P. O. HARDING.

METHOD OF AGGLOMERATING ORES.

APPLICATION FILED JUNE 12, 1915.

1,166,903.

Patented Jan. 4, 1916.

2 SHEETS—SHEET 1.

FIG. 2.

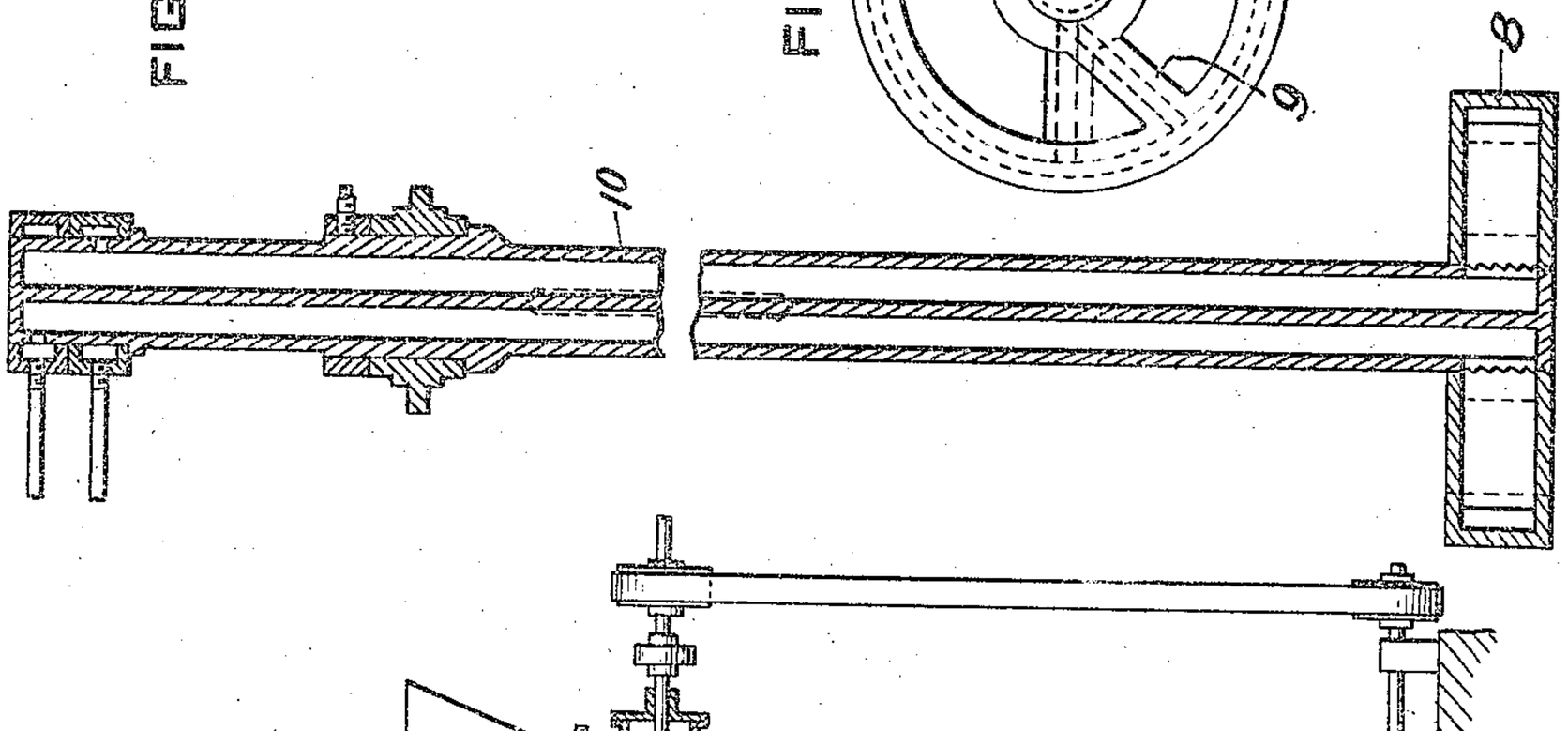
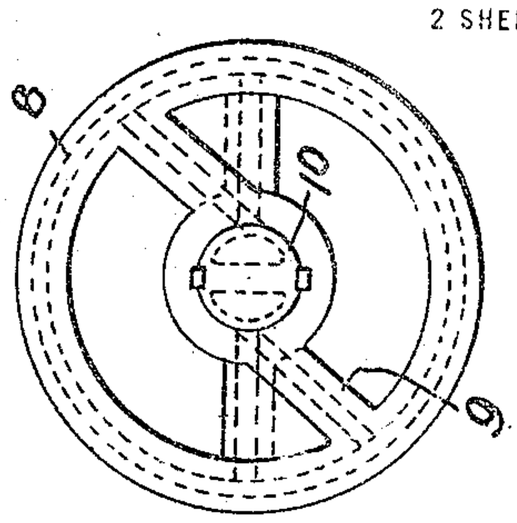


FIG. 4.



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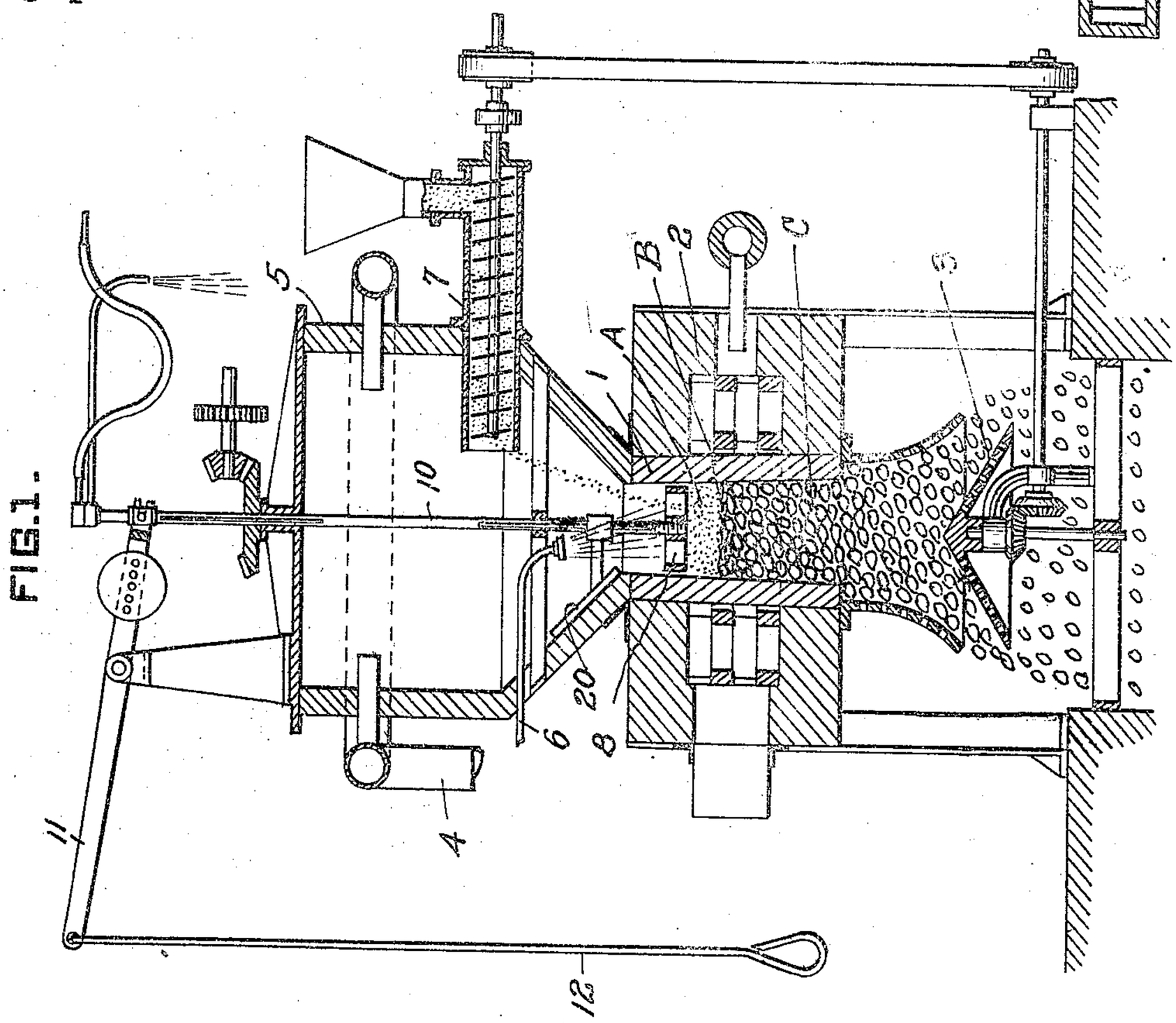

WITNESS:

Paul N. Critchlow

Francis J. Donahoe

INVENTOR.

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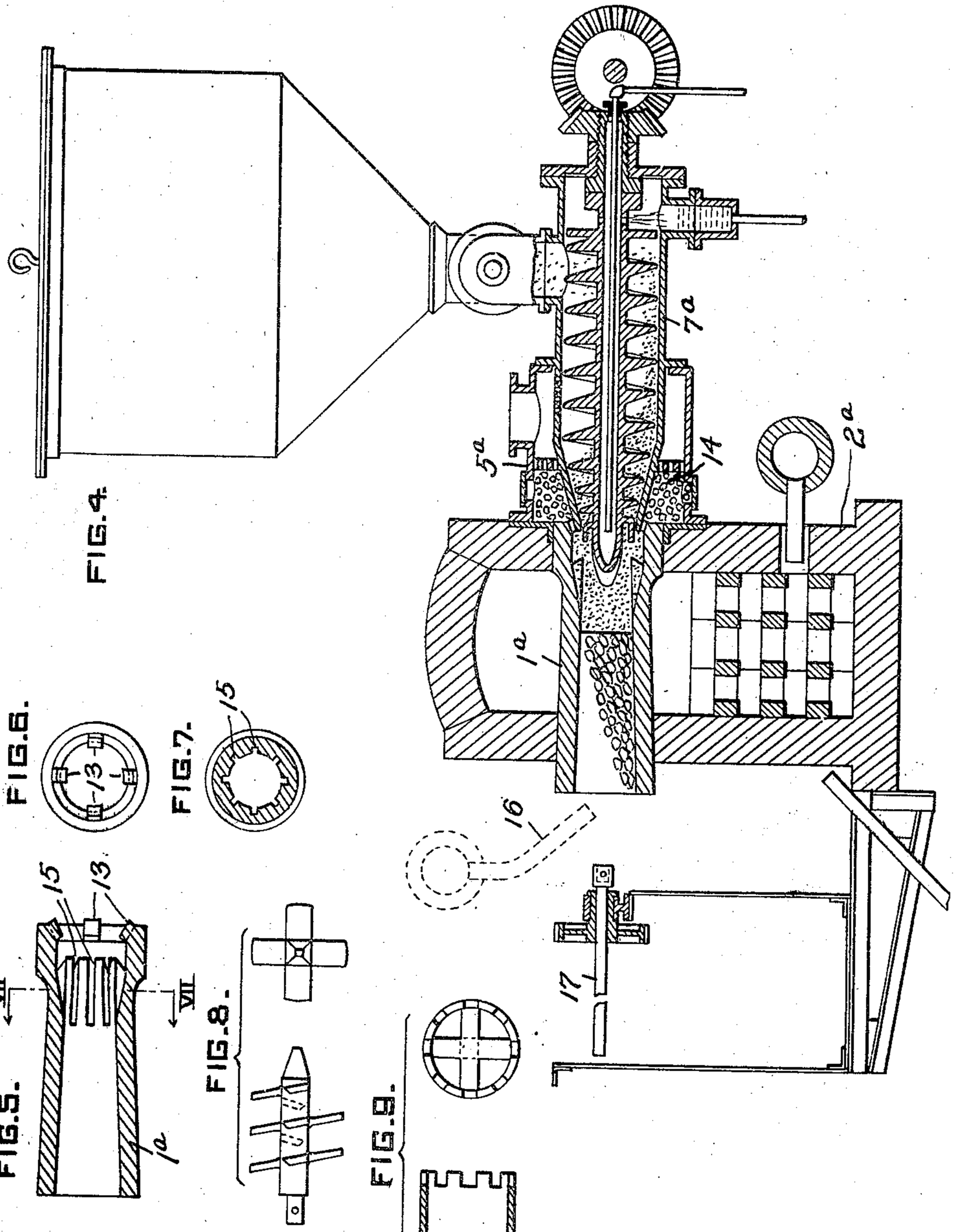

FIG. 4.

FIG. 6.

FIG. 7.

FIG. 5.

FIG. 8.

FIG. 9.

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UNITED STATES PATENT OFFICE.

PHILIP O. HARDING, OF PITTSBURGH, PENNSYLVANIA.

METHOD OF AGGLOMERATING ORES.

1,166,903. Specification of Letters Patent. Patented Jan. 4, 1916.

Application filed June 12, 1915. Serial No. 33,767.

To all whom it may concern:

Be it known that I, PHILIP O. HARDING, residing at Pittsburgh, in the county of Allegheny and State of Pennsylvania, a citizen of the United States, have invented or discovered certain new and useful Improvements in Methods of Agglomerating Ores, of which improvements the following is a specification.

My invention relates to the agglomerating of ore, particularly of iron ore, a procedure commonly called sintering.

In the ordinary operation of blast furnaces, particularly when finely pulverized ore is used, there is a large production of flue dust. This flue dust, though rich in iron, is, because of its finely divided condition, difficult to handle, and the recovery of its iron content has been found to be so costly that great quantities of flue dust from blast furnaces have been regarded as waste. Of late years efforts have been made to bring the flue dust to a condition better adapted for re-introduction into the blast furnace as part of the furnace charge, by submitting it first to the sintering operation. The flue dust is mixed with finely divided ore and the mixture is ignited. The flue dust is rich in carbon and, with provision for a suitable supply of air to sustain combustion, the mixture is changed by burning from a loose friable material to an agglomerated, clinker-like mass. The precise chemical changes which occur are obscure and but imperfectly understood. Necessarily, they vary as the chemical composition of the mass under treatment varies. But the physical change, indicated above, is the one which is important to the furnace operator.

It has been found a matter of great difficulty to obtain a uniform agglomeration and produce an article which does not contain within its body pockets of unaltered and friable material. Furthermore, apparatus heretofore devised such as is productive of material nearest to the furnaceman's requirements, is exceedingly costly both to install and to maintain in repair.

My invention consists primarily in subjecting a body of material to be agglomerated (which ordinarily will be a mixture of flue dust and finely divided iron ore) to a progressive combustion which advances through the body, in causing the current of combustion-sustaining gas (which ordinarily will be atmospheric air) to flow to the region of combustion through that portion of the body which has already been subjected to the agglomerating fire, and at the same time effecting a breaking-up or fragmentation of that portion of the body through which the flow of combustion-sustaining gas is advancing. Such breaking up of the mass opens the pockets of unchanged friable material, and the current of air sweeps the material so exposed back into the region of combustion where, now mingled with air and brought to proper temperature, it will undergo ignition and agglomeration.

My invention further consists in apparatus for performing the operation herein above defined. This apparatus is illustrated in the accompanying drawings, and I shall explain my invention by reference thereto.

In this application I do not lay claim to the apparatus employed but only to the method. In a co-pending application filed July 3rd, 1915, Serial No. 37922, I make claim to the apparatus.

Figure 1 shows the apparatus in preferred form and in vertical medial section; Fig. 2 is a view on larger scale and in vertical medial section of the spreader and pusher detached, which in Fig. 1 is shown in operative position; Fig. 3 is an end view of the said spreader and pusher; Fig. 4 is a view corresponding to Fig. 1 showing the apparatus in modified form; Fig. 5 shows in longitudinal section the passageway or hot tube of the apparatus of Fig. 4; Fig. 6 is a view in end elevation and Fig. 7 a view in transverse section of the tube of Fig. 5, the plane of section of Fig. 7 being indicated by the line VII—VII, Fig. 5; Fig. 8 shows in side and in end elevation an extractor applicable to the apparatus shown in Fig. 4; and Fig. 9 shows in longitudinal section and in end elevation an extractor of another form.

Referring first to Fig. 1, 1 indicates a chamber within which is contained a body of material under treatment. Within this chamber the ignition occurs which effects agglomeration, and this ignition takes place

progressively through the body of material. Such a procedure is conveniently accomplished by making the chamber of the tubular form shown, maintaining a zone of combustion at an intermediate point in the length of the tube (near the intake end) and in causing the material under treatment to advance by continuous feed through the tube. The zone of combustion is conveniently defined and combustion maintained by a heat-giving apparatus surrounding the tube. As shown in the drawings, this apparatus takes the form of an annular reverberatory chamber 2. The particular nature and character of this heat-imparting apparatus are not of the essence of the invention in its broader aspect, and indeed a proper selection and mixture of material to be treated and a proper control of the supply of combustion-sustaining gas may render the employment of any such heat-imparting apparatus unnecessary.

In Fig. 1 A indicates that portion of the body of material under treatment which has just been introduced into tube 1, B indicates the portion which is undergoing combustion, and C the portion which has already been agglomerated. The air for nourishing combustion in the advancing body of material A, B, C is drawn through the material itself and through that portion which has already undergone agglomeration; that is to say, air flows through the portion of the charge marked C, to the portion undergoing combustion, marked B. The material as it advances from the zone or region of combustion is broken up, for the purpose already defined. The means resorted to in the apparatus shown in Fig. 1 are these: The tube 1 is arranged vertically; it flares downwardly; and the charge within the tube rests upon a support 3. This support is conveniently of circular plan, arranged concentrically beneath the vertically arranged downwardly flaring tube, and it is spaced at an interval from the lower edge of the tube. Through this space the finished material finds escape. The support 3 is conveniently conical, as shown, and it is rotary on a central axis. The effect of rotation of the support 3 is that the downward sinking body of material is discharged through the annular orifice between the support 3 and the lower edge of pipe 2, and the further effect is to subject the whole agglomerated portion of the charge, marked C, to strains which cause it to break up, to separate into fragments. And the consequence is that the indrawn streams of air flow freely through the crevices so opened, and where the indrawn air encounters friable and unagglomerated material it will blow such material back into the zone of combustion where it will undergo the combustion which it had fortuitously escaped. Suction is maintained, to draw the air through tube 1 by means of suction pipe 4. It is desirable, for purposes presently to be stated, to form above tube 1 and communicating with it an air-exhausting chamber 5, from which chamber air is drawn through pipe 4. The lower portion of this chamber, adjacent the point of communication with the tube 1 is, as shown, upwardly flaring and hopper-shaped. This conformation is advantageous because the velocity of the current of air flowing from tube 1 is thus rapidly checked and accordingly the arrested current of air deposits practically all of whatever burden of powdery material it may have carried from tube 1. A water spray 6 may be provided to play upon the upper surface of the charge within tube 1, and its purpose is to the same end, to keep down and carry back into the tube whatever dust tends to rise from the material under treatment. As is well known it is common to mix the material with water in preparation for treatment, and for this same purpose—to prevent the flying of dust. The supply of water through this spraying apparatus may manifestly be controlled as desired. The chamber 5 thus is seen to be a closed chamber. The drawings show a feed pipe 7 leading to it and a worm feed within the pipe. It will be understood that such a feeding mechanism may be employed to feed in the material, continuously or intermittently as desired, and without serious interference with the maintenance of a draft through tube 1 by the means which have been described.

A spreader and pusher is indicated at 8 and more fully illustrated in Figs. 2 and 3. It consists essentially of a sweep like arm or arms 9 carried on a shaft 10 which is mounted centrally above tube 1. Shaft 10 is rotatable and as it turns the arm 9 (which is arranged within tube 1 and at its upper end at the level of the normal surface of the body of infed material) sweeps and levels the material which is gradually being fed in through conduit 7. It will be observed, in this connection, that the hopper-like bottom of chamber 5 serves not merely to check the rise of dust (as explained) but to collect and deliver to tube 1 whatever dust settles from the inflowing stream of air and whatever portion of the material fed in from conduit 7 falls to one side. Thus the spreader 8 maintains an even distribution of the charge in tube 1. A sweep 20 may be carried on shaft 10, rotating with it but preferably free to slide upon it as the shaft moves longitudinally. This sweep traverses the sloping hopper surfaces and assists in carrying into tube 1 whatever material lodges on these sloping surfaces. At times in the course of the operation the tube 1 may become clogged by material skulling and

caking within it. The member 8 is further arranged to serve as a pusher, to loosen and drive downward the agglomerated material whenever it tends to skull or cake in or near the zone of combustion. To that end the shaft 10 is mounted not only for rotation but also for longitudinal reciprocation. The structure is conveniently carried on a properly weighted lever or "walking beam" 11 and a suitable handle 12 may be provided for driving the member 8 up and down to effect the ends described.

It remains only to call attention to certain further features of the apparatus which may advantageously be employed. The support 3 for the material within tube 1 and the worm feed within conduit 7 may both be power-driven; and these two parts may, as shown, be driven in coördination, so that feed and discharge shall be at a constantly maintained relative rate. The lower portion of tube 1 and the support 3 may as indicated be perforate, to afford freer access of entering air to the body of material within tube 1.

The tube 1 and the proximate portions of chamber 5, where high temperatures are maintained, may be formed of fire brick built in an iron frame work. The stem and head of the spreader and pusher may as shown be provided with internal passages for the circulation of water.

The apparatus of Figs. 4–9 will readily be understood with a few additional words of explanation. The tube 1^a, instead of being vertically arranged, lies in horizontal position; the conduit 7^a for feeding in the material extends into the mouth of tube 1^a, and the spreader and pusher are dispensed with. The intake end of tube 1^a is provided, as particularly shown in Figs. 5 and 6, with lugs 13, against which the conduit 7^a makes bearing and between which the current of air is drawn, through an annular suction chamber 5^a which surrounds the conduit 7^a. This chamber may, at least in that part adjacent tube 1, be filled with a body 14 of loosely packed pebbles which serves to entangle and retain whatever burden of dust the stream of air which flows through may carry with it.

As particularly shown in Figs. 5 and 7, the intake end of the tube 1^a is modified by having radially extending slots 15 formed in its wall. These radial slots will less readily become packed with the entering body of material, and by their presence the freedom of flow of the stream of air may be insured.

The heater 2^a surrounds the tube 1^a and defines a zone of combustion, as in the case shown in Fig. 1.

In dotted lines, 16, Fig. 4, is shown a gas-supply pipe, directed into the discharge end of tube 1^a. By such provision and by so feeding in combustible gas with the stream of air or other combustion-nourishing gas, combustion within the body in the tube may be facilitated or intensified, and the external heater 2^a may or may not be employed. Such a supply of combustible gas may manifestly be provided in connection with the apparatus of Fig. 1.

The worm feed within conduit 7^a is water cooled as shown.

A shaft 17, rotatable and capable of being advanced and retracted longitudinally, is mounted opposite the discharge end of tube 1^a. Upon it may be mounted, either the extractor of Fig. 8, with its blades forming an interrupted helix, or the crown-like drill of Fig. 9. These are the means in this case employed to break up and form fissures in the body of material as it advances from the zone of combustion and agglomeration, and also to assist in the extraction of the agglomerated material from tube 1^a. Such breaking up, as has already been explained, gives access of the stream of air to the interstices, and causes the air to blow back into the zone of combustion whatever pockets of un-agglomerated material are thus opened up.

In the foregoing description I have spoken of the substance under treatment in general terms as a body of material to be agglomerated, and have said that this will ordinarily be a mixture of flue dust and finely divided ore. It remains only to be observed that I place no limitation upon my invention in this matter of the particular nature of the material to be treated. For example, it is not essential to mix flue dust with iron ore in order to obtain material which may be agglomerated; coke braize may be mixed with iron ore and the mixture will be amenable to my procedure; an iron ore which has a large sulfur content needs no admixture with any carbon-containing substance, but may itself be agglomerated. These instances will suffice to indicate that my invention in its broader aspect is not limited to any particular material or to the mixture of any particular materials, but is applicable generally to the treatment of ores which because of their finely divided condition are difficult to handle in reducing furnaces, and it requires only this: that the material shall be susceptible to agglomeration.

I claim as my invention:

1. The method of ore agglomeration herein described which consists in subjecting a body of material to a progressive combustion, breaking into fragments the agglomerated portion of such body left behind as combustion advances, and causing a gaseous stream to flow to the point of combustion through such agglomerated and fragmented portion of the body.

2. The method of ore agglomeration herein described which consists in subjecting a

body of material to a progressive combustion, breaking into fragments the agglomerated portion of such body left behind as combustion advances, and causing a stream of combustible gas to flow to the point of combustion through such agglomerated and fragmented portion of the body.

3. The method of ore agglomeration herein described which consists in causing the body of material under treatment to advance by continuous feed through a zone of high temperature, breaking into fragments the agglomerated portion of said body advancing from such zone, and causing a current of combustion-sustaining gas to flow to such zone of high temperature through the portion of the body of material agglomerated and fragmented as above indicated.

4. The method of ore-agglomeration herein described which consists in causing the body of material under treatment to advance by continuous feed through a zone of combustion, subjecting such body of material to a spray of water in the rear and to a current of air flowing through it from front to rear and in breaking and spreading the fragmented mass of material as it advances beyond said zone of combustion.

5. The method of ore-agglomeration herein described which consists in causing the body of material under treatment to descend through a vertically arranged and downwardly flaring passageway and in such progress to pass through a zone of combustion, causing an ascending stream of air to penetrate said descending body of material, and causing such descending mass of material to be broken up and subjected to a more searching penetration of the said ascending stream of air as it descends beyond said zone of combustion.

In testimony whereof I have hereunto set my hand.

PHILIP O. HARDING.

Witness:

FRANCIS J. TOMASSON.