United States Patent [19]

Sendzimir et al.

[11] **3,815,401**

[45] **June 11, 1974**

[54] **HOUSING CONSTRUCTION FOR CLUSTER TYPE COLD ROLLING MILLS**

[75] Inventors: **Tadeusz Sendzimir; John W. Turley,** both of Waterbury, Conn.

[73] Assignee: **T. Sendzimir Inc.,** Westbury, Conn.

[22] Filed: **Feb. 5, 1973**

[21] Appl. No.: **329,364**

[52] **U.S. Cl.** **72/242**

[51] **Int. Cl.** **B21b 13/14**

[58] **Field of Search** 72/241, 242

[56] **References Cited**

UNITED STATES PATENTS

2,776,586 1/1957 Sendzimir 72/242

Primary Examiner—Milton S. Mehr

Attorney, Agent, or Firm—John W. Melville; Albert E. Strasser; Stanley H. Foster

[57] **ABSTRACT**

A housing for cold rolling mills of the cluster type. The housing comprises two heavy side frames, and upper and lower transverse slabs which serve to back the casters of the mill, and thus the intermediate roll and the workrolls. The transverse slabs are oppositely tapered from the middle, being thickest at the center and becoming thinner toward both the front and rear sides of the mill, whereby the combined effect of the side frame deflection and slab deflections measured at the workroll is substantially constant along the entire operating length of the workroll. The result is a housing wherein metal may be rolled with zero crown.

3 Claims, 11 Drawing Figures

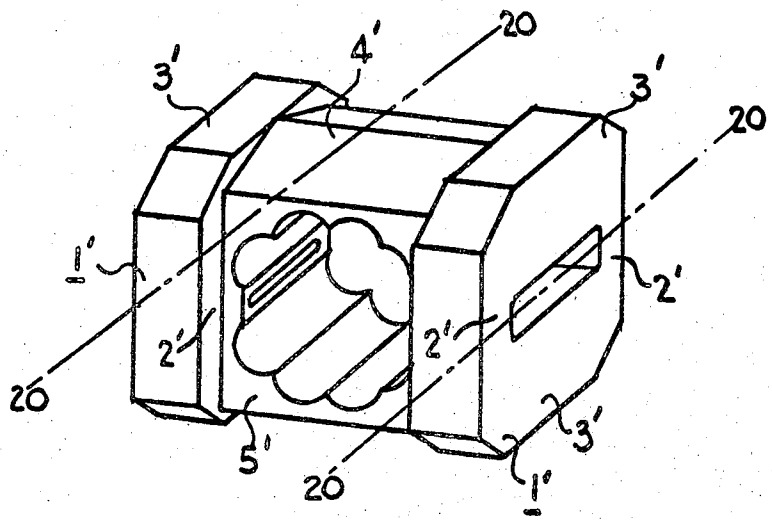
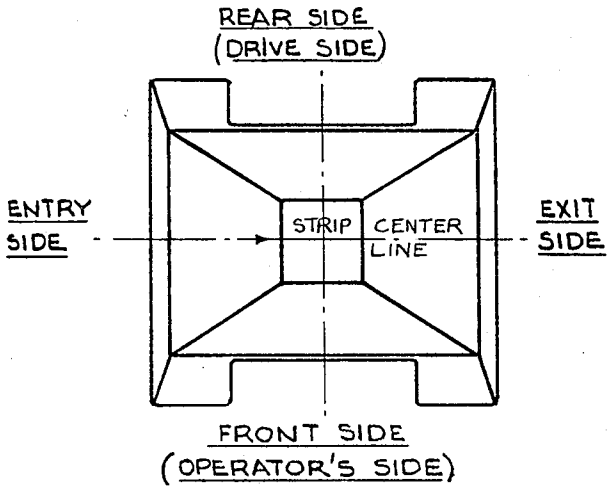


FIG. 1



PRIOR ART

FIG. 2

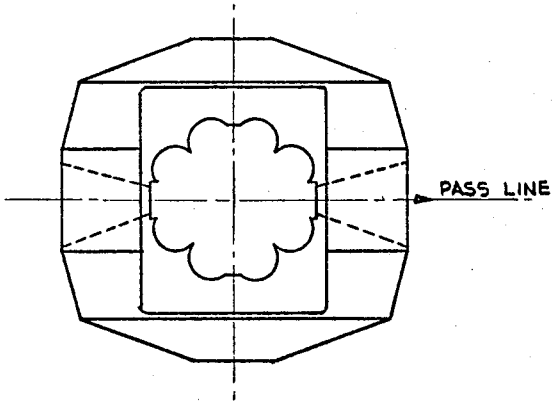
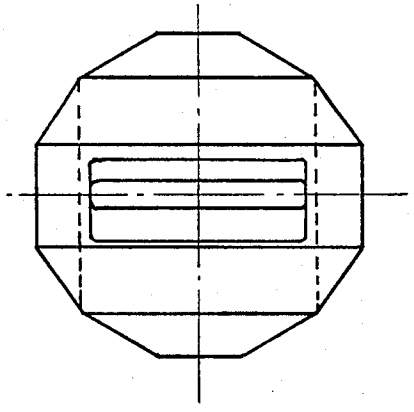


FIG. 3



PRIOR ART - SENDZIMIR MILL HOUSING

FIG. 4

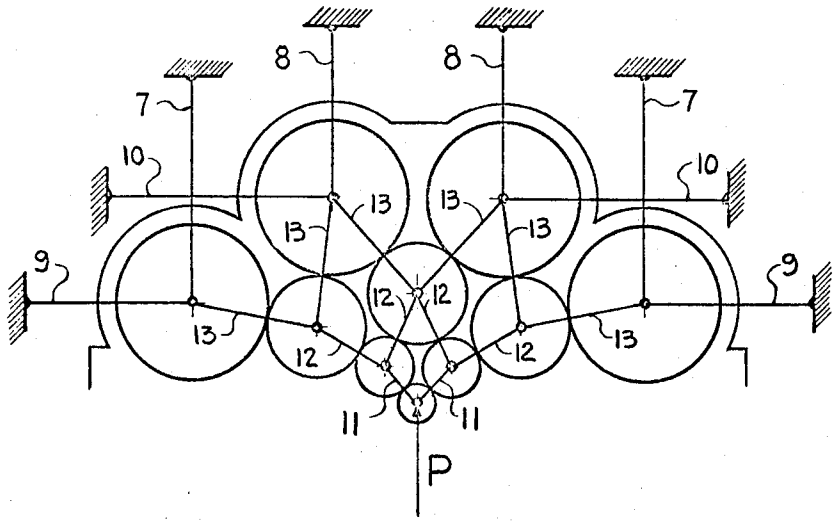


FIG. 5

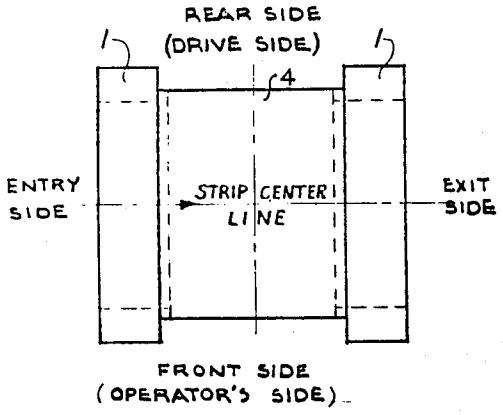


FIG. 6

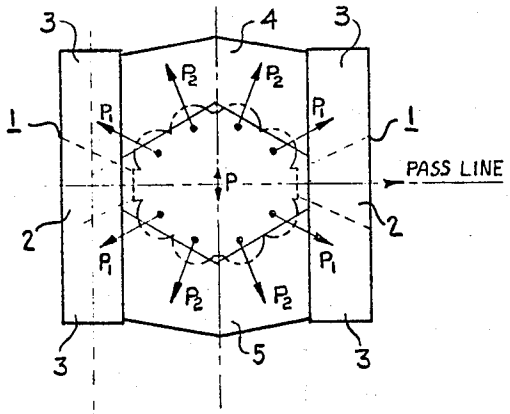


FIG. 7

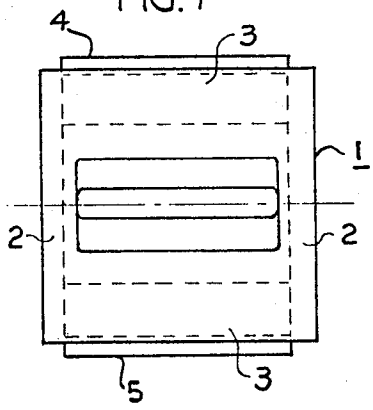


FIG. 8

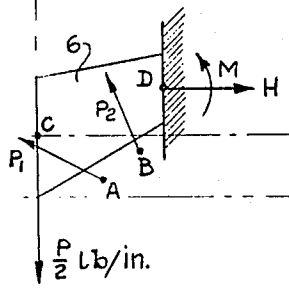


FIG. 9

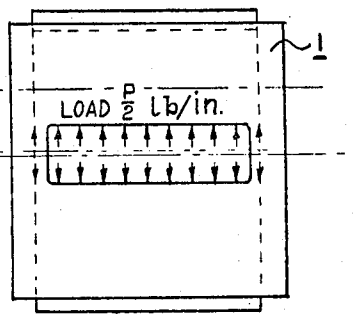


FIG. 10

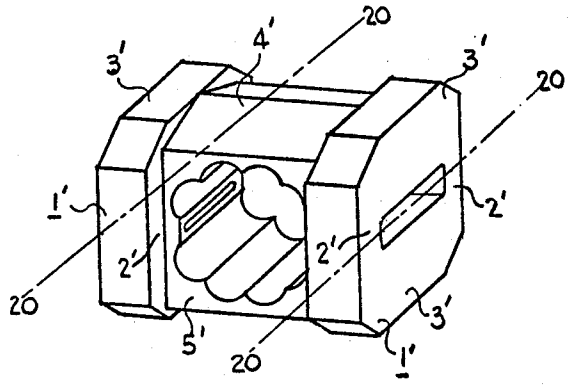
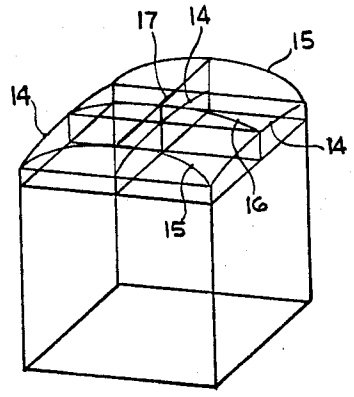


FIG. 11



HOUSING CONSTRUCTION FOR CLUSTER TYPE COLD ROLLING MILLS

BRIEF SUMMARY OF THE INVENTION

This invention relates to cold rolling cluster mills of the general type shown in Sendzimir United States Letters Pat. Nos. 2,169,711; 2,187,250 and 2,776,586.

The object of this invention is to provide improvements in the construction of such mills, with the objective of improving the shape or flatness of the work piece.

Conventional cold rolling mills, for example those of the two high variety, are constructed so that the roll separating forces acting on the bodies of the rolls are reacted at the roll ends. The curvature of the rolls resulting from this type of loading causes a non-uniform distribution of roll separating force, and non-uniform elongation of the strip, so that strip emerging from the mill has edges which are over-rolled and thus buckle when the strip is laid upon a flat horizontal surface in a tension free condition.

The four high mill offers some improvement over the two high mill by using a smaller work roll, which gives a smaller roll separating force, and a larger back-up roll which provides a stiffer roll, which therefore deflects with less curvature.

The Sendzimir cluster mills as described in the aforesaid Letters Patent offer further improvement in this respect, as in this type of mill very small work rolls are used and also the backing rolls are themselves supported essentially across their whole faces by the mill housing. The housing itself deflects under the action of the roll separating forces, thus leading to over-rolling of the strip edges, but because the housing can be made far stiffer than the back-up rolls of conventional mills, the effect is generally smaller than on conventional mills.

In United States Letters Patent No. 2,776,586 one of the present applicants showed how a further improvement could be obtained in the case of these mills by tapering the top and bottom beams of the housing in order to make the effective deflection at the edges of the strip closer to the deflection at the middle, thus reducing the curvature or crown of the housing, and the tendency of the mill to over-roll the edges of the strip.

In practice crowned rolls are used to compensate for the curvature or crown in cold rolling mills in order to produce strip which is acceptably flat, but this practice leads to the necessity of a large inventory of rolls with varying crowns ground in, in order to cover the full range of rolling schedules, since one particular crown is only correct at one value of roll separating force.

The subject of the present invention is a housing design for mills of the general type described in the aforesaid Letters Patent, which will deflect uniformly across the whole width of the strip being rolled, thus producing zero curvature, or zero crown, and therefore no tendency to over-roll the strip edges. This condition of zero crown is achieved regardless of the magnitude of the roll separating force.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1 is a plan view of a conventional cluster mill housing according to the prior art.

FIG. 2 is a front elevational view thereof.

FIG. 3 is a side elevational view thereof.

FIG. 4 is a diagram to assist in an understanding of the present invention.

FIG. 5 is a plan view of an approximation of the form of housing used for purposes of calculation.

FIG. 6 is a front elevational view thereof.

FIG. 7 is a side elevational view thereof.

FIG. 8 is a diagram showing the loading configuration for a transverse slab when viewed from the front of the housing.

FIG. 9 is a view similar to FIG. 7 showing the loading configuration for the side frame.

FIG. 10 is an isometric view of a housing according to the present invention; and

FIG. 11 is an isometric diagram showing the deflection curves for the housing of FIG. 10 and showing the resultant zero crown.

DETAILED DESCRIPTION

The purpose of FIGS. 1, 2 and 3, which show a housing for cluster mills as disclosed in the above mentioned Sendzimir patent, is for comparison with FIG. 10 showing a housing according to the present invention.

In order to arrive at an understanding of how a cluster mill housing deflects, reference is had to FIGS. 5, 6 and 7 which show respectively a plan, front elevation and side elevation of such a housing. The housing consists essentially of two side frames 1 which are linked at the top and bottom by the tapered slabs 4 and 5, respectively. The structure is symmetrical in all planes which pass through its geometric center. Each of the side frames through which the strip passes during rolling consists of two columns 2 and two horizontal beams 3. These may of course be integral and have been so shown in FIG. 7.

The housing structure is loaded by forces P_2 produced by the inner backing bearings and by forces P_1 produced by the outer backing bearings. These forces are indicated by arrows in FIG. 6.

The slabs 4 and 5 may each be considered to behave as two cantilevers and each cantilever is loaded as shown in the diagram of FIG. 8 wherein 6 represents a cantilever (one-half of the slab 4). As seen in FIG. 8, each cantilever is supported by the side frame at a point C and this side frame provides all the vertical reactions to the forces P_1 and P_2. The horizontal reaction is provided by a force H which is developed at the center of the slab D and a fixed end moment M is developed at D by the slab. For the purposes of calculation, the moment developed at C by the resistance of the side frame to rotation may be neglected.

By the application of conventional beam theory, the vertical deflections of the slab at the backing bearing shaft centers A and B in relation to the side frame upper beam axis C and the horizontal deflections relative to the stationary vertical axis of symmetry through D may be calculated. This calculation is made at several stations across the face of the slab from front to back. For each station the corresponding vertical deflection of the side frame at C is calculated by using the said conventional beam theory, and this deflection is added to the vertical deflection of the slab relative to C at the backing bearing shaft centers A and B to give the absolute vertical deflection at A and B.

Referring now to FIG. 4, the deflections of struts 7 and 8 represent the vertical deflections of the upper slab and the deflections of struts 9 and 10 represent the

horizontal deflections of the upper slab. The struts **11, 12** and **13** in this Figure represent the pin-jointed elastic structure formed by the upper roll cluster.

The structure of FIG. **4** is statically determinate; and since the lengths of all of the struts are equal to the known roll diameters, the forces in all the struts can be calculated in terms of the roll separating force by elementary statics theory. The force P_1 in FIG. **6** is the algebraic sum of the forces in the struts **7** and **9.** The force P_2 in FIG. **6** is the algebraic sum of the forces in the struts **8** and **10** of FIG. **4.** Castigliano's theorem can then be used to calculate the displacement of the workroll (which is the base of the structure in FIG. **4**) due to the deflection of the struts **7, 8, 9** and **10** at each station across the slab.

This displacement of the workroll at each station as calculated above, is known as the effective housing deflection since it is entirely and solely due to elastic deformation of the housing. The difference between effective housing deflection at the middle and deflection at the operator's or drive side of the slab is known as the crown of the housing.

It will be readily understood that the side frames deflect so as to give a greater deflection at the middle than at the front or rear side of the housing. In order to achieve a zero crown housing, it is therefore necessary to taper the upper and lower slabs so that they are thickest at the middle and taper downwardly toward the front and rear sides of the mill. In this way, the slab will deflect more at the front and rear sides than in the middle, so that the combined effect of slab and side frame deflection at the workroll is the same at the front and rear sides of the mill as it is in the middle.

Unexpectedly, except for housings for narrow mills, it is not possible for housings shaped as shown in said U.S. Pat. No. 2,776,586 and in FIGS. **1, 2** and **3** of the present application to deflect uniformly across its width. This is because the depth of the horizontal beams of the side frames is so small that the resultant relatively high side frame deflection is too great to compensate by tapering the top slab, unless the slab is made so thin that casting difficulties will result and permissible stresses will be exceeded.

The housing shown in FIG. **10** is one based upon the above considerations. By careful application of the theory described herein, the dimensions of a housing shaped as in FIG. **10** can be determined so that it will give zero crown when placed under load during the rolling of strip. It is to be understood that slight deviations from the shape shown in FIG. **10** are permissible in order to provide for such things as mounting bosses, lifting lugs, weight saving champfers and the like, without departing from the spirit of the invention.

The characteristic and novel feature of this housing is that the overall height of the side frames is equal to or greater than the maximum vertical distance from the bottom of the lower slab to the top of the upper slab. The reference numerals used in FIG. **10** correspond to those in FIGS. **5** to **7** inclusive with prime suffixes.

FIG. **11** is a diagram showing the deflection curves in the side frames and in the upper slab in a housing according to FIG. **10** under load. In this Figure, the curves **14** are the deflection curves for the side frames. The curves **15** are the deflections of the upper slab **4'** at the front and rear sides and the curve **16** is the deflection curve for the slab **4'** at the middle. The curve **17** represents the combined deflection curve which in the case of the zero crown housing will approximate a straight line.

It should be understood that the housing actually deflects in a more complex manner than shown; however, FIG. **11** clearly shows how the tapered slab deflects in a manner to compensate fully for the side frame deflection and thus to produce a zero crown housing.

The deflection and crown of the housing are affected by the width of the strip being rolled, since with narrower strip the roll separating force is concentrated more toward the middle of the housing. However, because the narrowest strip is generally no less than about half the widest strip, and because the roll separating force spreads itself more evenly from front to rear of the mill as it is transmitted from work roll through intermediate rolls and backing bearings to the housing, the housing is still subjected to a sufficiently uniform load to ensure that the mode of deflection of the housing is substantially unchanged, and that the zero crown condition is maintained, even when rolling the narrowest strip.

While it is preferred that the entire structure of FIG. **10** be integral, the beneficial results above described can be achieved by making the housing in two pieces and welding or bolting the upper and lower pieces together at or adjacent the central horizontal plane indicated by the broken lines **20, 20.** In the case of bolting, the bolts should be of adequate capacity to ensure positive pressure between the adjacent surfaces, even when maximum roll separating force is developed during rolling. The housing may also be fabricated by bolting or welding two or more pieces together with the joints at any plane, as for example, by joining at the vertical plane passing through the work rolls, or at the horizontal planes of intersection of the columns **2** with the beams **3** (FIG. **7**).

It will be understood that minor modifications may be made without departing from the spirit of the invention and that therefore no limitation not expressly set forth in the claims is intended and none should be implied.

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

1. A housing for a cluster mill having small diameter work rolls, said work rolls having backing means of the class consisting of (*a*) casters which directly back the work rolls, and (*b*) intermediate rolls which directly back the work rolls and are in turn backed by other casters, said casters, in each case in turn being backed against the housing, so as to support said work rolls throughout their working length; said housing comprising two heavy side frames, upper and lower transverse slabs extending therebetween, said slabs being tapered from their thickest section in the middle, to be thinner at the front and rear sides of the housing, and said side frames being of a height at least substantially equal to the maximum vertical distance from the bottom of the lower slab to the top of the upper slab, whereby the combined effect of side frame and slab deflections, measured at the work roll, is substantially constant throughout the working length of the work roll.

2. A housing according to claim **1** constituted of an upper and lower piece secured together approximately at the central horizontal plane to form a unitary structure.

3. A housing according to claim **1** constituted of a number of pieces secured together by welding or bolting.

* * * * *