Oct. 11, 1966 R. FAVRE 3,277,643

ELECTRONIC WATCH

Filed Jan. 15, 1965 5 Sheets-Sheet 1

FIG. 1

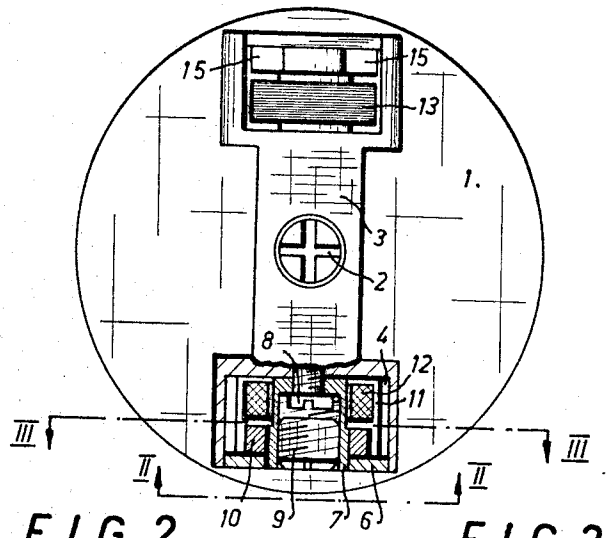


FIG. 2

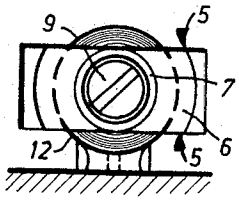


FIG. 3

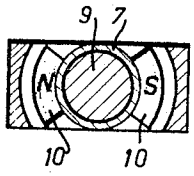
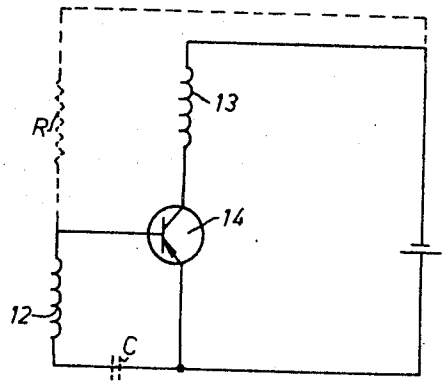


FIG. 4



Oct. 11, 1966

R. FAVRE

3,277,643

ELECTRONIC WATCH

Filed Jan. 15, 1965

5 Sheets-Sheet 2

FIG.5

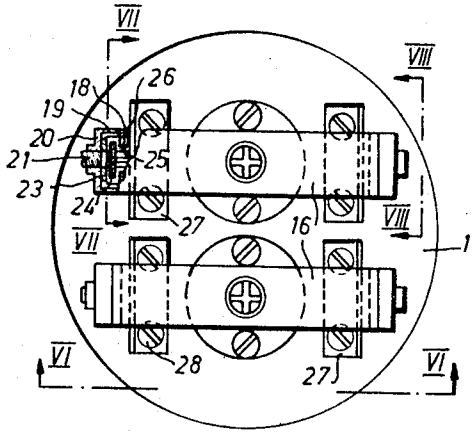


FIG.6

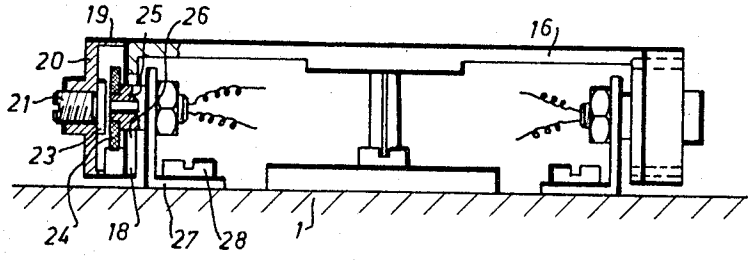


FIG.7

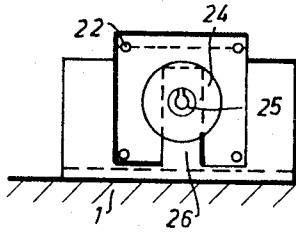
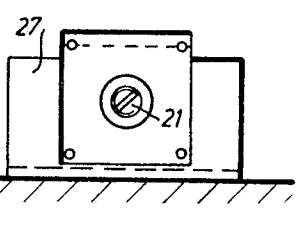


FIG.8



Oct. 11, 1966

R. FAVRE

3,277,643

ELECTRONIC WATCH

Filed Jan. 15, 1965

5 Sheets-Sheet 3

FIG.10

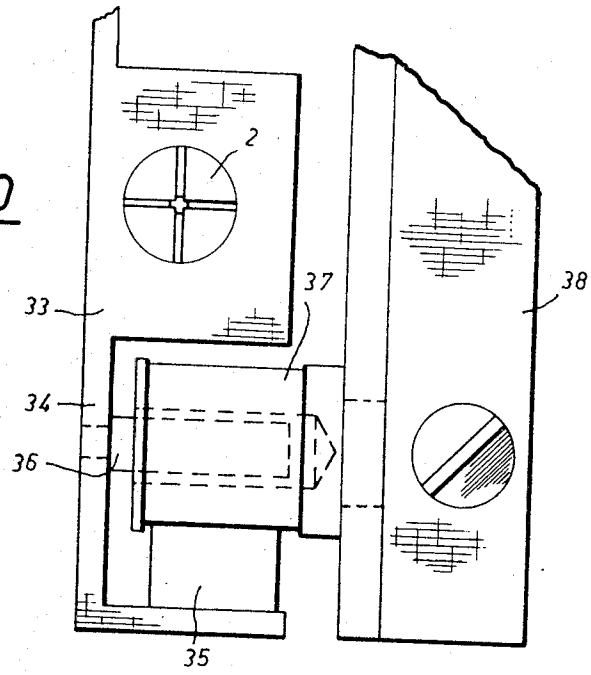
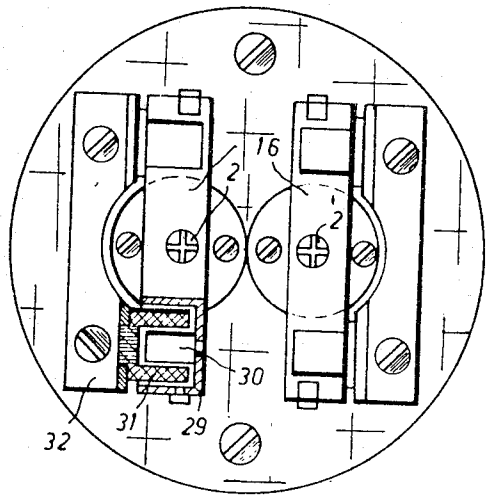


FIG. 9



Oct. 11, 1966 R. FAVRE 3,277,643

ELECTRONIC WATCH

Filed Jan. 15, 1965 5 Sheets-Sheet 4

FIG.11

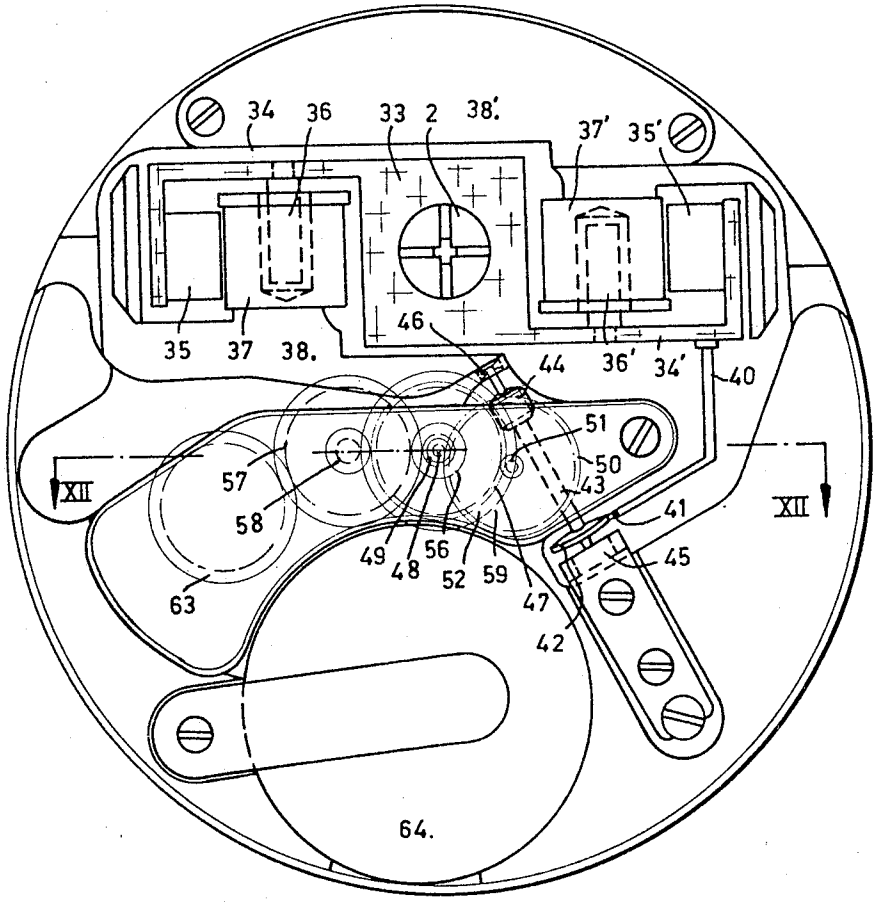
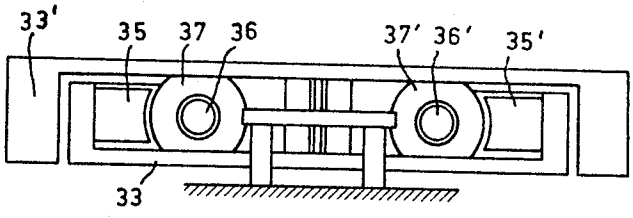


FIG.13



Oct. 11, 1966

R. FAVRE

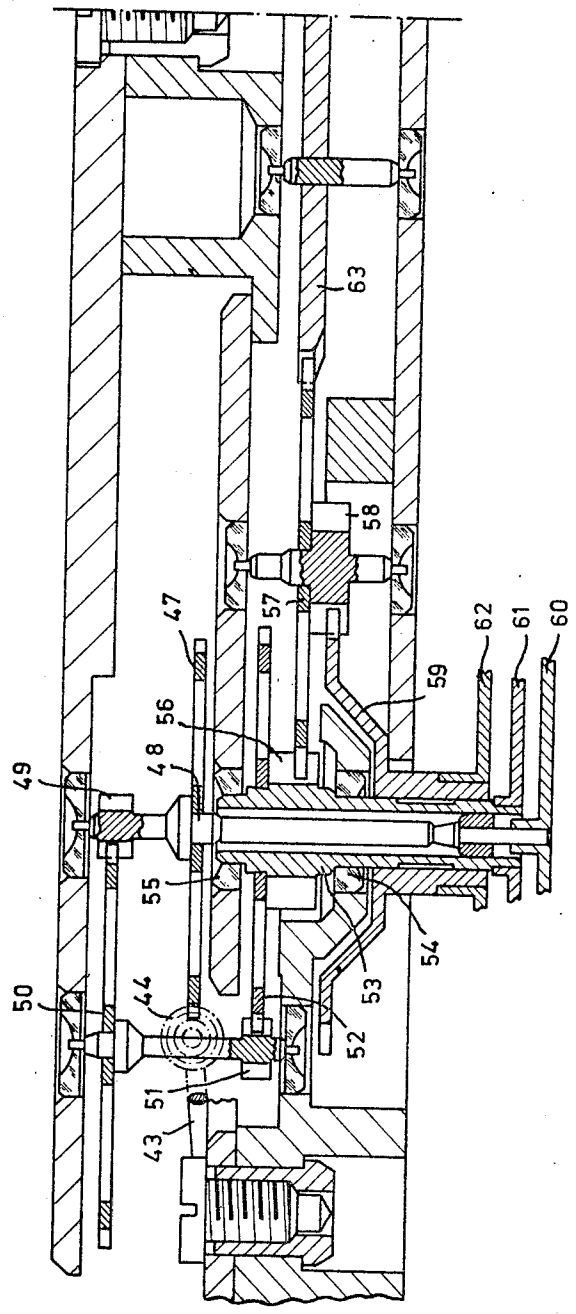
3,277,643

ELECTRONIC WATCH

Filed Jan. 15, 1965

5 Sheets-Sheet 5

FIG.12



United States Patent Office

3,277,643

Patented Oct. 11, 1966

3,277,643

ELECTRONIC WATCH

Robert Favre, 36 Servan, Lausanne, Switzerland

Filed Jan. 15, 1965, Ser. No. 425,873
Claims priority, application Switzerland, May 24, 1961, 6,072/61
3 Claims. (Cl. 58—23)

The present invention is a continuation-in-part of U.S. application Serial No. 196,814, filed May 22, 1962, now Patent No. 3,173,036.

It relates to an electronic watch, particularly a wrist watch working with a mechanical torsion oscillator, which has at least one oscillatory arm mounted in a plane parallel to the base-plate of the watch and fixed to a torsion spring.

The oscillation of said arm is maintained by means of an electronic circuit comprising at least one transistor, at least one control coil in the control circuit of said transistor, and at least one driving coil in the driving circuit of said transistor.

Said coils co-operate with magnetic elements fixed onto said arm.

Preferably, these are small permanent magnets moving in the zone of influence of said coils.

Such watches are known and have the advantages of relatively low frequencies, i.e. 10–150 cycles, a range between that of a balance-wheel and that of a piezo-electric oscillator.

But the drawbacks are numerous; in particular, the torsions are relatively long and the moving mass is small in order to save space. The length of the spring appears to be necessary in order to obtain a low-frequency, thereby increasing the thickness of the watch.

In order to reduce this thickness, it is known to provide springs in the form of a lamella, mounted parallel to the base-plate and fixed with one end near the circumference of the clockwork.

However, such a geometry is not satisfactory.

The long springs used until now, mounted parallel to the plane of the clockwork have other drawbacks. Under the influence of gravity, there are produced deformations which change with the position of the watch relatively to the direction of gravity. Such changing deformations are a bar to the constancy of the frequency of oscillations. Furthermore, each torsion spring is reduced in active length, such a reduction being proportional to the amplitude of oscillations. This is also a bar to the stability of frequency; moreover, the shortening of active length depends on whether the mass is located above or below the spring, i.e. whether a compression or a stretching is achieved. In the one case, the mass compresses the spring, and gravity counteracts the elastic re-setting of the spring; in the other case, the effects of gravity and elasticity are added.

The present invention eliminates the above-mentioned drawbacks.

This is achieved by the fact that the oscillating arm is parallel to the plane of the clockwork in the median area thereof, and extends over nearly the whole clockwork plane, the torsion spring being perpendicular to the base-plate and located in the median area of the clockwork and having a length which is only a fraction of that of the arm, the coils being mounted in the vicinity of the circumference of said clockwork.

The present invention offers many advantages: in particular, the low frequency is achieved in view of the use of a long flat arm (for instance 15–20 mm. long) and the height of the watch is reduced, in view of the use of a short spring (for instance 1–3 mm. long). In addition, since the torsion spring is very short, all the above-mentioned perturbations (influence of gravity and shortening in the active length) are eliminated. Moreover, there is enough space in the middle of the clockwork for fixing the spring; it is possible to use broad resilient lamellae which are fixed over the whole width, so that the thus constituted spring offers a great resistance against undesirable flexions without limiting the torsion.

Various possible forms of embodiment of the oscillatory system according to the present invention are illustrated in the accompanying drawing, in which:

FIG. 1 is a plan view of a first form of embodiment;

FIGS. 2 and 3 are sections along the lines II—II and III—III respectively of the constructional form shown in FIG. 1;

FIG. 4 shows an electric circuit for the oscillatory system according to the invention;

FIG. 5 is a plan view of a second form of embodiment of the oscillatory system according to the invention;

FIG. 6 is a section along line VI—VI of FIG. 5;

FIGS. 7 and 8 show partial views of the embodiment of FIG. 5 along lines VII—VII and VIII—VIII respectively;

FIG. 9 shows in plan a third constructional form of the oscillatory system according to the invention;

FIG. 10 shows a partial view of a fourth embodiment of the oscillatory system according to the invention;

FIG. 11 shows a further embodiment with two arms superposed;

FIG. 12 is a top plan view of a clockwork with torsion oscillator; and

FIG. 13 is a cross-section taken along line XII—XII of FIG. 11.

In FIG. 1, on the base-plate, or platine, of a time-measuring device there is a torsion spring **2** of cruciform cross-section, on the upper portion of which an oscillating arm **3** is arranged. The properties of such torsion springs, and the mounting thereof, are known, and are described in the Swiss patent application No. 66450.

The oscillating arm **3** has at each end a head, in which a part of the electro-magnetic operating device for the oscillatory system is lodged. Each of the heads is provided with an axial cavity 4, of generally cylindrical form, the two side surfaces **5** of which are cut away. The upper or outer part of the cavity is closed by a yoke **6**, which carries a central sleeve **7**, which extends into this cavity, and at the botom of this sleeve a screw **8** is provided for the purpose of securing the yoke in the cavity.

With the aid of a further screw **9**, which is screwed into the sleeve **7** from the outside, the moment of inertia of the arm can be adjusted, and, with it, the frequency of the oscillatory system.

On the inside of the yoke **6** are two sector-shaped permanent magnets **10**, so arranged that their polarities are oppositely directed.

In the cavity **4** closed by the yoke **6** is also arranged a coil **12**, which has, within an annular cavity **11**, a sufficiently large clearance in relation to the yoke **6** to avoid hampering the free oscillation of the arm **3**, with its head. The coil **12** is connected fast (FIG. 2) with the base-plate **1** of the time-measuring device.

The external circuit of the permanent magnet **10** is closed by way of this coil **12**, the yoke **6**, and the walls, formed by the head, of the cavity **4**.

The coil **12** forms the controlling coil. It is located in the emitter-base circuit of the transistor **14**, as shown in the circuit arrangement of FIG. 4.

At the other end of the arm **3** there is a head which is constructed in just the same way as the head just described, and which contains, in the same manner, a coil **13**, a yoke, and two permanent magnets **15**. The coil **13** is the operating coil of the oscillatory system, and is

located with the circuit arrangement of FIG. 4, in the collector circuit of the transistor **14**.

The currents induced in the controlling coil **12** by the oscillation of the permanent magnet **10** control the transistor **14** in a known manner, so that the coil **13** is excited by the collector current of the transistor **14**, and periodically exerts forces upon the two permanent magnets **15**, which maintain the oscillations of the system. The polarities of the two permanent magnets **15** are oppositely directed, like those of the permanent magnets **10**, so that their actions upon the coil are additive.

FIG. 5 shows a second embodiment of the oscillatory system according to the invention. In this constructional form there are arranged upon the base-plate **1** of the time-measuring device two oscillating arms **16**, which oscillate about the axes of their cruciform torsion springs, are located side by side, and move in directions which are at every instant in opposite directions to one another, so that the system is in dynamic equilibrium.

Each of the two heads of each arm is formed of a plate **18**, which is bent downwards at right angles to the arm. To the plate **18** is secured the edge **19** of a yoke **20**. The central portion of this yoke is provided with a screw **21** for adjusting the frequency of the oscillatory system, and also with four small pins **22** for securing the yoke to the plate.

At the bottom of the yoke are provided two sector-shaped permanent magnets **23**, the polarities of which are oppositely directed, and which co-operate with a coil **24**, which is arranged in the cylindrical cavity formed by the yoke and the plate. By its central portion this coil is secured to the end of a core **25**, which projects through a gap **26** hollowed out in the plate **18**, and is firmly secured at its other end, by means of a screw **28** and an angle-piece **27**, to the base-plate **1**.

This arrangement constitutes a particularly simple form of construction, and above all, facilitates the dismantling of the oscillatory system, without the coil first having to be removed. Moreover, the fastening of the coil itself is also very simple.

FIG. 9 illustrates a further constructional example of the oscillatory system according to the invention. As in the case of the second embodiment, on a base-plate of the time-measuring device, two cruciform torsion springs **2** are provided, and, on each of their upper ends, an oscillating arm **16**. The heads **29** at both ends of each oscillating arm have in this instance the form of parallelepipeds, project perpendicularly upwards at the ends of the arms, and enclose in each case a cylindrical cavity from the two walls of which those side surfaces that are parallel to the plane of oscillation of the arms are cut away. The axes of these cylindrical cavities, which are each open towards the side remote from the other arm, are perpendicular to the longitudinal axis of the arm and parallel to the plane of oscillation. In the middle of that wall of the head that forms the base surface of the cylinder is arranged a permanent bar magnet bar **30**, which projects into the cylindrical cavity. From the open opposite side a coil **31**, which is secured to the base-plate by means of an angle-piece **32**, dips into the cavity, and surrounds the magnet **30**.

The circular spaces intervening in each case between the wall of the head **29** and the coil **31** on the one hand, and between the internal wall surface of the coil **31** and the magnet **30** on the other hand, are so dimensioned that during the oscillation of the arm, the magnet **30**, without touching the coil, can dip into the coil, and the internal wall surface of the head **29**, likewise without touching the coil, can slip over the coil. The wall of the head **29** forms at the same time the return for the field of the permanent magnet.

Of the heads and coils, four altogether, which this arrangement carries at the ends of the arms, two form the controlling portion and two the operating portion of the oscillatory system.

FIG. 10 represents a further form of construction for the head of an arm of the oscillatory system according to the invention. The head **34**, which is again in the form of a parallelepiped and encloses a cavity, of the arm **33** suspended from the torsion spring **2**, projects perpendicularly downwards, in this case, at the end of the arm, and carries on the one hand a soft-iron core **36**, and also a cylindrical permanent magnet **35**. Whilst the axis of the soft-iron core **36** is perpendicular to the longitudinal axis of the arm and is located in the plane of oscillation, the magnetic axis of the permanent magnet **35**, which is secured to the internal wall surface of the outer end of the arm, is oriented perpendicularly to the axis of the soft-iron core. A coil **37**, secured to the base-plate **1** by means of an angle-piece **38**, surrounds the soft iron core **36**, one pole face of the magnet **35** being directed onto the outside of the coil **37**, and having a cylindrical form adapted to the likewise cylindrical form of the coil, so that this pole face, and the external wall surface of the coil, face one another at only a very small distance apart.

Again, the distances between the individual elements are so dimensioned that during the oscillation of the arm **33**, the soft-iron care **36** can plunge freely into the coil, and the permanent magnet **35** can move freely along the external coil surfaces. During the oscillation, in order to produce the greatest possible changes of magnetic flux, and therefore the greatest possible coil currents, the diameter of the magnet **35** is made substantially greater than the diameter of the iron core **36**.

This invention is not, of course, restricted to the forms of construction of the oscillatory system here described in detail, but it is within the sphere of the technologist to vary over a wide range the arrangement and construction of the head, the permanent magnets, and the coils.

For example, the heads and the coils may be arranged on both sides of one of the oscillating arms in such a way that the orientation of the heads and coils are not symmetrical about a central plane of the oscillating arm, as in the last two constructional examples described, but symmetrical about the axis of oscillation of the arm. That is to say, the orientation of the head and the coil at one end of the arm is turned through exactly 180° at the other end of the arm. The result can thereby be simply attained that the centre of gravity of the arm falls exactly into its axis of rotation.

In the clockwork shown in FIGS. 11 and 12, the oscillating system used is similar to that of the embodiment shown in FIG. 10.

The arm **33** fixed to torsion spring **2** is substantially parallel to a diameter of the clockwork and extends over nearly the total length of the secant. The permanent magnet **35** (resp. **35'**) carried by the head **34** (resp. **34'**) of arm **33** and the soft-iron core **36** (resp. **36'**), as well as coil **37** (resp. **37'**) secured to the base-plate by means of an angle piece **38** (resp. **38'**) are similar to those of the form of embodiment shown in FIG. 10.

On the outer side of head **34'** of arm **33** is applied a curved ratchet **40**, the end **41** of which is in mesh with an intermediate wheel **42**. This wheel **42** extends on a shaft **43** which is somewhat inclined with respect to the plane of the clockwork; that shaft **43** rests by its two extremities on bearings **45** and **46**, and it carries the helical screw **44**. This screw **44** meshes with the seconds-wheel **47**, which stands on an axle **48** located in the center of the clockwork. The minutes-wheel **52** is driven by the pinion **49** also mounted on axle **48** by the wheel **50** provided with a pinion **51**. The minutes-wheel **52** is placed in a known manner in a cannon-pinion **53**, which surrounds the axle **48** which a certain clearance. Said cannon-pinion **53** rests on the two bearings **54** and **55**. Finally, the hours-wheel **59** is driven by the cannon-pinion

56 and the wheel 57 with its pinion 58. Said hours-wheel 59 can rotate about cannon-pinion 53 by means of its cannon. Numerals 60, 61, and 62 designate the seconds-hand, the minutes-hand, and the hours-hand, respectively. The position of the hands can be corrected by means of a setting wheel 63 in mesh with wheel 57, in a known manner which will not be more fully disclosed; numeral 64 designates a battery.

While the length of the cross-shaped torsion spring 2, which is at right angles to the plane of the clockwork, must simply be comprised between 1 and 3 mm., the length of the oscillating arm 33 can reach 15 to 20 mm.

The arm 33 according to FIG. 11 is fixed to the upper end of the torsion spring 2, whereas, with a view to achieving the good dynamic balance of the oscillating system, a reaction arm is disposed at the other end of the torsion spring 2, and it oscillates in counter-phase with arm 33. A spring fixed by its middle portion to the base-plate, which on both sides has a free height of 1.5 mm. and the four outer extremities of which are on a cylinder of 1.5 mm. diameter, provides for instance oscillations having a frequency of about 90 cycles. If the orientation of a watch with such an oscillating system is changed from a position at which the longitudinal axis of the torsion spring is vertical to a position at which said axis is horizontal, then the frequency of oscillations is simply increased by a fraction 6/100,000, which represents merely a maximum error of about 5 seconds per day, under the most unfavourable circumstances.

The cross-section shown in FIG. 13 is similar to that of FIG. 6, but it comprises two similar arms superposed at both ends of the spring, which is mounted in the middle. One of these arms carries the control element at one end and the driving element at its other end, and both ends of the other arm are merely counterweights intended to provide a dynamic balance. Alternately, one arm can carry the control element at one end and a counterweight at its other end, and the other arm, the driving element at one end and a counterweight at its other end.

What is claimed is:

1. In an electronic watch having a mechanical torsion oscillator, a torsion spring, said oscillator comprising at least one oscillating arm mounted in a plane parallel to the base-plate of said watch and fixed to said spring, magnetic elements fixed to said arm, an electronic circuit adapted to maintain the oscillations of said arm, said circuit comprising at least one transistor, at least one control coil in the control circuit of said transistor and at least one driving coil in the driving circuit of said transistor, said coils being adapted to co-operate with said magnetic elements, said coils being located in the vicinity of the clockwork circumference, said oscillating arm being parallel to the plane of the clockwork and extending substantially throughout said clockwork in a median area thereof, said torsion spring being at right angles to the base-plate in a median area of the clockwork, the improvement consisting in said spring having a length which is only a fraction of that of the arm.

2. In an electronic watch, a mechanical torsion oscillator, a torsion spring, said oscillator comprising at least one oscillating arm mounted in a plane parallel to the base-plate of said watch and fixed to said spring, permanent magnets fixed to said arm, an electronic circuit adapted to maintain the oscillations of said arm, said circuit comprising at least one transistor, at least one control coil in the control circuit of said transistor and at least one driving coil in the driving circuit of said transistor, said coils being adapted to co-operate with said permanent magnets, said coils being located in the vicinity of the clockwork circumference, said oscillating arm being parallel to the plane of the clockwork and extending substantially throughout said clockwork in a median area thereof, said torsion spring being at right angles to the base-plate in a median area of the clockwork, the improvement consisting in said spring having a length which is only a fraction of that of the arm.

3. In an electronic watch, a mechanical torsion oscillator, a torsion spring, said oscillator comprising at least one oscillating arm mounted in a plane parallel to the base-plate of said watch and fixed to said spring, magnetic elements fixed to said arm, an electronic circuit adapted to maintain the oscillations of said arm, said circuit comprising at least one transistor, at least one control coil in the control circuit of said transistor and at least one driving coil in the driving circuit of said transistor, said coils being adapted to cooperate with said magnetic elements, said coils being located in the vicinity of the clockwork circumference, said oscillating arm being parallel to the plane of the clockwork and extending substantially throughout said clockwork in a median area thereof, said torsion spring being at right angles to the base-plate in a median area of the clockwork, the improvement consisting in said oscillating arm being from 5 to 20 times as long as said spring.

References Cited by the Examiner

UNITED STATES PATENTS

2,160,876	6/1939	Lakatos.	
2,939,971	6/1960	Holt	310—15
3,176,171	3/1965	Baumgartner	310—38

FOREIGN PATENTS

432,299	7/1935	Great Britain.

RICHARD B. WILKINSON, *Primary Examiner.*

G. F. BAKER, *Assistant Examiner.*