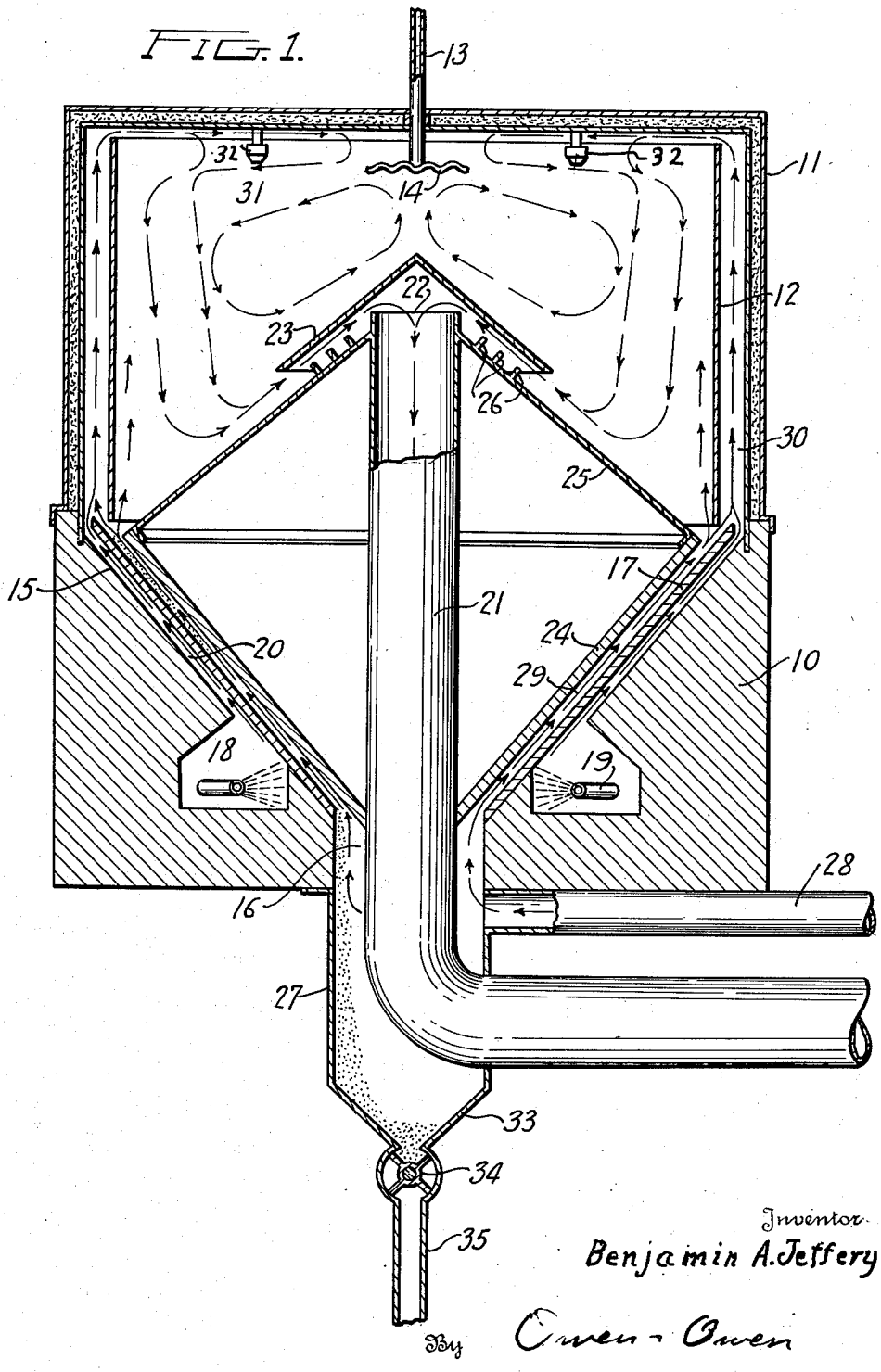
June 20, 1944. B. A. JEFFERY 2,351,765

REDUCING ORES AND FORMING SPONGE METALS AND ALLOYS

Filed Dec. 12, 1941

FIG. 1.



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Patented June 20, 1944

2,351,765

UNITED STATES PATENT OFFICE

2,351,765

REDUCING ORES AND FORMING SPONGE METALS AND ALLOYS

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Application December 12, 1941, Serial No. 422,670

11 Claims. (Cl. 75—34)

This invention relates to the reduction of metals, the forming of sponge metal, and the making of alloys.

The purpose of the invention is to provide a new and improved process for reducing ores, and particularly in that type of operations where the reduction takes place without complete fusion.

Another object of the invention is to prepare the ore in an advantageous way so that it may be reduced, if desired, in a stack by well known means.

Another object of the invention is to provide a method by which ore may be reduced without fusion and with high uniformity.

Another object of the invention is to provide a method by which sponge metal may be produced advantageously and of high uniformity.

Another object of the invention is to provide a method whereby alloys or mixtures may be produced with great uniformity and with any desired proportions of the respective ingredients.

Other objects and minor details of the invention will appear as the description proceeds.

One application of the invention will be described in some detail and then variations of the application of the invention will be indicated.

In the accompanying drawing forming a part of this application there is disclosed somewhat diagrammatically apparatus which may be employed in carrying out one form of the invention. The apparatus indicated in the drawing comprises a refractory base 10 upon which there is mounted a kiln 11. Within the kiln there is a concentric lining member 12 spaced inward from the outer wall. In the construction disclosed, the kiln is approximately circular in horizontal cross-section. Through the top of the kiln there projects a pipe 13 on the lower end of which there is a spraying device 14 indicated diagrammatically. In practice, this may be a pair of discs spaced apart and mounted for rotation.

Within the base member and below the kiln, there is a downwardly tapering recess 15 leading to a central opening 16. Resting upon the surface of the recess 15 immediately surrounding opening 16 there is a conical plate 17. In the wall of the recess 15 beneath plate 17 there is one or more recesses or an annular recess 18 in which there are mounted suitable burners 19. A space 20 is provided between plate 17 and the surface of recess 15 above the recess or recesses 18.

A downdraft flue 21 projects vertically through the opening 16 and upward into the kiln, the upper end being open at 22. Over this open upper end there is a conical cap 23. Mounted upon flue 21 just above plate 17 there is a substantially parallel plate 24. A plate 25 resting upon the upper edge of plate 24 tapers upwardly to the flue 21 near its upper end. In the construction shown, a plurality of baffles 26 are provided on plate 25 beneath cap 23.

A receptacle 27 is attached to base 10 beneath opening 16 and an inlet pipe 28 discharges into receptacle 27 around flue 21. Passageway 29 between plates 17 and 24 forms a continuation of the passageway between flue 21 and receptacle 27 and discharges at its upper end at the lower edge of lining plate 12 so that passages 20 and 29 both communicate to some extent with the bottom of passage 30 between kiln 11 and its liner 12. As shown, the liner is spaced downward slightly from the top of the kiln so that passageway 30 communicates at the top with the chamber 31 within liner 12, and passageway 29 also communicates with chamber 31.

In the construction shown, liner 12 is shown as suspended at the top by brackets 32.

The bottom of receptacle 27 is downwardly tapered at 33 to a discharge gate 34 from which a discharge pipe 35 leads downward.

Presuming that the apparatus described is to be employed in reducing iron ore, the procedure is as follows:

The iron ore is first procured in the form of a powder or reduced to a fine powder. This powder is mixed with fluid, which may be water, to approximately the consistency of a thick clay slip. Preferably carbonaceous material is mixed throughout the slip evenly.

After the slip has been thoroughly mixed so that it is uniform throughout, it is discharged downward through pipe 13 and sprayed by spraying means 14 so that it is thrown horizontally outward from that spraying means in the form of small drops.

As will be readily seen from an examination of the drawing, the products of combustion from burner 19 blow upward in the direction indicated by the arrows through passageways 20 and 30 and are discharged into the top of chamber 31, from which they are discharged through flue 21. At the same time, carbon monoxide or other gases may be introduced, if desired, through pipe 28.

When the drops of slip encounter the heated gases, they are dried into the form of round pellets which drop downward and encounter surface 25 from which they slide into passageway 29, and from thence into receptacle 27. If de-

sired, baffles may be placed upon the upper surface of plates 25 and/or 17 so as to delay the passage of the material, and it will be readily understood that the angle to the horizontal of these parts may be varied as the requirements of the particular material employed and the purpose for which it is to be used make advisable.

The dried pellets of material, if the spraying is properly controlled, will be approximately spherical in form and will roll readily, and even if the construction is such that passageway 29 is completely filled with these pellets, there will still be ready passageway for the heating gases. During the entire heating period, the gases will contact the surface of each pellet readily. It will be readily seen that by controlling the kind and quantity and temperature of gases introduced through pipe 28 and the discharge from burners 19 and the amount and character of carbonaceous material in the slip, the temperature can be quite accurately controlled at successive points, and the temperature at which reduction takes place can be adjusted as desired.

Of course, if desired, the plate 17 might be made of suitable material and the temperature raised sufficiently high to fuse the metal as it flows over the plate above the burners. Ordinarily, however, it is preferable to employ this method in connection with the reduction of the ore without fusion.

It has frequently been proposed hitherto to mix iron ore and carbonaceous material and feed it downward through a stack while controlling the temperature so as to reduce the ore without fusion. Such attempts have encountered many difficulties. It has been found difficult to feed the material uniformly and evenly downward through the stack. It has been found difficult to maintain the body of material within the stack sufficiently permeable so that gases would readily contact all parts. As a consequence, it is very difficult to maintain uniform temperature or uniform access of the various gases and fuels to different portions of the ore, and consequently some portions might be carbonized to an undesired extent, while some would be insufficiently reduced and others heated more than is desirable. It has been recognized that the results of the reduction vary quite materially with variations in the temperature and a method by which it can be rendered uniform is consequently an important improvement in this respect.

In the apparatus disclosed, it will be seen that the products of combustion at first heat the passageway 29, which may be considered roughly equivalent to the stack previously proposed, pass upward and then are employed for drying and preheating the ore before it reaches the stack. This arrangement is preferred because of its simplicity and economy in the use of fuel. However, it will be readily understood that the broad principles of the method could be carried out by spraying and drying the ore in one apparatus and then collecting this dried ore in pellet form and introducing it into any desirable stack. Because of the pellet form and its free flowing characteristics, it will readily pass through any suitable stack and at the same time allow passage of the gases which are employed to treat the material.

While this method is particularly suitable for procuring a uniform mixture of ore with carbonaceous material for treatment of this kind, it will be readily understood that where preferred, the ore might be formed into the slip and dried into pellets in the manner described and the reduction might take place by means of the reducing gases brought into contact with the pellets.

The treatment lends itself readily to the reduction of the ore at a temperature materially below the melting point of the iron. The material so produced will be delivered in pellet form and each pellet will be somewhat spongy. These pellets may then be introduced into a mold and formed into an article in any suitable way. The forming may be carried on so that the material will be condensed to the degree desired. If the pellets are adhered together at contacting points, as might be done, for example, by the passage of an electric current, the article may be extremely porous and readily permeable because of the passageways between the pellets. The individual pellets also may be porous, as indicated above, if reduced at a comparatively low temperature, or if preferred, the temperature may be raised so that the individual pellets may be relatively solid.

The treatment in this manner is simplified if the ore is relatively pure. However, the same method may be employed to advantage where there is a material amount of slag present. Under these circumstances, the temperature may be raised sufficiently so that the iron in each pellet will form a core with the slag surrounding it. The slag may then be removed from the pellets by tumbling or other rubbing and cleaning operation. With certain kinds of ores, the removal of the slag may be facilitated by dropping the pellets while still heated into a suitable cooling medium which chills the slag suddenly and thereby loosens it from the iron ore.

While the method has been described in connection with the treatment of iron ore, it will be readily apparent that it might be employed with advantage for reducing oxides of iron in lieu of the method disclosed, for example, in Patent No. 2,085,178, and similar uses where it is desirable to have the iron in finely divided form, and at the same time, it is desirable to have it in a form which can be readily handled. By spray drying iron sludge which had been employed in a chemical process resulting in its oxidation and then reducing the dried pellets, the iron could be promptly and easily recovered in a condition which would permit its advantageous handling and with the exact degree of porosity preferred.

While reference has been made above to the reduction of iron ore, it will be readily understood that other ores which are susceptible to reduction in a similar manner might be treated by this process. In other words, it would be advantageous in a case where the ore is to be subjected to the action of gases to form the ore into a slip and spray dry in pellet form so that it will be uniformly and thoroughly accessible to treatment by gases and at the same time may be readily handled and passed through the treating apparatus. If desired, different materials may be very uniformly distributed throughout the mass to be treated by mixing the powder in slip form and then spray drying. By this treatment, the material is distributed in the spray dried form as uniformly as in the slip. It is difficult to obtain such uniform distribution by other means. Because of this uniform distribution, it is relatively easy to distribute different kinds of ore and/or metal so that the composite pellets when treated will form a desired alloy.

While the steps disclosed above are particu-

larly adaptable for preparing material for reduction or similar treatment by gases, a slight variation renders it adaptable for forming alloys starting with the powdered metal, if preferred. In that case, the powdered metal may be formed into a slip, the liquid employed being treated or modified in each case so as to produce the desired suspension of the metal particles in the slip. When a slip of metal particles is spray dried, these particles will be uniformly distributed in the dried pellets, if they are uniformly distributed in the slip. Thereafter, these pellets may be heated to such a degree as to cause the interaction of the different metals to produce alloys or combinations of metal without complete fusion, and the uniform distribution is maintained. This is advantageous wherever sponge metal is to be formed of an alloy as will be clear from the foregoing description. Also, mixtures of metals may be formed in this way and by proper treatment sintered and compacted so as to form solid metal without affording the opportunity for segregation which occurs when the material is melted and poured into a mold for casting.

Not only could the material be prepared by spray drying as described above for reduction, for forming sponge metal, or for forming alloys, and then reduced or otherwise treated in a stack or like furnace, but, if desired, similar uniform mixes might be produced by spray drying, then molding or forming into any desired shape and heating by any suitable furnace, electric or otherwise.

What I claim is:

1. The method of obtaining metal from ore where the metal may be obtained by contact of fluid with the ore, which comprises forming a slip of the powdered ore and a vaporizable liquid, spraying the slip into separated drops, drying the drops into pellets, and contacting the pellets with a fluid by contact with which the metal is obtained from the ore.

2. The method of reducing ore, which comprises forming a slip of the powdered ore and a vaporizable liquid, spraying the slip into separated drops, drying the drops into pellets, and subjecting the pellets to reducing gas at a reducing temperature.

3. The method which comprises forming a slip of powdered oxide of iron suspended in a vaporizable liquid, spraying the slip into separated drops, drying the drops into pellets, and reducing the oxide of iron in the pellets to metallic iron.

4. The method of reducing ore, which comprises forming a slip of the powdered ore suspended in a vaporizable liquid and mixed with carbonaceous material, mixing the ore and material evenly throughout the slip, spraying the slip into separated drops, drying the drops into pellets, and contacting the pellets with heated gas until the desired reduction has been effected.

5. The method of reducing oxide of iron, which comprises forming a slip of the powdered oxide of iron suspended in a vaporizable liquid and mixed with carbonaceous material, mixing the oxide of iron and material evenly throughout the slip, spraying the slip into separated drops, drying the drops into pellets, and contacting the pellets with heated gas until the desired reduction has been effected.

6. The method of forming an alloy which comprises forming a slip of powdered material suspended in a vaporizable liquid, said material comprising metals in the proportions desired for the alloy, mixing the material evenly throughout the slip, spraying the slip into separated drops, drying the drops into pellets, contacting the pellets with heated gas until the metals are sintered together, and stopping the heating before complete fusion takes place.

7. The method of forming an alloy which comprises forming a slip of powdered material suspended in a vaporizable liquid, said material comprising atoms of metals in the proportions desired for the alloy, at least some of said atoms being in oxide molecules, mixing the material evenly throughout the slip, spraying the slip into separated drops, drying the drops into pellets, contacting the pellets with heated reducing gas until the metals are sintered together, and stopping the heating before complete fusion takes place.

8. The method of forming an alloy which comprises forming a slip of powdered material suspended in a vaporizable liquid, said material comprising atoms of metals in the proportion desired for the alloy and also comprising carbonaceous material, at least part of said atoms being in oxide molecules, mixing the materials evenly throughout the slip, spraying the slip into separated drops, drying the drops into pellets, and contacting the pellets with hot gas until the oxide is suitably reduced and the metals are sintered together.

9. The method of making sponge iron, which comprises forming a slip of powdered iron ore and carbonaceous material in a vaporizable liquid, mixing the materials evenly throughout the slip, spraying the slip into separated drops, drying the drops into pellets, contacting the pellets with hot gas until the desired reduction has taken place, and stopping the heating before the pellets are completely fused.

10. The method which comprises forming a slip of powdered iron ore and slag-producing material in a vaporizable liquid, spraying the slip into separated drops, drying the drops into pellets, contacting the pellets with heated gas under reducing conditions until the ore is reduced, continuing the heating until the slag is segregated on the exterior of the pellets, then suddenly subjecting the exterior of the pellets to a cooling medium and separating the metal cores of the pellets from the slag segregated on their exteriors.

11. The method of forming porous metal articles, which comprises forming a slip of suspended metalliferous material, spraying the slip into separated drops, drying the drops into pellets, eliminating non-metallic material from the metalliferous material in the pellets, introducing the metallic pellets into a mold, and adhering the pellets together without entirely closing the passages between the pellets.

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