Jan. 26, 1971 W. MÜHLBERG 3,557,614

MEASUREMENTS OF LONGITUDINAL STRESSES IN MOVING METAL BANDS AND DEVICES THEREFOR

Filed Jan. 23, 1967 2 Sheets-Sheet 1

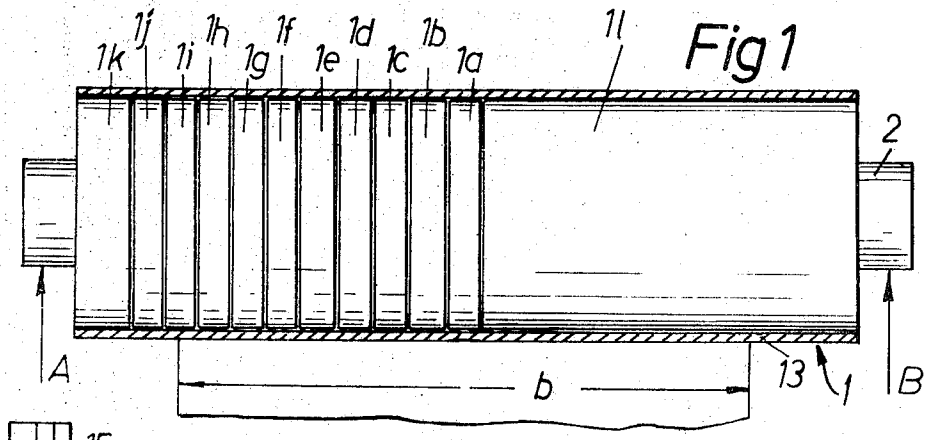


Fig 1

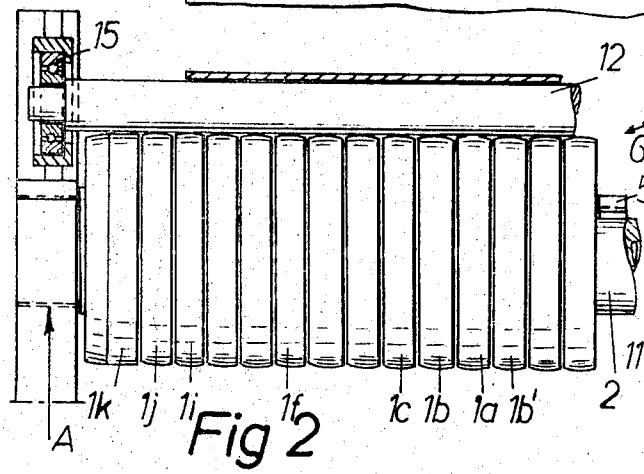


Fig 2

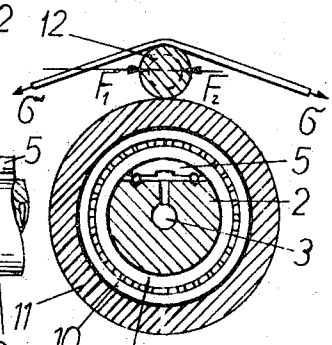


Fig 3

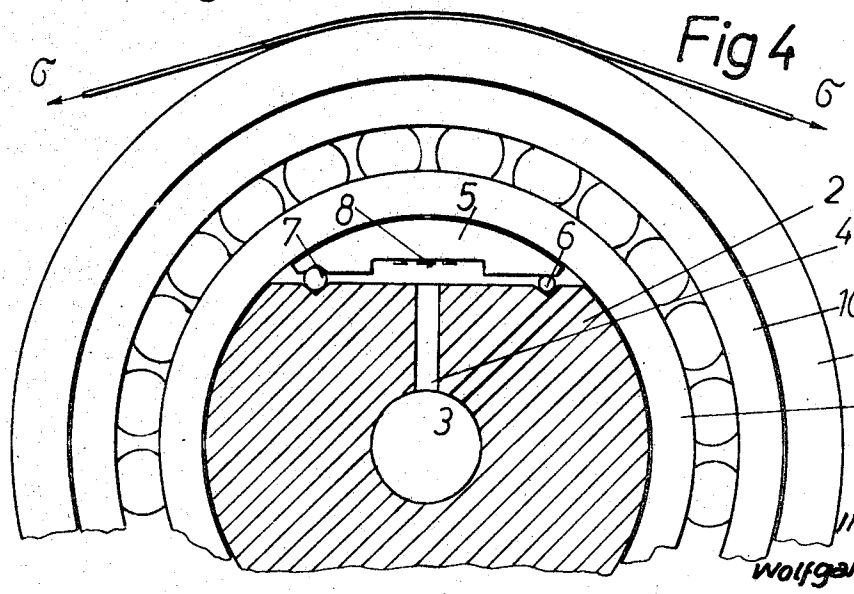


Fig 4

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Fig 5

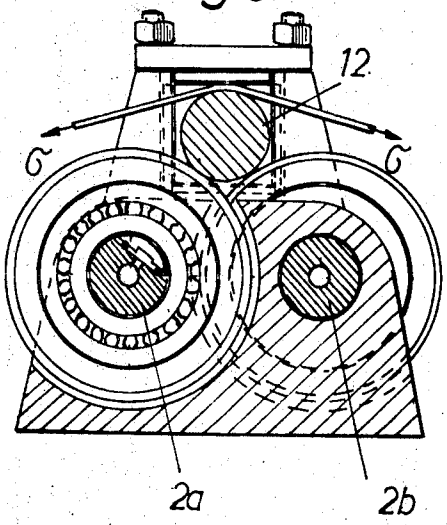


Fig 6

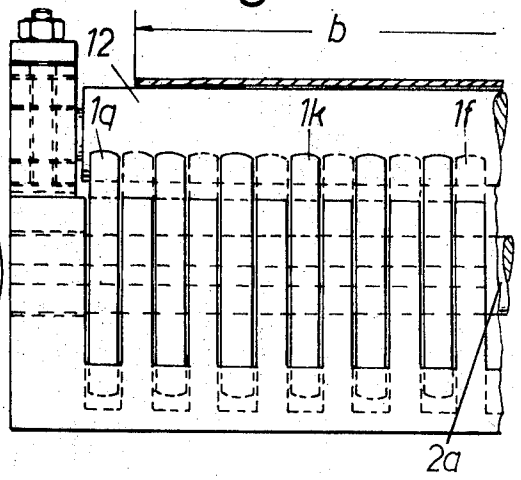
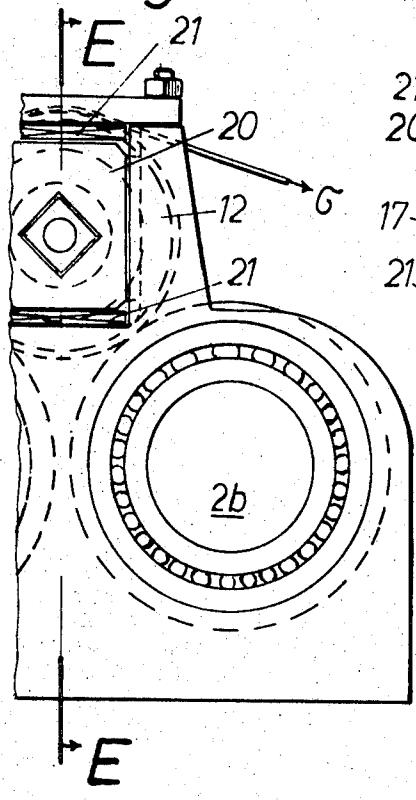


Fig 7



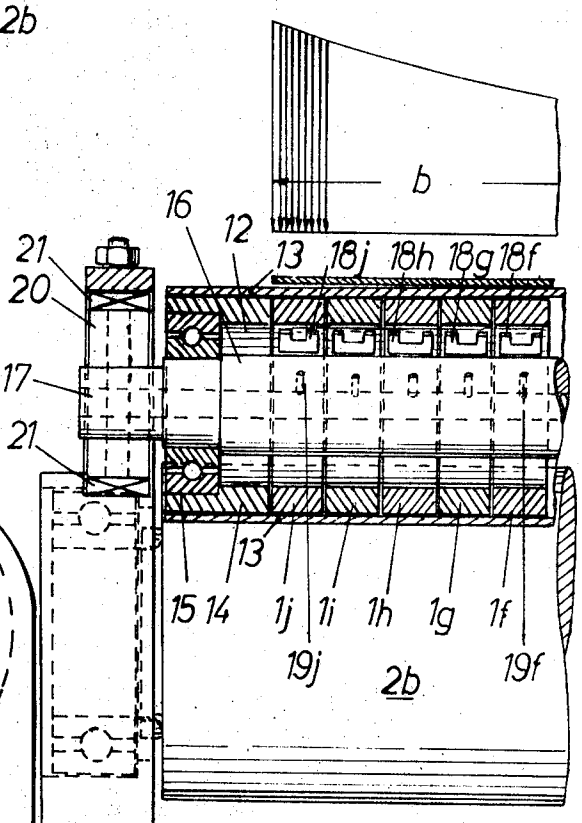


Fig 8

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MEASUREMENTS OF LONGITUDINAL STRESSES IN MOVING METAL BANDS AND DEVICES THEREFOR

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Int. Cl. G01l 5/10
U.S. Cl. 73—144 3 Claims

ABSTRACT OF THE DISCLOSURE

A device for measuring longitudinal stresses occurring across moving metal bands under longitudinal tension by means of a deflecting roller carrying measuring discs. The deflecting forces arising in the center of the band and at both edges are measured. These deflecting forces are proportional to the tensile stresses.

Upon rolling, especially cold rolling of very thin metal bands of difficultly workable or deformable material, tensile stress (or strain or tractive force) is imparted thereto, before and behind the roller gap in the mill wherein the material is worked, primarily by the pressure of the rollers. This stress not only influences the guidance of the bands, but also the deformation of the bands in the direction of the rolling process. The influence of the deformation becomes the more important the thinner band to be rolled and the more the cold work hardening of the material increases, caused by the deformation process.

The rolling process thereby is rendered more difficult, and it generally is attempted to compensate for this difficulty by applying high tensile stresses, acting in the direction of the rolling process. The magnitude of these longitudinal stresses, however, of necessity is limited in practice to approximately 25 to 30% of the working or deformation strength attained, in order to avert rupture of the bands. The reason for the application of these comparatively low tensile stresses is found in the fact that their distribution over the width of the band is uneven. For instance, if the band is stretched more on the edges than in the center (which occurs due to the use of rolls with a high crown or due to too much heat in the center of the roller body thus providing a greater diameter), the tensile stresses shift dangerously towards the edges with constant pulling force and simultaneous decrease of the tensile stresses in the center of the bands. Under the most unfavorable conditions, this uneven distribution may provide tensile stresses in the edge regions which amount to thrice the average calculated value, if considered evenly distributed, while the center region attains a tensile stress of a zero value so that center ripples do not form and no indication of this uneven distribution of the stresses is present. At the edges, therefore, a tensile stress of approximately 75–90% of the deformation strength attained prevails. The difference from the stretch-strain limit or deformation strength thereby is too slight to prevent rupture of the band. If central ripples do form on the bands, the stress at the edges is even higher and the peril of rupture of the band correspondingly greater.

The invention utilizes the well known fact that a moving metal band under longitudinal tension, when slightly

deflected from the direction of its movement by a roller, generates a corresponding deflecting force which acts as a load on the deflecting roller. This load is measured by permitting measuring discs, disposed on the deflecting roller, to act on the center and both edges of the band, as will be explained in detail hereinbelow. The measurements are transmitted to an indicating instrument, known per se, and read therefrom.

The embodiments of the invention will be illustrated with reference to the accompanying drawings. However, it should be understood that these are given merely by way of explanation, and not of limitation, and that changes may be made in the details without departing from the spirit and the scope of the invention as hereinafter claimed.

In the drawings,

FIGS. 1 and 2 are elevations of two embodiments of deflecting rollers provided with measuring discs;

FIG. 3 is a cross section of the roller shown in FIG. 2;

FIG. 4 is a cross section of a measuring disc;

FIG. 5 is a cross section of another embodiment of a deflecting roller;

FIG. 6 is an elevation of the roller shown in FIG. 5;

FIG. 7 is a cross section of still another embodiment of a deflecting roller; and

FIG. 8 is an elevation of the roller along lines E—E of FIG. 7.

Referring now to these drawings, to ascertain the longitudinal stresses of a moving metal band across its width *b*, the deflecting roller **1** according to FIG. 1 is formed as a measuring roll wherein a common fixed shaft carries a plurality of small measuring discs **1***a*–**1***j*, having equal shaft length, and the inactive roller parts **1***k* and **1***l* of different shaft length. Opportunely, according to FIG. 1, the active and inactive roller parts are disposed asymmetrically about the centrally located disc **1***a*, whereby corresponding measuring means simultaneously must be present for the support forces A and B of shaft **2** which acts as a beam with two supports.

If the measuring means indicate equal support forces A and B, the longitudinal stresses across the moving band are distributed symmetrically, so that the partial load resulting from the longitudinal stress therein present, leads to a corresponding signal at the measuring instrument connected to measuring disc **1***a*.

An asymmetrical distribution of the tensile stresses of the moving band across the band causes support forces A and B of different magnitude. These forces can be equalized, e.g., in a strip mill frame, by tightening of one set screw and simultaneous loosening of the opposite screw thus shifting the longitudinal stresses caused by the differential lengthening of the band. Hence, it suffices to distribute the active and inactive roller parts according to FIG. 1. It is, of course, also possible to distribute the measuring discs symmetrically over the roller or to provide the shaft **2** exclusively with measuring discs. Of the measuring discs **1***a* to **1***j* in FIG. 1, only three are connected to a measuring instrument, namely the one in the center of the band and those which just fully cover the edges.

Thereby the value at the band edges is not ascertained and compared to the value at the center, but the value in the corresponding edge area. However, the value at the edge can be calculated or deducted and the necessary countermeasures taken to reestablish the even distribution of the tensile stresses in the band. The measuring instruments connected with the measuring discs **1***a* and **1***h*, respectively, then indicate equal values.

It also suffices to install only one measuring disc adjustably relative to the width of the band, in the center of the deflecting roller or near one of its edges, respectively. This disc, through the measuring instrument connected to it, indicates the deflecting force apportioned to it which is proportional to the tensile stress in the course of this disc.

A preferred embodiment of a measuring disc is shown in FIG. 4. The disc consists of a casing **11** which is disposed on a roller bearing having an inner ring **9** and an outer ring **10**. The former is disposed on the stationary shaft **2** and exerts pressure on a measuring beam **5**, forming a fitting. An extensometer strip **8** is fastened to beam **5**, e.g., by means of an adhesive. Measuring beam **5** has two support points **6** and **7**. The wires from the measuring instrument to beam **5** are conducted through conduit **4** and central bore **3**, by way of amplifiers. The measuring instrument can be any one of conventional devices and is not shown in the drawings, nor are the amplifiers. The deflecting roller carrying individual discs might not be usable in certain instances, for instance, when grooves are generated on the moving metal band, rounding of the edges of these discs notwithstanding. Formation of such grooves detracts from the quality of these bands. To obviate this, the deflecting roller carrying the discs **1***a* to **1***l* is provided with a thin-walled jacket **13** which is shrunk or pressed onto it. Thus, the roller has a closed jacketed surface, as also shown in FIG. 1. Being thin-walled, this jacket does not jeopardize the technological advantages of the direct measurement of the deflecting forces in the paths of the discs **1***a* to **1***j* which are proportional to the prevailing tensile stresses, because the measuring error due to the load distributing effect of the jacket **13** is negligible. Moreover, the salient feature is the comparison of the tensile stresses in the center of the band with those at the edges.

The effect of a closed roller surface also is attained by deflecting the band by a solid or hollow roller **12** of small diameter, as shown in FIGS. 2 and 3. This roller **12** is supported by a plurality of measuring discs **1***a* to **1***j* and **1***b*′ . . . , also by the terminal discs **1***k* and **1***k*′, acting as a beam propped by several supports. By pinning the roller **12** down at both ends by means of bearings **15** (for instance roller bearings), the roller is fixed in the working plane by the forces **F1** and **F2**. The individual measuring discs **1***a* to **1***j* and **1***b*′ . . . , respectively, advantageously have a slight, concentrically ground, crown so that roller **12** only touches their central planes. This effects precisely defined support distances for the deflecting roller **12** which is a continuous beam. Here again, by suitable construction of roller **12**, the comparison of the loads determined by discs **1***a* to **1***j* and **1***b*′ . . . in the center and at the edges facilitates deduction of the tensile stresses across the moving band.

If roller **12** is of adequate volume, it suffices to prop the same at both ends and in the center on rotatable measuring discs and to determine the support forces which are an exact measure of the distribution of the tensile stress across the traveling band.

A variation of this measuring arrangement is illustrated in FIGS. 5 and 6. Here, a solid or hollow deflecting roller **12** is supported, throughout its length, in a saddle formed by two rows of offset measuring discs **1***f* to **1***q*. These discs are disposed on the stationary shafts **2***a* and **2***b*. Additional support of roller **12** at its ends merely serves to fasten the same and to prevent unintended lifting.

Again, it suffices to support a roller **12** of adequate volume by saddles in the center and at both ends, in the manner described and shown in FIGS. 5 and 6, or in a similar manner, and to determine the support forces of the beam traversing two equal sections in order to determine the distribution of the tensile stress. It even suffices to support the roller **12** of adequate volume at both ends in pressure pickup boxes and in the center by a rotating measuring disc to attain this determination.

The advantage of a saddle support of the actual roller **12** can be combined with the advantage of a direct measurement of the distribution of the tensile stresses when the arrangement according to FIG. 1, consisting of a plurality of discs and a shrunk-on or pressed-on thin-walled jacket, is so modified as is shown in FIGS. 7 and 8.

In the embodiment, the measuring roller **12** is constructed as a hollow roller consisting of the supporting rings of equal dimensions **1***f* to **1***j*, terminal rings **14**, accommodating the roller bearings **15**, and a superposed thin-walled tube **13** having a slight shrink fit. This hollow roller **12**, by means of its bearings **15**, is supported on a continuous shaft **16** which, in turn, is fastened in bearing **20**. The means **21** permit adjustment of the distance of measuring roller **12** from solid or hollow support rollers **2***a* and **2***b*, which forms a saddle. The local load of the deflecting roll, due to the locally prevailing tensile stress σ of the moving band, is determined as the deformation of the supporting rings **1***f* to **1***j* by measuring the radial distance of their internal curvatures from the shaft **16**. According to a preferred embodiment conforming to FIGS. 7 and 8, these changes in the radial distances of the internal curvatures can be determined as the changes of the air gap of the U-shaped magnets **18***f* to **18***j*, assigned to each of the supporting rings. The wiring for these magnets **18***f* to **18***j* is conducted through the central conduit **17** and the channels **19***f* to **19***j*, assigned to these magnets.

The changes in the radial distance of the internal curvatures of support rings **1***f* to **1***j* which, disregarding the negligible load-distributing effect of the thin-walled tube **13**, constitute a measure of the locally prevailing tensile stress in the band, also can be determined with the aid of any other suitable instrument of electrical, optical or pneumatic nature.

In lieu of the saddle-like support of measuring roller **12**, linear seating can be chosen, according to FIGS. 2 and 3. By adapting the angle of deflection to the thickness and the tension (or traction), the optimal measuring effect can be attained.

Another way of measuring the distribution of the tensile stresses across a moving metal band under longitudinal tension is to construct the deflecting roller in the form of a plurality of small rollers which preferably are seated in individual forks. These small rollers, deflecting the band to an equal extent, are put under load in correspondence to the tensile stress in their respective paths so that differential loads in the distribution of the stresses effect different load on the individual rollers. Only the deflecting forces of the rollers in the center of the band and those just fully covering the band edges are measured.

I claim as my invention:

1. A device for the measurement of longitudinal tensile stresses in a moving metal band under longitudinal tension which comprises a deflecting roller consisting essentially of a continuous shaft, a plurality of like supporting rings about said shaft, and a thin-walled jacket about said rings; a bearing at each end of said shaft; two support rollers below said deflecting roller, forming a saddle therefor; said supporting rings deforming under the loading of said deflecting roller by the moving band; and measuring means responsive to the change in the radial distance of the internal curvatures of said rings from said shaft caused by the deformation for measuring the prevailing tensile stresses.

2. A device according to claim **1** wherein said measuring means comprises a U-shaped electromagnet adjacent the internal curvature of each of said rings, said change in radial distance effecting a change in the air gap of said electromagnet.

3. A device for the measurement of longitudinal tensile stresses in a moving metal band under longitudinal tension which comprises; a deflecting roller across the width of said band, said deflecting roller consisting essentially of a continuous shaft, a plurality of like support-

ing rings about said shaft, and a thin-walled jacket about said rings; a bearing at each end of said shaft; two support rollers below said deflecting roller, forming a saddle therefor; means interposed between said deflecting roller and said support rollers for adjustment of the distance therebetween; said supporting rings deforming under the loading of said deflecting roller by the moving metal band; and measuring means responsive to the change in the radial distance of the internal curvatures of said rings from said shaft caused by the deformation for measuring the prevailing tensile stresses.

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