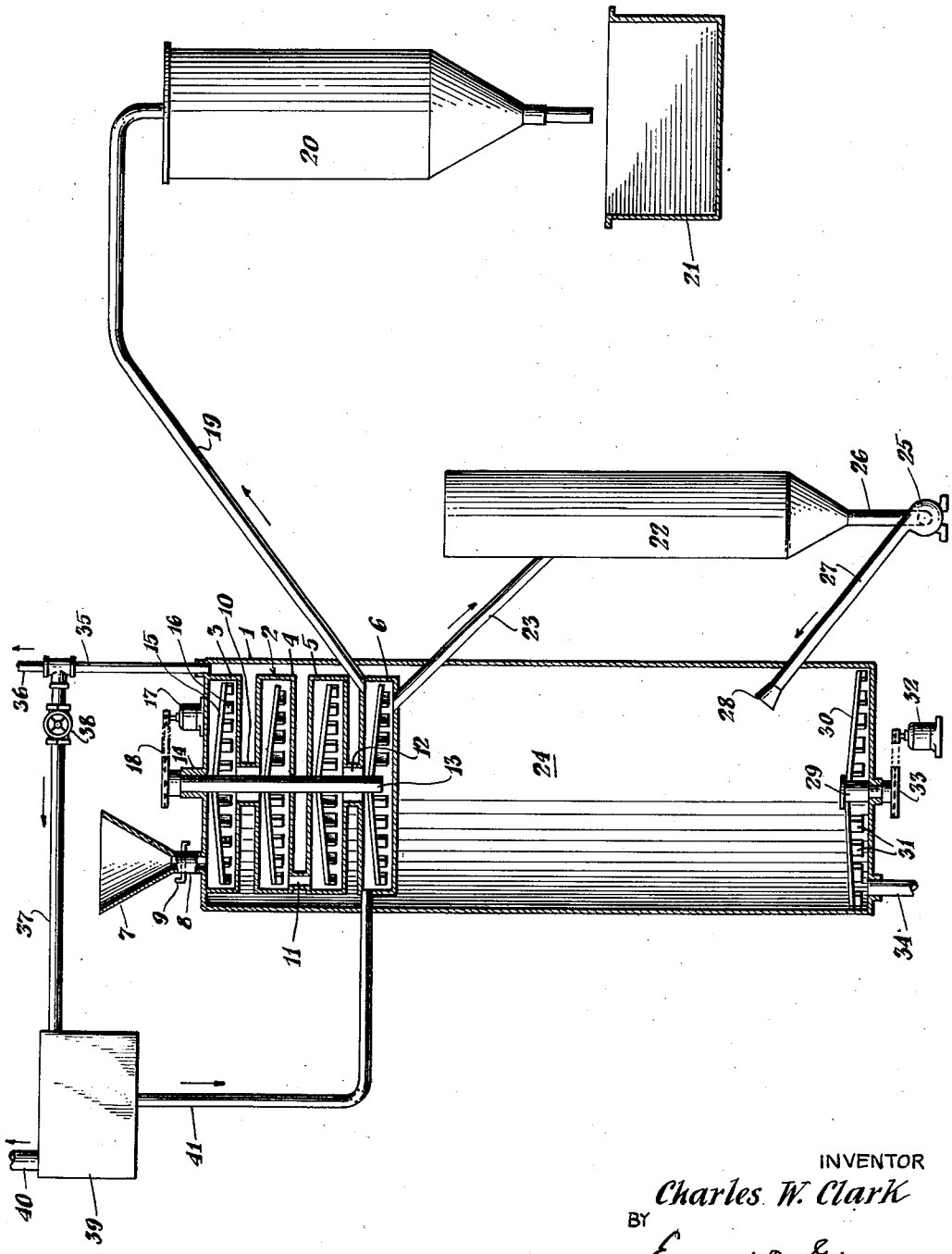
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METHOD OF RECOVERING FROM PYRITE THE VALUABLE CONSTITUENTS THEREOF

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METHOD OF RECOVERING FROM PYRITE THE VALUABE CONSTITUENTS THEREOF

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My present invention relates to a method of recovering from pyrite (FeS_2) the valuable constituents thereof and more particularly sulfur and iron oxide, and also if desired, sulfur dioxide, by utilizing the potential energy available in the material itself to provide the heat energy necessary for the separation therefrom of at least one atom of sulfur.

Various methods and apparatus have been devised in the prior art for the recovering from pyrite of the valuable constituents thereof to this same general end; but in most instances the process has been one of a progressive partial burning of the entire material in one or more intercommunicating chambers. The objection thereto is that the entire process takes place in a single chamber or some continuation thereof, so that the gaseous products of combustion are mixed with the sulfur distilled from the pyrite. This, in practice, presents an undesirable condition in that it is difficult to secure by such methods a maximum yield of relatively pure sulfur, which is one of the most valuable constituents of pyrite.

It has also been proposed in the prior art to distil sulfur from pyrite in the absence of air by the use of externally applied heat. However, this proposal contemplated the use of fuel of some sort from an external source. The present invention avoids the requirement for such fuel, and hence results in a measure of economy which constitutes the basis for a process as herein disclosed being commercially practicable.

One of the objects of the present invention is to provide for the recovery from pyrite of the valuable constituents thereof as generally hereinabove set forth, without requiring any external supply of fuel or other energy source except such minor amounts of power as may be required for the operation of the mechanically moving parts of the furnace contemplated for use in accordance with the present invention, and except for the fuel required initially to establish the required temperature in the furnace to start the process.

A further object of the present invention is to provide a commercially practicable method as hereinabove set forth by which the pyrite may be broken down into desired valuable products in a simple, effective and economical manner, so that those products may be marketed at prices comparing advantageously with the commercial prices of such respective materials when obtained from other sources.

Other and more detailed objects of the present invention will appear from the following description and appended claims when taken in connection with the accompanying drawings in which the single figure illustrates diagrammatically, partly in elevation and partly in vertical section, an apparatus for carrying out the method of this invention.

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The process of the present invention is carried out by the use of a means into which pyrite, preferably ground to a desired average particle size, is supplied into a muffle or distilling zone, in which sulfur is distiled therefrom substantially in accordance with the equation

$$FeS_2 + heat = FeS + S$$

The elemental sulfur thus recovered is removed from the muffle or distilling zone through a suitable duct to a condensing apparatus, wherein it is condensed and collected for sale or such use as may be desired therefor. The solid residue of iron sulfide is then passed by mechanical means from the muffle or distilling zone to a suitable storage chamber therefor, from which this material is supplied to a combustion chamber portion of the furnace in which the muffle is located. This iron sulfide is there burned with air to provide the heat necessary for heating the muffle or distilling zone and distilling sulfur from pyrite. As such, the products of combustion pass in indirect heat exchange relation to the distilling zone into which the pyrite is initially introduced. The products of combustion include the sulfur dioxide, which mixes with the remaining gaseous constituents in the combustion chamber to pass to a suitable recovery means and a stack, and also iron oxide. The iron oxide, which is solid, may be removed from the combustion chamber for any desired use, for example, to be refined by the usual metallurgical processes used in connection with iron ore to produce iron. The sulfur dioxide may be partly or wholly absorbed by scrubbing or other suitable means from the gaseous products of combustion leaving the combustion chamber so as to remove it from the gases discharged to the atmosphere. The absorbed sulfur dioxide may then be separated by any recognized method, usually by heat, from the absorbing liquid and used for such purposes as may be desired. In accordance with the present invention a part of this sulfur dioxide thus recovered and separated from the products of combustion is used as a "sweep" gas by passing it to and through a part of the muffle above referred to, so that it may serve as a gaseous ve-

hicle for carrying the vaporized sulfur from the muffle to the condensing means therefor.

Turning now particularly to the accompanying drawing, there is shown a furnace generally indicated at 1, including a muffle 2 which is divided into various portions or shelves as shown at 3, 4, 5 and 6. Pyrite, preferably ground to a predetermined average particle size, is adapted to be supplied to the muffle portion 2 through a suitable means here shown as a funnel or hopper 7 having a passage means 8 communicating with the uppermost shelf or muffle portion 3 for the supply of pyrite thereto, preferably adjacent to the outer edge thereof as shown. A suitable valve mechanism generally indicated at 9 is provided in the passage means 8 for controlling the supply of pyrite to the muffle portion 3, while preventing escape of gaseous sulfur therefrom through the passage means 8. The shelf or muffle portion 3 communicates with the next lowermost shelf or muffle portion 4 through a central enclosed passage 10. The muffle portion 4 communicates with the next lower muffle portion 5 through one or more enclosed passages 11 adjacent to the periphery thereof. Muffle portion 5 communicates with the lowermost muffle portion 6 through a central enclosed passage 12.

Means are provided for moving the solid material through the several muffle portions alternately inwardly or outwardly in a generally radial or spiral direction, such means comprising a rotatable shaft 13 which is journaled at 14 in the upper end portion of the furnace 1 and has secured thereto in each of the muffle portions 3 to 6 a plurality of laterally extending arms 15 having inclined rabbles 16 thereon. The direction of inclination of the rabbles is such as to move the solid material in each of the portions 3 to 6 inclusive toward the exit from that portion. Thus the rabbles in the uppermost of the muffle portions 3 are so directed, in view of the direction of rotation of the shaft 13, as to move solid materal progressively inwardly from the periphery of this portion to which this material is supplied from the passage means 8 toward the central passage 10. Suitable means are provided for rotating the shaft 13. As shown herein, such means comprise a source of mechanical power indicated as an electric motor 17, which is connected to drive the shaft 13 by a suitable sprocket chain and sprockets generally indicated at 18.

It is contemplated that the pyrite will be progressively heated as it moves through the various muffle portions 3 to 6 inclusive and finally will be brought up to a temperature such as to distil off one of the atoms of sulfur therefrom in accordance with the equation given above. This vaporized sulfur then passes through a suitable passage 19 from the lowermost muffle portion 6 to a condensing means generally indicated at 20, wherein it is condensed and the condensate collected at a collecting point diagrammatically illustrated as a pan or tray 21.

While the solid residue, which is substantially all iron sulfide (FeS), may be burned directly upon being discharged from the muffle, it is contemplated that a better control may be had of the process if this material be first discharged into a suitable storage chamber, such as that indicated diagrammatically at 22. For this purpose a downwardly inclined passage 23 is shown leading from the outer periphery of the bottom of the muffle portion 6 to the storage chamber 22.

A desired part or all of the material from the storage chamber may be returned to a combustion chamber portion 24 of the furnace 1 by being blown thereinto by a suitable blower 25, to which the material is supplied through a passage 26 from the storage chamber 22 and from and by which it is blown through a pipe or duct 27 having a nozzle portion 28 thereon directed into the combustion chamber 24. In the combustion chamber 24 substantially complete combustion will take place of the iron sulfide to produce as final products sulfur dioxide and iron oxide.

Means are provided in the lowermost portion of the combustion chamber 24 for disposing of the solid residue of iron oxide. Such means comprise a means similar to that used in the muffle portions for moving solid material therethrough and includes a shaft 29 having a plurality of arms 30 secured thereto and provided with rabbles 31. Means are provided for rotating this mechanism, comprising any available source of mechanical power here diagrammatically indicated as an electric motor 32, which is mechanically connected to drive the shaft 29 by means diagrammatically illustrated at 33 as sprockets and sprocket chain. This iron oxide is then moved to an outlet passage 34, from which it may be conducted to any suitable collection point therefor. This material is one of the final products of the process and may be further handled or treated in any desired way.

The gaseous products of combustion from the combustion chamber 24 pass thence through a pipe or passage here indicated at 35. A portion of the sulfur dioxide may be used in accordance with certain specific phases of the process of my present invention. Use of the remainder is per se not a part of this invention. Such remainder may pass through an extension 36 of the pipe 35.

In accordance with my present invention a branch pipe 37 is provided from the pipe 35, through which a selected portion of the products of combustion are withdrawn under control of a valve 38 therein. This portion of the products of combustion are then taken to a means for the segregation from the gases of sulfur dioxide. Such means may be of any type conventional in the art and may for example include means for absorbing the sulfur dioxide in a suitable absorbent liquid such, for example, as water, or aqueous solutions of ammonium sulfite, ammonium bisulfite, sodium borate, calcium borate, sodium phosphate, calcium phosphate and possible other materials. The sulfur dioxide thus absorbed may later be driven from the absorbent solutions by known methods such as the application of heat, resulting in substantially pure gaseous sulfur dioxide. This equipment, the details of which form per se no part of the present invention, is diagrammatically illustrated herein at 39. A passage 40 is shown leading therefrom for the remainder of the products of combustion, which have been freed from most, if not all, their content of sulfur dioxide; and a passage 41 is shown through which recovered sulfur dioxide may be passed to other portions of the process.

In accordance with the present invention, it is contemplated that a selected amount of this recovered sulfur dioxide will be used as a "sweep" gas. For this reason the pipe or passage 41 is shown leading to the lowermost muffle portion 6, so as to cause this gas to sweep through this muffle portion and act as a gaseous vehicle for

insuring the flow of the gaseous sulfur from the muffle to the condenser 20. Suitable means (not shown) may be provided associated with the condenser 20 for the recovery for subsequent use of non-condensible gases including, in accordance with the specific embodiment of this invention herein disclosed, primarily sulfur dioxide.

While there is shown and described herein but one principal form for the present invention, it will be obvious to those skilled in the art that both the process thereof and the apparatus may be varied within the teachings herein set forth. I do not wish to be limited, therefore, except by the scope of the appended claims, which are to be construed validly as broadly as the state of the prior art permits.

What is claimed is:

1. The method of recovering from pyrite the valuable constituents thereof, comprising the steps of introducing solely pyrite into a distilling zone out of contact with air and products of combustion as such, and therein continuously distilling sulfur therefrom to leave a solid residue by heat solely supplied externally of said zone, continuously condensing the gaseous sulfur from said zone and passing the resulting condensate to a collecting point, continuously burning at least a part of the solid residue from said distilling zone to generate heat and to produce iron oxide and sulfur dioxide, and passing the gaseous products of combustion in indirect heat exchange relation to said distilling zone so as to supply heat as aforesaid without contaminating the material in the distilling zone.

2. The method of recovering from pyrite the valuable constituents thereof, comprising the steps of continuously introducing a solid material consisting of pyrite ground to a predetermined average particle size into a distilling zone out of contact with air and products of combustion as such, continuously moving such pyrite through this zone, while supplying heat solely externally of said zone to distill sulfur continuously therefrom and leave a solid residue of iron sulfide, continuously passing the vaporized sulfur free from products of combustion as such to a condensing chamber and therein condensing it, passing the condensed sulfur from the condensing chamber to a collecting point therefor, continuously passing the solid residue of iron sulfide from said distilling zone to a storage chamber, continuously introducing iron sulfide from said storage chamber into a combustion chamber disposed in indirect heat exchange relation to said distilling zone and burning the iron sulfide in said combustion chamber with air to produce sulfur dioxide and iron oxide and to generate the heat necessary for the distillation of sulfur in said distilling zone as aforesaid without contaminating said solid material in the distilling zone, passing the sulfur dioxide thus produced to a selected point, and passing the iron oxide thus produced from said combustion chamber to a selected collecting point therefor.

3. The method of recovering from pyrite the valuable constituents thereof, comprising the steps of introducing a solid material consisting of pyrite into a distilling zone out of contact with air and products of combustion as such and therein continuously distilling sulfur therefrom by heat supplied solely externally of said zone to leave a solid residue of iron sulfide, continuously passing the vaporized sulfide free from products of combustion as such from said distilling zone to a condensing chamber and therein condensing it, passing the resultant condensate of pure sulfur to a collecting point therefor, continuously burning at least a part of the residue of iron sulfide from said distilling zone with air to produce iron oxide and gaseous products of combustion including sulfur dioxide and to supply heat as aforesaid without contaminating said solid material in the distilling zone, passing said iron oxide to a collecting point therefor, continuously recovering pure sulfur dioxide from the gaseous products of combustion, and continuously passing a selected part only of this recovered pure sulfur dioxide through said distilling zone as the sole sweep gas to act as a carrier for the vaporized sulfur from said distilling zone to the condensing chamber therefor.

4. The method of recovering from pyrite the valuable constituents thereof, comprising the steps of continuously introducing a solid material consisting of pyrite ground to a predetermined average particle size into a distilling zone out of contact with air and products of combustion as such, continuously moving the material thus introduced through said distilling zone, continuously distilling pure sulfur from the pyrite thus introduced during its passage through said zone to leave a solid residue of iron sulfide, continuously passing the vaporized sulfur free from products of combustion as such from said distilling zone to a condensing chamber and therein condensing it, passing the resultant condensate of pure sulfur to a collecting point therefor, continuously passing the solid residue of iron sulfide from said distilling zone to a storage chamber therefore, continuously passing iron sulfide from said storage chamber to a combustion chamber in indirect heat exchange relation with said distilling zone and therein burning it with air to provide gaseous products of combustion including sulfur dioxide and a solid residue of iron oxide and to supply the heat required for the distilling of sulfur as aforesaid without contaminating said solid material in the distilling zone, continuously moving the iron oxide thus produced out of said combustion chamber to a collecting point therefor, recovering a selected part of the sulfur dioxide from said products of combustion as pure sulfur dioxide and continuously passing such recovered pure sulfur dioxide into and through said distilling zone to act as the sole sweep gas and carrier for the vaporized pure sulfur en route from said distilling zone to said condensing chamber.

5. The method of recovering from pyrite the valuable constituents thereof, comprising the steps of continuously introducing a solid material consisting of pyrite ground to a predetermined average particle size into a distilling zone, out of contact with air and products of combustion as such, continuously moving such pyrite through this zone while supplying heat solely externally of said zone to distill pure sulfur continuously therefrom and leave a solid residue of iron sulfide, continuously passing the vaporized sulfur free from products of combustion as such to a condensing chamber and therein condensing it to form pure sulfur, passing the condensed pure sulfur from the condensing chamber to a collecting point therefor, continuously passing the solid residue of iron sulfide from said distilling zone to a storage chamber, continuously blowing iron sulfide by the use of combustion-supporting air from said storage chamber into a combustion chamber which is disposed in indirect heat exchange relation to said distilling zone, and burn-

ing said iron sulfide in said combustion chamber with combustion-supporting air to produce sulfur dioxide and iron oxide and to generate the heat necessary for the distillation of pure sulfur in said distilling zone as aforesaid without contaminating the material in the distilling zone, passing the sulfur dioxide thus produced to a selected point, and passing the iron oxide thus produced from said combustion chamber to a selected collecting point therefor.

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