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Larsen

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[54] **METHOD AND DEVICE FOR REGULATING THE TEMPERATURE OF ROTATING GRINDING ROLLS HAVING A HOLLOW INTERIOR**

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[52] **U.S. Cl.** **165/1,** 72/201, 165/89, 165/105, 241/66, 241/67

[51] **Int. Cl.** **B02c 4/44**

[58] **Field of Search** 165/89, 104, 105, 165/106; 241/66, 67; 72/200, 201

[56] **References Cited**

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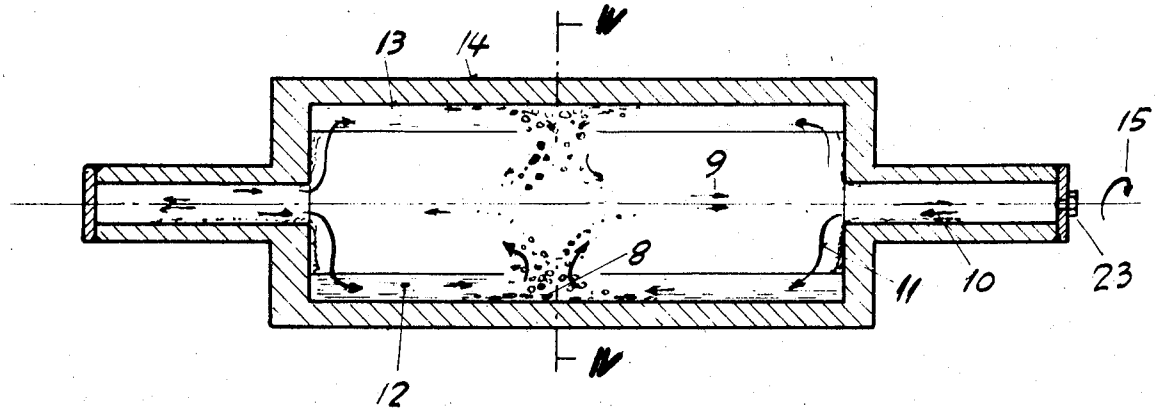
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Primary Examiner—Albert W. Davis, Jr.
Attorney—John J. McGlew et al.

[57] **ABSTRACT**

The hollow interior of the rolls contains heat equalizing media which can have both a liquid phase and a vapor phase, the hollow interior being only partly filled with the medium in the liquid phase. During operation, locally undefined heat concentrations of the roll, on the inner surface of the roll, are reduced by evaporation of the liquid heat equalizing medium, and the heat content of the resultant vapor is transmitted to points of the roll whose instantaneous temperature is lower than the mean operating temperature of the roll, by condensation of the vapor at these points. The condensation or evaporation temperature of the heat equalizing media is beween the maximum and minimum operating temperatures at the static operating pressure prevailing in the interior of the rolls, and the absolute static pressure may be varied. The media, present in two phases of the interior of the roll, is excited into two oppositely directed eddy currents. Grinding rolls used with the invention have end walls to which there are connected tubular shaft ends having bores communicating with the hollow interior of the roll, and at least one shaft end is used for filling the liquid medium into the roll. A flow restriction may be provided between a tubular shaft end and the interior of the roll.

12 Claims, 6 Drawing Figures



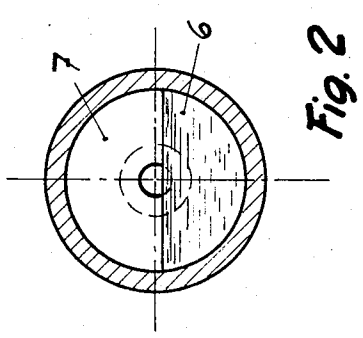


Fig. 2

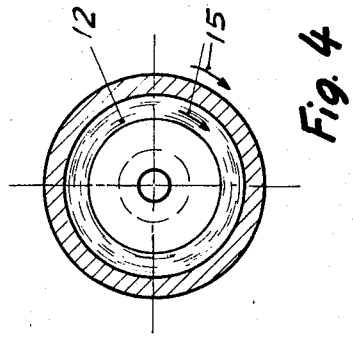


Fig. 4

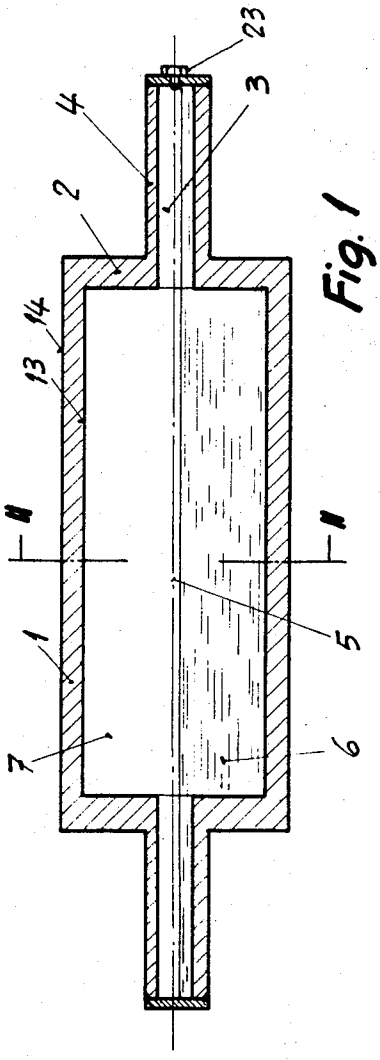


Fig. 1

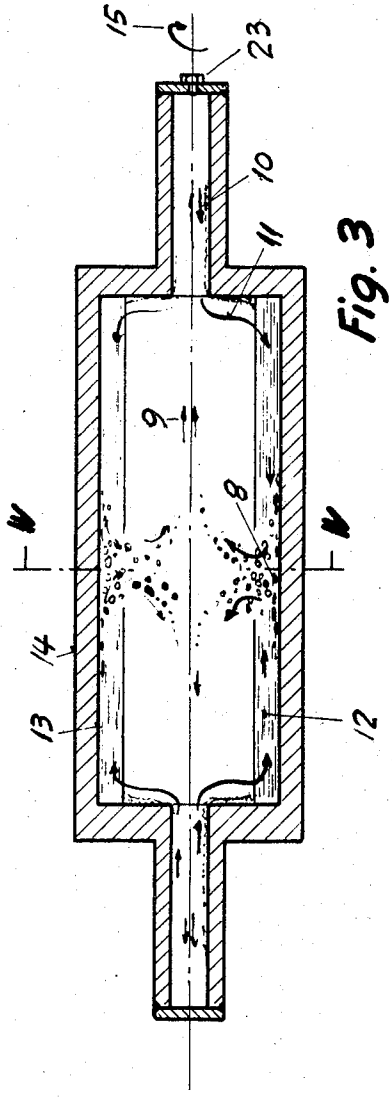


Fig. 3

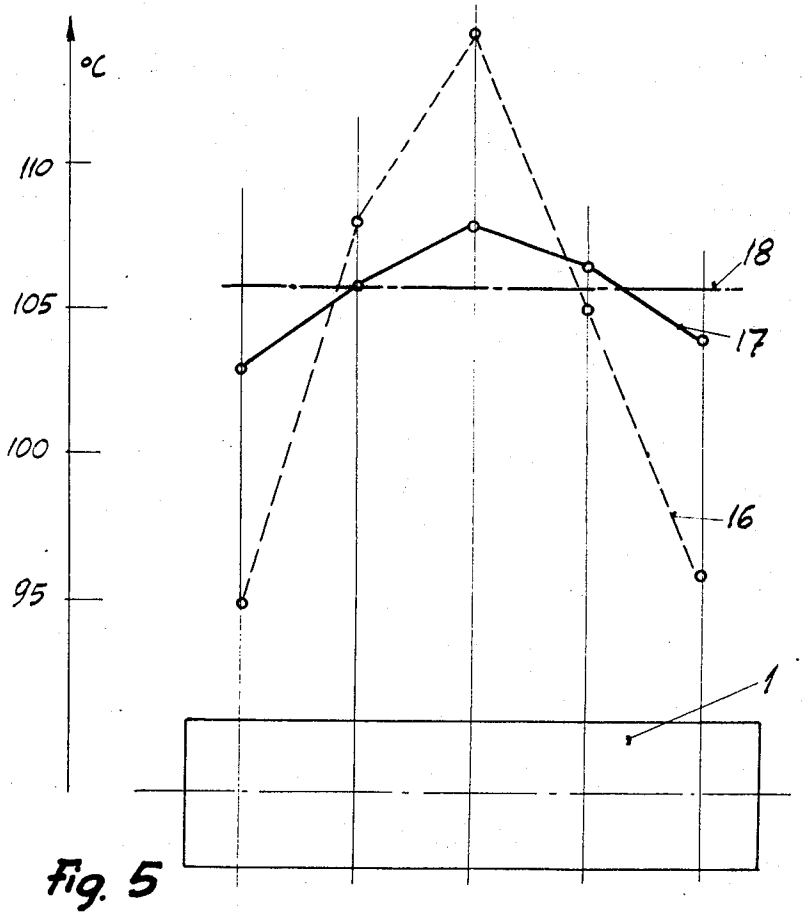


Fig. 5

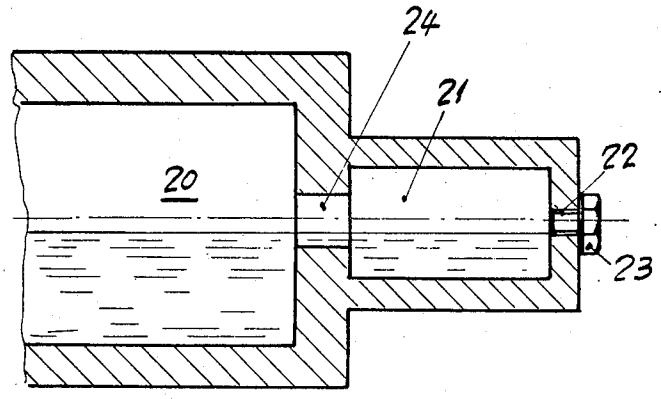


Fig. 6

METHOD AND DEVICE FOR REGULATING THE TEMPERATURE OF ROTATING GRINDING ROLLS HAVING A HOLLOW INTERIOR

FIELD AND BACKGROUND OF THE INVENTION

This invention relates to a method and a device for regulating the temperature of rotating grinding rolls having a hollow interior containing heat equalizing media.

Due to high grinding standards, the task of the designer is to control more and more completely the grinding process, in particular the grinding temperature. There are two solutions, one involving separate cooling of the grinding body and the other not involving separate cooling of the grinding body.

Separate cooling is presently carried out successfully with an externally induced water circulation through the high speed roll, and frequently through both the high speed roll and the low speed roll. This system requires a certain expenditure in construction costs, but it is possible to maintain very low roll temperatures of 30° C and less. If water cooling systems proper are disregarded, there is obtained, partly, considerable amounts of water which are no longer used in many cases. For this reason, this known system is used primarily in those cases where heat must be supplied to or eliminated from a roll.

As an alternative for separate cooling, the entire roll frame is designed for a certain maximum operating temperature of the rolls, and thus does not have any separate cooling of the rolls. The necessary roll dimensions, the embossing of the rolls, and particularly the tolerances have been determined in long test series as well as by practical experience.

Under extreme conditions in operation, whether due to excessive load or high speeds, various irregularities have been found in the grinding quality even in those grinding mills where all tolerances have been maintained by the manufacturer. Measurements have verified the suspicion that the roll shell has different stress fields related to circumference and length. By an additional stress relief heat treatment, these inconveniences could be eliminated. However, this stress relief heat treatment means an additional operation in the manufacture of the rolls.

It is known that a temperature increase of only 10° – 20° C on the circumference, whether resulting from local overstress due to eccentricity or from local increase caused by residual stresses, can eliminate the grinding gap, and this is very harmful for the grinding quality as well as for the roll.

It has therefore been suggested to fill the interior of a hollow grinding roll, with a continuous shaft, with a liquid. The shaft could thus be brought to approximately the same temperature as the shell, so that longitudinal stress, which frequently result in the destruction of the entire roll, can be avoided, while a certain equalization is attained in the shell itself. However, since only the specific gravity differences of a medium are utilized, this results in a flow of the heat primarily in a radial direction.

It has also been proposed to make the roll shell thicker, or even to produce it as a solid body. With a thick-walled shell, the heat concentration can be eliminated only partly. In addition to the difficulties in manufacture and balancing, a solid roll results in a relatively high cost.

SUMMARY OF THE INVENTION

The invention is directed to the problem of attaining a uniform temperature distribution in the roll body, so that the presently-required cooling of the rolls can be eliminated.

In accordance with the invention, this problem is solved in that locally undefined heat concentrations of the roll are reduced, on the interior of the roll, by evaporation of the liquid-heat equalizing medium, and transferred, by condensation of the vapor, to points of the roll whose instantaneous temperature is lower than the mean operating temperature of the roll.

This new method permits, in a surprisingly simple manner, the reduction of local heat concentrations and the equalizing of the temperature over the entire operating period, without the separate supply and elimination of energy, and even minor temperature differences can cause an effective and rapid heat flow in the radial as well as in the axial direction.

In a further development of the invention, the condensation temperature or the evaporation temperature of the heat equalizing media is assumed between the maximum and minimum operating temperatures, and it has been found to be advantageous if the condensation or evaporation temperature corresponds approximately to the mean operating temperature.

For a particularly advantageous application of the method of the invention, the static pressure, and possibly even the filling temperature, are varied during the filling. This permits a very wide range of application of the method with the same media, for example, with water and steam. It has been found expedient to make the interior of the roll as simple as possible, so that the two phases can be excited into eddy currents.

The device embodying the invention is characterized in that the hollow space of the roll is fitted with a two-phase medium, the liquid phase occupying, in the filling state, only a part of the interior volume. Thus, the prerequisites for an operable two-phase system are provided. The liquid medium, usually water or alcohol, can be filled into the roll by the manufacturer or by the customer in the case of a built-in, hence horizontal, roll.

In an advantageous embodiment of the device of the invention, the liquid phase occupies, in the filling state, about one-half the interior volume of the roll.

In a further development of the invention, bores are provided in the shaft butts on both ends of the roll, and these serve, on the one hand, for filling in the liquid and, on the other hand, for effectively including the roll butts in the temperature equalization.

In another embodiment of the invention, the diameter is reduced between the bores of the shaft butts and the hollow interior of the roll, so that a part of the liquid phase is retained constantly in the bores of the shaft butts. This provides a particular advantage of the invention device, since the heat now can flow from any point of the entire roll to any other point.

An object of the invention is to provide an improved method for attaining a uniform temperature distribution in grinding roll bodies having a hollow interior.

Another object of the invention is to provide such a method in which locally undefined heat concentrations of the roll are reduced, on the inner surface of the roll, by evaporation of a liquid heat-equalizing medium, and the heat is transferred by condensation of the vapor to points of the roll whose instantaneous temperature is

lower than the mean operating temperature of the roll.

A further object of the invention is to provide a device for performing the method.

Another object of the invention is to provide such a device embodying a hollow grinding roll having tubular shafts extending from its opposite ends and communicating with the hollow interior of the roll.

A further object of the invention is to provide such a device in which there is a restriction between each tubular shaft end and the hollow interior of the roll.

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the Drawings:

FIG. 1 is a longitudinal or axial sectional view through a roll, embodying the invention, with the roll being stationary;

FIG. 2 is a cross section on the line II—II of FIG. 1;

FIG. 3 is a view similar to FIG. 1, but illustrating the roll when it is rotating;

FIG. 4 is a cross sectional view taken on the line IV—IV of FIG. 3;

FIG. 5 is a diagram graphically illustrating temperature measuring values plotted against the roll length, with and without heat equalizing media; and

FIG. 6 is a partial axial sectional view, to a larger scale, illustrating the restriction between the bore in the shaft butt and the hollow interior of the roll.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIGS. 1 - 4, a hollow grinding roll embodying the invention comprises a cylindrical shell 1, end walls 2 and shaft butts 4 having bores 3. These elements define a hollow space 5 filled with heat equalizing media in the liquid phase 6 and the gaseous phase 7. When the roll is stationary, the liquid and gaseous phases maintain the positions, as indicated in FIGS. 1 and 2.

With a predominant heat supply in the center of the roll, as shown in FIGS. 3 and 4, the liquid medium 6 evaporates at the point 8 and arrives, in the interior of the roll, as vapor flowing as indicated by the arrows 9. The vapor flows toward the inner surface 10 of the tubular shaft end or butt 4, condenses on this interior surface 10, and returns as a liquid phase as indicated by the arrow 11. The liquid phase 12 rotates at a high speed, bearing on the interior surface 13 of the roll shell 1. The vapor phase also rotates in the core part, as indicated by the arrow 15 in FIG. 4. In FIG. 5, the mean circumferential temperature at various points along the length of the wall is indicated as a diagram. The curve 16 is derived from measuring values, after a long operating time with the grinding roll which contains only one medium in its interior. Curve 18 represents the mean temperature, and curve 17 the temperature distribution of a grinding roll, with the media according to the invention, after a long operation.

In the embodiment of the invention shown in FIG. 6, the hollow space 21 of the shaft end or butt is offset from the hollow space 20 of the roll proper, but connected thereto by a reduced cross section aperture 24. The media are filled into the hollow space 20 through bore 22, and are sealed hermetically with the lug 23 which has, at the same time, a sealing function.

Let is be assumed that 110° C is required as a maximum admissible operating temperature of the roll surface. The invention now permits designing the roll frame so that the mean temperature 18 comes very close to 110° C (see FIG. 5). Without the method according to the invention, the output would have to be reduced, or the roll frame itself would have to be increased. The roll is only half-filled with water for this example, and is subsequently sealed hermetically with lug 23. As known, water evaporates at sea level at a normal ambient pressure at 100° C. The hollow space of the roll limits expansion of the liquid. Consequently, evaporation of the water effects a pressure increase which results in an increase of the evaporation temperature. Since the roll frame is laid out for a mean temperature of about 106° C, for example, a corresponding vapor pressure is built up in the roll interior 5.

The partial or half-way filling assures, on the one hand, that the gaseous phase as well as the liquid phase always will be present in the operating state and, on the other hand, the presence of free points, namely the end walls 2 and parts of the shaft butts 4, where the steam condenses. In operation, the liquid rotates as a closed shell on the inner circumference 13 of the roll.

The end walls 2, as well as the shaft ends 4, receive no direct heat, except through the bearings. However, the temperature frequently will be highest at point 8 of FIG. 3. This temperature gradient results in the constant circulation of the temperature equalizing medium as indicated at 9. The steam condenses on the end walls 2 as well as on the shaft butts 10, since the temperature at these points is less than the mean roll temperature (FIG. 5). The condensate is driven, as indicated by the arrow 11, toward the outside into the proximity of the inner surface 13 of the roll, so that the liquid 12 evaporated at the roll center 8 is replaced.

Temperature peaks can appear, however, at any point of the roll interior surface 13. It is known that more heat can be supplied, particularly at the roll ends and hence in the proximity of the end walls 2. The method according to the invention permits reducing temperature peaks immediately at this point by evaporation with exactly the same efficiency by changing the flow pattern only slightly.

It should be clear that the heat is generated not on the entire surface of the roll but rather as a point or linear origin, namely in the zone of the grinding gap. Measurements have shown that the temperature at this point is considerably above the mean circumferential temperature. In particular, this inequality of the temperature on the circumference disappears completely when the method according to the invention is applied.

It is even possible, though to a limited extent, to eliminate heat which was caused by the bearings, by evaporation from this point, as is represented in FIG. 6.

The heat, which is generated on the exterior surface 14 of the shell and of the shaft butts 4, respectively, flows equally well in any direction because of the rotation, and particularly because of the vaporous heat carrier, that is, radially, axially and even circumferentially, the evaporation and condensation effecting a very rapid and intensive heat flow. The method of increasing the corrective forces while increasing the unequal weight can thus be used with corresponding simplicity for equalizing the roll temperature, with the advantage

that no energy has to be supplied or eliminated, naturally without any regulating mechanism.

In a further development of the inventive concept, a medium can be used at lower operating temperatures and whose evaporation temperature correspondingly is low. In a particular expedient application of the invention method, the evaporation temperature is determined in correspondence to the mean operating temperature of the roll.

In cases with extremely high temperatures, as well as extremely low temperatures, or for reasons of inventory in order to keep the number of various media low, it is advisable to vary the static pressure during the filling in order to obtain a predetermined evaporation temperature.

In the application of the invention method, it is advantageous to excite the liquid phase as well as the gaseous phase of the medium into an eddy current, which means that very clean surfaces are provided and that fittings are omitted. The method of temperature equalization in accordance with the present invention can be used for two or more rolls in the same roll frame, and it is of particular advantage in combination with the separate cooling of the roll since it fills a gap which exists at present. The advantage of the device embodying the invention resides particularly in its simplicity in manufacture as well as in operation.

Both shaft ends **4** are provided with a respective bore **3**. In principle, both ends **4** could be firmly welded closed after the liquid medium **6** has been filled in. However, a sealing screw or lug **23** preferably is provided, since other media can be later filled in and the magnitude of the static pressure can be varied.

The form of the roll surface **14** depends on the use. For practical reasons, the interior **5** of the roll is not filled with liquid up to the center or axis.

For reasons of strength, or for other reasons, it may be advantageous to provide a diameter reduction **24** between shaft bore **3** and hollow space **20** of the roll. In this way, a small part of the liquid is simultaneously retained in the shaft bore. To a limited extent, the temperature peaks caused by heating of the bearings can thus be eliminated. The method of operation of bore **21** remains exactly the same as that for hollow space **20.**

While specific embodiments of the invention have been shown and described in detail to illustrate the application of the principles of the invention, it will be understood that the invention may be embodied otherwise without departing from such principles.

What is claimed is:

1. A method for equalizing the temperature of rotating grinding rolls having a hollow interior containing heat equalizing media, said method comprising reducing locally undefined heat concentrations of a roll by evaporating a liquid heat equalizing medium on the inner surface of the roll; and transmitting the heat content of vapor phase heat equalizing medium to points of the roll whose instantaneous temperature is lower than the mean operating temperature of the roll, by condensation of the vapor phase at these points.

2. A method for equalizing the temperature of rotating grinding rolls, as claimed in claim **1,** in which the condensation temperature and evaporation temperature of the respective heat equalizing media is between the maximum and minimum operating temperature of the roll at the static operating pressure prevailing in the interior of the roll.

3. A method for equalizing the temperature of rotating grinding rolls, as claimed in claim **2,** in which the condensation temperature and evaporation temperature of the respective heat exchange media corresponds to the mean operating temperature of the roll.

4. A method for equalizing the temperature of rotating grinding rolls, as claimed in claim **1,** including adjusting the static pressure in the interior of the roll to control the evaporation temperature and condensation temperature of the respective media so that these are in agreement with desired operating conditions.

5. A method for equalizing the temperature of rotating grinding rolls, as claimed in claim **1,** including exciting the respective media in the interior of the roll to provide two oppositely directed eddy currents, with the outer eddy current being directed primarily in the liquid phase from the circumferential inner periphery of the roll toward its axis and with the central eddy being directed primarily in the gaseous phase from the center of the roll to the ends of the roll.

6. A method for equalizing the temperature of rotating grinding rolls, as claimed in claim **1,** comprising, with respect to two rolls in a roll frame, reducing locally undefined heat concentrations of each roll on the inner surface of the roll by evaporating a liquid heat equalizing medium; and transmitting the heat content of vapor phase heat equalizing media in each roll to points of the roll whose instantaneous temperature is lower than the mean operating temperature of the roll, by condensation of the vapor phase at these points.

7. A method for equalizing the temperature of rotating grinding rolls, as claimed in claim **1,** including separately cooling the high speed roll in a roll frame; reducing locally undefined heat concentrations of the low speed roll on the inner surface on the low speed roll by evaporating a liquid heat equalizing medium; and transmitting the heat content of vapor phase heat equalizing medium to points of the low speed roll whose instantaneous temperature is lower than the mean operating temperature of the low speed roll, by condensation of the vapor phase at these points.

8. A device for equalizing the temperature of rotating grinding rolls having a hollow interior containing heat equalizing media, said device comprising, in combination, a liquid phase heat equalizing medium sealed in said hollow interior; and a vapor phase heat equalizing medium sealed in said hollow interior; said liquid phase heat equalizing medium occupying only part of the volume of said hollow interior.

9. A device for equalizing the temperature of rotating grinding rolls, as claimed in claim **8,** in which said liquid phase heat equalizing medium occupies about one half the volume of said hollow interior.

10. A device for equalizing the temperature of rotating grinding rolls, as claimed in claim **8,** in which said roll is formed by a cylindrical roll shell having axially opposite end walls; and respective shaft ends secured to extend outwardly from each end wall; each shaft end having an axial bore communicating with the hollow interior defined by the roll shell and the end walls.

11. A device for equalizing the temperature of rotating grinding rolls, as claimed in claim **10,** in which at least one shaft end bore serves, in a built-in roll, as a filling opening for said liquid phase heat equalizing medium.

12. A device for equalizing the temperature of rotating grinding rolls, as claimed in claim **10,** including a flow restricting aperture in each end wall establishing communication between the associated shaft end bore and the hollow interior defined by the roll shell and the end walls, to retain a part of the liquid phase heat exchange medium in each shaft end bore.

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