Jan. 13, 1948. W. G. PFANN 2,434,286

METHOD OF FORMING A POINT AT THE END OF A WIRE

Filed Aug. 12, 1943 2 Sheets-Sheet 1

FIG. 1

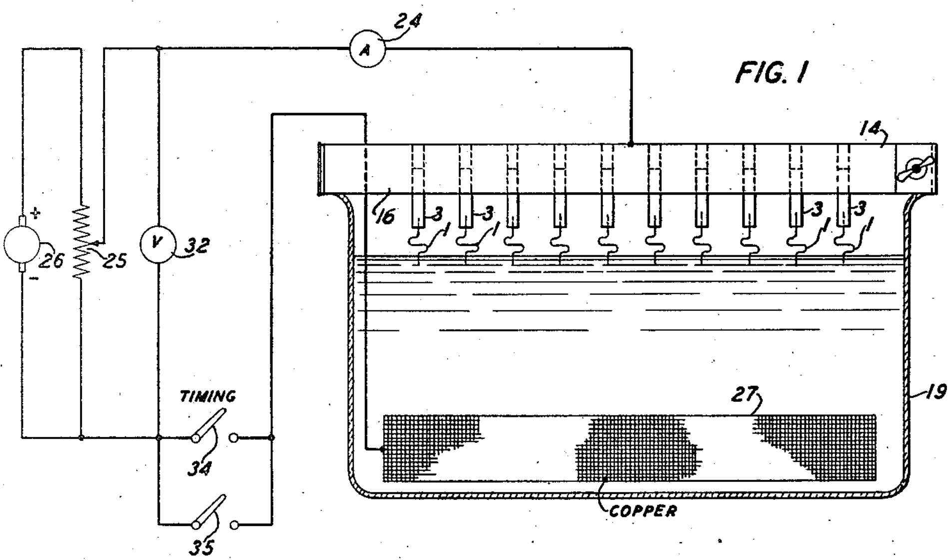
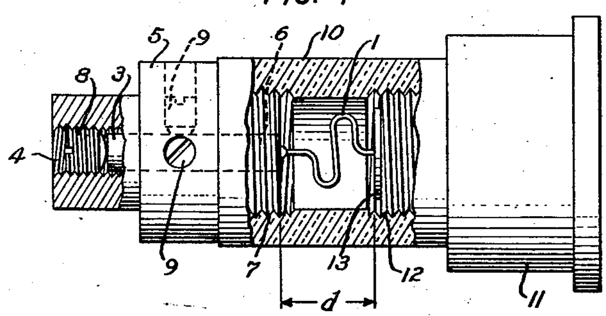


FIG. 4



INVENTOR
W. G. PFANN
BY M. R. McKenney
ATTORNEY

Jan. 13, 1948. W. G. PFANN 2,434,286

METHOD OF FORMING A POINT AT THE END OF A WIRE

Filed Aug. 12, 1943 2 Sheets-Sheet 2

FIG. 2

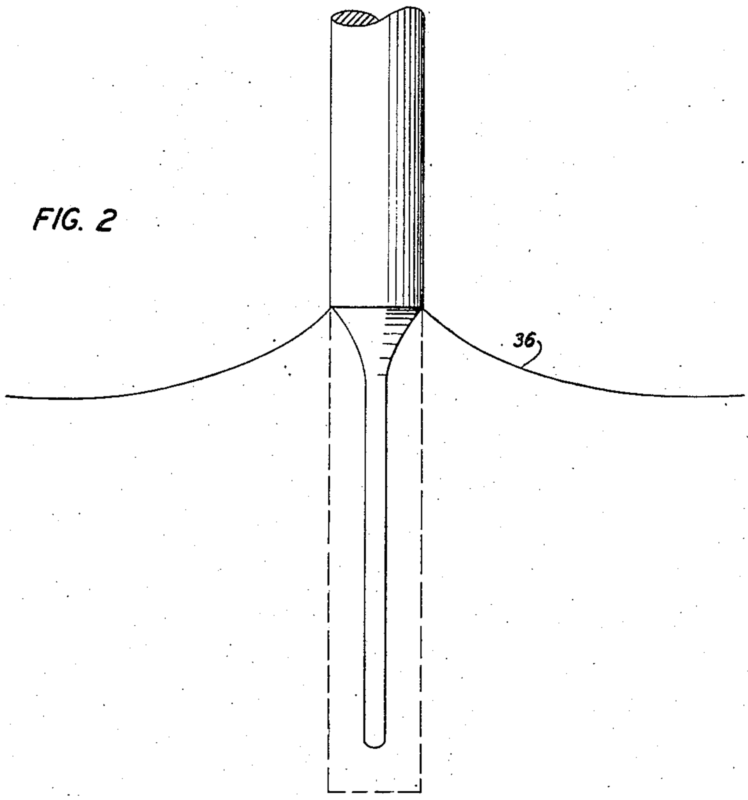
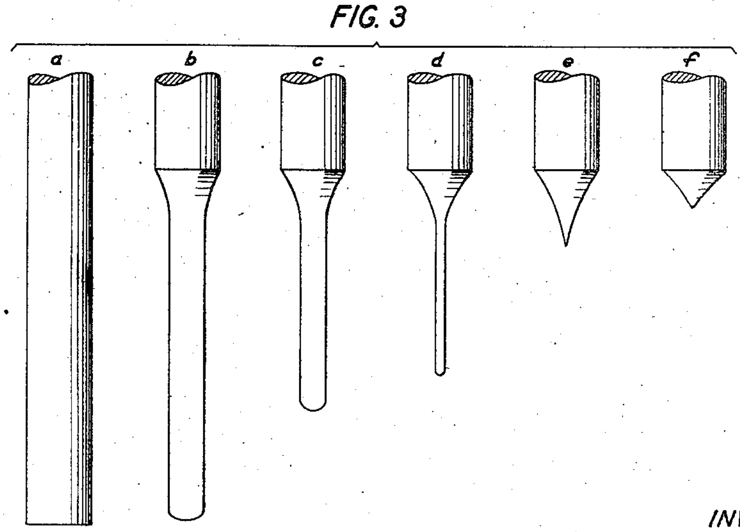


FIG. 3



INVENTOR
W. G. PFANN
BY
M. R. McKenney
ATTORNEY

Patented Jan. 13, 1948

2,434,286

UNITED STATES PATENT OFFICE

2,434,286

METHOD OF FORMING A POINT AT THE END OF A WIRE

William G. Pfann, Summit, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application August 12, 1943, Serial No. 498,376

2 Claims. (Cl. 204—142)

1

This invention relates to electrical conducting and translating devices and particularly to methods of making them.

The objects of the invention are to obtain a higher degree of uniformity and to realize greater economy and simplicity in the manufacture of conducting and translating devices; to increase their electrical efficiency; and to obtain other improvements in these devices and in the methods of making them.

To a very large extent the success with which ultra-high frequency signals, including those corresponding to wavelengths of a few centimeters, are employed in the radio and allied arts depends on the development of a translating device which is capable of detecting, converting, translating or otherwise utilizing signal waves of these extreme frequencies. Up to the present time the most promising translating device for these purposes is one of the point-contact type. In one of its forms it includes a fine tungsten wire mounted with the free end of the wire engaging the surface of an element having suitable rectifying properties such as a crystal of elemental silicon.

More specifically, one method heretofore used in making these rectifiers consists in grinding one end of the fine tungsten wire to a sharp point, soldering the other end of the wire into the end of a metal rod or holder, and carefully assembling the elements to bring the free ends of the wire first into proximity with but not touching the crystal surface. Thereafter the holder is adjusted until the point of the wire bears against the crystal with just the right degree of force. And it may be noted at this point that a slight excess of force destroys the contact point. Another method is to polish the point of the wire electrolytically in addition to the grinding step. There are objections to both of these methods. Both require the grinding operation which must be done with care and precision. Also in both cases the specification dimensions of the holder to which the contact wires are soldered must be closely met in the manufacturing process, which increases the cost, and any deviation from the specified dimensions necessitates a greater degree of care in the assembling operation. Otherwise the tip end of the contact wire is brought inadvertently into engagement with the crystal with excessive force, resulting in the destruction of the point.

In accordance with the present invention these disadvantages are surmounted by means of a new method of forming points on contact wires which eliminates entirely the preparatory grinding op-

2

eration and which automatically controls to very close limits the length of the contact wire in its supporting holder. More specifically a section of tungsten wire is cut to a length somewhat greater than that ultimately required, an approximation being sufficient, one end of this wire is soldered into a metallic holder, and the other end is treated in a specially prepared electrolytic solution to form a contact point of the desired shape and at a distance from the end of the holder, or from any other reference point thereon, which is exactly predetermined. This method not only dispenses with the preliminary grinding of the wire, a time-saving step in the process, but it also substantially eliminates the danger of destroying the contact during the assembling operation. Moreover, this latter achievement is realized without narrowing the limits of variation permissible in the manufacture of the contact holders, thus obviating the adoption of costly precision methods in making these holders. In fact the variation limits may be relaxed in some respects.

A feature of the invention is the method of shaping the end of a wire in which a portion of the wire is immersed in an etchant solution and in which the meniscus formed around the wire at the surface of the solution is controlled during the etching process to determine the shape of the point formed. This control over the meniscus is obtained by adding a particular ingredient to the etchant solution.

The foregoing and other features of the invention will be described more fully in the follownig detailed specification.

In the drawings accompanying the specification:

Fig. 1 illustrates the electrolytic apparatus for etching the contact wires;

Fig. 2 is a view illustrating the effect of the electrolyte on the contact wire; and

Fig. 3 illustrates the contact wire at different stages in the etching process.

Fig. 4 is a view partly in section of the fully assembled translator.

In one of these translating or rectifying devices designed for ultra-high frequency waves the critical part of the structure is the small contact point at the end of the contact wire which makes engagement with the surface of the rectifying crystal. To better understand the minute size of this contact point it may be noted at the outset that the tungsten contact wire used in these translating or rectifying devices has a diameter which is preferably as small as .005 inch and that the end of this wire is ground and shaped to form a contact engagement surface which is still smaller in diameter. After this contact point is formed on the end of the wire, the unit is assembled, and the contact point is advanced with care and precision into physical engagement with the surface of the crystal until the force exerted by the contact wire against the crystal is of just the right magnitude. In this manner the rectification contact is attained, and if excessive force is inadvertently applied the contact is ruined, and the wire must be discarded.

Before proceeding with a description of the process which constitutes the invention herein, a brief explanation will be given of the practice now followed in the preparation and assembling of these translating devices. Referring to Figs. 1 and 4 the tunsten wire is first cut to the estimated required length, following which this piece of wire 1 is soldered into the bore in an end of the cylindrical metal holder 3. Thereupon the tungsten wire 1 is given the shape shown in Figs. 1 and 4 to give it resiliency. There are a number of factors which tend to vary the distance *d* between the end face of the metal holder 3 Fig. 4 and the tip end of the contact wire 1. In the first place the bore holes in the ends of the holders will be subject to the usual manufacturing variations. Secondly, the amount of the wire 1 extending into the bore during the soldering operation will vary from one unit to another. Finally, the amount of wire used in the spring formation will also vary from unit to unit. Since it is desirable in the initial assembly to have the tip end of the contact wire 1 spaced only a short distance from the surface of the rectifying crystal, preparatory to the final adjustment, this variation in the distance *d* results in a large percentage of the contact wires being destroyed in the initial assembly. The method used, which is the most convenient one available, for performing the initial assembling operation is to insert the cylindrical holder 3 into the bore 4 of the cap member 5 and to adjust the set screw 8 until the end 6 of the holder is flush with the surface of the integral stud 7. Thereupon the set screws 9 are tightened enough to prevent any displacement of the holder 3. Next the threaded stud 7 is screwed into one end of the hollow ceramic cylinder 10, following which the base member 11 is added to the assembly. The base member 11 includes an integral metallic stud 12 which serves as the support for the silicon wafer 13. When, therefore, the threaded stud 12 is screwed into the opposite end of the ceramic cylinder 10 the enclosure within the cylinder is hidden from the operator's view, and the position occupied by the tip end of the contact wire 1 with respect to the surface of the silicon wafer 13 depends upon the distance *d*. If this distance is too great, the wafer 13 will engage the contact point and destroy it when the stud 12 is screwed into place.

Applicant's method of forming points on contact wires, whereby the foregoing difficulties are obviated and the processes heretofore used for making translator contacts are simplified, will now be described in detail. The initial steps are the same; the contact wires 1 are cut and soldered into the bore holes in the ends of the metal holders 3, and the wires are formed for resilience. The grinding operation, however, is omitted. A plurality of these units are now secured in a metallic holder 14 Fig. 1 which comprises two metal strips hinged at one end and containing a series of semicircular grooves, each pair of which receives one of the contact wire units. In assembling the units in the holder 14, a uniform distance between the lower edge 16 of the holder and the ends of the units 3 may be achieved by using a solid metal holder having holes drilled therein to a uniform depth for receiving the units 3. The holder 14 is now placed on a dish 19, containing an electrolyte, with the contact wires projecting downwardly. The dish 19 may be supported on a tripod having leveling screws, for adjusting the level of the electrolyte solution within the dish with respect to the rim on which the holder 14 is supported.

The etchant electrolyte in the dish 19 is preferably an aqueous solution of potassium hydroxide containing an ingredient, to be explained hereinafter, for controlling the meniscus formation at the surface of the solution. The metal holder 14 is connected through an ammeter 24 and potentiometer 25 to the positive pole of the source 26 causing the contact wires to serve as anodes in the electrolytic action. The cathode 27 is preferably formed of copper gauze and is connected through suitable switches 34 and 35 to the negative pole of the source 26. Before using, the copper gauze is permitted to remain in the solution long enough to acquire an oxide coating.

The level of the electrolyte within the dish 19 is controlled by any suitable means such as a pump and siphon arrangement, and it may be assumed that the level within the dish is relatively low when the holder 14, filled with contact wire elements, is placed in position on the rim of the dish. The level of the electrolyte may then be brought to the desired elevation for immersing the ends of the contact wires.

The first step in the point-forming process is to etch away the immersed section of each contact wire until a point of the desired configuration is formed thereon. As the electrolytic action proceeds, the major portion of the wire below the surface of the electrolyte retains in general its cylindrical form and gradually diminishes in diameter, as illustrated in Figs. 3*a*, 3*b*, 3*c* and 3*d*. However, the short section of the wire which lies within the zone of the meniscus 36 Fig. 2 is etched at a much lower rate, which decreases as the surface of the electrolyte is approached, becoming nil at the surface. The result of this phenomenon is the formation of a tapered section inside the meniscus as seen in Fig. 2. Finally the diminishing cylindrical section is wholly dissolved or is severed just before complete solution, leaving a sharply pointed taper as illustrated in Fig. 3*e*. Further action of the electrolyte causes the tapered point of Fig. 3*e* to become more and more rounded until finally, if the action is permitted to continue, the end of the wire assumes a substantially plane surface. Thus it is possible to select between the limits of Fig. 3*e* and a plane-ended wire any desired one of a large number of shapes.

Since the shaping of the point depends on the shape of the meniscus 36, it is important to control the extent of the meniscus and to insure its maintenance during the process. For wires of the size above mentioned (.005 inch in diameter) it has been found that a solution of potassium hydroxide, 25 per cent by weight, provides a meniscus of suitable form. But a meniscus formed by this liquid is too unstable for the purpose; it is adversely affected by transit vibrations and other disturbances. Applicant has discovered, however, that this obstacle may be overcome by introducing a certain amount of copper into the electrolyte solution. When this is done the sensitivity of the meniscus to outside disturbances is greatly reduced, it remains stable throughout the electrolytic process and controls the formation of the points as above explained. The introduction of copper into the electrolyte may be accomplished by using a cathode **27** of fresh copper gauze. A more satisfactory method, however, is to prepare a stock solution which may be added in proper amounts to the electrolyte. Such a solution may be made by dissolving 2 grams of cupric chloride ($CuCl_2 \cdot 2H_2O$) in 375 cubic centimeters of distilled water and then adding 125 grams of potassium hydroxide. Some of the copper remains in solution while the reminder precipitates as copper hydroxide, which in turn immediately changes to a black precipitate of cupric oxide. The precipitate is allowed to settle, and the blue solution, after being decanted, is used for the stock solution to control the electrolyte meniscus. About 30 cubic centimeters of the stock solution added to 600 cubic centimeters of potassium hydroxide electrolyte is found to give good results, although other amounts may be used with success.

Although a wide variety of contact point shapes may be obtained with this process, satisfactory rectifier performance may be had when a tungsten wire of .005 inch in diameter is etched until the curvature at the tip of the point is about .0003 inch in radius. It is possible to attain these and other desired dimensions with considerable accuracy by reason of the fact that the current flowing during the electrolytic process decreases continuously. As the surface of the immersed wire decreases in area, the resistance to the flow of current increases. Also the effect of polarization is to decrease the amount of current flowing. While these current values will vary for different electrolytes and for wires of different sizes, it has been found that a point of the desired shape may be obtained under the conditions herein assumed by using a voltage of 1 volt and continuing the electrolytic action until the current drops to a value between 0.25 and 0.30 milliampere per wire.

Referring again to Fig. 1, this result may be obtained by adjusting the potentiometer **25** until the meter **32** indicates 1 volt, closing the switch **35** and observing the ammeter **24** until it indicates the desired current per wire at which time the process is stopped. Thereupon the liquid within the dish **19** is lowered for a time, following which it is again elevated until the contact points are immersed. Finally the formed points are given several flashes at a higher voltage, say 1.9 volts, for a measured interval, say 0.3 second. This is accomplished by a timing switch **34** which will hold the circuit closed for the desired interval and then will open it automatically. The purpose of this flashing step is to give the formed point a high polish which greatly increases the effectiveness of the wire when used in the rectifier.

The advantage of this method in the manu-

facture of rectifier assemblies will now be apparent. The pointing operation in the electrolytic bath insures that all contact wire units have exactly the same distance d from the end of the holder **3** to the tip end of the point. Therefore, when the holders **3** are subsequently inserted in the caps **5** and these caps are screwed into the ceramic cylinders **10** the uniformity of the distance d insures the proper location of the contact point with respect to the crystal surface **13** when the cap **11** is screwed into place. Another advantage of this process is that it insures uniformity in the shaping and polishing of the contact points, and, as hereinbefore mentioned, it eliminates the grinding operation heretofore necessary in the formation of these points.

Although tungsten wires give excellent results when pointed by the method herein described, it will be understood that this method may also be used to point wires of other materials, such as molybdenum.

What is claimed is:

1. The method of shaping an electrical contact wire which comprises immersing one end of the wire below the free surface of an aqueous solution of potassium hydroxide to form a meniscus at the surface of said solution, applying an electrical potential to said wire to cause the etching thereof by electrolytic action and the formation of a symmetrical point in the region of said meniscus, and adding a soluble copper compound to said solution for the purpose of sustaining said meniscus while said symmetrical point is being formed.

2. The method of forming a point at the end of a tungsten contact wire which comprises immersing a section at one end of the wire in a 25 per cent solution of potassium hydroxide in water to form a meniscus around said wire at the point of entrance at the surface of the solution, anodically treating the immersed wire below the region of said meniscus to form within the region of said meniscus a symmetrical point on said wire, and having copper dissolved in said solution to stabilize said meniscus during the formation of said point.

WILLIAM G. PFANN.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,017,671	Jenkins	Feb. 20, 1912
1,906,888	Roth	May 2, 1933
1,731,269	Rich	Oct. 15, 1929
2,329,317	Atlee	Sept. 14, 1943

FOREIGN PATENTS

Number	Country	Date
272,731	Germany	Apr. 7, 1914
62,869	Austria	Jan. 10, 1914
976	Great Britain	of 1865
14,580	Great Britain	of 1897