United States Patent

Alexander

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[54] WOOD GRINDING

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[51] **Int. Cl.** **B27l 11/08**

[58] **Field of Search**.....241/15, 28, 33, 34, 35, 36, 241/280, 282

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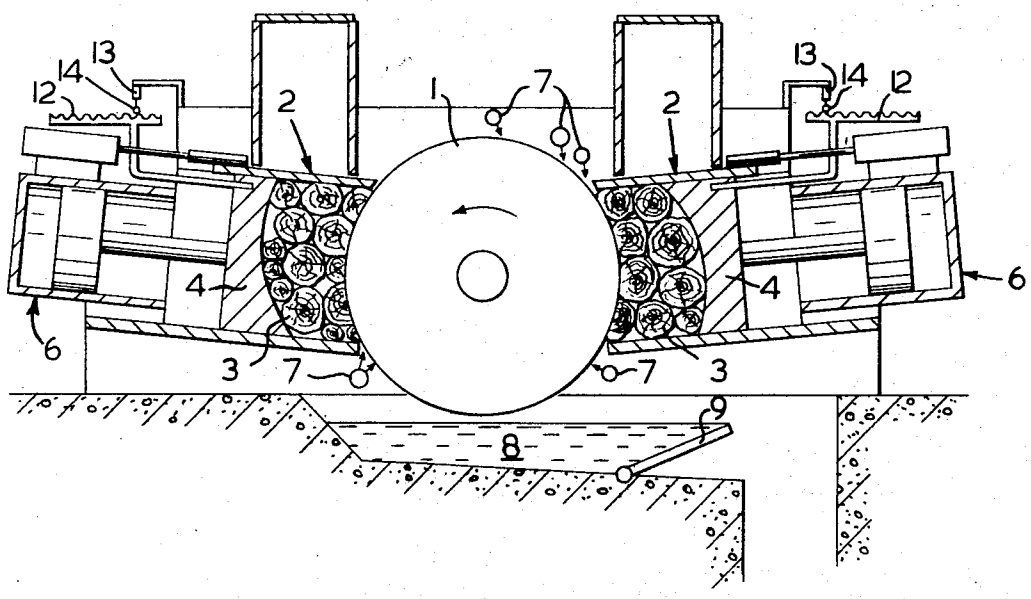
Primary Examiner—Granville Y. Custer, Jr.

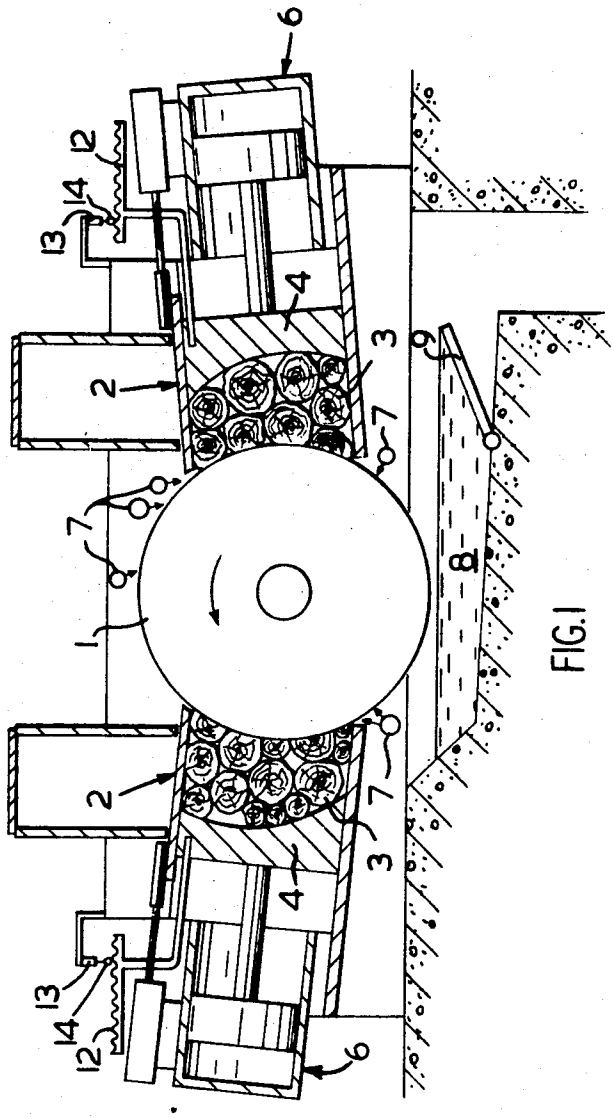
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[57] **ABSTRACT**

Wood is ground by forcing the wood against a grinding wheel rotated by a source of power, cooling the grinding area with a flow of cooling fluid and maintaining the energy supplied by the source of power per unit weight of ground wood at a substantially constant value.

14 Claims, 2 Drawing Figures




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12
14
13
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2
7
8
1
FIG. 1

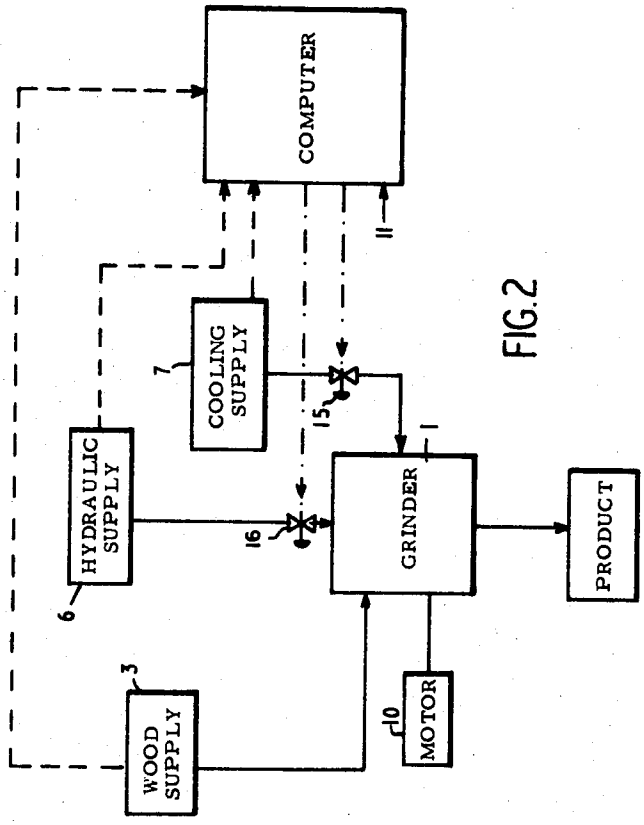

COMPUTER
11
COOLING SUPPLY
7
15
HYDRAULIC SUPPLY
6
16
GRINDER
1
PRODUCT
WOOD SUPPLY
3
MOTOR
10

FIG.2

WOOD GRINDING

This invention relates to the grinding of wood by forcing the wood against a rotating grinding wheel, a process commonly used in the paper-making industry.

In one type of grinder, the wood is supplied to one or more pockets adjacent the grinding wheel and is forced against the grinding wheel by hydraulic pressure. The grinding wheel is cooled by a flow of cooling fluid. This grinder is not continuous in operation since the pockets must periodically be re-charged with wood to be ground.

A second type of grinder is the continuous chain grinder in which the wood is continuously forced against the grinding wheel by means of an endless chain with projections which engage the wood. A ring grinder is a third type, in which the rotating grinding wheel is eccentrically mounted within a rotating ring, the wood being forced between the wheel and the ring.

The grinding wheels are frequently driven by electric power, and the amount of energy required to grind the wood depends upon many variables, for example the type of wood, the rate at which it is ground, the force with which the wood is urged against the grinding wheel, and the rate of flow of cooling fluid. These variables not only influence the energy required but also influence the quality of the product, namely the ground wood. Another variable which is known to affect the quality of the product is the wood temperature produced by the grinding process, and this temperature is influenced by the rate of flow of cooling fluid, as well as by other factors.

It has been a continuing problem in the paper-making industry to effectively control the quality of the ground wood. Various attempts have been made to control the various factors mentioned above in order to obtain a product of consistent quality with economic use of energy. Also, wood mills frequently have a series of grinders operating at the same time, and sometimes individual grinders are controlled to maintain the total rate of energy consumed by the grinders at a substantially constant value. For example, with electric power, it may be desired to maintain the total rate of energy consumed at a predetermined number of kilowatts. The power required for a grinder has in the past been controlled by varying the force with which the wood is urged against the grinding wheel, thereby varying the rate of grinding. However, such arbitrary control of individual grinders results in variation of the quality of the product.

It has now been found that the quality of the product can be very effectively controlled by maintaining the energy per unit weight of wood required to drive the grinding wheel at a substantially constant value which can be predetermined by calculation and/or experiment. The expression energy per unit weight of wood will hereinafter be represented by the symbol Ew.

It has also been found that *Ew* is a function of the ratio G/F of the rate of grinding G to the force F with which the wood is urged against the grinding wheel, and is also a function of the ratio G/C of the rate of grinding G to the rate of flow C of cooling fluid. The ratio G/F bears a relation to the state of the grinding wheel surface, and the ratio G/C bears a relation to the temperature of the grinding wheel/wood interface. This temperature and the state of the grinding wheel surface

are therefore taken into account. It is known that these variables play a significant part in determining the quality of the product.

Therefore Ew can be maintained constant by maintaining the ratio G/F and the ratio G/C at constant values. Variation of one ratio will affect the value of the other ratio to some extent, and therefore in some cases it is desirable to maintain each ratio as near as possible as its preselected value. In this way, the quality of the product can be predetermined and substantially maintained. Thus it is possible to produce a wide range of product characteristics at a preselected energy per unit weight of weight by suitable variation of the selected values of the two ratios G/F and G/C.

The rate of grinding may be measured in a conventional manner. For example, where hydraulic pressure is used to force the wood against the grinding wheel, the rate of travel of the hydraulic piston can be measured. Alternatively, the rate of accumulation of product can be measured. Such measurements may of course also require a knowledge of the density of the wood concerned.

The rate of flow of cooling fluid may of course be determined by means of a flow meter in the fluid supply line.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings, of which:

FIG. 1 is a sectional side view of a typical twin-pocket grinder, and

FIG. 2 is a diagram showing a control system of the grinder.

Referring to the drawings, FIG. 1 shows a twin-pocket grinder with a rotatable grinding wheel with a wood pocket 2 on each side of the wheel. Wood in the form of logs 3 in each pocket 2 are urged against the grinding wheel 1 by feet 4 actuated by hydraulic cylinders 6. The cylinders 6 may be conventionally operated by water pressure at two different levels, namely a low-pressure, high volume supply of the order of 150 pounds per square inch to both retract a foot 4 and to advance it rapidly for the initial compression of a new charge of logs 3 in a pocket 2, and a high-pressure low volume supply which may have a pressure up to 500 to 600 pounds per square inch for use during the actual grinding process. The flow of water to and from the cylinders 6 is controlled by a conventional valve arrangement.

Cooling fluid is supplied to the grinding wheel 1 from multi-orifice shower pipes 7 located at predetermined positions both on the top of and under the grinding wheel 1. The cooling fluid performs several functions, namely cleaning and extraction of heat from the grinding wheel, as well as serving as a vehicle for the discharge of product as stock to a collection flume 8. The stock level in the flume 8 may be controlled by a dam 9 of variable height.

Referring now also to FIG. 2 in which the same reference numerals as used in FIG. 1 will be employed to indicate the same items diagrammatically, the grinding wheel 1 is driven by an electric motor 10.

The rate of grinding is determined by the rate of travel of each foot 4. For this purpose, a rack 12 is connected to and travels with each foot, and a micro-switch 13 with a cam-follower 14 engaging the rack 12

is periodically actuated by movement of the rack. The number of times each micro-switch **13** is actuated is therefore a measure of the quantity of wood ground, and an appropriate quantity signal is sent to the computer **11** which also includes a clock timer to calculate the rate of grinding, convenient units for which are tons/hour. Since the micro-switch **13** is actually responsive to the volume of wood rather than to its weight, it is also necessary to know or assume a wood density value.

A pressure switch (not shown) is included in the micro-switch circuit so that the travel of the rack **12** is only measured when the hydraulic pressure in the cylinders **6** is above a predetermined value, for example **175** pounds per square inch, so that movement of the foot **4** is only recorded during grinding, and not while the pocket is being recharged. The pressure in each foot **4** is controlled by a pressure control valve **16**, whose control will be described later. The computer **11** is programmed to calculate an average rate of grinding of the two pockets **2**.

The quantity of cooling water flowing through the shower pipes **7** is measured by a flow meter, and this quantity is converted to rate of flow by the computer. The rate of flow is controlled by a flow control valve **15**, whose control will be described later.

At predetermined intervals, for example every fifteen minutes, the computer calculates the ratio G/F namely grinding rate over hydraulic pressure. This value is compared with the predetermined value, and the computer feeds back a signal to the pressure control valve **14** to adjust the pressure in a ratio correcting manner. The computer also calculates the ratio G/C, namely grinding rate over cooling flow rate, and causes an appropriate adjustment of the flow control valve **15** to maintain the ratio at the predetermined value. The two ratios are of course interrelated, and the adjustment of one would cause some change in the other. However, this method of ratio correction in sequence and at predetermined intervals brings the grinding process under satisfactory control.

The relationship between Ew and each of the two ratios is exponential, and can be represented:

$$\log Ew = a + b \log G/F + c \log G/C$$

where a, b and c are constants.

The various constants and ratios desired in a particular case are determined by calculation and/or experiment having regard to design limitations of the equipment and process limitations. Examples of the former are the speed of the grinding wheel, the available motor load, the available hydraulic pressure, and the size of the pockets. With regard to the latter, temperature imposes some limitations, since above some particular temperature level the wood becomes discolored and burned. These limits are known and within the operating experience of ground wood mill operators. There are also the economic considerations of employing excessive volumes of showering water, and so it is generally practical to operate with water quantities which maintain the end-product consistency at or above one per cent consistency. However it is possible to operate the process at lower temperature and product consistencies if this suits the specific economy and interests of the operator.

One specific example of operation of the grinder described above is as follows:

$$\frac{G}{F} = \frac{100 \times \text{Grinding rate (air-dry tons/hour)}}{\text{Hydraulic pressure, p.s.i.}}$$

$$\frac{G}{C} = \frac{\text{Grinding rate (air-dry tons/hour)} \times 10^4}{\text{Lbs. of shower water per minute}}$$

Ew = kilowatt hours per air/dry ton of output.

With a grinding wheel (pulp stone) of 67 inches diameter turning at 360 r.p.m., using shower water at 130°F and pH of 4.5, with wood species typical of the locality, principally Black Spruce, in pockets of 50 inches length and 36 inches height, the equation may be represented as:

$$\log Ew = 3.2 - 0.7 \log G/F - 0.1 \log G/C$$

If it is desired to operate the grinder with G/F at a value of 1.10 (say a grinding rate equal to 4.0 tons/hour for a pressure of 364 p.s.i.) and a G/C value of 5.0 (say for the 4.0 ton/hour grinding rate a mean shower water rate of 8,000 pounds per minute), then the energy used per ton will be approximately 1,260 kilowatt hours.

There are other ways to use the general relationship:

$$\log Ew = a + b \log G/F + c \log G/C$$

For example, in the case of a continuous pulp wood grinder, where the wood is forced against the grinding wheel by chains with projections engaging the wood, it is not easy to measure the grinding force F. In this case, the computer may be programmed to control the speed of the grinder motor to maintain Ew substantially constant. The computer would be fed with a signal of kilowatt hour energy consumption by the motor, together with signals of rate of grinding G and rate of cooling C. Thus, the motor speed and the rate of cooling C would be varied to maintain Ew and the ratio G/C substantially constant.

In a ring grinder, both grinding rate G and grinding force F are not easy to measure. In this case, grinding rate can be deduced from measurement of the output, for example by measuring its flow rate and consistency. Apart from this, the same method as with the continuous chain grinder may be used.

Similarly, if it was difficult to measure the rate of cooling C, the computer may be fed with signals of energy consumption, grinding force F and grinding rate G, and be programmed to vary the motor speed and the grinding force F to maintain Ew and the ratio G/C substantially constant.

The G/C ratio may be adjusted by the computer to compensate for variation in the temperature of the water, and either the supply water temperature or the temperature differential between the supply water and that in the product may be used as a signal to compute a correction factor. Similarly, the pH of the water may effect the energy of grinding, and changes in pH may be detected and used to compute a correction factor.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method of grinding wood including forcing the wood against a grinding wheel rotated by a source of power, cooling the grinding area with a flow of cooling fluid, and maintaining the energy supplied by the source of power per unit weight of ground wood at a substantially constant value.

2. A method of grinding wood including forcing the wood against a grinding wheel rotated by a source of power, cooling the grinding area with a flow of cooling fluid, maintaining the energy supplied by the source of power per unit weight of ground wood at a substantially constant value, and maintaining the ratio of the rate of grinding to the force with which the wood is urged against the grinding wheel at a substantially constant value.

3. A method of grinding wood including forcing the wood against a grinding wheel rotated by a source of power, cooling the grinding area with a flow of cooling fluid, maintaining the energy supplied by the source of power per unit weight of ground wood at a substantially constant value, and maintaining the ratio of the rate of grinding to the rate of flow of cooling fluid at a substantially constant value.

4. A method of grinding wood including forcing the wood against a grinding wheel rotated by a source of power, cooling the grinding area with a flow of cooling fluid, maintaining the energy supplied by the source of power per unit weight of ground wood at a substantially constant value, maintaining the ratio of the rate of grinding to the force with which the wood is urged against the grinding wheel at a substantially constant value, and maintaining the ratio of the rate of grinding to the rate of flow of cooling fluid at a substantially constant value.

5. A method of grinding wood including forcing the wood against a grinding wheel rotated by a source of power, cooling the grinding area with a flow of cooling fluid, measuring the rate of grinding, measuring the force with which the wood is urged against the grinding wheel, measuring the rate of flow of cooling fluid, varying said force to maintain the ratio of the rate of grinding to said force at a substantially constant value, and varying the rate of flow of cooling fluid to maintain the ratio of the rate of grinding to the rate of flow of cooling fluid at a substantially constant value, thereby maintaining the energy supplied by the source of power per unit weight of ground wood at a substantially constant value.

6. A method of grinding wood including forcing the wood against a grinding wheel rotated by a source of power, cooling the grinding area with a flow of cooling fluid, measuring the energy from the source of power, measuring the rate of grinding, measuring the rate of flow of cooling fluid, varying the power source to maintain the energy supplied by the source of power per unit weight of ground wood at a substantially constant value, and varying the rate of flow of cooling fluid to maintain the ratio of the rate of grinding to the rate of flow of cooling fluid at a substantially constant value.

7. A method of grinding wood including forcing the wood against a grinding wheel rotated by a source of power, cooling the grinding area with a flow of cooling fluid, measuring the energy from the power source, measuring the rate of grinding, measuring the force with which the wood is urged against the grinding wheel, varying the power source to maintain the energy supplied by the source of power per unit weight of ground wood at a substantially constant value, and varying the grinding force to maintain the ratio of the rate of grinding to said force at a substantially constant value.

8. A wood grinding assembly including a rotatable grinding wheel, a source of power for rotating the grinding wheel, means for forcing the wood against the grinding wheel, means for supplying cooling fluid to the grinding area, and means for maintaining the energy supplied per unit weight of ground wood at a substantially constant value.

9. A wood grinding assembly including a rotatable grinding wheel, a source of power for rotating the grinding wheel, means for forcing the wood against the grinding wheel, means for supplying cooling fluid to the grinding wheel, means for maintaining the energy supplied by the source of power per unit weight of ground wood at a substantially constant value, and means for maintaining the ratio of the rate of grinding to the force with which the wood is urged against the grinding wheel at a substantially constant value.

10. A wood grinding assembly including a rotatable grinding wheel, a source of power for rotating the grinding wheel, means for forcing the wood against the grinding wheel, means for supplying cooling fluid to the grinding area, means for maintaining the energy supplied by the source of power per unit weight of ground wood at a substantially constant value, and means for maintaining the ratio of the rate of grinding to the rate of flow of cooling fluid at a substantially constant value.

11. A wood grinding assembly including a rotatable grinding wheel, a source of power for rotating the grinding wheel, means for forcing the wood against the grinding wheel, means for supplying cooling fluid to the grinding area, means for maintaining the energy supplied by the source of power per unit weight of ground wood at a substantially constant value, means for maintaining the ratio of the rate of grinding to the force with which the wood is urged against the grinding wheel at a substantially constant value, and means for maintaining the ratio of the rate of grinding to the rate of flow of cooling fluid at a substantially constant value.

12. A wood grinding assembly including a rotatable grinding wheel, a source of power for rotating the grinding wheel, means for forcing the wood against the grinding wheel, means for supplying cooling fluid to the grinding area, means for measuring the rate of grinding, means for measuring the force with which the wood is urged against the grinding wheel, means for measuring the rate of flow of cooling fluid, means for varying said force to maintain the ratio of the rate of grinding to said force at a substantially constant value, and means for varying the rate of flow of cooling fluid to maintain the ratio of the rate of grinding to the rate of flow of cooling fluid at a substantially constant value, thereby maintaining the energy supplied by the source of power per unit weight of ground wood at a substantially constant value.

13. A wood grinding assembly including a rotatable grinding wheel, a source of power for rotating the grinding wheel, means for forcing the wood against the grinding wheel, means for supplying cooling fluid to the grinding area, means for measuring the energy from the

source of power, means for measuring the rate of grinding, means for measuring the rate of flow of cooling fluid, means for varying the power source to maintain the energy supplied by the source of power per unit weight of ground wood at a substantially constant value, and means for varying the rate of flow of cooling fluid to maintain the ratio of the rate of grinding to the rate of flow of cooling fluid at a substantially constant value.

14. A wood grinding assembly including a rotatable grinding wheel, a source of power for rotating the grinding wheel, means for forcing the wood against the grinding wheel, means for supplying cooling fluid to the grinding area, means for measuring the energy from the power source, means for measuring the rate of grinding, means for measuring the force with which the wood is urged against the grinding wheel, means for varying the power source to maintain the energy supplied by the source of power per unit weight of ground wood at a substantially constant value, and means for varying the grinding force to maintain the ratio of the rate of grinding to said force at a substantially constant value.

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