Referring now in detail to the drawing, a typical hydroseparator has been denoted by the reference numeral 10. As already indicated, such apparatus is sometimes referred to by other names such as sluitiators or deslimers, it can be explained that such apparatus is employed in the processing of ferrous ores for the recovery of a mineral from the rock in which it is found. The hydroseparator method of processing involves a preliminary grinding of the ore into a finely divided size to be mixed with the mill in the course of which it is mixed with a quantity of water to form a slurry which is commonly called "pulp." The pulp is introduced at the center of a large circular tank from which point it flows radially toward the perimeter where the water and much of the rock overflows as waste or tailings. The heavier concentrate settles to the bottom from which it is collected. One means of collection is to utilize an underflow pump which pumps the rather thick mixture or slurry of rich ore. What is called auxiliary wash water is added to the tank in order to increase the separation of the heavier ore particles from the lighter rock. In typical operation, a relatively distinct interface between the descending ore and the suspended rock particles will develop. The position or level of this silicamagnetic interface will vary in depth within the tank depending upon the amount of wash water added to the tank and since the top of the cake or the water level will be raised, the magnetic permeability of the material surrounding the cake increases, and as it falls, the permeability is decreased.

Accordingly, one of the object of the present invention is to provide a hydroseparator control system that will control the interface position or level automatically, thereby to improve the efficiency of the separation and to increase the amount of ore which can be processed through a hydroseparator of a given size. More specifically, it is an aim of the invention to first adjust the amount of auxiliary wash water that is being added to the hydroseparator to be sufficient to "lift" the rock particles into the waste stream without carrying the valuable ore particles therewith and under conditions where the limits of the wash water would be exceeded for the accomplishment of this purpose, to temporarily transfer the control to a more effective but less desirable control function, namely the speed of the underflow pump, until the more normal operating conditions can be re-established. The re-establishment of a preselected underflow pump speed upon the return to "normal" conditions is automatically accomplished by the teachings of this invention.

These and other objects and advantages of our invention will more fully appear from the following description, made in connection with the accompanying drawing, wherein like reference characters refer to the same or similar parts throughout the several views and in which:

The single figure constituting the drawing is a schematic diagram of one form that the interface control system can take, the electrical circuitry being shown in conjunction with a conventional hydroseparator.
mum position of the valve 24, this being its fully open position. Cooperable with the movable contact 60 is a fixed contact 64, the contact 60 being normally engaged with said contact 64. Another fixed contact 66 is spaced above the normal or unactuated position of the contact 60 by an amount that insures its closing by the coasting movement of the motor 48 when its energizing circuit is opened at contact 64. The construction of the second limit switch unit 58 is identical to that of the switch unit 56. Accordingly, the unit 58 includes a movable contact 68 having a lug or button 70 thereon, the movable contact 68 being normally engaged with a fixed contact 72 when in one position and when in a second position engageable with a fixed contact 74.

Next to be described is the pump motor 76. This motor 76 has a shaft 78 that is mechanically coupled to the pump 30. The motor also has a field winding 80. In order to control the speed of the motor 76, a rheostat 82 is incorporated into the circuitry, the rheostat 82 conventionally having a resistance 84 and a wiper arm 86.

In order to adjust the speed of the pump motor 76, a speed adjust motor 88 is employed. This motor 88 has associated therewith a pair of windings 90, 92 so that its direction can be reversed. Extending from the motor 88 is a shaft 94 having a pulley 96 at its free end. An endless belt or wire 98 is entrained about the pulley 96 and also about an idler pulley 100. The wiper arm 86 is mounted on the belt 98 so as to be movable in opposite directions, as indicated by the double arrow 102.

At this time, attention is directed to a first potentiometer 104 having a resistance 106 and a wiper arm 108. For convenience of explanation, the wiper arm 108 is also carried by the belt 98, since it is under the supervisory control of the motor 88 for a purpose presently to be made manifest. Hence, the wiper arm 108 moves upwardly and downwardly in the direction of the arrow 110 in the same fashion as does the wiper arm 56 which motion has been previously referred to as being indicated by the arrow 102. A second potentiometer 112 is employed, this potentiometer including a resistance 114 and a wiper arm 116. Unlike the wiper arm 108, the wiper arm 116 is manually adjustable and is left in its adjusted or set position for the purpose of determining the nominal speed of the pump motor 76 as will hereinafter be described.

While it will be referred to as an off-nominal detector 118, which is sensitive to voltage differences existing between the movable contacts on potentiometers 104 and 112, is employed for operating a relay 120. The relay 120 has four sets of contacts, two sets of these contacts being normally open and designated by the reference numerals 122, 124 and the other two sets being normally closed and indicated by the reference numerals 126, 128.

The operation of the interface control system will now be described. For the sake of discussion, it will be assumed that the interface position or level has fallen somewhat from the desired level indicated by the numeral 34, thereby indicating a low condition of the interface that should be corrected. Hence, the coil 36 supplies an appropriate signal to the interface detector which results in the "low" contacts 40 being closed. Inasmuch as the contacts 126 belonging to the relay 120 are normally closed, a circuit is completed through the contacts 40, the contacts 126, the movable contact 60, the contact 64, the field winding 46 and the armature of the motor 44. Hence, the motor 44 is connected to what will be regarded as a 115 volt power supply.

Since the interface has fallen with respect to the level 34, the valve 24 must be opened wider so as to add more auxiliary wash water via the conduit 18. It is the function of the motor 44 to do this and the energization thereof via the winding 46 causes the shaft 49 to rotate in a direction to turn rotate the valve stem 50 to open the valve 24 to a greater degree than the valve was open prior to the closing of the contacts 40.
sense a voltage differential between the potentiometers 304 and 312. This is by reason of the fact that the speed adjust motor 38 has advanced the wiper arm 108 from its normal or null balance position. Hence, the relay 120 remains energized or picked up with the consequence that the contacts 122, 124 remain closed and the contacts 126, 128 remain open.

With the contacts 40 open, though, there is no path for energizing either the valve motor 42 or the speed adjust motor 88. Consequently, the actual interface, due to the fact that the pump motor 76 is now running at a reduced speed, will continue to rise. This happening, quite obviously, will be influenced by the type of pulp being fed through the conduit 14. Assuming, though, that the interface rises to such a height that the contacts 42 are closed, then an electrical path can be traced through these contacts 42, the now closed contacts 124 (still closed because of the off nominal detector 118 is sensing a voltage differential between the potentiometers 104, 112), the field winding 90 and the armature of the motor 88. It will be noted that instead of the field winding 92 being energized, the field winding 90 is energized which causes the valve motor 42 to operate in a reverse direction, thereby causing the belt 98 to move the wiper arm 108 in a direction toward its null or balanced position. Continued movement in this direction, this being an increased direction as far as the pump 50 is concerned, will cause the motor 76 to speed up and increase the rate of underflow. If these same assumed conditions continue, then the difference in voltage between the potentiometers 104 and 112 will decrease sufficiently and the off nominal detector 118 will reflect this rebalancing with respect to the relay 120. The relay 120 will then become de-energized and the contacts 122 and 124 will open and the contacts 126 and 128 will close.

When the interface level has been lowered sufficiently, then the "high" contacts 42 will open and the entire system will be returned to a passive state but ready for any subsequent change that might require correction. It is important to note that the pump 50 has been returned to the speed at which it was operating prior to the sequence just described. This is an important feature of the invention, for the pump speed can be initially set through the agency of the potentiometer 112, more specifically its wiper arm 116, and after the interface has been returned to its proper level 34, then the pump 50 will return to its normal or preselected speed.

Owing to the detailed description presented with respect to the operation that occurs when the interface becomes too high with respect to its desired level 34, it is thought that the operation that takes place when the interface initially becomes too high with respect to said level 34 will be equally comprehensible without further explanation. All that occurs is that the disc 52 moves downwardly as the valve 24 is moved toward a closed position. When the maximum position, usually a complete closing of the valve 24, is reached, then the limit switch 58 is actuated by virtue of the engagement of the disc 52 with the lug or button 70. The inverse of the preceding operation then transpires.

It will, of course, be understood that various changes may be made in this form, details arrangements and proportions of the parts without departing from the scope of our invention as set forth in the appended claims.

What is claimed:

1. A control system for maintaining a desired interface level in hydroseparators comprising:
   (a) means for detecting the interface level in a hydroseparator;
   (b) means responsive to said detecting means for increasing the rate of flow of wash water to said hydroseparator when the interface has risen above said desired level between predetermined upper and lower limits, respectively, and (c) means controlled by said increasing and decreasing means for decreasing the rate of underflow from said hydroseparator when said upper limit is reached and increasing said underflow when said lower limit is reached.

2. A control system for maintaining a desired interface level in hydroseparators comprising:
   (a) means for detecting the interface level in a hydroseparator;
   (b) means responsive to said detecting means for increasing the rate of flow of wash water to said hydroseparator when the interface has fallen below said desired level and decreasing the rate of flow of wash water to said hydroseparator when the interface has risen above said desired level between predetermined upper and lower limits, respectively;
   (c) means for removing underflow from said hydroseparator at a substantially uniform rate, and
   (d) means controlled by said increasing and decreasing means for decreasing said uniform rate when said upper limit is reached and for increasing said uniform rate when said lower limit is reached.

3. A control system for maintaining a desired interface level in hydroseparators comprising:
   (a) means for detecting the interface level in a hydroseparator;
   (b) means responsive to said detecting means for increasing the rate of flow of wash water to said hydroseparator when the interface has fallen below said desired level and increasing the rate of flow of wash water to said hydroseparator when the interface has risen above said desired level between predetermined upper and lower limits, respectively;
   (c) means for removing underflow from said hydroseparator at a substantially uniform rate, and
   (d) means controlled by said increasing and decreasing means for decreasing said uniform rate when said upper limit is reached and for increasing said uniform rate when said lower limit is reached.

4. A control system for maintaining a desired interface level in hydroseparators comprising:
   (a) means for detecting the interface level in a hydroseparator that has become too low or too high with respect to said desired level;
   (b) means responsive to said detecting means for increasing the rate of flow of wash water to said hydroseparator to a predetermined value when said interface level has become too low with respect to said desired level and for decreasing the rate of flow of wash water to a predetermined value when said interface level has become too high with respect to said desired level;
   (c) means for normally removing underflow from said hydroseparator at a substantially uniform rate until either of said predetermined values has been reached;
   (d) means for decreasing the rate of said underflow when said first-mentioned predetermined value has been reached and for increasing the rate of said underflow when second-mentioned predetermined value has been reached, and
   (e) means for re-establishing said substantially uniform rate after said interface level has been returned to its desired level between said low and high levels.

5. A system for controlling between low and high levels the position of the interface in a hydroseparator to realize a desired interface level, the system comprising:
   (a) means for initiating an increase in the rate of flow of wash water to said hydroseparator when said low interface level below said desired level has been reached and for initiating a decrease in the rate of flow of wash water when said high interface level above said desired level has been reached,
(b) means for normally removing underflow from said hydroseparator at a given flow rate;
(c) means for stopping said increase in flow rate of wash water when a predetermined maximum has been reached (but continuing at said maximum rate) and for stopping said decrease in flow rate of wash water when a predetermined minimum has been reached (but then continuing at said minimum rate);
(d) means for normally removing underflow from said hydroseparator at a selected rate;
(e) means for decreasing said selected rate when said maximum rate of wash water flow has been reached and for increasing said selected rate when said minimum rate has been reached, and
(f) means for first returning said underflow to its selected rate prior to changing said wash water from either its said maximum or minimum rate as the case may be.

6. A control system for maintaining a desired interface level in hydroseparators comprising:
(a) means for detecting the interface level in a hydroseparator;
(b) a valve for increasing the rate of flow of wash water to said hydroseparator when the interface has fallen below said desired level and decreasing the flow of wash water to said hydroseparator when the interface has risen above said desired level;
(c) a motor for positioning said valve between predetermined positions which provide maximum and minimum wash water flow rates;
(d) means controlled by said detecting means for causing said motor to operate said valve toward an open position when said interface level is below said desired level and to operate said valve toward a closed position when said interface level is above said desired level;
(e) means for normally removing underflow from said hydroseparator at a given rate, and
(f) means for decreasing said given rate of underflow when said valve has moved to its maximum wash water flow rate position and for increasing said given rate when said valve has been moved to its minimum wash water flow rate position.

7. An interface control system in accordance with claim 6 including:
(a) means for returning to said given underflow rate after said desired interface level has been re-established.

8. A control system for maintaining a desired interface level hydroseparators comprising:
(a) means for closing a first set of normally open contacts when the interface has become too low with respect to said desired level and for closing a second set of normally open contacts when the interface has become too high with respect to said desired level;
(b) a valve for increasing the rate of flow of wash water to said hydroseparator when the interface has fallen below said desired level and decreasing the flow of wash water to said hydroseparator when the interface has risen above said desired level;
(c) a motor for positioning said valve between predetermined positions which provides maximum and minimum wash water flow rates;
(d) a first limit switch unit in circuit with said first contacts actuated by said motor when said valve has reached the predetermined position corresponding to maximum flow;
(e) a second limit switch unit in circuit with said second contacts actuated by said motor when said valve has reached the predetermined position corresponding to minimum flow;
(f) a pump for removing underflow from said hydroseparator;
(g) a motor for driving said pump;
(h) means for decreasing the speed of said pump motor when said first limit switch unit is actuated and for increasing the speed of said pump motor when said second limit switch unit is actuated;
(i) a first potentiometer adjusted by said speed decreasing and increasing means for providing an electrical signal variable in accordance with the amount said speed means has decreased or increased the speed of said pump motor;
(j) a second potentiometer adjusted manually to provide an electrical signal corresponding in value to the desired speed of said pump motor, and
(k) means for sensing any differences between said electrical signals including two sets of normally open contacts one of which sets shuts said first switch unit when closed and the other of which sets shuts said second switch unit when closed,
(l) said one set of contacts being in circuit with said first set of contacts and said other set of contacts being in circuit with said second set of contacts whereby said speed decreasing and increasing means is returned to a normal position and said first potentiometer is returned to a position of electrical balance with respect to said second potentiometer after whichever first or second sets of contacts that are closed have opened and upon subsequent closure of the other first or second sets of contacts as the case may be.

References Cited

UNITED STATES PATENTS
2,723,754 11/1955 Darby --- 209-5 X
2,811,257 10/1957 Hisle --- 209-500
5,208,592 9/1965 Smith --- 209-158

FRANK W. LUTTER, Primary Examiner.
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION


John R. Riede et al.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 44, for "lever" read -- level --; column 3, line 28, after "belt" insert -- 98 --; column 4, line 6, for "level", read -- level --; line 7, for "34" read -- 34, --; line 35, for "adjustor" read -- adjust --; column 5, line 18, strike out "of"; column 6, line 31, for "increasing" read -- decreasing --; line 40, for "decreasing" read -- decreasing --; column 7, line 50, after "level" insert -- in --.

Signed and sealed this 2nd day of January 1968.

(SEAL)
Attest:
Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents