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TRANSISTOR CIRCUIT HAVING TEMPERATURE COMPENSATING MEANS

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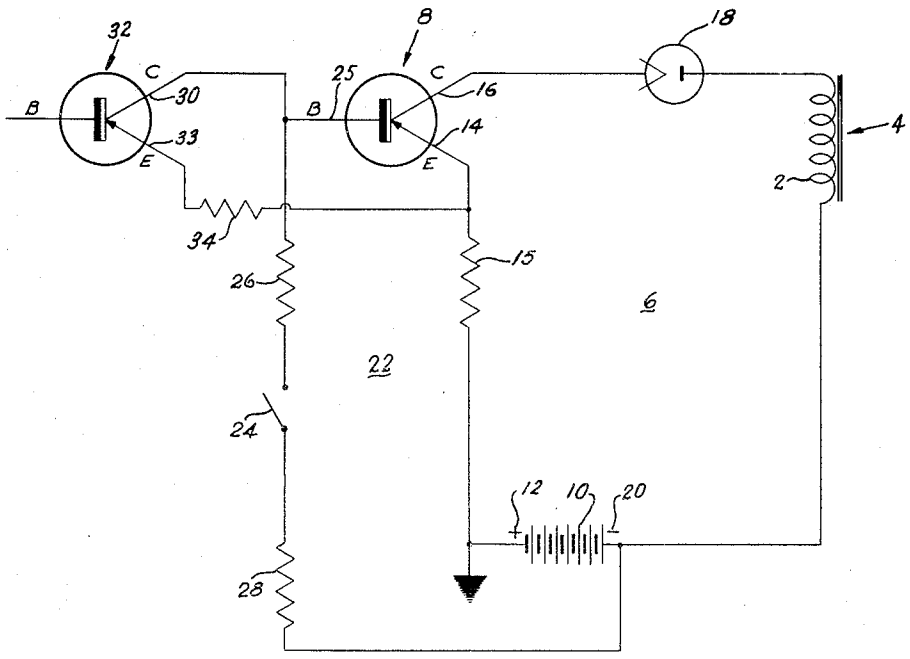

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TRANSISTOR CIRCUIT HAVING TEMPERATURE COMPENSATING MEANS

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1 Claim. (Cl. 307—88.5)

The present invention relates to relay circuits that are controlled by transistors. In arrangements of this kind the relay coil lies usually in the collector circuit of the transistor, and the collector voltage is so chosen that the collector current flowing through the relay coil is less than required to energize the relay, but even a very weak forward current passed from the emitter to the base of the transistor will decrease the resistance of the transistor and thus increase the current flow in the collector circuit to an extent where it will actuate the relay.

Arrangements of this type are of advantage under conditions wherein the control current available is very small, or must be kept small to safeguard other components in the control circuit that would be unable to stand heavier currents. Such a situation exists, for instance, in the control circuits of automatic steering devices for moving vessels which employ a reversible motor to operate the steering means and wherein a magnetic compass element serves to adjust the operation of the motor in response to departures of the vessel from its predetermined course. In arrangements of this type the compass element forms part of, or is arranged to actuate, the control switch of a circuit that controls the direction of operation of the steering motor by means of a relay, and in circuits comprising such delicate components as a compass needle to form, or actuate, a switch, electric current flow must be kept sufficiently light to reduce sparking at the point of contact between the switch elements and thus prevent fusion of said elements which would disrupt the operation of the control arrangement.

Transistor-controlled relay circuits, of the type briefly described above, have the disadvantage that the conductivity of transistors varies markedly with changes in the ambient temperature since the conductivity of semi-conductors increases with increasing temperature. As a result the resistance of the transistor in the power circuit of the relay may drop and cause an increase of current flow in the collector circuit that might energize the relay without application of a control signal between the emitter and the base of the transistor, effecting inappropriate operation of whatever device is controlled by the relay.

Such misoperation is likely to occur and is particularly harmful, in automatic steering arrangements of the type mentioned hereinbefore, because such arrangements are frequently located in places, close to the engine or motor of the vessels, that are subject to very considerable increases in the ambient temperature during operation of the engine or motor.

It is an object of my invention to provide a transistor-controlled circuit arrangement that is substantially independent of changes in the ambient temperature.

It is a particular object of the present invention to provide a transistor-controlled relay that is responsive to predetermined control signals only, irrespective of changes in the ambient temperature.

Furthermore, it is an object of the invention to provide a sensitive transistor-controlled D.C. relay circuit that

is dependable in operation and whose dependability is not adversely affected by variations in the ambient temperature.

These and other objects of my invention will be apparent from the following description of the accompanying drawing which illustrates a preferred embodiment thereof by means of a circuit diagram.

In accordance with the invention I connect a second transistor into the control circuit of the relay in such a manner that the collector of said second transistor delivers a reverse current to the base of the control transistor and in this manner increases the resistance of the control transistor in the relay circuit. Consequently, when an increase in the ambient temperature decreases the resistance of the control transistor, which might ordinarily be sufficient to effect energization of the relay, the accompanying decrease in the resistance of the auxiliary transistor increases the current flow through its collector circuit causing an increase in the reverse current applied to the base of the control transistor. This increases the resistance of the control transistor and in this manner compensates for any decrease of said transistor caused by the rise in temperature. Accidental premature energization of the relay in the collector circuit of the control transistor is therefore prevented and the operation of the relay is controlled solely by the application of an appropriate signal between the emitter and the base of the control transistor.

Having now reference to the drawing, the coil **2** of a relay **4** is connected into the collector circuit **6** of a grounded-emitter junction-type transistor **8**. A battery **10** provides the power for the energization of the relay **4**. Its positive pole **12** is connected to the emitter **14** of the transistor **8** through a suitable resistor **15**, while the collector **16** of the transistor is connected to one end of the coil **2** through a suitable diode **18** to protect the relay from accidental current reversals due to erroneous connection during the installation of the circuit. The opposite end of the coil **2** is connected directly to the negative pole **20** of the battery **10**. The size of resistor **15** is so chosen with regard to the voltage of the battery **10** and the resistance constituted by the transistor **8** in circuit **6** that the current ordinarily flowing through the relay coil is substantially less than required to energize the relay. The control circuit **22** of the transistor **8** comprises a normally open switch **24**, which may be the compass-actuated control switch of an automatic steering arrangement of the type mentioned hereinbefore. When said switch is closed, it causes a biassing current to flow from the positive pole **12** of the battery **10** through the emitter **14** to the base **25** of transistor **8**. Suitable high-ohmic resistors **26** and **28** at either side of the switch **24** hold the current flow through the control circuit **22** at the low level which compass-actuated switch elements are able to carry and which are sufficient to actuate the control transistor **8**. For instance, a few micro amperes applied across the emitter and the base of the transistor may be sufficient to lower the resistance of the transistor between its emitter and collector to such an extent as to produce a current flow of several milliamperes in the collector circuit **6**, which will be sufficient to operate the relay **4**.

To compensate for any temperature-dependent decrease in the resistance of the transistor **8** to current flow in the power circuit **6** such as might effect inappropriate energization of the relay **4**, I connect the collector **30** of another junction-type transistor **32** of preferably a substantially larger size and greater conductivity than the control transistor **8**, directly to the base **25** of the control transistor **8**, and I connect its emitter **33** to the positive pole **12** of the battery preferably at a point above resistor **15** through a suitable resistor **34**. In this man-

ner a small positive current is applied to the base **25** of the control transistor **8**, and when an ambient temperature rise causes the resistance of control transistor **8** in the power circuit **6** of the relay **4** to drop, which might effect inappropriate operation of the relay, the accompanying decrease in the resistance of the auxiliary transistor **32** will increase the positive current applied to the base **25** of the control transistor **8**, whose collector resistance is therefore increased. By appropriate choice of the value of resistor **34** with regard to the size of the compensating transistor **32**, the temperature-dependent increase in the positive current applied to the base of the control transistor **8** may be so accurately predetermined as to compensate effectively for any temperature-dependent decrease of the resistance of the control transistor **8** within the power circuit **6** of the relay **4**, without impairment of the responsiveness of the control transistor **8** to control signals applied between its emitter and base by closure of the control switch **24**. Thus, the control of relay **4** as provided by the transistor **8** is substantially independent of changes in the ambient temperature, yet it remains practically as sensitive to the application of extremely weak control currents as it was before.

In an exemplary embodiment of the invention as illustrated in the accompanying drawing I employed the following components:

Transistor **8**	2N132.
Transistor **32**	2N256.
Resistor **15**	13 ohms.
Resistor **26**	330K ohms.
Resistor **28**	100K ohms.
Resistor **34**	6.8K ohms.
Diode **18**	IN56 A.
Relay **4**	10K ohms.
Battery **10**	12 volts.

While I have explained my invention with the aid of an exemplary embodiment thereof, it will be understood that the invention is not limited to the specific electrical

quantities of the components listed above. Also, while I have explained my invention as employed for the purposes of compensating temperature-dependent irregularities in the operation of a transistor-controlled D.C. relay, it will be understood that the concept of compensating for temperature-dependent irregularities in the operation of a transistor by means of the temperature-dependent variations in the performance of another transistor has a much wider application than the control of D.C. relays.

I claim:

A temperature balanced transistor circuit comprising a first transistor having a base electrode, an emitter electrode and a collector electrode; signal output means for deriving an output signal from the collector electrode of said first transistor including a source of voltage having a positive pole connected to the emitter electrode of said first transistor and a negative pole connected to the collector electrode of said first transistor; signal input means for applying a signal to the base electrode of said first transistor including means for connecting the negative pole of said source of voltage to the base electrode of said first transistor; and compensating means for temperature-dependent changes in the operation of said first transistor including a second transistor having an emitter electrode connected to the positive pole of said source of voltage and a collector electrode connected to the base electrode of said first transistor, to deliver through said second transistor from the emitter electrode to the collector electrode thereof a reverse current to the base of said first transistor.

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