June 4, 1946. W. T. BROWN 2,401,410

DETECTION OF SULPHUR IN COAL

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Fig. 1.

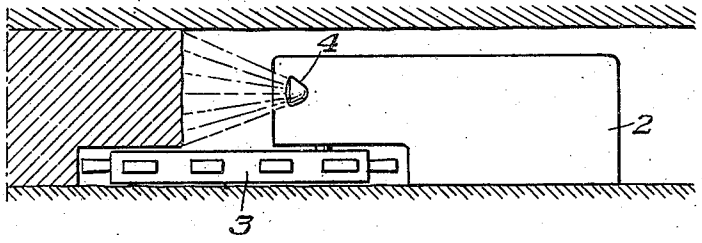
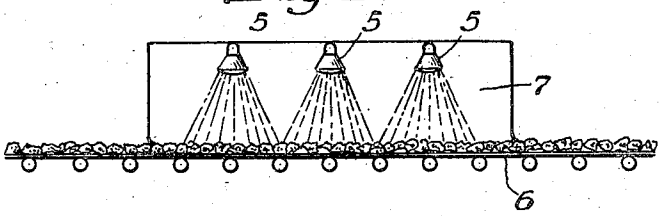


Fig. 2.



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DETECTION OF SULPHUR IN COAL

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2 Claims. (Cl. 250—71)

1

My invention relates to the use of the invisible, near-ultra-violet rays, known as the "black light," as a means of detecting bands or lenses of pyritic sulphur in coal seams or lumps of coal, which are shown as fluorescent material in the coal.

The use of the black light is well known in the advertising and theatrical fields for display purposes and is used in the steel industry as a means of detecting flaws in steel.

It is also well known that many coal seams contain pyritic sulphur, either finely disseminated throughout the seam, in balls or nodules, or in bands or lenses in the bottom, top or near shale or slate partings in the coal seam. It is the general practice in mines where the coal is hand loaded and in some mines using mechanical loaders, to cut the coal above the bottom section of the seam containing bands or lenses of pyritic sulphur or below the top section of the seam containing bands or lenses of pyritic sulphur. The object of this practice is to reduce the sulphur content of the coal, particularly when used for metallurgical purposes.

The thickness of the bands or lenses of pyritic sulphur varies throughout the seam, therefore much good coal is wasted or some high pyritic sulphur is mined, when the coal is cut a certain distance from the top or bottom, without knowing exactly the extent of the hands or lenses of pyritic sulphur in the coal seam.

My invention provides a means for detecting these bands or lenses of pyritic sulphur in the coal seam or lumps of coal, which will help the mine operator to save low sulphur coal and keep out the high sulphur coal going to the mine tipple, therefore enabling the mine to produce a larger quantity of lower sulphur coal per acre.

This invention is the result of considerable research work on the forms of sulphur found in coal, and the origin of the various forms. The present method of tests, generally used throughout the coal industry, shows that there are three forms of sulphur in coal, namely, sulphate, organic and pyritic. The sulphate sulphur is found in very small quantities in the coal and is the result of rapid oxidation of the pyritic sulphur in moist air. The organic sulphur is known as a complex carbon-sulphur compound, not soluble in 1.3 sp. gr. nitric acid, as used in the present methods of test.

My invention chiefly concerns the pyritic or iron disulphide (FeS_2) form of sulphur found in coal seams and is a means of detecting bands or lenses of pyritic sulphur, by means of the invisible, near-ultraviolet rays, known as the "black light." In order that those skilled in the art of coal chemistry may better understand the reason why the black light does show these bands or lenses of pyritic sulphur as fluorescent material, let us consider the origin of this pyritic sulphur.

2

Pyritic sulphur found in coal seams is chiefly iron (ferrous) disulphide (FeS_2) in the form of pyrite or marcasite, but other forms of sulphides of iron and other metallic sulphides may be present in with the pyritic sulphur.

The pyritic sulphur in coal is caused by sulphur bacteria and there are several sulphur bacteria or micororganisms, but I will limit this discussion to the *Beggiatoa alba* species, which are probably the most important sulphur bacteria.

These sulphur bacteria are iron-depositing, anaerobic microorganisms that thrive on decaying vegetable matter, in the presence of hydrogen sulphide. These bacteria obtain their food, carbon, from the decaying vegetable matter in the peat bogs and their oxygen from sulphates or carbonates from the swamp waters that percolated through the peat bog. These sulphur bacteria form in threads of varying lengths and thickness, containing a multiple of cells and have the characteristic of breaking up into a mass of "cocci," which is a rounded mass of plasma. These characteristics of the sulphur bacteria account for the reason we find pyritic sulphur in the form of bands, lenses, ball or nodules in coal. The so-called "sulphur balls" are the result of huge colonies or masses of bacteria plasma that have had a rapid growth under ideal conditions.

The sulphur bacteria first oxidize the hydrogen sulphide to elementary sulphur, which is deposited in the protoplasm as amorphous sulphur. This sulphur is gradually oxidized in the organism, to sulphuric acid, according to the following reactions:

$$2H_2S+O_2\rightarrow 2H_2O+S_2$$
$$S_2+3O_2+2H_2O\rightarrow 2H_2SO_4$$

The sulphuric acid set free, combines at once with the iron carbonates or iron sulphate in the percolating waters to produce iron sulphate ($FeSO_4$), iron disulphide (FeS_2) and oxygen, for another cycle in the growth of the bacteria, according to the following reactions:

$$FeCO_3+H_2SO_4\rightarrow FeSO_4+CO_2+H_2O$$
$$FeSO_4+H_2O+H_2S\rightarrow FeS_2+2H_2O+3O$$

These sulphur bacteria at the time the coal was formed, grew rapidly as long as they had sufficient carbon as food, hydrogen sulphide and carbonates or sulphates in the percolating waters in the peat bog. When the supply of either of these

necessities of life was cut off, the sulphur bacteria ceased to grow and the formation of iron sulphides, other sulphides and amorphous sulphur was stopped. Therefore, we find ferrous disulphide, other metallic sulphides and amorphous sulphur left in the remains of the mass of bacteria plasma.

A typical analysis of a pyritic sulphur ball or nodule, shows the presence of: iron (as Fe_2O_3) 41.85%, sulphur (as SO_2) 50.54%, silicon (as SiO_2) 0.385% and bituminous matter (by volatile matter test) 7.52%: total 100.3%.

The volatile or bituminous matter is derived from the membranes of the sulphur bacteria cells, which bacteriologists show contain a pigment known as bacteriopurpurin and bacteriochlorin, which show on the red and violet end of the absorption spectra by spectro-photometric methods.

According to the present invention, invisible or near-ultraviolet rays are projected on the coal to cause the pigment, known as bacteriopurpurin or bacteriochlorin to fluoresce with a yellow to yellowish-orange color to the eye. This fluorescence may be stronger in the presence of other chemicals incidentally associated with the sulphur in the coal, as sulphide of zinc and calcium, silicates, etc.

My invention may be explained in conjunction with the accompanying drawing which is schematic and is intended to illustrate specific applications of my invention. In the drawing:

Fig. 1 is a schematic view showing a projector of ultraviolet light in conjunction with a mining machine.

Fig. 2 shows the ultraviolet light source in conjunction with a coal carrying conveyor.

In Fig. 1, the mining machine **2** is any conventional underground coal processing equipment, as for example a cutter having a cutter bar **3**. It is provided with one or more, preferably several, ultraviolet ray projectors **4**, positioned to illuminate the face of the coal against which the machine is working.

The lamps may be mercury vapor bulbs of conventional form in a projector housing with visible ray filter so that only, or substantially only, invisible ultraviolet rays are emitted.

With this arrangement of the ultraviolet projector on the mining machine, the cutter bar may be manipulated to avoid sulphur bearing coal adjacent the bottom of the seam, or enable the location of high sulphur coal to be determined so that it may be indicated and separately removed.

In Fig. 2, the ultraviolet light projectors **5** are positioned over a conveyor **6** in a darkened chamber **7** that may be either below or above ground. Lumps of coal high in sulphur may in passing through the chamber, be detected and sorted out.

The foregoing are merely typical of certain applications of my invention which may be used on mining machines, loaders, conveyors, picking tables, tipples, etc., to enable high sulphur coal to be detected and sorted out from the cleaner high grade coal. The terms "ultraviolet" and "black-light" as used herein are intended to include those frequencies capable of causing the sulphur containing bodies in the coal to fluoresce.

I claim:

1. In a method of inspecting coal, the improvement in the detection of sulphur impurities present in the coal which comprises subjecting the coal to near ultra-violet light whereby such impurities will produce a visible orange fluorescence.

2. In a method of inspecting coal, the improvement in the detection of sulphur impurities derived from sulphur bacteria present in the coal which comprises subjecting the coal to near ultraviolet light whereby such impurities will produce a visible orange fluorescence.

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