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Photoelectric Concentrator for the Wet Concentrating Table

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PHOTOELECTRIC CONCENTRATOR FOR THE WET CONCENTRATING TABLE

by

R. A. Welsh[1] and A. W. Deurbrouck[2]

ABSTRACT AND SUMMARY

The Bureau of Mines has developed a photoelectric concentrator apparatus which is capable of collecting incremental products from the discharge of wet concentrating tables. The instrument uses photoelectric cells as sensors to differentiate between two products which have differences in color or reflectivity. The photocells provide a signal that controls a mobile splitting device that separates the products.

Tests conducted on a wet table demonstrated the ability of the apparatus to separate a product containing 81.5 percent pyrite from a lower-grade product containing only 68.8 percent pyrite.

The photoelectric concentrator should have a broad application for collecting concentrates with visible color or reflectivity differences from wet concentrating tables.

INTRODUCTION

Mineral processing units are designed to separate heterogeneous material into two or more products based on physical properties such as density, size, hardness, magnetic susceptibility, etc., or electrochemical properties of the particle surface which determine the amenability of the particle to flotation.

With the exception of hand picking operations, which selectively remove only the largest impurities from the desired product, little application has been made of the visual property color, as a physical characteristic upon which a separation could be made. There are a number of mineral washing devices, however, where a concentrated zone of material appears in a distinctly visible band, but the particles are too fine to permit a hand sorting separation.

The wet concentrating table provides visually detectable zones on the separating surface. In à recent Bureau of Mines study involving the

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collection of a concentrated pyrite product from a wet table, it was decided that an attempt should be made to effect a separation of the desired product from the lower-grade material, utilizing the color difference between pyrite and its associated refuse. This report describes how heavy minerals such as pyrite, cinnabar, and tungsten are collected along the end of the table and then retreated to obtain a concentrate. Such an operation has been necessary, since the zone of concentrate will fluctuate on a table, owing to variations in feed rate, percent solids, size consist, and amount of desired material in the feed. To effect a separation that would provide the maximum concentration of material required, a splitter apparatus which would be capable of following the material zone as it moved--a mobile splitter--had to be designed. Such an apparatus would provide a high-grade product requiring no further treatment. The adjacent low-grade concentrate could then be retreated in a smaller circuit at reduced costs.

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DEVELOPMENT OF THE PHOTOELECTRIC CONCENTRATOR

Research projects directed at the desulfurization of coal by physical means have generally had, as a secondary goal, the production of a pyrite concentrate that can be sold as a byproduct. Attempts to collect a pyrite concentrate from the end of a wet concentrating table have met with only limited success since the collected product generally contained excessive amounts of contaminates. The expense of a retabling to upgrade the pyrite concentrate would probably make the collection of pyrite as a salable byproduct unattractive because, at best, the profit to be made selling a pyrite concentrate would be minimal.

The visible zone of pyrite on a table occurs, as shown in figure 1, when a reasonable quantity of liberated pyrite is in the table feed.

A project was undertaken to adapt photoelectric cells as visual detectors in an apparatus that would be capable of sensing small differences in color between concentrated pyrite and adjacent pyrite containing unacceptably high concentrations of impurities, such as shale and carbonaceous shale. Initial tests to prove the suitability of photoelectric cells to detect differences in the table products were quite successful. Quantities of various table-zone products were glued to a board and then water was run over this surface to simulate actual operating conditions of a table. A photoelectric cell held over this surface readily actuated a relay when it was moved to a zone of different visual reflectance.

Two photoelectric cells were then mounted side-by-side on a frame that would allow them to be moved along the refuse discharge side of a table in a plane parallel to the deck surface. The sensors were set on either side of an approximate dividing line between the pyrite concentrate zone and the nonconcentrate zone. When the zone locations fluctuated owing to normal operating

FIGURE 1. - Pyrite Concentrate on Refuse End of Wet Concentrating Table.

condition changes the sensors actuated their respective relays. The varying light reflection on the slurry surface, owing to the shaking motion of the table, caused some concern; however, this problem was solved by the addition of a three-second time delay in the unit's sensor circuit, which eliminated unwanted signals caused by momentary reflections from the surface of the slurry.

A mobile splitter, which could use the control functions of the photoelectric sensors to position itself at the pyrite-shale dividing line and separate the two products, was built. The detectors were mounted on the splitter and extended 3 inches over the table surface where detection occurred.

Figure 2 is the wiring diagram of the apparatus. As shown, the contacts of the photocell-input units energize the coil of either the forward or reverse motor starter, depending on the corrective action necessary to bring the splitter to the desired location. The two units are electrically interlocked to avoid energizing both starters simultaneously. The supply voltage for the photocell units comes through the voltage stabilizer while the less

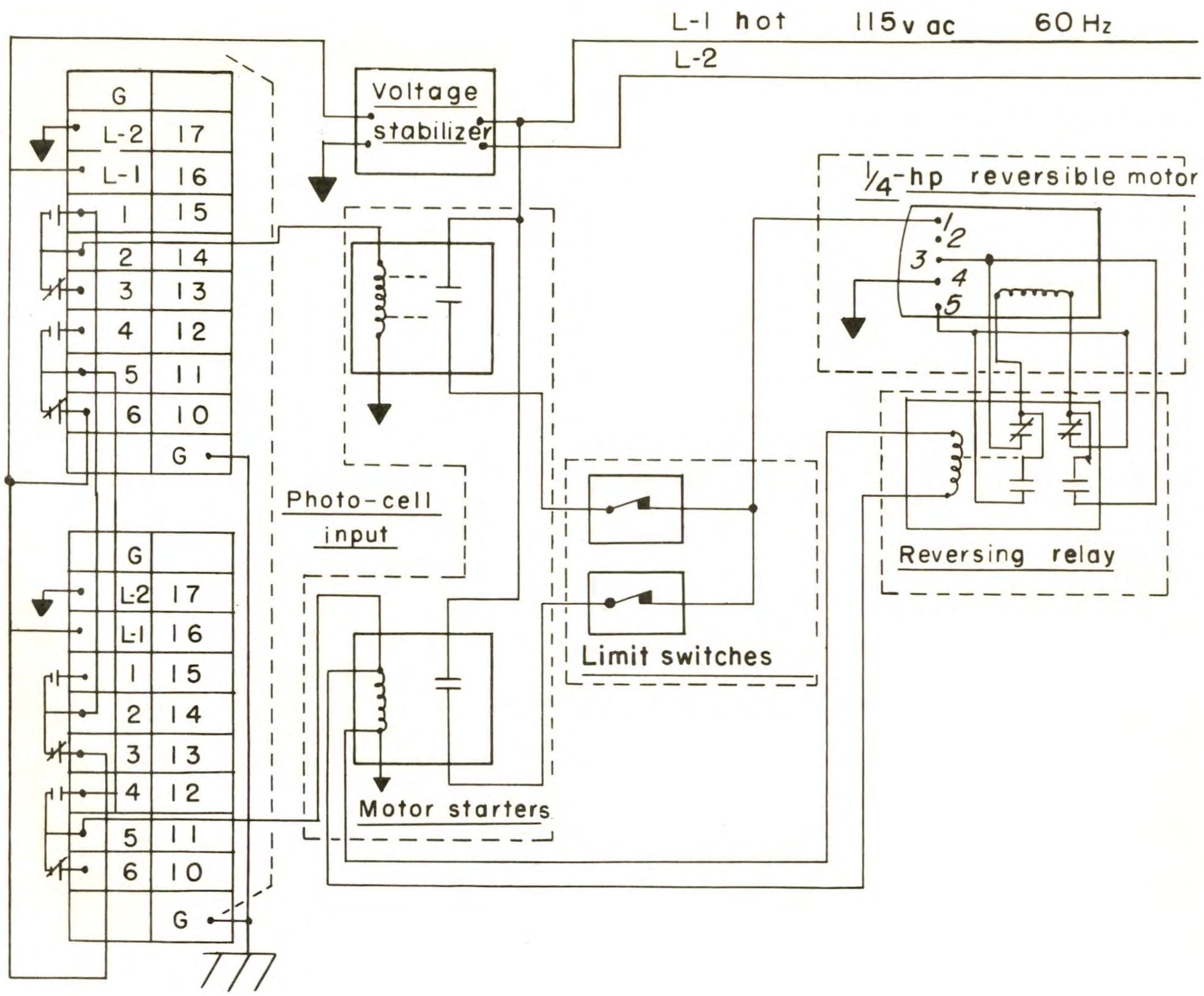

FIGURE 2. - Wiring Diagram of Photoelectric Concentrator.

critical motor supply voltage comes directly from the line. Normally closed limit switches shut down the motor in case of malfunction in the photocell detection circuit.

The photoelectric sensors are spaced 5 inches apart, twice the distance of travel of the mobile splitter after the unit is de-energized. Therefore, after a corrective movement is made, the cut point of the splitter will come to rest at the pyrite-shale dividing line. Unless unusual table operating conditions exist, a movement of 2-1/2 inches of the pyrite-shale dividing line should not occur too frequently, thus eliminating continual actuation of the splitter attempting to follow each small fluctuation of the pyrite-shale dividing line. Travel of the mobile splitter after the motor is de-energized could be easily reduced by installation of a magnetic brake; however, it was felt that the 2-1/2 inches of travel inherent in the apparatus did not adversely affect the final product quality.

TECHNICAL DESCRIPTION OF THE COMPONENTS

The completed photoelectric concentrator is shown in figure 3. The key components are numbered for ease of identification. A hood containing the photocells and light sources, No. 1, is suspended over the table about 3 inches above the detection area. The height above the table is adjusted by loosening the wing nuts on the slotted arm support and moving the hood up or down as necessary to focus on the target area. The hood protects the sensors from damage and shields the target area from excessive ambient light, which can make adjustment of the photoelectric amplifiers difficult. Electrical connections of the photocell receivers and photoelectric amplifiers are made through the support arm. The photoelectric amplifier-controller box, No. 2, which is mounted on the mobile splitter, also contains a constant voltage transformer. Two signal lights are mounted on the box to indicate motor starter operation and its direction. These lights are convenient at startup, when the photocell amplifiers are adjusted to energize the appropriate starter when the pyrite-shale dividing line passes under each sensor. The photoelectric product splitter operates on 110 volts, ac, which is controlled by

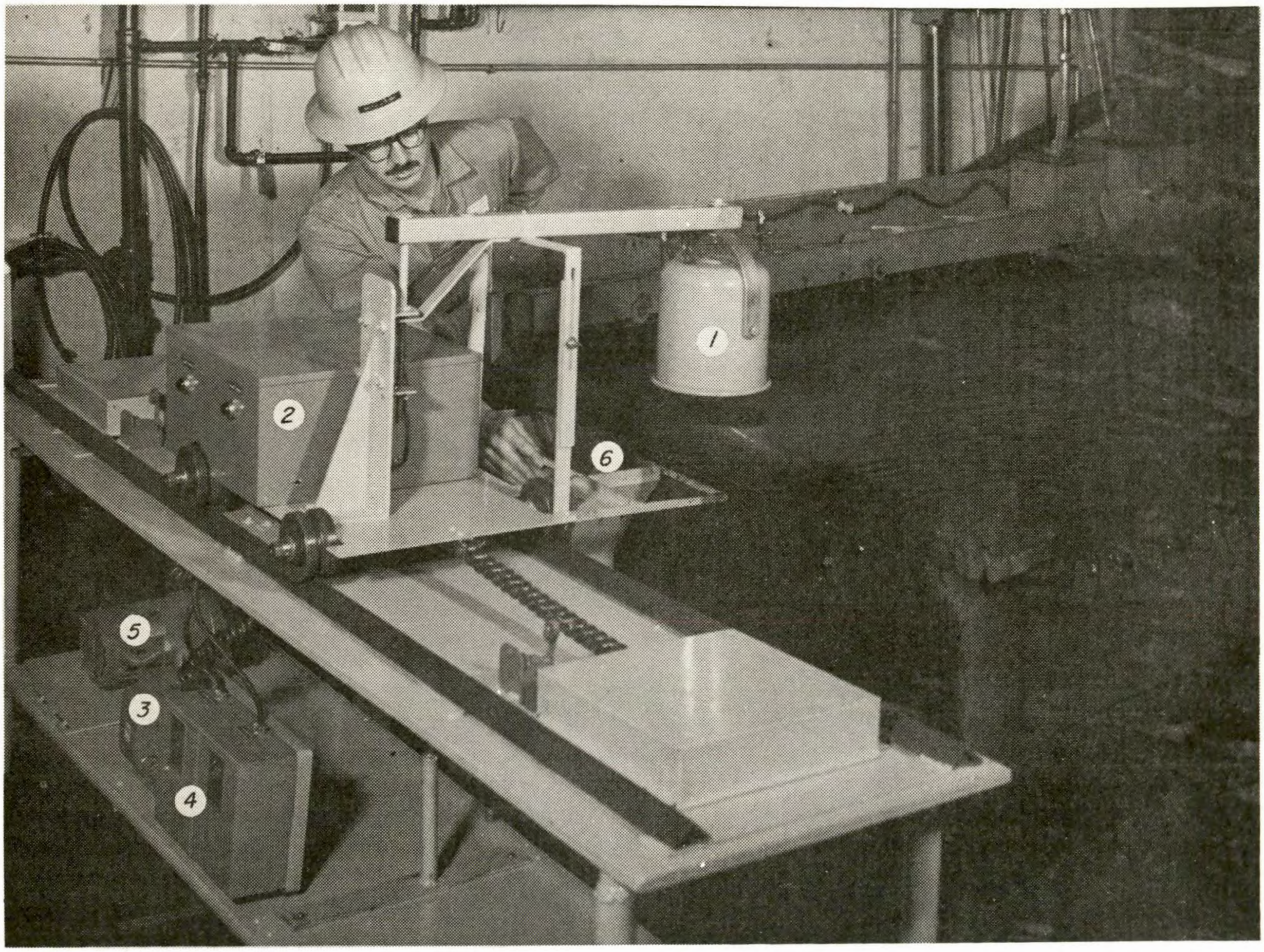

FIGURE 3. - Photoelectric Concentrator.

a fused service switch, No. 3. The motor starters, No. 4, are controlled by the pilot relays of the photoelectric sensors and provide forward and reverse motor control. The drive motor, No. 5, is a 1/4-hp reversible gearmotor. The splitter diverting chute, No. 6, will direct the concentrate into a final product collecting hopper.

The photocells are of the cadmium selenide type with a peak spectral response at a wavelength of 7,350 A, which lies in the orange-red portion of the visible spectrum. The photocell is basically a semiconductor whose resistance varies when exposed to changes in light intensity or color. In selecting a photocell for a given application the light intensity and color are of prime importance because each type photocell has a characteristic color or wavelength to which it is most sensitive.

The photoelectric amplifier-controller is a unit which accepts photocell or resistive input with an adjustable actuating point. The unit is equipped with a mode switch so that the relay can be actuated for either an increasing or decreasing input, providing for light- or dark-sensitive relay operation. Power to the unit is supplied by an integral 24-volt dc full-wave rectifier.

The mobile splitter moves at a speed of 1 inch per second and is mounted on grooved castors which move on tracks of inverted angle iron. The table on which the tracks are mounted has adjustable legs to facilitate the focusing of the sensors on the table and to compensate for the slope of the concentrating table so the sensors move in a plane parallel to the table surface.

TEST PROCEDURES AND RESULTS

Tests were conducted in our pilot plant on a 1/4-size table, to determine the quality of pyrite concentrate obtainable using the photoelectric concentrator. The diverting chute was replaced on the mobile splitter with a 24-1/2-inch-long by 4-inch-wide incremental sampler, which was divided into seven 3-1/2-inch compartments. Each compartment would thus collect the discharge material from a 3-1/2-inch section of the table. The first four compartments would collect a pyrite concentrate and the next three compartments would collect a low-grade pyrite product. Analysis of the material in the incremental sampler would indicate the effectiveness of the photoelectric concentrator. Each sample was analyzed for sulfur content which was then, by calculation, converted to pyrite (FeS_2) content.

Table 1 is a summary of the results from one test on a sample from the Lower Freeport bed, of high pyritic sulfur content coal crushed to 3/8-inch top size.

To collect a highly concentrated pyrite product with the aid of the photoelectric concentrator, it was necessary to select a cut-point that would reject a portion of the pyrite into the shale product. The pyrite varies from 88.0 percent in zone 1 to 81.5 percent in zone 4, which is the concentrate zone adjacent to the split point. Zones 5 through 7 show a decrease in pyrite contents from a high of 68.8 percent in zone 5, which is the shale zone adjacent to the split point, to a low of 28.5 percent in zone 7.

TABLE 1. - Pyrite content by zones collected about the cut-point determined by the photoelectric concentrator

Zone	Pyrite concentrate, 34.4 percent of sample				Low-grade pyrite, 65.6 percent of sample			
	Direct percent		Cumulative percent		Direct percent		Cumulative percent	
	Weight	Pyrite	Weight	Pyrite	Weight	Pyrite	Weight	Pyrite
1	6.2	88.0	6.2	88.0	-	-	-	-
2	12.8	79.9	19.0	82.5	-	-	-	-
3	32.8	82.5	51.8	82.5	-	-	-	-
4	48.2	81.5	100.0	82.1	-	-	-	-
5	-	-	-	-	26.6	68.8	26.6	68.8
6	-	-	-	-	30.2	61.0	56.8	64.7
7	-	-	-	-	43.2	28.5	100.0	49.0

A cumulative pyrite concentrate of 82.1 percent from zones 1 through 4 should be an excellent raw product for the production of sulfur or sulfuric acid. The remaining pyrite-shale mixture from zones 5 through 7 could be reprocessed if a higher recovery of the pyrite were desired.

The split point was chosen by eye at the line of greatest color contrast, which proved to be between 81.5 and 68.8 percent pyrite, a very significant difference in pyrite content. A more positive method of selecting a split point would be to collect zone samples first, and then set the splitter to obtain the desired concentration of pyrite. However, evaluation of the seven 3-1/2-inch-wide zone samples collected about the visually selected split point showed that the maximum pyrite concentrate difference was in the two zones adjacent to the selected point. These results demonstrate the validity of a visually selected concentrate zone.

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