

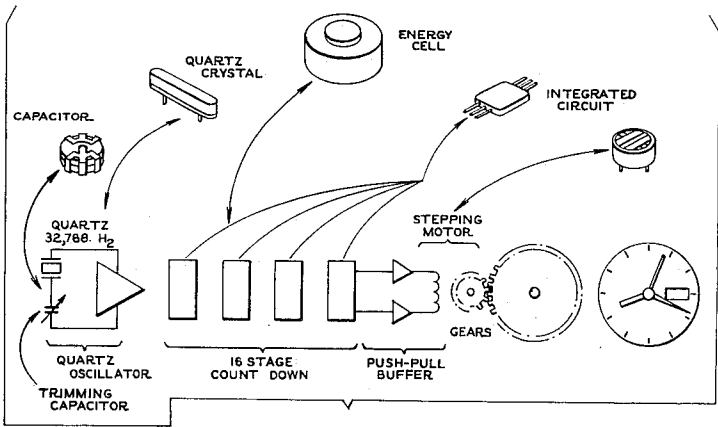
[54] **WATCH**
[75] Inventor: **Peter John Lupoli**, Hamden, Conn.
[73] Assignee: **Benrus Corporation**, Ridgefield, Conn.
[22] Filed: **May 22, 1973**
[21] Appl. No.: **362,736**
[52] U.S. Cl. **58/23 R, 58/23 A, 58/23 V, 58/55, 58/91**
[51] Int. Cl. **G04c 3/00, G04b 37/00**
[58] Field of Search ... **58/23 R, 23 AC, 23 A, 23 V, 58/50 R, 85.5, 91**

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Primary Examiner—Edith Simmons Jackson
Attorney, Agent, or Firm—H. Gordon Dyke

[57] **ABSTRACT**
This quartz crystal electronic watch eliminates watch parts formerly highly vulnerable to shock, but the quartz crystal assembly itself has high vulnerability to shock. This inventor determined that the quartz crystals resistance to shock is relatively high in all but one of its directions, and the cushioning effect of the watch's external parts is relatively high in all but one of the directions, and he produced an overall highly shock-resistant watch by orienting the quartz crystal's direction of maximum resistance to shock in the watch's direction of least cushioning.
1 Claim, 17 Drawing Figures



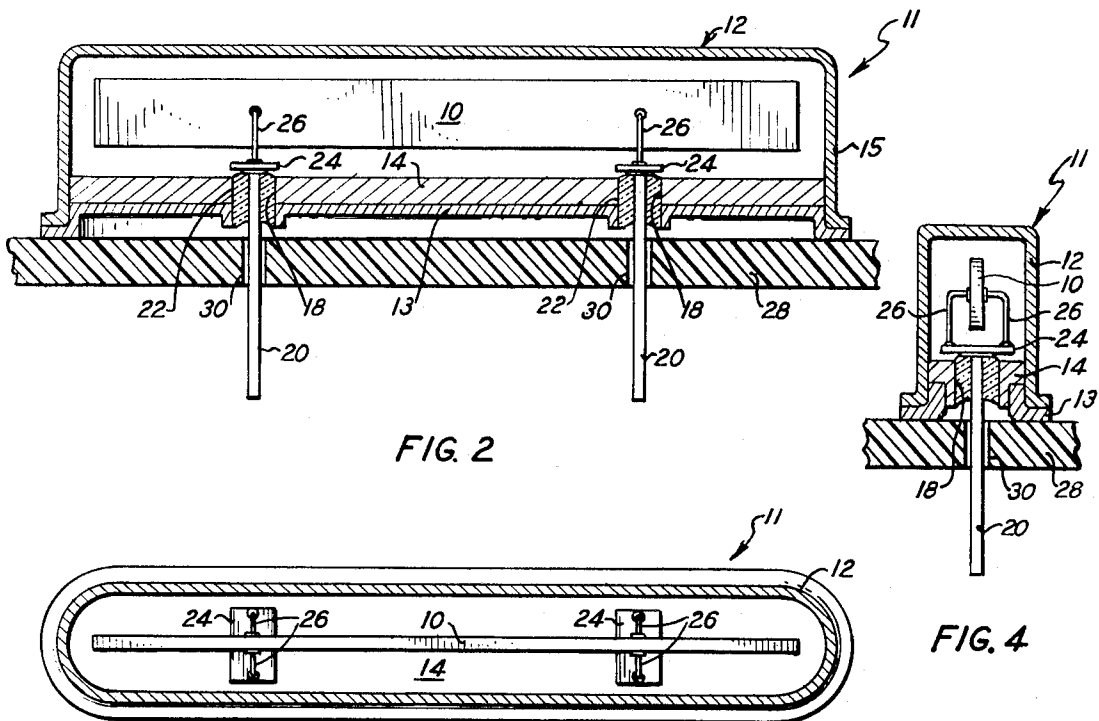
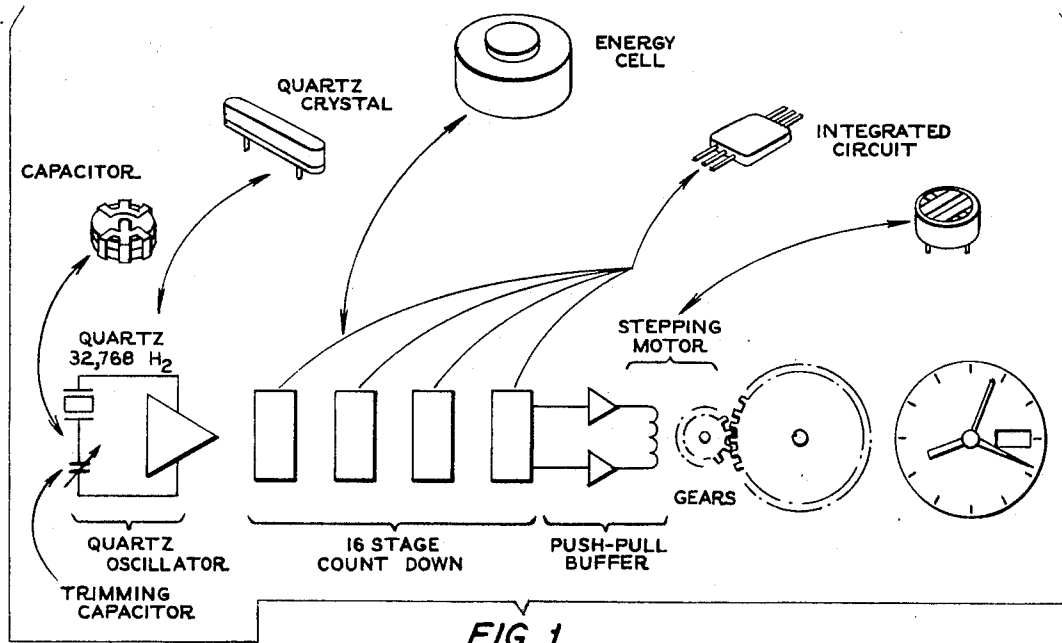


FIG. 3

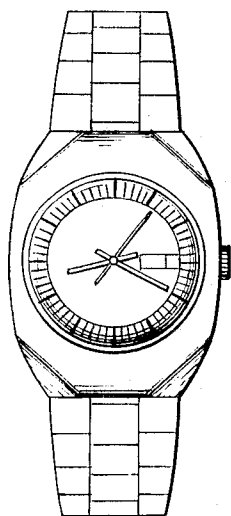


FIG. 5

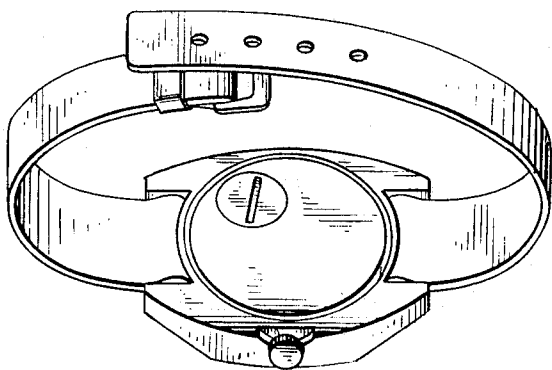


FIG. 6

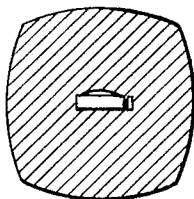


FIG. 7D

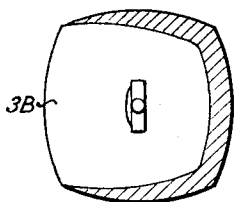


FIG. 7B

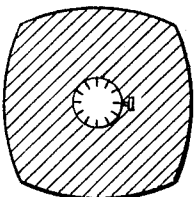


FIG. 7A

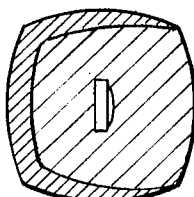


FIG. 7C

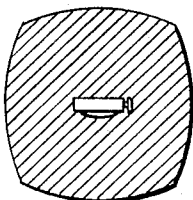


FIG. 7E

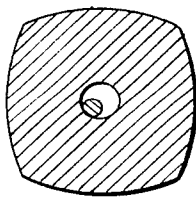


FIG. 7F

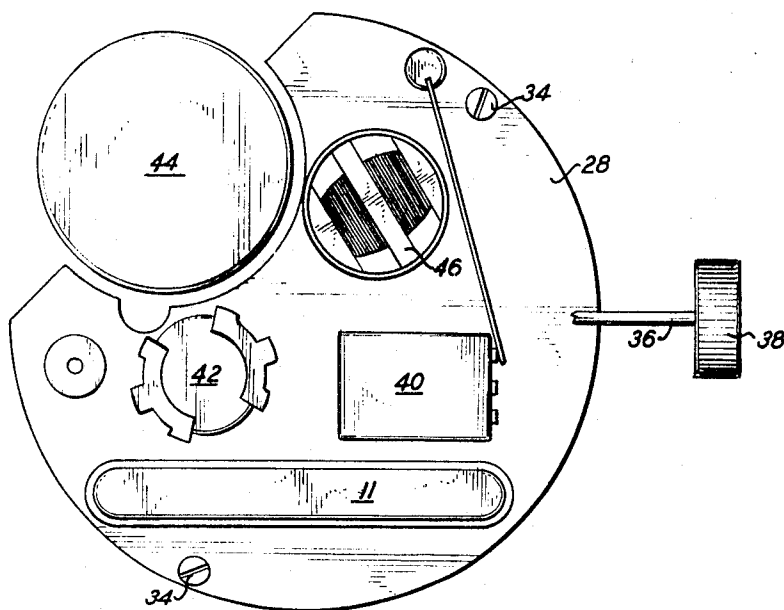


FIG. 8

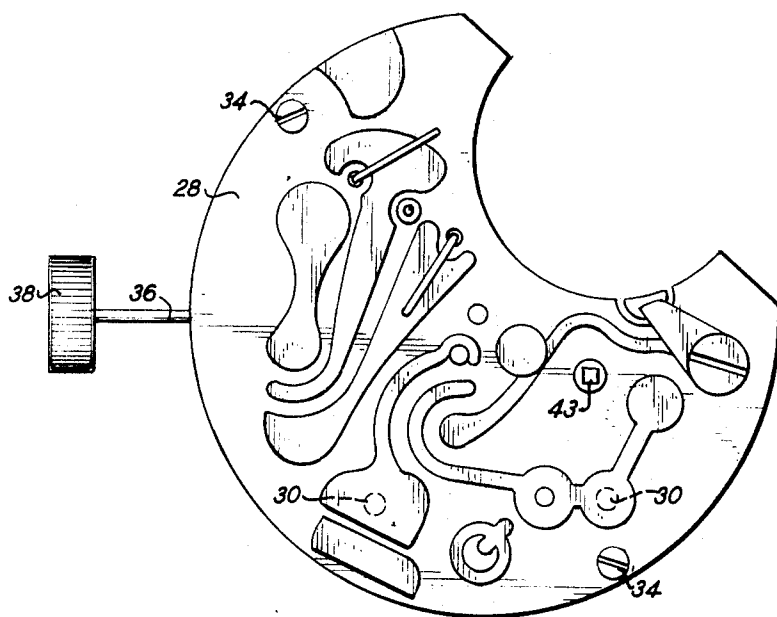


FIG. 9

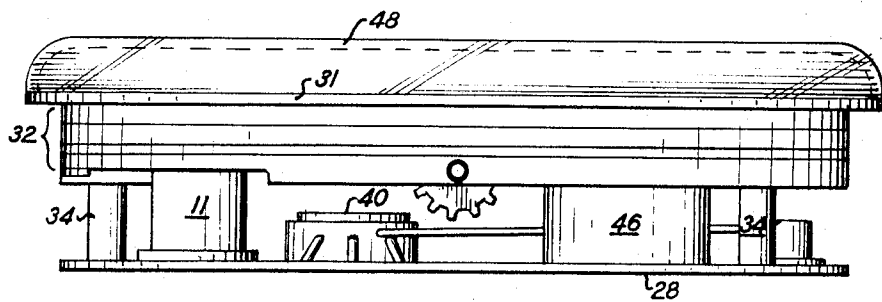


FIG. 10

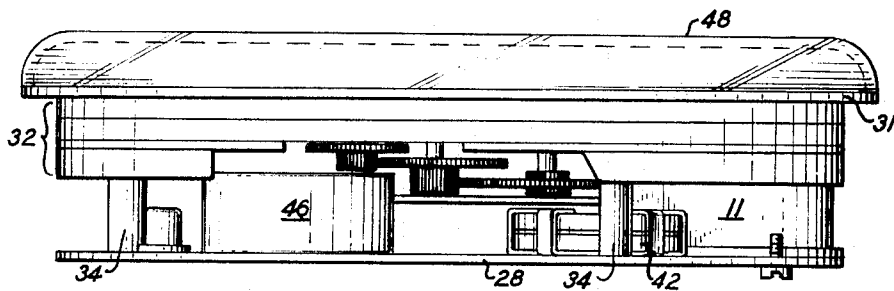


FIG. 11

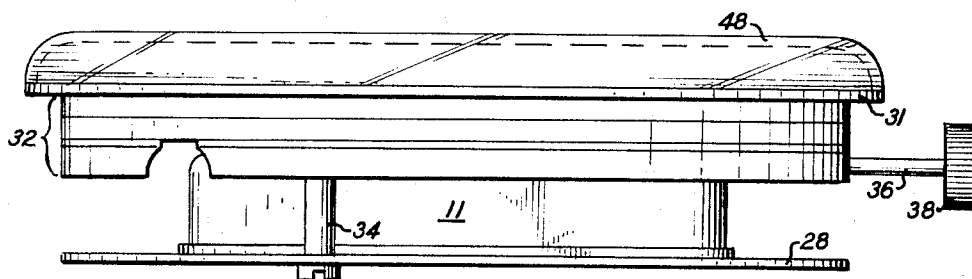


FIG. 12

1 WATCH

This invention is an improvement in quartz crystal wristwatches that makes them more shock resistant.

In the quartz crystal watch the delicate and vulnerable balance wheel is no longer present, together with it now appears that the quartz crystal and its support assembly constitute the most vulnerable component and will be the limiting factor in the watch's shock resistance. I postulate that by one particular choice of placement of one particular form of this new component I can make my quartz crystal watch more highly shock resistant.

The quartz crystal may be installed in the watch with any orientation and any rotational position about its axis. Among all these possibilities some of the choices are obvious, some are not. Since a watch is thin, the long dimension of the quartz crystal should lie in the general plane of the watch. Since the leads are normally arranged coming out the bottom of the quartz crystal housing, its rotational position should be with its bottom surface on the base it is mounted on.

The foregoing leaves still an open choice of orientation within the general plane of the watch. Because of lengthwise symmetry of the quartz crystal unit this choice narrows in practice to a range of 180°.

I have found that I can make my watch almost twice as shock resistant by orienting the quartz crystal unit within 10°, and preferably within 5°, of parallelism with the watch stem, for reasons that will be developed. The choice I make is within 20° (preferably 10°) out of 180°, or one specific part in 9 (preferably one specific part in 18.) By choosing this particular limited range of orientation I am able to make a more shock-resistant watch without any significant penalty for that achievement, in cost, size, appearance, or otherwise.

Essentially what I have done is to match the sturdiest orientation of the quartz crystal with that orientation of the watch in which greatest shock is transmitted. Stated conversely, I arrange the more vulnerable orientations of the quartz crystal so they coincide with the orientations of the watch assembly that provide the greater cushioning, giving them little or no component of orientation in that direction which can experience the most shock.

Basically the configuration I arrive at is first to choose a quartz crystal unit with supports made of a somewhat resilient alloy, so those supports can when shocked flex within their elastic limits and then return to their original position, and then to mount the quartz crystal with its longest dimension parallel to the stem axis of the wrist watch, and preferably extending from 7:30 to 4:30.

I mount the housed quartz crystal on the upper side of a somewhat resilient insulator board made of plastic reinforced with glass fiber with the base of the quartz crystal housing directly on this board and the leads extending through it. I also mounted the trimming capacitor, the circuit chip and the stepping motor on the upper side of that board, and I position the battery so it projects through a cut-out portion of the board. When I have thus arranged the quartz crystal, but specifically so it has its long dimension generally parallel to the watch stem and more specifically extending along the 4:30 to 7:30 line of the watch, I then am able to mount the other components optimally or near-optimally for their several requirements.

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The net result is a practical configuration of components that moreover as previously stated gives notably enhanced shock resistance, this being advantageous to both consumer and to manufacturer.

It will be understood that probability statistics are involved in this approach, the goal being to design the watch so that if a large number of them were dropped, from a given height greater than heretofore tolerated, with the orientations random, fewer of them by far would have their time-keeping ability impaired than would be the result without this special configuration.

The drawings illustrate an embodiment of my invention.

FIG. 1 is a diagrammatic view of a quartz crystal watch system such as mine.

FIGS. 2-4 show the quartz crystal, its mounting, and its housing,

FIG. 2 being a side view with the housing in vertical section,

FIG. 3 a top view with the housing in horizontal section, and

FIG. 4 an end view with the housing in vertical cross section.

FIG. 5 is a top view of the watch assembly, including its band.

FIG. 6 is a perspective of a watch with a strap.

FIGS. 7A through 7F are diagrammatic views representing the sum of the possible orientations of fall of the watch and indicating relative extent of cushioning when the watch falls in the various orientations.

FIG. 7A represents the watch landing on its bottom,

FIG. 7B landing on its left side,

FIG. 7C landing on its crown (right side),

FIG. 7D landing on its far edge,

FIG. 7E landing on its near edge, and

FIG. 7F landing on its face.

FIG. 8 is a simplified view of the top side of my plastic board, showing placement of components thereon.

FIG. 9 is a view of the bottom side of the board.

FIG. 10-12 are side views of the works of the watch, removed from the case,

FIG. 10 as seen from 3 o'clock,

FIG. 11 as seen from 11 o'clock, and

FIG. 12 as seen from 6 o'clock.

The diagrammatic layout of Fig. 2 illustrates the principle of the quartz crystal watch. A quartz crystal in a suitable oscillator circuit generates the frequency it is cut for, in this case 32,768 Hz (cycles per second). A trimming capacitor in this circuit makes it possible to adjust the frequency to remove any error, within moderate limits. The output of this oscillator system is fed to a series of dividers, which reduce the signal--by successive halvings--to one pulse each half second. Physically the trimming capacitor is one unit, while the oscillator circuit and divider circuits are on a circuit chip which is another physical unit.

The one-per-half-second pulses are fed to a stepping motor whose shaft bears a small gear wheel and thus starts the train of gears that drives the stepping second hand (which makes one step per second), the minute hand, the hour hand, and the day and date rings.

The balance wheel was formerly the component most easily damaged by shock. In the quartz crystal watch there is no balance wheel. The stepping motor can be

and is made fairly rugged in relation to its weight, and it is so mounted that its shaft has some free lengthwise scope of movement. As a result, it is not the quartz crystal that is the most delicate and vulnerable component of the watch.

FIGS. 2 through 4 show the quartz crystal, its mounting, and its housing.

The quartz crystal 10 has dimensions of the order of the following: length 0.642 inch, height 0.060 inch, and thickness 0.012 inch. It and its supports and housing are sometimes referred to as the quartz crystal unit or the quartz crystal assembly. The crystal is, and must be, out of contact with any objects that would resist its vibrations, and well shielded against factors that could affect the capacitance of the oscillator circuit, of which it is part. It may move when subjected to infrequent shock, but it must return to its original position to avoid capacitance change and resultant rate change. Also no permanent distortion of the supports can remain, else they change the capacitance and/or put strains into the crystal that can affect its rate.

The crystal is part of an assembly 11 that includes a can 12 having a base 13, reinforcing floor 14, and a case 15 which is like a miniature inverted tub constituting top, side, and end, walls. The base and floor have a pair of holes 18 in them through which extend two Kovar lead wires 20, about 0.018 inch in diameter. Glass insulation 22 surrounds the lead wires within those holes and separates them electrically from the metal base and floor.

Each lead wire terminates at its top end in a metal cross-bar 24 secured to it, atop the insulation 22. The cross-bar bears two spaced supports 26, which also serve electrically as bifurcated continuations of the leads. These two pairs of supports have arm portions that extend up, spaced somewhat out from the two faces of the quartz crystal, and wrist portions that turn in and end at the faces of the crystal, to which they are soldered. The crystal and the supports have clearance from the inside surface of the "tub" in all directions. The wrist portions of the supports 26 are about half the length of the arm portions. The supports 26 are about 0.0035 inch in diameter, and are made of phosphor-bronze wire, gold plated. Thus they can absorb some deceleration resiliently without breaking, and then return to original position without retained distortion. This will be true whether the supports are of uniform heights as shown or are staggered in height.

The quartz crystal housing is attached to an insulation board 28, about 0.015 inch thick and made of plastic reinforced with glass fibers. The attachment is by passing the leads through holes 30 in the plastic board. These leads are about 0.044 inch in diameter. Their ends that extend through the board are there soldered as seen in FIG. 9, thus securing the quartz crystal unit to the board.

ORIENTATION OF THE CRYSTAL

The quartz crystal unit could be suddenly decelerated along any of its three mutually perpendicular axes. Its ability to withstand damage to its time keeping ability is quite different for the three axes.

Should it fall with the base down the supports will act as stiff posts placed under lengthwise compression. Nearly the full force of the shock will be felt tending to rip the soldered ends of the supports loose from the crystal. The only way the shorter wrist portions can ac-

comodate is by bending and if they do that they make matters worse by placing a concentrated parting force at their leading edges, which concentrated force can move along as a wave as the soldering to the faces of the crystal progressively parts. The result of sudden deceleration in the opposite direction is much the same, substituting tension of the post-like supports for compression.

Should the quartz crystal unit fall with either side face down the main lengths of the supports can bend, but the pairs of supports will tend to go from their approximately square configuration into parallelograms. The wrist lengths will experience force in opposite directions, one in, and one out. This will apply a twist to the crystal, tending to peel the soldered elbow-piece joints off progressively. Torsion cannot relieve these forces.

Should the unit fall lengthwise of the crystal and land end-down it has better resistance to the shock. The main uprights of the supports can flex along their lengths. Moreover the stress on the soldered joints is rotary and so entire rather than progressive, wherefore the yield point is higher, and this stress can be relieved by torsion in the wrists and bending in the arms.

Thus the quartz crystal unit is more vulnerable to falls in which it lands top or bottom down or either side down, and it will safely withstand more shock when it lands with either end down. This advantage to landing this way is only partial when the crystal is angled off from the angle of arrival. The advantage is considerable when the crystal's orientation is within 10° of the axis of impact, better--and preferred--when within 5°, and optimum when the two directions coincide.

ORIENTATION OF THE WATCH CASE

Let us now consider the exterior of the watch--its case and band--and determine comparative cushioning in its different orientations of landing.

The watch assembly could fall and hit the floor in any orientation. The sum of all its possible orientations makes a sphere. This sphere can be divided into six equal quadrilaterals which together make up the entire spherical surface. This enables me to analyze and portray the different degrees of shock that the watch assembly will experience in falling with all its various possible orientations. We can think of the watch assembly having been fixed in an imaginary sphere which is then viewed from six different sides. Token miniature representations of the watch case illustrate its orientation of fall for each of the six views. The shading indicates cushioning.

Wristwatches are dropped far more often with their strap or band attached than without. Thus we can consider primarily the configuration of the watch assembly that includes its leather-type strap or metal band. There will be differences as between strap and band, with the band usually giving more protection, but statistically the differences between strap and band will be more in degree than in kind. Thus much the same comparative exposure to shock as between the various orientations will hold for both types of wristlet.

In considering comparative exposure to shock it must be kept in mind that even a small cushioning effect can considerably reduce the number of g's experienced within the watch.

FIGS. 7A-7F illustrate qualitatively the comparative exposure to shock for all orientations of the watch assembly, shading indicating cushioning.

FIG. 7A represents the watch as falling on its back, face up. In the great majority of times that the watch assembly falls this way the band or strap will break its fall and somewhat cushion the watch from shock.

FIG. 7B represents the watch as landing on its left side. For a fall squarely in this orientation (represented by the center area of 3B) the watch case has nothing to cushion it, and full shock is experienced. The strap or band gives some cushioning at the top and bottom and the extreme right of this sector, but nothing cushions the fall for the rest of this sector.

FIG. 7C represents the watch as landing on its right side. Here the strap or band will give some cushioning at the edges of this sector, as in FIG. 7B. Also the crown and stem (located along the line from center through 3 o'clock) will absorb some of the shock, being damaged themselves in the process if the fall is hard enough, but not thereby impairing the timekeeping heart of the watch. Since this cushioning is only partial the shading lines are farther apart.

FIG. 7D represents the watch as landing on its top, or far, edge. Here the band or strap will almost always provide cushioning.

FIG. 7F represents the watch as landing on its face, which means landing on its crystal. The preferred form of my watch includes a resilient plastic crystal 48, which will cushion this fall. Even in the less-preferred form having a glass crystal, in the case of a severe landing the crystal in breaking will absorb some of the shock, thereby lessening the shock felt by the works within the case.

RELATION BETWEEN THE ORIENTATIONS

With the foregoing information developed on vulnerability of quartz crystal unit vs. orientation, and cushioning of the shock of fall vs. angle of arrival, I elect to orient the quartz crystal within the watch with its axis of greatest ability to safely withstand sudden deceleration oriented parallel with that axis of the watch in which the exposure to shock is the greatest. In other words, I place an axis of the quartz crystal that has highest ability to resist shock in that orientation of the wristwatch assembly which is apt to experience the most shock. Conversely stated, I make the four directions of orientation of the quartz crystal that are the most vulnerable to shock coincide with the four directions of orientation of fall of the wristwatch assembly that are more cushioned from shock than are the other pair.

RELATIVE POSITIONING OF PARTS

Under the face plate 31 of my watch is what may be called a frame plate 32, namely a rugged structure made up of a plurality of members that are discs with portions removed, these members being joined flat to each other in a rigid manner. Together they form support for the various portions of the gear train and related parts of the watch.

Posts 34 depend from this frame plate and at their ends they support and secure the insulation board 28 which was previously mentioned. These posts are long enough that the board is held spaced somewhat away from the frame plate and the mechanisms which it di-

rectly carries. This leaves a space for components to be located.

In this space, on the upper side of the board, I mount the quartz crystal assembly 11. FIG. 8 is a plan view of the board and components mounted on it, looking down on the upper face of the board with the face plate and frame plate having been lifted off of it. The stem 36 and crown 38 are shown in their 3 o'clock relation. If the face plate with its hour numerals were present here its 12 would show at the top, 3 at the right, 6 at the bottom, and 9 at the left. It will be seen that I have mounted my quartz crystal unit parallel to the 9-3 direction of the board, which is also parallel to the stem. This places the quartz crystal's axis of greatest ability to withstand shock pointing in the same direction as that in which the wristwatch assembly is apt to experience the greatest shock.

More specifically I mount my quartz crystal unit along under the 7:30-4:30 line. This still gives me the desired orientation in relation to shock exposure, and it also facilitates favorable mounting of the other components.

I wish to mount the circuit ship 40 close to the crystal assembly 11 because both contain parts of the oscillator circuit, and I wish to mount the adjustable capacitor 42 close to one and preferably both because it too is part of the oscillator circuit. An adjusting rotor 43 for the capacitor is visible at the underneath face of the board (see FIG. 9). In my preferred arrangement I mount the circuit chip and the capacitor between the quartz crystal and the 9:00-3:00 line.

This allows me to devote the 9:00-12:00 sector to the replaceable battery 44, for which the insulation board is cut out in this sector. Then I can still mount the stepping motor 46 between 12:00 and 2:00, leaving room at 2:00 to 3:00 for the hacking mechanism (not shown), which needs to be closely associated with the stem 36, which is at its classic optimum position of 3:00. With this combination I prefer to mount the posts 34, which support the board from the frame plate, one at a little past 1:00 and the other at a little before 7:00. Considering the cut-out for the battery and the components mounted on the board, this gives approximate balance across the line joining the posts.

Thus there is achieved an optimum or near optimum relation in positioning the components at the same time that the quartz crystal assembly is mounted in the one orientation that gives the watch greater shock resistance than with any other orientation of the quartz crystal.

I claim:

1. Shock resistant wrist watch having upper and lower generally horizontal faces, said watch having a crystal over its upper face, strap fasteners at its far and near edges for securing a wristlet that will extend below the plane of its lower face, whereby said watch has high probability of some cushioning against impact when it falls in all solid angle orientations except the solid angle nearest the transverse horizontal axis, said watch having a quartz crystal frequency generator, said quartz crystal having its greatest dimension disposed substantially parallel to the watch's transverse horizontal axis, and said quartz crystal being supported by fine resilient metal lead wires, said lead wires comprising arms and wrists angled relative to each other and both the arms and the wrists lying substantially in a plane perpendicular to the transverse horizontal axis of the watch, the

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arms being substantially parallel to each other, and the wrists meeting the quartz crystal substantially perpendicular to its opposite side faces and terminating in butt joints securing the wrists to said faces, the relative orientations of the recited parts being such that the least 5

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vulnerable orientation of the quartz crystal assembly coincides with that orientation of the watch that is externally least protected from shock.

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