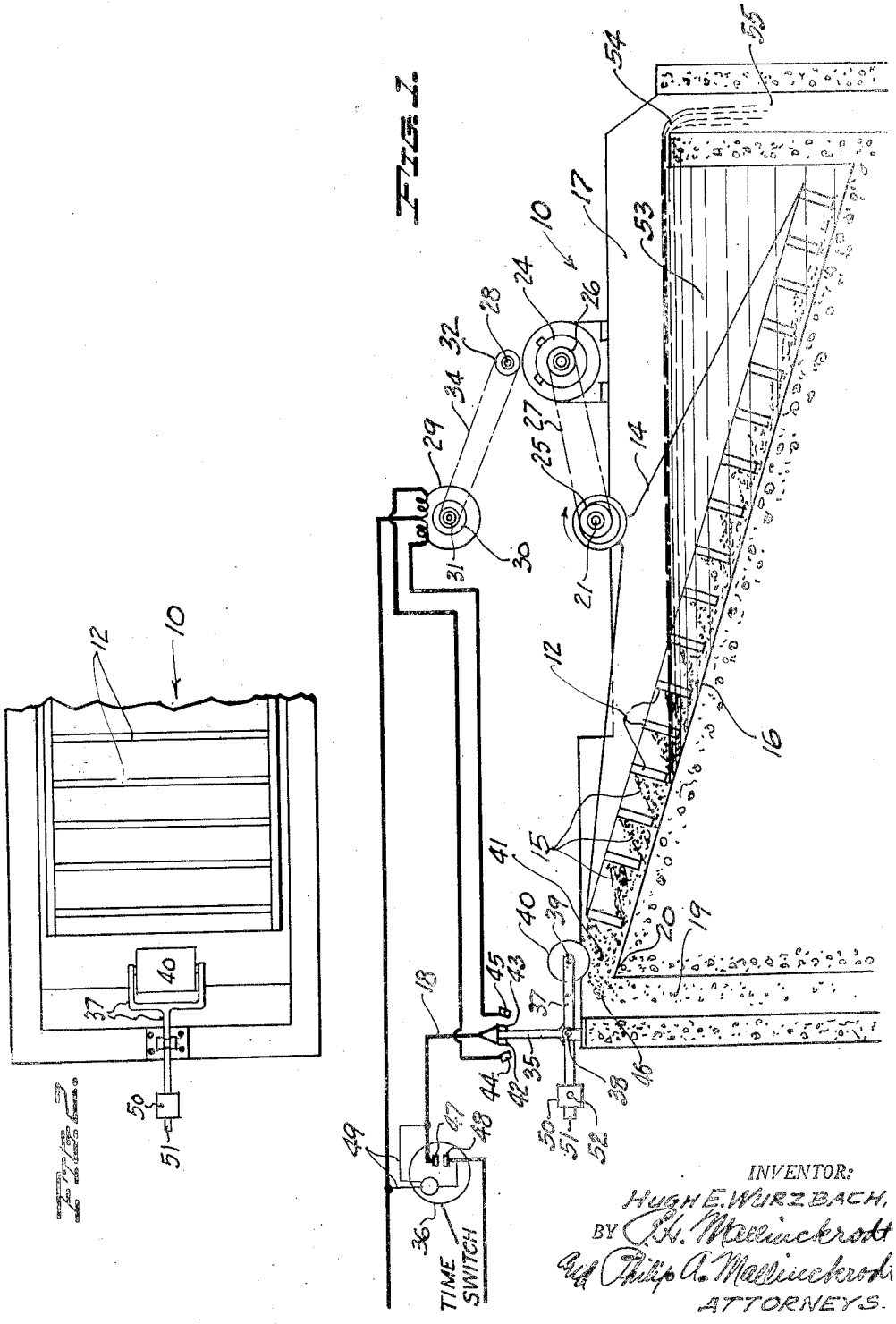
Jan. 29, 1952 H. E. WURZBACH 2,584,076

CONTROL SYSTEM

Filed Nov. 23, 1945 2 SHEETS—SHEET 1



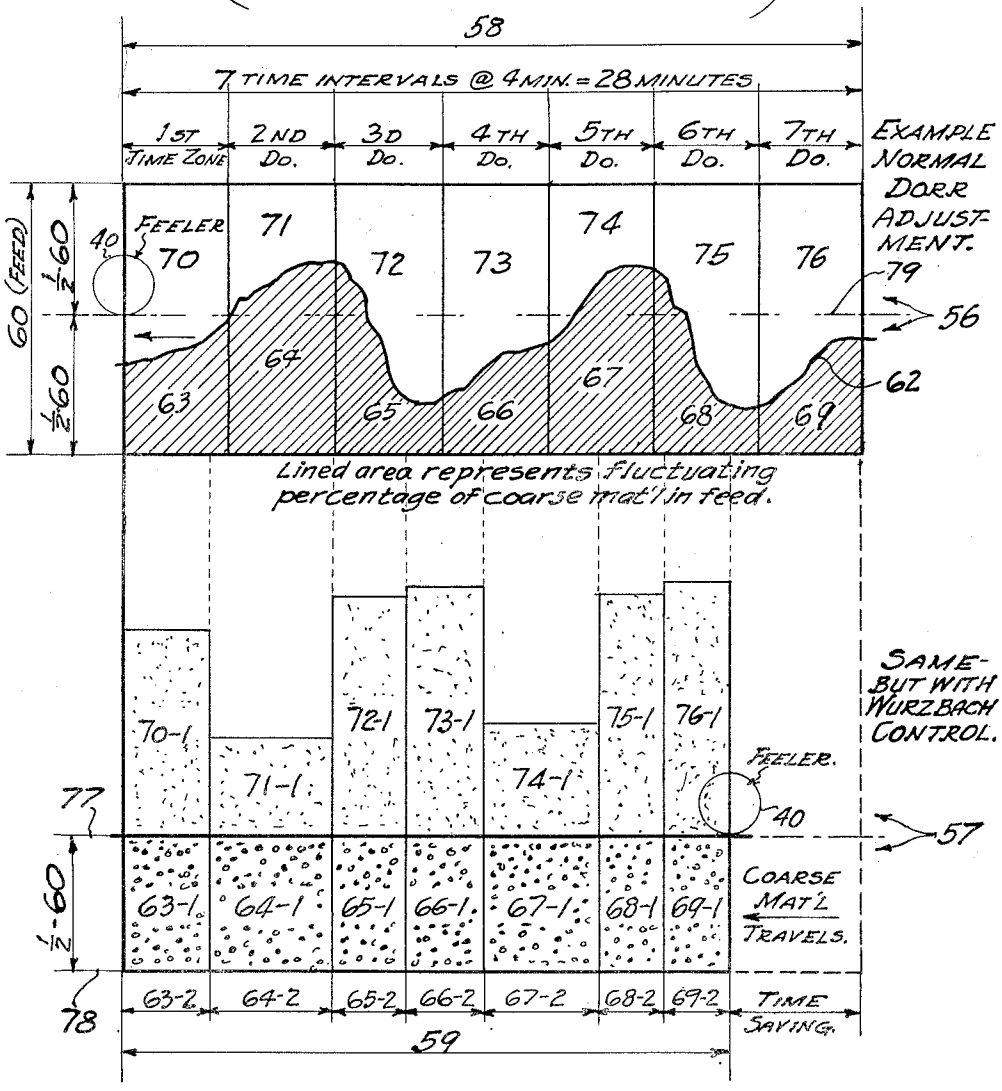
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FIG. 3.

(COMPARATIVE PERFORMANCE CHART.)



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CONTROL SYSTEM

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12 Claims. (Cl. 209—496)

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This invention relates to a control system, and more particularly to one that is effective to automatically regulate and supervise the performance of certain machinery, of which a drag-type classifier equipped with rakes is a prominent example. Since this is a typical use, it is convenient to herein described the invention specifically in connection with such a classifier, in particular a Dorr drag classifier, although the invention is not necessarily restricted to this use.

In classifiers of this type the pulp feed, which consists of more or less finely divided solids suspended in liquid, such as water, is conducted into a tank having an inclined bottom. The liquid overflows from the tank at a certain level carrying with it the finer solids, while the coarser solids tend to settle on the bottom and are raked upwardly to be discharged over a ledge located above the liquid level.

Drag classifiers are common in the art of ore dressing and their use in general is well understood. Nevertheless, it is not out of place to quote an authority to the effect that these machines "are capable of adjustment to cover considerable range of conditions" and further that "adjustments in slope of classifier tank, rake speed, and dilution of overflow pulp are necessary to obtain the desired closeness and mesh of separation."

In spie of this assumed capability of "adjustment" the fact remains that in actual practice the "desired closeness and mesh of separation" is not exact, for the reason that the adjustments, such as they are, are more or less fixed, while the ores, even from the same mine, vary so greatly in composition that the stated "adjustments" can be only crudely approximated to the average composition of an ore. As a consequence such adjustments still cause a classifier to be overloaded and choked with the coarser material at one time, and at another time to be loaded far below its capacity with material that is of lesser coarseness.

Among the principal objects of the invention may be summarized the following:

(*a*) To provide an automatic control system for machines such as Dorr classifiers, and adapted for running such machines at the minimum speed necessary for best results, consistent with the nature of the material being handled.

(*b*) To maintain a minimum rake speed for any particular sand load being moved, so as to cause the least amount of agitation in the settling area of a classifier.

(*c*) To maintain constant, as nearly as possible, the level of the coarse sands just in advance of the discharge ledge.

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(*d*) To maintain the maximum sand load on the rakes regardless of the quantity of feed passing into a classifier; for example, a drag classifier operates at its maximum efficiency when the coarse material is removed as fast as it enters, and settles in, the classifier.

(*e*) To cause the speed of the classifier to vary in such a way as to closely following changing load conditions, since it is desirable to operate the rakes as slowly as possible, but at the same time to keep the rakes fully loaded at all times.

(*f*) To provide periodic supervision.

Further objects will become apparent as the description proceeds.

In connection with the invention whatever adjusting means is commonly supplied as original equipment on the machine concerned to regulate sizes of material discharged and other conditions, must still be used. The device of the invention is intended to serve as a complement thereto. In short, the sole intent of the invention is to bring about the optimum performance of a regularly equipped classifier under any and all changing conditions.

According to the invention it is advantageous to control the speed of the classifier rakes rather than the input feed because the input can be controlled by the maximum capacity of the machinery preceding the classifier. It is not desirable to regulate the feed entering the classifier with reference to the capacity of the classifier at any given speed, for which reason a consideration of the invention is that the classifier shall accept the maximum feed in a system and have its own speed vary from one relatively short time period to another so as to avoid overloading or clogging, as well as to avoid underloading. Therefore the rake speed of the classifier is controlled or varied with respect to the significant level of the material against which the rakes work at the discharge end. The rake speed must be such that the coarse material returned to the circuit for regrinding plus the material in the finished overflow will equal the input feed.

Since the material discharged by the rakes contains liquid, it is desirable that the gauging element be made in the form of a relatively light, airtight drum or rotatable float adapted to ride on the material and to be partially submerged therein, the degree of submergence being proportional to the liquid content of the material passing through the machine. This drum or float can be counterbalanced or counterweighted to assist in providing the desired buoyancy. Thus, riding on the material, the float will take a position determined not alone by the compacted height of the solid particles

being discharged, but also by the density of that material. Accordingly, the performance of the classifier is controlled not solely by the actual height of the solids in the material but by a combination of that height with the density. This is in harmony with the practical characteristics of a classifier, because the loading depends largely upon the density of the material being handled. In other words, if the feed is hard and coarse, it is much drier when discharged than is the case when the feed is soft and fine. Consequently, the speed of the classifier rakes is referred to the passage of a material comprising massed discrete particles dispersed in a liquid.

In the accompanying drawings, which illustrates one embodiment of apparatus by means of which the invention is carried into practice:

Figure 1 represents a side elevation, largely in vertical section and in diagrammatic form, of a Dorr drag classifier, to which the invention is applied;

Fig. 2, is a fragmentary plan corresponding to Fig. 1; and

Fig. 3, a diagram showing graphically the approximate performance of a Dorr classifier without the advantages of the invention, compared with one having the advantages.

Referring to the drawing, the numeral 10, Fig. 1 indicates a drag classfier of the Dorr type. This type of classifier is provided with rakes, exemplified at 12, which are suspended from a structure 14, mounted for reciprocation so as to provide the peculiar motion necessary for the rakes to drag masses of material 15 upwardly on a suitable surface, such as that indicated at 16. The material operated on by the rakes is usually in the form of coarse sands which have settled out from crushed ore, these coarse sands being discharged at 19 over a ledge 20 in a cohesive stream, somewhat after the manner indicated. The way in which material is fed to the classifier is not important to the present issue, and, therefore, is not shown. The inclined bottom 16 is part of a tank 17.

The classifier is driven from the usual shaft 21, but, as an important part of the invention, the speed of rotation of this shaft is automatically varied from time to time in accordance with varying needs of operation of the classifier rakes, as hereinbefore stressed.

An advantageous way to impart the desired motion to the shaft 21 is by means of an alternating current electric motor of the brush-shifting type. In such a motor, if the brushes are shifted, the speed of the motor varies with the position of the brushes on the commutator. Another way is to use a direct current electric motor with a rheostat or other suitable regulating apparatus to vary the speed of the motor. However, all such regulating means are old, and per se do not form a part of the invention.

In the present instance, it is assumed that a variable speed motor 24 of the brush-shifting type is used. Power from the motor 24 to the shaft 21 is transmitted by any suitable and well known means, such as the respective pulleys 25 and 26 with a belt 27 running over these two pulleys. In this instance, a brush - shifting mechanism is not shown in detail, since leading manufacturers supply their own particular makes. Here, it is enough to show a shaft 28, the rotation of which in either direction shifts the brushes (not shown) accordingly.

At 29 is a reversible electric motor by means

of which the shaft 28 is rotated in either direction in order to control the operation of the motor 24. In the present instance, the speed of the control motor 29 is advantageously reduced before transmitting its motion to the brush-shifting shaft 28 of the motor 24. Such speed reduction is satisfactorily accomplished by means of a geared speed reducer 30 direct-connected to the motor shaft and having a sprocket wheel 31 mounted on the output shaft of the reducer. Another sprocket wheel 32 is mounted on the shaft 28, the two sprocket wheels being operatively connected by a chain 34, preferably of the roller type.

In its function of controlling the performance of the drag classifier, the motor 29 is connected electrically with a floating switch arm 35 and with a motor-operated make-and-break time switch 36. The floating switch includes an arm 37 pivoted at 38 and carrying a roller or drum 40 near its free end, the roller being made, for example, of sheet metal and mounted to rotate at 39.

The switch is so arranged that the sand at the discharge of the classifier is pushed under the roller 40, thereby raising or lowering it in proportion to the height of the bed 41 of sand being pushed over the discharge ledge 20 by the rakes. Two movable contacts 42 and 43 are mounted on the arm 35 and are connected to a leg 18 of the electric circuit, while two cooperating stationary contacts 44 and 45, respectively, are spaced apart sufficiently to give the arm the desired amount of play between the cooperating contacts, thus limiting the extreme upper and lower positions of the roller relative to the classifier discharge 46.

The arm 35 is shown in the neutral position where the switch contacts 42 and 43 are approximately midway between the terminals 44 and 45. In this position, the roller 40 is running on what may be taken as the mean or normal classifier load as represented by the quantity of sand discharged from the classifier. If there is an increase over the normal, the roller rises, finally causing contact 42 to touch terminal 44, thus, under certain conditions explained later herein, energizing the motor 29 to rotate the brush-shifting shaft 28 in the proper direction to cause the motor 24 to speed up, thereby lessening the height of the sand stream passing under the roller. As a result, the contacts 42 and 44 are again separated and the motor 29 stopped. If there should be a lessening of the sand stream below normal and finally to the point where the contact 43 touches the terminal 45, the motor 29 again becomes energized, but this time it will rotate counter to the first-mentioned direction and so will cause the brush-shifting shaft 28 to slow down the motor 24, thereby decreasing the speed of the classifier rakes, with the result that more material passes under the roller 40, thus causing the contact 43 to be moved away from the terminal 45. So long as the normal amount of material passes under the roller 40, the motor 24 will continue to rotate at a given speed.

It is to be observed that the motor-driven, make-and-break time switch 36 has the contacts 47 and 48, and is connected in a secondary circuit 49, which is itself connected in circuit with the two switch terminals 44 and 45. Now, since the reversible motor 29 is also connected in this latter circuit, it follows that, even though the two floating-switch contacts 42 and 44 touch,

as hereinbefore stated, the reversible motor 29 will not be energized unless at the same time the time-switch contacts 47 and 48 are closed also. The same statement holds true for the two floating-switch contacts 43 and 45.

The time switch 36 is adjustable for predetermining the duration of the operation period as well as the duration of the rest period of the reversible control motor 29, so it becomes possible to obtain almost any desired relation between the durations of such periods, which means that the frequency with which the operation periods occur is also predetermined. It is desirable that the operation periods be made as infrequently as is consistent with the economical operation of both the control equipment and the equipment thereby controlled.

Since the control circuit is periodically closed and opened, or vice versa, it becomes automatically supervisory in character to correct undesired operative conditions occurring in a drag classifier or other apparatus. The fact that the supervisory function is exercised regularly provides the assurance that any particular abnormal condition which may develop is allowed to continue not longer than the beginning of the next control period, and then only long enough to give time for its correction.

The roller 40 functions as a buoyant drum float feeler to feel out the significant level in the material passing over the discharge ledge thereby gauging the optimum flow of coarse sands over the discharge ledge in agreement with a given classifier rake speed. Frequently it is desirable to counter-balance the drum float 40 in order to increase its sensitivity. A counterweight 50 adjustably positioned along an arm 51 is provided for this purpose, the adjustment being effected by means of a set screw 52, or other suitable means.

The liquid in the classifier is indicated at 53 and the overflow thereof at 54. This overflow carries the finished fine material with it into the discharge passage 55 from where it is conveyed to any suitable point of disposal. The coarse material discharged at 19 plus the fines overflowed at 54 equal substantially the input feed (not indicated) of the classifier. The input feed may be led into the tank at any usual point.

Reviewing briefly the novel features of the invention, it is to be observed that the feeler 40 normally lies at a given level in or on a body of material in transit, and that any material that is added to the normal body becomes operative to raise or lower, as the case may be, the level at which the feeler rides. The electric contacts are disposed in positions that are in proximity to the given or normal position of the feeler, so that when the latter is caused to depart from that position, at least one set of the contacts becomes operative to energize an associated electric control circuit. This energizing of the circuit then becomes effective to start an associated reversible motor in the proper direction to bring about a change in the level of the body of material which change tends to correct the undesired condition and to allow the feeler to be restored to substantially its normal position.

The comparison between a Dorr classifier equipped in accordance with the novel apparatus of the invention and the performance of the same classifier equipped only as provided for by Dorr and without the novel apparatus graphically

illustrated in Fig. 3, should give a clear comprehension of the differences between those performances.

Referring to Fig. 3, the portion 56 thereof represents by means of ordinates and abscissas, the performance of a Dorr classifier as ordinarily adjusted, while the portion 57 represents the performance of the same classifier similarly adjusted but under the control of the novel apparatus.

For convenience it is assumed in the case of the portion 56, that the classifier is under observation for a fragmentary period of 28 minutes out of a regular day's run. This period is divided into seven unit intervals of four minutes each, these adding up to the ordinates having the arbitrary scaled dimension 58 representing graphically the 28 minute period.

In the case of the portion 57, the dimension of the ordinates result from rectifying the respective areas in the portion 56 and drawn to represent new conditions presently to be described. The abscissas in the portion 56 have the common dimension 60 and represent an arbitrarily assumed feed of material composed, for illustration, of a mixture of coarse and fine particles. The irregular line 62 represents the division between the relative proportions of fine and coarse material passing through the classifier at any moment during the different time intervals, but not segregated as suggested by the diagram. The composite area above the line 62 represents the fine material, and the composite area below, the coarse material.

The coarse material load at a particular instant is ascertained by dropping a perpendicular from the line 62 upon the base of the portion 56. Accordingly, irregular areas 63 to 69 represent the relative proportions of coarse material passing through during the respective four-minute time intervals, while the corresponding respective spaces 70 to 76 above the line 62 represent the corresponding proportions of fine material. It can readily be seen that the line 62 thus indicates a haphazard and not an optimum performance in the case of the ordinary Dorr classifier.

The portion 57 of the diagram visualizes the novel result attained when the ordinary Dorr classifier is equipped with the apparatus of the invention. Here the line 77 represents the level of separation assumed as the datum for the optimum performance corresponding to certain feed conditions.

Plotting the results of the corrective measures exercised by the novel control apparatus upon the undesirable operative conditions represented in the portion 56, the area 63 is rectified into the rectangular, equivalent area 63—1 extending vertically from the base line 78 to the datum line 77. Similarly, rectifying the irregular areas 64 to 69 into the respective equivalent rectified areas 64—1 to 69—1 will cause the original base ordinate to be changed from the dimension 59 to the new dimension 59, which latter, according to the present assumed conditions, is less than the dimension 58. The changed dimension results because in each of the areas 63—1 to 69—1 the horizontal dimension becomes larger or smaller than the horizontal dimensions of the corresponding areas 64 to 69 according as the irregular upper boundary of the respective areas 64 to 69 is located above or below the broken line 79 the level of which corresponds to that of the line 77. The irregular areas 70 to 76 are plotted

above the rectangles 63—1 to 69—1, as rectangles 70—1 to 76—1, respectively. These latter rectangles represent the corresponding fine material which overflows from the classifier tank.

The feeler 40 actually feels out the peaks and valleys of the line 62 and brings this line up to datum level, thereby producing results closely approximate to optimum performance.

Assuming that the material is moving from right to left along the line 79 under the feeler, the latter, above the area 63, immediately speeds up the control mechanism so that the rakes push up coarse material to fill the valley. In the area 64 the feeler acts to level off the peak above the line 79 by causing the control mechanism to slow down the rakes. As the successive irregular areas pass under the feeler, it acts upon the controls to speed up or slow down the rakes as the case may be, so as to even out the peaks and valleys of the line 62. Accordingly, the corresponding time periods as represented in the portions 56, are decreased or increased, as the case may be, thereby causing the line 58 representing the accumulated time period, to be shortened from that prevailing in the portion 56 to that represented by the line 59 prevailing in the portion 57.

Under the assumed conditions, material having the coarse content represented by the area below the line 62, will in the ordinary Dorr classifier, occupy a period of 28 minutes to be classified, while in the case of the invention, acting upon the same material, the time period for classifying is reduced according to the ratio existing between the lines 58 and 59. This means giving the classifier a greater capacity while actually reducing the wear and tear upon the machinery.

The rectangles 70—1 to 76—1 represent the fines corresponding to the respective coarse material amounts 63—1 to 69—1, these fines as before, being overflowed from the classifier tank.

The fact that the device of the invention replaces nothing that is provided with classifiers generally, is strongly emphasized.

It is designed to take supervisory control so as to cause the rake speed to vary by minute increments and decrements as required above and below the average speed and to follow all ore or other material changes for the attainment of maximum classification efficiency.

The present application is a continuation-in-part of the one filed by me April 29, 1942, Ser. No. 441,052, now abandoned.

While the foregoing description of the apparatus is largely specific, the invention is limited only by the terms of the following claims.

What is claimed is:

1. A control system, including in combination, an electric circuit; a reversible control motor connected in the said circuit and arranged to control the rate of propulsion of an aqueous pulp through a material-handling mechanism; and a floating switch mechanism having rotatable float means riding on a portion of a cohesively flowing and fluctuating stream of material handled by said material-handling mechanism, the said floating switch being connected in the said circuit and arranged so as to have a neutral position which corresponds to a given state of density of the said aqueous pulp material passing under the said float means, a second position in which contacts are closed in response to a decrease in the density of the said aqueous pulp whereupon the said float means drops a given distance below the said neutral position, thereby causing the said reversible motor to be energized and rotated in one direction, and a third position in which another set of contacts is closed in response to an increase in density of the said aqueous pulp whereupon the said float means is raised a given distance above the said neutral position, thereby causing the said reversible motor to be energized and rotated in a direction opposite to the said one direction.

2. The combination recited in claim 1 wherein there are additionally provided means operative to cause the change of rate of propulsion to occur only within periodically recurring time intervals.

3. A control system for regulating the operation of a drag classifier which has a sand discharge ledge and rakes disposed to drag sands over the discharge ledge, comprising a rake-speed control mechanism; a normally open electric switch having a rotatable float adapted to ride on the sands being discharged over said discharge ledge and to close said switch at predetermined ones of the fluctuating positions of said float; an electric motor having a variable-speed mechanism, the said motor being disposed to drive the drag classifier; electrical means for varying the speed of said electric motor; and electric circuit means in which both said electric switch and said electrical speed-varying mechanism are connected.

4. The combination recited in claim 3 wherein the electrical means for varying the speed of the variable-speed electric motor comprises a reversible electric motor operable upon the variable-speed mechanism of said variable-speed electric motor.

5. The combination recited in claim 3 wherein there are additionally provided means operative to cause the change of rate of propulsion to occur only within periodically recurring time intervals.

6. A control system, including in combination, an electric float switch having a rotatable float element disposed for riding on a cohesively flowing and a fluctuating stream of aqueous pulp material whose density and rate of feed varies from time to time, and having electric make-and-break contacts at given control levels; means for propelling said stream of material; a variable speed electric motor operative on said propelling means to control the rate of propulsion of the said stream of material; electric control means operative to vary the speed of the said motor; and an electric circuit in which the same make-and-break contacts and the said control means are operatively connected.

7. The combination recited in claim 6 wherein the electrical means for varying the speed of the variable-speed electric motor comprises a reversible electric motor operable upon the variable-speed mechanism of said variable-speed electric motor.

8. The combination recited in claim 6 wherein there are additionally provided means operative to cause the change of rate of propulsion to occur only within periodically recurring time intervals.

9. Apparatus operative upon a cohesively flowing stream of material composed of a mixture of fine particles and coarse particles in transit, whose density has a tendency to fluctuate because of variations in the composition thereof, the said apparatus including in combination, an electric float switch having a rotatable and buoyant cylindrical roller float element disposed for riding in or on the said material at a datum level, and having electric make-and-break con-

tacts at points in close proximity to and above and below the datum level; motive means operative to propel the said material; and variable speed drive means for said motive means whereby undue variation in the fluctuating density of the said material in transit is corrected; electric control means operative to vary the speed of the said drive means; and an electric circuit in which the said make-and-break contacts and the said electric control means are operatively connected.

10. In an automatic control system where the rate of flow and density state of a cohesively flowing stream of pulp-like material constitutes the control criterion; control means adapted to respond to fluctuations in the flow and density of said stream; said control means comprising an oscillating supporting structure; a buoyant cylindrical roller float rotatably mounted in said supporting structure and adapted to ride in or upon said stream; means effective to alter the rate of flow of the said stream; and a power-imparting mechanism operative from the said float to the rate-altering means.

11. A control system for a drag-type classifier, comprising control means for varying the rake speed of the classifier from moment to moment during a cycle of continuous running to obtain the optimum operation thereof; and regulating means responsive to variations in the density state of the stream of material passing in advance of the discharge ledge of the classifier, for actuating said control means, said regulating means including a buoyant cylindrical roller float disposed for riding in or on said stream of material.

12. A control system for a drag-type classifier, comprising control means for automatically increasing or for automatically decreasing the rake speed of the classifier during a continuous operation cycle; and means responsive to variations in the density state of the stream of material being discharged over the discharge ledge of the classifier, for actuating said control means, said control means being arranged to increase the said rake speed to an optimum degree when the said stream of material being propelled through the classifier is relatively deep, and to decrease the said rake speed to an optimum degree when the said stream of material being propelled through the classifier is relatively shallow, said responsive means including a buoyant cylindrical roller float disposed for riding in or on said stream of material.

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