

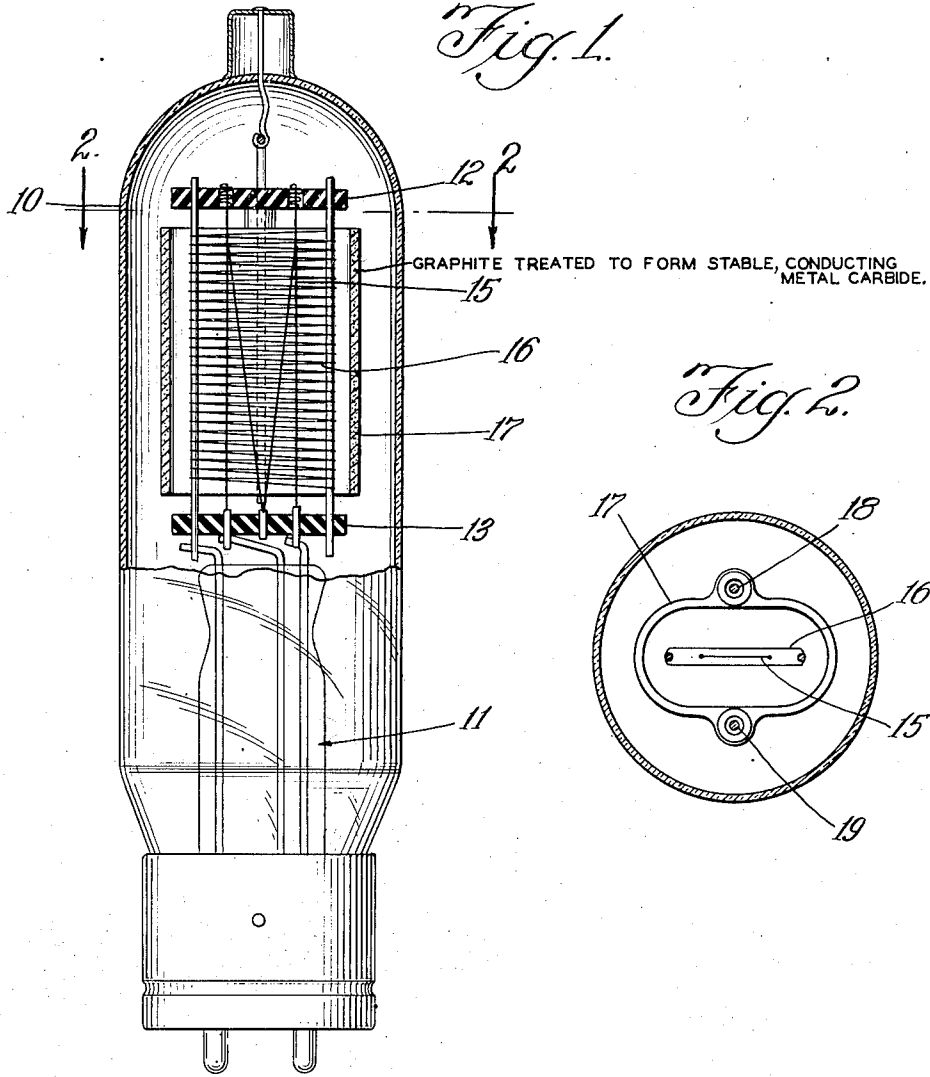
May 5, 1942.

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2,282,098

CARBON ELECTRODE

Filed Oct. 17, 1940



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UNITED STATES PATENT OFFICE

2,282,098

CARBON ELECTRODE

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Application October 17, 1940, Serial No. 361,470

9 Claims. (Cl. 250—27.5)

This invention relates to carbon electrodes for electron discharge devices and particularly to graphite electrodes in both vacuum and gas discharge devices.

In space discharge devices, whether of vacuum, gas or metal vapor type, extremely high standards of purity are required. This applies to electrode material and particularly to carbon electrodes.

The advantages of carbon for electrodes has long been known. As is well known, carbon electrodes can function in any capacity except as cathodes. Their greatest utility is as anodes for rectifiers or multielectrode tubes although they are useful as shields also.

As anodes in tubes, carbon electrodes have some desirable characteristics. Thus the carbon can withstand high temperatures and radiates heat better than most metallic electrodes. The carbon is usually massive enough so that no buckling under heat is possible whereas metallic electrodes must be flanged to prevent distortion. A carbon electrode will not back-emit even under the most adverse conditions.

On the other hand, carbon electrodes have presented problems of such difficulty that their use has been restricted compared to the normal use to which the advantages thereof entitle it. Graphite is the form of carbon used for electrodes, principally because it behaves better in the tube. As is well known, graphite, as well as other forms of carbon, have great gas absorptive powers. During the processing of the electrode, it is customary to heat the carbon to a temperature in excess of that encountered in normal tube usage. The gases released during this heat treatment are either removed during exhausting or fixed by getters during ageing.

However, in spite of all precautions, residual gas remains in the electrode and under certain overload conditions of tube operation may be released. The vacuum or normal gas content may be so changed that the recognized characteristics of the tube disappear making it worthless.

In the case of a tube having an oxide coated cathode, the flash back may easily cause the deposition of enough carbon on the cathode to kill emission.

Even under the best of conditions, the presence of a graphite electrode near an oxide coated cathode during exhausting never does the cathode good. As a rule, the first heating of the graphite during exhausting results in hydrocarbon vapors and these tend to damage the oxide coatings on the cathode.

By virtue of my invention, the disadvantages incident to the use of carbon as electrodes in electron discharge devices is eliminated to a great degree. Not only are the normal advantages of carbon for electrodes rendered more available for

every day use but the carbon is improved so that its natural advantages are enhanced while eliminating its natural drawbacks.

Thus a carbon electrode made according to my invention had decidedly greater mechanical strength and may be machined and threaded more expeditiously. In addition, the electrical and heat conductivity are improved thus making for more uniform electrode conditions. The contact resistance is lowered so that metal rods inserted into a carbon electrode have a more intimate electrical connection therewith.

By the use of my improved carbon electrode, economies in manufacture and reduced wastage are attained. The improved carbon may be degassed more easily and more thoroughly than before and will not release gas in a finished tube even under severe overload conditions. No deposition of carbon particles either on a cathode or glass occurs. In fact, the improved carbon electrode combines in itself the advantage of natural carbon and metal electrodes without the disadvantages of either.

In general this invention contemplates the dispersion within the carbon of a metal or metals, which I believe combine with some or all the carbon to form a carbide. The dispersion of the metal is conveniently effected by utilizing the sponge action of carbon on a metal bearing solution. The carbon is first rid of its oil content by burning and then wet as above. The subsequent heat treatment may then result in the metal or metals being deposited in the carbon and it is my belief that some combination between metal and carbon is effected.

The metal or metals that may be used must of course satisfy the normal commercial requirements of availability and workability; i. e. susceptible to being handled under readily attainable temperature and other conditions. Thus, for example, calcium carbide is unstable in the presence of water so that a carbon electrode having this material as a part thereof would have to be handled under difficult conditions. The electrode might even be dangerous after a tube containing it is carelessly discarded.

Another metal whose use is inconvenient is thorium. The oxide would normally be formed. Thorium oxide is highly stable and requires an extremely high temperature to break it down. Such high temperatures may be too severe on other parts of the tube.

It is understood however that calcium or thorium may be used in spite of the above disadvantages, if desired. However, other metals like molybdenum, iron or tungsten may be more advantageously used.

Of the metals readily available on the market molybdenum is preferred. As one example, an electrode may be processed in the following man-

ner. The graphite is first heated in air to a dull red heat preferably by an induction furnace so as not to introduce any contamination. The heating is continued until all oil and grease is burned away. The graphite is then dipped into an aqueous solution of molybdic acid. Thereafter the graphite electrode is heated in air enough to dry it. Then the dried graphite is heated in a hydrogen or other reducing atmosphere until the graphite is at a white heat and this is continued for a period of a few minutes for ordinary sizes of electrodes.

If a sufficient quantity of molybdenum has been absorbed and combined with the carbon, the graphite electrode will have a smooth fine grained finish somewhat resembling cast iron and when struck will emit a metallic ring. If the graphite electrode is not converted in this fashion, additional soakings in molybdenum bearing solution and heating may be repeated. After some experimentation, the solution concentration and time of soaking may be found so that one heating will accomplish the desired purpose.

The interior of the graphite, when properly treated, is also fine grained. I believe that loose carbon, and non-graphitic carbon are burned away or combined with metal to leave a homogeneous fine grained structure.

Excess of metal is not objectionable so that great care in either wetting or heating is unnecessary. The electrode may be heated by induction in a hydrogen atmosphere to reduce the metal and form the carbide. The usual technique may be pursued with the processed electrode.

A tube having an electrode treated as above provides better operating conditions for the cathode so that the tube life as a whole is prolonged.

Instead of molybdic acid, the nitrate or other readily soluble salt may be used. Tungsten may be handled by dissolving it in concentrated sodium hydroxide. Iron may be used in the chloride form. When using salts of a strong base or acid, as molybdenum nitrate, it has been found that a second wetting of the carbon electrode may tend to dissolve the metallic molybdenum or undo some of the effects of the process. In such case, it is preferable to plan one wetting and subsequent heating to accomplish the desired object. With molybdic acid, however, repeated wettings do no harm. However, it is preferred to use concentrated solutions so that only one cycle of the process is sufficient.

Zirconium, vanadium and chromium may also be used. Other metals either form unstable carbides or, like silicon for example, are difficult to introduce into the carbon or form a compound having a high electrical resistance. Silicon is undesirable for both of these reasons. Zirconium is satisfactory but the carbide can not withstand excessive temperature and must therefore be handled carefully. This means that a zirconium treated electrode would have to be kept below the decomposition temperature of the carbide.

Referring to the drawing:

Figure 1 shows an elevation of an electron discharge device;

Figure 2 is a section on 2—2 of Fig. 1.

The electron discharge device comprises an envelope 10 of glass or other material having a stem 11. Between spaced insulators 12 and 13 is an electrode assembly. This assembly con-

sists of an M-shaped cathode 15 which may be of the oxide coated type, a grid 16 and anode 17. The anode may be flanged as shown in Fig. 2 and be threaded with supporting rods 18 and 19. The anode may be of graphite processed as described above. The detailed construction of the device and the electrode connections are all well-known and will therefore not be described in detail.

For high power electron discharge devices, it is possible to make the control grids of graphite treated as described herein. In fact, any electrode may be made of the processed graphite. While the processed graphite is unsuitable for present day electron emitting cathode surfaces, it may be used as part of a composite construction where the graphite need only carry current. The processed graphite may be used in a vacuum, gas or metal vapor such as mercury or caesium.

What is claimed is:

1. The method of processing a carbon electrode which consists in treating said carbon with a solution of a metallic compound, and then heating the treated carbon in a reducing atmosphere to a high temperature, said metal being one to form a stable electrically conductive carbide.

2. The method of processing an oil free graphite electrode which consists in soaking said electrode in a solution of a molybdenum compound, heating the treated electrode to at least a red heat in a reducing atmosphere to form an electrode having a fine grain and metallic ring.

3. The method of processing a graphite electrode consisting in wetting it with a solution of a metallic compound, and heating by electrical induction in a hydrogen atmosphere, said metal being one to form a stable electrically conducting carbide.

4. The method of processing a graphite electrode consisting in burning away the oil and grease, wetting with a solution of a molybdenum compound, inductively heating at least to a red heat in a hydrogen atmosphere, said molybdenum and heating being in sufficient quantity to impart a fine grain and metallic ring to the electrode.

5. The method of claim 4 wherein said compound is molybdic acid.

6. In an electron discharge device, the combination of an oxide coated cathode and a non-emitting electrode of molybdenum carbide, said electrode being substantially uniform and homogeneous throughout its mass.

7. In the manufacture of electron discharge devices having graphite electrodes, the steps which include wetting of said graphite electrode in a molybdenum bearing solution and inductively heating the electrode to at least red heat while washing with hydrogen for a time long enough to form molybdenum carbide and impart a fine grain to said electrode.

8. An electrode consisting of graphite combined with a metal to form a stable, electrically conducting carbide, said electrode being uniform and homogeneous throughout its mass and characterized by fine grain, ringing response to striking, increased electrical and heat conductivity, and being substantially free of absorbed gases when processed for use in an electron discharge device in comparison to the untreated graphite.

9. The electrode of claim 8 wherein said metal is molybdenum.

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