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ELECTRONIC SWITCHING CIRCUIT

Filed July 17, 1961

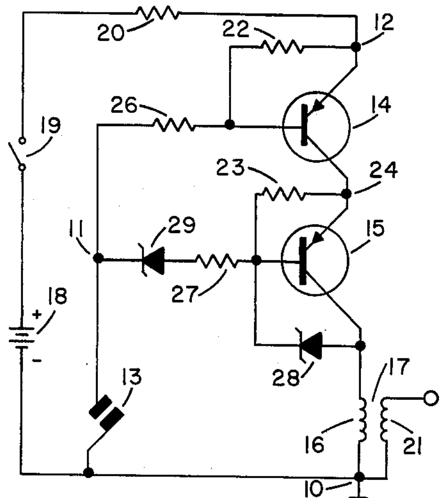

Fig. 1

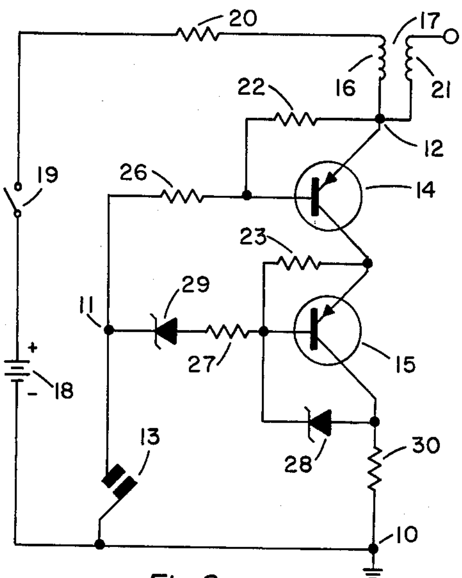

Fig. 2

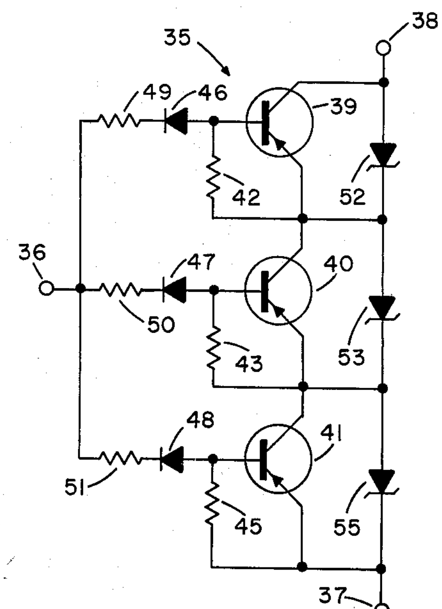

Fig. 3

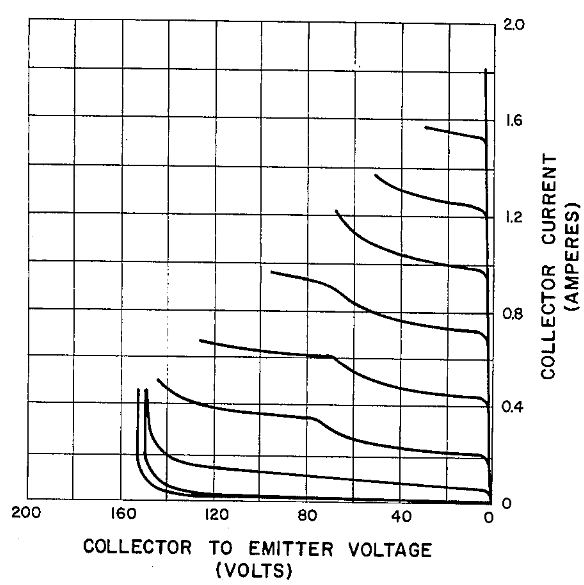

Fig. 4

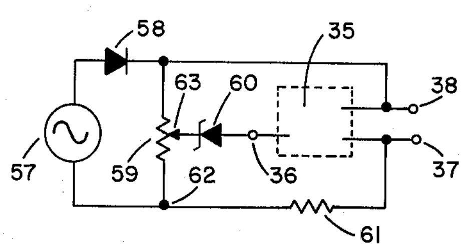

Fig. 5

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3,202,904
ELECTRONIC SWITCHING CIRCUIT
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This invention relates generally to transistor circuits for switching and amplifying applications, and in particular relates to a transistor circuit for use in the electrical ignition system of an engine and in other systems where a circuit capable of withstanding relatively high voltages is required.

It has been proposed that ignition systems be provided with an electronic circuit for switching and amplifying the current which is supplied to the ignition coil of the system through the breaker points. One purpose of such a circuit is to reduce the amount of current which passes through the breaker points, and thus reduce wear of the points which is caused by arcing between the points. Transistor circuits have certain well known advantages over electron tube circuits for such applications. For example, transistors are more rugged than electron tubes and they are operative as soon as they are energized whereas many tubes do not become operative until they warm up. Also, transistors can be expected to have a longer operating life than comparable tubes. However, known transistorized amplifying and switching circuits had some drawbacks which have held back their widespread commercial use in ignition systems.

One specific problem is that a relatively high voltage, 120 volts or more, may be developed across the primary winding of the coil in an ignition system for an internal combustion engine, and the transistors must be able to withstand this voltage if it appears across the output terminals of the amplifying and switching circuit. Transistors having a breakdown voltage greater than 100 volts are relatively expensive. The required over-all breakdown voltage can be obtained with two or more transistors whose output portions are connected in series, but most multiple transistor circuits of this type have required transformers in the input portion of the circuit which increases the over-all cost of the circuit substantially. The wide speed range of the internal combustion engine requires a wide range of spark frequencies making the transformer design difficult. Another problem is that in certain multiple transistor circuits which do not employ transformer coupling to the input terminals, there has been a tendency for the transistors to interact resulting in conduction in one or more of the transistors at times when they should be non-conducting.

Accordingly, it is an object of the invention to provide an improved amplifying and switching circuit for use in automotive ignition systems and other systems which require a circuit that will withstand high voltages.

Another object of the invention is to provide a multiple transistor circuit for switching and amplifying functions having an input circuit portion which prevents conduction of the transistors at times when they should be non-conducting.

A further object of the invention is to provide a multiple transistor circuit which has three terminals that are electrically equivalent to the emitter, base and collector terminals of a single transistor, such that the circuit can be handled like a single transistor for purposes of providing coupling into and out of the circuit.

A feature of the invention is a switching and amplifying multiple transistor circuit for an ignition system which includes a combination of diode and resistive elements forming an input portion for the circuit which will supply both direct current and alternating current to the transistors and which prevents the direct current bias voltage from causing any of the transistors to conduct when it is desired that the circuit be non-conducting.

A further feature of the invention is the provision of a transistor ignition system which includes one or more transistors having rectifiers connected in parallel relation with the output paths thereof, with the rectifiers having a breakdown voltage lower than that of the transisors so that the rectifiers conduct when the voltage across the output circuit exceeds the breakdown voltage thereof to protect the transistors from damage by excessive voltage.

Another feature of the invention is the provision of a multiple transistor circuit in which the output portions of the transistors are connected in series and the input portions are connected together by a combination of resistors and diodes so as to form a three terminal amplifying or switching circuit which exhibits electrical behavior similar to the behavior of a single high voltage transistor, but which is less costly than a single transistor with the same voltage rating.

FIG. 1 is a circuit diagram of an ignition system which includes a multiple transistor circuit in accordance with one embodiment of the invention;

FIG. 2 shows a modified form of the ignition system of FIG. 1 which represents another embodiment of the invention;

FIG. 3 shows still another embodiment of the multiple transistor circuit and in particular shows the three terminals of the circuit which are equivalent to the emitter, base and collector terminals of a single transistor;

FIG. 4 is a graph which shows the electrical characteristics of the circuit of FIG. 3; and

FIG. 5 shows a system in which the circuit of FIG. 3 is represented by an enclosure shown in dotted lines and whose purpose is to supply continuously variable power to a load.

The multiple transistor circuit of the invention includes at least two transistors whose emitter to collector circuit portions or regions are connected in series relation such that the overall voltage breakdown value of the circuit is the sum of the individual voltage breakdown values of the individual transistors. The base portions of the transistors are connected together to form an input circuit, and the input circuit includes a combination of resistors and diodes arranged so as to supply energizing voltage to the base electrodes of the transistors and also to prevent undesirable conduction of the transistors as a result of reverse leakage effects or because of the forward biasing of certain emitter-to-base circuits by the bias voltage. The voltage-current characteristics of the over-all circuit are quite similar to those of a single transistor, and the circuit is suitable for both alternating current and direct current amplifying and switching functions. The circuit is particularly useful in automotive ignition systems, and since it does not require the use of transformers or other special coupling circuits in the system, the over-all cost of the system is kept low. Rectifiers may be connected in parallel with the emitter-to-collector output circuits of the transistors which have breakdown voltage values lower than that of the transistors and which conduct to protect the transistors from excessive voltage.

FIG. 1 shows the circuit of the invention in an ignition system for an internal combustion engine. In this embodiment the input terminals are **10** and **12**, and terminal **10** is a common or ground connection. The breaker points of the ignition system are shown at **13** and these points serve to alternately make and break the connection to ground, thereby turning the transistors **14** and **15** on and off. When the points are closed, forward bias is applied to the bases of the transistors turning both transistors on. This results in a very low resistance path between terminals 10 and 12, thereby resulting in a current pulse through the primary winding 16 of the ignition coil 17. This current is delivered from the battery 18 through an ignition switch 19, and through the resistor 20. Resistor 20 limits the maximum current that can flow when the transistors are turned on. The making and breaking of the points 13, therefore, produces a changing current through the primary winding 16 of the ignition coil 17, and because the secondary winding 21 of this ignition coil has very many more turns than the primary winding 16, there is a large step up of voltage through the coil, resulting in a very high voltage appearing across the coil secondary winding 21. This voltage is delivered to the spark plugs of the engine.

The purpose of the resistors 22 and 23 is to provide a shunt path for the reverse leakage current of the transistors 14 and 15, thereby preventing the transistors from turning on as a result of this reverse leakage flow. If resistors 22 and 23 were not used, the leakage current of the transistors would be amplified through the collector to emitter circuits, and the output circuit would remain on during periods when it was desired to have the output shut off. Resistors 26 and 27 balance the current outputs of the transistors; that is, they make a correction for differences in gains between the transistors. Rectifier 28 is a Zener diode and protects transistor 15 from excessive voltages which may cause it to break down and possibly damage the transistor. Rectifier 28 will break down at a voltage below the breakdown voltage of the transistor 15. Rectifier 29, which is also a Zener diode, serves a similar purpose in protecting the transistor 14. The latter rectifier also prevents the source voltage 18 from forward biasing the emitter-to-base circuit of transistor 14 since such biasing would turn the device on during the period when the points are open. It is desired to have the device in a non-conducting state during this time.

Without rectifier 29 in the circuit, appreciable voltage drops would exist in resistors 22, 23, 26 and 27 as a result of the positive voltage existing between points 12 and 24. The polarity of the voltage drop existing across resistor 22 would bias the emitter-to-base circuit of transistor 14 positively thus causing the device to conduct. By using rectifier 29 practically all of the voltage is dropped across the rectifier, biasing in negatively, and therefore transistor 14 is not caused to conduct.

The high voltage that is generated in the secondary 21 of the ingition coil 17 occurs as a result of the collapse of the current supplied to the primary 16. The current collapses as a result of the cessation of conduction of transistors 14 and 15. The opening of the points 13 removes the forward bias from the bases of the transistors, causing the transistors to become non-conducting. This makes the circuit path from 12 to 10 a very high resistance and interrupts the current flow to the ignition coil primary 16. The high voltage developed in the secondary 21 is proportional to the product of the secondary inductance and the rate of change of current with time.

This configuration, with the ignition coil located in the collector circuit, has the advantage as compared to the circuit of FIG. 2 that the voltage across the points at break is approximately equal to the battery voltage, and there is no need for a saturation resistor in the collector circuit. However, in FIG. 1 the base currents do not flow through the coil 16 and appreciable power is dissipated in the base resistances.

FIG. 2 shows an example of the use of the circuitry of the invention in a transistorized ignition system, where the ignition coil 17 is located in the emitter circuit of the transstors 14 and 15. Since most of the circuit components in FIG. 2 are connected in the same way and serve the same functions as corresponding components in FIG. 1, the previous description will not be repeated. Corresponding elements in FIGS. 1 and 2 have the same

reference numbers. An advantage of locating the ignition coil 17 in the emitter circuit is that base currents will flow through the primary winding 16 of the coil and therefore add to the energy available to the secondary winding 21 of the ignition coil. A disadvantage of this configuration as compared to the embodiment of FIG. 1 is that the voltage across the points 13 at break will be somewhat higher than the voltage of the battery 18.

The over-all purpose of the circuit of FIG. 2 is the same as that of FIG. 1 and is to turn the transistors 14 and 15 on and off thereby generating a changing current in the primary 16 of the ignition coil 17. This results in a very high voltage generated in the secondary 21 of the ignition coil 17 and this voltage is thus available to fire the spark plugs of the engine. Both of the circuits in FIGS. 1 and 2 utilize the advantage of high frequency coil operation with a low inductance coil and high current levels to supply the necessary energy for the secondary of the ignition coil. This provides more available voltage at high engine speeds to maintain engine efficiency and also provides greater ability to fire fouled plugs.

FIG. 3 shows the fundamental circuit of a three terminal high voltage system 35. The circuit, which is quite similar to the circuits of FIGS. 1 and 2, includes three transistors 39, 40 and 41 connected as common emitter stages. The input circuit is between terminals 36 and 37 and it is here that an input signal is applied to the base electrodes of the transistors in parallel in the same manner as in FIGS. 1 and 2. The output circuit includes the emitter-to-collector paths of the transistors connected in series and appears between terminals 37 and 38. This system is turned on and off by application and removal of bias voltage to the input terminals 36 and 37. The system exhibits the electrical characteristics of a single transistor where terminal 36 is equivalent to the transistor base element, terminal 38 is equivaent to the collector element, and terminal 37 is equivalent to the emitter element.

FIG. 4 shows the electrical behavior of the three terminal system of FIG. 3. The collector current as measured at terminal 38 is plotted as the ordinate and the collector-to-emitter voltage, which is the voltage from terminal 38 to terminal 37, is plotted as the abscissa. The various curves branching off to the left represent diffferent values of base current, the larger values of current being at the top.

The circuit of the three terminal system of FIG. 3 will now be described in detail. Rectifiers 52, 53 and 55 of the Zener type are connected between the collector and emitter terminals of the transistor devices 39, 40 and 41. Each of these rectifiers serves the function of preventing the voltage appearing across the collector-to-emitter terminals of the transistors from exceeding the breakdown voltage of any given transistor. The rectifiers are so chosen that these rectifiers will breakdown at a voltage less than the breakdown voltage of the transistor with which it is in parallel, thereby putting a very low resistance path across the collector-to-emitter circuit of the transistor. This prevents any objectionably high voltage from existing between the collector and emitter terminals.

Resistors 42, 43 and 45 are connected between the base and emitter circuits of each of the transistor devices 39, 40 and 41. The purpose of these resistors is to provide a shunt path from the base to emitter of each transistor device to cause most of the reverse leakage current to pass through the resistors rather than allowing the current to pass through the collector-to-emitter circuit of the transistors. If these resistors were not used, the leakage current of the transistor devices would turn the devices on, thereby providing a low resistance circuit between output terminals 37 and 38 during the time when it is desired that the transistors be non-conducting. Thus, these resistors serve the same purpose as resistors **22** and **23** in FIGS. 1 and 2.

The rectifiers **47** and **48** which are connected in series with the input circuits of the transistor devices **40** and **41** prevent the bias voltage which appears between terminals **37** and **38** from causing untimely conduction of these transistors. If these rectifiers were not present, the negative voltage existing at terminal **38** would forward bias the base-to-emitter circuits of transistors **40** and **41** and cause these transistors to turn on during the time when it is desired that they be non-conducting. Rectifiers **47** and **48** are reversed biased by the bias voltage existing between terminals **37** and **38** and thus exhibit a very high resistance. This causes most of the bias voltage to be dropped across the rectifiers thus preventing an appreciable forward bias from developing across resistor **42** or **45**. The purpose of resistors **49**, **50** and **51** which are connected in series with the inputs to each of the transistor devices, and which are connected together at terminal **36** is to allow balancing of the gains of each of the transistor devices, thereby providing substantially equal outputs from each of the transistors.

The transistor devices **39**, **40** and **41** have their collector-to-emitter terminals connected in series; that is, the emitter of transistor **39** is connected to the collector of transistor **40**, the emitter of transistor **40** is connected to the collector of transistor **41**, and the emitter of transistor **41** is connected to the ground or common terminal **37**. Also, the collector of transistor **39** is connected to the output terminal **38**. The resistance between terminals **37** and **38** is dependent upon whether or not the string of transistors **39**, **40** and **41** is conducting or non-conducting. This in turn is determined by the voltage bias impressed on the input terminals **36** and **37**.

This system can be utilized as either a switching device or an amplifier. In switching applications the circuit between the terminals **37** and **38** is either caused to be a very low resistance or a very high resistance, depending upon the bias applied to the input terminals **36** and **37**. In amplifying functions, the current introduced into the input terminals **36** is amplified considerably by the system and appears in its amplified form in the circuit between terminals **37** and **38**.

FIG. 5 shows an example of the use of the three terminal system **35** to provide adjustable power to a resistive load **61** which, for example, might be a lighting load. It may be desired to vary the intensity of the lights by providing smoothly controlled variations of power to the load **61**. In this example the output terminals of the three terminal system are terminals **38** and **37** and the input terminals to the system are terminals **36** and **62**. The source voltage **57** is a standard 115 volt 60 c.p.s. voltage. The rectifier **58** provides half wave rectification of the source voltage **57** thereby providing pulses of D.C. voltage across bleeder resistor **59**. The voltage across bleeder resistor **59** is fed to the series combination of the load **61** and the system output terminals **38** and **37**.

The state of conduction or non-conduction of the system **35** is determined by the point at which the bleeder resistor **59** is tapped by the adjustable arm **63**. Zener diode **60** is biased in the conducting direction by the voltage taken off the bleeder resistor **59**. The point at which the tap **63** is set on the bleeder resistor **59** determines the portion of the time that the voltage across the bleeder resistor is connected to the load. Because the point at which the bleeder resistor is tapped can be varied, the system **35** can be made to conduct only during the portion of the cycle during which it is desired to deliver the voltage which appears across bleeder resistor **59** to the load. The setting on the tap **63** of the bleeder resistor **59** sets the bias between the emitter and base of the system **35** and therefore determines the point in the cycle when the system will conduct. During conduction a very low resistance path between output terminals **38** and **37** is provided, which connects the pulsating D.C. voltage through to the load **61**. In this configuration it is necessary for the output circuit of the system **35** to be able to withstand the peak voltage appearing across the bleeder resistor **59** which will reach approximately 165 volts during periods of non-conduction. The use of the system to provide this type of control is not limited to a lighting load application but could readily be used for numerous related functions which require variable power.

It is apparent from the foregoing description that the invention provides a multiple transistor circuit having electrical behavior much like that of a single transistor, and which can be readily turned on or off by bias changes to its input terminals. The system will perform as a switching device or as an amplifier, and is particularly advantageous in an ignition system. It will perform equally well for both A.C. and D.C. conditions and can handle high currents at especially high voltages.

I claim:

1. A multiple transistor circuit capable of withstanding voltages at the output thereof greater than the voltage breakdown values of the individual transistors, said multiple transistor circuit including in combination, a plurality of transistors each having emitter, base and collector portions, means connecting the emitter to collector paths of said transistors in series to form an output circuit, transformer means having a primary winding series connected in said output circuit, an input circuit having branch circuit portions connected respectively to the base portions of said transistors and having a common connection which is adapted to be coupled to a source of energizing voltage, means coupled to said output circuit and said input circuit for supplying bias voltage to said transistors including resistor elements connected respectively between the emitter and base portions of each of said transistors for shunting leakage current produced in said transistors by the bias voltage, diode means in said input circuit poled to block current in said branch circuit portions due to the bias voltage and to permit flow of current in said branch circuit portions responsive to an input signal for rendering said transistors conductive, and Zener diode means connected to said output circuit and forming a bypass path for preventing breakdown of said transistors due to voltages induced in said transformer means by the conduction of said transistors.

2. A multiple transistor circuit capable of withstanding voltages at the output thereof greater than the voltage breakdown values of the individual transistors, said multiple transistor circuit including in combination, energizing voltage means, first and second transistors each having emitter, base and collector portions, means connecting the emitter-to-collector paths of said first and second transistors in series with said energizing voltage means to form an output circuit, transformer means having a primary winding series connected in said output circuit, an input circuit having branch circuit portions connected respectively to the base portions of said transistors, means providing an intermittent bias voltage coupled to said input circuit, diode means in said input circuit poled to block current in said branch circuit portions due to the energizing voltage and to permit flow of current in said branch circuit portions responsive to the application of bias voltage to said input circuit to thereby render said transistors conductive, and Zener diode means connected to said output circuit and forming a bypass path for preventing breakdown of said transistors due to high voltage in said transformer means resulting from the conduction of said transistors.

3. A multiple transistor switching circuit for use in a spark-ignition system which includes an ignition coil and switching means for providing intermittent pulses, said multiple transistor switching circuit including in combination, first and second transistor means each having emitter, base and collector portions, means connecting the emitter to collector paths of said first and second

transistor means in series, means for connecting said collector portion of said second transistor to the ignition coil, further means connected to said emitter portion of said first transistor means for applying an energizing voltage thereto, impedance means connected between said emitter and base portions of each of said transistor means, an input terminal for connection to the switching means, control circuit means connected to said input terminal and including a portion connected to said base portion of said first transistor means and a portion including resistor means and a first Zener diode connected in series to said base portion of said second transistor means, a second Zener diode connected between said base and collector portions of said second transistor means, said first and second Zener diodes being poled to prevent current flow from said energizing voltage through said impedance means and the ignition coil and to provide a bypass path for preventing breakdown of said first and second transistor means due to voltages applied thereto from the ignition coil.

4. A multiple transistor switching circuit for use in a spark-ignition system which includes an ignition coil and a pair of intermittently opening breaker points for providing pulses, said multiple transistor switching circuit including in combination, first and second transistors each having emitter, base and collector portions, means connecting the emitter to collector paths of said first and second transistors in series, means for connecting said collector portion of said second transistor to the ignition coil, further means connected to said emitter portion of said first transistor for applying an energizing voltage thereto, first and second resistor means connected respectively between said emitter and base portions of said first and second transistors, a first resistor connected to said base portion of said first transistor for connecting said base portion to the breaker points, a second resistor and a first Zener diode connected in series to said base portion of said second transistor for connecting said base portion to the breaker points, a second Zener diode connected across said base and collector portions of said second transistor, said first and second Zener diodes being poled to block current flow through said resistor means during the period when said breaker points are open, and to permit flow of current through said resistor means upon closure of the breaker points to forward bias said first and second transistors and cause the same to conduct and energize the ignition coil.

5. A transistor switching circuit for use in a spark-ignition system which includes an ignition coil, switching means and energizing current supply means, said transistor switching circuit including in combination, transistor means having emitter, base and collector portions, means forming a first current path including said emitter and collector portions for connecting the energizing current supply means to the ignition coil, impedance means connected between said base and emitter portions of each of said transistor means, means forming a second current path including said impedance means connected to the energizing current supply means, means coupling the switching means to said second current path for causing intermittent energization thereof to thereby produce intermittent forward biasing of said transistor means and intermittent energization of said first current path, and Zener diode means connected between said first and second current paths and poled to prevent conduction from said second current path to said first current path, said Zener diode means forming a bypass path when in reverse conduction for preventing breakdown of said transistor means due to voltages in the ignition coil resulting from the intermittent energization of said first current path.

6. A multiple transistor switching circuit for use in a spark-ignition system which includes an ignition coil, switching means, and energizing current supply means, said multiple transistor switching circuit including in combination, first and second transistor means, each having emitter, base and collector portions, output circuit means forming a first current path including said emitter and collector portions of said transistor means for connecting the energizing current supply means to the ignition coil, first and second resistors connected respectively between said emitter and base portions of said first and second transistor means, means forming a second current path adapted for connection to the energizing current supply means for forward biasing said first and second transistor means, said second current path having first and second branch portions therein, said first branch portion including said first resistor and a third resistor in series therewith, said second branch portion including said emitter and collector portions of said first transistor means and said second resistor and further including a first Zener diode and a fourth resistor in series therewith, a second Zener diode connected across said collector and base portions of said second transistor means, and means coupling the switching means to said second current path causing intermittent energization of said second current path to thereby produce intermittent forward biasing of said first and second transistor means and intermittent energization of said first current path, said first and second Zener diodes being poled to prevent conduction from said second current path to said first current path.

7. A multiple transistor switching circuit for use in a system which includes energizing current supply means, control means and a load impedance, said multiple transistor switching circuit including in combination, first and second transistor means each having emitter, base and collector regions, output circuit means forming a first current path including said emitter-to-collector paths of said transistor means in series for connecting the energizing current supply means to the load impedance, first and second resistors connected respectively between said emitter and base regions of said first and second transistor means, input circuit means adapted for connection to the control means and to the energizing current supply means and forming a second current path for forward biasing said first and second transistor means, said second current path having first and second branch portions, said first branch portion being connected to said base region of said first transistor means and including said first resistor and a third resistor in series therewith, said second branch portion being connected to said base region of said second transistor means and including said emitter and collector regions of said first transistor means and said second resistor and further including a first Zener diode and a fourth resistor in series therewith, and a second Zener diode connected between said collector and base regions of said second transistor means, said control means causing intermittent energization of said second current path to thereby produce intermittent forward biasing of said first and second transistor means and intermittent energization of said first current path, said first and second Zener diodes being poled to prevent conduction from said second current path to said first current path.

8. A multiple transistor switching circuit for use in a system which includes energizing current supply means, control means and a load impedance, said multiple transistor switching circuit including in combination, first and second transistor means each having emitter, base and collector regions, output circuit means forming a current path including the emitter-to-collector paths of said transistor means in series for connecting the energizing current supply means to the load impedance, first and second impedance means connected respectively between said emitter and base regions of said first and second transistor means, input means for connection to the control means, a control circuit connected to said input means and including a first circuit portion connected to said base region of said first transistor means and a second current portion including resistor means and a first Zener diode connected in series to said base region of said sec-

ond transistor means, and a second Zener diode connected between said base and collector regions of said second transistor means, said first Zener diode being poled to prevent current flow from said energizing current supply means through said impedance means and said control circuit to render said first transistor means conducting, said first and second Zener diodes conducting in response to a predetermined voltage developed across the load impedance to prevent breakdown of said first and second transistor means.

9. A multiple transistor circuit capable of withstanding voltages at the output thereof greater than the voltage breakdown values of the individual transistors, said multiple transistor circuit including in combination, a plurality of transistors each having emitter, base and collector portions, means connecting the emitter-to-collector paths of said transistors in series to form an output circuit, transformer means having a primary winding series connected in said output circuit, an input circuit having branch circuit portions connected respectively to the base portions of said transistors and having a common connection which is adapted to receive an input signal, means coupled to said output circuit and said input circuit for supplying bias voltages to said transistors, diode means in said input circuit poled to block current in said branch

circuit portions due to the bias voltage and to permit flow of current in said branch circuit portions in response to an input signal for rendering said transistors conductive, and Zener diode means connected to said output circuit and forming a bypass path for preventing breakdown of said transistors due to voltages induced in said transformer means by the conduction of said transistors.

References Cited by the Examiner

UNITED STATES PATENTS

2,832,900	4/58	Ford	323—22
2,891,171	6/59	Shockley	307—88.5
2,899,571	8/59	Meyers	307—88.5
2,941,119	6/60	Ford	315—214
2,955,248	10/60	Short	323—62 X
2,957,993	10/60	Sichling	307—88.5
2,963,624	12/60	Meyer et al.	315—209
2,966,615	12/60	Meyer et al.	315—214
2,981,865	4/61	Fernback	315—206
3,016,477	1/62	Naborowski	315—206
3,068,392	12/62	Santelmann	321—18

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