Nov. 4, 1947. W. G. PFANN ET AL 2,430,028

TRANSLATING DEVICE AND METHOD OF MAKING IT

Filed March 16, 1943 2 Sheets-Sheet 1

FIG. 1

FIG. 2

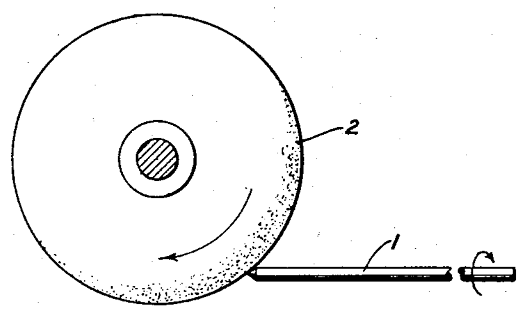

FIG. 4

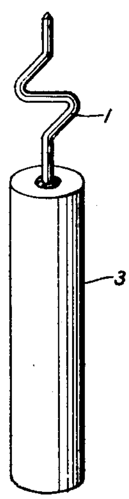

FIG. 3

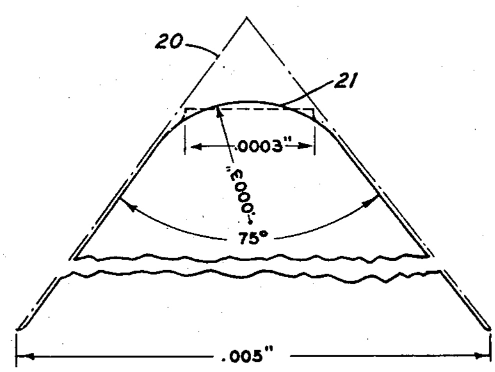

FIG. 9

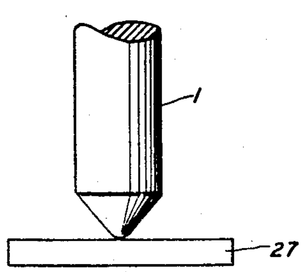

FIG. 10

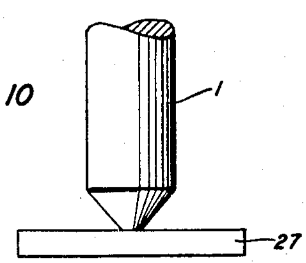

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FIG. 5

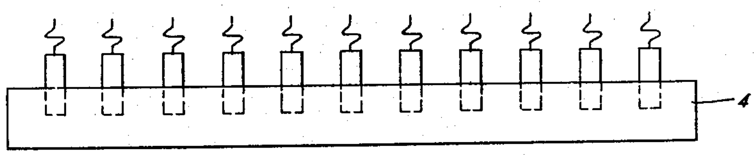


FIG. 6

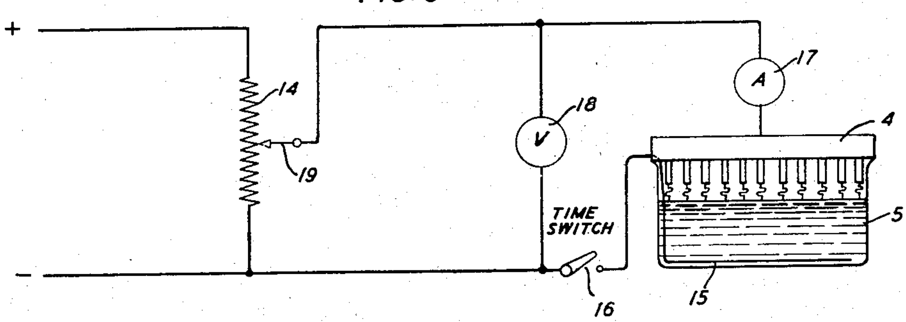
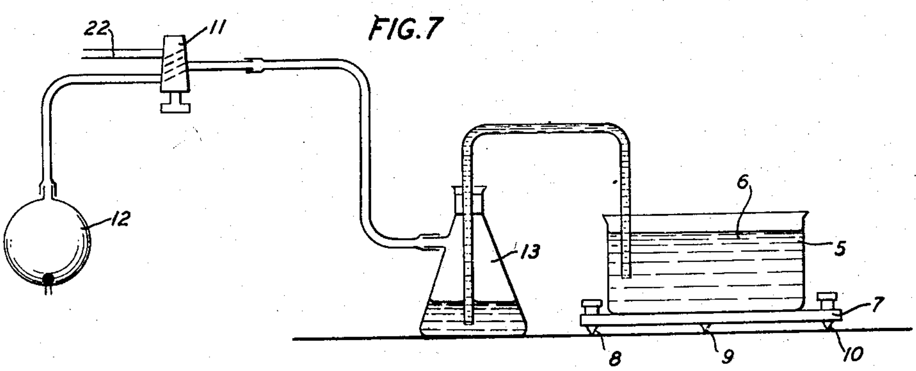


FIG. 7



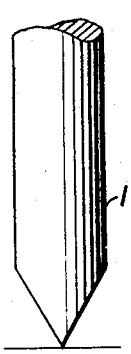


FIG. 11

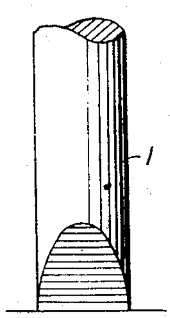


FIG. 12

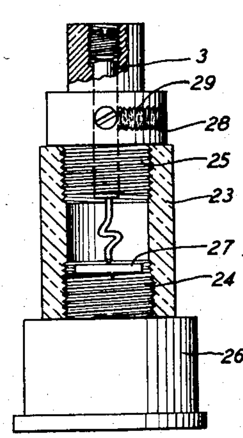


FIG. 8

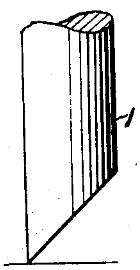


FIG. 13

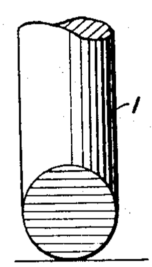


FIG. 14

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2,430,028

TRANSLATING DEVICE AND METHOD OF MAKING IT

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Application March 16, 1943, Serial No. 479,320

11 Claims. (Cl. 250—30)

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This invention relates to electrical translating devices and particularly to methods of making devices of this kind having small areas of contact between different materials.

The objects of the invention are to improve the efficiency of translation; to reduce noise currents and other undesirable effects in the output circuits of these devices; to realize a greater economy in manufacture; and to secure other improvements in devices of this kind and in methods of making them.

With the extension of signaling frequencies in the radio and allied arts into the ultra-high frequency range where waves of a few centimeters in length are employed for signaling purposes it has become necessary to develop new types of apparatus for receiving, translating, and utilizing the signal energy at these extreme frequencies. One of the problems has been to devise a satisfactory translating device which is capable of detecting, converting, or otherwise translating signal waves having frequencies of the order mentioned. Up to the present time the most promising solution of this problem has been a translating or rectifying device of the point-contact type. In one form a fine tungsten wire is mounted so that its free end engages the surface of an element having suitable rectifying properties, such as a crystal of elemental silicon.

More specifically, rectifiers of this kind have been made by grinding one end of the fine tungsten wire (.005 inch in diameter) to a conical point, carefully assembling the elements to bring the ground point into resilient contact with the surface of the crystal so as to flatten the pointed end of the wire until the contact engagement between the wire and the crystal surface becomes a small finite area, and finally tapping the assembled unit with light blows until this contact is so modified that the rectifier displays the desired electrical properties. In the ideal case the flattened end of the pointed wire should be circular, and the entire area of this small circle should make intimate contact with the surface of the assocated crystal. However, it has been almost impossible to attain this ideal, and in practice it is found that more often the upset or flattened end of the pointed wire is irregular in shape and irregular in its contact engagement with the crystal surface.

Experimental tests performed with rectifiers made by the method above described demonstrate clearly that the performance of the rectifier in signaling systems is adversely affected by the irregularities present at the contact surface of

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the tungsten wire. Chief among the performance factors of the rectifier are its translation or conversion efficiency and the noise power present in its output circuit. The noise power in particular is definitely correlated with microscopic irregularities in the shape of the flattened point and also with the microscopic grinding marks and burrs resulting from the grinding process.

According to the present invention, therefore, these disadvantages are overcome by an improved method of making translating devices of this character in which the fine spring contact wire is first ground to a desired conformation, such as a conical point or a wedge-shaped tip, in which the wire thus prepared is subjected to electrolytic action for the purpose of etching away a portion and reforming the tip to produce a rounded area instead, in which the wire is further treated electrolytically to polish the rounded point to a smooth and uniform surface, and in which the spring wire thus prepared is assembled in relation to the crystal surface and a force applied thereto to upset the reformed end of the wire and produce a contact area of desired shape and dimensions.

Another feature of the invention is the method of preparing the contact wire by grinding the end thereof to a conical point with a predetermined angle at the apex, etching and polishing said wire electrolytically to reform said conical point into a spherical point of predetermined radius, and flattening the rounded end of said wire to produce a circular surface of predetermined diameter.

As above noted, this method may be applied, if desirable, to the formation of oblong or other noncircular contact areas. In such a case the rectifier contacts are made by grinding or shearing the wire to a wedge-shaped point instead of a cone-shaped point. The shape of the wedge may result from the intersection of two planes with a cylinder so that the line of intersection lies in a plane approximately normal to the central axis of the cylinder or from the intersection of a single plane with a cylinder so that the line of intersection is at the periphery of the cylinder. As with cone-shaped points, irregularities at the contact surface of the wire adversely affect the performance factors of the rectifier.

When this improved method is followed a much greater degree of uniformity is obtained in the manufacture of these rectifier contact wires, and a large saving is realized by reducing greatly the number of finished rectifiers that need to be rejected. A microscopic examination of the etched and polished points shows them to be smooth, well-formed and free from ruptures, burrs and other irregularities which are known to be productive of noise effects. Furthermore, the final flat contact surface which engages the flat surface of the associated crystal and constitutes the rectifying area is more uniform and is more easily controlled as to the shape and size of the contact area desired for best operating performance.

Another definite advantage of this method is that the rectifiers thus made are capable of sustaining electrical power of much greater values than those heretofore produced by former methods.

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 shows a length of wire used for forming the contact spring;

Fig. 2 illustrates the step of grinding one end of the spring wire to a conical point;

Fig. 3 is a view greatly enlarged showing the shapes of the contact point following the different steps of the process;

Fig. 4 shows the ground contact wire after it has been fixed in the holder and formed to give it resilience;

Fig. 5 is a holder in which a plurality of contact springs are mounted during the electrolytic process;

Fig. 6 shows the electrical circuit for performing the electrolytic action;

Fig. 7 shows the apparatus used for controlling the level of the electrolyte;

Fig. 8 is an assembly view of one of the translating devices;

Fig. 9 is an enlarged view of the contact wire with a cone-shaped point, showing its relation to the rectifying crystal just before contact between the wire and the crystal is made;

Fig. 10 shows this relationship after completion of the adjusting and tapping processes;

Figs. 11 and 12 are front and side views respectively of the contact wire when ground to a wedge-shaped tip; and

Figs. 13 and 14 are front and side views respectively of an alternative form of the wire with a wedge-shaped tip.

As mentioned hereinbefore the best results in the microwave field are obtained from these contact rectifiers when the contact area between the fine spring wire and the crystal surface has a predetermined shape and size and when it is free from surface imperfections and irregularities. In accordance with the method about to be described, these essential requirements are attained and reproduced in manufacture with a high degree of uniformity.

Referring now to the drawings, the contact spring of the translating unit is made from a length of tungsten wire 1, which is preferably plated with a noble metal such as gold. Although the invention is not so limited it will be assumed for the present purpose that the tungsten wire has a diameter of .005 inch. The wire 1 is fixed in a rotating chuck, and one end is ground to a conical point by means of a high speed grinding wheel 2.

The angle at which the wire is applied to the grinding wheel is chosen so that the apex angle of the cone point falls between 70 degrees and 80 degrees, it having been found that the optimum value is about 75 degrees. This angle is illustrated in the enlarged view of Fig. 3.

After one end of the wire 1 has been ground, the other end is soldered into a cylindrical holder 3 of some suitable conducting material such as brass. Next the wire 1 is bent a number of times as seen in Fig. 4 to give it the property of a spring when pressure is applied to the free end thereof.

The ground contact wire is now ready for the etching and polishing steps of the electrolytic process. The apparatus for this purpose is shown in Figs. 5, 6 and 7. A plurality of the mounted contact wires, such as the one shown in Fig. 4, are affixed in a suitable metallic holding strip 4 as seen in Fig. 5. The holder 4 is then supported over the dish 5 with the contact wires projecting downwardly. The electrolyte 6 within the dish 5 is an aqueous solution containing 25 per cent by weight of potassium hydroxide. The dish 5 is supported on a tripod table 7 having leveling screws 8, 9 and 10 for adjusting the level of the electrolyte 6 with respect to the rim of the dish on which the holder 4 is supported.

The elevation of the electrolyte 6 in the dish 5 is controlled by the pump and siphon arrangement shown in Fig. 7, and it may be assumed that the level of the solution 6 is relatively low in the dish 5 when the holder 4, filled with spring elements, is placed in position on the rim of the dish. The level of the electrolyte 6 may now be brought to the desired elevation for immersing the ground points of the contact springs by adjusting the stop-cock 11 to the position illustrated in the drawing and applying pressure to the rubber bulb 12. Applied pressure within the vessel 13 forces the auxiliary supply of the electrolyte into the dish 5, and this action may be continued until the ground contact points are immersed to the desired depth. The necessity for precision in the depth of immersion is avoided by the use of gold plating on the wire 1. The tungsten of the wire is exposed to the electrolyte only at the ground point, and the gold plating which covers the remainder of the wire is not materially affected by the electrolytic action.

Referring now to Fig. 6, it will be noted that the spring contact wires are made anodic by connecting the metallic holder 4 through the resistance 14 to the positive pole of the current source. Cathode 15 is connected through a time switch 16 to the negative pole of the source. An ammeter 17 indicates the current flowing, and a voltmeter 18 indicates the applied voltage.

The first or etching step in the electrolytic process is performed by applying a potential difference of 0.80 volt for two seconds. This is accomplished by adjusting the rheostat contact 19 until the voltmeter 18 indicates 0.80 volt with the switch 16 open, and by closing the switch 16 for a period of two seconds. During this interval the material forming the extreme point 20 and to a small extent the material on the side surfaces of the cone (illustrated in Fig. 3 by the space between the broken lines and the solid-line contour) is etched away leaving a substantially spherical surface 21, the radius of which is about .0003 inch. Also all burrs, sharp points and grinding scratches are removed. The next or the polishing step in the process is performed by subjecting the etched point to two successive flashes of two volts, the duration of each flash being 0.2 second. These voltage and time values are obtained by adjusting the rheostat and the time switch accordingly. The purpose of these brief flashes at relatively high voltage is to eliminate all remaining surface irregularities and to attain a rounded point 21 having a very high polish.

The level of the electrolyte 6 is now lowered in the dish 5 by turning the stop-cock 11 to its alternate position. In the alternate position atmospheric pressure is established in the vessel 13 through the intake pipe 22, and the siphon action transfers some of the electrolyte 6 from the dish 5 to the vessel 13. Finally the holder 4 is removed.

After washing and drying, the polished contact elements are now ready for assembly in the complete rectifiers. One of these rectifiers is shown in Fig. 8. It consists of a ceramic cylinder 23, the two ends of which are closed by the threaded metal plugs 24 and 25 forming a chamber within. The plug 24, which is integral with the base and terminal cap 26, carries a wafer of crystalline silicon 27. The other plug 25 and the metallic cap 28, of which the plug is an integral part, contain a central bore for receiving the cylindrical holder 3. The holder 3 is adjusted to bring the rounded and polished point of the wire 1 into engagement with the surface of the crystal 27 with the desired degree of force where it is held by set screws 29. During this step the force exerted on the extreme tip of the wire flattens it to a small finite contact area. The assembled unit is now ready for the tapping process, which consists in striking the unit a light blow. By carefully regulating the force of this blow or by repeating it the desired electrical properties of the rectifier are obtained. The combined effect of the adjusting and tapping process produces the optimum flat contact area on the point of the wire, which, in the case of conical grinding, has been found to be circular and to have a diameter of about .0003 inch. A comparison of the contact point before and after the combined adjusting and tapping process is illustrated in the enlarged views of Figs. 9 and 10 and is also illustrated in the more highly magnified view of Fig. 3.

Figs. 11 and 12 are magnified views of a contact wire 1 which has been ground or otherwise reformed with a wedge-shaped tip, and Figs. 13 and 14 are similar views of the contact wire having an alternate form of wedge-shaped tip. The contact wires prepared with the wedge-shaped tips are, like those having conical tips, subjected to the same electrolytic treatment for etching and polishing the formed tips and also to the other steps of the procedure above described for upsetting the reformed tips and assembling them in the rectifier units.

What is claimed is:

1. The method of making an electrical translating device which comprises grinding the end of a fine wire to a conical point, subjecting said wire to electrolytic action to reform the ground end thereof, and mounting this wire with the reformed end thereof in electrical contact with the surface of an element of conducting material.

2. The method of making an electrical translating device which comprises grinding the end of a fine wire to a conical point, subjecting said wire to electrolytic action to reform the ground end thereof, mounting this wire with the reformed end thereof in physical contact with the surface of an element of conducting material, and subjecting said wire to a force for upsetting the reformed end thereof to form a plane surface of electrical contact between said wire and said conducting element.

3. The method of making an electrical translating device which comprises grinding the end of a fine wire to a conical point, etching away by electrolytic action a portion of said conical point to form instead a point substantially spherical in shape, mounting said wire with the reformed end thereof in physical contact with the surface of a conducting element, and subjecting said wire to a force for upsetting the rounded end thereof to form a plane surface of electrical contact between said wire and said conducting element.

4. The method of making an electrical rectifying device which comprises grinding the end of a fine tungsten wire to a conical point with a predetermined angle at the apex thereof, subjecting said wire to electrolytic action for etching away a portion of the conical point to form instead a point substantially spherical in shape with a radius of predetermined value, mounting said wire with the reformed end thereof in physical contact with the surface of a silicon crystal, and subjecting the element thus assembled to a physical force for upsetting the spherical end of said wire to produce a plane surface of predetermined diameter in engagement with said silicon crystal.

5. The method of making the pointed element of a point-contact rectifier which comprises grinding the end of a fine wire to a conical point and etching away electrolytically a portion of the ground point to form a rounded surface.

6. The method of forming the pointed element of a point-contact rectifier which comprises grinding the end of a fine wire to a conical point, etching away electrolytically a portion of the ground point to form a rounded surface, and polishing said rounded surface electrolytically to remove all surface irregularities.

7. The method of making an electrical rectifying device which comprises grinding one end of a fine wire to a conical point, securing the other end of said wire in a holder, bending said wire to form a number of turns intermediate its ends for the purpose of giving it the property of resilience, subjecting the free end of said wire to electrolytic action to reform the conical point thereon, mounting said holder to bring said reformed point into engagement with the surface of a conducting element under the resilient pressure of said wire, and subjecting said wire to a force for flattening the reformed end thereof to present an engagement surface of desired shape and size between said wire and said conducting element.

8. The method of making an electrical translating device which comprises shaping the extreme tip end of a wire to a desired conformation, subjecting said wire to electrolytic action to reform the tip end thereof, and mounting this wire with the reformed end thereof in electrical contact with the surface of an element of material having conducting properties.

9. The method of making an electrical translating device which comprises grinding the tip end of a fine wire to a wedge-shaped conformation, subjecting said wire to electrolytic action to reform the ground end thereof, mounting this wire with the reformed end thereof in physical contact with the surface of an element of conducting material, and subjecting said wire to a force for upsetting the reformed end thereof to form a surface of electrical contact between said wire and said conducting element.

10. The method of making an electrical trans-

lating device which comprises grinding the end of a fine wire to a sharp point of desired conformation, etching away by electrolytic action a portion of the ground sharp point to form instead a rounded point, mounting said wire with the reformed end thereof in physical contact with the surface of an element having conducting properties and subjecting said wire to a force for upsetting the rounded end thereof to form a plane surface of electrical contact between said wire and said element.

11. The method of making a point-contact rectifier which comprises grinding the end of a fine wire to a conical point having an apex angle of approximately 75 degrees, and etching away electrolytically a portion of the ground point to form a smooth rounded surface.

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