July 26, 1960 A. BEYNER ET AL 2,946,940

TIMEPIECE COMPRISING AN ELECTROMAGNETICALLY MAINTAINED OSCILLATING REGULATOR

Filed April 4, 1958

2 Sheets-Sheet 1

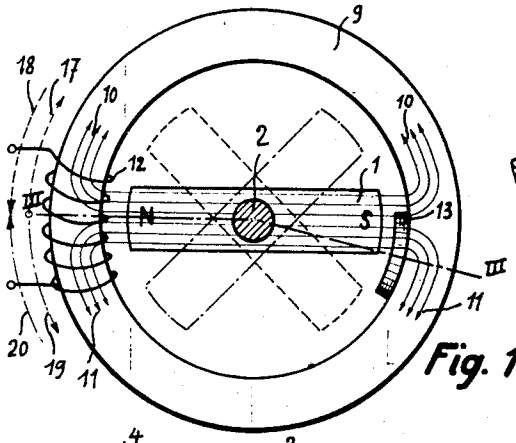


Fig. 1

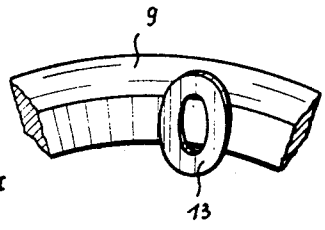


Fig. 2

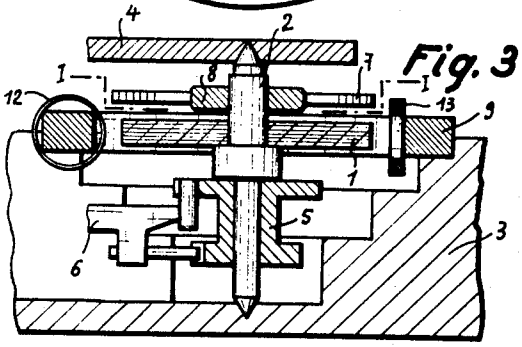
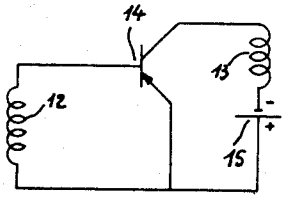


Fig. 3

Fig. 4



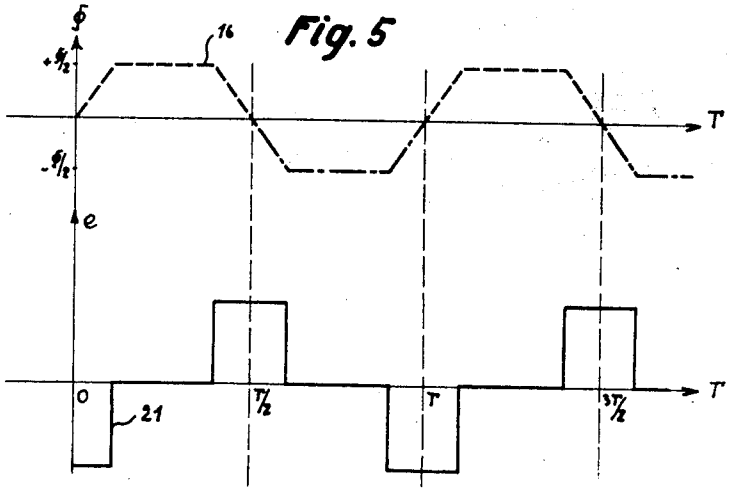


Fig. 5

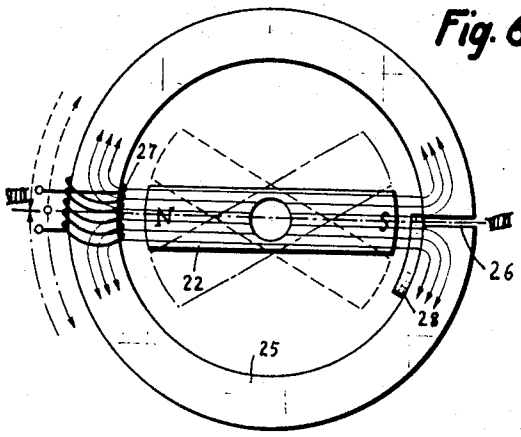
INVENTORS
André Beyner
Igor Scherrer
Henri Morier
By John B. Sommerhalder
Attorney

July 26, 1960 A. BEYNER ET AL 2,946,940

TIMEPIECE COMPRISING AN ELECTROMAGNETICALLY MAINTAINED OSCILLATING REGULATOR

Filed April 4, 1958 2 Sheets-Sheet 2

Fig. 6



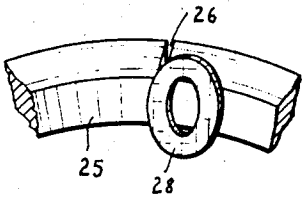


Fig. 7

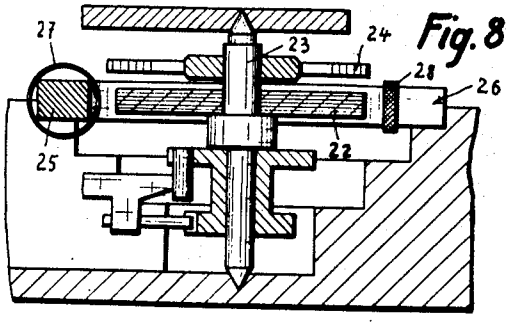


Fig. 8

INVENTORS
André Beyner
Igor Scherrer
Henri Morier
By John B. Armbrust
Attorney

United States Patent Office 2,946,940 Patented July 26, 1960

2,946,940

TIMEPIECE COMPRISING AN ELECTROMAGNETICALLY MAINTAINED OSCILLATING REGULATOR

André Beyner, Igor Scherrer, and Henri Morier, Neuchatel, Switzerland, assignors to Ebauches S.A., Neuchatel, Switzerland, a firm of Switzerland

Filed Apr. 4, 1958, Ser. No. 726,575

8 Claims. (Cl. 318—128)

The present invention relates to a timepiece comprising an electromagnetically maintained oscillating regulator.

In timepieces of the type in which the movement of the regulating member produces by induction, in a pick-up winding, an impulse signal controlling the feed of a driving winding, the balance wheel generally comprises a magnet moving oppositely to the pick-up winding. The arrangement is such that, as the magnet travels past, the flux varies in the pick-up winding from a zero value to a maximum and redescends to 0. This fluctuation occurs twice per oscillation of the balance. Since the induced voltage is a function of the derivative of the flux, each variation of the latter produces a positive voltage and a negative voltage. Consequently, two impulse signals—due to positive voltages and to negatives voltages respectively—are supplied to the driving winding at each oscillation of the balance. Now, from the viewpoint of isochronism, the maintenance of the balance at the rate of two driving impulses per oscillation, one in each direction of its movement, is not favourable, since the Airy conditions cannot be satisfied.

The object of the present invention is to obviate this disadvantage while providing an oscillating regulator device which is electromagnetically maintained at the rate of a single driving impulse per oscillation.

The timepiece according to the invention is characterised by an oscillating field magnet, by a torus having high magnetic permeability, surrounding the said magnet and canalising its magnetic flux in such manner as to divide it into partial fluxes, the number of which is equal to the number of poles of the magnet, by a pick-up winding wound around a portion of the said torus, and by a driving winding situated in the air gap separating the magnet from the said torus, the whole arrangement being such that the pick-up winding is exposed to a constant magnetic flux as long as it is not situated opposite one of the poles of the magnet, the value of which magnetic flux is equal to that of a partial flux, the said flux changing sign while passing through zero when a pole of the magnet travels past the said pick-up winding, whereby there is induced in the latter an impulse signal effecting the feed of the driving winding in such manner that the regulator thus receives one driving impulse per complete oscillation of the magnet.

The accompanying drawing, in which only the parts necessary for an understanding of the invention are shown, illustrates by way of example one constructional form of the subject of the invention and a modification.

Figure 1 is a plan view, partly in section along the line I—I of Figure 3, of a first constructional form of the regulating device of a timepiece.

Figure 2 is a view in perspective of a detail of the said device.

Figure 3 is a section along the line III—III of Figure 1.

Figure 4 is a skeleton diagram of the electric circuit of the timepiece.

Figure 5 is a diagram of the variations of the magnetic flux and of the voltage induced in the pick-up winding as a function of time.

Figure 6 is a plan view of a modified form of the regulating device of a timepiece.

Figure 7 is a view in perspective of a detail of the said device, and,

Figure 8 is a section along the line VIII—VIII of Figure 1.

The timepiece illustrated in Figures 1 to 4 comprises a balance **1** formed of a magnetised bar, the staff **2** of which is pivoted between the pillar plate **3** on the one hand and the balance cock **4** on the other hand. Mounted on the staff **2** is a roller **5** controlling a counting pallet **6** intended to convert the oscillating movements of the balance **1** into a discontinuous rotational movement of a moving member (not shown) connected to the hands. The hair spring is designated by **7**. Its inner end is fixed to a collet **8**.

Mounted on the plate **3** is a torus **9** consisting of a material having high magnetic permeability, which is coaxial with the balance **1** and situated in its plane of oscillation. The said torus is intended to canalise the magnetic flux of the bipolar magnet **1**, and to divide it into two half-fluxes along the lines of force **10** and **11** indicated in Figure 1. A pick-up winding **12** surrounds a portion of the torus **9**, while a driving winding **13** of pancake form is applied against the inner face of the said torus, in the free space situated between the magnet and the torus. This particular arrangement of the driving winding **13** avoids the danger of coupling between the input and the output of the amplifier hereinafter described. The position of equilibrium of the balance is shown in solid lines in Figure 1. The winding **12** is situated on the torus in a position opposite one of the poles of the balance, in this case the north pole, when the latter occupied its position of equilibrium. The driving winding **13** is then slightly offset in relation to the other pole.

The driving winding is connected on the one hand to the collector of a transistor **14** and on the other hand to the negative terminal of a source of current **15**, for example a 1.3 volt battery (Figure 4). The positive terminal of this source of current **15** is in turn connected to the emitter of the transistor **14**. Finally, the pick-up winding **12** is connected on the one hand to the base of the transistor **14** and on the other hand to the emitter of the said transistor.

The operation of this timepiece is as follows:

When the balance occupies its position of equilibrium, the flux Φ of the north pole of the magnet is divided into two equal parts in the two halves of the pick-up winding **12**, so that the total flux embraced by the said winding is zero. This position of the balance corresponds to the point **0** of Figure 5, in which the curve **16** indicates the variation of the flux to which the winding **12** is exposed. When the balance moves in the direction of the arrow **17** (Figure 1) from its position of equilibrium, in the course of which movement it passes from the position illustrated in chain lines in Figure 1, the flux to which the winding **12** is exposed increases to a maximum value of

$$+\frac{\Phi}{2}$$

As soon as this value is reached, it is maintained until the north pole of the magnet, in returning in the direction of the arrow **18**, again takes up a position opposite the winding **12**. The flux is then again decreased and passes through a zero value at the instant when the balance oc-

cupies its position of equilibrium (T/2 in Figure 5). The balance thereafter moves in the direction of the arrow **19**, in the course of which movement it passes through the position illustrated in dash-dotted lines in Figure 1. The flux surrounding the coil **12** increases to a minimum value of

$$-\frac{\Phi}{2}$$

which remains constant as long as the north pole of the magnet moves on the further side of the said winding. At the end of the complete oscillation (point T of Figure 5) and after the balance has finally moved in the direction of the arrow **20**, the flux has returned to a zero value. This variation of the flux produces, by induction, a voltage in the winding **12** in accordance with the law

$$e=-n\frac{d\Phi}{dt}$$

represented by the curve **21** in Figure 5. This signal, applied between the base and the emitter of the transistor **14**, releases the latter, so that the driving winding **13** is then fed by the source **15**, whereby a driving impulse is supplied to the balance. Since only one of the voltages, i.e. either the positive voltage or the negative voltage, is employed, it will be seen from the diagram of Figure 5 that the balance receives only one driving impulse per oscillation. In the illustrated example, in which the winding **12** is situated exactly opposite the position of equilibrium of the north pole of the magnet, the driving impulse is symmetrically distributed on either side of the position of equilibrium of the balance.

It is to be noted that the slightly offset position of the driving winding **13** in relation to the position of equilibrium of the south pole of the magnet is necessary in order that a driving effect may be produced on the latter when the said winding is fed. Finally, it should be noted that the amplitude of the oscillations of the balance must not exceed a limit value such that the north pole never takes up a position opposite the driving winding **13**.

The invention is not limited to the constructional form described and illustrated. The magnet needs not constitute the balance itself, but it may be fixed thereto. It may also comprise a number of poles greater than 2.

In the modified form illustrated in Figures **6** and **8**, the regulating member is also formed by an oscillating magnetic bar **22** mounted on the staff **23** and subjected to the action of a hair spring **24**. The said magnetic bar turns within a torus **25** of magnetic material which is open at **26**. In its position of equilibrium, as illustrated in solid lines in Figure 6, the bar **22** has one of its poles situated opposite the slot **26**.

Mounted on the torus, diametrically opposite the slot **26** therein, is a pick-up winding wound on the said torus and, in the neighbourhood of the said slot, a driving winding **28** of pancake form, applied against its inner face.

When the bar **22** occupies its position of equilibrium, its magnetic flux Φ is divided into two partial fluxes of equal value. Immediately the bar leaves its position of equilibrium, one of the partial fluxes passes through the slot **26**, which constitutes an additional air gap, thereby considerably reducing it in favour of the other partial flux to which the pick-up winding **27** is at this instant exposed. Experience has shown that a slot **26** of small width produces between the partial fluxes a difference such that one of them comprises almost all the flux Φ of the magnet, while the other is reduced to an almost zero flux.

By virtue of this arrangement, while the first constructional form permits of picking-up the voltage variations due to flux variations ranging from

$$+\frac{\Phi}{2} \text{ to } -\frac{\Phi}{2}$$

the present modification permits, with members of like dimensions, of using in the same time double the flux variation ranging substantially from $+\Phi$ to $-\Phi$. The signal set up at the terminals of the pick-up coil is thus substantially doubled.

The electric circuit arrangement is the same as in the first constructional form.

In order to avoid the danger of deformation of the torus, the aperture **26** in the latter may be filled by a member of non-magnetic material, for example brass.

What we claim is:

1. In a timepiece having an electromagnetically maintained oscillating regulator, an oscillating field magnet, a torus of high magnetic permeability surrounding the said magnet and canalising its magnetic flux so as to divide it into partial fluxes situated in a plane perpendicular to the axis of oscillation of the said magnet, the number of which is equal to the number of poles of the magnet, a pick-up winding wound around a portion of the said torus, in such a place along the said torus that this pick-up winding is situated opposite a pole of the magnet when the latter occupies its position of equilibrium, and a driving winding situated in an air gap separating the magnet from the said torus, the whole arrangement being such that the said pick-up winding is exposed to a constant magnetic flux as long as it is not situated opposite one of the poles of the magnet, the value of the said magnetic flux being equal to that of a partial flux, the said flux changing sign while passing through 0 when a pole of the magnet travels past the said pick-up winding, whereby there is induced in the latter an impulse signal of one sense only at each passage of a pole of the magnet in front of the pick-up winding.

2. In a timepiece having an electromagnetically maintained oscillating regulator, an oscillating field magnet, a torus of high magnetic permeability surrounding the said magnet and canalising its magnetic flux so as to divide it into partial fluxes situated in a plane perpendicular to the axis of oscillation of the said magnet, the number of which is equal to the number of poles of the magnet, a pick-up winding wound around a portion of the said torus, in such a place along the said torus that this pick-up winding is situated opposite a pole of the magnet when the latter occupies its position of equilibrium, and a driving winding constituted by a pancake coil situated against the said torus, in an air gap separating the magnet from the said torus, the whole arrangement being such that the said pick-up winding is exposed to a constant magnetic flux as long as it is not situated opposite one of the poles of the magnet, the value of the said magnetic flux being equal to that of a partial flux, the said flux changing sign while passing through 0 when a pole of the magnet travels past the said pick-up winding, whereby there is induced in the latter an impulse signal of one sense only at each passage of a pole of the magnet in front of the pick-up winding.

3. In a timepiece having an electromagnetically maintained oscillating regulator, an oscillating field magnet constituting the said regulator itself, a torus of high magnetic permeability surrounding the said magnet and canalising its magnetic flux so as to divide it into partial fluxes situated in a plane perpendicular to the axis of oscillation of the said magnet, the number of which is equal to the number of poles of the magnet, a pick-up winding wound around a portion of the said torus, in such a place along the said torus that this pick-up winding is situated opposite a pole of the magnet when the latter occupies its position of equilibrium, and a driving winding situated in an air gap separating the magnet from the said torus, the whole arrangement being such that the said pick-up winding is exposed to a constant magnetic flux as long as it is not situated opposite one of the poles of the magnet, the value of the said magnetic flux being equal to that of a partial flux, the said flux changing sign while passing through 0 when a pole of the magnet travels past the said pick-up winding, whereby there is induced in the latter an im-

pulse signal of one sense only at each passage of a pole of the magnet in front of the pick-up winding.

4. In a timepiece as claimed in claim 3, the feature that the angular position of the said pick-up winding and the said driving winding is such that when one of them is situated opposite one of the poles of the magnet the second is slightly offset in relation to the other pole.

5. In a timepiece having an electromagnetically maintained oscillating regulator, an oscillating magnetised bar constituting the said regulator, a torus of high magnetic permeability surrounding the said magnet, in the plane of this latter, and canalising its magnetic flux so as to divide it into partial fluxes situated in a plane perpendicular to the axis of oscillation of the said magnet, the number of which is equal to the number of poles of the magnet, a pick-up winding wound around a portion of the said torus, in such a place along the said torus that this pick-up winding is situated opposite a pole of the magnet when the latter occupies its position of equilibrium, and a driving winding situated in an air gap separating the magnet from the said torus, the whole arrangement being such that the said pick-up winding is exposed to a constant magnetic flux as long as it is not situated opposite one of the poles of the magnet, the value of the said magnetic flux being equal to that of a partial flux, the said flux changing sign while passing through 0 when a pole of the magnet travels past the said pick-up winding, whereby there is induced in the latter an impulse signal of one sense only at each passage of a pole of the magnet in front of the pick-up winding.

6. In a timepiece as claimed in claim 1, the feature that the said torus is open so that, outside the position of equilibrium of the magnet, the partial magnetic fluxes have appreciably unequal values, one of them being reduced in favour of the other by the additional air gap formed by the opening in the torus.

7. In a timepiece as claimed in claim 1, the feature that the said torus is open diametrically opposite the said pick-up winding, so that, outside the position of equilibrium of the magnet, the partial magnetic fluxes have appreciably unequal values, one of them being reduced in favour of the other, to which the pick-up winding is exposed, by the additional air gap formed by the opening in the torus.

8. In a timepiece having an electromagnetically maintained oscillating regulator, an oscillating field magnet, a torus of high magnetic permeability, a portion of which is made of non-magnetic material, surrounding the said magnet and canalising its magnetic flux so as to divide it into partial fluxes situated in a plane perpendicular to the axis of oscillation of the said magnet, and a driving winding situated in an air gap separating the magnet from the said torus, the whole arrangement being such that the said pick-up winding is exposed to a constant magnetic flux as long as it is not situated opposite one of the poles of the magnet, the value of the said magnetic flux being equal to that of a partial flux, the said flux changing sign while passing through 0 when a pole of the magnet travels past the said pick-up winding, whereby there is induced in the latter an impulse signal of one sense only at each passage of a pole of the magnet in front of the pick-up winding.

References Cited in the file of this patent

UNITED STATES PATENTS

2,769,946 Brailsford ---------- Nov. 6, 1956

FOREIGN PATENTS

1,134,560 France ---------- Dec. 3, 1956