

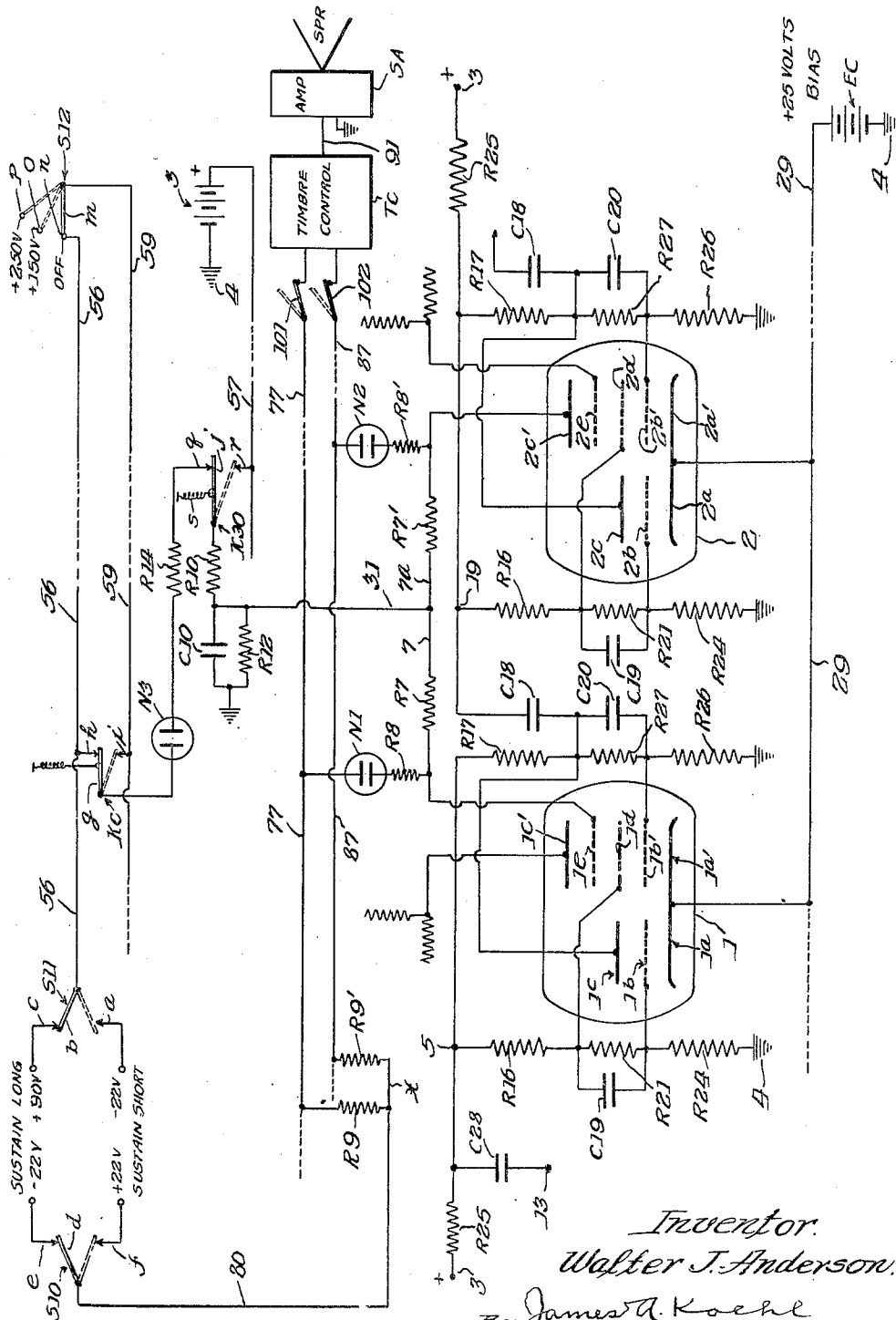
Feb. 11, 1958

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2,823,310

ELECTRICAL MUSICAL INSTRUMENT

Filed Oct. 28, 1955



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ELECTRICAL MUSICAL INSTRUMENT

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Application October 28, 1955, Serial No. 543,293

13 Claims. (Cl. 250—27)

This invention relates to electrical musical instruments and has particular reference to keyboard musical instruments of the class employing sources producing audio output signals at the vibration frequencies of different notes of the tempered scale, which sources are connected in an electrical system, whereby, in response to playing a keyboard output signals from selected ones of said sources are converted into audible sounds for musical expression.

The shapes of the dynamic envelope of a musical tone, the number and relative amplitudes of the partials of the tone and the rate at which the tone starts and stops are the factors that determine the tone qualities that enable distinguishing one instrument from the other, such, for example, sound produced by striking a tuned string, which, at the inception rises rapidly and decays slowly, as distinguished from instruments such as the pipe organ in which the sound builds up gradually, can be sustained as long as a playing-key is depressed and then decays gradually when the key is released. It suffices to say that tones characteristic of some instruments have both a slow attack and a slow decay, whereas others have a fast attack and a slow decay, the rates of both attack and decay varying with the different instruments, such as the celesta, harp, bells, etc. As will be pointed to presently, the herein disclosed invention has for its primary purpose the provision of a low cost electronic system that makes for greater versatility and can be played glissando, legato or staccato with rapid conversion of from one to the other in full conformity with music as written and for proper expression, and whereby, the attack and/or decay of tone can be readily controlled at the will of the player. It is a matter of fact that if a note played on a piano could be maintained at a constant level instead of decaying as it does, the tone would be very similar to that of a saxophone. As the rates of attack and decay can be changed at will while the instrument is being played, many interesting and pleasing effects are possible and with rapidity in changing from one effect to another, any tone, regardless of its named quality, can be sustained. Furthermore, as provided for herein, notes can be played in rapid succession as in piano playing without overlapping or undue delay between them.

In string instruments such as the violin, the characteristic tone has associated therewith certain bowing transients, apart from the pizzicato effect produced by plucking the strings. In the lieblich gedackt the starting transient is very prominent and involves a strong fifth harmonic. Regarding the natural characteristic transients, it is well known that the beauty in the music these transients offer would be lost if they did not exist. These wanted and necessary transients, however, are different from transients that originate in electric organs either at the generators or are present from other causes and electrical interference, and unavoidably mix with keyed envelopes that determine tones of given timbre such as when a "stop" is drawn, thereby adding extraneous frequencies to the keyed envelope that blur the timbre and in some

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cases destroy it as a useful timbre, both when it speaks by itself as well as when used as a voice in ensemble. With the above in mind, the herein claimed invention has for a further purpose the provision of means for the prevention of leakage at the generating system and harmful results incident to ground noises, capacitative disturbances, etc., thereby insuring a much higher degree of fidelity of tone than possible with prior instruments.

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

(1) The provision of means in an electronic musical instrument for rendering perceptible to the sense of hearing, tones that are artistic and enable rendition of music as written by the composer for a particular quality of tone any place in the musical score.

(2) The provision of means for controlling the length of time for sustaining a tone after a playing-key has been released, said means providing a greater number of individually usable time delay periods according as different musical effects are desired.

(3) The provision of means which, in addition to providing a wide choice of time delay periods for sustaining sound, functions automatically (in a system employing constantly operating tone frequency generators) to suppress residual leakage which, if not suppressed, would reflect at the sound reproducing device of the instrument and mar the beauty of tone, which said means also functions in the system in a manner enabling (a) intermanual coupling; (b) manual to manual coupling; (c) manual to pedal coupling, and (d) octave and other types of coupling.

(4) The provision of means in an electronic organ for producing reverberation effects.

(5) The provision of means enabling two or more footage tones to be sounded simultaneously from a single keyed element.

(6) The provision of means for coupling in various degrees of volume intensity by an improved switching technique.

(7) The provision of means for coupling from manual to manual or within a given manual a pitch other than in unison, i. e. 16 or 4 foot in relation to an 8 foot reference tone.

Other and further objects and advantages of the invention will become apparent from the following description, taken in conjunction with the accompanying drawing in which the single figure is a schematic illustration of the essential characterizing elements and circuits of the invention.

In carrying the invention into practice, tone frequency sources comprising thermionic tubes are employed, such that there will be one tube for an individual to each playing-key of the instrument's keyboard, the said tube producing an output signal having the tone frequency of the note associated with said key. For the purpose of my invention, two tubes respectively producing octavely related output frequencies are shown for producing what will be hereinafter referred to as "coupler effects." Each tube may be connected in its own individually tuned circuit, or any given number of tubes may be coupled together as frequency dividers, there being generally twelve similar sets of tubes, each set providing a tuned driver or master control stage and a plurality of successively coupled slave stages. In such an arrangement, there would be a set of tubes for producing output signals at the frequencies of octavely related C notes, a set producing signals for all C# notes, another set producing signals for all the D notes, etc., to and inclusive of a set producing signals for all the B notes at octave separation. Prior patents disclosing the above-named methods of operating vacuum tubes are: Larsen, No. 2,403,090; Larsen

et al., No. 2,568,644; Langer, No. 2,533,821; McKellip et al., No. 2,340,002, McKellip, No. 2,481,608. No claim is made herein for any of the above-named methods and it suffices to say that any well known means can be provided for operating each of said tone sources at its preassigned frequency. While I have shown and will describe pentode-triode thermionic tubes as a preferred type of space discharge device, this shall not be construed as a necessary limitation in that any well known type of tube can be substituted therefor, it being necessary that same shall have electrodes adapted to serve the purpose of my invention.

Referring to the drawing first as regards the generators, reference character 1 designates the first stage of a cascaded generator consisting of two groups of electrodes enclosed in the same envelope, one group of electrodes constituting a triode and the associated group of electrodes comprising a pentode. A second stage is designated at 2 similar in all respects to the first stage 1. The groups of electrodes in the stage 1 constituting the triode consists of the cathode 1a, the control grid 1b, and the plate 1c. The group of electrodes constituting the pentode comprises the cathode 1a', the control grid 1b', the screen grid 1d, the suppressor grid 1e, and the plate 1c'. The groups of electrodes in the second stage 2 correspond to the groups of electrodes in the first stage 1 and have been indicated by reference characters 2a, 2b, and 2c constituting the cathode, control grid, and plate of the triode section and 2a', 2b', 2d, 2e, and 2c' constituting the cathode, control grid, screen grid, suppressor grid, and plate of the pentode section.

The synchronizing signal is applied to the first stage 1 from the input terminal 13 and ground connection 4 from any suitable driving source such as a Hartley oscillator. The input signal is applied to the junction point 5 between resistors R16 and R17 through the condenser C28 and transmitted to the control grids 1b and 1b' through condensers C19 and C20. The plate 1c of the triode section of the first stage 1 and the screen grid 1d of the pentode section of said stage 1 in turn flop and the counter-action follows according to a flip-flop operation. The plate 1c' and suppressor 1e of the pentode section of stage 1 are electronically coupled to the cathode 1a', control grid 1b', and screen grid 1d of the pentode section by way of electrons within the tube. Thus a flip-flop signal appearing within the elements of the pentode is also seen at the plate 1c' and suppressor 1e when keyed with positive potential thereon. A synchronizing signal is transmitted from the plate 1c of the triode section of the stage 1 through condenser C18 to the junction point 19 of resistors R16 and R17 of the second stage or counter 2, and similarly to any number of counters in cascade.

The circuit of the stage 1 is completed by resistor R21 which is shunted between control grid 1b of the triode section and screen grid 1d of the pentode section. Cathodes 1a and 1a' are connected to a plus bias voltage source EC via conductor 29. The input circuit to the control grid 1b and cathode 1a of the triode section of the stage 1 is completed through the resistor R24. The positive potential supplied to the plate 1c of the triode and the potential supplied to the screen grid of the pentode is controlled by resistor R25. The input circuit to the pentode section of the stage 1 is completed through resistor R26. The output triggering circuit of stage 1 is completed by resistor R27 which connects between control grid 1b' of the pentode section and the plate 1c of the triode section in shunt with condenser C20.

The circuit of the cascaded stage tube 2 is similar in all respects to the circuit of stage tube 1. Cathodes 1a, 1a', 2a and 2a' are interconnected by lead 29. Each of the stage tubes operates in a similar manner and the take-off signal is derived from each tube without loading any of the elements in the tubes which are being used for counting purposes. The pentode plates 1c' and 2c' and

suppressors 1e and 2e are only activated when the positive potential is applied thereto. Signal therefrom is removed through the associated output networks as more fully described hereinafter.

The signal generating system is normally energized from a source of positive potential 3 and, as shown, there is connected to said source a bus 57 which connects to contact element *r* of a playing-key operated switch K30 comprising contactor *j* and contact element *q*, the contactor *j* connected to suppressor grid 1e of tube 1 and plate 2c' of tube 2 by resistor R10 in lead 31 and feed resistors R7 and R7' in the lateral branch paths 7 and 7a of lead 31. The keying switch K30 has connected in circuit therewith a storing condenser C10 for the purpose of building up a voltage upon close-circuiting the switch with source 3 and subsequently, upon open-circuiting the switch to discharge the voltage to suppressor 1e of tube 1 and plate 2c' of tube 2 through the respective resistors R7 and R7' in branch paths 7 and 7a respectively for a sustaining time which is a function of the time constant of condenser C10 and associated net circuit resistance. Leak resistor R12 is connected in parallel with storage condenser C10 but because of its high ohmic value has no bearing on the time constant of said condenser. It shall also be noted that resistor R10 is of a relatively low ohmic value and is employed merely as a protective element for switch K30. It is understood that in practice there will be one switch K30 for each separate playing-key and that for each switch there will be at least a pair of tube elements as tone frequency sources supplying output tone signals at the frequencies of the notes associated with a playing-key (not shown) common to a respective switch K30, hereinafter to be referred to as a first key-operated switch, such that when the key is depressed, contactor *j* will move off of a second contact element *q* and onto a first contact element *r*. It will be understood that the playing-key of the instrument is normally resiliently biased to a raised position in the conventional manner and for the sake of clarity a spring *s* is shown connected to contactor *j* for urging the latter towards and in engagement with contact element *q*.

Switch Kc will be hereinafter referred to as a "second key-operated coupler switch" in a system for obtaining coupler effects and, as shown, said switch comprises a contactor *g* which is coactive with a second contact element *h* and first contact element *i*, the latter connected to what can be properly referred to as a "firing bus" 59. Element *h* connects to an "off" bus 56. Said switch Kc may be considered associated either with the second manual of an organ or the first manual, in the latter case (as will be noted later) serving other than as a unison coupler. The movable contactor *g* of switch Kc is connected to contact element *q* of switch K30 by a series work circuit comprising a gas contained tube N3 and resistor R14. Said contactor *g* engages contact element *h* when the switch is in an "off" condition, and contact element *i* when in an "on" condition. Firing bus 59 connects contact element *i* to the movable contactor *m* of a coupler control switch S12, the contact elements *o* and *p* of which are connected respectively to sources supplying 150 and 250 volts of positive potential. Bus 56 is connected to contact element *n* of said switch S12 and to the contactor *b* of what will be hereinafter referred to as a "first sustain" control switch S11, the same embodying a "long sustain" position wherein is engaged contactor *b* when in the full line position with a first contact element *c* and a source supplying +90 volts of biasing potential, and when in what shall be referred to as "short sustain" position, said contactor engages a second contact element *a* connected to a source supplying -22 volts of biasing potential.

Resistor R8 and gas contained tube N1 connect suppressor grid 1e of thermionic tube 1 to a tab-operated switch 101 via conductor 77. Connected across this conductor

at the opposite end thereof is a load resistor R9. Switch 101 connects to a timbre control system Tc which is coupled at 91 to an audio amplifier and loud speaker unit SA. Similarly, the output-series connected work circuit consisting of resistor R8' and gas contained tube N2 connect the plate 2c' of tube 2 to collector 87—the latter terminating in a load resistor R9', tab-operated switch 102, connecting said collector to said timbre control system. The common terminal X of the respective load resistors R9 and R9' is connected by lead 80 to the movable contactor d of what will be hereafter referred to as a "second sustain" control switch S10. In its "long sustain" position, said contactor d engages first contact element e connected to the aforementioned source, furnishing -22 volts of biasing potential. In its "short sustain" position, the contactor d engages second contact element f at the source supplying +22 volts of biasing potential.

Assuming now that tubes 1 and 2 are producing octavely related tone frequencies, i. e. the frequency of tube 2 is 1f and that of tube 1 is 2f, it follows that suppressor 1e and plate 2c' will, when energized with B plus potential, simultaneously produce 4 foot and 8 foot tone frequencies respectively. When key switch K30 is in "off" condition, plate 2c' and suppressor 1e have no firing voltage applied thereto. However, and due to the inter-electrode capacity of the tube elements, a certain minimum high harmonic leakage signal is always present at plate 2c' and suppressor 1e, which leakage is blocked from collectors 87 and 77 by the series gas contained tubes N2 and N1 respectively. In the absence of this blocking action, this minimum leakage, generally in the form of background noise, would be sufficient to present a disturbing audible sound in the output system of the organ when no notes are being played and the expression control device is set for high level operation, and also to reflect at said output system as extraneous frequencies when the keyboard of the instrument is being played. I particularly stress this functional purpose of these elements as one of several additional new and useful functions these elements serve, as will be manifest later in this description.

When key switch K30 is in the dotted line position, i. e. contactor j engages contact element r, plus firing voltage from source 3 is applied to conductor 31 by way of bus 57 and through protective resistors R10, thereby fully charging condenser C10 in an interval which is a function of the RC time constants of resistors R10 and condenser C10. In practice, a time constant of about $\frac{1}{100}$ of a second has given satisfactory results with assurance of a desired fast attack. Condenser C10 is on the order of .5 microfarad. Resistor R12 is on the order of 20 megohms, as compared with resistor R10 of 20,000 ohms, the result being that resistor R12 does not appreciably enter into the charging or discharging circuit. Firing voltage from source 3 is transmitted by way of conductor 57 and switch K30 to firing resistors R7' and R7 respectively in the plate circuit 2c' of tube 2 and the suppressor circuit 1e of tube 1, thereby causing these two elements to conduct signal voltages and simultaneously causing gas contained tubes N2 and N1 associated respectively with said elements to ignite and effect conduction of said signal voltages by way of resistors R8' and R8 to collectors 87 and 77 and tab switches 102 and 101 respectively.

Importance is placed upon use herein of a single playing-key operated switch K30 for simultaneously impressing two octavely related tone signals on the input circuit of a sound reproducing system, thereby effecting a very substantial saving in production cost by dispensing with as many again of these switches and cabling as well as dispensing with complicated and not too reliable relays commonly used in keying systems of large and very expensive organs. Regardless of the size of an organ, the herein-claimed system enables it to be incorporated in instruments of any size, but is particularly useful in small

instruments as an inexpensive system enables a small inexpensive instrument to have embodied therein the features found only in higher priced organs. Now, and as long as switch K30 is in an "on" condition, four and eight foot tone signals will continue to be effective at tab switches 101 and 102. When said switch is in an "off" position, resistor R10 is in series with resistor R14 by reason of engagement of contactor j with contact element q of said switch, at which instant, condenser C10 is still charged to approximately the voltage of source 3. Assuming, now, that voltage at condenser C10 is 150 volts and contactor b of switch S11 is engaged with contact element c at which the potential is +90 volts, and that the voltage required to fire the gas in tube N3 is 70 volts, the bias of 90 volts applied to said tube via conductor 56 and switch S11 offers sufficient back voltage to prevent tube N3 from firing. After the charge on condenser C10 has been completely dissipated, tube N3 still is unfired in that the 90 volts of bias is offset by the normal bias EC on the cathodes of tubes 1 and 2 which is applied to the N3 tube through the electron stream of the pentode sections of said tubes, resistors R7 and R7', conductor 31, resistors R10 and R14. Said bias voltage EC is on the order of positive 25 volts. From this it is understood that said tube N3 is not a factor in determining the charge and discharge of said condenser C10. The only current drain on said sustaining condenser is that due to the plate 2c' and suppressor 1e of tubes 2 and 1 respectively and any DC losses through the respective output paths R8, R8', tubes N1 and N2, conductors 77 and 87, load resistors R9 and R9', conductor 80 and switch S10 to the -22 volt biasing source at contact element e of switch S10.

The function of the -22 volt bias supply source on switch S10 is to insure that in the long sustain position of said switch, tubes N1 and N2 will continue conducting until the voltages on plate 2c' and suppressor 1e will have been completely dissipated and said plate and suppressor no longer emit a useful sustaining tone, at which time said tubes N1 and N2 extinguish and in this manner prevent leakage to the collectors 77 and 87 respectively. However, when switch S10 is in the short sustain position, as indicated by dotted lines in the drawing, the gas in tubes N1 and N2 will have already been extinguished before said voltages on plate 2c' and suppressor 1e have been completely dissipated, the 44 volt differential from -22 volts to a +22 volts serving as a bias which, when applied to the collector side of tubes N1 and N2, prevents the gas in tubes N1 and N2 from remaining ignited until sustaining condenser C10 has expended all of its useful energy on said plate and said suppressor. In this manner said tubes N2 and N1 associated with said plate 2c' and said suppressor 1e respectively remain conductive for a shorter period of time after release of switch K30 when switch S10 is in the +22 volt position as compared with the function served when switch S10 is in the -22 volt position. It is noted that contactor b of switch S11 when engaged with contact element a (-22 volts) is also effective in reducing the sustain time upon releasing switch K30 from an "on" position. The voltage differential is such that the instant resistor R10 is connected to resistor R14 and tube N3, the gas in said tube immediately ignites and is a conductor to aid in the discharge of condenser C10, thereby causing plate 2c' and suppressor 1e to stop conducting quickly because of the absence of supply voltage on said condenser.

Referring now and in further detail to key switch Kc, earlier referred to as a second key-operated coupler switch is selectively electrically coactive with said key-operated switch, it is noted that when the coupler control switch S12 is in either the 150 or the 250 volt position of adjustment and switch Kc is in an "on" condition as indicated by dotted lines, the voltage appearing on conductor 59 (by reason of its connection with switch S12) will be applied to gas contained tube N3 which, when the gas therein is

fired, will apply a plus voltage through resistor R14 and switch K30 through resistor R10 to said sustaining condenser C10, conductor 31, resistors R7 and R7', suppressor 1e and plate 2c' respectively, thereby causing conduction of an audio signal respectively through resistors R8 and R8', gas contained tubes N1 and N2 to the four foot collector 77 and the eight foot collector 87 respectively. In this manner, tube N3 in coaction with switch Kc, sustaining "long" and "short" time switch S11 and coupler control switch S12 functions to (a) couple one manual to another or (b) couple one octave to another in a single manual of the organ and, also, (c) for controlling the time for sustaining a tone. Switch S12 serves either to connect conductor 59 to conductor 56 or to provide at conductor 59 two different firing voltages; namely, 150 and 250 as first above mentioned. This feature of the invention is important in that the player has at his disposal means by which two different volumes of coupling intensity are available. I stress also the new and novel feature which consists in the provision of gas contained tubes N1 and N2 functioning in the herein-disclosed system to (1) prevent audio leakage when the gas in the tubes is extinguished and (2) the function of said tubes to reduce the time a tone can be sustained after the tone has been keyed and when switch S10 is in the +22 volt position. It shall be further noted that when switch S11 is in the -22 volt position, gas contained tube N3 functions to assist in discharging said condenser C10 for a short sustaining period of the tone whereas, when switch S11 is in the +90 volt position, said tube N3 remains de-energized and does not function to discharge said condenser. Again, the arrangement is such that when coupling switch S12 is in +150 volt or +250 volt position, the aforementioned coupler effect is obtained.

It is apparent that by the judicious use of switches S10 and S11, various combinations of sustain periods may be had, varying from the extreme long when both switches are in the long sustain position to practically zero sustain time when both switches are in the short sustain position. It is emphasized that the prior art means of controlling the time for sustaining a tone has been to employ cumbersome and expensive electromagnetic multi-contact switches, the result being that sustain times are limited to only two degrees, i. e. sustain "on" and sustain "off."

Having described in full and proper detail the various electrically coactive elements in the various circuits of the herein-claimed system, a brief summary of the current and signal flow necessary for the several aforementioned functional results is as follows:

(1) Assuming key switch K30 to occupy the "on" position shown in dotted lines, voltage from supply source 3 is transmitted to suppressor 1e and plate 2c' via conductor 57, contact r, contactor j, resistor R10, charging condenser C10, conductor 31, divided resistive paths 7 and 7a, thereby causing signals to be generated on said suppressor and said plate and the gas in tubes N1 and N2 to be simultaneously ignited. This changes said tubes N1 and N2 from a state of high impedance and non-conductive to a state in which the tubes are of low impedance and conductive, thereby unblocking the suppressor and plate circuits with resultant conduction of the output signals to switches 101 and 102 for selective delivery of said signals to said timbre control system.

(2) When switch K30 is in the full line (off) position and coupler key switch Kc is in the dotted line (on) position and switch S12 is in the 250 volt position, voltage from source 250+ volts common to switch S12 is transmitted via conductor 59, contact element i and contactor g of switch Kc to ignite the gas in tube N3 with resultant flow of voltage from said source of 250+ volts to the suppressor 1e and plate 2c' via resistor R14, contact element q and contactor j of switch K30, resistor R10, condenser C10, conductor 31, paths 7 and 7a thereby causing a tone signal to be generated on said suppressor

and said plate and the gas in tubes N1 and N2 to be fired, thereby causing conduction of the signal to said output system.

(3) To lower the intensity of the keyed tone as distinguished from conditions prevailing in (2) above, switch S12 would be positioned for applying voltage from source 150 volts to said suppressor and said plate—it being understood that the output signal intensity generated at plate 2c' and suppressor 1e is in direct proportion to the said source voltage.

(4) With switch S12 in "off" position, the contacts h and i of switch Kc are electrically interconnected, causing switch Kc to be ineffective as a coupler switch and with the result that only biasing voltage from switch S11 is effective at switch Kc.

(5) Assuming the conditions as set forth in (1) above to exist and that key switch K30 has been returned to its full line ("off") position, the duration of time which condenser C10 sustains voltage for a useful decaying signal at output system SA is dependent upon the settings of sustain control switches S10 and S11, assuming condenser C10 and all associated resistive components to be held constant.

(6) Assuming the conditions as set forth in (5) above and switches S11 and S10 to be in sustain short, dotted line position, immediately upon release of key switch K30 to its full line ("off") position, tube N3 accelerates the discharge of condenser C10 as the tube is ignited by the voltage differential appearing between the negative bias voltage on switch S11 and the plus voltage charge on condenser C10, the interconnecting path being by way of switch S11, conductor 56, key switch Kc, tube N3, resistor R14, key switch K30 and resistor R10.

The +22 volts bias voltage from switch S10 applied to tubes N1 and N2 by way of conductor 80, load resistors R9 and R9' and collectors 77 and 87 respectively is also effective in producing a short time interval of tone signal sustain. Assuming that tubes N1 and N2 are extinguished when a voltage differential of less than 70 volts appears across the electrodes therein, then in that case as soon as a voltage on tube elements 1e and 2c' has decayed to 92 volts (92 volts minus 22 volts=70 volts), tubes N1 and N2 extinguish—this time interval being shorter than if the bias voltage were a negative 22 volts, as will be considered next. Thus the coaction of switches S11 and S10 causes respectively acceleration of the discharge of condenser C10 and the extinguishing of the gas in tubes N1 and N2 prior to complete discharge of condenser C10, both factors being contributory to a relatively short decay period at the output system SA.

(7) Considering (6) above but assuming switches S10 and S11 to be in an opposite position for a long period of decay of tone signal, then in that event (a) tube N3 is prevented from firing because the 90 volts bias applied to tube N3 from switch S11 by way of conductor 56 and switch Kc is sufficiently large to counteract the 150 volt charge on condenser C10—it being readily understood that the 150 volts is insufficient to offset the bias of 90 volts plus the approximate 70 volts required to fire tube N3 (90 volts+70 volts=160 volts). Thus in this instance, tube N3 is not a factor in discharging condenser C10 as was the case in (6) above and also, in that event (b) tubes N1 and N2 continue to fire until the voltages on tube elements 1e and 2c' have decayed to approximately 48 volts because the negative 22 volts bias applied to tubes N1 and N2 by way of switch S11, lead 80, resistors R9 and R9' and collectors 77 and 87, boosts said 48 volts to a total of 70 volts, which is the condition for remaining fired. At this voltage point, said tube elements 1e and 2c' no longer emit a useful tone signal, at which time tubes N1 and N2 extinguish without having shortened the decay time of the tone signals appearing at the output system SA. Thus in this above-stated long sustained position of switches S11 and S10, the coaction of tubes

N3 and N1, N2 is such as to not shorten the normal decay period of the tone signals appearing at the output system SA resulting from voltage stored on condenser C10 and discharged to tube elements 1e and 2c' after key switch K30 has been returned to "off" or solid line position.

The above reasoning in (7) and (6) would also apply if coupler key switch Kc were employed instead of key switch K30 to energize tube elements 1e and 2c' in coaction with charging condenser C10 as in (2) and (3) above and with subsequent return to "off" position of key switch Kc.

It also follows that by selectively positioning switches S10 and S11 in the various combinations possible, that various degrees of sustained periods may be obtained.

Referring again to tubes N1 and N2, it is noted that as the screen grids 1d and 2d have a relatively high order of generator voltage present thereon at all times, a sizable signal therefrom is conducted by way of the inter-electrode capacities to the suppressor 1e and plate 2c' even when the last said elements are not activated by a keying voltage. It is this non-keyed signal voltage referred to earlier as "background noise" that is annoying unless prevented from appearing on collectors 77 and 87 and the output system SA. Gas contained tubes N1 and N2 are so series placed in the output paths between said plate and suppressor and the respective collectors so as to effectively block said background signals except when said tubes N1 and N2 are caused to be conductive upon applying keying voltage to said tubes and simultaneously causing said plate and suppressors to conduct heavily.

The order of above-mentioned inter-electrode capacity is approximately 2 mmfd., whereas the series capacity interposed by tubes N1 and N2 is but a small fraction thereof when not fired. Thus it follows that said tubes N1 and N2 serve to reduce or block by many, many decibels said signal leakage, whereas when fired tubes N1 and N2 become capacitative elements of a very large order, serving to unimpede the signal flow in the output paths from the plate and suppressor to the respective collectors.

Schedule of component values

Resistors:	Ohms
R7, R7' -----	1,500,000
R8, R8' -----	4,700,000
R9, R9' -----	100,000
R10 -----	10,000
R12 -----	22,000,000
R14, R25 -----	47,000
R24, R26, R21, R27 -----	500,000
R16, R17 -----	100,000
Condensers:	Microfarads
C10 -----	.5
C28, C18 -----	150
C19, C20 -----	500

What I claim as my invention is:

1. In an electric organ, a plurality of thermionic tubes respectively producing output signals at octavely related frequencies, each of said tubes comprising a cathode, control grid, screen grid, suppressor grid and a plate; a timbre control system; collectors; each collector including switch means for connecting same to said timbre control system for conduction to said system of signal voltage impressed on said collector; a source of B+ voltage; a path connecting one of said collectors to the suppressor grid of one of said thermionic tubes, said path having therein a gas contained tube which is nonconductive when the gas therein is extinguished; a second path including a gas contained tube connecting the plate of the other thermionic tube to the other collector; and a keying circuit for connecting the suppressor grid of one of said thermionic tubes and the plate of the other thermionic

tube in closed circuit with said source of B+ potential for applying positive potential thereto and to ionize the gas in said gas contained tubes to thereby render said gas contained tubes conductive for impressing the outputs of the respective thermionic tubes on the respective collectors.

2. The combination of elements as set forth in claim 1, wherein there is also included condenser-resistive means connected in said keying circuit for causing rapid growth of signal voltages by said thermionic tubes and for sustaining said signal voltages for a predetermined period of time after the keying circuit has been operated to disconnect said thermionic tubes from said source of B+ potential.

3. The combination of elements as set forth in claim 1, wherein the keying circuit includes resistive paths connected to the collector-connecting paths in the suppressor grid and plate circuits of the respective thermionic tubes, and wherein there is connected to said keying circuit and the suppressor grid and plate circuits of said thermionic tubes, means for causing rapid growth of signal output voltages from said tubes and a prolonged decay of said voltages after actuation of the keying circuit to disconnect said source of B+ potential from said suppressor grid and plate circuits.

4. In an electric organ having space discharge devices producing audio signals at octavely related frequencies, said devices each having a control grid, suppressor grid, screen grid, plate and a cathode; a timbre control system including a first switch, a circuit connecting the first switch to the suppressor grid of one of said devices, and a second switch and a circuit connecting the second switch to the plate of another one of said devices whose output frequency is the octave of that of the first-mentioned device; a gas contained tube in each of said circuits adapted when the gas in said tube is extinguished to form a high impedance in said circuit and prevent conduction of signal voltage from said circuit; a key-operated switch; and a source of positive potential connected to said key-operated switch for concurrently supplying positive potential to the suppressor grid and plate circuits of the first and second named space discharge devices when said switch is in one actuated condition and for ionizing the gas in said tubes to concurrently render effective at said first and second named switches the outputs of said space discharge devices, and a loud speaker coupled to said timbre control system for translating the output of said system into audible sound.

5. An electric organ according to claim 4 wherein means are connected in circuit with said key-operated switch for controlling as a function of time the rate of growth and the rate of decay of the output signal voltages at said loud speaker upon delivery thereof to said loud speaker from said space discharge devices in response to actuation of said key-operated switch.

6. An electric organ according to claim 4 wherein means are connected in circuit with said key-operated switch to control as a function of time the rate of growth of the output signal voltages delivered to said first and second switches via said gas contained tubes, and wherein means are provided for electrical coaction with said key-operated switch for sustaining the output signal voltages of said space discharge devices a predetermined prolonged period of time after said key-operated switch has been actuated to disconnect said source of positive potential from the suppressor and plate circuits of the respective space discharge devices.

7. An electric organ according to claim 4, wherein means including a condenser in circuit with said key-operated switch and said source of positive potential are provided for controlling as a function of time the rate of growth of the output signal voltages delivered to said first and second switches by way of said gas contained tubes and wherein means including a source of negative potential and a control switch are provided for biasing

said gas contained tubes to cause slow extinguishing of the gas therein with resultant continuation of electrically effective signal voltages at said first and second switches after the keying circuit has been actuated to disconnect said source of B+ potential from the suppressor grid and the plate of the respective thermionic tubes.

8. An electric organ according to claim 4 wherein means including a condenser in circuit with said key-operated switch and said source of positive potential are provided for controlling as a function of time the rate of growth of the output signal voltages delivered to said first and second switches by way of said gas contained tubes and wherein means including a source of positive potential and a control switch are provided for biasing said gas contained tubes to cause fast extinguishing of the gas therein with resultant fast discontinuation of electrically effective signal voltages at said first and second switches after the keying circuit has been actuated to disconnect said source of B+ potential from the suppressor grid and the plate of the respective thermionic tubes.

9. An electric organ according to claim 4, wherein means are employed for coaction with said keying circuit when the latter is in an open circuit condition for preventing residual leakage to said collectors from said generators during said continuous operation of said generators.

10. An electric organ according to claim 4, wherein means including a condenser-resistive circuit are employed and connected to said generators, the collectors and said keying circuit for causing any desired rate of growth of output signal voltages being conducted to said timbre control system and for selectively causing any desired rate of decay thereof and for sustaining said voltages for a predetermined period of time after restoration of the keying circuit from a condition effecting conduction of the outputs from said generators to said collectors, to a condition of non-conduction of said outputs to said collectors.

11. In a musical instrument, tone signal generators respectively producing octavely related output signals, said generators consisting of vacuum tubes each having a triode section and a pentode section; a source of biasing potential connected to the cathodes of said vacuum tubes; a pair of collectors; a key-operated switch; a source of positive potential connected in circuit with said key-operated switch for conducting voltage from said source when the switch is in one operated condition; resistive means connecting said switch to the suppressor of the pentode section of one of said tubes and to the plate of the pentode section of the other tube; and output means including resistive paths each having therein a gas contained tube which is non-conductive when the gas therein is extinguished, said paths respectively connected to said suppressor and said plate of the respective vacuum tubes and to the respective collectors so that when said switch is in the aforementioned one operated condition, positive voltage is applied to the suppressor and to the plate of the respective vacuum tubes for causing ionization of the gas in said gas contained tubes and concurrently to conduct to the respective collectors the output signals from the respective vacuum tubes.

12. In a musical instrument, tone signal generators respectively producing harmonically related output signals, said generators comprising vacuum tubes each having a triode section and a pentode section; a source of biasing potential connected to the cathodes in said pentode sections; a pair of collectors; a playing-key operated switch; a source of positive potential connected in circuit with said

playing-key operated switch enabling conducting voltage from said source when said switch is in one operated condition; resistive means connecting said switch to the suppressor of the pentode section of one of said tubes and to the plate of the pentode section of the other thereof; and output means including resistive paths from the respective collectors, each separate path having a gas contained tube which is non-conductive when gas therein is extinguished, one of said paths connected to the suppressor of one of said vacuum tubes and the other of said paths connected to the plate of the pentode section of the other of said vacuum tubes so that when said switch is in the aforementioned one operated condition, positive voltage is applied to the said suppressor and to said plate to electrically activate same and ionize the gas in said gas content tubes and render said tubes conductive for concurrently impressing on the respective collectors, harmonically related output tone signals from said vacuum tubes.

13. In an electric organ, a plurality of thermionic tubes respectively producing output signals at octavely related frequencies, each of said tubes comprising a cathode, control grid, screen grid, suppressor grid and a plate; a timbre control system; collectors; each collector including switch means for connecting same to said timbre control system for conduction to said system of signal voltages impressed on said collector; a source of B+ voltage; a path connecting one of said collectors to the suppressor grid of one of said thermionic tubes, said path having therein a gas contained tube which is non-conductive when the gas therein is extinguished; a second path including a gas contained tube connecting the plate of the other thermionic tube to the other collector; a keying circuit including a switch having first and second contact elements and a contactor adapted in response to depression of a resiliently supported depressible playing-key to engage said first contact element and connect said source of B+ potential to said suppressor grid and said plate for activation thereof and to ionize the gas in said gas contained tubes and render said tubes conductive and unblock conduction of said signal voltages to the respective collectors, said second contactor serving upon release of said playing-key and engagement of said contactor with the second contact element to disconnect said source of B+ potential from said suppressor and said plate; a selectively actuatable switch including first and second contact elements and a contactor coactive therewith, a second source of positive biasing potential, a source of negative biasing potential; a selectively actuatable third switch including a contactor connected to the second contact element of the second named switch, said third switch including contact elements connected respectively to said sources of biasing potential for applying as desired either a positive or a negative biasing potential to the first contact element of said second switch; and a time control circuit connecting the contactor of the key-operated switch in the suppressor and plate circuits of said thermionic tubes, and including a gas contained tube in a path which connects the second contactor of the key-operated switch with the contactor of the selectively actuatable switch.

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