

Nov. 15, 1960

E. W. CLEM
WORM GEAR DRIVE

2,959,868

Filed April 17, 1957

5 Sheets-Sheet 1

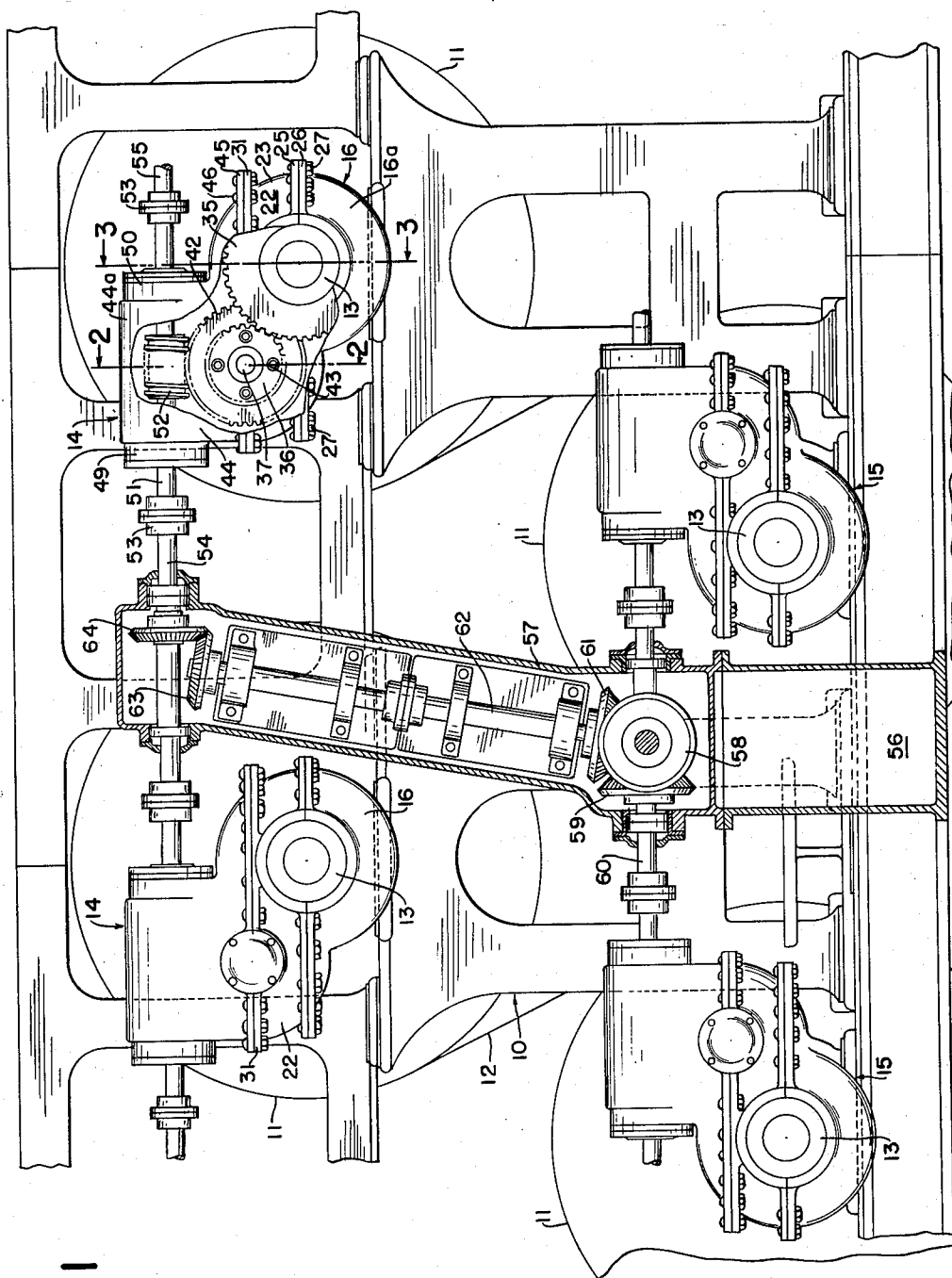


FIG. 1

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FIG. 2

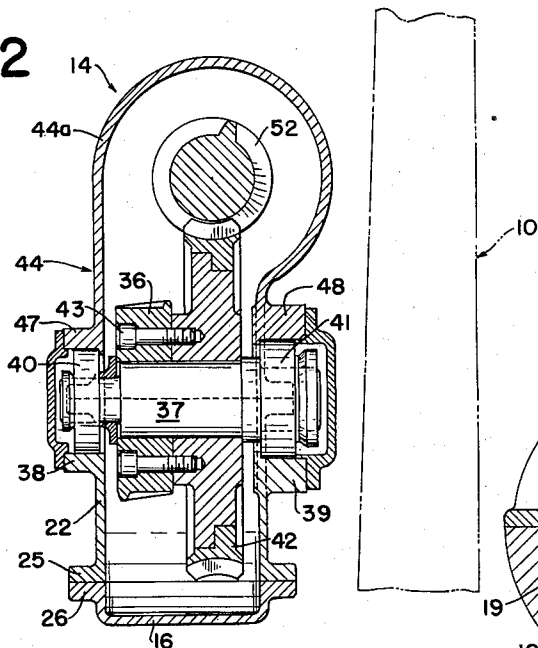


FIG. 4

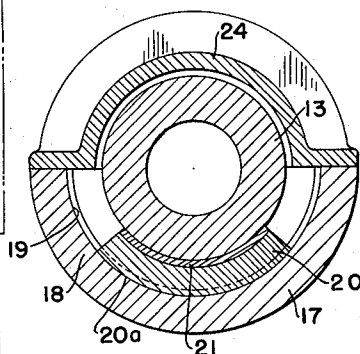
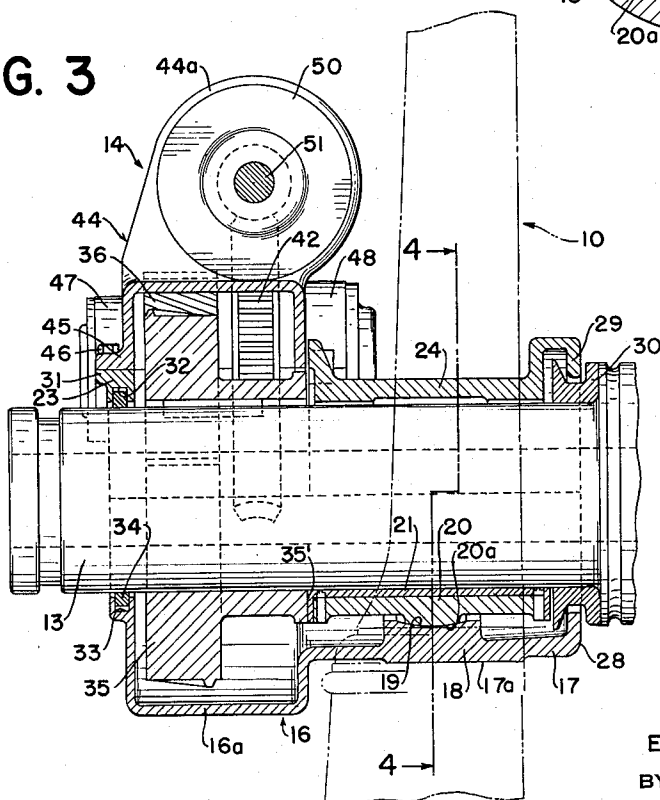


FIG. 3



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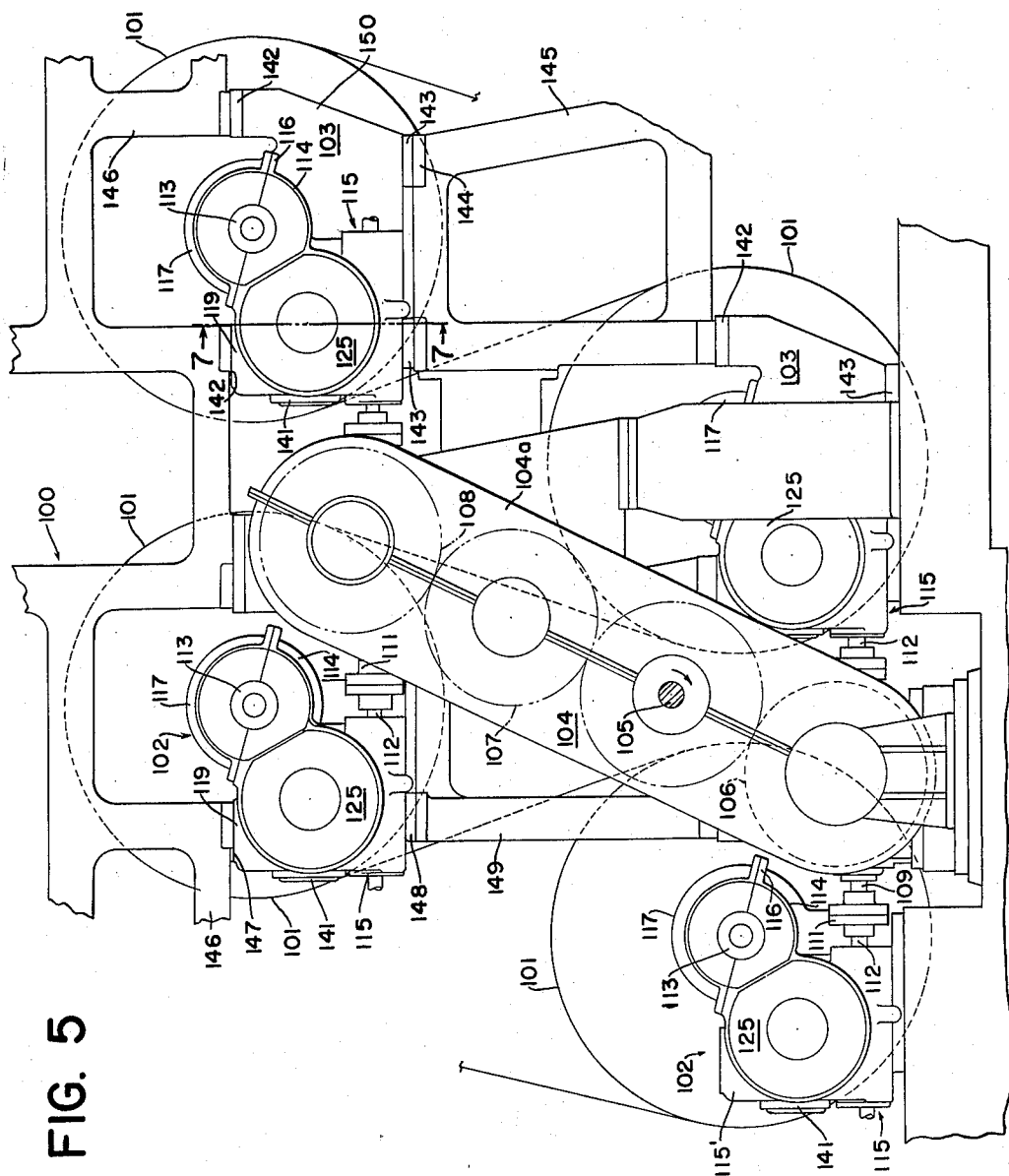
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FIG. 8

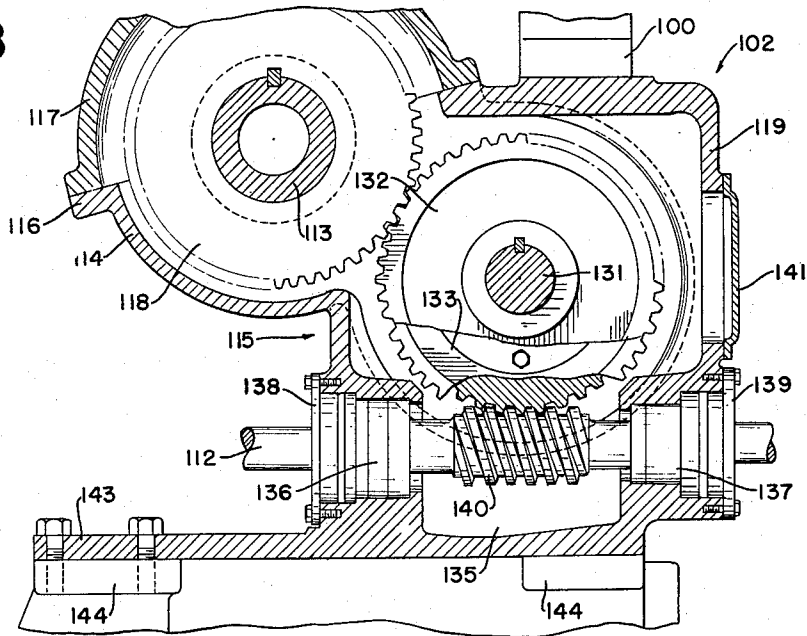
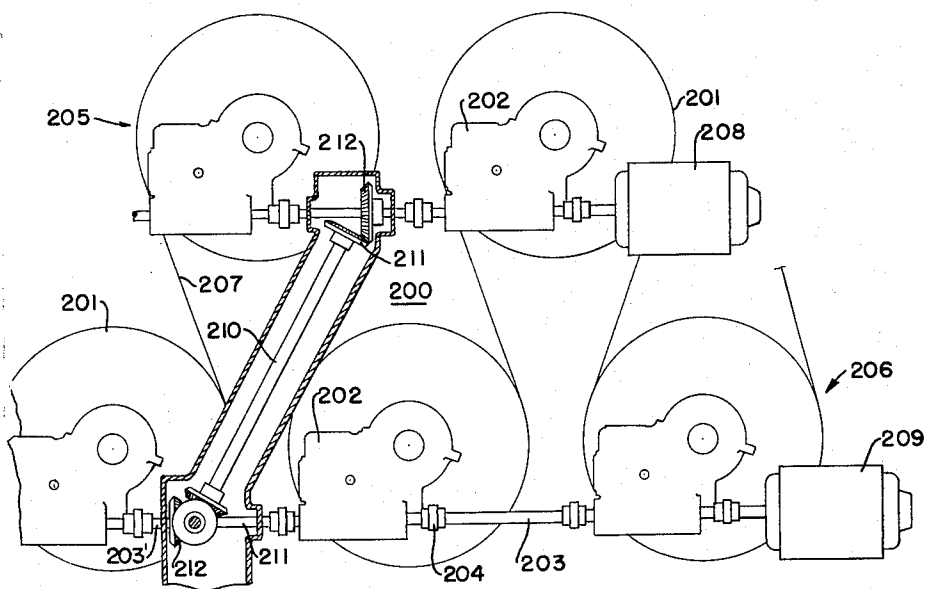


FIG. 9



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WORM GEAR DRIVE

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6 Claims. (Cl. 34—121)

This invention relates to worm gear drives for the direct driving of journaled apparatus, where the bearings thereof are subjected to severe conditions, such as operation over a wide range of temperatures, continuous operation at high temperature, operation under heavy load, etc. The new apparatus is especially useful in a drive system for paper machine dryer sections. However, it will be understood that the invention may be incorporated in various applications involving journaled apparatus.

Conventional dryer sections for paper-making machines usually comprise a large number of drying rolls or drums of relatively large diameter arranged in staggered relation and constituting the end section of the paper-making machine. The moisture-laden web of paper is entrained sinusoidally about the staggered rolls in such manner as to be in contact with the rolls and is normally held against the rolls and partially supported by a continuous felt. The rolls are rotated at a speed sufficient to remove the paper web from the paper-making machine as it is formed, and steam or other heating medium is supplied from a suitable source to the interior of the drying rolls, for heating the web.

As the moist web of paper enters the dryer section it has very little strength, and, accordingly, it is important that the peripheral speed of the dryer rolls accurately coincide with the linear velocity at which the web is formed. Likewise, it is important that the drive system for the various dryer rolls be as free as possible from backlash, to avoid the possibility of instantaneous speed variations between the rolls. Thus, the proper driving of the dryer rolls presents a considerable problem. The problem is rendered particularly difficult, moreover, because the large-diameter drying rolls have substantial mass and because most paper makers operate their paper machines at very high speeds. Another difficulty encountered results from the fact that steam or other heating medium is introduced into the interior of the dryer rolls through one or both of the journals thereof, so that a drive mechanism acting on the journal is subjected to wide variations in temperature and must be adapted for continuous operation at a relatively high temperature.

In my copending application, Serial No. 561,004, filed January 24, 1956, now Patent No. 2,914,864, there is disclosed and claimed one form of worm gear drive apparatus for hot journal applications which is useful in installations where the rotating apparatus is supported in roller or other anti-friction bearings, or may be adapted to be so supported. The apparatus of the copending application incorporates special arrangements whereby the tendency of the drive components to expand and contract as the temperature thereof changes does not materially affect the driving relationship of the worm and worm gear. While this arrangement is highly satisfactory for its intended uses, the range of temperatures to which it may be subjected, without eventual damage in continuous operation, is not adequate for some applications, particularly in certain modern, high-temperature dryer sections, for example. Accordingly, the present invention provides an improved

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worm gear drive which incorporates advantageous features of my earlier drives, but constitutes an improvement thereover in that it is capable of operating satisfactorily even though the journaled apparatus is subjected to a wide range of temperatures and/or subjected to continuous operation at relatively high temperatures. In this respect, the apparatus of this invention may be employed to particular advantage to drive the heated drums of a paper machine dryer section. Such dryer drums or rolls are heated by steam, for example, and are usually maintained in constant operation, twenty-four hours a day, day after day. The new drive effectively isolates the worm and worm gear from the direct heat applied to the dryer roll, so that the critical relationship of the worm and worm gear is not adversely affected during operation of the dryer section.

At the same time, the new drive is highly compact, and may be positioned adjacent one end of each dryer roll without materially affecting the openness of the dryer. Thus, with conventional drive arrangements, the drive side of the dryer section is substantially closed, interfering with the free circulation of air through the frame and greatly reducing the efficiency of the dryer section. In fact, with conventional drives, the drive side of the dryer section is known as the "wet side," since the edge of the paper web adjacent the drive side takes considerably longer to dry than the edge of the web adjacent the open side of the dryer. The present drive is, however, of such compactness as to be substantially wholly confined within the projected peripheral outlines of the dryer drums. Accordingly, the drive side of the dryer section is substantially as open as the "open" side, resulting in greater uniformity in the drying operation, and in substantially increased operating efficiency, to the extent that the dryer section can be shortened in many instances.

Another advantageous feature of the new drive resides in the fact that, in one of its forms, it may be readily installed as a conversion unit, in existing dryer sections. In many older installations, the dryer drums are supported by plain journal bearings, and, accordingly, the new drive is readily adaptable for use in machines utilizing either plain journal bearings or anti-friction bearings.

Where dryer rolls or similar apparatus incorporate conventional journal bearings, two important problems are encountered. Thus, in a conventional journal bearing assembly, the journal is supported by a bearing member of relatively soft material which is subject to wear. As the bearing becomes worn, the position of the journal is altered. The drive system therefore must be adapted to accommodate the changing positions of the journals without substantially changing the effectiveness of the drive. In the present instance, it is contemplated that the bearing liner may wear at least one-fourth to five-sixteenths of an inch without effecting the drive mechanism. A second problem arising in connection with conventional journal bearings is that the journal is free to move a certain distance in an axial direction unless special thrust bearings are provided. Accordingly, the new drive apparatus incorporates arrangements providing for a certain amount of lateral movement of the journal.

The invention further provides an improved drive system for a paper dryer section, whereby the rolls or drums of the dryer section may be provided with power from a plurality of sources. Thus, where the dryer section includes upper and lower flights of drums, separate power means may be employed for driving the separate flights of rolls, with means being provided to maintain the flights in exact synchronism.

In addition to the above, the new drive mechanism includes provisions facilitating maintenance and repair of the drive or of a journal bearing so that the down-time of the machine may be kept at a minimum. More specifically, the new drive includes improved housing arrange-

ments, whereby the parts of the drive are separately accessible, and may be quickly removed and replaced when necessary.

For a better understanding of the invention reference may be made to the following detailed description and to the accompanying drawing, in which:

Fig. 1 is a fragmentary elevation of the drive side of a paper machine dryer section incorporating one form of the improved worm gear drive of the invention;

Fig. 2 is an enlarged fragmentary cross-section taken generally along line 2—2 of Fig. 1;

Fig. 3 is an enlarged fragmentary cross-section taken generally along line 3—3 of Fig. 1;

Fig. 4 is a cross-sectional view taken along line 4—4 of Fig. 3;

Fig. 5 is a fragmentary elevation of the drive side of a paper machine dryer section incorporating a second form of the improved worm gear drive of the invention;

Fig. 6 is a fragmentary cross-sectional view of the dryer section and drive of Fig. 5;

Fig. 7 is an enlarged fragmentary cross-sectional view taken generally along line 7—7 of Fig. 5;

Fig. 8 is a fragmentary cross-sectional view taken generally along line 8—8 of Fig. 7; and

Fig. 9 is a simplified representation of an improved drive system for a paper dryer section, as arranged in accordance with the invention.

Referring now to the drawings, and initially to Figs. 1—4 thereof, illustrating one form of the invention, the numeral 10 designates generally the frame structure of the dryer section, which mounts a plurality of relatively large-diameter dryer rolls or drums 11. In accordance with usual practice, the rolls 11 are arranged in staggered relation and in two flights, so that a web of paper, supported by a continuous felt 12, may be threaded in a sinuous manner alternately about the upper and lower dryer rolls 11. A conventional paper-making machine may have a dryer section comprised of a large number of rolls 11.

Each dryer roll 11 has a hollow journal 13 which is rotatably supported in the frame structure 10 and has a portion projecting laterally or axially outward of the frame 10 in the manner indicated in Fig. 3. Suitable means (not shown) are provided adjacent the side of the frame structure 10 to supply steam or other heating medium into the interior of the dryer rolls 11, through the hollow journals 13 thereof. The rolls 11 are thus heated to a relatively high temperature, and as the moist paper web passes about the series of rolls it will be heated by the rolls and the moisture in the web is evaporated into the surrounding atmosphere.

In order to drive the rolls 11 in synchronism with the movement of the paper web, each roll 11 is provided with a driving mechanism. The driving mechanisms for the upper rolls are substantially identical and are generally designated by the numeral 14, while the driving mechanisms for the lower rolls are likewise substantially identical and are designated generally by the numeral 15.

Referring specifically now to the upper drive mechanism 14 (shown best at right in Fig. 1), the numeral 16 designates a lower housing part having a semi-circular outer portion 16a (see Fig. 3) and a generally cylindrical inner portion or neck 17 of reduced diameter. The lower side of the neck 17 is provided with suitable pads 17a whereby the housing part 16 may be mounted upon and rigidly secured to the frame structure 10. In the interior of the neck 17, there is a shoulder 18 which extends about the neck and has a spherical seating surface 19. The surface 19 supports a journal bearing member 20 having a lining 21 of babbitt or other suitable bearing material on its upper surface and on its axial end surfaces. The bearing member 20 has a spherical portion 20a adapted to be supported by the surface 19 in such manner as to permit a limited universal movement of the bearing member 20. The bearing member 20, with its liner 21, is in the form

of a segment of a cylinder extending over an arc of somewhat less than 180 degrees, and is adapted to support the dryer roll journal 13 for rotation. As will be understood, the spherical seating portions 19 and 20a permit of slight inaccuracies in the mounting of the housing portion 16 in the frame 10.

As will be apparent in Fig. 4, the lower housing part 16 (including its neck portion 17) extends only to the center line of the journal 13. Secured to the neck portion 17 of the housing part 16 is a generally semi-cylindrical cap 24 which covers the top portion of the journal 13. The cap 24 is held in place by bolts (not shown) or other suitable means, and is adapted for quick removal to expose the journal. When the cap 24 is so removed, the journal 13 may be raised slightly off its seat to permit the bearing 20 to be moved circumferentially in its seat for removal and replacement. It will be noted, in this respect, that the removal of bearing 20 may be accomplished upon the removal of the cap 24 alone, without affecting other parts of the housing and drive mechanism.

As indicated in Fig. 3, the neck portion 17 and cap 24 are provided at their inner ends with in-turned lip portions 28, 29, respectively, which project into a grooved collar 30 carried by the journal 13 to partly seal off the area surrounding the bearing 20. Substantial clearance is of course provided between the lips 28, 29 and collar 30 to accommodate slight axial movements of the journal 13 as well as vertical movements caused by wear of the bearing liner 21.

Mounted on top of the lower housing part 16 is a second housing part 22 having an enlarged outer portion 23. The intermediate housing part 22 has a lower flange 25 which is complementary to a flange 26 at the upper edge of the lower housing part 16 and, in the assembled drive mechanism, the flanges 25, 26 are secured together by means of a plurality of bolts 27.

In the first illustrated form of the invention, the intermediate housing part 22 extends slightly above the journal 13 and has a flange 31 at its upper end. The outer portions 23 and 16a (Fig. 3) of the housing parts 22, 16 therefore entirely surround the journal 13. Accordingly, each of the parts 16 and 22 is provided with a semi-circular opening in its forward wall, through which the outer end portion of the journal 13 may project. Suitable annular channels 32, 33 are provided in the housing parts 22, 16, respectively, to receive an annular sealing ring 34, providing a seal between the forward wall of the housing and the rotating journal 13.

As will be observed in Fig. 1, the housing parts 16, 22 define in part an enlarged circular casing surrounding the journal 13 near its projecting end portion. Received in the casing and keyed to the journal 13 is a helical gear 35 for driving the journal 13 and dryer roll 11. In accordance with the teachings of the invention, the gear 35 has relatively large teeth disposed at a relatively small helix angle. For example, the gear 35 may be in the order of eighteen inches in diameter, having approximately fifty-five teeth, with a diametral pitch of 2.78. The teeth are disposed at a helix angle in the order of fifteen degrees. The gear teeth are of a special form, permitting substantial tolerance in the pressure point or point of contact between gears, without adversely affecting the operation of the gears.

In the illustrated apparatus, the gear 35 has an end surface 35' adapted to bear against the outer end surface of the bearing liner 21. The gear and bearing liner thereby form a simple thrust bearing for the journal bearing assembly.

A helical pinion 36 which, in the illustrated apparatus, is smaller than the gear 35, meshes with the latter for driving the gear and journal 13. In accordance with the invention, the helical pinion 36 is mounted on a shaft 37 supported for rotation about an axis located above and to one side of the axis of the journal 13.

As indicated in Figs. 1 and 2, the intermediate housing

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part 22 has a pair of semi-circular neck portions 38, 39 opening at the top of the flange 31 and adapted to receive a pair of spaced anti-friction bearings 40, 41. The bearings 40, 41 may be conventional roller bearings and are adapted to support the shaft 37 for rotation about an accurately located fixed axis.

The shaft 37 also serves to support a worm gear 42 which is positioned beside the helical pinion 36 and is secured thereto by bolts 43 (Fig. 2) or other suitable means. The arrangement is such that the helical pinion 36 is driven by rotation of the worm gear 42.

Mounted upon the upper flange 31 of the intermediate housing part 22 is an upper housing part 44. The upper housing part has a flange 45 at its lower edge which is secured to the flange 31 by a plurality of bolts 46. The housing part 44 has a portion extending to the right (Fig. 1) and serving to enclose the top of the casing surrounding the helical gear 35. At its left-hand side, the housing part 44 has a pair of downwardly opening semi-circular recesses 47, 48 adapted to be received over the upper portions of the anti-friction bearings 40, 41. When the upper casing part 44 is tightly secured to the intermediate part 22, by means of the bolts 46, the bearings 40, 41 are tightly secured in fixed position.

At the top of the upper housing part 44 is a horizontally disposed cylindrical portion 44a having bearing supports 49, 50 at its opposite ends. A shaft 51 extends through the cylindrical portion 44a and is journaled for rotation therein by means of suitable anti-friction bearings (not shown) mounted in the supports 49, 50. Within the interior of the cylindrical portion 44a, the shaft 51 mounts a worm 52 which meshes with the worm gear 42. Thus, upon rotation of the shaft 51 the worm gear 42 will be caused to rotate, driving the dryer roll 11 through the helical gear and pinion 35, 36.

In a complete dryer section, a separate drive mechanism will be provided for each of the plurality of dryer rolls 11. Since all of the drive units are substantially identical, a specific description of a single unit is considered sufficient to describe the invention. However, it will be observed that the casing parts for the bottom roll drive units 15 are reversed in relation to the casing parts of the upper roll drive units 14. This is preferred in some cases where, as in the illustrated apparatus, the driven members are rotated in opposite directions.

At the opposite ends of the drive shaft 51 of each drive unit are detachable flexible couplings 53 by means of which the drive shafts may be connected to other shaft sections 54, 55. The arrangement is such that all of the drive units 14 for the upper dryer rolls may be connected in series, while all of the drive units 15 for the lower rolls may likewise be connected in series.

At a suitable place along the frame structure 10, preferably about centrally between its ends, there is a power station designated generally by the numeral 56 which includes a housing 57 supporting and enclosing a bevel gear 58 driven by a suitable driving means (not shown). The gear 58 meshes with a complementary bevel gear 59 keyed to a shaft 60 connected in series with the drive shafts for the lower roll drive units 15. The gear 58 also meshes with a complementary bevel gear 61 supported by an upwardly extending shaft 62. At its upper end, the shaft 62 mounts a bevel gear 63 meshing with a complementary gear 64 keyed to the shaft 54. The shaft 54 is connected in series with the drive shaft 51 of the upper roll drive units 14. Thus, rotation of the driving gear 58 causes all of the rolls 11 of the dryer section to rotate at identical speeds. In the illustrated apparatus the upper rolls rotate in a clockwise direction, while the lower rolls rotate in a counterclockwise direction.

The drive unit of Figs. 1-4 has several important advantages, one of the more obvious of which is the fact that the worm gear 42 is removed a substantial distance

from the journal 13. The worm gear is therefore not subjected to the widely varying temperatures of the journal and is not required to operate at the consistently high temperatures of the journal and immediately surrounding parts. This is of considerable importance, since in order to avoid undesirable backlash in the gears the worm 52 and worm gear 42 must be adjusted with respect to each other with considerable precision. Where wide temperature variations are encountered considerable clearances must be provided to accommodate expansion and contraction in the parts, and in such cases it is difficult to avoid backlash. The improved arrangement is also advantageous in that the worm gear 42 is supported by the anti-friction bearings 40, 41 for rotation about an accurately located and permanently fixed axis. Thus, the fact that there is considerable wear in the journal bearings of the dryer rolls does not affect the accurate adjustment of the worm and worm gear.

Another important feature of the drive unit of Figs. 1-4 resides in the use of drive gears 35, 36 having large teeth disposed at a relatively low helix angle and supporting the gears for rotation about axes spaced laterally from each other. The use of helical gears provides for smoother operation of the roll drive by virtue of the more continuous contact between the gear teeth. At the same time, since the gear teeth are disposed at a relatively low helix angle, only a slight axial thrust is imposed on the journal 13 so that complicated thrust bearings are not required. In addition, by locating the helical drive gears 35, 36 on laterally spaced axes, downward movement of the journal 13, caused by wearing of the bearing liner 21, will not greatly affect the meshing of the drive gears, and the present invention contemplates that the lining 21 may wear as much as one-fourth to five-sixteenths of an inch before replacement is required.

The drive unit may be easily dismantled to provide easy access to any part thereof for inspection or repair without interfering with the operation of the dryer section for an excessive length of time. Thus, when the repair of any drive unit is required, the housing may be separated by removing the bolts 45 or 27 or, if desired, by moving both sets of bolts. When one or both sets of bolts are removed, and the flexible couplings 53 for the drive unit in question are detached, the upper portion of the housing may be easily lifted away and removed. A length of shaft, not shown, is then coupled in the line in place of the removed drive shaft 51, so that the remaining drive units are properly connected to the drive gear 58. The drive housing is advantageously made in four parts so that it is unnecessary to dismantle the entire drive to repair only specific parts thereof. Thus, access may be had to the anti-friction bearings 40, 41 and gears 36, 42 and the worm 52 by merely removing the upper housing part 44. On the other hand, access may be had to the helical gear 35 and journal bearing by removing the bolts 27 and lifting off the assembled intermediate and upper housing parts 22, 44. Of still further importance is the ease with which the bearing 20-21 may be removed and replaced, by merely removing the cap 24 and lifting the journal 13 slightly, without affecting other parts of the drive unit in any way.

It is to be particularly noted that, in a paper dryer section, the drive units are substantially wholly within the projected peripheral outlines of the dryer rolls or drums 11 (see Fig. 1), so that the drive side of the dryer section is substantially open. This results in greatly improve air circulation about the dryer rolls, and provides for substantially greater efficiencies in the drying operation.

Referring now to Figs. 5-8, a second form of the new drive unit is illustrated, wherein provisions are made for anti-frictionally journaling the dryer rolls, and other advantageous features are incorporated. In Fig. 5, the numeral 100 designates a dryer section frame having a plurality of dryer rolls 101, each driven by a drive unit

102 or 103, with upper and lower flights of the rolls being connected together by a drive mechanism 104. A power input shaft 105 delivers power to the drive mechanism which, through a series of interconnected gears 106—108, delivers power to shafts 109, 110, to rotate them in opposite directions, at the same speed. The power input or drive mechanism 104 is housed in a casing 104a which is spaced outwardly from the frame of the machine a substantial distance, as indicated in Fig. 6. The upper and lower gears 108, 106 of the drive mechanism are connected by means of extension shaft 108a, 106a, respectively, and through suitable gears (not shown) to the shafts 109, 110.

Shafts 109, 110 are connected, through couplings 111, with the power input shafts 112 of the drive units 102, 103. The units 102, 103 are substantially identical, except for certain parts of their housing, and, accordingly, the description of one will apply equally to the other, except as to certain housing modifications which will be separately described.

In the second form of the invention, it is contemplated (although by no means necessary) that the shafts 113 of the dry rolls 101 will be mounted in suitable anti-friction bearings, not specifically shown, mounted in a semi-circular portion 114 of a drive housing part 115. As shown in Fig. 8, the semi-circular portion 114 of the housing opens upwardly, at a slight angle to the horizontal, and has flanges 116 at its upper edge. A cap 117 is received over the open top of the housing and encloses the upper portion of the roll shaft 113 and the supporting bearing therefor.

As a general rule, the shaft 113 is hollow, to receive steam, and has an end portion projecting outwardly of the housing for connection with a suitable steam supply, not shown.

Secured to the shaft 113, outwardly of the bearing support therefor, is a gear 118. The gear 118 may be a more or less conventional helix or spur gear, where anti-friction bearing means are employed, or of the special type described with reference to Figs. 1—4, if plain journal bearings are used to support the shaft 113.

Integral with the semi-circular housing portion 114 is an enlarged portion 119, having front and rear chambers 120, 121, respectively therein (Fig. 7). The rear chamber 121 has a back wall 122 provided with a central opening 123 for the reception of an anti-friction bearing 124. A front wall 125, of generally circular form, is removably received in an opening 126 in the front chamber 120 and has a central opening 127 therein for the reception of anti-friction bearing means 128. The front wall 125 is normally held in place by an annular plate 129 secured to the housing portion 119 by cap screws 130.

Journalled in the bearings 124, 128 is a shaft 131, adjacent the opposite ends of which are mounted a drive pinion 132 and a worm gear 133. Advantageously, both gears 132, 133 are of smaller diameter than the opening 126 receiving the front wall, so as to be removable therethrough. The worm gear 133 includes a hub 133a and an annular gear portion 133b secured thereto by bolts 134. The arrangement is such that upon removal of the front wall 125, the annular part 133b of the worm gear 133, or the entire assembly of shaft 131 and gears 132, 133 may be removed through the opening 126.

As indicated in Figs. 7 and 8, the semi-circular housing portion 114 is in open communication with the rear chamber 121 of the housing portion 119, and the gears 118 and 132 are in driving relation. Advantageously, the axis of gear 118 is above and to one side of the axis of the gear 132, the plane containing the respective axes making an angle of, for example, thirty degrees with respect to horizontal.

At the bottom of the front chamber 120 of the housing portion 119 is a small chamber 135, at the opposite

ends of which are suitable anti-friction bearings 136, 137, held in place by end caps 138, 139. The bearings 136, 137 journal drive shaft 112, on which is mounted a worm 140. The drive shaft 112 and worm gear shaft 131 are accurately located in fixed relation with respect to each other so that the worm and worm gear 140, 133 are maintained in proper driving relationship. As shown in Fig. 8, at least one of the bearings 136, 137 (i.e., bearing 136) is of larger diameter than the worm 140, so that the latter may be removed axially from the casing through the opening which receives the bearing 136.

In the form of the invention shown in Figs. 5—8, the chamber 135, at the bottom of the casing 115, advantageously serves as a lubricant reservoir, assuring that the worm and worm gear 140, 133 are adequately lubricated at all times. An access cover 141 is provided at one side of the casing portion 119 to facilitate periodical inspection of the lubricant and of the drive mechanism.

It will be observed that the dryer roll shaft 113 is located a substantial distance from the worm 140 and worm gear 133, so that the heat of the medium passing through the shaft 113 is at least partially isolated from the worm drive mechanism. This is advantageous in that the accurate adjustment of the worm and worm gear, which is necessary for proper, efficient operation over extended periods of time, is retained notwithstanding that the temperature of the shaft 113 may vary over a substantial range, or that the shaft 113 may be maintained at a high temperature for extended periods. Moreover, it will be observed that deflections caused by the weight of the dryer roll will not affect the relationship of the worm and worm gear in any material respect.

In accordance with the invention, the drive units 102, 103 for the dryer rolls 101 form integral parts of the structure of the dryer frame, so that an economy of materials is effected; and, of greater importance, the openness of the dryer frame is improved, whereby the air circulation about the dryer rolls is increased. Referring specifically to Fig. 5, it will be observed that the drive unit 103, or more particularly the housing part 115 thereof, includes upper and lower mounting pads 142, 143, respectively. The lower pads 143 are spaced horizontally, and are mounted upon and secured to parts of the dryer frame, as for example, pads 144 of frame section 145. The upper pads 142 are spaced on opposite sides of the dryer roll shaft 113, generally above the respective lower pads 143, and are adapted to support part of the dryer frame, such as section 146 thereof.

Drive units 102 are substantially similar to the units 103, except that the units 102 have only one set of upper and lower pads 147, 148. The lower pad 148 is adapted to rest upon part of the dryer frame, such as part 149, while the upper pad 147 supports another part of the frame, such as part 146. It will be observed that the housing part 115 of drive unit 103 has a web portion 150 for supporting a second pair of structural pads 142, 143, whereas the housing part 115' of drive unit 102 has no portion equivalent to the web 150. Both drive units 102, 103, however, form active parts of the frame structure of the dryer section and form the support means, as well as the drive means, for the dryer rolls 101.

The drive units of Figs. 5—8 are advantageously utilized in machines of new design, i.e., where the frame structure is built to accommodate the drive units as active structural elements, as distinguished from the drive units of Figs. 1—4, which are primarily intended for use as conversion units, for the replacement of conventional drive means on machines of existing design. The drive units of Figs. 5—8 are advantageous in that the worm and worm gear mechanism are contained in a unitary housing structure which is effective in maintaining the worm and worm gear in their accurately adjusted relationship, yet which permits the parts to be quickly removed and replaced whenever necessary. The worm is also mounted in the lower part of the housing, facilitating proper

lubrication of the worm and worm gear and thereby assuring long operating life.

The drive units 102, 103 are both arranged so that in either case substantially the whole of the drive unit lies within the projected peripheral limits of the dryer roll it drives. This permits uniform and adequate circulation of air about the dryer rolls, and eliminates the so-called "wet side" of the dryer section.

Maintenance of the drive units is facilitated by the housing design which provides access to any of the gears independently of the others, whereby a particular roll may be quickly disengaged from the driving system. Generally, a dryer roll thus disengaged may be rotated satisfactorily by means of the dryer felt, while repairs are completed. The down time of the apparatus is thus reduced to a practical minimum.

In the form of the invention shown in Fig. 9, the dryer section 200 of a paper-making machine includes a plurality of dryer rolls 201, each driven by a worm gear drive unit 202. The separate drive units 202 are connected together by shafts 203 and flexible couplings 204 so that all the drive units in a line thereof operate at the same speed.

According to conventional practice, the dryer rolls 201 are arranged into upper and lower flights 205, 206, respectively, so that a paper web and felt 207 may be passed sinuously through the dryer section, alternately about rolls of upper and lower flights. Of course, provision must be made for driving the several dryer rolls 201 (of which there may be a large number in each flight) in substantially exact synchronism.

In accordance with the present invention, the upper and lower flights 205, 206 of the dryer section are separately driven, as by means of electric motors 208, 209, for example. At least one of the flights of dryer rolls is interconnected with or otherwise related to the other components of the paper-making machine, so that the rolls of that flight are operating in synchronism with the rest of the paper-making machine.

While the representation of Fig. 9 shows the motors 208, 209 as being axially aligned with the drive shafts of the worm drive units 202, it will be understood that such representation is for purposes of illustration only. As a general rule, the motors 208, 209, or other driving means, will be mounted at the side of the frame for the dryer section, and perhaps at right angles to the shaft 203.

To provide synchronous operation of the upper and lower flights 205, 206 of dryer rolls, the series connected drive units 202 of each flight are mechanically interconnected, as by means of a synchronizing shaft 210 having bevel gears 211 at its ends in driving relation with bevel gears 212 carried by interconnecting shafts 203'. At one end of the shaft 210, the gear 211 acts through an intermediate gear 213 to drive the gear 212, so that the sets of drive units of each flight operate in opposite directions. Alternatively, an interconnecting gear train, similar to that shown in Fig. 5, may be employed to synchronize the respective flights of dryer rolls.

The new driving arrangement is advantageous in that a plurality of separate drive devices may be employed to drive the plurality of dryer rolls in exact synchronism. This permits the use of smaller motors, conveniently located and mounted, and provides for a reduction in the size of certain of the series connected shafts of the drive system, the shafts being required to transmit less power where a plurality of motors are employed. Advantageously, the motors 208, 209 may be conventional electric motors, and, where necessary or desirable, more than one motor may be employed in driving each flight of rolls.

It will be understood that the specific apparatus illustrated and described herein is intended to be illustrative only, as certain changes may be made therein without departing from the clear teachings of the invention. Reference should therefore be made to the following ap-

pended claims in determining the full scope of the invention.

I claim:

1. A worm gear drive unit for installation in a machine having a frame, a journal bearing, and a journal adapted to operate over a wide range of temperatures and support a heavy load, comprising a first gear secured to said journal, a second gear mounted for rotation on an axis fixed with respect to said frame and positioned in laterally spaced relation to said first gear, said second gear having meshing engagement with said first gear, a worm gear mounted on said fixed axis for rotation with said second gear, a drive worm meshing with said worm gear and mounted for rotation on a second axis fixed with respect to the first axis, and a housing surrounding said drive worm, said gears and a portion of said journal, said housing comprising a lower housing part secured to said frame and having an open upper portion, said lower housing part having means therein for movably supporting said journal bearing, said journal bearing being in the form of a segment of a cylinder, said housing further including a cap removably secured to the upper portion of said first housing part and enclosing said journal bearing and a portion of said journal, said cap being removable to permit circumferential movement of said bearing about said journal for removal of said bearing.

2. A worm gear drive unit according to claim 1, which includes a second housing part having an open top and having upwardly opening semi-circular neck portions, said drive unit including anti-friction bearing means received in said neck portions and supporting said first shaft, a third housing part secured to the top of said second housing part and having downwardly opening semi-circular neck portions received about and adapted to secure said anti-friction bearing means, said third housing part having means therein supporting said second shaft in fixed relation to said first shaft.

3. A worm gear drive unit for installation in a machine having an elongated frame, a plurality of journal bearings and a plurality of journals supported by said journal bearings and adapted to operate over a wide range of temperatures and support heavy loads, comprising a housing adapted to be secured to said frame, means in said housing for supporting a journal bearing and enclosing a portion of a journal, a first gear secured to said journal within said housing, a first shaft mounted in said housing for rotation about a fixed axis parallel to said journal and supporting a second gear adapted to mesh with said first gear over a predetermined range of vertical movements of said journal, the axis of said first shaft being vertically and laterally spaced with respect to the axis of said journal, a worm gear supported on said shaft, a second shaft extending through said housing adjacent said worm gear and mounted in said housing for rotation about an axis fixed with respect to the axis of said first shaft, a drive worm carried by said second shaft and meshing with said worm gear, said second shaft being disposed on a horizontal axis extending lengthwise of said frame in parallel relation thereto, means at the opposite ends of said second shaft for connecting said shaft with other shaft sections, and drive means for rotating said second shaft, said housing comprising first, second and third housing parts removably secured together, the axis of said journal lying substantially at the parting line between said first and second housing parts, the axis of said first shaft lying substantially at the parting line between said second and third housing parts, the arrangement being such that said first shaft may be exposed and removed upon separation of the said third housing part from said second housing part.

4. A worm gear drive unit for installation in a machine having an elongated frame, a plurality of journal bearings and a plurality of journals supported by said journal bearings and adapted to operate over a wide range of temperatures and support heavy loads, comprising a

housing adapted to be secured to said frame, means in said housing for supporting a journal bearing and enclosing a portion of a journal, a first gear secured to said journal within said housing, a first shaft mounted in said housing for rotation about a fixed axis parallel to said journal and supporting a second gear adapted to mesh with said first gear over a predetermined range of vertical movements of said journal, the axis of said first shaft being vertically and laterally spaced with respect to the axis of said journal, a worm gear supported on said shaft, a second shaft extending through said housing adjacent said worm gear and mounted in said housing for rotation about an axis fixed with respect to the axis of said first shaft, a drive worm carried by said second shaft and meshing with said worm gear, said second shaft being disposed on a horizontal axis extending lengthwise of said frame in parallel relation thereto, means at the opposite ends of said second shaft for connecting said shaft with other shaft sections, and drive means for rotating said second shaft, the means in said housing for supporting said journal bearing comprising an arcuate seat, said bearing being movable on said seat circumferentially of said journal, said housing including a cap normally enclosing said bearing and adapted upon removal to expose a portion of said journal to permit removal of said bearing.

5. A worm gear drive unit for driving a dryer roll supported by the frame of a paper machine dryer section comprising a first gear secured directly to said dryer roll at one end thereof, a gear shaft journaled for rotation parallel to said dryer roll and positioned in laterally offset relation to the axis of said dryer roll, a second gear mounted on said gear shaft and meshing with said first gear, a worm gear mounted on said gear shaft, a worm mounted for rotation about a horizontal axis at right angles to the axis of said dryer roll and meshing with said

worm gear, and a housing having a wall fixed to said frame and journaling one end of said gear shaft and a removable wall journaling the other end of said gear shaft, said removable wall being of greater size than either said second gear or said worm gear.

6. A worm gear drive unit for driving a dryer roll supported by the frame of a paper machine dryer section comprising a first gear secured directly to said dryer roll at one end thereof, a gear shaft journaled for rotation parallel to said dryer roll and positioned in laterally offset relation to the axis of said dryer roll, a second gear mounted on said gear shaft and meshing with said first gear, a worm gear mounted on said gear shaft, a worm mounted for rotation about a horizontal axis at right angles to the axis of said dryer roll and meshing with said worm gear, and a housing journaling said gear shaft and worm for rotation about fixed axes, said housing having means therein for supporting one end of said dryer roll for rotation, said housing also having means for journaling said worm below said worm gear, and said housing including a chamber below said worm gear for retaining lubricant for said worm and worm gear.

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