H. S. HATFIELD.

ELECTRICAL RESISTANCE, CONTACT, AND THE LIKE.

APPLICATION FILED DEC. 28, 1906.

978,022. Patented Dec. 6, 1910.

2 SHEETS—SHEET 1.

Fig. 1.

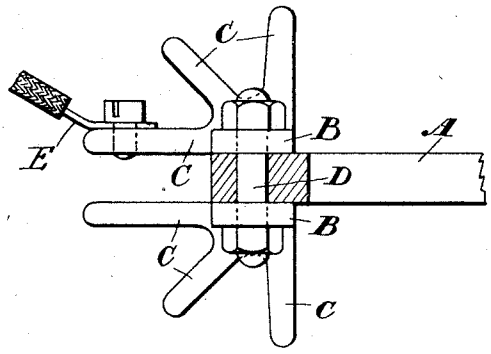


Fig. 2.

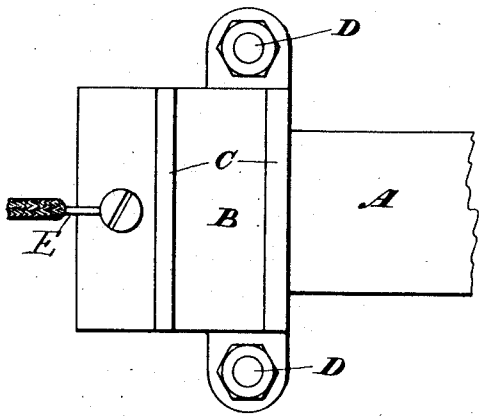
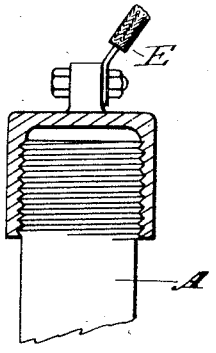


Fig. 3.



WITNESSES:

Helen Orford

Frank J. Seabolt

INVENTOR:

Henry S. Hatfield

by Albert G. Davis

Attorney

H. S. HATFIELD.

ELECTRICAL RESISTANCE, CONTACT, AND THE LIKE.

APPLICATION FILED DEC. 28, 1906.

978,022. Patented Dec. 6, 1910.

2 SHEETS—SHEET 2.

Fig. 4.

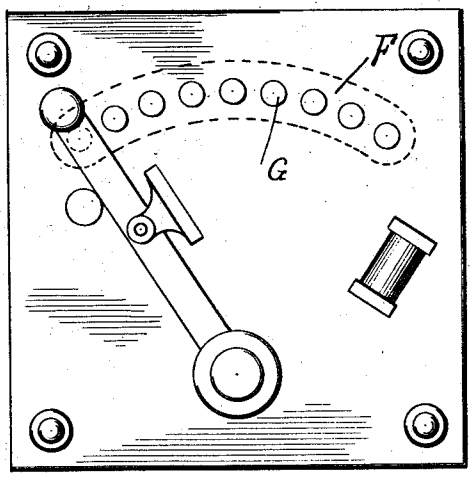


Fig. 5.

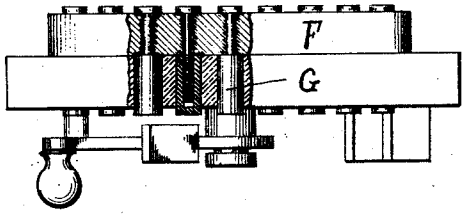
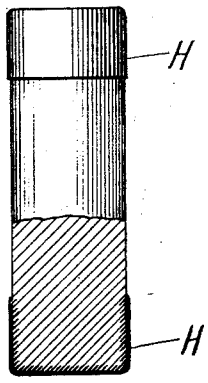


Fig. 6.



WITNESSES:

L. B. Penfield.

L. H. Barlow.

INVENTOR

Henry S. Hatfield

BY

John C. Purnell

ATTORNEY

UNITED STATES PATENT OFFICE.

HENRY STAFFORD HATFIELD, OF HOVE, ENGLAND.

ELECTRICAL RESISTANCE, CONTACT, AND THE LIKE.

978,022. Specification of Letters Patent. Patented Dec. 6, 1910.

Application filed December 28, 1906. Serial No. 349,859.

To all whom it may concern:

Be it known that I, HENRY STAFFORD HATFIELD, a subject of the King of Great Britain, residing at 18 Palmeira Square, Hove, Sussex, England, formerly of 11 Buckingham road, Brighton, England, electrochemist, have invented certain new and useful Improvements in Electric Resistances, Contacts, and the Like, of which the following is a specification.

My invention relates to electric resistances, contacts, and the like in which metallic silicon (or what is commonly known as massive metallic silicon or silicium) in the mass, either pure or alloyed with other materials, is used.

Silicon has a high resistance, and when in the massive form is extremely hard, and chemically inert even at high temperatures. It also has a low co-efficient of expansion and a high specific heat. It is therefore useful for such parts of electrical apparatus as are required to stand sudden or great elevation of temperature; mechanical, chemical or other conditions injurious to other materials; or those parts in which it is required to dissipate electrical energy.

One form of silicon which I may employ is the somewhat impure form of silicon which is obtained as a by-product in the manufacture of carborundum in the electric furnace. In order to obtain high electrical resistance it is necessary to select the purer samples of this product, or to purify it by suitable chemical means.

Silicon, or the impure form mentioned above, may be melted in the electric furnace in graphite crucibles, and cast in molds of carbon, core sand with a graphite wash, or other suitable materials, in any desired form.

In order to conduct current to or from the silicon when used as a resistance or as an electrical conductor, considerable difficulty is experienced in maintaining contact with the leading-in conductor when high current densities are used, and it is the object of my invention to overcome this difficulty.

I have found that the cause of inefficient contact is due to the fact that the silicon has a low co-efficient of expansion with heat, and therefore that when conducting clamps of copper or other ordinary metal are used for connecting the leading-in conductors to the silicon the relatively larger expansion of such metals which results from the heating of the joint produces separation of the silicon from the clamp.

My invention therefore consists in constructing the clamp or connecting conductor of a metal which has a low heat co-efficient or expansion preferably practically equal to that of the silicon.

In order that my invention may be readily understood I shall now describe it more particularly with reference to the accompanying drawings in which,

Figure 1 is a side elevation of a conducting clamp for conveying current to a bar of silicon, the latter being shown in part section; Fig. 2 is a plan of the clamp; Fig. 3 is a section of a modified form of conducting connection; Fig. 4 is a face view and Fig. 5 an edge view partly in section of a variable starting resistance for electric motors constructed in accordance with my invention, and Fig. 6 illustrates a resistance member constructed in accordance with my invention and having a superficial coating of an alloy of silicon and another metal.

Referring to Figs. 1 and 2, A is a bar of silicon, to the end of which are clamped contact pieces B B of any suitable metal such as brass, copper or cast iron, with webs C C C to radiate heat. The bolts D D which are used for clamping are of nickel-steel or other alloy of such composition that its expansion with rise of temperature is very small. The shaded portion of the silicon bar is copper-plated and carefully trued so as to make a good contact with the metal pieces. The current is led in by a terminal E screwed into one of the contact pieces. A similar contact leads the current out of the bar.

For many purposes sufficiently good contact may be made by copper plating the end of a circular bar of silicon A (Fig. 3) and by cutting a screw thread in the end of the bar, a thimble, cap or ferrule of nickel-steel or other metal having similar properties, to which the leading-in conductor is attached, being then screwed on the bar.

In the construction of variable resistances for starting electric motors, and for other purposes where the resistance is varied in steps by moving a contact arm over a series of contacts, the silicon may be cast in one piece F, as illustrated in Figs. 4 and 5 in a suitable shape, the contact studs G being

formed of nickel-steel bolts passed through the silicon, which is copper plated at these points.

Pure metallic silicon has a high resistance, upward of ½ ohm per cubic inch, and a temperature co-efficient of about the same amount as a pure metal such as copper, the resistance decreasing with rise of temperature. A small alloy (about 10%) of other metal greatly decreases resistance and co-efficient. In using silicon for making electric contacts, as well as for resistances where desirable, I prefer to make use of this alloy; iron, copper aluminum and other metals may form the other constituent. By electroplating or otherwise depositing metal on the surface of the silicon, and subsequently strongly heating, a superficial alloy as shown at H in Fig. 6, may be formed, and the electric resistance modified. Platinum and other metals may be employed in this manner.

I am aware that silicon has been alloyed in small proportions with other materials for electrical purposes. But it is of the essence of my invention that the silicon be used in a massive form, either pure or as the base constituent of a mixture or alloy. Amorphous or non-metallic silicon, as usually obtained for chemical purposes is useless for electrical resistance unless inclosed in a vacuum, as it oxidizes in the air at a moderate temperature.

Among the uses contemplated by me for current conducting connections for silicon resistances constructed according to my invention are,—resistances for controlling electric current, such as motor-starters, arc lamp steadiers, resistances in series with shunt coils, and the like: electrical heating apparatus, cigar lighters, and the like.

What I claim as new and desire to secure by Letters Patent of the United States is:—

1. The combination of silicon in a massive form with a current-conducting connecting clamp of metal having a low heat expansion co-efficient.

2. The combination of silicon in a massive form with a current-conducting connection of a nickel steel alloy.

3. The combination of silicon in a massive form with a current-conducting connecting clamp having heat radiating wings and in which the clamping member is made of metal having a low heat expansion co-efficient.

4. A resistance consisting of a body of silicon having a superficial coating of an alloy of silicon and another metal.

5. The combination with a resistance consisting of a body of silicon, of a current-conducting connection, the body of silicon having, at the points where it is engaged by the conducting connection, a superficial alloy of silicon and another metal.

In witness whereof, I have hereunto set my hand this 19th day of December, 1906.

H. STAFFORD HATFIELD.

Witnesses:
F. J. SKOYLES,
H. D. JAMESON.