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Kurita et al.

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[54] **ELECTRONIC TIMEPIECE**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** ..... **58/28 A,** 58/107, 310/36

[51] **Int. Cl.** **G04c 3/04,** G04b 17/00

[58] **Field of Search** ..... 58/23 TF, 28 A, 28 B, 58/28 D, 107; 310/36, 37; 331/156

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Assistant Examiner—Edith Simmons Jackmon
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[57] **ABSTRACT**

An electronic timepiece having a magnetic circuit including permanent magnets mounted on an oscillator, said magnetic circuit including an air gap. A driving and controlling device including at least one coil is pivotably mounted in said timepiece for displacement in a plane extending substantially parallel to the oscillating direction of said oscillator between an operative position at which said coil is positioned in said air gap and an inoperative position at which said driving and controlling device is positioned out of overlapping relation with said oscillator. The oscillator may take the form of a balance wheel assembly formed of a pair of spaced balance wheels mounted in spaced relation on a common arbor, one of said balance wheels being formed of a magnetic material, the other of said balance wheels being formed of a non-magnetic material.

1 Claim, 9 Drawing Figures

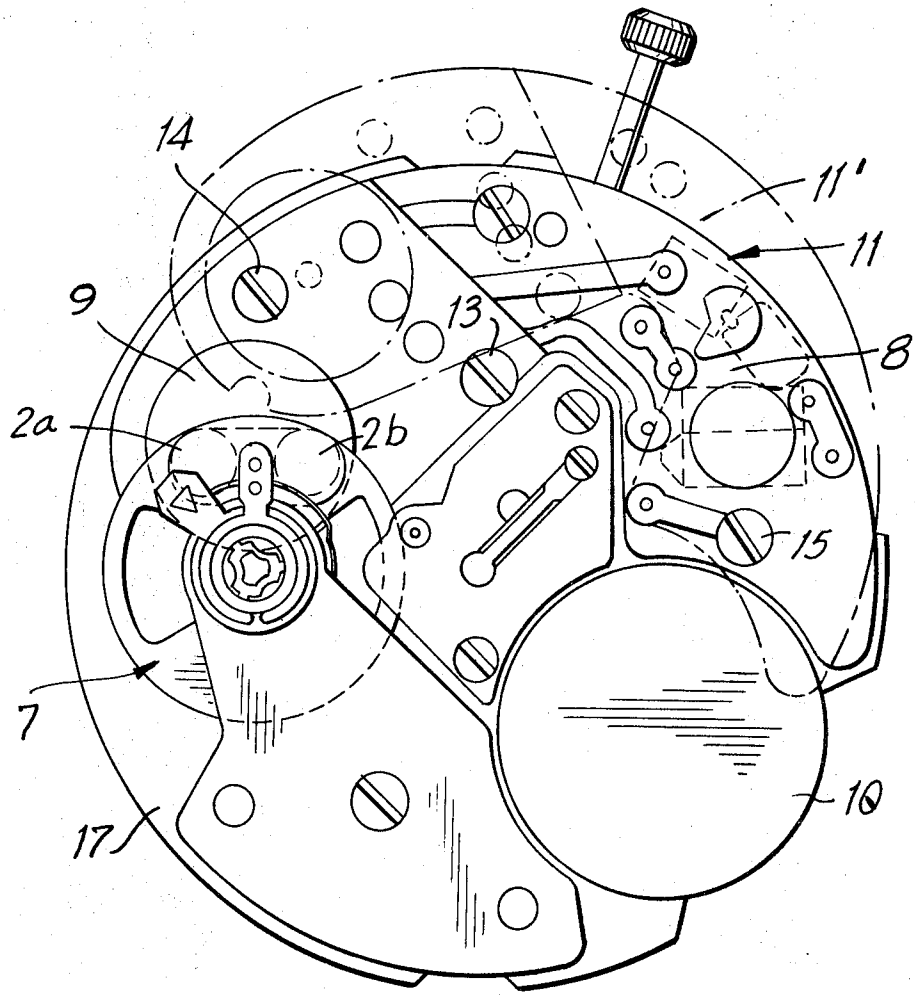


FIG. 1

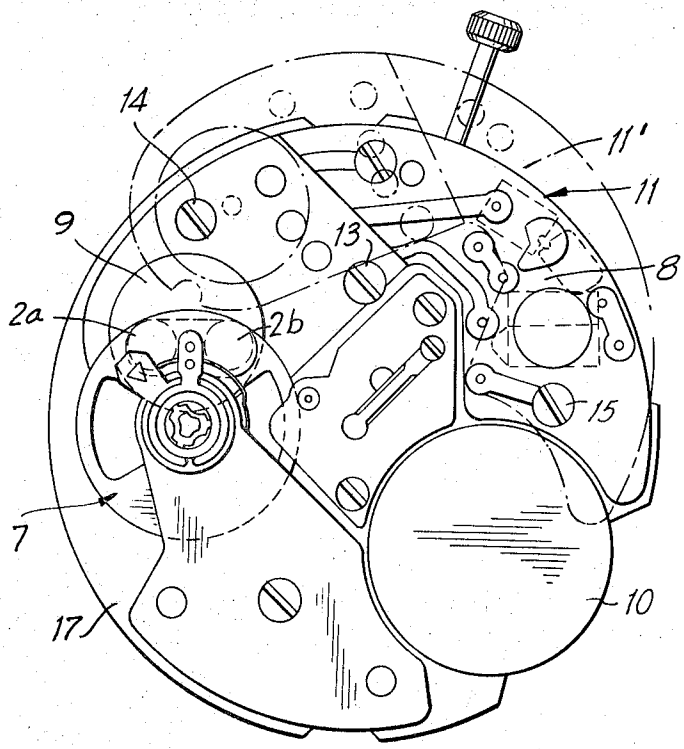
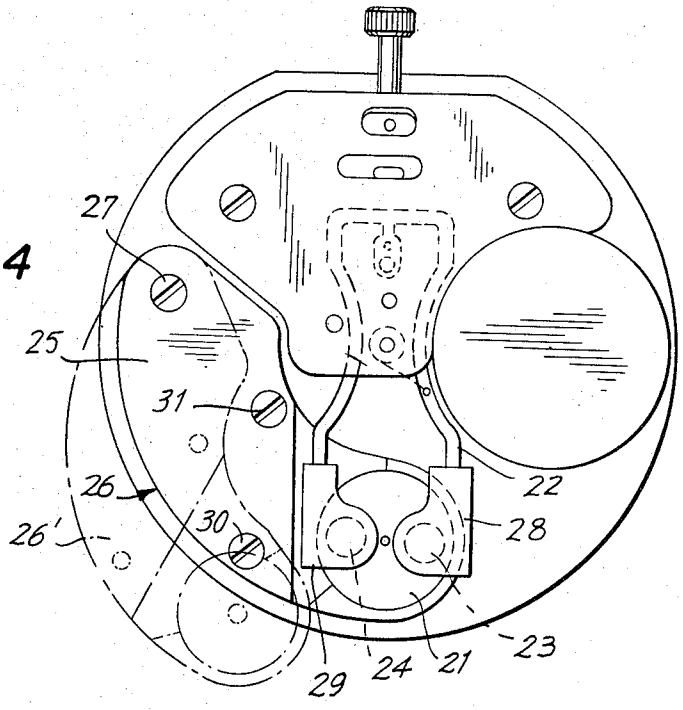


FIG. 4



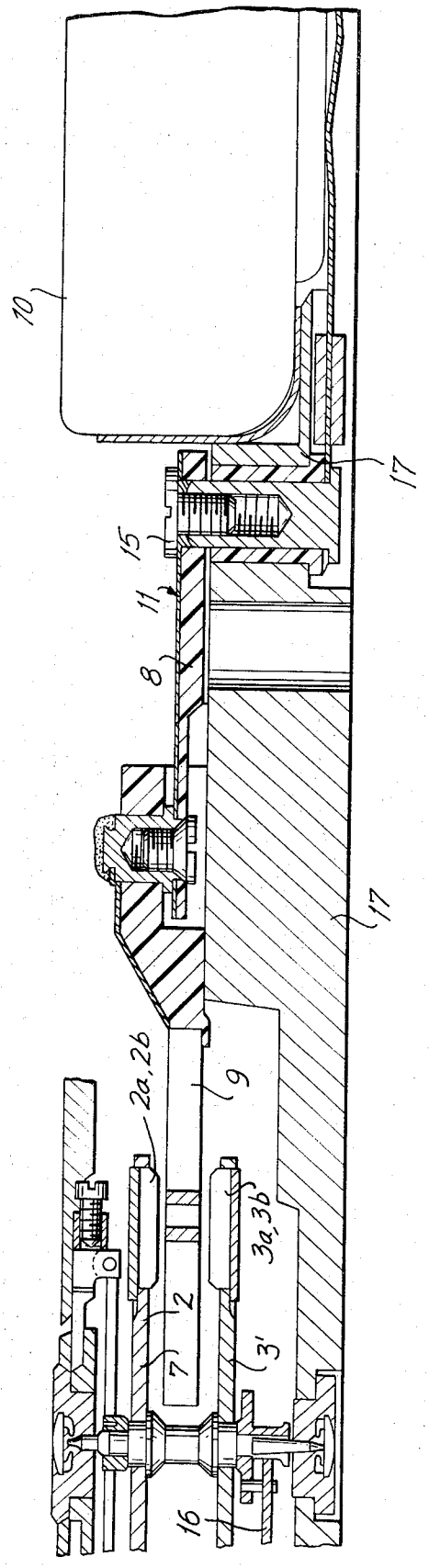


FIG. 2

FIG. 3a

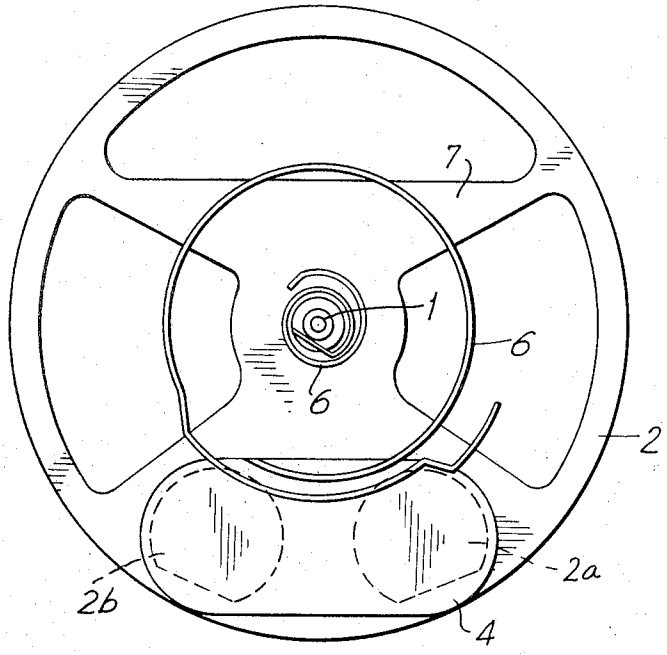


FIG. 3b

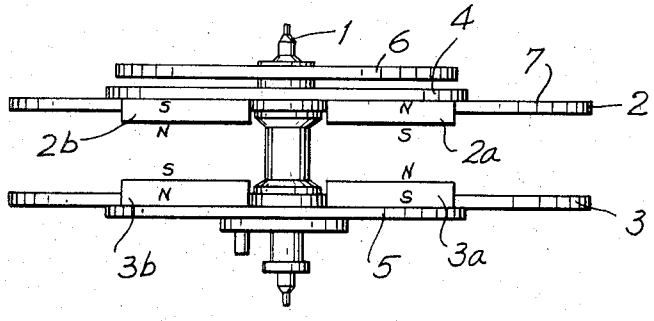


FIG. 5

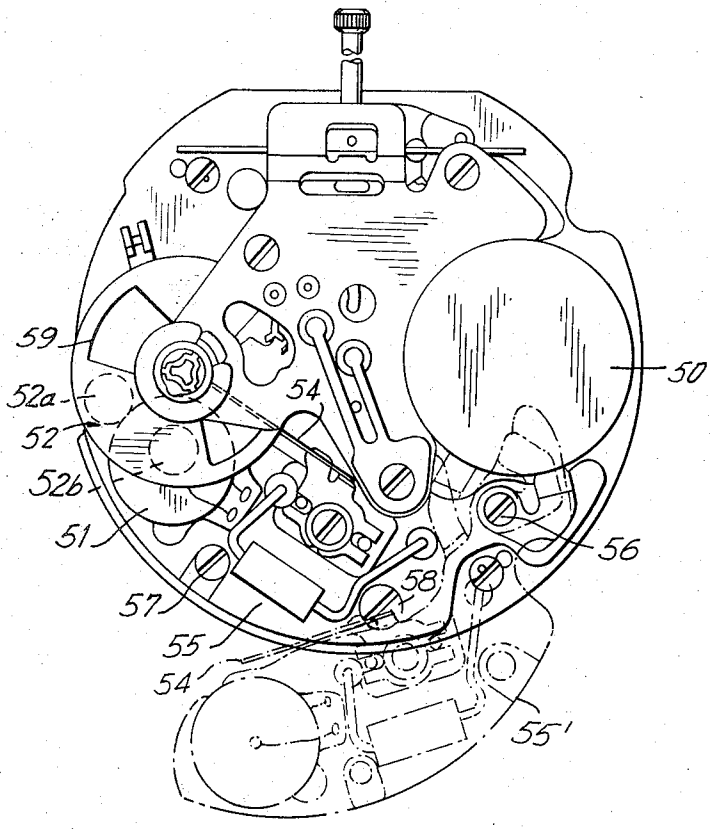


FIG. 6

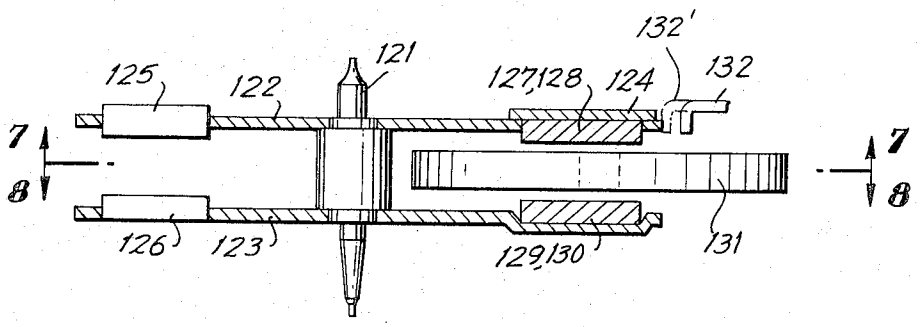

132'
121
125
122
127,128
124
132
7
8
7
8
126
123
129,130
131

FIG. 7

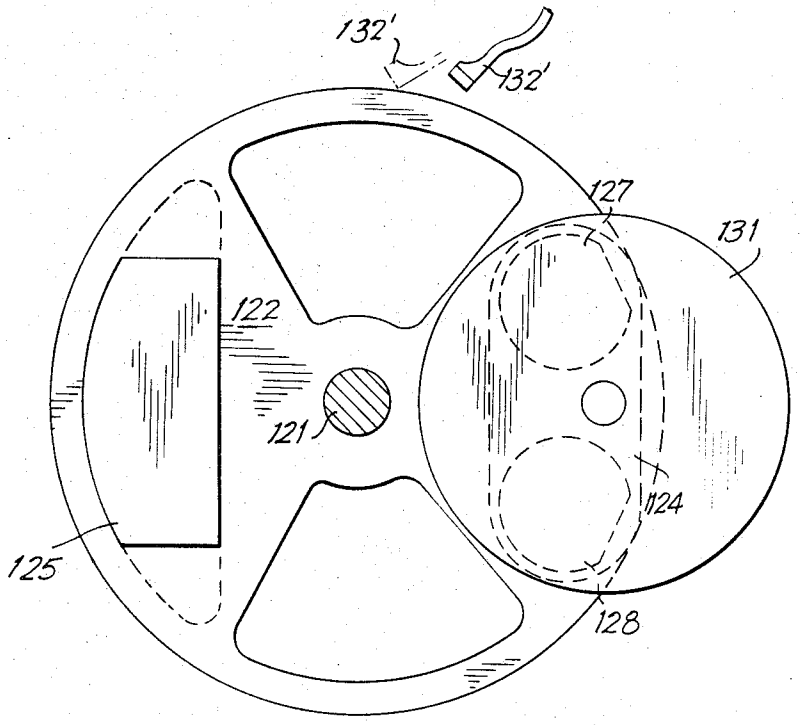
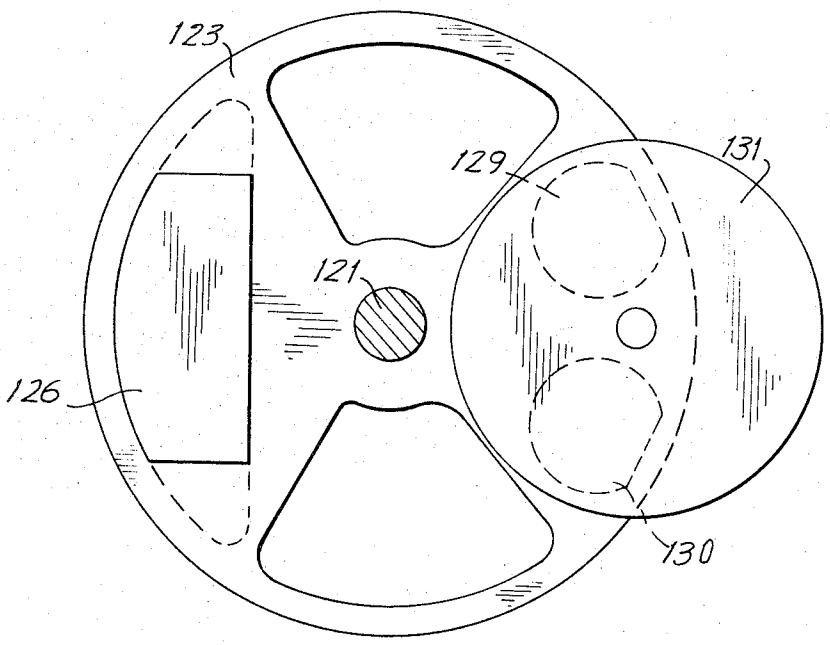

132'
132'
127
131
122
121
124
125
128

FIG. 8



ELECTRONIC TIMEPIECE

BACKGROUND OF THE INVENTION

This invention relates to electric timepieces incorporating oscillators formed with magnetic circuits which are controlled and driven by means of fixed coils and driving circuits mounted relative to said oscillator magnetic circuit. Further, this application relates to a specific construction for a balance wheel type oscillator.

In timepieces of the above-described type, the mounting or removal of the balance wheel or other oscillator required the removal of the blocks carrying the driving and detecting coils, as well as the blocks carrying the electronic circuitry associated with said coils. Since the gap between said coils and the permanent magnets mounted on the oscillator and forming a part of said magnetic circuit is extremely small, mechanical contact, between said coils and balance wheel resulted from such mounting and removal operations. This mechanical contact caused interruption in the coil frequency, requiring resetting of the watch, and increasing the cost of repairing the watch.

Where said oscillator is formed of a balance wheel, further difficulties were caused by the specific construction of the balance wheel. In small timepieces, such as wrist watches, when the balance wheel is formed of a non-magnetic material stray flux leaks from the permanent magnets mounted thereon to produce highly disadvantageous effects including substantial position errors. Further, in such constructions, other parts of the watch formed of magnetic materials, such as screws, wheels, the balance arbor and the hair spring, cause adverse magnetic influences on each other, which results in variations in the rate of the watch. On the other hand, a balance wheel made of a material having high saturation magnetic flux density and high permeability is usually soft and tends to warp. In such a construction, positioning of the balance wheel is difficult. In an attempt to cure these difficulties, it has been proposed to provide a balance wheel formed of non-magnetic material, material having a high saturation magnetic flux density and high permeability being mounted on said balance wheel to define a part of the magnetic circuit. This construction further increases the thickness of the balance, as well as its weight and power consumption, and also results in position errors.

SUMMARY OF THE INVENTION

Generally speaking, in accordance with the invention, an electronic timepiece is provided having oscillator means including magnetic circuit means, said magnetic circuit means being formed to define an air gap; driving and controlling means including at least one coil means; and means for pivotably mounting said driving and controlling means in said timepiece for pivotable displacement along a plane extending substantially parallel to the oscillating direction of said oscillator means between an operative position at which said coil means is positioned at least in part in said air gap and an inoperative position at which said driving and controlling means is positioned out of overlapping relation with said oscillator means. Said oscillator may constitute a balance wheel having permanent magnets mounted thereon and defining said air gap therebetween, or said oscillator may comprise a tuning fork.

Said timepiece may incorporate a balance wheel assembly having a pair of balance wheels mounted in spaced relation on a common arbor, one of said pair of balance wheels being formed of magnetic material, the other of said pair of balance wheels being formed of a non-magnetic material. A pair of permanent magnets is mounted on each of said balance wheels, said pairs of permanent magnets being in facing relation and of a polarity to define a magnetic circuit including the air gap between said permanent magnet. A plate of magnetic material is mounted on the outer surface of the balance wheel formed of non-magnetic material in the region between the pair of permanent magnets mounted thereon, said plate forming a part of said magnetic circuit.

Accordingly, it is an object of this invention to provide an electronic timepiece wherein the oscillator may be readily removed and mounted without effecting the frequency of the driving and controlling devices.

A further object of the arrangement according to the invention is to provide a balance wheel construction for such electronic timepieces which is regulateable, without providing the disadvantages of flux leakage and positional error.

Still other objects and advantages of the invention will in part be obvious and will in part be apparent from the specification and drawings.

The invention accordingly comprises the features of construction, combinations of elements, and arrangement of parts which will be exemplified in the constructions hereinafter set forth, and the scope of the invention will be indicated in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the invention, reference is had to the following description taken in connection with the accompanying drawings, in which:

FIG. **1** is a top plan view of one embodiment of the electronic timepiece according to the invention;

FIG. **2** is a partial cross sectional view of the electronic timepiece of FIG. **1**;

FIG. **3***a* is a top plan view of the balance wheel of the electronic timepiece of FIG. **1**;

FIG. **3***b* is a side elevational view of the balance wheel of FIG. **3***a*;

FIG. **4** is a top plan elevational view of a second embodiment of the electronic timepiece according to the invention;

FIG. **5** is a top plan view of a third embodiment of the electronic timepiece according to the invention;

FIG. **6** is a sectional view of the balance wheel assembly according to the invention; and

FIGS. **7** and **8** are sectional views taken along lines **7—7** and **8—8** respectively of FIG. **6**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIGS. **3***a* and **3***b*, the balance wheel assembly **7** consists of an upper balance wheel **2** and a lower balance wheel **3** mounted in spaced relation on a common balance wheel arbor **1**. Fixed to upper balance wheel **2** are a pair of permanent magnets **2***a* and **2***b*. A corresponding pair of permanent magnets **3***a* and **3***b* are fixed to lower balance wheel **3**. Said permanent magnets are aligned in facing relation with their polarities such that a magnetic flux flows in the gap between permanent magnets **2***a* and **2***b* and permanent magnets **3***a* and **3***b*. In order to close said magnetic circuits, an upper magnetic plate **4** is mounted on upper balance

wheel 2 interconnecting permanent magnets 2*a* and 2*b* while a lower magnetic plate 5 is mounted on lower balance wheel 3 interconnecting permanent magnets 3*a* and 3*b*. Said magnetic plates are formed of a high permeability material. A hair spring 6 is fixed to arbor 1 for the natural oscillation of balance wheel assembly 7. Electro-magnetic energy is applied to balance wheel 7 by an electronic circuit 8 more particularly shown in FIGS. 1 and 2, in order to maintain said balance wheel assembly in isochromatic oscillation.

As more particularly shown in FIGS. 1 and 2, said electromagnetic force is applied to the balance wheel in a conventional manner by means of a detecting-driving coil 9 connecting with the electronic circuit 8 and held in the gap intermediate permanent magnets 2*a* and 2*b* and permanent magnets 3*a* and 3*b*. There is no mechanical contact between said coil and said permanent magnets. The relative motion between said permanent magnets during the oscillation of balance wheel assembly 7 and detecting-driving coil 9 induces a voltage in said coil which is applied to electronic circuit 8 and controlled by an active elenent in said electronic circuit. In response to said induced voltage, the electrical energy of battery 10 is applied to said detecting-driving coil to maintain the oscillatory displacement of said balance wheel assembly.

Electronic circuit 8 and detecting-driving coil 9 are mounted as a unit on electric block 11, which is fixed to base plate 17 by means of setting screws 12, 13, 14 and 15. In this manner, the relative position between the detecting-driving coil and the permanent magnet is maintained during the operation of the timepiece. If setting screws 12, 13 and 14 are removed, setting screw 15 is loosened, and battery 10 is removed, electric block 11 may be pivotably rotated about the axis defined by setting screw 15 from the operative position to an inoperative position shown by dashed lines 11'. This rotation is in a plane extending substantially parallel to the plane of oscillation of the balance wheel assembly so that the electric block 11 is out of overlapping relation with the balance wheel assembly after such displacement. During such displacement, there is no engagement between any portion of the balance wheel assembly and any portion of the electric block 11. When the electric block 11 is positioned as shown in phantom lines in FIG. 1, balance wheel assembly 7 can be readily mounted and removed. In addition, the adjustment, conformation, mounting and removal of escapement 16, which is positioned beneath balance wheel assembly 7 is readily achieved.

Referring now to FIG. 4, a second embodiment of the electronic timepiece according to the invention is depicted, said embodiment incorporating a tuning fork as the oscillator. In said embodiment, detecting-driving coil 21 is mounted and maintained in the gap in magnetic circuits 28 and 29 mounted on tuning fork oscillator 22. Magnetic circuits 28 and 29 include permanent magnets 23 and 24 respectively and are attached to the end of the tines of said tuning fork. Detecting-driving coil 21 is connected to an electronic circuit 25, said electronic circuit and coil being mounted in a common electric block 26.

Electric block 26 may be released by removing setting screws 30 and 31 and loosening setting screw 27 so as to permit the pivotable rotation of said electric block in the clockwise direction as viewed in FIG. 4 about an axis defined by setting screw 27. When so rotated, the electric block 26 assumes the position shown in phantom lines at reference numeral 26', at which position the tuning fork may be readily removed.

A third embodiment of the electronic timepiece according to the invention is depicted in FIG. 5, wherein the timepiece incorporates a contact point construction between an electrical contact mounted on the balance wheel and a fixed spring contact for opening and closing the driving circuit associated with the driving coil. In the embodiment of FIG. 5, balance wheel assembly 59 is similar in construction to the balance wheel assembly depicted in FIG. 3, being provided with two pairs of permanent magnets and a pair of spaced balance wheels, of which permanent magnets 52*a* and 52*b* and balance wheel 52 is depicted in FIG. 5.

A coil 51 is mounted in the gap between said permanent magnets in the same manner as the coil shown in FIG. 2. This coil is fixed to an electric block 55 which also carries a contact point spring 54. Said electric block is fixed by means of setting screws 56, 57 and 58. When setting screws 57 and 58 are removed, setting screw 56 is loosened and battery 50 is removed, electric block 55 may rotate in the counter clockwise direction as viewed in FIG. 5 to a position shown in phantom lines at reference numeral 55'. Said rotation is about the axis defined by setting screw 56 in the direction of a plane extending substantially parallel to the plane of oscillation of balance wheel assembly 59. This arrangement not only permits the removal and mounting of the balance wheel assembly, but also permits the removal and mounting of the contact point spring 54 and the coil 51.

Referring now to FIGS. 6–8, a second embodiment of the balance wheel according to the invention is depicted. In said embodiment, the balance wheel assembly consists of a arbor 121 on which balance wheels 122 and 123 are mounted in parallel spaced relation. Balance wheel 122 is provided with a pair of permanent magnets 127 and 128 while balance wheel 123 is provided with a pair of permanent magnets 129 and 130. Permanent magnets 127 and 128 are in facing spaced relation with permanent magnets 129 and 130 respectively. Balance wheel 123 is formed of a material having a high saturation magnetic flux density and high permeability while balance wheel 122 is formed of a non-magnetic material and has a magnetic plate 124 of magnetic material attached on the outer surface thereof in the region between permanent magnets 127 and 128. Thus, the magnetic circuit includes the two pairs of permanent magnets, magnetic plate 124 and balance wheel 123.

Each of the balance wheels 122 and 123 are provided with a counter weight 125 and 126 respectively in order to compensate for the unbalance caused by the mounting of said permanent magnets thereon. A detecting-driving coil or coils 131 is provided in the air gap between said permanent magnets and is connected to an electric circuit incorporating an active element such as a transistor for driving said balance wheel assembly.

A regulating lever 132 is mounted within the timepiece for regulating the balance wheel. Said lever occupies the position indicator in phantom lines by reference numeral 132' when it regulates said balance wheel assembly. Since balance wheel 122 is formed of a non-magnetic material, regulation may be accomplished without deformation thereof. A shield member may be

provided near balance wheel **123** in order to eliminate stray fluxes caused by said balance wheel.

The balance wheel assembly of FIGS. **6-8** is extremely thin and operates with high precision, and is particularly adapted for application to wrist watches.

It will thus be seen that the objects set forth above, and those made apparent from the preceding description, are efficiently attained and, since certain changes may be made in the above constructions without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. An electronic timepiece comprising a balance wheel assembly including magnetic circuit means, said magnetic circuit means being formed to define an air gap; driving and controlling circuit means including at least one coil means and other circuit components for driving and controlling the mechanical oscillations of said assembly; support means carrying at least portions of said driving and controlling circuit means including said coil means and a plurality of said other circuit components; means for pivotably mounting said support means in said timepiece for pivotable displacement along a plane extending substantially parallel to the oscillating direction of said assembly between an operative position at which said coil means is positioned at least in part in said air gap and an inoperative position at which said driving and controlling means is positioned out of overlapping relation with said assembly; battery means electrically coupled to said driving and controlling circuit means but mounted separate therefrom wherein said assembly includes an arbor; a pair of balance wheels mounted in spaced relation on said arbor for oscillation therewith as a unit; a first of said balance wheels being formed of a non-magnetic material, the second of said balance wheels being formed of a magnetic material; first and second pairs of permanent magnets mounted in spaced facing relation on said first and second wheels respectively; and a plate formed of magnetic material mounted on the outer face of said first balance wheel in the region overlapping and intermediate said first pair of permanent magnets, said permanent magnets being of a polarity to define a magnetic circuit including said plate and said second balance wheel.

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