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W. H. FISHER ET AL

APPARATUS FOR TREATING IRON AND IRON ALLOYS

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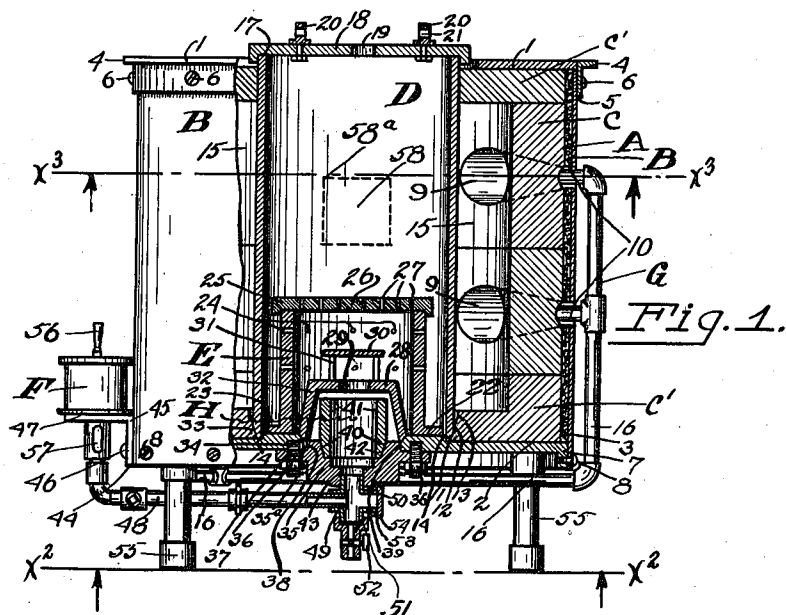


Fig. 2.

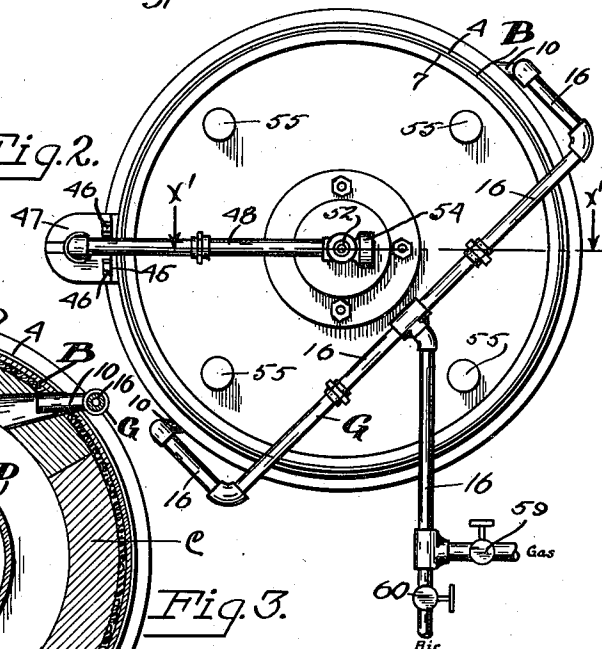
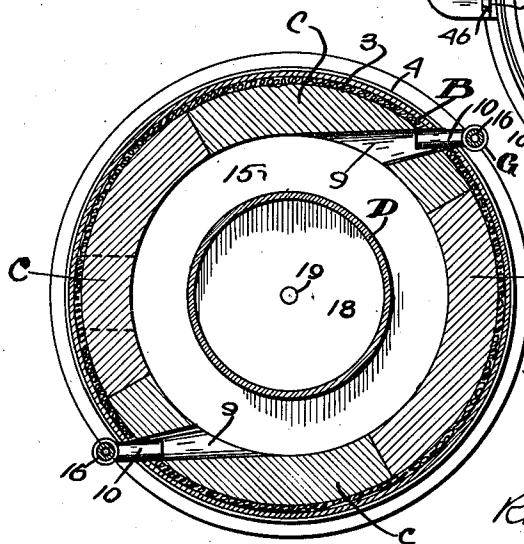


Fig. 3.



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APPARATUS FOR TREATING IRON AND IRON ALLOYS.

Application filed May 18, 1920. Serial No. 382,290.

To all whom it may concern:

Be it known that we, WILLIAM HOWARD FISHER and PETER CHAMBERS, citizens of the United States, residing at Los Angeles and Redondo Beach, respectively, in the county of Los Angeles and State of California, have invented new and useful Improvements in Apparatus for Treating Iron and Iron Alloys, of which the following is a specification.

This invention relates to apparatus for treating iron and iron alloys. It has for an object the provision of a suitable furnace which utilizes a particular liquid hydrocarbon which will not oxidize the steel used in the furnace. Another object is to provide a furnace using a liquid hydrocarbon which will perform the impregnating process or make the surface of the steel more dense with carbon in a shorter period of time than heretofore, and which impregnating process will be performed with uniformity, will leave no soft spots in the metal and reduce the cost in operation.

Preferably we use a particular liquid hydrocarbon with a specially constructed furnace, which hydrocarbon forms into a gas having certain properties and which gas escapes after the carbon has been removed from same and burns while escaping. The gas which is burning indicates the degree of work being performed in the interior of the furnace by the color of the burning gas, and the height to which it glows or burns. Thus it is possible without the use of artificial means, as now used, to know at a glance the degree of carbon being absorbed by the steel in the interior of the furnace.

In practicing the invention we provide a special hydrocarbon oil which is fed into a suitable retort at a pre-arranged speed. This retort connects with the interior of a cylindrical casing provided with perforations, which latter casing is arranged within a work-holding retort. Suitable heating means heats the retort and in so heating gasifies the liquid and the gasified liquid passes through the perforations and contacts with whatever work may be within the work-holding retort. Gas is allowed to escape through a vent in the cover of the retort after the carbon has been taken from same, and the gas as it escapes burns with a bluish flame. The particular color or change in the bluish color, as well as the

height which the flame reaches, indicates the amount of carbon that is being absorbed by the steel.

It has been customary to carbonize or case-harden steel by utilizing such carbonizing materials as charred leather, powdered bone, cyanide of potassium, wood and animal charcoal, prussiate of potash and other materials consisting of mixtures of carbonaceous materials and certain cyanides and nitrates. The steel articles to be impregnated with carbon are first packed in a suitable box after a layer of casehardening material has been placed upon the bottom of said box, the thickness of the layer depending on the size of the pieces to be hardened. Obviously in order to properly caseharden a metal it is necessary that the surfaces of the parts should be in direct contact with the carbonaceous material, and if the parts should happen to touch one another it is quite likely that the parts that touch will be softer at the space where they are in contact. It has been found that if there is not enough carbonizing material in the box the work is also liable to have soft spots. It has been found impossible to properly impregnate steel or make it more dense where considerable depth of carbon is required by packing the articles with bone or charcoal in an iron box and sealing on the cover. This is due to the fact that only a certain amount of carbon is present, and the longer the work is baked, the more there will be in the steel. When an equilibrium is established no more carbon will penetrate the metal, and to obtain a greater depth, the work must be packed in fresh carbonaceous material and the heating repeated. It has likewise been found very difficult to correctly determine the depth of impregnation of the carbon within the steel; and various degrees of heat have been determined at which points the iron or steel will contain certain amounts of carbon.

The inventors are aware that certain processes have been developed which do not require placing articles to be carbonized in iron boxes packed with carbonaceous material, and that such processes have been developed by Giolitti and by the American Gas Furnace Company. The Giolitti process consists essentially in packing the work with wood charcoal in a cylinder and when heated to carbonizing temperature a current

of carbon dioxide is injected into the cylinder. The American gas furnace process or method consists in using gas as a carbonizing material and placing the work in a small revolving, properly heated, cylindrical retort into which the carbonizing gas is injected under pressure. From the gas the work absorbs the volatile carbon.

It is obvious that a furnace of this type using a carbon gas would be less expensive in operation than the old method of first packing the articles to be impregnated with carbon, as at least three or four operations would be entirely done away with. It has been found that the use of carbon monoxide while capable of rapid penetration, has an oxidizing effect on steel, and is liable to form a scale that will spoil small work which cannot afterwards be ground. This oxidizing effect is more pronounced in chromium and manganese steels. Casehardening is mostly performed on small articles which must have a perfectly hard surface, and yet be of such internal structure that there is no chance of breaking them when in use. For example, in the making of axles, cups, cones and similar articles. The Giolitti process above mentioned depends upon passing carbon granules into a muffle or work-holding retort under pressure, and the carbon becomes mobile and flows like a liquid in the presence of heat, and in so flowing passes into all interstices surrounding the work. This process of course necessitates an accurate handling and expert attention to details, but it is more rapid than the old method of first packing the articles in boxes. As for the revolving furnace method, while this ensures an even distribution of heat, still the revolving process is liable to dump the different articles within the retort upon each other and if the articles should happen to be gears, to possibly break the teeth of same. With the idea of overcoming the objections now incident to furnaces of this latter type, the inventors have constructed a novel form of oven which utilizes a particular hydrocarbon fluid which will not oxidize the steel, thus spoiling small work. The interior of the work-holding retort is at all times dry; that is to say, water is not formed within the retort upon the heating of the gas, as is ordinarily the case; in fact, the presence of water is highly disastrous in furnaces of this form. Likewise the gas used does not have an oxidizing effect on the alloyed steels. The entire furnace with its liquid hydrocarbon is capable of being so adjusted that one attendant can readily perform all the operations necessary and incident thereto. Furthermore, the apparatus is simple in design and readily accessible.

It will be understood that the use of this hydrocarbon liquid and this furnace

is for performing the casehardening process only, and does not refer to the quenching or the tempering process that is necessary after the steel has been impregnated with carbon. The furnace is made of such a size that it gives a uniform heat throughout and performs its work more rapidly and more uniformly than is possible with any known process on the market today. The carbon removed from this hydrocarbon liquid will find its way into slots, holes and cavities which would not under ordinary circumstances receive the carbon from the granulated bone or any other solid packing material, and hence the uniformity of the product is greater. In many cases, low carbon steel treated by this particular process may be substituted for tool steel in machine construction. Furthermore, the percentage of carbon in the gas surrounding the work can be maintained at a permanent figure until the carbon has penetrated to any desired depth of the metal.

The invention has for further objects to provide an improved apparatus of the character above-mentioned, which will be relatively simple and inexpensive in carrying on or practicing or furtherance, taken in conjunction with efficiency speed and expediency and general adaptability.

The invention consists in the novel and useful means hereinafter disclosed and finally pointed out in claims.

It will be understood that many variations in detail may be made in departure from the specific definition of the process as well as the apparatus about to be disclosed.

The improved process for treating iron and its alloys is claimed in a divisional application filed October 13, 1920, Serial No. 416,657, and the improved composition for treating iron and its alloys was filed October 13, 1920, Serial No. 416,658 which application was allowed on July 19, 1921.

In the drawing:

Figure 1 is a fragmentary elevation, certain parts being shown in section of an improved furnace used in connection with a certain liquid hydrocarbon for casehardening steel, taken on the line x^1-x^1 Figure 2;

Figure 2 is a fragmentary bottom view of the device shown in Figure 1, and taken on the line x^2-x^2 , Figure 1, and looking in the direction of the appended arrows; and,

Figure 3 is a cross sectional view of the device shown in Figure 1 and taken on the line x^3-x^3 , Figure 1, and looking in the direction of the appended arrows.

Corresponding parts in all the figures are designated by the same reference characters.

Referring with particularity to the drawing, A designates a furnace of which B is

the outer casing wall, C heat resisting means, D a work-holding retort co-axially arranged within the furnace A, E a cylindrical perforated casing located in the bottom of the work-holding retort, F a sight feed reservoir for holding certain liquids used in connection with the furnace, G means for conducting gas for heating the interior of the furnace, and H a container for holding a liquid hydrocarbon within the perforated cylindrical wall member,—all of which elements are used in practicing one embodiment of the invention.

The furnace A is so constructed that all parts of the furnace are readily accessible. The furnace consists essentially in the outer cylindrical casing B provided with a cover member 1 and a base member 2. Within the outer casing B are arranged fire brick or other heat-resisting material C. This heat resisting material C is made in segments as shown in Figure 3. This particular construction overcomes any tendency for the furnace to crack or bulge due to excessive heat or excessive cold incident to cooling. Intermediate the outer periphery of the heat-resisting means C and the casing B is a fibrous substance 3 which will not conduct heat. The end portions 1 and 2 are likewise provided with heat-resisting means C', the cover 1 and the base 2 holding the heat-resisting means C' in position. In order to ensure the casing B maintaining its form a flanged rim 4 is provided at its upper end as at 5 and held in position thereto by bolt members or screws 6. The heat-resisting means C' is annular in form in order to accommodate the work-holding retort D, as shown in the drawings. The base member 2 is likewise annular in form and is provided with a downwardly directed flange 7 at its outer edge, which flange is perforated to accommodate bolts 8 for holding the outer casing B to said base and flange. Certain of the fire brick or heat-resisting elements C are provided with semi-conical perforations 9 which likewise extend through the non-conducting heat element 3 and the outer casing B. Disposed within a portion of this perforation 9 is a pipe 10 connecting with the source of supply of whatever fluid is to be burned to heat the furnace. The perforation 9 is purposely made in the form shown in Figures 1 and 3 so as to allow for an expansion of the gas as it is discharged from the opening in the pipe 10. The work-holding retort D which likewise acts as a muffle is disposed within the annular space formed by the members C' and supported upon the base member 2. The work-holding retort D is preferably cylindrical in form and has an end portion as at 11 slightly beveled as at 12 on the outer peripheral edge thereof. The lower annular heat-resisting means C' is likewise beveled as at 13 on its inner periph-

eral annular edge. The heat-resisting element C', as well as the work-holding retort D are made this way in order that there may be a close cooperation with their respective edges in order to ensure a close fit with little or no loss of gas or heat. The base member 2 is likewise provided with a flange 14 in order to aid in retaining the work-holding retort D in position upon same. Reference to the figures will show that there is a spaced portion 15 existing between the work-holding retort D and the inner peripheral surface of the heat-resisting elements C. Combustion of gases used in heating the furnace occurs in this spaced portion 15.

The means G used in conducting gas to the interior of the furnace comprises a series of inter-connecting pipe members 16 joined together by elbows, as shown in the figures. Referring to Figure 2 it will be noted that one portion of the means G communicates with an air supply and the other portion with the source of gas supply. The part that ordinarily is used in forcing air within the pipe members 16 is associated with a blower so as to give the necessary oxygen content to the gas, as well as to create a hot flame within the space 15 of the furnace A. It is customary to utilize an expansion tank in order to get a constant air pressure. Otherwise the pulsation from the blower will affect the heat in the furnace. However, in the particular construction of the furnace shown, it is not absolutely necessary to use the expansion tank, as the perforation 9 and the space 15 act to a certain extent as an expansion chamber.

The top 17 of the work-holding retort D is provided with a U-shaped or flanged cover member 18, which cover member is provided with a centrally located vent 19. The cover is likewise provided with gripping ring brackets 20, so that a rod might be run through the perforations 21 in said ring brackets 20 and the cover 18 removed from the end of the work-holding retort D in order to insert work or to remove work from the interior of said retort D. Supported upon the base member 2 as at 22, is a cylindrical casing E having one end as at 23 circumferentially and outwardly flanged, which flanged portion acts as a foot means for rigidly holding the cylindrical casing E in position. The cylindrical casing E is provided with a series of perforations 24 passing through the wall thereof, and is provided at its opposite end as at 25 with a flanged cover plate 26, which plate is likewise provided with a series of perforations 27. Within the cylindrical casing E and in spaced relation thereto is an inverted bucket-shaped member 28 provided with an enlarged hole 29 in what would be the base of said member 28, and disposed over the hole 29 is a protecting spaced plate 30 supported

upon legs 31. A side member 32 of the bucket-shaped element 28 has its end as at 33 beveled as shown at 34, and the beveled portion rests upon a correspondingly beveled portion 35^a on the inner peripheral annular edge of the base member 2, so that the member 28 may be always retained in a definite close fitting engagement with the base member 2.

10 A plate member 35 covers the open annular portion of the base member 2 and likewise the open interior portion of the bucket-shaped member 28, and is held in relation to the base member 2 by means of stay bolts 36. The member 35 is provided with a circumferential lug 37 which forms with the edge to which it is joined, flanged portions 38 and 39, which flanged portion 38 cooperates with the inner peripheral annular wall of the base member 2. Likewise the lug 37 is provided with perforations at certain distances in order to accommodate the stay bolts 36. The member 35 is internally chambered as at 40 to accommodate a cylindrical member 41, and the chamber wall portions 40 of the member 35 are made at a convergent downward angle while the end portions as 42 of the member 41 are correspondingly angled or beveled so as to form a close fit with the side walls of the chambered portions 40. Centrally located and communicating with the interior of the member 35 is a perforation 43. Located externally of the furnace A and joined to the casing near one end as at 44 is a bracket arm 45 held in position to the casing B by means of a bolt 46. A portion of the bracket 45 as at 47 supports thereon a sight feed reservoir F of any standard form. Communicating from the interior of the sight feed reservoir F is a fluid conducting pipe 48. Across head 49 joined to the pipe 48, has one of its terminals as 50 communicating with the perforation 43 and with the interior of the member 41. The oppositely directed portion 51, that is, the portion opposite the terminal 50 is provided with a valve cock 52, and a terminal 53 directly opposite the entrance of the conducting means 48 is provided normally with a cap 54.

The furnace is supported from the ground or flooring by means of a plurality of leg members 55 which are joined to the base 2 and held rigidly thereto.

55 The operation is as follows:

A liquid hydrocarbon is placed within the sight feed reservoir F and a control valve handle 56 is so set that a predetermined quantity of said hydrocarbon fluid will drop past the sight 57 and into the pipe 48 and thence fill the container 41. The handle 56 is so set that the liquid hydrocarbon will not overflow its container 41. A plate 58 shown by dotted lines in Figure 1 covers an opening 58^a provided in the members C. When

the source of gas supply is turned on by means of a valve cock 59 and the air through a valve cock 60 is connected with a blower or other suitable element, said gas may be ignited within the space 15 by opening the plate 58. The particular construction of the perforation 9 gives the gas and the air a whirling effect within the space 15 and consequently there is a solid mass of flame surrounding the work-holding retort D. The heat from the gas is communicated through the walls of the work-holding retort D and thence through the walls and perforations of the member E and finally to the fluid contained within the member 41. This heat causes the hydrocarbon fluid to vaporize and pass upwardly through the hole 29 in the bucket-shaped member 28 and from a vaporous stage it passes through perforations 24 and 27 in the form of a gas into the work-holding retort. The perforations are preferably made small so as to retard the passage of the gas as much as possible. The gas completely fills the work-holding retort D and contacts with the work supported upon the cover plate of the member E. As the carbon is constantly removed from the gas and uniting with the steel one of the products of said gas, which is hydrogen, passes upwardly through the vent 19 and is there ignited and burns with a pale flame. As is before explained, the particular color of this flame indicates the condition of the carburizing of the steel within the retort. It is customary to note temperature variation by inserting a thermo-couple or by focusing an optical pyrometer successively in different parts of the furnace, all of which is unnecessary in the present furnace. It has been found that very little or no residue of carbon is left within the retort after the carburizing operation has been performed; nor are the perforations 24 or 27 completely filled with carbon deposits after a carburizing operation.

The work such as gears, axles, etc., is stacked upon the cover plate 26 of the member E and the plate 18 then placed in position covering the work-holding retort. Ordinarily the carburizing operation requires some twelve hours of time, but with this device it has been found that it will perform the same amount of work in from three to four hours. In order to remove the work, means are slipped through the perforations 21 in the brackets 20 attached to the cover 18 and the cover removed and gripping irons may grasp the flanged portions of the cover plate 26 and lift the work completely out of the work-holding retort. It is a feature of this furnace that practically all air is excluded from same as the hydrocarbon fluid used contains little or no oxygen and the oxygen of the atmosphere is not permitted to come into contact with the work

because the gas rising from the hydrocarbon fluid prevents the air from coming into contact with the work as the work is lifted from the work-holding retort D. Obviously the source of heat supply could be diminished by turning the valve cocks 59 and 60 and the different articles allowed to cool, after which they might again be re-heated without using the hydrocarbon fluid and then removed from the work-holding retort and quenched on a rising heat, which is most desirable. It is commonly known that the actual carburization is due to the hot gases which are either liberated by the casehardening compound or formed by the re-action between the occluded air and the carbon. It is also well-known that the active casehardening reagent is a gas or a mixture of gases and that even when a powder is used that it is the gas liberated from the hot powder and not the solid itself that performs the work. Consequently the use of a particular liquid hydrocarbon which is utilized in this furnace readily performs its work in a most efficient and quick manner without waste. As to the reason why this gas does not make deposits of carbon within the perforations 24 and 27 or why it does not oxidize the steel, or why it has no oxidizing effect on chromium and other alloyed steels, is not known by the inventors.

Reference to Figure 1 shows that the hydrocarbon fluid may be readily drained from the member 41 by turning the valve cock 52 and closing the handle 56 which controls the sight feed reservoir. The plate 30 provided with the legs 31 covering the hole 29 of the member 28 is placed there for the express purpose of preventing any foreign substance, if any there be, from falling upon the liquid hydrocarbon contained within the member 41 and forming a surface coating upon said liquid that might prevent its ready vaporization. If it were desired to clean the internal parts of the furnace a removal of the stay bolts 36 would allow the plate 35 to be removed from the base member 2. This will allow the cross head 49 to be released from the perforation 43 and the plate 35 and the member 41 withdrawn from position. Thus the interior of the bucket-shaped member 28 might be cleaned. By removing the cover 18 the cylindrical member E might be drawn through the work-holding retort D and the member 28 likewise removed. If desired, the work-holding retort D could be drawn through the annular space formed by the heat-resisting elements C and C' and a new work-holding retort placed therein. Thus it will be observed that all parts are readily accessible for renewal or for repairs.

It has been found by experiment that a liquid hydrocarbon which consists essentially in using in proportion by volume pine

tar 40%, turpentine 20% and linseed oil 40%, will most efficiently when gasified carburize or caseharden steel. A combination of these particular elements to form the hydrocarbon fluid will perform all the functions that have been above attributed to said hydrocarbon fluid.

It is manifest that many variations and changes may be made with respect to the disclosure of the foregoing furnace such as reversing the parts within the work-holding retort D so that the liquid hydrocarbon might be injected through the top of the retort and the gas allowed to work downwardly through the interstices of the work therein;—all of the above changes, it being understood, may be made within a fair interpretation of the invention.

Having thus disclosed our invention, we claim and desire to secure by Letters Patent:

1. A furnace, comprising an outer wall of refractory material, an inner stationary retort wall spaced therefrom, said walls forming between them a continuous combustion space, means for supporting combustion in said combustion space, whereby said retort wall is heated; and means for supplying a hydrocarbon fluid to the space confined by said retort wall; said last named means comprising means for initially vaporizing said hydrocarbon fluid.

2. A furnace for carbonizing steel and like metals, including a work-holding retort, means for heating the retort, and means for passing a liquid hydrocarbon into the retort so that it gasifies under influence of the heat present for application to the metal; there being means associated with the retort for allowing the residue gas from which carbon has been removed to pass to the exterior of the furnace, and burn as it escapes, and by observation of the combustion determine the proportion of carbon being combined with the metal, and means for regulating the flow of the hydrocarbon fluid into the retort, whereby the carbonizing operation may be regulated as indicated by the combustion of the residue gas.

3. A furnace for carbonizing steel and like metals, including an outer casing, a base and top member, each of which is provided with a central opening, detachably joined to said casing; a heat-resisting wall within said outer casing, an inner work-holding retort wall spaced from said heat-resisting wall, said last named walls forming between them a continuous combustion space; means for supporting combustion in said combustion space so as to heat articles contained within the work-holding retort, and means for supplying a hydrocarbon fluid to the space confined by said work-holding retort.

4. A furnace for carbonizing steel and like metals, including an outer casing, said casing having a curved outer surface, an annular

base and top member for said casing, means for detachably joining said base and top members to said casing, walls composed of non-heat conducting material disposed adjacent the inner surface of the casing, an inner work-holding retort spaced from said non-heat conducting wall, said retort wall and said non-heat conducting wall forming between them a continuous combustion space, means for supporting combustion in said combustion space, and means for regulating the heat within said combustion space; means likewise being provided for supplying a hydrocarbon fluid to the space confined by said work-holding retort.

5. A furnace for carbonizing steel and like metals, including a curved outer casing, an annular base member and top member detachably joined to said casing, a portion of the inner edge surrounding the annular opening in said base being beveled, segmental walls composed of non-heat conducting material disposed adjacent the inner surface of the casing, annular segmental walls composed of non-heat conducting material disposed adjacent the base and top members; an inner work-holding retort wall spaced from said non-heat conducting walls, said work-holding retort wall and said non-heat conducting walls forming between them a continuous combustion space, means for supporting combustion in said combustion space whereby said work-holding retort wall is heated, and means for supplying a hydrocarbon fluid to the space confined by said work-holding retort.

6. A furnace for carbonizing steel and like metals, including a curved outer casing, an annular base member and top member detachably joined to said casing, a portion of the inner edge surrounding the annular opening in said base being beveled, segmental walls composed of non-heat conducting material disposed adjacent the inner surface of the casing, annular segmental walls composed of non-heat conducting material disposed adjacent the base and top members; an inner work-holding retort wall spaced from said non-heat conducting walls, said work-holding retort wall and said non-heat conducting walls forming between them a continuous combustion space, means for supporting combustion in said combustion space whereby said work-holding retort wall is heated, and means for supplying a hydrocarbon fluid to the space confined by said work-holding retort; said non-heat conducting wall disposed adjacent the base having its inner annular edge beveled, and the lower edge portion of the said work-holding retort being correspondingly beveled, the two beveled portions cooperating with each other to make an air-tight, close fit.

7. A furnace for carbonizing steel and like metals, including a curved outer casing, an

annular base member and top member for said casing, a heat-resisting wall disposed within said outer casing and adjacent the inner surfaces of the base and top members, said heat-resisting wall adjacent the base and top members being annular in form, an inner work-holding retort wall spaced from said heat-resisting wall, said work-holding retort being open at opposite ends, one end of which is supported upon the base member and the other end of which extends through the annular opening in the top member; a cover provided with a vent covering the open end of said work-holding retort; the outer wall surface of said work-holding retort and the inner wall surface of said heat-conducting material forming between them a continuous combustion space, means for supporting combustion in said combustion space, whereby articles contained within said work-holding retort may be heated, and means for supplying a hydrocarbon fluid to the space confined by said work-holding retort.

8. A furnace for carbonizing steel and like metals, including a curved outer casing, an annular base member and top member detachably joined to said casing, a portion of the inner edge surrounding the annular opening in said base being beveled, segmental walls composed of non-heat conducting material disposed adjacent the inner surface of the casing, annular segmental walls composed of non-heat conducting material disposed adjacent the base and top members; an inner work-holding retort wall spaced from said non-heat conducting walls, said work-holding retort wall and said non-heat conducting walls forming between them a continuous combustion space, means for supporting combustion in said combustion space whereby said work-holding retort wall is heated, and means for supplying a hydrocarbon fluid to the space confined by said work-holding retort; a member provided with a central orifice and a beveled edge portion cooperating with the beveled edge portion of the base, and a protective plate provided with supports mounted above said orifice.

9. A furnace for carbonizing steel and like metals, including a curved outer casing, an annular base member and top member for said casing, a heat-resisting wall disposed within said outer casing and adjacent the inner surfaces of the base and top members, said heat-resisting wall adjacent the base and top members being annular in form, an inner work-holding retort wall spaced from said heat-resisting wall, said work-holding retort being open at opposite ends, one end of which is supported upon the base member and the other end of which extends through the annular opening in the top member; a cover provided with a vent

covering the open end of said work-holding retort; the outer wall surface of said work-holding retort and the inner wall surface of said heat-conducting material forming between them a continuous combustion space, means for supporting combustion in said combustion space, whereby articles contained within said work-holding retort may be heated, and means for supplying a hydrocarbon fluid to the space confined by said work-holding retort; there being means mounted on the outer surface of the work-holding retort cover for removing same from the retort.

10. A furnace for carbonizing steel and like metals, including an outer casing, a base member and a top member for said casing, a heat-resisting wall within said outer casing, an inner work-holding retort wall spaced from said heat-resisting wall, said last named walls forming between them a continuous combustion space, means for supporting combustion in said combustion space whereby said work-holding retort wall is heated; means for supplying a hydrocarbon fluid to the space confined by said work-holding retort; said outer casing wall and the heat-resisting wall having an opening communicating from said combustion space to the exterior of the furnace, said opening having a progressively increasing diameter from the exterior of the furnace inwardly.

11. A furnace for carbonizing steel and like metals, including a curved outer casing, an annular base member and top member detachably joined to said casing, walls composed of non-heat conducting material disposed adjacent the inner surface of the casing, annular walls composed of non-heat conducting material disposed adjacent the base and top members; an inner work-holding retort wall spaced from said non-heat conducting walls, said work-holding retort wall and said non-heat conducting walls forming between them a continuous combustion space, said outer casing wall and the non-heat conducting wall adjacent thereto having an opening communicating from said combustion space to the exterior of the furnace, said opening having a progressively increasing diameter from the exterior of the furnace inwardly; means associated with said opening for conveying means to support combustion in said combustion space whereby said work-holding wall is heated, and means for supplying a hydrocarbon fluid to the space confined by said work-holding retort.

12. A furnace for carbonizing steel and like metals, including a curved outer casing, an annular base member and top member detachably joined to said casing, walls composed of non-heat conducting material disposed adjacent the inner surface of the casing, annular walls composed of non-heat con-

ducting material disposed adjacent the base and top members; an inner work-holding retort wall spaced from said non-heat conducting walls, said work-holding retort wall and said non-heat conducting walls forming between them a continuous combustion space, said outer casing wall and the non-heat conducting wall adjacent thereto having openings communicating from said combustion space to the exterior of the furnace, said openings having progressively increasing diameters from the exterior of the furnace inwardly; means associated with said openings for conveying means to support combustion in said combustion space whereby said work-holding retort wall is heated, and means for supplying a hydrocarbon fluid to the space confined by said work-holding retort.

13. A furnace for carbonizing steel and like metals, including a curved outer casing, an annular base member and top member detachably joined to said casing, segmental walls composed of non-heat conducting material disposed adjacent the inner surface of the casing, annular segmental walls composed of non-heat conducting material disposed adjacent the base and top members; an inner work-holding retort wall spaced from said non-heat-conducting walls, said work-holding retort being open at opposite ends, one end of which is supported upon the base member and the other end of which extends through the annular opening in the top member, said opening in the base member communicating with the interior of the work-holding retort; the outer surface of said work-holding retort and the inner wall surface of said non-heat-conducting material forming between them a continuous combustion space, means for supporting combustion in said combustion space, whereby articles contained within said work-holding retort may be heated, and means for supplying a hydrocarbon fluid to the space confined by said work-holding retort; a plate, provided with a circumferential lug, covering the annular opening of the base member; and means passing through the lug and into the base member for holding said plate detachably thereto.

14. A furnace for carbonizing steel and like metals, including a curved outer casing, an annular base member and top member detachably joined to said casing, segmental walls composed of non-heat conducting material disposed adjacent the inner surface of the casing, annular segmental walls composed of non-heat conducting material disposed adjacent the base and top members; an inner work-holding retort wall spaced from said non-heat-conducting walls, said work-holding retort being open at opposite ends, one end of which is supported upon the base member and the other end of which

extends through the annular opening in the top member, said opening in the base member communicating with the interior of the work-holding retort; the outer surface of said work-holding retort and the inner wall surface of said non-heat conducting material forming between them a continuous combustion space, means for supporting combustion in said combustion space, whereby articles contained within said work-holding retort may be heated, and means for supplying a hydrocarbon fluid to the space confined by said work-holding retort; a plate, provided with a circumferential lug, covering the annular opening of the base member, and means passing through the lug and into the base member for holding said plate detachably thereto; said plate being provided with a chambered portion having a central opening in the base thereof, and a side wall of said chamber being angularly disposed.

In testimony whereof, we have signed our names to this specification in the presence of two subscribing witnesses.

WILLIAM HOWARD FISHER.
PETER CHAMBERS.

Witnesses:

JENNIE SHUTT,
J. CALVIN BROWN.