Oct. 2, 1951 H. F. MATARÉ ET AL 2,569,570

CRYSTAL DIODES AND JOINT CONTACT DEVICE

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FIG. 1

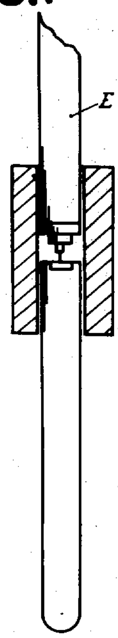


FIG. 2

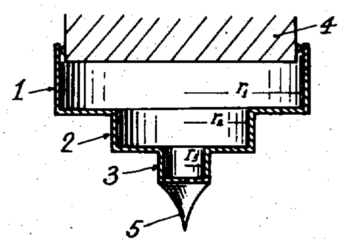


FIG. 3

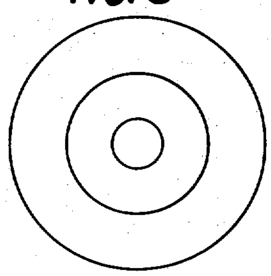


FIG. 4

FIG. 5

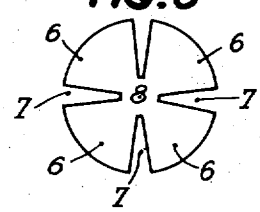


FIG. 6

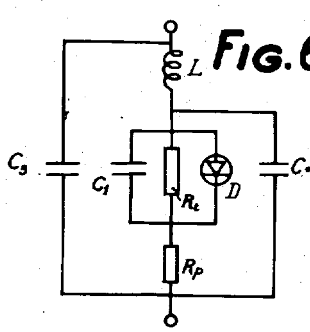
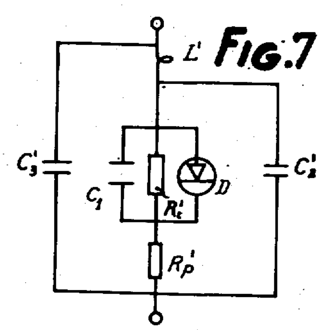


FIG. 7



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CRYSTAL DIODES AND JOINT CONTACT DEVICE

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4 Claims. (Cl. 175—366)

1

This invention relates to crystal diodes and more especially to contact devices adapted for use in establishing point contact with the crystal.

It is an object of this invention to provide means for improving this contact by fitting crystal diodes with a control device superior in many respects to those hitherto in use.

The greatest problem presented in the use of these diodes is presented by the so-called "contact needle," a very thin wire called upon to establish point contact with the crystal under an exactly predetermined pressure.

The needles hitherto used have been in the form of the spring coils capable of absorbing shocks or vibrations which occur during use while applying the necessary amount of pressure to insure permanent contact. Of necessity, such a spring coil must be as small as possible in order to minimize the forces tending to produce a displacement of the contact on the surface of the crystal or an interruption of contact as by a lifting of the needle point therefrom.

In order to secure the contact on the central point of the crystal, it has been proposd to control the spring coil by a core element serving to preserve the form of the spring and to guide the point. Also, to prevent deformation of the needle use has frequently been made of platinum or of one of its alloys with beryllium, iridium or gold, all of which are highly resistant and have a high limit of elasticity. Obviously, however, the volume manufacture of such coil spring needles formed with 3 or 4 windings of less than one millimeter diameter and of a wire thickness of one tenth of a millimeter encounters great difficulties.

In an electrical respect, it has been found that for wave lengths near the hyperfrequencies, the inductance of spiral coil needls is highly inconvenient. It is for this reason that efforts have been made to keep the needle wires as short as possible which, of course, causes a considerable reduction in their elasticity.

The contact device according to the present invention avoids all these drawbacks by solving the problem from an altogether different angle, while at the same time ensuring their ready volume production, to provide contact devices of remarkable uniformity in mechanical properties and which eliminate the greater part of electrical losses by inductance.

In the contact device according to this invention, the member that establishes the point contact has the form of a stepped cylindrical cap or capsule, the basic form of which is a pointed cone.

2

The form and number of steps may, of course, vary according to the flexibility required.

In the drawings accompanying this specification and forming a part thereof an embodiment of the invention is shown diagrammatically by way of example.

In the drawings:

Fig. 1 is an elevational view, partly in cross-section, of a diode equipped with the device according to this invention.

Fig. 2 shows on a larger scale a vertical axial section of the cap, while

Fig. 3 is a plan view.

Fig. 4 is a diagrammatic view of the cap in distorted condition.

Fig. 5 is a plan view of a blank from which the cap may be made by stamping or pressing.

Figs. 6 and 7 are wiring diagrams of equivalent circuits respectively of a crystal diode of a well known type in which the needle is formed of a mere spring and of a crystal diode fitted with a resilient capsule according to the invention.

The principle of the invention resides in the specific construction of the cap. As shown in Figs. 1 and 2 the cap is formed with three cylindrical portions **1**, **2** and **3** of decreasing diameters, the widest of which is welded to the end of an electrode **4**. **5** is the point which is fitted centrally to the narrowest part **3** of the cap.

In order to increase the resiliency of the capsule it may be formed of segments connected only at the center, as shown in Fig. 5, where a blank of clover-leaf contour with four segments **6** separated by deep gaps **7** merge only in the bottom section **8** designed to have the point fixed to it. This blank, when pressed into capsule shape, will produce a softer elasticity than the closed form shown in Fig. 2.

The point may be made either separately and fixed by welding to the cap, or a metal deposit may be made on the center of the cap which is subsequently ground into a pointed cone. This point-contact device offers the following advantages:

It lends itself to volume-production on the largest scale.

It provides for an automatic centering of great stability on the crystal.

It is substantially insensitive to mechanical shocks.

The inductance is reduced to a minimum whereby the inherent frequency of the detector is substantially enhanced.

In order to better illustrate the invention, a description will now be given of the resiliency or elasticity problem in relation to a point contact-system of this type, by comparing such resiliency with that of members utilized up to now for making the required point contact.

Where this contact action is obtained by means of a conventional cylindrical spring member (Fig. 1) the value of the deformation will be:

$$d_p=\frac{64nr^3}{d^4}\times\frac{P}{G} \qquad (1)$$

wherein

d_p=amplitude of the deformation in cm.
n=number of turns
r=radius
d=wire thickness of diameter in cm.
P=total pressure exerted in kg.
G=torsion modulus in kg./cm.^{2}

If a platinum spring is used, having the following characteristics:

$n=3$
$r=.034$ cm.
$d=.01$ cm.
$P=1.10^{-3}$ kg.
$G=7.10^5$ kg./cm.^{2}

then

d_p will be $=1.1\times10^{-3}$ cm. (2)

In the case of a stepped cut used as a point contact-member the value of the deformation may be calculated with an approximate formula deducted from the known formula for calculating the deformation of a cylindrical plate fixed by its edge. This formula was applied to the problem in question by assuming that the total value of the deformation is obtained by adding the respective values of deformation of the separate plates which form the successive steps of the member. Thus:

$$d_p=\frac{.217\times P}{E\times h^3}\left\{\left[r_1^2-.75\,r_2^2-r_2^2\ln\left(\frac{r_1}{r_2}\right)\right]+\ldots+\left[r_{n-1}^2-.75\,r_n^2-r_n^2\ln\left(\frac{r_{n-1}}{r_n}\right)\right]+r_n^2\right\} \qquad (3)$$

that is, in the case of a three-step capsule:

$$d_p=\frac{0.217\times P}{E\times h^3}\left\{\left[r_1^2-0.75\,r_2^2-r_2^2\ln\left(\frac{r_1}{r_2}\right)\right]+\left[r_2^2-0.75\,r_3^2-r_3^2\ln\left(\frac{r_2}{r_3}\right)\right]+r_3^2\right\} \qquad (4)$$

wherein:

d_p=value of the deformation in cm.
P=total pressure exerted in kg.
r_1=radius of the largest step
r_2 -- -- r_{n-1} =radiuses of the successive intermediate steps
r_n=radius of the smallest step
h=thickness of the plate or sheet used
E=elasticity modulus in kg./cm.^{2}.

By way of example, calculus will give, in accordance with the above formula, the deformation d_p for a three-step capsule whose plates are made of nickel of the following characteristics:

$P=1\times10^{-3}$ kg.
$r_1=.2$ cm.
$r_2=.13$ cm.
$r_3=.06$ cm.
$h=2\times10^{-3}$ cm.
$E=2\times10^6$ kg./cm.^{2}

has the value

$$d_p=.47\times10^{-3} \qquad (5)$$

This value is still greater if the elasticity modulus E is that of platinum or other highly elastic metal, which may of course also be used.

In the preceding Formula 3 the fact that d_p corresponds to the maximum deformation in the middle of the plates has been kept in consideration. However this small error is largely compensated for by the fact that the plates are not solid and their association actually forms a kind of funnel made of a succession of hollow cylinders the deformation of which will be higher than that calculated according to Formula 3.

In addition, it should be noted that the vertical walls will also be moved under the pressure exerted as illustrated in Fig. 4. The angle α formed after the deformation by the side wall of the intermediate step or annular portion with the general axis of the system will constitute an addiional variable which will increase the initially found value of d_p. The Formula 4 obtained by assuming a homogeneous pressure exerted centrally of the plates cannot be extended to the case where $r_2\rightarrow r_1$ or $r_3\rightarrow r_2$, which amounts to saying that the relations $r_1>r_2$ and $r_2>r_3$ should be constantly observed.

Considering all the capabilities of movement of the successive cylindrical envelopes the following formula could be adopted:

$$d_p=\frac{.217\times P}{E\times h^3}\left\{2.54\times r_1^2-1.52\,r_2^2-r_2^2\ln\left(\frac{r_1}{r_2}\right)\right\} \qquad (6)$$

This formula is applicable to the deformation of an annular plate bearing freely through its periphery on a support and subjected to a uniformly distributed pressure from within a circumference having an average radius of $2r_2$.

Taking the same values as for the calculations effected with Formula 4 for the various elements in question, d_p will thus become:

$$d_p=.92\times10^{-3} \qquad (7)$$

This value is higher than that resulting from the application of Formula 4. In fact the actual result in practice lies between these two values while being closer to the latter value.

In any case, it will be seen that the value of the deformation does not substantially differ from that obtained with a cylindrical spring. This is readily ascertained by comparing the results (2), (5) and (7).

It should be noted however that the elasticity limit of the material employed will be always more rapidy reached when the construction utilizes the cup-shaped element wherein the tension σ is calculated according to the formula:

$$\delta=\cong0.62P\left[\ln\left(\frac{r_1}{r_2}\right)+0.25\left(\frac{r_2}{r_1}\right)^2\right]/h^2 \qquad (8)$$

$$\sigma=\cong82\text{ kg./cm.}^2 \qquad (9)$$

which is lower than normal values afforded by nickel material.

It should furthermore be observed that the values of E may be advantageously improved by the use of alloys which will permit a substantial reduction of the rather high pressure of 1 gr. taken in the above calculations, by analogy with cylindrical springs of the type shown in Fig. 1 which is the pressure value usually accepted for these springs while keeping the d_p value substantially at the same level.

Side-displacements, due to mechanical shocks, the more detrimental of which would be those applying a component force at right angles with the vertical or normal axis of the capsule, has a much smaller chance of occurring in this case. Consequently, no disadvantage is secured if this pressure is further reduced while such reduction of the pressure at the same diminishes the electric capacity of contact between the point and crystal elements.

Comparing now the substitution or equivalent diagrammatic circuits shown in Figs. 6 and 7 which correspond respectively to the prior art spring system and the elastic cup system according to the invention (Fig. 7) respectively, it should be noted that:

$$L \gg L'$$
$$R_t < R'_t$$
$$C_1 > C'_1$$

while setting down:

$$C_2 \approx C'_2$$
$$C_3 \approx C'_3$$
$$R_p = R'_p$$

it will be apparent that a diode tube equipped with the contact member according to the present invention has electrical properties such that the energy of the hyperfrequencies is better concentrated at the limit or stopping layer D.

We claim:

1. A point-contact element for crystal diodes a hollow capsule of resilient material having the axial section of a low stepped cone.

2. The point-contact element for crystal diodes of claim 1 in which the capsule has the form of several cylindrical annuli of different diameters arranged in axial superposition, flat annuli connecting the bottom edge of a larger with the top edge of a smaller cylindrical annulus, and a bottom closing the smallest cylindrical annulus.

3. A crystal diode comprising the point-contact device of claim 1.

4. A point contact element for crystal diodes comprising in combination, a hollow apertured capsule formed from a blank provided with radial slots and shaped with at least one step defining at least two cylindrical parts of different diameters and at least one annular part and a flat and central part connecting the lower edges of said cylindrical parts, a pointed member being fixed to flat end central part.

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