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Jewell et al.

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[54] **REFINER PLATE CLEARANCE CONTROL SYSTEM**

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[51] **Int. Cl.** **B02c 7/14**

[58] **Field of Search** .... 241/285 R, 285 A, 244, 241/250, 251, 261.2, 259, 259.2, 33, 37; 51/111 R

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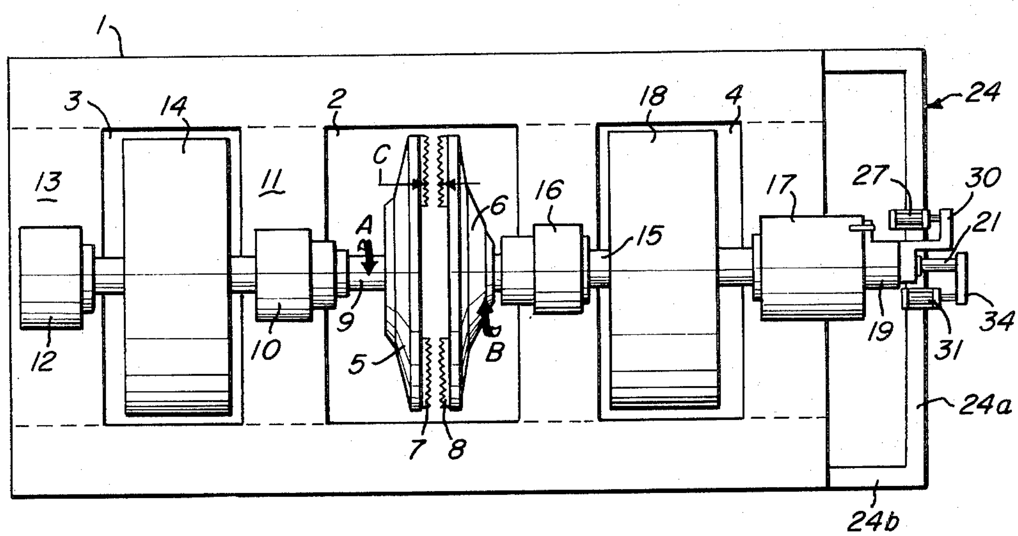
[57] **ABSTRACT**

An automatic control system for maintaining a constant preset distance between the operating surfaces of reduction equipment such as a disc refiner including means for moving one of opposed refining surfaces to and from the other. The control system comprises a first feed-back device which produces a voltage related to the position of one refining surface and a second feed-back device producing a voltage related to the position of the opposed surface. Means are provided to combine these voltages and produce a composite signal representing the distance between the refining surfaces at any one instant during a refining operation. This composite signal is referenced to a pre-set signal having a value corresponding to the desired spacing between the refining surfaces. Means are provided whereby a difference in these signals produces an appropriately controlled movement of the one refining surface toward or from the other until the combined feed-back signal corresponds to the pre-set signal.

16 Claims, 3 Drawing Figures



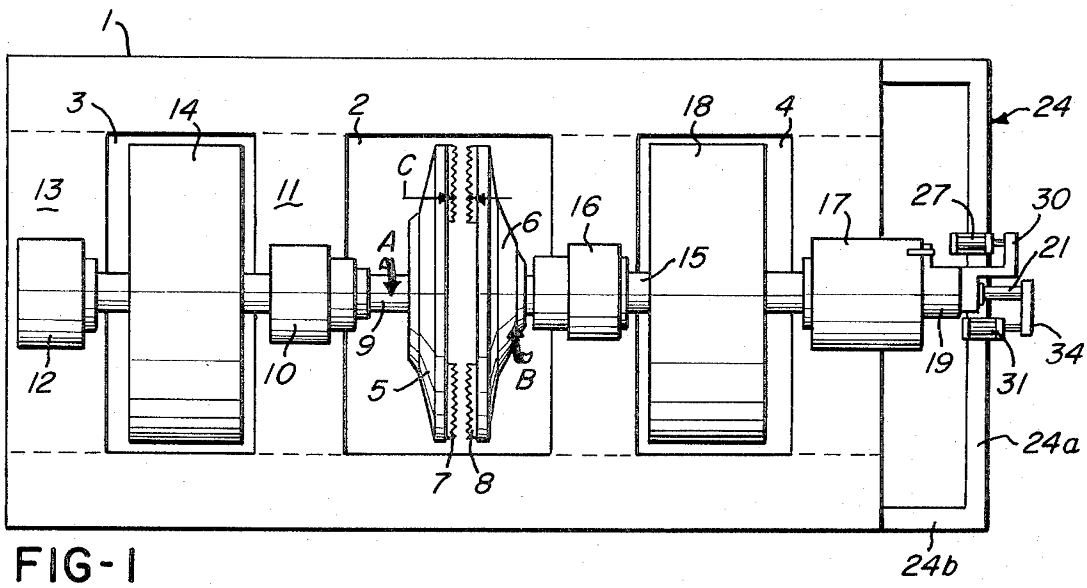


FIG-1

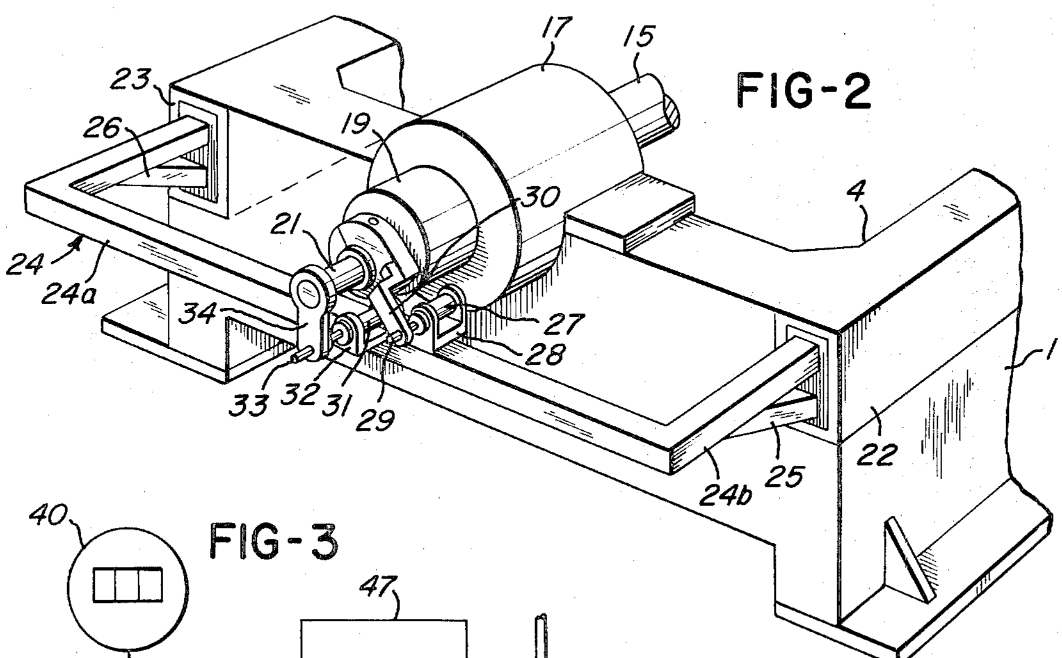


FIG-2

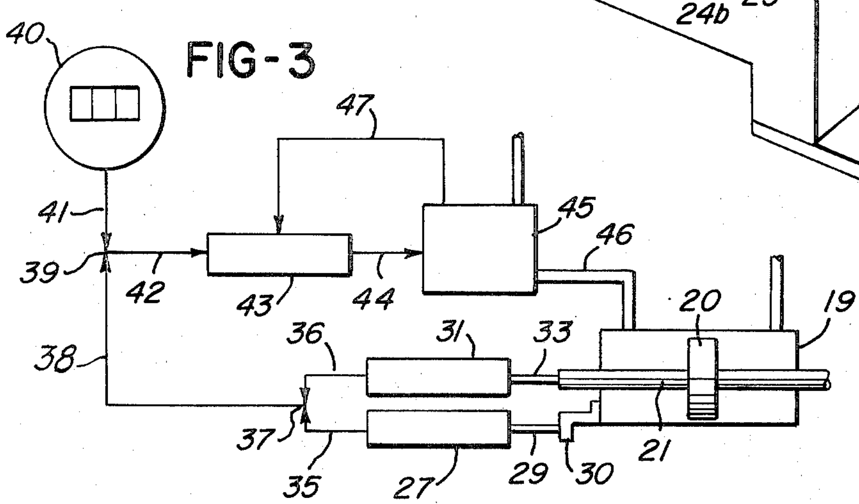


FIG-3

REFINER PLATE CLEARANCE CONTROL SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to an improved system for establishing and maintaining a desired spacing between opposed refining surfaces. It has particular advantage in application to a disc refiner installation and will be so described. It will be obvious however, that its application is not so limited and such is not intended.

In operating a disc refiner, to pulp fibrous material, for example, the desired uniformity of the resultant product has proven difficult to achieve. This is due in part to the fact that the pressures and temperatures generated by the material moved between the opposed refining surfaces tend to force them apart and otherwise distort their desired frame of reference. This pressure and the heat generated in the refining process is reflected through the refining components to the refiner base. The base, in turn, has a distortion the nature of which introduces a further problem in efforts to maintain a desired pre-set spacing between opposed refining surfaces. For this reason, using conventional controls, one must keep a constant watch and continuously adjust the spacing between its refining surfaces in efforts to approach uniformity of spacing and the end products of refining. In most cases the results are less than satisfactory.

One major factor of concern in operating a disc refiner is that the total distortion of the refiner structure when operating under load is frequently greater than the original spacing between the refiner surfaces. Also with loss of feed between these surfaces, a reactant condition can occur which causes the refining surfaces to come into contact, with consequent damage or complete destruction.

In prior art practice, efforts to combat the above noted problems have been generally limited to the objective of maintaining a constant closing pressure on the movable refining surface. This has ignored the total factors contributing to the described problems, including the distortion of the refiner base and the reflection thereof in the structure supporting the refining discs.

SUMMARY OF THE INVENTION

By contrast the control system of the present invention is so designed and arranged to constantly sense and correct for any variation in a pre-set spacing between opposed refining surfaces regardless of its source. As embodied in a disc refiner unit, the control structure provided mounts to a neutral beam supported in a connected relation to the refiner base. This beam mounts a pair of feed-back devices which are respectively arranged to sense and to produce a voltage related to the position of one or the other of the opposed refiner discs. Means are connected to continuously combine these voltages and to transmit a combined signal representing the actual distance between the refining surfaces in any one instant. The combined signal is fed to a differential amplifier in which it is compared with a transmitted signal the phase and amplitude of which are representative of the pre-set and desired spacing between the refining surfaces. The amplifier output is connected to actuating means which is continuously operated thereby to move a connected refining surface to and from the other as and to the extent required, if required. Since there is a constant monitoring of the positions of the refining surfaces, they will be maintained in a relative desired position to automatically insure a more uniform pulp quality. The system will in any event preclude inadvertent contact between and damage to the refining surfaces.

It is therefore a primary object of the invention to provide an improved control system for disc and other type refiner units for maintaining a desired spacing between opposed refining surfaces, which system is economical to fabricate, more efficient and satisfactory in use and unlikely to malfunction.

Another object of the invention is to provide means for constantly monitoring the distance between opposed refining surfaces and for adjusting to compensate for any variation therein.

A further object of the invention is to provide means for use in a disc refiner installation or the like which inhibits inadvertent contact between its opposed refining surfaces.

Another object of the invention is to provide means in connection with a refiner base which are adapted to reflect changes in position of opposed refining surfaces, and to accommodate consequent distortion in the refiner base, and to continuously induce the maintenance of a pre-set distance between the refining surfaces.

An additional object of the invention is to provide a control system for maintaining automatically the required spacing between opposed refining surfaces possessing the advantageous structural features, the inherent meritorious characteristics and the means and mode of use herein described.

With the above and other incidental objects in view as will more fully appear in the specification, the invention intended to be protected by Letters Patent consists of the features of construction, the parts and combinations thereof, and the mode of operation as hereinafter described or illustrated in the accompanying drawings, or their equivalents.

Referring to the drawings wherein there is shown, generally diagrammatically and schematically, one but not necessarily only one embodiment of the invention,

FIG. 1 is a diagrammatic top plan view of a double disc refiner installation illustrating a neutral beam support in connection with the refiner base and mounting a pair of feedback devices in accordance with the present invention;

FIG. 2 is a fragmentary perspective view further illustrating the relation of the invention control system to one end of the refiner base; and

FIG. 3 schematically illustrates the control system of the present invention.

Like parts are indicated by similar characters of reference throughout the several views.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As indicated above, while use of the control system of the present invention is not so limited, for purposes of illustration it is described as applied to a double disc refiner as conventionally installed in a refiner base. This type of refiner is shown in U.S. Pat. No. 3,129,898, issued Apr. 21, 1964.

As diagrammatically shown, the refiner has an installation in a base 1 which has defined therein a central well 2 and end wells 3 and 4. Since the precise construction of the base 1 or the disc refiner does not constitute a limitation on the present invention, the same is shown and described only to the extent necessary for an understanding of the present disclosure by one versed in the art. It is to be understood, of course, that the base 1 is so constructed as to be subjected to as little distortion as possible during the operation of the refiner.

In any event, as conventionally provided, a double disc refiner includes a housing (not shown) containing a pair of circular discs or plates 5 and 6 mounting facing refiner plates providing immediately opposed refining surfaces 7 and 8. As is well known by one versed in the art, the discs 5 and 6 are located within the housing the lower portion of which nests in the well 2. Moreover, the housing will include a pulp inlet and a pulp outlet for directing material for refining between and for discharge from the refiner discs.

As here shown, the disc 5 is fixed on one end of a drive shaft 9. The shaft 9 extends to one end of the refiner base and is rotatably supported at longitudinally spaced locations thereon in an inboard bearing housing 10 seated on the top of the base inboard pedestal 11 and in an outboard bearing housing 12 mounted on the base outboard pedestal 13. A drive motor 14 is positioned to partially nest in the well 3 between the inboard pedestal 11 and the outboard pedestal 13. The rotor portion of the motor 14 is conventionally secured in a driving relation to the shaft 9 while the stator portion of the motor 14 may be suitably supported on the side walls of the refiner base. Accordingly, on energizing the motor 14 the shaft 9 and the disc 5 are commonly rotated, for example in the direction of the arrow A shown in FIG. 1 of the drawings. The disc 6 is similarly mounted to a shaft 15 for rotation in an opposite direction as indicated by the arrow B in FIG. 1. In this case the shaft 15 projects through and rotates within the bearing housings 16 and 17 respectively secured on the inboard and outboard pedestals of the refiner base to the end opposite that supporting the bearing housings for the shaft 9. As diagrammatically shown, the shaft 15 has a drive motor 18 composition of which is similar to that of the motor 14, the motor 18 nesting in part in the well 4.

The shaft 15 differs from the shaft 9 in that it is axially movable with respect to the bearing housing 16 and 17. As will be obvious, an axial movement of the shaft 15 will produce a common movement of the disc 6 and its refining surface 8 appropriately toward and away from the disc 5 and its refining surface 7. The disc refiner housing (not shown) will be provided with appropriate sealing and bearing means to permit the projection therethrough and the relative axial movement of the shaft 15.

Axial movement of the shaft 15 may be accomplished by mechanism such as illustrated in the aforementioned U.S. Pat. No. 3,129,898. However, any equivalent means may be employed for achieving movement. Therefore, for purposes of illustration the means for adjusting the position of the shaft 15 and the connected disc 6 is illustrated only to the extent required for the present disclosure. For such purpose, the mode of power required for movement of the shaft 15 is shown to derive, by way of example, from a double acting hydraulic cylinder 19. As seen, the cylinder 19 may be mounted in connection with the bearing housing 17 and conventionally contain therein a piston 20 and in connection therewith a piston rod 21 projecting from the end of the cylinder remote from the bearing housing 17. Suitable means will be provided so that the movement of the piston 20 and the piston rod 21 will be translated into a corresponding movement of the shaft 15. Since this may be achieved by any mechanic versed in the art, the details of the interrlation of the piston and the piston rod with the shaft 15 are not here shown.

Conventionally the feed inlet of the housing for the discs 5 and 6 is located adjacent and to the rear of the disc 5. For this reason, the left hand of the refiner as shown in FIG. 1 is generally referred to as the feed end. Since the means for moving the disc 6 toward and away from the disc 5 is located at the right hand end of the refiner as viewed in FIG. 1, this end is generally referred to as the control end. Since the control system of the present invention is directed to the maintenance of a constant distance between the refining surfaces 7 and 8, for purposes of reference, this distance is defined between arrows C of FIG. 1.

The control system of the present invention is based upon the concept of providing and comparing a first signal corresponding to the actual positions of the refining surfaces 7 and 8 with a second signal corresponding to the desired or pre-set positions of these refining surfaces. Another way of putting this is that the first signal corresponds to the actual distance between the refining surfaces and the second signal relates to the desired distance. In practice, these two signals are compared and the hydraulic cylinder 19 is actuated to cause a movement of the disc 6 toward and away from the disc 5 until the actual and desired signals are the same. This indicates that the desired distance between the refining surfaces 7 and 8 is achieved and maintained. Both of the signals are maintained throughout the refining process and the hydraulic unit 19 is actuated in response to such signals whenever circumstances so require.

As here illustrated, to provide the first signal relating to the actual relative position of the refining surfaces 7 and 8 (or the actual distance between them), a pair of feed-back devices are used. The feed-back devices employed in the illustrated embodiment are in the form of linear displacement transducers, well known in the pertaining art. Such feed-back devices comprise measuring devices which produce an output signal in the form of a voltage which is precisely proportional to the mechanical displacement of an incorporated sensing probe. Basically these devices each comprise a linear voltage differential transformer (hereinafter referred to as an L.V.D.T.). In its simplest form the L.V.D.T. comprises a primary coil and a pair of secondary coils symmetrically arranged about an axially movable magnetic iron constituting a sensing probe in this instance. Ideally, when the core is in its central-most "null" position, A.C. voltages which are induced thereby in the secondary coils will be equal. If the secondary coils are connected in series opposition, these voltages will cancel and there will be no net output voltage. If, however, the magnetic core is axially displaced, one secondary voltage will increase and the other will decrease, resulting in a net output signal voltage proportional to the magnitude of the displacement and with a phase polarity corresponding to the direction of displacement of the magnetic core from its null position. The construction of the L.V.D.T. per se does not constitute a part of the present invention. Suffice it to say that the L.V.D.T. has been refined to a point where it is extremely accurate and capable of sensing displacements on the order of one-millionth of an inch or less. The displacements dealt with in the present invention are generally measured in thousandths of an inch and appropriate L.V.D.T.'s for use with the control system taught herein are readily available on the market.

In order to properly determine the position of refining surfaces **7** and **8** in accordance with the invention, both L.V.D.T.'s in the instant control system are mounted on a neutral support, i.e. a base or support not subject to the distortion by the double disc refiner or the refiner base. A discovery of the invention is that while various types of suitable support may be provided for the feed-back devices, an ideal position for the neutral support is at the control end of the refiner base, in connection with the upper side rails of the base **1**. As a matter of fact, testing of a double disc refiner in operation under closing pressures ranging from 200 to 1,200 p.s.i.g. shows that the upper side rails of the base **1** exhibited very little distortion (on the order of 0.002 inch) at maximum closing pressures. Accordingly, with reference to the base **1** in the drawings, it may be seen that they are schematically shown to position at **22** and **23**. Suitably affixed to the side rails **22** and **23** and to project from the control end of the base **1** is a generally U-shaped frame support **24**. The support **24** may be provided with additional angled braces **25** and **26**, as shown. In composition the frame **24** includes, spaced outwardly and generally parallel to the control end of the base **1**, a transversely disposed elongated base portion **24***a* which extends substantially the full width of the refiner base and is spaced from the control end thereof by right angled leg portions **24***b*. This elongated base portion **24a** of the frame **24** constitutes a neutral beam upon which the feed-back devices are mounted.

It is to be understood that it is within the scope of the present invention to provide a support similar to the frame **24** on the feed end of the refiner to sense the position of the disc **5**. However, in a further discovery of the invention has shown that with the base **1** symmetrical as indicated that the base **1** will reflect through the distortions or movement of the bearing housing **17** the changes in position of the refining surface of the disc **5**. Therefore, as a preferred expedient, only a single support frame **24** need be provided at the control end of the refiner base as shown.

Thus, in the illustrated embodiment, a feed-back device **27** is shown in FIG. **2** as mounted in a bracket **28** secured to the neutral beam portion **24***a* of the support frame **24**. The device **27** has a probe **29** operatively connected to one end of an arm **30** the other end of which is fixed to the housing of the cylinder **19**. Since the housing of cylinder **19** will have reflected therein any distortion of the base **1**, in respect to which symmetrical base the disc **5** has a relatively fixed position, the feed-back probe **29** will sense any such distortion and thereby the position of the disc **5** and its refining surface **7**.

A second feed-back device is shown at **31**. As in the case of the device **27**, the device **31** is mounted in a bracket **32** which is also affixed to the neutral beam portion **24a** of the frame **24**. The feed-back device **31** has a probe **33** operatively fixed in connection with one end of an arm **34**, the other end of which is attached to the projected end of the piston rod **21**. Thus, the feed-back device **31** will react to provide a voltage signal which is directly related to the position of piston rod **21**. Since rod **21** is connected to shaft **15**, and since shaft **15** is, in turn, connected to disc **6** and its refining surface **8**, the voltage signal of feed-back device **31** will correspond and directly relate to the position of refining surface **8**.

From the foregoing, it will be evident that the feed-back device **27** constantly monitors the position of the housing of the cylinder **19** (equivalent to the position of refining surface **7**). Also, the feed-back device **31** constantly monitors the axial position of the rod **21** which is equivalent to the position of the refining surface **8**. As noted previously, these readings will be taken with respect to the neutral beam **24***a* upon which both devices **27** and **31** are mounted. Since the neutral beam **24***a* is subject to a movement or distortion of only about 0.001 inch maximum under the most severe refiner loading conditions, providing the feed-back devices are properly calibrated, the devices will work together to continuously monitor the variations in distance between the refining surfaces **7** and **8**.

The feed-back devices **27** and **31** send their signals to an electrical circuit in which they are combined and compared to a signal corresponding to that which would be received if the refining surfaces **7** and **8** were actually at the desired distance from each other. Dependent on this comparison, as will be seen, the related system for adjusting the position of the disc **6** and its refining surface **8** will receive a signal causing it to function to move the shaft **15** and the connected disc **6** and its refining surface **8** toward or away from the refining surface **7** to achieve the desired spacing between the refining surfaces.

To better understand the control system as here provided, reference is made to the schematic of FIG. **3** of the drawings wherein like parts have been given like index numerals. As seen in FIG. **3**, the feed-back device **27** has its sensing element **29** in operative connection with the cylinder housing **19** through an arm **30** while the feed-back device **31** has its sensing element, in effect, interrelated to sense the position of the piston rod **21**, the position of which determines the position of the refining surface **8** through the medium of the shaft **15**. As seen in FIG. **3**, depending on the signals received by the feed-back devices **27** and **31** referenced to the position of the respective discs **5** and **6**, the outputs **35** and **36** of these feed-back devices will be combined as at **37** and transmitted through a lead **38** to a summing point **39**. A source for a command signal having a phase and amplitude representative of the desired and predetermined space in between refining surfaces **7** and **8** is diagrammatically indicated at **40**. This signal source **40** may be a potentiometer which has in association therewith a micro-dial mounted on a control panel and indicating the desired spacing of the refining surfaces. The output of the command signal source **40** is conducted by a lead **41** to the summing point **39**. The combined signal resulting at the summing point is transmitted by way of lead **42** to a differential amplifier **43**. The latter is of the type well known in the art having an output dependent upon the amplitude and phase relationships of its input signals. The output **44** of the amplifier **43** is connected to a servo valve **45** which together with the unit **19** comprises the means for furnishing the motive power for axially shifting the shaft **15** and thereby the position of the refining surface **8**. The servo valve **45** is operated to control the flow of oil into or out of the closing side of the cylinder **19** through hydraulic line **46** and is connected to a supply of hydraulic fluid. The valve **45** will have a conventional feed-back **47** to the amplifier **43**.

In summary, when the refiner is in operation and pulp material is being fed to the refiner housing (not shown) for the discs **5** and **6**, the position of the discs and the respective refining surfaces will be continually sensed by the feed-back devices **27** and **31**. As noted, feed-back device **27** will through the movements of the cylinder housing **19** obtain and signal a reading equivalent to the position of disc **5** and its refining surface **7**. Feed-back device **31** will directly sense the movement of the piston rod **21** and obtain a reading equivalent to the position of the disc **6** and its refining surface **8**. The outputs of the feed-back devices are combined to form a first signal which has a phase and amplitude equivalent to the actual positions of the refining surfaces **7** and **8**. This first signal will be compared to a signal from the command signal source **7** which has been pre-set to produce a signal having a phase and amplitude representative of the desired spacing between the refining surfaces **7** and **8**. With the refiner in operation, the combined and pre-set signal will be fed into a differential amplifier **43** which in turn produces a signal actuating the servo valve **45**. The latter will function in a conventional manner to cause an appropriate shifting of the piston **20** and piston rod **21**. The movements of the piston **20** will produce pressure through the hydraulic fluid involved to transmit through whatever mechanical means are employed a signal influence and appropriate shifting of the shaft **15** carrying the disc **6**. In this manner the refining surface **8** may be moved toward or away from the refining surface **7** to achieve and maintain the desired and predetermined spacing between the refining surfaces. It is to be understood that the nature of the invention system is such that upon failure of material feed or shut-down of a flow of material to and between the refining surfaces, the control system of the present invention will prevent the refining surfaces from coming into contact with each other upon sudden release of pressure therebetween, irrespective of the nature and degree of the pressure.

Thus, it will be clear that the invention has provided a simple but highly effective system for insuring a continuing control of refiner plate clearance which is automatic in character and which obviates the need for continuous attendance on the equipment in often futile efforts to maintain a uniformity of space in between the refining surfaces. Thus, a safety in operation and quality results are inherent in the practice of the invention.

From the above description it will be apparent that there is thus provided a device of the character described possessing the particular features of advantage before enumerated as desirable, but which obviously is susceptible of modification in its form, proportions, detail construction and arrangement of parts without departing from the principle involved or sacrificing any of its advantages.

While in order to comply with the statute the invention has been described in language more or less specific as to structural features, it is to be understood that the invention is not limited to the specific features shown, but that the means and construction herein disclosed comprise but one of several modes of putting the invention into effect and the invention is therefore claimed in any of its forms or modifications within the legitimate and valid scope of the appended claims.

Having thus described our invention, we claim:

1. An automatic control system for maintaining constant a pre-set distance between opposed refining surfaces of pulp refining equipment supported on a common base, said refining surfaces being relatively adjustable toward and from one another, including actuating means for moving one of said refining surfaces toward and away from the other, sensing means for continuously producing a first signal of the actual distance between said opposed refining surfaces, means for producing a second signal representative of the desired distance between said refining surfaces, means to receive and compare said first and second signals and to respond to differences to produce a third signal arranged to energize said actuating means to restore the desired distance between said refining surfaces.

2. An automatic control system as in claim **1** characterized by said actuating means being arranged to function until said first and second signals become equal.

3. An automatic control system as in claim **1** characterized in that said sensing means producing said first signal is comprised of independent means for sensing the respective positions of the respective refining surfaces, the combination of which sensing means produces said first signal.

4. An automatic control system as in claim **3** characterized by one of said means sensing the position of one of said refiningsurfaces being interrelated to sense the position of the said one refining surface through movements of said common base.

5. An automatic control system as in claim **1** characterized by its application to opposed refining surfaces supported on a common base, including a support means in connection with and having a relatively neutral position in reference to said base and any distortion which might be reflected therein, further characterized by said sensing means for producing said first signal being constituted by a plurality of sensing means positioned on said neutral support to independently respond to the position of a respective one of said refining surfaces, there being means combining said independent responses to produce said first signal.

6. An automatic control system as in claim **5** characterized by said independent sensing means being respectively related to directly sense the position of one of said opposed refining surfaces and to indirectly sense the position of the other of said opposed refining surfaces through said common base.

7. An automatic control system as set forth in claim **1** characterized by its application to refiner discs presenting opposed refining surfaces supported for relative rotation upon a symmetrical base, characterized by said sensing means having means mounting the same in connection with one end of said base to respectively sense the position of said discs and said refining surfaces through support means provided therefor on said base.

8. An automatic control system as in claim **7** wherein the respective discs are each supported by a shaft rotatably mounted on said base and directed respectively to extend to opposite ends thereof and characterized in that said sensing means includes independent sensing means one of which reflects the position of one of said refining surfaces through the shaft supporting the same and another of the independent sensing means sensing the position of the other refiner surface through distortion reflected through said base during a refining operation.

9. An automatic control system as in claim 1 in a refiner installation characterized by a symmetrical base mounting centrally thereof refiner discs including said opposed refining surfaces and said discs respectively mounting to a drive shaft, characterized by a neutral support beam connected to form an extension of said base to one end thereof and in a position constituting a relatively neutral position wherein any distortion of the base has a minimal influence and said sensing means for producing said first signal being mounted on said beam to sense the position of said refining surfaces through one of said shafts and through said base.

10. An automatic control system as in claim 9 characterized by said means for continuously producing a first signal being constituted by independent sensing means one of which has a direct operative relation to one of said shafts and the other of which has an operative relation to means in connection with said base.

11. An automatic control system for maintaining constant a pre-set clearance between opposed refining surfaces of pulp refining equipment supported on a common base, said refining surfaces being relatively adjustable toward and from one another, including actuating means for moving one of said refining surfaces toward and away from the other, sensing means for continuously producing a first electrical signal the phase and amplitude of which are representative of the actual clearance between said opposed refining surfaces, means for continuously producing a second electrical signal the phase and amplitude of which are representative of the desired clearance between said opposed refining surfaces, means for receiving and comparing said first and second signals and responding to differences therein to produce a third electrical signal energizing said actuating means to move said one refining surface in a direction relatively to the other to render said first and second electrical signals equal and thereby to restore the desired clearance between said opposed refining surfaces.

12. The structure claimed in claim 11, wherein said one refining surface is supported by a shaft rotatively mounted on said base and axially shiftable, said actuating means comprising an hydraulic cylinder having a piston with a piston rod operatively connected to said axially shiftable shaft and a servo valve to energize said hydraulic cylinder, said third signal being conveyed to said servo valve whereby to energize said servo valve and hence said hydraulic cylinder and to control the direction and amount of shift of said shaft and said one refining surface supported thereby.

13. The structure claimed in claim 12, wherein the source of said second electrical signal includes a potentiometer and said means for receiving and comparing said first and second electrical signals and for producing said third electrical signal comprises a differential amplifier.

14. The structure claimed in claim 13, wherein said sensing means comprises first and second linear voltage differential transformers, said first transformer sensing the position of said one of said opposed refining surfaces, said second transformer sensing the position of the other of said opposed refining surfaces, the combined outputs of said first and second providing said first electrical signal.

15. The structure claimed in claim 14, wherein said base is symmetrical, said opposed refining surfaces being located centrally of said base, said shaft supporting said one refining surface extending to a first end of said base, another shaft supporting the other one of said opposed refining surfaces being rotatively mounted on said base and extending to a second end of said base, a first bearing means affixed to said first end of said base for the said shaft supporting said one refining surface, a second bearing means affixed to said second end of said base for the shaft supporting the other of said opposed refining surfaces, said last mentioned shaft being axially non-shiftable within said second bearing, said hydraulic cylinder being mounted on said first bearing, said second transformer being connected to sense movement of said cylinder resulting from base distortion and said first transformer sensing movement of the free end of said piston rod.

16. The structure claimed in the claim 15, including support means for said first and second transformers in the form of neutral beam frame means affixed to said first end of said base.

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