FAST MAGNETIC DRUM ORE SEPARATOR CONTROL

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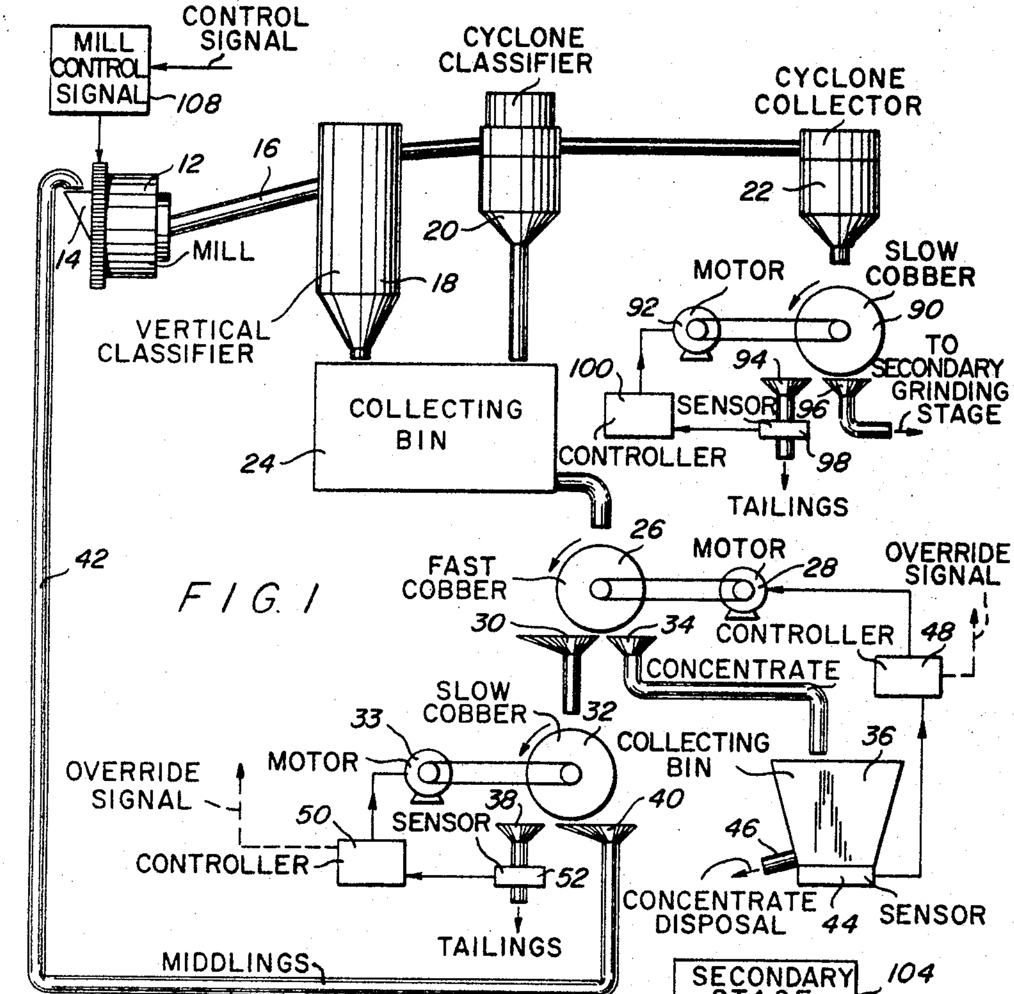

FIG. 1

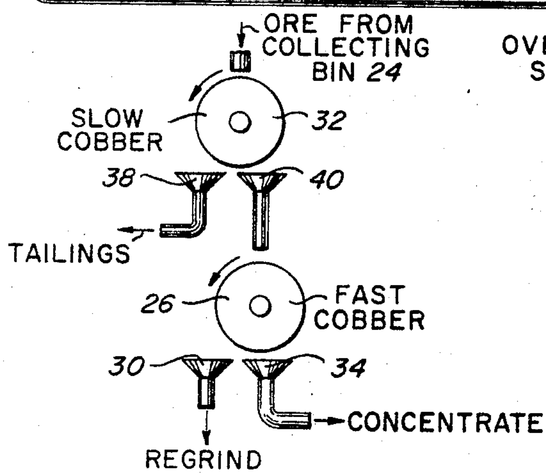

FIG. 2

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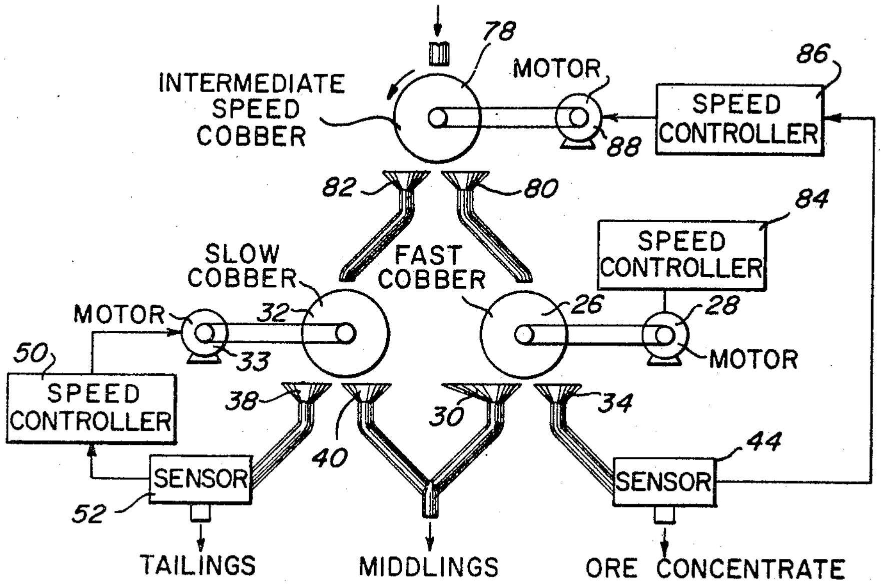

FIG. 3

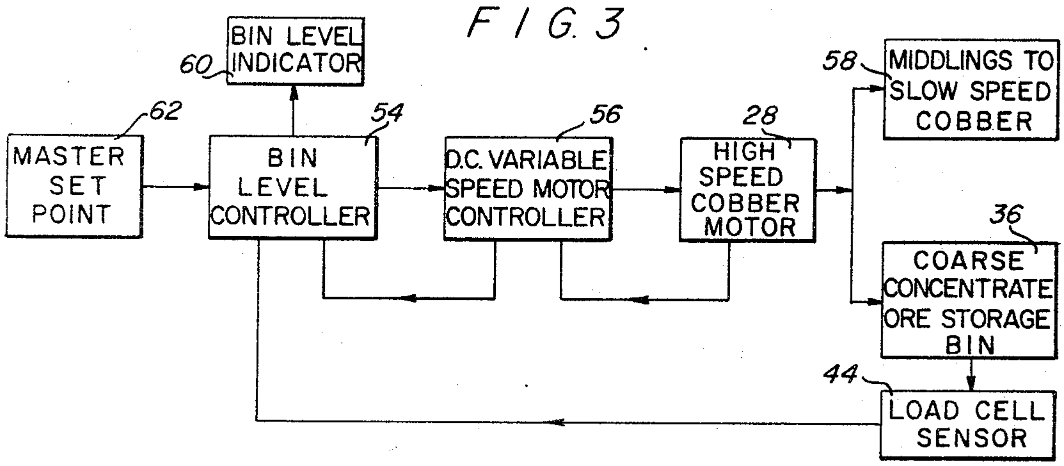

FIG. 4

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FAST MAGNETIC DRUM ORE SEPARATOR CONTROL

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U.S. Cl. 241—34 11 Claims
Int. Cl. B02c 4/32, 7/14, 9/04

ABSTRACT OF THE DISCLOSURE

Control device for rotary magnetic ore separator, having a weight sensor sensing the weight of ore concentrate separated out, and a speed controller for regulating the speed of rotation of the separator to regulate the quantity of ore concentrate separated out.

Background of the invention

This invention relates to control means for rotary magnetic separators in a magnetic ore processing system.

In the processing of magnetic ore, it is common to use rotary drum-type magnetic separators for classifying ground ore. Such separators are frequently arranged in series in the primary dry grinding stage of the ore processing system so as to yield an ore concentrate, tailings, and a middlings product for regrinding.

The rotary separators arranged in series generally include a faster separator for separating out a coarse ore concentrate separation product and a slower separator for separating out a tailings separation product. For economic operation of the system, it is usually desired that the quantity of ore concentrate separated out be relatively constant, and that the tailings separated out have an iron content lying within predetermined limits. To this end, in conventional ore processing systems, the speed of rotation of the faster rotary separator is preset to separate out the desired quantity of ore concentrate and the speed of the slower rotary separator is adjusted to separate the tailings having the desired iron content.

However, as there is variation from time to time in the quality and characteristics of the input ore, and as the other parameters in the ore processing system vary, the speed of rotation of both the faster and the slower rotary separators may depart from time to time from what is optimum for separating out the desired quantity of ore concentrate and the desired quality of tailings.

Summary of the invention

According to the present invention, in conjunction with the invention described in applicant's co-pending application Ser. No. 684,427 filed concurrently herewith, the above mentioned problems created by non-uniformity of input ore and variation in operating parameters can be overcome by providing speed control means for both the faster and the slower rotary magnetic separators for adjusting the speed of rotation automatically in response to measurable characteristics of the separation products. In the invention defined in application Ser. No. 684,427, which relates to control means for the slower rotary magnetic separator, a sensor is provided for sensing the proportion of magnetic material in the tailings separated out by the slower separator, and the speed control means responds to this sensor and adjusts the speed of rotation of the separator so as to regulate the proportion of magnetic material in the tailings. In the case of the faster separator, a sensor is provided for sensing the quantity of ore concentrate separated out by the faster separator, and the speed control means responds to this sensor and adjusts the speed of rotation of the faster separator so as to regulate the quantity of ore concentrate separated out.

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Summary of the drawings

FIGURE 1 is a schematic drawing illustrating an ore-processing system utilizing control apparatus according to the invention;

FIGURE 2 illustrates a modification of the inter-relationship of the rotary separators used in the system of FIGURE 1;

FIGURE 3 is a schematic diagram of a further alternative arrangement of the rotary separators, together with control apparatus according to the invention, for use in the system of FIGURE 1; and

FIGURE 4 is a schematic diagram of a control arrangement according to the invention for a high speed cobber.

Detailed description with reference to the drawings

In FIGURE 1, a rotary forced air grinding mill **12** of the type through which a stream of air is blown is fed iron ore via an input feed chute **14** attached to the mill **12**. An output duct **16** leading from the mill **12** conveys the ground ore through a vertical classifier **18** and thence through one or more cyclone classifiers **20**. Only one cyclone classifier **20** is shown by way of illustration in FIGURE 1, but it is to be understood that a plurality of such classifiers may be fed from the rotary mill **12**. The fines from the cyclone classifier **20** are collected in a cyclone collector **22** and thence distributed to the secondary grinding stage of the ore processing system for finer grinding.

The coarse particles from the vertical classifier **18** and the cyclone classifier **20** are distributed to a collecting bin **24** and thence are fed onto the top of a dry rotary drum-type magnetic separator (often referred to in the industry as a "cobber") **26** driven by a motor **28**. (The drive may be any convenient drive and the drawing is not intended to imply that a belt-type drive is appropriate.)

The cobber **26** typically comprises a cylindrical drum of the order of 3 feet in diameter and up to six feet in length, which is rotated about a stationary grouping of magnets which are generally located on the downward side of the drum's rotation. The ore fed from the collecting bin **24** includes a mixture of magnetically susceptible and non-susceptible particles, of which the susceptible particles have varying degrees of susceptibility. As the drum rotates, the magnetically susceptible particles tend to be held to the drum surface by the force of the magnetic field; the non-susceptible particles fall away due to the force of gravity and are thrown away from the drum surface by centrifugal force. The magnetically susceptible particles tend to adhere to the drum until they pass out of the field of the magnets, at which time they fall or are removed from the drum surface. In this manner, a separation of the ore into two groups of differing susceptibility can be obtained.

Most natural ores contain some relatively large mineral particles that may be liberated from their associated gangue minerals using a relatively coarse grind, while the remainder of the mineral particles remain physically combined with other particles of gangue minerals and require further grinding. Further, a coarse grind will also produce relatively large particles having a high percentage of gangue mineral and a very small percentage of ore. Accordingly, it is desirable to obtain a coarse ore concentrate, coarse tailings substantially free from ore, and a middling portion containing ore and gangue minerals that must be reground to separate the ore from the gangue minerals. To this end, two or more cobbers in series relationship (i.e., one cobber fed from one output of the other cobber) are arranged to yield the three desired separations.

In FIGURE 1, the cobber **26** is indicated as being a fast cobber, i.e. a cobber having a high speed of rotation. Accordingly, the bulk of the ore fed from the collecting bin **24** to the cobber **26** will not cling to the cobber but will be thrown off. If that portion of the ore which clings to the cobber is collected, such portion will yield a relatively high ore concentrate separation product. The larger portion of the ore, i.e. that which does not cling to the cobber **26**, can be fed to a second cobber rotating at much lower velocity which can be used to separate tailings having very low ore content from a middlings product which can be fed back to the rotary mill **12** to be reground.

Such an arrangement is shown in FIGURE 1. If the fast cobber **26** is rotating counterclockwise, as shown, the bulk of the ore fed onto the cobber will fall into a collecting trough **30**, whose output can be applied to the top of a slow speed cobber **32**. The ore fraction that clings to the fast cobber **26** will be released into a collecting trough **34** and can be fed to a collecting bin **36**, for example, and thence to a classification system, whose coarser product would be ground in a secondary grinding stage.

(In the drawings, the position, shape, size and configuration of the collecting troughs relative to the cobbers are not intended to be accurate; the drawings are simply intended to convey the idea that two separation products are collected from each cobber. In general, however, there should be no horizontal separation between the two collecting troughs through which ore particles may be lost.)

The ore fed onto the slow cobber **32** from the trough **30** is again divided into two fractions by means of collecting troughs **38** and **40**. The trough **38** is arranged to collect that fraction of the ore fed onto the top of the slow cobber **32** that has little or no iron content. The remainder of the particles are fed into the trough **40** as a middlings product which can be fed back via an appropriate feedback conduit or conveyor **42** to the input feed chute **14** of the rotary air mill **12**.

It will be noted that as the speed of the fast cobber **26** is increased a greater percentage of the ore applied to it from the collecting bin **24** will be thrown into the trough **30** while a smaller portion with an increased proportion of iron, will be fed into the collecting trough **34**. Similarly, as the speed of the slow cobber **32** is increased, a greater percentage of the ore applied to it will fall into the trough **38** and will be rejected as tailings. In the absense of a variable control arrangement, the speed of the fast cobber **26** is ordinarily adjusted to provide a quantity of concentrate which will be appropriate to the capacity of the processing unit which receives such concentrate as an input. The speed of the slow cobber is usually set so that only that portion of ore containing a very small percentage of iron (say, 1.5 percent) is rejected as tailings.

However, as the input ore is not of consistent quality, and as the operating parameters prevailing in the rotary forced air mill **12** are not constant, the cobbers **26** and **32** will not achieve an optimal separation of the ore into concentrate, tailings, and middlings, if the speed of the fast and slow cobbers is fixed.

Only one fast cobber **26** and one slow cobber **32** are shown by way of example in the drawings, but it is to be understood that there are often batteries of such cobbers.

According to the invention, the speed of the fast cobber is regulated by a speed control device that responds automatically to an appropriate sensor.

The sensor may take the form of a load cell or load cells **44** located underneath the collecting bin **36** and responsive to the weight of ore concentrate collected in the collecting bin **36**. In this arrangement, it is assumed that the collecting bin **36** is provided with an output port

46 out of which ore concentrate is fed to a further processing plant or to some other collecting device at a constant rate or at a rate governed by the plant receiving the output.

The sensor **44** sends a signal representative of the weight of material in the collecting bin to a controller **48** which is connected to the motor **28** and regulates the speed of the cobber **26**. The controller **48** may be any conventional motor speed controller which can respond to an electrical analogue of an input parameter. In this case, the controller **48** will regulate the speed of the motor **28** to keep the weight of the material in the collecting bin **36** within predetermined limits. If the weight of material in the collecting bin **36** increases beyond a preset limit, the controller **48** will cause the motor **28** to speed up, causing more particles to fall into the trough **30** and fewer particles to fall into the trough **34**, thus reducing the amount of concentrate fed into the bin **36**. Similarly, if the quantity of material in the collecting bin **36** falls below some preset limit, the controller **48** in response to the analogue of this information fed by the sensor **44** will cause the motor **28** to slow down thus causing more material to find its way into the trough **34** and to fill up the collecting bin **36**.

In addition to responding to the analogue information representative of the quantity of concentrate separated out by the fast cobber **26**, the controller **48** could also respond to an override control input; for example, to the percentage of iron contained in the ore concentrate collected in the trough **34**. To this end, an appropriate magnetic sensor might be applied to the conduit leading from the trough **34** to sense the proportion of magnetic material moving past the sensor, and this information could be passed on to the controller **48** as an override signal to maintain the speed of the cobber **26** sufficiently fast that only concentrate of the desired purity passes into the trough **34**.

It will be understood that instead of utilizing a collecting bin **36** and load cells **44**, any other appropriate means may be provided to sense the quantity of ore concentrate separated out by the fast cobber **26** in order that this information may be used to control the speed of the cobber **26**.

In applicant's co-pending application Ser. No. 684,427, the slow cobber control is described. The slow cobber **32** driven by the motor **33** is regulated by a speed controller **50** in response to a sensor **52** which detects the proportion of iron in the tailings output. The sensor **52** may be, for example, a Ramsay coil which produces an electrical signal whenever magnetic particles fall through it, the electrical signal being related in a predetermined manner to the proportion of magnetic material falling past the coil in a given time.

The speed of the slow cobber **32** is preferably regulated so that only a very small amount of magnetic material, say 1.0 to 1.5%, escapes in the tailings. Thus, when the Ramsay coil or other appropriate sensor **52** signals the controller **50** that the amount of magnetic material in the tailings is too high, the controller **50** will slow down the motor **33** so that more material is fed into the collecting trough **40** and less material, with a lower iron percentage, is fed into the collecting trough **38**. Conversely, if the sensor **52** detects a proportion of iron rejected in the tailings below some predetermined limit, say one percent, this indicates that the grinding mill **12** is regrinding too much low-grade ore and therefore more of the ground minerals should be rejected as tailings. Accordingly, the speed controller **50** will speed up the motor **33** so that a greater percentage of the separation product of the slow cobber **32** will fall into the trough **38**, and such percentage will have a slightly higher iron content.

The controller **48** may be a conventional analogue control device.

A more detailed schematic diagram of the control system for the fast cobber is shown in FIGURE 4. The control device is shown to comprise a bin level controller **54** which directly controls the motor controller **56** that regulates the speed of the fast cobber motor **28** whose separation product includes a middlings portion **58** which is sent to the slow speed cobber, and a coarse concentrate portion fed to the collecting bin **36**. The amount of ore in the collecting bin is sensed by load cell sensor **44** whose analogue output signal appears as one input to the bin level controller **54**. This electrical analogue signal is passed on to a visual bin level indicator **60** so that the operator may know how much coarse concentrate is being collected in the storage bin **36**.

The bin level controller **54** compares the analogue signal from the load cell sensor **44** with a preset analogue signal which may be initially registered by the operator as an adjustable master set points **62**. Having compared the signal from sensor **44** with the set point signal **62**, the bin level controller **54** produces an error signal whose magnitude and polarity (say) are indicative of the difference between the desired concentrate level or weight in the collecting bin **36** and the actual level or weight. The motor controller **56** responds to the error signal so as to increase or decrease the speed of the high speed cobber motor **28**, and as the speed of the cobber motor **28** adjusts itself to the correction signal supplied by the controller **56**, the speed adjustment is negatively fed back to the motor controller **56**, which in turn negatively feeds back a corresponding analogue signal to the bin level controller **54**, which signal tends to cancel out the error signal produced by the controller **54**, according to conventional analogue control technique.

The adjustment in speed of the motor **28** in response to an error signal produced by the bin level controller **54** may be more or less continuous and capable of fine adjustment or, if desired, the motor controller **56** may cause the motor **28** to speed up or slow down in stepped speed increments. Further, an appropriate delay device may be incorporated between the motor **28** and the speed controller **56** or between the speed controller **56** and the bin level controller **54**, or both, to prevent, following each speed adjustment, any further error signal from being transmitted for a specified time, until the system has had a chance to adjust itself to the new motor speed. Further, the bin level controller **54** may produce an output in response to a difference between the analogue signal produced by the sensor **44** and the master set point signal from the set point **62** only when such difference exceeds some preset amount. In other words, the system can be adjusted to tolerate small departures from a desired concentrate weight in the storage bin **36**, but an adjustment will be effected whenever the difference between the desired concentrate amount and the actual concentrate amount exceeds some predetermined limit.

The foregoing discussion has not taken into account the fact that many present day control devices include means for responding not only to the absolute magnitude of an analogue signal but also to the rate at which such signal is increasing or decreasing. However, the addition of further control features does not exclude the applicability of such more sophisticated control devices to the cobber speed control system described above.

Instead of the arrangement of the fast and slow cobber shown in FIGURE 1, the series relationship of the two cobbers can be reversed as indicated in FIGURE 2. In FIGURE 2, the slow cobber **32** receives the output from the collecting bin **24** and produces a tailings fraction which falls into collecting trough **38** and the middlings fraction which falls into a collecting trough **40**. The middlings fraction **40** is directed to the fast cobber **26** which separates out from the middlings portion a coarse ore concentrate which falls into the collecting trough **34**. The middlings portion which is to be reground by the mill **12** is collected in the collecting trough **30**. Exactly the same control arrangements can be made for the fast cobber and slow cobber as described with reference to FIGURE 1.

A further alternative arrangement called a "delta" arrangement of cobbers is illustrated in FIGURE 3. In this case the ore input from the collecting bin **24** is fed first to an intermediate speed cobber **78** which separates the ore into two fractions, one containing a relatively high percentage of magnetic material collected in collecting trough **80** and the other containing a relatively low percentage of magnetic material collected in the collecting trough **82**. The output of the collecting trough **80** is fed as an input to the fast cobber **26** which is driven by motor **28** whose speed is controlled by a speed controller **84**. The fast cobber **26** produces a coarse ore concentrate portion collecting in the collecting trough **34** and a middlings portion collected in the collecting trough **30**.

The ore containing the relatively low percentage of magnetic material is fed from the collecting trough **82** as an input to the slow cobber **32** which is driven by the motor **33**. The slow cobber **32** produces a tailings portion collected in the collecting trough **38** and a middlings portion collected in the collecting trough **40**. The ore collected in troughs **30** and **40** may be combined and recirculated to the mill **12** for further grinding.

The tailings collected by the trough **38** pass through a sensor **52** which may be identical to that shown in FIGURE 1, and the output of the sensor **52** is fed to a speed controller **50** again identical to that shown in FIGURE 1 which regulates the speed of the motor **33** in exactly the same way as has been described with reference to FIGURE 1.

However, the control of the opposite side of the separation arrangement is preferably different from that shown in FIGURE 1. While it is possible to have the load sensor **44** provide its output signal to the speed controller **84** which controls the motor **28**, it is preferable to provide instead a speed controller **86** for the motor **88** which drives the intermediate speed cobber **78**. The reason for this is that the fast cobber **26** is preferably driven at a constant speed so that iron ore concentrate having a relatively constant percentage of iron content is obtained as a separation output collected by the trough **34**. Accordingly, the speed controller **84** operates the motor **28** at a constant speed, but could, if necessary, be adjusted from time to time to take into account differences between different qualities of input ore. The fast cobber **26** therefore being regulated to produce an ore concentrate of a given purity, the quantity of ore of such purity produced may be regulated by having the intermediate speed cobber **78** feed more or less ore into the high iron content ore collecting trough **80**.

The interaction of the sensor **44**, speed controller **86**, and motor **88** can be identical to the interaction of the sensor **44**, the controller **48**, and the motor **28** described with reference to FIGURE 1, and the speed controller **86** can be of exactly the same type as the controller **48**.

An alternative arrangement, not shown, for use with the delta cobber arrangement of FIGURE 3 could involve an initial speed control of the speed controller **86** and an override control from that speed controller to the speed controller **84** in the event that the speed controller **86** were operating the motor **88** above or below a preset maximum or minimum limit. The reverse of this operation is also possible, in which the sensor signal is sent first to the speed controller **84**, which would send an override control signal to the speed controller **86** in the event that the motor **28** were operating at a preset maximum or minimum limit.

The override signal operates to remove the condition creating it. Thus, for example, if the speed controller **84** responds to the sensor **44** and sends an override signal to the speed controller **86**; and if the motor **28** is operating at maximum speed but there is still too much ore concentrate being separated out, then the override signal from the speed controller **84** to the speed controller **86** causes the speed controller **86** to increase the speed of the motor **88**, thus reducing the quantity of separation product fed into collecting trough **80**, which has the effect of reducing the quantity of separation product fed to collecting trough **34**, which is the result desired.

Referring again to FIGURE 1, the fines output from the cyclone collector **22** may be subjected to a separation prior to having the ore passed on to a secondary grinding stage. To this end a slow-speed cobber **90** may be provided, driven by motor **92**, to separate out a tailings separation product from the fines product sent on to the secondary grinding stage. The cobber **90** may be a wet cobber if the cyclone collector output is fed into a slurry to avoid unnecessary dust. The tailings product is collected in a collecting trough **94** and the fines to be sent to the secondary grinding stage is collected in a collecting trough **96**. Again a Ramsay coil or other appropriate sensor **98** is used to sense the percentage of iron in the tailings and the output signal is fed to a controller **100** which regulates the speed of the motor **92** and thus of the slow cobber **90** to ensure that the tailings product contains an iron portion kept within acceptable limits. The structure and operation of the coil **98**, the controller **100** and the motor **92** may be identical to that of the sensor **52**, the controller **50** and the motor **33**.

The primary grinding stage of the ore processing system preferably acts as a surge with respect to the secondary grinding stage fed from the collecting bin **36** and the trough **96** so as to maximize the efficiency of the secondary grinding stage. In other words, it is desired that the operating parameters prevailing in the secondary grinding stage be more or less constant to utilize the secondary grinding stage at optimum efficiency. To this end, each of the various operating units in the secondary stage is subjected to control by an appropriate secondary stage control device. In FIGURE 1, an exemplary secondary stage operating unit **102** is controlled by a corresponding secondary stage control device **104** which responds to a secondary stage sensor **106** responsive to the operation of the unit **102**. If, for example, the secondary grinding stage is a wet grinding stage, there may be provided pressure control devices for controlling the pressure of slurry entering secondary stage cyclone classifiers, density control devices for controlling the density of slurry fed into the secondary stage cyclone classifiers from a collecting sump fed from the primary grinding stage as well as from the secondary grinding unit, and a pump speed controller for controlling the rate of flow of slurry out of the collecting sump into the cyclone classifiers of the secondary grinding stage. An overall control arrangement for such a secondary grinding stage may be of the type described in copending application Ser. No. 615,755, filed Feb. 13, 1967, in the name of David Weston.

Secondary grinding stage demand may be met by adjusting (either manually or automatically) the output feed rate from the collecting bin **36**. The primary stage will thus automatically adjust itself in response to the secondary demand by maintaining a given quantity of ore in the collecting bin **36**.

It is also possible to provide further override control arrangements within the primary ore processing stage itself. For example, the controller **48** might provide an override signal to the mill control device **108** (say, the main fan damper) so as to increase or decrease the quantity of ore fed into the collecting bin **24** by the vertical classifier **18** and the cyclone classifier **20**. If, for example, too much ore concentrate were being delivered to the collecting bin **36** notwithstanding that the fast cobber **26** was operating at its maximum permissible speed, an override signal could be sent from the controller **48** to the main fan damper of the mill **12** to partially close the damper and thereby reduce the volume of air flowing through the mill **12**, which will result in finer particles ore being picked up from the mill **12**. The vertical and cyclone classifier outputs will decrease, giving a better separation at the fast cobber, yielding a lower volume, higher quality product in the collecting bin **36**.

Similar override signals could be provided from the speed controllers **50**, **84**, and/or **86** illustrated in FIGURE 3, if the delta arrangement of cobbers were used. However, there should be no override control to the mill feed controller, this will be governed by the usual sound and power sensors for optimum grinding efficiency.

In accordance with conventional control system design, delay devices may be provided to delay the operation of a control unit by an override signal for a predetermined period following the operation of a control device by any override signal. Control via override signals may be effected in stepped increments if desired, again in accordance with conventional control systems design practice. The particular choice of override control signals will depend upon the relative importance of the operating parameters of the system. For example, if the economics of the overall plant operation depend primarily on efficient operation of the secondary grinding stage, then override signals from the secondary grinding stage to the primary grinding stage must be given priority in terms of system design and operation. If, on the other hand, it is more important to maintain a constant rate of output of coarse ore concentrate of a given purity, then the override controls from the controllers of the quantity of coarse ore concentrate will be given preference over the requirements of the secondary grinding stage.

What I claim as my invention is:

1. In a magnetic ore processing system having a rotary magnetic separator yielding a higher magnetically-susceptible ore concentrate and a lower magnetically-susceptible product, a sensor for sensing the quantity of ore concentrate separated out by the separator, and speed control means for the separator responsive to the ore concentrate sensor and adjusting the speed of rotation of the separator so as to regulate the quantity of ore concentrate separated out by the separator.

2. Apparatus as defined in claim **1**, wherein the ore-processing system is a dry ore-processing system.

3. In a magnetic ore processing system having a faster rotary magnetic separator and a slower rotary magnetic separator in series relationship so as to yield an ore concentrate, tailings, and a middlings product;

a sensor for sensing the quantity of ore concentrate separated out by the faster separator; and

speed control means for the faster magnetic separator responsive to the ore concentrate sensor and adjusting the speed of rotation of the faster separator so as to regulate the quantity of ore concentrate separated out by the faster separator.

4. Apparatus as defined in claim **3**, wherein the ore-processing system is a dry ore-processing system.

5. In a magnetic ore-processing system having a faster rotary magnetic separator and a slower rotary magnetic separator in series relationship so as to yield an ore concentrate, tailings, and a middlings product;

an ore concentrate sensor for sensing the quantity of ore concentrate separated out by the faster separator,

first speed control means for the faster magnetic separator responsive to the ore concentrate sensor and adjusting the speed of rotation of the faster separator so as to regulate the quantity of ore concentrate separated out by the faster separator,

a tailings sensor for sensing the proportion of magnetic material in the tailings separated out by the slower separator, and

second speed control means for the slower separator responsive to the tailings sensor and adjusting the speed of rotation of the slower separator so as to regulate the proportion of magnetic material in the tailings separated out by the slower separator.

6. Apparatus as defined in claim **5**, wherein the ore-processing system is a dry ore-processing system.

7. Magnetic ore classification apparatus comprising

a faster rotary magnetic separator and a slower rotary magnetic separator in series relationship for yielding an ore concentrate separated out by the faster separator, tailings separated out by the slower separator, and a middlings product separated out by at least one of said separators;

an ore concentrate sensor for sensing the quantity of ore concentrate separated out by the faster separator; and

speed control means for the faster magnetic separator responsive to the ore concentrate sensor and adjusting the speed of rotation of the faster separator so as to regulate the quantity of ore concentrate separated out by the faster separator.

8. Apparatus as defined in claim **7**, wherein the ore-processing system is a dry ore-processing system.

9. Magnetic ore classification apparatus comprising

a faster rotary magnetic separator and a slower rotary magnetic separator in series relationship for yielding an ore concentrate separated out by the faster separator, tailings separated out by the slower separator, and a middlings product separated out by at least one of said separators;

a first sensor for sensing the quantity of ore concentrate separated out by the faster separator;

first speed control means for the faster magnetic separator responsive to the ore concentrate sensor and adjusting the speed of rotation of the faster separator so as to regulate the quantity of ore concentrate separated out by the faster separator;

a second sensor for sensing the proportion of magnetic material in the tailings separated out by the slower separator; and

second speed control means for the slower separator responsive to the tailings sensor and adjusting the speed of rotation of the slower separator to as to regulate the proportion of magnetic material in the tailings separated out by the slower separator.

10. Apparatus as defined in claim **9**, wherein the ore-processing system is a dry ore-processing system.

11. In a magnetic ore processing system having a primary grinding stage and a secondary grinding stage fed ore concentrate from the primary grinding stage;

a faster rotary magnetic separator and slower rotary magnetic separator in series relationship in the primary stage for yielding said ore concentrate separated out by the faster separator, tailings separated out by the slower separator, and a middlings product separated out by at least one of said separators;

an ore concentrate sensor for sensing the quantity of ore concentrate separated out by the faster separator;

first speed control means for the faster magnetic separator responsive to the ore concentrate sensor and adjusting the speed of rotation of the faster separator so as to regulate the quantity of ore concentrate separated out by the faster separator;

a tailings sensor for sensing the proportion of magnetic material in the tailings separated out by the slower separator;

second speed control means for the slower separator responsive to the tailings sensor and adjusting the speed of rotation of the slower separator so as to regulate the proportion of magnetic material in the tailings separated out by the slower separator;

variable speed feeding means feeding said ore concentrate to the secondary grinding stage;

a secondary stage sensor for sensing a parameter of the secondary stage resulting from the operation of a secondary stage operating unit; and

a secondary stage control device for controlling said secondary stage operating unit and providing a control signal to the feeding means so as to regulate the amount of ore concentrate fed to the secondary stage.

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TIM R. MILES, *Primary Examiner.*

U.S. Cl. X.R.

241—97, 153, 79.1; 209—223, 231