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PATENTED APR. 28, 1908.

R. BAGGALEY, C. M. ALLEN & E. W. LINDQUIST.
SMELTING CONVERTER AND FOREHEARTH.

APPLICATION FILED APR. 3, 1905.

4 SHEETS—SHEET 1.

Fig. 6.

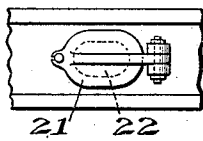
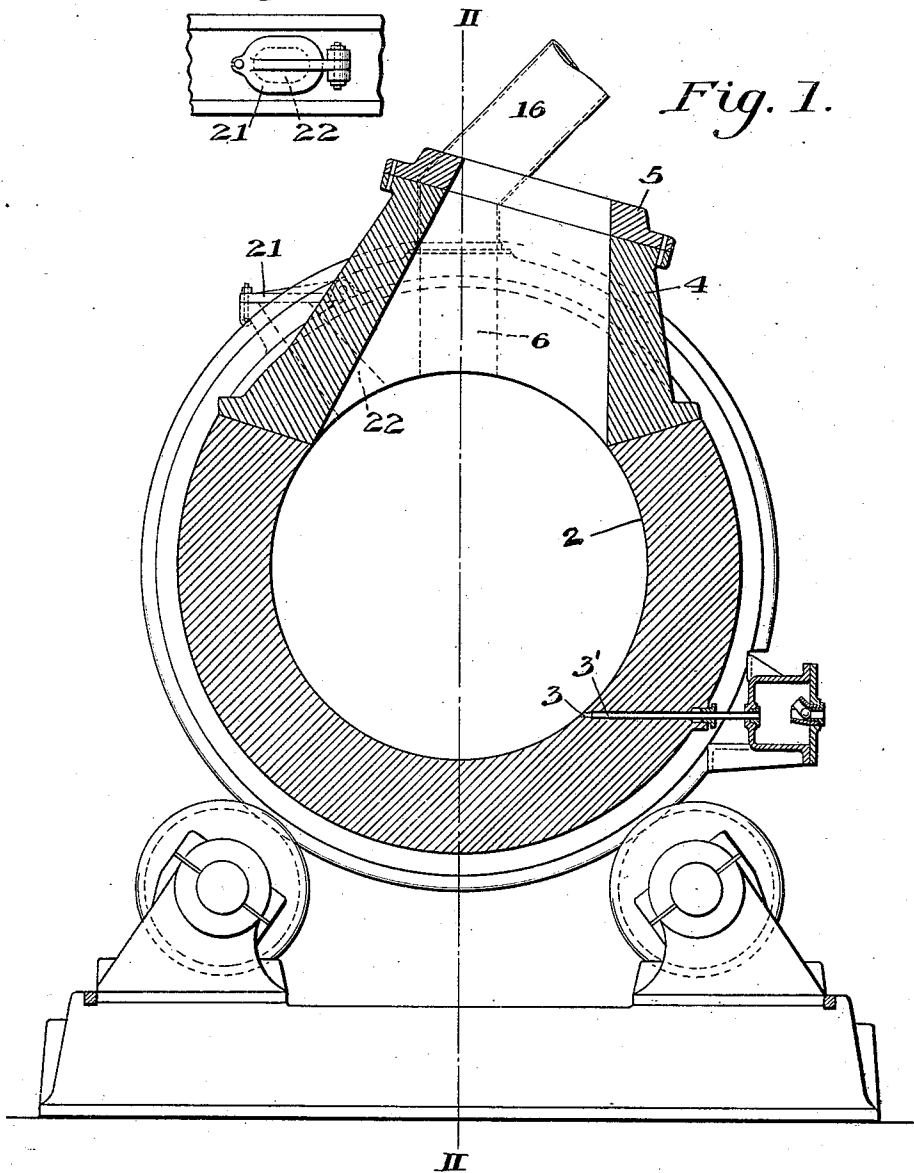


Fig. 1.



WITNESSES

Warren W. Swartz
H. M. Corwin

INVENTORS

Ralph Baggageley
Charles M. Allen
Edward W. Lindquist
by Baxendell & Byrnes, Attorneys

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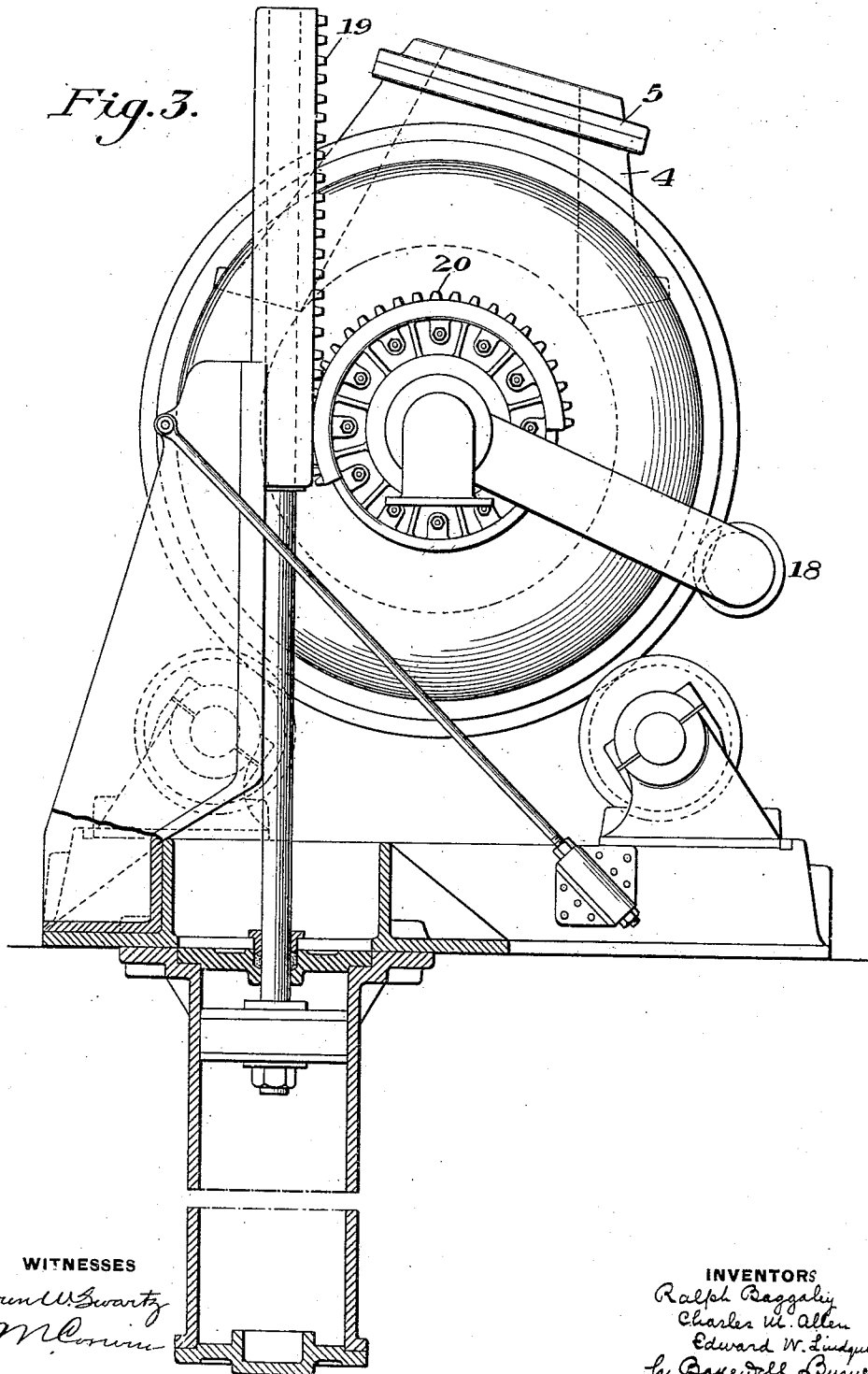
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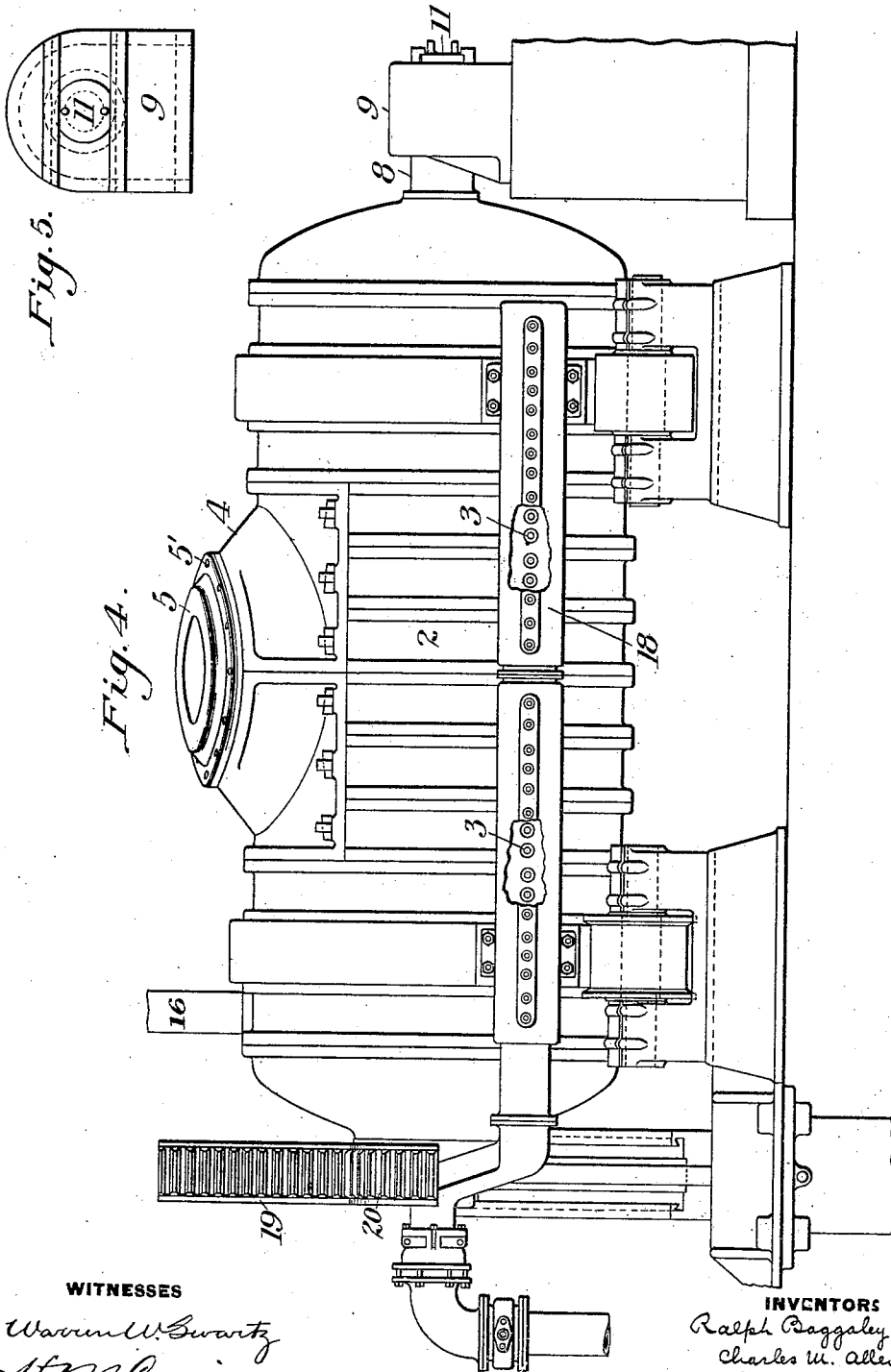


Fig. 5.

Fig. 4.

WITNESSES

Warren W. Swartz
A. M. Conner

INVENTORS

Ralph Baggageley
Charles W. Allen
Edward W. Lindquist
by *Boxwell & Barnes*
attorneys

UNITED STATES PATENT OFFICE.

RALPH BAGGALEY, OF PITTSBURG, PENNSYLVANIA, CHARLES M. ALLEN, OF LO LO, MONTANA, AND EDWARD WILLIAM LINDQUIST, OF CHICAGO, ILLINOIS; SAID ALLEN AND LINDQUIST ASSIGNORS TO SAID BAGGALEY.

SMELTING CONVERTER AND FOREHEARTH.

No. 886,030.

Specification of Letters Patent.

Patented April 28, 1908.

Application filed April 3, 1905. Serial No. 253,548.

To all whom it may concern:

Be it known that we, RALPH BAGGALEY, of Pittsburg, Allegheny county, Pennsylvania; CHARLES M. ALLEN, of Lo Lo, Missoula county, Montana, and EDWARD W. LINDQUIST, of Chicago, Cook county, Illinois, have invented a new and useful Smelting Converter and Forehearth, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part of this specification, in which—

Figure 1 represents a cross-section of our smelting converter on the line I—I of Fig. 2; Fig. 2 represents a longitudinal cross-section on the line II—II of Fig. 1, together with the blast-pipe inlet; hydraulic power-mechanism for tilting the vessel; the overflow-spout for the continuous discharge of slag and matte; the practically air-tight protecting cover for the slag and matte during their fall into the forehearth and a portion of the forehearth itself; Fig. 3 represents an end elevation of our smelting converter, with the hydraulic power-mechanism in section; Fig. 4 represents a side elevation of our smelting converter, showing the air-inlet; wind-box and converting twyers; as well as the slag and matte protected overflow and a portion of the forehearth and Fig. 5 illustrates the rolling metal door through which the overflow-spout may from time to time be examined and if necessary rodded by the operator. Fig. 6 represents in plan view, the heavy bolted door or lid covering the orifice in the vessel through which converter slag is delivered in molten form for the purpose of extracting the contained mineral values.

The object of our invention may be briefly stated as follows:

1st.—To provide apparatus in which a primary bath may be produced with great economy with which to practice the art disclosed in the new method of recovering values from ores by dissolving in a molten bath, described in United States Patent No. 766,654, issued August 2nd, 1904.

2nd.—To provide apparatus for the purpose stated, that will absorb and conserve the heat produced by the converting process.

3rd.—To provide apparatus that may be continuously operated, practically without repairs and without relining.

4th.—To provide apparatus that will enable one to conduct a continuous method of smelting on lines that will utilize for fuel purposes the volatile portion of sulfid ores which is now lost in all present forms of smelting.

5th.—To provide apparatus in which the smelting of ores may be conducted without the use of a blast furnace, with its heavy consumption of coke or other carbonaceous fuel and its heavy expenses for labor and for repairs.

6th.—To provide apparatus that will admit of the equivalent of what is popularly called "pyritic smelting" being conducted without the use of a hot blast that has been preheated with expensive carbonaceous fuel.

7th.—To provide apparatus that renders unnecessary, all present methods of treating copper; gold and silver ores by the expensive processes included under the head of "Water concentration" with their unavoidable mineral losses that vary from 20 per cent. as a minimum up to 40 per cent., or even more.

To that end, we preferably utilize apparatus such as that illustrated in the drawings; although apparatus of other construction; such for instance as water or air-jacketed apparatus may be utilized, without departing from the spirit of our invention.

There is probably as much latent heat lying unused in the earth's crust, in the form of sulfids; arsenids; antimonids and many other oxidizable elements and compounds, as are contained in the coal measures; or at least there is ample fuel thus lying dead and unused with which to refine all of the ores and metals that can be used in the arts. Many ores contain within themselves enough such fuel, if properly utilized, to effect the desired separation by fusion. The reason these latent fuels are not utilized is because past experimenters have made the fatal mistake of attempting to do this work in shaft furnaces. This inevitably results in the volatilization and the consequent escape and loss of one-half of the fuel values contained in the ores, before the zone of actual fusion in such shaft furnace has been reached.

The only possible method thus far discovered of catching, so that it cannot escape and of utilizing the volatile portion of all sulfids; arsenids; antimonids; &c., is by dis-

solving them in a molten bath; that is to say by bringing them directly into the fusion zone, before the volatile atom has been lost by distillation; as disclosed in United States Patent No. 766,654, hereinbefore referred to. If these natural fuels contained in the ores themselves be utilized intelligently and economically through a judicious and common sense assembling of one class of ores with another, we have proven in our work that their fuel-values are ample with which to refine such ores of both classes. Two classes of ores are naturally adapted to be treated together; because while the one class furnishes the requisite fuel with which to refine the other class, the silicious ores furnish the flux with which alone the iron of the other class may be separated for removal to the dump.

It is illogical and wasteful to wash out; to heap roast; to calcine and thus to lose the fuel-values, to the utmost possible extent, contained in all ores and thereafter to purchase coke with which to conduct the subsequent smelting treatment of these same ores. It is also wasteful to follow the present practice of crushing and of washing out the silica contained in ores and by this process to lose from twenty to thirty-five per centum of the contained mineral values and thereafter to purchase and to crush and to ram into converter linings, barren silica to take the place of that which has already been crushed and washed out of these ores, at a heavy expense and with great mineral losses. Yet this is the universal practice that exists to-day in the treatment of ores.

Our invention enables us to utilize the vast bodies of sulfid mineral-bearing ores that exist say, in the Bingham Canon or Tintic districts, in Utah as the requisite fuel with which to smelt the enormous deposits of highly silicious, rich ores of the Butte, Montana district and at the same time to utilize the rich, silicious ores of the Butte district with which to flux the iron from the sulfid ores of the Utah district; instead of utilizing barren quartz for the purpose. Smelting operations can be conducted on an enormous scale simultaneously at a suitable point in Utah and at a suitable point in Montana. Solid trains of ore cars can carry sulfid ores from Utah to Butte and on the return trip, Butte silicious ores can be carried to the smelting plant in Utah, thus providing ideal conditions for minimum transportation costs.

John Holway seems to have appreciated the fact that success should be sought in the converter and not in the blast furnace; although he failed of success. His experiments in this field were conducted in the years 1878 and 1879, in England, with Rio Tinto sulfid ores. He used for the purpose, an ordinary steel converter with the twyers located in the bottom; whereas it has been found that an operative Bessemer converter

for the treatment of copper matte demands that the twyers be located on the side and not in the bottom.

Referring now to the drawings:—2 in Fig. 1 represents the solid metal segment of a circle; preferably eighteen inches in thickness, of which the converter is preferably constructed. We prefer to use copper; steel; wrought iron or cast iron for this purpose; but other metals may be used.

3 illustrates a twyer hole for the entrance of the converting blast. It is preferably lined with seamless brass tubing 3', in order that this may be readily and cheaply replaced when worn, through the action of the punching bars. This converter is shown with bare metal walls; because we have found that these are sufficient to withstand the service. The interior may be supplemented with a refractory lining, if preferred, without departing from the spirit of my invention.

4 represents the removable top of the vessel, which is preferably made of heavy, solid metal; of sufficient thickness to successfully withstand the heat.

5 represents the reversible, heavy metal ring with which the top of the vessel is provided. The bolts or cap screws with their corresponding holes 5' that hold this ring in position, are made to register accurately in order that the ring may be placed in many different positions in order to withstand the cutting effect of the molten metal or matte without renewal.

6 in Figs. 1 and 2 illustrates the charging door or inlet for ores and 16 in Figs. 1; 2 and 4, the charging hopper that connects with it.

In starting the process, a bath of molten matte; preferably derived from the simple melting of sulfid ores is provided from any desired source. It may be melted within the vessel itself; but we prefer to provide the first bath with which the process is started from an outside source; because in this way we deliver into the vessel only a bath of matte that is free from silicious or aluminous slags and that is entirely free from the remnants of carbonaceous fuel such as coke. Our experience has shown that coke is a very objectionable obstruction, because it becomes enveloped in a nonconducting coating of slag, so that in this form it is absolutely infusible. After the first bath of matte has been charged into the vessel; which preferably is a bath as above stated derived from a simple melting of sulfid ores and which as a consequence contains heavy percentages of sulfur; iron and other oxidizable elements and compounds; the converting blast is turned on and this has the effect of producing great heat within the interior of the vessel. The escape of hot gases in this vessel will be choked and for this reason the internal heat is retained to a great extent. This has the effect of mate-

rially aiding the process. Our work indicates that this method of smelting ores cannot be successfully practiced in an open-top vessel, where the hot gases are permitted to freely escape into the stack.

Ore charges may be continually or intermittently fed into the hopper at 16 and into the converter through the orifice 6. Such ore charges are preferably preheated, as a means of drying out the moisture contained in them and for the purpose of proportionately increasing the melting capacity of the vessel. Such preheating must not however be carried to the point of distillation.

The converter as illustrated in Fig. 2 is preferably about six feet in diameter and twenty feet in length. It is provided with thirty-two blast tuyers, each about 1- $\frac{1}{4}$ inches in diameter. As the ore charges enter at 6, they drop onto a bath of very hot matte. They are thus submerged so that the volatile atom of sulfur is melted in a position where it cannot escape and as a consequence it is compelled to join the molten bath and it thereupon becomes available as fuel. In marked contrast with this practice, experiments in pyritic smelting have been conducted in shaft furnaces, with ore-columns and with certain percentages of carbonaceous fuel as the melting medium.

Two things occur in connection with pyritic smelting in a shaft furnace:—First:—The combustion of coke or other carbonaceous fuel is reducing in its action and this is in conflict with the oxygen of the blast. Second:—The volatile atom in all sulfid ores is distilled; released and it escapes through the stack; before the zone of actual fusion in the furnace is reached. For this reason, all past experimenters have been forced to confine their efforts at pyritic smelting to such ores as contained extremely high percentages of sulfur; so that after they had thus wasted say one-half of the contained natural fuel through the stack; there would still be enough left in the ore, to admit of their continuing the smelting process with the sulfur that remained. Thus ores that contain 18 per cent. of sulfur; when subjected to fusion in a shaft furnace will contain in the molten state say nine per cent. This is insufficient with which to continue the process; hence all such ores have been discarded by experimenters in the field of pyritic smelting. On the contrary, ores that contain primarily say 40 per cent. of sulfur, will after being melted in a shaft furnace, still contain 18 or 20 per cent., or enough with which to continue the process. For this reason, past experimenters have been forced to confine their efforts to the latter class of ores as stated.

In our present invention, by submersion in a hot bath, we catch and retain the volatile atom for use as fuel and this has the effect of increasing the fuel value of all sulfid ores

treated by our method by more than fifty per centum over that of any method of so-called pyritic smelting.

It is intended that the entering blast shall be so great, that at least a portion of its oxygen will pass unconsumed through the molten bath and act as an oxidizing agent on the floating ore charge, before the same has been dissolved. By this means we provide to a certain extent the equivalent of a hot blast, without expense for carbonaceous fuel. The ore-feed is regulated so that the undissolved layer cannot sink to any great depth in the molten bath. Care is taken that the ore charges shall be fed into the vessel in such manner that an ore-column cannot build up on the bottom of the vessel. In fact, the ore-feed is purposely arranged so that the floating layer cannot at any time approach near to the level of the converting tuyers.

It is a well known fact that slags are already oxidized materials and that an air blast delivered into them is chilling in its effect. This is one reason that many attempts at pyritic smelting in shaft furnaces have resulted in failure; because the chilling effect of the entering blast, acting on the mingled ore; flux and fuel; together with the enormous proportion of slag soon solidifies the contents of the furnace.

From the point at which the ore charges enter the vessel; as shown at 6 in Fig. 2, they are compelled to travel a distance of nearly twenty feet and during this travel they are subjected to the heat produced by a converting blast; while it is acting on a bath of matte, that is intended to be composed of ores, such for instance as sulfids; pyrrhotites, &c. We depend solely upon the heat thus produced to melt the entering ores and in this way we eliminate the expense of coke or other carbonaceous fuel. In melting sulfid ores almost exclusively in this primary bath-producing vessel and in producing the heat that results from this process, our slag and matte will always be very fluid. These flow together in a continuous stream, out through one axis of the smelting converter end at 7, Fig. 2, the same as they flow at present through the overflow-spout of the ordinary blast furnace.

It should be noted at this point that one of the important and indeed absolutely indispensable requirements for the successful dissolving of ores that have been fed onto a molten bath of matte; in contradistinction to the dissolving of ores in a molten bath as described in our U. S. Patent No. 766,654, issued August 2nd, 1904 is, that the slag must be removed as rapidly as it forms. If it is allowed to accumulate in the converting vessel, it will float the ore, above the matte and thus prevent the actual contact of ore and matte which is absolutely necessary to successfully accomplish the dissolving action.

Where slag is allowed to accumulate to any great extent in the vessel, it will be ejected violently from the converter through its nose or top opening and any floating ore would tend to aggravate the trouble so that the dissolving action would be rendered inoperative. Again, the contact of unfused ore with slag lowers the temperature of the latter and renders it viscid. The contact of unfused ore with matte on the contrary; during the converting action, produces heat, through the chemical combination of the oxid of iron in the matte with the silica of the ore. As fast as silicate of iron is thus formed it has the effect of presenting new surfaces of sulfids, for combination with the oxygen of the converter blast. It will thus be seen that it is essential that the slag should be removed as fast as it is formed. Inasmuch as the agitation produced in the converter by the action of the blast mixes the matte and slag to a certain extent, it is also essential that the slag should be discharged into a settling vessel, in order that the prills of matte that thus become mingled with the slag may separate; before the latter is finally discharged to the dump as a waste product. A continuous slag and matte flow from a converter that is used for dissolving ores, into a forehearth is broadly new. We have therefore claimed it.

8 illustrates a short overflow-spout which is preferably water-jacketed in order to successfully withstand the cutting action of the molten bath. We consider this construction important because the molten tonnage that passes through this short overflow-spout will be enormous and as a consequence the cutting action on it will be very great unless water-jacketed.

9 illustrates a practically air-tight cover and drop-tube, which is intended to retain the original heats of the molten slag and matte during their passage from this smelting converter into the forehearth. The joint at 10 is practically air-tight, in order to prevent the entrance of air and at the same time to prevent any material escape of hot gases.

11 in Figs. 2 and 5 illustrates a rolling, solid metal door, so arranged that it can be readily barred loose and rolled to one side, should slag or matte congeal upon its interior surface. It permits the operator to constantly examine the discharge of slag and matte from the vessel through the overflow and if necessary to rod or to bar loose any chilled accretions that may form upon it.

12 represents one wall of the large forehearth.

13 represents the bottom of the forehearth and 14 represents a refractory lining, which may be used or not, as may be preferred. The forehearth is preferably made very large; say 20 feet in diameter if circular, or say 20 ft. long by 8 or 10 ft. in width if a parallelogram. It is preferably made of heavy metal

blocks, for the following reasons: First.—That it shall conserve the original heats of the molten bath within it. Second.—That it shall be practically indestructible. Third.—That chilled accretions cannot build up on the bottom and thus cause stoppages in the smelting operation, as is the case where a water-jacketed forehearth is used.

At 15 and over the entire surface of the forehearth as shown in Fig. 2, a coping or covering of congealed slag will form; the same as it does at present in all other forehearths. This congealed slag covering forms a practically air-tight junction with the solid metal drop-tube 9 so that the molten bath contained in the forehearth 12; whether the same consists of slag 23 or matter 24 or both, will be effectually thereafter protected against the chilling effects of the atmosphere. We have found in our work, that this chilling effect is very great and that it is one of the numerous causes of undue losses of mineral values in the slag that is discharged to the dump.

In our present invention we retain the intense heat of both the matte and the slag, during their travel through a smelting converter that is twenty feet in length.

The molten bath of matte that exists continuously in the smelting converter is so much greater than the comparatively small charge of ore that enters through the inlet 6 at any one time, that the chill of such ore is quickly conquered by the heat of the molten bath itself and this ore, when dissolved thus joins the bath; without materially reducing the temperature thereof.

When the matte and slag pass beyond the heating influence of the converting blast in the converter and when they drop from the overflow-spout into the covered forehearth, they are continuously protected against the chilling effect of the atmosphere; both in their fall and during their subsequent travel for a distance through the covered forehearth of approximately twenty feet. This affords ideal conditions for the separation of all mineral values contained in the slag and it compels all matte-prills to join the body of molten matte in the lower portion of the forehearth; for which they naturally have a greater affinity than for the slag.

With the orifice 6 of the smelting converter constantly closed by the ore in the hopper 16, Figs. 1: 2 and 4, while the blast is in operation and with the converter slag entrance closed during the progress of actual work only two points of escape will remain for the hot gases, that are constantly produced in large volume through the converting action. The one point of escape is through the nose of the converter into the stack and the second point will be through the orifice 7. Through the latter they can only find their escape to the atmosphere after they have passed entirely

under the congealed slag covering of the fore-hearth and after they have reached the point of ultimate discharge of the worthless slag. Inasmuch as it is intended that the molten bath in the forehearth shall be in actual contact with its congealed slag covering, the escape of hot gases at this point will be unimportant. As before stated these hot gases are produced in enormous volume and their exit from the converter is purposely choked, as a means of holding their heat within the vessel for the purpose of facilitating the process. This has the effect of creating considerable pressure within the converting vessel.

Special attention is called to the fact that the slags and matte are thus maintained continuously at high temperatures, until the point of ultimate discharge of the slag has been reached and also that these slags are exclusively discharged from the surface of a body of low grade matte. Attention is also called to the fact that all converter slags that are derived from the secondary converter or converters in our complete system and which secondary converters are essentially finishing converters and which as a consequence necessarily produce slags that may be high in mineral values, are thus compelled to travel a distance of approximately forty feet; under the most favorable possible conditions of heat and fluidity, as a means of forcing a good separation. When ultimately discharged to the dump, they are then discharged exclusively from the surface of a body of matte that is always low grade. These things taken together insure a better separation; cleaner slags and much lower mineral losses than prevail in any present smelter work.

Fig. 3 illustrates the method of delivering the blast to the wind-box 18. It also shows the rack 19 and pinions 20 whereby the converter is turned on its axis, whenever it may be desired to empty it.

Fig. 4 illustrates the general proportions of the converter; the blast entrance; the hydraulic power mechanism for revolving the converter; the overflow-spout; the covered drop-tube 9 and a portion of the fore-hearth 12.

16 in Figs. 1; 2 and 4 illustrates a hopper, for the delivery of the unfused ore into the converter, which may be raised when the converter is rotated and which may be lowered for feeding ore-charges.

22 in Figs. 1 and 6 illustrates a separate opening at the side of the hopper 16 into which converter slag derived from other converters in the series is poured in the molten state for the purpose of separating its contained mineral values.

Fig. 6 illustrates in plan view the orifice 22 and its heavy metal lid or door 21.

The orifice 22 is provided with a heavy covering, so that it may be closed at all times as a means of preventing the escape of hot

gases from the vessel; excepting when converter slag is being poured into it. It will be noted that under all ordinary circumstances, this vessel while in actual operation, will remain continuously in its upright position. It is only intended to be tipped or inserted like ordinary converters when it becomes necessary from any cause to empty it.

Doubtless many modifications will suggest themselves to those skilled in the art, without departing from the spirit of our invention, since

What we claim is:—

1. Apparatus for recovering mineral values from ores, which consists in the combination of a smelting converter provided with an ore inlet at one end and with a water-jacketed slag and matte overflow-spout at the other end with a separating vessel and having a covered drop-tube between the overflow-spout and the separating vessel provided with means whereby access may be had to the overflow-spout for examination and rodding when occasion requires; substantially as described.

2. Apparatus for recovering mineral values from ores, which consists in the combination of a smelting converter provided with an ore inlet above the horizontal axis of the converter at or near one end thereof and a water-jacketed overflow-spout in the horizontal axis of the opposite end of the vessel; a separating vessel and a covered drop-tube provided with a covered orifice through which the overflow-spout may be examined and rodded; substantially as described.

3. Apparatus for recovering mineral values from ores, comprising a converter having its top at least partially closed to choke the escape of hot gases, and provided with an outlet above the bottom of the converter to control the level of the bath, the converter also being provided with twyer holes below the level of the outlet of the converter, a separating chamber, and a passage leading from the outlet of the converter to the separating chamber.

4. Apparatus for recovering mineral values from ores comprising an invertible converting vessel mounted upon a substantially horizontal axis and provided with an unobstructed outlet at one end of the vessel and in the axis thereof, the top of the vessel being at least partially closed to choke the escape of hot gases, twyers piercing a side of the converter above the bottom and below the axis thereof, a separating chamber, and a passage leading from the outlet of the converter to the separating chamber.

5. A smelting converter provided with twyers mounted for inversion upon its longitudinal axis and having its longitudinal axis disposed in a substantially horizontal direction, there being an unobstructed matte and slag outlet at one end of the longitudinal axis

of the converter, and a feed inlet through the top of the converter and adjacent the opposite end thereof, substantially as described.

6. A smelting converter provided with
5 twyers and having a pour-out opening in its top substantially midway of its ends, said converter being mounted for inversion upon its longitudinal axis and having said axis disposed in a substantially horizontal direction,
10 there being an unobstructed matte and slag outlet at one end of the longitudinal axis of

the converter, and a feed inlet through the top of the converter adjacent the opposite end thereof, substantially as described.

In testimony whereof, we have hereunto
set our hands. 15

RALPH BAGGALEY,
CHARLES M. ALLEN,
EDWARD WILLIAM LINDQUIST.

Witnesses:

WILLIAM M. KIRKPATRICK,
AZELLE E. HOBART.