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## METHOD FOR THE TRANSFORMATION OF PULVERULENT SOLIDS

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This invention relates to methods and apparatus for the transformation of pulverulent solids.

An object of this invention is to effect the transformation of a pulverulent solid by a gas while removing gaseous products at intermediate stages thereof.

Another object of this invention is to transform pulverulent solids continuously and by the continuous and steady movement of materials both solid and gaseous.

Another object of this invention is to utilize with minimal loss the heat generated in the transformation of a pulverulent solid in an exothermic reaction for effecting an endothermic reaction.

Another object of this invention is to recover profitably useful materials, such as iron oxide, elemental sulfur or sponge iron, from other pulverulent substances, such as pyrite, which are frequently discarded.

Another object of this invention is to maintain a high ratio of heat transfer surface in apparatus of high capacity but of limited size and adapted for utilizing heat generated in an exothermic transformation of a pulverulent solid to effect an endothermic transformation in another pulverulent solid.

In the manufacture or processing of many materials, there are by-products, the utility of which depends upon the economy and efficiency of the methods by which useful products may be obtained from them. Frequently, such by-products are discarded because suitable economical methods are unavailable to render it profitable for securing a useful product from them. For example, in the concentration by flotation of many copper ores, large quantities of pyrites (FeS<sub>2</sub>) are eliminated by means of selective flotation and sent to tailing dams. While the pyrite in most cases might be easily collected at low cost by a further floating step, no sufficiently satisfactory economical process is available for calcining the pyrite to obtain valuable products from it to warrant such recovery.

In accordance with this invention, processes and apparatus are provided whereby useful materials may be obtained profitably from by-products, such as pyrite, which are frequently discarded because of a lack of available economically feasible processes and apparatus for the recovery of such materials. The processes and apparatus of this invention involve the principle of fluidization, namely the maintenance of a mass of finely divided solids in a state of turbulent suspension by means of an upwardly moving gas stream.

In the processes of this invention, the pulverulent solid is passed in a fluidized state by means of a gas through an elongated horizontal channel to effect the transformation of the solid, and the resulting transformed solid is passed in a fluidized state through another elongated horizontal channel to effect a different transformation in the resulting solid. The heat generated by the transformation in either of the channels is employed to supply a portion or all of the heat required for the transformation in the other channel. One modification of this process involves passing the pulverulent solid in a fluidized state simultaneously through a pair of elongated horizontal channels by means of a gas and passing the combined product of the pair of channels in the fluidized state through a common elongated horizontal channel by means of a gas to effect the same or a further transformation in the combined product. In this modification, the heat generated in the pair of channels or in the common channel is utilized to supply a portion or all of the heat required for the other channel or channels.

An apparatus for practicing the processes of this invention involves a plurality of elongated horizontal channels adjacent each other, means in each adjacent channel for the passage of the material from that channel to its immediately adjacent channel, a heat conducting wall separating each immediately adjacent channel and means for introducing a gas in each of the channels to maintain and move the pulverulent solid in the fluidized state. An opening in the heat conducting wall separating adjacent channels and located at the bottom at one end of a channel is a convenient means for the passage of the material from one channel to its immediately adjacent channel. Again, in some installations in which the passage of some gas from one channel to an adjacent channel through such an opening in the heat conducting wall is undesirable for a particular transformation, an exit pipe may be provided in one channel, the material from that channel collected in a storage bin through such exit pipe and the collected material conveyed by screw conveyor to an adjacent or other channel for further transformation. Means, such as a hopper with screw conveyors, are also provided for supplying the pulverulent solid to be transformed to the first channel in which it is introduced. Other means are also provided in the final elongated horizontal channel or channels through which the material passes for discharging the transformed pulverulent solid after passage through the plurality of channels. The excess gases employed for maintaining and moving the solids through the channels and volatile products resulting from the transformation are removed by any suitable means, such as flues located in the tops of the channels.

The structure of the apparatus of this invention permits the construction of a furnace of high capacity for a particular transformation or transformations in which the ratio of heat surface transfer area to hearth area can be kept at any desired constant. This characteristic of the apparatus of this invention is in marked contrast to furnaces consisting of two or more concentric cylinders. In the latter type of furnace given the same depth of bed, the ratio of heat surface transfer area to hearth area varies inversely with the diameter of the hearth. Consequently, in order to achieve effective heat transfer with the cylindrical type of furnace, it is necessary to employ cylinders of small diameters. This requirement entails an inordinate number of cylinders if high capacities are to be obtained. The apparatus of this invention, on the other hand, is subjected to no such limitations.

The amount of gas employed for maintaining the solid in a fluidized state and for moving the solid through the elongated horizontal channels in the apparatus of this invention is fixed between limits which depend upon the character of the pulverulent material which is to be fluidized, by the dimensions of the channels through which it passes, and by the depth of the bed. If the velocity of the gases is too low, the bed does not fluidize; while if it is too high, excessive amounts of solid are carried out of the apparatus and into the flue as dust. Likewise, the depth of the material in the fluidized bed in the channel is maintained between the practical limits dictated by the principles of solid fluidization. Too shallow a bed is wasteful of space and frequently results in the channeling of the gas through the bed, thereby effecting difficult control and excessive dusting. With too deep a bed, on the other hand, the pressure of the material on the lower portion of the bed becomes excessive and requires more gas to maintain the suspension of the solids. The limits of the depth of the bed, like those of gas flow, are determined by the character, specific gravity and particle size of the materials as well as the magnitude of dusting permissible in a particular transformation. In general, a bed depth of 1½ to 4 or 5 feet is satisfactory for most applications, and a range of 30 inches to 40 inches is ordinarily the optimum limits of the depth of the bed in the elongated channel. The bed depth in each elongated horizontal channel may be regulated by any suitable means, such as weir, dam or discharge orifice set at the height desired.

The activating gas for maintaining and moving the pulverulent solid in a fluidized state in each of the chan-