

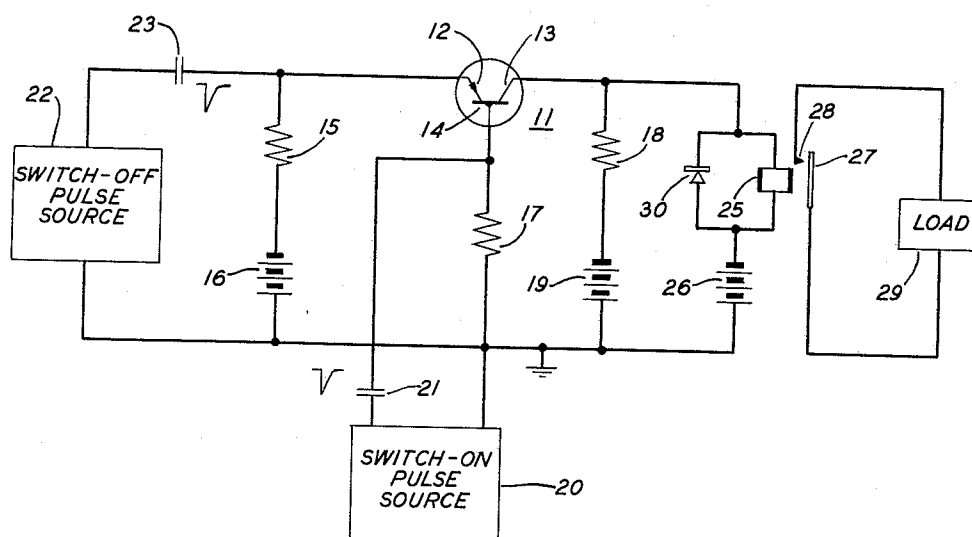
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TRANSISTOR CIRCUIT FOR OPERATING A RELAY

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1

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TRANSISTOR CIRCUIT FOR OPERATING A RELAY

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4 Claims. (Cl. 317—157)

This invention relates to transistor-operated relay circuits,

When a vacuum tube such as a triode is biased "off," the plate current is, for most practical purposes, zero. With transistors, however, a small, though appreciable, current flows in the collector and base electrodes even when the device is nominally biased "off." Further, this current, designated i_{co} , may vary by a ratio of 5 to 1 or more either with changes in temperature or from unit to unit. Although this small current will be unobjectionable in many, primarily alternating-current, circuits, it will sometimes effect undesired results in large signal circuits such as trigger circuits, either of the monostable, astable, or bistable type.

An example of the latter is an electromagnetic relay operated by a transistor trigger circuit. If the relay winding is connected in the collector-base circuit to take advantage of the larger current swings available in this circuit, the i_{co} may exceed the fall-out current of the relay so that it will fail to release when the trigger circuit is turned "off." Also, even though it may release, its release time may be increased excessively.

It is, therefore, an object of the invention to prevent variable transistor currents below a threshold value from interfering with the proper operation of a relay driven by the transistor. Another object is to improve the uniformity and reliability of transistor-operated relay circuits and in particular to insure that the relay will release when the transistor circuit is turned "off."

These and other objects of the invention, as well as its several features, may be better understood from a consideration of the following detailed description of an illustrative embodiment of the invention when read in accordance with the single figure in the attached drawing which is a schematic diagram of a relay operated by a transistor trigger circuit in accordance with principles of the invention.

The trigger circuit employed in the illustrative circuit of the figure is of the type disclosed and claimed in an application of A. J. Rack, Serial No. 79,861, filed March 5, 1949. By way of example, another type of trigger circuit which may be employed is disclosed in A. J. Rack Patent 2,579,336, dated December 18, 1951.

The central element of the trigger circuit shown in the figure is a current-multiplication transistor 11; for descriptive purposes, this transistor is a type-A, n-type transistor, forms of which are described in an article in the Bell System Technical Journal for July 1949 by R. M. Ryder and R. J. Kircher and entitled "Some Circuit Aspects of the Transistor" and also in J. Bardeen-W. H. Brattain Patent 2,524,035, dated October 3, 1950. The transistor 11 has three electrodes, an emitter 12, a collector 13, and a base 14. An emitter-base circuit includes the emitter 12, a resistor 15, an emitter bias battery 16, and a resistor 17. A collector-base circuit includes the collector 13, a resistor 18, battery 19, and the resistor 17. The resistor 17, common to both circuits just described, provides sufficient regenerative feedback over a range of positive emitter cur-

2

rents to give rise to a region of negative resistance in the emitter current-voltage characteristic of the transistor and thus give the circuit its trigger properties.

The operating points are determined primarily by the voltage of the emitter biasing battery 16 and the magnitude of resistor 15. By proper proportioning of these two elements, the circuit may be made either monostable, astable, or bistable; the present circuit is assumed to be bistable. Bistable operation may alternatively be obtained by the use of a biased diode in the emitter circuit, as is more fully described in a copending application of B. Ostendorf, Jr., Serial No. 292,875, filed June 11, 1952. Triggering pulses, to switch the circuit "on," are applied to the base electrode 14 from a pulse source 20 through a condenser 21. Negative pulses applied to the base will turn the circuit "on" if the circuit were previously "off." Since the circuit is bistable, it will remain in this state, characterized by a large collector current, until a negative pulse applied to the emitter 12 from the pulse source 22 by way of condenser 23 turns the circuit "off." Instead of using two pulse sources, a single source connected to emitter 12 and producing alternately positive and negative pulses could be employed.

The winding 25 of an electromagnetic relay is connected in series with a battery 26 in a circuit which includes the collector 13, resistor 17, and base electrode 14. When the relay is energized, its armature 27 makes a contact 28 and completes a circuit through a load 29. Were it not for the asymmetrically conducting impedance element 30 which shunts winding 25, and the current source comprising battery 19 and resistor 18, the collector current i_{co} which flows when the circuit is "off" and which varies in magnitude from transistor to transistor and with changes in temperature would interfere with proper operation of the relay either by permitting the relay to "hang up" or by retarding release of the relay when the trigger circuit is turned "off." Further, even though the relay would release, the inductive kick induced by winding 25 might produce a large enough pulse at the collector 13 to retrigger the circuit "on."

In accordance with principles of the invention, these undesirable effects are avoided by shunting the relay winding 25 with an asymmetrically conducting impedance element 30 which may, for example, comprise a germanium crystal diode. This diode is biased by the batteries 19 and 26 and is poled for low conduction for the direction of current which flows in the "on" condition. The batteries 19 and 26 and resistor 18 are so proportioned as to bias the diode in its low resistance condition for all currents in the collector electrode 13 below a threshold value which is slightly larger than the maximum expected i_{co} . In its low resistance condition, the diode shunts the small variable currents resulting from i_{co} from the relay winding and prevents their interfering with proper relay operation. For currents in collector electrode 13 above the threshold value, the diode is in its high resistance condition and permits full "on" collector current in excess of the threshold value to be applied to the relay. The diode also dampens any inductive transients induced by the relay winding and prevents their triggering the trigger circuit.

To give further understanding to the circuit just described, the following illustrative values will be mentioned. With a typical type-A transistor and a voltage of battery 26, of -30 volts, a battery 19 of -90 volts and resistor 18 of 30,000 ohms will provide for the maximum range of variation in i_{co} to be expected from most transistors so as to insure proper and reliable operation.

Although the invention has been described as relating to a specific embodiment, the invention should not be deemed limited to this specific configuration since it is merely illustrative and other embodiments and modifi-

3

cations will readily occur to one skilled in the art. For example, if a p-type transistor were used, currents would flow in the opposite direction so that the poling of the trigger pulses and of all batteries and of the diode 30 would be reversed.

What is claimed is:

1. In combination, a transistor trigger circuit having an "off" condition and an "on" condition comprising a current-multiplication transistor having an emitter electrode, a collector electrode, and a base electrode, an emitter-base circuit, a collector-base circuit, means for regeneratively coupling said collector-base and said emitter-base circuits, a relay having a winding and a circuit connected between said collector and base electrodes and comprising, in parallel, said winding and an asymmetrically conducting impedance element poled for low conduction in the direction of current flow in the "on" condition.

2. In combination, a transistor trigger circuit having an "off" condition and an "on" condition comprising a transistor having an emitter electrode, a collector electrode, and a base electrode, an emitter-base circuit and a collector-base circuit, means for regeneratively coupling said collector-base and emitter-base circuits, a source of direct current connected in said collector-base circuit, a relay having a winding, means connecting said winding in a circuit which shunts said source of current, and an asymmetrically conducting impedance element connected in parallel with said winding and poled for low conduction in the direction of current flow in the "on" condition.

4

3. The combination in accordance with claim 2 and means for biasing said asymmetrically conducting element in its high conduction condition for collector currents below a threshold value intermediate the "off" collector current and the "on" collector current and in its low conduction condition for collector currents which exceed said threshold value.

4. In combination, a transistor trigger circuit comprising a transistor having an emitter electrode, a collector electrode, and a base electrode, an emitter-base circuit and a collector-base circuit interconnected in trigger circuit configuration, said trigger circuit having an "off" stable operating point and an "on" stable operating point, a resistor and a source of direct current connected in series in said collector-base circuit, a relay having a winding, a circuit connected in shunt with said resistor and said source and including a second source of direct current, said winding and an asymmetrically conducting impedance element poled for low conduction in the direction of current which flows in the "on" condition, means connecting said asymmetrically conducting impedance element in parallel with said winding and said second source in series with the parallel combination of said winding and said impedance element, and means comprising said first and second sources of direct current for biasing said asymmetrically conducting impedance element in its high conduction condition when said trigger circuit is "off" and in its low conduction condition when said trigger circuit is "on."

No references cited.