No. 618,704. Patented Jan. 31, 1899.

H. S. MAXIM.

METHOD OF MANUFACTURING FILAMENTS FOR ELECTRIC LAMPS.

(Application filed Jan. 5, 1899.)

(No Model.) 2 Sheets—Sheet 1.

Fig. 2

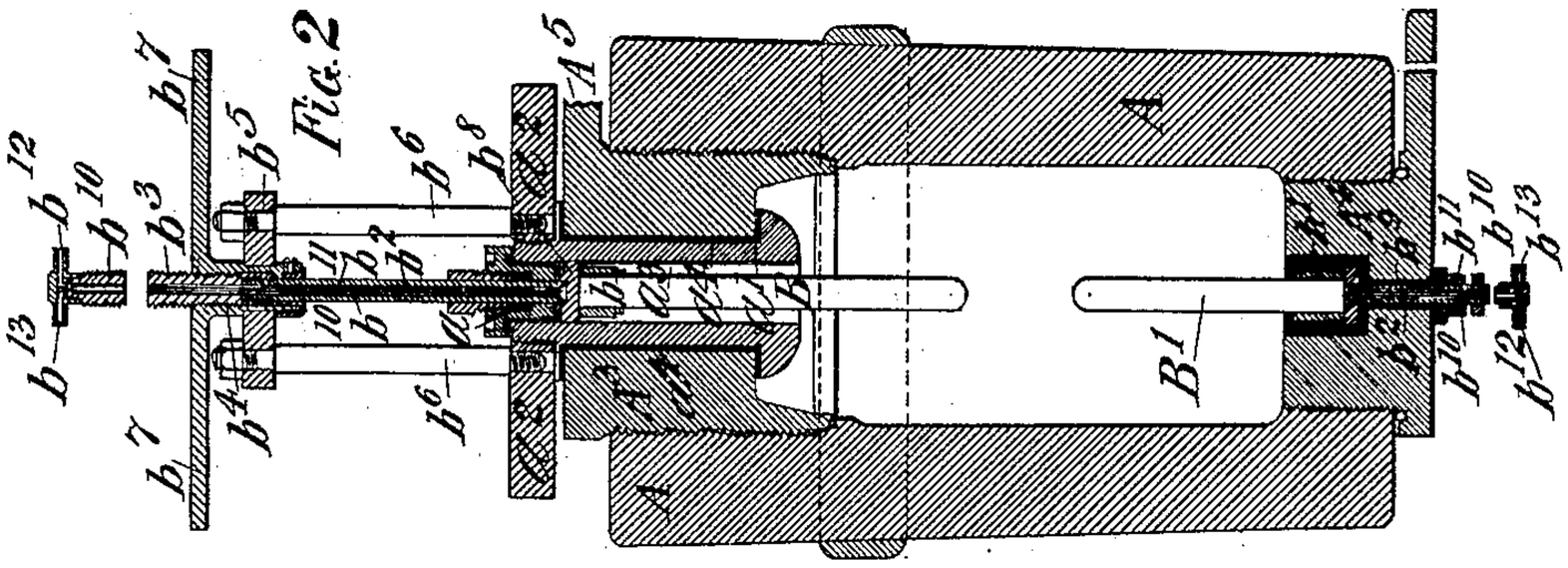


Fig. 3

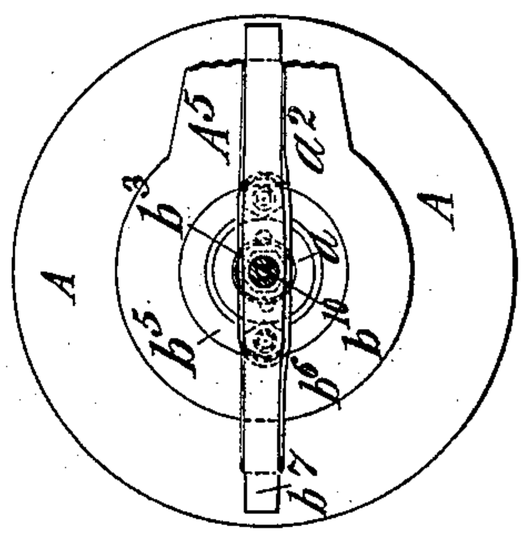
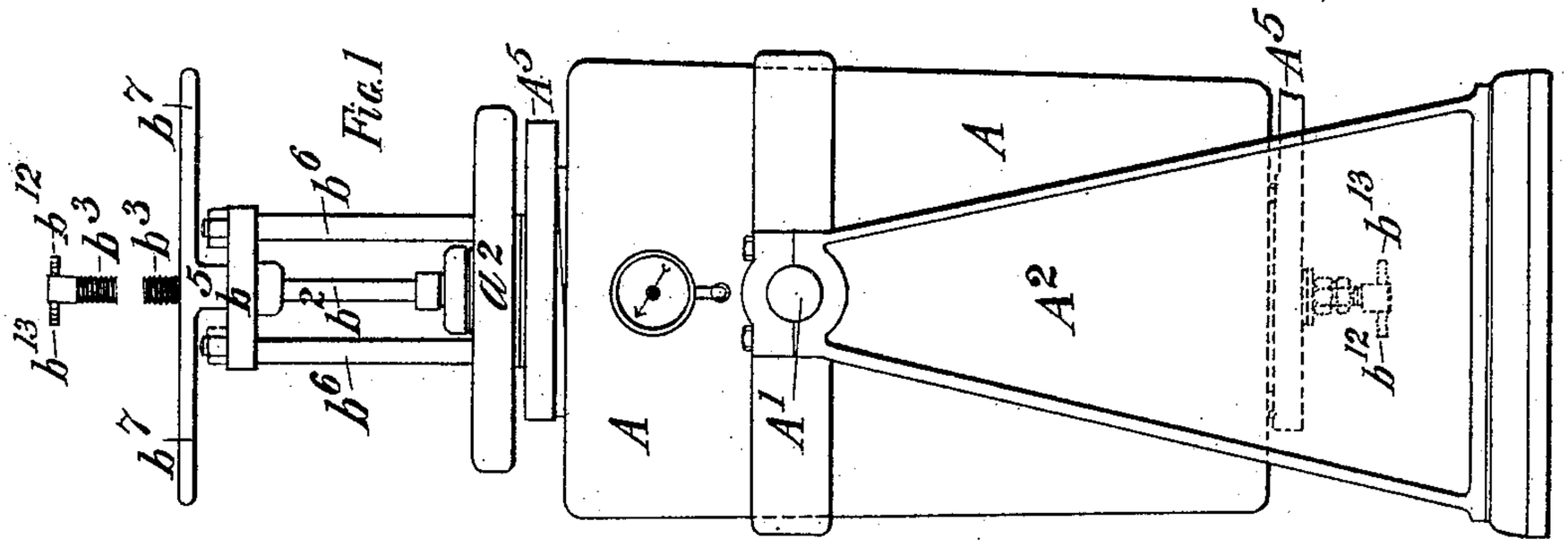


Fig. 1



Witnesses
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Fig. 4

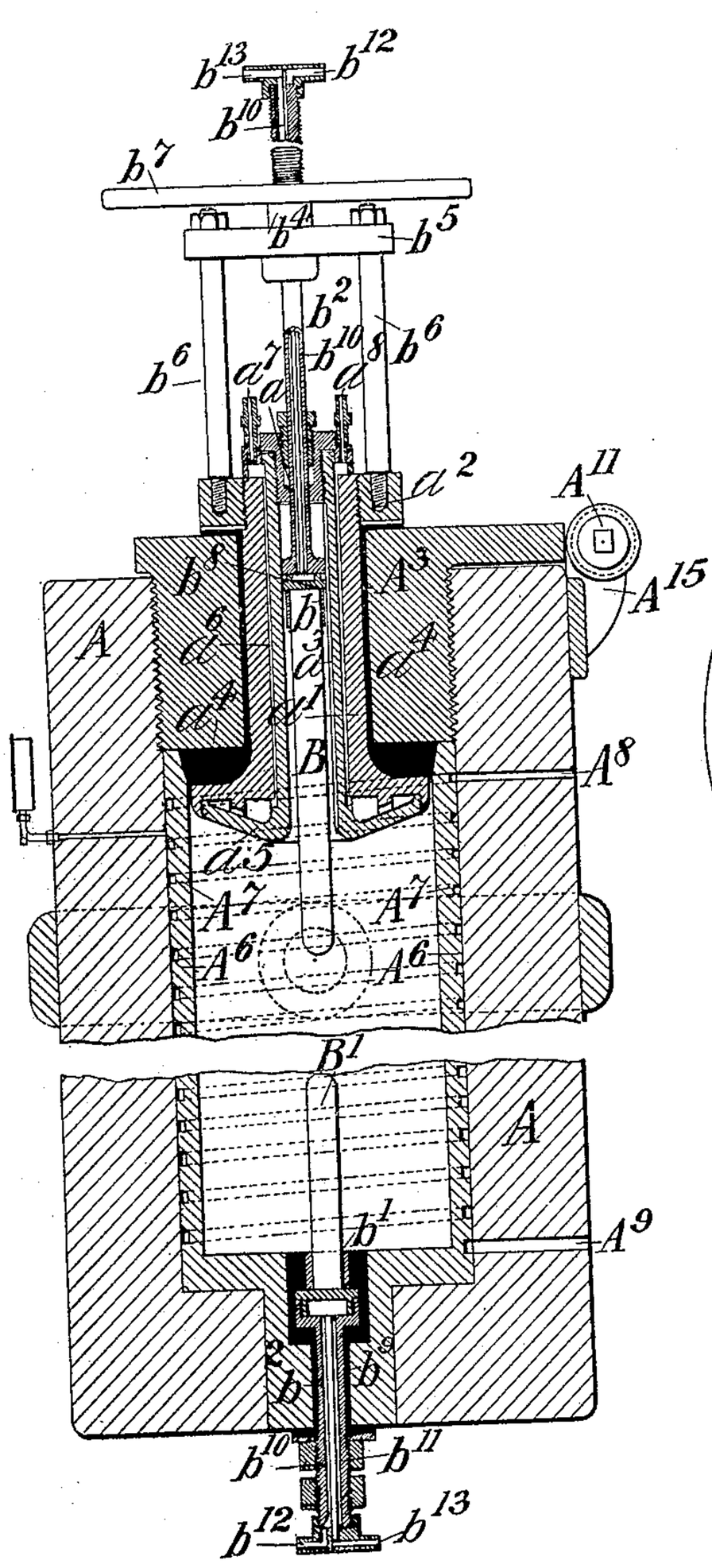
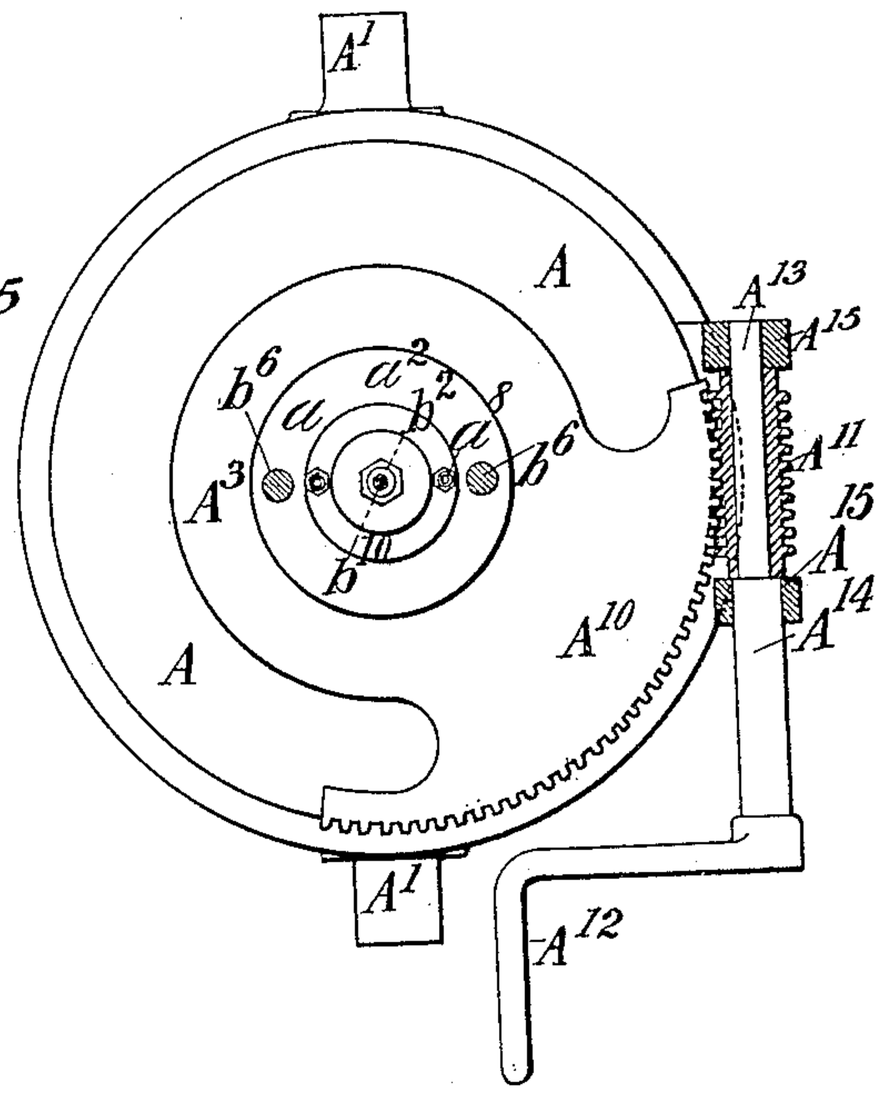


Fig. 5



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UNITED STATES PATENT OFFICE.

HIRAM STEVENS MAXIM, OF LONDON, ENGLAND.

METHOD OF MANUFACTURING FILAMENTS FOR ELECTRIC LAMPS.

SPECIFICATION forming part of Letters Patent No. 618,704, dated January 31, 1899.

Original application filed November 8, 1898, Serial No. 695,833. Divided and this application filed January 5, 1899. Serial No. 701,226. (No specimens.)

To all whom it may concern:

Be it known that I, HIRAM STEVENS MAXIM, a citizen of the United States, residing at 18 Queens Gate Place, London, in the county of Middlesex, England, have invented an Improved Method of Manufacturing Filaments for Electric Lamps, of which the following is a specification.

My invention relates to a method of manufacturing filaments for incandescent electric lamps.

The tendency at the present time in electric lighting is to use very high voltage, and in order to meet the new requirements arising from this tendency it is necessary to increase the resistance of the lamp-filaments as much as possible. This can only be done by making them extremely fine and long or by adding to the carbon of which they are composed some highly-refractory non-conducting material. When such materials as carbid of silicon and carbid of boron are employed with the carbon they are liable to be volatilized by the electric current when the lamp is in use and to form a thin opalescent film on the inside of the glass globe of the lamp. Now diamond-powder is not subject to this objection, as it will endure a very high temperature without being volatilized. Natural diamond-powder—*i. e.*, natural diamond reduced to powder—is, however, too expensive to be used for this purpose, even if made from the cheapest kind of stones that can be obtained; but according to my invention I am able to manufacture a species of carbon which, while closely, if not completely, resembling the diamond, will be less expensive than natural diamonds. For this purpose it is necessary to employ an extremely great pressure and a high temperature, and an important feature of my invention has reference to the manner in which such great pressure and high temperature are obtained.

It is well known that carbonic acid or carbon dioxid (CO_2) may be retained in the liquid condition at a pressure of about from five hundred to six hundred pounds per square inch at ordinary temperatures, but that if it be converted into carbon monoxid the pressure required to confine it is very much greater. I take advantage of this fact to obtain the high pressure and temperature I require by placing in a strong tightly-closed vessel carbonic acid in the liquid or solid condition, together with carbon, preferably a hydrocarbon, such as gasolene. The carbonic acid and the hydrocarbon are then decomposed by subjecting them to the voltaic arc, the oxygen of the carbonic acid being thus caused to take up another measure of carbon and to be thereby converted from carbon dioxid into carbon monoxid. This decomposition, together with the rise in temperature, will produce the necessary pressure, the temperature of the carbon being at the same time raised so extremely high that the carbon in immediate contact with or contiguous to the electric conductors between which the voltaic arc is produced will be converted into a species of diamond-scales which will scratch glass, while all the carbon will be very much modified. In some instances it may be necessary to continue the high temperature for a very long time in order to allow the carbon to crystallize out of the carbonaceous gases. Of course if the carbon or hydrocarbon be heated in carbonic acid alone very little effect would take place, as no very high pressure would be reached, whereas if a too large quantity of hydrocarbon be employed a loose, smutty, and soft deposit would be formed; but by having only a small excess of carbon—*i. e.*, just sufficient to convert all the carbonic acid present into carbon monoxid, with a little free hydrocarbon remaining—then the crystallization may take place from the residuum of gases, and if the process be continued long enough diamond-crystals or a species of diamond-carbon may be formed. The diamond-carbon instead of being of a very low resistance, which is peculiar to carbon whose temperature has been raised very high, will have imparted to it a high quality of electrical resistance. In fact, it may be so perfectly crystallized as to altogether prevent the passage of an electric current through it. This of course depends upon the length of time that the aforesaid treatment is continued and the temperature enployed during such treatment.

In some instances all the ingredients used

for forming lamp-filaments may be mixed and subjected to the high temperature and pressure, or the said ingredients may be treated singly. It will thus be possible to so change the constitution of the carbon or other ingredients as to render them highly advantageous for the filaments of electric lamps. In any case the temperature to which they are subjected is higher than that to which they will be subjected in the lamp itself.

The carbon obtained or the ingredients treated by my method are afterward reduced to extremly fine powder, mixed with suitable vehicles—such as tar, pitch, or sugar—and then molded into filaments, which are "retorted" and "flashed" in the usual manner. It will be obvious from what has already been stated that the electrical resistance of the filaments will be in proportion to the quantity of the diamond-carbon employed in their manufacture.

In the accompanying drawings, Figure 1 is a side elevation, Fig. 2 a vertical section, and Fig. 3 a plan, of one form of the apparatus for use in obtaining a high pressure and temperature according to my invention. Fig. 4 is a vertical section, and Fig. 5 a sectional plan, of a modified construction of the said apparatus.

Referring more particularly to Figs. 1 to 3, A is a strong vessel of approximately cylindrical shape furnished with trunnions A′ A′, by which it is pivotally supported in a frame A^2. This vessel is preferably made of steel lined with suitable refractory material, such as bricks of compressed silica or compressed magnesia, to protect it from the heat to which it is subjected internally when in use. The ends of the said vessel are provided with strong detachable screw-covers or screw-stoppers A^3 A^4, each of which has a lever-handle A^5 to enable it to be conveniently unscrewed when either of the said covers is required to be removed for the purpose of obtaining access to the interior of the vessel.

B B′ are carbon pencils or electrodes mounted in metallic holders b b', forming part of hollow stems b^2, that extend through the aforesaid covers A^3 A^4. The carbon pencils are arranged coaxial with the vessel A, one of them being capable of longitudinal movement with respect to the other, so that the distance between their adjacent ends can be varied according to requirements. For this purpose the stem b^2 of the holder b passes through a stuffing-box a, forming part of the plug-piece a'. This stem b^2 is connected at its outer end with another stem b^3, which is screw-threaded and passes through a nut b^4. The said nut is mounted in a cross-piece b^5, so as to be capable of revolving without sliding, the cross-piece b^5 being connected by bolts b^6 to a disk or bar a^2, which is screwed to the aforesaid plug-piece a' and secures the latter to the cover A^3. The nut b^4 is furnished with lever-handles b^7 to permit of its being revolved, while the stems b^2 b^3 are prevented from revolving by a feather b^8 on the carbon-holder engaging with a longitudinal groove a^3 in the plug-piece. This plug-piece is insulated from the surrounding metal by suitable insulating material a^4. The other carbon pencil B′ is carried by the stationary holder b', the stem b^2 of which passes through the screw-plug A^4 and is insulated therefrom by insulating material b^9, such as mica or asbestos. In order to keep the carbon-holders cool, I make the said stem b^2 b^3 of the movable holder b and also the stem b^2 of the fixed holder b' hollow and arrange within them a central pipe or tube b^{10}, with an annular space b^{11} around it. The extremities of the stems are provided with inlet and outlet nozzles b^{12} b^{13}, one of which communicates with the pipe b^{10} and the other with the annular space b^{11}. Cold water can thus be allowed to circulate through the carbon-holders and the parts directly connected therewith.

The apparatus illustrated by Figs. 4 and 5 is provided with a lining A^6, upon which the vessel A is shrunk, the said lining having a spiral water-course A^7 around it for the circulation of cold water, which enters at A^8 and escapes at A^9. The plug-piece a' is likewise formed with a hollow head a^5, communicating with longitudinal passages a^6 and with inlet and outlet nozzles a' a^8 for enabling cold water to circulate through said plug-piece and keep it cool. The screw-stopper A^3 is in this example provided with an obturator $A^\times$, composed of asbestos and plumbago, with a slight admixture of paraffin-wax for assisting in rendering the vessel A gas-tight. It is also provided with a toothed segmental portion A^{10}, adapted to gear with a worm A^{11}, mounted on an axle furnished with a crank-handle A^{12} for revolving it. The said upper stopper A^3 is formed with interrupted screw-threads, so that by giving approximately a quarter-turn thereto it will be released from engagement with the corresponding interrupted screw-threads on the vessel A. To permit of its then being readily removed from the vessel, the said worm and the crank-handle are adapted to be disconnected by forming the worm with a longitudinal central hole of rectangular shape to receive the axle, which is also of rectangular shape at the part where the worm fits it. The end A^{13} of the said axle and the portion A^{14} are made cylindrical to fit the bearings A^{15}. When the axle has been revolved a sufficient number of times to turn and release the stopper as aforesaid, the said axle can be withdrawn longitudinally from the bearings A^{15} and also from the worm, whereby both these parts are at one operation detached from the vessel A.

In using the apparatus the carbon or hydrocarbon is placed within the vessel A, together with a quantity of carbonic acid, preferably in its solid or snow-like condition. The vessel is then hermetically sealed by tightly screwing on the screw-stoppers, and the electric current is then allowed to pass

between the carbon pencils. As the temperature rises by the heat generated by the electric current the solid carbonic acid in the presence of the carbon will be converted into carbon monoxid and a great pressure be thereby generated within the vessel, as aforesaid. The continuance of such high temperature and great pressure will convert the carbon into a very hard and crystalline condition, which after its removal from the vessel is crushed into fine powder for use with the carbon employed in the manufacture of the filaments, as already explained above.

I do not claim herein the apparatus described and illustrated for manufacturing filaments for electric lamps, the same having been made the subject-matter of a separate application filed by me November 8, 1898, bearing Serial No. 695,833.

What I claim is—

The process of manufacturing high-resistance filaments for electric lamps which consists in subjecting solid or liquid carbonic acid and carbon in a closed vessel under great pressure to the action of the voltaic arc, thereby converting the carbon into a dense crystalline form, then comminuting the resulting product, mixing the same with a suitable binder, molding the mixture into filaments, and finishing the filaments in the usual manner as hereinbefore set forth.

In testimony whereof I have hereunto set my hand this 23d day of December, 1898.

HIRAM STEVENS MAXIM.

Witnesses:
DRURY W. COOPER,
HILLARY C. MESSIMER.