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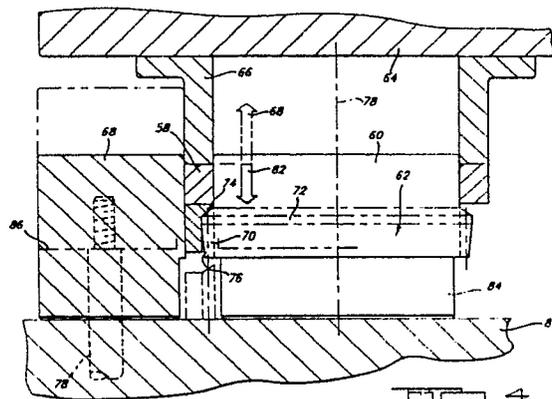
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(54) **Cold extrusion process for internal gear teeth.**

(57) A cold extrusion process for forming internal gear teeth comprising machining an internal ring gear blank (58) with precision internal and external diameters, mounting the ring on a pilot diameter of a mandrel (62) on which is formed external die teeth (70) having a metal forming region, a metal guiding entrance region and a tapered metal flow exit region, mounting a support ring (68) around the mandrel (62) and the workpiece (58) and pressing the workpiece through the support ring and through the die teeth (70) in sequential steps, the initial step resulting in formation of internal teeth in the workpiece (58) for a substantial axial length of the workpiece and the following step resulting in forcing a subsequent blank against the workpiece (58) by the press (64) which results in full internal tooth formation, the

finished gear being removable as the support ring (68) and mandrel (62) are retracted to the original position and as a subsequent workpiece is loaded on the pilot diameter of the mandrel (62).



EP 0 354 682 A2

COLD EXTRUSION PROCESS FOR INTERNAL GEAR TEETH

The invention relates to an internal ring gear extension. It is adapted especially for the manufacture of ring gears for use in automotive vehicle transmissions. It is usual practice in the manufacture of such ring gears to broach or shape a ring gear workpiece, the workpiece being a ring formed from tubular stock. The broaching or shaping operation is followed by a by heat treatment. These operations are relatively slow; and they are relatively costly because of the high cost of the required machine tools, accessory equipment and tool maintenance.

The improved process has some characteristics that have been disclosed in U.S. patent 3,910,091 and 4,622,842, which are assigned to the assignee of this invention. Patent 3,910,091, for example, describes an extrusion process for forming pinions for external gear teeth. The pinion blank in that process is extruded through a die having internal die teeth. The die teeth are provided with a lead-in edge, an abbreviated metal forming region that forms the involute shape of the external gear teeth and a recessed relieved portion, the latter allowing the formed gear blank to pass through the die. Patent '091 describes also method steps for sequentially loading the gear blanks whereby a press acting on one gear blank forces a preceding gear blank through the die until it is ejected at the trailing edge of the die teeth.

According to the present invention there is provided an internal ring gear extrusion process comprising the steps of, mounting a mandrel with a cylindrical pilot portion in alignment with a die press punch in the form of a sleeve, preparing an annular workpiece with predetermined inside and outside diameters, mounting said workpiece over said pilot portion, said mandrel having metal forming die teeth, said die teeth having a metal forming portion between a lead-in tapered portion and a relief portion, the outside diameter and tooth thickness of said relief portion being reduced relative to said metal forming portion, advancing said punch toward said mandrel until a major portion of the axial length of said workpiece is extruded through said die teeth, withdrawing said punch away from said workpiece and inserting another workpiece adjacent the aforesaid workpiece, and advancing again said punch to complete the extrusion of the teeth of the aforesaid workpiece as the other workpiece forces the aforesaid workpiece through said die teeth.

The improved method of this invention makes it possible to use an extrusion process in the manufacture of high quality, precision internal tooth ring gears. The method is adaptable for either steel

or aluminium materials. In some applications the loading of the gear teeth is such that it is possible to use aluminium stock, rather than steel stock. The improved process also provides tooth length during one stroke of said punch and wherein provides for improved quality consistency, and it eliminates material volume loss because no metal cutting is required to form the extruded teeth. If additional accuracy or surface finish are required in a particular application, the extruded gear can be finished machined by roll finishing, shaving or by using various grinding techniques known in the art.

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

Figure 1 shows in schematic form an automatic transmission gear system having a ring gear wherein the ring gear is capable of being manufactured by my improved gear extrusion process.

Figure 2 is a chart that shows the engagement and release pattern of the clutches and brakes of the transmission in Figure 1.

Figure 3 is a cross-sectional view of a portion of the gearing illustrated schematically in Figure 1 including a ring gear that may be made using my improved manufacturing process.

Figure 4 is a cross-sectional view of a press and die assembly, together with a workpiece that is being extruded using my improved manufacturing process. Portions of the assembly at the right side of the view are not shown.

For the purpose of describing a typical environment for a ring gear manufactured by the invention, there is shown a gear system in Figure 1 having a ring gear 10. In the particular embodiment shown in Figure 1, ring gear 10 is stressed with relatively low gear tooth forces relative to the other planetary gear elements of the system. It is possible, therefore, for the ring gear 10 to be extruded from aluminium alloy stock material, rather than steel stock. I contemplate, however, that the process of my invention may be adapted for use in extruding steel as well as aluminium.

In the structure of Figure 1 a hydrokinetic torque converter 12 has an impeller 14 connected to an engine, and a turbine 16 which distributes torque to turbine shaft 18 and to the carrier 20 of a first planetary gear unit 22. Sun gear 24 of the gear unit 22 can be braked by friction brake 27. Ring gear 26 of gear unit 22 is adapted to be clutched by friction clutch 28 to the sun gear 24 to effect a 1:1 drive ratio to the gear unit 22. An overrunning coupling 30, which complements the action of the clutch 28, is in parallel disposition with respect to the clutch 28.

Torque can be distributed with a 1:1 driving ratio with respect to the input torque. When the gear unit 22 is locked up, turbine torque is received by intermediate shaft 32 which is adapted to be connected to the common sun gears 34 by friction clutch 36. Sun gears 34 form a part of simple planetary gear units 38 and 40. Clutch 36 is engaged during third speed ratio operation and fourth speed ratio operation, the latter being an overdrive. It is engaged also during reverse drive operation.

Sun gears 34 can be braked by friction brake 42 during operation in the fourth speed ratio. Torque is distributed to brake 42 through overrunning coupling 44 arranged in series with brake 42.

Shaft 32 is adapted to be connected to the ring gear 46 of planetary gear unit 38 through clutch 48, which is the forward drive clutch. It is engaged during operation in each of the forward drive ratios.

During reverse drive brake 50 is applied. This anchors the carrier 52 of planetary gear unit 40.

Carrier 54 of planetary gear unit 48, as well as ring gear 10 of gear unit 40, are connected to output shaft 56.

In the chart of Figure 2 the "X" marks designate an engaged clutch or brake and the blanks designate a released state for the clutches and brakes. It is apparent from Figure 2 that ring gear 10 is subjected to a relatively low level of torque during reverse drive operation because the input torque delivered to the gear set 40 drives the sun gear of the planetary gear unit 40 during operation in the first gear ratio. The torque to which the ring gear 10 is subjected is, therefore, relatively low because in that instance a split torque delivery is effected through the planetary gear units 38 and 40. Only a portion of the torque being distributed from the ring gear 10 to the output shaft 56 while the balance of the torque is distributed from the carrier 54 to the output shaft 56. The ring gear 10 then is a perfect candidate for the extrusion process of my invention using aluminium material rather than steel.

Figure 3 is a cross-sectional view of an actual embodiment of a portion of the gear mechanism of Figure 1. A complete description of Figure 3 is not necessary since the ring gear 10 is a principal element that relates to the improvements of my invention. For purposes of understanding Figure 3, reference numerals are used in the illustration of the actual cross section of Figure 3 and in the schematic representation of Figure 1.

In Figure 4 the structure that is used during the extrusion process is shown. It includes a first workpiece 58 that is machined with a precise inside diameter and a precise outside diameter. It is positioned as shown prior to a cold forming operation.

The workpiece 58 may be machined from tubular stock. It is provided with a precise internal

diameter to effect a precise fit over the pilot portion 60 of a mandrel 62.

A press 64, which may be a hydraulic press, includes a sleeve portion 66 that can be moved vertically in the direction of the arrow. This provides clearance to permit loading of the workpiece 58 for registry with the mandrel portion 60.

A die support ring 68 surrounds the mandrel and the workpiece during the extrusion process. This support ring has an internal diameter precisely matching the external diameter of the workpiece.

The mandrel 62 has die teeth 70 which comprise a major diameter portion 72, a lead-in tapered portion 74 and a relief portion 76. The die teeth spaces assume the shape of the finished gear teeth, which preferably involute teeth. The die teeth extend axially with respect to the centre line of the mandrel. The tangential thickness of the teeth of the die decrease progressively as measurements are taken at progressively lower points on the die teeth. The height of the die teeth are relieved to form a tapered relief section 76.

When the press is actuated, the extrusion forces are of considerable magnitude. For example, 240 tons is a typical force required for SAE 5130 steel.

The die ring 68 is a compression ring. It is raised and lowered by lower pressure operated cylinders, not shown, which include cylinder rods 78. The die ring 68 and the mandrel 62 are positioned on a firm bed 80 for the press. The sleeve 66 acts as a punch. It is carried by the ram portion of the press in the direction 10 the arrow 82 during the extrusion process.

In forming the workpiece 58, the outside diameter is machined to match the support ring 68. The inside diameter corresponds to the minor diameter of the gear tooth part. A shortened gear tooth length is determined by computing the volume of the tooth space material that is displaced and converted into axial growth during the extrusion process.

The blank is precisely machined to maintain concentricity requirements. For example, inside diameter to outside diameter runout must be carefully controlled since this determines the pitch diameter concentricity of the finished part. For optimum lubrication during extrusion the blank may be coated with zinc phosphate and soap. It also may be tumbled, 25 desired, with molybdenum disulphide.

During operation with the ram and the punch in its upward position, blank 58 is loaded by placing it over the pilot diameter portion 60 of the mandrel. During its downward travel the punch axially forces the blank into the entrance ramp 74 and the tooth area of the mandrel. It stops, in a preferred embodiment of my invention, about .06 inches short of

contact of the teeth of the mandrel. This leaves a blank configuration as shown by reference character 58'. When in the position shown, the blank is retained in place with high friction between the mandrel and the die ring as the punch retracts to its upward position.

Following the preceding steps another blank is inserted in the same fashion and is loaded into the position previously occupied by the first blank in piggy back relationship. Downward motion of the punch then forces the second blank against the partially extruded first blank until the latter is extruded the final distance through the dies teeth. It then is free to drop into the recess area 84 as a fully extruded internal ring gear.

As the punch is retracted, air cylinder rods 78 raise in unison the entire die ring, blank and mandrel system to the level designated by reference character 86 thus providing access for an automated robot, for example, to grab and slide the extruded gear from the confines of the tooling. After ejection of the gear, the air cylinders return the die cylinder to the original position to accept the loading of the next blank.

The mandrel itself is floating and self-centring. It is, therefore, capable of accommodating any eccentricity that may be built into the machined blank. Because of the continuous high frictional contact exerted by the partially extruded blank when it is in the position designated by reference character 58', the composite assembly of the ring, the blank and the mandrel may function as a unit during workpiece ejection.

If the teeth of the die are helical teeth, the finished part is a helical gear with internal helical teeth. The mandrel may rotate slightly due to its free floating characteristic to accommodate the displacement in a rotary direction due to the helix angle of the teeth.

The relief portion 76 of the teeth prevent spalling of the metal, during the extrusion of the teeth, at the major diameter portions 72 of the die teeth. It also eliminates unnecessary forces because of the reduced friction resulting from the relief of the teeth.

Claims

1. An internal ring gear extrusion process comprising the steps of, mounting a mandrel (62) with a cylindrical pilot portion (60) in alignment with a die press punch (66) in the form of a sleeve, preparing an annular workpiece (58) with predetermined inside and outside diameters, mounting said workpiece (58) over said pilot portion (60), said mandrel having metal forming die teeth (70), said die teeth having a metal forming portion (72) between a

lead-in tapered portion (74) and a relief portion (76), the outside diameter and tooth thickness of said relief portion (76) being reduced relative to said metal forming portion, advancing said punch (66) toward said mandrel (62) until a major portion of the axial length of said workpiece is extruded through said die teeth, withdrawing said punch (66) away from said workpiece (58) and inserting another workpiece adjacent the aforesaid workpiece, and advancing again said punch (66) to complete the extrusion of the teeth of the aforesaid workpiece as the other workpiece forces the aforesaid workpiece through said die teeth.

2. A process as claimed in Claim 1, which further comprises raising said mandrel, workpiece and die ring in unison following sequential extrusion of each workpiece to permit removal of the finished, extruded part.

3. A process as claimed in Claim 1 or 2, wherein said workpiece teeth are extruded for an axial length substantially greater than one-half of the gear tooth length during one stroke of said punch and wherein the extrusion is completed during the next stroke of said punch.

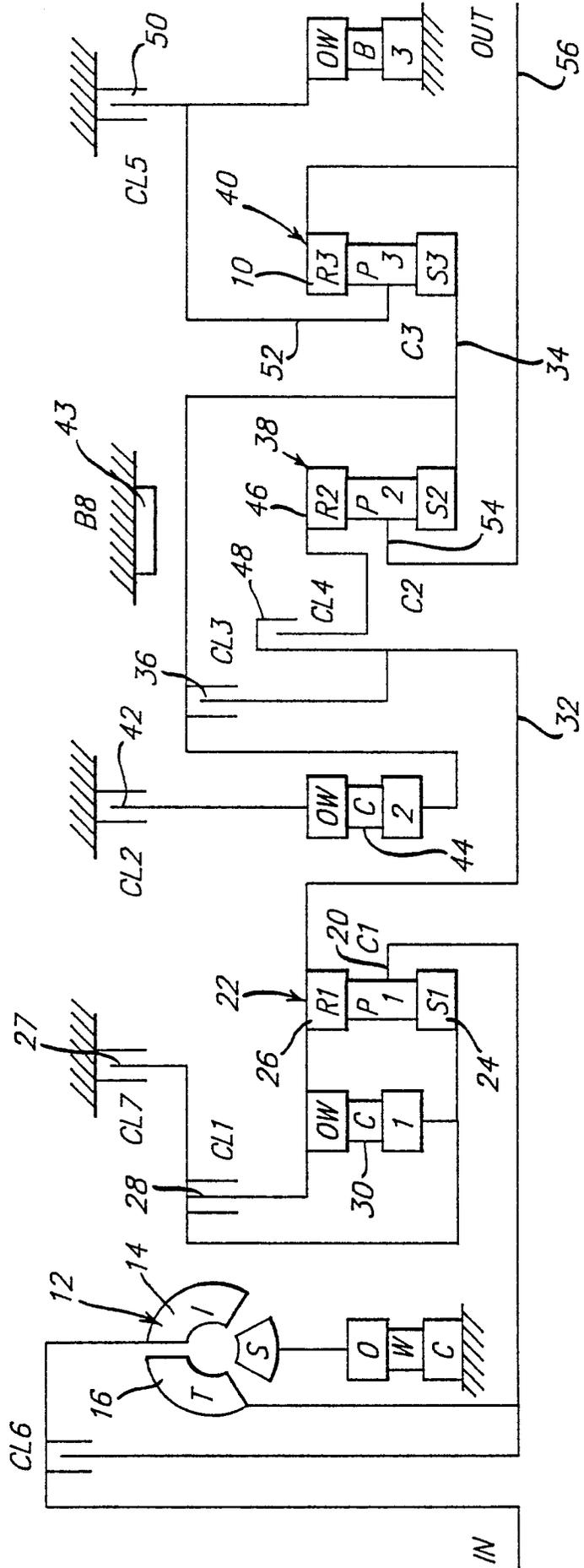


FIG. 1.

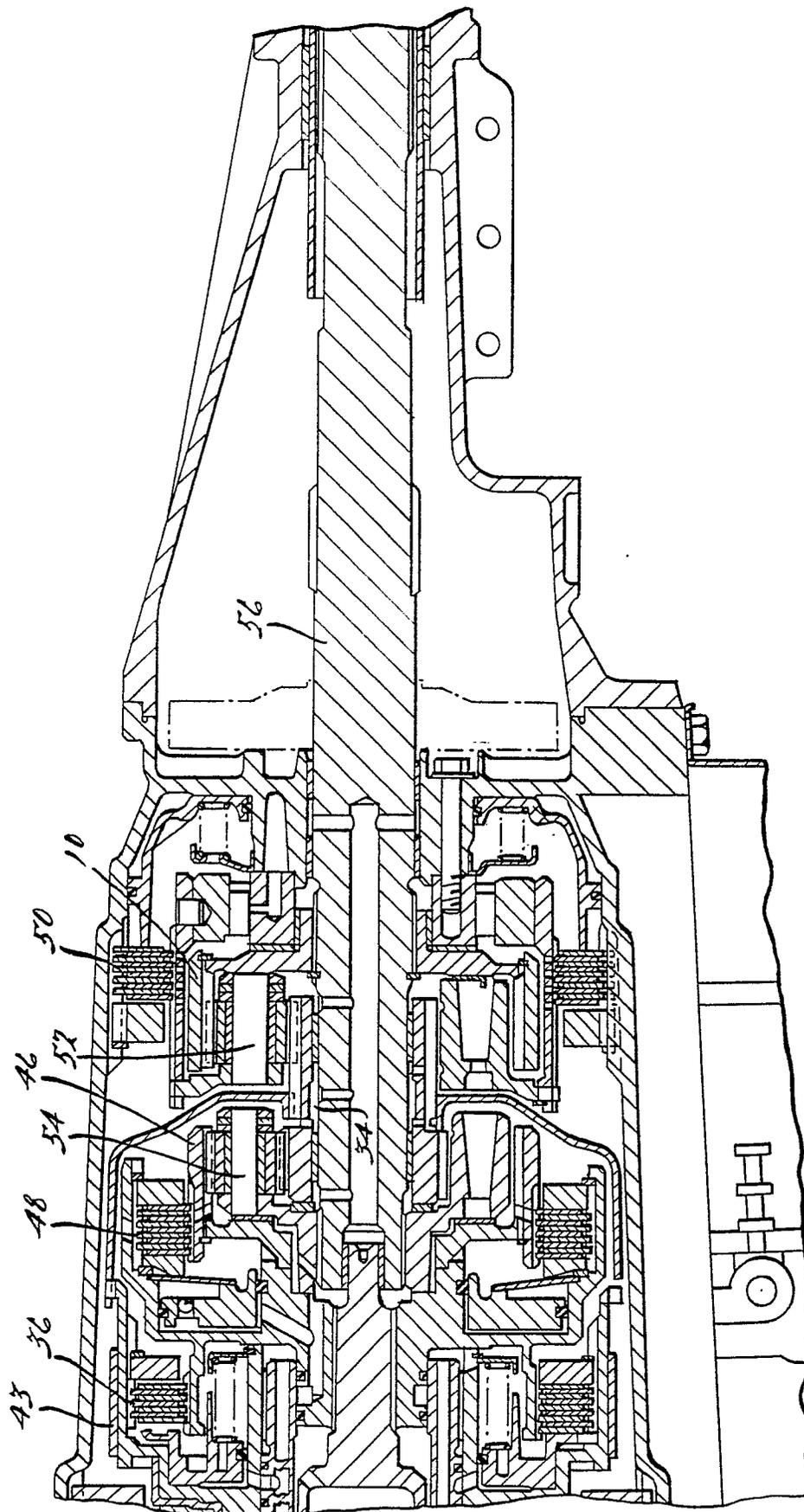


FIG. 2.

