# United States Patent

[11] 3,540,662


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[73] Assignee **the United States of America as represented by the Secretary of the Interior**


## [54] DRY PROCESS FOR REMOVAL OF PYRITE FROM COAL

**5 Claims, 2 Drawing Figs.**


[52] **U.S. Cl.** ..... **241/19**
[51] **Int. Cl.** ..... **B02c 21/00**
[50] **Field of Search** ..... 241/19, 24, 14, 79.2, 20, 79, 76, 60



[56] **References Cited**

UNITED STATES PATENTS

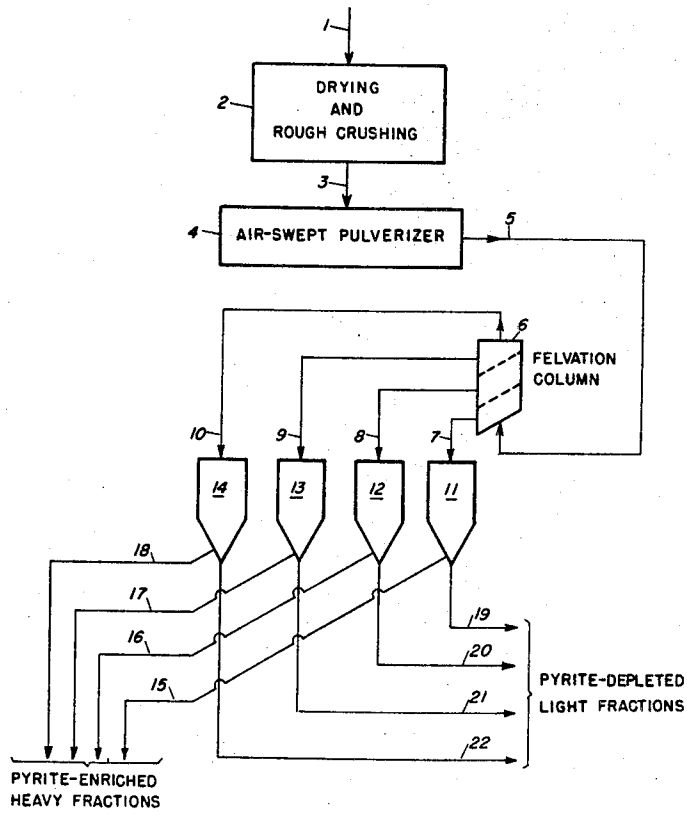
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**ABSTRACT:** Pyritic sulfur is removed from pulverized coal by sequentially subjecting the coal to two separations; one of the separations being based upon particle size and the other based upon particle mass.

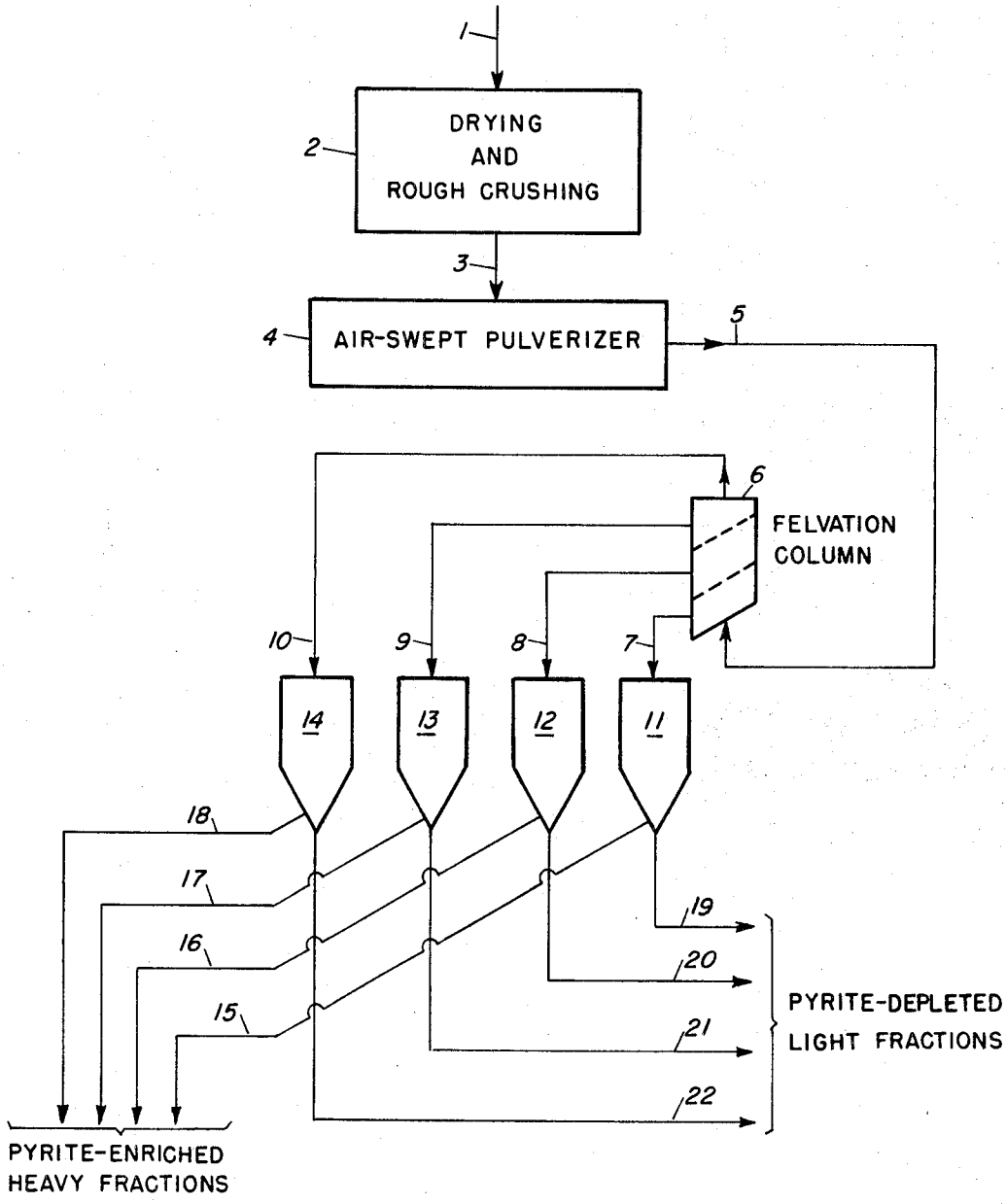



FIG. 1

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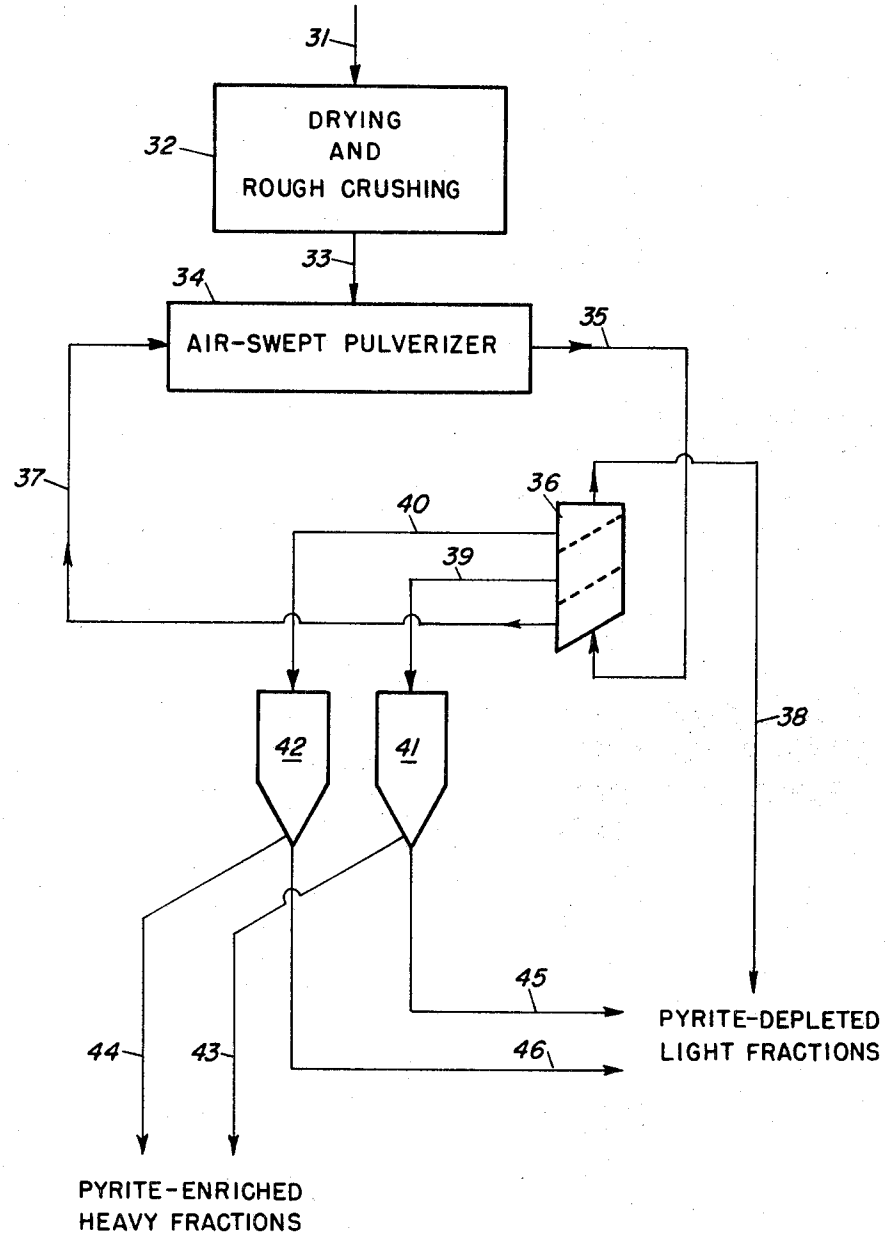



FIG. 2

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# DRY PROCESS FOR REMOVAL OF PYRITE FROM COAL

## BACKGROUND OF THE INVENTION

Sulfur content of bituminous coals mined in the United States ranges from less than 1 percent to as much as 6 percent or more. Pyritic sulfur generally makes up from about 40 to 80 percent of the total sulfur present with the balance being chiefly organic sulfur compounds.

Compliance with sulfur dioxide emission standards, such as those proposed for New York city, forces utilities and other coal users to rely either on scarce, naturally occurring low sulfur coals or on coals which have been processed to lower their sulfur content.

Wet processing of coal to reduce pyrite content is currently practiced but is generally restricted to the larger sizes of coal. These larger coal particles often contain smaller particles of pyrite disseminated through them which cannot be removed by washing or floatation. In addition, wet processing of coal has the added disadvantages of requiring a drying step and of creating a water pollution or waste disposal problem. Dry processing eliminates these disadvantages and is potentially less costly.

The present invention comprises a dry processing method for removing pyritic sulfur from coal. In the process, coal is pulverized and separated into a plurality of fractions, each of which is thereafter subjected to a second separation step to produce a pyrite-enriched heavy portion and a pyrite-depleted light portion.

Thus, it is an object of this invention to remove a heavy component from a lighter matrix material.

It is a specific object of this invention to provide a dry process for the removal of a major portion of pyrite from a particulate coal feed.

## DESCRIPTION OF INVENTION

The invention will be more clearly understood from the following description of a preferred embodiment wherein reference is made to the accompanying drawings.

FIG. **1** is a schematic flow diagram of a preferred embodiment of the pyrite removal process.

FIG. **2** is a schematic flow diagram showing alternative recycle features of the invention.

Referring now to FIG. **1**, a stream of mine-run coal **1** is dried if necessary and subjected to rough crushing at **2**. After rough crushing, typically to a size range of −2 inches, the coal is transported by any convenient conveying means **3** to an air-swept pulverizer **4**. Pulverizer **4** preferably comprises a conventional rod or ball mill. Air flow through the pulverizer is adjusted to produce a major portion of the coal within a predetermined size range in a manner which is well known in the art.

The particle size range of coal produced by pulverizer **4** should conform as nearly as is conveniently possible to the size range producing maximum pyrite availability, or substantial physical release of pyrite crystals from the coal matrix. Size of pyrite particles is known to vary widely between different types of coals so the preferred particle size range produced by the pulverizer is dependent primarily upon the particular coal being processed. Particle size range producing maximum pyrite availability will vary generally in the broad range of 40 to 400 mesh. In this particular size consist of Pittsburgh seam coal, maximum pyrite availability occurs in the range of 200 to



400 mesh. Determination of the proper size range to produce maximum pyrite availability can be accomplished by standard float-sink tests of sized fractions.

An air-entrained particulate coal fraction is transported from the pulverizer, via conduit **5**, to sizing means **6**. Sizing means **6** preferably comprise a felvation column, as is shown on the drawing, but any sizing process which separates particles into fractions on the basis of particle size or volume and not on the basis of particle mass may be used. Felvation is a separation process well known in the art wherein a stream of air-entrained particles is carried upwardly through sizing screens.

In felvation column **6**, the coal is separated into sized fractions **7** through **10**. Each fraction comprises a relatively narrow particle size range such that the ratio of maximum particle volume to minimum particle volume for each fraction is less than 4 and most preferably is less than about 2. In a typical separation, fraction **7** has a maximum particle size of about 60 mesh, or about 250 microns, while fraction **10** has a maximum particle size of 400 mesh or about 37 microns. Fractions **8** and **9** have maximum particle sizes intermediate those of fractions **7** and **10**. As illustrated in the drawing, coal stream **5** is separated into four sized fractions. However, depending upon the coal being processed and upon the pyrite removal efficiency desired, that stream may be separated into as few as two or as many as six or seven sized fractions.

Fractions **7**—**10** are conveyed to air classifiers **11**—**14** wherein a separation is made primarily on the basis of particle mass. Any conventional centrifugal separator may be used in the process. An example of a satisfactory device is disclosed in British Pat. No. 1,018,020. Pyrite-enriched heavy fractions **15**—**18** and pyrite-depleted light fractions **19**—**22** are withdrawn from the separators. The light fractions, significantly depleted in pyritic sulfur, may be charged directly into a coal burning furnace or they may be further processed for other conventional uses. The heavy, pyrite-enriched fractions may be further processed for recovery of the contained pyrite, as by flotation, or may be discarded as waste.

Referring now to FIG. **2**, a stream of mine-run coal **31** is dried if necessary and subjected to rough crushing at **32**. Dried and crushed coal is transported via means **33** to air-swept pulverizer **34** from which an air entrained coal stream **35** is transported to felvation column **36**. An oversize fraction **37** is recycled back to pulverizer **34** and an undersize fraction **38** is transported from the system without further treatment. It has been found that air classification of a very fine fraction, typically −400 mesh, does not result in any significant pyrite removal. Intermediate-sized fractions **39** and **40** are subjected to a separation based upon particle mass in air classifiers **41** and **42**. Pyrite-enriched streams are removed from the process by means of conduits **43** and **44**. Pyrite-depleted light product fractions **45** and **46** are mixed with undersize fraction **38** for utilization in any conventional manner.

It is preferred that the coarse, pyrite-enriched fraction from each air classifier be limited to less than 20 percent of the feed to that classifier. In a most preferred mode of operation, the coarse fraction is limited to less than about 10 percent of the feed to each classifier.

### *EXAMPLE*

A coal sample from the Pittsburgh seam was ground and sized by screening into seven fractions. Each fraction was subjected to an air classification step from which was recovered a

pyrite-enriched heavy fraction and a pyrite-depleted light fraction. Results of the processing are set out in the following table:

TABLE 1.—SEPARATION OF PYRITE FROM A NARROW-SIZED FEED

| Fraction | Particle size range of feed | | Fine fraction, weight percent of— | | Coarse fraction, weight percent of— | | Pyritic sulfur enrichment of coarse fraction [1] | Availability of pyritic sulfur, percent of total pyritic sulfur [2] |
|---|---|---|---|---|---|---|---|---|
| | U.S. sieve number | Diameter, microns | Total feed | Total pyritic sulfur | Total feed | Total pyritic sulfur | | |
| 1 | 60–80 | 250–177 | 89.4 | 81.8 | 10.6 | 18.2 | 17.2 | 36.0 |
| 2 | 80–100 | 177–149 | 91.0 | 87.1 | 9.0 | 12.9 | 14.3 | 50.6 |
| 3 | 100–140 | 149–105 | 93.5 | 88.6 | 6.5 | 11.4 | 17.6 | 51.9 |
| 4 | 140–200 | 105–74 | 86.1 | 71.6 | 13.9 | 28.4 | 20.4 | 62.5 |
| 5 | 200–270 | 74–53 | 89.4 | 68.1 | 10.6 | 31.9 | 30.1 | 53.9 |
| 6 | 270–400 | 53–37 | 91.6 | 51.0 | 8.4 | 49.0 | 58.3 | 86.8 |
| 7 | −400 | 37 | 88.6 | 95.9 | 11.4 | 4.1 | 3.6 | 42.3 |

[1] Percent of total pyritic sulfur in coarse fraction amounting to 10% of feed.
[2] Determined as the percent of total pyritic sulfur in the sink at a specific gravity of 1.58.

As may be seen from the data presented, each of the fractions with the exception of the finest fraction 7, had a ratio of maximum particle size to minimum particle size of less than 2. A significant pyrite enrichment of the coarse fraction was achieved in each case, again with the exception of fraction 7. In the particular coal used, maximum pyrite availability and maximum pyrite removal occurred in the 140 to 400 mesh (approximately 105 to −37 micron) particle size range.

A second series of tests were run which demonstrate the importance of first separating the feed into a plurality of fractions prior to preforming the second separation step on each of the fractions. In these tests, Pittsburgh seam coal was ground to a size range such that 70 percent of the product passed through a 200 mesh screen. This sizing is typical of that routinely produced by an air-swept pulverizer. Results of those runs are presented in the following table:

TABLE 2.—SEPARATION OF PYRITE FROM A WIDE-SIZE-RANGE FEED

| Run | Feed size U.S. sieve | Added pyrite (wt. percent) | Fine fraction, percent of— | | Coarse fraction, percent of— | | Pyrite enrichment of coarse fraction [1] |
|---|---|---|---|---|---|---|---|
| | | | Total feed | Total pyritic sulfur | Total feed | Total pyritic sulfur | |
| 1 | 70%–200 | 0 | 53.5 | 44.0 | 46.5 | 56.0 | 12.0 |
| 2 | 70%–200 | 0 | 56.2 | 48.5 | 43.8 | 51.5 | 11.7 |
| 3 | 70%–200 | 0 | 49.8 | 40.4 | 50.2 | 59.6 | 11.9 |
| 4 | 70%–200 | 3.0 | 58.6 | 46.4 | 41.4 | 53.6 | 12.9 |
| 5 | 70%–200 | 3.0 | 49.0 | 35.0 | 51.0 | 65.0 | 12.7 |
| 6 | 70%–200 | 3.0 | 88.7 | 88.0 | 11.3 | 12.0 | 10.6 |

[1] Percent of total pyritic sulfur contained in 10 percent of feed.

In runs 4—6, 3 percent by weight of pyrite having a size range comparable to that of the coal was added to each sample. In each case, the coarse fraction showed a slight but relatively insignificant enrichment in pyrite. There was no apparent difference in pyrite removal between runs 1—3 and 4—6 to which additional pyrite had been added.

In the described tests, the first separation was based upon particle size while the second separation was based upon particle mass. This is the preferred sequence of separation steps. However, good results may also be obtained if the separation sequence is reversed; *i.e.*, basing the first separation upon particle mass and the second separation upon particle size.

While the invention has been described and illustrated specifically in relation to the removal of pyrite from coal, the same technique may be applied to other separations. Broadly the invention may be used for the separation of any free-milling heavy component from a lighter matrix material.



While there have been shown and described the novel features of the invention as applied to a preferred embodiment, it will be understood that other forms and applications will be obvious to those skilled in the art. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

We claim:

1. A method for concentrating a heavy pyritic component contained in discrete particulate form within a lighter coal matrix material which comprises:

a. comminuting said heavy, pyritic component-containing, coal matrix material to a particle size range of about 60 to about 400 mesh resulting in substantial physical release of the particulate heavy component from the lighter matrix material;

b. first separating said comminuted matrix material and contained heavy component into a plurality of fractions;

c. and secondly, separating each of said fractions into two portions; one of said first and second separations being based upon particle size and the other of said separations being based upon particle mass, the separations based upon particle mass comprising centrifugal air classification; and

d. recovering from each of said second separations a heavy component-depleted portion and a heavy component-enriched portion.

2. The process of claim 1 wherein said first separation step is based upon particle size and said second separation step is based upon particle mass.

3. The process of claim 2 wherein the ratio of maximum particle size to minimum particle size of each of said sized fractions is less than about 4.

4. The process of claim 3 wherein said ratio is less than about 2.

5. The process of claim 4 wherein said separation on the basis of particle size is performed by felvation.