

PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Electronic Watch

We, CENTRE ELECTRONIQUE HORLOGER S.A., of 2 rue Bréguet, Neuchâtel, Switzerland a Swiss Body Corporate, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to an electronic watch comprising a mechanical deflection resonator serving both as a time-basis and as a driving member.

In the watches of this type, the mechanical resonator has in general the elongated shape of a conventional tuning-fork and is located in the central portion of the case. Such an arrangement has various drawbacks, since the space defined by the case is thus divided into two parts, which makes it difficult to mount the gear-train for driving the hands and the date disc. Again, the room available for the battery is very limited, so that under certain circumstances it is necessary to resort to the use of several batteries or to a battery the cross-section of which is not circular.

In addition, there is the risk that the whole device be urged by forces beyond its yield strength, since all the deformation energy is dissipated in a relatively small space in the vicinity of the tuning-fork foot.

The object of the present invention is to provide a resonator which is devoid of the above-mentioned drawbacks.

The invention accordingly consists in an electronic watch with a mechanical resonator serving both as a time basis and as a driving member, said resonator being characterised in that it follows through the main portion of its length the periphery of the watch movement.

The features of the present invention will be disclosed hereafter, reference being had to the accompanying drawings in which:

Figure 1 is a plan view of a watch movement according to the invention,

Figure 2 is a cross-section of Figure 1 along the line II—II,

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

Figure 4 is a partial cross-section of Figure 1 along the line IV—IV,

Figure 5 is the diagram of the electric circuit of the watch,

Figure 6 is a plan view of a second form of embodiment of the watch according to the invention, showing only the resonator in its case, and

Figure 7 is a cross-section of Figure 6 along the line VII—VII.

Figures 1 and 2 show a base-plate 1 to which is fixed, by means of three screws 2, the V-shaped foot 3a of an audio frequency resonator 3. The oscillating parts of that resonator have approximately the shape of a small omega, and they are connected to the foot 3a by a link 3b. The oscillating parts are essentially constituted by two arms 3c and 3d which, through the major portion of their length, run along the periphery 1a of the base plate 1 which is at the same time the periphery of the watch movement. A clearance is provided between arms 3c, 3d, on the one hand, and base plate 1, on the other hand, in order that the arms can oscillate freely.

At the extremity of each of the arms 3c and 3d is welded a magnetic head, respectively 14 and 15.

Figure 3 shows that the magnetic head 14, which is in mirror-symmetry with the magnetic head 15, is constituted by a soft iron part 4, the cross-section of which is in the shape of a U, and by pole pieces 5a and 5b fixed to the arms 4a and 4b of the U shaped iron 4, the shape of which corresponds to substantially that of half the coils. Whereas the resonator proper 3 is preferably made of a material

with a low thermo-elasticity coefficient such as for instance an alloy going by the name of "Elinvar", NIVAROX which is a registered Trade Mark, "Ni-Spain-C", or "Thermelast", one can use for part 4, instead of soft iron, a material such as that known by the Trade Mark PERMENDUR. "Elinvar" is an alloy composed of 36% Ni, 12% Cr, 4% W, at most 0.1% C, and at most 2% mn, residue: Fe. NIVAROX consists of: 35—40% Ni, 1% Be, 0.1% C, traces of Mg, Si and Ti, residue: Fe. "Ni-Spain-C" and "Thermelast" consists of: 35—40% Ni, traces of other elements, residue: Fe. PERMENDUR consists of 50% Fe, 50% Co, or 49% Fe, 49% Co and 2% V. Pole pieces 5a and 5b are made of a material with a high coercitive field, such as an alloy containing platinum and cobalt. The magnetic field in the air gap between pole pieces 5a and 5b is essentially homogeneous, and the lines of forces are at right angles to the plane of the base plate 1 and, therefore, to the plane in which the resonator 3 is located and in which the arms 3c and 3d oscillate.

On each of the magnetic heads 14 and 15 is placed, by means of a screw 6, a finger 7 which is interference fitted, with its axis of rotation at right angles to the oscillation plane and its centre of gravity not coincident with its axis of rotation, so that when the finger is rotated, its centre of gravity and, therefore, the centre of gravity of the whole oscillating arm, is shifted and the natural frequency of that arm is modified. Each of the magnetic heads 14 and 15 carries a scale respectively 14a and 15a, on which can be read the frequency changes in seconds per day. Fingers 7 are preferably each constituted by a small pointed metal tongue, squeezed under the head of the corresponding screw 6. In order to prevent the resonator from being damaged by shocks, an amplitude limiter 47 is fixed in the base plate 1 in the vicinity of each of the magnetic heads, with a view to restricting the oscillation amplitude of said magnetic heads in the direction towards and away from the periphery of the base plate.

Figure 5 is a diagram of the electric circuit for maintaining the resonator in oscillation. This circuit comprises the pick-up coil 9, the energizing coil 10, the capacitor 11, the resistor 12, the transistor 13 and the battery 8. The base-electrode 13b of transistor 13 is connected through resistor 12 to the collector-electrode 13c, on the one hand, and through capacitor 11 and pick-up coil 9 to the emitter-electrode 13a, on the other hand, said emitter-electrode being itself connected to collector-electrode 13c through energizing coil 6 and battery 8. The electric connection between energizing coil 10 and the negative pole 8a of the battery is achieved through the base plate 1 of the watch movement. It is clear that the pole of the battery which is connected

to the base plate can be either the positive pole or the negative pole, according to the transistor used.

As can be seen in Figures 2 and 3, the two coils 9 and 10 are flat elliptic coils, and they are removably mounted on a rib 16a of a case 16 of plastic material. In said elliptic case are also mounted the capacitor 11, resistor 12 and transistor 13, whereas the two coils 9 and 10 are so dimensioned as to intersect all the lines of force of the magnetic field appearing in the air-gap of magnetic heads 14 and 15. Battery 8 rests by its negative pole 8 on bottom plate 1; it is housed in a cylindrical recess 1b of base plate 1, and kept in that position by a spring 17 fixed in turn by a screw 18 which is electrically insulated from base plate 1. Between spring 17 and the cover of battery 8, which at the same time constitutes its positive pole 8b, there is gripped an electric conductor 19 which connects that positive pole to screw 20, screwed in metal socket 20a and connected to resistor 12, on the one hand, and to the collector-electrode 13c of transistor 13, on the other hand. In Figure 1 can be seen the conductor 21 which connects capacitor 11 to pick-up coil 9 and also the conductor 22 which connects the emitter-electrode 13a of transistor 13 to the junction point of coils 9 and 10.

The circuit operates as follows:—

Whenever one of the arms of resonator 3 is shifted under the action of a random movement, a voltage is induced in pick-up coil 9, which results in the production of a current in the energizing coil 10, said current giving rise to a magnetic field which drives magnetic heads 14 and 15 in the direction of the original displacement. As soon as the amplitude defined by the resiliency of resonator 3 is reached, the arms oscillate in the opposite direction. After a few to-and-fro movements, the oscillation is stabilized and arms 3c and 3d oscillate at a constant frequency and with a constant amplitude, so that magnetic heads 14 and 15 periodically draw near to, and withdraw from, each other.

The adjustment of the desired frequency can be obtained in the course of manufacturing, by slightly varying the dimensions of oscillating arms at some place or other: the arc-shaped segments 3e and 3f of arms 3c and 3d can be made thinner, for instance by means of a rotary file.

The conversion of the movement of translation of the arms to a rotary movement is achieved by means of a pawl fixed to one of the arms (in the present instance, arm 3d), said pawl driving a ratchet-wheel 23. The teeth of said ratchet-wheel are so dimensioned that wheel 23 rotates by one tooth for every oscillation of the resonator. The backward rotation of wheel 23 is impeded by a blocking pawl 25 fixed to base plate 1. To the staff of ratchet-wheel 23 is fixed a pinion 23a in

mesh with a toothed wheel 26, the pinion 26a of which meshes in turn with wheel 27. None of the spindles of these wheels is shown in the figures, in order to render these wheels more visible. Wheel 27 drives, through the medium of a wheel 28, the seconds-wheel 29, to the staff 30 of which is fixed the seconds-hand 31, as can be seen in Figure 4. Pinion 28a is connected to wheel 28 over a free wheel, and meshes with a wheel 32, the pinion 32a of which meshes in turn with a wheel 33. Pinion 33a integral with wheel 33 meshes with the minutes-wheel 34, fixed to a cannon-pinion 35 co-axial with the seconds staff 30 and carrying the minutes-hand 36, and also a pinion 34a driving an intermediate wheel 37, the pinion 37d of which meshes with the hour wheel 38. The latter is fixed to the cannon-pinion 39 carrying the hour hand 40. The movement of the resonator 3 is thus transmitted to hands 31, 36, and 40. For correcting the position of the hands, there is provided a hand-setting stem 43 provided with a crown-button 44 outside the case and with a transmission-wheel (or crown-wheel) 45 within said case. The hand setting arrangements is conventional. The hand-setting stem is located substantially in the plane of resonator 3. The resonator is symmetrical with respect to a plane perpendicular to the oscillation plane and passing through the hand-setting stem, and it comprises an indentation forming a free space between the periphery of the watch movement 1a and the resonator 3, said free space serving to house the hand-setting stem 43. Said stem can be axially shifted, so that when it is drawn out, the transmission-wheel 45 slides axially inwards on the stem 43 through the medium of a lever 46 and rocking bar 47, and causes a castle wheel (not shown) to mesh with the hand-setting wheel 41.

The hand-setting wheel 41 in turn meshes with wheel 42, the pinion 42a of which drives the intermediate wheel 37.

With such an arrangement of the clockwork movement, it is possible to fix a dial 49 provided with feet in the base plate 1 which is provided with holes 1c for the dial feet and inner threads 1d for the fixing screws.

As can be seen, the special shape of the resonator, the arms of which following the periphery of the watch movement through the major portion of their length, leaves a large free space within which can be easily housed not only the gears necessary for driving the hands, but also other gears such as those which are necessary for driving a date-disc. Again, a sufficient space is provided for locating the battery, so that it is possible to use a circular battery having a fairly large diameter, which can be inserted between the resonator arms.

The resonator having the shape of a small omega permits the use of a hand-setting stem of a conventional type.

A second form of embodiment, shown in

Figures 6 and 7, represents a watch movement similar to the above-described movement, with the exception that its resonator is of slightly different shape, this shape deriving from mechanical motives which will be given hereafter.

In a resonator corresponding to the first form of embodiment, there appear mechanical effects which have been neglected heretofore, since they were negligible factors in the case of resonators such as tuning-forks with rectilinear arms.

Considering a tuning-fork with rectilinear arms, it can be seen that elemental masses dm of the arms of the tuning-fork follow during their oscillations a path which is substantially at right angles to the axis of symmetry of the tuning fork, so that the forces $dm \frac{dv}{dt}$

resulting from the acceleration of these masses are perpendicular to said axis of symmetry. Since the masses of the two arms oscillate in phase-opposition, the resultant of the forces for the two arms of the tuning-fork is nil. However, this is not the case with the resonator according to the present invention. In fact, in the latter, the elemental masses of one arm describe circular arcs, the centre of which is located in the vicinity of the fixing point of the resonator and, since the various radius-vectors of these elemental masses are divergent, the path followed by the said elemental masses are also divergent. It follows that the integral $\int dm \frac{dv}{dt}$ of the elemental forces $dm \frac{dv}{dt}$ is most often different from zero.

In the case of a perfectly symmetrical resonator, the resultant force expressed by the above integral is exerted at the fixing point in the direction of the axis of symmetry. The fixing point is thus subjected to an oscillating movement caused by the reactive force and this implies that the watch as a whole is subject to the oscillator movement. The oscillating movement thus generated can become very important and, since it is damped down quite unevenly, not only it produces a loss of energy but it also disturbs the frequency of oscillations.

With a view to lessening the effect of that reaction and achieving a good stability of the frequency of oscillation, we have endeavoured to achieve an oscillator, the arms of which are fairly light and are however fairly rigid. However, if it is desired to increase the accuracy of the watch, it is advisable to increase the frequency of oscillations. To this end, it is necessary, if it is not desired to increase the cross-section of the oscillating mass, to reduce still further the weight of the oscillator arms. It is then necessary to further decrease the thickness of the oscillating arms,

which results in further decreasing their stiffness.

It is however possible to solve the above problem by using a resonator with perforated arms, so that its weight is lessened and the distribution of masses are modified, without however substantially decreasing its rigidity.

Figure 6 shows such a resonator 53, the V shaped foot 53a of which is fixed to the base plate 51 by means of three screws 52. Again, the oscillating portions of that resonator have approximately the shape of a small omega and are connected by a link 53b to the foot 53a. Said oscillating portions are essentially constituted by two arms 53c and 53d in mirror-symmetry, which follow, through the major portion of their length, the periphery 51a of base plate 51, which also constitutes the periphery of the watch movement.

Moreover, between arms 53c and 53d and base plate 51, a space is left which is sufficient for allowing the arms to oscillate freely. To the two free extremities of arms 53c and 53d are welded, or fixed by brazing, magnetic heads 64 and 65. According to Figure 7, the magnetic head 65, which is in mirror-symmetry with head 64, is constituted by a soft iron member 54 of U-shaped cross-section, with pole pieces 55a and 55b fixed to the free extremities 54a and 54b, respectively, of the soft iron member 54, and having a shape adapted to that of the coil 80. The material used for manufacturing resonator 53 and members 54, 55a and 55b, is preferably the same as that described in the first described embodiment.

In each magnetic head 64 and 65 is made a cylindrical hole perpendicular to the oscillation plane. The object of said hole is twofold: in the upper portion thereof is located a cylindrical member 67, friction-tight fitted in the hole and which can be rotated by means of a screw-driver inserted in a slot 66 and the mass of which is eccentrically distributed. Such an eccentric distribution of the mass is ensured by a recess 68 provided in the lower half of said member. The desired friction between cylindrical member 67 and the corresponding magnetic head is achieved by means of a diametral slit made in the face 69 of said cylindrical element, which provides the latter with a certain resiliency which permits to urge it against the wall of its housing; the slit which coincides with the screw slit also serves as a finger moving along a scale 70 carried by each of the magnetic heads and having '+' or '-' marked to indicate the direction of adjustment. The member 67 has, over the known precision setting members, the advantage of being flush with the magnetic head.

The eccentric masses in the heads 64 and 65 allow a precision setting of the frequency, since, when said masses are turned, their centres of gravity and, therefore, the centre of

gravity of the whole oscillating part, are shifted, so that the natural frequency of oscillation of the oscillating mass is modified. Into the lower portion of hole 66 is introduced a pin 71, fixed to the base plate, of a smaller diameter than that of the hole and adapted to restrict the oscillation amplitude in the plane of oscillation, with a view to prevent the resonator from being damaged by shocks.

In order to reduce to nil the resultant force acting upon foot 53a, the oscillating portion of the resonator is given a suitable shape. One can easily see that this condition arises if the elemental masses forming the whole oscillating mass, describe paths which are approximately convergent and the tangents of which define the lines of action of the elemental

forces $dm \frac{dv}{dt}$. The oscillating mass must

therefore be distributed so that the vectorial integral of the elemental forces $dm \frac{dv}{dt}$ is nil.

In view of the symmetry of the resonator, that condition can be reduced to $\int dm \frac{v_y}{dt} = 0$, v_y designating the component of the velocity in the direction of the resonator axis of symmetry.

However the shape of the arm is essentially conditioned by the other parts of the watch (not shown), such as the battery, the gears, the electric circuit, the periphery of the bottom-plate and also the desired oscillation frequency and the desired rigidity of the arms; it follows that the distribution of masses cannot be achieved simply by properly choosing the shape of the resonator.

In order to achieve the desired distribution of masses, each of the resonator arms is provided with three holes 72, 73 and 74, whereby the distribution of the oscillating masses can be modified without however substantially decreasing the rigidity and the mechanical resistance of the resonator.

By means of the holes made in the arms, it is also possible to increase the frequency of oscillations. The condition that the integral

of the elemental forces $dm \frac{dv}{dt}$ be nil can be

determined by a graph for instance; the thus obtained reduction to zero of the forces in the direction of the axis of symmetry is in general incomplete and requires slight corrections.

To this end, the resonator, alone or mounted on the bottom-plate, is placed on a base responsive to oscillations, connected to a measuring instrument. The symmetry of this oscillator is adjusted in known manner by slightly stripping with a file at appropriate places the resonator arms, whereas the integral

of the elemental forces acting in the axial direction is reduced to zero by perforating the resonator arms. It is also possible to reduce the integral to zero by filing each arm at a place in the vicinity of the centre of oscillation, e.g. 53f. By filing the arms at such a place, the centre of oscillation is shifted, with the result that the paths of the elemental masses are modified, a suitable displacement allowing integral to be reduced to zero.

When mass produced, the resonators can be so cut that they all have a resultant acting in the same direction, for instance in the direction of the coil. It is thus possible, by filing the inside of the curvature 53f, to adjust the frequency and symmetry, and to reduce to zero the integral of the elemental forces, by enlarging the perforations made in the arms.

Of course, the resonator according to the present invention is not restricted to the above-described particular forms of embodiment. In particular, it is possible without going beyond the scope of the invention as defined by the appended claims to modify the number and the distribution of the perforations made in the arms.

WHAT WE CLAIM IS:—

1. An electronic watch with a mechanical resonator serving both as a time basis and as a driving member, said resonator being characterised in that it follows through the main portion of its length the periphery of the watch movement.

2. An electronic watch according to claim 1, in which the resonator is an audio frequency resonator.

3. An electronic watch according to claims 1 or 2, in which said resonator comprises perforations which modify the position of its centre of gravity with no lessening of its rigidity.

4. An electronic watch according to claim 1, 2 or 3 wherein a hand-setting stem is located in the plane of the movement, and wherein said resonator comprises two arms fixed to each other and is symmetrical with respect

to a plane which passes through the axis of the hand-setting stem, and is perpendicular to the plane of the movement, said resonator having an indentation in the region where the two arms are fixed to each other which leaves a free space between the oscillator and the periphery of the movement, that space serving to house the hand-setting stem which is located at least approximately in the plane of oscillation of the resonator.

5. An electronic watch according to claim 4 in which each of the resonator arms is provided at its extremity with a member rotatable about an axis perpendicular to the plane of oscillation of the resonator, the centre of mass of the member being eccentric with respect to its axis of rotation, whereby rotation of the member changes the natural frequency of the resonator.

6. An electronic watch according to claim 4 or 5, in which each of the resonator arms is provided with at least one perforation adapted to modify the distribution of the accelerations of the elemental masses of the arms during oscillation, so that the resultant of the said accelerations is nil.

7. An electronic watch according to claim 5, in which each of the members located at the extremity of each of said arms is provided with an opening which receives an amplitude limiter, which protects the resonator against too large amplitudes in the case of shocks.

8. An electronic watch having an audio frequency mechanical resonator substantially as described with reference to and as illustrated in Figures 1, 2 and 3, of the accompanying drawings.

9. An electronic watch having an audio frequency mechanical resonator substantially as described with reference to and as illustrated in Figures 6 and 7 of the accompanying drawings.

MARKS & CLERK,
Chartered Patent Agents,
Agents for the Applicant(s).

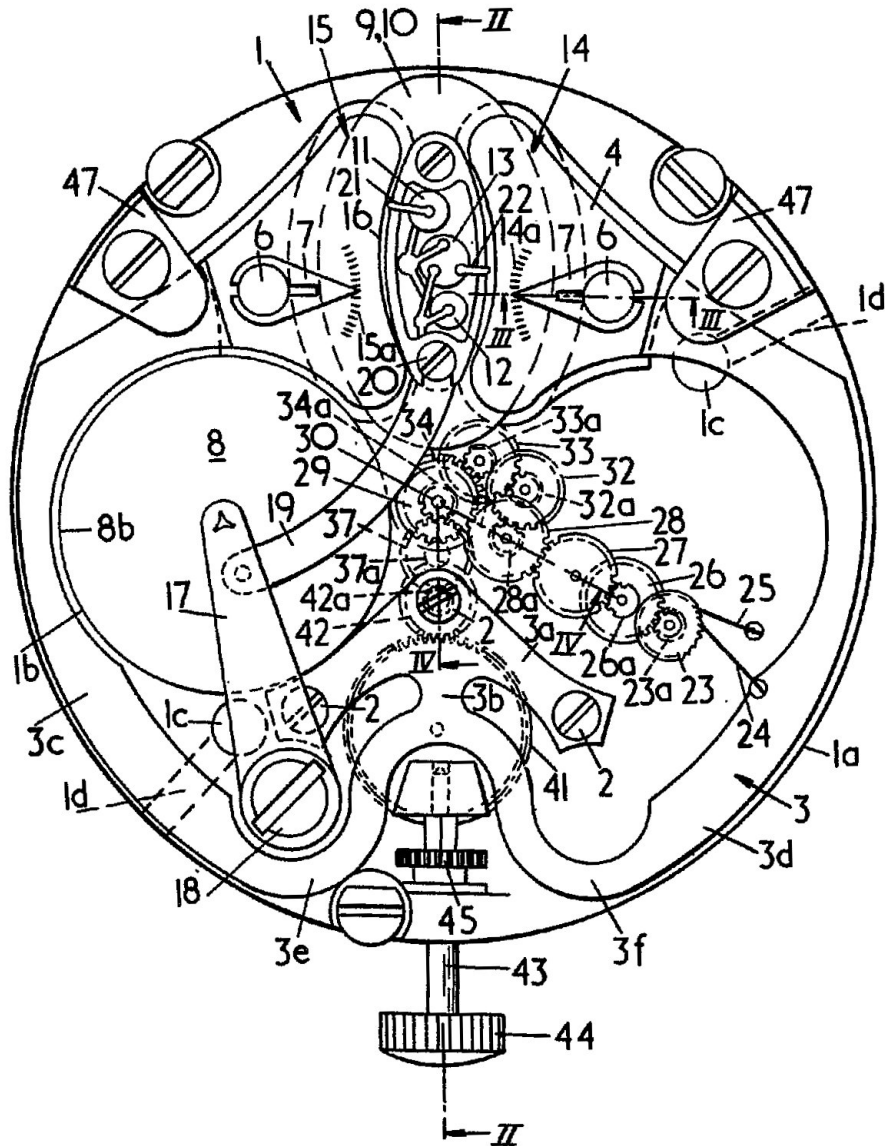


FIG. I.

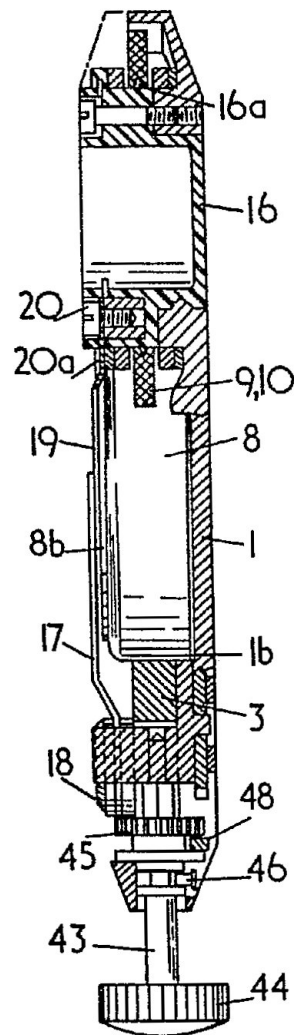


FIG. 2.

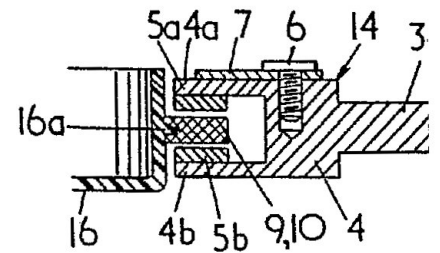


FIG. 3.

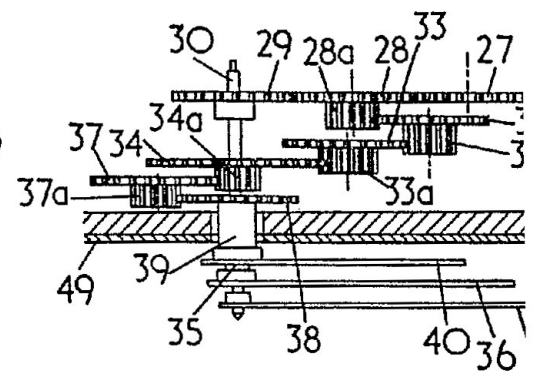


FIG. 4.

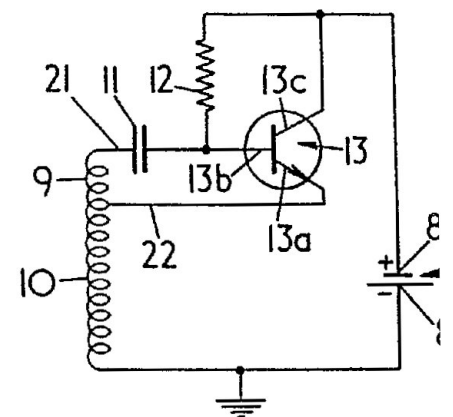


FIG. 5.

FIG.6.

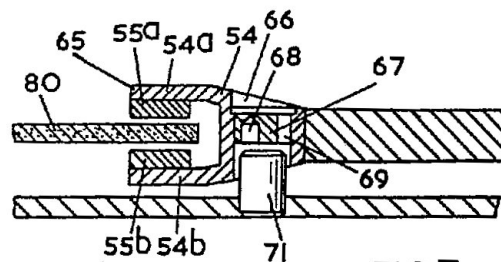
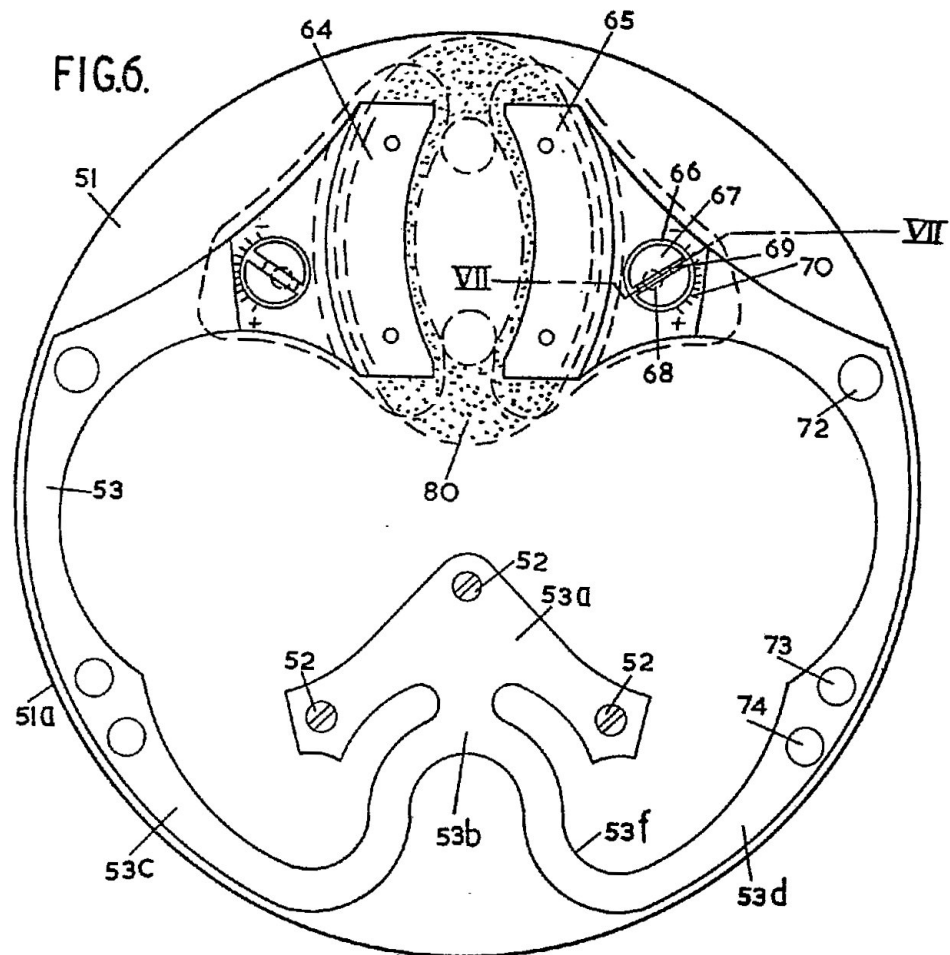
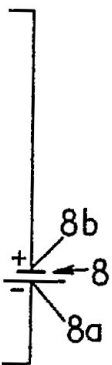
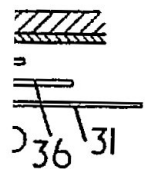
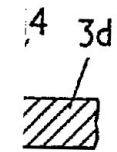


FIG.7.



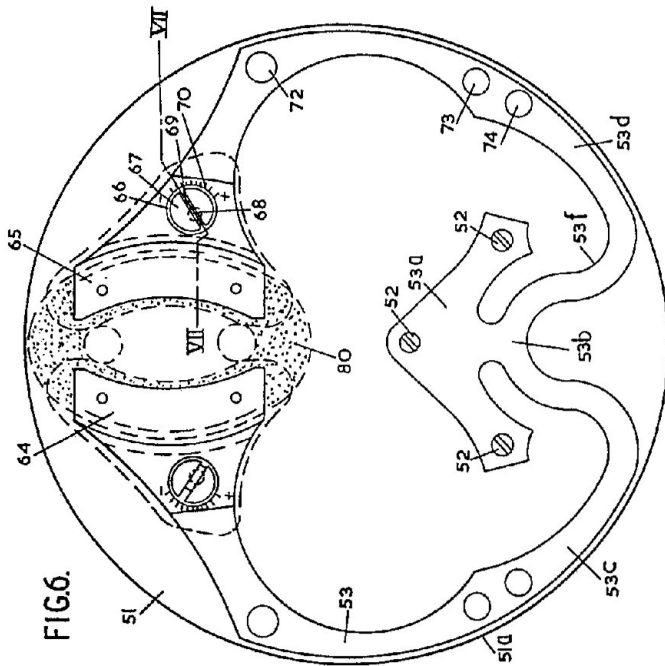


FIG. 6.

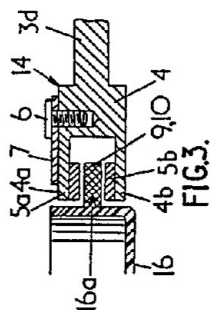


FIG. 3.

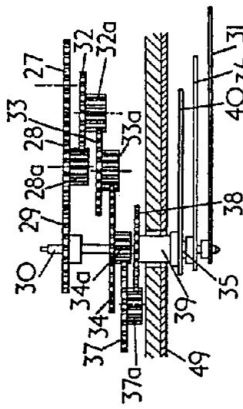


FIG. 4.

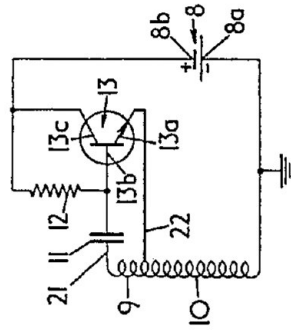


FIG. 5.

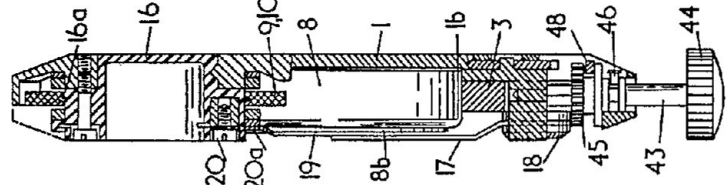


FIG. 2.

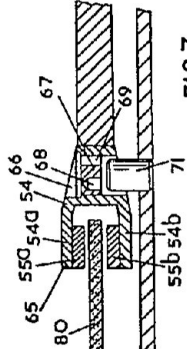


FIG. 7.