United States Patent [19]

Vuffray

[11] **3,778,999**

[45] **Dec. 18, 1973**

[54] **ELECTRONIC WRISTWATCH**

[75] Inventor: **Georges C. Vuffray**, La Chaux-de-Fonds, Switzerland

[73] Assignee: **Girard-Perregaux SA**, La Chaux-de-Fonds, Switzerland

[22] Filed: **Dec. 13, 1972**

[21] Appl. No.: **314,670**

[52] **U.S. Cl.** ..... **58/23 R**, 58/55

[51] **Int. Cl.** **G04c 3/00**, G04b 37/00

[58] **Field of Search** ..... 58/23 R, 23 A, 53–55, 58/88

[56] **References Cited**

UNITED STATES PATENTS

3,676,993	7/1972	Bergey et al.	58/23 R
3,553,957	2/1969	Dome et al.	58/23 A
3,654,757	4/1972	Takamune et al.	58/23 A
3,616,636	11/1971	Chopard et al.	58/23 TF

Primary Examiner—Richard B. Wilkinson

Assistant Examiner—Edith C. S. Jackmon

Attorney—Richard K. Stevens et al.

[57] **ABSTRACT**

An electronic wristwatch having a printed circuit which is flexible in part and reinforced in part. An integrated circuit is mounted on the reinforced part while a motor, which drives the hands of the watch, is connected to the flexible part. The flexible part has clamps which extend therefrom and cooperate with conductive studs located on the motor to connect the motor to the integrated circuit. Also, the flexible part and the reinforced part lie in different planes with a permanent fold connecting the two planes. At the fold copper conductive paths lying on a flexible insulating support have a cross-section, as compared with the cross-section of the insulating support, such that the malleability of the copper assures the permanence of the fold. A frequency standard element located near the reinforced part of the printed circuit is connected to the integrated circuit by flexible conductors to limit mechanical coupling.

11 Claims, 3 Drawing Figures

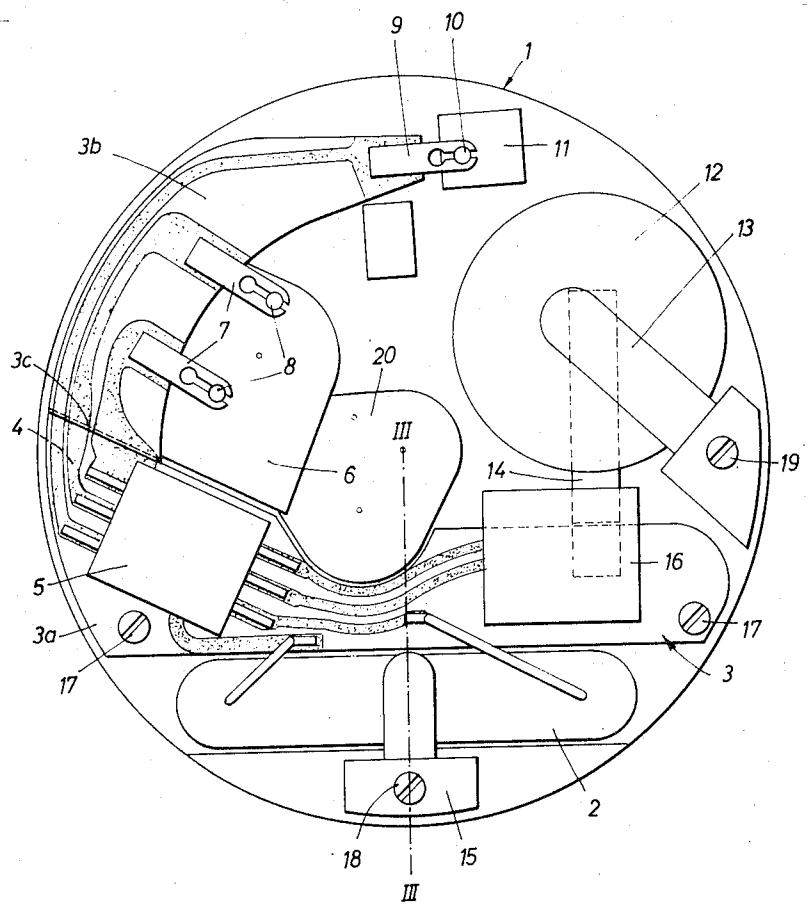
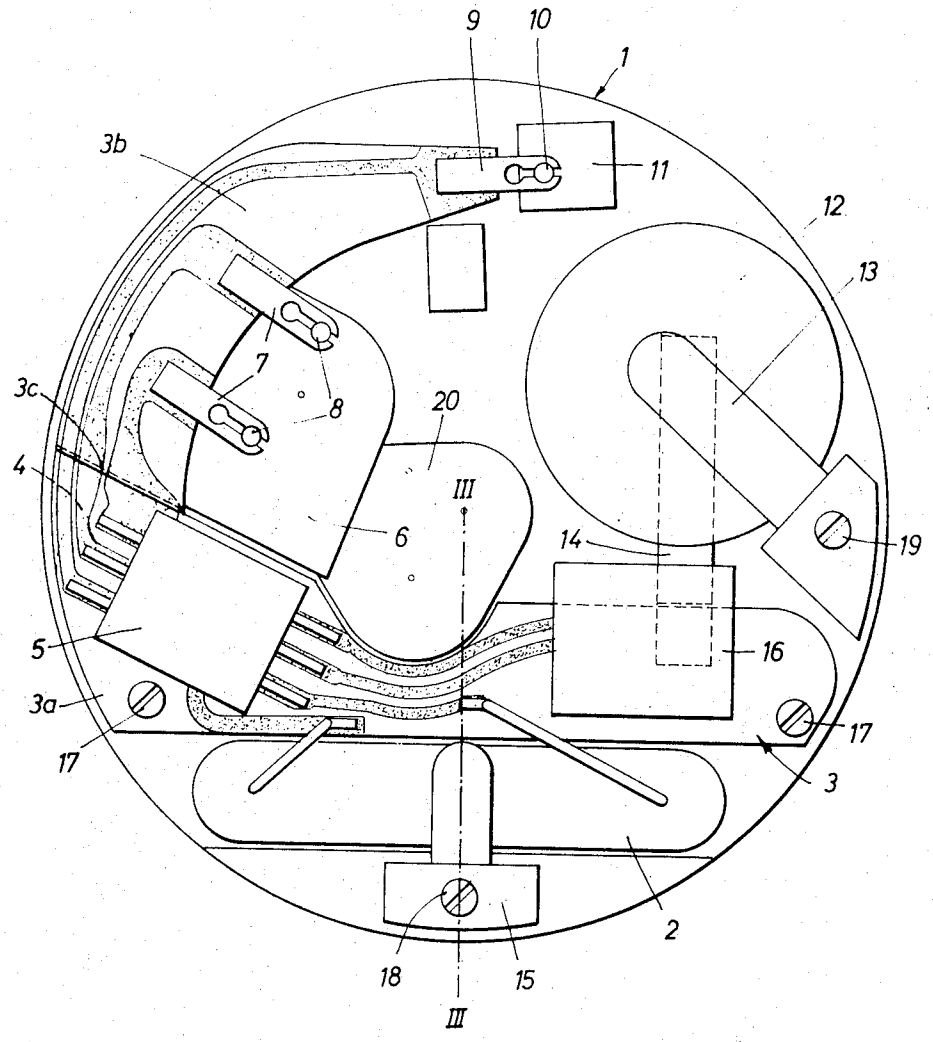


FIG. 1



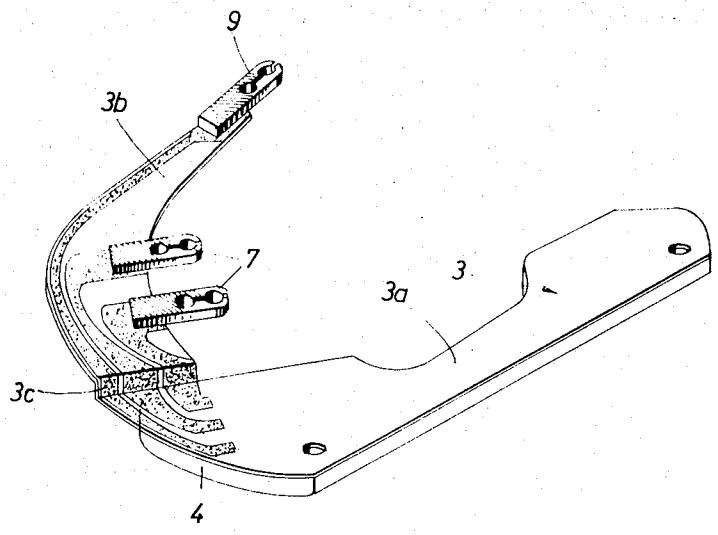


FIG. 2

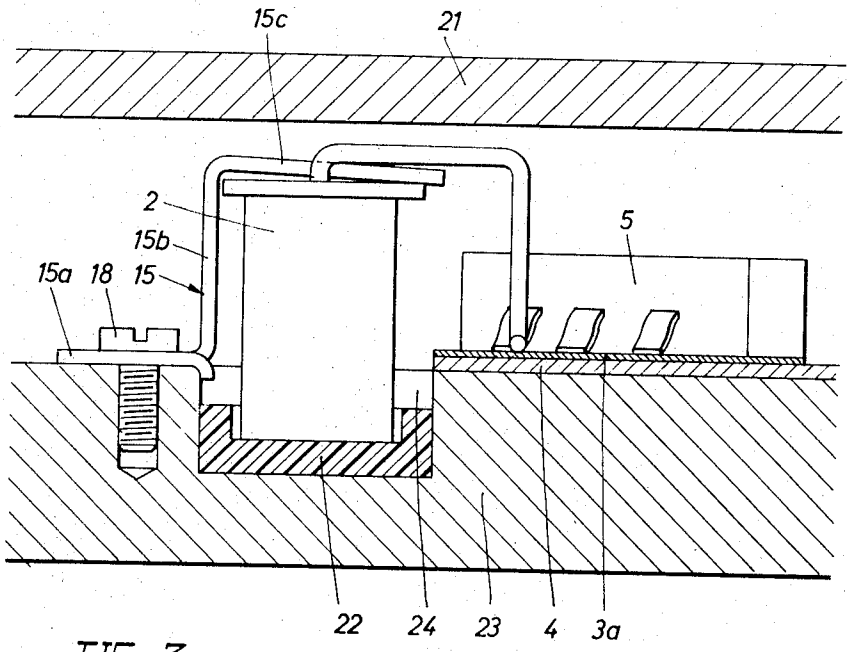


FIG. 3

ELECTRONIC WRISTWATCH

The present invention concerns an electronic wristwatch comprising a frequency standard element, at least one integrated circuit to establish, in cooperation with the frequency standard element, a signal having the frequency determined by said standard and for dividing the frequency of the signal, a step-by-step motor adapted to drive the hour indicating members at the rate of one step per second or per fraction of a second, the integrating circuit being adapted to divide the frequency of the standard element up to the frequency corresponding to the rate of drive of the step-by-step motor, and a printed circuit on which the integrated circuit is mounted and to which there are connected the frequency standard element and the step-by-step motor.

Such a watch all of whose components must be of very small dimensions raises problems of mounting and wiring. It is desirable in particular that the electronic portion and the mechanical portion can be removed independently of each other, and it is important to avoid insofar as possible the necessity of having to effect solderings for the connection of the electronic components when the latter are already mounted in the watch.

The use of a printed circuit makes it possible in a conventional manner to economize on a large part of the wiring work. The electronic elements, for instance the integrated circuit or circuits, which are mounted on the printed circuit may be soldered to the latter while it is not yet mounted in the watch. The mounting of elements on a printed circuit, however, involves the fact that this circuit has a certain rigidity, which is a condition in order to obtain a fastening of the assembly which is dependable and has good resistance to shocks. If, for instance, the integrated circuit were fastened to a printed circuit which did not have sufficient rigidity, the appearance of shocks would result in unequally distributed forced and therefore create a very great risk of damage. The printed circuits conventionally used have the desired rigidity and therefore give satisfaction with regard to this point.

For the connection to the printed circuit of the components which are not mounted on it, recourse is had, with the conventional rigid printed circuits, to a connection by flexible wires, most of the time soldered to the printed circuit. When these components form part of the electronic assembly, as, for instance, the frequency standard member, this soldering does not raise any problem; it can be effected as done previously and, upon the putting in place of the electronic assembly, the printed circuit, the elements borne by it and the elements not borne by it but already connected to it are mounted in the watch in a single operation. For the non-electronic but mechanical components which must however have an electrical connection with the electronic assembly, that is to say, in particular for the step-by-step motor, the use of flexible wires which are to be welded is inconvenient and has the great disadvantage of requiring solderings to be effected in the watch itself, which solderings must furthermore be undone and remade upon each dismounting either of the mechanical assembly or of the electronic assembly. One can, of course, instead of solderings, use attachments by fastening elements permanently connected on the one hand to the end of flexible wires and on the other hand either to the printed circuit or to the element to be connected to it. Such a construction is, however, complicated and bulky.

One could contemplate effecting an attachment by connecting elements without passing through flexible wires, but this solution proves unfavorable due to the rigidity of the printed circuit which, for a connection without flexible wires with a mechanical element rigidly mounted in the watch, excludes the presence of the play and flexibility necessary for a suitable electrical connection by means of connecting elements.

Furthermore, there are already printed circuits known as "flexible printed circuits" which have a thickness of approximately 0.1 mm and have been used up to now, as far as the applicant is aware, only to replace harnesses of conductive wires for the wiring of apparatus but which, due to the fact that they are not rigid, do not lend themselves, in the condition in which they naturally are, to the mounting on them of electronic components such as an integrated circuit. These flexible printed circuits which are of interest for use as simple connections therefore could not be used as printed circuits constituting both the wiring and the support for components as is conventional with the rigid printed circuits.

The object of the present invention is to provide an electronic wristwatch of the above-indicated type in which the problem of the connections, particularly between the electronic assembly and the mechanical assembly, is solved in an advantageous fashion which does not require the use of flexible wires to be soldered or to be connected in place, while permitting easy dismounting and remounting both of the electronic assembly and of the mechanical assembly.

For this purpose, the present invention proposes a wristwatch of the above-indicated type, characterized by the fact that the printed circuit is formed of a flexible printed circuit at least the portion of the flexible printed circuit on which the integrated circuit is mounted is reinforced by a stiffening base and at least the portion of the flexible printed circuit to which the motor is connected is left free of the stiffening base and bears electric connecting elements for the step-by-step motor in such a manner that the connecting and disconnecting of the motor to and from the printed circuit are possible by simple flexing of the portion of the printed circuit which is thus left flexible, the connecting elements then moving with the flexing of the flexible portion of the printed circuit to come into or out of engagement with corresponding connecting elements which are rigidly connected with the motor.

In one particularly advantageous embodiment by which one attempts to obtain a substantial saving in space by placing the connecting elements rigidly connected with the motor outside of the surface plane of the reinforced portion of the printed circuit on which the integrated circuit is mounted, the wristwatch is furthermore characterized by the fact that the portion of the printed circuit which is left flexible is located partially in a plane other than that of the reinforced portion of the printed circuit with the flexible portion having at least one permanent fold which is imparted to it at a place where the section of the copper lying flat on the flexible insulating support of the printed circuit is of such size as compared with the cross-section of the insulating support that the malleability of the copper assures the permanence of the fold.

The frequency standard element furthermore advantageously comprises a quartz crystal and is held in the watch near the reinforced portion of the printed circuit, and is connected to it on its reinforced portion by conductors which have a certain flexibility. Thus the necessary galvanic connection between the printed circuit and the frequency standard element introduces only a limited mechanical coupling due to the flexibility of the wires and moreover, due to the fact that the ends of these wires are soldered on the reinforced portion of the printed circuit, the very small residual mechanical coupling which can never be entirely eliminated is on the other hand accurately established and stable, with no risk of changing by any flexing or twisting of the printed circuit portion to which the flexible conductors coming from the frequency standard element are connected. The frequency standard element with quartz crystal is advantageously held in the watch by an elastic strap pressing it into a recess against a shock absorbing cushion; there is thus obtained an improvement in the mechanical and electrical stability of this frequency standard element in the event that the watch suffers impacts.

In order to facilitate the mounting and dismounting of the electric and electronic assemblies while obtaining a saving in space, the wristwatch of the present invention is furthermore advantageously characterized by the fact that the motor is located at least partially below the portion of the printed circuit which has been left flexible, the position in plan view of the motor with respect to the portions of the printed circuit which have been left flexible and have been reinforced being such, in proportion to the maximum elastic curvature which can be undergone without damage by the flexible printed circuit, that an elastic flexure of the portion left flexible makes it possible to free the necessary passage for the removal of the motor.

The accompanying drawing illustrates by way of example one embodiment of the object of the invention; in this drawing:

FIG. 1 is an overall view of an electronic wristwatch from the back side of the watch case, this back being removed,

FIG. 2 is a view in perspective of the printed circuit of the watch shown in FIG. 1, with a stiffening base arranged below a portion of the printed circuit, and

FIG. 3 is a sectional view along the line III—III of FIG. 1, showing the manner in which the quartz frequency standard element of the wristwatch is held and connected.

FIG. 1 shows a wristwatch designated generally as 1. This figure shows in simplified manner the arrangement of the various electronic and mechanical components in the wristwatch.

First of all, there can be noted from FIG. 1 a frequency standard element 2 formed of a quartz crystal. Reference will be had later on, in connection with FIG. 3, to the particular manner in which this quartz standard element is mounted in the watch. There can also be noted a printed circuit 3 which comprises two portions, 3*a* and 3*b*, this printed circuit being of the "flexible printed circuit" type of a total thickness (support of insulating material and copper) of the order of one-tenth mm. The portion 3*a* of the printed circuit is reinforced by a stiffening base 4 glued below the printed circuit. FIG. 2 shows more precisely how the printed circuit and the stiffening base are arranged with respect to each other; the arrangement shown in plan view of FIG. 1 will be understood more easily by considering at the same time the perspective view given in FIG. 2.

The flexible printed circuit is formed of copper-plated Mylar or possibly of a copper-plated polymide material sold, for instance, under the name "Kapton." This printed circuit, of a thickness of approximately one-tenth mm, is very flexible and would not lend itself as such to the fastening to it of electronic components. The stiffening base 4, as shown in FIGS. 1 and 2 imparts to the portion 3*a* of the flexible printed circuit a rigidity comparable to that of the conventional printed circuits. This stiffening base 4 is advantageously glued below the portion 3*a* of the flexible printed circuit; it is made preferably of epoxy glass or possibly of eloxyated aluminum or other metal; it is preferable to use for this base an insulating material of a noninsulating but insulated material, which, however, is not mandatory.

As can be noted, on the reinforced portion 3*a* of the printed circuit 3 there is mounted an integrated circuit 5. This integrated circuit comprises, on miniature scale, all the electronic elements necessary first of all to establish an oscillation of high frequency in cooperation with the quartz frequency standard 2, then to divide this frequency, preferably by means of flip-flop elements comprising complementary field effect transistors MOS to a frequency of the order of 1 cycle per second, and finally to supply at the frequency of the order of 1 cycle per second, the pulses necessary to advance a step-by-step motor 6. In this electronic wristwatch, there is preferably employed as step-by-step motor, a motor which advances one step under the effect of each of a train of alternate pulses, that is to say, a motor which requires an electric impulse once in one direction and once in the other, which means that in fact the frequency to which the standard frequency must be divided in order to drive the step-by-step motor is a frequency of 0.5 cycle per second, and therefore a frequency which, at a given moment, has an alternation in one direction and one second after an alternation in the other direction. The stage of the integrated circuit 5 which supplies this frequency of half a cycle can be considered either as being the last stage of the frequency divider or as forming part of the output pulse shaping means; this is of no consequence since all the electronic means necessary for the obtaining of the pulses conveniently shaped for the driving of the motor are incorporated in the integrated circuit 5.

In the electronic wristwatch described here, the electrical connections between the printed circuit 3 and the step-by-step motor 6 are effected in a manner free of flexible conductive wires by means of two connecting elements 7 which have the shape of small clamps and which are fastened to the portion 3*b* of the printed circuit 3. The clamping parts of these clamps 7 extend beyond the printed circuit in such a manner that two electrically conductive studs 8 which form the two connecting terminals of the step-by-step motor 6 come into engagement to establish the electrical connections between this motor and the printed circuit. A part of the motor 6 is covered by the portion 3*b* of the printed circuit which, not having a stiffening base below it, retains the flexibility which distinguishes the printed circuits of flexible type. The connecting studs 8 extend from the step-by-step motor at places thereof which are not located below the portion 3b of the printed circuit and

which correspond rather precisely in plan view to the places where the clamping parts of the clamp 7 are located. One of the conditions for establishing a suitable electrical connection is that at least one of the elements which comes into contact has a certain flexibility of positioning. This is realized in the present case by the fact that the portion 3b of the printed circuit is flexible. In order to disconnect the step-by-step motor 6 from the printed circuit, it is therefore sufficient to cause the portion 3b to undergo a flexure directed perpendicular to the plane of FIG. 1 in such a manner that the clamping parts of the clamp 7 come out of engagement with the studs 8.

The spearate mounting and dismounting of the electronic components (mounted on the printed circuit or connected to it) and of the mechanical components (of which the step-by-step motor forms a part) can therefore be effected in very simple fashion without it being necessary to proceed to effect any solderings once the elements are mounted in the watch. In order to remove the step-by-step motor 6, a part of which is hidden behind the flexible portion 3*b* of the printed circuit, one can after having slightly flexed the portion 3*b* to disconnect the clamps 7 from the studs 8, bend the portion 3*b* further so as to free the passage of the step-by-step motor in a direction perpendicular to the plane of the figure. The arrangement of the step-by-step motor with respect to the printed circuit must, however, be such that the flexing for the freeing of the passage for the motor can be effected without going beyond the maximum stress which the flexible printed circuit can bear without damage.

In the watch shown in FIG. 1, in order to save space for the housing of the wheel trains driven by the step-by-step motor, the level of the flexible portion 3*b* of the printed circuit is raised with respect to the level of the reinforced portion 3a of this printed circuit. For this reason, the flexible printed circuit has been subjected before mounting to a double folding at 3c. This can be noted in a more easily comprehensible fashion in FIG. 2. In order to be able to effect this bending permanently, one utilizes the malleability of the copper covering the flexible printed circuit, and this is why the copper-plated conductors present on the printed circuit at the place of this bend 3c have a maximum width in order to maintain a cross-section of copper which is at least equal to one-quarter of the corss-section of the Mylar or Kapton insulating support of the flexible printed circuit (if the cross-section of copper were too small as compared with the cross-section of insulating support, it would be very difficult, if not impossible, to form the bend 3*c* in such a manner that it is permanently maintained).

In FIG. 1 there can furthermore be noted, aside from the parts already mentioned, a contact part 11 which, via a stud 10 and a clamp 9 similar to the studs 8 and clamps 7, supplies the feed voltage to the printed circuit. This voltage is supplied by a battery 12 held by a clamping strap 13; one of the poles of the battery is grounded via the clamping strap 13 and the other rests against a battery terminal 14 which itself is in contact with a place of the printed circuit 3 in the reinforced portion 3a of the latter. The battery contact 14 is insulated from ground and therefore feeds to the printed circuit a potential other than ground so that, in order to supply the two feed terminals to the printed circuit, it is sufficient to connect a conductor from the printed circuit to ground; this is what is done with the contact element 11 which is connected to ground and therefore to the other terminal of the cell via the clamping strap 13.

There can furthermore be noted in FIG. 1 a part for adjusting the frequency of the standard oscillator, this element being a miniature variable capacitor 16 mounted on the reinforced portion 3*a* of the printed circuit.

The printed circuit is fastened in the watch by means of two fastening screws 17 which pass through the reinforced portion of this printed circuit, as well as the stiffening base located under said reinforced portion, and in order to remove the printed circuit it is therefore necessary to loosen these two screws 17 as well as a screw 18 which, via a clamping strap (bridle) 15, holds in place the frequency standard element 2 connected by flexible conductors to the printed circuit. After having previously removed the battery, one can then remove the assembly formed of the printed circuit, the elements borne by it (integrated circuit 5 and variable capacitor 16) and the frequency standard element 2 connected to said printed circuit. In order to remove the electric battery 12, it is necessary likewise to unscrew a fastening screw 19 which holds the clamping strap 13 of the battery.

There should furthermore be noted, with respect to FIG. 1, the presence of the wheel trains 20 driven by the step-by-step motor and adapted to advance the time indicating hands (hours, minutes and seconds) as well as possibly date indicating elements. With the step-by-step motor driven by the two alternations of a frequency of 0.5 cycle, the second hand will advance in jump fashion once a second. It will be noted that in FIG. 1 the wheel trains 20 are shown in a very schematic manner and that in actual fact the space that they take up may be different from what is shown in this figure.

FIG. 3 shows, in a sectional view along the line III—III of FIG. 1, the manner in which the quartz frequency standard element is mounted. In this FIG. 3, there can be noted the reinforced portion 3*a* of the printed circuit and the stiffening base 4 mounted on a pillar plate or on a similar part of the watch 23. For clarity in illustration, there has also been shown in the background the integrated circuit 5 and there has also been shown the back 21 of the watch case which was assumed removed in the showing of FIG. 1.

It is seen that the quartz frequency standard element 2 is positioned just alongside of the reinforced portion 3*a* of the printed circuit in a longitudinal recess 24 provided in the pillar plate 23. This quartz frequency standard which comprises a quartz crystal encapsulated in an airtight box rests on the bottom of the recess 24 via a shock absorbing cushion 22. It can be noted furthermore that the bridle 15 is bent twice so as to define three portions — a portion 15*a* by which the bridle is fastened to the pillar plate by means of the screw 18, a portion 15*b* perpendicular to the pillar plate and rising vertically alongside the quartz encapsulating housing, and a portion 15*c* which forms a bend with respect to the portion 15*b* and holds the quarts encapsulation housing from the top thereof. This portion 15*c* is not entirely horizontal but slightly oblique so that it does not rest on the top of the quartz encapsulation housing at the place where the bend connecting the portion 15*c* to the portion 15*b* is located. Thus, by a slight flexing

of the bridle at the place of this bend, the portion 15*c* which rests on the top of the quartz encapsulation housing can carry out a small vertical elastic movement. The double elasticity with which the quartz frequency standard element 2 is held on the one hand by the shock absorbing cushion 22 and on the other hand by the flexible portion 15*c* of the bridle 15 permits an elastic suspension of the element containing the quarts, which effectively protects the latter from excessively rough impacts which the watch might experience.

Two conductive wires emerge from the quartz encapsulation housing and are connected by soldering to the reinforced portion 3*a* of the printed circuit 3. These conductive wires are flexible wires so as to eliminate as far as possible a mechanical coupling between the quartz encapsulation box and the other elements of the watch. It is clear that one can never completely eliminate a slight mechanical coupling, and it is good that the ends of the semi-flexible conductors which connect the quartz element 2 be soldered to relatively rigid portions of the printed circuit; in this way, the residual mechanical coupling, if it cannot be eliminated, is at least precisely defined and does not undergo the risk of suffering variations due to a possible flexing or twisting of the printed circuit. This is the reason why, in the wristwatch described, the ends of the connecting wires of the quartz element are soldered to the reinforced portion of the printed circuit.

The electronic wristwatch which has just been described therefore has substantial advantages with regard to its mounting and simplicity of construction; it permits independent mounting of the mechanical components on the one hand and of the electronic components on the other hand, and it makes it possible to assure a positioning of the quartz frequency standard element in a manner which protects the latter from impacts to the greatest extent possible.

It is also important to note that the printed circuit copper conductive paths which are drawn on the printed circuit shown in FIG. 1 have been entered in this figure only to improve an understanding thereof by making it clear that the element 3 is a printed circuit. These paths are on the other hand not to be considered as actually corresponding to the connecting lines which connect the different electronic components and/or the different connecting elements. The path of the copper-clad connections of the printed circuit of the electronic watch could also (and will probably in practice) be entirely different from what is shown in FIG. 1, both with respect to the design formed by this path and with respect to the different points of connection of the components which are connected by this path.

What is claimed is:

1. Electronic wristwatch comprising a frequency standard element, at least one integrated circuit to establish, in cooperation with said frequency standard, a signal having the frequency determined by said standard and to divide the frequency of said signal, a step-by-step motor adapted to drive time indicating members at the rate of one step per second or fraction of a second, said integrated circuit being adapted to divide the frequency of the standard element to the frequency corresponding to the rate of drive of the step-by-step motor, and a printed circuit on which said integrated circuit is mounted and to which said frequency standard element and said step-by-step motor are connected, characterized by the fact that said printed circuit is formed of a flexible printed circuit, at least the portion of said flexible printed circuit on which said integrated circuit is mounted being reinforced by a stiffening base, and at least a portion thereof to which said motor is connected being left free of said stiffening base and bearing first electric connecting elements for said step-by-step motor in such a manner that the connecting and disconnecting of the said motor to and from said printed circuit are possible by simple flexing of the portion of the printed circuit which is thus left flexible, said first connecting elements then moving with the flexing of said flexible portion of the printed circuit to come into and out of engagement with corresponding second connecting elements which are rigidly connected with the motor.

2. Wristwatch according to claim 1 characterized by the fact that said stiffening base is made of epoxy glass and is bonded under the portion of the printed circuit which it reinforces.

3. Wristwatch according to claim 1 characterized by the fact that said portion of the printed circuit which is left flexible is located partially in a plane other than the plane of the reinforced portion of said printed circuit, said flexible portion having at least one permanent bend which is imparted to it at a place where the cross-section of copper located on the insulation of a flexible insulating support of the printed circuit is of such amount, as compared with the cross-section of said insulating support, that the malleability of the copper assures the permanence of the bend.

4. Wristwatch according to claim 3 characterized by the fact that at the place of said bend, the flexible printed circuit has a cross-section of copper equal at least to one-fourth of the cross-section of its flexible insulating support.

5. Wristwatch according to claim 1 characterized by the fact that said motor is located at least partially below the portion of the printed circuit left flexible, the position in plan view of the motor with respect to the portion left flexible and the reinforced portion of the printed circuit being, as compared with the maximum elastic curvature capable of being suffered without damage by the flexible printed circuit, such that an elastic flexure of said portion left flexible makes it possible to free the necessary passage for the removal of the motor.

6. Wristwatch according to claim 1 characterized by the fact that said portion of the printed circuit which is left flexible furthermore bears at least a third electric connecting element for the connection of a source of electric power located in the watch.

7. Wristwatch according to claim 1 characterized by the fact that said frequency standard element comprises a quartz crystal.

8. Wristwatch according to claim 7 characterized by the fact that said quartz crystal standard element is held in the watch near the reinforced portion of the printed circuit and is connected to said printed circuit on the reinforced portion thereof by flexible conductors.

9. Wristwatch according to claim 8 characterized by the fact that said quartz crystal standard element is held in the watch by an elastic flange resting in a housing against a shock absorbing cushion.

10. Wristwatch according to claim 1 characterized by the fact that it furthermore comprises an element for adjusting the frequency determined by said frequency standard, said adjustment element being mounted on the reinforced portion of the printed circuit.

11. Wristwatch according to claim 1 characterized by the fact that said stiffening base is made of eloxyated aluminum and is bonded under the portion of the printed circuit which it reinforces.

* * * * *