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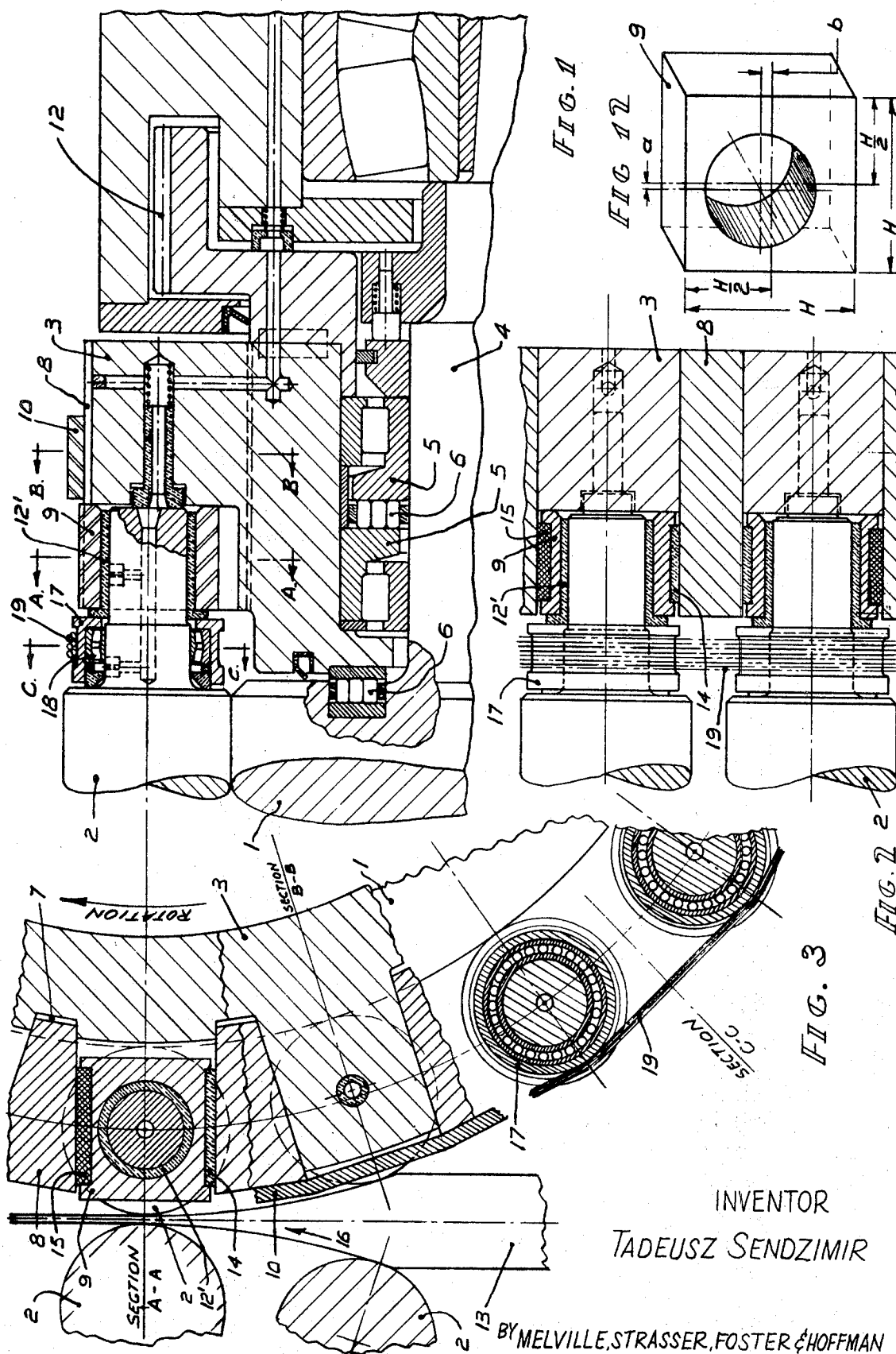
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PLANETARY WORKROLL CAGES FOR PLANETARY ROLLING MILLS

Filed April 4, 1968

2 Sheets-Sheet 1



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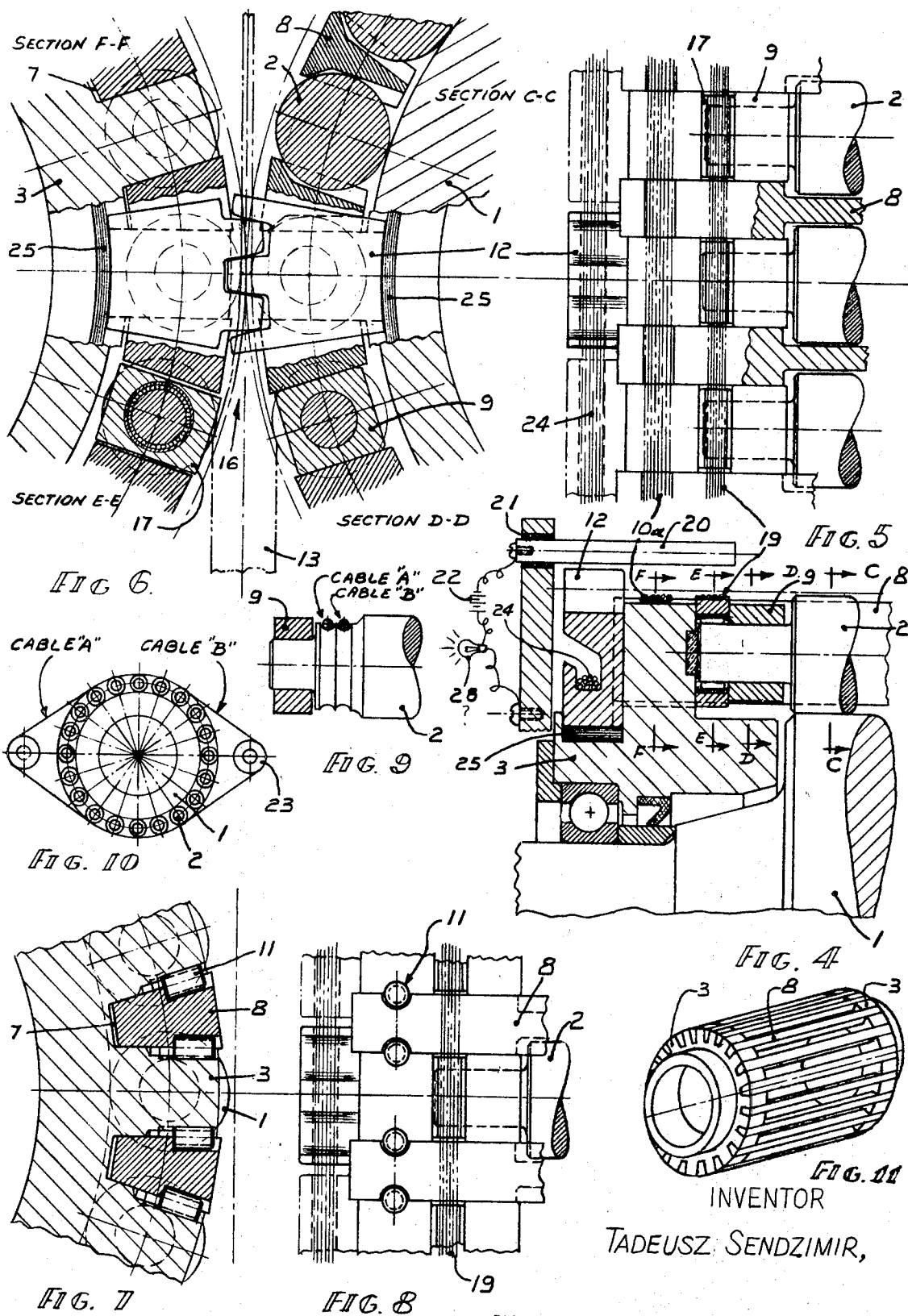
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**PLANETARY WORKROLL CAGES FOR
PLANETARY ROLLING MILLS**

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ABSTRACT OF THE DISCLOSURE

The invention relates to so-called planetary rolling mills for flat articles which consist of two assemblies each with one backing roll and a plurality of small workrolls uniformly spaced around it. The invention is an improvement over previous systems for securing even spacing of the planetary workrolls around the backing rolls.

BACKGROUND OF THE INVENTION

In the planetary mill of the backing roll-driven type, such as disclosed in U.S. Pat. 3,138,979, each backing roll 2, (see FIG. 7) has two cages 57, 58 one each at the right and left-hand sides of the roll face, to carry the workroll chocks 64 (see FIG. 9) in true synchronism, top roll against bottom roll, and in parallelism. Said chocks are attached to elastic means, such as springs, to urge the roll necks towards the backing roll axis, so that the workrolls press against the backing roll in spite of the centrifugal force.

A further characteristic of the existing structures is the provision of workroll cages having the openings or pockets provided for the workroll chocks milled out in the solid cage rings. These openings are difficult to harden to make them wear resistant, and, what is worse, in case of a damage which as is liable to occur in time of cobbles, the lugs between individual workroll chocks pockets may become bent. As a consequence, with the damage of one such pocket, the whole expensive part may have to be scrapped.

SUMMARY OF THE INVENTION

The present invention avoids the problems of the prior art by providing a planetary mill of the backing roll-driven type with a pair of cages concentric with the backing roll and adapted to accommodate a plurality of working rolls. These working rolls are mounted in chocks which are received in spaced-apart pockets about the sides of the cages.

The pockets are formed by inserting lugs at spaced apart intervals into slots provided in the sides of the cages. The pocket is thus formed by the sides of adjacent lugs and an annular face portion of the cage. To insure a rigid, yet readily maintained assembly, pressure means are provided to urge the lugs into the slots toward the axis of the cage.

The sides of the slots, and therefore the lugs inserted therein, are angled so as to provide an essentially rectangular pocket to receive the working roll chocks. By this means, it is possible to hold the sets of working rolls in the proper angular position about the backing roll. That is, the axis of the backing roll will be parallel to each axis of the surrounding working rolls. On the other hand, such an arrangement for the working rolls permits changes in their radial displacement resulting from wear on the working rolls.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial sectional view taken along the plane including the axis of a working roll and backing roll of one embodiment of the invention.

FIG. 2 is a partial sectional view taken along the plane

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including the axis of two adjacent working rolls of the same embodiment.

FIG. 3 is a partial cross-sectional view of the same embodiment taken at three different planes at right-angles to the roll axis.

FIG. 4 is a partial sectional view similar to FIG. 1, but on a smaller scale, showing a second embodiment of the invention.

FIG. 5 is a partial sectional view similar to FIG. 2, but on a smaller scale, showing the second embodiment of FIG. 4.

FIG. 6 is a partial cross-sectional view similar to FIG. 3, but on a smaller scale, showing the second embodiment of the invention as illustrated in FIGS. 4 and 5, showing section views at four different locations, and including in part, an end view of the cage.

FIG. 7 shows a reduced partial cross-section of a cage with means for attaching the staves.

FIG. 8 shows a partial top view of the detail illustrated in FIG. 7.

FIG. 9 is a reduced partial side view of one working roll to illustrate certain improved details of each embodiment of this invention.

FIG. 10 is a reduced end view of one set of working rolls of the type illustrated in FIG. 9 and mounted in a cage about a backing roll.

FIG. 11 shows a reduced perspective view of both cages of one set of rolls joined rigidly together by means of continuous staves according to the embodiment of the invention shown in FIGS. 3-5.

FIG. 12 is a perspective view of one synchronizing workroll chock, indicating the off-centered position of the bore.

DETAILED DESCRIPTION OF THE INVENTION

The embodiment represented in FIGS. 1, 2 and 3 show the backing roll 1 surrounded by a group of workrolls 2 whose even spacing around the periphery of backing roll 1 is maintained by cages 3, one at each end of roll 1. These cages are free to rotate around the necks 4 of roll 1, which are mounted on two spaced radial bearings 5 to maintain co-axial rotation with the backing rolls 1 and two thrust bearings 6, the latter to maintain their axial position.

Cages 3 have spaced grooves 7 provided around their periphery in which are fitted lugs 8, the inclination of the walls of the grooves and, therefore, faces of adjacent lugs being such that the protuberant portions of lugs 8, which extend the length of workroll chock 9 are parallel to each other. This insures that the workroll chock 9, and workroll 2 received therein, is held in its angular position around the backing roll 1, and parallel to it, as long as the correct position of the two cages 3 of one backing roll 1 is maintained, but permitting radial displacement of the workroll in order to take care of roll wear.

Lugs 8 are held securely and with considerable pressure in their grooves 7 by outside pressure means, such as a shrunk ring 10, or equivalent (e.g., tensioned spring wire coil 10a, in FIGS. 4 and 5), thus forming virtually one body with cage 3. Where it is desirable to provide for a possibility of removing and individual workroll from the mill, the lugs can also be secured by screws 11, as shown in FIGS. 7 and 8, where the screw threads are in engagement with the tapped half-hole provided in cage 3, the other half-hole which is provided in lug 8 is not threaded and has a sliding fit over the outer diameter of the screw 11.

The technical advantage of this design is the following:

In case of a mill wreck involving one or more of lugs 8, which may become bent or damaged, they can be replaced immediately and inexpensively by simply inserting

new ones and not the whole cage as in the case with the present design.

Moreover, owing to their form, that can be made of a material with hardened and wear-resistant surfaces which, as experience has proven, is a most valuable feature in a planetary mill where minute vibrations in presence of scale and cooling water cause a rapid wear of the cage pockets in the present design. This is true even when using contacting rubber pads which are referred to later.

The vertical walls of each two adjacent lugs 8 form a pocket for a workroll chock 9. When worn, the faces of lugs 8 can simply be reground permitting the corresponding lugs 8 to sit deeper in their grooves 7. This does not affect the geometry of the spaces between them which serve as pockets for the workroll chocks.

The rotation of cages 3 (FIGS. 1-3) in synchronism with each other as well as with the pair of cages belonging to the opposite backing roll, is secured by outside means, such as engaging gear 12. This construction is described in detail in U.S. Pat. 3,138,979 noted above, specifically reference is made to FIG. 7 of the patent. The sole function of the lugs 8 is, to ensure proper angular position of each workroll 2, through the intermediary of the workroll chock 9 and its bushing 12 with relation to the cage and, therefore, with relation to all other rolls. This applies more particularly to the position of each pair of workrolls as they first contact the workpiece 13 (see FIGS. 3). If there should be any hesitation on the part of a workroll 2 to engage the workpiece, such as through slippage in its contact with the driving back roll 1, it is the corresponding lug 8 which will force it into engagement. If it is judged advisable for any particular type of a planetary mill to soften slightly the impact of that engagement, resilient liners 14 attached to workroll chock 9 may be provided, note the liners in FIGS. 2 and 3.

It is preferable to fit even more resilient liners 15 on the opposite side of each chock 9, so as to give said chock 9 some liberty to move ahead of its angular position within the cage. This movement is towards the end of the rollbite 16 (FIG. 3) when the portion of the workpiece in contact with the workroll 2, is already reduced in thickness and, therefore, moving faster.

It has been found that with this type of a cage a further improvement over chocks described in the aforementioned U.S. Pat. 3,138,979, can be made by limiting the role of workroll chocks 9 to the sole function of assuring the angular position and synchronism of workrolls 2. This is accomplished by providing additional chocks 17 solely for the function of pressing the workroll 2 against the backing roll 1. When so limited, chocks 9 are only subjected to one shock load during each revolution of cage 3, which is of the order of 100 r.p.m. Consequently, they generate very little heat so that even oilless plastic bearings are acceptable. I prefer to use a glass fiber-reinforced plastic with molybdenum disulphide addition. Such material I found to be shock resistant and it shows relatively little wear, thereby ensuring correct synchronization of the mating workrolls with only a tolerable amount of play.

The second workroll chocks 17, called "pressure chocks," and their bearings 18, which are mounted on workroll neck 2 are beyond the reach of lugs 8, as shown on FIG. 2. This means they are protected from synchronizing shock loads. However, they are subjected to a steady pressure exerted by outside means, urging them in the direction of the backing roll with a force greater than the centrifugal force. For a load of this nature, I prefer to employ roller bearings 18, which have a longer life, are easier to lubricate and do not generate much heat due to their low frictional properties.

While individual springs or other means may be employed for urging the chocks 17 of each workroll 2 against their backing roll 1, the cage design according to this invention makes it possible to employ an encircling means 19, such as a steel wire wound under considerable tension. The latter means urges all workrolls against backing

rolls with exactly the same pressure exerted on each workroll 2, which is of big practical advantage. The second advantage is safety from spring breakage which may cause accident when a roll flies out of the mill.

The safety of this system is due to the fact that it is unlikely that all wires 19 would break simultaneously. If one wire should break, the mill can still run a certain time before pressure on the chocks is relaxed due to internal friction between the windings. Yet such breakage can be detected by a signalling device, such as shown in FIG. 4. The signal device may comprise an electrically conductive rod 20, insulated from the mass by bushings 21, which may be energized by battery 22 or its equivalent, and mounted in close proximity to the coil of wire 19. The circuit will be closed and the signal operative if and when one of the wires 19 break, since the centrifugal force will force said wire ends out and in contact with the conductor rod 20.

On smaller mills, a further simplification is possible in that the pressure chocks 17 and bearings 18 can be completely omitted and a steel wire or cable trying to contact the ring of rolls can be run directly over the roll necks in a tensioned closed loop. Preferably, two separate loops may be employed so as to cover the whole periphery, whereby said loops are kept under tension by outside means. Such arrangement is diagrammatically shown in FIG. 9, where the neck of workroll 2 shows two grooves, one for each cable, designated A and B; and FIG. 10 showing an end view of backing roll 1 surrounded by a plurality of workrolls 2, with both cables A and B in position. The purpose of this arrangement is to ensure an even and constant pressure urging each workroll 2 to contact the backing roll 1. For this purpose each of the two cables A and B are led over the necks of workrolls 2, then over an idle pulley 23, which operates as tensioner to take care of the unavoidable expansion of such steel cables and is operated by air cylinders or other known means, not shown.

While theoretically the synchronization of mating planetary workrolls should be geometrically perfect, in actual practice it is necessary to adjust slightly. The adjustment is usually within the limits of 25% of the thickness of the finished gauge of the rolled product and can be accomplished by advancing either the bottom or the top workroll. There are various inaccuracies that can only be compensated for in this way, e.g., the pass line of the feed rolls may be higher or lower than the pass line of the planetary assemblies, or the slabs may be heated hotter on top than at the bottom.

To provide for such adjustment, I make the synchronizing chocks square, so that they can be inserted in the cages in any of the four possible positions. At the same time, I provide the bore in the chock which forms the bearing for the workroll neck, out of center, as shown in FIG. 12, the height difference (a) being different than the side difference (b). Since the chock is free to move radially within its pocket, they may be inserted in any one of the four positions and thereby will place the workroll neck in a different angular position with relation to the cage.

On top of it, it is also possible to exchange the synchronizing chocks 9, of the top planetary assembly, with the chocks of the bottom assembly making in total eight possible positions of synchronization adjustments, which is entirely adequate in normal practice.

In planetary mills where it is not essential to provide workrolls of maximum diameter that the mill geometry permits, it is possible to further improve the design of the system shown in FIGS. 1, 2 and 3.

The improvement which is shown in FIGS. 4, 5, 6 and 11, consists simply in extending the lugs 8 from one cage, between the two adjacent workroll chocks 9, then between the two adjacent workrolls 2 and finally between the two chocks 9 on the opposite side and into the grooves of the

opposite cage 3. Such cage construction is shown in perspective view in FIG. 11.

This design, where individual lugs 8 are solidly wedged into tapered slots in cages 3, joins the right and left cages into one solid body, like a rigid basket, having a high torsional stiffness. In addition, the lugs 8, suitably profiled in the manner shown in FIG. 6 to provide clearance for workrolls 2, give the mill a still greater safety in that a workroll cannot fly out of the mill. This is the case not only when a chock 9 should become detached, but even if a workroll itself should break in two.

Furthermore, such double cage structure makes it possible to considerably simplify the synchronizing gearing for the cages because all that is necessary is to directly connect the top and bottom cages, e.g., by suitable adjustable diameter or floating gears, with each other to ensure that they run in synchronism. The parallelism is already guaranteed by the rigidity of the combined double cage (FIG. 11). FIGS. 4, 5 and 6 show one embodiment of such simplified synchronization in which gear 12, consisting of individual segments, one for each workroll 2, is affixed onto the outside shoulder of cage 3. As a means of fastening, a spring steel wire 24 is wound under great tension in a suitable groove in these gear segments 12.

The permissible variation of distance between centers of these teeth is adequate for screwdown setting during rolling. The difference in thickness between the thickest and thinnest strip ranges usually from 0.250" to 0.100", a typical value being 0.150". Such discrepancy in center distance can be tolerated if the teeth of the gears 12 are large and of suitable profile. As the rolls wear and are later ground to smaller diameters, it becomes necessary to adjust the pitch diameter of the gears 12 and this is preferably done by removing some of the shims 25 which were placed over the extension of cage 3.

Since it may become apparent to those skilled in the art that modifications may be made in this invention, no limitation is intended to be imposed herein except as set forth in the appended claims.

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

1. In a planetary rolling mill having a pair of cooperating backing rolls, a plurality of workrolls disposed about the periphery thereof, and two rotatable concentric cages with each said backing roll, one of said cages at each end with bearings for the necks of said workrolls provided therein to insure the even spacing of same, whereby the parallelism and synchronism between the respective opposing cages is assured by gearing means connecting said cages, the improvement comprising in combination therewith, the provision of individual pockets, one for each workroll bearing, the parallel walls of each said pocket being formed by separate bars received in suitable slots evenly spaced about the periphery of said cages.

2. The planetary rolling mill claimed in claim 1 including means for forcing said bars into the slots in said cages with sufficient pressure to assure that they act as one rigid system with said cages.

3. The planetary rolling mill claimed in claim 1 including a second bearing on the necks of each of said workrolls disposed beyond the reach of said bars, and means for urging said bearings toward the axis of said backing roll with a force considerably in excess of the centrifugal force component exerted by each workroll.

4. The planetary rolling mill claimed in claim 3 wherein said last named means comprises an elastic encircling means, such as a multi-wrap coil of spring wire whose ends have been secured, whereby to assure that the said force is even for all of said bearings.

5. The planetary rolling mill claimed in claim 1 wherein said workroll bearings have two faces parallel with the roll axis and each other such that the distance between said faces is substantially equal to the width of said pockets.

6. The planetary rolling mill claimed in claim 5 including an elastic liner of a first order disposed between the leading face of each said bar and its adjacent bearing.

7. The planetary rolling mill claimed in claim 5 including an elastic liner of a second order disposed between the trailing face of each said bar and the opposite side of the bearing.

8. The planetary rolling mill claimed in claim 3 wherein said last named means comprises an elastic encircling means directly contacting suitable grooves provided in the workroll necks.

9. The planetary rolling mill claimed in claim 8 wherein said elastic encircling means comprises two endless cables, each encircling at least one half of the workroll necks of a backing roll.

10. The planetary rolling mill claimed in claim 1 wherein said bars are extended all the way across the face of the work-rolls and into slots in the opposite cage, thereby uniting both cages of one backing roll into a rigid body.

11. The planetary rolling mill claimed in claim 10 wherein the portions of said extended bars disposed between two adjacent workrolls are so profiled as to leave room for said workroll, but are of such a shape that minimum distance between any two adjacent bars is less than the diameter of the workroll.

12. The planetary rolling mill claimed in claim 10 wherein the coaxial rotation of the double cage structure around its backing roll is assured by providing one bearing in each cage, said bearing being located on the necks of said backing roll.

13. The planetary rolling mill claimed in claim 10 including a gear means for each said cage, said means comprising a plurality of toothed segments, one for each pocket, secured to each cage and meshing directly with the toothed segments of the cage on the opposing backing roll.

14. The planetary rolling mill claimed in claim 13 including means for adjusting the pitch diameter of said toothed segments, which means include variable thickness shims placed at the bottom of each said segment.

15. The planetary rolling mill claimed in claim 10 in which the workroll bearing is square and contains a bore offset from the center thereof.

References Cited

UNITED STATES PATENTS

3,138,979 6/1964 Sendzimir ----- 72-240

LOWELL A. LARSON, Primary Examiner

U.S. Cl. X.R.

72-241