April 23, 1968 H. A. BURTON 3,379,085

OPERATIONAL CIRCUITRY FOR PIPE ORGANS

Filed Aug. 18, 1965

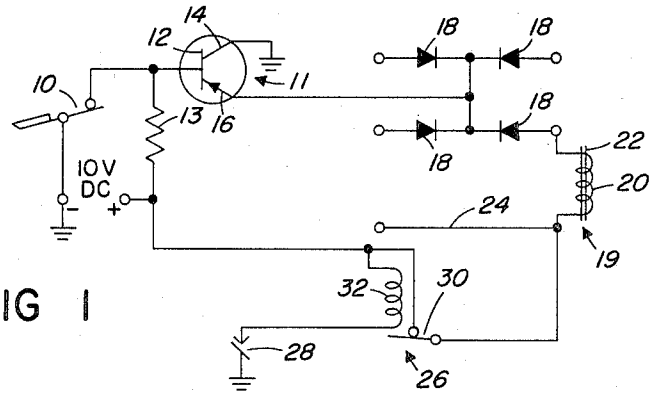


FIG 1

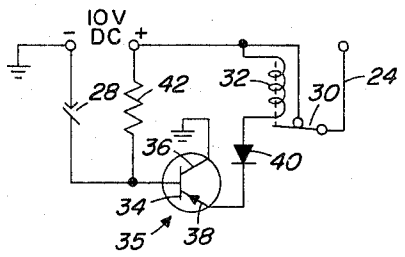


FIG 2

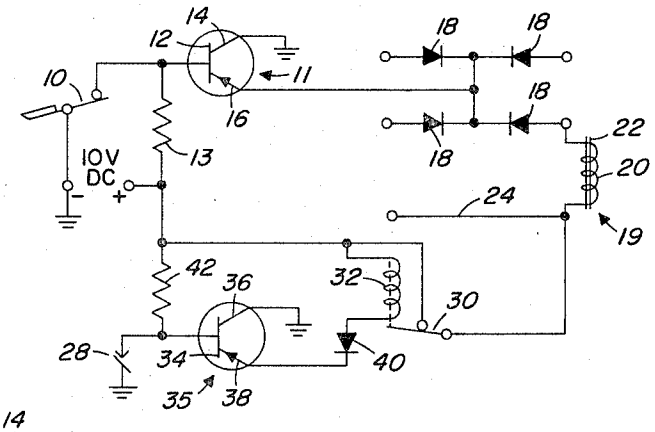


FIG 3

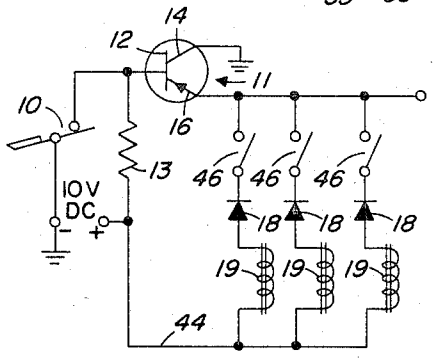


FIG 4

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United States Patent Office 3,379,085 Patented Apr. 23, 1968

3,379,085

OPERATIONAL CIRCUITRY FOR PIPE ORGANS

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Filed Aug. 18, 1965, Ser. No. 480,699
9 Claims. (Cl. 84—337)

ABSTRACT OF THE DISCLOSURE

A solid state electronic circuit for use in the key and stop action circuits of pipe organs to control the valves operating the organ pipes.

This invention relates to operational circuitry for pipe organs and more particularly relates to solid state circuits for use in the key and stop action circuits of direct electric and electropneumatic pipe organs.

Until very recent times, the prior art relating to direct electric and electropneumatic pipe organs has employed the use of mechanical and electropneumatic relays in the organ key and stop action circuits. For example, in a typical direct electric organ, a wire wound coil with an iron core magnet is used to activate a direct electric magnet which opens the valve to a given organ pipe when the key circuit is closed by depressing the organ key for that particular note. Similarly, in a typical electropneumatic pipe organ, the iron core magnet actuates an air valve and the pipe is operated by the use of air pressure. Similar circuitry has been employed for the stop action. With these arrangements, the organ keyboards have thus consisted of a group or groups of electric switches for the making or breaking of the circuits to the coils or magnets.

With the invention of solid state semi-conductors, such devices have recently been used in organ key circuits. For example, a solid state key circuit is disclosed in U.S. Patent No. 3,138,052, issued June 23, 1964, to M. M. Wick and entitled, "Organ Key Circuit." However, the circuits disclosed in this patent and other existing circuits have certain inherent disadvantages which affect their reliability and performance, even though such circuits are much superior to the circuits which employ mechanical and electropneumatic relays.

It is therefore a principal object of my invention to provide improved circuits for the operation of organ keys and stop actions, which circuits utilize solid state semiconductors to accomplish all the requirements applicable to electropneumatic or direct electric organs and associated equipment.

Another object of my invention is to provide an improved solid state circuit for use in key and stop action organ circuits, which circuit employs a single diode and coil combination that blocks sneak or phantom circuits through which current could flow in reverse to actuate some of the chest magnets and possibly cause damage to the transistors used in the circuits.

A further object of my invention is to provide an improved solid state circuit for use in organ key and stop action circuits in which the collector of each transistor is grounded to a common negative pole of the power supply, thus, providing for the use of a metal mounting panel as a common ground and as a heat sink for the transistors to dissipate the heat normally developed within the transistors.

A still further object of my invention is to provide an improved solid state circuit for use in organs in which a fixed resistor is connected to the base of each transistor at the positive pole of the power supply, thus providing a continuous positive bias to the point of cutoff and preventing the flow of current within the transistor until the circuit is closed. A circuit constructed according to the

principles of my invention will thus prevent the possibility of damage to the transistor when the circuit is open or in an unkeyed state.

It is another object of my invention to provide an improved solid state circuit for use in both key and stop action circuits for organs, which circuit is extremely reliable, relatively inexpensive, and which is so constructed that the tuning of the organ is greatly simplified,

These and other objects and advantages of my invention will be readily apparent from consideration of the following description taken in connection with the accompanying drawing which shows a preferred embodiment of my invention and in which:

FIG. 1 is a schematic wiring diagram for one key or note of an organ manual or pedal board and illustrates the principles of my invention for a transistorized key circuit in connection with a "straight" chest, showing the use of a single diode in series with the chest magnets;

FIG. 2 is a schematic wiring diagram illustrating the principles of my invention as applied to a transistorized stop action circuit;

FIG. 3 is a schematic wiring diagram showing the transistorized stop action circuit of FIG. 2, combined with the basic transistorized key circuit of FIG. 1; and

FIG. 4 is a schematic wiring diagram showing the principles of my invention as applied to a key circuit for an augmented pedal or manual.

It will be understood that the key circuits illustrated in FIGS. 1 and 3 of the drawing are for a single key which activates the same note in each chest or rank of organ pipes, and each chest or rank is controlled by a stop through an individual circuit as shown in FIG. 2. Referring now to the drawing, and particularly to FIG. 1, a key contact **10**, which is actuated by depressing a key on the organ, is connected to the ground or negative side of a suitable D-C power supply supplying, for example, 10 volts of direct current power. The other side of key contact **10** is connected to the base **12** of a suitable power transistor **11**, such as a 2N555 power transistor. A fixed carton resistor **13** is also connected between the positive side of the power supply and the base **12** of the transistor **11** in order to bias the transistor to a positive polarity at its base. The collector **14** of the transistor **11** is connected to the ground or negative pole of the power supply, as shown, and the emitter **16** is connected to four parallel branches which represent four typical chest circuits each containing a series diode **18** which has a low resistance path from its cathode to its anode. It will be understood that the number of parallel circuits will depend upon the number of chests or ranks of pipes in the particular organ in which the circuit is used. Although four such parallel branches are indicated, for purposes of simplicity only one of said branches is shown in connection with a single electropneumatic or direct electric chest magnet **19**, it being understood that the other branches would be similarly connected. It will be further understood by those skilled in the art that each chest circuit will contain a plurality of chest magnets **19**, e.g. sixty-one or more. Each magnet **19** controls a different pipe or note in that chest, and the same note in each chest will be controlled by one of the sixty-one key contacts **10**. Each chest magnet **19** consists of a coil **20** and a core **22**, the coil **20** of each magnet being connected directly to a common return wire **24**, one such "common" being provided for each chest of pipes. It will be understood that all the chest magnets **19** in each chest of pipes will be connected to a common wire **24**.

Since in the typical organ a stop is provided to control each rank or chest of pipes, I have illustrated a common and well known stop action circuit in connection with my novel key circuit. Such a circuit usually contain a relay **26** and a stop action switch **28** as shown. The relay **26**

has a single throw switch **30**, one side of which is connected to the common wire **24**, the other side of switct **30** being connected to the positive pole of the power supply. The switch **30** is actuated by a coil **32**, one side of which is also connected to the positive pole of the power supply, the other side being connected through the stop action switch **28** to the ground or negative pole of the power supply.

Thus, it will be evident that when the key contact **10** is closed, no note will speak unless the stop action switch **28** for at least one of the chests of pipes is closed to energize armature **32** and close relay switch **30** in that stop action circuit. Moreover, when the key contact **10** is closed, the notes will speak in all of the chests of pipes whose stop action switches **28** have been closed.

The positive bias of transistor **11** provided by resistor **13** will prevent current from flowing from the collector **14** to the emitter **16** thereby preventing damage to the transistor **11** when the key circuit is open or in an unkeyed state. However, when the key contact **10** is closed, the positive bias will be removed from the base **12** of the transistor **11** allowing current to flow from the negative side of the power supply through the collector **14** to the emitter **16**. If the stop action switch **28** is closed in one or more of the stop action circuits, the relay **26** in that circuit will be activated to close relay switch **30** and complete the circuit between the common wire **24** and the positive side of the power supply. Current will then flow through diode **18** and through the chest magnet **19**, the coil **20** of which is wired to the common wire **24**, and through relay switch **30** to the positive side of the power supply. With chest magnet **19** thus activated, a valve will be opened to sound the organ pipe in the chest which has been activated by closing of stop action switch **28**.

Because of the "reverse" current characteristic that is always present within any transistor, there are at least three normal conditions which can occur during which the transistor experiences self-degeneration in the form of "runaway" or "avalanche-like" response. These conditions are: (1) change in polarity; (2) voltage spike; and (3) excessive heat. My novel circuits avoid these conditions and thus improve the life of the transistors used and provide for extremely high reliability.

When the key contact **10** is released and the circuit open, a counter-electromotive force from the coil **20** of the chest magnet returns a voltage of reverse polarity to the circuit which can cause damage to the transistor **11** or activate other key circuits in the organ. This highly undesirable but normal condition is prevented from causing harm in each key circuit by diode **18** which has a high resistance reverse current flow, thus preventing anything but a negligible and harmless current to return through the circuit. Moreover, as previously indicated, when the key contact **10** is open, the resistor **13** biases the transistor **11** to a positive polarity at base **12** which prevents current from flowing through the collector **14** to the emitter **16** and thereby prevents damage to transistor **11** while the circuit is in unkeyed state.

Since the collector **14** of each transistor **11** is at the negative polarity of the power supply, this permits the transistors for all the key circuits to be mounted on a metal panel which will serve as a "heat sink," thereby dissipating heat generated within the transistors and improving their life and the reliability of the key circuits. This is particularly important due to the inherent temperature sensitivity of transistors.

Also, because of my novel circuit arrangement, if the diode **18** should fail, the only effect will be that one note or pipe in a single chest will "speak." In prior art solid state circuits known to me, failure of a diode will permit that note in all of the chests to "speak," an obviously undesirable condition particularly when the number of chests of pipes is large. Since only a single note will speak if a diode should fail in my circuit, this diode can be quickly detected and replaced.

Moreover, in the key circuit illustrated in FIG. 1, all of the chests or ranks of pipes are tied to the common wire **24**. This permits control of that note in all of the chests through the use of a single relay switch whereas prior art circuits have required the use of multiple switches or a "stack" switch, one switch for each note in each chest. This, of course, adds to the cost and complexity of the circuitry and decreases its reliability.

Referring now to FIG. 2, the principles of my invention are illustrated in connection with a solid state transistorized stop action circuit, and in FIG. 3 the circuit of FIG. 2 is shown in combination with the key circuit of FIG. 1. As shown, the stop action switch **28** is connected to the negative side of the power supply and to the base **34** of a power transistor **35** of any suitable design or type similar to that used in the circuit of FIG. 1. The collector **36** of the transistor **35** is connected to the ground or negative side of the power supply, and the emitter **38** is connected in series with a diode **40** which has a low resistance path from its cathode to its anode. The diode **40** is then connected in series with the coil **32** of the relay **26** which is connected to the positive side of the power supply. Coil **32** actuates the relay switch **30** which is in the circuit between the common wire **24** and the positive side of the voltage supply. Similar to the key circuit of FIG. 1, a resistor **42** between the base **34** of the transistor **35** and to the positive side of the power supply, will bias the transistor **35** to a positive polarity at the base **34** and prevent damage to the transistor even when the circuit is open. Also, the collector **36** is at a negative polarity which permits the mounting of all the stop action transistors on a metal panel that serves as a heat sink.

The stop action circuit of FIG. 2 operates in a similar manner to the circuit of FIG. 1 to control the pipes in a particular chest. Thus, when the stop action switch **28** is closed, the positive bias is removed from the base **34** of the transistor **35** and current flows from the negative side of the voltage supply through the collector **36** to the emitter **38** and through diode **40** to energize the coil **32** of the relay **26**. This closes the relay switch **30** to complete the circuit between the common wire **24** and the positive side of the power supply. Thus, the pipes in that chest will speak when the keys are depressed to close the key circuits.

Diode **40** has a high resistance reverse current flow similar ot diode **18** which prevents transient voltages from returning to the emitter **38** of the transistor **35** when the circuit is open.

Referring now to FIG. 4, the principles of my invention are illustrated as applied to a key circuit for an augmented pedal or manual, which arrangement is built in many organs and which permits the "borrowing" of a note for a given stop.

To illustrate, a single chest of pipes which will permit the notes in that chest to speak at a two-foot pitch, as well as either a four or an eight-foot pitch, will consist of eighty-five pipes. The manual, for example, will consist of sixty-one keys or notes, but to permit each note to speak at the various pitches, it is necessary to "borrow" notes, as is well known to those skilled in the organ construction art. The alternative is to provide a separate pipe for each note and each pipe, which is obviously expensive and space-wasting.

In FIG. 4, reference numeral **10** represents the key contact for a single note, as before, and transistor **11** is connected as in FIG. 1 and FIG. 3 with the base **12** biased to a positive polarity by resistor **13** and with the collector **14** connected to ground. The emitter **16** of transistor **11** is connected to a plurality of parallel circuits which represent the circuits for a single note at three different pitches in a single chest of pipes.

In each of these parallel circuits is a diode **18** which has a low resistance path from its cathode to its anode. Each

diode **18** is connected in series with a chest magnet **19** which in turn is connected to a common wire **44** that is connected to the positive side of the power supply. In each parallel circuit, also in series with diode **18**, is a switch **46**. Switches **46** are preferably each part of a separate relay and therefore actuated by the relay coil when it is energized. The relay may be actuated by closing of a stop action switch in a circuit such as that shown in either FIG. 1 or 2. It will be understood that for each pitch there will be sixty-one switches **46**, one of each note or key, and all sixty-one switches **46** for that pitch will be closed by a single stop action switch. To accomplish this, a suitable multiple contact "gang" or "stack" switch can be used as is well known to those skilled in the art.

Thus, the basic principles of my invention can be applied to both key and stop action circuits, and these two circuits utilized together will provide extremely high reliability in the operation of either direct electric or electropneumatic organs. My novel circuitry relieves the normally heavy current on the chest magnets thereby minimizing the burning out of the key contacts. The circuits are extremely simple but yet are so designed that the transistors used will be completely protected from reverse currents which might damage them. Also, the design of the circuitry permits the mounting of the transistors on a metal panel which can serve as an excellent heat sink to dissipate the heat normally generated in the transistors, particularly the collectors. The system, although simple, eliminates phantom circuits which might otherwise actuate chest magnets in unkeyed circuits or cause damage to the transistors. Moreover, by biasing the transistors to a positive polarity at the base immediately upon opening of the circuits, there is no flow of current within the transistors until the circuits are closed and the bias removed.

It will be obvious to those skilled in the art that the basic principles of my novel circuit have a wide variety of applications and that various revisions and modifications can be made therein without departing from the spirit and scope of my invention. It is my intention, however, that any such revisions or modifications which are obvious to those skilled in the art will be included within the scope of the following claims.

I claim:

1. A circuit for controlling the operation of pipes in an organ having a direct current power supply and a chest magnet, including a coil, controlling the action of each organ pipe, said circuit comprising a power transsistor having a base, an emitter, and a collector, said collector being connected to the negative side of the power supply, a switch operable by the organist and connected at one side of the negative side of the power supply and at the other side to the base of said transistor, a diode having its cathode connected to said emitter and its anode connected to said magnet coil, a resistor connected between the base of said transistor and the positive side of said power supply to bias said transistor to a positive polarity when said switch is open, and means operable by the organist to open and close said circuit.

2. The circuit of claim **1** in which said switch is a key switch and there are a plurality of chest magnet coils in parallel circuits, each of said parallel circuits containing one of said diodes in series with each magnet coil, a common wire connects the positive sides of said coils, and said means includes a switch in each of said parallel circuits whereby each parallel circuit may be closed independently of the other.

3. A circuit for controlling the operation of pipes in an organ having a direct current power supply and a chest magnet, including a coil, controlling the action of each organ pipe, said circuit comprising a power transistor having a base, an emitter and a collector, said collector being connected to the negative side of the power supply, a key switch operable by the organist and connected at one side to the negative side of the power supply and at the other side to the base of said transistor, a diode having its cathode connected to said emitter and its anode connected to said magnet coil, means for opening and closing the circuit between said magnet coil and the positive side of said power supply, and a resistor connected between the base of said transistor and the positive side of said power supply to bias said transistor to a positive polarity when said switch is open.

4. The circuit of claim **3** in which said means includes a second transistor having a base, an emitter, and a collector connected to the negative side of the power supply, a second stop switch operable by the organist and connected at one side to the negative side of the power supply and at the other side to the base of said second transistor, a relay including a coil and a switch and having the switch connected between said magnet coil and the positive side of said power supply, and a second diode having its cathode connected to the emitter of said second transistor and its anode connected to the coil of said relay, the other side of the relay coil being connected to the positive side of the power supply, and a second resistor connected between the base of said second transistor and the positive side of said power supply to bias said second transistor to a positive polarity when said second switch is open.

5. The circuit of claim **3** in which there are a plurality of chest magnet coils in parallel circuits, each of said parallel circuits containing one of said diodes in series with each magnet coil, a common wire connects the other sides of said coils, and said means is connected between said common wire and the positive side of the power supply.

6. The circuit of claim **4** in which there are a plurality of key switch circuits controlling a plurality of organ pipes, each key switch controlling a pipe for the same note in a chest of pipes, a plurality of stop action circuits one for each chest of pipes, the chest magnet coils in each chest are in parallel circuits, each of said parallel circuits containing one of said first named diodes in series with each chest magnet coil, a common wire connects the other sides of said coils in each chest, and the relay switch in each stop action circuit connected between the common wire for that chest and the positive side of the power supply.

7. A circuit for a pipe organ having a direct current power supply and a chest magnet, including a coil, controlling the action of the organ pipe, said circuit comprising a power transistor having a base, an emitter, and a collector, said collector being connected to the negative side of the power supply, a stop action switch operable by the organist and connected at one side to the negative side of the power supply and at the other side to the base of said transistor, a relay including a coil and a switch and having the switch connected between said magnet coil and the positive side of the power supply, a diode having its cathode connected to said emitter and its anode connected to the coil of said relay, the other side of the relay coil being connected to the positive side of the power supply, a resistor connected between the base of said transistor and the positive side of said power supply to bias said transistor to a positive polarity when said stop switch is open, and means for opening and closing the circuit between said magnet coil and the negative side of said power supply.

8. The circuit of claim **7** in which there are a plurality of chest magnet coils in parallel circuits, a common wire connects to one side of each of said magnet coils, and said relay switch is connected between said common wire and the positive side of said power supply.

9. In a circuit for controlling the operation of a pipe organ having a direct current power supply, a chest magnet controlling the action of the organ pipe, and a manually operated switch opened and closed by the organist; a power transistor having a base connected to the negative side of said power supply through said

switch, a collector connected directly to the negative side of the power supply, and an emitter; a diode having a low resistance path from its cathode to its anode and having its cathode connected to the emitter of said transistor and its anode connected to said chest magnet; and a resistor connected between the base of said transistor and the positive side of said power supply to bias said transistor to a positive polarity when said switch is open.

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