequency of the notes associated therewith is $C_1=64.+$ cycles per second. The resistances in said resistive output paths are high relative to the internal impedance of a respective generator to prevent "robbing" amongst divided portions of signal voltage that are concurrently supplied different keying circuits, thereby preventing diminution of voltage supplied said circuits.

In practice, an organ embodying our invention may have one or any number of manuals, each of any desired octave range. The pedal clavier may embrace any desired range of bass tone frequencies. In each case the keys will be in the sequential order of notes in the tempered scale as is typical of the pipe organ.

In that an important feature of our invention is an improved pedal clavier connected in an electrical network of an electronic organ to control the rate of growth and de-

cay of bass tones when an electroacoustic translating system is activated by signal voltages derived from pretuned tone signal generators, we shall first describe said pedal clavier and point to the functionality of the interrelated, electrically coactive elements thereof. Later in this description we will describe in detail the manuals of the organ and how these and the pedal clavier are connected in an electrical network having means for translating signal voltages into audible sounds of any desired volume.

At Figure 2 of the accompanying drawings is shown a pedal clavier having thirteen individually depressible keys, 1 through 13, the same being respectively indicative of notes C₁, C#₁, D₁, D#₁, E₁, F₁, F#₁, G₁, G#₁, A₁, A#₁, B₁ and C₂, there being five black and eight white keys. For each of these keys and actuable thereby is a switch organization operating when a key is depressed to control the rate of growth of a tone at an electroacoustic translating system and similarly to control the rate of decay of the tone when foot pressure is removed from the key.

To avoid confusion and complications in illustrating the various keying circuits of the pedal clavier and as all of said circuits are substantially identical, both structurally and functionally, only two of said circuits are shown at Figure 1, the same connected in an electrical signal transmission network to enable selective conduction of tone signals to said electroacoustic signal translating system, the operation at the pedal clavier section of the instrument distinguishing somewhat from the operation of the manual sections in that in the pedal clavier section it is proposed that only one note at a time shall be sounded, whereas in the manual sections chords can be played the same as is typical of the pipe organ.

The description to follow will also stress another important feature of our invention, the same comprising a submultiple trigger circuit interposed between a common signal collector and an electroacoustic translating system for selectively converting a signal from a respective generator into a signal which is a submultiple thereof. Stated differently, and assuming that the output of a generator is a signal corresponding to an eight-foot tone, same may be selectively converted into a signal corresponding to a sixteen-foot tone. The submultiple trigger circuit is designed and adapted to count down by a factor of 2, and a more complete description thereof will be given hereinafter.

Now, and with particular reference to Figure 1 of the accompanying drawings, 104 is a common collector connected to ground 104' through a load resistor R2. 108 is an electroacoustic translating system comprising an audio amplifier 108', in the output circuit of which is a loud-speaker 108''. At 100 and 101 are respective amplifiers each shown as a triode of the vacuum tube type. Tube 100 will be hereinafter referred to as a first amplifier and tube 101 a second amplifier, and as shown, the control grid of amplifier 100 is connected to said common collector 104 by a conductor 106 having a blocking condenser C3, across which and connected to ground 106 is a load resistor R5. The plate circuit of said amplifier is connected to a source B3 of plate supply current through a load resistor R6.

Interposed between first and second amplifiers 100 and 101 is a submultiple trigger circuit shown as comprising two vacuum tubes T1 and T2 of the triode type, the plate circuits of which connect to a common junction point P through resistors R9b and R8a respectively. Point P connects to a source of plate supply potential through a resistor R7. The cathode circuits of said tubes are connected to a common junction point P1, the latter connected to a source of biasing potential B2. Interposed between amplifier tube 100 and said submultiple trigger circuit is a switch organization 109 with movable contactor 110 connected to the plate of amplifier tube 100 by means of lead 111. Blocking condenser C4 connects contact element 110a to juncture point P of the trigger circuit,

and blocking condenser C6 connects contact element 110b to the grid of tube T1 of the trigger circuit. The plate circuit of tube T1 connects to the grid circuit of tube T2 via a condenser-resistive mesh R9, C9, and similarly, the plate circuit of tube T2 connects to the grid circuit of tube T1 via a condenser-resistive mesh R8, C8. The plate circuit of tube T2 is connected to the grid circuit of amplifier 101 via a blocking condenser C5, the grid of said amplifier being connected to ground through a resistor R12. The cathode circuit of amplifier 101 is connected to ground through resistor R14. A conductor 116 couples the plate circuit of amplifier 101 to the input circuit of amplifier 108'. Also connected in the plate circuit of amplifier 101 is a resistance R13 in series with a conductor 115, the purpose of which will be described presently.

Referring now to generators 1 and 13, the output side of each thereof has a lead 200 which connects to the aforementioned common collector 104, said lead having a blocking condenser C1, ahead of resistor R1. Following said resistor R1 is a miniature gas discharge tube G of the type having two spaced apart cold electrodes E—E which are connected in lead 200 so that when gas in the tube is extinguished, the tube functions as an impedance of infinite value, preventing flow of signal voltage to said common collector 104. When gas in the tube is ignited from a source of ionizing energy, the tube is conductive, the value of the impedance in lead 200 changing from an infinite value to a relatively low value, it being understood that the rate at which signal voltage builds up at amplifier 100 may be first predetermined as will be hereinafter described.

At point P8 in the output lead 200 from a respective generator, which point is situated intermediate to resistor R1 and gas discharge tube G, is a resistor R3 which connects to movable contactor 304 of a switch organization comprising spaced apart contact elements 302, 303 and 305, between which elements the contactor 304 is disposed so as to be spaced apart therefrom when no keys of the pedal clavier are depressed. Element 302 is grounded, as shown. Contactors 303 and 305 are adapted to be contacted simultaneously by element 304 in response to motion of a respective key of the pedal clavier. Element 304 is connected to ground by condenser C2. Contactors 303—303 are connected to each other by a lead 307. Contactors 305—305 are connected to each other by a lead 306.

Conductor 115 from the plate circuit of amplifier 101 connects to the contactors 305 of the switch organizations for generators 1 and 13 through variable resistor R15. Connection with contactor 305 common to generator 13 is at point P6, and at said point P6 contactor 305 is connected to ground through a variable resistor R15 and a condenser C7. The junction of C7, R15 and lead 115 is connected to contactor 410 by variable resistor R16 and lead 115a. Element 410 electrically contacts grounding member 405 except when any key of the pedal clavier is depressed.

Normally, i. e. when the keys of the pedal clavier are in their non-playing positions, the contactor 304 is open-circuited. The gas in the signal isolating tubes G is extinguished and the tube 101 is non-conductive.

Assuming that the key associated with generator 1 is depressed, contactor 304 will engage respective contact elements 303 and 305, connecting the circuit to a source of direct current B1.

Current from this source is then impressed on said contactors 304 and 305, such that current from source B1 gradually charges condenser C2 to approximately 250 volts, the time interval between initiating and completing the charge being determined by the time constants of resistor R4 and condenser C2. For the purpose of this invention the time to charge condenser C2 is substantially instantaneous. Current from source B1 is concurrently effective to ionize the gas in tube G through resistor R3, thereby firing the gas in said tube and rendering the tube

conductive, resulting in unblocking path 200 and conduction of signal voltage to common collector 104, it being understood that on ionizing the gas, the impedance of the tube decreases to a relatively low value.

Ionization of gas in tube G continues as long as a key of the pedal clavier which is common to contactor 304 is depressed. When pressure is removed from said contactor to break the circuit between same and the direct supply source B1, the gas gradually deionizes at a rate determined by the aforementioned time constants of resistors R2 and R3 and condensers C2 from approximately 250 volts to approximately 70 volts, at which time gas in tube G extinguishes.

When contactor 304 in the switch organization common to generator 1 engages contact element 303, contactor 304 associated with all others of the switch organizations of the pedal clavier will be simultaneously grounded by contactors 302, as will be more fully described herein-after. This discharges all condensers C2 except the one associated with a contactor 304 of the depressed key, thereby completely inactivating all other keying circuits with the result that there is no interaction between said circuits.

It follows that when a selected pedal is depressed, signal voltage from a respective generator will be impressed on the common collector 104 and on the control grid of amplifier 101 via blocking condensers C3 and load resistor R5, the signal being thereby amplified and developed through load resistor R6, the amplified signal being then conducted to point P of the submultiple trigger circuit comprising tubes T1 and T2. The signal is then impressed on the grid of second amplifier 101 via blocking condenser C5 and load resistor R12, said amplifier being biased by resistor R14. Plate load resistor R13 is connected to contactor 305 via lead 115 and resistor R15. When contactors 303, 304 and 305 are simultaneously close-circuited upon depressing a key of the pedal clavier, contactor 303 applies B+ potential through R15 to condenser C7 and tube 101, at which time path 200 is unblocked and gas in tube G has been ignited. When contactor 304 in the switch organization common to generator 1 engages contact element 305, all contact elements 410 are disengaged from element 405. This removes variable resistor R16 from ground 104' during the interval that B+ potential is being applied to condenser C7.

Thus, the growth of a tone at loud-speaker 108'' is a function of the time constants of resistor R15 and condenser C7 in the keying circuit comprising contactor 304 and contact element 305. When pressure is removed from the key that has been depressed, the rate of decay of the tone is a function of the values of condenser C7 and plate load resistor R13, the current drain of amplifier 101, the biasing resistor R14 and the value of the variable resistor R16.

In practice, the time constant discharge rate of resistor R3, condenser C2 and tube G in a respective generator circuit will be longer than the rate of decay that is determined by the time constants of resistors R13, R14, R16 and amplifier 101 and can be readily predetermined by proper calculation of the values of these components. This longer period for the delay of a tone is required in that as gas in tube G extinguishes, there is a certain amount of signal voltage variation tending to upset the submultiple trigger circuit. The time constants of condenser C7, resistors R13, R14 and R16 associated with amplifier 101 are such that the amplifier does not function as an amplifier when gas in any tube G is extinguished.

Pointing now to the herein disclosed means for selectively determining the footage of signal voltage effective at loud-speaker 108'', it is noted that contactor 110 is adjustable for engagement with any one of the contact elements 110a and 110b. When contactor 110 engages contact element 110b, trigger signal from tube 101 is placed on the grid of tube T1. Assuming that a keying

circuit has been completed, as when a key of the pedal clavier is depressed so as to unblock the flow of signal voltage from a generator, such for example, generator 1 which denotes $C_1=64+$ cycles per second, and that this voltage is applied to the submultiple trigger circuit in the manner aforesaid, said trigger circuit will deliver an output signal of exactly the same frequency as the signal produced by said generator. When contactor 110 engages contact element 110a, trigger signal from tube 100 is applied to the junction point of tubes T1 and T2, at which time said trigger circuit counts down to half the frequency of the output signal from said generator 1. The signal is thus divided by a factor of 2 and the signal delivered from the trigger circuit is 32 cycles per second, which, in pipe organ nomenclature, corresponds to a sixteen-foot tone as distinguished from what can be considered the normal eight-foot pitch of the instrument.

The pedal clavier shown at Figure 4 comprises a suitable metallic base member 400 having a rearwardly disposed horizontal ledge 401 to which the back ends of flat leaf springs 402 are attached, and as illustrated, there is one such spring for and secured at 403 to each of said keys. The base member is shown as a hollow structure including a downwardly flared wall 404. Tiltably mounted for vertical movement on the under side of wall 404 is a member 405, the same comprising a longitudinally extending metallic bar of a length slightly less than that of said wall 404. At Figure 1 we have shown and described contact elements 302—302, and it is to be understood that said elements are integral portions of said member 405 in that, in carrying out the invention, all of said elements are adapted to be moved concurrently. The front downwardly directed flange 302 on said bar 405 shall be understood to represent elements 302 shown at Figure 1, and in said figure, the full and dot-and-dash lines which connect elements 302—302 to each other shall designate bar 405 shown in detail at Figure 4, said bar connected to common ground 104'. Said bar 405 is resiliently urged to the upper limit of its pivotal motion by leaf spring 405a and against a pin 406 which extends transversely through the bifurcated lower end of a depending stem 407 which is preferably an integral part of a respective key of said pedal clavier. It shall be further understood that each of the keys of the pedal clavier are similarly formed and that when all keys are fully raised, the pins 406 on the stems 407 thereof freely engage the upper surface of said bar 405.

The contactor 304 shown at Figure 4 is the same as any one of the similar contactors 304 shown at Figure 1, it being understood that there is one thereof for and common to each individual key of said pedal clavier. Said contactor comprises a coil spring, one end of which is attached to and insulated from the U bar 408, the other end thereof being attached to a fixed insulating bracket 409. When the spring is mounted in this manner, it is practically under no longitudinal stress and same occupies a substantially straight line, inclining downwardly and forwardly toward the front of said pedal clavier. The contact element 303 shown at Figure 1 is identified by the same reference numeral as the same element shown in Figure 4, and in like manner is this true of contact element 305. When the key 5 is raised as shown at Figure 4, bar 405 is resiliently disposed at the uppermost limit of its pivotal motion and the element 302 is disengaged from said contactor 304. Contactors 303 and 305 are also out of engagement with said contactors 304. Contactor 410 is arranged to be in electrical contact with grounding member 405 only when the key 5 is raised in non-playing position.

At Figure 5, it is assumed that key 5 is depressed, at which time it is noted that the lower end of stem 407 has engaged and depressed contactor 304, forcing same into effective electrical engagement with contact elements 303 and 305, at which time ionizing energy is supplied the gas content tube in a respective keying circuit and cur-

rently therewith condensers C2 and C7 are charged from source B1.

Now, and referring to Figure 6, it is also noted that, simultaneously with the depressing of key 5, all other elements 304 are connected to ground and all elements 410 are removed from ground in consequence of downward motion of element 302, which occurs as aforesaid when key 5 is depressed.

In Figure 7, the electrical network of the organ comprises two playing manuals, a pedal clavier, a system of generators respectively producing audio signals at the tone frequencies of sequentially related notes of the even tempered musical scale, and an electroacoustic translating system which may include one or more loudspeakers. Both forms of our invention may be used in substantially identical networks, except that in the embodiment first described there will be included the trigger circuit which couples amplifier 100 to amplifier 101 and enables frequencies corresponding to eight-foot tones either to trigger the circuit directly at the eight-foot pitch or to be converted thereby into sixteen-foot tones.

The playing manuals are connected in the signal transmitting network so that they can be played as a polyphonic instrument, the pedal clavier being connected in said network to enable bass tones to be sounded individually and successively as in the so-called melody or solo instruments.

It is not intended that the invention be limited to any specific number of tone frequency generators nor to the number of keys comprising any individual manual nor to the number of keys that will comprise the pedal clavier. However, and as distinguished from instruments of the prior art, there shall be a tone signal generator for and common to each key of like note letter of the musical scale and each key of the pedal clavier, such for example, if there are two manuals, each individual tone generator will constitute a tone signal source from which divided portions of the output of a respective generator will supply signal voltage to keys of the manuals denoting notes of the same letter in the scale and similarly to supply a respective key of the pedal clavier with signal voltage, the vibration frequency of which corresponds to a note of said like letter. In the instant case, each generator is a pretuned source of signal voltage so that, and as aforesaid, the output of any generator is available for simultaneous usage at different places in the instrument.

We will assume that in this embodiment of our invention the organ comprises generators for a range of tone frequencies, as follows:

C¹=32.+cycles per second
C#¹=34.+cycles per second
D¹=36.+cycles per second
D#¹=38.+cycles per second
E¹=40.+cycles per second
F¹=43.+cycles per second
F#¹=45.+cycles per second
G¹=48.+cycles per second
G#¹=51.+cycles per second
A¹=54.+cycles per second
A#¹=57.+cycles per second
B¹=61.+cycles per second
C²=64.+cycles per second
C#²=68.+cycles per second

and so on to and inclusive of note B⁷=3900.+cycles per second. The pedal clavier has thirteen individually depressible keys adapted to be respectively supplied with signal voltages from generators furnishing signal voltages at tone frequencies C¹=32.+cycles per second through C²=64.+cycles per second.

It is understood that an electronic organ embodying the herein disclosed invention will have any well known means for predetermining the timbre of the tone to be sounded at any instant, and that the volume of sounds

emitted can be controlled by devices well known in the art.

The network shown at Figure 7 essentially comprises generators 10 producing tone frequencies for a range of seven octaves, wherein C¹=32.+cycles per second and B⁷=3900.+cycles per second. Only fifteen of the generators are shown and referred to herein, thus to avoid wiring complications which would render the drawings unnecessarily confusing.

Generators 10 respectively bearing the note letters C¹—C#²—through B⁷ are each connected to a common ground 104' and to an output lead 12, each generator having a plurality of high-resistive paths R1, R17, R18.

An upper manual bus bar 16 and a lower manual bus bar 17 are connected to an electroacoustic translating system 18 as at 19, the said system preferably comprising an audio amplifier 20 having a loud-speaker 108'', the latter adapted to be activated by signal voltage in the output circuit of said amplifier. A third bus bar 104 which is individual to the pedal clavier of the organ has its output terminal connected to an amplifier 100 and, as shown, said amplifier 100 is also operatively connected to said loud-speakers 108''.

The resistive output paths R18 are electrically coactive with key actuated electric switches 24, each having one terminal connected to bus bar 16. The resistive paths R17 from each generator are similarly connected by electric switches 25 to bus bar 17, and as shown, the condenser resistive paths from generators C¹—C#² have gas tubes E connected to bus bar 104. From each generator the output signal voltage therefrom is divided by as many times as there are occasions simultaneously to utilize a tone signal of the same frequency at different playing keys of the organ. To prevent robbing amongst the plural output paths from a respective generator, the resistances in said paths are high relative to the internal impedance of said generators. No claim is made for this feature except as used in the herein disclosed environment.

It is known that the most acceptable conditions for speaker and audience shall correspond to a time of reverberation of about 1 second for small rooms, increasing to 1.5 or 2 seconds for large rooms, where in any case speaking tends to be more deliberate. As different types of music demand different times of reverberation for their effect on precision and detail, as commonly in chamber music, a short time of reverberation is necessary, whereas in the case of choral and organ music, a longer time of reverberation is called for, thus making it desirable to provide in an electronic organ means at the disposal of the player to introduce artificial reverberation in rooms that are lacking in reflecting surfaces or not acoustically constructed and designed to insure a necessary amount of reverberation.

In the schematic illustration, Figure 7 of the accompanying drawings, the pedal clavier of the organ essentially comprises switches 26, each having a contactor 304, a contact element 302 connected to a common ground 104' via a common metallic ground out bar and a contact element 303 connected to a direct current source such as battery B1 via conductor 307 which is common to all contact elements 303. Conductor 307 has a variable resistance R15 by means of which the amount of current drawn from source B1 can be controlled. For the purpose of our invention, the +B supply source B1 will be about 150 volts, the negative side of which is connected to common ground 104'. Each switch 26 of the respective keys of the pedal clavier section of the instrument has its contactor 304 connected by a resistor R3 to point P8 in the output path C1R1 of a respective generator C1, etc. of the thirteen generators common to said pedal clavier, and as illustrated, the output path from a respective generator has operatively connected therein an electronic blocking device which preferably comprises a miniature gas content tube G of the type having two spaced apart cold electrodes E—E, similar to the tube G in the

embodiment of our invention disclosed at Figure 1, whereby and when gas in the tube is extinguished, there is an impedance in the path which is variable from an infinite value when the tube is extinguished to a value which gradually lowers to approximately zero when the tube is fired, thereby enabling un-impeded flow of signal voltage to said bus bar 104. The resistor R3 from a respective switch 26 connects to a respective output path from a coactive generator at a point P8 which lies between the tube G and a resistor R1, the latter connected to said generator by blocking condenser C1.

Connected across bus bar 104 at the input to amplifier 100 is a variable resistance R16 for controlling as a function of time the rate at which sound decays at said loud-speaker 108".

Connected between bus bar 307 and B+ potential B1 is a variable resistance R15 for controlling as a function of time the rate at which firing voltage is built up across condenser C2 and thus controlling the rate at which sounds build up in loud-speaker 108".

While we show thirteen tone generators connected to supply tones for a like number of keys that comprise the gamut of the pedal clavier and fifteen generators connected for use at as many keys of the upper and lower manuals of the organ, it is understood that each and all keys of said manuals will, in practice, be similarly connected to generators that are individual thereto. Also in practice, it is preferred that the manuals will embrace a range of five octaves, the keys of which have associated therewith notes of the tempered scale.

When depressing a selected key of the pedal clavier, three operations occur, namely, (1) all contactors 302 except the one associated with the key being depressed make electrical contact with element 304, thereby discharging any condensers C2 still charged as a result of any previously depressed key; (2) a keying circuit of an associated key of the pedal clavier causes activation of the gas content tube, thereby lowering the impedance in said circuit and unblocking the circuit for uninterrupted transmission of signal voltage; and (3) a discharge of the capacitor C2 through resistor R3 is effected after switch element 304 is disengaged from switch element 303, with resultant decay of tone for a period.

Values of the resistances and condensers that have given desired results are:

C1	-----microfarad-----	.001
C2	-----do-----	1.0
C3	-----do-----	.01
C4	-----do-----	.01
C5	-----do-----	.01
C7	-----do-----	.2
C8	-----do-----	.0005
C9	-----do-----	.0005
R1	-----ohms-----	470,000
R2	-----do-----	47,000
R3	-----megohms-----	2.2
R4	-----ohms-----	100,000
R5	-----megohm-----	1
R6	-----ohms-----	100,000
R7	-----do-----	47,000
R8	-----do-----	470,000
R8a	-----do-----	100,000
R9	-----do-----	470,000
R9b	-----do-----	100,000
R10a	-----do-----	470,000
R10b	-----do-----	470,000
R12	-----megohm-----	1
R13	-----megohms-----	2
R14	-----ohms-----	10,000
R15	-----megohms-----	.1-5
R16	-----do-----	.1-5

Regarding devices of the prior art, we point particularly to the Smiley Patent No. 2,083,246 (Re. 20,831), wherein use is made of relatively costly vacuum tubes which

are normally biased beyond cut-off, there being one each of said vacuum tubes for each separate keying circuit of the instrument. In devices of this character, the filament of the tube is constantly incandescent, resulting in constant drainage on the life of the tube, in addition to which there is necessary to be taken into consideration the power supply transformer requirements.

An important feature of the herein disclosed invention is a pedal clavier embodying a single vacuum tube, namely, 101 in Figure 1, which is common to a plurality of keying circuits, each embodying therein a space discharge device available at a small fraction of the cost of vacuum tubes, which device when used in this environment insures operability for an almost immeasurable period as compared with the relatively short life of a vacuum tube. This gas element functions in the keying circuits as a variable impedance device which is subject to definite changes in the condition thereof, such that in one possible condition there is provided an impedance of infinite value to block in a dependable manner the flow of the output to a common vacuum tube, and in its second condition to provide an impedance of a low value to enable the flow of the output from said generator to said vacuum tube. When cold space discharge devices are used in combination with a frequency divider and connected to a source of energy so as concurrently to render the gas discharge device conductive and the divider circuit operative to produce an output which is a submultiple of the impressed input frequency, not only is there further simplification in the composite organization of elements, but in addition thereto said gas tubes definitely prevent any interaction between the respective keying circuits that in any manner would interfere with an intended functioning of the divider circuit.

Wherever herein the gas content tube G in the output paths of generators 1-13, etc., are each thereof referred to as an infinite impedance when the gas in the tube is extinguished, thus to prevent flow of signal voltage to common collector 104, this shall be taken to mean that the peak of the alternating current signal voltage from any given generator is of insufficient amplitude to fire the gas in the tube. It suffices to say that the magnitude of the output voltage can be limited in any manner well known to those experienced in the art to which the invention relates.

What we claim as our invention is:

1. In an electrical musical instrument; a highly biased space discharge tube having an anode, a heated cathode and a control grid; a common source of B+ potential having its B- side connected to ground; a plurality of tone signal generators, each individual generator having an output path provided therein with a gas content tube adapted when the gas therein is extinguished to prevent flow of signal voltage from said path; a common collector to which the output paths from said generators are connected; an electroacoustic translating system coupled to the anode of said space discharge tube; and means including said common source of B+ potential and a control switch for each generator for simultaneously connecting said source to the output lead from said generator and to the anode of said space discharge tube when the switch is in one possible actuated condition to thereby simultaneously ionize the gas in said tube and apply B+ voltage to the anode of said space discharge device for conducting signal voltage to said translating system; and condenser-resistive means connected in circuit with the aforementioned control switches, said source of potential and the space discharge tube for controlling as a function of time the rate of decay of sound at said sound reproducing system.

2. In a musical instrument having a plurality of selectively depressible keys, an electrical switch for an actuable by each of said keys, a plurality of tone signal generators each having a signal output path for and controlled by a respective one of said switches, a collector common to the output paths of all of said generators, a sound re-

producing system connected to said common collector for activation by signal voltage from said generators, a gas discharge tube for and connected in each individual signal output path and providing therein an impedance which is variable from an infinite value blocking conduction of signal voltage to said common collector when the gas in the tube is deionized to a relatively low value when the gas is ionized to render the tube conductive and allow signal voltage to be impressed on said common collector from a respective generator, means including a source of +B potential having its negative side connected to ground and serving when depressing a selected key of said plurality of keys to ionize the gas in the tube in a signal output path common to the switch that has been actuated by the depressed key and to control as a function of time conduction of signal voltage supplied said sound reproducing system from said common collector, each key-actuated switch comprising a contactor connected to a respective signal output path, a fixed bus-bar connected to said source of +B potential and having a set of longitudinally spaced apart contact elements, and a resiliently supported bus-bar movable relative to said fixed bus-bar upon depression of a respective key, the movable bus-bar connected to the common B— side of said source of potential and provided with a set of longitudinally spaced apart contact elements coactive with the contact elements on the first named bus-bar to provide therewith a pair of spaced apart contact elements for each contactor, and spring means for biasing the movable bus-bar to a position in which all of its contact elements are out of electrical engagement with the movable contactors in the absence of pressure applied to said movable bus-bar against the urge of said spring means and so that when any key is depressed the switch actuated thereby will be polarized from said +B supply source and concurrently therewith to connect all others of the switches to the common B— side of said source of potential.

3. In an electrical musical instrument, a sound reproducing system, a set of generators respectively producing output signals at the tone frequencies of notes of the chromatic scale, a signal output path from each generator, said path having therein a gas discharge tube and a resistor, the latter located between the generator and said gas discharge tube, a collector common to and connected to the output paths of all generators and to ground through a resistor; a control tube having a cathode, an anode and a control grid, the cathode of which is connected to ground through a biasing resistor and whose control grid is coupled to the common collector through a blocking condenser and a resistor to ground, a source of B+ potential having a common B— side; a load resistor connecting said source to the anode of said control tube; capacitive-resistive means comprising a capacitor for each separate signal output path connected to the common B— side of said source of potential and to said path through a resistor at the junction point between the gas discharge tube and the resistor in said path; a set of individually depressible keys each resiliently biased to a raised position; a system of switch means including a switch means for and actuable by each key upon depression thereof to connect said source of potential in closed circuit with the gas discharge tube in the signal output path common to said key to thereby charge the capacitor from said source and ionize the gas in said tube to render the tube conductive for impressing the output signal on the common collector and so that when the key is raised, the capacitor will discharge and the gas in the tube deionized to gradually block said path.

4. The combination of elements as set forth in claim 3 wherein means coactive with the output paths of said generators and their respective switch means are provided so that during depression of any key to actuate a respective switch means to fire the gas in the discharge tube in a selected path, the capacitors in all others of said paths will be connected to the common B— side of said source

of potential and completely discharged prior to charging the capacitor in said selected path to thereby prevent capacitive interaction between the selected path and all others of said paths, said coactive means comprising a depressible metallic bar common to all of said switches and adapted when depressed to connect all but one of said switches to the common B— side of said source of potential.

5. The combination as set forth in claim 3 wherein condenser-resistive means are connected in circuit with the respective switch means, the source of +B potential and the load resistor in the anode circuit of the control tube to control as a function of time the rate of decay of sound produced by said sound reproducing system in response to actuation of a selected key and for prolonging the sound a predetermined interval of time after return of the key to its raised position, said capacitive-resistive means connected to the source of B+ potential via a respective one of the switches of the aforementioned switch means so that on operation of any single switch, B+ potential from said source of potential is applied to the anode of said control tube.

6. In a musical instrument, a source of B+ potential, the negative side of which is connected to ground, a common collector connected to ground through a load resistor, a sound reproducing system, a first amplifier, a second amplifier, the control grid of the first amplifier connected to said common collector by a conductor having a blocking condenser, across which and connected to ground is a load resistor, the cathode of the second amplifier being connected to ground through a biasing resistor; the said source of potential having its B+ side connected to the anode of said first amplifier through a load resistor; a frequency divider coupling the first amplifier to the second amplifier and adapted to receive signals via said common collector and convert same into signals which are submultiples thereof, a conductor connected to the anode of the second triode through said load resistor; a set of generators respectively producing output tone signals having the frequencies of different notes of the chromatic scale; each generator having a signal output path connected to said common collector, and having a gas discharge tube adapted when the gas therein is deionized to provide in said path an impedance preventing conduction of output signal to said common collector from said path and serving when the gas is ionized to impress said signal on said collector; a capacitor connected to ground and to each signal output path through a resistor at the junction point between the load resistor and the gas discharge tube in said path; a set of depressible keys resiliently biased to raised positions; a B+ supply source, a switch system including switch means for and adapted to be operated by each key of said set of keys and connected to said current supply source so that when a key is depressed the capacitor in the signal output path common to said key will be charged from said source through the resistor in the aforementioned conductor and simultaneously therewith ionize the gas in the gas discharge tube in said path and effect conduction of the output signal from the generator common to said path to said common collector; and condenser-resistive means coactive with said switch means and including the resistor in the anode circuit of the second amplifier for causing sound emitted by said sound reproducing system to decay at a variable rate and the sound to continue a predetermined time after the aforementioned key has been returned to its raised position.

7. The combination as set forth in claim 6 wherein the switch system includes means operating when any selected key of said set of keys is depressed to charge the capacitor in a signal output path common to said key and connect to ground the capacitors in all others of said paths and thereby prevent interaction between said paths.

8. In a musical instrument, a plurality of generators respectively producing output signals at tone frequencies

of different notes of the chromatic scale, each generator having an output path provided therein with a blocking condenser, a load resistor ahead of said condenser and a gas discharge tube ahead of said load resistor, a resistor connected to said path at the junction point between the load resistor and said gas discharge tube, a capacitor for each path and connected to ground and in series with the second named resistor, a common collector connected to ground through a resistor and to the output paths from all of said generators, a source of polarizing energy, switch means for each path and connected to said polarizing source and to the second named resistor so that when in one possible operated condition energy from said source will charge said capacitor and supply said path with energy through said second named resistor to ionize the gas in said gas discharge tube and whereby when the switch means is in the second possible operated condition the capacitor common thereto will discharge so as to gradually deionize the gas therein.

9. In a musical instrument, a sound reproducing system, a set of generators respectively producing output signals at tone frequencies of different notes of the chromatic scale, each generator of said set of generators having a signal output path provided with a blocking condenser, a load resistor ahead of said condenser and a gas discharge tube ahead of said load resistor, a resistor connected to said path at the junction point between the load resistor and said gas discharge tube, a capacitor for each path and connected to ground and in series with the second named resistor, a common collector coupled to said sound reproducing system and to ground through a resistor and also to the output paths from all generators, a source of positive potential, switch means for each path and connected to said source of positive potential and in circuit with the second named resistor and said capacitor so that when the switch means is close-circuited energy from said source of positive potential will charge said capacitor and supply said path with positive potential to ionize the gas in said tube and render the tube conductive and when open-circuited to discharge the capacitor with resultant deionization of the gas at a variable rate.

10. In an organization of the class described, tone signal generators, an amplifier, a sound reproducing system connected to the amplifier for amplifying output signal voltage from said system, signal output paths connecting the generators to said amplifier, a gas content tube in each of said paths; switches comprising pressure-responsive movable contactors connected to respective ones of said paths and each having a condenser connected to ground; fixed contact elements spaced apart from said contactors; a source of potential having a B+ side and a B- side; a metallic bar connected to the B- side of said source and resiliently mounted for movement against said movable contactors to establish electrical engagement of all but one thereof with said bar and connect same to the negative side of said source and concurrently connect said one movable contactor to the B+ side of said source, thereby energizing said one movable contactor and supplying the path associated therewith with energy for ionizing the gas in the tube contained in said path and render the tube conductive and effect conduction of signal voltage to said amplifier from a respective generator, said tube providing in said path an impedance which is variable from an infinite value preventing conduction of signal voltage to said amplifier when the gas in said tube is deionized, to a relative low value enabling conduction of signal voltage to the amplifier from said generator when the gas in said tube is ionized.

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