March 11, 1952 F. H. BRITTAIN ET AL 2,588,956

CRYSTAL RECTIFIER

Filed Feb. 23, 1949

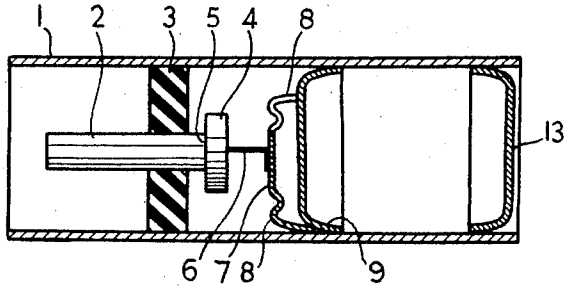


FIG. 1

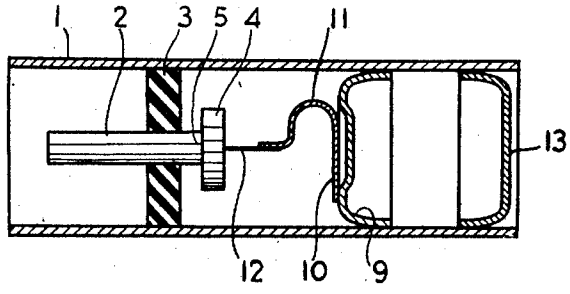


FIG. 2

INVENTORS
FRANCIS HUGH BRITTAIN
EMRYS GWYNNE JAMES
BY Lawrence B. Dodds
ATTORNEY

Patented Mar. 11, 1952

2,588,956

UNITED STATES PATENT OFFICE

2,588,956

CRYSTAL RECTIFIER

Francis Hugh Brittain and Emrys Gwynne James, Pinner, England, assignors to The General Electric Company, Limited, London, England

Application February 23, 1949, Serial No. 77,764
In Great Britain July 31, 1946

7 Claims. (Cl. 175—366)

1

This invention relates to crystal rectifiers of the type comprising within a capsule a semi-conducting crystal and a metal whisker supported from the capsule so that the tip of the whisker is resiliently pressed against a surface of the crystal. Such crystal rectifiers are used, for example, in ultra high frequency mixers or frequency changers or detectors in which they often constitute terminations of coaxial or concentric lines.

In one well known construction of such a crystal rectifier the capsule has the form of a metal tube of circular cross section from which is supported, coaxially, a metal rod insulated from the tube. A suitable metal whisker, for example of tungsten, of approximate length 5–6 mm., is soldered or welded to one end of the rod, is bent into the shape of an S and the pointed, free end is brought to bear on the surface of a suitable crystal affixed to the face of a circular metal block which is fitted tightly into the metal tube. The elasticity of the S-shaped whisker maintains the necessary resilient pressure of the point on the crystal.

This unit is satisfactory for many purposes, but the relatively long length of wire constituting the whisker has appreciable inductance which is often disadvantageous, for example, it renders difficult to design a mixer capable of operating over a wide range of frequencies without tuning adjustment.

The object of this invention is to provide a novel construction of rectifier of the type specified, and especially a novel modification of the said known construction, in which the inductance of the whisker is very small.

According to the invention in a crystal rectifier of the type specified the metal whisker consists of a short spike projecting from a metal body of low inductance and the required resilience between the whisker and the crystal is provided wholly, or at least mainly, by one or more resilient parts in the supports from the capsule for the crystal and/or the spike.

The term "short spike" implies that the length of the spike projecting from the metal body is much less than the hitherto usual length for the whisker of about 5 mms., and is preferably not longer than 2 mms.

The term "metal body of low inductance" implies that the inductance introduced by the metal body into the current path through the rectifier is less than the inductance of a piece of wire having the mean diameter of the spike and of length equal to the length of the current path, or shortest branch of the current path if the body is branched, provided by the body.

2

The metal body may be supported directly from the wall of the capsule or the metal body may be supported from a further member which is itself supported directly from the wall of the capsule. In either case the metal body is preferably made resilient so as to provide the whole or the greater part of the required resilience between the spike and crystal, and the crystal is then mounted rigidly or with only slight resilience. The spike may however in some cases be rigidly mounted and the required resilience provided wholly or mainly by the crystal mounting.

One suitable form which the metal body carrying the spike may take is that of a resilient metal cup to the base of which the spike is attached and the skirt of which is fixed relative to the wall of the capsule, for example by direct attachment of the skirt to the wall of the capsule or by attachment of the skirt to a support which is itself attached to the wall of the capsule.

In order to provide sufficient resilience sections of the cup may be cut away to provide a framework more resilient than the basic cup form and corrugations may also be provided in the cup for increasing its resilience. Thus in some cases the metal body may consist of a tripod structure having resilient legs, the ends of the legs of the tripod being fixed relative to the wall of the capsule and the spike being attached to the vertex of the tripod, which may be formed with one or more corrugations.

In another case the metal body may consist of a U-shaped metal member, the arms of which are fixed relative to the wall of the capsule and to the base of which the spike is attached.

Another resilient form for the metal body which is often convenient is a U-shaped metal strip of which at least part of one arm is fixed relative to the wall of the capsule whilst the other arm supports the spike which is preferably attached to the arm near the free end thereof. Preferably also the first said arm of the U is fixed relative to the wall of the capsule by attaching it to the base of a metal cup the skirt of which is attached to the wall of the capsule.

It will be appreciated that resilient metal bodies of the kind just described may also be used for providing a resilient mounting of the crystal; the spike is then preferably attached to a substantially rigid metal member of low inductance.

In a rectifier in accordance with this invention the tip of the spike will usually be formed, as by grinding, into a point, as with the larger

whisker used in the known rectifiers, and it will in general be convenient to form the point after the spike has been fixed in position on the metal member of low inductance from which it projects, which may limit the shortness of the spike attainable. In some cases, however, the end of the spike may be flat and, as has previously been proposed in other crystal rectifiers, the end face presented to the crystal may be inclined so that contact is made by the edge of the face; this arrangement may have the advantage in crystal rectifiers in accordance with this invention that the length of the spike may be made much shorter than would be possible if a pointed spike was used, and the inductance of the spike may be correspondingly decreased.

Preferably in the manufacture of a crystal rectifier in accordance with this invention the parts of the supports for the crystal and spike which abut against the wall of the capsule are coated prior to assembly with a layer of a suitable cement, preferably a cement which will polymerise upon heating, and after assembly the assembly is heated to fix the said parts to the wall of the capsule by means of the cement.

The tip of the spike and the surface of the crystal may also be coated with the cement prior to assembly so that after the heating a meniscus is formed round the tip of the spike which prevents lateral movement of the tip of the spike over the surface of the crystal.

Two embodiments of the present invention will now be described by way of example with reference to Figures 1 and 2 of the accompanying drawing each of which represents an axial section of a crystal rectifier in accordance with the invention wherein the capsule is a metal tube and a tungsten spike whisker is supported by a resilient metal body.

In the rectifier shown in Figure 1, the capsule consists of a copper tube 1, of dimensions 1'' length, $\frac{1}{32}$'' external diameter, $\frac{5}{16}$'' internal diameter, within which is rigidly fixed a rod 2 of nickel-iron alloy, having dimensions $\frac{5}{16}$'' length, $\frac{1}{16}$'' diameter which rod is held coaxially within the tube 1, and insulated from the tube, by a ceramic bead 3, $\frac{3}{32}$'' long through which the rod passes and metallised surfaces of which are soldered to both the rod 2 and the tube 1. A silicon crystal 4 is soldered at a metallised surface thereof to the end face 5 of the rod.

An L-shaped tungsten wire 6 of which one arm is about 2 mm. long and pointed at the tip, has the other arm of the L welded to, so that its first said arm lies along the axis of the tube 1, as a spike projecting from, the flattened vertex 7 of a tripod of beryllium-copper alloy. The arms 8 of this tripod are symmetrically placed about the flattened vertex 7, which is formed with one circular corrugation coaxial with the spike. The free ends of the arms 8 are welded to a copper-nickel cup 9, the hollow of which is turned away from the tripod and spike, and which copper-nickel cup is a force-fit within the tube 1.

In the process of assembly the rod 2 carrying the crystal 4 is first rigidly fixed in the required position inside the tube 1 by means of the bead 3 which is soldered to the rod and tube. The cup 9, tripod 7, 8 and tungsten spike 6 are assembled separately. Then the surface of the crystal 4, the tip of the spike 6, and the ends of the tripod arms 8 and the inner wall of the tube 1 at their regions of mutual contact, are all coated with a thin layer of butyl-methacrylate cement. The copper-nickel cup 9 bearing the tripod and

spike is then forced into the tube 1 until the tip of the spike exerts a suitable pressure on the surface of the crystal. The whole assembly is then baked at a temperature of about 100° C. so that the cement polymerises and holds the components in position so as to prevent relative movement after assembly. The cement also forms a meniscus round the point of the spike 6 which prevents its lateral displacement over the surface of the crystal 4.

In another embodiment of this invention, shown in Figure 2 of the accompanying drawing, the components of the crystal rectifier assembly are the same as those of Figure 1, and are numbered the same with the exception of the spike and its mounting.

In the embodiment of Figure 2 the tripod member 7, 8 and the L-shaped tungsten wire forming the spike 6 in Figure 1 are replaced respectively by a U-shaped bent strip 10, 11, about 2 mm. wide, of beryllium-copper alloy and a short straight piece of tungsten wire 12, pointed at one end. One arm 10 of the U-shaped strip is welded to a copper-nickel cup 9 having a re-entrant dent, positioned under the said arm of the U so as to permit flexure of the arm, whilst the free end 11 of the U has its tip bent substantially parallel to the sides of the cup and to this tip is welded the straight tungsten wire 12 to form a spike lying along the axis of the tube 1, with its pointed end presented to the crystal.

As in the embodiment shown in Figure 1, the cup 9 is a force fit within the tube 1 and the assembly technique is similar, the tip of the spike 12, the face of the crystal 4, and the contacting walls of the cup 9 and tube 1 being coated with butyl-methacrylate cement and the whole baked as before to polymerise the cement.

In both embodiments, after assembly and baking, in order to render airtight the space occupied by the spike and the crystal, a copper-nickel cup 13 may be forced rim foremost and may be cemented into the end of the metal tube 1 remote from the bead 3, so that the base of the cup 13 lies just within the end of the tube 1. The bead itself serves to seal the tube on the other side of the crystal.

It will be appreciated that the present invention is not limited to the embodiments nor the dimensions described above; thus for example for the spike-supporting metal body of low inductance may be used metals other than beryllium-copper, for example a chrome-nickel alloy, and metals other than tungsten may be used for the spike, for example platinum-iridium alloy or platinum-rhodium alloy and the spike-supporting metal may be for example an approximately V-shaped strip bent at a right angle; also crystals other than silicon may be used, for example germanium crystals. Also in some cases the ceramic bead may be replaced by a glass bead fused to the tube and to the rod which it supports.

We claim:

1. A crystal rectifier comprising within a capsule a semi-conducting crystal and a metal whisker, supported from the capsule so that the tip of the whisker is resiliently pressed against a surface of the crystal, wherein the metal whisker consists of a short spike and projects from the vertex of a resilient metal tripod structure of low inductance, the ends of the tripod legs being fixed relative to the wall of the capsule which tripod structure provides substantially the whole of the required resilience between the whisker and the crystal.

2. A crystal rectifier comprising: a capsule; a semi-conducting crystal and a metal whisker supported within the capsule so that the tip of the whisker is resiliently pressed against a surface of the crystal, wherein the metal whisker consists of a short spike, of which one end is flat and presented to the crystal at an angle so that contact with the crystal is made by the edge of the end face of the spike; supporting members for the crystal and the whisker including a metal body of low inductance positioned within the capsule and attached to the other end of the spike so that the spike projects from the body and wherein substantially the whole of the required resilience between the whisker and the crystal is provided by the members which support the crystal and spike.

3. The manufacture of a crystal rectifier comprising within a capsule a semi-conducting crystal and a metal whisker, members including a metal body of low inductance for supporting the crystal and the whisker from the capsule so that the tip of the whisker is resiliently pressed against a surface of the crystal, wherein the metal whisker consists of a short spike projecting from the metal body of low inductance, and substantially the whole of the required resilience between the whisker and the crystal is provided by the members which support the crystal and spike, in which manufacture the parts of the supporting members for the crystal and spike which abut against the wall of the capsule, the tip of the spike, and the surface of the crystal are all coated prior to assembly with a layer of a cement which will polymerise upon heating, and after assembly the assembly is heated to polymerise the cement and fix the said parts to the wall of the capsule and form a meniscus of cement round the tip of the spike which prevents lateral movement of the tip over the surface of the crystal.

4. A crystal rectifier comprising: a capsule; a semi-conducting crystal; a metallic whisker in the form of a short spike; and means including a resilient substantially U-shaped metal member of low inductance positioned within said capsule and with at least one arm of said member in fixed relation to the inner wall of said capsule, said means supporting said crystal and said whisker with the tip of said whisker resiliently pressed against a surface of said crystal and said U-shaped member providing substantially the whole of the required resilience between said whisker and said crystal.

5. A crystal rectifier comprising: a capsule; a semi-conducting crystal; a metallic whisker in the form of a short spike; and means including a resilient U-shaped metal member of low inductance positioned within said capsule and with a portion of one arm of said member in fixed relation to the inner wall of said capsule and a portion of the other arm thereof attached to one end of said whisker, said means supporting said crystal and said whisker with the other end thereof resiliently pressed against a surface of said crystal and said U-shaped member providing substantially the whole of the required resilience between said whisker and said crystal.

6. A crystal rectifier comprising: a metallic tube; a semi-conducting crystal; a metallic whisker in the form of a short spike; an insulator maintained in a fixed position within said tube; a rigid metallic rod supported in a fixed position by said insulator and supporting said crystal; and a resilient U-shaped member of low inductance positioned within said tube with a portion of one arm of said member in fixed relation to the inner wall of said tube and a portion of the other arm thereof attached to one end of said whisker, said U-shaped member supporting said whisker with the other end thereof resiliently pressed against a surface of said crystal and providing substantially the whole of the required resilience between said whisker and said crystal.

7. A crystal rectifier comprising: a metallic tube; a semi-conducting crystal; a metallic whisker in the form of a short spike; an insulator maintained in a fixed position within said tube; a rigid metallic rod supported in a fixed position by said insulator and supporting said crystal; a metallic cup maintained in a fixed position within said tube; and a resilient U-shaped member of low inductance secured within said tube to said cup with a portion of one arm of said member in fixed relation to the inner wall of said tube and a portion of the other arm thereof attached to one end of said whisker, said U-shaped member supporting said whisker with the other end thereof resiliently pressed against a surface of said crystal and providing substantially the whole of the required resilience between said whisker and said crystal.

FRANCIS HUGH BRITTAIN.
EMRYS GWYNNE JAMES.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,469,569	Ohl	May 10, 1949

FOREIGN PATENTS

Number	Country	Date
78,069	Austria	Sept. 10, 1919