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ELECTRICAL TRANSLATING MATERIALS AND DEVICES AND METHOD OF MAKING THEM

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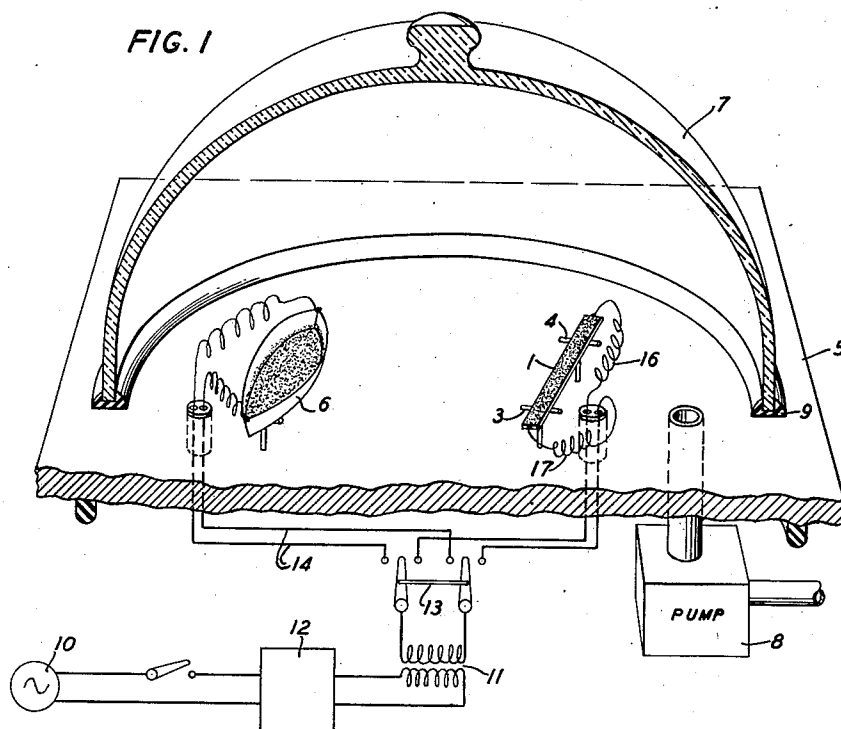


FIG. 2

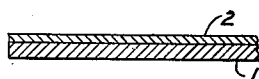


FIG. 3

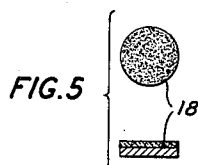
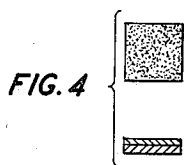
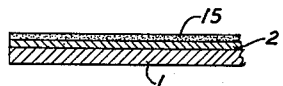
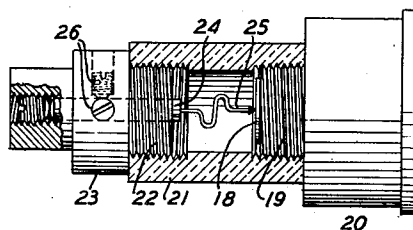


FIG. 6



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ELECTRICAL TRANSLATING MATERIALS
AND DEVICES AND METHOD OF MAKING
THEM

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5 Claims. (Cl. 250—31)

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

The objects of the invention are to improve the electrical efficiency of translating devices; to increase the activity of elements used for rectification and other translation purposes; and to obtain other improvements in devices of this character and in the methods by which they are manufactured.

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 device which is capable of detecting, converting, translating, or otherwise utilizing 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 of such a device 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, the silicon crystal elements of these prior rectifiers have been prepared by melting powdered silicon of high purity in a furnace and cutting the resulting ingot into small wafers of suitable diameter and thickness. The crystal wafer is then mounted on a terminal block, and the fine tungsten wire is adjusted so that its end makes a point-contact with the surface of the crystal.

In accordance with the present invention it is possible to improve the efficiency and usefulness of these translating devices by means of a new translating element and by means of a new method of making the same. This new element is more active and more efficient than those heretofore used. It consists of a body of crystallized silicon having a surface layer which is specially treated with oxides or other compounds of metals, such as lead. While this treatment may be applied to any suitable silicon body, particularly good results are obtained with a crystallized layer of thermally deposited silicon on a backing strip of some suitable metal, such as tantalum, the surface of the silicon layer being treated with lead oxide. In the process by which these translating elements are prepared a strip or filament of tantalum is heated electrically in a reaction chamber to a predetermined temperature with a

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vaporous mixture of silicon tetrachloride and hydrogen, causing thereby the deposition of a layer of silicon on the surface of the tantalum strip. Next the deposited layer of silicon is raised to a melting temperature, whereupon it is permitted to cool and crystallize. Thereafter a coating of lead oxide is deposited upon the surface of the silicon, and heat is applied to produce a reaction between the oxide and the silicon, resulting in the liberation of metallic lead, some of which alloys with the silicon resulting also in a substantial crust or coating of lead silicate which overlies the surface of the strip. Finally, the crust of lead silicate is removed to expose the silicon surface. The strip is then cut into units of suitable size and shape for mounting in the rectifier assemblies.

Rectifiers prepared in this manner are found to be very active and unusually high in electrical efficiency. Their translation losses and noise factors are also comparatively small.

Other features and advantages of the invention will be discussed more fully in the following detailed specification.

In the drawing accompanying the specification:

Fig. 1 illustrates the apparatus with which the process is performed;

Fig. 2 is an enlarged sectional view of a metallic filament prepared with a coating of crystalline silicon;

Fig. 3 is a similar view of the filament following the deposition of an oxide coating thereon;

Figs. 4 and 5 illustrate rectifier elements cut from the filament after the process has been completed; and

Fig. 6 shows one form of rectifier assembly including one of the rectifier elements.

The first step in the process is to prepare a metallic strip or filament with a thin coating of crystallized silicon having a very high degree of purity. This may be done as above noted by effecting the thermal decomposition of silicon tetrachloride vapor to cause the deposit of silicon on the metallic strip. Such a method is the subject of the copending application of J. A. Becker, Serial No. 496,417, filed July 28, 1943. It will be understood, of course, that the present invention is not limited to any particular metal for the strip upon which the silicon layer is deposited. Experiments have been made with such metals as tantalum, platinum, molybdenum and tungsten, and of these it is found that tantalum has the least tendency to enter into solution with the silicon.

After the tantalum strip 1 has been prepared with the coating of crystalline silicon 2, it is placed on the insulating supports 3 and 4 projecting from the surface of the table or base plate 5. Plate 5 also contains similar supports for a metallic boat 6 in which a quantity of lead oxide powder is deposited. A bell jar 7 is now placed on the surface of the plate 5 covering the strip 1 and boat 6, and the air is exhausted from the jar by means of a pump 8. A seal 9 of any suitable material serves to facilitate the exhaustion of the space within the bell jar 7.

The apparatus is now ready for depositing a thin coating of the lead oxide on the surface of the strip 1. The deposition is effected by heating the boat 6 electrically, causing the lead oxide to evaporate and settle upon the surface of the filament 1. A suitable source 10 supplies current for this purpose to the primary winding of the transformer 11, a regulator 12 being used to regulate the voltage to the desired value. When ready to start the deposition process the switch 13 is thrown to the left, and current flows over the circuit 14 through the boat 6.

After a sufficient layer 15 of lead oxide has been deposited on the surface of the strip 1, illustrated in Fig. 3, switch 13 is thrown to the right, and current of the proper intensity is applied to the filament 1 to heat it to a desired temperature. This heating of the filament 1 produces a chemical reaction between the layers of silicon and lead oxide, the physical manifestation of which is the formation of a glaze on the surface of the strip. The chemical reaction results in the liberation of elemental lead and the probable formation of a lead silicate. Some of the lead alloys with the silicon to form a thin layer of lead silicon alloy.

The final step in the process is to remove the glaze that forms over the surface of the strip to expose the surface of the silicon layer containing some of the lead. The overlying glaze or crust may be removed by mechanical methods, such as chipping and abrading, or by any other suitable method.

The material is now ready for cutting into units of desired shapes and sizes such as those illustrated in Figs. 4 and 5. One of the rectifier units 18 is included in the assembled rectifier of Fig. 6 and is mounted on the threaded metallic stud 19. The mounting of the silicon unit on the stud 19 may be accomplished by any suitable method. For example, the tantalum side of the unit 18 may be plated with nickel and then welded to the surface of the stud 19. Following the attachment of the rectifier unit 18 to the stud 19, which is integral with the metallic base member 20, the stud is screwed into one end of the ceramic cylinder 21. In like manner the threaded stud 22, which is integral with the metallic cap 23, screws into the opposite end of the cylinder 21. The cap member 23 contains a central bore for receiving the cylindrical metallic contact holder 24; and this holder is adjusted within the bore until the tip end of the tungsten contact wire 25, the opposite end of which is soldered in the holder 24, makes contact with the surface of the unit 18. When the desired degree of force is applied to the contact engagement of the wire 25 with the unit 18, the set screws 26 are tightened to seize the holder 24.

In the foregoing specification applicant has described a vacuum evaporation process for depositing the lead oxide on the metallic strip or filament. It will be understood, of course, that

this method is subject to numerous variations and that other methods of depositing the oxide coating may also be used. For example, the oxide may be formed as a paste and sprayed or painted over the surface of the filament. Or a thin uniform layer of lead oxide can be produced on the silicon by placing a small quantity of lead acetate on the silicon surface, heating the combination until the acetate melts and spreads over the surface, and then raising the temperature until the acetate decomposes to lead oxide. At a still higher temperature the lead oxide reacts with the silicon as above explained. It will also be understood that other compounds may be used for the purpose of creating an alloy of silicon and another metal near the surface.

What is claimed is:

1. The combination in an electrical translating device of a translating element comprising a metallic base having a layer of silicon deposited thereon, the surface of said silicon layer containing an alloy of silicon and lead, and a spring contact wire making a point-contact with the surface of said silicon layer.

2. The combination in an electrical translating device of a translating element comprising a thin base of tantalum having a layer of silicon deposited and crystallized thereon, the surface of said silicon layer containing an alloy of silicon and lead derived from a reaction between the silicon and a lead compound, and a fine spring contact wire making a point-contact with the surface of said silicon layer.

3. The method of making a translating device for electric waves of ultra-high frequency which comprises depositing a layer of silicon upon the surface of a metal base, causing a reaction to take place between the silicon of said layer and a metallic compound to form an alloy of the metal with the silicon near the surface of the silicon layer and to form a silicate of the metal covering the surface of the silicon layer, and removing the covering of silicate to expose the surface of the silicon layer.

4. The method of making a translating device which comprises decomposing a substance containing silicon and depositing the silicon in a layer upon the surface of a metal base, fusing said silicon layer to crystallize the same, depositing a layer of lead oxide upon the surface of said silicon, causing a chemical reaction to occur resulting in an alloy of silicon and lead near the surface of the crystallized silicon and a coating of lead silicate covering the silicon surface, and removing the coating of silicate to expose the surface of the silicon layer.

5. The combination in an electrical translating device of a translating element comprising a body of crystallized silicon, the surface layer of said silicon body consisting of an alloy of silicon and lead, and a contact wire making a point-contact with the surface of said body.

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REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
70 1,990,277	Feussner et al.	Feb. 5, 1935
925,988	Von Bolton	June 22, 1909

FOREIGN PATENTS

Number	Country	Date
75 6,051	Great Britain	July 16, 1908