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 [33] **Germany**
 [31] **M 67 742 and M 70 826**
Continuation of application Ser. No.
603,377, Dec. 20, 1966.

[50] Field of Search..... 73/144, 143

[56]

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[54] **PROCESS FOR MEASUREMENTS OF
 LONGITUDINAL STRESSES IN METAL BANDS
 UNDER LONGITUDINAL TENSION**
 4 Claims, 7 Drawing Figs.

[52] U.S. Cl. 73/144
 [51] Int. Cl. G011 5/04

ABSTRACT: A process for the measurement of the longitudinal stresses prevailing across metal bands which are under longitudinal tension, by subjecting the bands to transverse deflection at different spots and determining the magnitude of the deflection which are a direct measure of the tensions within the different zones. The deflection is produced by mechanical means, i.e., a knocking device, gas or liquid bursts, acoustical or magneto-electrical means.

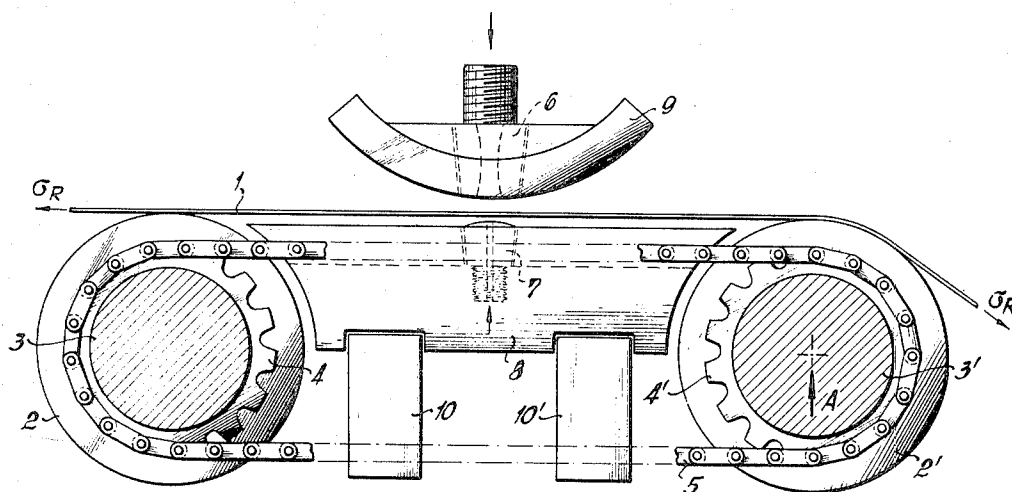


FIG. 1

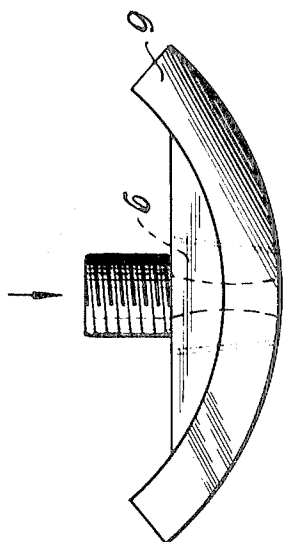
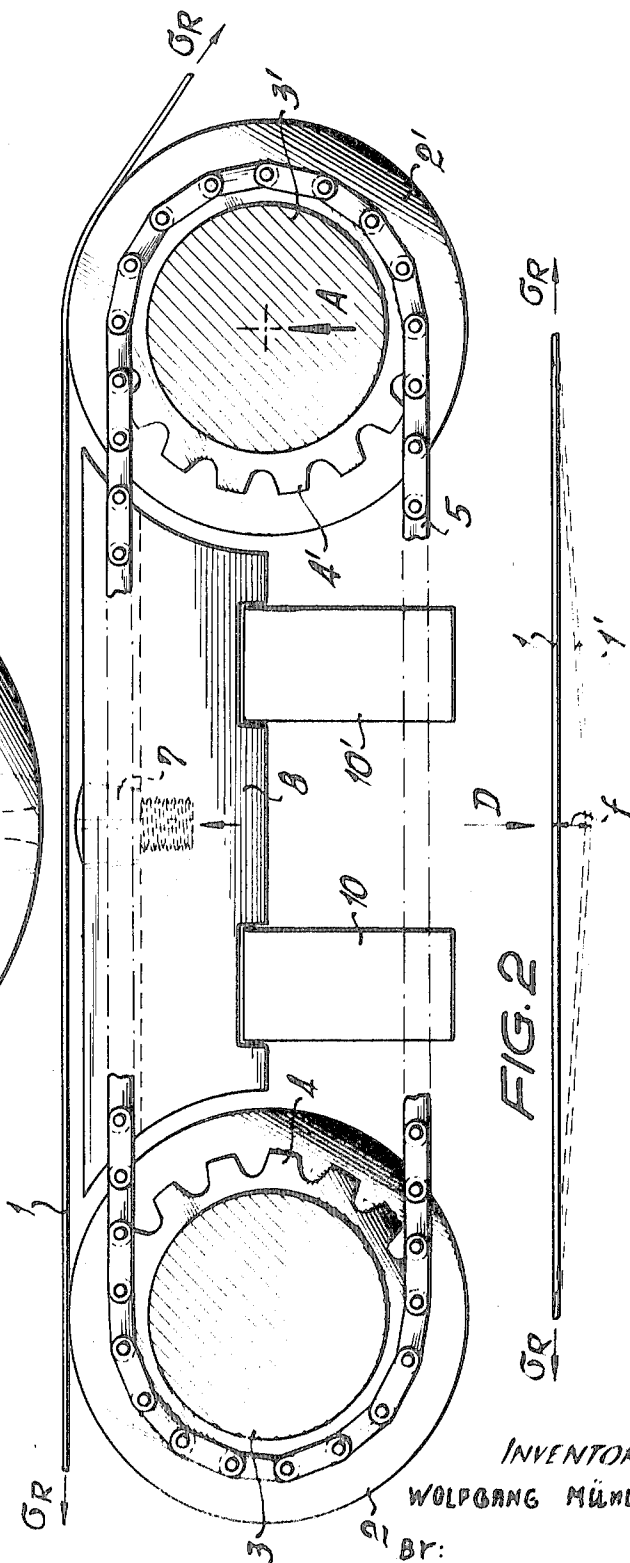


FIG. 2

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FIG. 3

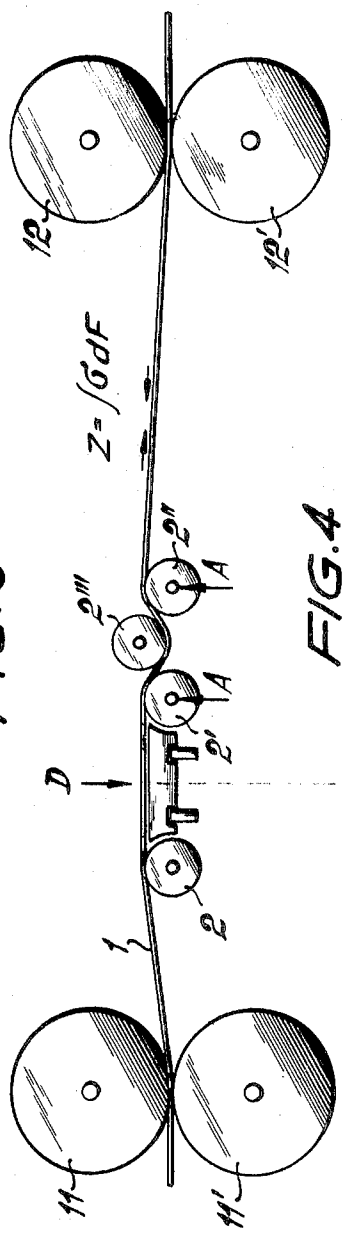
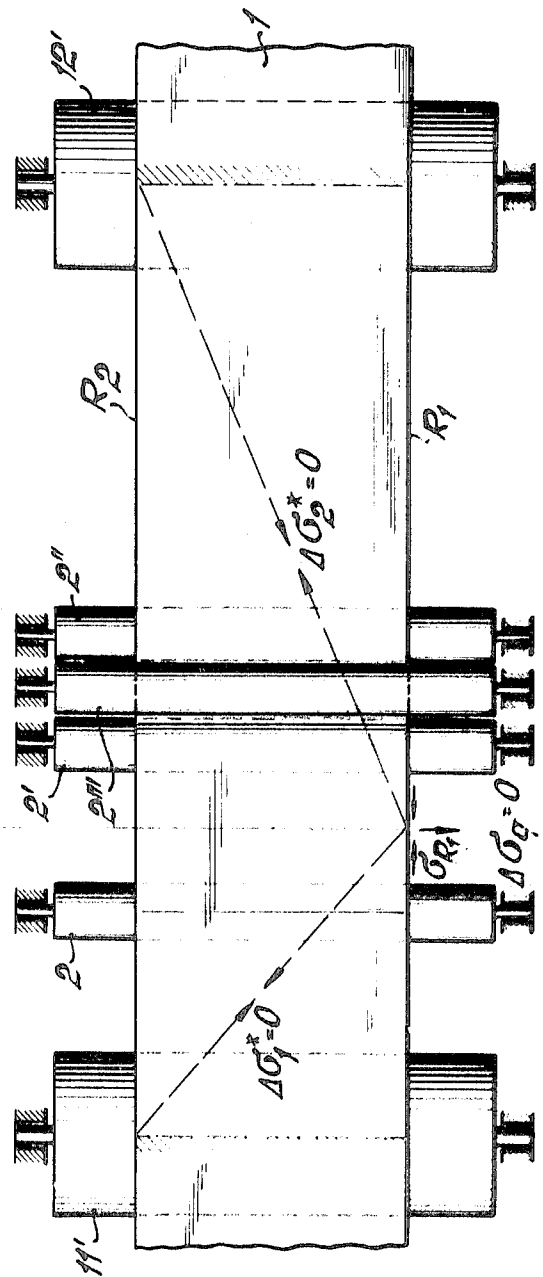


FIG. 4



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FIG. 5

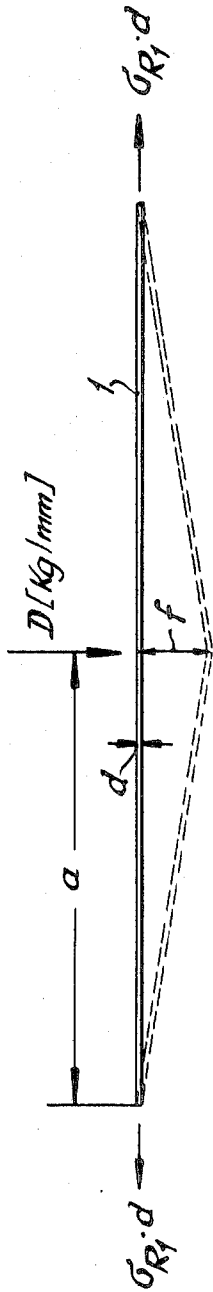


FIG. 6

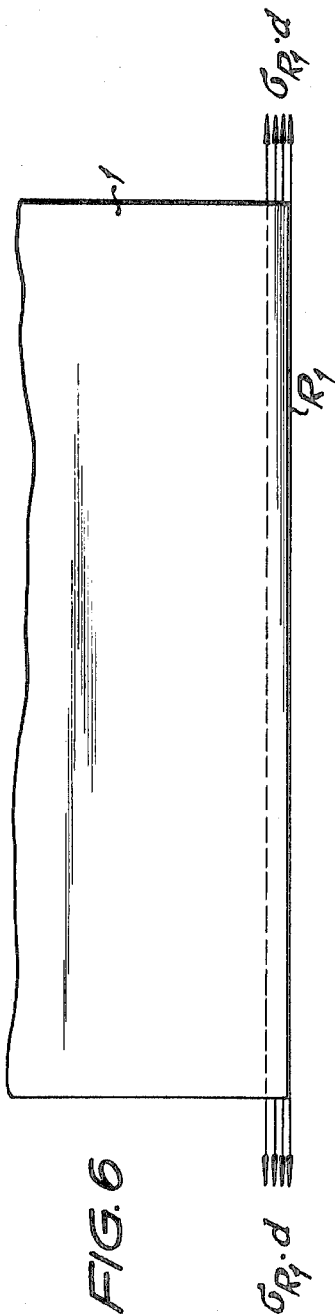
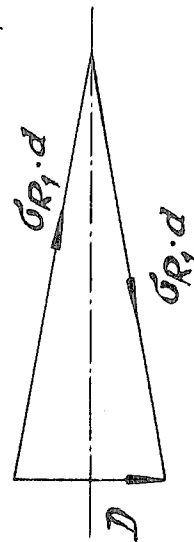


FIG. 7



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PROCESS FOR MEASUREMENTS OF LONGITUDINAL STRESSES IN METAL BANDS UNDER LONGITUDINAL TENSION

This is a continuation of application Ser. No. 603,377, filed Dec. 20, 1966.

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 the 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 percent 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 percent 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.

It is the object of the invention to provide a process of measuring the distribution of the tensile stresses across the width of the bands in order to enable the use of higher tensile stresses. This is accomplished by subjecting the bands to deflection forces at their edge or edges and to determine the magnitude of these forces as a direct measure of the different tensile stresses prevailing in the several transverse zones of the band.

It is self-understood that the measurement results also can be utilized for an exact control of the roller frame and for a continuous control of the tensile stress applied. The maintenance of a high-safety factor, as named above, hence is no longer necessary.

According to the invention, it is preferable to apply the deflecting forces in the two zones defined as the left edge, and right edge of the band so that a sufficient amount of measuring results is obtained.

In one embodiment of the invention, the band, at known total stress and hence average tensile stress, is subjected to deflection forces solely at one edge, the tensile stress calculated and compared to the average. For control purposes, a corresponding deflecting force also can be applied to the other edge zone whose effect also is measured.

The deflecting force may be applied periodically and thereby impart slight vibrations to the band. This can, e.g., be accomplished by providing suitable knocking devices above the band which impart sufficiently strong knocks to make the

edge zones vibrate. The larger the tensile stress in the individual zone, the smaller the amplitude of the vibrations produced by the knocking forces. Therefore, the vibrations provide a direct measure of the stress in the edge zones. In lieu of a mechanical knocking device, nozzles may be used through which a gas or liquid is ejected under corresponding pressure in bursts or pulses.

Instead of the periodic influence of the deflecting means, a steady deflection force may be exerted which may act on one edge, or on both edges. This steady or continuous deflecting force may be produced by a continuous gas or liquid stream or, e.g., by a vibrating disc.

The deflection as described requires determination. This can be done by providing nozzles below the band from which a gas or liquid is ejected under low pressure. The deflection of the band causes a change in the distance from these nozzles which cause changes in the pressure of the liquid or gas stream which can readily be used as test values.

When the bands consist of magnetizable material, it is feasible to dispose, with periodically acting deflecting forces, horseshoe magnets provided with induction coils below the individual deflection zones. The band acts as armature over the poles of the permanent magnets while traversing the horseshoe and is subjected to vibrations and induces voltages in the coils, due to changes in the magnetic flow resistance, caused by the changes in the distance of the band from the magnet poles. The voltages thus produced are a measure of the tensile stresses present in the band zones.

When a constant deflecting force is applied, i.e., when the band does not vibrate, a horseshoe electromagnet can be installed below the deflected magnetizable band. The windings of the magnet produce, due to an alternating current applied, a magnetic field in one shank of the horseshoe whose flow through the band, serving as armature, produces a voltage in the windings of the other shank. This induced voltage is dependent upon the distance of the band from both poles of the electromagnet.

A further means of determining the deflection in the case of periodically deflected forces is to determine the vibrations in the individual band zones acoustically, by suitable microphones, and to indicate the results in a suitable measuring instrument.

The invention now will be further illustrated with reference to the accompanying drawings. However, whereas these drawings exemplify particularly the embodiment of measuring one edge zone, it is evident that like conditions are given for measuring the other zones. The drawings are to be understood to be mere explanations and not limitations, and changes may be made without departing from the spirit and the scope in the invention as hereinafter claimed.

In the drawings,

FIG. 1 is a schematic of a cross-sectional view of a measurement device of the deflection of a band.

FIG. 2 is a schematic, in cross section, showing the deflection of the band under the influence of the deflecting force.

FIG. 3 is a schematic of the entire measuring device, in cross section.

FIG. 4 is a schematic in plan view, showing the tensile stresses.

FIGS. 5, 6 and 7 show other occurring tensile stresses, similar to FIG. 4.

Referring now to these drawings, FIG. 1 shows that the deflection of a band 1, which is subjected to a tensile stress σ_R , is continuously controlled by liquid or gaseous media expelled from a nozzle 6. The latter is protected by frame 9. The control is accomplished in such a manner that, through nozzle 7, an even stream of a gas or liquid is conducted against band 1. Nozzle 7 is disposed below the band 1 in a support 8, 10, 10', which can be adjusted to the width of the band, and is opposite nozzle 6. The change in pressure of the medium (gas or liquid), effected by the change in the distance of the deflected band 1 from the correspondingly formed nozzle 7, is then measured in the customary manner.

The measuring plane for the determination of the deflection preferably is formed by a plane fixed by the rollers 2 and 2'. To fix this plane, the rollers 2 and 2', rotating on their rigid axles 3 and 3', are forcedly synchronized, e.g., by a toothed belt 5 and ring gears 4 and 4'. The deflection f of band 1, due to a constant deflection force D , opportunely is measured after one rotation of the rollers so that errors arising from eccentricities of the rollers are compensated, as is shown in FIG. 2.

The constant deflection force D also can be provided by a gaseous or liquid medium ejected from a nozzle under constant pressure, or it can be provided by the weight of a vibrating disc running at the extreme edge of the band. It suffices to determine the tensile stress of the band by measuring the deflection at one edge, at a given total stress

$$Z = \sigma_o F$$

wherein σ_o is the average tensile stress of the band, when presumed constant across the band width f . The total stress Z and thus the average tensile stress σ_o can be controlled by a three-roller device 2', 2'', 2''', as shown in FIG. 3. This figure also illustrates that, even if the tensile stresses are distributed over the cross section of the band unevenly or askew, the stresses can be measured due to the differentiating reaction A of the rollers 2', 2'' and 2''' on the support.

According to FIGS. 5, 6 and 7, it is possible to deduct a clear and well-defined interrelation between the deflection f of the band under longitudinal stress in the edge area R_1 and the tensile stress σR_1 present in the edge zone.

FIG. 4 shows that the deflection in edge zone R_1 , due to a constant deflecting force D , has no influence on the other band zones. For instance, a like measuring device, provided as control at the opposite edge zone R_2 , could simultaneously take measurements without mutual interference, i.e., the stresses shown in FIG. 4 as $\Delta\sigma 1$ and $\Delta\sigma 2$ are almost zero. Owing to the absence of a band tension $\Delta\sigma q$ in transverse direction, which would tauten the band, the deflection f , due to the constant deflecting force D , merely causes a movement of the band edge toward the middle, said movement being

smaller by several magnitudes relative to the deflection f .

FIGS. 5, 6 and 7 illustrate the relationship between the deflection f of a band 1 and the thickness d by the constant deflecting force D and the band stress σR_1 at edge R_1 .

FIGS. 5 and 7 permit the establishment of the following proportions between half the length a of the measuring plane defined by the rollers 2 and 2' and the deflection f , also between the deflecting force D and the product of the band stress σR_1 by the band thickness d :

$$\begin{aligned} \frac{1}{2}D: \sigma R_1 d &= f:a \\ \sigma R_1 &= D.a./2d.f. \\ \sigma R_1 &= (D.a.)/(2d) \cdot 1/f \end{aligned}$$

I claim:

1. A method for measuring the deviations of the tensile stress at an edge of a rapidly moving thin metallic tape under high-tensile stress with respect to a mean reference tensile stress,

comprising the steps of,

applying to at least one zone of said tape near one edge portion of a major tape surface a deflection force having a magnitude operating in a direction transverse to the longitudinal direction of said tape thereby deflecting said tape in said transverse direction; and

measuring the magnitude of said deflection from the other surface of the opposite major surface near said zone.

2. The method as claimed in claim 1,

the step of measuring the magnitude further comprising, allowing fluid to issue under slight pressure from a nozzle positioned near the opposite major surface and near said zone of said tape, and measuring changes in pressure in said fluid.

3. The method as claimed in claim 1,

wherein said deflection force is applied intermittently by a burst of fluid under high pressure.

4. The method as claimed in claim 1,

wherein said deflection force is applied continuously by a stream of fluid under high pressure.

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