United States Patent

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[54] **INFERENTIAL MASS RATE CONTROL SYSTEM FOR PAPER REFINERS**
8 Claims, 1 Drawing Fig.

[52] **U.S. Cl.** **241/37**
[51] **Int. Cl.** **B02c 7/14**
[50] **Field of Search** 241/37, 63, 64; 162/253, 254

[56] **References Cited**

UNITED STATES PATENTS

1,815,155	7/1931	Lewellen et al.	241/37
2,727,694	12/1955	Helmick, Jr. et al.	241/37
3,078,051	2/1963	Patterson	241/37 X

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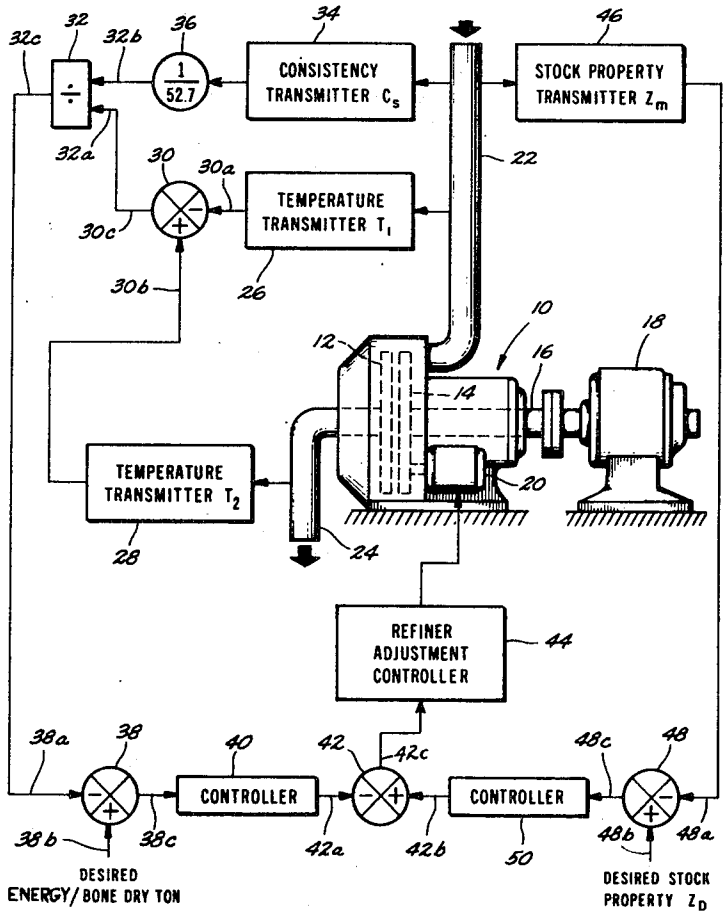
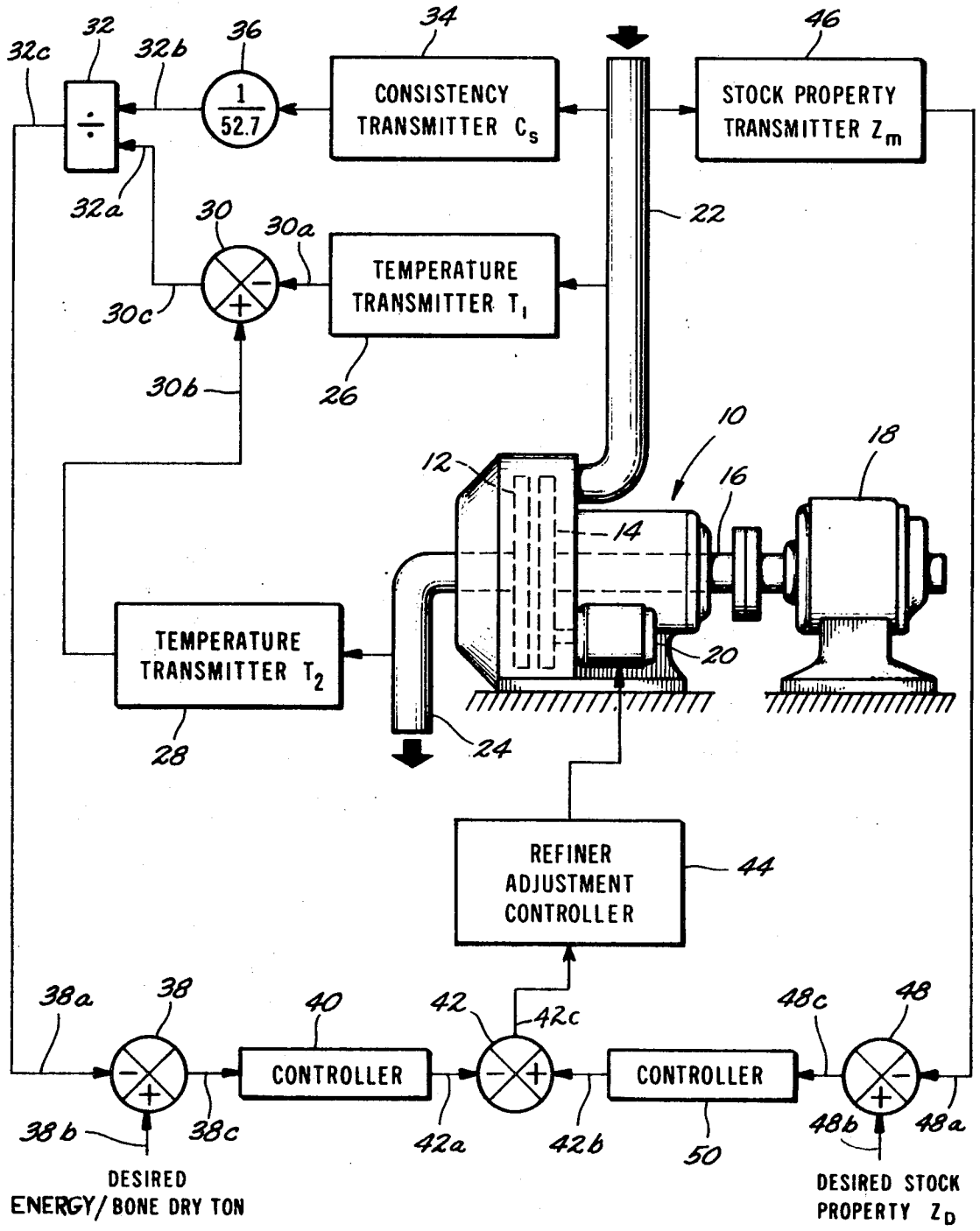
ABSTRACT: An inferentially derived kilowatt-hour-per-ton signal is provided by the measurement of differential temperature and consistency of the fluid stock flowing through the refiner. This signal is used to the motor that relatively positions the beater elements of the refiner to maintain a substantially uniform power consumption. Also, provision is made for modifying the action of the control motor in accordance with a given stock property of the stock flowing through the refiner to make prompt adjustment for changes in the particular stock property.




CONSISTENCY TRANSMITTER C_s
STOCK PROPERTY TRANSMITTER Z_m
TEMPERATURE TRANSMITTER T_1
TEMPERATURE TRANSMITTER T_2
REFINER ADJUSTMENT CONTROLLER
CONTROLLER
CONTROLLER
DESIRED ENERGY/BONE DRY TON
DESIRED STOCK PROPERTY Z_D
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INFERENTIAL MASS RATE CONTROL SYSTEM FOR PAPER REFINERS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to refiners for processing fluid paper stock, and pertains more particularly to a control system utilizing differential temperature and consistency data for determining the load imposed upon the refiner.

2. Description of the Prior Art

Attention is directed to U.S. Pat. No. 3,309,031, issued Mar. 24, 1967 to Richard F. McMahon et al. for MATERIAL WORKING APPARATUS, which patent is owned by the present assignee. The control system described and claimed in said McMahon et al. patent has performed exceptionally well. However, the one outstanding shortcoming of the McMahon et al. structure is that it is only flow sensitive and does not take into account changes in the consistency of the stock passing through the refiner. The present invention makes use of both consistency and the difference in temperature, as well as deviations in a given stock property from a desired value to assure a relatively constant power consumption.

SUMMARY OF THE INVENTION

It is highly desirable in refining paper stock to maintain the power consumption of the drive motor substantially constant. Where only the temperature rise between the stock entering the refiner and the stock being discharged from the refiner is employed, this does not allow a rapid compensation for such important factors as the consistency of the flowing stock. Accordingly, one object of the present invention is to provide a control system for paper stock refiners that will be sensitive or responsive to both temperature and consistency.

Another object of the invention is to provide a control system of the foregoing character that can be adapted so as to additionally compensate for changes in a selected stock property such as freeness, average fiber length and the like.

A still further object of the invention is to provide a control system that will be economical, yet sufficiently accurate so that the power consumed by the drive motor for the refiner will remain fairly constant, at least sufficiently constant, to warrant its adoption as a practical solution to the problem.

Yet another object of the invention is to obviate the need for relatively costly electrical measuring equipment, the present invention determining a simulated power relationship with respect to the energy required per ton of bone-dry stock without resort to more expensive and sophisticated power-measuring instrumentation.

Still another object of the invention is to minimize the need for computing equipment, it being feasible to employ only a simple divider and multiplier that will assist in providing the appropriate simulation of energy per ton.

BRIEF DESCRIPTION OF THE DRAWING

The sole FIGURE illustrating the invention is largely in block form, although typical refining apparatus has been superimposed thereon in a schematic or diagrammatic form.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now in detail to the drawing, a typical refiner has been denoted generally by the reference numeral **10**. The exemplary form is of the so-called disc variety and includes a stationary beater disc or refining element **12** and a rotary beater disc or refining element **14**. The invention, though, is susceptible to use with a conical plug-type refiner, this type of refiner generally being known as a Jordan refiner in which a rotatable conical plug is moved axially with respect to a complemental shell in which the conical plug is contained.

The refiner **10** as illustrated in the drawing has a drive shaft **16** connected with the rotary element **14** so as to produce the required rotation of this particular element. Inasmuch as the

invention is regarded as an improvement over the previously referred McMahon et al. patent, reference can be made to this patent for further explanation as to the construction of the refiner. In the McMahon et al. patent, a pneumatic motor is referred to as the means for positioning the movable beater element with respect to the stationary element; in the situation at hand, it is planned that an electric motor **20** will perform this function. Such motor may well function as described in U.S. Pat. No. 1,933,814, issued on Nov. 7, 1933 to Darcy E. Lewellen et al. for STOCK CONSISTENCY CONTROL. Although not of recent innovation, the said Lewellen et al. patent is additionally pertinent because it deals with a Jordan refiner and very succinctly shows a motor for rotating a threaded shaft that is employed for positioning the conical plug with respect to the shell enclosing same.

As far as the present drawing is concerned, it will be appreciated that the fluid stock to be refined enters the refiner **10** via an inlet conduit **22** and leaves or is discharged through an outlet conduit **24**. For the purpose of sensing the temperature T_1 of the incoming stock there is a temperature transmitter **26** that provides a signal representing this temperature. Similarly, a temperature transmitter **28** senses the outlet temperature T_2 of the stock after it has passed through the refiner **10** to provide a second signal that reflects the value of this higher temperature. It will be appreciated that the rise in temperature ΔT, that is T_2-T_1, is indicative or representative of the work performed on the stock by the beater elements **12**, **14**. This is fully explained in said McMahon et al. U.S. Pat. No. 3,309,031.

The temperature representing signal T_1 is delivered to a summing junction or comparator circuit **30** having first and second input terminals **30*a*** and **30*b***. More specifically, the temperature transmitter **26** has its output side connected to the input terminal **30*a*** of the comparator **30**, whereas the transmitter **28** supplies the second input terminal **30*b*** with a signal representative of the temperature T_2. Any difference between the values of the signals impressed on the input terminals **30*a***, **30*b*** appears at an output terminal **30*c*** of the comparator **30**. In other words, any difference between the two temperatures T_2 and T_1 is forwarded via the output terminal **30*c*** as a ΔT signal.

Although the express purpose therefor will not be manifest from the description that has been given up to this point, it will be noted that a calculator in the form of a divider **32** has a pair of input terminals **32*a*** and **32*b*** and an output terminal **32*c***. The divider **32** merely provides a ratio of the signal delivered via its input terminal **32*a*** with respect to the signal delivered via the input terminal **32*b*** which latter signal is described below.

The signal that is fed to the divider **32** over the input terminal **32*b*** is furnished by a consistency transmitter **34** that provides a signal indicative of the consistency of the incoming stock delivered through the conduit **22**. This signal is forwarded to a multiplier **36** that multiplies the signal by an appropriate constant which will cause the divider **32** to produce a proper output or ratio signal at the terminal **32*c*** which will be representative of the energy per unit mass of stock. More specifically, it will be perceived that the following equation exists:

$$(T_2-T_1)\times 52.7/C=\text{KWH/T}$$

where:

KWH = energy, kilowatt hours
T_1 = inlet temperature, ° F.
T_2 = outlet temperature, ° F.
C = consistency percent
T = bone-dry stock, tons

whereas the ratio or output signal from the divider **32** which is forwarded via the terminal **32*c*** is representative of the inferential energy per unit mass, more specifically kilowatt hours per ton, this signal is to be compared with a set point signal representative of the desired energy/bone-dry ton, more specifically, KWH/bone-dry ton. Accordingly, a summing junction or comparator circuit **38** is employed which has a

pair of input terminals 38*a*, 38*b* and an output terminal 38*c*, the ratio or output signal from the divider 32 being impressed on the input terminal 38*a*. The set point is applied via the input terminal 38*b*. In this way, any difference between these input signals appears as an error signal on the output terminal 38*c* and when processed by a controller 40 is delivered to still another summing junction or comparator circuit 42 having a pair of input terminals 42*a*, 42*b* and an output terminal 42*c*.

The signal impressed on the input terminal 42*b* will presently be referred to. However, at this time it will be seen that the output terminal 42*c* of the comparator 42 is connected to a refiner adjustment controller labeled 44 which is responsible for providing the control motor 20 with the proper amount of power so that the axially shiftable beater or refining element 14 is properly positioned so that the desired amount of load is shouldered by the refiner 10.

Focusing attention now on a feedforward correction that will assist in effecting the requisite adjustment of the refining element 14 via the control motor 20, there is a stock property transmitter 46 that provides a signal representative of a given stock property such as freeness, average fiber length and the like. This measured stock property signal can merely be identified as Z_M and this signal is delivered to a summing junction or comparator circuit 48 having its input terminal 48*a* connected to the transmitter 46. A second input terminal 48*b* belonging to the comparator 48 introduces a set point signal representative of the desired stock property which signal has been assigned the character Z_D. Any difference between the measured signal Z_M and the desired signal Z_D appears as an error signal at the output terminal 48*c* of the comparator 48. When processed by the controller 50, the signal that results is forwarded to the input terminal 42*b* where it is compared with the signal forwarded from the controller 40. Hence, any difference between the values of the signals from the controllers 40 and 50 will be differenced by the comparator 42 and the ensuing signal will be delivered via the output terminal 42*c* to the refiner adjustment controller 44 and in turn this controlling determines the energization of the control motor 20 to effect proper positioning of the refiner element 14 with respect to the element 12.

It will be appreciated that in actual practice, the functions performed by the comparator 38 and the controller 40 can be combined into a single controller that is designed to perform the desired comparison. The same thing holds true for the comparator 48 and the controller 50. Such controllers are commercially available. However, by showing the components 38, 40, 48 and 50 separately it is believed to facilitate an understanding of the invention.

Having presented the foregoing description, largely with a considerable portion of the operation included therein, only a brief additional description need be given which is directed exclusively to the operation of the depicted system. In this regard, it will be appreciated that a ΔT temperature differential is derived via the temperature transmitters 26, 28 and this is specifically accomplished with the comparator 30. The resulting signal appearing on the output terminal 30*c* is representative of the difference or ΔT temperature and hence the work performed on the fluid stock flowing through the refiner 10.

The consistency transmitter 34, together with the multiplier 36, provides a signal that is introduced via the input terminal 32*b* to the divider 32 so that the output signal from the divider reflects the proper value which is representative of the energy per unit mass. Since this measured signal may frequently, or at least randomly, deviate from a desired value, the measured value is compared with a desired value or set point signal by means of the comparator 38. The error or difference signal from the terminal 38*c* of the comparator 38 is processed by the controller 40 and its output is in turn compared with whatever signal appears at the output side of the controller 50. It will be recalled that the controller 50 receives any difference or error signal between the measured stock property signal Z_M and the desired stock property signal Z_D. Hence, the actual energization of the control motor 20 is influenced by the values of two separate and distinct loops, the net effect of the two loops being determined by the comparator 42 and the resulting signal that is forwarded therefrom to the controller 44.

I claim:

1. In combination with a refiner for processing fluid paper stock which includes a pair of relatively rotatable and axially movable refining elements, a drive motor for relatively rotating said elements and a control motor for axially shifting one of said elements with respect to the other, a control system comprising means providing a signal indicative of the rise in temperature of the stock flowing through said refiner, means providing a signal indicative of the consistency of said stock, means providing a signal representative of the ratio of said first signal with respect to said second signal to provide an output signal inferentially representative of the energy per unit mass required by said refiner for the particular temperature rise of the stock passing therethrough, means for comparing said output signal with a set point signal which is representative of the desired energy per unit mass, and means for controlling said control motor in accordance with any difference between said output signal and said set point signal.

2. The combination set forth in claim 1 in which said comparing means includes a first temperature transmitter for sensing the temperature of the stock entering the refiner, a second temperature transmitter for sensing the temperature of the stock leaving the refiner, and a comparator for comparing the signal from said first temperature transmitter with the temperature for said second transmitter to provide said signal representative of the rise in temperature of the stock passing through said refiner.

3. The combination set forth in claim 2 in which said means providing a signal representative of the consistency of said stock includes a transmitter for providing a signal in accordance with the consistency of the stock, said last-mentioned means further including means for multiplying the signal provided by said consistency transmitter by a predetermined constant to provide said signal representative of the consistency of said stock, whereby said means providing a ratio of said signals furnishes an output signal having the inferential relationship that is representative of the energy per unit mass consumed by the refiner as said stock passes therethrough.

4. The combination set forth in claim 1 including means for providing a measured signal indicative of a given stock property and additionally controlling said control motor in accordance with any difference between said measured stock property signal and a set point signal representative of a desired stock property.

5. The combination set forth in claim 4 in which said last-mentioned means includes a transmitter for measuring the given stock property and a comparator for comparing said measured stock property signal with a desired stock property signal to provide an error signal in accordance with any difference therebetween.

6. The combination set forth in claim 5 including a comparator for comparing said error signal with said signal representative of any difference between said output signal and said first-mentioned set point signal.

7. In combination with a refiner for processing fluid paper stock which includes a pair of relatively rotatable and axially movable refining elements, a dive motor for relatively rotating said elements and a control motor for axially shifting one of said elements with respect to the other, a control system comprising a first temperature transmitter for sensing the temperature of the stock entering said refiner to produce a first temperature signal, a second temperature transmitter for sensing the temperature of the stock leaving said refiner to produce a second temperature signal, a first comparator for comparing said first and second temperature signals to provide a first error signal representative of any difference between said first and second temperature signals, a consistency transmitter for sensing the consistency of the stock flowing through said

refiner to produce a signal indicative of the consistency of said stock, means for dividing said error signal by said consistency signal to provide an output signal inferentially representative of the energy per unit mass required by said refiner, a second comparator for comparing said output signal with a desired energy per bone-dry ton signal to provide a second error signal, and means for controlling said control motor in accordance with the value of said second error signal.

8. The combination set forth in claim **7** including a transmitter for providing a measured signal indicative of a given stock property of the stock flowing through said refiner, a comparator for comparing said measured stock property signal with a set point signal representative of a desired stock property to provide a third error signal representative of any difference therebetween and an additional comparator for comparing said second and their error signals to provide an additional error signal, said additional error signal controlling said control motor.