

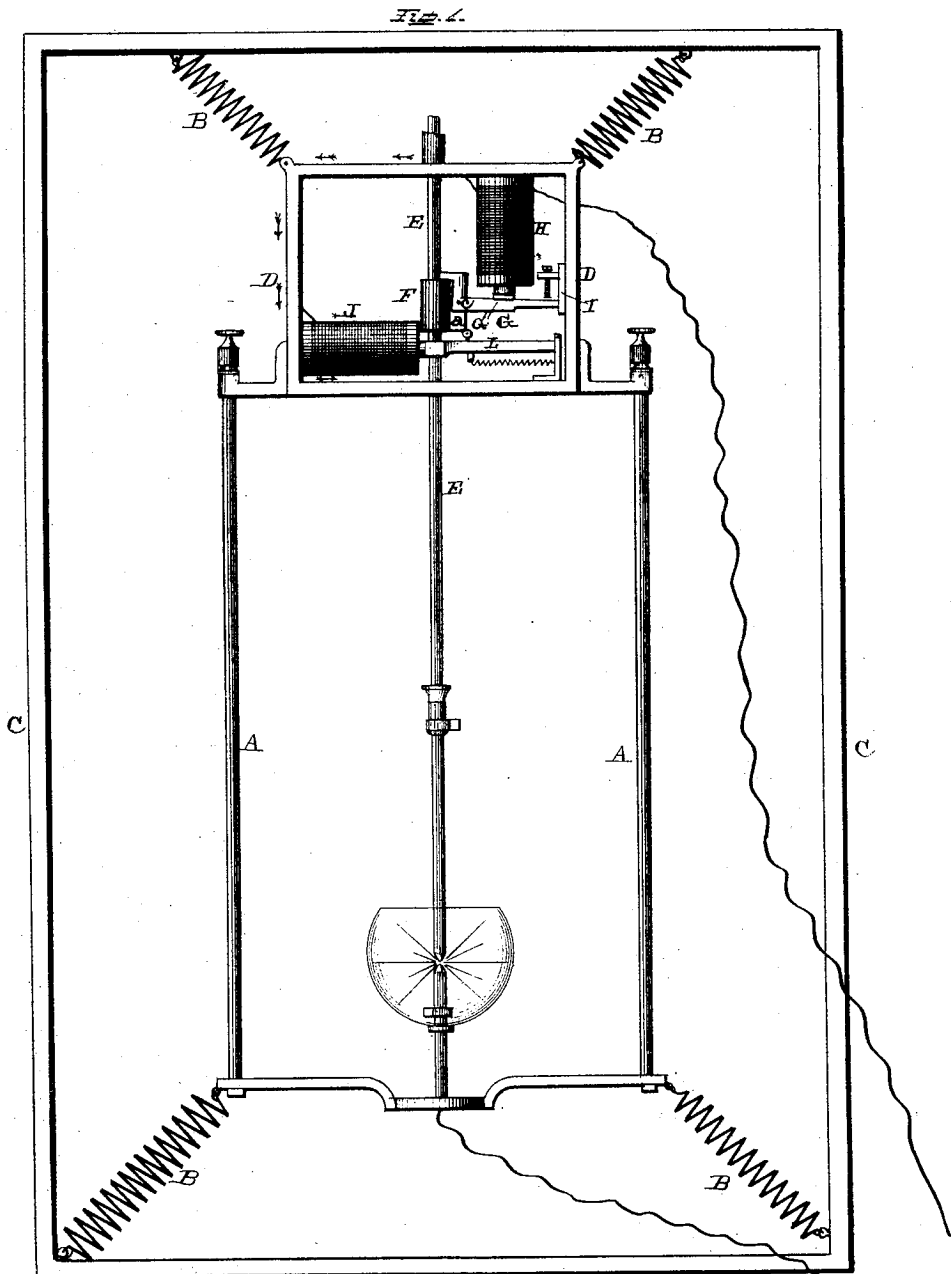
(No Model.)

3 Sheets—Sheet 1.

L. G. WOOLLEY.
Electric Lamp.

No. 241,112.

Patented May 3, 1881.



Witnesses
Wm. C. Mortimer
A. C. Kiskadden

Inventor
L. G. Woolley
per
J. A. Lehmann,
att'y

(No Model.)

3 Sheets—Sheet 2.

L. G. WOOLLEY.
Electric Lamp.

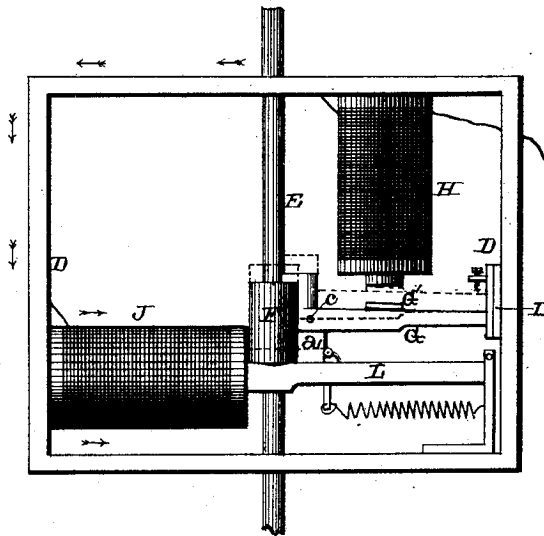
No. 241,112.

Patented May 3, 1881.

Fig. 2.



Fig. 3.



WITNESSES
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Inventor
L. G. Woolley,
per
F. A. Lehmann,
att'y

(No Model.)

3 Sheets—Sheet 3.

L. G. WOOLLEY.
Electric Lamp.

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Fig. 4.

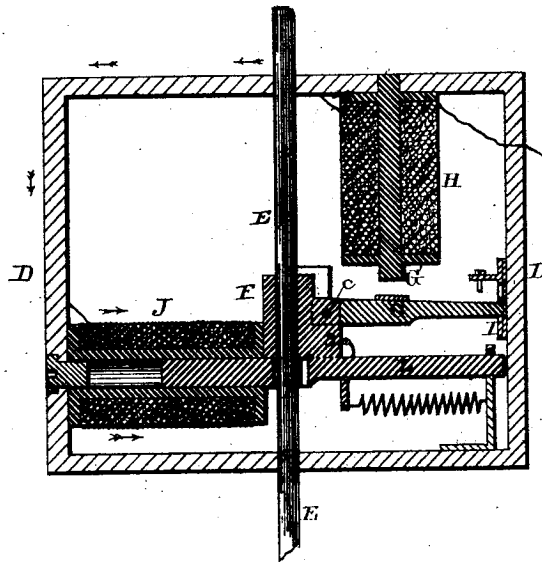


Fig. 5.



WITNESSES.

Wm. M. ...

A. C. Kiskadden.

INVENTOR.

L. G. Woolley,

per

J. A. Lehmann,
Att'y.

UNITED STATES PATENT OFFICE.

LEONIDAS G. WOOLLEY, OF MENDON, MICHIGAN.

ELECTRIC LAMP.

SPECIFICATION forming part of Letters Patent No. 241,112, dated May 3, 1881.

Application filed November 24, 1880. (No model.)

To all whom it may concern:

Be it known that I, LEONIDAS G. WOOLLEY, of Mendon, in the county of St. Joseph and State of Michigan, have invented certain new and useful Improvements in Electric Lamps; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it pertains to make and use it, reference being had to the accompanying drawings, which form part of this specification.

My invention relates to an improvement in electric lamps; and it consists, first, in a polygonal lamp-frame which is suspended in position by a series of opposing springs applied to its corners, which springs neutralize the jarring and shaking movements in such a manner as to adapt the lamp for use as a head-light on a locomotive; second, in the combination of the carbon-holder, a sliding collar placed thereon, a clamping-lever pivoted upon the collar and provided with an armature, a device for regulating the distance the outer end of the lever shall rise, and an electro-magnet for raising the lever, collar, and carbon-holder upward; third, in the combination of a horizontal helix and a perforated endwise-moving bar or rod, which extends into the center of the helix so as to act as an armature, and through which the carbon-holder passes, whereby, when the endwise-moving bar becomes electrified by the action of the magnet, the bar is drawn into the magnet with sufficient force to prevent the carbon-holder by frictional contact from dropping downward too rapidly; fourth, in the arrangement and combination of parts which will be more fully hereinafter set forth.

The object of my invention is adjusting the movement or feeding of the carbons by a very simple and inexpensive mechanism, and to dispense with all the wheels, clock-works, and other such expensive devices as have heretofore been used.

Figure 1 is a side elevation of my invention complete. Fig. 2 is a vertical section through the upper part of the frame-work taken at right angles to Fig. 1. Fig. 3 is a detail view. Fig. 4 is a vertical section of my invention. Fig. 5 is a detail view of the clamping device and carbon-holder.

A represents the frame in which the lamp

is supported, and which may be either of the form here shown or any other that may be preferred. Attached to each corner of this frame A is a spring, B, of any desired shape, size, or construction, and which prevent any shaking or vibrating of the frame which would have a tendency to interfere with the perfect acting of the light. If so preferred, the two lower springs may be coiled ones and the upper ones flat-bar springs, or all of the springs may be of the same construction as is here shown.

The great objection heretofore existing to the use of the electric lamp as a head-light upon locomotives has been that the jarring and shaking of the locomotive when in motion are so great that the different parts of the lamp have been shaken and jarred to such an extent that the lamp soon becomes inoperative. This shaking has heretofore caused the carbons to break and the upper carbon-holder to work so unsteadily that the lamp was practically useless as a locomotive head-light.

These objections I completely overcome by supporting the lamp-frame by means of a suitable number of springs in an outer frame, C, which may be attached to the front of the locomotive or any other object in any suitable manner, and which springs serve to neutralize the jarring and shaking motion to such an extent that the slight and almost imperceptible vibratory movement of the frame A causes no inconvenience. The frame A, as here shown, is supported in an outer frame by means of four springs; but it is evident that this frame or any other suitable form of frame may be supported upon a suitable number of springs, and which will have to a very great extent the same effect, though not as perfect a one as when the springs are applied to the corners, as here shown.

Upon the top of the frame A is placed the iron frame D, of any suitable shape, and which is cast in one continuous piece, so as to form a magnetic conductor between the two magnets. Passing down through the center of this frame is the carbon-holder E, over which, inside of the frame, is placed a preferably non-magnetic collar, F, which slides freely upon the carbon-holder and serves principally as a pivot upon which the clamping-lever G is supported. Upon one side of this collar is formed a flange, a, and

the angular end of the lever is cut out so as to fit over this flange and vibrate freely upon its pivot, which passes through the flange. Upon the top of this clamping-lever, which may be of the shape here shown or any other that may be preferred, is secured an armature, G', so that whenever the current of electricity is passed through the magnet H this armature is attracted to the pole of the magnet and the clamping device thus lifted horizontally upward. The end of the clamping device which is in contact with the carbon-holder is so shaped that when the device is raised upward the frictional contact of this device against the side of the carbon-holder will cause the carbon-holder to be raised upward a sufficient distance to separate the upper carbon from the lower one far enough to produce the arc. The outer and longer end of this clamping lever or device is made to catch in the stop I, which is secured to the inner side of the frame D, and which stop is placed in such relation to the pole of the magnet that as the clamping device is being raised horizontally upward, carrying the carbon-holder with it, the outer end of the clamping device strikes this stop before the armature comes in contact with the pole of the magnet, and as the clamping device continues to move upward it is tilted or turned slightly upon its pivot c in such a manner as to release its hold upon the carbon-holder, and thus let the carbon-holder drop downward, while the clamping device remains suspended against the pole of the magnet. This stop I may be of any suitable form, and will be preferably provided with a set-screw, so as to bear against the outer end of this clamping device, and thus cause it to release the carbon-holder at any point during the upward travel of the clamping device, and in this manner regulate the distance which the carbon-holder shall be raised upward.

When the clamping device releases its hold upon the carbon-holder the holder would drop its full length down through the frame were it not that some other means are provided so as to regulate the speed at which the holder shall move downward by its own gravity. Secured in the frame D at right angles to the magnet H is placed a helix, J, which, instead of being provided with a stationary pole like the magnet H, is made hollow, and its armature is formed by the endwise-moving bar or rod L, which has a hole made through its center for the carbon-holder to pass through. Upon the top of this armature is placed a small friction-roller, which bears against the edge of the flange upon the vertically-moving collar, and which roller prevents any endwise movement of the armature L until the vertically-moving collar has been raised to that point by the friction-clamp where the friction-clamp releases its hold upon the carbon-holder, when the armature, being free to move, is drawn endwise into the helix so as to exert just a sufficient frictional contact against the side of the carbon-holder to prevent it from moving too rapidly by its own gravity. The hole or opening through this arma-

ture for the carbon-holder to pass through is made slightly elongated, so that when the armature is not drawn into the helix it exerts no power upon the carbon-holder. Attached to this armature at any suitable point is a small spring of suitable shape, size, or construction, and which moves the armature outward as soon as it is left free to move.

One of the wires is connected with the magnet H, and the other one with the lower carbon-holder, as shown in Fig. 1. The two magnets, H J, are connected by means of their wires or in any other suitable manner with the frame D, and the current passes from the one H through the frame, as shown by the arrows.

After the friction-clamping device has raised the carbon-holder upward the clamping device remains suspended until the current is broken, when it immediately drops downward and is ready for another hold upon the carbon-holder, and this clamping device serves no other purpose than to merely separate the carbons in starting or lighting the lamp.

As the ends of the carbon burn away and the points become separated the electric current becomes weakened, and in proportion as this current becomes weakened so the pole of the helix to attract the armature L becomes weakened and exerts a less drawing pressure upon the armature, and thus releases the carbon-holder sufficiently to let it descend from its own weight, and as soon as the two points of the two carbons approach each other sufficiently near to fully re-establish the current the power of the helix is increased at the same instant, and it exerts a drawing-pull upon the armature L sufficiently strong to prevent the carbon from descending any farther. In this manner the current is made to regulate the feeding of the carbons and a bright and steady light is obtained.

In order to prevent the carbon-holder from descending too rapidly, a dash-pot or other well-known device may be used for controlling its descent.

The construction and operation of the lamp is such as is now in ordinary use, and need not be more fully described here.

Having thus described my invention, I claim—

1. In an electric lamp, the combination of a polygonal frame and a series of supporting-springs which are applied to opposing corners of the frame, substantially as shown.

2. In an electric lamp, the combination of the carbon-holder E, a sliding collar, F, placed thereon, the lever G, pivoted upon this collar and provided with an armature, G', a device for regulating the distance the outer end of the lever shall rise, and the electro-magnet H, the inner end of the lever forming a clamp for lifting the carbon-holder upward, substantially as described.

3. The combination of a carbon-holder, a sliding collar placed thereon, a friction-clamp pivoted upon the collar and provided with an armature, an electro-magnet, and a stop, whereby, as

the friction device is raised upward carrying the carbon-holder with it the outer end of the friction-clamp is arrested by means of a stop, so as to release the carbon-holder while the friction-clamp remains suspended, substantially as shown.

4. In an electric lamp, the combination of an electrically-operated friction-clamp for raising the carbon-holder, and a second electrically-operated friction-clamp to prevent the carbon-holder from descending too rapidly from its own gravity, substantially as specified.

5. In an electric lamp, the combination of the

helix J, the perforated armature L, and a spring for withdrawing the armature from the helix and from against the side of the carbon-holder with a friction-clamping device and an electromagnet for operating the same, substantially as shown.

In testimony that I claim the foregoing I have hereunto set my hand this 24th day of November, 1880.

LEONIDAS G. WOOLLEY.

Witnesses:

WM. H. KERN,

WM. W. MORTIMER.

(No Model.)

D. B. MACDONALD & H. W. WOODMAN.

ELECTRIC LAMP.

No. 339,908.

Patented Apr. 13, 1886.

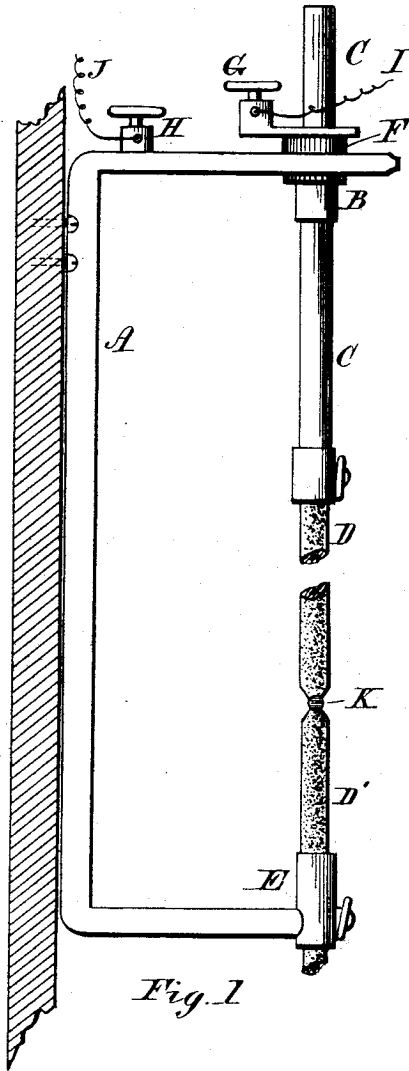


Fig. 1

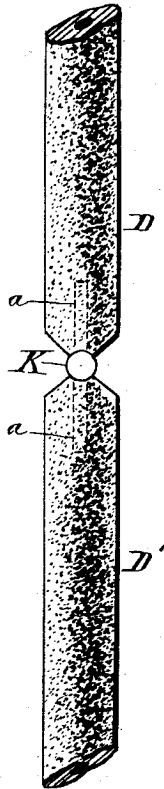


Fig. 2.

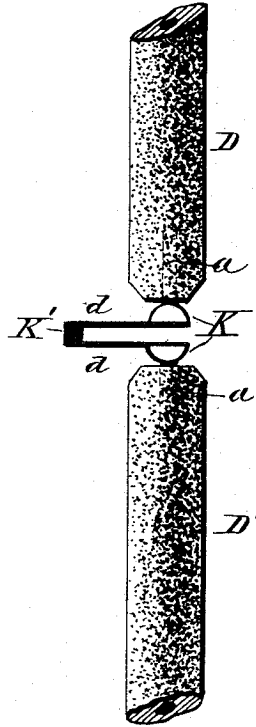


Fig. 3

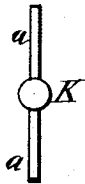


Fig. 4.

Witnesses

J. L. Lohr
Richard D. Pierley

Inventors.

David B. Macdonald.

H. W. Woodman.

By W. Bruce
Att'y

UNITED STATES PATENT OFFICE.

DAVID BARKER MACDONALD AND HANNIBAL WILLIAM WOODMAN, OF
HAMILTON, ONTARIO, CANADA.

ELECTRIC LAMP.

SPECIFICATION forming part of Letters Patent No. 339,908, dated April 13, 1886.

Application filed December 10, 1885. Serial No. 185,369. (No model.)

To all whom it may concern:

Be it known that we, DAVID BARKER MACDONALD and HANNIBAL WILLIAM WOODMAN, both of the city of Hamilton, in the county of Wentworth, in the Province of Ontario, Dominion of Canada, have jointly invented a certain new and useful Improvement in Electric-Arc Lamps; and we do hereby declare that the following is a full, clear, and exact description of the construction and operation of the same.

The invention relates to an improvement in electric-arc lamps by which all the devices heretofore used for regulating the feed of the carbons may be dispensed with, rendering an electric lamp much more simple and comparatively inexpensive.

The invention consists, first, in a device for controlling the length of the arc at the points of the carbons, or any substitute for carbons, by interposing a body or substance of any kind which will stand the heat between the carbon points, so that the said body will rest upon the lower carbon, and the point of the upper carbon will rest upon the body, and by means of which the carbon points will always be the same distance apart, as the top one will feed down by its own weight to the lower one as the carbons are consumed; second, the interposing body placed between the points of the carbons may be of any shape or form, and placed in any position to the carbon points, or any substitute for carbons, by placing the said body exactly between the points of the carbons or to one side thereof in any convenient manner.

By reference to the drawings forming a part of this specification it will be seen that Figure 1 represents a very simple electric lamp; Fig. 2, a section of the upper and lower carbons with body interposed directly between the carbon points; Fig. 3, a similar view, but showing body cut in two and separated, but connected with the body interposed between two arms attached to the upper and lower portions of the body. Fig. 4 is the

interposing body detached from the carbon points.

A represents a very simple frame of a lamp secured to any convenient holder, as A'. 50

B is a brass bushing.

C is a carbon rod.

D is the upper carbon, let into the carbon rod C, and secured in any convenient manner.

D' is the lower carbon, let into the lower carbon-holder, E. 55

F is an insulator under and around the positive binding-post G.

H is the negative binding-post.

I is the positive conducting-wire. 60

J is the negative conducting-wire.

K is the interposing body placed between the two carbons D and D'. It is formed with a central body, which may be globular or otherwise, and provided with upper and lower projecting-pins *a a*, made to enter the carbons, which are made hollow, or rather constructed with a central opening, *c*, running through their entire length, sufficiently large to receive the projecting pins *a a* of the body K. 65 70

It will be observed that the said body K may be cut in two through the center, as seen at Fig. 3, and two short arms, *d d*, secured to the upper and lower portions, respectively, of the body K, and have interposed between the said arms, at their outward ends, a body, K'. This means also prevents the upper carbon from touching the lower one as when the body K is interposed directly between the points of the carbon, as in Fig. 2. 75 80

It will further be observed that we do not confine ourselves to the particular manner in which the body K is made to separate the carbon points, two only of which are shown, as at Figs. 2 and 3. 85

Having thus described our device and its advantages, what we claim as our invention, and desire to secure by Letters Patent, is—

1. In an electric lamp, the combination, 90 with the lower stationary carbon and the upper movable carbon, located one above the

other, of the insulating-body K, interposed between the points of said carbons, said upper carbon being constructed to rest by gravity upon the interposed insulating-body, substantially as described.

5 2. In an electric lamp, the combination, with the perforated stationary lower carbon, D', and the perforated upper movable carbon, D, of the interposed insulating-body K, hav-

ing arms *d d*, fitting in the perforations in the carbons, substantially as described.

Dated at Hamilton, Ontario, Canada, this 2d day of December, A. D. 1885.

DAVID BARKER MACDONALD.

HANNIBAL WILLIAM WOODMAN.

In presence of—

JOHN KENRICK,

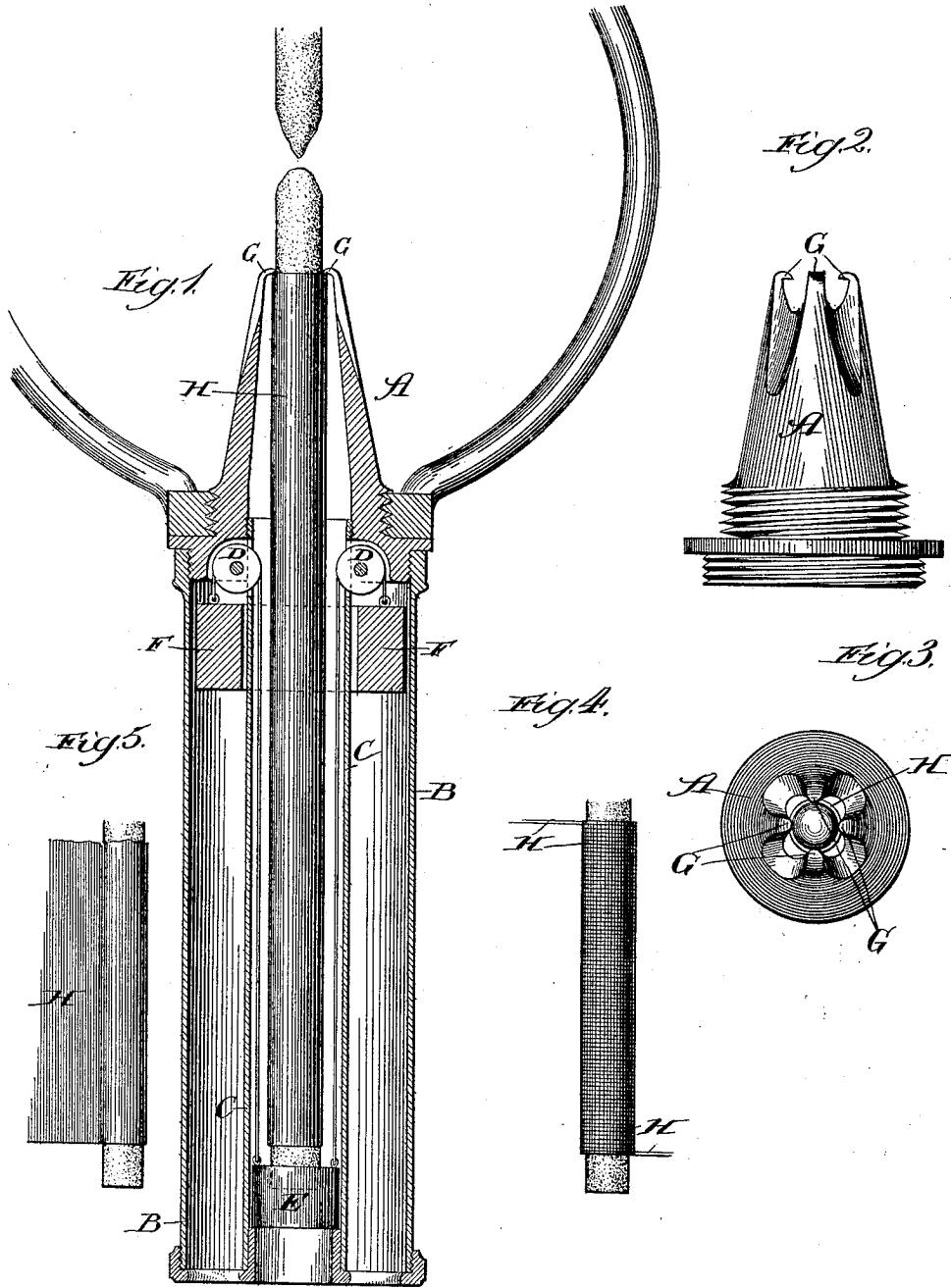
WM. BRUCE.

(No Model.)

S. E. NUTTING.
ARC LAMP.

No. 440,604.

Patented Nov. 11, 1890.



Witnesses:
Edw. Claydon
Efford N. White

Inventor:
Samuel E. Nutting
By Penning & Penning & Bayson
Attys

UNITED STATES PATENT OFFICE.

SAMUEL E. NUTTING, OF CHICAGO, ILLINOIS, ASSIGNOR TO THE NUTTING
ELECTRIC MANUFACTURING COMPANY, OF SAME PLACE.

ARC LAMP.

SPECIFICATION forming part of Letters Patent No. 440,604, dated November 11, 1890.

Application filed March 10, 1890. Serial No. 343,312. (No model.)

To all whom it may concern:

Be it known that I, SAMUEL E. NUTTING, a citizen of the United States, residing at Chicago, Illinois, have invented certain new and useful Improvements in Arc Lights, of which the following is a specification.

The object of my invention, in general terms, is to devise means for advancing the carbons or electrodes of an arc light to keep them in their proper relative positions, so that they will constantly focus at the same point.

In the drawings, Figure 1 is a vertical section taken through the lower portion of an arc lamp; Fig. 2, a side elevation of the carbon-holder; Fig. 3, a plan view of the same; and Figs. 4 and 5, side elevations of the carbon covered or inclosed, as hereinafter described.

In making my improvement in arc lights I arrange a hollow and preferably cone-shaped shell A in the lower portion of the lamp-frame. For convenience I term this shell the "carbon-holder." As shown in the drawings, it is provided with screw-threads and is screwed into the lower portion of the lamp-frame, although it may be attached and secured to the frame in other ways, and, in fact, in any convenient manner. This holder is preferably made of a non-heat and non-current conducting substance and of a refractory and non-fusible material. The higher the refractory quality of the material is the better.

In my application of the invention to use I have usually employed what is generally known as "lava," although any highly-refractory material capable of standing the intense heat of the arc when arranged a short distance therefrom may be used. I preferably arrange the shell B extending below the frame of the lamp and attached to it in any convenient way. As shown in the drawings, this shell is screwed to the lower edge of the carbon-holder, although it may be attached to or sustained by the frame in any desired way. I preferably arrange another shell C within the shell B, so that there is an annular space between the two and open at the bottom, as shown in Fig. 1. This inner shell is shown as screwed to the inner side of the carbon-holder, although it may be secured in place

in any convenient manner, or, in fact, entirely dispensed with. Its principal office is to afford a guideway to assist in holding the carbon in its proper vertical position, which could be formed by rods or in other convenient manner.

I arrange pulleys or sheaves D in some convenient place, but preferably immediately under the lower edge of the carbon-holder, as shown in Fig. 1. I also arrange a block or cup E, in which to place the lower end of the carbon, adapted to move up and down in the shell C and be guided in its movement thereby, and run cords from this cup or block up over the pulleys and attach them to the weights F, arranged to move up and down in the annular space between the two shells B and C. As shown in the drawings, these weights are arranged in one annular ring, although they may be made in separate and distinct pieces, if desired. When the carbon is arranged with its lower end in the cup E and its point in the right position for the arc, the cup will be at its lowest position and the weights at their highest; but as the point of the carbon is consumed by the heat of the arc the weights will gradually move downward and draw the cup with the carbon upward.

Unless there be something employed to retard the upward movement or advance of the carbon it is obvious that the weights would immediately advance it against the upper carbon and constantly hold it in that position. To provide against this and to retard the upward movement of the carbon to just that degree of advance necessary to constantly keep its point in the right position to focus the light at the same place, some means must be employed that will permit an advance in proportion to the constant consumption of the carbon or electrode at its point. I secure this proper degree of advance and retardation by providing the holder with inwardly-projecting points or fingers G, directed toward each other, but with sufficient space between to nicely and easily permit the carbon to move upward through the opening. To enable these fingers or points to hold the carbon against the upward tendency caused by the pressure of the weights, I wrap or incase the

carbon in a covering H, which is not quite extended up to the point of the carbon. This covering or wrapping need be of only sufficient thickness to enable the points of the holder to impinge against it at its upper edge and to prevent the carbon from moving upward so long as the covering remains intact and undisturbed. The covering or wrapping, however, is made of such material or in such a way as to be burned, changed, disintegrated, or destroyed by the heat of the arc at a lower temperature than that necessary to consume the carbon. This covering or wrapping may be made of thread, paper, cloth, carbon-dust less compacted than the carbon itself, or any other material, no matter what, which will burn, crumble, break, or disintegrate under the heat of the carbon with the same degree of slowness or rapidity that the carbon itself is consumed. As the upper edge of the wrapping or covering is always the same distance below the point of the carbon, it must be capable of crumbling or being destroyed at a lower temperature than that which consumes the point of the carbon, and its distance from the point of the carbon should be so proportioned as to enable it to be consumed or destroyed with the same degree of rapidity as the point of the carbon is consumed. The different materials therefore which may be used for a wrapping or covering should be placed closer to or farther from the point of the carbon as they may be of greater or less refractory nature. For instance, material that is easily destroyed should be farther from the point, while material that is more difficult to be changed by the heat of the arc should be closer to the point. A little experiment with different materials will enable a manufacturer to readily determine the proper distance from the point to have the upper edge of the covering or wrapping. As the covering material is subjected to the heat of the arc, it becomes changed, so that it breaks and crumbles away at the points of the holder and enables the pressure of the weights to move the carbon upward. The breaking and crumbling away of the upper edge of the covering is so gradual, however, that the upward movement of

the carbon is maintained in a constant or even advance or progress.

To enable the points of the holder to receive sufficient air to keep them from melting or being destroyed, I prefer to cut away spaces between them, as shown in Fig. 2. This enables the air coming in at the bottom of the shell B to pass up through the holder and out at the spaces between the points, thus constantly protecting them in a measure from the intense heat of the arc.

While I have shown and described my improvement in connection with only one of the carbons or electrodes of the light, I wish it to be distinctly understood that I shall apply it to both if I so desire.

What I regard as new, and desire to secure by Letters Patent, is—

1. In an arc lamp, the combination of an electrode, a covering for the same of a material that disintegrates under the heat of the arc at a temperature lower than is necessary to consume the electrode, with its edge next to the arc at a distance therefrom to cause it to be disintegrated with the same degree of rapidity as the electrode is consumed, and a holder bearing against the edge of the covering next to the arc and holding the electrode from advancing until the edge of the covering is changed, consumed, or destroyed, substantially as described.

2. In an arc lamp, the combination of an electrode, a covering for the same of a material that disintegrates under the heat of the arc at a temperature lower than necessary to consume the electrode, with its edge next to the arc at a distance therefrom to cause it to be disintegrated with the same degree of rapidity as the electrode is consumed, and a holder provided with separate inwardly-turned points bearing against the edge of the covering next to the arc and holding the electrode from advancing until the edge of the covering is changed, consumed, or destroyed, substantially as described.

SAMUEL E. NUTTING.

Witnesses:

GEORGE S. PAYSON,
SAMUEL E. HIBBEN.

(No Model.)

F. M. LYTE.
ELECTRODE.

No. 507,374.

Patented Oct. 24, 1893.

FIG. 1.

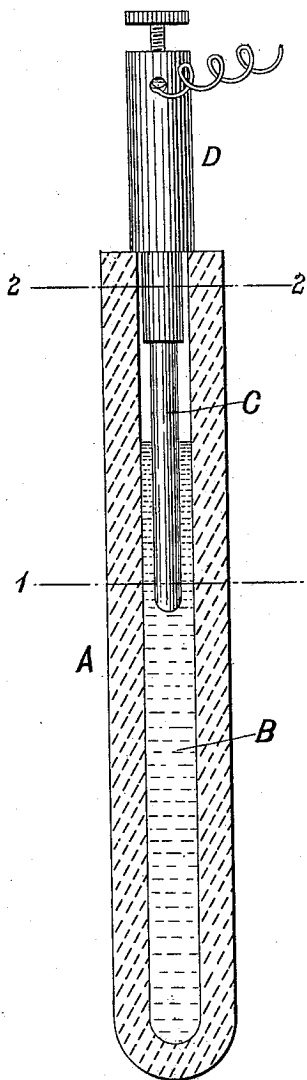


FIG. 3.

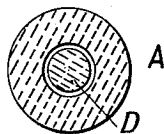
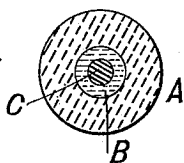


FIG. 2.



WITNESSES.

C. E. Holske
C. Sedgwick

INVENTOR:

F. M. Lyte
BY *Munn & Co*

ATTORNEYS

UNITED STATES PATENT OFFICE.

FARNHAM MAXWELL LYTE, OF LONDON, ENGLAND.

ELECTRODE.

SPECIFICATION forming part of Letters Patent No. 507,374, dated October 24, 1893.

Application filed July 1, 1893. Serial No. 479,363. (No model.)

To all whom it may concern:

Be it known that I, FARNHAM MAXWELL LYTE, analytical chemist, of 60 Tinborough Road, London, England, have invented new and useful Improvements in Electrodes for Use in the Electrolytical Decomposition of Metallic Salts, of which the following is a full, clear, and exact description.

My invention relates to the carbon electrodes used in the electrolytic decomposition of metallic chlorides or other metallic haloids in a fused condition.

The invention has for its object to obtain the advantage, as regards conductivity, of a metal core for the carbon, without the liability of defective electrical contact between the carbon and the core, or of bursting the carbon in consequence of the different ratios of expansion of the metal and carbon, when heated by immersion in the fused salt to be decomposed.

To this end the invention consists essentially in the combination with a hollow carbon electrode closed at bottom and open at top, of a core of metal or alloy which is fusible at the same or at a lower temperature than the metallic salt to be decomposed, so that the core will melt and in the fluid state will make intimate electrical contact with the carbon of the electrode, but will exert no bursting strain thereon in consequence of the expansion of the metal. The terminal of the electrode is put in electrical communication with the fusible core by a conducting rod dipping into the fusible core but entirely free from the carbon. By means of this fusible metallic core, the thickness of the carbon to be traversed by the current may be so much reduced and the electrical resistance so greatly diminished, that the current will easily traverse the carbon throughout its whole area, thereby enabling electrodes of considerable length to be used.

Reference is to be had to the accompanying drawings, forming part of this specification, wherein—

Figure 1 is a vertical section and Fig. 2 a cross section on line 1—1, and Fig. 3 is a cross section on line 2—2 of Fig. 1 of one form of electrode embodying my invention; but it must be understood that my invention is not limited to any particular external or internal form of the electrode.

A, is the carbon electrode in the form of a hollow cylinder closed at the lower, and open at the upper, end but any other form may be adopted provided it is hollow and closed at the lower end. It may either be molded hollow, or be made solid and bored out, and may be made either of retort carbon or of plumbago.

B, is the fusible core of lead, tin, or any other metal or alloy which fuses at the same or a lower temperature than the metallic salt to be decomposed. The fusing point of the metal or alloy of which the core is composed should of course not be so far below the fusing point of the salt to be decomposed, as to render the core liable to be sublimed or volatilized by the heat necessary to fuse the salt. In the case of decomposing fused plumbic chloride, for which this invention is principally intended, I find that lead will answer the purpose.

C, is a rod of difficultly fusible metal, such as copper or iron, attached to the terminal D which is shouldered and fits quite loosely in the upper end of the carbon, so as to exert no bursting strain thereon, or is otherwise supported so as to maintain the rod C in position, the rod, which is of considerably smaller section than the bore of the carbon, plunging into the fusible core B. This rod, if of iron, may be coated with another metal, lead for instance, to prevent corrosion and insure good electrical contact with the fusible core B.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be performed, I declare that what I claim is—

1. The combination, with a hollow carbon electrode closed at bottom, of a core of metal

or alloy which is fusible at or below the temperature at which the electrolytic decomposition of a fused metallic salt is to be performed, substantially as specified.

- 5 2. The combination, with a hollow carbon electrode closed at bottom, of a core of metal or alloy which is fusible at or below the temperature at which the electrolytic decomposition of a fused metallic salt is to be performed,
10 and of a terminal conductor of metal, not fusible at that temperature, which is plunged into the fusible core and is free from the car-

bon so as to exert no bursting strain whatever thereon, substantially as specified.

Dated this 16th day of June, 1893.

FARNHAM MAXWELL LYTE.

Witnesses:

T. W. KENNARD,

*Clerk to A. M. & Wm. Clark, Patent Agents,
53 Chancery Lane, London.*

G. F. WARREN,

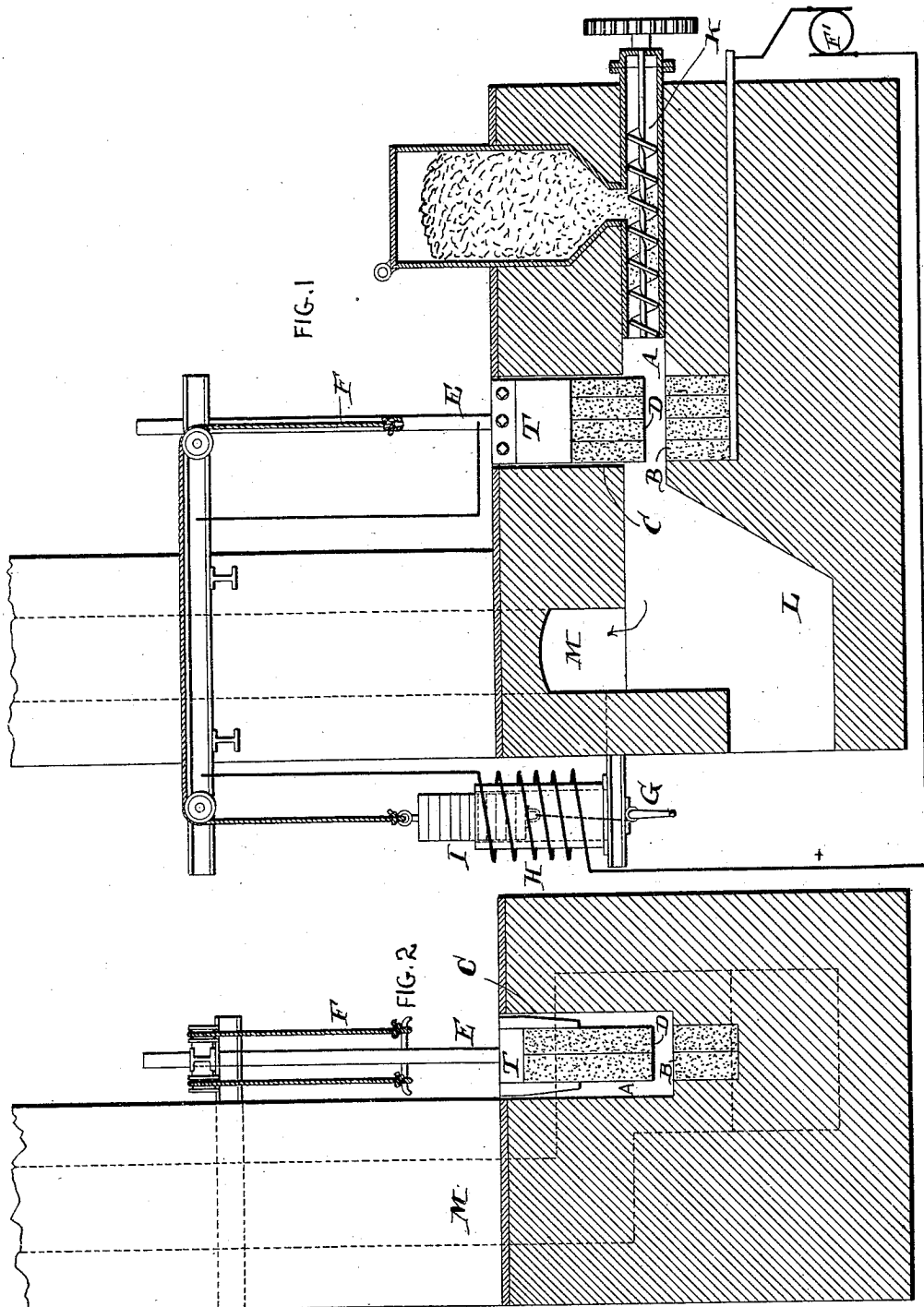
Notary Public, 17 Gracechurch Street, London.

(No Model.)

J. A. VINCENT.
ELECTRIC SMELTING FURNACE.

No. 551,014.

Patented Dec. 10, 1895.



WITNESSES:
Henry Denny
And. H. Beau

INVENTOR:
 Jos. A. Vincent
 By his atty *[Signature]*

UNITED STATES PATENT OFFICE.

JOSEPH A. VINCENT, OF PHILADELPHIA, PENNSYLVANIA.

ELECTRIC SMELTING-FURNACE.

SPECIFICATION forming part of Letters Patent No. 551,014, dated December 10, 1895.

Application filed July 18, 1895. Serial No. 556,316. (No model.)

To all whom it may concern:

Be it known that I, JOSEPH A. VINCENT, of the city and county of Philadelphia and State of Pennsylvania, have invented an Improvement in Electric Smelting-Furnaces, of which the following is a specification.

My invention has reference to electric smelting-furnaces; and it consists of certain improvements, all of which are fully set forth in the following specification and shown in the accompanying drawings.

My invention comprehends certain improvements in electric smelting-furnaces, and more particularly consists in providing two electrodes with a channel-way between them, through which the materials or ores to be treated are fed, to the end that the operation may be a continuous one. The electrodes may be fed, relatively toward each other to compensate for consumption thereof, and the feeding may be accomplished by automatic means, such as an electrical or mechanical regulator. The channel-way is preferably horizontal, and the ores or materials to be smelted are fed into one end under the action of a screw or other suitable feeding device and the smelted product discharged into a pit at the other end. The use of a horizontal channel-way supports the materials to be smelted and prevents them moving, except under the action of a positive force. Hence in using the words "horizontal" or "substantially horizontal" I have used them to designate such a position to the channel-way as will not cause the materials to move under the action of gravity.

In carrying out my process I propose to cause the movement of the materials to be smelted between the electrodes to be a positive and regular movement mechanically produced.

These improvements will be better understood by reference to the accompanying drawings, in which—

Figure 1 is a sectional side elevation of an electric smelting-furnace embodying my invention, taken on line *xx* of Fig. 2; and Fig. 2 is a transverse section of same on line *yy* of Fig. 1.

A is a horizontal channel-way having a bed or bottom B of carbon, which is stationary and acts as one of the electrodes.

C is a vertical or transverse opening extending into the channel-way, and in this is arranged the other or positive electrode D, it consisting of rectangular or suitably-shaped carbon-blocks held in a metal clamp T, which is raised and lowered by a rod E, chains or ropes F, and windlass G. As the carbon D is consumed, the electrode is bodily lowered, so as to approximately keep the two electrodes at the same or uniform distance apart to maintain an arc consuming substantially a constant current and voltage.

As it is more desirable to make the feeding of the movable or positive electrode automatic, I may accomplish it by providing a helix or solenoid H in series with the electrodes B and D, in which a magnetic core I moves. This core I is connected to the chains or ropes F and by them raises or lowers the electrode D in accordance with the requirements. When this electrode-regulator is used, the connection with the windlass G is only used in setting the electrode in position. It is desirable that the clamp T substantially close the vertical opening C, so that little or no air can enter to abnormally consume the carbon of the electrodes.

The ore or material to be treated is finely pulverized and placed in a hopper J, from which it is received by the feeding-screw K, which forces it into the channel-way between the electrodes. As the smelted product is formed, the incoming unsmelted material forces it into the pit L, where it is collected and kept in a hot atmosphere until ready to be removed. It is evident that any suitable kind of barrow or truck may be placed in the pit to receive the smelted product to reduce the labor of handling; but this is immaterial to my invention.

M is the stack for the escape of gases generated by the smelting operation or process and opens laterally from the channel-way at its discharge end, it being desirable to have the channel-way continuous and uniform in cross-section throughout its length, especially where it receives the electrodes B and D.

In place of an electric regulator for the electrode D any desirable mechanical regulator may be used.

My improved furnace is suitable for electrosmelting of all kinds, and is especially

adapted for the rapid and cheap production of calcium carbide. In carrying out the process for producing said carbide I mix together lime and carbon in a state of fine subdivision and place it in the hopper J, from which it is continuously fed by the feedingscrew into the zone of the arc between the electrodes B and D. This carbide thus formed is pushed through the channel-way into the pit by the advancing mixture of lime and carbon. It will thus be seen that the process is a continuous one.

The current used between the electrodes B and D is preferably a continuous current of constant potential, but may be an alternating current, if so desired. The generator of electricity is indicated at F'.

I do not confine myself to the mere details of construction shown, as they may be varied without departing from the spirit of my invention.

What I claim as new, and desire to secure by Letters Patent, is—

1. In an electric furnace, the combination of a substantially horizontal channel way for supporting the material to be smelted, two electrodes of different polarity arranged transversely to said channel way, a positively acting feeding device arranged to force the material to be treated into the channel way at one end and between the electrodes, and a discharging pit arranged at the opposite end of the channel way and opening into it.

2. In an electric smelting furnace, the combination of a substantially horizontal channel way for supporting the material to be smelted, two electrodes arranged in said channel way, means to positively feed the electrodes relatively one to the other to compensate for the consumption thereof and maintain them as boundary walls of the channel way, a feeding device for positively forcing the materials to be smelted through the channel way and between the electrodes, a discharge opening from the channel way, and a chimney flue to carry off the products of combustion and vaporization.

3. In an electric smelting furnace, the combination of a substantially horizontal channel way for supporting the material to be smelted, two electrodes arranged in said channel way and constituting a part of the walls thereof, means to feed the electrodes relatively one to the other to compensate for con-

sumption thereof and maintain them as boundary walls of the channel way, a positively acting feeding device consisting of a screw for forcing the materials to be smelted through the channel way and positively between the electrodes, a hopper for containing said materials and delivering them to the feeding screw, a discharge opening from the channel way, and a chimney flue to carry off the products of combustion and vaporization from the discharge end of the channel way.

4. In an electric smelting furnace, the combination of a substantially horizontal channel way for supporting the material to be smelted, two electrodes arranged in said channel way and constituting a part of the walls thereof, means to feed the electrodes relatively one to the other to compensate for consumption thereof and maintain them as boundary walls of the channel way, a positively acting feeding device consisting of a screw for feeding the materials to be smelted through the channel way and between the electrodes, a hopper for containing said materials and delivering them to the feeding screw, a discharge opening from the channel way, a chimney flue to carry off the products of combustion and vaporization, and automatic electrically controlled devices for regulating the means for feeding the electrodes relatively one to the other.

5. An electric furnace for continuous smelting consisting of the combination of a substantially horizontal channel way for supporting the material to be smelted, with mechanical devices for positively feeding the materials to be smelted and smelted product through the channel way in a continuous or practically continuous manner, and two electrodes of different polarity having their active surfaces extended into the channel way and in the path of the moving material and constituting a part of the walls of the channel way, whereby the materials are required to pass slowly and regularly between the said electrodes during the maintenance of the arc independently of the action of gravity upon said materials.

In testimony of which invention I hereunto set my hand.

J. A. VINCENT.

Witnesses:

ERNEST HOWARD HUNTER,
R. M. HUNTER.

(No Model.)

W. C. CLARKE.
MANUFACTURE OF CARBIDE OF CALCIUM.

No. 552,890.

Patented Jan. 14, 1896.

Fig. 1

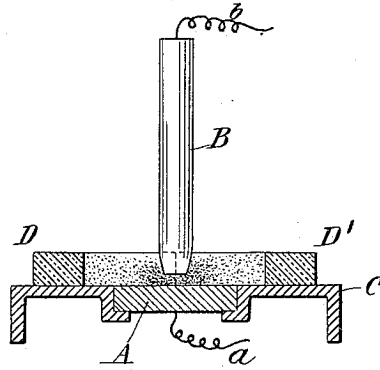


Fig. 2

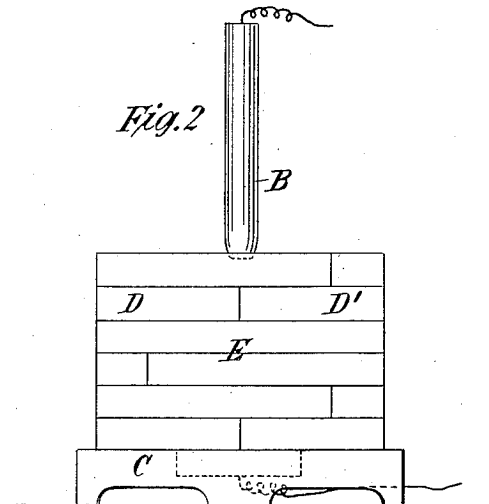
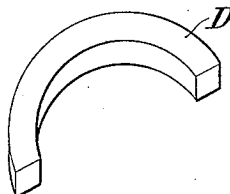


Fig. 3



Witnesses:
Raphaël Jetter
Saunder F. Kaudall

William C. Clarke Inventor
by *Clarkson A. Collins* Attorney.

UNITED STATES PATENT OFFICE.

WILLIAM C. CLARKE, OF NEW YORK, N. Y.

MANUFACTURE OF CARBIDE OF CALCIUM.

SPECIFICATION forming part of Letters Patent No. 552,890, dated January 14, 1896.

Application filed August 24, 1895. Serial No. 560,382. (No specimens.)

To all whom it may concern:

Be it known that I, WILLIAM C. CLARKE, a citizen of the United States, residing in the city of New York, in the county and State of New York, have invented certain new and useful Improvements in the Manufacture of Carbide of Calcium, of which the following is a specification.

The object of my improvements is to render more convenient and inexpensive the production of carbide of calcium, which, as is well known, may be formed by subjecting a mixture of lime and carbon to a high degree of heat in an electric furnace, the lime being decomposed and the carbon uniting with the metallic calcium to form the carbide.

In carrying my invention into effect I use an electric furnace in which the electrodes are vertically disposed to each other, and in order to prevent the excessive heating of the upper electrode which has heretofore been experienced where vertical electrodes are employed I keep the lower end of the upper electrode approximately at the level of the upper edge of the furnace-wall, so that its body is at all times above and outside of the furnace and out of contact with the material under treatment as I am enabled to do by the means hereinafter described. At the same time in order to further facilitate the formation of the carbide and its removal from the furnace I so charge the furnace with the material to be treated that only the central part of it is subjected to a decomposing temperature, the remainder being highly heated, but remaining in the granular state between the carbide formed and the furnace-wall. To these ends the lower electrode, which is preferably circular in shape and forms a portion of the bottom of the furnace, is set in a suitable bed, which may be simply a piece of sheet-iron laid upon the ground. The upper electrode is suspended above the lower in any usual or suitable manner and provided with any usual or suitable mechanism for bringing it in contact with the lower electrode and separating it therefrom when required. Around the lower electrode I loosely construct a low wall which may be done simply by placing in position two semicircular pieces or several curved pieces of tile, fire-brick or other material not readily affected by heat, so as to form a circular inclosure around and of somewhat greater diameter than the electrode.

This inclosure I then fill or nearly fill with the material to be treated, consisting of pulverized lime and carbon in the proportion of substantially twenty parts of lime to twelve parts of carbon. The electrodes being brought in contact current is then turned on and upon separating the electrodes an intense heat is developed between them by which the lime is decomposed and the carbon combines with the metallic calcium, forming carbide of calcium.

When the decomposition of the material between the electrodes has been nearly or quite effected, the wall of the furnace is raised by adding another tier of the wall material, the electrodes are further separated by raising the upper one and a fresh charge of material is thrown into the furnace on top of that already treated. This process of building up the wall, separating the electrodes and adding fresh charges of material is continued until the furnace has reached as great a height as is convenient or where the resistance between the electrodes cannot be increased without inconvenience when the current is turned off. In this manner a column of carbide is built up resting on the lower electrode, which constitutes a practical extension of such electrode as the operation progresses. The material which is outside of the circumference of the electrode not being exposed to such intense heat as that immediately between the electrodes will not be decomposed, but will remain as a layer of granular material around the carbide and interposed between it and the wall of the furnace.

The loose furnace-wall is removed as soon as the carbide has sufficiently hardened, permitting the undecomposed material to fall away, when the carbide is easily removed and the operation is repeated.

By reason of the layer of granular material interposed between the wall of the furnace and the carbide, which until partially cooled is in a soft state, any sticking of the carbide to the walls of the furnace is prevented and its removal from the furnace is facilitated. By keeping the lower end of the upper electrode always near the upper edge of the furnace-wall, the hot gases generated in the furnace are permitted to escape without coming in contact with the body of the electrode, the life of which is thus prolonged.

The invention will be better understood

by reference to the accompanying drawings, forming a part hereof, in which—

Figure 1 shows a vertical section of the furnace as it appears at the beginning of the operation. Fig. 2 is a vertical elevation of the furnace as it appears at the close of the operation; and Fig. 3 is a view in perspective of a semicircular tile or fire-brick, which may conveniently be used in building up the furnace-wall.

The same letters of reference indicate corresponding parts throughout the drawings.

A is the lower and B the upper electrode, preferably composed of carbon, which are respectively connected by conductors indicated at *a* and *b* with any suitable source of electricity, as a dynamo-machine. The lower electrode A is set in an opening in the base C, which may be simply a piece of sheet-iron laid upon the ground. D is one of the curved bricks or tiles, shown in the present case as forming half of a circle of which the furnace-wall is composed.

In carrying out the operation, two or more of the semicircular bricks or tiles D D' are placed in position upon the base C around the electrode A, forming a circular inclosure somewhat greater in diameter than the electrode. This inclosure is then filled with a charge of the mixture of pulverized lime and carbon to be treated, and current is caused to pass between the electrodes which are sufficiently separated so that that portion of the charge lying upon the electrode A will be subjected to a decomposing temperature. When the decomposition of this initial charge has been substantially effected, the wall of the furnace is raised by laying another tier of bricks or tiles upon the tiles D D', an additional charge of the material to be treated is thrown into the inclosure and the electrodes are still farther separated. When the mass of carbide has been built up to as great a height as is convenient, or when the electrodes have become so far separated that the resistance between them is as great as is desirable, the current is turned off, the wall E is taken down, and the carbide is removed.

It will be observed that the lower end of the upper electrode is kept at all times at or only a short distance below the upper edge of the furnace-wall, so that the hot material in the furnace does not come in contact with the body of the electrode and the hot gases set free in the process of forming the carbide are not confined around the electrode, but are free to pass away from it, and the body of the electrode is thus kept comparatively cool and its durability thereby increased.

The undecomposed layer of material between the carbide formed and the furnace-wall prevents any adhesion of the newly-formed carbide to the wall of the furnace, which is thus readily removed, and the granular material falling down as the wall is removed is ready to be again thrown into the furnace as a part of a subsequent charge.

Being already highly heated it is in better condition to be treated than when put in the furnace in a cold state, so that I thus utilize the otherwise waste heat of the furnace.

As the carbide formed retains its heat for a considerable period, the removal of the hot mass from the furnace is greatly facilitated by the taking down of the furnace-wall after the formation of the carbide is completed, as the carbide will then cool more rapidly and can be easily grappled and carried away.

It is evident that the invention herein claimed can be applied to the manufacture of other material than carbide of calcium, and I therefore do not limit my claim to the manufacture of carbide of calcium alone.

What I claim as new, and desire to secure by Letters Patent, is—

1. The hereinbefore described improvement in the manufacture of carbide of calcium, which consists in building up the furnace-wall as the formation of the carbide progresses, adding fresh charges of the material to be treated as the wall is built up and keeping the lower end of the upper electrode at all times near the upper edge of the furnace wall.

2. In the process of manufacturing carbide of calcium in an electric furnace having vertical electrodes, the hereinbefore described method of preventing the heating of the upper electrode which consists in building up the furnace wall as the electrodes are separated, whereby the body of the upper electrode is kept above the furnace wall.

3. The hereinbefore described improvement in the manufacture of carbide of calcium, which consists in subjecting mingled lime and carbon to a decomposing temperature between vertical electrodes, adding fresh charges of material from time to time, as required, to continue the operation, building up a retaining wall, as required, to hold in place the material added, and finally removing such wall, substantially as and for the purpose set forth.

4. The hereinbefore described improvement in the manufacture of carbide of calcium, which consists in forming around the lower of two vertically disposed electrodes, an inclosure greater in diameter than such electrode, charging into such inclosure the material to be treated and subjecting it to a decomposing temperature by means of an electric current between such electrodes, adding fresh charges of material and separating the electrodes as required to continue the operation and building up the wall of the inclosure as required to contain the material added.

In testimony whereof I have hereunto subscribed my name this 2d day of August, A. D. 1895.

WM. C. CLARKE.

Witnesses:

E. A. OLENDORF,
CLARKSON A. COLLINS.

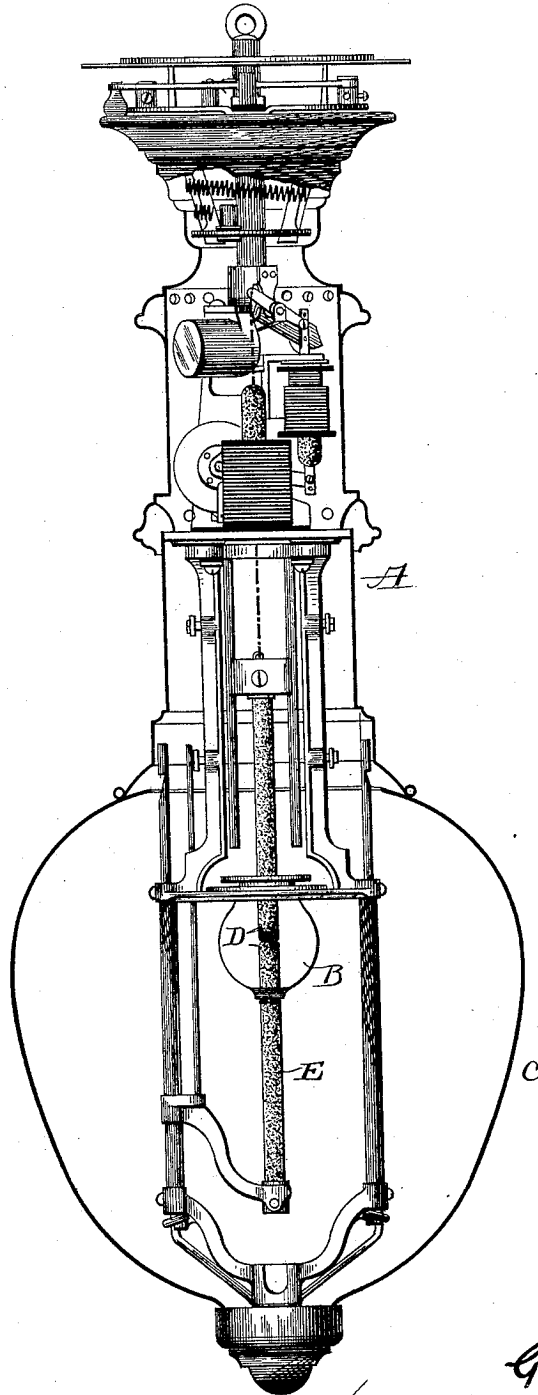
(No Model.)

G. R. LEAN, Dec'd.
J. POTTER, Administrator.
ELECTRIC ARC LAMP.

2 Sheets—Sheet 1.

No. 593,899.

Patented Nov. 16, 1897.



Witnesses
C. D. Nottingham.
G. F. Downing.

H. A. Symour

Inventor
G. R. Lean
By *H. A. Symour*
Attorney

(No Model.)

G. R. LEAN, Dec'd.

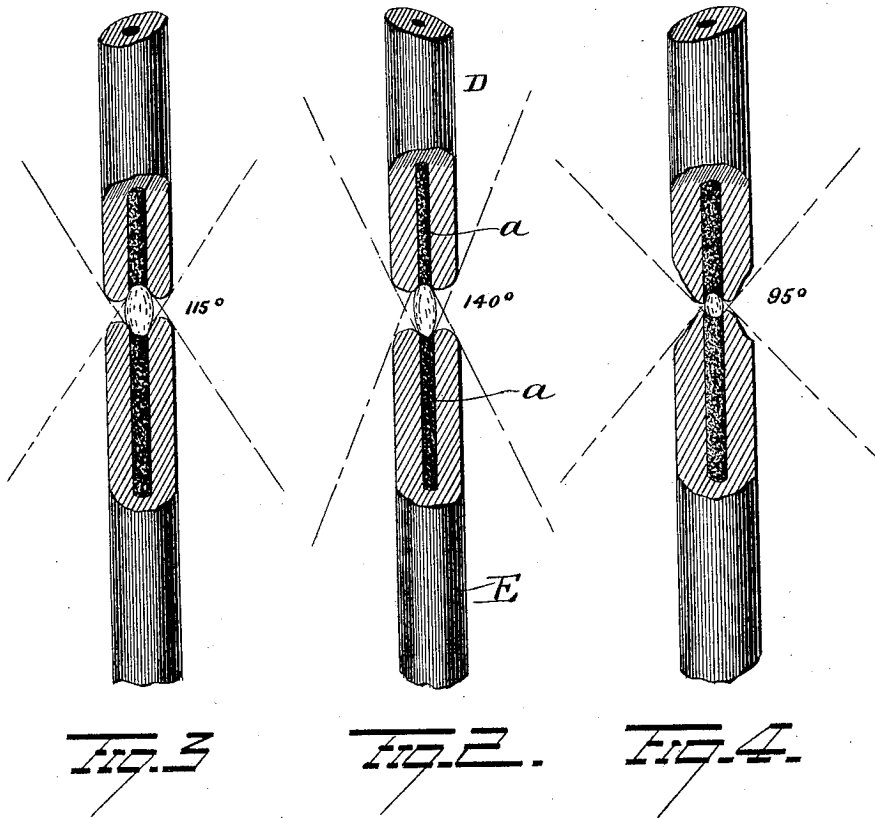
2 Sheets—Sheet 2.

J. POTTER, Administrator.

ELECTRIC ARC LAMP.

No. 593,899.

Patented Nov. 16, 1897.



Witnesses
E. J. Nottingham
G. J. Downing

Inventor
G. R. Lean
By X. A. Seymour
Attorney

UNITED STATES PATENT OFFICE.

GEORGE R. LEAN, OF CLEVELAND, OHIO; JOTHAM POTTER, ADMINISTRATOR OF SAID LEAN, DECEASED, ASSIGNOR TO THE JANDUS ELECTRIC COMPANY, OF SAME PLACE.

ELECTRIC-ARC LAMP.

SPECIFICATION forming part of Letters Patent No. 593,899, dated November 16, 1897.

Application filed January 23, 1897. Serial No. 620,435. (No model.)

To all whom it may concern:

Be it known that I, GEORGE R. LEAN, a resident of Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Electric-Arc Lamps; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to an improvement in electric-arc lamps, and more particularly to the construction of the carbons with respect to the arc to be formed between them and to the regulating mechanism for controlling their separation.

To insure the successful operation of electric-arc lamps with alternating electric currents, it has been found desirable, and in fact necessary, to employ electrodes having cores of soft carbon the particles of which traverse the space intervening between the carbons and serve, in effect, to form a conducting-bridge from one carbon to the other for the alternating currents and thus prevent the constant breaking of the arc and the consequent unsteadiness of the light.

Cored carbons which have been and are now being used in the ordinary open-air alternating-current arc-lamps are constructed with a core of about one-eighth of an inch in diameter. In such lamps the arc is about one-sixteenth of an inch in length and is maintained by a current of about thirty volts and fifteen amperes. The arc thus produced is so short and thick that it is prevented from entering to any appreciable distance within the cores of the carbons, and hence the feed and consumption of the carbons are maintained sufficiently uniform to insure a light sufficiently uniform and constant in its brilliancy to answer the requirements in commercial use.

In the attempts which have been made to operate arc-inclosed alternating-current arc-lamps it has been found impracticable to use cored carbons of the construction heretofore in use, owing to the extreme fluctuations of the light which result from the employment of such carbons and also to the fact that the

inner surface of the arc-inclosing globe soon became so coated with carbon as to materially obscure the light emitted from the adjacent ends of the carbons.

The object of my invention is to obviate the difficulties and objectionable features above noted; and with this end in view the invention consists in certain features of construction and combinations of parts, as will be hereinafter set forth, and pointed out in the claim.

In the accompanying drawings, Figure 1 is a view of an electric-arc lamp embodying my invention. Fig. 2 is an enlarged view of two electrodes exemplifying my invention. Fig. 3 is a view showing the effect of the use of electrodes with large soft-carbon cores in an alternating-current arc-inclosed lamp, and Fig. 4 is a similar view of the electrodes of an open-air alternating-current lamp.

A represents an alternating-current electric-arc lamp. The lamp is provided with electromagnetic-regulating mechanism which may be of any desired construction capable of drawing and regulating a long arc between the carbons, the arc being confined within a close arc-inclosing globe B, supported in a suitable manner by the lamp-casing. The inner arc-inclosing globe is itself inclosed by a large outer globe C, as is usual with modern arc-inclosed electric-arc lamps.

Each electrode D E of the lamp is constructed with a small longitudinal bore or hole *a*, which is preferably about one-sixteenth of an inch in diameter, or about one-half the diameter of the cores of the cored carbons which have heretofore been used. The core is filled with carbon which is much softer than the body of the electrode.

In the operation of arc-lamps of this type the carbons are maintained normally separated by a space of about three-eighths of an inch, which requires an expenditure of an electromotive force of about eighty volts and a current of about five amperes to maintain the arc between the carbons thus separated. In the attempts which have been made to use ordinary cored carbons in this type of arc-lamp it was found that the excessively long and attenuated arc which it is necessary to

produce and maintain would center itself on the adjacent ends of the carbons, and the opposite ends of the arc would gradually eat their way into the cores of the carbons instead of eating and wearing away the ends of the carbons uniformly, with the result that as the carbons were fed together the ends of the arc would be concealed within the large cores thus eaten away and operate to materially diminish the amount of light emitted by the adjacent ends of the carbons.

The angle of the rays of light with a long arc between electrodes having cores of one-eighth of an inch in diameter and burned in an arc-inclosing globe will be about one hundred and fifteen degrees. These remarks apply to a considerable extent also to an open-air alternating-current lamp employing electrodes with large cores, the arc in the latter case being very short and the normal angle of the rays of light being about ninety-five degrees. In both cases the rapidly and abundantly escaping carbon particles from the soft cores will become lodged upon and form a coating within the globe and thus obscure the light.

By making the soft cores of the electrodes very small—viz., about one-sixteenth of an inch in diameter—a minimum amount of fine carbon particles will be liberated, just about enough to maintain the conducting-bridge between the ends of the carbons and insure the continuity of the arc. The small amount of carbon particles discharged from the small cores in a given length of time as compared with the large amount emitted from large cores such as heretofore employed will be entirely consumed by the intense heat of the inclosed arc, and no black ash or sediment will collect within the globe, and the latter will not therefore be given a semitranslucent coating, such as occurs when electrodes with large cores are employed.

With electrodes having soft-carbon cores of less diameter than the normal, such as I propose to employ, the consumption of the body of the electrode and its core will be practically uniform, the wasting away of the core being commensurate with that of the body of the carbon. The electrode ends will therefore remain a uniform distance apart during the continuance of the normal arc. The light-giving capacity of the arc will not

be diminished by the entrance of the arc within the bores of the electrodes, (the ends of the body of the electrode being always practically flush with end of the core,) as has been experienced with electrodes having large cores, and the maximum angle of about one hundred and forty degrees of the rays of light from the arc will remain constant. I also find the proportion above mentioned between the body of the carbon and its core to be valuable when used as the lower electrode for a continuous-current arc-inclosed electric-arc lamp in that the "spinning of the arc," one of the most objectionable features of the long-arc lamp now so generally used, is reduced to a minimum. The conditions, of course, are the same as in the alternating-current lamp in regard to the discoloration of the globe and unsteadiness of the light with the use of electrodes having cores of greater diameter than the length of the normal arc, but at the same time the advantage of a cored carbon to concentrate the arc in the center of the electrodes is obtained. Two of these carbons are necessary for an alternating-current arc-lamp to produce the best results, but for a continuous-current arc-lamp one such carbon only is necessary, preferably the lower carbon, although an upper carbon of this type could be used, or both upper and lower, but, as above explained, one is sufficient with a continuous current.

My improvement, though simple, is of great importance in insuring the successful operation of alternating-current arc-inclosed electric-arc lamps, and by means of it annoying defects and objections heretofore encountered will be successfully obviated.

Having fully described my invention, what I claim as new, and desire to secure by Letters Patent, is—

The combination with an arc-inclosed alternating-current arc-lamp, of cored carbons the cores of which are one-sixteenth of an inch in diameter or less, substantially as set forth.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

GEORGE R. LEAN.

Witnesses:
SHELDON CARY,
J. M. SEE.

UNITED STATES PATENT OFFICE.

EDWARD GOODRICH ACHESON, OF BUFFALO, NEW YORK.

METHOD OF MANUFACTURING GRAPHITE ARTICLES.

SPECIFICATION forming part of Letters Patent No. 617,979, dated January 17, 1899.

Application filed November 3, 1898. Serial No. 695,405. (No specimens.)

To all whom it may concern:

Be it known that I, EDWARD GOODRICH ACHESON, a citizen of the United States, residing at Buffalo, in the county of Erie and State of New York, have invented certain new and useful Improvements in the Method of Manufacturing Graphite Articles, of which the following is a specification.

My invention relates to new and useful improvements in the art of manufacturing graphite articles or in producing articles containing a greater or less percentage of graphite, and it has for its object the improvement and simplification of the production of such articles; and it consists in the various features of invention substantially as hereinafter more particularly pointed out. Heretofore in general practice when it was desired to make an article consisting essentially or materially of graphite—such, for instance, as motor brushes, carpenter or lumbermen's pencils and crayons, crucibles, stove-polish, and other articles—it has been the custom to first prepare the graphite and the desired binding material and then mold or otherwise form the articles from such materials into the desired shape.

By my present invention I provide an improved method of manufacturing various articles containing the desired percentage of graphite—such, for instance, as brushes for electric motors or generators, lead-pencils, crayons, stove-polish, crucibles, and other articles.

Broadly stated, by my invention I first take the various raw materials in the desired proportions necessary to produce the intended result, and then mold under pressure or otherwise form the mixture into the shape of the article to be made therefrom, and then convert a greater or less portion of the materials into graphite, while the materials retain their molded or formed condition. Thus, for instance, amorphous carbon, in the form of coke, charcoal, lampblack, or any other form in which it exists in nature or has been produced, is granulated or powdered to any desired degree of fineness and is mixed with some material, as an elemental substance capable of combining with carbon or an oxid or salt capable of being reduced by carbon and the base of which will combine with carbon, and

to which is added an appropriate binding material, and then mold or form the mixture into the shape or configuration of the article to be produced. This article is then subjected to a temperature sufficiently high and for a sufficient time and under such conditions as to cause more or less of the carbon in the article to be converted into graphite. Then the amorphous carbon in a pulverulent, granulated, or powdered form, for instance, is mixed with a metallic salt, as sulfate of iron, or an oxid of an element, as peroxid of iron, dioxid of silicon, or one of the elements in a state of fine subdivision, as iron filings. These materials may be mixed with the amorphous carbon, either dry or in the form of a solution of the salts or oxids, and when they are mixed thoroughly they are moistened with water, which may have a little sugar, molasses, tar, pitch, or any other suitable binding material in solution, so as to form a paste or mixture that can be readily molded or pressed or otherwise formed into the desired shape of the article to be produced. This shape or article is then placed in an electric furnace and subjected to a temperature and for sufficient time to cause portions of the amorphous carbon contained therein to be converted into graphite. A greater or less percentage of the amorphous carbon can thus be converted into graphite, according to the purposes desired, and in some instances I have found it advisable to leave a portion of the amorphous carbon unconverted, as it tends to render the article stronger.

While any desired form of electrical furnace suitable for the purpose may be used and the requisite temperature may be produced in any desired way, I have found the following a most successful method of treating the articles.

The articles to be treated are embedded in fine carbon, the bed containing the articles and the surrounding carbon preferably being made into a substantially cylindrical or oblong form, and this is preferably surrounded by a layer of granular amorphous carbon, which is sufficiently thick to prevent the rapid radiation of heat. The bed of carbon and its contained articles embedded therein are arranged in the furnace so that

a current of electricity of sufficient value to raise the temperature to the point necessary for the production of the graphite may be passed through it. In this way I produce
 5 articles containing a greater or less proportion of graphite by first mixing the materials and molding the articles out of the mixture of amorphous carbon and metallic salt or
 10 equivalent material and then converting portions of said carbon into graphite, while the article retains its desired shape.

While I have stated that a metallic salt or an oxid of an element or elements may be mixed with the amorphous carbon, I do not
 15 limit myself to what may be technically known under these names, but include therein all materials or substances which are reduced by and are capable of entering into chemical association with the carbon at the
 20 temperatures to which they are exposed, which associations, if actually made, are afterward broken or disassociated, leaving the carbon in the form of graphite. The amount of metallic salt used in connection
 25 with the amorphous carbon will vary, depending upon the particular character of the salt, the desired amount of graphitization, its mode of treatment and other conditions, and the given or specific instances, as in the manufacture of motor-brushes I take about ninety-seven parts of amorphous carbon, in the form of coke or charcoal reduced to a powder, and mix therewith about three parts of oxid of iron and form or mold the article out of this
 30 mixture. The value of the current necessary depends upon a number of conditions, as the character of the materials, the nature of the articles, &c.; and, as an example, if, for instance, the electrodes of the electric furnace
 35 are sixteen feet apart and the connecting cylinder of carbon containing the articles to be graphitized is twenty inches in diameter, the current at starting is about one hundred and fifty volts and three hundred amperes,
 40 and as the graphite is formed in the article it becomes a better conductor, reducing the resistance, so that the voltage of the current can be reduced and the amperage increased until the graphitization is completed to the
 45 desired extent, and at the end of the furnace operation the volts may be about one hundred and the amperes seven thousand.

In carrying out the process above described, while I have not been able to determine with
 55 absolute certainty the exact chemical or other changes which occur in said furnace, there is reason to believe, and I am at present of the opinion, that all volatile matters are driven off as the temperature rises to the several
 60 points of volatilization, and the salts or oxids are decomposed or reduced and their volatile constituents dissipated either in a free state or in association with a portion of the carbon, leaving in the path of the current the
 65 carbon of the molded article in a free or pure state and the metal or metallic base of the salt or oxid.

Those portions of the free carbon that are in immediate contact or proximity with the base unite therewith to form a carbid, and as
 70 the temperature rises the carbid is decomposed, separating the carbon in a graphitic form, and the base thus separated unites with another portion of the free carbon to form further carbids and is again decom-
 75 posed, so that the action may be said to be a progressive one, in that successive portions of the free carbon are successively converted into graphite by what seems to be a progressive formation and decomposition of a carbid. 8c

It may be said that a true carbid is not formed and decomposed and that the free carbon is converted into graphite without actually forming a carbid; but whatever may be the exact action or reaction taking place
 85 the actual result of this treatment is that a large portion of the carbon of the article is actually changed into graphite. My reasons for this theory are based somewhat upon the fact that there is not enough of the base or
 90 oxid to combine at once with the free carbon to form sufficient carbid, which on being decomposed would produce the amount of graphite actually produced if these elements combined in their proportions and weights
 95 usually understood to be necessary to form carbids.

The graphite blocks or articles made as above stated may in some instances be broken or powdered for use, as in the case of
 100 blocks for use as stove-polish, &c.

What I claim is—

1. The method, substantially as hereinbefore set forth of producing articles containing a greater or less percentage of graphite,
 105 which consists in forming the articles from a mixture of carbon, and a metallic salt, having a base capable of being reduced by and combining with carbon and then subjecting them to a temperature sufficiently high and
 110 for a sufficient time to form and then decompose a carbid, and thereby convert the carbon into graphite.

2. The method, substantially as hereinbefore set forth, of producing articles containing a greater or less percentage of graphite,
 115 which consists in forming the articles from a mixture of carbon and a metallic salt, having a base capable of being reduced by and combining with carbon, the relative proportions of the carbon and salt, being less than
 120 that necessary to form a carbid of all the carbon desired to be converted into graphite, and then subjecting them to a temperature sufficiently high to progressively form and
 125 then decompose a carbid, and thereby progressively convert the carbon into graphite.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

EDWARD GOODRICH ACHESON.

Witnesses:

GEO. R. RAYNER,
 A. D. KYSOR.

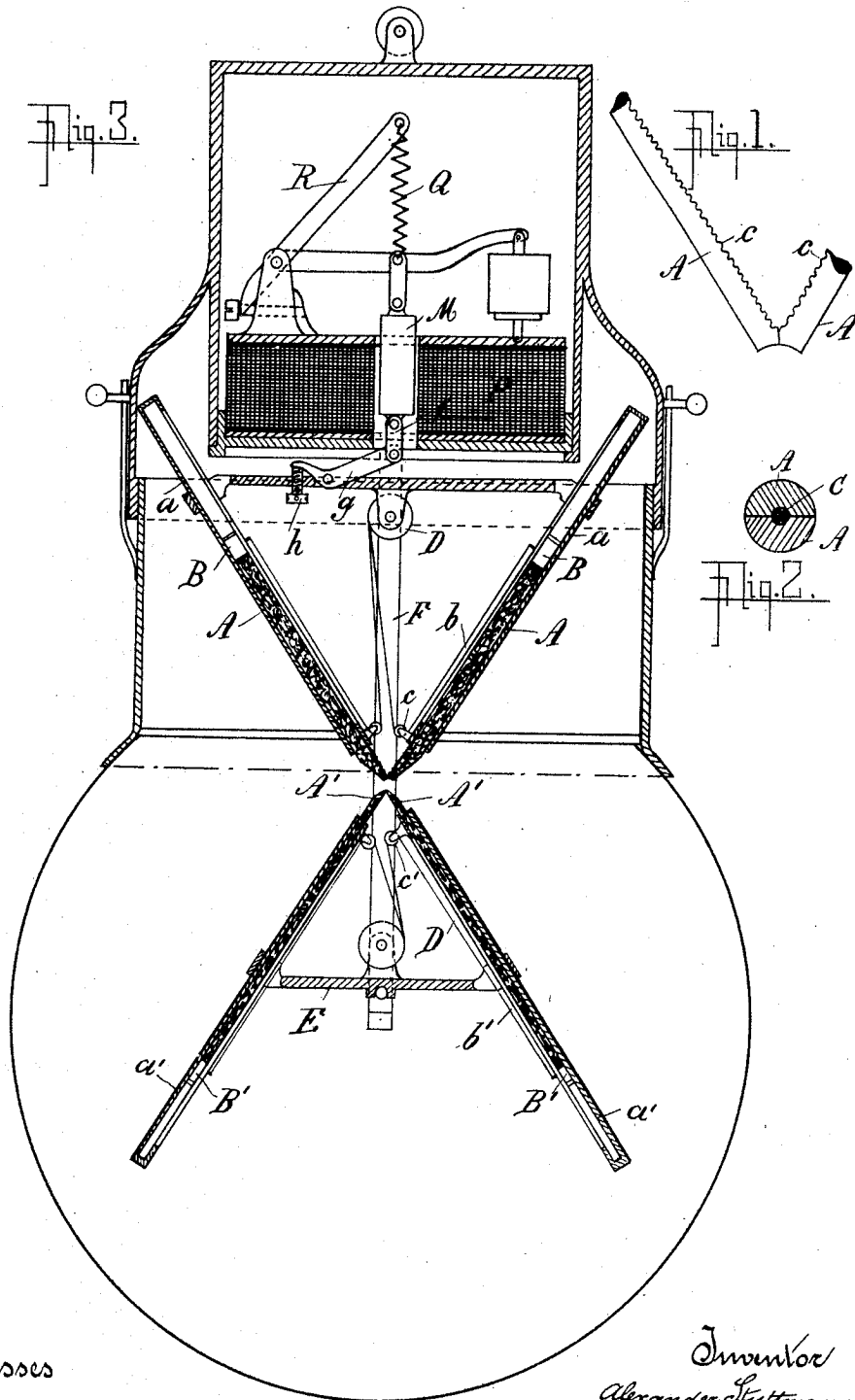
No. 630,470.

Patented Aug. 8, 1899.

A. STUTTMANN.
ELECTRIC ARC LAMP.

(Application filed Dec. 14, 1898.)

(No Model.)



Witnesses
R. Aberlin
Charles Smith

Inventor
Alexander Stuttman
By Friesen & Mauch,
his Attorneys.

UNITED STATES PATENT OFFICE.

ALEXANDER STUTTMANN, OF RUSSELHEIM, GERMANY.

ELECTRIC-ARC LAMP.

SPECIFICATION forming part of Letters Patent No. 630,470, dated August 8, 1899.

Application filed December 14, 1898. Serial No. 699,240. (No model.)

To all whom it may concern:

Be it known that I, ALEXANDER STUTTMANN, engineer, residing at Russelheim-on-the-Main, in the Empire of Germany, have invented new and useful Improvements in Electric-Arc Lamps, of which the following is a specification.

Attempts to fix the luminous point in an arc-lamp by feeding two carbons at an angle toward the same constant burning-point have been unsuccessful for many reasons. First, in using the ordinary carbons, and particularly cored carbons, a good light cannot be obtained for the reason that two craters are formed in the upper carbon, which also accounts for the fact that the proper softening and incandescing of the mass does not take place at the point of contact with the two carbons, toward which point they are pressed by spring power or other means, so that the feed takes place only by fits and starts at the times at which the edge of the crater is breaking away; but it has further been found that carbons cannot be produced with such uniformity or homogeneity as to insure the uniform burning away necessary for a uniform feed, and consequently one carbon soon moves past the other.

The present invention has for its object to completely obviate these drawbacks.

The formation of a central crater the deepest point of which extends close up to the meeting-point of the two carbons may be insured by employing cored carbons whereof what I term the "core," for the want of a better expression, is exposed at the side which is situated within the angle which the two carbons form with each other—*i. e.*, angle of convergence. By "core" in this case I mean a continuous body of material inlaid in the side of the carbon and of a substance other than carbon. Such carbons are preferably made of semicircular form in cross-section and placed with the flat sides together. The manufacture of such carbons is more simple than that of the ordinary cored carbons. The fact that the luminous arc is kept in the center and that the heat is concentrated close to the point of contact of the carbons insures that the carbon becomes burned at that place and becomes soft, so that the carbons can be fed on toward this point. For

the purpose of preventing with complete certainty all movement of the carbons past each other both carbons may be transversely fluted or serrated on their adjacent sides, so that if at any time the circumstances at the point where the carbons bear against each other should be such that one carbon tends to slip past the other then this carbon would at once catch by the point of its next tooth or serration against the point of the corresponding tooth or serration of the other carbon. Further, the uniform forward feed of the carbons may be effected, in case the carbons are formed perfectly homogeneous, by connecting the feeding mechanism positively in such a manner that the corresponding carbons shall advance through equal distances in equal times. Finally, it may be stated that with this arrangement of the carbons the use of a closed air-tight globe containing the entire lamp mechanism is considerably facilitated because it is possible to place the whole mechanism in the interior of a hermetically-closed casing.

In the accompanying drawings, Figure 1 shows two carbons with their flutings and with the crater formed by them.

Fig. 2 is a section through the two carbons where they bear against each other. A and A are the serrated carbons, *d* indicating the serrations, and C is the core.

Fig. 3 shows the general arrangement in a closed casing. The carbons A A are guided in the slotted tubes *a a*, in which followers B B are drawn toward their point of intersection by means of the cords *b b*, passing over the pulleys *c c* and a spring-barrel D. The same applies to the lower carbons A' A', tubes *a' a'*, small blocks B' B', cords *b' b'*, pulleys *c' c'*, and the spring-barrel D'. The tubes *a a* are stationary with relation to the globe N. The tubes *a' a'* and the spring-barrel D' are fixed to an arm E of the rod F, which is connected to the soft-iron core M of a solenoid-coil P. The core M is suspended from a lever R by means of a spring Q, and to its lower end is connected by a link *f* a lever *g*, which by meeting a set-screw *h* limits the ascending movement of the core M. The solenoid-coil P acts in the well-known manner to produce the upward and downward movement of the core M and serves in a considerable degree to

raise the core M, and with it the carbons A' A', sufficiently to strike the arc and to allow them to descend again to the proper distance after the luminous arc has been formed.

5 Now what I claim, and desire to secure by Letters Patent, is the following:

1. In an electric-arc lamp, the combination
 10 of a set of converging carbons meeting at a point each of which carbons has inlaid therein a continuous body of material along its side which is included within the angle of convergence, the said carbons being of the same polarity, with another set of converging carbons meeting at a point each of which carbons has inlaid therein a continuous body of material along its side which is included within the angle of convergence, the said converging carbons being of a polarity opposite to that of the first-mentioned carbons whereby
 15 an arc may be maintained between the meeting points of the two sets of carbons.

2. In an electric-arc lamp, the combination of an electrode constituted by a set of converging carbons meeting at a point, each carbon having a continuous body of inlaid material along its side lying within the angle of

convergence, and a second electrode cooperating with the set of carbons to form the arc.

3. In an electric-arc lamp, employing carbons meeting at an angle, each carbon having a continuous inlaid portion within the angle of convergence, means for preventing the carbons from becoming displaced comprising teeth or serrations located upon the sides of the carbons which lie within the angle of convergence, the said teeth or serrations being adapted to engage with each other to prevent the carbons from slipping past each other.

4. As a new and useful article of manufacture, a carbon substantially semicircular or half-round in cross-section with a continuous body inlaid in the side of the carbon corresponding to the diameter of the circle, substantially as described.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ALEXANDER STUTTMANN.

Witnesses:

JEAN GRUND,
 DEAN B. MASON.

No. 653,468.

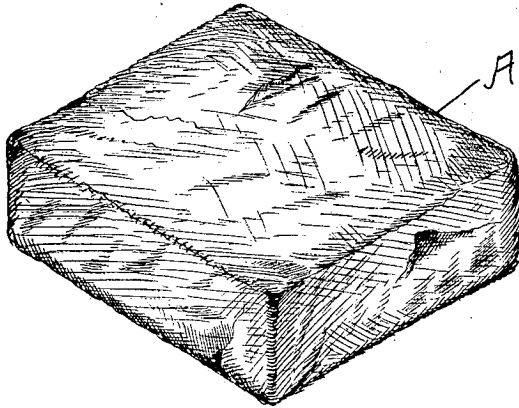
Patented July 10, 1900.

W. J. BURKE.

METHOD OF RENDERING ANTHRACITE COAL CONDUCTIVE, &c.

(Application filed Apr. 27, 1900.)

(No Model.)



Witnesses
F. L. Curran
J. M. Coppenhafer

Inventor
Wm. J. Burke
by *Geo. H. Evans*
Attorney

UNITED STATES PATENT OFFICE.

WILLIAM J. BURKE, OF SCRANTON, PENNSYLVANIA, ASSIGNOR OF ONE-HALF TO HENRY A. KAUFHOLD, OF SAME PLACE.

METHOD OF RENDERING ANTHRACITE COAL CONDUCTIVE, &c.

SPECIFICATION forming part of Letters Patent No. 653,468, dated July 10, 1900.

Application filed April 27, 1900. Serial No. 14,622. (No specimens.)

To all whom it may concern:

Be it known that I, WILLIAM J. BURKE, a citizen of the United States, residing at Scranton, Laekawanna county, Pennsylvania, have
5 invented a certain new and useful Method of Rendering Anthracite Coal Conductive and the Article Produced Thereby, of which the following is a specification.

My invention relates to the production of
10 a conductive material for use in electrical and metallurgical apparatuses.

The object of my invention is to so treat anthracite or hard coal in a retort closed to external air as to drive off all impurities in
15 the form of gases until practically-pure commercial carbon is produced, the article so produced being a good conductor of electricity.

The invention will first be described and then specifically pointed out in the claims.

20 The drawing shows in perspective an electric brush or conductor formed of a single piece of my new conducting material.

In carrying out my improved process I take anthracite or hard coal of any size and place
25 it in a suitable retort. This retort I fill to within a short distance of the top and then place a sheet of paper or other suitable material upon the coal, after which I seal the top with clay, upon which I place a covering of
30 fine coal dust or ashes to prevent air from entering the retort. Heat will now be applied to the exterior of the retort sufficient to drive off the impurities contained in the coal, and these impurities issue from the sealed top of the retort in the form of gases, which ignite
35 and are consumed. This heating is kept up for several hours, or until the gases from the retort cease to burn. I have produced a good conductor of electricity by this method in
40 about two hours; but a longer time may be taken without injury to the product and according to the use to which the product may be employed. It is best to allow the material thus treated to cool gradually in the retort
45 without exposure to the atmosphere.

The anthracite or hard coal treated by my method, where electric pencils, brushes, electrodes, or contacts are to be formed, is in lumps or blocks, and after treatment the pen-

cils or other forms of conductors may be made
50 by turning them out in a lathe or other machine, or, if preferred, these pencils, &c., may be first formed by suitable machinery from lumps or blocks of coal and then placed in the retort. Where a granular conductor is
55 to be formed—such, for instance, as that employed as a core between the electrodes of an electrical metallurgical furnace—I take granular anthracite or hard coal and subject it to the foregoing process, after which it is ready
60 for use. In the drawing the brush A shown was first formed from a lump of anthracite coal and then subjected to my above-described process or method of treatment. The carbon
65 thus produced may also be finely ground and employed as a "facing" for molds in foundry-work instead of the graphite and other expensive facings now employed to keep the sand from adhering to the molded articles. My new conducting material may also be em-
70 ployed for heating by electricity.

In my present process I do not add to the coal any oleaginous material and also dispense with several steps and cheapen the product claimed in my allowed application,
75 Serial No. 740,573, filed December 16, 1899.

What I claim as new, and desire to secure by Letters Patent, is—

1. The herein-described method of rendering anthracite or hard coal electrically con-
80 ductive, or of transforming it into a conductor, which consists in heating the same in its natural condition of solidity, in a retort closed to external influences until the impurities are driven off.

2. The herein-described method of rendering anthracite or hard coal electrically con-
90 ductive, or of transforming it into a conductor, which consists in placing the same in a retort, then covering the coal with a layer of suitable fabric, then applying a layer of clay and finally a layer of coal dust or ashes, then heating the retort to drive out the objectionable elements in the form of gases and to convert the coal to commercially-pure carbon,
95 and continuing the heat till the escaping gases cease to burn.

3. As a new article of manufacture, con-

ducting-carbon formed from anthracite or
hard coal by freeing it from its volatile non-
conducting elements or constituents.

4. As a new article of manufacture, a car-
5 bon formed from a piece of anthracite coal
freed from its volatile non-conducting ele-
ments or constituents and cut to shape.

In testimony whereof I affix my signature
in presence of two witnesses.

WILLIAM J. BURKE.

Witnesses:

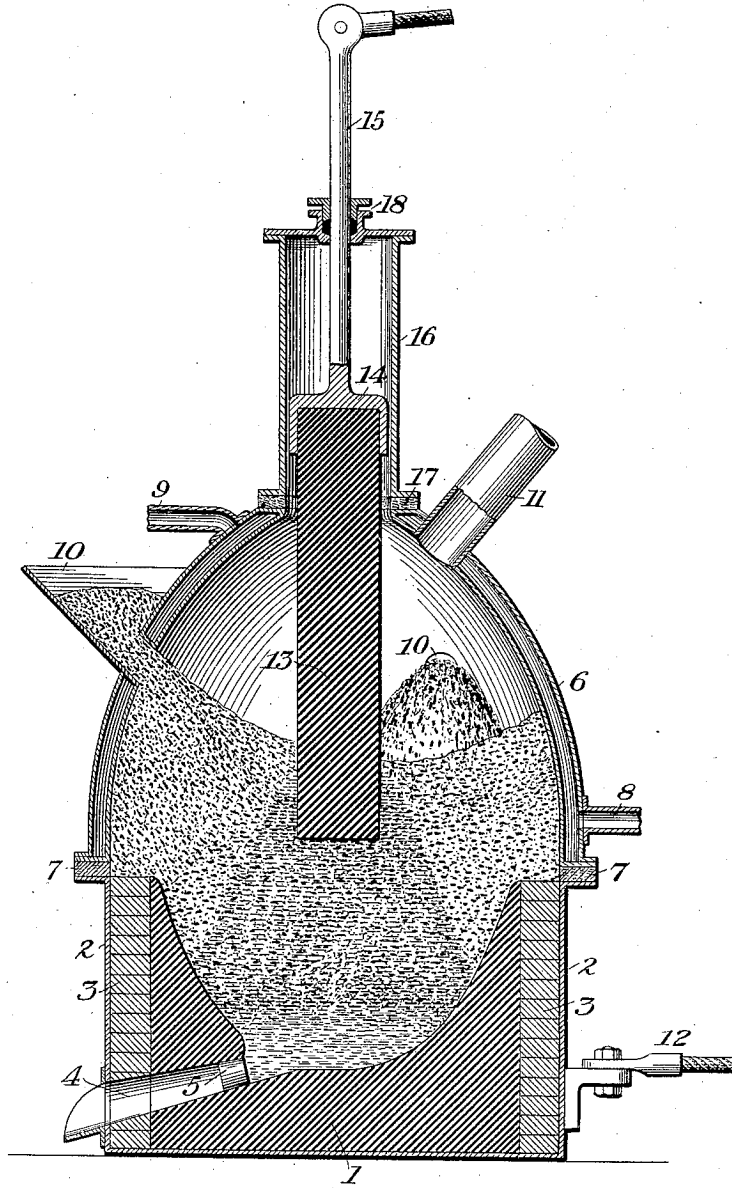
GRACE P. BRERETON,
GEO. H. EVANS.

No. 760,312.

PATENTED MAY 17, 1904.

A. H. COWLES,
PROCESS OF MAKING CALCIUM CARBID.
APPLICATION FILED JUNE 28, 1902.

NO MODEL.



Witnesses:

R. A. Baldwin,
W. E. Neff

Inventor:

Alfred H. Cowles,
by Reginald Townsend,
Attorneys.

UNITED STATES PATENT OFFICE.

ALFRED H. COWLES, OF CLEVELAND, OHIO.

PROCESS OF MAKING CALCIUM CARBID.

SPECIFICATION forming part of Letters Patent No. 760,312, dated May 17, 1904.

Application filed June 28, 1902. Serial No. 113,639. (No specimens.)

To all whom it may concern:

Be it known that I, ALFRED H. COWLES, a citizen of the United States, residing at Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Processes of Making Calcium Carbide, of which the following is a specification.

This process is intended for the continuous production of calcium carbide and involves the use as a means for heating the charge of raw materials of a resistance-conductor which is raised to a high temperature by the passage of an electric current through it. The process further involves the use of a sufficient temperature to melt the carbide or maintain it in a molten condition and the removal of the carbide from the furnace through a tap-hole or other suitable outlet, fresh materials being supplied as required to replace those converted into carbide. The resistance-conductor may be a carbon rod or core having suitable terminal connections to the source of electric current. The mixture of lime and carbon is then packed around the core and raised to the necessary temperature by the heat radiated from the incandescent core. It is desirable, however, to use as the resistance-conductor the mixture of lime and carbon which constitutes the furnace charge. The charge in this case may be one containing large pieces of carbon which lie in contact with each other at various points, and thereby afford direct paths for the flow of current, the lime being distributed in the interstices between the pieces of coke. If the normal charge, however, consists of a not sufficiently conducting mixture of coke and lime, the furnace may first be put into operation by use of a conducting-core or by otherwise providing initial paths for the flow of current. The current passing in the first instance soon raises the temperature of that portion of the mixture between the electrodes to a point which will enable it to act as a resistance-conductor. In normal working condition the body of material between the electrodes may consist partly of incandescent but unreduced material and partly of molten or semimolten carbide. The temperature maintained in the furnace is pref-

erably sufficient to cause a pool of the molten carbide to collect adjacent to the tap-hole, the carbide being tapped out either intermittently or continuously, as desired, according to the output of the furnace.

The process may be carried out in a furnace or container of any desired shape. A furnace is not even requisite, as the resistance-conductor, material undergoing reduction, and molten carbide may be held in a cavity made within a pile of the mixture of lime and coke constituting the charge. For the sake of illustration, however, one form of furnace is shown in the accompanying drawing, in which the figure is a vertical central section. The furnace shown comprises a solid carbon hearth 1, surrounded by a sheet-iron casing 2, a layer of firebrick 3 being interposed between the sides of the hearth and the casing. A tap-hole 4, having plug 5, serves to deliver the molten product from the lower portion of the hearth. A dome-shaped water-jacketed top 6 is supported upon the casing 2, being insulated therefrom by a ring 7, of asbestos. This top has double walls, preferably of sheet-iron, and water inlet and outlet pipes 8 9, leading to the space between the walls. Feeding-hoppers 10, here shown as three in number, are arranged to discharge raw material through the top into the furnace. A pipe 11 serves to deliver waste gases from the furnace. The carbon hearth serves as one of the electrodes of the furnace, current being supplied to it through the bottom of the casing 2 and a terminal 12, bolted to the casing. The other electrode 13 is made of carbon, suspended vertically within the furnace by a metal terminal 14, having an upwardly-extending stem 15. A sheet-metal casing 16 is supported on the top of the furnace, being insulated therefrom by an asbestos ring 17. The stem 15 of the upper electrode passes adjustably through a stuffing-box 18 at the upper end of this casing. The electrodes are connected to a suitable source of current, preferably an alternating one.

In operation the charge of lime and coke is fed in through the hoppers until it fills the furnace to a height somewhat above the lower end of the upper electrode. That portion of the charge between the electrodes is then

brought to incandescence in any well-known manner and maintained at a temperature sufficient to effect conversion of the charge into carbid. Molten carbid accumulates on the
 5 hearth and is removed through the tap-hole, and further portions of the charge are fed in through the hoppers, the process thus being a continuous one. If the normal charge is a not sufficiently conducting mixture of lime and
 10 coke, it soon becomes heated as it descends into the furnace by the heat thrown off from the resistance-conductor or that portion of the charge between the electrodes and by the waste gases rising from the zone of reduction to a
 15 temperature which will enable it to act as a resistance-conductor when it descends into the paths of current flow.

While the resistance-conductor employed is preferably the charge itself or the resulting
 20 carbid, a permanent resistance-conductor, such as a carbon rod, may be inserted between the electrodes 1 and 13, as indicated by dotted lines.

The word "tapping" as used in the claims
 25 is intended to cover the removal of molten carbid through a tap-hole or by any suitable means. The term "body of superheated molten carbid" used in the claims is intended to mean a body of carbid which has not only been
 30 produced and melted by the heat from the resistance-conductor, but which has also been raised thereby to such a temperature that it will run through a suitably-located tap-hole without requiring further heat to be supplied
 35 to it to compensate for that lost by conduction and radiation. It is not practicable to tap molten calcium carbid from an electric furnace unless it is either superheated or more
 40 heat is supplied to it at the tap-hole, its temperature of fusion being so high and the heat losses during its transit to and through the tap-hole being so great that it will otherwise become viscid or solid and clog the tap-hole.

I claim—

45 1. The process of making calcium carbid, which consists in heating a resistance-conductor to incandescence by passing an electric current through it, subjecting carbid-forming materials placed around said conductor to the
 50 heat from said conductor and thereby producing a body of superheated molten carbid, and tapping out carbid and supplying fresh materials as required.

2. The process of making calcium carbid, which consists in heating a resistance-conductor of carbid-forming materials or carbid produced therefrom to incandescence by passing an electric current through it, subjecting carbid-forming materials placed around said conductor to the heat from said conductor and thereby producing a body of superheated molten carbid, and tapping out carbid and supplying fresh materials as required. 55 60

3. The process of making calcium carbid, which consists in heating carbid-forming materials to a temperature sufficient to produce a body of superheated molten carbid by passing an electric current through said materials, or carbid produced therefrom, acting as a resistance-conductor, and tapping out carbid and supplying fresh materials as required. 65 70

4. The process of making calcium carbid, which consists in maintaining a resistance-conductor of carbid in a superheated molten condition by passing an electric current through it, subjecting carbid-forming materials placed around said conductor to the heat from said conductor and thereby producing further amounts of superheated molten carbid, and tapping out carbid and supplying fresh materials as required. 75 80

5. The process of making calcium carbid, which consists in heating a vertical resistance-conductor to incandescence by passing an electric current through it, subjecting carbid-forming materials placed around said conductor to the heat from said conductor and thereby producing a body of superheated molten carbid, and tapping out carbid and supplying fresh materials as required. 85 90

6. The process of making calcium carbid, which consists in heating a vertical resistance-conductor of carbid-forming materials or carbid produced therefrom to incandescence by passing an electric current through it, subjecting carbid-forming materials placed around said conductor to the heat from said conductor and thereby producing a body of superheated molten carbid, and tapping out carbid and supplying fresh materials as required. 95 100

In testimony whereof I affix my signature in presence of two witnesses.

ALFRED H. COWLES.

Witnesses:

A. E. ROBINSON,
 HORACE W. POWERS.

C. OLIVER.
ELECTRIC ARC LAMP.
APPLICATION FILED FEB. 29, 1904.

2 SHEETS—SHEET 1.

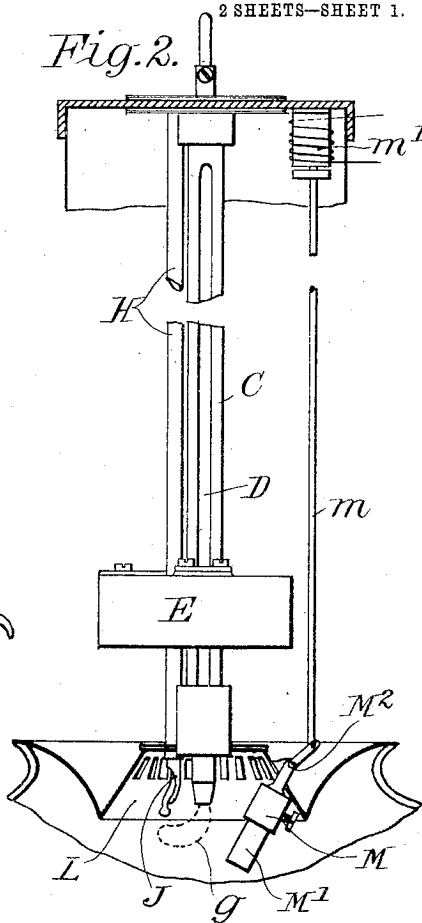
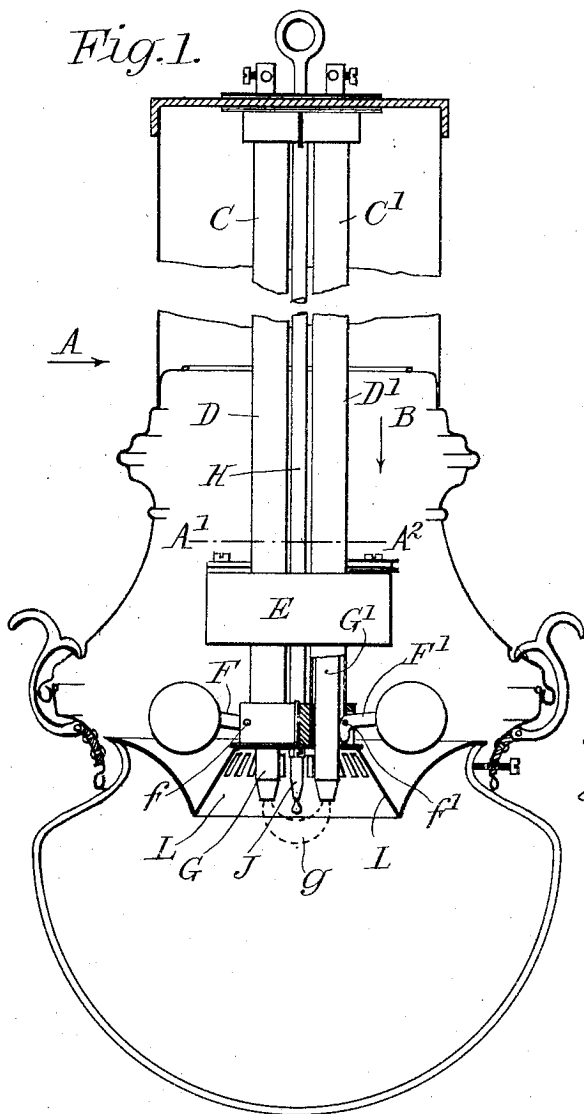
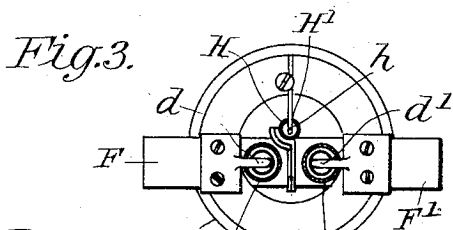
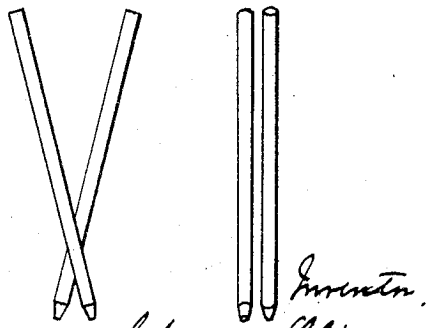


Fig. 8. Fig. 8a.



Witness
Stephen Hinster
W. May. Duvall.

Inventor
Charles Oliver
 By *Wilkinson & Fisher*
 his Attorneys

C. OLIVER.
ELECTRIC ARC LAMP.
APPLICATION FILED FEB. 29, 1904.

2 SHEETS—SHEET 2.

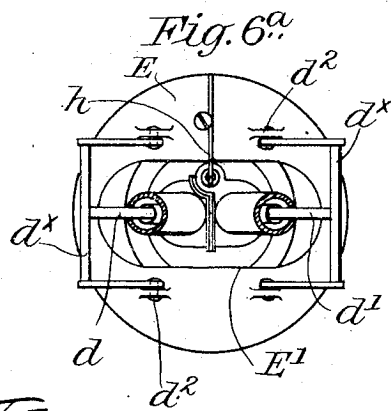
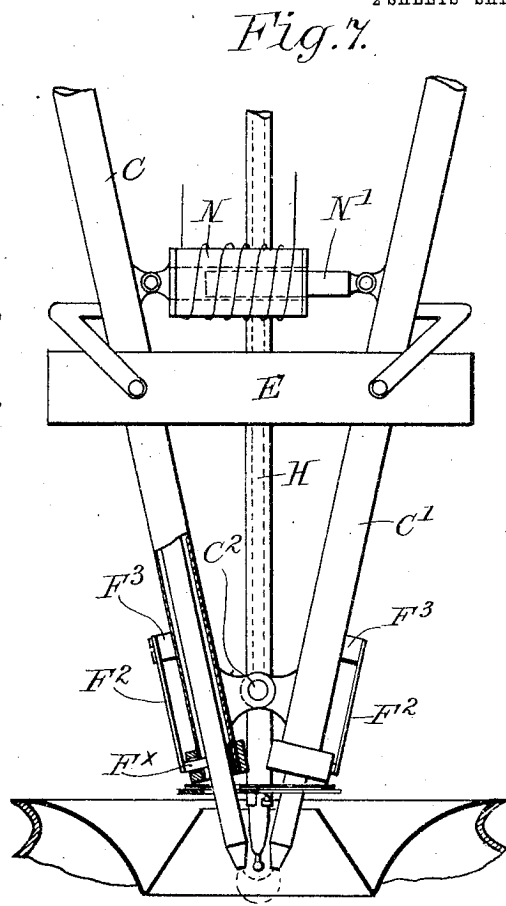
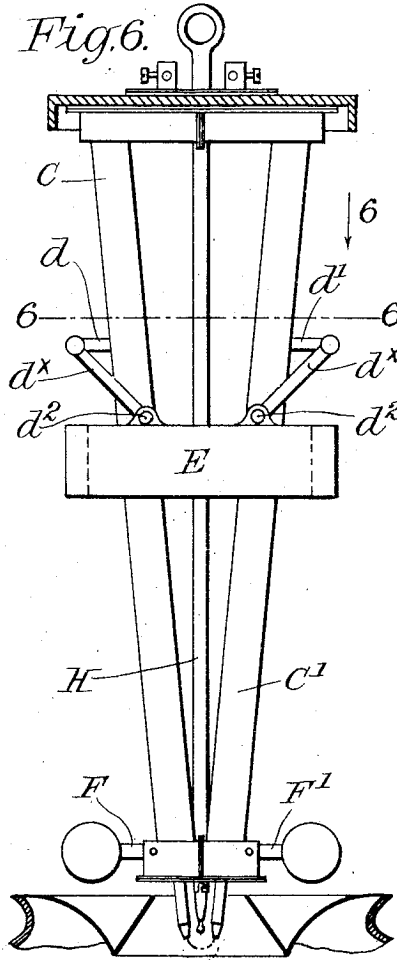


Fig. 4^a Fig. 4.

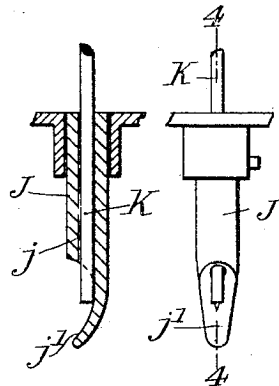
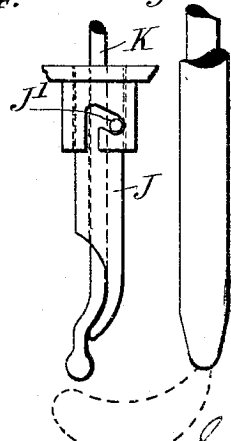


Fig. 5.



Witness:
Stephen Kinsten
W. Max. Durrall.

Inventor
Charles Oliver
By Wilkinson & Finner
his Attorneys

UNITED STATES PATENT OFFICE.

CHARLES OLIVER, OF WOOLWICH, ENGLAND.

ELECTRIC-ARC LAMP.

SPECIFICATION forming part of Letters Patent No. 785,516, dated March 21, 1905.

Application filed February 29, 1904. Serial No. 195,913.

To all whom it may concern:

Be it known that I, CHARLES OLIVER, electrical engineer, of the firm of Oliver & Co., a subject of the King of Great Britain, residing
 5 at Cambridge Place, Burrage Road, Woolwich, in the county of Kent, England, have invented certain new and useful Improvements in or Relating to Electric-Arc Lamps, of which the following is a specification.

10 In arc-lamps which burn with long luminous arcs and wherein the electrodes contain or are impregnated with metallic salts and are arranged parallel or inclined toward each other instead of vertically above one another, as is
 15 usual with the arcs burning at the lower ends of the carbons under a reflector and under magnetic influence or not, the mechanism hitherto in use for feeding them forward together to keep the arc in a fixed position has been
 20 complicated, expensive, and in many cases unreliable.

This invention is designed (*inter alia*) to overcome the above undesirable features, and a lamp constructed accordingly is exceedingly
 25 efficient, simple, and cheap to manufacture.

According to my present invention I provide carbons in pairs fixed either vertically or otherwise parallel to each other or inclined toward each other, but always in such a position that the arc can be formed between the
 30 lower end of each carbon, each of which has its burning-point pointing downward. A reflector or shield or top plate (hereinafter referred to as the "reflector") placed just above the points of the carbons where the arc takes
 35 place is advantageously of an inverted-cup form or other suitable form advantageously but not necessarily so that it incloses or partly incloses or surrounds or partly surrounds said
 40 points. It may be made either closed at the top or open or partly open, as required. Any suitable carbons or electrodes may be employed in lamps constructed according to the present invention, such lamps, however, being
 45 specially suitable for use with carbons or electrodes which produce a long luminous flame or arc, such as the present well-known flame carbons or electrodes which contain or are impregnated with metallic salts, and the
 50 use of which latter for the sake of example I

will hereinafter describe. The points of the carbons between which the arc is formed project from above through the top or sides of this reflector. The carbons are fed forward together as they burn away, their sizes being
 55 proportioned so that they consume evenly throughout. Contacts to carry the current to the carbons are provided just above the arc.

An insulated carbon holder or holders may be provided, into which the upper ends of the
 60 carbons are fixed or held and fed forward as required, or I may advantageously dispense with carbon-holders such as these and in their place provide an arrangement only for pushing forward the carbon or carbons, in which
 65 case I preferably make the contact devices above mentioned of such a strength as to hold the carbons by friction in their position except at such times as they are being fed forward through them. One advantage of this
 70 last arrangement is that the carbons do not require any special fastening. They are slipped into position from below, a tube being advantageously provided for each carbon into which to insert it.
 75

In order to start the arc between the carbon points, I employ a starting device, such as a bridge-piece, which acts as a conductor. For example, a small connecting-piece of carbon or other suitable conducting material is
 80 provided, which is automatically inserted between the carbon points to make a circuit and is automatically withdrawn when the current passes through them, so striking the arc by means which are readily understood, or the carbons
 85 are caused to touch each other, and when current passes they are separated and the arc is formed in the known manner.

In order to feed the carbons forward at the rate at which they burn away—that is, to keep
 90 the arc or "flame" in a certain fixed position in relation to the reflector—I provide a length of glass or other suitable material affected by heat—for example, a rod or rods of glass—of any suitable section or form advantageously
 95 arranged parallel to the carbons and of equal length, the lower end or ends of which will, owing to the gradual consumption of the carbons and the consequent adjacent position of the arc and heat therefrom, be caused to slowly
 100

soften or to fuse or to disintegrate or to be consumed thereby or to be so altered or affected continuously or otherwise during the burning of the carbons as to enable them to be
 5 moved or operated in such wise as to keep the arc or flame located in the desired plane or position relatively to the reflector.

For the sake of example I will describe my present invention as carried into practice with
 10 each pair of carbons provided with a single stick or rod of glass extending throughout the length of the said pair of attached carbons and parallel to them, such glass rod or stick being attached either directly or indirectly to the
 15 said pair of carbons. For instance, the glass rod or stick may be fixed in or be operated on by the same holder or device or means, (such as a weight,) which hold or force down or operate on the pair of carbons. An abutment
 20 or stop or other means are interposed in the path of travel of said glass rod at or near the point where the arc takes place, this stop, &c., consequently serving to normally prevent the descent of the glass rod, and thereby normally
 25 preventing the descent of the attached pair of carbons. The glass rod is slipped into a slotted tube or other suitable guide specially provided for the purpose, so as to prevent its being bent or broken when under the action of
 30 the feeding-weight.

The feed takes place as follows: The lamp having been started, as the carbon points burn away consequently the arc approaches or tends to approach toward the point where the stop,
 35 &c., arrests the descent of the glass rod, and the heat from the arc gradually softens or melts or affects the lower end of the glass rod, and thereby allows a gradual descent of said glass rod, and consequently causes the descent
 40 of the carbon pencils, and the further melting or softening of the glass ceases until the arc again approaches the aforesaid point, where the glass rod is controlled and the operation is repeated, and so on. In practice, however, the
 45 carbon points come to rest at what I may term a "point of equilibrium," the glass rod being continuously but very gradually and steadily softened or melted or affected, and so continuously feeding the carbons and keeping the
 50 lower-carbon points in the desired position—*i. e.*, practically in the same plane throughout the burning of the lamp. In practice I have successfully employed a short metal tube or sleeve or socket, the lower end of which is
 55 provided with a curved piece or extension, against which the end of the glass rod normally rests and is arrested, and as the heat from the arc acts upon said lower end of said glass rod it is softened and descends the curved
 60 plate or stop and is thereby bent, (and eventually this lower end of the glass rod melts away,) and so permits the gradual feed and steady descent of the carbons.

I find that both with alternating and continuous currents, but especially with alternat-

ing current, I obtain an advantage in slightly projecting or directing the arc or flame magnetically, or otherwise to one side of the carbons in the direction of the fusible rod for the
 70 purpose of directing its heat with greater certainty upon it to thereby feed the carbons with greater reliability.

As a modification I may make the glass rod of longer or of shorter length than the carbons; but in such cases special gear must be
 75 provided in order that the glass rod may feed relatively to the carbons more slowly or more rapidly, as the case may be, or said fusible, &c., rod or rods may be bent or of curved or of any other suitable formation, suitable
 80 means being provided within the lamp to feed the said rods or devices in order to feed the carbons in the aforesaid manner—that is, by the continuous melting or disintegration of the said rod or rods. Also instead of a weight
 85 to force down the carbons the action of a spring may be employed for the same purpose.

In carrying this invention into practice in order to make or provide a long-hour or long-burning lamp I may arrange a plurality of pairs
 90 of carbon pencils, each pair provided with a glass rod, &c., as aforesaid, for regulating the location of the arc, or, if desired, a single glass rod can be arranged to feed more than one
 95 pair of carbons, and I so arrange such plurality of pairs of carbons that upon the burning of one pair of carbons being finished the current is then automatically switched or directed through another pair, and so on with each pair in the lamp, as will be readily understood. 100

In constructing my arc-lamp for working on constant-potential circuits when inclined electrodes are used instead of their being arranged parallel to each other it is necessary
 105 to employ automatic means to keep the voltage across the points of the carbons constant or practicably constant, as there is a disturbing element in that an arc of higher or lower temperature (such as one of higher or lower
 110 voltage, and consequently also varying current) will influence the feeding action quite apart from the distance of the arc from the fusing, &c., point. Furthermore, with arc-lamps constructed with inclined electrodes the points of which do not remain at a sufficiently
 115 uniform distance apart there is difficulty in maintaining reliable regulation—for instance, a slightly-increased current, and consequently increased heating effect, would feed the carbons forward—*i. e.*, downward—and
 120 also together reducing the distance between their points, and consequently the resistance of the arc, which in its turn would again increase the current through the arc, and so on.

Sometimes it is more convenient when it is
 125 necessary to employ electrodes arranged inclined to each other to place them with their points crossing. In this way a greater inclination of the carbons can be obtained, accompanied by a smaller possible variation in the 130

length of the arc in the lamp. When, therefore, I construct a lamp according to my invention having electrodes inclined to each other at such a large angle as to render the lamp defective owing to the above undesirable features coming into practical effect, I provide special means, magnetically or otherwise, to keep the distance between the carbon points uniform at whatever relative position they may occupy to the feeding-stop. This is accomplished by moving one or both of the carbons nearer to or farther away from the other or each other, the regulating-gear being operated by either the main current or by a shunt, or both combined, or by other suitable means. For instance, in some cases I can arrange to keep a sufficiently uniform voltage of arc by acting on it magnetically notwithstanding the distance between the points of the carbons varying. When I employ any such arrangement, it is convenient to allow the points of the carbons to touch each other before striking the arc instead of employing a separate bridge-piece, and in this case the same mechanism may be used for striking the arc as for maintaining its uniform length or voltage.

In order that my said invention may be more easily understood and readily carried into practice, I will proceed to further describe same with reference to the drawings hereunto annexed.

Figure 1 is a view, in elevation and partly in section, of a lamp having carbons arranged parallel to each other. Fig. 2 is a view of the lamp looking in the direction of the arrow A, Fig. 1—*i. e.*, at right angles to Fig. 1. Fig. 3 is a sectional plan through line A' A', Fig. 1, looking in the direction of the arrow B. Figs. 4 and 4^a are detailed drawings, showing fusible rod and stop, Fig. 4 being a view in elevation, and Fig. 4^a being a vertical section on line 4 4, Fig. 4. Fig. 5 is a local view in detail, on an enlarged scale, showing the position of the carbon points, luminous arc, and glass rod during the burning of the lamp. Figs. 6, 6^a, and 7 are detailed views of lamps arranged with inclined electrodes, each arrangement being hereinafter described. Figs. 8 and 8^a show a pair of carbons specially disposed to each other, as hereinafter described.

Referring to Figs. 1, 2, and 3, C and C' are the two carbon holders or tubes, connected together at each end and insulated from each other. These tubes C C' are slotted at D D' throughout their length, through and in which slots, pins, or projections *d d'* pass and are guided. These pins *d d'* are fixed to the weight E, which is free to move up and down over the tubes C C', it being guided by said pins in said slots. At the lower end of the tubes C C' there are weighted levers F F', pivoted at *f f'*, (or, if desired, spring-clips,) so arranged as to clip and hold by friction the carbons G G' in the tubes. Running parallel

with the two tubes C C' there is another slotted tube H, having a longitudinal slot H', in which another pin, *h*, is guided and projects through. This pin *h* (which bears on the top end of the glass rod K in said tube H) is connected to the circular weight E, as are the pins *d d'*, which latter bear on the top end of the carbons G G'. At the lower end of this tube H a collar or stop J is provided, which is readily attached or removed from the tube H or lower part thereof—for example, by means of the bayonet-joint J'. (See Fig. 5.) A glass rod K (see Figs. 4 and 5) of about an equal length to the carbons G G' is inserted in this tube H, and the said stop J being in position normally prevents the glass rod from falling out or descending. Thus the weight E is mainly supported by its pins *h* bearing on the top of the glass rod K, while its pins *d d'* bear on the top of the carbons G G', as aforesaid. The stop J is shown in Fig. 4^a in section and has a hole *j* through which the glass rod K passes and is guided. A tongue or bent portion *j'* projects under the hole *j* and acts as a stop on which the glass rod rests. A reflector L is fitted at the lower end of the tubes, and the arc *g* between the points of the carbons G G' takes place in about the position shown, or said arc may take place entirely within the reflector L. The striker M, with carbon or other conductor M', (pivoted at M²), is actuated through the connecting-rod *m* by the magnetic coil or solenoid *m'*.

In order to strike the arc, the lower points of the carbons G G' are bridged by the striker or conducting bridge-piece M', and when the current passes and the striker is automatically withdrawn the arc *g* is formed. The feeding of the carbons commences when they are burned away so as to bring the arc *g* sufficiently close to the tongue *j'* and the end of the glass rod K, whereby the lowermost part of the glass rod softens by the heat, and owing to the pressure from above exerted by the weight E the said glass rod K is slowly pressed past the tongue *j'*, which in its rigid condition was not possible, thus allowing the slow descent of the weight E, and consequently the pins *d d'* at the same time also press downward on the top of the carbons G G' and feed them down together, and so removing the arc *g* farther away from the end of the glass rod K and tongue *j'*, which movement results in the retardation of or stopping of further motion until the glass is further affected by the heat and permits further feeding action, and so on.

Figs. 4 and 4^a show a large-scale view of stop J with glass rod K before the action of the heat upon it. Fig. 5 shows the stop under or after the action of the heat. The end of the glass rod K gradually melts, and from time to time drops of glass fall from it. Fig. 6 shows a modified arrangement somewhat similar to that shown in Figs. 1, 2, and 3, but having

the carbons inclined at a slight angle to each other, Fig. 6^a being a cross-sectioned view on the line 6 6, Fig. 6, looking in the direction of the arrow 6, Fig. 6. In this modified arrangement the pins $d d'$ (which bear on the top of the carbons as aforesaid) are rigidly fixed to the swinging frames or bails d^x , each of which latter is pivoted at d^2 to the weight E, which latter carries the pin h , extending into the glass tube H, as aforesaid, a central aperture E' being provided in said weight of a size and shape (such as shown in Fig. 6^a) to allow said weight to travel vertically throughout the length of the carbon-holder tubes C C', notwithstanding that same are inclined to each other, as shown in these figures. If desired, the tubes C C' may be slotted on both sides opposite to one another and (instead of the separate pins $d d'$, as shown) one single pin or horizontal bar may be employed, which would connect the two bails or swinging frames d^x , or the swinging frames could be done away with and the pin or bar connected directly to the weight E, either of these arrangements acting in a similar manner as before.

Fig. 7 illustrates another modification—namely, the inclined tubes C C' are pivoted or hinged at C² to a fixed part of the lamp-frame, while a magnetic arrangement (such as the solenoid N, attached to the tube C, and the core N', attached to the tube C') operates upon the hinged tubes C C' in such wise (when the current flows) as to swing or move said tubes so as to strike the arc, and, if desired, this magnetic arrangement may also be utilized during the burning of the lamp to vary or adjust automatically the length of the arc as occasion requires. In this view, Fig. 7, I have illustrated another modification—namely, instead of the weighted levers F F', as employed in Fig. 1 and Fig. 6, I may employ a spring F², attached at F³ to the outside of each tube C C', respectively, the lower end of each said spring F² being provided with a pin F^x, which is normally kept pressed inward by the spring F² against the carbons G or G', and thus retain the latter in their normal position, this spring-pressure, however, being such as to be easily overcome by the weight E, so that as the latter is caused or allowed to descend it will push the carbons G G' downward past the spring-actuated pins F^x. This spring-clip arrangement F² F^x, as shown in this view, Fig. 7, may be used (in place of the weighted levers F F') in and with the other constructions of the lamp—as, for example, with parallel carbons, as shown in Fig. 1.

Figs. 8 and 8^a show views at right angles of a pair of carbons with their points crossing. This disposition of the carbons may be employed for my purpose instead of having the carbons inclined toward each other, especially if no arc-regulating appliance is used, for it is possible by this arrangement of the carbons

with their points crossing to place the carbons in this manner at a much larger inclination or angle without such a great variation of arc length.

It is to be observed that in the drawings hereunto annexed, and more especially in Figs. 1 to 3, the carbons are for the sake of clearness represented farther apart than would be the case in actual practice, as in the actual construction and use of lamps of the type illustrated in Figs. 1 to 3 I find it advantageous to locate the carbons G G' at a distance apart of about one-eighth of an inch.

Having now described my invention, what I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In an electric-arc lamp wherein the electrodes are arranged with their burning-points directed downward; the combination with such electrodes of a rigid rod of fusible material, means to afford escape of that part of the fusible material which has been sufficiently acted on by the heat from the arc, means which will prevent downward movement of said fusible rod while the latter is in the rigid state, means to cause descent of the electrodes, a connection between the rigid material and the means to cause descent of the electrodes so that such descent is governed by said rigid material, guides for the electrodes, means to normally prevent the electrodes dropping out of their guides, contact-making devices to normally bear against the electrodes and convey current to the latter near their burning-points, and a guide to support the fusible material throughout its length in order to prevent buckling or breakage thereof, substantially as and for the purposes hereinbefore set forth.

2. In an electric-arc lamp wherein the electrodes are arranged with their burning-points directed downward; the combination with such electrodes of a rigid rod of glass, means to afford escape of that part of the glass rod which has been sufficiently acted on by the heat from the arc, means which will prevent downward movement of said glass rod while the latter is in a rigid state, a weight to cause descent of the electrodes, a connection between the glass rod and the weight so that such descent is governed by said glass rod, guide-tubes for the electrodes, means to normally prevent the electrodes dropping out of their guide-tubes, contact-making devices to normally bear against the electrodes and convey current to the latter near their burning-points, and a guide-tube to support the glass rod throughout its length in order to prevent buckling or breakage thereof, substantially as and for the purposes hereinbefore set forth.

3. In an electric-arc lamp wherein the electrodes are arranged with their burning-points directed downward; the combination with such electrodes of a rigid rod of fusible material, means to afford escape of that part of the fusible material which has been sufficiently acted

on by the heat from the arc, means which will prevent downward movement of said fusible rod while the latter is in the rigid state, means to cause descent of the electrodes, a connection between the rigid material and the means to cause descent of the electrodes so that such descent is governed by said rigid material, guides for the electrodes, means to normally prevent the electrodes dropping out of their guides, and a guide to support the fusible material throughout its length in order to prevent buckling or breakage thereof, substantially as and for the purposes hereinbefore set forth.

4. In an electric-arc lamp wherein the electrodes are arranged with their burning-points directed downward; the combination with such electrodes of a rigid rod of glass, means to afford escape of that part of the glass rod which has been sufficiently acted on by the heat from the arc, means which will prevent downward movement of said glass rod while the latter is in a rigid state, a weight to cause descent of the electrodes, a connection between the glass rod and the weight so that such descent is governed by said glass rod, guide-tubes for the electrodes, means to normally prevent the electrodes dropping out of their guide-tubes, and a guide-tube to support the glass rod throughout its length in order to prevent buckling or breakage thereof, substantially as and for the purposes hereinbefore set forth.

5. In an electric-arc lamp wherein the electrodes are arranged with their burning-points directed downward; the combination with such electrodes of a rigid rod of fusible material, means to afford escape of that part of the fusible material which has been sufficiently acted on by the heat from the arc, a stop such as J comprising a metal tube sleeve or socket having means at the top thereof for attaching same to the lamp and provided at its lower end with a bent tongue or extension such as *j'* which interposes in the path of travel of the fusible rod such as K through the tubular part of said stop, means to cause descent of the electrodes, a connection between the rigid material and the means to cause descent of the electrodes so that such descent is governed by said rigid material, guides for the electrodes, means to normally prevent the electrodes dropping out of their guides, contact-making devices to normally bear against the electrodes and convey current to the latter near their burning-points, and a guide to support the fusible material throughout its length in order to prevent buckling or breakage thereof, substantially as and for the purposes hereinbefore set forth.

6. In an electric-arc lamp wherein the electrodes are arranged with their burning-points directed downward; the combination with such electrodes of a rigid rod of glass, means to afford escape of that part of the glass rod which has been sufficiently acted on by the heat from

the arc, a stop such as J comprising a metal tube sleeve or socket having means at the top thereof for attaching same to the lamp and provided at its lower end with a bent tongue or extension such as *j'* which interposes in the path of travel of the fusible rod such as K through the tubular part of said stop, a weight to cause descent of the electrodes, a connection between the glass rod and the weight so that such descent is governed by said glass rod, guide-tubes for the electrodes, means to normally prevent the electrodes dropping out of their guide-tubes, contact-making devices to normally bear against the electrodes and convey current to the latter near their burning-points, and a guide-tube to support the glass rod throughout its length in order to prevent buckling or breakage thereof, substantially as and for the purposes hereinbefore set forth.

7. In an electric-arc lamp wherein the electrodes are arranged with their burning-points directed downward; the combination with such electrodes of a rigid rod of fusible material, means to afford escape of that part of the fusible material which has been sufficiently acted on by the heat from the arc, a stop such as J comprising a metal tube sleeve or socket having means at the top thereof for attaching same to the lamp and provided at its lower end with a bent tongue or extension such as *j'* which interposes in the path of travel of the fusible rod such as K through the tubular part of said stop, means to cause descent of the electrodes, a connection between the rigid material and the means to cause descent of the electrodes so that such descent is governed by said rigid material, guides for the electrodes, means to normally prevent the electrodes dropping out of their guides, and a guide to support the fusible material throughout its length in order to prevent buckling or breakage thereof, substantially as and for the purposes hereinbefore set forth.

8. In an electric-arc lamp wherein the electrodes are arranged with their burning-points directed downward; the combination with such electrodes of a rigid rod of glass, means to afford escape of that part of the glass rod which has been sufficiently acted on by the heat from the arc, a stop such as J comprising a metal tube sleeve or socket having means at the top thereof for attaching same to the lamp and provided at its lower end with a bent tongue or extension such as *j'* which interposes in the path of travel of the fusible rod such as K through the tubular part of said stop, a weight to cause descent of the electrodes, a connection between the glass rod and the weight so that such descent is governed by said glass rod, guide-tubes for the electrodes, means to normally prevent the electrodes dropping out of their guide-tubes, and a guide-tube to support the glass rod throughout its length in order to prevent buckling or breakage thereof, sub-

stantially as and for the purposes hereinbefore set forth.

9. In an electric-arc lamp wherein the electrodes are arranged with their burning-points directed downward the combination therewith of a stop such as J comprising a metal tube sleeve or socket having means at the top thereof for attaching same to the lamp and provided at its lower end with a bent tongue or extension such as *j'* which interposes in the path of travel of the fusible rod such as K

through the tubular part of said stop, substantially in the manner and for the purposes hereinbefore described with reference to and as illustrated in the drawings hereunto annexed particularly Figs. 4, 4^a and 5.

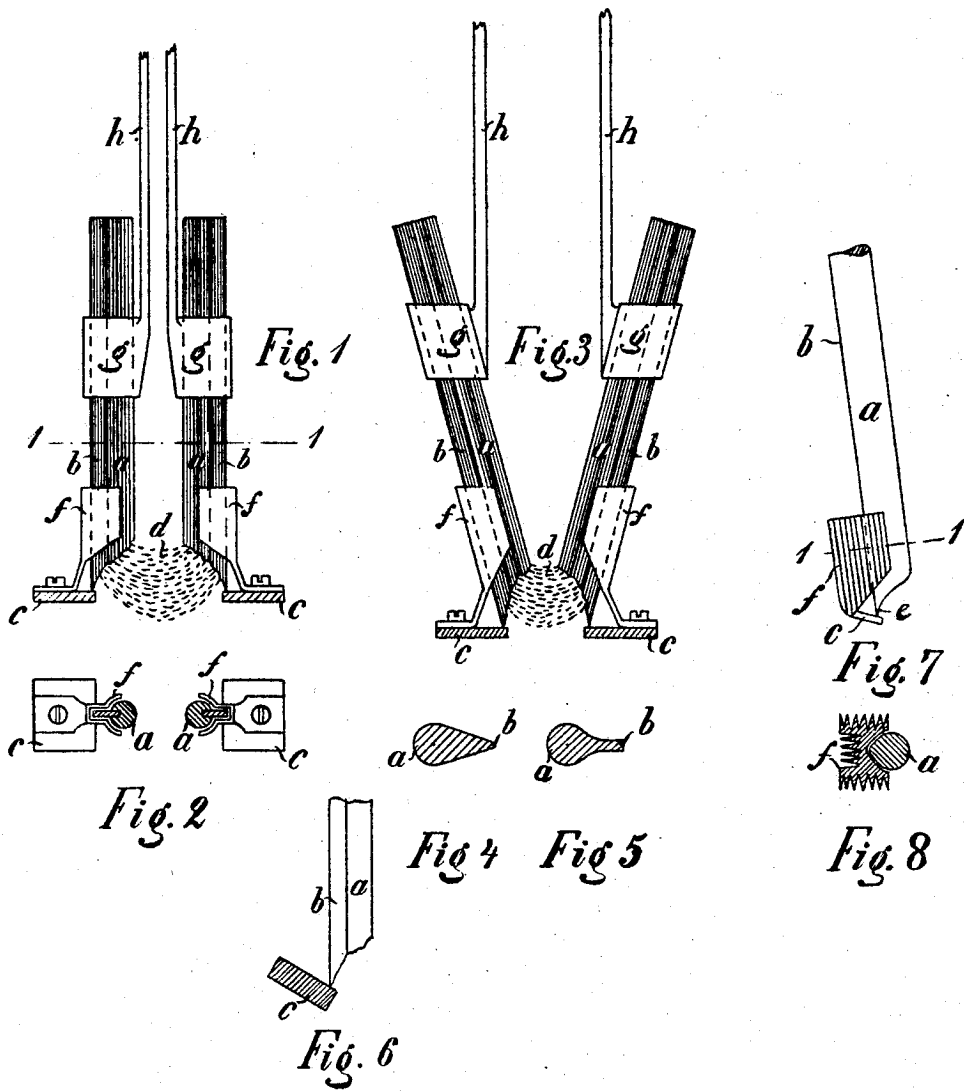
In witness whereof I have hereunto set my hand in presence of two witnesses.

CHARLES OLIVER.

Witnesses:

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ELECTRIC ARC LIGHT.
APPLICATION FILED JAN. 21, 1904.



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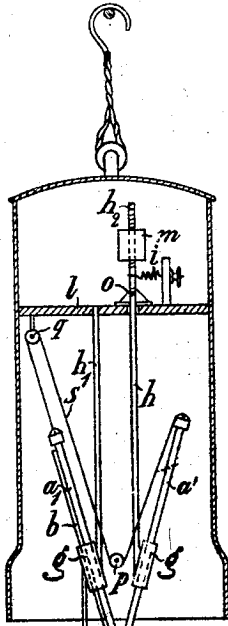


Fig. 9

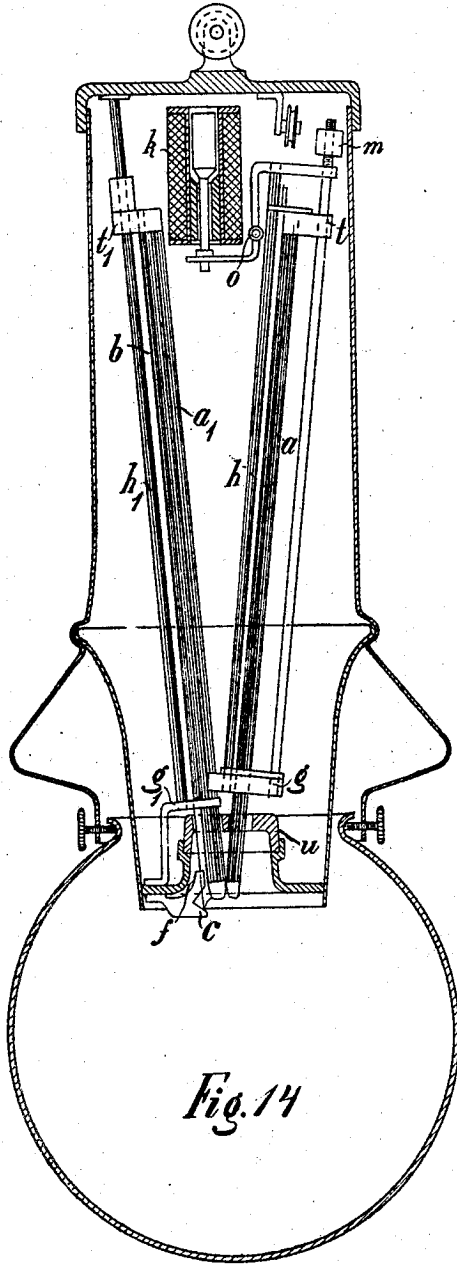


Fig. 14

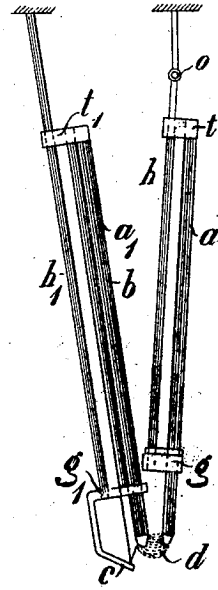


Fig. 10

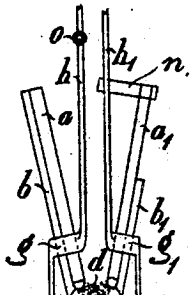


Fig. 12

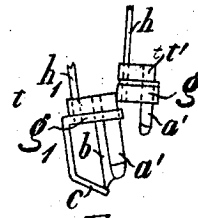


Fig. 11

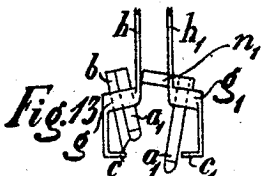


Fig. 13

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UNITED STATES PATENT OFFICE.

HEINRICH BECK, OF MEININGEN, GERMANY, ASSIGNOR OF ONE-HALF TO THE FIRM OF PHYSIKALISCH-TECHNISCHES LABORATORIUM G. M. B. H., OF MEININGEN, GERMANY, AND ONE-HALF TO THE FIRM OF ALLGEMEINE LICHTGESELLSCHAFT MIT BESCHRÄNKTER HAFTUNG, OF BERLIN, GERMANY.

ELECTRIC-ARC LIGHT.

No. 795,681.

Specification of Letters Patent.

Patented July 25, 1905.

Application filed January 21, 1904. Serial No. 195,320.

To all whom it may concern:

Be it known that I, HEINRICH BECK, civil engineer, a subject of the German Emperor, residing at 7 Leipzigerstrasse, in the city of Meiningen, in the German Empire, have invented certain new and useful Improvements in Electric-Arc Lights, of which the following is a specification.

The advantages of my new electric-arc lamp for continuous current, as well as for alternating current, are based upon a new principle for regulating the feed of the electrodes. This principle is characterized by the electrode resting laterally upon a support with its extreme end, this end, which constitutes the supporting-point of the electrodes, being gradually consumed by the heat of the arc-light, so that the electrodes will descend in a perfectly uniform manner. The lateral edge of the electrode, the end of which rests upon a suitable support, consists in my invention of carbon or of some material which is converted into carbon by combustion and which shows a similar behavior. The lateral edge, the extreme end of which constitutes the resting-point of the electrode, may consist of a special narrow ridge of carbon or the like, which is laterally attached to the electrode, or it may be formed by shaping the electrode itself correspondingly. It is essential in my invention that the electrode with lateral supporting-ridge, the extreme end of which rests upon a support, is pointed and hollowed out at the side which faces the arc-light in such a manner that a lateral starting or supporting point, so to speak, is provided for the arc-light, whereby a quiet burning of the electric arc is produced in the new lamp. The lateral supporting-ridge may be provided on both electrodes; but it is sufficient to have the positive electrode only resting with the end of its outer edge upon a support and then securing the uniform feed of both electrodes by suitably coupling the electrodes with each other. In order to protect the electrodes against the lower parts of the supporting edges burning out laterally, this part of the electrodes in a modification of my invention is provided with a device for limiting the supply of air—a sleeve or the like, for instance, preferably made of metal and being of sufficient size and presenting a suffi-

cient cooling-surface for transmitting the heat resulting from the electrode to the air without becoming incandescent itself. Inasmuch as the supporting edges are made of carbon or the like, a perfectly uniform combustion or evaporation of the pointed end of the supporting-ridges is produced by the electric arc; nor is there any disturbance of the arc or coloration of the same by material dripping down from the supporting-ridges. For the purpose of operating and for cutting out electric-arc lamps of this kind igniting and extinguishing devices of most simple construction may be employed.

Hereinafter some modifications of my invention are shown and will be illustrated in the accompanying drawings.

In the drawings, Figure 1 shows an arrangement of the electrodes in form of two vertical and parallelly-arranged carbon rods or pencils provided with lateral combustion-ridges. Fig. 2 is a section through Fig. 1 on the line of section 1 1, a part being shown in plan view. Fig. 3 shows an arrangement of electrodes having two carbon rods arranged at an angle to each other. Figs. 4 and 5 are two different cross-sections through carbon rods of different outer shape. Fig. 6 represents an arc-light electrode, the supporting-ridge of which rests upon an inclined supporting-surface. Figs. 7 and 8 represent in elevation and in sectional view an arc-light electrode with lateral supporting-ridge protruding only slightly outward and with an air-protecting sleeve or casing with cooling-ribs. Fig. 9 represents a convenient form of coupling and of suspension of two arc-light electrodes arranged at an angle to each other, of which the positive electrode is provided with a lateral supporting-ridge. Figs. 10, 11, 12, and 13 are representations of two different automatic extinguishing devices for arc-light electrodes with lateral supporting-ridge in the normal and in the operative position. Fig. 14 is a section through the interior of a modification of an electric-arc-light lamp in accordance with my invention.

In the drawings, Fig. 1 represents two arc-light electrodes vertically and parallelly-arranged with relation to each other, the said electrodes *a* being provided with longitudinal

supporting or combustion ridges *b* of carbon. These supporting-ridges *b* are attached by glue or some other similar adhesive to the electrodes, which are provided with a corresponding groove, as shown in plan and in section on the line 1 1 in Fig. 2 of the drawings. The tapering ends of the supporting-ridges *b* rest each upon a supporting-surface *c* of metal or of refractory material. These supporting-surfaces are preferably arranged adjustably in relation to the electrodes. These supporting-ridges, as appear from Figs. 1, 3, and 6 of the drawings, become pointed in a peculiar manner in the heat of the arc, and if made of sufficient thickness they reach beyond the carbon pencils *a* upon the burning away of the electrodes. The points of the supporting-ridges *b*, which reach beyond the carbon pencils, preferably provided with a core, form at the same time the lateral bordering of the arc-light *d*, in consequence whereof the variations of this arc-light are considerably reduced. The sleeves *f*, which are attached to the supporting-surfaces *c* and which surround part of the supporting-ridges *b* above the supporting-points, restrict the admission of air to these parts of the supporting-ridges, which parts are yet exposed to the immediate influence of the heat of the electric arc, and they thereby prevent the objectionable lateral burning out of the supporting-ridges above their supporting-points. This lateral air protection is of considerable importance for the uniform feed of the electrodes.

The electrodes *a* in the form of execution of the invention (represented in Figs. 1 to 3 of the drawings) are free to slide, with their supporting-ridges *b*, in sleeves or shoes *g*, surrounding the electrodes and secured to parallel electrode-supports *h*. In the burning away of the carbon pencils *a* the projecting tapered ends of the supporting-ridges *b* are also gradually consumed in proportion, so that the electrodes descend uniformly within the shoes *g* without any special device. The increase or reduction of the distance of the lower edges of the air-protecting sleeve from the supporting-surface of the supporting-ridge presents a means for adjusting the feed of the electrodes with more or less exactness inasmuch as the burning away or the wearing off of the fine points of the supporting-ridges takes place in longer or shorter periods, respectively, according to the height of the air-protecting sleeve. If the two electrodes of a lamp are suitably connected or coupled to each other, a supporting-ridge will only be necessary on one electrode and in particular on the positive electrode. As the arc-light of the positive electrode is most subject to variations, the lateral bordering of the arc-light by the pointed end of the combustion-ridge on the positive electrode is sufficient, as a rule.

The above-described lamp may also be employed with four or more carbon pencils.

The arrangement shown in Fig. 3 of the drawings is distinguished from the form illustrated in Fig. 1 only by the inclined position of the electrodes.

Figs. 4 and 5 show arc-light electrodes in cross-section where the longitudinal combustion-ridges are formed by giving a suitable shape to the carbons.

In order to prevent the accumulation of ashes and the like upon the supporting-surface *c* of the supporting-ridge *b*, this supporting-surface *c* is preferably inclined, as shown in Fig. 6 of the drawings.

I have found from experiments that when using an air-protecting casing or sleeve of a material which is a good conductor of heat and which affords a sufficient heat-radiating surface or volume the lateral combustion-ridge of the arc-light electrode needs only to be very narrow and that it can even be discarded entirely when the conditions are very favorable without the continued formation of a lateral supporting-ridge for the electrode and the uniform consumption of the said supporting-ridge being interfered with. By means of an air-protecting casing or sleeve of sufficient mass or body and of sufficient radiating-surface I have succeeded to also control the feed of circular electrodes for arc-lights by means of lateral supporting-ridges.

Figs. 7 and 8 of the drawings represent in side view and in cross-section a form of execution of the feeding device according to this invention, where the carbon pencil *a* is only provided with a very narrow combustion-ridge *b*, which projects but slightly beyond the circular section, the said combustion-ridge resting with its point upon a supporting-surface which is somewhat downwardly inclined. Above the supporting-point the arc-light electrode is surrounded by a metal sleeve *f*, which presents a comparatively large mass and body and sufficient radiating-surface so as to be able to carry off to the air the heat taken up by the electrode without becoming red-hot itself. The support *c* preferably forms a whole with the metal sleeve *f* in order to thus effect a sufficient carrying off of the heat of the supporting-ridge, as clearly shown in the hereunto annexed drawings.

In order to induce the formation of the arc, igniting devices of any suitable and well-known construction may be used. Electrodes which are arranged at an angle to each other are preferably suspended from electrode-containing supports or holders, one or both of which are rotatably or rockingly arranged, Fig. 14, so that the points of the carbon rods will touch each other when the lamp is without current, thus making the contact necessary for the formation of the arc upon the switching on of the lamp. For the purpose of keeping the points of carbon pencils which

are arranged at an angle to each other at the required distance during the operation of the lamp a small pulling-magnet k , operatively connected to the movable electrode-support h , may be employed, Fig. 14.

Instead of movably suspending both electrode-holders one of them may be rigidly secured, as shown in Fig. 9 of the drawings, which represents an arrangement of electrodes with downwardly-inclined carbon pencils a a_1 in vertically-depending electrode holders or supports h h_1 , with shoes g . The electrode-holder h is rockingly suspended from a wall-support, and it is extended upwardly in a vertical direction beyond the point of suspension. To the threaded end of this extension is operatively connected a spring, which may be regulated by means of a screw. This spring serves only for the suitable adjustment of the electrodes with respect to each other.

By means of the displaceable weight m the electrode-holder may be poised in such a manner as to be in the position of neutral equilibrium, any oscillations of the electric lamp in consequence of exterior forces being thus unable to disturb the equilibrium of the movably-suspended electrode-holder h . The equilibrium of the movably-suspended electrode may also be regulated by increasing or diminishing the mass of the weight m .

In Fig. 9 a preferred means of coupling the two electrodes a a_1 to each other is shown, whereby a preferably uniform descent of both electrodes is secured, while a supporting-ridge is only used in connection with one electrode. Only one of the carbon pencils a is provided with a longitudinal supporting-ridge b of carbon, which rests against a support c . To the upper end of the carbon pencil a_1 a tape or chain s or the like is fastened, which passes around two stationary rollers p and q , and the other end of which is fastened to the second electrode a' . As the supporting-ridge b is gradually consumed by the arc-light in accordance with the combustion of the electrode a_1 , the said electrode will also descend into the shoe g . The tape s , to which the second electrode is suspended and which passes around the rollers p and q , is thereby shortened in the part directed toward the electrode a_1 , which movement is immediately followed by a corresponding lengthening of the part of the tape directed toward the electrode a . In consequence thereof the carbon pencil a' descends the same distance as the electrode a_1 has descended in accordance with the burning away of the supporting-ridge b .

The positively-connected feeding device of the carbon rods or pencils, (shown in Fig. 9,) which operates by means of but one combustion-ridge b on the positive electrode a_1 and by means of the roller and rope transmission device s p q , also contributes to the quieting or damping of the oscillations of the rotatably or rockingly suspended electrode-

holder h' inasmuch as there will be a slight displacement of the carbon rod a' within the corresponding shoe g accompanying these oscillations, the friction caused thereby between the carbon and the shoe operating to counteract these oscillations.

Apart from the above-mentioned advantages the longitudinal supporting-ridges of the carbon rods or pencils afford a simple means for the automatic switching out of circuit of the electric-arc lamp in all cases where the carbon pencils are burned away to such a degree that a melting action on the metal parts of the lamp by the burning of the arc-light is to be feared.

In the form of execution of an automatic extinguishing device shown in Figs. 12 and 13, the feeding of the electrodes is regulated by the combustion of the supporting-ridges b and b_1 , the extreme ends of which rest upon supporting-surfaces c and c_1 . The supporting-ridge b_1 of the electrode a_1 is recessed in its upper part, or it may be entirely dispensed with. If the consumption of the carbon pencil a_1 has advanced sufficiently so that the supporting-ridge b_1 is used up by the arc-light up to the commencement of the recess, the carbon pencil a_1 , which has now become deprived of its support, drops down suddenly for a somewhat larger distance, and in consequence of the displacement of the pointed ends of the carbon pencils a and a_1 in relation to each other resulting therefrom the arc of light d is broken off and the lamp is extinguished. (See Fig. 13.) The reformation of the arc of light is prevented in this form of execution by an arm provided at the upper end of the carbon pencil a_1 and consisting of insulating material or which is correspondingly insulated and which keeps the rotatably-arranged carbon-holder h locked in the position in which it is at a distance from the carbon-holder h_1 .

In Figs. 10 and 11 I have shown an automatic extinguishing device for arc-light-lamp electrodes with combustion-ridges. Of the electrodes a and a_1 the electrode a is provided with a laterally-arranged combustion-ridge b , of carbon, which insures a uniform feed of this electrode in accordance with the combustion. By coupling the two electrodes a and a_1 with each other in any suitable manner the second electrode a' is also fed forward correspondingly. The electrode a_1 slides down along the electrode-holder h_1 , and it is partly guided within a ring g_1 , while at the upper end the current-admission device t_1 embraces the holder h_1 . The extreme end of the combustion-ridge b rests upon a supporting-surface c , provided upon the electrode-holder h , the said supporting-surface being connected to the guide-ring g of the electrode-holder. The arc-light electrode a' slides down within the guide-ring g' and along the electrode-holder h' , together with the cur-

rent-admission device t' , the holder being rotatable on the pivot o . The guide-ring g' of the movable electrode-holder h' of the carbon pencil a' is arranged higher than the guide-ring g of the electrode-holder h of the carbon pencil a . Hence the current-admission piece t touches the pole-piece g' of the electrode-holder h after the carbon pencil a is sufficiently consumed and already before the current-admission piece t_1 of the other carbon pencil a_1 touches the guide-ring g_1 of the electrode-holder h_1 . Thus the further dropping down of the carbon pencil a is prevented, before even the dropping down of the other carbon pencil a_1 is stopped. Hence the carbon pencil a_1 descends gradually proportionately with the consumption of the ridge b , while the carbon pencil a , which is kept arrested, burns off and becomes shortened more and more, so that the extreme ends of the two carbon pencils a and a_1 become more and more distant until the gradually-lengthened arc of light d finally breaks off and the lamp is extinguished, Fig. 11.

Fig. 14 represents in sectional view taken through the lamp-casing an electric-arc lamp in accordance with this invention which is provided with a regulating-electromagnet k and with an extinguishing device in accordance with Figs. 10 and 11. The lower ends of the carbon rods are surrounded by a cylindrical reflector and economizer u , of fireproof material.

What I claim, and desire to secure by Letters Patent of the United States, is—

1. In an electric-arc lamp, a pair of carbon electrodes arranged points downward, a lateral support on which one of said electrodes rests with its extreme lower point, and means for retarding the consumption of the part of the electrode turned away from the arc of light.
2. In an electric-arc lamp, a pair of carbon electrodes arranged points downward, one of said electrodes having a longitudinal ridge projecting beyond the lower point of the electrode, a lateral support on which said ridge rests with its extreme lower point, and means for retarding the consumption of the ridge.
3. In an electric-arc lamp, a pair of carbon electrodes arranged points downward, a lateral support on which one of said electrodes rests with its extreme lower point, and means for limiting the access of air to the part of the electrode turned away from the arc of light and retarding the consumption of said part of the electrode.
4. In an electric-arc lamp, a pair of carbon electrodes arranged points downward, one of said electrodes having a longitudinal ridge projecting beyond the point of the electrode, a lateral support on which said ridge rests with its extreme lower point, and means for limiting the access of air to the lower part of the ridge causing it to be consumed more slowly than the electrode.

5. In an electric-arc lamp, a pair of carbon electrodes arranged points downward, a lateral support on which one of said electrodes rests with its extreme lower point and means for conducting the waste heat away from the part of the electrode turned away from the arc of light causing retardation of the consumption of that part of the electrode.

6. In an electric-arc lamp having carbon electrodes with points downward and lateral supports for said electrodes, the combination of carbon-holders permitting the carbon pencils to move in a downward direction only, said carbon pencils resting with their extreme lower ends turned away from the arc of light on said lateral supports, means causing the resting-points of the electrodes to be consumed more slowly than the other parts of the lower ends of said electrodes and means for forming an arc of light between the inner faces of the lower ends of the carbon electrodes.

7. In an electric-arc lamp having carbon electrodes with points downward, the combination of carbon-holders permitting the carbon pencils to move in a downward direction only, a lateral support upon which one of said carbon pencils rests with its extreme lower end turned away from the arc of light, the support being of a relatively large piece of metal so as to cool the resting-point of the electrode and means for forming an arc of light between the inner faces of the lower ends of the carbon electrodes.

8. In an electric-arc lamp having carbon electrodes with points downward, the combination of lateral supports for said electrodes, carbon-holders permitting of the carbon pencils to move in a downward direction only, said carbon pencils having longitudinal ridges of carbon, resting with the extreme lower ends of said carbon ridges on said lateral supports and said carbon ridges being metal-plated to cause them to be consumed more slowly than the other parts of the lower ends of the electrodes, and means for forming an arc of light between the lower ends of the carbon electrodes.

9. In an electric-arc lamp having carbon electrodes with points downward, the combination of carbon-holders permitting the carbon pencils to move in a downward direction only, a lateral support on which one carbon electrode rests with its extreme lower end, opposite to the arc of light, means causing the resting-point of this electrode to be consumed more slowly than the other part of its lower end, means through which one of the carbon-holders is movably suspended, a guide-roller fixed near the lower part of the lamp, another guide-roller at one side of the upper part of the lamp, a flexible connection passing over said guide-rollers and having its ends secured to the upper ends of the carbon electrodes, an electromagnet having an armature in operative connection with the movably-suspended

carbon-holder, means for arresting the downward movement of one of the electrodes within its holder before arresting the downward movement of the other electrode within its holder, and a casing surrounding all of said parts.

10. In an electric-arc lamp, the combination of a lateral support, a carbon electrode arranged point downward and resting with its extreme lower end on said support, a second carbon electrode arranged point downward, holders for said electrodes, one of said holders being movably suspended and the electrodes being displaceably arranged within said holders, an extension on the movable holder

projecting beyond its point of suspension, a balance-weight on said extension, an adjustable spring in operative connection with said extension and adapted to move the electrodes toward each other, an electromagnet having an armature in operative connection with said extension, and a casing surrounding all of said parts.

In witness whereof I have hereunto set my hand in the presence of two witnesses.

HEINRICH BECK.

Witnesses:

OSKAR ARENDT,
HENRY HASPER.

H. N. POTTER.
ELECTRIC FURNACE.
APPLICATION FILED JULY 23, 1903.

2 SHEETS—SHEET 1.

Fig.1

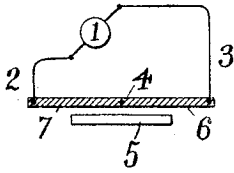


Fig.2

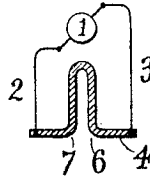


Fig.3

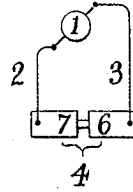


Fig.4

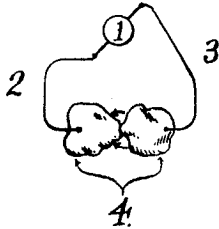


Fig.5

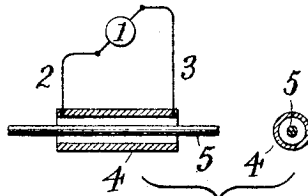


Fig.6

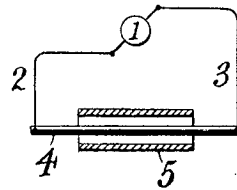


Fig.7

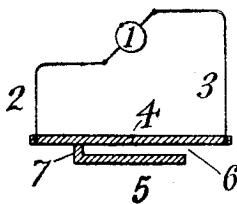


Fig.8

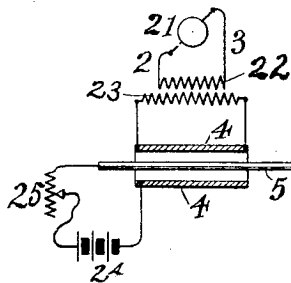


Fig.9

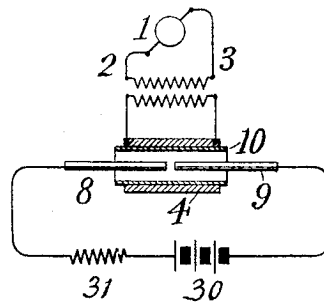
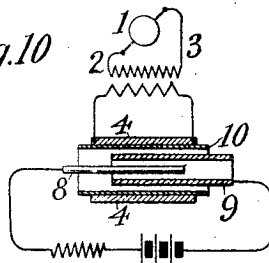


Fig.10



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APPLICATION FILED JULY 23, 1903.

Fig.11

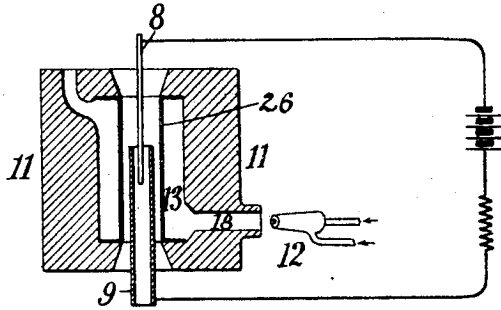


Fig.12

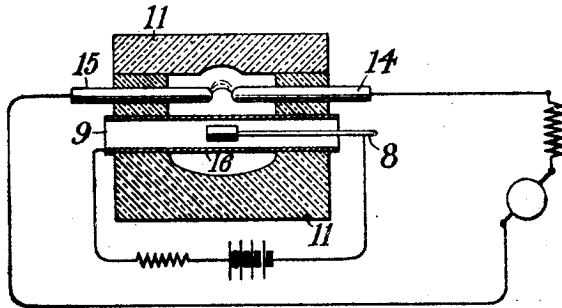


Fig.13

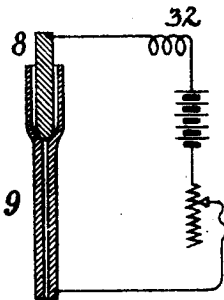


Fig.14

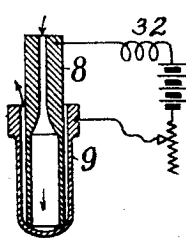


Fig.15

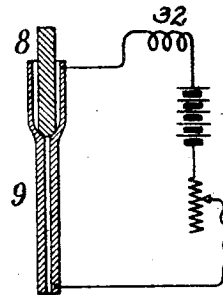
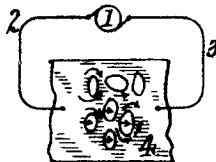


Fig.16



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UNITED STATES PATENT OFFICE.

HENRY NOEL POTTER, OF NEW ROCHELLE, NEW YORK, ASSIGNOR TO
GEORGE WESTINGHOUSE, OF PITTSBURG, PENNSYLVANIA.

ELECTRIC FURNACE.

No. 797,747.

Specification of Letters Patent.

Patented Aug. 22, 1905.

Application filed July 23, 1903. Serial No. 166,669.

To all whom it may concern:

Be it known that I, HENRY NOEL POTTER, a citizen of the United States, and a resident of New Rochelle, county of Westchester, State of New York, have invented certain new and useful Improvements in Electric Furnaces, of which the following is a specification.

I have discovered that when two parts of an otherwise continuous circuit are separated within a region of intense heat, as in the interior of a highly-heated tube-furnace, electric current will traverse the gap between the electrodes thus formed under a greatly reduced potential as compared with what would be required to maintain an arc under atmospheric conditions or even under conditions of moderate heat. This discovery can be utilized for the purpose of reinforcing the heat of the furnace itself, whether such heat is derived from an electric current or from any other source.

It is especially convenient to utilize the described arrangement in connection with an electric tube-furnace, and in the present description such a furnace will be assumed, although, as already indicated, heat may be derived from any preferred source. It is also true that the shape of the furnace may be varied to suit working conditions.

By putting a gap of the character described inside of a furnace and applying by means of the latter sufficient heat to render the gap conductive a condition is obtained where a current may be passed under such moderate differences of potential that it becomes practically possible to add to the heat of the furnace any desired quantity of heat developed in the gap. In this manner it is possible to produce a range of temperatures beginning with that reached by the unaided furnace and ending at temperatures at least as high as those of the electric arc.

In resistance-furnaces hitherto constructed there has been an upper limit to the temperature imposed by the heat conductivity of packings and by the speedy disintegration of the resistance constituting the furnace. The maximum temperature at which it has been practical to operate has been considerably lower than that produced by the arc. On the contrary, in arc-furnaces temperatures lower than that of the arc itself have been only obtainable at a distance from the arc, and such

temperatures are difficult to maintain and control. By my system it becomes possible to pass current across a gap at voltages which are too low to maintain such current-passage unaided. From one point of view it may be stated that the function of ionization of the vapors in the gap is not solely performed by current traversing these vapors, but is assisted by an auxiliary ionizing agency. The conducting-gap thus established appears to have all the electrolyzing qualities of the electric arc, so that I am able to combine in the furnace the effects of great heat and those which are peculiar to the arc or conducting-gap. For the above reasons, without determining the question as to how nearly allied the described phenomenon is to an electric arc, I prefer to designate it as a "conducting-gap."

The furnace itself may be supplied by any adequate source of heat and may be of any convenient or suitable material. For example, it may be built of refractory earths and heated by oxy-gas jets. In general, however, I prefer to heat the furnace itself by electrical means, and when the furnace itself is supplied with heat from a source of electric current I may utilize an alternating current for generating the furnace portion of the heat and may then pass current across the gap in any desired quantity by means of either direct or alternating currents.

One of the simplest forms of furnace is an electric tube-furnace (such as that described in Letters Patent issued to me on the 9th day of December, 1902, numbered 715,508) provided with auxiliary electrodes between which the gap or gaps is or are established. These auxiliary electrodes may be of carbon, and in certain cases the wall of the tube-furnace or a portion thereof may itself constitute an electrode.

Another form is to use a furnace in which the heating-conductor is a dry electrolyte or a mixture of dry electrolytes in the form of a tube within which may be mounted auxiliary electrodes composed of conductors of either the first or second class, one of which may, as in the case of carbon, be the wall of the heating-tube itself. A modification of this latter form is to construct the tubular heating-conductor of iridium or similar material, within which an auxiliary electrode or electrodes consisting of a conductor or con-

ductors of the second class are suitably mounted.

The regulation of temperature in the above furnace may be effected in various ways. For example, the temperature of the main heating-furnace may be varied. The length of the gap may also be varied and the auxiliary work expended at the gap. In certain forms of furnace the gap becomes the space between a central rod and the walls of the tubular furnace. The current-flow across the gap may therefore be considered radial and spread over a considerable extent. This is a particularly satisfactory form for gas reactions, for which this type of furnace is in general especially well adapted.

To render my invention clear to those skilled in the art, I have illustrated certain embodiments in the accompanying drawings, Figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, and 15. It will be understood that these drawings are to a large extent diagrammatic, such obvious and subordinate details as terminal constructions, packing, housings, &c., being omitted, as their form and application can be appreciated by reference to publications, in particular to my former Letters Patent referred to above.

In the first figure of the drawings, 1 represents a suitable source of current connecting through leads 2 and 3 with a heating resistance 4, composed of carbon, iridium, or refractory dry electrolyte, either solid or fused. A conductor 5, also of any refractory material, is arranged in general parallel to and at a short distance from the resistance 4. If now a current be passed through the resistance 4, there will be a potential drop between the points 6 and 7 of the rod 4, which points lie opposite the ends of the conductor 5. The rod 5 will be at the same potential throughout as long as it does not carry current. There will therefore be set up a difference of potential between the resistance 4 and the conductor 5, which will vary from point to point along the conductor 5. If the temperature produced in the resistance 4 and communicated to its environment is sufficiently high, current will leak across from the resistance 4 to the conductor 5 and after flowing a distance in the conductor will leak back again to the resistance, thus traversing the intervening vapor or gas.

By bending the conductor 4 of Fig. 1 into a loop, as shown in Fig. 2, the points of different potential represented by 6 and 7 may be brought close together and the conductor 5 will be superfluous, the leakage taking place directly between the points 6 and 7. This is analogous to the leakage under conditions of high vacuum in certain incandescent lamps.

Instead of bending the conductor 4 the points 6 and 7 of different potentials may be brought closer together by making part of

the conductor 4 of relatively smaller diameter, as shown in Fig. 3. Here the leakage current will flow parallel to and around the contracted portion of the part 4. This idea may be applied to a porous or granular or powdered conductor, for, if we consider two contacting grains, as in Fig. 4, where they are shown greatly magnified, it is clear that the grains 6 and 7 together constitute the electrically-uninterrupted conductor 4 of the former figures. They contact over a small area and approach closely, but do not contact at other places. Thus we have the conditions of heat, proximity, and difference of potential, which has been shown to be sufficient to effect a leakage current across a gap.

There are a great variety of forms of apparatus suited to assist in maintaining the conductivity of a gap by external thermic means, and these are in general modifications of those already shown. In Fig. 5 the design of Fig. 1 is modified by developing the conducting resistance 4 into a tube surrounding the rod conductor 5, while in Fig. 6 the conductor 5 becomes a tube surrounding the resistance 4.

It is clear that if for any reason adjacent portions of the elements 4 and 5 should be held at the same potential this may be accomplished by connecting them by a non-gaseous conductor instead of through a gas or vapor. In Fig. 7 the construction illustrated in Fig. 1 is shown with such modification. In the foregoing the difference of potential maintaining the gap-current has not exceeded that employed in heating the resistance 4. However, such a limitation is not necessary, nor is it necessary that the same kind of current be used for the gap and the heating resistance 4. For example, in Fig. 8 I show a modification of the construction shown in Fig. 5, wherein an alternating current is employed to heat the part 4 and a direct current is maintained across the gap. The alternating-current source is shown at 21, and at 22 and 23, respectively, appear the primary and secondary of a transformer. The source of direct current is indicated at 24 and a regulating resistance at 25.

It is not always desirable to have the heating resistance 4 constitute one electrode of the gap. For instance, it is often desirable to make the part 4 of carbon and line it with a refractory lining to prevent carbon vapors within the tube. In such a case the electrodes may be iridium or electrolytic conductors arranged as shown in Fig. 9. Here 8 and 9 are gap-electrodes with a source of voltage 30 and a regulator 31. A lining for the heating-tube 4 is shown at 10.

It is sometimes an advantage to make the area of the conducting-gap large and the current density therein fairly even. This is accomplished by producing practically a fixed

drop across all portions of an equally long gap, as shown in Fig. 10.

In Fig. 11 is shown an arrangement wherein the heating function of the part 4 is performed by an oxygen-fed flame. This arrangement is particularly in place where iridium is heated, as it has been observed that this expensive material wastes away much quicker when heated electrically than when heated to the same temperature by a flame. At 11 appears the outer furnace-wall, at 12 the burner, and at 26 an iridium tube.

It is advantageous where extremely high temperatures are required to produce the heating by an arc instead of by gas or resistance heating of solid or liquid conductors. Such an arc-heated gap is shown in Fig. 12, which is a Moissan furnace with a tube 16 of carbon, within being the gap-electrode 8, the tube constituting the electrode 9, as in Figs. 10 and 11.

There is still another variation of the idea introducing the element of time, whereby during an interval heat is stored until a sufficient temperature is reached, then the heating-current interrupted and a gap introduced supplied with a small potential difference not sufficient to produce a current to maintain the temperature. As long as the temperature remains high current will pass and will cease unless after a little, more heat is supplied. Such a device is shown in Figs. 13 and 14. Here the gap-electrodes 8 and 9 are shaped like parts of a valve and are shown in contact. Current traverses them and the contact, heating them. If now the potential be—let us say, ten volts, and a current of gas be forced upward through the electrode 9 the electrode 8 may be raised, producing a gap across which current will flow while all remains hot. By arranging the gas-pressure and gas-friction in the tubes properly a stuttering opening and closing of the contact between the electrodes will be effected and the gases passing submitted to the electrolyzing action of the electric gap-current. By the addition of a coil 32, possessing self-induction in series with the electrodes, the current across the gap can be increased by the coil discharge at each break when direct current is employed for operating the furnace. Care must be exercised, however, not to use enough self-induction to produce a constricted arc or spark discharge across the gap, as such a discharge would be local and much of the passing gas would not be subjected to the electrolyzing action.

Up to this point I have described relative arrangements of parts. It remains to show more specifically how such furnaces are controlled. There are several factors conspiring to produce a given condition, and in general a change in any of the factors will effect the resultant condition produced by all together.

It is clear that the auxiliary heat can be

controlled by regulating the current through the resistance 4 in Fig. 5, or through the arc in Fig. 12, or the gas-supply in Fig. 11. It is also clear that the gap-potential can be controlled in Figs. 8, 9, 10, 11, and 12. The area of the gap can be varied in Figs. 10 and 11 by pushing the electrode 8 more or less into electrode 9. The length of the gap can be varied in Fig. 9 by moving either electrode 8 or 9 axially relative to its cooperating member.

In Figs. 13 and 14 the period of vibration of the electrode 8 can be modified by controlling the gas-pressure, as stated, and the activity of the gap-current increased by increasing the self-induction of the circuit, including the electric source 33, the regulator 34, and the electrodes 9 and 8. A further modification can be effected by shunting the gap 8 9, as shown in Fig. 15.

In the case of a furnace such as illustrated in Fig. 11 or Fig. 12 the action is greatly affected by blowing a gas or mixture of gases or vapors through the tube 9. Such a gas cools the gap, and where a reaction is produced the cooling depends not only on the initial and end temperature of the gas, but also on the energy absorbed or set free by the reaction itself.

All methods of control affect the dimensions of the gap, the temperature of the gap, or the electric fall of potential across the gap, and any agency which affects any of these may serve as a control.

What has been said in the foregoing concerning the thermally-induced conductivity of the gap and the passage therethrough of current under moderate differences of potential must not be taken to exclude from my invention the combination of a gap, a source of high temperature affecting the gap, and a current across said gap under a difference of potential as high or higher than that necessary to maintain an arc. The auxiliary heat need not become unimportant even under these conditions, as its effect is to steady and expand the arc and to allow it to be lengthened more than otherwise possible. The tendency to constriction is reduced and in general the volume of the arc materially increased, so that the current tends to flow between the electrodes as if they were immersed in a conducting liquid. The temperature gradients are naturally less steep in such an arc, and it is therefore preferable where reactions are desired which are reversed by excessive temperatures.

Fig. 16 represents a modification of the device shown in Fig. 4, the material in this instance being represented as porous, such a material serving the conditions required in that it has surfaces of different potential at high temperature and near together. Assuming that the porous material is in the form of a tube, gases might enter the inside of the

tube and be subjected to electrification at high temperature in passing through the pores and might then pass out to a collecting device.

The furnace herein described may be used under conditions of pressure above or below atmospheric pressure.

In a divisional application filed July 1, 1905, Serial No. 267,913, claims are made upon certain features of construction disclosed herein.

I claim as my invention—

1. The method of supplying heat to a furnace of the character described, which consists in heating the body of the furnace by any suitable means, and adding to the heat thus produced the heat energy derived from a conducting-gap.

2. The method of supplying heat to an electric furnace, which consists in heating the furnace-walls by utilizing the body of the furnace as an electrical resistance, and adding to the heat thus produced the heat energy derived from a conducting-gap.

3. The method of reducing the terminal voltage of a conducting-gap, which consists in subjecting the said gap to the influence of great heat.

4. The method of reducing the terminal voltage of a conducting-gap, which consists in subjecting the said gap to the influence of great heat, and confining the gap within a suitable chamber.

5. The method of regulating the terminal voltage of a conducting-gap, which consists in subjecting the said gap to the influence of variable degrees of heat.

6. The method of regulating the terminal voltage of a conducting-gap, which consists in subjecting the said gap to the influence of great heat and varying the resistance of the circuit including the gap.

7. The method of producing reactions in a furnace, which consists in applying to the ma-

terials within the furnace, the effects of great heat derived from external sources, and the electrolyzing effects of a conducting-gap.

8. The method of producing reactions in an electric furnace, which consists in subjecting the materials to be acted upon to influence of intense heat from the walls of the furnace, and also subjecting them to the influence of a conducting-gap carrying a current of lower voltage than that of the normal electric arc.

9. The method of supplying heat from two sources to an electric furnace, which consists in utilizing as one source of heat the electrical resistance of a conducting solid body, and as the other source of heat the electrical resistance of a conducting gas or vapor, and regulating the relative values of the heat energy supplied from the said sources.

10. The method of producing heat inside an electric furnace, which consists in developing conductivities locally in two current-paths and heating such paths by the passage of electric current.

11. The method of producing heat inside an electric furnace, which consists in arranging a conducting resistance and a vapor resistance, one within the other, and heating both resistances simultaneously by the passage of electric current.

12. The method of producing heat inside an electric furnace, which consists in introducing into the interior of a solid conducting resistance a vapor resistance, heating the said conducting resistance and thereby rendering the said vapor resistance conductive and afterward utilizing the heat of both resistances.

Signed at New York, in the county of New York and State of New York, this 15th day of July, A. D. 1903.

HENRY NOEL POTTER.

Witnesses:

WM. H. CAPEL,

THOS. H. BROWN, Jr.

No. 879,180.

PATENTED FEB. 18, 1908.

O. KÖNITZER.
ARC LAMP.

APPLICATION FILED JAN. 19, 1906.

Fig. 1.

Fig. 3.

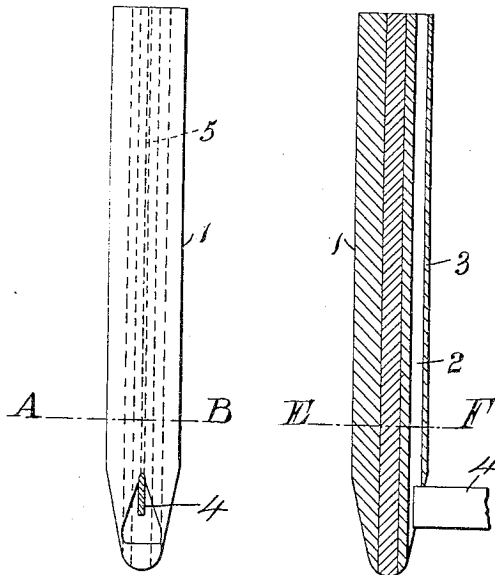
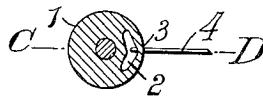
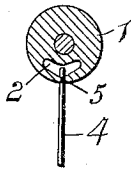


Fig. 2.

Fig. 4.



Witnesses.
Stanley Hood.
Robert P. ...

Inventor.
Oskar Könitzer.
by
...
Attorney.

UNITED STATES PATENT OFFICE.

OSKAR KÖNITZER, OF MUNICH, GERMANY.

ARC-LAMP.

No. 879,180.

Specification of Letters Patent.

Patented Feb. 18, 1908.

Application filed January 19, 1906. Serial No. 296,819.

To all whom it may concern:

Be it known that I, OSKAR KÖNITZER, a subject of the German Emperor, residing at Munich, in the Empire of Germany, have invented a certain new and useful Arc-Lamp, of which the following is a specification.

This invention relates to a device for preventing the excessive heating and ultimate destruction of the supporting piece of such arc lamps, in which the mechanism for adjusting the distance between the carbons, which is actuated by the electric current and which is usually of a very complicated character, is replaced by a device acting in a purely mechanical manner and consisting of a supporting piece provided with an edge which cuts through the layer of the carbon resting upon it, that has been rendered porous by the action of the luminous arc, to a depth that corresponds to the burn and so causes the carbon to drop.

Two different forms of carrying out the invention are illustrated in the accompanying drawing.

Figure 1 is a front view. Fig. 2 is a transverse section on the line A—B Fig. 3 a longitudinal section on the line C—D and Fig. 4 a transverse section on the line E—F.

A longitudinal channel, which is filled with air or other comparatively diathermic material, is so provided in the upper carbon electrode 1 that the wall 3 of the carbon electrode is thinnest at the point of contact of the supporting piece 4. The narrow portion of

the electrode resting on the supporting piece 4 will be sufficiently heated to become covered with the porous layer which is necessary to the feeding of the electrodes without the heat of the crater injuriously affecting the supporting piece 4.

The line of contact between the supporting piece 4 and the carbon electrode 1 which corresponds practically with the line passing through the points where the wall 2 is thinnest, may also be determined by arranging in the electrode 1 a narrow slot 5 into the lower end of which the supporting piece 4 fits.

What I claim as my invention and desire to secure by Letters Patent is:—

1. In an electric arc, the combination of an eccentrically perforated carbon and a feed stop engaged by the thin disintegrating wall at the side of said carbon opposite from the major portion of its mass which is involved in the arc.

2. An arc lamp electrode provided with an eccentric longitudinal passage close to one side thereof, and a supporting piece upon which the thin wall of the electrode formed by said channel rests substantially as described.

In testimony whereof I have hereunto signed my name to this specification in the presence of two subscribing witnesses.

OSKAR KÖNITZER.

Witnesses:

ULYSSES J. BYWATER,
GEORG KÖRNER.

UNITED STATES PATENT OFFICE.

EDGAR F. PRICE AND FRANK J. TONE, OF NIAGARA FALLS, NEW YORK.

ELECTRODE FOR ELECTRIC FURNACES AND PROCESS OF MAKING THE SAME.

No. 887,123.

Specification of Letters Patent.

Patented May 12, 1908.

Application filed January 8, 1906; Serial No. 295,093. Renewed December 26, 1907. Serial No. 408,150.

To all whom it may concern:

Be it known that we, EDGAR F. PRICE and FRANK J. TONE, citizens of the United States, residing at Niagara Falls, in the county of Niagara and State of New York, have invented certain new and useful Improvements in Electrodes for Electric Furnaces and Process of Making the Same, of which the following is a specification.

The electrodes usually employed in electric furnaces consist either of a mixture of amorphous carbon and a binder, or of graphitized carbon produced, for example, by the process of U. S. Patent Number 702,758, to E. G. Acheson.

Amorphous carbon electrodes are hard, brittle, non-homogeneous and of relatively low density and electrical conductivity. Graphitized electrodes are expensive and are of such high heat conductivity as to require water-cooled holders and cause serious heat losses; the conversion into graphite is also apt to be incomplete, in the case of large electrodes.

The present invention relates to the production of an electrode comprising a mixture of electrically-produced graphite and a binder, specifically one containing graphite and amorphous carbon in such proportions as to give the desired electrical and heat conductivity.

In manufacturing the new electrode, graphitized carbon produced by any usual electric furnace method is pulverized or ground and mixed with a suitable hydrocarbon capable of being converted into a permanent binder. The mixture is then molded and baked at a temperature sufficient to decompose the hydrocarbon and drive off the volatile constituents, leaving residual carbon which serves as a binder for the graphite. For certain purposes, it has been found desirable to employ electrodes having a lower heat conductivity than pure graphite electrodes possess, but having a higher electrical conductivity than is characteristic of ordinary amorphous carbon electrodes. In such cases it is advantageous to replace a portion of the graphite by ordinary amorphous carbon. The electrical and heat conductivities of the product are then a function of the ratio between the amounts of contained graphite and amorphous carbon and may therefore be fixed at any predetermined figure. The electrodes made by the herein described process are of uniform composition, through-

out, are dense and strong, and can be easily machined. They can be produced at a much lower cost than electrodes which are electrically graphitized after being molded as the large percentage of breakage incident to the manufacture of the latter is obviated; and moreover the electric heat is more efficiently utilized. The low mechanical strength of electrodes which are electrically graphitized after being molded has been found to be a serious disadvantage in electric furnace practice, especially when employing electrodes of large size or extreme length. The use of electrodes made by the herein described process has been found to offer considerable advantage on account of their superior mechanical strength.

We claim:

1. An electrode for electric furnaces, comprising a mixture of electrically-produced graphite and a binder, as set forth.

2. An electrode for electric furnaces, consisting of a mixture of electrically-produced graphite, amorphous carbon and a binder, as set forth.

3. An electrode for electric furnaces, consisting of a coked mixture of electrically-produced graphite, amorphous carbon and a hydrocarbon binder, as set forth.

4. The process of making electrodes, which consists in shaping a mixture of electrically-produced graphite and a hydrocarbon binder into an electrode, and heating it to a temperature sufficient to coke the binder, as set forth.

5. The process of making electrodes, which consists in shaping a mixture of electrically-produced graphite and a hydrocarbon binder into an electrode, and heating it in a nonoxidizing atmosphere to a temperature sufficient to coke the binder, as set forth.

6. The process of making electrodes, which consists in shaping a mixture of electrically-produced graphite and a hydrocarbon binder into an electrode, and electrically heating it to a temperature sufficient to coke the binder, as set forth.

7. The process of making electrodes, which consists in shaping a mixture of electrically-produced graphite and a hydrocarbon binder into an electrode, and electrically heating it in a nonoxidizing atmosphere to a temperature sufficient to coke the binder, as set forth.

8. The process of making electrodes, which consists in shaping a mixture of electrically-produced graphite, amorphous carbon and a

hydrocarbon binder into an electrode, and heating it to a temperature sufficient to coke the binder, as set forth.

9. The process of making electrodes, which consists in shaping a mixture of electrically-produced graphite, amorphous carbon and a hydrocarbon binder into an electrode, and heating it in a nonoxidizing atmosphere to a temperature sufficient to coke the binder, as set forth.

10. The process of making electrodes, which consists in shaping a mixture of electrically-produced graphite, amorphous carbon and a hydrocarbon binder into an electrode, and electrically heating it to a temperature sufficient to coke the binder, as set forth.

11. The process of making electrodes,

which consists in shaping a mixture of electrically-produced graphite, amorphous carbon and a hydrocarbon binder into an electrode, and electrically heating it in a nonoxidizing atmosphere to a temperature sufficient to coke the binder, as set forth.

In testimony whereof, we affix our signatures in presence of two witnesses.

EDGAR F. PRICE.

FRANK J. TONE.

Witnesses as to the signature of Edgar F. Price:

J. S. JACKSON,
F. B. O'CONNOR.

Witnesses as to the signature of Frank J. Tone:

ASHMEAD G. RODGERS,
FRANK L. BUELL.

F. JANECEK.
 ELECTRODE FOR ABC LAMPS.
 APPLICATION FILED MAY 18, 1907.

903,383.

Patented Nov. 10, 1908.

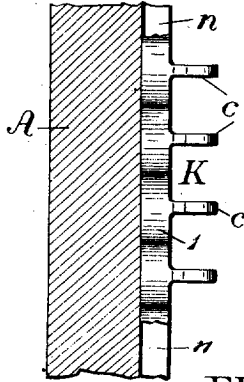


FIG. 1.

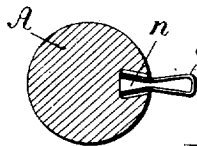


FIG. 2.

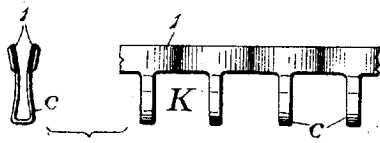


FIG. 3.

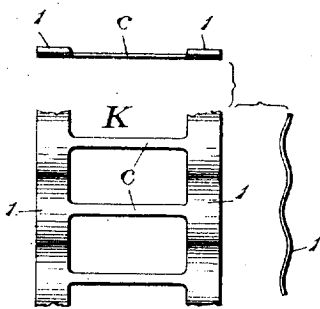


FIG. 4.

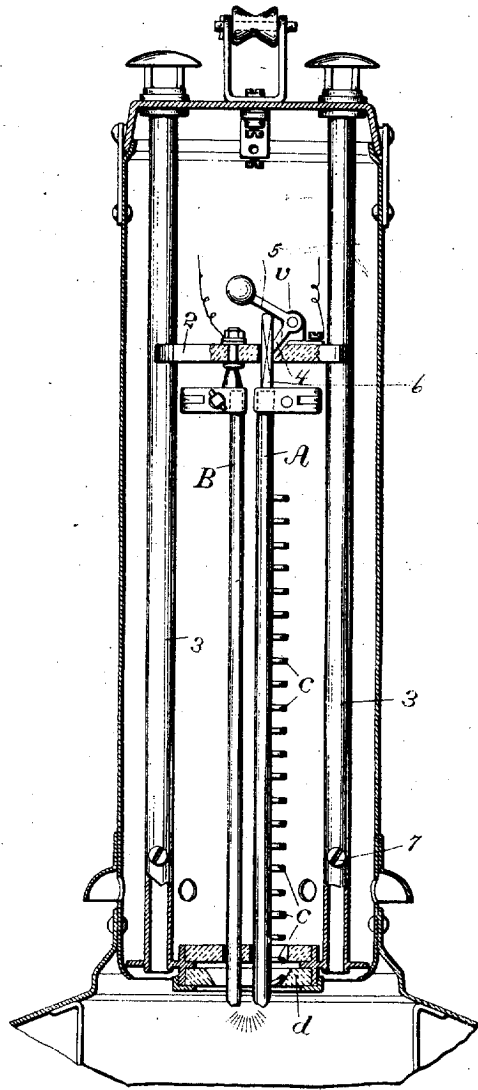


FIG. 5.

Witnesses,
 Miloslav Hrubý
 Adolph Fischer

Inventor,
 Franz Janeček,
 by Paul D. Hilling
 his attorney.

UNITED STATES PATENT OFFICE.

FRANZ JANEČEK, OF KARLÍN, NEAR PRAGUE, AUSTRIA-HUNGARY

ELECTRODE FOR ARC-LAMPS.

No. 903,383.

Specification of Letters Patent.

Patented Nov. 10, 1908.

Application filed May 16, 1907. Serial No. 373,997.

To all whom it may concern:

Be it known that I, FRANZ JANEČEK, a subject of the Emperor of Austria-Hungary, residing at Karlín, near Prague, Bohemia, Austria-Hungary, have invented certain new and useful Improvements in Electrodes for Arc-Lamps, of which the following is a specification.

The present invention relates to improvements in arc lamp electrodes of that type in which the rod is furnished with pins or stops, and my invention consists in providing the electrode with stops projecting from a strip of metal and therefore all in metallic connection.

The invention is illustrated in the accompanying drawing, in which—

Figure 1 is a vertical section through a portion of the new arc lamp electrode. Fig. 2 is a cross section through the same. Fig. 3 shows a cross section and side elevation respectively of a fragment of the metal strip folded ready for insertion into the electrode. Fig. 4 shows a cross section, edge view and plan of a fragment of the metal strip prior to being folded. Fig. 5 is a vertical section through a portion of an arc lamp fitted with the new electrode.

In carrying out my invention I employ a strip of sheet metal K having sinuous or corrugated marginal portions 1 (Fig. 4) and so stamped out centrally as to present cross bars *c*, somewhat resembling the rungs of a ladder. This metal strip K I bend or fold over on its longitudinal center-line, so that when seen in side elevation (Fig. 3) it presents approximately the form of a comb, whose back is constituted by the marginal bands 1, and whose teeth are represented by the doubled over bars *c*. This pectinate metal strip I insert into the electrode A (Fig. 1) which is longitudinally grooved at *n* to receive it. In Figs. 1 and 2 the groove *n* is shown of dovetail shape and the strip K can be readily inserted therein by pinching the two portions 1 together and pushing them into the groove. The resiliency of the strip will cause the parts 1 to press outward, whereby sufficient hold is obtained without the aid of auxiliary means.

The corrugations on the margins 1 make intimate contact with the electrode A at a large number of places, so that the comb K also serves the purpose of a metal core and renders any such device for reducing the resistance altogether redundant.

Fig. 5 illustrates the manner in which the improved electrode is employed in an arc lamp. The coupling of the electrode A (Fig. 5), by means of its guide pin 6, with the sliding member 2, is obtained by means of the bell crank contact lever *v*, one contact arm 4 of which is turned down obliquely against the side of the pin, while its other, weighted, arm 5 rests upon the top of the pin 6. In this manner a reliable contact of pin 6 with the arm 4 is assured since the supported electrode presses with its guide pin 6 against the arm 5. If the electrodes burn down, whereby further movement of the sliding member 2 is stopped by the stop 7, and the last electrode tooth *c* has dropped off the rest *d*, then at the moment when the electrode A is no longer supported and drops, the contact between guide pin 6 and arm 4 will be interrupted without sparking because the arm 5 will form the contact with the guide piece, and the sparking takes place only upon breaking of the contact of the guide pin 6 with the arm 5. The contact arm 4 and the side wall of the guide pin, therefore, are protected against being damaged by sparking and a constant contact is assured.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is—

1. An electrode for arc lamps comprising a rod provided with a longitudinal dovetail groove and a ladder-shaped metal strip doubled upon itself on its longitudinal axis, said doubled strip being located and held in the groove by its own resiliency and the points formed by the doubling projecting beyond the rod, substantially as described.

2. An electrode for arc lamps comprising a rod provided with a longitudinal dovetail groove and a corrugated ladder-shaped metal strip doubled upon itself on its longitudinal axis, said doubled strip being located and held in the groove by its own resiliency and the points formed by the doubling projecting beyond the rod, substantially as described.

In testimony whereof I affix my signature in presence of two witnesses.

FRANZ JANEČEK.

Witnesses:

MILOSLAV HRUBY,
ADOLPH FISCHER.

959,045.

Patented May 24, 1910.

Fig. 1.

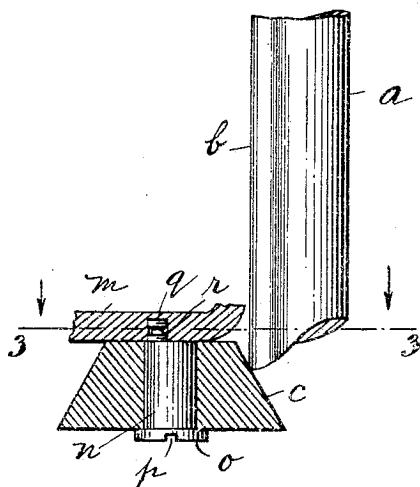


Fig. 2.

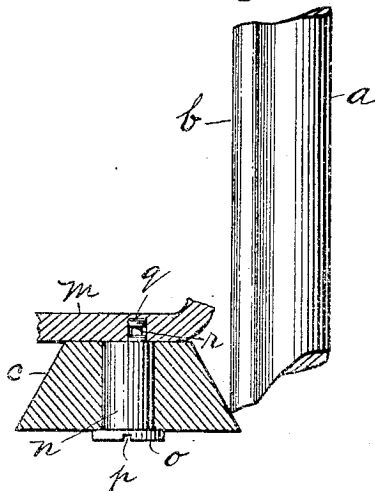


Fig. 3.

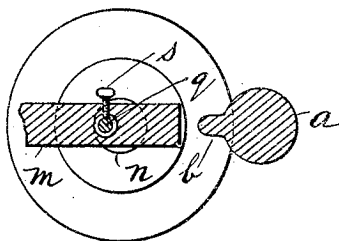


Fig. 4.

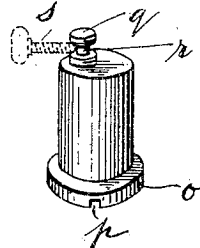


Fig. 5.

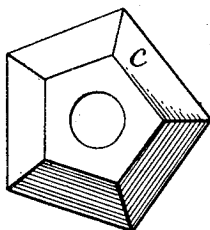


Fig. 6.

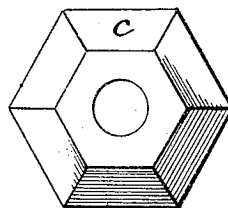
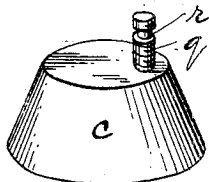


Fig. 7.



Attest:
Herman Meyer
Alan McDonnell.

Heinrich Beck, Inventor:
by William R. Baird
his Atty.

UNITED STATES PATENT OFFICE.

HEINRICH BECK, OF FRANKFORT-ON-THE-MAIN, GERMANY, ASSIGNOR TO BECK
FLAMING LAMP COMPANY, OF CANTON, NEW YORK, A CORPORATION OF NEW YORK.

ELECTRIC-ARC LAMP.

959,045.

Specification of Letters Patent. Patented May 24, 1910.

Application filed November 14, 1906. Serial No. 343,450.

To all whom it may concern:

Be it known that I, HEINRICH BECK, a
subject of the German Emperor, residing at
Frankfort-on-the-Main, Germany, have in-
vented certain new and useful Improve-
ments in Electric-Arc Lamps, of which the
following is a specification.

My invention relates to electric arc lamps
and more particularly to the carbon holders
thereof and its novelty consists in the con-
struction and adaptation of the parts as
will be more fully hereinafter pointed out.

In Letters Patent of the United States
No. 795,681, granted to me July 25, 1905,
I have described a lamp, which among other
instrumentalities, comprises an electrode
provided with a longitudinal rib or ridge
and a lateral support for the said rib so that
the electrode rests on this support while the
lamp is in operation. My present invention
is an improvement upon the form of support
for the electrode disclosed in that patent
and in brief consists in making the electrode
support movable, removable and adjustable
with respect to its electrode, so that in case
of injury to the support either a fresh sur-
face can be presented to the electrode or the
old support may be removed and a new sup-
port can be at once put in its place without
disorganizing the other parts of the lamp,
while at the same time the support may be
adjusted to move the electrode a variable
distance from a fixed point on the frame-
work.

In the drawings, Figure 1 represents in
elevation a portion of the lamp showing the
lower part of an electrode, my improved
support with part of the framework of the
lamp to which the support is secured, all
non-essential parts being omitted; Fig. 2 is
a similar view showing the electrode sup-
port rotated to move the electrode farther
away from the framework; Fig. 3 is a plan
view of the parts below the plane of the
line 3—3 in Fig. 1; Fig. 4 is a perspective of
the electrode support bolt and its set screw;
Fig. 5 is a plan view of a modification of the
electrode support when it is made in the
form of a frustum of a pyramid with five
sides; Fig. 6 is a view similar to Fig. 5
showing a frustum of a pyramid of six sides
and Fig. 7 is a perspective of a conical sup-
port having its screw teat made integral
therewith.

In the drawings, *a* represents an electrode
suitably supported against lateral displace-
ment in a holder (not shown) in the man-
ner described in Letters Patent above refer-
red to. It is provided with a longitudi-
nal rib or ridge *b* and rests by gravity upon
the support *c* which is secured to and pro-
jects from any suitable carrying element
therefor, as the framework *m* of the lamp
for example. The support *c* is preferably
made of metal or a suitable fireproof mate-
rial or of carbon. It is preferably made of
symmetrical form with respect to its vertical
axis, for instance, in the form of the frustum
of a cone, as shown in Figs. 1 and 2, or in
the form of a frustum of a pyramid, as
shown in Figs. 5 and 6, so that it presents
externally a downwardly sloping surface
upon which the rib *b* of the electrode is
adapted to rest. The support is centrally
apertured to permit of the passage of a bolt
n having a head *o* slitted at *p* and which
terminates in a threaded teat *q* adapted to
engage in a threaded aperture formed for
that purpose in the framework *m*. The teat *q*
is eccentrically placed with respect to the
center of the bolt *n* and it is provided with
an annular groove *r*, adapted to receive the
point of a set screw *s* also passing through a
threaded aperture in the framework *m* by
means of which the teat and consequently
the bolt may be held in place after adjust-
ment.

It will be apparent that the means herein
described provide two distinct adjustments
for the support, namely:—a rotative one
around the bolt *n*, by which a different por-
tion of the surface thereof is brought into
supporting relation with the arcing end of
the electrode, without affecting the extent of
projection of the support with respect to
the frame-work, or, in other words, without
affecting lateral adjustment of one electrode
relatively to the other; and, an adjustment
by means of the eccentrically placed teat,
whereby the position of the supporting sur-
face relatively to the frame, is changed. By
means of these two adjustments of this frus-
tum shaped support, and the possibility of
combining the same, a multiplicity of
changes is possible.

Provided the support *c* is made of the
proper material, it is, of course, possible to
make the teat *q* integral with the support

itself and omit the bolt, such a construction being shown in Fig. 7.

What I claim as new is:—

1. In an apparatus of the kind described,
5 a conoidal electrode support, the external surface of which engages the electrode and a pivot having connection with the support and arranged eccentric to the axis thereof.
2. In an apparatus of the kind described,
10 downwardly-extending electrode, a carrier, and an electrode support having a conoidal portion engaged with the lower end of the electrode and a pivot arranged eccentric to the axis of said conoidal portion and connecting the support to the carrier.
3. In an apparatus of the kind described,
15 a support for an electrode, having a frustum shaped portion adapted externally to engage the electrode and provided with an eccentrically placed teat for connecting it with a suitable carrier and whereby it is adapted to be adjusted relatively to the electrode supported by it, for the purpose set forth.
4. In an apparatus of the kind described,
20 the combination of a carrier, and an electrode support connected therewith and having a plurality of independent adjustments, one of which is eccentric, said electrode support provided with a downwardly sloping
30 external wall to engage the electrode.
5. In an apparatus of the kind described,
the combination of a carrier and a conoidal electrode support the outer tapered surface of which is adapted to engage the electrode,
35 and means for connecting the support with the carrier, adapted to provide a plurality of independent adjustments, one of which is eccentric to the axis of the support and another of which is around the center of the
40 same.
6. In an apparatus of the kind described,
a carrier, an electrode support having a downwardly sloping external wall, and an
45 support and carrying the same, said element and support being rotatably movable relatively to each other, and means for connect-

ing said element to the carrier, eccentrically placed with relation to the former.

7. In an apparatus of the kind described, 50
a carrier, an electrode support having a downwardly sloping external wall, and a bolt extending through the center of the support, said bolt and support being movable rotatively with relation to each other, 55
and a teat eccentrically placed with respect to the bolt and projecting therefrom and connecting the same with the carrier.

8. In an apparatus of the kind described, 60
a carrier, an electrode support of frustum shape having an eccentrically placed projection engaging the carrier, and means engaging said projection, for removably securing 65
connecting the same with the carrier.

9. In an apparatus of the kind described, 65
a carrier, an electrode support of frustum shape, means by which the support is rotatably mounted, arranged in the center thereof, an eccentrically placed projection 70
from the support, engaging the carrier, and securing means engaging said projection.

10. In an apparatus of the kind described,
an apertured carrier, an electrode support of frustum shape, a removable supporting bolt 75
upon which the same is rotatably mounted, said bolt extending through the center of the support and provided with means for attaching it to the carrier, comprising a teat 80
which extends into the aperture of the latter and is arranged off the center of the support.

11. In an apparatus of the kind described,
a relatively-movable conoidal electrode-support and a supporting means therefor, having 85
a portion which is eccentric to the axis of the electrode, whereby the lateral position of the electrode is varied in the relative movement of the parts.

In testimony whereof I affix my signature in presence of two witnesses.

HEINRICH BECK.

Witnesses:

JEAN GRUND,
CARL GRUND.

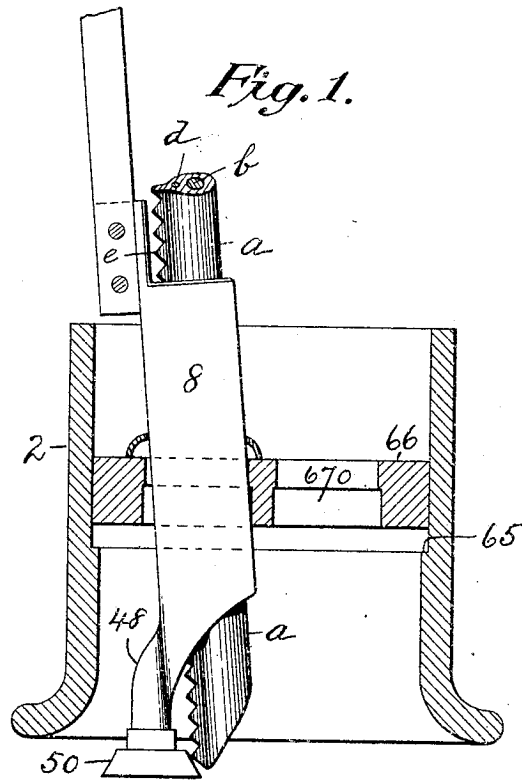


Fig. 2.

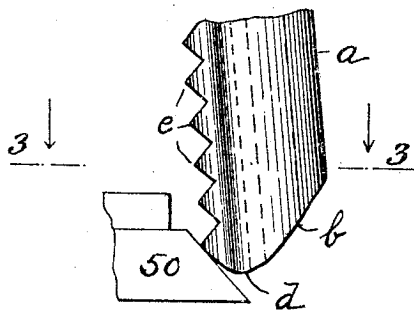
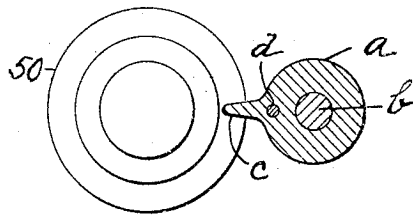


Fig. 3.



Attest:

Sarah S. Clarke
Stephen S. Newton

Josef H. Hallberg, Inventor:
by William R. Baird
his Atty.

UNITED STATES PATENT OFFICE.

JOSEF H. HALLBERG, OF NEW YORK, N. Y., ASSIGNOR TO THE BECK FLAMING LAMP COMPANY, OF CANTON, NEW YORK, A CORPORATION OF NEW YORK.

ARC-LAMP ELECTRODE.

959,133.

Specification of Letters Patent.

Patented May 24, 1910.

Application filed April 26, 1907. Serial No. 370,348.

To all whom it may concern:

Be it known that I, JOSEF H. HALLBERG, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Arc-Lamp Electrodes, of which the following is a specification.

My invention relates to electric arc lamps and particularly to certain improvements in the electrodes thereof of that type embodying a rib to engage a support.

In lamps of this character, in which the electrodes to be burned are composed of columns of material of different degrees of fusibility, there results at times an unsteadiness of the light due to the movement of the arc with respect to the longitudinal center of the electrode because of the fact that the arc will leave the core of the electrode, or the place where the more fusible salts are located, and moving elsewhere will vary the resistance and make the light unsteady. The tendency of the arc is to move to the point of lowest resistance and the purpose of my invention is so to locate this point with respect to the fusible core that a practically uniform consumption of the electrode will result. I accomplish this by furnishing the electrode with a metallic conductor embedded either in the rib or in the body of the electrode between the core and the rib. The arc naturally seeks the point of least resistance which is, of course, the lower terminal of the metallic conductor. This brings the arc to a point where the flame is always in contact with the body of the electrode near the core and causes a substantially uniform consumption of the entire electrode, because the indirect heat of the arc assists in the consumption of the electrode around the metallic conductor. I also provide the rib of the electrode with serrations along its rear edge. As each one of the teeth is consumed the electrode at once drops so that the next tooth above is brought to rest upon the support.

In the drawings, Figure 1 is a central vertical section and partial elevation of the lower part of an arc lamp embodying one of the electrodes of my invention, the other electrode not being shown; Fig. 2 is an enlarged detail of the lower end of the electrode and its support; Fig. 3 is a section

on the plane of the line 3—3 in Fig. 2; and Fig. 4 is a transverse section through the form of electrode in which the conductor is embedded in the rib.

In the drawings 2 is a base preferably cylindrical in form and suitably supported. 66 is a transverse apertured plate of non-conducting material adapted to rest in its lowermost position upon a shoulder around the inner wall of the base 2.

Hangers 6 are suitably supported from the upper part of the lamp and terminate at the bottom in sleeves 8 adapted to support and encircle the electrodes which move through them. The sleeves 8 pass through suitable apertures 670 in the plate 66 and are each provided with brackets 48 to the lower extremities of which are secured conical permanent supports 50 upon which the ribs of the electrodes rest.

Each electrode comprises a body *a* made of carbon in the usual manner and preferably cylindrical or polyhedral in form. At or near the central of the body is a core *b* made of suitable fusible salts of the alkaline metals in a manner well known to the art. At the rear of the body *a* and preferably made integral with it, and made of the same material as the body *a* is a longitudinal rib *c* and longitudinally arranged either within the rib or in the body *a* between the rib and the core *b* is a metallic conductor *d* in the form of a wire.

The rear edge of the rib *c* is preferably provided with teeth *e* arranged in series and presenting the appearance of a saw edge. The angle of the lower edges of the teeth should be substantially the same as the angle of the edge of the permanent support 50 with the horizon, so as to afford as much supporting surface to the rib as possible.

The mode of operation of my improved electrode is readily understood. When the lamp is energized and the arc is formed it seeks the wire *d* and draws the flame across the body of the carbon *a* and past the lower extremity of the core *b*. It also assists in the combustion of the rib *c*, by its indirect heat. As one of the teeth *e* burns away and finally crumbles the electrode drops until the next tooth above rests upon the support 50.

The electrode herein described and claimed is well adapted for use in a lamp of the construction exemplified by the application for

United States patent which was filed by me March 9, 1907, and is numbered, serially, 361,465.

What I claim as new is:—

- 5 1. An electrode for arc lamps, comprising a body of carbon having a core, a radially projecting external rib, and a longitudinal conductor arranged in the electrode in a plane which is approximately between the
- 10 core and the outer surface of the rib.
2. A cored electrode for arc lamps, having an external longitudinally extending rib and provided with a longitudinal metallic conductor which is arranged in the elec-
- 15 trode in substantially the same radial plane as the rib.
3. A carbon electrode for arc lamps, comprising a body of carbon, a core, a radially

projecting external rib and a longitudinal metallic conductor embedded in the rib. 20

4. A carbon electrode for arc lamps, having a radially projecting external rib, and a longitudinal metallic conductor embedded in the rib.

5. A cored electrode for electric arc lamps, 25 having its body portion provided with an external serrated rib, said electrode also provided with a longitudinal metallic conductor which is arranged between the core and the serrated edge of the rib. 30

In testimony whereof I affix my signature in presence of two witnesses.

JOSEF H. HALLBERG.

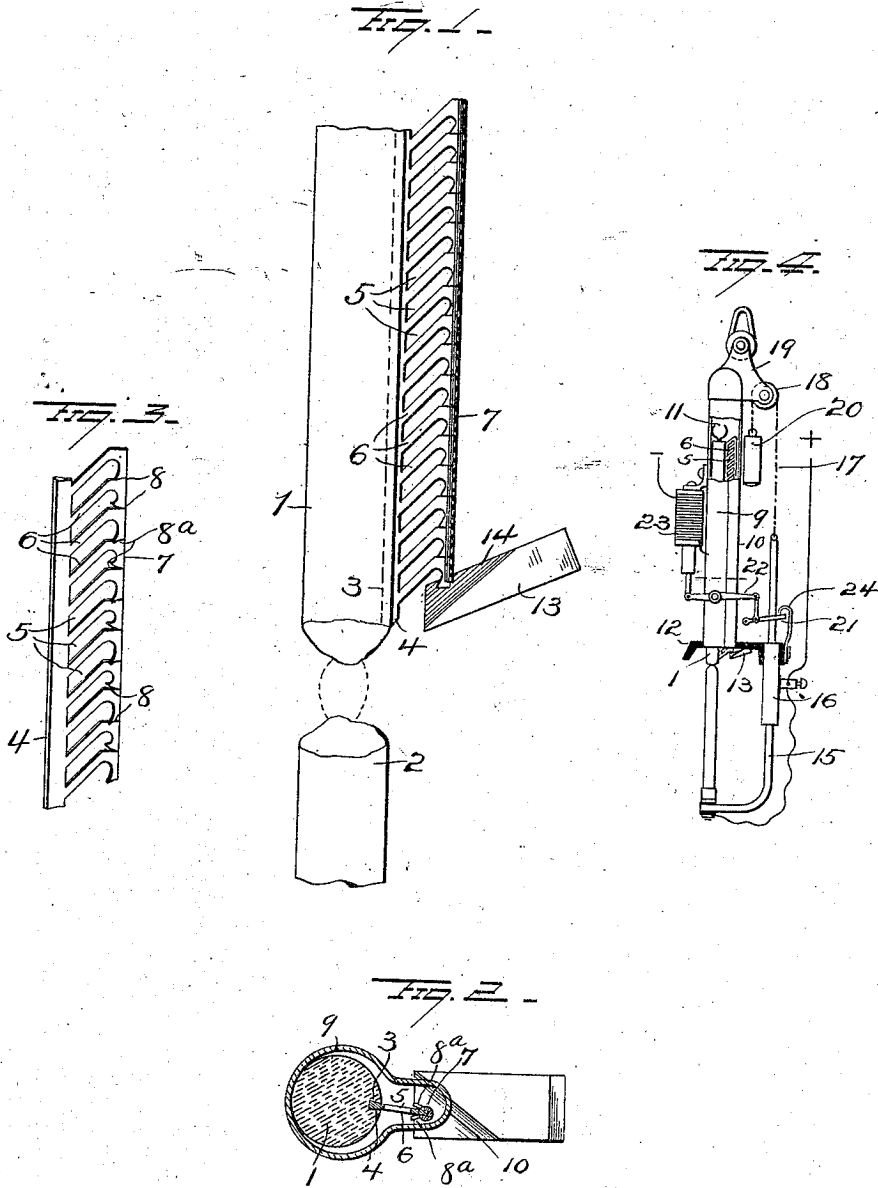
Witnesses:

STEPHEN S. NEWTON,
WM. R. BAIRD.

T. E. ADAMS.
ELECTRIC ARC LAMP.
APPLICATION FILED JULY 14, 1909.

963,736.

Patented July 12, 1910.



WITNESSES
E. Nottingham
G. J. Downing.

INVENTOR
T. E. Adams
By A. G. Seymour
Attorney

UNITED STATES PATENT OFFICE.

THOMAS EDGAR ADAMS, OF CLEVELAND, OHIO, ASSIGNOR TO THE ADAMS-BAGNALI
ELECTRIC COMPANY, OF CLEVELAND, OHIO.

ELECTRIC-ARC LAMP.

963,736.

Specification of Letters Patent.

Patented July 12, 1910.

Application filed July 14, 1909. Serial No. 507,648.

To all whom it may concern:

Be it known that I, THOMAS EDGAR ADAMS, of Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Electric-Arc Lamps; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to improvements in electric arc lamps and more particularly to that type in which one of the electrodes is provided with lateral projections removable successively by heat from the arc to accomplish the feeding of said electrode.

It has heretofore been proposed to provide an electrode with laterally projecting metal pins removable by heat from the arc but with prior constructions, the electrodes had to be handled with great care to avoid distortion of the lateral projections, such distortion being apt to render the lamp employing the electrode inoperative. To make the ribs or projections as heretofore constructed, sufficiently strong to withstand the usual treatment, would require more metal than would be conducive to a perfect arc when the electrode is in use in a lamp, and the large amount of molten metal would be likely to spot the globe or lodge, as cinder, between the electrode and prevent relighting.

The object of my present invention is to avoid the difficulties incident to prior constructions and to provide an electrode with laterally projecting devices adapted to be removed by heat from the arc and to so construct such devices that they shall be mechanically strong with the use of a minimum amount of metal.

A further object is to so construct an arc lamp of the type referred to that the lateral projections and the stop with which they cooperate shall be so located relatively to each other and to the arc that said stop will not be unduly affected by heat from the arc and thus permit the accurate feeding of the electrodes as the lateral projections become successively detached from the electrode.

With these objects in view the invention consists in certain novel features of construction and combinations of parts as hereinafter set forth and pointed out in the claims.

In the accompanying drawings, Figure 1 is an enlarged view showing portions of two electrodes and the relation of my improvements to the upper electrode. Fig. 2 is a transverse sectional view. Fig. 3 is a face view of the blade which forms the lateral projections for the electrode, and Fig. 4 is a view of an arc lamp showing the application of my improvements thereto.

1, 2, represent the upper and lower electrodes respectively, and in the present instance, the upper electrode is provided with a longitudinal groove 3 for the reception of a member 4 at one edge of a blade such as shown in Fig. 3. This blade is made of suitable sheet metal and provided with a series of diagonal slots 5,—the portions of the metal separating said slots constituting projections 6 which are disposed diagonally or upwardly inclined with relation to the axis of the blade and the electrode. At their inner ends, the projections 6 are integral with the member 4 which is disposed in the groove of the electrode.

The metal of the blade which forms the outer ends of the slots 5 constitutes a member 7 but this member is slit or cut between each two projections 6 as shown at 8, the slots extending from the outer edge of the member 7 horizontally and intersecting the slots somewhat below the upper ends thereof and the metal above each slit is bent laterally to form a tooth 8^a whereby a substantial bearing for the blade upon a stop block, is formed as hereinafter explained. The cut portions of the member 7 are connected by solder so as to render the blade easy to handle without danger of distorting the same, but in the operation of the lamp these solder connections will be melted before the adjacent lower projection shall have been melted to cause the severance of the latter from the electrode.

The upper electrode 1 having the lateral projections above described secured thereto, may be inserted into a tube 9 which forms a portion of the framework of a lamp,—said tube having a lateral longitudinal enlargement 10 for the accommodation of the lateral projections on the electrode. The upper end of the electrode 1 is provided with a contact device 11 to engage the tube 9 and the lower end of the electrode is adapted to pass through a suitable opening in the floor plate 12 of insulating material,

secured to the lower portion of the lamp frame or tube 9. The floor plate supports a stop-block 13 having a beveled face 14 upon which the lower end of the member 7 having a lateral tooth 8^a below the lowermost projection 6 rests. By providing the stop block 13 with the beveled face 14, the member 7 at the outer ends of the projections 6 is caused to bear against the wall of the enlarged portion 10 of tube 8 so as to cause the latter to absorb a portion of the heat from the outer ends of the projections 6 and thus facilitate the steady feeding of the electrodes as the projections 6 melt away. By making the projections 6 extend upwardly and outwardly obliquely to the axis of the electrode, the stop block can be located an appreciable distance from the arc, thus enabling the durability of said stop block.

The lower electrode 2 is supported by a suitable holder at the lower end of a rod 15 which is vertically movable through a tube or sleeve 16 supported by the base of the lamp frame. To the upper end of this rod, the lower end of a chain 17 is attached and this chain, after passing over a pulley 18 supported by the top bracket 19 of the lamp, is provided with a weight 20. A clutch 21 engages the rod 15 and is connected with one end of a lever 22 pivotally supported between its ends by the lamp frame. The other arm of this lever is connected with the core of a solenoid 23,—the latter being included in series with the electrodes. A stop 24 is provided for the clutch 21.

Assuming that the electrodes are in contact when the lamp is not in circuit,—it will be seen that when the lamp circuit is closed the solenoid 23 will be energized and, raising its core, will cause the descent of the clutch 21 and with the latter the descent of the rod 15 and the lower electrode 2, thus establishing the arc. As the upper electrode becomes consumed and the arc lengthens, the projections 6 will be melted by heat

from the arc and thus permit the upper electrode to feed down by gravity step by step. It will be apparent that the regulation of the arc between the periods at which the projections 6 become removed, can be effected by the movements of the lower electrode under the control of the solenoid 23.

Having fully described my invention what I claim as new and desire to secure by Letters-Patent, is,—

1. The combination with an electrode, of a blade secured thereto and comprising members parallel with the axis of the electrode, and projections spaced apart and connecting said members.
2. The combination with an electrode, of a blade secured thereto, said blade comprising parallel members, one of which is secured to the electrode, and projections connecting said members and spaced apart, the outer member being cut between the projections and united with solder.
3. The combination with an electrode, of a blade secured thereto, said blade comprising a strip of metal having diagonal slots forming parallel members parallel with the axis of the electrode and oblique projections, and a stop to cooperate with said blade.
4. The combination with an electrode, of a blade secured thereto, said blade comprising two members and diagonal projections connecting the same and spaced apart, the outer member having slits intersecting the slots between the projections below the upper ends of said slots and bent to form lateral teeth, the slit portions of the outer member connected by solder.

In testimony whereof, I have signed this specification in the presence of two subscribing witnesses.

THOMAS EDGAR ADAMS.

Witnesses:

J. H. WORBS,
J. R. ORPUTT.

H. J. J. JABURG, JR.
ELECTRODE AND PROCESS FOR MAKING THE SAME.
APPLICATION FILED AUG. 30, 1909.

968,949.

Patented Aug. 30, 1910.

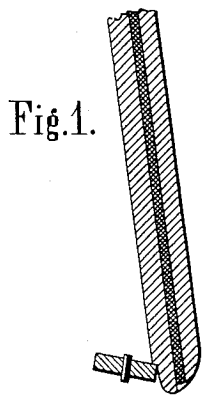


Fig. 1.

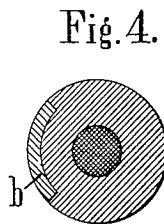


Fig. 4.

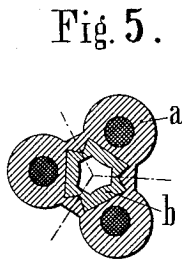


Fig. 5.

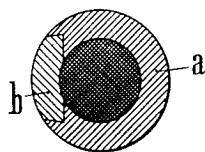


Fig. 2.

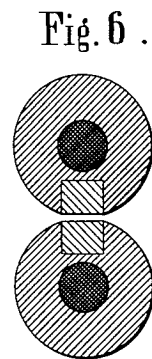


Fig. 6 .

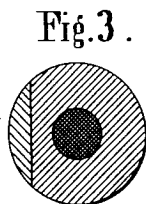


Fig. 3.

Witness:
J. H. Vinton
Byron B. Collings

Inventor:
Hendrick J. J. Jaburg, Jr.
Cy. Williams, Fisher & Williams
his Attorneys

UNITED STATES PATENT OFFICE.

HENDRICUS JOHANNES JACOBUS JABURG, JR., OF AMSTERDAM, NETHERLANDS.

ELECTRODE AND PROCESS FOR MAKING THE SAME.

968,949.

Specification of Letters Patent. Patented Aug. 30, 1910.

Application filed August 30, 1909. Serial No. 515,334.

To all whom it may concern:

Be it known that I, HENDRICUS JOHANNES JACOBUS JABURG, Jr., electrical engineer, a citizen of the Kingdom of the Netherlands, and resident of 20 Helmerstraat, in the city of Amsterdam, Netherlands, have invented new and useful Improvements in Electrodes and Processes of Making the Same, of which the following is a specification.

10 My invention relates to electrodes for arc lamps and more particularly to an electrode or carbon circular in cross section and which is appropriately supported for the purpose of automatic adjustment while burning.

15 The edge of the support is of sufficient width and strength to hold the electrode in the proper position and the support may be rotatable if desired. Various devices have been made with a view to obviate the burning away of the support or the irregular burning away of the supporting edge, by the employment of appropriate materials. Thus, for instance, a rib or strip of readily melting metal has been placed or fitted in a longitudinal notch or groove of the electrode in any desired manner. Or a rib of carbon has been formed on the electrode and consisting of the same material as the latter. However, none of these devices has given the desired result.

20 It has been found that in order to form a supporting edge on the electrode the material most suitably adapted and which neither leaves a dripping slag or residue on the support nor causes the latter to be scorched is pure carbon of a smaller density than that of the remaining portion of the electrode. The supporting edge therefore as well as the electrode itself are accordingly made of carbon, but the body of the supporting edge is less dense than the electrode itself, consequently a smaller quantity of heat is necessary for its combustion. The heat supply is not impeded nor is the lateral distance of the supporting edge increased as in the case of flanged or ribbed carbons, because the amount of heat used is proportional to the material consumed by combustion. By appropriately selecting a supporting edge of the proper density, the burning away of this edge can be so controlled as to maintain a certain distance between the support or carrier and the point of the electrode. The support therefore is relatively remote from the crater and the point of highest temperature, while a large

surface area is offered to the air for the consumption of the carbon. Moreover a carbon round in cross section is always preserved and as already mentioned no slag can drop on to the support. To the burning edge which burns away, a substance giving off or developing oxygen is preferably added, such as, for instance, dioxid of barium or manganese or the like, in order to provide during the burning away of the carbon for the presence of a sufficient quantity of oxygen. If desired the whole electrode may be provided with a coating or cover made of the supporting substance.

In order that my invention may be more fully understood reference is made to the accompanying drawing in which:

Figure 1 shows an electrode, in section, resting on its support. Fig. 2 is a cross section of the electrode shown in Fig. 1. Figs. 3 and 4 are cross-sections of different forms of electrodes. Figs. 5 and 6 illustrate the method of forming double or multiple electrodes as a whole from which single electrodes, according to this invention, can be subsequently made by division.

It will thus be seen that the object of my present invention is to arrange on the electrode a supporting edge of pure carbon, maintaining the electrode of ordinary circular or round cross-section but having the supporting edge less dense than the other part of the electrode in order that the supporting edge will burn at a lower temperature than is required to burn the body of the electrode, owing to the smaller density of the edge. The supporting edge may be made of lamp black or powdered charcoal compacted together and mixed with substances which will give off oxygen under the action of heat, such as dioxid of barium or manganese. By this arrangement the supporting edge will always be burned away at some distance from the point or crater of the electrode so that the arc can not reach the support. Electrodes of this kind can be produced in various ways. For instance, an electrode can be provided with lateral grooves and the supporting edge can be glued in.

An excellent form of electrode made according to this invention is shown in Fig. 2, in which an outer body or covering *a* of dense carbon of the cross sectional form shown is made in any known manner, but hollow and having a longitudinal slot on one

side. A separate supporting edge *b* is then separately made and inserted in the slot of the body *a*, after which an appropriate filling or wick substance is so forced or pressed into the central cavity of the body *a* that the supporting edge is secured in its place and unable to move in its seat. Or several electrodes as a whole can first of all be made as shown in Fig. 5 or 6 and subsequently split up or divided into single electrodes. But the outer body or covering of hard carbon and the supporting edge can also be produced simultaneously and pressed together. Also the supporting edge can be impregnated with substances giving off oxygen or with other material; its cross section may vary and it may be sunk in a groove of the electrode. Or the supporting edge may be produced by treating a portion or strip *b* (Fig. 4) of the outer body of the electrode by changing the nature or consistency of the material at that point. During the pressing in of the substance the electrodes can if desired be covered. Or an ordinary electrode can be impregnated laterally with the substance giving off or developing oxy-

gen. Preferably the support is made of a material which is a bad conductor of heat as, for instance, corundum.

I claim:

1. An electrode having a body of hard carbon and a supporting edge made of carbon less dense than the body of the electrode and impregnated with a substance which gives off oxygen when heated, substantially as described.

2. The process of making electrodes which consists in forming a number of electrodes joined together, made of hard carbon and inserting in one side of each of said electrodes carbon less dense than the body of the electrode, and then severing the electrodes from each other, substantially as described.

In testimony, that I claim the foregoing as my invention, I have signed my name in presence of two witnesses, this eighteenth day of August 1909.

HENDRICUS JOHANNES JACOBUS JABURG, JR.

Witnesses:

W. F. TAKES,

A. HUIDEKOPER.

R. H. WOLFF.
ELECTRODE.
APPLICATION FILED JAN. 14, 1910.

974,008.

Patented Oct. 25, 1910.

Fig. 1.

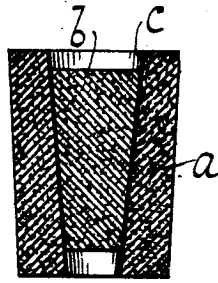


Fig. 2.

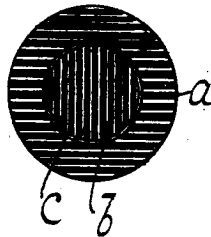


Fig. 3.

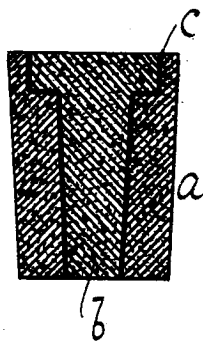


Fig. 4.



Witnesses
William Miller
Christian Almstaedt

Inventor
Raphael H. Wolff
By his Attorneys
Haufler + Harland

UNITED STATES PATENT OFFICE.

RAPHAEL H. WOLFF, OF NEW YORK, N. Y.

ELECTRODE.

974,008.

Specification of Letters Patent. Patented Oct. 25, 1910.

Application filed January 14, 1910. Serial No. 538,018.

To all whom it may concern:

Be it known that I, RAPHAEL H. WOLFF, a citizen of the United States, residing at New York city, county of New York, and State of New York, have invented new and useful Improvements in Electrodes, of which the following is a specification.

My invention relates to electrodes made of carbon mixtures used principally for electro-metallurgical operations. Such as are used in electric furnaces have to be of large dimensions and it is difficult to bake them in such a way so they are heated uniformly, and also difficult to expel the gases that form in the interior during the process of baking. To heat them sufficiently so the core of such large electrodes will be as thoroughly baked as the exterior and expel the gases completely involves a danger of spoiling the product. In order to overcome these difficulties I have devised a carbon-electrode of two or more pieces each of them made separately.

This invention is set forth in the following specification and claims and illustrated in the annexed drawing in which—

Figure 1 represents a longitudinal section of an electrode embodying this invention. Fig. 2 shows a plan view of Fig. 1. Figs. 3 and 4 show longitudinal sectional views of modifications.

I provide an exterior and interior electrode. The latter may be one piece or consist of a number of pieces. The exterior electrode or electrode part is indicated at *a* and the interior part is indicated at *b*. A suitable binder or binding material indicated at *c* can be applied to secure the two parts against separation. The exterior or its component parts can be of any shape or configuration required as for example round, oval or otherwise as indicated in the various figures of the drawing.

The exterior electrode is hollow. The hole or opening in the exterior may be wider at one end, it may be a tapered hole or it may be a cylindrical hole widened at one end so another electrode fitting in the opening of the exterior electrode may be inserted. This is to prevent the inner electrode from falling through and holding same to the exterior electrode or having it supported or confined by any means within the exterior electrode. Any space left open between the inside and outside electrodes may be filled

in with tar, pitch or any suitable binder or material or a combination of same, that will fill all openings and spaces and connect both pieces or the interior, consisting of one or more pieces, as solidly as possible with the exterior electrode to insure a uniform product.

The interior opening of the outside electrode and the form of the interior electrode to be inserted therein, may be of any suitable shape, for instance as in sketch annexed, to fit into each other in any way that may accomplish the purpose, in fact any design or shape or method that will hold them together. It may be done by inserting the inner electrode either of one solid piece or a combination of pieces, to conform to the form of the hollow space in the interior of the electrode and infuse the tar pitch or any other suitable binder or material, or combination of same to fill in any open spaces afterward, substantially as described.

I claim:

1. The preparation of an electrode which consists in forming several parts of the electrode so that one part can be inserted into another to be retained therein and filling the spaces or interstices with suitable material, substantially as described.

2. As a new article of manufacture an electrode of several parts each formed of carbonaceous mixture and placed one within another and having the spaces filled with suitable binding material.

3. A new article of manufacture consisting of a number of electrode parts of carbonaceous mixture suitably formed and placed one within another, the inner part being formed of several pieces and the outer part being made to confine the inner one, said electrode having the space between the parts filled with binding material.

4. The process of making combination electrodes, consisting in previously made electrode parts so formed that the interior electrode part can be inserted into the exterior part and all spaces filled with a suitable material, to produce a uniformly solid combination electrode, substantially as described.

5. A new article of manufacture produced by forming two electrode parts of carbonaceous mixture an interior and an exterior and inserting the interior electrode part into the exterior part and then filling the open

spaces with a suitable binding material, to make one solid uniform electrode.

6. A new article of manufacture consisting of two electrode parts previously made
5 of carbonaceous mixture, consisting of properly shaped inside electrode parts of one or more pieces inserted in a correspondingly properly formed outside electrode part and confined therein, the open spaces infused
10 and filled with a suitable binding material,

producing one solid combination electrode as a uniform article.

In testimony whereof I have hereunto set my hand in the presence of two subscribing witnesses.

RAPHAEL H. WOLFF.

Witnesses:

CHRISTIAN ALMSTAEDT,
W. C. HAUFF.

R. M. DOOLEY.
 HEADLIGHT.
 APPLICATION FILED JAN. 27, 1910.

Patented Oct. 31, 1911.

1,007,435.

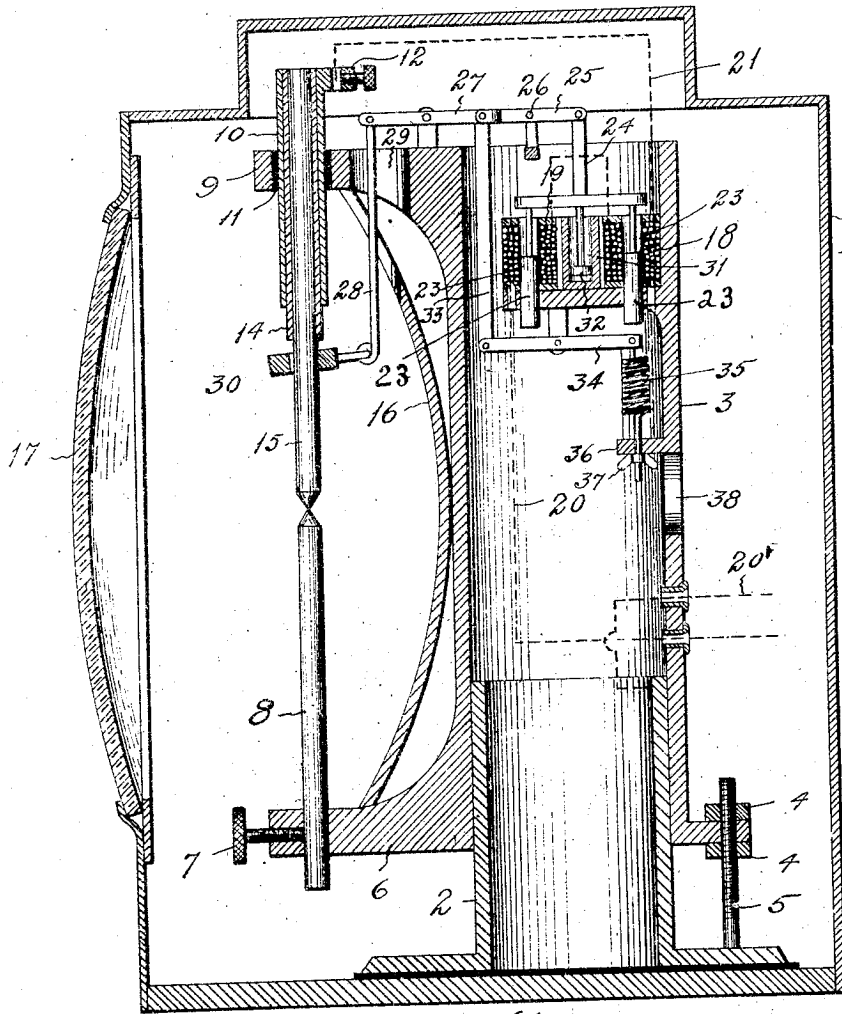


Fig. 1.

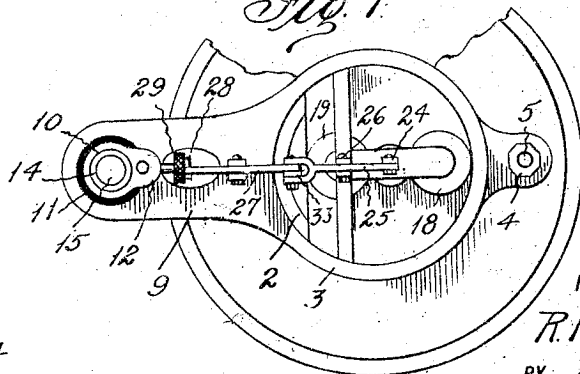


Fig. 2.

WITNESSES.

J. L. Bowling
 A. E. Vanhook

INVENTOR

R. M. Dooley.

BY *Shelby Davis*
 ATTORNEYS

UNITED STATES PATENT OFFICE.

ROBERT M. DOOLEY, OF ROCKLAND, TEXAS.

HEADLIGHT.

1,007,435.

Specification of Letters Patent.

Patented Oct. 31, 1911.

Application filed January 27, 1910. Serial No. 540,310.

To all whom it may concern:

Be it known that I, ROBERT M. DOOLEY, citizen of the United States, residing at Rockland, in the county of Tyler and State of Texas, have invented certain new and useful Improvements in Headlights, of which the following is a specification.

My invention relates to new and useful improvements to head-lights and more particularly to electric head-lights.

The object of my invention is to provide an electric head-light which will adjust the carbons of the arc lamp without the usual vibration.

Another object of my invention is to provide an adjustable stand for an arc light which will allow the same to be properly focused in a head-light.

Finally the object of my invention is to provide a device of the character described which will be simple, strong, durable and efficient, and one in which the several parts will not be likely to get out of working order.

With these and other objects in view, my invention has relation to certain novel features of construction and operation, an example of which is described in the following specification and illustrated in the accompanying drawings, wherein:

Figure 1. is a vertical section of my device, and Fig. 2. is a plan view of the arc lamp.

In the drawings the numeral 1 designates a suitable housing, and numeral 2 designates a central stand on which a tubular supporting member 3 is mounted to slide up or down. This movement is regulated by nuts 4 arranged to turn on a bolt 5 mounted on the base of the stand 1. The tubular member carries an arm 6 near its lower extremity which is provided with a set screw 7 adapted to engage with a carbon 8. At the top of the tubular member an arm 9 extends over the arm 6 and carries a vertical sleeve 10 which is insulated therefrom by a non-conducting collar 11.

A suitable binding post 12 is arranged on the sleeve while another sleeve 14 is arranged to slide in the first named sleeve and to engage with a carbon 15. Normally the carbons 8 and 15 contact at a point directly opposite the center of the reflector 16 and the lens 17.

Solenoids 18 and 19 are mounted within the tubular member and have electrical con-

nection with the lead wire 20 and are connected up in circuit with the upper carbon 15 by the conductor 21, which is secured to the binding post 12 of the sleeve heretofore described. The frame of the lamp is connected to the lead wire 20' below the lead 20, the lower carbon being in circuit therewith through the carrying arm 6. These solenoids are so positioned that upon being energized, the cores 23 thereof will be moved upwardly raising the arm 24 and one end of the lever 25, which latter is pivoted at 26. The other end of the lever 25 engages with one end of a lever 27 pivotally mounted on the tubular member. The other end of the lever 27 engages with a link 28 which extends downward through an aperture 29 in the arm 9 and connects to a ring 30. The ring engages the carbon on its upward movement but will slide down without engaging with the carbon.

Between the solenoids 18 and 19 a dash-pot 31 is mounted to receive a piston 32 connected in alinement with the arm 24. A lever 33 extends downward from the end of the lever 25 and connects with one end of a lever 34 which is pivoted below the support of the magnets.

A spring 35 having connection with the other end of the lever 34 extends downward and has connection with a lug 36 made on the interior of the tubular member and is made adjustable by a nut 37. This nut may be reached by the operator through an aperture 38 in the tubular member.

When the carbons are close together the resistance is at a minimum and the solenoid coils will be energized enough to raise the electrode 15 against the tension of the spring 35. As the electrode is raised the resistance is increased and energy exerted by the solenoids is decreased until it is neutralized by the tension of the spring. When the electrodes are further separated by reason of their being burned away the spring will overcome the action of the solenoids and then the dash pot and the electrode will be returned to its normal position.

It is obvious that an arc lamp so constructed can be installed in places where the space is very limited and that the mechanism being inside of the stand will be protected and will not be liable to get out of adjustment. All the levers used in the mechanism being short and the mechanism being compact decreases the liability of the

electrodes being affected by vibration should the lamp be used as a headlight on a moving vehicle.

What I claim is:

- 5 1. In an electric headlight, the combination with a base, of a tubular stand supported on the base, means for raising or lowering the stand with relation to the base, an arm arranged near the lower extremity of the stand adapted to support an electrode, a second arm arranged at the upper extremity of the stand, a sleeve fixed in the last named arm and insulated therefrom, a second sleeve arranged to slide in the first named sleeve and to support an electrode, a ring clutch adapted to surround the last named electrode, a lever pivoted on the stand, a link connecting one end of said lever with the ring clutch, two opposite vertical solenoids supported within the stand, cores arranged to operate in the solenoids and adapted to have upward movement upon the energizing of said solenoids, a second lever pivoted upon said stand between and pivotally connected to the free end of said first named lever and said cores, a horizontal lever pivoted beneath said solenoids, a vertical link extending parallel to the solenoids and pivoted to the pivotal point of connection between the first named levers and the inner end of said horizontal lever, a spring concealed within the stand and secured to the free outer end of the horizontal lever, and means for adjusting the tension of said spring.
2. In an electric headlight, the combination with a base, of a tubular stand supported on the base, means for raising or lowering the stand with relation to the base, an arm arranged near the lower extremity

of the stand adapted to support an electrode, a second arm arranged at the upper extremity of the stand, a sleeve fixed in the last named arm and insulated therefrom, a second sleeve arranged to slide in the first named sleeve and to support an electrode, a ring clutch adapted to surround the last named electrode, a lever pivoted on the stand, a link connecting one end of said lever with the ring clutch, two opposite vertical solenoids supported within the stand, cores arranged to operate in the solenoids and adapted to have upward movement upon the energizing of said solenoids, a second lever pivoted upon said stand between and pivotally connected to the free end of said first named lever and said cores, a horizontal lever pivoted beneath said solenoids, a vertical link extending parallel to the solenoids and pivoted to the pivotal point of connection between the first named levers and the inner end of said horizontal lever, a spring concealed within the stand and secured to the free outer end of the horizontal lever, means for adjusting the tension of said spring, a dash pot positioned between said solenoids and operatively connected with said second named lever, said solenoid cores being adapted for upward movement upon the energizing of said solenoids, and said solenoids, electrodes and arms adapted for the passing of an electrode circuit there-through.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

ROBERT M. DOOLEY.

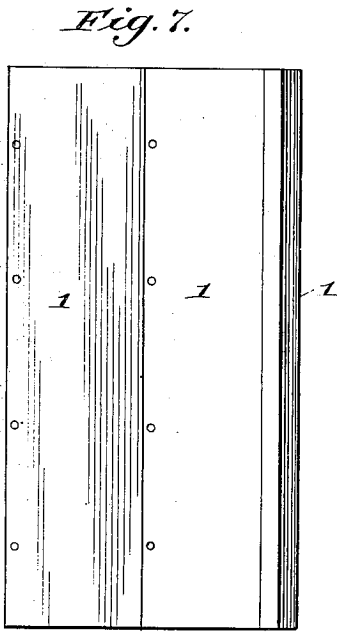
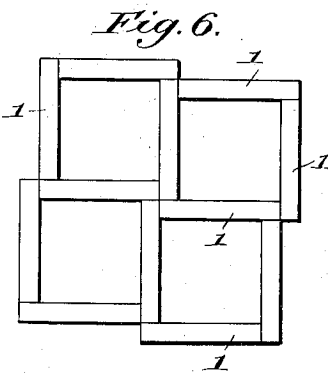
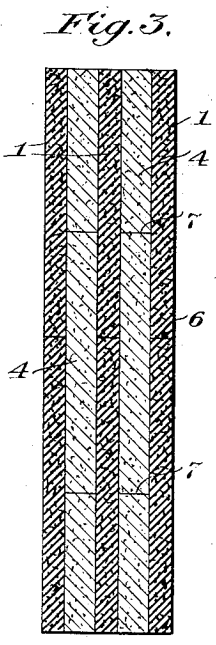
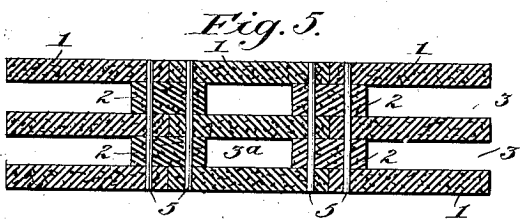
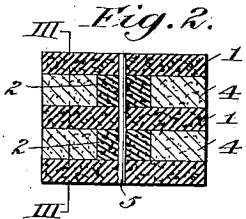
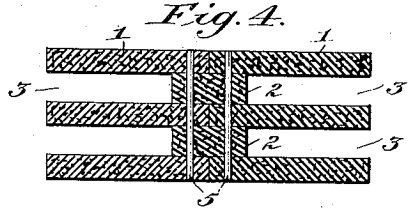
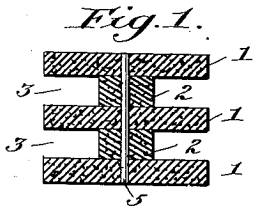
Witnesses:

J. F. CARTER,
N. H. CARTER.

W. A. SMITH.
 ELECTRODE.
 APPLICATION FILED, MAY 29, 1911.

1,032,247.

Patented July 9, 1912.



Witnesses:
 R. J. Hulsizer.
 C. H. Potter.

Inventor:
 William Acheson Smith,
 By Byrnes, Dounsud & Brickenstein
 Att'ys

UNITED STATES PATENT OFFICE.

WILLIAM ACHESON SMITH, OF NIAGARA FALLS, NEW YORK, ASSIGNOR TO INTERNATIONAL ACHESON GRAPHITE COMPANY, OF NIAGARA FALLS, NEW YORK, A CORPORATION OF NEW JERSEY.

ELECTRODE.

1,032,247.

Specification of Letters Patent.

Patented July 9, 1912.

Application filed May 29, 1911. Serial No. 630,033.

To all whom it may concern:

Be it known that I, WILLIAM ACHESON SMITH, a citizen of the United States, residing at Niagara Falls, in the county of Niagara and State of New York, have invented certain new and useful Improvements in Electrodes, of which the following is a specification.

This invention relates to electrodes for electric furnaces, the object of the invention being the provision of improved electrodes consisting of or containing conductive members disposed to provide an increased effective area at the working end of the electrode, as compared with an equal weight of conductor arranged in a compact prismatic or cylindrical form.

Certain preferred embodiments of the invention are illustrated in the accompanying drawings, wherein—

Figures 1, 2, 4 and 5 are transverse sectional views of certain electrode constructions; Fig. 3 is a longitudinal section on line III—III of Fig. 2; Fig. 6 is a plan view of another form of electrode; and Fig. 7 is an elevation of the construction shown in Fig. 6.

It has been found desirable, for certain electrothermic purposes, to provide electrodes which may be of very large size, their transverse section often comprising several square feet. In such cases it has proven desirable, instead of constructing the electrode of a compact homogeneous mass or body of conductive material, as graphite or carbon, to distribute the conductive members in separated relation, often in conjunction with a filling or bedding mass of lower electrical conductivity.

According to the present invention there is provided an improved electrode construction wherein the conductive members are assembled in such manner as to provide an efficient distribution of the current at the working end of the electrode, the arrangement being such that the cross-sectional area of the electrode may be increased as desired in either dimension.

It is characteristic of the preferred embodiments of the invention that the several conductive members are in electrical contact with each other, usually throughout their length, and are disposed to provide a plurality of parallel interspaces or channels,

which may be left void or filled with material of lower conductivity according to the intended use of the electrode.

It is further characteristic of the invention, in its preferred embodiments, that certain of the conductive members are laterally exposed at the exterior of the electrode in such manner that effective electrical contact may be made with them at any desired point.

Referring to the drawings, the construction of Fig. 1 comprises conductive members 1, 2, alternately wider and narrower, whereby there are provided a plurality of interspaces or channels 3. The conductive members 1, 2, are usually of graphite, but may be of non-graphitic carbon. The relative arrangement of these members is such as to provide a large effective working area at the end of the electrode. The several members may be secured together by any appropriate means, as by the use of graphite pins 5.

The interspaces or channels may be filled with a material of lower conductivity than the members 1, 2, as indicated at 4 in Figs. 2 and 3. This filling is preferably also of lower heat conductivity than graphite, and may comprise a mixture of coke and tar, other carbonaceous material and binder, or a composition comprising a slag or slag-forming mixture appropriate to the use for which the electrode is intended, such mixture usually having cementitious properties.

Fig. 4 illustrates an essentially similar electrode, in which each of the wider members consists of two laterally abutting conductive plates 1, the joints being covered and secured by members 2 narrower than the combined width of the members 1, thereby providing parallel channels 3. In this as in all other cases, the channels may be filled as described in connection with Figs. 2, 3.

Fig. 5 shows a further extension of the electrode, consisting in this case of a multiple series of three abutting plates 1, with intermediate members 2. This construction provides in addition to the exterior channels 3, interior channels 3^a, making a cellular electrode, whereof the channels or interspaces may be filled or not.

A further modification is illustrated in Figs. 6 and 7, in which the plates 1 are assembled to provide a cellular electrode con-

sisting of a plurality of hollow prismatic forms having their adjacent sides in common.

One of the principal advantages of the forms shown is that the cross-sectional area of the electrode is capable of indefinite extension in either dimension by assembling the desired number of standard parts. Furthermore, the length of the electrode may be increased as desired, its composite character permitting the addition of members with abutting ends, as indicated at 6, 7 in Fig. 3.

I claim:—

1. An electrode having conductive members assembled in contact with each other to provide a plurality of substantially parallel interspaces.
2. An electrode having graphite members assembled in contact with each other to provide a plurality of substantially parallel interspaces.
3. An electrode having conductive members assembled in contact with each other to provide a plurality of substantially parallel interspaces, said interspaces filled with a material of lower electrical conductivity.
4. An electrode having graphite members assembled in contact with each other to provide a plurality of substantially parallel interspaces, said interspaces filled with non-graphitic carbon.
5. A prismatic electrode composed of conductive members assembled in contact with each other, and an intermediate filling of material of lower electrical conductivity.
6. A prismatic electrode composed of

graphite members assembled in contact with each other, and an intermediate filling of material of lower electrical conductivity. 40

7. A prismatic electrode composed of graphite members assembled in contact with each other, and an intermediate filling of non-graphitic carbon.

8. An electrode comprising exterior members of conductive carbon assembled in conductive relation to each other, and an intermediate filling of lower electrical conductivity. 45

9. An electrode comprising exterior members of graphite assembled in conductive relation to each other, and an intermediate filling of lower electrical conductivity. 50

10. An electrode comprising exterior members of graphite assembled in conductive relation to each other, and an intermediate filling of non-graphitic carbon. 55

11. An electrode comprising exterior and interior members of conductive carbon, and an intermediate filling of lower electrical conductivity. 60

12. An electrode comprising exterior and interior members of graphite, and an intermediate filling of lower electrical conductivity. 65

13. An electrode comprising exterior and interior members of graphite, and an intermediate filling of non-graphitic carbon.

In testimony whereof, I affix my signature in presence of two witnesses.

WILLIAM ACHESON SMITH.

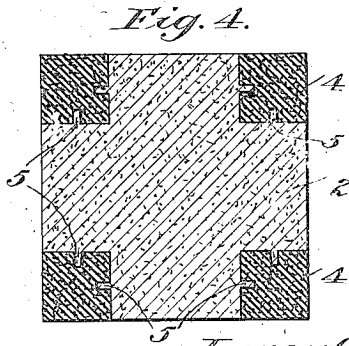
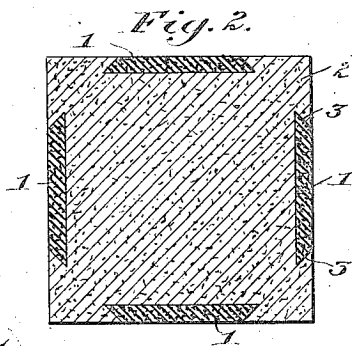
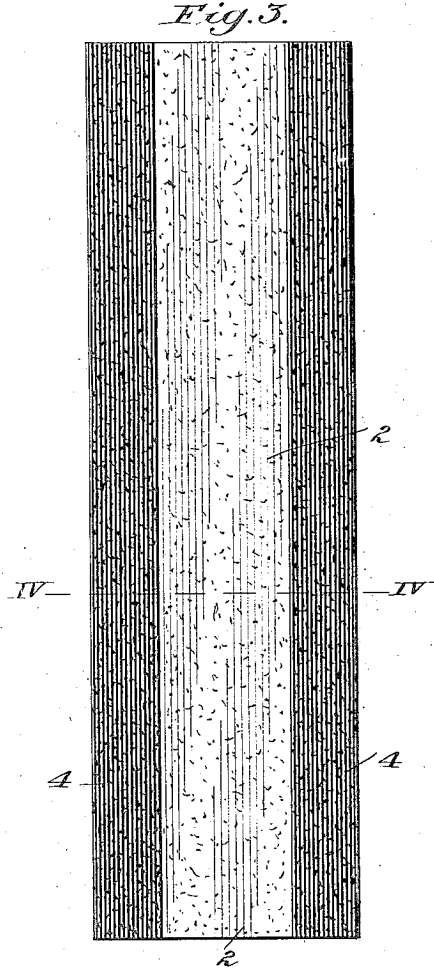
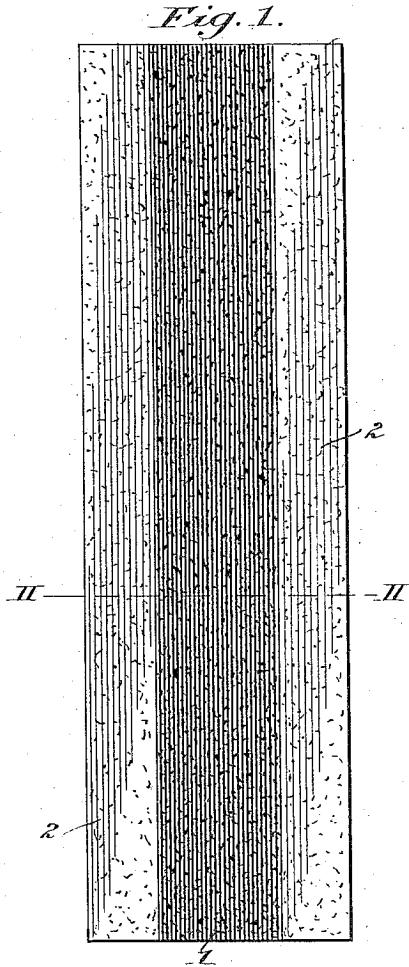
Witnesses:

ORRIN E. DUNLAP,
C. A. TRYON.

W. A. SMITH.
 COMPOSITE ELECTRODE.
 APPLICATION FILED JUNE 5, 1911.

1,032,248.

Patented July 9, 1912.



Witnesses:
 R. J. Schulzger.
 C. H. Potter.

Inventor:
 William Acheson Smith,
 by Byrnes, Townsend & Brocklebank
 Att'ys

UNITED STATES PATENT OFFICE.

WILLIAM ACHESON SMITH, OF NIAGARA FALLS, NEW YORK, ASSIGNOR TO INTERNATIONAL ACHESON GRAPHITE COMPANY, OF NIAGARA FALLS, NEW YORK, A CORPORATION OF NEW JERSEY.

COMPOSITE ELECTRODE.

1,032,248.

Specification of Letters Patent.

Patented July 9, 1912.

Application filed June 5, 1911. Serial No. 631,344.

To all whom it may concern:

Be it known that I, WILLIAM ACHESON SMITH, a citizen of the United States, residing at Niagara Falls, in the county of Niagara and State of New York, have invented certain new and useful Improvements in Composite Electrodes, of which the following is a specification.

This invention relates to electrodes intended particularly for electrothermic work, the object of the invention being the provision of an improved composite electrode, wherein the several parts are firmly united.

It is often desirable in connection with electrothermic operations to provide electrodes of large cross-sectional area and consisting of conductive members of carbon or graphite in conjunction with a filling or supporting body of lower electrical conductivity.

According to the present invention an interlocking engagement is provided between such conductive member or members and the filling. This presents several technical advantages of great importance, among them a diminished liability to fracture or separation under the extremes of temperature to which the electrode is submitted, and a greatly improved electrical contact between the conductive members which receive the current and the mass of lower conductivity to which the current is usually in part diverted.

Certain preferred embodiments of the invention are shown in the accompanying drawings, wherein—

Figure 1 is a view in elevation of one form of electrode embodying the invention; Fig. 2 is a transverse section thereof on line II—II; Fig. 3 is a view in elevation of a modified form of electrode; and Fig. 4 is a transverse section on line IV—IV of Fig. 3.

Referring to Figs. 1 and 2, 1, 1, indicate conductive members, which are usually of graphite, although other forms of carbon or carbonaceous materials may be used; and

2 indicates a filling of lower electrical conductivity. In this embodiment of the invention the conductive members 1 are beveled at their edges as shown at 3, and the filling interlocks with these edges in such manner as to hold the conductive members firmly in place under all conditions of manufacture, transportation and use. An electrode of this kind is conveniently prepared by merely inserting the members 1 in a prismatic form and casting therein the filling material 2, which may comprise for example a heated mixture of carbon and tar, or a cement or concrete of slag or other material not objectionable for the purposes for which the electrode is to be used; or the filling may consist of silica or other non-conductive or slightly conductive material.

In Figs. 3 and 4 the conductive members 4 consist of rectangular prisms located at the corners of the composite electrode, and provided on their interior faces with longitudinal grooves or depressions 5, with which the filling 2 interlocks. The manner of forming the electrode is as above described.

Electrodes thus prepared may be baked by the usual methods, in case the filling consists of a carbon-tar mixture or other composition capable of being hardened by heat. Preferably the conductive members are not completely embedded in the filling mass, but are exposed laterally in such manner that the electrical connections may be applied at any desired point in the length of the electrode, or may be arranged to slide thereon. In certain cases however a single member, interlocking with the filling, supporting or embedding mass, may be used.

The means for securing the interlocking connection may be varied as desired, and may comprise either depressions or projections of any kind in or upon the conductive member or members, and either integral therewith or in the form of pins or rods so

disposed as to afford the necessary interlocking connection between the components of the electrode.

I claim:—

- 5 1. A composite electrode consisting of a graphite member or members, and a supporting material of non-graphitic carbon interlocking therewith.
2. A composite electrode consisting of a

laterally-exposed conductive member or 10 members, and a filling of lower electrical conductivity interlocking therewith.

In testimony whereof, I affix my signature in presence of two witnesses.

WILLIAM ACHESON SMITH.

Witnesses:

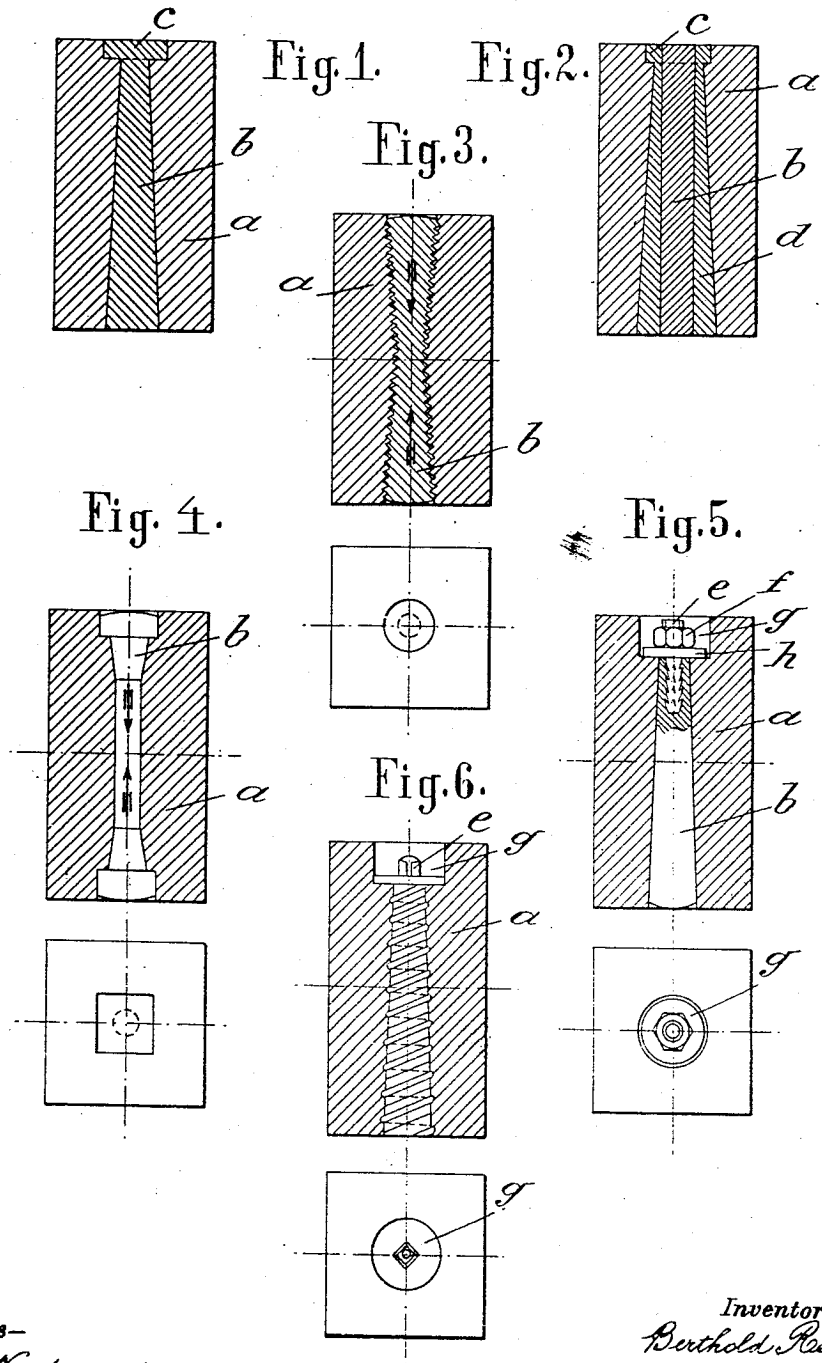
ORRIN E. DUNLOP,
C. A. TRYON.

BEST AVAILABLE COPY

B. REDLICH.
CARBON ELECTRODE FOR ELECTRIC FURNACES.
APPLICATION FILED FEB. 19, 1912.

1,048,581.

Patented Dec. 31, 1912.



Witnesses—
Stanford
H. W. Blake

Inventor
Berthold Redlich
by
W. S. King
Attorney.

UNITED STATES PATENT OFFICE.

BERTHOLD REDLICH, OF RATIBOR, GERMANY, ASSIGNOR TO THE FIRM OF PLANIA-WERKE AKTIENGESELLSCHAFT FÜR KÖHLENFABRIKATION, OF RATIBOR, GERMANY.

CARBON ELECTRODE FOR ELECTRIC FURNACES.

1,048,581.

Specification of Letters Patent.

Patented Dec. 31, 1912.

Application filed February 19, 1912. Serial No. 678,603.

To all whom it may concern:

Be it known that I, BERTHOLD REDLICH, subject of the Emperor of Austria-Hungary, residing at Ratibor, Upper Silesia, Germany, doctor of chemistry, have invented certain new and useful Improvements in Carbon Electrodes for Electric Furnaces, of which the following is a specification.

The carbon electrodes in which metal cores which offer a considerably reduced electrical resistance are embedded offer various difficulties in their production. If the metal core is inserted into the carbon electrode before burning, the metal, especially iron, absorbs carbon during the burning process and thus becomes brittle, so that its mechanical durability, which is of importance when it is in use is influenced. If the core is inserted into the hollow spaces or recesses, provided in the electrode, after burning the production of a sufficiently secure contact on the employment of very simple and marketable cross sections, offers difficulties. Experiments have proved that a good contact between the metal core and the electrode is obtained by casting molten metal or metal alloys into the hollow spaces provided in the electrode. If in this manner great advantages are obtained, difficulties are still met with, as the metal contracts on solidification and the carbon retains its shape, so that the metal core after solidification may be separated from the electrode by a thin air space thus producing a bad contact between the metal core and the carbon electrode. This disadvantage can be avoided by providing the metal core and the bore in the carbon of a corresponding form and employing the property of the solidifying metal or metal alloys, which contract to a high degree, for the purpose of effecting a firm pressing of the metal core against the electrode wall. The form of the metal core can also be so chosen that, after casting it can be made to fit accurately into the form of the hollow space by suitable mechanical auxiliary means.

In the drawing are shown a few constructional forms of the improvement.

Figure 1 is a cross section of an electrode provided with a metal core. Fig. 2 is a cross section of a modification. Fig. 3 is a cross section of a further modification and a corresponding plan. Fig. 4 is a cross section of another modification and a corresponding

plan and Figs. 5 and 6 show further modifications with corresponding plans.

Fig. 1 shows the carbon electrode which is provided with a conical bore. The metal core *b* which has been cast into this is by reason of the end plate *c* firmly pressed against the inner walls of the carbon on solidification.

According to Fig. 2, a metal core *b* is loosely inserted into the carbon electrode *a*. The bore of the carbon electrode in this instance is also conical and between the inner wall of the carbon and the metal core *b* a metal or metal alloy is cast, which on solidification forms a good contact between the hollow body and the core due to its contraction.

In Fig. 3 the metal core *b* is provided of a slight conical form at both ends. After pouring in the cast mass, the metal contracts both in a longitudinal and in a transverse direction. In this manner a high pressure is exerted in the direction of the arrows and the metal shrinks firmly against the wall of the carbon electrode. It is advisable to provide these walls with grooves for the purpose of increasing the contact surface.

In Fig. 4 the metal core is of cylindrical form but its ends are conical and terminate in cylindrical or rectangular portions. Also in this case, an adhesion of the metal core along the conical surfaces as also at the end castings takes place. This arrangement simultaneously operates as the armature for the electrode, as a strong pulling action takes place in the direction of the arrows.

Fig. 5 shows a constructional form in which the metal core is pressed into the hollow space provided in the body of the carbon by mechanical means. The metal core *b* is of slightly conical form and into its end is cast a screw-bolt *e*. After casting, there is inserted in the recess *g*, provided at the other end of the electrode, a strong washer *h* and on this a nut *f*. If, on casting, the core has shrunk, and an air space has been formed between the metal core and the electrode, an intimate contact with the walls of the electrode is effected by a powerful tightening of the nut *f* on the bolt.

Fig. 6 shows the same principle in another arrangement. On the employment of the electrode care must be taken that the conical part of the core in which the bolt is secured is continually directed upward.

By the heat which is produced in the electric furnace the metal core expands more than the carbon, and therefore also during the employment of the electrode a firm pressing and thus also a good contact is effected between the metal core and the electrode.

What I claim as my invention and desire to secure by Letters Patent is:

10 1. A carbon electrode for electric furnaces consisting of a carbon member having a hole, means for reducing the electrical resistance of the carbon member comprising a metal core in said hole, said metal core extending along the whole length of the electrode and being retained in intimate contact with the carbon member.

20 2. A carbon electrode for electric furnaces comprising a carbon member, means for reducing the electrical resistance of the carbon member, consisting of a metal core cast and shrunk into the carbon member, said metal core extending along the whole length of the carbon member.

25 3. A carbon electrode for electric furnaces comprising a carbon member, means for reducing the electrical resistance of the carbon member consisting of a metal core cast and shrunk into the carbon member, said metal

core extending along the whole length of the carbon member, and means for retaining the core in said carbon member.

4. A carbon electrode for electric furnaces comprising a carbon member having a hole, means for reducing the electrical resistance of the carbon member consisting of a metal core cast into said hole and extending substantially along the whole length of said carbon member, the hole and the core being of such form that the core on solidification will shrink into said hole and firmly contact with the carbon member.

5. A carbon electrode for electrical purposes comprising a carbon member having a hole, said hole extending along the whole length of the carbon member and being partly conical, means for reducing the electrical resistance of the carbon member consisting of a metal core, cast into the hole and on solidification contracting and firmly contacting with the carbon member.

In testimony whereof I have hereunto signed my name to this specification, in the presence of two subscribing witnesses.

BERTHOLD REDLICH.

Witnesses:

FRANK G. POTTS,

ERNST KATZ.

A. T. HINCKLEY.
ELECTRIC FURNACE CARBON ELECTRODE.
APPLICATION FILED FEB. 2, 1912.

1,058,057.

Patented Apr. 8, 1913.

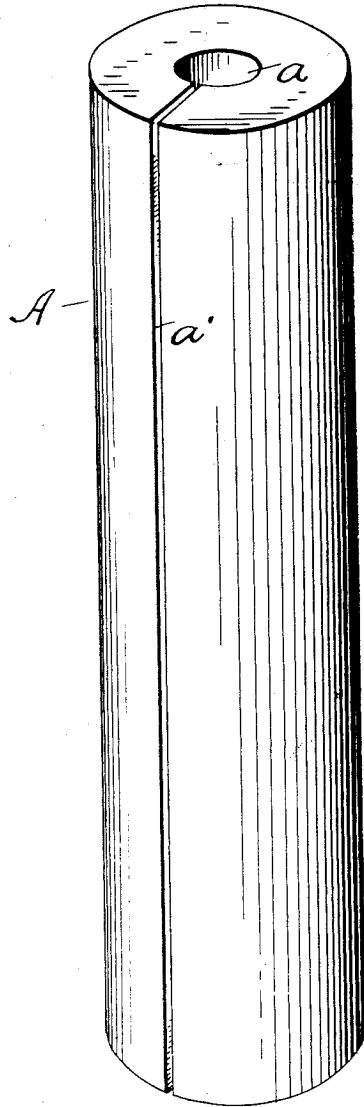
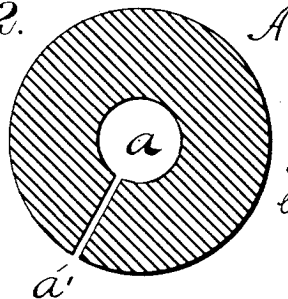


Fig. 1.

Fig. 2.



Witnesses.
E. B. Christ
H. P. Sullivan

Inventor
Arthur J. Hinckley
by *Shurston & Kins*
Attorneys

UNITED STATES PATENT OFFICE.

ARTHUR T. HINCKLEY, OF NIAGARA FALLS, NEW YORK, ASSIGNOR TO NATIONAL CARBON COMPANY, OF CLEVELAND, OHIO, A CORPORATION OF NEW JERSEY.

ELECTRIC-FURNACE CARBON ELECTRODE.

1,058,057.

Specification of Letters Patent.

Patented Apr. 8, 1913.

Application filed February 2, 1912. Serial No. 674,936.

To all whom it may concern:

Be it known that I, ARTHUR T. HINCKLEY, a citizen of the United States, residing at Niagara Falls, in the county of Niagara and State of New York, have invented a certain new and useful Improvement in Electric-Furnace Carbon Electrodes, of which the following is a full, clear, and exact description.

The object of this invention is to increase the durability of carbon electrodes, especially of the larger sizes, when used in electric furnaces; and particularly to reduce the chances that such carbon electrodes will break or shale as the result of differences in temperature of the outer and inner parts of said electrodes, which result from putting them into or taking them from electric furnaces.

When a large carbon electrode of the ordinary construction is put into an electric furnace at high temperature, the electrode will become intensely hot on the outside, while the center thereof is still comparatively cool. This is owing to the fact that the heat conductivity of carbon is relatively low. It may well happen that a carbon electrode, of say 14 inches diameter, may be so heated that its center will be at a temperature of 500° only, while the outer surface may have a temperature of say 1000°. The disruptive force caused by these temperature differences is very great, and much breakage of electrodes results therefrom, as will be readily understood if one considers that the coefficient of tensile elasticity of such carbon electrodes is only about one-tenth that of steel.

In practice, it is necessary, or, at least, it is common to put a cold carbon electrode into a very hot electric furnace. Very frequently the result of so doing is the disruption of the electrode. When the electrodes do not break, they frequently shale, which is exceedingly objectionable and troublesome.

The electrode shown in the drawing and hereinafter described and claimed is of such construction that the above mentioned undesirable action occurs rarely when the electrodes are put into or used in electric

furnace work. Said electrode is tubular and has a narrow longitudinal slit extending from the outer surface to the central hole, and extending from end to end.

In the drawing, Figure 1 is a perspective view of a carbon electrode embodying this invention; and Fig. 2 is an end view thereof.

Referring to the parts by letters, A represents a tubular electrode; that is to say, an electrode having a longitudinal hole *a* running through it from end to end. Additionally, a narrow slit *a'* is formed from the hole to the outer surface, which slit is extended from end to end of said electrode. Such electrodes may be made of any suitable carbon or carbonaceous mix,—and may be compressed and formed in any manner before baking; and may have any desired external configuration.

It is evident that, in an electrode A having a hole *a* running through it lengthwise in the center, the distance through which the disruptive force of temperature differences will act is reduced from the radius of the electrode to one-half the thickness of the annular wall; because, by convection, the exposed surface of the wall of the hole reaches furnace temperature substantially as soon as the external surface. There will, of course, be some unequal expansion which might cause breakage even with a tubular carbon, but the liability that this unequal expansion shall produce the injurious results referred to is practically eliminated by the longitudinal slit referred to. If this slit in a 16 inch carbon is one-quarter of an inch wide it will serve its purpose admirably.

Having described my invention, I claim:

A carbon electrode for electric furnace work having a hole formed through it longitudinally from end to end, and having through its wall a narrow slit which also extends from end to end.

In testimony whereof, I hereunto affix my signature in the presence of two witnesses.

ARTHUR T. HINCKLEY.

Witnesses:

H. R. SULLIVAN,
E. L. THURSTON.

E. B. JEWETT.
ELECTRODE FOR USE IN ELECTROTHERMAL PROCESSES.
APPLICATION FILED FEB. 14, 1912.

1,067,031.

Patented July 8, 1913.

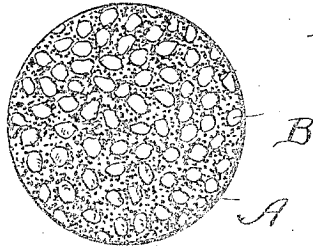


Fig. 1.

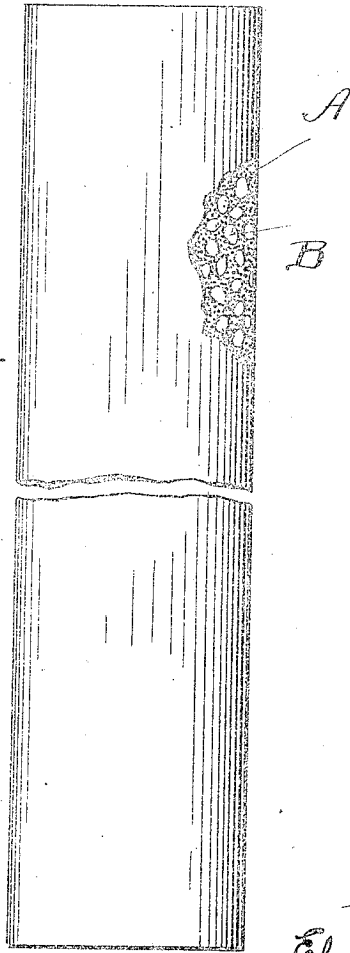


Fig. 2.

Witnesses
E. B. Gilchrist
H. B. Sullivan

Inventor.
Elmer B. Jewett
by Thurston Alvis
Attorney

UNITED STATES PATENT OFFICE.

ELMER B. JEWETT, OF CLARKSBURG, WEST VIRGINIA, ASSIGNOR TO NATIONAL CARBON COMPANY, OF CLEVELAND, OHIO, A CORPORATION OF NEW JERSEY.

ELECTRODE FOR USE IN ELECTROTHERMAL PROCESSES.

BEST AVAILABLE COPY
1,067,031.

Specification of Letters Patent.

Patented July 8, 1913.

Application filed February 14, 1912. Serial No. 877,537.

To all whom it may concern:

Be it known that I, ELMER B. JEWETT, a citizen of the United States, residing at Clarksburg, in the county of Harrison and State of West Virginia, have invented a certain new and useful Improvement in Electrodes for Use in Electrotthermal Processes, of which the following is a full, clear, and exact description.

The object of this invention is to construct carbon electrodes for use in electric furnaces so as to prevent, or at least very greatly minimize, the breaking and cracking which has heretofore attended such uses of ordinary carbon electrodes.

In electrothermal processes it is frequently necessary to place a cold electrode in a hot furnace, or to withdraw a hot electrode. Either of these operations causes disruptive stresses in the electrode owing to the more rapid expansion or contraction of the surface than of the center. This stress is a function of the furnace temperature, the heat conductivity of the material, the coefficient of expansion of the material, and the diameter of the electrode. It varies directly as the furnace temperature and the diameter of the electrode, and as the coefficient of expansion of the material. With small electrodes or larger ones of high heat conductivity, breakage due to such stresses is inappreciable, but with large electrodes of fine grain and low heat conductivity the stress is often sufficient to cause cracks which deepen with alternate heating and cooling of the electrode until breakage occurs.

This invention is an electrode which differs from the ordinary carbon electrodes previously used in that it has, distributed through it as evenly as possible, lumps or relatively large particles of carbon or carbonaceous material, such, for example, as electrode scrap, anthracite coal or coke, said included lumps or particles being of such size and strength as are necessary to prevent the formation or spreading of cracks, such as are commonly caused by the before mentioned stresses. It is impossible to state with exactness the relative size or volume of such included lumps. But these facts must be taken into account. If they are too large in diameter, or if their volume be relatively too large, the electrode will lose in strength. If they are too small or too few, the purpose for which they are en-

ployed will not be fully subserved. Also, the larger the electrodes are in diameter, the larger these included lumps should be. Also, the higher the heat of the furnace in which they are to be used, the larger should be the included lumps. A series of experiments have been conducted with a view to determining as nearly as possible what should be the diameter and what should be the relative volume of these included lumps to get the best results, all things considered. As a result of those experiments, it is my present belief that about 25 per cent. of the electrode should be made of these included lumps or particles, the remainder being composed, as is common, of carbon flour and a suitable binder, such as pitch. I believe also that the diameters of the lumps to be employed with electrodes of different diameters should be such as is represented by the abscissæ of a parabola whose ordinates are the diameters of the electrodes, and whose focus is 266 inches from its directrix. This formula is the result of plotting the results obtained in the experiments referred to which were conducted with a furnace whose temperature was substantially 1500° centigrade. It is not, however, my intention to limit the size of the included particles or lumps to the sizes which this formula will indicate. I simply state the formula as the best which I now know for determining the smallest diameters of lumps which, when used in electrodes of various diameters, will in a practical and efficient degree prevent the cracking and breaking of the electrodes by the stresses specified. Obviously, however, these included lumps may be larger in diameter up to any size which will not unduly weaken the electrodes. If they are smaller, they will, although in a less degree, prevent breaking and cracking. Also, if the electrodes are to be used in electric furnaces wherein the temperature is to be higher than 1500° centigrade, the size of these included lumps should be increased. If they are to be used in furnaces having a temperature materially less than 1500° centigrade, the size of these included particles may be decreased.

In the drawing, Figure 1 is a transverse sectional view of an electrode embodying the invention. Fig. 2 is a side elevation thereof partly broken away.

Referring to the parts by letters, A represents

represents a mixture of carbon flour agglomerated by carbonaceous coke, and B represents the particles of carbonaceous material which are distributed throughout the electrode.

Having thus described my invention, I claim:

An electrode for use in electrothermal processes consisting of carbon flour agglomerated by a carbonaceous coke, and having

distributed throughout its mass relatively large particles of carbonaceous material substantially as and for the purpose specified.

In testimony whereof, I hereunto affix my signature in the presence of two witnesses.

ELMER B. JEWETT.

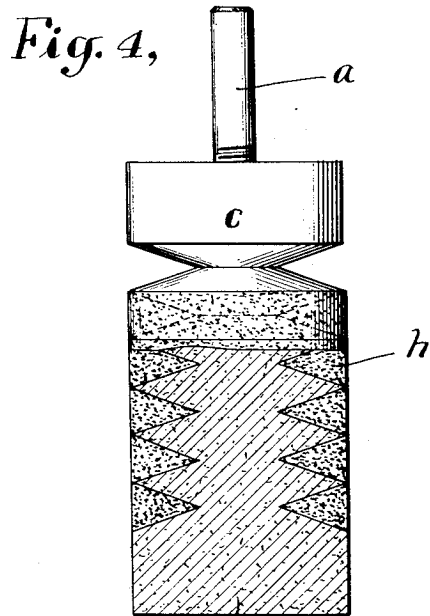
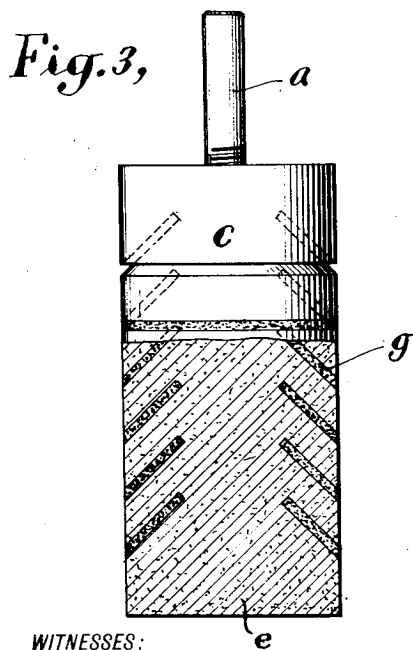
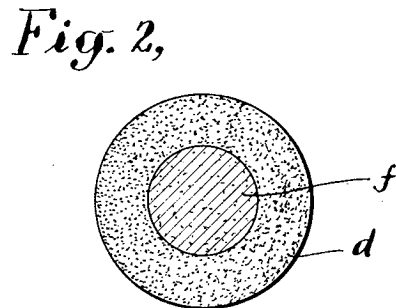
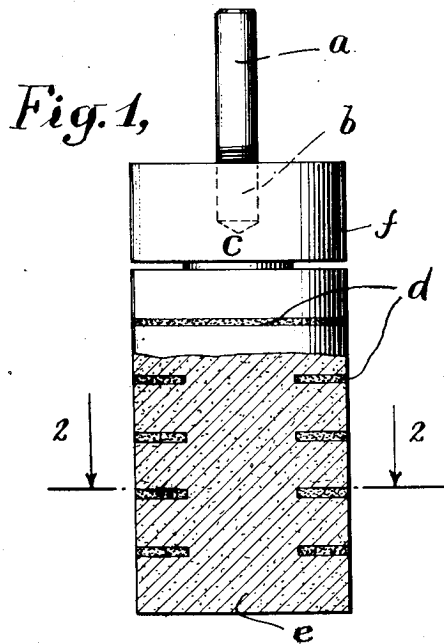
Witnesses:

CHARLES LONG,
JOHN C. LONG.

1,088,296.

Patented Feb. 24, 1914.

2 SHEETS—SHEET 1.



WITNESSES:
H. M. Lewis
M. A. Bill

INVENTOR:
J. W. Richards
BY
Hennie Davis & Holbrook
ATTORNEYS.

1,088,296.

Patented Feb. 24, 1914.

2 SHEETS—SHEET 2.

Fig. 5,

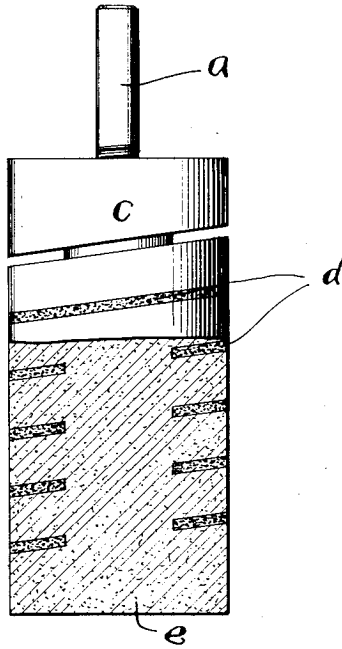
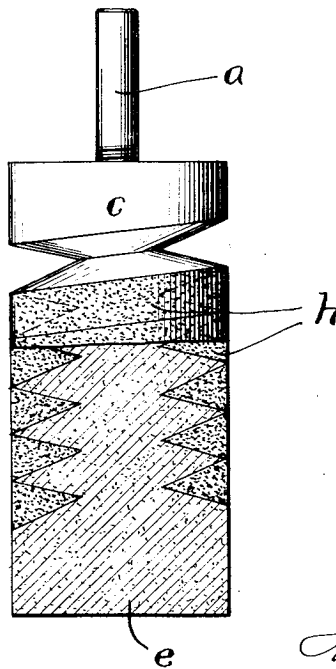


Fig. 6,



WITNESSES:

M. A. Rice
Bertram Scheuer

INVENTOR:

Joseph W. Richards,
BY
Thuric, Davis & Goldborough,
ATTORNEYS

UNITED STATES PATENT OFFICE.

JOSEPH W. RICHARDS, OF SOUTH BETHLEHEM, PENNSYLVANIA.

ELECTRODE.

1,088,296.

Specification of Letters Patent.

Patented Feb. 24, 1914.

Application filed May 12, 1913. Serial No. 766,934.

To all whom it may concern:

Be it known that I, JOSEPH W. RICHARDS, a British subject, having declared my intention to become a citizen of the United States, and residing at South Bethlehem, Northampton county, State of Pennsylvania, have invented certain new and useful Improvements in Electrodes; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

In electrodes which dip into hot electrolytes, or which serve as terminals or conductors of electricity to or from electric furnaces or other apparatus operated above the ordinary temperature, the power of the electrode or terminal to conduct heat away from the hot apparatus and to disperse it by radiation and conduction, is often a highly important factor in the economic working of the apparatus. Some electrode materials have low heat conductivity but also low electric conductivity; others have high heat conductivity and also high electric conductivity; none are at present known with low heat conductivity and high electrical conductivity, which would be the ideal material to use if it existed.

The object of the present invention is to provide an electrode of satisfactory electrical conductance for the uses referred to, but whose heat conductance, as an electrode, is considerably diminished. The principle employed by me to effect this object is probably mainly based upon the fact that the electricity conducted away from an electrode passes away only at a definite point (where the conductor terminals are clamped or fastened in any other way to the electrode), while the heat conducted away is for the most part dissipated by conduction to the air and radiation from the whole exposed outer surface of the electrode, and usually only a small part of it through the holders or conductor terminals or similar metallic contacts. Since, then, electricity escapes at a definite point on the terminal, while heat escapes all over the exposed surface, this makes possible devices for changing the relative values of its electrical conductance and its heat conductance.

In the accompanying drawing,—Figure 1 illustrates, partly in section and partly in elevation, an electrode embodying my in-

vention, in one of its forms or applications; Fig. 2 represents a transverse sectional view thereof on the line 2—2 of Fig. 1; Figs. 3 and 4 represent, partly in elevation and partly in section, modifications of the form shown in Fig. 1; and Figs. 5 and 6 illustrate a helical arrangement of peripheral recesses.

Similar letters of reference indicate similar parts throughout the several views.

The several forms or modifications illustrated in the drawing are but typical of many others that might be chosen to show the application of the fundamental principle of the invention and its adaptability to practical use. The form of electrode selected for such illustration is an ordinary cylindrical electrode having an electrical connection at its upper end and intended to project at its lower end into the furnace, bath, or other hot apparatus for which it is intended.

The electrode may be connected to the source of current supply in any suitable manner, as, for instance, by a metallic electrical connection *a* screw-threaded at *b* into the electrode head *c*. The working end of the electrode is indicated at *e*, and *f* indicates its outer periphery, more or less of which may be exposed to the air or to the atmosphere of the furnace, as the case may be.

Extending inwardly from the periphery of the electrode are gaps or recesses, preferably continuous, such as may be conveniently made, for instance, by a saw or other cutting tool. These gaps or recesses are indicated in Figs. 1, 2 and 5, at *d* and are of relatively small breadth. In Fig. 3, the gaps or recesses are indicated at *g* and in Figs. 4 and 6, at *h*.

The gaps or recesses may be left simply as spaces, freely open to the air, or they may be filled partly or entirely with loose or compressed fibrous, powdery, or solid material of lower heat conductivity than the material composing the substance of the electrode. The practical effect of these gaps or recesses is to reduce to some extent the electric conducting power of the electrode as compared with a plain cylinder of the same outside diameter, but to reduce in a much greater proportion its heat conducting power as regards heat conducted away from the bath, furnace, or the like, and dissipated to the air or surroundings or through metallic contacts. The reason for this effect appears to

me, at the present time, to be that the heat currents in a plain cylindrical electrode, supplying the heat losses to the outside, are mainly upward through the outer layers of the electrode, because that is their shortest path to the outside surface, while the electrical currents are either uniform throughout its cross-section or converge toward the center at the top. When such an electrode is provided with gaps or recesses, as in Fig. 1, the electrically conducting cross-section is diminished somewhat in the proportion of the area cut off (but not quite so greatly), while the thermally conducting cross-section is greatly reduced because of the cutting of the outside layers through which most of the main heat currents were flowing. The heat currents are thus forced to take a devious or more extended path to reach the surface than before, and thus the practical heat conducting and dissipating power of the electrode is greatly diminished. Concerning the depth of these gaps or recesses, I have determined by experiment that when they equal in depth (toward the axis of the electrode) their distance apart, the area thus severed from direct current connection still retains approximately one-fourth of its original electrical conductance. If, for instance, as in Fig. 1, the cuts extend two-thirds of the distance toward the center, the un-severed area is one-ninth of the whole, while the severed area is eight-ninths, but since the disconnected area retains effectively one-fourth its original conductance, the whole electrode has

$$1/9 + 1/4(8/9) = 1/3$$

of the electrical conductance of a plain cylinder of the same outside diameter. Assuming the electrode end *e* to be immersed in the bath to the first gap or recess, then the heat conducting power to the outer surface of the first section above *e* is diminished to about 1/5 of its conductance without the first gap; the next superior section to about 1/4; and, since these are the hottest parts of the electrode surface, the total heat loss is thus very materially less than if the gaps were absent.

Fig. 3 shows the gap or recesses *g* inclining toward the axis of the electrode; in this manner, still further lengthening the path of the heat currents in reaching the outside periphery *f* from which the principal heat dispersion occurs, while the electrical conductance is approximately the same as in the form shown in Figs. 1 and 2.

Fig. 4 shows the gaps as peripheral V-shaped cuts, with the interstices filled with suitable poor heat-conducting material. If the electrodes are continuously consumed in the apparatus in which they are used, the poor heat conducting material must be of such composition as not to be harmful to the

product of the apparatus; it may, in many such cases, be material such as is being regularly consumed by or fed into the apparatus for treatment, *e. g.*, in the production of aluminium, it may be alumina or other aluminium compounds such as may be useful in the electrolytic bath. In the case of an electrode not being rapidly consumed, a wider choice of the poor heat conducting material placed in the gaps or recesses is permissible.

Fig. 5, illustrates a helical arrangement of the recesses *d*, such as are shown in annular arrangement in Figs. 1 and 2; and Fig. 6, shows a similar helical arrangement of the inwardly narrowing recesses *h* of the kind shown in annular arrangement in Fig. 4.

In the industrial production of electrodes having forms suitable for utilizing the principles of this invention, various methods are possible. If the electrodes are of soft material or material not too difficult to work, the gaps or recesses may be made as cuts or incisions produced by hand or machine work, upon the electrode itself; *e. g.*, as with graphite or metal electrodes. If the electrodes are molded (as distinguished from being "forced" or "squirted"), the gaps or recesses may be produced in the finished article by embedding strips, washers, or layers of volatile or easily fusible or removable material of suitable poor heat conductivity in the body of the electrode as it is being molded. During the baking, such embedded inclusions either volatilize, decompose, or melt, thus leaving the gaps or recesses at the places desired, or else they remain as layers of easily removable material, or as permanent fillings of poor heat conducting and electrically insulating material, thus constituting an electrode utilizing advantageously the principles of this invention.

In the practical use of this invention, it must not be forgotten that in almost all electric furnaces or apparatus in which high temperatures prevail and electrodes are used, the energy losses by heat flowing out of the apparatus through the electrodes are of very much greater amount and importance than the small energy losses caused by the electrical resistance of the electrodes. It results that very considerable reductions of the electrical conductance of an electrode are practicable and profitable, if at the same time the heat conductance is materially reduced, since the saving in energy lost as heat flow may easily be made to exceed the increased energy required by the increased electrical resistance. It is therefore quite possible, in many instances, to effect a large net saving in electrical energy if, for example, the practical heat conductance of the electrode be diminished say 25 per cent.,

even though in doing so the electrical conductance be diminished say 50 per cent. or more. The energy losses by heat radiated from electrodes are frequently large and serious, and even a small percentage of saving therein can easily compensate for and more than permit a very considerable increase of their electrical resistance.

Having thus described my invention what I claim is:

1. An electrode provided with heat-retarding gaps or recesses extending inwardly from its periphery transverse to the general direction of heat flow through the electrode; substantially as described.
2. An electrode having encircling heat-retarding peripheral recesses; substantially as described.
3. An electrode having encircling heat-retarding peripheral recesses said recesses narrowing inwardly; substantially as described.
4. An electrode having encircling heat-retarding peripheral recesses containing ma-

terial of lower heat conductivity than the material constituting the main substance of the electrode; substantially as described.

5. An electrode having heat-retarding peripheral annular recesses; substantially as described.

6. An electrode having heat-retarding peripheral annular recesses containing material of lower heat conductivity than the material constituting the main substance of the electrode; substantially as described.

7. A carbonaceous electrode having heat-retarding gaps or recesses transverse to the general direction of heat flow through the electrode, said heat-retarding gaps or recesses containing a compound of aluminum; substantially as described.

In testimony whereof I affix my signature, in presence of two witnesses.

JOSEPH W. RICHARDS.

Witnesses:

M. A. BILL,
H. M. LEWIS.

J. W. BROWN.
ELECTRODE.

APPLICATION FILED JULY 28, 1911.

1,091,559.

Patented Mar. 31, 1914.

Fig. 2.

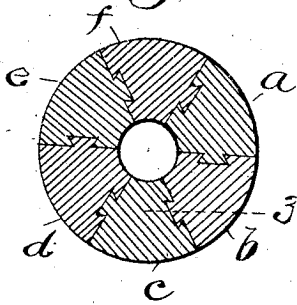


Fig. 1.

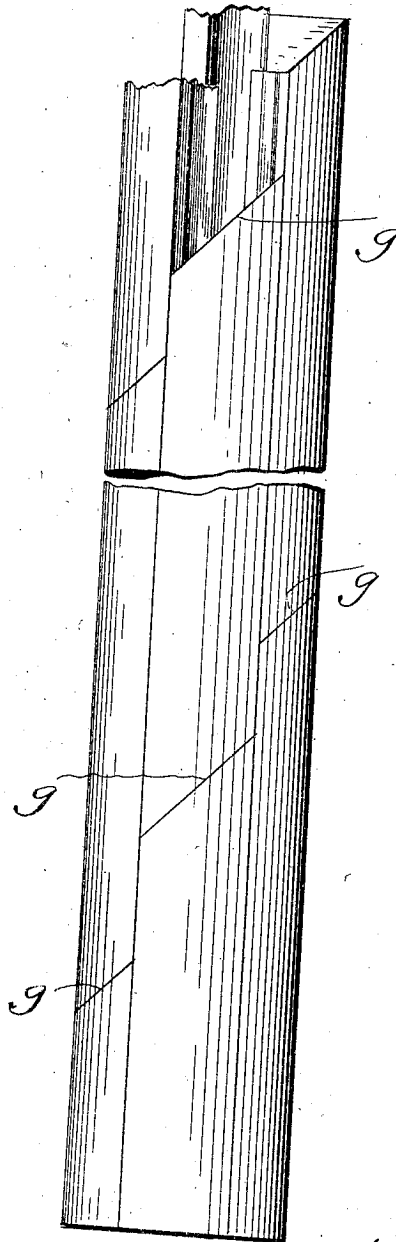


Fig. 4.

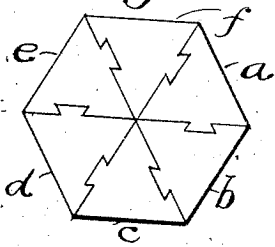
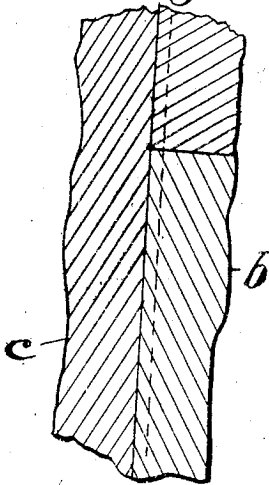


Fig. 3.



Witnesses

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H. P. Sullivan

Inventor
John W. Brown
by Thurston & Lewis
Atty

UNITED STATES PATENT OFFICE.

JOHN W. BROWN, OF LAKEWOOD, OHIO, ASSIGNOR TO NATIONAL CARBON COMPANY,
OF CLEVELAND, OHIO, A CORPORATION OF NEW JERSEY.

ELECTRODE.

1,091,559.

Specification of Letters Patent. Patented Mar. 31, 1914.

Application filed July 28, 1911. Serial No. 641,123.

To all whom it may concern:

Be it known that I, JOHN W. BROWN, a citizen of the United States, residing at Lakewood, in the county of Cuyahoga and State of Ohio, have invented a certain new and useful Improvement in Electrodes, of which the following is a full, clear, and exact description.

This invention relates to electrodes of large size such as may be used in electric furnaces, and under similar circumstances, the object of the invention being to produce a built-up electrode, that is, one which is made of several segments or parts that are suitably secured together to form a unitary structure.

A further object is to construct an electrode which may be continually built up and added to as the electrode is consumed in its use.

Generally speaking, the invention comprises the elements and combinations thereof set forth in the accompanying claims.

Reference should be had to the accompanying drawings forming a part of this specification in which—

Figure 1 is a vertical elevation of one form which the electrode may assume. Fig. 2 is a horizontal cross section of the showing in Fig. 1. Fig. 3 is a partial vertical section upon the line 3—3 of Fig. 2. Fig. 4 is a top plan view of a modified form of electrode.

It is the usual practice at the present time to make electrodes such as are used in electric furnaces by forcing a suitable carbon mix through a suitable die which produces a solid electrode of the desired size. Such electrodes after being baked, are ready for use. The size or diameter of electrodes which may be thus forced is limited and this limiting size is reached when the friction between the die and mix retards the movements of the outer portion of the mix to such an extent that the central part of the mix moves faster than the sides, resulting in the uneven forcing of the mix, which produces checks and cracks in the finished electrode.

The limit as to diameter of electrode which may be forced is much below that which it is frequently desired to force. Hence the larger size electrodes must be otherwise made, if at all, and one way of accomplishing the making of large elec-

trodes is herein shown. However, it should be understood that no limitation is herein intended to be placed upon the size of electrodes which may be produced, for the invention is susceptible of being used in the manufacture of electrodes of any size desired.

The electrode shown in Figs. 1 and 2 is cylindrical and is composed of the segments *a, b, c, d, e* and *f*, although the precise number of segments is not essential, that being a matter of choice. The segments are secured each to the other, and as one means for the purpose, the segments may be keyed together, that is, each segment may be provided with a groove and projecting ribs upon opposite sides thereof, the groove being complementary to the rib. In assembling the various segments, the rib upon each segment engages with the groove upon the segment adjacent to it, as will readily be understood from an inspection of the drawing. Preferably, the rib and groove should engage each other with a wedging action in order that the segments may come close together, and therefore the ribs are shown with sides which slant so that the part of the rib which joins the body is the narrowest part thereof. The grooves are undercut in a manner to complement the ribs. When the sections are thus formed, they are assembled by starting a rib of one segment into the groove upon another segment, at one end of such groove, and then sliding one or the other or both of the segments longitudinally until they are correctly positioned with respect to each other. The segments should fit snugly together, otherwise the resistance of the electrode will be greatly increased. The segments may be prepared either by forcing through suitable dies or in any other manner which may be found suitable.

It will be readily seen that an electrode constructed as just described may be either solid or cored, the first form being shown in Fig. 4, while the second form is shown in Fig. 2. If it is desired to produce an electrode of a predetermined length, the segments are preferably of one piece, and each end of the electrode is finished flat. At the present time, it is the practice to use electrodes in an electric furnace of a predetermined length and these electrodes are used until all is consumed but the butt end, which is that part engaged by the electrode holder.

When the electrode is consumed, the butt end is removed and discarded as waste, and a new electrode inserted in its place.

As was stated in the first part of this specification, an electrode constructed in accordance with this invention may be so made that it may be continually built up while being held in a suitable furnace electrode holder, and the electrode fed into the furnace as the active end thereof is consumed. Such a construction has advantages which at once become apparent,—namely,—no loss of material in the form of stubs; no loss of time to replace an electrode which has been consumed, these, together with other advantages which are more or less germane to those given. In carrying out this idea, it is proposed to start an electrode with a series or set of electrodes which vary in height or length. Therefore, the first set of electrodes will present the appearance of spiral steps. These segments are joined together in the same manner as has heretofore been indicated. To the first series of segments, there is added a second series which are of equal length, these being fitted upon the segments of the first set, from which it will be apparent that the ends of the second set of segments also present the appearance of spiral steps. The ribs and grooves of the second set of segments engage with the ribs and grooves of the first set throughout portions of their length and in building up an electrode when a third set of segments is added, they will engage with the second set and so on *ad infinitum*. The reason for starting the electrodes with the segments of varying length is that the joints in the various segments, as they are built up, may break with each other, and thus produce an electrode of unbroken continuity. The ends of the segments are preferably beveled as indicated at *g* in Fig. 1. When, therefore, two alined segments engage each other, there is a wedging action between them which forces them into close relationship with each other and with adjacent segments.

Fig. 4 illustrates an electrode having a different external form than that shown in Figs. 1 and 2, although the construction is otherwise the same. It is therefore intended to place no limitation as to the external shape which the electrode may assume. If desired, the contacting surfaces of the various segments of the electrode may be coated

with some form of cementitious material which will cause the adjacent segments to adhere to each other. When a hollow or cored form of the electrode herein shown is used the continuity of the hollow portion may be interrupted in any desired manner either by the use of solid or grinding material completely or partially filling the hollowed portion.

Having thus described my invention, what I claim is:

1. An electrode comprising a plurality of segments, each segment being formed with an undercut rib and a complementary groove, the rib upon each segment fitting in a groove of an adjacent segment.

2. An electrode adapted to be continuously built up comprising a plurality of segments which are secured to each other, an end of each segment being beveled, other segments having beveled ends in alinement with the first mentioned segments, the last mentioned segments being joined to each other and to the first mentioned segments, the beveled ends of the segments cooperating to bring the segments into close engagement with each other.

3. An electrode adapted to be continuously built up comprising a plurality of segments keyed to each other, and other segments in alinement with the first mentioned segments, the last mentioned segments being keyed to each other and keyed to the first mentioned segments, the joints between the alined segments being staggered with respect to each other.

4. An electrode adapted to be continuously built up comprising a plurality of segments, each segment being formed with an undercut rib and a complementary groove, the ribs upon each segment fitting in the groove upon the segment adjacent thereto, other segments formed with ribs and grooves and adapted to engage with the ribs and grooves upon the first set of segments, the said second set of segments being in alinement with the first set of segments and the joints between the two sets of segments being staggered with respect to each other.

In testimony whereof, I hereunto affix my signature in the presence of two witnesses.

JOHN W. BROWN

Witnesses:

A. J. HUDSON,
H. R. SULLIVAN.

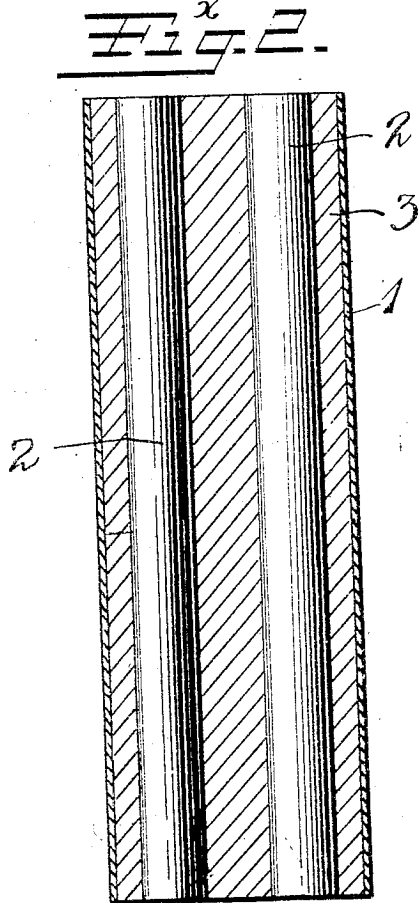
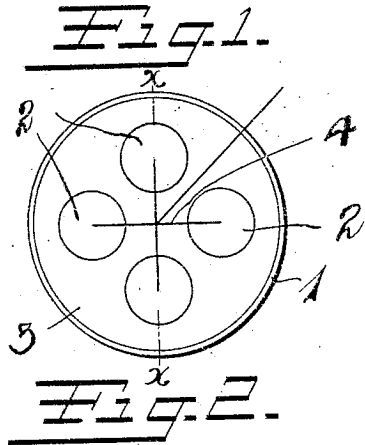
F. J. MACHALSKE.

ELECTRODE.

APPLICATION FILED JUNE 27, 1913.

1,099,558.

Patented June 9, 1914.



Witnesses:
Chas. W. ...
John J. Grote

Inventor
F. J. MACHALSKE
By his Attorneys
Partlett, Prinnell & ...

UNITED STATES PATENT OFFICE.

FLORENTINE J. MACHALSKE, OF PLATTSBURG, NEW YORK, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AMERICAN FERROELECTRIDE CORPORATION, OF PLATTSBURG, NEW YORK, A CORPORATION OF NEW YORK.

ELECTRODE.

1,099,558.

Specification of Letters Patent.

Patented June 9, 1914

Application filed June 27, 1913. Serial No. 776,157.

To all whom it may concern:

Be it known that I, FLORENTINE J. MACHALSKE, a citizen of the United States, residing at Plattsburg, Clinton county, New York, have invented certain new and useful Improvements in Electrodes, of which the following is a full, clear, and exact description.

My invention relates to improvements in electrodes for smelting furnaces, and has for its object to provide an electrode which shall supply current through a large area and at the same time shall not have a large area of carbon.

It further has for its object to provide an electrode which shall be largely composed of slag-producing material.

The following is a description of an embodiment of my invention, reference being had to the accompanying drawings, in which—

Figure 1 is a plan view of an electrode embodying my invention, and Fig. 2 is a longitudinal section of the same on the line $x-x$ Fig. 1.

Referring more particularly to the drawings, 1 is a casing, preferably sheet iron.

2 is a plurality of carbon rods within said casing. These rods may be of ordinary carbon or may be of artificial graphitic carbon or graphite, the former being preferred on account of cheapness. Within the casing, and filling the spaces around the carbon rods, is a filler 3 of magnesium oxid, or, as found in a state of nature, dolomite, calcium-magnesium carbonate ($MgCaC_2O_6$). This magnesium oxid, before being placed in the casing, is mixed with a suitable binder, such as hot tar or silicate of soda, only enough of the binder being used to form the oxid into a cohering mass. The oxid with its binder is tamped in place within the casing so as to form a solid mass, and after the casing is filled, the electrode is baked so as to expel all the moisture therefrom. The carbon rods are provided with suitable electric connections 4 at one end so that they can be connected to a source of electric current.

In operation, the electrode is used in an electric smelting furnace in the ordinary way, the lower end of the electrode being applied to the charge. As the current is supplied to the electrode, it passes through

the carbon rods, heating their lower ends to incandescence and heating the surrounding magnesium oxid also to incandescence. Magnesium oxid, as is well known, is a refractory magnesium compound and has the peculiar property of becoming a conductor of comparatively low resistance when highly heated. The lower end of the electrode, as a whole, therefore, becomes incandescent as the current passes, and forms an incandescent area of relatively large extent in contact with the charge. Moreover, the incandescent portion of the electrode is very largely composed of magnesium oxid ("dolomite" $CaMgC_2O_6$) and only to a small extent composed of carbon so that there is little carbon exposed to the molten metal at any time. Moreover, the lower ends of the carbon rods, as they are heated, become automatically converted by the electric current into artificial graphite, which is not substantially acted upon by the molten metal or dissolved thereby. A minimum amount of carbon is, therefore, introduced into the molten metal by reason of the use of my electrodes. Moreover, the magnesium oxid ("dolomite" $CaMgC_2O_6$) is a slag-forming compound, so that the heat supplied is practically always supplied through slag and the carbon in the electrode is practically kept out of contact with the molten metal and the carburizing of the metal is reduced to a minimum.

What I claim is:

1. In an electrode for smelting furnaces, the combination of a refractory magnesium compound of relatively high conductivity when heated, and carbon, the magnesium compound providing the major portion of the conducting surface.

2. In an electrode for smelting furnaces, the combination of a refractory magnesium compound of relatively high conductivity when heated, and graphite, the magnesium compound providing the major portion of the conducting surface.

3. In an electrode for smelting furnaces, the combination of a refractory magnesium compound of relatively high conductivity when heated, and carbon closely associated therewith, the latter forming a conducting path extending lengthwise of said electrode.

4. In an electrode for smelting furnaces, the combination of a refractory magnesium

compound of relatively high conductivity when heated, and a carbon rod closely associated therewith, the latter forming a conducting path extending lengthwise of said electrode.

5. In an electrode for smelting furnaces, the combination of a refractory magnesium compound of relatively high conductivity when heated, and a plurality of carbon rods closely associated therewith, the latter forming conducting paths extending lengthwise of said electrode and embedded in said magnesium compound.

6. In an electrode for smelting furnaces, the combination of a refractory magnesium compound of relatively high conductivity when heated, and a plurality of carbon rods associated therewith, the latter forming conducting paths extending lengthwise of said electrode.

7. In an electrode for smelting furnaces, the combination of a refractory magnesium compound of relatively high conductivity when heated, and carbon closely associated

therewith, the latter forming a conducting path extending lengthwise of said electrode, and a sheath surrounding the magnesium compound and carbon.

8. In an electrode for smelting furnaces, the combination of a refractory magnesium compound of relatively high conductivity when heated, and a plurality of electrically connected carbon rods associated therewith, the latter forming conducting paths extending lengthwise of said electrode.

9. In an electrode for smelting furnaces, the combination of a refractory magnesium compound of relatively high conductivity when heated, a plurality of electrically connected carbon rods associated therewith, the latter forming conducting paths extending lengthwise of said electrode, and a sheath surrounding the magnesium compound and carbon rods.

FLORENTINE J. MACHALSKE.

Witnesses:

W. H. CLARK,

T. G. HOYT.

BEST AVAILABLE COPY

F. J. MACHALSKE.

ELECTRIC FURNACE.

APPLICATION FILED JUNE 27, 1913.

1,099,559.

Patented June 9, 1914.

Fig. 1.

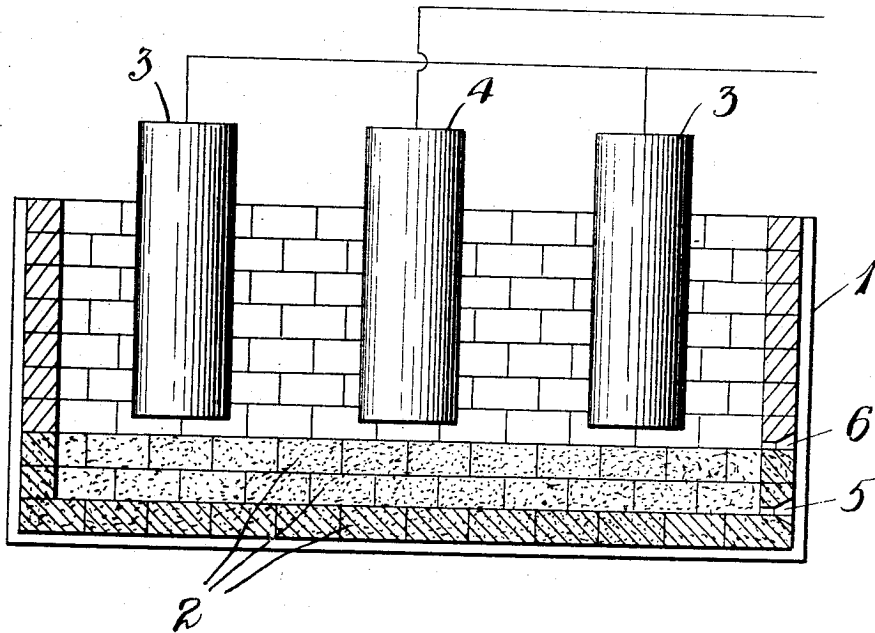


Fig. 2.

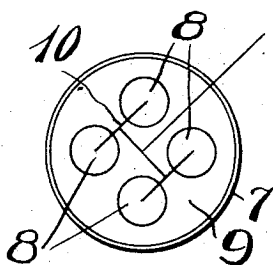
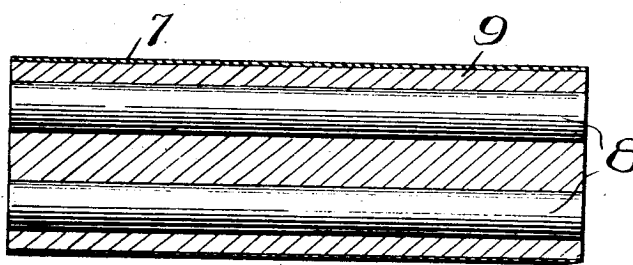


Fig. 3.



Witnesses:
Chas. A. ...
John J. ...

Inventor
F. J. MACHALSKE
By his Attorney
Bartlett, Maxwell & Melville

UNITED STATES PATENT OFFICE.

FLORENTINE J. MACHALSKE, OF PLATTSBURG, NEW YORK, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AMERICAN FERROELECTRIDE CORPORATION, OF PLATTSBURG, NEW YORK, A CORPORATION OF NEW YORK.

ELECTRIC FURNACE.

1,099,559.

Specification of Letters Patent.

Patented June 9, 1914.

Application filed June 27, 1913. Serial No. 776,158.

To all whom it may concern:

Be it known that I, FLORENTINE J. MACHALSKE, a citizen of the United States, residing at Plattsburg, Clinton county, New York, have invented certain new and useful Improvements in Electric Furnaces, of which the following is a full, clear, and exact description.

My invention relates to electric furnaces and has for its object to provide an electric furnace for smelting ores, more particularly iron ores, having a permanent lining which is practically unaffected by the molten metal and does not combine therewith so as to produce impurities therein.

In electrically smelting ores, especially where the furnace charges are of basic character, an ordinary carbon lining will not resist the action of the molten metal or the slag and a lining of other refractory materials like magnesite brick, while partly resisting the action of the slag, will not resist the action of molten iron. Linings such as either of those above mentioned which are now commonly used, are destroyed very rapidly, and, moreover, where an ordinary carbon lining is used, the carbon enters into combination with the molten metal, thereby affecting its properties and reducing its value.

I have discovered that if the lining of a smelting furnace, where it comes in contact with the molten iron, is made of electrically produced graphite and at other points is made of a suitable refractory material, the above mentioned objections and difficulties are overcome, so that the life of the lining is of long duration and the iron is not affected by the combination of the lining with the molten metal.

The following is a description of an embodiment of my invention, reference being had to the accompanying drawings, in which—

Figure 1 represents a cross section of a furnace of the open type, Fig. 2 is a plan view of one of the electrodes, and Fig. 3 is a longitudinal section of the same.

Referring more particularly to the drawings, 1 is the casing of the furnace having at its bottom a layer of bricks of artificial graphitic carbon or graphite, namely, electrically treated carbon known as Acheson graphite. The subjecting of ordinary car-

bon to the heat of an electric arc converts it into such artificial graphite and produces a substantially pure graphite product greatly superior to native graphite for my purposes. The lower portion of the walls of the furnace is composed of bricks of the artificial graphite. In the drawings the two layers of brick 2 are of this artificial graphite brick. In the furnace I use, the graphite brick upon the walls extends upward a distance of about six inches from the bottom. Above the graphite brick, the walls are composed of magnesite (magnesium carbonate) brick, this being a highly refractory material which is practically unaffected by the slag. 3-3-4 are electrodes which are inserted in the charge, being located near the bottom of the furnace at the start, and after the charge has become somewhat heated, raised so as to be slightly above the upper surface of the molten metal and surrounded at their lower ends by the slag. The electrodes 3-3 are connected to one terminal of a source of current, while the electrode 4 is connected to the other terminal of said source. The furnace is provided with a tap hole 5 at the bottom for drawing off the molten metal and a tap hole 6 located just above the graphite portion of the walls for drawing off the slag.

In connection with this furnace I prefer to use a special form of electrode, although other forms may be used. This form of electrode is shown in detail in Figs. 2 and 3 and consists of a metal sheath or casing 7 of any desired diameter, preferably of sheet iron, the diameter which I have used being about twenty inches. Within this metal sheath or casing, and extending the full length thereof, are four carbon rods 8, which, for the sake of cheapness, may be of ordinary carbon, although they may also be of graphite. The space within the casing surrounding the four carbon rods is filled with a filling 9 of closely packed magnesium oxid or "dolomite" (calcium-magnesium carbonate— $MgCaC_2O_6$). I mix the filler (magnesium oxid or dolomite) with some binding material, such as tar or silicate of soda, the binder, when tar is used, being heated during the mixing process. I use only enough of the binder to form the filler (magnesium oxid or dolomite) into a cohering mass. After the filler

mixture is packed into the casing around the carbon rods, the electrode is thoroughly baked to drive off any remaining moisture. The carbon rods when the electrode is in use are electrically connected together as at 10 and to the source of current. With such an electrode when it is used in a furnace, the lower ends of the carbon rods first become highly heated by the passage of the current and then communicate the heat to the lower portions of the magnesium oxid surrounding the same, which then becomes a conductor of relatively low conductivity, with the result that the electrode has when in use a very extended incandescent area at its lower portion, which condition is the desired condition in a smelting furnace. The magnesium oxid (dolomite) being a slag forming element, adds to the slag formed in the furnace and protects the molten metal from the carbon. The lower ends of the carbon rods, however, are quickly converted into graphitic carbon or artificial graphite so that even if they come in contact with the molten metal, they are not attacked thereby nor is the metal combined therewith so as to be carburized. The particular composition and construction of the electrode above referred to, while disclosed herein, is not claimed herein, being the subject matter of another application filed simultaneously herewith Serial No. 776157.

In operating the furnace, the tap 6 is ordinarily left open so as to drain off the

slag. The tap 5 is opened from time to time so as to drain off the molten metal, the molten metal being maintained at a height corresponding to the height of the graphite portion of the walls of the furnace during substantially the period of operation of the furnace. When the furnace is tapped to draw off the molten metal, more of the charge is shoveled in so as to quickly make up for the metal drawn off. The charge used in operating this furnace should be a basic charge as distinguished from an acid charge, and is preferably of the character described in another application filed simultaneously herewith Serial No. 776,156, viz., a charge in which artificial graphite is used as the reducing or de-oxidizing agent.

What I claim is:

1. A furnace having its bottom and the lower portions of its side walls lined with artificial graphitic carbon and having the adjacent portions of its walls covered with magnesite.

2. A furnace having its bottom and the lower portions of its side walls lined with artificial graphitic carbon and having the adjacent portions of its walls covered with a magnesite lining and having taps located adjacent to the bottom of the furnace and at the top of the graphitic lining.

FLORENTINE J. MACHALSKE.

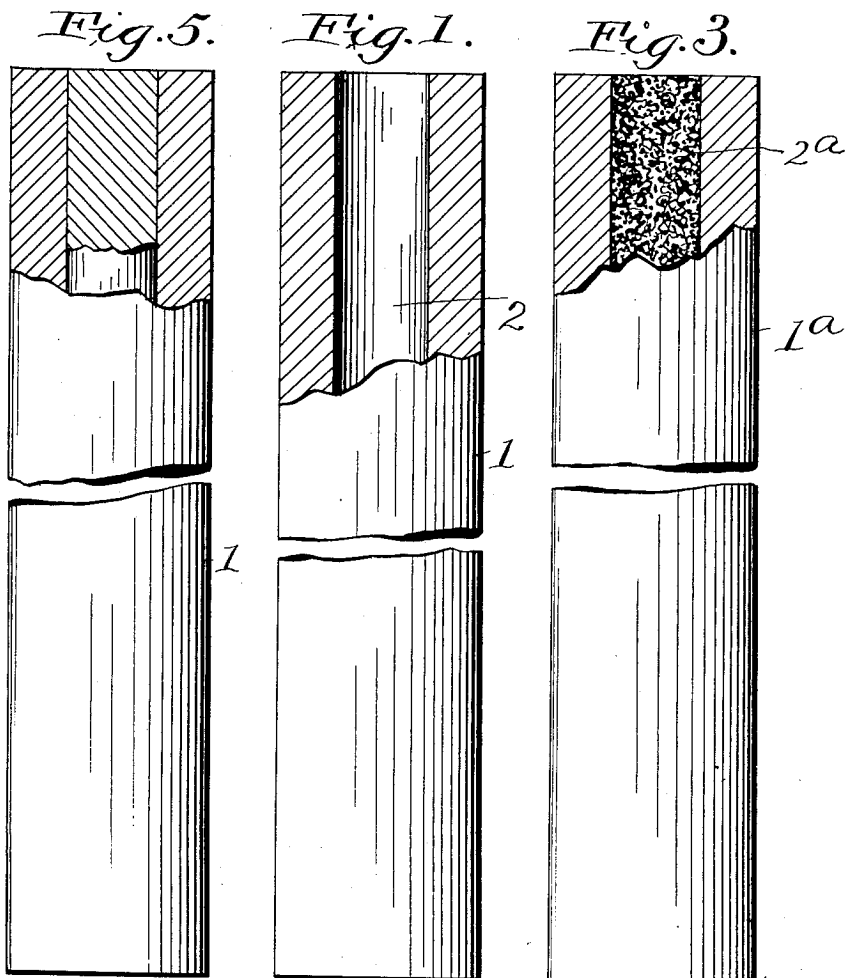
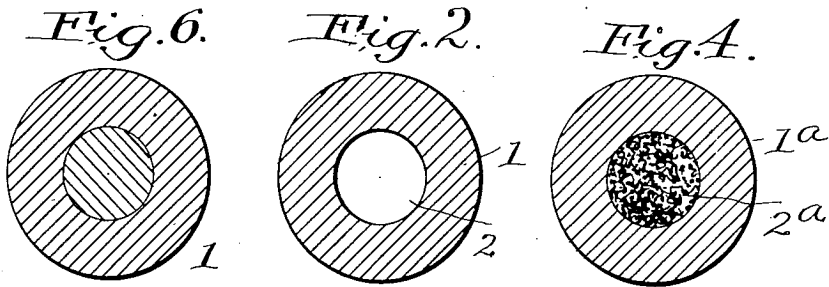
Witnesses:

W. H. CLARK,
T. G. HOYT.

R. L. SEABURY,
ELECTRODE.
APPLICATION FILED AUG. 2, 1911.

1,115,027.

Patented Oct. 27, 1914.
2 SHEETS—SHEET 1.



Witnesses
E. B. Gilchrist,
H. B. Sullivan

Inventor,
Ralph L. Seabury
by Thurston & Hurler
attys

R. L. SEABURY.

ELECTRODE.

APPLICATION FILED AUG. 2, 1911.

1,115,027.

Patented Oct. 27, 1914.

2 SHEETS—SHEET 2.

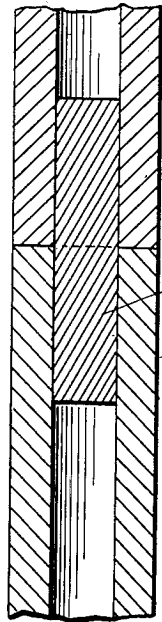


Fig. 7.

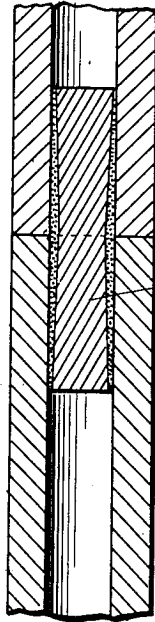


Fig. 8.

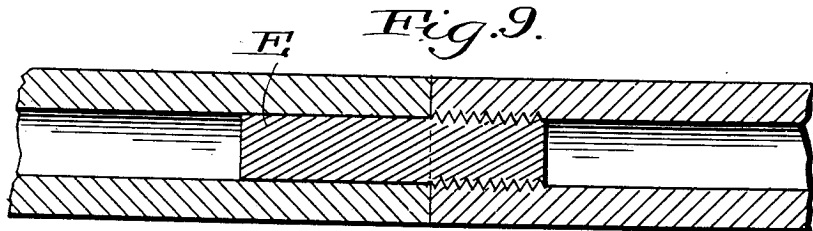


Fig. 9.

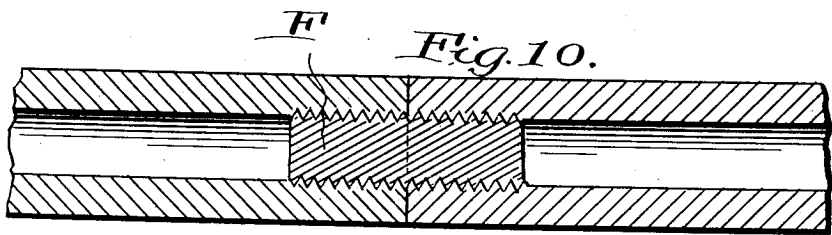


Fig. 10.

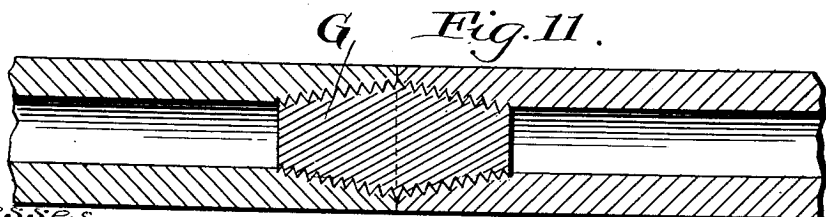


Fig. 11.

Witnesses.
E. B. Gilchrist.
H. B. Sullivan.

Inventor
Ralph L. Seabury
by Thurston & Harris
Attys

UNITED STATES PATENT OFFICE.

RALPH L. SEABURY, OF LAKEWOOD, OHIO, ASSIGNOR TO NATIONAL CARBON COMPANY, OF CLEVELAND, OHIO, A CORPORATION OF NEW JERSEY.

ELECTRODE.

1,115,027.

Specification of Letters Patent.

Patented Oct. 27, 1914.

Application filed August 2, 1911. Serial No. 641,919.

To all whom it may concern:

Be it known that I, RALPH L. SEABURY, a citizen of the United States, residing at Lakewood, in the county of Cuyahoga and State of Ohio, have invented a certain new and useful Improvement in Electrodes, of which the following is a full, clear, and exact description.

This invention relates to carbon electrodes, primarily intended for use in electric furnaces, and seeks to provide an electrode which will more uniformly distribute the heat generated incident to its use, to the charge of material operated upon and also will apply the heat over a greater area of the furnace charge than is possible with electrodes as at present constructed.

Furthermore, the invention comprises a method by which it is possible to form electrodes of a greater size by forcing them through dies than is possible under the present method of forming electrodes.

The invention also includes the fastening of the electrodes together to form a continuing electrode which may be lowered into the furnace as it is used.

Generally speaking, the invention comprises the elements and combinations thereof set forth in the accompanying claims.

Reference should be had to the accompanying drawings, in which—

Figure 1 is a front elevation, partly in section of one form of my invention; Fig. 2 is a horizontal cross section thereof; Fig. 3 is a front elevation partly in section of another form of electrode; Fig. 4 is a horizontal cross section thereof; Fig. 5 is a vertical elevation partly in section of a third form of electrode; Fig. 6 is a horizontal section thereof; Figs. 7, 8, 9, 10 and 11 are longitudinal cross sections of abutting electrodes showing means for securing them together.

At the present time, in the making of electrodes for electric furnaces and in general electrodes of large size, it is customary to form them by forcing a proper mix through dies which deliver the electrode as one solid piece of carbon. These electrodes may be made in various shapes, but the most common form is round. The electrodes are next baked and are then ready for use. When such solid electrodes are used in an electric furnace, but a short time elapses until the active end of the electrode or the end

of the electrode which is adjacent the charge in the furnace, becomes pointed, and by so much reduces the area of the electrode which is adjacent the arc, and from which the arc must spring. Inasmuch as the arc travels over all the surface of the electrode which is presented to the charge, it will be apparent that as the end of the electrode approaches a point, the area of the charge upon which the arc is acting is being constantly reduced, and by so much, the zone of activity in the furnace is reduced.

In Fig. 1 there is shown an electrode 1 which is cylindrical, although not necessarily so, this form being merely illustrative. Through the center of the electrode there is a cored out portion or cylindrical opening 2, which may be of any suitable dimension, and of course is proportional to the external diameter of the electrode. This electrode may be formed in the usual manner by forcing through dies, it merely being necessary to use a form of die which will produce the central opening. Such an electrode is baked in the usual manner and is then ready for use.

When an electrode, such as has been described, is used in an electric furnace, it will at once be seen that the electrode cannot burn to a point, and therefore this electrode overcomes a serious cause for objection in solid electrodes which has heretofore been pointed out, but further, the construction shown has a positive advantage in that for a given cross sectional area of carbon, the zone of operation of the electrode, or in other words, the area of the bath to be treated, which is affected by the arc spring from the electrode is much greater than where a solid electrode is used. Therefore from the fact that the heat developed by the passage of the current is distributed over a greater area of the bath, it follows that the zone of activity in the furnace is also enlarged.

In some instances, it may be undesirable to use an electrode having an open passage throughout the length thereof, and in such an event, means may be employed to obstruct the continuity of the passage or central opening, and as one means for accomplishing this result, I have shown the construction disclosed in Figs. 3 and 4, wherein the electrode body 1^a is provided with the

opening 2^a, which opening is filled with some refractory material, as for instance, granular carbon. This may be mixed with some suitable binding material and inserted in the electrode, either before the electrode is baked, in which event, it is baked at the same time as the electrode, or the granular carbon mixture may be inserted after the latter has been baked and in this condition used in the electric furnace. Aside from the advantages to be derived by the use of an electrode constructed as shown and described, additional advantage is gained in the ease of manufacture, particularly of electrodes of large size.

Practically all electrodes are made by forcing the carbon mixture through dies to give them their form, and it is found in forcing solid electrodes that a limit as to size is soon reached, for the friction of the material upon the sides of the die becomes so great that the portions of the mass being forced which are pressing against the sides of the die are retarded in their movement, while the central portion of the mix moves faster than the sides thereof, which, of course results in an imperfect electrode and produces cracks and check marks upon the exterior portion, which upon baking becomes more accentuated. However, if the electrode be cored, as shown in Figs. 1 and 2, the whole situation is changed, for the friction of the moving mix upon that portion of the die which forms the core, prevents the central portion of the mix from moving faster than the outer portions of the mix. Therefore, the resultant electrode is more uniform and may be forced without the objectionable results encountered when forcing a large solid electrode. Therefore, it is possible to force electrodes in this manner of considerably larger diameters than is possible in the case of solid electrodes. This then presents an advantage, inasmuch as it permits the manufacture of electrodes having cross sectional surface areas which may affect larger areas of the furnace bath or charge when they are used in an electric furnace than is possible to obtain with solid electrodes. However, if it be desired to produce a solid electrode of large diameter, it may be accomplished by first forcing a hollow carbon body having an external diameter, the same as that desired for the solid electrode. Then forcing a carbon body of a diameter to snugly fit the hollow or cored out portion of the first carbon body, and while both bodies are still in their green state, placing the second carbon body within the hollow portion of the hollow carbon body, and then while the two electrodes are in this assembled condition baking them. It is found that when two bodies are treated in this way, after baking the two bodies are substantially uni-

tary and inseparable. In this way solid electrodes may be made which it would be absolutely impossible to force through dies.

At present carbon electrodes when used in an electric furnace are supported by suitable means which permits of the lowering of the electrode into the furnace as the electrode is consumed. The use of the electrode continues until such time as there remains only a butt or stub portion, which is that portion of the electrode grasped by the means which supports it. It is customary to remove these butts, which are then useless and to replace the consumed electrode by a new electrode.

With the hollow electrode herein shown and described, it is possible to join electrode to electrode in such a manner as to produce a continuously built up electrode.

The successive electrodes may be joined together in any suitable manner, several of which are suggested in Figs. 7 to 11 inclusive. In Fig. 7, the electrode A is joined to the electrode B, by means of a plug or rod C, which is of conducting material and is formed so as to snugly fit within the cored out or hollow portion of the electrodes A and B. In Fig. 8 there is shown a plug D for joining the electrodes, this plug being tapered from both ends toward the center. The spaces between the tapered sides of the plug and the walls of the electrode may be filled with any suitable granular conducting material which will insure good electrical conductivity between the walls of the two electrodes. In Fig. 9, the plug or rod E is inserted within the hollow portion of one of the electrodes and is caused to fit snugly therein, while the opposite end of the plug is screw threaded and is adapted to fit with a screw thread formed upon the wall of the cored out portion of the electrode, which is to be joined to the first electrode. In Fig. 10, the plug or rod F is screw threaded throughout its length. The abutting ends are screw threaded within the hollow portion for a short distance, and the threads upon the plug are adapted to engage the threads upon the two electrodes so that they are substantially united. In Fig. 11, the same idea is shown as that embodied in Fig. 10, with the exception that the plug G is made with a double taper and the adjacent ends of the electrodes are formed to complement the taper upon the plug. As will be seen from the drawing, the plug and the interior walls of the electrodes are provided with screw threads which permit the plug to join the two electrodes together.

Having thus described my invention, what I claim is:—

1. An electrode for electric furnaces comprising a tubular body portion of substantially uniform cross sectional area and an-

other body of carbon occupying the interior of the tubular carbon body.

2. The process of making electrodes for use in electric furnaces which consists in forcing a tubular carbon body and a second carbon body of a diameter to fit within the tubular body, then inserting the second body within the tubular body and baking the combined bodies.
- 10 3. The process of making electrodes for use in electric furnaces, which consists in

forcing a tubular carbon body, placing carbonaceous material to substantially fill the tubular carbon body, then baking the combined bodies.

15

In testimony whereof, I hereunto affix my signature in the presence of two witnesses.

RALPH L. SEABURY.

Witnesses:

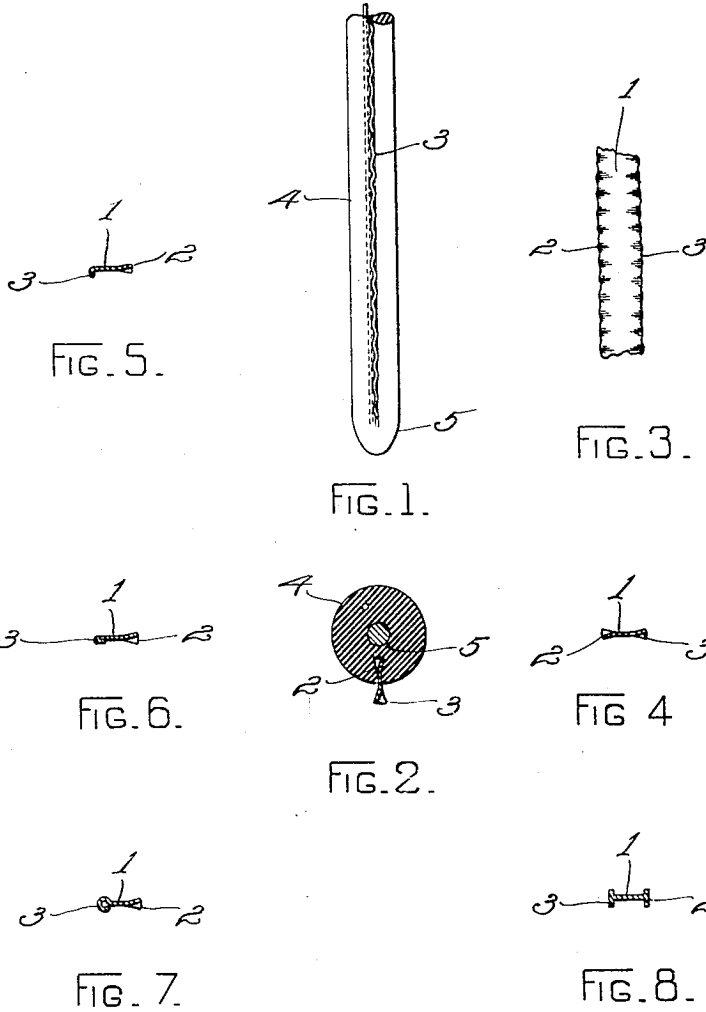
RICHARD H. HANEY,
HARRY R. ALLISON.

M. H. BAKER.
ARC LAMP ELECTRODE.

APPLICATION FILED OCT. 22, 1909. RENEWED APR. 23, 1914.

1,118,464.

Patented Nov. 24, 1914.



WITNESSES:
Joshua D. Robinson
Lester B. Allen

INVENTOR.
MALCOLM H. BAKER.
BY *Charles H. Lanning*
ATTORNEY.

UNITED STATES PATENT OFFICE.

MALCOLM H. BAKER, OF BOSTON, MASSACHUSETTS, ASSIGNOR TO AMERICAN FLAMING ARC LAMP COMPANY, A CORPORATION OF MASSACHUSETTS.

ARC-LAMP ELECTRODE.

1,118,464.

Specification of Letters Patent.

Patented Nov. 24, 1914.

Application filed October 22, 1909, Serial No. 523,990. Renewed April 23, 1914. Serial No. 833,977.

To all whom it may concern:

Be it known that I, MALCOLM H. BAKER, a citizen of the United States, and a resident of Boston, in the county of Suffolk and Commonwealth of Massachusetts, have invented certain new and useful Improvements in Arc-Lamp Electrodes, of which the following is a specification.

My invention refers particularly to the type of electrode having a longitudinal metallic feed regulating strip secured thereto, the said strip being adapted to operatively engage at its lower end with a lateral support, and thus to permit a downward feed of the electrode as the said strip is fused by the heat of the arc, the said feed regulating strip being attached to the electrode in any suitable manner. Long continued experiment with this type of electrode shows it to be of great advantage to limit the amount of metal in the feed strip. While such electrodes, and particularly flaming arc electrodes, are usually provided with an internal metallic wire to reduce ohmic resistance, and while a metallic feed strip longitudinally attached thereto serves also as a current conductor through the electrode, yet its necessary cross section as a feed strip greatly exceeds that required as a current conductor. The introduction of this relative increase of metallic mass in the feed strip tends to introduce disturbance in the operative burning of the electrode. For this reason, I have found it advantageous to limit the amount of metal in the feed strip as much as possible. Such feed strips, in general, operate in cooperation with a support upon which they rest during their gradual fusion. The radial dimension of the strip can not be limited beyond a point which gives a safe engagement between the said strip and the support. To limit the mass as desired I have, therefore, found it desirable to limit its thickness to the lowest practicable dimensions. For instance, I may employ a strip having a thickness of about .006 inches, but such a strip, particularly of a metal of low fusibility and of a low annealing point, such as aluminum which has been found well adapted for the purpose, and which I preferably employ, may be, and generally is, subjected to the heat effects of the arc for a considerable distance up from the point of support; and the said strip, carrying as it may the weight of the electrode or of inter-

connected electrodes, tends to collapse side-wise at or near the said point of support, and thus to produce an over feed of the electrode. This chance of collapse of the feed strip is notably present in aluminum, on account of the low temperature at which this metal anneals,—about 500° F., although its fusing point is 1100° F.,—and for this reason a stiffening formation for the portion of the said aluminum exterior to the electrode is practically an inherent necessity. I have sought, therefore, not only to limit the amount of metal in the strip, and to insure its firm union with the electrode, but particularly to limit the amount of metal exterior to the electrode, and to so form this exterior portion as to strengthen it laterally, and thereby to minimize the chance of strip collapse and consequent irregularity of feed, or over feed. To accomplish this result, I have developed the forms of feed strips herein shown, all of which, while of very thin cross section interior to and at the line of union with the electrode, are given a stiffening formation exterior to the said electrode, and as a preferable form, I have, after long experiment, devised and adopted a form which has the same thin cross section, but which, by means of corrugations, preferably regular longitudinally of the strip, is stiffened to a marked degree and yet without the introduction of more metal to accomplish this result. The object of this corrugation, or its equivalent, is, otherwise expressed, to maintain a constant radial alignment between the electrode slot and the feed governing strip, and the said corrugation may be applied either before or after the strip is locked in place in the electrode, but, as a convenient manufacturing method, I prefer to cut the feed strip from thin metal of uniform gage, and to give to the outer and inner edges each a corrugating formation, the outer corrugation being for the purpose of stiffening the strip, and the inner corrugation being for the purpose of locking the strip securely within the electrode slot when the said strip is drawn there through. Instead of corrugating the outer edge of the strip, I may bend, fold, or otherwise distort it, or I may merely place a series of indentations along the edge, the sole object being to give rigidity to the portion of the strip projecting outside of the body of the electrode. I may also roll or

press the strip of metal into the shape of an I beam or other equivalent shape and thereby obtain both the electrode locking and exterior stiffening results, but I prefer to use metal of uniform thickness as first described, in order to employ a minimum amount of the said metal.

I have illustrated my invention in the annexed drawings, in which—

Figure 1 is an elevation of a complete electrode provided with my improved feed regulating strip, Fig. 2 an enlarged plan of the same in section, Fig. 3 an enlarged side elevation of the strip alone, and Fig. 4 a plan of the same in section. Fig. 5 is a plan of a strip in which the reinforcement or strengthening is obtained by bending the outer longitudinal edge at right angles, Fig. 6 illustrates an edge turned over and flattened, Fig. 7 shows the edge rolled over, and Fig. 8 is a plan of a strip rolled or pressed into the form of an I beam.

In the figures, 1 is the main or central portion of the strip, 2 the inner longitudinal edge which locks in the electrode slot, and 3 the outer longitudinal or stiffening edge. The electrode appears at 4 and the electrode slot at 5.

In actual practice I have found, with the electrodes of ordinary commercial length, from 400 to 650 millimeters, that improved results are had by eliminating the usual internal conducting wire and causing its function to be performed by the feed strip. When the support and strip are properly arranged, I further find that about 80 per cent. of the total metallic mass of the strip is retained above the support and is thus prevented from entering the arc.

I claim as my invention:

1. An arc lamp electrode provided with an external longitudinal metal extension, the said extension being given a stiffening formation substantially along its outer longitudinal edge and entirely outside of the electrode.

2. An arc lamp electrode having a longitudinal externally projecting metal feed regulating extension operatively attached thereto, the portion of said extension exterior to the electrode having a stiffening formation relatively stiffer than said strip at its junction with the electrode.

3. An arc lamp electrode having, in combination with a main electrode portion provided with a longitudinal slot, a longitu-

nal externally projecting metal feed regulating strip entering said slot, the portion of said strip exterior to the main electrode portion having a stiffening formation relatively stiffer than said strip where it enters said slot.

4. An arc lamp electrode having a longitudinal external metal feed regulating strip secured thereto, the said strip having an electrode engaging longitudinal portion of substantially uniform cross section, and the exterior portion of the said feeding strip being given a stiffening formation.

5. An arc lamp electrode having, in combination with a main electrode portion provided with a slot having a contracted entrance and an inwardly expanding portion, a continuous longitudinal metal feed regulating strip having a maximum cross section substantially at its opposite longitudinal edges and a contracted portion located in said contracted portion of said slot, said strip being locked to the main electrode portion by the engagement of its inner longitudinal edge with the enlarged portion of said slot.

6. An arc lamp electrode having, in combination with a main electrode portion provided with a slot having a contracted entrance and an inwardly expanding portion, a continuous longitudinal metal feed regulating strip formed of sheet metal of substantially uniform thickness but corrugated along its longitudinal edges and having a plane portion between the said corrugated portion located in said contracted portion of said slot, said strip being locked to the main electrode portion by the engagement of its inner longitudinal edge with the enlarged portion of said slot.

7. An arc lamp electrode having a longitudinal externally projecting metal feed regulating strip secured thereto and of substantially uniform thickness, said strip having an electrode-engaging longitudinal rectilinear portion, and the external portion being laterally stiffened by corrugations extending across said external portion and located wholly externally of the electrode.

Signed at Boston, in the county of Suffolk and Commonwealth of Massachusetts this twentieth day of October, A. D. 1909.

MALCOLM H. BAKER.

Witnesses:

CHARLES D. JENNINGS,
JOSHUA D. ROBINSON.

1,150,021.

Patented Aug. 17, 1915.

2 SHEETS—SHEET 1.

Fig. 1.

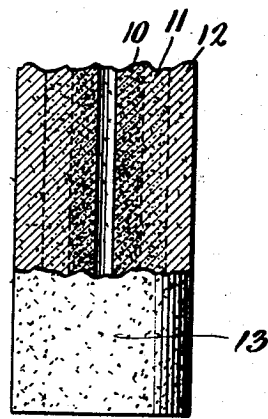
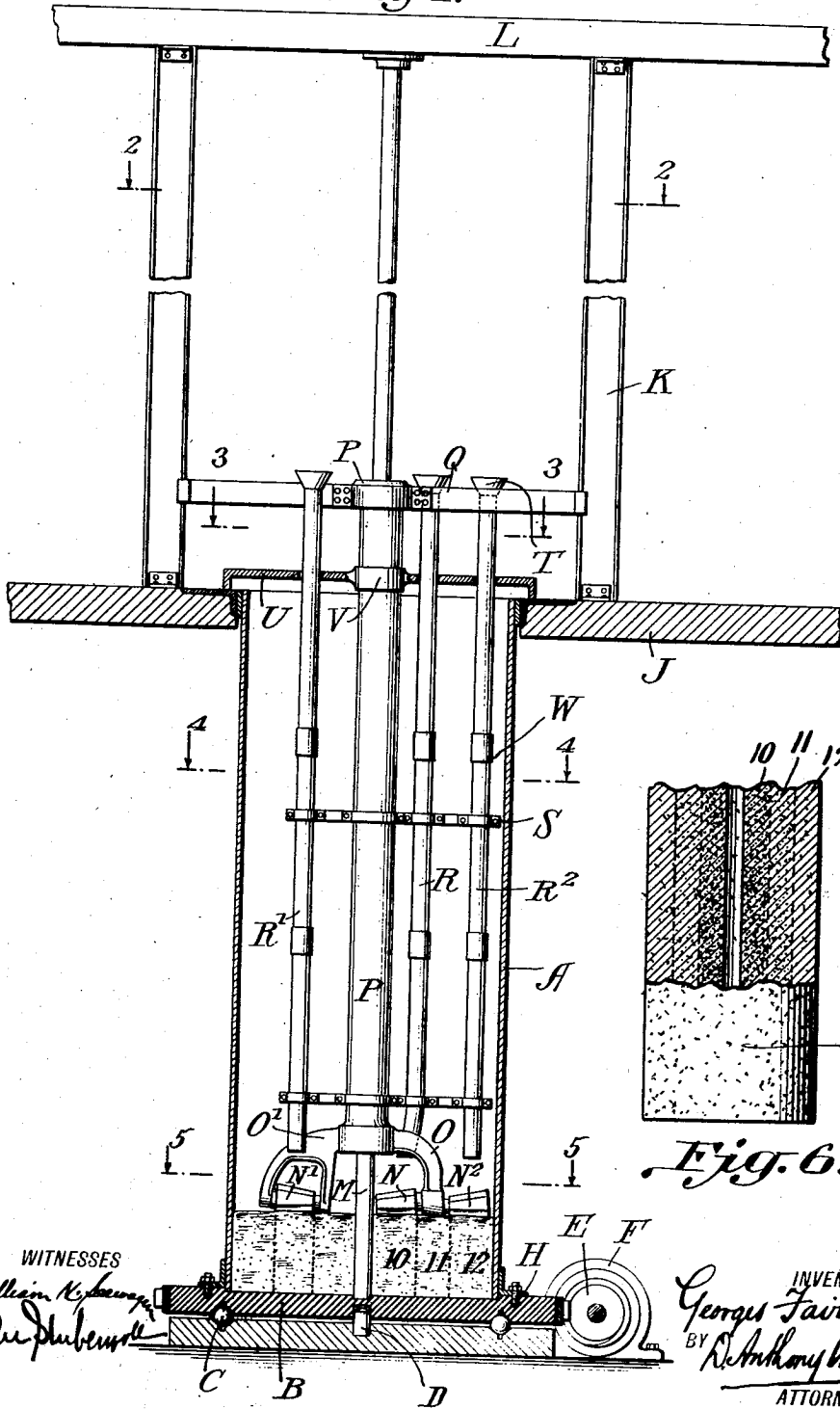


Fig. 6.

WITNESSES
William K. ...
Arthur ...

INVENTOR
Georges Favier
BY *Anthony ...*
ATTORNEY

1,150,021.

Patented Aug. 17, 1915.
2 SHEETS—SHEET 2.

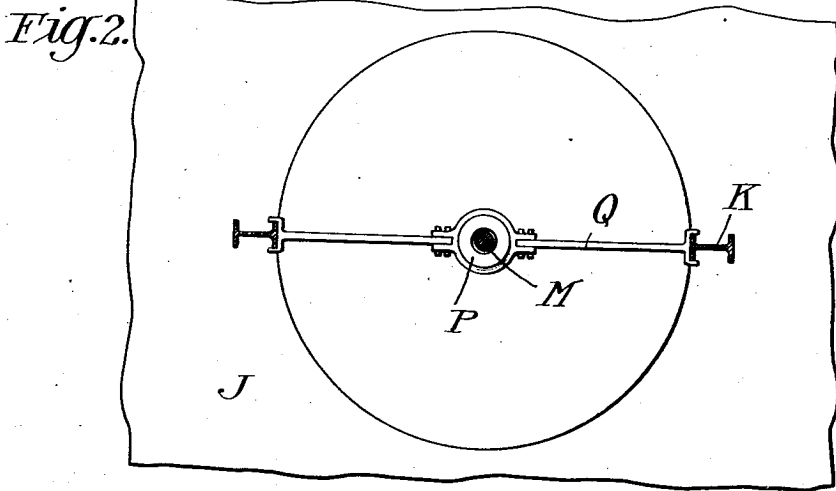


Fig. 3.

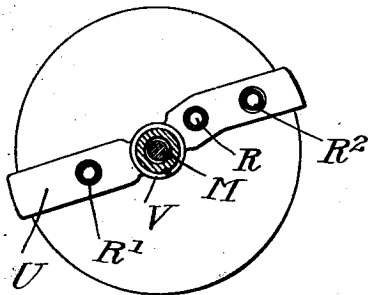
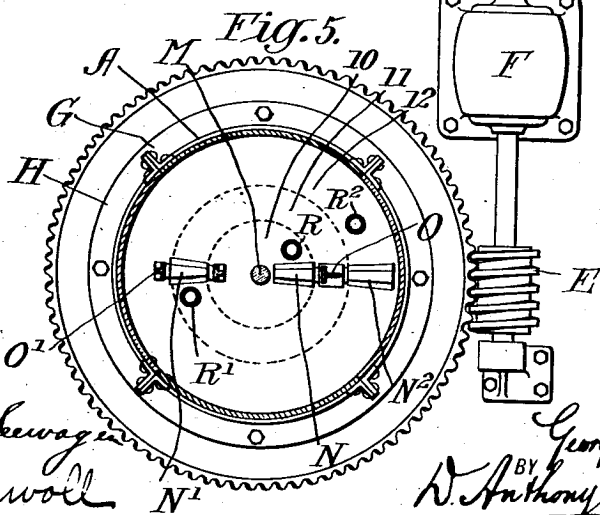
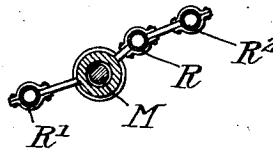


Fig. 4.



WITNESSES

William K. Seewagen
Julius Stuberwoell

INVENTOR

George Favier
BY N. Anthony Usina
ATTORNEY

UNITED STATES PATENT OFFICE.

GEORGES FAVIER, OF SUSPENSION BRIDGE, NEW YORK.

MOLDING ELECTRODES.

1,150,021.

Specification of Letters Patent.

Patented Aug. 17, 1915.

Application filed April 15, 1914. Serial No. 832,007.

To all whom it may concern:

Be it known that I, GEORGES FAVIER, a citizen of the Republic of France, residing in Suspension Bridge, New York, have invented certain new and useful Improvements in Molding Electrodes, of which the following is a specification.

This invention aims to provide certain improvements whereby electrodes of large sizes and of great length can be made with comparatively little difficulty and of a desired composition throughout their cross-section at a low cost.

My process involves two principal points of improvement and certain improvements in detail which are referred to at length hereinafter. The two principal points of improvement are the progressive pressing of the electrode paste as the length of the pressed portion gradually increases, the pressing being preferably effected by means of rollers working on the interior portion of the cross-section as well as on the outer portion; and second, the employment of special pastes which make the central portion of the electrode spongy or porous during the subsequent baking or burning thereof and which greatly facilitates such burning, the pastes being preferably graduated so as to increase the porosity gradually from the outer portion toward the center.

The accompanying drawings illustrate a suitable machine for carrying out the process.

Figure 1 is a vertical diametral section through the mold and adjacent parts, showing the parts within the mold in elevation; Figs. 2, 3, 4 and 5 are respectively horizontal sections on the similarly numbered lines in Fig. 1 the outer casing being omitted from Fig. 4. Fig. 6 is partly a longitudinal section and partly an elevation of an electrode made in accordance with this invention.

These large electrodes are used chiefly in metallurgical furnaces, but may be used in other classes of electrical apparatus.

Referring to the apparatus illustrated, a mold A of cylindrical or similar shape is mounted at its lower end upon a horizontal base B supported upon balls C and upon a pivot D and rotated continuously by means of a worm gear E driven by a motor F. The mold may be divided into four or any other desired number of segments fastened together by means of vertical flanges G

mounted thereon and bolted together as indicated in Fig. 5. At its lower end the mold is mounted on the base B by means of a similar flange H. At its upper end the mold is held in a suitable opening in the floor J which carries a pair of guides K connected by a cross beam L for a purpose hereinafter explained. At the center of the mold there is fixed a round wooden rod M fastened to the base B and extending upward clear to the cross beam L. This rod serves to guide the pressing rollers and also forms the center of the completed electrode.

The compressing of the paste of which the electrode is to be formed is accomplished by means of rollers such for example as the three rollers N, N' and N². The roller N' covers substantially the middle third of the space between the central rod M and the mold; and the rollers N and N² cover respectively the inner and the outer third of such space. These rollers may be polygonal as indicated or may be circular or may be of any other desired shape, and are preferably smaller at their inner ends to compensate for the comparatively slower rate of movement as the rollers rotate about the rod M. The rollers are mounted in arms O, O' on the lower end of a tube P which surrounds the rod M freely. The tube P extends upward above the floor J and carries arms Q, the ends of which embrace the guides K so as to prevent rotation of the tube P. Thus as the base B and mold A are rotated the central rod M is also rotated, but the rollers N, N' and N² (though rotating on their individual axes) do not rotate around the rod M. There is thus a relative rotation of the mold and of the paste therein on the one hand and the rollers N, N' and N² on the other hand.

The paste is fed continuously and regularly and is compacted by the relative movement of the rollers thereon. As the quantity of molded paste increases the rollers continually ride on the top and, therefore, rise slowly, carrying with them the entire frame P, Q on which they are mounted. There is thus produced a very thorough compacting of the paste throughout the cross section and throughout the height of the electrode. The paste may be fed into the mold in various ways and by various means using the above described method of compacting it uniformly and making it of any desired height. I prefer, however, to

feed the paste in the particular way herein-
 after described. I feed several different
 compositions of paste at different points be-
 tween the center and the outer surface of
 5 the electrode. Preferably three different
 pastes are used and each is fed just in ad-
 vance of one of the respective rollers N, N'
 and N² so as to produce a plurality of
 10 roughly outlined concentric zones or rings
 10, 11 and 12 (Figs. 1 and 5) of differing
 materials graded toward the center. The
 paste which is fed just in front of the out-
 ermost roller N² is the purest graphite or
 15 similar conducting material. The paste fed
 in front of the intermediate roller N' is a
 mixture of the paste used for the outermost
 ring with saw dust or similar material
 which will burn out during the burning of
 20 the electrode and will render the latter more
 or less spongy so as to facilitate the escape
 of the gases produced in the burning and
 thus permit a very quick and a very regular
 burning, which in turn produces an economy
 25 of time and of fuel. In front of the inner-
 most roller N there is fed a paste containing
 a still greater proportion of saw dust or the
 like. Thus an electrode of increasing poros-
 ity toward the center is produced. At the
 30 same time the distribution of the material is
 very regular and substantially the same
 throughout the cross section at all points in
 the height. The wooden rod M is converted
 into charcoal during the first moments of
 35 the burning of the electrode and by reason
 of the great porosity of such charcoal it
 forms practically a chimney for the escape
 of the gases generated. Such gases, there-
 fore, escape readily from all points in the
 40 cross section inward and do not exert any
 serious pressure upon the outer surface of
 the electrode.

In the apparatus illustrated the means
 for feeding the paste comprise a set of ver-
 45 tical tubes R, R' and R² mounted in
 brackets S carried by the tube P and pro-
 vided at their upper ends with hoppers T
 into which the material is fed at a rate
 which is uniform for the three hoppers.
 50 These hoppers are located just above a plat-
 form U which covers the top of the mold
 and facilitates access of the workmen to the
 feed hoppers. The platform U rests on the
 floor J and has a central ring V surrounding
 55 the tube P and through which this tube
 rises as the height of the molded electrode
 increases. The pipes R, R' and R² are made
 in sections of any desired length, say three
 feet, united by couplings W. When the
 60 feeding has continued sufficiently to bring
 the hoppers T more than three feet above
 the platform then the uppermost section of
 each feed pipe may be taken off and the
 hoppers may be applied to the next sections
 of the pipe so as to keep the hoppers within
 reach of the workmen on the platform U.

Though I have described with great par-
 ticularity of detail a certain apparatus yet
 it will be understood that various styles of
 apparatus may be used for carrying out my
 70 improved process. The rollers are prefer-
 ably of truncated pyramidal shapes in
 order to effect a certain amalgamation of the
 paste, but they may be conical or otherwise
 75 shaped. They may be solid or hollow or of
 practically any composition, though I pre-
 fer that their external portions shall contain
 some copper because this metal does not ad-
 here strongly to the paste. Of course, it is
 only necessary to have a relative movement
 80 of rotation of the roller-carrying frame with
 respect to the mold. Either may be rotated
 about the central axis of the mold while the
 other is held stationary with the same result
 upon the material being molded. Similarly
 85 the relative vertical movement may be se-
 cured either by causing the contacting roll-
 ers to rise as the height of the molded paste
 increases or by lowering the body of paste
 similarly. The number of rollers used may
 90 be increased or diminished according to the
 diameter of the electrode to be molded and
 other circumstances and their shape may be
 varied. Likewise the number of rings of
 paste of different compositions may be
 95 greater or less than the three described and
 their compositions may also be different
 from those described. The paste may be fed
 either by hand or by any usual or suitable
 mechanism for feeding regular quantities
 100 of such materials. The wooden rod at the
 center may be made of greater or less size
 depending on the size of the electrode and
 upon the composition of the paste and the
 expected volume of gases generated in the
 105 paste during burning. There is no great
 amount of strain on this rod and it may be
 entirely omitted, especially in electrodes of
 comparatively small diameter and other
 means used for holding the roller-support-
 110 ing frame centrally of the mold.

A portion of an electrode 13 molded ac-
 cording to this invention and then burned
 in the usual way is shown in Fig. 6.

It will thus be seen that by this process
 115 we can make electrodes of any desired diam-
 eter and of any desired length with no
 practical difficulties and that such electrodes
 may be molded of any internal composition.
 It will also be seen that the molded elec-
 120 trode will be of the greatest homogeneity
 and will permit an economical and rapid
 burning and when burned will possess in
 the highest degree the virtues of conducti-
 bility and great regularity and will be prac-
 125 tically without cracks or similar defects.

The burning referred to is necessary for
 all electrodes in order to eliminate volatile
 particles or gases. With electrodes molded
 in the old way of uniform density it has not
 130 been possible in all cases to effect a complete

distillation. Such imperfectly burned electrodes tend to break into pieces under sudden increase of temperature when in use in electric furnaces, thus stopping the operation of the furnace as well as losing the electrode. In burning an electrode of one meter diameter for example, supposing it molded in the old way of uniform density, the heat will penetrate very slowly from the outside toward the center and the distillation will generally be imperfect in the center, and there will be occasional surface irregularities due to the escape of gases outward suddenly at particular points; whereas in burning an electrode molded according to this invention, the more porous center will liberate its gases more freely, so as to compensate in a measure for the slower heating of the interior; and with a wooden core, which is quickly converted to charcoal, the heat will have quick access and the distillation products an easy exit from the central part of the electrode. Thus electrodes of this character can be burned more rapidly and more cheaply and will be found of a more uniformly good quality than those heretofore known.

What I claim is—

1. In the manufacture of electrodes the method which consists in molding the electrode of different compositions arranged in concentric zones, the inner zone having a greater percentage of combustible material

in its composition, and then burning the combustible material whereby the inner zone is rendered more porous than the outer zone. 35

2. An electrode comprising concentric zones of material of increasing porosity toward the center. 40

3. An electrode comprising concentric zones of material of increasing porosity toward the center, the particles of one zone being intermingled with those of the next to form a unitary structure. 45

4. An electrode comprising concentric zones of material of increasing porosity toward the center, the outer zone being of the most highly conductive material and the center being of charcoal. 50

5. An electrode comprising concentric zones of material of increasing porosity toward the center, the outer zone being of the most highly conductive material. 55

6. An electrode comprising concentric zones of material of increasing porosity toward the center, the center being of charcoal. 60

In witness whereof, I have hereunto signed my name in the presence of two subscribing witnesses. 60

GEORGES FAVIER.

Witnesses:

ANDREW THOMPSON,
PAUL MORRIS.

C. B. HILLHOUSE.
ART OF REDUCING METAL ORES AND FUSING OTHER MATERIALS.
APPLICATION FILED NOV. 25, 1912.

1,193,783.

Patented Aug. 8, 1916.
2 SHEETS—SHEET 1.

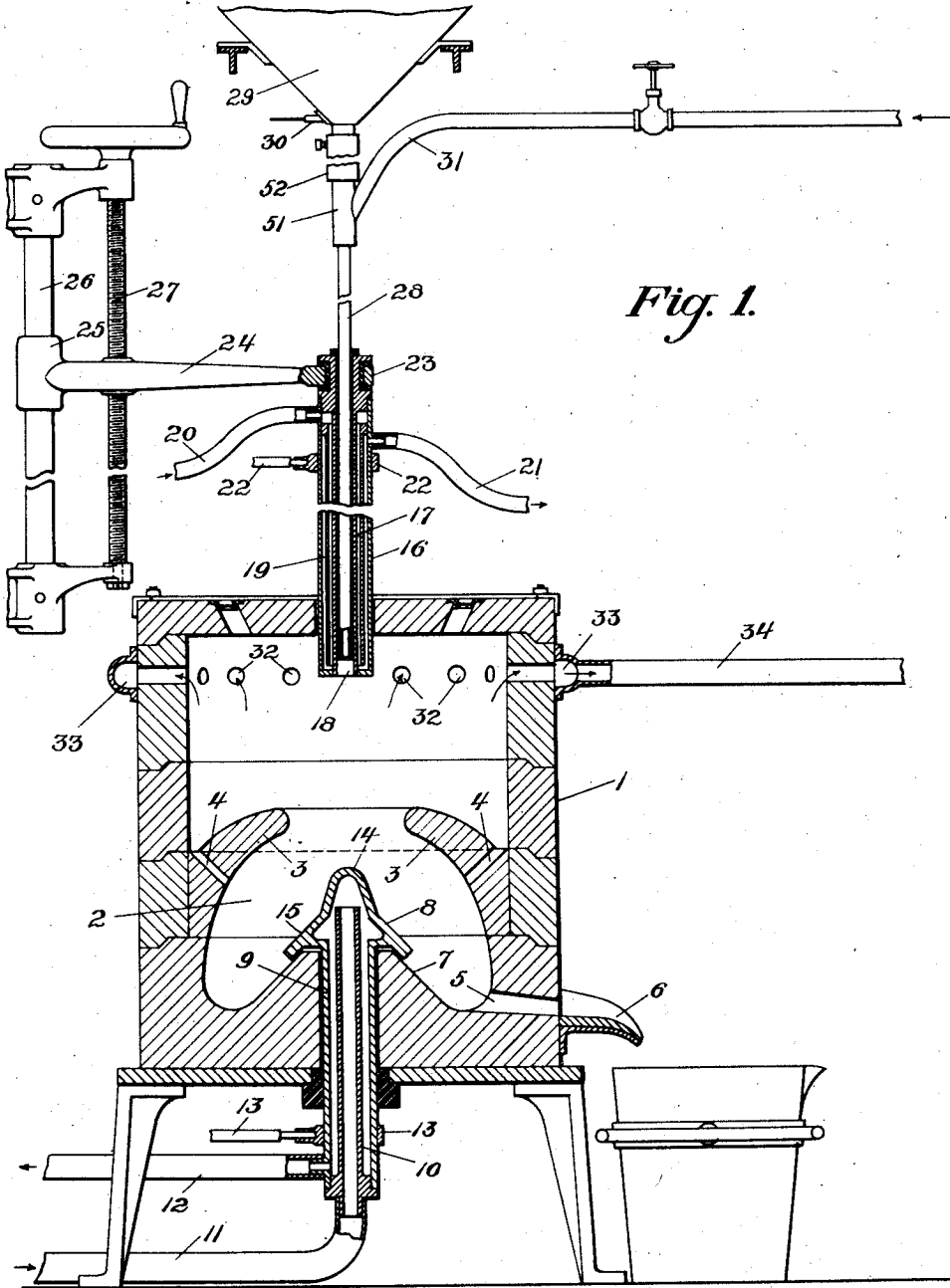


Fig. 1.

Witnesses:
L. F. Browning
M. L. Smith

Charles B. Hillhouse Inventor
By *Edward C. Landau* Attorney

C. B. HILLHOUSE.
 ART OF REDUCING METAL ORES AND FUSING OTHER MATERIALS.
 APPLICATION FILED NOV. 25, 1912.

1,193,783.

Patented Aug. 8, 1916.
 2 SHEETS—SHEET 2.

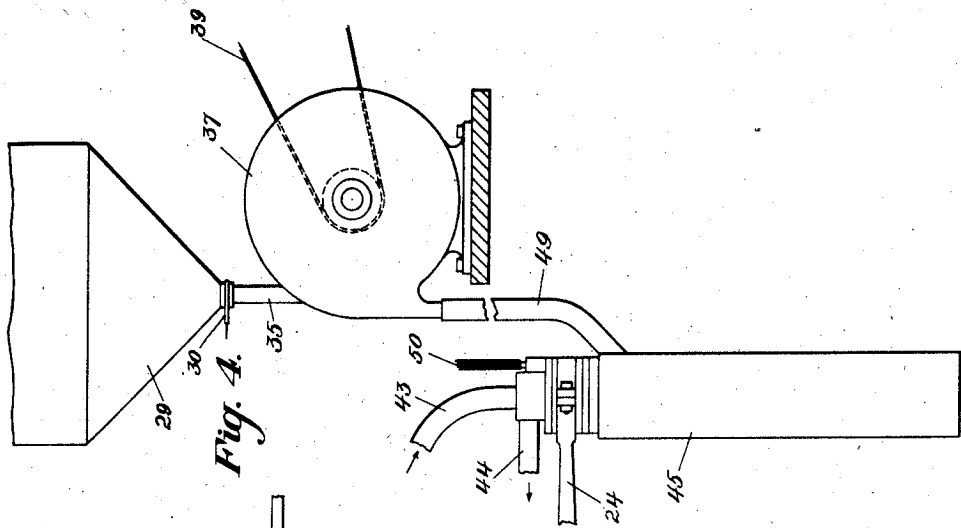


Fig. 4.

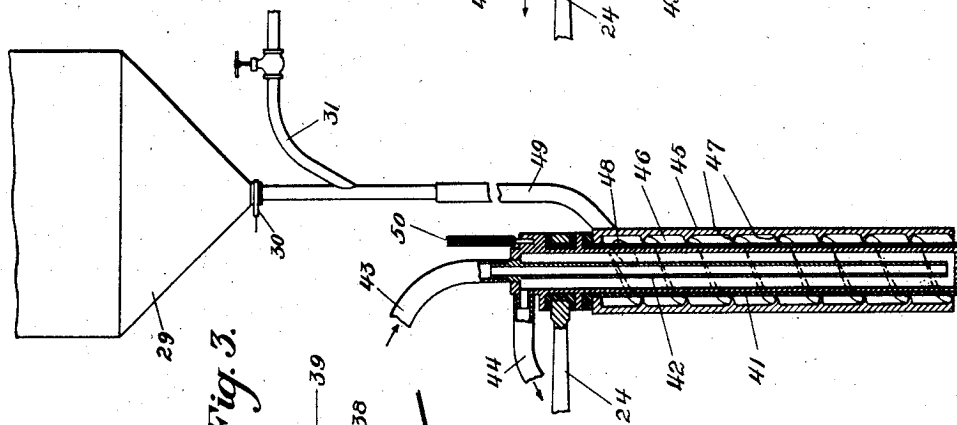


Fig. 3.

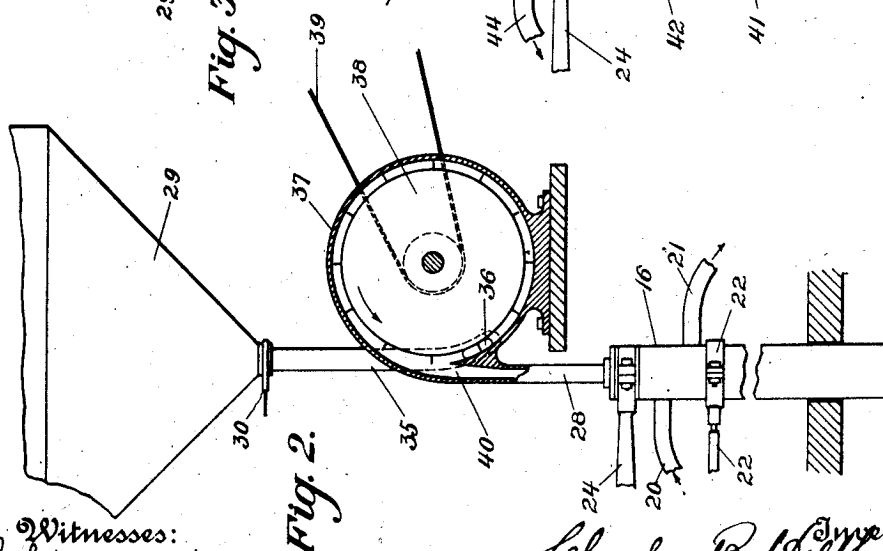


Fig. 2.

Witnesses:
 L. F. Browning
 M. L. Smith

Inventor
 Charles B. Hillhouse
 By *Edward C. Davidson*
 Attorney

UNITED STATES PATENT OFFICE.

CHARLES B. HILLHOUSE, OF NEW YORK, N. Y.

ART OF REDUCING METAL ORES AND FUSING OTHER MATERIALS.

1,193,783.

Specification of Letters Patent.

Patented Aug. 8, 1916.

Application filed November 25, 1912. Serial No. 733,303.

To all whom it may concern:

Be it known that I, CHARLES B. HILLHOUSE, a citizen of the United States of America, residing in the borough of Manhattan, city, county, and State of New York, have invented a certain new and useful Improvement in the Art of Reducing Metal Ores and Fusing other Materials, of which the following is a specification.

The process comprising the subject matter of this invention is one in which finely divided ore mixed with flux or reducing agents, as occasion may require, is fed through or along an electric arc or arcs where it is subjected to a sufficient temperature to effect its reduction during transit. The degree of fineness to which the ore is reduced should be appropriately related to the arc area and its intensity. The electric arc or arcs may be arranged horizontally and the comminuted ore passed therethrough vertically, or the arc or arcs may be arranged at various angles through which, vertically or at an angle, the ore may be passed; or, again the arc may be disposed vertically and the ore passed through or along the arc lengthwise. An important feature of the invention is feeding the comminuted ore at accelerated speed beyond that afforded by a mere gravity drop. The apparatus employed may assume a variety of forms although in the drawing but one general arrangement of arc is illustrated.

In the accompanying drawings which show an organization of apparatus appropriate for practising this invention; Figure 1 is a general view partly in elevation and partly in vertical section in which the comminuted ore is fed by an air blast; Fig. 2, a detail elevation partly in section indicating a modification in which the ore is fed at accelerated speed by a centrifugal apparatus; Fig. 3, a modification in the arrangement of one of the electrodes and feed passage for the ore which is indicated as fed by an air blast; and Fig. 4, a side elevation indicating apparatus such as is shown in Fig. 3 except that the ore is fed by a centrifugal apparatus.

Referring to Fig. 1, 1 is a retort that may be built up of sections of appropriate refractory material. In its cover there is centrally disposed an aperture for an electrode and in its bottom there is a co-incident aperture for a corresponding electrode. Around the lower aperture is a depressed annular

chamber 2 having an upwardly and inwardly extending overhanging annular wall 3 through which there are apertures 4 of any appropriate number. From the bottom of this chamber opens a discharge passage 5 leading to a chute 6 that discharges into any suitable receptacle. The central elevated floor 7 of chamber 2 is flat and in it is centrally formed the aperture through which the lower electrode passes. This electrode 8 is formed with an exterior shell 9 fitting the aperture in the floor of the retort and an inner tube 10 open at the top and connected for cooling purposes with an inlet water supply 11, a water outlet 12 being connected with the shell or outer tube of the electrode. 13 indicates the electrical connection with the exterior of the electrode. These connections are all located below the bottom of the retort. The electrode head 14 has an annular flange or curtain 15 that extends below the flat floor of the central portion of the chamber 2. The upper electrode comprises an outer shell 16 and an inner shell 17 thus leaving an open central bore or passage way 18. Between the shells 16 and 17 is disposed an annular shell 19. Cooling water is introduced at 20 and withdrawn at 21. 22 indicates the electrical connection with the outer shell 16 of the electrode. It is designed that the electrode shall be movable vertically through the aperture in the top of the retort and to this end it is embraced by a collar 23 from which extends a horizontal arm 24 having a hub 25 that runs on a shaft 26. A screw shaft 27 passing through the arm 24 and provided with an appropriate hand wheel serves to elevate or lower the electrode. Disposed in the central bore 18 of the upper electrode is a feed pipe 28 that receives the comminuted ore with or without flux or reducing agents as may be required. The ore is placed in the hopper 29 which has an ordinary gate valve 30 and below the valve there is introduced an air or other gas jet under appropriate pressure through pipe 31 which may be flexible. The air at appropriate pressure may be taken from any suitable source. In the upper part of the wall or retort are a plurality of apertures 32 opening to an annular chamber 33 on the exterior of the retort and to which is connected a pipe 34 leading to an exhaust fan or other apparatus for removing gases from the retort.

When the arc is established between the

electrodes the finely divided ore is fed, at a speed in excess of that obtainable by gravity, by means of the air jet and is introduced into or to the arc axially thereof.

5 The purpose of accelerating the speed is to increase the out-put of the furnace. So far as I am aware, however, I am the first to pass comminuted ore axially through or along an electric arc or arc area. It is designed that the ore shall be reduced during transit through the arc and that the molten product of the operation shall be drawn from the chamber 2 either continuously or from time to time. The greater the intensity of the arc and the greater its length, the higher the speed at which the comminuted ore may be passed through it and, as before stated, the degree of fineness to which the ore is ground or crushed may be such that the particles thereof will break down or be reduced during transit through or along the arc. The apertures 4 serve to discharge into chamber 2 reduced or melted material that may fall outside of the overhanging wall 3.

The feed pipe at 51 may be formed with a telescoping section 52 to afford adjustment of the feed pipe relatively to the electrode.

30 The stream of ore, as accelerated by a jet of air or other gas, will make feasible a longer arc than would otherwise be obtainable. The stream of comminuted material may be of any desired cross section.

Referring now to Fig. 2, assuming the apparatus to be as already described except with respect to the air jet, it will be seen that the comminuted ore from the feed pipe 35 is tangentially introduced at 36 into the shell of a centrifugal machine 37 having a driving cylinder 38 with radial plates or blades dividing the annular space between it and the shell. This inner disk or cylinder is driven at appropriate speed by a belt 39 or otherwise and the comminuted ore is discharged tangentially at 40 into the feed pipe 28.

Fig. 3 shows a different construction of electrode there being an outer shell 41 within which is disposed a tube 42. Cooling water enters at 43 to the inner tube and leaves the outer shell at 44. Around the electrode is disposed a shell 45 so spaced as to leave an annular chamber 46 between it and the outer shell of the electrode. The outer chamber is divided into a helical passage way by helical ribs 47 on the interior of the shell 45. Comminuted ore is introduced tangentially into the annular chamber 46 at 48 from which a pipe 49 leading to the

hopper and into which below the hopper 60 enters a compressed air jet through pipe 31. In this figure the electrical connection with the electrode is indicated by 50. The ore passes around the outside of the upper electrode and falls on to the lower electrode. 65 The arc or arcs area is determined by the electric current flowing between various portions of the under surface of the upper electrode and lower electrode, so that the ore, etc., is intimately associated with the arc, 70 and is submitted to the full action of the arc as its flow is coincident with the axis of the arc area. The fineness to which the ore is ground or pulverized will be governed by the speed of flow of the ore, the intensity of 75 the current and the length of the arc and its area.

Fig. 4 indicates an apparatus such as is shown in Fig. 3 except that instead of the air jet the centrifugal apparatus 37 is employed to accelerate the speed of the ore. This feature of passing the material through a helical passage, thus causing the stream to flow spirally longitudinally through or along the electric arc, is elaborated and claimed in 85 an application for Letters Patent filed by me July 3, 1913, under Serial No. 777,143.

I claim:

1. An improvement in the art of reducing metal ores which consists in passing finely 90 divided ore at higher speed than that due to gravity axially through or along an electric arc area.

2. An improvement in the art of reducing metal ores which consists in passing finely 95 divided ore at higher speed than that due to gravity axially longitudinally through and along an electric arc.

3. An improvement in the art of reducing material which consists in passing it 100 vertically when comminuted axially through or along an electric arc area at accelerated speed beyond that due to gravity, the axis of the arc being vertically arranged.

4. An improvement in the art of reducing 105 material which consists in passing it by means of a gas under pressure at a speed greater than that due to gravity axially through or along an electric arc area whose axis is vertically arranged, the said material 110 falling upon a surface included in and heated by the arc circuit.

In testimony whereof, I have hereunto subscribed my name.

CHARLES B. HILLHOUSE.

Witnesses:

LAURA E. SMITH,
MILDRED L. SMITH.

UNITED STATES PATENT OFFICE.

JÖRGEN ERNST THOMSEN, OF JERSEY CITY, NEW JERSEY, ASSIGNOR TO THE JOSEPH DIXON CRUCIBLE COMPANY, OF JERSEY CITY, NEW JERSEY, A CORPORATION OF NEW JERSEY.

ELECTRODE AND PROCESS OF MAKING THE SAME.

1,243,009.

Specification of Letters Patent.

Patented Oct. 16, 1917.

No Drawing.

Application filed February 2, 1917. Serial No. 146,204.

To all whom it may concern:

Be it known that I, JÖRGEN ERNST THOMSEN, a citizen of the United States, residing in Jersey City, in the county of Hudson, in the State of New Jersey, have invented certain new and useful Improvements in Electrodes and Processes of Making the Same, of which the following is a specification.

My invention relates to electrodes or electrical conductors and particularly to that class of electrodes which are composed partly of carbon. An object of my invention is to produce a harder and stronger article of this class than those in common use at present. Electrodes of my invention are of particular value as dynamo brushes, but they have numerous other uses.

In order that my invention may clearly be understood, I will describe in detail a specific embodiment of it.

In producing my electrode, I first mix together finely divided carbon, a phenol or cresol or a compound or mixture containing phenols and creosols, such as pitch, tar or creosote oil, and formaldehyde or a formaldehyde derivative, such as paraformaldehyde, and hexamethylenetetramin. I find it preferable not to have the carbon content of this mixture reduced to a uniform degree of fineness. It should preferably consist of particles of graphite of different sizes. If formaldehyde is used, I find it desirable also to add a small quantity of alkali, as, for example, ammonia, to the mixture.

The strength of the final material as well as its electrical conductivity may be varied by varying the proportion of the carbon to the other ingredients in the mixture. One formula which I have found to give a very satisfactory product is as follows:—

64% carbon (containing particles of different sizes),
18% coal tar,
15% creosote,
3% hexamethylenetetramin.

The above described mixture is then heated to a temperature not exceeding 450° F. to drive off the volatile matter and the remaining mass is ground to a powder.

The powder thus formed is then pressed into molds at a pressure which must vary according to the hardness and density desired in the product. When making the

electrode for use as a motor brush, I find a pressure of two tons per square inch satisfactory.

The molded blocks are then calcined at a temperature above the decomposition points of the condensation products of the formaldehyde and the phenols and creosols. It is necessary to surround or cover the blocks with fine carbon during the calcining or otherwise prevent oxygen from coming in contact with the blocks when heated about a red heat. In calcining, the temperature must be raised very slowly up to the point where the condensation products of the formaldehyde and the cresols and phenols are fully carbonized and all the gases from their decomposition have been expelled. When this point is reached, the calcination is complete and a further increase in the temperature has no effect.

I wish it clearly understood that my invention is by no means limited to the specific embodiment which I have described. My invention is defined in the following claims, in which I have used the word "tar" in a generic sense to include either wood tar, coal tar or a mixture of the two or any substance or substances containing phenols or creosols or both.

I claim:—

1. An electrode consisting of a hard non-inflammable body produced from a mixture of carbon, tar, and a compound containing the formaldehyde radical.

2. An electrode consisting of a hard non-inflammable body produced from a mixture of finely divided carbon including particles of different sizes, tar, and a compound containing the formaldehyde radical.

3. An electrode consisting of a hard non-inflammable body produced from a mixture of the following components in about substantially the following proportions: carbon 64%, tar 33%, and formaldehyde derivative 3%.

4. An electrode consisting of a hard non-inflammable body produced from a mixture of finely divided carbon containing particles of different sizes, phenols and creosols, and a compound containing the formaldehyde radical.

5. A process of making electrodes, comprising mixing together carbon, tar, and a compound containing the formaldehyde

105

radical, pressing the mixture into blocks, and calcining the blocks at a temperature above the decomposition point of the condensation products present.

5 6. A process of making electrodes, comprising mixing together finely divided carbon containing particles of different sizes, tar, and a compound containing the formaldehyde radical, pressing the mixture
10 into blocks, and calcining the blocks at a temperature above the decomposition point of the condensation products present.

15 7. A process of making electrodes, comprising mixing carbon, tar, and a compound containing the formaldehyde radical, heating the mixture sufficiently to drive off the volatile matter, pressing the mixture into blocks, and calcining the blocks at a temperature above the decomposition point of
20 the condensation products present.

8. A process of making electrodes, comprising mixing together carbon, tar, and a compound containing the formaldehyde radical, heating the mixture sufficiently to drive off the volatile matter, grinding the
25 resulting mass to a powder, pressing the powder into blocks, and calcining the blocks at a temperature above the decomposition point of the condensation products present.

9. A process of making electrodes, comprising mixing together finely divided carbon about 64%, tar about 33%, and formaldehyde derivative about 3%, heating the mixture to a temperature not exceeding 450°
30 F. to drive off the volatile matter, grinding the resulting mass to a powder, pressing the powder into blocks, and calcining the blocks at a temperature above the decomposition point of the condensation products present.
35

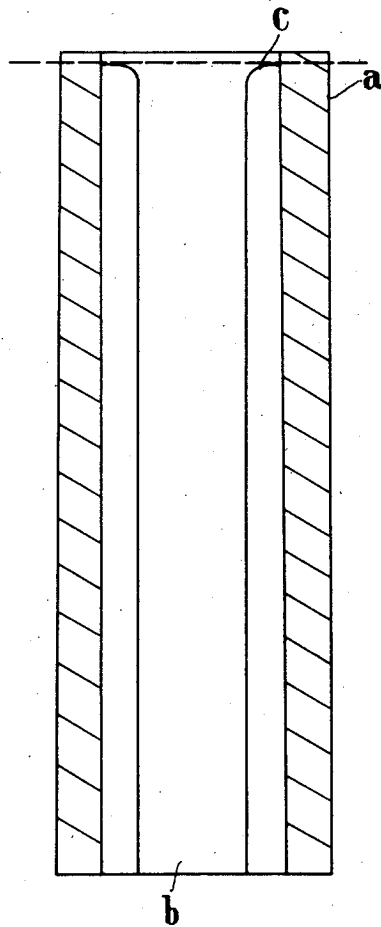
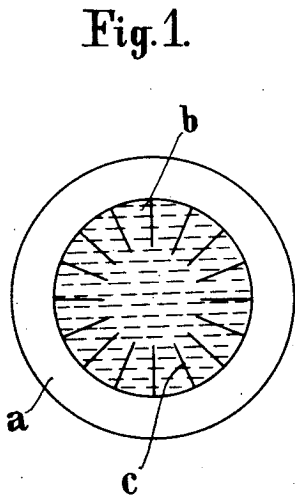
JÖRGEN ERNST THOMSEN.

H. NATHUSIUS.
ELECTRODE FOR USE IN ELECTRIC FURNACES AND FOR OTHER PURPOSES.
APPLICATION FILED JULY 19, 1916.

1,268,483.

Patented June 4, 1918.

Fig.2.



Inventor
by Hans Nathusius
B. Singer
Attorney

UNITED STATES PATENT OFFICE.

HANS NATHUSIUS, OF FRIEDENSHÜTTE, KREIS BEUTHEN, GERMANY.

ELECTRODE FOR USE IN ELECTRIC FURNACES AND FOR OTHER PURPOSES.

1,268,483.

Specification of Letters Patent.

Patented June 4, 1918.

Application filed July 19, 1916. Serial No. 110,052.

To all whom it may concern:

Be it known that I, HANS NATHUSIUS, residing at Friedenshütte, Kreis Beuthen, Germany, have invented a certain new and useful Electrode for Use in Electric Furnaces and for other Purposes, of which the following is a specification.

This invention relates to electrodes adapted for use in electric furnaces and for other purposes and consisting of a conductor of the second order, and to a process for manufacturing such electrodes. As is known, electrodes are at present made of conductors of the first order, *e. g.* British anthracite which is compressed in suitable molds after a binder such as tar, pitch, etc., has been added.

It is difficult to obtain suitable anthracite and it is therefore desirable to find a substitute for that material.

I have found that electrodes can be made of conductors of the second order, *e. g.* dolomite, if a material of this character is mixed with conductors of the first order such as metals. Any suitable binders, such as tar, pitch or the like, and coke or other materials containing carbon, may be added. The mixture is compressed in suitable molds. After molding, it is baked and further treated in the same manner as carbon electrodes or converter linings.

Reference is to be had to the accompanying drawings in which Figure 1 is a longitudinal and Fig. 2 a cross section of an electrode mold with the electrode mass and its insertions in position.

The mass *b*, composed of dolomite and additions, is forced into the mold by stamping. The conductors of the first order *c* are so arranged as to make contact with the terminals even if the conductor of the second order is not yet heated and, consequently, has not yet become conductive.

When current flows through the electrode, the metallic substances will melt. They are, so to say, disseminated in the dolomite and

are thereby combined with it to such an extent that the electrode remains conductive even if cold.

Preferably, I make the metal substances of sheet metal, as illustrated, in the form of strips, clips, spirals, etc. Their percentage in relation to the conductor of the second order is determined by the required minimum conductivity of the electrode.

Any metal may be used which does not contaminate the charge of the furnace.

It is possible, but not indispensable, that the substances of which the electrode is composed will undergo certain chemical reactions with each other. This, however, has no detrimental effect on the operation of the electrodes.

A particular advantage of the electrodes manufactured by my improved process apart from their cheapness, is that they are extraordinarily strong and dense and have no tendency to break. Even if, in consequence of careless operation, particles of the electrodes should fall into the bath, they have no detrimental influence on it, as, owing to the small percentage of carbon contained in the electrode, they do not increase the carbon content of the bath to any appreciable extent. It follows that soft charges can be obtained which was difficult with the carbon electrodes heretofore in use.

It has been proposed to provide carbon electrodes with insertions, etc., or cores of metal but only with the object of increasing the conductivity of such electrodes which *per se* consist of a conductor of the first order. The metal insertions in these old electrodes are however not disseminated in the mass of the electrodes.

This has no bearing on my process in which a conductor of the second order forms the skeleton of the electrode. The same process and the same composition of electrode mass may be advantageously applied to the manufacture of substitutes for arc lamp

electrodes, contact electrodes etc. in all cases where a solid conductor of not too limited conductivity should be used.

I claim:

- 5 1. A process for manufacturing electrodes from conductors of the second order consisting in inserting metal into dolomite, adding suitable binders and substances containing carbon, stamping the mass in molds, baking
10 it and melting the metal insertions by means of electric current.

2. An electrode consisting of a conductor of the second order, comprising dolomite and a binder, and containing metal disseminated within its mass.

In testimony whereof I affix my signature in presence of two witnesses.

HANS NATHUSIUS.

Witnesses:

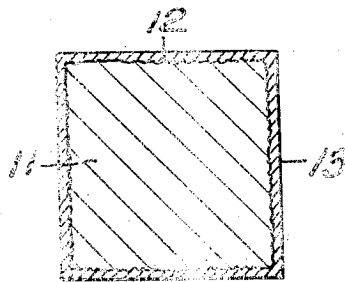
HENRY HASPER,
ALLEN F. JENNINGS.

J. C. KING.
ELECTRODE.

APPLICATION FILED OCT. 9, 1917.

1,312,260.

Patented Aug. 5, 1919.



Inventor
Jesse C. King

By

J. C. King
ATTYS.

UNITED STATES PATENT OFFICE.

JESSE C. KING, OF MONTREAL, QUEBEC, CANADA.

ELECTRODE.

1,312,260.

Specification of Letters Patent.

Patented Aug. 5, 1919.

Application filed October 9, 1917. Serial No. 195,578.

To all whom it may concern:

Be it known that I, JESSE C. KING, a citizen of the United States, and resident of the city of Montreal, in the Province of Quebec and Dominion of Canada, have invented certain new and useful Improvements in Electrodes, of which the following is a full, clear, and exact description.

This invention relates to improvements in electrodes for use in electric furnaces and the like.

It is well known that electrodes which usually consist of carbon waste or burn away quite rapidly at points remote from the active end, thus reducing the efficiency and life of the electrode. The carbon body becomes heated to very high temperatures for a considerable distance back from the end, and this heating renders the carbon more or less readily combinable with oxygen of the air or with other gases, with the result that the electrode burns away, thus reducing the sectional area and consequently altering the resistance and conductivity of the electrode.

The main object of my invention is to provide an electrode having on the outer surface thereof a thin coating of non-oxidizing material designed to protect the body of the electrode from combination with gases at all parts of the surface not in actual operation. I have found that a coating of finely ground bauxite is very suitable for this purpose, and the coating may be applied in the manner described in my copending application, Serial No. 99,104, filed May 22nd, 1916. After the application of the protective coating, the electrode is preferably baked, so that the core and the coating become for all practical purposes integral.

Referring to the drawing, which represents a cross sectional view of the electrode with the coating applied thereto, 11 designates the core or electrode proper of carbon having the surface 12 roughened by any suitable means. The coating of bauxite 13 is then applied to the roughened surface,

preferably in a plastic condition. The electrode is then baked to drive off the moisture and gases, and to harden both the core and the coating. The bauxite which is ground to a suitable fineness may be molded, pasted, pressed or sprayed on to the roughened carbon core, and when suitably hardened, this coating forms an impenetrable coating between the electrode and the gases of the furnace. If it is desired to mold the surface coating onto the carbon electrode, the latter may be used in a suitable mold as a core and the surface coating may be pressed into the mold around the core in the usual manner. If the surface coating is to be pasted onto the core, a trowel or other suitable implement may be used and this surface coating in plastic condition may be pasted onto the roughened surface of the core, in as even a manner as possible. To spray the coating onto the core, any suitable implement such as a cement gun may be employed.

In some cases, it may be desirable to use a binder consisting of a small proportion of pitch or other carbonaceous bonding material. When a small quantity of such a binder is used, it holds the coating during the baking process where it becomes thoroughly hardened.

Having thus described my invention, what I claim is:—

1. A coating for electric furnace electrodes, consisting of finely ground bauxite and a carbonaceous binder for same.
2. An electric furnace electrode comprising a carbon core having a roughened surface, and a coating of bauxite bonded on to the roughened surface.
3. An electric furnace electrode comprising a carbon core having a roughened surface, and a coating of bauxite mixed with a carbonaceous binding material bonded or baked on to the roughened surface.

In witness whereof I have hereunto set my hand.

JESSE C. KING.

1,313,126.

M. SHOELD.
ELECTRIC FURNACE ELECTRODE.
APPLICATION FILED OCT. 21, 1918.

Patented Aug. 12, 1919.

Fig. 1.

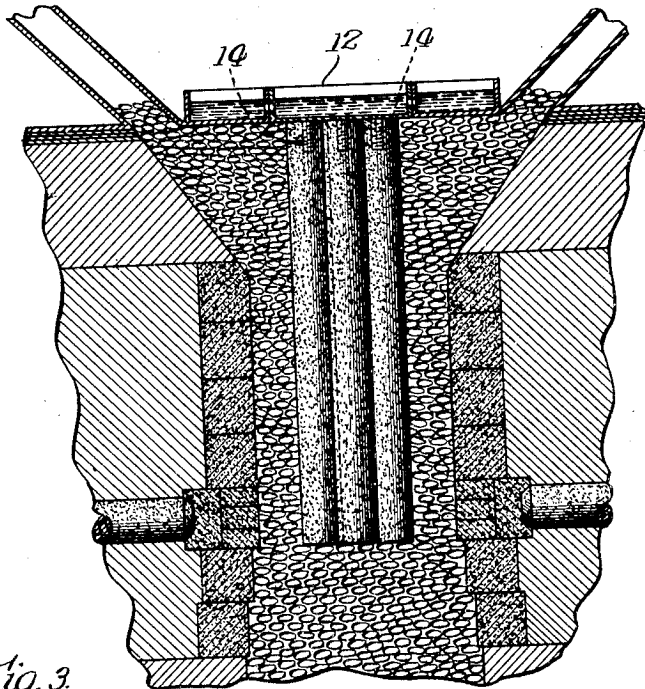
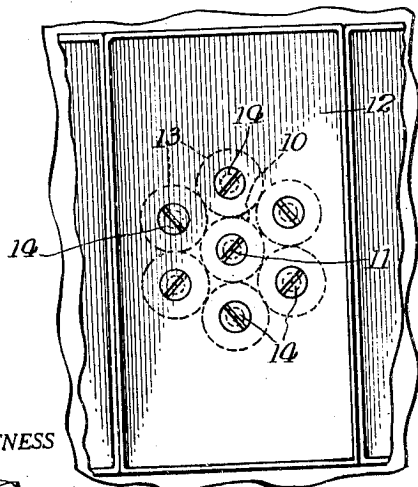


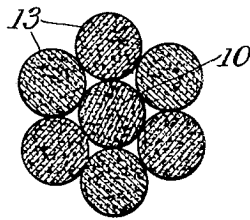
Fig. 3.



WITNESS

Ed. Brown

Fig. 2.



INVENTOR.

Mark Shoeld
BY *Walter M. Fuller*
ATTORNEY

UNITED STATES PATENT OFFICE.

MARK SHOELD, OF CHICAGO, ILLINOIS, ASSIGNOR TO ARMOUR FERTILIZER WORKS, OF CHICAGO, ILLINOIS, A CORPORATION OF NEW JERSEY.

ELECTRIC-FURNACE ELECTRODE.

1,313,126.

Specification of Letters Patent.

Patented Aug. 12, 1919.

Application filed October 21, 1918. Serial No. 258,942.

To all whom it may concern:

Be it known that I, MARK SHOELD, a subject of the King of Sweden, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Electric-Furnace Electrodes, of which the following is a specification.

Vertically-arranged electrodes for electric furnaces, especially those supported solely from their upper ends, are subject to breakage and other injuries in service because of their frailty and fragility and the prime object of the present invention is to obviate these various difficulties, giving the electrodes longer life and permitting them to perform their functions more satisfactorily. It is practically impossible to obtain single large sizes needed for some furnaces, possibly due to size limitations in the production of graphite members by the ordinary and well-known processes, and the employment of the features of this invention also overcomes this difficulty. A further salient feature of the invention is the provision of an electrode of this general type which is easier to support and more readily replaced than a single large electrode would be. Other purposes of the invention are to make the electrode sectional or in parts whereby if one of its elements breaks the electrode as a whole is not materially or irreparably injured, to construct the member in such a way as to expose a large surface to the mass to be treated thereby maintaining a reduced current-density at the surface of the electrode, to provide an element of this character which causes a more uniform heating of the mass to be treated, to produce an electrode which because of its sectional character can adapt itself to reasonable warping and twisting, and to accomplish other desirable objects.

To the accomplishment of these and other ends, in the preferred embodiment of the invention, the electrode comprises a central, cylindrical element, surrounded by a plurality or set of like elements contacting therewith and with one another for mutual support and reinforcement, all of these members being individually supported at their top ends only and unitedly forming a sectional depending electrode.

In the accompanying drawing, illustrat-

ing such a desirable embodiment of the invention and throughout the various views of which like reference characters refer to the same parts, Figure 1 is a central, vertical section through an electric-furnace illustrating one of the improved electrodes;

Fig. 2 is a horizontal section through the electrode; and

Fig. 3 is a plan view of the central portion of the furnace showing the manner of supporting the parts of the electrode.

As is clearly illustrated in this drawing the electrode or electric terminal is composed of a central or inner cylindrical element or rod 10 of graphite or other suitable electrically-conductive material, which is usually more or less fragile and subject to breakage, supported from above only by means of a single screw 11, fastening its top end to the bottom wall of a properly-supported pan 12 adapted to contain cooling water. Grouped or arranged around this main electrode element is a plurality of like members 13, 13, six in number in the present instance, each in longitudinal line contact with the element 10 throughout their length and in a similar bearing relation with the two companion elements on opposite sides of it, whereby all of these members mutually and collectively reinforce one another and unitedly strengthen the electrode as a whole, rendering the same less subject to breakage if accidentally knocked or struck a blow. As is the case with the enclosed or central member, these outer elements are individually or separately supported at their top ends only by means of screws 14, 14 securing them to the bottom wall of the pan, each of these screws fitting in a threaded hole in the upper end of the corresponding graphite rod which it supports.

The inner, central, electrode member, except possibly at its lower face, does not necessarily come into contact with the material being treated, which, usually in the form of briquets, passes downwardly around all sides thereof as will be readily understood and as is shown in the drawings. Its principal function is to act as a common or inner support or strengthening member for the surrounding outer elements and, if desired, to transmit a part of the electric current. The corrugated, grooved, fluted or furrowed surface presented to the briquets

by the united, outer, graphite rods not only increases the surface exposed as compared with a single, large, cylindrical electrode, but a more efficient contact is had with the 5 briquets, the current-density at the surface of the electrode is reduced, and a more effective cooling of the electrode is possible.

By separately or individually supporting the various component parts of the electrode 10 as a whole, it is rendered more flexible, thus permitting it to more or less readily accommodate itself to warping and twisting strains and if any element accidentally becomes broken it can be comparatively easily 15 replaced, and in many instances successful operation can be continued until it becomes convenient to effect such repair.

Having presented in detail one desirable embodiment of the invention it is not to be 20 understood that this is the only way in which the invention can be put into practical commercial form, but rather it should be appreciated that the invention is susceptible of a variety of satisfactory embodiments 25 all incorporating the main general features and principles on which the invention rests. For example, the rods of which the electrode is composed need not necessarily be cylindrical in cross-section, the 30 inner one may in some cases be entirely omitted, and in other instances may be made of relatively non-conducting material.

I claim:

1. An externally longitudinally fluted or furrowed electrode for an electric furnace 35 or the like, comprising in combination a central, vertically-disposed, cylindrical, electrically-conductive element, a plurality of vertically-disposed, parallel, cylindrical, electrically-conductive elements surrounding 40 ing said central element and each in longitudinal contact with said central element and with the two outer elements on the opposite sides of itself, and means supporting 45 said electrodes individually from their upper ends only, substantially as described.

2. An externally longitudinally fluted or furrowed electrode for an electric furnace or the like, comprising a central, cylindrical, electrically-conductive element and a plurality 50 of parallel, cylindrical, electrically-conductive elements surrounding and in contact with said central element and each in contact with the two outer elements on the 55 opposite sides thereof, substantially as described.

3. A longitudinally fluted or furrowed electrode for an electric furnace or the like, comprising in combination, a plurality of 60 parallel electrically-conductive rods, and means to support said rods from their upper ends only and in longitudinal contact with one another, substantially as described.

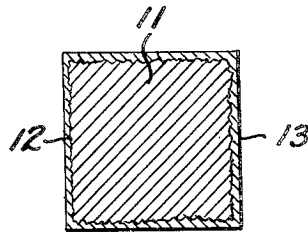
MARK SHOELD.

J. C. KING.
ELECTRODE.

APPLICATION FILED-MAR. 21, 1917. RENEWED APR. 7, 1919.

1,322,491.

Patented Nov. 18, 1919.



Inventor
J. C. King
By *J. H. Sturtevant*
ATTYS.

UNITED STATES PATENT OFFICE.

JESSE C. KING, OF MONTREAL, QUEBEC, CANADA.

ELECTRODE.

1,322,491.

Specification of Letters Patent.

Patented Nov. 18, 1919.

Application filed March 21, 1917, Serial No. 156,442. Renewed April 7, 1919. Serial No. 288,219.

To all whom it may concern:

Be it known that I, JESSE C. KING, a citizen of the United States, and resident of the city of Montreal, in the Province of Quebec and Dominion of Canada, have invented certain new and useful Improvements in Electrodes, of which the following is a full, clear, and exact description.

This invention relates to improvements in electrodes for use in electric furnaces and the like, and the object of the invention is to provide an electrode having on the outer surface thereof a thin coating of material designed to protect the body of the electrode at all parts of the surface not in actual operation.

Carbon electrodes, when used in electric furnaces or the like, become heated to high temperatures for a considerable distance from the active end, and this high temperature renders the carbon more or less combinable with oxygen or other gases, with the result that the electrode burns away very rapidly, thus reducing the sectional area and consequently altering the resistance and conductivity of the electrode.

My invention is designed to cover the surface of the electrode with a thin coating of incombustible material, so that wasting away will be limited to the normal waste caused by the passage of the arc. I have found that a mixture of silica and graphite is suitable for this purpose, and this mixture may be applied in the manner described in my copending application, Serial Number 99,104, filed May 22nd, 1916. After the application of the protective coating, the electrode is preferably baked, so that the electrode and coating become for all practical purposes integral.

Referring to the drawing, which represents a cross sectional view of the electrode with the coating applied thereto, 11 designates the core or electrode proper of carbon having the surface 12 roughened by any suitable means and applied thereto a coating 13, comprising a mixture of silica and graphite. This coating mixture is applied to the carbon core, preferably while the latter is in a plastic condition, and the electrode is then baked to drive off the moisture and gases from the electrode and harden same. The proportions of silica and graphite may vary largely, but for ordi-

nary purposes, I prefer to use a mixture of approximately equal parts of the two ingredients. Pure silica and carbon may be used if the former ingredient can be obtained, but usually commercial silica contains a percentage of alumina or iron, or both, and it is to be understood that my invention covers the use of either pure silica or silica in its ordinary commercial state.

When an electrode thus coated is used in a furnace or other apparatus wherein a large portion of the electrode is subject to high heat and the action of gases, the coating remains substantially inert, as neither the silica nor the graphite will be attacked by oxygen or other gases present. Graphite at high temperatures does not readily combine with oxygen or other gases, but neither graphite nor silica alone would form a perfect coating. A mixture of the two ingredients, however, produces a coating which has approximately the same expansion and contraction as the carbon of the electrode, and the coating is therefore not liable to split or crack and expose portions of the core to the action of gases.

The silica is ground to suitable fineness and is mixed with finely ground graphite in proportions which may range from 25% of silica and 75% of graphite, to 90% of silica and 10% of graphite, but I prefer to use approximately equal proportions by weight of each of the ingredients. This mixture may be molded, pasted, sprayed or pressed on to the roughened carbon core, and when suitably hardened forms an impenetrable coating between the electrode and the gases of the furnace.

Having thus described my invention, what I claim is:—

1. A coating for electrodes comprising a mixture of silica and graphite.

2. A coating for electrodes consisting of a mixture of finely divided silica and finely divided graphite in approximately equal parts by weight.

3. An electrode having a surface coating of from 25 to 90 per cent. silica mixed with from 75 to 10 per cent. graphite respectively substantially as set forth.

In witness whereof, I have hereunto set my hand.

JESSE C. KING.

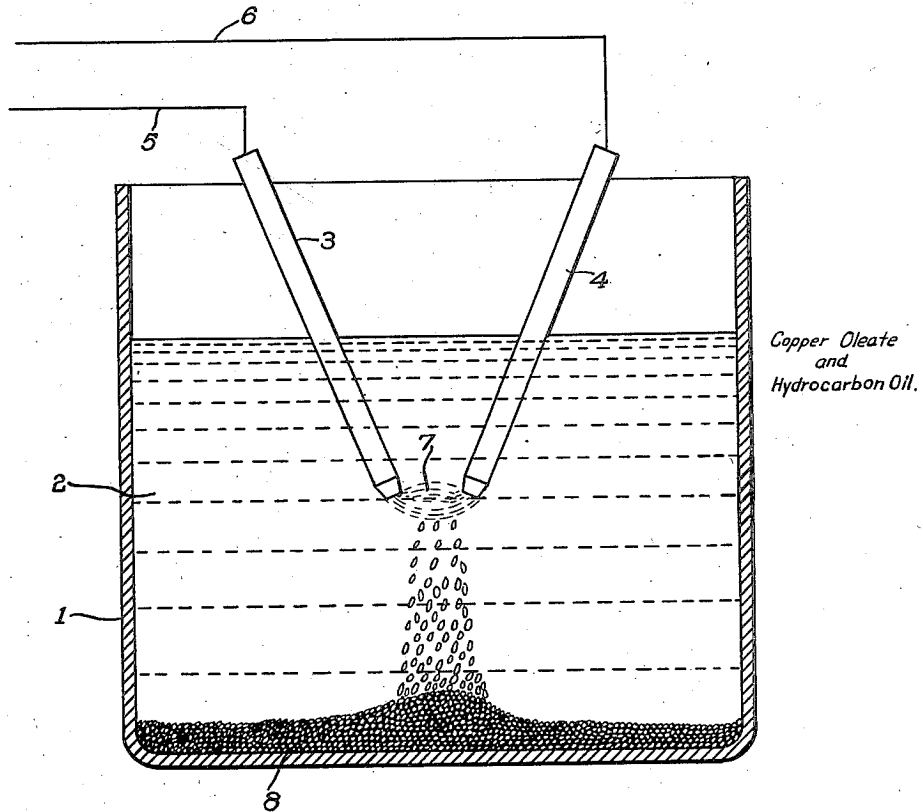
Dec. 14, 1926.

1,610,592

C. J. RODMAN ET AL.

DEOXIDIZER

Filed Dec. 21, 1923



Copper Oleate
and
Hydrocarbon Oil.

WITNESSES:

A. J. Schiefelbein.
H. C. Bierman

INVENTORS
Clarence J. Rodman and
James G. Ford

BY
Herbert G. Carr
ATTORNEY

UNITED STATES PATENT OFFICE.

CLARENCE J. RODMAN AND JAMES G. FORD, OF WILKINSBURG, PENNSYLVANIA, ASSIGNORS TO WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

DEOXIDIZER.

Application filed December 21, 1923. Serial No. 682,074.

This invention relates to means for removing oxygen from atmospheres containing the same, more particularly to the removal of oxygen from the spaces above the oil in electrical apparatus such as transformers, circuit breakers, oil switches and the like.

In such electrical apparatus, the space above the oil is generally filled with air and upon an arm forming in the oil, accidentally or during the normal operation of the device, combustible gases which mix with the air are produced, forming an explosive mixture. This mixture has, on different occasions, been ignited by arcs within the apparatus, causing explosions which damaged the apparatus and endangered the lives of the workmen.

To overcome this difficulty it has been proposed to provide a material, either in the space above the oil or in communication therewith, which is capable of removing the oxygen from said space, and thus prevent the formation of explosive mixtures.

Our invention relates to materials of this character, it being among the objects thereof to provide a material capable of removing oxygen from atmospheres which shall be highly efficient in operation and which may be produced at a low cost.

In practising our invention, we provide a mixture of finely divided copper and carbon intimately mixed and in an extremely active state. This mixture may be prepared in a variety of ways, but we prefer to make the same by subjecting a hydro-carbon oil containing a copper soap, to a high potential arc. This breaks down the oil to provide finely divided carbon which is in a highly reducing condition and, therefore, is very active. Together with the carbon, there is precipitated very finely divided copper which is obtained by the decomposition of the copper soap. The mixture is filtered, washed with ether to remove all traces of oil, and is then dried.

The mixture has been found to be very reactive with the oxygen of the air. The rate of reaction may be so rapid that in the open air spontaneous combustion may occur and the carbon be burned to carbon dioxide and the copper to cuprous and cupric oxides. Apparently, the carbon is in activated form and it catalyzes the oxidation of the copper,

at the same time reacting with oxygen to form carbon dioxide.

If it is desired to accelerate the reaction in a closed container, we may add to the mixture of copper and carbon a small quantity of a salt such as cupric nitrate, ammonium chloride or the like.

In the accompanying drawing, constituting a part hereof, the single figure is a vertical cross-sectional view of an apparatus suitable for carrying out our process.

The tank or container 1 is filled to a suitable point with a mixture 2 of a hydro-carbon oil and copper oleate or other fatty acid soap of the metal to be precipitated. Electrodes 3 and 4 of carbon or other suitable material are connected to leads 5 and 6, respectively, which are connected to a suitable source of high voltage.

Current is passed between electrodes 3 and 4 forming a high-tension arc 7, which, acting upon the mixture 2, causes decomposition thereof, forming finely divided copper and carbon together with a certain amount of gas, which is given off. The copper and carbon material 8 settles to the bottom of the container 1 and is removed therefrom in any suitable manner. The material is centrifuged, washed with ether or other suitable solvent for the mixture 2, and dried ready for use.

Although we have described our invention setting forth a specific embodiment thereof, it is obvious that various changes may be made therein within the scope of our invention. For instance, instead of carbon electrodes, we may utilize electrodes of chromium or platinum, which have high resistance to corrosion. We may omit the copper soap and utilize instead thereof, electrodes of copper or brass which, under the influence of the arc produce copper in finely divided form, which provides a mixture with the carbon liberated from the oil. Any type of hydro-carbon oil which has been refined to remove sulphur, acid and asphaltic products may be used. Generally, an oil heavier than kerosene is preferred.

The particles of the material produced by our process may be varied in size by varying the electrical characteristics of the source of energy. Generally, we prefer to use a high-frequency high-voltage source with a low current in order to obtain very finely

divided particles. Using a low voltage and a high current gives larger particles.

We claim as our invention:

- 5 1. A material for deoxidizing atmospheres comprising a mixture of a plurality of oxidizable constituents, one of which is finely divided carbon and another is copper, said material being so finely divided as to be capable of spontaneous combustion.
- 10 2. A material for deoxidizing atmospheres comprising a mixture of finely divided copper and finely divided carbon, said material being capable of spontaneous oxidation.
- 15 3. A method of making deoxidizing material which comprises immersing metal containing electrodes in oil and then subjecting said oil to the action of an arc.
- 20 4. A method of making deoxidizing material which comprises providing an oil containing cuprous material and then subjecting said oil to the action of an arc between electrodes immersed in said oil.
- 25 5. A method of making deoxidizing material which comprises mixing an organic compound of copper with an oil, immersing electrodes in said mixture and then subjecting said mixture to the action of an arc between said electrodes.
- 30 6. A method of making deoxidizing mate-

rial which comprises subjecting a solution of a hydro-carbon oil and a copper fatty acid compound soluble in the said oil, to the action of an arc.

7. A method of making a deoxidizing material which comprises immersing terminal electrodes in a bath of oil associated with a cuprous metal and then subjecting the bath to the action of an arc.

8. A method of making a deoxidizing material which comprises immersing terminal electrodes in a bath of oil associated with copper and then subjecting the bath to the action of an arc.

9. A method of making a deoxidizing material which comprises immersing terminal electrodes in a bath of oil associated with copper oleate and then subjecting the bath to the action of an arc.

10. A method of making a deoxidizing material which comprises immersing terminal electrodes in a bath of oil associated with a fatty acid salt of copper and then subjecting the bath to the action of an arc.

In testimony whereof, we have hereunto subscribed our names this 17th day of December, 1923.

CLARENCE J. RODMAN.
JAMES G. FORD.

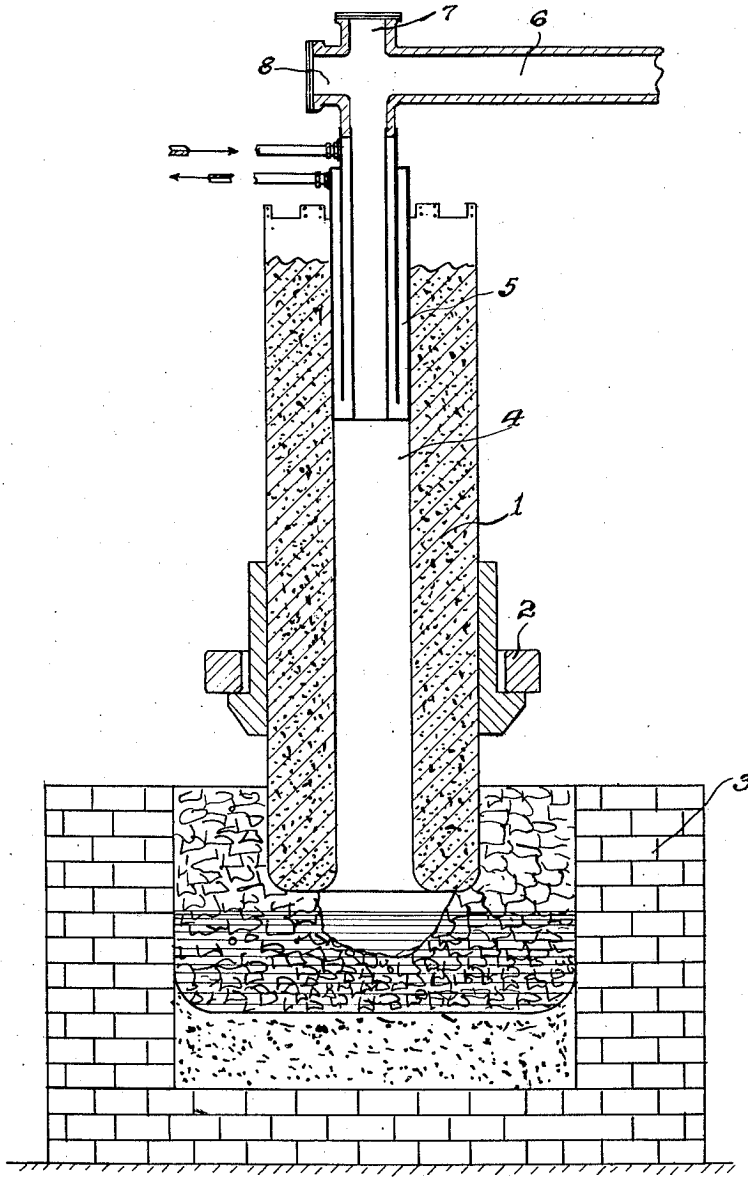
Aug. 30, 1927.

1,640,735

C. W. SÖDERBERG

PROCESS OF MAKING CHANNELED CONTINUOUS ELECTRODES

Filed May 10, 1924



Inventor
Carl Wilhelm Söderberg

By *Doney & Cole*
Attorneys

UNITED STATES PATENT OFFICE.

CARL WILHELM SÖDERBERG, OF OSLO, NORWAY, ASSIGNOR TO DET NORSKE AKTIE-
SELSKAB FOR ELEKTROKEMISK INDUSTRIE, OF CHRISTIANIA, NORWAY.

PROCESS OF MAKING CHANNELED CONTINUOUS ELECTRODES.

Application filed May 10, 1924, Serial No. 712,423, and in Norway May 16, 1923.

This invention relates to channeled continuous electrodes for electric furnaces and the object of the invention is a process for making such electrodes whereby first class mechanical and electric qualities are obtained.

In my U. S. Patent No. 1,442,031 I have described a method of producing channeled continuous electrodes. My present process is an improvement of the process described in that patent and is preferable in such cases when very hot gases or charges pass through the electrode.

My present process may be used in connection with any type of electric furnace and the suspension of my electrode may be carried out as desired in each special case. It will especially be advantageous in connection with closed furnaces and makes it possible to carry out therein a number of processes which have hitherto only been carried out in open furnaces, as for instance the production of carbide, and many products which get lost in open furnaces may now be recovered. As an example I may state that a carbide furnace per ton carbide gives about 372 kg. of carbon monoxide which carry along about 204 kg. of dust. Instead of being disagreeable to the neighbourhood of the furnace these products may be recovered by employing my channeled electrode.

In order to carry out my invention I provide a usual continuous selfbaking electrode with one or more longitudinal channels. Such electrodes consist of a lower baked part and an upper unbaked part. I have found that it is essential to the production of a first class electrode to always maintain a part of the electrode in unbaked condition in order to give a homogeneous connection with the new electrode mass to be tamped thereupon. If now in the case of a channeled electrode very hot furnace gases are drawn out through the electrode the upper part of the electrode may become baked by the heat given off from the gases. The same may of course take place if very hot gases are introduced through a channeled electrode. I have now found that this difficulty may be avoided by placing a cooled tube in the channel or channels at the upper end of the electrode. The cooled tube will then protect the surrounding raw electrode mass from being baked. The tube may either be in solid connection with the col-

lecting arrangements for the furnace gas or in solid connection with the electrode and in flexible connection with said collecting arrangement. As the electrode is lowered the unbaked electrode mass outside the tube will follow downwards. Consequently the tube must from time to time be raised if it is in solid connection with the electrode. I may of course also heat insulate such a tube instead of cooling it so as not to bake the surrounding electrode mass.

In the drawing forming part of the application a vertical sectional view of an electrode and furnace used in carrying out my invention is shown:

Referring more particularly to the drawing, 1 is a continuous selfbaking electrode suspended by means of an external holder 2. 3 is an electric furnace. 4 is a longitudinal channel inside the electrode. 5 is a water cooled tube in the unbaked part of the electrode. 6 is the outlet for the furnace gas, 7 and 8 are openings for cleaning the tubes.

When the furnace is in operation a strong draft will on account of the great heat form in the channel 4 acting as a flue and I may now regulate the draft in such manner that the gases formed in the furnace escape without air being drawn in through the furnace. I may if desired regulate the conditions so that part of the gas escapes each way. The regulation may easily be carried out for instance by means of a door or a fan.

It is easily understood which improvements in the operation of the furnace are obtained by the removal of the furnace gas. The great amounts of hot and intensely illuminating gases which are developed in the usual carbide and ferroalloy furnaces form the principal difficulty in the handling of the furnace. By having the gases removed from the furnace through a hollow electrode all drawbacks are eliminated and the furnace is easily and comfortably handled.

The method described is of special importance when smelting materials in powder or with little porosity. Such material is for instance a mixture of powdered iron ore (purple ore or the like) with powdered coke or similar powdered reduction material. Such powdered materials are generally much cheaper than other raw materials. They have, however, the drawback that the charge becomes too tight and impenetrable for gas.

Consequently the furnace "blows", that is, the gas will force its way through the charge at certain places, forming open channels through which it escapes. Little or no contact between gas and material is therefore obtained and neither the heat content nor the reduction value of the gas is utilized. By drawing gas out through the electrode the blowing is avoided and at the same time the gas is collected and may subsequently be utilized for preheating, roasting or reduction of charges which may partly be charged through the electrode channel in counter current with the gases.

A furnace such as that herein described is especially noteworthy on account of the fact that it possesses in combination the advantages of both an open and a closed furnace.

If the furnace gases contain volatile elements as for instance zinc, phosphorus or the like, these may be recovered as usual by leading the gas through a condensing system connected with the furnace.

As previously stated the process herein described may also be employed for blowing gas into the furnace. If desired I may of course also draw gas through the furnace and the electrode. Such procedures may for instance be employed for effecting reaction of a gas with carbon, for instance in the production of hydrocyanic acid.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. The process of making continuous self-baking channeled electrodes for electric furnaces comprising the introduction of a body in the unbaked part of the electrode protecting the surrounding raw electrode mass against the heat from the channel and thus preventing the baking of said raw electrode mass.

2. The process of making continuous self-baking channeled electrodes for electric furnaces comprising the introduction of a tube in the unbaked part of the electrode protecting the surrounding raw electrode mass

against the heat from the channel and thus preventing the baking of said raw electrode mass.

3. The process of making continuous self-baking channeled electrodes for electric furnaces comprising the introduction of a cooled tube in the unbaked part of the electrode protecting the surrounding raw electrode mass against the heat from the channel and thus preventing the baking of said raw electrode mass.

4. The process of making continuous self-baking channeled electrodes for electric furnaces comprising the introduction of a water cooled tube in the unbaked part of the electrode protecting the surrounding raw electrode mass against the heat from the channel and thus preventing the baking of said raw electrode mass.

5. A channeled electrode baked in the furnace in which it is used and adapted for the introduction into the furnace or removal therefrom of gas, said electrode comprising when in use a baked portion an unbaked portion and within a part of the unbaked portion means for protecting the raw electrode mass against heat from the channel.

6. A channeled electrode baked in the furnace in which it is used and adapted for the introduction into the furnace or removal therefrom of gas, said electrode comprising when in use a baked portion, an unbaked portion and within said unbaked portion a tube protecting the raw electrode mass against heat from the channel.

7. A channeled electrode baked in the furnace in which it is used and adapted for the introduction into the furnace or removal therefrom of gas, said electrode comprising when in use a baked portion, an unbaked portion and within said unbaked portion a water cooled tube protecting the surrounding raw electrode mass against the heat from the channel and thus preventing the baking of said raw electrode mass.

CARL WILHELM SÖDERBERG.

UNITED STATES PATENT OFFICE

BARTLEY E. BROADWELL, OF LEWISTON, AND ARTHUR T. HINCKLEY, OF NIAGARA FALLS, NEW YORK, ASSIGNORS TO THE REPUBLIC CARBON COMPANY, OF NIAGARA FALLS, NEW YORK, A CORPORATION OF DELAWARE

ELECTRODE

No Drawing.

Application filed January 4, 1930. Serial No. 418,649.

The present invention relates to electrodes and more especially to electrodes containing natural graphite, and to a process of forming such electrodes.

5 Natural graphite is a material having peculiar characteristics which well adapt it for use in electrodes, but which have heretofore prevented such use. Natural graphite is a flaky material, being made up of flakes or
10 laminae. The surfaces of the flakes are smooth as compared with artificial graphite, and therefore present surfaces resistant to oxidation in use. The smooth surfaces of the flakes, however, have rendered the natural graphite unsuitable in manufacture of
15 electrodes by the usual processes, and attempts to make electrodes containing a material proportion of natural graphite have not met with success.

20 In addition to the desirable smooth and oxidation resisting surfaces of the natural graphite, natural graphite is relatively cheap and is available in large quantities.

25 The particles of natural graphite when subjected to shearing strains tend to rupture along cleavage planes between the flakes or laminae. In making the mixes for electrodes, a sticky, viscous bituminous binder, such as tar or pitch, is usually employed, the mixture being heated to render the binder semi-fluid.
30 In forming the mix the binder wets the surfaces of the solid particles of the mix and cements them together in the finished electrode.

35 It has been found, however, that where the binder is used in a mix containing a considerable proportion of natural graphite, and an attempt is made to form an electrode in the usual way, that certain weaknesses are
40 developed. This weakness is apparently caused by the rupture and splitting of the graphite flakes or laminae along their cleavage planes, exposing dry surfaces, that is, surfaces which have not been wet with the
45 binder and which, therefore, do not have a good bond with the remainder of the material.

50 It has been found, for example, that if it is attempted to make an electrode from a mixture containing a considerable proportion

of natural graphite by the customary extrusion process, the electrode thus formed is badly cored. This coring has been variable in degree, in many cases resulting in the formation of concentric conical sections which
55 could actually be displaced one inside the other. When the graphite-containing mix is extruded through the extrusion die, the mix being extruded is subjected to severe mechanical strains, causing shearing stresses to be
60 applied to the graphite particles. These shearing strains tend to turn the graphite flakes in the direction of the shearing motion and to rupture the flakes, causing the laminae to slide over each other along their natural
65 cleavage planes, tending to form slip planes in the electrode.

The surfaces of these cleavage or slip planes formed by the rupture of the graphite particles during the extrusion are, or tend
70 to be, dry surfaces, that is, not wet by the binder, and therefore cause planes of weakness in the electrode. Such electrodes therefore would have a short life due to spalling along the slip planes between the laminae or
75 flakes. The same difficulty has been encountered in attempts to manufacture electrodes containing natural graphite by the other processes in vogue. For example, attempts
80 to make such electrodes by the usual tamping processes have proved unsuccessful. In the tamping process the electrode is formed in a mold and a tamping tool having a number of projections or fingers is used to tamp the
85 mix in the mold. The tamping fingers rupture the particles of the natural graphite and cause the cleavage or slippage planes between the laminae or flakes as above described. The mix tends to adhere to the tamping tool and
90 pack irregularly, so that irregular laminations roughly perpendicular to the direction of tamping are formed. The resultant electrode has structural weaknesses due to the dry cleavage planes and is also packed irregularly,
95 so that the electrodes tend to not only spall, but also to overheat locally.

Attempts to form electrodes containing natural graphite by a simple pressing operation have also been unsuccessful, since the
100 heavy pressures employed rupture the par-

articles of natural graphite, forming the weakening cleavage or slippage planes between the flakes or laminae as characterized by glazed surfaces similar to the familiar geological slickensides.

Attempts, therefore, to manufacture electrodes containing a material or considerable proportion of natural graphite have met with failure and have not been commercial despite the advantages which might be attained of using natural graphite in the electrodes, such as its low cost and smooth, relatively unpitted, oxidation resisting surfaces. So far as we are aware, no commercially successful electrodes have been made from a mix containing any material proportion, as, for example, 20% or over, of natural graphite. We have, however, succeeded in making electrodes mainly composed of or containing a considerable proportion of natural graphite, thus rendering available natural graphite for electrode use. These electrodes have not only the advantages incident to natural graphite, such, for example, as its smooth, unpitted oxidation resisting surfaces and its low cost, but also have certain novel and advantageous characteristics.

We will now describe more specifically the process of making our improved electrodes and their characteristics. We form a mix containing a suitable binder and a granular dry material containing a considerable proportion of natural graphite with or without other electrode materials, such as electrode scrap, carbon, and so forth. As a specific example, we make electrodes from a mix containing about 50% of crushed natural graphite having flakes about $\frac{1}{4}$ " in diameter on the average and about 50% of graphite flour or ground electrode scrap. The fineness of the material and the proportion of natural graphite to the dry portion of the mix may be varied to suit conditions. The mix may contain the natural graphite mixed with other materials, such as electrode scrap or graphitized carbon, or the mix may consist entirely of natural graphite as the dry portion of the mix. The dry materials are mixed with a suitable binder, for example, about 10% to 20% of a mixture of tar and pitch. The mixture is heated and thoroughly mixed to distribute the binder and wet the surfaces of the particles of the mix.

The electrode is formed from the mix by a jolting operation. The mix is placed in an electrode mold, which is raised and dropped against a stop or anvil so as to subject the mix to repeated jolting or jarring which consolidates it but without material rupture of the graphite particles, as would be the case in the usual extrusion, tamping or pressing operations. The mold is gradually filled while it is being jolted, and after the mold is filled a presser head is applied to the top of the mold to assist in the consolidation

of the mix and the jolting of the mold is continued until the mix is consolidated to form the completed electrode.

A jolting mold which can be utilized for this purpose is described in the Doerschuk Patent No. 1,683,587 of September 4, 1928. Instead of the cam-held weight of the Doerschuk patent, we prefer to use a follower which positively and instantaneously follows up the momentary consolidation or settling of the mix at the moment of impact. Such a follower or presser head may be formed of a plunger fitting into the upper end of the jolting electrode mold and having above it a hydraulic chamber supplied with water under pressure through a small and instantaneously operating check valve which permits water under pressure to follow up the descent of the plunger at the moment of impact of the mold against the anvil, but which prevents the escape of the water and the tendency of the plunger to rebound. A hydraulic follower of this type is described in the pending application of Semmeon M. McNulty, Serial #390,949, filed September 7, 1929.

The electrode mold is preferably heated to maintain the mixture in a plastic condition during the jolting and consolidating operation, which is continued until the desired density and orientation of particle is imparted to the electrode. The electrode is then preferably maintained under the pressure in the mold while it is chilled in order to prevent expansion of the mix during the chilling.

The forming of small carbon articles by simultaneous heating and pressing of cold mix containing the binder uniformly disseminated through the mass either in the form of finely comminuted particles or in the form of films upon the carbon particles is well known. This procedure fails to produce uniform density of the formed article when one dimension of the article is materially greater than the other two as in the case of a cylinder or parallelepiped whose length is several times its diameter, width or thickness. By forming such an article from such cold mix with simultaneous jolting and heating however, the desired density and desired orientation of particles is secured uniformly throughout the formed article together with uniform distribution of binder without the necessity of hot mixing prior to the placing of the mix in the mold, and this modification of the use of jolting in forming electrodes is also within the scope of our invention.

The electrode is then removed from the mold and baked at a temperature of approximately 800° to 1100° centigrade in the manner well-known in the art of making carbon electrodes. The baking transforms the viscous bituminous binder into a carbonized binder in the completed electrode in the usual way. The formed electrode may alternative-

ly be heated high enough to graphitize the binder if so desired.

We have found it possible to produce an electrode containing natural graphite having a strength and density in excess of that obtainable by forming an electrode in the usual way, such as by the extrusion or tamping processes. It is possible to secure a graphite electrode having a density of up to 1.98 before baking and 1.83 after baking, although the densities of 1.6 or over after baking are satisfactory for general use. These densities may be compared with the usual densities of 1.56 for carbon electrodes after baking or 1.54 for graphitized electrodes formed in the usual way. The high density of the electrode, combined with the natural resistance to oxidation of the natural graphite, produces an electrode having an exceptionally long life in operation. This is of obvious advantage in giving a greater furnace yield per electrode and reducing the labor of changing electrodes. The life of our electrodes is greater than that of the usual graphitized electrodes of the same size and nearly double that of the usual carbon electrodes.

In addition to the high density, resistance to oxidation and long life, our electrodes have other valuable and characteristic properties. The natural graphite flakes are relatively thin compared with their width. During the jolting operation the flaky particles tend to so orient themselves that the flat faces lie in a plane normal to the direction of jolting, or at right angles to the axis of the electrode when the jolting is in a direction axially of the electrode. An electrode is therefore produced having a striated or laminated structure, which is, however, mechanically sound, uniform and substantially free from dry slip or cleavage planes. While it is preferred to jolt the electrode endwise so that the laminae are normal to the axis of the electrode, it is possible by jolting the electrode sidewise to cause the laminae to lie axially of the electrode. This arrangement of the thin flat natural graphite flakes, which constitute a considerable proportion of the electrode, results in certain desirable characteristics, such as that of selective thermal and electrical conductivity. The thermal conductivity is greater in the direction of the planes of the graphite flakes than it is normal to such planes, or in an electrode formed by endwise jolting the thermal conductivity axially of the electrode is reduced.

While the thermal conductivity axially of the electrode may be reduced somewhat in an electrode formed of irregular particles such as crushed coke or graphitized electrode scrap, as described in the Doerschuk Patent 1,683,587, the selective thermal conductivity is much more pronounced when the flaky natural graphite is employed.

The following table shows numerically ob-

servations of thermal conductivities. The first example is that of an electrode formed of carbon by the extrusion process and graphitized in the usual way. The second example is that of an electrode made from the normal mix containing natural graphite, such for example, as that of the specific example given above of an electrode containing about 50% of crushed natural graphite and about 50% of graphite flour or ground electrode scrap as the dry constituents of the mix, and jolted as herein described. The third example is of a mix consisting principally of a very flaky natural graphite and jolted as herein described:

	Axial	Lateral	Directional thermal conductivity ratio (axial/lateral)
(1) Graphitized.....	.176	.137	1.28
(2) Jolted normal mix.....	.0381	.0459	0.83
(3) Flaky graphite jolted.....	.0233	.1314	0.18

The values for the thermal conductivity in the above table are given in calories per cubic centimeter, per degree centigrade, per second; mean values being between about 150° C. and 300° C.

As above shown, the ratio of axial to lateral conductivity of the graphitized electrode was greater than 1, whereas the jolted electrodes containing natural graphite had a ratio of axial to lateral conductivity of less than 1, the second example being about 5 to 6, and the third example being less than 1 to 5. The ratio of axial to lateral thermal conductivity in our electrodes will vary somewhat depending upon conditions, such as the proportion of natural graphite used in the mix, etc., but is in general lower than that of the usual graphitized electrodes or that obtainable by the use of irregularly shaped electrode-making materials even when subjected to jolting. The ratio of axial to lateral thermal conductivity in our electrodes is in general less than 1 and usually less than $\frac{7}{8}$.

The low ratio of axial to lateral thermal conductivity secured by the orientation of natural graphite flakes is of considerable advantage in impeding the flow of heat axially of the electrode to the outside of the furnace. Less heat is lost by conduction from the interior of the furnace, and the rate of oxidation and the "spindling" of the electrode is materially reduced. Because of the higher lateral thermal conductivity the internally generated heat can readily escape laterally of the electrode, thus preventing overheating.

Our electrodes when jolted with axis vertical also have a greater electrical conductivity laterally than axially, because of the orientation of the graphite particles transversely of

the electrode axis. This tends to cause the current to distribute itself more uniformly over the cross-section of the electrode and probably assists in preventing spindling or the tendency of the electrode to eat back along the periphery faster than at the axis, which is encountered in the ordinary graphitized electrode or other electrode.

A further advantage of our electrodes in comparison with the extruded, molded or tamped types resides in a greater resistance to thermal shock. In the processes of extrusion, molding and tamping, the particles of the mix are subjected to mechanical shearing and other stresses which tend to break down the particle size and yield a fine grained body. In our electrodes the particles are not so broken down but retain their original size, and consequently our electrodes may be given a coarser texture, which better resists thermal shock, like a coarse textured firebrick in comparison with a fine textured firebrick.

Tests have indicated that there is less tendency to pitting or to spindling than in the usual graphitized electrodes as heretofore made. For example, with an electrode originally 8" in diameter we have found that toward the end of the life of the electrode the lower end of the electrode had a diameter of approximately 7½", whereas an electrode of the ordinary graphitized type at a similar stage had a diameter at the lower end of 6 to 6½" and tapered back for a considerably greater distance from the end than was the case with our electrode.

In our electrodes we have entirely overcome the difficulties encountered in previous and unsuccessful attempts to utilize natural graphite in electrodes, and we have produced electrodes having the requisite structural strength, homogeneity and freedom from spalling due to cleavage planes. The greater homogeneity of our electrodes results in a steadier arc as compared with ordinary electrodes in which internal variations in structure and resistance cause frequent variations in the position of the arc at the end of the electrode.

Our electrodes are to be distinguished from the so-called graphitized electrodes which are first formed of ungraphitized carbon and are subjected to heat treatment to graphitize the carbon in the electrode. Such graphitized electrodes are more expensive to make, they do not have the advantageous selective directional thermal and electrical conductivity, and do not have the graphite in the form of the smooth and unpitted oxidation resisting flakes of the natural graphite. Our electrodes are also to be distinguished from electrodes containing artificial graphite, such as electrode scrap. Artificial graphite does not have the smooth-surfaced flaky formation or the density of the natural graphite, but exists

in irregular particles having pitted surfaces and therefore does not impart to the electrode the resistance to oxidation or the desirable selective thermal and electrical conductivities imparted by the natural graphite.

In addition to the desirable physical characteristics imparted to our electrode by the natural graphite, the electrodes are cheaper to make due to the relatively low cost of natural graphite.

While we have specifically described the preferred embodiment of our invention and the preferred process of making our electrodes, it is to be understood that the invention is not so limited but may be otherwise embodied and practiced within the scope of the following claims.

We claim:

1. An electrode containing a material proportion of natural graphite. 85
2. An electrode containing natural graphite to an amount over 20% of the dry constituents of the mix.
3. An electrode containing natural graphite to an amount at least 30% of the dry constituents of the mix. 90
4. An electrode containing natural graphite to an amount at least 50% of the dry constituents of the mix.
5. An electrode containing natural graphite as its major constituent. 95
6. An electrode containing natural graphite having its flakes oriented generally normal to the axis of the electrode.
7. An electrode containing natural graphite and a binder and substantially free from dry cleavage planes between the laminae of the graphite. 100
8. An electrode containing natural graphite having its particles in the substantially unruptured condition obtained by consolidating the electrode mix in a plastic state by a jolting operation. 105
9. An electrode containing natural graphite and characterized by the physical condition and orientation of the flaky graphite particles obtained by consolidating the electrode mix by a jolting operation. 110
10. An electrode containing natural graphite and having greater lateral than axial heat conductivity. 115
11. An electrode containing natural graphite and having a ratio of axial to lateral heat conductivity of less than seven-eighths.
12. An electrode containing natural graphite and having a ratio of axial to lateral heat conductivity of not over about 5 to 6. 120
13. An electrode containing natural graphite and having the greater lateral than axial heat conductivity obtained by consolidating the electrode mix by a jolting operation. 125
14. An electrode containing natural graphite and having a greater lateral than axial electrical conductivity.
15. An electrode containing natural graph- 130

ite and having the selective heat and electrical conductivities and the density, mechanical strength and resistance to thermal shock obtained by the consolidation of the electrode mix in a plastic state by a jolting operation.

5 16. An electrode containing natural graphite and having a density of not less than 1.6.

10 17. An electrode containing natural graphite in an amount over 20% of the dry constituents of the mix and having the flaky graphite particles in a substantially unruptured condition and oriented in a direction generally normal to the axis of the electrode.

13 18. An electrode containing natural graphite in an amount over 20% of the dry constituents of the mix and a heat hardened bituminous binder and having a density of not less than 1.6.

20 In testimony whereof we have hereunto set our hands.

BARTLEY E. BROADWELL.
ARTHUR T. HINCKLEY.

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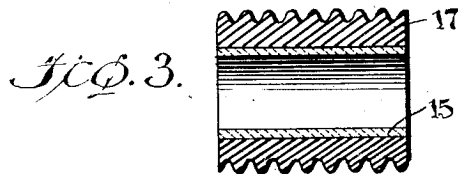
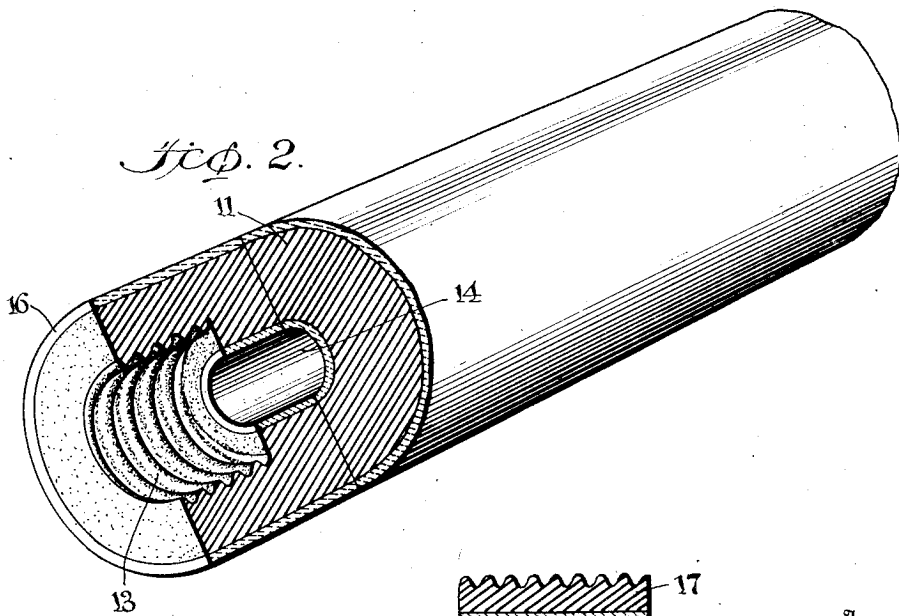
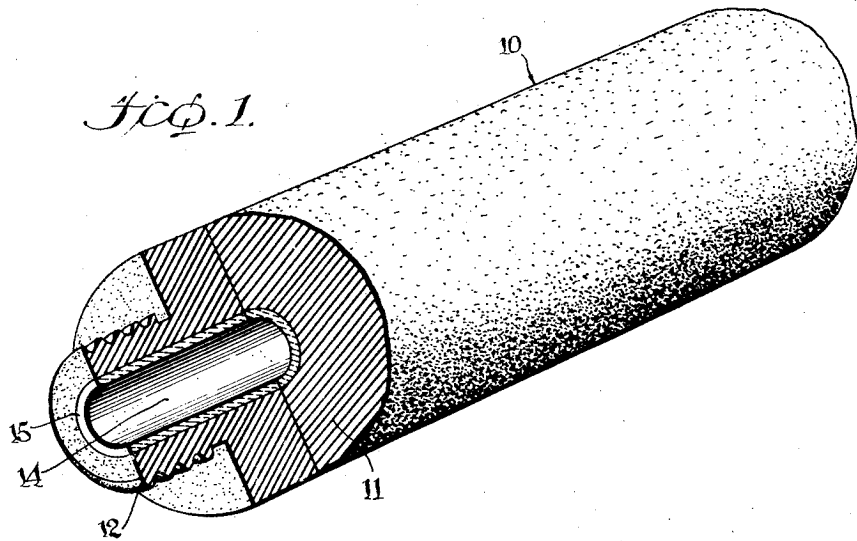
June 6, 1933.

S. T. WILES

1,912,560

REFRACTORY LINED HOLLOW ELECTRODE

Filed June 2, 1930



Inventor
Sydney T. Wiles,

³³⁴
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UNITED STATES PATENT OFFICE

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REFRACTORY LINED HOLLOW ELECTRODE

Application filed June 2, 1930. Serial No. 458,979.

This invention relates to electrodes, and more particularly to hollow electrodes having refractory linings.

In the preparation of certain metals or metalliferous products, a method of reduction of the ore and extraction of the metallic products therefrom depending upon the propagation of the chemical reducing action during the passage of a mixture of ore and reducing agent through horizontally disposed carbon electrodes, and the passage of the finished product through an electric arc formed at the end of these electrodes, was disclosed in a co-pending application, Serial No. 374,251, filed June 27, 1929.

In the working of this process, a cold mixture of the finely ground and intimately admixed charge is fed into one end of the hollow electrode, is passed therethrough, being heated by radiation and convection from the electrode and by electrical resistance during this passage, whereby chemical reactions are initiated and endothermic reductions occur with production of metallic products which fall from the end of the electrode through the arc and into the molten bath in the hearth beneath.

In the production of certain metalliferous products, notably ferro-manganese, ferro-chromium, premium grades of pig iron, etc., the carbon content of which should be held within certain definite and specified limits, and in most cases, is desirably the least possible amount attendant upon the process of manufacture, undue contact with carbon is undesirable.

In the process mentioned above, metalliferous reduction products are formed in hollow electrodes in contact with the graphite of the electrodes and may absorb carbon therefrom, thus producing a product with a higher carbon content than would normally be produced from the composition of the mixed charge. It is, therefore, desirable to minimize, insofar as possible, any contact between the carbon electrodes and the reduced metallic product.

During the production of certain metallic products, these products, in contact with the carbon of the electrodes, act upon the carbon

and leave the interior surface of the electrodes in a pitted and corroded condition. This condition prevents free and unimpeded motion of the charge through the electrode, and permits of the formation and collection of free metallic materials in the electrodes, whereby excessive contamination with carbon occurs.

The present invention has as an object the provision of an electrically conducting tube or electrode suitable for use as a feeding as well as heating device in connection with certain types of electric furnace operation. It further provides an electrode through which mixtures of ore and reducing agents may be passed without contact of the finished metallic product with carbon other than that calculated and used as a reducing agent in the charge, or with carbon adventitiously placed in the lining of the electrode, and therefore with a consequent control of the carbon content in the final metallic product. There is also provided a hollow electrode having interior and exterior coatings of refractory material, thus decreasing the wear and attrition upon the interior core of the electrode and preserving the life thereof, and reducing the amount of heat lost by conduction and radiation from the exterior of the electrode.

The drawing appended hereto shows in Fig. 1 a perspective view of an interiorly coated electrode with certain parts cut away;

Fig. 2 shows another type of electrode in perspective with parts broken away to indicate more clearly the exterior and interior linings.

Fig. 3 is a sectional view of a connecting electrode portion.

Fig. 1 shows a detailed delineation of an electrode 10 which is, for the most part, of an electrically conducting material, such as carbon or graphite, which portion is designated as 11. The general size and dimension of the electrode being dependent wholly upon the service which it is to render, suffice it to say that in general, the length of the electrode is materially greater than the diameter thereof. In the manufacture of the finished electrode, the shape, size and hardness are determined by its subsequent use. It is, however,

provided with attaching means 12 whereby additional lengths of electrodes may be added in electrically conducting relation as the electrode material is worn away and shortened, consequent to its use. The attachment may be of the type indicated, although other well known forms have been used, that is the provision of a threaded male portion 12 at one end of the electrode and a female threaded portion 13 at the other end for reception of the first mentioned portion. Another form of attachment by which additional length of electrode may be connected is shown in the threaded connecting portion 17 which is screwed into interiorly threaded portions 13 at either end of the electrode. An electrode portion of average type will be approximately five feet in length and have a diameter of from twelve to eighteen inches with an aperture 14 axially longitudinally of the electrode of three to four inches; the diameter of this axial passage depending upon the quantity of current passing through the electrode, upon its diameter therefore, and upon the bulk of the material to be passed therethrough.

To prevent undue contact of charged material and end products of the reaction, which in most cases consist of molten or spongy metal, the interior portion of the hollow electrode is provided with a refractory lining 15 which is substantially nonreactive with respect to the constituents of the charge and with respect to the products of the chemical reaction occurring as the charge progresses from the cold end of the electrode to the heated end. The chemical nature of this refractory material is adapted to the particular type of chemical reaction occurring within the electrode, the temperature attained, and the corrosive action of the slag or metal produced therein.

The various types of linings for the carbon electrode are those which have been advantageously used heretofore in metallurgical operations; they are the "acid", "neutral", and "basic". That is to say, with certain types of reactive mixtures, burned magnesite, or calcined dolomite, possess very desirable properties as basic linings where such are found necessary, and function as chemical reagents whereby certain injurious and deleterious products, otherwise tending to remain in the metallic end products, are removed. Among the neutral lining materials may be mentioned chromite which has been found to be a desirable lining due to its resistance, both to heat and chemical reactions. Refractory fire clays have also been advantageously used, as have silicious linings where conditions require an acid lining.

The method by which these linings are placed within the interior wall of the hollow electrode consists essentially of three steps; in the first place, the ground lining is mixed

with a binder, such as tar, or silicate of soda; secondly, this pasty mass is tamped upon the walls of the electrode to the desired thickness; and thirdly, the plastic lining hardened by a process depending upon the type of lining used, which process is in general a heating and conditioning process.

The hollow electrode is mounted axially upon a core member of sufficient diameter that the outside surface of the core is spaced from the inner wall of the hollow electrode for the reception of the mixture of the refractory substance and binder. The extent of this spacing is variable and entirely dependent upon the thickness and physical properties desired in the lining. It is, however, usually from a quarter of an inch to one inch in thickness. When the fluent mixture of refractory and binder has been tamped between the core member and the inner walls of the electrode, the refractory material is subjected to a heating process, which process may be performed after the removal of the core, or, where the core is metallic, by heating the core while still in the electrode.

Where a moderately good conductor is desirable as a lining, the refractory material is mixed with tar or molasses, or similar viscous and carbonaceous material, which upon pyrolysis decompose with the liberation of gaseous materials and deposition of a hard conducting carbon as a binder forming a coherent lining. Where a non-conducting lining is found desirable, an inorganic binder, such as sodium silicate may be used efficaciously, as it will flux and cement the constituents normally found in either acid, basic, or neutral refractories.

Under certain operating conditions, an exterior lining or facing 16 of refractory has been found to be desirable as the heat conductivity of this facing is considerably less than that of the graphite electrode itself, and where such electrode has been coated, heat losses from the furnace by way of the electrode are materially decreased.

The exterior facing or coating of refractory upon the electrode is formed by placing the electrode in a cylindrical mold spaced from the electrode at a distance equal to the desired thickness of the refractory coating, packing and tamping the fluent refractory between the mold member and the electrode, and thereafter subjecting the coating to a heating or baking process, thus producing a refractory facing completely surrounding the electrode.

The casing or mold member may be removed prior to the heating or may be made a portion of an electrical circuit and heat added to the coating material by heating the metallic mold member, thereby fluxing and hardening the refractory facing.

The finished electrode as illustrated in Fig. 2 contains therefore inner and outer

concentric tubes of refractory material, 15 and 16 respectively, with an intermediate conducting electrode portion 11 therebetween. The outer casing serves essentially
5 as a heat economizer as it prevents excessive radiation of heat from the graphite portion of the electrode. The inner tube, on the other hand contains a carbonaceous binder and permits the flow of heat from
10 the electrode portion to the charge, preserves the electrode portion from excessive wear from attrition of the moving charge, and prevents contact of the metallic end products of the reduction with undue amounts of carbon, and thereby tends to reduce the final
15 carbon content of the metallic product.

What I claim is:—

1. An oblong electrode having a charge receiving opening extending axially therein
20 for reduction of the charge as it moves through the electrode, and an electrically conducting coating of refractory material on the inner surface of the electrode to provide a smooth guideway for the moving charge
25 and to prevent wear on the electrode by the charge as it passes through the latter.

2. An oblong electrode having a charge receiving opening extending axially therein for reduction of a reactive charge as it moves
30 through the electrode, an electrically conducting coating of refractory material having a carbonaceous binder therein and bonded to the inner surface of the electrode, said coating being substantially non-reactive with
35 respect to the constituents of the charge to minimize carbon pick-up by the moving charge and to minimize wear by attrition.

3. An oblong electrode having a charge receiving opening extending axially there-
40 through for the reduction of the charge of reactive material when the electrode is heated and as such charge moves through the electrode, an electrically conducting lining of refractory material bonded to the
45 inner surface of the electrode to minimize carbon pick-up by the moving charge and to minimize wear by attrition in the electrode as the charge moves therein, and a coating of refractory material bonded to
50 the outer surface of the electrode and composed of material different from the material of the inner lining whereby the outer coating minimizes the loss of heat from the electrode.

55 SYDNEY T. WILES.

May 15, 1934.

F. SPALOSS
CARBON HOLDER

1,959,008

Filed April 5, 1932

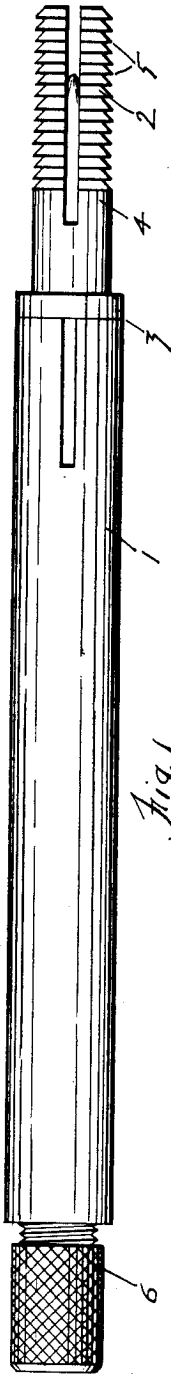


Fig. 1

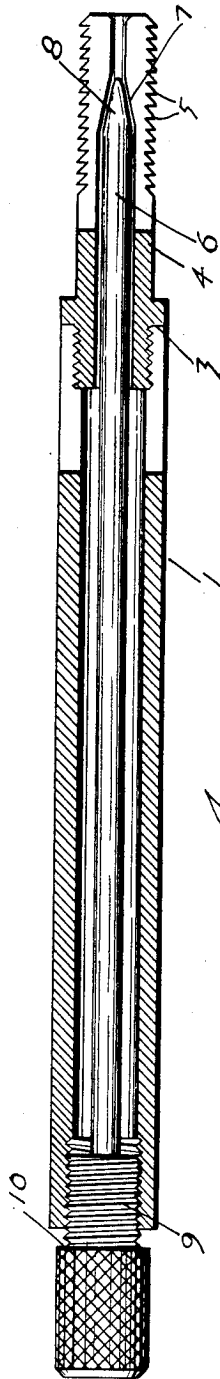


Fig. 2



Fig. 3

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INVENTOR.

UNITED STATES PATENT OFFICE

1,959,008

CARBON HOLDER

Frank Spaloss, Hoboken, N. J., assignor, by direct and mesne assignments, to Ludwic A. Wilczek, New York, N. Y.

Application April 5, 1932, Serial No. 603,314

2 Claims. (Cl. 176-119)

My invention relates to a carbon holder for arc light carbons and more particularly of the type as used in projecting apparatus for motion pictures.

As is well understood, the commercial carbon is furnished in pieces of two to three feet in length and such a piece is mounted in the feeding device of the projector and is automatically fed at the rate required by the combustion at the arc. To prevent overheating, the feeding device is placed at an appreciable distance from the point of combustion and when the carbon has been consumed to an extent, that only the piece extending from the feeding device to the arc, remains, a new carbon must be inserted and the aforesaid piece is discarded.

It is the object of this invention to provide means for salvaging the greater part of the short pieces of carbon that now can not be used, by providing a carbon holder on which these pieces can be mounted and which can be inserted in the feeding device of the projector and fed, the same as a piece of carbon. By these means, all, but a very short piece of carbon, can be used, thereby appreciably reducing waste and cost of operation.

Fig. 1 is a view of the device as assembled for use.

Fig. 2 is a longitudinal section through the center.

Fig. 3 is an end view.

The cylindrical body 1 is of the same diameter as the carbon for which it is intended, so that it will fit into the feeding mechanism of the projector and it is hollow and internally threaded at both ends. A gripping member 2 is threaded up to the shoulder 3 to fit into one end of the body member and in order to facilitate the detaching or unscrewing of the gripping member, when it has become worn from the heat, the body member is slotted, so that it is slightly yielding. The gripping member is made of heat resisting material and the extension 4 thereof is grooved or threaded as shown, to provide teeth 5 and it furthermore is slotted, so that it can be expanded to force the

teeth outward into the carbon. The pieces of carbon can be drilled out to fit over the extension 4, in any suitable manner, or the carbon can be moulded with the hole in it. To expand the gripping member, an expanding needle 6 is provided and extends through the body member, into the gripping member. The end of the gripping member has a small hole and a larger hole extends through the main body thereof and a taper shoulder 7 connects the two holes. The expanding needle has a tapered point 8 and a threaded portion 9, which screws into the rear end of the body member and to expand the gripping member, the needle is screwed into the body member, so that the point 8 presses against the shoulder 7 of the gripping member, thereby expanding the extension 4 and forcing the teeth into the carbon. To prevent too much expansion of the gripping member and thereby cracking of the carbon, the threaded portion of the needle terminates against a shoulder or enlarged portion 10, so that when the needle is screwed in against the shoulder, the gripping extension is properly expanded.

What I claim is:

1. A carbon holder having an extension adapted to be inserted into the carbon; slots in the extension, to adapt it for expansion to grip the carbon; an expanding member, to expand the extension and a stop on the expanding member, to limit the expansion, to prevent breakage of the carbon.

2. A carbon holder, comprising a tubular body member; a gripping member detachably mounted on one end of the body member; slots in the gripping member, to adapt it to be expanded for gripping; teeth in the gripping member to grip the carbon; slots in the body member, to permit a slight expansion thereof, to ease the detaching of the gripping member; an expanding member mounted in the tubular body member and adapted to be manually operated to expand the gripping member and a stop to limit the movement of the expanding member, substantially as shown and described.

FRANK SPALOSS. 100

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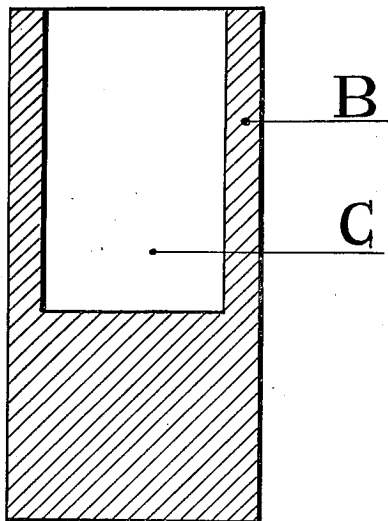
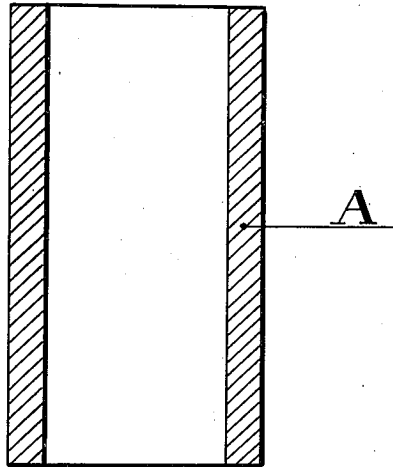
July 3, 1934.

P. SOULARY

1,964,832

ELECTRODE FOR ARC FURNACES

Filed Nov. 25, 1932



Pierre Soulang Inventor
By *Raymond A. Robie* Attorney

UNITED STATES PATENT OFFICE

1,964,832

ELECTRODE FOR ARC FURNACES

Pierre Souлары, Le Perray, France, assignor to
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et L'Exploitation Des Procédes Georges Claude,
Paris, France

Application November 25, 1932, Serial No. 644,251
In Great Britain November 26, 1931

4 Claims. (Cl. 204—31)

The present invention relates to an electrode used in furnaces, in which a fluid having a great dielectric strength, such as liquid hydrocarbon, is submitted to a fixed or rotary arc, or to disruptive discharges. This electrode is opposite to, and at a little distance from, a hollow electrode, having substantially the same axis and through the interior of which the fluid to be treated is supplied to the arc. In proportion of their wear, the electrodes are fed one to the other in order to maintain the small suitable length of the arc, bound to the dielectric strength of the fluid to be treated.

When the electrode, of which the present invention is an improvement, is solid, it is worn in such a manner that a larger and larger projection is progressively formed in its central part, owing to the more rapid wear of the adjacent peripheral parts, which are opposite to the solid active part of the hollow electrode. Therefore, when the two electrodes are fed together to maintain the arc at the small desired length, this projecting part, even if small, engages in the fluid supply conduit of the hollow electrode and may provoke short-circuits, if it comes into contact with this hollow electrode, the wear of which is therefore made irregular.

The present invention has particularly for its object to remedy these drawbacks; it consists in using, as an electrode situated substantially opposite to the hollow electrode, an electrode (that will be also thereafter called counter-electrode) that is provided with a central cavity extending from its active end for a part of its length towards its closed end and in which the sections perpendicular to its axis, along its hollow part, made at different distances from its active end are identical to the sections of the opposite electrode, perpendicular to its axis, made at the same distances from the active end of said electrode.

This counter-electrode is constituted, for example, by a cylindrical rod of carbon bored for a certain part of its length or even by a cylindrical tube one of the extremities of which is provided with a cap, so as to close the interior cavity of this tube.

Preferably the counter-electrode terminates in a flat face perpendicular to its axis and the hollow electrode terminates also in a flat face perpendicular to its axis.

The counter-electrode and the hollow electrode constitute a set of electrodes in which the active surfaces from which the arc jumps at the extremity of each electrode are, at each moment of the working of the furnace, equal and parallel to-

gether and perpendicular to the axis of the electrodes. The arc jumps therefore in a uniform manner between the two electrodes and these are equally worn away. Consequently, in spite of the wear of the electrodes, their active surfaces remain substantially parallel and the steadiness of the arc is obtained. This parallelism of the active surfaces of the electrodes affords a particularly important advantage in the case where liquid hydrocarbons are treated by the arc, for the length of the arc is only a few millimetres.

An embodiment of the invention is diagrammatically illustrated, by way of an example, in the accompanying drawing.

In this drawing A denotes a cylindrical tubular rod through the interior of which the liquid to be treated is supplied to the arc which jumps between this electrode A and an opposite electrode B. This electrode B is a cylindrical rod, coaxial with the electrode A and having the same diameter; it is provided with a cylindrical cavity C, which extends only for a part of its length from its active end and the diameter of this cavity is equal to the inner diameter of the tubular electrode A. The electrodes A and B terminate in a flat annular face, which is perpendicular to their common axis, and constitutes the active part of these electrodes.

Instead of using the counter-electrode in its hollow form, its cavity may be filled, before the electrode being used, by a suitable substance, able to be progressively brought away under the influence of the heat of the arc (or of the current of fluid supplied through the hollow opposite electrode) simultaneously with the wear of the active part of this counter-electrode: for example, use may be made of pitch for this purpose.

When liquid hydrocarbons are to be treated by the arc, it is not necessary to previously fill the cavity of the counter-electrode: this cavity becomes automatically filled, after the arc is struck, with a pasty mass constituted by a mixture of the liquid hydrocarbon submitted to the treatment by the arc and of the carbon formed by the decomposition of this hydrocarbon; this pasty mass is also worn away progressively at the same time as the active part of the counter-electrode is worn.

Although the wear of the electrodes generally takes place regularly over their whole active face, it is possible, with a view to make such wear more uniform, to impart to one of the electrodes (or to both electrodes) an axial rotary movement, the current supply being effected by suitable contact brushes and rings. Further the electrodes

may be fixed and the arc could be submitted to the action of a magnetic field such as would impart to the arc a rotary movement around the axis of the electrodes.

5 What I claim is—

1. In a set of electrodes for furnaces in which a fluid having a great dielectric strength is submitted to an electric treatment, a hollow electrode through the interior of which the said fluid is supplied to the arc, a counter-electrode situated substantially opposite to the first electrode and at a small distance from said electrode, a central cavity in said counter-electrode extending from its active end along a substantially long part of said counter-electrode, a solid part at the rear end of said electrode closing the said cavity, the sections of the said counter-electrode, perpendicular to its axis, made at different distances from its active end along its hollow part being identical to the sections of the opposite electrode, perpendicular to its axis, made at the same distances from the active end of said electrode.

2. In a set of electrodes for furnaces in which a fluid having a great dielectric strength is submitted to an electric treatment, a cylindrical electrode, a central cylindrical channel extending along the entire length of said electrode and through which the said fluid is supplied to the arc, a cylindrical counter-electrode situated at a small distance from the first electrode and with its axis in alignment with the axis of said electrode, said counter-electrode having the same transversal shape as the opposite electrode, a central cylindrical cavity in said counter-electrode extending from its active end along a substantially long part of said counter-electrode, said cavity having the same transversal shape as the channel in the first electrode, and a solid part at the rear end of said counter-electrode closing said cavity.

3. In a set of electrodes for furnaces in which

a fluid having a great dielectric strength is submitted to an electric treatment, a cylindrical electrode, a central cylindrical channel extending along the entire length of said electrode and through which the said fluid is supplied to the arc, said cylindrical electrode terminating in a flat face perpendicular to its axis, a cylindrical counter-electrode situated at a small distance from the first electrode and with its axis in alignment with the axis of said electrode, said counter-electrode having the same transversal shape as the opposite electrode, and terminating in a flat face parallel to the end face of the first electrode, a central cylindrical cavity in said counter-electrode extending from its active end along a substantially long part of said counter-electrode, said cavity having the same transversal shape as the channel in the first electrode, and a solid part at the rear end of said counter-electrode closing said cavity.

4. In a set of electrodes for furnaces in which a fluid having a great dielectric strength is submitted to an electric treatment, a hollow electrode through the interior of which the said fluid is supplied to the arc, a counter-electrode situated substantially opposite to the first electrode and at a small distance from said electrode, a central cavity in said counter-electrode extending from its active end along a substantially long part of said counter-electrode, a substance capable of being worn away in proportion to the wear of said counter-electrode filling the said central cavity, a solid part at the rear end of said electrode closing the said cavity, the sections of the said counter-electrode, perpendicular to its axis, made at different distances from its active end along its hollow part being identical to the sections of the opposite electrode, perpendicular to its axis, made at the same distances from the active end of said electrode.

PIERRE SOULARY.

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June 4, 1935.

P. L. J. MIGUET ET AL

2,003,653

ELECTRIC FURNACE OPERATION

Original Filed April 12, 1933

Fig. 1.

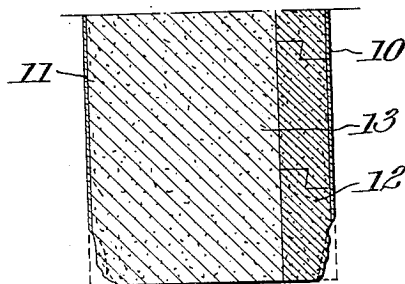


Fig. 2.

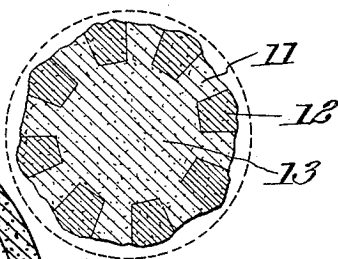


Fig. 4.

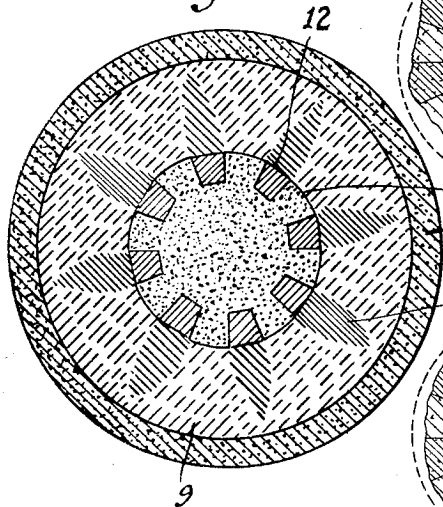
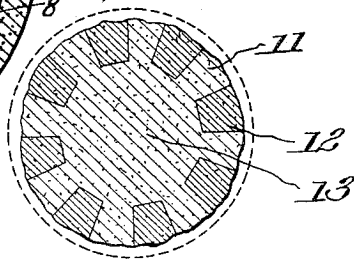


Fig. 3.



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UNITED STATES PATENT OFFICE

2,003,653

ELECTRIC FURNACE OPERATION

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Continuation of application Serial No. 665,787,
April 12, 1933. This application July 16, 1934,
Serial No. 735,492. In France April 30, 1932

1 Claim. (Cl. 13—34)

This application is a continuation of our application Serial No. 665,787, filed April 12, 1933.

This invention relates to an improved form of electrode for electric furnaces, and particularly to a compound electrode especially adapted for use in connection with the method of operating electric furnaces described in our prior Patent No. 1,944,521, issued Jan. 23, 1934.

In the prior patent is described a method of operating electric furnaces characterized by the charging of the materials in alternate vertical zones comprising in alternation a zone of a conductive mixture of all of the reducing material and only a part of the material to be reduced, and a zone comprising the remainder of the material to be reduced in the form of lenticular masses regularly spaced through the mass of the charge. This method of charging has the advantages of providing a discontinuous lateral spreading of the current without endangering the refractory lining of the furnace, without excessive radiation from the surface, without premature fusion of the material to be reduced, and without being influenced by the depth of molten product on the hearth of the furnace.

However, the operation of this process has shown that the perimeter of the electrode hanging in contact with the reacting mass is subjected to uneven wearing or consumption which is greater when the whole electrode mass is baked in place than when the perimeter is entirely composed of pre-baked elements. This unevenness consists of furrows excavated in the electrodes opposite the lenticular masses by the oxidizing action of the reducible materials of which they are composed.

This unevenness, more or less accentuated according as the periphery of the electrode is pre-baked or not, results in insufficient support opposite the furrows for the material being treated, causing falling-in of the charge, emulsification by the excessive production of carbon monoxide, chilling, and even reversion of the production already obtained.

The invention will be particularly described with reference to the accompanying drawing in which:

Fig. 1 is a vertical section, and Figs. 2 and 3 are horizontal sections, of an electrode embodying the principle of the present invention. Fig. 4 is a horizontal section through a furnace and charge embodying the principle of the invention.

It has now been found that the disadvantages described above may be avoided by providing an

electrode of which the periphery is alternately composed of baked and unbaked segments as shown in the figures; the unbaked segments 11, of greater chemical activity, being disposed opposite the portions 9 of the charge free from the lenticular masses, and the pre-baked segments 12 being disposed opposite the lenticular masses 8 as shown more particularly in Fig. 4.

In Figs. 1, 2 and 3, the dotted lines indicate the original contour of the electrodes before use.

The new electrode undergoes a uniform lateral consumption and maintains a perfectly regular contour when used in the presence of lenticular masses as shown in Fig. 3, and also maintains a slope much closer to the vertical than to the natural angle of repose of the material.

The unbaked portion of the new electrode may be made of a rammed mass having metallurgical coke as a base, and for this reason it has the additional advantage of a much lower cost than the prior electrodes. Even when used with charges free from lenticular masses, as shown in Fig. 2, the wearing of the electrodes is sufficiently regular that they may be advantageously used with such charges, in view of their low cost of manufacture.

The use of a metallic jacket 10 is very desirable, in order to provide a supporting mold for the ramming of segments of unbaked material 11 between the segments of pre-baked material 12; the central filling 13 is preferably rammed in at the same time. Any of the known means for joining and suspending the pre-baked elements may be utilized.

We claim:

The improvement in the operation of electric furnaces wherein the materials are charged in alternate vertical zones comprising in alternation a zone of a conductive mixture of all of the reducing material and only a part of the material to be reduced, and a zone comprising the remainder of the material to be reduced in the form of lenticular masses regularly spaced through the mass of the charge which comprises supplying current to the charge through electrodes of which the periphery is alternately composed of prebaked and unbaked segments, the unbaked segments being disposed opposite the portions of the charge free from lenticular masses and the prebaked segments being disposed opposite the lenticular masses.

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UNITED STATES PATENT OFFICE

2,027,732

ELECTRODE FOR USE IN ELECTROTHERMAL PROCESSES FOR THE PRODUCTION OF CARBON BLACK

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No Drawing. Application August 20, 1934,
Serial No. 740,637

3 Claims. (Cl. 204—31)

This invention is directed to an advantageous type of carbon electrode, and more particularly to an electrode having characteristics which make it advantageous for use in certain electrothermal reaction processes such as in the electrothermal dissociation of organic liquids to form carbon-black.

In the production of carbon-black by electrothermal dissociation of organic liquids after the manner set forth in United States Patents to Jakosky No. 1,597,277, Jakosky No. 1,673,245 and No. 1,872,297 and Jakosky et al. No. 1,912,373 and No. 1,931,800, difficulties have been experienced in the production of carbon-black which is free of carbon particles of macroscopic proportions. As is well known, carbon-black finds its principal use as a filler in rubber compounding, and the particular advantage of carbon-black for this purpose appears to lie in its extremely fine subdivision. It is apparent, therefore, that the presence in a carbon-black of any appreciable quantity of material which fails to be properly dispersed to microscopic or sub-microscopic proportions by the ordinary milling procedure in rubber manufacture, is of serious disadvantage.

It has been noted that carbon electrodes used in such electrothermal dissociation processes are subject to uneven arc "erosion", that is, subject to pronounced pitting over the arcing surface. The degree of pitting varies with different compositions of electrodes but all available electrode materials show such pitting to some degree. It has been found that such pitting causes portions of the electrode material to be broken-away from the electrode body and disseminated into the surrounding organic liquid, and due to the fact that such broken away portions are fragments of macroscopic proportions, their presence is detrimental unless they are of such character as to be readily milled into a rubber mix. The conventional carbon electrode, being designed for a materially different use, is very hard and dense, and therefore is not at all susceptible to subsequent dispersion by such milling procedure.

The presence of the macroscopic particles in a carbon-black produced by methods involving electrothermal dissociation of organic liquids as described in the above-mentioned patents, appears to also be due in large part to the formation of so-called carbon "trees" which build up on the surface of the electrode. These "trees" are apparently formed of microscopic or sub-microscopic carbon particles which have been cemented or otherwise bonded together to form aggrega-

tions which are not to any appreciable extent dispersible in rubber milling.

The carbon "trees" thus formed are actually aggregates of carbon particles having microscopic or sub-microscopic dimensions bonded together so intimately as to substantially resist the dispersing action of a rubber mill. Experimental investigation of the problem indicates that these particles start as very minute deposits on the electrode surface, being possibly cemented to the electrode surface by the action of the electric arc in the formation of a "coke-like" material from a particular constituent of the organic liquid undergoing dissociation. The minute coked particles which adhere to the electrode surfaces provide starting points for further agglomeration and cementing of additional carbon particles and thus facilitate the formation of rather large-size aggregate or "trees", some of which may reach one-half inch or more in length. These carbon "trees" apparently grow until they are knocked off of the electrode surface and are picked up by the liquid surrounding such electrodes. Furthermore, when these "trees" are dislodged they may also carry with them, mechanically, adhering fragments of the electrode material itself.

The presence of such macroscopic carbon particles has long been recognized in the art, but heretofore the energies of investigators have been directed toward minimizing and eliminating the formation of such particles by using constantly changing arcing surfaces. Careful control of the operation of carbon-black treaters has resulted in a material reduction in the quantity of such macroscopic particles, but it is now found that the character of the electrode material and the electrode surface plays an important part in the formation of these macroscopic particles.

In view of the above, therefore, one of the principal objects of the present invention is to provide an electrode useful as an arcing element in the electrothermal production of carbon-black by dissociation of carbon-bearing liquids, of such character as to minimize the production of macroscopic carbon particles in such a carbon-black.

A further object of the invention is to provide an electrode for the above-specified purpose which is formed of a material which is in itself susceptible to dispersion in rubber milling.

A further object of the invention is to provide an electrode surface for the purpose above set forth which will prevent the formation of difficultly milled aggregates of carbon-black.

According to the present invention, the elec-

trode material is preferably of such nature as to be of itself easily dispersible under the action of a rubber mill, so that any particles which are broken away from the electrode body either co-

3 incidentally with the washing away of a deposited carbon particle or at other times due to other causes, such as a result of pitting, will be of such nature as to freely mill into a rubber mix according to the customary milling procedure.

10 As a further feature of the present invention, an electrode material is provided which is of such a nature that there is little tendency for any adhering carbon particles to build up to any appreciable size, the electrode material being of

15 such nature that the deposited carbon particles do not strongly adhere to the electrode and are consequently washed from the surface thereof by the action of the arc and/or the circulating submerging liquid before they have had an opportunity to grow to any appreciable dimensional proportions.

I have found that a highly advantageous electrode for the present use may be made principally or substantially wholly of carbon-black itself, suitably bonded through the agency of a bonding or cementing material such as tar, pitch or mixtures thereof and properly dried and baked to give a modicum of physical strength to the electrode which will enable it to be handled and used without excessive breakage, but which will

30 at the same time be of a nature such that particles thereof may, if broken-away from the electrode surface and distributed with the carbon-black produced in the electrothermal reaction,

35 be easily milled into a rubber mix along with such produced carbon-black in the compounding of rubber. Other bonding agents are also useful in forming the carbon-black electrode of the present invention, such as sugar solutions or other syrups, water soluble gums such as gum

40 arabic, agar-agar or the like, or resins, gum resins or the like.

Previous to the present disclosure, electrodes for electric arcs have been made of one or another form of carbon thoroughly bonded so that

45 a hard electrode material is realized and while the prior art shows that lampblack has been employed in the production of arc carbons the only successful electrodes containing lampblack were those which also contained a relatively large

50 proportion of a suitable coke or other form of hard carbon, the mixture being thoroughly baked to obtain the desired flint-like electrode material. To the best of applicant's knowledge no electrode

55 has been hitherto proposed which is in itself sufficiently soft and friable to fulfil the objects of the present invention, this type of electrode being entirely contrary to the established practice of electrode manufacture.

60 As a specific example of preparation of an electrode according to the present invention, I may mix carbon-black with a suitable proportion of binding material such as coal tar residue, pitch or other comparable material in solution in a suitable solvent medium such as benzene, thoroughly intermixing the above ingredients to obtain a homogeneous semi-plastic mass. This mass may then be formed into the desired electrode shape under pressure or by extrusion as

desired, the electrode suitably dried at a relatively low temperature to remove the principal proportion of the solvent material and subsequently baked to a sufficient temperature to cause the binding material to cement the particles of carbon-black together. The relative proportion of carbon-black and binding material, as well as the drying and baking temperatures and time, are subject to variation, depending upon the type and characteristics of the binding material employed, and it will be appreciated that in any event the proportions and baking conditions are so selected as to provide a bonding of the carbon-black particles into an integral electrode body of such character as to provide the

10 above-described dispersibility in a rubber mix, during a milling operation, of any fragments thereof which may have been loosened from the electrode body during the use thereof in the production of the carbon-black used in said rubber

15 mix. While the above type of electrode is not as resistant to arc wear as are the customary coke or graphite electrodes hitherto employed for the purpose, they are greatly to be preferred in view of their physical characteristics.

It will be appreciated that the electrode of the present invention may be made of any desired shape, according to the teaching of any of the above-mentioned patents. They may be made of ring-shape, disc-shape, rod-shape, or of any other

30 useful shape. In the teaching of the above patents, the electrodes are mounted in a closed reaction chamber provided with means for maintaining a body of dissociable carbon-bearing liquid in said chamber, and the electrothermal

35 reaction is realized by maintaining one or more arcs between said electrodes beneath the surface of said liquid body, that is, with the electrodes submerged in the liquid at the vicinity of the arc. The arc zone is thus continually supplied

40 with dissociable liquid, and the desired carbon-black is immediately disseminated into the surrounding liquid medium.

I claim:

1. An electrode, for use in the electrothermal

45 dissociation of organic liquids to form carbon-black, containing carbon-black as its principal constituent and characterized by being easily dispersed in a rubber mix by the ordinary rubber milling procedure.

2. An electrode, for use in the electrothermal dissociation of organic liquids to form carbon-black, consisting principally of carbon-black and a binding agent and formed into an integral structure of a soft and friable nature, characterized by being easily dispersed in a rubber mix by the ordinary rubber milling procedure.

3. An electrode, for use in the electrothermal dissociation of organic liquids to form carbon-black, in which electrodes are employed in submerged relation to such liquids, characterized by being soft and friable in nature whereby disintegration of such electrode in the dissociation operation will result in the dissemination of electrode particles within such liquid which are easily dispersed in a rubber mix by the ordinary rubber milling procedure, and containing carbon-black as its major constituent.

JOHN J. JAKOSKY.

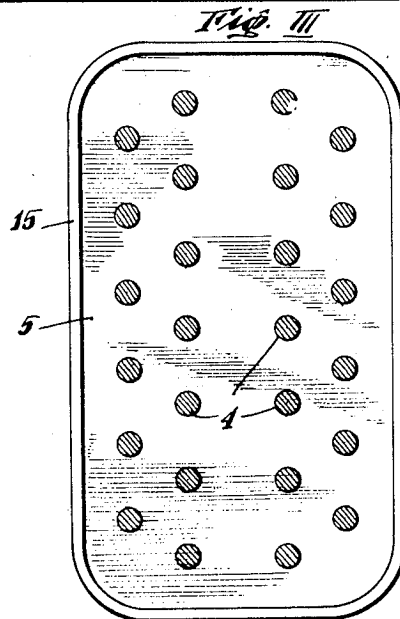
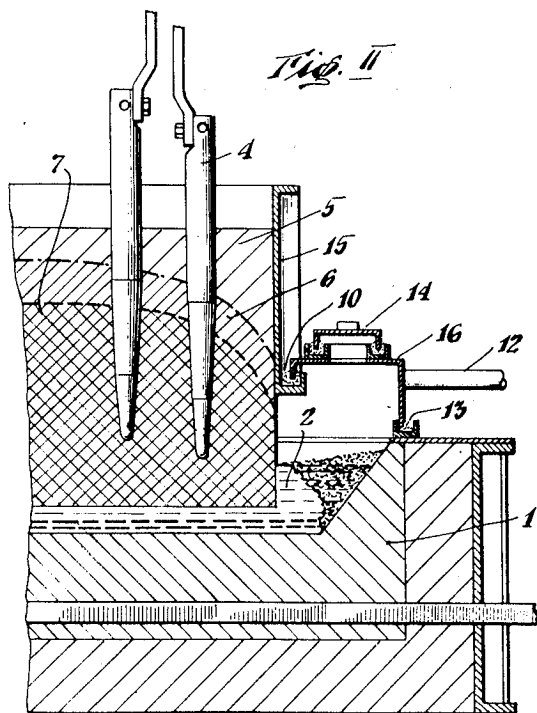
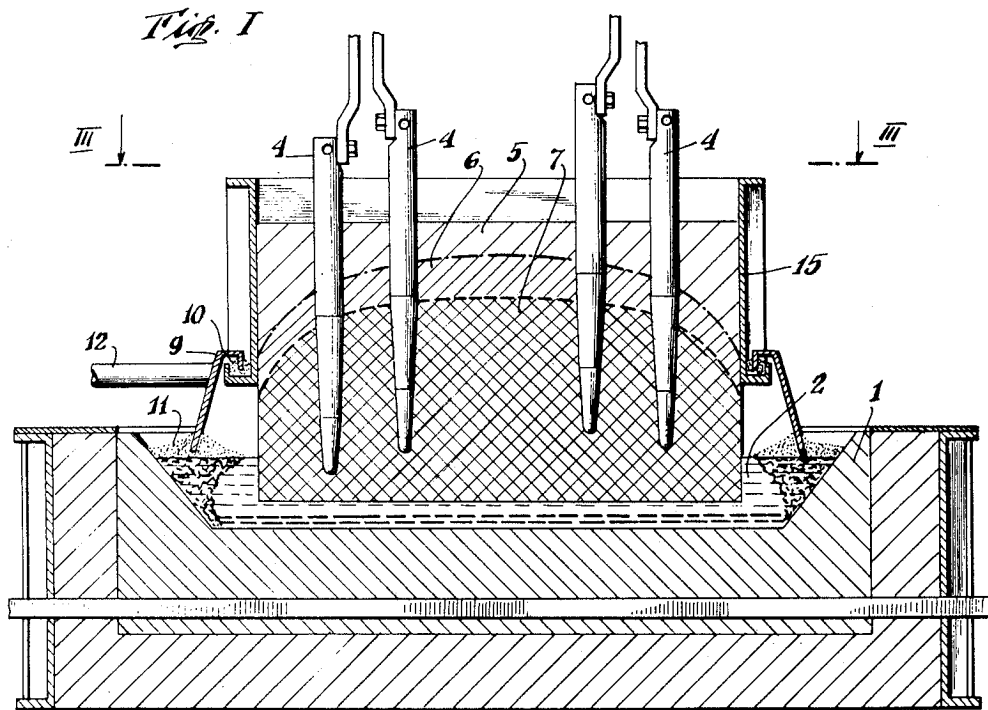
Oct. 24, 1950

J. SEJERSTED

2,526,876

METHOD OF HANDLING CONTINUOUS ELECTRODES

Filed April 30, 1949



INVENTOR.
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UNITED STATES PATENT OFFICE

2,526,876

METHOD OF HANDLING CONTINUOUS ELECTRODES

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Application April 30, 1949, Serial No. 90,594
In Norway May 8, 1948

5 Claims. (Cl. 13—34)

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This application relates to methods for handling continuous electrodes of the so-called Söderberg type and particularly to electrodes used for low voltage electrolytic work as in the case of aluminium furnaces.

Electrodes of this type are made by putting so-called "paste" into a casing having an internal shape corresponding to the shape of the desired electrode. The paste is a mixture of carbonaceous material such as coke, and a binder. Ordinarily the binder has a melting point somewhat above normal atmospheric temperature so that the paste is solid at room temperature. The upper part of the electrode (either at the top or a short distance down in the electrode mass) is hot enough so that the binder of the paste melts and ordinarily the paste flows without the necessity of tamping to take the shape of the electrode. The nature of a type of paste commonly employed is described in U. S. Patent No. 1,670,052.

As the electrode is consumed at the bottom it is very slowly lowered in the casing through zones of gradually increasing temperature until it finally becomes incandescent considerably above the point of consumption. As the paste mass becomes hotter, the more volatile ingredients in the binder are first distilled off so that the mass which was originally solid and then liquefied, again solidifies. Substantial solidity is reached some time before the binder is fully carbonized and in this stage the particles of carbonaceous matter are held bound together in solid form by substantially non-liquid tars. While in this state the electrode mass will hold its shape but it still has sufficient flexibility so that an iron bar can be driven into its side. At this stage the temperature of the mass will be below 425° C. and ordinarily will be somewhat lower, say between 300° C. and 350° C.

As the temperature still further rises, the tars undergo cracking and chemical decomposition until finally a mass is obtained which is substantially fully carbonized. This final baking begins to take place at about 425° C. and therefore is substantially complete when the mass becomes incandescent.

In past years it was customary to form the casing for the electrode from separate bars which moved down with the electrode mass and which could be removed from around the electrode when it has finally become carbonized and was approaching the bath of metal subjected to the action of the electrode. Such a construction is

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illustrated, for example, in Torchet Patent No. 2,073,356 and Legeron Patent No. 2,169,563.

In more recent years it has been proposed that the casing be made fixed and that the electrode slide through the casing and be supported by studs or contact members passing vertically down from the top into the electrode mass (see, for example, Manfredini Patent No. 2,224,739). One difficulty with this system has been that the electrode which is only moved intermittently tends to stick to the casing. At first this sticking may not be serious but gradually the amount of adhering baked paste increases until a point is reached where the sliding of the electrode mass through the permanent casing is substantially hindered. This, of course, causes difficulties in the operation of the furnace, for the only way of removing the adhered paste is to remove a portion of the permanent casing and clean it. Such an interference with production is extremely expensive.

The present invention is dependent upon my discovery that the tendency of the electrode mass to bake onto the metal of the casing occurs after the mass has solidified and during the stage when the tars are finally carbonized. Taking advantage of this discovery, I have developed a method of handling continuous electrodes in a furnace for producing aluminium or the like which comprises putting a paste mass into a casing having an internal section of the shape desired for the electrode. Such mass is then brought into a zone where it will melt to assume the shape of the electrode and is gradually moved downward into a zone hot enough to cause the mass, or at least its outer portion, to solidify but not to be fully carbonized. The temperature at this stage is between 300° C. and about 400° C. When the mass is in this condition and before the temperature of its outer shell adjacent the casing exceeds 425° C. it is moved downwardly out of the casing, the bottom edge of which is held above the bath a sufficient distance so that the heat of the furnace does not cause the outer portion of the electrode mass to reach the carbonizing temperature while within the casing. Ordinarily the temperature of the mass toward the center is hotter than around the outside so that the carbonizing zone will be higher in the middle than toward the outer edges. However, the phenomena which we are here discussing take place at the outer part of the electrode mass and therefore it is the outer temperature of the mass which is critical. Ordinarily the bottom of the casing should be at least 15-20 centimeters above

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the bath or somewhat higher, depending on details of design.

After emerging from this casing the electrode is lowered further into a hotter zone where it is progressively heated until it becomes incandescent and carbonized fully. In this latter part of the operation, the sides of the electrode are not supported and this permits the decomposition products and vapors resulting from the cracking of the tars to escape outwardly through the sides of the electrode mass, and entirely prevents the mass from baking onto the casing. The electrode finally enters the furnace bath in which it functions, which has a temperature of about 950° C.

If the mass at the temperature of incandescence were left exposed to the air, it would tend to burn and corrode, causing very substantial loss. I find, however, that by supplying a member forming a confined space surrounding the bottom part of the electrode (but out of contact with its surface) and by maintaining a non-oxidizing atmosphere in such space, combustion and corrosion of the sides of the electrode are prevented. In this connection I have found that combustion of the tar vapors or their cracking products and gases that evolve from the exposed faces of the electrode will ordinarily be sufficient to consume oxidizing gases such as CO₂ as may be present and thus maintain a sufficiently non-oxidizing atmosphere in the enclosed space. Provision should be made so that the products of combustion can be withdrawn as desired.

When the casing is so constructed that it is held about 15 to 30 centimeters above the level of the bath in the furnace, the temperature at the bottom of the casing will be above about 300° C., a temperature necessary for solidifying but below the critical temperature of 425° C. which should not be exceeded. Ordinarily when an electrode is lowered within the casing to compensate for the normal consumption which takes place within the bath, the amount of lowering which is done at one time is only from 2 to 5 millimeters. In an aluminium furnace it is customary periodically for the aluminium to be tapped off and at this time a larger movement of the electrode is necessary. The depth of aluminium tapped off is from 3 to 5 centimeters and would ordinarily not exceed 7 centimeters so that it is safe to assume that there is no necessity of lowering the electrode more than about 7.5 centimeters. Within this amount of movement there is virtually no danger of a non-solidified portion of the electrode mass coming down below the bottom of the electrode casing into an area where it will be unsupported on its sides.

This system contemplates the use of vertical studs. One of the difficulties found with the use of vertical studs has been the tendency of the electrodes to crack. The cracks ordinarily pass through the spaces in which the vertical studs are located. If such cracks run longitudinally of the electrode (which ordinarily is made with a length much greater than its width) there is a tendency for the gases generated at the bottom surface of the electrode to be caught by such cracks. These gases consist largely of CO₂, and there is a tendency for the CO₂ to react with the carbon of the electrode to form CO, thus tending to increase the size of the cracks. Such cracks also mean a higher voltage drop in the electrode and should therefore be avoided.

It has been found that if the cracks run transversely from the outer ring of the electrodes

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these take care of the shrinkage of the electrode mass and there is relatively little tendency for the longitudinal cracks to form. The transverse cracks running out longitudinally from the outer line of contact studs do relatively little harm as the gas escapes rapidly from them into the nearby gas-collecting ducts so that there is relatively little consumption of the electrode mass. In order to direct the crack formation in this transverse direction it is desirable to space the electrode supports or studs further apart from each other longitudinally than the distance between these studs and the outer wall of the electrode. Heretofore this placing of the studs near the outer electrode wall tended to emphasize the danger of having the electrode mass stick to the casing (since it caused localized heating). However, by the use of my present invention where the electrode mass emerges from the casing before the final carbonization, this tendency to stick is done away with and this permits the vertical studs to be located quite close to the outer margin of the electrode mass. For example it is quite feasible to locate the studs so that the distance in the horizontal plane between the center points of the studs longitudinally is at least 33% greater than the distance from the center line of the outer row of studs to the outer margin of the electrode mass. This spacing has previously been indicated as for example in Patent No. 2,224,739, but heretofore no particular reason for this spacing had been stated nor was any construction known in which it could be employed to the best advantage.

Further details of my invention can readily be understood from the example illustrated in the accompanying drawings in which Fig. 1 shows a transverse section of an electric aluminium furnace embodying my invention; Fig. 2 shows a transverse section of one-half of a similar furnace illustrating a modified form of construction and Fig. 3 is a plan view of the electrode showing the location of the electrode studs.

In Fig. 1 the numeral 1 designates an electric aluminium furnace; 2 is the molten bath and 3 is the electrode provided with internal vertical contact studs 4 which extend down into the lower part of the electrode 3 where they are anchored in the carbonized mass. The numeral 5 indicates that portion of the electrode 3 which is unbaked and pasty, and 6 is the portion of the electrode where a sufficient amount of volatile matter has been driven out of the paste so that the mass in this zone will be solid but not fully baked. The approximate line of demarcation between portion 5 and portion 6 of the electrode mass is indicated by a dot and dash line. 7 is the lower part of the electrode which is fully coked or carbonized and the approximate line of separation between the zone 7 and zone 6 is indicated by a dotted line. It is understood that these zones are not sharp and definite but are only approximated by the lines indicated.

The numeral 15 indicates the casing for the electrode which is suspended from the usual superstructure (not shown) in any conventional manner. The interior of this casing will ordinarily be rectangular with its length substantially greater than its width as indicated in Fig. 3. Since the electrode mass will slide smoothly within the casing 15 without any danger of sticking, it has been found that the height of this casing need not be as great as in previous constructions of this type.

The numeral 9 indicates a member which

serves to form a gas-collecting duct or space around the lower portion of the electrode mass. This is preferably connected to the casing by a gas-tight sand lock 10 and at its lower end it is imbedded as at 11 in alumina which acts as a gas lock. Gases which occur within the space defined by member 9 may be led away through pipe 12.

In Fig. 2 the space around the lower part of the electrode is formed by a member 16 connected to the casing 15 by the sand lock 10 and to the furnace pot by the sand lock 13. Openings are formed in the top of member 16 and these are provided with removable covers 14 which connect with the member 16 by appropriate sand locks. These covers can readily be removed when additional alumina must be added to the furnace or when the crust has to be broken down, or other work done.

While I have indicated the temperatures of the various zones which are critical to the operation of this invention, these zones may also be checked by mechanical means. Specifically it will be found that the mass in zone 7 is baked so hard that one cannot drive a metal bar into it without cracking it. On the other hand, zone 6, while sufficiently solid so that it does not flow, is soft enough so that a metal bar can be driven into it.

In Fig. 3 I indicate the spacing of the electrode studs 4 relative to the casing 15. It will be noted as stated above, that the distance between the center point of the studs longitudinally and taken in a horizontal plane is at least 33% greater than the distance from the center line of the outer row of studs to the outer margin of the electrode mass. By this arrangement if any shrinkage cracks occur, they will tend to run transversely out to the sides of the casing rather than longitudinally.

It is understood that the examples given are intended only as illustrations and that my invention may be modified in many particulars.

What I claim is:

1. The method of handling a continuous electrode in an aluminium furnace which comprises putting a usual paste mass into a fixed casing having an internal section of the shape desired for the electrode, bringing such mass into a zone where the mass melts to assume such shape, moving the mass downwardly within and in contact with such casing into a zone hot enough to cause the outer portion of the mass to solidify but not to be fully carbonized, moving the mass downwardly out of the casing while in such partly baked condition and into a hotter zone where the mass will no longer be in contact with the casing and will become incandescent and can carbonize before entering the bath where it functions, maintaining a substantially gas-tight seal between the fixed casing and the surface of the bath surrounding the lower part of the electrode whereby admission of air into the area surrounding the exposed portion of the electrode is substantially prevented and generated gases enter such area, and withdrawing portions of such gases from such area through an escape pipe while a substantially non-oxidizing atmosphere is maintained around that portion of the electrode which extends from the bottom of the casing to the surface of such bath

to prevent combustion of the exposed face of the electrode.

2. A method as specified in claim 1 in which the temperature of the outer portion of the electrode mass as it emerges from the casing is between 300° C. and 425° C.

3. A method as specified in claim 1 in which the electrode mass as it emerges from the casing is soft enough so that an iron bar can be driven into it without causing it to crack.

4. A method of handling a continuous electrode in an aluminium furnace which comprises shaping the electrode and baking it at a temperature of between 300° C. and 400° C. in a fixed casing whereby the outer portion of the electrode is solidified but not fully carbonized, withdrawing it downwardly from the casing at a temperature not in excess of 425° C., passing the electrode with its sides substantially unsupported downwardly towards and into the furnace bath while raising the temperature progressively to incandescent temperature whereby the electrode is fully carbonized, and maintaining a substantially gas-tight seal between the fixed casing and the lower surface of the bath surrounding the lower part of the electrode whereby admission of air into the area surrounding the exposed portion of the electrode is substantially prevented and generated gases enter such area, and withdrawing portions of such gas from such area through an escape pipe so that a substantially non-oxidizing atmosphere around the electrode while passing it down from the fixed casing to the furnace bath.

5. A method as specified in claim 1 in which the electrode mass is supported by vertical studs anchored in the carbonized portion of the electrode which studs are positioned so that the distance in a horizontal plane between the center point of the studs longitudinally is greater than the distance from the center line of the outer row of studs to the outer margin of the electrode mass whereby shrinkage cracks will tend to run out from the studs to the sides of the electrode rather than longitudinally.

JOHANNES SEJERSTED.

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July 15, 1952

C. H. CHAPPELL

2,603,669

LARGE ELECTRODE WITH THERMAL STRESS RELIEF

Filed Oct. 26, 1948

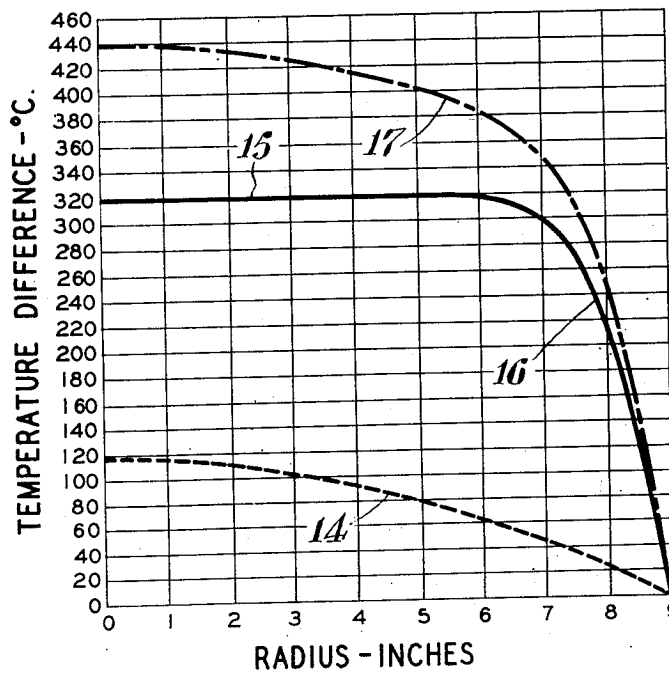
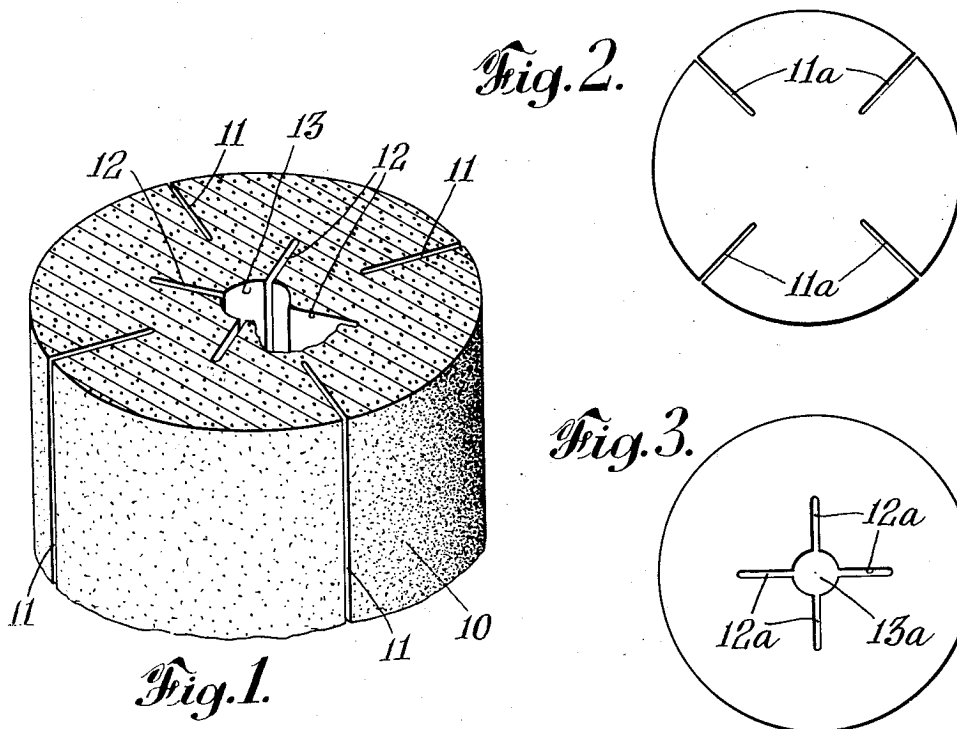


Fig. 4.

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2,603,669

LARGE ELECTRODE WITH THERMAL STRESS RELIEF

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Application October 26, 1948, Serial No. 56,647

23 Claims. (Cl. 13—18)

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The problem of thermal stress in furnace electrodes has been recognized for over 35 years and has become more troublesome as electrodes with increased diameters have been produced. These stresses are due to non-uniformity in temperature throughout the electrode and are greatest on its immersion in a hot furnace and upon its withdrawal. Contraction of the outer surface especially of an extruded electrode on cooling imposes tensional stresses which cause spalling and longitudinal cracks. A longitudinal crack may change direction to a fatal transverse crack.

One early suggestion for reducing thermal stresses is found in the patent to Hinckley 1,058,057, April 8, 1913, in which a longitudinal slot extended all the way through a radial wall of an electrode provided with a central bore. One objection to this proposal is the danger of a longitudinal crack opposite the slot developing from the clamping stress to which the electrode is subjected from its holder. Another objection to that proposal is the danger of rupture from the nipple pressing against the socket when electrodes are connected end to end by the usual threaded carbon or graphite nipple. Since that time electrodes have increased in size and the time of maximum internal stress is believed to be no longer on starting but in stopping the operation of the electrode and on its withdrawal into the air. At that time the inside of the electrode has been heated to a high temperature and after the outer portion has been cooled for a minute or two, a steep thermal gradient is produced adjacent the outer surface imposing a tensional stress around the circumference of an electrode transverse cross section tending to form a longitudinal crack.

A large majority of the large size furnace electrodes are of the extruded type in which cracks are practically never noted to start in a transverse direction but begin in a longitudinal direction and then may change into a transverse direction to be more serious and objectionable in nature. Molded electrodes tend to have a smaller transverse coefficient of expansion and therefore lower transverse stresses, the longitudinal direction containing the larger coefficient of expansion, wherefore the danger of longitudinal cracks developing in molded electrodes is usually less than in extruded electrodes. By carbon is meant either carbon or graphite.

This invention relates to large carbon electrodes, especially those of the extruded type, for electric furnaces and has for an object to reduce the danger of longitudinal cracks.

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Another object is to reduce the thermal stress developed within the electrode, particularly on cooling.

According to this invention, one or more narrow slots extend longitudinally and deep enough to lessen the degree of such thermal stress but shallow enough to leave a substantial part of the radial depth of the electrode wall, thereby providing a firm foundation to resist the tendency to fracture possessed by an electrode having a slot radially all the way through its wall. These narrow slots are preferably filled with a yieldable conductive carbon to lessen the likelihood of rapid oxidation of the carbon side walls. Preferably, both inside and outside radial slots are provided, symmetrically arranged with the inside slots angularly displaced from the outside slots. The outside slots have been found to be the more important slots. However, the inside slots reduce the formation of high compressive stress on the inside and are thus useful in alleviating the danger of excessive tensional stress on the outer portion of an electrode.

Referring to the drawings:

Fig. 1 is a perspective partly in section of a preferred embodiment of an electrode under the present invention;

Fig. 2 is an end view of a cylindrical electrode having only outside slots;

Fig. 3 is an end view of a cylindrical electrode having only inside slots;

Fig. 4 shows the calculated temperature gradient in an electrode of 9 inch radius.

Referring to the drawing, a large cylindrical carbon electrode 10 for use in an electric furnace is provided with three or more symmetrically arranged and substantially equally, angularly spaced, generally radial outside slots 11 for the purpose of reducing tensional stress in the outer portions of an electrode cross section. These slots 11 have a depth of from .1 to .5 or more of the radial depth of the electrode and a width of $\frac{1}{8}$ " to perhaps an inch the bases of the slot being rounded as illustrated to minimize stress concentration. The maximum figure named is arbitrary since the slots should not be so wide as to substantially reduce the transverse cross sectional area of the electrode thereby impairing its conductivity. The minimum width suggested for the slots 11 is determined by the manner in which the same may be formed in manufacture. It is understood that the width of these slots should be large enough to prevent the side walls from touching when the electrode is placed in a hot furnace. Symmetrically spaced angu-

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larly from the external slots 11 are an equal number of internal slots 12 radiating from a central bore 13. In cooling it has been found that these inside slots tend to reduce the compressive stress in the heated central portion of the electrode and therefore also tend to reduce the formation of dangerous tensional stress in the outer portions of the electrode. An axial bore 13 is usually provided when internal slots 12 are provided. The diameter of this bore 13 may vary from .1 to .6 or more of the electrode diameter though the small size bore is preferable in order not to reduce the conductivity of the electrode excessively.

The slots 12 may be from .005" to 1" in width. Their minimum width should be such that, on cooling, the side walls of the slot 12 are not closed. The upper limit for the slot width is such that the conductivity of the electrode is not unduly reduced. Here again, the base of each slot 12 is rounded for strength. It will be seen from the drawing that each internal slot 12 is spaced 45° from an external slot 11.

The transverse cross-sectional area of the electrode has been reduced by both slots 11 and 12 less than 10% and preferably between 2% and 7%. The inner slots 12 should reduce the cross-sectional area of the electrode by less than 4%, exclusive of axial bore, and the outer slots by less than 4.4% in order that the conductivity of the electrode may not be impaired. These values represent what has been found to be good practice. The problem solved by this invention does not exist in small electrodes of less than two inches diameter. As shown in the drawing the depth of the inner slots is preferably slightly shorter than the depth of the outer slots.

The embodiment illustrated in Fig. 2 is a large cylindrical electrode having only the external slots 11a of the size and extent indicated for the slots 11 in Fig. 1.

The electrode of Fig. 3 contains only the internal slots 12a radiating from the axial bore 13a and of the size mentioned for those slots 12 in Fig. 1.

The slots of each embodiment and the axial bore of Figs. 1 and 3 preferably are each filled with an inert conductive material of a soft and pliable nature to prevent the access of air or oxidizing gases to the slot walls yet to permit movement of the side walls of each slot toward and from one another. Materials suitable for such filling include graphite, bituminous coal, foundry coke, petroleum coke, sawdust or other carbonaceous material, decomposed carborundum, or mixtures of these materials, each crushed and mixed with any suitable binder. A suitable filler composition is a mixture of 23 parts tar with 77 parts graphitized lump foundry coke crushed to 1/4" size and smaller.

The tangential stress on the surface of an electrode 18 inches in diameter has been calculated to be 163 pounds per square inch when the surface temperature is 1600° C., when the electrode is carrying 30,000 amperes and is at equilibrium thermally. Under these conditions the thermal gradient is only 117° C. and such is shown by the curve 14 in Fig. 4. It has also been calculated that if the same electrode is uniform in temperature and carries no current but is exposed to room temperature, the stress in the outer fibers will reach 735 pounds per square inch after one minute exposure and 805 pounds per square inch after two minutes ex-

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posure. The radial temperature gradient under these conditions was calculated to be 320° C. and 375° C. respectively. The curve 15 in Fig. 4 indicates what is believed to be a temperature gradient for the electrode one minute after it has begun cooling in the air if the conditions of curve 14 had not existed. It will be noted that the steepest portion 16 of this gradient is in the outer two inches of the electrode radial depth. Curve 17 is a composite of curves 14 and 15. Curve 17 is believed to give an idea of the total temperature gradient in an electrode.

Where external slots are used to reduce the stress in the outer portion of the electrode it will be apparent that such slots should be at least two or three inches in depth in order that they may extend through the portion of the electrode where the steepest temperature gradient occurs. The maximum estimated stress is about 900 pounds per square inch in tension, which is 50% greater than the normal transverse strength usually reported for this type of graphite at room temperature. The neutral stress zone is believed to be .575 of the radius from the center in a solid cylindrical electrode. Although the coefficient of expansion, modulus of elasticity, elastic limit, etc. of electrode materials are known at room temperature, these values are not as well known at the high temperatures to which an electrode is subjected and their accurate measurement at these temperatures is difficult.

What is claimed is:

1. In a cylindrical carbonaceous electric furnace electrode having a diameter of at least several inches, the combination therewith of means for reducing the tendency for a longitudinal crack to form due to a substantial temperature gradient between the inner and outer portions of the electrode, said means including the provision in the electrode of at least one generally radial slot extending longitudinally thereof but of less depth than the radial thickness of the electrode, said slot being adjacent at least one of an inner and an outer portion of the radius and of a width to prevent the side walls of the slot closing under substantial pressure due to extremes in temperature encountered within the electrode, the total reduction in cross sectional area of the electrode due to said slot being not more than 7 percent, said slot being free of any material which would appreciably impede movement of its side walls toward each other due to temperature changes and free of any material contaminating a bath in which the electrode is adapted to be placed, the unslotted portion of the electrode radially beyond said slot having a substantial depth and providing a foundation against which any clamping stress of an electrode holder may be exerted.

2. An electrode according to claim 1 in which said at least one longitudinal slot is in a radial inner portion of the electrode but outside of an axial bore.

3. An electrode according to claim 2 in which the radial inner slotted portion contains at least three substantially equally spaced slots of a size reducing the transverse cross sectional area of the electrode by no more than about 4%, exclusive of said axial bore.

4. An electrode according to claim 1 in which said at least one longitudinal slot is in an outer portion of the electrode and opens onto an outer circumference and an unslotted portion of the electrode is radially inside of said slot.

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5. An electrode according to claim 4 in which the externally slotted portion contains at least three substantially equally spaced longitudinal slots of a size reducing the transverse cross sectional area of the electrode by no more than 4.4% and the bases of said slots are rounded to better withstand thermal stress tending to move the side walls of the slot toward and from one another.

6. An electrode according to claim 1 in which an axial bore is provided with said at least one radial slot extending outward from said bore and at least another generally radial slot of less depth than the electrode radial wall extends inwardly from the periphery, said slots being angularly displaced from one another, not substantially overlapping radially, and a substantial portion of the electrode wall between said slots being unslotted both radially and angularly.

7. An electrode according to claim 1 in which there are at least three but not more than eight generally radial slots substantially equally spaced angularly.

8. In a generally cylindrical, uniform and homogeneous electric furnace electrode having a diameter in excess of three inches, the combination therewith of the improvement for reducing the tendency of a longitudinal crack to form due to a substantial temperature gradient between the inner and outer portions, said improvement including the provision of at least one generally radial slot extending longitudinally of the electrode of less depth than the radial thickness of the electrode, having a width to prevent the side walls of the slot closing under substantial pressure due to temperature differences in the electrode, of a width effecting a total reduction in transverse cross sectional area of the electrode due to the slotted portion of not more than 7 percent and the slotted portion is free of any material which would significantly impede movement of its side walls toward each other due to temperature differences within the electrode and free of any material contaminating a bath in which the electrode is adapted to be placed, the unslotted wall of said electrode radially beyond said slot being of a radial depth providing a foundation against which a clamping stress may be exerted, the slotted portion being filled with a yieldable carbonaceous conductive material whereby the electrode is integral structurally except for the material filling said slot.

9. An electrode according to claim 8 in which the slotted portion reduces the cross sectional area of the electrode between 2% and 7%.

10. A cylindrical electric furnace electrode having an outside diameter in excess of 8 inches provided with at least three angularly spaced slots extending inwardly from the periphery, a distance of .1 to .5 of the radial thickness of the electrode, extending longitudinally throughout at least a major portion of the length of the electrode from one end thereof, each slot being of a width to prevent the side walls touching under pressure on immersion of a cold electrode in a hot furnace, the slotted portion effecting a reduction in transverse cross sectional area of the electrode due to the slots which does not exceed 10%, said slots being free of any stiff material appreciably impeding movement of the side walls toward each other and free of any material contaminating a bath in which the electrode is adapted to be placed, the unslotted portions of the electrode providing a foundation

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against which a clamping stress of an electrode holder may be exerted.

11. In a cylindrical electrode for an electric furnace and having an outside diameter greater than eight inches, the combination therewith of the improvement for reducing the danger of a longitudinal crack being formed due to a temperature gradient between the inner and outer portions of the electrode, said improvement comprising a longitudinal non-axial recess extending throughout at least the major portion of the electrode length from one end thereof, of a width and depth capable of allowing slight relative movement between opposite sides of said recess toward and from one another under stress due to a temperature difference between the inside and outside of said electrode, the transverse cross sectional area of said electrode being reduced less than 10% by said recess, a substantial portion of the electrode radial depth one side of said recess constituting an imperforate foundation against which a clamping stress of an electrode holder may be exerted.

12. A cylindrical carbonaceous electric furnace electrode having a diameter in excess of eight inches and having the improvement for reducing a tendency for a longitudinal crack to form due to a substantial temperature difference between inner and outer portions of the electrode, said improvement including at least one generally radial slot extending longitudinally and of less depth than the radial thickness of the electrode, the total cross sectional area of any and all of said generally radial slots of the electrode being no more than 7% of the cross sectional area of the electrode, said slot being free of rigid material which would impede movement of its side walls toward each other due to temperature changes and free of any salts contaminating a bath in which said electrode is adapted to be placed.

13. A cylindrical carbonaceous electric furnace electrode having a diameter in excess of eight inches and having the improvement for reducing a tendency for a substantial crack to form due to a substantial temperature difference between inner and outer portions of the electrode, said improvement including at least one generally radial slot extending longitudinally and of less depth than the radial thickness of the electrode, the total cross sectional area of any and all of said generally radial slots of the electrode being between 2% and 7% of the cross sectional area of the electrode, said slot being free of rigid material which would impede movement of its side walls toward each other due to temperature changes and free of any salts contaminating a bath in which said electrode is adapted to be placed.

14. A cylindrical carbonaceous electric furnace electrode having a diameter in excess of three inches and having the improvement for reducing a tendency for a longitudinal crack to form due to a substantial temperature difference between inner and outer portions of the electrode, said improvement including outer slots having a cross sectional area of not over 4.4% of the cross sectional area of the carbonaceous electrode and extending less than the radial depth of the electrode.

15. A cylindrical carbonaceous electric furnace electrode having a diameter in excess of three inches and having the improvement for reducing a tendency for a longitudinal crack to form due to a substantial temperature difference be-

tween inner and outer portions of the electrode, said improvement including inner slots having a cross sectional area of not over 4% of the cross sectional area of the carbonaceous electrode around a central bore and less depth than the radial depth of the electrode.

16. A cylindrical carbonaceous electric furnace electrode having a diameter in excess of three inches and having the improvement for reducing a tendency for a longitudinal crack to form due to a substantial temperature difference between inner and outer portions of the electrode, said improvement including radially inner and outer slots of substantially the same width and having a cross sectional area of not over 10% of the cross sectional area of the electrode around a central bore.

17. A cylindrical carbonaceous electric furnace electrode having a diameter in excess of three inches and having the improvement for reducing a tendency for a longitudinal crack to form due to a substantial temperature difference between inner and outer portions of the electrode, said improvement including radially inner and outer slots having a cross sectional area of not over 10% of the cross sectional area of the electrode.

18. A cylindrical carbonaceous electric furnace electrode having a diameter in excess of three inches and having the improvement for reducing a tendency for a longitudinal crack to form due to a substantial temperature difference between inner and outer portions of the electrode, said improvement including outer slots having a cross sectional area of not over 4.4% of the cross sectional area of the carbonaceous electrode and a depth of .1 to .5 of the radial depth of the carbonaceous electrode.

19. A cylindrical carbonaceous electric furnace electrode having a diameter in excess of eight inches provided with means to reduce a tendency for a longitudinal crack to form due to a substantial temperature difference between inner and outer portions of the electrode during or after use, said means including at least one generally radial slot extending longitudinally, said slot being deep enough for its side walls to be free to move toward and from each other due to temperature differences within the electrode, the depth of said slot being substantially less than the radial depth of the electrode exclusive of any core or bore.

20. A cylindrical carbonaceous electric furnace electrode having a diameter in excess of eight inches provided with means to reduce a tendency for a longitudinal crack to form due to a substantial temperature difference between inner and outer portions of the electrode during or after use, said means including at least one generally radial slot extending longitudinally, said slot being deep enough for its side walls to be free to move toward and from each other due to temperature differences within the electrode, the depth of said slot being substantially less than the radial depth of the electrode exclusive of any core or bore, but the slot depth not extending beyond a neutral stress zone due to said temperature difference within the electrode.

21. A cylindrical carbonaceous electric furnace electrode having a diameter in excess of eight inches provided with means to reduce a tendency for a longitudinal crack to form due to a substantial temperature difference between inner and outer portions of the electrode during or after use, said means including at least one generally radial slot extending longitudinally, said slot being deep enough for its side walls to be free to move toward and from each other due to temperature differences within the electrode, the depth of said slot being substantially less than the radial depth of the electrode exclusive of any core or bore, said slot being open radially outwardly.

22. A cylindrical carbonaceous electric furnace electrode having a diameter in excess of eight inches provided with means to reduce a tendency for a longitudinal crack to form due to a substantial temperature difference between inner and outer portions of the electrode during or after use, said means including at least one generally radial slot extending longitudinally, said slot being deep enough for its side walls to be free to move toward and from each other due to temperature differences within the electrode, the depth of said slot being substantially less than the radial depth of the electrode exclusive of any core or bore, said slot extending for the full length of the electrode.

23. A cylindrical carbonaceous electric furnace electrode having a diameter in excess of eight inches provided with means to reduce a tendency for a longitudinal crack to form due to a substantial temperature difference between inner and outer portions of the electrode during or after use, said means including at least one generally radial slot extending longitudinally, said slot being deep enough for its side walls to be free to move toward and from each other due to temperature differences within the electrode, the depth of said slot being substantially less than the radial depth of the electrode exclusive of any core or bore, said electrode being provided with an axial bore and the slot opening radially inwardly into said bore.

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JOINING OF GRAPHITE MEMBERS

Morris A. Steinberg, University Heights, Ohio, assignor to Horizons Incorporated, Princeton, N.J., a corporation of New Jersey

No Drawing. Filed Sept. 28, 1956, Ser. No. 612,599

5 Claims. (Cl. 29—470)

This invention relates to an improvement in the joining of graphite products to one another to provide a joint which retains its strength at temperatures up to as high as 3000° C.

Many methods have been proposed in the past for joining carbon to other materials, including metals, ceramics, and other carbon members. Such proposals have, generally, envisioned the use of tar, pitch, resins, and other adhesives as illustrated in United States Patents 473,841; 974,008; 1,158,171; 2,412,081; 2,670,311; and 2,512,230. Such adhesives function satisfactorily at relatively low temperatures, e.g. up to about 400° F., but lose their strength at higher temperatures and hence have only a limited applicability. Others have suggested the use of inorganic bonding materials such as sodium silicate, as in United States Patent 1,709,892, or elemental bonding agents such as selenium or tellurium, as in British Patent 604,293. A more recent proposal involves the use of a solder based on a metal such as copper and a refractory bonding material such as titanium hydride or zirconium hydride, as described in United States Patent 2,570,248. One common difficulty with each of the foregoing has been the inability of the joint to perform at elevated temperatures.

I have now discovered a process in which graphite members may be bonded to other graphite members or to other materials by materials which function in an entirely different manner from the simpler adhesives of the prior art and which produce structures which remain bonded at elevated temperatures.

Briefly, instead of an adhesive type bonding material, I have found that a material which is capable of entering into chemical combination with the graphite should be used to effect the bonding. Thus, elemental titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, tungsten, or some of the rare earths or indeed any elements which form carbides, may be used to accomplish the desired bond. The carbide-forming element must be one whose carbide may contain a variable amount of carbon. This carbon must be able to precipitate as graphite as the carbide is heated above the carbide-forming temperature and cooled, and to nucleate and grow into large graphite plates.

In accordance with my invention I provide a joint-forming or bonding material, such as elemental zirconium metal, either (1) in finely divided form, e.g. as a free flowing dry powder, or as a slurry or paste composition containing the bond-forming material as a powder, or (2) in the form of a thin layer or wafer-shaped to any desired configuration. The bond-forming material is applied to the surfaces to be joined and then heat, or a combination of heat and pressure are applied to raise the temperature of the joint region to an extent necessary to form a carbide zone.

The joining material may, as previously indicated, consist of any of the elements which form carbides, or of mixtures of two or more of such elements or their alloys. When used in finely divided form, the bonding material

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should be of a reasonably fine particle size. Dry powders of between 100 mesh (Tyler Standard) and 325 mesh (Tyler Standard) have been successfully used, and the particle size does not appear to be critical. Finer particle sizes permit the application of elevated temperatures for shorter intervals than coarser particles.

The temperature at the interface should be between 1750° C. and 2500° C., or even higher, depending on the specific joining material used. Such temperatures are conveniently obtained electrically, e.g. by resistance heating or induction heating or even by an arc. Whatever the means employed, it is necessary that the temperature developed at the interface be sufficient for a carbide to form at the interface, so that the bond ultimately comprises the carbide so formed, together with any carbon rejected by the carbide as graphite at temperatures exceeding about 2000° C. Thus the joint material may comprise either a carbide or a carbide-graphite combination produced by the rejection of some carbon from the carbide.

Many carbides have a tendency to fracture under tension. Hence, when a combination of heat and pressure is used to form the joint, it is preferable to use moderate pressures, for example pressures up to 1500 pounds per square inch, to avoid destruction of the joint or rupture of the graphite.

The following examples will serve to further illustrate the practice of my invention and are to be taken as illustrative and not limitative thereof.

Example I

Two graphite rods, one-half inch in diameter, were clamped in a resistance welder so that they were butted together with a layer of —200 mesh (Tyler Standard) zirconium metal powder between their ends. A pressure of 200 pounds was used to urge them together. The assembly was mounted in a furnace provided with means to maintain an argon atmosphere thereunder. The rods were heated by resistance heating by passing a direct current through the rods sufficient to produce a temperature of about 2150° C. at the joint. The pressure increased to 350 pounds as the temperature was raised. The interface region remained at about 2150° C. for 10 seconds, and then the heating was discontinued. When the rods had cooled, it was found that the two rods were firmly bonded together. Photomicrographs taken of the joint region showed that considerable graphitization had occurred. While I do not wish to be bound by any specific theory, I believe that at the elevated temperature to which the zirconium-graphite assembly was heated, some zirconium carbide formed and that as the carbide cooled, some carbon precipitated from the carbide and that this carbon, under the prevailing conditions, had become converted to graphite. The resultant joint, then, is characterized as a graphite to graphite joint bonded by graphite. Because of the appearance and strength of this joint, I believe that the decomposition of the bonding material produced graphite flakes which grew perpendicular to the joint with the result that a partially graphitized joint was produced, and at the same time at elevated temperatures some of the zirconium may have been volatilized. It will be seen, therefore, that by maintaining the materials at a sufficiently elevated temperature below the temperature at which the graphite volatilizes that most of the carbide-forming metal itself may be eliminated from the joint region and that ultimately an all graphite bond is formed in which the graphite flakes formed by the decomposition of the carbide have grown into each of the members being united.

Example II

The procedure employed in Example I was repeated at

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a temperature of about 2325° C. for 10 seconds and at at slightly higher initial pressure of 250 pounds. When tested in tensile the joined rods broke in the graphite and not in the joint, showing that the joint was at least as strong as the graphite.

One further matter should be noted in connection with my invention. Because of its properties, graphite is an excellent material for the construction of reactors and of other apparatus for processing fissionable materials. Because many of the carbide-forming elements have suitable neutron absorption coefficients, my invention may be peculiarly adapted to the fabrication of apparatus to be used in processing such material. By selecting the proper carbide-forming bonding materials, joints may be formed wherein the bond zone has substantially the same neutron capture as the graphite portions of the apparatus.

Having now described my invention in accordance with the patent statutes, I claim:

1. A method of forming a graphite bond between graphite members which comprises: assembling at least two graphite members having a common surface about a carbide-forming metal selected from the group consisting of titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, and tungsten; subjecting the region adjacent said carbide-forming material to a temperature between 1750° C. and 2500° C. and sufficient to form a carbide of said metal; maintaining said region at said temperature for a time sufficient to permit the volatilization of a portion of said carbide-

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forming metal, and cooling said region, whereby graphite precipitates perpendicular to said common surface and forms a substantial portion of the resulting material joining said members.

2. The method of claim 1 in which said carbide-forming metal is in the form of a powder having a particle size between 100 mesh and 325 mesh.

3. The method of claim 1 in which moderate pressure is applied to the members of the assembly in order to maintain them in abutting relation during said heating step.

4. The process of claim 1 wherein said carbide-forming metal consists of finely divided zirconium particles.

5. The product of the process of claim 1.

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② SEARCH ROOM

United States Patent Office

2,979,814
Patented Apr. 18, 1961

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2,979,814

JOINING OF GRAPHITE MEMBERS

Morris A. Steinberg, University Heights, Ohio, assignor to Horizons Incorporated, Cleveland, Ohio, a corporation of New Jersey

No Drawing. Filed Dec. 4, 1957, Ser. No. 700,557

6 Claims. (Cl. 29-470)

This invention relates to an improvement in the joining of pieces of graphite to one another. More particularly one object of this invention is to provide a joint between two or more graphite members which retains its strength at temperatures up to as high as 3000° K.

Many methods have been proposed in the past for joining carbon to other members of carbon, metals, ceramics, and other materials. Such proposals have, generally, envisioned the use of tar, pitch, resins, and other adhesives as illustrated in United States Patents 473,841; 947,008; 1,158,171; 2,412,081; 2,670,311; and 2,513,230. Such adhesives function satisfactorily at relatively low temperatures, e.g. up to about 400° F., but lose their strength at higher temperatures and hence have only a limited applicability. Others have suggested the use of inorganic bonding materials such as sodium silicate, as in United States Patent 1,709,892, or elemental bonding agents such as selenium, or tellurium, as in British Patent 604,293. A more recent proposal involves the use of a solder based on a metal such as copper and a refractory bonding material such as titanium hydride or zirconium hydride, as described in United States Patent 2,570,248. One common difficulty with each of the foregoing has been inability of the joint to perform at elevated temperatures. Another disadvantage inherent in many such joints arises from the presence of a foreign material other than carbon, at the joint.

In an earlier application filed by me, Serial No. 612,599 filed September 28, 1956, there was disclosed a process in which graphite members could be bonded to other graphite members or to other carbonaceous materials by materials which functioned in an entirely different manner from the simpler adhesives of the prior art and which produced structures which remained bonded at elevated temperatures.

Briefly, instead of an adhesive-type bonding material, it was proposed that a material which is capable of entering into chemical combination with the graphite should be used to effect the bonding. Thus, elemental titanium, zirconium, hafnium, vanadium, niobium, tantalum, chromium, molybdenum, tungsten, or some of the rare earths or indeed any elements which form carbides, were envisioned as useful for the accomplishment of the desired bond. In the resulting article, the bond between two graphite bodies would then consist of metal carbide.

The present application constitutes a continuation-in-part of application Serial No. 612,599.

I have now discovered that a joint in which carbon is joined directly to carbon is to be preferred, for many purposes, over prior art joints in which one or more metals or metal compounds served as the "cement" between the

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carbon bodies being joined. In order to achieve a carbon to carbon joint free of any foreign material or adhesive, only certain of the carbide-forming elements disclosed in my earlier application may be used. As taught therein, the carbide-forming elements employed, either singly or in combination, must be those whose carbides may contain a variable amount of carbon and this carbon must be capable of precipitating as graphite under the processing conditions. The temperature and pressure at which this will occur is determined by the carbide formed and decomposed.

It has been further found that only those elements which form meta-stable carbides and which can thereafter be eliminated from the joint will yield a metal-free carbon to carbon joint having the properties desired. I have found two methods applicable to the removal of the metal of the meta-stable carbide from the region of the joint. In the first, the joined members are subjected to heating either in an inert gas atmosphere, such as one of the noble gases, or preferably in a vacuum for a time sufficient, at the temperature selected, to accomplish decomposition of the meta-stable carbide and the escape of the metal into the atmosphere. In the second, meta-stable carbides which decompose on cooling, e.g. magnesium carbide, are chosen for the initial bond and, after the bond has formed, the carbide is permitted to decompose, by cooling, to produce a volatile metal and graphite as the end products.

Below there are tabulated many of the elements which form carbides, together with certain of their properties.

ELEMENT			CARBIDE	
Element	Melting Point, °C.	Boiling Point, °C.	Carbide	Melting Point and Stability of Carbide
Na.....	97.7	892	Na ₂ C ₂ ...	unstable.
K.....	63	770	K ₂ C ₂ ...	unstable.
Be.....	1280	2770	Be ₂ C.....	unstable Be and graphite form.
Mg.....	650	1202	MgC ₂ ...	unstable above 800° C. decomposes to Mg(gas) and C.
Ca.....	850	1440	CaC ₂ ...	decomposes on heating.
Al.....	900	2060	Al ₄ C ₃ ...	2290° C. Forms at 1000° C. Unstable above 1800° C. Sublimes decomposes.
La.....	826	1519	LaC ₂ ...	unstable on heating.
Ce.....	600	?	CeC ₂ ...	unstable.
Ti.....	1,730	-----	TiC.....	3250° C. stable.
Zr.....	1,850	-----	ZrC.....	3175° C. meta-stable.
Hf.....	2,500	-----	HfC.....	3890° C. stable.
Si.....	1,430	2300	SiC.....	unstable above 2100° C. C rejected.
V.....	1,700	-----	VC.....	decomposes.
Nb.....	2,500	-----	NbC.....	stable.
Ta.....	3,000	-----	TaC.....	stable.
Cr.....	1,950	-----	Cr ₃ C.....	meta-stable 1895° C.
Mo.....	2,600	4800	MoC.....	2695° C. stable.
W.....	3,380	-----	Mo ₂ C.....	2690° C. stable.
U.....	1,130	2065	WC.....	2330° C. stable.
Fe.....	1,537	2740	W ₂ C.....	2700° C. stable.
			UC.....	unstable.
			Fe ₃ C.....	melts to take in C rejects on cooling.

It will be seen that many of the carbide-forming elements are disqualified for the bonding of carbon directly to carbon either because they form extremely stable carbides which are not decomposed by heating, or, in instances where the carbide is decomposed, the metal cannot be volatilized to effect its removal from the region of the joint. Thus molybdenum which has been used before, to join graphite to metal or to graphite, as de-

T-4286
140
X1539
X1574
X1561
300
325

587

scribed in United States Patent 2,431,975, cannot be used to produce a metal-free joint because the metal does not exhibit a sufficient vapor pressure at elevated temperatures to permit its removal after the carbide has been decomposed, for instance, by heating to 3000° C.

Of the carbide-forming elements listed above, I have found the following to be useful in my process: aluminum, zirconium, magnesium and beryllium.

In accordance with my invention I provide a joint-forming or bonding material, such as elemental aluminum metal, either in finely divided form, or in the form of a thin sheet or wafer. When the finely divided metal is used it may be as a free flowing dry powder, or as a slurry or paste composition containing the bond-forming material as a powder. When a solid piece of bonding material is used it may be in the form of a thin layer or wafer-shaped to any desired configuration. The bond-forming material is applied to the surfaces to be joined and then heat, or a combination of heat and pressure are applied to raise the temperature of the joint region to an extent necessary to form carbide zone.

The joining material may, as previously indicated, consist either of any of the elements designated as suitable, or of mixtures of two or more of such elements or their alloys. When used in finely divided form, the bonding material should be of a reasonably fine particle size. Dry powders of between 100 mesh (Tyler Standard) and 325 mesh (Tyler Standard) have been successfully used, and the particle size does not appear to be critical. Finer particle sizes permit the application of elevated temperatures for shorter intervals than coarser particles. The choice of a particle size will also in some instances be conditioned to some extent by the area of the bond.

The temperature at the interface should initially approach 1800° C. to 2500° C., and may be even higher, depending on the specific joining material used. Such temperatures are conveniently obtained electrically, for instance, by resistance heating or induction heating or even by an arc. Whatever the means employed, it is necessary that the temperature developed at the interface be sufficient for a carbide to form at the interface, so that the bond initially comprises the carbide so formed, together with any carbon rejected by the carbide. Thereafter, as the heating is continued, at temperatures sufficient to decompose the carbide and then to vaporize the element resulting from the decomposition of the carbide. At the same time, the carbon formed by the decomposition of the carbide precipitates under the existing conditions, into flakes perpendicular to the joint surface.

Many carbides have a tendency to fracture under tension. Hence, when a combination of heat and pressure is used to form the joint, it is preferable to use moderate pressures, for example pressures up to 1500 pounds per square inch, to avoid destruction of the joint or rupture of the graphite.

The following examples will serve to further illustrate the practice of my invention and are to be taken as illustrative and not limitative thereof.

Example I

Two graphite rods, one-half inch in diameter, were clamped in a resistance welder so that they were butted together with a layer of -200 mesh (Tyler Standard) zirconium metal powder between their ends. A pressure of 200 pounds was used to urge them together. The assembly was mounted in a furnace provided with means to maintain an argon atmosphere surrounding the assembly. The rods were heated by resistance heating by passing a direct current through the rods sufficient to produce a temperature of about 2000° C. at the joint. The pressure increased to 350 pounds as the temperature was raised. The interface region remained at about 2150° C. for 10 seconds, and then the heating was discontinued. When the rods had cooled, it was found that the two rods were firmly bonded together. Photo-

micrographs taken of the joint region showed that considerable graphitization had occurred. While I do not wish to be bound by any specific theory, I believe that at the elevated temperature to which the zirconium-graphite assembly was heated, some zirconium carbide formed and that as the carbide cooled, some carbon precipitated from the carbide and that this carbon, under the prevailing conditions, had become converted to graphite. The resultant joint, then, is characterized as a graphite to graphite joint bonded by graphite. Because of the appearance and strength of this joint, I believe that the decomposition of the bonding material produced graphite flakes which grew perpendicular to the joint with the result that a partially graphitized joint was produced, and at the same time at elevated temperatures some of the zirconium may have been volatilized. It will be seen, therefore, that by maintaining the materials at a sufficiently elevated temperature below the temperature at which the graphite volatilizes that substantially all of the carbide-forming metal itself may be eliminated from the joint region and that ultimately an all-graphite bond is formed in which the graphite flakes formed by the decomposition of the carbide have grown into each of the members being united. Also, the zirconium carbide which melts at 3250° C. will dissolve extra carbon above stoichiometry and give an eutectic of zirconium carbide saturated with carbon at about 2550° C. On cooling this extra carbon is rejected as graphite.

Example II

The procedure employed in Example I was repeated at a temperature of about 2325° C. for 10 seconds and at a slightly higher initial pressure of 250 pounds. When tested in tensile the joined rods broke in the graphite and not in the joint, showing that the joint was at least as strong as the graphite.

Example III

Two pieces of ATJ graphite were butted together using minus 325 mesh (Tyler Standard) aluminum powder at the joint. Over a period of four minutes the assembly was heated to 1800° C. to form a joint bonded by aluminum carbide. The argon atmosphere was pumped from the furnace and the body was held for less than one minute at 2100° C. in a vacuum. The aluminum carbide decomposed and the aluminum volatilized away leaving a substantially metal-free bond.

One further matter should be noted in connection with my invention. Because of its properties, graphite is an excellent material for the construction of reactors and of other apparatus for processing fissionable materials. My invention is peculiarly adapted to the fabrication of apparatus to be used in processing such material. By selecting the proper carbide-forming bonding materials, joints may be formed wherein the resulting metal-free zone has substantially the same neutron capture as the other graphite portions of the apparatus.

I claim:

1. A method of bonding graphite to graphite by means of a metal-free bond consisting essentially of carbon which comprises: bringing at least two pieces of graphite to be joined into abutting relationship with a finely divided bonding material selected from the group consisting of aluminum, beryllium, magnesium, and zirconium disposed at the interface constituting the joint, heating the region adjacent the joint to a temperature sufficient to form a carbide by reaction between said finely divided solid and the graphite pieces being joined, further heating the region adjacent the joint to a temperature sufficient to decompose the carbide and to boil away the resulting elemental metal released by decomposition of the carbide, thereby producing a joint formed entirely of carbonaceous material.

2. The method of claim 1 in which the heating is accomplished in an inert atmosphere.

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3. The method of claim 1 in which the bonding material is aluminum.

4. The method of claim 1 in which the bonding material is zirconium.

5. The method of claim 1 wherein the further heating is performed while the region adjacent the joint is evacuated.

6. An article of manufacture having a carbon to carbon joint produced by the method of claim 1.

6

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July 9, 1963

C. E. LE ROW, JR., ETAL
HIGH ENERGY ARC ELECTRODES

3,097,321

Filed Dec. 5, 1960

2 Sheets-Sheet 1

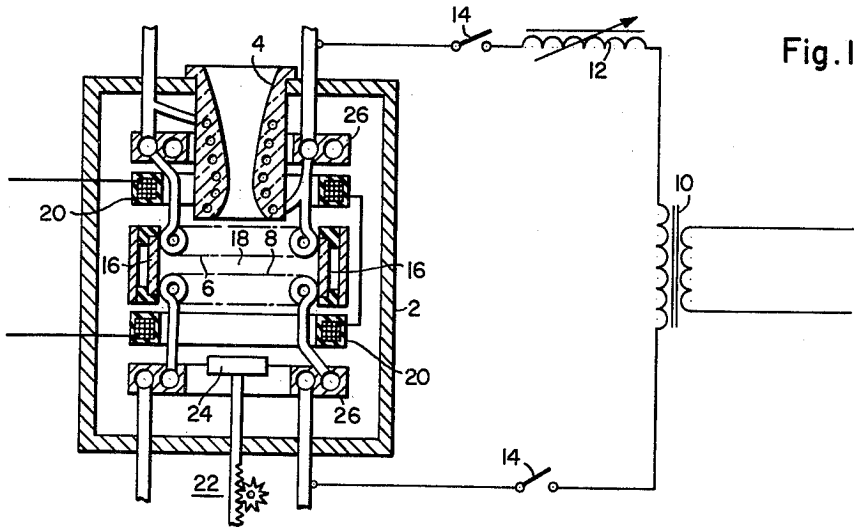


Fig. 1.

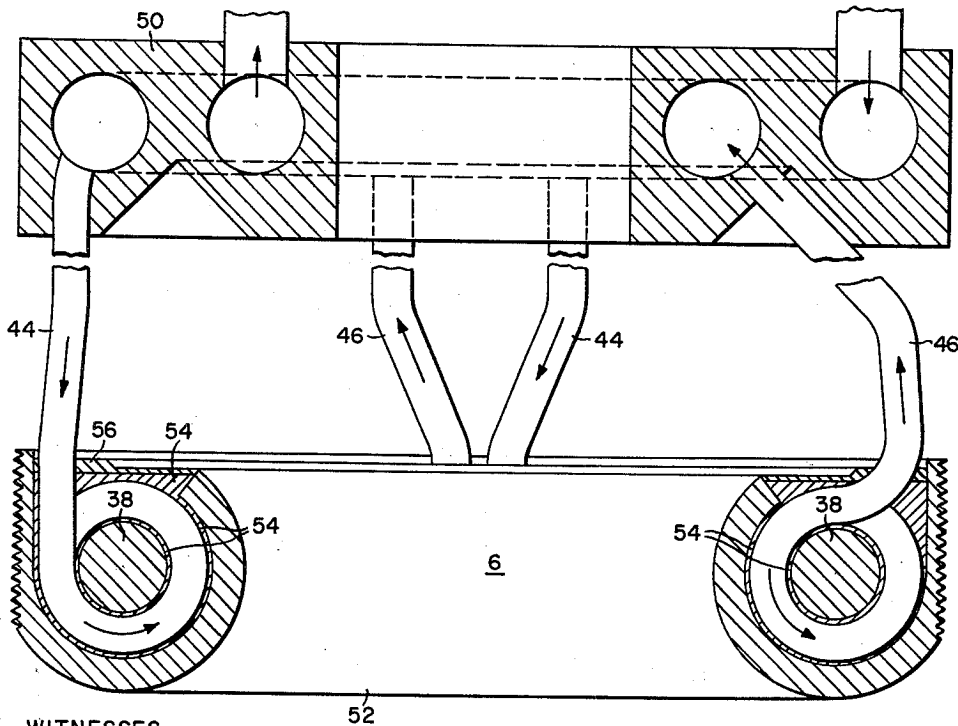


Fig. 3.

WITNESSES

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3,097,321

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2 Sheets-Sheet 2

Fig. 2.

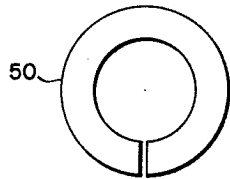
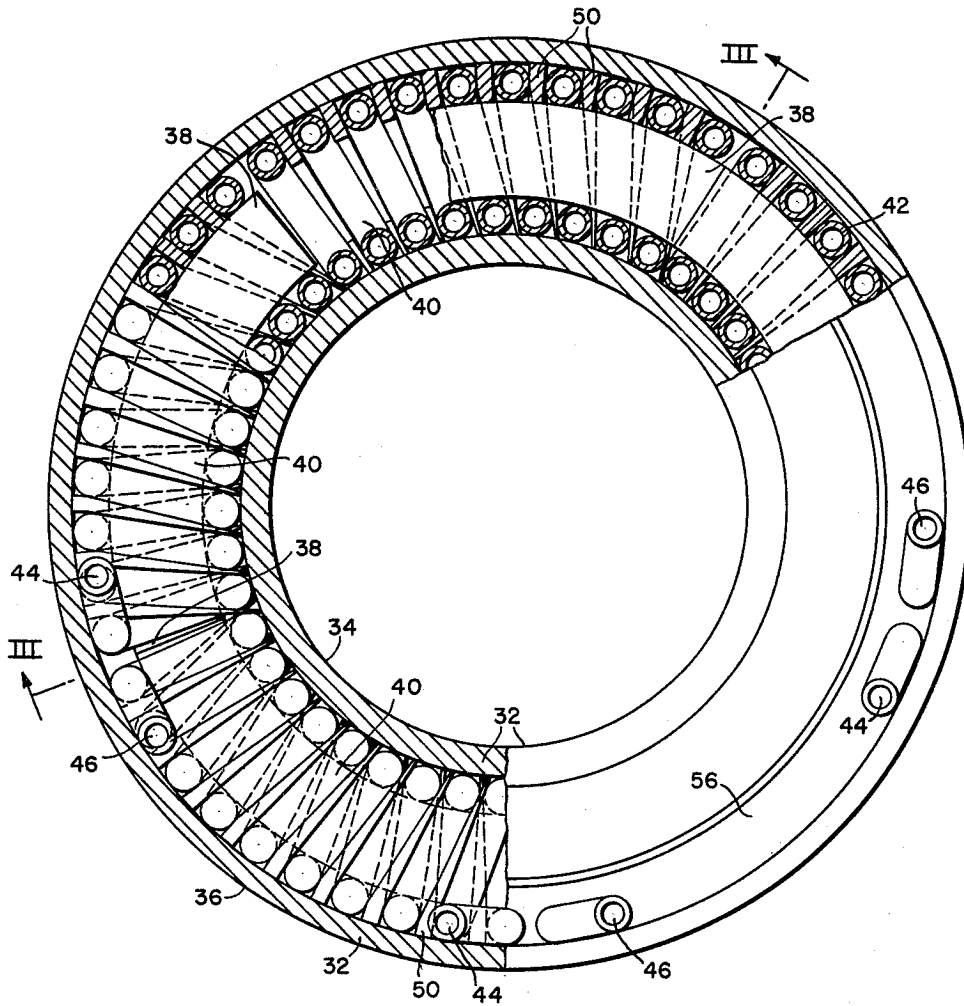


Fig. 4.

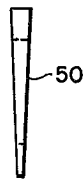


Fig. 4A.

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3,097,321

HIGH ENERGY ARC ELECTRODES

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Filed Dec. 5, 1960, Ser. No. 73,831

8 Claims. (Cl. 313—32)

The present invention relates generally to high energy arc electrodes and more particularly to an electrode of large heat transfer capability.

With the advent of hypersonic flight, it has become very desirable to provide test facilities for missile study and the like. An arc chamber capable of increasing the enthalpy of a gas and supplying a stream at high temperature and pressure for a wind tunnel test section has been claimed and disclosed in a copending application by Werner S. Emmerick, Serial No. 19,528, filed April 4, 1960, and assigned to the same assignee as the present invention. It is desirable to provide such an arc chamber with electrodes capable of sustaining a high energy electric arc for extended periods of time. However, an arc column terminating on an electrode will develop a hot spot thereon which may destroy the electrode. The electrode may erode thereby contaminating the gas flow to the test section.

An electrode in accordance with the present invention sustains a high energy arc for prolonged periods and at an extremely low level of contamination by means of the highly efficient heat transfer path provided from the arc terminating area to the cooling medium.

An object of the present invention is to provide a new and improved electrode capable of sustaining an electric arc of extremely high energy.

Another object of the present invention is to provide an electrode capable of sustaining a high energy arc at an extremely low level of contamination.

Another object of the present invention is to provide an electrode capable of sustaining a high energy arc while greatly reducing ablation and erosion of the electrode.

Another object of the present invention is to provide an electrode having a new and improved heat transfer configuration.

Another object of the present invention is to provide an electrode having a very efficient heat transfer path from the terminal point of the arc to the cooling medium.

Further objects and advantages of the present invention will be readily apparent from the following detailed description taken in conjunction with the drawing in which:

FIGURE 1 is a schematic diagram of an illustrative embodiment of the present invention in an arc chamber for increasing the enthalpy of a gas;

FIG. 2 is a plan view, partly in cross-section and partly in further cross-section, of the illustrative embodiment shown in FIG. 1;

FIG. 3 is a sectional view taken along the line III—III in FIG. 2 showing its interconnection with another portion, in section, of the present invention; and

FIGS. 4 and 4A are elevational side and end views respectively of still another portion of the present invention.

To more clearly understand the present invention, reference is made to FIG. 1 wherein an arc chamber 2 with a nozzle 4 extending therethrough is illustrated. As claimed and more fully described in the aforementioned copending application, an upper electrode 6 and lower electrode 8 are disposed from each other within the chamber 2 and connected with an ionizing potential thereacross provided by a power transformer 10, reactor con-

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troller 12 and circuit interrupting means 14. A heat shield 16 forms an envelope 18 around the electrodes. A magnetic field provided by the coils 20 drives the electric arc column around the ring electrodes. The heated gases escape via the nozzle block 4 which may lead to a test chamber for a hypersonic wind tunnel, or the like. As claimed and more fully described in a copending application by Harry J. Lingal, Serial No. 25,762, filed April 29, 1960, and assigned to the same assignee, an arc starting mechanism 22 initiates the arc between the electrodes by advancing a starting electrode 24 to close proximity with the upper electrode 6 and drawing an arc which is transferred to the lower electrode 8 as the starting electrode 24 retracts from the envelope 18. A manifold 26 provides for the distribution of a cooling fluid within the arc electrodes 6 and 8.

A plan view of the upper electrode with some sections removed and others in cross section is illustrated in FIG. 2. The electrode is shown with a suitable metal jacket 32, substantially toroidal or ring shaped in form and having an inner circumference 34 and an outer circumference 36. Within the jacket 32 is a plurality of filler rods 38, connected in end to end relationship, a total of five being illustrated. A plurality of tubular coils 40 are helically wound upon the filler rods within the jacket 32. While five tubular coils have been illustrated it is to be understood that any suitable number of such coils may be used as well as any suitable number of filler rods 38. Each helical coil 40 comprises in turn a plurality of turns 42 with an entrance lead 44 and an exit lead 46 for the passage of a fluid in heat transfer relationship within the tubular coils 40. Since each tubular coil 40 has an entrance lead and exit lead 44 and 46 respectively, a manifold is provided for the simultaneous feeding of fluid through each tubular coil 40. The manifold will be discussed more fully hereinafter.

It can be seen that when the tubular coils 40 are wound upon the filler rods 38 that space remains between each turn 42, which space is greater between the portion of the turns 42 located adjacent the outer circumference 36 in comparison to that portion of the turns 42 located adjacent the inner circumference 34. To fill this accessible space between adjacent turns 42, a plurality of spacers 50 is provided as shown in FIGS. 4 and 4A.

Each spacer 50 is of split ring form and has a linearly increasing thickness along a diameter lying in the plane of the portion removed or split from the spacer 50. The thickness increases from the end of the diameter located at the removed portion of the spacer 50 to the opposite end of the diameter. It can be seen from FIG. 4 that the free ends of the spacer 50 may be displaced axially from each other and thereby positioned to fill the accessible space between turns 42 within the jacket 32. Thus, all accessible space is filled with solid rods 38 and spacers 50 within and around each turn 42 of each tubular coil 40.

FIG. 3 illustrates a section view taken along the line III—III wherein an entrance lead 44 and exit lead 46 are shown leading into the jacket 32 and to a particular turn respectively of an associated tubular coil 40. FIG. 3 affords an understanding of the fluid flow within the ring electrodes. A manifold 50 having means leading to and from an external heat exchanger and to each tubular coil 40 is illustrated with arrows indicating the direction of fluid flow through the system. Within the manifold 50 the cooling fluid is dispersed for entry into the helically wound cooling coils 40 and hence returned to the manifold 50 by the exit leads 46 for return to the external heat exchanger.

Referring to FIG. 3 it can be seen that an arc sustained between the upper electrode 6 illustrated and a

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lower electrode will terminate on each electrode on an arc terminating area 52. Since the arc column terminates on the area 52 it is readily apparent that this area of the electrode is most susceptible to the development of a hot spot offering potential destruction of the electrode unless the heat is efficiently and swiftly removed from the arc terminating area 52. Should a hot spot impinge upon the electrode the heat generated at the spot where the arc impinges can establish steam formation within the helical cooling coils 40. The resultant air pocket formed by steam formation has a relatively poor heat conductivity and further increases the difficulty of maintaining the arc terminating area 52 at as low a temperature as possible. Therefore the tubular coils 40 are disposed to provide a tangential flow of fluid across the inside of the jacket 32, obtaining a greater scrubbing action in the inner recesses of the electrode. Since the motion of the arc column and the direction of flow of the cooling fluid are perpendicular to each other, maximum heat exchange is obtained. As the terminal of the arc column is driven around the arc terminating area 52 by the magnetic field applied transversely thereto, the cooling fluid maintains a direction of flow perpendicular to the arc column and its track.

In constructing an electrode in accordance with the present invention the electrode is machined from a rolled copper plate with a channel formed therein for the receipt of the tubular coils 40. The coils 40 are mounted as shown and all accessible space filled with solid copper rods 38 and spacers 50. The purpose of this filling is of course to obtain the best possible construction to facilitate heat transfer. A mandrel presses the inner circumference of the electrode block around the tubular coils 40 without crushing them. Any remaining space within the jacket 36 is then filled by a phosphorus copper braze which is heated to a temperature just below the melting temperature of the elements within the electrode, usually constructed of copper. As the phosphorus boils out it is scraped from the surface until a substantially pure deposit of copper braze reaches the inner recesses of the electrode jacket 32 and fills all voids therein. Of course, the copper braze is an excellent heat transfer solder so that every element is intimately connected with the inner side of the arc terminating area 52. Thus, an ideal heat transfer path is provided from the arc terminating area 52 to the cooling fluid passing within the tubular coils 40. The braze 54 is then capped by a pure silver metal 56, or other suitable metal preventing oxidation of the copper braze 54. Of course, any non-oxidizing surface metal may be used for the capping purposes. To facilitate the mounting of the ring electrodes and allow the spark gap between the upper electrode 6 and lower electrode 8 to be varied, an outside edge of the electrode is threaded for mounting and positioning within the arc chamber 2.

In operation, the cooling fluid is delivered to the tubular coils 40 at a pressure which may be 400 pounds per square inch. Since the cooling fluid passes through the coils at a high speed and with a scrubbing action which prevents gas layers or bubbles from developing and interfering with the cooling of the electrode, a highly efficient heat transfer system is provided, allowing the development of a higher energy electric arc between the electrodes. From the tubular coils 40 the outgoing fluid is returned to the manifold 50 and hence to an external heat exchanger means after which the fluid may be again returned for reuse within the heat transfer system.

While the present invention has been described with a particular degree, for the purposes of illustration, it is to be understood that all equivalents, alterations and embodiments within the spirit and scope of the invention are herein meant to be included. For instance, it is to be understood that while only two electrodes have been illustrated as in a single phase power supply system, that additional electrodes may be used for a multi-phase

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power system. The present invention is also applicable for D.C. power supply systems. While the present invention has been described in relation to an arc chamber for use with a hypersonic wind tunnel, it is to be understood that its use is universal to all apparatus requiring electrodes with a high energy arc thereacross.

We claim as our invention:

1. An electrode comprising, in combination; a substantially ring shaped member having an electrical arc terminating area; a plurality of tubular coils each helically wound on an annular axis disposed between the inner and outer circumference of said ring shaped member; said tubular coils adapted to allow fluid flow therethrough in a direction perpendicular to the arc column of said electric arc.

2. An electrode comprising, in combination; a substantially ring shaped member having an arc terminating area of annular configuration; a plurality of rods peripherally spaced within said ring shaped member in an end to end relationship and disposed on a circumference between the inner and outer circumference of said ring shaped member; a plurality of tubular coils helically wound upon said plurality of rods and peripherally spaced in an end to end relationship within said ring shaped member; each coil having an entrance means and exit means for cooling fluid; said tubular coils providing a path for said cooling fluid perpendicular to the track of the arc terminal on said arc terminating area.

3. An electrode comprising, in combination; a substantially ring shaped member having an arc terminating area; a plurality of rods peripherally spaced within said ring shaped member in an end to end relationship and disposed on a circumference between the inner and outer circumference of said ring shaped member; a plurality of tubular coils helically wound upon said plurality of rods and peripherally spaced in an end to end relationship within said ring shaped member; a plurality of spacers each disposed between adjacent turns of each said coil; each said spacer being of split ring configuration having a linearly increasing thickness along a diameter located in the plane of the split and having the free ends of the spacer displaced axially from each other to straddle one turn of one said coil and to fill the void between adjacent turns of said one coil; each coil having an entrance means and exit means for a cooling fluid; said tubular coils providing a path for said cooling fluid substantially perpendicular to an arc column and its track on said arc terminating area.

4. An electrode comprising, in combination; a substantially ring shaped member having an arc terminating surface area; a plurality of rods peripherally spaced within said ring shaped member in an end to end relationship and disposed on a circumference between the inner and outer circumference of said ring shaped member; a plurality of tubular coils helically wound upon said plurality of rods and peripherally spaced in an end to end relationship within said ring shaped member; each coil having an entrance means and exit means for a cooling fluid; said tubular coils providing a path for said cooling fluid perpendicular to the track of an arc column on said arc terminating area; a plurality of spacers each disposed between adjacent turns respectively of a coil; said member, rods, coils and spacers having substantially similar thermal expansion characteristics; of similar thermal and a metal braze expansion characteristics disposed within the voids and crevices of said member whereby every part of the surface of each said tubular coil is intimately connected to the arc terminating surface of said electrode in heat transfer relationship therewith.

5. An electrode comprising, in combination; a substantially ring shaped member having an arc terminating area; a plurality of rods peripherally spaced within said ring shaped member in an end to end relationship and

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disposed on a circumference between the inner and outer circumference of said ring shaped member; a plurality of tubular coils helically wound upon said plurality of rods and peripherally spaced in an end to end relationship within said ring shaped member; each coil having an entrance means and exit means for a cooling fluid; said tubular coils providing a path for said cooling fluid perpendicular to the track of an arc column on said arc terminating area; a plurality of spacers each disposed between adjacent turns respectively of a coil; said member, rods, coils and spacers having substantially similar thermal expansion characteristics; and a heat transfer metal of similar thermal expansion characteristics disposed within the voids and crevices of said member whereby every part of the surface of each said tubular coil is intimately connected to the arc terminating surface of said electrode in heat transfer relationship therewith; and a non-oxidizing surface metal capping the exposed surface of said heat transfer metal.

6. In combination, a first electrode and a second electrode, each electrode being substantially ring shaped in form, means for sustaining an electric arc therebetween, means for driving said electric arc around said electrodes, and coil means within said electrodes between the inner and outer circumference of said electrodes adapted to allow fluid flow perpendicularly to said electric arc and its track across the electrodes.

7. Apparatus for increasing the enthalpy of a gas by electrical energy comprising, in combination; a chamber; at least two ring electrodes disposed within said chamber

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and spaced apart to form a spark gap; means for connecting an ionizing potential across said electrodes to sustain in arc thereacross; magnetic means for subjecting said arc to a magnetic field transverse to said arc; and heat transfer means for cooling said electrodes including coil means within said electrodes adapted to allow fluid flow perpendicularly to the track of said arc as it rotates around said ring electrodes.

8. Apparatus for increasing the enthalpy of a gas by electrical energy comprising, in combination; a chamber; at least two ring electrodes disposed within said chamber and spaced apart to form a spark gap; means for connecting an ionizing potential across said electrodes to sustain an arc thereacross; magnetic means for subjecting said arc to a magnetic field transverse to said arc; and heat transfer means for cooling said electrodes including coil means within said electrodes adapted to allow fluid flow perpendicularly to the track of said arc as it rotates around said ring electrodes; said coil means comprising a plurality of geometrical arc sections peripherally spaced within said ring electrodes and fluid manifold means for dividing fluid flow to all sections within a given ring electrode from an external heat exchanger.

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E. FITZER ETAL
POROUS CARBONACEOUS BODY WITH SEALED SURFACE FOR USE
AS ARC-FURNACE ELECTRODE OR STRUCTURAL
COMPONENT OF NUCLEAR REACTORS
Filed Nov. 18, 1958

3,120,453

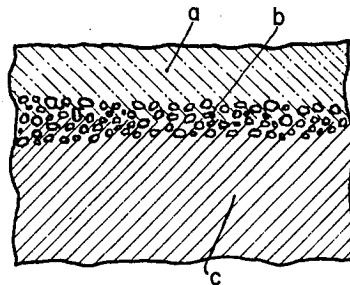


FIG. 1.

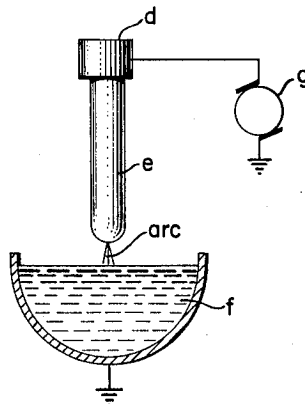


FIG. 2.

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POROUS CARBACEOUS BODY WITH SEALED SURFACE FOR USE AS ARC-FURNACE ELECTRODE OR STRUCTURAL COMPONENT OF NUCLEAR REACTORS

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Filed Nov. 18, 1958, Ser. No. 774,773

Claims priority, application Germany Nov. 22, 1957

23 Claims. (Cl. 117—217)

Our invention relates to shaped bodies of porous carbonaceous materials, such as graphite, coke, silicon carbide and other carbons by example for use as arc electrodes, as structural components in nuclear power reactors or for similar purposes requiring a thermally or electrically conducting and refractory carbonaceous body, though generally porous, to possess a gas and liquid-tight surface.

It is an object of our invention to improve such bodies by providing them with a surface coating that not only secures maximum protection of the porous carbonaceous material from oxidation, burn-off or other attack at high temperatures, but also maintains or improves the good thermal or electrical conductivity desired for the above-mentioned uses.

The surface of carbon electrodes for furnaces must be protected from oxidation by presenting oxygen from having access to the carbon substance proper. Structural components for nuclear reactors, preferably consisting of graphite, must also possess a sealed surface so that gaseous or liquid coolants or moderators cannot penetrate into the pores of the component but are strictly confined to the prescribed flow path.

It is known to provide steel-furnace electrodes with a protective coating to reduce consumption of the carbon by combustion which, in conventional bare electrodes, accounts for about 60% of the carbon losses. If such burn-off can be reduced, an outstanding economical advantage is obtained. The great percentage of carbon burn-off is primarily due to the fact that, in the vicinity of the arc, the electrode burns down to a steeply conical taper. The resulting reduction in conducting cross-section and the corresponding increase in electric resistance cause the pointed taper to be additionally heated by Joule's heat. The increase in resistance also causes voltage losses, and the current in the arc declines accordingly. Hence, for making such an electrode suitable for sustaining high electric loads, the supply of current to the arc must be secured by reducing the electric resistance in the electrode or along its surface. However, the above-mentioned electrode coatings for protection from combustion consist of high-melting constituents which comprise highly refractory oxides. Such coatings are insulators or very poor electrical conductors and hence must be disposed beneath the contact cheeks of the electrodes. Even so, the oxidation-preventing coatings do not contribute to the desired good conductance of the electrode and impair the maintenance of an optimum current supply up to the immediate vicinity of the arc.

It is also known to provide carbon electrodes with a protective coating of metal consisting of a galvanically deposited copper layer and a surface layer of chromium. Such a metallic coating tends to melt away near the arc so that the desired burn-off protection is prematurely lost. Protective coatings containing essentially metallic oxides, while resistant to oxidation, are poor electric conductors and tend to scale off since they are not chemically bonded to the carbon and in some cases are chemically reduced by the carbon.

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Better results are obtained if the protective coatings consists of metal carbides that are electrically conducting. For example, it is known to coat carbon electrodes with silicon carbide or zirconium carbide. However, the burn-off protection is slight because such carbide coatings are not free of pores or fissures, so that the electrode carbon will oxidize and burn out at fault locations.

It is, therefore, one of the more specific objects of our invention to obviate the detrimental effects of faulty spots in a protective carbide coating on a body of carbon and to increase the electric conductance of the protective coating.

To this end, and in accordance with a feature of our invention, the coating is formed of a refractory metal carbide layer anchored in the carbon body, and a covering layer consisting of high-melting metals, or alloys of metals, from the *a* portion of each of the fourth to sixth groups of the periodic system of elements, the shaped main body of porous carbon or the like carbonaceous substance, the intermediate refractory carbide layer and the metallic cover layer being intimately bonded and merged together to form a single, integral structure.

We have found that the saturated carbides of titanium, zirconium, silicon, chromium and molybdenum, or mixtures thereof are particularly well suitable for the intermediate carbide layer. Titanium carbide, zirconium carbide and silicon carbide are preferentially applicable in many cases.

The metal, or main metal component of the electrically conductive cover layer may consist of one or more of titanium, zirconium, silicon, chromium and molybdenum, either in form of the metal itself or in form of an alloy or electrically conducting compound. The metal or main metal component of the cover layer may differ from the carbide-forming metal of the intermediate layer, but it may also be identical with the carbide-forming metal as will more fully appear hereinafter.

According to another feature of the invention, the metallic cover layer as well as the underlying carbide layer may additionally contain other metallically conducting compounds of the metals of the *a* groups from IVa to VIa of the periodic system with nitrogen, beryllium, boron, aluminum, silicon or phosphorus. Examples of such additional compounds are $TiSi_2$, TiN , Cr_3Si .

The cover layer, instead of consisting of the high-melting metals or alloys above specified, may also be formed of metallically conducting compounds of such metals. Suitable compounds are those formed by the particular metals with the elements of the last-mentioned group, namely N, Be, B, Al, Si or P. Preferably used are silicides of the particular metal, such as $TiSi_2$.

Generally, the metallic elements throughout the stratified coating, namely the metals to be used in form of a carbide in the intermediate layer and in form of the metal, alloy or the above-mentioned compounds in the outer layer, are those that form stable and metallically conducting carbides in order to secure a fast-adhering bond between these carbides with the main substance of the electrode even under maximum changes in temperature occurring during the intended high-temperature use.

It has been found particularly favorable to embed and distribute in the metallic cover layer such hard and highly refractory materials as carbides, nitrides, silicides or borides in order to prevent grain coarsening of the metal layer when being deposited, which coarsening would tend to make the cover layer scale off.

The carbides of the intermediate layer adhere particularly well to the surface of the carbon body because they form with the carbon substance the carbide of the particular metal that can be deposited upon the carbon body. For this reason it is essential that the intermediate layer consist of a carbide which is well anchored in the porous

carbon structure of the body. The outer metal layer adheres to such an intermediate carbide layer more readily and more firmly than to the carbon body itself because a metal carbide is wetted by liquefied metal to a greater extent than the carbon substance. This explains why a stratified coating according to the invention exhibits a particularly firm and reliable connection with the main body of the electrode and is not affected by high temperatures nearly up to the melting point of the metal carbide and metal being used. The stratified coating is further distinguished by high electric conductivity and is particularly dense so that no oxidizing atmosphere can reach the carbon at temperatures up to near the melting point of the protective coating.

Various methods of forming the carbide intermediate layer and the metallically conducting cover layer on a molded or extruded carbon body will be described below with reference to specific examples. In principle, two different ways are available. One way is to produce the carbide layer directly upon the porous carbon body by first depositing a metal on the carbon and then subjecting the carbon to incandescent reaction temperature, thus producing the carbide directly in contact with the carbon body. The other way is to start from a metal carbide and to deposit it on the shaped carbon body, for example in form of a paste, and to subsequently bond the carbide to the carbon body by processing at incandescent temperature.

The electrically good conducting cover layer of high-melting metal can be deposited upon the carbide layer by immersing the carbide-covered carbon body in a melt of the metal, by spraying the metal upon the carbide layer, by depositing the metal from the vaporous phase, or galvanically. For forming the required good bond of the cover layer with the carbide layer, the cover layer deposited upon the carbon body must be burned-in, preferably by applying a temperature of about 1000° C. or more in an inert atmosphere. For this purpose, the cover layer of metal, or metal silicide to be formed upon the carbide layer can be heated to melting temperature either before using the carbon body as an electrode or during such use.

In most cases, the stratified coating is preferably formed by a two-step method. At first the carbide intermediate layer is formed on the carbon body, and subsequently the cover layer of high-melting metal, alloy or conducting compound is deposited. However, it is also possible to employ a single-step method by forming the carbide layer and simultaneously covering it with a metallically conducting cover layer.

FIG. 1 is a fragmentary cross section on an enlarged scale of a body according to the invention; and

FIG. 2 is a diagrammatic illustration of an electrode body according to the invention and electrical circuit as it may be used in an electric arc furnace.

For further explanation, there is shown in FIG. 1 of the drawing a cross-sectional view on enlarged scale of a coated carbonaceous body according to the invention. It comprises a porous body *c* of graphite intimately bonded with a cover layer *a* of high melting metal. The material of the cover layer penetrates into the rather irregular and fissured carbide layer *b* and the carbide layer penetrates into the marginal pores of the carbon body, so that all layers merge and form a single refractory and electrically conductive body, such as the body of a furnace electrode, or a carbon block for use in the core structure, reflector or other structural portion of a nuclear reactor.

Stratified coatings according to the invention are applicable to various types of molded or extruded industrial carbons of natural and synthetic origin as well as to silicon carbide. When using the invention with bodies of natural graphite, it affords the additional advantage of mechanically strengthening such bodies by the formation of the double-layer coating.

As shown in FIG. 2, the electrode body *e*, with its

stratified coating as above described, is connected at only one end thereof by a terminal or other connecting means *d* to a grounded generator or source of electric current *g*. The other end of electrode *e* is free. The metal to be melted is placed in a furnace *F* which is also grounded. An arc is thus produced between the electrode *e* and the metal in furnace *f*.

The invention will be further described with reference to the following examples:

Example 1

Graphite electrodes for electric steel furnaces were coated with a mixture of about 90% VSi_2 and about 10% TiC in a 5% alcoholic solution of polyvinyl alcohol. The coated electrodes were passed through a channel furnace heated to 200° C. Thereafter the dried graphite electrodes were rapidly heated to 1600° C. in an inert atmosphere by direct resistance heating, that is by passing electric current through the electrodes. The electrodes were then permitted to cool slowly to room temperature. A mixture of titanium hydride and silicon was deposited upon the carbide-coated electrodes. The titanium and silicon in the mixture was in the stoichiometric atomic ratio of 1:2. The body thus coated was heated to the reaction temperature of 1350° C. which resulted in the formation of a TiSi_2 layer. This layer was melted by the heat of reaction and penetrated into the surface of the underlying carbide layer. A continuous TiC intermediate layer (*b* on the drawing) intimately bonded with the graphite body (*c*) was formed and was merged with, and densely covered by, a continuous titanium disilicide surface zone (*a*). Similar results were obtained by the same method when using for the first coating somewhat differently composed polyvinyl alcohol solutions TiSi_2 and TiC within the range of 85% to 97.5% TiSi_2 and 2.5% to 15% TiC , all percentages being by weight.

Example 2

Graphite electrodes for electric steel furnaces were coated with titanium metal by means of an acetylene blower, using a titanium wire. The coated electrodes were passed through a channel furnace at 800° to 1000° C. within a period of about 15 minutes. The furnace contained a reactive atmosphere of nitrogen. As a result, a bonded TiC layer was formed in the junction zone between graphite and titanium, whereas the surface of the coated electrode was covered with oxidation resistant TiN .

Example 3

High-intensity arc electrodes were coated with Cr powder in a binding agent consisting of a 10% dextrin solution, and then dried in a drying cabinet at 110° C. for 30 minutes. Then the electrodes were shoved into a carbon-tube furnace preheated to about 1900° C. and were thus rapidly heated in an argon atmosphere up to the melting point of the chromium. After a few seconds, the temperature was reduced to about 1200° C. and this temperature was maintained about 3 to 10 minutes for tempering the carbon bodies.

The melting operation resulted in the formation of a uniform chromium coating firmly adhering to the carbon surface. The tempering process produced in the C—Cr fusion zone an intermediate layer of Cr_3C_2 a few microns thick. A chromium layer of about the same thickness remained at the surface due to the fact that the surface zone of the chromium layer was not reacted with C. The intermediate layer of Cr_3C_2 and the covering layer of Cr showed excellent adherence even under extreme alternating thermal stresses. The electrodes permitted an increased current loading with reduced burning of the electrode material.

Example 4

Welding carbons were coated by spraying with a mix-

ture of about 80% by weight of Cr_3Si and about 20% of Ti to which were added 15 parts by weight of ethyl silicate per 100 parts solids, in a solution of alcohol of 75% concentration. The carbon electrodes thus coated were dried at 110°C . for two hours. The dried electrodes were individually packed in $\alpha\text{-Al}_2\text{O}_3$ powder and were heated to the melting point of the coating metal and silicide in an induction furnace under protective gas atmosphere. The electrodes then removed from the furnace exhibited a fusion of the carbon surface with the metal silicide mixture under partial formation of carbide. Thereafter another coating of titanium was sprayed onto the electrodes. The electrodes thus coated exhibited, in comparison with the original bare electrodes, a much more quiet operation and slower burn-off similar to jacketed electrodes. Similar results were obtained by the same method when using for the first coating somewhat differently composed Cr_3Si -Ti mixtures within the range of 70% to 95% Cr_3Si and 30 to 5 Ti by weight.

Before describing examples relating to carbonaceous bodies for use as structural components in nuclear reactors, the following explanations will be of interest.

Graphite is one of the most important structural materials for nuclear reactors, because its small absorption cross-section for thermal neutron affords a good neutron economy and because this material is resistant to highest temperatures. Silicon carbide, in principle, is also applicable as structural material in nuclear reactors because of its slight neutron absorption. Particularly significant is the good electrical and thermal conductivity of these two materials, greatly exceeding in this respect such other refractory materials as ceramics. Furthermore, the moderating effect of the carbon structures can be utilized in thermal reactors.

However, an essential disadvantage of these carbonaceous materials is their porosity. As a result, any coolants such as gases or liquids are not strictly confined to the prescribed path but may penetrate into the porous material. With sodium-graphite reactors, such penetration increases the absorption cross section due to the sodium coolant remaining in the pores. In water-cooled reactors any steam formation in the pores is detrimental and may damage or destroy the material. In gas-cooled reactors, the gaseous coolants, under the effect of radiation, may cause combustion in the pores already below the otherwise critical temperature. This causes loosening of the texture within the carbonaceous material. Furthermore, graphite and silicon carbide are not suitable as canning materials because their porosity permits radioactive fission products to penetrate and to contaminate the coolant.

By virtue of the present invention such porous carbonaceous substances are made impermeable to liquid and gas thus greatly improving the utility of these materials for use in nuclear reactors and in some cases affording for the first time the possibility of using these materials for nuclear-reactor purposes to which they were not previously amenable.

It is known as such to make graphite and silicon carbide gas- and liquid-tight. In sodium-graphite reactors, for example, the graphite components have been jacketed in a sheet metal sleeve or zirconium. This is expensive and requires large quantities of metal which, besides, impairs the neutron economy. It is also known to make graphite gas- and liquid-tight by means of synthetic resins. Such sealing is limited to temperatures below 200°C . and hence is of limited applicability for nuclear reactors.

It is further known to provide graphite with oxide coatings. Such coatings, however, are not in direct thermal equilibrium with the carbon, so that the application of high temperatures causes reactions to occur in the protective coating with the effect of causing it to scale off.

Another known method of sealing graphite is to provide it with filler materials of the same type as the graphite, namely pyrolytically segregated carbon or re-

duced graphitic acid. These methods have not resulted in a really impervious graphite.

All these difficulties are eliminated by the present invention, namely by providing the shaped carbonaceous body with a metallicly conducting coating comprising a high melting or virtually non-melttable intermediate layer of carbide, and an outer layer of metal or metal silicide formed of one or more metals of the *a* groups from IVa to VIa of the periodic system.

It is known to use silicon carbide coatings on graphite as protection from oxidation. Although such protective carbide layers satisfactorily delay consumption by burning, they are not completely tight to liquid and gas. Silicon carbide is not melttable and therefore forms only a crystalline layer whose texture is similar to that of a sintered ceramic body. Consequently, some porosity will always remain. If such a silicon carbide coating is used only for protection from oxidation, the pores may be temporarily clogged by the evolving silicic acid. This, however, does not take place when using the material in nuclear reactors operating with non-oxidizing coolants. Furthermore, such coatings are not resistant to alkali metals.

It is also known to use silicide coatings, for example MoSi_2 or TiSi_2 on graphite for protection from burn-off. The effect of such silicide layers is predicated upon partial conversion of these layers into vitreous SiO_2 —skin layers which are very dense and which temporarily cover fissures in the coating. These coatings, however, are not readily applicable in the construction of nuclear reactors because the latter purpose does not as much call for oxidation resistance as for gas tightness which is to be effective also with respect to inert substances. Furthermore, the protective effect must occur already at relatively low temperatures, for example somewhat above 100°C . Such absolute sealing, not obtainable with the known silicon carbide and silicide coatings, is achieved by virtue of the invention, namely by applying an intermediate carbide layer and a cover layer of metal or metal-silicide.

As with furnace electrodes, the intermediate layer of carbide is indispensable because when melting a metal or metal silicide cover layer upon the carbonaceous body without previously providing the body with the carbide layer, the substance of the cover layer will react with the carbon or silicon carbide of the body. This may result in converting the cover layer into a porous compound, namely a carbide or silicide, with the effect of causing the cover layer to scale off when solidifying from the fused state. Besides, it is also essential for the invention to obtain the desired sealed surface zone on the shaped carbonaceous body not only by virtue of the cover layer but also by filling the pores in the fusion zone with layer-forming elements, thus obtaining a double-acting seal.

It is further essential to select as carbide forming substances for the purposes of the invention, such metals that possess a high affinity to carbon and thus form very rapidly a stable and high-melting or non-melttable carbide capable of acting as an effective barrier to the penetration of solid carbon by diffusion. As in the case of the furnace electrodes dealt with above, we found that titanium is well suitable for nuclear-reactor purposes. Particularly favorable, however, is zirconium. The tendency of zirconium to form a carbide is somewhat inferior to that of titanium. Hence, when depositing the zirconium upon the carbonaceous body, the formation of a carbide barrier layer does not take place as spontaneously as with titanium. This results in a better filling of the marginal pores and thus secures a better anchoring of the carbide layer upon the carbonaceous body, and the desired sealing of the surface zone penetrates to a greater depth. Silicon is even more tardy in forming carbides. When using silicon for forming the carbide intermediate layer, it penetrates very deeply into the carbonaceous material of the shaped body, this phenomenon being known as such from

methods for manufacturing shaped bodies of silicon carbide.

In comparison with the known method of depositing silicides or metals upon graphite without an intermediate carbide layer, the invention provides a greatly superior adherence of the cover layer due to better wetting and due to the exclusion of carbide-forming reactions in the sealed skin layer.

All following examples relate to shaped carbonaceous bodies for use as structural components of nuclear reactors.

Example 5

Shaped graphite bodies were given a sealed surface coating as follows. The shaped body was first coated with a layer of zirconium of 0.05 to 0.1 mm. This was done by spraying zirconium wire onto the surface with an oxyhydrogen or acetylene blow pipe. The coated graphite bodies were heated in a graphite tube furnace with a carbon monoxide (CO) atmosphere for one hour at a temperature of 1800° C. Thereafter the temperature was increased to 2500° C. After maintaining the increased temperature for one-half hour, all metal was found converted into carbide. The bodies, removed from the furnace and now coated with a layer (*b* on the drawing) of zirconium carbide (ZrC), were again coated with zirconium in the above-described manner and were then subjected at 1100° C. in a tubular furnace to the flow of a gas mixture composed of SiCl₄ and H₂. After a reaction period of approximately one-half hour, a good adhering surface coating (*a*) of pure zirconium disilicide on top of the carbide was obtained.

Example 6

Graphite sleeves for use as cannings were coated with TiSi₂ as follows. The graphite tubes were immersed in a TiSi₂ melt heated to 1560° C. under a protective atmosphere of argon. The immersion was maintained only for a short period of approximately 30 seconds. It caused the silicide to penetrate into the pores of the graphite body (*c*). The work piece, still warm, was subsequently tempered in a furnace at 1400° C. for two hours in vacuum. As a result, the silicide was completely converted into carbide (*b* on the drawing). The carbide-coated body was again immersed in titanium disilicide to obtain complete sealing of its surface. The carbide layer (*b*) and the disilicide layer (*a*) had a total thickness of approximately 80 to 120μ.

Example 7

Graphite bodies in ball shape and tubular shape, were painted with a suspension consisting of 80% by weight of CrSi₂ and 20% SiC in a 10% solution of dextrin. The coated bodies were dried in a dryer cabinet at 110° C. and then heated under helium in some cases, and under argon in other cases, by direct resistance heating with the aid of high-frequency current at a temperature of approximately 1600° C. The bodies were kept at this temperature for 20 seconds. Thereafter the temperature was reduced to 1250° C. and maintained for 10 minutes in order to temper the body. After such processing the cooled work pieces comprised an intermediate carbide layer (*b*) of chromium carbide and silicon carbide. The coated graphite body thus obtained was given another coating formed of 90% by weight of TiSi₂ and 10% of MoSi₂ in a dextrin solution. After drying the coating, the body was heated for 30 seconds by high frequency in inert gas at 1550° C. A fused cover layer (*a*) was formed, consisting of an alloy of TiSi₂ and MoSi₂. The coatings were found to form a gas-tight seal as required for nuclear-reactor purposes.

Example 8

A tube of silicon carbide with a pore volume of 15% and a wall thickness of 2 mm. was sealed as follows. A coating of titanium was spread onto the work piece up

to a thickness of 20μ. The coated silicon carbide tube was heated in argon at 1600° C. for 15 minutes. This caused a reaction of the free carbon of the silicon carbide with the titanium to form additional SiC. Subsequently, the tubular work piece was immersed in a melt of zirconium silicide for 30 seconds at 1600° C. and was permitted to cool in a flow of argon. This resulted in the formation of a dense zirconium silicide cover layer.

We claim:

1. A shaped silicon carbide electrode body adaptable for use as an arc electrode, comprising a main structure of porous silicon carbide and an electrically conducting surface zone sealing said structure, said electrode body having at only one end thereof means for connection to a source of electricity, the other end thereof being free, said zone comprising an intermediate layer of refractory carbide bonded with said porous material and a cover layer bonded with said carbide layer and formed essentially of substance selected from the group consisting of alloys of and electrically conducting compounds with each other of metals in the *a* groups from IV*a* to VI*a* of the periodic system and of silicides and nitrides of said metals.
2. In a shaped electrode body according to claim 1, said intermediate layer being formed essentially of substance selected from the group consisting of zirconium carbide, silicon carbide, titanium carbide and chromium carbide.
3. In a shaped electrode body according to claim 2, said cover layer being formed essentially of substance selected from the group consisting of the elements zirconium, silicon, titanium and alloys of said elements.
4. In a shaped electrode body according to claim 1, said surface zone comprising additional substance selected from the group consisting of compounds of said carbide-forming metals with nitrogen, beryllium, boron, aluminum, silicon and phosphorus.
5. In a shaped electrode body according to claim 1, said intermediate layer consisting essentially of titanium carbide, and said cover layer consisting of titanium.
6. In a shaped electrode body according to claim 1, said intermediate layer consisting essentially of titanium carbide, and said cover layer consisting of chromium.
7. In a shaped electrode body according to claim 1, said intermediate layer consisting essentially of titanium carbide, a third layer of titanium nitride being disposed between, and fusion-bonded with, said carbide layer and said cover layer.
8. A shaped electrode body, comprising a main structure of porous material selected from the group carbon, graphite and silicon carbide, said electrode body having at only one end thereof means for connection to a source of electricity, the other end thereof being free, a refractory intermediate layer essentially of vanadium carbide bonded to and enclosing said structure, and a second cover layer of chromium fusion-joined with said vanadium carbide layer and forming together therewith an electrically conducting and fluid-tight seal.
9. A shaped body having a porous main structure comprising a substance selected from the group consisting of carbon and silicon carbide and having a metallically conducting surface zone thereon resistant to oxidation and to penetration by coolants and moderators of nuclear reactors, said zone comprising an intermediate layer of refractory carbide bonded with said porous material and a cover layer of a substance selected from the group of metals consisting of titanium, zirconium, chromium, molybdenum and vanadium and their silicides and nitrides, said surface zone comprising also additional substance selected from the group consisting of compounds of said metals with nitrogen, beryllium, boron, aluminum, silicon and phosphorus.
10. A shaped electrode body of electrically conducting carbon-containing substance adaptable for use as electrode in an arc furnace, comprising a porous main structure

of relatively high electrically conductive material selected from the group consisting of carbon and silicon carbide, said electrode body having at only one end thereof means for connection to a source of electricity, the other end thereof being free, and a metallic electrically conducting surface zone sealing said structure, said zone comprising an intermediate layer of refractory carbide bonded with said porous material and a cover layer bonded to said carbide layer and formed essentially of at least one substance selected from the group consisting of alloys of and electrically conducting compounds with each other of high-melting metals in the *a* groups from IVa to VIa of the periodic system and silicon, and of silicides and nitrides of said metals, said refractory carbide being a carbide of one of said metals.

11. A shaped electrode body of electrically conducting carbon-containing substance adaptable for use as an arc electrode, comprising a porous main structure of relatively high electrically conductive material selected from the group consisting of carbon and silicon carbide, said electrode body having at only one end thereof means for connection to a source of electricity, the other end thereof being free, and a metallic electrically conducting surface zone sealing said structure and filling the adjacent pores of said material, said zone comprising an intermediate layer of refractory carbide bonded with said porous material and a cover layer bonded to said carbide layer and formed essentially of substance selected from the group consisting of alloys of and compounds with each other of metals in the *a* groups from IVa to VIa of the periodic system and silicides and nitrides of said metals, said refractory carbide being a carbide of one of said metals.

12. A shaped body of electrically conducting carbon-containing substance adaptable for use as a structural component of nuclear reactor cores, comprising a porous main structure of electrically conductive material selected from the group consisting of carbon and silicon carbide and having a metallic electrically conducting surface zone thereon sealing said body and in direct thermal equilibrium therewith, said zone comprising a dense intermediate layer impervious to liquid and gas and bonded with said porous material and a cover layer bonded with said intermediate layer, said intermediate layer consisting essentially of refractory substance selected from the group consisting of the carbon-saturated carbides of zirconium, silicon, titanium and chromium, and said cover layer consisting essentially of at least one substance selected from the group of metals consisting of titanium, zirconium, chromium, molybdenum and vanadium and of silicides and nitrides of said metals, said surface zone comprising also additional substance selected from the group consisting of compounds of said metals with nitrogen, beryllium, boron, aluminum, silicon and phosphorus.

13. A shaped electrode body comprising a porous main structure of relatively high electrically conductive carbon-containing material and having at only one end thereof means for connection to a source of electricity, the other end being free, said main structure being provided with a first layer intimately bonded thereto and consisting essentially of at least one carbide selected from the group consisting of titanium carbide, chromium carbide, molybdenum carbide, silicon carbide, zirconium carbide; a second layer over and bonded to said first layer and consisting essentially of a highly electrically conductive layer of a substance selected from the group consisting of the elements molybdenum, chromium, titanium, zirconium, silicon and metallically conducting compounds of said elements with one of the further elements: nitrogen, beryllium, boron, aluminum, silicon and phosphorus.

14. A body as set forth in claim 13, said first layer additionally containing at least one metallically conducting combination selected from the group consisting of compounds of the elements molybdenum, chromium, titanium,

zirconium, silicon with an element of the group: nitrogen, beryllium, boron, aluminum, silicon and phosphorus.

15. A body as set forth in claim 13, the bond between said second layer and said first layer being a fusion joint forming together with said two layers an electrically conducting and fluid-tight seal.

16. A body as set forth in claim 13, said first layer consisting essentially of titanium carbide and the second layer consisting essentially of titanium metal.

17. A body as set forth in claim 13, said first layer consisting essentially of titanium carbide and the second layer consisting essentially of chromium metal.

18. The body as set forth in claim 13, said first layer consisting essentially of titanium carbide, said structure being provided with a third layer consisting essentially of titanium nitride disposed between, and fusion-bonded with said first layer and said second layer.

19. A shaped electrode body, comprising a main structure of porous material selected from the group consisting of carbon, graphite and silicon carbide, said electrode body having at only one end thereof means for connection to a source of electricity, the other end thereof being free, a refractory intermediate layer of titanium carbide bonded to and enclosing said structure, and a dense cover layer of substance selected from the group consisting of titanium, titanium disilicide and titanium nitride, said two layers forming together an electrically conducting and fluid-tight seal.

20. A shaped electrode body, comprising a main structure of porous material selected from the group consisting of carbon, graphite and silicon carbide, said electrode body having at only one end thereof means for connection to a source of electricity, the other end thereof being free, a refractory intermediate layer essentially of chromium carbide bonded to and enclosing said structure, and a dense cover layer of chromium fusion-joined with said carbide layer and forming together therewith an electrically conducting and fluid-tight seal.

21. A shaped electrode body, comprising a main structure of porous material selected from the group consisting of carbon, graphite and silicon carbide, said electrode body having at only one end thereof means for connection to a source of electricity, the other end thereof being free, a refractory intermediate layer bonded to and enclosing said structure and consisting essentially of carbide and silicide of chromium and silicon, and a dense cover layer of titanium, said two layers forming together an electrically conducting and fluid-tight seal.

22. A shaped body, comprising a main structure of porous material selected from the group consisting of carbon, graphite and silicon carbide, a refractory intermediate layer of zirconium carbide bonded to and enclosing said structure, and a dense cover layer of zirconium disilicide fusion-joined with said carbide layer and forming together therewith an electrically conducting and fluid-tight seal.

23. A shaped body, comprising a main structure of porous material selected from the group consisting of carbon, graphite and silicon carbide, a refractory intermediate layer of chromium carbide and silicon carbon bonded to and enclosing said structure, and a dense cover layer of an alloy of titanium disilicide and molybdenum disilicide fusion-joined with said carbide layer and forming together therewith an electrically conducting and fluid-tight seal.

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Sept. 29, 1964

G. HANNAPPEL ET AL
PROCESS FOR SUBSTANTIALLY REDUCING
THE CONSUMPTION OF ARC ELECTRODES
Filed April 28, 1961

3,151,266

FIG. 1

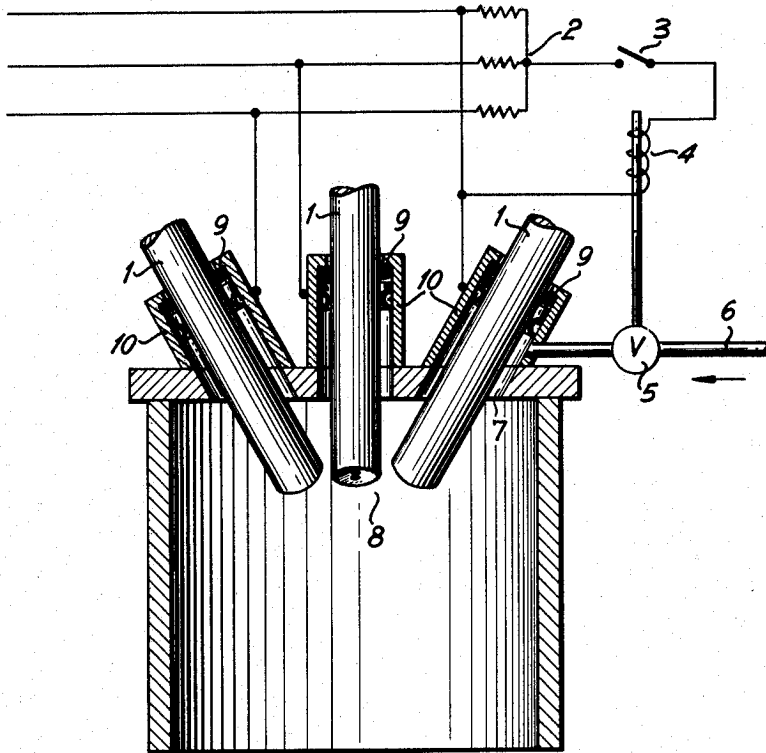
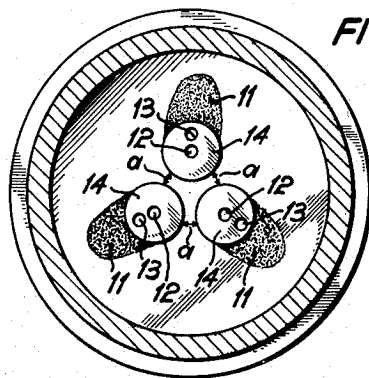


FIG. 2



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3,151,266

PROCESS FOR SUBSTANTIALLY REDUCING THE CONSUMPTION OF ARC ELECTRODES

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Filed Apr. 23, 1961, Ser. No. 106,331

10 Claims. (Cl. 314-25)

The present invention relates to a process for substantially reducing the consumption of arc electrodes.

It is a characteristic feature of high power-loaded positive arc electrodes that the frontal area facing the electric arc is strongly heated due to the striking of electrons mainly originating from the arc plasma and additionally accelerated in the anode fall. Thus, above a definite current strength the electrode is notably evaporated so that the electrode is consumed in a relatively short period. In order to reduce this undesired consumption of metal electrodes at least to a large degree it is known to cool the electrodes with liquid or gaseous media. However, in spite of the cooling, the consumption of metal electrodes cannot be avoided completely owing to the thermal surface evaporation and partially also for chemical reasons.

With specifically the same load the consumption of carbon electrodes is considerably greater than that of cooled metal electrodes. This results from the impossibility to cool the carbon effectively and from the fact that carbon electrodes evaporate especially strongly on the frontal area under atmospheric conditions and approximately under a current load from 40 ampere/cm.² onward.

The aforesaid current density is, however, often much too small for the industrial application of the carbon-electric arc process, especially in chemical processes. In principle, it is possible further to increase the current density, but in this case the consumption of the carbon electrodes increases linearly to a greater extent than the current strength. This fact and the impossibility to use cooled metal electrodes for chemical reasons in a great number of chemical processes, for example, owing to the detrimental action of the metal electrode vapor, represent economic and technical disadvantages.

The great consumption of carbon electrodes is not only uneconomical in view of the high price of the carbon but also in view of the required labor for exchanging in relatively short periods of time the consumed electrodes for fresh ones so as to obtain a continuously burning electric arc.

Furthermore, in the known electric arc installations with carbon electrodes considerable operative disturbances occur when the electrodes which, in the interest of a continuous burning, are connected preferably by screwing and/or bonding, are mechanically blocked or break on being forwarded due to uneven joints. During the continuous operation uneven joints of carbon electrodes can only be worked with great technical expenditure, and in spite of this, absolute safety for the operators cannot be guaranteed since the electrodes are always under voltage, which may amount in installations of this kind to several thousand volts. It is quite obvious that already the fixing of electrodes under such high voltages by means of nipples is very dangerous.

The present invention provides a process for at least substantially reducing the aforesaid disadvantages of either metal or carbon electrodes in electric arc processes by introducing in the direct neighbourhood of the electrodes and/or in the space between several electrodes a definite amount of an organic compound, preferably a hydrocarbon compound and/or elementary carbon, decomposing the organic compound in the arc space and

depositing the formed and/or the introduced elementary carbon in controllable manner on the electrodes as the carbon contacts the electrodes and adheres thereto.

By this process the electrode material which evaporates and/or is chemically decomposed during the burning of the arc is complemented in controllable manner by the carbon introduced into the arc space, which carbon deposits by way of chemical transformation and/or physical deposition on the electrodes.

The introduction of carbon into the electric arc is already known. But hitherto efforts were made not to allow the carbon to deposit on the electrodes. It has now been found that by a controllable deposition of carbon on the electrodes the consumption thereof can be reduced to at least a substantial degree.

For obtaining a rotation-symmetrical form of the deposition on the electrodes the latter are rotated. The deposition has preferably a cylindrical form but other rotation-symmetrical forms are likewise suitable. For compensating uneven or too small carbon deposits, the electrodes can additionally be moved in longitudinal direction.

Suitable electrodes on which carbon is deposited by the process of the invention are carbon electrodes or cooled metal electrodes.

The organic compound and/or the elementary carbon is introduced through the electrodes which are provided with a concentric and/or an eccentric canal in the interior or with a groove which preferably runs in the direction of the longitudinal axis of the electrode in the surface of the electrode. The organic compound and/or the elementary carbon can likewise be supplied through an annular space concentrically or eccentrically surrounding the electrode.

When the organic compound and/or the elementary carbon is supplied eccentrically, the carbon deposits in the form of a shoe on the frontal area of the electrode. Thus the frontal area is enlarged whereby the current load per sq. cm. of electrode surface is considerably reduced, while the distance to the neighbouring electrode parts remains practically unchanged.

Alternatively, it is suitable to supply the organic compound and/or the elementary carbon in the form of at least one jet directed on the electrodes in a manner such that the discharge zone is completely enveloped spatially.

The deposition of the carbon is controlled by known arrangements and manual means, in automatic dependency on the electric arc voltage or power, or by electro-optical scanning devices. The latter controlling means permit, when arranged in suitable manner, a control of the electrode diameter and of the electrode position. Furthermore, the current of the electric arc can be regulated in a manner such that the average electrode consumption remains unchanged. Moreover, the amount and/or the spatial distribution of the organic compound and/or the elementary carbon striking on the electrode and serving for building up the electrode is regulated so that the medium electrode distance remains unchanged.

The accompanying drawing diagrammatically illustrates by way of example a mode of execution of the invention.

FIGURE 1 represents an arc furnace for three phase current, in which the amount of organic compound supplied, in the present case hydrocarbon, is automatically regulated in dependency on the electrode consumption via the arc voltage.

FIGURE 2 is a view from below of a shoe-like deposition of carbon on the electrodes of a three phase current furnace.

Since, on the one hand, the arc voltage increases with the growing arc length and, on the other hand, the amount of carbon depositing on the electrodes becomes greater with the increasing amount of hydrocarbon supplied, a regulation can be readily carried out by known means.

FIGURE 1 shows that the voltage between the electrode 1 and the artificially formed star point 2, which voltage is proportional to the arc voltage, is conducted via a voltage dependent switch 3 to the coil 4 of a magnet valve 5 which opens when the coil 4 is excited and thus allows hydrocarbon above a limit voltage to flow through conduit 6 in the direction of the arrow and through annular space 7 along the electrode 1 on which carbon shall deposit into the arc zone 8. The numeral 9 designates a packing ring which prevents the gas from escaping from the current supply sleeve 10. By adjusting the striking voltage of the switch 3 and by the gas streaming from the annular space 7 in definite direction the loss of material occurring on the electrode 1 is compensated by the newly depositing carbon. FIGURE 2 shows that the shoe-like deposition 11, that is to say a one-side deposition, takes place in a manner such that the original electrode distance *a* remains practically unchanged. The organic compound and/or the elementary carbon is supplied through borings 12, 13 which are arranged centrally or eccentrically in electrodes 14. In the present case the electrodes 14 are stationary. For controlling the distance *a* optic devices are installed in the furnace, preferably in the center above electrodes 14 which are connected with regulating means for the amount and direction of the arriving organic compound.

It is likewise possible to supply hydrocarbon continuously and only to regulate quantitatively a part of it.

The process of the invention can be carried out in most different ways and it is not limited to the example illustrated diagrammatically in the accompanying drawings. The individual parts can be constructed and arranged in any desired manner depending on the requirements in each case.

We claim:

1. In the process for substantially reducing the con-

sumption of arc electrodes by introducing in the immediate vicinity of the electrodes a substance selected from the group consisting of an organic compound and elementary carbon, the substance decomposing in the arc space, and building up a deposit of carbon on the electrodes as said substance comes into contact with said electrodes and adheres thereto, the improvement consisting of introducing said substance in excess of that which will produce a reducing atmosphere and in sufficient quantity to produce a material electrode coating.

2. The method of claim 1 wherein the introduction of said substance is initiated when the arc voltage reaches a predetermined limit.

3. The process of claim 1 wherein said substance is supplied through an annular space concentrically surrounding the electrode.

4. The process of claim 1 wherein said substance is supplied through an annular space eccentrically surrounding the electrode.

5. The process of claim 1 wherein said substance is directed in the form of several jets on the electrodes.

6. The process of claim 1 wherein the organic compound is a hydrocarbon compound.

7. The process of claim 1 wherein for producing a rotation-symmetrical deposition on the electrode the latter is rotated during the deposition of carbon.

8. The process of claim 7 wherein the carbon is deposited in cylindrical form.

9. The process of claim 1 wherein the electrode is a carbon electrode.

10. The process of claim 1 wherein the electrode is a cooled metal electrode.

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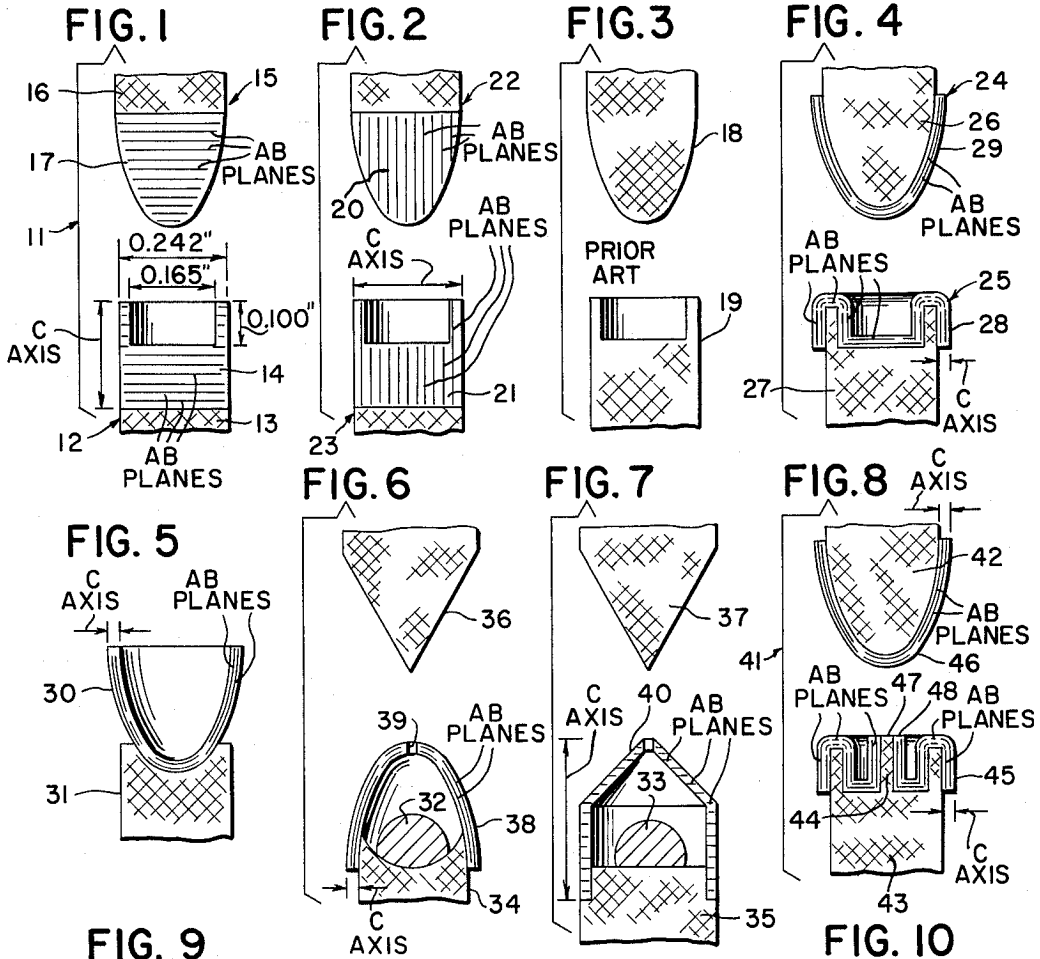
April 26, 1966

L. J. GARBINI ET AL

3,248,592

ANISOTROPIC ARC-SPARK EMISSION ELECTRODES

Filed Sept. 10, 1963



ELEMENT	WAVE-LENGTH	LINE / BACKGROUND		
		GRAPH-ITE	PYRO-LYTIC GRAPH-ITE C-AXIS	PYRO-LYTIC GRAPH-ITE AB-PLANE
Co	3453.5	8.2	2.60	9.53
Y	3242.1	1.37	1.34	11.5
Pb	2833.1	2.98	1.60	11.9

RELATIVE INTENSITIES FROM $Li_2 CO_3$

WAVE-LENGTH	% TRANSMISSION		
	GRAPH-ITE	PYRO-LYTIC GRAPH-ITE C-AXIS	PYRO-LYTIC GRAPH-ITE AB-PLANE
2400	52	69	75
3070	37	49	81
4300	25	7	98
4500	20	5	82

BACKGROUND COMPARISON

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3,248,592

**ANISOTROPIC ARC-SPARK EMISSION
ELECTRODES**

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Filed Sept. 10, 1963, Ser. No. 307,990
19 Claims. (Cl. 313—355)

This invention relates in general to arc-spark electrodes and more particularly to anisotropic arc-spark emission spectroscopy electrodes and anisotropic illumination electrodes.

Qualitative and quantitative analysis by spectroscopic or spectrochemical techniques has become an extremely important analytical tool in practically speaking all of the scientific disciplines dealing with matter and its properties. Regardless of which analytical method is employed, qualitative or quantitative, and regardless of which of the various specific techniques such as visual photographic, with or without internal standards, etc., is used by the analyst, the characteristics of the electrodes employed to generate the arc are of paramount importance in achieving meaningful and accurate results.

The physical characteristics of the electrodes, both sample and counter are important contributors in determining the properties of the arc produced. Naturally, materials having extremely high melting points and a high degree of purity are used in emission spectroscopy. One of the most widely used materials possessing the above characteristics is graphite. Ordinary or commercial graphite is isotropic that is, it has a random orientation of its crystals. Thus the electrical and thermal properties of graphite are uniform in all dimensions. Therefore, ordinary graphite electrodes employed in emission spectroscopy work will conduct heat as easily along the surface from which an arc is being drawn as well as perpendicular thereto. This results in inefficiency due to uneven burning of the electrodes. Furthermore, arcs produced from ordinary isotropic graphite have a tendency to wander or drift about the electrode surface and this is highly undesirable since it results in nonuniform volatilization and/or excitation of the specimen under analysis. Furthermore, hot spots develop on the electrodes due to uneven burning and cause either electron or ion bombardment of the electrode which will burn off electrodes unevenly and result in uneven rates of volatilization of different areas of the sample or specimen which results in questionable validity of multiple studies of a given specimen.

Arc-spark electrodes for illumination applications such as for search lights, motion-picture projectors, etc., are enhanced by utilization of stable sources and such sources have heretofore not been as stable as desired.

The present invention through the utilization of anisotropic electrodes enhances the stability of the source for such illumination applications.

The present invention obviates the above deficiencies in prior art emission spectroscopic electrodes through the utilization of novel electrodes comprising anisotropic physical parameters so oriented with respect to the arc, of the specimen under consideration such that increased spectral sensitivity, more uniform burning of the arc and electrodes, and enhanced arc stability are achieved thereby individually or collectively, depending on the particular electrode form and orientation chosen. The present invention, through the use of anisotropic pyrolytic graphite emission spectroscopic electrodes having the C-axis and A-B planes thereof oriented in a predetermined manner with respect to the central axis of the arc drawn

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between the electrodes, results in heretofore unattainable arc characteristics with resultant enhanced emission spectroscopic properties. The present invention further provides a variety of electrode configurations having novel characteristics by virtue of the anisotropic characteristics and preselected orientation of the C-axis and A-B planes of the electrode material. Pyrolytic graphite is herein defined as that form of vapor deposited carbon which is frequently referred to as anisotropic pyrolytic graphite. The A-B planes of pyrolytic graphite are characterized by having properties similar to a conductor whereas the C-axis is characterized by having properties similar to an insulator. Therefore, as will be explained in more detail hereinafter, the electrical and thermal conductivity in the A-B planes is much greater than along the C-axis. Hereinafter, A-B plane signifies the plane of high thermal and electrical conductivity of an anisotropic material such as pyrolytic graphite while C-axis signifies the axis of an anisotropic material such as pyrolytic graphite which has low electrical and thermal conductivity in relation to the A-B plane.

A principal object of the present invention is the provision of improved emission spectroscopic electrodes.

A feature of the present invention is the provision of emission spectroscopic electrodes having anisotropic physical parameters.

Another feature of the present invention is the provision of emission spectroscopic electrodes formed from pyrolytic graphite.

Still another feature of the present invention is the provision of various electrode configurations formed from an anisotropic material wherein the C-axis and A-B plane of the material are selectively preoriented in order to obtain desired characteristics for an arc drawn from or drawn to said electrode or between electrode pairs.

These and other features and advantages of the present invention will be more apparent upon a perusal of the following specification taken in conjunction with the accompanying drawings wherein,

FIG. 1 is a sectional view of a pair of electrodes having anisotropic arcing surfaces wherein the A-B planes of the materials forming the arcing surfaces are disposed normal to the central axis of the arc to be drawn between said electrodes.

FIG. 2 is a sectional view of a pair of electrodes having anisotropic arcing surfaces, wherein the A-B planes of the material forming the arcing surfaces are disposed parallel to the central axis of the arc to be drawn between said electrodes.

FIG. 3 is a sectional view of typical prior art electrodes formed from isotropic graphite.

FIG. 4 is a sectional view of a pair of electrodes having a typical prior art configuration as shown in FIG. 3 and having a base or substrate of conventional isotropic material, wherein an anisotropic material is deposited thereon to form the arcing surface such that the A-B planes of the deposited material parallel the particular surface configuration of the base or substrate.

FIG. 5 is a section view of a pyroformed anisotropic cup shaped electrode supported by a base of conventional material.

FIG. 6 is a sectional view of a boiler type pair of electrodes, wherein the boiler cap is formed from a pyroformed anisotropic material.

FIG. 7 is a sectional view of another boiler type pair of electrodes, wherein the boiler cap is formed from an anisotropic material.

FIG. 8 is a sectional view of a pair of conventional isotropic electrodes, wherein the electrode has a central arcing post and wherein the opposing surfaces of both of said electrodes are formed from an anisotropic material.

FIG. 9 depicts a chart comparing the relative spectral sensitivities for dimensionally equivalent electrodes conforming to FIGS. 1-3 for a few specimen elements using Li_2CO_3 as a matrix.

FIG. 10 depicts a chart comparing the percent transmission at different wavelengths of ordinary or non-coherent light through film previously exposed to arcs using electrodes conforming to FIGS. 1-3.

Directing our attention now to FIG. 1, there is depicted a pair 11 of electrodes wherein the sample electrode 12 has a base or substrate 13 material which is preferably of isotropic graphite. Isotropic is used to define a material having for all practical purposes, uniform physical characteristics in every direction. Mounted on base 13 is a cup shaped tip of an anisotropic material, preferably pyrolytic graphite, wherein the A-B planes of the polycrystalline material are disposed parallel to the counter electrode 14, or expressed another way, normal to the central axis of an arc drawn between electrodes 12 and 15. The C-axis of the tip material is aligned with the central axis of an arc drawn between the electrodes. The counter electrode 15 has a conventional base 16 of graphite or any other suitable material and a cone shaped tip portion 17 of an anisotropic material preferably identical to the cup shaped tip 14. The A-B planes of the polycrystalline tip of counter electrode 15 are oriented in the same manner as the cup shaped tip electrode 14.

The properties of anisotropic pyrolytic graphite are such that the individual crystals are highly oriented as opposed to the random orientation between individual crystals of ordinary or commercial graphite. Pyrolytic graphite is at present manufactured by vapor deposition of carbon from an organic vapor state onto a substrate which is maintained at elevated temperatures such as for example, 2100°C . under pressures of around 10 cm. Hg. Methane is a suitable gas for producing pyrolytic graphite. The orientation of the individual crystals deposited on the substrate is such that the planes of deposition (parallel to the deposition substrate) hereinafter and previously referred to as A-B planes, have different physical and electrical properties than the axis normal to these planes, hereinafter and previously referred to as the C-axis. For example, it has been determined that thermal conductivity in the A-B plane is around 200 times greater than along the C-axis. The electrical characteristics of pyrolytic graphite exhibit similar directionality. For example, very low electrical resistivity, such as 4×10^{-4} ohm-cm. at room temperature occurs along the A-B planes. Thus it might be said that pyrolytic graphite behaves like an insulator along the C-axis and like a conductor in the A-B plane. Therefore, pyrolytic graphite is said to be anisotropic.

The above mentioned characteristics are advantageously utilized in the electrode configuration depicted in FIG. 1 as follows:

Since the A-B plane exhibits high uniform thermal conductivity, it will conduct heat rapidly and uniformly across the entire arcing surface to produce an extremely stable arc. Furthermore, since thermal conductivity along the C-axis is negligible in comparison to thermal conductivity in the A-B planes, heat will tend to concentrate at the arcing surface rather than diffusing down or up, as the case may be, into the region of and into the base or substrate. Therefore, the present invention depicted in FIG. 1 achieves higher electrode temperatures for a given voltage and current in comparison to ordinary isotropic graphite electrodes 18 and 19 having equivalent physical parameters as depicted in prior art FIG. 3. This is particularly useful if fast volatilization and/or excitation of the specimen is desired.

FIG. 2 depicts a similar electrode configuration as shown in FIGS. 1 and 3 with the exception that in this case, the tip portion 20, 21 of electrodes 22 and 23 have the C-axis disposed parallel to and forms the arcing surface while the A-B planes are paralleled with the central

arc axis. The benefits to be derived from this orientation are a lower average surface temperature for a given energy input which provides reduced background or white radiation and thus enhances spectral sensitivity.

FIG. 4 depicts a pair of isotropic electrodes 24, 25 with base or substrate portions 26, 27 having an isotropic coatings 28, 29 deposited thereon. Pyrolytic graphite is formed by vapor deposition of an organic vapor on a substrate and the A-B planes will be paralleled with the substrate surface upon which the pyrolytic graphite is deposited while the C-axis will accordingly be normal thereto. This technique is advantageously employed to form the coatings depicted in FIG. 4. All the advantages derived from having the A-B planes form the arcing surface as described in connection with FIG. 1 are present in the embodiment of FIG. 4. Furthermore, even more rapid heat up times to peak arc operating temperature are achieved with the coated version since heat can flow uniformly along the internal portions of the cup without encountering any C-axis thermal resistance.

FIG. 5 depicts a pyroformed anisotropic cup electrode 30 mounted on a base 31. Pyroformed is defined as any vapor deposited anisotropic pyrolytic graphite preformed shape which has been removed from the substrate upon which it was deposited. Pyrolytic graphite deposited on a base 26 such as coating 29 as shown in FIG. 4, can easily be removed from the base as for example by positioning a collar around the substrate and pulling the substrate or base through the collar thus forcibly removing the deposition from the base. The electrode cup of FIG. 5 provides a high degree of uniformity over the entire surface and again short warm up times to peak arcing temperatures and uniform surface temperatures are achieved because of the circular nature of A-B plane orientation.

FIGS. 6 and 7 depict boiler type electrode configurations with representative samples 32, 33 deposited on base members 34, 35 with isotropic counter electrodes 36, 37. In FIG. 6 a tip portion is formed from a cup similar to cup 30 depicted in FIG. 5. A central aperture 39 is bored in the tip thereof as shown. Any suitable cement may be used to bond the boiler tip 38 to the base 34. The advantages to be derived from this configuration utilizing pyroformed anisotropic pyrolytic graphite oriented as shown are as follows:

As in all boiler or furnace electrodes the sample volatilized in the furnace evolves through hole into arc for excitation. This separates the area of evolution and excitation and favors the more volatile elements such as mercury, cadmium, zinc, arsenic, etc., since the pyroformed furnace heats rapidly and uniformly to a relatively high temperature for furnace electrodes. Furthermore, an anisotropic substrate or base may advantageously be employed for the boiler electrodes of FIG. 6 to further concentrate the heat while still achieving uniformity of heat distribution.

In FIG. 7, the boiler tip 40 is machined from a block of pyrolytic graphite such that the A-B planes are disposed normal to the central arc axis and the C-axis is disposed parallel to the central arc axis. The advantages to be derived from this orientation are as follows. As in FIG. 6, the boiler electrode in this case has the combination of the hot and stable arc with a furnace that is thermally insulated by the C-axis of the pyrolytic graphite. Such electrodes favor the most volatile elements particularly mercury since the sample temperature is kept low and uniform volatilization results.

In FIG. 8, a pair of electrodes 41 having conventional base portions 42, 43 of graphite or the like are shown. Center post 44, specifically the A-B edges surrounding the post on base 43 draws the arc. Stability and uniformity as well as rapid warm up time to peak operating arc temperature are enhanced by anisotropic coatings 45, 46. As shown, the coating on the top surface 47 of the post 44 is removed. This provides a A-B edge or

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C-axis facing border 48 around the tip. Due to the circular orientation of the A-B planes surrounding the tip, the resulting uniform temperature distribution will aid in maintenance of a stable arc. Furthermore, the arc will strike the A-B edge and thus concentrate in the center post and be precluded from wandering to the sides of the cup because of the low thermal and electrical conductivity of the C-axis. The remaining surfaces of the cup being formed from A-B planes have all of the advantages discussed previously in connection with FIG. 4. The chart on FIG. 9 shows a comparison of spectral sensitivities using dimensionally equivalent electrodes conforming to FIGS. 1-3 and having the dimensional parameters indicated in FIG. 1 for a few specimen elements using Li_2CO_3 as a matrix and .015% by weight sample specimens of Co, Y and Pb. Examination of the line background readings (dimensionless ratio of intensities) for the three samples vs. wavelength (angstroms) using a D.C. arc running at 6 amp. for 30 sec. shows the order of improvement achieved with pyrolytic graphite having the A-B plane parallel to the arc axis.

FIG. 10 depicts a comparison of the electrodes depicted in FIGS. 1-3 with respect to the arcing characteristics of the individual electrodes as evidenced by the background radiation produced by each type. Percent transmission is a measure of the percent transmission of a white or non-coherent light source through film previously exposed to arcs produced by the electrodes depicted in FIGS. 1-3 for certain representative wavelengths. The higher the value of percent transmission the less background intensity emanating from the arc at the particular wavelength under consideration. It is to be noted from FIG. 10 that background intensity is considerably reduced for A-B plane orientations thus providing excellent spectral sensitivities.

In any event the A-B plane or C-axis orientations will result in enhanced consistency of the background radiation emanating from the arc and thus considerably enhance the validity of plural analysis of a given sample to provide a high degree of accuracy heretofore unattainable in emission spectroscopic analysis. It is to be understood that the counter electrode shapes depicted in FIGS. 1-8 are merely illustrative and are not to be taken as being the only shape utilized for the particular sample electrode involved.

Other applications wherein a stable illumination source is required are search lights, motion picture projectors, illuminators for metallagraphs and arc image furnaces. Anisotropic pyrolytic graphite electrodes such as shown and described herein are advantageously utilized in such applications. In particular, where the C-axis or low thermal and electrical conductivity axis is disposed parallel (aligned with) the axis of the arc, increased source stability is achieved.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. For use in an apparatus for the production of an intense arc between a pair of electrodes disposed in spaced relation with respect to each other such that an arc is drawn between mutually opposed tip portions of said pair of electrodes for the spectroscopic analysis of a sample of material, an emission spectroscopic electrode having a tip portion which has a substantial portion thereof composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said A-B planes of the pyrolytic graphite tip portion of said electrode being dis-

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posed normal to the central axis of said emission spectroscopic electrode.

2. For use in an apparatus for the production of an intense arc between a pair of electrodes disposed in spaced relation with respect to each other such that an arc is drawn between mutually opposed tip portions of said pair of electrodes for the spectroscopic analysis of a sample of material, an emission spectroscopic electrode having a tip portion which has a substantial portion thereof composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said A-B planes of the pyrolytic graphite tip portion of said electrode being disposed parallel to the central axis of said emission spectroscopic electrode.

3. For use in an apparatus for the production of an intense arc between a pair of electrodes disposed in spaced relation with respect to each other such that an arc is drawn between mutually opposed tip portions of said pair of electrodes for the spectroscopic analysis of a sample of material, an emission spectroscopic electrode having a tip portion which has a substantial portion thereof composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said A-B planes of the pyrolytic graphite tip portion of said electrode being disposed normal to the central axis of said emission spectroscopic electrode, said emission spectroscopic electrode having a base portion made of isotropic materials and said tip portion being an anisotropic pyrolytic graphite coating deposited on said base portion.

4. For use in an apparatus for the production of an intense arc between a pair of electrodes disposed in spaced relation with respect to each other such that an arc is drawn between mutually opposed tip portions of said pair of electrodes for the spectroscopic analysis of a sample of material, a first emission spectroscopic electrode having a tip portion which has a substantial portion thereof composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said A-B planes of the pyrolytic graphite tip portion of said electrode being disposed parallel to the central axis of said emission spectroscopic electrode, said emission spectroscopic electrode having a base portion made of isotropic material, said tip portion being an anisotropic pyrolytic graphite coating deposited on said base portion, the other electrode of said pair of electrodes being disposed along a common axis and having a tip portion made of anisotropic pyrolytic graphite.

5. For use in an apparatus for the production of an intense arc between a pair of electrodes disposed in spaced relation with respect to each other such that an arc is drawn between mutually opposed tip portions of said pair of electrodes for the spectroscopic analysis of a sample of material, an emission spectroscopic electrode having a tip portion which has a substantial portion thereof composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said electrode being disposed in combination with a mutually opposed counter electrode, each of said pair of electrodes including a base portion made of isotropic carbon and each of said tip portions being coatings of pyrolytic graphite deposited on said base portions, the A-B planes of the pyrolytic graphite tip portion of said one electrode being disposed parallel to the

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central axis of said one emission spectroscopic electrode and the A-B plane of the pyrolytic graphite tip portion of the other electrode of said pair of electrodes being disposed perpendicular to the central axis of said other emission spectroscopic electrode.

6. For use in an apparatus for the production of an intense arc between a pair of electrodes disposed in spaced relation with respect to each other such that an arc is drawn between mutually opposed tip portions of said pair of electrodes for the spectroscopic analysis of a sample of material, an emission spectroscopic electrode having a tip portion which has a substantial portion thereof composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said tip portion defining an open cup of pyroformed pyrolytic graphite.

7. For use in an apparatus for the production of an intense arc between a pair of electrodes disposed in spaced relation with respect to each other such that an arc is drawn between mutually opposed tip portions of said pair of electrodes for the spectroscopic analysis of a sample of material, an emission spectroscopic electrode having a tip portion which has a substantial portion thereof composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said tip portion of said emission spectroscopic electrode defining at least a portion of an enclosed cavity having its cover portion formed from pyrolytic graphite, said cavity forming a boiler for volatilization of a sample of material said boiler having an aperture in the cover portion thereof at the central axis of the electrode.

8. For use in an apparatus for the production of an intense arc between a pair of electrodes disposed in spaced relation with respect to each other such that an arc is drawn between mutually opposed tip portions of said pair of electrodes for the spectroscopic analysis of a sample of material, an emission spectroscopic electrode having a tip portion which has a substantial portion thereof composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said tip portion of said emission spectroscopic electrode defining at least a portion of an enclosed cavity having its cover portion formed from pyrolytic graphite, said cavity forming a boiler for volatilization of a sample of material, said boiler having an aperture in the cover portion thereof at the central axis of the electrode, said boiler cover portion having the A-B planes of said pyrolytic graphite disposed normal to the central axis of said electrode.

9. For use in an apparatus for the production of an intense arc between a pair of electrodes disposed in spaced relation with respect to each other such that an arc is drawn between mutually opposed tip portions of said pair of electrodes for the spectroscopic analysis of a sample of material, an emission spectroscopic electrode having a tip portion which has a substantial portion thereof composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said tip portion of said emission spectroscopic electrode defining at least a portion of an enclosed cavity having its cover portion formed from pyrolytic graphite, said cavity forming a boiler for volatilization of a sample of material, said boiler having an aperture in the cover portion

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thereof at the central axis of the electrode, said boiler cover portion having the A-B planes of said pyrolytic graphite disposed parallel to the external defining surface thereof.

10. For use in an apparatus for the production of an intense arc between a pair of electrodes disposed in spaced relation with respect to each other such that an arc is drawn between mutually opposed tip portions of said pair of electrodes for the spectroscopic analysis of a sample material, an emission spectroscopic electrode having a tip portion which has a substantial portion thereof composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said tip portion of said emission spectroscopic electrode forming a cup having a central post therein, said tip portion and the sides of said central post having a coating of pyrolytic graphite deposited thereon.

11. For use in an apparatus for the production of an intense arc between a pair of electrodes disposed in spaced relation with respect to each other such that an arc is drawn between mutually opposed tip portions of said pair of electrodes for the spectroscopic analysis of a sample of material, an emission spectroscopic electrode having a tip portion which has a substantial portion thereof composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said tip portion of said emission spectroscopic electrode forming a cup having an open cavity for receiving a sample of material for volatilization, the surfaces of said cup being characterized by having the A-B planes of said pyrolytic graphite disposed parallel thereto.

12. In an apparatus for the spectroscopic analysis of a sample of material, a lower electrode having a cavity in its top portion for containing said sample of material, and an upper electrode spaced from the lower electrode, said upper electrode having a cylindrical body with a tapered lower end portion, said lower electrode having its cavity surface composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis.

13. In an apparatus for the spectroscopic analysis of a sample of material, a lower electrode having a cavity in its top portion for containing said sample of material, and an upper electrode spaced from the lower electrode, said upper electrode having a cylindrical body with a tapered lower end portion, said lower electrode having its cavity surface composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said upper electrode having its tapered lower end portion composed of anisotropic pyrolytic graphite.

14. An electrode for producing an intense light by an arc discharge between at least a pair of electrodes, said electrode being characterized by having its tip portion formed from a hollow generally cone shaped deposit of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said hollow generally cone shaped deposit of anisotropic pyrolytic graphite being deposited on the tip portion of an elongated rod of isotropic graphite.

15. A generally elongated rod shaped electrode for producing an intense light by an arc discharge between at least a pair of electrodes, said electrode being characterized by having its tip portion forming a cavity for receiving a sample of material, said cavity having its internal surface composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, the A-B planes of said anisotropic pyrolytic graphite being disposed parallel to the internal surface of said cavity.

16. A generally elongated rod shaped electrode for producing an intense light by an arc discharge between at least a pair of electrodes, said electrode being characterized by having its tip portion forming a cavity for receiving a sample of material; said cavity having its internal surface composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, the A-B planes of said anisotropic pyrolytic graphite being disposed normal to the central axis of said rod shaped electrode.

17. A generally elongated rod shaped electrode for producing an intense light by an arc discharge between at least a pair of electrodes, said electrode being characterized by having its tip portion forming a cavity for receiving a sample of material, said cavity having its internal surface composed of anisotropic pyrolytic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said A-B planes of said anisotropic pyrolytic graphite being disposed parallel to the central axis of said rod shaped electrode.

18. A generally elongated rod shaped electrode for producing an intense light by an arc discharge between at least a pair of electrodes, said electrode having its tip

portion composed of anisotropic pyrolytic graphite deposited on the end portion of a rod of isotropic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said anisotropic pyrolytic graphite forming said tip portion having its C-axis disposed parallel with respect to the central axis of said rod.

19. A generally elongated rod shaped electrode for producing an intense light by an arc discharge between at least a pair of electrodes, said electrode having its tip portion composed of anisotropic pyrolytic graphite deposited on the end portion of a rod of isotropic graphite, said anisotropic pyrolytic graphite being characterized by having A-B planes and a C-axis wherein said A-B planes exhibit high thermal and electrical conductivity relative to the thermal and electrical conductivity of said C-axis, said anisotropic pyrolytic graphite forming said tip portion being a coating of anisotropic pyrolytic graphite having its A-B planes disposed parallel to the tip surfaces.

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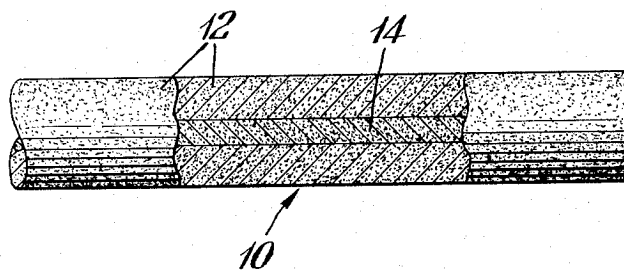
July 19, 1966

M. R. RIEK

3,262,005

HIGH INTENSITY CARBON ELECTRODE

Filed Aug. 26, 1963



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3,262,005

HIGH INTENSITY CARBON ELECTRODE

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 Filed Aug. 26, 1963, Ser. No. 304,637
 7 Claims. (Cl. 313-311)

The invention relates to a high intensity arc carbon electrode for use in arc lighting, motion picture projectors, solar simulation, and the like, and to means by which the power rating of such an electrode can be improved.

High intensity arcs are usually developed between a negative carbon electrode and a positive carbon electrode which comprises a shell and a core therein containing a substantial amount of flame material which becomes highly luminescent under the action of electrons in the arc. The current density in the high intensity positive carbon is frequently as high as 1500 amperes per square inch and above, and at such a high current density the core material is vaporized more rapidly than that of the shell until a deep cup-like crater is formed in the working face. The electrode vapors of carbon and flame materials in the crater are heated to a very high temperature and radiating efficiency, and produce a brightness several times that possible with a solid carbon electrode or an electrode without flame material, such as that used for the negative.

Although high intensity arc carbons are operated at high current densities, there is a maximum current density beyond which the arc becomes unsteady. For example, a standard 11 millimeter high intensity positive arc electrode begins to squeal and pop at about 200 to 210 amperes. This effect is undesirable since operation at higher currents provides a greater total light output from the arc. The maximum power at which the arc carbon can operate at a reasonably steady condition is referred to as its power rating.

The main object of the invention is to provide a means by which the power rating of a high intensity arc carbon electrode can be improved. Another object is to provide an arc carbon electrode having improved power characteristics.

The invention by means of which this and other related objects are achieved will be described with reference to the accompanying drawing wherein the sole figure is an illustration of an electrode typical of the electrode of the invention.

Broadly, the objects are achieved by the incorporation of at least one oxide of the metals zirconium and titanium in the shell of a high intensity arc carbon electrode in an amount sufficient to improve the power rating of the electrode. Ordinarily, between about 0.1% and about 6% oxide incorporated in the shell is preferred. If titanium oxide is employed, however, between about 0.1% and 3% oxide provides the most satisfactory results in electrodes for general use. The percentages are computed as metal dioxide based on the weight of the shell before incorporation of the oxide.

The oxide may be a simple oxide of zirconium or titanium, or it may be in the form of an alkaline earth metal salt, such as the barium, calcium, and magnesium titanates. If such salts are used to incorporate the oxide in the shell, the percentage by weight must be calculated as if the simple oxide were incorporated. Alkali metal salts could also be employed except that alkali metals cause shell flashing, and their presence is therefore in general undesirable.

Referring to the drawing, a high intensity arc carbon electrode 10 comprises an outer shell 12 and an inner core 14. The shell 12 has incorporated therein at least one oxide of the metals zirconium and titanium in an amount between 0.1% and 6% oxide. The core 14 may

typically be composed of a predominant amount of carbonaceous material and flame material as will herein-after be further described.

The arc carbon electrode may be made in accordance with the invention by first mixing the oxide with the mix composition of the shell, extruding the mix into the form of a shell, and then baking the shell in accordance with conventional procedures. Standard procedures may also be used to make the core for the shell. Such cores usually contain a predominant amount of carbonaceous material and flame material. The flame material is preferably oxides or fluorides of the rare earth metals, but may also be materials such as thorium, iron, nickel, cobalt, manganese, and vanadium. Compounds other than oxides and fluorides of the rare earth metals may also be employed, and such techniques are known in the art. The cores are easily made by extruding the core mix, baking the mix, and then inserting the baked core with a suitable binder therearound into the baked shell to form the final high intensity arc carbon anode.

Arc carbons made in accordance with the invention have as much as twice the power rating of an electrode consisting of the same ingredients but without the oxide of zirconium or titanium. For example, a standard 11 millimeter high intensity arc carbon was made according to conventional practice and then tested to determine its power rating. The standard electrode had a maximum operating current of 200 amperes at from about 70 to 80 volts. If the electrode is operated above 200 amperes, it will begin to overload and exhibit an unsteady arc. Several other carbon electrodes of the same type and size but with varying percentages of titanium dioxide in the shell were compared with the standard electrode. The results are shown in Table I below:

TABLE I.—ELECTRODES OF INVENTION COMPARED WITH PRIOR ART ELECTRODES

Carbon	Maximum Current, amperes	Crater Depth, Inches	Arc Voltage
Standard 11 mm. High Intensity Arc Carbon	200-210	0.308	74-76
11 mm. High Intensity Arc Carbon—1/2% TiO ₂ in shell	260	0.190	73-75
11 mm. High Intensity Arc Carbon—1% TiO ₂ in shell	400	0.177	72-74
11 mm. High Intensity Arc Carbon—2% TiO ₂ in shell	(1)	0.100	71-74

¹ Not overloaded at 500 amperes.

The results in Table I show that a 2% addition of titanium dioxide in the shell of an 11 millimeter high intensity arc carbon increases the power rating of the electrode more than 250 percent. A further advantage obtained by the incorporation of the oxide in the shell is that the depth of the crater formed in the work face of the electrode during operation is decreased. This is advantageous since the shallower crater permits the luminescent gas ball, the area of highest light intensity, to increase in size and illuminate a much larger area. Thus, the total light output is increased by the larger exposed area of the gas ball. The above effects, however, cannot be obtained by incorporating the oxide in the core of the arc carbon.

The addition of titanium dioxide to the shell of the arc carbon also permits the reduction in the size of the core for an electrode of a given power rating. A reduction in core size is advantageous since the thickness of the shell wall can then be increased without increasing the overall diameter of the arc carbon. The thicker shell wall permits threaded joints to be made in the shell for joining electrodes end-to-end for the purpose of continuous operation. For example, a 16 millimeter standard high intensity positive electrode has a shell too thin to permit

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threaded joints. The inclusion of ½% titanium dioxide in the shell, however, permits a reduction of the core size from 0.475 inch to 0.445 inch while maintaining a given power rating. This reduction in core size and subsequent increase in shell wall thickness from 0.077 inch to 0.093 inch permits threaded joints to be machined in the shell wall, and also makes extrusion of the shells appreciably easier while maintaining standard amperage for a 16 millimeter arc carbon of 400 amperes.

What is claimed is:

1. A high intensity arc carbon positive electrode comprising a core and a shell, said shell containing between 0.1 and 6 percent by weight of at least one oxide of the metals zirconium and titanium, said percent by weight being computed as metal dioxide based on the weight of said shell without said oxide.

2. A high intensity arc carbon positive electrode comprising a core consisting predominantly of a carbonaceous material and flame material, and a shell consisting predominantly of carbonaceous material and containing between 0.1 and 6% by weight of at least one oxide of the metals zirconium and titanium, said percent by weight being computed as metal dioxide based on the weight of said shell without said oxide.

3. The electrode defined in claim 2 wherein said oxide of a transition metal is titanium dioxide.

4. The electrode defined in claim 2 wherein said oxide of a transition metal is zirconium dioxide.

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5. A high intensity arc carbon positive electrode comprising a core predominantly consisting of carbonaceous material and rare earth oxides and fluorides, and a shell predominantly consisting of carbonaceous material and containing between 0.1 and 6 percent by weight of at least one oxide of the metals zirconium and titanium, said percent by weight being computed as metal dioxide based on the weight of said shell without said oxide.

6. The electrode defined in claim 5 wherein said oxide of a transition metal is titanium dioxide.

7. The electrode defined in claim 5 wherein said oxide of a transition metal is zirconium dioxide.

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Oct. 24, 1967

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3,348,929

PROTECTING CARBON MATERIALS FROM OXIDATION

Filed Jan. 30, 1963

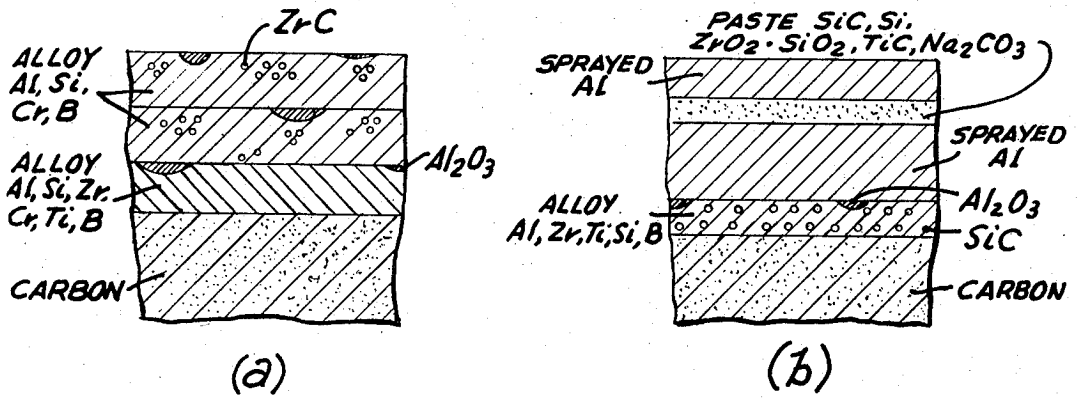


FIG. 1

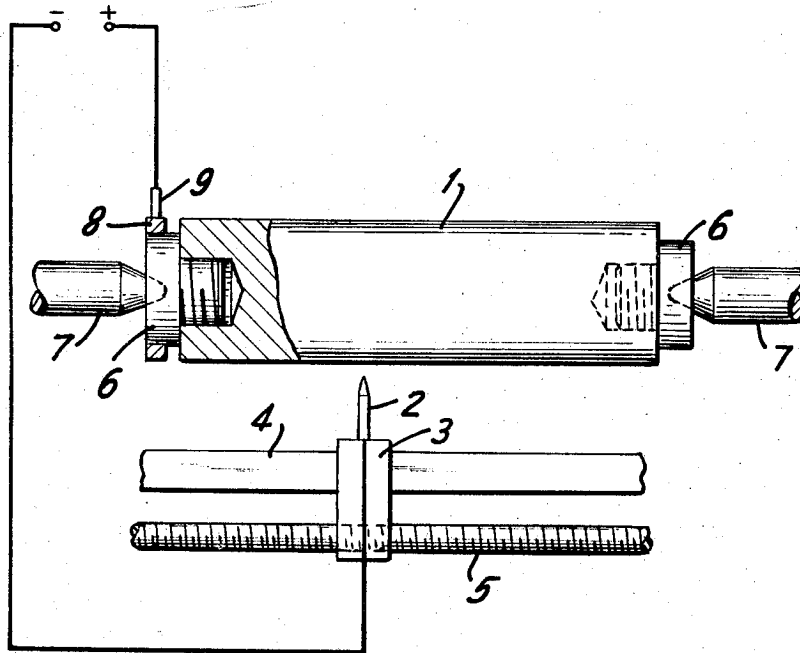


FIG. 2

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3,348,929

PROTECTING CARBON MATERIALS FROM OXIDATION

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Filed Jan. 30, 1963, Ser. No. 255,126

Claims priority, application Germany, Apr. 16, 1962, M 52,521; Japan, Sept. 28, 1962, 37/41,965

17 Claims. (Cl. 29—180)

This invention generally relates to carbonaceous material such as carbon proper and graphite (hereinafter referred to as "carbon material"), and is particularly directed to a procedure for imparting carbon material with protective oxidation-preventing coatings.

Considered from another aspect, the invention is concerned with the production of electrodes of carbon material which are highly resistant to oxidation.

As is generally known, carbon material is particularly suitable for various kinds of uses under high temperature conditions as carbon material displays exceptional properties at elevated temperatures. Thus, for example, the evaporation temperature of carbon material is extremely high and evaporation takes place without intermediate melting. Further, the coefficient of linear expansion is very low, even at relatively high temperatures. Another beneficial property of carbon material is its high degree of heat conductivity. Further, the strength and stability of carbon material, in fact, increases with the temperature, a feature which, of course, is most beneficial for many purposes. It should also be mentioned that the electric conductivity of carbon material remains almost constant under varying temperature conditions, which again is a very advantageous characteristic. Generally speaking, there is no other material available for high temperature operations which possesses the combination of favorable characteristics of carbon material. However, as is also well known, carbon material has a very important shortcoming, that is, it is easily oxidized at relatively low temperatures. For this reason, the use of carbon material under high temperature conditions has, in practice, been severely restricted, and in many cases an otherwise desired employment of carbon material for high temperature operations could not be effected due to the tendency of the carbon material to oxidize. Generally, if carbon is used under high temperature conditions in an oxidizing atmosphere, this entails great expense on its part.

A major use of carbon material under high temperature conditions is, of course, as carbon electrodes used in electrothermal processes employing electric arcs. According to statistics published in the pertinent literature, the consumption of carbon electrodes is chiefly dependent on the degree of oxidation of the surface of the heated electrodes. Evaporization and pulverization of the electrodes caused by the electric arc is only a minor cause for electrode consumption and, in fact, only 6 to 30% of the consumption is due to such pulverization. The oxidation of carbon electrodes usually takes place at temperatures ranging between 400 and 1600° C. As, of course, a great number of substances are available which resist such temperatures, various proposals have been advanced in the literature to protect carbon material with such substances in order to minimize, if not prevent, the oxidation of the carbon. Thus, for example, carbon electrodes have been coated with ceramic and metallic constituents or the carbon surface has been impregnated with various chemicals. All these prior art attempts, however, have not been entirely successful.

A considerable difficulty in protecting carbon from oxidation is caused by its low coefficient of linear expansion

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$\lambda=1.5$ to 5.5×10^{-6} . Most fireproof materials have a linear coefficient of expansion of over 7×10^{-6} . As a result of this, the coatings crack and fall off upon repeated heating and cooling.

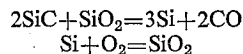
There do exist high-grade coatings of silicon compounds such as silicon carbide, molybdenum disilicide and titanium disilicide. These coatings show a much better link with carbon and they do not crack and peel off as a result of temperature changes on account of their suitable coefficient of expansion. The process of their application to the surface, however, is very expensive.

The coatings of silicon carbide are usually obtained by means of gas silication. This process demands prolonged heating of the entire carbon article at temperatures above 1500° C. and in a special atmosphere.

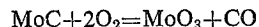
The coatings of molybdenum disilicide and titanium disilicide are usually effected by applying a smear of these substances and by heating the entire article to temperatures ranging between 1500° and 2000° C., in a protective atmosphere such as argon. There exist also methods according to which the carbon article is immersed in the molten silicide, this being done at very high temperatures and in a protective atmosphere.

Their high cost is not the only shortcoming of these coatings. There is a sharp increase in the chemical activity of the substances under conditions of high temperature. As a result of this, the coatings are destroyed at considerably lower temperatures than could be expected. For instance, the highest temperature for a durable utilization of coatings of silicon carbide and molybdenum disilicide is not more than 1500° C.

The thin layer of silicon dioxide which is formed over the silicon carbide and protects it from oxidation begins to act as an oxidizer at temperatures of over 1500° C. The destruction of the silicon carbide under these conditions follows the reactions:



The protective coating of molybdenum disilicide on carbon is destroyed on account of the accelerated diffusion of the carbon in the coating under conditions of high temperature. The binary system "molybdenum-silicon" is transformed into a ternary system of "molybdenum-silicon-carbon." Molybdenum carbide which possesses no protective properties is easily oxidized at the surface of the coating according to the following reaction:



At high temperatures, both products of the above reaction are gases.

In view of its low melting point (1540° C.), titanic disilicide cannot be used as higher temperatures.

Generally speaking, the high-grade protective coatings for carbon known so far are very expensive and can be utilized for a long period of time only at temperatures under 1500° C.

Graphite articles which are most widely produced and used at the present moment are the graphite electrodes used in the steel furnaces of the electric-arc type. Protective coatings for graphite electrodes can find industrial application only if they can withstand temperatures of at least 1650° C. and are sufficiently low-priced. The coatings known at present do not conform to these two requirements and hence they have not been applied on an industrial scale.

Accordingly, it is a primary object of this invention to provide carbon material with a heat resistant coating which is firmly united with and bonded to the carbon material proper and which is not affected by temperature fluctuations. This coating is to be impervious to gases and chemi-

cally resistant under the respective conditions of operation.

Still another object of this invention is to provide a carbon electrode, e.g. for use in arc furnaces, which electrode has an oxidation-preventing coating which is electroconductive and which is firmly united with the carbon material proper.

Generally speaking, it is an object of this invention to improve on the art of coating carbon material including carbon electrodes.

The words "coating" and "layer" are used to denote different things. The finished coating of the carbon article generally consists of several successive coatings each one of which has a different chemical composition and is applied or treated in a different manner.

Very often, on account of a number of considerations of a different character, the application and treatment of a particular coating cannot be done in a single operation. In such cases, the particular coating consists of several layers which possess principally a related chemical composition and are applied and treated in almost the same manner.

In some cases, a particular coating must contain small quantities of certain substances which cannot be applied in the manner in which the coating itself has been applied. These substances, applied between two layers of identical successive coatings, are called "layers" as well.

Generally, the term "coating" is applied to the separate types of coating which have a related chemical composition and are applied and treated in the same manner, as well as to the finished coating of the carbon article, regardless of how many coatings it may consist. The term "layer" is used to denote one of the various layers of a one-type coating as well as thin films which are applied between the layers of the one-type coatings.

Briefly, and in accordance with this invention, we have found that aluminum alloys and carbide (or nitride) materials could be welded onto the carbon surface by means of electric arc. The term "welding-on" as used herein always refers to electric arc treatment. The process of welding-on is cheap and highly productive. As explained in greater detail further on, the protective coating obtained during this process is consecutively subjected to treatment at temperatures of over 2200° C. The treatment proper, i.e. the process of heating in the arc, lasts from 0.1 to 0.3 sec. Due to the brief treatment period there is no need of protective atmosphere, this in itself being a great advantage. On the other hand, irrespective of the high temperature of processing, the article on which the coating is applied, such as an electrode, is heated to a much lower temperature—about 200° C.—which makes the entire process a very cheap one.

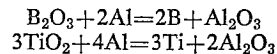
Welding-on by means of electric arc can successfully be applied within broad limits—from 100 percent carbides and 0 percent aluminum to 0 percent carbides and 100 percent aluminum alloy. In the first instance, 100 percent carbides, it is silicon carbide which is mainly used. When the content of aluminum increases, the silicon carbide can be entirely substituted by other carbides such as boric carbide, titanium carbide, zirconium carbide, chromium and molybdenum carbides, as well as by titanium nitride and zirconium nitride. However, increasing the aluminum content of the coating must be accompanied by adding carbide-forming elements such as boron, silicon, titanium, zirconium, chromium and molybdenum. This must be done independently from the carbides used because when the aluminum is increased the carbides cease being the basic skeleton of the coating and become a filling. Besides that, the separate grains of the carbides, or of the nitrides, respectively, are included in the aluminum alloy.

By its essence, the welding-on of an aluminum alloy by means of electric arc is a pyrometallurgical process performed in the presence of a great surplus of aluminum. It is obvious that all elements and compounds, with the exception of those which show great stability at high tem-

peratures such as most of the carbides, will form alloys with the aluminum. When titanium disilicide is used, for instance, it can no longer be found as a particular chemical compound in the coating after the process of welding-on. The result is rather a ternary "aluminum-titanium-silicon" alloy.

Besides that it is quite natural that substances like molybdenum and chromium carbides which, comparatively speaking, oxidize more readily, can stand this brief high-temperature treatment without undergoing any changes since the great surplus of aluminum protects them from oxidation.

On the other hand, the desired carbide-forming elements can be introduced as oxide compounds such as diboric trioxide, titanous dioxide, dichromic trioxide, etc. With the utilization of an outer source of heat such as electric arc the oxides react with the aluminum and are reduced to the respective metals



It follows from the above that it is possible to use both separate oxides and oxide systems such as titanium silicate, titanium silicoborate, etc.

In its most general aspect the coating is of the following type: a homogeneous aluminum alloy with inclusions of grains of carbides (nitrides respectively) and of bialuminum trioxide. The latter can be introduced as an initial substance or can be obtained as a result of the reactions described.

The aluminum alloy can be absent in the final instances, as is the case with weldings-on of carbide where the coating represents carbide grains welded to one another, or it may contain no visible carbide inclusions, as is the case with aluminum weldings-on where carbides are not used as initial substances. The presence of aluminum trioxide is chiefly determined by the extent to which the desired elements have been introduced as oxides.

It follows from all that has been said above that there exists great freedom in the utilization of initial substances and that great number of compounds and alloys can be used. The following example will serve to make this clearer: Three different recipes can be used to obtain a coating composed of 65 percent aluminum, 20 percent silicon, 10 percent zirconium and 5 percent boron, namely:

(1) 65 parts of aluminum, 20 parts of silicon, 10 parts of zirconium, and 5 parts of boron;

(2) 71.2 parts of aluminum, 20 parts of silicon, 12.5 parts of zirconium-boron alloy (20 percent boron), and 12.2 parts of boric acid.

(3) 72.9 parts of aluminum, 16.9 parts of silicon, 20.0 parts of zirconium silicate, and 5 parts of boron.

A calculation made indicates that the alloy obtained from the three recipes has the same composition. The difference lies only in the different content of bialuminum trioxide in the coatings. It is 0 percent upon applying recipe (1), 11.7 percent with recipe (2), and 14.9 percent with recipe (3).

In view of its chemical stability and high degree of refractoriness, the content of bialuminum trioxide does not affect the quality of the coating within certain limits.

In practice, the substances used in making the coatings are in the form of powder and are applied as suspensions. One exception to this rule is aluminum which can be applied both as aluminum powder and by means of metallization.

It is a common practice to apply the greater part of the aluminum by metallization, the remaining part being applied as a suspension in mixture with silicon carbide and other substances.

Coatings of this kind which are welded on the carbon surface adhere reliably to the carbon material so that, in fact, an integral structure of carbon and coating is obtained from which the coating does not flake, chip or

otherwise is removed, even under conditions of great stress. Further, the coating is not affected by rapid and significant temperature changes, is capable of wetting by certain oxide fusions and does not react with them even at extremely high temperatures.

When part of the aluminum is applied by means of metallization, the protective coating obtained is sufficiently impervious to gases. A porous coating is obtained in the process of welding-on, if the aluminum is applied in the form of aluminum powder mixed with silicon carbide and other substances. With a view to rendering this coating impervious to gases, the welded-on coating may be subjected to an additional electric arc treatment. As the result of this operation, the layer partially fuses or melts so as to form a compact and dense coating, impervious to gas.

The method of welding-on by means of electric arc can be successfully applied up to a certain layer thickness. The maximum thickness is different for the different initial substances used and varies from 0.5 to 1.0 mm.

There are many purposes to which one layer welded onto the carbon is not sufficient to ensure the desired duration of protection, as under certain conditions of operation the coating must often be in contact with harmful substances which gradually destroy it. Such objectionable substances are alkali oxides, alkali-earth oxides, and the oxides of certain heavy metals such as zinc, lead, etc.

As a rule, the protective coatings of the graphite electrodes used in electric furnaces for steel consist of two, three or four layers welded one on top the other. The number of layers depends on the capacity of the furnace, on the diameter of the electrodes, and on the nature of the process involved. The protective coatings of electric-resistance elements made of graphite have from two to six layers welded one on top the other.

Carbon articles are used under a great variety of conditions. In some instances they are subjected to the highest possible temperature below the decomposition point. Great endurance of the coating and the absence of all defects therein are necessary in other instances. The coating must usually be electroconductive though in some instances it must not conduct electric current.

A particular composition of the layers welded on is necessary in each single instance in order to obtain the desired properties. For instance, increasing the content of boron in the aluminum alloy improves the cohesion with the carbon but at the same time it lowers the temperature of decomposition. A great increase of the content of chromium in the aluminum alloy results in greater resistance to oxidation but the coating becomes sensitive to frequent changes of temperature. Increasing the quantity of the carbides, such as silicon carbide, titanium carbide and others, renders the coating resistance to frequent changes of temperature though it reduces its degree of impermeability to gases.

The above specific properties of separate elements and of compounds of theirs constitute only a small part of the regular trends which have been established in this field. Their purpose is simply to show that the essence of this invention is not to create a coating with a strictly determined composition for one particular purpose. Using the method of welding on by means of electric arc and the subsequent additional treatments of the coatings which will be described further on, it is possible to obtain a wide range of coatings of various properties and with maximum endurance to heat between 1550° C. and 1820° C.

In practice, the coating of the heat resistant material on the carbon material is effected as follows: When the aluminum is applied as aluminum powder, the desired blend is mixed with a liquid binder or adhesive so as to form a paste or slurry. The paste is then evenly smeared over the surface of the carbon article to be coated. The application of the paste to the carbon article may, of

course, be effected in any manner known per se as, for example, by a brush, by pulverization, immersion or the like. Once the carbon article has been coated with the smear, the coated article is heated to a suitable temperature ranging from 50 to 500° C. Arc welding is then effected in the following manner: A direct current arc is employed, the anode (+) being connected to the carbon article, while the cathode (-) is connected to a small, preferably tapered, graphite electrode. Current is then applied and the arc thus formed between the graphite cathode and the carbon article constituting the anode causes the welding of the heat resistant coating material on the carbon surface, while the binder material and any solvent which may be still present burns off (see also FIG. 2).

When the aluminum or a part thereof is applied by means of metallization, the carbon article is first metallized in a familiar manner, e.g. by electric arc metallization, metallization by gas flame, high frequency metallization, etc. The smear of the desired composition is then applied on the metallized layer. The further treatment is then effected as described above.

As has already been indicated, it is possible to weld only one layer, though for a great number of purposes it is necessary to weld several layers one on top the other.

In many instances, carbon articles provided with protective coatings formed by arc welding may be used directly without any further treatment.

In other instances, the welded-on coating may subsequently be metallized by means of aluminum in any manner known per se.

When aluminum is metallized in quantities exceeding 1 kg./m.², it is almost always necessary to carry out the metallization in two layers. Between the layers are applied substances to correct the chemical composition. Under conditions of higher temperatures, these substances reduce the point of softening of the coating. Further, they reduce the coefficient of linear expansion of the coating and bring it closer to that of the carbon.

In actual practice, it is possible to add a great number of substances here, as is the case with weldings-on by means of electric arc. Upon electric arc treatment, the aluminum alloy is obtained immediately as a result of briefly heating to a temperature of over 2000° C. In this particular instance, there is no heating involved in the process of making the coating. However, the same reactions take place upon using the protected carbon article at temperatures over 1500° C., though over a longer period of time.

As, in view of practical considerations, the requirements towards a metallized coating are lower, compared with a welded-on coating, the substances used here are less. They are usually the elements boron, silicon, titanium and zirconium, their carbides (boric carbide, silicon carbide, titanium carbide and zirconium carbide), their oxides (diboric trioxide, silicon dioxide, titanium dioxide and zirconium dioxide), as well as the silicates of titanium and zirconium. In addition to that, sodium compounds such as sodium tetraborate, sodium carbonate, sodium silicate, and sodium chloride are specially used to bring down the point of softening and to make the metallized coating impervious to gases.

It is also possible to apply other chemicals to the welded-on coating, simply by preparing a smear or solution of the respective chemicals which thereafter is applied to the previously welded-on coating. Thus, for example, boric acid and, if desired, additional agents, may be smeared on the welded-on coating.

Diboric trioxide may be melted by heating it to a temperature of about 620° C. and the molten mass may then be applied to the original coating, or the boric acid may be first applied in the form of a suspension or paste, whereafter heating to the indicated temperature is effected. The surface coating obtained in this manner is extremely sensitive to even small amounts of certain metal oxides

such as ZnO, PbO and others. The durability of such a diboric trioxide coating is increased manifold if aluminum is then metallized over it.

In the event that a diboric trioxide coating is employed, it is advantageous to apply paraffin to this coating in order to prevent the absorption of moisture, as diboric trioxide is hygroscopic.

From the foregoing, it will have been realized that protective coatings of varying kinds may be readily applied to the carbon material in accordance with this invention. Carbon electrodes which have been coated in the manner described may successfully be used in the production of electric steel. Our experiments have shown that the consumption of graphite electrodes in electric furnaces of a three-ton capacity which produce ordinary carbon steel in a basic process drops from 9.90 kg. of uncoated graphite electrodes per ton of steel to 5.50 kg. in the event that graphite electrodes coated in accordance with this invention are used.

Further, the use of coated graphite electrodes in arc furnaces for steel manufacture makes it easier to obtain compact packing in the furnace.

In the event that carbon or graphite electrodes coated in accordance with this invention are used, the contact sockets should advantageously be made of copper if no cooling for the electrodes is provided.

We have ascertained that electrical resistance rods of graphite coated in accordance with this invention may be used under high temperature conditions reaching 1650° C. without that any destruction or decomposition in the protective coating leading to oxidation of the graphite could be observed.

The invention will now be described by several examples, it being understood, however, that these examples are given by way of illustration and not by way of limitation, and that many change and alterations may be made in choice of raw material, quantities and process conditions in general without affecting in any way the scope and spirit of this invention as recited in the appended claims.

In the following examples, all quantities mentioned refer to one square meter of carbon surface. In all instances, the protective coating is applied to carbon articles of cylindrical shape. For this reason, the term "peripheral speed" as used in the examples denotes the speed of movement of the small graphite cathode electrode relative to the surface on which the coat is to be welded.

Example I

Composition of coating to be welded on carbon article: silicon carbide (Carborundum No. 200) SiC: 250 g., aluminum powder Al: 150 g., titanium oxide (TiO₂): 50 g., titanium carbide (TiC): 50 g., titanium (Ti): 50 g., boric carbide (B₄C): 30 g., ferrochromium (chromium Cr 70%): 50 g., alloy of molybdenum Mo and boron B (boron 10%): 30 g. The components were thoroughly mixed with a 15% aqueous bone glue solution. The amount of the glue solution was chosen so as to obtain a paste which thereafter was evenly smeared over the surface of the carbon article. This coatings was then welded by twice applying a direct current arc in the manner previously explained. Both welding procedures were effected with a peripheral speed of 6.0 cm. per second, a pitch of 5.3 mm. and current conditions of 160 amperes and a voltage of 30 volts.

A second coating was applied to the first coating after the latter had been welded on. The composition of the second coating was as follows: silicon carbide (Carborundum No. 200) SiC: 200 g., powdered aluminum Al: 200 g., bichromium trioxide Cr₂O₃: 40 g., bialuminum trioxide (white corundum No. 200) Al₂O₃: 50 g., alloy of titanium Ti and boron B (boron 30%): 30 g., silicon (Si): 40 g., boric acid (H₃BO₃): 30 g., chromium (Cr): 50 g. Again, a paste was prepared from the powderous mixture of the components by admixing the

components with a bone glue solution and the arc welding was effected as in the case of the first coating.

Example II

The carbon surface is metallized with aluminum according to the known methods of applying metal by spraying in a molten state such as electric-arc metallization, gas metallization, high-frequency metallization or the like.

Metallizing continues until 1 kg. of aluminum is applied on 1 square meter of carbon article. Thereafter, a mixture of the following composition is prepared: silicon carbide (Carborundum No. 200) SiC: 300 g., powdered aluminum Al: 60 g., titanium dioxide TiO₂: 100 g., silicon Si: 50 g., boric acid H₃BO₃: 80 g., chromium carbide Cr₃C₂: 80 g. and bichromium trioxide Cr₂O₃: 100 g. The powderous materials are mixed with a 15% solution of bone glue and are applied on the metallized surface. The welding-on by electric arc is carried out under the following conditions: peripheral speed 7.2 cm./sec., pitch 4.3 mm., current of 240 ampere, and voltage 30 to 35 v.

Example III

750 g. of aluminum are metallized on the carbon surface under the conditions of Example II. Thereafter, a mixture of the following composition is prepared: powdered aluminum Al: 100 g., silicon Si: 200 g., alloy of zirconium Zr and boron B (boron 20%): 100 g., titanium dioxide TiO₂: 50 g., bichromic trioxide Cr₂O₃: 120 g. and silicon dioxide SiO₂: 50 g. The powderous materials are mixed with a 15% solution of bone glue and are applied on the metallizer surface. The welding-on by electric arc is carried out under the conditions of Example II.

This is followed by the metallization of additional 750 g. of aluminum. A mixture of the following composition is prepared: silicon Si: 150 g., zirconium carbide ZrC: 100 g., chromium Cr: 300 g. and boric acid H₃BO₃: 150 g. Application and welding-on is carried out under the conditions of Example II.

This is followed by applying and welding-on of a third layer, for which all manipulations for the second layer (metallization, application, welding-on by the arc method) are repeated.

Example IV

A first coat was applied to a carbon article. This first coat had the following composition: silicon carbide (Carborundum No. 200) SiC: 200 g., powdered aluminum Al: 120 g., titanium nitride TiN: 40 g., boron B: 30 g., alloy of aluminum Al and silicon Si (silicon 30%): 80 g., titanium aluminate TiO₂.Al₂O₃: 50 g., silicon dioxide SiO₂: 40 g., zirconium silicate ZrO₂.SiO₂: 50 g. and alloy of chromium Cr and silicon Si (50% silicon): 30 g. The powderous components were mixed in a 15% aqueous solution of bone glue acting as a binder. The paste thus formed was again applied in an even manner to the carbon surface. An electric arc was then generated and the welding performed under the following conditions: peripheral speed 6.0 cm./sec., pitch 10.6 mm., current: 180 amperes, 30 volts. This resulted in a relatively porous layer. In order to render the layer gas impervious, a second electric arc was applied to the porous coat. The conditions of the second arc treatment were as follows: peripheral speed 6.0 cm. per second, pitch 5.3 mm., current: 200 amperes, 30 volts. The coat melted partially during the arc treatment and formed a gas impervious surface.

A second coat was thereafter applied to the first coat. The composition of the second coat was as follows: silicon carbide (Carborundum No. 200) SiC: 100 g., silicon carbide (Carborundum No. 70) SiC: 70 g., powdered aluminum Al: 150 g., bialuminum trioxide (white corundum No. 200) Al₂O₃: 80 g., titanium disilicide TiSi₂: 50 g., molybdenum carbide MoC: 60 g.,

molybdenum disilicide MoSi_2 : 30 g. and titanium silicate $\text{TiO}_2 \cdot \text{SiO}_2$: 80 g. A paste was prepared from the mentioned components and the paste was applied to the first coat. An electric arc was then generated under the following conditions: peripheral speed 7.2 cm. per second, pitch 8.5 mm., current: 160 amperes, 30 volts. This layer is then metallized with 500 g. of aluminum. The latter is carried out under the same conditions as in Example II.

Example V

A first coat had the following composition: silicon carbide (Carborundum No. 200) SiC: 100 g. silicon carbide (Carborundum No. 70) SiC: 100 g., powdered aluminum Al: 190 g., zirconium Zr: 80 g., alloy of zirconium Zr and boron B (boron 20%): 30 g., alloy of zirconium Zr and silicon Si (silicon 20%): 20 g., bialuminum trioxide (white corundum No. 200) Al_2O_3 : 40 g., and titanium dioxide TiO_2 : 50 g. These powdery constituents were thoroughly mixed with a 15% aqueous solution of bone glue so as to obtain a paste. The paste was evenly smeared over the carbon article and an electric arc was then produced. The welding conditions were as follows: peripheral speed 6.0 cm. per second, pitch 8.5 mm., current strength 200 amperes, voltage 30 volts.

The coat thus obtained was then metallized with 1000 grams of aluminum. The procedure for metallizing the coat was the same as in the preceding examples. After the first 500 grams of aluminum had been applied to the coat, a paste of the following composition was applied: silicon carbide (Carborundum No. 200) SiC: 50 g., silicon Si: 50 g., zirconium silicate $\text{ZrO}_2 \cdot \text{SiO}_2$: 50 g., titanium carbide TiC: 50 g. and sodium carbonate Na_2CO_3 : 50 g., admixed with a 2% aqueous solution of bone glue. The sodium carbonate can be substituted by an equivalent quantity of sodium silicate (water glass) or sodium tetraborate (borax) and up to 20% by sodium chloride.

Thereafter, the remaining 500 grams of aluminum were metallized in the same manner as previously explained.

Example VI

A carbon article was coated with a first coat of the following composition: silicon carbide (Carborundum No. 200) SiC: 750 g., titanium dioxide TiO_2 : 70 g., titanium carbide TiC: 50 g., and silicon dioxide SiO_2 : 50 g. The components were mixed with a 15% aqueous solution of bone glue in order to form a paste. The paste was spread in a thin layer over the carbon surface, whereafter an electric arc was generated, and welding was effected under the following conditions: peripheral speed 7.2 cm. per second, pitch 8.5 mm., current strength 200 amperes, voltage 30 volts.

A mixture of boric acid (H_3BO_3): 550 g., silicon carbide (Carborundum No. 200) SiC: 40 g., silicon Si: 40 g., silicon dioxide SiO_2 : 30 g., powdered aluminum Al: 30 g. and bialuminum trioxide (white corundum No. 200) Al_2O_3 : 30 g., with a 5% aqueous solution of bone glue was prepared and spread over the welded-on coat. The entire carbon article was then heated to about 620° C. to smelt the boric acid.

Example VII

The layer of smelted diboric trioxide metallizing thereover 500 grams of aluminum in the manner described in Example IV. The aluminum layer was then coated with 500 grams of paraffin.

Example VIII

FIGS. 1a and 1b illustrate two carbon articles with plural layers, FIG. 1a corresponding to the composition of Example III and FIG. 1b corresponding to the composition of Example V.

FIGURE 2 is a diagrammatical showing of the welding procedure pursuant to which the coating is welded onto the carbon article by means of an electric arc. In this fig-

ure reference numeral 1 denotes the article processed and 2 denotes the lateral electrode fixed in holder 3 which in turn moves along the guide 4 by means of the guiding screw 5. The article 1 is held in position by the two end-pieces (holders) 6 in the centers 7 and revolves around its axis. The article 1 is continuously attached to the source of electric current through the brush 8 of the contact ring 9. The lateral electrode 2 is connected to the same source of current by a flexible connection. The electric arc burns between the article 1 and the lateral electrode 2 and it gradually treats the entire surface upon the revolving of the article 1 and upon the longitudinal travel of the lateral electrode 2.

The function of the lateral electrode is to maintain the electric arc. Its composition does not take part in making the coating and it is usually made of graphite. The electric arc affects the article on an area of 8 to 12 mm. in diameter and it heats to a high temperature of a stripe of the same width in the course of its relative movement over the treated surface.

By selecting the electrical pattern and the speed of the relative movement it is possible to obtain a surface heating of about 2,000° C. for 0.1 to 0.3 second, this period of time being sufficient for the course of the desired pyrometallurgical process, namely, the alumino-thermal reactions and the alloying of the desired elements with aluminum. The rapid heating and cooling of the coating in the presence of a large surplus of aluminum makes it possible to carry out the treatment with electric arc in open installations and in ordinary atmosphere without any noticeable oxidation of the components of the coating.

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the inventive principles, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. An article of carbon, such as a graphite electrode, having an oxidation preventing coating of a material selected from the group consisting of

(a) aluminum alloys, wherein the alloying component is selected from the group consisting of boron, silicon, titanium, zirconium, chromium and molybdenum;

(b) high-melting carbides and nitrides selected from the group consisting of boric carbide, silicon carbide, titanium carbide, zirconium carbide, chromium carbide, molybdenum carbide, titanium nitride and zirconium nitride; and

(c) bialuminum trioxide,

said coating consisting of at least one layer formed on the carbon article by first applying the coating forming material to the carbon article and thereafter electric arc treating the material to a temperature above 2,000° C. for less than half a second without substantially heating the carbon article proper.

2. An article as claimed in claim 1, wherein said coating comprises a plurality of superimposed layers each of which is separately applied.

3. An article as claimed in claim 1, wherein said coating of smelted diboric trioxide contains a substance selected from the group consisting of aluminum, silicon, bialuminum trioxide, silicon dioxide and silicon carbide.

4. An article as claimed in claim 1, wherein an outer coating of aluminum, applied by means of metallization, covers said coating of smelted diboric trioxide.

5. An article as claimed in claim 1, wherein said coating contains a layer of smelted diboric trioxide.

6. An article as claimed in claim 1, wherein said coating in turn is coated with a second coating of aluminum applied by means of metallization.

7. An article as claimed in claim 6, wherein said aluminum coating consists of two layers between which there is interposed an intermediate layer consisting of material selected from the group consisting of boron, sili-

con, titanium and zirconium, their carbides and oxides, titanium silicate and zirconium silicate.

8. A method of forming protective oxidation preventing coatings of

- (a) aluminum alloys, wherein the alloying component is selected from the group consisting of boron, silicon, titanium, zirconium, chromium and molybdenum;
- (b) high-melting carbides and nitrides selected from the group consisting of boric carbide, silicon carbide, titanium carbide, zirconium carbide, chromium carbide, molybdenum carbide, titanium nitride and zirconium nitride; and
- (c) bialuminum trioxide

on carbon articles, such as graphite electrodes, which comprises:

- (1) applying the coating forming material to the surface of the carbon article;
- (2) electric arc treating said coating forming material by generating an electric arc between the carbon article with the coating forming material applied thereonto and an electrode laterally spaced from said carbon article;
- (3) moving the electrode and thus the arc at substantially constant speed relative to said carbon article so that the coating forming material is heated to above 2,000° C. for less than half a second while the carbon article proper is not substantially heated, whereby a coating layer is formed on the carbon article which cools substantially instantaneously and has a distinct boundary zone adjacent said carbon article without intermeshing or intertwining with the adjacent carbon surface.

9. A method as claimed in claim 8, wherein said electric arc treatment is carried out in air atmosphere, said lateral electrode being of graphite.

10. A method as claimed in claim 8, wherein the surface of the carbon article is first metallized with a layer of aluminum metal, whereafter a liquid suspension of coating forming material in powder form is applied onto said aluminum layer, said electric arc treatment being carried out upon drying of said suspension, whereby oxidation-reduction alumino-thermal reactions take place at the time of heating.

11. A method as claimed in claim 8, wherein said

coating forming material is applied to the surface of said carbon article in form of powder suspended in a liquid, said electric arc treatment being carried out upon drying of the suspension.

12. A method as claimed in claim 8, wherein the electric arc treatment is carried out twice on the same layer.

13. A method as claimed in claim 8, wherein at least a second coating layer is superimposed on the first layer formed on the carbon article by applying coating forming material on the electric arc treated first layer and thereafter electric arc treating said last mentioned coating forming material in substantially the same manner as the coating forming material of the first layer has been treated.

14. A method as claimed in claim 13, wherein metallic aluminum is applied to the second layer.

15. A method as claimed in claim 13, wherein a first metallic aluminum layer is applied to the second layer whereafter a layer of coating forming material is applied to the metallic aluminum layer, said coating forming material layer being subsequently covered with an additional layer of metallic aluminum.

16. A method as claimed in claim 13, wherein the second layer is covered with boric acid, whereupon the entire carbon article is heated at least to the melting point of diboric trioxide.

17. A method as claimed in claim 16, wherein a layer of metallic aluminum is applied onto the layer of diboric trioxide.

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May 21, 1968

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3,384,467

METHOD OF AND MEANS FOR CONVERTING COAL

Filed Feb. 3, 1964

2 Sheets-Sheet 1

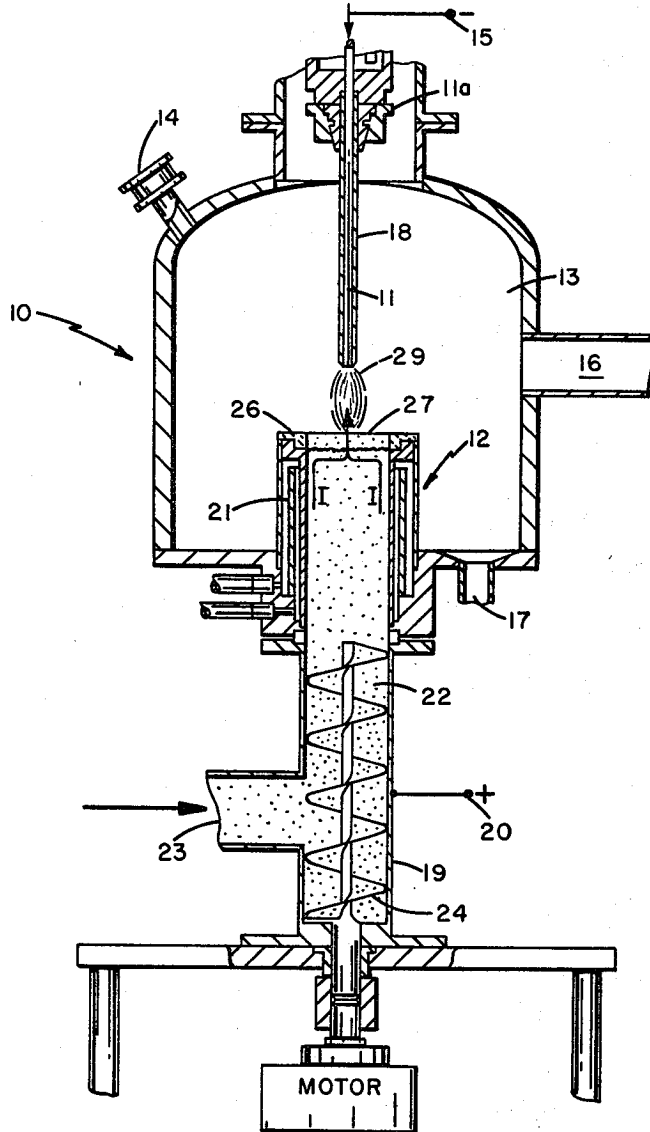


Fig 1

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METHOD OF AND MEANS FOR CONVERTING COAL

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2 Sheets-Sheet 2

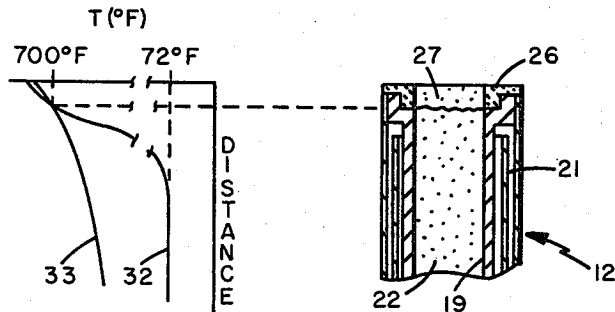


Fig 2

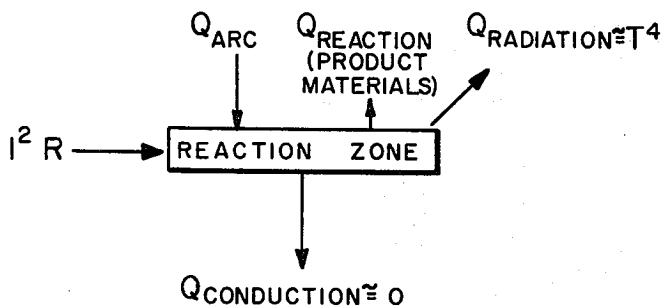


Fig 3

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METHOD OF AND MEANS FOR CONVERTING COAL

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Filed Feb. 3, 1964, Ser. No. 342,180
8 Claims. (Cl. 48-65)

ABSTRACT OF THE DISCLOSURE

The invention covers a process and means for rapidly decomposing carbonaceous material, coal in particular, into lower molecular weight hydrocarbons. The decomposition is accomplished by causing the carbonaceous material to absorb heat at a rate in the order of several hundred B.t.u.'s/lb.-sec. While the heat could be supplied from any convenient source, an embodiment using an electric arc furnace is preferred and described.

This invention relates generally to processes for converting coal into its lower molecular weight components, and in particular to an electric arc process and apparatus for accomplishing the aforementioned conversion. The meaning of coal as used herein has been broadened to include similar materials such as tar, oil, lignite, charcoal, and coke, for example, all of which could be converted to other fuels and chemical compositions in the manner indicated below.

The structure of a typical bituminous coal has been portrayed graphically in a recent issue of "Industrial Engineering Chemistry," vol. 54, Issue 6 (1962), pp. 36-39, by Hill and Lyon. The structure is exceedingly complex and contains a large proportion of aliphatic chains in which the H/C ratio is 2:1 and a relatively small fraction of polynuclear aromatics (in which the H/C ratio is less than 1). In contrast, anthracite coals also comprise a complex structure but have a small fraction of aliphatic groups and a large fraction of polynuclear aromatics.

In general, the pyrolysis of coal is accomplished through two basic competing reactions, decomposition and polymerization. However, it is recognized that many complex chemical reactions take place during coal pyrolysis.

Of the methods used to convert coal, coking is perhaps the most widely known and used process. During the course of a coking operation, the temperature of coal is raised to a temperature of 700° F. to 2000° F. over an extremely long time. The weakest bonds rupture first. With increasing temperature, successively stronger bonds begin to rupture, but resonance-stabilized carbon-carbon bonds in aromatic rings are apparently preserved. In other words, the basic carbon structure is preserved, and only the groups attached to the carbon structure are driven off. These groups, for example, usually comprise oxygen, hydrogen, and some sulfur and nitrogen. The rate at which heat energy is absorbed in a typical coking operation is in the order of 2.0 B.t.u./lb.-sec.

Coal has also been converted by injecting extremely fine particles of coal, powders, into a plasma generating device. In this process, the coal is heated by the extremely high temperature plasma generated in the plasma generating device. The residence time of the coal powders within the plasma stream is extremely short, in the order of a millisecond or less, and therefore the heat energy entering the particles is also relatively small, and the extent of conversion is small. The reaction rate is of the order of one million B.t.u./lb.-sec. In spite of the high

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rate, the thermal efficiency of the process is only of the order of a few percent.

Attempts have also been made to convert coal by other arc techniques. In general, these processes have not produced satisfactory yields of low molecular weight fuels and chemicals.

It is an object of the invention to provide means for and method of converting coal which avoids the limitations and disadvantages of the prior art processes.

It is another object of the invention to provide a coal conversion process wherein the coal is converted to low molecular weight hydrocarbon gases such as methane and typically unsaturated products such as ethylene and acetylene.

It is yet another object of the invention to provide a process for converting coal wherein heat energy is supplied to the coal at an extremely high rate and with high electrical efficiency.

It is still another object of the invention to provide a coal conversion process wherein the high energy bonds are ruptured.

It is still another object of the invention to provide an efficient electric arc apparatus for converting coal.

It is yet another object of the invention to provide an electric arc apparatus for converting coal wherein the coal becomes an active apparatus structure.

It is yet another object of the invention to provide an electric arc apparatus for converting coal wherein the rate at which heat energy is absorbed in the coal is high, efficient and controllable in a simple and facile manner.

In accordance with the invention, a method of converting coal comprises absorption of heat energy in the coal at a rate greatly exceeding the heat transfer rate typically used in coking. The heat transfer rate encountered in performing this process is typically 600 to 1,000 B.t.u./lb.-sec. or greater.

Another aspect of the invention is an electric arc furnace for converting coal which comprises at least two spaced electrodes. One of the electrodes is a sleeve having a central passage. The end of the sleeve to which an arc is struck (the arc end) is terminated with an electrical insulator. The arc furnace also includes means for supplying coal to said central passage and for conveying the coal to the arc end of the sleeve.

The novel features that are considered characteristic of the invention are set forth in the appended claims; the invention itself, however, both as to its organization and method of operation, together with additional objects and advantages thereof, will best be understood from the following description of a specific embodiment when read in conjunction with the accompanying drawings, in which:

FIGURE 1 is a schematic representation of an electric arc apparatus useful for converting coal and which embodies the principles of the present invention;

FIGURE 2 includes a schematic representation of the anode electrode of the FIGURE 1 apparatus and a curve useful in explaining the operation of the invention;

FIGURE 3 shows a heat energy utilization diagram.

In FIGURE 1 there is shown a schematic representation of an electric arc coal converting apparatus generally designated 10. It includes a pair of spaced electrodes 11 and 12 connected to means for supplying electrical power 15 and 20, respectively, and a reaction chamber 13.

The reaction chamber 13 is a sealed container which includes a sight glass 14 and exit port 16 for gas products produced therein and a withdrawal pipe 17 for removing solid residue, resulting from the coal conversion process, from the reaction chamber.

The electrode 11 is a graphite rod which is held in a water-cooled holder 11a and containing a central passage

18. Electrode 11 acts as a cathode electrode. Electrode 12, the anode electrode, comprises a sleeve 19 including a water-cooled jacket 21 at its upper end and a central passage 22. The passage 22 is preferably completely filled with coal particles supplied thereto through an entrance port 23 in one side of the sleeve 19 and propelled upward through the passage 22 by a continuously rotating screw feed mechanism 24. A cap 26 formed from any suitable refractory electrical insulating material such as alumina covers the arc end of the sleeve 19 opposite the cathode 11. The number 27 denotes a reaction zone in which substantially all of the coal conversion takes place. The electric arc is identified by the numeral 29.

As is well known, coal, whether it is bituminous or anthracite coal, is at best an extremely poor conductor of electricity at ambient room temperatures, about 72° F. It is also well known that when coal is charred or heated to a temperature at which incipient fusion is noticed, it becomes a good conductor of electricity. There is a direct relationship between temperature and conduction above the fusion point.

Pulverized coal is fed through the entrance port 23 to the passage 22 where it is advanced by the screw feed 24 to the reaction zone 27. When the passage 22 is filled with coal, electrical power is supplied to strike and maintain an arc between the cathode 11 and the anode 12.

Since electrical current cannot flow from cathode 11 to the sleeve 19 because of the insulating cap 26, the coal within the reaction zone 27 must be heated to improve its conductivity to a point where it is capable of carrying the arc current. The reaction zone 27 may be heated initially by coating its surface with a char and striking an arc to the char in a conventional fashion. Thereafter, the arc is sustained by the electrical current and the continuous reaction of the coal in the reaction zone 27.

Referring to FIGURE 2 of the drawings, there is an enlarged, partly schematic representation of the arc end of the anode 12. It is seen that the reaction zone 27 is limited to a small volume at the extremity of the anode 12. The curve 32 portrays the temperature distribution within the anode 12 as a function of the distance from the exposed surface of the reaction zone 27, for the case of rapid feeding of the coal. The slope of the curve 32 is a function of the coal feed rate velocity. It will be seen that the temperature drops off extremely rapidly immediately behind the reaction zone 27. There is a slight temperature gradient within the reaction zone 27 probably due to the heat energy being absorbed in the chemical reactions taking place therein.

FIGURE 3 is an energy utilization chart. The heat energy applied to the reaction zone 27 is derived principally from the arc and particularly by the striking by high energy electrons at the surface, with a small contribution from the I²R losses generated by the current passing through the reaction zone 27. The heat losses occur from conduction through the anode which is substantially zero for even modest coal feed velocities, from radiation which amounts to about 4 percent. The heat of reaction accounts for about 96 percent.

The parameters effect a conversion of the coal and, manifestly, the power supplied to the reaction zone 27 by the arc and the rate at which coal is supplied to the reaction zone 27. Since the temperature of the reaction zone 27 ranges from 700° F. to about 2000° F., the heat energy loss through heat radiation remains substantially small, even as the power and the coal supply rate are varied. The latter is varied by controlling the rotational speed of the screw feed 24.

Important considerations, therefore, are the heat absorption rate, which for the purposes of this discussion is defined as the B.t.u.'s per pound of coal per second (B.t.u./lb.-sec.) and the efficiency with which the energy is used for coal conversion.

Whereas essentially all of the heat supplied to a coking bin is utilized, the heat absorption rate is very low. In

plasma devices the heat absorption rate is very high, but the efficiency with which the energy in plasma is used to convert coal is very low.

In contrast to both coking and plasma generator conversion, the heat absorbed by the reaction zone 27 is efficiently utilized, at least 50 percent for high loss apparatus and at least 85 percent for an average electric arc furnace. Additionally, the heat absorption rate exceeds that of coking by at least two orders of magnitude.

Whereas the substantially slow pyrolysis process of coking results predominantly in polymerization of the coal and the retention of a solid carbonized substance, higher heat absorption rates such as are experienced through the practice of the above-described process shock the coal into decomposing, with a substantial severance of the high energy basic bond structure, and particularly the carbon bonds and the consequential production of low molecular weight products. Heat energy absorption rates as low as 200 B.t.u./lb.-sec. would result in substantial decomposition products and a lesser proportion of polymerization products. The preferential heat energy absorption rates for low and high volatile coals lie in the range of 600 to 1,000 B.t.u./lb.-sec. Heat utilization efficiencies range from 50 to 96 percent.

Interpreted in another way, conversion of coal by decomposition results when coal is brought to a temperature of at least 700° F. and vaporized within several seconds; the time element is commonly referred to as the residence time and these are typically 18 seconds for 200 B.t.u./lb.-sec. and 3 and 6 seconds for 600 to 1,000 B.t.u./lb.-sec. respectively. Data relating to a typical conversion process is provided in Table I below:

Table I

35	Coal analysis (wt. percent):	
	C -----	82.5
	H -----	5.71
	O -----	6.27
	N -----	0
40	S -----	1.0
	Ash -----	4.48
	Product gas (mole percent):	
	H ₂ -----	72.34
	CO -----	8.37
45	CH ₄ -----	9.42
	C ₂ H ₆ -----	0.95
	CO ₂ -----	2.40
	C ₂ H ₄ -----	1.46
50	C ₂ H ₂ -----	5.06
	Absorption rate -----B.t.u./lb.sec...	600
	Heat utilization efficiency -----percent...	96
	Anode diameter -----inches...	2
55	Reaction zone depth -----inch...	¼
	Residence time -----seconds...	3

In the foregoing, the gas products were estimated to be 15 percent (by weight of the initial coal). Theoretically, with this composition a 30 percent conversion should be possible, assuming all of the original hydrogen appears in the gas phase.

Experience has shown that the proportions of low molecular weight products produced will vary if the coal feed rate and the energy supply per unit of coal fed is varied. Additionally, the structure of the reaction chamber 13 also affects these proportions. For example, unless the gas products are removed immediately after they are produced, there is a tendency for a portion of these products to come in contact again with the arc and undergo further conversion. Generally, this second conversion results in products which are thermodynamically more stable at high temperatures since additional heat energy is supplied to the initial reaction products by the arc during the second or subsequent passage of these initial products through the arc.

Additionally, it is possible to recirculate reaction products through the arc or introduce additional reactive agents to mix with and react with the reaction products through passage 18 in cathode 11.

Given a specific arc furnace, the coal feed rate and electric arc power may be adjusted to optimize the production of a particular reaction product. By performing an instantaneous analysis of the reaction products and utilizing automatic processing equipment to adjust the electric power and coal feed rate, it is possible to adjust the production of a particular reaction product.

The various features and advantages of the invention are thought to be clear from the foregoing description. Various other features and advantages not specifically enumerated will undoubtedly occur to those versed in the art, as likewise will many variations and modifications of the preferred embodiment illustrated—particularly in relation to the broad definition of coal used herein—all of which may be achieved without departing from the spirit and scope of the invention as defined by the following claims.

We claim:

1. A method of converting coal to lower molecular weight hydrocarbons in an electric arc furnace having at least two spaced electrodes, one of said electrodes having electrically insulated surfaces facing said other electrode, comprising:

- (a) utilizing coal to form at least a portion of said one electrode wherein said coal forms an exposed surface opposing said other electrode;
- (b) heating said exposed surface of said coal electrode opposing said other electrode and a reaction zone immediately behind said surface to substantially increase the electrical conductivity of said surface and reaction zone;
- (c) striking and maintaining an arc and terminating said arc on said exposed surface for supplying heat energy to said coal for gasifying substantially all of said surface and reaction zone; and
- (d) replenishing coal gasified from said surface and reaction zone at a rate commensurate with the gasification rate.

2. An electric arc furnace for converting coal to lower molecular weight hydrocarbons comprising:

- (a) at least two spaced electrodes, one of said electrodes being a sleeve having a central passage, the arc end of said sleeve being terminated with an electrical insulator;
- (b) means for feeding coal to said central passage for supplying said arc end with coal;
- (c) means coupled to said electrodes for supplying electrical current to an arc struck between said electrodes; and
- (d) means for removing conversion product from the furnace.

3. An apparatus as described in claim 2 in which said electrical insulator is a refractory ceramic material.

4. A process for converting coal to lower molecular

weight hydrocarbons in an electric arc furnace comprising:

- (a) utilizing coal to form at least a portion of one electrode wherein said coal forms an exposed surface opposing said other electrode;
 - (b) heating a reaction zone of coal behind said exposed surface to at least 700° F.;
 - (c) striking a high intensity arc and terminating one end of said arc on said reaction zone for maintaining said reaction zone at at least 700° F. for thermally converting said coal into lower molecular weight components; and
 - (d) feeding coal to said reaction zone to replenish converted coal, said arc intensity and coal feed rate being adjusted such that the coal in the reaction zone absorbs heat at the rate of 200 to 1000 B.t.u.'s/lb.-sec.
5. A method of converting coal to lower molecular weight hydrocarbons comprising supplying heat to said coal under conditions whereby the coal absorbs heat at the rate of in the order of 200 to 1000 B.t.u.'s/lb.-sec. to decompose said coal.

6. A method of converting coal to lower molecular weight hydrocarbons as described in claim 5 wherein the coal absorbs heat at the rate of 600 to 1000 B.t.u.'s/lb.-sec.

7. A method of converting coal to lower molecular weight hydrocarbons in an electric arc furnace having at least two spaced electrodes comprising:

- (a) utilizing coal to form at least a portion of one electrode wherein said coal forms an exposed surface opposing said other electrode;
- (b) heating said exposed surface of said coal electrode opposing said other electrode and a reaction zone immediately behind said surface to substantially increase the electrical conductivity of said surface and reaction zone;
- (c) striking and maintaining an arc to said surface for supplying heat energy to said coal so that said coal absorbs the heat energy at a rate in the order of magnitude of 200 B.t.u.'s/lb.-sec. to 1000 B.t.u.'s/lb.-sec.; and
- (d) replenishing coal gasified from said surface and reaction zone at a rate commensurate with the gasification rate.

8. A method as described in claim 7 in which said heat energy absorption is in the range of 600 to 1000 B.t.u./lb.-sec.

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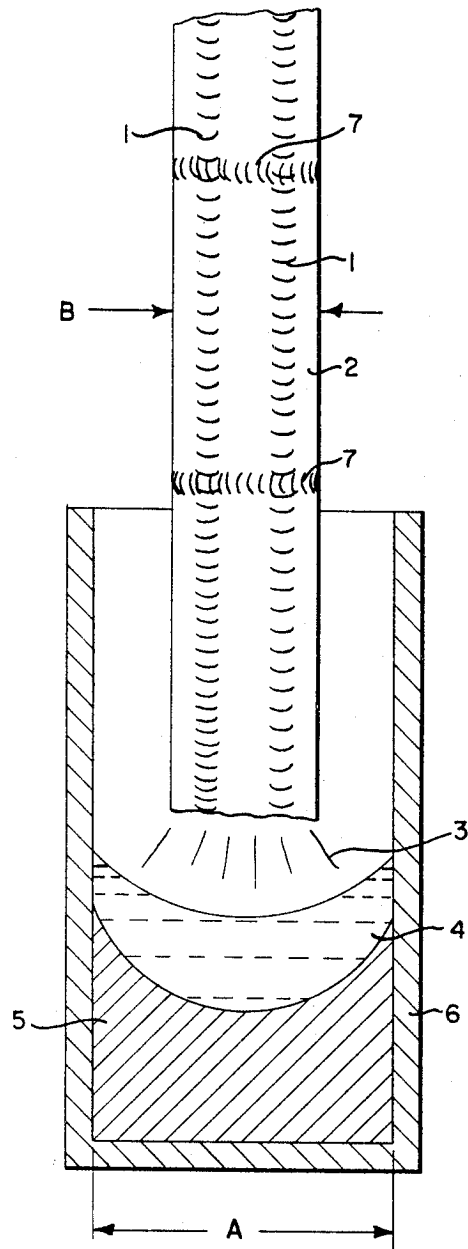
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Sept. 3, 1968

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CONSUMABLE ELECTRODE STABILIZED AGAINST WARPING, FORMED
FROM COMPACTED REFRACTORY METAL PARTICLES
Filed April 9, 1965

3,400,206



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CONSUMABLE ELECTRODE STABILIZED AGAINST WARPING, FORMED FROM COMPACTED REFRACTORY METAL PARTICLES

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Filed Apr. 9, 1965, Ser. No. 446,899

9 Claims. (Cl. 13-18)

ABSTRACT OF THE DISCLOSURE

A process for arc-melting, and a consumable electrode for use in electric arc-melting prepared by compacting particles of a refractory metal within a foil container of the said metal, wherein the electrode has at least one metallic strip of lower electrical resistance than that of the electrode welded along substantially the entire length of the periphery of the electrode to provide stability against warpage of the electrode during use.

This invention pertains to an improvement in the electric arc-melting of compacted electrodes. More particularly the invention is directed to the improvement, in a process for arc-melting a vertically-mounted consumable electrode prepared by compacting particles of a refractory metal and having the characteristic of warping when an electric arc melting current is passed through it, which comprises providing at least one metallic path of lower electrical resistance than that of the compacted, consumable electrode, substantially throughout the length of said electrode and in electrical contact with its top.

In the drawing there is shown, in cross section, an embodiment of the invention wherein the path of low electrical resistance is provided by a pair of weld-beads 1 longitudinally disposed along the periphery of the consumable electrode 2, 90° apart, from the top to the bottom. At the bottom of the electrode is the melting arc 3, which forms a pool of melted metal 4, on top of the solidified ingot 5. The solidified ingot is formed by cooling the molten metal in water-cooled crucible or mold, 6. The consumable electrode is made up of a plurality of compacts butted end-to-end and welded together with girth beads 7. The ratio of the diameter of the consumable electrode B to the interior diameter of the cooled crucible A can vary considerably, as from 0.4 to 0.7, the advantages of the invention becoming more apparent as this ratio approaches unity. At the top, the consumable electrode is mounted in an adapter and connected to a source of electrical current, not shown.

Refractory metals to which this invention pertains are high melting, strong metallic elements such as columbium, chromium, molybdenum, tantalum, tungsten and vanadium and alloys of at least two of these with each other. These metals are often prepared or recovered in particulate form such as sponge, granules, powder, chips or turnings which require consolidation to form solid sound ingots from which useful forms of the metal can be made. This consolidation is usually effected by arc-melting a compacted, consumable electrode of the metal in a cold crucible. The crucible is usually made of copper and is externally water-cooled to prevent it from melting. Vacuum and/or inert gas atmosphere is maintained in the crucible to avoid reaction of these metals with, for example, air. Usually the crucible bottom is protected against the deleterious action of the initial arc by providing a bed of metal particles of the same composition as intended for the ingot. When the arc is struck between the vertically-mounted, compacted electrode and this bed of particles,

the particles and the tip of the electrode melt, but quickly solidify in the crucible. The arc is then maintained between the melting electrode and the pool of molten metal at the top of the growing ingot.

5 For practical reasons, inasmuch as these metals are almost always double arc melted, the ingot diameter is not much greater than that of the electrode. It is therefore necessary to position the electrode in the center of the crucible so that no part of it comes within arcing distance of the side wall. This is possible to accomplish within quite good tolerance if the electrode is straight. However, compacted electrodes of the high melting metals frequently bend or warp when the heavy arc current is applied. This often leads to wall arcing and even to contact between crucible wall and electrode. In either case, it is necessary to shut down the operation, remove, straighten and reposition the electrode. Not only is this time-consuming and expensive, but the side-wall arcing or contact is very likely to cause a "burn through" and this may lead to an explosion if the cooling water contacts the molten metal.

It is, therefore, an object of this invention to prevent warping and lateral displacement of refractory metal compacted electrodes during arc-melting. A further object is to prevent such warping without contaminating or changing the desired chemical composition of the ingot being produced. Other objects will appear hereinafter.

Now according to the present invention it has been found that an electrode which presents the aforementioned difficulties can be improved by providing an electrical conductor having relatively low electrical resistance, said conductor being positioned along the periphery of the vertically-mounted electrode and in electrical contact therewith from its upper electrical contact to its lower, melting end during the arc-melting operation. This conductor provides a path of low resistance, and hence improved conductivity, along the electrode. The conductor can consist of a strip, or strips, of sound metal extending from the upper electrical contact down the side of the compacted electrode substantially to the point of arc-melting at the lower end. The strip or strips are of such a size that they provide sufficient cross-section to conduct the necessary current without excessive resistance-heating of the electrode. The strips are preferably of the same chemical compositions as the ingot, or nearly so.

While the strips can be attached to the electrode by welding, it is preferred that they be formed from the compact itself by running a weld bead of sufficient depth and width to provide the desired path of low electrical resistance down the side of the electrode. At least one such strip or bead is used, but it is preferred to use two or more. When several are employed it is preferable to space them equidistant around the electrode. The required total cross section of the strips can be determined experimentally for each type of metal compact and each electrode size. Experience is usually available which will enable one to estimate quite closely the amount of current required in the melting operation. Thus, knowing the electrical conductivity of the metal, the cross section required can be calculated and the strips or beads prepared accordingly. No ill effect of additional bead cross section has been noted other than the expenditure of effort in making it. Two to four longitudinal beads are usually adequate. For example on a 2 inch diameter columbium compact two welds 180° apart, 3/4 to 1 inch wide and 1/4 to 1/2 inch deep, were found satisfactory when the compact was arc-melted in a four inch crucible allowing only a one inch circumferential clearance.

It is usually expedient and safest to continue the beads or other strips all the way of the lower tip of the initial

electrode. However, for the prevention of harmful warping only, the strips can be terminated as much as one diameter of the compact from bottom end. Such treatment affords a path of good conductivity from the point of electrical contact at the top substantially to the lower tip. Shortly after melting begins the path is complete as to the unmelted portion. To obtain the full benefit of this invention, including easier striking of the arc, a full length path is justified.

As a further assurance of adequate electrical conductivity, the longitudinal beads, or strips, can be inter-connected by transverse peripheral strips or beads. This is conveniently done, because in actual practice several relatively short compacts are butt-welded to form the consumable electrode. It is a simple matter to interconnect this butt weld with the longitudinal weld beads.

It is also desirable to establish good electrical contact between the upper end of the strips or beads and the electrode holder or clamp to which the main electrical connection is made. While various clamps can be used, it is preferable, especially in view of the close crucible clearances made possible by this invention, to use an adapter made of a metal compatible with the electrode. This adapter is mounted, e.g., by a threaded connection, on the electrode holder, which is usually a water-cooled copper pipe mounted in a raising and lowering mechanism for positioning and feeding the electrode. The compacted electrode is butt-welded to this adapter. By being compatible it is meant that the adapter metal can be welded to the compact and will not contaminate it unduly. An adapter of the same composition, of course, is usually ideal. When the compact is welded to the adapter as described the desired electrical path is easily completed by welding the side strips or beads into the adapter itself.

The exact function of the weld beads or strips used in this invention has been open to some speculation. It was thought that they might serve as a strengthening framework and thereby keep the electrode from warping. On the other hand, it was observed that compacted electrodes became very hot, bright red or hotter, when melted without the strips. When strips were used the electrode remained much cooler. It was therefore theorized that warping was due to the uneven resistance heating of the electrode as the heavy current passed through it. Heating resulted because, in the compact, there was insufficient sound metal to conduct such a current without heating. Furthermore, since such compacts were not physically uniform throughout, an uneven resistance heating could cause uneven expansion and sintering to cause warping. This phenomenon is most frequently noticed in compacts of tantalum and tungsten which have such high melting points that it is very difficult to establish the necessary electrical conductivity by normal sintering procedures. The foregoing explanations appear to fit the facts, but the invention is not limited thereto, except as is inherent in the appended claims.

This method of stabilizing electrodes is well adapted to instances where a plurality compacted consumable electrodes are mounted side by side in spaced relationship for melting.

EXAMPLE 1

Columbium granules, produced by hydrogen reduction of NbCl_5 and having an average diameter of about two millimeters, were hydrostatically compacted to form consumable electrode units 2 inches in diameter and 15 inches long, in the following manner: The granules were enclosed in 20 mil columbium foil, and a tough polyester film. This package was placed in a heavy rubber, cylindrical compaction container and the whole assembly hydrostatically compacted at 60,000 p.s.i. This procedure is more fully described in copending application, Ser. No. 314,610, filed Oct. 8, 1963. The rubber and organic films were removed from the foil-covered, cylindrical compact so produced.

Three of these compacts were butt-welded end-to-end, under argon, to form an electrode about 45 inches long. Using an inert-gas shielded electric arc, two weld beads 180° apart were run longitudinally from end-to-end along the sides of the electrode. In this instance careful, slow welding was required in order to avoid burning away the foil, which was needed to prevent the granules from running out. The beads were approximately $\frac{3}{4}$ " wide and $\frac{1}{3}$ " deep. The electrode was then butt-welded to the adapter member of the arc-melting apparatus with good electrical contact to the weld beads, and subjected to the usual vacuum arc-melting operation.

The melting was smooth and the arc maintained excellent characteristics, because the lower end of the electrode remained well centered in the cold crucible. In other trials, without the weld beads, these slender electrodes warped under the uneven heating effected by poor conductivity, and arced against the crucible side wall. Immediate shutdown was required to prevent disastrous crucible burn through.

EXAMPLE 2

A blend of metal granules proportioned to yield a tantalum base alloy containing 30% Cb and 8% V was prepared. The batch consisted of 89.5% of Ta-Cb master alloy granules (30.6% Cb), 2.5% pure Cb granules, and 8% vanadium chips. The thoroughly mixed granules were packaged and compacted as in Example 1, except that the compacts were about 4.5 inches in diameter.

These compacts were butt-welded to form an electrode. Four weld beads, 90° apart, were run longitudinally along the electrode from end to end. The beads were approximately 1" wide and $\frac{1}{2}$ " deep. They appeared continuous and sound. The butt welds in this case were made circumferentially continuous; thus each interlinked the longitudinal welds in four places and thereby assured a low-resistance electrical path to the melting tip.

This electrode was then welded to a columbium adapter member and mounted in the arc-melting furnace. The electrode was arc melted in an 8" I.D. cold copper crucible, thus allowing a maximum of 2" clearance therebetween. A current ranging from 6700 to 7000 amperes at from 28-31 volts was used to melt the electrode. The melting was satisfactory, with substantially no warping occurring. A further advantage of ease in starting the arc was noted and attributed to the increased conductivity along the weld bead network.

I claim:

1. In a process for arc-melting a vertically mounted, consumable electrode prepared by compacting particles of a refractory metal packaged within a foil container of the said metal, which electrode has the characteristic of warping when an electric arc-melting current is passed through it, the improvement which comprises welding at least one metallic strip of lower electrical resistance than that of the compacted consumable electrode, substantially throughout the length of said electrode and in electrical contact with its top.

2. In a process for arc-melting a vertically mounted, consumable electrode prepared by compacting particles of a refractory metal selected from the group consisting of columbium, chromium, molybdenum, tantalum, tungsten, and vanadium, and alloys of at least two of these metals with each other, which electrode has the characteristic of warping when an electric arc melting current is passed through it, the improvement which comprises providing at least one weld bead of lower electrical resistance than that of the compacted, consumable electrode, along its periphery substantially throughout its length and in electrical contact with its top.

3. The process of claim 1 wherein the said metallic strip is a weld bead.

4. The process of claim 3 wherein the said weld bead is formed from the same material as the said compacted refractory metal.

5. The process of claim 2 wherein the said weld bead

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is formed from the same material as the said compacted refractory metal.

6. A warpage stabilized, consumable electrode for use in electric arc-melting, comprising a consumable electrode of compacted particles of a refractory metal packaged within a foil container of the said metal, the said electrode having welded substantially along the entire length of its periphery at least one metallic strip of lower electrical resistance than that of the said electrode.

7. The electrode of claim 6 wherein the said refractory metal is selected from the group consisting of columbium, chromium, molybdenum, tantalum, tungsten, and vanadium, and alloys of at least two of these metals with each other.

8. The electrode of claim 7 wherein the said metallic strip is a weld bead.

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9. The electrode of claim 8 wherein the said weld bead is formed from the same metal as the said compacted refractory metal.

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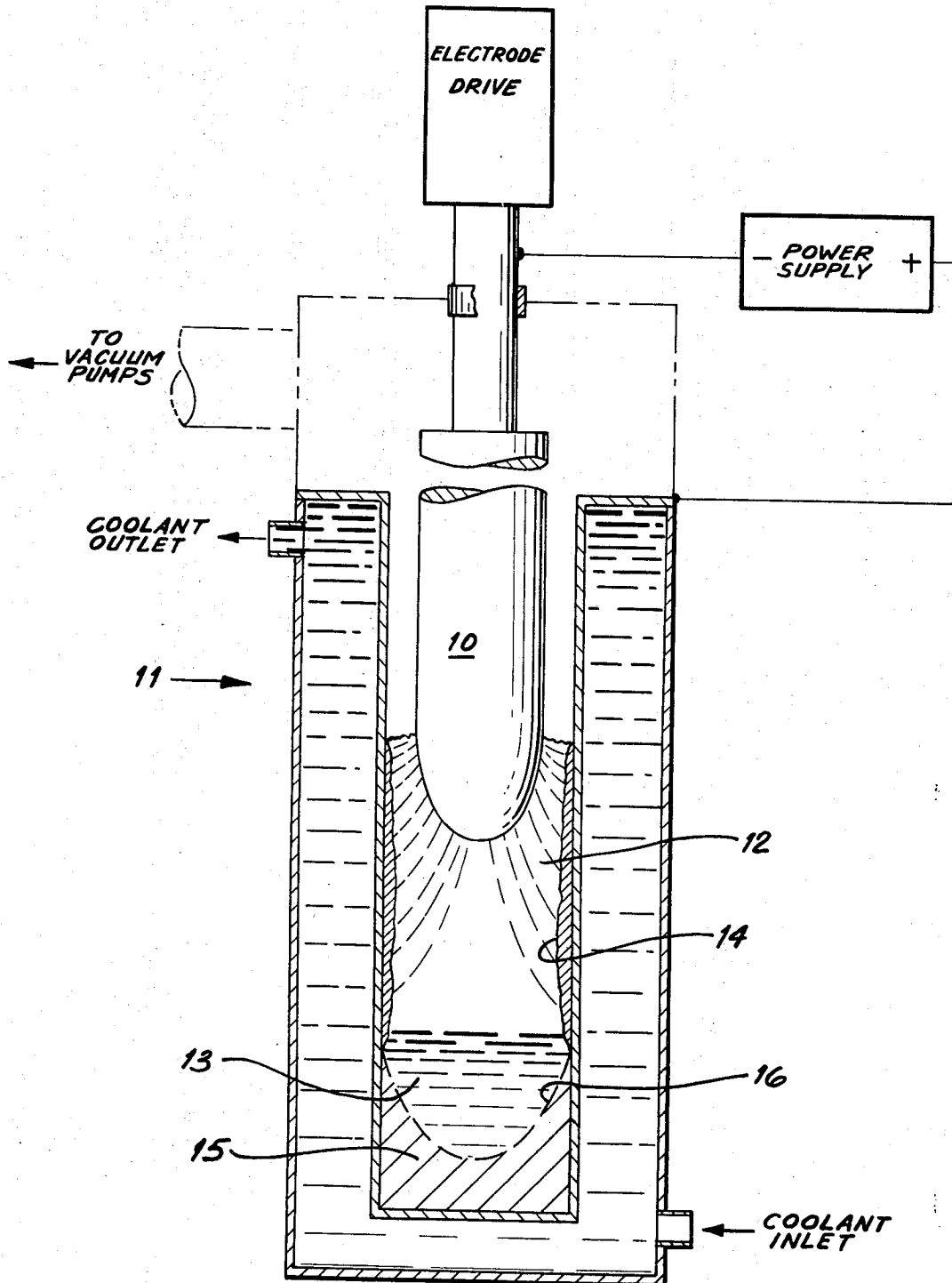
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CONSUMABLE ELECTRODE MELTING PROCESS

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2 Sheets-Sheet 1

FIG. 1



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CONSUMABLE ELECTRODE MELTING PROCESS

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FIG. 2

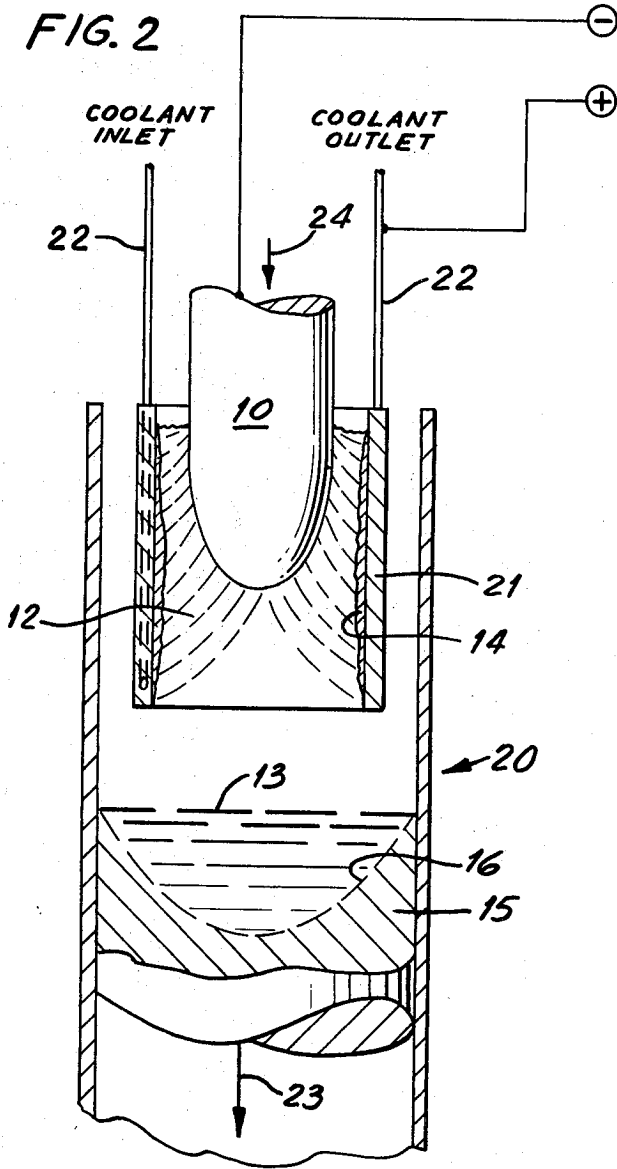
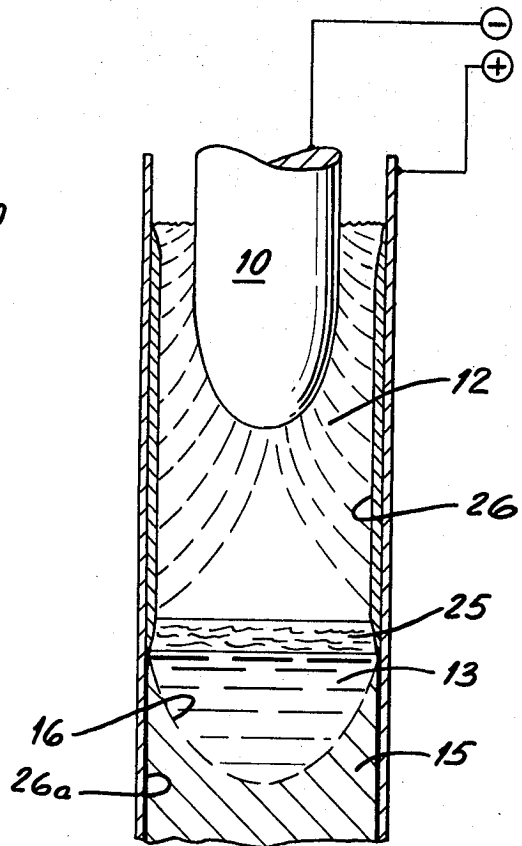


FIG. 3



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3,542,931

CONSUMABLE ELECTRODE MELTING PROCESS
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Filed June 9, 1969, Ser. No. 831,317

Int. Cl. H05b 7/18

U.S. Cl. 13—9

13 Claims

ABSTRACT OF THE DISCLOSURE

A consumable electrode melting process in which the consumable electrode is melted by a diffuse electric space discharge between the consumable electrode and a counter electrode which can be the wall of the melting chamber with little, preferably none, of the discharge going to the molten metal pool.

This invention relates to a process for refining metals and more particularly to such a process in which the metal in the form of a consumable electrode is melted under vacuum pressure conditions by means of an electric space discharge.

Consumable electrode melting techniques have long been used in the production of refined ingots of both pure metals and metal alloys. Usually in carrying out the process, a cylindrical electrode is formed having an analysis similar to that wanted in the final product. The electrode is used as an electrical conductor from which an arc is initiated to the bottom of the crucible or to additional metal placed there for that purpose. The electrode, the ingot being formed, and the electric arc between them are all contained in a water-cooled crucible or melting chamber from which the air has been removed. The heat of the electric arc melts the end of the electrode presented toward the bottom of the crucible, and eventually it is completely consumed. Drops of molten metal fall from the electrode tip, through the arc zone to replenish a pool of molten metal floating on top of the ingot being formed by the solidification of metal from the pool.

Normally, the diameter of the crucible in which the ingot is solidifying is greater than that of the electrode which is being melted by the arc to form the ingot. Consequently, as melting progresses, the height of the ingot increases and the molten pool supported on it rises at a slower rate than that at which the melting end of the electrode recedes from the surface of the molten metal pool. Hitherto, for the electrode tip to recede from the pool had been considered to be highly objectionable not only because in the case of many alloys it resulted in a poor, if not useless, product as a result of variations in the melting rate and concomitant variations in the thermal conditions of the melting process, but also because it was likely to result in destruction of the crucible with risk of injury to personnel.

Various equipments have been developed and are now in use for the purpose of maintaining within close limits a short arc gap between the end face of the electrode and the surface of the molten pool to prevent the arc from jumping from the molten pool to the wall of the crucible. Most of such equipment control the arc gap length, that is the distance from the end of the electrode to the molten metal pool, by sensing and responding to variations in arc voltage or arc current or both that accompany changes in the arc gap so as to maintain the arc gap substantially constant thereby minimizing thermal fluctuations during the melting process. Some equipment monitor the very large and rapid fluctuations that occur when molten metal bridges the gap to cause partial short

circuits called drip shorts, although some partial short circuits of the arc may also be the result of waves or splashes of molten metal in the pool which bridge the gap.

Though the vacuum arc consumable electrode process as hitherto practiced is highly successful commercially, it nevertheless has a number of serious drawbacks. Expensive and relatively complex electrode feed and control means are required to maintain the desired short arc gap between the bottom end of the electrode and the surface of the molten metal pool. The close juxtaposition of the electrode to the surface of the pool resulted in the formation of a relatively high pressure region between them as compared to the pressure measured at the outlet to the furnace, the difference in pressure being as great as 10 to 100 times or more. The agitation of the molten metal pool by the electric arc tends to interfere with the manner in which the metal solidifies. The molten metal falling as drops from the consumable electrode through the arc, though only for a short distance, is further heated as is also the surface of the molten pool, and such superheating results in the need to transfer more heat across the liquid-solid metal interface.

We have now discovered that, contrary to previous experience, ingots metallurgically sound in structure can be melted from consumable electrodes by means of an electric space discharge extending between the consumable electrode and a counter electrode, which can be the wall of the melting chamber, with little, preferably none, of the discharge going to the molten metal pool, so long as the distance between the surface of the molten metal pool and the portion of the electrode exposed to the discharge is at least substantially equal to the diameter of the counter electrode, and there is no magnetic field in the zone of the discharge strong enough to result in disruption of the diffuse discharge characteristic of the present process so that it becomes a concentrated, visible arc discharge.

Advantages of our process include significantly faster production rates of a given product as compared to the time required to produce it by conventional consumable electrode vacuum arc melting, for a given crucible outlet pressure a much lower pressure than hitherto is maintained directly over the molten metal pool, a considerably simplified electrode feed control system and electrode to pool distance control can be used because in this process the electric space discharge gap is primarily, preferably entirely, between the electrode and the counter electrode which can be the crucible, the molten metal pool is not subjected to the turbulence or the heat of the arc characteristic of the conventional process, and metal drops from the electrode are no longer heated by the arc as they fall into the pool.

Further objects and advantages of the present invention will be apparent from the following detailed description thereof and the accompanying drawings in which

FIG. 1 is a diagrammatic view illustrating the process of the present invention with the diffuse electric space discharge extending between the consumable electrode and the wall of the melting chamber formed by a water-cooled crucible;

FIG. 2 is a similar view of modified apparatus for carrying out the present process; and

FIG. 3 is a similar view illustrating the use of a flux on the surface of the molten metal pool.

In carrying out the process of the present invention, the consumable electrodes to be used are produced in the same manner as hitherto. The process can be carried out using conventional consumable electrode vacuum electric arc melting equipment as is diagrammatically shown in FIG. 1, but it is to be understood, as will be more fully pointed out hereinafter, various modifica-

tions can be made to conventional equipment to simplify it and/or adapt it for carrying out the present process more effectively.

The starting procedure of the present process can be the same as in conventional melting. An electrode 10 is mounted in the feed mechanism (not shown), the crucible 11 is sealed, pumped down, and the current is turned on with the bottom end of the electrode against the bottom of the crucible or some starting metal placed in the bottom of the crucible for that purpose. At this time, coolant is circulating through the walls of the crucible. Initially, an arc is struck on the opening of a gap between the bottom end of the electrode 10 and the metal immediately below it; and up to this point, the starting procedure of conventional consumable electrode vacuum arc melting has not been departed from. In the prior practice, the electrode-to-molten metal pool distance (the arc gap of the conventional practice) is controlled to prevent the discharge and the discharge current from leaving the molten pool and going to the crucible to any appreciable extent. In carrying out our process, at least a substantial part of the discharge is shifted from the molten metal that is formed on start-up and is prevented from returning to it during the remainder of the process. When the process is being carried out in a conventional crucible with conventional control equipment, this can be accomplished by raising the electrode to increase the electrode-pool gap distance or the electrode can be held stationary so that the discharge melts the tip of the electrode back away from the pool. If desired, raising the electrode and melting the tip away with the discharge can be combined to establish the desired electrode-pool gap.

As the electrode-pool distance increases, the operating voltage is seen to rise and initially the voltage increases at about 1 volt per inch of increase in the arc gap. As the distance is increased from that conventionally used of about one inch, the number of short duration short circuits resulting from molten metal bridging the electrode-pool gap is reduced to zero, and this seems to occur when the gap is equal to about two to three inches. It also can be observed that as the arc gap increases, the voltage becomes less and less affected by changes in the electrode-to-pool distance and becomes more and more dependent upon the electrode and crucible geometry and upon the amount of current in the discharge. More specifically, as the distance between the electrode and the molten pool is increased and other things including the current remain constant, the discharge voltage becomes more and more a function of the ratio of the interior diameter of the crucible to the diameter of the electrode. The voltage is believed to asymptotically approach a value determined by that ratio, and further increases in the electrode-to-pool distance do not affect the discharge voltage.

The increasing discharge voltage in response to increasing electrode-to-pool distance reflects more and more of the discharge current passing between the electrode and crucible and not the molten pool. When the voltage becomes independent of further increases in the electrode-to-pool distance, it is evident that essentially all the current of the discharge as indicated at 12 passes directly between the electrode and the crucible and virtually none passes through the molten pool. As a practical matter, that condition will usually be present when the electrode-to-pool distance is at least equal to the diameter of the crucible but it can be present at somewhat closer spacings as can be readily determined by measuring the electrode-to-pool distance that is present when the discharge voltage is no longer affected by increases in that distance. Such a measurement can be carried out by noting the distance through which the electrode must be fed downward to contact the molten pool and short circuit or extinguish the discharge.

The increase in voltage that is experienced as the result only of increasing the electrode-to-pool distance to

the point where further increase has no effect on the voltage is dependent upon the crucible and electrode geometry. In the case of a crucible having an interior diameter of 8 inches and a consumable electrode of 4 inches, conventional vacuum arc melting was carried out at a voltage of about 24.5 to 25.5 volts with a current of 2,500 amperes. The same current was passed at about 28.5 volts with the electrode-to-pool distance increased to where further increases did not affect the discharge voltage. At relatively light current loads, the rise is no more than a few volts. When the current was increased to 5,000 amperes, the voltage rose from 28.5 volts to 37.5 volts.

With a crucible having an interior diameter of 14 inches and a consumable electrode 9 inches in diameter, conventional vacuum arc melting was carried out at about 24 volts with a current of about 5,000 amperes. When the distance between the electrode and pool was increased until further changes did not affect the voltage, and with the current at about 9,000 amperes, the voltage was equal to about 40 volts.

The aforementioned values of current and voltage were obtained at pressures, measured near the crucible outlet, of about 1-10 microns of mercury. However, it is to be noted that the pressure and composition of the atmosphere are not believed to be critical. The process can be carried out at a pressure of 1-500 microns of mercury and at lower and higher pressure if that should be desirable. At the higher pressures, a more suitable atmosphere than air, such as argon or other gases and mixtures thereof which are not undesirably reactive with the metal, is provided. Increasing the pressure above about 1 mm. of mercury to about 10 mm. of mercury, thereby causing an increase in the discharge voltage of about 10 to 20 volts, can provide a hotter discharge in the zone where metallic vapors can otherwise condense on the surface of the counter electrode, and can be used to prevent such condensation or to remelt it if that should be desired. For this purpose, a pressure no more than about 5 mm. of mercury is preferred, although a pressure of up to about 8 to 10 mm. of mercury can be used. However, above about 10 mm. of mercury, it becomes difficult to maintain the stable diffuse discharge of the present process.

When carrying out the present process in conventional upright equipment with the consumable electrode positioned vertically, a net vertical magnetic field in the discharge space tends to disrupt the quiet, substantially invisible discharge characteristic of this process and causes the formation of what appear to be concentrated arcs emanating from a number of discrete spots distributed circumferentially around the tapered tip of the electrode. Such arcs obscure the view of the molten pool and are accompanied by a haze in the discharge zone. They are usually accompanied by a voltage drop. Because of the large currents used in consumable electrode melting, care should be exercised in locating the current conductors to avoid inducing disturbing magnetic fields in the discharge space. However, when such a field is present, its effect can be eliminated by inducing an equal and opposite field to cancel it out as for example by means of an external electromagnetic coil as is well known in this art. While the reasons why such a magnetic field tends to disturb the discharge characteristic of the present invention are not fully understood, its presence can be readily detected by its effect on the discharge as was noted above. With the short arc gap characteristic of a conventional vacuum arc melting process, the presence of a stray magnetic field can be demonstrated by rotation of the molten pool resulting from interaction of the field and the electric discharge current in the molten pool. And with the pool rotating solely as a result of the interaction of the current and the field, raising the electrode until substantially none of the electric current passes through the pool will cause the pool to stop rotating. Thus, substantial elimination of the current, which in the conventional

process flows in the molten pool, renders the latter insensitive to such magnetic fields.

Because the discharge of the present process extends entirely or at least primarily between the side of the consumable electrode and the counter electrode, which can be the crucible, and not, as hitherto, substantially entirely between the end face of the consumable electrode and the close-by surface of the molten metal pool, the discharge is free to and does spread over a much larger surface area of the consumable electrode. When the process stabilizes after start-up, the tip of the electrode is seen to be tapered, and this results in an even greater portion of its surface being involved in the discharge which extends to a corresponding area of the counter electrode. Thus, the discharge of the present process is not a concentrated arc discharge, but is a highly diffuse electric space discharge.

From a consideration of the flow of energy in the conventional vacuum arc process, it can be shown that with an electrode-to-pool discharge gap of about 0.75 to 1 inch, close to 100% of the electric arc energy in the form of heat enters the molten pool. Although precise measurement of the portion of that heat entering the molten pool as latent heat in the droplets of metal has not been carried out, calculations based on the measurements that have been made indicate that only about 40% of the arc energy does enter the pool as latent heat in the droplets of metal. In other words, the molten metal pool in such a process receives about 150% more heat energy beyond the amount required only to melt the electrode at the rate being used. In the present process, with substantially all of the discharge current going not to the molten pool 13 but to a counter electrode such as the wall of the crucible 11, substantially the only electric discharge energy that enters the molten pool 13 is that in the form of latent heat in the metal droplets, and the remaining discharge energy goes to the crucible wall where it does no harm because of the large area over which it is distributed. Using as a guide the aforementioned discharge energy distribution of about 40% to the molten pool as latent heat and about 60% to the crucible wall, then in the present process to provide a heat input to the molten pool 13 equal to that of the prior process operating at a given melting rate, the melting rate must be increased to about 2.5 times that of the prior process.

The metallurgical structure of the ingot that is cast from the consumable electrode is determined by such solidification parameters as the molten pool depth and shape, the thermal gradient across the molten pool-solid metal interface, the solidification rate as well as other factors. For example, in the case of the pool depth, if it becomes too deep, the metallurgical structure of the ingot is adversely affected in the case of certain compositions as is well known to those skilled in this art. As a consequence, the need not to exceed a prescribed pool depth then effectively determines the maximum melting rate that can be used and, other things being equal, the permissible rate for the present process is at least about twice that of the prior practice. On the other hand, a too-shallow pool can also adversely affect the metallurgical structure of the ingot as could occur when the present process is operated at the same melting rate as the prior process was required to be operated to provide and maintain a minimum pool depth. Under those conditions, the present process would result in the formation of a relatively shallow pool which in turn would result in an inadequate time for diffusion and other transport processes to be effective in properly refining the metal before solidification. In that event, the economically desirable faster melting capability of the present process would be required to provide a good quality product.

Thus, in accordance with one embodiment of the present invention, not only is the discharge carried out with the end of the consumable electrode spaced from the surface of the molten metal pool by a distance which is at least substantially equal to the diameter of the counter

electrode, but also the current in the discharge is increased to provide a melting rate fast enough to maintain the molten metal pool as the distance between the tip of the electrode and the surface of the pool is increased. And the rate at which the current is increased is controlled to avoid thermal shock to the metal as well as adverse effects on the surface properties and segregation in the metallurgical structure.

When the present process is carried out under a pressure of less than about 1 mm. of mercury in conventional apparatus so that the discharge zone traverses portions of the crucible ahead of the rising metal which solidifies to form the ingot, and the distance between the rising surface of the metal pool and the bottom of the electrode tip is such that substantially all of the discharge current flows between the electrode 10 and the crucible 11, then, as shown in FIG. 1, the metallic vapors which condense on the wall of the crucible 11 along the discharge zone form a relatively long shell 14. Under the conditions stated, the length of the shell 14 will be approximately equal to the distance between the surface of the molten pool 13 and the bottom of the electrode tip plus the distance the discharge extends up along the tapered side of the electrode tip. On solidification, the metal of the shell 14, which has an irregular surface, contracts and pulls a small distance away from the cooled crucible wall 11, leaving a space which acts as a thermal barrier. For best results, the shell 14 should be remelted as the molten pool 13 rises within it to minimize surface porosity and other conditions that may otherwise occur.

When necessary, in some instances this can be accomplished by increasing the melting rate and thereby the depth and temperature of the molten pool 13. On the other hand, if the melting rate cannot be increased to the extent that may be required with a specific composition because, for example, the metallurgical structure desired in the ingot cannot then be attained, the electric discharge and melting of the consumable electrode can be confined to one portion or chamber of the crucible, and casting of the ingot can take place in another as will be more fully described in connection with FIG. 2. In this way, the shell formed along the discharge zone cannot affect the metallurgical structure of the ingot.

Consumable electrode melting both by the process of vacuum electric arc melting as hitherto practiced and by the present diffuse electric discharge process is useful in connection with a very large variety of compositions such as pure elements and also alloys ranging from those containing a relatively small amount to those containing a large amount of alloying elements. Such alloys include the tool steels, the high-strength aging and maraging steels, and the high-temperature steels and nonferrous base alloys. Thus, without intending thereby to limit the present process, it will now be described in connection with the melting of a consumable electrode of A.I.S.I. type No. 685 usually sold under the designation Waspaloy. An electrode of that composition, weighing about 1,820 pounds, having the shape of a sixteen-sided polygon with a diameter of 9 inches measured between opposed flats, and about 91 inches long, was mounted in the usual way in a conventional water-cooled crucible 14 inches in diameter and having a 15,000 ampere power supply regulated to provide constant current.

After the crucible had been sealed and after about 15 minutes of pumping, the pressure measured near the outlet to the pumps was about 10 microns of mercury. A conventional type of electric arc space discharge was initiated by backing the electrode away about one inch from some starting metal at the bottom of the crucible. The arc was struck with a current of 2,000 amperes at about 21 volts which was then immediately increased to 5,000 amperes at about 25 volts. Under those conditions, conventional melting was carried out for about 16 minutes. After about 16 minutes, the consumable electrode was backed off about 18 inches, and the current was

increased to 9,000 amperes with an operating voltage of 37 volts. During the next 15 minutes, there was a gradual rise in the operating voltage from 37 volts to 40 volts. After about 30 minutes from start-up, equilibrium was reached. As melting continued, the electrode was fed downward at a rate of from 2 to 2.25 inches for each 10-minute interval. Completion of the melt was evident from a sharp rise in voltage when the surface area of the electrode available for the discharge was rapidly reduced. On termination of the discharge, the distance between the bottom of the electrode and the top of the ingot was 28 inches.

Melting of an ingot weighing about 1,785 pounds was completed in about 178 minutes giving an average overall melting rate of about 600 pounds per hour. However, taking into account that the first 16 minutes were at the lower current of 5,000 amperes, the actual melting rate for most of the melt was at a faster rate. In fact, the last 55 inches of the electrode were found to have been melted at the rate of about 725 pounds per hour.

Upon examination, both the surface of the ingot and the microstructure of a disc cut from a 9-inch square billet forged from the ingot were found to be satisfactory. The carbide distribution of the billet was seen to be similar to that of billets of the same alloy remelted by conventional consumable electrode vacuum arc melting techniques. The significance of this will be more fully appreciated when it is borne in mind that the melting rate utilized for melting Waspaloy consumable electrodes by the conventional vacuum arc process is about 325 pounds per hour.

Turning now to FIG. 2, crucible 20 which can be cooled in the usual way, has a fixed counter electrode 21 mounted therein. As shown, the counter electrode 21 is made of copper for good electrical conductivity and is supported by copper conduits 22 which, in addition to supporting the electrode, also function as bus bars for the electric current and conduits for a suitable coolant such as water. The remaining upper structure of the crucible can be constructed in the known manner including the drive for the consumable electrode 10 and the power supply which is connected between the consumable electrode 10 and the counter electrode 21, the latter preferably being connected to the positive side of the power supply. The counter electrode 21 is preferably electrically insulated from the wall of the crucible so as to minimize the tendency for any of the current of the electric discharge to flow through the molten metal pool. As indicated, a shell 14 like that described in connection with FIG. 1 is shown formed on the surface of counter electrode 21 exposed to the discharge.

The surface of the molten metal pool 13 is maintained at a substantially fixed distance from the bottom of the counter electrode 21 by drawing the solidified metal ingot 15 downward as indicated by arrow 23 at a rate substantially equal to the rate at which the interface 16 between the molten metal pool 13 and the solidified metal ingot would otherwise rise while keeping the depth of the molten pool substantially constant. Such arrangements are well known in the art and need not be described here because those details form no part of the present invention.

In carrying out the present process in the apparatus of FIG. 2, the discharge is initiated between the consumable electrode 10 and the counter electrode 21 by first bridging the gap with a suitable starting material such as a relatively fine wire or metal wool preferably having the same composition as that of the consumable electrode 10. When the current is turned on, the starting material is immediately vaporized and the discharge is started. It is, of course, not necessary to back the electrode away at the outset. As the electrode 10 is melted away, it is fed downward. If the rate of feed is too slow, then the voltage rises as less and less of the consumable electrode 10 is juxtaposed to the counter electrode 21. That rise in voltage is used to control the feed of the electrode 10 by

initiating a downward stroke of the electrode, as indicated by arrow 24, for the distance required to maintain its tip at about the center of the counter electrode. Such apparatus is also well known to the art and need not be described here.

Except for the manner in which the discharge is initiated and the driving of both the consumable electrode 10 and the ingot 15, the process is carried out in the same manner as has been described. An important advantage of the apparatus shown in FIG. 2 resides in that the molten metal pool 13, the interface 16 and the solidified metal 15 do not rise in the crucible to traverse the electric discharge zone. Consequently, the formation of a solid shell of condensed metal on the surface of the counter electrode 21 cannot interfere with the ingot, and therefore no special steps need be taken to remelt the shell.

The present process lends itself to the melting of consumable electrodes to form ingots or bars having a smaller diameter than the electrode. To this end, the crucible is divided into two chambers, an upper chamber which can be identical to that shown in FIG. 2 down to just below the counter electrode 21, and a lower chamber which is of smaller diameter, but in other respects is the same as the lower portion of the crucible 20. If desired, the consumable electrode can be preformed with a taper to facilitate dripping of molten metal into the smaller diameter lower chamber during the period immediately following start-up when tapering would otherwise be effected by the diffuse discharge.

Yet another technique which can be used in minimizing the formation of condensed metal vapors or their effect, resides in the use of a flux in accordance with a further embodiment of the present invention which provides other important advantages. As shown in FIG. 3, the apparatus for carrying out this embodiment of the process can be the same as was described in connection with FIG. 1. After melting has been initiated and equilibrium reached, flux is added slowly enough not to disrupt the discharge. After the flux has been added, the discharge once again becomes stabilized in about 1 to 2 minutes. The flux is fused on being added and floats on the surface of the molten pool as indicated at 25. While a shell 26 forms on the crucible wall, it is now formed primarily from condensed flux vapor rather than metal. In addition, the flux coats the crucible and the surface of the ingot 15 as indicated at 26A. This has a beneficial effect upon the surface of the ingot being cast in the crucible. By its presence on the surface of the molten pool, the flux also serves to quiet further the molten pool as by dampening the effect of the falling metal droplets.

While the process of the present invention has been described in connection with crucibles which are circular in cross section, it is to be understood that the shape of the electrodes and the equipment used in carrying out the present process may be varied as desired. Consumable electrodes, crucibles and counter electrodes that are non-circular in cross section can be used. In that event when "diameter" is referred to herein, including the claims, the shorter transverse dimension such as the minor axis of an ellipse or the width of a rectangle is intended.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. The method of melting a consumable electrode by means of an electric space discharge about one end portion of the consumable electrode in a melting chamber so that molten metal from said end portion of the electrode forms a molten pool from which the metal solidifies to form an ingot, which includes the steps of maintaining the distance between the surface of said molten metal

pool and said electrode larger than the maximum distance at which molten metal can bridge the distance between said consumable electrode and said molten metal pool and at least substantially equal to the minimum distance at which a diffuse electric space discharge can be maintained between said end portion of said consumable electrode and a counter electrode spaced from said molten metal pool with no more than a minor portion of the discharge current passing through said molten metal pool, maintaining said diffuse electric space discharge primarily between said consumable electrode and said counter electrode while at least a major portion of said electrode is consumed, and maintaining magnetic fields in said melting chamber transverse to said electric space discharge less than the minimum required to disrupt said diffuse electric space discharge.

2. The method of claim 1 which includes the steps of maintaining the distance between the surface of said molten metal pool and said consumable electrode at least substantially equal to the diameter of said melting chamber in the zone of the discharge.

3. The method of claim 1 which includes the step of maintaining the distance between the surface of said molten metal pool and said consumable electrode at least substantially equal to a value such that increases in said distances have substantially no effect upon the voltage drop of said electric space discharge.

4. The method of claim 1 in which said counter electrode is a portion of the wall of said melting chamber spaced from said molten metal pool.

5. The method of claim 1 in which the pressure in said melting chamber is maintained less than about 10 mm. Hg.

6. The method of claim 5 in which the pressure in said melting chamber is maintained less than about 500 microns Hg.

7. The method of claim 5 in which an atmosphere that

is non-reactive with the molten metal is maintained in said melting chamber.

8. The method of claim 7 in which said atmosphere is argon.

9. The method of claim 7 in which the pressure is from about 1 mm. Hg to about 5 mm. Hg.

10. The method of claim 1 in which flux is fused on the surface of said molten metal pool, and the consumable electrode is spaced from the surface of said flux.

11. The method of claim 1 which includes the steps of initiating said electric space discharge by withdrawing said end of said consumable electrode from the bottom of said melting chamber, and increasing the current in said electric space discharge as the distance between said consumable electrode and said molten metal pool is increased.

12. The method of claim 11 which includes the step of holding said consumable electrode substantially stationary after the discharge is initiated as the distance between said consumable electrode and said molten metal pool is increased by the melting away of said consumable electrode.

13. The method of claim 11 which includes the step of continuing to withdraw said consumable electrode after the initiation of said discharge at least until the distance between said consumable electrode and said molten metal pool is at least substantially equal to the diameter of said melting chamber.

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13-31; 219-72; 313-146, 156

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,542,931 Dated November 24, 1970

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It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 7, line 54, for "solified" read -- solidified --
Column 8, line 73, in claim 1, after "molten" insert
-- metal --.
Column 9, line 26, in claim 3, for "distances" read
-- distance --.
line 28, in claim 4, for "mehod" read
-- method --.
Column 10, line 3, in claim 8, for "mehod" read
-- method --.
line 29, References cited, for "2,933,954"
read -- 2,933,594 --.

Signed and sealed this 10th day of December 1974.

(SEAL)
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[21] Appl. No. **833,841**

[22] Filed **May 19, 1969**

[45] Patented **June 28, 1971**

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[32] Priority **May 24, 1968**

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[31] **P-17-58-394.7**

[50] Field of Search..... 13/18, 20,
31; 117/228; 314/60

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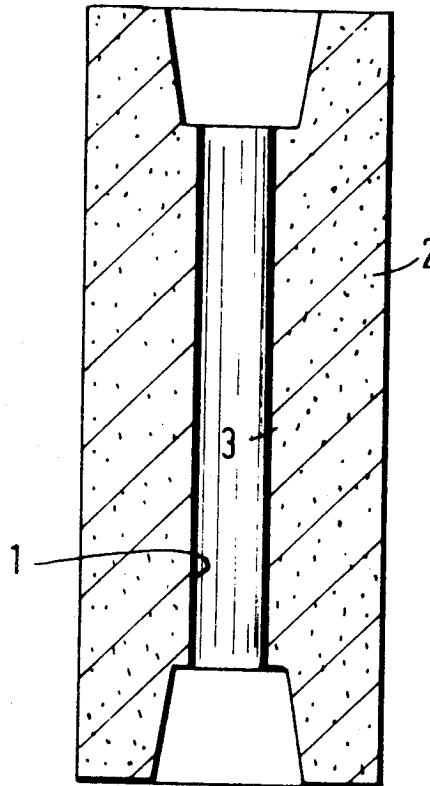
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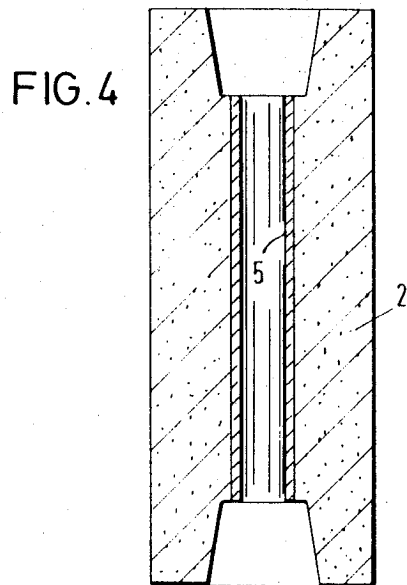
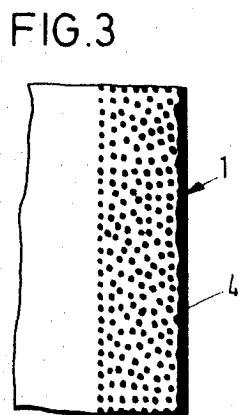
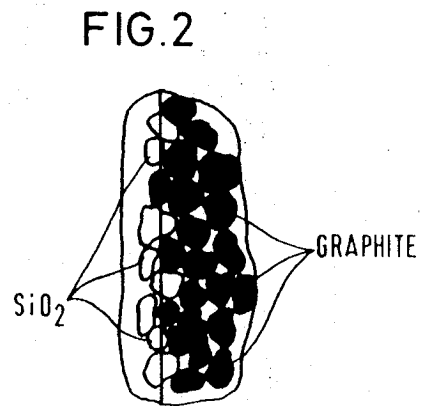
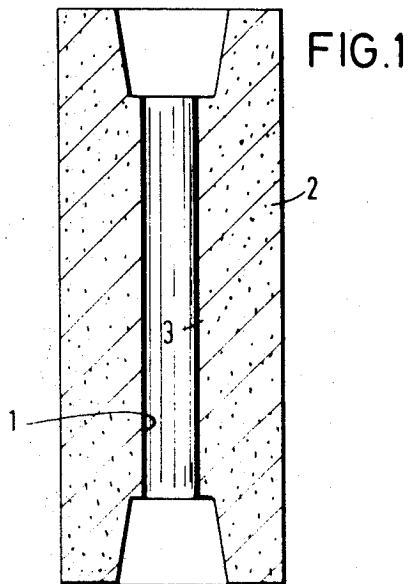
[54] **HOLLOW CARBON ELECTRODE**
11 Claims, 4 Drawing Figs.

[52] U.S. Cl..... 13/18

[51] Int. Cl..... H05b 7/06

ABSTRACT: A hollow electrode with a longitudinal passage therethrough which consists of carbon material and in which the surface of the passage is made substantially gas-impermeable.





HOLLOW CARBON ELECTRODE

In electrothermal processes, especially in connection with the production of electrosteel, it is known to employ hollow or wick electrodes because the annular design of the electrode ends stabilizes the electric arc.

It is also known by introducing ionizing gases, as for instance argon, nitrogen, and the like, to bring about a further increase in the stabilization of the electric arc and to considerably improve the burning conditions of the electric arc inasmuch as the thermal degree of efficiency is increased and an unfavorable effect upon the network is reduced while, above all, the life of the fire resistant lining which considerably contributes to the costs of the electrosteel is materially extended.

Inherent to the manufacturing process of the electrodes, due to the disintegration of the binding agent, a certain porosity is obtained through the entire structure of the electrode. A portion of the gas introduced under a certain pressure escapes through these pores and is lost so that it will not be available at the burning end of the electrode for the stabilization of the electric arc. Therefore, numerous but vain attempts have been made to eliminate these losses since the employed gases, as for instance argon, are rather expensive.

It is, therefore, an object of the present invention to provide a hollow carbon electrode (the term also includes graphite) which will eliminate the loss of ionizing gases.

It is also an object of the present invention to provide a hollow electrode as set forth in the preceding paragraph, which will avoid gas loss and thus the pressure drop in the electrode which pressure drop disadvantageously affects the operation of the electrode.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawing, in which:

FIG. 1 diagrammatically illustrates a hollow or tubular carbon electrode having its interior wall surface sealed in conformity with the present invention.

FIG. 2 is an enlargement of an interior portion of an electrode according to the invention in which the inner wall of the graphite electrode is made gas-impermeable by SiO_2 .

FIG. 3 shows a cutout of the interior portion of a graphite electrode having its interior wall surface made gas-impermeable by a metallic coating.

FIG. 4 is a further embodiment of the invention according to which a tubular graphite electrode has its interior wall surface sealed by a metallic tube firmly pressed thereinto.

The hollow electrode of carbon material according to the present invention for the introduction of gases for the stabilization of the electric arc is characterized primarily in that the inner wall surface is sealed or made gas-impermeable.

More specifically, according to the present invention, the inner surface 1 of the tubular electrode 2 is sealed with substances 3 which during a thermal treatment under the exclusion of air will coke while having properties similar to those of the electrode material. Such substances are well known in connection with impregnating methods for carbon or graphite material and such substances are in particular tar and tar products, such as pitch, and also synthetic resins, sugar solution, water glass solution, or the like. In the last mentioned instance, a filling of the pores with silicic acid will increase the desired effect. Depending on the desired degree of compacting, the said substances are caused to penetrate into the electrode body to a greater or lesser extent. Such sealing of the inner wall surface of the axial bore of the electrode is shown in FIGS. 1 and 2. Particularly effective as far as the sealing of the inner surface 1 of the hollow electrode is concerned, is the formation of pyrolytic carbon from the gaseous phase.

Extensive research in connection with the present invention

has shown that also other suitable materials will bring about the desired effect. Thus, for instance, it is possible, in conformity with the present invention, to cover the inner surface 1 of the hollow electrode by a metallic coating 4 as shown in FIG. 3. Depending on the magnitude of the inner axial bore of the electrode and the required sealing effect, the thickness of the metallic skin will be selected. The metallic skin may be deposited electrolytically or by disintegration of organic metallic compounds.

According to a further modification of the invention as illustrated in FIG. 4, the inner wall surface of the electrode 2 is covered by a metal pipe 5 which is firmly pressed into the bore of the electrode. If desired, the metal pipe may also be replaced by a pipe of carbon material which has been sealed prior to its insertion into the electrode.

In conformity with a further development of the present invention, a still further improvement has been obtained by inserting oriented substances. In this connection, for instance, KBF_4 , K_2SO_4 , WC, TiC have proved effective as sealing material while additionally having a stabilizing effect on the electric arc.

It is, of course, to be understood that the present invention is, by no means, limited to the particular showing in the drawing and the materials set forth above but also comprises any modifications within the scope of the appended claims. Thus, other ionizing substances with similar or better effects may be employed. It is also to be understood that as sealing mass a fire resistant material may be employed by means of which the surface of the central passage is coated. In this connection reference is made to the Torkrett method.

We claim:

1. A hollow electrode of carbon material for the introduction of gases for stabilizing the electric arc, which has a longitudinal passage therethrough, and in which the inner wall of the electrode body is sealed so as to make the same substantially gas-impermeable, there being a means to supply gas and direct it through the electrode rendered gas impervious.

2. An electrode according to claim 1, in which the inner surface of the electrode is sealed by substances adapted to be coked, said substances being selected from the group consisting of tar, pitch, synthetic resin and sugar solution.

3. An electrode according to claim 1, in which the pores on the inside of the electrode are sealed by silicic acid and the inner surface of the electrode is covered by water glass solution.

4. An electrode according to claim 1, in which the inner surface of the electrode is coated with a fire resistant material.

5. An electrode according to claim 1, in which the inner surface of the electrode is sealed by the formation of pyrolytic carbon from the gas phase.

6. An electrode according to claim 5, in which as pyrolytic carbon material is used a substance selected from the group consisting of hard carbon and pyrographite.

7. An electrode according to claim 1, in which the inner surface of the electrode is sealed by a metallic coating.

8. An electrode according to claim 1, in which the inner surface of the electrode is sealed by a pipe having a gas-impermeable inner surface.

9. An electrode according to claim 8, in which said pipe is a pipe consisting of carbon material.

10. An electrode according to claim 8, in which said pipe is a metallic pipe.

11. An electrode according to claim 1, in which the sealed inner surface of the electrode contains substances adapted to stabilize the electric arc, said substances consisting of ionizing material selected from the group consisting of KBF_4 , K_2SO_4 , WC, TiC.

United States Patent

Zollner et al.

[15] 3,644,654

[45] Feb. 22, 1972

[54] **GIANT ELECTRODE**

[72] Inventors: **Dieter Zollner**, Erlangen; **Bernhard Reichelt**, Nurnberg-Laufamholz, both of Germany

[73] Assignee: **C. Conradt**, Nurnberg, Germany

[22] Filed: **June 11, 1970**

[21] Appl. No.: **45,426**

[30] **Foreign Application Priority Data**

June 13, 1969 GermanyP 19 30 052.8

[52] U.S. Cl.13/18

[51] Int. Cl.H05b 7/06

[58] Field of Search13/18; 314/60; 313/354

[56]

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Primary Examiner—Bernard A. Gilheany

Assistant Examiner—R. N. Envall, Jr.

Attorney—Walter Becker

[57]

ABSTRACT

A giant electrode of graphite for high-output operation of electric arc furnaces in which the electrode is provided with an electric arc stabilizing wick.

2 Claims, 2 Drawing Figures

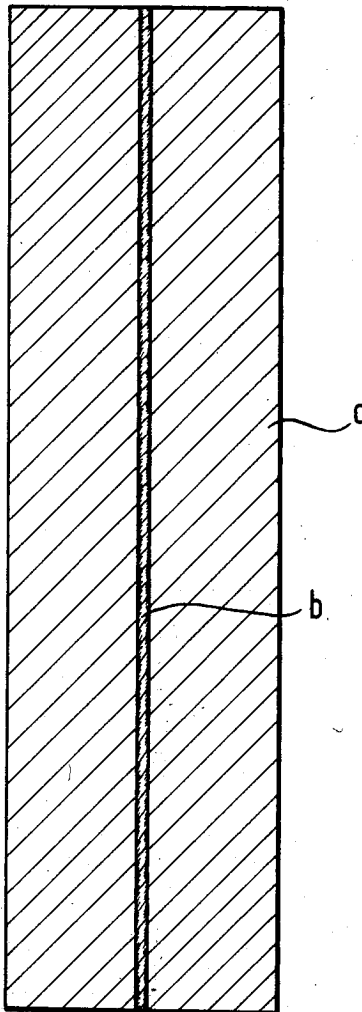


Fig.1

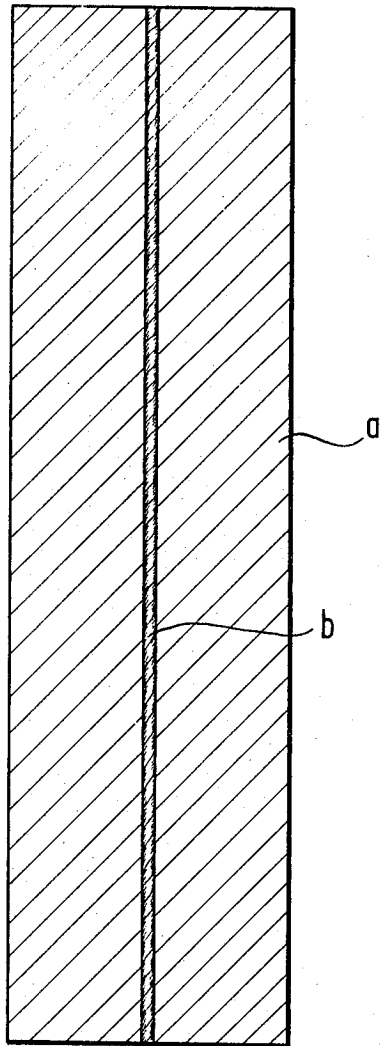
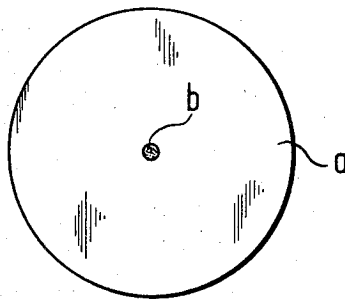


Fig.2



INVENTORS:
Dieter Zöllner
Bernhard Reichelt

BY:

Walter Becker

GIANT ELECTRODE

The present invention relates to a giant electrode of graphite for electric arc furnaces.

The technical requirement to convey extremely high electric power in connection with the melting operation of electric arc furnaces to the material to be melted and heated in the hearth has lead to numerous improvements in graphite electrodes. However, with regard to the extent to which solid graphite electrodes can be subjected to current loads has principally reached a limit. In order, in spite of this limit, still to be able to transmit greater power, resort has been taken to increasing the voltage. The increase in the voltage while retaining the current, however, entails other difficulties in the electric arc furnace operation. Thus, the electric arc which, in view of the higher voltages is longer, causes an unsteady burning behavior and, in view of this instability, brings about a considerable turbulence in the surface of the melt. These turbulences bring about that steel and slag particles are thrown against the lateral hearth lining and thus result in an intolerable extreme wear of the furnace lining.

Therefore, it became imperative to stabilize the electric arc as far as possible. To this end, hollow electrodes of graphite have been used. In view of the tendency of the foot point of the electric arc to burn in the interior of the central bores, a stabilization was realized which could be improved further by the supply of gases, such as argon, for stabilizing the electric arc and by stabilizing additions at the walls of the electrode.

While these methods bring about considerable advantages, very frequently the graphite consumption figures were considerably higher than expected or the operating costs with gas-stabilized hollow electrodes became too high.

It is, therefore, an object of the present invention to provide a giant electrode which will overcome the above-mentioned drawbacks.

This object and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawing, in which:

FIG. 1 is a section through an electrode according to the invention, while

FIG. 2 is a top view of the electrode of FIG. 1.

The present invention, which concerns a giant electrode of graphite for maximum output operation of electric arc furnaces, is characterized in that it comprises an electric arc stabilizing wick.

Wick electrodes with small diameter are principally known for use in connection with movie projection lamps and for illuminating purposes. In such an instance, synthetic carbon products are involved of a diameter of up to 20 mm. and a length of approximately 50 cm.

The present invention is concerned with the application of this principle of increasing the power of electrodes to giant electrodes for the electric arc furnace. The advantage of this new electrode results from a combination of individual effects. In this connection there are to be mentioned:

We claim:

1. A giant electrode of graphite for maximum power operation of electric light arc furnaces, which comprises a graphite body having an axial central bore of small diameter therethrough compared to total electrode cross section, and a thin wick arranged centrally in said bore, said thin wick specifically assuring stabilization of electric light arc furnace operation and simultaneously reducing graphite consumption.

2. An electrode of electric light arc furnaces according to claim 1, in which the mass of the thin wick contains a compound selected from the group consisting of n TiC and TiN in which n is selected from one to four for stabilization at higher current load demand during maximum power operation of electric light arc furnaces.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,644,654

Dated February 22, 1972

Inventor(s) Dieter Zollner, et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, after line 20, insert the following:

1. **Higher electric current loadability.** Thus, while an ordinary graphite electrode of 20" diameter can be subjected to an electric current load of 50 kA, which by impregnation with tar and pitch prior to the graphitizing operation can be increased to nearly 60 kA, it is possible to subject a 20" wick electrode of graphite according to the invention also without impregnation to loads of 70 kA. The drawbacks of impregnated electrodes, such as increased tear danger in view of the high density and accordingly reduced thermo-shock resistance, are completely absent with the wick electrode according to the invention. Similar to the hollow electrode, the safety of operation is even considerably increased because in view of the porous wick structure, as compared to the solid electrode, the graphite electrode has also expansion possibilities with regard to the wick.

2. With the hollow electrode, the stabilizing effect is dependent on the size of the bore so that a relatively high graphite waste results from producing a sufficiently large bore. In contrast thereto, the wick electrode according to the invention gets by with very small bores. Thus, with an electrode having a diameter of 500 mm, for instance, a bore of 10 mm will suffice for producing the desired stabilizing effect.

3. The wick electrode according to the invention generates a completely quietly burning arc which has almost ideal sine voltage characteristics and thus permits very long arcs of high voltages.

4. Finally, the consumption of the solid graphite is determined by the graphite evaporation which is necessary for maintaining the electric arc and thus is proportional to the load conveyed in the electric arc. In view of the wick salts, the electric arc stabilization can be conveyed away from the graphite onto the wick salts and thus the graphite consumption can be lowered by suitable dosing. Particularly favorable re-

salts have been obtained with an electrode in which an electric arc support the mass of the wick contains a compound, such as TiC / TiN , in which n equals from 1 to 4. The formation of TiC / TiN may be obtained from titanium oxides or other titanium compounds as well as from titanium organopolymers.

As will be seen from the drawing, the electrode a of graphite has a central bore in which is provided the wick b. The mass of the wick b may consist of the compounds referred to above.

It is, of course, to be understood that the present invention is, by no means, limited to the specific disclosure set forth above but also comprises any modifications within the scope of the appended claims.

Signed and sealed this 26th day of February 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents

U

[54] **ARC FURNACE ELECTRODES**
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 [73] Assignee: **British Steel Corporation**, London, England
 [22] Filed: **Oct. 4, 1972**
 [21] Appl. No.: **294,900**

[30] **Foreign Application Priority Data**
 Oct. 19, 1971 Great Britain..... 48,594/71
 [52] U.S. Cl. 13/18
 [51] Int. Cl. **H05b 7/06**
 [58] Field of Search..... 13/18

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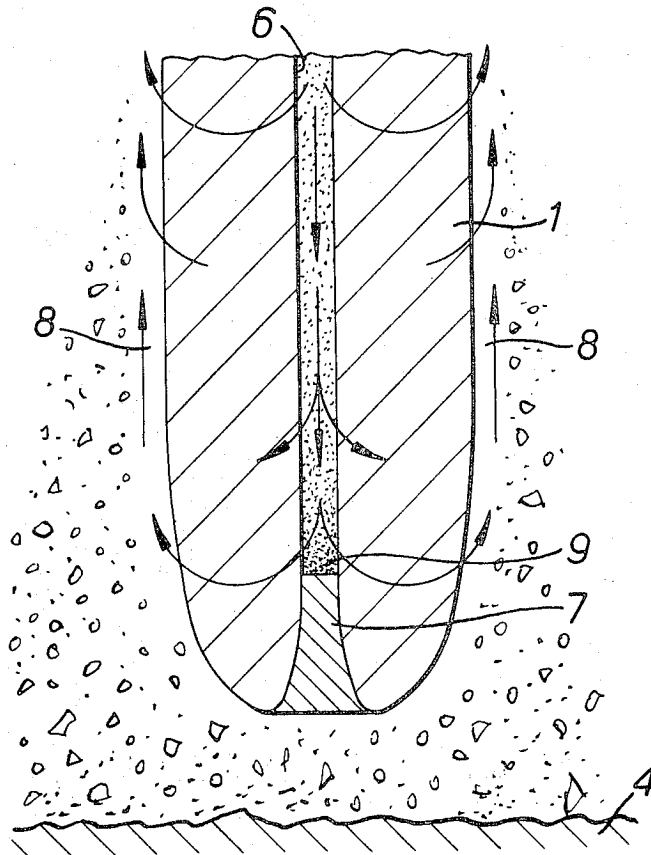
Primary Examiner—Roy N. Envall, Jr.
Attorney—Leo A. Rosetta et al.

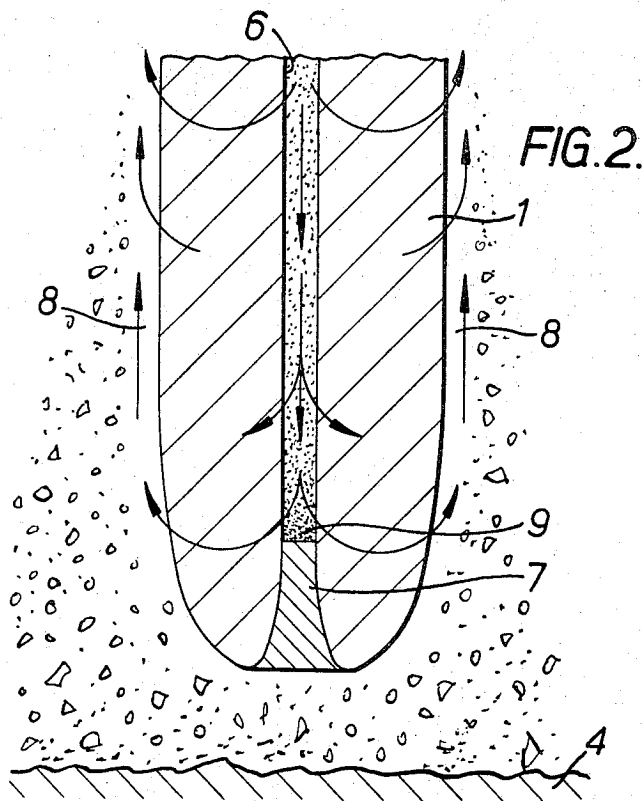
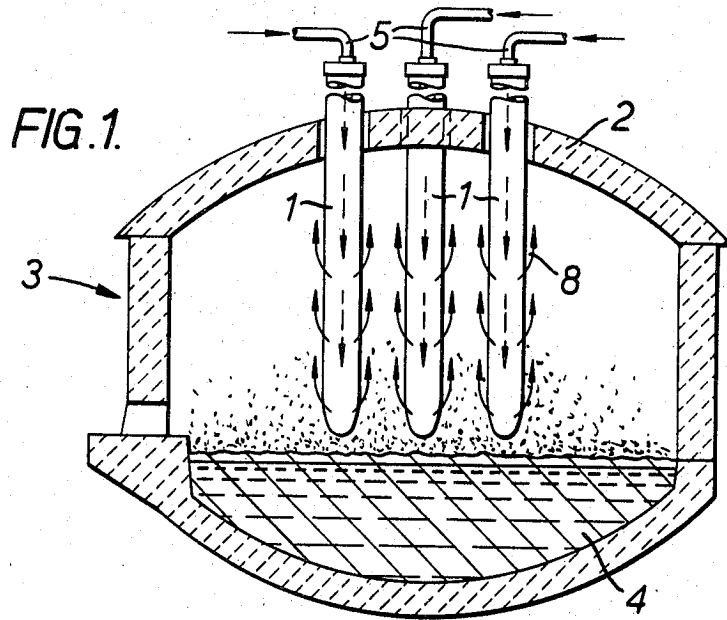
[57] **ABSTRACT**

A method of shrouding an electrode in an arc furnace by forcing nitrogen along a bore in the electrode, which is plugged at its tip, the gas diffusing through the electrode walls so as to create a protective shroud around its sides. The gas entrains along the bore a particulate carboniferous material which coagulates and fuses together and with the plug so as to constitute a growth in this plug along the bore and compensate for erosion of the electrode tip.

It is effective on both uncoated and coated electrodes - in the latter case, the gas will function to shroud only when this coating has been eroded, i.e., it serves as a secondary protective measure.

8 Claims, 2 Drawing Figures





ARC FURNACE ELECTRODES

This invention relates to an arc furnace electrode and more particularly is concerned with increasing the life of the electrode within the harsh environment of an operating furnace.

The present invention consists in a method of shrouding an electrode in an arc furnace by forcing an inert gas along an axial bore in the electrode which is plugged at its tip, the gas diffusing through the electrode walls so as to create a protective shroud around its sides and entraining along the bore a particulate material which coagulates and fuses together with the plug, so as to constitute a growth in this plug along the bore and compensate for erosion of the electrode tip.

With a graphite or carbon electrode the plug and the particulate material may be carboniferous; the gas may conveniently be nitrogen. The electrode may or may not have a non-porous oxidation-resistant protective coating on its surface. If it has the gas will function to shroud only when this coating has been eroded, i.e., it serves as a secondary protective measure. In either case, the lifetime of the electrode will be extended compared with the case where this measure is not adopted.

In particular, it is known that oxidation of arc furnace electrodes amounts to between 45 percent and 50 percent of their overall consumption. The majority of this oxidation occurs at the side surfaces of the electrodes and is attributable to the free oxygen in the furnace atmosphere. With the method according to this invention it is envisaged that the side loss rates will be reduced by up to 50 percent compared with an unprotected electrode, depending on size, the tip loss remaining substantially the same. This saving in electrode consumption far outweighs the increased cost in nitrogen consumption which, it is estimated, will be covered by a saving of only between 3 percent and 10 percent in side loss.

In order that the invention may be fully understood, one embodiment thereof will now be described, by way of example, with reference to the accompanying drawings in which:

FIG. 1 schematically illustrates a three-phase electric arc furnace; and

FIG. 2 illustrates a hollow plugged electrode through which nitrogen gas is forced in accordance with this invention.

Referring now to FIG. 1, carbon or graphite electrodes 1 extend through the roof 2 of an arc furnace generally indicated at 3 and housing a molten scrap charge 4. The electrodes are hollowed and are fed with nitrogen gas through piping 5.

In FIG. 2, one of the electrodes 1 is shown in more detail; in particular, the hollow bore 6 is terminated by a carboniferous plug 7.

In operation, as the electrodes 1 are lowered into the furnace nitrogen gas is forced through the piping 5. The gas passes along the bore 6 in each electrode and it diffuses through its sides, which are porous to this gas, so as to create a protective shroud 8 around the electrode, thus shielding it from the harsh environment in the furnace.

Since during operation the tip of the electrode is eroded as melting progresses, means must be provided for ensuring that the plug 7 at the tip remains intact, otherwise the density of the shroud is reduced and the

electrode will be more susceptible to cracking. This is effected by entraining a particulate carboniferous material in the gas stream, e.g. carbon and pitch products, which particles coagulate and fuse together at the bottom of the bore adjacent the plug (shown at 9), thus building it up.

Consequently, as the electrode tip is eroded the plug is effectively built-up, preferably at the same rate it is eroded, thus maintaining stable conditions. In practice, however, some fluctuation in the gas flow rate is realised during operation, the rate dropping as the temperature increases due to increased gas viscosity.

Although this invention has been described with reference to the particular embodiment illustrated, it is to be understood that the scope of this invention is not so restricted. For example, the method according to this invention can be used with surface coated electrodes which normally function to extend the electrode life. In this instance, the protective shroud would not be manifested until the coating has been eroded, so that the use of nitrogen gas in this manner would serve only as a secondary measure of protection. Nonetheless, it is particularly advantageous since the coated electrodes are, in practice, subject to severe erosion not only as a result of the harsh atmosphere but by physical abrasion particularly by the slag on the surface of the molten charge.

We claim:

1. A method of shrouding an electrode in an arc furnace comprising the steps of forcing an inert gas along an axial bore in the electrode which is plugged at its tip, and introducing a particulate material into the gas stream, the gas diffusing through the electrode walls so as to create a protective shroud around its sides and entraining along the bore the particulate material which coagulates and fuses together with the plug, so as to constitute a growth in this plug along the bore and compensate for erosion of the electrode tip.

2. A method according to claim 1, in which the gas is nitrogen.

3. A method of shrouding a graphite or carbon electrode in an arc furnace comprising the step of blowing an inert gas along an axially extending bore in the electrode which is plugged at its tip with a carboniferous material, and introducing a carboniferous particulate material into the gas stream, the gas diffusing through the electrode walls so as to create a protective shroud around its sides and entraining along the bore the particulate material which coagulates and fuses together with the plug, so as to constitute a growth in this plug along the bore and compensate for erosion of the electrode tip.

4. A method according to claim 3, in which the electrode has a protective oxidation-resistant coating on its side walls, the gas diffusing through the electrode walls following the erosion of this surface coating in the furnace environment.

5. A method according to claim 4, in which the gas is nitrogen.

6. A graphite or carbon furnace electrode having an axial bore therethrough, and a plug of carboniferous material within said axial bore only at the tip end of the electrode closing said axial bore only at the electrode tip, said axial bore providing a passage for introducing an inert gas into the interior of the electrode, and said plug forming a stopper at the inner end of said passage.

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7. A graphite or carbon furnace electrode according to claim 6 in which the side walls of the electrode are sufficiently porous to permit the passage therethrough of an inert gas.

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8. A graphite or carbon furnace electrode according to claim 7 in which the outer side wall of the electrode is covered with a protective oxidation-resistant coating.

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[54] CARBON ELECTRODE FOR AN ARC LAMP

[76] Inventor: Shigeru Suga, Yoyogi 5-20-2, Shibuya-ku, Tokyo, Japan

[22] Filed: Mar. 4, 1974

[21] Appl. No.: 448,049

[52] U.S. Cl. 314/60, 13/18

[51] Int. Cl. H05b 31/06

[58] Field of Search 13/18; 314/60; 313/355; 219/146

[56] References Cited

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Primary Examiner—R. N. Envall, Jr.
Attorney, Agent, or Firm—Wenderoth, Lind & Ponack

[57] ABSTRACT

A carbon electrode for an arc lamp used as a light source for apparatus for measuring fading and weathering of such materials as paints and fabrics. The electrode is a carbon electrode bar coated with aluminum or an aluminum alloy on all the peripheral surface thereof except the discharge tip. The electrode bar can be further coated with a film of aluminum oxide or silicon oxide other than at the discharge tip and the electrode holding section.

1 Claim, 12 Drawing Figures

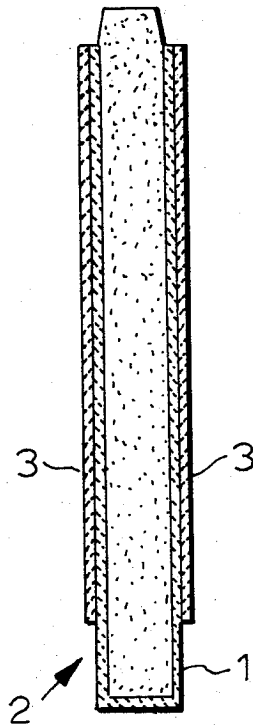


FIG. 1

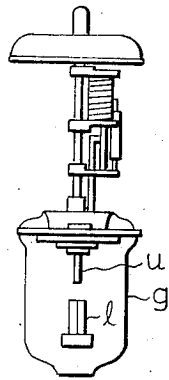
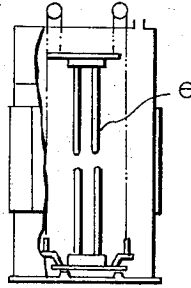
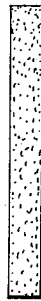
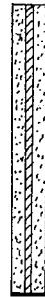


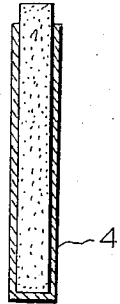
FIG. 2



(PRIOR ART)



(PRIOR ART)



(PRIOR ART)

FIG. 3a. FIG. 3b FIG. 3c

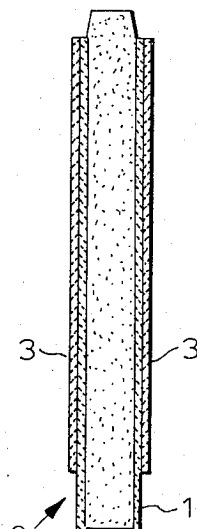
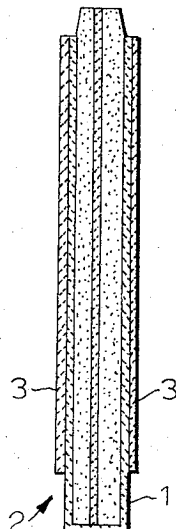


FIG. 4a FIG. 4b FIG. 4c FIG. 4d

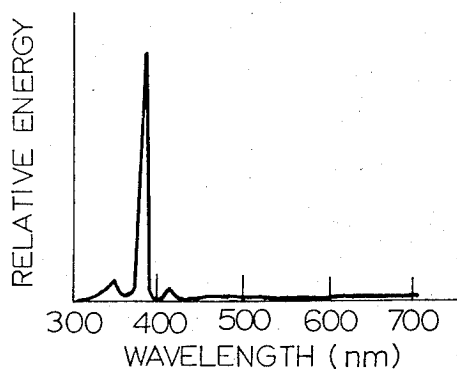


FIG. 5a

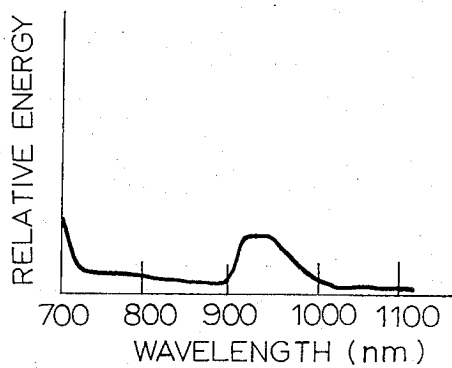


FIG. 5b

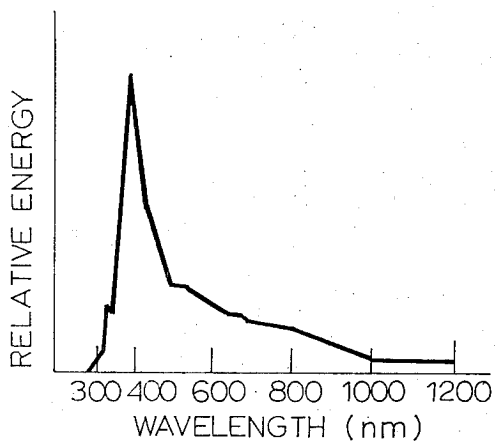


FIG. 6

CARBON ELECTRODE FOR AN ARC LAMP

BACKGROUND AND BRIEF DESCRIPTION OF THE INVENTION

This invention relates to a carbon electrode for an arc lamp used in fading or weathering tests of materials such as paints or fabrics.

A sunshine carbon arc lamp used for fading and weathering meters is shown in FIG. 1, and an ultra-violet carbon arc lamp used for such meters is shown in FIG. 2. The ultra-violet arc lamp is intended chiefly to produce ultra-violet light, and has an upper carbon electrode μ and a lower carbon electrode l , both of which are uncoated. The conventional carbon electrode used with such ultra-violet arc lamps consists merely of a cored or a non-cored carbon electrode bar as shown in FIGS. 3b and 3a. They are adapted to discharge the current in a satisfactorily sealed glass globe. The arc lamp is kept in a state of stable luminance over a prolonged combustion period. If the globe is not sealed tightly, the combustion may proceed too rapidly, and a large amount of infra-red radiation may be omitted on account of high temperature of the electrode. The sunshine carbon arc lamp is fitted with a ventilating blower for removing the cinders and exhaust gases produced by the current discharge. The carbon electrode l used with this arc lamp, as shown in FIG. 3c, is usually coated with copper 4 on all of its peripheral surface except the discharge tip to reduce the heating of the electrode, but toxic copper fumes or copper oxide may be produced and be present in the exhausted gas. In addition the thickness of the film can not be controlled so as to be uniform because the copper film is usually deposited on the carbon electrode by plating or a similar operation.

The object of this invention is to obviate the above defects inherent in the conventional carbon electrodes and to provide a carbon electrode for use with carbon arc lamps and comprising a carbon electrode bar coated with aluminum or aluminum alloy on all the peripheral surface thereof except the discharge tip, and which can further be coated with a film of aluminum oxide or silicon oxide on the peripheral surface thereof other than said discharge tip and the electrode holding portion, whereby carbon consumption can be reduced and the carbon electrode will produce a satisfactory spectrum of radiations for fading or weathering tests.

BRIEF DESCRIPTION OF THE FIGURES

This invention will now be described by referring to an embodiment thereof shown in the accompanying drawings, in which:

FIG. 1 is a diagrammatic elevation view of the structure of a sunshine arc lamp;

FIG. 2 is a similar view of an ultra-violet arc lamp;

FIG. 3a-3a are sectional views of conventional carbon electrodes;

FIG. 4a-4d are sectional views of the carbon electrodes of the present invention;

FIGS. 5a and 5b are graphs showing the spectrum of an arc lamp using the ultra-violet carbon electrode according to the invention coated with aluminum or aluminum alloy film, FIG. 5a showing the ultra-violet and visible light ranges and FIG. 5b showing the infra-red range with the energy value magnified by 20 times to make the energy value in said range more apparent; and

FIG. 6 is a graph showing the spectrum of an arc lamp using the dual coated sunshine carbon electrode according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

The carbon electrode of this invention for use with carbon arc lamps consists of a carbon electrode bar 10 coated with a coating 1 of aluminum or an alloy predominantly of aluminum on all the peripheral surface thereof except the discharge tip. The electrode bar can be uncored as in FIG. 4a or cored as in FIG. 4b. According to a modification, the aluminum or aluminum alloy coating on the electrode bar can be further coated with a coating of aluminum oxide or silicon oxide 3 on the surfaces other than the electrode holding portion 2. The electrode bar can be cored as in FIG. 4c or uncored as in FIG. 4d. The aluminum or aluminum alloy coatings can be deposited by any convenient method, as for instance by spray ejecting molten metal with the aid of compressed air, or placing the aluminum or aluminum alloy coating around the carbon rod and bonding the coating to the rod with an electrically conductive adhesive, or metallizing metal particles under a vacuum. The aluminum oxide or silicon oxide film can also be deposited by any convenient method, as for instance by spray ejecting the aluminum or silicon with a plasma torch or an oxyacetylene torch.

The thickness of the aluminum and aluminum alloy coating, and the thickness of the aluminum oxide or silicon coating should be 0.05 - 0.5 mm. An example of the composition of the aluminum alloy is aluminum 99.85% - silicon 0.15%.

Turning first to the carbon electrode consisting of a carbon bar coated with an aluminum or aluminum alloy coating, the discharge current flows through the aluminum or the aluminum alloy coating which has a smaller electrical resistance than the carbon, and the electrode itself will thus be heated to a minimum degree. Thus, when the lamp is kept lighted, due to the presence of the coating, the carbon rod will be subjected to less oxidation than an uncoated rod because it is protected from the ambient air, and the carbon consumption will be reduced accordingly.

FIGS. 5a and 5b show the spectrum of the luminous ultra-violet carbon electrode coated with aluminum or aluminum alloy. As seen from these FIGS., the energy value in the ultra-violet range known to cause the deterioration of the carbon electrode is about the same as that observed for a conventional ultra-violet carbon electrode, but the energy value in the infra-red range is lower than that observed for the conventional electrode. The radiation responsible for the deterioration of the test specimen in a fading and weathering test is the ultra-violet light, and the energy in the infra-red range has, in general, the effect of raising the temperature of the test specimen.

If the energy of the radiation in the infra-red wavelengths is low, the radiant heat received by the test specimen can be reduced, and the test can be conducted at a lower temperature, which is desirable because a higher energy in said radiation may cause excessively high temperatures and consequent inaccurate test results. For this reason, the carbon electrode according to this invention is highly suited for use as a light source in apparatus for conducting fading and weathering tests. In the spectrum of the sunshine carbon electrode, not shown, the energy emitted by the

electrode in the ultra-violet range is about the same as that emitted by the conventional carbon electrode, but the energy emitted by the former electrode in the infra-red range is generally low, and hence the electrode can be used advantageously as light source for fading or weathering tests. During light emission from the sunshine carbon arc lamp at the time of current discharge an air stream is passed over the electrode, thus resulting in dispersion of cinders and exhaust gases which are generated. With the conventional copper-coated carbon electrode, toxic copper fumes or copper oxide are apt to be produced and scattered in the ambient atmosphere. This situation can be avoided by the use of the present carbon electrode.

The carbon electrode further coated with aluminum oxide or silicon oxide has the same advantages as described in the foregoing, and also has an additional advantage that, as the discharge tip of the electrode is consumed during the current discharge and the aluminum coating is gradually heated and starts to melt, the melted aluminum metal will not be peeled from the carbon electrode immediately, but is combined with the aluminum oxide or silicon oxide, the melting points of which are higher than the melting point of the metallic aluminum, into a vitreous ceramic substance at the prevailing high temperature. The vitreous ceramic substance so formed is not scattered into the ambient air, but descends gradually under the effect of gravity. In addition, any abnormal discharge from the side surfaces of the electrode can be avoided during the current discharge due to the elevated electrical resistance of the aluminum oxide. It has also been discovered that the life of an arc lamp using the carbon electrode according to the invention is increased by about 20 percent over that of the arc lamp using a conventional electrode. It should also be mentioned that the exhaust gas is composed of non-toxic aluminum, aluminum oxide and silicon oxide, which is a great advantage in overcoming the problem of pollution.

FIG. 6 shows the spectrum of a sunshine arc lamp having the dual coated carbon electrode according to the invention. The spectrum of the ultra-violet part is

about the same as that shown in FIG. 5a.

As described above, when used as light source in an apparatus for carrying out fading and weathering tests, the carbon electrode for arc lamps according to this invention has the following advantages,

1. Owing to the lower electrical resistance of aluminum metal, the heating of the electrode due to the discharge current is reduced, while insulation against the external heat is provided by the aluminum oxide or silicon oxide film, thus preventing carbon consumption caused by oxidation with ambient air, and increasing the time over which combustion takes place.
2. The reduced energy value in the infra-red range observed in the spectrum makes it possible to conduct fading or weathering tests at the desired lower temperatures.
3. The cinders formed by combustion consist mainly of nontoxic aluminum oxides and silicon oxides.
4. The emitted light is stable since the aluminum oxide and silicon oxide are nonconductive and the discharge occurs solely at the tip of the electrode.
5. The dispersion of aluminum metal and hence the contamination of the glass filter and reduction in its transmittance is avoided due to the dual coating on the carbon electrode, and the volume of light is kept constant during the test period.

What is claimed is:

1. A carbon electrode comprising:
 - a carbon electrode bar having at one end thereof a discharge tip and having at the other end thereof an electrode holding section;
 - a first coating on all the peripheral surfaces of said bar other than said discharge tip, said coating material being from the group consisting of aluminum and alloy consisting predominantly of aluminum; and
 - a second coating of material taken from the group consisting of aluminum oxide and silicon oxide coating all the peripheral surfaces of said bar other than said discharge tip and said electrode holding section.

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[54] LONG-LIFE CARBON ELECTRODES FOR WEATHER TESTER AND THE LIKE

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[22] Filed: Oct. 7, 1974

[21] Appl. No.: 512,882

[52] U.S. Cl. 313/354; 314/60

[51] Int. Cl. H05b 31/10; H01j 1/02

[58] Field of Search 313/354, 357; 13/18; 314/60

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Primary Examiner—Alfred E. Smith

Assistant Examiner—Wm. H. Punter

Attorney, Agent, or Firm—Wenderoth, Lind & Ponack

[57] ABSTRACT

Improved carbon electrodes for use in a carbon arc lamp are disclosed. The improved electrodes, which are utilized in pairs, have a diameter ratio of the upper to lower electrodes within the range of 1.4 - 1.6 : 1. The electrodes consist of a core section, a carbonaceous portion surrounding the core section and a layer of material covering the carbonaceous portion. The ratio of the sectional area of the carbonaceous portion to that of the core portion in the upper carbon electrode should be within the range of 9 - 14 : 1 with the ratio in the lower carbon electrodes being within the range of 5 - 9 : 1. Electrodes produced according to the subject invention provide spectroscopically stabilized light at a discharge voltage and current of 50 volts and 60 amps., and have improved long life performance.

1 Claim, 9 Drawing Figures

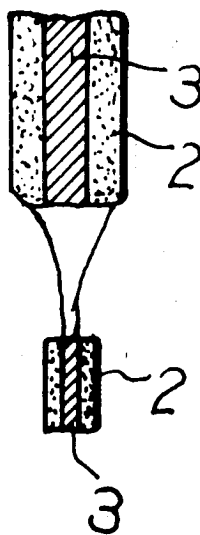


Fig. 4

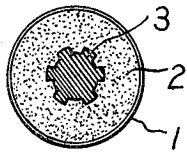


Fig. 3

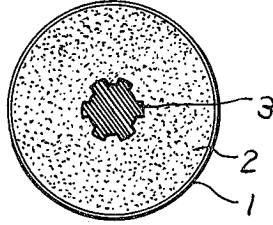


Fig. 2

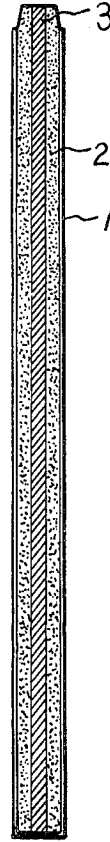


Fig. 1

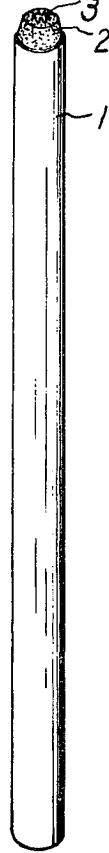


Fig. 8

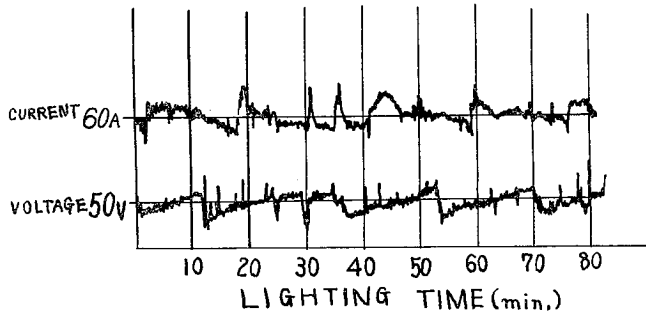


Fig. 9

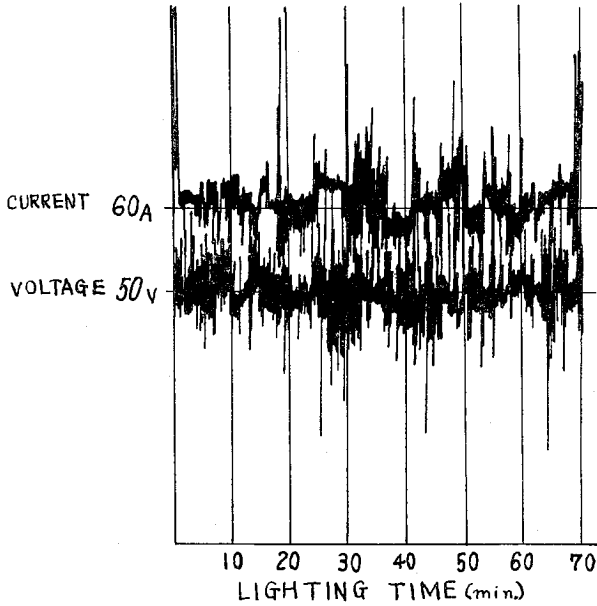
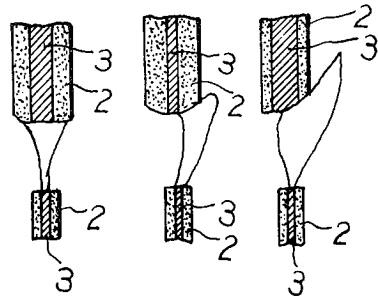


Fig. 7 Fig. 6 Fig. 5



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LONG-LIFE CARBON ELECTRODES FOR WEATHER TESTER AND THE LIKE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The subject invention relates to improvement in the carbon electrodes which are used in carbon arc lamps for weather testers or climatic testing machines and the like.

2. Description of the Prior Art

Arc lamps for weather testers and the like typically comprise four sets of vertically arranged carbon electrodes which are energized by, for instance, a servo motor at a voltage and current of 50 volts and 60 amperes, respectively, to light the lamp. A specimen being tested is placed around the arc lamp for testing. Each of the carbon electrodes include a core portion made of a luminous material such as cerium fluoride and has a gear-shape configuration with the number of teeth ranging from 6 to 12. A carbonaceous portion surrounds the core portion of the carbon electrode and a layer of copper or the like coats the carbonaceous portion.

Commonly used carbon electrodes have lengths of approximately 305 mm. with upper electrode diameters of 23 mm. and lower electrode diameters of 13 mm. An assembly of four sets of upper and lower carbon electrodes, when continuously activated, has a functional life of approximately 20 to 22 hours.

The life of the carbon electrode can be doubled by doubling its length. This, however, necessitates a corresponding enlargement of the arc lamp control mechanism, lamp housing and other elements and creates problems of economy. Another known manner of prolonging the life of the carbon electrode is to increase the diameter thereof. However, if the carbon volume is doubled, that is, if the diameter is increased 1.41 times by, for instance, increasing the outer diameter of the upper carbon electrode from 23 mm. to 32.5 mm. and the diameter of the lower carbon electrode from 13 mm. to 18 mm., the life of the electrode is only increased 1.6 times. This is partially attributable to the fact that the relation between the sectional area of the core portion and that of the carbonaceous portion therearound is not suited to the discharge pattern of the electrode.

SUMMARY OF THE INVENTION

It is a primary object of the subject invention to produce improved carbon electrodes for use in a carbon arc lamp having a longer useful life than heretofore obtainable with conventional carbon electrodes.

It is a further object of the subject invention to provide improved carbon electrodes for use in a carbon arc lamp having spectroscopically stabilized light at a discharge voltage and current which is comparable to that normally found in weather testers and the like.

The above objects are achieved in accordance with the present invention by the provision of upper and lower electrodes wherein the diameter ratio of the upper and lower electrodes is within the range of 1.4 - 1.6 : 1.0. Moreover, the ratio of the sectional area of the carbonaceous portion to that of the core portion in the upper carbon electrodes should be within the range of 9 - 14 : 1 with the ratio in the lower carbon electrodes within the range of 5 - 9 : 1. A carbon arc lamp having electrodes produced in accordance with the

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above noted specification is capable of continuously producing spectroscopically stabilized light for a time period in excess of 24 hours. In addition, upper and lower carbon electrodes produced in accordance with the subject invention also have similar ratios of combustion to length.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the invention will be described in more detail below with reference to the accompanying drawings wherein:

FIG. 1 is a partial prospective view of an electrode produced in accordance with the present invention;

FIG. 2 is a longitudinal sectional view of FIG. 1;

FIG. 3 is a cross-sectional view of an upper carbon electrode produced in accordance with the subject invention;

FIG. 4 is a cross-sectional view of a lower carbon electrode produced in accordance with the subject invention;

FIGS. 5, 6 and 7 are sectional views showing discharge patterns between upper and lower electrodes having various sectional configurations;

FIG. 8 is a chart depicting the operability of the device of FIG. 7; and

FIG. 9 is a chart depicting the operation of the electrode assembly shown in FIG. 6.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, reference numeral 1 indicates the copper coating or layer which covers the carbon electrodes. The carbonaceous portion is indicated by reference numeral 2 and the core portion, filled with a luminous material stabilizer is indicated by reference numeral 3. This 3-layered configuration is known in the art. However, the specific ratios of area which will be disclosed hereinbelow have neither been suggested nor disclosed in the prior art and produce new, useful and unobvious results as compared with the results obtained by conventional electrodes.

FIGS. 5, 6 and 7 disclose electrode combinations of upper electrodes respectively, having a large core portion, a medium core portion, and a small core portion while utilizing identical lower electrodes. When arc lamps using the respective combination of upper and lower electrodes are lighted, the discharge pattern shown in FIGS. 5 through 7 are produced. If a large core is used, a large discharge arc is produced, which causes rapid wear of the electrode since the carbon portion is thin as may be seen in FIG. 5. On the other hand, if the core is small the discharge arc is produced at the carbon portion, off the core, and the arc moves unstably, as shown in FIGS. 6 and 9. When the core is medium in size (having a matched diameter), a correct arc is produced between the upper and lower carbon electrodes and very stable light is produced. This is particularly shown in FIGS. 7 and 8.

In view of the above noted data, the carbon portion must be increased to prolong the life of the electrode and the core size must be slightly enlarged to stabilize the emitted light. This may be accomplished by designing electrodes having specific ratios of core portion sectional areas to carbonaceous portion sectional areas.

Applicant has determined that the ratio of the carbon portion sectional area and the core portion sectional

area should preferably be within the range of 9 - 14 : 1 for the upper carbon electrode and the lower carbon electrodes should have a corresponding ratio of 5 - 9 : 1. Furthermore, the ratio of the outer diameter of the upper carbon electrode to the outer diameter of the lower carbon electrode should be within the range 1.4 - 1.6 : 1 to produce optimum results.

The following Table presents a comparison of structure and performance of typical prior art carbon electrodes with carbon electrodes produced according to the teachings of the present invention.

	Carbon electrodes of prior art		Carbon electrodes of present invention	
	Upper	Lower	Upper	Lower
Diameter (electrodes)	23 mm	13 mm	35 mm	23 mm
Ratio (upper/lower)	1.77		1.52	
Coaw (sectional area)	70.8 mm ²	23.7 mm ²	70.8 mm ²	58.6 mm ²
Carbonaceous portion (sectional area)	344 mm ²	109 mm ²	891 mm ²	356 mm ²
Ratio of sectional area carbon/core	4.85	4.59	12.6	6.0
Copper coating	about 0.1 mm thick		about 0.1 mm thick	

The efficacy of the subject invention has thus been confirmed by experimental data. In a preferred embodiment, it was established that long life and most stable light can be obtained by using upper carbon electrodes having a diameter of 35 mm. and in which the sectional area ratio of the carbonaceous portion to the core portion is approximately 12 : 1 and in which the lower carbon electrodes have a diameter of 23 mm. and a corresponding ratio of 6 : 1.

As noted earlier, it is quite desirable that carbon arc lamps used for weather testers and the like have a long continuous lighting capability. The subject invention has succeeded in extending the functional capabilities of carbon electrodes from the conventional 20 to 22 hours to more than 40 hours. Not only does this result in great economy, but it also permits operation of testing devices during holiday and the like when maintenance personnel are otherwise unavailable.

It will be apparent to those skilled in the art that many modifications of the above specifically described apparatus may be made without departing from the spirit and scope of the present invention.

I claim:

1. In a carbon arc lamp for use in weather testers and the like and including pairs of upper and lower electrodes, each of said upper and lower electrodes comprised of a core portion formed of a luminous material, a carbonaceous portion surrounding said core portion and a layer of copper or like material positioned over

30 said carbonaceous portion, the improvement which comprises the diameter ratio of the upper to the lower electrodes being within the range of 1.4 - 1.6 : 1.0, and the ratio of the sectional area of the carbonaceous portion to that of the core portion in the upper carbon electrodes being within the range of 9 - 14 : 1 with the ratio in the lower carbon electrodes being within the range of 5 - 9 : 1, whereby an improved carbon electrode combination is provided in which the upper and lower carbon electrodes have the same rate of combustion to length and can provide spectroscopically stabilized light at a discharge voltage and current of 50 V and 60A respectively, normally used in weather testers, and which also has improved long-life performance in excess of 24 hours of continuous lighting.

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[54] **DIRECT CURRENT ELECTRIC ARC FURNACE AND METHOD FOR MELTING METAL SCRAP**

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[22] Filed: **Nov. 16, 1973**

[21] Appl. No.: **416,400**

[30] **Foreign Application Priority Data**

Nov. 17, 1972 Sweden..... 14953/72

[52] U.S. Cl. 75/10 R; 13/9

[51] Int. Cl.² C22B 4/00; H05B 7/18

[58] Field of Search 13/9; 75/10-12

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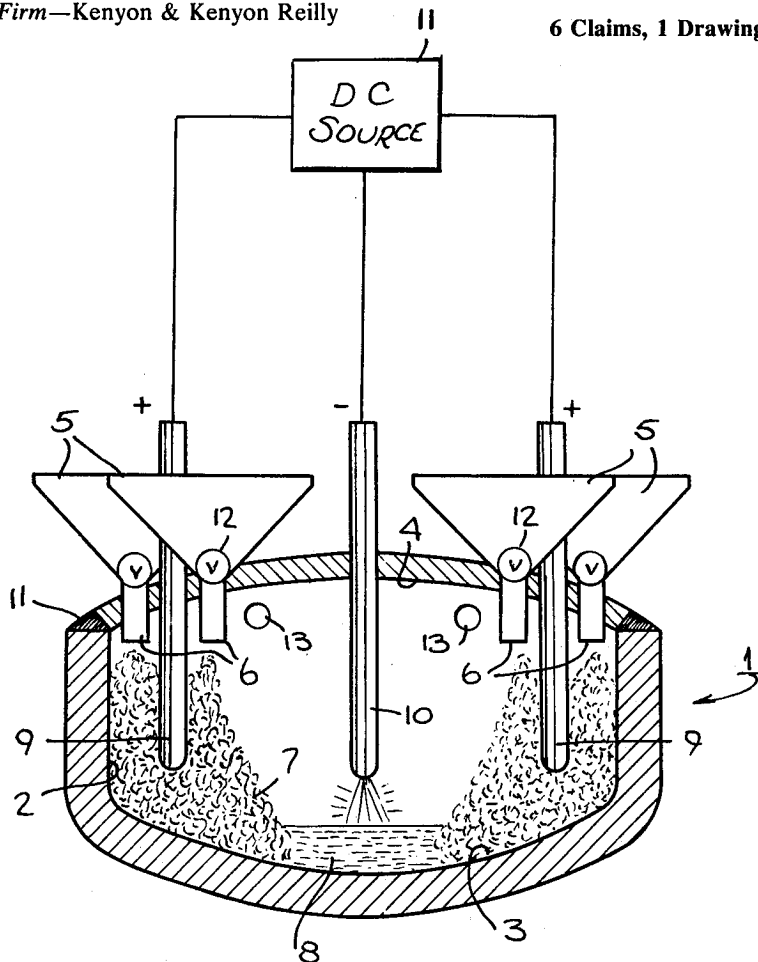
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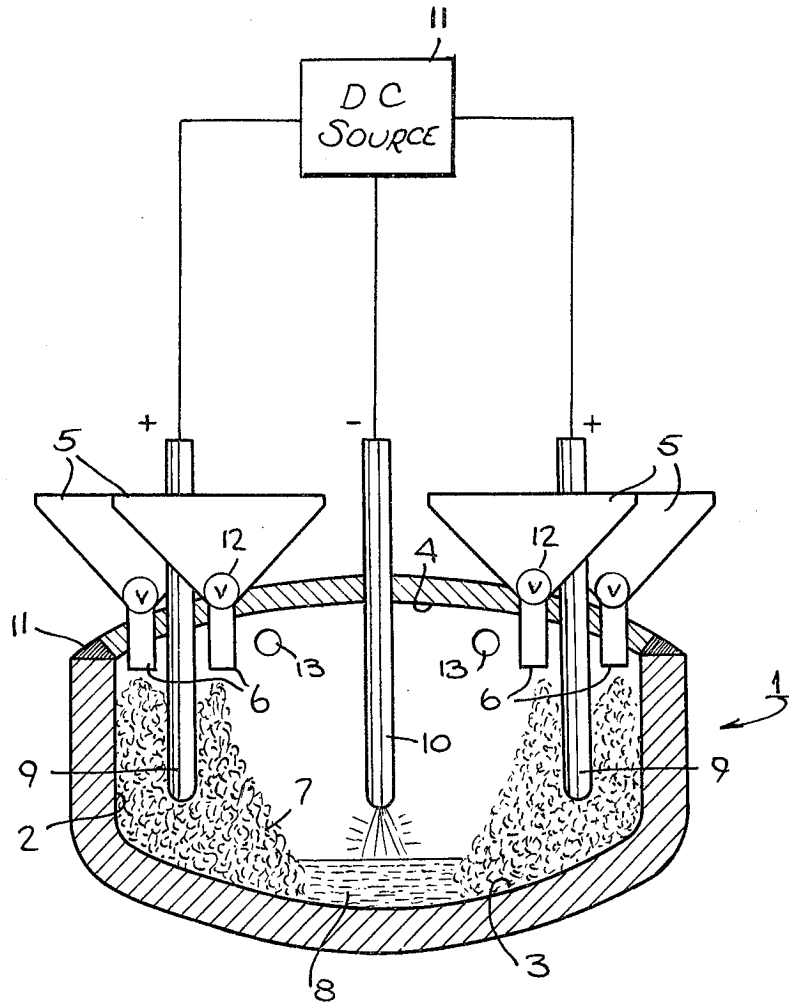
Primary Examiner—Peter D. Rosenberg
 Attorney, Agent, or Firm—Kenyon & Kenyon Reilly Carr & Chapin

[57] **ABSTRACT**

For direct current electric arc furnace melting of metal scrap a furnace includes a vessel having a bottom wall shaped so that a portion of the melt is collected in the latter after initial melting or introducing of molten metal to start the operation. This vessel has means for feeding scrap in pieces to the peripheral portion of the bottom wall to form at that location an annular pile, or one or more separate piles, of unmelted scrap contacting and electrically connecting with the melt but extending upwardly to a level above the melts level. An electrode is positioned vertically with an arcing and maintained above the level of the melt to form an arc therebetween, this electrode being spaced from the pile or piles of scrap when the operation has started. The melt is made an anode by maintaining a positive electrical connection from a DC power source with the pile or piles of scrap at a position above the level of the melt so that the current passes through the unmelted scrap, with consequent heating of the scrap while magnetically tending to keep it piled, and through the melt and via an arc to the arcing electrode, the latter being negatively connected with the power source. The arcing electrode is made of carbon and in the described way enjoys the advantages of operating as a cathode without requiring an arcing anode electrode or an electrically conductive vessel bottom. More than one negatively connected arcing electrode may be used.

6 Claims, 1 Drawing Figure





DIRECT CURRENT ELECTRIC ARC FURNACE AND METHOD FOR MELTING METAL SCRAP

BACKGROUND OF THE INVENTION

Today, metal scrap, particularly steel scrap, is usually melted in a furnace powered by three-phase alternating electric current and using three carbon electrodes, one for each phase, the charge forming the zero point in the three-phase system. The arcs formed between the electrodes and the metal charge in the furnace, are free or direct arcs extending between the electrodes and the metal in the furnace.

Heretofore, the use of direct current has required at least two carbon electrodes respectively of positive and negative polarity, to form direct or free arcs between the electrodes and the metal. This means that one electrode operates as a cathode and the other operates as an anode with respect to the melt. If a single electrode is used, the hearth supporting the metal must be made electrically conductive which has disadvantages from the construction, installation and operating viewpoints. In all such instances, a plurality of electrodes may be used having the same polarity so that they function like a single electrode.

SUMMARY OF THE INVENTION

The object of the present invention is to provide a direct current electric arc furnace and method for melting metal scrap using one or more carbon or graphite electrodes operating as a cathode and forming direct or free arcs between their ends and the charge, without requiring an electrically conductive hearth or the use of one or more other carbon arcing electrodes which must operate as an anode.

Such a furnace is desirable because by using one or more carbon electrodes powered by direct current and operating as a cathode, as compared to their operation as an anode, and as compared to the alternating current type furnace, the following advantages are obtained:

1. Less electrode consumption
2. More stable arcs
3. More efficient heat transfer to the charge
4. Less wear on the furnace lining

According to the present invention, for direct current electric arc furnace melting of metal scrap, particularly steel scrap, for example in small pieces, a suitable vessel is used, normally cylindrical, having a bottom wall of hearth shaped so that at least a central or otherwise chosen portion of the melt is collected in the latter during operation of the furnace, and the vessel, normally having a closed top or cover, is provided with means for feeding the scrap charge to the peripheral portion of this hearth to form an annular pile, or one or more separate piles, of unmelted scrap physically contacting end electrically connecting with the melt and extending upwardly to a level above the latter's level. One or more cathode carbon or graphite arcing electrodes, negatively connected with a suitable DC power source, are positioned, normally vertically, above the level of this charge or melt in arcing relation therewith and spaced from the unmelted scrap. The hearth is shaped so that the scrap can be plied at a position where it is in electrical contact with the melt by physical contact therewith, and the positive electrical connection with the DC power source is made through the scrap so that the current travels through the latter for at least some distance before reaching the melt from

which the arc then jumps to the cathode electrode or electrodes. Preferably this electrical connection with the scrap is effected by one or more vertical non-arcing electrodes arranged adjacent to the periphery of the vessel's bottom wall or hearth and its side wall and which extend vertically into the pile of scrap far enough to establish good electrical contact with the scrap but so that the bottom end or ends of the electrode or electrodes are maintained always above the rising level of the melt. The last-mentioned electrodes with the surrounding pile will be positively connected to the DC source and will be acting as anodes.

When the furnace is in operation, the current travels through the unmelted metal scrap, heating it by electrical resistance heating and magnetically causing it to tend to cling to the positive electrode, and to the melt and via the arc to the cathode electrode or electrodes.

The result is that all arcing carbon electrodes operate as a cathode with the attendant advantages previously described, freed from the complications of an electrically conductive hearth and without the necessity for one or more of the carbon electrodes operating as an arcing anode electrode having none of the advantages described. All the positively connected electrodes are in contact with solid charge and will not act as arcing electrodes where said advantages were not present.

BRIEF DESCRIPTION OF THE DRAWING

The accompanying drawing schematically shows in vertical section one example of a furnace embodying the principles of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring to this drawing, the vessel 1 has a cylindrical side wall 2 and a concave bottom wall or hearth 3. The top of the vessel is closed by a cover 4. A plurality of hoppers 5 lead to ducts 6 extending vertically down through the cover 4 adjacent to the periphery of the bottom wall or hearth 3 and adjacent to the side wall 2. The furnace is charged via these hoppers and spouts so as to form an annular pile of solid or unmelted scrap 7, the central portion of the concave hearth 3 containing at least a portion of the melt 8.

The scrap should be in the form of small enough pieces to permit the charging and the formation of the annular pile of unmelted scrap. Separate piles may be formed beneath each spout, but the annular form has advantages. Also, the concavity or other shape that may be used for the bottom wall or hearth 3 should be such as to permit the formation of the pile or piles of unmelted scrap as well as the formation and maintenance of the centralized (or otherwise located) melt or pool of molten metal 8.

A plurality of non-arcing electrodes 9 are passed through the roof 4 far enough to project into the pile or piles of unmelted scrap 7 to form good electrical contact with the latter but so that the lower ends of these electrodes are always spaced above the level of the melt 8. A single carbon arcing electrode is shown at 10, this being vertically passed through the roof 4 with its lower end positioned to form an arc 10a extending to it from the melt 8. More than one of these electrodes 10 may be used if electrically interconnected with the same polarity, vertically positioned as are the non-arcing electrodes 9. The arcing electrode 10 is a carbon or graphite electrode and the non-arcing electrodes 9 may also be carbon or steel electrodes or of other conductive material. In all instances these may be elec-

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trodes made from carbon in graphite form such as are used for electric arc metallurgical furnaces in general, recognizing that the electrode or electrodes 10 may possibly include elements intended for possibly subsequent metallurgical processing of the metal scrap as suggested hereinafter.

As shown, the electrodes are connected with a source of direct electric current 11 so that the non-arcing electrodes 9 are of positive polarity while the arcing electrode or electrodes 10 are of negative polarity to operate as a cathode.

The non-arcing electrodes 9 may form an annular series of uniformly interspaced electrodes. They should extend far enough into the unmelted scrap to reduce the electrical contact resistance to the lowest possible minimum. Although not illustrated, the melt 8 during melting of the scrap may extend beneath the bottom of the pile 7, but the bottom ends of the electrodes 9 should be maintained always spaced above the level of the melt 8. The spacing should be such as to avoid arcing between the bottom ends of the non-arcing electrodes 9 and the melt because if this occurred the electrodes 9 would operate as arcing anodes. As shown, the non-arcing electrodes 9 function only as electrical conductors capable of resisting the high temperatures involved by the furnace operation.

The current goes radially inwardly through the scrap 7 to the centrally located melt 8 and via the arc 10a to the electrode 10 with the latter enjoying the advantages previously stated.

The furnace of this invention may be designed for batch or continuous operation. When batch operated, the furnace is charged so that the pile 7 extends into the central portion of the hearth 3. The arc is struck and the melting begins. When the pile 7 reduces to the point where there is a risk of either an excessively high electrical resistance or an open circuit or arcs from the electrodes 9, the melt 8 correspondingly increasing, the operation is stopped, the melt is tapped, wholly or partially, the furnace is recharged to again form the highest possible pile of the scrap 7 and the furnace operation renewed. Together with the surrounding solid charge 7 these electrodes 9 are acting as anodes, but not as arcing electrodes.

The furnace may be designed to be tapped centrally with respect to the hearth 3 so that continuous scrap charging is possible. Possibly the furnace may be designed as a tilting furnace having a side tapping spout or opening with the melt flowing through any remaining unmelted scrap representing the residue of the pile 7. These details are not shown because their design should be within the ability of any person of skill in this art.

It may be desirable to operate the furnace so that the melting proceeds under some atmosphere other than air, such as a suitable inert atmosphere. In such an instance the cover or roof 4 may be sealed with the vessel 1 as schematically indicated at 11, and the electrodes may be passed through this cover in the same fashion they are in the case of arc furnaces operated under either a vacuum or as containing a gas, this applying correspondingly to the spouts 6 of the hoppers 5. In this case the hoppers 5 would be provided with suitable valves 12 which are open for charging and thereafter closed, and the furnace may be provided with one or more ports 13 for evacuation and/or gas filling purposes.

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Electrical engineering knowledge is available for designing the furnace to determine the height of the pile 7 relative to the space confined by the vessel 1 and its cover, and the distribution of this pile, to obtain a substantial production of heat from the electrical resistance the pile offers to the current passing from the non-arcing electrodes 9 to the melt 8 and via the arc 10a to the arcing cathode electrode 10. Thus, in carrying the current so that the non-arcing electrodes 9 need not operate as arcing anodes, the electrical resistance involved by the pile of scrap 7 results in a useful heat input to the furnace. The major heating is, of course, via the arc or arcs 10a depending upon whether or not one or more of the arcing electrodes 10 are used, while the nature of scrap metal in small pieces serves mainly to keep the scrap in piled condition.

The electrical resistance involved by the passage of the current through the pile of scrap 7 has another advantage, as explained below.

In the case of any electric arc the current/voltage characteristics of the arc are such that increasing current causes a reduced voltage drop in the arc. This requires the use of ballast in the electric circuit. With the present invention this ballast is wholly or partially provided by the electrical resistance of the scrap, instead of by an external resistance somewhere in the circuit of the power system where the ballast heat must be dissipated uselessly and lost. When alternating current must be converted to direct current to operate any direct current electric arc furnace, without a suitable ballast the alternating current power supply may suffer an undesirable power factor whereas with the present invention with the ballast automatically provided by the scrap 7, with the resulting heat being used to advantage, with proper design of the furnace the alternating current power system need not have its power factor unduly affected by the furnace operation.

It is possible to start the operation of the furnace by first charging a small amount of molten metal to initially form the pool 8 with the pile or piles of scrap charged as described. After melting a judicious amount of the unmelted scrap or charge, the furnace may be tapped but allowed to retain some of the molten melt. This operation may be continued repetitiously. In all events, the unmelted scrap is initially heated not only by the electric resistance previously described, but by the heat radiated by the arc 10a directly inwardly into the unmelted scrap, this promoting more rapid melting. This also protects the side wall of the vessel 1 because the pile of scrap may be formed as an annulus or shield between the arc heat and this side wall.

Throughout the foregoing, the concept has been to melt scrap metal, particularly steel scrap, but the furnace and the principles of its operation may be used for melting any electrically conductive material capable of being piled. In the case of steel scrap the melt would normally be further refined by any suitable steel refining method and equipment.

However, assuming that all of the electrodes are carbon or graphite electrodes, the furnace may also be used for refining. In such an instance, when the pile of scrap 7 has been melted down as fully as possible, the polarity of the electrodes may be reversed with the positive and negative electrodes then operating in series as arcing electrodes, the electrode or electrodes 10 then being the anode and permitting the refining operation to proceed. This involves rapid loss or burn-off of

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the electrode or electrodes 10 but this is to be expected in the case of a steel refining operation.

In all cases the non-arcing electrodes 9 and arcing electrodes 10 may be vertically moved up and down by using normal electric arc electrode position controlling equipment (not shown). The equipment required to feed the scrap, in particle or piece form, into the vessel 1 may be designed in the same manner as is equipment used for making furnace additions to electric arc metallurgical refining furnaces providing they are properly located to form the annular pile of material previously described.

What is claimed is:

1. A direct current electric arc furnace for melting metal scrap, comprising means for containing a molten scrap melt and a charge of unmelted scrap in electrical contact with this melt, said scrap extending from this melt to a location free from said melt, at least one carbon electrode positioned to form an open arc between this electrode and said melt, a direct current power source and means for electrically conducting direct current from said source to said unmelted scrap at said location and through said unmelted scrap and melt and an arc, to said electrode so that the said electrode operates as a cathode.

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2. The furnace of claim 1 in which said containing means comprises a vessel having a side wall and a bottom wall shaped so that at least a portion of said melt is maintained centrally thereon, said vessel having means for feeding said charge to the peripheral portion of said bottom wall to form a pile of unmelted scrap contacting said portion and extending upwardly to a level above said melt, said electrode being positioned substantially vertically above the level of said melt and spaced from said pile of scrap.

3. The furnace of claim 2 in which said electrically conducting means includes at least one vertical electrode extending downwardly into said pile of unmelted scrap in electrical contact therewith and having a lower end terminating above the level of said melt.

4. The furnace of claim 3 in which said electrode included by said electrically conducting means is a carbon electrode:

5. The furnace of claim 3 in which said electrode included by said electrically conducting means is a steel electrode.

6. The furnace of claim 3 in which said vessel has a closed top through which said electrodes and said charge feeding means pass.

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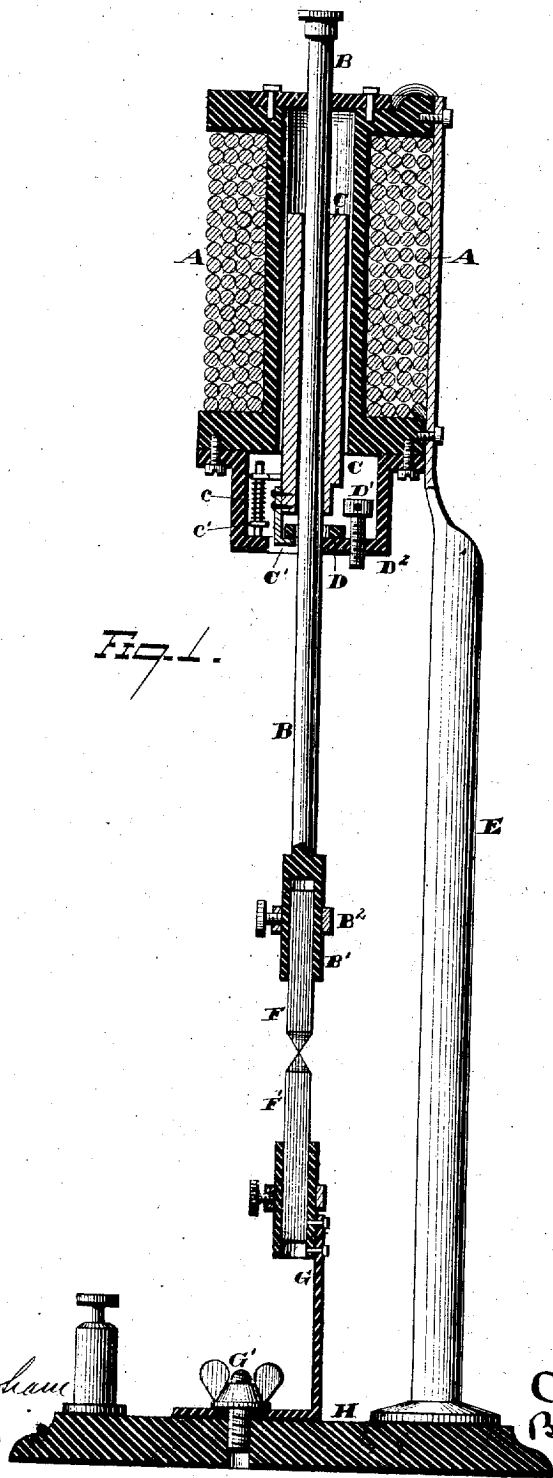
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C. F. BRUSH.
Electric-Lamp.

No. 8,718.

Reissued May 20, 1879.



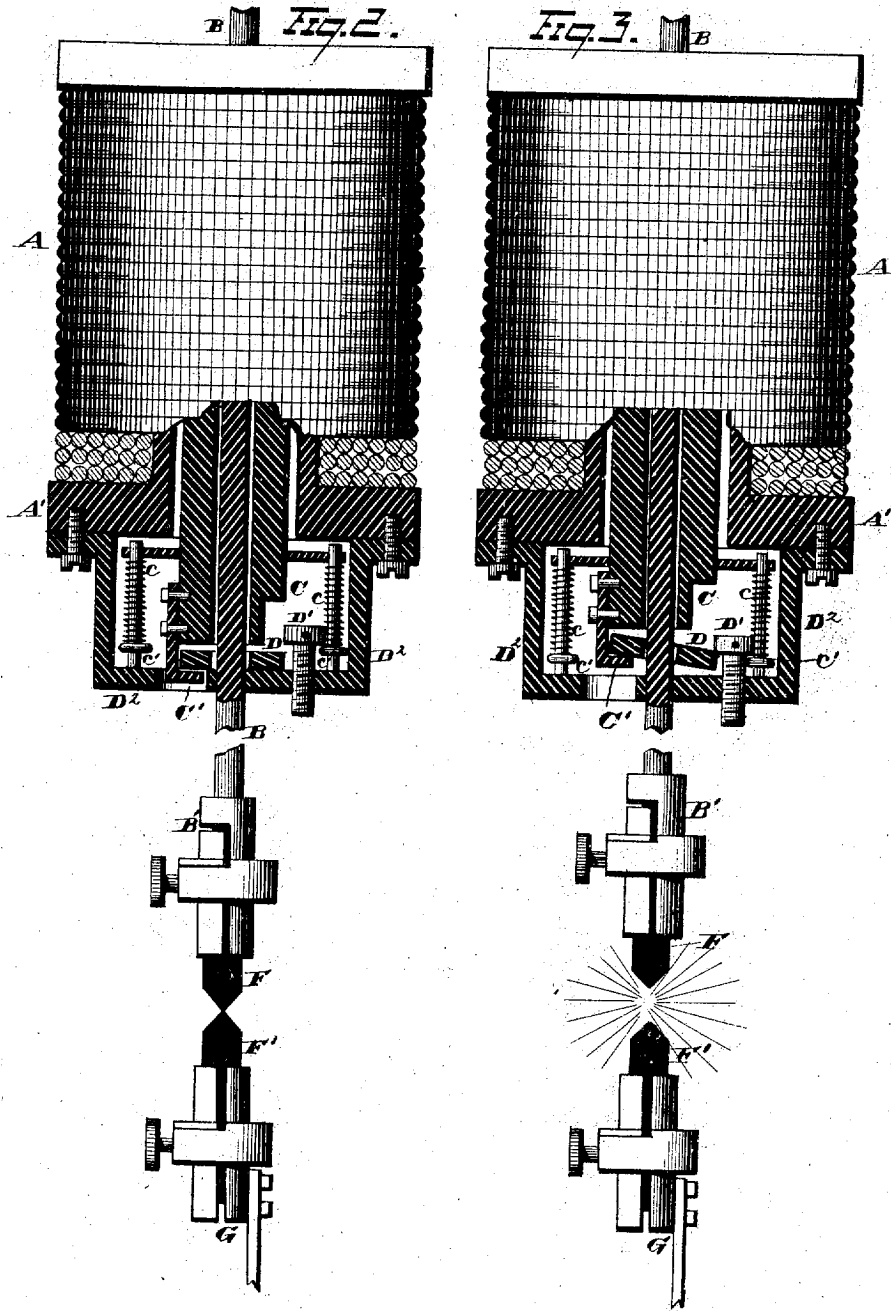
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Electric-Lamp.

4 Sheets—Sheet 3.

No. 8,718.

Reissued May 20, 1879.

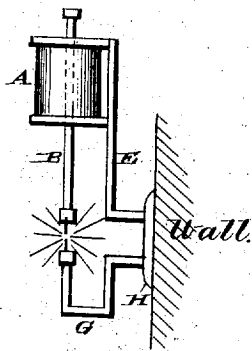
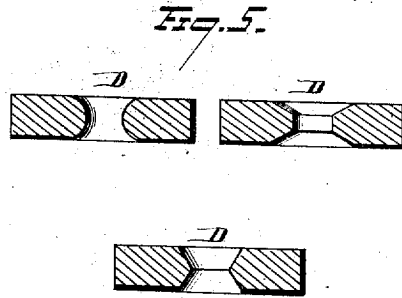
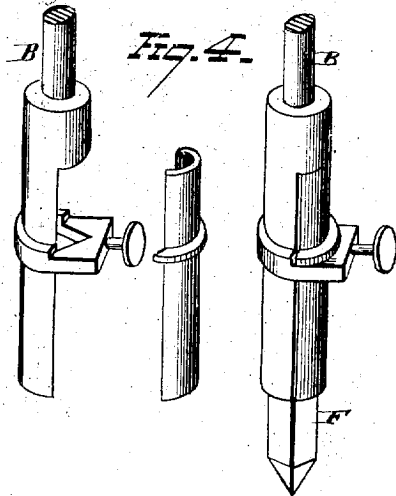
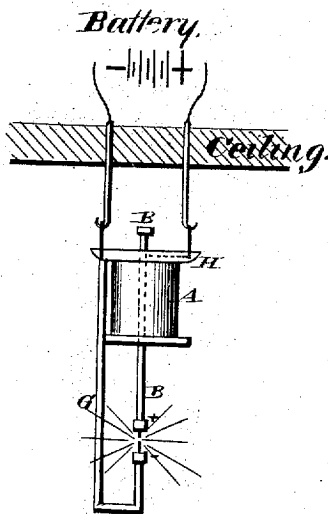
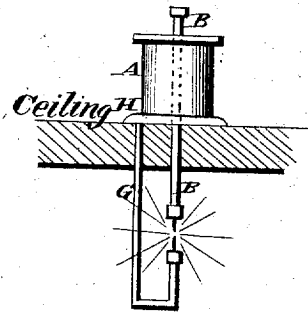


Fig. 5.



WITNESSES

E. J. Nottingham
A. M. Bright

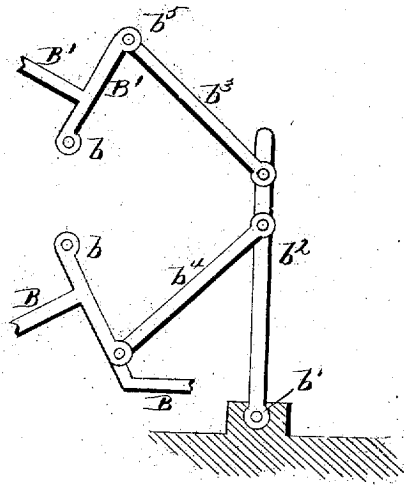
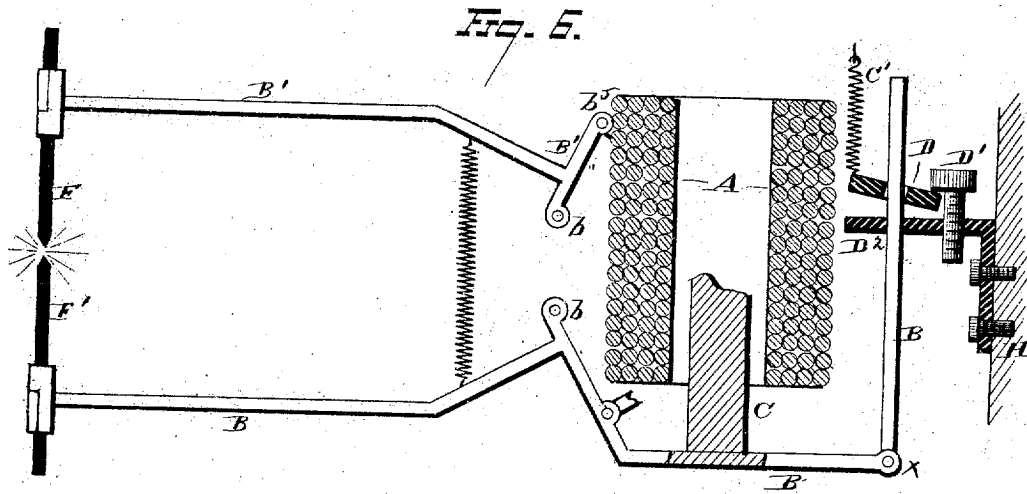
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Electric-Lamp.

No. 8,718.

Reissued May 20, 1879.



WITNESSES

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A. M. Bright

INVENTOR

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By Dequette & Dequette.
ATTORNEYS.

UNITED STATES PATENT OFFICE.

CHARLES F. BRUSH, OF CLEVELAND, OHIO

IMPROVEMENT IN ELECTRIC LAMPS.

Specification forming part of Letters Patent No. 203,411, dated May 7, 1878; Reissue No. 8,718, dated May 20, 1879; application filed April 14, 1879.

To all whom it may concern:

Be it known that I, CHARLES F. BRUSH, of Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Electric Lamps; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it pertains to make and use it, reference being had to the accompanying drawings, which form part of this specification.

My invention relates to electric-light mechanism; and it consists in the following specified device, or its equivalent, whereby the carbon sticks usually employed are automatically adjusted, and kept in such position and relation to each other that a continuous and effective light shall be had without the necessity of any manual interference.

My invention likewise consists in an arrangement and construction, as will hereinafter appear, whereby the simple act of suspending a lamp in position will place it in circuit ready for operation.

In the drawings, Figure 1 is a view, in longitudinal section, of a device embodying my invention. Fig. 2 is a detached view, showing my ring-clamp and lifter as it appears while not in operation; Fig. 3, the same as it appears while in operation. Fig. 4 is a detached view, showing my improved carbon-holder. Fig. 5 comprehends a few of various modifications of which my invention is susceptible without a departure from the spirit and principles thereof; and Fig. 6 represents a form, in which my invention may be applied to a lamp that moves both of its carbons.

I will now describe the device shown in Fig. 1. A is a helix of insulated wire, said helix being in the form of a tube or hollow cylinder, resting upon an insulated plate, A', upheld by the metallic post or standard E. Within the cavity of the helix A is contained the iron core C and the rod B, which passes loosely through the core C. The core C is also made to move very freely within the cavity of the helix A, and it is partially supported within the cavity of the said helix by means of the springs c, whose tension is regulated by the set-screws c'. These springs push upward against ears attached to the core C.

D is a ring of metal, preferably such as will

not be attracted by the magnet surrounding the rod B just below the core C. One edge of the ring D is over a lifting-tongue, C', or its equivalent, which is attached to the core C, while the opposite edge of said ring is a short distance below the crown of an adjustable set-screw, D'. This arrangement is susceptible of various modifications, and suitable means of any description may be employed whereby one point of the ring D may be lifted in such way as to clamp the rod B, while a limit is placed to its upward movement, or to the upward movement of the core C.

The standard or support E, which may also act as a conductor, is fastened to a suitable base, H, to which base is also attached the mechanism for holding the carbon F'. This mechanism consists of a support, G, terminating in a port similar in construction to the port B'. The lower part of this support is bent at a right angle and rests upon the base H, and is fastened to said base by the thumb or set screw G', or any equivalent device.

It is necessary that the carbons F F' should present in accurate apposition to each other, and to accomplish this the set-screw G' is made to pass through a hole in the support G considerably larger than the shaft of said set-screw.

It will thus readily appear that when the set-screw G' is loosened the support G may be moved about until its carbon F' shall properly present toward the carbon F, when it may be secured in proper position by tightening the set-screw G'. Now, one pole of a battery or other suitable source of electricity being attached to the support G, while the other pole is connected to the support E, the electric current passes from the latter, through the helix A, rod B, and carbons F F', down to the support G, thus completing the circuit.

The core C, by the force of the axial magnetism thus created, is drawn up within the cavity of the helix, and, by means of the finger C', it lifts one edge of the ring D until, by its angular impingement against the rod B, it clamps said rod, and also lifts it up to a distance limited by the adjustable stop D'.

While the ring D retains this angular relation with and impingement against the rod B said rod will be firmly retained and prevented from moving through said ring. The adjust-

able stop D^1 is fixed so that it shall arrest the lifting of the rod B when the carbons $F F'$ are sufficiently separated from each other. While the electric current is not passing the rod B can slide readily through the loose ring D and the core C, and it will be readily seen that in this condition the simple force of gravity will cause the carbon F to rest down upon the carbon F' , thus bringing the various parts of the device into the position of closed circuit. Now, if a current of electricity is passed through the apparatus, it will instantly operate, as just explained, to lift the rod B, and thus separate the carbons $F F'$ and produce the electric light.

The tension of the springs c is so adjusted by means of the screws c' or equivalent that they, together with the magnetic attraction of the helix, shall be just sufficient to support the core C, rod B, and carbon F in the position described for producing light.

As the carbons burn away, thus increasing the length of the voltaic arc, the electric current diminishes in strength, owing to the increased resistance. This weakens the magnetism of the helix, and accordingly the core, rod, and carbon F move downward by the force of gravity until the consequent shortening of the voltaic arc increases the strength of the current and stops this downward movement. After a time, however, the clutch-ring D will reach its floor or support D^2 , and its downward movement will be arrested. Now, any further downward movement of the core C, however slight, will at once release the rod B, allowing it to slide through the ring D until it is arrested by the upward movement of the core C, due to the increased magnetism.

In continued operation, the normal position of the ring D is in contact with its lower support, the office of the core C being to regulate the sliding of the rod B through it. If, however, the rod accidentally slides too far, it will instantly and automatically be raised again, as at first, and the carbon points thus continued in proper relation to each other.

The rod B may be of such length that the longest carbon sticks may be employed, and with the device just described I experience no difficulty whatever in consuming a carbon stick of any length and obtaining a continuous and very effective light without the least manual interference.

The carbon holder here shown, which I consider to be novel with myself, consists, essentially, of a split cylinder having a square or angular cavity. One of the pieces is attached to the rod B or standard G, while the other part is loose, and is constructed to rest upon a stirrup, B^2 . A screw passing through the stirrup B^2 serves to clamp and bind the carbon between the two parts just specified.

I do not limit myself narrowly to the ring D, as other devices may be employed which would accomplish the same result. Any device may be used which, while a current of electricity is not passing through the helix A, will permit the rod B to move freely up and

down, but which, when a current of electricity is passed through the helix, will, by the raising of the core C, operate both to clamp and to raise the rod B, and thereby separate the carbon points $F F'$ and retain them in proper relation to each other.

Various devices may be used whereby the base H may be shifted or dispensed with. For instance, it may be attached in such manner as that it may be fastened to a wall or post; or it may be placed above the light in such manner as that the mechanism shall be suspended from it; or, as shown in Fig. 5 of the drawings, the base H may be placed above the light and suspended from two hooks, so as to be readily removable, if desired, and these two suspending hooks may be the positive and negative poles of the apparatus, and the hooks or eyelets to which they are swung or attached may be the positive and negative poles of the electric apparatus. Thus the mere suspension of the lamp will put it within the electric circuit, ready for operation. These variations are desirable when the device is to be used for illuminating purposes in such positions that the base H would cast an objectionable shadow.

When the light is designed to be used in light-houses, or for projecting images, &c., through lenses, it is necessary that the point of illumination be kept in one position. In such cases any appropriate means may be employed, such as, for instance, a device for raising and lowering the entire lamp.

If the ring D is employed, its opening may be provided either with sharp or angular edges, or the cavity may be beveled or rounded, as shown in Fig. 5 of the drawings. It is entirely immaterial how this ring is constructed, so long as it will act to clamp and lift and release the rod B, as heretofore specified.

I have thus far referred to my invention as applicable to a lamp wherein but one of the carbons is moved; but as it is equally applicable to lamps that move both carbons, I will now proceed to demonstrate the same by reference to the modified device shown in Fig. 6 of the drawings.

Here A is again the helix; C, the core of iron; D, the clamping-ring, grasping a rod directly connected to and controlling the movements of the rod B, holding the carbon F. C' is a spring lifting up one edge of the ring D, similarly to the finger C in Fig. 1, and the adjustable stop D^1 is identical with the one heretofore specified. In this modification the motion of the core C is transmitted to the rod B, substantially as heretofore described, and the exact motion of the rod B^1 through suitable link-and-lever connections, $b^1 b^2 b^3 b^4$, is communicated in reverse to the rod B^1 , carrying the carbon F' .

The operation of this device is substantially similar to that of the device shown at Fig. 1. A current of electricity being passed through the helix A, the core C is, by force of the axial magnetism thus created, drawn up within the

cavity of said helix. The spring S, or its equivalent, acts as gravity does in the rod B (shown in Fig. 1) to keep the carbons together, and the force of the magnetism through the core C resists this tendency of the spring S to draw the carbons into actual contact. The rod B, in this instance, also passes through the ring D, which is held in its angular clamping position by the spring C', which is the equivalent of the finger C' of Fig. 1.

The adjustable stop D¹ is in all respects identical with the same element hereinbefore specified. The ring D, in this instance, acts in a similar manner as heretofore described in governing and controlling the rod B.

The main point of difference between the devices shown in Figs. 1 and 6 is this: In the former one carbon is stationary and the other moves; in the latter one carbon-holder is moved substantially in the same manner as in the former, but it is made to impart a similar reverse motion to the holder of the other carbon by suitable link-and-lever connections.

I have practically and thoroughly tested the two forms of my invention as shown in the devices just specified, and in point of their capacity to consume long carbon sticks and produce a continuous and effective light without the necessity of manual interference I find them perfectly operative.

It may be proper to specify more clearly the link-and-lever connection between the rods B and B¹. Each rod is pivoted to a common frame at b. The rod B extends from the carbon F' to a point beyond the ring D, having a joint, x, where it is made to turn beyond the helix A. It is journaled at or near the end of a swinging lever, b², said lever hinged to the common frame at b¹. The rod B¹ extends from the carbon F to the point b², where it journals with a link, b², which connects it to the lever b² at or very near the point of connection of the rod B.

It will now readily be seen that a motion given to either rod B or B¹ will be imparted in reverse to the other.

Among the numerous advantages secured by my invention, as above specified, may be enumerated the following:

First, by the use of copper-coated carbons it is entirely feasible to employ a lamp that moves only its positive carbon. The waste of the negative carbon is so very slow that the point of illumination is kept practically at one point for a considerable length of time—say, one or two hours or more.

Second, carbon sticks of any length may be entirely consumed, and an effective light produced without manual interference.

Third, whenever the light is put out the carbon points will certainly be brought into actual contact, and in this condition the lamp will automatically produce the electric light upon the establishment of the electric current.

This feature of always being in condition to

automatically set and continue itself in effective operation I consider to be an effect never before practically attained, although many efforts have been made in that direction that have been partially successful.

What I claim is—

1. In an electric lamp, the combination, with the carbon-holder and core, of a clamp surrounding the carbon-holder, said clamp being independent of the core, but adapted to be raised by a lifter secured thereto, substantially as set forth.

2. In an electric lamp, the combination of the clamp D and adjustable stop D¹, or their equivalents, by means of which the carbon points are prevented from becoming so far separated as to break the electric current and extinguish the light, substantially as specified.

3. In an electric lamp, the combination of the core or armature C, the clamp D, and adjustable stop D¹, or their equivalents, whereby the points of the carbons are separated from each other when an electrical current is established, prevented from separating so far as to break the current, and gradually fed together as the carbons are consumed, substantially as described.

4. In combination with the core C, one or more adjustable sustaining-springs, c, substantially as and for the purpose shown.

5. In an electric lamp, the combination, with a carbon-holder, of an annular clamp surrounding the carbon-holder, said clamp adapted to be moved, and thereby to separate the carbon points by electrical or magnetic action, substantially as herein set forth.

6. In an electric lamp, an annular clamp adapted to grasp and move a carbon-holder, substantially as shown.

7. An electric lamp provided with suspending or attaching hooks, loops, or their equivalent, representing and placed in electrical connection, respectively, with the positive and negative poles of the lamp, substantially as shown.

8. An electric lamp provided with suspending or attaching hooks, loops, or their equivalent, representing and placed in electrical connection, respectively, with the positive and negative poles of the lamp, in combination with stationary hooks, loops, or their equivalent, placed in electrical connection, respectively, with the positive and negative poles of the battery, dynamo-electric machine, or other source of electric current, said stationary hooks or loops being located at the place where the lamp is intended to be used, substantially as specified.

In testimony whereof I have signed my name to this specification in the presence of two subscribing witnesses.

CHARLES F. BRUSH.

Witnesses:

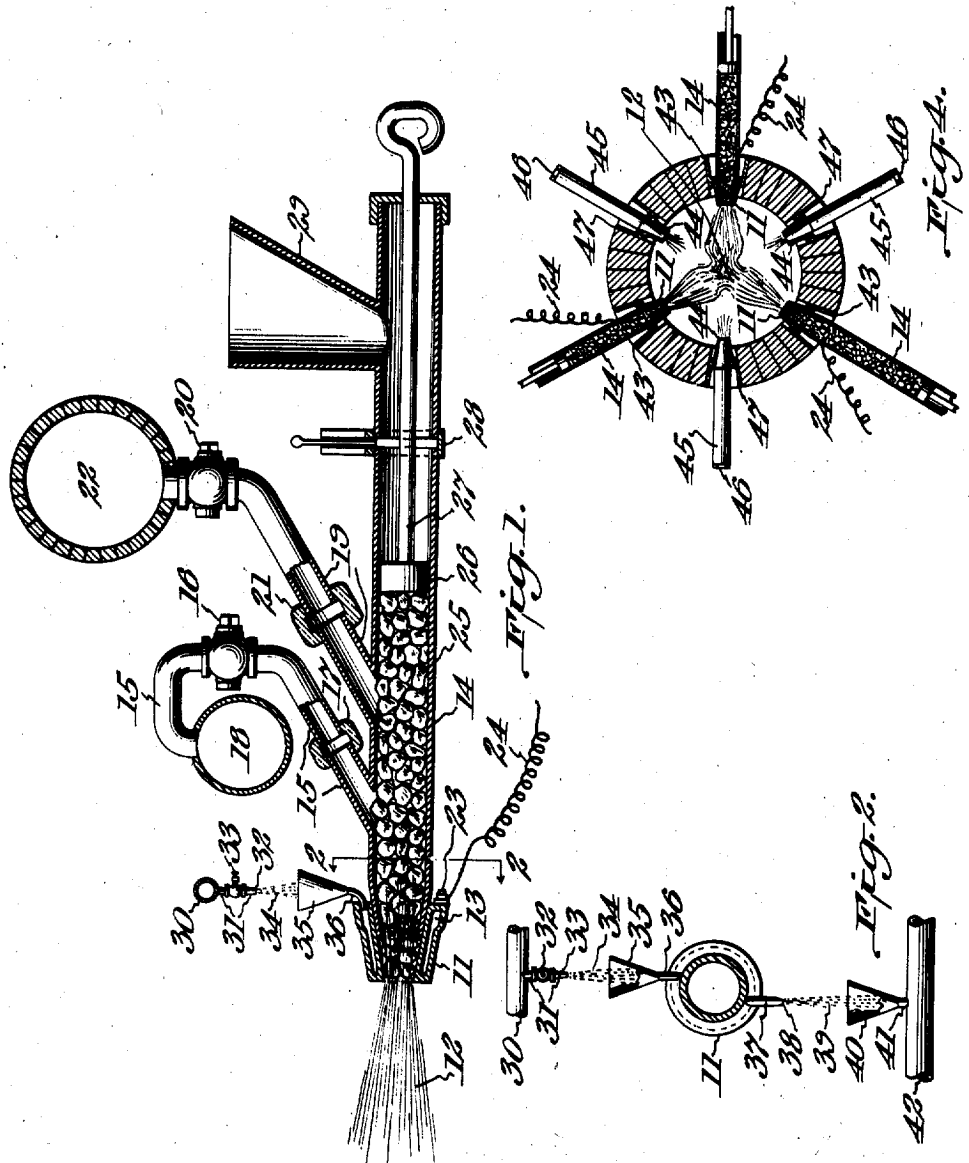
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Aug. 25, 1925.

Re. 16,149

G. T. SOUTHGATE
PROCESS AND APPARATUS FOR INTRODUCING ELECTRIC
ENERGY INTO A SPACE OF ACTION
Original Filed March 8, 1922

2 Sheets-Sheet 1



Inventor:

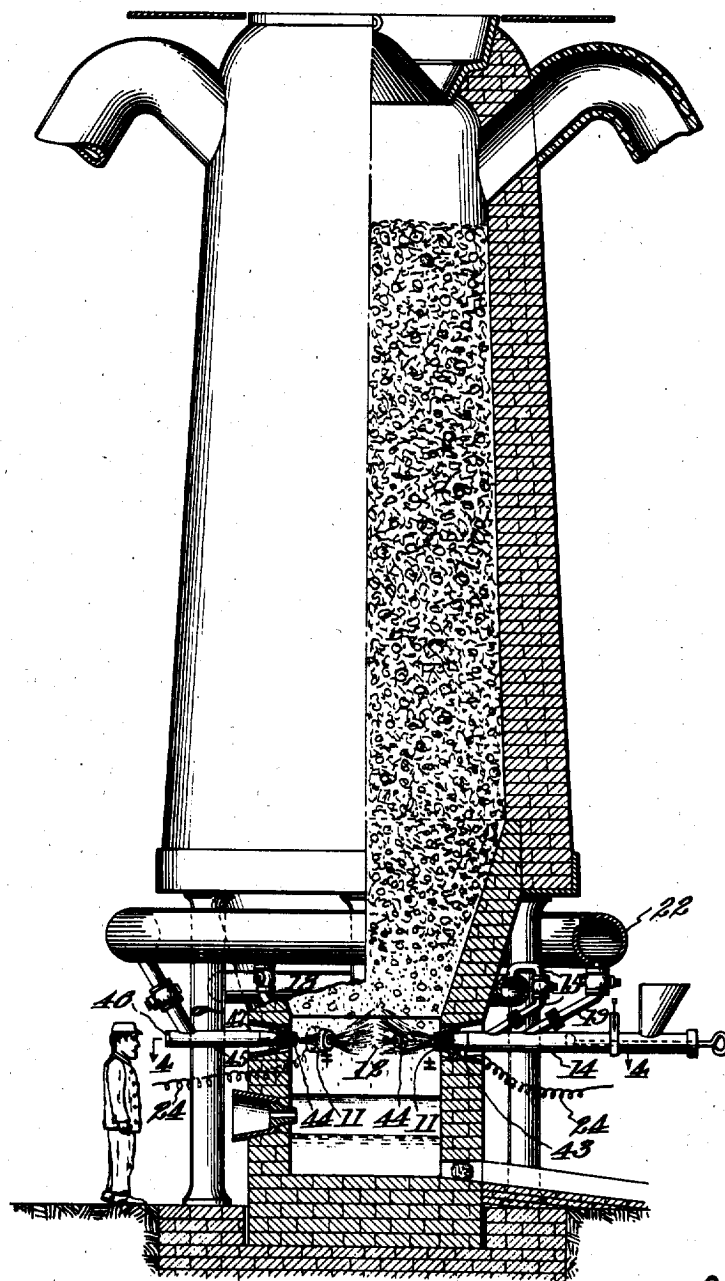
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Aug. 25, 1925.

Re. 16,149

G. T. SOUTHGATE
PROCESS AND APPARATUS FOR INTRODUCING ELECTRIC
ENERGY INTO A SPACE OF ACTION
Original Filed March 8, 1922

2 Sheets-Sheet 2



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Reissued Aug. 25, 1925.

Re. 16,149

UNITED STATES PATENT OFFICE.

GEORGE T. SOUTHGATE, OF ANNISTON, ALABAMA.

PROCESS AND APPARATUS FOR INTRODUCING ELECTRIC ENERGY INTO A SPACE OF ACTION.

Original No. 1,443,439, dated January 30, 1923, Serial No. 541,988, filed March 8, 1922. Application for reissue filed November 3, 1924. Serial No. 747,694.

To all whom it may concern:

Be it known that I, GEORGE T. SOUTHGATE, a citizen of the United States, residing at Anniston, in the county of Calhoun and State of Alabama, have invented certain new and useful Improvements in Processes and Apparatus for Introducing Electric Energy into a Space of Action, of which the following is a specification.

This invention relates to a process and apparatus in which combustion flames, blown from nozzle-electrodes, are employed for conducting, directing and controlling electric arcs, and in which the gases thus heated are utilized for transmitting the electrically supplied heat along with the combustion heat to wherever desired. For blowing the flames from the nozzle electrodes, a mixture of a combustible material such as coal gas with a combustion supporting gas such as air is forced through the nozzle electrodes. The invention has for one of its objects to improve the efficiency of the use of electricity in smelting, industrial chemistry, melting, welding and the like, especially in those applications where intense electric heating may be advantageously superimposed upon fuel heating.

Another object of my invention is to provide a process and apparatus, for the use of electricity in furnace operations, which may be applied to existing types or even existing erected units of non-electric furnaces with but relatively little change in the construction of said furnaces except the addition thereto of my improved electric apparatus and the use therewith of my improved process.

Another object of my invention is to provide a process and apparatus, for the use of electricity in furnace operations, which may be conveniently put out of use without hindering the operation of the furnace with other sources of heat; as for example in those seasons when the use of electricity drawn from hydroelectric power plants on streams of very variable flow may be less economical than the use of fuel in the furnace.

Another object of my invention is to replace the cumbrous, expensive and rapidly consumed electrodes of ordinary electric furnaces by small, easily mounted, less expensive and less rapidly consumed elec-

trodes, in which the wearing parts are separate from the main body of the electrode, are composed of carbon and are readily and continuously replenishable.

Another object of my invention is to avoid the employment in electric furnaces of low electromotive forces and heavy currents and the consequently required massive conductors, by using the properties of my improved process and apparatus wherein the working portions of the circuits, within the furnace, have high effective resistance and consequently give high heat generation with relatively small currents.

Another object of my invention is to provide a means of performing, in an intensified degree, operations which utilize the special properties of electric arcs, such as producing waves in the ether for radio transmission of messages and of power, the detection of waves in the air or in the ether by the "response" of arc flames, and the radiation of large amounts of light and heat into space for use per se.

With these and other objects in view, my invention consists in the novel steps and combinations of steps constituting the process, and in the novel combinations of parts constituting the apparatus; all as will be more fully hereinafter disclosed and described with reference to the two accompanying drawings forming a part of this specification, and particularly pointed out in the claims.

The novel features of my invention relate to processes and apparatus which utilize the electrically conducting properties of gases heated in close proximity to conducting electrodes, and the energy-distributing properties of said gases, as means of introducing electric currents and advantageously transmitting the energy thereof wherever desired.

In my improved process and apparatus the heating of the gases for rendering them electrically conducting may be accomplished in any approved manner; but the method I prefer is to cause a portion of the heating to take place at and near the points where said gases are introduced into the space of action, by combustion thereof; and the apparatus which I prefer to use for the accomplishment of said purpose is a set of fittings combining in themselves the functions of gas nozzles and of electrodes bringing

electricity of suitable high electromotive force to said gases.

In the foregoing and following explanations, wherever the word gas or gases is used in connection with the tuyères or electrodes, I refer not only to clear gases, but also to any suitable matter in a gaseous state or in a finely divided state so that it resembles gas in the freedom of its movement, as for example smoke, dust clouds or sprays of liquid.

One of the known properties of a combustion flame is that it is capable of conducting away electricity from conductors charged at suitably high voltages, i. e., a flame can be made to act as a conductor of an electric current. Because of the high electric resistance of flame, additional heat is generated therein by such electric current, in amount proportional to the square of the current. It is also known that in any gas ambient to electric conductors, an effect can be produced by the impressing of high electromotive forces on said conductors and that this effect is apparently one of atomic disintegration or "ionization." Surrounding such conductors there may be seen under sufficiently dim illumination an artificial light, variously called "corona," "electric glow," "electrode rays," etc. At magnitudes of increasing electromotive force dependent upon the form, size, spacing, disposition, surface and other features of the conductors and upon the composition, temperature, pressure and other properties of the gas, this effect becomes very pronounced, and especially the electric conductivity of the gas increases. The dissipation of electric energy into heat in the gas is also greatly increased with increasing electromotive force.

This increase of electromotive force, with its corresponding increase of heat dissipation, may be continued until upon reaching a certain voltage per unit of distance between electrodes, a disruptive discharge or arc is established. A substantially lower voltage suffices for starting this disruptive discharge in flame than in the atmosphere, but in either case a much higher electromotive force is required to maintain the arc than is needed for causing an equal current in either loose or aggregate masses of solid resistance materials. Conversely, therefore, we may employ in practical furnaces for the same amount of electric power and heating much smaller currents and far less massive conductors and electrodes, by projecting combustion flames into unobstructed spaces thereof and establishing relatively long electric arcs in such wise as to be directed in and along these flames.

In my invention disclosed in United States Letters Patent Numbers 1,373,639 (granted Apr. 5, 1921) and 1,369,714 (granted Feb. 22, 1921) for respectively a process and an

apparatus for the fixation of gases by means of electric discharges or arcs, I have taken advantage of this gaseous conduction of electricity for the purpose of causing the atomic decomposition of the gases treated and their susceptibility to differing recomposition—also for the purpose of momentarily heating by the electric currents to such high temperatures as are conducive to their combination, gases having relatively little mutual affinity.

In the invention disclosed herein any direct chemical action exerted upon the inducted gases, by the ionizing effect and heat of the electric arcs is not the purpose sought, but is only incidental; said purpose actually being the use of the electric conductance of the hot gases as the means of introducing the currents of electricity for converting the electric energy into heat and other forms of energy, and, in heating apparatus, the distribution of said heat wherever desired by the flow of said gases. It is also the object of this invention to utilize in heating apparatus the heat that is generated by the previously mentioned combustion of the gases inducted through the electrodes.

In the accompanying drawings, Fig. 1 is a mid-sectional view of a combined electrode and gas nozzle constituting one form of my improved apparatus. Fig. 2 is a detail of piping forming a part of the apparatus of Fig. 1, but not convenient to show therein; being a section in the vertical plane indicated by the line 2—2. Fig. 3 represents a type of furnace in the operation of which my improved process and apparatus may be applied; the upper portion left of the central vertical axis being an elevation and the lower portion of that side and all of the right-hand side being a mid-section. Fig. 4 is a horizontal section of the furnace shown in Fig. 3, in the plane indicated by the line 4—4. Similar numbers refer to similar parts throughout the several views.

In the drawings, hollow casting 11 is a nozzle, in and through which gases are partly burned and inducted into the space-of-action 12. Casting 11 serves also as the electrode mentioned hereinbefore and hereinafter in the phrases "electrodes provided with holes," "through holes in electrodes," etc.; and wherever the words "nozzles," "electrodes" or "nozzle-electrodes" are mentioned below in the description or claims of my invention fittings similar to casting 11 are meant. In order to prevent being melted or rapidly eroded, casting 11 preferably should be cooled by any suitable means; and I prefer to employ therefor the circulation of water in the hollow space of said casting. The method and means of supplying said water is explained hereinafter. A metal blowpipe 14 is connected to

nozzle 11; and the gases inducted through said nozzle are supplied by way of said blowpipe. Combustible-gas pipe 15 is connected at one end to blowpipe 14; and in said pipe 15 there are inserted valve 16 and hollow electric insulator 17, which insulates blowpipe 14 from all parts of pipe 15 except the end thereof adjacent to said blowpipe. The other end of pipe 15 is connected to any suitable source of a combustible gas under pressure, as the main 18. An oxidizing-gas pipe 19 is also connected at one end to blowpipe 14; and in said pipe 19 there are inserted valve 20 and hollow electric insulator 21, which insulates blowpipe 14 from all parts of pipe 19 except the end thereof adjacent to said blowpipe. The other end of pipe 19 is connected to any suitable source of an oxidizing gas under pressure, as the main 22. Any suitable oxidizing gas may be employed, but in the majority of cases I prefer to use air. The means of supplying combustible gas to main 18 and oxidizing gas to main 22 form no part of my present invention, and the usual practices in such cases may be followed.

Electric terminal 23 is mounted on nozzle-electrode 11; and electric connection is made as by the wire 24, from a suitable source of electromotive force.

Nozzle 11, and the portion of blowpipe 14 near said nozzle are filled with pieces of electrically conducting thermally refractory material, such as carbon. Any kind of carbon may be employed, and in any suitable form adapted to be moved through the blowpipe and nozzle; but I prefer to use coke because of its cheapness, and I prefer to use coarse lumps because of the high electric conductivity, great permeability for gases and sufficient mobility of that form.

Blowpipe 14 is extended in the direction opposite from the discharge end of nozzle 11, into a cylinder in which a piston 26, driven by a piston-rod 27, is fitted. A slide valve 28 is mounted in and intersects blowpipe 14, and near the rear end of the blowpipe is provided a suitable means of feeding therein the aforementioned pieces of conducting material, as by the hopper 29.

For the cooling-water supply to nozzle-electrode 11 suitable provision must be made, whereby the nozzle shall not be electrically grounded or short-circuited by either the water or its conduit. I prefer to employ therefor an arrangement in which the water is delivered both to and from nozzle 11 in broken streams, and in which there is no metallic or other solid connection between nozzle 11 and either the water-supply system or the drain system. It is known that a broken stream of water, as from a hose, may with impunity be played on a conductor charged at very high voltage, and that be-

cause of the separation of the drops no appreciable electric conduction takes place in said broken stream.

Referring to Fig. 2 and also, in part to Fig. 1, from water-supply header 30 is taken supply pipe 31; which terminates in a nozzle 32 capable of breaking up the discharged water into a spray 34 of small drops. Valve 33 is used to regulate the quantity of water discharged by pipe 31. The sprayed water falls into funnel 35 and is carried to nozzle-electrode 11 by pipe 36. From nozzle 11 the spent water is similarly discharged to the drainage system via pipe 37, nozzle 38, spray 39, funnel 40, pipe 41 and drain header 42.

When my process and apparatus are applied in a smelting furnace, nozzle 11 may be mounted in a hollow ring 43, which may be water-cooled by a method and apparatus similar to that provided for nozzle 11 itself and shown by Fig. 2. Ring 43 must be insulated from other metal parts of the furnace.

In Fig. 3 and Fig. 4 are shown an application of my new process and apparatus in the operation of a furnace similar to a standard iron blast furnace; the general construction and operation of said furnace, other than the process and apparatus for introducing electric energy, not being embraced in my invention. My improved apparatus is mounted in the furnace at any suitable level, as in the plane of the regular furnaces tuyères 44 and air blowpipes 45.

An advantage is gained from thus placing the nozzle-electrodes in the plane of and spaced among the tuyères, because of the resultant thorough commingling of the gases from the nozzle-electrodes with the air from the tuyères. A further advantage is gained from this arrangement in that the usual peep-hole or "eyesight" 46 in the end of each air blowpipe 45 may be used to inspect the condition, and the effect within the furnace, of not only the air blasts from said blowpipes but also of the flames from nozzle-electrodes 11. A still further advantage obtains in those cases where a furnace previously heated wholly by fuel is to be heated wholly or partly by electricity, or where a furnace already having my improved electric apparatus is to be operated for a season with the heat from fuel only, in that the usual hollow rings 47 employed in mounting the tuyères 44 may be constructed and cooled similarly to rings 43 in which electrode-nozzles 11 are supported; and that in such similar rings, tuyères and electrode-nozzles with their respective accessories, may be interchanged at will.

The operation of my new process and apparatus is as follows:—

Nozzle-electrode 11 and a portion of blowpipe 14 being filled with lumps of coke,

combustible-gas valve 16 and oxidizing-gas valve 20 are partly opened and the gases allowed to flow through the nozzle-electrode. The mixed gas is then ignited by any suitable means, burning among and through the coke lumps and beyond the end of nozzle 11, and heating the said coke. At the beginning, an excess of oxidizing gas over that required for perfect union with the combustible gas may be used, in order to promote the quick heating of the coke by the partial combustion thereof. After heating the coke, however, I prefer to regulate the valves of the two gas-supply pipes in such wise that there is insufficient oxidizing gas for perfect combustion of the other gas, but a sufficient total flow of gases to cause very hot flame in the nozzle-electrode. During the further operation of the apparatus, the coke in the nozzle-electrode and in the blowpipe is gradually consumed, and the assembly thereof somewhat loosened. In order to keep this coke content reasonably compact in the nozzle and blowpipe, piston 26 should be occasionally pushed forward by hand, by means of piston-rod 27. When necessary the coke may be replenished through hopper 29, after drawing back piston 26 to the end of its travel and closing valve 28. The valve is then reopened and the new charge of coke pushed up against the old coke by means of the piston. During these operations on the apparatus either the electromotive force mentioned below must be temporarily removed, or the operator must stand on a well insulated platform, for his safety.

While I prefer usually to follow the method just described, in which a separately introduced combustible gas is employed to form matter for combustion flame, and coke employed for renewable wearing surface-of-contact between said gas and the balance of the electric circuit, yet my invention includes as one of its equivalent methods of application the employment of lumps of bituminous coal or the like, in lieu of the coke and the said combustible gas. This method is equivalent for the reason that the bituminous coal when so used will distill and form simultaneously and continuously both coke and the combustible gas, and will form both in those zones of blowpipe 14 and nozzle 11 where desired.

The apparatus being in steady operation as above described, a circuit of suitably high electromotive force from an external source is now completed by way of nozzle-electrode 11 and the flame therefrom which plays into the space-of-action 12. When the process and apparatus are used in a furnace, the circuit from one nozzle-electrode may be completed by way of its flame to the flame from one or more other similar

nozzle-electrodes and through said other flames to said other nozzle-electrodes. For example there may be a total of three such electrodes and three flames, giving a three-phase connection, as shown in Fig. 3 and Fig. 4. When the process and apparatus are used in heating, cutting, welding or burning metal, only one nozzle-electrode and its accessories need be used; and the electric circuit may be closed by way of the said metal. When the process and apparatus are employed in utilizing the special properties of the arc, such as in producing or detecting waves in the ether for radiodynamic purposes, producing, detecting or amplifying sound in the air or telephonic electric current variations in a circuit, light and heat radiation, and all other uses of intensified arcs, two or more nozzle-electrodes may be used to form respectively single-phase or polyphase circuits according to the requirements of the application. The nozzle-electrodes may thus be used as torches in space, for general lighting or heating with the same construction and mode of operation characteristic of the other forms of the invention.

When electric currents flow through the matter of the flames as described, the properties of electric arcs are intensified. This is especially true of the heating action of said arcs—additionally to the heat of combustion of the flame—and of the heat-transmitting properties of the combined arc and combustion flame. A greater amount of electric energy can be poured into such a combustion-flame arc; and the resistance between electrodes and arcs is reduced in my process and apparatus by the high heating of the large surfaces of coke within the electrode-nozzle, with the result that the I^2R heat in the circuit is generated less at the electrodes and more in the flame, where desired.

In order to regulate the input of electric energy to the flames in my new process and apparatus, we may vary the electromotive force impressed on the nozzle-electrodes; whereby the quotient E^2/R , which equals the electric energy converted into heat, will be changed. Or we may conveniently vary the divisor of this formula, by varying the input of gases to the flames.

The consumption of the wearing portion of the electrodes in my apparatus, i. e., of the coke, is relatively slow, for the reason that the burning mixed gas passing through the electrode-nozzle and the coke-mass is a reducing gas; there being a deficit of oxidizing gas in the mixture, as stated hereinbefore.

When my new process and apparatus are used in a furnace, any proportion of the heating thereof may be done by the burning of the combustible portion of the matter

inducted through the nozzle-electrodes, and by the burning of any other fuel supplied to the furnace; the balance of the heat being supplied by the conversion of electric energy thereinto in the space-of-action affected by the operation of my new process and improved apparatus.

It is obvious that those skilled in the art may vary the steps of the process, as well as the arrangement of parts constituting the apparatus, without departing from the spirit of my invention; and they may apply my new process and apparatus to purposes additional to those specified. Therefore, I do not wish to be limited to the above disclosure except as may be required by the claims. It will be seen also that in the operation of my new process, it is necessary to use improved apparatus similar to what I have described above, and that in properly employing my improved apparatus it is necessary to operate by a process similar to the foregoing new method. For this reason, I have described the process and the apparatus together as one invention.

I claim:—

1. The process of converting electrical energy into radiant energy in the presence of combustion, which comprises forcing mobile combustible and oxidizing matter through a nozzle containing a porous, electrically conducting, thermally refractory filling; producing a combustion flame of said matter, and impressing upon said filling an electromotive force suitable to cause electric arc conduction therefrom into and along said combustion flame.

2. The process of supplying heat to a furnace which consists in converting electrical energy into heat by forcing mobile matter, both combustible and oxidizing, through nozzles containing within their bores bodies of electrically conducting, thermally refractory solids, producing combustion flames of said matter in said furnace, and impressing upon said bodies electromotive forces suitable to cause electric arc conduction therefrom into and along said combustion flames.

3. The process of supplying electric energy to a furnace which consists in inducting streams of matter into said furnace through electrodes having longitudinal holes containing bodies of electrically conducting, thermally refractory solids; said matter being a mixture of combustible substance with an oxidizing gas; said oxidizing gas being not sufficient in proportion to oxidize said combustible substance completely; partly but not completely burning said matter while passing through said electrodes; and impressing upon said electrodes electromotive forces suitable to cause electric arc conduction from said bodies into and along said streams.

4. In smelting, the process of supplying

to a furnace heat additional to that generated therein by chemical means, which consists in forcing mobile matter, both combustible and oxidizing, into said furnace through nozzles containing within their bores, electrically conducting, thermally refractory solids, producing combustion flames of said matter, and impressing upon said bodies electromotive forces suitable to cause electric arc conduction therefrom into and along said combustion flames.

5. The process of converting electrical energy into radiant energy in the presence of combustion, which comprises forcing mobile matter, both combustible and oxidizing, through a nozzle having within its bore bodies of fixed carbon, producing a combustion flame of said matter, and impressing upon said bodies an electromotive force suitable to cause electric arc conduction therefrom into and along said combustion flame.

6. The process of converting electrical energy into radiant energy in the presence of combustion, which comprises forcing mobile matter, both combustible and oxidizing, through a nozzle having within its bore bodies of carbonaceous matter capable upon heating of becoming changed to fixed carbon and of liberating combustible gases which are added to said mobile matter, producing a combustion flame of said mobile matter, and impressing upon said bodies an electromotive force suitable to cause electric arc conduction therefrom into and along said combustion flame.

7. The process of utilizing cheap materials in electrodes which consists in inducting through said electrodes, in holes therethrough containing bodies of electrically conducting, thermally refractory solids, streams of fluid matter; burning said matter in said streams; and impressing suitable electromotive forces on said electrodes to cause electric arc conduction in said streams.

8. The process of utilizing cheap materials in electrodes which consists in inducting through said electrodes, in holes therethrough containing bodies capable upon heating of becoming carbonized to electrically conducting, thermally refractory solids, streams of fluid matter; burning said matter in said streams; and impressing suitable electromotive forces on said electrodes to cause electric arc conduction in said streams.

9. The process of directly applying electrical energy which comprises inducting streams of combustible and oxidizing matter through holes in electrodes, directing said streams into the desired space of action of said energy, burning said matter by combustion in said electrodes and in said streams, and impressing upon said electrodes electromotive forces suitable to cause

electric arc conduction therefrom into and along said streams.

10. The process as claimed in claim 9, wherein the supply of combustible and oxidizing matter is so controlled that the oxidizing matter is not sufficient in proportion to burn the combustible matter completely.

11. The process as claimed in claim 1, in combination with the step of controlling the supply of electric energy to the combustion flame by varying, in the same direction as the desired change in magnitude of electric energy, the rate of supply of combustible matter.

12. The method of supplying radiant energy to a space to be heated, which comprises providing a continuous supply of energy from combustion flames directed into said space, and periodically impressing upon said combustion flames electromotive forces suitable to cause electric arc conduction therealong and into said space.

13. The process as claimed in claim 1, employed in heating a furnace continuously with fuel and intermittently with both electricity and fuel.

14. Apparatus comprising an electrode having a longitudinal passageway terminating at the arcing end of the electrode, means for forcing combustible and oxidizable mobile matter through said passageway, said passageway being so proportioned with respect to the volumes of mobile matter normally employed that the combustion flame of said matter will contact with the arcing end of the electrode, and means for impressing upon said electrode an electromotive force suitable to cause electric arc conduction therefrom into and along the combustion flame.

15. Apparatus comprising a nozzle-electrode having a longitudinal bore extending therethrough, a porous mass of electrically conducting material in said bore, means for forcing a combustible mixture through said bore, means for impressing upon said mass an electromotive force suitable to cause electric arc conduction therefrom into the flame produced from said combustible mixture, and means for advancing said porous mass through said bore.

16. A nozzle-electrode comprising a tubular shell of refractory material, a nozzle thereon, means for supplying a mixture of combustible and oxidizing matter to said tubular shell, means for supplying bodies of electrically conducting, thermally refractory solids to said tubular shell, and means for impressing an electromotive force upon said bodies.

17. A nozzle-electrode comprising a tubular body of refractory material, a nozzle for said body and having a bore of less cross-sectional area than that of said body, an electrically conducting, thermally refractory

filling in and providing longitudinal passages through said body, means for forcing fluid matter through said passages, means for impressing an electromotive force upon said filling, and means on said body and spaced from the nozzle end thereof for replenishing said filling.

18. Apparatus for converting electric energy to radiant energy and heat, said apparatus comprising a hollow nozzle, means for supplying mobile matter, both combustible and oxidizing, to said nozzle, whereby a combustion flame may be projected from said nozzle, a porous, electrically conductive, thermally refractory filling in said nozzle, and means for impressing upon said filling an electromotive force suitable to cause electric arc conduction therefrom into and along said combustion flame.

19. Apparatus for converting electric energy to radiant energy in the presence of combustion, said apparatus comprising a plurality of nozzles, solid bodies of electrically conducting, thermally refractory material in said nozzles, means for supplying combustible material and oxidizing gas to said nozzles at such pressure that combustion flames may issue from said nozzles and in contact with at least some of said solid bodies, and means for supplying electricity to said bodies at electromotive forces suitable to cause electric arc conduction therefrom into and along said combustion flames.

20. In apparatus for supplying electric energy to a furnace, the combination with electrically conducting nozzles arranged to feed fluid matter into said furnace, of induction tubes connected to said nozzles; means for continuously inducting fluid matter through said nozzles by way of said induction tubes; bodies of solid, electrically conducting, thermally refractory material in the bores of and in electric connection with said nozzles and said induction tubes; means for so regulating said inducted fluid matter that it will burn while in contact with at least some of said solid bodies in said bores; and means for supplying electricity to said nozzles at electromotive force suitable to cause electric arc conduction from said solid bodies into said fluid matter and along the streams thereof.

21. In electrode apparatus adapted to be conveniently installed in and removed from a furnace at will, the combination with nozzles resembling and spatially interchangeable with furnace tuyères, and made of electrically conducting material; of means for producing combustion flame in and from said nozzles; and means for supplying electricity of suitable electromotive force to said nozzles.

22. Apparatus as claimed in claim 19 in combination with means for varying the

volume and intensity of the combustion flames.

23. Apparatus as claimed in claim 18 wherein said nozzle resembles and is spatially interchangeable with a furnace tuyère.

24. In electric arc apparatus adapted to consume relatively cheap electrode materials, the combination with electrodes having longitudinal holes, of bodies of electrically conducting, thermally refractory solids in said holes; means for inducting fluid matter through said holes; means for burning said matter by combustion while and after passing through said holes; and means for impressing on said electrodes electromotive force of magnitude suitable to cause electric arc conduction into said inducted matter and along the streams thereof.

25. In electric arc apparatus adapted to consume relatively cheap electrode materials,

the combination with electrodes having longitudinal holes, of bodies capable upon heating of becoming carbonized to electrically conducting, thermally refractory solids, in said holes; means for inducting fluid matter through said holes; means for burning said matter by combustion while and after passing through said holes; and means for impressing on said electrodes electromotive force of magnitude suitable to cause electric arc conduction into said inducted matter and along the streams thereof.

26. Apparatus as claimed in claim 19, wherein said nozzles are so arranged that the electric circuit shall be from a nozzle to and along its flame, to the flame of another nozzle, and so to the said other nozzle.

In testimony whereof, I affix my signature.

GEORGE T. SOUTHGATE.

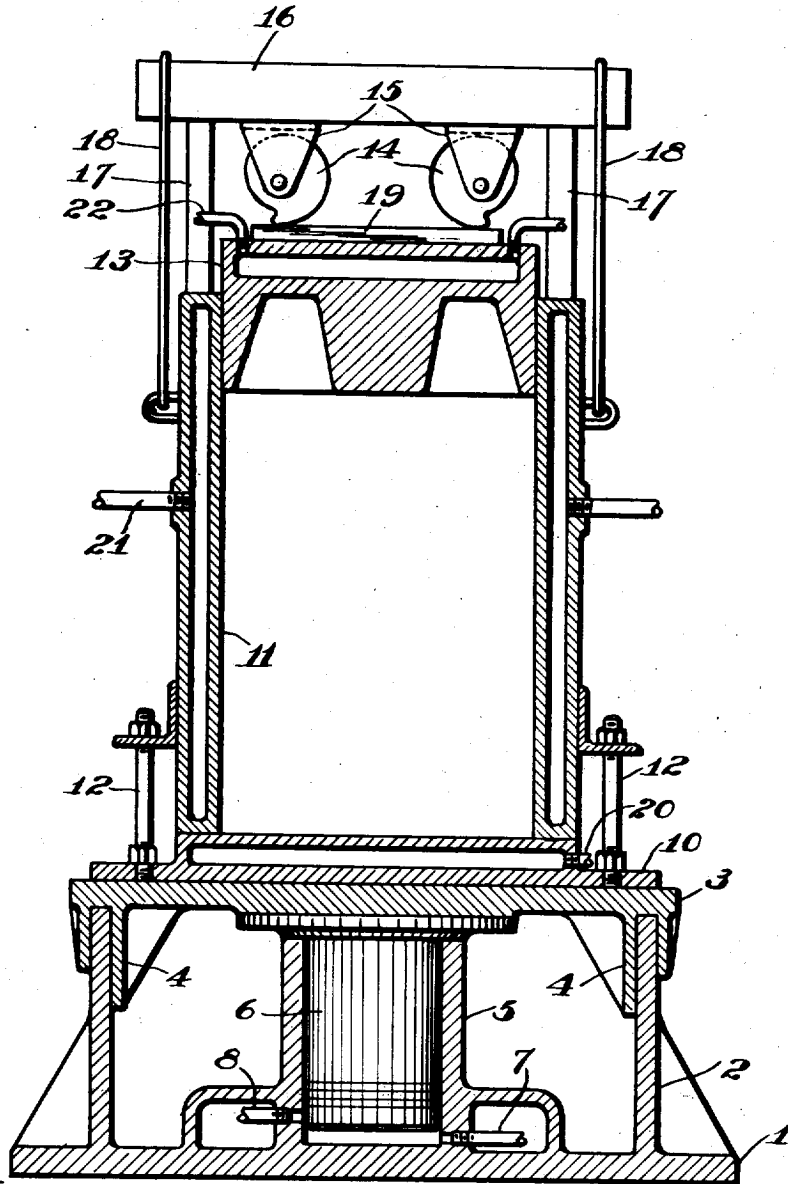
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May 5, 1931.

CARBON ELECTRODE AND METHOD OF MOLDING THE SAME

Original Filed July 19, 1927

Re. 18,062



WITNESS

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CARBON ELECTRODE AND METHOD OF MOLDING THE SAME

Original No. 1,683,587, dated September 4, 1928, Serial No. 206,922, filed July 19, 1927. Application for reissue filed August 27, 1930. Serial No. 478,259.

The invention relates to the molding of mixtures of granular materials, such as coke and silicon carbide, and plastic binders of relative viscous bitumens such as pitch and tar, the binder being added to and mixed with the granular materials to render them coherent when molded. While in its broader aspects the invention is unlimited to any specific article or class of articles, it is particularly applicable to the manufacture of carbon electrodes such as are used in electric furnaces for metallurgical and like operations.

In the manufacture of such electrodes, ground coke, or other suitable granular carbonaceous material, is mixed with tar or pitch, or with a mixture of tar and pitch, to form a mass which is then molded into desired form by tamping or pressing it in a mold, or by extruding it under high pressure through a die. Thereafter the molded article is fired or baked at a temperature of about 1000° C. to harden it and to remove the volatile constituents of the binder. By reason of its bituminous binder, the mixture just explained is stiff, unconsolidated, contains voids or air pockets, and tends to ball up when handled and because of these physical characteristics it is difficult in the prevailing tamping and extrusion molding processes to secure the desired degree of density and freedom from interior defects, particularly in larger articles such as electrodes of twenty inches or more in diameter. Also, when electrodes are molded by the extrusion process, cores are formed because the mixture does not flow equally throughout the cross section of the die.

The object of this invention is to provide a method of molding mixtures of granular materials and viscous bitumens whereby articles having uniform increased density may be economically formed.

The invention is predicated upon by discovery that a granular material mixed with a bituminous plastic binder to form a normally non-coherent and unconsolidated mass, may be readily molded into a compact coherent mass of substantially uniform increased density throughout, and substan-

tially free from internal defects, by confining the mixture in a mold and subjecting the mold and its contents to a repeated jarring action.

In forming carbon electrodes of the type to which reference has been made, the general practice is to prepare a mixture containing from about 70 to 88% of crushed or ground carbon, such as anthracite, petroleum coke, and electrode scrap or graphite which has been calcined to uniformly and thoroughly remove its volatile constituents, and from about 12 to 30% tar and pitch. The relative proportions of the tar and pitch vary for different service requirements of the electrodes, and with respect to the different conditions of the mix itself. In fact, due to variations in these and other factors, the mixes may contain from 50 to 95% of ground carbonaceous material and from 5 to 5% of binder. These materials are thoroughly mixed in a suitable mixer, and the mixture, because of its bituminous binder, has the physical characteristics previously explained.

According to the present invention, an unconsolidated mix, which may be the same as heretofore used, is placed in a suitable vertical mold adapted to be supported by, or forming a part of, a jolting machine of any suitable or desired construction. Prior to being placed in a mold, the mix is preferably heated to a temperature of about 100° C. or higher, depending of course on the character of the binder and to prevent the chilling of the mix by its contact with the walls of the mold, the mold is preferably heated prior to the introduction of the mix. This mix may be shoveled into the mold, or conveyed to it by a continuous belt or other type of conveyor. While it is being filled with the mix the mold is preferably jolted and, when supplied with the required amount of the mix, a heated weight is placed upon its upper surface to confine it and to exert pressure upon it while the jolting operation is continued in a vertical direction for a sufficient period of time to thoroughly compact and densify the mix. In place of a weight, other instrumentalities may be used to confine the upper portion of the mix in a mold during the jarring operation.

At the end of the jarring operation it has been found to be advantageous to cool the mold and the surface of the molded article before removing the molded article from it.

5 Various forms of jolting machines of the type contemplated are well known, and commonly used in the forming of sand molds in foundries for casting metals, and for other purposes. By way of illustration and not
10 of limitation, there is somewhat diagrammatically shown in the accompanying drawing a vertical central sectional view of a form of pneumatic jolting machine which may be used, and supported on such machine there
15 is shown a vertical central sectional view of a mold for forming a carbon electrode.

The jarring machine comprises a base 1 having sides 2 and a table 3 provided with downwardly extending guides 4 which tele-
20 scopically receive the upper end of sides 2. The base is provided centrally with a cylinder 5 which receives a piston 6 attached to table 3. For raising the table, pressure fluid may be supplied to cylinder 5 through a pipe 7,
25 and to permit the table to fall the pressure fluid may be exhausted from the cylinder through a pipe 8. In dropping, the table falls onto the top of the sides 2 of the base, these sides forming an anvil for stopping the
30 downward travel of the table. By this means a considerable jolt is imparted to the mold and its contents at the end of the downward movement of the mold.

The mold resting upon table 3 comprises a
35 base 10 and a vertical side wall 11 which may be attached to the base by bolts 12, as shown. A weight 13 is arranged in the upper portion of the mold to confine the upper end of an electrode mixture during the jarring operation. To hold the weight against displacement,
40 a pair of gravity cams 14 pivotally mounted eccentrically in brackets 15 attached to the lower end of a bar 16 extending transversely of the mold, the bar being supported by posts 17, and tied to the mold by links
45 18. Between cams 14 and the top of weight 13 there is a filler 19 of variable thickness. As material in the mold becomes compacted in a jarring operation, gravity cams 14
50 gradually wedge themselves between bars 16 and a filler 19 to hold weight 13 firmly against the top of the material. The weight 19 constitutes a follower at the top of the mold while the cams 14 function to maintain the
55 follower continuously in contact with the material. When the downward movement of the mold is suddenly stopped the inertia of the mass of material within the mold tends to carry it down so that the moment of greatest compression of the material occurs at this
60 time. Due to the fact that the cams are off-center, the same inertia effect will tend to rotate them so that the cams will be most strongly urged toward the follower plate at
65 the moment of greatest compression of the

material. Since the follower itself is also carried down by this inertia effect this movement of the cams encounters the least resistance at this time.

As shown, mold base 10, vertical wall 11,
70 and weight 13 may be of double-wall construction for heating these parts before a molding operation, steam or other heated fluid being supplied to those parts through pipes 20, 21 and 22. At the end of the mold-
75 ing operation, a cooling fluid may be introduced into these mold parts to facilitate the removal of a molded electrode. By the provision of fluid circulating passages entirely around the mold, as well as at the top and
80 bottom thereof, it is possible to preheat the mold so that upon the introduction of the mix, the mix is prevented from cooling to a point where it will no longer respond to the jarring of the mold. The provision of means
85 for heating the top and bottom surfaces of the electrode is particularly desirable in securing a uniform texture near the ends of the electrode. The jacketing of the mold also allows for the rapid cooling of the molded
90 electrode by providing a passage through which a cooling fluid can be circulated after the compacting operation has been completed.

By way of example, I have found that in the manufacture of carbon electrode a mixture formed of about 35% coarse petroleum
95 coke, 43% fine petroleum coke, 10% ground butts of electrodes, 9% pitch and 3% tar, when placed in a mold for forming an electrode having a cross section 12" x 16", may be thoroughly compacted to form a coherent
100 and uniformly dense molded mass by jarring the mold for five minutes on a heavy duty jolting machine, using a weight of about two thousand pounds upon the top of the mix after the mold has been supplied with the
105 required amount of it.

As an example of the applicability of the invention to the economical production of
110 much larger electrodes, a mixture composed of about 40% baked electrode scrap ground to pass a one inch mesh screen, about 30% calcined anthracite coal flour ground so that 60% of it passed through a 200 mesh screen
115 and approximately 30% pitch as a binder was gradually fed into an octagonal mold supported on a jolting machine which was operated at the rate of sixty drops per minute while the mix was being added. The great-
120 est sectional dimensions of this mold were 26 and 44 inches. The mix, at a temperature of about 150° C. was continuously added at the rate of several hundred pounds per minute, the mold being previously heated to about
125 165° C. After the mold was supplied with the required amount of mix, a weight of about six thousand pounds was placed on top of the mix and the machine run for three minutes. This electrode was 139 inches long, weighed
130

8240 pounds, and the total time required to make it was 29 minutes.

By jarring the mold during the time the mix is being introduced, a large part of the compacting of the material occurs while the mold is being filled, so that the length of the mold does not have to be excessively greater than the length of the completed electrode. Moreover, this step in the operation allows for the adjustment of the particles in the mix at a time when they are under less pressure.

Carbon linings of furnaces used in metallurgical operations, such as those used in the production of aluminum by the well known Hall process, may be molded in place in a similar manner. In making such linings the mixture may be about 86% of metallurgical bituminous coal coke and about 14% tar and pitch, although other proportions and mixes may be used. The mixture is placed in the furnace shell itself, a form and weight is placed on top of the mixture, and the entire furnace shell, lining forming mixture, form, and weight then jolted until the mixture is properly compacted.

In the manufacture of articles of the type herein contemplated, the green molded mixtures are baked to harden them and to remove the volatile constituents of the binder, its non-volatile constituents remaining in the article as coke or graphite, depending on the temperature of baking. In electrodes and furnace linings it is particularly desirable that they be as free as possible of voids. By the practice of this invention this desideratum is readily attained, particularly in the case of very large articles, which, prior to this invention, have been largely made by hand and therefore less uniformly dense.

An important advantage incident to the manufacture of electrodes according to this invention has to do with the prevailing position in which irregularly shaped particles of a mix lie by reason of the jolting operation.

In the extrusion process of molding electrodes the tendency is for the larger dimensions of non-uniform particles of carbon to lie in the direction of the extrusion, and in the tamping process there is little if any tendency towards any definite orientation of the particles. In the practice of this invention, the introduction of the material into the mold and the subsequent jolting thereof is carried on under conditions inductive of and for the purpose of not only compacting the mass, but causing the majority of such particles as have at least one dimension greater than another to so orient themselves that they lie with their greatest cross-sectional area in a direction at right angles to the jolting, or in other words, with the longest axis at right angles to the longitudinal axis of the finished electrode. The particles therefore lie in a direction to increase the radial heat conductivity of the electrode and the resistance to heat conduc-

tivity axially of the electrode. The resistance to heat conductivity along the axis of the electrode lessens the transfer of heat from the lower to the upper portion of an electrode when the lower portion is subjected to a high temperature, as by being immersed in a molten bath, and, to the extent that such conduction of heat is lessened, the rate of oxidation of the upper portion of the electrode is lowered. Furthermore, such heat as is generated in and conducted to the upper portion of the electrode is dissipated with greater rapidity by reason of the increased radial heat conductivity.

A further advantage of this invention, as compared to the prevailing extrusion process, is that electrodes may be manufactured much more economically because of the relatively inexpensive machinery that is required, and of the light inexpensive molds which may be used instead of expensive dies. Cheap weights, or equivalent pressure-applying instrumentalities, replace the very heavy and expensive presses, hydraulic accumulators, pumps and other apparatus used in the extrusion process. These advantages taken in connection with the increased uniformity of density effected by the practice of the invention, result in improved products manufactured by manifest economies.

By the use of a follower with a following up hold-down means in the molding of an electrode from a viscous bituminous mix, electrodes of high density can be obtained. When the downwardly moving mold comes to a sudden stop, the inertia of the mix in the mold causes the mix to continue its downward movement. The follower moves down with the mix. The hold-down means prevents back travel of the follower upon any rebound or expansion of the viscous mass, thus keeping it compacted and causing the liberation of entrapped gases. This results in securing a high density in the finished electrode, including the upper end portion. Because electrodes are subsequently shaped to screw together, it is important that a high density be procured at the ends of the electrode where this joint is formed.

Furthermore, as previously indicated, the invention is applicable to the molding of granular materials other than carbon when mixed with a bituminous binder.

According to the provisions of the patent statutes, I have explained the principle and mode of operation of my invention, and have given specific examples of how it may be practiced. However, I desire to have it understood that, within the scope of the appended claims, the invention is not limited to the specific examples given, nor to the size of articles or the forms in which they are molded.

I claim as my invention:

1. The method of molding into a coherent

mass a normally unconsolidated mixture of granular material and a viscous bituminous binder, comprising placing the mixture in a mold, and jarring the mold.

2. The method of molding into a coherent mass a normally unconsolidated mixture of granular carbon and a viscous bituminous binder, comprising heating the mixture, placing the heated mixture in a mold, and jarring the mold.

3. The method of molding into a coherent mass a normally unconsolidated mixture of granular carbon and a viscous bituminous binder, comprising heating the mixture, placing the heated mixture in a heated mold, and jarring the mold.

4. The method of molding into a coherent mass a normally unconsolidated mixture of granular carbon and a viscous bituminous binder, comprising heating the mixture to a temperature of not less than about 100° C., placing the heated mixture in a heated mold, jarring the mold to consolidate the mixture, and cooling the mold body before removing the molded mass.

5. The method of making a carbon electrode comprising forming an unconsolidated mixture of from about 70 to 88% ground carbon and from about 12 to 30% of viscous bituminous binder, placing the mixture in a mold, and jarring the mold to consolidate the mixture.

6. The method of making a carbon electrode comprising forming an unconsolidated mixture of from about 70 to 88% ground carbon and from about 12 to 30% of a binder composed of tar and pitch, placing the mixture in a mold, and jarring the mold to consolidate the mixture.

7. The method of making a carbon electrode comprising forming a mixture of from about 70 to 88% ground calcined coke, and from about 12 to 30% of a binder composed of tar and pitch, heating the mixture, placing the heated mixture in a mold, and jarring the mold to consolidate the mixture.

8. The method of molding into a coherent mass a normally unconsolidated mixture of granular material and a viscous bituminous binder, comprising placing the mixture in a mold, confining and adding pressure to the upper surface of the mixture, and jarring the mold to consolidate the mixture.

9. The method of molding into a coherent mass a normally unconsolidated mixture of from about 70 to 88% ground carbon and from about 12 to 30% of a viscous bituminous binder, comprising heating the mixture, placing the heated mixture in a heated mold, confining and adding pressure to the upper surface of the mixture, and jarring the mold to consolidate the mixture.

10. A carbon electrode comprising a baked mixture of ground carbon and a bituminous

binder, the electrode having greater lateral than longitudinal heat conductivity.

11. A carbon electrode comprising a baked mixture of ground carbon and a bituminous binder, the major portions of the particles of carbon having their largest cross sectional areas lying in planes transverse to the longitudinal axis of the electrode whereby the electrode has greater lateral than longitudinal heat conductivity.

12. A carbon electrode comprising a baked mixture of from about 70 to 88% ground carbon, and from about 12 to 30% of bituminous binder, the major portions of the particles of carbon having their largest cross sectional areas lying in planes transverse to the longitudinal axis of the electrode whereby the electrode has greater lateral than longitudinal heat conductivity.

13. The method of making carbon electrodes from a mixture of a bituminous binder and ground carbon, which comprises placing the mixture in a mold and jarring it under such conditions and for a length of time sufficient to effect an orientation of the majority of such carbon particles as have at least one dimension greater than another with their major axes in a direction generally at right angles to the jolting, whereby the electrode is more thermally conductive in a transverse direction than an axial direction.

14. The method of making a carbon electrode which is more thermally conductive in a direction transversely of the longitudinal axis thereof than in a coaxial direction, which comprises introducing a mix of granular carbon and a heat softened binder into a mold and jarring the mold for a sufficient time and while maintaining the mix under such conditions as to secure an orientation of the majority of such particles as have at least one dimension greater than another with their major axes approximately perpendicular to the major axis of the mold.

15. The method of making a carbon electrode which comprises forming a mixture of granular carbon and a bituminous binder, introducing it into a mold and jolting the mold while the mixture is being introduced.

16. The method of making a carbon electrode in a mold which comprises forming a mixture of granular carbonaceous material and a binder, jolting the mold while adding the mixture thereto, and thereafter compressing the mixture in the mold while continuing the jolting.

17. The method of making a carbon electrode which comprises heating a mixture of granular carbonaceous material and a bituminous binder, introducing the mix into a heated mold and subsequently compacting the heated mix in the heated mold by jolting the mold.

18. The method of forming electrodes which comprises placing a heated mixture of

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carbonaceous particles and a bituminous binder in a mold after the mold has been heated to a temperature higher than that of the mix, jolting the mold to compact the mix, and thereafter cooling the mix and then removing it from the mold.

19. The method of forming electrodes which comprises heating a mix of carbon particles and a bituminous binder to a temperature at which the mix possesses mobility and at which the carbon particles in the mix are free to adjust themselves in the mix, introducing the mix in this condition into a mold and jolting it in such manner as to cause orientation of the carbon particles with their largest cross-sectional area at approximately right angles to the direction of jolting.

20. The method of forming an electrode having a thermal conductivity which is greater in a lateral direction than an axial direction, which comprises forming a mix of granular carbon particles a portion of which have greater cross-sectional areas in one direction than in directions perpendicular thereto, mixing therewith a bituminous binder, the mobility of which increases upon heating, heating the mix and subsequently jolting the heated mix in a mold under such conditions and for a length of time such that the majority of the particles which have a greater cross-sectional area in one direction have their major axes at approximately right angles to the direction of jolting, the jolting being effected in the direction of the longitudinal axis of the mold.

21. The method of making a carbon electrode which comprises forming a granular mix of carbon particles and a binder, introducing the mix in a plastic state into a mold while the mold is being jolted in a vertical direction, thereafter applying pressure to the material at the top of the mold and continuing jolting the mold.

22. The method of making electrodes from a mix of carbon particles and a heat softened bituminous binder, which comprises heating the mix to a temperature at which the binder is softened, heating the walls of the mold to a temperature above the temperature of the mix, introducing the heated mix into the heated mold and jolting the mold, and thereafter circulating a cooling fluid around the mold to chill the mix, and then removing the mix from the mold.

23. The method of making elongated electrodes of high density, which comprises introducing a mixture of granular carbon and a viscous bituminous binder into a mold which is open at its upper end, jolting the mold in the direction of its longest axis by raising and dropping the mold and suddenly checking the downward movement thereof, maintaining a follower on the surface of the mix in the top of the mold which is free to move down in the mold with the compacting

of the mix therein, and continuously holding the follower in intimate contact with the mix during a portion of the jolting operation and thereby preventing the rebound of the mix during this stage of the jolting.

24. The method of making an elongated electrode of high density, which comprises introducing a heated mixture of granular carbon and a bituminous binder into a vertical mold which is open at its upper end, jolting the mold vertically by raising it and dropping it and suddenly checking the downward movement thereof and continuously holding a follower against the surface of the material at the top of the mold and preventing the rebound of the follower during the operation of jolting to thereby compact the material and hold it against expansion during the operation of jolting to simultaneously secure a high density throughout the length of the electrode and procure an orientation of the major portion of such carbon particles as have at least one dimension greater than another with their greatest axes approximately perpendicular to the axis of the electrode.

25. The method of forming an electrode which comprises simultaneously jolting and compressing a mix of carbon particles and a binder in a mold while heating the upper and lower surfaces of the mix in the mold.

In testimony whereof I have hereunto set my hand.

VICTOR C. DOERSCHUK.

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