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N. AESCHMANN

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TIMEPIECE

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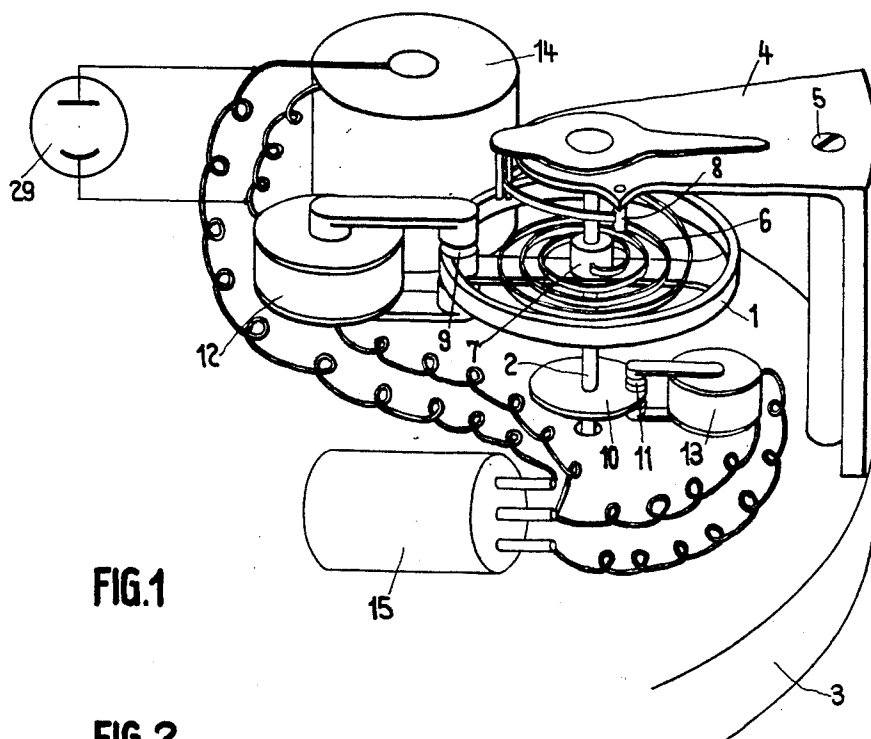


FIG. 1

FIG. 2

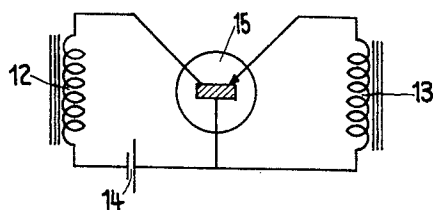


FIG. 3

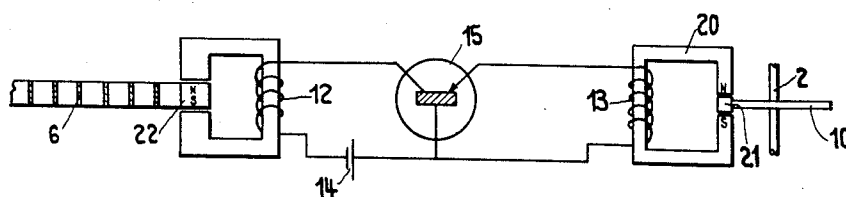
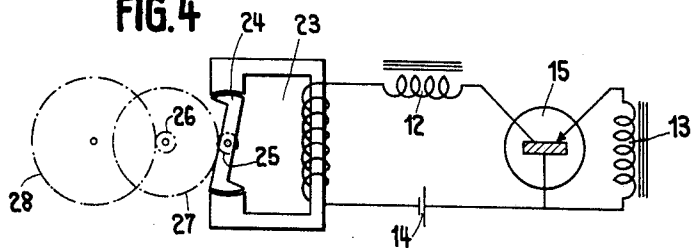


FIG. 4



INVENTOR
NICOLAS AESCHMANN
BY *Edward R. Roush*
ATTORNEY

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TIMEPIECE

Nicolas Aeschmann, Bienne, Switzerland, assignor to Omega, Louis Brandt & Frere S.A., Bienne, Switzerland

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The present invention relates to timepieces actuated by an electric source of direct current.

It has been tried for a long time to provide watches and small clocks of this type, but these constructions comprise a mechanical switch for the electric current. After some time this switch becomes oxidized and deteriorated, so that it can no longer guarantee a regular and precise running of the timepiece. In addition, this switch requires a rather great mechanical force for performing its function.

The invention aims at overcoming these drawbacks. According to the invention there is provided an electronic switch for the electric current and this electronic switch, on the one hand, is controlled by the voltage induced in at least one coil having a core permeable to the magnetism by the periodic variation of the magnetic flux produced by the movement through the gap of this coil of at least one piece permeable to the magnetism and rigidly fixed to an oscillating member and, the electronic switch on the other hand, controls the currents required for sustaining the oscillations of the said oscillating member through means provided for this purpose.

Preferably the electronic switch will be a transistor.

The accompanying drawing shows, by way of example, an embodiment of the invention.

Fig. 1 is a perspective view thereof.

Fig. 2 illustrates the wiring diagram of the electronic switch.

Figs. 3 and 4 illustrate two modifications of the wiring diagram.

The timepiece shown in Fig. 1 comprises a mechanical oscillating member, formed by a balance 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 ferromagnetic piece 9 which is made for instance from ferro-cubes, fritted ferrites, etc. A disc 10 keyed onto the staff 2 carries a magnet 11. The balance 1 with its ferromagnetic piece 9 and the disc 10 with its magnet 11 form a balance wheel assembly. Near the balance 1 are arranged two coils 12 and 13 with U-shaped ferromagnetic cores straddling the rim of the balance and the peripheral edge portion of the disc 10, so that when the balance 1 oscillates the piece 9 freely passes through the gap of the core of the coil 12, whereas the magnet 11 freely passes through the gap of the coil 13. Both coils 12 and 13 are stationary with respect to the pillar plate 3. The coils 12 and 13 and the pieces 9 and 11 are arranged in such a manner that when the balance is at rest, the ferromagnetic piece 9 is completely engaged in the gap of the coil 12 completing the magnetic circuit thereof and the magnet 11 is completely engaged in the gap of the coil 13 completing its magnetic circuit. This position is illustrated in Fig. 1.

The timepiece comprises in addition a source 14 of direct current, which may be a battery or an accumulator

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adapted to be recharged by the current of a photo-volatic cell 29 which is periodically exposed to the rays of a light-source, and an electronic switch 15, formed in the illustrated case by a transistor.

The coil 13 is inserted in the control circuit of the electronic member, i.e., in the diagram of Fig. 2, the circuit emitter-base of the transistor 15. The coil 12 and the source 14 of direct current are inserted in the controlled circuit of the electronic member, i.e., in the diagram of Fig. 2, the circuit collector-base of the transistor 15.

The operation is as follows:

When the balance 1 is moved away from its position of equilibrium and then is released, the magnet 11 induces, by passing through the gap of the coil 13, an alternating voltage in this coil 13. This voltage is applied between the emitter and the base of the transistor 15. In the transistor 15 described by way of example, the current of the collector depends on the voltage applied to the emitter: The current of the collector is zero if the voltage of the emitter is zero or positive with respect to the base. On the contrary, the current of the collector is important if the voltage of the emitter is negative with respect to the base. It will immediately be seen that if the alternating voltage produced in the coil 13 by the passage of the magnet 11 is applied between the emitter and the base of the transistor 15, the current collector-base will be zero during the positive half-period and on the contrary will be important during the negative half-period. The current flowing in the circuit collector-base passes through the coil 12 and produces therein a magnetic field. The electric circuit is arranged in such a way that the negative voltage be produced when the magnet 11 approaches the coil 13. During this approach movement of the magnet 11, the current of the collector produces in the coil 12 a magnetic field which attracts the ferromagnetic piece 9 carried by the balance 1. Since the magnet 11 and the piece 9 enter and leave simultaneously the gaps of their respective coils, it will be seen that the voltage induced by the magnet 11 will become zero when the flux is maximum and then will become positive when the flux decreases, thus interrupting the current of the collector and the magnetic field acting on the piece 9. The different elements of the construction are designed so that the impulse given to the balance 1 owing to the attraction by the coil 12 of the piece 9 compensates for the losses due to friction and the other possible losses as well as the mechanical energy used for advancing the gear train if this train is advanced mechanically. If the elements of the device are correctly designed, the oscillations of the balance 1 are sustained.

In the preceding example the piece 9 was ferromagnetic. It might also be replaced by a magnet, but in this case the circuit should be modified so that the coil 13 gives a negative voltage after the passage of the maximum flux and so that the coil 12 produces at this moment a magnetic field repulsing the said magnet.

According to another modification, the magnet 11 might be replaced by a ferromagnetic piece, but in this case, the armature of the coil 13 should comprise at least one permanent magnet, so that the passage of the ferromagnetic piece between the poles of the armature of the coil 13 produces a variation of the magnetic flux in the said coil, this variation itself producing an electromotive force.

One embodiment of this type is schematically shown by way of example in Fig. 3. The basical circuit shown in Fig. 2 has not been changed, but the core of the coil 13 is a permanent magnet 20, whereas the permanent magnet 11 fixed on the disc 10 is replaced by a soft iron piece 21. On the other hand, the soft iron piece 9 is replaced by a permanent magnet 22.

From the above specification it is seen that any kind of permanent magnet piece or soft iron piece may be attached to the rim of the balance wheel and to the disc portion 10 respectively, the only condition being that a permanent magnet piece or a permanent magnet core is provided in the control system of the transistor. Therefore, when reciting pieces of magnetizable material in the attached claims, such pieces of magnetizable material stand for permanent magnet pieces, that is, permanently magnetized pieces of magnetizable material as well as for soft iron pieces.

The transistor has been chosen intentionally because it does not involve any cathodic heating circuit and its use is particularly economical in the contemplated case. However, any other electronic member might assume the same function, provided care is taken of the voltages and senses of the currents required for the correct operation of these other electronic members.

The advance of the gear train and of the hands of the timepiece as shown and described may be obtained mechanically through known means, for instance by means of a lever, as shown in the French patent specification No. 833,874, but the most advantageous solution is provided by using the alternative voltage delivered by the coil 13 or the electric impulses furnished by the current of the collector for feeding a small electric motor, e.g. a synchronous motor which drives the gear train. Alternatively, a stepping motor 23 may be connected in series with the coil 12 as schematically shown in Fig. 4. The armature 24 of the motor 23 rotates by half a revolution at every pulse passing through the coil 12 in the manner described, thereby advancing the hands of the timepiece over a reduction gear of well-known type of which are schematically shown pinions 25 and 26 and wheels 27 and 28.

While certain representative embodiments and details have been shown for the purpose of illustrating the invention, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit or scope of the invention.

What I claim is:

1. A timepiece comprising an electric source, a balance wheel, an electronic switch, a control circuit and a controlled circuit associated with the said electronic switch for pulse-wise control of the driving power from the said source for the balance wheel of the timepiece, the balance wheel having a rim portion and a disc portion axially spaced from each other, a piece of magnetizable material fixedly attached to each of the said rim and disc portions, a first and second U-shaped core of magnetizable material each defining a yoke portion and an air gap between the leg portions opposite the yoke portion, the leg portions of the said first core straddling the rim portion of the balance wheel, the rim portion and the piece of magnetizable material attached thereto passing through the air gap formed between the leg portions of the first core on oscillation of the balance wheel, and the leg portions of the second core straddling the disc portion between them, the disc portion and the piece of magnetizable material attached thereto passing through the air gap of the second core on oscillation of the balance wheel, a coil on each of the first and second cores, one of the coils being connected into the input circuit and the other of the coils being connected into the output circuit of the said electronic switch, a control system being formed by the coil connected into the input circuit, the core of this coil and the piece of magnetizable material adapted to pass through the air gap of its core, permanent magnet means in this control system adapted to produce a magnetic flux through the said core and piece of magnetizable material of the control system, the pieces of magnetizable material and the said cores being so disposed as to be positioned in the air gaps when the balance wheel is in its position of equilibrium and simul-

taneously pass through their respective air gaps on oscillation of the balance wheel, a voltage being induced in the coil connected into the input circuit of the electronic switch due to a change of magnetic flux in the core of the control system and a current pulse flowing through the coil connected into the output circuit of the electronic switch on each passage of the pieces of magnetizable material through the air gaps, consecutive current pulses initiating mechanical driving pulses on the piece of magnetizable material in its air gap during consecutive passages of the pieces of magnetizable material through the air gaps.

2. A timepiece comprising a balance wheel assembly mounted on a first axis, an electric source, an electronic switch, a control circuit and a controlled circuit associated with the said electronic switch for pulse-wise control of the driving energy for the balance wheel assembly, the balance wheel assembly carrying two separate pieces of magnetizable material, fixed core means of magnetizable material, air gap means in the said core means, the pieces of magnetizable material passing through the air gap means on oscillation of the balance wheel assembly, coil means on the core means including a control coil connected into the control circuit of the electronic switch and a driving coil connected into the controlled circuit of the electronic switch, the pieces of magnetizable material passing simultaneously through the air gap means when the balance wheel assembly is near its position of equilibrium, the balance wheel assembly having a predetermined angular amplitude of oscillation, the armature means having a predetermined angular extension, the angular extension of the armature means being appreciably less than the angular amplitude of oscillation of the balance wheel, means for producing magnetic flux through the said control coil, whereby a short voltage pulse is induced in the said control coil due to variation of the said magnetic flux by passage of its piece of magnetizable material through its air gap means and a short current pulse is transmitted by the electronic switch to the driving coil thereby imparting a short mechanical driving pulse to its piece of magnetizable material on each passage thereof through its air gap means.

3. A timepiece comprising a balance wheel assembly, a pivot axis carrying the balance wheel assembly for rotative movement, a source of electricity, an electronic switch for controlling current from said source of electricity, a control circuit for the electronic switch, a controlled circuit responsive to the electronic switch, stationary coil means including a control coil connected into the control circuit, a driving coil connected into the controlled circuit, armature means of magnetizable material carried by the balance wheel assembly, the armature means and the coil means being arranged so that the armature means completes the magnetic circuits of the coil means during rotative movement of the balance wheel assembly, means to set up magnetic flux in at least one of the magnetic circuits, the armature means being in maximum magnetic circuit completion position when the balance wheel assembly is approximately at its position of equilibrium, the balance wheel assembly having a predetermined angular amplitude of oscillation, means forming an extension of said magnetic circuit so that the magnetic circuit is maintained substantially complete for a predetermined angular movement of the balance wheel assembly less than the angular amplitude of oscillation thereof, whereby there is a variation in the magnetic flux through the control coil on each oscillation of the balance wheel through its position of equilibrium producing a voltage pulse in the control coil operative through the electronic switch to produce a current pulse in the driving coil so that a driving pulse is likewise produced for each oscillation of the balance wheel through its position of equilibrium.

4. A timepiece comprising a balance wheel assembly, a pivot axis carrying the balance wheel assembly for rota-

tive movement, a source of electricity, an electronic switch for controlling current from said source of electricity, a control circuit for the electronic switch, a controlled circuit responsive to the electronic switch, stationary coil means including a control coil connected into the control circuit and a driving coil connected into the controlled circuit, armature means of magnetizable material carried by the balance wheel assembly and operatively associated with the coil means, the magnetic circuit of the control coil and the magnetic circuit of the driving coil being completed by the armature means during rotative movement of the balance wheel assembly, means to set up magnetic flux in the magnetic circuit of the control coil, the armature means being in maximum magnetic circuit completion position when the balance wheel assembly is approximately at its position of equilibrium, the balance wheel assembly having a predetermined angular amplitude of oscillation, the said armature means and coil means having an extension so that the said maximum magnetic circuit completion position is maintained substantially for a predetermined angular movement of the balance wheel assembly less than the angular amplitude of oscillation thereof, whereby there is a variation in the magnetic flux through the control coil on each passage

of the balance wheel approximately through its position of equilibrium producing a voltage pulse in the control coil operative through the electronic switch to produce a current pulse in the driving coil so that a driving pulse is likewise produced for each passage of the balance wheel approximately through its position of equilibrium.

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