

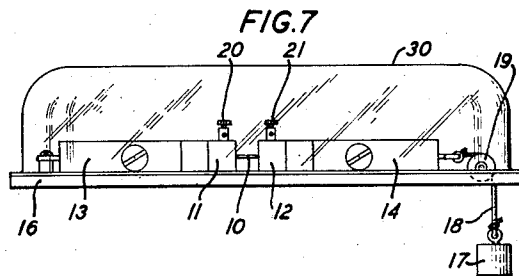
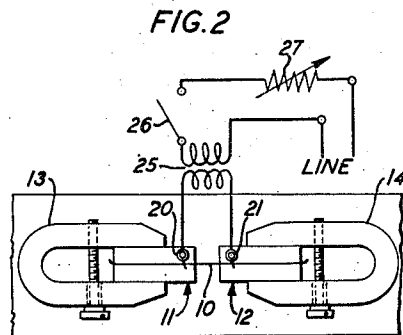
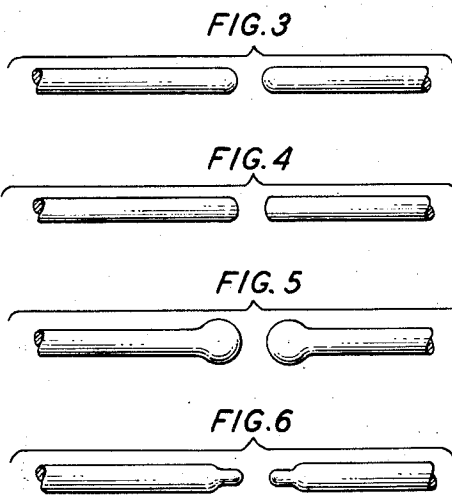
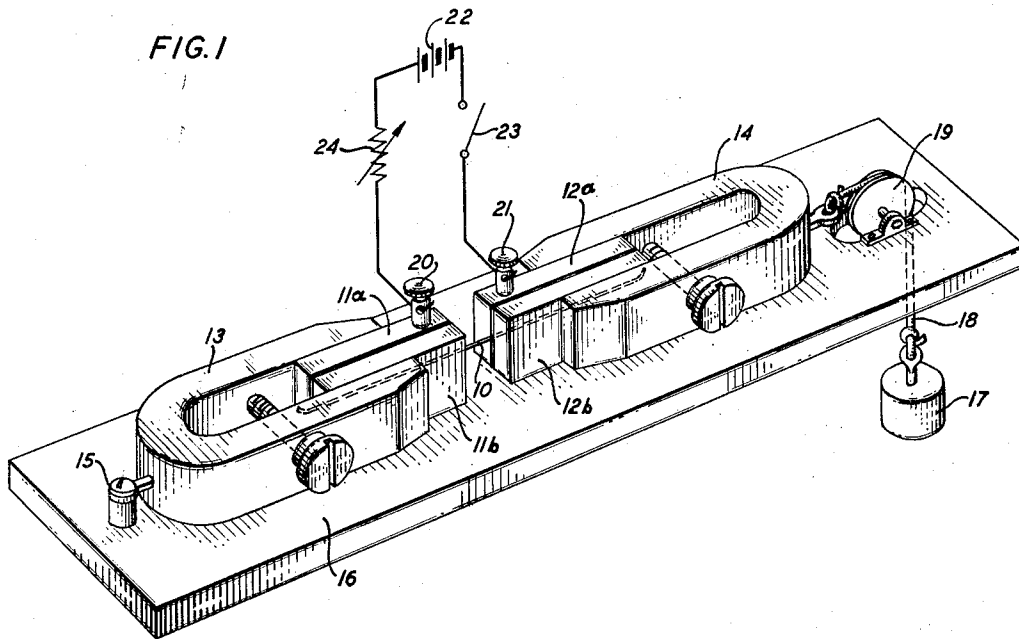
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FORMATION OF ELECTRODE TIP BY ELECTRIC CURRENT HEATING

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FORMATION OF ELECTRODE TIP BY
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1 Claim. (Cl. 219—1)

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This invention is concerned with the shaping of the ends of wires or filaments and more particularly to making spherical terminations on such wires or filaments, which are to be used, for example, as electrodes. Wires thus terminated are suitable for use as the contact wires in crystal rectifiers of the point contact type and for similar devices.

It is desirable in the manufacture of point contact wires for crystal rectifiers and like devices to closely control the area of contact between the wire and the crystal surface. For example, in point contact devices of this type, which are to be used at very high frequencies, an optimum contact area capable of exhibiting at the same time suitable resistance and capacitance characteristics is of considerable importance.

Contact wires falling in the category under discussion are usually made with a spring section, the function of which is to apply a suitable contact pressure. The spring section may take various shapes, e. g., helical, C-shape, S-shape, etc. The S-shape is commonly used and may conveniently form the basis for a description of some of the details of this invention.

The area of contact between the wire tip or point and the crystal surface, for example, may be considered as a function of several factors, one of which is point shape. With the usual sharp point, a considerable force is expended in the inelastic deformation of the point to produce a suitable area of contact. A spherical point on the other hand would have a greater and a more predictable range of elastic deformation. Such a point would allow the realization of a contact area of suitable proportions with a much smaller total force than that required with sharper points. This would result among other things, in a lower unit contact pressure and consequently less strain at or near the surface of the crystal.

The foregoing and other desirable features may be realized by making spherical points or terminations in accordance with the method of this invention.

An object of this invention is to enable the ready fabrication of an electrode or contact wire having a spherical point, free from surface irregularities and composed of fine grain homogeneous material.

A feature of this invention resides in controllably melting a small portion of a wire by Joulean heat, whereby a spherical surface of relatively fine grain material is formed.

A further feature of this invention pertains to cooling portions of a wire adjacent to the heated portion to confine the melting to the desired zone and to aid in controlling the shape of the point made.

Another feature of this invention resides in

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controlling the speed of heating to aid in determining the size and configuration of the spherical portion of the wire.

Other and further objects and features of this invention will appear more fully and clearly from the following description of exemplary embodiments thereof taken in connection with the appended drawings in which:

Fig. 1 is a perspective view of an apparatus suitable for carrying out the method of this invention, the heating circuit being of the direct-current type;

Fig. 2 is a plan view of like apparatus with an alternating-current circuit illustrated;

Figs. 3 to 6, inclusive, show various point configurations obtainable with this method, and

Fig. 7 is an elevational view of the apparatus provided with a cover to confine the heating zone to a desired ambient atmosphere.

As illustrated in Figs. 1, 2 and 7, a wire 10 of tungsten, Phosphor bronze, platinum or other suitable material, may serve as the basis for making two spherical points. The wire is, in this embodiment of the invention, clamped between two pairs of conductive blocks 11a—11b and 12a—12b by clamps 13 and 14, respectively.

An important function of the pairs of blocks 11a—11b and 12a—12b is to serve as heat sinks or storage means to aid in confining the heating, later to be described, to a limited zone of the wire 10 intermediate these two heat sinks. The heat sinks may for convenience be designated respectively as 11 and 12.

In order that tension may be applied to the wire 10, the clamp 13 is secured by the fastening means 15 to the base 16. A weight 17 secured by a cord 18 to the clamp 14 passes over pulley 19 to apply tension to the wire. The size of the weight 17 may be chosen to give a desired tension on wire 10 or if different values of tension are needed a plurality of graded weights may be used. Other means such as a spring of suitable proportions, motor means, etc., may be employed instead of the weight 17 to apply the proper tension to the wire 10.

Electric power for heating the wire 10 may be introduced by various means such as the binding posts 20 and 21 secured respectively to the heat sinks 11 and 12. Either direct or alternating current may be used.

A direct current may be obtained from a battery 22 connected through a switch 23 and an adjustable resistor 24 for limiting the current to a suitable value, as illustrated in Fig. 1. If an alternating current is to be used, means comprising a transformer 25, a switch 26, and an adjustable impedance 27 may be connected between the binding posts 20—21 and an alternating-current power line, as illustrated in Fig. 2. Other suitable current supply means may obviously be

used, one such being a means for applying a condenser discharge to the wire.

In those cases where it is desirable to exclude oxygen from the wire to avoid oxidation there- of during heating, or to control the pressure, or other characteristics of the ambient atmosphere, an enclosure may be provided. This may take various forms one of which may be a glass or like cover 36 as illustrated in Fig. 7. If a non-oxidizing lighter-than-air gas, such as hydrogen, is to be used, the cover may simply rest on the base 15. The hydrogen may be introduced through the opening that accommodates cord 18 or by any other convenient means. If another gas requiring a tighter enclosure or if pressure higher or lower than atmospheric is used, the enclosure may be sealed by any convenient expedient.

The formation of points on the wire 10 is accomplished by passing sufficient current through the wire to heat its intermediate portion to the melting point, whereby the wire is severed and spherical ends formed thereon due to the effect of surface tension forces in the wire.

Figs. 3 to 6, inclusive, illustrate some point configurations which may be obtained. The points of Fig. 3 are of substantially the same radius as the wire. This illustrates what may be called an intermediate situation. That is, with a given size of wire and spacing of heat sinks, the point radius is a function of the speed of heating. A moderate speed will give a point as in Fig. 3. If the heating speed is higher, less material is melted and a large radius, relatively flat point as at Fig. 4, is formed. At a relatively low heating speed more material is melted and the point takes the appearance of Fig. 5 with a radius greater than that of the wire and a "ball" point. In other words, the points of Fig. 3 are minimum radius points. The variations in point contour thus far described assume substantially no deformation of the wire due to the tension thereon.

If a point of less radius than that of the wire is desired, it may be obtained by relatively slow speed heating and relatively high tension. Under these conditions the wire, while in a plastic condition prior to melting, may be reduced or necked by the tension and may break before melting. In this case the arc across the break will melt the ends of the wire and produce spherical surfaces of smaller radius than that of the wire as illustrated in Fig. 6. In order to have the arc of sufficient duration to melt the wire ends, a direct-current source should be used, since an alternating-current arc would extinguish too quickly to accomplish the purpose.

If the minimum radius required is that of the wire, as illustrated in Fig. 3, the tension on the wire should be relatively small along with a moderate heating rate as previously noted. It has been found that an optimum heating rate for producing the Fig. 3 type of point may be found for a fair range of tensions. For example, tensions of from three pounds to less than one-half pound were used successfully with tungsten wire .005 inch in diameter.

Spherical points may be made with substantially no tension on the wire, although low tension appears to be somewhat more advantageous. It is possible to make spherical points by clamping separate wires in the two heat sinks, bringing their ends together, applying direct current to the joined wires and then pulling the wires apart to draw an arc which melts the wire ends.

This is somewhat like what is done in forming the points of Fig. 6 without the initial reduction in diameter and parting of the wire during the plastic stage.

If rectifier contact wires having an S-shaped or other convoluted portion are to be pointed by this method, the blocks 11a and 11b may be provided with mating grooves of proper configuration to locate the wire so that the point will be formed at the proper place. Grooves of this type may also be provided in blocks 12a and 12b so that two contact wires of given configuration may be pointed at the same time.

The heat sinks may be of copper, brass or other material of relatively high thermal conductivity. With .005 inch diameter wire, blocks of brass or of copper .625 inch square and .250 inch thick have been used giving a heat sink .625 inch by .625 inch by .500 inch. Heat sinks about $\frac{1}{8}$ the volume of the foregoing are also satisfactory. The spacing between the heat sinks for a .005 inch diameter wire may be from .075 to .150 inch, the greater separation giving larger "balls" at the end of the wire. With both heat sinks of about the same heat absorbing ability, the wire is severed at a point substantially equidistant from each sink.

The size of the "balls" on the wire ends may be controlled by the pressure of the ambient atmosphere, being large for a vacuum, medium for atmospheric pressure, and small for pressures above atmospheric. The effect of this environmental control is correlated with the other heat controlling factors to secure a desired over-all effect.

The fine drawn wires of tungsten and other suitable materials used for the point contacts in rectifiers and like devices usually have a grain structure that is coarse relative to their diameters. As a consequence of this grain structure it is necessary when making points by etching or grinding, to be extremely careful to avoid a rough surface. The melting of the present invention fines the grain of the metal and makes for a very smooth as well as a spherical point or tip.

The term spherical as herein employed denotes a surface that is a portion of a sphere and is not intended to cover a complete sphere.

Although this invention has been described by means of illustrative embodiments thereof it is not intended that these be taken as limiting the scope of the invention.

What is claimed is:

Apparatus for making a spherical termination on a wire filament by the operation of heat and surface tension forces therein, that comprises a base, spaced U-shaped clamps supported by said base with their open ends in facing relation, means for anchoring one of said clamps to said base, means for applying a measured force to the other of said clamps to move said clamp away from the anchored clamp, a pair of removable massive heat absorbing blocks secured in each of said clamps for gripping spaced portions of the filament, and a regulatable source of electric power connected across said blocks for heating the portion of the filament intermediate said blocks.

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