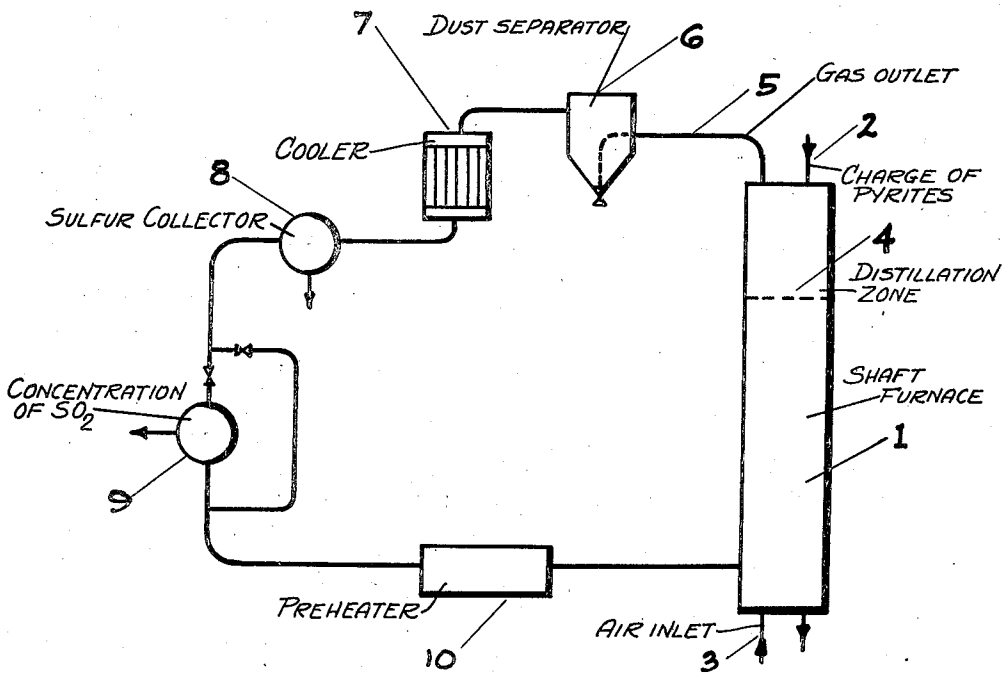
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BURNING OF PYRITES

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BURNING OF PYRITES

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This invention relates to the burning of pyrites or iron sulfide with air or other oxygen-containing gas in order to produce iron oxide and sulfur, with or without sulfur dioxide.

It is known that the labile sulfur atom in pyrites can be removed in the form of free sulfur by simple distillation, and it is also known that free sulfur can be obtained by reaction at an elevated temperature, e. g. 900° C., between ferrous sulfide and sulfur dioxide.

When pyrites is roasted in a burner with a quantity of air less than that corresponding to the equation $4FeS_2+11O_2=2Fe_2O_3+8SO_2$, the material first encountered by the air is burnt to iron oxide and sulfur dioxide and the zone in which this combustion occurs extends so far as there remains any oxygen in the gases; the pyrites beyond the combustion zone is subjected to the action of the hot gases leaving the same and the labile sulfur is distilled. The zone of maximum temperature corresponds to the level at which all oxygen has been used up from the combustion gases and above this zone the labile sulfur atom of the pyrites is distilled chiefly by means of the sensible heat of the gases. In this way up to half of the total sulfur as a maximum may be obtained as free sulfur and half as SO_2, provided that the sensible heat of the gases passing through the burner is sufficient to distill all of the labile sulfur. If an attempt is made to increase the proportion of free sulfur by further restricting the air supply, incomplete combustion results and the iron oxide produced is contaminated with large amounts of iron sulfide, which is not removed as might be expected by reaction with the sulfur dioxide present owing to the low concentration of the same.

I have now found that an increased proportion of free sulfur and an iron oxide product which is low in sulfur can be obtained (with correspondingly restricted air supply) provided that the sulfur dioxide concentration in the combustion zone of the burner is increased by the addition of concentrated or pure SO_2 to such an extent that the final concentration of SO_2 in the combustion zone, i. e. at the top or just above the combustion zone, is at least 20 per cent. by volume of the gases, the balance of which is constituted by nitrogen.

The additional gas may be obtained by recirculating the gases leaving the burner after removal of their sulfur content and after enrichment in SO_2. Such additional gas also serves the purpose of controlling the temperature in the combustion zone at a suitable degree, e, g. 800–1,000° C. and of providing the additional sensible heat required for the distillation of the labile sulfur in the case where the quantity of oxygen approximates to that of the equation $4FeS_2+3O_2=2Fe_2O_3+8S$.

According to the invention, therefore, pyrites is roasted with a restricted quantity of air or other oxygen-containing gas and a sulfur dioxide concentration of at least 20 per cent is maintained at the top of or just above the combustion zone by feeding sulfur dioxide or a sulfur dioxide-containing gas into the burner. By a restricted quantity of air or other oxygen-containing gas I mean a quantity of air or other gas containing less oxygen than that corresponding to the equation $4FeS_2+7O_2=2Fe_2O_3+4S+4SO_2$ but containing at least sufficient oxygen to combine with all of the iron.

According to one form of the invention, the exit gases from the burner, which contain free sulfur, nitrogen and sulfur dioxide, are treated for removal of dust and are then cooled and treated for the removal of free sulfur in any suitable manner, as, for instance, by the process described in British Patent #355,832. The cold residual gas, consisting of nitrogen and sulfur dioxide, is then enriched in sulfur dioxide by liquefaction or absorption in some suitable absorbent such as silica gel, or some suitable solvent. The concentrated sulfur dioxide is recovered in known manner and part or all of it is recirculated to the burner, while the residual nitrogen is purged away from the system. A portion of the circulated gas, after removal of free sulfur, may be allowed to by-pass the concentration plant, the purge of nitrogen being thereby controllable and adjusted to be equal to the amount of nitrogen introduced to the burner in the combustion air.

The volume of gas circulated per unit time relative to the volume of air supplied to the burner per unit time, controls the maximum temperature in the burner, and in the case in which a large proportion or the whole of the sulfur is obtained in the free state, the volume of circulating gas required to maintain the temperature at its optimum value is so much reduced that it may contain insufficient sensible heat to effect the distillation of the labile sulfur in the upper part of the burner.

A modification of the invention, therefore, consists in a process for roasting pyrites to generate mainly or entirely sulfur and iron oxide, in which the circulating gases are preheated (the preheated gases still being substantially lower in

temperature than the combustion zone) prior to their introduction into the burner. In this way a larger volume of circulating gas relative to the combustion air may be used, but since it will be at a higher inlet temperature the maximum temperature of the burner will remain unaltered and consequently the gases passing this zone are considerably increased in volume and therefore contain sufficient sensible heat to effect the distillation of the pyrites in the upper zones.

The value of the iron oxide produced in this process is very largely dependent upon the efficient reduction of its sulfur content. A further modification of the invention relates to a means whereby this sulfur content can be reduced to a value lower than that usually obtained in pyrites burners. The burner is operated as already described, gases rich in sulfur dioxide being injected at a point or depth below the zone of maximum temperature in which the greater portion of the combustion occurs, but somewhat higher than that at which the combustion air is injected. This air is preferably preheated and in this manner the incompletely desulfurized material in the lower zones of the kiln or furnace is subjected to the most vigorous oxidizing conditions, thus reducing the sulfur content of the iron oxide to a minimum. The air used for combustion may, if desired, be preheated by means of heat interchange with the gases which are withdrawn from the top of the burner before being passed to the sulfur separators.

One form of the invention is illustrated in the accompanying diagram. A shaft furnace **1** is charged with lump pyrites at **2**, air being injected at the base of the furnace **3**. The air supply is restricted as hereinbefore described and under these conditions a separate distillation zone is formed in the upper part of the furnace **4**. The gases leaving the top of the furnace are withdrawn as indicated at **5**, and are passed firstly to a dust separator **6**, then to a cooler **7** and to a sulfur collector **8**. The cooler and sulfur collector may suitably be combined into the form of a waste heat boiler fitted with electrostatic precipitation means as described in British Patent #354,207. The cold gases freed from sulfur are recirculated to the pyrites burner after having been subjected in part or completely to concentration of their sulfur dioxide content in a plant **9**. The concentration plant may suitably comprise a washing tower supplied with a solvent to absorb the sulfur dioxide and the said sulfur dioxide is subsequently recovered in a substantially pure state by heating and/or reduction of pressure. The concentration plant **9** may alternatively consist of a liquefaction system in which the sulfur dioxide is prepared in substantially pure liquid form and subsequently allowed to evaporate. A proportion of the dilute sulfur dioxide gas is allowed to by-pass the concentration plant so that the gases re-circulated to the burner may be given any desired sulfur dioxide concentration. They are preheated in a heat exchanger **10** and admitted to the furnace at a point below the zone of major combustion but above the point of admission of the primary combustion air. Under these circumstances the sulfur dioxide concentration in the furnace is sufficiently high to bring about to a considerable extent a reaction between ferrous sulfide and sulfur dioxide and the sulfur content of the pyrites may be recovered entirely in the elementary form, or if desired, partly in this form and partly as sulfur dioxide. It should be understood that the ratio between the sulfur and sulfur dioxide produced is governed by the quantity of combustion air admitted at **3** in relationship to the quantity of pyrites admitted in the same unit of time at **2**, and this quantity of air in turn determines the degree of concentration to which the sulfur dioxide gases are subjected since the amount of nitrogen added with the combustion air must be equal over a period of time to the amount of nitrogen purged away from the concentration plant. Having fixed therefore the rate of feed of pyrites and combustion air and the quantity of nitrogen purged, the temperature of the major combustion zone in the furnace **1** may be controlled by varying the rate at which the gases are recirculated. If desired, in the case where the amount of combustion air admitted is such as would normally lead to the production of both sulfur and sulfur dioxide, the amount of sulfur may be increased at the expense of the sulfur dioxide by adding a reducing agent, e. g. coke, to the upper part of the furnace. Thus a proportion of coke may be mixed with the initial charge of pyrites.

By way of illustration of the invention, a pyrites furnace as described is fed with pyrites at the rate of 318 tons per day and combustion air is supplied at the rate of 7450 cubic metres per hour. The furnace gases are withdrawn having an exit temperature of 550° C. and amounting to 37,200 cubic metres per hour of gas containing 25 per cent sulfur dioxide, 6 per cent sulfur vapor and 69 per cent of nitrogen. After cooling and separation of free sulfur 8000 cubic metres per hour of the gas, now containing 27 per cent sulfur dioxide, are treated in the concentration plant from which 5000 cubic metres per hour of waste gases are purged and the concentrated gases are combined with the remainder which are allowed to by-pass the concentration plant. The mixed gas amounts in all to 29,000 cubic metres containing 32 per cent sulfur dioxide and these gases are preheated to a temperature of the order of 300° C. and recirculated to the furnace. Under these circumstances substantially the whole of the sulfur content of the pyrites is recovered in the elementary form. All the gas quantities mentioned in this paragraph are calculated for the normal temperature and pressure.

This application is a continuation in part of my application, Ser. No. 542,681, filed June 6, 1931.

I claim:

1. In a process of roasting pyrites the step of moving pyrites in a roasting furnace through a distillation zone and a combustion zone in counter current to a gas stream, said gas stream being formed by introducing into said combustion zone a restricted quantity of a gas containing free oxygen and an amount of a sulfur dioxide containing preheated gas, said amounts of gases being so adjusted that the gases around the top of the combustion zone are substantially free from oxygen and have a sulfur dioxide concentration of at least 20%.

2. In a process of roasting pyrites the step of moving pyrites in a roasting furnace through a distillation zone and a combustion zone in counter current to a gas stream, said gas stream being formed by introducing into said combustion zone a restricted quantity of an oxygen containing gas and an amount of a sulfur dioxide containing preheated gas, said amounts of gases being so adjusted that the gases around the top of the combustion zone are substantially free from

oxygen and have a sulfur dioxide concentration of at least 20%, removing the gases from the top of the furnace, separating elemental sulfur therefrom, concentrating the sulfur dioxide from the residual gases and feeding such concentrated sulfur dioxide gases back into the furnace.

3. A process as claimed in claim 1 in which the free oxygen containing gas is introduced into the burner at a point below the point of introduction of the additional sulfur dioxide gas.

4. A process as claimed in claim 1 in which the free oxygen containing gas is preheated.

5. The process of claim 1 in which a reducing agent is added to the upper part of the furnace.

6. The process of claim 1 in which coke is mixed with the initial charge of pyrites.

7. In a process of roasting pyrites the step of moving pyrites in a roasting furnace through a distillation zone and a combustion zone in counter current to a gas stream, said gas stream being formed by introducing into said combustion zone a restricted quantity of atmospheric air and an amount of a sulfur dioxide containing, preheated gas, said amount of gases being so adjusted that the gases around the top of the combustion zone are substantially free from oxygen and have a sulfur dioxide concentration of at least 20%, removing the reaction gases from the top of the furnace, separating elemental sulfur therefrom, dividing these residual reaction gases into two streams, feeding one of said streams into the furnace, treating the second stream to separate sulfur dioxide and nitrogen contained therein, feeding the so obtained concentrated sulfur dioxide into the furnace and adjusting the amount of thus separated nitrogen to be substantially equal to the amount of nitrogen contained in the atmospheric air introduced into the furnace.

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