

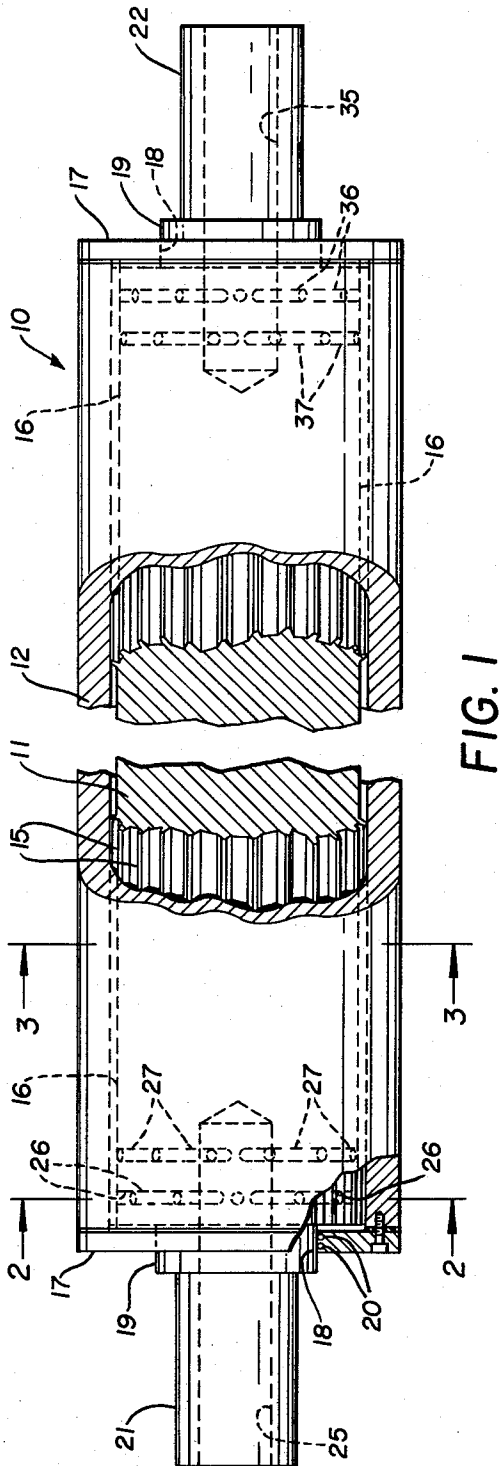
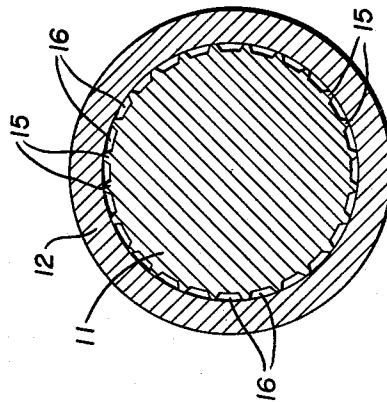
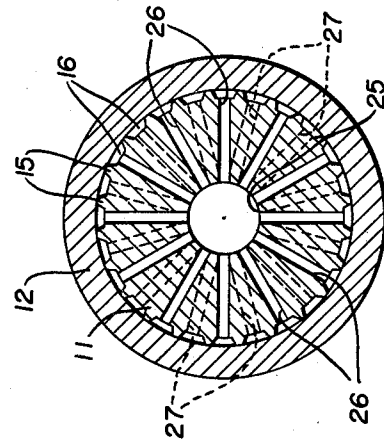
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LEVELING ROLL

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3,135,319 LEVELING ROLL

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This invention relates to leveling rolls for leveling or smoothing sheets of hot or molten material, such as molten glass. The invention relates particularly to leveling rolls of the type intended to be employed with a coolant, such as water, in which the wall of the roll which is between the coolant and the hot material transfers heat from the hot material to the coolant at a sufficiently high rate to prevent softening of the roll surface but at a sufficiently low rate to avoid freezing of the hot material being leveled.

In more specific structural terms, the invention pertains to coaxial inner and outer roll members having means provided therebetween to define longitudinally extending uniformly cross-sectioned channels of flow for a coolant such as water, and the outer member of which is appropriately dimensioned as to thickness to provide the proper rate of heat flow in glass rolling applications and the like, taking into account the heat transfer rating of the particular metal comprising the outer member. I have discovered that rolls may be provided which will hold dimensional tolerances to within limitations of about 15 mils in prolonged service of several months or more as contrasted with prior rolls which, other conditions (including materials, operating temperatures and capacities, service life, amount of maintenance required, absence of costly elaborations such as schemes for applying coolants at varying rates in different locations on the same roll and the like) being equal, achieve tolerances of 25–30 mils.

The attainment of accuracy in leveling sheets of molten glass is of great commercial importance because of the extremely high cost of grinding the glass sheet to precise thickness dimensions after it has cooled. A rough rule of thumb in the industry currently applicable to several plate glass production lines is that a reduction of 1 mil ($\frac{1}{1000}$ inch) in the range of thickness variation downstream of the leveling roll results in a savings of \$1,000 per day in production costs.

The invention contemplates the provision of an inner roll member and an outer tubular member affixed thereto. One of the two members is fluted. The inner and outer members are affixed together to constitute a roll body with the flutes defining fluid-carrying longitudinally extending passages between the inner and outer members.

The invention contemplates the application of suitable criteria in the selection of metals for the inner and outer roll members, such as strength, cost of material and fabrication, corrosion resistance, attainability and maintainability of sufficiently uniform grain, and acceptably limited crystal growth. In addition, the invention contemplates a selection and employment of metals in cross-sectional dimensions such that the beam strength, or more precisely the ratio of stress moments, i.e., moments of resistance (as formulated for example in the Mechanical Engineer's Handbook, Fifth Edition, McGraw-Hill, p. 431), of the inner to the outer roll members or beams, each considered separately, is substantially at least unity. The invention further contemplates angular spacing between the flutes or ridges which define the coolant passages extending longitudinally along and between the inner and outer roll members, which angular spacing is sufficiently small to establish peripherally continuous stiffening association between the outer roll member and the inner roll member without "washboarding" of the outer roll member. The outer and inner roll members are associated and interengaged in stiffening interrelationship as

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by shrink-fitting with the arrangement such as to allow longitudinal growth of the outer roll member due to thermal expansion as it comes up to operating temperature. By way of example, such growth is not unusually in the order of .75 inch at each end of a 144-inch roll used for leveling a 132-inch sheet of molded glass. The arrangement is also such that the coolant is contained against significant leakage and in an operative manner for circulation through the roll. Also it is possible to advantageously form the inner member of the roll to provide for continuous integral extension thereof entirely across the width of the production line from a point of supported relationship with a bearing journal on one side of the production line to a point of supported relationship with a bearing journal on the opposite side of the production line.

The above and other aspects of the invention are more concretely set forth in the following description of an embodiment of the invention. This description is given merely by way of example and the practice of the invention does not necessarily call for the practice of every particular of this example.

In the accompanying drawings, FIGURE 1 is an elevational view, partly in cross-section and with the longitudinally central section broken out, showing a roll embodying the invention, and FIGURES 2 and 3 are cross-sections taken respectively on the planes of lines 2—2 and 3—3 in FIGURE 1.

The leveling roll body or assembly shown in FIGURE 1 is indicated generally by the reference numeral 10. This body comprises the inner and outer roll members 11 and 12.

Means are provided mounting the outer roll member 12 in shrink-fitted relationship with the inner roll member 11, but also mounting the outer roll member 12 for longitudinal growth and attendant relative movement with respect to the inner roll member 11. Such means comprises a plurality of longitudinally extending flutes 15 distributed around the periphery of the inner roll member 11. The longitudinally extending flutes 15 are parallel to the common axis of the inner and outer roll members so that when the outer roll member 12 grows longitudinally as a consequence of thermal expansion, the resulting relative movement between the outer roll member 12 and the inner roll member 11 does not involve movement across edges of the flutes 15. Accordingly, the longitudinal growth of the outer member and the resulting relative movement between the outer and inner roll members is accommodated despite the shrink-fit relationship between the inner and outer roll members and despite the close structural interaction between the inner and outer roll members in which stresses and deformations tending to be established in the outer roll member 12 under operating conditions are resisted by the stiffening effect of the inner roll member 11 acting as an elastic beam.

As previously mentioned, the metals chosen for the inner and outer roll members will be chosen by considerations of suitable criteria such as strength, cost of material and fabrication, corrosion resistance, attainability and maintainability of suitably uniform grain, and acceptably limited crystal growth. In general, these factors will be critical for the outer roll member 12. One example of a suitable material is the iron-nickel alloy known as Invar and which has been known also under the name of Nilvar, Nilex, and Indilitans and consisting essentially of an iron alloy containing 36 percent nickel (see H. Scott, Trans. Amer. Soc. Steel Treat., 13, 1928, 829–847). Another example of a suitable material is a cast iron known as Invar Cast Iron or Minovar (the latter being the trade-name of the International Nickel Company). Basically this comprises a close grained gray cast iron containing 34–36 percent nickel (see F. G. Seifing and D. A. Nemser,

Product Engineering, November 1945). The inner roll member 11 may comprise any suitable metal such as plain carbon steel S.A.E. Nos. 1020 or 1045 (American Iron and Steel Institute Nos. C 1020 or C 1045).

Whatever specific metals are chosen for the inner and outer roll members 11 and 12, the cross-sectional relationship between these two roll members should be such that the ratio of the stress moment of the inner roll member 11 to the stress moment of the outer roll member 12 is substantially at least unity for all roll cross-sections along the work-engaging portion of the longitudinal extent of the leveling roll and normal to the principal axis of the roll. Such work-engaging portion of the longitudinal extent of the roll will be understood to comprise the majority of the length of the leveling roll intermediate the ends thereof. Of course the above cross-sectional relationship may be achieved by roll assemblies having hollow inner roll members of sufficient wall thickness as well as by those having solid inner roll members as in the case of the particular leveling roll illustrated in the drawings.

A plurality of passages 16 are defined between adjacent pairs of the flutes 15 and extend longitudinally within the body of the leveling roll between the ends thereof.

Means is provided associated with each end of the leveling roll between each end portion of the outer roll member 12 and the corresponding longitudinal portion of the inner roll member 11 for containing coolant fluids flowing through the passages 16 against leakage from the ends of the passages 16 while at the same time accommodating longitudinal growth of the outer roll member 12 with respect to the inner roll member 11. Currently no flexible diaphragm materials are known to be available at acceptable costs which will stand up under the extremely high temperatures and severe service conditions encountered in this application, and it presently appears highly advantageous to comprise such seal establishing means in the form of a sliding and sealing mating relationship between structures associated respectively with said outer and inner roll members 12 and 11. In the apparatus illustrated, a circular plate 17 is bolted or otherwise affixed at each end of the outer roll member 12. The plate 17 has a sealing-bore-defining annulus 18. A sealing-plunger-defining male periphery 19 is formed on the inner roll member 11 and is engaged in mating sliding and sealing engagement with the annulus 18. Completeness of sealing may be promoted by sealing rings or the like indicated by the reference numeral 20, which in the particular apparatus illustrated are received in suitable grooves formed in the sealing-bore-defining annulus 18. An identical arrangement may be provided at the opposite end of the roll. Where it is possible and practical in the fabrication of the assembly to form the flutes 15 by removing the metal at the location of the passages 16 by machining operations in such a way that the passages 16 extend to a point short of the ends of the large-diameter longitudinally central portion of the inner roll member 11, it will then be understood that the end portions of the inside diameter of the outer roll member 12 in such case each constitute a sealing-bore-defining annulus and the corresponding longitudinal portions of the inner roll member 11 each constitute a sealing-plunger-defining male periphery.

The leveling roll 10 is provided with first and second journal shaft means 21 and 22 at opposite ends of the leveling roll. Desirably, the journal shaft means 21 and 22 comprise journal shaft portions formed integrally with the inner roll members 11 and toward each end thereof so that the inner roll member extends as a continuous integral extension entirely along the length of the leveling roll from one journal shaft portion 21 to the other journal shaft portion 22.

Formed in the journal shaft means 21 is a bore 25 which extends partially into the central portion of the inner roll member 11. A first group of radial passages

26 communicates with one series of passages 16 and another group of radial passages 27 communicates with the remainder of the passages 16, the arrangement preferably being such that the groove 16 communicating with the radial passages 26 and 27 alternate around the periphery of the inner roll member 11. The same arrangement may be repeated at the opposite end of the roll structure associated with the journal shaft means 22, as by the provision of a bore 35 and radially extending passages 36 and 37.

In the leveling roll as illustrated, flow of incoming coolant is supplied at one end of the roll assembly and is exhausted from the other end thereof. Cross flow or reverse flow may alternatively be provided for by end caps or stoppers and flanged tube arrangements or the like for dividing the flow into or out of the sets of radial passages 26 and 27 and if desired for dividing the flow into or out of the sets of radial passages 36 and 37, all as disclosed in my copending application Serial No. 652,851 filed April 15, 1957 and now abandoned.

Rolls constructed according to the invention can meet or exceed standards of leveling accuracy met by the rolls of the prior art and at the same time can be provided at lower cost than can any conventional or known structure capable of approaching such standards.

What is claimed is:

1. A leveling roll for leveling molten sheet material and the like by contacting said material in rolling engagement at a work-engaging portion of the longitudinal extent of the leveling roll, comprising coaxial inner and outer roll members, the ratio of the stress moment of the inner roll member to the stress moment of the outer roll member being at least unity for all roll cross-sections along the work-engaging portion of the longitudinal extent of said leveling roll, the transverse cross-sectional area of said outer roll member being at least as great at the longitudinal center of said leveling roll as at other locations along the work-engaging portion of the longitudinal extent of said leveling roll, and said outer roll member being further characterized by the absence of longitudinally and annularly extending seams along the work-engaging portion of the longitudinal extent of said leveling roll, means mounting said outer roll member in shrink-fitted relationship with said inner roll member for longitudinal growth with respect thereto comprising a plurality of longitudinally extending flutes distributed around the periphery of said inner roll member parallel to the axis thereof, a plurality of passages each defined between an adjacent pair of said flutes and extending longitudinally within said leveling roll between the ends thereof, seal establishing means associated with each end of said leveling roll between each end portion of said outer roll member and the corresponding longitudinal portion of said inner roll member for containing the coolant against leakage from the ends of said longitudinally extending passages to the exterior of said roll means while accommodating said longitudinal growth of said outer roll member with respect to said inner roll member, said seal establishing means comprising for each end of said leveling roll a sealing-bore-defining annulus associated with said outer roll member, and a sealing-plunger-defining male periphery associated with said inner roll member in mating sliding and sealing engagement with said annulus, said inner roll member having a journal shaft portion formed toward end thereof and said inner roll member extending as a continuous integral extension entirely along the length of said leveling roll from one said journal shaft portion to the other, passageways defined in said inner roll member and communicating from at least one of said journal shaft portions to said longitudinally extending passages.

2. A leveling roll for leveling molten sheet material and the like by contacting said material in rolling engagement at a work-engaging portion of the longitudinal extent of the leveling roll, comprising coaxial inner and outer roll members, the ratio of the stress moment of the inner roll

member to the stress moment of the outer roll member being at least unity for all roll cross-sections along the work-engaging portion of the longitudinal extent of said leveling roll, the transverse cross-sectional area of said outer roll member being at least as great at the longitudinal center of said leveling roll as at other locations along the work-engaging portion of the longitudinal extent of said leveling roll, and said outer roll member being further characterized by the absence of longitudinally and annularly extending seams along the work-engaging portion of the longitudinal extent of said leveling roll, means mounting said outer roll member in shrink-fitted relationship with said inner roll member for longitudinal growth with respect thereto comprising a plurality of longitudinally extending flutes distributed around the periphery of said inner roll member parallel to the axis thereof, a plurality of passages each defined between an adjacent pair of said flutes and extending longitudinally within said leveling roll between the ends thereof, seal establishing means associated with each end of said leveling roll between each end portion of said outer roll member and the corresponding longitudinal portion of said inner roll member for containing the coolant against leakage from the ends of said longitudinally extending passages to the exterior of said roll means while accommodating said longitudinal growth of said outer roll member with respect to said inner roll member, said inner roll member having a journal shaft portion formed toward each end thereof and said inner roll member extending as a continuous integral extension entirely along the length of said leveling roll from one said journal shaft portion to the other, passageways defined in said inner roll member and communicating from at least one of said journal shaft portions to said longitudinally extending passages.

3. A leveling roll for leveling molten sheet material and the like by contacting said material in rolling engagement at a work-engaging portion of the longitudinal extent of the leveling roll, comprising coaxial inner and outer roll members, the ratio of the stress moment of the inner roll member to the stress moment of the outer roll member being at least unity for all roll cross-sections along the work-engaging portion of the longitudinal extent of said leveling roll, the transverse cross-sectional area of said outer roll member being at least as great at the longitudinal center of said leveling roll as at other locations along the work-engaging portion of the longitudinal extent of said leveling roll, and said outer roll member being further characterized by the absence of longitudinally and annularly extending seams along the work-engaging portion of the longitudinal extent of said leveling roll, means mounting said outer roll member in shrink-fitted relationship with said inner roll member for longitudinal growth with respect thereto comprising a plurality of longitudinally extending flutes distributed around the periphery of said inner roll member parallel to the axis thereof, a plurality of passages each defined between an adjacent pair of said flutes and extending longitudinally within said leveling roll between the ends thereof, seal establishing means associated with each end of said leveling roll between each end portion of said outer roll member and the corre-

sponding longitudinal portion of said inner roll member for containing the coolant against leakage from the ends of said longitudinally extending passages to the exterior of said roll means while accommodating said longitudinal growth of said outer roll member with respect to said inner roll member, said seal establishing means comprising for each end of said leveling roll a sealing-bore-defining annulus associated with said outer roll member, and a sealing-plunger-defining male periphery associated with said inner roll member in mating sliding and sealing engagement with said annulus, first and second journal shaft means at opposite ends of said leveling roll, passageways defined in said inner roll member and communicating from at least one of said journal shaft means to said longitudinally extending passages.

4. A leveling roll for leveling molten sheet material and the like by contacting said material in rolling engagement at a work-engaging portion of the longitudinal extent of the leveling roll, comprising coaxial inner and outer roll members, the ratio of the stress moment of the inner roll member to the stress moment of the outer roll member being at least unity for all roll cross-sections along the work-engaging portion of the longitudinal extent of said leveling roll, the transverse cross-sectional area of said outer roll member being at least as great at the longitudinal center of said leveling roll as at other locations along the work-engaging portion of the longitudinal extent of said leveling roll, and said outer roll member being further characterized by the absence of longitudinally and annularly extending seams along the work-engaging portion of the longitudinal extent of said leveling roll, means mounting said outer roll member in shrink-fitted relationship with said inner roll member for longitudinal growth with respect thereto comprising a plurality of longitudinally extending flutes distributed around the periphery of said inner roll member parallel to the axis thereof, a plurality of passages each defined between an adjacent pair of said flutes and extending longitudinally within said leveling roll between the ends thereof, seal establishing means associated with each end of said leveling roll between each end portion of said outer roll member and the corresponding longitudinal portion of said inner roll member for containing the coolant against leakage from the ends of said longitudinally extending passages to the exterior of said roll means while accommodating said longitudinal growth of said outer roll member with respect to said inner roll member, first and second journal shaft means at opposite ends of said leveling roll, passageways defined in said inner roll member and communicating from at least one of said journal shaft means to said longitudinally extending passages.

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