

July 7, 1970

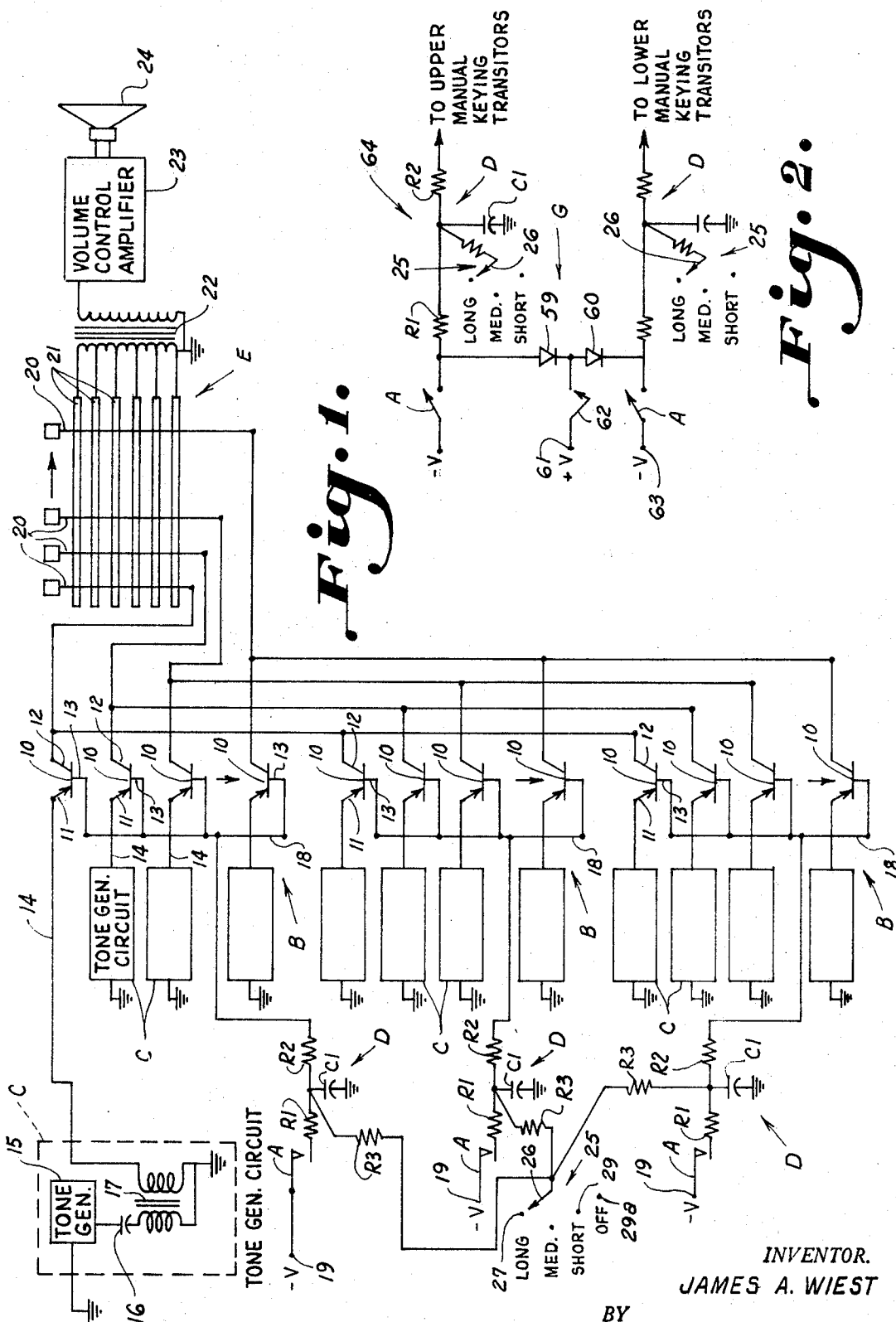
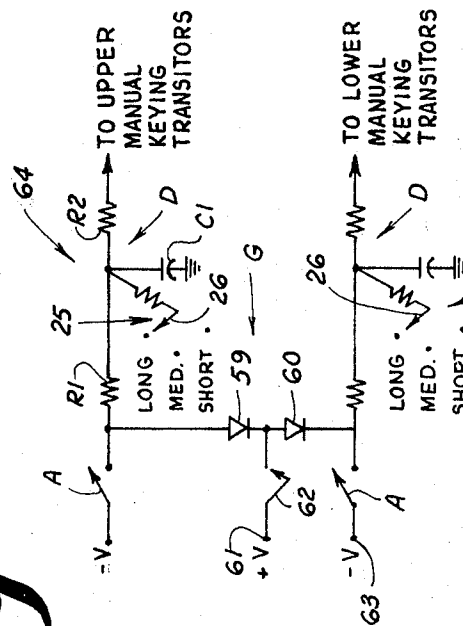
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3,519,723

SUSTAIN TONE DEVICE FOR ELECTRICAL MUSICAL INSTRUMENTS

Filed Dec. 20, 1966

6 Sheets-Sheet 1



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SUSTAIN TONE DEVICE FOR ELECTRICAL MUSICAL INSTRUMENTS

Filed Dec. 20, 1966

6 Sheets-Sheet 2

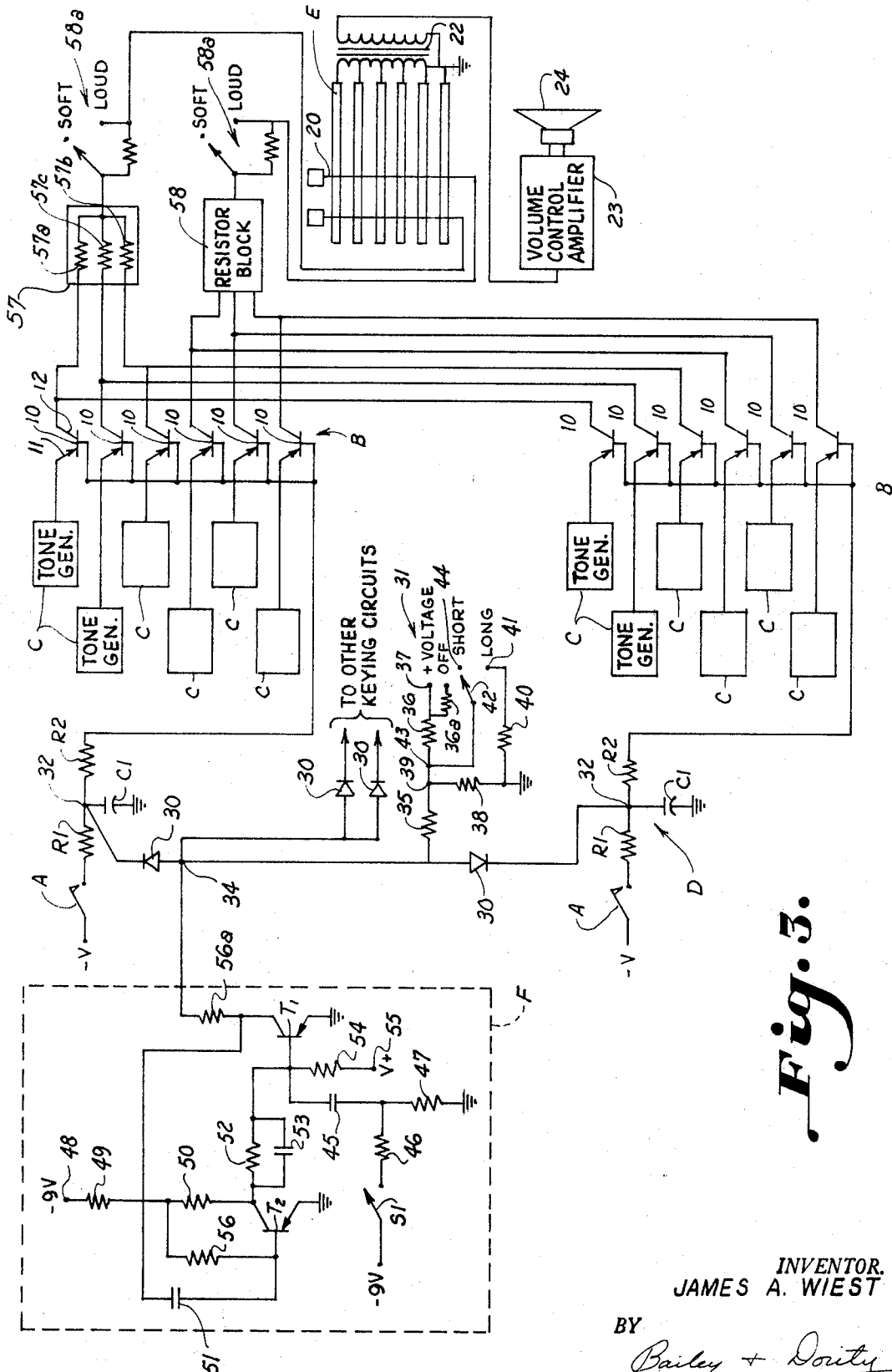


Fig. 3.

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SUSTAIN TONE DEVICE FOR ELECTRICAL MUSICAL INSTRUMENTS

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6 Sheets-Sheet 3

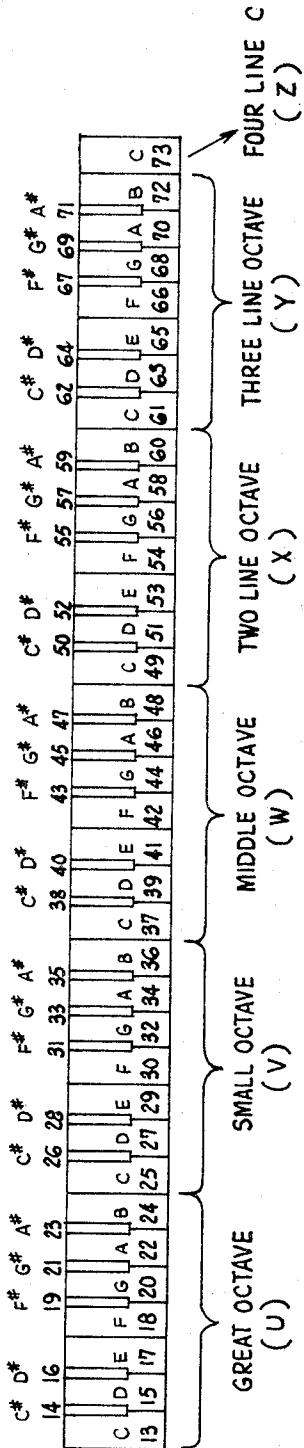


Fig. 4.

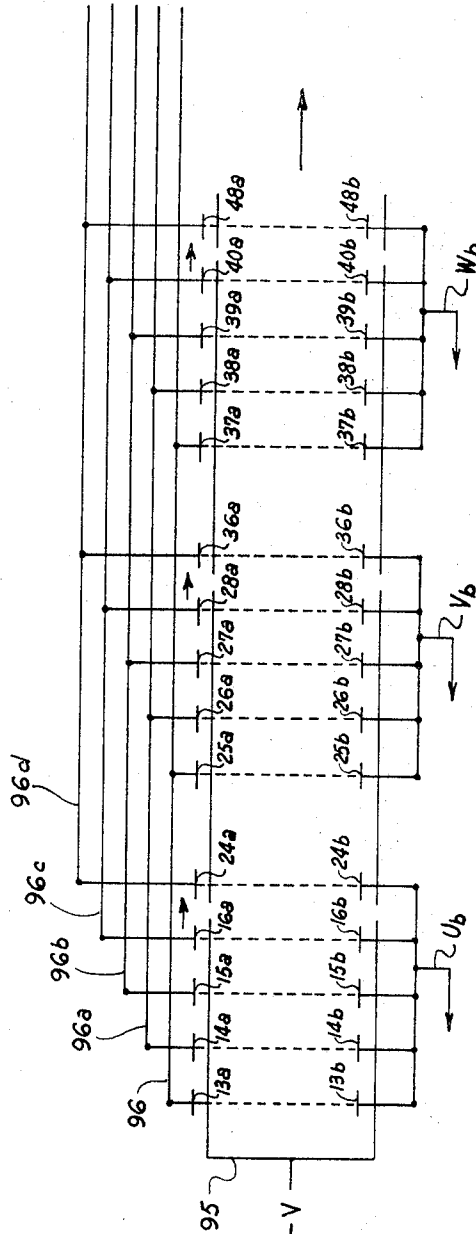


Fig. 5.

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SUSTAIN TONE DEVICE FOR ELECTRICAL MUSICAL INSTRUMENTS

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6 Sheets-Sheet 4

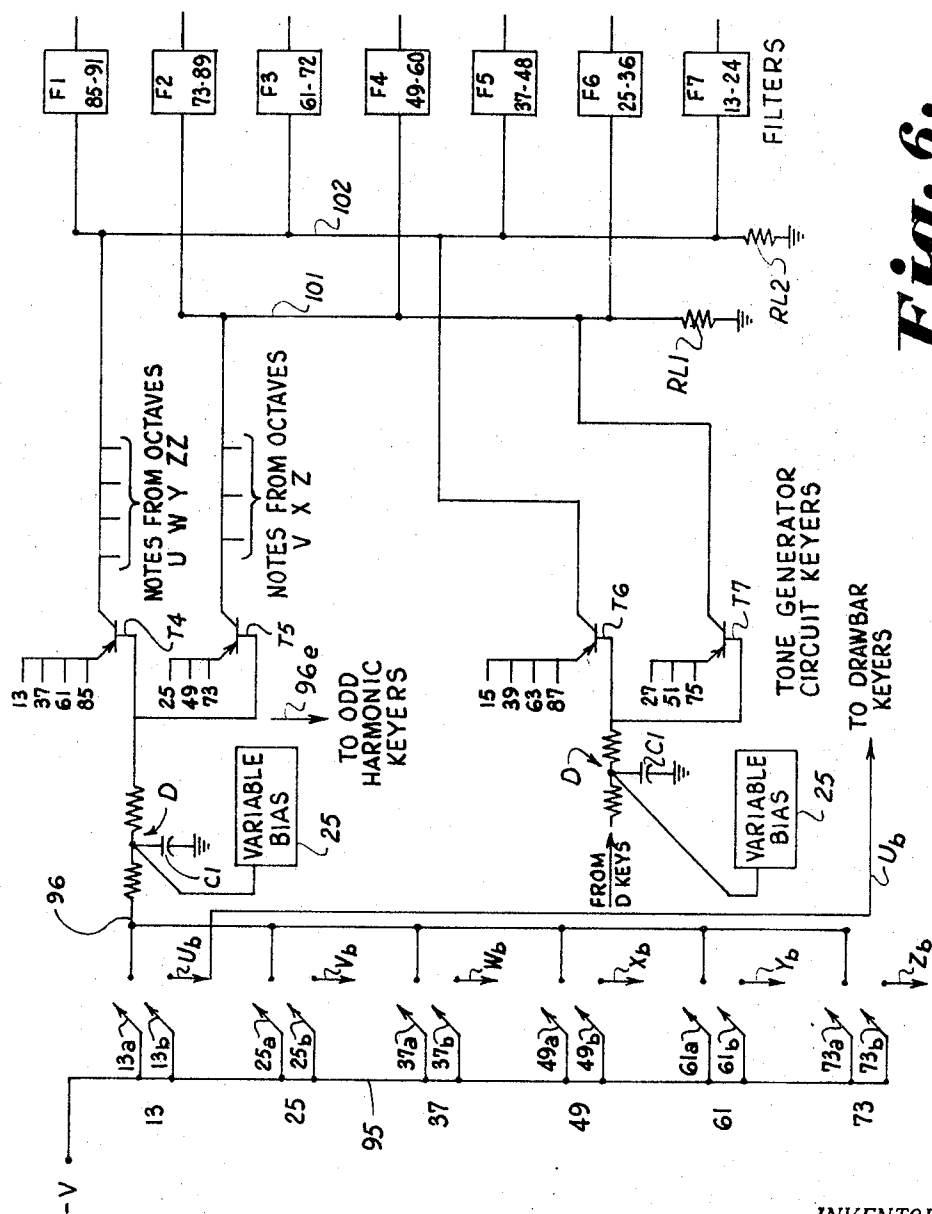


Fig. 6.

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SUSTAIN TONE DEVICE FOR ELECTRICAL MUSICAL INSTRUMENTS

Filed Dec. 20, 1966

6 Sheets-Sheet 5

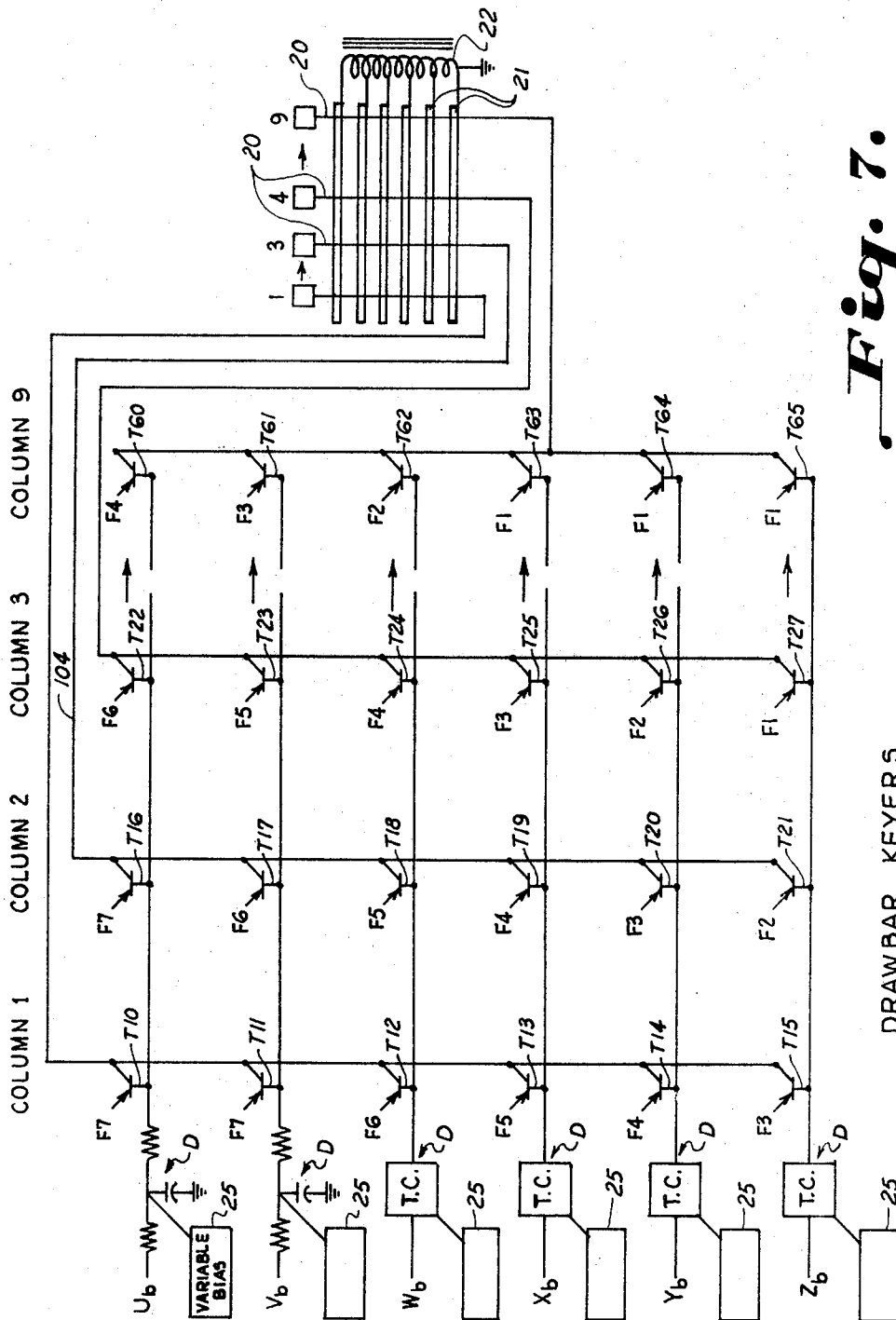


Fig. 7.

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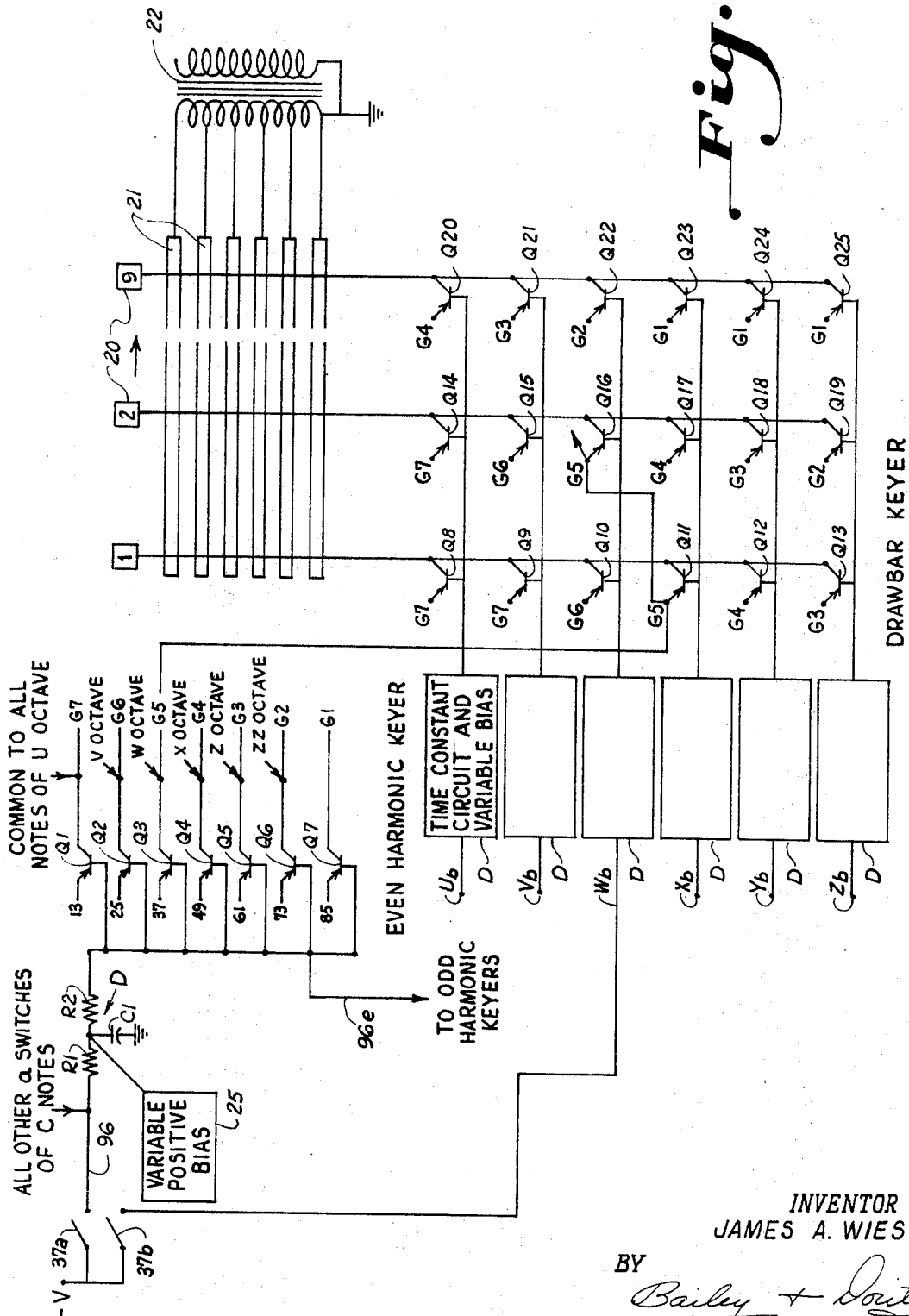
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SUSTAIN TONE DEVICE FOR ELECTRICAL MUSICAL INSTRUMENTS

Filed Dec. 20, 1966

6 Sheets-Sheet 6



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3,519,723

SUSTAIN TONE DEVICE FOR ELECTRICAL MUSICAL INSTRUMENT

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Int. Cl. G10h 1/02

U.S. Cl. 84-1.26

8 Claims

ABSTRACT OF THE DISCLOSURE

An electrical keying circuit which causes the tones produced on an organ to decay at a predetermined rate after release of a playing key. A time-constant circuit is coupled to the playing keys and a plurality of gating devices causing the tones to decay at a predetermined rate. In one particular embodiment a knock-off circuit is provided for discharging the capacitors associated with the time-delay circuit so that a note can be abruptly terminated when a subsequent key is depressed.

This invention relates in general to electronic musical instruments, such as an organ, and in particular to an electrical keying circuit for producing a predetermined rate of decay of a tone after a playing key is released. Moreover, this invention relates to a pedal sustain circuit for an organ or the like, wherein a decaying note is terminated abruptly upon depressing another key or pedal on the organ so as to avoid a displeasing beat note.

In recent years electronic organs began to add new effects to the organ tones. One type of effect was the sustained effect (similar to the sound achieved by the sustained pedal on a piano). With this effect the tone would decay at a predetermined rate after the release of the playing key. This differs from the percussion effect which sounds and decays while holding a key down. Today many organs utilize the sustained feature, but normally by means of a stop tablet arrangement.

One well-known organ for years has featured a drawbar system in which the harmonics of any note could be added at the discretion of the playing artist. In this way the artist was not limited to one prearranged stop tablet tone, but was able to achieve an almost infinite variety of tones or sounds. However, when the sustained or percussion feature was added to the organ such did not operate through the drawbar feature and was limited to a stop tablet arrangement. Thus, much of the possibility of the organ for special effects was minimized.

Another problem in certain of the electronic organs is that the signal or tone generators are keyed directly, thus causing the tone to start and stop instantaneously in accordance with the operation of the playing key. This produces a transit or key thump in the sound reproducing system which, particularly in electronic organs, is considered to be a very undesirable musical effect.

Generally, in order to produce a desired musical note it is necessary to blend several individually generated tones which may be keyed by a single key on the manual of the organ. Such is accomplished by positioning from nine to twelve keying switches, depending on the type of organ being utilized, directly beneath the key on the manual so that upon depressing the key all of the switches are physically closed. For example, in the Hammond organ Model Nos. E-100 and H-100 each of the switches completes a circuit between a tone generator and a respective drawbar of a set of harmonic drawbars. Each of the particular tone generating circuits have been provided with a time-delay circuit for producing a predetermined decay of the note over a very limited range of

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notes equal in scope to one drawbar after the playing key is released.

It is also desirable to provide the bass pedal system of an organ with sustain, however, each note in the bass pedal system should terminate completely prior to the keying of the next note. This removes the undesirable beating effect caused by playing two low frequency notes simultaneously.

In order to prevent the sounding of two notes simultaneously, some circuits utilized a mechanical latching system which latch in one note at a time while simultaneously releasing all other notes. One particular latching system incorporated solenoids for mechanically locking in a note when a bass pedal was depressed. When a second note was generated by depressing another bass pedal, such overloaded an electrical circuit and caused the first solenoid to be deenergized, releasing the first depressed note and causing a solenoid associated with the second depressed note to latch in for holding the switches associated with the second note down. One disadvantage of this system is that it operates too slowly, and it is difficult to adjust the threshold of the solenoid release.

Accordingly, it is an important object of the invention to provide a variable sustain note for an organ, while minimizing the circuitry necessary for obtaining such.

Another important object of the present invention is to minimize key clicks and thumps which are often produced in the playing of a conventional organ or instrument.

Another important object of the present invention is to provide a sustaining note "knock-off" for the bass pedals of an electronic musical instrument, such as an organ.

Still another important object of the present invention is to provide a circuit for producing a sustain note on an electronic musical instrument which utilizes a transistor circuit which does not require the use of a separate voltage supply for the collector circuit.

A further important object of the present invention is to provide a gating circuit for an electronic organ which has fewer components than circuits heretofore utilized.

Still another important object of the present invention is to provide intermanual coupling on an electronic musical instrument which has a plurality of manuals or sets of playing keys.

The construction designed to carry out the invention will be hereinafter described, together with other features thereof.

The invention will be more readily understood from a reading of the following specification and by reference to the accompanying drawings forming a part thereof, wherein an example of the invention is shown and wherein:

FIG. 1 is a circuit diagram illustrating an electrical keying system for an organ having a plurality of playing keys which produces a predetermined rate of decay of a tone after the release of a playing key.

FIG. 2 is a schematic diagram, illustrating intercoupling between a key of one manual and a key of another manual whereby by depressing a single key a note is produced simultaneously on both manuals.

FIG. 3 is a circuit diagram for an electronic musical instrument provided with a "knock-off" circuit wherein only a single note is played at a time.

FIG. 4 is a schematic illustration of an organ keyboard.

FIG. 5 is a schematic diagram of the wiring circuit for switches located under a keyboard of an organ.

FIGS. 6 and 7 are circuit diagrams of a modified form of the invention.

FIG. 8 is a circuit diagram of still another modified form of the invention.

Referring in more detail to FIG. 1 of the drawings, such illustrates an electrical keying circuit for a musical instrument, such as an organ, which has a plurality of playing keys A. The electrical keying circuit causes the tones produced by the organ to decay at a predetermined rate after the release of a playing key. A bank of electronic gating devices B, each having an input, output and control electrode, is associated with each key A for selectively gating tones to an output circuit for producing a musical note. A respective tone generating circuit C is connected to the input electrode of each gating device and supplies a constant tone thereto. The control electrodes of each gating device are coupled together so that all of the gating devices in a particular bank B may be turned on and cut off simultaneously. Each of the playing keys A is electrically connected between a voltage source and the coupled control electrodes for selectively connecting the voltage source to the control electrodes within a bank of gating devices when depressed. When the voltage source is connected to the control electrodes the respective gating devices B gate the tones to the output circuit. A time-constant circuit D, which includes a resistor and a capacitor, is interposed between the playing keys and the control electrodes of a bank of gating devices B for producing a controlled decay of voltage on the control electrodes when the associated playing key is released. Thus, when a key A is depressed the bank of gating devices B associated therewith, gates the tones produced by the tone generating circuits C to the output circuit and upon releasing the key the tones decay at a predetermined rate. The output circuit includes a harmonic drawbar assembly E wherein, the drawbars associated with the assembly may be pulled out for mixing the tones in various proportions for producing a desired musical note.

FIG. 3 of the drawings illustrates the bass pedal circuitry for the organ, which is operated by the foot pedals. The keying circuit is similar to that illustrated in FIG. 1, however, a "knock-off" circuit F is provided for discharging the capacitors associated with the time-constant circuits D so that a note is abruptly terminated when a subsequent key is depressed. This removes the undesirable beating effect caused by playing two low frequency notes simultaneously.

Frequently, it is desired to mix tones produced by the keys of one manual with the tones produced by keys of another manual. Heretofore, such was accomplished by playing the keys of one manual with one hand and playing the keys of the second manual with another hand. The intercoupled circuit G of FIG. 2 permits the tones of two different manuals to be played simultaneously by depressing keys on a single manual.

Referring in more detail to FIG. 1, such illustrates a circuit wherein a plurality of gating devices B gate tones to an output circuit responsive to depressing a key A associated with the particular gating device. Each gating device includes a plurality of P-N-P transistors 10, each of which has an emitter electrode 11, a collector electrode 12, and a base electrode 13. The number of transistors utilized in each gating device depends on the number of tones that are desired to be mixed in order to create a particular musical note. In some organs from nine to eleven tones are blended together in order to produce a single note. Thus, each gating device would include from nine to eleven transistors. Heretofore, in one well-known electronic organ the tones from the tone generators were electrically connected to the drawbar system E by means of a plurality of key switches located directly below the playing key on a manual. Thus, when the playing key was depressed all of the key switches located therebelow would be closed. The subject keying circuit eliminates such switches.

A tone generating circuit C is electrically connected to

the emitter 11 of each transistor by means of a lead 14. Any suitable tone generator circuit may be utilized and one suitable circuit is used in the Hammond organs, particularly, Model No. E-100. Each of the tone generator circuits includes a tone generator 15 comprising a spinning wheel which is rotating to induce a particular tone in a magnetic pickup (not shown), which in turn, feeds the tone through a filter capacitor 16 to a matching transformer 17. The transformer 17 is generally tuned to a particular frequency and the impedance of the transformer 17 is utilized in the circuit as a load impedance for the emitter 11 of the transistor 10.

In most organs, and in the particular circuit illustrated, when the organ is turned on the tone generators produce a constant tone and supply such to the emitters of the transistors in the keying circuit. In order to key the tones from a particular group of tone generator circuits C to an output circuit it is necessary to put a negative voltage on the base electrode 13 of each of the transistors associated with that particular key or a positive voltage if an N-P-N transistor is being used.

Thus, there is a bank of transistors or gating device B associated with each playing key A on the organ. All of the base electrodes 13 of a particular bank of transistors are coupled together as by leads 18 so that by placing a voltage thereon, all of the transistors within the particular bank of transistors can be turned on and off simultaneously. A negative potential source is connected to each terminal 19, and when the key A associated with such terminal is depressed such voltage is applied to the base electrodes 13 of the transistors 10 associated with the key A, causing the transistors to turn on. When the transistors begin conducting the tones or frequencies produced by the tone generating circuit are gated through the transistors 10 to the output circuit.

The collectors 12 of the transistors are connected to a respective drawbar 20 of a conventional drawbar system E, such as utilized in the previously mentioned Hammond organs. By pulling the drawbars 20 out electrical contact is selectively made with one of the bus bars 21 of a harmonic drawbar system. The harmonic drawbar system is illustrated schematically, since such is a conventional item as is commonly used in the Hammond organs. The bus bars 21 are tapped onto the primary winding of the transformer 22. The secondary winding of the transformer is connected to a volume control amplifier 23 and feeds the musical note or composite tone to an output speaker 24.

By pulling the drawbars 21 out selected amounts the tones created by the tone generators C may be blended in a substantially unlimited manner.

It is noted that in the subject device no additional load resistors for the collectors 12, nor any additional load resistors for the emitters 11 of the transistors are necessary. The subject circuit merely uses the existing impedances, such as provided by the tone generator transformer 17, and such as provided by the impedance of the transformer 22 associated with the drawbar system.

A time-constant circuit D is interposed between each of the playing keys A and the control or base electrodes 13 of each bank of gating devices for producing a predetermined rate of decay of voltage on the control electrodes B when the playing key is released. Thus, when the playing key is released instead of the musical note terminating abruptly it tapers off gradually according to the charge on a capacitor C1 and the value of the variable bias source generally designated at 25. The time-constant circuit includes a resistor R1, a capacitor C1, and a resistor R2. The resistor R1 and capacitor C1, also, constitute a thump filter for the key while resistor R2 and the capacitor C1 form the decay network. The time-constant circuit is connected by means of a resistor R3 to a variable positive bias voltage 25 for controlling the length of the decay of each note. By moving a contact

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arm 26 the positive voltage can be varied from an upper terminal 27 wherein, the positive bias is at a minimum to a lower terminal 29 when the positive bias is at a maximum. Thus, when the positive bias is at a minimum the length of decay of the note is longer than when the positive bias is at a maximum. Such is due to the fact that the bias aids in controlling the discharge of the capacitor C1 of the time-constant circuit D. When the arm is connected to the "off" terminal 29a a high positive voltage is applied to the time-constant circuit and there is substantially no sustain. Another purpose of the variable bias source 25 is to maintain a positive bias at all times on the bases of the transistors 10 in order to prevent bleeding through or leakage of the transistors. Such eliminates what is generally referred to as note cyphering.

The circuitry of FIG. 1 illustrates a simple, inexpensive, and convenient method of selectively gating tones of a plurality of tone generators 15 to a harmonic drawbar system E for producing musical notes.

FIG. 3 illustrates the bass pedal circuitry for the organ which is operated by foot pedals. The keying arrangement for each of the keys or foot pedals A is identical to that of the keying arrangement used on the manuals described above in connection with FIG. 1, and such description will not be repeated, except for the differences between the two circuits.

The bass pedal circuitry has a "knock-off" circuit F, shown in dotted lines, for causing a note to terminate abruptly when a subsequent key is depressed. Such removes the undesirable beating effect caused by playing two low frequency notes simultaneously. It is noted that each of the time-constant circuits D associated with the respective keys of the foot pedals are connected through diodes 30 to a variable bias source generally designated at 31. The diodes are wired so that their cathodes are connected to a terminal 32 of a respective time-constant circuit D to which capacitor C1 is connected. The anodes of each of the diodes are connected to terminal 34. The variable bias source 31 is also connected to the terminal 34 for controlling the length of the decay of the musical note when the key or bass pedal A is released.

The variable bias source includes a pair of voltage dividing resistors 35 and 36, respectively, which are connected in series with the positive voltage source 37. A current limiting resistor 38 is connected between resistors 35 and 36 to terminal 39. The other side of resistor 38 is connected to ground. A second current limiting resistor 40 has one end connected to ground and the other end connected to the terminal 41. A movable contact arm 42 having one end connected to a terminal 43 located between resistors 35 and 36 is provided for varying the voltage supplied to the anodes of the diodes 30. When the movable arm is in contact with terminal 44 the voltage coupled to capacitor C1 of the discharging circuit is such to cause the capacitor to discharge in a short period of time. When the movable arm is placed in contact with terminal 41 the voltage supplied by the variable voltage source 31 is small compared to when the arm is in contact with terminal 44, and as a result the period of discharge of the capacitor C1 in the time-delay circuit D is much longer. When arm 42 is placed in the "off" position, much higher positive bias is placed on the capacitance C1 by means of resistor 36a and there is substantially no sustain.

As previously mentioned, it is desired in the bass pedal circuitry to terminate a note completely when a subsequent pedal or key is depressed so as to avoid undesirable beating. Such is accomplished by use of the "knock-off" circuit F. The "knock-off" circuit has a switch S1 therein, which is closed simultaneously when any of the pedals A are depressed causing the "knock-off" circuit to provide a discharge path for the capacitors C1 of the time-constant circuits D associated with each playing key or pedal. Thus, if a note was decaying when a subsequent pedal were depressed the decaying note would terminate

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abruptly due to the capacitor discharging through the "knock-off" circuit.

The "knock-off" circuit in the preferred embodiment is a monostable multivibrator, which when activated by closing switch S1 makes one complete flip so as to momentarily provide a discharge path for the capacitors C1 of the time-constant circuits. The closing of switch S1 connects a negative voltage to one side of capacitor 45 through the voltage dividing circuit consisting of resistors 46 and 47. When the potential on capacitor 45 builds up to the cut-on potential of a transistor T1 capacitor 45 discharges and supplies a pulse to the base of transistor T1 causing such to turn on. Normally, transistor T2 is conducting due to the flow of current from the negative voltage source 48 through resistors 49 and 50. However, when transistor T1 begins to conduct the collector voltage decreases, and since such is coupled to the base of transistor T2 through capacitor 51 such causes the base current and collector current of transistor T2 to decrease. The increasing collector voltage of transistor T2 (coupled to the base of transistor T1 through resistor 52 and capacitor 53) then increases the forward base current of transistor T1. This regeneration rapidly drives transistor T1 into saturation and transistor T2 into cut-off. Capacitor 53 then discharges through resistor 52 and the lower saturation resistance of transistor T1. As the base potential of transistor T2 becomes slightly negative, transistor T2 again conducts. The decreasing collector potential of T2 is coupled to the base of transistor T1 and transistor T1 is driven into cut-off while transistor T2 becomes saturated. This stable condition is maintained until another pulse triggers the circuit, such as by closing switch S1. It is noted that the base of transistor T1 is maintained at a positive potential by means of connecting such through resistor 54 to a positive potential connected to terminal 55. Such is to cut-off the transistor T1 and prevent it from bleeding down. It is also noted that there is a bias resistor 56 connected between the collector electrode and the base electrode of transistor T2.

Thus, when the transistor T1 of the monostable multivibrator is conducting a discharge path is provided for the capacitors C1 of the time-constant circuits D through the diodes 30, resistor 56a, transistor T1 to ground. If any note were decaying when a subsequent key was depressed, such abrupt discharge of the capacitor C1 would terminate that note immediately. The monostable multivibrator is a conventional multivibrator which is discussed in the RCA Transistor Manual.

The output circuit for the bass pedal circuit is similar to that of the manual output circuit. However, in the bass pedal circuit the collectors of selected transistors of each bank of transistors B are fed into resistor blocks 57 and 58, respectively, for blending different harmonics in order to produce the desirable bass tone. The resistor blocks include a plurality of various size resistors 57a, 57b, and 57c, which are in series with the collector outputs. The output of the resistor block is fed to a loud-soft switch 58a, and then to a respective drawbar 20 of a harmonic drawbar system. The harmonic drawbar system may be the same drawbar system as is illustrated in FIG. 1 used for the manuals, or it may be an entirely different drawbar used specifically for the bass pedal circuitry. The output of the drawbar system is fed through a transformer 22, a volume control amplifier, and a speaker (not shown).

FIG. 2 illustrates one means of utilizing a plurality of keys for keying the same note. For example, one key may be located on the lower manual, while the other key may be located on the upper manual. Intermanual coupling may be achieved by placing isolating diodes in the circuitry. Such intermanual coupling could also take place between the pedals and one of the manuals.

In this particular circuit a pair of diodes 59 and 60, respectively, are coupled in series between a pair of keys A located on different manuals with a positive volt-

age 61 positioned between the two diodes. When a normally closed switch 62 is opened the positive potential is removed from between the two diodes permitting the voltage from the negative source 63 to be supplied to its own keying system which in the circuit illustrated is on the lower manual keying transistors, as well as to a keying system of the upper manual which is generally referred to as 64. This permits a mixing of tones produced by a key of the lower manual with that of the upper manual. For example, if there is a string combination on the upper manual and a flute combination on the lower manual you could play them simultaneously from the lower manual by merely closing switch 62, rather than playing with one hand on the upper manual and the other hand on the lower manual.

The modified form of the invention illustrated in FIGS. 4 through 7 discloses another circuit in which a musical note is permitted to decay at a predetermined rate after a playing key is released. This circuit minimizes the number of transistors utilized by mixing all notes of a single type (all C's or all G's, etc.) and keying them with a pair of transistors rather than keying each tone separately as is the case in the circuit illustrated in FIG. 1.

The output of the pair of transistors contain all the C's which appear anywhere on the manual. The next function is to separate the mixed tones (each separated by two octave intervals), apply them to a drawbar keyer circuit and then to their respective drawbars.

In order to facilitate ones understanding of the modified form of the invention illustrated in FIGS. 5, 6, and 7 a keyboard is illustrated schematically in FIG. 4 and the keys on the manuals of the organ are numbered 13 through 73, respectively. On a normal or conventional organ manual you have five octaves of keys. Starting at the lowest pitched octave keys 13 through 24 are referred to as the great octave, keys 25 through 36 are referred to as the small octave, keys 37 through 48 are referred to as the middle octave, keys 49 through 60 are referred to as the two line octave, keys 61 through 72 are referred to as the three line octave, and key number 73 is generally referred to as the four line C. Each of the octaves has been assigned a reference character U through Z, respectively.

Each key on the manual has associated therewith, two switches *a* and *b*, respectively. For example, key 13 would have an *a* and *b* switch thereunder, which are identified as C 13*a* U and C 13*b* U, respectively. The C identifies the type note; the 13 identifies the particular key; the *a* or *b* identifies the particular switch located under the key; and the U identifies the octave in which the key is located. The E of that same octave would be identified as E 17 U. To refer to an E in the middle octave you would refer to it as E 41 W. To aid in understanding the subject invention one note C will be discussed and traced throughout the entire circuitry. All of the other eleven notes of the musical scale would operate in the same manner.

As previously mentioned, under each key there are a pair of switches *a* and *b* (FIG. 5), respectively. The *a* switches are utilized to control the tone generator circuit keyers, whereas, the *b* switches are utilized to control the drawbar keyers. It is noted that all of the *a* switches for any given note are coupled together by leads 96, 96*a*, 96*b*, 96*c* and 96*d*, respectively. For example, the C in the great octave which is key 13, is wired by lead 96 to the C in the small octave, key 25; the C in the middle octave, key 37; the C in the two line octave, key 49; and the C in the three line octave, key 61, and also the C in the four line octave key 73. It is noted that the *b* switch which feeds the drawbar keyers are wired together octavely. For example, all notes from 13 to 24 have their *b* switches wired together.

Assume that key 37 which is middle C (W octave) is

depressed. Such causes switches 37*a* and 37*b* located therebelow, to be closed. When switch 37*a* is closed a negative potential which is supplied to bus bar 95 is placed on lead 96 which is connected to the coupled bases of transistors T4 and T5 (FIG. 6) by means of a time-delay circuit D. The time-delay is a sustain decay network which operates in conjunction with transistors T4 and T5 in a similar manner as was described in the circuits of FIGS. 1 and 3 above. There is a positive variable bias potential 25 associated therewith for controlling the discharge of capacitor C1 when the key is released. To the emitters of the transistors T4 and T5 are connected the respective conventional tone generator circuits for the C keys. It is noted that the outputs of tone generator circuits 13, 37, 61 and 85 are all coupled to the emitter of transistor T4, while the outputs of tone generators 25, 49 and 73 are connected to the emitter of transistor T5. The reason the tone generators associated with all of the C notes are connected to two transistors T4 and T5, respectively, rather than fed through a single transistor is to achieve octave isolation for facilitating a delineated filtering at a subsequent stage when it is desired to separate the notes. Thus, on the output or collector of transistor T4 the C notes 13, 37, 61 and 85 are mixed together, while on the output of transistor T5 the C notes 25, 49 and 73 are mixed together. It is noted that the output from transistor T4 is connected to lead 102 and the output from transistor T5 is connected to lead 101. The outputs from all other note generator keyers are common to either of the leads 101 or 102. For example, in the keyer for note D the output of transistor T6 is connected to lead 102 and the output transistor T7 is connected to lead 101. It is also noted that on the emitter of transistor T6 tone generators 15, 39, 63 and 87 are coupled thereto, while tone generators 27, 51, and 75 are coupled to the emitter of transistor T7. Each of the notes in an octave has a similar keying arrangement, such as illustrated, for the C and D notes, respectively. Leads 101 and 102 are connected to ground through load resistors RL1 and RL2, respectively.

Leads 101 and 102 are coupled to a plurality of filtering networks F1 through F7, respectively. These filters are conventional bandpass filters wide enough to pass frequencies within one octave. For example, filter F5 will pass the notes of the middle octave which includes keys 37 through 48. Thus, when any C note is depressed, in this case C37, each filter will permit only the C in its bandpass to pass therethrough. For example, on the output of filter F1 C85 will be present, on the output of filter F2 C73 will be present, on the output of F3 C61 will be present, etc. One suitable bandpass filter is illustrated in the book "Hand Book of Electronic Tables and Formulas" published by Howard W. Sams & Co. of New York, N.Y. The outputs of the filters F1 through F7 are then applied to a plurality of drawbar keyers shown in FIG. 7.

The drawbar keyers include a plurality of banks of transistors wherein rows of such are keyed by respective octave *b* switches, and the emitters for the transistors in each column are supplied with the outputs of the filters. For example, transistor T10 in column 1 has its base electrode connected to lead Ub through a time-constant network D including a variable bias 25. It is noted that the bases of the transistors T16, T22 and T60 are also coupled to the same lead line Ub. There are five more columns having similar connections which are not shown. On the emitter of transistor T10 the output of filter F7 is supplied.

Since we are discussing the tone produced by key 37, which has come through filter F5, it is found that the tone is being supplied to the emitters of transistor T13, transistor T18 and transistor T23, and several others in the columns, not shown. However, since only row W*b* is keyed by closing the *b* switch under key 37, the tone from key 37 will only come through transistor T18 and

be connected by lead line 104 to drawbar 3. In addition to transistor T18 being keyed all of the transistors in the row Wb are keyed; namely T12, T24, etc., each of which will supply its respective drawbar 1, 3, etc., with its proper tone, which will be harmonically related to key 37. Thus, by pulling out the drawbars 1 through 9, respectively, the harmonic tones could be blended together and made available on the output transformer 22 for producing a musical note.

Since the other rows of keys are not keyed, no other tones except those associated with row Wb will be permitted to get through to the drawbar system. The time-constant circuit D associated with each row operates in the same manner as the time-constant circuits described previously in connection with FIG. 1 and produces a sustained decay after the key is released. The output circuit associated with the drawbar system may be the same as illustrated in FIG. 1.

It is noted that the number of transistors are substantially reduced from that utilized in the circuit illustrated in FIG. 1 by merely supplying the playing keys with an additional row of switches which in this case are the b switches. The circuit illustrated in FIGS. 4 through 7 is also much simpler to wire especially with regard to the keyer switches.

Harmonics not octavely related may be keyed in the same manner as the octavely related tones by connecting the base electrodes of a pair of transistors similar to transistors T4 and T5 lead 96e and keying the transistors simultaneously with transistors T4 and T5. The non-octavely related harmonics are supplied to the emitters of the transistors. The outputs of the non-octavely related transistor keyers are fed through filters, the drawbar keyer and to a non-octavely related drawbar. Thus, all octavely related keying can be accomplished with approximately 72 transistors and all secondary keying or non-octavely related keying can be accomplished with approximately 72 transistors.

FIG. 8 illustrates still another modified form of the invention wherein a musical note decays gradually when the key for activating such is released. The circuit is similar to that illustrated in FIGS. 5 through 7 with the exception that banks of transistors keying circuits similar to those illustrated in FIG. 1 are utilized instead of a pair of transistors and the plurality of bandpass filters.

Each of the playing keys on the organ have a pair of switches a and b located therebelow, which are wired together in the same manner as those illustrated in FIG. 5. The tone produced by the operation of key 37, which is middle C, will be traced through the entire circuit in order to illustrate the operation of the circuit. The a switch associated with key 37, as well as the a switches of all the other C keys, when closed causes a negative potential to be applied to the time-constant circuit D causing the capacitor C1 to charge. The time-constant circuit has a variable positive bias voltage 25 associated therewith, for controlling the discharge time of capacitor C1 when the key is released. The negative voltage is also applied to the base electrodes of one bank of transistors which includes transistors Q1 through Q7. This bank of transistors is associated with the C note and the other common notes, such as D's, E's, etc., have a respective bank of transistors associated therewith in a similar manner. The tone generator circuits associated with the C notes are connected to the emitter electrodes of the transistors Q1 through Q7, respectively. For example, the tone generator circuit for key 13 is connected to the emitter of transistor Q1, the tone generator circuit for key 25 is connected to the emitter of transistor Q2, etc. Thus, when one of the C's on the organ is depressed the tones connected to the emitters of the transistors Q1 through Q7 pass through the collectors of the transistors to the output leads G1 through G7, respectively.

Each of the output leads G1 through G7 is common to all of the notes of a respective octave. For example, all

of the notes of the great octave U are common to the output lead G7, all of the notes from the small octave V are common to the lead G6, etc. The leads G1 through G7 are then connected to the respective G emitter electrodes of the transistors in the drawbar keyer circuit. For example, the note 37 will be connected by lead G5 to the emitters of transistors Q11, Q16 and a number of other transistors in columns not shown.

Since switch 37b, when closed, connects a negative voltage to the base of transistors in the row Wb, note 37 can only come through transistors Q16 to drawbar 2. It is, also, noted that the negative voltage is applied to the base of electrodes of all of the transistors in the Wb row, and by pulling out the drawbar associated with such row the notes being played may be mixed. Each of the rows has a time-constant circuit D associated therewith, and each of the time-constant circuits has a variable positive bias potential source connected thereto (not shown) for controlling the decay of the notes being supplied to the transistors of the drawbar keys. Harmonics not octavely related may be keyed by connecting the base electrode of another keyer to lead 96e and keying such in a similar manner as discussed in connection with FIGS. 6 and 7.

In summarizing the operation of the circuit illustrated in FIG. 8 when a key, such as the middle C, is depressed switches 37a and 37b are closed. When switch 37a is closed a negative potential is placed on the base electrode of the harmonic keyer including transistors Q1 through Q7. Such would also be true if any of the C notes on the organ would have been depressed. The negative voltage is also applied to capacitor C1 in the time-constant circuit causing such to charge. When the negative voltage is placed on the base of the transistors the respective tones coupled to the emitter electrodes of the transistors, which in this case are from tone generator circuits 13, 25, 37, 49, 61, 73 and 85, are permitted to pass to the output circuit of the transistors which are designated as leads G1 through G7, respectively. After the key is released switch 37a is opened and the charge on capacitor C1 of the time-constant circuit permits the voltage on the base of the transistors of the harmonic keyers to gradually decrease, providing a gradual decay of the tones passing through the transistors of the keyer. By varying the positive bias from the source 25 the duration of the decay can be altered. The outputs of the harmonic keyer are fed to the emitter electrode of respective transistors of the drawbar keyer as indicated in the drawing. It is noted that there is an output on each of the output leads G1 through G7, since the base electrodes of the keyer are coupled together and all of the transistors Q1 through Q7 are turned on simultaneously. It is also noted that other tones or notes of the same octave are coupled to a respective output lead G1 through G7 when one of the notes is depressed.

When key 37 was depressed switch 37b was closed causing a negative voltage to be supplied to the base electrodes of a particular row of transistors located in the drawbar keyer. In this case the negative voltage will be supplied by means of lead Wb through a time-constant circuit D which includes a variable bias to the base electrodes of transistors Q10, Q16, Q22, and other transistors in columns not illustrated. Such causes the transistors in that particular row to be turned on to permit the notes being fed to the respective emitters to pass to the output circuit or collector of the particular transistor. In the present case, since there is a note being supplied to transistor Q1, such will pass the tone or note to the drawbar 2 of the drawbar output circuit. This tone is in turn fed through the output transformer 22, the volume control device and the output speaker in the same manner illustrated in connection with the device in FIG. 1. Other notes coupled to the emitter electrodes of the transistors in the row Wb may be blended in with the notes being passed by transistor Q16 by pulling out the drawbars 1 through 9, respectively, coupled to the output circuit of

the respective transistors. For example, if drawbar 1 and 9 were pulled out, transistors Q10 and Q22, respectively, would permit the tone coming in on leads G2 and G6, respectively, to pass to the harmonic drawbar system to be blended with note 37.

The time-constant circuit and variable bias of the drawbar keyer should be balanced with the time-constant circuit associated with the even harmonic keyer so that the notes decay at a predetermined rate when the switches 37a and 37b are opened by releasing the key 37. It is also noted that key thumps are minimized in the present circuit due to the manner in which the time-constant circuits are connected thereto, as well as for other unexplainable reasons.

While a preferred embodiment of the invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that changes and variations may be made without departing from the spirit or scope of the following claims.

I claim:

1. For use in a musical instrument such as an organ having a plurality of playing keys, an electrical keying circuit for providing a gradual decay of a musical note when the playing key is released comprising: a plurality of banks of transistors, each bank being associated with a playing key; each transistor having a base, emitter and collector electrodes; the base electrodes of each transistor within a bank being electrically connected together; a respective tone producing circuit connected to the emitter electrode of each transistor; an output circuit including a harmonic drawbar system, each collector electrode in a bank of transistors being connected to a drawbar of said drawbar system; a voltage source; each of said playing keys being electrically connected between said voltage source and the base electrodes of a respective bank of transistors for selectively connecting the voltage source to the base electrodes when depressed and placing said transistors in a conductive state whereupon said tones supplied to the emitters of said transistor are gated to the output circuit; a time-constant circuit including a resistor and a capacitor electrically coupled to each key for producing a controlled decay of voltage on said bank of transistors when said playing key is released, whereby said tone being gated through a transistor decays in accordance with the decaying voltage on the base electrode of the transistor, and means for abruptly discharging the capacitor of the time-constant circuit associated with the previously depressed key when another key is depressed for preventing overlapping of notes.

2. The keying circuit as set forth in claim 1 wherein said means for abruptly discharging the capacitor includes an electronic circuit which momentarily provides a discharge path for the capacitors of the time-constant circuits when a key is depressed.

3. For use in a musical instrument such as an organ having a plurality of playing keys, an electrical keying circuit for producing a predetermined rate of decay of a tone after release of a playing key and terminating such decay upon depressing another key comprising: an electronic gating device associated with each key for selectively gating tones to an output circuit for producing a musical note; a tone generating circuit connected to each gating device for supplying a constant tone thereto; a voltage source; each of said playing keys being electrically connected for selectively coupling the voltage source to a gating device when depressed whereupon when said voltage source is connected to the gating device such gates the tone to the output circuit; a time-constant circuit including a resistor and capacitor for producing a controlled decay of voltage on said gating device when said playing key is released; and means including a monostable multivibrator for abruptly discharging the capacitor of the time-constant circuit associated with the previously de-

pressed key when a subsequent key is depressed for preventing overlapping of notes.

4. For use in a musical instrument such as an organ having a plurality of playing keys, an electrical keying circuit for producing a desired tone having a predetermined rate of decay after release of a playing key comprising: a plurality of tone gating devices; a selected group of tone generating circuits connected to each gating device for supplying a plurality of tones thereto; a voltage source; a switch means coupled to said voltage source and each tone gating device, said switch means operated responsive to depressing said key for supplying a voltage to said gating device, said gating devices passing the tones supplied thereto to their outputs responsive to the voltage being supplied thereto from the voltage source; a filtering circuit coupled to the outputs of said gating devices isolating said tones into groups having a common frequency range and supplying each group to a respective output channel; a matrix including a plurality of switching devices; means for supplying groups of tones from the output channels of said filtering circuit to selected switching devices of said matrix; an output sound reproducing circuit; said switch means supplying a voltage to selected switching devices of said matrix when operated responsive to depressing said key for causing said switching devices having tones supplied thereto to be activated and to pass the tones to said output sound reproducing circuit; and time-delay means for each tone gating device providing a gradual decay of voltage to a gating device responsive to releasing said playing key associated with said gating device, whereby when a playing key is depressed a tone will be gated to an output circuit and when the key is released the tone decays at a gradual rate.

5. The device as set forth in claim 4 wherein each tone gating device includes a pair of transistors, each having an emitter, base and collector electrode, and wherein a portion of said selected group of tone generating circuits are connected to the emitter of one transistor and the remainder of said tone generating circuits of said group are connected to the emitter of said other transistor, said base electrodes of the transistors of each gating device being coupled together and said voltage source supplying a voltage to said coupled base electrodes when said switch actuating means is operated responsive to depressing said key.

6. The device as set forth in claim 4 wherein said filtering circuit isolates said tones into groups corresponding to octaves on an organ.

7. For use in a musical instrument such as an organ having a plurality of playing keys, an electrical keying circuit for producing a desired tone having a predetermined rate of decay after release of a playing key comprising: a plurality of tone gating devices; a selected group of tone generating circuits connected to each gating device for supplying a plurality of tones thereto; a voltage source; a switch means coupled to said voltage source and each tone gating device, said switch means operated responsive to depressing said key for supplying a voltage to said gating device; each of said gating devices passing the tones supplied thereto to a plurality of output channels responsive to the voltage being supplied thereto from the voltage source; a matrix including a plurality of switching devices; means for supplying tones from the output channels of said gating devices to selected switching devices of said matrix; an output sound reproducing circuit; said switch means supplying a voltage to selected switching devices of said matrix when operated responsive to depressing said key for causing said switching devices having tones supplied thereto to be activated and to pass the tones to said output sound reproducing circuit; and time-delay means for each tone gating device providing a gradual decay of voltage to a gating device responsive to re-

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leasing said playing key associated with said gating device, whereby when a playing key is depressed a tone will be gated to an output circuit and when the key is released the tone decays at a gradual rate.

8. The device as set forth in claim 7 wherein said tone gating device includes a plurality of transistors, each having an emitter, base and collector electrode, and wherein each tone generating circuit of said selected group is connected to an emitter electrode of a respective transistor of said gating device, said base electrodes of the transistors of each gating device being coupled together and said voltage source supplying a voltage to said coupled base electrodes when said switch actuating means is operated responsive to depressing said key for turning on the corresponding gating device.

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