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R. R. RIDGWAY

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LIGHTNING ARRESTER

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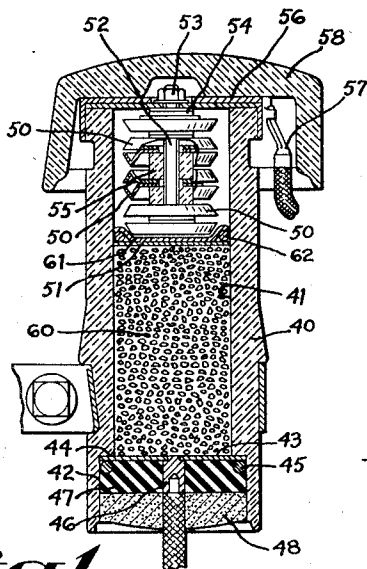


Fig. 1

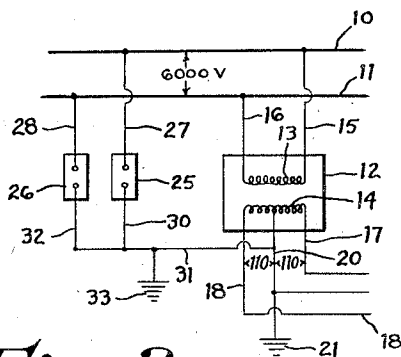


Fig. 2

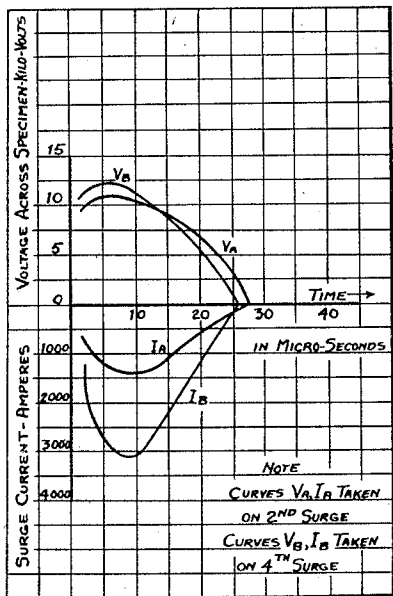


Fig. 3

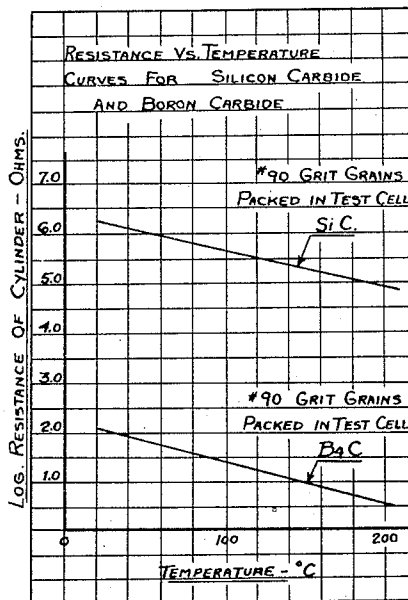


Fig. 4

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LIGHTNING ARRESTER

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17 Claims. (Cl. 201—72)

The invention relates to a lightning arrester and a composition of matter for use therein.

One object of the invention is to provide granular material for the manufacture of lightning arresters which prevent the establishment of high voltages on power lines or other apparatus being protected. Another object of the invention is to provide granular material for lightning arresters having good valving action. Another object of the invention is to provide granular material for a lightning arrester which will not readily core. Another object of the invention is to provide a lightning arrester which will operate successfully over a long period of time.

Another object of the invention is to provide a method of manufacture of lightning arrester material which is simple and readily controlled in practical manufacture. Another object of the invention is to provide a lightning arrester with high surge discharge capacity without physical or chemical breakdown of the material of the arrester. Another object of the invention is to provide lightning arrester grain of a composition which can be duplicated with comparative ease and the elements of which are readily available. Another object of the invention is to provide lightning arrester grain which will not clinker and which has an excellent shut-off valve action.

Another object of the invention is to provide an arrester particularly adapted to low voltage lines without providing unusual sizes and shapes. Another object of the invention is to provide a long arrester for high voltages permitting the use of a thin-walled porcelain container of small cross-section which is, therefore, inexpensive. Another object of the invention is to enhance the shut-off characteristics of an arrester. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts, 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 pointed out hereinafter, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawing illustrating one of many possible embodiments of the mechanical features of the invention,

Figure 1 is a vertical axial sectional view of an arrester constructed in accordance with the invention;

Figure 2 is a diagram of a typical power line protected by arresters; and

Figure 3 is an oscillogram showing the performance of a typical arrester under surge discharge conditions.

Figure 4 is a curve showing resistance plotted against temperature for boron carbide and silicon carbide respectively, the resistance being on a log scale.

Referring now to Figure 2, I illustrate a typical power line, but the arrester may be used in any circuit, that shown being illustrative merely. In Figure 2, A. C. power lines 10 and 11 have an impressed E. M. F. of 6000 volts. A transformer 12 has a primary coil 13 and a secondary coil 14. The primary coil 13 is connected by leads 15 and 16 to the power lines 10 and 11, respectively. The secondary coil 14 is connected by leads 17 and 18 to a low voltage secondary circuit and may operate, for example, at 110 volts. To a midpoint on the secondary coil 14 is connected a ground wire 20 grounded at 21.

I provide arresters 25 and 26. Arrester 25 is connected by a line 27 to the main power line 10 to protect the main power line 10 from lightning discharges and induced charges resulting from lightning bolts. The lightning arrester 26 is connected by a line 28 to power line 11 similarly to protect the power line 11. The arrester 25 is connected by a wire 30 to a ground wire 31. The arrester 26 is connected by a wire 32 to the ground wire 31. The ground wire 31 is also connected to the ground wire 20 and to a ground 33. In the form of the invention herein illustrated, the arresters 25 and 26 may be identical and may be of the loose grain type.

Referring to Figure 1, I provide a hollow cylindrical porcelain body 40 having throughout the greater part of its length a unidiameter bore 41 and adjacent to one end thereof, an enlarged diameter bore 42. A metal plate 43 rests against an annular shoulder 44 joining the bores 41 and 42 and forms with the bore 41 a chamber. The plate 43 is held against the shoulder 44 by means of a metal ring 45. A terminal 46 is attached to the plate 43 and extends downwardly through base seals of plastic cement 47 and non-plastic cement 48.

At the other end of the lightning arrester is an arcing unit assembly consisting of a plurality of brass discharge plates 50 of saucer shape with annular V peripheries. These are held together in spaced relation by means of a bottom plate 51 and bolt 52 attached thereto. A nut 53 and washers 54 hold the parts together and the plates

are spaced by porcelain insulators 55. A metal cap 56 fits the end of the porcelain cylinder 40, a portion of it being between the nut 53 and the washers 54. A terminal 57 is suitably attached to the metal cap 56. A porcelain cap 58 covers the top of the arrester and keeps moisture and dirt out of it.

I fill the space between the plates 43 and 51 with granular material 60 according to the invention. This should be thoroughly compacted and I provide an additional disk 61 having a semi-circular groove formed therein by upsetting the metal, which receives a ring 62. When the disk 51 and the disk 61 are pressed downwardly they and the ring 62 may readily move, but they resist any force tending to raise them by reason of a wedging action.

Prior to this invention lightning arrester granules have been made of semi-conducting materials which are also refractory. Such materials have been primarily composed of silicon carbide of various degrees of purity. Prior to my invention the characteristic of refractoriness was always accompanied with less body conductivity of the granule than was desirable for best engineering design. Thus it is well known that silicon carbide has an appreciable vapor pressure at 1800° C. and is known to boil rapidly at 2200° C., giving off vapors which cause the grains to recrystallize and knit together. I have discovered that boron carbide B_4C does not have a measurable vapor pressure at temperatures as high as 2300° C. There is no tendency to melt until approximately 2500° C. is reached. It will be seen that this grain, therefore, provides a refractory conductor which exceeds the capabilities of all previously used materials, because boron carbide does not vaporize at high temperatures as does silicon carbide. Furthermore boron carbide does not recrystallize as readily as silicon carbide and thus there is less danger of coring. Therefore I have found that boron carbide constitutes a superior material for the valve of lightning arresters for certain practical installations.

One of the chief characteristics of boron carbide is its relatively high body conductivity as compared with materials which have been customarily used for lightning arrester valves. In accordance with the law $W=I^2R$ a material of low resistivity can be embodied in a smaller valve than a material of high resistivity, the heat evolved per unit volume of valve being the limiting factor. The importance of heat liberated per unit volume has not heretofore been sufficiently appreciated, and I have found that under surge conditions the interfaces between grains are instantaneously heated to temperatures sufficient to bring about chemical changes and the deterioration of the grains as valves.

A further advantage of using boron carbide is that since the grain itself has a high inherent conductivity within the body of the crystal, a much finer grit size can be used for equivalent conductance under surge than can be used with a poorer conducting material such as silicon carbide. It is feasible to make arrester bodies of boron carbide with grit size 150 mesh and finer and still have a low enough resistance to permit the handling of large quantities of surge current without damaging the arrester body because of power liberated within it. The advantage of using a larger number of contacts in a fixed volume of the arrester body resulting from the smaller grit size resides in the excellent valving or shut-off characteristics. Thus boron carbide

grain of small grit size will give excellent results for the type of installations required with high voltages.

Referring now to Figure 4 there is therein shown the resistance of boron carbide and silicon carbide respectively plotted against temperature, the resistance being given on a log scale. Cylinders 1.13 inches in diameter and .125 inch long were packed with 90 grit size grains of boron carbide and silicon carbide respectively. The resistance at the various temperatures is indicated in Figure 4. Since the slope of the curve for boron carbide is steeper than that for silicon carbide it will be seen that the boron carbide granules will increase in conductivity with the current demands put upon them by the size of the surge more than the silicon carbide. The outstanding difference between the materials, however, is the much lower resistance of boron carbide.

Referring now to Figure 3, it is customary to use various electrical tests to examine the properties of silicon carbide which make it useful for a valve material in lightning arresters. Various manufacturers of lightning arresters have standardized on a wide variety of electrical tests to discover the suitability of a given lot of refractory carbide material before such material is introduced into the arresters in loose grain form or is manufactured into disks or blocks containing many types of bonds. A desired electrical characteristic in the arrester is that of decreasing the apparent resistance to ground with increasing current leakage while the current is rising in the arrester circuit. It is this property which permits the arrester to discharge large surges to ground without having a peak voltage appear on the line which would destroy the insulation of transformers and other electrical equipment which would be connected to said line. It is transient peak voltages which do the damage to the insulation of the line and the electrical equipment attached thereto. Therefore, it is customary for the builders of lightning arresters to examine the transient phenomena by means of a cathode-ray oscillograph where instantaneous voltage drops and corresponding currents may be recorded for judging the performance of the valve material. A typical cathode-ray oscillogram of a lot of grain of my invention is herein given in Figure 3. The measurement was made on loose grain held in an insulating body under standard conditions of packing and with a fixed ratio of length to cross section. The pressure of the grain was standardized. The second and the fourth surges on the oscillogram correspond to the second and fourth artificial lightning strokes applied to the arrester. In the case of this specific test plotted it will be noted that the size of the current stroke was more than twice as great on the fourth as it was on the second test. A suitable means for comparing the quality of arrester materials is to subject them to surges of increasing magnitude until they break down. A breakdown has been shown in some unsuitable materials in 10 microseconds. In such a case the voltage would go to zero and the arrester would act as a short circuit on the line. The voltage curve shown by the fourth surge is smooth and shows no breakdown. It also shows a very definite cut-off indicated by the sharp point of deflection at 27 microseconds in the case of the second surge and at 25 microseconds in the case of the fourth surge.

It is a feature of this invention that some of the advantages may be achieved by mixing a small

amount of boron carbide grain with a larger amount of silicon carbide grain. The benefits ascribed to boron carbide and silicon carbide individually can be achieved in combination in the following manner.

I provide silicon carbide of relatively large grit size, for example of the order of 60 mesh. I then coat this silicon carbide with boron carbide of much finer size, for example 150 to 200 mesh. While there are many practical ways of coating silicon carbide with boron carbide I may attach the boron carbide to the silicon carbide with sodium silicate. For example if silicon carbide grains of the desired size are mixed with a sodium silicate solution containing one mol Na_2O to two mols of SiO_2 then partially dried boron carbide can be mixed in with the grains and will adhere to the silicon carbide. Furthermore it is now known to the art to form a mixed carbide consisting in part of boron carbide and in part of silicon carbide and a material of this nature may be used in carrying out my invention.

Boron carbide suitable for this application is preferably free from uncombined graphite, free boron, and suboxides of boron, the presence of which destroys the desirable electrical properties which are characteristic of the material. Such a product is described in my United States Patent No. 1,897,214. The method of manufacture of this carbide is described in detail therein.

With regard to the proportions of boron carbide and silicon carbide, respectively, there is no upper limit since as aforesaid I can use pure boron carbide B_4C . In order to have an appreciable advantage over plain silicon carbide, it is sufficient to use one per cent of boron carbide.

It will thus be seen that there has been provided by this invention an article 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, or shown in the accompanying drawing, is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. A lightning-arrester valve-element comprising as its basic material, a loose mass of crystalline granules of the mixed carbide of boron and silicon in which the proportion of silicon to the carbon of the mixed carbide, not combined with boron is in the ratio SiC and the proportion of boron to the remainder of the carbon in the mixed carbide is in the proportion B_4C , the mixed carbide having at least one per cent of boron carbide.

2. A lightning-arrester valve-element comprising as its basic material, boron carbide, B_4C .

3. A lightning-arrester valve-element comprising as its basic material, silicon carbide SiC grains and boron carbide B_4C grains, the boron carbide grains being bonded to the silicon carbide grains and there being no less than one per cent of boron carbide.

4. A lightning-arrester valve-element comprising as its basic material, silicon carbide SiC grains and boron carbide B_4C grains, the boron carbide grains being bonded to the silicon carbide grains with alkaline silicate and there being no less than one per cent of boron carbide.

5. A lightning-arrester valve-element in which the basic material consists of granular boron

carbide B_4C and no other substance in any substantial amount.

6. A lightning-arrester valve-element according to claim 3 in which the boron carbide grains are substantially smaller than the silicon carbide grains.

7. A lightning-arrester valve-element according to claim 4 in which the boron carbide grains are substantially smaller than the silicon carbide grains.

8. A lightning arrester valve element comprising in combination silicon-carbide grains and means for lowering the resistance of said silicon-carbide grains consisting of boron-carbide grains bonded to said silicon-carbide grains.

9. A lightning arrester valve element comprising in combination silicon-carbide grains and means for lowering the resistance of said silicon-carbide grains consisting of boron-carbide grains bonded to said silicon-carbide grains of substantially smaller grit size than said silicon-carbide grains intimately associated with said silicon-carbide grains.

10. A lightning arrester valve element comprising in combination a mass of silicon-carbide grains and means for lowering the resistance of the mass of silicon-carbide grains comprising boron-carbide grains substantially smaller than said silicon-carbide grains, bonded to said silicon-carbide grains.

11. A lightning arrester valve element comprising in combination a granular mixture formed largely of silicon-carbide grains with which are mixed in intimate relation a relatively small amount of boron-carbide grains.

12. A lightning arrester valve element comprising in combination a granular mixture formed largely of silicon-carbide grains with which are mixed in intimate relation a relatively small amount of boron-carbide grains, the grit size of said boron-carbide grains being substantially smaller than the grit size of said silicon-carbide grains.

13. A lightning arrester valve element comprising silicon-carbide grains coated with boron-carbide grains substantially smaller than said silicon-carbide grains.

14. A lightning arrester valve element comprising in combination a relatively large amount of silicon-carbide grains of large grit size having means for lowering the resistance of said silicon-carbide grains without substantially increasing the space required for said silicon-carbide granules consisting of a relatively small amount of boron-carbide grains of small grit size bonded to some of said silicon-carbide grains.

15. A lightning arrester valve element comprising a body of mixed granules of silicon-carbide and boron-carbide the volume of said body being determined by the amount of silicon-carbide granules, and said boron-carbide granules being present in the interstices between said silicon-carbide granules.

16. A lightning arrester valve element comprising silicon-carbide granules of a grit size on the order of 60 mesh, having attached thereto boron-carbide granules of a grit size on the order of 150-200 mesh.

17. A lightning arrester valve element comprising silicon-carbide granules of a grit size on the order of 60 mesh, compacted with boron-carbide granules of a grit size on the order of 150-200 mesh.

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