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(54) **HIGH SPEED NECKING CONFIGURATION**

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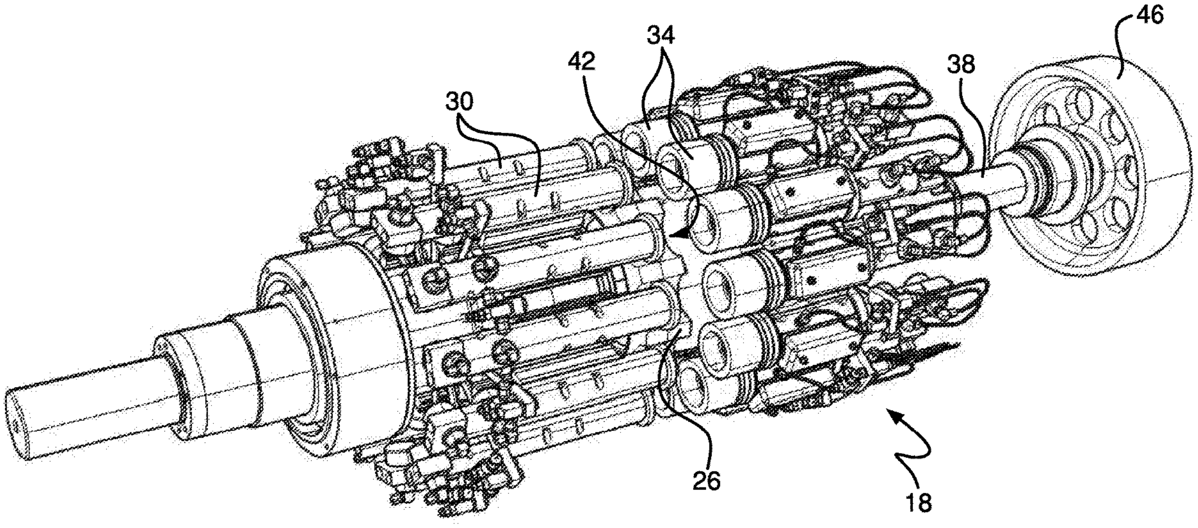
(57) **ABSTRACT**

A horizontal can necking machine assembly includes a plural of main turrets and a plural of transfer starwheels. Each main turret includes a main turret shaft, a main gear mounted on the main turret shaft, a pusher assembly, and a die capable of necking a can body upon actuation of the turret shaft. Each transfer starwheel includes a transfer shaft and a transfer gear mounted on the transfer shaft. The main gears are engaged with the transfer gears such that lines through the main gear center and the centers of opposing transfer gears form an included angle of less than 170 degrees, thereby increasing the angular range available for necking the can body. The main turrets and transfer starwheels may operate to neck and move at least 2800 cans per minute, and each pusher assembly may have a stroke length relative to the die that is at least 1.5 inches.



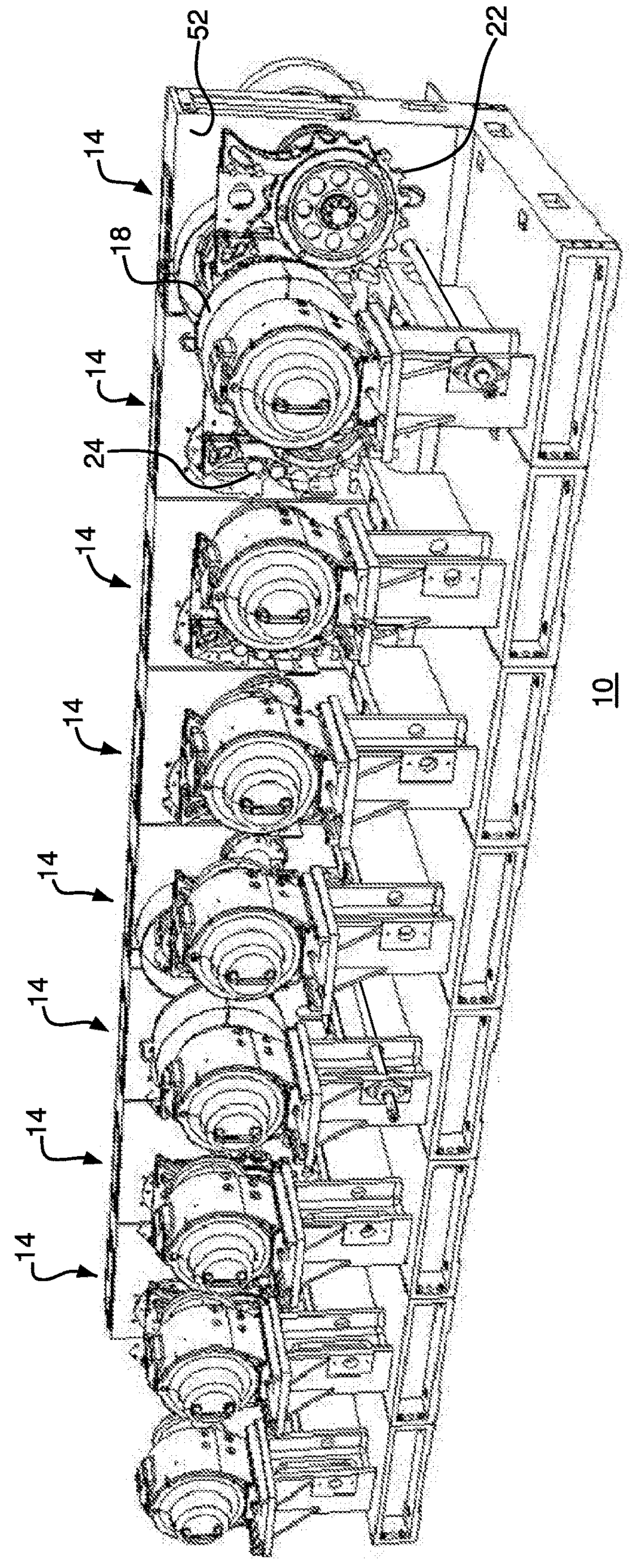


FIG. 1

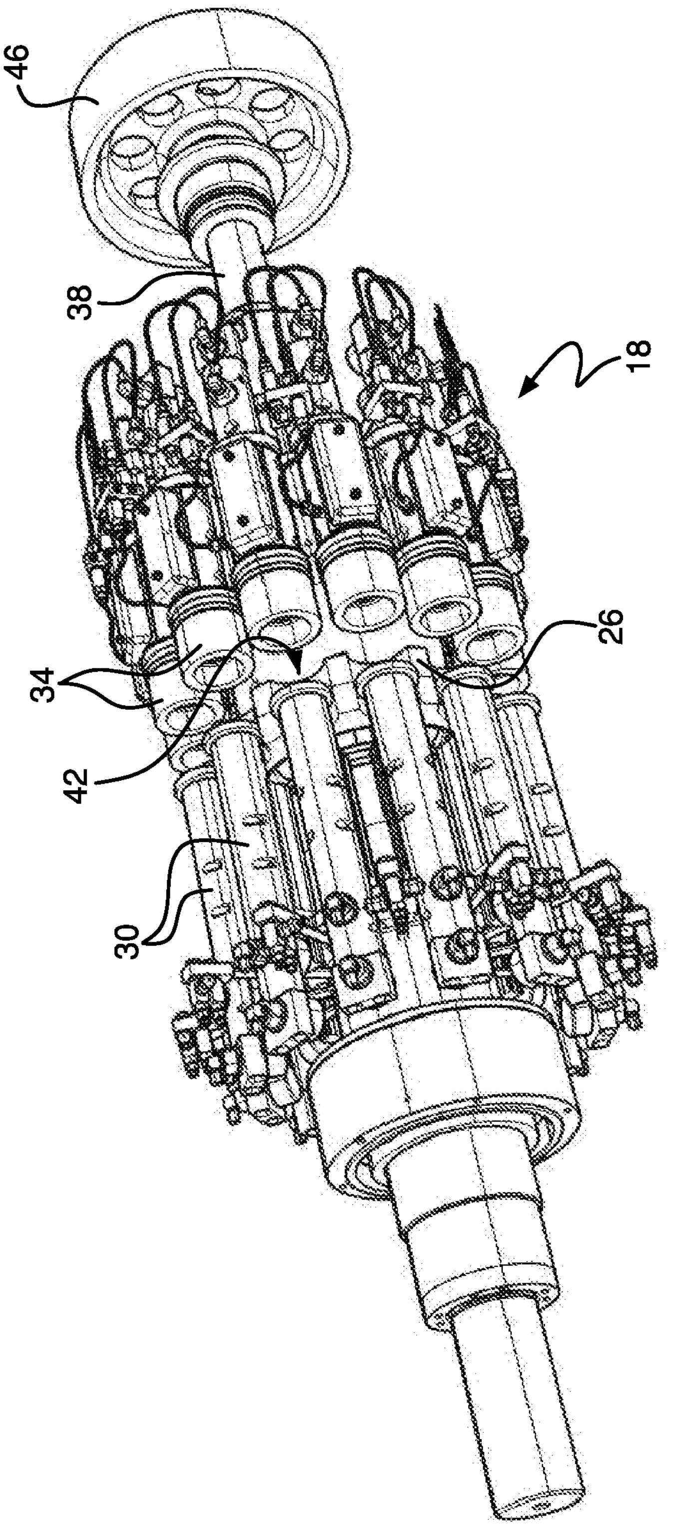


FIG. 2

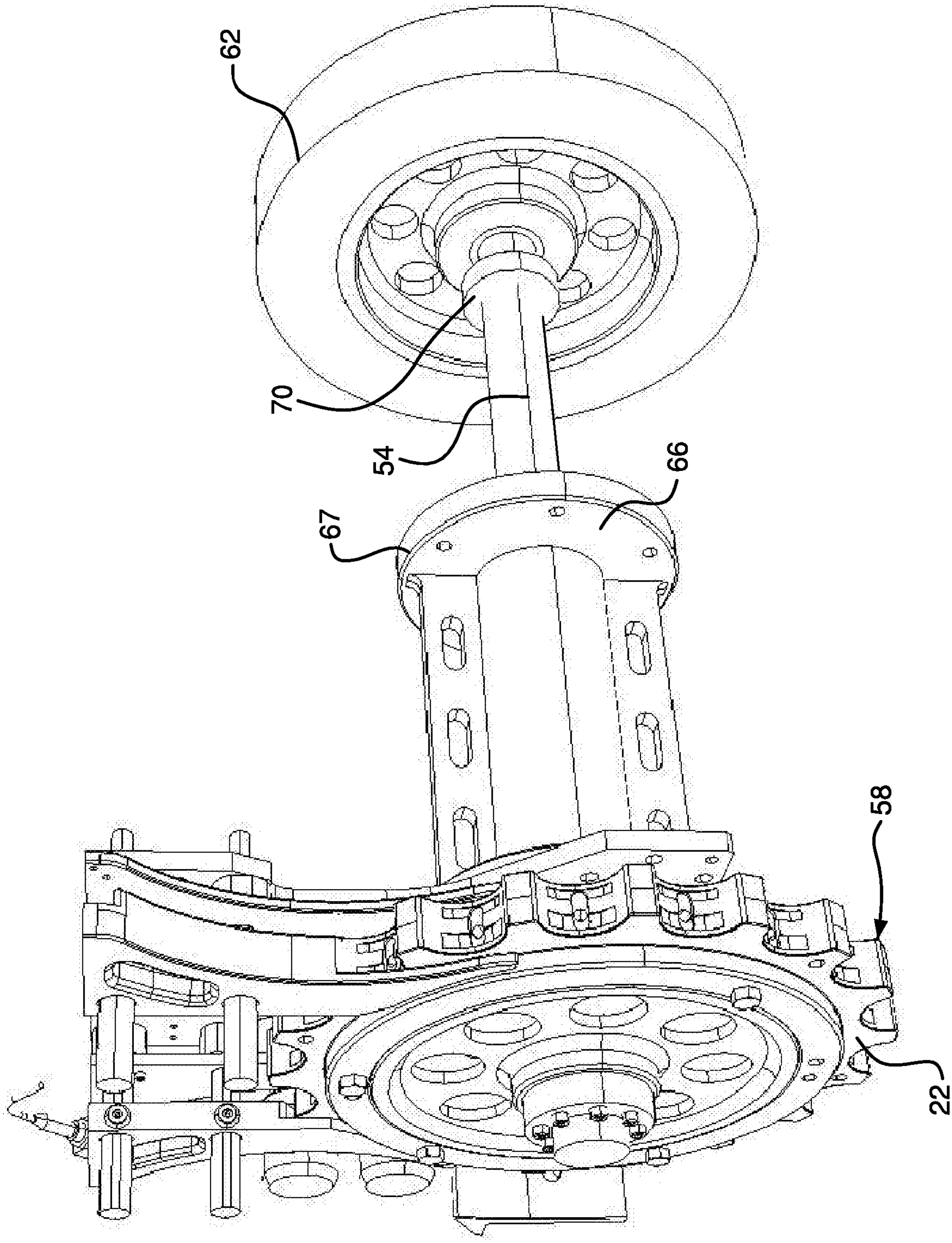


FIG. 3

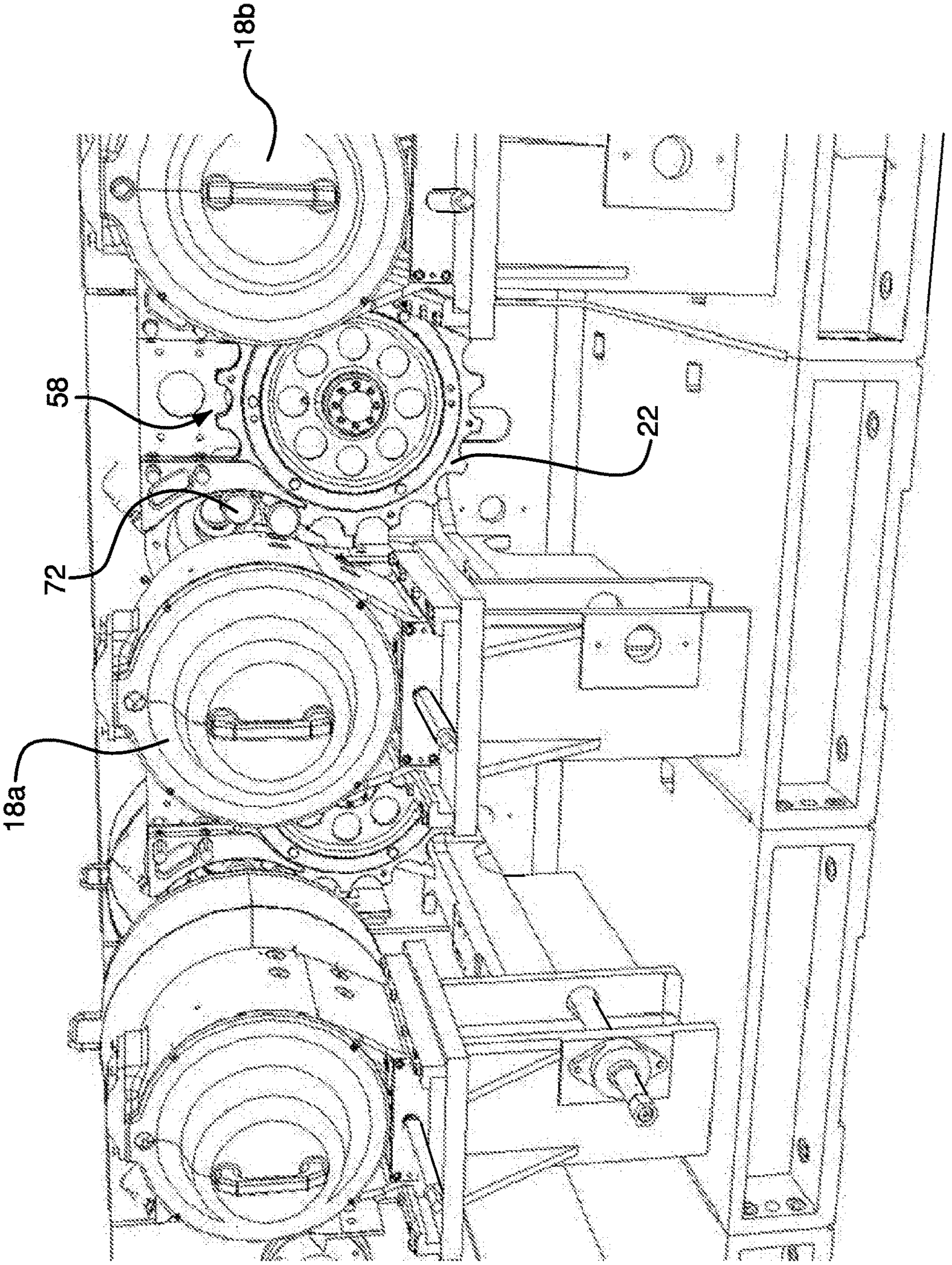


FIG. 4

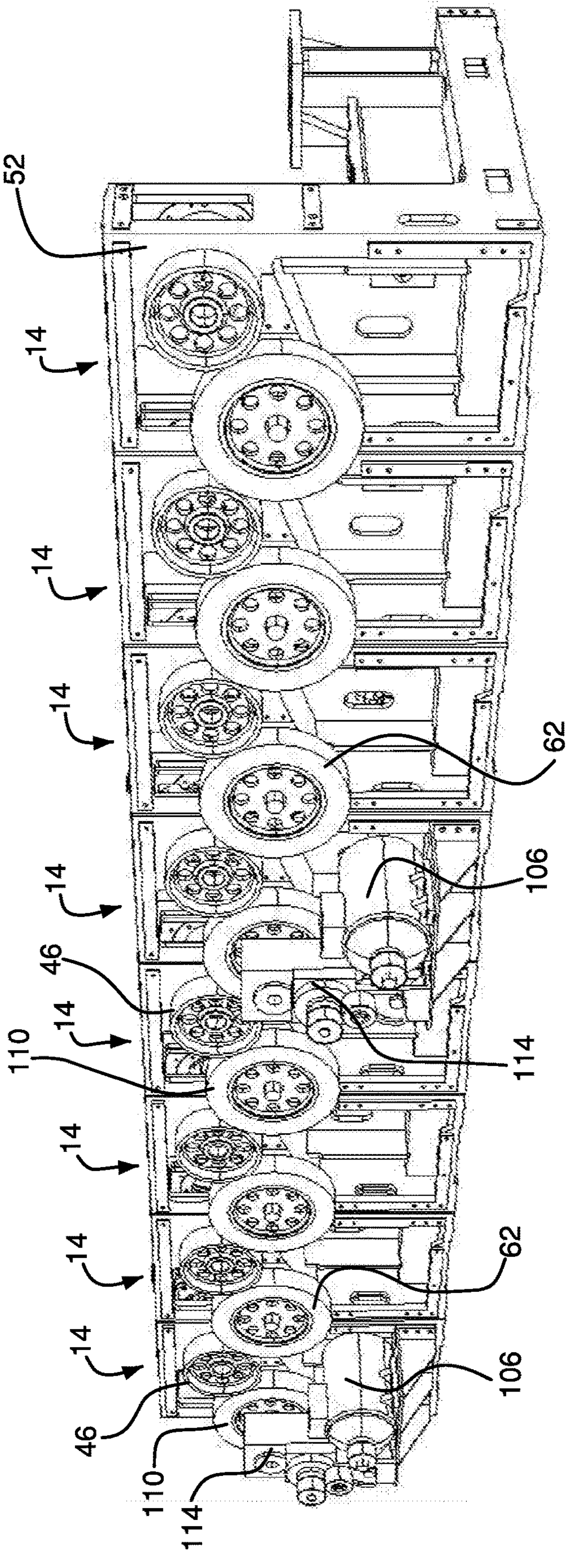


FIG. 5

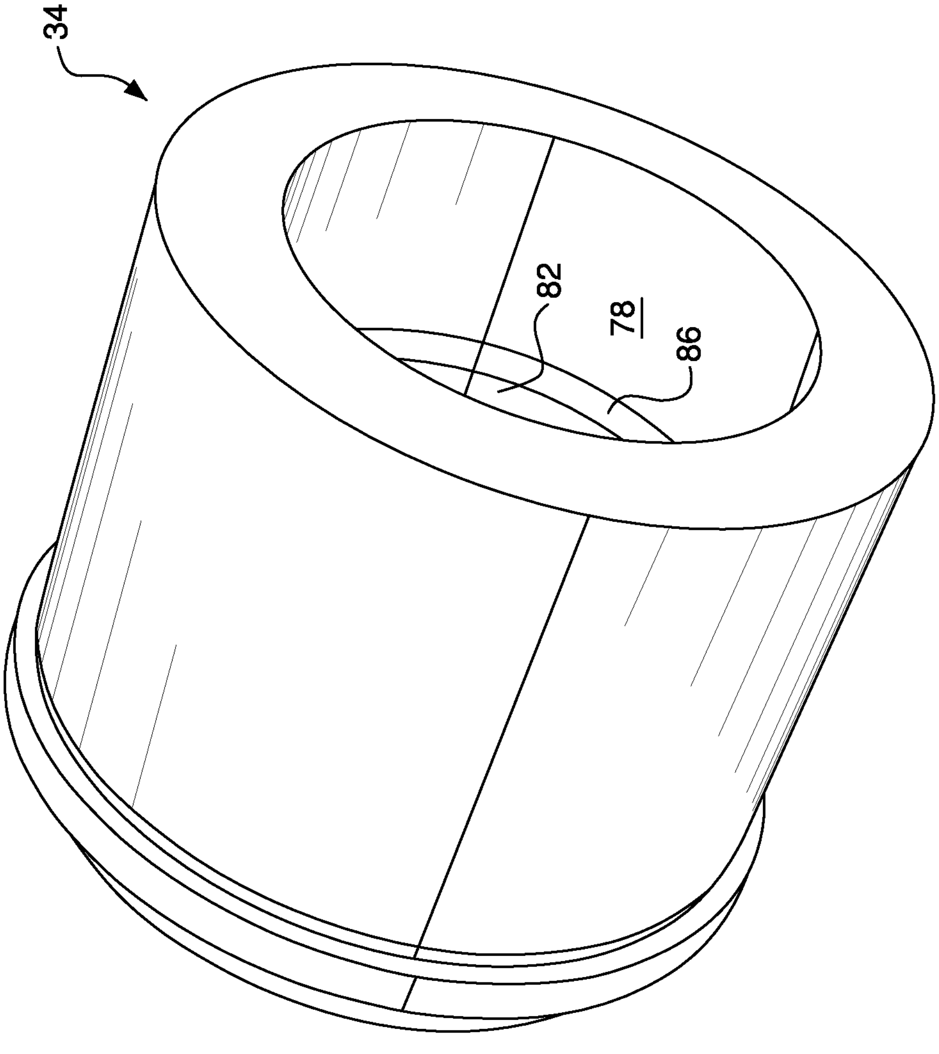


FIG. 6A

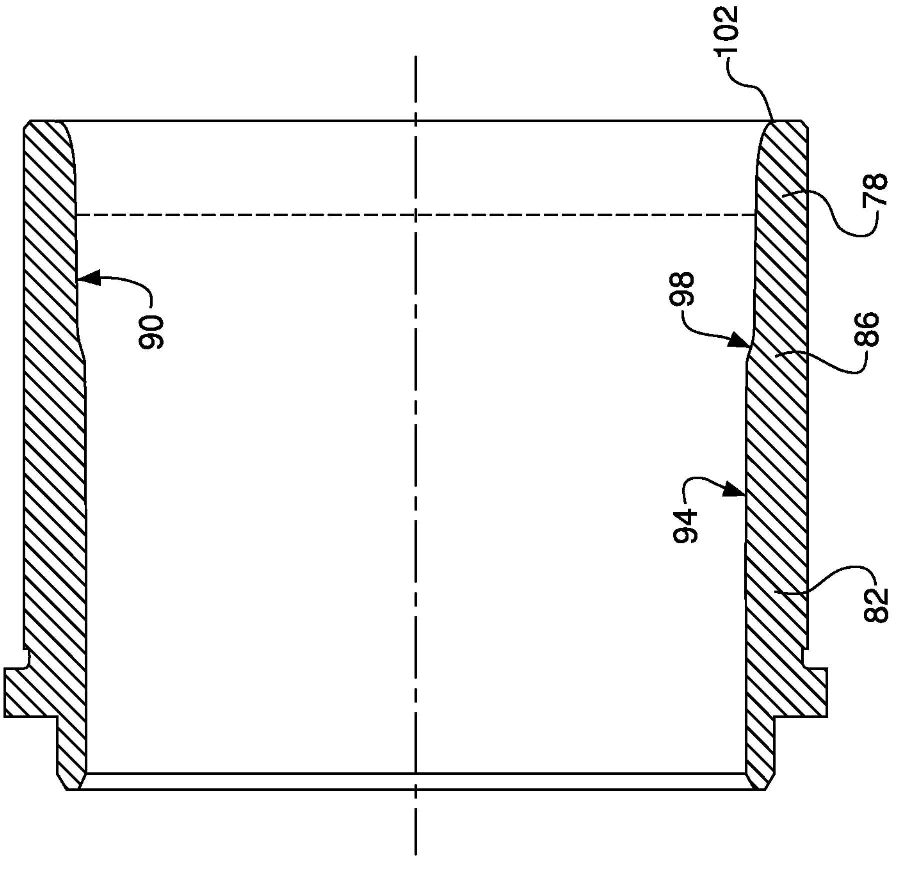


FIG. 6B

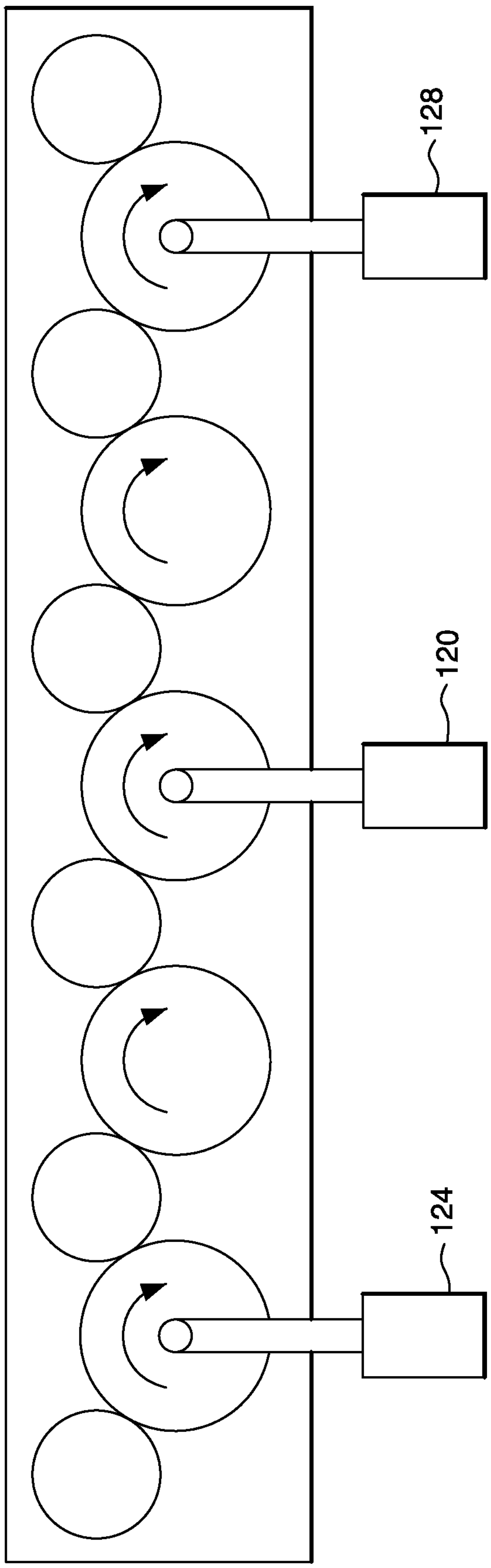


FIG. 7

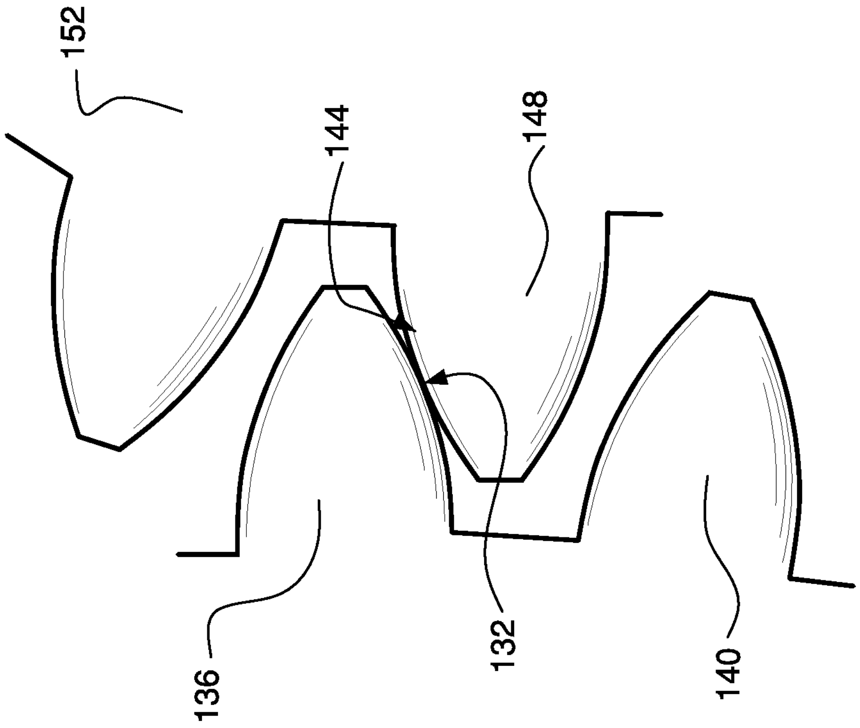


FIG. 8

HIGH SPEED NECKING CONFIGURATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of application Ser. No. 15/928,984, filed Mar. 22, 2018, which is a continuation of application Ser. No. 15/088,691, filed Apr. 1, 2016, which is a continuation of application Ser. No. 14/070,954, filed Nov. 4, 2013, now U.S. Pat. No. 9,308,570, which is a continuation of application Ser. No. 12/109,176, filed Apr. 24, 2008, now U.S. Pat. No. 8,601,843, and is related by subject matter to the inventions disclosed in the following commonly assigned applications: U.S. patent application Ser. No. 12/109,031, filed on Apr. 24, 2008 and entitled "Apparatus For Rotating A Container Body", now issued U.S. Pat. No. 7,997,111, U.S. patent application Ser. No. 12/108,950 filed on Apr. 24, 2008 and entitled "Adjustable Transfer Assembly For Container Manufacturing Process", now U.S. Pat. No. 8,245,551, U.S. patent application Ser. No. 12/109,058, filed on Apr. 24, 2008 and entitled "Distributed Drives for A Multi-Stage Can Necking Machine", now U.S. Pat. No. 8,464,567, U.S. patent application Ser. No. 12/108,926, filed on Apr. 24, 2008 and entitled "Container Manufacturing Process Having Front-End Winder Assembly", now U.S. Pat. No. 7,770,425, and U.S. patent application Ser. No. 12/109,131, filed on Apr. 24, 2008 and entitled "Systems And Methods For Monitoring And Controlling A Can Necking Process," now U.S. Pat. No. 7,784,319. The disclosure of each application is incorporated by reference herein in its entirety.

FIELD OF THE TECHNOLOGY

[0002] The present technology relates to a multi-stage can necking machine. More particularly, the present technology relates to a horizontal multi-stage can necking machine configured for high speed operations.

BACKGROUND

[0003] Metal beverage cans are designed and manufactured to withstand high internal pressure—typically 90 or 100 psi. Can bodies are commonly formed from a metal blank that is first drawn into a cup. The bottom of the cup is formed into a dome and a standing ring, and the sides of the cup are ironed to a desired can wall thickness and height. After the can is filled, a can end is placed onto the open can end and affixed with a seaming process.

[0004] It has been conventional practice to reduce the diameter at the top of the can to reduce the weight of the can end in a process referred to as necking. Cans may be necked in a "spin necking" process in which cans are rotated with rollers that reduce the diameter of the neck. Most cans are necked in a "die necking" process in which cans are longitudinally pushed into dies to gently reduce the neck diameter over several stages. For example, reducing the diameter of a can neck from a conventional body diameter of $2\frac{11}{16}^{th}$ inches to $2\frac{6}{16}^{th}$ inches (that is, from a 211 to a 206 size) often requires multiple stages, often 14.

[0005] Each of the necking stages typically includes a main turret shaft that carries a starwheel for holding the can bodies, a die assembly that includes the tooling for reducing the diameter of the open end of the can, and a pusher ram to push the can into the die tooling. Each necking stage also typically includes a transfer starwheel shaft that carries a starwheel to transfer cans between turret starwheels.

[0006] Multi-stage can necking machines are limited in speed. Typically, commercial machines run at a rate of 1200-2500 cans per minute. While this is a high rate, there is a constant need to produce more and more cans per minute.

[0007] Also, concentricity of cans is important. A small misalignment at the beginning of the necking stages may result in concentricity problems between the can body and neck. For illustration, a difference in the centers of 0.020 inches (twenty thousandths) could result in a weak seam or even result in an insufficiently seamed can.

SUMMARY

[0008] A horizontal can necking machine assembly may include a plural of main turrets and a plural of transfer starwheels. Each main turret may include a main turret shaft, a main gear mounted proximate to an end of the main turret shaft, a pusher assembly, and a die capable of necking a can body upon actuation of the turret shaft. Each transfer starwheel may include a transfer shaft and a transfer gear mounted proximate to an end of the transfer shaft. The transfer starwheels may be located in an alternating relationship with the main turrets, and the main gears may be engaged with the transfer gears such that lines through the main gear center and the centers of opposing transfer gears form an included angle of less than 170 degrees, thereby increasing the angular range available for necking the can body. The saw tooth configuration of turret and transfer shafts that provides this included angle yields, compared with configurations defining a 180 degree included angle, increased can residence time in the operational zone for a given rotational speed, which increased time enables longer or slower spindle stroke, and/or higher can throughput for a given residence time, or a combination thereof. In this regard, the main turrets and transfer starwheels may be operative to neck and move at least 2800 cans per minute, and each pusher assembly may have a stroke length relative to the die that is at least 1.5 inches, and preferably 3400 cans per minute at a stroke length of 1.75 inches.

[0009] A die for necking a can body may include a neck portion, a body portion, and a transition portion. The necking portion may have an inner wall that defines a cylinder having a first diameter. The body portion may have an inner wall that defines a cylinder having a second diameter. The transition portion may have an inner wall that smoothly transitions from the inner wall of the neck portion to the inner wall of the body portion. The first diameter is larger than the second diameter, and the neck portion is at least 0.125 inches long, and preferably 0.375 inches long.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** is a perspective view depicting a multi-stage can necking machine;

[0011] FIG. **2** is a perspective view depicting a necking station and gear mounted on a main turret shaft of the multi-stage necking machine shown in FIG. **1**, with surrounding and supporting parts removed for clarity;

[0012] FIG. **3** is a perspective view depicting a transfer starwheel and gear mounted on a starwheel shaft of the multi-stage necking machine shown in FIG. **1**, with surrounding and supporting parts removed for clarity;

[0013] FIG. **4** is a partial expanded view depicting a section of the multi-stage can necking machine shown in FIG. **1**;

[0014] FIG. **5** is a perspective view depicting a back side of a multi-stage can necking machine having distributed drives;

[0015] FIG. **6**A is a perspective view depicting a forming die;

[0016] FIG. **6**B is a cross-sectional view of the forming die depicted in FIG. **6**A;

[0017] FIG. **7** is a schematic illustrating a machine having distributed drives; and

[0018] FIG. **8** is a partial expanded view depicting gear teeth from adjacent gears engaging each other.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0019] A preferred configuration for driving a multi-stage can necking machine is provided. The multi-stage can necking machine incorporates technology that overcomes the many shortcomings of known multi-stage can necking machines. The present invention is not limited to the disclosed configuration, but rather encompasses use of the technology disclosed, in any manufacturing application according to the language of the claims.

[0020] As shown in FIG. **1**, a multi-stage can necking machine **10** may include several necking stages **14**. Each necking stage **14** includes a necking station **18** and a transfer starwheel **22**. Each one of the necking stations **18** is adapted to incrementally reduce the diameter of an open end of a can body, and the transfer starwheels **22** are adapted to transfer the can body between adjacent necking stations **18**, and optionally at the inlet and outlet of necking machine **10**. Conventional multi-stage can necking machines, in general, include an input station and a waxer station at an inlet of the necking stages, and optionally include a bottom reforming station, a flanging station, and a light testing station positioned at an outlet of the necking stages. Accordingly, multi-stage can necking machine **10**, may include in addition to necking stages **14**, other operation stages such as an input station, a bottom reforming station, a flanging station, and a light testing station of the type that are found in conventional multi-stage can necking machines (not shown). The term "operation stage" or "operation station" and its derivative is used herein to encompass the necking station **14**, bottom reforming station, a flanging station, and a light testing station, and the like. Preferably, multi-stage can necking machine **10** is operative to neck and move at least 2800 cans per minute, more preferably at least 3200 cans per minute, and even more preferably at least 3400 cans per minute.

[0021] FIG. **2** is a detailed view depicting operative parts of one of the necking stations **18**. As shown, each necking station **18** includes a main turret **26**, a set of pusher rams **30**, and a set of dies **34**. The main turret **26**, the pusher rams **30**, and the dies **34** are each mounted on a main turret shaft **38**. As shown, the main turret **26** has a plurality of pockets **42** formed therein. Each pocket **42** has a pusher ram **30** on one side of the pocket **42** and a corresponding die **34** on the other side of the pocket **42**. In operation, each pocket **42** is adapted to receive a can body and securely holds the can body in place by mechanical means, such as by the action pusher ram and the punch and die assembly, and compressed air, as is understood in the art. During the necking operation, the open end of the can body is brought into contact with the die **34** by the pusher ram **30** as the pocket **42** on main turret **26** carries the can body through an arc along a top portion of the necking station **18**.

[0022] Die **34**, in transverse cross section, is typically designed to have a lower cylindrical surface with a dimension capable of receiving the can body, a curved or angled transition zone, and a reduced diameter (relative to the lower cylindrical surface) upper cylindrical surface above the transition zone. During the necking operation, the can body is moved up into die **34** such that the open end of the can body is placed into touching contact with the transition zone of die **34**. As the can body is moved further upward into die **34**, the upper region of the can body is forced past the transition zone into a snug position between the inner reduced diameter surface of die **34** and a form control member or sleeve located at the lower portion of pusher ram **30**. The diameter of the upper region of the can is thereby given a reduced dimension by die **34**. A curvature is formed in the can wall corresponding to the surface configuration of the transition zone of die **34**. The can is then ejected out of die **34** and transferred to an adjacent transfer starwheel. U.S. Pat. No. 6,094,961, which is incorporated herein by reference, discloses an example necking die used in can necking operations.

[0023] As best shown in FIG. **2**, a main turret gear **46** (shown schematically in FIG. **2** without teeth) is mounted proximate to an end of shaft **38**. The gear **46** may be made of suitable material, and preferably is steel.

[0024] As shown in FIG. **3**, each starwheel **22** may be mounted on a shaft **54**, and may include several pockets **58** formed therein. The starwheels **22** may have any amount of pockets **58**. For example each starwheel **22** may include twelve pockets **58** or even eighteen pockets **58**, depending on the particular application and goals of the machine design. Each pocket **58** is adapted to receive a can body and retains the can body using a vacuum force. The vacuum force should be strong enough to retain the can body as the starwheel **22** carries the can body through an arc along a bottom of the starwheel **22**.

[0025] As shown, a gear **62** (shown schematically in FIG. **3** without teeth) is mounted proximate to an end of the shaft **54**. Gear **62** may be made of steel but preferably is made of a composite material. For example, each gear **62** may be made of any conventional material, such as a reinforced plastic, such as Nylon 12.

[0026] As also shown in FIG. **3**, a horizontal structural support **66** supports transfer shaft **54**. Support **66** includes a flange at the back end (that is, to the right of FIG. **3**) for bolting to an upright support of the base of machine **10** and includes a bearing (not shown in FIG. **3**) near the front end inboard of the transfer starwheel **22**. Accordingly, transfer starwheel shaft **54** is supported by a back end bearing **70** that preferably is bolted to upright support **52** and a front end bearing that is supported by horizontal support **66**, which itself is cantilevered from upright support **52**. Preferably the base and upright support **52** is a unitary structure for each operation stage.

[0027] FIG. **4** illustrates a can body **72** exiting a necking stage and about to transfer to a transfer starwheel **22**. After the diameter of the end of a can body **72** has been reduced by the first necking station **18***a* shown in the middle of FIG. **4**, main turret **26** of the necking station **18***a* deposits the can body into a pocket **58** of the transfer starwheel **22**. The pocket **58** then retains the can body **72** using a vacuum force that is induced into pocket **58** from the vacuum system described in co-pending application (Attorney Docket Number CC-5163), which is incorporated herein by reference in its entirety, carries the can body **72** through an arc over the bottommost portion of starwheel **22**, and deposits the can body **72** into one of the pockets **42** of the main turret **26** of an adjacent necking station **18***b*. The necking station **18***b* further reduces the diameter of the end of the can body **72** in a manner substantially identical to that noted above.

[0028] Machine **10** may be configured with any number of necking stations **18**, depending on the original and final neck diameters, material and thickness of can **72**, and like parameters, as understood by persons familiar with can necking technology. For example, multi-stage can necking machine **10** illustrated in the figures includes eight stages **14**, and each stage incrementally reduces the diameter of the open end of the can body **72** as described above.

[0029] As shown in FIG. **5**, when the shafts **38** and **54** are supported near their rear ends by upright support **52**, and the ends of the shafts **38** and **54** preferably are cantilevered such that the gears **46** and **62** are exterior to the supports **52**. A cover (not shown) for preventing accidental personnel contact with gears **46** and **62**, may be located over gears **46** and **62**. As shown, the gears **46** and **62** are in mesh communication to form a continuous gear train. The gears **46** and **62** preferably are positioned relative to each other to define a zig-zag or saw tooth configuration. That is, the main gears **46** are engaged with the transfer starwheel gears **62** such that lines through the main gear **46** center and the centers of opposing transfer starwheel gears **62** form an included angle of less than 170 degrees, preferably approximately 120 degrees, thereby increasing the angular range available for necking the can body. In this regard, because the transfer starwheels **22** have centerlines below the centerlines of main turrets **26**, the operative portion of the main turret **26** (that is, the arc through which the can passes during which the necking or other operation can be performed) is greater than 180 degrees on the main turret **26**, which for a given rotational speed provides the can with greater time in the operative zone. Accordingly the operative zone has an angle (defined by the orientation of the centers of shafts **38** and **54**) greater than about 225 degrees, and even more preferably, the angle is greater than 240 degrees. The embodiment shown in the figures has an operative zone having an angle of 240 degrees. In general, the greater the angle that defines the operative zone, the greater the angular range available for necking the can body.

[0030] In this regard, for a given rotational speed, the longer residence time of a can in the operative zone enables a longer stroke length for a given longitudinal speed of the pusher ram. For example, with the above identified configuration, the pusher ram **30** may have a stroke length relative to the die **34** of at least 1.5 inches. Preferably, the pusher ram **30** will have a stroke length relative to the die **34** of at least 1.625 inches and even more preferably the stroke length is at least 1.75 inches. For the embodiment shown in the figures, the stroke length is approximately 1.75 inches.

[0031] The angular range available for necking of greater than 180 degrees enables the die used to reduce the diameter of the end of the can body to be designed to improve the concentricity of the can end. As shown in FIGS. **6**A and **6**B, the die **34** includes a throat portion **78**, a body portion **82** and a transition portion **86**. As shown, the throat portion **78** has an inner surface **90** that defines a cylinder having a first diameter, the body portion **82** has an inner surface **94** that defines a cylinder having a second diameter, and the transition portion **86** has an inner surface **98** that extends smoothly (and maybe curved) from the inner surface **90** of the throat portion **78** to the inner surface **94** of the body portion **82**. The first diameter should be large enough to receive the can body and the second diameter should be sized so that the diameter of the end of the can body can be reduced to a desired diameter.

[0032] To help improve the concentricity of the can end the throat portion preferably has a length of at least 0.125 inches, more preferably a length of at least 0.25 inches and even more preferably a length of at least 0.375 inches. The embodiment illustrated in the figures has a throat length of approximately 0.375 inches. Furthermore, an inlet **102** of the throat portion **78** may be rounded.

[0033] During operation of conventional stroke machines, the first part of the can that touches the die is the neck or necked rim. Any error in the neck portion often becomes worse, throughout the necking stages. In the long stroke machine illustrated herein, when the can goes into the die, it first locates itself in the die before it touches the transition portion. Therefore, by having a longer throat portion **78** compared with the prior art, the die **34** is able to center the can body prior to necking. Additionally, by having a longer throat portion **78**, the die **34** is able to seal the compressed air sooner. Until the can is sealed, the compresses air blows into the ambient atmosphere, which can be costly.

[0034] Referring back to FIG. **5**, the multi-stage can necking machine **10** may include several motors **106** to drive the gears **46** and **62** of each necking stage **14**. As shown, there preferably is one motor **106** per every four necking stages **14**, as generally described in copending application ______ (Attorney docket number CC-5164). Each motor **106** is coupled to and drives a first gear **110** by way of a gear box **114**. The motor driven gears **110** then drive the remaining gears of the gear train. By using multiple motors **106**, the torque required to drive the entire gear train can be distributed throughout the gears, as opposed to prior art necking machines that use a single motor to drive the entire gear train. In the prior art gear train that is driven by a single gear, the gear teeth must be sized according to the maximum stress. Because the gears closest to the prior art drive gearbox must transmit torque to the entire gear train (or where the single drive is located near the center on the stages, must transmit torque to about half the gear train), the maximum load on prior art gear teeth is higher than the maximum tooth load of the distributed gearboxes according to the present invention. The importance in this difference in tooth loads is amplified upon considering that the maximum loads often occur in emergency stop situations. A benefit of the lower load or torque transmission of gears **46** and **62** compared with that of the prior art is that the gears can be more readily and economically formed of a reinforced thermoplastic or composite, as described above. Lubrication of the synthetic gears can be achieved with heavy grease or like synthetic viscous lubricant, as will be understood by persons familiar with lubrication of gears of necking or other machines, even when every other gear is steel as in the presently illustrated embodiment. Accordingly, the gears are not required to be enclosed in an oil-tight chamber or an oil bath, but rather merely require a minimal protection against accidental personnel contact

[0035] Each motor **106** is driven by a separate inverter which supplies the motors **106** with current. To achieve a desired motor speed, the frequency of the inverter output is altered, typically between zero to 50 (or 60 hertz). For example, if the motors **106** are to be driven at half speed (that is, half the rotational speed corresponding to half the maximum or rated throughput) they would be supplied with 25 Hz (or 30 Hz).

[0036] In the case of the distributed drive configuration shown herein, each motor inverter is set at a different frequency. Referring to FIG. **7** for example, a second motor **120** may have a frequency that is approximately 0.02 Hz greater than the frequency of a first motor **124**, and a third motor **128** may have a frequency that is approximately 0.02 Hz greater than the frequency of the second motor **120**. It should be understood that the increment of 0.02 Hz may be variable, however, it will be by a small percentage (in this case less than 1%).

[0037] The downstream motors preferably are preferably controlled to operate at a slightly higher speed to maintain contact between the driving gear teeth and the driven gear teeth throughout the gear train. Even a small freewheeling effect in which a driven gear loses contact with its driving gear could introduce a variation in rotational speed in the gear or misalignment as the gear during operation would not be in its designed position during its rotation. Because the operating turrets are attached to the gear train, variations in rotational speed could produce misalignment as a can **72** is passed between starwheel and main turret pockets and variability in the necking process. The actual result of controlling the downstream gears to operate a slightly higher speed is that the motors **120**, **124**, and **128** all run at the same speed, with motors **120** and **128** "slipping," which should not have any detrimental effect on the life of the motors. Essentially, motors **120** and **128** are applying more torque, which causes the gear train to be "pulled along" from the direction of motor **128**. Such an arrangement eliminates variation in backlash in the gears, as they are always contacting on the same side of the tooth, as shown in FIG. **8**. As shown in FIG. **8**, a contact surface **132** of a gear tooth **136** of a first gear **140** may contact a contact surface **144** of a gear tooth **148** of a second gear **152**. This is also true when the machine starts to slow down, as the speed reduction is applied in the same way (with motor **128** still being supplied with a higher frequency). Thus "chattering" between the gears when the machine speed changes may be avoided.

[0038] In the case of a machine using one motor, reductions in speed may cause the gears to drive on the opposite side of the teeth. It is possible that this may create small changes in the relationship between the timing of the pockets passing cans from one turret to the next, and if this happens, the can bodies may be dented.

[0039] The present invention has been described by illustrating preferred embodiments. The present invention is not limited to an configuration or dimensions provided in the specification, but rather should be entitled to the full scope as defined in the claims.

What is claimed:

1. A horizontal beverage can necking machine assembly for forming necked beverage can bodies suitable for forming a seam with a beverage can end, the assembly comprising multiple horizontal necking stages adapted for necking at least **3000** beverage can bodies per minute;

each one of the main turrets including a substantially horizontal main turret shaft, a main turret starwheel having plural main pockets adapted for carrying can bodies, and a main gear adapted to drive the main turret shaft;, each one of the main pockets having a necking assembly including a necking die; wherein each one of the main turrets is configured to supply compressed air into the can body upon contact of the can body with the necking assembly;

each one of the transfer turrets including a substantially horizontal transfer turret shaft, a transfer turret starwheel having plural starwheel pockets adapted for carrying can bodies, and a transfer gear adapted to drive the transfer shaft;

the main turrets and the transfer turrets being arranged such that the main turret gears and transfer turret gears form a sawtooth configuration; each one of the main gears formed of a composite material comprising a plastic and each one of the transfer gears formed of a composite material comprising a plastic such that main gears and transfer gears are configured to operate without being disposed in an oil-tight chamber;

wherein the sawtooth configuration of the main turrets and the transfer turrets provides a greater necking operative zone compared with a necking operative zone of in-line turret necking machines.

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