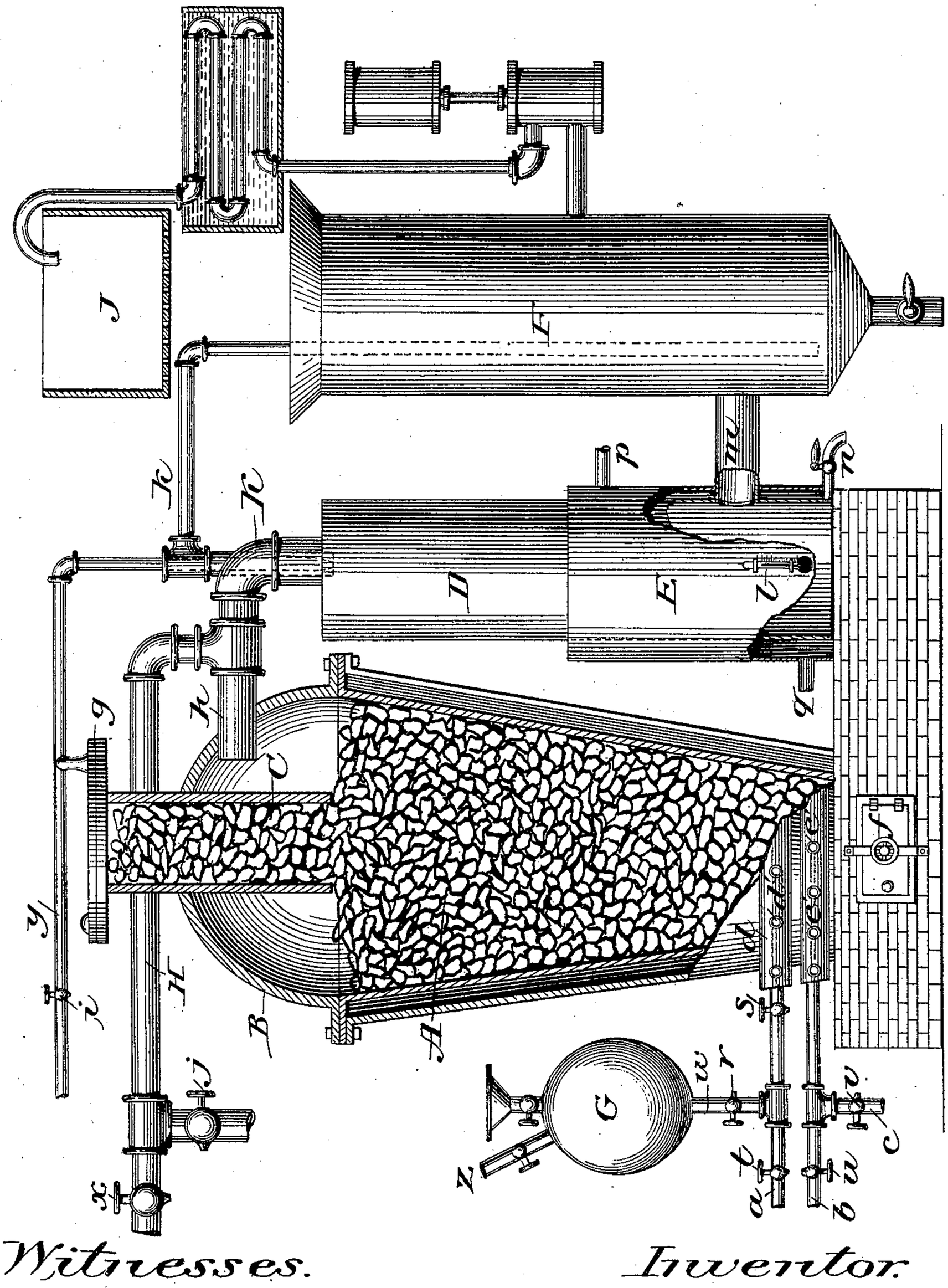
(No Model.)

# C. W. STICKNEY.

## PROCESS OF AND APPARATUS FOR ROASTING ORES.

No. 587,068. Patented July 27, 1897.




Witnesses.

Rolla B. Gaple.

G. D. Stickney.

Inventor.

Charles Wade Stickney.

# UNITED STATES PATENT OFFICE.

CHARLES WADE STICKNEY, OF KETCHUM, IDAHO.

## PROCESS OF AND APPARATUS FOR ROASTING ORES.

SPECIFICATION forming part of Letters Patent No. 587,068, dated July 27, 1897.

Application filed January 4, 1894. Serial No. 495,692. (No model.)

*To all whom it may concern:*

Be it known that I, CHARLES WADE STICKNEY, of Ketchum, in the county of Alturas and State of Idaho, have invented certain new and useful Improvements in Processes of and Apparatus for Ore-Roasting, of which the following is a specification.

My invention is of the class of ore-roasting which has for its object the separation and saving of the sulfur in ores in a solid form, and is a modification and improvement upon my United States Patents of May 31, 1892, No. 475,824, and January 2, 1894, No. 512,235.

It relates, primarily, to the method of keeping the ore at a red heat and at the same time generating the sulfureted hydrogen and sulfurous-acid gases in such proportion that there is no great loss of sulfur in the gaseous form. Other processes attempting to recover solid sulfur have been commercially impracticable because of this loss, which results from the large proportion of air necessary to keep up the heat, resulting in a great excess of sulfurous acid. In my patent of January 2, 1894, No. 512,235, I have kept up the heat by heating the exterior of the furnace. I have found it to be advantageous to heat the ore by using limited quantities of fuel and air burned inside the furnace in such proportions to the steam that there is no excess of either sulfureted hydrogen or sulfurous acid formed. It is easier to regulate these proportions than to superheat the steam and apply external heat to the furnace.

My invention differs from smelting operations in that it limits the proportions of fuel, steam, and air, so that the ore never attains a smelting temperature, which would at once stop the roasting. It differs from all roasting heretofore done in that it uses fuel to keep up the temperature and steam and air in just the proportions necessary to generate the proportions of sulfureted hydrogen and sulfurous-acid gas necessary to bring down the sulfur in solid form. This general process applies whether the fuel is used in the solid, liquid, or gaseous form. The primary form is the use of coal where the fuel is used merely to keep up the proper temperature. As an improvement on this I use a fuel composed largely of hydrogen, which, when burned with the proper proportion of air in contact with red-hot ore, not only keeps the ore at red heat, but produces steam at red heat. As gaseous fuels I use natural gas, coal-gas, water-gas, producer-gas, or petroleum vaporized or any of its derivatives. The choice of a fuel will depend on locality.

As another improvement I maintain such a temperature in the first precipitating-chamber as results in producing the sulfur in a liquid form and such a temperature in the second chamber or tank as results in a continued evaporation of the solution, so as to keep up its strength, which would otherwise become continually weaker from the water formed by the union of the two sulfur-gases, as

$$2H_2S+SO_2=2H_2O+3S,$$

and also that formed by liquid or gaseous fuel, as

$$CH_4+2O-O=CO_2+2H_2O, \text{ steam}.$$

To carry out the process I have also invented a furnace with attachments.

In the drawing the figure represents the furnace A with attachments, cap B, feed-chute C, cooling-chamber D, steam or water jacket to cooling-chamber E, tank F, liquid-fuel reservoir G, connecting-passage to ore-burners and air-blast H, and spraying-tank J.

A is an ordinary water-jacketed furnace, but differing therefrom by having a close-fitting cap B over the top, by which all casual and redundant air is excluded, and no air can enter except through the twyers below. There are two sets of twyers, each set leading from a separate wind-chest *d* and *e*, each set being designated as *d'* and *e'*, respectively. A door *f* serves to withdraw the roasted ore, which screws up tight. The cap B is provided with a funnel C, which feeds the ore as fast as it is withdrawn below, and feed-chute C is closed air-tight by a heavy plate *g*, ground on the flange of C, which may be swung to one side when filling the funnel with ore. Any other device may be used for feeding and for excluding the air after filling, as shown in my Patent No. 475,825, dated May 31, 1892.

G is a tank for liquid fuel, connected by a pipe *w* with one set of twyers *d'* and controlled by cocks *r* and *s*. The other set of twyers *e'* is connected by pipe *b* with a source

of steam controlled by cock *u*, and connected by pipe *c* with the source of an air-blast controlled by cock *r*. The first set of twyers also is connected by pipe *a* with a source of gaseous fuel controlled by cock *t*.

The gas exit of the furnace is through the large pipe or flue *h*, which enters the top of the cooling-chamber D. Into *h* runs another pipe H, which branches, the branches being controlled respectively by cocks *x* and *j*.

Passage H may or may not be used according to the method of running the furnace, but when used one branch is connected with a source of sulfurous acid, controlled by cock *x*, and the other branch with the source of an air-blast controlled by cock *j*.

D is the first precipitating-chamber and is provided with means for keeping the temperature at about 250° Fahrenheit. The means may be the water-jacket E, as represented, or a cold or hot spray directed against the exterior, or a coil inside. In case the chamber D is too large or the weather too cold for the incoming gases to keep it above 239° Fahrenheit, the coil or water-jacket may be emptied of water and used for steam to bring the temperature up.

K is an atomizer, consisting of a pipe *y* from a steam or air blast, terminating just inside the outlet of a solution-pipe K, which has its other end immersed in the solution in tank F. This atomizer is placed inside the furnace-exit pipe *h*, near its debouchment into chamber D. A thermometer *l* is placed on water-jacket E, near its bottom, communicating with the surface of chamber D, so that the temperature of the inside of the chamber-walls may be readily known.

At the extreme bottom of chamber D a cock *n* is placed to draw off the liquid sulfur. Somewhat above the bottom of chamber D a large passage *m* connects it with the second precipitating chamber or tank F, which is adapted for holding a solution in its bottom part. The solution may be any cheap soluble sulfate, such as the sulfates of alumina, ammonia, iron, &c., as given in my former patents. I have found sulfate of alumina to give best results.

J is a tank with perforated bottom to which the solution in tank F is continually pumped, returning in a shower into tank F. This shower, while it causes more of the gases to unite and drop sulfur, is also an additional means of controlling the temperature of chamber D as well as of tank F. If showered lightly, the temperature in both is higher than if the shower is denser. The gases coming through the passage *m* are at 250° Fahrenheit and the evaporation goes on at the top of chamber F. The degree of evaporation may be controlled by any convenient device, such as passing the solution through a cooling-coil on its way to tank J.

The process is as follows: If the fuel is coal or charcoal, it is fed into the furnace with the ore, of which it may form as high as five per cent. If liquid fuel is used, it is placed in tank G and the quantity regulated by cocks *r* and *s*, a pressure being maintained on top of the liquid by an air-blast through pipe Z, or, preferably, by an air-pump delivering compressed air through pipe *z*. The quantity of liquid fuel is regulated according to its effect in keeping the ore at red heat, but not melting it. If the fuel is gaseous, it is fed from a reservoir under pressure through the pipe *a* and its quantity is regulated by cock *t*, according to its effect in keeping the red but not melting heat. Practically the liquid fuel is a gaseous one by the time it reaches the twyers. The peep-holes in the outer casing of the wind-chest *d* are stopped with glass or mica eyes, through which the heat can be observed without opening them.

The fuel having been introduced into the furnace the air is turned on until a medium red heat is obtained in the ore at the twyers. Steam is then turned in cautiously. As soon as the red heat begins to grow dull more air is turned in. If gaseous fuel is used, more of this is turned in at the same time with the air. When the heat goes up to a bright color, more steam is let in. When five per cent. of coal is used, more air invariably produces more heat. More steam decreases it. When liquid or gaseous fuel is used, if more air does not bring up the temperature more fuel is called for, and if more air produces more heat, but a smell of sulfurous acid in the tank, the remedy is more gaseous fuel. When the proportions are right between fuel, air, and steam, the peep-holes show a moderate red heat and there is no preponderating smell of either sulfureted hydrogen or sulfurous acid in the tank-vapors. In this state of regulation there is coming off at the furnace-exit two volumes of sulfureted hydrogen to one of sulfurous acid and a considerable quantity of free sulfur-vapor. As soon as the mixed gases strike the atomizer-spray their temperature is reduced to 212°, the sulfur is condensed, the two sulfur-gases for the most part unite, forming water and sulfur, and the sulfur from both sources flies to the walls of the chamber, which are regulated to a temperature above 239° and below 300° Fahrenheit, (preferably about 250° Fahrenheit.) The sulfur melts and runs down the sides and is drawn off by cock *n*. The furnace-gases carrying yet considerable sulfur in the form of the gases named in the proper proportion pass with the steam formed in chamber D into tank F, and on their way out at the top they pass through the shower of solution from tank J and almost all the sulfur is thrown down, leaving only carbonic acid and steam to escape. The water formed in the process is thus continually evaporated, keeping up the strength of the solution.

There are two modifications of the process, resembling somewhat the processes heretofore patented by me, but differing from them in the matter of using fuel burned in contact

with the ore and more especially in the use of liquid and gaseous fuels. These are improvements on the foregoing. First, by using more solid fuel and less air and more steam I produce a large excess of sulfureted hydrogen. By using more gaseous fuel composed largely of hydrogen, as petroleum vaporized, which has about four atoms hydrogen to one of carbon, and less air and little steam or none at all, I also produce sulfureted hydrogen in large excess. This I treat in two ways: First, by turning an air-blast into the passage H through cork *j*, I produce the sulfurous-acid gas in the proper proportion to sulfureted hydrogen,

$$3H_2S+3O=2H_2S+SO_2+H_2O,$$

or since the gases probably unite at once perhaps a better way of explaining the facts would be to say I burn the hydrogen and leave the sulfur unburned,

$$2H_2S+O-O=2H_2O+2S.$$

The second way of treating this excess of sulfureted hydrogen is to turn into the pipe H through the cock *x* one volume of sulfurous-acid gas (derived from any of the many forms of independent air-roasting furnaces or kilns or stalls) to two of the sulfureted hydrogen produced in my furnace,

$$2H_2S+SO_2=2H_2O+3S.$$

The results of these modifications are the same in the condensing chamber and tank.

I am aware that steam and air have been injected into contact with ore at red heat, either alternately or mixed, to produce gases which will deposit sulfur. I have found it to be commercially impracticable by reason of the impossibility of keeping the ore at red heat unless the air be so greatly in excess as to produce a great excess of sulfurous-acid gas, entailing a loss of about one-half the sulfur in gaseous form. In my patent of January 2, 1894, No. 512,235, I keep up the heat by heating the outside of the furnace and superheating the steam. In this present invention I use ordinary steam and burn fuel in contact with the ore and generate the gases in proper proportion and maintain a red heat by limiting the air and fuel to proper proportions to produce the solid sulfur.

I am aware that fuel—solid, gaseous, and liquid—has been burned in contact with ore in smelting operations. No sulfur in solid form is thus produced, the sulfur at the furnace-exit being in gaseous form by reason of the excess of air present in such operations, not only entering by the twyers but also as casual and redundant from the feed-doors.

I am not aware of any process which burns fuel in contact with ore with air and steam in such proportions as to produce no excess of either sulfureted hydrogen or sulfurous acid, nor of any which burns gaseous fuel in contact with ore in such proportion to air as to produce no excess of either of the gases named for the production of solid sulfur.

The essential features of my invention lie in the discovery that a certain proportion must exist between the agencies fuel, air, and steam in order to produce the greater part of the sulfur in solid form. These proportions might be stated, but would be more or less theoretical, and they are more practically determined by the tests given above from their results in the tank-vapors.

With some ores which have a great tendency to sinter agitating the ore is an improvement, in which case the apparatus described in patent issued to me January 2, 1894, No. 512,235, may be used, some of the twyers being used for steam and some for air and some for liquid or gaseous fuel.

In localities where oil or natural gas is cheap it is advisable to use a small amount of coal or charcoal mixed with the ore and inject the gas also or the petroleum vaporized. By this means the heat is more quickly and easily controlled, while the greater part of it is furnished by the cheaper fuel, and the liquid or gaseous fuel may be injected by any of the many forms of air-injectors operated by a steam jet. The air may also be injected by a steam jet.

I claim—

1. The process of recovering sulfur in solid form from ore, by forcing currents of steam, and air under pressure, and gaseous fuel, composed largely of hydrogen under pressure, simultaneously into contact with the red-hot ore, and regulating the quantities of steam, air and fuel in such proportions that the ore is maintained at or above a red heat, while there is approximately no excess of either free sulfureted hydrogen, or free sulfurous acid in the final resulting gases, and cooling the vapors below the vaporizing-point of sulfur, substantially as described.

2. The process of recovering sulfur in solid form from ore, by forcing currents of steam and air under pressure and gaseous fuel composed largely of hydrogen under pressure simultaneously into contact with the red-hot ore, and regulating the quantities of steam, air and fuel in such proportions that the ore is maintained at or above a red heat, while there is approximately no excess of either free sulfureted hydrogen or free sulfurous acid in the resulting gases, and cooling the vapors below the vaporizing-point of sulfur and bringing the final vapors into intimate contact with the solution of a mineral salt, substantially as described.

3. The process of recovering sulfur in solid form from ore by forcing currents of steam and air under pressure and gaseous fuel, composed largely of hydrogen under pressure simultaneously into contact with the red-hot ore, and regulating the quantities of steam, air and fuel in such proportions that the ore is maintained at or above a red heat, while

there is approximately no excess of either sulfureted hydrogen or free sulfurous acid in the resulting gases, and cooling the vapors below the vaporizing-point of sulfur and simultaneously agitating the ore by mechanical means, substantially as described.

4. The process of recovering sulfur in solid form from ore by forcing currents of air under pressure and a gaseous fuel composed largely of hydrogen under pressure simultaneously into contact with the red-hot ore, and regulating the quantities of steam formed from the fuel and air and the remainder of the air injected in such proportions that there is approximately no excess of either free sulfureted hydrogen or free sulfurous acid in the final resulting gases and cooling the vapors below the vaporizing-point of sulfur, substantially as described.

5. The process of recovering sulfur in solid form from ore by forcing currents of air under pressure and a gaseous fuel composed largely of hydrogen under pressure simultaneously into contact with the red-hot ore, mixed with a solid fuel and regulating the quantities of steam, formed from the fuel and air, and the remainder of the air injected, in such proportions that there is approximately no excess of either free sulfureted hydrogen or free sulfurous acid in the final resulting gases and cooling the vapors below the vaporizing-point of sulfur, substantially as described.

6. In apparatus for roasting ore, a closed ore-receptacle provided with means for feeding it with ore and for excluding casual and redundant air, and with twyers, connected by conduits with sources of air under pressure greater than atmospheric pressure, and gaseous fuel under pressure and having a gas-exit conduit leading into a cooling-chamber, substantially as described.

7. In an apparatus for roasting ore, a closed ore-receptacle provided with means for feeding it with ore and for excluding casual and redundant air, and with twyers connected by conduits with sources of air under pressure greater than atmospheric pressure and gaseous fuel under pressure and steam, and having a gas-exit conduit leading into a cooling-chamber, substantially as described.

8. In an apparatus for roasting ore, a closed ore-receptacle, provided with means for feeding it with ore and for excluding casual and redundant air, and with twyers, connected by conduits with source of air under pressure and gaseous fuel under pressure and having a gas-exit conduit leading into a cooling-chamber, with means for keeping said chamber at a temperature below the vaporizing-point of sulfur and for keeping the walls of said chamber above the melting-point of sulfur, substantially as described.

9. In an apparatus for roasting ore, a closed ore-receptacle provided with means for feeding it with ore and for excluding casual and redundant air, and with twyers connected by conduits, with source of steam and of air under pressure greater than atmospheric pressure, and having a gas-exit conduit connected with a conduit from the source of an air-blast and leading into a cooling-chamber, substantially as described.

10. In an apparatus for roasting ore, a closed ore-receptacle provided with means for feeding it with ore and for excluding casual and redundant air, and with twyers connected by conduits with sources of steam, of air under pressure greater than atmospheric pressure and gaseous fuel and having a gas-exit conduit connected with a conduit from the source of an air-blast and leading into a cooling-chamber, substantially as described.

11. In apparatus for roasting ore, a closed ore-receptacle, provided with means for feeding it with ore and for excluding casual and redundant air, and with twyers connected by conduits with sources of air under pressure greater than atmospheric pressure and gaseous fuel and having a gas-exit conduit connected with a conduit from a source of sulfurous-acid gas and leading into a cooling-chamber, substantially as described.

12. In an apparatus for roasting ore, a closed ore-receptacle provided with means for feeding it with ore and for excluding casual and redundant air and with twyers connected by conduits with sources of steam, air under pressure greater than atmospheric pressure and gaseous fuel, and having a gas-exit conduit connected with a conduit from a source of sulfurous-acid gas and leading into a cooling-chamber, substantially as described.

In testimony whereof I have hereunto set my hand in the presence of two witnesses.

CHARLES WADE STICKNEY.

Witnesses:
A. C. McMillan,
G. I. Stickney.