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MULTIPLE-INPUT SHAFT-MOUNTED DRIVE

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4 Sheets-Sheet 1

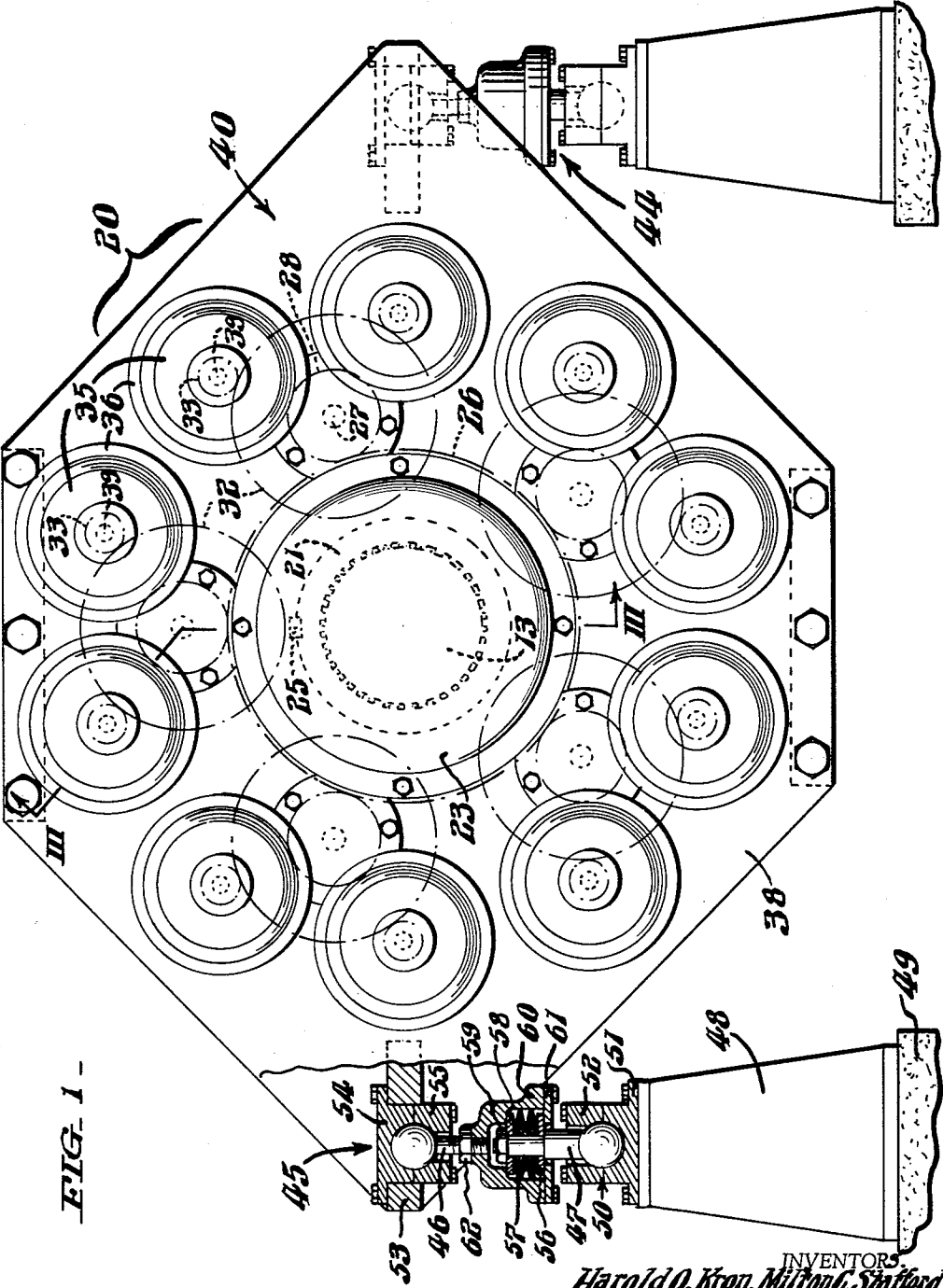


FIG. 1 -

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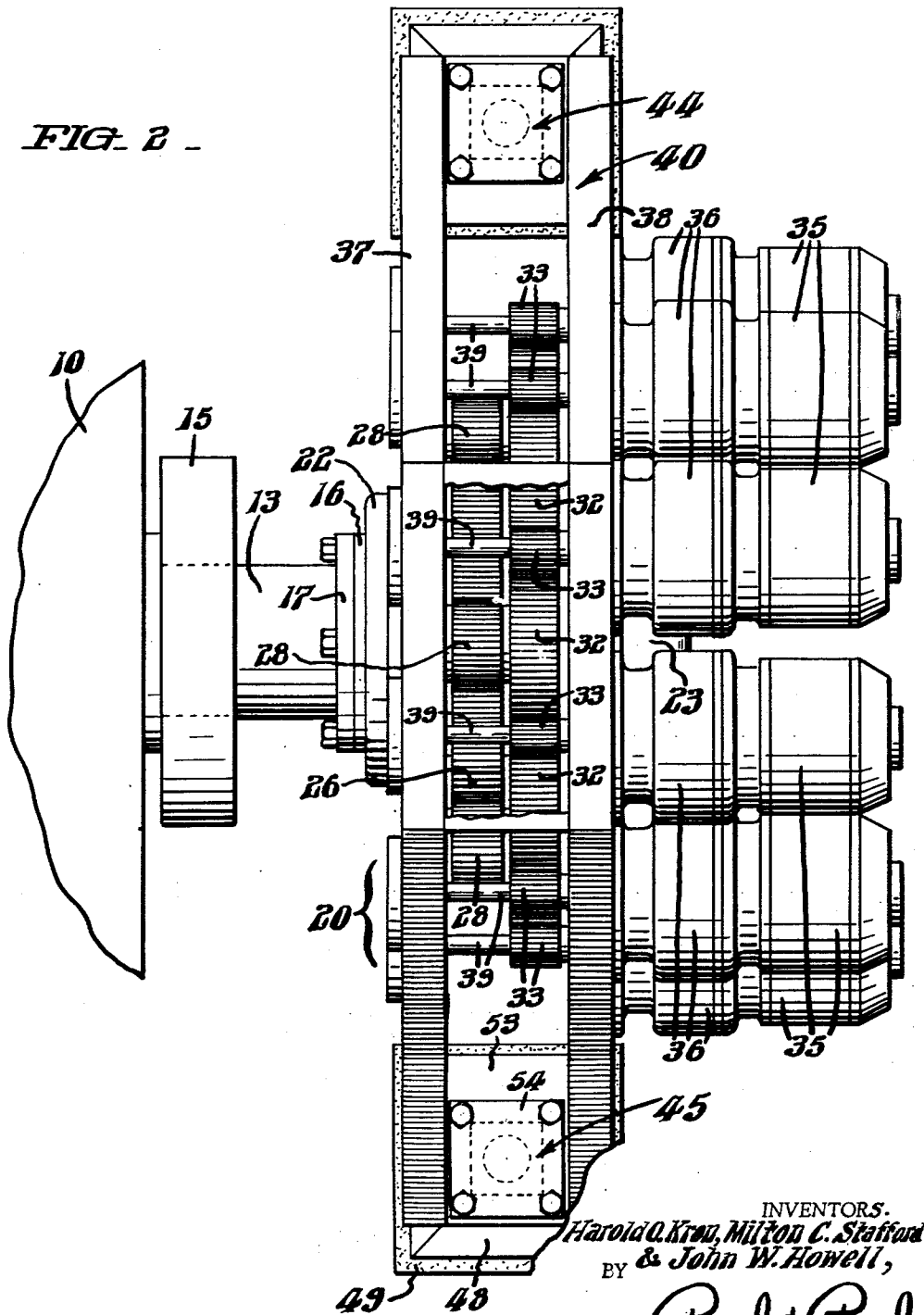
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FIG. 2 -



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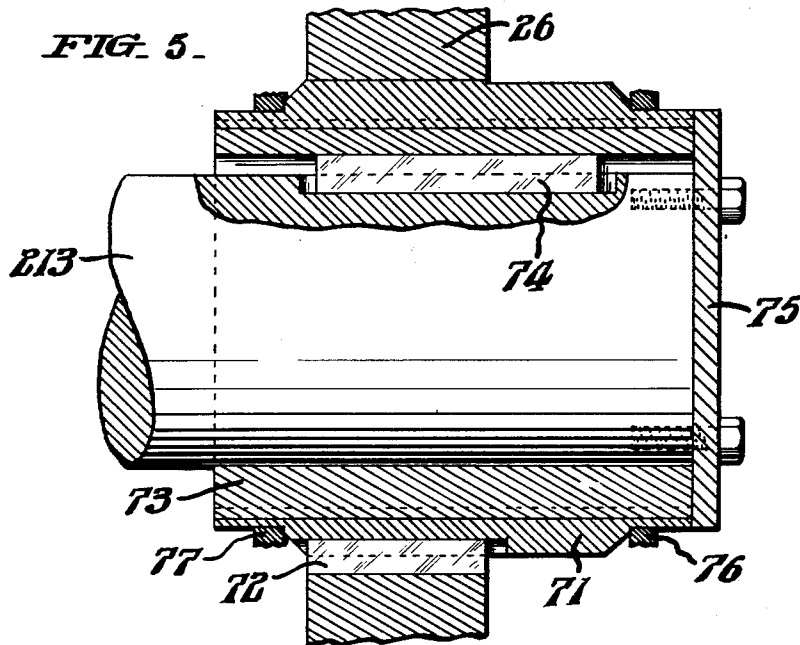
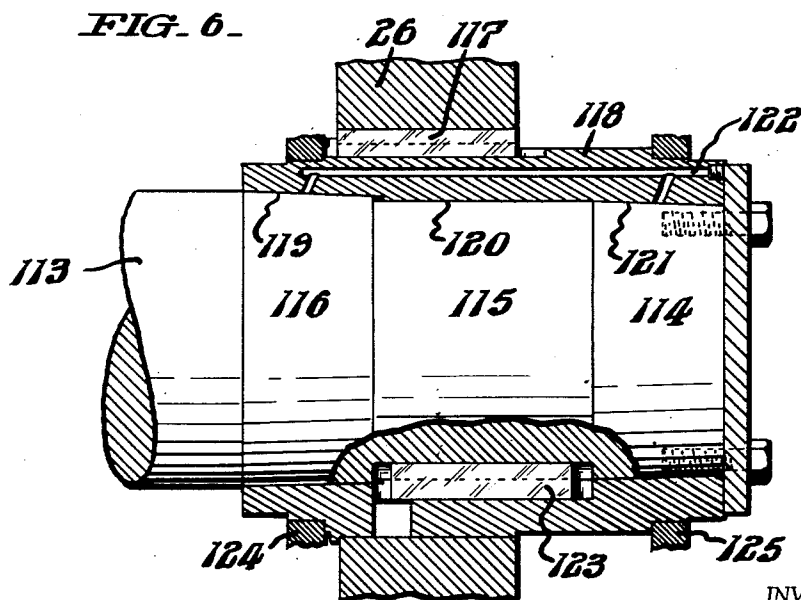
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MULTIPLE-INPUT SHAFT-MOUNTED DRIVE

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5 Claims. (Cl. 74-665)

This invention relates to an improved drive for driving rotationally very heavy load shafts. The new drive is especially suited, for example, for pivoting on their trunnion shafts the heavy refractory vessels or furnaces employed in the steel mills in the making of steel by the oxygen process.

Heretofore, drives for such steel-making vessels have employed large motors and large gear reduction units, and are conventionally floor mounted. During rotation, the center of rotation of the trunnion shaft tends to shift radially by a relatively small amount, a fraction of an inch or so, due to manufacturing tolerances, load, and other factors, thereby causing the rotating trunnion to have a slight eccentric movement. Such eccentric movement of the trunnion makes it difficult, if not impossible, to maintain satisfactory gear contact between the drive pinion and the driven main gear when mounted directly on the trunnion shaft. This difficulty has been overcome heretofore by interposing a coupling between the driven main gear and the trunnion shaft. Such couplings, however, are required to be very large and heavy, and are extremely expensive, for example, of the order of \$50,000 or so.

The principal object of the present invention is to provide a drive which is equally suitable for pivoting the above type of heavy vessel but considerably less expensive to install and to use than the prior art drive.

The foregoing object is achieved, in accordance with our present invention, by providing a multiple-input drive unit which is mounted directly on the trunnion shaft of the refractory vessel or furnace employed in the making of the steel. Such a shaft-mounted drive unit follows the eccentric movements of the shaft, and accordingly, the maintaining of good gear contact in the drive unit presents no problem. It is, however, necessary to provide means for preventing the drive unit from rotating about the trunnion shaft, and in accordance with the present invention, torque-restraining means for such purpose are provided. Such torque-restraining means are so designed as to allow for any eccentric movement of the trunnion-mounted drive unit caused by eccentric movement of the rotating trunnion shaft. Suitable mounting means are provided for mounting the drive unit on the trunnion shaft of the heavy steel-making vessel.

Our invention will become clear from a consideration of the following detailed description of one embodiment selected for illustration in the drawings, in which:

FIG. 1 is a side elevational view of the trunnion-mounted drive unit showing one of the torque-restraining units in section;

FIG. 2 is a top plan view of the drive unit of FIG. 1 with the housing cover removed;

FIG. 3 is a view, in section, along the staggered line III-III of FIG. 1, showing one of the multiple units of the drive and showing one arrangement for mounting the complete drive unit on the trunnion shaft;

FIG. 4 is a diagrammatic plan view, showing the relationship between the steel-making vessel and the trunnion-mounted drive unit;

FIG. 5 is a view, in section, of an alternate, and presently preferred, arrangement for mounting the main drive gear on the trunnion shaft; and

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FIG. 6 is a view, in section, showing still another way of mounting the main drive gear on the trunnion shaft.

In describing the preferred embodiment of the invention illustrated in the drawing, specific terminology has been resorted to for the sake of clarity. However, it is not our intention to be limited to the specific terms so selected, and it is to be understood that each specific term includes all technical equivalents which operate in a similar manner to accomplish a similar purpose.

Referring first to FIG. 4, reference numeral 10 depicts one of the large heavy vessels employed in the making of steel by the oxygen process. For example, such a vessel may have a diameter of about 22 feet and a height of about 28 feet. It may weigh about 450 tons empty, and close to 700 tons when filled with molten steel and slag. The vessel is in the form of a hopper or urn having a circular opening 11 at the top through which steel and slag material used in the steel-making oxygen process is delivered to the vessel, and through which the molten steel is poured at the completion of the process. To accomplish these operations, the vessel 10 is tilted about its horizontal axis; and for this purpose, the vessel is conventionally mounted on trunnion shafts 12 and 13 journaled in floor-based trunnion pedestals 14 and 15. Trunnion shafts 12 and 13 may, in a typical case, each have a diameter of 36".

According to our present invention, the drive unit 20 comprises a ring-like cluster of drive motors 35 and associated gear-reduction drives, to be described, all supported between the side members 37, 38 of the drive unit housing 40. The drive unit 20 is mounted on a hollow shaft or drive sleeve 21 which is splined or keyed or otherwise secured to and supported by the trunnion 13 of the steel-making vessel 10. Torque resistance is provided by a pair of oppositely disposed torque units 44 and 45 bolted or otherwise secured to the base or floor on which vessel 10 is situated.

Only one drive unit 20 will be required in many installations. In other installations, a second similar drive unit may be mounted on the other trunnion 12 on the opposite side of the vessel 10, as indicated in FIG. 4 by the dotted line representation. In the description which follows, only one of the trunnion-mounted drive units 20 will be described in detail. When used, the second drive unit is substantially identical to the first. Drive unit 20 may, in a typical case, weigh as much as 30 tons, but its weight is small relative to the total weight of the vessel 10, and the mounting of a single drive unit 20 on one side only, i.e., on one only of the trunnion shafts, introduces no particular problem due to weight unbalance.

The structural details of the drive unit 20 are shown in FIGS. 1-3. Sleeve 21 is a hollow steel shaft or drive sleeve which is fitted over the trunnion shaft 13 and splined or keyed or otherwise secured thereto. Other ways of mounting the drive unit on the trunnion shaft are shown in FIGS. 5 and 6 later to be described.

In the embodiment shown in FIG. 3, sleeve 21 is shown to be splined to the trunnion 13. Surrounding sleeve 21 and keyed thereto as by key 25 is the main output gear 26.

Sleeve 21 is mounted for rotation in the side members 37 and 38 of the housing 40 of the drive unit 20 by the roller bearing means 24 and 31. As illustrated in FIG. 3, the bearing means 24 and 31 are inclined inwardly and retained by suitable retaining means so as to exert an inward force relative to the main housing. The main housing 40 of the drive unit 20 is a huge drum-like structure which, unless retaining means were provided, would tend to bow out near the center region, i.e., at the rotation axis of the housing. In FIG. 3, the bearing 24 is shown to be retained by an annular spacer 16 and a retaining ring 17 shown bolted to the drive sleeve 21. Bearing 31 is similarly retained by the annular spacer

18 and by the retaining cap 19 which is bolted to the sleeve 21. Cover plates 22 and 23 cover the bearings 24 and 31, respectively. Reference numeral 42 depicts an oil seal.

Disposed at equal spacing along a circular loci outside the periphery of the output gear 26 are a plurality of intermediate shafts 27 mounted for rotation in housing side members 37 and 38 by the roller-bearing means 29 and 30. Keyed to each intermediate shaft 27 is an output pinion 28. Five shafts 27 and five output pinions 28 are shown in the cluster in the illustrated embodiment (FIG. 1).

Also keyed to each of the five shafts 27 is an input gear 32, there being five input gears 32 in the illustrated embodiment. Each of the five input gears 32 meshes with two input pinions 33, there being a total of ten input pinions 33 in the cluster in the illustrated embodiment.

Each of the ten input pinions 33 is keyed to a separate one of ten input shafts 39, the input shafts 39 being disposed at equal spacings along a circular loci outside the loci of the intermediate shafts 27. Each input shaft 39 is supported for rotation in housing side members 37 and 38, as by roller bearings 34.

Each of the ten input shafts 39 is driven by a separate drive motor 35 through a gear-reduction unit 36, the drive motors 35 and gear-reduction units 36 being illustrated as flange-mounted on the housing side member 38 of the drive unit 20. Other suitable mountings may, however, be used.

In a typical case, each of the drive motors 35 may be a 75 H.P. reversible motor; and each gear reducer 36 may be a double-reduction unit. The input pinions 33 and input gears 32 may have a gear-reduction ratio of 5:1; and the output pinions 28 and output gears 26 may also have a gear-reduction ratio of 5:1. The drive motors 35, driving through the overall speed reducing mechanism just described, drive sleeve 21 and trunnion shaft at from 1.00 to 1.75 revolutions per minute.

Torque-restraining units 44 and 45 are provided, one at each end of the drive-unit housing 40, for preventing the trunnion-mounted drive unit 20 from turning about the trunnion shaft 13 while nevertheless allowing the drive unit 20 sufficient freedom of movement so that it may follow any small eccentric movements of the trunnion shaft as it rotates. The torque-restraining units 44 and 45 are substantially identical, so that it will be necessary to describe but one of the units.

As illustrated in FIG. 1, torque-restraining unit 45 is mounted on a pedestal 48 constructed of steel or other suitable material and secured to a concrete or other foundation 49. Unit 45 includes a pillow block 50 having a base 51 and an upper portion in the form of a retaining collar 52. Base 51, which is bolted to the pedestal 48, has a semi-spherical recess for receiving the spherical head of the lower torque pin 47. After the pin 47 has been placed in the base 51, the retaining collar 52 is bolted to the base 51, thereby to hold captive the spherical head of the lower torque pin 47. The diameter of the central hole of the retaining collar 52 is made larger than the diameter of the shank of the lower torque pin 47 so as to allow limited pivotal movement of the lower torque pin in any direction.

The upper torque pin 46 is mounted in a manner inverted but otherwise generally similar to that of the lower torque pin. The housing 40 of the drive unit 20 is provided with a horizontal cross member 53 connecting the housing side members 37 and 38, and to the cross member 53 is bolted or otherwise secured the inverted pillow block base 54 having a semi-spherical recess for receiving the spherical head of the upper torque pin 46. An inverted retaining ring 55 is bolted to the pillow block base 54 for holding the spherical head of pin 46 captive. The internal diameter of retaining ring 55 is larger than the diameter of the shank of pin 46 so as to allow limited pivotal movement of the torque pin.

The end portion of the lower torque pin 47 is of reduced diameter, forming a shoulder against which a heavy washer 56 is placed. The washer 56 forms a base for compression spring 57. Spring 57 may be a heavy coil compression spring but is preferably, as shown in FIG. 1, formed of a plurality of heavy dished washers arranged in opposing relation. The dished washers of spring 57 are held under compression by means of an upper flat washer 58 and a retaining nut 59. Covering the dished-washer spring 57 structure just described is a bell-shaped cap nut 60 to the undersurface of which is bolted an annular plate 61. The central hole of plate 61 has a diameter larger than that of the full shank diameter of the lower torque pin 47 to allow pivotal movement of the pin. The upper or apex portion of the cap nut 60 is provided with a threaded hole for receiving the threaded end portion of the upper torque pin 46. A retaining nut 62 holds the torque pin 46 fixed relative to cap nut 60. The inner surface of cap nut 60 is characterized by a lower larger cavity and an upper smaller cavity, forming therebetween a shoulder against which the washer 58 is retained against upward movement.

It will be seen, in FIG. 1, that when the left end of the drive unit 20 tends to move upward, the cap nut 60 pulls the lower retaining washer 56 of the spring 57 upward, tending to compress the spring against the upper retaining washer 58 which is prevented from moving upward by the nut 59. Thus, spring 57 tends to be compressed and a reaction force is set up which opposes the upward movement. Similarly, if the left end of the drive unit 20 tends to move downward, the upper retaining washer 58 tends to be pushed down by the internal shoulder of the cap nut 60. The lower retaining washer 56 is prevented from moving downward by the shoulder on the shank of the lower torque pin 47 and thus the spring 57 tends to be compressed. A reaction force is thereby established which tends to oppose the downward movement of the left end of the drive unit 20.

While the units 45 and 44 provide torque restraint, as just described, these units nevertheless allow limited movement of the drive-unit housing in any horizontal direction. Thus, the drive unit 20 is allowed to move sufficiently to follow any eccentric movements of the trunnion shaft on which it is mounted.

Referring now to FIG. 5, this figure shows an alternate and presently preferred form of connection for mounting the drive unit 20 on the trunnion shaft. In the form shown in FIG. 5, the main output gear 26 is keyed to an internally splined sleeve 71, as by key 72, and an externally splined adapter sleeve 73 is keyed to the trunnion shaft 213, as by key 74. A retaining plate 75 is bolted to the end of the trunnion shaft. The reference numerals 76 and 77 depict fragments of the bearing means in which the drive sleeve 71 rotates. The form of mounting shown in FIG. 5 wherein the splined drive sleeve 71 of the drive unit 20 is slid onto the splined adapter sleeve 73 of the trunnion allows greater flexibility than in the case of FIG. 3 wherein the drive sleeve is splined directly to the trunnion shaft.

FIG. 6 shows still another way in which the drive unit 20 may be mounted on the trunnion shaft. In this form, the trunnion shaft 113 is tapered at the extreme end portion 114. Immediately behind the tapered end portion 114 is a flat portion 115 followed by a second tapered portion 116. The output gear 26 is keyed, as by key 117, to a drive sleeve 118 having a bore which has a tapered end portion 119 and rearward thereof a smaller diameter flat portion 120 followed by a tapered portion 121. The tapered portions 119 and 121 of the sleeve 118 form a tight fit with the tapered portions of the trunnion shaft 113. The flat portion 120 of the sleeve forms a slip fit with the flat portion 115 of the trunnion. The sleeve 118 is provided with a passage-way 122 leading to each of the tapered portions for applying hydraulic fluid to the tapered surfaces during instal-

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lation of the sleeve 118 onto the trunnion shaft 113. The flat portion 115 of the trunnion shaft is keyed to the sleeve 118 by key 123. Fragments of the bearing means in which the sleeve 118 rotates are depicted in FIG. 6 and identified by the reference numerals 124 and 125.

While preferred embodiments of this invention have been described in some detail, it will be apparent to one skilled in the art that various modifications may be made without departing from the invention as hereinafter claimed.

Having described our invention, we claim:

1. Shaft-mounted drive means for driving rotationally a shaft journaled for rotation in base support means; said drive means comprising: a drive sleeve connected to and supported by the shaft to be driven; a housing encircling, rotatably mounted on, and supported solely by, said drive sleeve and shaft to be driven; a main drive gear within said housing encircling, secured to, and supported by, said drive sleeve; a plurality of intermediate shafts supported in said housing at regularly spaced intervals along a circular path, said intermediate shafts supporting a plurality of output pinions mounted in a ring-like cluster about said main drive gear and in mesh therewith at regularly spaced intervals, each intermediate shaft also supporting an input gear secured to and mounted for rotation with each output pinion; a plurality of input shafts supported in said housing at regularly spaced intervals along a circular path larger in diameter than said first-mentioned circular path, said input shafts supporting a plurality of input pinions mounted in a ring-like cluster about said input gears and in mesh therewith at regularly spaced intervals; a plurality of drive motors supported on said housing at regularly spaced intervals along said larger circular path, there being one drive motor coupled to each input pinion; anchor means at opposite ends of said housing; and resilient torque-re-

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straining means coupling each end of said housing to said anchor means for preventing rotation of said housing about said drive sleeve when said drive motors are energized to drive rotationally said shaft.

2. Apparatus as claimed in claim 1 further characterized in that said torque-restraining means includes pivotal means connected to spring means for allowing limited universal movement of said housing.

3. Apparatus as claimed in claim 2 further characterized in that said pivotal means comprises ball-and-socket means.

4. Apparatus as claimed in claim 3 further characterized in that first ball-and-socket means connect said spring means to said housing and second ball-and-socket means connect said spring means to said anchor means.

5. Apparatus as claimed in claim 4 further characterized in that retaining means are provided for retaining the housing in the region of said drive sleeve against outward movement in the axial direction of said sleeve.

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