United States Patent

[11] 3,593,200

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[21] Appl. No. 800,146
[22] Filed Feb. 18, 1969
[45] Patented July 13, 1971
[32] Priority Oct. 20, 1968
[33] Switzerland
[31] 15737/68

[54] ELECTRONIC SWITCHING ARRANGEMENT FOR TIME KEEPING EQUIPMENT
3 Claims, 1 Drawing Fig.

[52] U.S. Cl. 331/116, 58/23, 331/109, 331/156
[51] Int. Cl. H03b 5/36
[50] Field of Search 331/109, 116, 156; 58/23

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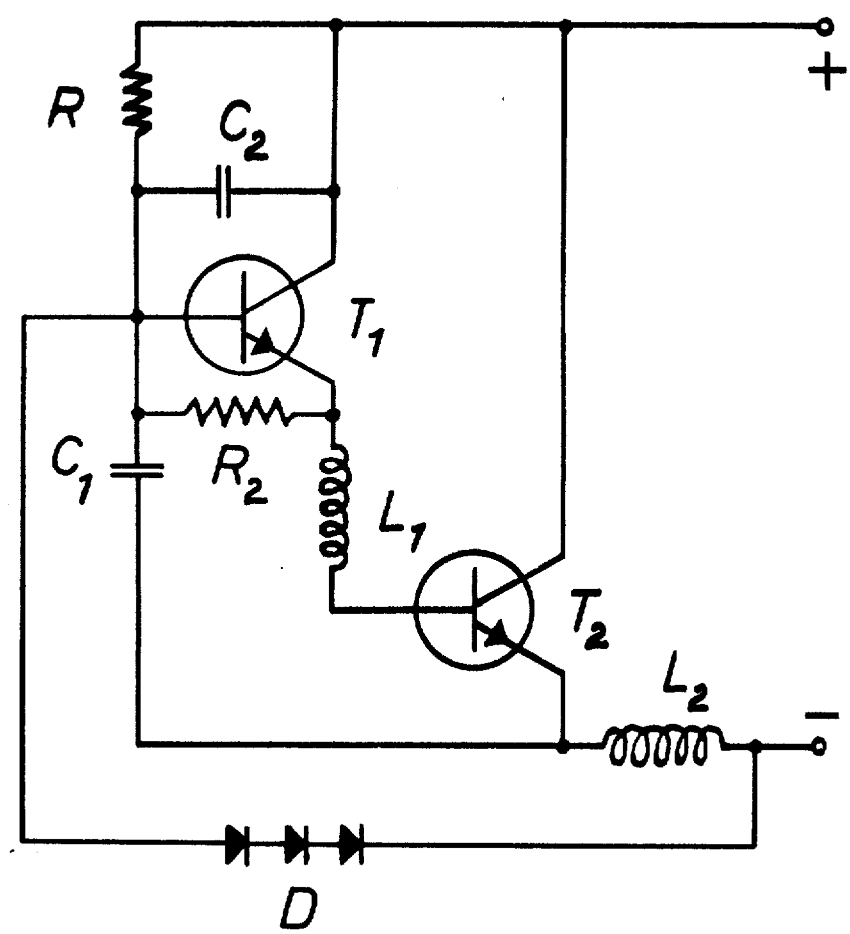
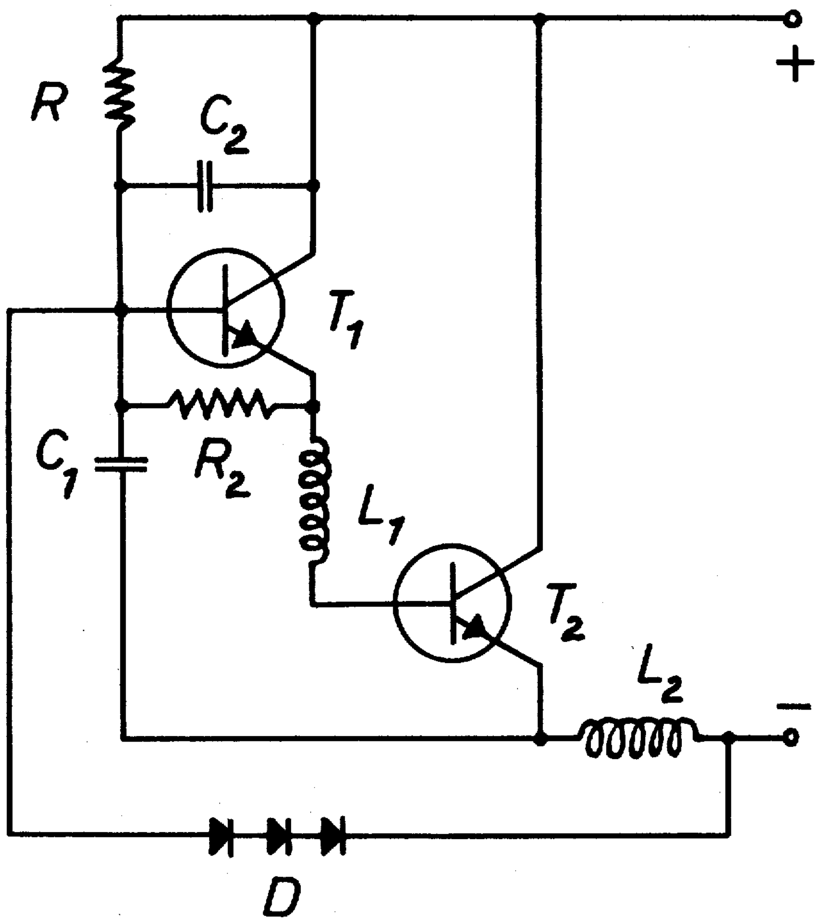
ABSTRACT: A self-exciting electronic circuit for driving the mechanical rate element of a time-keeping device including means to vary the width of the drive pulse to compensate for amplitude differences caused by temperature or voltage changes.





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ELECTRONIC SWITCHING ARRANGEMENT FOR TIME KEEPING EQUIPMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an electronic switching circuit for clocks and other timekeeping equipment with any desired magnet system.

2. Description of the Prior Art

In the electronic circuits currently used with time keeping equipment, the accuracy of the clock speed depends on the voltage and temperature affecting the circuits and this dependence in turn can be traced back mainly to the transistor properties. Attempts have been made to eliminate the temperature dependence primarily by using various switching techniques. To eliminate the voltage dependence, breakdown diodes have been preferred. These known measures do produce a more or less significant success which is obtained, however, at the expense of a considerable output loss because, based on the level of the minimum output available immediately prior to battery replacement, the initial surplus portion of the output is intentionally lost. Such an output loss is particularly disadvantageous in a small clock which works with a supply voltage of only about 1 volt.

SUMMARY OF THE INVENTION

This invention provides a completely new electronic circuit for clocks and other timekeeping equipment, for use with any desired magnet system. Both the way of looking at the problem and the means of solution of the problem are new.

The novel circuit is characterized by the fact that it is self-exciting and that it is adapted to elongate the pulse width upon decrease of voltage or temperature (and their effective combination, respectively,) and to shorten the pulse width upon increase of voltage or temperature (and their effective combination, respectively,) thereby keeping constant the product of voltage and time t, i.e. the pulse intensity: $Vt=I$.

The basic technical improvement over all known circuits with voltage and temperature compensation is that the new circuit works without loss. Furthermore, the operating range can be expanded in a very simple manner to include supply voltages of up to about 24 volts.

BRIEF DESCRIPTION OF THE DRAWING

The electronic circuit according to the invention is illustrated in the sole figure by way of example.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The circuit shown comprises two coils L_1, L_2, which cooperate in a known manner with any desired magnet system (not illustrated). It is immaterial here whether the magnet system is fixed to the rate regulator and the coils are stationary or vice versa. It is only important that the relative motion between the magnet system and the coils causes the coils periodically to get into the magnetic field and thus to be coupled. Furthermore, there are two transistors T_1 and T_2 of the same type (in the drawing, they are illustrated as NPN type but the PNP type could be used in a corresponding altered circuit). The first transistor T_1 is connected with the second transistor T_2 while the first coil L_1 is connected in between the two. Between the emitter and the negative terminal of the voltage source (not further illustrated) is the second coil L_2. The collectors of transistors T_1 and T_2 are connected to the positive terminal of the battery, as is the base of the first transistor T_1, the latter being connected via a resistance R. A capacitive feedback link C_1 is arranged between the emitter of the second transistor T_2 and the base of the first transistor T_1. A capacitor C_2 is connected between the base and the collector of the first transistor T_1 for the attenuation of spurious parasitic oscillations. Resistance R_2, which is connected between the base and the emitter of the first transistor T_1, and is used to adjust the pulse ratio, is necessary here only if the battery voltage is greater than about 1.6 volts (up to a maximum of about 24 volts). Then resistance R_2 is in the range of several kilohms, while a high-impedance resistance is provided as R. The capacitive feedback link C_1 and coil L_2 which thus are connected in series are bridged by three silicon diodes D (two diodes are enough at a battery voltage of up to 1.5 volts). By the silicon diodes D the voltage on the emitter of the transistor T_1 is limited and thereby the maximum pulse amplitude. The capacitor C_1 couples the pulse from the emitter of the transistor T_2 to the base of the transistor T_1. Though the voltage on the emitter of the transistor T_1 is constant by variations of the battery voltage the voltage on the emitter of the transistor T_2 varies. If the battery is fresh full voltage is on the emitter of the transistor T_2 and the capacitor C_1 is discharged during a predetermined period of time. If the battery voltage and in consequence the voltage on the emitter of the transistor T_2 drops off the time for discharging of the capacitor C_1 is rising and both transistors are conductive during a longer period of time than with the full voltage.

The circuit illustrated operates in such a fashion that, due to the sudden self-excitation start, the first transistor T_1 becomes conductive and thus causes the second transistor T_2 to become conductive. The positive voltage occurring at the emitter of the second transistor T_2 is applied to the base of the first transistor T_1 by means of feedback link C_1, because of which this first transistor becomes even more strongly conductive. Thus the current, flowing through coils L_1 and L_2 is amplified in avalanche-fashion. Both coils operate as working coils. The circuit thus, in contrast to all previously known circuits, does not reveal a special exciter coil. The processes in the switching arrangement are triggered the moment both coils are connected by the magnetic field of the magnet system, while there is a disconnection during the departure from the magnetic field and the processes in the switching arrangement are thus cut off.

Since transistors T_1 and T_2 are not connected in a complementary fashion, this is not dealing here with a multivibrator but rather with a completely new circuit in which one can determine the energy level by selecting R and C_1. When C_1 is smaller there is a larger amplitude and when R is larger there is a smaller amplitude. As the temperature drops, there is a greater impulse width.

In a typical circuit according to the present invention, after one day the temperature and voltage errors are smaller than one second per degree Centigrade or per volt so that the spring error is also controlled here.

I claim:

1. A self-exciting electronic circuit for timekeeping equipment adapted for magnetic interaction with a magnet means to thereby physically drive said equipment, comprising:
   a. positive and negative terminals adapted to supply DC power,
   b. a first and second coils adapted to be coupled by said magnet means,
   c. a first and second transistor of the same conductivity type, said first transistor being intercoupled in cascade through said first coil with said second transistor connected through said second coil to one of said terminals,
   d. a feedback link consisting of a first capacitor connected between the output of said second transistor and the base of said first transistor,
   e. a first resistor connected between the base of said first transistor and the other of said terminals,
   f. means for connecting the input of said first transistor to the other of said terminals,
   g. means for connecting the input of said second transistor to the other of said terminals, and
   h. a second capacitor connected between the input and the base of said first transistor.

2. A circuit according to claim 1, wherein a point between the first coil and the first transistor is connected through a second resistor to the base of the first transistor.

3. A circuit according to claim 2, wherein the feedback link and the thus series connected second coil are bridged by at least two silicon diodes.