

March 15, 1966

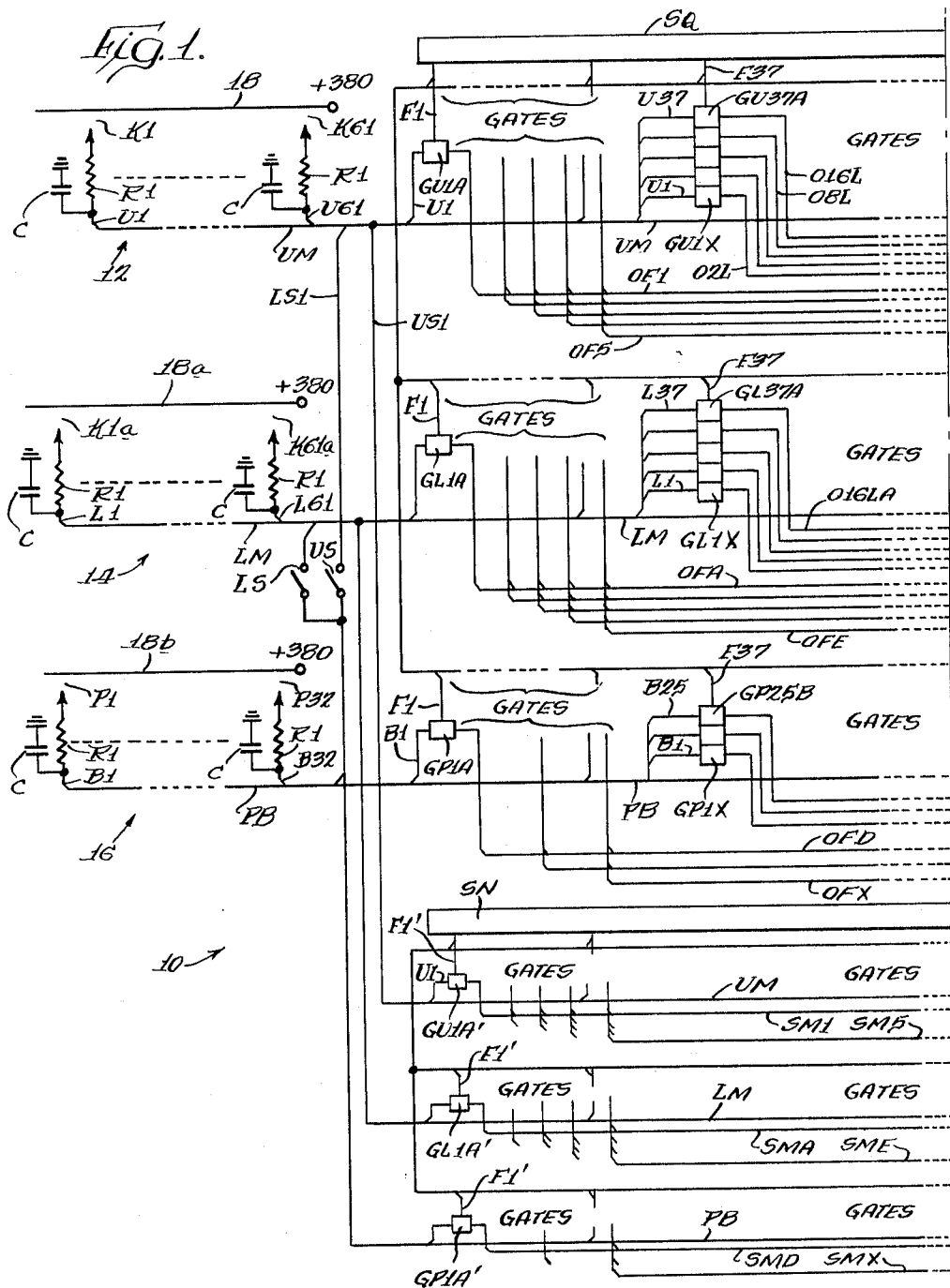
J. M. HANERT

3,240,858

ELECTRICAL MUSICAL INSTRUMENT

Filed Nov. 26, 1962

5 Sheets-Sheet 1



March 15, 1966

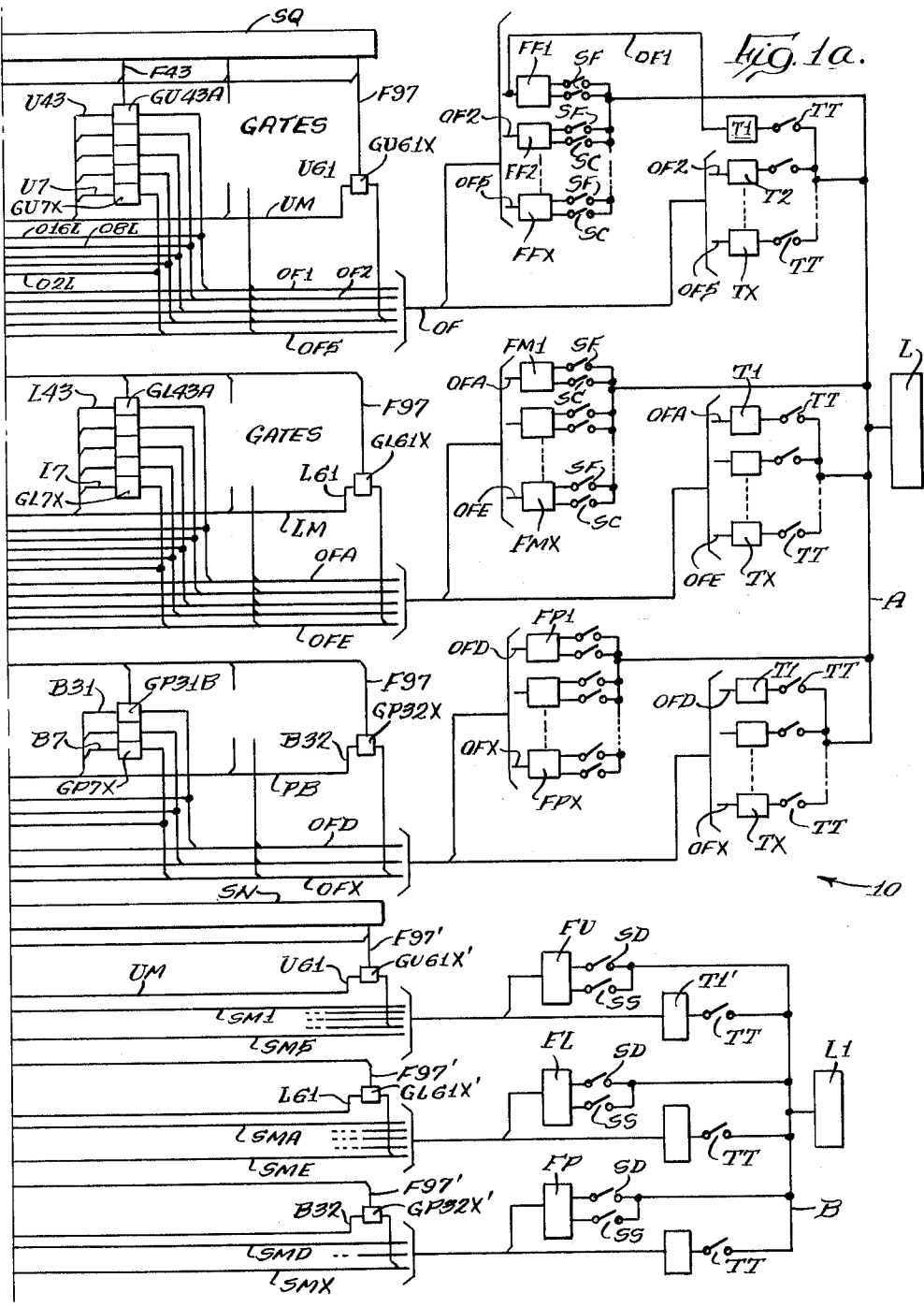
J. M. HANERT

3,240,858

ELECTRICAL MUSICAL INSTRUMENT

Filed Nov. 26, 1962

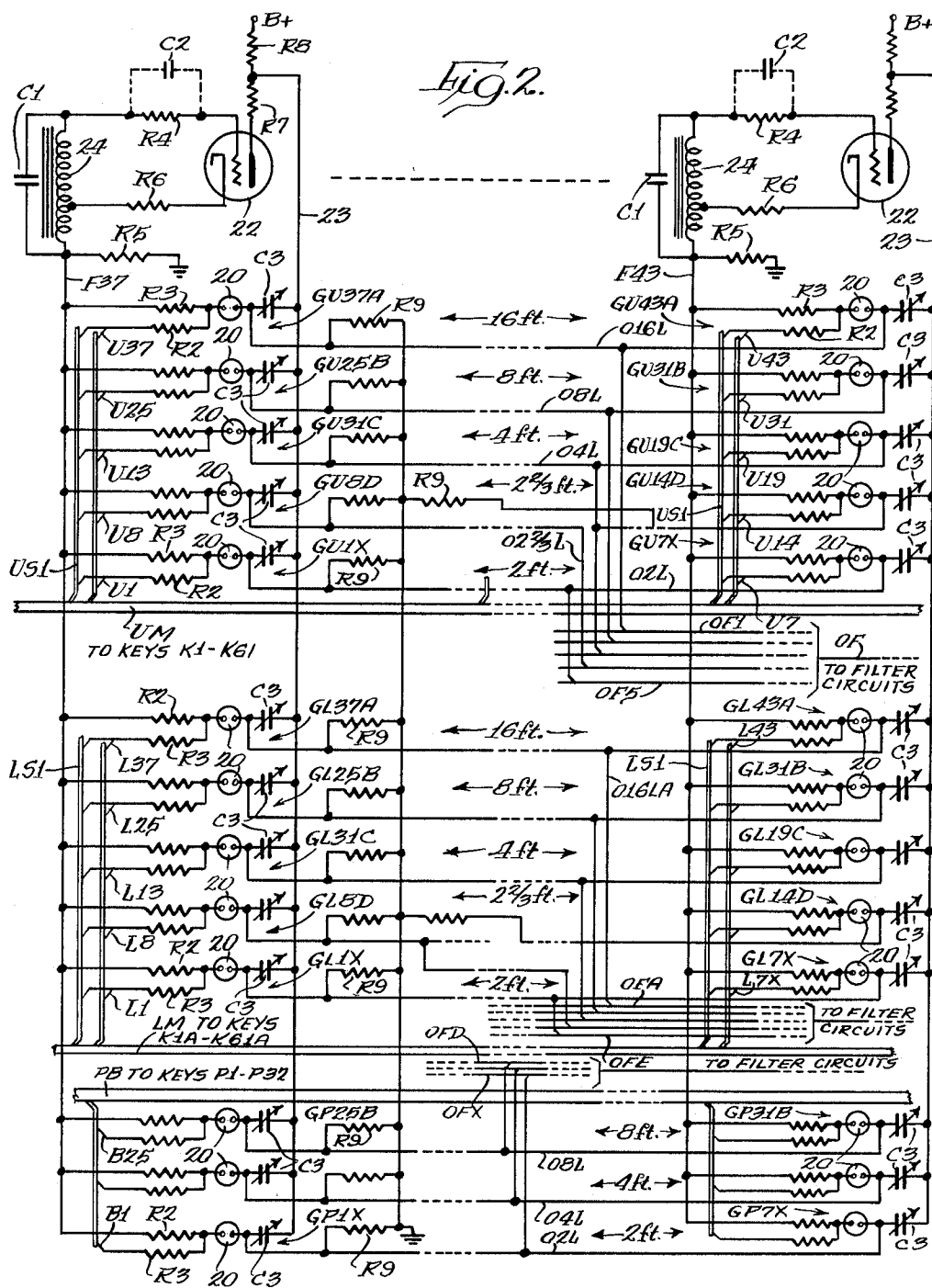
5 Sheets-Sheet 2



J. M. HANERT
ELECTRICAL MUSICAL INSTRUMENT

5 Sheets-Sheet 3

Fig. 2.



March 15, 1966

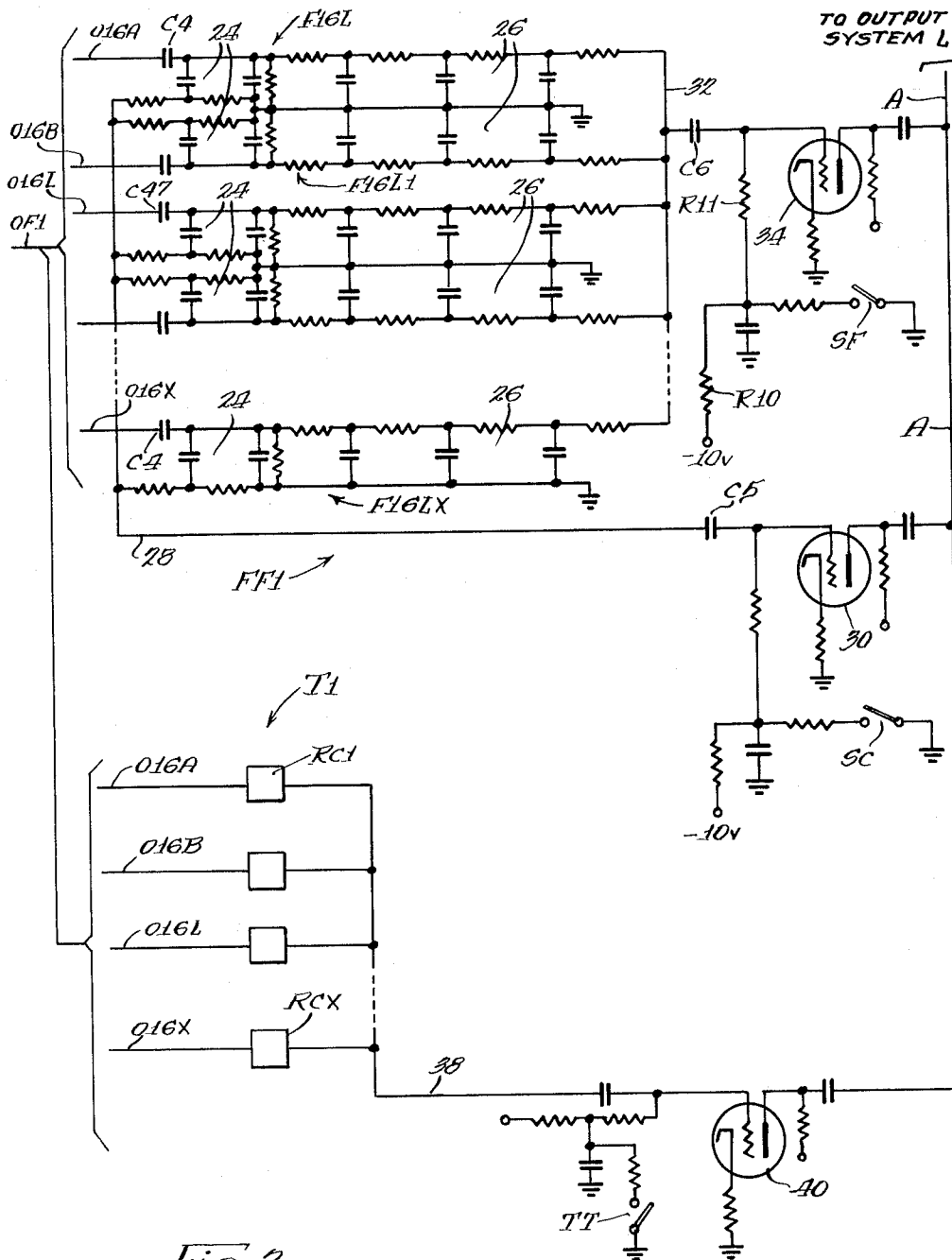
J. M. HANERT

3,240,858

ELECTRICAL MUSICAL INSTRUMENT

Filed Nov. 26, 1962

5 Sheets-Sheet 4



March 15, 1966

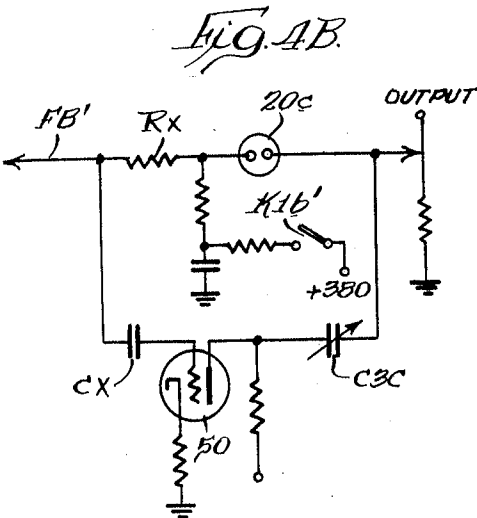
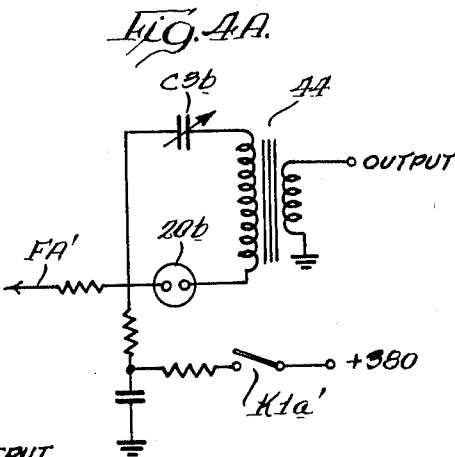
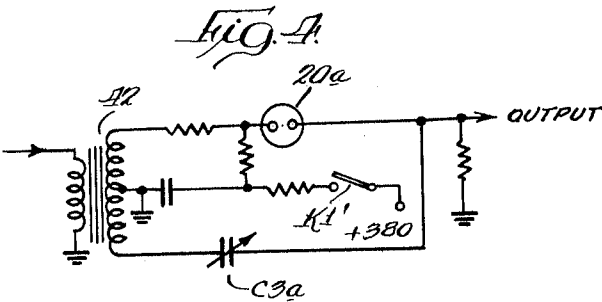
J. M. HANERT

3,240,858

ELECTRICAL MUSICAL INSTRUMENT

Filed Nov. 26, 1962

5 Sheets-Sheet 5



1

3,240,858

ELECTRICAL MUSICAL INSTRUMENT

John M. Hanert, deceased, late of Des Plaines, Ill., by Harris Trust and Savings Bank, administrator, Chicago, Ill., assignor to Hammond Organ Company, Chicago, Ill., a corporation of Delaware

Filed Nov. 26, 1962, Ser. No. 240,174

12 Claims. (Cl. 84-1.01)

This invention relates in general to an organ utilizing gas tubes such as neon tubes for controlling tone signal outputs and more particularly to an arrangement for stabilizing the operation of such neon tubes to enable outputs of a desired characteristic to be produced despite the capacitative effects introduced by the use of large numbers of such tubes.

While there have been a number of attempts to utilize gas tubes, especially neon tubes, in organs for keying or gating oscillator outputs as typified by Faulkner Patent No. 2,811,069, they have not received practical acceptance despite the large economies which they present. The reason lies in the instability of the tube outputs especially where large numbers are connected in common since a considerable capacitative effect may exist between their electrodes. The result is that signals of undesired character may appear in the output.

It is therefore a primary object of the present invention to provide an arrangement for facilitating the use of gas or neon tubes to key or gate organ tone output signals. Basically, this is achieved in a unique and ingenious manner by the simple provision of a neutralizing capacitor connected between the tone signal source and the output terminal of each neon tube to provide a signal which is of opposite polarity with respect to the input signal normally appearing at the input terminal of the tube. This reduces or eliminates the capacitative effect across the electrodes of the neon tube when it is not ionized. By maintaining the signal of opposite polarity at a comparatively small value, it is completely over-ridden when the tube is rendered conductive to transmit the tone signal so that the output of the tube is comparatively unaffected by the signal of opposite polarity.

In addition, it is among the other objects of the present invention to provide an improved organ arrangement which is capable of economically synthesizing a large variety of tonal effects with only a single contact for each key. Thus, for example, the various key contacts are each connected to a plurality of neon tube gate circuits which are adapted to gate the output of octavely related oscillators for providing the fundamental tone signal assigned to each key and a desired number of harmonics. The output signals in turn are applied to groups of filter circuits which are selectively chosen to provide either of several types of output tone qualities.

The manner in which the foregoing objects of the invention together with others are achieved will become apparent on examination of the following specification and claims together with the drawings wherein:

FIGS. 1 and 1a illustrate the general layout of the circuit elements of the organ in schematic form;

FIG. 2 illustrates the circuit details of the gates and their relationships;

FIG. 3 illustrates the nature of the filter circuits; and

FIGS. 4-4b illustrate other arrangements for neutralizing the capacitative effect across the electrodes of the neon tube gates.

A circuit arrangement for an organ utilizing the principles of the invention is indicated generally in FIGS. 1 and 1a by the reference character 10. It is controlled by a pair of keyboards 12 and 14 commonly called an upper manual and lower manual respectively in accordance with

2

their position on the organ console and a pedal board 16.

The upper manual comprises a group of sixty-one key contacts K1-K61 which are adapted to be operated for forwarding a plus 380 volt potential from a bus bar 18 through a respective resistor R1 having a capacitor C in shunt therewith and over a corresponding lead U1-U61 extended through a cable UM. This potential is extended to a respective series of octavely related gates individual to the lead in each of two groups of gates GU1A-GU1X . . . GU61A-GU61X and GU1A'-GU1X' . . . GU61A'-GU61X' for keying the respective two series of gates GU1A-GU1X and GU1A'-GU1X', for example.

Each group of gates GU1A . . . GU61X and GU1A'-GU1X' is associated with a respective series of 97 oscillators indicated by the blocks marked SQ and SN. Each gate in a respective series is assigned to an oscillator generating signals octavely or harmonically related to the fundamental tone assigned to the corresponding key. The gate in each series assigned to the oscillator generating the fundamental is designated as a 16 foot rank while the gates assigned to the octave and non-octavely related oscillators are designated as 8-foot, 4-foot, 2 $\frac{3}{4}$ -foot and 2-foot ranks respectively. Each gate in a series will therefore pass a harmonically related tone signal from the respective oscillator on the receipt of the 380 volt potential.

The lower manual 14 also comprises a group of sixty-one key contacts K1a-K61a, each adapted to be operated for forwarding a plus 380 volt potential from a bus bar 18a through a respective resistor R1 having a capacitor C in shunt therewith and over a corresponding lead L1-L61 extended through a cable LM. This potential is extended to a respective series of octavely related gates individual to the lead in each of two groups of gates GL1A-GL1X . . . GL61A-GL61X and GL1A'-GL1X' . . . GL61A'-GL61X' for opening the gates of a respective series associated with the respective groups of oscillators SQ and SN. Each gate on opening passes a signal from the respective oscillators as explained for the gates associated with the upper manual.

The pedal board 16 comprises a group of 32 pedal key contacts P1-P32, and these too are adapted to be operated for forwarding a plus 380 volt potential from a bus bar 18b through a respective resistor R1 having a capacitor C in shunt therewith, and over a corresponding lead B1-B32 extended through a cable PB. This potential is extended to a respective series of octavely related gates in each of two groups GP1A-GP1X . . . GP32A-GP32X and GP1A'-GP1X' . . . GP32A'-GP32X' for opening the gates of a respective series associated with the respective groups of oscillators SQ and SN and each gate on opening passes a signal from the respective oscillator.

In the case of the pedal board contacts, however, gates corresponding to the 16 foot rank may be omitted for oscillators generating tones assigned higher values than the available number of pedal board keys and in addition gates corresponding to the 2 $\frac{3}{4}$ -foot rank may also be omitted and in their place gates corresponding to a 1-foot rank are utilized with the oscillators SN.

Since it may also be desirable to play the tones usually associated with either the upper manual or lower manual on the pedal board keys, a pair of coupling switches US and LS are provided for connecting the keys P1-P32 through respective leads in cables LS1 and US1 respectively to respective gates normally keyed from the lower and upper manuals respectively.

Thus the key contacts of the upper and lower manuals and pedal board are each adapted to control two parallel groups of oscillators SQ and SN. The 97 oscillators indicated by the block marked SQ each produce square waves for deriving odd harmonics such as produced in stopped

flute organ pipes or clarinet tones. The output frequencies of the oscillators SQ are transmitted along respective output leads F1-F97. The other group of 97 oscillators indicated by the block marked SN each generate narrow pulses for deriving diapason or string tones. The output frequencies of the oscillators are transmitted along respective output leads F1'-F97'. It will be understood, of course, that the number of oscillators may be varied as needed and that if desired a single oscillator may be used for generating a fundamental tone from which other tones are derived for application to respective output leads.

As may be appreciated from the foregoing, since the oscillators may generate a tone assigned a value corresponding to fundamental and/or to a harmonic associated with any of the keys, each of the output leads F1-F97 is coupled to a respective plurality of groups of gate circuits. These are, for example, a group of gates GU37A-GU1X associated with the upper manual 12, but each connected to a different key thereon; a group of gates GL37A-GL1X associated with the lower manual 14, but each connected to a different key thereon; and a group of gates GP25B-GP1X, for example, associated with the pedal board 16, but each connected to a different key thereon. Each of the output leads F1'-F97' of the oscillators SN is likewise coupled to a plurality of groups of gate circuits with one group for the upper manual 12, one group for the lower manual 14, and one group for the pedal board 16 respectively, but each connected to a different key. The gate circuits are normally closed so that with the oscillators operating, no output is ordinarily passed through the gate circuits. It will also be understood that the number of gates utilized in each group may be varied as desired in accordance with the expected uses of the tones generated by any oscillator.

The output of each gate representing a fundamental or 16 foot rank for the upper manual and associated with the oscillators SQ is extended through a cable OF1 to a group of filter circuits indicated by the block FF1. As will be noted in FIG. 1, a common output lead 016L is provided for each gate in the 16-foot rank such as GU37A-GU43A which are associated with oscillators generating tones lying within one-half an octave. This lead 016L is extended to an individual filter circuit in the block FF1. Similarly, the output of each gate representing an 8-foot, 4-foot, etc., rank is extended over respective cables OF1-OF5 and through a common cable OF to a respective group of filter circuits represented by blocks marked FF2-FFX. Each group of gates assigned similar values and passing signals differing by one-half an octave are likewise coupled in common, as indicated by leads 08L-02L associated with oscillators connected to leads F37-F43. These leads are each extended to an individual filter circuit in groups FF2-FFX.

The gates representing the 16-foot rank and other ranks for the lower manual and pedal board are likewise coupled over respective cables OFA-OFE and OFD-OFX to individual groups of filter circuits indicated by blocks marked FM1-FMX and FP1-FPX respectively with the output leads of gates assigned to the same rank and passing signals differing by only one-half an octave being connected in common over a lead such as 016LA to a respective filter circuit in a respective group of filter circuits.

The gates representing respective stops associated with the oscillators SN are coupled over cables SM1-SM5, SMA-SME and SMD-SMX in a manner similar to the gates associated with oscillators SQ to individual groups of filter circuits indicated by blocks marked FU, FL and FP respectively. The gates whose outputs differ by only one-half an octave are of course connected in common to a respective filter circuit in a respective group of filter circuits as explained for the output of the gates associated with the oscillators SQ.

In addition, the gates associated with oscillators SQ

and representing respective ranks, such as the 16-foot, etc., are coupled over cables such as OF1 to respective groups of tone selecting filters indicated by boxes marked T1-TX individual to the upper and lower manuals and the pedal board respectively. Similar groups of tone selecting filters indicated by boxes T1', T2' and T3' are provided for the gates associated with oscillators SN. The respective groups of tone selecting filters are associated with respective special stops on the organ such as 8-foot Vox Humana, 8-foot Trumpet or 16-foot Viola and the common leads such as 0L16 are connected to an individually corresponding filter circuit in the respective group of tone selecting filters.

Each group of filter circuits, such as FF1, FM1 and FP1 are selectively keyed as indicated by the switches SF and SC to provide flute and clarinet tones while the filter circuits FU, FL and FP are selectively keyed in a similar manner to provide diapason and string tones as indicated by the switches SD and SS. Each group of tone selecting filters such as T1-TX and T1'-T3' are also individually keyed as indicated by switches TT to provide tones of corresponding character.

The outputs from the groups of filters FF1-FPX and T1-TX associated with oscillators SQ are extended along lead A to a suitable output system indicated by block L for application to a loud speaker. Means for controlling the volume and introducing a vibrato or other effects are also provided in the output system, but since the same are well known, they are not illustrated. A similar output system L1 is connected over lead B to the output of the filters FU-FP and T1'-T3' associated with the oscillators SN.

The gates such as illustrated by GU37A-GU1X and GU43A-GU7X, seen in detail in FIG. 2, each comprise a neon tube 20. The input electrode of each tube is connected to a respective one of the leads U37-U1 and U43-U7 respectively through a respective resistor R2 to a respective upper manual key contact having assigned thereto a fundamental or harmonic corresponding to the frequency of the signal appearing on a respective one of the leads F37 or F43. As indicated by the cable US1 each input electrode may also be connected through respective leads in cable US1 to pedal board key contacts on operation of switch US.

The resistors R2 have a value of approximately .47 megohms and together with the respective condenser C and resistor R form an RC network which determines the rate of tonal attack and decay when the corresponding key is operated to apply the plus 380 volt potential to the tube and is released to remove the potential. Thus, when a key is operated, the 380 volt potential charges the associated capacitor C at a rate determined by the time constant of resistor R and capacitor C. As soon as the capacitor C is charged to a value corresponding to the firing potential of the tube 20 connected thereto, the tubes will fire to pass any input signal appearing on the input electrode. When the key is released, the fired tube will remain fired, while capacitor C discharges through resistor R2 and when its charge falls below the sustaining potential of the tubes they will extinguish to terminate further output signals. Thus, if capacitor C is made large, the output tones will be sustained to provide an effect similar to reverberation. The input electrode of each tube 20 is also coupled to a respective oscillator output lead such as F37 and F43 through a .27 megohm resistor R3.

As shown in FIG. 2, the oscillators may each comprise a triode 22 having a resonant circuit, including an inductive winding 24 and a capacitor C1 in shunt therewith. The winding 24 is connected at one end to the grid of the tube through a resistor R4 and a capacitor C2. In the case of oscillators generating square waves, the capacitor C2 is omitted. The other end of the winding 24 is connected to the respective output lead F1-

F97 or F1'-F97' as the case may be and to ground through a resistor R5. A tap on the winding is connected through a resistor R6 to the cathode of tube 22. The plate of tube 22 is connected to a source of positive potential through a pair of serially connected resistors R7 and R8 having a resistance value of approximately 10K and 1K respectively. The juncture of resistors R7 and R8 is connected over a respective lead 23 to the output electrode of each gate, to which the respective oscillator supplies signals through an individual adjustable neutralizing capacitor C3.

The output electrode of each neon tube 20 is also connected through a respective 4.7K resistor R9 to ground and to an output lead such as 016L-02L. The output leads 016L-02L are each common to a respective group of gate GU37A-GU43A, for example, controlled by the upper or lower manual contacts or pedal board contacts respectively and whose input signals lie within one-half octave and which correspond to a particular rank such as the 16-foot rank. In the case of the outputs for gates such as GU14D assigned a harmonic corresponding to the 2 $\frac{3}{4}$ -foot rank and lying in the upper range of frequencies for any particular one-half octave, the outputs are coupled to the lead such as 04L.

Each neutralizing capacitor C3 feeds its respective gate with a signal of opposite polarity with respect to the input signal appearing on the respective one of the leads F1-F97 or F1'-F97' to thereby cancel or minimize the capacitative effect appearing across the neon control tube electrodes. This permits a large number of neon tubes to be coupled without danger that the capacitative effect appearing between the respective electrodes will give rise to undesired output signals.

Thus, each key K1-K61, etc., when operated to supply a plus 380 volt potential on the corresponding lead L1-L61 will place a potential across the neon tube 20 associated with the oscillator corresponding to the fundamental frequency assigned to the key. This potential is sufficient to fire the tube and pass the fundamental frequency supplied by the oscillator connected thereto. The key will perform the same function at gates associated with oscillators generating other octave and non-octave related frequencies so that a group of harmonically related frequencies appear on respective output leads extending to the respective filter circuits in groups such as FF1.

The filter circuit groups such as FF1 are each common to either a fundamental such as the 16-foot rank or respective harmonics such as the 8-foot, 4-foot, 2 $\frac{3}{4}$ -foot or 2-foot ranks and each comprises a series of filter circuits, for example F16L-F16LX. The filter circuits F16L-F16LX are each connected to a respective lead such as 016A, 016B, 016L or 016X individual to a group of gates whose input is derived from a group of oscillators generating frequencies within one-half an octave or less as the case may be. Each filter circuit such as F16L comprises an input capacitor C4 and a pair of resistor-capacitor networks 24 and 26.

The networks 24 are each adapted to produce clarinet type tones and a common output lead 28 is provided for the networks 24. This lead is extended through a capacitor C5 to the grid of a gating triode 30. The other networks 26 are each adapted to produce flute type tones which are applied over a common output lead 32 and a capacitor C6 to the grid of a gating triode 34.

Each triode tube 30 and 34 is normally biased off by a -10 volt battery source connected through a pair of 4.7 megohm resistors R10 and R11 to the grid of the respective tube. The triodes 30 and 34 are keyed by an associated stop switch SF or SC respectively which connect ground through a 150K resistor R12 to the tube grids for providing an amplified output signal derived from the networks 24 and 26 respectively. The signal is transmitted to the output system L over lead A.

The filter groups FU, FL and FP are likewise similarly

arranged and each comprises a network for deriving diapa-son and string tones which are selectively keyed through triodes similar to 30 and 34 at switches SF and SC to feed corresponding output signals over lead B to the output system L1.

The tone selecting filters such as T1, T2 and T3 each comprise a group of resonant circuits such as indicated by boxes RC1-RCX with each group likewise being common to either a respective fundamental or respective harmonics such as the 8-foot, 4-foot, 2 $\frac{3}{4}$ -foot and 2-foot ranks. The circuits RC1-RCX are likewise each connected to a different output lead such as 016A, 016B, 016L or 016X extending from respective gates whose input is derived from oscillators whose frequencies are within one-half octave. It will be appreciated, of course, that the number of such filters are varied as desired, but that each group has a common output lead such as 38 which is connected to the grid of a gating tube such as 40. The tube 40 is normally biased off as explained for tubes 30 and 34 and is keyed by a respective stop switch TT to provide an output from the associated filter group to the respective output system L or L1 as the case may be.

In FIGS 4-4b, various alternative neutralizing arrangements for neon tube gates are illustrated. In FIG. 4, the input terminal of a neon tube 20a is connected to one end of the secondary of a center-tapped input transformer 42 across which two oppositely polarized portions of a tone signal appear. The other end of the transformer secondary is connected through a neutralizing condenser C3a to the output terminal of the neon tube 20a. An oppositely polarized signal therefore normally appears at the output of the neon tube to neutralize the capacitative effect. The secondary signal voltage of transformer 42 with respect to ground potential is insufficient to fire the tube. A key contact K1' is operated to place a 380 volt potential across the tube, and it fires to pass the signal appearing at transformer 42 at a level far exceeding the level of the out of phase signal provided by the capacitor C3a.

In FIG. 4a, the oscillator tone signal is provided on a lead FA' to the input electrode of a neon tube 20b. The output electrode of the tube is connected to ground through the center tap on the primary of an output transformer 44. The input electrode is connected to one end of the transformer primary through a capacitor C3b so that a signal of opposite polarity is derived from the transformer and magnetically superimposed on the output electrode of the tube 20b to cause a neutralization of the signal across the tube, when deionized. The neon tube 20b is keyed or gated at the contacts K1a' to transmit the input signal on lead FA' through the tube to the transformer 44.

In FIG. 4b, a neon tube 20c has an input tone signal applied thereto from lead FB' through a resistor RX. The tone signal on lead FB' is also fed through a capacitor CX to the grid of a tube 50. The plate circuit of the tube 50 is connected through a neutralizing capacitor C3c to the output terminal of tube 20c, thus providing a signal of opposite polarity on the output electrode of tube 20c. The tube 20c is rendered conductive on operation of the key K1b' which applies a plus 380 volt potential to the keying network for the input electrode of tube 20c.

The foregoing has entailed a description of an organ arrangement utilizing twin element gas tubes for enabling tone synthesis in a stable and economical manner, but since the invention is believed capable of many adaptations and modifications, its scope is more adequately set forth in the following claims.

I claim:

1. In an electrical musical instrument having playing keys, a source of complex electrical audio tone signal waves, an output circuit including a transducer for receiving said signal waves, a glow discharge switching means for coupling the source with the output circuit when ionized, means rendered effective upon operation of one of said playing keys for applying a direct current

voltage to said glow discharge switching means for rendering said switching means ionized and conductive for transmitting said signal waves to said output circuit, and means for superimposing an additional complex signal wave on the output terminal of said switching means, said additional complex wave having substantially the same wave shape and identical frequency as the source signal wave but of opposite polarity so as to effectively cancel out the capacitative transmission of the source signal wave through the glow discharge switching means when said switching means is not ionized.

2. The combination claimed in claim 1 in which said source has an additional output signal terminal for providing a signal of substantially identical wave shape but of opposite polarity, means for coupling said additional terminal to the output terminal of said glow discharge switching means to thereby effectively cancel the capacitative coupling of the signal across the terminals of said switching means when in a deionized state.

3. The combination claimed in claim 1 including means for connecting said source to said output circuit, the last said means comprising a signal polarity reversing means whereby the first said signal and the polarity reversed signal are effective to mutually cancel each other when the glow discharge device is in a deionized state.

4. A gas tube gate circuit arrangement comprising a plurality of normally deenergized gas tubes each having a pair of electrodes, and means connecting one electrode of each tube to a tone signal input source comprising an amplifying device from which signals of differing polarity are derived, and means applying one of said signals to each of said one electrodes, means for selectively energizing each of said tubes to permit the passage of the connected one of said signals through the energized tube, and means for connecting another of said signals to the other electrode of each tube whereby a signal of differing polarity from said one signal is applied to each tube for neutralizing the capacitative effect existing across said electrodes.

5. A gas tube gate circuit arrangement comprising a plurality of groups of normally deionized gas tubes each having a pair of electrodes, means connecting one electrode of each tube in a group in common to a respective tone signal input source, means for rendering each tube normally non-conductive, means for selectively ionizing one of said tubes in a plurality of said groups to permit the passage of an input tone signal from the respective source through the energized tube, and means for transmitting a signal of opposite polarity with respect to the input signal from the respective tone source to the other electrode of each tube in a respective group to thereby neutralize the capacitative effect existing across said electrodes.

6. A gas tube gate circuit arrangement comprising a plurality of normally deionized gas tubes each having a pair of electrodes, means connecting one electrode of each tube in common to a tone signal input source, means for selectively ionizing each of said tubes to permit the passage of an input tone signal from the source through the ionized tube at a minimum voltage level, and means for transmitting a signal of opposite polarity with respect to the tone signal to the other electrode of each tube to thereby neutralize the capacitative effect existing across said electrodes at a voltage level considerably below said minimum level.

7. The arrangement claimed in claim 6 in which said means for transmitting a signal of opposite polarity comprises means for deriving a signal of opposite polarity with respect to said tone signal, means connecting the re-

spective other electrodes to said deriving means, the last said connecting means including adjustable impedance element.

8. The arrangement claimed in claim 7 in which said impedance elements each comprises a capacitor.

9. A gas tube gate circuit comprising a tone signal source, a two electrode normally non-conductive gas tube, means connecting one electrode of said tube to said tone signal source, means for ionizing said tube to permit the passage of a tone signal from said signal source through the ionized tube, and means for transmitting a signal of opposite polarity with respect to the tone signal from said source to the other electrode of said tube to thereby neutralize the capacitative effect existing across said electrodes when said tube is not ionized.

10. In an electrical musical instrument having playing keys, a source of a complex electrical tone signal in the audio range, an output circuit including a transducer for receiving said signal, an electronic switching means connected for coupling the source to the output circuit, means normally rendering said switching means non-conductive except for a small value leakage signal, means rendered effective upon operation of the appropriate one of said playing keys for applying a direct current potential to said electronic switching means for rendering said switching means conductive for transmitting said signal from said source to said output circuit, means for superimposing an additional complex signal on the output of said switching means, said additional complex signal having substantially the same wave shape and frequency range as at least a portion of the source signal but of opposite phase to the said portion of the source signal so as effectively to cancel at least a portion of the said leakage signal transmitted through the switching means when said switching means is rendered not conductive.

11. The combination called for in claim 10 in which said electronic device and the means for superimposing an additional complex signal comprises a capacitative coupling between said source and said output.

12. In an electrical musical instrument having playing keys, a source of a complex electrical tone signal in the audio range, an output circuit including a transducer for receiving said signal, an electronic variable impedance means connected for coupling the source to the output circuit, means normally rendering said variable impedance means non-conductive except for a low level leakage signal, means rendered effective upon operation of the appropriate one of said playing keys for applying a direct current potential to said variable impedance means for rendering said variable impedance means conductive for transmitting a high level signal from said source to said output circuit, means for superimposing an additional complex signal on said output circuit, said additional complex signal having substantially the same wave shape and frequency range as at least a portion of the low level leakage signal but of opposite phase to the said portion of the leakage signal so as effectively to cancel at least a portion of the said leakage signal transmitted through the variable impedance means when said variable impedance means is rendered not conductive except for said leakage signal.

References Cited by the Examiner

UNITED STATES PATENTS

2,622,150	12/1952	Coulter et al.	330—149
2,811,069	10/1957	Faulkner	84—1.01
2,811,887	11/1957	Anderson et al.	84—1.01

ARTHUR GAUSS, *Primary Examiner*.