Nov. 29, 1960 A. A. KWARTIROFF ET AL 2,962,643

TIME-PIECE

Filed April 16, 1956

FIG.1

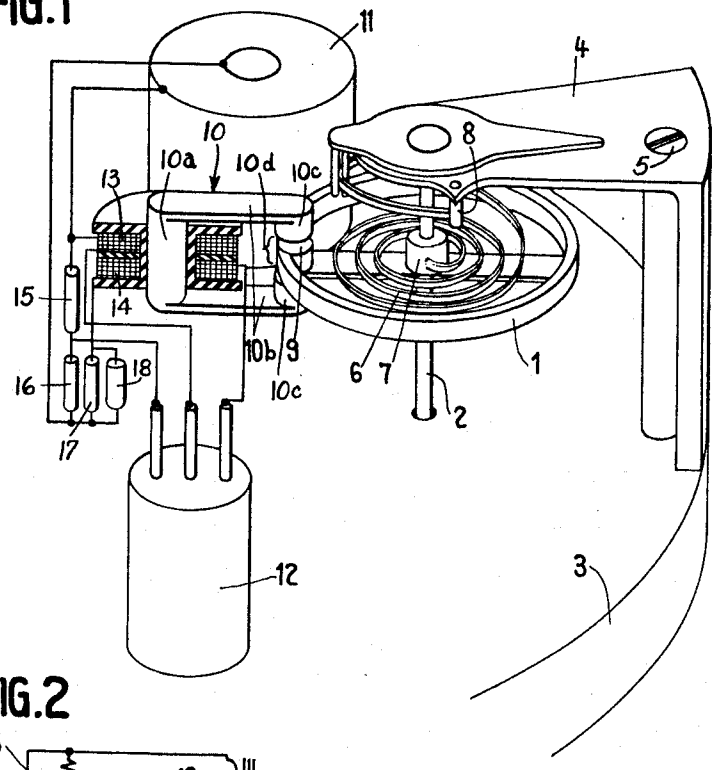


FIG.2

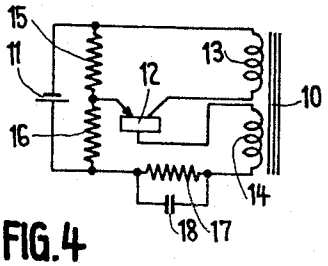


FIG.3

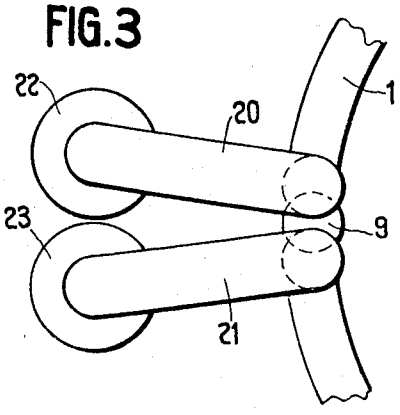
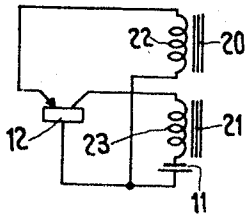


FIG.4



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2,962,643

TIME-PIECE

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5 Claims. (Cl. 318—132)

This invention relates to a time-piece actuated by an electric source and having an electronic switch for pulse-wise control of the driving energy of a mechanical rotary oscillator, for instance a balance wheel. A time-piece of that type is disclosed in the copending patent application Serial No. 476,704 of Nicolas Aeschmann.

In the time-piece disclosed in the above prior patent application two different magnetizable parts are fixed on the said rotary oscillator, the one of such magnetizable parts serving for inducing electric pulses for control of the electronic switch, for instance a transistor or a vacuum tube and the other magnetizable part serving for taking up the driving or accelerating pulses for sustaining the oscillation of the rotary oscillator. Two different winding and core systems were required each for cooperation with one of the said magnetizable parts fixed on the rotary oscillator.

This invention aims in simplifying time-pieces of the kind set out above. The time-piece of this invention is broadly characterized in that one single magnetizable part, preferably a permanent magnet is fixed on the said rotary oscillator, for instance on a balance wheel, the said magnetizable part causing the production of electric pulses for controlling the said electronic switch and the mechanical driving pulses produced by magnetic pulses being imparted to the said magnetizable part for sustaining the oscillation of the said rotary oscillator. Thereby it is possible to use one single core carrying the required windings.

In the drawing two embodiments of this invention are illustrated by way of example, the figures showing only the parts of the time-pieces necessary for a ready understanding of the invention.

Fig. 1 is a perspective view of the essential parts, partially in section,

Fig. 2 is an electric circuit diagram of the first embodiment of the time-piece, and

Figs. 3 and 4 illustrate a constructive detail and an electrical circuit diagram of the second embodiment of the time-piece.

The time-piece shown in Fig. 1 comprises a mechanical rotary oscillator, constituted by a balance wheel **1**, the staff **2** of which is pivoted in the pillar plate **3** and in a bridge **4** (cock) fixed to the pillar plate by means of a screw **5**. A hair spring **6** of conventional type is attached at its inner end to a collet **7** maintained on the staff **2**, whereas its outer end is fixed to the cock **4** by means of a stud **8**.

The rim of the balance **1** carries a magnetizable part or armature, for instance a permanent magnet **9**. Near the balance **1** is fixed a magnetizable core, for instance a soft iron core **10** carrying two separate windings **13** and **14** (Fig. 2). Core **10** has a cylindrical yoke 10_a passing through coils **13** and **14**, two parallel leg portions 10_b and inwardly directed pole pieces 10_c, enclosing an air gap 10_d between them. The core **10** is so disposed that the magnet **9** may freely pass through the air gap of the core **10** fixed on the plate **3**. Further, the relative position of the magnet **9** and the core **10** is so designed that the magnet **9** is completely and symmetrically engaged in the air gap of the core **10** when the balance **1** is at rest. This relative rest or zero position of the parts is illustrated in Fig. 1.

The time-piece has a direct current source **11** and an electronic switch, in the embodiment shown a transistor **12**.

Fig. 2 is an electric circuit diagram of the time-piece shown in Fig. 1. The winding **13** wound onto the core **10** is connected into the collector circuit of the transistor **12** and the sender of the transistor is kept at a suitable operating potential, for instance by means of a voltage divider comprising resistors **15** and **16**, which is connected to the battery **11**. The base of the transistor **12** is connected to the one end of winding **14**, the other end of this winding being connected to the one battery terminal over a resistor **17** and a condenser **18**.

The transformer ratio and the coupling coefficient of the transformer constituted by the windings **13** and **14** and core **10** are so designed that the circuit may operate as a blocked oscillator. However, the rest potential of the transistor base and sender are such that the blocking oscillator will not start to oscillate itself and will not remain in oscillating state without external starting or synchronizing pulse.

When the balance **1** is displaced from its rest position illustrated in Fig. 1 and is then released, a voltage will be induced in the winding **14** when the magnet **9** first approaches the core **10**, the direction and value of the voltage being such that the transistor which had been in cut-off condition becomes conducting. The winding direction of the winding **13** is so designed that by the current increase occurring in the same the magnetic flux in the core **10**, increases in the same direction as for the approach of the magnet **9** to the core so that by this further increase of the magnetic flux in the core **10** a still higher voltage of the same polarity as before is induced in the winding **14**, this voltage rise causing another current increase in the collector circuit of the transistor and in the winding **13**. In the manner well known for blocking oscillators this increase of current flow in the collector circuit of the transistor goes on until saturation of the collector current begins, whereupon the voltage induced in the winding **14** and consequently the current pulse in the coil **13** breaks down. Therefore, for every control pulse induced in the winding **14** the blocking oscillator is controlled to produce one single aperiodic oscillation or pulse.

By suitable design of the coils **13** and **14**, of the elements **17** and **18** connected into the base circuit of the transistor and of the base rest potential the beginning of the current increase in the transistor **12** and in the winding **13** is so delayed with respect to the control pulse induced in the coil **14** that this current pulse and the magnetization of the core **10** caused by the same only occurs when the magnet **9** fixed on the balance **1** has reached at least its rest position. When the magnet **9** has overpassed its rest or mid-position, the magnet **9** is repelled by the increasing magnetic flux in the air gap of core **10** whereby a driving or accelerating pulse is imparted to the magnet **9** and consequently to the balance **1** so that the oscillation is sustained. During the next passage of the magnet **9** through the air gap of the core **10** exactly the same events will take place so that the magnet **9** receives a driving or accelerating pulse at every passage through the air gap of the core **10**.

In the embodiment of the time-piece according to this invention shown in Figs. 3 and 4 of the drawing two magnetizable cores **20** and **21**, both similar to the core **10** of Fig. 1 are arranged side by side, the cores **20** and

21 carrying windings 22 and 23 respectively. The windings 22 and 23 are connected into the sender circuit and the collector circuit respectively of the transistor 12 as shown in Fig. 4. It is again assumed that a small permanent magnet 9 is fixed on the rim of the balance wheel 1, the cores 20 and 21 being made of soft iron or other magnetizable material having no or little remanence. It is further assumed that practically no collector current flows in the transistor when the time-piece is at rest.

When the balance wheel oscillates and the permanent magnet 9 approaches the air gap of the core 20 a voltage is induced in the winding 22 in such a direction that the current in the collector circuit of the transistor and in the winding 23 increases, whereby the core 21 is magnetized in such a direction that the permanent magnet 9 is repelled. When the magnet 9 moves from the upper right corner of Fig. 3 downwardly and to the left the magnetization of the core 21 will occur too early for taking a noticeable influence on the magnet 9. But when the magnet is moving in the opposite direction, that is from the lower left corner in Fig. 3 the magnetization of the core 21 will occur when the magnet 9 is approximately in the position illustrated in Fig. 3 so that the magnet 9 is repelled in the direction of its motion whereby a driving or accelerating pulse is imparted to the balance wheel 1.

The circuit might as well be designed in such a way that the said electric pulse causing an increase in collector current in the transistor and in the winding 23 might be induced in the winding 22 whenever the magnet 9 leaves the air gap of the core 20. In this case magnetisation of the core 21 shall have an attractive effect on the magnet 9.

By means of the oscillation of the balance wheel 1 the hands of the time-piece are driven in a well known manner by mechanical means. The hands of the time-piece might also be driven by means of a stepping motor fed by the current pulses occurring in the collector circuit of the transistor. To this end a suitable air gap might be provided in the core 10 or 21 respectively and an armature might displaceably be arranged in this air gap the armature being displaced for every excitation of the core for acting onto a stepping wheel advancing the hands of the time-piece. The electric pulses occurring in any one of the circuits illustrated might also be used for synchronizing another blocking oscillator whereby a motor for driving the hands of the time-piece would be energized by this blocking oscillator.

The above described blocking oscillator (Fig. 2) might as well be designed for self sustained oscillation at a frequency slightly below the balance wheel frequency, the blocking oscillator being synchronized with the balance wheel for instance by the electric pulses induced in the winding 14.

Instead of a transistor 12 another electronic switch, for instance a vacuum tube might be used.

One single winding might also be provided on the core 10 (Figs. 1 and 2) in which the electric pulses for controlling the electronic switch would be induced and through which the driving current pulses would flow.

Instead of a permanent magnet 9 a soft iron piece might be fixed on the rim of the balance wheel 1 in the embodiment shown in Figs. 3 and 4 whereby the core 20 might be a permanent magnet or comprise a permanent magnet setting up a magnetic field in the air gap through which the magnetizable soft iron piece of the balance wheel passes. It is also feasible to produce the desired magnetisation in the core 20 by means of the rest current flowing in the winding 22 or in another suitable winding. Thereby a change of the magnetic flux would occur in the core 20 whenever the soft iron piece fixed on the balance wheel enters the air gap of the core and the electric pulse for controlling the electronic switch would be induced by this change of magnetic flux.

While the invention has been described and illustrated with reference to specific embodiments thereof, it will be understood that other embodiments may be resorted to without departing from the invention. Therefore, the forms of the invention set out above should be considered as illustrative and not as limiting the scope of the following claims.

What we claim is:

1. A timepiece actuated by an electric source, comprising a balance wheel, an electronic switch associated with a control circuit and a controlled circuit for pulse-wise control of the driving energy for the said balance wheel, one single separate piece of magnetizable material fixedly attached to the said balance wheel, fixed core means of magnetizable material, air gap means in the said core means, the said piece of magnetizable material passing through the said air gap means on oscillation of the balance wheel, the size of the said core means and the size of the said piece of magnetizable material being so correlated with the amplitude of the balance wheel that the transit path of the said piece through the said air gap means is small compared with the said amplitude of the balance wheel, a first coil on the said core means connected into the control circuit associated with the said electronic switch and a second coil on the said core means connected into the controlled circuit associated with the said electronic switch, a short voltage pulse being induced in the said first coil on passage of the said piece of magnetizable material through the said air gap means and a short current pulse being initiated through the said electronic switch and the said second coil by the said voltage pulse, the said current pulse passing through the second coil imparting a mechanical driving pulse to the said piece of magnetizable material passing through the said air gap means.

2. A time-piece according to claim 1, wherein the said core means comprise one single core and one single air gap, the said first and second coils being accommodated on the said single common core.

3. A timepiece actuated by an electric source, comprising a balance wheel, an electronic switch associated with a control circuit and a controlled circuit for pulse-wise control of the driving power for the said balance wheel, one single separate piece of magnetizable material fixedly attached to the said balance wheel, fixed core means, means of magnetizable material comprising at least one U-shaped core having two leg portions, a yoke portion and an air gap between such leg portions opposite the said yoke portion, the said leg portions enclosing the said balance wheel between them, the size of the said piece of magnetizable material and the size of the said core means being so correlated with the amplitude of the balance wheel that the said piece of magnetizable material attached to the balance wheel passes through the said air gap formed between the said leg portions within a small part of the amplitude of the said balance wheel, first and second coil means on the yoke portion of the said core means, the said first coil means being connected into the control circuit associated with the said electronic switch and the said second coil means being connected into the said controlled circuit associated with the said electronic switch, a short voltage pulse being induced in the said first coil means on passage of the piece of magnetizable material through the air gap of the said core means and a short current pulse being initiated through the said electronic switch and the said second coil means by this voltage pulse, the said current pulse initiating a mechanical driving pulse on the said piece of magnetizable material attached to the balance wheel.

4. A timepiece actuated by an electric source comprising a balance wheel, an electronic amplifier associated with a control circuit and a controlled circuit for pulse-wise control of the driving energy for the said balance wheel, one single separate piece of magnetizable material fixedly attached to the said balance wheel, one single

fixed core of magnetizable material having an air gap, the said piece of magnetizable material passing through the said air gap on oscillation of the balance wheel, a first coil on the said core connected into the control circuit associated with the said electronic amplifier and a second coil on the said core connected into the controlled circuit of the said electronic amplifier, the said first and second coils being coupled with each other by the said core of magnetizable material in a manner to constitute together with the said electronic amplifier a blocking oscillator adapted for free oscillation at a first natural frequency, the said balance wheel being adapted for free oscillation at a second natural frequency, the said first natural frequency of the blocking oscillator being somewhat lower than the said second natural frequency of the balance wheel and the said blocking oscillator being synchronized at the said second natural frequency of the balance wheel by voltage pulses induced in the said first coil on passage of the said piece of magnetizable material through the air gap of the said core.

5. An electric timepiece actuated by an electric source, of the type having a balance wheel and an electronic amplifier associated with a control circuit and a controlled circuit for pulse-wise control of the driving energy for the said balance wheel of the timepiece, comprising one single separate piece of magnetizable material fixedly attached to the balance wheel, one single fixed core of magnetizable material having one single air gap, the said piece of magnetizable material adapted to pass through the said air gap on oscillation of the balance wheel, winding means on the said core, feed-back means interconnecting the said winding means with the said control circuit and connecting means between the said controlled circuit and the said winding means, a blocking oscillator being formed by the said electronic amplifier, the said winding means and the said feed-back means, a change of magnetic flux being produced in the said core and a voltage being induced in the said winding means due to the said change in magnetic flux when the said piece of magnetizable material passes through the said air gap, this voltage being adapted for pulse-wise operating the said blocking oscillator, whereby a current pulse is produced in the said controlled circuit and winding means respectively, a driving pulse being applied to the said piece of magnetizable material by the said current pulse occurring in the said winding means.

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