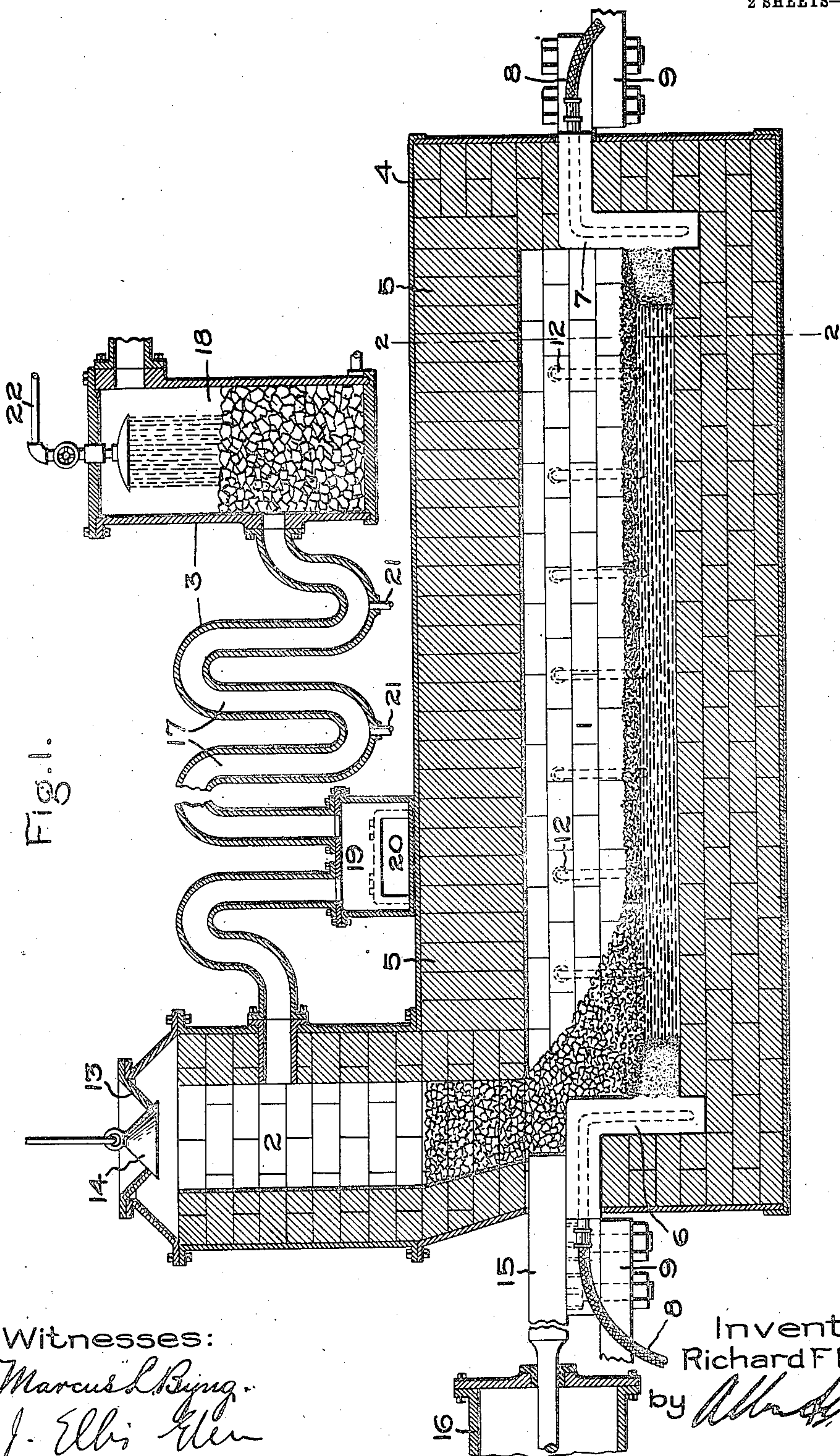


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SMELTING SULFUR ORES.  
APPLICATION FILED JUNE 20, 1908.

945,926.

Patented Jan. 11, 1910.

2 SHEETS—SHEET 1.



Witnesses:  
Marcus L. Bying.  
J. Ellis Allen

Inventor:  
Richard Fleming,  
by *Alfred J. Davis*  
Att'y.

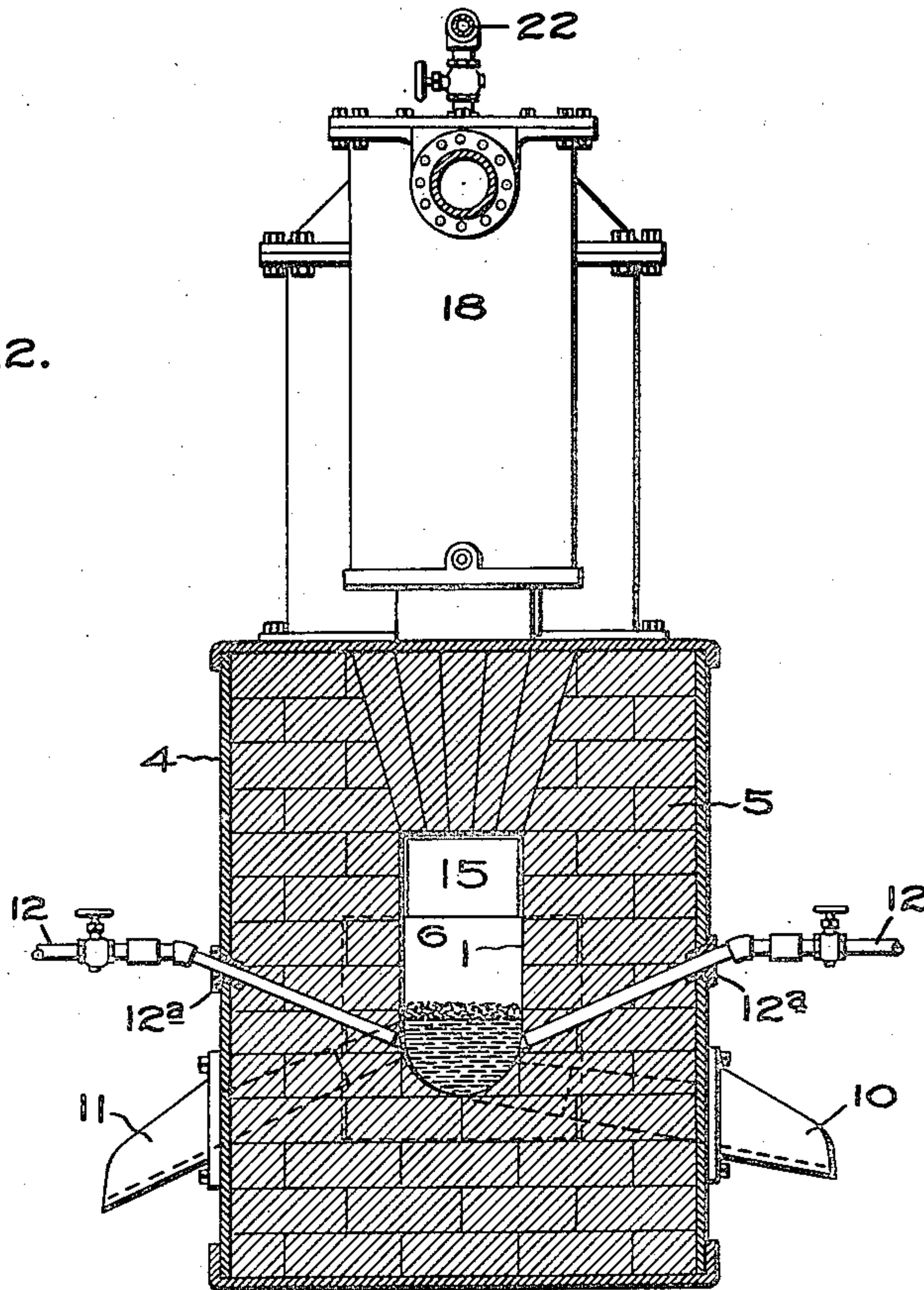


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Fig.2.



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Richard Fleming,  
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# UNITED STATES PATENT OFFICE.

RICHARD FLEMING, OF SWAMPSCOTT, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

## SMEETING SULFUR ORES.

945,926.

Specification of Letters Patent.

Patented Jan. 11, 1910.

Application filed June 20, 1908. Serial No. 439,521.

*To all whom it may concern:*

Be it known that I, RICHARD FLEMING, a citizen of the United States, residing at Swampscott, in the county of Essex and State of Massachusetts, have invented certain new and useful Improvements in Smelting of Sulfur Ores, of which the following is a specification.

My invention relates to a method of smelting ores containing sulfur. It effects removal of nearly all of the sulfur, which is recovered as a by-product, and results in the production of a nearly pure metal. In some of the present methods of smelting these ores the sulfur is burned, and the noxious fumes, which escape constitute a serious nuisance in the vicinity of the smelter. My procedure not only eliminates this nuisance, but recovers a valuable product. Other impurities, such as zinc and arsenic, are recovered with the sulfur, and are subsequently purified.

As will be hereinafter more fully described, my process is carried on in a totally inclosed furnace capable of continuous operation. It is important to carry on the smelting in an inclosed space so as to avoid escape of the vapors, and oxidation of the same. As the walls of the furnace are made relatively thick, it possesses a high heat efficiency, which is especially desirable as the smelting is carried on while the ore is in a fused state. The heat necessary to melt the ore and maintain the same in fusion during the smelting operation is generated in the interior of the furnace by means of electrical energy. This method of heating makes it possible not only to keep the ore out of communication with the atmosphere but enables the highly corrosive melted mass to be confined by thick walls of refractory material. Furthermore, the heat is generated just where it is needed, and may be readily regulated to suit the conditions of the smelting operation.

The furnace in which my process is carried out is illustrated in the accompanying drawing, of which—

Figure 1 is a longitudinal section and Fig. 2 is a cross-section along the line 2—2.

The features of novelty of my invention will be pointed out in the appended claims.

I will first proceed to explain the construction of the furnace used in connection with my invention, and then will explain

the smelting operation itself as carried out in this furnace.

Similar numerals in all cases refer to similar parts.

As shown best in Fig. 1, the furnace consists of a smelting chamber 1, a charging chamber 2 in communication therewith, and a condensing chamber 3, which in turn is in communication with the charging chamber. The casing 4 of the smelting chamber and charging chambers is lined with a thick layer of refractory brick 5. In the case of certain ores, which are basic in character, this refractory lining is best made of basic material, such as chromite or magnesia, as a silicious or acid lining would be rapidly attacked by the charge. The smelting chamber is provided at each end with electrodes 6, 7. These electrodes can be made of some metal, as copper, cast about an iron pipe through which a cooling liquid is passed when the furnace is in operation. The cooling pipe has been shown in dotted outline in Fig. 1. The cooling solution is introduced into the ducts in the electrodes through the tubes 8. The leads 9, which are bolted to the electrodes and are shown as broken off in the drawing, pass to a suitable source of current.

The smelting chamber is provided with two drains, 10 and 11, as shown in Fig. 2, which enter the chamber at different levels so as to permit the matte, or metal, to be drawn off from the lower level or the slag from the upper level. A series of twyers, 12, lead into the smelting chamber from each side of the furnace for the introduction of a blast into the ore, as will be later explained in connection with the description of the smelting process. The twyers are insulated from the metallic casing by an insulating bushing 12<sup>a</sup>. The ore is introduced into the vertical charging chamber through the cup-shaped opening 13, which may be closed by raising the bell 14 by means of a motor, or in any suitable way. The lower end of the charging chamber is provided with a reciprocating piston 15, which may be directly connected to a stem cylinder 16, as diagrammatically indicated in the drawing. This piston or plunger serves to push the ore forward into the smelting chamber 1.

The condensing chamber 2 is somewhat diagrammatically shown as consisting of a



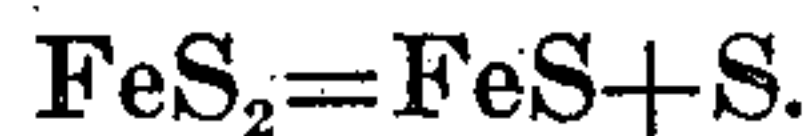
series of air-cooled coils 17 and a gas-washing chamber 18. As more or less solid material may condense in the anterior part of the condensing chamber, this part is provided with a dust chamber 19, of any desired size, which is provided with a vertically-opening door 20. As many of these chambers are added as required. The end coils of the condenser are provided with drains 21, as diagrammatically indicated, through which condensed liquid products may be drawn off. The gas-washing chamber 18 is filled with broken brick, or some other inert material, over which water is trickling, introduced through the pipe 22. Any gases which may be produced in the furnace and which are not condensed in the coils of the condensing chamber are here absorbed by the film of water on the broken material of the chamber. The condensing chamber has been shown broken in the central portion in order to indicate that it is to be made as large as necessary to suit the conditions. It may be water-cooled, if desired, instead of air-cooled.

Having now explained the construction of the furnace, I will proceed to set forth the steps of the smelting of the ore in said furnace.

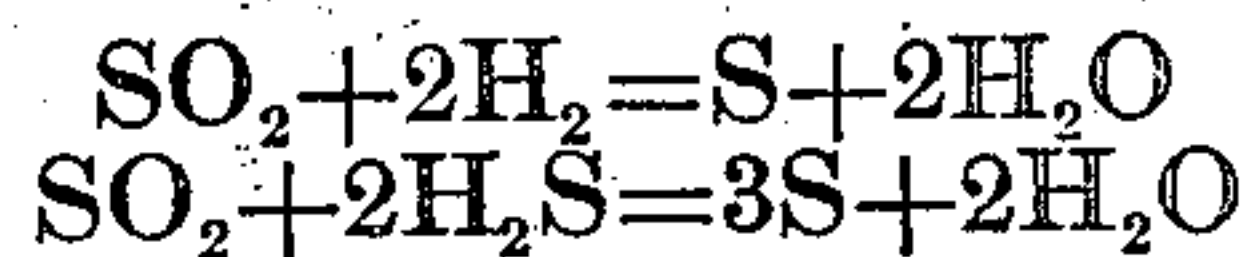
My process may be applied to a variety of ores containing sulfur with such slight modifications of treatment as will readily suggest themselves to those skilled in the art of metallurgy. However, for the purpose of illustration, I will explain the process in detail as applied to copper ores of the pyritic variety, although other ores, as, for example, lead sulfid or galena might have served almost equally as well for the purposes of illustration. Copper ores of this variety occur associated with iron pyrites, often with considerable amounts of the latter. They frequently contain zinc, arsenic, and other elements.

When the furnace is charged for the first time the ore may be melted independently and introduced into the furnace in a fused state, if desired, so as to distribute it continuously to the electrodes, or a bar of metal may be placed in the bottom of the furnace from electrode to electrode to serve as a heater, and thus melt the ore which is introduced in the solid state. In either case a continuous conducting layer covering the bottom of the furnace and extending from one electrode to another is to be obtained. In the case of the ores above mentioned, a certain amount of silicious material is introduced with the ore as a flux. This flux combines with the iron to form a slag, as will be later explained. A flow of cooling liquid, as water, is then started through the electrodes and a current sent through the charge. The charge if not already melted is liquefied by the heat generated by the

passage of the current. The chilled electrodes cause a certain amount of the charge to solidify on their surface, as indicated, thus protecting the electrode surface. When the temperature begins to rise, at first considerable sulfur is liberated, the iron pyrites losing one atom of sulfur according to the equation



Sulfur vapor passes up through the crushed ore in the charging chamber, to which it gives up part of its heat and then passes on into the condensing chamber or dust chamber where it is condensed. A blast of steam which may be superheated, is now introduced into the molten sulfid through the twyers 12. The steam decomposes the melted sulfids and drives out the sulfur, at the same time oxidizing the iron to form iron oxid. When sulfid ores at an elevated temperature are treated with steam there ordinarily is formed hydrogen sulfid. However, as the temperature is gradually raised an increasing per cent. of hydrogen sulfid is broken up into sulfur and hydrogen. In the vicinity of the temperatures employed in the present process this decomposition is almost complete, and the result of forcing steam into the melted bath results, therefore, in the formation of a certain percentage of hydrogen sulfid, and considerable amounts of sulfur and hydrogen. If desired, a certain amount of air may be forced into the melted sulfid together with the steam in order to completely oxidize the ores and furnish a certain amount of sulfur dioxid, which will interact with the free hydrogen as well as with the hydrogen of the hydrogen sulfid. Sulfur dioxid will interact with hydrogen and with hydrogen sulfid according to reactions, as given below to form sulfur and water.



As the reactions take place in the melted bath at high temperature they proceed rapidly. The sulfur vapor, watery vapor, together with vapors of other substances associated with the copper, such as arsenic and zinc, are carried off and condensed in the condensing chamber. They are further purified according to well known methods. Should there be any sulfur dioxid or possibly hydrogen sulfid which has not been decomposed it will be absorbed in chamber 18. The ferrous oxid  $\text{FeO}$ , formed by the interaction of the steam with the iron sulfid combines with the silica to form silicates of iron. The heat from the oxidation of the iron and the formation of the slag will furnish considerable heat at this stage of the smelting operation, which will aid in maintaining the bath in fluid state. The copper will settle



to the bottom of the furnace as a matte, containing some sulfur. The slag may now be partially withdrawn and an additional charge introduced into the furnace. The operation of blowing is repeated. When a sufficient amount of copper matte has accumulated in the furnace it may either be run off to another furnace to be finally purified, or it may be separately blown with either steam, or with steam and air, in the same furnace. It is finally drawn off as metallic copper containing a small amount of impurities.

In the case of lead ore, the smelting operation is carried on in much the same way, yielding as end products metallic lead and sulfur.

What I claim as new and desire to secure by Letters Patent of the United States, is,

1. The process of treating ores containing sulfur, which consists in melting said ore, electrically maintaining the ore in fusion out of communication with the atmosphere, forcing steam through the ore, and cooling the resulting vapors.

2. The process of treating ores containing sulfur, which consists in melting said ore, electrically maintaining the ore in fusion, forcing steam and air through the ore, collecting the resulting vapors, and cooling the same.

3. The process of treating ores containing sulfur which consists in electrically melting and electrically maintaining the ore in fusion, forcing steam through the ore, collecting the resulting vapors and cooling the same.

4. The process of treating ores containing sulfur which consists in electrically melting and electrically maintaining the ore in fusion, forcing currents of steam and air through the ore, collecting the resulting vapors, and condensing the same.

5. The process of treating sulfid ores which consists in electrically melting and electrically maintaining the ore in fusion in an inclosed space, forcing steam through the ore, and condensing the resulting vapors.

6. The method of recovering sulfur from a sulfid ore, which consists in melting and

electrically maintaining the ore in fusion out of communication with the atmosphere, forcing steam through said ore, and cooling the resulting vapors.

7. The method of recovering sulfur from a sulfid ore, which consists in melting and electrically maintaining the ore in fusion in an inclosed space, forcing steam and air through said ore, and cooling the resulting vapors.

8. The process of treating ores containing sulfur, which consists in melting said ore, electrically maintaining the ore in a fused state out of communication with the atmosphere, passing steam through the melted ore, and cooling the resulting vapors to a temperature below the vaporizing temperature of sulfur.

9. The process of recovering sulfur from ore, which consists in melting said ore, electrically maintaining the ore in fusion out of communication with the atmosphere, forcing currents of steam and air into said melted ore, and cooling the resulting vapors to a temperature below the vaporizing temperature of sulfur.

10. The process of recovering sulfur from ore, which consists in melting said ore, electrically maintaining the ore in fusion out of communication with the atmosphere, forcing currents of steam and air into said melted ore in such proportion that but little excess of free hydrogen sulfid or sulfur dioxide will be present in the resulting vapors, and cooling these vapors below the vaporizing temperature of sulfur.

11. The process of reducing copper ores containing sulfur and iron, which consists in melting said ore, adding a flux to said ore, forcing currents of steam and air into said melted ore while electrically maintaining the same in fusion, and cooling the resulting vapors to a temperature below the vaporizing temperature of sulfur.

In witness whereof, I have hereunto set my hand this 18th day of June, 1908.

RICHARD FLEMING.

Witnesses:

HELEN ORFORD,  
JOSEPH LYONS.