J. B. ETHERINGTON.

APPARATUS FOR TREATING ORES IN PREPARATION FOR MAGNETIC SEPARATION.

APPLICATION FILED JAN. 12, 1911.

1,051,494. Patented Jan. 28, 1913.

2 SHEETS—SHEET 1.

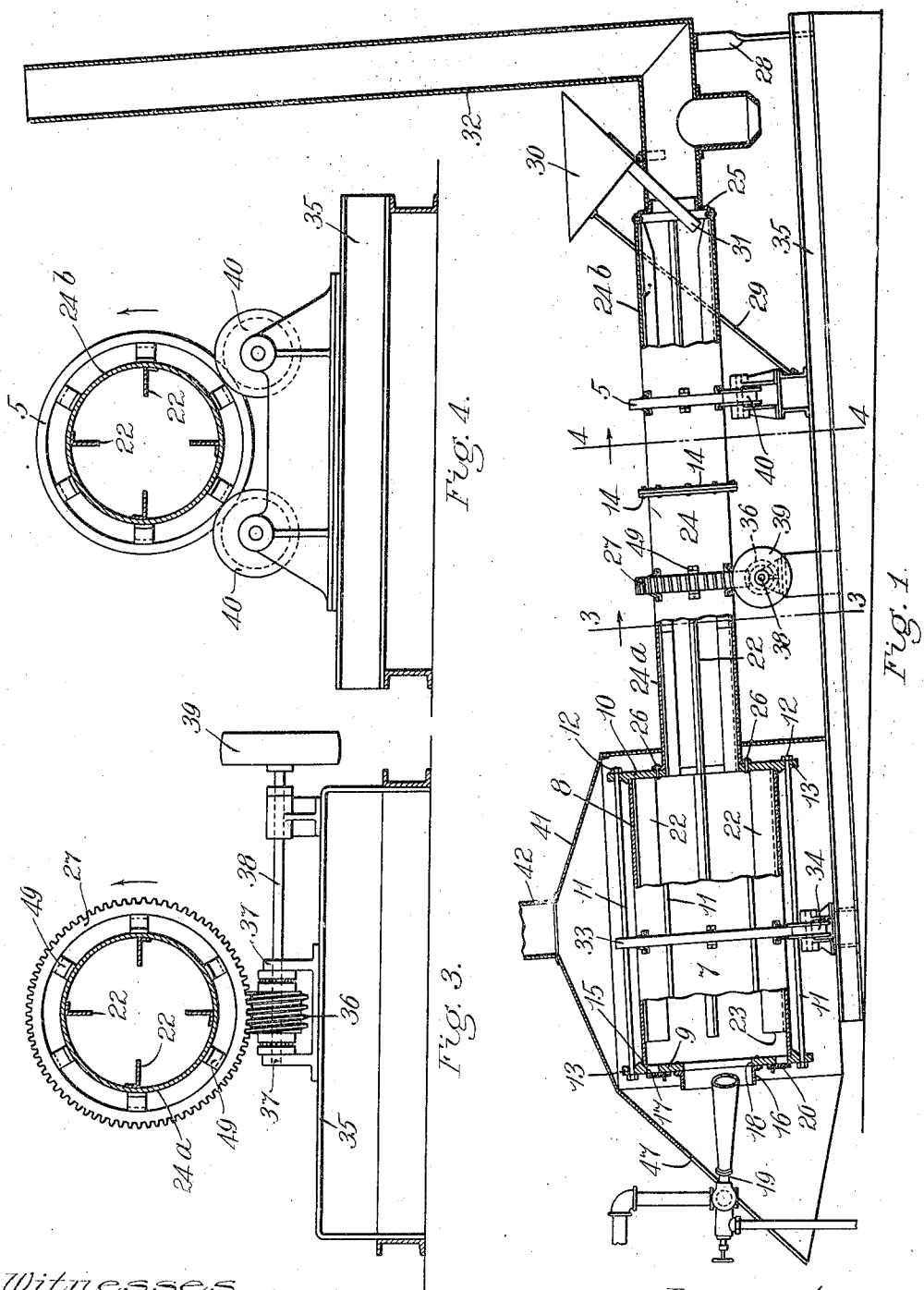

Fig. 1.

Fig. 4.

Fig. 3.

Witnesses.
Harold C. Haskell.
Elmer E. Briggs

Inventor:
James B. Etherington
by Chas. F. Perkins Atty

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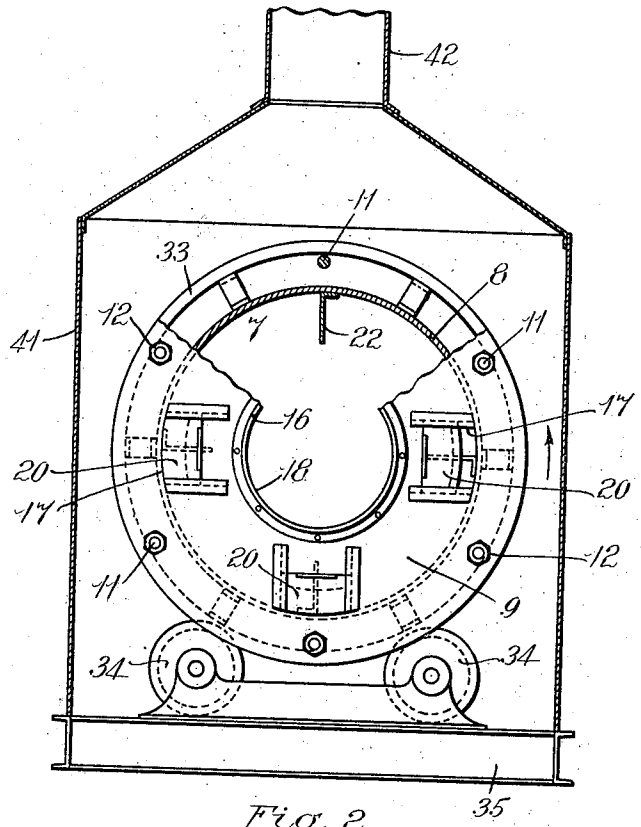

Fig. 2.

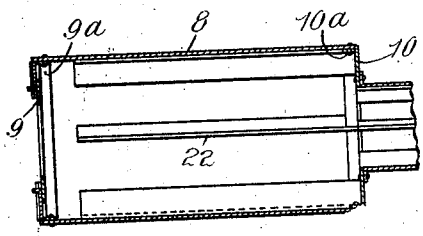

Fig. 5.

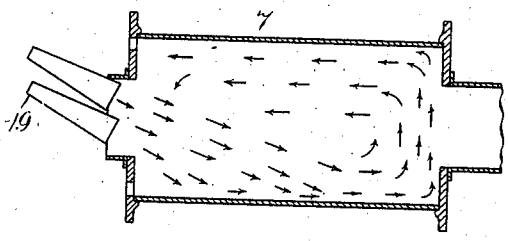

Fig. 6.

Witnesses.
Harold C. Haskell.
Elmer L. Briggs

Inventor:
James B. Etherington
by Chas. F. Perkins Atty

UNITED STATES PATENT OFFICE.

JAMES B. ETHERINGTON, OF WINTHROP, MASSACHUSETTS, ASSIGNOR TO CAMPBELL MAGNETIC SEPARATING COMPANY, A CORPORATION OF ARIZONA.

APPARATUS FOR TREATING ORES IN PREPARATION FOR MAGNETIC SEPARATION.

1,051,494. Specification of Letters Patent. Patented Jan. 28, 1913.

Application filed January 12, 1911. Serial No. 602,177.

To all whom it may concern:

Be it known that I, JAMES B. ETHERINGTON, a citizen of the United States, residing at Winthrop, in the county of Suffolk and State of Massachusetts, have invented a new and useful Apparatus for Treating Ores in Preparation for Magnetic Separation, of which the following is a specification.

This invention relates to the treatment of ferruginous ores containing sulfids, and its object is to provide an apparatus adapted to render such ores susceptible to magnetic or electrical influences without volatilizing or materially oxidizing the metallic constituents, and to furnish details of construction for convenience and economy of manufacture and use as hereinafter particularly set forth.

The apparatus consists primarily of a furnace so constructed that a non-oxidizing atmosphere, or an atmosphere possessing a minimum amount of free oxygen, may be maintained at all times while the furnace is in operation. I have discovered that in order to get the best results in magnetizing non-magnetic ores by heat it is desirable to admit only sufficient air to support the combustion of the fuel without materially oxidizing the metallic constituents of the ore, and I have applied for Letters Patent of the United States for a process embodying the same.

The apparatus described and claimed in the present application is designed especially for the practice of this process.

I am aware that prior to the invention of my process, it was discovered that the ferruginous constituent in non-magnetic pyritiferous ores containing, in addition to the iron, other base or precious metals, could be magnetized by subjecting the same to heat for a brief time without removing substantial portions of any of the solid constituents of the ore, and that Letters Patent were granted for such process to Henry F. Campbell, No. 723,363 dated March 24, 1903, which invention I am utilizing, in my process herein described, to the greatest practical and commercial advantage.

Prior to the invention of my process it was the general practice to roast sulfid ores for a number of hours while freely exposed to oxidation, in order to render them magnetic, employing therefor costly and ponderous apparatus, and producing wasteful results. By means of my process I am able, employing comparatively light and inexpensive apparatus, to treat non-magnetic pyritiferous ores commercially and economically so as to render the ferruginous constituents magnetic by subjecting said ores to heat for a few minutes.

The principal feature of my process consists in conveying the ores through a furnace into which is blown a flame created outside the furnace and carrying with it into the furnace practically only sufficient air to support the combustion of the fuel in the blast, thereby preventing any considerable oxidation of the ore. This is contrary to the former methods. Heretofore it has been a common practice to roast the ore in a furnace with an abundance of air circulating through it, in order to oxidize fully and as rapidly as possible the sulfur of the ore, thereby converting the iron into an oxid. The fire was built and run inside of the roaster and depended upon a free draft of air through the furnace to maintain it. There were no means, nor any attempt to provide means, to limit the supply of air, but on the contrary to furnish the maximum amount of oxygen to the ore, was considered indispensable to good results. The difference between the prior art methods and my process is radical in this respect. My invention resides in heating the ore while exposed to the minimum amount of oxygen. The prior art consists in exposing the ore to the maximum amount of oxygen while roasting it. In the methods of roasting ore, prior to my invention, the heat was not applied to the ore with such precision and uniformity that any reliance could be placed upon magnetizing the ore that passed through the furnace, without excessively roasting a large percentage, and actually fusing some of its constituents. There were two serious evils in the apparatus and methods of the prior art, namely,—first, the dependence upon a natural draft of air through the roaster to support the fire within it; and secondly, the great length of time required to insure the roasting of all parts of the ore, owing to the inability to control the degree of heat, and to apply it to the ore with precision. The effect of this old method of roasting ores containing the sulfids of iron and zinc was not only to oxidize the ore excessively, but to volatilize and

waste the zinc and other metals; and to oxidize and waste the sulfur. The preservation of the sulfur in the ore during the magnetizing process increases the commercial value of both the zinc and iron sulfids after separation.

In the practice of my process, there is a direct and uniform application of heat to the ore, so that all particles of the ore are exposed to the same degree of heat for a brief time and practically the same length of time; and the result of which is that all particles of the ore are subjected to a predetermined degree of heat, and for a brief and pre-determined time, which is barely sufficient to magnetize the iron constituent of the ore without volatilizing any of the metals or otherwise removing from it any substantial quantities of its metallic constituents, and without materially oxidizing the same.

An important feature of my invention consists in avoiding the loss of the fine particles of ore through the stack or flue. Dust composed of zinc, iron, sulfur or other valuable constituents of the ore escape in large quantities through the flue and stack of the roasters heretofore commonly used through which a strong draft was maintained, and was necessary to support the fire within them. In the practice of my invention the escape of materials through the stack is reduced to a minimum, on account of the ability to dispense with a draft for supporting the fire.

The commercial practice of my process is accomplished by the apparatus which I have invented, and which forms the subject matter of the present application for Letters Patent, and the essential feature of my apparatus is the means for restricting and limiting the supply of air to the heating chamber.

The roasting furnaces employed in the prior art were large and heavy and very expensive to construct and operate. They were invariably lined with cement or brick, to which the ore had a tendency to adhere when heated,—particularly if fused to the slightest extent,—resulting in an accumulation of ore upon the lining in irregular forms and masses, and thereby reducing the interior diameter and capacity of the furnace, and obstructing the passage of the ore through it. On this account, as well as others, no dependence could be placed upon the time occupied for the passage of the ore through and its delivery from the roaster. Furthermore, such irregularities on the interior surface of the roaster materially interfered with the exposure of all portions of the ore to the same degree of heat, or to any approximation of the same. These roasters required many hours to prepare them for use. It was necessary to heat them slowly and gradually to raise their great bulk of iron and brick to the intense heat required to oxidize the ore,—the time occupied for this purpose being 24 to 30 hours. After the roaster was heated, it was necessary to maintain the temperature and keep the roaster in operation day and night for months at a time, because if permitted to cool, the brick arches were liable to fall, in which case the roaster had to be re-lined. Whenever any repair was necessary, such as removing the ore which had adhered to the lining, it could not be done without a delay of several days to permit the cooling of the roaster. All these evils are obviated by my invention.

My furnace consists of an unlined cylinder approximately six feet long and three feet in diameter, made of sheet steel or iron $\frac{3}{8}$ths of an inch or more in thickness. No time is consumed in preparing the furnace for use. It cools quickly, and shortly after the flame is withdrawn, is cool enough to handle and repair. I do not limit my invention to the dimensions specified, as I find by experience that a great variety of sizes may be successfully employed.

My invention further consists in providing means for circulating air, water, or other cooling medium, around the exterior walls of the furnace, and in the preferred form of construction illustrated in the drawing, it consists in surrounding the furnace with a hood or jacket between which and the outer wall of the furnace a narrow space is provided through which the air is circulated by means of an exhaust fan, for the purpose of cooling the furnace.

I find that the durability or length of life of the furnace is prolonged by providing artificial means for circulating a cooling medium around it. It has been my practice to use a blower for the circulation of atmospheric air at the ordinary temperature, and this has proved efficacious. It would, of course, be an additional advantage to reduce the temperature of the air by refrigeration, as the length of life of the furnace would be increased thereby. Any means of artificially cooling the furnace is within the scope of my invention. The durability of the furnace is also increased by my method of permitting only sufficient oxygen for supporting the flame to be introduced into the furnace, or at least only a minimum in excess of such amount. Not only is the ore itself prevented from oxidation, but also the material of which the furnace is composed.

By controlling the degree of heat, making a direct application of the flame to the ore and artificially reducing the temperature of the shell of the furnace, I am able to prevent the adhesion of the ore to the wall of the furnace and thereby always to

present a smooth surface for the passage of the ore through the same.

My invention further consists in constructing the apparatus of cylindrical sections and circular heads assembled by means of separable connections, whereby the parts may be removed and replaced at will, and so that the structure may be readily taken apart for shipment or other purposes, and may be readily re-assembled.

The particular construction of my apparatus consists of two or more hollow, cylindrical sections, the ends of which are arranged to be coupled with circular heads. One of these sections is designed as a furnace, and the other section or sections are designed for feeding the ore to the furnace and drying and heating the same in its passage. The heads of the furnace are connected by bolts or rods, and said cylindrical sections are provided with bearing rings which engage with rollers for the purpose of permitting the rotation of the furnace.

It is obvious that an unlined furnace is less protected from the deteriorating action of heat than one having a brick or cement lining, and that it is desirable to have the parts readily removable, so as to be able to replace them conveniently and economically, and especially those parts which are most perishable. For this reason, I have constructed my furnace in sections with separable connections, for the purpose of a convenient and ready replacement of parts, and also for the additional advantage of compactness.

In the accompanying drawing similar numerals of designation represent similar parts throughout the several views.

Figure 1 is a side elevation partly in section of my furnace and the hood covering the same, together with the burners and blowers and the mechanism for rotating the furnace. Fig. 2 is an end elevation partly in section of the furnace and hood shown in Fig. 1 showing the discharge openings and interior of the cylindrical furnace. Fig. 3 is a section on line 3—3 of Fig. 1, looking in the direction of the arrow, showing the rotating mechanism. Fig. 4 is a section of the furnace on line 4—4 of Fig. 1, looking in the direction of the arrow, and showing one of the bearing rings and rolls therefor. Fig. 5 is a longitudinal section of a modification of the general construction of my furnace. Fig. 6 is a diagrammatic plan view illustrating the burners and the course of the flames and heat in the furnace.

Referring to the drawing, the furnace 7 consists of the hollow cylinder 8, preferably formed of heavy plate steel or iron, or of cast iron, and the circular heads 9 and 10 connected together by means of the rods 11, the ends of each of which are threaded to engage with nuts 12. Holes 13 are drilled in each of the heads 9 and 10 for the reception of the rods 11, and each head has an annular recess 15 on the inner surface to receive and hold one end of the cylinder 8, forming the furnace. To the outer side of the head 9 is secured the annular flange 16, which surrounds the central opening 18 through which the flame from the hydrocarbon burner 19 is projected into the furnace 7. For my purpose, I prefer to use the type of burner shown in the United States patent to Barker, No. 825,290, issued July 10th, 1906. But any burner employing either fuel oil, coal gas, or the like, and capable of producing a jet of flame when projected by a blast of air into the furnace, will suffice for my purpose. To regulate the size of the opening of the ports 17, I prefer to adjust the same by means of the gates 20. The furnace 7 is provided with radial shelves 22, made of plate steel or iron or other suitable material, extending from the interior wall of the furnace and secured thereto in any desired manner. The said shelves preferably extend longitudinally from the receiving end of the furnace nearly to the discharge end thereof, leaving a narrow space 23 free for the reception of the ore adjacent to the discharge ports. The cylinder 24 is likewise provided with similar radial shelves, and is formed in two sections 24^a and 24^b, and is preferably about 18 inches in diameter. It is connected with the furnace 7, at a central opening in the head 10. Said sections, 24^a and 24^b, are bolted together through the flanges 14 at their respective ends, the other end of section 24^a being secured in like manner to the head 10 by the bolts 26, and the other end of section 24^b being secured to the casting 25. The hopper 30 is provided for the purpose of feeding the ore into the cylinder 24^b through the spout 31, and is braced by means of the rods 29. For the escape of the gaseous products of combustion I provide the flue 32 communicating with the upper end of the cylinder 24 as shown, and supported by the struts 28.

I support the furnace 7 by means of the removable bearing rings 33 engaging with friction rollers 34, which are suitably mounted in the well known way upon the inclined base 35. The worm gear 27 is detachably secured to struts 49 which in turn are bolted to the cylinder 24^a, and is operated by the worm 36, which is mounted upon said base 35, in bearings 37. The worm 37 is mounted on one end of the shaft 38, on the other end of which is mounted the driving pulley 39. Friction rollers 40 mounted on said base and similar to rollers 34 serve to engage with the bearing ring 5, and thereby provide a means for supporting and rotating the cylinder 24. The axis of rotation of the apparatus is slightly inclined so that the ore

will readily travel by gravity toward the discharge end of the furnace.

In Figs. 1 and 2 is shown the air cooling device which in this case consists of a hood or shield 41, closely covering the furnace 7, and is supported in any suitable manner, one end of said shield being cut away to form the opening 47 in order that the discharge end of the furnace may be made accessible for the hydro-carbon burner 19. The hood 41 is connected with an exhaust fan (not shown) by the pipe 42, said exhaust fan being preferably located near the top of the structure in which my furnace is used. The hood 41 is somewhat larger than the furnace 7, in order to form an air space between them through which a circulation of cold air may be created by an exhaust fan, blower, or other suitable means. I have found in practice that the life of the furnace may be greatly prolonged where this cooling device is used, and that it is possible to use the furnace indefinitely without the ore adhering to the wall of the furnace 7.

It is obvious that the cylinder 24 could be composed of more than two sections and could be made of different diameters if desired. In the modification of the furnace shown in Fig. 5 the heads 9′, 10′, are provided with circumferential flanges 9^a, 10^a, to which the shell 8′ is bolted. This is an economical construction, but has the disadvantage that the parts cannot be readily replaced.

The operation of my apparatus is as follows:—I first adjust the hydro-carbon burner 19 to produce the degree of heat required. I also adjust the size of the ports 17 to discharge the ore in such amounts as may be necessary. The ore is then fed into the hopper 30, from which it descends through the spout 31 into the cylinder 24 preferably in such quantities as to permit the shelves 22 to produce their maximum amount of agitation. The cylinder is then slowly rotated, causing the ore to fall from one of the shelves to another and by gravity slowly to travel along the cylinder 24 and to fall into the furnace 7 through the opening in its receiving end. I prefer to employ two burners, and to project the flames against the wall of the furnace. The flames and heat are deflected from the wall, then strike the head of the furnace, from which they are again deflected back into the furnace, forming an intense heat. The ore is tumbled about from shelf to shelf into and through the flames and heat as it advances along the furnace, which maintains the ore at a red heat for a few minutes when it is discharged through the ports 17. The flange 16 is provided to protect the burner from the falling ore.

Referring to Fig. 6, I have shown two burners arranged side by side and directed toward the right hand side of the furna
It is obvious that the flame of one will
projected against the wall of the furna
in advance of the other, as shown by the
rows, and that the flames of both will be
flected by the wall and head of the furna
returning upon themselves and eddyi
about so as to form an intense body of he
in the region through which the ore is fa
ing from the shelves. The furnace is rot
ing in the direction of the arrow, so th
the ore is falling from the right ha
shelves directly into the flames.

It is obvious that the several parts of
apparatus may be readily replaced wh
worn or burned out. This is desirable
to all parts, but particularly so with
spect to the shell of the furnace 7 which
exposed to the severest usage. With
construction for quickly uncoupling
parts and my arrangement for cooling
furnace quickly, the frequent replaceme
of a shell of the furnace is a matter of
considerable expense or inconvenience.
feature of making the apparatus in sh
lengths readily separated and coupled
gether affords a great advantage in acc
sibility to the interior of the cylinders
repairs. I am now enabled to make
several parts of the apparatus of a stan
ard size, to replace any part at short noti
and by taking the apparatus apart, I a
able to conveniently handle and ship
same from place to place.

For the successful practice of my inve
tion, the air blast and oil vapor should
carefully and homogeneously mixed togeth
in the manner of which the hydro-carb
burner of the type shown in the drawing
capable. By its use the oil is convert
into a spray, and forms a mechanical mi
ture with the air. The air which is ut
ized for burning the oil is for the m
part derived from the air pipe directly co
nected with the burner, and in smaller pa
from the free air in the vicinity of
nozzle of said burner, the free air bei
drawn into the furnace by the blast fro
said pipe along with the spray of burni
oil. By carefully adjusting the stop coc
of the pipes supplying air and oil to sa
burner, the blast of flame after it issu
from said nozzle will carry with it on
sufficient of the outside air in connecti
with the air of the blast to maintain co
bustion of the oil.

The construction of the furnace and t
method of operation are designed esp
cially to provide means for applying co
mercially and economically the inventi
described in the hereinbefore mentioned L
ters Patent to Campbell. In this respe
an important feature of the construction
the furnace 7, is the relative diameter
the same and that of the central opening

through which the ore is delivered into the furnace. The heat is thereby effectually confined within the furnace and controlled. It is directed upon the ore to the best advantage, and uniformly upon all its particles as they are tumbled freely about in the furnace. The progress of the ore through the furnace is determined by its inclination and speed of rotation. The ore is subjected to the heat in the furnace for a few minutes only, varying with the kind of ore. The ore is sufficiently magnetized thereby to enable the most profitable magnetic separation of the same to be made. Practically all the iron particles are sufficiently magnetized to result in the most profitable separation, and the time of exposure to heat is too short to materially waste the constituents of the ore by oxidizing or volatilizing the same. The rapid magnetization of the ore in the furnace is faciliatated by the previous heating of the ore during its approach to the furnace through the cylinder 24.

The small cylinder 24 is provided with an interior annular flange near its opening into the flue, for the purpose of confining the heat and preventing the escape of ore as much as possible consistently with permitting the products of combustion to escape and avoiding the smothering of the flame.

What I claim and desire to secure by Letters Patent is:

1. An apparatus for treating ores in preparation for magnetic separation, consisting of a rotatable cylinder having an air inlet opening, combined with a source of heat created outside of said cylinder, and means for projecting a blast of heat into said cylinder and for admitting a predetermined amount of air into the cylinder, whereby oxidation of the contents of the latter is materially restricted.

2. An apparatus for treating ores in preparation for magnetic separation consisting of a furnace, means for feeding ore through said furnace and subjecting it therein to the action of fire combined with means for creating and maintaining said fire outside of said furnace and independent of the natural draft therethrough, said means also including means for admitting a predetermined amount of air into the furnace, whereby oxidation of the contents of the latter is materially restricted.

3. An apparatus for treating ores in preparation for magnetic separation consisting of a furnace, and means for feeding ore through said furnace and subjecting it therein to the action of fire combined with means for creating and maintaining said fire outside of said furnace, said means also including means for admitting a predetermined amount of air into the furnace, whereby oxidation of the contents of the latter is materially restricted.

4. In an apparatus for treating ore in preparation for magnetic separation, the combination of an unlined metallic furnace, a source of heat created outside of said furnace, and means for projecting heat therefrom into said furnace and for controlling the supply of air to said furnace.

5. A furnace for treating ore preparatory to the magnetic separation thereof consisting of a rotatable furnace, combined with a burner located outside of said furnace, and means for blowing the flame of said burner into said furnace and for admitting a predetermined amount of air to the furnace, whereby oxidation of the contents of the latter is materially restricted.

6. In an apparatus for treating ore in preparation for magnetic separation, the combination of an unlined metallic furnace, a source of heat created outside of said furnace and independent of the natural draft therethrough, and means for projecting heat into said furnace from said source of heat.

7. In an apparatus for treating ore in preparation for magnetic separation, the combination of an unlined metallic furnace, a source of heat created outside of said furnace and independent of the natural draft therethrough, means for projecting heat into said furnace from said source of heat, and means for cooling the walls of said furnace.

8. In an apparatus for treating ore in preparation for magnetic separation, the combination of an unlined metallic furnace, means for projecting a flame into said furnace produced by a burner located outside of the same and for admitting a predetermined amount of air to the furnace, and means for causing a circulation of air over the exterior surface of the furnace to cool the latter.

9. In an apparatus for treating ore in preparation for magnetic separation, the combination of a furnace, means for feeding the ore through the same, means for projecting a blast of heat into said furnace, and subjecting the ore to the action of the same, and a hood covering said furnace and separated from the same by a slight space, with means for artifically circulating air through said space.

10. In an apparatus for treating ore in preparation for magnetic separation, a furnace consisting of a cylindrical shell, combined with circular heads detachably connected together by longitudinal rods extending through the heads.

11. In an apparatus for treating ore in preparation for magnetic separation, a furnace consisting of a cylindrical shell, combined with circular heads detachably connected together by longitudinal rods extend-

ing through the heads, combined with means for projecting a non-oxidizing flame into said furnace, and means for causing a circulation of air over the exterior surface of the furnace to cool the latter.

12. In an apparatus for treating ore in preparation for magnetic separation, a furnace consisting of a cylindrical shell and circular heads detachably connected together by longitudinal rods extending through said heads, combined with means for projecting a blast of heat into said furnace and for admitting a predetermined amount of air to the furnace, and means for cooling said furnace.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses, this 28th day of December, 1910.

JAMES B. ETHERINGTON.

Witnesses:

HAROLD C. HASKELL,

ELMER L. BRIGGS.