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COMPOSITION FOR IGNITER FOR RECTIFIERS

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The invention relates to a composition of matter and with regard to its more specific features to a composition for igniter tips for rectifiers.

One object of the invention is to provide an inexpensive igniter tip. Another object of the invention is to provide a general composition for igniter tips from which articles with predictable properties can be readily made. Another object of the invention is to provide a composition of the type indicated which has the desired resistivity. Another object is to provide igniter tips of long life.

Another object is to provide an igniter with small negative coefficient of resistance. Another object is to provide a refractory igniter with the desired resistivity and a small negative coefficient of resistance. Another object of the invention is to provide a refractory composition of matter that is not wetted by mercury, that has a resistivity in the range from .5 to 5. ohm-inches, and a negative coefficient of resistance not greater than three-quarters of one percent per degree centigrade. Another object is to provide a composition for igniter tips of desired resistivity which resistivity shall not drop excessively on the surface of the igniter tip during use thereof. Another object of the invention is to find a satisfactory bond for titanium nitride to make refractory semi-conductors of readily precalculated resistance. Another object is to provide a strong refractory material which can be readily molded. Another object is to provide a material useful for the manufacture of resistors, for example heating elements for industrial furnaces. Another object is to make a refractory and corrosion resistant material. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the combinations of elements and in the several steps and relation and order of each of said steps to one or more of the others thereof, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

For a description of a mercury arc rectifier known as the ignitron an important element of which is an igniter tip, reference may be had to an article by Joseph Slepian entitled, "The ignitron, a new mercury arc power converting device" in Transactions of the Electrochemical Society, volume 69, pp. 399-415 (1936). The ignitron is a mercury arc rectifier. In any mercury arc rectifier the electrons are emitted from what is known as the cathode spot. This cathode

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spot is useful only during the current carrying period. Its existence at other times promotes arc-backs or back-fire. In the ignitron a semi-conducting rod called the igniter is immersed part way into the mercury pool and is connected to convey current from a shunt circuit into the pool during the current carrying period. Thus a properly timed current pulse is given to the igniter at the beginning of each desired current carrying period. One convenient arrangement for thus imparting the proper current pulses to the igniter involves connecting the igniter terminal to the anode of the rectifier externally through a small thermionic cathode tube, which is a simple rectifying tube. The cathode spot is thus maintained during the current carrying period and at the end of each such period the cathode spot automatically is extinguished. Such construction makes a highly efficient rectifier and indeed has permitted rectification in circuits and for uses not hitherto possible or practicable. The life of an ignitron is also usually greater than that of previous types of rectifiers. Many thousands of ignitrons are now in successful use and have been for years.

The efficiency and continued operation of an ignitron, however, are dependent upon the use of an igniter rod of proper characteristics. The desirable characteristics of igniter rods are that they shall not be wet by mercury, they shall have a resistivity of the order of 5. to .5 ohm-inches, and that the resistivity shall not break down on the surface. Especially desirable features are indicated in the objects hereinbefore given.

Igniter tips, sometimes referred to as igniter rods or merely as igniters, may be made in various shapes or dimensions but as an illustrative example an igniter tip may consist of a cylinder ¼'' long, ¼'' in diameter, capped by an integral cone ⅝'' long, the cylinder merging into the base of the cone. A convenient way to make such igniters is to make a cylinder somewhat over ⅞'' long, and ¼'' in diameter, grind a conical tip with an altitude of ⅝'', then cut off the cylindrical part to the desired length, in this case ¼ inch.

I have found that superior results are achieved by making igniters out of titanium nitride (TiN) bonded with any suitable non-conducting bond and in this connection non-conducting means substantially dielectric. Many different bonds might be used such as various ceramics, oxides or mixtures of oxides and in this connection alumina (Al_2O_3) which can be molded at around

1800° C. is particularly useful. However, my preferred bond is beryl.

Beryl is a natural mineral and I obtain good results using the natural material. Beryl is a variable mineral of a general composition sometimes written $3BeO.Al_2O_3.6SiO_2$. I can use all forms of beryl which are recognized as being substantially pure beryl. Some emeralds are chemically pure beryl in crystalline form and indeed beryl as such is always crystalline.

Beryl has a melting point in a range between 1400° and 1500° C. and molds readily over a range of temperatures below 1500° C. In this respect it acts like a glass. I prefer that whatever bond is used it should be moldable between 1000° C. and 1800° C. under pressure. Beryl is an electric insulator in the dielectric range which is high relative to the resistivity of titanium nitride. It is dense, mechanically strong and makes a good bond.

Titanium nitride is not wetted by mercury, neither as such nor when it is bonded with beryl. It fuses at around 2900° C. Its resistivity at 20° C. is about $.21 \times 10^{-4}$ ohm-centimeters. This is the same as $.0827 \times 10^{-4}$ ohm-inches. When titanium nitride is molded with 75% beryl, the resistivity is about 5. ohms to the inch. When titanium nitride is molded with 65% beryl, the resistivity is about .5 ohm-inches. Since the above is the desired range for igniters I prefer the limits 25% to 35% TiN, the parts being by weight. One feature of the invention is that by varying the percentage, I can control the resistivity within fairly close limits as compared with other compositions.

For the manufacture of a rod from which to make an igniter, I may proceed as follows:

I provide a graphite mold of cylindrical shape having preferably a number of bores all parallel to the axis of the cylinder and each one ¼ of an inch in diameter. I provide graphite mold plungers each ¼ of an inch in diameter. The mold bores are filled with a mixture consisting of from 25 to 35% by weight titanium nitride, the balance beryl. The particle size of the titanium nitride is preferably small, for example around 10 microns. The beryl is also in powdered form. For example, I may crush it and select the particles that pass a screen 325 meshes to the linear inch. I prefer that the beryl particles be 40 microns or finer, the finer the better.

The two ingredients are well mixed in a ball mill and then charged into the bores of the multiple graphite mold, one set of plungers having been inserted before the mold is charged. Then the other set of plungers is inserted and the mold is placed within the graphite resistor tube of an electrical furnace such as disclosed in the U. S. patent to R. R. Ridgway No. 2,125,588. Pressure is then applied against the mold plungers by means of the graphite plungers 136 of the Ridgway patent with or without the intermedaite graphite spacers 173 of said patent, and coincidentally or previously the furnace is energized to heat the graphite resistor tube 59 of the patent which heats the mold and the mixtures contained therein.

I desirably use a pressure of 2500 pounds to the square inch because these furnaces are customarily operated at such pressure and calculations may be readily made thereat. However, other pressures might be used. I heat the material to a temperature of around 1400 to 1500° C. This is not indefinite because the plungers move slightly when the material sinters, and after the temperature has reached 1400° C. and the plungers have moved, the heat is maintained for about two minutes and then the circuits are opened. When the mold has cooled to around 500° C., the pressure may be released.

After the mold and the furnace have cooled sufficiently, the furnace is opened and the mold is removed. The mold is then cut open and the cylindrical pieces of titanium nitride bonded with beryl are extracted. These may then be ground and cut to the desired size and shape as already indicated. Igniter tips made as described are dense and strong mechanically. The resistivity will be in the range stated, namely from about .5 to 5. ohm-inches.

One feature of the invention resides in the fact that titanium nitride has a positive temperature coefficient of resistance. Most other semi-conductors have a negative temperature coefficient of resistance. The combination of titanium nitride bonded with beryl has a negative coefficient of resistance but it is small. Measured in percentage change per degree centigrade this coefficient is around −0.25% to −0.40%. A low temperature coefficient of resistance is desirable in an igniter tip.

The titanium nitride used to make the composition of this invention may be made as described in the literature or procured on the open market. It is desirable to use fairly pure material, however high purity is not essential. The variety I have used was about 85% pure, the remainder being mostly titanium oxide or oxides with probable traces of titanium carbide. This is satisfactory material for the purpose of making igniters.

The peak current through an igniter is frequently of the order of 20 amperes at around 50 volts. The pulse rate, of course, depends upon the frequency of the circuit which may be 25 or 50 but more usually 60 cycles. The current at the contacts between the igniter and the mercury rises to very high density even to several thousand amperes per square centimeter and the voltage drop at the contact may be of the order of 10 volts. These requirements rule out the use of ordinary metals for igniters and require an igniter to be refractory. Many materials which have hitherto been tried for igniters have a relatively short life. This is apparently because they are not resistant to heat shock. The igniters that are made in accordance with this invention last a long time and result in efficient operation of the ignitrons.

In the ignitor tips as formed by molding, the titanium nitride is dispersed at random throughout a matrix of beryl. The titanium nitride occurs in massive yellow grains and golden dendrites and in aggregates. Thus, it appears that many of the crystals, which were originally of the order of 10 microns in size, have grown together to make large crystals. In most cases, the pores of the aggregates are filled with beryl, but there are some voids.

While an important use for the composition of the invention is for the manufacture of igniter tips, the composition TiN+ beryl is a strong refractory material in wide proportions of TiN to beryl and may be used to make other articles. Thus for resistors, TiN may be bonded with beryl in proportions beyond the limits of 25% to 35% TiN in either direction. For example, resistor bars for high temperature electric furnaces can be made out of the composition of this invention. The desired resistivity for such bars is of the order

of .5 to .02 ohm-inch. To obtain a resistivity of .02 ohm-inch, 50% TiN, 50% beryl is approximately the right proportion. Resistors of resistivity much greater than 5 ohm-inches may be made, even up to resistivities of megohm-inches, by increasing the amount of beryl above 75%.

It will thus be seen that there has been provided by this invention an article and a composition in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved.

As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. An igniter in which the semi-conductive element is titanium nitride of a purity of about 85% and upwards and in an amount in the range from about 25% to 35% bonded with a refractory bond into a dense strong article with resistivity of the order of .5 to 5. ohms-inches at 20° C., the titanium nitride being well dispersed throughout the bond.

2. An igniter consisting of titanium nitride bonded with beryl, the titanium nitride being about 85% pure and upwards and consisting of from about 25% to about 35% by weight of the article, the titanium nitride being in finely divided form and well dispersed through the beryl bond.

3. As a new composition of matter an intimate sintered mixture of titanium nitride and beryl.

4. As a new composition of matter, titanium nitride in granular crystalline form bonded with beryl.

5. An igniter of titanium nitride bonded with beryl.

6. An igniter of titanium nitride bonded with beryl having a negative coefficient of resistance no greater than .75% per degree centigrade.

7. An igniter of titanium nitride bonded with beryl having a resistivity of from .5 to 5. ohm-inches.

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REFERENCES CITED

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

FOREIGN PATENTS

Number	Country	Date
23,351	Great Britain	Oct. 12, 1909