

S. J. VERMAES.
 ROTARY KILN.
 APPLICATION FILED APR. 26, 1920.

1,401,212.

Patented Dec. 27, 1921.
 3 SHEETS—SHEET 1.

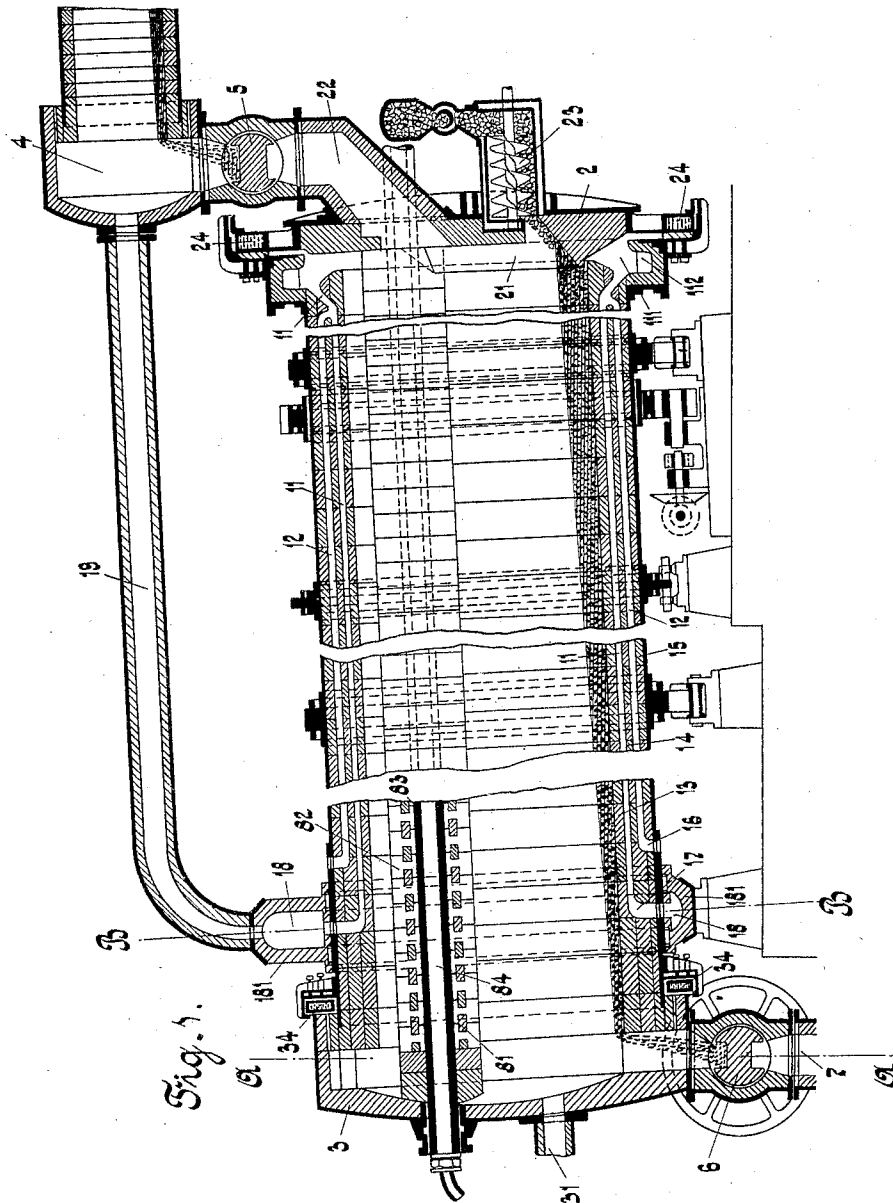


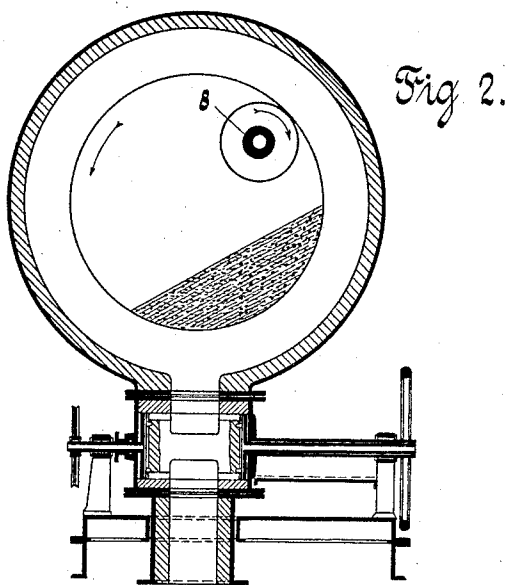
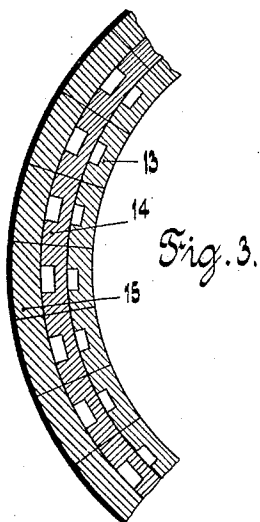
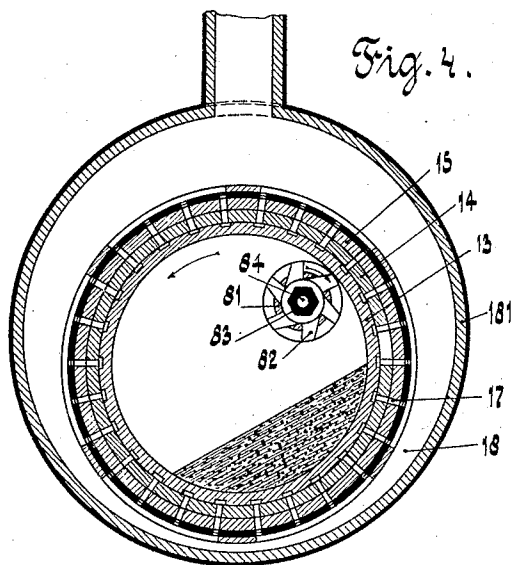
Fig. 1.

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3 SHEETS—SHEET 3.

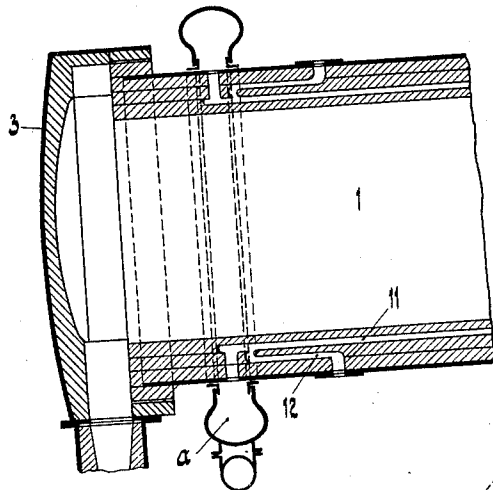


Fig. 5.

Fig. 7.

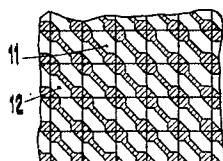
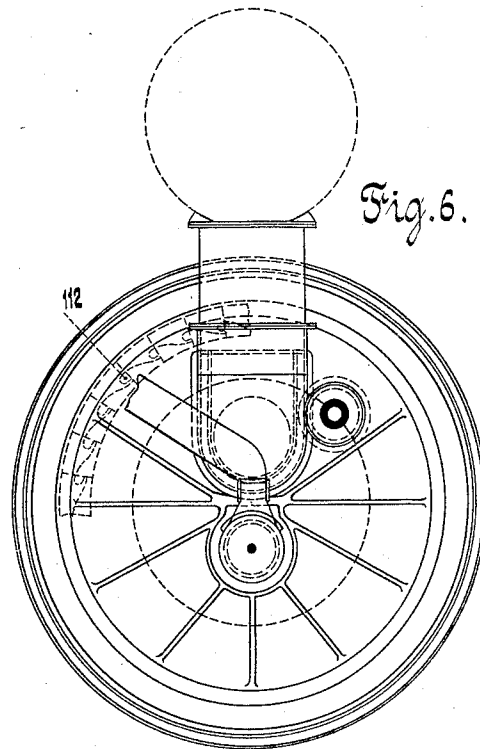


Fig. 6.

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UNITED STATES PATENT OFFICE.

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ROTARY KILN.

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To all whom it may concern:

Be it known that I, STEFANUS JOHANNES VERMAES, a subject of the Queen of the Netherlands, residing at Delft, in the Province of South Holland, Kingdom of the Netherlands, have invented certain new and useful Improvements in a Rotary Kiln, of which the following is a specification.

The rotary kiln which comes more and more into use in the metallurgical and chemical industries because it has many advantages frequently cannot be used when the gases produced by the heating of the kiln must be kept out of the interior of the kiln. The object of the present invention is to enable the rotary kiln to be employed in cases where it is essential to prevent the combustion gases from mixing with the gases which are used in the kiln or produced therein. According to the invention this is obtained by heating the kiln with gaseous fuel which is burnt in channels constructed in the wall of the kiln.

These channels may be constructed in the form of straight lines definitive of a cylindrical surface or in the form of helical lines having a greater or smaller pitch in order to increase the length of the channels. By varying the cross section of the channels and thereby varying the velocity of the fuel gases or by varying the thickness or the material of the wall which separates the channels from the interior of the kiln, it is possible to regulate the heating of different parts of the kiln to different temperatures.

The combustion in the channels may be conducted in parallel current or in counter current with the movement of the charge in the kiln. In the first case the inlet of the channels is at the charging side of the kiln and most of the heat will be given off to the first part of the kiln. In the other case the channels must begin at the discharge end of the kiln, and the largest part of heat will be transmitted at the end of the kiln. The method which is preferable depends on the reactions which take place in the kiln. Of course it is also possible to use combinations of the two principles of heating and also to heat only a part of the length of the kiln.

When combustible gases are produced in the kiln they may be used as fuel for heating the kiln by making a communication be-

tween the inlet side of the channels and the interior of the kiln.

When the gaseous fuel is taken from outside, this may be done by means of an annular channel extending around the rotary kiln, with which the fuel channels in the wall communicate at their inlet ends.

Because the heating of the kiln according to the invention is effected indirectly, it is of great importance that no crusts are formed on the walls. Such crusts would decrease the transmission of heat and become superheated themselves. In many cases they would therefore gradually increase in thickness and hinder more and more the reaction in the kiln.

To prevent this drawback a scraper may be provided extending over the whole length of the kiln. Such a scraper should not rotate with the kiln and consequently would scrape off always a fresh part of the wall. It is advantageous to give a rotating motion to the scraper in opposite direction to the kiln and about an eccentric axis.

The kiln is suitable for several reactions especially when a gas is evolved which should be obtained in non-diluted condition or when the reaction of air or fuel gases or the products of combustion on the charge should be prevented.

The kiln may be used especially for the reduction of finely divided iron-ore by granular carbonaceous material (coke, coal, charcoal and the like).

The accompanying drawings disclose one form of kiln constructed in accordance with the invention.

In the drawings:

Figure 1 is a vertical longitudinal section of the rotary kiln with the connections to further apparatus for the reduction of grained iron ore by granular carbon.

Fig. 2 is a cross section along the line A A of Fig. 1 perpendicular to the axis of the kiln.

Fig. 3 is a cross section of a part of the wall provided with heating channels.

Fig. 4 is a cross section along the line B B of Fig. 1.

Fig. 5 is a vertical longitudinal section of the discharge end of another type of the rotary kiln.

Fig. 6 is a front view of the charging side of the rotary kiln according to Fig. 1.

Fig. 7 is a side view of a part of the wall of the rotary kiln in which the outer covering and the exterior layers are removed showing another form of the channels in the furnace wall.

In the drawings 1 is the rotary part of the kiln; 2 is a fixed front covering; 3 a fixed back covering; 4 is a preheating kiln for the ore, in this case a directly heated rotary kiln of known type; 5 is a valve for feeding regularly equal parts of preheated finely divided ore into the kiln 1, without making gas communication between the parts 1 and 4. The valve 6 is of a similar construction and discharges the reduced ore into the conduit 7 which may communicate, for instance, with a melting and refining kiln. The kiln 1 is rotated in the way usual for rotary kilns, the rotating mechanism being indicated generally at 100 in Fig. 1.

Pre-heated ore is discharged from the kiln 4 by the valve 5 through the conduit 22 into the kiln. A helical conveyer 23 introduces granular carbon. The regular introduction of ore and carbon and the rotary motion of the kiln assure a good mixture of both substances. If necessary or desired, a suitable flux may be introduced with the ore or with the carbon. The conveyer 23 is covered in such a way, that the kiln is shut off gastight from the atmosphere.

The mixture of ore and carbon is now brought to reaction in the kiln and the ore is reduced to iron and the carbon burns chiefly to carbon monoxid. The iron is removed through the valve 6. The produced gas has a very high calorific value and is used for heating the rotary kiln. To this end it is conducted into the channels 11 in the wall of the kiln. In the wall are also channels 12 by which air is introduced and which discharge into the inlet ends of the channels 11 and cause combustion therein.

In the construction illustrated in Fig. 1 the gas channels 12 are exterior of the channels 11 and pass through the largest part of the kiln wall, so that the air is preheated before it enters the gas channels.

The combustion is effected in parallel current with the movement of the charge in order to maintain as nearly as possible the same temperature in the whole kiln, to effect the greatest transmission of heat in the beginning where it is required by the endothermic reaction of reduction and to prevent super-heating of the reduced iron which would lead to melting and undesired carbonizing.

To prevent solid material from coming into the channels 11 which would plug them, the lower part of the covering 2 is provided with an approximately semi-circular rib 21 of V-section, over which the ore and the carbon fall directly upon the interior of the rotating wall.

Below the rib 21 and the beginning of the interior kiln wall is an annular channel 111 in the rotary part of the kiln, in which the channels 11 begin. As the rib 21 only covers the lower part of the covering 2, there is ample gas communication between the channel 111 and the interior of the kiln. Near the periphery of the channel 111 are small partitions slanting in the direction of rotation, by which cups 112 (Fig. 6) are formed in such a way, that, when eventually solid material comes into the channel it is taken upward and falls there upon the rib 21 over which it slides into the kiln.

The gas-tight joints between the kiln 1 and the coverings 2 and 3, are obtained by water-cooled annular spaces 24 and 34, on the coverings 2 and 3, over which slide surfaces which are connected to the rotary part 1, which surfaces may be pressed against these annular spaces, while lubrication with oil may be applied.

The wall of the kiln consists of an iron or steel shell, which is rotated in the usual way upon rollers, and in which are three layers 15, 14 and 13 of fireproof material. The inner layer should come up to the highest requirements, not only regarding its fire-proof quality but especially also mechanical resistance against the friction and the scraping action of the ore and the scraper.

In the layer 13 the heating channels 11 are formed. In the layer 14 are the air-channels 12 (Fig. 3).

The discharge ends 17 of the heating channels 11 in the wall discharge into an annular channel 18, which does not rotate and is eccentric with regard to the rotary kiln and has a discharge at its top (Figs. 1 and 4).

The said ends 17 of the channels 11 are radial and go through the layers 14 and 15 and the shell. In order not to weaken these too much, the section of these discharge channels is elongated with the long side parallel to the axis of the kiln, while the section of the channels 11 is also elongated but with the long side in the direction of the periphery of the circle in order to increase the heating surface.

The interior of the channel 18 is of fire-proof material 181, which encircles and fits against the shell of the cylinder which is reinforced in this place. In the construction illustrated, friction is prevented by roller-bearings on both sides.

The inlet ends 16 of the channels 12 are made in a similar way to the discharge ends of the channels 11. The gases escaping from the annular space 18 into the conduit 19, are still very hot and may be used for several purposes, for example, for pre-heating the ore as shown in the drawing.

The rear covering 3 has an aperture 31

through which gas may be introduced or withdrawn, according to whether more or less gas is formed than is necessary for heating the kiln 1. In this manner it is possible to introduce, for instance, water gas or producer gas when the kiln is put into action. When the furnace is well in action, more gas is produced with most ores than is necessary for the heating of the kiln. The surplus may be used for melting and refining the produced iron, the pre-heating of the ore and other purposes.

A scraper 8 extends through the whole kiln 1. This scraper consists of a steel shaft 83 of hexagonal section having a bore 84 for the passage of cooling water there-through, said shaft extending through the covers 2 and 3 which are made gas-tight at such points. Upon this shaft are mounted the sockets of a series of T-shaped scrapers 82 of "Monel" metal, the sockets and the scrapers proper fitting close against each other and the whole being kept together by means of end pieces upon the shaft by the covers 2 and 3. The open spaces between the sockets and the scrapers proper are filled up with fire-proof non-conducting material 81 to prevent as far as possible any loss of heat.

The scraper 8 is rotated in the opposite direction to the kiln, so that the scrapers 82 act against the wall of the furnace and scrape off all crusts. The scraper may be moved in any suitable way. (Not shown.)

Fig. 5 represents another construction of the rotary kiln according to which the heating is effected in counter current with the movement of the charge; the gas is not taken directly from the interior of the kiln and the air is not (or only very little) pre-heated. The annular channel *a* in Fig. 5 is fixed and is shut off gas tight against angle irons provided upon the shell of the rotary kiln. The shutting off may also be effected in any other suitable way.

In order to obtain an evenly distributed heating, it is advantageous to construct the heating channels on helical lines around the kiln as indicated in Fig. 7.

In the form of kiln illustrated in Fig. 1 the heating and air channels run along straight lines which define a cylindrical surface.

When now the draft in the upper part of the kiln is stronger than below, the upper channels will receive more gas and the heating will be most intense in the upper part. Though the rotation in the kiln diminishes more or less both drawbacks, yet they are important. If, however, the air and fuel channels are wound in helical lines around the cylinder, both drawbacks are wholly removed, the heating is everywhere equal and the distribution of gas is the same in all channels.

Fig. 7 shows how this may be obtained by forming channels of slanting direction in the inner layer of bricks of the wall, the said channels registering with the channels in adjacent bricks. The helical form of the channels has also the advantage of increasing the length the more so when (as represented in Fig. 7) the channels are more or less curved.

What I claim is:

1. A rotary kiln comprising a gas-tight barrel, means for rotating said barrel, combustion channels in the wall of said barrel, and means for supplying gas and air for combustion in said channels for heating the kiln without said combustion gases entering the interior thereof.

2. A rotary kiln comprising a gas-tight barrel, means for rotating said barrel, combustion channels in the wall of said barrel for supplying exterior air to said combustion channels for the firing of the gas and the heating of the kiln.

3. A rotary kiln comprising a gas-tight barrel, means for rotating said barrel, a plurality of combustion channels formed in the longitudinal wall of said barrel and extending from one end of said wall toward the other end, and means for supplying combustible gas and air to said channels.

4. A rotary kiln comprising a gas-tight barrel, means for rotating said barrel, combustion passages formed in the wall of said barrel, said passages being in connection at one end with the interior of the barrel to receive the combustible gases produced therein, and air passages in the wall of said barrel for supplying external air to said combustion tubes and maintaining the combustion of said gases therein and means for exhausting said combustion gas external to the kiln.

5. A rotary kiln comprising a gas-tight barrel, means for rotating said barrel, a plurality of longitudinal combustion channels in the wall of said barrel connected with an external source of combustible gas, and air channels in the wall of said barrel connecting the said combustion channels with the exterior of the barrel to supply air to said combustible gas to maintain combustion in said combustion channels.

6. A rotary kiln comprising a gas-tight barrel, means for rotating said barrel, a plurality of helically arranged combustion passages in the wall of said barrel, an annular channel in said barrel connecting the interior of the latter with said combustion channels, and air passages in the wall of the barrel supplying external air to said combustion tubes.

7. A rotary kiln comprising a gas-tight barrel, means for rotating said barrel, a plurality of helically arranged combustion

channels in the wall of said barrel connected with an external source of combustible gas, and air channels in the wall of said barrel connecting said combustion channels with the exterior of the barrel to supply air to said gas to maintain combustion.

8. A rotary kiln comprising a gas-tight barrel, means for rotating said barrel, a plurality of combustion channels in the wall of said barrel, said channels being of varying sectional area in different parts of the barrel to vary the heat distribution, and means for supplying gas and air to said channels for combustion therein.

9. A rotary kiln comprising a gas-tight barrel, means for rotating said barrel, a plurality of combustion channels in the walls of said barrel and extending along the length thereof, and means for supplying combustible gases to said channels in parallel current with the movement of the charge passing through the kiln.

10. A rotary kiln comprising a gas-tight barrel, means for rotating said barrel, a plurality of channels in the walls of said barrel, and extending along the length of said barrel and means for supplying combustible gases to said chambers in contra-flow to the movement of the charge passing through the kiln.

11. A rotary kiln comprising a gas-tight barrel, means for rotating said barrel, a plurality of combustion channels in the wall of said barrel, said channels being connected with an external source of combustible gas by means of a fixed annular channel encircling the barrel, and means for supplying air for the combustion of the gas in said channels for heating the kiln.

12. A rotary kiln comprising a rotating gas-tight barrel having combustion channels in the wall thereof, means for supplying fuel gas and air to said channels for heating said barrel, and a scraper arranged adjacent the interior of the wall of the barrel for removing scale.

13. A rotary kiln comprising a rotary gas-tight barrel having combustion channels in

the wall thereof, a scraper rotatably mounted on an eccentric axis within said barrel, and means for rotating said scraper oppositely to the rotation of the barrel.

14. A rotary kiln comprising a rotatably mounted barrel having combustion channels in its wall, fixed end-coverings for the barrel having surfaces forming gas-tight joints between the said coverings and the barrel, means for feeding materials to the kiln whereby the interior is maintained gas-tight, and means for supplying gas and air to the channels in the wall of the drum for combustion in the said passages without said combustion gases entering the interior of the kiln.

15. A rotary kiln comprising a rotatably mounted barrel having combustion channels in its wall, means for feeding fuel gas and air to said channels, fixed end-coverings for the barrel forming gas-tight joints therewith, feed-openings in one end-covering, means for feeding materials through said openings into the kiln while maintaining it air-tight, a rib on said end-covering reaching above the interior surface of the rotating drum, and an annular channel in the drum connected with the combustion channels and formed with partitions slanting in the direction of rotation to form cups.

16. A rotary kiln comprising a rotatable barrel having combustion channels in its wall, means for rotating said barrel, and fixed end-coverings having water-cooled faces making gas-tight joints with the rotating barrel.

17. A rotary kiln comprising a barrel with an interior wall composed of three layers of slabs of heat-resisting material, said slabs having grooves in their faces to form channels in said interior wall, and means for supplying gas and air to said channels for combustion therein to heat the kiln.

In testimony whereof I have hereunto set my hand.

STEFANUS JOHANNES VERMAES.