No. 812,785. PATENTED FEB. 13, 1906.

A. M. DAY.

PROCESS OF SMELTING AND CONVERTING ORES.

APPLICATION FILED APR. 19, 1905.

3 SHEETS—SHEET 1.

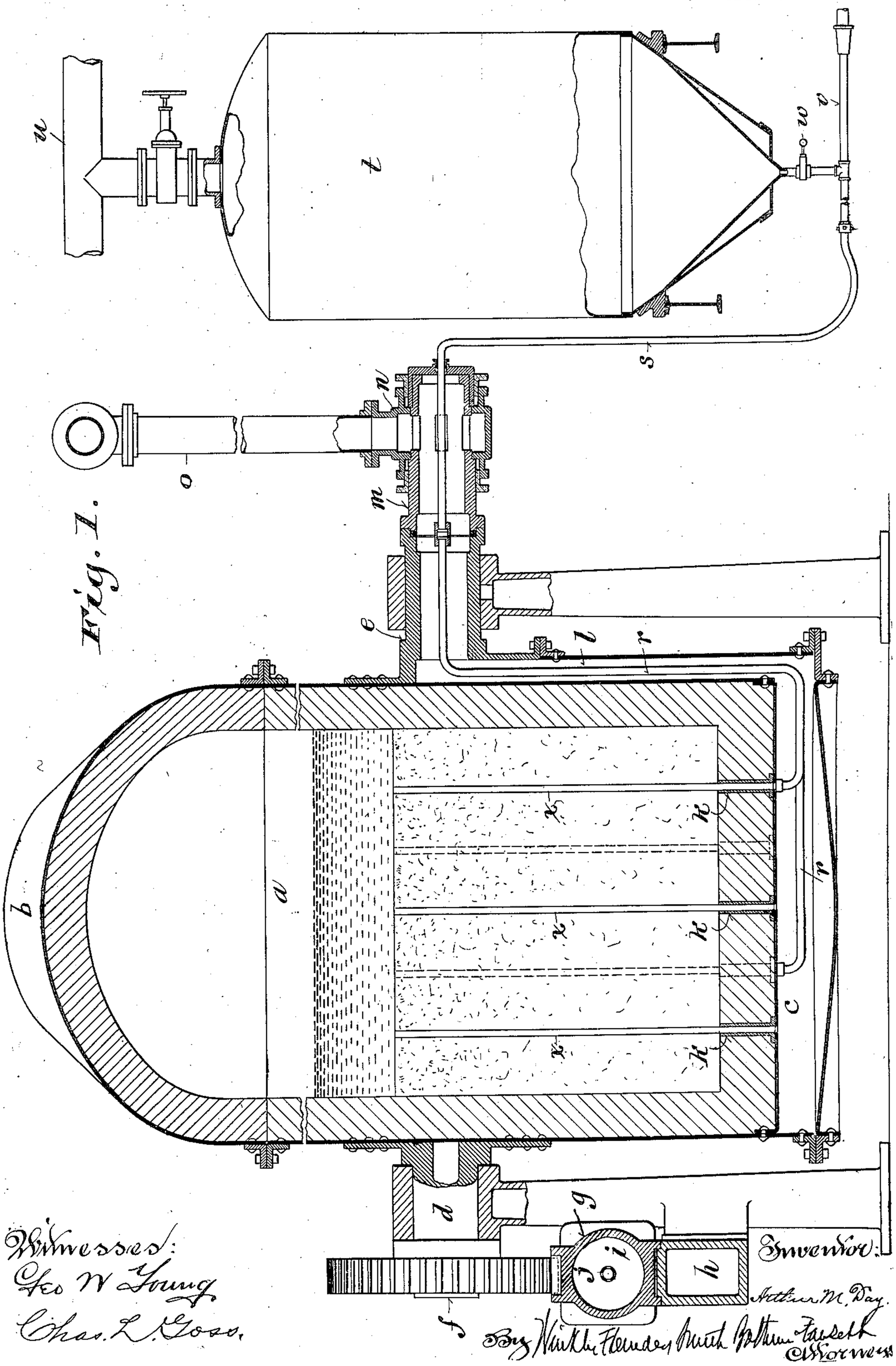

Fig. 1.

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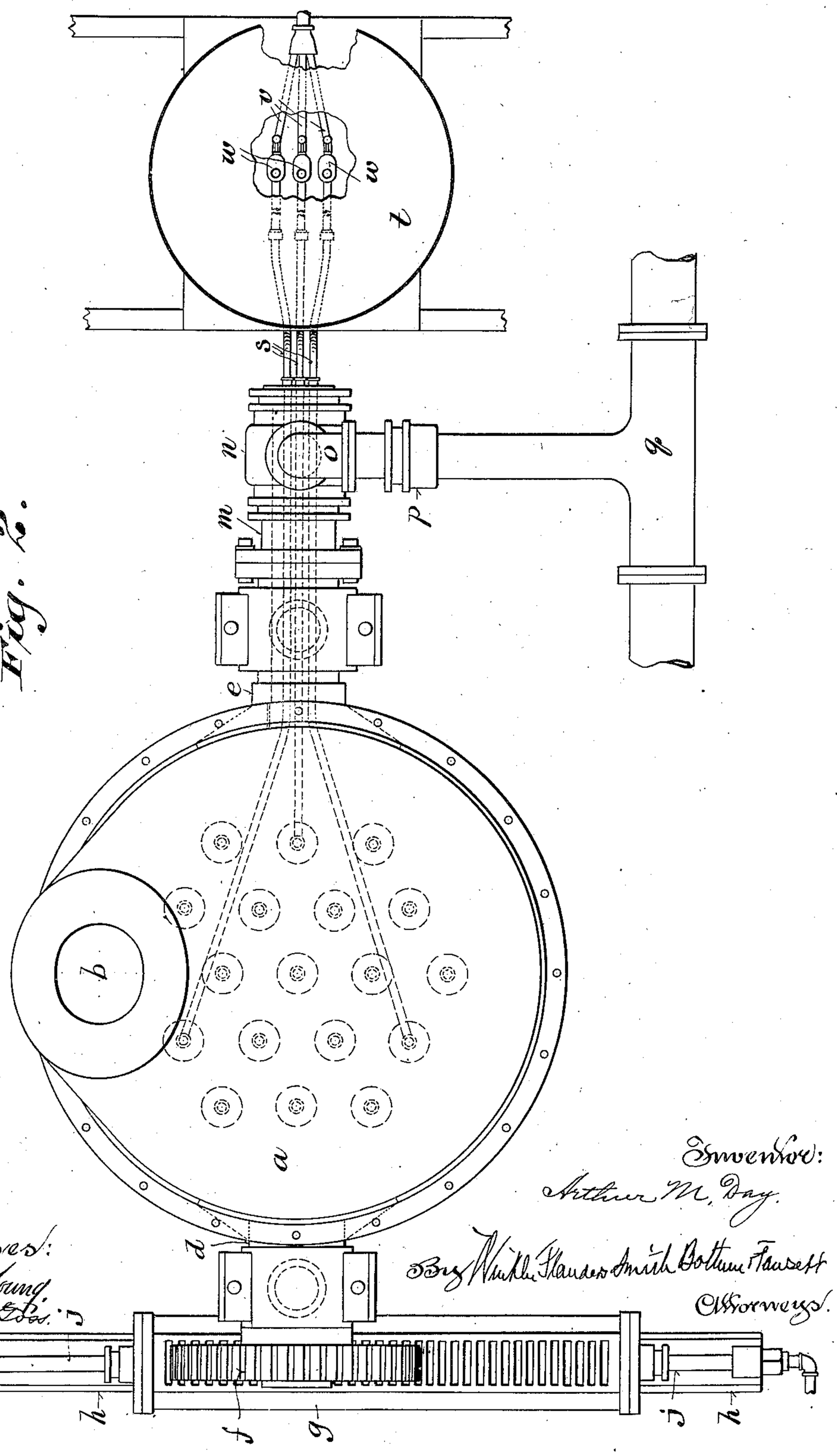
3 SHEETS—SHEET 2.

Fig. 2.



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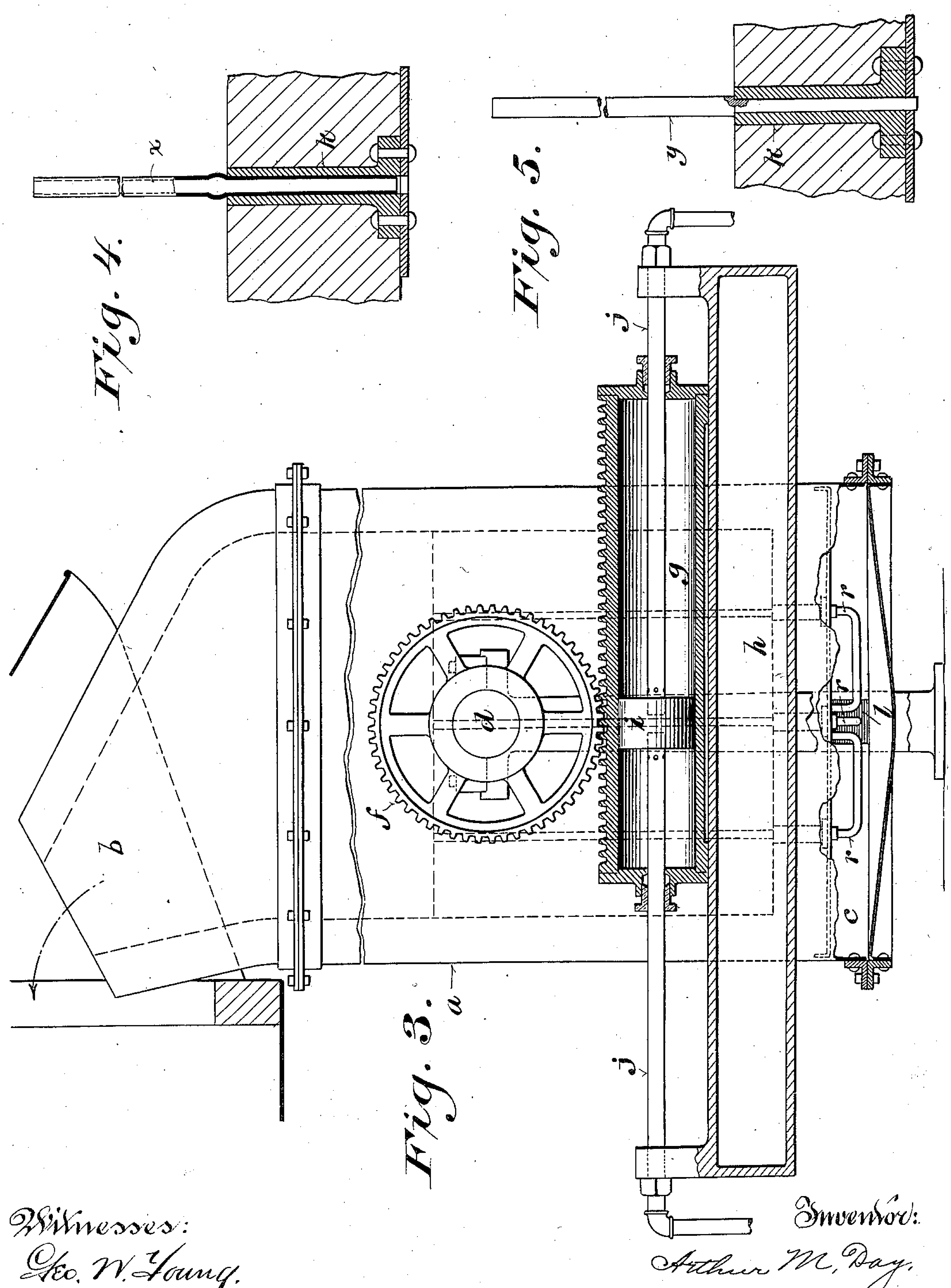
3 SHEETS—SHEET 3.



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UNITED STATES PATENT OFFICE.

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PROCESS OF SMELTING AND CONVERTING ORES.

No. 812,785. Specification of Letters Patent. Patented Feb. 13, 1906.

Original application filed October 29, 1904, Serial No. 230,468. Divided and this application filed April 19, 1905. Serial No. 256,484.

To all whom it may concern:

Be it known that I, ARTHUR M. DAY, a citizen of the United States, residing at Butte, in the county of Silverbow and State of Montana, have invented certain new and useful Improvements in Processes of Smelting and Converting Ores, of which the following is a specification, reference being had to the accompanying drawings, forming a part thereof.

This invention relates more particularly to the smelting of raw or crude sulfid copper ores and to the conversion of copper matte into pig-copper, although it is applicable to the treatment of other ores containing or mixed with substances which can be utilized for fuel in the smelting operations.

The main objects of the invention are to utilize the sulfur or other fuel contained in crude ores for smelting them, thereby effecting a saving in fuel; to avoid the losses in fuel and metal incident to the ordinary concentrating and calcining or roasting operations and a part of the losses incident to smelting according to the usual methods; to admit of the employment of permanent or durable linings in place of the silicious linings commonly used in treating matte produced from this class of ores; to keep the twyers open without thrusting rods or bars through them, according to the usual practice; to inject into the molten charge of ore or matte a positive supply of fuel, flux, or silica as it is required in a fluent form (powdered or liquid) with an air-blast separate and distinct from the main air-blast, thereby admitting of accurate regulation of the supply of such material and preventing the same from lodging in and clogging the main-blast passage; to deliver the air-blast, which supplies oxygen for combustion, and the fuel, flux, and silica or other substances required for the smelting and converting operations to the charge of ore or matte at or near the melting zone or level as fusion progresses downward, and generally to simplify, cheapen, and improve processes of this class.

The invention consists in the novel processes and operations, as hereinafter particularly described, and pointed out in the claims.

In the accompanying drawings, illustrating apparatus suitable for performing the process, like characters designate the same parts in the several figures.

Figure 1 is a vertical longitudinal section and partial elevation of the apparatus. Fig. 2 is a plan view of the same. Fig. 3 is a side elevation as seen from the left with reference to Fig. 1 of the smelting vessel or converter-bowl and the mechanism for tilting the same, certain parts being broken away and shown in vertical section. Fig. 4 is a detail sectional view, on an enlarged scale, of one form of twyer extension constituting a part of the apparatus; and Fig. 5 is a similar view showing means for forming twyer extensions in another way.

a designates the smelting vessel or converter-bowl, which is made of boiler-plate or sheet metal lined with fire-brick and provided at the top with a nozzle *b* and at the bottom with a wind-box or air-chamber *c*. It is provided on opposite sides with trunnions *d* and *e*, which are fitted to turn in bearings provided therefor on columns or other suitable supports. For tilting the vessel *a* from and back to an upright position a gear-wheel *f* is fixed on the outer end of the trunnion *d* and meshes with a rack formed or provided on a hydraulic cylinder *g*, which is mounted and movable endwise upon a guide *h*. A centrally-located piston-head *i*, fitted in said cylinder, is connected by tubular rods *j*, passing through stuffing-boxes in the cylinder-heads, with brackets on the ends of the guide *h*, and to the outer ends of these rods are attached pipes, as shown in Fig. 3, through which water is admitted under pressure to either end of the cylinder and exhausted from the opposite end by way of said piston-rods under the control of suitable valves or valve mechanism, which are not shown. The tubular piston-rods are formed close to the piston *i* with holes through which the water passes in entering and escaping from the cylinder.

The vessel or bowl *a* is provided with a number of twyers *k*, extending upwardly through the bottom from the wind-box or air-chamber *c*, with which they communicate.

The trunnion *e* is made hollow and is connected with the wind-box *c* by a passage *l* at the side of the vessel *a*. A tubular extension *m*, detachably fastened to the outer end of the trunnion *e*, is fitted to turn in an internally-recessed sleeve *n*. A pipe *o*, having an elbow, is attached at one end to and communicates with said sleeve and is connected at the other end by a packed swivel-joint *p* with the main air-blast or supply-pipe *q*. The sleeve *n* is formed at the ends with stuff-

ing-boxes and provided with glands and is held in place upon the extension *m* by the flanged head of said extension and an opposing shoulder thereon. The internal annular recess or passage in the sleeve communicates with the interior of the trunnion extension through lateral openings therein, as shown in Fig. 1.

Some of the twyers *k* are connected by pipe-sections *r*, passing through the wind-box *c*, main blast-passage *l*, and trunnion *e*, with a bridge-piece extending across the outer end of said trunnion. In a corresponding bridge-piece across the inner end of the sleeve *n* are secured flexible hose or pipe sections *s* in position to register with the ends of the pipe-sections *r*.

The apparatus comprises a number of closed reservoirs or receptacles *t*, one only of which is shown. Each of these receptacles is connected at the top with a compressed-air-supply pipe *u* by a branch pipe containing a valve and at the bottom, which is preferably funnel-shaped, with a corresponding number of auxiliary air-blast or compressed-air-supply pipes *v* by branches provided with valves or gates *w*. The pipes *v* are connected at one end with the compressed-air supply and at the other end, by the flexible hose-sections *s*, passing through stuffing-boxes in the head of the trunnion extension *m*, with the pipe-sections *r* and certain of the twyers *k*, with which said pipe-sections communicate.

With the apparatus hereinbefore described the process constituting the present invention is performed or carried out as follows: Tubular extensions *x* being inserted in the several twyers *k*, as shown in Fig. 1, and the receptacles *t* being supplied, one with fuel, such as powdered coal or coke or oil, another with a suitable flux, such as powdered limestone or iron ore, and another with powdered silica, the vessel *a* is filled to the top of the twyer extensions *x* with the ore to be treated—such, for example, as crude copper-sulfid ore. The charge is then dried sufficiently to prevent explosions by kindling a wood or coal fire on top of it or by otherwise applying heat thereto. Compressed air is turned on from the main supply-pipe *q* through the main blast-passage *l*, wind-box *c*, and twyers *k*, communicating therewith, and the vessel *a* is tilted into a convenient position to receive molten matte or other suitable substance containing sufficient heat to start the smelting operation. The vessel *a* is now turned back into an upright position, the molten matte or other substance flowing over and covering the top of the charge. The air supplied through the twyers under sufficient pressure to prevent the molten matte from flowing into them coming in contact therewith produces intense heat at that point, and the smelting operation begins at the top of the charge, progressing gradually downward until the entire charge has been fused. As the operation proceeds the smelting vessel is turned down and the molten slag accumulating at the surface is drawn off from time to time through the nozzle *b* in order to avoid an unnecessary increase of pressure to force the air through the slag and, on the other hand, a diminution of the volume of air passing through the matte and consequent abatement of the smelting operation. As the melting zone or level progresses downward the tubes *x* are melted off, so that the air is delivered to the top of the charge of ore below the molten covering. The ore is mixed, if possible, so as to produce a self-fluxing charge; but when this is impracticable the flux required to properly fuse the charge is supplied from one of the receptacles *t* by opening one or more of the valves or gates *w* below said receptacle, thereby admitting the powdered flux into one or more of the auxiliary blast-pipes *v*, from which it is carried through the connections hereinbefore described to one or more of the twyers and delivered at the top of the charge below the molten covering, where the greatest heat is produced and maintained. The oxidation of the sulfur and iron or other combustible substances ordinarily contained in the ore produces sufficient heat to smelt the ore, the operation having been started by the covering of molten matte or other substance. In case, however, the ore contains insufficient fuel to maintain the required degree of heat powdered coal or coke or even oil is supplied, as required, from one of the receptacles *t*, this additional fuel-supply being regulated by the adjustment of the valve or valves *w* and delivered by the twyer extensions to the charge where the operation of fusion is most active. To keep the twyers open, a small quantity of powdered silica is supplied from one of the receptacles *t* to one or more of the twyers. The silica injected into the charge while it is agitated by the air-blast is diffused through the entire charge and brought into contact with the iron which is contained in the charge and with which it combines and forms a fluid slag. The chemical reactions which thus take place throughout the entire molten portion of the charge while the demand of the iron for silica is being satisfied operate to keep the twyers open. By this means the ordinary method of keeping them open by thrusting bars through them from time to time is discarded, an operation that would be difficult and inconvenient to perform in connection with an upright smelting vessel like that herein shown, having twyers in the bottom.

With the arrangement shown and described of several separate and distinct connections between each of the receptacles *t* and certain of the twyers fluent material from either one of the receptacles may be

supplied simultaneously through all of the several connections to the smelting vessel, or one kind of material may be supplied through two of said connections, while another kind is supplied from another receptacle through the third connection, or three kinds of material—fuel, flux, and silica—may be supplied simultaneously from the several receptacles, one connection being used with each receptacle for one kind of material.

With some kinds of ore the twyer extensions may be formed by tamping the ore around rods *y*, temporarily inserted in the twyers *k*, as shown in Fig. 5, while the smelting vessel is being charged, these rods being withdrawn and leaving openings or passages from the twyers to the surface of the charge. In this case the ore itself forms fusible twyer extensions, which take the place and serve the purpose of the tubes *x*.

With the auxiliary blast-pipes leading through the main blast-passage to and connecting with certain twyers a positive and accurately-regulated supply of fuel, flux, silica, or other material in a fluent form may be delivered to the charge in the smelting vessel independently of the main air-supply thereto, and in this way the lodging of such material in and the clogging of the main air-blast passage are avoided.

For the conversion of copper matte to pig-copper the twyer extensions are dispensed with, the air and powdered or fluent material being delivered directly from the twyers *k* into the bottom of the vessel *a*. This may be done in the same vessel after the smelting operation hereinbefore described has been completed, molten matte from other smelters being supplied to complete the charge, or the matte may be transferred from the vessel in which the crude ore has been smelted to another like or similar apparatus for converting it into pig-copper. In the conversion of the matte into copper the twyers are kept open, the same as in smelting crude ore, by introducing powdered silica or silicious ore through one or more of the twyers, and the silica or silicious ore in this case serves the additional purpose of combining with the iron contained in the matte, and thereby liberating the copper. By the method herein described of introducing fuel in a fluent form with an air-blast separate and distinct from the main air-blast into the charge high-grade matte, which would otherwise have to be mixed with low-grade matte, can be successfully converted.

The method employed in my process of injecting powdered silica into the charge admits of the use of permanent or durable fire brick or clay linings in the furnace or converter, and thereby dispenses with the silicious linings which are commonly employed and are a source of trouble, expense, and danger, since they are rapidly consumed and have to be frequently renewed, and in case the molten charge breaks through the lining it will immediately melt and destroy the sheet-metal shell of the smelter or converter.

With my improved process as hereinbefore described crude low-grade ores, which could not otherwise be profitably treated in localities where fuel and water are scarce or dear, can be successfully smelted and converted, since the sulfur or other fuel contained in such ores is utilized and the preliminary operation of concentrating the ores, which requires a large volume of water, is eliminated.

Various modifications in the order and manner of performing the several steps or operations of the process may be made within the principle and intended scope of the invention.

I claim—

1. The process of smelting ore consisting in covering a charge of the ore with a molten substance containing sufficient heat to start fusion of the charge, and supplying air to the charge at or near the varying melting-level as fusion progresses downward, substantially as described.

2. The process of smelting ore consisting in covering a charge of the ore with a molten substance containing sufficient heat to start fusion of the ore, and injecting fuel in a fluent form with air into the charge at or near the melting zone or level below the molten covering as fusion progresses downward, substantially as described.

3. The process of smelting ore consisting in applying heat to the top of the charge, forcing air into the charge and simultaneously injecting into the charge at or near the melting-level as fusion progresses downward, fluent material with an auxiliary air-blast separate from the main air-blast, substantially as described.

4. The process of smelting ore or matte consisting in injecting into the charge of ore or matte at the melting-level fuel in fluent form with a blast of air separate and distinct from the main air-blast, substantially as described.

5. The process of smelting or converting ore or matte consisting in forcing air into the charge and injecting fuel in fluent form with an air-blast separate and distinct from the main air-blast, substantially as described.

6. The process of smelting ore consisting in applying heat to the top of the charge, forcing air into the charge and simultaneously injecting into the charge at or near the melting-level as fusion progresses downward, independently-regulated supplies of different kinds of material with auxiliary air-blasts separate from the main air-blast, substantially as described.

7. The process of smelting ore and converting matte which consists in forcing air

into the charge of ore or matte and injecting into the charge independently-regulated supplies of fuel and silicious material in a fluent form with air-blasts separate from the main air-blast, substantially as described.

8. The process of smelting ore consisting in covering a charge of the ore with a molten substance containing sufficient heat to start fusion of the charge, supplying air to the top of the charge below the molten substance as fusion progresses downward, and injecting a flux and fuel in a fluent form with air into the charge at or near the melting zone or level as it progresses downward, substantially as described.

9. The process of smelting ore consisting in covering a charge of the ore with a molten substance containing sufficient heat to start fusion of the charge, supplying air under pressure to the top of the charge below the molten covering and injecting with separate and distinct air-blasts, fuel and silicious material delivered at or near the melting-level as it progresses downward, substantially as described.

10. The process of smelting ore consisting in drying the top of the charge, covering it with a molten substance containing sufficient heat to start fusion of the charge, and supplying air under pressure to the charge at or near the melting-level as fusion progresses downward, substantially as described.

11. The process of smelting ore consisting in covering a charge of the ore with a molten substance containing sufficient heat to start fusion of the charge, supplying air under pressure to the top of the charge below the molten covering and drawing off from time to time the slag accumulating at the surface as fusion progresses downward, substantially as described.

12. The process of smelting crude ore containing or mixed with a combustible substance such as sulfur, consisting in covering a charge of the ore with a molten substance containing sufficient heat to start fusion of the charge, supplying air under pressure to the top of the charge below the molten covering as fusion progresses downward, and injecting fuel, flux and silicious material in a fluent form, with air-blasts delivered at or near the melting-level, substantially as described.

13. The process of smelting ore or matte consisting in the application of heat and a blast of air to the charge and in forcing fuel in a fluent form into the charge with an air-blast separate from the main air-blast, substantially as described.

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

ARTHUR M. DAY.

Witnesses:
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ERNEST C. TRASK.