

Dec. 9, 1947.

D. A. McLEAN ET AL

2,432,116

CRYSTAL DETECTOR MOUNTING

Filed April 19, 1943

FIG. 1

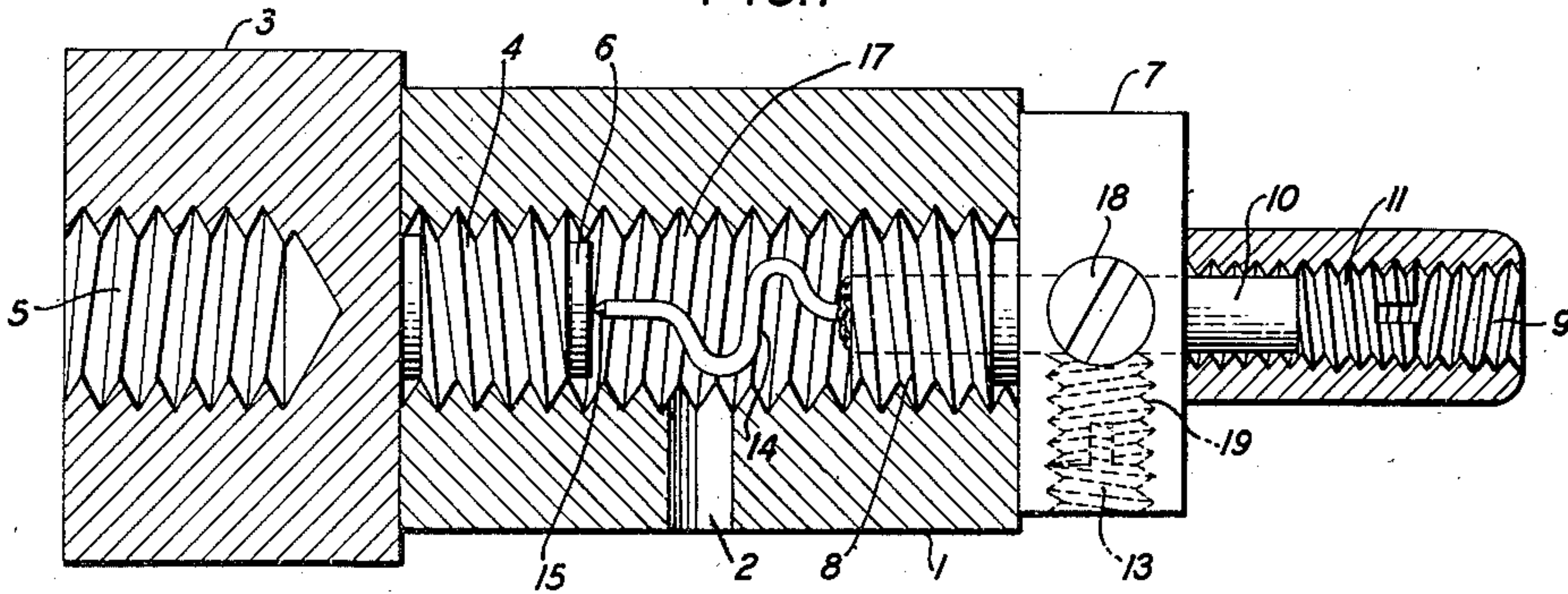


FIG. 2

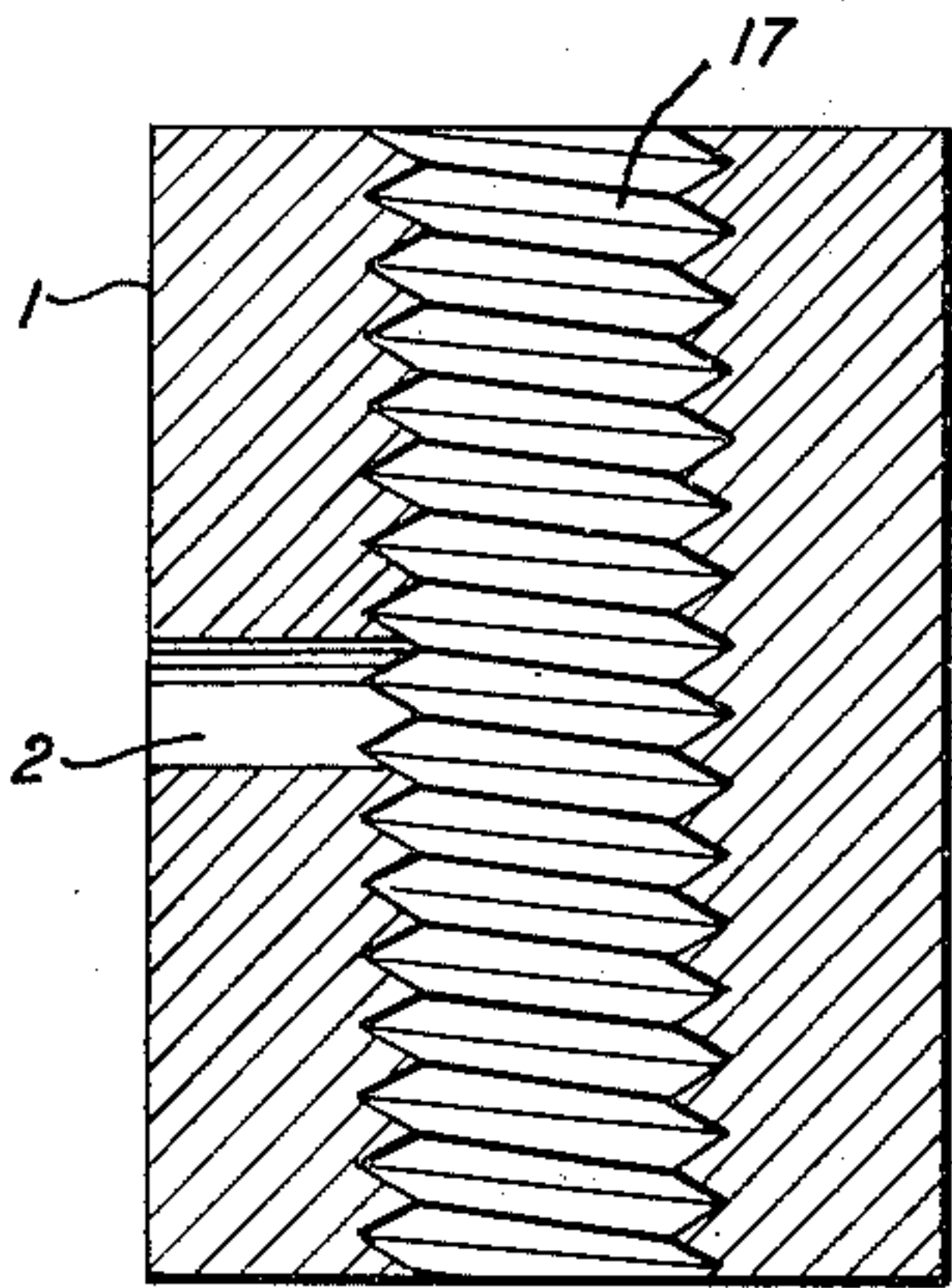


FIG. 3

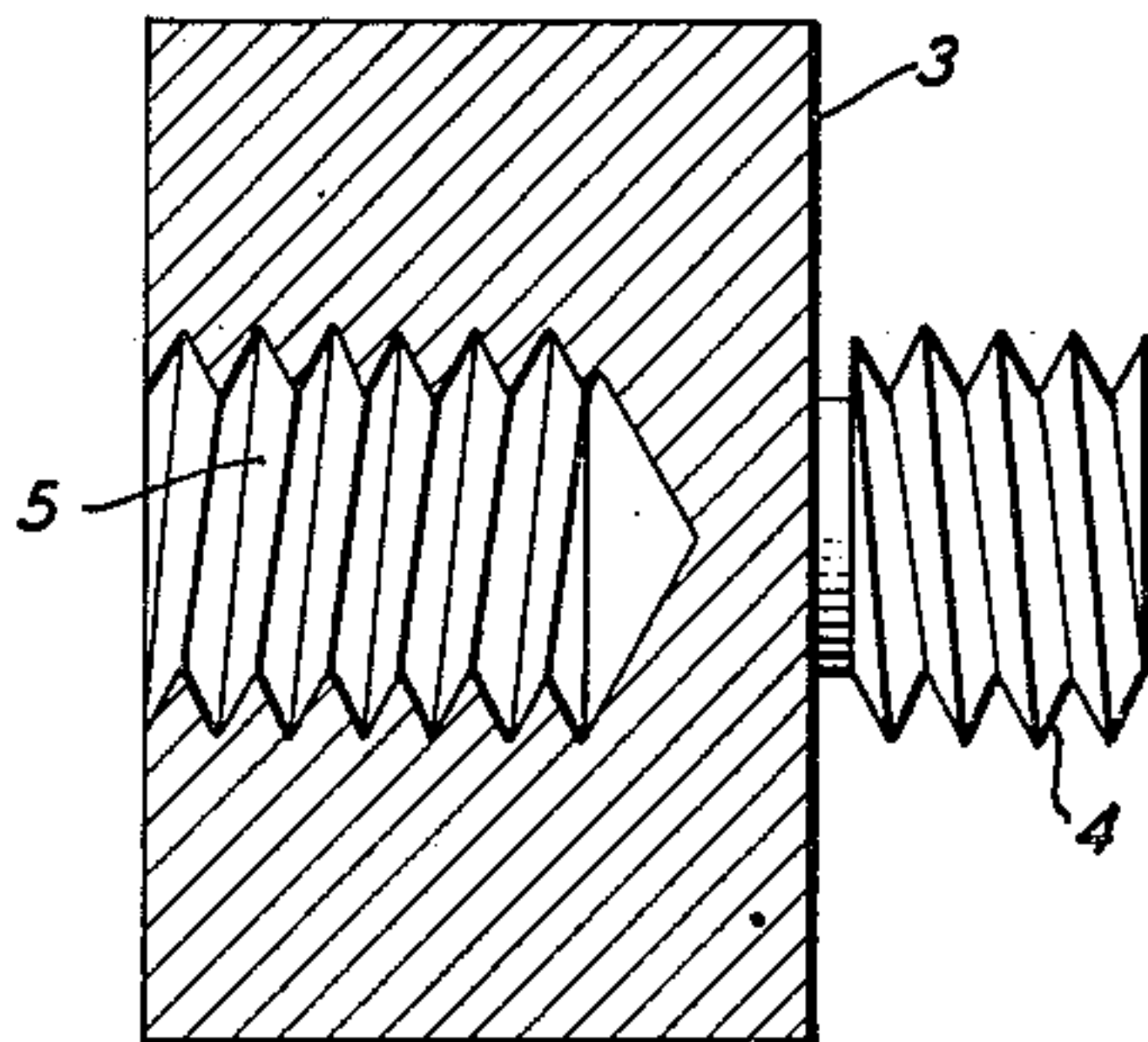


FIG. 4

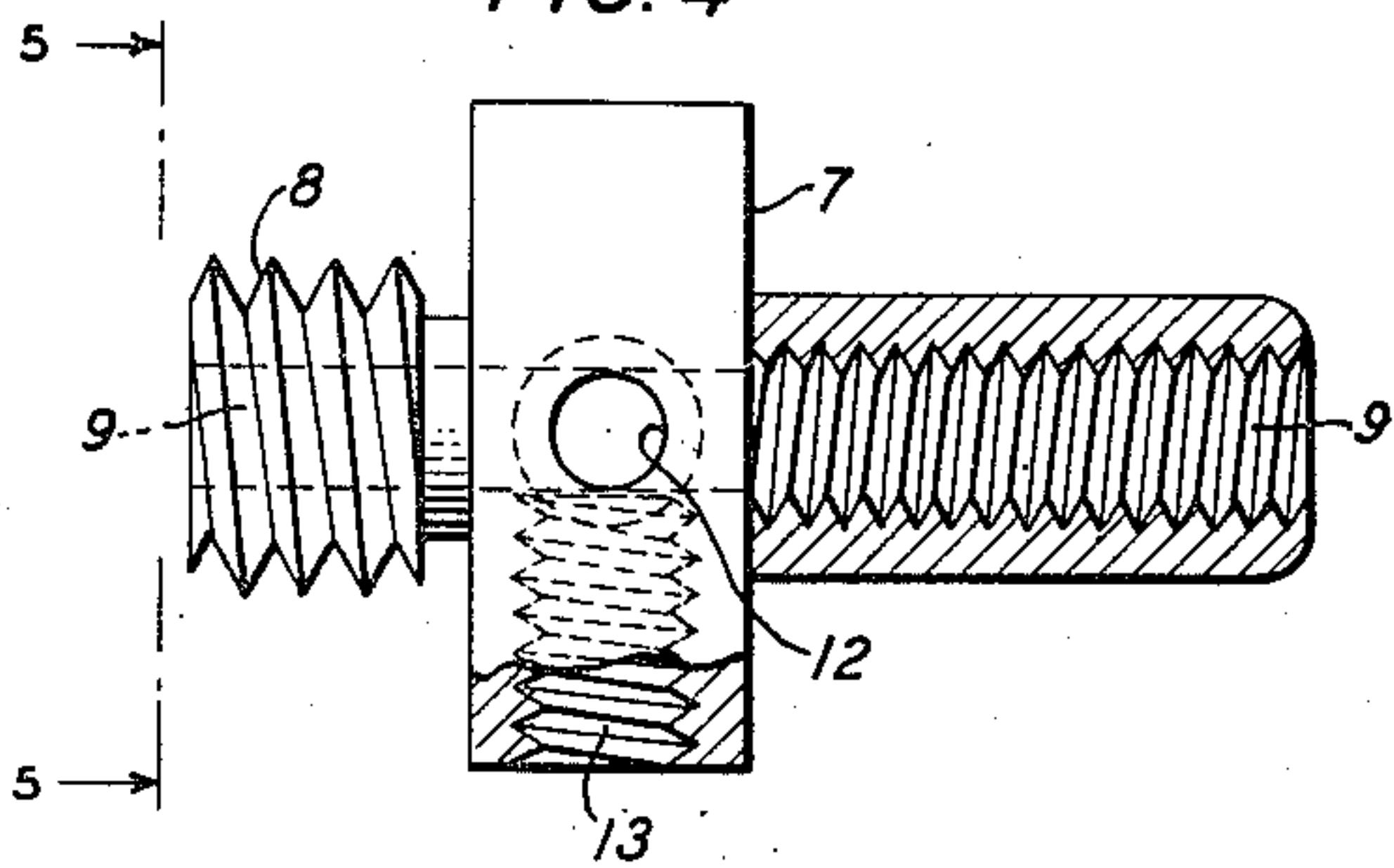


FIG. 5

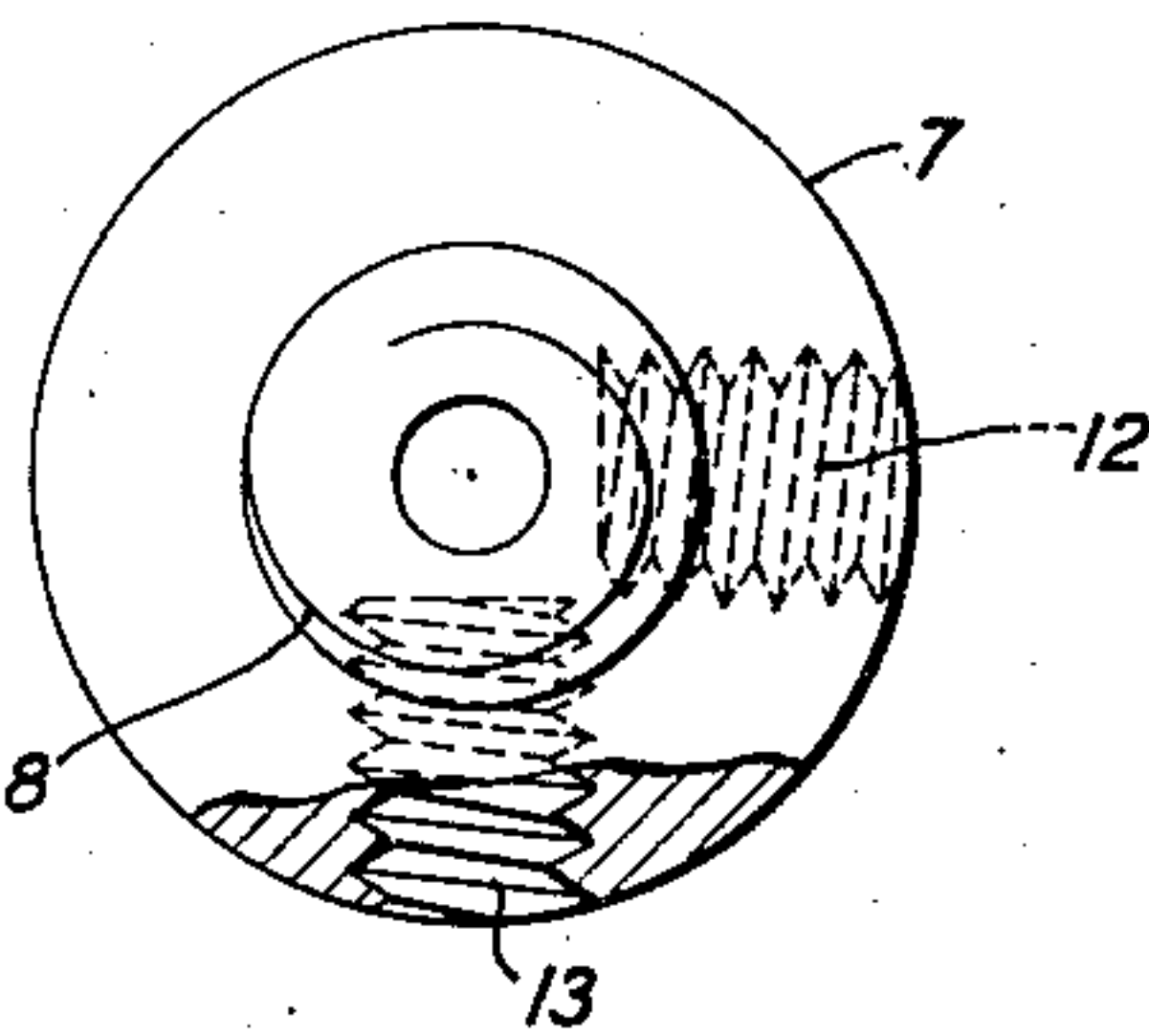


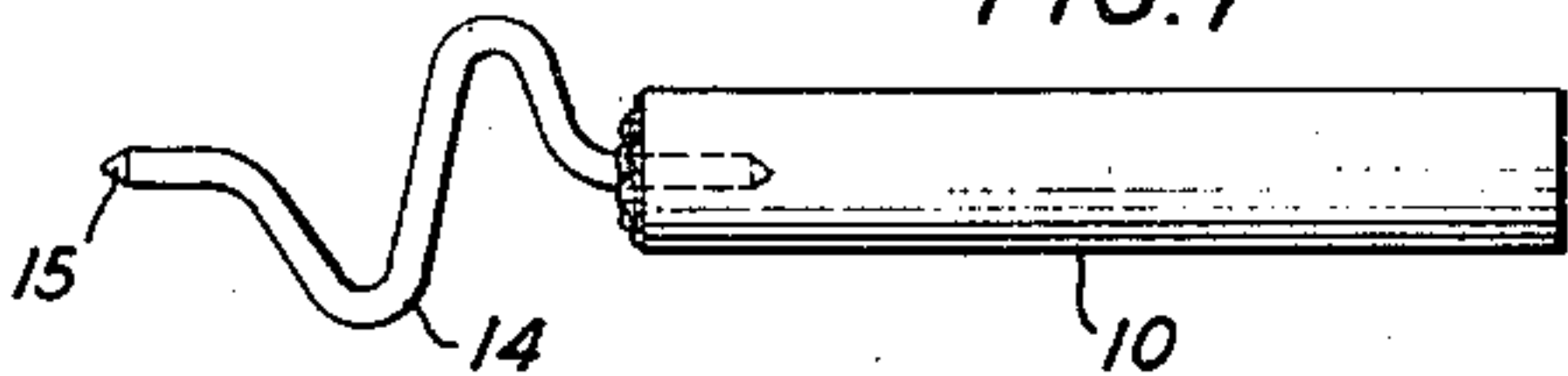
FIG. 6



FIG. 8



FIG. 7



D. A. MC LEAN
INVENTORS: H. C. THEUERER

BK *W. T. McKinney*
ATTORNEY

UNITED STATES PATENT OFFICE

2,432,116

CRYSTAL DETECTOR MOUNTING

David A. McLean, Chatham, N. J., and Henry C. Theuerer, New York, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application April 19, 1943, Serial No. 483,616

6 Claims. (Cl. 250—31)

1

This invention relates to translating devices and methods of making them and particularly to rectifying and detecting devices for the translation of electric waves.

The objects of the invention are to procure a greater degree of stability in translating devices and especially those having delicate structural parts; to obtain a protective material for these devices which is capable of withstanding wider temperature ranges; to increase the useful life of these devices; to increase their electrical efficiency; and in other respects to effect improvements in devices of this character.

In the field of microwave transmission in which signal waves are used having frequencies as high as 3,000 megacycles, translating devices, such as the conventional discharge tubes, are inadequate, and in their stead it has been necessary to use devices of the contact type, particularly in the early or conversion stages of the signal receivers. Moreover, rectifiers and detectors of the various contact types which have been generally known in the art heretofore are also unsuitable for the translation of waves with frequencies of the order above mentioned. The exacting requirements imposed at these extreme frequencies have, therefore, led to a specially designed contact rectifier consisting essentially of a crystal of some suitable substance, such as silicon, and a contact spring of fine wire making a point engagement with the surface of the crystal. Structurally such a rectifier unit includes a hollow ceramic cylinder internally threaded to receive in opposite ends the threaded plugs of two metallic end caps. One of these threaded plugs carries a thin wafer of crystalline silicon, and the other plug carries a contact of fine spring wire, the pointed end of which engages the surface of the silicon crystal when the threaded plugs are secured into position in the ceramic cylinder.

Since the successful performance of the rectifier depends largely on the maintenance of a uniform contact relation between the contact wire and the crystal, it has been proposed to safeguard this contact against corrosion, contamination, or other disturbing influences by filling the chamber formed between the threaded plugs with wax materials. However, these materials have not been satisfactory where the units are subjected to wide variations of ambient temperature. At the lower end of the desired temperature range a filler of wax, which of course completely surrounds and covers the fine contact wire and the crystal surface, contracts and changes the relation between the contact point and the crystal. Numerous liq-

2

uid fillers have also been tried, but these were all found to be unsatisfactory for the reason that they are unable to withstand temperatures at the upper end of the desired range. At these higher temperatures all known liquids which would meet the requirements in other respects undergo a change of fluidity which makes them unsatisfactory.

With these difficulties in mind applicants have devised a material which is free from the disadvantages above mentioned and which possesses all of the characteristics essential to the intended purpose. More specifically, applicants' new material is derived by combining a liquid and a wax to form a gel having the desired consistency and being stable to a high degree over a sufficiently wide range of temperatures to satisfy the requirements.

A feature of the invention, therefore, is a translating device having a fine contact element mounted in a chamber which is filled with a gel having a high degree of stability over a wide range of temperatures.

These and other features of the invention will be discussed more fully in the following detailed specification.

In the drawings accompanying the specification:

Fig. 1 is an assembly view of a rectifier unit illustrated largely in cross section;

Fig. 2 is a cross-sectional view of the ceramic cylinder which forms the housing for the rectifying elements;

Fig. 3 is a cross-sectional view of the bottom end cap;

Figs. 4 and 5 show side and end views respectively of the upper cap;

Fig. 6 is a perspective view of the rectifying crystal;

Fig. 7 shows the spring contact wire and its holder; and

Fig. 8 is one of the set screws for holding the contact holder in position.

Before discussing the improved filling material a description will be given of the mechanical structure of the rectifier unit. Referring to the drawings for this purpose, which show the unit greatly enlarged, the protective chamber for the crystal and spring contact is formed by a hollow cylinder 1 of a ceramic having the requisite electrical and mechanical properties. The cylinder 1 has a small hole 2 in the side thereof extending through to the hollow interior for a purpose which will be explained hereinafter.

The bottom cap 3, which closes the lower end of the cylinder 1, is preferably made of brass and

3

plated with silver. Integral with the main body of the cap 3 is a threaded stud or plug 4 which screws into corresponding interior threads in the ceramic cylinder 1. A tapped bore 5 is provided in the base of the cap 3 to facilitate the manufacturing process and may also be used later for mounting purposes.

The rectifying element of the unit consists of a cylindrical wafer 6 of crystalline silicon which is soldered or otherwise secured to the end of the plug 4.

The upper cap 7, which is likewise made of brass and silver-plated, is provided with a threaded plug 8 engaging the interior threads of the ceramic cylinder 1. A bore 9 of suitable diameter passes longitudinally through the cap 7 and plug 8 and serves to receive the spring contact holder 10. The upper end of the bore 9 is threaded for a distance to receive one of the set screws 11. The body of the cap 7 also contains two tapped holes 12 and 13, disposed at right angles, for receiving a pair of the set screws 18 and 19.

The remaining mechanical element of the device, the spring contact assembly, consists of the holder 10, cylindrical in form and preferably of brass, which is designed to slide freely in the bore 9 through the cap 7 and plug 8. One end of the holder 10 is orificed to receive the spring contact element 14. The element 14 consists of an extremely fine wire of some suitable material such as tungsten. It is first coated with a suitable contact metal and is then formed in a bending machine to give it the necessary resiliency. Finally the spring wire is secured in place in the holder 10 by means of a soft solder. The tip or contact end 15 of the spring wire 14 is ground to a point, the angle of the cone thus formed being chosen at any desired value.

To assemble the unit, the holder 10 of the contact assembly is inserted in the bore 9 of the cap 7, and the set screws 18 and 19 are adjusted to frictionally retain the holder 10 lightly in its tentative position. This preliminary position of the holder 10 in the cap 7 is carefully selected so that the contact point 15 of the spring 14 will lie safely above the surface of the crystal 6 when the parts are finally assembled. Next the ends of the ceramic cylinder 1 are coated with some sealing substance such as orange shellac, and the end caps 3 and 7 are secured firmly into position by means of a wrench. The top set screw 11 is now inserted and turned to advance the contact point 15 toward the crystal surface, care being taken that the side screws 18 and 19 are reasonably tight. When the desired degree of initial pressure has been obtained between the contact point and the crystal surface, the unit is given a tap with a light hammer. This tap blunts the conical end of the contact slightly and establishes the desired engagement surface between the contact and the crystal. Thereafter the direct current characteristics of the unit are observed by any suitable measuring equipment, such as an oscilloscope, and further adjustments are made if necessary. As the tests and adjustments proceed the set screws 11, 18 and 19 are gradually tightened until the holder 10 is firmly seized in its final position.

The successful performance of the rectifier in circuits involving the extremely high frequencies heretofore mentioned depends upon the maintenance of the delicately adjusted contact relation between the spring wire 14 and the surface of the silicon crystal 6. While the invention is not limited, of course, to any specific dimensions for

4

the parts concerned, it may be noted by way of emphasizing the fineness of the contact engagement that the contact wire 14 may be as small as .005 inch in diameter or even smaller and that the silicon wafer 6 may be as thin as .015 inch and may have a diameter of .077 inch or less. It is highly essential, therefore, that the conditions prevailing in the chamber 17 shall be maintained uniform regardless of temperature changes, atmospheric changes or mechanical disturbances to which the assembled unit may be subjected in actual operation. Unless some provision is made to guard the rectifying contact the presence of moisture, corrosive vapors or gases would soon bring about an impairment in the performance of the device. In view of the necessity for adjusting the contact pressure between the spring 14 and wafer 6 it would be very difficult if not impossible to enclose these elements in a vacuum or in the atmosphere of a protective gas. Moreover, the rectifier unit is subject to shock in handling and in use, and some provision must be made to safeguard the delicate point contact against these hazards. These and other factors indicate, therefore, the desirability of filling the chamber 17 with some protective substance.

To find a substance which would meet all of the requirements, however, presented a most difficult problem. Among the severest of these requirements is the necessity for substantial stability over a wide range of temperatures. In practical use the rectifier units may be subjected to temperature ranges varying from +70° to -40° centigrade. Substances such as heavy liquids, which might serve the purpose fairly well at low temperatures, increase in fluidity to such an extent at the higher temperatures that they are wholly unsatisfactory. Other substances, such as waxes, were found to be fairly stable at the higher temperatures, but at the lower end of the temperature scale the contraction they undergo is sometimes sufficient to alter the adjustment of the contact and in some cases to displace the spring wire with respect to the crystal.

With these circumstances in mind, applicants have devised a novel filling substance which has a consistency well suited to the protection of the spring contact against the mechanical disturbances, which is impervious to moisture, vapors and gases, which has a high degree of stability over the wide temperature range to which the units are subjected, and which also has a minimum temperature coefficient of expansion. This substance is derived from a solution of hydrogenated castor oil in a liquid comprising a solution of a high molecular weight hydrocarbon polymer in a refined mineral oil. The solution of hydrocarbon polymer in the mineral oil is chosen to give a heavy viscous and tacky liquid. A suitable composition for this hydrocarbon polymer-mineral oil solution has been found to be about 5 to 10 per cent of polyisobutylene in a refined mineral oil of viscosity corresponding to S. A. E. 10 to S. A. E. 20. The other component, the hydrogenated castor oil, is a hard flaky wax. The hydrocarbon polymer solution and the castor oil wax are brought together in the neighborhood of 80 parts to 20 parts by weight, respectively, and heated to a temperature of 100° centigrade for a minimum period of two hours. At this temperature all the components enter into a complete solution. The temperature is then decreased, and as a point somewhat above 80° centigrade is approached some of the wax precipitates out in finely divided particles, and the remainder of the

5

solution forms a stiff gel which holds the precipitated wax in suspension. The resulting mass, therefore, comprises a gel in continuous phase holding in stiff suspension a discontinuous phase of the solid wax. This gel filler is introduced into the chamber 17 through the opening 2. It completely surrounds the spring wire 14, protects it from mechanical shock and from corrosive influences, and remains in a stable condition through all temperature changes that may be imposed on the unit.

The gel filler is introduced into the chamber 17 through the small hole 2 in the side of the ceramic cylinder by means of a vacuum impregnation process. First the assembled unit is baked at a temperature of 90° centigrade for a minimum of ten minutes to dispel all moisture and gases. A rack containing a plurality of the units is suspended in a tube above a mass of the filling solution at a temperature of 90° centigrade as above explained. The tube is then evacuated and the rack is lowered into the liquid solution until the filling holes 2 are below the surface. Air pressure is then admitted into the tube to force the molten solution into the chamber 17 of the rectifier units. The rack is then removed from the liquid and placed in an electrically heated oven in which the liquid within the rectifier units is permitted to cool and solidify at a controlled rate.

What is claimed is:

1. The combination in a translating device of a housing member forming an enclosed chamber, a translating element mounted in said chamber, a fine resilient contact wire mounted within said chamber and adjustable to form a point contact between the free end thereof and the surface of said translating element, and a gel filling said chamber and surrounding said contact wire to protect it and to maintain a uniform relation between it and the translating element, said gel having a high degree of stability over a wide range of temperatures.

2. The combination in a translating device of a housing member forming an enclosed chamber, a translating element mounted in said chamber, a fine resilient contact wire mounted within said chamber and having its free end adjustable to form a point contact with the surface of said translating element, and a stiff gel filling said chamber and surrounding said contact wire and covering the surface of said translating element, said gel having a stable consistency and being substantially free from expansion and contraction over a temperature range from +80° to -75° centigrade.

3. The combination in a translating device of a housing member, a small crystal mounted in said housing member, a fine resilient contact wire mounted in said housing member and having its free end adjustable to form a point contact with the surface of said crystal, a protective substance surrounding said contact wire and serving to maintain a uniform relation between the end of said wire and the crystal surface over a wide range of temperature changes, said substance constituting a gel in continuous phase derived

6

from a heat-treated solution of polyisobutylene and mineral oil and hydrogenated castor oil, said gel holding suspended in discontinuous phase a fine precipitate of the hydrogenated castor oil.

4. The combination in a translating device of a hollow ceramic cylinder, a pair of caps sealing the opposite ends of said cylinder to form an internal chamber, a wafer of crystalline silicon secured to one of said caps and located within said chamber, a fine contact wire secured to the other one of said caps and located within said chamber, means for adjusting said contact wire to establish a point contact between its free end and the surface of said wafer, and a protective gel filling said chamber, said gel having a stable consistency and being substantially free from expansion and contraction over a temperature range from +80° to -75° centigrade.

5. The method of making a translating device having elements forming a fine translating contact point which comprises mounting said contact elements within an enclosed chamber having a small passage leading thereto from the exterior, preparing a mixture of hydrogenated castor oil and polyisobutylene and mineral oil, raising the temperature of the mixture until the components enter into complete solution, introducing the liquid solution through said passage until said chamber is filled therewith, lowering the temperature of the solution to permit the formation of a stiff gel containing a discontinuous phase of precipitated wax, said gel having a high degree of stability over a wide range of temperatures and serving to protect and maintain the stability of said translating contact point.

6. The combination in a translating device of a housing member forming an enclosed chamber, a translating element mounted in said chamber, a fine resilient contact wire mounted within said chamber and having its free end adjustable to form a point contact with the surface of said translating element, said housing member having a small opening therein for the introduction of a protective filling into said enclosed chamber, and said filling which comprises a stiff gel which remains at a stable consistency over a wide range of temperatures and surrounds the contact wire and translating element and protects and maintains said point contact in a stable condition.

DAVID A. McLEAN.
HENRY C. THEUERER.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,280,860	Smyers	Apr. 28, 1942
2,226,590	Smyers	Dec. 31, 1940

FOREIGN PATENTS

Number	Country	Date
139,904	Great Britain	Mar. 18, 1920
496,562	Great Britain	Nov. 11, 1919