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TRANSISTOR COUNTING SYSTEM

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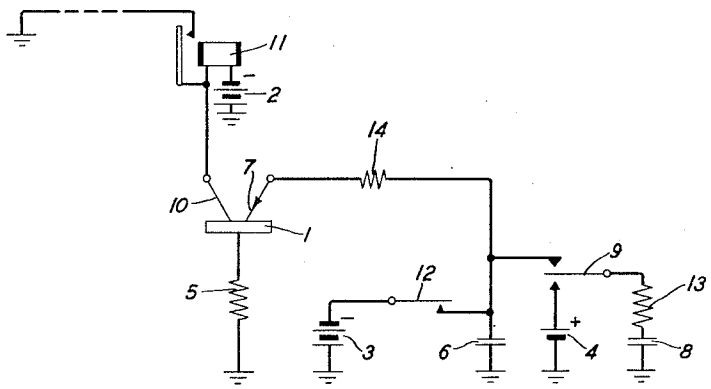

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TRANSITOR COUNTING SYSTEM

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This invention relates to counting systems and more particularly to counting systems comprising in combination a transistor, a storage condenser and a charging condenser for changing the charge on said storage condenser in discrete steps or increments.

The counting systems in the prior art wherein a small condenser is employed to change the charge on a larger condenser in discrete steps require either a vacuum tube or a gas tube to indicate the state of charge on the larger or storage condenser. Such arrangements are subject to stray fields and currents due to the high impedance of such devices. Furthermore, such devices either require a hot cathode or else the tubes vary widely from tube to tube so that a counting arrangement employing such tubes cannot be depended upon to count accurately. In addition when hot cathode tubes are employed considerable time is required for the cathode to reach the operating temperature.

An object of this invention is to provide an improved counting circuit which overcomes these difficulties by using a transistor in combination with the counting condensers.

A transistor comprises a base element comprising a semi-conducting or rectifying material, a collector electrode of small dimensions held in contact with the base element and usually biased in the non-conducting or high resistance region of the characteristic of the semiconductor material, and an emitter electrode also of small dimensions held in contact with the base and usually in close proximity to the collector electrode. Silicon and germanium with certain impurities are two materials suitable for base elements of a transistor. Other rectifying crystal elements may be employed for the base elements when desired.

A feature of this invention relates to the use of a resistor in the base circuit of the transistor to produce a positive feedback effect from the collector current, thus increasing the collector current.

The foregoing as well as other objects and features of this invention may be more readily understood from the following description of an exemplary embodiment when read with reference to the attached drawing.

Briefly, in accordance with the exemplary embodiment described in detail herein the arrangement for counting and denoting the number of operations of contacts, includes in combination a first condenser charged from a source of energy under control of contacts and a second condenser charged from the first condenser under control of said contacts. This operation is repeated until the second condenser has accumulated a charge which has a sufficient potential to overcome the bias voltage of the emitter of the transistor. The collector then conducts current and operates a relay or other responsive device indicating that the contacts have operated a certain number of times.

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Thus in accordance with an exemplary embodiment of this invention the base of the transistor is maintained at a certain potential and a first condenser included in the emitter circuit is given a definite charge to create a potential on the emitter which is negative in respect to the base potential. The condenser is then discharged in small increments through a second condenser which is alternately charged from the first condenser and discharged by the repeated operations of said control contacts. This discharging of the first condenser is continued making the emitter potential less and less negative with respect to the base potential until a discharge path is provided through the collector and base circuit of the transistor to operate a relay to denote the number of operations of said control contacts.

In order to facilitate the description of the exemplary embodiment of the invention set forth herein the change in charge or voltage upon the condensers is referred to as a charge or discharge. It is to be understood, however, this invention may be employed equally well in systems where the change in charges is reversed so that these terms would be also reversed in describing these alternative systems.

The invention is illustrated in the accompanying drawing in which base 1 of the transistor is connected through resistance 5 to ground. The condenser 6 is normally connected between the emitter 7 and ground. One side of the condenser 8 is connected to ground and the other side through a resistance 13 to contacts 9 which may connect the condenser 8 alternately to the emitter 7, and one side of condenser 6 or to a positive voltage indicated by battery. The collector circuit extends from battery 2, through relay 11 to the collector 10, base 1 and resistor 5 to ground.

The operation of this system is as follows: The condenser 6 is first momentarily given a negative charge from battery 3 through a key 12, condenser 6 to ground which raises the potential on the emitter 7 to a point negative in respect to the potential on the base 1, thus preventing appreciable current from passing through the collector 10 circuit when contact 12 is closed. After con-

tacts 12 are opened the contacts 9 are operated to close connections alternately from the condenser 8 to condenser 6 or from condenser 8 to positive battery 4. When the connection through the contacts 9 is closed between the condensers 6 and 8 the condenser 8 assumes an increment of the potential on condenser 6 and when the contacts 9 are closed to battery 4 the condenser 8 is discharged. These operations are repeated until the potential on condenser 6 has been sufficiently reduced or become sufficiently positive to cause the potential on emitter 7 to become of such critical value that it will permit or cause current to flow in the circuit of collector 10 through the winding or relay 11. This critical value may, depending on the characteristics of the transistor, be such that the potential difference between the emitter and the base is slight. Current then flowing through the winding of relay 11 causes this relay to operate. The current flowing in the output circuit between the base and collector and the winding of relay 11 also flows through resistor 5, thus lowering the voltage of the base which in turn has the effect of increasing the initial current in the collector over what it would be without the resistor. The condenser 6 is partially discharged in the transistor emitter circuit. Resistor 14 delays the discharge of condenser 6 thereby prolonging the time during which sufficient current is provided for operating relay 11. Relay 11 may lock operated if desired.

The operation of this relay denotes the number of operations of the contacts 9. This number depends on the ratio between the capacities of condensers 8 and 6, the normal potential on the condenser 6 and the potential characteristics of the transistor.

The resistance 13 is inserted in the circuit for the condenser 8 to safeguard against the premature operation of transistor and relay 11. The potential drop across the resistance 13, due to the discharge current from condenser 6 when contacts 9 are closed to connect the condensers, prevents such a premature operation as it prevents the emitter from becoming more positive than the upper plate of condenser 6.

As pointed out hereinbefore the basic operation of the system is dependent upon change in charge on the condensers. The change in charge in one system may be a charge in one system and a discharge in a similar or equivalent system. For example, battery 4 may be connected to the bottom terminals of either or both condensers 6 and/or 8. With the bottom terminal of condenser 6 connected to negative battery 4 this condenser 6 would be charging instead of discharging during counting.

It is to be understood that the above-described arrangements are illustrative of the application of the principles of the invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In combination, apparatus for counting a definite number of operations of contacts comprising a storage condenser, means for charging said storage condenser to a voltage representing the number of operations of said contacts, a charging condenser, means for alternately connecting said charging condenser to said storage condenser and then to a fixed reference voltage under control of said contacts, a transistor having an emitter, a base, and a collector, an input circuit connected to said emitter and including said storage condenser, and indicating means connected in an output circuit including said base and collector, and bias voltages applied to said transistor elements to actuate said indicating means after said definite number of operations of said contacts.

2. In a counter, a set of contacts, a storage condenser, a charge-changing condenser, apparatus controlled by each cycle of operation of said contacts for connecting said charge-changing condenser, alternately to said storage condenser and to a reference voltage, a transistor having an emitter element and a base element and a collector element, an input circuit including said storage condenser and said emitter element indicating means connected in an output circuit including said base and collector elements, bias voltages applied to said elements to actuate said indicating means after a number of cycles of operation of said contacts, and a resistor connected to said base element to increase the collector current.

3. In combination, apparatus for counting a definite number of operations of contacts comprising a storage condenser, means for initially applying a predetermined voltage and polarity condition to said condenser, another condenser, means operative under control of said contacts for alternately connecting one terminal of said other condenser to one terminal of said storage condenser and then to a predetermined reference voltage having a polarity opposite to the polarity initially applied to said storage condenser, a transistor having an emitter, a base, and a collector, an input circuit connected to said emitter and to said storage condenser, and indicating means connected in an output circuit including said base and collector, and bias voltages applied to said transistor elements to actuate said indicating means after a predetermined number of operations of said contacts.

4. In combination, a transistor comprising a base of semi-conducting material, a collector electrode in contact with said base, an emitter electrode in contact with said base in close proximity to said collector electrode, an output circuit including said base and collector elements, an input circuit including said base and emitter elements, a condenser connected in said input circuit, bias means for applying biasing voltage between the elements of said transistor for biasing said elements in a high resistance region of the transistor field of operation, means for changing the charge on said condenser to initiate a flow of current between said base and each of said other electrodes, a feedback resistor connected in the base circuit of said transistor to increase the output current from said transistor, and delay means for prolonging the output current from said transistor comprising a resistance connected in the emitter circuit of said transistor.

5. In combination, a transistor comprising a base member of a semi-conducting material, an emitter and a collector electrode in contact with said base member, means for normally biasing said elements to the non-conducting region, a condenser connected in said input circuit, means for changing the voltage on said condenser to a conducting condition, and means for increasing the response of said transistor comprising a resistor connected in series with the base element of said transistor, and apparatus for prolonging

said increased response comprising a resistor connected in series with the emitter element to retard the change of voltage of said condenser.

6. In combination, apparatus for counting a definite number of operations of a pair of contacts comprising a storage condenser, means for initially applying a voltage of predetermined magnitude and polarity to said storage condenser, a second condenser, means for discharging said storage condenser in discrete steps and then charging said storage condenser to a voltage of opposite polarity comprising a set of contacts for alternately connecting one terminal of said second condenser to one terminal of said storage condenser and then to a predetermined reference voltage having a polarity opposite to the initial polarity of voltage applied to said storage condenser, a transistor having an emitter element and a base element and a collector element, an input circuit connected to said emitter element and to said storage condenser, responsive means connected in an output circuit including said base element and said collector element, means including voltage sources for applying biasing voltages to said transistor elements to actuate said responsive means by a predetermined voltage of said reverse polarity on said storage condenser in response to a predetermined number of operations of said contacts, a feedback resistor connected in series with said base element to increase the output current from said transistor, and delay means for prolonging the flow of output current from said transistor comprising a resistor connected in series with said emitter element.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,114,016	Dimond	Apr. 12, 1938
2,481,112	Hanley	Sept. 6, 1949
2,486,776	Barney	Nov. 1, 1949

OTHER REFERENCES

The Transistor-A Crystal Triode, "Electronics" pages 68–71, September 1948.