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"AN ARTICLE INCLUDING A DISPLAY PANEL AND A SOUND
GENERATOR IN A CASING"

The present invention relates to an article including a display panel and a sound generator in a casing.

In prior-art display articles such as a wristwatch with an alarm function (e.g., with a buzzer), a diaphragm is mounted inside a casing in contact relationship therewith so that vibration of the diaphragm causes sound to give forth, which sound is transmitted outward through one or more openings provided through a back cover. However, problems have been encountered with such a type of wristwatch, in that since the diaphragm sound generator is covered with the casing and the back cover sound generated is attenuated or lessened before being emitted from the wristwatch, the provision of one or more openings through the back cover deteriorates the waterproofness, and the necessity for the diaphragm to be protected results in a thicker wristwatch.

In accordance with the present invention, there is provided an article having a display panel and sound generator in an electrically conductive casing, the sound generator comprising a transparent covering and vibrating plate member having its peripheral portion carried on the casing and being on the front side of the

display panel, a transparent piezoelectric plate and a pair of transparent electrodes sandwiching the piezoelectric plate, the piezoelectric plate and electrodes being secured to and integral with the covering and vibrating plate member so that mechanical force produced by the piezoelectric plate is effectively transmitted to the plate member to vibrate the plate member to generate sound, and an elastic and electrically conductive member being provided between the peripheral portion of the plate member and the casing, the elastic and electrically conductive member being arranged both to provide a seal between the plate member and the casing and to provide an electrical connection between the casing and one of the transparent electrodes.

15 In the accompanying drawings:

Fig. 1 is a schematic cross-sectional view of a prior-art display article such as a wristwatch;

Fig. 2 is a cross-sectional view, on an enlarged scale, of a portion of the article shown in Fig. 1;

20 Figs. 3 to 5, 7 and 8 are schematic cross-sectional views of different embodiments of display article in accordance with the present invention;

Fig. 6 is a plan view of any one of the display articles in Figs. 3 to 5; and

25 Fig. 9 is a perspective view of a portion of a wristwatch having grounding and output contacts.

Before describing the present invention, first, explanation will be directed to Figs. 1 and 2 showing a prior art structure, for better understanding of the present invention.

Figs. 1 and 2 show a display article such as a wristwatch heretofore proposed and in which a display panel 1, a driving energy source 2, a driver or module 3, are placed in a watch casing 4 and a transparent cover 5 is provided on the front side of the casing 4 so that direct vibration of the cover 5 causes sound, that is, the cover itself acts as a sound generator. For the vibration of the cover 5 the arrangement is in the following manner. As shown in Fig. 2, the cover 5 is coated at its inner peripheral surface with an electrode 6. A transparent adhesive 7 is provided to apply to the cover 5 and to the electrode 6 a transparent piezoelectric ceramic plate 10 having on its both surfaces transparent electrodes 8 and 9. The electrodes 8 and 6 are electrically connected to each other (though not shown). A contact 11 is in contact with the transparent electrode 6 provided on the cover 5, while a contact 12 is in contact with the transparent electrode 9 on the lower side of the piezoelectric ceramic plate 10 as viewed in the drawing. With such an arrangement a voltage is applied across the transparent piezoelectric ceramic plate 10 via the contacts 11 and 12 so that the plate 10 vibrates to cause the cover 5 integral with the plate 10 to vibrate, thereby emitting sound. The cover 5 is coupled to the casing 4 through a packing member 13 which provides water-proof and cushioning effect therebetween.

With such an arrangement, however, the vibration will be reduced or weakened because the cover is fixed directly to the casing 4 at its peripheral portion which forms a node of the vibration.

5 Turning now to Fig. 3 and Fig. 6, there is shown an embodiment of a wristwatch in accordance with the present invention in which Fig. 3 is a cross-sectional view of the wristwatch and Fig. 6 is a plan view thereof. The wristwatch has a transparent cover
10 14 made of, for example, a transparent glass which covers the front face of a display panel and is capable of vibrating to generate sound. The transparent cover 14 has on the lower surface of its peripheral portion a frame-like blind layer 15 printed. The blind layer 15
15 is optionally provided, but it is useful for providing a geometrically arranged shape of the display area to the display panel, i.e. a good appearance of the wristwatch when viewed from the front side, because the blind layer 15 covers the periphery edge of the transparent piezo-
20 electric plate 17 which is adhered via a transparent adhesive 16 to the layer under the transparent cover 14. The blind layer 15 may be provided on the transparent cover 14 side with other display symbols, if desired. Further, under the lower surface of the blind layer 15 is
25 formed a frame-like conductive layer 18 such as an evaporated aluminum film. Furthermore, the piezoelectric plate 17 has on both

surfaces transparent electrodes 19 and 20 which are made, for example, of $\text{In}_2\text{O}_3\text{-SnO}_2$. The transparent electrode 19 on the upper surface of the plate 17 is adhered and electrically connected to the conductive layer 18. The transparent cover 14 is coupled via an elastic packing (such as an elastomer rubber) 21, which is electrically conductive, to an electrically conductive casing 22 in a fitting relationship. The frame-like packing 21 is rectangular in cross-section as viewed in a plane widthwise of the cover 14. As a result, the transparent cover 14 is supported elastically at its peripheral portion thereof which functions as a node of vibration, the vibration can take place effectively, thereby to give forth a sufficiently high level of sound.

The conductive layer 18 is in electrical contact with the casing 21 so that the electrode 19 is electrically connected with the casing 22. Since the packing 21 is of an electrically conductive material, the electrode 19 on the piezoelectric plate 17 is also connected electrically to the casing 22 via the layer 18 and the packing 21. It is apparent that electrical connection between the electrode 19 and the packing 21 may be achieved by any other suitable conductive member instead of the conductive layer 18.

Meanwhile, an output contact 23 of the piezoelectric plate 17 is made to contact with the transparent

electrode 20 right below the blind layer 15. For this reason, the output contact 23 can not be seen from the front side of the wristwatch, because the contact is located out of the indication area (visual area) (shown
5 by 2) of the transparent cover 14, as will be seen from Figs. 3 and 6. A grounding contact for the piezoelectric plate 17 becomes unnecessary as long as the casing 22 is kept at the grounded level, since the transparent electrode 19 of the piezoelectric plate 17 is electrically
10 connected through the conductive layer 18 and the casing 22.

Since the transparent cover 14 is elastically supported, the vibration produced by the piezoelectric plate 17 will not be weakened. This means that sound
15 at a level sufficient for an alarm purpose can be generated.

Further, in this embodiment, as long as one of the electrodes of the piezoelectric plate is electrically connected to the casing and the casing
20 is kept at the ground potential, it will be unnecessary to provide a grounding contact for the piezoelectric plate.

Fig. 4 shows another embodiment of the present invention, in which a frame-like packing 21' is interposed between a casing 22 and a transparent cover 14 capable
25 of vibrating to generate sound, and is L-shaped as viewed in a plane widthwise of the cover 14. As in the above first embodiment, a frame-like blind layer 15 may

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not be necessarily provided in this embodiment. The electrically conductive layer 18' is carried on the casing 22 through the L-shaped packing 21' which is made of an electrically conductive material. The other
5 structure in Fig. 4 may be the same as that in Fig. 3.

Fig. 5 shows a further embodiment of the present invention. A frame-like packing is interposed between a casing 22 and a transparent cover 14 capable of vibrating to generate sound, and includes two
10 rectangular section pieces 21a and 21b of electrically conducting material arranged in an L-shaped form as viewed in a plane widthwise of the cover 14. The other structure in Fig. 5 may be the same as that in Fig. 4.

Further, as an alternative, the packing as
15 shown in Figs. 3 to 5 may be constituted by an electrically conductive adhesive having elasticity (not shown), for elastically securing the transparent cover 14 at its peripheral portion to the casing 22.

With the embodiments of Figs. 3 to 6 described
20 above, there have been provided a display device structure which can avoid the attenuation of the generated sound and the deterioration of the water-proof capability. In addition, no necessity of providing the grounding contact for the piezoelectric plate will allow the less number
25 of contacts thereof.

In the embodiment shown in Fig. 7, a contact structure is further employed which facilitates and ensures the electrical connection between a piezoelectric plate that provides a vibration force to a transparent cover of a sound generator and a module that drives the piezoelectric plate.

The wristwatch in Fig. 7 has an electrically conductive watch casing 22. The casing 22 encloses a display panel 35 incorporated with a liquid crystal display unit, a module 36 for driving and controlling the display panel 35, and an electric cell 37 mounted on the module 36. The module 36 includes lead terminals 38, an LSI circuit device unit 39 resin-molded with portions of the two lead terminals 38 and a crystal oscillator 41 mounted on a resin-molded block 40. The casing 22 is covered on the display panel side with a transparent cover 14 capable of vibrating to generate sound and made of, for example, glass, and on the module side with a removable back cover 43. The transparent cover 14, as in the similar way to that in Fig. 3, is fitted at its peripheral portion to the conductive casing 22 by means of an elastic packing 21 which is electrically conductive. Although the frame-like packing 21 is rectangular shaped as viewed in a plane widthwise of the cover 14 in Fig. 7, it will be easily appreciated that the packing 21 may be replaced with the packing 21'

shown in Fig. 4 or the packing pieces 21a and 21b shown in Fig. 5. The transparent cover 14 is coated on its inner face with a transparent conductive layer 44. To the central portion of the layer 44 is applied a transparent piezoelectric plate 47 which has on both surfaces transparent electrodes 45 and 46. Between the transparent electrode 46 (on the module side) of the piezoelectric plate 47 and one of the lead terminals 38 leading from the LSI unit 39, is disposed in compressed relationship a contact member 48 of an elastic and electrically conductive rubber. The contact member 48 serves as an output contact. In a similar way, between another lead terminal 38 and the transparent conductive layer 44 on the transparent cover 14 there is disposed in compressed relationship another contact member 49 of an elastic and electrically conductive rubber. The contact member 49 serves as a grounding electrode. Here in this embodiment in order for the output and grounding conductive members 48 and 49 not to be seen from the front side of the wristwatch, they must be located out of the indication area (visual area) (shown in Fig. 7 by $\mathcal{L}$) of the transparent cover 14. To this end, a frame-like blind layer 15 as shown and described with reference to Figs. 3 to 5 may be provided at the lower peripheral surface of the transparent cover 14. As a result, only the indication area of the liquid crystal display panel 35,

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i.e., of the transparent cover 14 can be seen when viewed from the front side of the wristwatch. The piezoelectric plate 47 vibrates when a voltage is applied between the output and grounding conductive rubbers 48 and 49 thereof, since the transparent conductive layer 44 is in an electrical contact with the adhesive side transparent electrode 45 of the piezoelectric plate 47, this vibration of the plate 47 causes the transparent cover 14 to vibrate, thereby generating alarm sound. On the other hand, the back cover 43 is fitted to the casing 22 in air-tight relationship with the casing 22 by means of a packing 50. Reference numeral 51 designates a contact for the electric cell.

With the wristwatch of the type described above, the assembling can be carried out in such a manner that openings are formed at the peripheral portion of the display panel 35 and the conductive rubbers 48 and 49 are inserted into the associated openings between the lead terminals 38 and the associated electrode 46 and the conductive layer 44, thereby providing a tightly compressed contact structure beneath the transparent cover 14. In this connection, the diameter of each conductive rubber 48 or 49 may be determined so as to be slightly larger than that of each opening in the display panel 35 to avoid the slipping of the once-inserted conductive rubbers out of the associated openings, allowing easy assembling.

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Referring to Fig. 8, electrically conductive coiled springs 38 and 38' are employed in place of the elastic contact members of an electrically conductive rubber in Fig. 7. More specifically, the spring 38 is
5 interposed in pressure engagement between one of the lead terminals of an LSI circuit device unit 39 and a transparent conductive layer 44 for electrical connection therebetween while the spring 38' is interposed in pressure engagement between another terminal of the LSI unit 39
10 and a transparent electrode 46 of the piezoelectric plate 47 for electrical connection therebetween. The other structure with an electrically conductive portion 21 may be the same as that in Fig. 7. Therefore, the packings and/or blind layers as shown and described with
15 reference to Figs. 3 to 5 may be used in the structure of Fig. 8.

In the watch shown in Fig. 9 the various packings, pieces and frame-like blind layer are not illustrated although they will be present as described with reference
20 to Figs. 3 to 5. In this watch a grounding contact and an output contact are constituted by leaf springs 66 and 67 which are mounted on a ceramic plate 62 by means of mounting screws 65 for holders 64, the holders securing a liquid crystal panel 63 on the ceramic plate 62. In
25 this case, it is necessary to electrically insulate at least the output contact 67 from the holder 64 and the ceramic plate 62.

The above-mentioned embodiments of the display device structure with reference to Figs. 7 to 9 have additional advantages over the embodiments shown in Figs. 3 to 6 in that necessary electric connection
5 is ensured between the piezoelectric plate mounted on the transparent covering glass and the module and further assembling is facilitated.

In addition, the present invention may be applied not only to a watch but also to other articles
10 having a display such as a calculator or a radio receiver.



CLAIMS

1. An article having a display panel and sound generator in an electrically conductive casing, the sound generator comprising a transparent covering and vibrating plate member having its peripheral portion
5 carried on the casing and being on the front side of the display panel, a transparent piezoelectric plate and a pair of transparent electrodes sandwiching the piezo-
electric plate, the piezoelectric plate and electrodes
being secured to and integral with the covering and
10 vibrating plate member so that mechanical force produced by the piezoelectric plate is effectively transmitted to the plate member to vibrate the plate member to generate sound, and an elastic and electrically conductive member
being provided between the peripheral portion of the
15 plate member and the casing, the elastic and electrically conductive member being arranged both to provide a seal between the plate member and the casing and to provide an electrical connection between the casing and one of the transparent electrodes.

20 2. An article according to claim 1, wherein the elastic and electrically conductive member is rectangular as viewed in a plane widthwise of the plate member.

3. An article according to claim 1, wherein the elastic and electrically conductive member is L-shaped
25 as viewed in a plane widthwise of the plate member.



4. An article according to claim 1, wherein the elastic and electrically conductive member includes two rectangular section elastic and electrically conductive pieces arranged in an L-shaped form as viewed in a plane
5 widthwise of the plate member.

5. An article according to any preceding claim, wherein a frame-like blind layer is provided on the inner surface of the peripheral portion of the plate member.

6. An article according to claim 5, wherein a
10 double layer including the frame-like blind layer and an electrically conductive frame-like layer is provided, with the frame-like blind layer being in contact with the peripheral portion of the plate member and the electrically conductive frame-like layer being in
15 electrical contact with either the elastic and electrically conductive member or both the elastic and electrically conductive member and the casing.

7. An article according to any preceding claim wherein the elastic and electrically conductive member
20 is formed of an elastic and electrically conductive adhesive material.

8. An article according to any preceding claim, further comprising a module having terminals arranged to be powered by an electric cell for driving at least
25 the display panel and the piezoelectric plate and at least two contact members having elasticity and being



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electrically conductive, the contact members being in pressure engagement between respective ones of the terminals of the module and being electrically connected with the transparent electrodes of the piezoelectric
5 plate for electrical connection between the module and the piezoelectric plate.

9. An article according to claim 8, wherein each of the contact members includes an electrically conductive rubber member.

10 10. An article according to claim 8, wherein each of the contact members includes a spring.

11. An article according to any preceding claim, wherein the elastic and electrically conductive member is comprised by a packing member.

15 12. An article including a display panel and a sound generator in a casing, said article being constructed and arranged to operate substantially as hereinbefore described with reference to and as shown by Figures 3 to 9 of the accompanying drawings.

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