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Oxlade

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[54] **ROLLING MILL WORK ROLL ASSEMBLIES**

[75] Inventor: **Roy Ronald Oxlade**, London, England

[73] Assignee: **The British Iron & Steel Research Association**, London, England

[*] Notice: The portion of the term of this patent subsequent to Apr. 16, 1991, has been disclaimed.

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[21] Appl. No.: **435,625**

Related U.S. Application Data

[63] Continuation of Ser. No. 881,801, Dec. 3, 1969, Pat. No. 3,803,683.

[30] **Foreign Application Priority Data**

Dec. 10, 1968 Great Britain 58650/68

[52] **U.S. Cl.** **29/125**, 29/129.5

[51] **Int. Cl.** **B21b 31/08**

[58] **Field of Search** 29/125, 129.5, 110, 123, 29/132

[56] **References Cited**

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Primary Examiner—Alfred R. Guest

Attorney, Agent, or Firm—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

A method of manufacturing a rolling mill work roll assembly which comprises a work roll held in position on a hollow shaft member by the shaft member being in a stressed condition to exert radial loading and preferably also axial loading on the work roll. The grip is sufficient to transmit normal driving torque. The method comprises axially stretching the shaft by hydraulic pressure means acting within the hollow, and this causes reduction of the diameter of the hollow shaft to permit insertion and removal of the shaft into and from the work roll bore. The hollow shaft has a larger diameter than the work roll bore when not so stretched. After insertion the hydraulic pressure is removed and the shaft assumes the above stressed condition.

10 Claims, 4 Drawing Figures

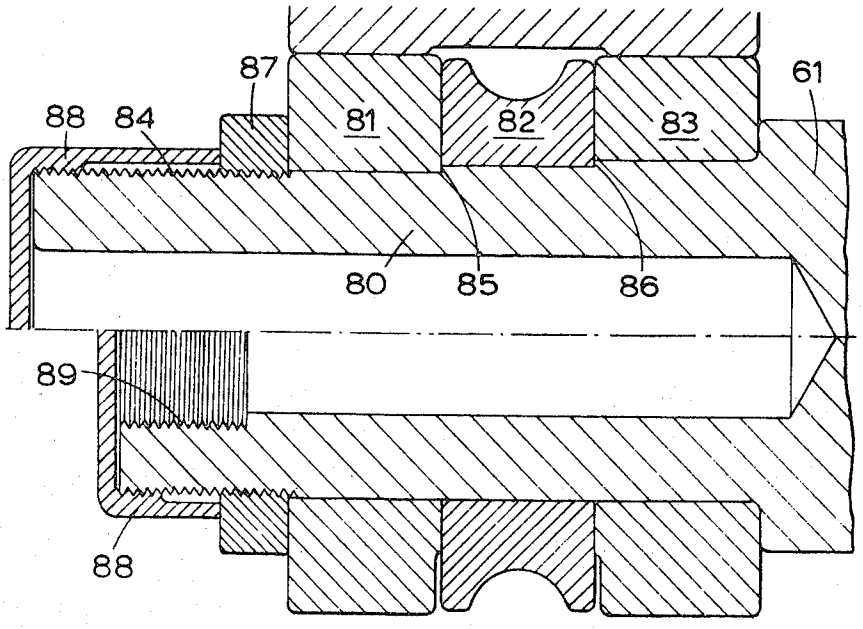


FIG. 1.

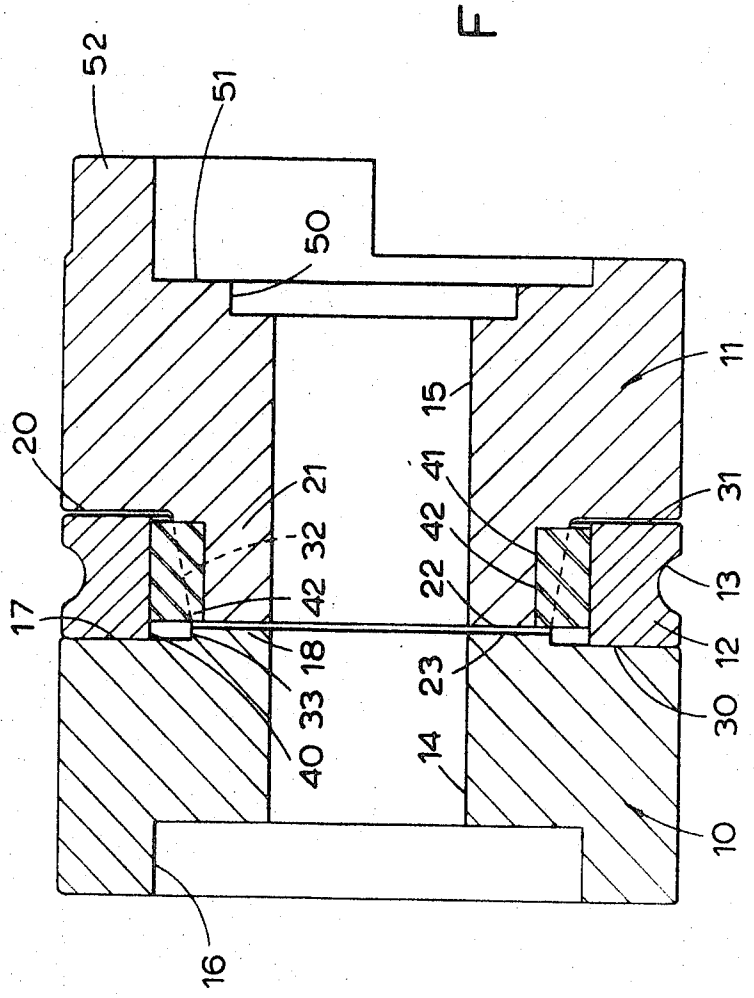


FIG. 2.

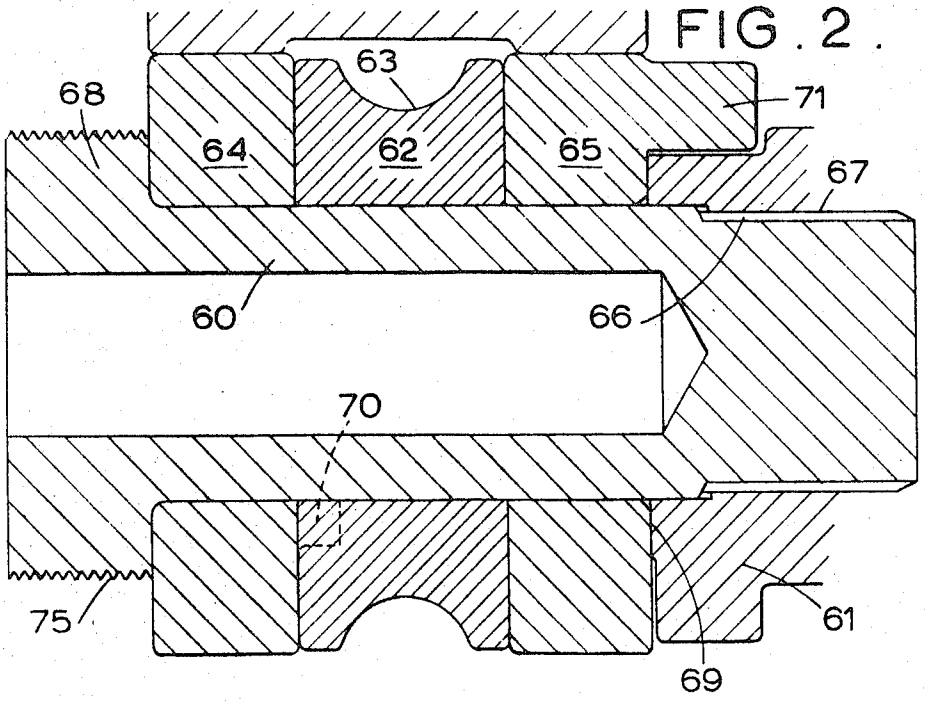
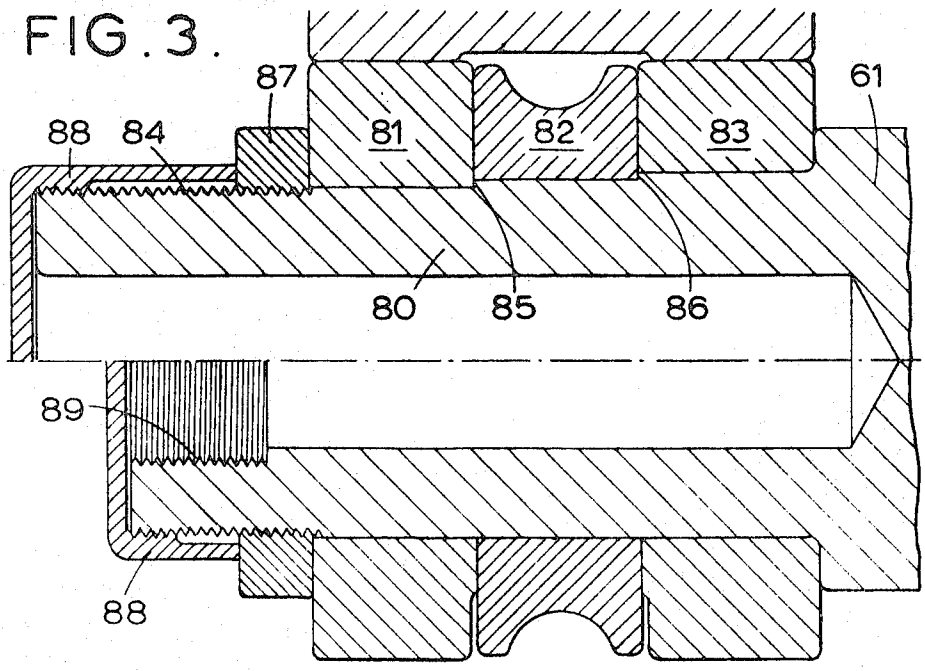

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FIG. 3.


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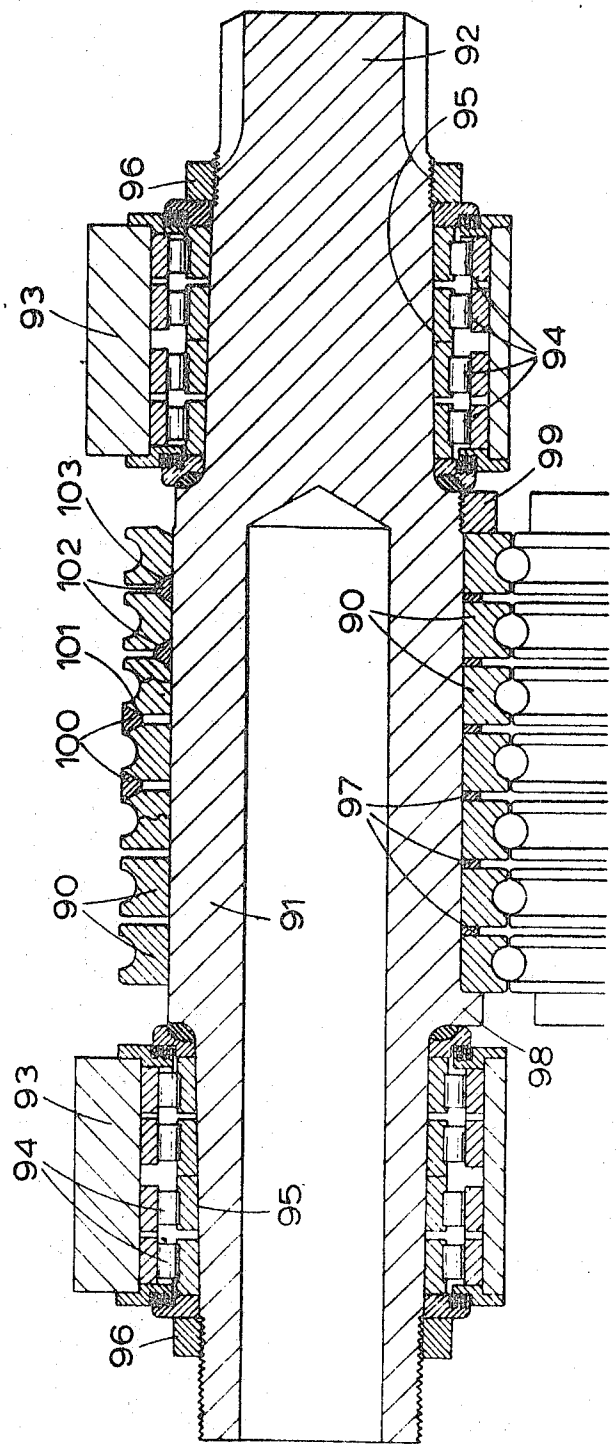


FIG. 4.

ROLLING MILL WORK ROLL ASSEMBLIES

This is a Continuation of application Ser. No. 881,801, filed Dec. 3, 1969 now U.S. Pat. No. 3,803,683 issued Apr. 16, 1974.

This invention relates to methods of manufacturing work roll assemblies for use in rolling mills. Particular applications for such assemblies may be found in two high or in four or more high rod or bar mills, embodiments of the latter being disclosed for example in U.S. Pat. Nos. 3587267; 3611531 and 3613428.

It is generally desirable that mill work rolls be removable so that they can be exchanged for different rolls to permit a variety of rod or bar sizes and shapes to be rolled on the same mill and also to permit worn rolls to be replaced. The work rolls are accordingly removably carried on roll drive shafts which are rotatably mounted and driven in the mill frame. The mounting of the roll on the shaft so as to facilitate the ready removal thereof whilst still enabling the roll to withstand the heavy rolling loads without damage to the mounting or shaft is a continuing problem for the mill designer.

An object of the invention is accordingly to provide a method of manufacturing a work roll assembly so that it is readily removable from the drive shaft.

According to the present invention there is provided a method of manufacturing a rolling mill work roll assembly, said assembly comprising a hollow shaft member which is coaxially secured to or formed integrally with a work roll drive shaft which extends co-axially in a bore of a work roll, said work roll including an annular member formed to define a rolling groove or surface of the work roll, said method including applying a force axially to stretch said shaft member to cause sufficient diametrical reduction thereof to permit insertion thereof into its assembled position in said work roll bore, said shaft member when not so stretched having a diameter too large to permit such insertion, and removing said applied force to cause the shaft member to assume a stressed condition in which it exerts radial loading outwardly on said work roll to provide radial location of said work roll with respect to said shaft member.

In preferred embodiments of the invention the annular member is supported on both sides by sleeve members. Accordingly the ring member may be of, e.g. tungsten carbide and the sleeve of, e.g. steel. The tungsten carbide provides a long, accurate roll groove life, which resists wear, thermal shock and rolling fatigue. The roll groove thus has the advantages of tungsten carbide but the roll as a whole is not so heavy or as expensive as a solid tungsten carbide roll would be. Moreover if the annular member is damaged, it is readily replaceable, without the necessity of replacing the steel sleeve member. A damaged tungsten carbide solid roll would have to be scrapped as a whole. The provision of a composite roll in this manner which can readily be dis-assembled, also provides the advantages of ease of handling, and the storage bulk of the mill inventory of different groove size rolling members is reduced. Finally the composite roll can, in some forms, be more adequately cooled in use.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

FIG. 1 is a longitudinal section of a work roll which forms part of an assembly according to the invention for use in a four or more high rod or bar mill,

FIGS. 2 and 3 are longitudinal sections of work roll assemblies according to the invention, also for use in a four or more high mill, and

FIG. 4 is a longitudinal section showing embodiments of an assembly for use in a two high mill.

FIG. 1 shows a composite work roll fabricated as first and second separable supporting sleeve parts indicated generally at **10** and **11**, and a ring or sleeve member **12** provided with a single circumferential rolling groove **13**. The sleeves have axial bores **14** and **15**. The first sleeve has an outer end portion presenting a recess **16** for a purpose to be described below. The inner end portion of the first sleeve presents an annular seat **17** accurately perpendicular to the roll axis, and a vestigial spigot **18** radially inward of the seat **17**.

The second sleeve **11** has an outer end portion adapted to locate the roll axially and radially on a work roll shaft as will be explained below. The inner end portion of the second sleeve presents an annular surface **20** perpendicular to the roll axis, and a frusto conical spigot **21** radially inward of the seat **20**. Spigot **21** converges away from the sleeve **11** and terminates in an annular face **22** opposed to an annular face **23** presented by the end face of the spigot **18**.

The ring member **12** has a constant cross-section in the general shape of a trapezium. The parallel annular side faces **30, 31** are perpendicular to the roll axis. The axial length of the ring is equal or marginally less than the summed axially lengths of spigots **18** and **21**.

The inner surface of the central aperture of the ring **12** is a frusto conical surface **32** over the major portion of its axial length, the cone angle, axial length and datum diameter of surface **32** being substantially equal to the corresponding external dimensions of spigot **21**. The remainder of the inner surface of the central aperture of ring **12** is a cylindrical surface **33** substantially equal in diameter and axial length to the diameter and axial length of spigot **18**.

Two diametrically opposed pairs of registering axially directed key-ways **40, 41** are provided, the key-ways of each pair being formed in the inner surface of the ring **12** and in the outer surface of the spigot **21**. A key member **42** is shaped for sliding movements into each said pair of key-ways.

The outer end portion of the second sleeve **11** is constructed in the same manner as the equivalent end portion of the work roll particularly described in and with reference to FIGS. 2 and 3 of the drawings of our copending U.S. Pat. application No. 52086/67. Briefly the end portion presents an axial recess **50** shaped to receive a work roll shaft spigot, an annular seating surface **51** radially outward of the recess **50**, and a curved wall key member **52** extending circumferentially of the part **11** to slightly less than 180° of the roll circumference. Recess **50** locates the roll radially on the shaft spigot, surface **51** locates the roll axially on the shaft seat, and key member **52** mates with a key-way and an optional wedge associated with a work roll shaft substantially to prevent backlash between the roll and its shaft.

In use the three parts **10, 11** and **12** of the work roll, and key members **42**, are assembled as shown in the drawings. The work roll is then mounted to a work roll shaft by means of a hydraulic hollow bolt (not shown)

extending from within an axial bore in the shaft and through bores **14** and **15** of the work roll. A nut is threaded on the end of the bolt. A radial face of the nut bears against the annular face within the recess **16** of part **10.** When the nut has been tightened on the bolt and the bolt has been de-pressurised to relax into a state of considerable axial tension, it will be seen that the parts **10, 11** of the roll are urged axially together into pre-loaded engagement. The annular seat **17** on part **10** provides axial support and location in one axial direction for the ring shape part **12.** Support and location for part **12** in the other axial direction is provided basically by tapered spigot **21** engaging tapered surface **32** of ring **12.** This latter engagement also provides radial support and location for ring **12** on part **11.** Parts **10** and **12** are located radially by the engagement of vestigial spigot **18** and surface **33.** Backlash between ring **12** and part **11** which is the driven part of the roll is substantially prevented by friction assisted by key members **42,** which also serve to drive the ring **12.**

The support parts **10** and **11** would normally be of steel and the ring member **12** of tungsten carbide. An advantage of this embodiment is thus that the ring member **12,** which is the part containing the groove **13** and thus most subject to wear in use, can be made of considerably harder and longer lasting material than the remainder of the work roll. Expense of making the whole roll of hard wear resistant material is thus avoided, and similarly it may be possible to achieve a work roll whose support parts **10, 11** and ring **12** wear at substantially the same rate, although part **12** is subject to greater wear in use. Moreover the roll is separable into parts and thus a worn ring can readily be replaced. In addition the ring **12** can readily be replaced by a ring defining a differently shaped rolling groove **13.** In another embodiment ring **12** may be provided with two or more rolling grooves.

Furthermore tungsten carbide is approximately twice as heavy as steel, so the weight of a solid tungsten carbide roll would render the roll difficult to handle. Finally, parts **10** and **11,** which in use roll on a back up roll surface, could be formed of a fatigue resistant steel not suitable for roll groove material but with longer life when serving only to define a back up work roll contact surface.

If necessary, instead of or in addition to keying, the roll part may be glued or brazed together and/or the roll may be glued or brazed to the drive shaft.

Referring now to FIG. **2** there is shown a longitudinal section of a work roll assembly for a four or more high rod or bar mill comprising a work roll mounted on a hollow shaft member **60** secured to a drive shaft **61.** The work roll comprises a ring member **62** defining a rolling groove **63.** The ring member **62** is axially located and supported by two sleeve members **64, 65.** The three members **62, 64, 65** are mounted on hollow shaft member **60** which has a threaded end portion **66** received in a threaded recess **67** in the end of the drive shaft **61.** A head flange **68** on the hollow shaft member engages sleeve **64,** and an annular seat **69** on the end of shaft **61** engages sleeve **65.** Consequently flange **68** and seat **69** provide axial location in both directions for the work roll.

The member **60** serves as a form of hydraulically expansible bolt. In its unassembled unstressed state its diameter is slightly greater than the diameter of the bore through the parts of the composite work roll. In order to insert the member **60** through the bores, the member **60** is axially stretched by hydraulic pressure means acting internally thereof. The axial stretching is accompanied by a diametrical shrinkage sufficient to permit the three roll parts to be mounted on the member **60.** The member **60** is then threaded into the drive shaft **61** and tightened thereon by simple mechanical means, this is, no special effort is made to tighten it very securely. The hydraulic pressure within the hollow is then released, thus causing the member **60** to expand in diameter, so far as it is able, and to shrink in axial length, to assume a stressed condition.

The diametrical expansion causes the member **60** to exert substantial radial loading on the work roll members **62, 64** and **65** whereby to locate them radially (provided their relative bore diameters are correctly chosen in relation to the bolts diameter); and the axial shrinkage causes the member **60** to exert substantial axial loading on the work roll members by means of flange **68** and seat **69.**

It should be noted that the threaded portion **75** on the head of the hollow shaft member **60** serves for attachment of a valved pressure device through which the hydraulic pressure fluid is forced to build up on the head of a plunger. The tail of the plunger engages the inner end of the hollow, whereby to cause the hydraulic pressure to act directly to stretch the bolt and permit its diameter readily to shrink as described. When in use the hollow in the bolt is protected from dirt by a dust cap shown e.g., at **88** in FIG. **3.**

If desired additional location can be afforded by keying means, such as mating spigots, on the roll members and the drive shaft, one such being shown schematically at **70.**

The torsional drive of the roll is transmitted by virtue of a combination of the axial clamping force and the radial grip which effectively also comprehends circumferential location by friction. The drive from the drive shaft **61** to the roll is provided by the key **71,** similar to that described in relation to FIG. **1.** If desired two or more similar keys spaced circumferentially may be used. The torque transmission capability can be enhanced, if desired, by keying means acting between the assembled parts, e.g., knurling the outer surface of the member **60,** providing keys between the roll sleeves, or by glueing or brazing mating surfaces of the roll sleeves, or the outer peripheries of the three members **62, 64** and **65** can be provided with mating noses and recesses.

Referring now to FIG. **3,** two embodiments are shown in the upper and lower halves of the drawing respectively. In each embodiment a hollow shaft member **80** acts in a similar manner to the hollow shaft member **60** described in relation to FIG. **2,** except that in this case it is formed integrally with the drive shaft **61.** Consequently, it is not possible to place the work roll sleeves **81, 82** and **83** on the hollow shaft member from the right hand end thereof. In the upper half of the figure the valved pressure device, which threads on the head **84** of the hollow shaft member, is of larger diameter than the bore of the sleeves **81, 82** and **83.** Thus the sleeve cannot be mounted from the left hand end when the member **80** is pressurized.

To solve this difficulty the hollow shaft member is either given a gradual taper (not shown) or is stepped as shown at **85** and **86.** The sleeves are of appropriate internal diameters as shown. To assemble the assembly,

the sleeves are placed on the unpressurized unstressed member 80 onto diameters displaced one step to the left of their final position. The valved pressure device can then be attached to threaded portion 84 and the member pressurized. The sleeves can then be moved one step to the right onto their final positions as shown, and the bolt then depressurized to assume a stressed condition to provide location as described above in relation to FIG. 2. In this case a nut 87 or other locking device serves the purpose of flange 68.

In the lower half of FIG. 3 the inner diameter of the hollow shaft member 80 is threaded at 89 and the valved pressure device for use in pressurizing the bolt is dimensioned to be wholly of less diameter than the bores of the sleeves. Consequently the sleeves can then be placed in position on the member 80 over the pressure device, thus avoiding the need for steps 85 and 86.

Referring now to FIG. 4, there is shown a work roll assembly for a two high mill, and four embodiments are partly illustrated in this Figure.

In the first embodiment a plurality of work roll grooved rings 90 are spaced along a hollow shaft member 91 and are maintained in position, radially and axially, simply by the stressed condition in member 91 exerting sufficient radial loading thereon. The torque transmission capability can be enhanced if required by knurling the member 91 or providing flats or keys between the ring bore and the member 91, or by glueing or brazing the rings to the member 91. Cooling of this embodiment would be very efficient since cooling fluid could penetrate the annular grooves between adjacent rings 90.

The hollow shaft member is shown as formed integrally with a drive shaft 92 and is supported for rotation on two chocks 93, provided with suitable roller bearings 94. The chocks and member 91 are axially mutually located by virtue of the slow taper of shaft portions 95, and by end nuts 96.

FIG. 4 also shows, in its lower half, rings 90 spaced by spacing rings 97. The sequence of alternate rings 90 and 97 are axially clamped and located between a flange 98 on the member 91 and a nut 99, which is tightened before de-pressurizing of the hollow shaft member 91 in a similar manner as described before. In this embodiment, of course, the radial loading by member 91 is not essential, since the axial loading and location can be sufficient to transmit the necessary torque.

This Figure also shows rings 90 spaced by spacing rings 100 which are trapezium shaped in cross-section and taper inwardly, the taper matching outer bevels 101 on the rings 90. Spacing rings 102 are also shown, which are trapezium spaced and taper outwardly, the taper matching undercut bevels 103 on the rings 90. The rings 100 are usually preferable since their hoop stress in use exerts compression on the rings 90, whereas rings 102 cause extra tension in rings 90. When the rings 90 are of tungsten carbide, compressional forces are more suitable to the material. In the latter two embodiments the angles of the trapezium are chosen to compensate for any difference between the co-efficients of thermal expansion of the material of the work roll rings and the material of the hollow shaft member.

Many advantages of the above described embodiment have already been given, but finally it should be noted in addition that the use of composite work rolls which are radially loaded or axially loaded, or preferably both, by a stressed hollow shaft member, leads to a stiffer work roll assembly (where stiffness means the deflection of a selected point per unit load) than many of the assemblies in use at the present time.

The drawings have shown work rolls with rolling grooves. In applying the invention to flat strip mills, the work rolls would have cylindrical rolling surfaces instead of the grooves.

I claim:

1. A rolling mill work roll assembly comprising a hollow shaft member which is co-axially secured to or formed integrally with a work roll drive shaft and which extends co-axially in a bore of a work roll, said work roll including an annular member formed to define a rolling groove or surface of the work roll, said shaft member having a first end face and an axial hollow in said shaft member open at one end onto said first end face and closed at the other end, said closed end of said hollow presenting a first reaction surface, means integral with the shaft members adjacent said open end of said hollow to provide a second reaction surface facing in the opposite direction to said first reaction surface, whereby said hollow shaft member is adapted to be axially stretched by load applying means acting on and between said first and second reaction surfaces to cause sufficient diametrical reduction of said hollow shaft member to permit insertion and removal thereof into and from its assembled position in said work roll bore, said shaft member when not so stretched having a diameter too large to permit such insertion and removal, said shaft member thereby exerting radial loading outwardly on said work roll when the stretching force is removed, thereby determining radial location of said work roll with respect to said hollow shaft member.

2. An assembly as claimed in claim 1 wherein said radial loading exerted outwardly on said work roll by said shaft member is sufficient also to provide circumferential location by friction so that normal driving torque may be transmitted between the two members.

3. An assembly as claimed in claim 1 wherein said drive shaft has a threaded recess at one end thereof and said hollow shaft member is co-axially secured to said drive shaft by means of threaded engagement with said threaded recess.

4. An assembly as claimed in claim 1 further comprising a plurality of spacing rings and a plurality of said annular members spaced axially of one another by means of said spacing rings.

5. A stressed rolling mill work roll assembly comprising a hollow shaft member which is co-axially secured to or formed integrally with a work roll drive shaft and which extends co-axially in a bore of a work roll, said work roll including an annular member formed to define a rolling groove or surface of the work roll, said hollow shaft member having first and second end portions adjacent the opposite ends thereof, said first end portion providing a first load bearing reaction surface and said second end portion providing a second load bearing reaction surface, said first and second load bearing reaction surfaces substantially facing one another whereby said hollow shaft member is adapted readily to be axially stretched by applying loading force means reacting on and between said first and said second load bearing reaction surfaces to cause sufficient diametrical reduction of the hollow shaft member to

permit insertion and removal thereof into and from its assembled position in said work roll bore, said shaft member when not so stretched having a diameter too large to permit such insertion and removal, said shaft member thereby exerting radial loading outwardly on said work roll when said stretching force is removed, thereby determining radial location of said work roll with respect to said hollow shaft member.

6. An assembly as claimed in claim **5** wherein said hollow shaft member comprises an annular wall portion between said first and second end portions, said annular wall portion defining said hollow axially of said shaft member, said first end portion being substantially solid to define a closed inner end face of said hollow, said first load bearing reaction surface being constituted by said closed inner end face of said hollow, and said second end portion defining an axial opening to said axial hollow.

7. An assembly as claimed in claim **5** wherein said second end portion is provided with a screw thread ridge generated about the shaft member axis, said second load bearing reaction surface being constituted by a spiral surface portion of said screw thread ridge.

8. An assembly as claimed in claim **7** wherein said screw thread ridge is generated on the exterior surface portion of said second end portion.

9. An assembly as claimed in claim **7** wherein said screw thread ridge is generated on the interior surface portion of said second end portion.

10. An assembly as claimed in claim **1** wherein said means integral with the shaft member comprises a screw thread ridge integral with said shaft member.

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