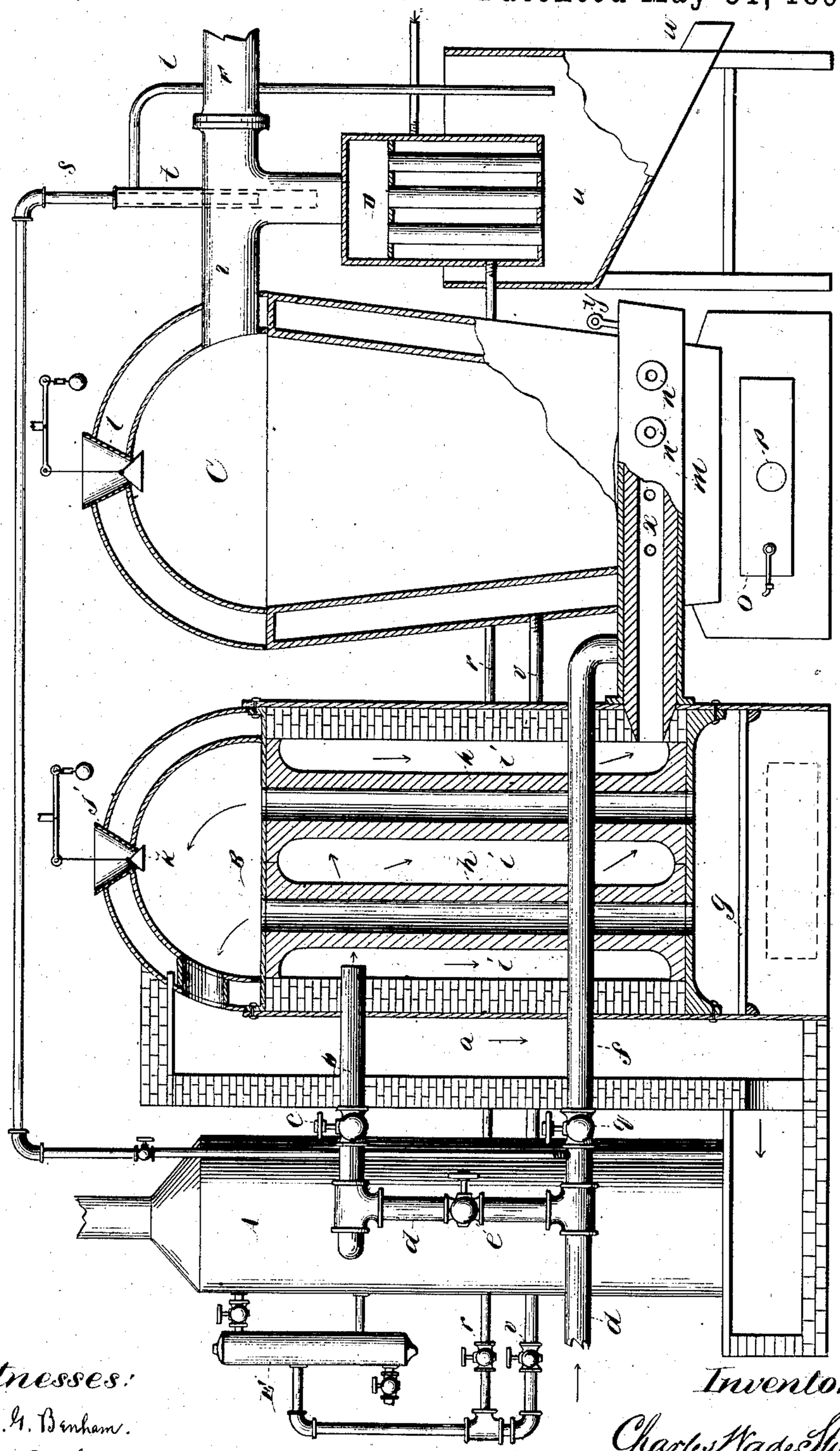
(No Model.) 2 Sheets—Sheet 1.

C. W. STICKNEY.

PROCESS OF ROASTING ORES.

No. 475,824. Patented May 31, 1892.



Witnesses:
W. G. Benham.
G. D. Stickney.

Inventor:
Charles Wade Stickney

(No Model.) 2 Sheets—Sheet 2.

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Fig. 2.

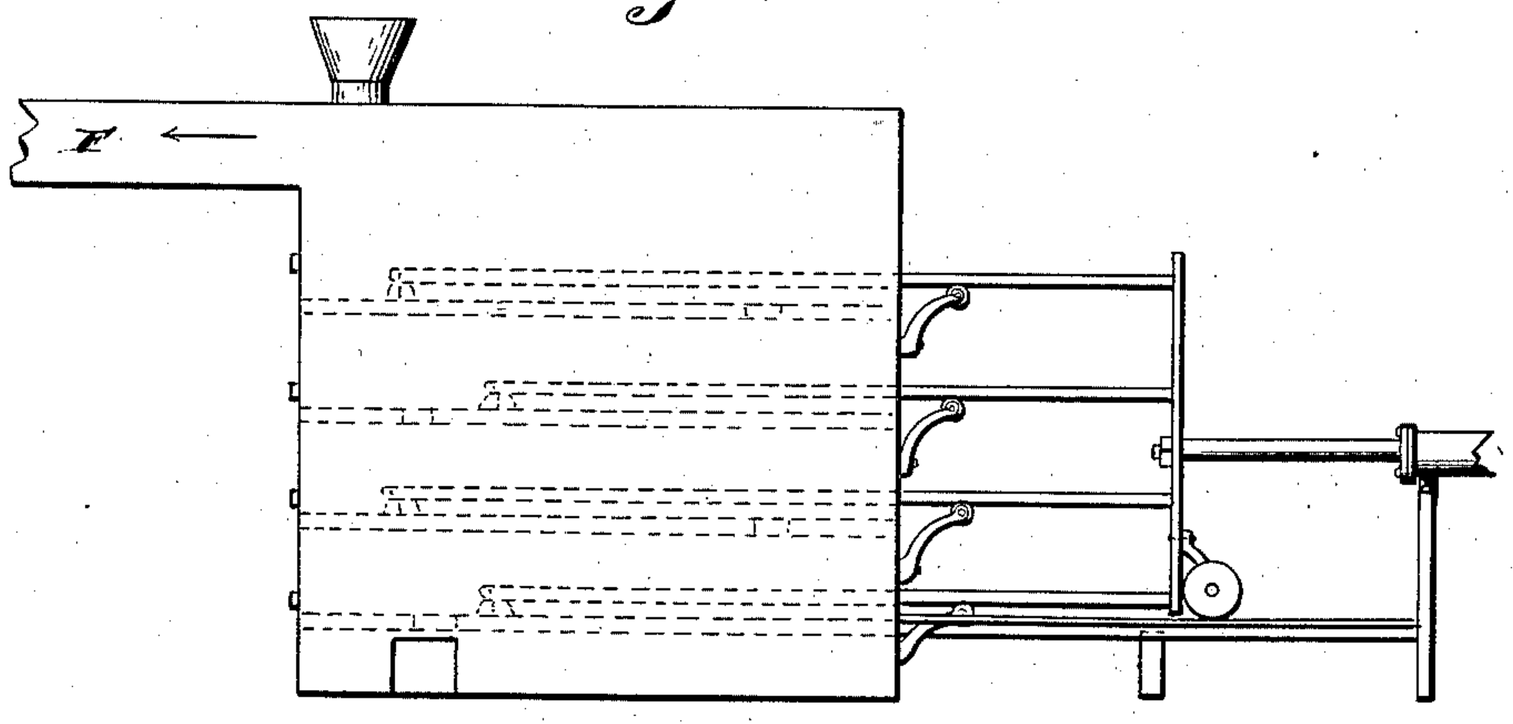
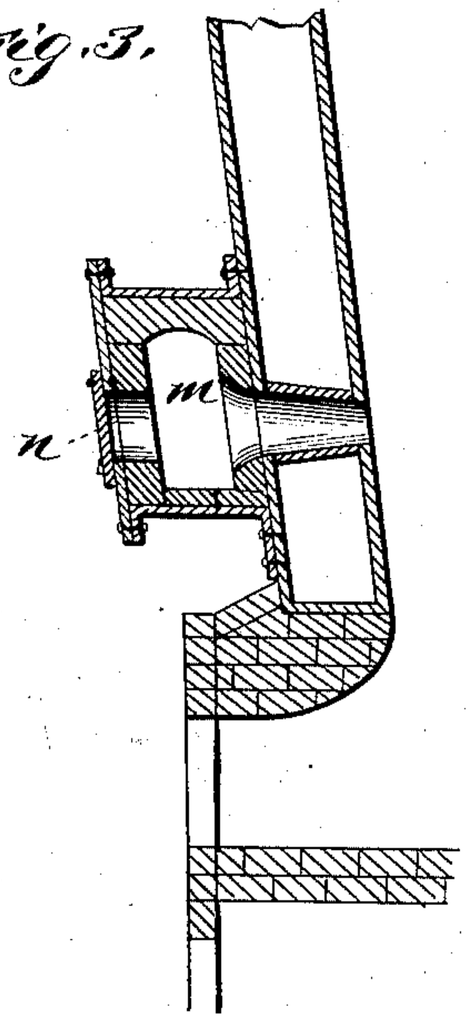


Fig. 3.



Witnesses:

W. G. Bingham.

G. A. Stickney.

Inventor:

Charles Wade Stickney

UNITED STATES PATENT OFFICE.

CHARLES WADE STICKNEY, OF BUTTE CITY, MONTANA.

PROCESS OF ROASTING ORES.

SPECIFICATION forming part of Letters Patent No. 475,824, dated May 31, 1892.

Application filed December 29, 1890. Serial No. 376,185. (No specimens.)

To all whom it may concern:

Be it known that I, CHARLES WADE STICKNEY, a citizen of the United States, residing at Butte City, Montana, have invented a certain new and Improved Process for Roasting Ores, of which the following is a specification.

My invention is an improvement on the process of roasting ores preparatory to smelting by means of steam, or by steam and air, by converting the contained sulphur into sulphureted hydrogen and sulphurous-acid gas and the mingling of these gases under new and peculiar conditions, and thereby precipitating the sulphur in solid and ready-settling form, whereby the roasting of the ore ceases to be a nuisance and leaves the ore in proper condition for smelting.

I am aware that ore has been roasted by steam, and also by steam and air combined, and that superheaters have been used for this purpose. The difficulty and impracticability of such processes have been that the superheaters were made of metal, and while they would work at temperatures below a red heat and either convert the ores into sulphates or mechanically carry off a large part of the sulphur they cannot economically roast the ores to such a low per cent. of sulphur as to fit them for smelting for the base metals for the reason that when the sulphur has been reduced to below fifteen per cent. the ore is so reduced in heat that the steam is not fully decomposed, and in consequence a large part of the ore escapes complete desulphurization unless the steam be made red-hot before entering the ore. Superheaters of metal at a red heat themselves decompose the steam and rapidly oxidize. I have obviated this difficulty by the material and peculiar construction of my superheater, using an outside metal casing or frame to resist pressure and a non-metallic non-oxidizable refractory lining, and exposing a very large intensely-heated surface in the interior.

I am also aware that ore has been roasted by steam and air in such manner as to produce sulphureted hydrogen and sulphurous-acid gas in such proportions that they will unite and drop their sulphur when brought into contact with water where the sole object was to get the sulphur. The difficulty of using this process for smelting purposes is that it cannot roast close enough without using a separate superheater, which can maintain the steam at red heat independent of the temperature of the ore, and also that the sulphur so formed is in the form of a powder so impalpable as to form a sort of milk from which the sulphur will not settle in any reasonable time, making the process impracticable where there is but little water and no water-shed which can be used to run off the milk without being a nuisance to thousands of people. To obviate this difficulty, I make use of the action of sulphate of alumina for causing the sulphur to aggregate in coarse particles and readily settle, leaving the water clear to be used over again without loss of or chemical action upon the salt.

In the drawings, Figure 1, A shows a steam-generator; B, the superheater, having a heating-chamber *i*. *m* shows the steam and air duct leading to the ore-furnace C. *z* is the gas-escape pipe. *s t* are pipes forming the atomizer. *u* is the tank for solution of salts. D is the cooling-boiler. F is the connecting-pipe, leading gas from an ordinary Spence air-roasting furnace. (Shown in Fig. 2.)

Fig. 3 shows a cross-section of the air and steam duct *m*.

The construction is as follows: The steam-generator is an upright boiler, through the flues of which the smoke and waste heat from the superheater B are made to pass by the flue *a*. From this boiler a pipe *b*, controlled by a valve *c*, conveys the steam to the superheater. Into the pipe *b* leads a pipe *d* from an air-blast controlled by a cock *e*, and from the pipe *d* branches off a pipe *f*, with a control-valve, which leads directly to the tuyeres of the ore-furnace.

B is the superheater. Both material and construction of this are important. It must be of non-metallic refractory non-oxidizable material and heavily ironed externally, easily charged with coal or coke, and expose a large heated surface internally. I prefer to make it of boiler-iron and line it with fire-clay bricks and fire-clay mortar. It has a grate *g* and an ash-pit below. Above the grate it has iron girders, which support several pipes made of fire-clay *h h*, &c. These pipes stand on end and extend to near the top of the heater. The interiors form flues for the fire and the ex-

teriors form the heating-surface of the superheating-chamber *i*. These pipes are molded with square tops or collars and similar bottoms, so that when stood up together the tops and bottoms form ceiling and floor of the heating-chamber, which are then covered with a layer of fire-clay. The flues may have an iron pipe for inside lining. A top piece covers the ceiling, (except the flue-holes,) which is bolted to the base by long rods. The top of the superheater is a brick arch. At the apex is set a hopper *j*, closed with an inverted conical pan K, made of boiler-iron, closing the aperture tight after the coal is let in. The coal dumped into the hopper *j* is allowed to fall through the flues into the fire-box. The heating-chamber *i* has no communication with the fire-box or flues. From the heating-chamber *i* an iron flue lined with fire-brick leads around the base of the ore-furnace C, which is an ordinary water-jacketed furnace having an arched top of fire-brick surmounted by a hopper and cone-stopper *l* similar to those on the top of the superheater. This is the means for charging the furnace with ore. The steam-tuyeres X are upon one side of the furnace and the air-tuyeres on the other side.

The object of the split in the blast-pipe is this: When the ore in the furnace contains a great deal of sulphur, the air is advantageously turned in cold; but when the bulk of the sulphur is eliminated and the ore becomes too cold to decompose the steam the air may then be turned in through the superheater. In the latter case a damper *y* in the base-duct *m* is opened, allowing both steam and air to enter together both sides of the furnace.

On the outside of the base-duct *m* and opposite each tuyere-hole there is a series of holes *n n*, &c., usually closed by a plug or plate, but which can be readily opened and a rod inserted into the furnace for breaking up any crusts that may form.

Just below the duct *m* is a door *o* for removing the roasted ore. In the door is a tap-hole *p*. In running some ores it is advantageous to raise the heat sufficiently to melt the roasted ore and run it out as a matte. The gases, sulphureted hydrogen, and sulphurous-acid gas are formed from the steam and sulphur, while the air oxidizes the ore, the relative quantities being carefully regulated to produce this result. The gases escape into a fire-clay duct *z*, where they meet with a cloud of atomized water holding in solution sulphate of alumina. The manner of producing this cloud is to convey a jet of air or steam from the air-blast or boiler into the duct *z* by a pipe *s*, and unite the latter with a pipe *t* (preferably non-metallic) for water, so that the jet blows out of pipe *t* near its end. The other end of pipe *t* extends down into the tank *u*, which is filled with the solution, which is thus drawn up and atomized in the duct *z*. The latter leads down into the tank *u* below the water-level. In some cases, however, it is advisable to pass the gases and atomized water through the flues of a boiler D, supplied with cold water, and in case it is not desired to save the sulphur the tank and salts may be omitted and the sulphur blown out through the cooler flues into the air, and subsequently treated mechanically to extract metallic dust. If the tank and salts are used, the heat of the gases evaporates the water, keeping up the strength of the solution. The boiler is used so that heat is saved to return to the boiler generating steam. The latter may then draw a hot-water supply from the boiler D by means of an injector E and the pipe *r*, or may draw from the water-jacket of the furnace by a pipe *v*. The temperature of the water-jacket is controlled in the usual way with blast-furnaces.

The operation is as follows: Ore is charged into the furnace and coal into the superheater, a fire having been started in the latter. When the pipes are red-hot and steam up, the steam valve is opened, and entering the superheater is raised to or above 1000° Fahrenheit, and thus entering the ore it is decomposed, forming sulphureted hydrogen and sulphurous-acid gas. Air is then turned in, producing oxides of the metals and more sulphurous-acid gas. Theoretically the reactions are as follows:

$$9FeS_2+3CuS_2+16H_2O+6(O-O) \text{ produce } 9FeO+3CuO+16H_2S+8SO_2.$$

The gases pass out into the duct *m*, where they meet and mingle with the cloud produced by the atomizer carrying the salts in solution. The sulphur precipitates in a ready-settling form and settles in the bottom of the tank and, after some accumulation, is drawn off at *w*, washed, and the washings returned to the tank, in order to lose as little of the salts as possible. The sulphur is removed from the metallic dust by a simple and rapid method of concentration by reason of its slight specific gravity. The reaction by which it is precipitated is as follows:

$$16H_2S+8SO_2=16H_2O+24S.$$

Practically the smell of the tank is the test for regulating the steam and air. When just right, there is practically no odor a short distance away.

I do not claim, broadly, the process of generating sulphureted hydrogen from the ore by means of steam, and sulphurous acid by means of air, and the precipitation of the sulphur by means of water or steam jets, for I am aware that this has been done where the sole object was to get the sulphur, and the residue was worthless for metal; but my combination of a superheater for the steam which will bear a red or higher heat without being rapidly eaten out makes it possible to deposit the sulphur in solid form, and at the same time leave valuable metal ores in a fit state for smelting to extract the metallic contents. My method, also, of causing the sulphur to rapidly settle is new in the process of ore-roast-

ing. In my process I use sulphate of alumina, as it gives a cheap method of keeping up the strength of the solution in the atomized water and tank, so that it is not necessary to wash the sulphur to recover the salts. I dissolve sulphate of alumina in the tank; but instead of renewing it I mingle in any convenient way a small stream of water with the solution coming out of the atomizer, holding in suspension a clay having a large per cent. of hydrate of alumina. I regulate the air so that there shall be a slight excess of sulphurous-acid gas arriving at the atomizer. The latter, used with an air-blast or air mingled with steam, generates small quantities of sulphuric acid, which, reacting on the clay, forms sulphate of alumina, thus making up the loss caused by some of it adhering to the removed sulphur. The sulphur can then be removed from the metallic dust by melting, while the metallic dust settles to the bottom. If the sulphur is desired for use, it can be obtained free from clay by distillation.

In case air-roasting furnaces are already built and it is desired to destroy the noxious fumes from these their gas-outlets are joined with the gas-exit duct of my furnace, as shown at F. Steam alone is then let into my furnace. This causes one-half the sulphur to distill in solid form, vaporized, and the steam to divide between the ore and the remaining sulphur, giving the reaction:

$$3FeS_2+CuS_2+4H_2O=3FeO+CuO+4S+4H_2S.$$

Two tons are roasted in my furnace to dispose of the gas in one ton in ordinary air-roasters; but this is made easy from the great rapidity of action of my furnace when working the steam at or above a red heat.

I am aware that superheaters for steam comprising tubes of fire-clay have been used in the process of making oil and water gas; that ducts of refractory material have been used to convey hot gases or vapor to and from ore-kilns, and that outer openings have been used in the wind-chest to pigment-furnaces; that in the manufacture of coal, oil, and water gas water-jackets have been used around a furnace and pipes run from thence to supply hot water to the steam-generator. I do not claim any of these, except as above described, in connection with the process of roasting ores and depositing the sulphur in solid form.

I am not aware that any process of roasting ores for smelting has ever been heretofore invented or used which gets the steam to a red heat in a separate heating-chamber before entering the ore and also deposits the sulphur at the furnace-exit in solid form, nor that in any process of ore-roasting mineral salts in solution have ever been used to cause the sulphur to readily settle. I am not aware that sulphate of alumina has ever been used in any process to cause finely-divided sulphur to agglomerate.

I claim, in a process for desulphurizing ores and depositing the sulphur in solid form, the following:

1. The process which consists in generating steam in a boiler, passing it into a chamber maintained at a red or higher heat, and thence through suitable ducts into a separate furnace containing ore, and conducting the resulting gases into a cloud of atomized water holding sulphate of alumina in solution, substantially as described.

2. The process which consists in generating steam in a boiler, passing it into a chamber maintained at a red or higher heat, and thence through suitable ducts into a furnace containing ore, and mingling the resulting gases in contact with a solution of sulphate of alumina, substantially as described.

3. The process which consists in injecting steam at a red or higher heat into a furnace containing ore, whereby sulphureted hydrogen is generated, roasting another portion of ore by means of air, whereby sulphurous-acid gas is generated, and mingling these gases in contact with a solution of sulphate of alumina, whereby the sulphur precipitates in coarse and ready-settling particles, substantially as described.

4. The process which consists in injecting steam at a red or higher heat into a furnace containing ore, whereby sulphureted hydrogen is generated, and roasting another portion of ore by means of air, whereby sulphurous-acid gas is generated, and mingling these gases in contact with water holding clay in suspension, whereby sulphate of alumina is generated and its solution mingled with the gases, substantially as described.

CHARLES WADE STICKNEY.

Witnesses:
G. I. STICKNEY,
W. W. WESHON.