

Aug. 1, 1950

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GRID FOR ELECTRON DISCHARGE DEVICES

Filed Jan. 16, 1946

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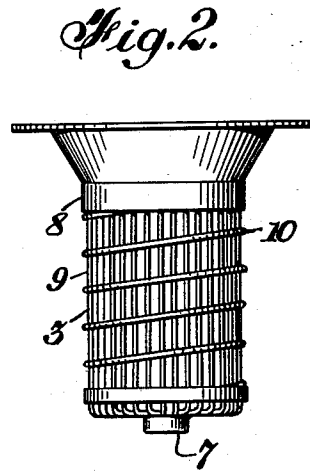
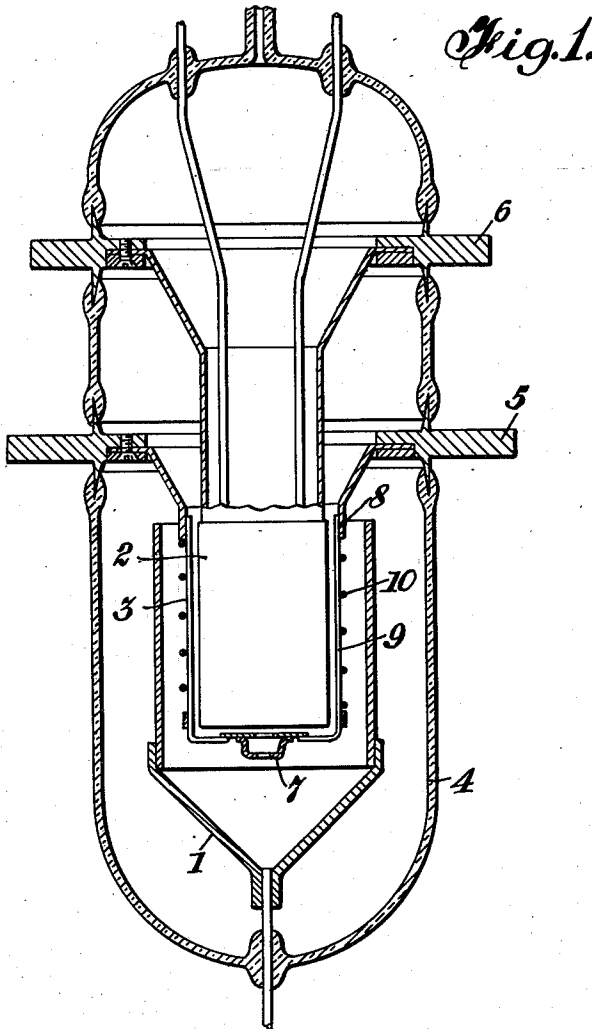
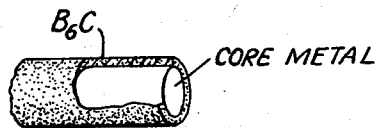


Fig. 3.



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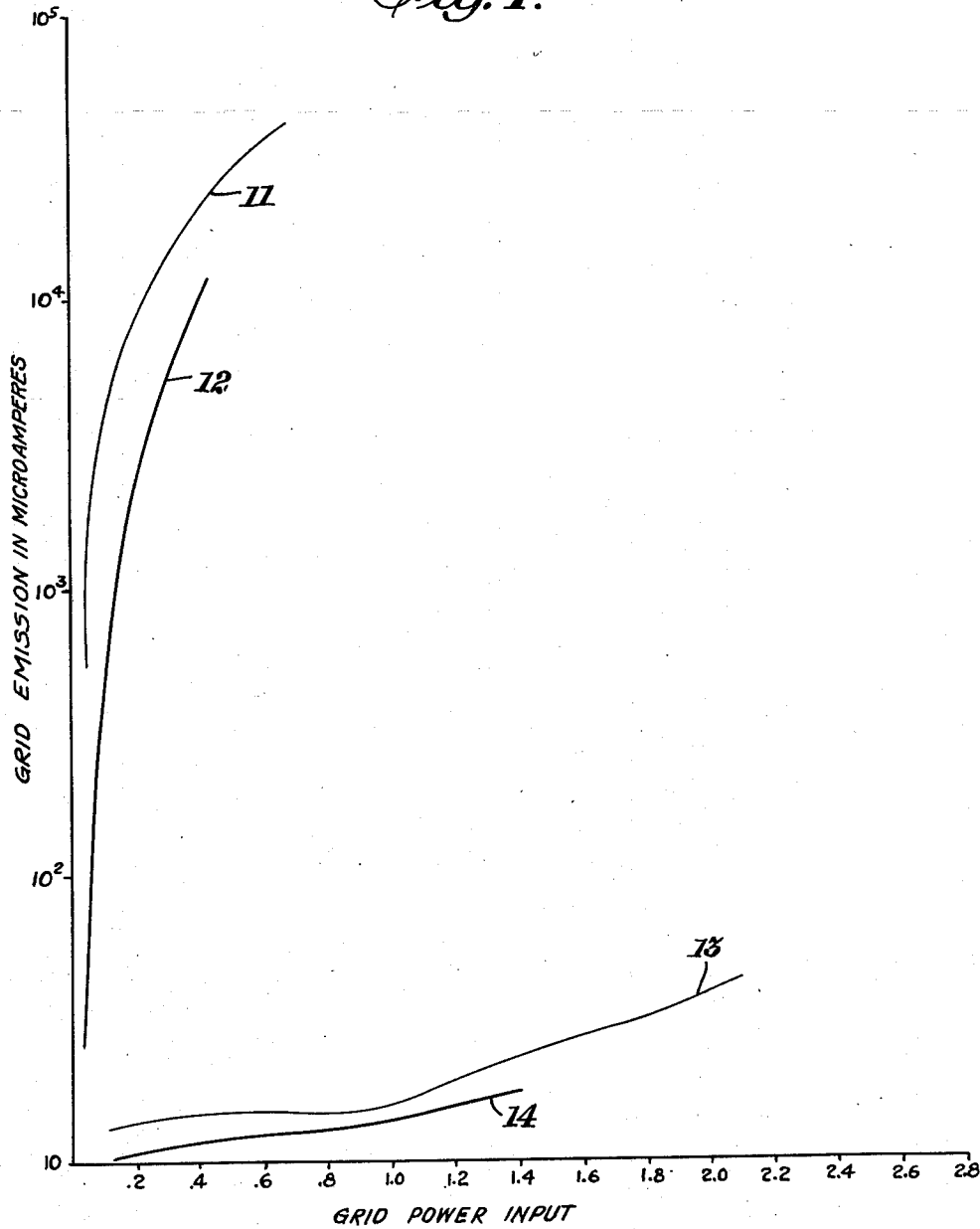
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Fig. 4.



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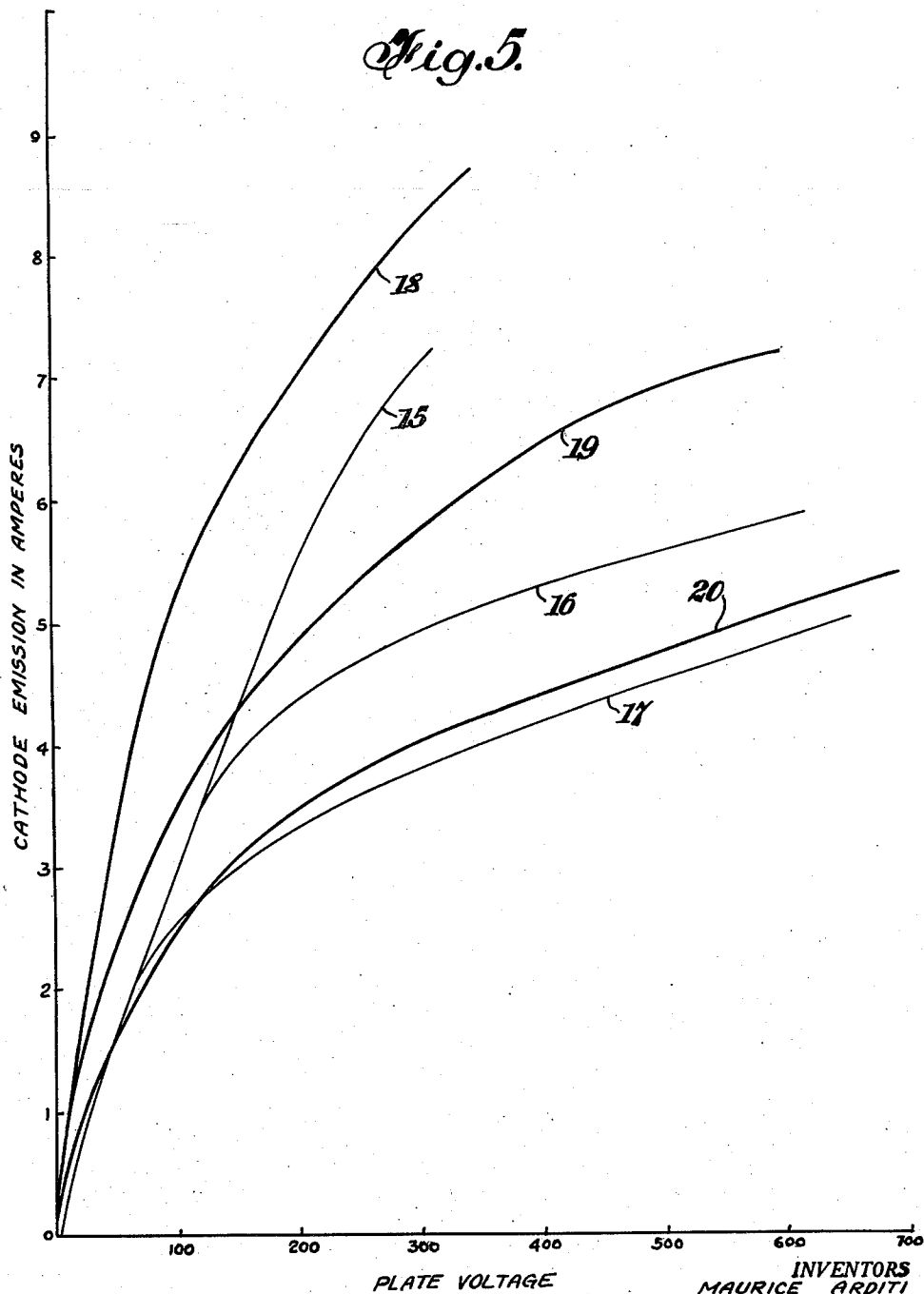
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GRID FOR ELECTRON DISCHARGE DEVICES

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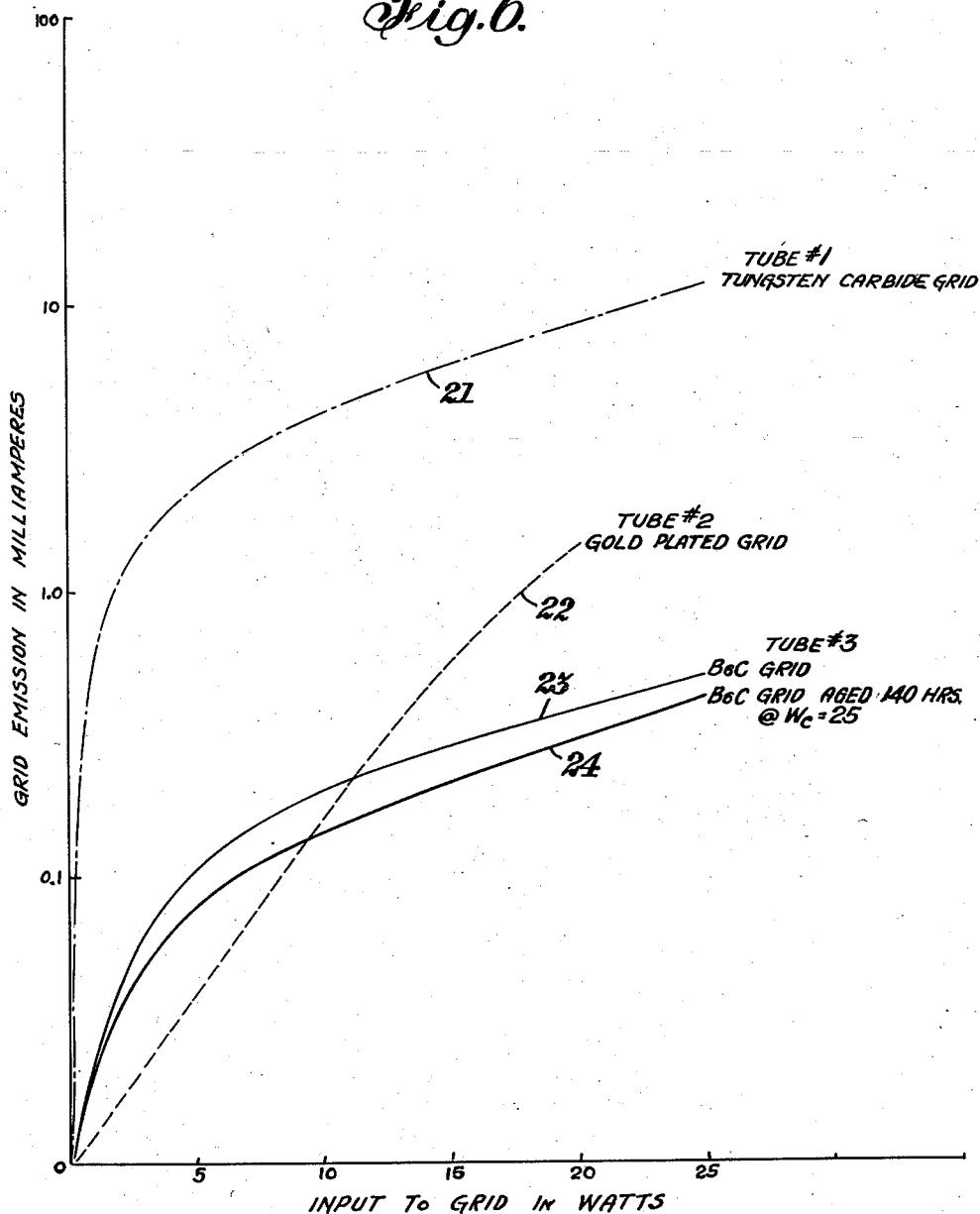
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Fig. 6.



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GRID FOR ELECTRON DISCHARGE DEVICES

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3 Claims. (Cl. 250-177)

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This invention relates to grids for electron discharge devices. Grid structures in the anode-cathode space of radio tubes which operate at ultra-high and micro-wave frequencies usually must dissipate disproportionately large amounts of heat energy. The grid is heated by induction, by electron and ion bombardment, and by radiation from the cathode, and because of the fine-wire construction of the grid, the grid is first to reach the limiting temperature of the tube. Even at temperatures below which the grid normally operates, there may be considerable primary emission from the wires and a consequent reduction in tube input impedance. Finally, gas evolved and metals evaporated from the grid will poison and reduce cathode emission.

An object of this invention is improved grids for electron discharge devices.

A more specific object of this invention is a grid of metal having a high melting point, and having a surface with black body characteristics, low primary and secondary emission, low vapor pressure, and good electrical conductivity.

The characteristic features of this invention are defined in the appended claims, and a preferred embodiment is described in the following specification and shown in the accompanying drawings, in which:

Fig. 1 is a vertical sectional view of one electron discharge device having the novel grid of this invention;

Fig. 2 is a typical grid structure;

Fig. 3 is a section of the novel grid; and

Figs. 4, 5 and 6 are curves showing comparative operational characteristics of grids treated according to our invention.

The discharge device of Fig. 1 is of the medium power, high frequency type in which the grid is subject to considerable heating. The anode 1, cathode 2 and grid 3 are cylindrical and coaxial and are sealed in envelope 4, the lead-in for the anode being sealed at the lower end of the envelope, well removed from the grid and cathode supports 5 and 6 respectively. The desirable properties of the novel grid here described are obtained when the cathode is the conventional, barium-strontium oxide coated core. One simple grid structure shown in Fig. 2 comprises an upper central supporting member 7 and a spaced supporting band or collar 8 to which are secured by spot welding a plurality of fine vertical grid wires 9. A spiral of fine wire 10 is wound around the cylinder formed by wires 9 and secured to the wires, for example, by welding to make the structure rigid.

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The grid core metal is preferably molybdenum or tungsten or any workable high melting metal which will not sag or warp at red or even white operating temperatures. Molybdenum is a desirable metal for the grid and spiral supports because of its malleability. The surface of the core metal, according to the characteristic feature of this invention, and as shown in Fig. 3, is a layer of carbide of boron (B_2C). Finely powdered boron carbide is made to adhere to the core preferably by sintering, the depth of the coating being sufficient to substantially conceal the underlying core, and the grain size of the powder being such as to give an even, smooth non-porous and somewhat carbonized appearance to the grid. One suitable grain size for use is found to be 800 mesh.

Electron discharge devices having a grid with a boron carbide surface have been found to operate throughout a normal life at rated power levels, with low grid emission, and normal cathode emission. Good results were obtained with medium and high power short-wave tubes of the type shown in Fig. 1 in which the grid-cathode spacing was about .076 inch and .005 inch as well as intermediate limits. The emission from the cathode with an oxide coating indicated no tendency to drop below normal despite the abnormally close grid-cathode spacing. In addition to the low emission from the grid and the complete absence of poisoning effects on the cathode, the boron carbide coating on the grid has good conductivity for high frequency currents. When operated at 600 megacycles, the Q of a resonant cavity made between such a coated grid and an anode was about 1200, as compared with 1025 for pure molybdenum and 1700 for pure tantalum grid.

The above-described grid was made by spraying a wet mixture of the powdered boron carbide on the wires of a prefabricated grid structure. One specific mixture found to give good results was prepared by ball milling commercial boron carbide. An inert liquid binder and vehicle for the powder consisting of 26 cc. of pyroxylin or nitrocellulose dissolved in 243 cc. of amyl acetate was used; sufficient powder being mixed in the liquid to produce a paint of such a consistency as to spray well from an air-operated spray gun. Uniform coatings on the grids were obtained by mounting the grids in rotating fixtures and alternately spraying and drying with infra-red radiation. The passes were repeated until about 10 milligrams of coating per square centimeter were deposited, whereupon the coating was baked under an infra-red light. The coated grids were then

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rum fired to degas the grid and to firmly adhere the coating to the core. When heated to 1 degrees centigrade in vacuum, boron carbide appears to form a sintered layer at the surface of the carbide powder and the core. The grid is black and smooth in appearance, similar to a carbonized surface.

Another grid coating which was also satisfactory was prepared as follows:

To 25 cc. of tetraethyl orthosilicate is added 2 cc. of material composed mainly of ethyl alcohol denatured with methyl alcohol, ethyl acetate, ethyl isobutylketane and aviation gasoline. The added material is commercially available under the trade name of "Synasol." This mixture is stirred until it is uniform. Then to this mixture is added 5 cc. of 3% hydrochloric acid. The solution is stirred until hydrolysis is completed and allowed to stand three hours before

27 grams of boron carbide (800 mesh) are introduced into a mortar and 40.5 cc. of the binder mixture described above is put in at the rate of about 1 cc. at a time. Between each addition of the binder the mixture is ground with a pestle until uniform, care being taken to see that the final mixture is free of all lumps.

Grids to be coated with this mixture should be vapor degreased in trichloroethylene and then heated in an atmosphere of hydrogen at 100 degrees C. for fifteen minutes. When these operations are complete the grids are not touched with bare hands. The prepared boron carbide mixture is then sprayed on the surface of the grid using as fine a spray as possible. In order to facilitate the deposition of a smooth uniform coating, the grids should be rotated at about 100 R.P.M. during application of the coating. Sufficient coating should be sprayed onto the surface to insure complete coverage. It was found that about 3 milligrams per square centimeter of coated surface is the optimum weight of coating. After the grid has been sprayed the coating should be dried by placing it about four inches from an infra-red radiating lamp, the grid being slowly turned. The coated grid may then be mounted in the tube. If desired the grids may be first vacuum fired before they are assembled in the final tube.

The vacuum firing may be carried out in the tube in which the grid is finally mounted, or the other electrodes, or the firing may be carried out in a separate envelope or bell-jar before mounting, high frequency induction being the most practical source of heating energy.

Turning now to Fig. 4, the operating characteristics of the tube prepared in accordance with the invention may be observed. This figure shows grid emission in microamperes plotted on a semi-logarithmic scale against the grid power input in watts. Curves 11 and 12 illustrate the emission obtained from pure molybdenum grids after twenty one and thirty two hours of operation respectively, while curves 13 and 14 illustrate grid emission curves on the same scale for grids treated with boron carbides. This shows that grid emission is reduced to an extremely low value while the untreated grids have extremely high emission.

Turning now to Fig. 5, a comparison is shown between the cathode emission and plate voltage of tubes having treated and untreated grids. In untreated grids as shown in curves 15, 16 and 17 filament voltages of 7, 6.3 and 6 volts respectively, are shown. At 18, 19 and 20 are shown similar respective curves for the cathode

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emission in tubes having the treated grids. It is seen that the cathode emission is higher for these tubes with the treated grids than it is for the tubes using the untreated grids, again the filament voltages being 7, 6.3 and 6 respectively.

In Fig. 6 is shown curve 21 illustrating the grid emission in milliamperes plotted against grid input in watts for a tube having a tungsten carbide treated grid. Curve 22 shows a similar grid emission curve in a common standard in low grid emission, that is, a gold plated grid. Curves 23 and 24 illustrate boron carbide treated grids, curve 24 showing the operation after ageing for one hundred and forty hours. For all grid inputs the boron carbide grids are shown to be far superior to the tungsten carbide treated grids. For all grid inputs above ten the boron carbide grid is shown to be superior to the gold plated grid. Furthermore, after one hundred and forty hours of ageing with a power input to the cathode as high as 25 watts the grid emission from the boron carbide treated grid is even lower than it was initially as clearly demonstrated in curve 24.

The grid of this invention will emit negligible quantities of electrons even at high operating temperatures and will not adversely affect cathode emission. The grid has good conductivity for high frequency current and is simple and easy to manufacture.

We claim:

1. An electron discharge device comprising a cathode having an emissive coating of mixed oxides of barium and strontium, and a control electrode, said control electrode comprising a core of molybdenum bearing an adherent, external coating of a mixture of boron carbide and an inert binder on said core.

2. An electron discharge device comprising a cathode having an emissive coating of mixed oxides of barium and strontium, and a control electrode, said control electrode comprising a core of molybdenum, a layer of sintered particles of boron carbide and the core material on said core, and a layer of a mixture of boron carbide and an inert binder on said layer of sintered particles.

3. An electron discharge device comprising a cathode having an emitting surface of barium-strontium oxides and a control electrode, said control electrode comprising a core of molybdenum, a layer of sintered particles of boron carbide and the core material on said core, and a smooth, external layer of a mixture of boron carbide and an inert binder on said layer of sintered particles.

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