PATENT SPECIFICATION

DRAWINGS ATTACHED

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1,169,220

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COMPLETE SPECIFICATION

Electric Timepiece

We, CITIZEN TOKEI KABUSHIKI KAISHA, a Japanese Corporate Body, of No. 74, 2-chome, Tsunohazu, Shinjuku-ku, Tokyo, Japan, 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: —

This invention relates to electronic time pieces, e.g. watches.

According to the invention there is provided an electronic time piece adapted to utilize a battery as its power source, and comprising a transistor drive circuit suitable to be fed by the battery, vibrator means acting as a timebase and electromagnetically driven by said drive circuit to form therewith a resonant combination, feed magnet means which the vibrator means comprise, a magnetic wheel magnetically coupled with said feed magnet means, a gear train mechanically coupled with said magnetic wheel, and a time indicator mechanism driven by said gear train, said vibrator means comprising a vibratory member of elastic metallic material having the same shape as a member made from sheet material, having substantially a W-shape, by bending the W-shape with right-angle bends along four parallel axes, so as to present two substantially U-shaped vibratory arms.

By reciting the "W-shape", we intend so to restrict the scope of the invention claimed as to exclude an embodiment having a vibratory element shaped as indicated in Figures 5 and 6 of Japanese utility model application No. 108403 filed on 30th December, 1965.

Electronic watches now commercially available are predominantly fitted with either the balance wheel type or the tuning fork type of oscillator as a timebase. These oscillators are subject to a considerable amount of positionel error due in different ways to the influence of the earth's magnetic and gravitational fields upon the oscillator and dependent upon the accidental positioning and orientation of the watch in those fields. Other electronic watches are fitted with vibrating blades in place of the balance wheels or tuning forks to provide a timebase. This kind of vibrator is subjected also to considerable positional error to the same, or an even larger degree, than that met within the foregoing kinds of vibrators in said commercially available watches.

Another difficulty caused by the employment of such vibrators resides in the stringent space requirements imposed by the relatively voluminous self-contained power source or battery and the electronic circuit unit to be positioned within the limited available space of the timepiece, which must naturally be fitted with a conventional gear train requiring again a large space.

The embodiments hereinafter described of the invention disclose an electronic watch having an optimum combination of a three dimensional, well-balanced vibrator, feed magnet means and gear train, in which the battery and the drive circuit unit can be positioned at either side of said combination and at the same level as that of said combination so as to provide a substantially flat conformation, the watch being capable of functioning regularly even when it is subjected to an outside physical disturbing force and capable of minimizing possible adverse effects of the feed magnetic means upon the vibrator proper, and the watch being such that the oscillating frequency of the vibrator is easily and finely adjustable, and the coupling phase between said feed magnet means and said magnetic wheel is adjustable so as to provide an optimum motion-converting efficiency between them.

The invention will now be more particularly described with reference to the accompanying drawings, in which:—

Fig. 1 is an exploded perspective view of the movement of an electronic watch embodying the invention as defined above.

Fig. 2 is a plan view of the watch movement shown in Fig. 1 after assembly and when seen from the back cover side of the watch, i.e. looking from the top of Fig. 1.

Fig. 3 is a plan view of the assembled watch movement when seen from the bottom of Fig. 1, i.e. from the dial side of the watch.

Fig. 4 is a perspective view of the vibrator assembly cooperating with a magnetic wheel and comprising two vibratory arms, two feed magnets mounted thereon, two magnetic yokes again mounted on said arms and two counter weight masses mounted on said feed magnets, together with two coil assemblies of which one is shown as separated from its working position and the other is shown positioned in place, wherein however the electronic drive circuit unit is shown additionally and schematically in block form.

Fig. 5 is a developed plan view, equivalent to a view before folding, of a mechanical vibrator contained in the vibrator assembly shown in Figs. 1 and 4.

Fig. 6 is an end view of the vibrator shown in Fig. 5, when formed by folding.

Fig. 7 is an enlarged sectional view of the mounting part of the vibrator which is fitted with an eccentric cam for the adjustment of the general orientation of the vibrator assembly relative to the frame plate of the watch.

Fig. 8 is an enlarged sectional view of the magnetic wheel assembly to be magnetically coupled with said vibrator assembly.

Fig. 9 is a top plan view of a feed magnet.

Fig.10 is a similar view to Fig. 5, illustrative of a slightly modified vibrator.

Fig. 11 is an end view thereof, when formed.

Fig. 12 is a similar view to Fig. 10, illustrating a still further modified vibrator.

Fig. 13 is a similar view to Fig. 11, illustrating the formed shape of the modified vibrator of Fig. 12 in end view.

Fig. 14 is a similar view to Fig. 9, illustrating a slightly modified form of feed magnet from that shown therein.

Fig. 15 is an end view thereof.

Fig. 16 is a top plan view of a still further modified feed magnet, to which is attached a U-shaped counter weight mass.

Fig. 17 is a side view thereof.

Fig. 18 is a top plan view of a still further modified feed magnet.

Figs. 19, 20 and 21 are a perspective view, a top plan view and a partial end view, respectively, of a comparative conventional vibrator assembly, shown in a highly simplified schematic form.

Fig. 22 is a perspective view of a part of the vibrator assembly shown in Figs. 1 and 4.

Fig. 23 is an enlarged sectional view of a part of the watch movement shown in Figs. 2 and 3.

Fig. 24 is a similar enlarged sectional view of an adjoining part of the watch movement, relative to that shown in Fig. 23, the joining plane being shown by chain line X—Y in both figures.

Now referring to the accompanying drawings, especially Figs. 1—8 thereof, numeral 10 denotes a base or frame plate of a watch movement embodying the invention, said frame plate being made of a conductive metal and circular in its top plan view and having a circular flange 10a for accurately positioning said plate in and relative to a watch casing, not shown, which may be of any conventional design.

Along a diameter of the frame plate 10 and thus in line, there are provided successively a bearing opening 11 for seventh wheel 101, same at 12 for sixth wheel 102, same at 13 for fifth wheel 103, same at 14 for second wheel and fourth wheel 99, same at 15 for third wheel 105, a stepped and tapped sleeve 16 for wheel mounting plate 30 and a stop pin 17 for the prevention of an excessive vibration amplitude of vibrator assembly 100. An elongated projection 18 is made integral with the frame plate 10 extending in the crosswise direction relative to said specific diameter, for the protection of two yokes 106 and 106a of said vibrator assembly. In close proximity to said stop pin 17 and at both sides of said specific diameter, there are a pair of viewing openings 20 and 21 separated a small distance from each other, their purpose being set forth hereinafter. An opening 19 is also provided for a purpose to be given hereinafter.

On the frame plate 10, there is an intermediate platform 22 which is adapted for receiving an electronic drive circuit unit 107 as will be later described in detail. Substantially opposite to said platform 22 relative to said specific diameter, there is a recess 23 made substantially circular, adapted for the reception of a battery 108 through the intermediary of its detachable mount 109.

At the centre of the recess 23, there is a cylindrical projection 24 made integral with the frame plate 10, so as to act as a negative stationary contact for said battery 108 for feeding the drive circuit.

Numeral 25 indicates a conventional stem shaft rotatably mounted in the frame plate 10, said shaft being formed with male screw threads at 25a for receiving a stem, not shown.

There are provided a plurality of shims 26—28, three being shown herein by way of example, preferably of different thicknesses from each other, so as to maintain the height of a lower mount 29 when it is attached to the frame plate 10 at its intermediate shoulder 110, together with an upper mount 31 with a magnetic wheel 32 rotatably mounted between the mounts. For this assembly purpose, set screws 111, 112 and 113 are led through openings 33, 34, 35 and 36, 37, 35a, respectively.

Magnetic wheel 32 is formed integrally with a flywheel mass 39 and a wheel shaft 40, the latter being mounted at both ends, in bearing openings 41 and 42, which are formed in the upper and lower mounts 31 and 29, respectively.

The gear train comprising said wheels 101, 102, 103, 104, 105 and 99, is mounted rotatably between the wheel mounting plate 30 and the frame plate 10 by screwing three set screws 114, 115 and 116 into tapped sleeves 43, 44 and 16 which are pressure-fitted into the frame plate 10 and through the intermediary of three screw openings 45, 46 and 47, respectively, which are bored through the wheel mounting plate 30. The latter plate is further bored with a bearing opening 48 for receiving rotatably an eccentric cam 49, the purpose and function of which will be later described hereinafter.

Electronic drive circuit unit 107 comprises a conventional drive circuit comprising at least one transistor, several capacitors and resistors, for instance as disclosed in our British patent Application No. 7661/66, Serial No. 1103283. The unit 107 comprises a moulded plastics member, preferably embedding these circuit components, although the present invention is not limited to such a moulded configuration.

The plastics mass 107a is provided with four terminals 50—53 and an arm 54 carrying adjustably a coil assembly, generally shown by reference 55. This assembly 55 comprises, although not shown, a sensing or search coil and a drive coil, as conventionally, which coils are wound on a cylindrical bobbin 55a. There is provided a magnetic screw 56. By screwing this magnetic screw inwards or outwards the magnetic properties of the electromagnet which this coil assembly helps to constitute can be modified as will be described in more detail hereinafter.

The unit 107 together with the coil assembly 55 is fixed detachably upon frame plate 10 and above platform 22 by means of positioning and fixing screws 57—59. For this purpose, the plate 10 is formed with a tapped opening 60 and provided with a pair of tapped sleeves 61 and 62 embedded in the plate 10.

Battery mount 109 is made of an insulating material such as synthetic resin and formed with a considerable opening 63 and a concentric recess 64, the latter being adapted for receiving the battery 108 in a definite position. For this positioning, there are provided a resilient pressure strip 65 and two set screws 66 and 67.

The mount 109 is formed with a projecting arm 70 similar to that denoted 54 and being adapted for positioning a coil assembly 73 comprising a bobbin 71 and a sensing and a driving coil, together denoted by a single reference numeral 72. This assembly 73 is perfectly similar in its design and function to that shown at 55, so that no further description in this respect will be necessary. But, it is to be noted that the battery mount 109 together with its coil assembly 73 is detachably fixed to the frame plate 10 by means of set screws 68 and 69 which are threaded into correspondingly tapped sleeves 74 and 75, respectively. These sleeves are embedded in the plate 10, as shown.

Vibrator means in the form of assembly 100, the details of which are to be described hereinafter by reference to Figs. 4—9, are detachably attached through a mounting piece 74 to mounting plate 30 by means of two set screws 75 and 76 which pass through said piece 74 and are received in tapped sleeves 77 and 78, respectively, studded on said plate 30. The vibrator means act as a timebase and are electromagnetically driven by the drive circuit, forming a resonant combination therewith.

The thus assembled electronic timepiece movement is shown in its top plan view in Fig. 2 which is however in practice the rear view of the timepiece with its back cover removed, although the latter is not shown in the drawings.

When seen from the bottom, the movement assembled as in the case of Fig. 2 will present a view as shown in Fig. 3, wherein however the dial of the timepiece has been removed in order to illustrate the inner working parts of the movement. In this figure, numeral 79 denotes a conventional cannon wheel; 80 a minute pinion engaging therewith; 81 a minute wheel made integral with said pinion 80; 82 a cannon pinion engaging with said wheel 81 and mounted rotatably and concentrically with said cannon wheel; and 83 a setting wheel kept in engagement with said minute wheel.

Next, referring to Figs. 4—9, the vibrator assembly 100, comprising feed magnet means 119, 120 and a vibratory member 84, will be described in more detail. As shown in Fig. 5, a sheet element 84 having substantially the configuration of a "W", being somewhat elongated and modified, comprises a fixing part 84a formed with two openings 75a and 76a adapted for the reception of said set screws 75 and 76, respectively, the openings being sufficiently large to allow positional adjustment of the vibrator. The part 84a is connected integrally through a reduced neck 84b, formed with side recesses 117 and 118, with a connecting part 84c having a broader width. The part 84c is united rigidly at its ends with vibratory arms 84d and 84e, each having an elongated U-shape as shown and being enlarged at its free end so as to form a lateral extension 84f or 84g for fixedly mounting a feed magnet 119 or 120. Sheet element 84, which may be called the vibrator proper, is fabricated such as by punching from a permanently elastic sheet material frequently and commonly used by those skilled in the art. Among others, a kind of Ni-Cr-Fe alloy such as "Elinvar", having substantially a constant temperature coefficient of expansion is highly recommended. The punched sheet 84 is bent in mirror symmetry at right angles about each of the four parallel axes a—a' and b—b' or c—c' and d—d', respectively, so as to present a box-like shape, with a channel-shaped end view as illustrated in Fig. 6, having two substantially U-shaped vibratory arms. This vibrator proper when formed may have as its three dimensional sizes 2.5 mm. (height: "*h*")×5.0 mm. (width: "*w*")×9.95 mm. (length: "L"), as a preferred example. In this respect, reference should be had to Figs. 5 and 6. The thickness of the sheet may preferably amount to 0.22 mm.

In Figs. 10 and 11, a slightly modified shape of punched sheet 85 is shown. This modification can be used in place of the foregoing sheet element 84, if the related mounting parts and procedure are correspondingly modified.

A still further modified sheet element is shown by reference 86 in Figs. 12 and 13, in a similar manner to Figs. 5 and 6.

A preferred configuration of the feed magnet 119 or 120 (so called because they impart motion of the magnetic wheel 32 which is magnetically coupled with them) is illustrated in Fig. 9, said magnet being preferably punched out of a conventionally employed permanent magnet sheet stick such as magnetic ferrite, 0.24 mm thick, for instance, and having generally a rectangular shape, 3.75 mm×15.85 mm, for instance, yet formed with a small gap 121 (by which it is magnetically coupled to the magnetic wheel 32) at its free end and with a bridge 122 magnetically connecting the side chords 123 and 124 of the magnet laterally together at a point adjacent to said gap. This bridge 122 acts as a short circuiting member for suppressing stray fluxes emanating from the main magnetic circuit and passing laterally through the neighboring part or the related vibratory arm 84d or 84e. On addition, this bridge 122 acts as a lateral reinforcing member for increasing the physical rigidity of the feed magnet in the neighborhood of the gap 121. Said side chords 123 and 124 are connected rigidly together by the root portion 125 of the magnet. When assembling a pair of such magnets are attached rigidly at their roots 125 to said lateral extension 84f and 84g of said vibrating arms 84d and 84e, respectively, of the vibrator proper 84, by riveting, screwing or welding, to be carried thereby. For easy identification of this attaching mode, a plurality of small circles indicating the places of attachment and marked alike by only a single reference numeral 200 are shown in Figs. 5 and 9.

A slightly modified feed magnet is shown in Figs. 14—15. In this case, the magnet is formed with side flanges 126 and 127 along the side chords 123' and 124', respectively, of the feed magnet, for improving the rigidity of the whole of the magnet. Gap 121' and connecting bridge 122' are provided also in this case.

A still further modified feed magnet from that shown in Figs. 14—15, is illustrated in Figs. 16—17. In this case, the magnet comprises a magnetic C-piece 128 having a gap 128a similar to that denoted 121' in Fig. 14, said C-piece being kept in contact with a hollow rectangular support 129 made of similar material to that used for the vibratory sheet element 84, 85 or 86. Both parts 128 and 129 are united rigidly together by attaching to them a counter weight mass 130, for instance, by spot welding. Welded spots are denoted, in this case, by small circles and circular arcs shown respectively in Figs. 16—17.

In a still further modified embodiment shown in Fig. 18, a sheet magnet 131 is formed as a whole into an elongated C, having a gap 131a, a separate bridge element 132, made of a ferro-magnetic material, being provided so as to establish a short-circuiting path for the magnetic circuit of the magnet, which includes said gap 131a.

In a vibrator assembly known to the applicants in Japan, shown for comparison in Figures 19 to 20, adapted for magnetic driving of magnetic wheel 134, an elongated C-shaped feed magnet 133 having a coupling gap 135a is fixed at its root 135b to the free end of a U-shaped vibrator blade 136 by spot-welding or the like fixing technique, said blade being formed with a depending leg 136a rigidly mounted at its lowermost end on a frame plate 137 only schematically shown in Fig. 19. With use of such an arrangement, magnetic fluxes will flow through the feed magnet arms 135 as hinted by a chain-dotted line 138 in Fig. 20. These fluxes, however, adversely affect the neighboring vibrator blade 136 in that the resonant frequency of the blade is thereby considerably disturbed from the value for which the blade was designed, resulting in an inaccurate steppingly driven movement of the magnetic wheel 134 coupled magnetically through the gap 135a with the feed magnet. On the other hand, the vibrator unit may frequently perform spurious vibration as hinted by small arrows in Fig. 21, which shows member 133, viewed from its gap end and deformed in the course of such a vibration in the directions indicated by these arrows, which vibration is caused by the asymmetrical spatial configuration of the vibrator assembly. The first disadvantage is substantially avoided by the provision of a bridging part 122, 122′ or 132 for each feed magnet, as shown in Fig. 9, 14 or 18. In these cases, a highly concentrated magnetic circuit will be established including both the magnetically coupling gap and the bridging part. This effect will be easily seen by reference to the short circuited magnetic circuit denoted by numeral 139. It will be clear that a similar effect can be attained with use of the modified feed magnet shown in Figs. 16—17. In contrast to the asymmetrical space configuration of the vibratory assembly shown in Figs. 19—21, the possible spurious vibration may substantially be suppressed by the employment, in an embodiment of the invention, of what in effect is a pair of vibratory assemblies, having the shape or form for example described above with reference to Fig. 6, providing a highly improved symmetrical and well-balanced space configuration.

After the vibrator having integral components 84a—84g has been fabricated as was described hereinbefore by reference to figs, 5 and 6, a member consisting of feed magnet 119 or 120 is fixedly attached to the outside of the lateral extension 84f or 84g of the vibratory arm 84d or 84e. This attaching mode will be most clearly seen from Fig. 22. At the same time, an angular intermediate piece 87 is attached fixedly to said lateral projection 84f or 84g, respectively, for rigidly mounting the yoke 106a or 106, as the case may be and fixedly attaching same to one end of said lateral projection, wherein the desired rigid connection between the intermediate piece 87 and the yoke 106a or 106 is attained by welding or fusing as illustrated in Fig. 22 at 89. At the opposite end of the feed magnet 119, i.e. remote from its end where the yoke 106 is mounted, there is fixedly mounted and attached a U-shaped counter weight mass 141, which is rigidly attached thereto such as by welding, fusing, riveting or the like attaching means. In a similar way, another feed magnet 120 is provided at its corresponding end with a similar counter weight mass 141a. The arrangement, dimensions and weights of the massive yokes 106 and 106a, and counter weights 141 and 141a are so selected that they are well balanced dynamically with respect to each other for performing oppositely phased vibrating movements by means of the two vibratory arms 84d and 84e, which move together with respective feed magnets 119 and 120, yokes 106 and 106a, and counter weight masses 141 and 141a, carried thereby. The directions of vibration of the two vibrating elements of the vibrator assembly 100 are shown by small arrows in Fig. 4.

The yoke 106a comprises a pair of oppositely arranged arcuate segments 201 and 202 and a cone 203, made from a ferromagnetic material and integral with its base 204.

The relative position of the magnetic yoke 106a and the corresponding electromagnetically co-operating coil assembly 73 when the vibrator occupies its neutral position is most clearly seen from Fig. 2. Although the details of the magnetic yoke 106a and its cooperative coil assembly 73 have been illustrated above only for one side of the vibratory assembly, that comprising feed magnet 120, the same applies equally to the other side of the vibratory assembly comprising feed magnet 119.

The peripheral zone of the magnetic wheel 32 passes through the gap 121 of the feed magnet 119 on one side of the assembly said wheel being formed into a perforated wheel similar to the magnetic escape wheel shown in Fig. 19.

The coil assembly 55 or 73 comprises, as already described, a sensing or search coil and a drive coil, although the details thereof are not shown. The search coil may comprise 2500 turns of insulated copper wire of thickness 12 microns, while the drive coil may consist of 8500 turns of insulated copper wire of the same kind.

These coils of coil assembly 55 are electrically connected, through four wire conductors, generally denoted by references 205 and 206, with the coils of assembly 73 and said four terminals 50—53 of the electronic circuit unit 107, only schematically shown by a block in Fig. 4. The coils of assembly 73 may be of similar design and arrangement to those of the assembly 55. The battery 108 adapted to feed the necessary energy to the unit 107 may be a mercury battery, rated at 1.3 volts, 80—100 milliampere hours.

According to our experiments, the coupling relation or relative phase between the coupling gaps, 121, of the respective feed magnets 119 and 120 is of great importance for self-starting of this kind of electronic timepiece, for which purpose there is a designed optimum coupling condition between the gaps and the magnetic wheel 32. If there is a minor phase difference from the designed optimum coupling condition, the turning torque imposed on the magnetic wheel 32 upon the initiation of energization of the battery-driven vibratory assembly 100 will not be large enough to drive the gear train and the time-indicating mechanism of the watch movement. According to the present embodiment, the vibrator assembly 100 can be adjusted in its general orientation about the set screw 76 as its pivot. In Fig. 7, the parts denoted 30, 48, 49, 75, 75a, 76, 76a, 77, 78, 84a, and 174 are the same as those described in the foregoing. As seen, the fixing part 84a of vibrator proper 84 is, in practice, spot-welded to mounting piece 174 at several places marked 207 and the eccentric cam 49 is positioned so as to exert a turning force in one or other direction to a surrounding acuate recess 208, by rotating the cam manually in a corresponding turning direction by means of a screw driver, not shown, applied to the screw head 49a. By this adjustment, viewable through hole 19, the general orientation of the vibrator assembly 100 may be finely regulated about set screw 76 so as to establish an optimum phase relation in the above-mentioned sense and thus optimum coupling between the coupling gap 121, say 0.28 mm long, of feed magnet 119 and the magnetic wheel 32. This wheel may have an O.D. 6.2 mm; thickness 0.1 mm; and twenty teeth. In addition, if necessary, one or more of the shims 26—28 may be replaced by one or more new ones of different thickness or thicknesses from those of the prevailing shims, so as to modify the height of the magnetic wheel 32 (i.e. adjust its axial position) relative to said gap 121 of the feed magnet means, so as to attain again an optimum phase relation.

Each of the two vibrating systems is so designed that the centre of mass of the two extreme masses formed by the magnetic yoke and counter weight lies substantially at the centre of deflection of the vibratory arm 84d or 84e, which is made possible partly thanks to the U-shape of the arms. The accurate maintenance of the standard frequency for which the assembly is designed is further assured by the provision of the two oppositely working vibrating systems. Thanks to the U-shape of the vibratory arm, the working frequency of the whole vibrator assembly 100 can be kept as low as at 100 cycles per second, as was already mentioned, which is highly suitable for the magnetic drive of the wheel 32.

If there should be a slight difference between the actual working frequencies of the respective vibrating systems, it is only necessary to advance or withdraw the magnetic screw 56 or 156 for the coil assembly 55 or 73, respectively, by turning the screw manually, to achieve equal frequency. When one or both of the screws are advanced, the electromagnetic coupling between the related coil assembly and magnetic yoke will be adjustable and the vibration of the magnetic yoke or yokes will be altered so that the vibration frequency will be decreased in a finely adjustable manner.

The position of the yoke 106 or 106a relative to the related coil assembly 55 or 73, respectively, can be observed through the related inspection opening 20 or 21, when adjusting to achieve optimum relative position.

From Fig. 8, the mounting details of magnetic wheel 32 can be easily understood. But, it should be noted that the flywheel mass 39 is freely rotatable on the wheel shaft 40. Motion is transmitted from the magnetic wheel through its shaft 40 and a pinion 209 mounted rigidly thereon, to the seventh wheel 101. The pinion 209 and seventh wheel 101 are fitted with what are called reversible teeth (i.e. teeth that permit drive from one wheel to the other but not *vice versa*) so that any adverse shock or the like transmitted from outside through the gear train may be checked at this point and the vibrator assembly is perfectly protected from such shock and any resulting spurious vibration.

The operation of the aforementioned electronic watch is as follows:

When the stem shaft 25 is manually pushed inwards so as to close the switch 210, Fig. 4, through a comonly known transmission, not shown, current is thereby fed from the battery 108 to the electronic drive unit 107 and thus, as commonly known, both the vibratory arms 84d and 84e of the vibrator assembly 100, each carrying the related feed magnet, magnetic yoke and counter weight mass as already referred to, are caused to vibrate, preferably at 100 cycles per second, through the electromagnetic coupling of the yokes 106 and 106a with the respective coil assemblies 55 and 73, respectively, in opposite senses about their axes of oscillation Y and Z, respectively (see, also, Fig. 4).

Thus, the magnetic wheel 32 is magnetically driven by the vibrator assembly 100 as explained hereinbefore with reference to Figures 19—21 and the seventh wheel 101 of the gear train is rotated, being mechanically coupled with the magnetic wheel 32.

Further transmission of the driving torque is carried out in the same manner as conventionally employed, viz, through sixth wheel 102, fifth wheel 103, fourth wheel 99, third wheel 105 and second wheel 104 to the conventional time-indicating mechanism including seconds hand 220, minute hand 221 and hour hand 222, as will be easily seen from Figs. 23 and 24 in combination, said indicator hands being shown only schematically by chain-dotted lines.

When the vibrator assembly is projected on the frame plate 10, the projected outline includes therein all the main constituent wheels of the gear train, or more specifically the second, third, fourth, fifth, sixth and seventh wheels, being the wheels driven by the magnetic wheel and driving the minute hand shaft. The elevational outline of the vibrator assembly also includes these gear train components. Thus the main gear wheels of the gear train are contained in a space delineated by the vibratory member 84, the feed magnets 119, 120, and the counterweight masses 141, 141a. Therefore, a highly compact arrangement of these gears relative to the vibrator assembly can be realized.

All the necessary adjustments of the vibrator assembly in its relative phase and operating frequency can be adjusted without stopping the vibrating operation of said assembly 100.

WHAT WE CLAIM IS:—

1. An electronic time piece adapted to utilize a battery as its power source, and comprising a transistor drive circuit suitable to be fed by the battery, vibrator means acting as a timebase and electromagnetically driven by said drive circuit to form therewith a resonant combination, feed magnet means which the vibrator means comprise, a magnetic wheel magnetically coupled with said feed magnet means, a gear train, mechanically coupled with said magnetic wheel, and a time indicator mechanism driven by said gear train, said vibrator means comprising a vibratory member of elastic, metallic material having the same shape as a member, made from sheet material, having substantially a W-shape, by bending the W-shape with right angle bends along four parallel axes, so as to present two substantially U-shaped vibratory arms.

2. A time piece as claimed in claim 1, comprising an eccentric cam arranged for adjusting the general orientation of the vibrator means.

3. A time piece as claimed in claim 1 or 2, wherein said feed magnet means comprise a feed magnet carried by each said arm, and said timepiece comprises a weight mass in the form of a magnetic yoke fixedly attached to one end of each said arm and a counter weight mass fixedly attached at one end portion of each said feed magnet.

4. A time piece as claimed in claim 3 wherein said transistor drive circuit is made in a moulded unit which carries thereon terminals for connecting two coil assemblies of the time piece each comprising a search coil and a drive coil and each being aranged to co-operate electro-magnetically with a coresponding one of said magnetic yoke.

5. A time piece as claimed in claim 4, wherein each said coil assembly is provided with a magnetic screw for adjustment of the electro magnetic coupling between the related coil assembly and magnetic yoke.

6. A time piece as claimed in claim 3 or 4 or 5, wherein the main gear wheels of said gear train are contained in a space delineated by said vibratory member, said feed magnets and said counter weight masses.

7. A time piece as claimed in any one of claims 3 to 6, wherein each said feed magnet is bridged magnetically at a place adjacent to a coupling gap by which it is magnetically coupled to the magnetic wheel.

8. A time piece as claimed in any preceding claim, wherein said magnetic wheel is adjustable in its axial position relative to said feed magnet means.

9. A time piece as claimed in any preceding claim, comprising a battery arranged to feed the drive circuit.

10. An electronic time piece substantially according to any example hereinbefore described with reference to Figures 1 to 18 and 22 to 24 of the accompanying drawings.

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FIG. 1.

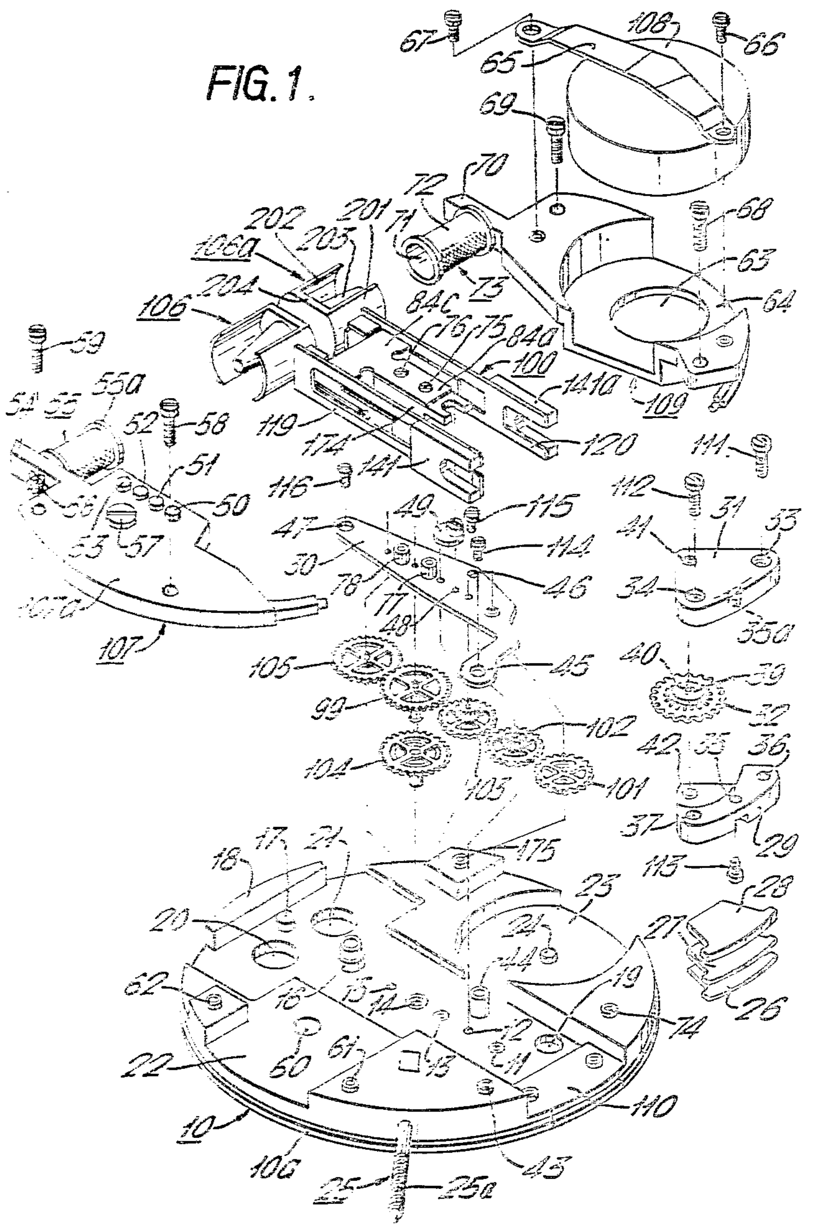
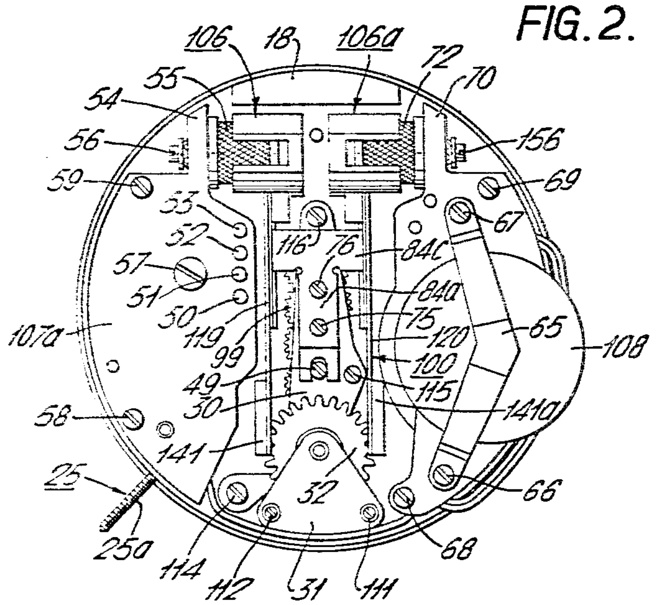


FIG. 2.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76
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84a
50
75
65
108
107a
119
120
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66
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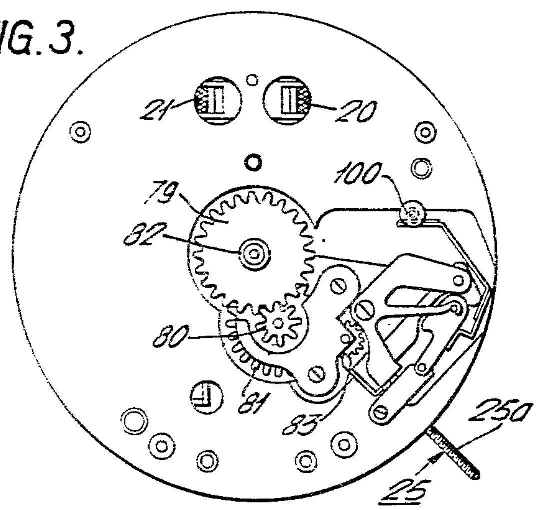
114
112
31
111
68

FIG. 3.


21
20
100
79
82
80
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83
25a
25

1169220 COMPLETE SPECIFICATION

8 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

FIG. 4.

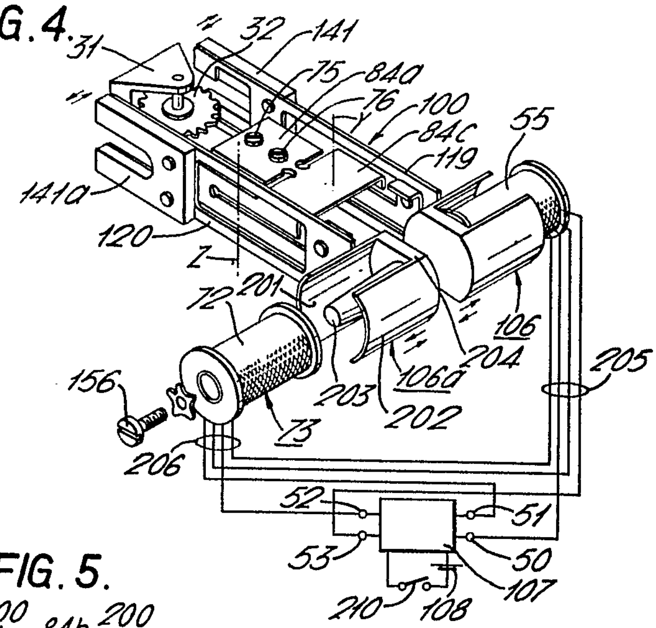

FIG. 5.

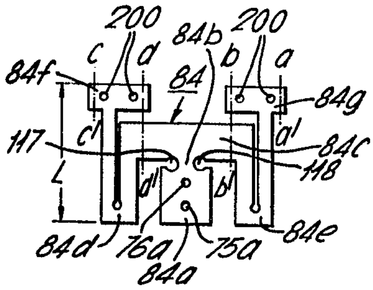

FIG. 6.

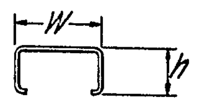

FIG. 7.

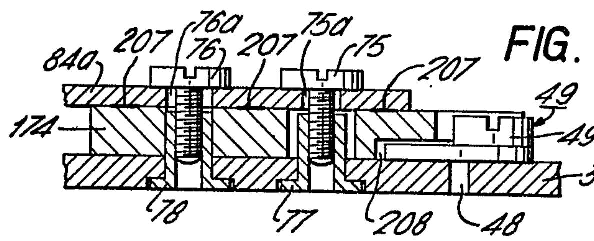

FIG. 8.

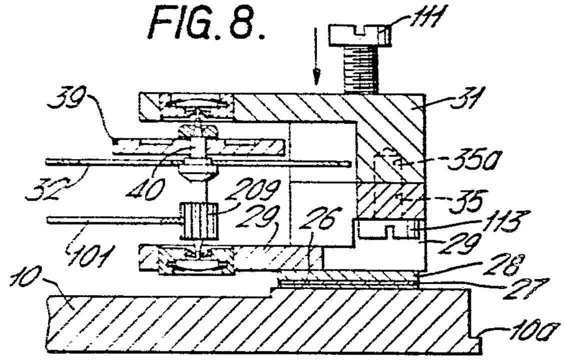

FIG. 9.

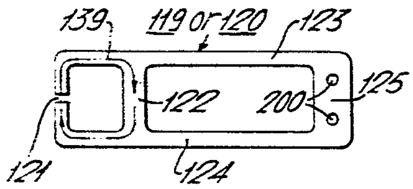

FIG. 10.

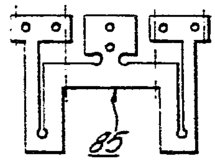

FIG. 11.

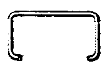

FIG. 12.

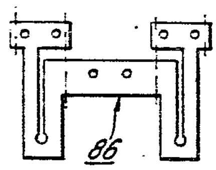

FIG. 13.

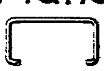

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FIG.14.

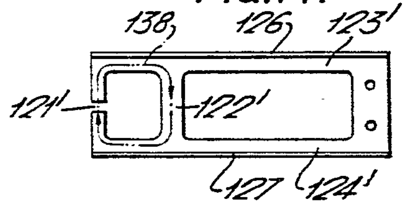


FIG.15.

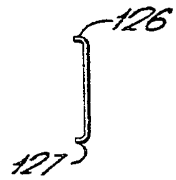


FIG.16.

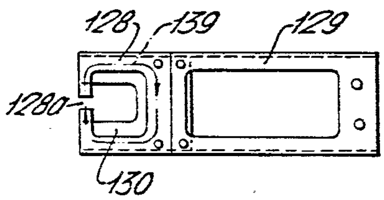


FIG.17.

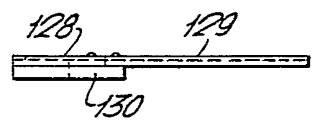


FIG.18.

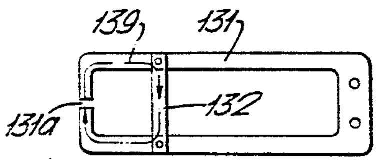


FIG.19.

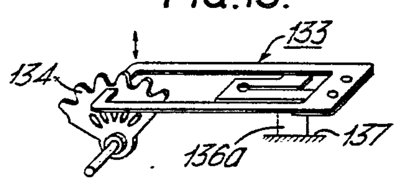


FIG.20.

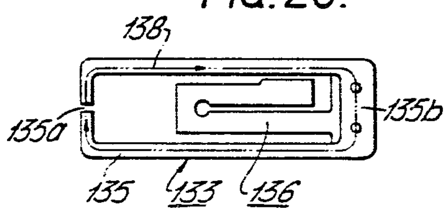


FIG.21.

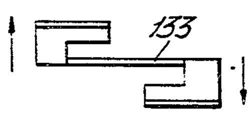
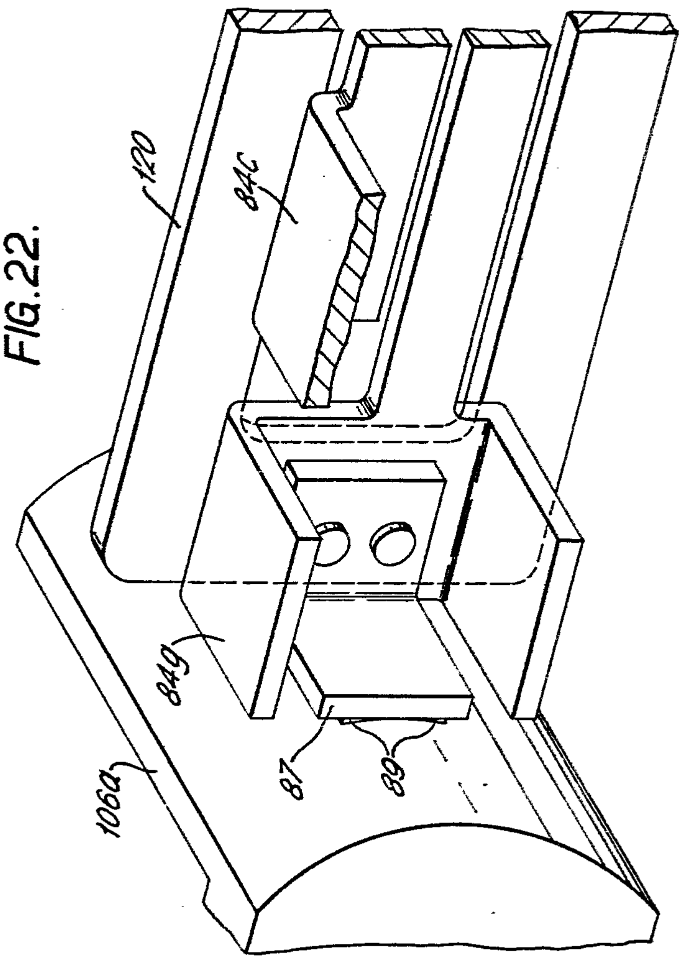


FIG.22.



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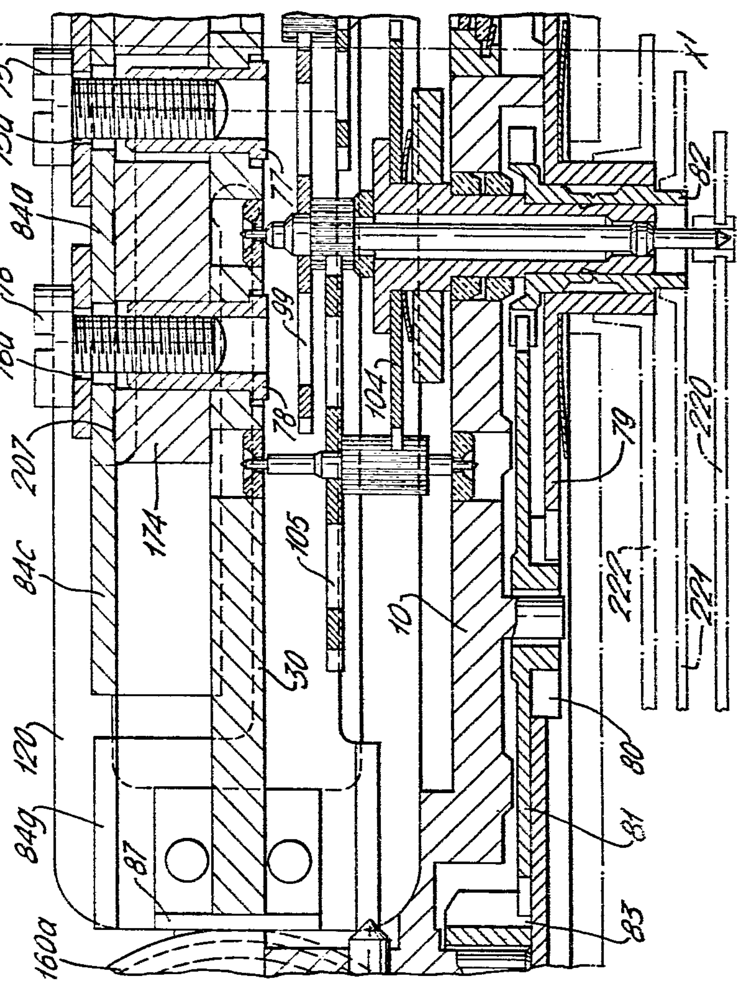

FIG. 23.

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FIG. 24.