E. FINK.

SMELTING APPARATUS.

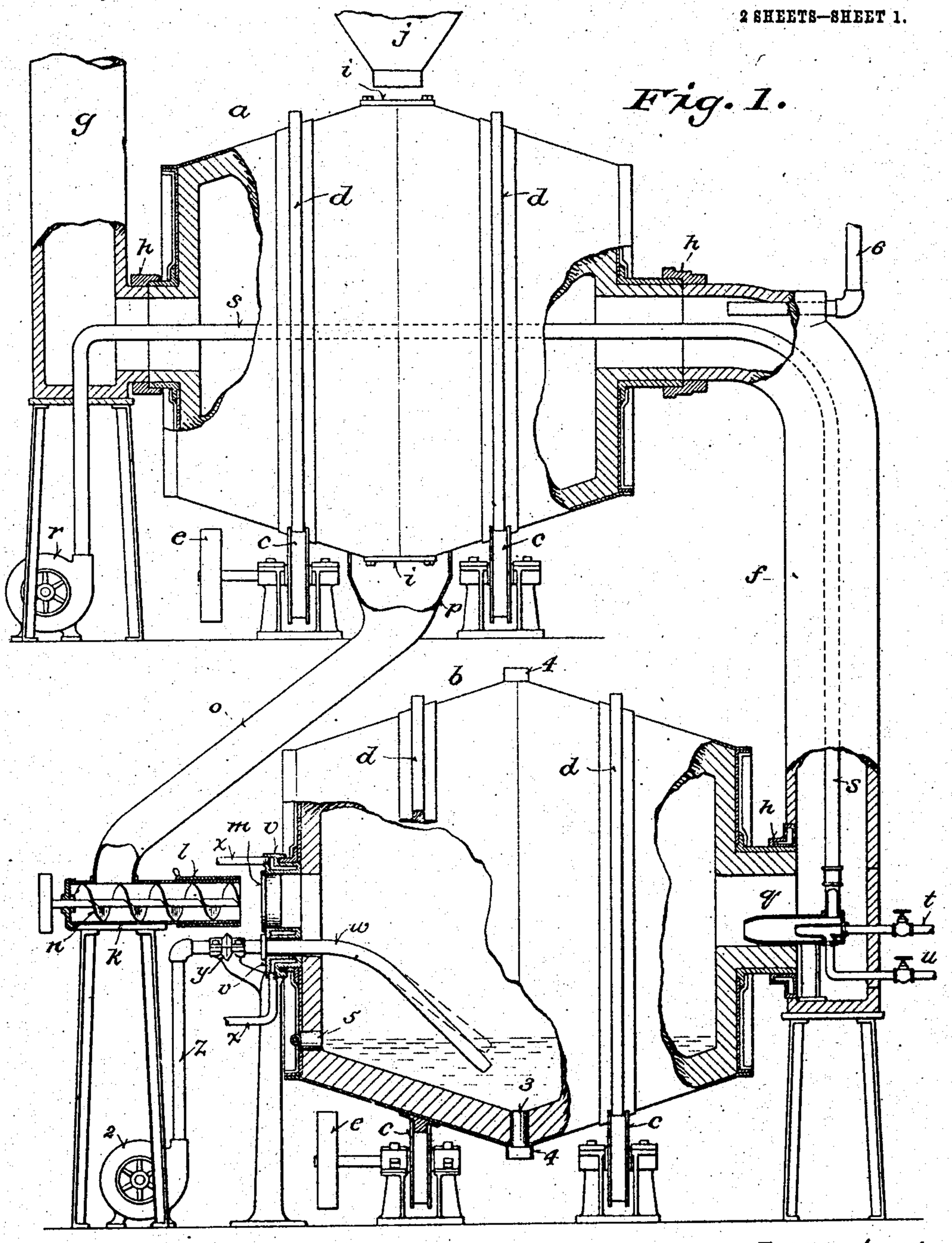
APPLICATION FILED MAR. 28, 1908.

948,468.

Patented Feb. 8, 1910.

2 SHEETS—SHEET 1.

Fig. 1.



Witnesses:

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2 SHEETS—SHEET 2.

Fig. 3.

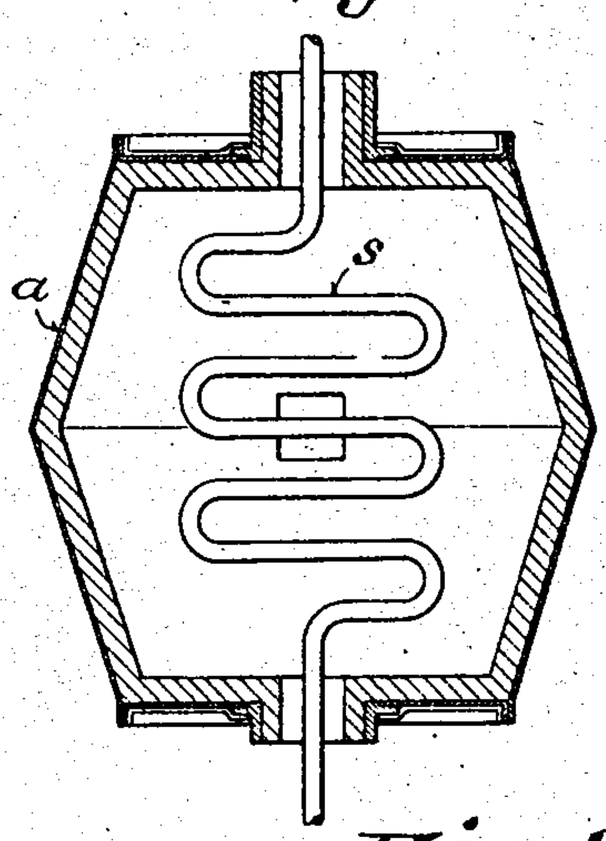

Fig. 2.

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UNITED STATES PATENT OFFICE.

EDWARD FINK, OF MILWAUKEE, WISCONSIN.

SMELTING APPARATUS.

948,468. Specification of Letters Patent. Patented Feb. 8, 1910.

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To all whom it may concern:

Be it known that I, EDWARD FINK, a citizen of the United States, residing at Milwaukee, in the county of Milwaukee and State of Wisconsin, have invented certain new and useful Improvements in Smelting Apparatus, of which the following is a specification, reference being had to the accompanying drawing, forming a part thereof.

This invention relates more particularly to apparatus for smelting and converting or refining ores and mattes. Its main objects are to facilitate and reduce the cost of smelting and converting or refining ores, mattes and the like; to bring within the scope of such operations ores and other products which it has hitherto been found impracticable to directly subject thereto or which it has been necessary to prepare therefor by separate and costly processes or other treatment; and generally to improve the construction and operation of apparatus of this class.

The invention consists in certain novel features of construction and in the peculiar arrangement and combinations of parts of which the apparatus is composed.

In the accompanying drawing like characters designate the same parts in the several figures.

Figure 1 is a side elevation of the apparatus embodying the invention, certain parts being broken away and shown in vertical section; Fig. 2 is an end elevation of the apparatus and partial vertical cross section; and Fig. 3 is a central horizontal section on the line 3 3, Fig. 2, of the heating barrel.

For the treatment of certain ores, such as carbonate or oxid ores, pyritiferous ores containing copper, and sulfid ores, which may be gently roasted without forming sticky masses, the apparatus comprises a rotary heating barrel *a*, and a rotary smelting barrel *b*, which are arranged one above the other with their axes horizontal or substantially so. These barrels may be formed of boiler plate or heavy sheet metal lined with fire brick or clay or suitable refractory material to protect the metal shells or casings. They may be and are preferably made of substantially the same form and size, and are each mounted upon supporting wheels or rollers *c* so as to turn around their horizontal axes, the wheels or rollers being preferably flanged or grooved and the barrels provided with annular rails *d* fitting between the flanges or into the grooves of said wheels or rollers. One or more of the supporting wheels *c* associated with each barrel is provided with a pulley *e* or other driving connection for rotating the barrel. Each barrel has the approximate shape of two conical or pyramidal frustums joined base to base, the side walls inclining or sloping outwardly or away from the axes toward their junction at the center of the barrel and forming a continuous internal trough. The ends of the barrels are formed with central openings and provided around such openings with outwardly projecting flanges or rims. The opening in one end of the barrel *a* is connected by a flue *f* with the opening in one end of the barrel *b*, and the opening in the opposite end of the barrel *a* communicates with a chimney or escape flue *g*, the joints between the stationary flues and the rotating flanges or rims on the ends of the barrels being closed by sleeves or collars *h*.

The barrel *a* is formed at the junction of its inclined side walls with charging and discharging openings and provided with suitable closures *i* therefor. A hopper *j* for charging the barrel *a* is arranged above it so as to register with said openings. A stationary feed tube *k* arranged in line with the charging opening in the end of barrel *b* opposite the flue *f*, has a movable sleeve or sliding extension *l* adapted to be projected into and withdrawn from said opening, which is provided with a removable closure *m*. A spiral conveyer *n* is rotatably mounted in the tube *k* and adapted to feed the material supplied thereto into the barrel. A tubular conduit or chute *o* terminating at its upper end in a hopper *p* on the under side of the barrel *a* in position to register with the peripheral openings therein, leads downwardly therefrom into the tube *k*. A twyer or burner nozzle *q* directed from the flue *f* into the barrel *b* through the exit opening therefrom, is connected with a blower *r* by a pipe *s* passing lengthwise through the flue *f* and through the barrel *a*, where it is coiled or bent back and forth, as shown in Fig. 3, to present an extended heat absorbing surface in said barrel. An oil or fuel supply pipe *t* provided with a regulating valve, and a steam supply pipe *u* also provided with a regulating valve, are connected with the nozzle *q*, as shown in Fig. 1.

When the apparatus is to be used for con-

verting or refining operations, a stationary hollow or chambered ring or plate *v* is fitted into the feed opening in barrel *b*. In this ring or plate one or more twyers *w* is removably and adjustably fitted, the ring or plate having water circulating connections *x* for keeping it cool. The outer end of each twyer is supported and capable of being turned in a coupling *y* by which it is detachably connected with the blast or discharge pipe *z* of a blower 2. At its inner end each twyer is curved or bent downwardly terminating in the upper part of the trough on the lower side of the barrel, so that by turning the twyer in the ring or plate *v* and coupling *y* it may be adjusted as indicated by dotted lines on Fig. 1, to vary the level of the discharge orifice at its inner end with relation to the surface of the molten material held in the trough in the lower part of the barrel.

The barrel *b* is formed at the junction of its inclined side walls with a number of tap holes which are closed by plugs 3 of clay or other refractory material, and the shell is provided on one side of each of these tap holes, with a pouring lip or spout 4. At the junction of one of the end and inclined side walls adjacent to its charging opening the barrel *b* is also formed with tap holes which are provided with plugs or closures 5 of refractory material. A pipe connection 6 leads into the upper end of the flue *f* for supplying air to the barrel *a* whenever it may be desired.

In smelting ores of the kind hereinbefore mentioned, the apparatus operates as follows: Both barrels being charged with pulverized ore and the requisite flux, are rotated, the peripheral openings in the barrel *a* and the tap holes in the barrel *b* being closed, the twyer *w* being removed from the barrel *b*, and the opening therefor, as well as the adjacent charging opening, being closed. By the rotation of the barrels the ore and flux are thoroughly mixed and agitated, so that different portions thereof are exposed most effectively to the action of the hot blast in the smelting barrel and to the effect of the products of combustion issuing therefrom and passing through the heating barrel. Fuel and air being supplied to the burner nozzle *q*, the flame thus produced is projected into the barrel *b* over the charge of ore in the lower part thereof, and the hot gases and products of combustion escaping from barrel *b* into the flue *f*, are conducted into the barrel *a* through which they pass over the charge of ore therein into the chimney or flue *g*. The ore in the barrel *a* is thus gradually heated, and if it contains considerable sulfur this is ignited, and the ore begins to roast, air being supplied thereto if necessary or desirable through the connection 6. The air passing through the pipe *s* is heated by the hot gases to which it is exposed in the barrel *a* and flue *f*, so that a hot blast is supplied to the burner, thus materially aiding and accelerating the smelting of the charge in barrel *b* and effecting an appreciable saving of fuel.

By the rotation of barrel *b* the larger and heavier particles of ore which require a longer time to melt, work downward toward the center of the barrel and collect in the lower part of the trough on the under side of the barrel, while the smaller and lighter particles collect on the surface of the charge. These smaller particles having a greater surface exposed to the flame of the barrel, are more easily melted, and when melted the hot liquid flows down over and submerges the larger particles which collect at the bottom of the trough, thereby hastening the fusion of these particles. The molten globules of metal or matte and slag are thus separated from the unfused particles of ore, and collect in the lower part of the trough, where a separation of the heavier molten metal and matte from the slag is also constantly taking place. Fresh particles of ore are constantly brought by the rotation of the barrel under and subject to the action of the flame, which plays over the charge and returns with the heated gases and products of combustion through the upper part of the barrel into the flue *f*, the heat being reflected from the inclined walls on the upper side of the barrel toward the center of the barrel and concentrated upon the charge below, and the wall of the barrel highly heated by the return flame from the burner and the hot products of combustion being carried by the rotation of the barrel into contact with the charge below and transferring its heat thereto, thus aiding and expediting the smelting operation. As soon as the charge in barrel *b* is melted, the slag, constituting the greater part of the molten mass, and separated from and covering the matte or metal which settles in and occupies the V-shaped trough below the end walls of the barrel, is rapidly drawn off through the end tap hole which is turned into position for the purpose and is located above the matte or metal level. After the greater part of the slag has been thus disposed of, what remains is poured from the trough through one of the peripheral tap holes which is brought to the level of the molten mass, the barrel being turned so as to carry the hole slowly downward. When the slag has been removed the matte or metal is poured through the same peripheral tap hole into molds or other receptacles, or it may be retained in the barrel and subsequently converted or refined therein as hereinafter explained. The tap holes being again closed, the closure *m* is removed from the feed opening and the sleeve *l* is moved into said opening. The closures *i* are now re-

moved and the barrel *a* is rotated, discharging its contents through the openings therein into the hopper *p* at the upper end of the chute or conduit *o* through which it flows freely and is carried by gravity into the tube *k*. From the tube *k* it is fed into the barrel *b* by the spiral conveyer *n*. As soon as the smelting barrel has thus been recharged, the sleeve *l* is withdrawn, and the closure *m* is replaced over the feed opening. One of the openings of barrel *a* being closed, another charge of ore is introduced from the hopper *j* through the opposite opening, which is then closed. The apparatus is now ready for another melt, and the operations hereinbefore explained are repeated.

For converting or refining operations, as for example, converting matte, produced from copper ores containing considerable sulfur, into an enriched matte or blister copper, one or more twyers *w* are introduced into the barrel *b* through the opening or openings provided therefor in the plate or ring *v* and are connected with the blast pipe *z* of the blower 2. Each twyer is turned or adjusted so that its inner end will project slightly below the surface of the molten matte contained in the trough in the lower part of the barrel. Air is now forced through the twyer or twyers, the barrel is rotated, and a strong oxidizing flame is projected from the nozzle *q* over the matte. To simply blow air alone over the molten matte has little or no effect, but a strongly oxidizing flame, produced by supplying an excess of air to the burner nozzle, materially hastens the refining operation.

The air introduced through the twyer or twyers *w* below the surface of the charge causes the sulfur contained in the matte to burn and liberates oxid of iron, which attacks the lining of ordinary converters and forms slag. To prevent this and to preserve the lining of the smelting barrel, pulverized silica or silicious ore is fed into the barrel through the feed tube *k* by the spiral conveyer *n*. The silica or silicious ore which is supplied to the charge adjacent to the introduction of the air blast through the twyer or twyers *w* where the sulfur is being burned and oxid of iron liberated, is immediately mixed with the matte by the rotation of the barrel and the consequent agitation of the charge, and united with the liberated oxid of iron, thereby forming slag and preventing the oxid of iron from attacking the lining. The enriched matte or blister copper being heavier than the unrefined matte, collects in the lower part of the trough on the under side of the barrel, where it is protected against further action of the hot blast by the unrefined matte and slag which float on the surface.

It is advisable to remove the slag from time to time, which can be done without interfering with the blowing operation, as the converting or refining operation is facilitated and expedited when the surface of the molten matte is comparatively free from slag, which tends to obstruct or interfere with the action of the twyer or twyers *w*, and if allowed to remain would necessitate a stronger air blast.

The nozzle *q* and its air blast and fuel supply connections avoid danger of the freezing or congealing of the charge, since it may be maintained at the desired temperature by the introduction of additional fuel so that it is practicable with the apparatus herein shown and described to refine small charges which it would be impossible to successfully treat in ordinary converters. In case a charge is overblown so as to produce copper oxid, this can be readily converted into metal by increasing the supply of fuel and thus producing a strong reducing flame, or by the direct addition of carbonaceous matter to the charge.

It rarely occurs that sufficient matte is obtained from one smelting operation to warrant concentration in the manner above described, so that it is advisable to remove only the slag after the first smelting operation or operations, and to allow the matte from two or more charges to accumulate in the barrel *b* before the converting or refining operation is undertaken.

For the treatment of some ores, such as antimony, sulfid, certain bismuth ores, galena, etc., which melt easily and tend when heated to form sticky masses, the heating barrel *a* may be dispensed with and such ores introduced directly into the barrel *b*, the air supply to the burner nozzle *q* being heated by the waste products of combustion escaping through the flue *f*.

The construction of the smelting barrel *b* with inclined or sloping side walls as shown and described, so as to form a V-shaped trough on the under side of the barrel, besides affording strength and rigidity, facilitates the separation of the larger and heavier particles from the smaller and lighter particles of the ore, hastens the smelting operation, facilitates the separation of the fused from the unfused portion of the charge, facilitates tapping and drawing off the slag and the matte or metal, and concentrates the heat from the flame and products of combustion to the best advantage upon the charge. The corresponding shape of the heating barrel *a* also affords strength facilitates the discharge of the contents of the barrel through the peripheral openings therein and concentrates the heat upon the charge.

The arrangement of the heating barrel *a* above the smelting barrel *b* and their connections as hereinbefore described, admit of utilizing the products of combustion from

the smelting barrel to roast or heat the contents of the upper barrel preparatory to smelting the same in the lower barrel and to incidentally heat the supply of air to the burner by which the charge in the lower barrel is fused, and facilitates the transfer of material from the upper into the lower barrel.

Various changes and modifications in details of construction and arrangement of parts may be made without departing from the principle and scope of the invention. By the term "rotary" as herein employed, it is intended to include rotation alternately in opposite directions, or a rocking or oscillating movement, as well as continuous rotation in one direction.

I claim:

1. The combination with a rotary barrel, of an independently supported flue in communication therewith for conducting the products of combustion therefrom, and means adapted to feed fuel into said barrel in a direction opposite to the flow of the products of combustion from said barrel in order to heat the charge contained therein and the wall of the barrel above the charge.

2. The combination with a rotary barrel, of an independently supported flue communicating therewith for conducting the products of combustion therefrom, and an independently supported nozzle adapted to direct fuel into said barrel opposite to the direction of flow of the products of combustion from the barrel in order to heat the charge contained therein and the wall of the barrel above the charge.

3. In smelting apparatus, a rotary barrel arranged with its axis approximately horizontal and having side walls inclining away from the axis toward the center and forming an internal trough around the barrel, and a tap hole adjacent to the junction of an end and side wall, substantially as described.

4. In smelting apparatus, a rotary barrel arranged with its axis approximately horizontal and having side walls inclining away from the axis toward the center and forming an internal trough around the barrel, and tap holes at the junction of the inclined side walls and at the junction of a side and end wall, substantially as described.

5. In smelting apparatus, the combination of a rotary barrel arranged with its axis approximately horizontal and having a central opening in one end, an escape flue communicating with said opening, an air supply pipe running through said flue and opening into said barrel, and means for forcing air through said pipe, substantially as described.

6. The combination with a rotary barrel having a central opening in one end, an escape flue communicating with said barrel through said opening, a nozzle arranged to inject fuel into the barrel in a direction opposite to the flow of the products of combustion therefrom, and a supply conduit leading to said nozzle and exposed to the heat of the products of combustion escaping through said flue.

7. In smelting apparatus, the combination of a rotary barrel having an approximately horizontal axis and an opening in one end, an escape flue for the products of combustion communicating with the interior of the barrel through said opening, a nozzle directed into the barrel through said opening, an air supply pipe running through said flue and connected with said nozzle, and a fuel supply pipe connected with said nozzle, substantially as described.

8. In smelting apparatus, the combination of a rotary barrel having an approximately horizontal axis and central openings in the ends, an escape flue communicating through one of said openings with the interior of the barrel, a nozzle directed into the barrel through the same opening, an air supply pipe running through said flue and connected with said nozzle, a fuel supply pipe connected with said nozzle, and a removable closure for the opening in the other end of the barrel, substantially as described.

9. In smelting apparatus, the combination of a rotary barrel having an approximately horizontal axis, a central opening in one end and side walls inclined outwardly from the ends toward the center and forming an internal trough around the barrel, an escape flue communicating through said opening with the interior of the barrel, a nozzle directed into the barrel through said opening, an air supply pipe running through said flue and connected with said nozzle, and a fuel supply pipe connected with said nozzle, substantially as described.

10. In smelting apparatus, the combination of a rotary barrel having an approximately horizontal axis, central openings in the ends and side walls inclined outwardly from the ends toward the center and forming an internal trough around the barrel, an escape flue for products of combustion communicating through one of said openings with the interior of the barrel, a nozzle directed through the same opening into the interior of the barrel, an air supply pipe passing through said flue and connected with said nozzle, a fuel supply pipe connected with said nozzle, means for feeding material to be treated into the barrel through the other end opening, and a removable closure for said opening, substantially as described.

11. In smelting apparatus, the combination of a rotary barrel having an approximately horizontal axis, central openings in the ends and side walls inclining outwardly from the ends toward the center and forming an internal trough around the barrel,

an escape flue communicating with the interior of the barrel through one of said openings, a nozzle directed into the barrel through the same opening, an air supply pipe passing through said flue and connected with said nozzle, a fuel supply pipe connected with said nozzle, a horizontal feed tube arranged in line with the other opening and provided with a sliding extension adapted to be projected into and withdrawn from said opening, a removable closure for said opening, and a spiral conveyer rotatably mounted in said tube, substantially as described.

12. In smelting apparatus, the combination of a rotary barrel having an approximately horizontal axis, central openings in the ends and side walls inclined outwardly from the ends toward the center and forming an internal trough around the barrel, an escape flue communicating with the interior of the barrel through one of said openings, a nozzle directed into the barrel through the same opening, air and fuel supply pipes connected with said nozzle, a stationary ring or plate fitting into the opening in the other end of the barrel and having an opening provided with a removable closure for the introduction of material into the barrel, a twyer passing through said ring or plate and directed downwardly at its inner end, and means for forcing air through said twyer, substantially as described.

13. In smelting apparatus, the combination of a rotary barrel having an approximately horizontal axis, central openings in the ends and side walls inclined outwardly from the ends toward the center and forming an internal trough around the barrel, an escape flue communicating through one of said openings with the interior of the barrel, a nozzle directed through the same opening into the barrel, air and fuel supply pipes connected with said nozzle, a stationary ring or plate fitting into the opening in the other end of the barrel and having an opening provided with a removable closure for introducing material into the barrel, a twyer removably fitted in said ring or plate and directed downwardly at its inner end, and a detachable air supply connection for said twyer, substantially as described.

14. In smelting apparatus, the combination of a rotary barrel having an approximately horizontal axis. openings in the ends and side walls inclined outwardly from the ends toward the center and forming an internal trough around the barrel, an escape flue communicating with the interior of the barrel through one of said openings, a nozzle directed into the barrel through the same opening, air and fuel supply pipes connected with said nozzle, a stationary ring or plate fitting into the opening in the other end of the barrel and having an opening provided with a removable closure for the introduction of material into the barrel, a curved twyer passing through said ring or plate and capable of being turned therein so as to vary the elevation of its inner end, and means for forcing air through said twyer, substantially as described.

15. In smelting apparatus, the combination of rotary heating and smelting barrels arranged one above the other and having openings in the ends, a flue connecting said barrels through the openings at one end thereof, an escape flue with which the other end opening of the heating barrel communicates, a nozzle directed into the smelting barrel through the escape opening in one end thereof, an air supply pipe passing through the heating barrel and the flue connecting it with the other barrel to said nozzle, and means for discharging the contents of the heating barrel into the smelting barrel, substantially as described.

16. The combination of rotary heating and smelting barrels, a flue connecting said barrels at one end thereof, an escape flue communicating with the other end of the heating barrel, a burner nozzle directed into the smelting barrel through the opening with which said connecting flue communicates, and means for conveying the contents of the heating barrel into the smelting barrel.

17. In smelting apparatus, the combination of rotary heating and smelting barrels arranged one above the other and having openings in the ends and side walls inclined outwardly from the ends toward the center, a flue connecting said barrels through the openings in one end thereof, an escape flue with which the opening in the other end of the heating barrel communicates, a nozzle directed into the smelting barrel through the exit opening in one end thereof, an air supply pipe passing through the heating barrel and the flue connecting it with the smelting barrel to said nozzle, means for forcing air through said pipe, a fuel supply pipe connected with said nozzle, a spiral conveyer arranged to feed material into the smelting barrel through the opening in the opposite end thereof, and a chute leading from the heating barrel into said conveyer, substantially as described.

18. In smelting apparatus, the combination of rotary heating and smelting barrels arranged one above the other with their axes horizontal and having openings in their ends, the smelting barrel having side walls inclined outwardly from the ends toward the center and forming an internal trough around the barrel, and a tap hole in the deeper part of the trough, and the heating barrel having a charging and discharging opening, a flue connecting said barrels through the openings in one end thereof, an

escape flue with which the other end opening of the heating barrel communicates, a nozzle directed into the smelting barrel through the exit opening therefrom into said flue, an air supply pipe passing through the heating barrel and the flue connecting it with the smelting barrel and connected with said nozzle, means for forcing air through said pipe, means for supplying fuel to said nozzle, a spiral conveyer movable into and out of the opening in the other end of the smelting barrel, a closure for said opening, and a conduit leading from the heating barrel into said conveyer, substantially as described.

19. In smelting apparatus, the combination of a rotary barrel having an approximately horizontal axis and central openings in the ends, an escape flue communicating with the interior of the barrel through one of said openings, a nozzle directed into the barrel through the same opening, an air supply pipe connected with said nozzle, a stationary ring or plate fitted into the opening in the other end of the barrel and having an opening provided with a removable closure for the introduction of material into the barrel, a twyer passing through said ring or plate and directed downwardly at its inner end into the lower part of the barrel, and means for forcing air through said twyer, substantially as described.

20. The combination of a rotary barrel having a central opening in one end and side walls inclining away from its axis toward the middle of the barrel and forming an internal trough around it, an escape flue communicating with said barrel through said opening and a burner arranged to project its flame into said barrel in a direction opposite to the floor of the products of combustion therefrom into said flue.

21. The combination of a rotary barrel having a central end opening and side walls inclining away from its axis toward the middle of the barrel and forming an internal trough around it, an escape flue communicating with said barrel through said opening, a burner arranged to project its flame into the barrel in a direction opposite to the flow of the products of combustion therefrom into said flue, and means for feeding material into the barrel through one end thereof while it is in motion.

22. The combination of a rotary barrel having an end opening, a twyer arranged to direct a refining agent into the charge contained in the barrel while it is in motion, and means for simultaneously feeding solid material into the barrel while it is in motion through said end opening.

23. The combination of a rotary barrel having an end opening, an escape flue communicating with said barrel through said opening, a burner adapted to project fuel into the barrel in a direction opposite to the flow of the products of combustion from the barrel into said flue, and a twyer adapted to discharge into the material contained in the barrel while it is in motion.

24. The combination of a rotary barrel, having an end opening, an escape flue communicating with said barrel through said opening, a burner directed into said barrel through said opening, a twyer adapted to direct a refining agent into the charge contained in the barrel while it is in motion, and means for feeding solid material into the charge while the barrel is in motion.

In witness whereof I hereto affix my signature in presence of two witnesses.

EDWARD FINK.

Witnesses:
CHAS. L. GOSS,
ALICE E. GOSS.