No. 812,186. PATENTED FEB. 13, 1906.

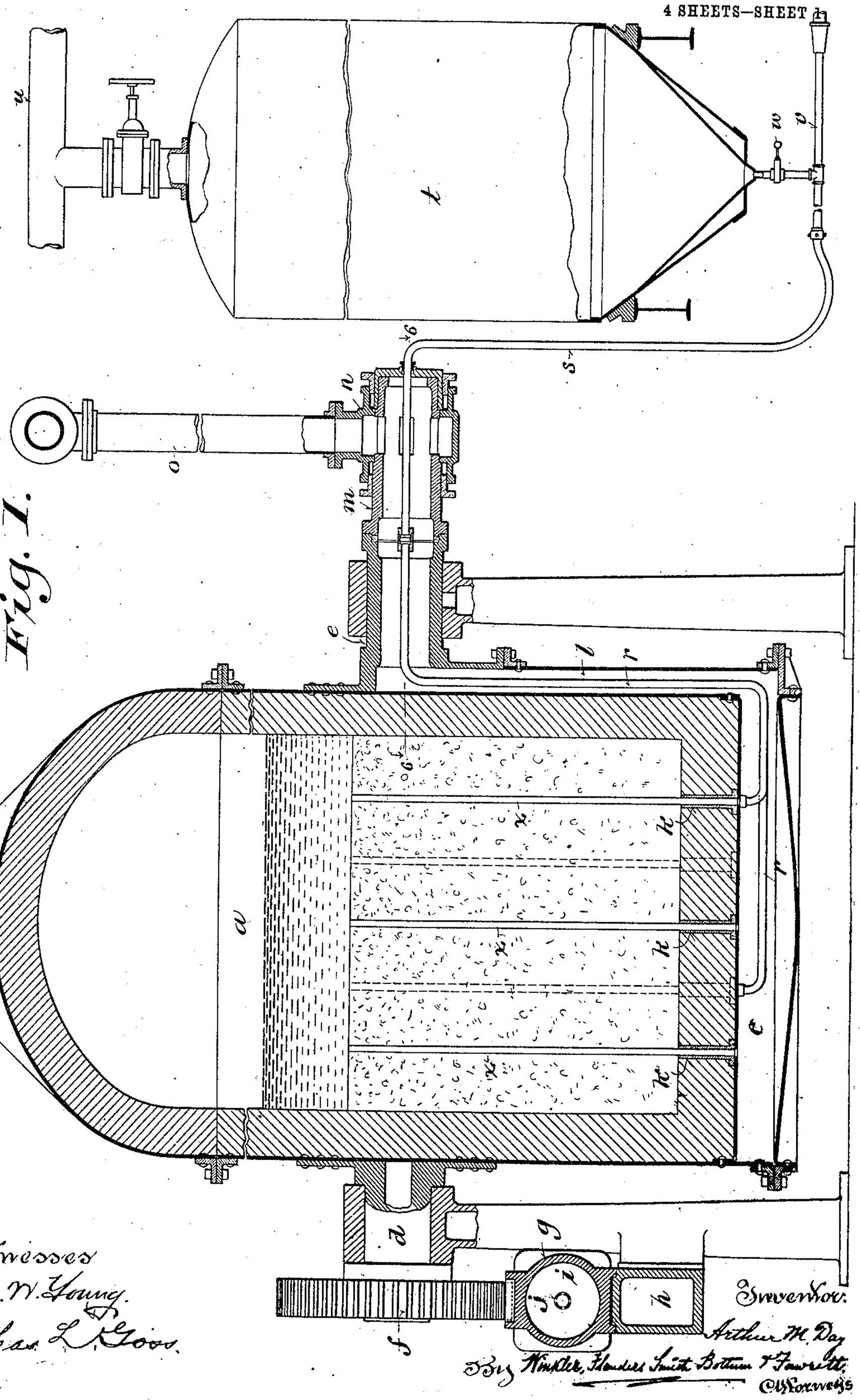
A. M. DAY.

APPARATUS FOR SMELTING AND CONVERTING ORES.

APPLICATION FILED OCT. 29, 1904.

4 SHEETS—SHEET 1.

Fig. 1.

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4 SHEETS—SHEET 2.

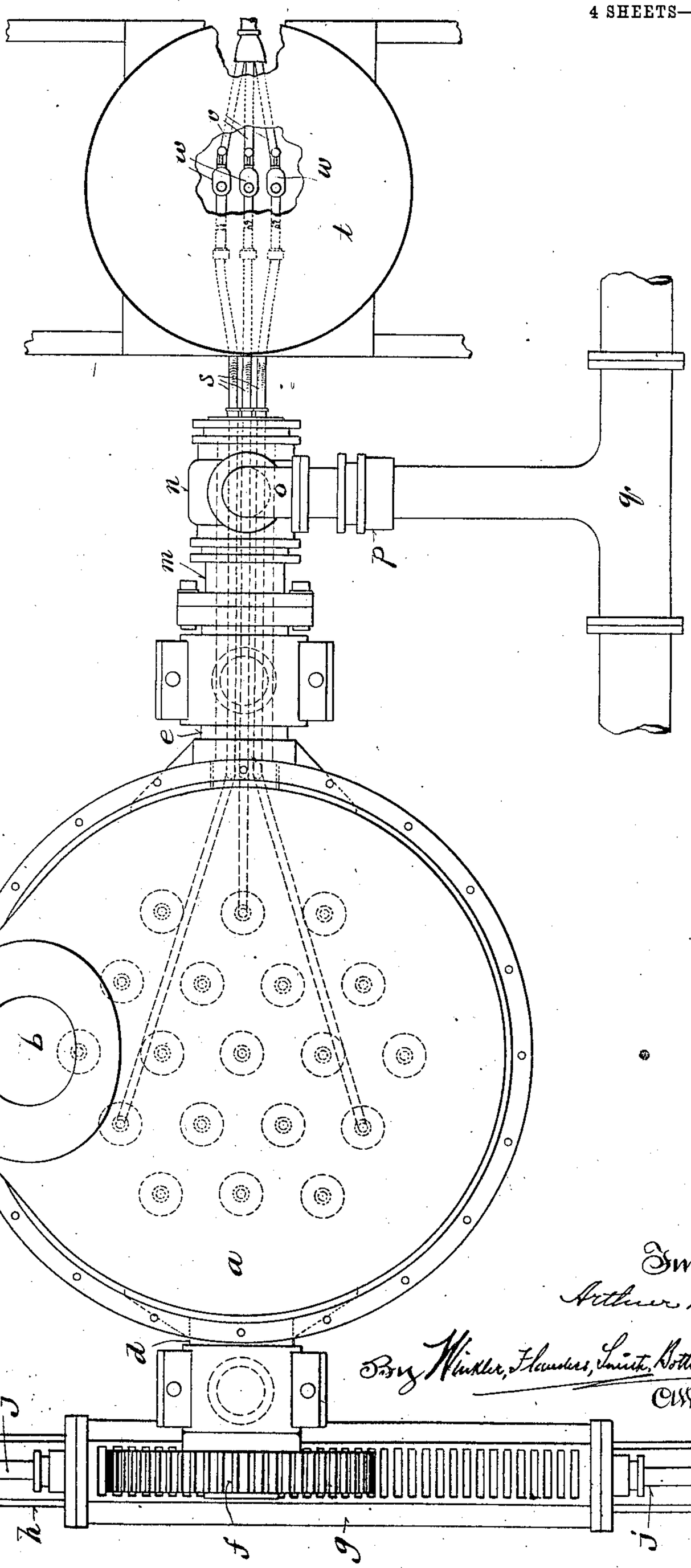


Fig. 2.

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4 SHEETS—SHEET 3.

*Fig. 4.*

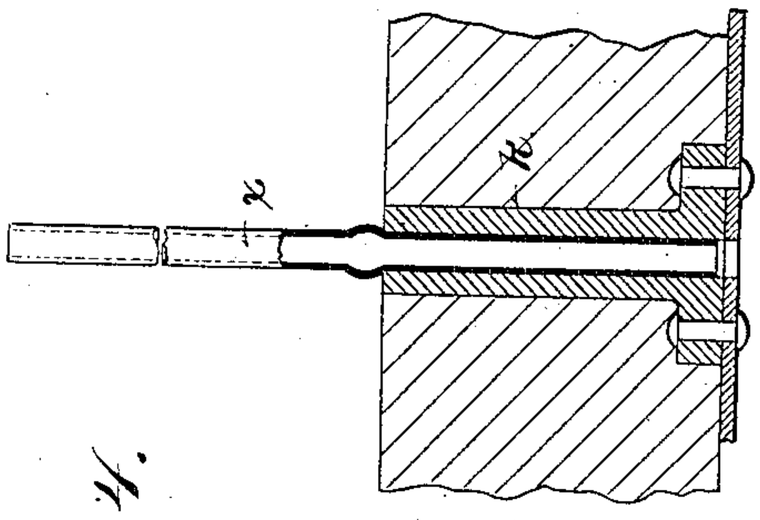



*Fig. 5.*

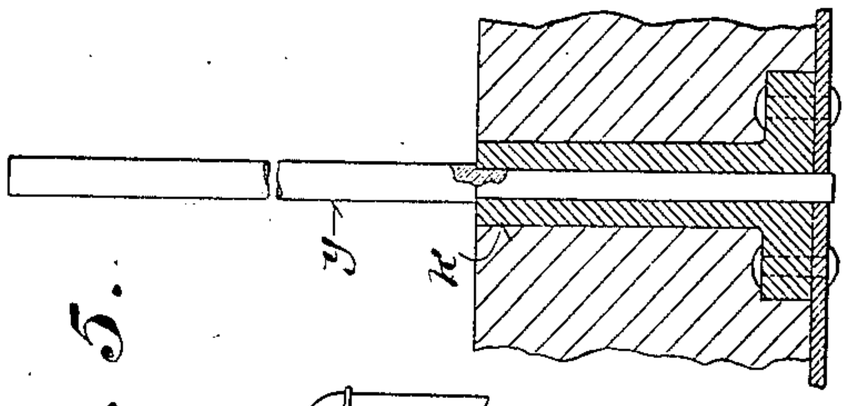
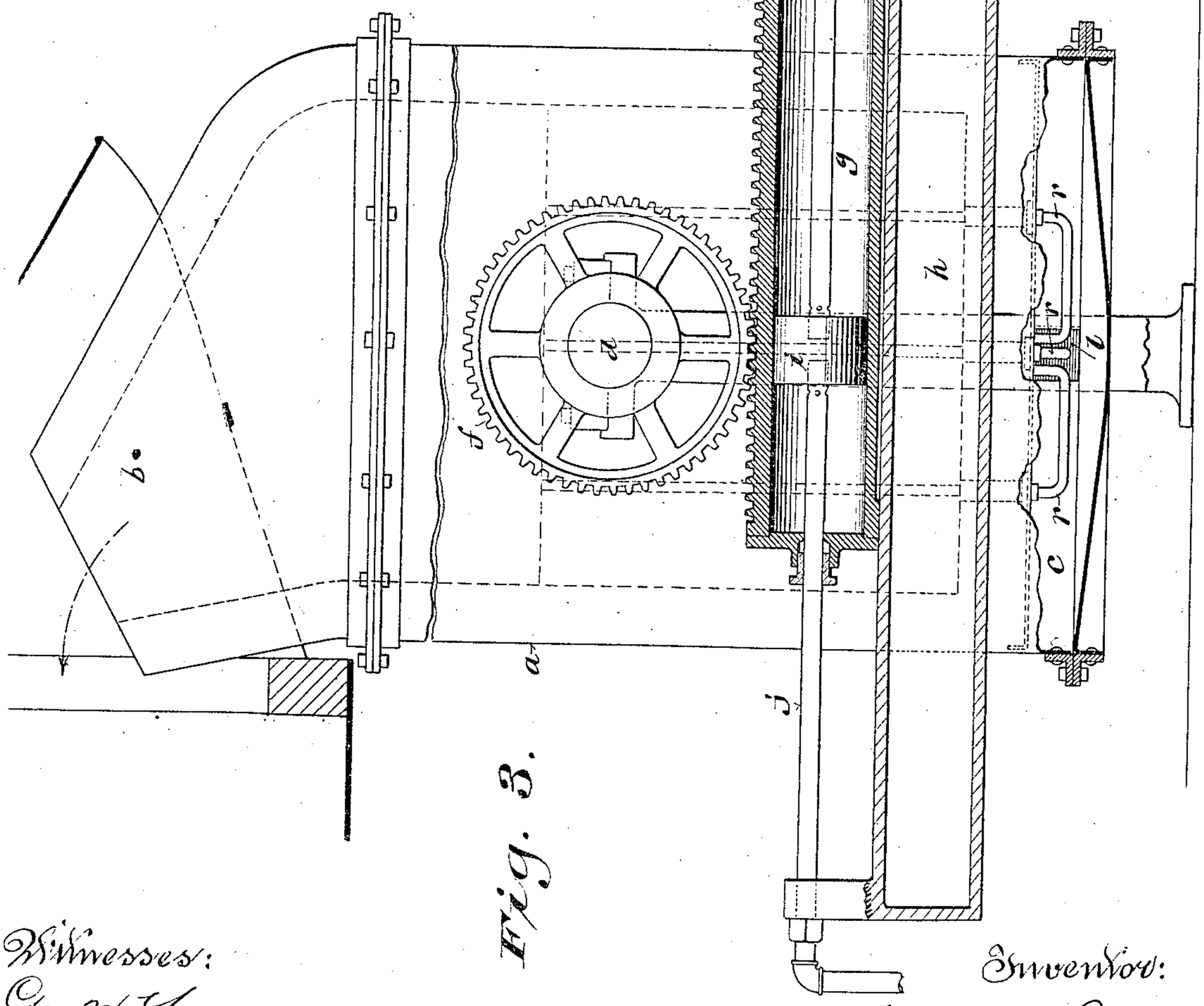



*Fig. 3.*

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4 SHEETS—SHEET 4.

Fig. 7.

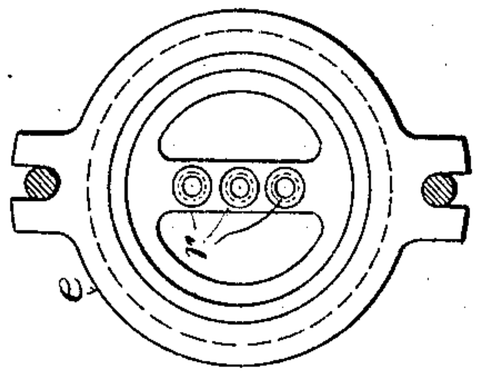



Fig. 6.

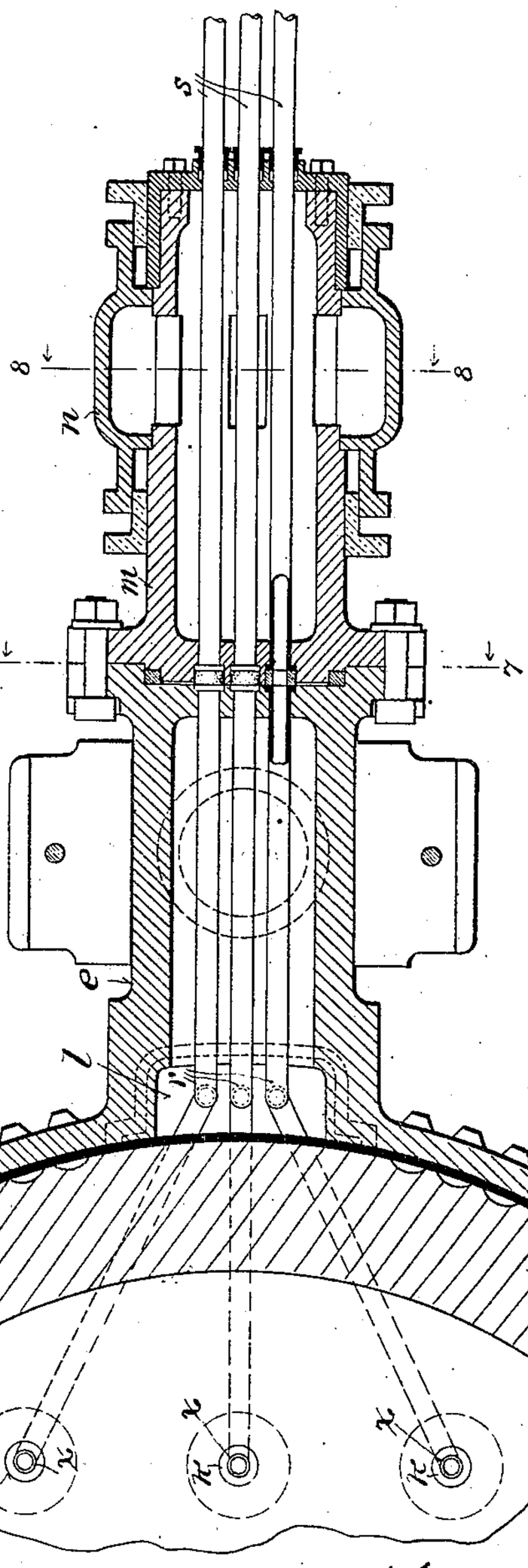
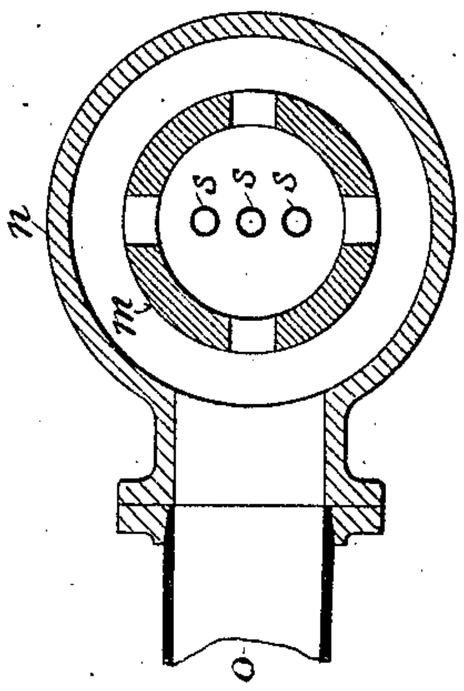



Fig. 8.

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# UNITED STATES PATENT OFFICE.

ARTHUR MILTON DAY, OF BUTTE, MONTANA.

## APPARATUS FOR SMELTING AND CONVERTING ORES.

No. 812,186. Specification of Letters Patent. Patented Feb. 13, 1906.

Application filed October 29, 1904. Serial No. 230,468.

*To all whom it may concern:*

Be it known that I, ARTHUR MILTON 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 Apparatus for 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 apparatus for smelting raw sulfid copper ores and for converting copper matte into pig-copper, although some or all of the improvements constituting the invention may be embodied in apparatus for treating other ores or substances.

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 with apparatus now general in use; 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 when 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 and preventing the same from lodging in and clogging the main blast-passage; to deliver the air-blast supplying oxygen for combustion and the fluent 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 [illegible]evel as fusion progresses downward and [illegible]erally to improve the construction and operation of apparatus of this class.

The invention consists in certain novel features of construction and in the peculiar a[illegible]angement of the component parts of the apparatus, as hereinafter particularly described, and pointed out in the claims.

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

Figure 1 is a vertical longitudinal section of apparatus embodying the invention. 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. Fig. 5 is a similar view showing means for forming the twyer extensions in another way. Fig. 6 is an enlarged horizontal section on the line 6 6, Fig. 1, of the detachable air blast or supply connections of the smelting vessel; and Figs. 7 and 8 are vertical cross-sections on the lines 7 7 and 8 8, Fig. 6.

*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 inter-

nally-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 stuffing-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 Figs. 1 and 6.

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, as shown in Fig. 6. 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*, air-tight joints being made between the meeting ends of said sections when the parts are assembled by means of packing-rings inserted in one of the bridge-pieces around the ends of the pipe or hose sections secured therein, as shown in Fig. 6. An air-tight joint is also made between the trunnion and trunnion extension by a rubber gasket or packing-ring inserted in an annular recess between said parts, which are drawn and held together by bolts passing through notched ears or lugs formed on opposite sides of said parts.

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.

The apparatus hereinbefore described operates 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 *l* 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 [illegible] may be delivered to the charge in the smelting vessel independently of the [illegible] supply thereto, and in this way the [illegible] 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 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 provision made in my apparatus for injecting powdered silica into the charge admits of the use of permanent or durable fire brick or clay linings in the furnace or converters, 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 the apparatus 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 rendered unnecessary by my apparatus.

With the detachable connection shown in the drawings between the trunnion *e* and its extension *m* and the associated couplings between the sections *r* and *s* of the auxiliary blast-pipes the smelting vessel or converter-bowl *a* can be readily removed and replaced or one substituted for another by simply removing and replacing the two bolts connecting said trunnion and its extension and tightening the nuts on said bolts when the parts are connected to make air-tight joints between them. The uncoupling and coupling of the blast connections with a vessel *a* are further facilitated by the joint *p*, which permits the trunnion extension *m*, with all its permanent pipe connections, to be swung from and toward said vessel.

In plants supplied with a number of smelters or converters the main blast-pipe *q* has a corresponding number of branches each provided with a valve for cutting off the air-blast from the associated smelter or converter independently of the others.

Various changes in the details of construction and arrangement of parts of the apparatus may be made within the principle and intended scope of the invention.

I claim—

1. In apparatus for smelting and converting ores, the combination of a smelting vessel having a wind-box and a number of twyers leading therefrom into the lower part of the smelting-chamber, and fusible twyer extensions leading upwardly from the twyers, substantially as described.

2. In apparatus for smelting and converting ores the combination of a smelting vessel provided with a wind-box having an air-blast connection and with a number of twyers

leading from the wind-box into the smelting-chamber, fusible twyer extensions leading upwardly from the twyers, a separate compressed-air-supply connection with one of the twyers, and a closed receptacle for holding fluent material connected at the top with a source of compressed air and at the bottom with the air-supply connection leading to one of the twyers, substantially as described.

3. In apparatus for smelting and converting ores the combination of a smelting vessel provided with a wind-box having an air-blast connection and with a number of twyers leading from said wind-box into the smelting-chamber, fusible twyer extensions leading upwardly from the twyers, a separate compressed-air-supply connection with one of the twyers, and a closed receptacle for holding fluent material, having a valve-controlled connection with the air-supply connection leading to one of the twyers, substantially as as described.

4. In apparatus for smelting and converting ores, a smelting vessel having an air-blast connection at the bottom and fusible twyer extensions leading upwardly into said vessel from the lower part thereof, substantially as described.

5. In apparatus for smelting and converting ores, the combination of a smelting vessel having an air-blast connection at the bottom and fusible twyer-tubes extending upwardly therefrom, substantially as described.

6. In apparatus for smelting and converting ores, the combination of a smelting vessel provided with twyers, a main air-supply connected with some of the twyers, and a closed receptacle for holding fluent material connected at the top with a compressed-air supply and at the bottom with an auxiliary pipe or passage leading from the air-supply to one of said twyers, substantially as described.

7. In apparatus for smelting and converting ores, the combination of a smelting vessel provided with twyers and mounted on trunnions, one of which is hollow and has a detachable tubular extension connected with the twyers and formed with a lateral opening, and an air blast or supply pipe provided with a sleeve in which the trunnion extension is adapted to turn and with which it forms an annular passage in communication with the lateral opening in said extension and with said air blast or supply pipe, substantially as described.

8. In apparatus for smelting and converting ores, the combination of a smelting vessel provided with twyers and mounted on trunnions one of which is hollow and has a detachable tubular extension connected with the twyers and formed with a lateral opening, an air blast or supply pipe and a branch pipe provided with a sleeve in which said trunnion extension is adapted to turn and with which it communicates through said lateral opening, said branch pipe having a swivel connection with the main blast-pipe whereby said trunnion extension when detached may be swung away from the associated trunnion, substantially as described.

9. In apparatus for smelting and converting ores, the combination of a smelting vessel provided with twyers and mounted on trunnions one of which has a detachable extension forming therewith an air-supply connection to the twyers, an air blast or supply pipe provided with a sleeve in which said trunnion extension is adapted to turn and through which it communicates with said pipe, an auxiliary air-blast pipe connected with a twyer and running through the main air-blast passage to said trunnion extension, and a flexible extension of said auxiliary pipe connected therewith by a joint which is adapted to be made and unmade by the coupling and uncoupling of the trunnion extension, substantially as described.

10. In apparatus for smelting and converting ores the combination of a smelting vessel provided with twyers, a main air blast or supply pipe connected with some of said twyers, a number of closed receptacles or reservoirs for holding fluent material, each connected at the top with a source of compressed air and having at the bottom a valve-controlled connection with an auxiliary blast-pipe leading from the source of compressed air to one of said twyers, substantially as described.

11. In apparatus for smelting and converting ores the combination of a smelting vessel provided with twyers, a main air-supply pipe connected with some of the twyers, a number of closed receptacles for holding fluent material connected at the top with a source of compressed air and each having at the bottom valve-controlled connections with a like number of auxiliary blast-pipes each leading to a twyer and connected with the source of compressed air, substantially as described.

12. In apparatus for smelting and converting ores the combination of a smelting vessel provided with twyers and mounted on trunnions, one of which has a detachable extension forming therewith an air-supply connection to the twyers, a compressed-air-supply pipe provided with an internally-recessed sleeve in which said trunnion extension is adapted to turn and through which it communicates with said pipe, a number of closed receptacles for holding fluent material connected at the top with a source of compressed air and having at the bottom valve-controlled connections with auxiliary blast-pipes which communicate with the compressed-air supply and have flexible connections with said trunnion extension, and pipes leading therefrom through the associated trunnion

to certain twyers and adapted to make tight joints with the corresponding pipes in said extension when it is attached to said trunnion, substantially as described.

13. In apparatus for smelting and converting ores the combination of a smelting vessel provided with twyers and mounted on trunnions, one of which is hollow and is connected with some of the twyers and with an air-blast supply, and an auxiliary air-blast pipe leading through said hollow trunnion to one of the twyers, substantially as described.

14. In apparatus for smelting and converting ores the combination of a smelting vessel provided with twyers and mounted on trunnions, one of which is hollow and has a detachable tubular extension forming an air-supply connection for some of the twyers, a main air-blast pipe connected with said extension, an auxiliary passage leading from said hollow trunnion to one of the twyers and an auxiliary air-blast pipe leading into said extension and adapted to make a tight joint with the auxiliary passage in the trunnion when said extension is coupled thereto, substantially as described.

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

ARTHUR MILTON DAY.

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