March 17, 1931. H. E. COLEY 1,797,130

REDUCTION OF ORES, OXIDES, AND THE LIKE

Filed Feb. 7, 1929 4 Sheets-Sheet 1

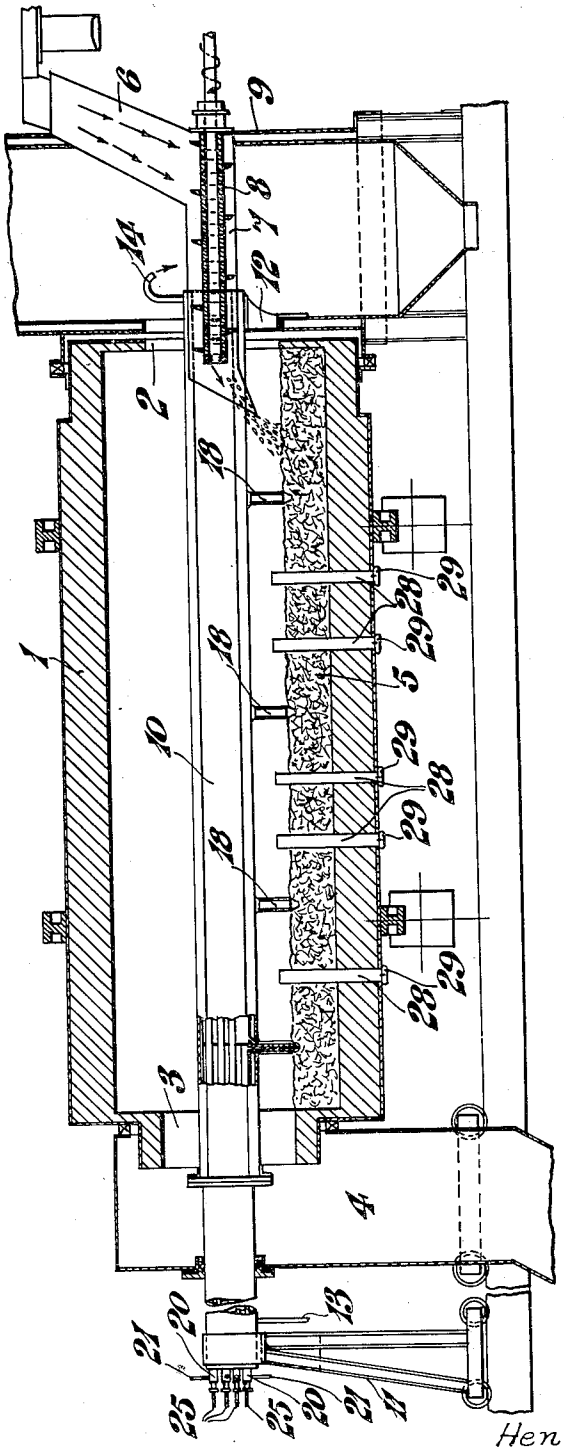

Fig. 1

Inventor

Henry Edwin Coley

By J. Kaplan Attorney

March 17, 1931. H. E. COLEY 1,797,130

REDUCTION OF ORES, OXIDES, AND THE LIKE

Filed Feb. 7, 1929 4 Sheets-Sheet 2

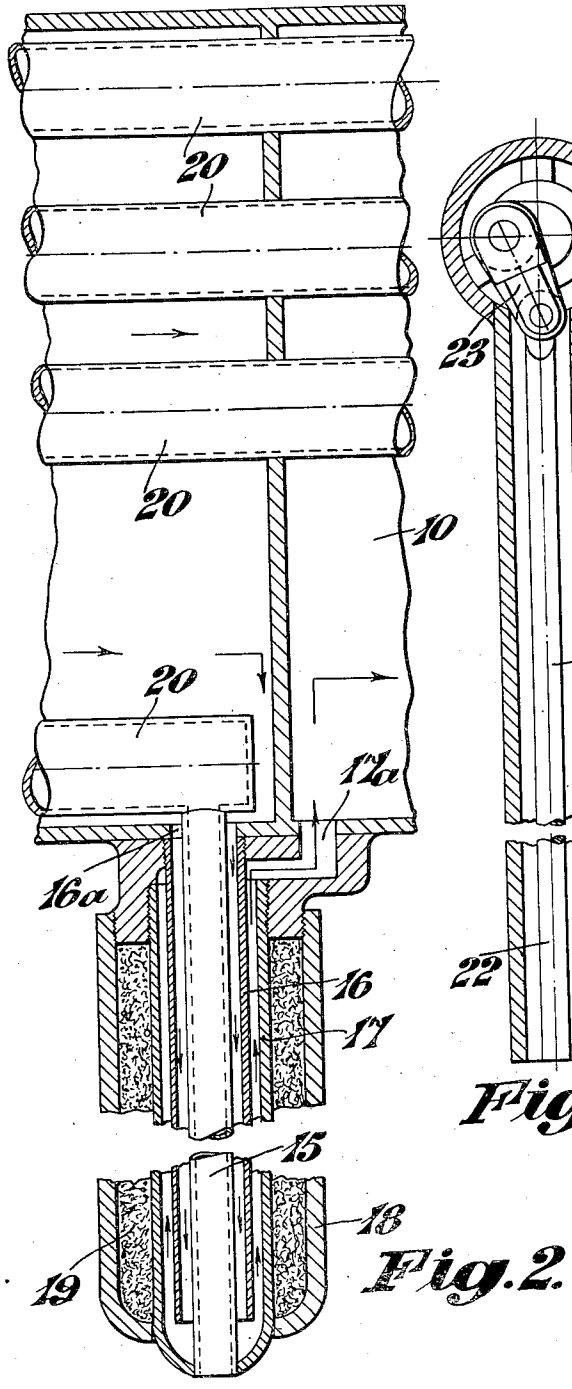

Fig. 2.

Fig. 3.

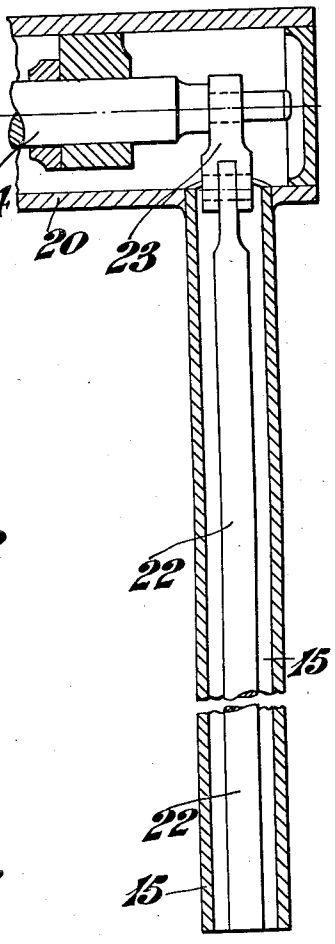

Fig. 4.

Inventor

Henry Edwin Coley

By J. Kaplan attorney

March 17, 1931. H. E. COLEY 1,797,130

REDUCTION OF ORES, OXIDES, AND THE LIKE

Filed Feb. 7, 1929 4 Sheets-Sheet 3

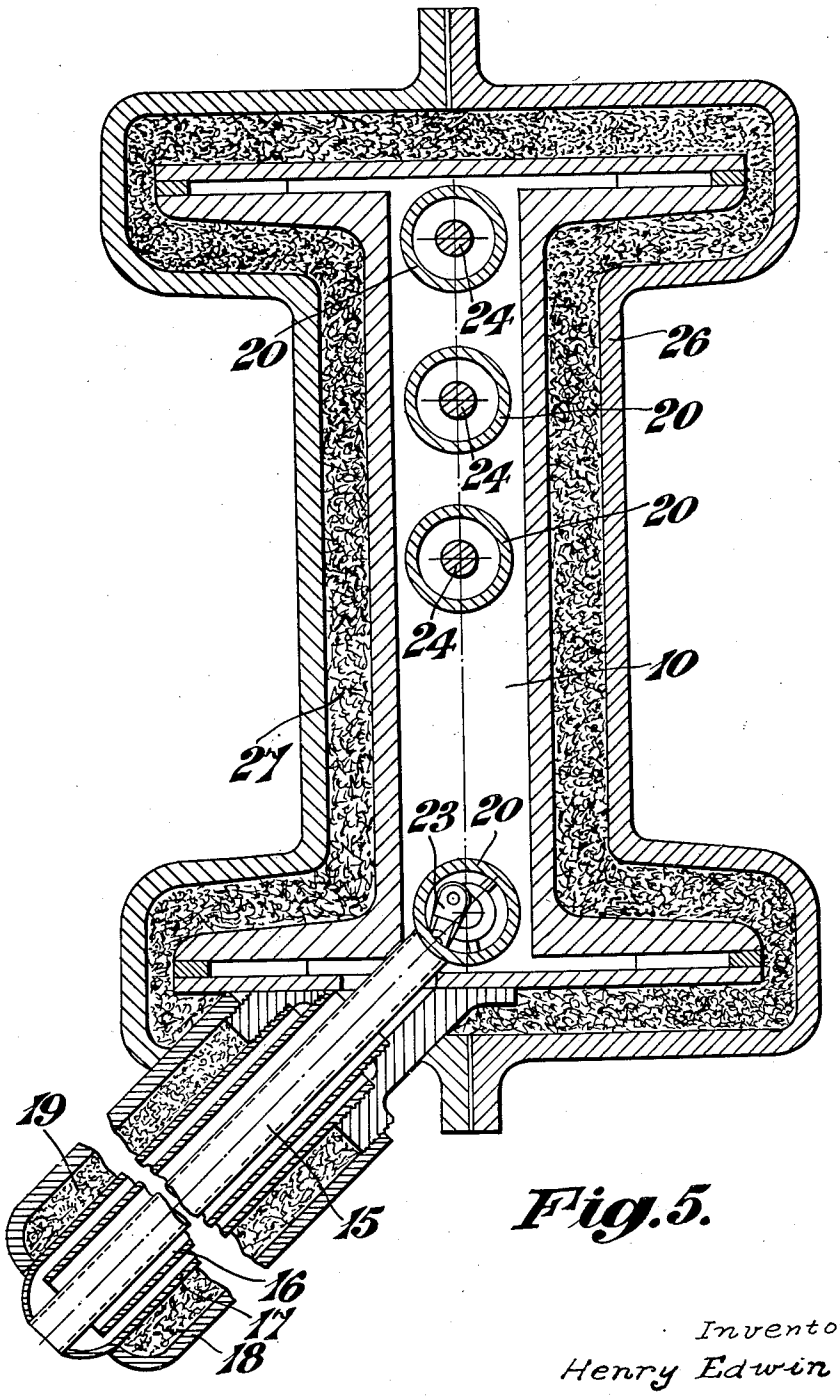

Fig. 5.

Inventor
Henry Edwin Coley

By J. Kaplan
Attorney

March 17, 1931. H. E. COLEY 1,797,130

REDUCTION OF ORES, OXIDES, AND THE LIKE

Filed Feb. 7, 1929 4 Sheets-Sheet 4

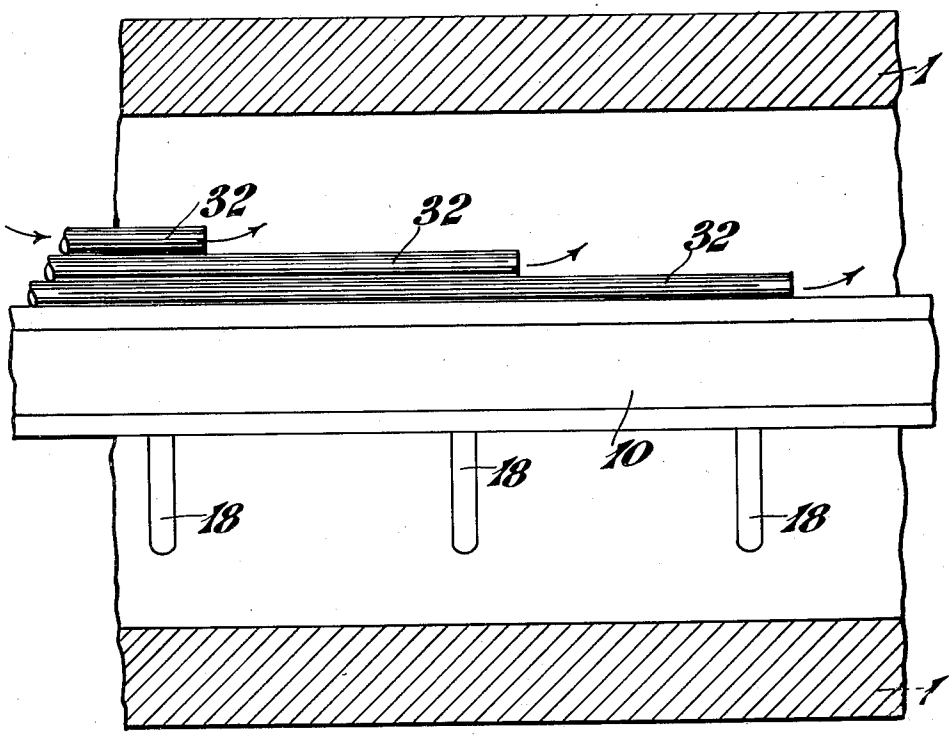

Fig. 6.

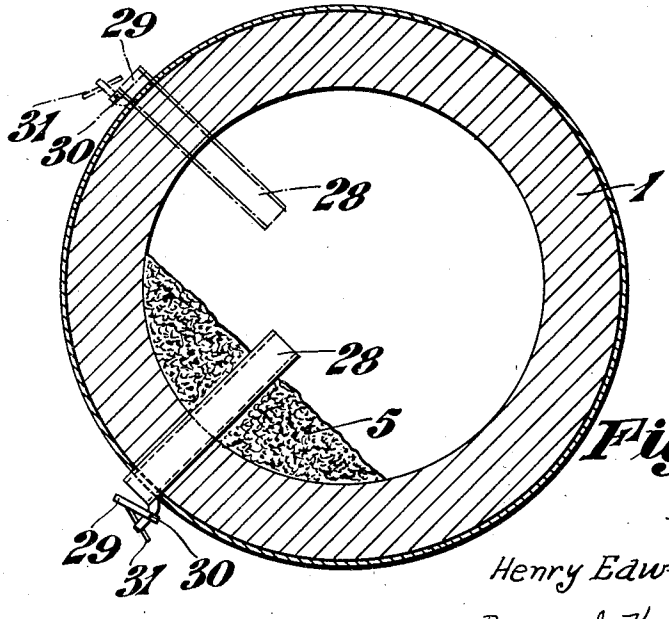

Fig. 7.

Inventor

Henry Edwin Coley

By J. Kaplan Attorney

Patented Mar. 17, 1931 1,797,130

UNITED STATES PATENT OFFICE

HENRY EDWIN COLEY, OF LONDON, ENGLAND

REDUCTION OF ORES, OXIDES, AND THE LIKE

Application filed February 7, 1929, Serial No. 338,311, and in Great Britain January 18, 1929.

This invention relates to the reduction of ores, oxides and the like.

One of the objects of the invention is to provide a new method of internally heating the chamber in which reduction of the material is effected consisting in cracking a hydrocarbon by bringing it into contact with heated ore, oxide or the like within the reducing chamber and burning the combustible vapours produced by means of separately introduced air. A further object of the invention is to utilize a hydrocarbon to effect both the heating of the material to be reduced and its reduction contemporaneously by cracking the hydrocarbon by bringing it into contact with a body of the ore, oxide or the like heated to its reducing temperature and admitting air to the region where such cracking takes place sufficient to effect combustion of the combustible vapours produced and the production of a non-oxidizing atmosphere.

By means of this method reduction of the ore or the like is effected by means of nascent carbon or carbon in its atomic condition as distinct from carbon in its ordinary or molecular condition whilst by the separate admission of just sufficient air for the purpose in the region where the cracking of the hydrocarbon takes place the combustible vapours given off are burnt without producing an oxidizing atmosphere.

Apparatus suitable for carrying the invention into effect is illustrated in the accompanying drawings in which:—

Fig. 1 is a longitudinal vertical section through a reducing chamber of the rotatable tube type adapted for reducing volatile metals such as zinc and embodying means for introducing a hydrocarbon and air for carrying the present invention into effect.

Fig. 2 is a fragmentary section to an enlarged scale of the means illustrated in Fig. 1 for introducing a non-cracked hydrocarbon into the body of ore or the like in the reducing chamber.

Figs. 3 and 4 illustrate a means for clearing the outlets of the hydrocarbon feed pipes.

Fig. 5 is a transverse vertical section to an enlarged scale through the hydrocarbon feeding mechanism illustrated in Fig. 1.

Fig. 6 is a fragmentary vertical section of the same reducing chamber illustrating a modified means for introducing the air for combustion.

Fig. 7 is a transverse section on an enlarged scale through the reducing chamber illustrated in Fig. 1 showing two positions of the air inlet pipes and the operation of the automatic valves controlling the inlet end of such pipe.

Referring to the drawings the reducing chamber illustrated is in the form of a rotatably mounted tube 1 having openings 2 and 3 at opposite ends, said openings being suitably sealed against the free ingress of air the opening 2 being for the removal of the vapourous products of reduction and the opening 3 for the removal, by way of the chute 4 of the gangue or residue. The ore, a bank of which is indicated at 5 in position along the interior of the reducing chamber is fed in by way of the opening 2 by means comprising an inclined chute 6, a communicating horizontal or substantially horizontal tube 7 and a worm or other conveyor 8. These ore feeding means are supported by and extend through a water-jacketed tower 9 in which is effected the condensation of the metallic vapours and their separation from the other gases produced by the reduction as described in the specification of my pending application for Letters Patent No. 301,889. Extending longitudinally through the centre of the reducing tube is a stationary tube or hollow girder 10 which is supported at opposite ends by supports 11 and 12. Through the interior of this tube or girder water is continuously circulated, the inlet for such water being at one end and indicated at 13 and the outlet at the opposite end, being indicated at 14, such outlet discharging into the interior of the aforesaid condensing tower 9.

Extending radially and at spaced intervals from the tube or girder 10 are a plurality of nozzles, the construction of which is indicated clearly in Fig. 2. These nozzles comprise a comparatively small inner tube 15 each of which is water-jacketed to its extremity by means comprising inner and outer spaced tubes 16 and 17, the latter tube clos-

ing in against the extremity of the small inner tube 15. The interior of the tube 16 communicates with the interior of the tube or girder 10 by means of an inlet opening 16*a* and similarly the interior of the outer tube 17 also communicates with the interior of the tube or girder 10 by means of an outlet passage 17*a*. Water from the interior of the tube or girder 10 is thus caused to circulate through the spaces formed by means of the concentric tubes 16 and 17 in the direction of the arrows shown in Fig. 2. The inner small tube 15 is thus always maintained comparatively cool. As an additional precaution in this direction the outer tube 17 is enclosed by means of an outside casing 18 having an interposed packing 19 of any suitable heat insulating material.

The inner tubes 15 which at their extremities open into the interior of the reducing chamber are adapted to deliver, in a non-cracked and comparatively cool condition, a liquid hydrocarbon and for this purpose each such tube communicates at its inner end with a tube 20 which latter tubes extend longitudinally through the water space within the interior of the tube or girder 10. These tubes 20 project through the left hand end closure of the tube or girder 10 and are thus outside of the reducing chamber and such exposed extremities are each fitted with feed or inlet pipes 21 communicating with the main hydrocarbon supply.

As will be seen from Fig. 5 the water-cooled hydrocarbon supply nozzles extend into the interior of the reducing chamber at an angle to the vertical so that during the rotation of the reducing tubes the outlets of these nozzles are always normally covered by the bank of ore.

Means are provided, in the example illustrated, for preventing the outlets of the hydrocarbon delivery pipes or tubes 15 from becoming choked with coke such means comprising pricker rods 22 which extend down through the centre of each such pipe 15 and are adapted to be periodically reciprocated by means of a crank connection 23 between such pricker rods and further rods 24 located within the longitudinal feed tubes or pipes 20 which latter rods may be oscillated or partially rotated for the purpose from their outer extremities 25.

As shown in Fig. 5 the water-cooled tube or girder 10 may be additionally protected against the radiant heat within the reducing chamber by means of an exterior shrouding 26 and an interposed packing 27 of a suitable non-conducting material.

By these means a liquid hydrocarbon is conveyed in a non-cracked condition into actual contact with a bank of ore heated to its reducing temperature. As a result of the contact between the comparatively cool hydrocarbon and the hot ore the hydrocarbon and the hot ore the hydrocarbon is cracked in situ producing carbon in its most active form, namely, in its atomic or nascent form and in this form effects the reduction of the ore.

When a hydrocarbon is cracked there are given off a quantity of combustible gases which it is one of the objects of this invention to use for the purpose of heating the ore to and maintaining it at its reducing temperature within the reducing chamber. This object is attained according to the present invention by separately introducing air into the reducing chamber in proximity to the region or regions where the cracking of the hydrocarbon takes place the quantity of air thus admitted being sufficient to effect complete combustion of the said combustible gases without producing an oxidizing atmosphere within the reducing chamber. In the arrangement illustrated in Figs. 1, 2, 3, 4, 5 and 7 this air is introduced into the interior of the reducing chamber by means of a plurality of tubes 28 which extend radially through the wall of the reducing chamber. In practice it is found to be essential to prevent this air from being projected directly onto the exposed surface of the bed of hot ore and to this end the outer end of each tube is provided with a flap valve 29 each of which is hinged at 30 a stop 31 being provided to limit their opening movement. These valves thus operate by gravity and remain closed until the rotation of the reducing chamber brings the tubes to a position where their inner ends project through the bank of hot ore as shown most clearly in Fig. 7. In this position of the reducing chamber the valves fall open automatically and allow air to enter and by reason of the particular location of the air tubes relatively to the hydrocarbon inlets, to support combustion of the combustible gases evolved by the cracking in situ of the introduced hydrocarbon. During the remaining revolution of the reducing chamber the valves 29 remain closed.

In the modified arrangement illustrated in Fig. 6 the air is introduced by means of a plurality of longitudinal tubes 32 of varying lengths. As the outlets of these tubes serve to discharge the air away from the bank of hot ore the provision of controlling valves as in the former arrangement, is rendered unnecessary.

Claims:

1. Apparatus for reducing ores comprising a reducing chamber rotatable about an approximately horizontal axis, means for introducing into said chamber the material to be reduced, a plurality of water-cooled pipes mounted upon a fixed support outside of the chamber and extending into said reducing chamber and having their outlets disposed at intervals along the length of the reducing chamber adjacent the lower

wall thereof so as to be normally covered by the material to be reduced, means for feeding said pipes with a non-cracked liquid hydrocarbon when the material covering their outlets is at a temperature sufficient to cause said hydrocarbon to be cracked on contact and a plurality of air supply pipes having their outlets disposed so as to project the air into the interior of the reducing chamber in proximity to the regions where contact is made between the non-cracked hydrocarbon and the heated material but in a direction away from the surface of such material for the purpose of supporting combustion of the combustible gases produced by the cracking of the hydrocarbon and thereby heating the interior of the reducing chamber throughout its length with the production therein of a non-oxidizing atmosphere.

2. Apparatus for reducing ores comprising a reducing chamber rotatable about an approximately horizontal axis, means for introducing into said chamber the material to be reduced, a plurality of water-cooled pipes mounted upon a fixed support outside of the chamber and extending into said reducing chamber and having their outlets disposed at intervals along the length of the reducing chamber adjacent the lower wall thereof so as to be normally covered by the material to be reduced, means for feeding said pipes with a non-cracked liquid hydrocarbon when the material covering their outlets is at a temperature sufficient to cause said hydrocarbon to be cracked on contact, and a plurality of air supply pipes extending at intervals radially through the wall of the reducing chamber having valves controlling their inlets, said valves opening when the supply pipes are on the underside of the reducing chamber so as to admit air only when the pipes are in a position where the air is discharged away from the surface of the heated material within the reducing chamber.

3. Apparatus for reducing ores comprising a reducing chamber rotatable about an approximately horizontal axis, means for introducing into said chamber the material to be reduced, a plurality of water-cooled pipes mounted upon a fixed support outside of the chamber and extending into said reducing chamber and having their outlets disposed at intervals along the length of the reducing chamber adjacent the lower wall thereof so as to be normally covered by the material to be reduced, means for feeding said pipes with a non-cracked liquid hydrocarbon, means for periodically cleaning said outlets, and a plurality of air supply pipes extending at intervals radially through the wall of the reducing chamber having gravity operated flap valves controlling their inlets, said valves opening when the supply pipes are on the underside of the reducing chamber so as to admit air only when the pipes are in a position where the air is discharged away from the surface of the heated material within the reducing chamber.

4. Apparatus for reducing ores comprising a reducing chamber rotatable about an approximately horizontal axis, means for introducing into said chamber the material to be reduced, a hollow member mounted upon a fixed support outside of said chamber and extending longitudinally through said chamber, means for circulating water through said member, a plurality of pipes extending through the water space in the interior of said hollow member, outlets projecting radially at intervals from said member each outlet communicating with one of said pipes and extending downwards to a point adjacent the bottom of said reducing chamber, means for water-cooling said outlets, means for feeding said pipes with a non-cracked liquid hydrocarbon, and a plurality of air supply pipes having their outlets disposed so as to project the air into the interior of the reducing chamber in proximity to the regions where contact is made between the non-cracked hydrocarbon and the heated material but in a direction away from the surface of such material for the purpose of supporting combustion of the combustible gases produced by the cracking of the hydrocarbon and thereby heating the interior of the reducing chamber throughout its length with the production therein of a non-oxidizing atmosphere.

5. Apparatus for reducing ores comprising a reducing chamber rotatable about an approximately horizontal axis, means for introducing into said chamber the material to be reduced, a hollow member mounted upon a fixed support outside of said chamber and extending longitudinally through said chamber, means for circulating water through said member, a plurality of pipes extending through the water space in the interior of said hollow member, outlets projecting radially at intervals from said member, each outlet communicating with one of said pipes and extending downwards to a point adjacent the bottom of said chamber, means for water-cooling said outlets, means for feeding said pipes with a non-cracked liquid hydrocarbon, and a plurality of air supply pipes extending at intervals radially through the wall of the reducing chamber having gravity operated flap valves controlling their inlets, said valves opening when the supply pipes are on the underside of the reducing chamber so as to admit air only when the pipes are in a position where the air is discharged away from the surface of the heated material within the reducing chamber.

6. Apparatus for reducing ores comprising an internally heated reducing chamber,

means for feeding ore into said reducing chamber, an outlet for the gangue, an inlet for delivering a hydrocarbon material to the ore within said reducing chamber, means to prevent the decomposition of said hydrocarbon material in said inlet whereby the hydrocarbon material is delivered to the ore in a substantially non-decomposed condition, and an inlet for admitting combustion air into said reducing chamber so as to effect the combustion within the reducing chamber of the combustible products produced by the cracking of the hydrocarbons in the introduced hydrocarbon material.

7. Apparatus for reducing ores comprising an internally heated reducing chamber rotatable about an approximately horizontal axis, means for feeding ore into one end of said reducing chamber, an outlet for the gangue at the opposite end of the reducing chamber, sealing means at both ends of the reducing chamber to prevent the free ingress of air into the interior of said chamber, an inlet extending into said reducing chamber for delivering to the ore contained in said reducing chamber a hydrocarbon material, a jacket surrounding said inlet, an inlet and an outlet to said jacket for the circulation through said jacket of a cooling liquid, and a further inlet for admitting combustion air into said reducing chamber to effect the combustion within the reducing chamber of the combustible products produced by the cracking of the hydrocarbons in the introduced hydrocarbon material.

8. Apparatus for reducing the ores of volatile metals comprising an internally heated reducing chamber, means for feeding ore into one end of said reducing chamber, an outlet for the reduced metallic vapours at the same end of the reducing chamber, an outlet for the gangue at the opposite end of the reducing chamber, sealing means at both ends of the reducing chamber to prevent the free ingress of air into the interior of said reducing chamber, an inlet extending into said reducing chamber for delivering to the ore contained in said chamber a hydrocarbon material, a jacket surrounding said inlet having an inlet and an outlet for the circulation through said jacket of a cooling liquid, and a further inlet for admitting combustion air into said reducing chamber to effect the combustion within said chamber of the combustible products simultaneously with the metallic vapours by the cracking of the hydrocarbon in the introduced hydrocarbon material.

9. Apparatus for reducing ores comprising an internally heated reducing chamber rotatable about an approximately horizontal axis, means for feeding ore into one end of said reducing chamber, an outlet for the gangue at the opposite end of said chamber, a pipe fixed by one end outside the reducing chamber and extending into the interior thereof to near the bottom of said chamber for the conveyance of a liquid hydrocarbon to the ore contained within said chamber, a jacket surrounding said pipe having an inlet and an outlet for the circulation through said jacket of a cooling medium to prevent the cracking of the liquid hydrocarbon within said pipe, and a plurality of inlets in the wall of the reducing chamber for admitting combustion air to effect the combustion within the reducing chamber of the combustible products produced simultaneously with the metallic products by the cracking of said liquid hydrocarbon.

10. Apparatus for reducing ores comprising an internally heated reducing chamber rotatable about an approximately horizontal axis, means for feeding ore into said reducing chamber, an outlet for the gangue, an inlet for delivering a hydrocarbon material to the ore within said reducing chamber, an inlet for admitting combustion air into said reducing chamber and a valve on said inlet controlling the admission of said air, said valve opening only when said inlet is on the underside of the reducing chamber to effect the combustion within the reducing chamber of the combustible products produced by the cracking of the hydrocarbons in the introduced hydrocarbon material with the maintaining of a non-oxidizing atmosphere.

11. Apparatus for reducing ores comprising an internally heated reducing chamber rotatable about an approximately horizontal axis, means for feeding ore into said reducing chamber, an outlet for the gangue, an inlet extending into the reducing chamber for delivering a hydrocarbon material to the ore within said reducing chamber a jacket surrounding said inlet having an inlet and an outlet for the circulation through said jacket of a cooling liquid, sealing means at both ends of the reducing chamber to prevent the free ingress of air into said chamber and a plurality of radial air inlets disposed at intervals along and extending through the wall of said reducing chamber.

In testimony whereof I affix my signature.

HENRY EDWIN COLEY.